MEMORANDUM TO: Michael E. Mayfield, Acting Director
Division of Engineering Technology
Office of Nuclear Regulatory Research

THRU: Edwin M. Hackett, Acting Chief
Materials Engineering Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

FROM: Wallace E. Norris, Project Manager
Materials Engineering Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

SUBJECT: REQUEST TO INITIATE WORK UNDER CONTRACT RES-99-047 (Y6095)

I recommend that you approve the attached contractual action for Job Code Y6095, "Feasibility of Underwater Welding of highly Irradiated In-Vessel Components of Boiling-Water Reactors." My recommendation is based on the following:

- The research is relevant to a risk-significant regulatory issue; i.e., the incidence of environmentally assisted cracking found during examinations of BWR core internals (as explained in the Background section of the attached SOW).

- The research results are expected to resolve the regulatory issue by demonstrating whether repair of BWR vessel internals is feasible and if so, providing a technical basis for permitting continued operation after repair of vessel components (as discussed in the Background section of the attached SOW).

- The estimated cost is justified by the knowledge to be gained. This problem is generic to all BWRs, and the NRC received requests from NEI, EPRI, and BWR Vessel Internals Project (BWRVIP) to proceed with this cooperative program.

- In selecting the direction and approach for the research, several meetings have been held between the NRC, EPRI, the BWRVIP, and the Japanese Owners Group (JOG).

- The research will be timely because results will be available by early calendar year 2000. There have been a number of reported cases of environmentally assisted cracking of BWR core internals in recent years. It is only a matter of time until cracking occurs in a component which cannot be replaced, or it is not economically reasonable to replace.

- The delivery schedule is consistent with an NRR user request from Samuel J. Collins, Director, NRR, to David L. Morrison, Director, RES, dated March 12, 1997, to address uncertainties after the literature search results were provided in NUREG-1616 (November 1997).

- A peer review is not needed in this case because the program is a cooperative effort between the NRC, EPRI, the BWRVIP, with input from the JOG. Thus, the technical direction of the program as well as the results will have an appropriate level of industry review. Applicable reviews related to the proposed procurement action have been completed as shown by user office concurrence.

Attachment: Statement of Work

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Approved: _____ Date: _____

Michael E. Mayfield, Acting Director
Division of Engineering Technology
Office of Nuclear Regulatory Research

**NOTE:** After approval - Original to Project Manager, copy to P. Cross-Prather, MA.

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| NAME | W.Norris | | E. Hackett | | M. Mayfield | | | | | |
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Attachment A

STATEMENT OF WORK FOR RES-99-047

TITLE: Feasibility of Underwater Welding of Highly Irradiated In-Vessel Components of BWRs

## I. INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) and the Electric Power Research Institute (EPRI) have signed a Memorandum of Understanding (MOU) to permit and encourage cooperation in nuclear safety research which provides benefits for both NRC and the nuclear industry, such as technical information exchange and the sharing of costs, whenever such cooperation and cost sharing can be accomplished in a mutually beneficial manner. A program for determining the feasibility of underwater welding of highly irradiated in-vessel components of boiling-water reactors (BWRs) is being developed between NRC and EPRI. Under this program, technical information and overall program costs will be shared by the NRC and EPRI. An effort is underway to determine if a suitable method is available to obtain metallic samples from reactor vessel components at three BWR plants. Analysis of the samples will be performed by Pacific Northwest National Laboratory (PNNL). The specific work to be performed under this contract will provide an element of NRC's participation in the overall program.

