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Add = J. Rikhoff (JJR2)
S. Schneider (SXS4)

To: Nuclear Regulatory Commission
Subject: Concerns regarding San Onofre's Steam Generator replacement project

October 22nd, 2009

The most dangerous times for any nuclear power plant are: Initial start-up or during a restart, and during a shut-down, especially an emergency shut-down.

Three Mile Island Unit II, for instance, had been in commercial operation for less than three months when it partially melted down. It was only slightly different from, slightly more powerful than, Unit 1, which, today, was relicensed by the same careless Nuclear Regulatory Commission we seek redress from today as well -- for another 20 years -- until April 19, 2034. Some of Three Mile Island Unit 1's parts will be 60 years old when it is finally "retired" -- irradiated, thermally heated, pressurized, chemically embrittled, and cycled on and off hundreds or even thousands of times.

The Emergency Core Cooling Systems, mandatory for all commercial reactors, have never actually been tested, and many scientists have asserted that their calculations have indicated the ECCSs may not work when needed. Not only that, but several ECCSs, such as Monticello's, were found to be completely inoperative several decades after installation, and would definitely not have worked. Control rods have jammed, fuel rods have been bent, plutonium has escaped... and one reactor, Davis-Besse, nearly corroded all the way through before anyone noticed! Except maybe the filter salesman.

Many of San Onofre's sea-encrusted, rusted, dilapidated parts will be 60 years old, too, if it makes it to retirement age.

And with all the NEW parts they are installing at San Onofre right now -- miles of pipes, dozens of pumps, scores of valves, hundreds of new sensors, drum after drum of electrical cables -- there will be new pressures and fluid flows throughout the system, new control mechanisms, and even relatively new, or completely new, operators. People quite a bit younger than the plant itself, who don't know how hard people fought to stop it in the first place. Who don't know that almost all our fears have ALREADY been realized, from cancers in the community because of the plant, to fraud at the plant, to piling nuclear waste problems, to threats of terrorism. Yes, it was all foreseen.

Right now, one by one, each of San Onofre's two remaining operable reactors are being rebuilt, top to bottom. That is, pieces of them are being replaced, top to bottom (even the fog lights, and certainly the sump pumps). But despite the retrofit, vastly more pieces are never being touched, never even being inspected.

How much inspection can such a small crew as the NRC leaves "on site" really do? There is only one inspector for every couple of hundred workers.

Furthermore, a climate of cover-up still exists at the plant, according to whistleblowers this author has talked to. And no doubt no one from The Shaw Group wants to expose their mistakes, since they are all new at the site and the last group or operators -- Bechtel and their subcontractors -- were fired en masse after about 40 years of running the most dangerous thing on earth, on August 30th, 2009.

During the retrofit -- a different division of Bechtel is doing that work -- the danger is probably a lot less than during an average day the plant is running. Criticality is not occurring at the shut-down reactor. Water isn't screaming through the system at enormous velocities and pressures. Lazy, sleepy operators on mood-altering cardiac beta blockers for health problems due to sitting all day long aren't using inaccurate and faulty instrumentation to monitor the whole thing and stop it from melting down.

So I'm less scared when the plant is shut down than at any other time. But the restart AFTER this major retrofit will be an especially dangerous time.

And then, the continued operation of the plant for 20 more years may well spell doom for SoCal at some point -- for any of a million different reasons. The old welds might start failing, let alone all the new ones that weren't done right, or were done right in Japan or elsewhere in the world, but didn't get shipped properly to America, or broke during installation. And nobody reported anything, because of the climate of cover-up.

During the actual retrofit, at least the reactor that is being refitted is not increasing the quantity of spent fuel with nowhere to put it by an average of 250 pounds per day per reactor, as happens each day the reactor is operating (500 lbs per day for San Onofre altogether, when both reactors are running). That's in addition to the tritium which is released and poorly tracked, and the hundreds of pounds per year of noble gases which are not tracked or stopped in any way at all, and the daily releases of radioactive isotopes of all known elements, in varying quantities, as allowed by ALARA.

All nuclear facilities vent radioactive isotopes to the public. HEPA filters were originally designed in the 1940s for cleaning the air of radioactive particles but they only achieve a 99.97% success rate (by definition). 3 particles in 10,000 may not sound like a lot, and might have been good enough for The Manhattan Project, but when you are releasing billions of billions of particles every day INTO the filters, it means you are letting a lot of children die in your community DESPITE the filters. And HEPA filters don't work for isolating tritium (a lot more H3 could be removed, but not that way) nor do they do anything to stop the release of the noble gases, which flow right through them. The legal limit for releases of tritium each year by each reactor at San Onofre is about one thirtieth of a teaspoon. Tritium is extremely hazardous, and even this seemingly small amount is way, way too much. And besides, whenever they release more than a thirtieth of a teaspoon, the NRC gives them two special dispensations: One not to say anything, and one not to do anything.

So-called "low-level" waste, such as the old steam generators, and the old pumps, pipes, valves, etc., which are being swapped out at the same time as the steam generator replacement project is going on, will be irradiating people, and will get into our children's braces eventually.

No reactor should ever be restarted. Period. Shut them ALL down and dismantle / decommission them. All other choices are folly.

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The author has developed and distributed award-winning educational software for more than 25 years and has customers at over 1000 colleges and universities in over 100 countries. His company web site -- www.animatedsoftware.com -- gets millions of "hits" every month. Hoffman has studied nuclear power for about 40 years and wrote approximately 1000 blog entries on nuclear issues prior to authoring The Code Killers in 2008 (and several dozen since).

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February 5, 2009

Annette L. Vietti-Cook, Secretary
United States Nuclear Regulatory Commission
Washington, D.C. 20555-0001
ATTN: Rulemakings and Adjudications Staff

RE: Comments on Proposed Waste Confidence Decision Update (Docket ID-2008-0482)
10 C.F.R. Part 51.23(a)

Dear Secretary Vietti-Cook:

INTRODUCTION

The Attorney General of California (Attorney General) submits these comments pursuant to his independent authority under the California Constitution, common law, and statutes to represent the public interest of the People of the State of California. The Attorney General has the power to protect the natural resources of the State from pollution, impairment, or destruction. *See* Cal. Const. Art. V, sec. 13; Cal. Gov. Code §§ 12511, 12600-12; *D'Amico v. Board of Medical Examiners*, 11 Cal.3d 1, 14-15 (1974). These comments are made on behalf of the Attorney General and not on behalf of any other California agency or office. The Attorney General believes that the environmental impacts from storage of spent nuclear fuel at commercial reactors have not been adequately analyzed to date, and that changes in the Waste Confidence Decision (10 C.F.R. Part 51.23(a)) proposed by the Nuclear Regulatory Commission (NRC) at 73 Fed. Reg. 59551 (October 9, 2008), will only exacerbate this failure.[1] The NRC should find instead that there is the potential for a significant environmental impact from leaks, accidents or acts of terrorism, and require site-specific NEPA evaluation and compliance during licensing and relicensing decisions involving spent nuclear fuel storage at power plants. In particular, the Attorney General believes that "Finding 4" is unsupported by the latest information about the storage of spent nuclear fuel and its susceptibility to leaks, accidents, or terrorist attacks.

[1] On the same day, October 8, 2008, the NRC requested comment on its Finding 2 that spent nuclear fuel could be stored safely and without significant environmental impact until there was a repository available (73 Fed.Reg. 59547). To the extent that finding relies on the Waste Confidence Decision discussed in these comments, California urges the NRC to reconsider Finding 2 as well.

DISCUSSION

The NRC Relies On Flawed Findings from its Denial of Recent California and Massachusetts Petitions for Rulemaking

In 2006 and 2007, the Attorneys General of Massachusetts and California filed petitions for rulemaking with the NRC, asking that 10 C.F.R. Part 51 be revised in light of new information. (Massachusetts, Petition for Rulemaking No. PRM-51-10; California, Petition for Rulemaking No. PRM-51-12, joined by the Attorney General of New York). The petitions asked, *inter alia*, that the NRC revise 10 C.F.R. Part 51 in consideration of new and significant threats that have developed since these regulations were last revised in 1990, namely, heightened risk of accidents in overcrowded spent fuel storage pools, and the enhanced terrorist threat. The petitions also proposed changes in the regulations based on the Ninth Circuit Court of Appeals finding in *San Luis Obispo Mothers for Peace v. NRC*, 449 F.3d 1016 (9th Cir. 2006), cert. denied, 127 S.Ct. 1124 (2007), that the National Environmental Policy Act (NEPA) required an analysis of the potential environmental impacts from acts of terrorism during NRC licensing decisions.[2] These petitions were rejected by the NRC on August 1, 2008. 73 Fed. Reg. 46204 (August 8, 2008).

The NRC has now compounded that failure to comply with NEPA by proposing to adopt into regulation a conclusive presumption that spent nuclear fuel can be safely stored onsite at a nuclear facility after the licensed life of the reactor without significant environmental impact for a full sixty years, twice as long as previously presumed. 73 Fed. Reg. 59551 (October 9, 2008). The revision is not supported by new safety information or improved scientific analysis; rather, it appears to be primarily intended to address the fact that the application to use Yucca Mountain as a permanent nuclear waste repository has been challenged[3], and that Yucca Mountain is unlikely to be opened within the time frame set out in the existing regulations. Indeed, the proposed Waste Confidence Decision update refuses to deal with its own administrative record, in that it fails to include in its discussion the data provided by the State of Massachusetts in its petition for rulemaking regarding the threats posed by long term storage of nuclear waste in crowded spent nuclear fuel pools, data that fatally undermine the Waste Confidence Decision. The Massachusetts information appears not to have been any part of the NRC's analysis of the proposed regulation, in violation of well established principles of the Administrative Procedure Act, 5 U.S.C. section 705, that require an agency to deal with the full administrative record in a rulemaking proceeding. *Burlington Truck Lines, Inc. v. United States*, 371 U.S. 156, 168 ("the agency must examine the relevant data and articulate a satisfactory explanation for its action. . ."); *Lands Council v. McNair (Lands Council II)*, 537 F.3d 981, 987 (9th Cir. 2008) (*en banc*) ("we will reverse a decision as arbitrary and capricious only if the agency . . . entirely failed to consider an important aspect of the problem . . . .").

[2]California and Massachusetts also petitioned the NRC to reverse its finding that the effects of high density storage of spent fuel rods may *never* be significant for purposes of NEPA.

[3]See, 73 Fed. Reg. 59549 (October 9, 2008).

Since the NRC is proposing to revise 10 C.F.R. Part 51.23(a), we request in the strongest possible terms that the NRC reconsider the information it received from Massachusetts and California in their petitions for rulemaking. The NRC has not provided a reasoned explanation, reviewable by the public and the courts, as to why it has not considered the new data about the greater risk of accidents in overcrowded spent fuel pools. Instead, the NRC, in its discussion of the justification for its proposed changes to the Waste Confidence findings at 73 Fed. Reg. 59548-59549, appears to base its proposed regulation principally on information it cited in its decision to deny the petitions of California and Massachusetts. That decision heavily relied on the "Sandia Studies," 73 Fed. Reg. 46207, fn. 6 (August 8, 2008). The NRC states that these studies, performed after September 11, 2001, support its finding that the risk of a successful terrorist attack is very low. This study has been withheld from the public, and a version that was made available to the public via a response to a Freedom of Information Act request is so redacted as to be worthless. Instead of solely relying on studies that the public is not allowed to see and whose conclusions are not reviewable, the NRC should have, as Commissioner Jaczko noted in his dissenting view, considered the information supplied by the petitioners and should have used the information as part of its analysis. 73 Fed. Reg. 46212 (August 8, 2008).

<u>The Waste Confidence Decision Violates Core Principles of NEPA Regarding Supplementation of Environmental Impact Statements</u>

NEPA requires supplementation of an environmental impact statement for a project when: 1) there is significant change in the circumstances under which a project is carried out; or 2) there is significant new information regarding the environmental impacts of the project. *Marsh v. Oregon Natural Resources Council, et al.*, 490 U.S. 360, 374 (1989). NRC regulations governing NEPA review apart from the Waste Confidence Decision incorporate these NEPA requirements at 10 C.F.R. section 51.92, subdivision (a)(1) and (a)(2).

As to many matters other than long-term storage of spent fuel, NRC cases hold that significant changes in circumstances or significant new information trigger the NEPA duty to supplement the environmental analysis for the project in question. *In the Matter of Shaw Areva MOX Services*, 66 N.R.C. 169, 192 (2007) ("Supplementing the EIS is to be done when 'significant new circumstances or information relevant to environmental concerns' become apparent.") However, the Waste Confidence Decision not only makes such supplementation not required, it makes it legally impossible under NRC regulations, simply because the subject matter is on-site waste storage. The NRC has not shown a clearly articulated justification, based on substantial evidence in the record, for the proposed extension of this presumption that <u>no</u> change in circumstance, and <u>no</u> new information, can <u>ever</u> trigger the NEPA duty to supplement the environmental analysis of the long-term on-site storage of nuclear waste.

Under the proposed rule, no supplemental EIS could ever be required – indeed, it would be effectively forbidden – even if (as occurred at Diablo Canyon) a major new fault with a high capability for seismic movement was discovered near a plant that has long-term storage, even if actual leaks from a spent fuel pool were detected that might reach groundwater, or even if other serious new circumstances arose that substantially changed the environmental picture as to any specific facility. Under the Waste Confidence Decision, individual circumstances and facts do not matter, no matter what they may be. This is contrary to the well-settled requirements of NEPA and is, therefore, invalid as an unreasonable interpretation of NEPA, a statute applicable to the NRC.

Further, under the proposed rule, a very serious and substantial change can be made in an existing nuclear facility, namely the change from a working power plant to a long-term nuclear waste storage facility, without environmental review. A prime goal of Congress in enacting NEPA was to ensure that the public is informed as to the possible environmental consequences of decisions that federal agencies make and projects those agencies approve. *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 349 (1989). The proposed changes to the Waste Confidence Decision would defeat that goal by allowing nuclear power plants to be substantially re-purposed and transformed into long-term storage facilities, a function and activity for which they were neither initially designed or approved, without environmental review. When a project -- here, a nuclear power plant -- undergoes such a profoundly significant change in purpose, scope, and duration as this transformation from power provider to semi-permanent nuclear waste dump, NEPA may require supplementation of the initial NEPA documents. The initial NEPA documents prepared and reviewed by the public for the nuclear power plant covered a very different project, function, and time frame, and those documents are simply adequate for the approval of such a fundamental change in the project. It is not consonant with the purposes and requirements of NEPA to take such supplementation of NEPA documents completely, permanently, and categorically off the table by regulation, regardless of the circumstances involved in individual cases, solely because they involve storage of nuclear waste.

NRC regulations governing NEPA compliance at 10 C.F.R. section 51.92, subdivision (a) make EIS supplementation mandatory if there are "substantial changes" or "new and significant information." While the NRC often interprets that regulation narrowly, it at least makes supplementation the legitimate question that NEPA cases hold it should be. The Waste Confidence Decision effectively repeals those NEPA requirements for one category of nuclear project, and does so for cases whose individual facts are not yet known, and for several decades. We believe that this is invalid and beyond the legal authority of the NRC to adopt.

Doubling the "Safe Storage" Period Only Exacerbates NRC's Noncompliance with NEPA Given That the *Mothers for Peace* Decision Found That The Risk of Terrorism Is Not Low

The NRC's proposed regulatory action does not comply with the holding of the Ninth Circuit Court of Appeal in *San Luis Obispo Mothers for Peace v. NRC* case, which found that NEPA requires an examination of the environmental impacts that would result from an act of terrorism against a nuclear power plant. The plaintiff sued the NRC for refusing to consider environmental impacts of terrorist attacks on proposed interim spent fuel storage installations, or on the Diablo Canyon nuclear facility as a whole. The Ninth Circuit cited statements and evidence made or produced by the President and the United States Department of Homeland Security, in holding that the threat of a 9/11-style terrorist attack is reasonably foreseeable and not speculative, and that the NRC must recognize it as such and consider it as part of its NEPA analysis of the above-ground waste storage facility. The Ninth Circuit reasoned that the NRC is at least required under its own formulation of the rule of reasonableness to make determinations of the environmental effects of a terrorist attack consistent with NRC policy statements and procedures. *Mothers for Peace* at 449 F.3d. at 1031. The Court held that the NRC's categorical refusal under NEPA to consider environmental effects of terrorist attack, on the basis that terrorist attacks were "remote and highly speculative," was not reasonable in light of the federal government's efforts and expenditures to combat that type of attack against nuclear facilities. The risk that a terrorist attack will be directed at a particular nuclear facility is reasonably foreseeable and quantifiable. Given that spent fuel pools tend to have less structural protection than reactors themselves (e.g., no containment building at Diablo Canyon), it is also reasonably foreseeable that any such attack could have devastating effects on the environment.

In the discussion of its proposed revision to the Waste Confidence Decision (73 Fed. Reg. 59547-59548), the NRC cites to its denial of the petitions for rulemaking for support of its position that the risk of a successful terrorist attack is "very low." 73 Fed. Reg. 46207 (August 8, 2008). The Denial Decision refuses to follow the *Mothers for Peace* decision, suggesting it is only applicable in the Ninth Circuit and is wrongly decided. 73 Fed. Reg. 46211 (August 8, 2008). This conclusion ignores the statements from the Bush administration describing the risk of terrorist attack to nuclear facilities. Indeed, the Ninth Circuit noted, "The NRC's actions in other contexts reveal that the agency does not view the risk of terrorist attacks to be insignificant." *Mothers for Peace* 449 F.3d at 1032. The National Academy of Sciences , in *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report* (2006), found that storage pools were susceptible to fire and radiologic release from actions such as a intentional attack with a civilian aircraft. Despite this extreme risk, the Design Basis Threat regulations (72 Fed.Reg. 12705, March 19, 2007), do not require nuclear power plant operators to plan defenses to attacks from the air.

The proposed changes in the Waste Confidence Decision ignore these facts, as well as the facts and legal arguments set out in the Petition for Rulemaking No. PRM-51-10, and in the Massachusetts Attorney General's Request for a Hearing and Petition to Intervene With Respect to Entergy Nuclear Operation Inc.'s Application for Renewal of the Pilgrim Nuclear Power Plant Operating License, etc., Docket No. 50-293. Indeed, NEPA, as interpreted by the *Mothers for Peace* case, requires an analysis of the environmental impacts of terrorism in reactor licensing and relicensing decisions, and any revision of the Waste Confidence Decision must include and be consistent with such an analysis. We are aware of the NRC's position that it is not legally obligated to comply with the *Mothers for Peace* decision outside the Ninth Circuit. *In the Matter of Amergen Energy Company, LLC*, 65 N.R.C. 124,128-129 (2007). However, notwithstanding the NRC's obligation to follow the holding of *Mothers for Peace*, the facts upon which that holding was based must be addressed by more than a simple statement that the NRC disagrees. In this rulemaking proceeding, the NRC is bound by the APA to provide a reasoned response to those facts and the discussion of them by the Ninth Circuit, something it has not done.

The Risk from Accidental Fires

The National Academy of Sciences has pointed out that the dense storage of spent nuclear assemblies in pools is a major new development that creates a risk of fire that did not exist under less crowded conditions; this needs to be closely considered by the NRC. See, NAS Committee on the Safety and Security of Commercial Spent Nuclear Fuel Storage, *Safety and Security of Commercial Spent Fuel Storage*, at pp. 53-4 (The National Academies Press 2006). The overcrowding increases the potential for severe accidents if water is partially lost from the pool. If the water drops to the point where the top of the spent fuel assemblies are exposed to the air, they will burn and the fire may spread to other assemblies in the pool, potentially leading to a catastrophic fire and release of radioactive aerosols. Because the California plants are operating in active earthquake fault zones, an incident that could involve loss of water from the pools is a reasonable possibility. As a case in point, a moderate earthquake caused damage to the Humboldt Bay Nuclear Plant in Eureka, California, which was then closed because a seismic retrofit was not economical.[4] This information concerning the risk caused by high density pool storage is new and significant information that should be considered by the NRC in this proposed revision, and calls out for further analysis in licensing decisions that impact spent nuclear fuel pools. Instead, again relying on its denial of the petitions for rulemaking, the NRC refers to the confidential Sandia studies to justify its determination that the risks of such a fire are low, leaving the public – and the courts –without sufficient information to evaluate this determination. 73 Fed. Reg. 46211 (October 8, 2008).

Leaks from Storage Pools

In addition to the risks discussed above, the NRC apparently believes that it lacks regulatory authority to require groundwater testing to detect leaks from spent fuel pools, and relies on voluntary compliance from the industry. *Liquid Radioactive Release Lesson Learned Task Force Final Report* (Sept. 1, 2006.) (Indian Point Unit One), at 13. It has also concluded that systems or structures that are buried or that are in contact with soil, such as spent fuel pools, are particularly susceptible to undetected leakage. *Id.* at iii, 33. It was recently discovered that a leak in the spent fuel pool at the Brookhaven National Laboratories had been occurring for 12 years. General Accounting Office, *Information of the Tritium Leak and Contractor Dismissal at the Brookhaven National Laboratory* (GAO/RCED-98-26), November 1997. Radioactive leaks have been reported at six other nuclear power plants; such a history suggests that each facility should be subjected to site specific NEPA review, and further demonstrates the irresponsibility of making a generic determination that storage of spent nuclear fuel can never have a significant environmental impact.

[4] "Nuclear Power in California: Status Report, Final Consultant Report," at p. 31, California Energy Commission (March 2006), CEC 150-2006-001-F.

CONCLUSION

The NRC has an affirmative duty to carry out NEPA's mandate for full public disclosure of reasonably foreseeable environmental effects that may result from federal actions or approvals. The existing NRC regulations preclude the NRC from carrying out NEPA's action-forcing mandate by authorizing it to ignore its legal duty to disclose and analyze reasonably foreseeable significant risks that will affect the environment. These are risks that the President, the NRC itself, and many other federal agencies and public organizations recognize now exist and have existed since September 11, 2001. The proposed Waste Confidence Decision must not repeat this mistake and make it worse, but should instead fully consider the implications of new information about the risks from accidents and terrorism. California opposes any generic determination that spent nuclear fuel can be stored safely at all nuclear facilities without any significant environmental impacts.

Sincerely,

BRIAN W. HEMBACHER
Deputy Attorney General

For EDMUND G. BROWN JR.
Attorney General

DISPOSAL OF HIGH-LEVEL NUCLEAR WASTE

by

James C. Warf, Ph.D. and Sheldon C. Plotkin, Ph.D.

Global Security Study No. 23

September 1996

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DISPOSAL OF HIGH-LEVEL NUCLEAR WASTE

By James C. Warf, Ph.D. and Sheldon C. Plotkin, Ph.D.

More than a half century after the beginning of the Nuclear Age, there is no satisfactory answer to the serious dilemma of how to dispose of the large quantities of radioactive wastes created by military and civilian uses of nuclear energy. This paper examines technological options for waste disposal, and concludes by favoring Midtibarrier Monitored Retrievable Storage (MMRS) The authors point out, however, that this form of storage (it is not really disposal) will require "continuous monitoring... essentially forever. " Thus, the best of the options will require something akin to a "nuclear priesthood" to pass along their skills at monitoring these wastes for thousands of generations — a sobering thought.

Our century's indulgence in nuclear technology has created radioactive wastes that are a problem not only in the present but will affect thousands of generations in the future. The problems are so long-term that they are beyond our capacity to plan for adequately. At a minimum, we should cease — with all due speed — to generate more nuclear wastes.

The Nuclear Age Peace Foundation s directors issued a policy statement on nuclear power in May 1996 calling for "a world adequately supplied by renewable, environmentally benign energy sources, and the worldwide elimination of nuclear power." A copy of the full statement is available from the Foundation.

—David Krieger

Introduction

Disposal of highly radioactive nuclear waste is a critical problem for our time and will remain so well into the future. There are two main waste sources: Nuclear power reactors and bomb-related nuclear material from the production facilities and from the decommissioned U.S. and (former) U.S.S.R. nuclear weapons.

This paper deals with disposal of (a) reactor spent fuel rods and (b) waste sludge from the bomb-grade plutonium separation process. Disposal of bomb-grade plutonium from decommissioned weapons and from existing stockpiles present somewhat different problems which are not treated here.* Nuclear waste disposal poses a number of different yet interconnected problems, all of which must eventually be resolved in an integrated fashion: technical, economic, health-related, environmental, political. The present paper addresses primarily technical issues, and does not attempt an analysis of the overall problem.

Management of radioactive waste is a complex, multi-faceted procedure. Spent commercial fuel rods present the most demanding challenge of all waste problems because of the high level of radioactivity. The fuel rods, relatively harmless before entering the reactor, emerge having become dangerously radioactive. They require storage tor at least ten years under circulated water in a pool inside the reactor containment structure.

By statute, the government, through the Department of Energy's Office of Civilian Radioactive Waste Management, has promised to provide disposal capacity for the waste generated by the nation's nuclear power plants. Some of the waste which has accumulated over 45 years of Cold War nuclear bomb production also falls into the high-level category.

The term "high-level" nuclear waste has had its meaning changed in the U.S. over the years. At the present time the Nuclear Regulatory Commission (NRC) has defined "high-level" very narrowly as mostly, but not entirely, spent fuel elements and reprocessed military wastes, such as sludges. They further define "spent fuel," concentrates of strontium-90 and cesium-137, and transuranics as something not necessarily included in their definition of "high-level" waste.

Because this NRC definition is contrary (if not actually contradictory) to standards of the rest of the world and makes no sense to the authors, "high-level" nuclear waste is defined here as all radioactive waste material coming from nuclear reactor fuel rods whether confined or not:

a) Spent nuclear fuel rods, clad or declad, from commercial electricity generating reactors; average radioactivity being more than 2.5 million curies per cubic meter.

b) Semi-liquid sludge from nuclear bomb fabrication waste processing residue — average radioactivity being about 3500 curies per cubic meter.

