ORNL/HSSI (W6953)/MLSR-2002/07

HEAVY-SECTION STEEL IRRADIATION (HSSI) PROGRAM (W6953)

Monthly Letter Status Report

April 2002

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HEAVY-SECTION STEEL IRRADIATION

PROGRAM

JCN W6953

MONTHLY LETTER STATUS REPORT

FOR

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Submitted by

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Submitted to
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PREFACE

This report is issued monthly by the staff of the Heavy-Section Steel Irradiation (HSSI) Program (JCN:W6953) to provide the Nuclear Regulatory Commission (NRC) staff with summaries of technical highlights, important issues, and financial and milestone status within the program.

This report gives information on several topics corresponding to events during the reporting month: (1) overall project objective, (2) technical activities, (3) meetings and trips, (4) publications and presentations, (5) property acquired, (6) problem areas, and (7) plans for the next reporting period. Next the report gives a breakdown of overall program costs as well as cost summaries and earned-value-based estimates for performance for the total program and for each of the six program tasks. The six tasks, including a project management task, correspond to the 189, dated March 7, 2001. The final part of the report provides financial status for all tasks and status reports for selected milestones within each task. The task milestones address the period from October 2000 to March 2003, while the individual task budgets address the period from October 2001 to December 2002.

Beginning in October 1992, the monthly business calendar of the Oak Ridge National Laboratory was changed and no longer coincides with the Gregorian/Julian calendar. The business month now ends earlier than the last day of the calendar month to allow adequate time for processing required financial reports to the Department of Energy. The precise reporting period for each month is indicated on the financial and milestone charts by including the exact start and finish dates for the current business month.

Thomas M. Rosseel

Thomas M. Rosseel, Manager
Heavy-Section Steel Irradiation

MONTHLY LETTER STATUS REPORT
April 2002

Job Code Number:	**W6953**
Project Title:	**Heavy-Section Steel Irradiation Program**
Period of Performance:	**4/1/98 to 4/1/03**
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1. PROJECT OBJECTIVE:

The primary goal of the Heavy-Section Steel Irradiation (HSSI) Program is to provide a thorough, quantitative assessment of the effects of neutron irradiation on the material behavior, and in particular the fracture toughness properties, of typical pressure vessel steels as they relate to light-water reactor pressure vessel (RPV) integrity. The program includes studies of the effects of irradiation on the degradation of mechanical and fracture properties of vessel materials augmented by enhanced examinations and modeling of the accompanying microstructural changes. Effects of specimen size; material chemistry; product form and microstructure; irradiation fluence, flux, temperature, and spectrum; and post-irradiation mitigation are being examined on a wide range of fracture properties. This program will also maintain and upgrade computerized databases, calculational procedures, and standards relating to RPV fluence-spectra determinations and embrittlement assessments. Results from the HSSI studies will be incorporated into codes and standards directly applicable to resolving major regulatory issues that involve RPV irradiation embrittlement such as pressurized-thermal shock, operating pressure-temperature limits, low-temperature overpressurization, and the specialized problems associated with low upper-shelf welds. Five technical tasks and one for program management are now contained in the HSSI Program.

2. TECHNICAL ACTIVITIES:

TASK 1: Program Management (T. M. Rosseel)

This task is responsible for managing the program to ensure that the overall objectives are achieved. The management responsibilities include three major activities: (1) program planning and resource allocation; (2) program monitoring and control; and (3) documentation and technology transfer. Program planning and resource allocation includes: (a) developing and preparing annual budgetary proposals and (b) issuing and administrating subcontracts to other contractors and consultants for specialized talents not available at Oak Ridge National Laboratory (ORNL) or that supplement those at ORNL. Program monitoring and control includes: (a) monitoring and controlling the project through an earned-value, project-management system; (b) ensuring that quality assurance (QA) requirements are satisfied; and (c) issuing monthly management reports. Documentation and technology transfer includes: (a) participating in appropriate codes and standards committees; (b) preparing briefings for the NRC; (c) coordinating NRC and internal ORNL review activities; (d) coordinating domestic and foreign information exchanges approved by NRC; and (e) documenting the activities of the program through letter and NUREG reports.

(Milestone 1.1.A) The draft FY 2002 budget document and proposal was prepared during this reporting period. It is anticipated that the revised document will be submitted to the NRC at the end of the first week of the next reporting period. Mid-year funding options were discussed with the NRC program manager. Final action will be dependent on the actual cost of the waste disposal of the 10th irradiation series capsules. (Please see 1.4.A).

(Milestone 1.2.B.1) The FNR resumed operation on April 5, 2002. Please see Task 6 for additional details.

(Milestone 1.3.C) The HSSI Program Manager was asked to prepare a cost estimate and brief proposal to the Nucleoelectrica Argentina S. A. (NASA) operators of the Atucha-I Nuclear Power Plant and the Nuclear Regulatory Autority (ARN), the Argentina nuclear regulatory agency. The project would include irradiating various subsized PCVN specimens to an end of life condition and to a life extension condition followed by testing in the IMET hot cells.

(Milestone 1.3.D) The NUREG report, D. W. Heatherly, K. R. Thoms, and M. T. Hurst, UT-Battelle, LLC, Oak Ridge, Tenn., *Heavy-Section Steel Irradiation Program's Reusable Irradiation Facility,* USNRC NUREG/CR-XXXX, (ORNL/TM-2002/77) was resubmitted with a corrected figure.

(Milestone 1.4.A) The disposal of the HSSI 10th Irradiation Series Capsule was discussed with the FNR Laboratory Manager. This non-reusable capsule and assembly, currently stored in the pool, was last used by the Program in 1992. Estimates of the cost to dispose this material will be finalized during the next reporting period.

Task 2: Fracture-Toughness Transition Issue and Master-Curve Methodology (M. A. Sokolov)

Fracture-toughness transition and Master Curve (MC) methodology will be broadly explored for pressure-vessel applications through a series of experiments, analyses, and evaluations in eight subtasks. Specifically, the effects of irradiation on fracture-toughness curve shape for highly embrittled RPV steels, dynamic effects, crack arrest, intergranular fracture, and subsized specimens will be explored; guidelines for the application of "surrogate" materials to the assessment of fracture toughness of RPV steels will be evaluated; and the fluence received in the HSSI irradiation experiments will be determined.

Subtask 2.1: Fracture-Toughness Transition-Temperature Shifts (M. A. Sokolov)

The purpose of this subtask is to collect and statistically analyze pertinent fracture-toughness data to assess the shift and potential change in shape of the fracture-toughness curves due to neutron irradiation. The MC methodology will be applied to provide a statistical analysis of the fracture-toughness data and Charpy data will be fitted by hyperbolic tangent functions. The resulting reference fracture-toughness temperature, T_0, shifts will be compared with Charpy shifts determined by various indexing methods.

(Milestone 2.1.A) The report by M. A. Sokolov and R. K. Nanstad, *Comparison of Irradiation-Induced Shifts of K_{Jc} and Charpy Impact Toughness for Reactor Pressure Vessel Steels*, NUREG/CR-6609 (ORNL/TM-13755), was published by the NRC in November 2000. No significant progress during this reporting period. However, as they become available, additional data sets will be analyzed and added to the database.

Subtask 2.2: Irradiation Effects on Fracture-Toughness Curve Shape (M. A. Sokolov)

The purpose of this subtask is to evaluate the assumption of constant shape for the MC even for highly embrittled RPV steels. The evaluation will be performed through the testing of a pressure-vessel steel weld that has been irradiated to a neutron fluence sufficient to produce a fracture-toughness transition-temperature shift (T_0) of about 150°C (270°F). A specially fabricated radiation-sensitive weld was selected to perform a pilot study on the ability of highly embrittled material to maintain the master curve shape. This weld had been fabricated and studied in Germany and supplied to ORNL by MPA, Stuttgart through a Memorandum of Agreement (MOA). The capsules, loaded with 21 1T compact specimens and a larger number of smaller specimens of Weld KS-01, were irradiated to a target fluence of 8.4 x 10^{18} n/cm^2 at the FNR during the first HSSI-IAR irradiation campaign. Evaluation of the MC shape will be determined with sufficient numbers of 1T compact specimens, 1T C(T), to allow for testing at three temperatures in the transition-temperature region. Additionally, 0.5T C(T), and pre-cracked Charpy V-notch (PCVN) specimens, using both quasi-static and dynamic methods, will be tested to investigate the use of more practical surveillance-size specimens. Tensile specimens will also be tested to determine the irradiation-induced hardening. Testing of irradiated specimens is dependent upon the availability of suitable hot-cell facilities. Evaluation of the mechanical properties of the unirradiated weld has been completed.

Specimens of the Midland beltline weld were fabricated and placed into the IAR facility at the FNR for irradiation to a fluence of at least 2.5 x 10^{19} n/cm^2 (>1 MeV). This irradiation is being conducted to evaluate the assumption of constant shape for the master curve with highly embrittled low upper-shelf RPV steels that exhibit onset of stable ductile tearing at relatively low fracture toughness.

Irradiated high-nickel welds from the Palisades steam generator will also be examined. Not only will this material provide additional information on curve shape effects, but it will permit experimental validation of an assumption of linear relationship between Charpy 41J and fracture toughness shifts for highly-embrittled materials.

(Milestone 2.2.A) Irradiation of the Midland beltline weld and a high-nickel weld from the Palisades steam generator is under way and irradiation of the remaining specimens is proceeding on schedule in the University of Michigan FNR. Please also see Task 6.1. Some of the Palisades steam generator specimens irradiated to an intermediate fluence were removed previously and have been received at the ORNL hot cells. They are scheduled for testing during the May-June timeframe.

(Milestone 2.2.C) As noted in the last report, 21 1T compact specimens of the submerged-arc weld KS-01, irradiated to $\sim 0.8 \times 10^{19}$ n/cm^2 (>1 MeV), were successfully tested as follows: six at 125°C, six at 150°C, five at 175°C, and four at 200°C. Following evaluation of the results, six additional 0.5T compact specimens were also at 100°C. The results have been evaluated relative to the shape of the master curve. As a preliminary observation, the fracture toughness data up to a median K_{Jc} value of about 130 MPa√m reasonably follow the shape of the master curve. Above that value, however, the fracture toughness test results deviate substantially from the shape of the curve in a manner indicating a shallower curve shape. For this material, this latter effect is believed to be due, at least in part, to the occurrence of intergranular fracture in the test specimens and shows the same behavior as that observed in the intergranular fracture study performed within subtask 2.6. On the other hand, the unirradiated specimens also exhibited significant intergranular fracture, but the results did not deviate from the shape of the master curve. Further statistical analysis will be performed with these data.

Three additional tensile tests have been completed at 250, 200, and –100°C. These results may shed light on the effects of the intergranular fracture observations relative to expected irradiation-induced hardening. Additionally, an NRC Letter Report is in preparation, a presentation will be made at the IGRDM meeting in Japan in May, and an abstract has been submitted for presentation at the ASTM International Symposium on Radiation Effects in Materials in Tucson, Arizona, June 2002.

The computer numerically controlled (CNC) milling machine in the hot cell has been exercised recently in preparation for machining of 0.4T compact specimens from the broken irradiated 1T compact specimens of KS-01 previously tested. Additionally, programming of the CNC system and design of fixtures has continued. These 0.4T specimens will be tested in the same general temperature range as the 1Ts to expand the database for this material. This activity will be performed under Task 2.9.

(Milestone 2.2.G formerly 2.4.D) The final report, *Evaluation of WF-70 Weld Metal from the Midland Unit 1 Reactor Vessel*, by D. E. McCabe, R. K. Nanstad, S. K. Iskander, D. W. Heatherly, and R. L. Swain, NUREG/CR-5736 (ORNL/TM-13748), was published by the NRC in November 2000.

Subtask 2.3: Dynamic Fracture Toughness [Combines previous subtasks 2.3 and 2.5] (R. K. Nanstad)

The purpose of this subtask is to evaluate the applicability of the master curve to dynamic fracture toughness of RPV steels. There are limited data available that suggest reasonable applicability of the master curve to such data; however, sufficient data under high-rate loading conditions for a reliable statistical assessment are not available. Previous plans within the HSSI Program included the evaluation of data from precracked Charpy specimens tested under impact conditions. Although the development of such techniques and resulting data are desirable, the first recommended step in evaluation of the master curve is high-rate loading of standard bend or compact specimens under non-impact conditions.

(Milestone 2.3.A) No significant progress during this reporting period. However, compact specimens (either 0.5T or 1.0T) will be machined from a material with a Master Curve pedigree, such as HSST Plate 02 or HSSI Welds 72W/73W, and tested at a rate consistent with the dynamic elastic-plastic fracture toughness annex in ASTM E-1820-2001. This will allow for a direct comparison between T_o from quasi-static and dynamic tests.

Subtask 2.4 - Statistical Representation of Valid K_{Ic} Data for Irradiated RPV Steels (R. K. Nanstad and J. G. Merkle)

The purpose of this subtask is to develop a statistical representation of valid K_{Ic} data for irradiated RPV steels from available elastic-plastic fracture toughness data. In the estimation of failure probabilities for RPVs subjected to postulated pressurized thermal-shock loadings, it is necessary to employ realistic statistical representations of both flaw size and fracture toughness. The rationally based statistical model of weak-link behavior incorporated in ASTM Standard E1921 and available large-scale experimental fracture mechanics data, are the potential bases for developing an improved representation of the statistical behavior of valid K_{Ic} data, with the expectation that uncertainties will be less than those resulting from the present method.

(Milestone 2.4.A) The draft letter report was completed in December. An initial review resulted in identification of some minor changes as well as the need for preparation of example calculations to be incorporated in the report. The draft letter report was sent to three knowledgeable persons outside of ORNL for independent review. Comments have been received from two of those reviewers.

Three example calculations have been completed; (1) the ASME K_{Ic} database, (2) the ORNL thermal shock vessel tests, and (3) HSST Plate 02 precracked Charpy data. The example calculations have been very useful in the identification of the significance of various parameters, particularly the α parameter that describes the specimen size criterion in E 399 and is equal to 2.5 in that test standard for K_{Ic}. In the first example calculation, the ASME K_{Ic} database was adjusted to 1T equivalent values, T_o was calculated, and the 2% and 98% tolerance bounds to K_{Ic} were calculated using an α value of 2.5. This works for the K_{Ic} data, but the size effects involved are only the assumed statistical size effects. When two independent sets of data, one for small specimens (EPFM) and one for large (LEFM) data, are to be reconciled, constraint effects as well as statistical size effects will appear. In this case, a reference stress, σ_R, is defined as $\sigma_Y/\sqrt{\alpha_o}$. The next step is then to determine a value of the reference stress that reconciles at least independent pairs of data for the same family of steels. The second and third examples, then, result in a value of 10 for α to provide a tolerance bound for all the data.

A presentation based on the method and including the above example calculations was presented by R. K. Nanstad to the IAEA Coordinated Research Program Task Group on Master Curve Guidelines, 10-12 April in Paris, France. The example calculations will be incorporated into the letter report and published in June.

Subtask 2.5 (formerly 2.10): Dosimetry and Fluence Analysis of the IAR Irradiation Capsules (C. A. Baldwin, I. Remec, and T. M. Rosseel)

The purpose of this task is to measure and analyze the dosimeters used during the HSSI-IAR irradiation campaigns and to obtain accurate fluence determinations.

(Milestone 2.5.A formerly 2.10.A) No significant progress during this reporting period. However, with the completion of the exposure parameters calculations for the first metallurgical specimens (KS-01 specimens) irradiated in HSSI IAR facility, a draft report was completed and reviewed as noted previously. This report is anticipated to be incorporated as appendices in appropriate NUREG reports discussing specimens whose dosimetry was calculated from this report. Additionally, radiometric dosimeter sets will be prepared for each IAR capsule shelf or cell so as to provide a more accurate characterization of the fluences as specimens are shuffled within the irradiation facility to maximize irradiation efficiency. These will be prepared prior to any additional specimens being added to the IAR.

