**From:** Mark Kirk / RES
**To:** Cayetano Santos
**Date:** 9/12/02 5:06PM
**Subject:** Re: Draft SOW for Davis Besse Crack

Tanny (et al):

Great write up for such a short time frame ... many thanks. I'd offer only the following comments, all regarding Task 2A (Burst Tests):

1. I think that if we have to go to the trouble of fabricating new cladding that it is not worth doing the testing at all. I think it is good if we can test something (reasonably) representative (reasonably) quickly (i understand from what i overheard that getting something representative is not as easy as originally hoped for). Anyway - if we can't find something representative quickly then (to my mind at least) the benefit of running the tests goes down considerably (certainly in a cost-benefit sense ... and in an absolute sense too, i think). But ... this is just my opinion.

In the sense of being helpful, we might also want to try to reach out to our colleagues in the industry to find cladding sources. My thoughts in this regard include Bob Hardies, Brian Hall (of Framatome in Lynchburg) and Stan Rosinski ... maybe they have access to "vintage" material that we do not ... particularly hardies. I tried calling Bob earlier today, unfortunately he is out till Monday.

2. I think that the value of running pre-flawed burst disks should be examined very carefully. Unless it is demonstrated that the "crack" in DB was pre-existing (like a lack of fusion defect, rather than the material just opening up under loading along weak metallurgical planes) i do not see the point in running pre-flawed burst disks. To me the value of doing cladding burst disks is that the flaw distribution characteristic of the cladding is "in there" ... i don't think we need to (or should) add anything else.

3. I understand the desire to include a thermal gradient to make this a more "prototypic" test. However, i am not sure that this is necessary ... or even helpful ... if we are to use these results to "calibrate" the finite element failure model. I think some discussions with both Richard Bass and Paul Williams would be helpful in determining what is the best way to go on this matter.

4. While i was (briefly) in your meeting today i heard Bill Cullen's reservations about adequately modeling the "deformation history" of the cladding as the wastage area evolved from 0 sq. in. to the final size that existed in Feb '02 at DB. If Bill's concern was not subsequently dismissed i was thinking that it would not be an exceedingly complex matter to "pre-condition" the burst disk specimens in a similar way in the laboratory.

Again - really good effort. Let me know if i can do anything to help.

Mark

>>> Cayetano Santos 09/12/02 04:39PM >>>
Attached is draft SOW we put together today to try to address the cracking found in the cladding of Davis Besse.

**CC:** Carolyn Fairbanks; Deborah Jackson; Jeffrey Hixon; Nilesh Chokshi; Robert Tregoning; Shah Malik; William Cullen

H-5

**From:** Robert Tregoning RET
**To:** Jeannette Torres
**Date:** 11/27/02 8:25AM
**Subject:** Fwd: Draft SOW for Davis Besse Crack

**From:** Cayetano Santos RES
**To:** Carolyn Fairbanks; Deborah Jackson; Jeffrey Hixon; Mark Kirk; Nilesh Chokshi; Robert Tregoning; Shah Malik; William Cullen
**Date:** 9/12/02 4:39PM
**Subject:** Draft SOW for Davis Besse Crack

Attached is draft SOW we put together today to try to address the cracking found in the cladding of Davis Besse.

OFFICE OF NUCLEAR REGULATORY RESEARCH
DIVISION OF ENGINEERING TECHNOLOGY
STATEMENT OF WORK

PROJECT TITLE:

JOB CODE:
CONTRACTOR:
SITE:
STATE:

NRC PROJECT MANAGER: NAME
PHONE

B&R NUMBER: 2XXXXXXXXXX

PERIOD OF PERFORMANCE: The period of performance, including a start date and end date for the entire project must be provided.

ORDER PERFORMANCE PERIOD: Use for mods or urgent requirements

LEVEL OF EFFORT: In staff years. State the level of effort in staff hours, broken down by task(s).

BACKGROUND

Include a brief statement of the purpose of the work and discussions of pertinent work previously accomplished, technical problems, suggested approaches, possible methodologies for problem solution, and expected results. Provide explanations or constraints necessary to understand the requirement; how the requirement arose and its relationship to previous, concurrent, and future programs; and details that reveal the purpose and significance of the requirement.