All this waste contains five shorter lived and longer lived radionuclides of main concern. The shorter lived are strontium-90 whose half life, $t_{1/2}$ is 28.5 years, and cesium-137 whose half life, $t_{1/2}$ is 30 years. See Ref. 1 for the half-life values used in this study. The radioactivity of these shorter lived nuclides is approximately 95% of the total radioactivity of the nuclides of concern. Total hazardous life for these shorter lived nuclides is considered to be between 600 years and 1000 years depending upon one's point of view.

The longer lived isotopes are plutonium-239 whose $t_{1/2}$ is 24,110 years, plutonium-240 whose $t_{1/2}$ is 6,540 years, and curium-245 whose $t_{1/2}$ is 8,500 years. Plutonium-238 whose $t_{1/2}$ is 88 years will have essentially disappeared after several thousand years, so in storage terms of the longer lived elements this isotope is not of concern as long as it will have been successfully contained for the next several thousand years. As for the life of these longer lived materials, the NRC considers 10,000 years as the storage time required; however, some people consider a lifetime as long as 100,000 years to 500,000 years as more appropriate.

A recent analysis, **Management and Disposition of Excess Weapons Plutonium, was published by the National Academy Press, 1994*

Table I
Radioactivity for 100 Tons of Spent Fuel *
Curies Remaining

Isotope	$t_{1/2}$ yrs	10 yrs	500 yrs	1000 yrs	10,000 yrs	100,000 yrs	200,000 yrs
Sr-90	28	2,000,000	15	trace			
Cs-137	30	3,000,000	40	trace			
Pu-239	24,110	22,000	27,000	29,000	56,000	8,000	240
Pu-240	6,540	49,000	175,000	170,000	69,000	7	trace
Cm-245	8,500	56,000	52,500	52,000	25,000	0.5	trace

* A typical 1000 megawatt reactor contains about 100 tons of enriched uranium, one-third of which is renewed each year.

Table I (above) extracted from Ref. 2 should be helpful. It must be noted that as some radioactive isotopes disintegrate, they create other radioactive isotopes in the process. Thus Pu-239 and Pu-240 increase at first and do not begin decreasing until many years later.

Table I illustrates, as does Figure 1 (below), rather spectacularly the fallacy of the NRC rationale for a 10,000 year waste storage lifetime, when the radioactivity for the plutonium isotopes are greater after that long period than at the outset. However, it must be noted that this Pu-239 is relatively confined and in general will not be disturbed, so the basic health hazards from such radioactive materials as radon and radium from uranium ores appear to be far more serious.

The general nuclear waste disposal approach is that the repositories should not be more dangerous than natural ores of uranium and thorium. In fact, they might be much less hazardous; after all, the natural ores have no barriers such as containers, and radium is leached from many of the ores so that traces get into the food chain. Spent fuel rods have to be stored between 13,000 and 14,000 years before their level of radioactivity decreases to that of natural uranium ore.

One of the most serious engineering problems is that of allowing for release of the prodigious heat emanating from stored nuclear power waste. Most of the heat comes from the strontium-90 and cesium-137 at the start, but the longer-lived actinides produce more in later years. As noted in

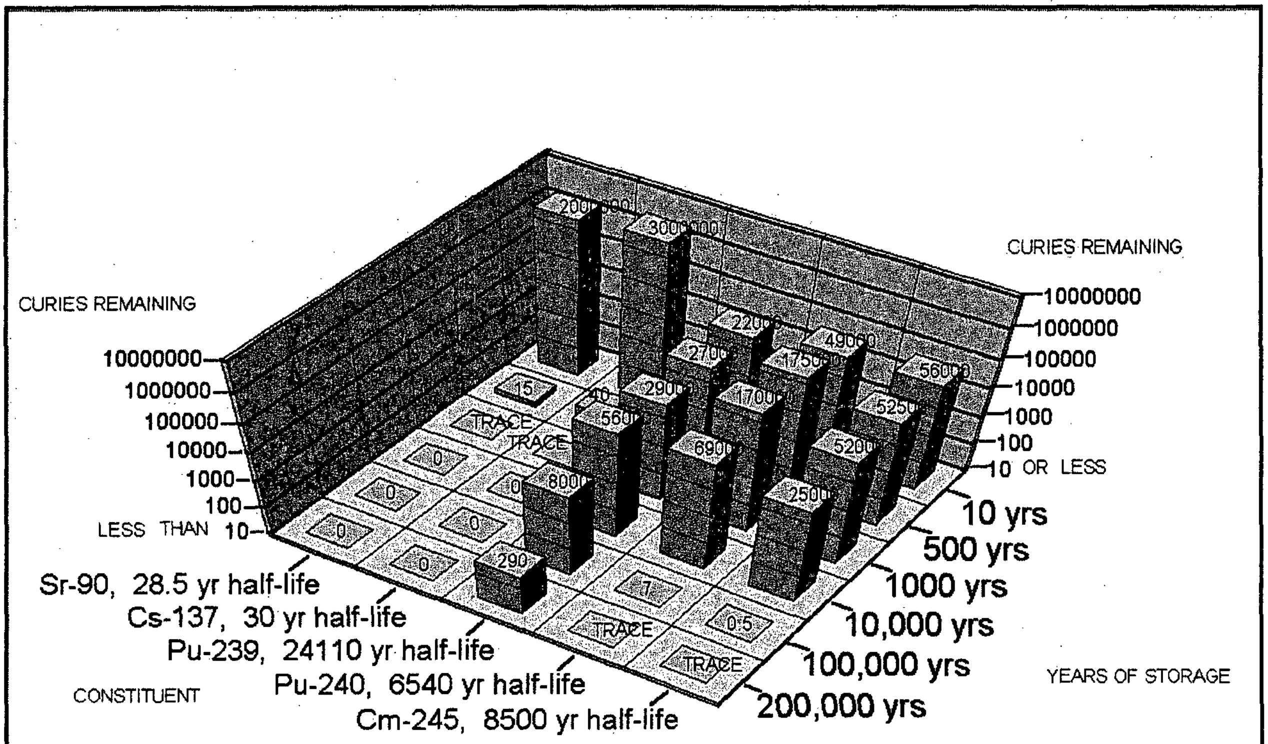

Figure 1. Radioactive Decay of 33 Tons of Spent Reactor Fuel. A typical (1000 MW) reactor contains about 100 tons of enriched uranium, about 33 tons of which becomes radioactive waste each year.

Table II (below), the heat liberated by spent nuclear reactor fuel decreases significantly as it ages.

From a practical engineering standpoint there is little difference between a 500 year lifetime and a 500,000 year lifetime. The 500 years is so long a time that no storage prototype system can ever be tested, thus the basic engineering considerations remain unchanged regardless of the waste lifetime. It is on this fact that any long-term storage conclusions are predicated. As is discussed below, any storage technique that utilizes permanent or nonretrievable ground burial is fundamentally a violation of basic engineering principles. This was pointed out to the nuclear industry over 25 years ago, but their response at that time was that they had "faith" that some satisfactory new technique would be developed, by the government of course and at taxpayers' expense, before it would be necessary to initiate long-term storage. Obviously, that has not happened and we are now faced with a nuclear waste disposal problem that has no fully satisfactory solution and probably never will have.

Multibarrier Monitored Retrievable Storage (MMRS)

This, unfortunately, is the final technique of choice for this particular waste disposal problem. It is unfortunate because there must be a continuous monitoring of the waste essentially forever. There are two fortunate aspects deserving mention: (1) the total volume of the waste involved is small by world standards, i.e., one football field for each type of waste each ten or twelve stories high, and (2) the number of people theoretically required to perform the monitoring task is also quite small, perhaps one hundred people or less worldwide. A ball park estimate of costs in present day dollars indicates that about $100 million is required over a 10,000 year time period for each 1000 megawatt nuclear power plant.

For the nuclear power plant waste, which consists of spent fuel rods, the most desirable inner barrier is the original cladding used for the nuclear fuel in the basic power plant configuration. This excellent cladding barrier is usually zirconium but sometimes stainless steel is used. The lifetime of this cladding has never been tested, so there is no telling exactly how long it can be depended upon. Safety engineering, however, dictates that because this barrier has already proved to be very reliable, it should be left in place and not removed. Further barriers have to be determined as a result of experimental development based upon both thermal characteristics and mechanical properties. Possibilities include glass, copper, ceramic, additional zirconium, stainless steel, nickel, or titanium. All this is for the power plant spent fuel rods only. Bomb waste having been processed requires another barrier or cladding before application of the "standard" multibarriers.

Because the bomb waste is initially in a semi-liquid sludge form, it has to be solidified at the outset. The quantities involved are approximately 105 million gallons for the U.S. as of 1994, so the total quantity worldwide would be about 200 million gallons. A ball park estimate of the solidified quantity results in roughly the same volume as the power plant waste with the identical radioactive nuclides. The major difference between this solidified nuclear bomb waste and the spent fuel rods will be that the former will probably be contained in vitrified or glassified cylinders as compared with the latter being in long slender cylindrical fuel rods with metallic cladding. Actually, if we fabricated the bomb waste's vitrified cylinders in long slender rods the same size as the spent fuel rods, the remainder of the waste disposal process could be identical for both waste components.

Of special note here is that the final configuration must be a solid container or cask whose outer surface is monitored. Engineering jargon usually refers to this approach as placing the canister in a "bath tub." Sensitive radioactive sensors in the "bath tub" must monitor this outer container surface continuously in an automated fashion. Such automation must incorporate Built-In-Self-Test, making use of many space exploration techniques.

While the waste canisters or containers are stored in shallow, underground but easily accessible facilities, all testing and monitoring should be performed by automated equipment. Such techniques preclude human errors caused by boredom, undetected equipment malfunctions, and misinterpretation of displayed information. Human intervention is necessary only for overall supervision and periodic testing of the automated equipment because of multiple error causation possibilities beyond the original design. We have to remember that there is nothing that is 100% safe; nuclear bombs for example only possessed six or seven safety

Table II
Thermal Power per Metric Tonne* of Spent Fuel

Age (years)	Rate of heat liberated (watts)	Percent of heat from strontium and cesium
1	12300	67
5	2260	69
10	1300	72
20	950	68
50	572	56
100	312	31
200	183	5

* 1 metric tonne = 1000 kilograms = 1 long ton = 2200 lbs

interlocks. Periodically, the nuclear waste monitoring equipment must be replaced and the waste canisters themselves will require retrieval and automatic repackaging every hundred years or more. It is noted that there are essentially two sets of automatic equipment, (1) the canister "bath tub" monitors and (2) the retrieval/repackaging mechanism. The latter might well be simply remote controlled equipment or a combination of semi-automatic components.

A summary of our viewpoint is that the best disposal method known to date consists of sealing the zirconium or stainless steel-clad spent fuel rods, without reprocessing, in copper or steel canisters and storing these in a geologic but easily accessible repository. This is the once-through fuel cycle. The spent fuel rods should be allowed to stand at least ten years under water so that most of the radioactive materials decay, and the rate of heat generation has fallen by about 86%. The repositories must have multiple barriers. The canisters must be arranged so that sufficient cooling air can circulate around them after disposal. The waste density must not exceed that required for adequate heat flow.

A major point to be made is that a very responsible and conscientious group of people is required to take care of our long-term nuclear garbage. This group must have substantial credentials for at least several centuries of resource concern and responsible treatment of their environment. Few groups in the world will qualify and it is worth considerable remuneration from the society at large to this select management group to perform the waste monitoring required. The compensation referred to, while quite large for the equipment and personnel involved in terms of the select group, will be minuscule compared with the monetary interest the U.S. presently pays on its debt or the amount societies throughout the world have been willing to spend on weapons of mass destruction.

> *"In the end it does not look as though we can possibly have sufficient confidence in any one geologic site that would allow permanent disposal. One possibility, of course, is to treat the waste similarly to the way we instituted nuclear power in the first place, i.e., proceed with what seems satisfactory at the time and leave any serious long-term problems to be solved only after they have actually arisen. In other words, there is always the irresponsible option of letting our distant descendants be plagued with our 20th century errors."*

Nonretrievable Geologic Storage

The major effort toward long-term high-level nuclear waste disposal has been in the area of depositing in the ground all the dangerous material in some sort of containers. This approach seeks to find a permanent disposal technique so the waste can be left for posterity without any possibility of future generations being at risk. While the motivation and results sought after are commendable, the reality of what is being attempted has not really been fully recognized.

Of prime importance here is the basic engineering principle alluded to above that any truly new system has to be tested for at least one life cycle in order for there to be reasonable confidence that there have been no design or fabrication errors. Given a new disposal system that has a life cycle of at least 300 years, the required engineering prototype test is nor possible. After twenty-five years, the faith of responsible nuclear power parties that government would figure out an acceptable solution eventually is as remote a possibility today as it was in the first place. Needless to say, that confidence in a permanent solution has now been thoroughly shaken, as basic engineering considerations dictated at the outset.

The geologic materials investigated throughout the world have included salt, granite, volcanic tuff, and basalt. Each particular site chosen, after much consideration of geologic and scientific aspects, has proven to have some flaw that makes such contemplated irretrievable burial unacceptable. In some instances fractures in the structure have occurred or been discovered whereby the nuclear waste could eventually get outside the confinement volume. Other problems include the buildup and then outflow of water. Earthquake susceptibility is always of concern and automatically precludes use of some sites.

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Burying of Casks Inside Underground Bomb Test Cavities

Given the already contaminated underground cavities made by bomb-testing in Nevada, a logical option would appear to be the use of these voids for permanent waste disposal. An important factor to be considered is the high level of radioactivity already present within those cavities. While leaks into the air occurred in some tests, in most cases all of the radioactivity from the explosions was confined. After all, this was the bomb-testing option of choice to prevent contamination of the atmosphere. A typical test was the Chesire experiment, conducted on February 14, 1976. It was a hydrogen bomb with a yield between 200 and 500 kilotons. It was detonated at a depth of 3830 feet, which was 1760 feet below the water table.

There is already considerable experience in drilling into bomb cavities. The purpose was to sample the radioactive materials for analysis, in order to estimate the yield and efficiency (which is the percentage of U-235 and/or Pu-239 which underwent fission). If the deeper cavities are chosen (to insure that they are well below the water table), it would be easiest to drill a shaft in the same place as the original one. By now, the fission products which are most dangerous, such as iodine-131, have all decayed. The only gaseous fission product left is krypton-85, with half-life 10.7 years. It is not nearly as dangerous as radon, and in any case only a small amount would diffuse out. Casks of waste would be lowered into the cavity using a cable suspended from a derrick, with the operator inside a shielded housing, if necessary. At the end, the cavity is filled with earth, and the shaft closed.

Although this burial technique looks promising and deserving of further study, it is by no means clear that this technique for disposing of hazardous waste is satisfactory. It could develop that creating new cavities for the express purpose of using them as repositories could become attractive. In that case, the site would be carefully chosen with the water table in mind, and the cavity blasted very deep. Hydrogen bombs might be best since most of the energy comes from deuterium fusion, thus minimizing the amount of radioactivity created.

So much for the positive aspects. Negative aspects include the idea that just because deep underground cavities are already contaminated with long lived radioactive nuclides from nuclear bomb explosions, we are not justified increasing the potential future health hazards by orders of magnitude. As with other geologic burials, there are possibilities of earthquakes, ground fractures, and unanticipated failures in the deep drilled shafts that would cause water leakage. However, of all the possible permanent disposal sites, these deep holes of hazardous remnants from past bomb development follies appear to be the most attractive, even though a time period of at least 10,000 years is too long to confidently conclude that there are no significant failure-modes.

Because permanent geologic disposal in nuclear bomb cavities violates fundamental engineering principles, it can be considered to be irresponsible for present generations to pursue that option. Perhaps considerations of our lack of knowledge today of what the worldwide land usage was many thousands of years ago will provide an understanding of our cautious conclusions here. We simply cannot be reasonably certain how the use of land throughout the world will evolve over the forthcoming thousands of years. Thus conscientious adherence to responsible behavior requires our not utilizing this bomb cavity technique at present. Further study might possibly result in something useful a hundred or more years hence.

Burial Between Tectonic Plates

The interior of the Earth contains the elements potassium, uranium, and thorium, all slightly radioactive. This radioactive decay liberates heat, which keeps the Earth's core hot. The consequence of a hot, liquid core is movement of floating tectonic plates, and formation of mountain ranges and continents. Were this not the case, mountains and all land would erode down, and our planet would be covered with water. Without this radioactivity, we would not exist.

Geologists discovered many years ago that the continents are in constant motion relative to each other. Far below the ground tectonic plates are sliding very slowly over each other. The continents rest on these plates, so the oceans are changing size and shape while the surface continents are moving relative to one another. At the edge of a plate whose motion is toward the ocean, there will be a suhduction layer between that tectonic plate and the one below. Any material between the plates at that point will be pulled in between and remain there for at least several million years.

Concern over the years has been to consider just how one could perform the placement of high-level nuclear waste into a tectonic plate subduction layer. One major problem is digging down to that depth. But even more stringent than that is the problem of construction of shaft walls that will withstand the weight of all the earth above. The same problem is encountered when constructing a research module to descend to the ocean floor. While the ocean depth is a maximum of about 6 miles, the tectonic plate depth is as much as 50 miles. Finally, there are the construction strength problem differences between an enclosed submerged module in the ocean and the side wall problems in a shaft through which nuclear waste canisters are to be lowered.

There has not been, nor is there even a contemplated possibility of constructing a shaft that would be strong enough for this nuclear waste disposal option. Thus, another apparently attractive approach seems to be beyond our reach.

"Because permanent geologic disposal in nuclear bomb cavities violates fundamental engineer ing principles, it can be considered to be irresponsible for present generations to pursue that option. Perhaps considerations of our lack of knowledge today of what the world-wide land usage was many thousands of years ago will provide an understanding of our cautious conclusions here. We simply cannot be reasonably certain how the use of land throughout the world will evolve over the forthcoming thousands of years. "

Transmutation

Soon after commercial generation of electricity via reactors started and their high-level waste began to accumulate, ways to simplify and manage the problem were sought. Among these was reprocessing to separate the waste into several fractions, and then, using neutrons, to transmute via fission the transuranium elements (neptunium, plutonium, americium, etc.) into nuelides which have relatively short half-lives so that they lose their radioactive sting in a repository during an abbreviated storage time. The transuranium elements would require sequestering in a repository for many thousands of years.

If the nuclear waste is bombarded with neutrons, electrons, or other atomic particles so that it is changed from a long-lived to a short-lived radioactive material, the process has been termed "transmutation." About thirty years ago, people inquiring about the long-term nuclear waste disposal for commercial reactors were told that the military had the identical problem for its nuclear bomb waste. Because the military waste was already twenty years old, the word to one of the authors was that the military had not only decided that transmutation was the best solution to this problem but had already worked out all pertinent details. Many years and many nuclear reactors later, of course, we found out that the military had not developed any viable transmutation waste disposal system at all.

In fact, the basic problems with transmutation have been perennial. Each nuance has resulted in the same general result. Any process based on transmutation would require reprocessing to separate the waste into several fractions, and then, using neutrons, to transmute via fission the transuranium elements (neptunium, plutonium, americium, etc.) into nuclides which have relatively short half-lives. Considerable research has been carried out recently on these nuclear incineration techniques. Tests are being conducted at Hanford, Los Alamos, and Brookhaven National Laboratory on Long Island. Success of the proposed procedure depends on reprocessing spent fuel by either the PUREX process or a technique similar to the TRUMP-S process. The actinides would then be reintroduced into the reactor or bombarded with neutrons generated using an accelerator. Thus neutron sources might be either nuclear reactors, perhaps of the breeder type, or linear accelerators to produce high-energy protons, which collide with lead, bismuth, or tungsten targets. This produces abundant neutrons, which must be moderated using heavy water. The neutrons then cause fission of the actinides, and liberation of huge amounts of energy, as in a nuclear reactor.

Disposal of wastes by transmutation is intimately related to fast breeder reactors. While American reactors of this type were phased out by Congress in 1983, a new type, the Integral Fast Reactor, is now being studied. These breeder reactors use liquid sodium as coolant and have no moderator. They are being promoted as a way to cope with nuclear waste. The problem, of course, is that "we've heard that story before."

Even though the outlook for nuclear transmutation is most unpromising, a few details are perhaps in order. The accelerator procedure is highly unfavorable from the standpoint of energy consumption. The steel and other parts would be activated by neutrons, and become radioactive. It seems that about as much radioactive waste would be produced as is consumed, as stated above, if not more. Costs would be fantastic. The procedure could not easily be used with fission products. They absorb neutrons poorly; after all, they were in a neutron environment for years, and survived. Only two, iodine-129 and technetium-99, are easily transmuted to nonradioactive nuclides, and these are not particularly important. Technetium-99 (half-life nearly a quarter of a million years) is converted by neutrons into technetium-100 (half-life only 16 seconds) forming ruthenium. If this process is carried out while a stream of ozone is passed through the apparatus, volatile ruthenium tetroxide is constantly removed. Transmutation might be successful in this case, and perhaps that of iodine-129, but in general the technique is not expected to be satisfactory.

In 1992 a group of nine qualified experts finished an exhaustive assessment of disposing of waste through transmutation via fast breeder reactors, accelerators, and high temperature electrolysis techniques (the Ramspott report, after the first author). These scientists are associated with the Lawrence Livermore National Laboratory, two universities, and a private firm. The study concluded that high-temperature electrolysis procedures for separating actinide metals in reprocessing high-level waste offers no economic incentives or safety advantages. Unfortunately, actinide separation and transmutation cannot be considered a satisfactory substitute for geological disposal.

Spacecraft Transport to the Sun

Of all the theoretically possible disposal techniques one can think of, this is one of the most preferable. Materials on the sun are already similar to our waste products, so our depositing high level nuclear materials on the sun would blend right in. Unfortunately, the numbers are such that we cannot do the job, either technologically or economically.

Given the liquid sludge nuclear bomb waste of about 10' gallons for the U.S. alone, the following ballpark numbers apply:

~0.1 = conversion factor for solidification.
~0.1 = conversion factor for gallons to cu ft.
~100 Ibs/cu ft density.
10,000 Ib effective spacecraft waste payload for an Apollo-type vehicle assuming the additional 7000 Ib payload will be required for containers and the retro-rockets.
10^8 x 0.1 x 0.1 x 100 x 10^{-4} = 10^4 spacecraft for only accumulated U.S. military waste.

Besides the fact that the U.S. does not have the economic resources to fund such a gigantic number of spacecraft, each vehicle would have to have perfect launch systems that would not blow up on the launch pad plus perfect guidance systems that would insure the vehicle not turning around back toward the Earth. Obviously, this is beyond any forseeable capability and must be abandoned as a possible option.

Conclusions

A major point emphasized in this study is that it is unethical to force a known potential environmental hazard on future generations when a reasonable alternative exists. This aspect was phrased above in engineering terms, i.e.

basic engineering principles; however, it could easily have been phrased in more socially oriented terms. This leads to the only responsible choice being the multibarrier monitored retrievable storage (MMRS) technique which will cost in present dollars between $100 million and $1 billion per 1000 megawatt power plant over a 10,000 to 100,000 year storage period.

It also needs to be pointed out that there are some important lessons to be learned from Mother Nature:

1) The natural nuclear reactors at Oklo in Gabon, West Africa, demonstrated that the plutonium and most metallic fission products did not leach out, even over thousands of centuries of leaching. Even the strontium-90 stayed in place until it decayed. The cesium-137 did migrate out, and the iodine fission products evaporated. Despite this favorable result, strictly speaking it applies to the particular geology of that area.

2) Another natural site teaches us more valuable lessons about the behavior of radioactive materials during long storage. There is a hill called Morro do Ferro in Brazil where there are 30,000 tons of thorium and 100,000 tons of rare earths. Much of the fission products are rare earths. Chemically, thorium resembles plutonium in some ways and the rare earths resemble curium and americium. Again, the evidence is that migration of the most dangerous materials from the surface over eons of weathering has been negligible.

3) Still another area whose study yields valuable lessons is the Koongarra ore body in Australia. This is a giant deposit of uranium ore in a common type of geological formation through which groundwater has been flowing for millions of years. Movement of uranium and its decay products has been investigated by drilling a series of holes through the ore body and surrounding layers. The results indicate that migration of only a few tens of meters has occurred on the weathered surface, and virtually no movement has taken place underground.

So with responsible behavior designing and implementing the MMRS long-term nuclear waste system, there is reasonable historical assurance that future disasters will probably be avoided even if some failures should occur in that system.

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The Future of Nuclear Power

-- by Robert D. Furber, Ph.D., James C. Warf, Ph.D., and Sheldon C. Plotkin, Ph.D.

Introduction

Understanding the future of nuclear power requires a few basic principles regarding atoms. Each chemical element is distinguished by a particular number of positively charged protons in the nucleus. An equal number of negatively charged (and much less massive) electrons may be bound to the nucleus by the attractive electric force between the oppositely charged nucleus and the electrons. Such an electrically neutral system is called an atom of the element. The simplest and least massive atom is hydrogen, an atom consisting of a single proton and a single electron in the bound state.

The nucleus usually contains neutrons as well as protons. The neutron is electrically neutral and is only slightly more massive than the proton. Neutrons and protons are mutually attracted by the strong force. The strong force also acts between protons and between neutrons. Unlike the electron, each neutron and proton is a compound system with internal structure, and is best described as a system of quarks and gluons. These latter are called "elementary particles". The electron is another elementary particle. Protons and neutrons are called nucleons. In this discussion the internal structure of the nucleon will not be considered.

The deuteron is a form of hydrogen with a nucleus consisting of a single proton bound tightly to a single neutron. There are four basic forces in nature: the strong nuclear force (or simply strong force), gravity, the electromagnetic force, and the weak nuclear force. As its name implies, the strong force is the strongest of the four. However, it also has the shortest range, meaning that particles must be extremely close before its effects are felt. The strong force is very strong when nucleons are in close proximity. However, as the separation between a pair of nucleons increases, the strong force weakens. (At extremely small separations, on the order of the separation between nearest neighbors in nuclei, the force becomes highly repulsive). This is quite different from the electric force between charged particles. The electric force is an example of a long range force, and the strong force is an example of a short range force. Between a pair of protons in a small nucleus, the attractive strong force is much greater than the repulsive electric force. However, in a very large nucleus containing many nucleons, such as uranium-235 with 235 nucleons, the separation between a pair of protons can become sufficiently large that the electric force of repulsion can compete effectively with the attractive strong force. This can lead to the breakup of the nucleus, called fission.