(Milestone 2.5.B formerly 3.2.B) Neutronics Analysis of the IAR/UCSB Irradiation Capsules - (I. Remec, E. D. Blakeman, and C. A. Baldwin). The report entitled, *Characterization of the Neutron Field in the HSSI/UCSB Irradiation Facility at the Ford Nuclear Reactor*, by I. Remec, E. D. Blakeman, and C. A. Baldwin, NUREG/CR-6646 (ORNL/TM-1999/140) was submitted to the NRC in September 1999.

Subtask 2.6: Intergranular Fracture (R. K. Nanstad and J. G. Merkle)

This subtask will address the issue of whether the MC technique can be applied to materials that experience brittle fracture by an intergranular mechanism. Specifically, it will be determined whether steels that experience intergranular fracture can be correctly characterized by the MC T_o temperature and whether the transition-curve shape can be changed by different fracture modes. Complete intergranular fracture from temper embrittlement occurs only at lower-shelf temperatures. As it is with transgranular cleavage, the transition to upper shelf is marked by an increased volume percentage of ductile rupture mixed with the lower-shelf, brittle-fracture mechanism. Since the onset of crack instability is most likely triggered in the brittle zones, the critical issue is understanding the influence of the triggering mechanism on the distribution of K_{Jc} values obtained. This information can be obtained on the lower shelf and, in part, into the transition range.

The proposed approach is to determine if there is an operational weakest-link effect when instability is triggered within an intergranular region. If an effect is observed, there should also be a measurable specimen-size effect on K_{Jc}. It will also be determined if the temper-embrittled materials exhibit a change in the J-R fracture toughness since such steels do not show a significant change in upper-shelf CVN energy.

The modified A302 grade B steel selected to evaluate intergranular-fracture effects on the universal MC shape assumption was specially heat treated to temper embrittle the material, and fracture-toughness testing was performed. In the analysis of the data, however, it became clear that additional testing was deemed necessary to allow for a more definitive conclusion regarding the relationship between the intergranular fracture results and the Master Curve. Additional 0.5 T C (T) specimens have been fabricated and testing is underway.

(Milestone 2.6.A) All testing has been completed on this project. A presentation and paper on this subject were prepared and delivered by R. K. Nanstad at the IAEA Specialists' Meeting on Master Curve in Prague, Czech Republic, in September. The paper will be published in the IAEA meeting proceedings.

(Milestone 2.6.B) A total of about 50 compact specimens of 0.5T, 1T, and 2T were tested from –125 to 100ºC, with brittle intergranular fracture up to 50ºC. The fracture toughness vs temperature relationship appears to follow the master curve shape up to about 150 Mpa√m with an apparent T_o of -100ºC. However, the ductile to brittle transition-temperature behavior is significantly different than that observed for cleavage fracture in that brittle intergranular fracture is still observed for this material at test temperatures up to 150ºC above the master curve T_o. Additionally, the relationship between fracture toughness and Charpy toughness was significantly different from cleavage fracture results.

(Milestone 2.6.C) The draft letter report has been completed and is currently in the review process. It will be submitted to the NRC Program Manager in May. Results of this project were incorporated in a presentation at the NRC Workshop on Fracture Mechanics in Rockville on February 20-21 and were also incorporated in a presentation and a paper by R. K. Nanstad at the NATO Advanced Research Workshop in Kiev, Ukraine, 21-25 April, 2002. The paper will be published in a NATO Technical Series book following technical review.

Subtask 2.7: Sub-sized Specimens (M. A. Sokolov)

The purpose of this subtask is to evaluate the applicability of the weakest-link theory-based size-adjustment procedure in the MC methodology to specimen sizes that are the most likely to be present in surveillance capsules. The MC methodology will be applied using precracked Charpy-size or smaller specimens to test the lower-size limit applicability. Testing will be performed at two or more temperatures with at least six specimens at each temperature. The exact number of temperatures and specimens will be determined following analysis of initial results. The testing of these subsize specimens will also satisfy the HSSI Program suggested testing matrix within the New Coordinated Research Program (CRP) of the International Atomic Energy Agency (IAEA). Subsized specimens will be fabricated from previously characterized materials within the HSSI Program, such as HSST Plate 02, HSSI Welds 68W through 73W, the Midland beltline weld and plate JRQ.

(Milestone 2.7.A) The testing and analysis of specimens has been completed. These specimens were machined from three blocks of materials into 1T C(T) and precracked Charpy specimens for the size effect study. Two of the blocks are broken halves of 4TC(T) specimens of two A302B plates previously tested by the HSSI Program. The third block of material is the well-characterized Plate 13A. This study is specifically designed as an evaluation of the precracked Charpy specimen. However, a series of subsize specimens of JRQ steel has also been completed. The specimens are 0.2TC(T) and 0.4TC(T), and 5×5 mm and 5×10 mm SE(B) specimens. Results of this project were incorporated in a presentation at the NRC Workshop on Fracture Mechanics in Rockville on February 20-21. A letter report is in preparation.

Subtask 2.8: Quantification of Surrogate Materials for use in a Statistics-Based Fracture Toughness Assessment (R. K. Nanstad and J. G. Merkle)

The purpose of this subtask is to identify issues and make recommendations for the use of surrogate or non-identical materials in the assessment of fracture toughness of RPV steels. In many cases, surveillance programs for RPVs include specimens of a material that are not identical to the critical material in the RPV and test results from those surveillance specimens are used to represent the critical material in RPV analysis. This issue has been identified as an overarching issue in that a more complete understanding of most other issues is needed in order to reduce the uncertainties associated with material variability.

(Milestone 2.8.A) Further review of data, both unirradiated and irradiated, is continuing, which will eventually result in the preparation a table of uncertainties that could be utilized for evaluating the application of surrogate materials. This work is intended to be included in the final NUREG report on this subject. A different methodology is being evaluated for potential application to this issue. The methodology involves a combination of non-linear estimators including domain models, neural networks, vector space methods, and nearest neighbor regressions. The evaluation will examine, in a very preliminary manner, whether the methodology appears applicable to the issue and whether it can be implemented in a relatively straightforward manner. This effort, which began in July, has been completed except for the final report to the HSSI Program Manager.

(Milestone 2.8.B) A draft NUREG report, *Considerations for Use of Surrogate Materials Data for Reactor Pressure Vessels*, by R. K. Nanstad, J. G. Merkle, and J. Galt, was previously prepared and sent to the NRC technical monitor for review.

Subtask 2.9: Application of the Master Curve to Highly Embrittled Materials (M. A. Sokolov)

The purpose of this task is to determine the effect of the interaction of low-energy ductile crack initiation and intergranular fracture with cleavage in the transition region for highly embrittled materials. The approach used is to prepare up to twelve 0.4T C(T) specimens from previously irradiated and tested KS01 specimens and determine fracture toughness. These data will be compared with results from small and large compact specimens as well as pre-cracked Charpy specimens from the same material in the unirradiated and irradiated conditions.

(Milestone 2.9.A) No significant progress during this reporting period

Subtask 2.10: Investigate the Bias Term Added to T_0 Values Determined from Pre-Cracked Charpy Specimens (R. K. Nanstad)

The purpose of this task is to perform a systematic study of the bias term added to T_0 values determined from pre-cracked Charpy specimens, such as that used in the Kewaunee evaluation. The approach would utilize both analytical and experimental methods. HSSI Plate 02 material will be used since extensive C(T) data on this material are available.

(Milestone 2.10.A) No significant progress during this reporting period

Task 3: Irradiation Embrittlement of RPV Steel **(R. K. Nanstad)**

The purpose of this task is to examine two important issues affecting the application of thermal mitigation procedures to irradiated RPVs. The first will address the effects of temper embrittlement on the coarse-grained HAZ in RPV steels. The second will examine the effects of reirradiation on K_{Jc} and K_{Ja} in order to evaluate the relative changes in the recovery and reembrittlement between CVN and fracture-toughness properties and a detailed examination of reembrittlement rates. These questions will be addressed in-part using specimens supplied by the Swiss HSK and PSI.

Subtask 3.1: HAZ Embrittlement (M. A. Sokolov and R. K. Nanstad)

The purpose of this subtask is to determine the susceptibility of RPV heat affected zones (HAZ) to irradiation/thermal aging-induced temper embrittlement. Research conducted to date by ORNL and AEA-Technology on temper embrittlement of the coarse-grain materials in HAZs of RPV steel multi-pass welds has revealed the potential for such embrittlement under some conditions. AEA-Technology discovered that using high-temperature austenitization to produce very coarse grains, followed by thermal aging resulted in large transition-temperature shifts. Further, post-irradiation thermal annealing of such material resulted in an even greater increase of the transition temperature. Subsequent research at ORNL under the previous HSSI Programs used five commercial RPV steels to investigate potential temper embrittlement. Since the amount of intergranular fracture observed was unexpected, further studies are required to resolve the issue.

The first phase of this project simulated the AEA-Technology heat treatment and observed large transition-temperature shifts, although not as large as those from AEA-Technology. The second phase of the ORNL study used the same five RPV steels, but used the Gleeble system (an electrical-resistance heating device) to produce material deemed representative of the coarse-grain region in RPV welds. These materials revealed very high toughness in the initial condition (i.e., from the Gleeble). After thermal aging at about 454°C for 168 hours the materials exhibited only modest transition temperature increases, however, after aging at the same temperature for 2000 hours, significant transition temperature increases were observed. Of course, 2000 hours is much in excess of the time that RPV steels would be exposed to mitigation cycles, but potential synergistic effects of irradiation and thermal aging are unknown. Moreover, questions also remain regarding other time-temperature effects, such as post-irradiation mitigation at somewhat lower or higher temperatures.

(Milestone 3.1.A) The letter report by R. K. Nanstad, D. E. McCabe, M. A. Sokolov, C. A. English, and S. R. Ortner, *Comparison of Effects of Thermal Aging, Irradiation, and Thermal Annealing on Propensity for Temper Embrittlement on an RPV Submerged-Arc Weld HAZ*, ORNL/NRC/LTR-01/07, has been published and distributed.

(Milestone 3.1.B) As noted previously, progress to investigate the effect of cooling rate following postweld heat treatment, additional material would be treated in the Gleeble system to simulate the coarse-grain HAZ as accomplished previously. This would then be followed by thermal aging, as well as by irradiation and thermal annealing. Excess material from the original investigation has been identified, and the proposed study has been discussed with the NRC technical monitor and approved. Plans are now underway for specimen machining in preparation for Gleeble treatment. Consideration is also being given to reirradiation of the remaining specimens from the initial series.

Subtask 3.2 (formerly 3.3): Evaluation of Reirradiated JRQ Specimens (R. K. Nanstad, E. T. Manneschmidt, and T. M. Rosseel)

The purpose of this subtask is to examine the fracture-toughness behavior of a model steel that has been irradiated, tempered, and re-irradiated. The specimens, which were fabricated from a heat of A533 grade B class 1 steel identified as JRQ, were prepared by the Paul Scherrer Institute (PSI) as part of the IAEA CRP 3. This steel has been used for various studies sponsored by the IAEA and is under consideration as a reference material for various other RPV studies, including surveillance programs. This subtask is collaboratively conducted under a Memorandum of Agreement (MOA) between ORNL and PSI. Charpy impact, pre-cracked Charpy, and tensile specimens are available in the irradiated, and in the irradiated/annealed/re-irradiated conditions. Testing of irradiated specimens is dependent upon the availability of suitable hot-cell facilities.

(Milestone 3.2.A formerly 3.3.A) A total of 46 Charpy V-notch impact specimens were previously tested and the results were presented in a previous progress report. A presentation on this work, to include previous work by PSI, was presented by R. K. Nanstad at the International Atomic Energy Agency (IAEA) Specialists' Meeting on Radiation Embrittlement and Mitigation in Gloucester, U.K., 14-17 May 2001. The presentation was co-authored by Ph. Tipping (Swiss HSK), G. Waeber (PSI), and Kalkhof (PSI). A previous progress report graphically showed the results.

During this period, the four remaining Charpy impact specimens in the irradiated condition have been tested and the data reanalysed. A number of other specimens in the two irradiation/annealed/reirradiated (IAR) conditions have been thermally annealed at 460EC for either 18 h or 168 h and tested to provide data for the material in the IARA condition. Additionally, some of the IAR specimens were thermally annealed and will be inserted into the HSSI irradiation facility for further reirradiation to provide results in the IARAR condition. Some of the precracked Charpy specimens were also thermally annealed and will be tested along with those in the irradiated and IAR conditions in May.

Task 4: Validation of Irradiated and Aged Materials (R. K. Nanstad)

The purpose of this task is to validate the assessment of the effects of neutron irradiation on the fracture-toughness properties of typical RPV materials obtained in the previous HSSI (L1098) Program, Tasks 2 and 3 of this program, and retired RPVs. This will be accomplished through the examination of the effects of neutron irradiation on the fracture toughness (ductile and brittle) of the HAZ of welds and of typical plate materials used in RPVs. The irradiated materials from retired RPVs will be machined and tested in the Irradiated Materials Examination and Testing (IMET) hot cells. The aging of stainless steel welds will also be explored in this task. Other issues to be address include foreign interactions and technical assistance to the NRC.

Subtask 4.1: (formerly 4.3) Toughness Changes in Aged Stainless Steel Welds (R. K. Nanstad)

The purpose of this subtask is to evaluate the effects of irradiation on fracture-toughness testing of irradiated stainless-steel weld-overlay cladding specimens at 288°C. This will complete the testing of the matrix from the HSSI (L1098) 7th Irradiation Series. The PCVN specimens were irradiated in HSSI Capsule 10.06.

(Milestone 4.1.B formerly 4.3.B) The report, *The Effect of Aging at 343°C on the Microstructure and Mechanical Properties of Type 308 Stainless Steel Weldments*, by D. J. Alexander, K. B. Alexander, M. K. Miller, and R. K. Nanstad, NUREG/CR-6628 (ORNL/TM-13767), was published in November 2000.

Subtask 4.2: (formerly 4.4) Foreign Interactions (R. K. Nanstad)

The purpose of this subtask is to provide technical support and continued collaboration for a number of cooperative relationships with foreign institutions in the area of radiation effects on RPV steels. Collaborative relationships may be developed during the course of this program and will be developed with the cognizance of NRC. Current relationships are:

1. Cooperation with SCK-CEN in Belgium regarding the supply of well-characterized materials and comparison of test results, including dynamic PCVN testing for development of RPV testing standards.

2. Collaboration with AEA-Technology in the United Kingdom regarding fracture toughness testing and temper embrittlement of RPV HAZs.

3. Collaboration with institutes in the Czech Republic, Germany and Finland on fracture toughness with small specimens in support of MC evaluations.

4. Collaboration with PSI in Switzerland on evaluation of reirradiation effects.

5. Information and data exchange with all of the above and other countries, especially regarding RPV surveillance data and comparisons of fracture toughness and Charpy impact data.

6. Participation, including membership on the Executive Committee, in the International Group on Radiation Damage Mechanisms (IGRDM).

7. Participation in two coordinated research programs (CRPs) sponsored by the International Atomic Energy Agency (IAEA), informally designated CRP-5 and CRP-6. These CRPs will investigate: the use of PCVN specimens to determine fracture toughness of RPV steels, and effects of nickel on irradiation-induced embrittlement of RPV steels, respectively.

8. Collaboration with NRI, Rez (Czech Republic) in the area of microstructural evolution in RPV steels as a consequence of reirradiation.

9. Collaboration with MPA-Stuttgart in Germany regarding applicability of the master curve to highly embrittled RPV steels.

10. Collaboration with researchers at the University of Lille, France, in the area of primary radiation damage simulation.

(Milestone 4.2.A, formerly 4.4.B) R. K. Nanstad attended the IAEA Specialists' Meeting on Master Curve Fracture Toughness, held in Prague, Czech Republic, in September 2001. Additionally, R. K. Nanstad attended a meeting of the IAEA CRP-5 in Prague. A trip report was completed by R. K. Nanstad in January 2002 and submitted (ORNL/FTR-142586). R.K. Nanstad attended a meeting of the IAEA CRP-5 in Paris, France in April, 2002 and submitted a trip report (ORNL/FTR-156789). R. K. Nanstad also attended a NATO Advanced Research Workshop in Kiev, Ukraine in April, 2002; a trip report is in preparation.

