June 26, 2017

MEMORANDUM TO: Paul G. Krohn, Deputy Director
Division of Construction Inspection
and Operational Programs
Office of New Reactors

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Office of New Reactors

SUBJECT: SUMMARY OF JUNE 7, 2017, PUBLIC MEETING WITH GE-HITACHI NUCLEAR ENERGY AMERICAS, LLC TO DISCUSS GENERAL ASPECTS OF ADDITIVE MANUFACTURING

BACKGROUND

On June 7, 2017, the U.S. Nuclear Regulatory Commission (NRC) staff held a public meeting at NRC Headquarters in Rockville, Maryland with GE-Hitachi Nuclear Energy Americas, LLC (GEH) to discuss general aspects of additive manufacturing.

The meeting was noticed on May 16, 2017, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17136A042) and included open and closed portions. The list of meeting attendees, including those participating by telephone, is provided in Enclosure 1. The publicly available meeting handout is provided in Enclosure 2. The non-publicly available meeting handout is provided in Enclosure 3.

DISCUSSION

The meeting began with a presentation by GEH on an overview of additive manufacturing; also referred to as 3-Dimensional printing of metallic components. Additive manufacturing involves the melting of metal powders to build up a component, as compared to subtractive manufacturing which removes material through drilling, grinding, etc., to arrive at the proper dimensions for a part. For parts with complex dimensions, additive manufacturing may provide improvements in (1) speed of delivery, (2) better part performance, (3) cost reduction, and (4) enhanced chemistry

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Upon removal of Enclosure 3, this document is uncontrolled.

control. Additive manufacturing is already being used in other industries, such as the aerospace industry, for parts with complex dimensions and configurations. Metals that can be welded can be used in additive manufacturing, although certain metals, such as aluminum, may pose a fire hazard in powder state and high temperatures.

The additive manufacturing process described by GEH is Direct Metal Laser Melting (DMLM). Other additive manufacturing processes, such as electron beam melting, also exist and operate on a similar principle. The process begins with a computer-aided design (CAD) of the part that is to be manufactured. The CAD is translated by software to instructions that control the DMLM machine. Essentially, the translation software creates very thin layers of the 3D CAD part for which the DMLM machine will use to construct the part, layer by layer, until the part is completely built up. For each layer, the DMLM machine will lay a thin layer of metal powder, followed by a laser which fuses the metal power to the part in areas where the part is to be built up. Once the part is completely built up, there are post-treatment processes, including annealing and hot isostatic pressing, to reduce voids and strain in the part and to achieve an optimum grain structure in the metal (100 percent austenitic grain structure).

Following post-treatment of the parts, the resulting part is comparable, or better, in many characteristics to wrought metal of the same chemical composition due to properties such as grain structure. Example characteristics include hardness, ductility, and tensile strength. Fatigue resistance is one area where additive manufacturing may not perform as well as parts developed through traditional subtractive manufacturing. One explanation is the rough finish on parts developed by additive manufacturing may contribute to reduced fatigue resistance as the rough surface provides sources for crack initiation under cyclic stress. The rough finish is a result of the sintering process of nearby powders and the potential effect of gravity on the melted metal as it is being finished. Polishing parts created by additive manufacturing may be one means to improve fatigue resistance.

Since additive manufacturing is a new process, there are few standards available on the subject. However, GEH has been involved with the development of the ASTM International F3184-16, “Standard Specification for Additive Manufacturing of Stainless Steel Alloy (UNS S31603) with Power Bed Fusion.” During the meeting, participants discussed how additive manufacturing has similarities to existing welding processes and some of the same controls used in welding must also be applied in additive manufacturing.

GEH discussed how they are conducting research and development for nuclear components that may benefit from additive manufacturing. Candidate components include the debris filter at the bottom of the fuel assemblies, fine motion control rod drive labyrinth seals, channel fasteners, and AVS compliant springs. For the debris filter and other parts, GEH is currently conducting testing in radiation environments and evaluating the performance characteristics of such parts. From a quality assurance standpoint, GEH indicated they may use commercial grade dedication to utilize other departments in General Electric to conduct additive manufacturing. The NRC mentioned that recent vendor inspection findings at other suppliers using commercial grade dedication indicate issues with the control/oversight of sub-suppliers to a commercial supplier. In the case of the additive manufacturing process, the metal powder supplier would be such a sub-supplier and the metal powder may have critical characteristics that would need to be controlled. In addition, since the additive manufacturing process is heavily automated, NRC staff suggested new guidance on commercial grade dedication of

design and analysis software found in Regulatory Guide 1.231, “Acceptance of Commercial-Grade Design and Analysis Computer Programs Used in Safety-Related Applications for Nuclear Power Plants,” may be helpful.

Enclosures:
1. Meeting Attendees
2. Meeting Handout (Publicly Available, ADAMS Accession No. ML17163A266)
3. Meeting Handout (Non-Publicly Available, ADAMS Accession No. ML17163A265)

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Dated: June 26, 2017

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NAME	TLamb	JBurke	TJackson
DATE	06/23/17	06/26/17	06/23/17

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Meeting Attendees
Public Meeting with GE-Hitachi Nuclear Energy Americas, LLC to Discuss
General Aspects of Additive Manufacturing
Thursday, June 7, 2017 1:00 P.M. – 4:00 P.M.

Name	Organization
Betancor, Felipe	GE Hitachi
Bolger, Fran	GE Hitachi
Burke, John	NRC
Connor, Myles	GE Hitachi
Galletti, Greg	NRC
Godfrey, Mark	GE Hitachi
Head, Jerald	GE Hitachi
Hull, Amy	NRC
Jackson, Terry	NRC
Jacobson, Jeffrey	NRC
Jean, Uldrick	Exelon
Krohn, Paul	NRC
Makar, Greg	NRC
Malik, Shah	NRC
McIntyre, Richard	NRC
McMurray, Nicholas	NRC
*Palmer, Nathan	EPRI
Prokofiev, Iouri	NRC
Rebak, Raul	GE Hitachi
Satterlee, Nicholas	NRC
Savwoir, Nicholas	NRC
Schade, Eric	Exelon
Webb, Michael	NRC
Widrevitz, Daniel	NRC
Wood, Kent	NRC
Yeshnik, Andrew	NRC

*Indicates remote participation via teleconference or webinar

Enclosure 1