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LOCKHEED MARTIN

ORNL/HSSI(6953)/MLSR-2000/1

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

MONTHLY LETTER STATUS REPORT

FOR

OCTOBER 1999

Oak Ridge National Laboratory
Oak Ridge, Tennessee

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HEAVY-SECTION STEEL IRRADIATION PROGRAM

JCN W6953

MONTHLY LETTER STATUS REPORT

FOR

OCTOBER 1999

Submitted by

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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 eight program tasks. The six tasks correspond to the 189, dated March 23, 1998. 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 April 1998 to December 2000, while the individual task budgets address the period from October 1998 to November 1999, thereby covering both the Department of Energy's fiscal year 1999 and the second year of the NRC's current performance period for the W6953 HSSI Program.

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 (W6953) Program

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Thomas M. Rosseel

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Heavy-Section Steel Irradiation (W6953) Program

MONTHLY LETTER STATUS REPORT
October 1999

Job Code Number:	**W6953**
Project Title:	**Heavy-Section Steel Irradiation Program**
Period of Performance:	**4/1/98 to 12/30/00**
Performing Organization:	**Oak Ridge National Laboratory**
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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 data bases, 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. Six 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). Plans for developing machining techniques in preparation for the examination of the decommissioned Maine Yankee RPV were placed on hold due to uncertainties in obtaining material in the near term.

(Milestone 1.2.A) Unusually large year-end cost variances charged to the HSSI Program in September were carefully reviewed for accuracy and source. It was determined by the HSSI Program Manager, senior division managers, and finance officers, that nearly half of the allocated variance was charged in error due to a July input mistake in the ORNL cost accounting system. That variance was reversed in October resulting an unusually low October monthly cost. The remaining year-end variance was determined to be due to unexpected costs at the Irradiated Materials Evaluation and Testing (IMET) Laboratory. The cause of these additional costs were reviewed by the IMET manager and senior division managers and found to be valid. Although these costs could not be mitigated, a commitment was made by division management to reduce costs in FY 2000 and to set a limit on the total charge for the 55 hot cell days requested by the HSSI Program.

(Milestone 1.2.B) Use of the HSSI reusable irradiation facilities at the University of Michigan, Ford Nuclear Reactor (FNR) by outside users was discussed with the NRC program monitor.

(Milestone 1.3.B) R. K. Nanstad traveled to Bethesda MD on behalf of the HSSI Program to participate in the 27th Water Reactor Safety Meeting and in discussions with the NRC program monitor and other contractors concerning embrittlement issues.

(Milestone 1.3.D) The MOA between the Paul Sherrer Institut (PSI) and ORNL, to examine the fracture-toughness behavior of steel that has been irradiated, annealed, and reirradiated, and which has been signed by PSI and ORNL, is awaiting final DOE-ORO concurrence. (Please see sub task 3.3 for additional details).

A narrated, 15-minute videotape and a tri-fold brochure describing the HSSI Program's reusable irradiation facilities located at the University of Michigan, Ford Nuclear Reactor were prepared in response to discussions with the NRC program monitor regarding use of the irradiation facilities by other NRC contractors or qualified interested parties.

Task 2: Fracture-Toughness Transition 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. For example, pertinent fracture-toughness data needed to assess the shift and potential change in shape of the fracture-toughness curves due to neutron irradiation will be collected and statistically analyzed. The effects of irradiation on fracture-toughness curve shape for highly embrittled RPV steels, dynamic effects, crack arrest, intergranular fracture, and subsized specimens will also be explored. Finally, guidelines for the application of "surrogate materials" to the assessment of fracture toughness of RPV steels will be evaluated.

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) No significant activity during this reporting period.

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 submitted to the NRC for publication in May 1999.

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 irradiation of a pressure-vessel steel to a neutron fluence sufficient to produce a fracture-toughness transition-temperature shift (T_0) of about 150 ^{0}C (270 ^{0}F). 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 precracked Charpy V-notch (PCVN) specimens, for both quasi-static and dynamic tests, will be irradiated and tested to investigate the use of more practical surveillance-size specimens. Tensile specimens will also be included to determine the irradiation-induced hardening. A comprehensive test program with unirradiated material will be included to provide the necessary baseline data for comparison.

(Milestone 2.2.A) The IAR-2 capsule with remaining KS-01 specimens was moved from low-flux to high-flux position. It is anticipated that the specimens in capsule IAR-2 will reach a target fluence of 8.4×10^{18} n/cm^2 during November 1999.

Twelve 1T C(T), twelve 0.5T C(T), 15 Charpy, and six tensile specimens were machined from the Midland beltline weld. These specimens have been precracked and will be loaded into IAR capsules (after KS-01 weld) for irradiation up to 2.5 to 3×10^{19} n/cm^2. The purpose of this experiment is to evaluate a potential for interaction between ductile tearing and cleavage fracture of highly embrittled low upper-shelf weld and whether or not it might cause change in the transition curve shape.

Subtask 2.3: Dynamic Effects, Including Precracked Charpy V-Notch Testing (S. K. Iskander)

As reactors age, the operating window between the startup or shutdown K_a curve, generated from the allowable pressures and temperatures, and the K_{Ia} curve becomes smaller, making it difficult for plants to startup and shut-down. Dynamic testing of relatively small specimens will be evaluated as an alternative method to determine a lower bound to fracture toughness. Results from Subtask 2.5 (crack-arrest), which measures dynamic properties, will also be used in this subtask.

(Milestone 2.3.A) The installation and programming of two electronic boards to record signals from instrumented strikers will begin as soon as possible. These boards will replace the aging digital oscilloscopes that are expensive to repair or replace. In parallel, the origin of "noise" in instrumented traces of precracked Charpy V-notch (PCVN) specimens during dynamic precracked Charpy testing must be traced. "Noise" obscures the useful signal from instrumented strikers tracing.

Subtask 2.4: Irradiation Effects on Fracture Toughness of Midland RPV Weld (D. E. McCabe)

The purpose of this subtask is to determine the transition-temperature shift and to evaluate transition-toughness curve shape for a low Charpy upper-shelf weld metal at a relatively high neutron fluence that will produce greater embrittlement damage than previously obtained with irradiations at lower fluences. This subtask will evaluate the assumption of constant shape for the

MC with highly embrittled low-upper-shelf RPV steels that exhibit onset of stable ductile tearing at relatively low-fracture toughness. The evaluation will be performed through irradiation of the beltline weld from the Midland Unit 1 RPV to a fluence of about 2.5 to 5 x 10^{19} n/cm^2 (>1 MeV) for which a substantial database of unirradiated and irradiated results to a fluence of 1 x 10^{19} n/cm^2 (>1 MeV) already exists. This research is needed to assess the fracture-toughness behavior of such a weld at high-embrittlement levels. Evaluation of the MC shape will be determined with sufficient numbers of 0.5T C(T) to allow for testing at three temperatures in the transition-temperature region. Additionally, PCVN specimens, for both quasi-static and dynamic tests, will also be irradiated and tested to investigate the use of more typical surveillance-size specimens, and tensile specimens will be included to determine the irradiation-induced hardening. A comprehensive-test program with unirradiated material was previously completed under the first HSSI Program (L1098) 10th Irradiation Series, except for dynamic testing of PCVN specimens, which will be included to provide the necessary baseline data for comparison.

(Milestone 2.4.D) The final report, *Evaluation of WF-70 Weld Metal from the Midland Unit 1 Reactor Vessel - Final Report*, by D. E. McCabe, R. K. Nanstad, S. K. Iskander, D. W. Heatherly, and R. L. Swain, NUREG/CR-5736 (ORNL/TM-13748), was submitted to the NRC for publication in February 1999.

Further evaluation of the Midland beltline weld will be performed under Subtask 2.2.

Subtask 2.5: Crack-Arrest including Midland (S. K. Iskander)

In this subtask, the low-temperature operating pressure regulatory concerns will be addressed through testing of the 15 irradiated, Midland crack-arrest specimens. This evaluation will provide an excellent opportunity to determine whether the lower bounds of crack initiation and arrest toughness coincide for this very important class of irradiated LUS welds. These specimens, which were produced and irradiated as part of the previous HSSI (L1098) program, will be used to evaluate the lower and transition arrest-toughness values.

(Milestone 2.5.A) Results of crack-arrest testing of three welds previously obtained by the HSSI Program were compiled and transmitted to the HSST Program for a reevaluation of the basis of ASME K_{Ia} crack-arrest curve. Engineering judgement was exercised with borderline values that did not meet all five ASTM E 1221-96 plane strain validity criteria. A total of 62 crack-arrest toughness values were transmitted from unirradiated testing of HSSI Weld 72W (32 values) and 73W (26 values), as well as the Midland Weld WF-70 (4 values). Besides values for other materials, there were 50 values for HSST Plate 02 in the original ASME K_{Ia} database.

(Milestone 2.5.A) Progress continued on the preparation of the NUREG report entitled, *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).

Subtask 2.6: Intergranular Fracture (D. E. McCabe)

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.

(Milestone 2.6.B) The testing of 2T compact specimens has been completed during this reporting period. The results, when considered in perspective with earlier tests, seem to indicate that coarse grain steel that displays predominant intergranular fracture has unique transition range characteristics. Shear lips do not develop when the material is tested through a supposed transition range. The fracture surface appearance is the same at all test temperatures. In fact, the classical evidence of a brittle-to-ductile fracture transition temperature range could not be demonstrated. Evaluation and report preparation is currently under way.

Subtask 2.7: Subsized 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) Two previously characterized materials (A302B) were identified in sufficient volume to machine 1T C(T) and precracked Charpy specimens from identical locations. The purpose of this experiment is to accumulate data regarding compatibility of fracture toughness results from 1T compact and precracked Charpy specimens. Those data will be evaluated together with data from the database where T_{100} values were determined both with the precracked Charpy and compact specimens. Assembly of this database is under way.

Subtask 2.8: Quantification of surrogate materials for use in a statistics-based fracture toughness assessment (R. K. Nanstad, J. G. Merkle, and M. A. Sokolov)

The purpose of this subtask is to establish guidelines for the use of "surrogate materials" in the assessment of fracture toughness of RPV steels. A plan will be developed to describe the information acquired and the means of collecting it, the method of evaluating the information, and the methods for using the information. Analyses will be performed to provide a methodology for determining limits for predicting fracture toughness of one material, i.e., a surrogate material, with measured fracture toughness of similar materials.

No significant activity occurred during this reporting period.

(Milestone 2.8.A) No significant activity during this reporting period.

<u>Task 3: Irradiation Embrittlement of RPV Steel</u> (S. K. Iskander)

The purpose of this task is to examine two important issues affecting the application of mitigation procedures to 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_{Ia} 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 using the IAR facility designed, fabricated, and installed as part of the previous HSSI (L1098) program and with a matrix of irradiated and tempered specimens supplied by the Swiss HSK and PSI. Further data on reirradiation embrittlement will be obtained through reconstitution and reirradiation of previously irradiated specimens at the RRC-KI.

<u>Subtask 3.1: HAZ embrittlement</u> (D. E. McCabe)

Research conducted to date 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 mitigation of such material resulted in an even greater increase of the transition temperature. Subsequent research at ORNL under the previous HSSI Program (L1098) used five commercial RPV steels to investigate potential temper embrittlement. The first phase 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 ^{0}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.B) The final part of this subtask is to evaluate the potential synergism of neutron bombardment and 288° C aging to create a temper embrittlement contribution to transition temperature shift. The irradiation capsule contains Charpy specimens of embrittlement-sensitive modified A 302 grade B steel as well as embrittlement-insensitive specimens. The exposures will be completed during the next reporting period and testing will follow, given allowance for an appropriate activity decay time.

<u>Subtask 3.2: Embrittlement Rate of Reirradiated Steel</u> (S. K. Iskander, I. Remec, E. D. Blakeman, C. A. Baldwin, and D. W. Heatherly)

This subtask will examine the effects of reirradiation on K_{Ic} and K_{Ia} toughness of RPV steel so as to evaluate the relative changes in recovery and reembrittlement between CVN and fracture-toughness properties and to provide a detailed examination of reembrittlement rates. This will be accomplished using the HSSI IAR and the University of California Santa Barbara (UCSB) irradiation facilities at the University of Michigan, Ford Nuclear Reactor (FNR), and through the reirradiation of previously irradiated specimens at RRC-KI, if funding is available. Emphasis will also be placed on completing dosimetry calculations for the new IAR facility.

(Milestone 3.2.B) Neutronics Analysis of the IAR/UCSB Irradiation Capsules (I. Remec, E. D. Blakeman, 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.

(Milestone 3.2.C) (S. K. Iskander and D. W. Heatherly)
Ten Charpy specimens that were reirradiated in the UCSB high-flux position have been tested and the results are being analyzed. The HSSI Weld 73W Charpy specimens accrued about 1.8 x 10^{19} n·cm^{-2} (>1 MeV), were then annealed at 454°C for 168 h, and finally reirradiated for an additional dose of 3 x 10^{19} n·cm^{-2} (>1 MeV). The wire dosimeters that were in grooves of the Charpy V-notch specimens were retrieved for counting.

Subtask 3.3: Evaluation of reirradiated JRQ specimens (M. A. Sokolov, R. K. Nanstad, 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, identified as JRQ, will supplied by the Swiss HSK and PSI from a terminated research program.

