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Radiological Accident Releases Underestimated in Emergency Response Preparation Documents for the Idaho National Laboratory

Emergency response planning documents for the Idaho National Laboratory were recently reviewed because of questions brought to Environmental Defense Institute by a state employee in downwind neighboring state Wyoming. Emergency Management Hazards Assessment, EHA-50, available for the Advanced Test Reactor Complex, dated 2010 obtained by Freedom of Information Act request, was suggested as a possible applicable document. This emergency planning document developed protective action distances for airborne radiological releases based on the 1992 EPA guidance manual.[1] This guidance recommended that protective action distances be determined for a 1 rem [2] total effective dose equivalent (TEDE) and 5 rem thyroid committed dose equivalent (CDE).

In looking over EHA-50 and other relevant documents pertaining to severe accident source terms [3] , some variations existed due to simplifications in EHA-50 because it considered only the radioisotopes that predominantly contribute to the short term accident plume passage dose rather than the entire 300 million curie inventory of radioisotopes. However, a significant error was found in EHA-50 in that it significantly under represents the radiological release and therefore the protective action distances for a canal or combined reactor/canal draining accident. [4]

The protective action distances for a severe reactor accident at the Advanced Test Reactor accident, excluding canal fuel, for 95 percent worst-case meteorology was 30,000 meters due to thyroid dose and 54,000 meters (or 33 miles) for TEDE. The lethality distance was also

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[1] U.S. Environmental Protection Agency, "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," EPA 400-R-92-001, May 1992. http://www.epa.gov/radiation/docs/er/pag-manual-interim-public-comment-4-2-2013.pdf

[2] Roentegen equivalent man (Rem) is a unit of dose equivalent - ionizing radiation exposure that will cause the same biological effect as one roentgen of x-ray or gamma-ray exposure. One rem = 0.01 Sieverts.

[3] Source Term – The amount of specific pollutant (e.g., chemical, radionuclide) emitted or discharged to a particular environment (e.g., air, water) from a source or group of sources.

[4] The ATR canal is a water storage pool for the reactor spent nuclear fuel that joins the reactor vessel. Fuel is transferred underwater between the vessel and canal during reactor outages. Canal water provides necessary shielding for the high radiation field of the fuel and also cools the fuel recently operated in the reactor which will melt if exposed to air, releasing fission products outside of confinement.

calculated as 1,800 meter (1.1 miles).[5] While 100 percent of the core was assumed to melt, many of the release fractions for a reactor accident are significantly less than 1.0. [6]

The protective action distances for a severe accident at the Advanced Test Reactor involving canal draining are also given and include the description that "multiple core quantities of spent fuel may be in storage at any given time." The protective action distances from EHA-50 for a canal draining severe accident at the Advanced Test Reactor for 95 percent worst-case meteorology was 105,000 meters due to thyroid dose and 105,000 meters (or 65 miles) for TEDE. The lethality distance was also calculated as 19,400 meter (12 miles). The release fractions for the canal are assumed to be 1.0.

While the canal draining release source term and subsequent protection action distance of 65 miles is indication of the potential for a massive uncontained release of radionuclides that would cause tremendous environmental, economic, and human displacement issues, it still under represents the bounding accident. Why? The ATR canal accident, as EHA-50 points out, can contain more than the fuel elements for a single core loading. In fact, the most recent reactor core loading can be in the core or canal and some of the additional fuel in the canal will not have cooled sufficiently to prevent it from melting due to a canal draining accident.[7] An older version of the ATR safety analysis report, SAR-153 Chapter 15 [8] indicates that two cores in the canal would be vulnerable to fuel melt, but it is unknown whether this remains bounding because the results of reanalysis of canal fuel cooling times to preclude fuel melt has been revised by INL. In any event, the protective action distances for the ATR canal draining accident do not bound the worst case accident. While the highest thyroid dose will be released from the most recently operated fuel, thyroid and TEDE dose would increase when all the material at risk of fuel melt is included. [9]

Why would the canal draining accident dose be underestimated? Consider the inconvenience of DOE acknowledging that Idaho Falls, about 65 miles from ATR, would need to be evacuated. Regarding the level of conservatism in the canal draining radiological release estimates, of the fuel that is vulnerable to melting in a canal draining accident (at least two cores worth), 100 percent of the fuel would melt. And mitigation of the accident becomes extremely difficult after the canal level lowers, reducing protective shielding and precluding human entry to the area. After fuel begins to melt, emergency operator responses may become virtually impossible. In

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[5] EHA-50, "Emergency Management Hazards Assessment for TRA-670, Advanced Test Reactor Building, Tables D-6, D-31 and D-32 for source term release designator ATRPDS-1. The source term for ATR in EHA-50 was simplified and limited to Kryton, Xenon, Cesium, Tellurium, and Iodine.