R. K. Nanstad, as secretary of the International Group on Radiation Damage Mechanisms (IGRDM) in Pressure Vessel Steels, has updated the IGRDM membership list and is revising the IGRDM charter. The next meeting of the IGRDM will be held in Awaji Island, Japan, from 20-24 May, 2002. Preliminary organization of the meeting is a cooperative effort between the secretary, the chairman (T. J. Williams, Rolls-Royce), the technical area coordinators, and the local host committee (chaired by Dr. Naoki Soneda, CRIEPI). A total of 87 presentations have been offered by the members and the preliminary draft of the program has been prepared. R. K. Nanstad, M. A. Sokolov, R. E. Stoller, and M. K. Miller have all sent pre-registration information to the local host committee for the purpose of securing adequate lodging, while all four members have also recently submitted proposed presentation titles as required. Nanstad will be supported by the HSSI Program. The other three staff members will be supported by DOE.

Subtask 4.3: (formerly 4.5) Technical Assistance (R. K. Nanstad and M. A. Sokolov)

The purpose of this subtask is to provide special analytical, experimental, and administrative support to the NRC in resolving various regulatory issues related to irradiation effects. Specific activities will be identified, on an as-needed basis, by the NRC Project Manager. Examples of such activities include: 1) evaluation of the effects of post-weld heat treatment (PWHT) on the copper solubility and fracture toughness of unirradiated RPV steels and 2) machining of material removed from retired irradiated RPVs for evaluation of through-thickness attenuation of irradiation embrittlement.

(Milestone 4.3.B formerly 4.5.F) A presentation of progress on the PWHT study was made at the IGRDM meeting in September in Leuven, Belgium, and was also made at the IAEA Specialists' Meeting on Radiation Embrittlement and Mitigation in Gloucester, U.K., 14-17 May 2001. Because of hot cell scheduling issues, testing of the irradiated subsize Charpy specimens has not been conducted, but is now anticipated for April-May. A letter report will be prepared following completion of all testing and evaluation. A paper, for which M. K. Miller was the lead author, with the unirradiated Charpy results and the atom probe tomography results was presented at the Tenth International Conference on Environmental Degradation of Materials in Nuclear Power Systems - Water Reactors, August 5-9, 2001, in Lake Tahoe, Nevada. R. K. Nanstad attended the meeting and presented the paper. Additionally, M. K. Miller, S. S.

Babu, M. A. Sokolov, R. K. Nanstad, and S. K. Iskander, “Effect of Stress Relief Temperature and Cooling Rate on Pressure Vessel Steel Welds,” *Mater. Sci. Eng. A 327*, 76-79 (2002) was published.

(Milestone 4.3.C, formerly 2.5.A) The draft NUREG report, *Detailed Results of Testing Unirradiated and Irradiated Crack-Arrest Toughness Specimens from the Low Upper-Shelf Energy, High Copper Weld, WF-70*, by S. K. Iskander, C. A. Baldwin, D. W. Heatherly, D. E. McCabe, I. Remec, and R. L. Swain, NUREG/CR-6621 (ORNL/TM-13764), is finished, but completion of the final report and submission to the NRC for publication will be delayed until about June of 2002 due to personnel reductions.

(Milestone 4.3.D formerly 3.2.C) Irradiated, annealed, and reirradiated specimens of HSSI Weld 73W were reinserted into the IAR facility at the FNR to accumulate additional fluence. The results obtained from tests of some of the reirradiated specimens showed a much lower transition temperature shift than expected. The target total fluence for the specimens is about 4×10^{19} n/cm^2 and the irradiation has been completed. The specimens have been received at the ORNL hot cells and will be scheduled for testing in the near future.

(Milestone 4.3.E formerly 4.1.2.B) The NUREG report (ORNL/TM-2000/343), *Attenuation of Charpy Impact Toughness Through the Thickness of a JPDR Pressure Vessel Weldment*, by S. K. Iskander, J. T. Hutton, L. E. Creech, M. Suzuki, K. Onizawa, E. T. Manneschmidt, R. K. Nanstad, T. M. Rosseel, and P. S. Bishop, was submitted to the NRC in January, 2001 as part of an Office of Research Operational Milestone.

(Milestone 4.3.F) As part of the NRC evaluation of control rod drive mechanism housing materials, the HSSI Program was asked to perform special tensile testing of Inconel 182 weld metal and three other materials. The Inconel 182 weldment was supplied by Battelle Columbus Laboratories (BCL). The weld metal was solution annealed at 1900°F for 30 minutes and air cooled, followed by machining into 0.25-in.-diam tensile specimens. In collaboration with BCL and Engineering Mechanics Corporation (ECM) of Columbus, tensile tests have been conducted at five temperatures: room temperature, 600, 1000, 1400, and 1800°F. All the tests have been completed and the digital stress-strain curves sent to BCL and EMC. Similar specimens have been machined from A508 class 3 forging steel, a piece of the Midland Reactor Vessel, obtained at ORNL. This material will be tested in the as-received condition. Testing of these specimens has been initiated and will be conducted at the same test temperatures as those of the Inconel 182.

(Milestone 4.3.G, formerly 4.2.A) The NUREG report, K. Onizawa, E. van Walle, W. Pavinich, and R. K. Nanstad, UT-Battelle, LLC, Oak Ridge, Tenn., *Results and Analysis of The ASTM Round Robin On Reconstitution*, USNRC NUREG/CR-XXXX, (ORNL/TM-2001/34) was resubmitted to the NRC due to mail security damage.

<u>Subtask 4.4: Obtaining RPV material for SONGS-1</u> (R. K. Nanstad, R. E. Stoller, and T. M. Rosseel)

The purpose of this subtask is to obtain Southern California Edison’s, the owner of San Onofre Nuclear Generating Station (SONGS) Unit 1 Reactor, consent and assistance in obtaining trepans from the SONGS-1 RPV and to provide a preliminary estimate of the potential problems that could be encountered during this operation as well as a preliminary estimate of the cost to obtain the trepans. This effort, which would permit the evaluation of through-thickness attenuation of irradiation embrittlement of a service-irradiated RPV, will be coordinated with EPRI. A letter report will also be prepared that describes the progress and status of that effort.

(Milestone 4.4.A) The letter report by R. E. Stoller and R. K. Nanstad, “A Proposal for Sampling the SONGS-1 Reactor Pressure Vessel,” (ORNL/NRC/LTR-02/12), which incorporates the conceptual study of the scope and cost estimate to remove up to six, five-inch-diameter through-wall trepan samples from the San Onofre (SONGS) Unit 1 pressure vessel, was issued in final form during the previous reporting period.

<u>Task 5: Modeling & Microstructural Characterization and Embrittlement Data Base</u> (T. M. Rosseel)

This task shall determine the microstructural basis for radiation-induced property changes in RPV materials to aid in understanding and applying the experimental results obtained in Tasks 2 through 4. The three subtasks will comprise: (1) theoretical modeling and data analysis; (2) experimental investigations; and, (3) maintaining and updating the Embrittlement Data Base (EDB). The modeling work will include the development of an improved description of primary-damage formation in irradiated materials, and the further development and use of predictive models of radiation-induced microstructural evolution and its impact on the mechanical behavior of RPV materials. The experimental component will focus on detailed microstructural characterization of RPV materials in relevant conditions, including long-term, thermally-aged and high-fluence irradiated materials. The information obtained from the experiments and microstructural characterization will be used to support validation of the theoretical models. Further model verification will be carried out through use of the mechanical property data contained in the EDB, and data generated in other experiments coordinated by this task. Updated versions of the EDB will be issued as appropriate.

The major areas of inquiry include: (a) the effects of chemical composition; (b) the role of displacement rate (neutron flux); (c) damage attenuation through the RPV wall; and, (d) potential new hardening mechanisms and embrittlement behavior at very high fluence. The overall goal of the task is to provide an embrittlement model that can be used in a predictive way to anticipate the response of RPV materials at high fluences near or slightly beyond their nominal end-of-life, and to provide support to the NRC for related safety or licensing questions. The tools developed in this task will also be used to support the analysis of experimental results obtained in other program tasks. Both the modeling and experimental research will be coordinated with complementary activities carried out by other NRC contractors and the international community.

The nature of the modeling and data analysis carried out under this task requires that it extend over the lifetime of the program. Model development and validation is coordinated with the experimental activities in an iterative fashion. Work and milestone schedules will be contingent on available funding.

<u>Subtask 5.1: Modeling of Damage Evolution</u> (R. E. Stoller)

The modeling of damage evolution will focus on the development of an integrated microstructural model that includes components developed at ORNL and by other NRC contractors and will provide the basis of an improved embrittlement model. The integrated model may include thermodynamic components to account for chemical effects that may be particularly important at high-fluence and in low-copper steels. A more detailed treatment of point defect and solute clustering will also be pursued.

(Milestone 5.1.B) The NUREG report entitled *Evaluation of Neutron Energy Spectrum Effects Based on Primary Damage Simulations in Iron*, NUREG/CR-6670, (ORNL/TM-1999/334) was submitted to the NRC in July, 2000.

Subtask 5.2: Microstructural Characterization (M. K. Miller and K. F. Russell)

APFIM characterization will be used to determine whether additional radiation-induced phases are forming. In addition, the methods of APFIM, SANS, and field-emission scanning transmission electron microscopy (FEGSTEM) have been used to determine the matrix copper content and the chemical composition of radiation-induced precipitates in RPV materials. Although there is qualitative agreement between the three methods, some significant inconsistencies exist. Comparisons among the techniques will be performed so as to resolve the apparent inconsistencies.

(Milestone 5.2.A) The microstructure of neutron irradiated KS-01 weld has been characterized by atom probe tomography. This weld was selected for characterization because the levels of copper, manganese, nickel and chromium were each amongst the highest of all the steels used in reactor pressure vessels and it exhibited a high sensitivity to neutron irradiation at a relatively low fluence. The composition of this weld is Fe- 0.37 wt% Cu, 1.23% Ni, 1.64% Mn, 0.70% Mo, 0.47% Cr, 0.18% Si, 0.017% P, 0.012% S, 0.06 % C (Fe- 0.33 at. % Cu, 1.17% Ni, 1.67% Mn, 0.41% Mo, 0.50% Cr, 0.36% Si, 0.031% P, 0.021% S, 0.28% C). The weld was examined after neutron irradiation to a relatively low fluence of 0.8 x 1019 n. cm-2 (E > 1 MeV) at a temperature of 288°C in the HSSI IAR facility at the University of Michigan FNR. After neutron irradiation, this weld exhibited a large Charpy 41J shift of 169K and a large fracture-toughness transition-temperature shift of 160K. It also exhibited a significant decrease in upper shelf energy (USE) from 124 J to ~78 J, and an increase in the yield strength from 600 to 826 MPa.

Atom probe tomography revealed a high number density (~3 x 10^{24} m^{-3}) of Cu-, Mn-, Ni-, Si- and P-enriched precipitates in the neutron irradiated weld. A lower number density (~1 x 10^{23} m^{-3}) of P clusters was also observed. The average radius of gyration, *l*g, of the Cu-, Mn-, Ni-, Si- and P-enriched precipitates was determined to be 3.3 ± 0.8 nm. The average elemental radii of gyrations, *l*g, are as follows: (Cu) 2.6, lg (Ni) 2.9, lg (Mn) 3.4 nm. The elemental radii of gyration based on the Cu, Ni and Mn atoms in each precipitate indicate that the copper is concentrated at the core of the precipitate, the manganese has a more extensive profile into the matrix and the nickel is enriched at the precipitate-matrix interface. The average composition of the individual precipitates, as determined by the maximum separation envelope method, was Fe-13.3 at. % Cu, 9.7% Ni, 26.6% Mn, 0.86% Si, 0.27% Cr, 0.20% P, and 0.17% Mo. These values revealed significant enrichments of Cu (89x), Ni (29x), Mn (24x), Si (2.7x), and P (5.9x) and depletions of Cr (0.5x), Mo (0.6x) and Fe (0.5x) compared to the matrix composition. The high copper, manganese and nickel levels in the weld produce a high super saturation of copper and hence a high number density of precipitates.

A draft NUREG report entitled, *Effect of Reirradiation Rate on The Charpy Properties of an Irradiated/Annealed High Copper Reactor Pressure Vessel Weld HSSI 73W*, that incorporates the atom probe tomography results on weld 73W specimens, has been prepared.

<u>Subtask 5.3: Modeling and Embrittlement Data Base (formerly 7.1)</u> (J.-A. Wang)

This subtask was, until March 1, 1999, part of the Embrittlement DataBase (EDB) and Dosimetry Evaluation Program, JCN: 6164. The objectives of the subtask have been reduced but the focus remains the same. Nuclear radiation embrittlement information from radiation embrittlement research on nuclear RPV steels and from power-reactor surveillance reports will be maintained in a database to be published on a periodic basis. The information will assist the Office of Nuclear Reactor Regulation and the Office of Nuclear Regulatory Research to effectively monitor current procedures and data bases used by vendors, utilities, and service laboratories in the pressure vessel irradiation surveillance program. The specific activity of the subtask is to maintain and update the EDB. Additional work on statistical analysis of toughness databases will also be performed. The purpose of this effort is to design a new data fitting procedure to generate a new multi-space trend surface that can properly reflect the inhomogeneity of the surveillance materials, and utilize this multi-space trend surface to link and to project the surveillance test results to that of reactor pressure vessel steels.

(Milestone 5.3.A) The completed UPDATE-11 of PR-EDB was transmitted to the US NRC technical program monitor in July 2000. No new surveillance reports have been received.

(Milestone 5.3.B) The feasibility study for developing a new fitting model for surveillance materials is continuing and nearly complete. The report will be completed early in the next reporting period.

<u>Task 6: Test Reactor Irradiation Coordination</u> (K. R. Thoms)

This task provides the support required to supply and co-ordinate irradiation services needed by NRC contractors (such as the UCSB and the ORNL HSSI Program) at the University of Michigan FNR. These services include the design and assembly of irradiation facilities (and/or capsules), as well as arranging for their exposure, periodic monitoring by remote computer access and interaction with the FNR staff, and return of specimens to the originating research organization.

<u>Subtask 6.1: Operate the HSSI Irradiation (IAR) Facility</u> (K. R Thoms and D. W. Heatherly)

With the fabrication, installation, and initial testing of the HSSI IAR facility at the University of Michigan FNR completed as part of the previous (L1098) HSSI program, the activities associated with the new program include supervising the irradiation of the reusable irradiation capsules in the dual-capsule irradiation facility at FNR. A NUREG report on the design, assembly, installation, and operation of the HSSI IAR facility will be prepared.

(Milestone 6.1.A) Irradiation of the ORNL specimens in the HSSI-IAR irradiation facilities resumed during this reporting when the FNR resumed operation after several weeks of being shut down.

As describe in the previous reporting period, the FNR was shut down after only 11.4 hours of operation in early March due to reactor administrative-operation problems. The FNR remained shut down for the remainder of March while the problems were addressed and new procedures were put into place. The necessary adjustments and procedural changes were completed and the FNR staff received restart permission early in this reporting period. Operation of the reactor resumed on April 5, 2002 with a shortened reactor half-cycle number 470A.

The HSSI-IAR irradiation facilities continued to operate without incident during this reporting period. During this period, the HSSI-IAR facilities were irradiated for 3.4 days of the shortened reactor half-cycle 470A and for 10 days during reactor half-cycle 470B. Reactor half-cycle 470B ended on 4/26/02.

During the 3.4 days of reactor half-cycle 470A, the IAR irradiation facilities received a total of 81 EFPH (effective full power hours) followed by an additional 232 EFPH during the full 10-day reactor half-cycle 470B. During this reporting period, the HSSI-IAR irradiation facilities received a total of 313 EFPH.

At the beginning of this reporting period, the second group of specimens to be irradiated in the new IAR facilities had been irradiated for a total of 9886 EFPH. At the end of this reporting period, the second group of specimens had been irradiated for a total of 10,199 EFPH. The facilities have been in service for a total of 14,908 EFPH. The HSSI-IAR irradiation facilities were installed and began operation at the FNR in December, 1998.