(Milestone 3.3.A) Based on information received from the Paul Scherrer Institute (PSI) in Switzerland, the ORNL Shipping Department completed calculations of the necessary radiation shielding required for the retrieval of the irradiated JRQ specimens from the PSI. Wood inserts were also designed for the containers. All necessary correspondence was completed with the appropriate staff at PSI and six drums (55 gal), each with two lead shields, were sent via Federal Express to PSI on October 13 and were received by PSI on October 25. The PSI staff will load the irradiated specimens into the drums and ship them to ORNL in November.

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 RPVs retired. 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 feasibility of reconstitution for CVN and 0.5T C(T) and 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: Examination of materials from retired RPVs (S. K. Iskander and J. T. Hutton)

This subtask will examine the issue of neutron-irradiation-induced damage attenuation through the RPV wall. The damage will be related to measurements of received dose, such as displacements per atom (dpa) through the wall. The HSSI program will obtain suitable-size trepans of materials from previously decommissioned RPVs, because these materials would incorporate conditions from actual operating reactors such as the effects of irradiation on stressed material. A sufficient number and size of trepans will be obtained to permit use of the MC approach to relate measures of damage to the fracture toughness. Specimens will be machined on the CNC milling machine located in Cell 6 of the IMET facility. Depending upon availability and appropriateness, trepans from the Japan Power Demonstration Reactor (JPDR) project, Trojan, and Maine Yankee RPVs may be examined.

(Milestone 4.1.2.B) The results of testing 42 full-size Charpy specimens machined from eight trepans that originated from the Japan Power Demonstration Reactor (JPDR) pressure vessel are being analyzed. The preliminary results had been presented in a draft letter report transmitted to the NRC. The letter report is now being finalized. The trends appear to be reasonable with respect to the location of the specimens regarding whether they originated from the beltline or the core regions of the vessel, and also whether they were from the inside or outside regions of the vessel wall. However, the ORNL Charpy energy values appear to be shifted towards higher temperatures compared to those obtained by Japan Atomic Energy Research Institute (JAERI). The reasons for this difference are being investigated. The most likely reason is the different orientation of the JAERI (T-S) and ORNL (T-L) Charpy specimens.

Subtask 4.2: Reconstitution of irradiated toughness specimens (S. K. Iskander)

Feasibility studies for reconstitution of CVN, PCVN, and 0.5T bend bar specimens will be prepared. To adequately survey the state-of-the-art capabilities, on-site evaluations of US and international facilities will be required. A letter report that includes the estimated costs of either using existing and available facilities or implementing a reconstitution facility at ORNL will be prepared at the completion of this task.

No work is currently funded in this subtask.

Subtask 4.3: Toughness changes in aged stainless steel welds (R. K. Nanstad)

The purpose of this subtask is to evaluate the effects of irradiation and thermal aging on stainless-steel weld metals. Two projects are incorporated in this subtask. The first involves completion of fracture-toughness testing on irradiated stainless-steel weld-overlay cladding specimens at 288 ^{0}C to complete the testing of the matrix from the HSSI (L1089) 7th Irradiation Series. The PCVN specimens were irradiated in HSSI Capsule 10.06. The second project involves completion of a NUREG report on thermal aging of stainless-steel welds for nuclear piping, a project that began before the inception of the HSSI (L1098) Program and involved thermal aging at 343 ^{0}C for up to 50,000 hours.

(Milestone 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 submitted to the NRC for publication in July 1999.

Subtask 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. U.S.-Russia Joint Coordinating Committee for Civilian Nuclear Reactor Safety (JCCCNRS) Working Group on Radiation Embrittlement and Aging of Components.

2. 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.

3. Collaboration with AEA-Technology in the United Kingdom regarding fracture-toughness testing of intergranular embrittlement of RPV HAZs;

4. Collaborative studies on fracture properties of high-copper RPV materials with Korean institutes such as KAERI.

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

6. Collaboration with PSI in Switzerland on re-irradiation.

7. 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.

8. Participation, including membership on the executive committee, in the International Group on Radiation Damage Mechanisms (IGRDM).

9. Participation in the IAEA New CRP on use of PCVN specimens to determine fracture toughness of RPV steels.

(Milestone 4.4.C) As discussed in the previous progress report, Mr. John Wintle of The Welding Institute in the United Kingdom agreed to send a portion of the fracture surface from the NESC-1 spinning cylinder experiment to R. K. Nanstad for potential examination by ORNL. The portion of interest is that in the region of "defect B" which was reported to exhibit intergranular fracture. Subsequent correspondence between Mr. Wintle and the Joint Research Centre of the European Commission led to the provision of a portion of that fracture surface and some relevant documents. One of these documents is a report, ECN-R--98-024, "Metallographic and Fractographic Investigations for NESC-1," by E. W. Schuring. The scanning electron fractographs in that report clearly indicate the presence of intergranular fracture in the region of defect B. A portion of the fracture surface containing defect B was received at ORNL. Although the surface has suffered from significant oxidation, a preliminary examination of the fracture surface in the scanning electron microscope confirmed the presence of intergranular fracture in the region of defect B. Further examination of the fracture surface will be conducted to compare it with observations of intergranular fracture in the heat-affected zone temper embrittlement study under way in Subtask 3.1.

Plans are under way for R. K. Nanstad to attend two meetings at the International Atomic Energy Agency (IAEA) in Vienna, Austria, November 17-24. They are the IAEA Coordinated Research Program on RPV Structural Integrity and the IAEA Consultants Meeting to Plan New CRP on Surveillance Programs Application. A trip report will be submitted in December.

Subtask 4.5: Technical assistance (R. K. Nanstad)

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 identified activities are incorporated in this subtask, while other activities may be included through modification to the task by the NRC. The currently identified activities involve evaluation of the irradiated specimens contained in capsules previously irradiated at the University of Michigan FNR by Materials Engineering Associates (MEA), evaluation of highly irradiated high-nickel weld surveillance specimens from the Palisades Reactor, evaluation of the effects of post-weld heat treatment (PWHT) on the copper solubility and fracture toughness of unirradiated RPV steels, and compilation of available materials at ORNL and elsewhere for studies of irradiation effects on RPV steels.

(Milestone 4.5.A) Planning is under way for testing of the specimens contained in the MEA capsule which was irradiated in the Ford Nuclear Reactor and subsequently shipped to ORNL for disassembly and testing. We anticipate testing the specimens during the next 2 months. depending on the crane installation scheduled in our hot cell facility. Contact was made with R. G. Carter (EPRI) and W. L. Server (ATI Consulting) to obtain the most recent information regarding these materials in surveillance programs in the EPRI/CRIEPI research program.

(Milestone 4.5.B) The letter report on RPV materials available for irradiation studies is in progress.

(Milestone 4.5.F) The high-copper weld referred to in the previous monthly report continues to undergo various aging treatments and irradiation in the IAR facility at the Ford Reactor.

Task 5: Modeling & Microstructural Analysis (R. E. Stoller)

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 two major components: (1) theoretical modeling and data analysis, and (2) experimental investigations. The modeling work will focus on 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 consist of special-purpose irradiation experiments to isolate particular irradiation variables (neutron-flux level and energy spectrum), and detailed microstructural characterization of RPV materials in relevant conditions. These conditions include: long-term, thermally-aged, irradiated, post-irradiation mitigation (IA), and reirradiated (IAR). 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 extensive use of the commercial-reactor surveillance data and test-reactor data contained in the NRC-funded Embrittlement Database (EDB), and data generated in other experiments coordinated by this task.

The major areas of inquiry will be: (a) the effects of chemical composition, (b) the role of displacement rate (neutron flux level), (c) the impact of differences in neutron-energy spectrum, (d) potential differences in hardening and embrittlement behavior at very high fluence, and (e) the response of materials that are reirradiated following a post-irradiation mitigation. Damage modeling will also address such questions as attenuation through the RPV wall. 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.

Subtask 5.1: Modeling of damage evolution (R. E. Stoller)

The modeling and analysis work will include completion of the development required to incorporate alloying effects in the embrittlement model. Additional thermodynamic components are needed to account for chemical effects, particularly for the simulation of high-fluence effects and thermal mitigation. Enhancements to the code used for simulating displacement cascades will permit the investigation of the effects of alloying elements on primary damage formation.

(Milestone 5.1.A) The statistical analysis of the iron displacement cascade database is ongoing, with the first three 100 keV simulations having been completed. A preliminary analysis of the results indicates that dependence of total defect survival on cascade energy (equivalent to the NRT damage energy) has changed. Between about 20 keV, where subcascade formation becomes a dominant mechanism, and 50 keV, the total defect survival increased at a greater than linear rate with cascade energy. The highest expected dependence was linear, and understanding the origins and limits of this superlinear behavior is relevant to the issue of damage attenuation through a pressure vessel. It now appears that the expected linear dependence will be observed above 50 keV.

Subtask 5.2: Microstructural analysis (R. E. Stoller and M. K. Miller)

Round-Robin studies, using atom probe field-ion microscopy (APFIM), small angle neutron scattering (SANS), and field-emission scanning transmission electron microscopy (FEGSTEM), will be coordinated to resolve the inconsistencies between these techniques that have been used to determine the matrix copper content and the chemical composition of radiation-induced precipitates in RPV materials. Additionally, APFIM characterization will be used to determine whether additional radiation-induced phases are forming.

(Milestone 5.2.B) Irradiated material was acquired for APFIM analysis as part of the APFIM-SANS-FEGSTEM round-robin analysis of matrix chemistry and precipitate composition. The materials include a model steel and two Fe-Cu binary alloys that were irradiated at both 260 and 316 C to a fluence of 0.8x10^19 n/cm^2. Analysis of these materials will begin in November.

The NUREG report entitled, "Atom Probe Tomography Characterization of the Solute Distributions in a Neutron-Irradiated and Annealed Pressure Vessel Steel Weld,"NUREG/CR-6629, (ORNL/TM-13768), was submitted to the NRC in September.

Subtask 5.3: Experimental verification of neutron flux and energy spectrum effects (R. E. Stoller)

An experimental examination of neutron-flux level (displacement rate) and neutron energy spectrum effects (thermal-to-fast-flux ratio) will be conducted in collaboration with other NRC contractors.

No significant activity occurred in this subtask during this reporting period.

Task 6: Test Reactor Irradiation Coordination (K. R. Thoms)

This task will provide the support required to supply and coordinate 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.

Subtask 6.1: Operate the HSSI Irradiation (IAR) Facility (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 1 and 2 irradiation facilities continued during this reporting period. At the beginning of the reporting period, the IAR-2 capsule was rotated 180 degrees (to the forward position) in the IAR-2 facility. The capsule will remain in this position until the specimens currently in the capsule are removed. Removal of the specimens is expected to occur sometime during the next reporting period.

A minor incident occurred during the first startup after the IAR-2 capsule was rotated. Because the capsule was rotated back to the "forward" position, the temperature controlling logic in the IAR computer was switched to the "forward" position. However, it was not evident to the operator that if the logic switching screen on the IAR computer was closed before the entire program had changed from the "reverse" to the "forward" logic (a process requiring ~ one minute), the system would default back to the "reverse" logic. Apparently this is exactly what happened resulting in a very non-uniform heat up of the IAR-2 capsule during the first startup after rotation. The reason for the non-uniformity is that all heater zones in the IAR-2 facility were controlled by thermocouples on the opposite side of the IAR-2 capsule. This mode would eventually result in high temperatures on one side of the capsule and low temperatures on the other. The unusual temperatures were noticed by FNR operators, who notified the ORNL Project Leader. The Project Leader in turn requested immediate shutdown of the facility. The problem was corrected within a few hours and normal operations resumed. To prevent a similar situation from occurring in the future, the computer program was changed such that the logic switching screen will not allow the operator to close the screen until the entire logic switching process has been completed. After completion, the screen now notifies the operator that the logic switching has been completed and allows the screen to be closed.

During this reporting period, the reactor operated for approximately 8.2 days during half-cycle 437B, and approximately 9.3 days during half-cycle 438A. Both half-cycle 437B and 438A were shorter than the normal 10 day half-cycle due to work that had to be performed in the reactor pool. The nature of the work required that the reactor be shut down while the work was being completed.

During the 8.2 days of half-cycle 437B, the IAR irradiation facilities received a total of 197.2 EFPH (effective full power hours). The facilities then received 223.5 EFPH during half-cycle 438A. The total irradiation time during this reporting period was 420.7 EFPH

At the beginning of this reporting period, the first metallurgical specimens in the new IAR facilities had been irradiated at the desired temperature of 288 degrees C for a total of 3710 EFPH. At the end of this reporting period, the remaining specimens had been irradiated for a total of 4131 EFPH.

Subtask 6.2: Operate the UCSB Irradiation Facility (K. R. Thoms and D. W. Heatherly)

This subtask includes supervising the overall operation and provide assistance to the reactor personnel in the routine operation and maintenance of the UCSB irradiation facilities. 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 UCSB irradiation facility continued without incident during this reporting period.

During this reporting period, the reactor operated for approximately 8.2 days during half-cycle 437B, and approximately 9.3 days during half-cycle 438A. Both half-cycle 437B and 438A were shorter than the normal 10 day half-cycle due to work that had to be performed in the reactor pool. The nature of the work required that the reactor be shut down while the work was being completed.