OBJECTIVE

Describe the expected results to be obtained, with a description of how the end product(s) will be used in the regulatory process.

TECHNICAL AND OTHER SPECIAL QUALIFICATIONS REQUIRED

Specify the labor categories and any special expertise that is required to perform the proposed effort. If applicable, specify whether site access or unescorted site access will be required and provide instructions on acquisition of the site access authorization.

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SCOPE OF WORK

Task 1 Analysis

The following assumptions shall be used in the following analyses

- Clad thickness = 0.25"
- Temp=600 F (except for Task 1E in which a temperature gradient is to be applied)
- Clad material is Type 308

1A. Estimate crack driving forces as a function of flaw size and applied membrane stress in cladding. This will be done by performing elastic-plastic finite element analyses of sharp surface breaking flaws in flat plates under biaxial tension. The flaw depths shall vary from 5%, 25% and 50% of the clad thickness. The flaw lengths shall be varied from 3/8", 1" and 2". The applied stresses shall be representative of the membrane stresses at the center of the wastage area cavity. Also, a flaw geometry simulating the actual DB flaw should be evaluated once this is determined. The J-integral calculated from these analyses shall be compared to appropriate JR curves for the cladding material.

1B. Estimate the plastic collapse as a function of flaw size and applied membrane stress in cladding. This will be done by performing elastic-plastic finite element analyses of a finite root tip (blunted) surface breaking flaws in flat plates under biaxial tension. The flaw depths shall vary from 5%, 25% and 50% of the clad thickness. The flaw lengths shall be varied from 3/8", 1" and 2". The applied stresses shall be representative of the membrane stresses at the center of the wastage area cavity.

1C. Similar to Task 1A except that instead of a flat plate geometry, the finite element model of the flaw shall be driven by the submodel of the wastage area cavity which in turn will be driven by the global model of the full RPV head and closure flange.

1D. Similar to Task 1B except that instead of a flat plate geometry, the finite element model of the flaw shall be driven by the submodel of the wastage area cavity which in turn will be driven by the global model of the full RPV head and closure flange.

1E. Estimate crack driving forces as a function of flaw size and applied membrane stress in cladding. This will be done by performing elastic-plastic finite element analyses of sharp surface breaking flaws in flat plates. The flaw depths shall vary from 5%, 25% and 50% of the clad thickness. The flaw lengths shall be varied from 3/8", 1" and 2". The applied stresses shall biaxial tension representative of the membrane stresses at the center of the wastage area cavity. In addition a temperature gradient shall be imposed. The thermal gradient expected across the cladding should also be simulated as closely as possible. The internal surface is expected to be roughly 600F while the outer surface temperature is app. 250F. The J-integral calculated from these analyses shall be compared to appropriate JR curves for the cladding material.

1F. Estimate the plastic collapse as a function of flaw size and applied membrane stress in cladding. This will be done by performing elastic-plastic finite element analyses of a finite root tip (blunted) surface breaking flaws in flat plates. The flaw depths shall vary from 5%, 25% and

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50% of the clad thickness. The flaw lengths shall be varied from 3/8", 1" and 2". The applied stresses shall biaxial tension representative of the membrane stresses at the center of the wastage area cavity. In addition a temperature gradient shall be imposed. The thermal gradient expected across the cladding should also be simulated as closely as possible. The internal surface is expected to be roughly 600F while the outer surface temperature is app. 250F.

Task 2 Experiment

The materials to be used for this experimental task shall come from either (1) mockups made to simulate the cladding from the Davis Besse RPV head and/or (2) other clad material taken from other (ie PVRUF, Midland, Shoreham, River Bend). Whatever cladding material is chosen MUST be fabricated using the tandem arc process. The cladding material shall be Type 308 or Type 308L stainless steel as appropriate. Because the intent is to simulate the DB material as closely as possible, the DB cladding microstructure in the vicinity of the cracked and necked region should be determined. Also, the chemistry within this general vicinity should be evaluated to determine the cladding alloy. Crack depth should also be determined at the approximate center location (axially) of the crack and at each end. This profile will be utilized in both the subsequent experimental tests, but will also be modeled within the numerical failure predictions..