(Milestone 6.1.B) The revised NUREG report, D. W. Heatherly, K. R. Thoms, and M. T. Hurst, UT-Battelle, LLC, Oak Ridge, Tenn., *Heavy-Section Steel Irradiation Program's Reusable Irradiation Facility*, USNRC NUREG/CR-XXXX, (ORNL/TM-2002/77) was resubmitted to the NRC with a corrected figure and a few other minor changes.

<u>Subtask 6.2: Operate the HSSI/UCSB Irradiation Facility</u> (K. R. Thoms and D. W. Heatherly)

This subtask includes supervising the overall operation and providing assistance to the reactor personnel in the routine operation and maintenance of the HSSI-UCSB irradiation facility. A NUREG report on the design, assembly, installation, and operation of the UCSB facility will be prepared.

(Milestone 6.2.A) Irradiation of the UCSB specimens in the HSSI-UCSB irradiation facility resumed during this reporting when the FNR resumed operation after several weeks of being shut down.

As describe in the previous reporting period, the FNR was shut down after only 11.4 hours of operation in early March due to reactor administrative-operation problems. It remained shut down for the rest of March while the operational problems were addressed and new procedures were put into place. The necessary adjustments and procedural changes were completed and the FNR staff received restart permission early in this reporting period. Operation of the reactor resumed on April 5, 2002 with a shortened reactor half-cycle number 470A.

The HSSI-UCSB irradiation facility continued to operate without incident during this reporting period. During this period, the irradiation facility was irradiated for 3.4 days of the shortened reactor half-cycle 470A and for 10 days during reactor half-cycle 470B. Reactor half-cycle 470B ended on 4/26/02.

During the 3.4 days of reactor half-cycle 470A, the HSSI-UCSB irradiation facility received a total of 81 EFPH (effective full power hours) followed by an additional 232 EFPH during the full 10-day reactor half-cycle 470B. During this reporting period the irradiation facilities received a total of 313 EFPH.

At the beginning of this reporting period, the HSSI-UCSB facility and original specimen compliment had been irradiated for a total of 21,747 EFPH. At the end of this reporting period, the irradiation facility and original specimen compliment had been irradiated for a total of 22,060 EFPH. The original irradiation plan received from the UCSB experimenters indicated that the final specimens would be removed from the facility after 13,500 EFPH. Additional specimen irradiations have been added to the original plan and, at the end of this reporting period, the UCSB irradiation program had obtained 163% of the original desired irradiation time**.** The HSSI-UCSB irradiation facility has been in operation at the FNR since December, 1996.

Former Task 7: Embrittlement Data Base and Dosimetry Evaluation (T. M. Rosseel)

This task was until March 1, 1999, the Embrittlement DataBase (EDB) and Dosimetry Evaluation Program, JCN: 6164. The objectives of the two subtasks listed below have been reduced but the focus remains the same. Nuclear radiation embrittlement information from radiation embrittlement research on nuclear RPV steels and from power-reactor surveillance reports will be maintained in a database to be published on a periodic basis. The information will assist the Office of Nuclear Reactor Regulation and the Office of Nuclear Regulatory Research to effectively monitor current procedures and data bases used by vendors, utilities, and service laboratories in the pressure vessel irradiation surveillance program. It will also provide technical expertise and analysis to the NRC regarding dosimetry and transport calculations and methodologies.

Subtask 7.1: Embrittlement Data Base (J.-A. Wang)

The purpose of the subtask is to maintain and update the EDB. This task has been incorporated into Task 5.3

Subtask 7.2: Dosimetry Evaluation (I. Remec)

Technical expertise and analysis regarding dosimetry and transport calculations and methodologies will be provided as needed to the US NRC. Specifically, work will be performed to complete the review of, and hold final discussions with the NRC concerning, the dosimetry guide, DG-1053. This activity was eliminated as directed by SOEW 60-99-356.

3. MEETINGS AND TRIPS:

On April 6-13, R. K. Nanstad traveled to Paris, France, for meetings of the International Atomic Energy Agency (IAEA) Editorial Board and the task group of a Cooperative Research Program to develop guidelines for application of the fracture toughness Master Curve to reactor pressure vessels.

On April 19-27, R. K. Nanstad traveled to Kiev, Ukraine, to participate in a NATO Advanced Research Workshop on Scientific Fundamentals for the Lifetime Extension of Reactor Pressure Vessels.

4. PRESENTATIONS, REPORTS, PAPERS, AND PUBLICATIONS:

The NUREG report, K. Onizawa, E. van Walle, W. Pavinich, and R. K. Nanstad, UT-Battelle, LLC, Oak Ridge, Tenn., *Results and Analysis of The ASTM Round Robin On Reconstitution*, USNRC NUREG/CR-XXXX, (ORNL/TM-2001/34) was resubmitted to the NRC in the previous reporting due to mail security damage.

D. W. Heatherly, K. R. Thoms, and M. T. Hurst, UT-Battelle, LLC, Oak Ridge, Tenn., *Heavy-Section Steel Irradiation Program's Reusable Irradiation Facility*, USNRC NUREG/CR-XXXX, (ORNL/TM-2002/77) was resubmitted

R. K. Nanstad, D. E. McCabe, M. A. Sokolov, C. A. English, and S. R. Ortner, *Comparison of Effects of Thermal Aging, Irradiation, and Thermal Annealing on Propensity for Temper Embrittlement on an RPV Submerged-Arc Weld HAZ*, ORNL/NRC/LTR-01/07 (January 2002).

R. E. Stoller and R. K. Nanstad, *A Proposal for Sampling the SONGS-1 Reactor Pressure Vessel*, ORNL/NRC/LTR-02/12 (January 2002).

J. G. Merkle and R. K. Nanstad, "Master Curve Derived Fracture Toughness and a Statistical Representation of Valid K_{Ic} Data," presented by R. K. Nanstad, IAEA Cooperative Research Program Meetings, Paris, France, 8-12 April 2002.

R. K. Nanstad, M. A. Sokolov, D. E. McCabe, and J. G. Merkle, "Applicability of the Fracture Toughness Master Curve to Irradiated Highly Embrittled Steel and Intergranular Fracture," presented by R. K. Nanstad, NATO Advanced Research Workshop, Scientific Fundamentals for the Lifetime Extension of Reactor Pressure Vessels, Kiev, Ukraine, 22-25 April 2002.

R. K. Nanstad, *Report of Foreign Travel to Paris, France*, ORNL/FTR-156789, May 6, 2002.

5. PROPERTY ACQUIRED:

Items listed in this section include all nonconsumable project purchases that were actually paid for during this reporting period. They do not include either accruals or accrual reversals and hence may not accurately reflect total material procurement charges within this period.

Item	Cost ($)

6. PROBLEM AREAS:

None

7. PLANS FOR THE NEXT REPORTING PERIOD:

The plans for the next reporting period are described in Section 2.

FINANCIAL STATUS for W6953 — Reporting Period: 3/25/02-4/21/02

		Current Month	Fiscal Year to Date	Cumulative Project to date
I.	Direct Staff Effort	10 MM	4.8 MY	43.2 MY
II.	A. Direct Lab Staff Effort ($)			
	Direct Salaries	98,017	489,960	4,334,842
	Materials and Services	4,832	21,641	409,086
	ADP Support	21	179	2,383
	Subcontracts	108,374	179,276	679,473
	Travel	5,109	20,679	163,547
	Other: NRC-PO Tax	3,505	18,743	193,243
	General and Administrative	51,566	238,018	1,973,221
	Total UT-Battelle Costs	271,424	968,496	7,755,795
	B. DOE Federal Admin. Costs	8,143	29,055	70,968
	TOTAL PROJECT COSTS	279,567	997,551	7,826,763

Percentage of available cumulative funds costed	82
Percentage of available current FY funds costed	37
Funds Remaining	1,678,237
Commitments:	65,339
BA Remaining	1,612,898
BA Remaining Less Projected FAC	1,564,017

III. Funding Status

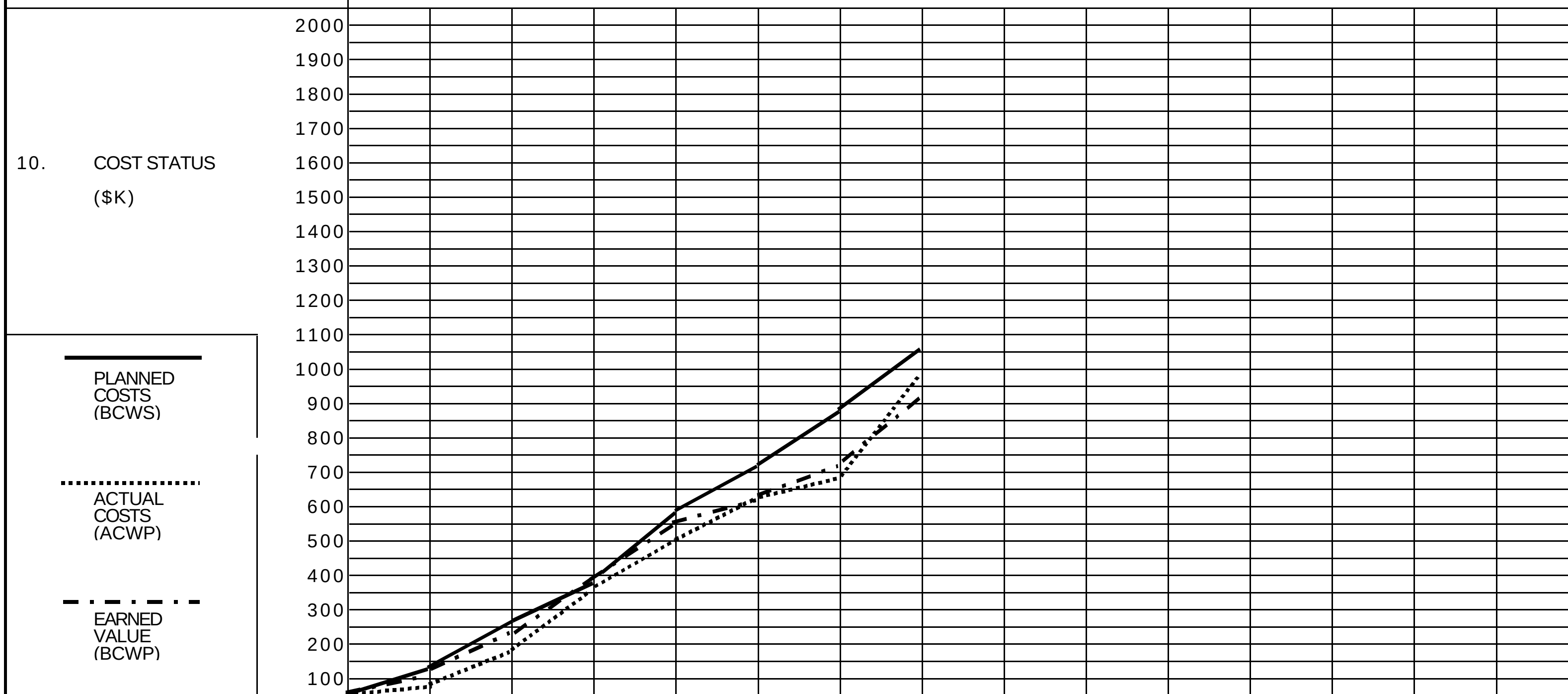
Prior FY Carryover	FY 02 Projected Funding Level	FY 02 Funds Received to Date	FY 02 Funding Balance Needed	Cumulative Amt. Obligated	Cumulative Amt. Costed
514,538	2,146,000	2,146,000	0	9,505,000	7,826,763

Comments: The Federal Administration Charge of 3% is applied to monthly costs.

1. CONTRACT REPORTING ELEMENT **HSSI - Heavy-Section Steel Irradiation Program**		2. REPORTING PERIOD **3/25/2002 - 4/21/2002**	3. JCN NO. **W6953**
4. CONTRACTOR (NAME AND ADDRESS) **OAK RIDGE NATIONAL LABORATORY** **P. O. BOX 2008** **OAK RIDGE, TN 37831**		5. CONTRACT PERIOD **FY 1998 - 2003**	6. ACTIVITY NUMBER **W41 W5 85 3W 1**
		7. NRC B&R NO. **860 15 21 20 05**	8. DOE B&R NO. **40 10 01 06**

9. MONTHS: O N D J F M A M J J A S O N D

10. COST STATUS ($K)



COST PLAN DATES
05/03/02

PLANNED COSTS FOR ELEMENT ($K)
2205

ELEMENT COSTS FOR PRIOR FYS ($K)
514

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	126	126	129	198	157	159	164	148	153	148	146	141	142	141	122
ACTUAL	77	97	181	139	126	77	271	0	0	0	0	0	0	0	0
EARNED	105	128	131	143	112	87	205	0	0	0	0	0	0	0	0
CUM. PLANNED	126	252	381	579	736	895	1059	1207	1360	1508	1654	1795	1942	2083	2205
CUM. ACTUAL	77	174	355	494	620	697	968	0	0	0	0	0	0	0	0
CUM. EARNED	105	233	364	507	619	706	911	0	0	0	0	0	0	0	0

11. REMARKS

Total/Planned Cost reflects reduction in funds received due to FAC.

1. CONTRACT REPORTING ELEMENT **HSSI - 1. Program Management**	2. REPORTING PERIOD **3/25/2002 - 4/21/2002**	3. JCN NO. **W6953**
4. CONTRACTOR (NAME AND ADDRESS) **OAK RIDGE NATIONAL LABORATORY** **P. O. BOX 2008** **OAK RIDGE, TN 37831**	5. CONTRACT PERIOD **FY 1998 - 2003**	6. ACTIVITY NUMBER **W41 W5 85 3W 1**
	7. NRC B&R NO. **860 15 21 20 05**	8. DOE B&R NO. **40 10 01 06**

9. MONTHS: O N D J F M A M J J A S O N D

10. COST STATUS ($K)

PLANNED COSTS (BCWS)

ACTUAL COSTS (ACWP)

EARNED VALUE (BCWP)

COST PLAN DATES

05/03/02

PLANNED COSTS FOR ELEMENT ($K)

330

ELEMENT COSTS FOR PRIOR FYS ($K)

52.5

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	18	16	19	24	23	23	28	21	18	24	24	22	25	27	23
ACTUAL	22	18	17	21	21	18	18	0	0	0	0	0	0	0	0
EARNED	15	25	13	18	14	14	31	0	0	0	0	0	0	0	0
CUM. PLANNED	18	34	53	77	100	123	151	172	190	214	238	260	285	312	335
CUM. ACTUAL	22	40	57	78	99	117	135	0	0	0	0	0	0	0	0
CUM. EARNED	15	40	53	71	85	99	130	0	0	0	0	0	0	0	0

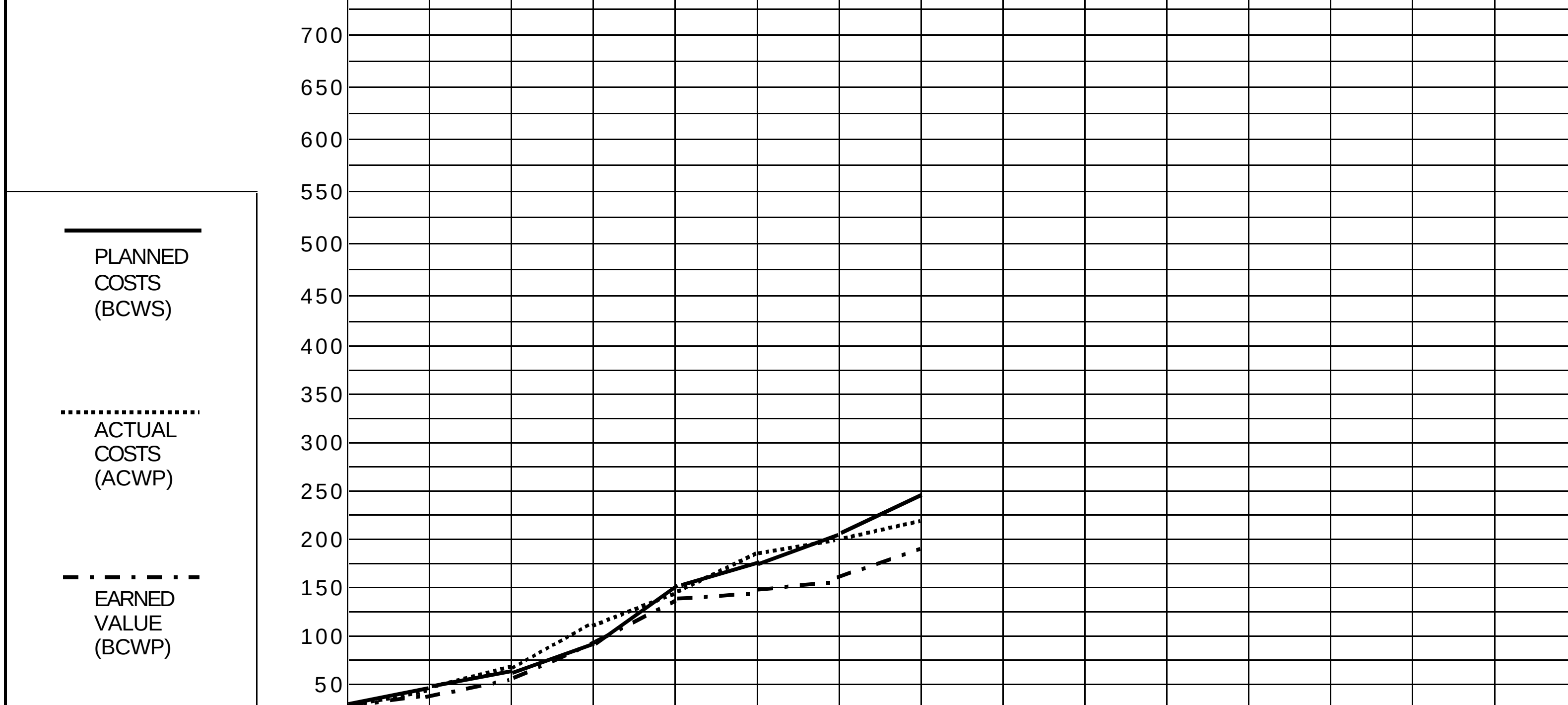
11. REMARKS

Total/Planned Cost reflects reduction in funds received due to FAC.