## II. BACKGROUND

Environmentally assisted cracking of BWR core internals fabricated from stainless steel and high nickel alloys has been detected during examination. The industry will have to make decisions whether to repair or replace those components for which continued structural integrity cannot be assured, and the NRC will have to review repair or replacement strategies. Because of the scarcity of data pertaining to welding highly irradiated materials in an underwater environment, the level of activity in the commercial nuclear industry related to the generic issues associated with the reactor vessels and internals, especially repair options, has been increasing. There are many complicated issues to be addressed in developing welding technology for use in repairing in-vessel components. For example, the thermal fluence at the vessel wall is not well benchmarked. Two problems specific to welding highly irradiated materials are: (1) cracking during the welding process as a result of helium entrapment in the material; and (2) cracking attributable to irradiation-damaged microstructure in the components. In addition, access to in-vessel components for inspection or repair typically is limited, and the high radiation levels usually require a remote repair approach or a well-shielded work environment. One of the purposes of this research is to determine the concentrations of boron and helium in BWR reactor vessel components at several U.S. BWRs. Estimates of the ranges of concentrations for the U.S. fleet will then be developed. With this information and estimates of the thermal fluence, the feasibility of using standard welding techniques, as well as modified techniques, to effect the structural repair in these locations can be determined.

NRC and EPRI are sharing the costs of obtaining samples at the three plants. EPRI will be responsible for funding the sampling at the first plant. NRC will be responsible for funding the sampling at the second and third plants. Since the plants to be sampled could change based on factors such as change in outage schedules, for the purpose of submitting proposals to the NRC, offerers should assume that one of the plants is located in the Eastern U.S. and one of the plants is located in the midwest. Any special considerations (e.g., cost, personnel, shipping equipment) which may result from this uncertainty should be discussed. Another factor which

should be considered by the offerers is the potential for EPRI and NRC to select different contractors for obtaining the samples.

The NRC will be responsible for selecting the laboratory where the samples will be analyzed. It is anticipated that the sampling will be performed at Pacific Northwest National Laboratory, if that can be justified. The NRC will be responsible for funding the analysis of the samples for helium and boron concentrations. This information will be made publicly available.

## III. OBJECTIVE

The overall objective of the program is to investigate the feasibility of welding highly irradiated materials as a repair methodology for degraded boiling water reactor (BWR) in-vessel components. The specific objective of this contract is to obtain samples from vessel components in order to determine the range of boron and helium concentrations expected in components considered for weld repair.

## IV. SCOPE OF WORK

- In-Vessel Sampling

    - Four metallic samples from the Jet Pump Riser Brace Pad Assembly in the reactor vessel are to be obtained at each of three BWR plants. The plants will be selected through consultations between NRC and EPRI.

    - The contractor will make arrangements with the utility(s) to perform this work through no-cost agreements.

    - The NRC will not be responsible for disposal of contaminated equipment.

    - The anticipated schedule for obtaining the surveillance samples at plants 2 and 3 is: Plant 2 - 9/1/00; and Plant 3 - 10/7/00 (presuming the candidate plants are confirmed).

    - Offerers will describe in detail the tooling and techniques which will be used to perform this work. The proposal must address the effects of metal removal on both the sample and base metal. The metallic samples extracted should be small such that repair of the sampled component is not required. Five to 10 mg is a convenient sample size range, and specimens are cut from this (the optimum sample mass for helium analysis is between 0.5 to 2 mg). The offerers must address in the proposal sample size range and the “as-left” condition of the component. As a deliverable to the participating plant utility and the NRC, the contractor(s) chosen will be required to submit a technical justification for leaving the sampled surface as-is following sample removal. This justification will become part of the NRC’s public record.

    - Offerers shall discuss the need to design, develop, procure, and assemble a suitable plant mockup for training personnel (field team) to perform the sampling.

After the contract has been awarded, access to the jet pump riser brace pad must be verified. Drawings and photos and/or videos will be required for each of the areas to be sampled to confirm local geometry.

- The contractor will ship the equipment to the selected plant site per the agreed schedule, set up the equipment on the plant refuel floor, operate the equipment as required, and extract four azimuthal samples from the riser brace pad. The estimated time for on-site work is three days for each plant including mobilization, setup, sampling, and demobilization. Actual sampling is expected to take from 2 to 3 shifts.