[6] Release fraction of 1.0 is 100%. 0.5 = 50%. Note that 100% core melt is assumed for the Large Hypothetical LOCA but less than 100% for the analysis of molten core behavior in Chapter 15.12.

[7] EHA-50, Section D-1.4.2.1.2 (page 40), Tables D-20, D-31 and D-32 for source term release designator ATRPRD-7.

[8] Upgraded Final Safety Analysis Report for the Advanced Test Reactor, SAR-153, Chapter 15.12. Revision 14, August 2010.

[9] "Many of the 600-700 irradiated fuel assemblies stored in the canal have decay times short enough that natural air convection cooling alone may not be sufficient to remove decay heat without melting." Upgraded Final Safety Analysis Report for the Advanced Test Reactor, SAR-153, Chapter 15.12.9, Revision 10, 8/10/04.

contrast, some reactor core accidents might melt less than 100 percent of the core. Regarding the release fractions, assumed to be 1.0, for a canal draining accident, there is little chance of significant hold-up of fission products in water or the building to support significantly lower release fractions. Don't let vague and analytically unsupported assertions from INL officials about excess conservatism cloud the issue.

There is a long history of the nuclear industry ignoring or downplaying spent fuel storage risks. The Nuclear Regulatory Commission (NRC) that regulates commercial nuclear power reactors but not DOE reactors is only relatively recently including spent fuel pool storage accidents in their generic Environmental Impact Statements and relicensing analyses, at least in part because of lawsuits forcing it to.[10] This explains some of the historical precedence for ignoring spent fuel accidents in the DOE complex. The Department of Energy has not included detailed assessment of beyond design basis canal draining accidents in its safety basis documentation or INL NEPA documentation including the Spent Fuel Environmental Impact Statement.[11]

ATR fuel is not subject to spent fuel pool fires like commercial nuclear spent fuel and also has lower decay heat and therefore lower boil-off rates. But while there are significant differences in zirconium alloy commercial spent fuel and aluminum clad ATR spent fuel and storage pool design, ATR spent fuel storage canal safety vulnerabilities exist and involve a multiple of the 300 million curies for a single core. The ATR canal is vulnerable to cask drops from frequent cask handling into and out of the canal and also to building collapse from fires, seismic events, or terrorism.

While the DOE (and NRC) have focused on the human health effects of an airborne radiological release, this is far from the whole story. While early on the NRC focused entirely on public health consequences from airborne releases of radiological contamination, in the 1990s the NRC admitted that it could also contaminate groundwater from a reactor accident. This admission would be relevant to some ATR accidents including loss-of-coolant accidents that currently reduce the airborne release because the fission products are soluble in water. This water would leak into the ground because the concrete basements of the ATR would leak the same as any concrete basement. [12]

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[10] Environmental Organizations' Petition to Consider New and Significant Information Regarding Environmental Impacts of High-Density Spent Fuel Storage and Mitigating Alternatives in Licensing Proceedings for New Reactors and License Renewal Proceedings for Existing Reactors and Duly Modify All NRC Regulations Regarding Environmental Impacts of spent Fuel Storage During Reactor Operation, February 18, 2014. http://www.nirs.org/radwaste/atreactorstorage/fuelstoragepetition21314.pdf

[11] DOE Programmatic Spent Nuclear Fuel Management and INEL Environmental Restoration and Waste Management Programs Final Environmental Impact Statement, EIS-0203-F, 1995.

[12] Upgraded Final Safety Analysis Report for the Advanced Test Reactor, SAR-153, Chapter 15.12, Revision 10, 8/10/04. Note that 100% core melt is assumed for the Large Hypothetical LOCA but not the analysis of molten core behavior in Chapter 15.12, which ultimately showed that the core debris, if coolable, might not fail the vessel but "to adequately assess the impact on the vessel would require further analysis." When the core debris

The regulatory focus on human health effects of lethal dose and latent fatality dose that assume optimistic evacuation and interdiction of contaminated food obscures the tremendous environmental and ecological contamination, economic losses and disruption to human lives from land contamination that could result, not to mention the potential for contamination of the Snake River Plain aquifer from soluble fission products not released into the air.