2A. Burst Tests
Burst tests shall be performed on flawed and unflawed 0.25" thick cladding material to determine failure pressures. The surface area of the cladding test specimen shall be approximately the same as the wastage area of the Davis Besse RPV head. The tests shall approximately simulate the loading, geometry, thermal, and material degradation experienced by the DB head. As such, the burst tests should be biaxially loaded, either through a flat disk under pressure, a pipe-flanged arrangement, or spherical-arc shaped segment. The thermal gradient expected across the cladding should also be simulated as closely as possible. The internal surface is expected to be roughly 600F while the outer surface temperature is app. 250F. Initial thermal feasibility tests shall ensure that this gradient can be maintained throughout the test. If it is not possible to maintain during the test, the thermal strains induced by this gradient should be measured and used to predict the thermal stresses induced in the cladding.

The flaw geometries should be consistent with those utilized in the numerical study. The depths shall vary from 5%, 25% and 50% of the clad thickness. The flaw lengths shall be varied from 3/8", 1" and 2". Also, a flaw geometry simulating the actual DB flaw should be tested. Experiments shall be performed until complete failure. The failure strains shall be monitored along with failure load and the crack opening displacement at failure (if appropriate). Three repeat tests per condition should be conducted.

2B. Material Property Characterization Test
Tensile, microhardness and metallography tests shall be performed on the cladding material used in Task 2A described above.
Macroscopic tensile tests shall be machined from the cladding. These tests shall be performed at 300 F, 450 F and 600 F. A minimum of 3 tests shall be performed at each temperature. All

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tests shall be done at quasi-static loading rates. Microhardness traverses shall also be done both through the cladding thickness and perpendicular to the cladding axis. The perpendicular traverses should encompass three side-by-side cladding passes (one pass is 6 wires). One traverse should be at the carbon steel interface, one at the mid-cladding thickness, and one near the free surface. One through-thickness traverse should sample microstructure consistent with the DB cracking location; the other two locations will sample other regions of interest. The microhardness results shall be used to determine sections for metallography. The metallography should characterize all pertinent unique microstructural features within the cladding, but should especially concentrate on those features near the DB cracking location. Also, microstructural and microhardness inhomogeneities shall indicate possible locations for measuring tensile property anisotropy. Two disparate microstructures should be evaluated at a single temperature to be determined. Gleeble simulation may be required to reconstruct the microstructure within macroscopic tensile specimens.

Triplicate fracture(J-r curve) toughness tests in the L-S orientation should be performed at 300F and 600F. These results will be utilized within the numerical predictions to simulate failure. Other mechanical tests as required by cladding material specifications should also be performed to ensure that the material meets minimum requirements.

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REPORTING REQUIREMENTS

**NRC Project Managers should**: Provide a concise list of reports to be provided, the desired level of contractor management review of reports, and the frequency, content, and distribution of the reports.

Monthly Letter Status Report

A Monthly Letter Status Report (MLSR) is to be submitted to the NRC Project Manager by the 20$^{th}$ of the month with copies provided to the following:

Michael E. Mayfield, Division Director, Mail Stop T-10D20
ATTN: Peggy Cross-Prather, Management Analyst, Mail Stop T-10D20
Branch Chief, (Daniel H. Dorman, Mail Stop T-10L1) or (Nilesh C. Chokshi, Mail Stop T-10E10)
Division of Contracts, Office of Administration (Mail Stop T-7I2)

The MLSR will identify the title of the project, the job code, the Principal Investigator, the period of performance, the reporting period, summarize each month's technical progress, list monthly spending, total spending to date, and the remaining funds and will contain information as shown in Exhibit 10 of NRC Management Directive 11.7. 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.

