Public Comment Submittal on the U.S. Department of Energy Final Environmental Assessment for Microreactor Applications Research, Validation and Evaluation (MARVEL) Project at Idaho National Laboratory (DOE/EA-2146)

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SUMMARY STATEMENT

The Department of Energy has made available its Final Environmental Assessment for the Microreactor Applications Research Validation and Evaluation (MARVEL) project microreactor to be placed inside the INL's Transient Reactor Test Facility (TREAT). [1] An *Environmental Assessment* is a short-sheeted version of an Environmental Impact Statement and this one is laden with an unacceptably high quantity of unsubstantiated claims.

I oppose the Department of Energy's MARVEL microreactor project and recommend that the No Action Alternative which is that the MARVEL microreactor project not be implemented. The MARVEL microreactor project should not be implemented because of the cost, nuclear accident risk and nuclear waste issues posed by the project.

BACKGROUND

According to the Department of Energy, MARVEL is a sodium-potassium (NaK) cooled, thermal microreactor with a power level of less than 100 kilowatts of electricity, although the EA states it is expected to provide only 20 kilowatts of electricity. It is important to know, however, that the Department of Energy considers anything up to 20 megawatts-thermal (or 20,000 kilowatts-thermal) to be included in the category of "microreactor" and sweeping statements are made in the EA about any "microreactor."

The program will use 150 kilograms of about 20 percent uranium-235 enrichment, with about 30 kg of uranium in 36 fuel pins. The design of the fuel and where the fuel will be made have not been determined. MARVEL's 30 kilograms (kg) or about 66 lbs of uranium-235 fuel in the reactor is significant — the rather inefficient atomic bomb dropped on Hiroshima contained only 64 kg of uranium-235.

The fuel material is to be a uranium-zirconium-hydride in stainless-steel cladding. Each fuel pin is about 38-in. long and will be sodium-bonded. MARVEL will be using High-Assay Low-Enriched Uranium (HALEU) and use heat exchangers known as Stirling engines which are to be closed-cycle lead-bismuth heat exchangers, heated by the circulating NaK that cools the reactor.

[1] Department of Energy, Final Environmental Assessment for the Microreactor Applications Research, Validation, and Evaluation (MARVEL) Project at Idaho National Laboratory, DOE/EA-2146, June 2021. https://www.id.energy.gov/insideNEID/PDF/DOE%20EA-2146%20Final%20Environmental%20Assessment%20for%20the%20MARVEL%20Project%20at%20INL.pdf and https://www.id.energy.gov/insideNEID/PDF/CLN211013%20signed%20final.pdf

The Department of Energy has stated they plan to have MARVEL operating by late 2022 or early 2023. [2] The costs of this boondoggle are going to be extraordinary.

UNIQUE, UNTESTED MARVEL FUEL

The EA names two options for obtaining MARVEL microreactor fuel: INL production or supply from TRIGA International. TRIGA International, a General Atomics (GA) and Compagnie pour l'Etude et la Realisation de Combustibles Atomiques joint venture, have re-established the TRIGA fuel manufacturing capability in France that was previously performed by GA in San Diego, California.

The MARVEL microreactor fuel is supposed to use a new, undesigned fuel similar to TRIGA fuel, which according to a 2020 report, which may not perform well in accident conditions with elevated temperatures. [3] The INL even states that "Despite its use in previous experiments, its integrity over time under irradiation, thermal aging, and exposure to sodium need to be evaluated against MARVEL's expected operating conditions and lifetime expectations" and "Because of the fission gas pressure, the likelihood of stress rupture needs to be evaluated." [4]

Yet, the Department of Energy's unspecified design, unspecified quality controls, and new and unique fuel for MARVEL, the Department of Energy's Final EA makes the broad and unsubstantiated claim that: "Microreactors are inherently safe because they are self-regulating and do not rely on engineered systems to ensure safe shut down and removal of decay heat."

MARVEL MICROREACTOR IS INHERENTLY UNSAFE

The Department of Energy's assertions about the MARVEL reactor and any microreactor being "inherently safe" are hubris and bordering on fraudulent.

Apparently, the Department of Energy has learned nothing from its past reactor accidents, particularly the Stationary Low Power Reactor 1 (SL-1) reactor accident in 1961.