Fusion involves the merging of small nuclei, and is in that sense the opposite of fission. In order to discuss nuclear fusion a few more examples of small nuclei will be helpful. Two cases of hydrogen, hydrogen-1 and hydrogen-2 or deuterium, have already been described. A third example of hydrogen is tritium, hydrogen-3, in which the nucleus contains two neutrons and a single proton. These three forms of hydrogen are called isotopes of hydrogen and are the only relatively stable isotopes of hydrogen. In order to understand why a stable "hydrogen-4" cannot exist, the laws of physics must be applied to the general behavior of this system of three neutrons and a single proton. This branch of physics is called quantum mechanics. When quantum mechanics is applied to this system, the result shows that such a system can exist only in the unbound state. That is, one of the four nucleons cannot remain part of the nucleus, but instead must immediately be ejected from the system. Nevertheless, physicists do study the properties of unbound, or unstable isotopes of nuclei. Therefore, for example, a typical handbook of the properties of nuclei will contain those of hydrogen-1 through hydrogen-7. After hydrogen, the next element is helium. There are only two stable forms of helium, helium-3 and helium-4. The nucleus of helium-3 has two protons and a single neutron, and the nucleus of helium-4 has two protons and two neutrons. The handbooks will also provide the properties of the unstable isotopes helium-5 through helium-10.

The history of nuclear power plants for generating electricity goes back to 1951, when the first commercial reactor was built. This was a breeder reactor. Most commercial units were of the boiling water type, which used the cooling water directly over the reactor producing steam to drive the turbo-generators. A certain amount of radioactive particles would leak through the fuel rods into the water, some of which then would become airborne from the cooling tower. Because releasing radioactivity into the air is unacceptable, a pressurized water design was developed. This involves a dual heat transfer loop, i.e., high pressure and superheated water pass through the fission reactor, which then transfers energy through a heat exchanger into the secondary low-pressure loop. This secondary loop produces steam pressure to the turbo-generator for electric energy output. Most of the 103 power reactors in the U.S. at present are of this pressurized light water type.

Rather than using water for moderating the neutron flow, i.e., slowing down their velocity, carbon can be used instead. Such graphite-moderated reactors are used in the U.S. to produce useful isotopes for medical purposes, tritium (hydrogen-3), and plutonium for bombs. The USSR reactors have used graphite moderation for electric power generation. Chernobyl was of this type. Unfortunately, this results in energy storage in the carbon (Wigner effect) from neutron bombardment. Release of this energy occurs under high temperature conditions when output power is raised beyond design limits. Such abrupt release of excess energy creates explosions, as the world knows.

A small UCLA educational reactor was graphite moderated and almost blew up on at least one occasion. This could have contaminated Westwood and some of the surrounding area. Nuclear power accidents are not confined to any one country. However, it should be noted that satisfactory education of the operators should prevent most such accidents because operation beyond design limits are always under operator control.

Another type of nuclear reactor is the breeder, which generally uses plutonium-239 as a fuel. This type of reactor uses the neutron flux to bombard uranium-238, the preponderant isotope in the fuel, to create plutonium-238, 239, and 240. The idea is to create more plutonium-239 than that used in the fission process in the reactor. Liquid sodium is the cooling medium of choice for these breeder reactors.

All reactors discussed above are of the slow neutron variety, which requires a moderator to slow down the neutron speed for the fission process. In order to shut down the reactor, cadmium control rods are inserted to absorb the neutrons and stop the fission process. Fast neutrons would cause the uranium-238 to undergo fission in addition to causing the uranium-235 or plutonium-239 to undergo fission. Fast neutron reactors operate at high temperatures, use liquid sodium as a coolant, and create plutonium-239. Production of plutonium-239 results in the risk of proliferation for bomb making, and is the reason its control is the subject of the non-proliferation treaty.

Another facet of nuclear reactor operation, perhaps the major impediment, is the high-level waste created, and the associated disposal problem. After some length of time, several months to several years, the major components are the shorter lived cesium-137 and strontium-90. Both have half-lives of about 30 years, and the longer lived transuranics, i.e., uranium and heavier species, last many thousands of years. These waste components are mixed together within the fuel rods along with the non-fissioning uranium-238, the most prevalent isotope.

To date no acceptable technique has evolved or been developed to properly handle these ionizing radioactive waste components. At present they have to be stored, monitored and repackaged when necessary. This inability to satisfactorily dispose of the high-level waste from power reactors has stopped all construction in the US. All US nuclear plants are protected by the

Price-Anderson Act, which forces the taxpayer to be responsible for any large-scale accident. Utility companies cannot afford the insurance for full coverage and would have to shut down operation if Congress rescinded the Price-Anderson coverage.

Such has been the nuclear power reactor development situation until global warming became an issue and the end of cheap petroleum became evident. The nuclear power industry has always argued that nuclear power should be one of the energy options to be considered, but now they use the global warming issue to argue that nuclear power should be the option of choice. Interestingly, the high-level waste disposal problem is barely mentioned, and then, only to claim that a potentially acceptable solution is now on the horizon.

Safety and High Costs

Attempts to reduce the high cost of nuclear power consists of specifying a generic reactor, the design of which will not have to be reviewed every time an application is made for a construction license. Another tactic is to reduce the stringency of safety requirements, which would significantly reduce the processing time for the license and automatically reduce costs.

Of course a few problems arise with these approaches. Freezing reactor designs precludes the inclusion of improvements without a return to lengthy licensing procedures. Relaxing safety requirements to reduce costs is just exactly the industry approach that stimulates massive public opposition. Perhaps some acceptable technique for high-level waste disposal would allay public concerns to the point where higher costs for safety would be acceptable. However, all estimates of nuclear power costs include only a small fraction of the real cost of waste disposal and decommissioning.

The latter involves a form of low-level waste disposal. What is most interesting regarding the cost is the efforts of the nuclear power industry to put the burden onto the general public as opposed to accepting the responsibility themselves. The public is persuaded to think the cost of nuclear power is acceptable by minimizing ratepayer costs while the substantially subsidized costs are buried in public taxes.

Safety Basics

Basic engineering principles as applied to safety acknowledges that nothing is 100% safe, but that any level of safety can be achieved by spending enough money. As applied to nuclear power plants, sufficient money must be expended to train operators in the areas of plant operation and plant security. Critical components of the physical structure can always incorporate redundant units or multiple units for even higher safety levels.

Maximum cost should be provided and a determination of whether the concomitant safety level would be acceptable. Unfortunately, the safety level for one person may not be satisfactory for another person. Obviously, some type of technically justifiable decision-making process should be established.

Waste Problems

Considering the long time required for the high-level radioactive waste to decay, the ethics of leaving this problem to future generations points to the irresponsibility of the US over the last 50 years. Other countries share in this irresponsibility. Assuming that authorities are people of essentially good character, and that technology will figure out some satisfactory solution to the problem of waste disposal is wishful thinking.

Given that about half the U.S. waste is at the Hanford Washington site in the form of radioactive sludge acquired during the building of nuclear weapons, only about half of the U.S. waste is from the use of nuclear power plants. Plans have been made to solidify the sludge and to vitrify the solid into large glass logs. While the waste in this form will not disperse into the environment because of its solidity, and while it will not undergo fission because of the neutron absorbing chemicals in the glass, the question remains as to what can possibly happen after several thousand years. Can these large stockpiles of potentially hazardous material break up into smaller elements, which could mix with normal rocks and soil? Pulverization could conceivably release particles into the atmosphere. This is just one scenario to lead us to ask: "Is this what we want to allow to happen by chance?"

Another factor, which has not been determined yet, is the cost of such a process. It will be expensive and the taxpayer will certainly be stuck with the bill. Thus far no government has risked tackling this problem. So, it is ignored and is left to future administrations. Unfortunately the leaking Hanford tanks are getting worse as the waste is beginning to contaminate the Columbia River. Gradually, it is becoming evident that the US must do something. As contaminated as much of the world is, particularly the former USSR, the Hanford area is among the most contaminated of any place.

<u>Reactor Waste</u>

Most of the 103 US nuclear power reactors today are of the pressurized light water type, use control rods, which build up high-level radioactive waste in the fuel rods. The spent fuel rods are stored in what are called swimming pools. Water is used for cooling the physically hot radioactive materials. So, now that these storage areas are pretty full, the problem of what is to be done needs to be faced. Building more and larger swimming pools only delays the day for carrying out a decision of what the long-term future will be for the troublesome material. A multitude of geological burial techniques has been proposed, but all have been found to have significant problems, and do not yet meet long-term engineering standards.

It is not necessary to present details here other than to mention the basic engineering system principle that requires the testing of any new system for at least one life cycle in order to make sure that there has not been a mistake or that an inadvertent design error has not been made. Needless to say, we cannot do this before deployment. The life cycle of any waste disposal system depends on ones point of view. However, the estimates vary from 10,000 to 240,000 years, which are all impractically long. Thus no geologic burial will ever meet basic engineering requirements, which would be necessary for us to bury the waste in good conscience.

<u>Industry Plans</u>

The nuclear industry, knowing all the above too well, has resorted to newer designs and techniques, while claiming the problems are solved. First, there is the reuse of nuclear fuel in the waste by the development of breeder reactors. These bombard the uranium-238 isotope fuel blanket with neutrons to create larger quantities of plutonium-239 than are consumed in the original fission process. The idea is to create increasing quantities of nuclear fuel in an already-operating reactor, while waste is also being increased. This would increase the supply of fuel.

The waste in the new reactors would be treated by new pyro-processing separation techniques. The transuranics, or heavy long-lasting waste components of uranium and heavier elements, would be separated from the lighter and shorter-lived isotopes such as cesium-137 and strontium-90. With half lives of about 30 years, the effective period during which these isotopes pose a danger is on the order of 300 to 600 years, depending on one's point of view.

Because the heavier isotopes are only a few percent of the waste stockpile, there are a few problems the industry tries to "sweep under the rug". The transuranic separation requires a molten cadmium bath at high temperature. That is the origin of the term "pyro-processing". This very toxic separation process, like that of any electroplating approach, is not perfect, and the separation is something less than 100% efficient. The industry plans for building new nuclear power reactors increases whatever problems exist by that increased amount. In the end, we have the original disposal problem.

The new pyro-processing techniques have only been achieved in laboratory apparatus at present. As engineers are well aware, there is a big jump much of the time between theoretical and experimental successes and the final commercially manufactured version.

Present efforts to solve the disposal problem for high-level nuclear waste have not resulted in any acceptable solution. Disposal in monitored, retrievable containers for at least 10,000 years is the only ethically responsible alternative. Essentially all future generations will be plagued by our nuclear power folly. Using nuclear fission to boil water for electricity generation is a flawed concept. Authorities all had "faith" that future engineers and scientists would figure out some satisfactory waste disposal technique. Unfortunately, they did not do their homework, but, instead, were driven by corporate profit interests or bureaucratic power.

The Future of Fusion

Since the middle of the last century physicists have conducted both theoretical and experimental research to lead to the development of practical nuclear fusion to produce power. If this were possible, the advantages of fusion over fission would be realized. One of greatest of these advantages is that of safety. The products of the fusion of light nuclei are other light nuclei, as opposed to the toxic and long-lived radioactive products of fission events. The fuel is also relatively benign. The simplest and most likely controlled fusion process that can be expected in the future will use helium and hydrogen isotopes as fuel.

Unfortunately, for decades this goal has been out of reach. Several concepts are under development. The one receiving the greatest financial investment is the plasma confinement concept. At the center of a star, such as our sun, the light nuclear material (hydrogen, helium, etc.) present in mid or early life exists under conditions of very high temperature and density, forming what is called plasma. As noted above, in this environment positively charged nuclei move at such high speeds that a significant fraction in any given time will be able to overcome their mutual electrical repulsion and come close enough that the strong short range nuclear force can act to cause fusion to occur. The result is the conversion of light nuclei to heavier nuclei. The product nuclei have less mass than the sum of the masses of the light nuclei undergoing fusion. The difference in mass appears as energy in accordance with Einstein's famous equation, $E=mc^2$. This energy is present both in the form of motion and of radiation (gamma rays). In the sun the gravitational compression of the enormous mass of the body itself confines the material. In the laboratory confinement must be achieved by other means. The preferred method of confinement has been by the effect of carefully designed magnetic fields on embedded plasma. This branch of physics, called magneto-hydrodynamics, is too involved to describe here.

Success for such schemes has proven very difficult to achieve. One reason is that the confined plasma must not be allowed to come into contact with the walls of the confining vessel. Instabilities in the plasma have plagued these efforts for decades. However, over time many lessons have been learned, and today many in the fusion community have confidence that the probability of success of the confinement method is dependent upon an increased size of the device.

At a Geneva superpower summit meeting in November 1985, after conferring with President Mitterand of France, Premier Gorbachev proposed to President Reagan that an international effort be undertaken to build an advanced fusion reactor of this kind, called a tokamak. Agreement was reached to go forward. While the project has had many twists and turns, it has nevertheless continued, and is reaching the construction phase this year, 2007. The project is called ITER, and construction of the facility is to start this summer in a town in the south of France called Cadarache. The participants today are the European Union, represented by EURATOM, Japan, the People's Republic of China, India, the Republic of Korea, the Russian Federation and the United States. Cost of the project is on the order of ten billion euros. There are many phases, and the schedule is of necessity a very long range one. Full operation is not expected until 2050.

The ratio of the output to input power for these devices is called Q. A Q larger than one means the device can deliver net power. A Q equal to one is breakeven. At the present time the most advanced tokamak is the Jet project, which has produced a Q of 0.65. The goal of ITER is to achieve a Q greater than 5.

The basic reaction involved is the fusion of hydrogen-2 and hydrogen-3 (deuterium and tritium) to produce a helium-4 nucleus and a neutron. This reaction is preferred over others, because the charge to mass ratios of the deuterium and tritium are small. Therefore, the coulomb barrier (mutual electrical repulsion) is lower and the probability of fusion occurring is higher.

However, the neutron produced by the reaction is somewhat disadvantageous. A free neutron undergoes beta-decay in a matter of minutes, resulting in a proton, an electron and an electron neutrino. This time is long enough that before decay can occur, the neutron will penetrate into the structure. In addition to causing some radioactivity of the container, this process leads to the eventual breakdown of the structure and the need to replace it.

A more difficult feat would be the fusion of deuterium and helium-3, resulting in the production of a helium-4 nucleus and a proton. This is more difficult because the charge to mass ratio of helium-3 is higher than that of tritium, and the coulomb barrier is more difficult to overcome. The device would have to achieve higher density and temperature than the deuterium and tritium process. However, the resulting fast moving proton constitutes an electrical current and would allow coupling to a direct electrical energy output without the structural degradation caused by neutrons.

Conclusions

Regardless of how attractive it may seem or how hard the Bush Administration promotes the interests of his nuclear power industry supporters, electricity from nuclear fission is still so hampered by the problem of high-level waste disposal, that any building of new plants would be a serious mistake. The analysis that two of the authors performed some years ago is still valid[1,2]. Recent technical advances are still grossly inadequate, and the future of nuclear power, as we know it, is very poor at best.

On the other hand, experiments using nuclear fusion, appear to offer sufficient promise that the efforts should not only be continued but enhanced if possible. Electricity generation from this source is very attractive; however, it will be so long in coming, 2050 at least, that other nonpolluting sources of electricity have to be developed as soon as possible to address the global warming problem.

1). Warf, James C. and Plotkin, Sheldon C., "Disposal of High-Level Nuclear Waste", Global Security Study No. 23, Nuclear Age Peace Foundation, September, 1996.
2). Warf, James C., **All Things Nuclear**, Figueroa Press, 2004.

To: "Lyn Harris Hicks" <lynharrishicks@cox.net>
Subject: Production of Plutonium in commercial reactors -- a review of the literature from the past half century

July 4th, 2008

Dear Readers,

Let's BBQ! More specifically, let's BBQ ourselves from the inside with radioactive particles.

And let's refute the hollow assertions made by the new spokeswoman for San Diego Gas & Electric, who made the following specious and false claims to an activist recently (and no doubt makes them to media throughout Southern California, as well):

"San Onofre does not produce plutonium."

"San Onofre does not emit any radioactive waste."

So: Do commercial nuclear reactors produce plutonium? And do they emit radioactive waste?

Yes, and yes. They all do. Let's concentrate on plutonium production, and consider the evidence from decades' worth of literature.

All U.S. commercial reactors are Light Water Reactors (LWRs). About 70% are Pressurized Water Reactors (PWRs). The rest are Boiling Water Reactors (BWRs).

First up: From a very popular nuclear physics textbook from the mid 1950's, the figure of 0.46 pounds per ton per year is given for the conversion of U-235 to Pu-239 in the Brookhaven reactor (a small early research reactor on Long Island, NY). An equal amount of (radioactive) fission products were also produced (1).

In 1974, The Ubiquitous Atom described the formation of plutonium in the Radiation Laboratory, Berkeley, California, in March, 1940: "This element, unknown to nature, was formed by uranium 238 capturing a neutron, and thence undergoing two successive changes in atomic structure with the emission of beta particles" (2).

In Edward Teller's 1979 book, the father of the H-Bomb describes a "provocative series of articles in The New Yorker" from December 1973 which discussed: "nuclear sabotage, and the possibility that plutonium produced by nuclear reactors might be stolen and used to construct a homemade nuclear explosive. With the continuing prevalence of terrorism, these dangers should not be disregarded" (3).

From No Nukes: Everyone's Guide to Nuclear Power (1979): "The average commercial reactor sold today produces around 500 pounds of plutonium each year. The bomb that destroyed Nagasaki was made with 10 pounds of plutonium -- one fiftieth of the yearly output" (4).

According to Plutonium, Power, and Politics (1979), reactor fuel for LWRs starts at "about 3 percent U-235 and 97 percent U-238. After its full residence in the core (about three years for a PWR, four for a BWR), the spent fuel consists (by mass) of about 95 percent U-238, 1 percent plutonium, 1 percent residual U-235, and about 3 percent light elements produced by fission of uranium and plutonium" (5).

Nuclear Power in Crises (1989), noted: "The purpose of reprocessing is to separate unburned uranium and other potential fuel isotopes, like plutonium, from the useless by-products of the fission process: in theory this maximizes the energy value of the fuel and minimizes the residues of highly radioactive waste. Unfortunately, the technology is difficult and dangerous, especially for the treatment of thermal oxide fuels used in light water reactors (Bunyard, 1981), and few countries have been willing to persist with its development." The book notes that "even" the U.S.A. had, at the time, abandoned reprocessing (6). The U.S.A. still does not reprocess spent fuel.

Caldicott points out in If You Love This Planet (1992) that: "Wherever the world's nuclear power plants are located, radioactive wastes are discharged into seas, rivers, or lakes. All reactors need thousands of gallons a day for cooling, and this water is routinely flushed back into the water system, inevitably polluted with radioactive elements" (7).

Megawatts and Megatons (2002), states that at the reprocessing plant at La Hague, France (operated by AREVA): "The spent fuel from low-enriched uranium contains about 1% plutonium -- about 200 kg to 250 kg from the annual download of 20 to 25 tons from each reactor" (8). French reactors are almost exclusively PWRs.

Clearly, the spokesperson for SDG&E is intentionally misspeaking. Perhaps it is because she knows that: "Statements made by the public affairs officers of a NRC licensee are not regulated activities. Therefore, the veracity of such statements will not be investigated by the NRC" (9).

Sincerely,

Ace Hoffman
Carlsbad, CA

The author, an award-winning educational software developer, has studied nuclear issues for more than 35 years.

References:

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(1) Principles of Nuclear Reactor Engineering, Samuel Glasstone, Consultant, US Atomic Energy Commission (with assistance from staff members of Oak Ridge National Laboratories) Foreword by Lewis L. Strauss, Chairman, USAEC, D. Van Norstrand & Co, New Jersey, 4th Edition, Sept., 1956, pages 396-399.

"Assuming a conversion efficiency of uranium-235 to plutonium-239 of 100 per cent . . . after one full year of operation of the Brookhaven reactor is . . . approximately 23 lb [of plutonium]. The small quantity of plutonium destroyed by fission and nonfission capture reactions may be neglected. The composition of the spent fuel will thus be roughly as follows:

Uranium (all isotopes): 99.954%
Plutonium-239: 0.023%
Fission products: 0.023%

These figures are given to provide some idea of the magnitude of the problem involved in the recovery and purification of fertile and fissionable materials in the processing of spent reactor fuel. Each ton of such fuel, according to the foregoing considerations, will contain about 0.46 lb of plutonium, 0.46 lb of fission products, and just over 1999 lb of uranium. The proportion of uranium-235 in the latter will have been reduced from the normal value of 0.71 to slightly over 0.68 per cent, partly by fission and partly by conversion to uranium-236 as a result of neutron capture."

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(2) The Ubiquitous Atom, Grace Marmor Spruch and Larry Spruch, "Based upon material from booklets in the series "Understanding the atom, produced under the aegis of the United States Atomic Energy Commission." Charles Scribner's Sons, New York, 1974,

Page 281.

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(3) Energy from Heaven and Earth, Edward Teller, W. H. Freeman & Co., San Francisco, 1979, page 192.

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(4) No Nukes: Everyone's Guide to Nuclear Power, Anna Gyorgy & Friends, South End Press, Boston, MA, 1979, page 301

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(5) Plutonium, Power, and Politics: International Arrangements for the Disposition of Spent Nuclear Fuel, Gene I. Rochlin, University of California Press, 1979, page 83. The quote continues: "There are also small amounts of other heavy elements, particularly neptunium, americium, and curium, that are produced by a complex series of neutron absorptions and radioactive decays." On page 79 it states: "There is no doubt that throughout the twenty-plus-year history of commercial nuclear power, and the twenty year history of the dissemination of the technology for fuel reprocessing, it has been the assumption of nuclear industry and nuclear agencies alike that spent reactor fuel would be reprocessed . . . Alternatives to reprocessing for the disposition of spent fuel were never given serious consideration." On page 86 it points out that a "uranium-only recycle would provide no economic incentive to reprocess spent fuel at this time." To be economically viable, the plutonium must also be recovered.

----

(6) Nuclear Power in Crises: Politics and Planning for the Nuclear State, Edited by Andrew Blowers and David Pepper, Nichols Publ. Co., New York, 1987, page 69.

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(7) If You Love This Planet: A Plan to Heal The Earth, Helen Caldicott, M. D., W. W. Norton & Co., New York, 1992, page 87.

----

(8) Megawatts and Megatons: The Future of Nuclear Power and Nuclear Weapons, by Richard L. Garwin and Georges Charpak, University of Chicago Press, 2001, 2002, page

136.

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(9) Letter to the author from the Nuclear Regulatory Commission, received following a complaint about the spokesperson for Southern California Edison (SCE) lying intentionally (2001).

To:
From: Ace Hoffman <rhoffman@animatedsoftware.com>
Subject: http://ydr.inyork.com/ci_13618834
Cc:
Bcc:

Attached:

Three Mile Island renewed for another 20 years

Daily Record/Sunday News
Updated: 10/22/2009 05:01:32 PM EDT

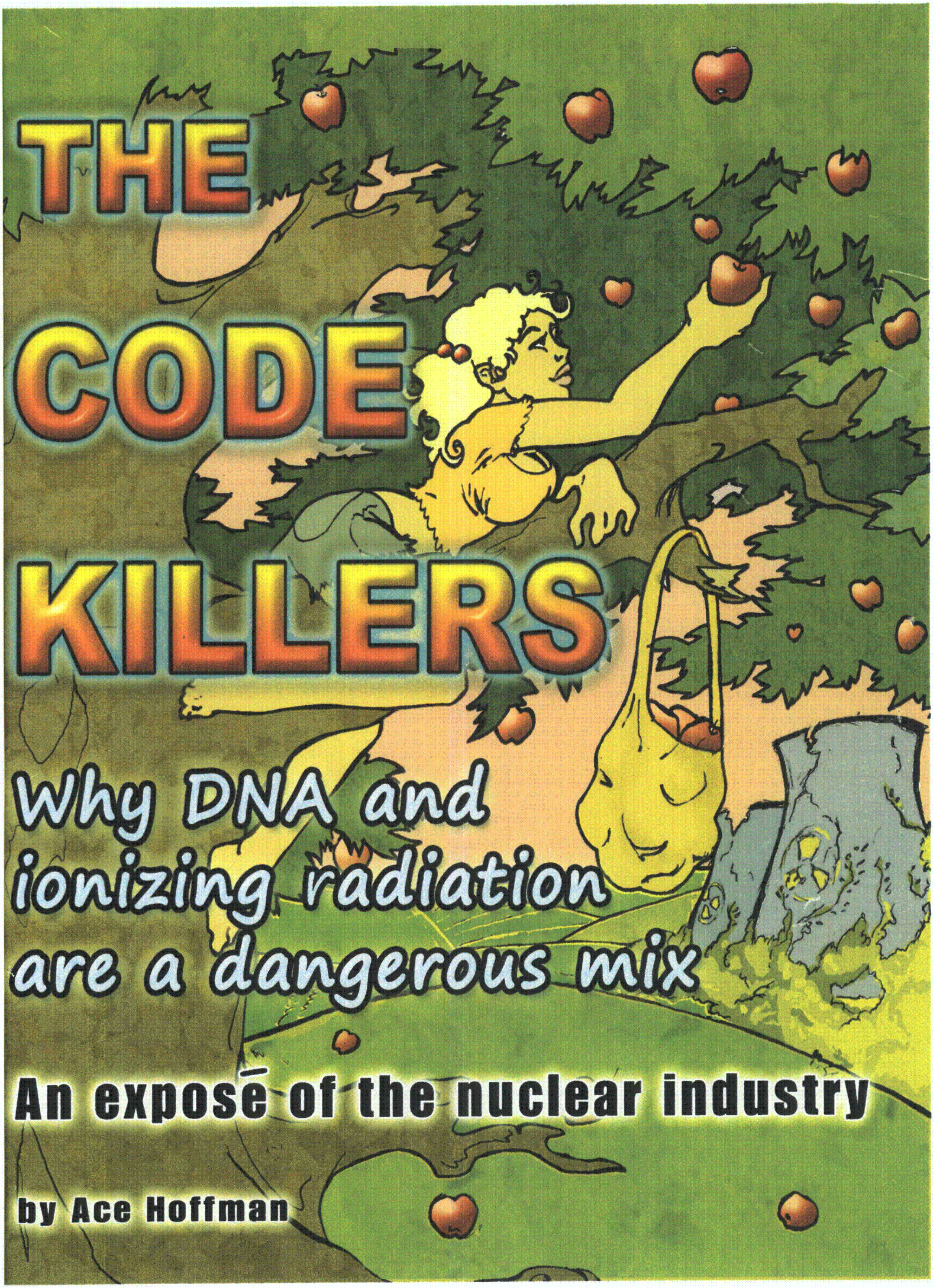
Read the release that details how TMI will operate for an additional 20 years
The U.S. Nuclear Regulatory Commission has renewed the operating license for Three Mile Island Unit 1 in Dauphin County.