NRC has implemented a new document management system, Agencywide Documents Access and Management System (ADAMS). For the present, DOE mail will not be placed in ADAMS. All documents mailed from DOE to NRC (e.g., letters, technical reports, NRC Form 189s, MLSRs, and other mail) should have "Addressee Only" on the envelope to keep it from being entered into ADAMS. Send mail for the addressee and cc's as separate mailings. NRC Form 173, will be accepted by the Office of the Chief Financial Officer (OCFO) with or without the "Addressee Only" designation.

PUBLICATIONS NOTE

RES encourages the publication of the scientific results from RES sponsored programs in refereed scientific and engineering journals as appropriate. If the laboratory proposes to publish in the open literature or present the information at meeting in addition to submitting the required technical reports, approval of the proposed article or presentation should be obtained from the NRC Project Manager. The RES Project Manager shall either approve the material as submitted, approve it subject to NRC suggested revisions, or disapprove it. In any event, the RES Project Manager may disapprove or delay presentation or publication of papers on information that is subject to Commission approval that has not been ruled upon or which has been disapproved. Additional information regarding the publication of NRC sponsored research is contained in NRC Management Directives 3.8, "Unclassified Contractor and Grantee Publications in the NUREG Series," and 3.9, "NRC Staff and Contractor Speeches, Papers, and Journal Articles on Regulatory and Technical Subjects."

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If the presentation or paper is in addition to the required technical reports and the RES Project Manager determines that it will benefit the RES project, the Project Manager may authorize payment of travel and publishing costs, if any, from the project funds. If the Project Manager determines that the article or presentation would not benefit the RES project, the costs associated with the preparation, presentation, or publication will be borne by the contractor. For any publication or presentations falling into this category, the NRC reserves the right to require that such presentation or publication will not identify the NRC's sponsorship of the work.

NEW STANDARDS FOR CONTRACTORS WHO PREPARE NUREG-SERIES MANUSCRIPTS

The U.S. Nuclear Regulatory Commission (NRC) began to capture its official records electronically on January 1, 2000. All records will be saved electronically in the Agencywide Documents Access and Management System, known as ADAMS.

The NRC will capture each final NUREG-series publication in its native application. Therefore, commencing January 1, 2000, please submit your final manuscript that has been approved by your NRC Project Manager in both electronic and camera-ready copy.

All format guidance, as specified in NUREG-0650, Revision 2, will remain the same with one exception. You will no longer be required to include the NUREG-series designator on the bottom of each page of the manuscript. The NRC will assign this designator when we send the camera-ready copy to the printer and will place the designator on the cover, title page, and spine. The designator for each report will no longer be assigned when the decision to prepare a publication is made. The NRC's Publishing Services Branch will inform the NRC Project Manager for the publication of the assigned designator when the final manuscript is sent to the printer.

For the electronic manuscript, prepare the text in WordPerfect 8, and use any of the following file types for charts, spreadsheets, and the like.

| File Types to be Used for NUREG-Series Publications | |
|---|---|
| File Type | File Extension |
| WordPerfect® | .wpd |
| Microsoft® PowerPoint® | .ppt |
| Corel® QuattroPro® | wb3 |
| Corel® Presentations | .shw |
| Lotus® 1-2-3 | .wk4 |
| Portable Document Format | .pdf |

This list is subject to change if new software packages come into common use at NRC or by our licensees or other stakeholders that participate in the electronic submission process. If a portion of your manuscript is from another source and you cannot obtain an acceptable electronic file type for this portion (e.g., an appendix from an old publication), the NRC can, if necessary, create a tagged image file format (file extension.tif) for that portion of your report. Note that you should continue to submit original photographs, which will be scanned, since

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digitized photographs do not print well.

If you chose to publish a compact disk (CD) of your publication, place on the CD copies of the manuscript in both (1) a portable document format (PDF); (2) a WordPerfect 8/9 file format, and (3) an Adobe Acrobat Reader, or, alternatively, print instructions for obtaining a free copy of Adobe Acrobat Reader on the back cover insert of the jewel box.