During the 8.2 days of half-cycle 437B, the UCSB irradiation facility received a total of 197.2 EFPH (effective full power hours). The facility then received 223.5 EFPH during half-cycle 438A. The total irradiation time during this reporting period was 420.7 EFPH

At the beginning of this reporting period, the UCSB facility and original specimen compliment had been irradiated for a total of 11,242 EFPH. At the end of this reporting period, the UCSB facility and original specimen compliment had been irradiated for a total of 11,663 EFPH. The latest irradiation plan received from the UCSB experimenters indicates that the final specimens will be removed from the UCSB facility after 13,500 EFPH. At the end of this reporting period, the UCSB irradiation program had obtained 86.3% of the desired irradiation time.

No specimen transfers were performed during this reporting period. A large specimen transfer and insertion of flux monitors is planned for the next reporting period.

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

This task was until March 1, 1999, the Embrittlement Data Base (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 data base 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 includes evaluating surveillance reports, entering the data into the EDB, and providing an update to the NRC by the end of the fiscal year.

(Milestone 7.1.A) No significant activity occurred during this reporting period.

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:

R. K. Nanstad traveled to the University of California, Santa Barbara, to discuss irradiation effects and fracture mechanics in RPV steels, October 1, and to the University of Missouri, Rolla, October 4, 1999, to discuss collaborations on testing of RPV steels and special techniques for removing material from decommissioned RPVs.

R. K. Nanstad traveled to Bethesda, Maryland, to make a presentation and participate in the NRC 27th Water Reactor Safety Information Meeting, October 25; and meet with NRC staff, October 27-29, 1999.

Dr. Josef Jansky, BTB Jansky GmbH, Leonburg, Germany, visited S. K. Iskander and HSSI staff members, toured the Fracture Mechanics Group laboratory and discussed creep of pressure vessel steels, October 20, 1999.

4. PRESENTATIONS, REPORTS, PAPERS, AND PUBLICATIONS:

D. W. Heatherly, K. R. Thoms, I. I. Siman-Tov, and M. T. Hurst, "Design, Fabrication, and Initial Operation of a Reusable Irradiation Facility," ORNL/NRC/LTR-99/16.

D. E. McCabe, *Initial Evaluation of the Heat-Affected Zone, Local Embrittlement Phenomenon as it Applies to Nuclear Reactor Vessels*, ORNL/NRC/LTR-99/10, September 1999.

R. K. Nanstad, S. K. Iskander, D. E. McCabe, T. M. Rosseel, M. A. Sokolov, and R. E. Stoller, "Overview of Irradiation Effects on Fracture Toughness and Crack-Arrest Toughness of RPV Steels, Heavy-Section Steel Irradiation Program," presented by R. K. Nanstad at the NRC 27th Water Reactor Safety Information Meeting, Bethesda, Maryland, October 25, 1999.

G. R. Odette , G. E. Lucas, R. K. Nanstad, K. R. Thoms, D. W. Heatherly, M T. Hurst, T. M. Rosseel, and P. A. Simpson, "The Role of the Michigan Memorial Phoenix Project in Irradiation Material Science," presented by G. R. Odette at the University of Michigan Phoenix 50^{th} Anniversary Symposium, October 21-22, 1999.

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 ($)
None	

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: 10/1/99-10/24/99

	Current Month (MM)	Fiscal Year to Date (MY)	Cumulative Project to date (MY)
I. Direct Staff Effort	8	0.7	20.6
II. A. Direct Lab Staff Effort ($)			
Direct Salaries	25,692	25,692	2,078,931
Materials and Services	625	625	321,789
ADP Support	67	67	1,068
Subcontracts	73,938	73,938	271,242
Travel	-1,904	-1,904	88,604
Indirect Labor Costs	0	0	0
Other: NRC PO Tax	0	0	93,500
General and Administrative	14,218	14,218	961,068
Total LMER Costs	112,636	112,636	3,816,202
B. DOE Added Factor Costs	0	0	0
TOTAL PROJECT COSTS	112,636	112,636	3,816,202
Percentage of available cumulative funds costed		95	
Percentage of available current FY funds costed		37	
Funds Remaining		193,798	

III. Funding Status

Prior FY Carryover	FY 00 Projected Funding Level	FY 00 Funds Received to Date	FY 00 Funding Balance Needed	Cumulative Amt. Obligated	Cumulative Amt. Costed
306,434	1,600,000	0	1,600,000	4,010,000	3,816,202

Comments:

An FY 1999 year end variance error of $44,191 (including overhead) was corrected, resulting in lower labor (salaries) and overhead (G&A) charges for the October business month.

1. CONTRACT REPORTING ELEMENT
HSSI - Heavy-Section Steel Irradiation Program

2. REPORTING PERIOD
10/1/99-10/24/99

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 1998-1999

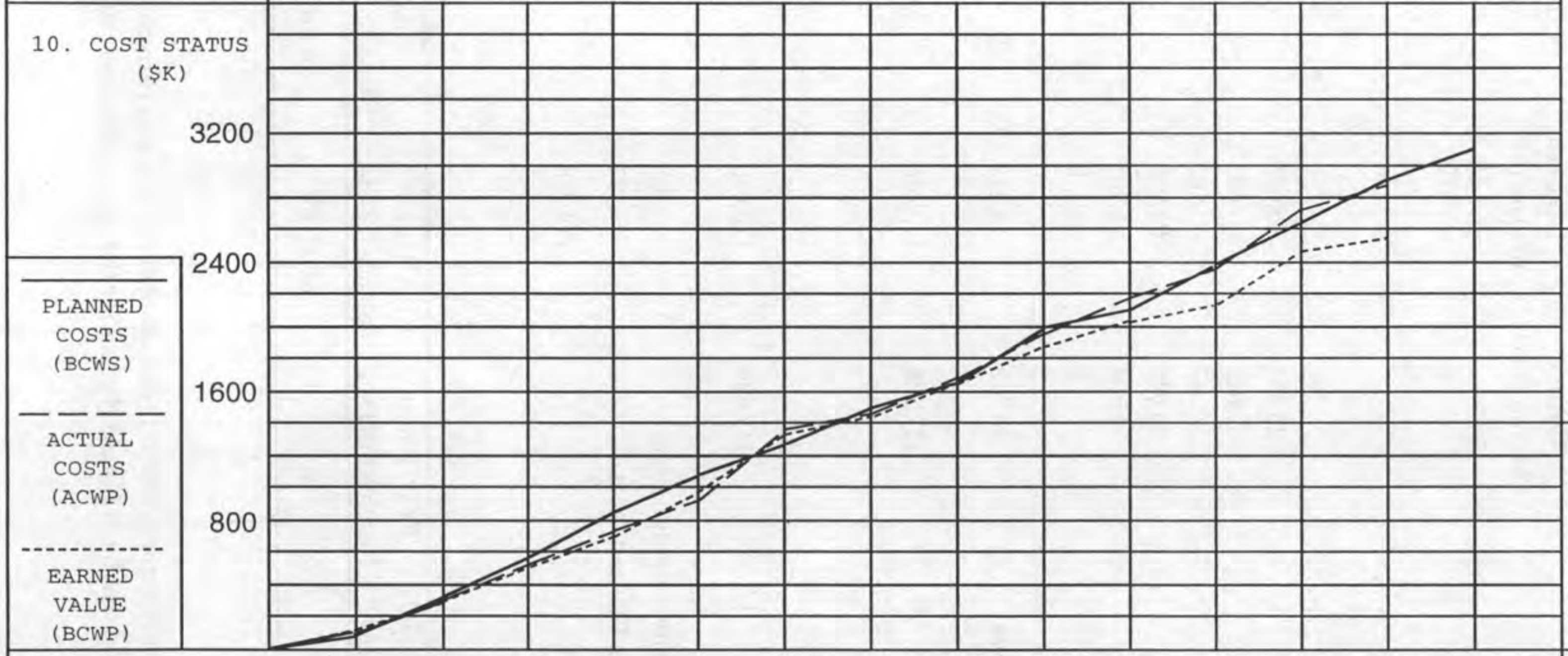
6. ACTIVITY NUMBER
41 W6 95 3W 1

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

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

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

10. COST STATUS ($K)



COST PLAN DATES
10/11/99

PLANNED COSTS FOR ELEMENT ($K)
3,047

ELEMENT COSTS FOR PRIOR FYS ($K)
962

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	135	241	220	211	209	234	263	234	235	201	230	228	217	189	
ACTUAL	142	209	209	189	203	338	197	263	214	233	153	391	113		
EARNED	159	187	196	200	252	261	212	169	193	178	160	244	178		
CUM. PLAN.	135	376	596	807	1016	1250	1513	1747	1982	2183	2413	2641	2858	3047	
CUM. ACT.	142	351	560	749	952	1290	1487	1750	1964	2197	2350	2741	2854		
CUM. EARN.	159	346	542	742	994	1255	1467	1636	1829	2007	2167	2411	2589		

11. REMARKS:

1. CONTRACT REPORTING ELEMENT
HSSI - 1. Program Management

2. REPORTING PERIOD
10/1/99-10/24/99

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 1998-1999

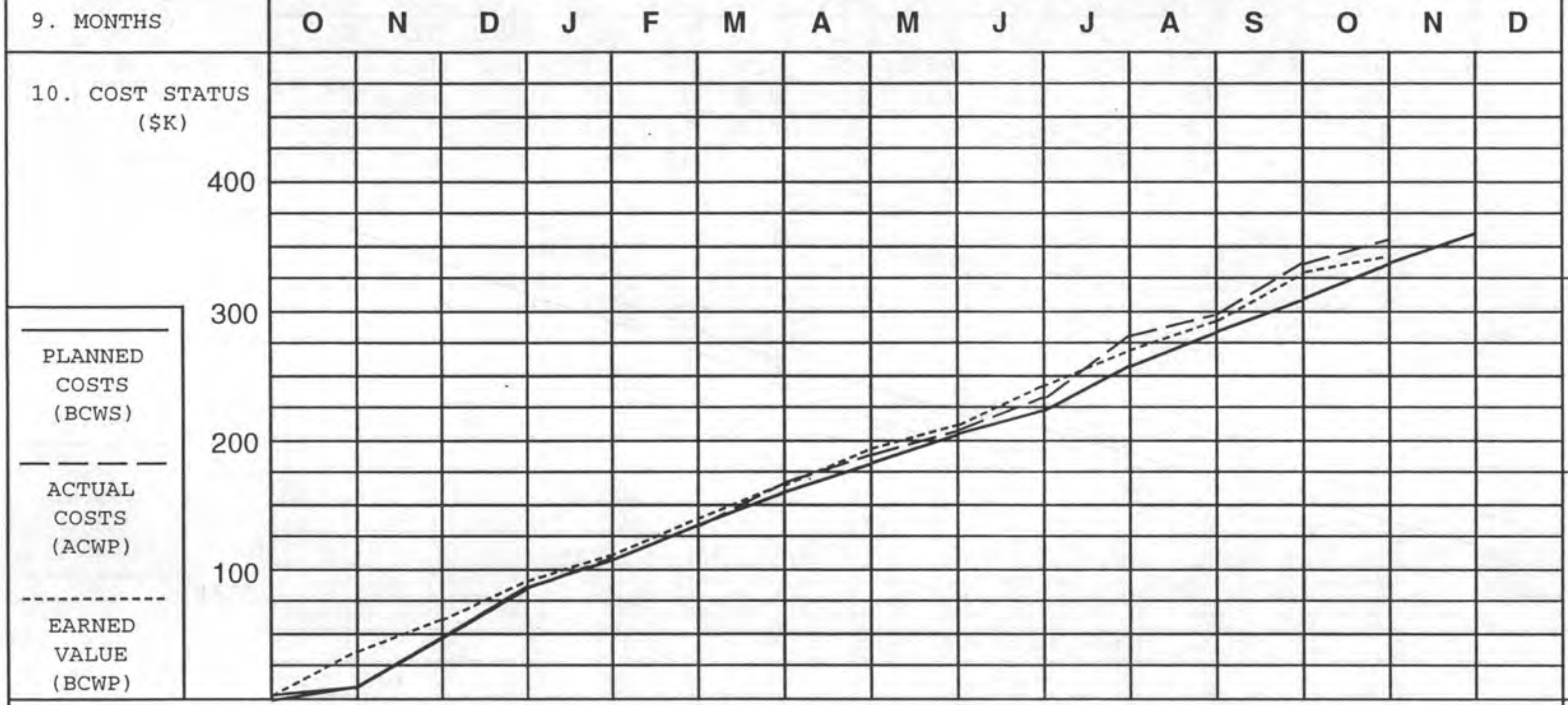
6. ACTIVITY NUMBER
41 W6 95 3W 1

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

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

9. MONTHS

10. COST STATUS ($K)



COST PLAN DATES
8/25/99

PLANNED COSTS FOR ELEMENT ($K)
365

ELEMENT COSTS FOR PRIOR FYS ($K)
184

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	18	31	32	24	25	27	25	24	24	24	25	27	27	32	
ACTUAL	18	31	32	22	27	34	22	28	22	41	22	36	18		
EARNED	32	28	25	23	27	29	28	26	28	22	27	32	18		
CUM. PLAN.	18	49	81	105	130	157	182	206	230	254	279	306	333	365	
CUM. ACT.	18	49	81	103	130	164	186	214	236	277	299	335	353		
CUM. EARN.	32	60	85	108	135	164	191	217	245	267	294	326	344		