The federal approval will extend TMI's license for an additional 20 years and will expire April 19, 2034.

The reactors original 40-year license was set to run out April 19, 2014.

"I am very happy with the NRC's decision to renew Three Mile Island's operating license," said Daryl Lehew, Chairman, Londonderry Township Board of Supervisors. "TMI is a good neighbor and I am very pleased for our community that the plant will be able to operate for another 24 years."

The renewal of TMI represents the 55th reactor license renewed by the NRC.


THE
CODE
KILLERS
Why DNA and
ionizing radiation
are a dangerous mix
An exposé of the nuclear industry
by Ace Hoffman

THE CODE KILLERS

Why DNA and ionizing radiation are a dangerous mix

An exposé of the nuclear industry

by Ace Hoffman

ace@acehoffman.org

POB 1936 Carlsbad CA 92018

Dedicated to:

The millions of victims of radiation poisoning, and the scientists, whistleblowers and citizens who, through books, videos, reports, emails, telephone calls and conversations, taught the author everything he is now trying to pass on to you.

First published (by the author)
October 2008
Current version: 5.5
October, 2009
(please see web site for errata and upgrade info)

For those who want to find the edges of a nuclear advocate's knowledge:
Use this guide to discuss each of the issues. The author has never met any pro-nuker who will claim to understand all these issues. Yet we all MUST be able to interlock ALL the pieces of a puzzle to solve it properly!

Cover art by Zoe Friend

This document was created by someone who wishes to be called a writer, or an educator, or a humanist, or a futurist, or a technologist, or a gadfly . . . but NOT an "activist!" Not that there's anything really wrong with activism, except that so-called "activism" is a last resort. Attending public hearings makes you a CITIZEN, NOT an activist. I've done a lot of that. Writing makes you a writer. I've done a lot of that, too. Programming makes you a programmer -- I do that, too. I am an artist. This is my painting. This is a "legal" document -- a testimony. It is the truth, the whole truth, and nothing but the truth, as plain as I can say it.

Contrast that claim with the following, from a letter to this author from the NRC: ***"Statements made by the public affairs officer of a NRC licensee are not regulated activities. Therefore, the veracity of such statements will not be investigated by the NRC."***

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WHO THIS BOOK IS FOR

VIP observers of a nuclear blast

"Duck and Cover"

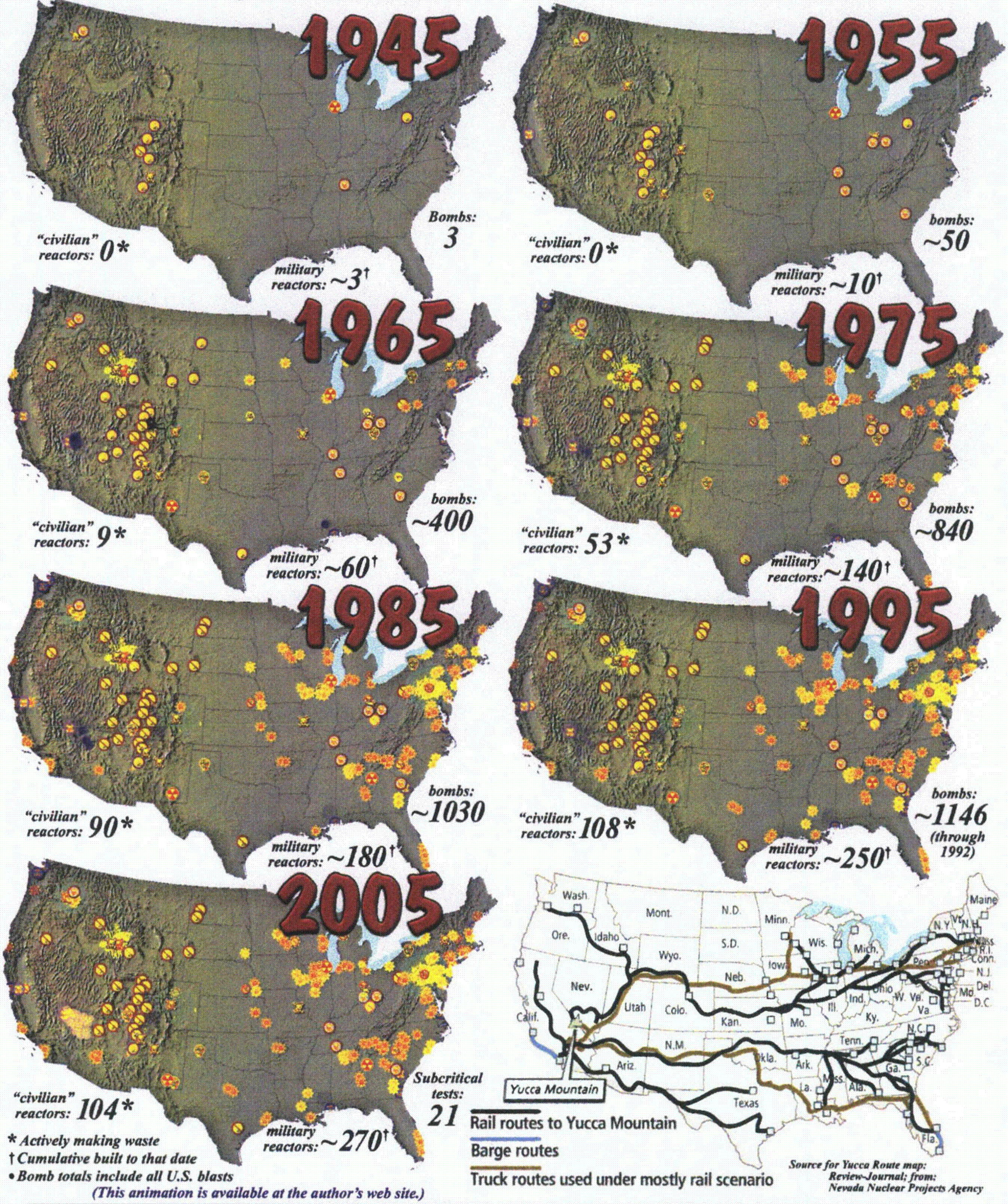
I had every resource imaginable available to help create this book (except infinite time). Whoever, pro- or con-, had the best descriptions, I based my own artwork on. This is what YOU most need to know about nuclear issues. It will be a refresher course for some, an introduction for others. Hopefully you'll want to know more -- but everyone should know *this*.

This book is especially for:

- STUDENTS and YOUNG PEOPLE
  exploring nuclear issues for the first time. You'll sound like a "pro" in no time!
- NEW ACTIVISTS and NEW ENVIRONMENTALISTS
  who, while all for reducing fossil fuel use, etc., wish to solve even bigger problems.
- THE CURIOUS
  who want the facts, fast, and don't want to wade through minutia, or waste time.
- SEASONED ACTIVISTS
  who want a handy reference and memory jogger. What's a rem, rad, α, β, γ, etc.?
- PEOPLE WHO SUSPECT THEY ARE RADIATION VICTIMS
  who want to begin to grasp how radiation can cause so many different illnesses.
- VICTIMS' LAWYERS, STATE ATTORNEYS GENERAL, JUDGES
  who want to understand the "big picture" so they can enter court prepared.
- MOTHERS, FATHERS, and MOTHERS- and FATHERS-TO-BE.
  who want to protect their children's DNA and their environment.
- NUCLEAR WORKERS and FIRST RESPONDERS
  who are concerned about potential accidents, and / or their personal risks.
- HEALTH CARE PROFESSIONALS
  who want to protect their patients from an excess of radiation.
- ELECTED OFFICIALS
  who want an unvarnished assessment from someone with no "vested" interest.
- TEACHERS
  who want a guide to the science and politics of nuclear issues.
- REPORTERS
  who don't like being lied to by government and industry toadies.
- OPTIMISTS, FUTURISTS, HUMANISTS and HUMANITARIANS
  who want to grasp the full magnitude of the problem, so they can get us out of it.

POISON FIRE USA

Major U.S. nuclear incidents, events, structures, etc.



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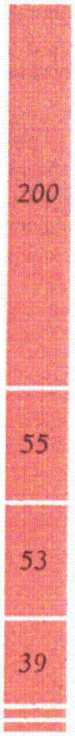
Radiation: What's in you today?



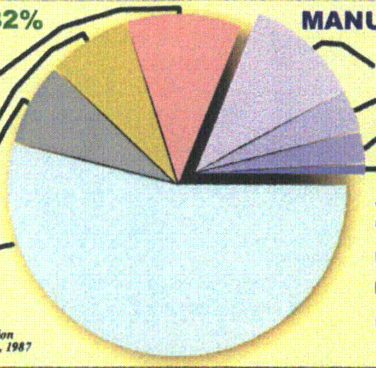
Source: Yucca Mountain, 2001

Annual Exposure Expressed in "Effective Dose Equivalent"

	mrem
Natural:	
Radon	200
Other	100
Occupational	0.90
Nuclear Fuel Cycle	0.05
Consumer Products:	
Tobacco	(?)
whole body dose equivalent dose estimate to a portion of lung	16,000
Other	5 - 13
Environmental Sources	0.06
Medical:	
Diagnostic X-rays	39
Nuclear Medicine	14
Approximate Total:	**360**

Source: U.S. NRC; NCRP Report #93, 1987

NATURAL 82% **MANUFACTURED 18%**



Occupational	0.3% (1 mrem)
Fallout	<0.3% (<1 mrem)
Nuclear Fuel Cycle	0.1% (0.3 mrem)
Miscellaneous	0.1% (0.3 mrem)

Original Source: National Council on Radiation Protection & Measurements, 1987

Note: Discrepancies, math errors, etc., even when the values are supposedly based on the same source (such as with the nuclear fuel cycle values shown above) are not uncommon in science...

It's as if you took a plane from LA to NYC...

You get about 4 mrem (0.04 mSv) round trip. If there is a solar storm and/or the pilot flies at an unusually high altitude, your exposure could be significantly higher.

Medical Procedure	mSv	chest x-ray equivalent	natural background time equivalent
Chest x-ray (PA film)	0.023	1	2.4 days
Skull x-ray	0.07	4	8.5 "
Lumbar spine	1.3	65	158 "
CT head	2	100	243 "
I.V. urogram	2.5	125	304 "
Upper G.I. exam	3	150	1 year
Barium enema	7	350	2.3 years
CT abdomen	10	500	3.3 "

Source: Radiology Today, 2004, adapted from the European Commission

They used to say (1940s and earlier) that you got about 100 mrem per year. Then 160. Then 240. Then 320. Now 360, and sometimes 380 or more. What changed?

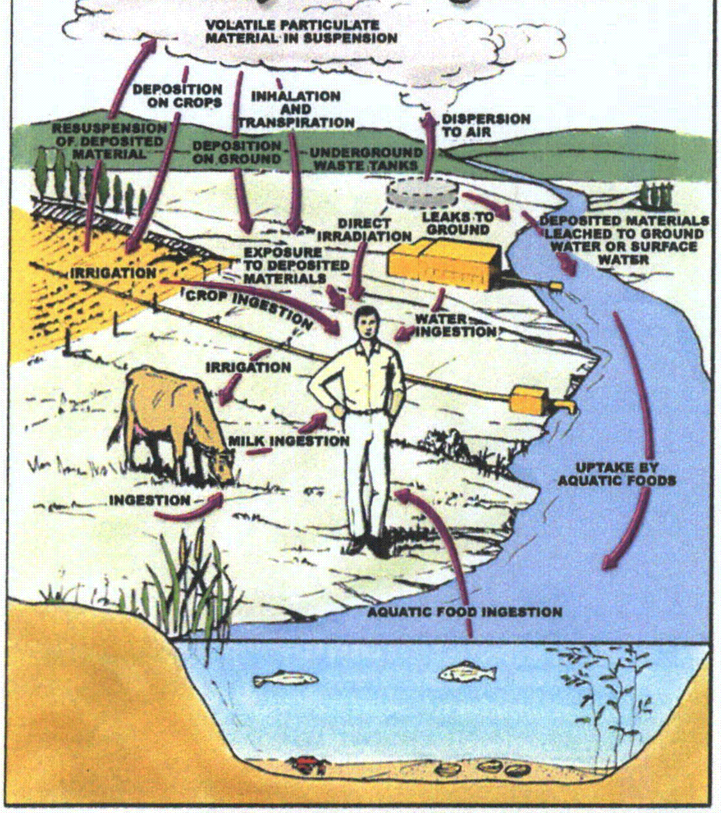
The longer you live, the more radiation your body must endure. Radiation is everywhere. But nevertheless, the less you get, the better. To some extent, and maybe to a large extent, your cumulative dose determines your risk.

Natural radioactive "hits" per second:	**~15,000***
∴ cumulative over 80 years:	**~38,000,000,000,000**
"Hits" per second in your body allowed by U.S. EPA from tritium alone:	**29,600**
∴ cumulative over 80 years:	**~75,000,000,000,000**
From a "typical" medical x-ray:	**>1,000,000,000,000***
∴ from one CT-Scan	**~500,000,000,000,000**

The risk of cancer from one CT Scan is currently estimated at about one in one thousand -- but even after all these years, nobody really knows.

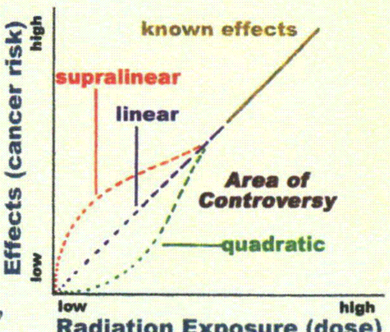
** Source: Cohen: The Nuclear Energy Option, Chapter 5.*

Pathways to Ingestion:



Colorized from: Understanding Radioactive Waste, 3rd Edition, by Raymond L. Murray, 1989 p. 98

The controversy about so-called low-level radiation, (greatly simplified: Cancer, for example, isn't the only "effect").



Source: Nuclear Power: Both Sides, Edited by Kaku & Trainer, 1982, p.30

Biological Half-life

The biological half-life of an element (the point in time when half of a foreign substance once in the body is no longer in the body) is NOT the same as the radiological half-life. After 20 radiological half-lives, only 2^{-20} of a substance will remain (about one millionth of the original amount). But when, for example, tritium poisons the body, some of it will bind "permanently," masquerading as a stable, useful hydrogen atom, until the moment of radioactive decay.

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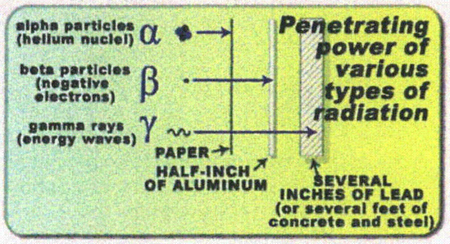
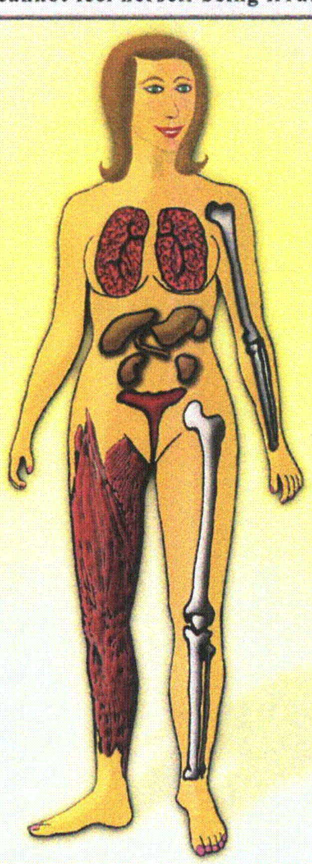
IONIZING RADIATION

High-energy, high-speed emissions, such as alpha (α) and beta (β) particles, neutrons, protons, x-rays and gamma (γ) rays, penetrate the human body and other things, causing biological, chemical, and /or physical damage. Energy of emissions is usually measured in megavolts (MeV). The biological half-life will be the same for all isotopes of a substance but will *not* always be the same for all organs. In any case, the biological half-life should be taken with a large "grain of salt" since some portion of *any* biological assault usually remains permanently in your body. Short radiological half-lives have no biological half-life listed: The assumption is that they will probably decay internally before the body might expel them.



Key: Symbol $^{\text{atomic weight}}$ *emission type* [max. MeV] (2nd type), half life / biological half-life (2nd component)

She is smiling because radiation is odorless, tasteless, and colorless. It cannot be detected by any sense organ. She cannot feel herself being irradiated.



BRAIN

At^{211} α [5.87 MeV], 7 h

SKIN

S^{35} β [0.16 MeV], 87.4 d / 623 d (90 d)

If you are contaminated with beta emitters on your skin:

"First, decontaminate yourself! *Flush* with plain soap and water (*no* scrub-brush!). Remove any contaminated clothing." *(Source: Duke U.)*

THYROID

Tc^{99} β [0.29 MeV], 211,000 y / 12 h
I^{131} β [0.97 MeV] (γ), 8 d / 110 d
I^{132} β [2.12 MeV] (γ), 2.3 h
I^{133} β [1.27 MeV] (γ), 20.8 h
I^{135} β [2.63 MeV] (γ), 6.6 h

LIVER

Mn^{56} β [3.70 MeV] (γ), 2.6 h / 4 d (40 d)
Co^{60} β [0.31 MeV] (γ), 5.72 y / 6 d (60 d)
Ce^{141} β [0.58 MeV] (γ), 32.5 d / 9 y
Ce^{144} β [0.31 MeV] (γ), 285 d
Pr^{143} β [0.93 MeV] (γ), 13.5 d
Pr^{144} β [2.99 MeV] (γ), 0.3 h
Nd^{147} β [0.90 MeV] (γ), 11 d
Pu^{242} α [4.98 MeV], 373,300 y / 82 y

PANCREAS

H^{3} β [0.02 MeV], 12.3 y

OVARIES

K^{42} β [3.52 MeV] (γ), 12.36 h
Kr^{85} β [0.67 MeV] (γ), 10.72 y
Co^{60} β [2.82 MeV] (γ), 5.27 y
Cs^{134} β [2.06 MeV] (γ), 2.1 y
I^{131} β [0.97 MeV] (γ), 8 d / 4 d
Pu^{241} α [4.90 MeV] (β,γ), 14.4 y / 80 y

MUSCLE

K^{42} β [3.52 MeV] (γ), 12.36 h
Cs^{135} β [0.21 MeV], 2,300,000 y / 70 d

WHOLE BODY

H^{3} β [0.02 MeV], 12.3 y / 9.4 d
C^{14} β [0.16 MeV], 5,715 y / 12 d
P^{32} β [1.71 MeV], 14.3 d / 257 d
Cs^{137} β [1.18 MeV] (γ), 30 y / 70 d
Ce^{144} β [0.31 MeV] (γ), 285 d / 9 y
Pu^{240} α [5.17 MeV] (γ), 6,563 y / 175 y

LUNGS

Kr^{85} β [0.67 MeV] (γ), 10.72 y
Ce^{144} β [0.31 MeV] (γ), 285 d / 180 d
Rn^{222} α [5.59 MeV] (γ), 3.8 d / 10 y
U^{238} α [4.2 MeV] (γ), 4,500,000,000 y / 3.8 y
Pu^{238} α [5.50 MeV] (γ), 87.75 y / 1.5 y

SPLEEN

Po^{209} α [4.88 MeV] (γ), 103 y / 50 d
Po^{210} α [5.31 MeV] (γ), 138.4 d

KIDNEYS

Ru^{106} β [0.04 MeV], 372 d / 7.2 d

....and everything else...

BLADDER

Po^{210} α [5.31 MeV] (γ), 138.4 d

....and everything else...

BONE

P^{32} β [1.71 MeV], 14.3 d / 3 y
Ca^{45} β [0.26 MeV], 163 d
Mn^{56} β [3.70 MeV] (γ), 2.6 h / 40 d
Sr^{89} β [1.46 MeV] (γ), 55.6 d / 40 d
Sr^{90} β [0.55 MeV] (γ), 29 y
Y^{90} β [2.27 MeV] (γ), 64.1 h
Y^{91} β [1.55 MeV] (γ), 58.5 d
Ba^{140} β [1.02 MeV] (γ), 12.7 d
La^{140} β [3.76 MeV] (γ), 40.3 h
Ce^{144} β [0.31 MeV] (γ), 285 d / 9 y
Nd^{147} β [0.90 MeV] (γ), 11 d
Ra^{226} α [4.78 MeV] (γ), 1,600 y / 10 y
U^{233} α [4.82 MeV] (γ), 160,000 y / 200 y
U^{235} α [4.70 MeV] (γ), 710,000,000 y
Pu^{239} α [5.15 MeV] (γ), 24,131 y / 200 y

"It is the ability of some radioisotopes to masquerade as their close chemical cousins (e.g., strontium 90 as calcium, radioactive iodine as natural iodine, cesium 137 as potassium), and thus be absorbed into the body, that makes them particularly dangerous. The body has very efficient mechanisms for capturing iodine and concentrating it in the thyroid gland, for directing calcium and other bone-seeking elements to the skeleton and holding them there, and for concentrating other elements at specific points. Consequently the full destructive force of a radioactive material may focus on a single organ."

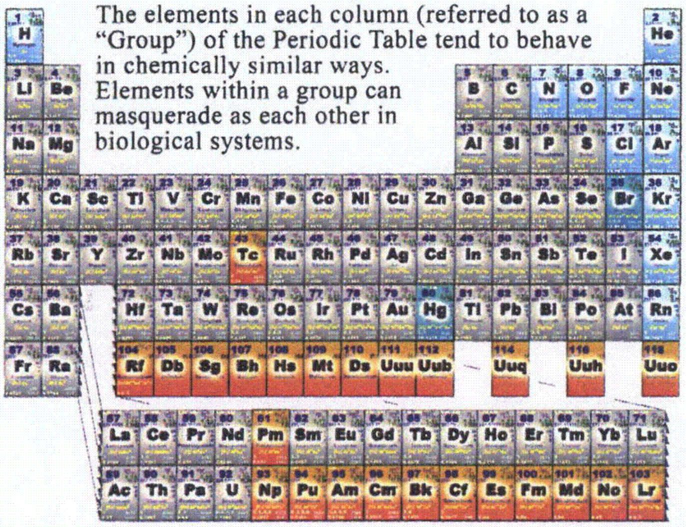
-- W. O. Caster, From Bomb to Man (Fallout, Basic Books, 1960, p 41)

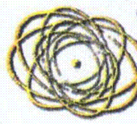
All reproductive organs are attacked by radiation. Many isotopes cross the placenta. Plutonium also concentrates in the gonads. Radiation causes birth defects, mutations and miscarriages in the first and / or successive generations after exposure. A fetus is much more vulnerable to radiation than an adult. Girls are more vulnerable than boys. Women are more vulnerable than men. Nevertheless, radiation "safety" standards are based mainly on adult male resistance levels. Cancers, leukemia, heart failure, amnesia, neuromuscular diseases, and many other health effects may take years to develop. There is no minimum dose; *any* dose can be fatal and any dose causes some amount of damage.

Elements and Isotopes

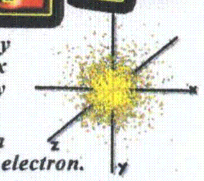
The Periodic Table of the Elements

The elements in each column (referred to as a "Group") of the Periodic Table tend to behave in chemically similar ways. Elements within a group can masquerade as each other in biological systems.





(Left) The atom as envisioned by Niels Bohr, utilizing Max Plank's Quantum Theory of discrete energy levels.
(Right) Typical positions for a hydrogen atom's lone electron.

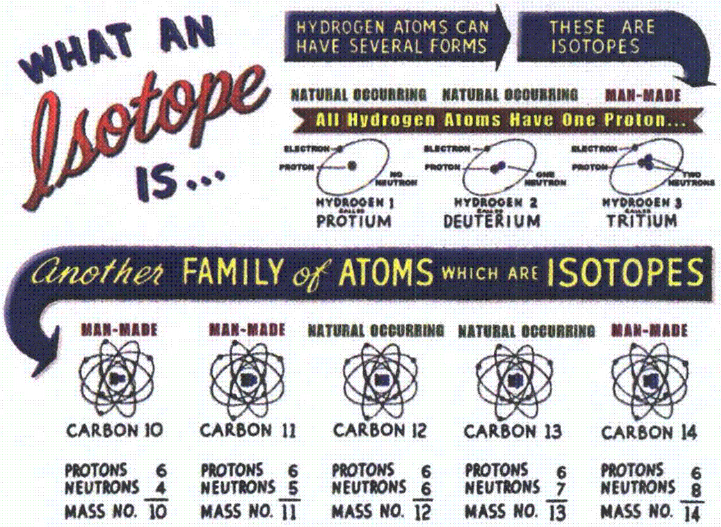


An atom is about a million times smaller than the width of a human hair. A uranium atom (#92) weighs more than 200 times as much as a hydrogen atom (#1), but the diameter is only about three times greater.

