October 21, 2003

Mr. Joseph Ziegler, Director
U.S. Department of Energy
Office of Repository Development
P.O. Box 3644629 M/S 523
North Las Vegas, NV 89036-8629

SUBJECT: COMMENTS REGARDING THE NONDESTRUCTIVE EVALUATION METHODS USED TO INSPECT CLOSURE WELDS OF THE WASTE PACKAGE

Dear Mr. Ziegler:

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the U.S. Department of Energy's (DOE) June 18, 2003, agreement response related to PRE 7.04. During the review of TDR-EBS-ND-000007, Rev 01, "Weld Flaw Evaluation and Nondestructive Examination Process Comparison Results for High-Level Radioactive Waste Package Manufacturing Program," dated May 2003, the NRC identified specific concerns that should be addressed within DOE's license application for the proposed repository at Yucca Mountain. NRC needs for additional information related to the staff's concerns are enclosed. NRC considers agreement PRE 7.04 as needing additional information.

If you have any questions regarding the NRC comments please contact Mr. Tim Kobetz of my staff at 301-415-5170.

Sincerely,

/RA/

Janet R. Schlueter, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: See attached distribution list

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NRC On-Site Representatives

S. Devlin

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THE OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS REVIEW OF THE U.S. DEPARTMENT OF ENERGY KEY TECHNICAL ISSUE AGREEMENT RESPONSE TO PRE 7.04 FOR A PROPOSED GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA PROJECT NO. WM–00011

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) goal of issue resolution during this interim prelicensing period is to assure the U.S. Department of Energy (DOE) has assembled enough information about a given issue for NRC to accept a license application for review. Resolution by the NRC during prelicensing does not preclude anyone from raising any issue for NRC consideration during the licensing proceedings. Also, and just as important, resolution by the NRC during prelicensing does not prejudge what the NRC's evaluation of that issue will be after its licensing review. Issues are resolved by the NRC staff during prelicensing when the staff have no further questions or comments about how DOE addresses an issue. Pertinent new information could raise new questions or comments about a previously resolved issue.

To satisfy the informational needs of Key Technical Agreement PRE 7.04, DOE submitted by letter[1] a report titled Weld Flaw Evaluation and Nondestructive Examination Process Comparison Results for High-Level Radioactive Waste Package Manufacturing Program TDR–EBS–ND–000007, Rev. 01. It was noted that this report replaces the previously titled Waste Package Operations Fabrication Process Report, listed in PRE 7.04.

The agreement response provides information about the use of nondestructive examination methods for detecting flaws in the weld metal and heat affected zone of waste package closure welds. In addition, the report provides information about the types of flaws, flaw sizes, and flaw distributions in simulated waste package closure welds. Specifically, DOE states NRC information needs regarding the agreement are satisfied by the report and the agreement should be considered closed. The NRC evaluation of the DOE KTI Agreement response to PRE 7.04 is provided below in section 4.0.

2.0 WORDING OF THE AGREEMENT

Section 1 of the DOE response identified KTI Agreement PRE 7.04 as being satisfied by the information provided within the report. The NRC review of the DOE response is based on DOE providing the requested information identified in NRC letter[2] dated August 14, 2001, (ADAMS ML012290017).

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[1]Ziegler, J.D. "Transmittal of a Key Technical Issue (KTI) Agreement Item Preclosure (PRE) 7.04." Letter (June 18) to J.R. Schlueter, NRC. Las Vegas, Nevada: DOE. 2003.

[2]Reamer, C.W. "U.S Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Preclosure Safety." Letter (August 14) to S. Brocoum, DOE. Washington, DC: NRC. 2001.

The wording of the agreement states the following:

PRE.07.04: "Demonstrate that the nondestructive evaluation methods used to inspect the Alloy 22 and 316 nuclear grade plate material and closure welds are sufficient and are capable of detecting all defects that may alter waste package mechanical properties. DOE will provide justification that the non-destructive evaluation methods used to inspect the alloy 22 and 316 nuclear grade plate material and welds are sufficient and are capable of detecting defects that may adversely affect waste package pre-closure structural performance. DOE agrees to provide the information in FY03 and document the information in the Waste Package Operations Fabrication Process Report."