11. REMARKS:

1. CONTRACT REPORTING ELEMENT
HSSI - 2. Fracture Toughness Transition and MC Methodology

2. REPORTING PERIOD
10/1/99-10/24/99

3. JCN NO.
W6953

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

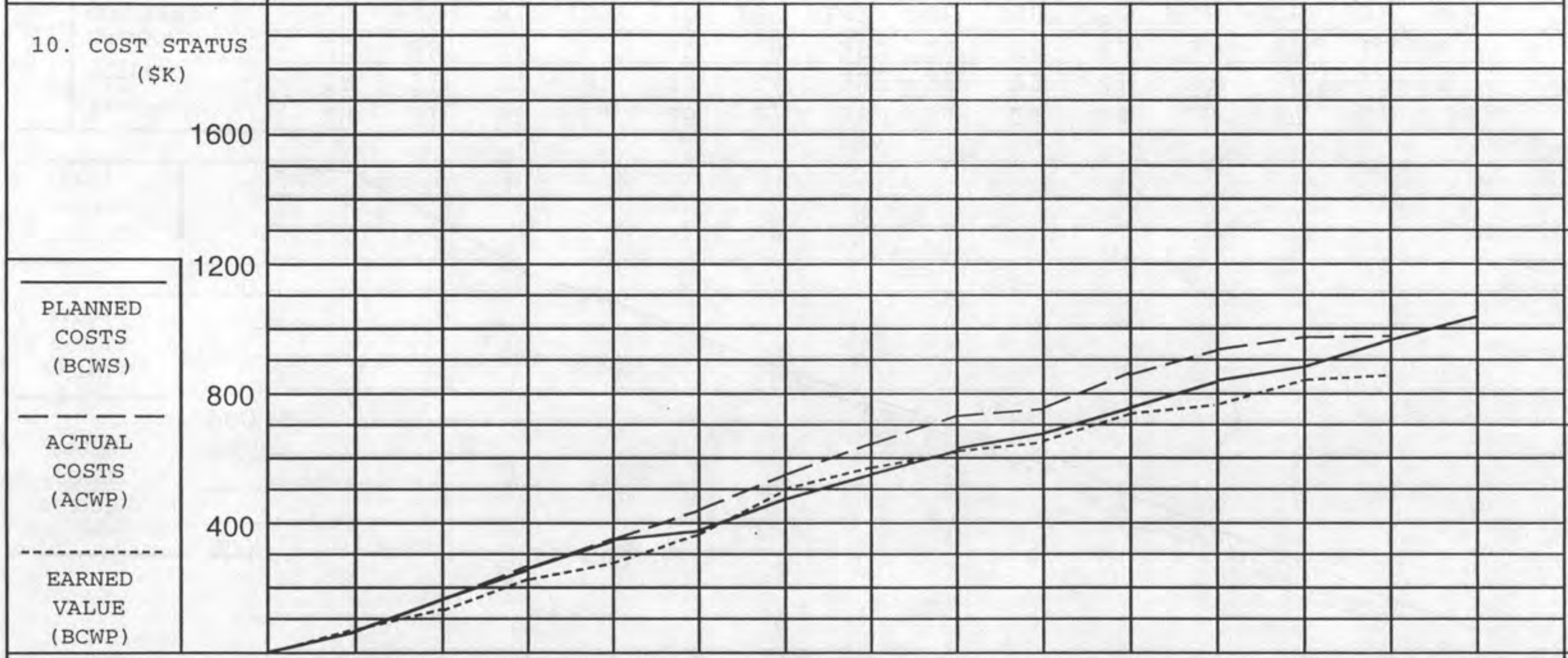
5. CONTRACT PERIOD
FY 1998-1999

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

10. COST STATUS
($K)



COST PLAN DATES
9/30/99

PLANNED COSTS FOR ELEMENT ($K)
1015

ELEMENT COSTS FOR PRIOR FYS ($K)
1015

9. MONTHS		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
ACCRUED COSTS ($K)	PLANNED	61	110	80	76	66	77	76	70	70	62	81	69	68	49	
	ACTUAL	61	110	79	79	89	114	103	75	55	96	47	86	-17		
	EARNED	62	76	71	66	116	108	65	44	57	52	39	57	38		
	CUM. PLAN.	61	171	251	327	393	470	546	616	686	748	829	898	966	1015	
	CUM. ACT.	61	171	250	329	418	532	635	710	765	861	908	994	977		
	CUM. EARN.	62	138	209	275	391	499	564	608	665	717	756	813	851		

11. REMARKS:

1. CONTRACT REPORTING ELEMENT
HSSI - 3. Irradiation Embrittlement of RPV Steel

2. REPORTING PERIOD
10/1/99-10/24/99

3. JCN NO.
W6953

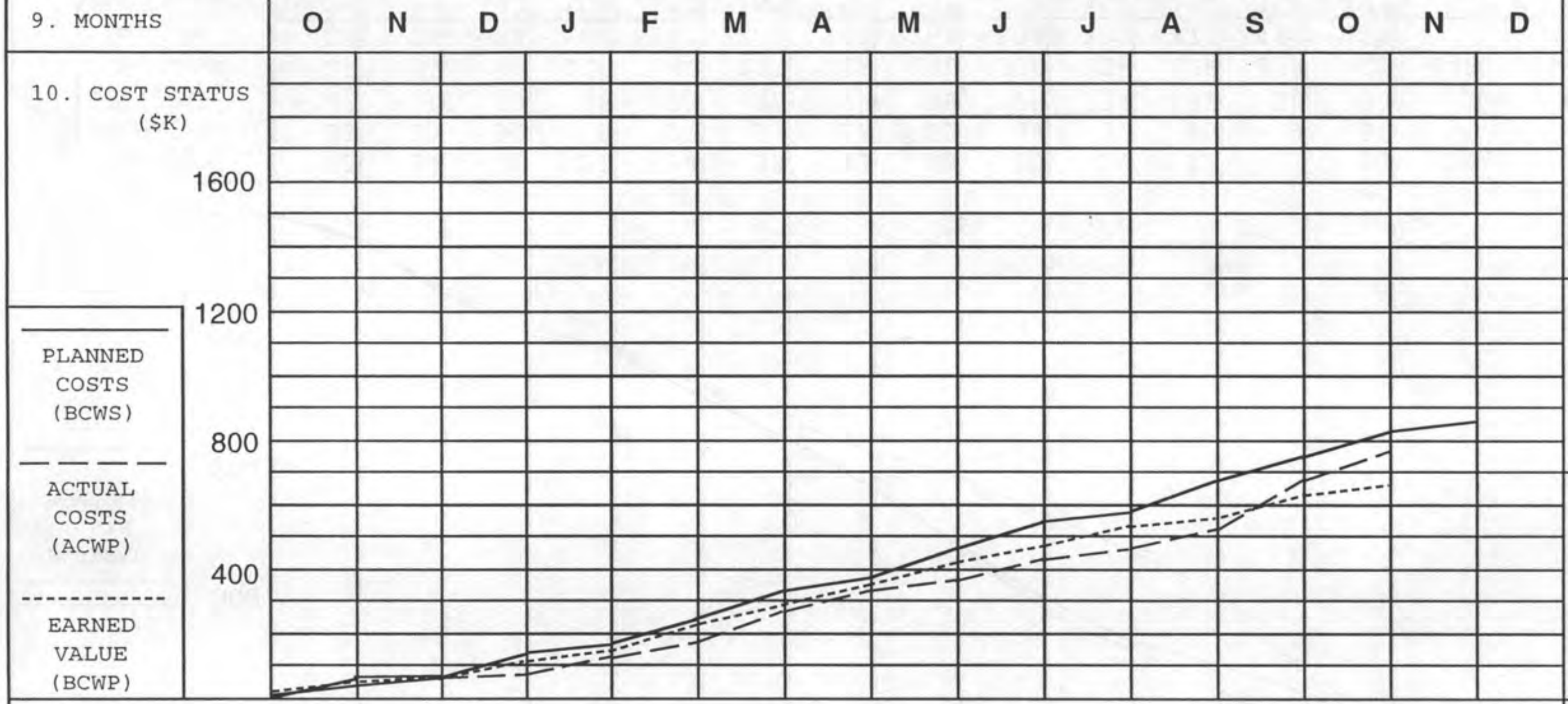
4. CONTRACTOR (NAME AND ADDRESS)
OAK RIDGE NATIONAL LABORATORY
P.O. BOX 2008
OAK RIDGE, TN 37831

5. CONTRACT PERIOD
FY 1998-1999

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



COST PLAN DATES
8/25/99

PLANNED COSTS FOR ELEMENT ($K)
848

ELEMENT COSTS FOR PRIOR FYS ($K)
187

		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
ACCRUED COSTS ($K)	PLANNED	28	42	47	60	61	66	87	74	70	57	78	83	52	43	
	ACTUAL	35	11	37	41	50	116	31	46	72	44	29	169	93		
	EARNED	32	32	39	60	67	66	65	53	56	42	35	64	68		
	CUM. PLAN.	28	70	117	177	238	304	391	465	535	592	670	753	805	848	
	CUM. ACT.	35	46	83	124	174	290	321	367	439	483	512	681	778		
	CUM. EARN.	32	64	103	163	230	296	361	414	470	512	547	611	679		

11. REMARKS:

1. CONTRACT REPORTING ELEMENT
HSSI - 4. Validation of Irradiated and Aged Materials

2. REPORTING PERIOD
10/1/99-10/24/99

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 1998-1999

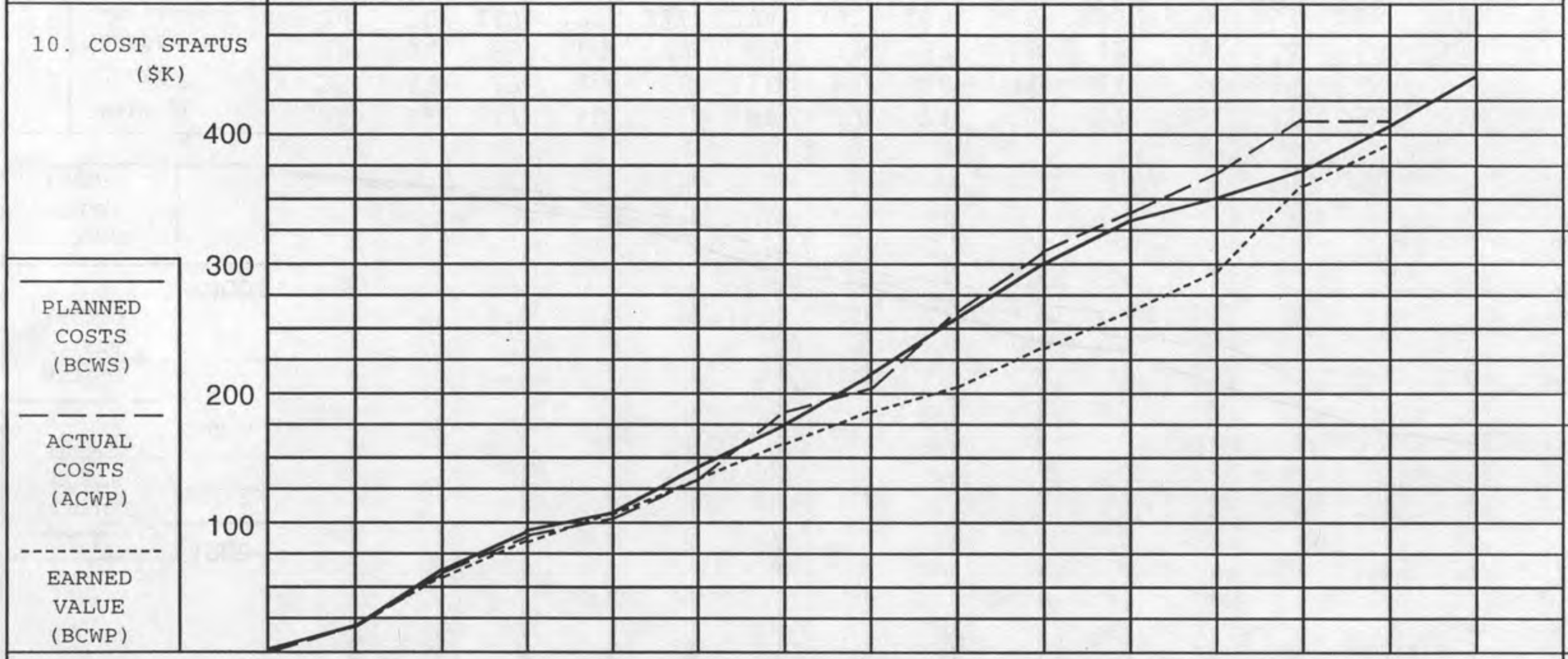
6. ACTIVITY NUMBER
41 W6 95 3W 1

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

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

9. MONTHS

10. COST STATUS ($K)



COST PLAN DATES

10/1/99

PLANNED COSTS FOR ELEMENT ($K)

448

ELEMENT COSTS FOR PRIOR FYS ($K)

188

		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
ACCRUED COSTS ($K)	PLANNED	23	34	30	21	34	33	43	42	40	28	22	23	36	39	
	ACTUAL	23	33	30	18	27	53	18	62	44	27	35	49	0		
	EARNED	23	30	27	28	23	26	25	19	29	34	32	58	33		
	CUM. PLAN.	23	57	87	108	142	175	218	260	300	328	350	373	409	448	
	CUM. ACT.	23	56	86	104	131	184	202	264	308	335	370	419	419		
	CUM. EARN.	23	53	80	108	131	157	182	201	230	264	296	354	387		