A 1950s vintage documentary film by the AEC presenting the Boiling Water Reactor Experiments (BORAX) tests [5] states "The [BORAX] experimental reactor was built for the purpose of testing this self regulation [reactor power reduction due to steam formation] and its most important consequence—the inherent safety of the reactor. The reactor is inherently safe

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[2] Jess C. Gehin, Battelle Energy Alliance, Microreactor Research Development and Demonstrations at Idaho National Laboratory, INL/CON-21-61799-Revision-0, March 2021. https://inldigitallibrary.inl.gov/sites/STI/STI/Sort_33173.pdf#search=MARVEL

[3] Dennis D. Keiser, Jr. et al., Battelle Energy Alliance, LLC for the Department of Energy, *An Investigation of Liquefaction in Irradiated TRIGA Fuel Exposed to Relatively High Temperatures*, November 2020. https://www.osti.gov/biblio/1737565-investigation-liquefaction-irradiated-triga-fuel-exposed-relatively-high-temperatures "The specimen tested at 1000°C still had over 75% of the cladding that was unreacted."

[4] Adrian R. Wagner et al., Battelle Energy Alliance, LLC for the Department of Energy, *MARVEL Fuel System*, INL/EXT-21-61273, Rev. 1, January 2021. https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_27532.pdf

[5] Borax – Safety experiment on a Boiling Water Reactor. Film produced by the Argonne National Laboratory. Operated for the U.S. Atomic Energy Commission by the University of Chicago. circa late 1950s. The destructive BORAX-1 experiment was conducted in 1954 at the Idaho site.

against the accidental addition of any amount of excess reactivity ***which can be removed by the formation of steam before the power rises to a dangerous level***. [Emphasis added]" The need to pay particular attention to the last caveat would be demonstrated again by the SL-1 accident that occurred at the Idaho National Laboratory due to extremely poor safety management by the Atomic Energy Commission which is now the Department of Energy.

Interestingly, many of the BORAX tests increased reactivity by dropping the water temperature in the reactor tank. Investigators of the SL-1 accident would later comment that the SL-1 accident, with water initial temperature of 90 to 100 degree F increased the peak power by a factor of 10 what it would have been had the water been at saturation temperature. [6] [7]

The narrator in the BORAX film states: "Extension of experimental data to such a condition was considered important **even though the accidental addition of so much excess reactivity to an operating reactor has almost negligible probability**. **Addition of so much reactivity is not easy, for unless the ejected control rod is very large and is moved rapidly**, **the reactor will shut itself down** by steam formation before the desired amount of reactivity has been added. [Emphasis added]"

The safety analysis for the SL-1 did not include consideration of any accident involving melting of fuel and release of fission products, let alone destruction of the reactor from a prompt criticality achieving a total energy release of 133 MW-sec. [8] [9]The fuel cladding of the SL-1 reactor was twice as thick as the BORAX design—and other aspects of the fuel design had made it more susceptible to reaching a prompt critical condition than the BORAX reactor. It would be determined that the SL-1 reactor needed only 2.4 percent delta-K compared with the 3.3 percent delta-K reactivity insertion for the BORAX-1 destructive test. [10]

It was known with the BORAX experiments that movement of a rod of sufficient reactivity worth, in a few tenths of a second, could result in increasing the reactor power so rapidly that neutron population doubling occurred in milliseconds. Such rapid power increase in the fuel from fission heated the fuel plates in the SL-1 reactor "to a point near or above melting, depending upon location in the core. In the center regions of maximum neutron flux, the fuel within the plates experienced vaporization temperatures and burst the plate cladding. Thus the spewing of hot vaporized fuel rapidly produced steam in the surrounding water. The steam was generated at a rate far faster than could be dissipated. . ."

This is the Department of Energy's experience with claiming their reactors were ***inherently safe*** and then causing a reactor accident due to gross safety mismanagement of the poorly designed, poorly fabricated and poorly managed SL-1 reactor. The remedy for the problem was to blame the SL-1 accident was due to the deliberate act by one of the crewmen. This lie is repeated in many college-level nuclear textbooks. The stuck control rod was overlifted during an

[6] ibid. IDO-19313, p. 151.
[7] ibid. IDO-19300. p. 132 in contrast to IDO-19313, says the temperature in the reactor vessel was 73 F based on log entries, an even worse situation for providing heat transfer to reactor fuel plates.
[8] ibid. IDO-19300, p. 170.
[9] ibid. IDO-19311. Table III-I.
[10] ibid. IDO-19311. p. IV-25.

outage and anyone who has worked over a reactor top making manual lifts knows that the overlift of a stuck control rod was basically unavoidable. That reactor's design put so much reactivity worth into one rod and had no prevention for such an accidental overlift to occur.