Every solid thing in the universe (including you) is made of atoms. Atoms are made of protons, neutrons, and electrons. The number of protons determines which element an atom is, and the number of electrons orbiting the nucleus is normally (in the "ground state") the same as the number of protons in the nucleus.

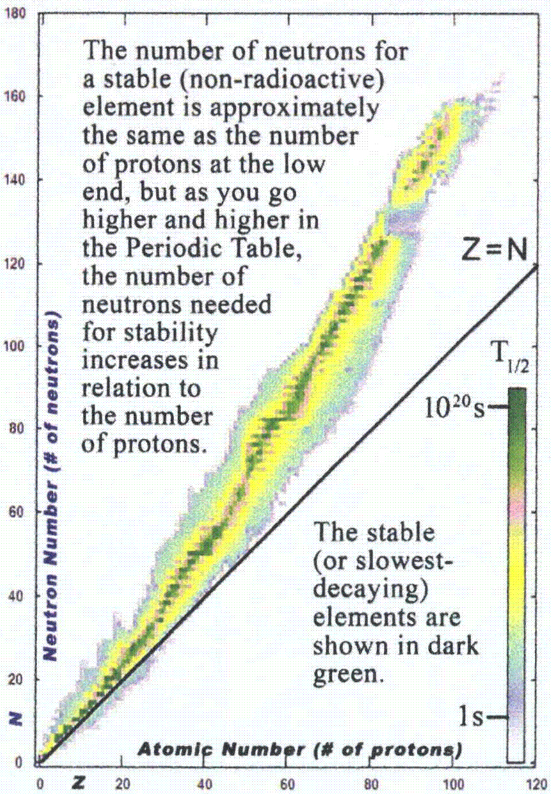
Along with protons, neutrons also occupy the nucleus. The number of neutrons, however, can vary for any particular element. Atoms with the same number of protons but different numbers of neutrons are called different isotopes of the same element. Only the first element -- Hydrogen -- exists (most of the time) without any neutrons.

For some elements, there are no stable isotopes. Prior to the atomic age, only a few radioactive isotopes existed in the environment.



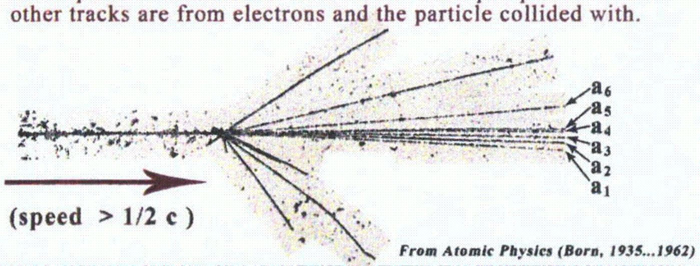
From: The Story of Atomic Theory and Atomic Energy (Feinberg, 1960)

THE STABILITY CURVE



The nucleus forms into alpha particles as much as possible...

An aluminum nucleus (Z=13+/-1) traveling at a little over half the speed of light, collides with a particle in an emulsion, which decomposes the aluminum nucleus into six alpha particles. The other tracks are from electrons and the particle collided with.



From Atomic Physics (Born, 1935...1962)

Particles, Rays, Mass, & Energy

Powerful Emissions from the Nucleus of the Atom

Ionizing Radiation is usually described as being composed of energy waves (also known as rays) and / or of extremely fast particles.

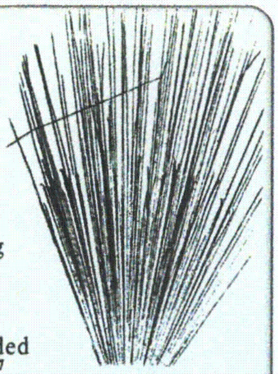
In any case, ionizing radiation has enough energy to knock other atoms' electrons out of their orbits and to break all types of molecular bonds, including all biological bonds.

*Alpha particles are composed of 2 protons and 2 neutrons and turn into nuclei of the second-lightest element (helium). They have tremendous mass compared to other radiations: They are about 7,345 times more massive than beta particles, and have a charge of 2. When ejected from the nucleus, alpha particles are traveling at about **98%** of the speed of light.*

Beta particles, which have a charge of -1, shoot out of the nucleus of the atom at >~99.7% the speed of light. After slowing, they are normal electrons, and bind with nuclei in the normal ways.

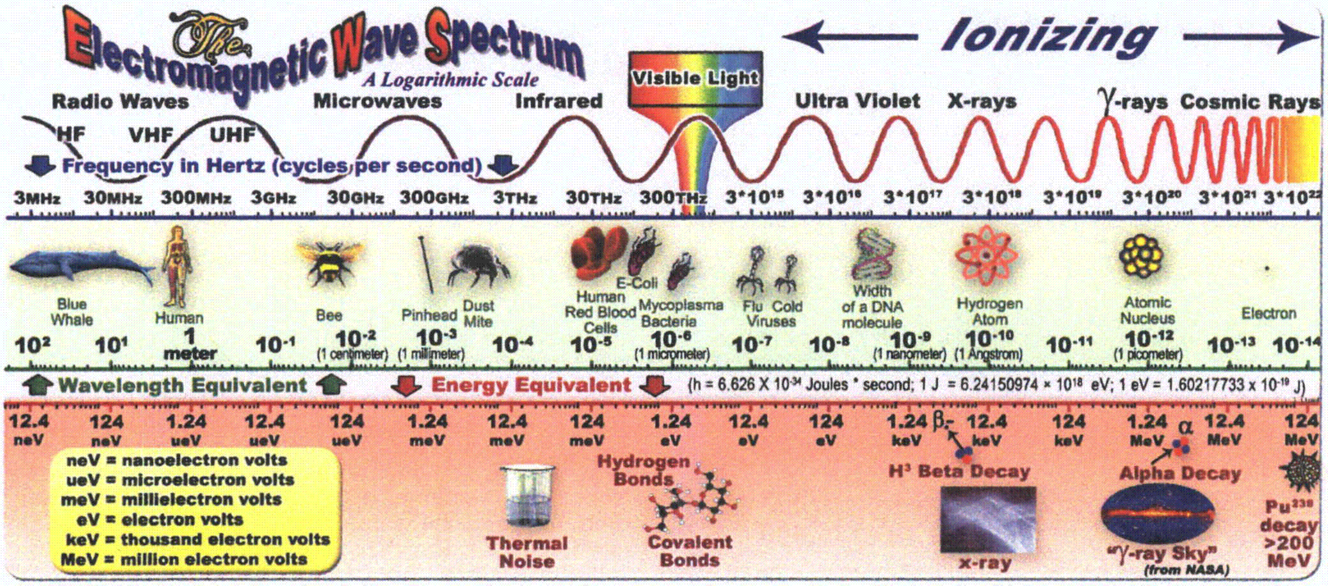
Tracks from alpha particles (He^4) emitted from a blend of Pb^{212} and Bi^{212}. One alpha particle has struck an N^{14} nucleus. As a result, a proton (H^1) has gone flying a long way off.

Meanwhile, the N^{14} nucleus has rebounded too, and become O^{17}.



From Atomic Physics (Born, 1935...1962)

Particles slow down as they hit things or, if they are charged particles, if they just simply go near things that are also charged. Gamma rays and x-rays do not slow down; they either hit things which absorb them (usually giving off another ray, or a particle, later), or they ricochet. Most often, of course, they miss things entirely, which is why they can penetrate so deeply.



Radiation Conversion Factors

1 rad = an *absorbed dose* of 0.01 joules (J) of energy per kilogram (kg) of tissue, or 100 erg per gram
1 rad = 1,000 millirad
1 gray (Gy) = 100 rad = 1 J / kg
1 roentgen = 0.876 rads (*in air*)
1 rem = 1.07185 roentgen
(rem stands for "roentgen equivalent in man")
1 rem = 1,000 millirem
1 sievert = 100 rem
1 becquerel = 1 disintegration per second
1 curie = 37,000,000,000 disintegrations per second
1 curie = 37,000,000,000 becquerel
1 becquerel = 2.7E-11 curies
1 becquerel = 27 picocuries
1 curie = 1,000,000,000,000 picocuries
1 picocurie = 0.037 disintegrations per second
1 microcurie = 37,000 disintegrations per second
1 megacurie = 1,000,000 curies
1 kilocurie = 1,000 curies

Units of Measure for Radioactivity

Becquerels	Grays	Sieverts
A count of decays	*An energy density*	*A damage assessment*

Highly modified from: C.E.A.

The *number* of apples that fall in a given unit of time can be compared to the **curie** or **Bq** (decays per second).

The total *energy* of all the apples that hit the sleeper in a given unit of time can be compared to **rads** or **grays** (absorbed dose).

The *effect* on the body, depending on the size, weight, and speed of the apples, can be compared to **rems** or **sieverts** (effective dose).

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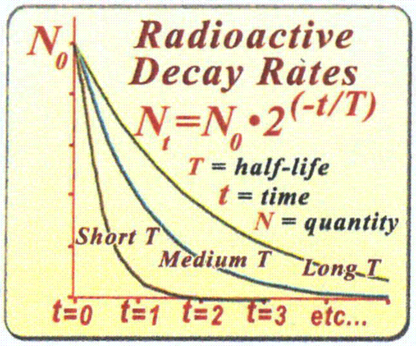
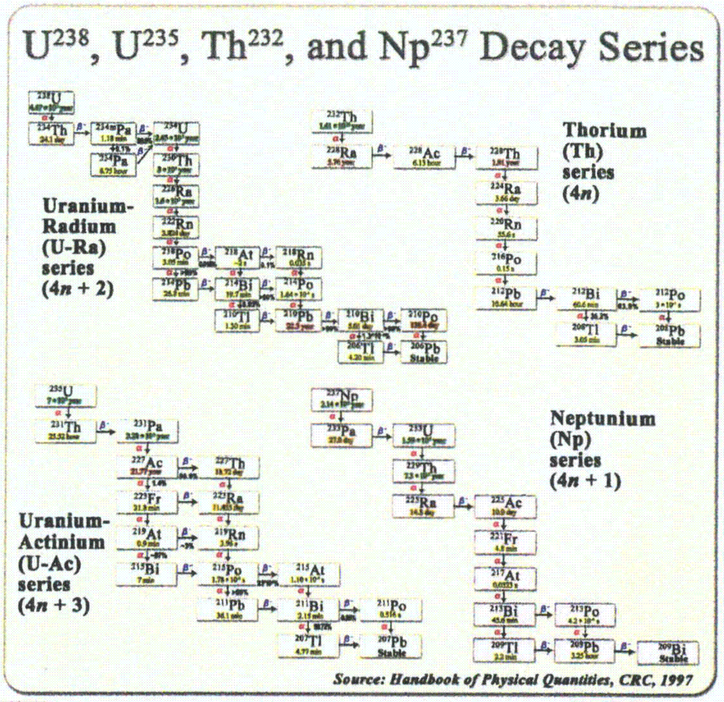
WHAT IS A HALF-LIFE?

A half-life is a statistical value

It is the time it takes for half the atoms in a pure sample of a single isotope of an element to decay into some other element. After one half-life, half the atoms of the original isotope will still be unchanged. After two half-lives, a quarter of them will still be unchanged.

If you start with 1,000,000,000 (one billion) atoms, after 20 half-lives about 1000 atoms of the original isotope will remain -- about one millionth (0.000095%) of the initial amount.





Source: Handbook of Physical Quantities, CRC, 1997

Specific Activity

The specific activity is the rate of decay times the quantity. The specific activity of Radium-226 is one curie per gram.

isotope	primary emission type	half-life	specific activity in curies per gram
Noble Gases:			
Krypton-85	β	10.72 *y*	392
Xenon-133	β	5.27 *d*	186,000
Other Fission Products:			
Strontium-90	β	28.1 *y*	141
Molybdenum-99	β	66.7 *h*	474,000
Iodine-131	β	8.07 *d*	123,500
Cesium-135	β	2,500,000 *y*	0.0008
Cesium-137	β	30.2 *y*	86.4
Cerium-144	β	285 *d*	3,182
Natural Elements:			
Uranium-235	α	710,000,000 *y*	0.00000241
Uranium-238	α	4,500,000,000 *y*	0.000000334
Transuranics:			
Plutonium-238	α	86 *y*	17.47
Plutonium-239	α	24,400 *y*	0.0613
Plutonium-240	α	6,580 *y*	0.226
Plutonium-241	β	13.2 *y*	112
Americium-241	α	458 *y*	3.24
Americium-243	α	7,370 *y*	0.200

β Tritium (H^3): ...nothing "soft" about it!

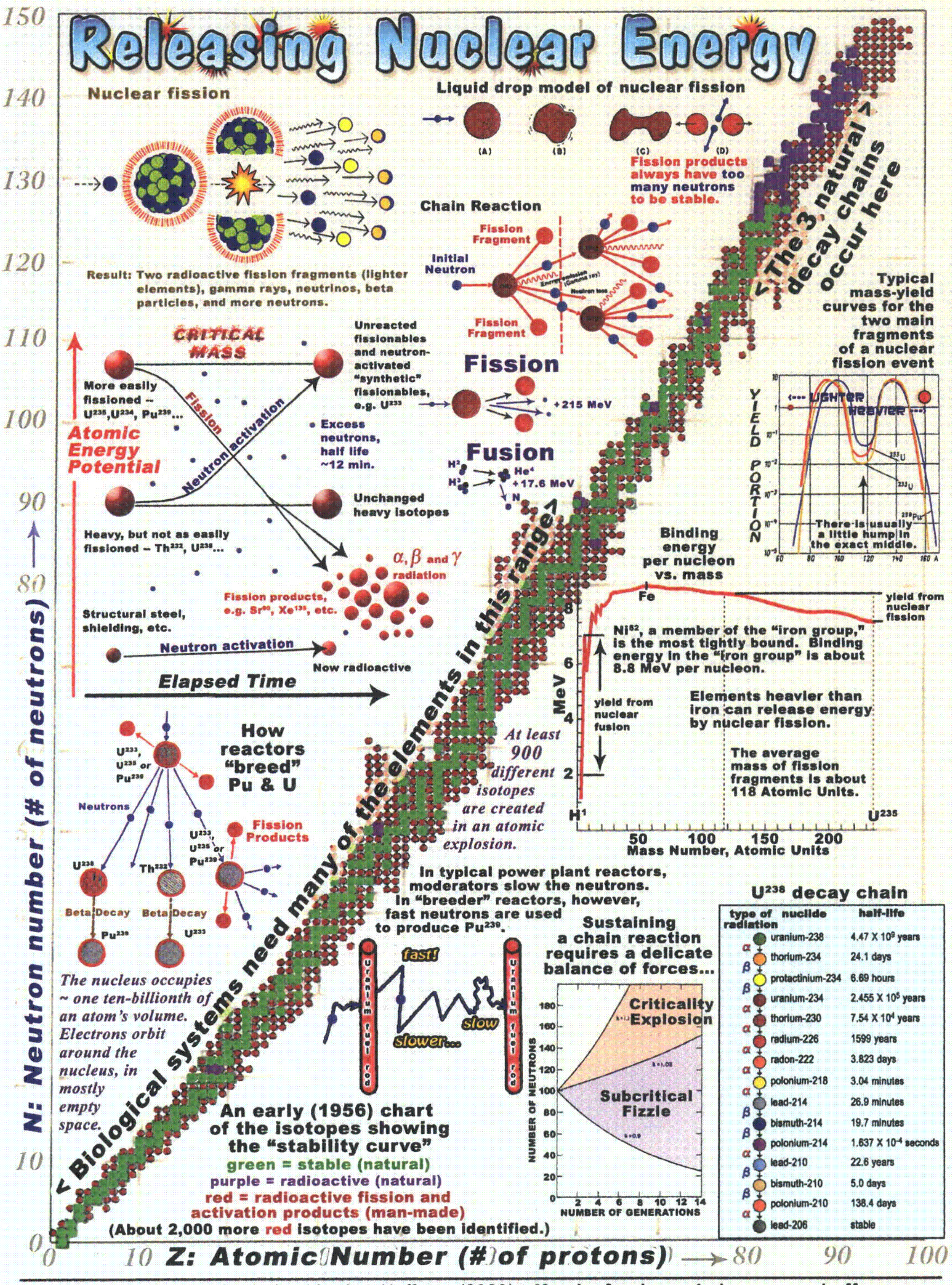
β 18keV

Tritium is a hydrogen isotope with two neutrons. Tritium has a half-life of about 12.3 years. It decays by beta emission: 6 keV avg., 18 keV max..

There are about **10,000** curies in a gram of tritium, or **3.7 * 10^{14}** decays per second per gram. There are about **3.7 * 10^{11}** stars in the Milky Way -- a thousand times LESS than the number of decays per second emanating from a single gram of tritium. U.S. nuclear reactors routinely release about a tenth of a gram of tritium every year, but an entire gram might be released in a bad year -- about once per decade per reactor. CANDU reactors release ~ 20X more tritium than U.S. reactors.

And just how much damage can a single one of those **370 trillion** (370,000,000,000,000) decays per second do if it occurs inside our bodies? One decay can break your DNA chain and begin a cancer. One gram of H^3 would kill you instantly. But a millionth of a gram (370,000,000 decays per second) would kill you pretty quickly, too. The power plants have to dilute it a lot more than that to be allowed to release it.

The United States' EPA standard for tritium in drinking water allows **740** nuclear decays per second per liter. Your body has about 40 liters of water, so the EPA thinks that adding a burden of about **30,000** additional nuclear breakdowns PER SECOND to your body -- just from tritium alone -- is PERFECTLY OKAY (but more is not). This compares with **4,400** nuclear breakdowns per second for all 17 milligrams of natural radioactive potassium (K-40) in your body, which doesn't have nearly as many additional effects. Is K-40 dangerous? Yes, a little -- but it's utterly unavoidable.



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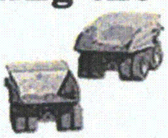
Steps in the Nuclear Process

Prospecting for Uranium Ore

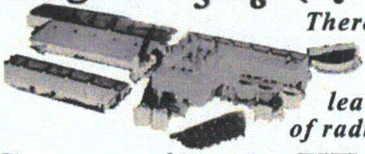
Uranium is a plentiful metal, found in dozens of countries, but high-grade ore is much more rare -- and costly.

Mining the Uranium Ore



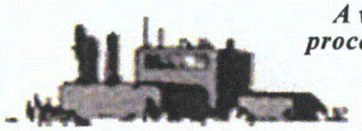
Mining uranium ore is dirty and carbon-intensive. It often involves some amount of "environmental racism," too.

Milling to U_3O_8 ("yellowcake")



There are several dozen uranium mills in the U.S.. Each leaves enormous piles of radioactive "tailings."

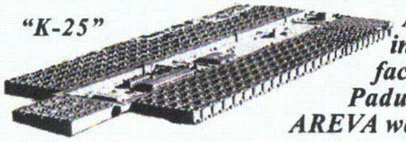
Conversion to UF_6 ("hex")



A very dirty step in the process. Currently there is only one facility in the U.S., in Metropolis, IL.

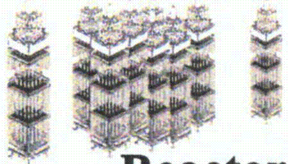
U^{235} Enrichment

"K-25"



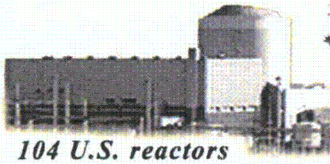
Another very dirty step in the process. Of three facilities in the US., only Paduca, KY operates. But AREVA wants to build another.

Fuel / Bomb Fabrication



"Fat Man" -- destroyed Nagasaki

Reactors / Bombs



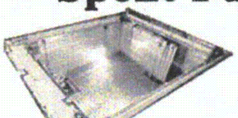
104 U.S. reactors

Naval Propulsion

There are still about 10,000 nuclear bombs in the U.S. arsenal.

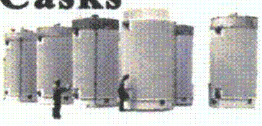
"Trinity" at 0.034 seconds

Spent Fuel Pools



Most pools are so full they are triple-racked; Total: About 60,000 tons (as of 2008).

Dry Storage Casks

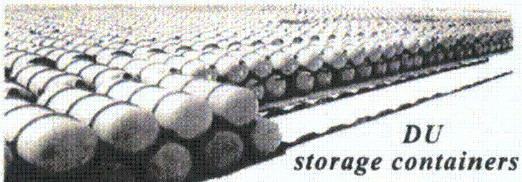


Natural uranium is ~0.7% U^{235}, ~99.3% U^{238}, and a little U^{234}, too. Most nuclear power reactors and all atomic bombs require U^{235} enrichment. The remaining "depleted" uranium is ~99.5% U^{238}, with from 0.2% to 0.4% U^{235}. DU is used by the U.S. military for shells, missiles, bombs, armor, and counterweights. DU is pyrophoric, so on impact, DU projectiles usually burst into flame, producing radioactive poisonous plumes of extremely fine aerosols, nanoparticles, and dust.

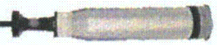
Nuclear reactors and atomic bombs create new radioactive elements, including Pu^{239}. Isotopes such as Ce^{137} and Sr^{90} can bioaccumulate in living organisms, multiplying their dangers tens of thousands of times. Nuclear reactors release radioactive poisons to the environment continuously.

Used nuclear reactor cores are lethal for millions of years. There is no safe, cost-effective storage or transportation solution.

The nuclear industry is very profitable for the corporations. Most costs are paid later, by victims (incl. industry workers) of radioactive pollution. The taxpayer (YOU!) pays many of the "up-front" costs. Government enthusiastically licenses each step AND prevents true public scrutiny by sealing virtually all records of accidents, leaks, etc.. Opportunities to lie, falsify records, cover things up, etc., are taken with frightening regularity.



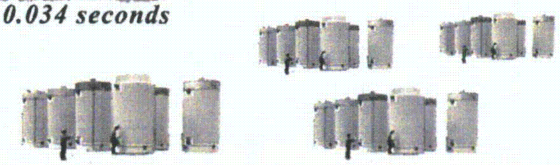
DU storage containers



DU projectiles

DU armor

Tomahawk Cruise Missile

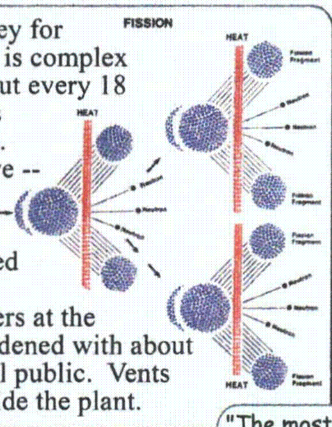


Thousands of Dry Storage Casks are being built across the U.S.. A fraction of one can contaminate a large state. Dry Storage Casks are vulnerable to terrorists (including "inside jobs"), tornados, tsunamis, jets, accidents due to poor construction, etc..

How Do Reactors Work?

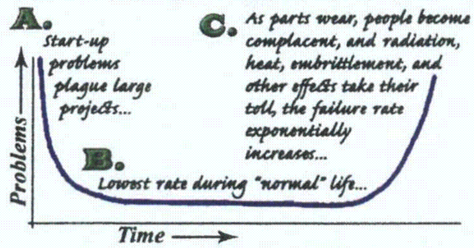
Nuclear reactors boil water to make money for their owners. Turning a reactor off or on is complex and costly. 1/3 of the fuel is replaced about every 18 months to two years. When the fuel goes into the reactor, it is "mildly" radioactive. When it comes out, it is wildly radioactive -- expensive to handle and very dangerous, releasing decay heat for many millennia.

Radioactive activation isotopes are created in the fuel rods, in the coolant water, throughout the building, and in the workers at the plants. Nuclear industry workers are burdened with about five times more radiation than the general public. Vents prevent build-up of radioactive gases inside the plant.



The "Bathtub Curve" of Product Reliability

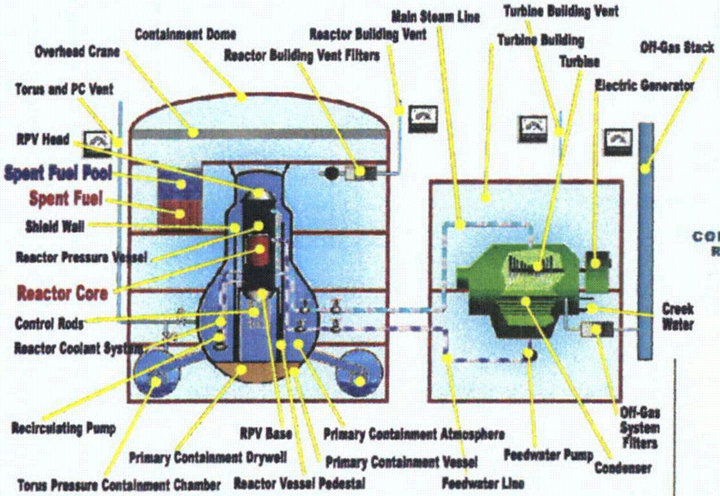
(applies to **any** large and complex engineering project)



"The most intolerable reactor of all may be one which comes successfully to the end of its planned life having produced mountains of radioactive waste for which there is no disposal safe from earthquake damage or sabotage."

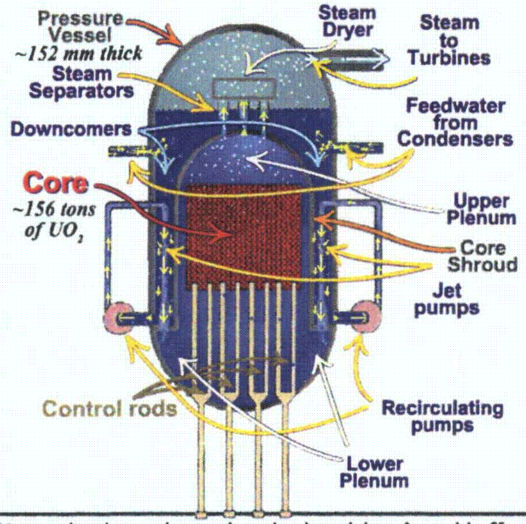
A. Stanley Thompson, early-era nuclear physicist and author of a college textbook on reactor technology, then later, the author of a book explaining the dangers of runaway power fluctuations.