1. CONTRACT REPORTING ELEMENT **HSSI - 2. Fracture Toughness Transition and MC Methodology**		2. REPORTING PERIOD **3/25/2002 - 4/21/2002**	3. JCN NO. **W6953**
4. CONTRACTOR (NAME AND ADDRESS) **OAK RIDGE NATIONAL LABORATORY** **P. O. BOX 2008** **OAK RIDGE, TN 37831**		5. CONTRACT PERIOD **FY 1998 - 2003**	6. ACTIVITY NUMBER **W41 W5 85 3W 1**
		7. NRC B&R NO. **860 15 21 20 05**	8. DOE B&R NO. **40 10 01 06**

9. MONTHS: O N D J F M A M J J A S O N D

10. COST STATUS ($K)



COST PLAN DATES

05/03/02

PLANNED COSTS FOR ELEMENT ($K)

608

ELEMENT COSTS FOR PRIOR FYS ($K)

150

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	36	31	31	37	38	38	35	43	54	58	55	42	44	40	26
ACTUAL	32	41	28	41	34	24	20	0	0	0	0	0	0	0	0
EARNED	25	30	41	26	21	12	34	0	0	0	0	0	0	0	0
CUM. PLANNED	36	67	98	135	173	211	246	289	343	401	456	498	542	582	608
CUM. ACTUAL	32	73	101	142	176	200	220	0	0	0	0	0	0	0	0
CUM. EARNED	25	55	96	122	143	155	189	0	0	0	0	0	0	0	0

11. REMARKS

1. CONTRACT REPORTING ELEMENT **HSSI - 3. Irradiation Embrittlement of RPV Steel**	2. REPORTING PERIOD **3/25/2002 - 4/21/2002**	3. JCN NO. **W6953**	
4. CONTRACTOR (NAME AND ADDRESS) **OAK RIDGE NATIONAL LABORATORY** **P. O. BOX 2008** **OAK RIDGE, TN 37831**	5. CONTRACT PERIOD **FY 1998 - 2003**	6. ACTIVITY NUMBER **W41 W5 85 3W 1**	
	7. NRC B&R NO. **860 15 21 20 05**	8. DOE B&R NO. **40 10 01 06**	

9. MONTHS: O N D J F M A M J J A S O N D

10. COST STATUS ($K)

PLANNED COSTS (BCWS) — solid line

ACTUAL COSTS (ACWP) — dotted line

EARNED VALUE (BCWP) — dash-dot line

COST PLAN DATES: 5/3/02

PLANNED COSTS FOR ELEMENT ($K): 637

ELEMENT COSTS FOR PRIOR FYS ($K): 178

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	31	43	38	56	48	56	43	38	36	34	38	43	43	43	47
ACTUAL	3	7	92	14	1	0	148	0	0	0	0	0	0	0	0
EARNED	30	41	41	35	30	27	65	0	0	0	0	0	0	0	0
CUM. PLANNED	31	74	112	168	216	272	315	353	389	423	461	504	547	590	637
CUM. ACTUAL	3	10	102	116	117	117	265	0	0	0	0	0	0	0	0
CUM. EARNED	31	72	112	147	177	204	269	0	0	0	0	0	0	0	0

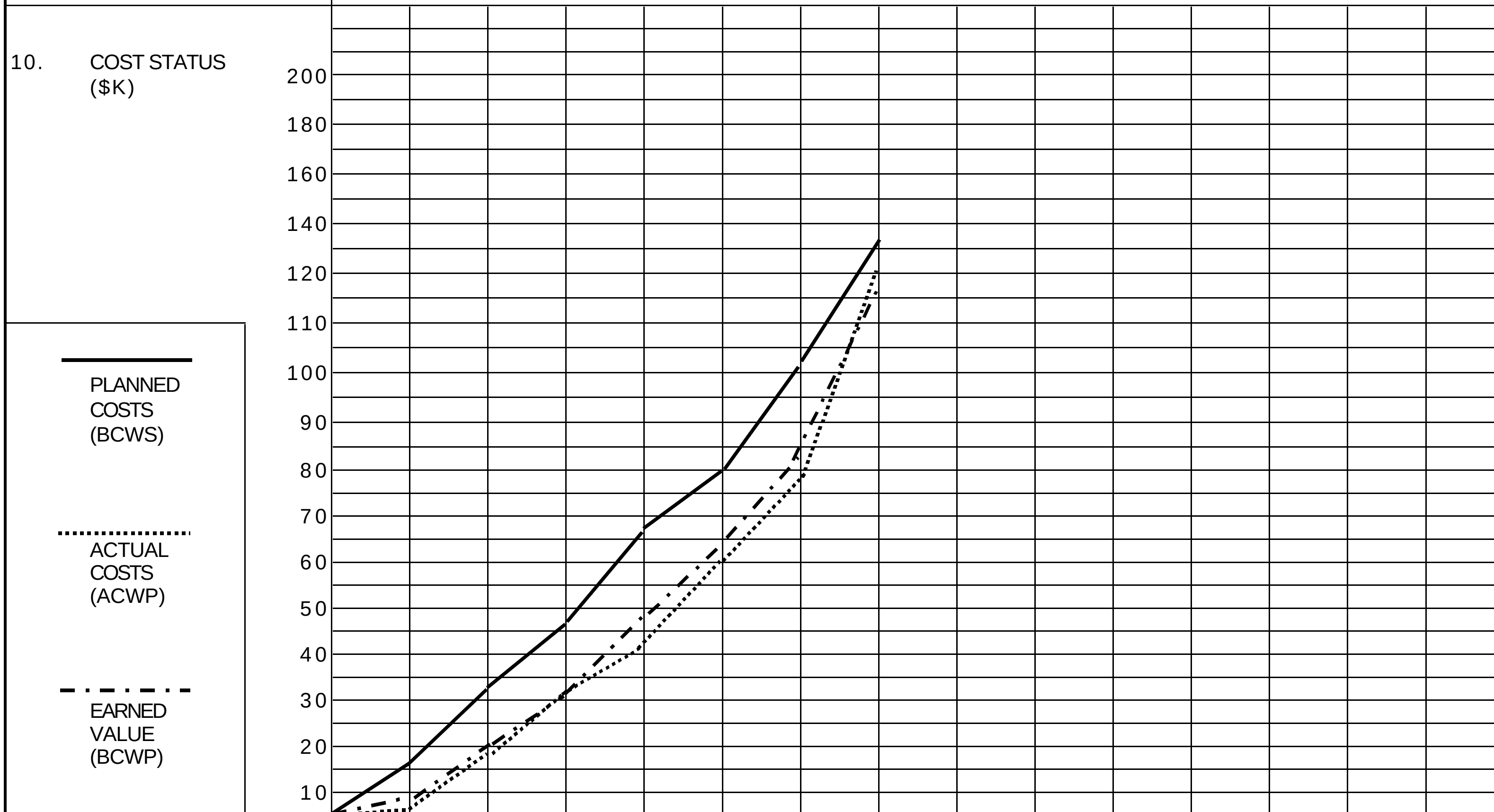
11. REMARKS

Total/Planned Cost reflects reduction in funds received due to FAC.

1. CONTRACT REPORTING ELEMENT	2. REPORTING PERIOD	3. JCN NO.
HSSI - 4. Validation of Irradiated and Aged Materials	**3/25/2002 - 4/21/2002**	**W6953**
4. CONTRACTOR (NAME AND ADDRESS)	5. CONTRACT PERIOD	6. ACTIVITY NUMBER
OAK RIDGE NATIONAL LABORATORY	**FY 1998 - 2003**	**W41 W5 85 3W 1**
P. O. BOX 2008	7. NRC B&R NO.	8. DOE B&R NO.
OAK RIDGE, TN 37831	**860 15 21 20 05**	**40 10 01 06**

9. MONTHS: O N D J F M A M J J A S O N D

10. COST STATUS ($K)



COST PLAN DATES

05/03/02

PLANNED COSTS FOR ELEMENT ($K)

289

ELEMENT COSTS FOR PRIOR FYS ($K)

79

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	16	16	15	19	14	22	30	30	28	18	15	18	20	17	11
ACTUAL	4	14	14	10	19	17	45	0	0	0	0	0	0	0	0
EARNED	9	11	1	19	14	18	38	0	0	0	0	0	0	0	0
CUM. PLANNED	16	32	47	66	80	102	132	162	190	208	223	241	261	278	289
CUM. ACTUAL	4	18	32	42	61	78	123	0	0	0	0	0	0	0	0
CUM. EARNED	9	20	31	50	64	82	120	0	0	0	0	0	0	0	0

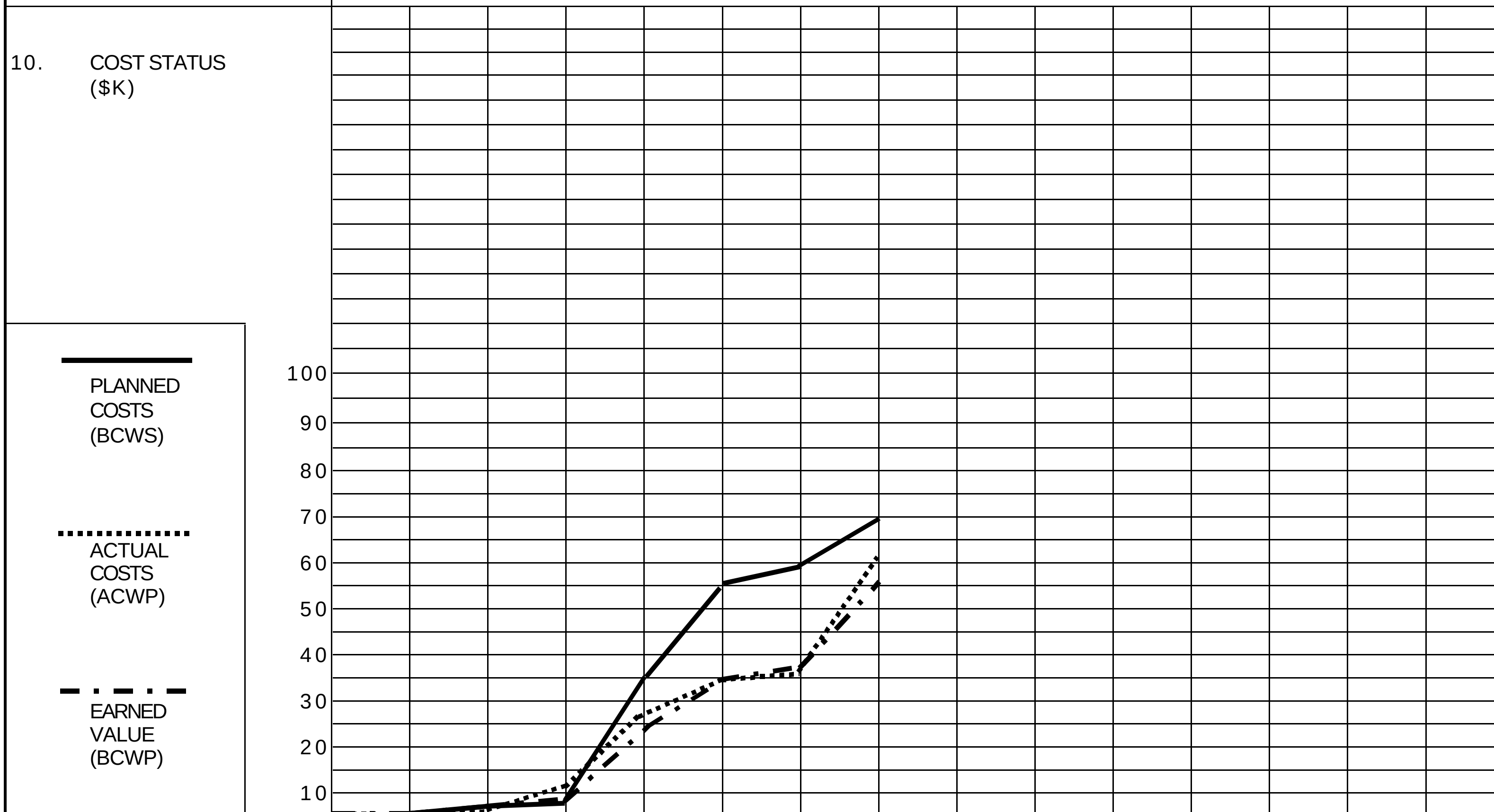
11. REMARKS

Total/Planned Cost reflects reduction in funds received due to FAC.