In terms of immediate emergency response, the limited air and ground monitoring stations in various locations at the INL are unlikely to be particularly useful in estimating the total air borne releases from an INL accident, particularly in early or intermediate stages. The 2013 EPA draft document expresses its expectation that: "Nuclear facilities, for example, have continuous, real-time radioactive effluent monitoring capabilities to monitor radioactive material released to the environment and may have a network of off-site measurement stations." I know of no reason to support any expectation that the INL would have any meaningful measurement of its effluent release during a severe accident. [13] Estimates would likely be based on gross approximations and guess-work of how much fuel had melted, similar to Chernobyl and Fukushima accidents.

It should be noted that the EPA has released a new draft EPA document for protective action guides for radiological incidents.[14] EPA has closed the comment period and says on its website that the draft is appropriate for interim guidance. The biggest change is that the thyroid protective guide has been tightened to limit the thyroid dose to 5 rem in a child, rather than an adult. The rationale appears to be based on the accepted knowledge of increased thyroid cancers to children exposed to the Chernobyl accident. While it is a step in the right direction, it is a "baby step" — that forgets the baby! Babies and the unborn are much more vulnerable to radiation exposure. Adopting this change would also show that the EHA-50 protective action distance of 65 miles for ATRPDS-7 is not a large enough distance, because a child's thyroid is more sensitive than an adult's.

In the past, when I have asked the Idaho Department of Environmental Quality about preparation for providing potassium-iodine in the event of an ATR emergency, they have responded "no," because they think it would be too complicated.

It is worth pointing out that while nuclear accidents involving freshly operated reactor fuel would have the thyroid iodine-131 concern, the EPA guide does not reflect the fact that other types of nuclear facilities may have a different limiting organ dose. However, assessing the organ doses depends on regulatory organ dose limits and on industry organ dose conversion factors which may under estimate organ doses. The adequacy of lung and bone organ dose limits in protecting

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is not coolable, a steam or hydrogen explosion may result. And while analysis has shown that the vessel head stays bolted on, the vessel may jump, shearing off piping to the vessel. Also, the ATR, like a Boiling Water Reactor, has numerous bottom head penetrations through which molten fuel can flow.

[13] Failure to identify and document an equipment deficiency associated with the ATR Stack Effluent Real Time Monitor; DOE-ID MAR Dec. 2006 # ISS-OM-1/10/2007-68042, Price-Anderson Amendments Act Nuclear Safety Non-Compliance Determination, 1/23/07.

[14] U.S. EPA, PAG Manual – Protective Action Guides and Planning Guidance for Radiological Incidents, 2013, Draft.

the public from plutonium/americium releases from various DOE nuclear facilities should also be a concern, especially given the release from the INL ZPPR [15] and/or WIPP facility in New Mexico. [16]

Article by Tami Thatcher, former nuclear safety analyst at INL and a nuclear safety consultant

Debate over "Linear no-Threshold" Model of Radiation Effects

The perennial debate about the "linear no-threshold" model of radiation health effects at low doses is about whether or not there is a "safe" level of radiation that the nuclear industry can ignore. This is the thrust behind Steven Piet's recommended article by Maurice Tubiana and others.[17] The Tubiana article discusses well-known problems in the linear no-threshold model and the well-known fact that damaged cells can often repair themselves. The problem is the article's conclusions require tossing out any human evidence not supporting their effort to keep hope alive for existence of a meaningful threshold limit. For all the bluster, the article boils down to animal cell studies where they conclude that "the concept of a practical threshold for carcinogenesis is plausible."

Many of the flaws in the Tubiana article's optimistic charade are described in detail in the same journal volume by authors Mark P. Little and Richard Wakeford[18] who conclude that existing human evidence does not support a threshold above 100 mrem. They recognize that Alice Stewart's Oxford study from the 1950s cannot be thrown out and that it showed "strong evidence that low dose irradiation of the fetus in utero. . .causes an increased risk of cancer in childhood." Also, nuclear workers exposed in daily increments yet receiving doses far under the protection limits also have elevated cancer risk.

Both articles focus on external radiation from "low linear energy transfer" or "low LET" radiation from gamma, X-ray and beta rays. The passing mention of "high LET" radiation from alpha emitters is limited to studies of radium dial painters and medical exposures to thorotrast which, like the atomic bomb Japanese survivor studies, also rely on guesstimates of dose and

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[15] Zero Power Physics Reactor (ZPPR) plutonium release accident 11/8/11.
[16] Waste Isolation Pilot Plant, www.wipp.energy.gov
[17] Tubiana, M., MD, Feinendegen, L. E., MD, Yang, C., MD, Kaminski, J. M., MD, "The Linear No-Threshold Relationship Is Inconsistent with Radiation Biologic and Experimental Data, Radiology: Volume 251: Number 1, April 2009. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2663584/pdf/radiol.2511080671.pdf
[18] Little, M. P., DPhil, Wakeford, R. PhD, Tawn, E. J., PhD, Bouffler, S. D., PhD, de Gonzalez, A. B., DPhil, "Risks Associated with Low Doses and Low Dose Rates of Ionizing Radiation: Why Linearity May Be (Almost) the Best We Can Do," Radiology: Volume 251: Number 1, April 2009. http://pubs.rsna.org/doi/abs/10.1148/radiol.2511081686

ignore the unusually high number of premature deaths within five years of the exposure, thus underestimating the cancer death risk.