11. REMARKS:

1. CONTRACT REPORTING ELEMENT
HSSI - 5. Modeling and Microstructural Analysis

2. REPORTING PERIOD
10/1/99-10/24/99

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 1998-1999

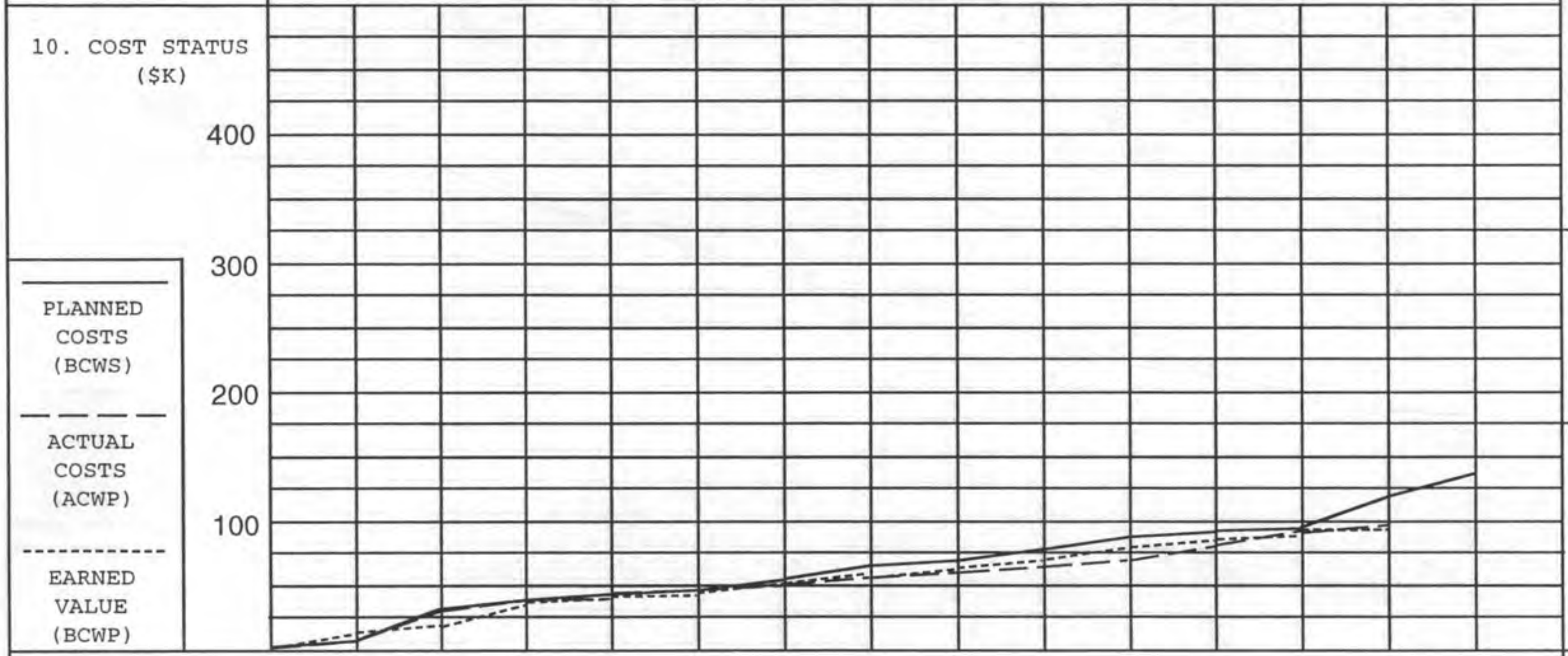
6. ACTIVITY NUMBER
41 W6 95 3W 1

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

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

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

10. COST STATUS ($K)



COST PLAN DATES
1/22/99

PLANNED COSTS FOR ELEMENT ($K)
136

ELEMENT COSTS FOR PRIOR FYS ($K)
59

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED	4	23	5	8	5	7	7	6	11	5	5	10	24	16	
ACTUAL	4	23	5	7	6	5	5	4	5	9	8	13	4		
EARNED	6	16	10	6	4	9	7	5	6	7	7	6	5		
CUM. PLAN.	4	27	32	40	45	52	59	65	76	81	86	96	120	136	
CUM. ACT.	4	27	32	39	45	50	55	59	64	73	81	94	98		
CUM. EARN.	6	22	32	38	42	51	58	63	69	76	83	89	94		

11. REMARKS:

1. CONTRACT REPORTING ELEMENT
HSSI - 6. Irradiation Coordination

2. REPORTING PERIOD
10/1/99-10/24/99

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 1998-1999

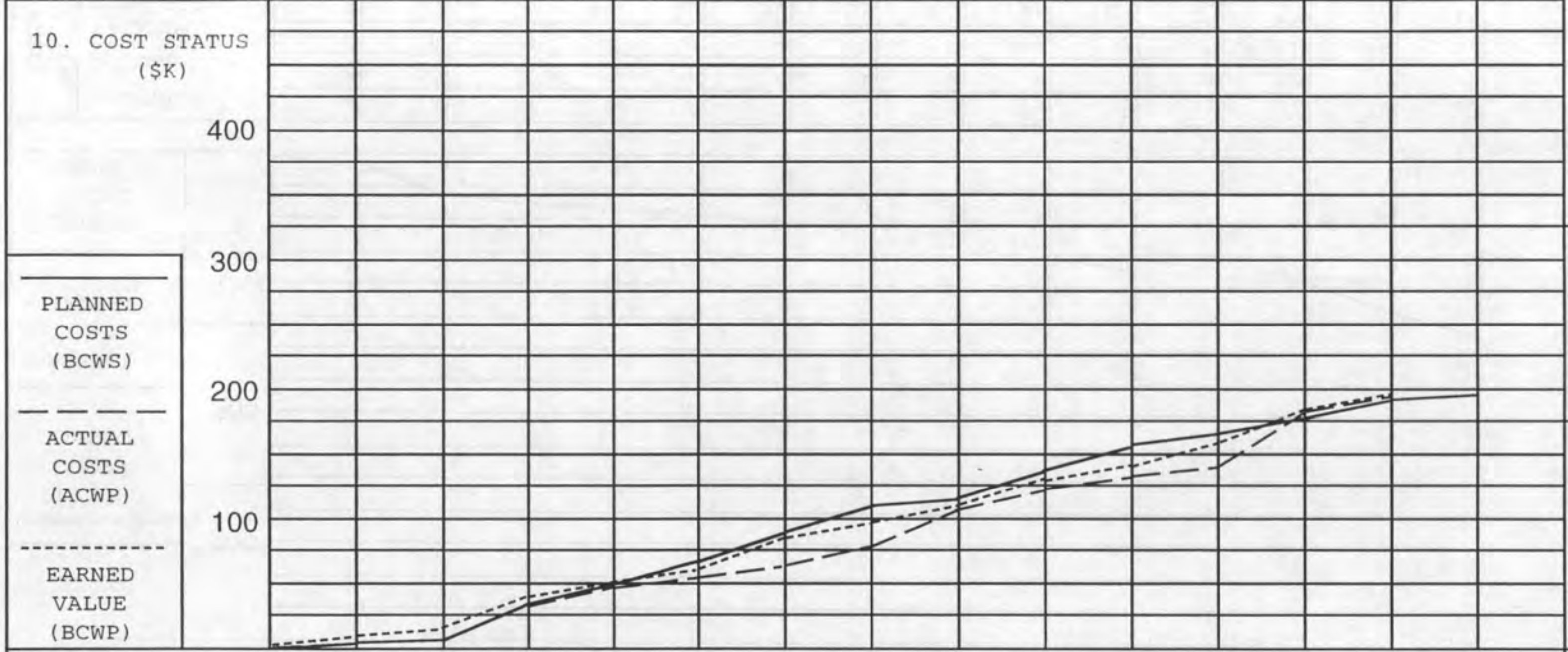
6. ACTIVITY NUMBER
41 W6 95 3W 1

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

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

9. MONTHS

10. COST STATUS ($K)



COST PLAN DATES
10/1/99

PLANNED COSTS FOR ELEMENT ($K)
196

ELEMENT COSTS FOR PRIOR FYS ($K)
1

	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
ACCRUED COSTS ($K) PLANNED	1	1	26	22	18	20	20	12	16	16	12	12	10	10	
ACTUAL	1	1	26	21	3	16	8	34	13	7	14	35	16		
EARNED	4	5	24	17	15	17	16	16	14	13	13	26	16		
CUM. PLAN.	1	2	28	50	68	88	108	120	136	152	164	176	186	196	
CUM. ACT.	1	2	28	49	52	68	76	110	123	130	144	179	195		
CUM. EARN.	4	9	33	50	65	82	98	114	128	141	154	180	196		

11. REMARKS:

1. CONTRACT REPORTING ELEMENT
HSSI - 7. Embrittlement DB & Dosimetry Evaluation

2. REPORTING PERIOD
10/1/99-10/24/99

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 1998-1999

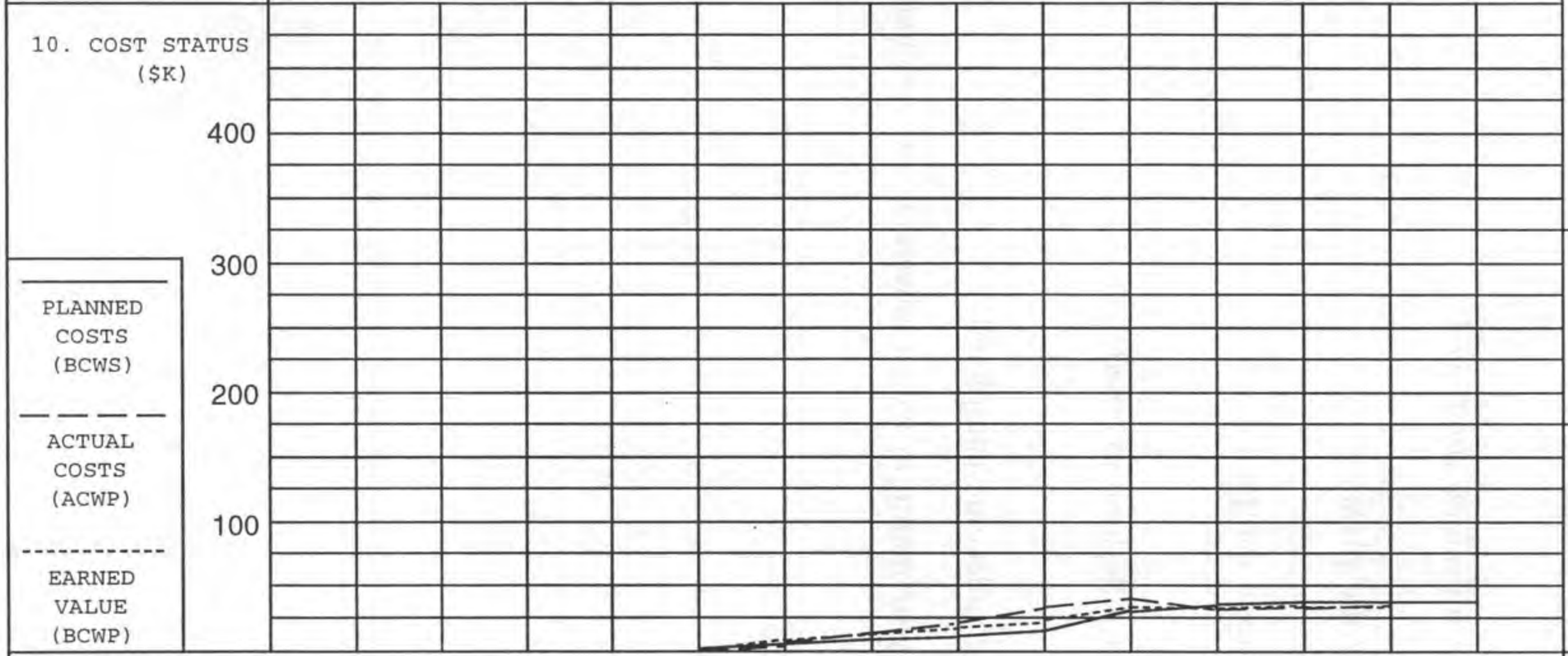
6. ACTIVITY NUMBER
41 W6 95 3W 1

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

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

9. MONTHS

10. COST STATUS ($K)



COST PLAN DATES
8/25/99

PLANNED COSTS FOR ELEMENT ($K)
39

ELEMENT COSTS FOR PRIOR FYS ($K)
0

ACCRUED COSTS ($K)	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
PLANNED						4	5	6	4	9	7	4	0	0	
ACTUAL						3	10	11	5	7	-2	4	0		
EARNED						6	7	6	3	8	7	1	0		
CUM. PLAN.						4	9	15	19	28	35	39	39	39	
CUM. ACT.						3	13	24	29	36	34	38	38		
CUM. EARN.						6	13	19	22	30	37	38	38		

11. REMARKS:

Milestone Symbology

▽ Intermediate milestone planned

▼ Intermediate milestone completed

△ Major milestone planned

▲ Major milestone completed

◇^{n} Rescheduled milestone planned

◆^{n} Rescheduled milestone completed

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

1. CONTRACT REPORTING ELEMENT
HSSI - 1. Program Management

2. REPORTING PERIOD
10/1/99 - 10/24/99

3. JCN NO.
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4. CONTRACTOR (NAME AND ADDRESS)
OAK RIDGE NATIONAL LABORATORY
P.O. BOX 2008
OAK RIDGE, TN 37831