3.0 TECHNICAL INFORMATION PROVIDED IN THE AGREEMENT RESPONSE

The report provided by the DOE documents the methodology used to fabricate Alloy 22 waste package closure weld specimens. No information regarding Type 316 nuclear grade stainless steel was included in the report. The size and geometry of the closure weld specimens were designed to duplicate the configuration of the waste package for 21 pressurized water reactor fuel assemblies. Specimens were remotely welded using the gas tungsten arc welding process. The remote welding operation used to fabricate the test specimens was similar to closure welding operations to be carried out in the closure cell facility of the waste handling building at the proposed repository site. After welding was completed, the specimens were examined using four nondestructive examination methods. Volumetric examinations were conducted using ultrasonic and radiographic testing. A surface inspection was conducted using liquid penetrant and eddy current testing. The report indicates inspection of the waste package closure welds would most likely be performed using ultrasonic and eddy current testing. Radiographic and liquid penetrant testing will not be possible because of the waste package design and anticipated temperature constraints. Nevertheless, radiographic and penetrant testing were included in the study to provide a comparison to the ultrasonic and eddy current methods.

Volumetric flaws identified in the nondestructive examinations were characterized using standard metallographic techniques by size and position and classified as either a round or a linear flaw. Agreement was found between ultrasonic and radiographic test methods. Identification and characterization of surface flaws using penetrant and eddy current testing were similar. Several linear flaws were identified in the welded specimens by ultrasonic and radiographic methods. Most of these linear flaws were lack of fusion between weld passes. The size of the indications varied from approximately 3 to 38 mm [0.12 to 1.5 in] in length. Based on the results of ultrasonic tests, the cumulative length of all flaws was 0.16 percent of the total length of the weld material. In addition to the flaws identified using ultrasonic and radiographic test methods, porosity was also identified in metallurgical analyses. The pores were less than 1 mm [0.04 in] in diameter and were rounded and, therefore, unlikely to promote cracking. Clustering of the pores was not observed in any of the welded specimens.

4.0 NRC EVALUATION AND COMMENT

The intent of this agreement was to determine if the NDE methods used to inspect Alloy 22 and Type 316 nuclear grade stainless steel plates and closure welds could detect flaws that may affect the preclosure mechanical performance of the waste package. It is important that the

welds meet the waste package design requirements. Nondestructive examination methods used to inspect waste package welds should have sufficient resolution to detect all unacceptable defects and be compatible with the waste package design, operational temperature, radiation background, and remote operations.

Since the agreement was drafted, DOE has modified the design of the waste package. The revised waste package design uses a mechanical closure with seal welds for the Type 316 nuclear grade stainless steel inner container. The new design was presented to the NRC by DOE at the June 4, 2003, Waste Package Design Technical Exchange.[3] Because the revised design of the inner container does not use a welded closure lid, Key Technical Issue PRE 7.04 is no longer applicable to the inner container closure. Fabrication welds for the Type 316 nuclear grade stainless steel inner container will be examined using both surface and volumetric methods. As noted before, the report submitted by the DOE, does not specifically address the inner container fabrication welds. The design of the fabrication welds and welding methods used to construct the Type 316 nuclear grade stainless steel inner container are similar to the methods used for the Alloy 22 outer container. Prior to disposal container assembly both the inner and outer surfaces of the Alloy 22 and Type 316 nuclear grade stainless steel containers are accessible allowing additional nondestructive examination methods to be used such as radiographic testing. Nondestructive evaluation methods used to inspect the Alloy 22 outer container may also be used to examine the Type 316 nuclear grade stainless steel inner container. Resolution of the nondestructive examination methods used for Alloy 22 are anticipated to be sufficient to evaluate welded Type 316 nuclear grade stainless steel.

Also, DOE does not provide the minimum acceptable flaw size that can affect the mechanical behavior of the plates and welds. The only reference to an acceptable flaw size was the ASME Boiler and Pressure Vessel Code, Section III, Division I for the ~1-mm [0.04-in] diameter spherical gas-induced pores. The ASME Boiler and Pressure Vessel Code, Section III, Division I, (ASME International, 2001) gives an acceptable elongated imperfection size of 6 mm [0.24 in] for the 2-cm- [0.79-in]-thick Alloy 22 plate which is much greater than the diameter of the gas bubbles. However, Section III, Division I, NC–5330 states for ultrasonic testing, that "indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length," and NC–5320 states for radiographic testing that "any indication characterized as a crack or zone of incomplete fusion or penetration" is unacceptable. The DOE report identifies several lack of fusion flaws, which according to the ASME Boiler and Pressure Vessel criteria, are unacceptable. Lack of fusion flaws smaller than those detected in this study may also exist. An assessment of the effect of flaw size on mechanical performance of the waste package in the preclosure period is necessary to assess if the nondestructive examination detection limit is acceptable.