1. CONTRACT REPORTING ELEMENT **HSSI - 5. Modeling and Microstuctural Analysis**	2. REPORTING PERIOD **3/25/2002 - 4/21/2002**	3. JCN NO. **W6953**
4. CONTRACTOR (NAME AND ADDRESS) **OAK RIDGE NATIONAL LABORATORY** **P. O. BOX 2008** **OAK RIDGE, TN 37831**	5. CONTRACT PERIOD **FY 1998 - 2003** 7. NRC B&R NO. **860 15 21 20 05**	6. ACTIVITY NUMBER **W41 W5 85 3W 1** 8. DOE B&R NO. **40 10 01 06**

9. MONTHS: O N D J F M A M J J A S O N D

10. COST STATUS ($K)



COST PLAN DATES

05/03/02

PLANNED COSTS FOR ELEMENT ($K)

71

ELEMENT COSTS FOR PRIOR FYS ($K)

6

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	2	3	3	27	20	4	10	1	1	0	0	0	0	0	0
ACTUAL	0	5	10	16	8	1	25	0	0	0	0	0	0	0	0
EARNED	1	2	3	19	8	4	18	0	0	0	0	0	0	0	0
CUM. PLANNED	2	5	8	35	55	59	69	70	71	0	0	0	0	0	0
CUM. ACTUAL	0	1	11	27	35	36	61	0	0	0	0	0	0	0	0
CUM. EARNED	1	3	6	25	33	37	55	0	0	0	0	0	0	0	0

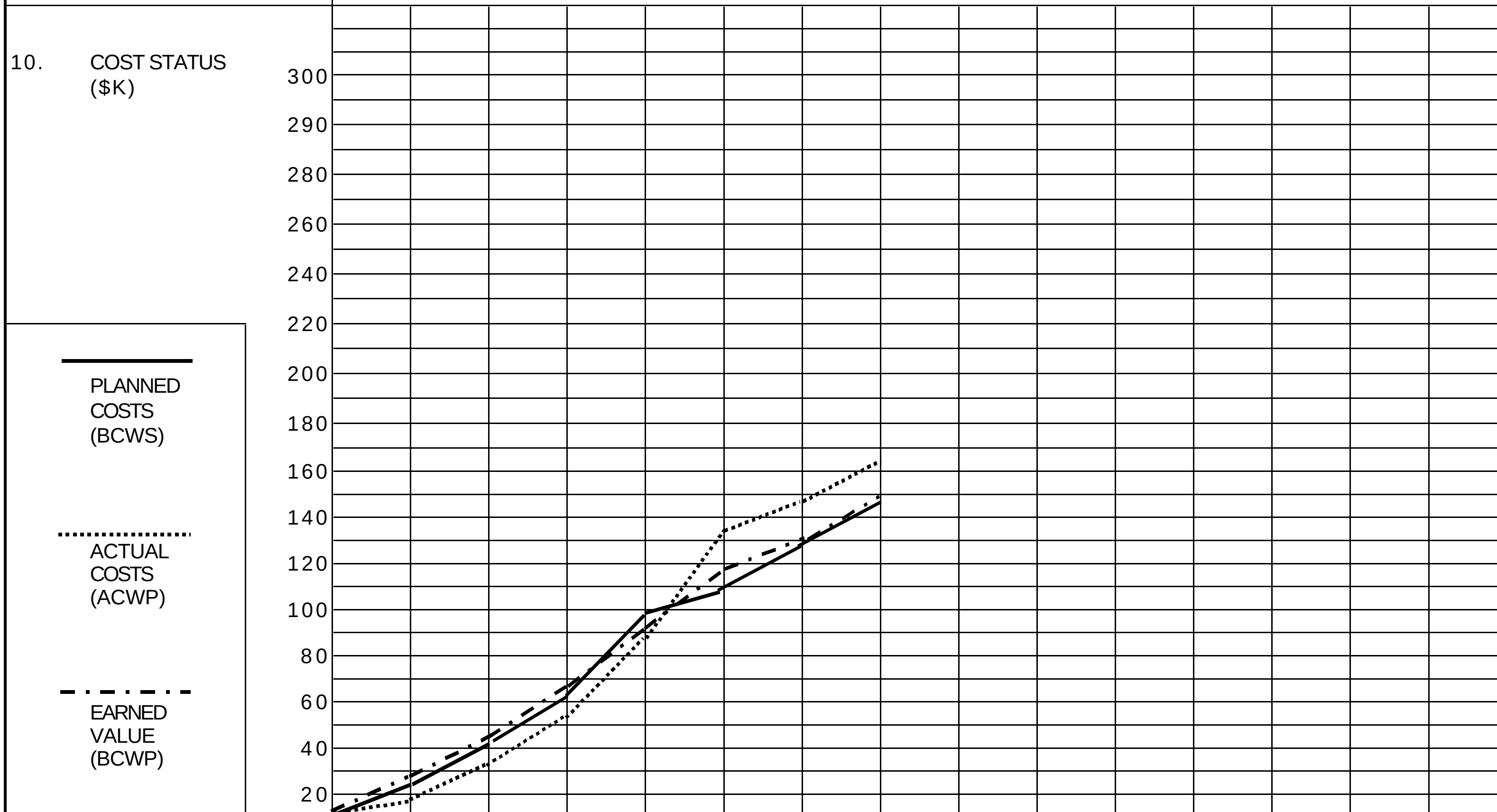
11. REMARKS

Total/Planned Cost reflects reduction in funds received due to FAC.

1. CONTRACT REPORTING ELEMENT **HSSI - 6. Irradiation Coordination**	2. REPORTING PERIOD **3/25/2002 - 4/21/2002**	3. JCN NO. **W6953**
4. CONTRACTOR (NAME AND ADDRESS) **OAK RIDGE NATIONAL LABORATORY** **P. O. BOX 2008** **OAK RIDGE, TN 37831**	5. CONTRACT PERIOD **FY 1998 - 2003** 7. NRC B&R NO. **860 15 21 20 05**	6. ACTIVITY NUMBER **W41 W5 85 3W 1** 8. DOE B&R NO. **40 10 01 06**

9. MONTHS: O N D J F M A M J J A S O N D

10. COST STATUS ($K)



COST PLAN DATES

05/03/02

PLANNED COSTS FOR ELEMENT ($K)

265

ELEMENT COSTS FOR PRIOR FYS ($K)

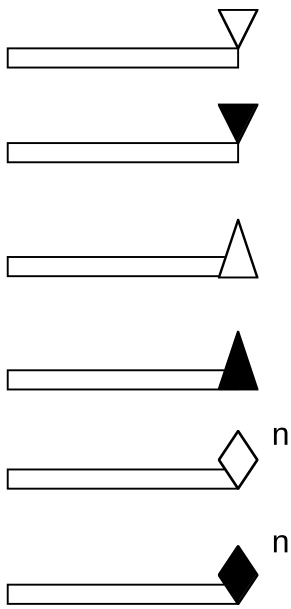
35

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	23	18	23	35	14	16	18	14	16	14	14	16	16	14	14
ACTUAL	15	17	20	37	45	15	15	0	0	0	0	0	0	0	0
EARNED	26	19	22	26	24	12	19	0	0	0	0	0	0	0	0
CUM. PLANNED	23	41	64	99	113	129	147	161	177	191	205	221	237	251	265
CUM. ACTUAL	15	32	52	89	134	149	164	0	0	0	0	0	0	0	0
CUM. EARNED	26	45	67	93	117	129	148	0	0	0	0	0	0	0	0

11. REMARKS

Total/Planned Cost reflects reduction in funds received due to FAC.

Milestone Symbology



Intermediate milestone planned

Intermediate milestone completed

Major milestone planned

Major milestone completed

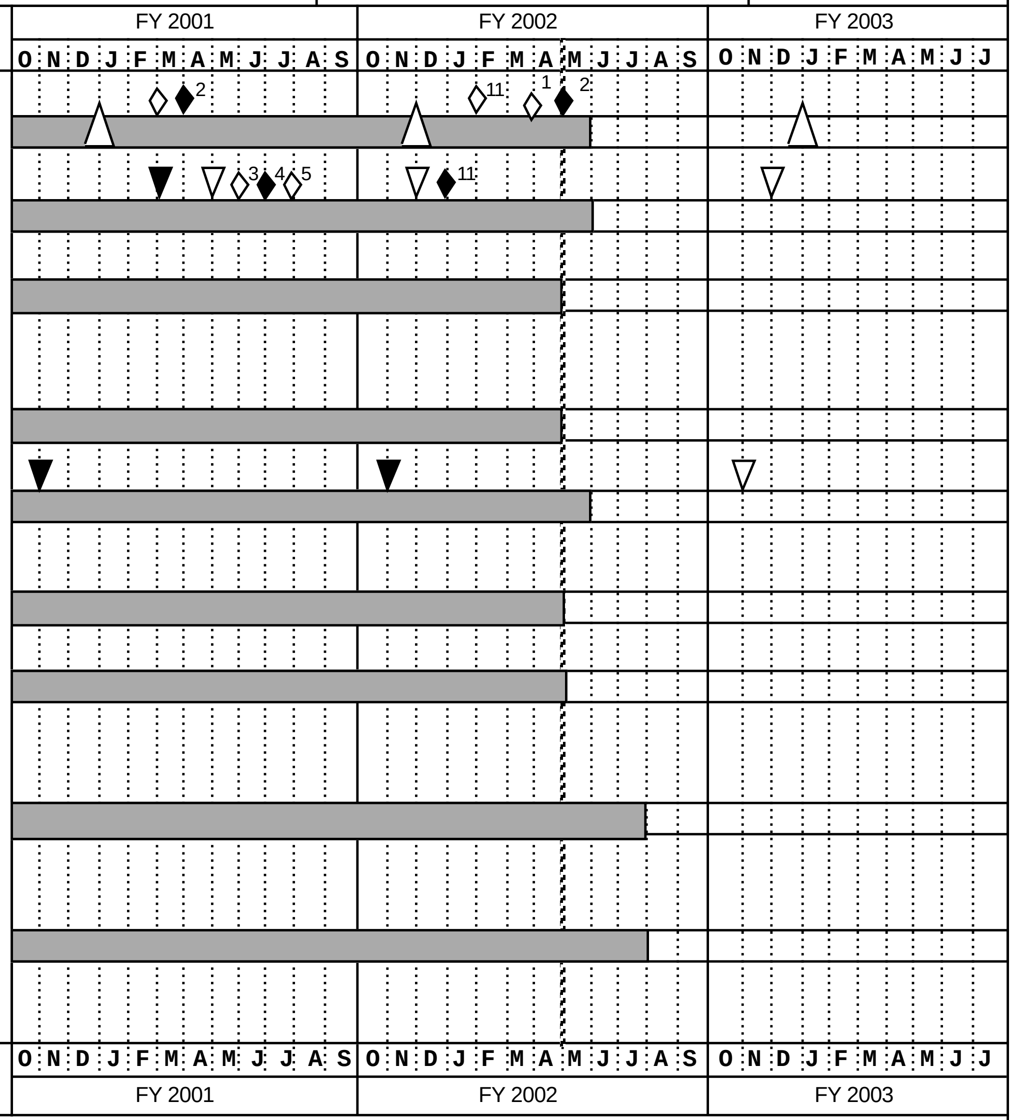
Rescheduled milestone planned

Rescheduled milestone completed

n = number of calendar-year month in which milestone was rescheduled

1. CONTRACT REPORTING ELEMENT	2. REPORTING PERIOD	3. JCN NO.
HSSI - 1. Program Management	**3/25/2002-4/21/2002**	**W6953**
4. CONTRACTOR (NAME AND ADDRESS)	5. CONTRACT PERIOD	6. ACTIVITY NUMBER
OAK RIDGE NATIONAL LABORATORY **P. O. BOX 2008** **OAK RIDGE, TN 37831**	**FY 1998-2003**	**41 W6 95 3W 1**
	7. NRC B&R NO.	8. DOE B&R NO.
	860 15 21 20 05	**40 10 01 06**

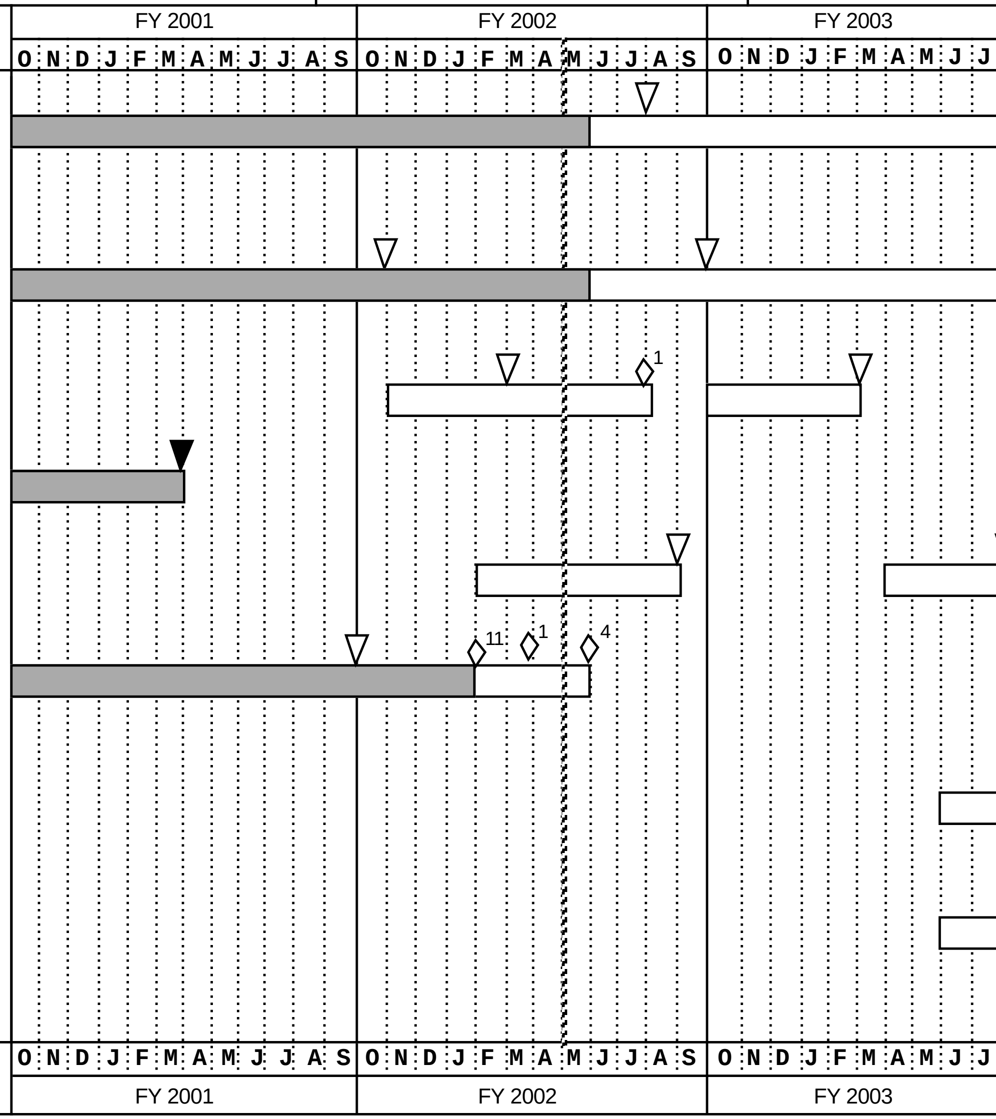
9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
1.1.A.	Issue Project & Budget Proposal
1.1.B.	Select and Administer Subcontracts
1.2.A.	Issue Earned Value Based Monthly Management Reports (by the end of subsequent month)
1.2.B.	Ensure QA Requirements are met
1.3.A.	Participate in NRC-Sponsored Meeting and Discussions
1.3.B.	Coordinate NRC and Internal Reviews
1.3.C.	Coordinate Domestic and Foreign Information Exchange as Approved by NRC-RES
1.3.D.	Coordinate HSSI Letter and NUREG Reports
1.3.E.	Document the Historical Information Generated by the Old HSSI Program



11. REMARKS

1. CONTRACT REPORTING ELEMENT **HSSI - 2. Fracture Toughness Transition & MC Methodology**	2. REPORTING PERIOD **3/25/2002-4/21/2002**	3. JCN NO. **W6953**
4. CONTRACTOR (NAME AND ADDRESS) **OAK RIDGE NATIONAL LABORATORY** **P. O. BOX 2008** **OAK RIDGE, TN 37831**	5. CONTRACT PERIOD **FY 1998-2003**	6. ACTIVITY NUMBER **41 W6 95 3W 1**
	7. NRC B&R NO. **860 15 21 20 05**	8. DOE B&R NO. **40 10 01 06**