MEETINGS AND TRAVEL

**NRC Project Managers should**: Identify both domestic and foreign travel necessary for the performance of the work. Specify the purpose of each meeting or trip, the number of people necessary, and the estimated length of time. If specific dates for meetings or trips are known, they should be provided. This information is provided to the DOE laboratory in order to permit a more precise estimate of the costs involved in performance of the work. The laboratory should address the NRC's requirements in its proposal. The laboratory may also suggest or propose addition, deletion, or substitution of meetings and/or trips. Such proposed changes to the NRC's SOW should be considered and evaluated by the Project Manager in light of what is required to perform the work as described in the SOW. Unnecessary trips and meetings should be disapproved.

If no travel is expected or required, state "none." Foreign travel must be addressed separately and approval must be obtained by processing NRC Form 445, in addition to being provided as part of the approved proposal.

NRC-FURNISHED MATERIAL

**NRC Project Managers should**: Identify specific reports, journals, documents, equipment, or other items that are to be provided to the DOE laboratory by the NRC. Identify the date this material will be provided. If none, state no NRC-furnished material is required.

DOE-ACQUIRED MATERIAL

Normally, the purchase of property costing $500 or more (including Information Technology (IT) resources) will be approved through issuance of a work order accepting the proposal in which the property is listed. If additional property costing $500 or more (including IT resources) is needed after work starts, the laboratory must request approval of the additional property in writing to the RES Project Manager. This written request can be in the form of a revised proposal or a letter.

SUBCONTRACTING/CONSULTANT INFORMATION

Describe any technical support effort that is proposed to be performed by a subcontractor or consultant. Identify the level of effort, by task, of any proposed subcontractor or consultant and provide an explanation of the need for subcontracting that portion of the effort. Note that "pass through" contracting is not allowed under the requirements of the DOE/NRC Memorandum of Understanding. For the purposes of this effort, a "pass through" contract is generally defined as subcontracting 50 percent or more of the technical effort. For any subcontract or consultant effort, describe the following:

- the necessity of subcontracting,
- the tasks and subtasks the subcontractor or consultant will perform,
- the level of effort proposed for the subcontract effort,
- the status and expected time frame for selection, and
- the method of selection of the subcontractor or consultant.

INFORMATION TECHNOLOGY (IT) RESOURCES:

When IT resources are proposed by a DOE Laboratory that are not specifically identified in the Statement of Work, the need for and cost of those resources must be justified. Proposed IT resources should be those required to accomplish the work, but which are not available from within the laboratory's inventory of IT resources. Common office automation equipment and software, i.e., personal computers, word processing and spreadsheet software, and printers, should not routinely be proposed as they should normally be provided as part of the laboratory's information processing infrastructure. Whenever IT resources are proposed, justification is necessary for the NRC to be able to evaluate the requirements and to approve their acquisition.

In addition to the total cost of IT resources to be reported on the NRC Form 189, the following justification is to be included in the proposal:

4. IT Resource Requirements. List as line items each IT resource (hardware, e.g., laptop computer, engineering workstation; software - by product name; and services, e.g., computer time, database services) proposed for acquisition and estimate the cost of each item by fiscal year. Funding should be indicated for the year in which the IT resources is needed. Provide totals for all items for each fiscal year which match the costs listed on the line labeled IT RESOURCES on the NRC Form 189. Any IT acquisition shall conform to the acquisition and reporting requirements identified in NRC Management Directive 11.7, Part IX.

5. Justification. For each required IT resource with an acquisition cost of $500 or more, or group of resources, e.g., a system, provide specifications or the specific make/model, and other acquisition and reporting requirements identified in NRC Management Directive 11.7, Part IX. Briefly discuss how the IT resources will be used, including information about workload to be processed, required capacities, throughput, transfer rates, compatibility and expandability requirements, or any other information that supports the need to acquire the specific resources being proposed.

TECHNICAL DIRECTION

Technical direction will be provided by the Project Manager, **(add name)**, who can be reached at:

Mail Stop: (mail stop)
U. S. Nuclear Regulatory Commission

JCN:

Rockville, MD 20555-0001

Phone: (301) 415-XXXX
Fax: (301) 415-XXXX
Email: (email @nrc.gov)

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