The ultrasonic testing conducted on the simulated closure welds is not representative of the current waste package closure weld design. In the revised waste package design, ultrasonic examination from the outer surface of the waste package would not be possible because of a trunnion welded to the Alloy 22 outer container. The change in the waste package design means that linear flaws, such as lack of fusion defects, may be more difficult to detect.

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[3]Brown, N.R. "Background—Waste Package Design." *Presentation at the NRC/DOE Technical Exchange on Waste Package Design, June 4, 2003.* Las Vegas, Nevada. 2003.

Need for Additional Information

The NRC staff has reviewed DOE's agreement response to PRE 7.04 of June 18, 2003. During the review the NRC identified potential issues related to the non-destructive evaluation methods and the identification of the minimum flaw size that may affect the mechanical performance of the waste package. The following needs for additional information are provided by the NRC staff for further consideration by DOE as it prepares a license application for a potential repository at Yucca Mountain, Nevada:

- DOE should demonstrate that volumetric testing techniques can be successfully used to inspect the new Alloy 22 waste package closure weld as presented at the June 4, 2003, Technical Exchange on waste package design.

  In TDR-EBS-ND-000007, Rev 01, "Weld Flaw Evaluation and Nondestructive Examination Process Comparison Results for High-Level Radioactive Waste Package Manufacturing Program," dated May 2003, successfully demonstrated that it could perform an ultrasonic test (UT) inspection of the previous closure weld design. However, the new design uses a trunnion sleeve which appears to make it difficult to perform a UT inspection of the weld. The demonstration should also take into account other variables such as the temperature of the waste package and the remote location of the waste package during welding and non-destructive testing.

- DOE should provide the basis for the minimum flaw size.

  The only reference to an acceptable flaw size was the ASME Boiler and Pressure Vessel Code, Section III, Division I for the ≈1-mm [0.04-in] diameter spherical gas-induced pores. The ASME Boiler and Pressure Vessel Code, Section III, Division I, (ASME International, 2001) gives an acceptable elongated imperfection size of 6 mm [0.24 in] for the 2-cm [0.79-in]-thick Alloy 22 plate which is much greater than the diameter of the gas bubbles. However, Section III, Division I, NC-5330 states for ultrasonic testing, that "indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length," and NC-5320 states for radiographic testing that "any indication characterized as a crack or zone of incomplete fusion or penetration" is unacceptable. The DOE report identifies several lack of fusion flaws, which according to the ASME Boiler and Pressure Vessel criteria, are unacceptable. Lack of fusion flaws smaller than those detected in this study may also exist. An assessment of the effect of flaw size on mechanical performance of the waste package in the preclosure period is necessary to assess if the nondestructive examination detection limit is acceptable.

5.0 SUMMARY

The NRC reviewed the DOE KTI Agreement response to determine if any aspect of the agreement was excluded from the response. In addition, the NRC staff, with assistance from the Center for Nuclear Waste Regulatory Analyses, performed an independent assessment to determine if the information provided would support submission of a potential license application for a geologic repository. On the basis of the above review, the NRC found that the agreement was not satisfied by the information assembled in the DOE response.

6.0 STATUS OF THE AGREEMENT

Based on the above review, the NRC determined that additional information is needed to satisfy the agreement. Therefore, NRC considers agreement PRE 7.04 as needing additional information.

7.0 REFERENCES

ASME International. "Rules for Construction of Nuclear Power Plant Components, Division 1, Subsection NC, Class 2 Components." *Section III of the 2001 ASME Boiler and Pressure Vessel Code*. New York City, New York: ASME International. 2001.

Bechtel SAIC. "Weld Flaw Evaluation and Nondestructive Examination Process Comparison Results for High-Level Radioactive Waste Package Manufacturing Program." TDR–EBS–ND–000007. Rev 01. Las Vegas, Nevada: Bechtel SAIC. 2003.

Bechtel SAIC. "Waste Package Project FY–01 Closure Methods Report." TDR–EBS–ND–000006. Rev. 00. Las Vegas, Nevada: Bechtel SAIC. 2001a.

Bechtel SAIC. "Waste Package Operations Fabrication Process Report." TDR–EBS–ND–000003. Rev 02. Las Vegas, Nevada: Bechtel SAIC. 2001b.