Boiling Water Reactor (BWR)



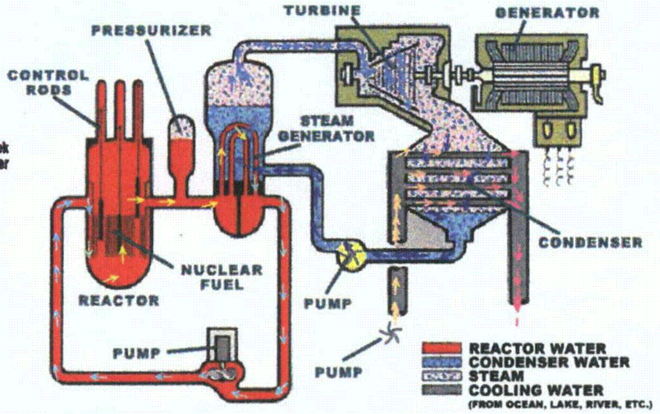
Note the location of the BWR's **spent fuel pool** -- above the reactor! BWRs are generally older, less reliable, and less efficient than PWRs. About one third of U.S. reactors are BWRs. The rest are PWRs.

BWR Reactor Pressure Vessel (RPV) with main circulation paths, control rods, and connections



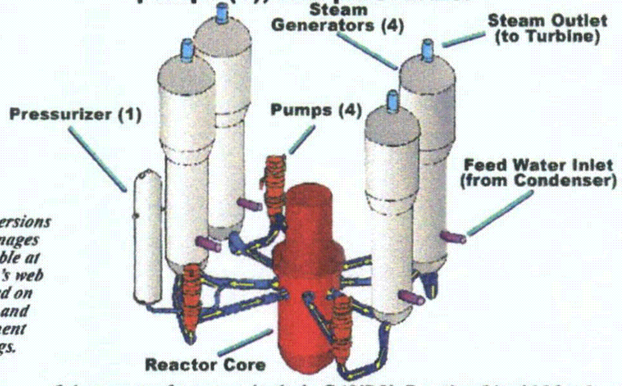
Animated versions of these images are available at the author's web site. Based on industry and government drawings.

Pressurized Water Reactor (PWR)



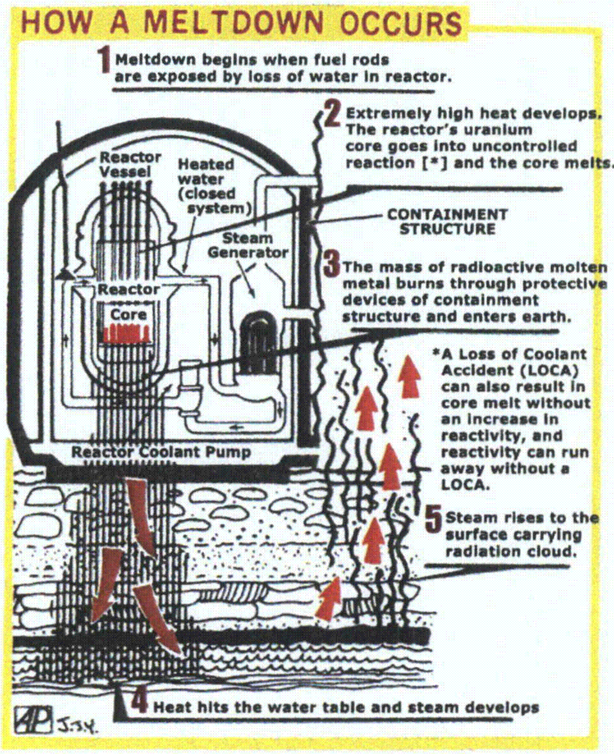
To prevent boiling, the pressure in the **primary coolant loop** of a PWR is ~2200 to ~2300 P.S.I.. Steam generators contain thousands of individual tubes for heat exchange. About 1,000,000 gallons per minute is drawn from the local water source, heated, and irradiated.

PWR Reactor Pressure Vessel (RPV) with steam generators (4), primary coolant loop, pumps (4), and pressurizer

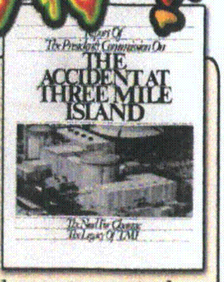


Other types of reactors include CANDU, Breeder, Liquid Metal, etc..

WHAT IS A MELTDOWN?



Adapted from: Bridgeport (CT) Post, March 31st, 1979 AP Laserphoto



In **1979**, the new Three Mile Island reactor partially melted down. The "root cause" was determined to be mainly human error. An estimated 15 million Curies of radiation was released, but numerous measuring devices failed during the crisis.

In **1986**, technicians at the Chernobyl reactor tried an unauthorized experiment, without proper safety equipment on-line. An explosion of the hydrogen and oxygen that had built-up occurred, as well as a partial core melt. An estimated ten billion Curies of radiation was released. Thyroid cancer rates in surrounding areas are dozens of times normal, and many other cancer rates are also elevated.

In **2002**, more proof of the nuclear industry's "failure-to-learn" came when the Davis-Besse reactor (in Ohio) nearly melted down. Pressure from the 2200 PSI primary coolant loop was pushing out the stainless steel reactor pressure vessel liner when the RPV head's boron corrosion was found. This was hardly D-B's first close call or long shut-down.

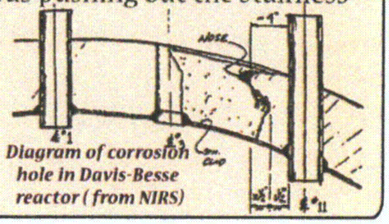


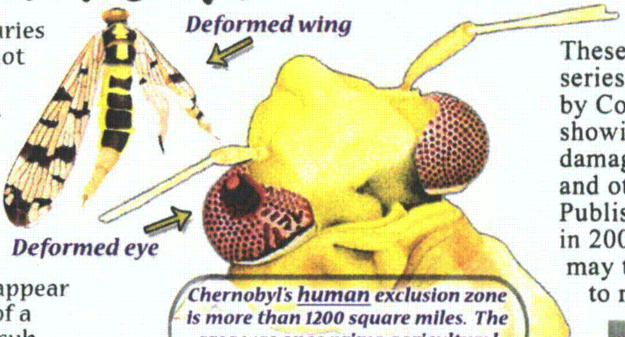
Diagram of corrosion hole in Davis-Besse reactor (from NIRS)

HOW DANGEROUS IS A MELTDOWN? *(very)*

Reactors contain about 15 billion Curies of radiation. A museum near (but not too near) Chernobyl is dedicated to deformities caused by the accident.

Birds fell dead out of the sky, and people collected them from their yards by the bushel-basket after Three Mile Island.

Most military nuclear disasters disappear without a visible trace, in the dust of a bomb or the poison from a sunken sub.

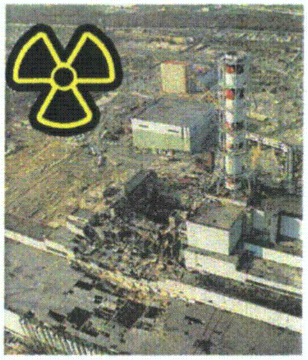


Chernobyl's human exclusion zone is more than 1200 square miles. The area was once prime agricultural land: the pride of Ukraine.

These insects are from a series of technical drawings by Cornelia Hesse-Honegger, showing radiation-induced damage around Chernobyl and other nuclear facilities. Published in New Scientist in 2008. Genetic damage may take many generations to manifest its horrors.

HOW LIKELY IS A MELTDOWN? *(very)*

According to an infamous **1982** government study known as CRAC-2, a reactor meltdown can be expected for every 20,000 years of accumulated operation. That's an average of one meltdown every 192 years in America, with 104 reactors. However, CRAC-2 ignored or underestimated the risk of scores of meltdown causes, such as Emergency Core Coolant System (ECCS) failure, including ECCS failure ***after*** shutdown. The NRC ***still*** will not even attempt to quantify the risk from terrorism, nor does it properly quantify other risks. Since CRAC-2 was released, nuclear reactors have aged, fuel pools have filled, dry casks have been built, and populations near the plants have skyrocketed.



Much of the Chernobyl reactor was "missing" after the accident!

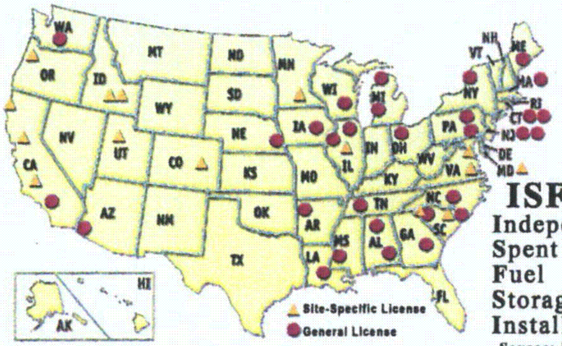
Written, designed, and colorized by Ace Hoffman (2008) ***May be freely copied*** www.acehoffman.org

What's Worse Than A Meltdown?

A spent Fuel Pool Fire

How could this be worse than a meltdown? Because there is often 30 or 40 times MORE fuel in the pools than in the reactor. A significant portion of the full load of many of the most dangerous fission products still remains in the fuel. The zirconium cladding of the fuel pellets is pyrophoric. The pools are over-crowded and, in the case of some older BWRs (the General Electric Mark 1s, for instance), the pools are five stories above the ground -- and protected from airplanes by a corrugated steel roof!

This is worse than unsafe. It's criminally negligent. Too bad there aren't any solutions that are much better.



ISFSIs
Independent Spent Fuel Storage Installations
Source: NRC, 2008

A Dry Cask Fire

Dry casks were invented because spent fuel pools are expensive to maintain and take up a lot of space. Dry casks look harmless enough. Some are built vertically, some in a horizontal configuration, which just shows that the nuclear industry doesn't have a clue as to which way is better. However, dry casks are inherently more dangerous than spent fuel pools for several reasons: The zirconium will be exposed to air in virtually any accident since the fuel is not in water, and does not have 30 feet of water above it. Also, the fuel rods cannot be inspected as easily, or removed for special handling if they are found to be flawed.

A single dry cask contains enough poisons to cause the permanent evacuation of a large state, such as Pennsylvania, or virtually all of New England. But evacuation will always come too late for many -- millions could be killed if an airplane were to crash into a series of dry casks, and half of America could be rendered uninhabitable.

One of these days, inevitably, a dry cask will be ignited, because there is no end to how many of these there will be -- dozens now, and within a decade several hundred. Then thousands, and then tens of thousands. The more **opportunities** there are for that "one in a million" (which often isn't anwhere near that rare) accident to happen, the more **likely** it is to happen.

A Steam Explosion with a Zirconium Fire and / or a Complete Core Rubblization

The NRC has what they call the "design basis accident" and this scenario doesn't fall within those specifications. Does that mean it's impossible?

Absolutely not! All it means is that at some time in the distant past, some government committee decided that the likelihood of such an accident was below one in one million, or perhaps one in ten million.

The scientific basis for their decision is unavailable to anyone and was probably not properly documented to begin with. But the ramifications are devastating.

Any time these seemingly-Rube Goldberg-ish (to the NRC) but utterly plausible accidents are brought up by a citizen, the NRC says they are "outside the design basis accident" which, for some reason, means they will not be discussed. Try it. You'll see.

Yet, all actual near-misses in the past were later determined to have come as a "complete" surprise...

Being Lied To

Once you've lost the truth, there is no hope for anything else going your way. Lies can be built on other lies, compounding the problem.

The nuclear industry is not known for honesty, and never will be. Yet honesty is a fundamental principle of democracy and of fair commerce and proper science.

All Of The Above

A meltdown can cause a spent fuel pool fire, a dry cask fire, the rubblization of the core, and the meltdown of other nearby nuclear power plants. And all this will be followed by lies. Lots and lots of lies.

What Else Can (and does) Go Wrong?

Lax Security

Sleeping on the job and falsifying records are recurrent themes among the security teams at nuclear power plants. The job is boring, the pay is low, the hours are bad, and if anything ever DOES go wrong, you'll probably be overwhelmed with "superior" forces and killed anyway. So why bother doing a good job?

"Inside Jobs"

The average nuclear power plant has about 1500 employees. Some are alcoholics, some are on unprescribed medications, some are on prescribed medications that cause mood swings the Nuclear Regulatory Commission has ignored. Some are improperly cleared foreign nationals.

Staffing Problems

The shortage of qualified workers at nuclear power plants is severe and will likely remain so forever. Why? That's simple enough to understand -- most people are smart enough not to want to go into a field which is so dangerous, so disliked, and so ruthless and dishonest.

Radioactive Drinking Fountains

A nuclear power plant in Florida had a drinking fountain which dispensed water from a radioactive holding tank, because the pipes had been crossed when the plant was built. Luckily, someone with a Geiger counter just happened to test the water.

Lax Maintenance

The basic attitude at all nuclear power plants these days is "if it hasn't broken yet, don't fix it."

Pumps, pipes, valves, vessels, control cables, instrumentation, and everything else that can fail is allowed to, and then fixed afterwards.

Riots, floods, tsunamis, earthquakes, asteroids, wars, tornados, airplane crashes, nearby chemical explosions, wildfires, avalanches, space weapons malfunctions

The nuclear industry considers everything they can't control (and many things they can but which they consider too expensive) to be so unlikely as to not be worthy of serious consideration. Airplane strikes like we saw on 9-11? No worries -- the TSA will keep the skies terrorist-free forever! The nuclear industry assumes everyone is perfect -- and equipped with the proper tools.

Lax Fire Safety

For at least four years, the fire records at San Onofre Nuclear Generating Station in Southern California were faked, and the inspection rounds were not performed. This was AFTER 9-11. Did anyone go to jail for this violation? Oh, come on! Not a chance!

Hidden Design Flaws

The Emergency Core Cooling System is a nuclear power plant's final backup before meltdown. Some plants even maintain thousands of large buckets of ice "just in case." None of these systems have ever been properly tested. One ECCS, for the Monticello nuclear power plant, was found to be inoperable for 30 years, because shipping bolts had been left on during initial installation. It NEVER would have worked!

Lax Oversite

The Nuclear Reguatory Commission cannot watch everything that happens at a nuclear power plant, so they rely on industry to police itself. Industry loves this, since it means they don't have to do anything.

"We're working on it"

Go ahead. Complain all you want. But even if your complaint is so ironclad that even the NRC cannot entirely dismiss it, the best you can ever expect is to be told they are aware of the issue and are working on a solution. And that can go on for decades.

Information Overload

The situation in the control room of a nuclear power plant can go from normal to meltdown in a fraction of a second. When problems start, panic among the workers -- even if they are highly trained -- can cause them to make bad decisions, or fail to make decisions at all.

Lax Safety Standards

This pilot was grounded for 30 days after pulling this "stunt" near the nuclear aircraft carrier J.C. Stennis. He reportedly likes the picture and thinks it was "worth it."

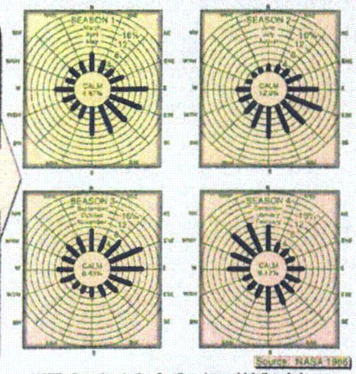
This "cowboy" attitude is especially pervasive among nuclear workers.

No One Understands How The Things Work

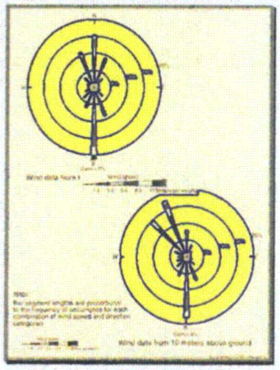
Nuclear power plants are complicated and require tens of thousands of "man-years" to complete. At that point, there is not one person who understands the entire plant, then the best experts start retiring.

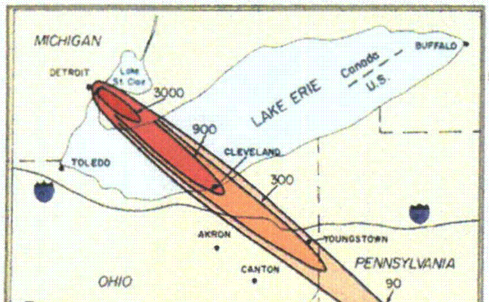
How Far Does Radiation Spread?

Shown on the right are "wind roses" from typical Environmental Impact Reports. But, when evaluating the costs of nuclear power, no state environmental agency will consider the effects of meltdowns, including where a meltdown's deadly plume will travel. "Not our jurisdiction" they'll claim, saying only the Federal Nuclear Regulatory Commission or Department of Energy have any authority over "safety." State agencies are only too happy and quick to give up authority over things they don't understand very well anyway.



NOTE: Bars denote the directions from which the winds occur.

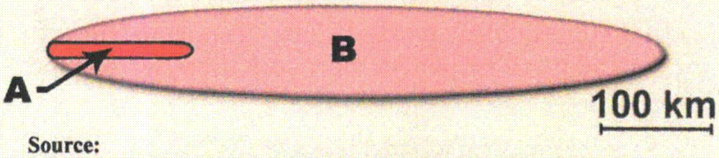




Source:
Radiation Protection: A Guide for Scientists and Physicians, 3rd Ed., by Jacob Shapiro, pg 419, Harvard University Press, MA, 1972, 1981, 1990 (According to the caption, the original source was OTA, 1979.)

On the left is a "typical" plume from a one megaton nuclear explosion. The plume stretches from Detroit, MI ("Ground Zero") to beyond Pittsburgh, PA. The graphic assumes a uniform 15-mph northwest wind. Contour lines show the one-week accumulated dose of 3000, 900, 300, and 90 rem (assuming no shielding).

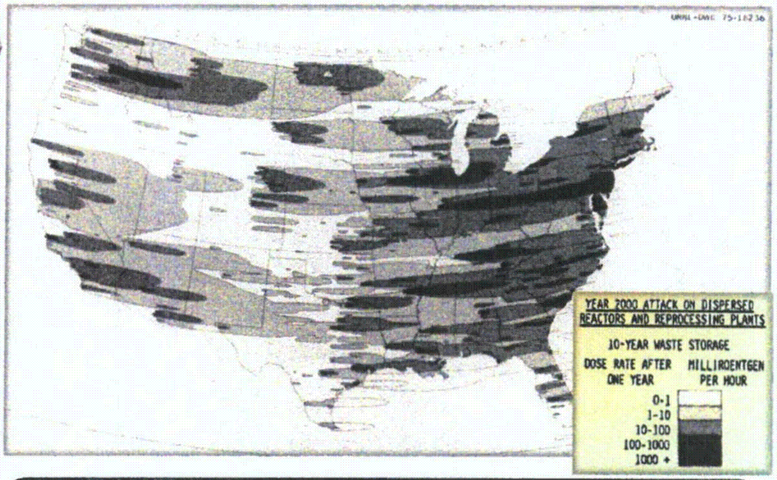
Below, again, is a typical bomb plume (area "A"). Area "B" is the expected plume from a nuclear attack against a nuclear power plant. A standard evacuation planning area for a nuclear power plant, however, is only 10 miles in radius.

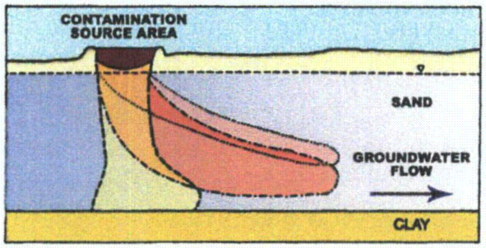


Source:
Environmental Consequences of Nuclear War, SCOPE 28, Vol. 1, Physical and Atmospheric Effects, 2nd Ed., pg 271, Scientific Committee on Problems in the Environment, John Wiley & Sons, 1985, 1989.

The map in the lower-right shows plumes from potential attacks on our reactors and fuel reprocessing plants. Dose rates are shown in the inset. Reactors now store much more fuel than the assumed ten years' worth.

The map is from:
Nuclear Power Plants as Weapons of the Enemy: An Unrecognized Military Peril by Bennett Ramberg, Univ. of CA Press, 1980, original source: Chester & Chester, "Civil Defense Implications for the U.S. Nuclear Power Industry," p. 334.





LEGEND

- Light Immiscible Plume
- Main Plume
- Heavy Immiscible Plume
- Top of Water Table (Piezometric Surface)

The graphic on the left shows typical ground contamination. Radioactive contamination -- or any contamination -- in our water system is nearly impossible to remove. Our aquifers, farmland, lakes and rivers are all at great risk of destruction from nuclear accidents. Many are already contaminated.

Source for diagram on the left:
The American West at Risk (2008) p. 362, originally based on U.S.EPA 1985

Nuclear Waste: Your Gift to Tomorrow

If you thought your share of the "national debt" was big (and it is), your share of the fission burden on this earth is more dangerous to the future than your debt. After all, a debt can be wiped out with a pen. But nuclear waste is the gift that keeps on sucking your money and causing cancers, etc..

Some gift!

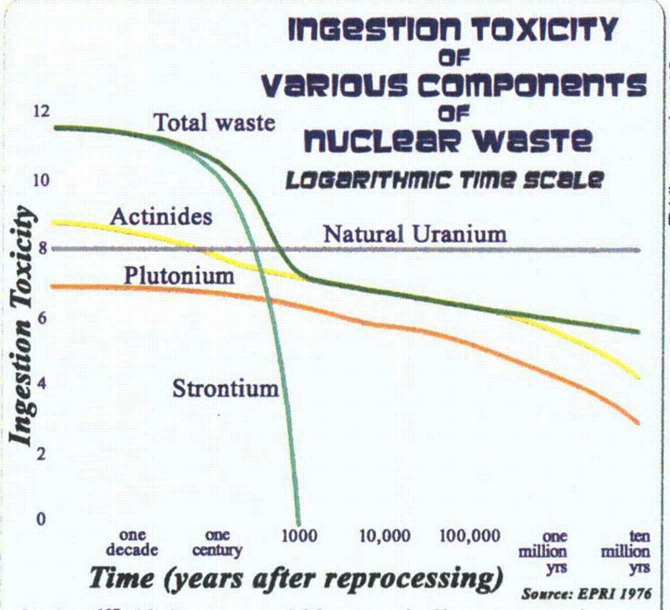
Pro-nukers like to point out the VOLUME of nuclear waste produced in a year for a family of four, which may seem like a small amount -- for example, a beer can, or half a beer can, or something similar. But only a millionth of a gram of many of these fission products is a deadly dose -- and half a beer can could hold hundreds of billions of lethal doses.

How many deadly doses are you willing to make, and leave for the future, each day, just so you can power your lights one way, instead of a safer way? Radioactive poisons are stealthy: INVISIBLE, DIFFICULT to CONTAIN, and COSTLY to ISOLATE. Even if you reprocess the waste to use more of the U^{235} and Pu^{239}, you'll still have no use for virtually all the thousands of other radioactive isotopes which are created, and which remain hazardous for thousands of years.

The most polluted, poisonous places on earth are the nuclear wastelands such as Hanford, the Nevada Test Site, the Savannah River Site, and so on (Russia and other countries have similar areas of devastation). Where will it end? In an unsurvivable global poisoning, or in closing the plants and stopping the failed "experiment"? YOU will decide: ***CHOOSE A SUSTAINABLE FUTURE!***

An estimated $60 Billion dollars have been put into finding a solution so far, and NOTHING'S WORKED. This should come as no surprise to anyone who has studied the problem carefully, since radiation destroys any container you put it in, and since a wide variety of decay rates and all possible types of radiation, at all possible energy levels, result from the fission process.

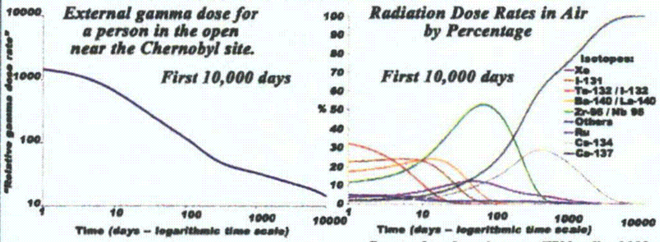
You cannot store nuclear waste safely. You cannot transport it safely. You cannot reprocess it safely, and there is no good reason to reprocess it anyway, since ALL the reactors should be shut off, forever.



$Cesium^{137}$, if shown, would have a similar curve to the $Strontium^{90}$ curve. Other shorter-lived isotopes would have curves that drop off more steeply. The seven fission products with half-lives >200,000 years don't seem to appear at all in the graphic above, but they are polluting our planet (and our bodies) in ever-increasing amounts.

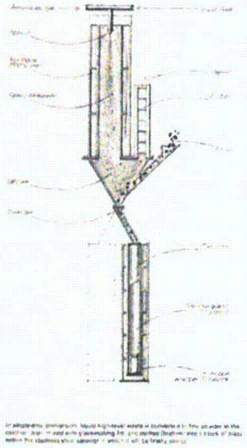
The ignoble seven: *Technetium-99, Tin-126, Selenium-79, Zirconium-93, Cesium-135, Palladium-107, Iodine-129*

Chernobyl Radiation Doses



Source for above images: Wikipedia, 2008

One Bad Idea After Another (and another, and another...)



The nuclear waste control idea shown here didn't work, and nor did anything else ever proposed by anyone. Do YOU have ANY idea about what to do with nuclear waste?

Someone will say your idea is going to solve the problem, and the industry will continue for a few more decades. No matter how stupid your idea is, or how unworkable, and even if it was tried years earlier and didn't work. In that case, just give it a new name. And of course, you'll be well-paid for your efforts.