Neither article addresses the underestimation of health risks from internal radiation from inhalation or ingestion of radionuclides. And neither article adequately addresses genetic effects of radiation. Human evidence of genetic effects from radiation is mounting — from Chernobyl fallout and from exposure to depleted uranium.[19]

The attention given to the linear no-threshold model overlooks the large uncertainties in estimating the dose received by the public in the first place. It ignores the large uncertainty in the cancer death coefficients derived from studies of atomic bomb survivors carefully honed to reduce the stated risks while ignoring a multitude of other serious health impacts. It does not address the variation in radiosensitivity among people, with the developing unborn child being the most vulnerable of all, even vulnerable to radiation exposure of either parent prior to conception.

I don't mind that Steven Piet is not worried about radiation exposure. But I do find propaganda masquerading as science in order to fool the public to be very troubling.

Article by Tami Thatcher, former nuclear safety analyst at INL and a nuclear safety consultant

Climate Change Panel Doesn't See Nuclear Energy as Solution

The 5th United Nations Intergovernmental Panel on Climate Change [20] have concluded that actions to limit carbon emissions need to happen within the next 15 years. The good news is that the IPCC concludes that renewable energy and energy efficiency can meet the need. This is good news, that is, unless you are a nuclear booster.

Nuclear boosters cannot conceive of meaningful low carbon energy solutions other than nuclear power. Remember John R. Sndyer's statement about the International Energy Agency's assessment that there are 1.3 billion people, most of them living in rural areas that live without access to adequate energy because they cannot afford to pay for it? Snyder states that "to suggest

[19] Busby, C., "Aspects of DNA Damage from Internal Radionuclides," INTECH, 2013.

[20] *Intergovernmental Panel on Climate Change, Climate Change 2014: Mitigation of Climate Change, See Chapter 7.* http://www.ipcc.ch/report/ar5/wg3/

that the world 'eliminate' nuclear energy and technologies condemns 1.3 billion people to economic poverty." [21] He does not acknowledge renewable energy as a possible solution.

While the IPCC agrees that nuclear energy cannot be phased out immediately, it does not see nuclear energy as a significant part of the solution because of "a variety of barriers and risks." Those include: "operational risks, and the associated concerns, [like another Fukushima], uranium mining risks, financial and regulatory risks, unresolved waste management issues, nuclear weapon proliferation concerns, and adverse public opinion."

Diverting continued government subsidies to nuclear energy is betting on the wrong horse. No more than four new reactors are expected to come online in the U.S. before 2020, while 13 existing reactors in the U.S. are at a high risk of closure due to high costs and various safety and reliability issues.[22]

According to the IPCC's report, the best solution for lowering carbon emissions is wind, solar and other renewable energy technologies, which "have achieved a level of technical and economic maturity to enable deployment at a significant scale." But the report adds, "many RE [renewable energy] technologies still need direct and/or indirect support, if their market shares are to be significantly increased."

We need to focus on the funding and flexible grid design to deploy the solutions for clean, safe and more affordable renewable energy.

Still not convinced? *RE Futures*, funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy,[23] has already concluded that renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050 while meeting electricity demand on an hourly basis in every region of the country. See this report and others concerning the viability of renewable energy on the Stella Group website provided by long time clean energy promoter Scott Sklar.[24]

Convincing people that renewable energy like solar, wind, and biomass are viable solutions for replacing fossil fuel remains the challenge. And it requires the elimination of fossilized thinking.

Article by Tami Thatcher, former nuclear safety analyst at INL and a nuclear safety consultant

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[21] *John R. Snyder, Ph.D., "Teaching Men to Fish", Idaho Falls Post Register, April 22, 2014.*

[22] *"Nuclear Power in the USA," World Nuclear Association, April 25, 2014. http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/USA--Nuclear-Power/*

[23] *RE Futures*, funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, http://www.nrel.gov/analysis/re_futures/

[24] The Stella Group, LTD, Scott Sklar's Top 27 Energy Reports, http://thestellagroupltd.com/our-resources/fact-sheets/sklars-top-27-energy-reports/