- After removal of the samples at each plant, a letter report, which will become part of the NRC's public record, is to be provided within 30 days which contains the following:

    - A diagram of the jet pump riser brace pad assembly showing the size, location, and orientation where each sample was removed.

    - A vessel geometry diagram(s) of the jet pump riser brace pad assembly relative to the core showing details such as size, location, and distance.

(I) After the samples from the second plant have been obtained and analyzed, a determination will made by NRC and EPRI whether it is necessary and prudent to proceed with obtaining samples at the third plant. The contractor must obtain permission from the NRC/RES project manager before proceeding with this sampling.

(2) Ship Samples to Laboratory for Analysis

(A) The contractor will ship the samples to PNNL for analysis. PNNL is responsible for the shipping costs. The contractor will specify and procure encapsulation containers suitable for shipping sample material to the laboratory. Proposals must contain a shipping plan and address the applicable Federal and State requirements.

(B) The laboratory will be responsible for disposal of the samples.

(3) Quality Assurance

All work at the participating plant sites shall be governed by their respective quality assurance programs.

The adequacy and accuracy of all utility supplied information is the responsibility of the respective participating utility.

## V. REPORTING REQUIREMENTS

(1) A MSLR is to be submitted to the NRC project manager with a copy to the Division of Contract and Property Management, Office of Administration, by the end of each month. The MSLR shall summarize each month's technical progress, and list monthly spending, total spending to date, and the remaining funds. Any administrative or technical difficulties which may affect the schedule or costs of the project shall be immediately brought to the attention of the NRC project manager.

(2) The anticipated schedule for obtaining the samples and shipping them to the laboratory for analysis is to be included and reported in the second MSLR.

(3) After removal of the samples at each plant, a letter report, which will become part of the NRC's public record, is to be provided within 30 days which contains the following:

(A) A diagram of the jet pump riser brace pad assembly showing the size, location, and orientation where each sample was removed.

(B) A vessel geometry diagram(s) of the jet pump riser brace pad assembly relative to the core showing details such as size, location, and distance.

(4) The NRC project managers are to be immediately notified by the contractors principal investigator in the event that the contractor is unable to meet its commitments, the schedule for obtaining samples at a plant significantly changes, or if a plant is unable to comply with its commitments.

(5) Individual plant names are to be considered proprietary; i.e., not to be used in publicly available reports.

VI. DELIVERABLES AND DELIVERY SCHEDULE

(1) The vessel samples from the second plant are to be received by the laboratory within two weeks from the date of the removal of the samples from vessel.

(2) The vessel samples from the third plant are to be received by the laboratory within two weeks from the date of the removal of the samples from vessel.

VII. MEETINGS AND TRAVEL REQUIREMENTS

Travel to two U.S. nuclear power plants. No other travel is anticipated.

VIII. LEVEL OF EFFORT

To plan, initiate, and complete this contract, it is estimated that 680 contractor staff-hours will be required as follows:

| | |
|---|---|
| Principal Investigator | 100 hours |
| Personnel Training | 100 hours |
| Shipping Equipment | 30 hours |
| Site Specific Radiation Training | 150 hours |
| Sampling | 300 hours |

IX. PERIOD OF PERFORMANCE

Twenty-seven (27) months from date contract is initiated.

X. TECHNICAL DIRECTION

The NRC Project Manager is:

Wallace E. Norris
Materials Engineering Branch
Division of Engineering Technology
M/S T-10E10
Washington, DC 20555-0001

Telephone: (301) 415-6796
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e-mail: wen@nrc.gov

XI. PUBLICATIONS

RES encourages the publication of the scientific results from RES sponsored programs in refereed scientific and engineering journals as appropriate. If the contractor proposes to publish in the open literature or present the information at meetings in addition to submitting the required technical reports, approval of the proposed article or presentation will be obtained from the NRC Project Manager.