At Lea$t I'm In$ured, Right?

WRONG! *(unless you own the nuke plant)*

Read Your Homeowner's Insurance Policy!

In the 1950s the nuclear industry just wasn't getting started. Try as they might, the U.S. government could not get investors to pay for new nuclear power plants, because investors couldn't get insurance for their investments.

So the utilities and government formed a collusion to simply DENY insurance by PRETENDING to self-insure themselves. And thus, the PRICE-ANDERSON ACT was formulated and passed. The capitalist system was thrown out the back door, on the grounds that nuclear power was simply too new for any insurance company to have enough faith in it. It didn't occur to the government (let alone, to the fledgling nuclear industry) that insurance companies would have been perfectly willing to insure the plants if only they could have been proven safe. Can't get insurance? That means you're doing something which is too risky, or even simply foolish. Nuclear plants ***still*** can't get insurance, and we ***still*** have Price-Anderson, which has been periodically (and idiotically) renewed.

It ***is*** a unique situation: Namely, the COST of a potential accident would bankrupt even the largest insurance company. On this, there is little disagreement. After a nuclear accident do not expect more than a hundredth of a cent on the dollar for your losses. And then, only if you can PROVE incontrovertably that there was DIRECT damage from the accident.

Look for the exclusion about nuclear accidents. You'll find it.

Check the fine print.

Any policy. Any insurer. Anywhere in the world.

All countries operating nuclear power plants have adopted some form of the U.S.'s Price-Anderson Act.

But at least OSHA and other federal agencies are protecting workers and the public, right?

WRONG AGAIN!

OSHA and many other federal watchdog agencies were pushed out of nuclear power plant regulation long ago. The Nuclear Regulatory Commission (NRC) takes on ALL the regulatory activities at nuclear facilities -- not JUST the nuclear side of regulating the power plants.

This is extremely unusual, and has helped destroy the normal "checks and balances" of government regulation (which is as much about protecting against corruption IN goverment as it is about using the government to protect the public from illegal private enterprises).

That huge overhead crane in the containment dome? OSHA, which regulates virtually every other crane in the country, doesn't regulate it.

What about local and state agencies? Aren't they helping to protect the public from harm?

NO!

State agencies were so quick to abdicate their responsibilities and authories in the field of nuclear, that nobody noticed such abdication was illegal, immoral, and unjustified. But there it is.

More than 30 states signed "Abdication of Responsibility" agreements (they are now known formally simply as "agreement States") so that people opposing nuclear power could NOT turn to ANY state agency, EVER, for relief or to insist on proper regulation.

So, once a year the Feds (NRC) sweep through town, listen to a few citizens complain (NOT UNDER OATH) and promise (NOT UNDER OATH) to get back to the citizens soon, but they never get back on ANY hard question, ever.

Visible Effects of Radiation

Immediate Damage

A Japanese female noncombatant victim of the atomic bomb, 1945.

The pattern of her dress has been etched into her skin by the intensity of the blast.

She received alpha, beta, gamma, and neutron radiations, as well as thermal radiation, pressure blasts, and debris injuries, followed by intense thirst and anguish.

Delayed Damage

In November, 2006, KGB whistleblower Alexander Litvinenko, who had defected to the United Kingdom and been granted U.K. citizenship, was poisoned in London with Po^{210}, apparently by his former employers. Po^{210} has a half-life of 138 days. Less than a millionth of a gram caused his organs to shut down, one by one, and he died within a few weeks.

A hero's dying words:

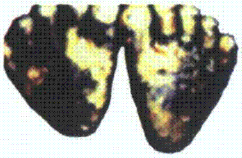
"The bastards got me, but they won't get everybody."

Radiation doses of 600 rem are almost always fatal within two weeks. Lower doses can also be fatal, although very low doses will not show an immediate effect, except in the case of causing a heart attack by fizzling the heart's electrical system at a vulnerable moment or due to an existing weakness of that person's heart.

New Symbol for Ionizing Radiation Danger

Radiation damage causes cancer, leukemia, birth defects, heart disease, and many other health effects. Damage can take many years or many generations to show up. One gamma ray can damage a pregnant woman, her fetus, and the fetus's own forming egg cells, thereby damaging three generations of human life with one radioactive decay event.

Child's feet after radiation burns from Bikini test



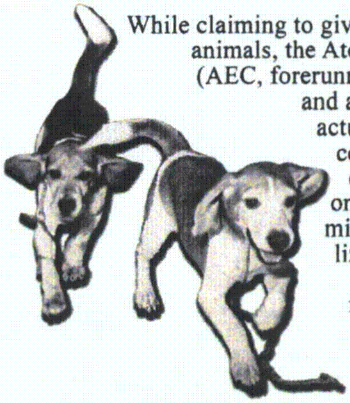
Bikini baby's hair falling out after irradiation from bomb test

Marshallese Islands Deformed Child

Atomic bomb veteran's daughter -- on oxygen

A lethal dose / LD50

As with many pollutants, it is difficult, and, surprisingly, not especially useful, to find an exact value for a 100% "lethal dose." So in radiation research, and elsewhere, scientists often search for the dose which will be a lethal dose (LD) to 50% of a given population.



While claiming to give humane treatment to all animals, the Atomic Energy Commission (AEC, forerunner of the DOE and NRC) and all the other radiation labs actually performed / perform countless cruel (and crude) experiments -- sometimes on humans -- but mostly on millions of mammals, birds, lizards, fish, crustacea, and hundreds of millions of insects. This picture is of beagles arriving in their "new" home. They are happy now...

No Safe Dose

"ANY DOSE IS AN OVERDOSE" -- JOHN W. GOFMAN

Categories of papers (over 150) published by John W. Gofman (1918 - 2007)

- Lipoproteins, atherosclerosis, and coronary heart disease.
- Ultracentrifugal discovery and analysis of the serum lipoproteins.
- Characterization of familial lipoprotein disorders.
- The determination of trace elements by X-ray spectrochemical analysis.
- The relationship of human chromosomes to cancer.
- The biological and medical effects of ionizing radiation, with particular reference to cancer, leukemia, and genetic diseases.
- The lung-cancer hazard of plutonium.
- Problems associated with nuclear power production.

Dr. Gofman's many honors and awards included the Gold-headed Cane Award as a graduating senior from UC Med. School in 1946, the Modern Medicine Award in 1954 for outstanding contributions to heart disease research, the Lyman Duff Lectureship Award of the American Heart Association in 1965 for research in atherosclerosis and coronary heart disease, the Stouffer Prize (shared) in 1972 for outstanding contributions to research in arteriosclerosis, and in 1974, the American College of Cardiology selection as one of 25 leading researchers in cardiology of the previous quarter century.

Gofman was Associate Director of Lawrence Livermore Laboratory from 1963 to 1969 and held three patents. One was on the slow and fast neutron fissionability of Uranium-233, one on the sodium uranyl acetate process for separation of plutonium from uranium and fission products from irradiated fuel, and one on the columbium oxide process for the separation of plutonium from uranium and fission products from irradiated fuel.

Hidden Effects of Radiation

Inflammation

Your body's ability to repair itself is remarkable, but NOT infinite.

Inflammation occurs when your body uses its white blood cells and other tools to fight an invading organism or poison. When a cut gets infected or inflamed it is easy to see the effects, but when ionizing radiation damages your body, the effect is not necessarily visible. A person receiving a fatal dose of radiation may feel nothing at the time and show no signs of distress for some period of time after the dosing.

So-called low levels of radiation also do the same kind of damage, but not to a fatal degree. However, these doses can cause premature aging, neuromuscular problems, cardiovascular problems, and many other diseases.

Ionization Damage

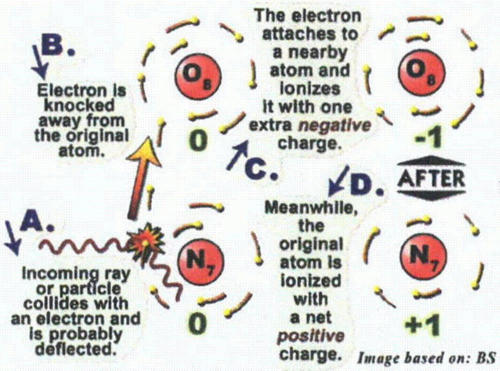
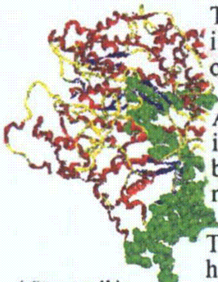


Image based on: BS of A

One radioactive decay can create thousands of "pairs" of positive and negative ions.

These ions can be very damaging to biological systems.

Leftover / Recoil Damage



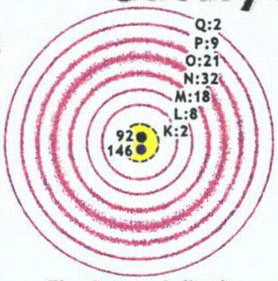
A "transcribing T7 RNA polymerase initiation complex" (from LLNL)

Tritium (H_3) and other radioactive isotopes also cause damage by the recoil of the remaining nucleus after a decay.

Additionally, whatever the new element is, it's not the element that might have been part of some complex protein molecule, for instance, or DNA, etc..

Tritium atoms masquerade as common hydrogen atoms, so they might be found anywhere in your body. When the tritium atom decays, it becomes a helium atom, which the body cannot use.

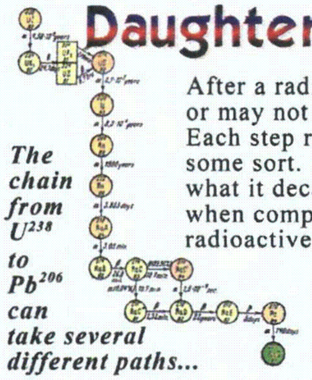
Catalytic Damage



The electron shells of a uranium atom hold 92 electrons, making U both adaptive and destructive.

Many radioactive elements are significant catalysts, as well as heavy metal hazards, in addition to their radiological threat. The nuclear process releases these dangerous elements into the environment where they have been shown to mimic hormones in mice, and to cause dozens of serious ailments. Catalytic effects of DU are considered one possible factor in "Gulf War Syndrome."

Daughter Products



The chain from U^{238} to Pb^{206} can take several different paths...

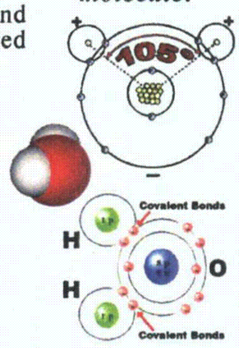
After a radioactive atom decays, it may or may not decay a second time, or more. Each step releases ionizing energy of some sort. How an isotope decays, and what it decays into, must be considered when comparing dangers of various radioactive exposures.

Decays by Alpha
Decays by Beta
Stable

Image source: Atoms A- Z

"Free Radical" Damage

Three ways to depict the H_2O molecule:



A particularly damaging type of atom or molecule is known as a free radical. A free radical has one or more unpaired electrons. Uranium has four unpaired electrons in its outer shells.

The free radical will find an atom which holds its outermost electron less tightly, and will grab that electron. Then that atom will be "ionized," and so on down the ladder of energy levels, one atom ionizing another, in a long sequence.

When tritium decays, the decayed atom might have been part of a water molecule. The left-over OH molecule is a free radical and is particularly hazardous to living cells because it is a strong oxidizer and can suddenly appear anywhere in the body when created by this method.

Hot Particles

A single particle of Depleted Uranium one milligram in size is very small. Many U.S. soldiers, enemy combatants and civilians caught in the crossfire have far more than that lodged in their bodies. Such particles are known as "hot" particles and leave a path of destruction in their wake.

Despite DU's long half-life of **4.5 billion years**, and its extremely high density, there are still enough atoms of DU in one milligram (about **2,530,000,000,000,000,000**) so that more than **a million atoms** will decay every day.

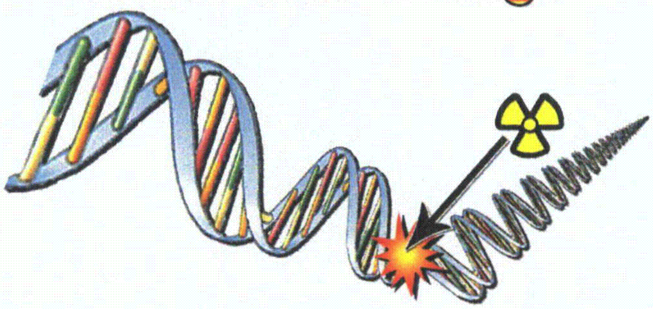
Bystander Effect

When one cell in your body is damaged, the death or altered behavior of that cell can cause other cells to also fail. When mice were irradiated on just the lower half of their bodies, they developed brain tumors.

... there are many other hidden and subtle effects of radiation poisoning ...

IT'S ALL ABOUT THE DNA

Direct DNA Damage



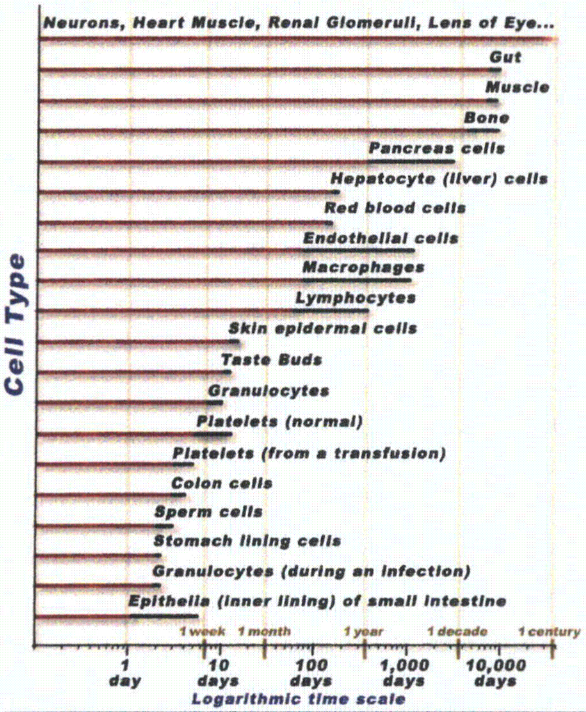
Ionizing radiation (even a so-called "weak" beta decay) has enough energy to break thousands of chemical bonds in your body, or in other structures. Sometimes the body can repair direct DNA damage, but sometimes repairs are incomplete or produce cancerous results.

ANY damage to ANY cell can cause problems

During the life of a cell, it performs tens of thousands of functions (e.g., making proteins and other molecular building blocks of life, filtering crud out of, or nutrients into, your body, etc., etc.). In some cases, it does these things thousands of times every second.

Short-lived cells may have thousands of generations of daughter cells during your lifetime, and many opportunities for altered DNA to express itself (e.g., cancer).

Lifespans of Various Human Cells



Mitochondrial DNA Damage

Mitochondrial DNA is inherited much more directly than "normal" or nuclear DNA -- and damage is more likely to be permanent. Unlike nuclear DNA, mitochondrial DNA is NOT recreated every generation from the DNA strands of two different people, with the opportunity that gives for repair. Mitochondrial DNA is inherited directly from the mother, and then replicated thousands of trillions of times, and then one cell's mitochondrial DNA is passed on to the next generation.

Also, mitochondrial DNA is not as protected within the individual cell as is nuclear DNA.

Lastly, mitochondrial DNA is the "workhorse DNA," responsible for much of the activities of the cell, while the nuclear DNA is mainly for cellular reproduction. Because of its frequent use, damaging mitochondrial DNA can cause immediate, if subtle, effects.

DNA Damage and Radiation: There's NOTHING good about it!

Your DNA strands -- all 100,000,000,000 of them (more exactly, between 10 trillion and 100 trillion, with 100 trillion the more commonly seen number) -- are each about four billion (4,000,000,000) bits long in a base four system.

No one knows why, when sperm meets egg and their DNA join, a particular part of "A" is taken and a particular part of "B" is taken. But it is known that the number of possible combinations probably exceeds the number of atoms in the known universe. (The author writes "probably" because it is possible that many combinations are impossible. But even so, the number of possibilities so greatly exceeds the number of humans that will ever live, that you can rest assured that your DNA is, and always will be, yours and only yours -- even as it changes and diverges throughout your life). Other forms of replication, besides the joining of two DNA strands, also do not need random mutation to "evolve" -- and in fact, "evolving" does not seem to be the grand design of most life forms. (It just happens.)

Nowhere in this scheme of things is there room for, or a need for, DNA damage by radiation. DNA replication in the thermal bath of life -- with all the other assaults (chemical, viral, bacterial, etc.) which all life must endure -- is a bit of a miracle. It does not need ANY amount of damage done to it by ionizing radiation.

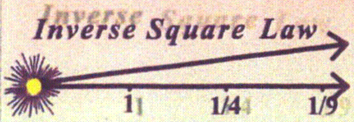
An enormous amount of variation is already inevitable, and variation is of questionable benefit, anyway. So the one last hope of the pro-nukers, that at least "natural, background radiation" is necessary for our DNA to "evolve," is dashed, without the need to resort to any religious arguments whatsoever.

And it's ungodly, too!

Out of respect, let us not ignore the religious arguments against ionizing radiation. If God made us in His image, then randomly damaging His image delivery system is blasphemous, dangerous, irreverent, and rude. Chaos rules regarding nuclear decay, whereas direction -- a positive direction -- IS God's will.

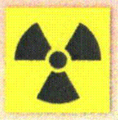
How Can I Protect Myself And My Family?

Staying Out of the Danger Zone



All other things being equal, doubling the distance from a point source of radiation will quarter the dose received, following the standard equations for the increasing area of a sphere.

To calculate the damage from an actual radiation exposure, one needs to use the RBE (Relative Biological Equivalent). Multiply the absorbed dose's energy (expressed in grays, for example) by the RBE (aka "Quality" factor, Q) for the type of radiation exposure to get the biological dose equivalent (in sieverts, for this example). The RBE for alpha particles is usually set to 20, while for gamma rays, x-rays, and beta particles it is set to one. For neutrons, it depends on the energy (speed).



International Radiation Warning Symbol

(Warning: Sign may be missing.)

Don't work for the "*Demon Hot Atom*"

It usually starts either with a job on a submarine, or as a "nuclear engineer." Sounds harmless enough, or even patriotic. BUT IT ISN'T.

If you feel compelled to study radiation, study the harm it causes. Study nuclear waste disposal. Or study medical uses, or even nuclear particle physics. But not "reactors."

Eat right, exercise, don't smoke

Staying healthy protects you in many ways. Tobacco smoke contains large amounts of Po^{210}.

Choose non-radioactive smoke detectors and other options

In normal everyday life, you seldom get options regarding nuclear choices, but you have a few. Choose non-irradiated food, non-radioactive exit signs, non-radioactive gun sights, etc. etc. etc..

Avoid unnecessary x-rays and other radiological procedures

When you need an x-ray, get an x-ray. But if you fall asleep during a CT-SCAN, which is not uncommon, they'll simply give you another. This will double your dose and *at least* double your risk. If you break a bone, they will often take 10 or more x-rays for a simple, easily-set fracture. Serial ultrasounds provide a better baseline than mammograms and are completely safe. Always ask: "Is there a nonradiological option?"

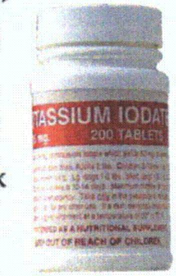
Get a radiation detector

Everyone should have one (or more) and online, real-time data should always be available to everyone. Keychain models are comforting (the author owns one), but the most accurate and useful detectors are quite expensive. But even an inexpensive one might give you a vital early warning -- and a more honest value than you will get from anyone else.

Don't live near a nuclear power plant

Scientists have written peer-reviewed ("vetted") reports showing the dangers of living near an operating nuclear power plant -- one that hasn't melted down. Published in peer-reviewed scientific journals are data showing increases in cancer and prenatal mortality in those living in proximity to nuclear power plants, but more importantly, there was an improvement in both parameters when local nuclear power plants were shut down. (Mangano, Sherman)

Keep KI handy



If taken early enough KI will prevent your body from taking up radioactive iodine after a meltdown or other radioactive release. Some states stock KI, but it will be too late if you don't own it yourself. (Do not take KI unless instructed by authorities.)

Take anti-oxidants every day

Damage from radiation comes in part from "free radicals," ionized particles with unpaired electrons. Each radioactive decay can create thousands of free radicals and other hazardous elements and molecules. Anti-oxidants, such as vitamins C and E, help your body deal with free radicals and other problems. So take your vitamins.

Change the laws

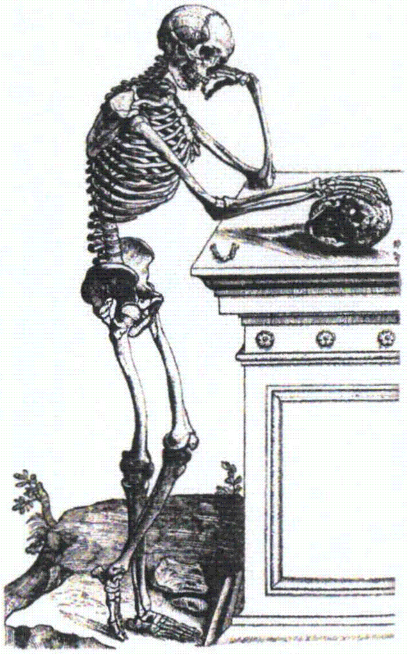
Local, state, and federal laws regarding nuclear issues are missing, illogical, unconstitutional, ambiguous, irrational, and / or criminally negligent and immoral.

You CAN'T

Radiation is odorless, colorless, and tasteless -- truly stealth. That is why good policies are our best hope.

An Industry in Denial

To be a pronuker, you must be willing to ignore obvious facts. You must be comfortable denying well-established scientific truths. You must be unable to follow simple logic, and unwilling to doubt your own opinion. You must be willing to abuse the public trust, and, perhaps most of all, you must be willing to make money from the death and suffering of others. Here are some of the many thousands of issues which pro-nukers are unable to face properly:



Hormesis (the idea that a little radiation is good for you)

The main government scientific body concerning radiation and human health, known as the BEIR committee VII (Biological Effects of Ionizing Radiation VII) confirmed -- AGAIN -- the LNT (Linear, No Threshold) theory, and -- AGAIN -- could find no basis for the theory of Hormesis. What few tests have shown any trends towards Hormesis have been small, short, and looked only at a few of the many health effects of radiation poisoning.

Nukes can provide electricity that is "too cheap to meter"

An infamous claim made in **1954** by then-chairman of the Atomic Energy Commission Lewis Strauss to the National Association of Science Writers, who for years thereafter apparently believed it would come to pass. In fact, it never came close. Nuclear power plants have to heat water, convert it to steam, turn a turbine, condense the water, store the waste, prevent meltdowns, and have a staff of about 1500 people per reactor. It's not efficient, and never can be. Renewable energy systems often are completely passive after installation, making them models of efficiency and reliability.

Nukes create jobs

Anything costing tens of billions of dollars provides jobs. But nuclear jobs are particularly high paying so there are fewer of them per dollar, because they are highly specialized, dangerous, and carry an enormous amount of responsibility. Not everyone working in the industry meets these requirements, by any stretch of the imagination.

Legal releases of radiation are "safe"

All nuclear operations leak radioactivity into the environment. And for this, the industry has ALARA, which stands for As Low As Reasonably Achievable. ALARA is, in effect, a license to murder. They are allowed to release as much as necessary for them to continue operations in a cost-effective and efficient manner. Does such a philosophy of operation say anything about how much damage the released radiation can do? NO! NOT A WORD! Actual amounts allowed under ALARA vary greatly: Sometimes thousands of curies, sometimes thousandths OF a curie. But in neither case is your safety paramount. The successful operation of the industry is paramount.

Nuclear energy was democratically chosen by the people

The people have never "chosen" nukes, and millions have marched, signed petitions, and risked being arrested during peaceful protests to try to stop nukes. First there was the "Atoms for Peace" program. Then there was Shippingport (in 1957) and other "loss-leaders" which pretended to be successes while covering up numerous leaks, near-misses, and cost over-runs. Then there were the cries of oil and gas shortages, which always came just when the opponents of nuclear power were making some headway.

Renewables can't compete

They can, in a fair market. But vested interests make money from burning oil, coal, and gas, and from fissioning uranium.

People who oppose nuclear power just don't understand how it works

If you believe that, I guess you'll believe anything. But more to the point, why not go out and confirm everything you've read here for yourself? There is no need to "believe" anything or anyone. Get the facts and decide for yourself.

The Future Looks Rosy to Those Who Are Blind

Tomorrow's nukes will be more efficient -- and safer

Tomorrow's nukes -- the ones they really are planning to build if no one stops them -- are NOT models of efficiency and design. They are nothing more than larger and smaller versions of the same old waste-producing devices for boiling water under pressure to produce steam to turn turbines. Even Niels Diaz, former head of the NRC, admitted that there can be no really great efficiency gain until we do away with the turbines, with boiling water (or other fluid), and convert to direct capture of the energy of decay.

What he neglected to mention was that we tried that, too. In fact, NASA still uses this method for space probes, the CIA uses it for deep sea, harbor, and spy satellite power sources, and we used it in pacemakers for a while. Tritium-laced exit signs and target graticles also use the energy of decay more-or-less directly. However, direct use of the energy of decay isn't practical on a large-scale, nor is it safe on ANY scale. Nuclear power is inherently unsafe because a small error at any stage can have large consequences. It is the nuclear industry's policy to describe these consequences as "unforeseen."

They'll solve the waste problem eventually

No they won't. Don't count on it, don't bet the farm on it, don't bank on it, don't plan the world's energy future on it. Ionizing radiation destroys any container you put it in. There is no chemical bond which can withstand even a thousandth of the typical force of an atomic decay. So building a containment structure is out of the question for this reason alone.

