April 14, 2015

United States Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, MD 20852

Attn: Mr. Mark A. Satorius
Executive Director for Operations

Subject: Lead Test Assemblies of Lightbridge-designed Fuel

This letter is to support the NRC's planning process in order for the NRC to be prepared to review an advanced nuclear fuel design. This letter is submitted by the Nuclear Utility Fuel Advisory Board ("NUFAB") on behalf of its members. NUFAB is a group of electric utilities that own and operate roughly 50 percent of the nuclear generation in the United States that serves in an advisory role in the development of a new fuel product by Lightbridge Corporation. The members of NUFAB include Dominion, Duke Energy, Exelon, and Southern Nuclear. NUFAB believes this fuel product provides opportunities to significantly improve safety and fuel cycle economics.

Lightbridge is pursuing a series of operations with fuel samples at the Halden Test Reactor in Norway. Subsequent Post Irradiation Examination (PIE) of these fuel samples is planned to support an application to the NRC for the use of Lead Test Assemblies. The goal is to submit this application in 2017 and insert the Lead Test Assemblies (LTAs) into an operating U.S. pressurized water reactor as early as 2020, although the basic fuel design can also be used in boiling water reactors as well as small modular reactors.

NUFAB intends to serve in an advisory role throughout this test and LTA program, including consultation during preparation of the documentation required by the NRC to approve use of the LTAs and during meetings with the NRC with Lightbridge executives to discuss the planned test program. Should you have any questions regarding NUFAB's role or interest in the new fuel product being developed by Lightbridge, please feel free to contact any of the NUFAB members below.

A summary of the fuel design is attached.

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Lightbridge Corporation is developing an advanced metallic nuclear fuel rod that utilizes a unique fuel composition and fuel rod geometry to provide increased safety margins and improved economics for Light Water Reactors (LWRs).

The Lightbridge-designed metallic fuel rod consists of three components: a zirconium alloy central displacer which serves to reduce centerline temperatures and allows for the incorporation of burnable poison material within the rod; a fuel core composed of δ-phase Zr-U alloy (with U weight fraction of approximately 50%), and a Zr-1Nb cladding alloy. The three components are metallurgically-bonded to one another during the fuel rod fabrication process giving each fuel rod a monolithic form composed entirely of metal.

The fuel geometry is multi-lobed and helically twisted (shown in Figure 1 below). The circumscribed diameter of the rod is equal to the pin-to-pin pitch of conventional cylindrical fuel rods and, as such, each rod contacts adjacent fuel rods at several locations along the length of the fuel assembly. In this way the fuel rods in the assembly are self-spacing and no spacer grids are required in the assembly. In a square array fuel assembly the fuel rods will have four lobes as shown below. This rod geometry increases the surface area available for heat transfer to the reactor coolant by approximately 35% compared to an equivalent conventional cylindrical rod, providing significantly improved margin to the standard fuel thermal failure criteria of departure from nucleate boiling. This increased margin can be utilized to allow for increased linear heat generation within the fuel rod, for which Lightbridge® has set an initial design limit of 17.7 kW/ft (30% increase compared to conventional UO2 fuel).

The ability of any particular nuclear power plant to utilize the metallic fuel for increased core power output must be evaluated on a case-by-case basis. Nuclear steam supply system capacities and containment designs will affect the power uprate capability for existing plants up to the 30% increase potential with this advanced metallic fuel. With a power uprate of up to 10%, the metallic fuel also allows today's pressurized water