MARVEL MICROREACTOR OFFSITE DOSES UNACCEPTABLE

The stated accident dose from a MARVEL accident at the site boundary 6000 meters from the facility is stated to be 0.131 rem in Table 10 and stated to be 2.65 rem in Table 11, with no explanation of the difference and each described as "the highest postulated accident consequences." The radiation dose to the public from a radiological release from a MARVEL accident is unacceptable.

With the 2.65 rem dose to the offsite public from a MARVEL accident, it should be understood that recommended limits on radiation exposure to an embryo or fetus should not exceed 200 mrem to the abdomen surface (ICRP) and not exceed 50 mrem/month (NCRP). [11]

The radiological release from a severe accident involving the MARVEL microreactor would depend on the fuel burnup at the time of the accident as well as the type of accident. The Final EA does admit that there are numerous ways that a MARVEL reactor may have an accident and release fission products and actinides. The ways a MARVEL microreactor can have an accident that would pose a risk to southeast Idaho include a natural phenomena hazard (seismic event), a failure of the control drives to insert, and intentional sabotage. A loss of adequate cooling has been deemed not to able to cause an accident.

The Department of Energy's Final EA does not list the radionuclides that would be released due to a MARVEL severe accident, but it would be the usual large array of fission products including strontium-90 and cesium-137 and the plutonium-238, plutonium-239, plutonium-240, plutonium-241, curium-244, neptunium-237 and americium-241. The radiological release would yield not only plume passage doses, but also chronic radiation doses from breathing and ingesting these long-lived radionuclides, which become incorporated into the body.

The 2.65 rem at the site boundary from Table 11 does not fully explain the damage to radioactively contaminated farms and vehicles, which are not financially insured for radioactive contamination. This is in no way within acceptable levels of radioactivity to the public. The EA falsely portrays the accident dose as being a one-time dose, while omitting the chronic doses from inhalation and ingestion of radionuclides that will persist in the air, soil and water after an accident.

The EA claims that the accident release consequences are only a few rem, yet fails to acknowledge only short-term dose and ignores the long term ingestion consequences, the crop interdiction, the uncompensated and uninsurable car, home, business, livelihood and health costs of an accident radiological release. The EA must explain the curie amount of each radionuclide that would be released in an accident and must explain the full economic impacts of such a release.

[11] Eric J. Hall, *Radiobiology for the Radiologis*t, Fifth Edition, Lippincott Williams & Wilkins, 2000. Table 15.4 Summary of Recommended Dose Limits.

The EA incorrectly states that "INL maintains the necessary apparatus, equipment, and a state of the art Emergency Operations Center in Idaho Falls to respond to emergencies, not only at from the MARVEL microreactor and other INL Site operations, but also throughout local communities." **The EA fails to acknowledge decades of repeated inadequate emergency preparation for site emergencies in terms of training, decontamination, radiological medical treatment, inadequate emergency radiological monitoring during and after the emergency.**

MARVEL MICROREACTOR ACCIDENTS

The EA discusses reactivity control for MARVEL using rotation of control drums but inadequate information is provided to determine the safety adequacy of this design.

In another document, it was stated that "Its reactor control systems will consist of four independent vertical control drums and a central shutdown rod." [12] Nothing in the EA provides confidence in the reactivity control system safety of MARVEL.

The seismic design requirements for MARVEL remain unstated.

Seismic design category 2 of the TREAT building means that the building is vulnerable to large seismic events which would be unacceptable for a hazard category I reactor. MARVEL is stated to be less than a hazard category I reactor; however, it is erroneous to conclude that the facility is not vulnerable to seismic events.

The EA states: "No environmental impacts are assessed from the MARVEL microreactor in TREAT as a result of potential future earthquakes. The TREAT Reactor building is classified as a seismic design category (SDC), SDC-2. Per DOE Order 420.1C, *Facility Safety* (2019), implemented through DOE Standard, DOE-STD-1020, *Natural Phenomena Hazards Design and Evaluation Criteria* (2016), seismic design criteria for TREAT are obtained from the International Building Code (IBC). The MARVEL microreactor and its installation in TREAT will be designed to withstand vibratory ground motions (or ground shaking) as specified by IBC. Ground shaking levels are obtained from the U.S. National Seismic Hazard maps available online from the U.S. Geological Survey (https://www.sciencebase.gov/catalog/item/5d5597d0e4b01d82ce8e3ff1) for the specific rock conditions and geographical location of TREAT. Because no impacts from the MARVEL microreactor would occur as a result of earthquakes, cumulative impacts are not expected."