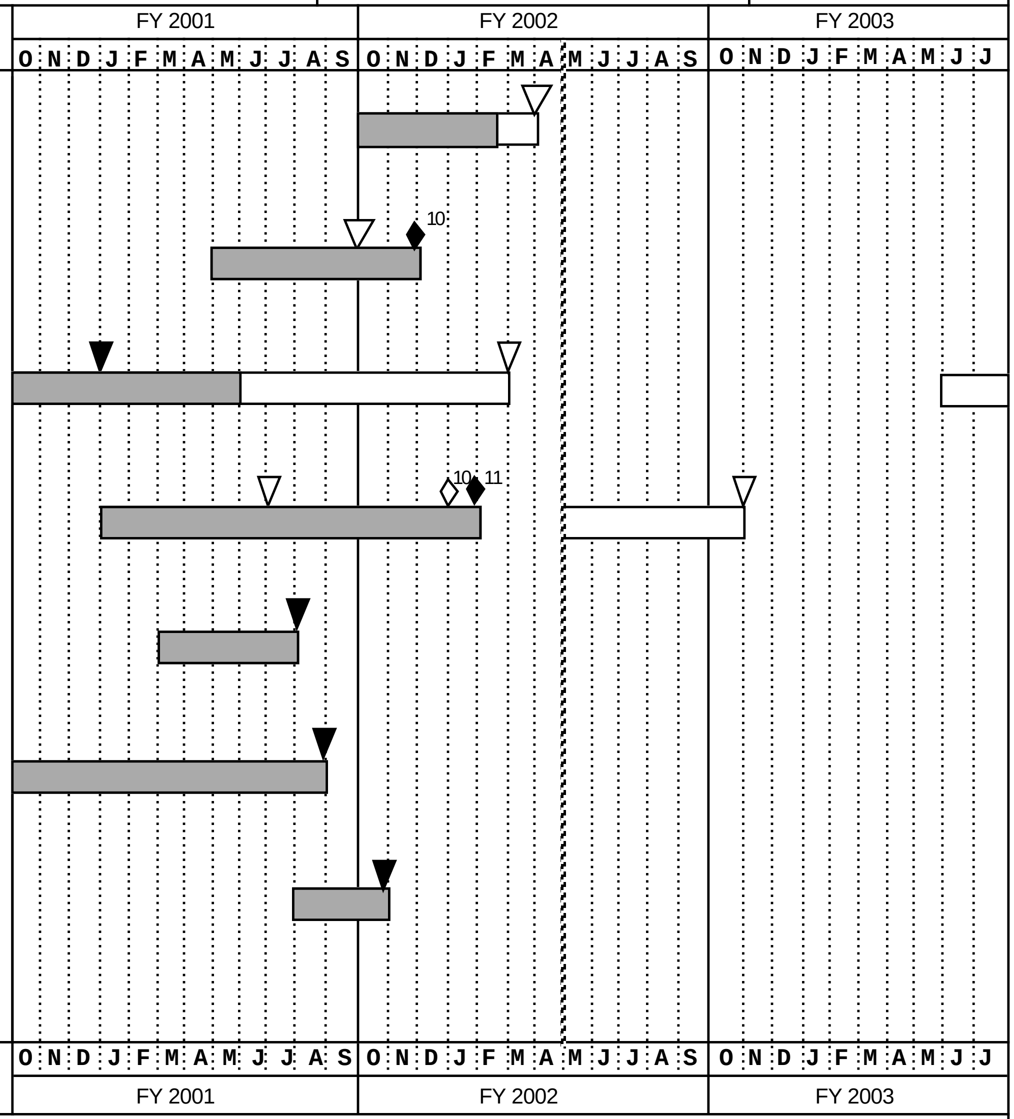
9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
2.1.A.	Continue to accumulate data on Comparison of CVN and Fracture Tougness Shifts
2.2.A.	IIrradiate Midland and Hi-Ni Speciments
2.2.B.	Receive Specimens
2.2.C.	Test Unirradiated & Irradiated KSØ1 for Master Curve
2.2.D.	Test Unirradiated & Irradiated Hi-Ni Midland Weld Specimens
2.2.E.	Draft Letter and NUREG Report for KSØ1
2.2.F.	Draft Letter and NUREG Report for Midland Weld
2.2.G.	Draft Letter and NUREG Report for High Ni



11. REMARKS

1. CONTRACT REPORTING ELEMENT **HSSI - 2. Fracture Toughness Transition & MC Methodology**	2. REPORTING PERIOD **3/25/2002-4/21/2002**	3. JCN NO. **W6953**
4. CONTRACTOR (NAME AND ADDRESS) **OAK RIDGE NATIONAL LABORATORY** **P. O. BOX 2008** **OAK RIDGE, TN 37831**	5. CONTRACT PERIOD **FY 1998-2003**	6. ACTIVITY NUMBER **41 W6 95 3W 1**
	7. NRC B&R NO. **860 15 21 20 05**	8. DOE B&R NO. **40 10 01 06**

9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
2.3.A.	Develop Testing Plan for Dynamic Fracture Toughness Effects on MC
2.4.A.	Letter Report on Statistical Representation of Valid K_{JC} Data
2.5.A.	Measure Activity and Prepare Report
2.5.B.	Calculate Fluence and Prepare Report
2.6.A.	Complete Testing of 0.5C(T)
2.6.B.	Fractography Specimens
2.6.C.	Final IGF Report



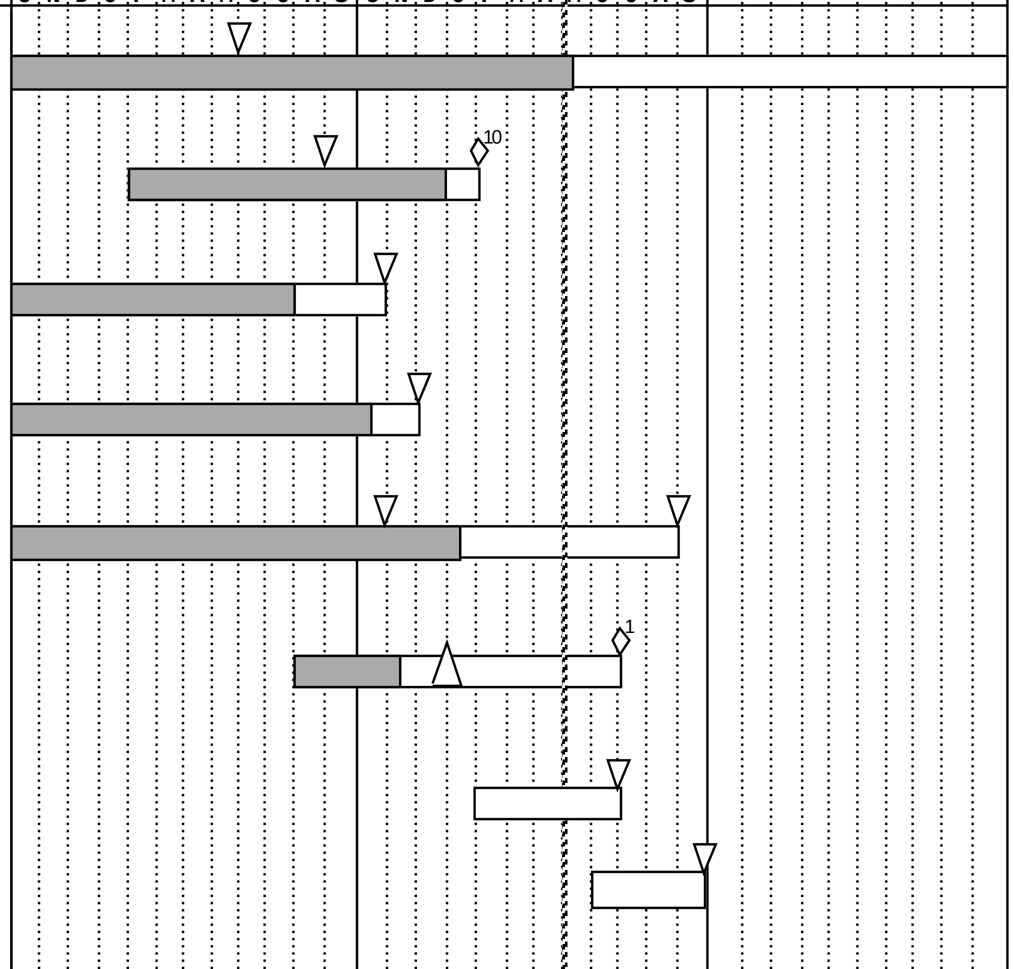
11. REMARKS

1. CONTRACT REPORTING ELEMENT	2. REPORTING PERIOD	3. JCN NO.
HSSI - 2. Fracture Toughness Transition & MC Methodology	**3/25/2002-4/21/2002**	**W6953**

4. CONTRACTOR (NAME AND ADDRESS)	5. CONTRACT PERIOD	6. ACTIVITY NUMBER
OAK RIDGE NATIONAL LABORATORY **P. O. BOX 2008** **OAK RIDGE, TN 37831**	**FY 1998-2003**	**41 W6 95 3W 1**
	7. NRC B&R NO.	8. DOE B&R NO.
	860 15 21 20 05	**40 10 01 06**

9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
2.7.A.	Complete Testing of Subsize Specimens
2.7.B.	Testing of JRQ Plate
2.7.C.	Complete Letter Report on Results of Subsize Specimen Fracture Toughness Tests
2.8.A.1	Complete Assembly and Compilation for Irradiated Materials for Surrogate Materials DB
2.8.A.2	Complete Statistical Analysis of Data Base for Irradiated Materials
2.8.B.	Submit NUREG Report
2.9.A.	Develop Machining Procedures
2.9.B.	Machine Specimens

FY 2001: O N D J F M A M J J A S | FY 2002: O N D J F M A M J J A S | FY 2003: O N D J F M A M J J



11. REMARKS

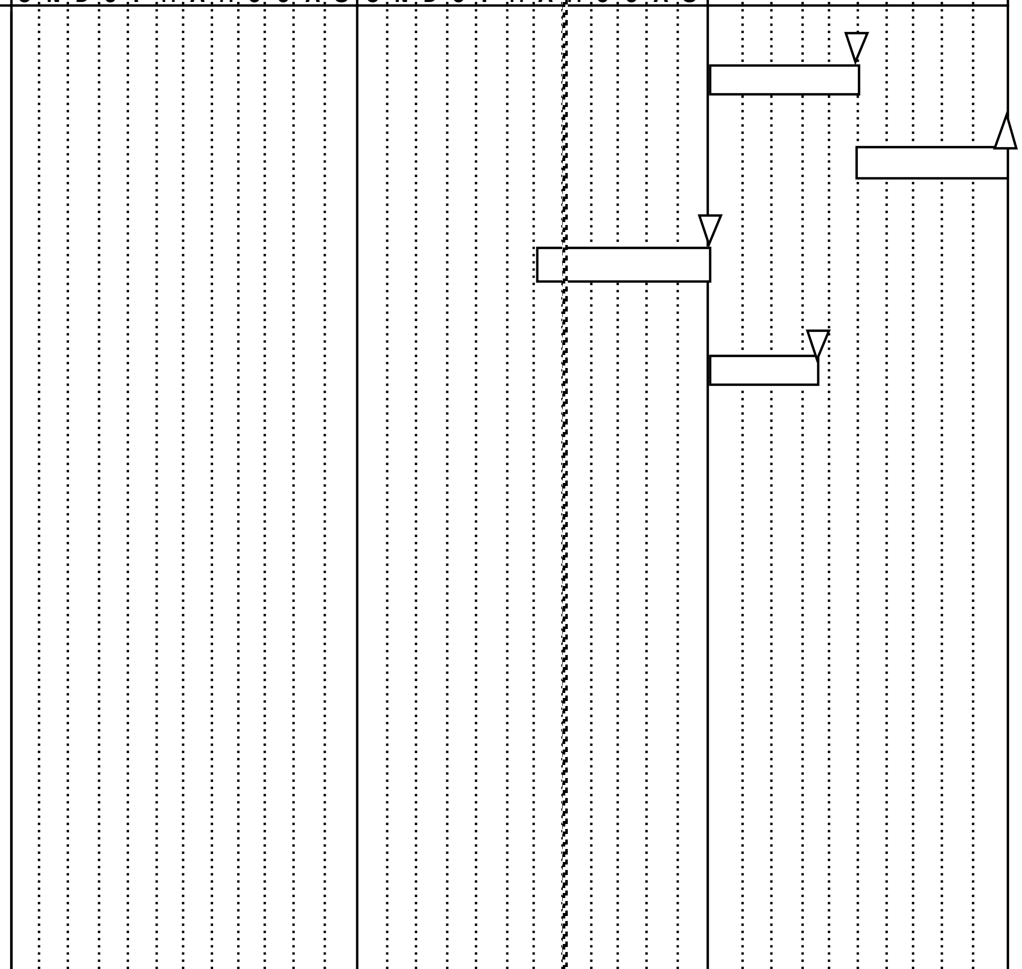
1. CONTRACT REPORTING ELEMENT	2. REPORTING PERIOD	3. JCN NO.
HSSI - 2. Fracture Toughness Transition & MC Methodology	**3/25/2002-4/21/2002**	**W6953**

4. CONTRACTOR (NAME AND ADDRESS)	5. CONTRACT PERIOD	6. ACTIVITY NUMBER
OAK RIDGE NATIONAL LABORATORY **P. O. BOX 2008** **OAK RIDGE, TN 37831**	**FY 1998-2003**	**41 W6 95 3W 1**
	7. NRC B&R NO. **860 15 21 20 05**	8. DOE B&R NO. **40 10 01 06**

9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
2.9.C.	Test Specimens
2.9.D.	Prepare Draft NUREG Report
2.10.A.	Test 3-point Bend and PCVN Specimens
2.10.B.	Prepare Draft NUREG Report

FY 2001 | FY 2002 | FY 2003

O N D J F M A M J J A S | O N D J F M A M J J A S | O N D J F M A M J J



O N D J F M A M J J A S | O N D J F M A M J J A S | O N D J F M A M J J

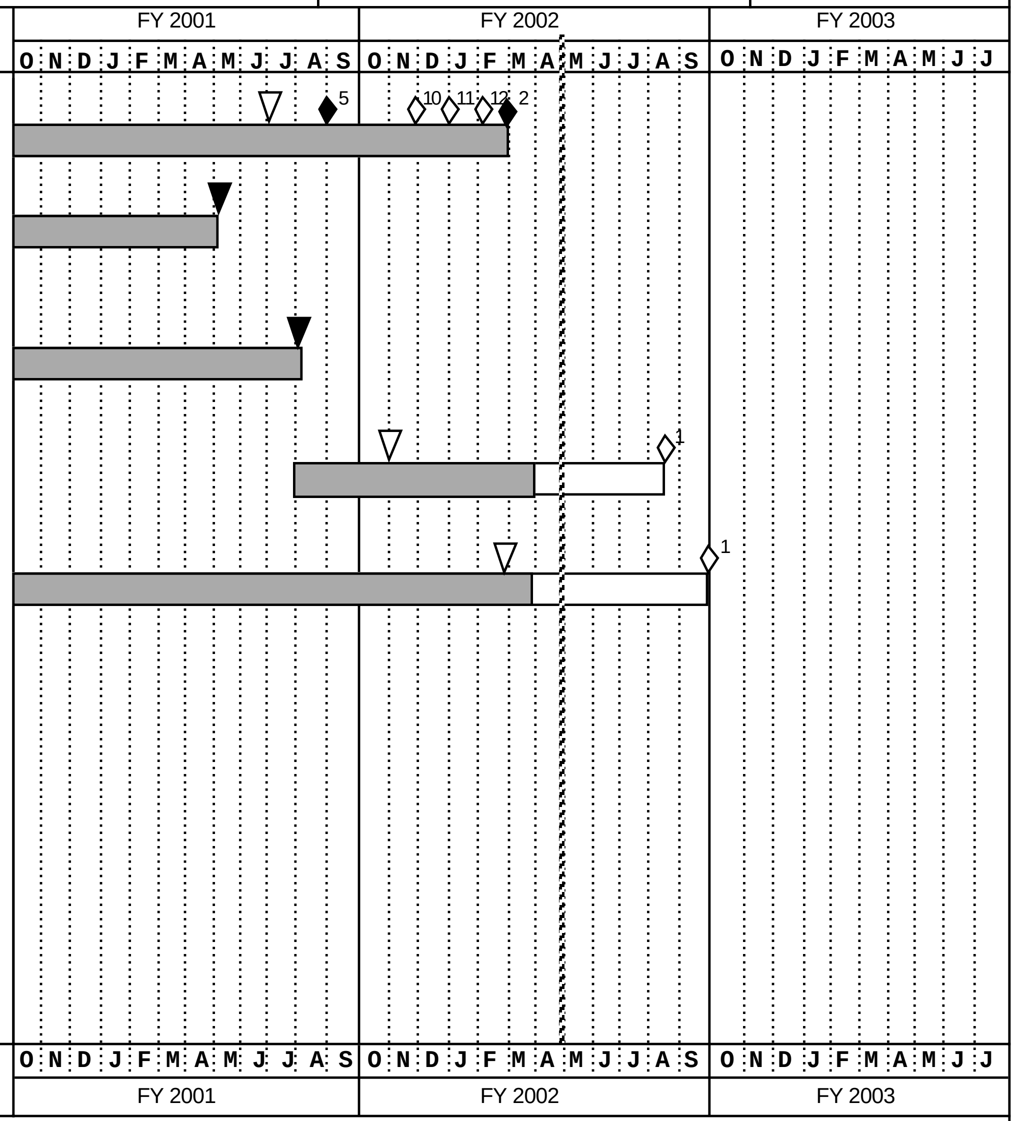
FY 2001 | FY 2002 | FY 2003

11. REMARKS

1. CONTRACT REPORTING ELEMENT	2. REPORTING PERIOD	3. JCN NO.
HSSI - 3. Irradiation Embrittlement of RPV Steel	**3/25/2002-4/21/2002**	**W6953**