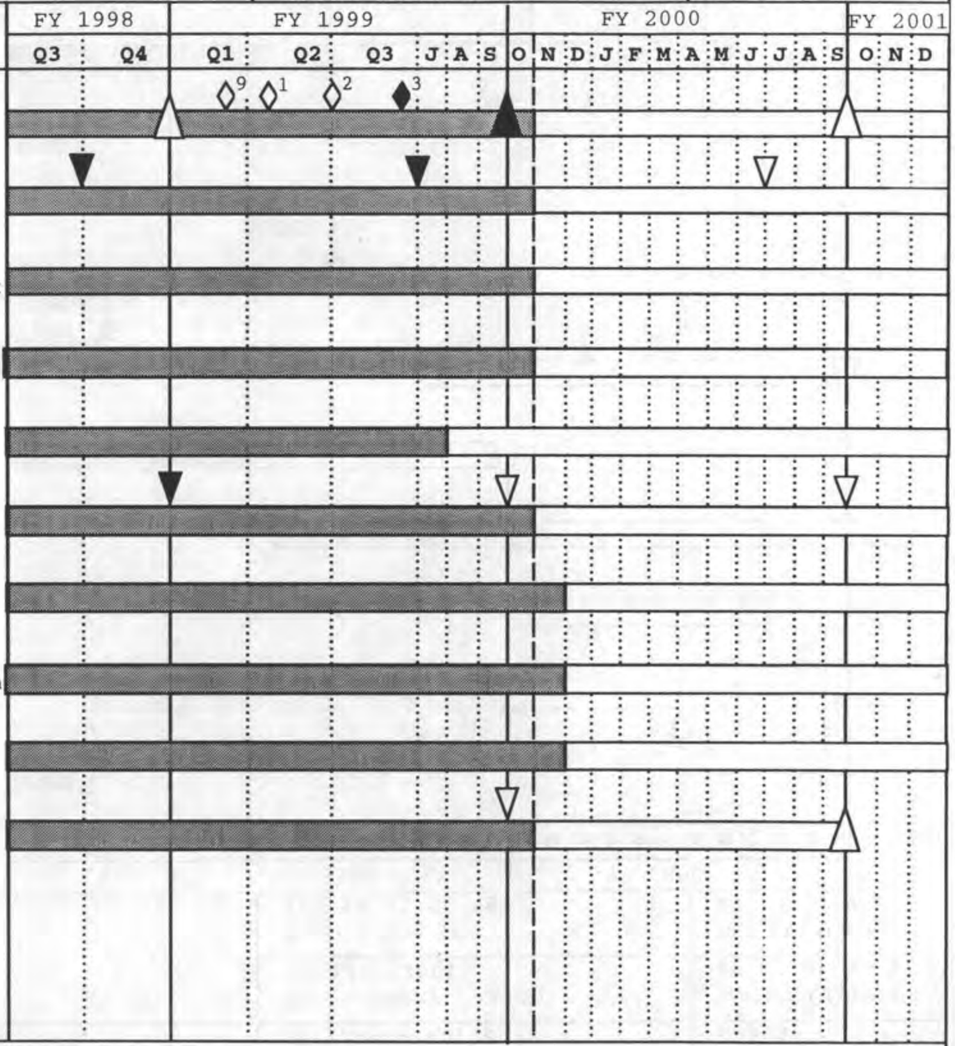
5. CONTRACT PERIOD
FY 1998-2001

6. ACTIVITY NO.
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
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 Appropriate Codes and Standards Committees
1.3.B.	Participate in NRC-Sponsored Meetings and Discussions
1.3.C.	Coordinate NRC and Internal Reviews
1.3.D.	Coordinate Domestic and Foreign Information Exchange as Approved by NRC-RES
1.3.E.	Coordinate HSSI Letter and NUREG Reports
1.3.F.	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
10/1/99 - 10/24/99

3. JCN NO.
W6953

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

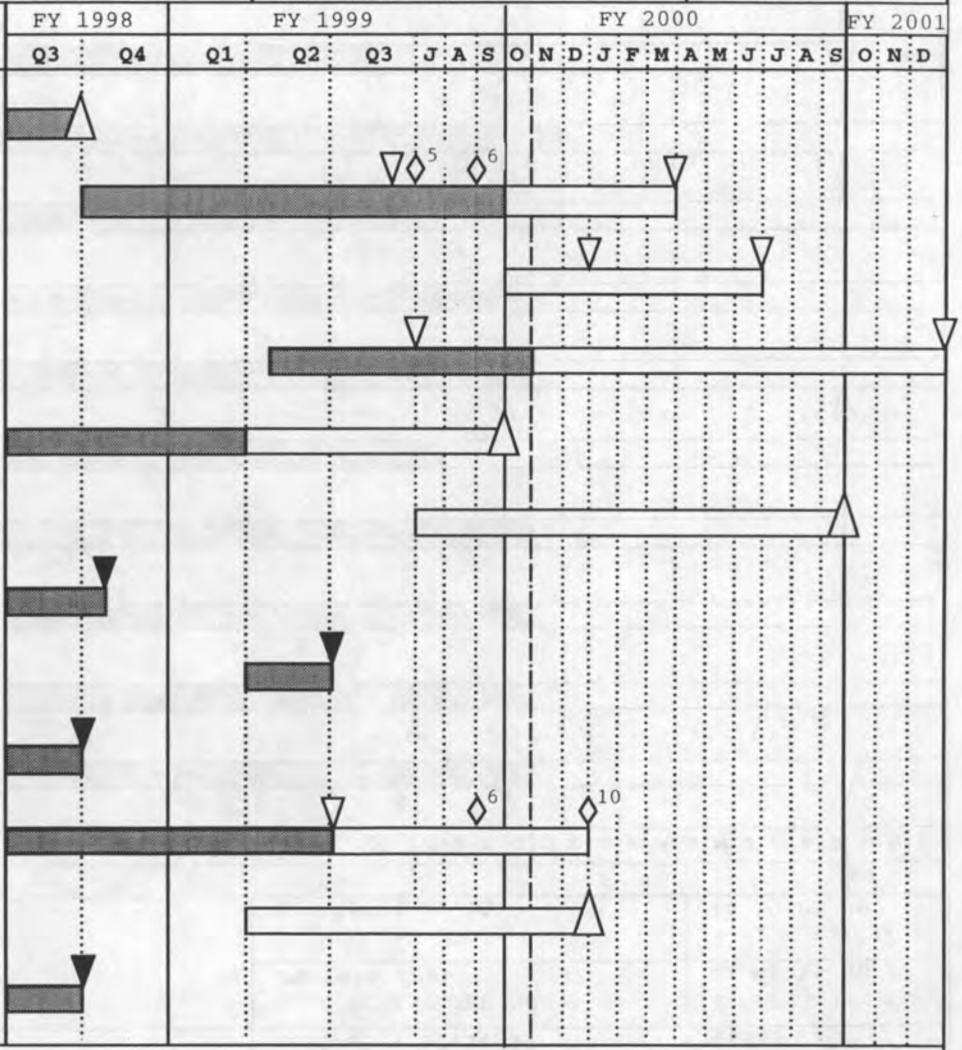
5. CONTRACT PERIOD
FY 1998-2001

6. ACTIVITY NO.
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.	Complete Draft NUREG Report on Comparison of CVN and Fracture Toughness Shifts
2.2.A.	Sample Preparation and Irradiation for Master Curve
2.2.B.	Receive Specimens
2.2.C.	Test Unirradiated & Irradiated Master Curve Specimens
2.3.A.	Design, Fabrication, Calibration, Evaluation and NUREG Report for Phase I
2.3.B.	Phase II: NUREG on MC Evaluation
2.4.A.	Midland Weld Evaluations
2.4.B.	Pressure Vessel and Piping (ASME) Report
2.5.A.1.	Test Midland Crack Arrest Specimens
2.5.A.2.	Analyze Crack Arrest Data & Draft NUREG
2.5.B.	Prepare a Comprehensive NUREG
2.6.A.	IG Fracture Obtain & Machine HT Pieces



11. REMARKS

1. CONTRACT REPORTING ELEMENT
HSSI - 2. Fracture Toughness Transition & MC Methodology

2. REPORTING PERIOD
10/1/99 - 10/24/99

3. JCN NO.
W6953

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

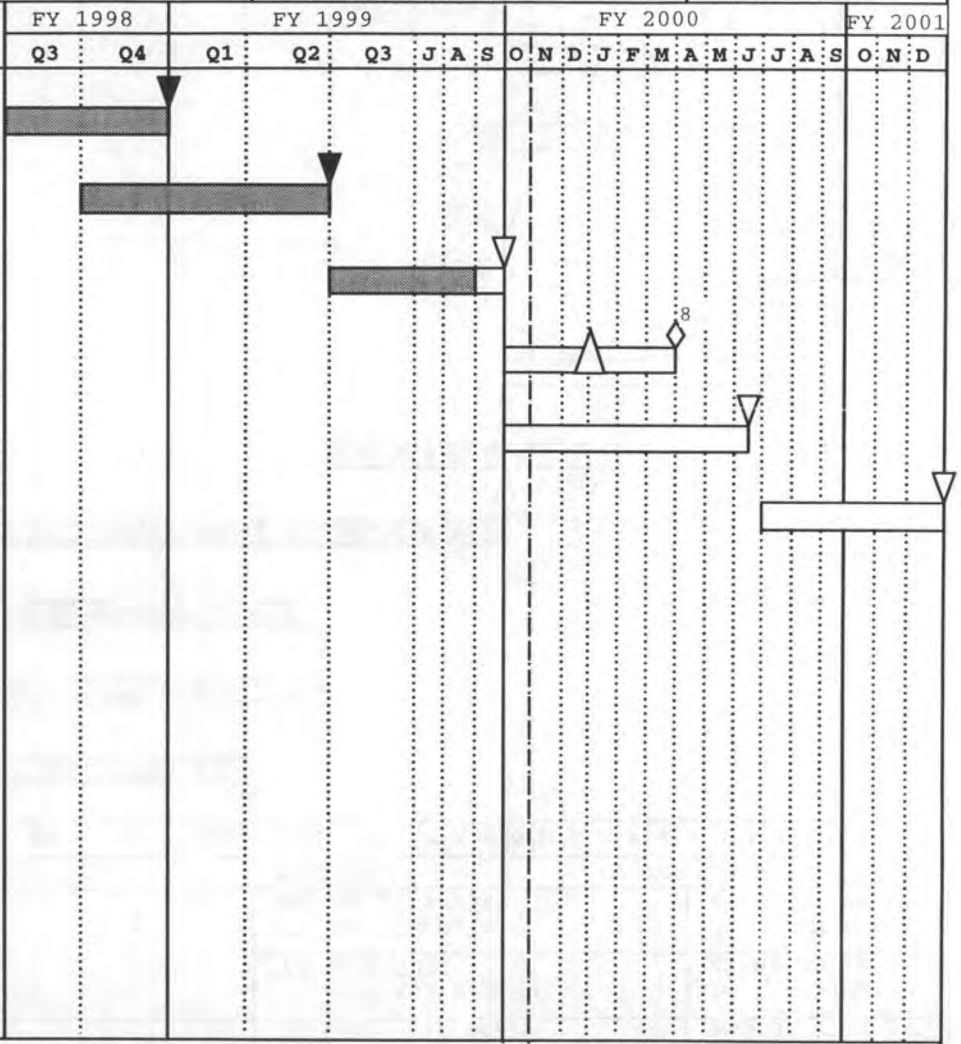
5. CONTRACT PERIOD
FY 1998-2001

6. ACTIVITY NO.
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
2.8.A.	Complete Plan for Assembly and Compilation of Surrogate Materials Data Base
2.8.B.	Complete Assembly and Compilation for Unirradiated Materials
2.8.C.	Complete Statistical Analyses of Data Base for Unirradiated Materials
2.8.D.	Complete Draft NUREG Report on Guidelines for use of Surrogate Materials to Establish
2.8.E.	Complete Assembly and Compilation for Irradiated Materials
2.8.F.	Complete Statical Analysis of Data Base for Irradiated materials