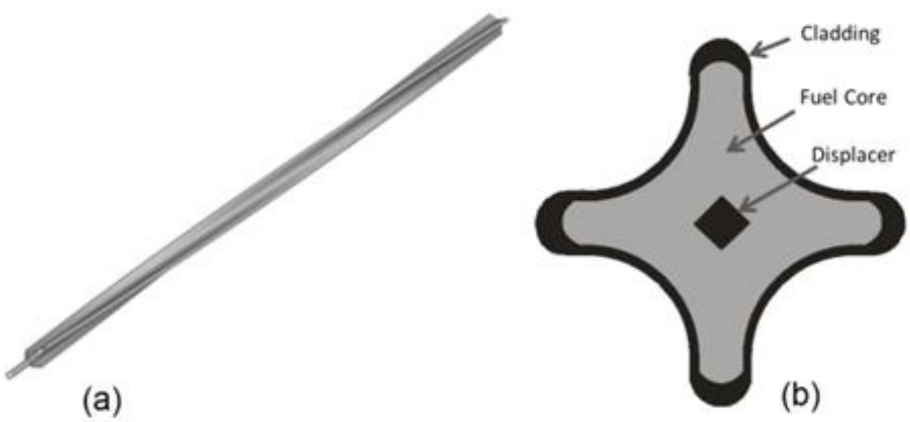

Figure 1. Schematic of Lightbridge's metallic fuel rod for PWRs. (a) Segment of rod showing helical twist; (b) cross-section showing the fuel core, central displacer and cladding. [Not to scale].

reactors (PWRs) to operate on 24-month fuel cycles, which, in concert with the safety benefits afforded by the fuel, make it quite attractive to nuclear utilities.

The Lightbridge® advanced metallic fuel rod has significantly improved strength and robustness compared to conventional pellet-in-tube fuel designs. This is largely due to the fact that the fuel rod is monolithic and each component shares all mechanical loads, greatly reducing the importance of the cladding as pertains to maintaining structural integrity and fuel coolability. The increased mechanical *toughness* of the fuel, along with a simplified fuel rod fabrication process results in a fuel that is much less likely to undergo damage from mishandling during fabrication, transportation, and fuel maneuvers on site.

The fuel composition and geometry result in drastic improvements to fuel rod heat transfer capabilities compared to pellet-in-tube oxide fuels. The unirradiated fuel alloy has a thermal conductivity approximately five times greater than uranium dioxide fuels. The metallurgically-bonded components and stable fuel microstructure during irradiation eliminate the presence and formation of gaps or cracks that can degrade heat conduction in the fuel. The multi-lobed geometry effectively reduces the linear distance heat must travel to reach the reactor coolant by ~ 40% compared to an equivalent conventional cylindrical fuel rod.

These heat transfer improvements result in very low fuel operating temperatures, with an average fuel rod temperature of 370 ^{o}C (~700 ^{o}F) in a typical PWR with a 30% power uprate. Lightbridge® has set a design limit on the peak fuel rod temperature at 560 ^{o}C (1040 ^{o}F). At these temperatures, diffusion-controlled phenomena are severely inhibited during fuel operation. As an example, the mobility of gaseous fission products is reduced enough that they do not tend to form large (several micron diameter) fission gas bubbles within the fuel and instead occupy lattice sites within the fuel material near where they are created. Coupled with the absence of a fuel-clad gap, there is no accumulation of an inventory of fission product gases that would be immediately released in the event of a cladding breach; all radionuclides would have to diffuse through the fuel matrix to the location of the breach prior to being released to the coolant water. In this manner, the advanced alloy fuel material itself becomes part of the first barrier to radioactive release in the event of a fuel failure.

Lightbridge-designed metallic fuel also stores a significantly lower amount of thermal energy compared to conventional uranium dioxide fuels. The lower sensible heat and the improved heat transfer characteristics of the fuel are expected to provide increased margin to fuel failure during normal operation, anticipated operational occurrences, and design basis events. As an example, Lightbridge® has evaluated a design-basis loss of coolant accident in a PWR-type reactor, comparing peak cladding temperature of conventional UO_2 fuel to that of a variant of the Lightbridge® advanced metallic fuel. The peak cladding temperature of the conventional UO_2 fuel quickly spikes at the initiation of the LOCA and, as blowdown occurs, a significant length of cladding experiences temperatures in excess of 850 ^{o}C until reflood is complete (several hundred seconds). Conversely, the Lightbridge® advanced metallic fuel undergoes an initial spike up to ~ 500 ^{o}C and in less than 60 seconds the cladding has cooled to below 350 ^{o}C where it remains through the reflood stage.

From a neutron physics perspective the fuel behaves quite similarly to conventional fuels as the fissile atom density in each fuel rod is comparable. Lightbridge's preliminary analyses suggest that no changes will be required to existing major components and reactivity control systems and procedures in order to safely operate today's nuclear plant designs with its advanced metallic fuel.

Lightbridge's advanced metallic fuel is an evolutionary step forward in nuclear fuels, providing improved safety, performance, and economics for existing as well as new and advanced water-cooled nuclear power plants.