4. CONTRACTOR (NAME AND ADDRESS)	5. CONTRACT PERIOD	6. ACTIVITY NUMBER
OAK RIDGE NATIONAL LABORATORY **P. O. BOX 2008** **OAK RIDGE, TN 37831**	**FY 1998-2003**	**41 W6 95 3W 1**
	7. NRC B&R NO. **860 15 21 20 05**	8. DOE B&R NO. **40 10 01 06**

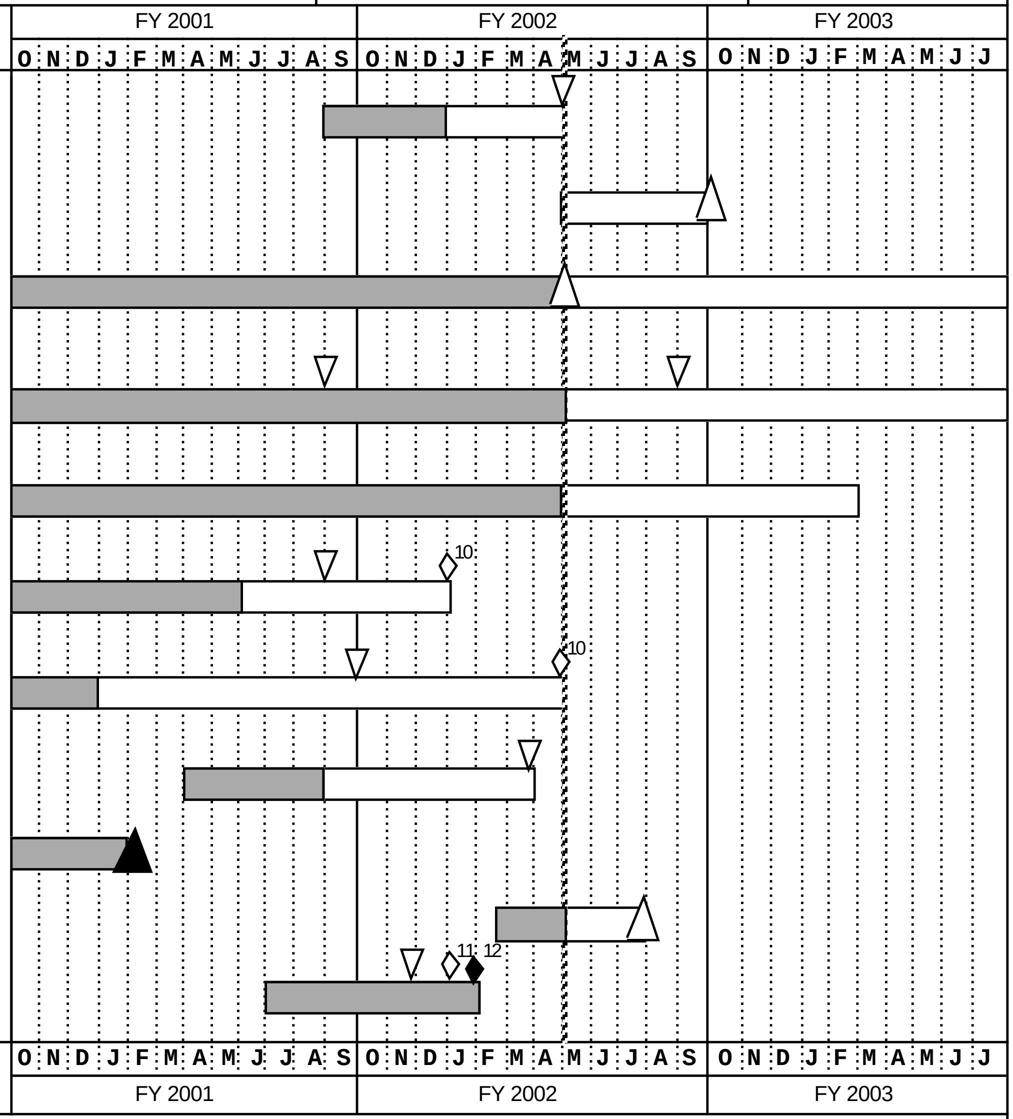
9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
3.1.G.	HAZ Letter Report
3.1.H.	Evaluate Need for Additional Specimen Testing
3.2.A.	Complete JRQ Charpy Testing
3.2.B.	Complete PCVN Testing
3.2.C.	Complete Draft NUREG Report on IAR Results of JRQ



11. REMARKS

1. CONTRACT REPORTING ELEMENT **HSSI - 4. Validation of Irradiated and Aged Materials**	2. REPORTING PERIOD **3/25/2002-4/21/2002**	3. JCN NO. **W6953**
4. CONTRACTOR (NAME AND ADDRESS) **OAK RIDGE NATIONAL LABORATORY** **P. O. BOX 2008** **OAK RIDGE, TN 37831**	5. CONTRACT PERIOD **FY 1998-2003** 7. NRC B&R NO. **860 15 21 20 05**	6. ACTIVITY NUMBER **41 W6 95 3W 1** 8. DOE B&R NO. **40 10 01 06**

9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
4.1.A.	Toughness Tests on SS Cladding
4.1.B.	Letter Report
4.2.A.	Participate in Periodic Meetings of IGRDM
4.2.B.	Complete Progress Reports of Collaboration Activities
4.3.A.	Letter Report on PWHT and Copper
4.3.B.	Complete Letter Report on RPV Materials Available for Irradiation Study
4.3.C.	Complete Crack Arrest NUREG Report
4.3.D.	Complete Letter Report on IA of 73W
4.3.E.	NUREG Report on JPDR Attenuation Effect
4.3.F.	CRDM Tensile Tests
4.4	Letter Report on SONGS-1 Acquisition

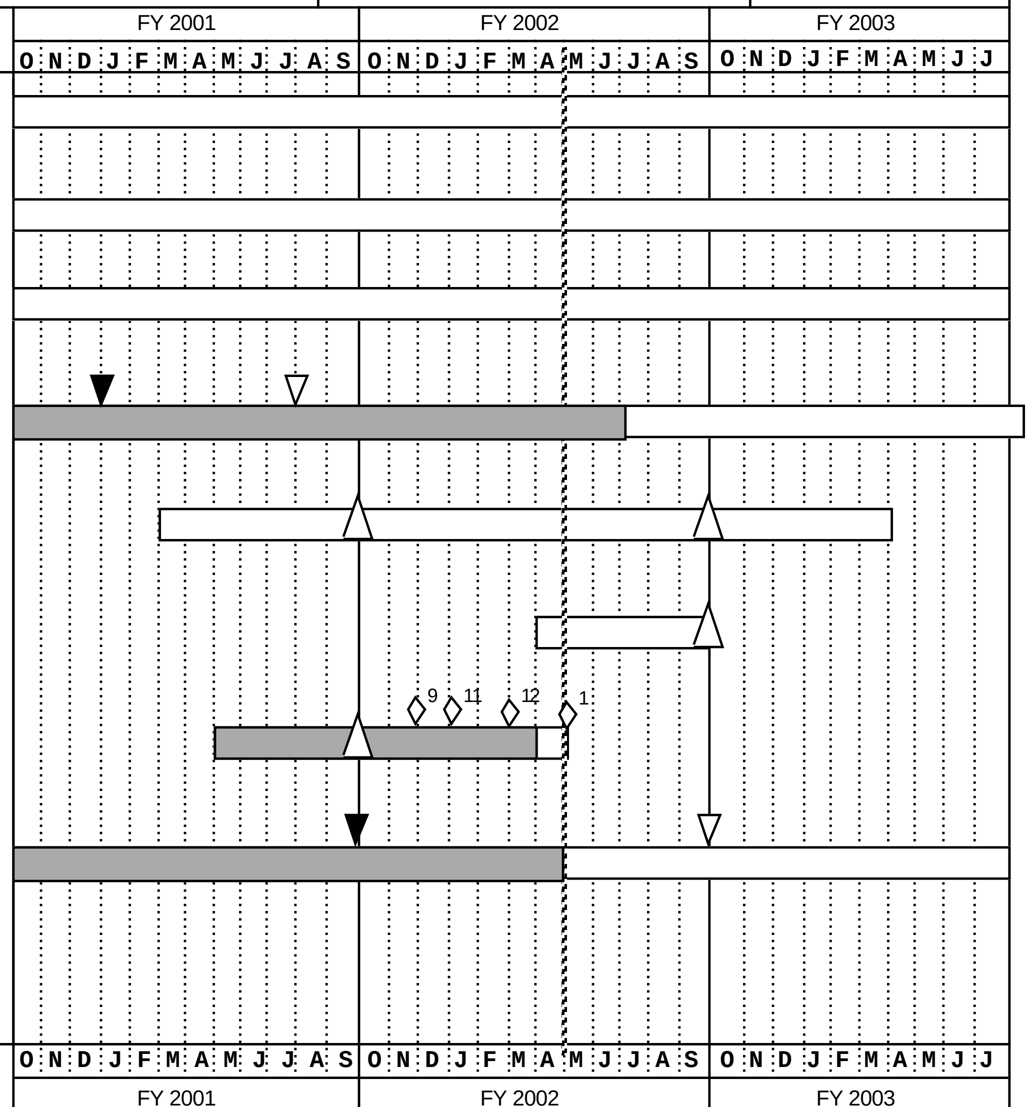


11. REMARKS

1. CONTRACT REPORTING ELEMENT	2. REPORTING PERIOD	3. JCN NO.
HSSI - 5. Modeling & Microstructural Analysis	**3/25/2002-4/21/2002**	**W6953**

4. CONTRACTOR (NAME AND ADDRESS)	5. CONTRACT PERIOD	6. ACTIVITY NUMBER
OAK RIDGE NATIONAL LABORATORY **P. O. BOX 2008** **OAK RIDGE, TN 37831**	**FY 1998-2003**	**41 W6 95 3W 1**
	7. NRC B&R NO.	8. DOE B&R NO.
	860 15 21 20 05	**40 10 01 06**

9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
5.1.A.	Development and Predictive use of Embrittlement Model
5.1.B.	Model Validation and Data Analysis
5.2.A.	Coordinate and Analyze APFIM/SANS/FEGSTEM Round Robin Experiment
5.2.B.	APFIM Characterization
5.3.A.1	Evaluate and Input Surveillance Reports into Embrittlement Database
5.3.A.2	Complete Update 12
5.3.B.	Database Modeling Studies
5.4.	Administration of Task Activities



11. REMARKS

1. CONTRACT REPORTING ELEMENT
HSSI - 6. Irradiation Coordination

2. REPORTING PERIOD
3/25/2002-4/21/2002

3. JCN NO.
W6953

4. CONTRACTOR (NAME AND ADDRESS)
OAK RIDGE NATIONAL LABORATORY
P. O. BOX 2008
OAK RIDGE, TN 37831

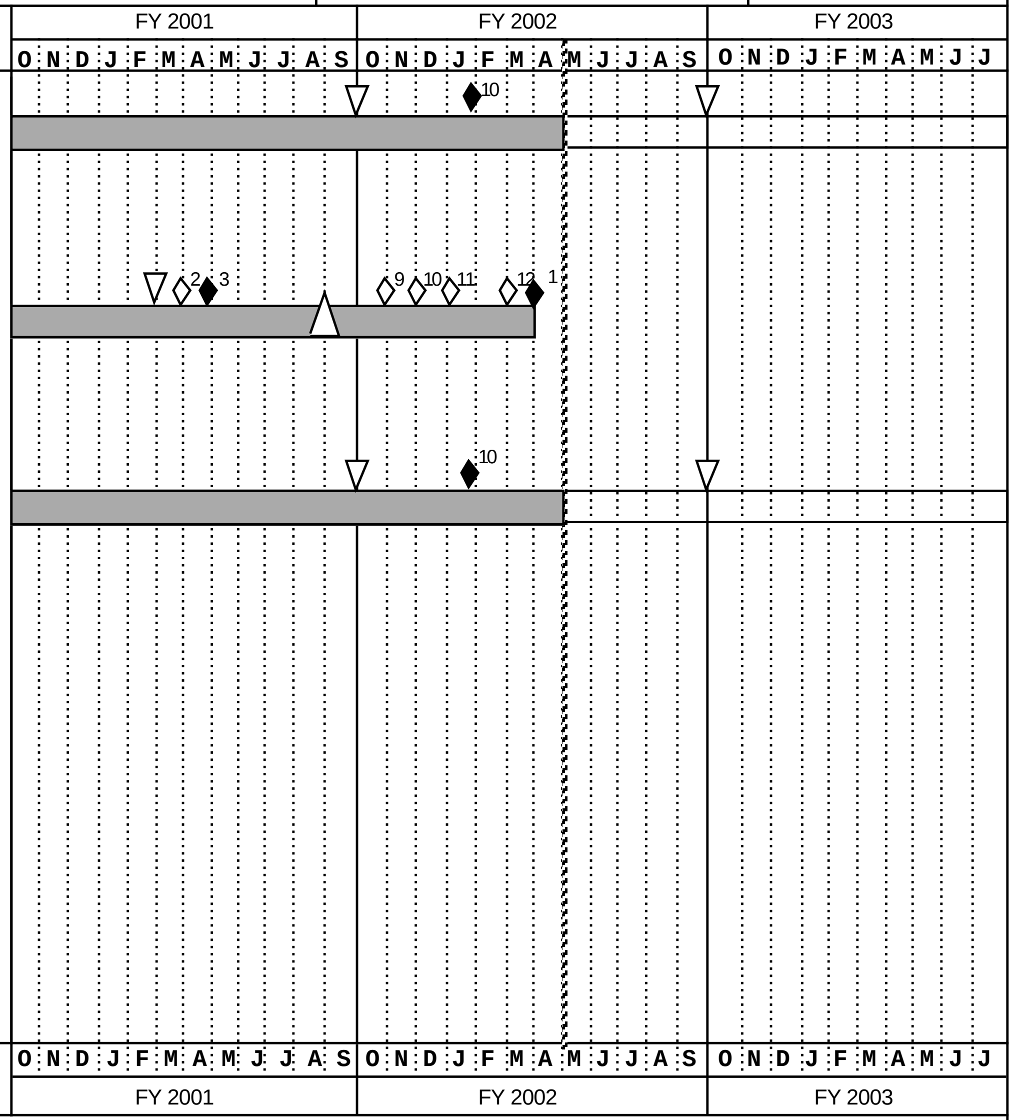
5. CONTRACT PERIOD
FY 1998-2003

6. ACTIVITY NUMBER
41 W6 95 3W 1

7. NRC B&R NO.
860 15 21 20 05

8. DOE B&R NO.
40 10 01 06

9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
6.1.A.	Coordinate the Operation, Data Collection, and Maintenance of the HSSI IAR Facility
6.1.B.	Comprehensive Report on Reusable Irradiation Facilities and Report on Facility Options
6.2.A.	Coordinate the Operation, Data Collection, and Maintenance of the UCSB Irrad. Facility



11. REMARKS