11. REMARKS

1. CONTRACT REPORTING ELEMENT
HSSI - 2. Fracture Toughness Transition & MC Methodology

2. REPORTING PERIOD
10/1/99 - 10/24/99

3. JCN NO.
W6953

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

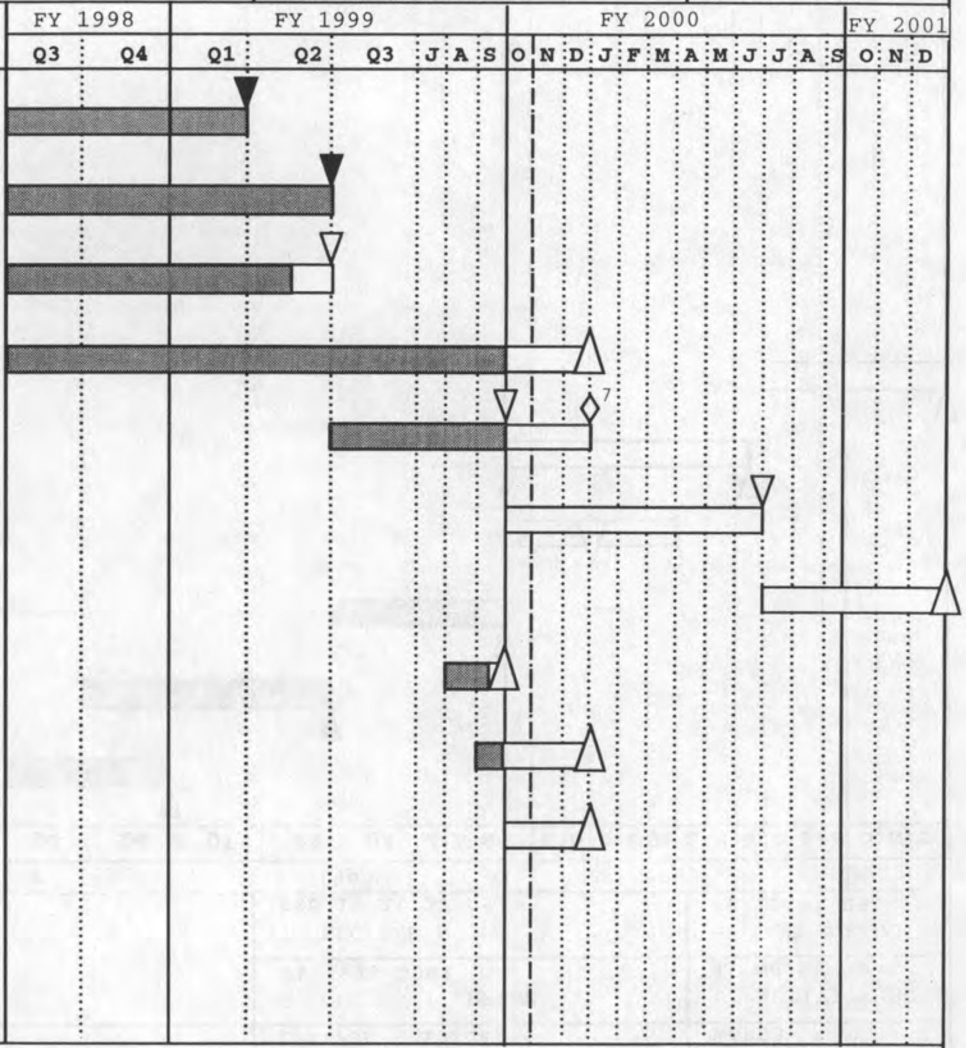
5. CONTRACT PERIOD
FY 1998-2001

6. ACTIVITY NO.
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
2.6.B.	Age & Evaluate by CVN
2.6.C.	Machine C(T)s and Test
2.6.D.	MC Impact Evaluations
2.6.E.	Reports and Administration
2.7.A.	Complete Fabrication and Preliminary Testing of Subsize Specimen
2.7.B.	Complete Testing of Subsize Specimens
2.7.C.	Complete NUREG Report on Results of Subsize Specimen Fracture Toughness Tests
2.7.D	Fabricate A302B PCVNs from 3 Heats
2.7.E.	Test and Analyze
2.7.F.	Prepare Letter Report



11. REMARKS

1. CONTRACT REPORTING ELEMENT
HSSI - 3. Irradiation Embrittlement of RPV Steel

2. REPORTING PERIOD
10/1/99 - 10/24/99

3. JCN NO.
W6953

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

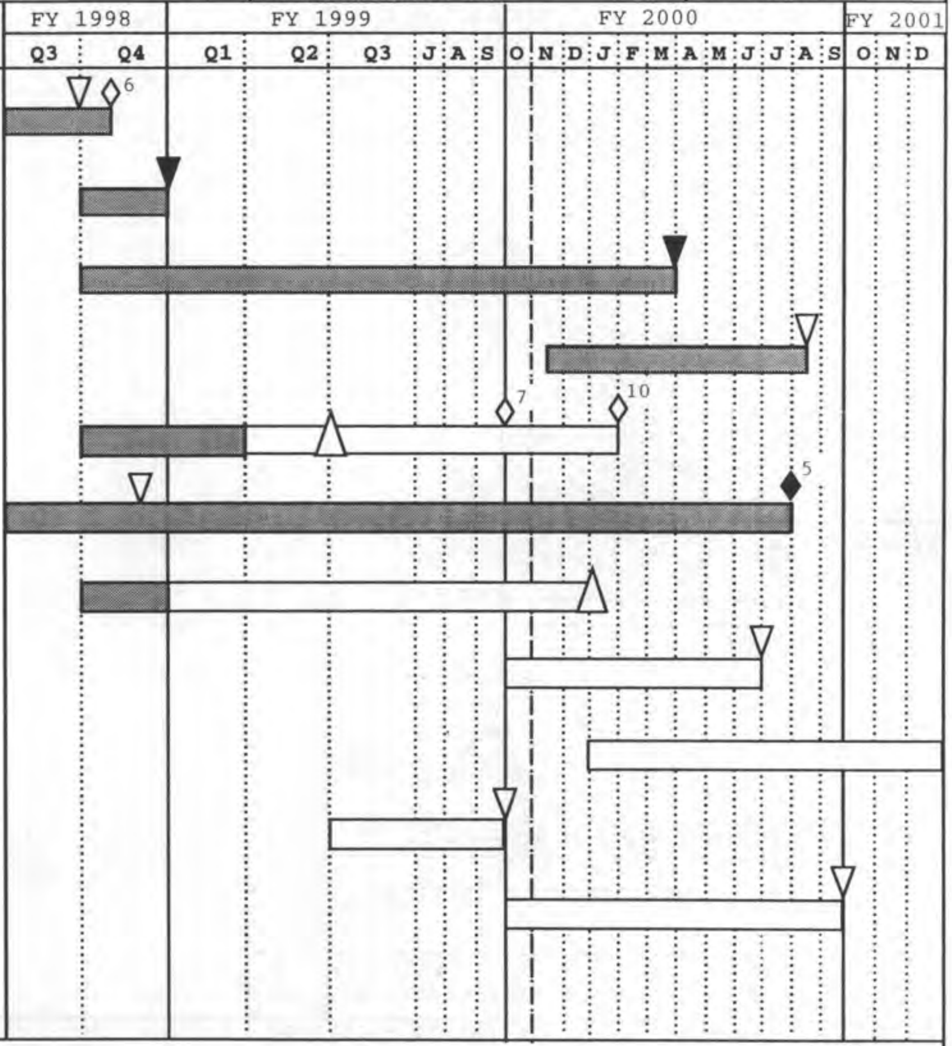
5. CONTRACT PERIOD
FY 1998-2001

6. ACTIVITY NO.
41 W6 95 3W 1

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

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

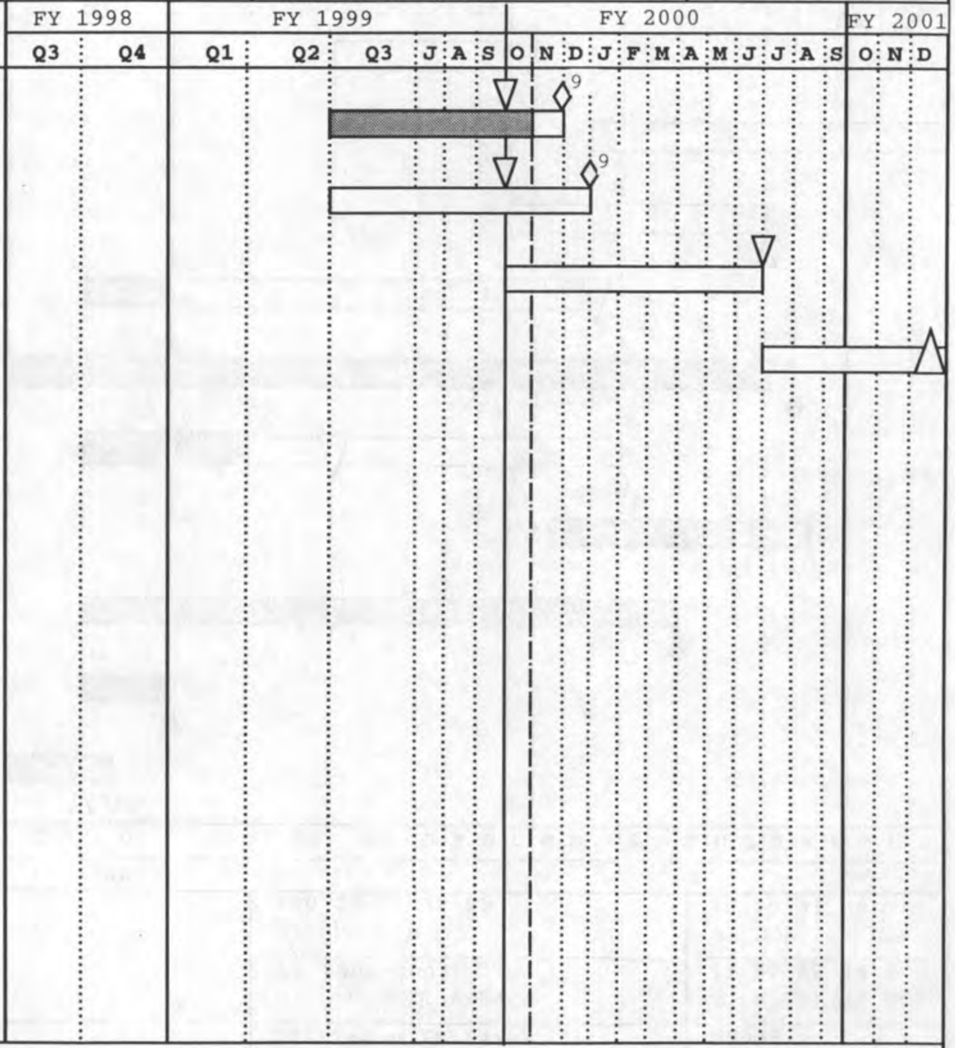
9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
3.1.A.	Age HAZ Materials
3.1.B.	Machine CVN Specimens
3.1.C.	Evaluate Results and Report
3.1.D.	Irradiate Capsules
3.2.A.	NUREG on IA Work to Date
3.2.B.	Dosimetry of 30 CVNs
3.2.C.	NUREG on 30 CVNs (IAR)
3.2.D.	Test Plan for Critical Materials
3.2.E.	IAR of Critical Materials
3.2.G.	Complete Reconstitution of Irradiated CVN Specimens
3.2.H.	Reirradiation of HSST Plate 02



11. REMARKS

1. CONTRACT REPORTING ELEMENT **HSSI - 3. Irradiation Embrittlement of RPV Steel**	2. REPORTING PERIOD **10/1/99 - 10/24/99**	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 1998-2001** 7. NRC B&R NO. **860 15 21 20 05**	6. ACTIVITY NO. **41 W6 95 3W 1** 8. DOE B&R NO. **40 10 01 06**

9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
3.3.A.	Ship JRQ Specimens From PSI to ORNL
3.3.B.	Complete Test Plan
3.3.C.	Complete JRQ Specimen Testing
3.3.D.	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
10/1/99 - 10/24/99