This statement in the EA shows that the INL has not provided adequate seismic design criteria in place to protect Idaho from an accident. The truth of the matter is that at a likelihood greater than 1 in 100 years, a seismic event would cause failure of the building and any containers of spent nuclear fuel or the reactor. Using 150 years of seismic experience is inadequate to conclude that no impacts due to seismic events would occur.

[12] Andrew Foss et al., Battelle Energy Alliance for the Department of Energy (NE), *NRIC Integrated Energy Systems Demonstration Pre-Conceptual Designs*, INL-EXT-21-61413, Rev. 1, April 2021. https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_27617.pdf See p. 8.

INADEQUATE RADIATION HEALTH CONSEQUENCE DISCUSSION

The final EA states: “To protect workers from impacts from radiological exposure, 10 CFR Part 835 imposes an individual dose limit of 5,000 mrem (5 rem) per year.”

The final EA provides an estimate of the latent cancer fatality for receiving a total lifetime dose of 1 rem, stating: “The consequence of a dose to an individual is expressed as the probability that the individual would incur fatal cancer from the exposure. Based on a dose-to-risk conversion factor of 0.0006 latent cancer fatality (LCF) per person-rem, and assuming the linear no-threshold model, an exposed worker receiving a dose of 1 rem would have an estimated lifetime probability of radiation-induced fatal cancer of 0.0006 or 1 chance in 1,700.”

It would be far more useful to discuss the dose of the Department of Energy’s allowed 5 rem per year to an adult worker. If the worker’s career was to span 30 years, and the allowed dose were received each year, then the total radiation dose would be 5 rem times 30, or 150 rem. Then according to their accepted model, the lifetime probability of radiation-induced fatal cancer would be 0.0006 LCF/rem times 150, or 0.09 or 1 chance in about 1 chance in 11. The chance of severe heredity effects would be 20 percent of that, or 0.018 or about 1 chance in 56. And the increased health risk for non-cancer illnesses is simply not evaluated by the “effective dose” which uses tissue/organ weighting factors largely selected only based on the expected cancer mortality. So, the shortened life span is really not accounted for by the EA’s computations, and the Department of Energy apparently assumes that the people of Idaho don’t care about hereditary effects.

If the example uses it non-binding, discretionary 2 rem per year guidance value, that it does not enforce as a legal limit, for a worker receiving 2 rem/yr for 30 years, the radiation-induced fatal cancer would be 0.0006 LCF/rem time 2 rem times 30 years, or 0.036, or about 1 chance in 28.

I think the obvious pattern of deception in the Department of Energy’s final EA, is exemplified by the final EA’s use as an example, of 1 rem total lifetime dose causing 1 chance in 1,700 of a fatal cancer.

The Department of Energy’s repeated use antiquated terminology “Roentgen-equivalent-man” for rem leaves open for interpretation what level of absorbed dose forms the bases for the Department of Energy’s dose. A roentgen corresponds to 87.7 ergs per gram of air absorbed dose, whereas a rad corresponds to 100 ergs/gram. The EA leaves unstated whether it is still using Roentgens or whether it nows defines rem in terms of the definition of a sievert.

The latent cancer fatality risk used is a population average and the cancer fatality risk to women, children, embryos and fetuses is significantly higher than to adult men. Although not labeled as using the assumption of a low dose and low dose rate reduction factor, this assumption has not scientific basis. The latent cancer fatality uses the dose reduction factor based on the assumption that the consequences at lower doses are half of the consequences observed at higher doses, yet diverse studies have found that the dose reduction factor is not valid.

UNSOLVED RADIOACTIVE WASTE PROBLEMS

The radioactive waste management issues are unavoidable and the Department of Energy's assertions about the radioactive waste are misleading and irresponsible. The Department of Energy asserts that it breaks no laws by creating a threat to human health and all life on Earth by continuing to make more radioactive waste and ignoring how much the problem is going to cost to solve, if the waste can actually be isolated from the biosphere for the time frame that the waste is hazardous, more than hundreds of thousands of years.

The EA allows the careless disposal of spent nuclear fuel over the Snake River Plain aquifer if DOE deems the spent nuclear fuel to be related to research. This artificial definition defies science and is simply to shortcut proper disposal to isolate the material from soil, air and groundwater.

Treatment of the MARVEL fuel requires using dilapidated and aging facilities at the Materials and Fuels Complex, which is already far behind in treatment of sodium bonded fuels.

The MARVEL EA relies on the existence of Yucca Mountain which has not been funded since 2010 and was never granted a license-to-construct. The Department of Energy is no closer to finding a solution to isolate spent nuclear fuel from the biosphere now than it was over 60 years ago.