If containment doesn't work, what does? They considered everything: Rocketing the waste to the sun, dumping it at sea (still legal in many cases, but it should be completely banned), and they finally decided (at least in America) on this: Drive it 50 miles onto an Indian reservation and dump it. Getting it there is dangerous, storing it there is also dangerous, and reprocessing it is the most dangerous option of all. We are, literally, stuck with it, and it's going to cost us a fortune, year in and year out, for far longer than any human civilization or artifact has survived. By far the best thing to do is to stop making more nuclear waste *right now*, and forevermore.

Nukes can solve global warming

Nuclear power plants are part of a cycle that is very fossil-fuel intensive. Worse, the waste will warm the environment and require constant attention (wasting $ and resources) for thousands of generations. Accidents are a constant threat. For every dollar you put into nuclear power, you could buy much more carbon abatement by spending the money on wind, solar, geothermal, or efficiency. So in addition to nuclear's many direct contributions to global warming, spending precious dollars on nuclear gets you much less carbon reduction than if you used that money for clean, safe energy.

If we don't switch to nuclear power eventually, we'll run out of oil

Knowing we will run out of oil some day doesn't mean nuclear power is the solution. (It DOES make renewable energy the solution). Uranium like oil, is in short supply worldwide, and, like oil, its price is controlled by cartels. Nuclear power burns fossil fuels during construction, during fuel mining and enrichment, as well as all the fossil fuels burned by the workers (and their families). More fossil fuel is usually burned during shutdowns, too. And if there is an accident or a meltdown, the fossil fuel footprint will be enormous for that, too. Guarding nuclear waste will require a lot of fossil fuel, too.

They'll find a cure for cancer soon

Cancer is a mutation of a single individual's unique DNA code, causing those cells to mulitply too fast, die too slowly, or grow and die at the normal rate, but grow in place of a vital organ, or crowd one out, and in any case, stop that organ from functioning. By the time it is noticeable, cancer usually has many millions of cells, each with their disrupted version of your DNA. (The author had bladder cancer in '07.)

Unfortunately, there is no reason to believe we will ever "cure" -- let alone *prevent* many, if not most, cancers. Yet, *every* pro-nuker believes such a day is just around the corner. And they don't even care if the "cure" costs thousands of dollars, carries an enormous risk itself, and is painful and debilitating.

Even if they found a cure for cancer, to make radiation safe they would also have to find a cure for heart disease, Alzheimer's, leukemia, autism, and hundreds of other diseases WHICH HAVE BEEN LINKED TO RADIATION DAMAGE AS A CAUSE OR ACCELERATOR.

False Claims by Pro-Nukers about Anti-Nukers

A pro-nuker tries to make you ***believe*** they are right, and thus get you to stop ***investigating*** for yourself. They have a number of techniques they use to try to stop all reasonable debate. One of their favorite tactics is to portray the anti-nuker as stupid, ignorant, misguided, or even dishonest. If you believe any of those things, you won't bother to find out if the anti-nuker is right or not. So rather than argue the facts, an argument the pro-nuker cannot win, they will argue absurd secondary issues, or they will simply accuse the other person of being a scaremonger, a "commie," a "Luddite" or worse.

Claim	Reality
"Anti-nukers think nuclear power plants can blow up just like an atomic bomb – but they can't."	There are several realities here. First, most anti-nuclear activists know that there normally isn't enough U^{235} and / or Pu^{239} in a reactor to make a "nuclear" explosion possible. Second, the first point doesn't really matter, because, in terms of radiological content, a nuclear power plant contains about a thousand times ***more*** poison than a nuclear bomb, so the fallout effects would be a thousand times worse if the radioactivity was released. Third, a steam explosion can cause the reactor to explode so violently, the "RPVH" (Reactor Pressure Vessel Head) could be thrown half a mile high.
"Anti-nukers are simply anti-technology."	Actually, pro-nukers are the ones who are against modern technology! They are against wind power, geothermal power, wave power, atmospheric vortex engines, solar rooftop panels, ocean thermal energy conversion technology, and every other green source of electricity possible. Nuclear power is old-fashioned. The clean energy of the future is available today.
"Anti-nukers are commies who want to live in a cave. They hate capitalism, democracy, and The American Way."	America started the nuclear age, but that doesn't mean supporting nuclear power plants, a failed technology, makes you a patriot. Should it be mentioned that Russia's nuclear policies are worse? Should it be mentioned that nuclear energy has never operated in a fair economic environment -- it has always been heavily subsidized? And should it be mentioned that numerous anti-nuclear groups are global in reach and outlook, and make extensive use of technology to communicate with each other and with their elected and appointed officials, and with the media and the public?
"Without nukes, more children will get asthma and more people will die of lung cancer caused by increased coal use."	There is no reason to simply compare nuclear, with all its problems, to the next-worse choice. And no reason to "lump that choice all in one (coal) bucket!" There are many energy choices available to serve our needs. Even if we choose coal, there are many different grades of coal, and many different ways of cleaning the coal, and many different ways of extracting the coal from the earth. Anyone who wants to urge Congress to adopt cleaner coal standards is encouraged to do so. But no one should presume that concerns about coal negate concerns about nuclear power. Coal plants aren't targets for terrorists, and don't create high-level nuclear waste or bomb material.
"Without nukes, the lights will go out."	No, they won't. Okay, they will if the power utilities, the transmission line owners, the government, or other unscrupulous groups want to scare you -- as HAPPENED in California in 2000 - 2001. There was plenty of energy -- we were using thousands of megawatts LESS than previous peaks that had NOT resulted in blackouts. However, with three of our four nuclear power plants down, the utilities did not want us to realize we could get by without them. So we had blackouts, instead. *It doesn't have to be that way!*

Beneficial Uses of Radioactivity

...always come with hidden costs...

Medical Diagnosis

X-rays for looking at broken bones are ionizing radiation and have been shown to cause low birth weight in a fetus after just ONE dental x-ray of the mouth for the mother.

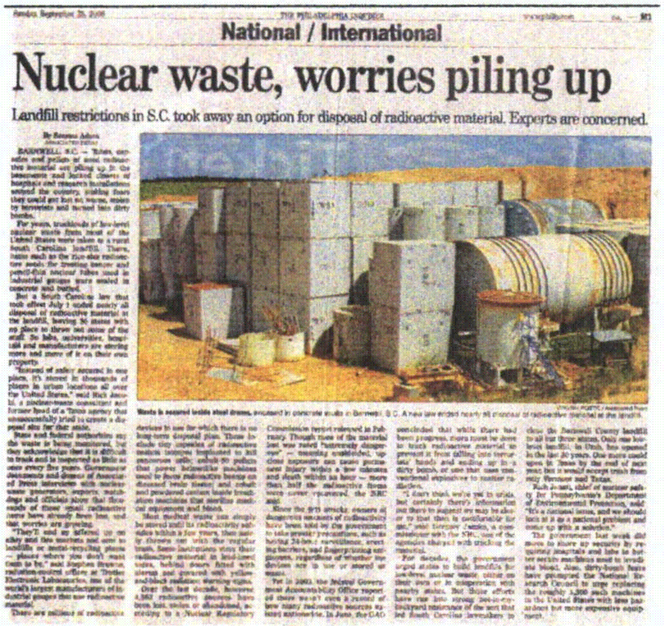
CT-SCANS are vital tools, but many are given without proper cause, or are given when nonradiological options are available instead. Unfortunately, once a hospital has bought a CT-SCAN machine, the only way to pay for it is to use it as often as possible. And unfortunately, sometimes only a CT-SCAN will do, so even if a hospital would otherwise be willing to purchase a less harmful piece of equipment, they would still need to purchase a CT-SCAN device, so they often forego making two purchases.

Other Uses

Gizmos used for industrial measuring purposes, university research waste from goulish experiments on animals (and even occassionally on unsuspecting humans), and military waste of all sorts are included in this catch-all category of human health hazards.

And it all ends up where?

Shown below is a September 2008 article about the lack of disposal space for so-called low-level nuclear waste. (Note the blue ladder in the foreground for scale.) If even the LLRW cannot be properly stored, what chance is there that the spent fuel rods will ever be properly isolated from humanity for the quarter-million years (approximately) that they will be hazardous?



National / International

Nuclear waste, worries piling up

Landfill restrictions in S.C. took away an option for disposal of radioactive material. Experts are concerned.

From: Philadelphia Inquirer, September 28, 2008, page M1)

Cancer and other Medical Treatments

In the correct doses, properly administered, when no other options are available, radiation can save lives, and does, every day.

Rice-size pellets of cesium-137 are implanted directly into a tumor to irradiate it to death with gamma rays, killing the tumorous cells and hopefully not irradiating the healthy cells too much.

Pellets of cobalt-60 are used to create focused beams of gamma rays, which can kill cancerous brain tissue. Or cause cancer in healthy tissue.

Radioactive cobalt and cesium together are used to sterilize blood as well as medical equipment.

The last procedure in particular does not require the radioactive isotopes, but other options are somewhat more expensive.

The big problem for society, however, is that all these practices produce waste -- which is piling up at hospitals and medical centers across the country, since the only waste facility that used to take the so-called "low-level" radioactive waste, in Barnwell, South Carolina, closed its doors to most states in July 2008.

National Security

Scanning devices which can detect radiation are usually radi[redacted]themselves, and [redacted] induce [redacted]ion in whatever [redacted]

Space weapon[redacted]xpected to be d[redacted]some time in th[redacted]g years, time-fr[redacted]own. Ho[redacted]e militarization of [redacted]lready occ[redacted]d and [redacted] at an [redacted]incre[redacted]sing pace.

[redacted] the Chinese [redacted]ntly [redacted]posefu[redacted] caused [redacted] created approximately a quarter-[redacted]llio[redacted]ieces of new space debris, which will b[redacted]or[redacted]nd the earth for an e[redacted]ated quarte[redacted]illennia or more.

Nuclear "bunk[redacted]rs [redacted] being designed and may be deployed a[redacted] Th[redacted]e will cause [redacted] releases of r[redacted]ioa[redacted]ssio[redacted]ucts since the explosions [redacted]nva[redacted]bly be ve[redacted]allow blasts releasing [redacted] -- and fissio[redacted]ucts -- into the atm[redacted]

Radi[redacted] weapons including dirty bo[redacted]re expec[redacted] be use[redacted], as well, according to Dick Cheney, and has he ever lie[redacted] the American people?

What Is a Whistleblower?

It's easier NOT to blow the whistle. You get to keep your job, your friends, and your fragile beliefs. Studies have actually proven that if someone who appears to be in authority says something is okay, people will believe it is okay. Okay to torture. Okay to lie. Okay to steal. Okay to create and spread radionuclides throughout the planet. But WHO said it was okay? Was it someone who understood all the math, all the physics, all the biology, all the genetics, all the economics, all the stuff they didn't even know back when it started? No -- it was a committee! NOT someone committed to truth.

someone like Karl Z. Morgan

Karl Morgan was the father of the science of Health Physics, the director of health physics at ORNL for 29 years, and the first president of the Health Physics Society. But when Morgan realized there were serious problems, he -- and his views -- were simply rejected by the HP "society."

In written testimony to the DOE in 1989, Morgan wrote: "During the 58 years I have been working with ionizing radiation, I have seen so many mistakes, misstatements, cover-ups and untrue statements by members of our government agencies (e.g. AEC, DOE, NRC, NASA, etc.) and by representatives of the nuclear industry that I seek independant safety evaluations of radiation risks before I trust their accuracy."

someone like Leo Szilard

In August 1939, Leo Szilard coaxed his friend Albert Einstein into writing the famous letter that initiated the Manhattan Project. On March 25, 1945, Szilard again coaxed Einstein to write another letter -- his fourth -- to President Roosevelt, this time about the "lack of adequate contact" between scientists "who are doing this work and those members of your Cabinet who are responsible for formulating policy." Roosevelt died April 12, 1945, never having been shown the letter.The atomic bomb was used against civilians -- and against many scientists' unheard better judgment -- on August 6, 1945. A new age of global terror and lack of reason had begun.

someone like Doug Rokke

Doug Rokke has taught graduate courses in environmental science, environmental engineering, nuclear physics, and emergency management. Major Rokke has been subjected to ongoing retaliation from Department of Defense officials. They do not want information getting out regarding adverse health and environmental effects of uranium weapons, as well as their own mandatory requirements to provide medical care to *all* casualties, and to clean up *all* environmental contamination.

someone like Richard Webb

The author of The Accident Hazards of Nuclear Power Plants (1976). Webb earned a baccalaureate degree in Engineering Physics in 1962, and a doctorate in Nuclear Reactor Physics and Engineering in 1972. His doctoral research dissertation investigated explosive power transients in fast breeder reactors.

From 1963 to 1967 he served in the US AEC Division of Naval Reactors as a Junior Engineer for the reactor part of Shippingport -- the first "civilian" reactor. He received further reactor education at Bettis and KAPL, but when working at Big Rock Point (an old BWR), he quit in order to be able to do independent analysis.

someone like Oscar Shirani

Until Shirani was fired for telling the truth, he had no interest in the so-called "anti-nuclear" movement and simply did his job as an inspector at a dry cask storage manufacturer.

But when one area after another that he looked into had problems -- from bad welds to uninspected parts to substandard alloys, broken bolts, etc. -- he called for outside help from the Nuclear Regulatory Commission. He found one guy there who would listen -- but then the NRC ignored their own expert!

Even though Oscar Shirani was not anti-nuclear, he now says he is MORE worried about the safety of the nuclear plants than the anti-nuclear activists, because he is: "From inside and knows how the nuclear industry is run: By a bunch of crooks and mafia types who are willing to sell their mother for money."

someone like Jack Shannon

Jack Shannon designed nuclear propulsion reactors for the U.S. Navy, including the most widely-used design, the D1G. But when he saw asbestos-related health problems among the workers and fraudulent practices among the management at Knoll's Atomic Power Laboratories (KAPL) where he was director of plant safety, he began to realize that the entire framework of the nuclear navy and its prime contractors such as General Electric was designed so that real problems could be ignored at every level. Not only was no one in charge actually responsible for their mistakes, but if you complained, their only interest was in stifling your complaint.

someone like Hyman Rickover

When Admiral of the Navy Hyman George Rickover was 82, and giving his farewell address to a joint session of Congress he stated, "when we go back to using nuclear power, we are creating something which nature tried to destroy to make life possible... Every time you produce radiation, you produce something that has life, in some cases for billions of years, and I think there the human race is going to wreck itself, and it's far more important that we get control of this horrible force and try to eliminate it."

So it is not appropriate to dredge up comments Rickover made long before then, and pretend his conclusion, with all he had learned, was to keep going forward with the nuclear option. It wasn't.

Yet that is what Representative Roscoe Bartlett did in 2007, to "commemorate" the 50-year anniversary of an obscure presentation Rickover made to the Minn. State Medical Association on May 14, 1957!

There are PLENTY of Alternatives to Nuclear Energy

Wind Power Works

And it's cheap, too! Cheaper than nuclear, cheaper than coal, cheaper than just about anything else on the market today, but pro-nukers will always point out (as if you always don't know) that the wind doesn't blow all the time. They'll do this, and ignore the fact that nuclear power plants are lousy "baseline" electrical power generators too, prone to long, sudden, and expensive outages, at the worst possible times.

Anyone who says all hydro is bad doesn't know all hydro

Okay, maybe they know a lot about big hydro, how it periodically floods the discharge stream in unnatural ways (this can be mitigated), how it covers up great areas of nature's beauty to store the water (clean, fresh, non-radioactive water), or even that it creates pressure on the earth's surface, and lots of dams being filled by monsoons in one place are said to be responsible for earthquakes thousands of miles away. Okay, big hydro has problems. But what about in-stream, slow-speed turbines? These are tried-and-true, and they don't gobble fish like nuclear power plants do, when they suck in millions of gallons a minute from nearby lakes, rivers, streams, etc..

If ever there is an easy "devil's choice" to make, surely any hydro option is better than the best nuclear option.

Wave Energy is Reliable

It varies in intensity but it's always there. Combined wave-and-wind offshore energy farms could provide all the energy America uses. We have thousands of miles of coastlines. These systems can, in many cases, even be placed so far offshore as to be out of sight of land.

Atmospheric Vortex Engines are ideal in many ways

These are power turbines which use natural convection and even sometimes natural heat sources or waste industrial heat sources to produce a controlled vortex (you could call it a weak, man-made tornado) above the device.

Clean coal? It costs more, and it's worth the extra cost

Coal provides about three times more electricity for America than nuclear power does. And we have a lot of it. And it's relatively inexpensive. And it can't melt down. If it's a question of the lesser of evils (and in many ways, it is), "clean coal" is more of an economic challenge than a technological challenge, unless you want PERFECTLY clean coal, which is not possible. Is coal's worst real price the carbon in the atmosphere or the coal miners and others who die digging the stuff? Or live, digging the stuff?

Biomass: It's not just Ethanol

Do you know the biggest problem with ethanol?

It's that 37,000 children a day are dying of hunger, and ethanol is made from corn. Nuclear power will not feed the hungry. Other forms of biomass (such as hemp) are available, which do not take away from the food supply. The author utilizes hemp extensively. It wears better than cotton and is far safer in a fire than nylon. It's more comfortable, too. Our founding fathers grew hemp. Simply wearing hemp *could* close a few nukes!

Solar Energy Pays Off

Did you know you can use solar power beyond Saturn? Safe, reliable, simple technology is available for all sorts of places: Rooftops, car tops, parking lot shade covers, and even the very roadways we drive on can all be turned into solar collectors.

So why aren't they? This author cannot answer *that* question!

Conservation is STILL in its infancy!

If you just go by the numbers, you could close ALL the current operating nuclear power plants simply by getting Americans to do a really serious job of conserving energy. And you CAN just go by the numbers. It would work, we just have to want to equate the events closely. Otherwise, once we've done everything we can to conserve energy, we'll still be producing nuclear waste every day, with no safe way to store it.

Geothermal -- it's worked for centuries

Geothermal power includes the simple idea of running a few pipes into the ground for more efficient building heating and cooling, which can be done virtually everywhere in America. If we really want to cut our energy usage, this is EASY. Geothermal also includes far more complex technological marvels which can provide many thousands of megawatts of power for the nation.

Tide Power is wasted twice a day

Tide comes in, tide goes out. Tide comes in, tide goes out. You can't get much more reliable than that, if you REALLY are worried about providing the citizens with so-called "baseline power."

Space-Based Mirrors are a safe use of Low Earth Orbit

The mirrors can be manufactured in space of extremely thin polymers, then aimed progressively at various places around the globe to provide a few extra hours of evening or morning light. Properly designed, it would be very cost-effective.

America CAN choose "all of the above"

HOW MUCH DOES ALL THIS COST?

Plenty.

Everywhere you look, the costs are out of control.

Government subsidies are "needed" because the costs of nuclear power are simply outrageous. And when government pays, we all pay.

In 2005, Thomas E. Capps, CEO of Dominion Resources, which operates four nuclear power plants, said a new 1400 megawatt power plant would cost $2.6 billion and take 6.5 years to build. He stated Dominion was "not going to build under those financial conditions" without massive government subsidies. But regardless, his price estimate was probably off by triple, or quadruple, or even more, when he made it.

From 1971 to 1986, Northeast Utilities experienced a 22-fold increase in the cost of constructing their nuclear power plants.

In 2005, Capps and other rich CEOs were promised loan guarantees for up to 80% of the cost of the first six new nuclear power plants. And they were given $3 billion in research and development funding. So far, it still hasn't been enough to get a new nuclear power plant started since Three Mile Island. And costs will surely skyrocket even more in the post-Bush economy.

By 1981, building a nuclear power plant took as long as 20 years. And if anything delays it, it will cost more than a million dollars a day while the problem is sorted out. The industry wants to be guaranteed income during this period, no matter how long it lasts, no matter what the reason for the delay -- even if it's negligence on their part!

The initial cost estimate for many commercial nuclear power plants turned out to be a third or less of the actual final cost. Even then, the first units of each type were usually sold at a terrible financial loss to the manufacturer.

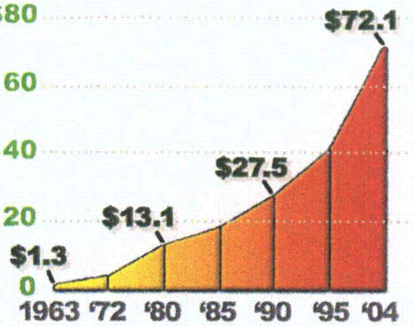
And there are lots of upcoming bills, too.

The estimated cost of Yucca Mountain has risen by $38.7 billion since 2001, a 67% increase. *Source: USA Today, August 2008*

The amount committed to the nuclear waste fund is $31.4 billion dollars, of which $9.5 billion has already been spent. *Source: Nuclear Energy Institute, 2008*

The only "bargain" in any of this is the deal we are making with the devil. He's gotten a great bargain!

Cancer treatment spending, in billions



Original Source: National Cancer Institute

$1,600: The average cost of a one-month supply of a typical cancer drug.

Source: Managed Care, Aug 2007

Colon cancer drugs over a 10 period went from $500 to $250,000. The average life expectancy went from 11 months to a little over two years.

Source: Dr. Leonard Saltz of Sloan-Kettering (published in Business Week)

. . . and that's just the cost of treatment.

There's also lost productivity, lost great people, and lost great ideas:

2005: Total cost of cancer care [including lost productivity] in the U.S.: $209.9 billion. *Source: NIH*

Has cancer cost you someone you loved?

Me too.

Maybe radiation was responsible.

...and radiation causes many other illnesses besides cancer...

Written, designed, and colorized by Ace Hoffman (2008) *May be freely copied* www.acehoffman.org

Digging Deeper

This book has only scratched the surface.

Dr. Richard Webb points out (right) that the radioactive releases from Three Mile Island went OFF THE CHART for a period of time (even though these are logarithmic scales!), and the strip chart "stops" for two critical hours. The NRC and the President's Commission misrepresented this monitor, claiming it was "onscale" when in fact it wasn't.

Dr. Webb has also done some calculations on the hazards of a spent fuel accident:

"160,000 sq. miles rendered uninhabitable due to Cs-137 alone; 338,000 sq. miles of land ruined agriculturally due to Sr-90 fallout; 200,000 sq. miles ruined by plutonium contamination alone -- a lung cancer dust hazard." Since performing those calculations, he has also concluded that radiation is a lot more harmful than he had assumed, and that in the first two days after a reactor accident, 30 to 100 million people would be seriously damaged (or killed) by radiation fallout.

Langer et al. FISSION PRODUCT RELEASE PATHWAYS 23(a)

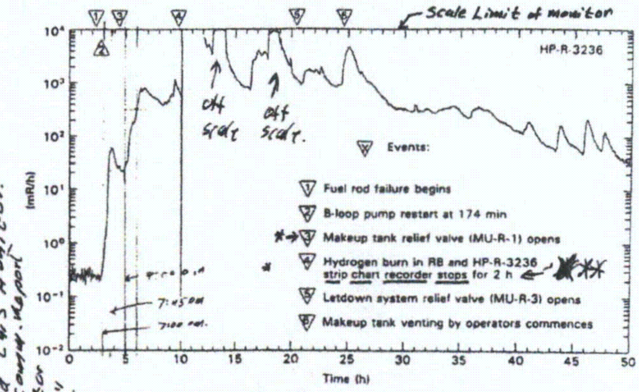


Fig. 2. Gamma radiation levels near the RB purge unit.

Russell: This goes with my June '83 Affidavit: Proof that the NRC & President's Commission on TMI misrepresented this monitor. The NRC's Rogovin Report and Pres. Comm. Report alleged/state that this monitor remained "onscale".

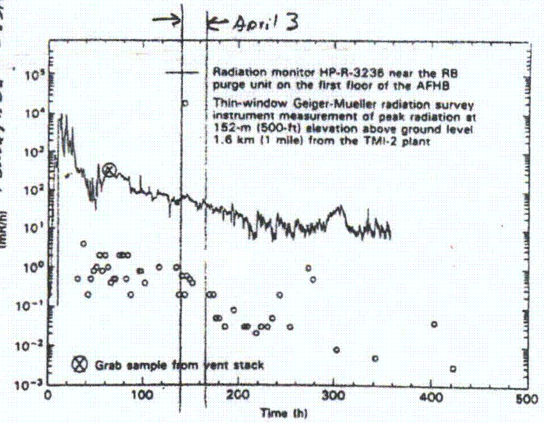


Fig. 3. Comparison of airborne radiation survey with in-plant gamma monitor.

200 NUCLEAR TECHNOLOGY VOL. 87 AUG. 1989

U.S. Department of Labor

Occupational Safety and Health Administration
71 Stevenson Street
San Francisco, California 94105

Reply to the Attention of:
Dan Mouney
(800) 18002 12

June 8, 2001

RUSSELL HOFFMAN
P.O. BOX 1936
CARLSBAD, CA 920181936

Dear Mr. HOFFMAN:

We have received your notice of alleged hazards against SAN ONONFRE NUCLEAR GENERATING STATION. After careful review, we have decided not to conduct an investigation because:

1. Federal Occupational Safety and Health Administration does not have jurisdiction over this establishment, please notify the Department of Energy regarding your concerns.

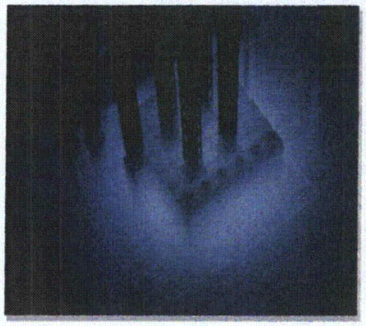
Your interest in workplace health and safety is appreciated.

Respectfully,

for Leonard Limtiaco
Director, Enforcement & Investigations

Letter to author from the Department of Labor, pointing out OSHA's lack of jurisdiction at nuclear facilities.

This glow has mesmerized many...



Cerenkov Radiation

(Also called Cherenkov Radiation.)

"The Blue Glow"

Light produced by electrons rushing through the water at "greater than the speed of light in water." Seen in the Purdue University Reactor. (1-kilowatt; LEU as of Sept. 2007; known as PUR-1).

Source: Purdue University Post Card; DOE