3. JCN NO.
W6953

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

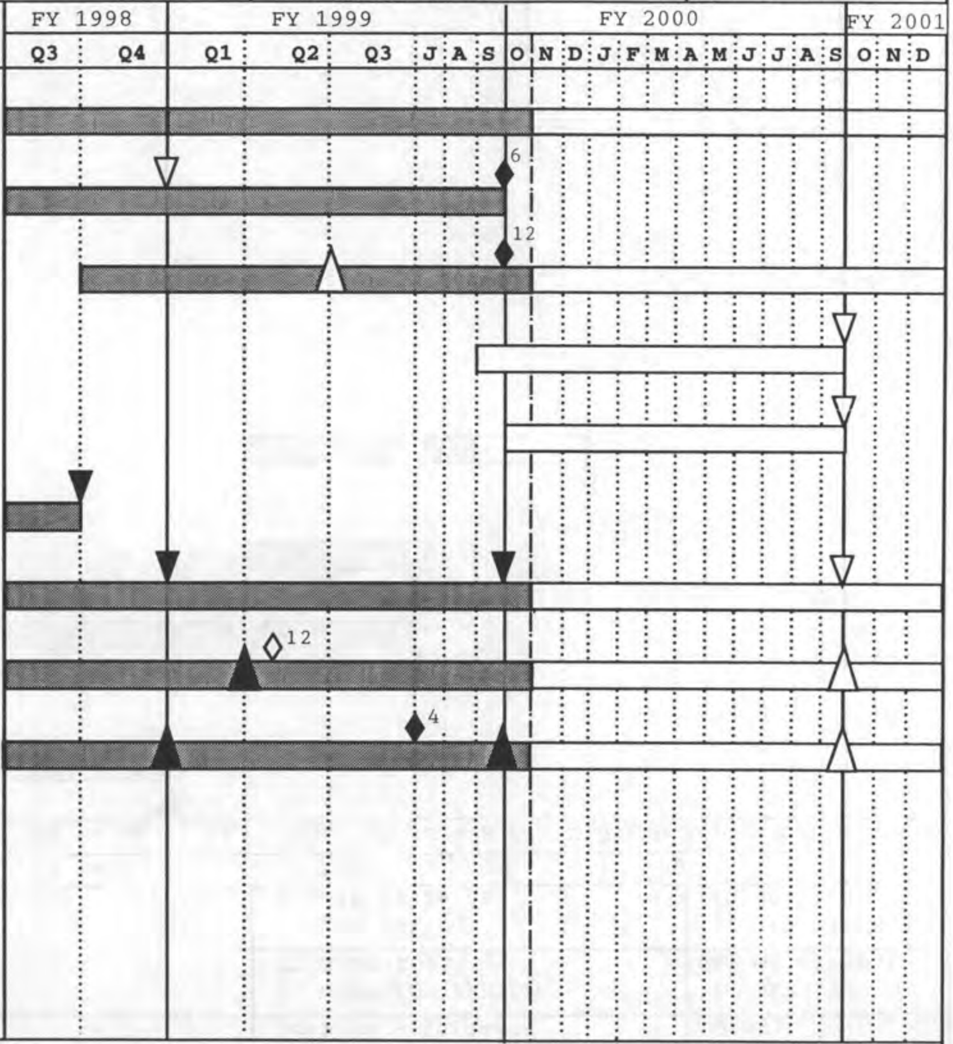
5. CONTRACT PERIOD
FY 1998-2001

6. ACTIVITY NO.
41 W6 95 3W 1

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

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

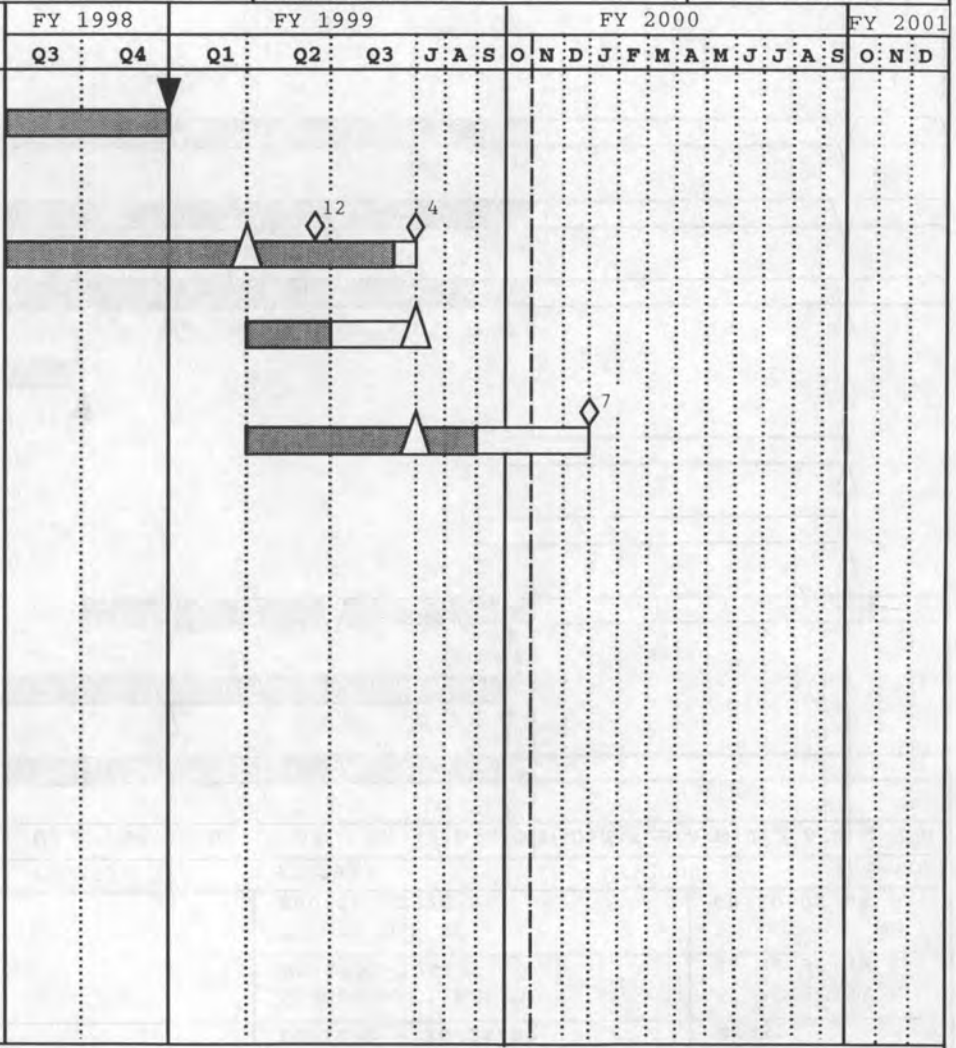
9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
4.1.1.A.	JPDR Information Exchange with JAERI
4.1.1.B.	Machining & Inspection of JPDR
4.1.1.C.	Testing & NUREG Report
4.1.2	Zion RPV Feasibility Study
4.1.3	Maine Yankee RPV Feasibility Study
4.3.B.	Complete Draft NUREG Report on Thermal Aging of SS Welds
4.4.A.	Complete Preparation of List of Anticipated Foreign Travel
4.4.B.	Participate in Periodic Meetings of IGRDM
4.4.C.	Complete Progress Reports of Collaboration Activities



11. REMARKS

1. CONTRACT REPORTING ELEMENT **HSSI - 4. Validation of Irradiated and Aged Materials**	2. REPORTING PERIOD **10/1/99 - 10/24/99**	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 1998-2001**	6. ACTIVITY NO. **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
4.5.A.	Complete Plans for Testing of Specimens in MEA Capsule, Procurement and Testing of Palisades Capsule & Evaluation of PWHT Sheets
4.5.B.	Complete Letter Report Regarding RPV Materials Available for Irradiation Study
4.5.C.	Complete NUREG Report Regarding RPV Materials Available for Irradiation Studies
4.5.D.	Complete Letter Report on Test results From MEA Capsule



11. REMARKS

1. CONTRACT REPORTING ELEMENT
HSSI - 5. Modeling & Microstructural Analysis

2. REPORTING PERIOD
10/1/99 - 10/24/99

3. JCN NO.
W6953

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

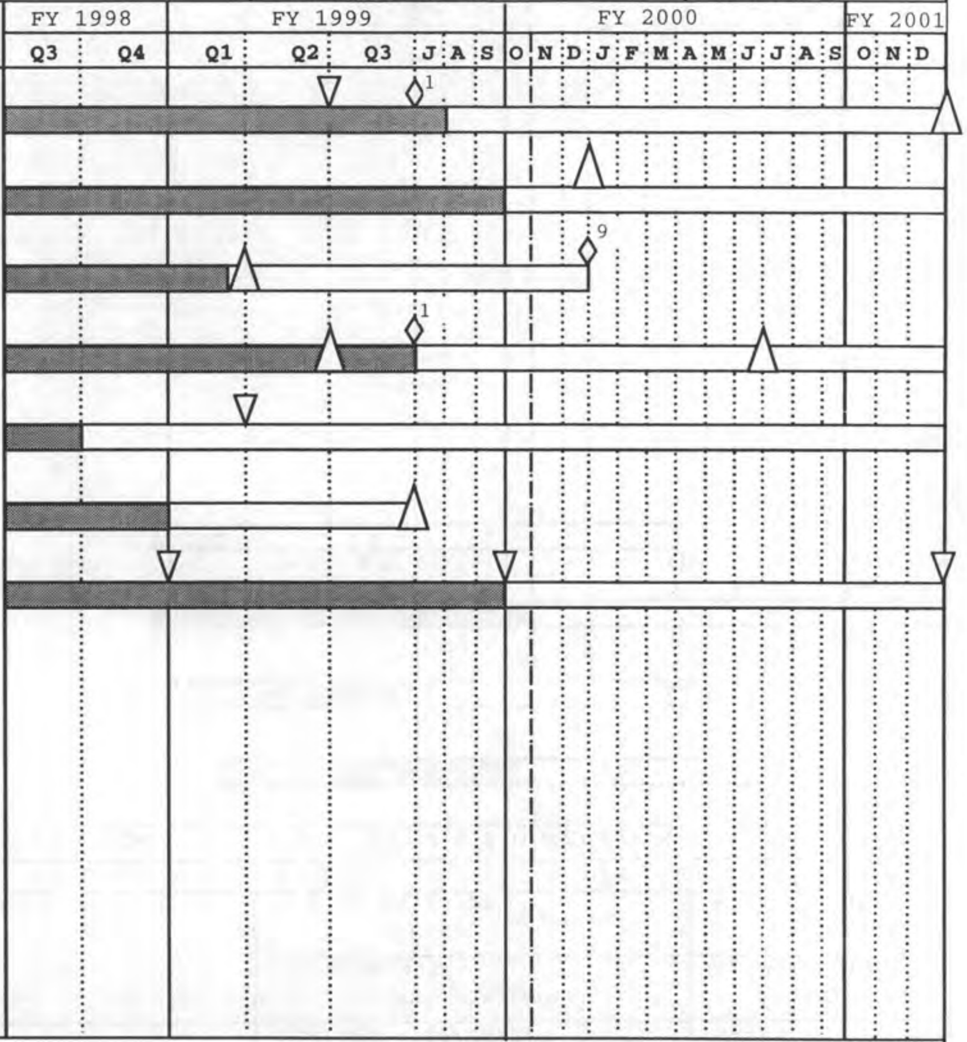
5. CONTRACT PERIOD
FY 1998-2001

6. ACTIVITY NO.
41 W6 95 3W 1

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

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

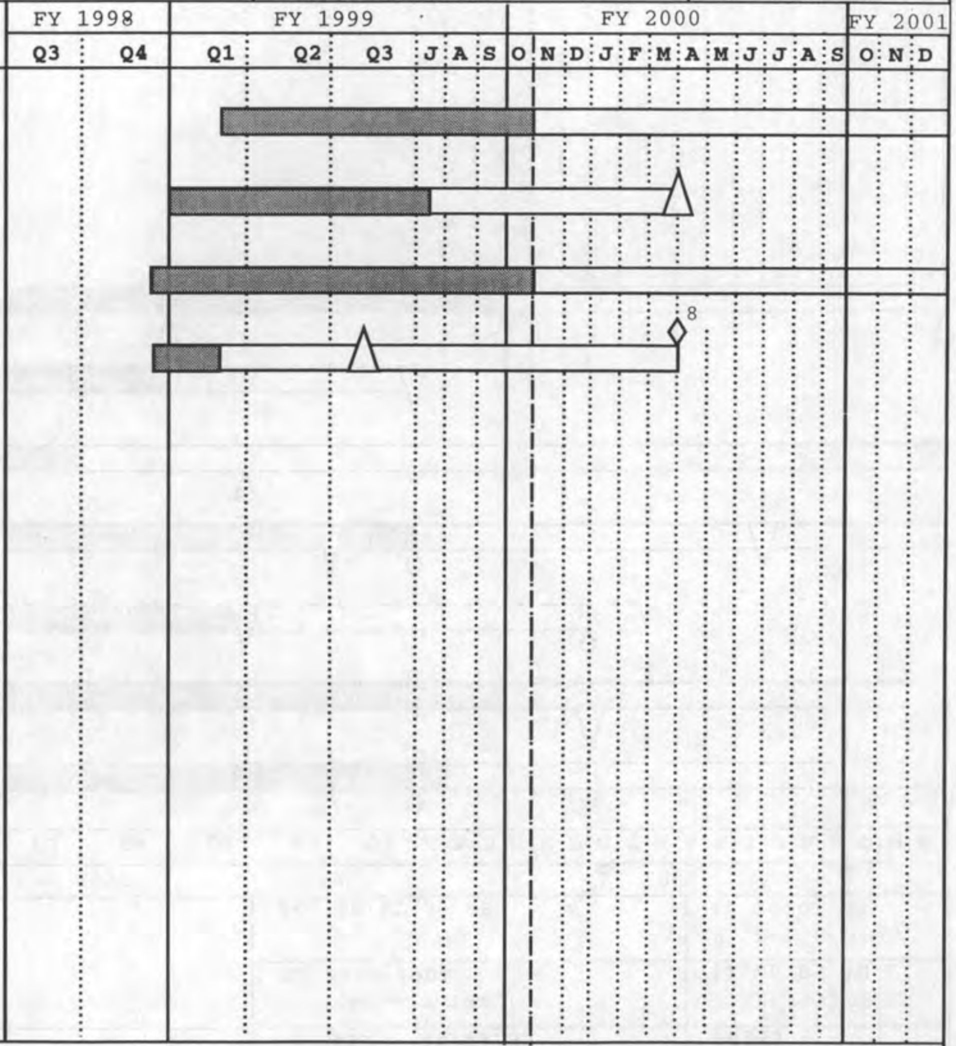
9. MILESTONE IDEN. NO.	10. MILESTONE DESCRIPTION
5.1.A.	Development and Predictive use of Embrittlement Model
5.1.B.	Model Validation and Data Analysis
5.2.A.	Coordinate and Analyze APFIM/SANS/FEGSTEM Round Robin Experiment
5.2.B.	APFIM Characterization
5.3.A.	Conduct and Coordinate Experiments in HFIR HFBR, and FNR
5.3.B.	High-Flux Irradiation-Annealing-Reirradiation in HFIR
5.4	Administration of Task Activities



11. REMARKS

1. CONTRACT REPORTING ELEMENT **HSSI - 6. Irradiation Coordination**	2. REPORTING PERIOD **10/1/99 - 10/24/99**	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 1998-2001**	6. ACTIVITY NO. **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 the IAR Facility
6.2.A.	Coordinate the Operation, Data Collection, and Maintenance of the UCSB Irrad.Facility
6.2.B.	Comprehensive Report on the UCSB Irradiation Facility



11. REMARKS

1. CONTRACT REPORTING ELEMENT
HSSI - 7. Embrittlement DB & Dosimetry Evaluation

2. REPORTING PERIOD
10/1/99 - 10/24/99

3. JCN NO.
W6953

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P.O. BOX 2008
OAK RIDGE, TN 37831

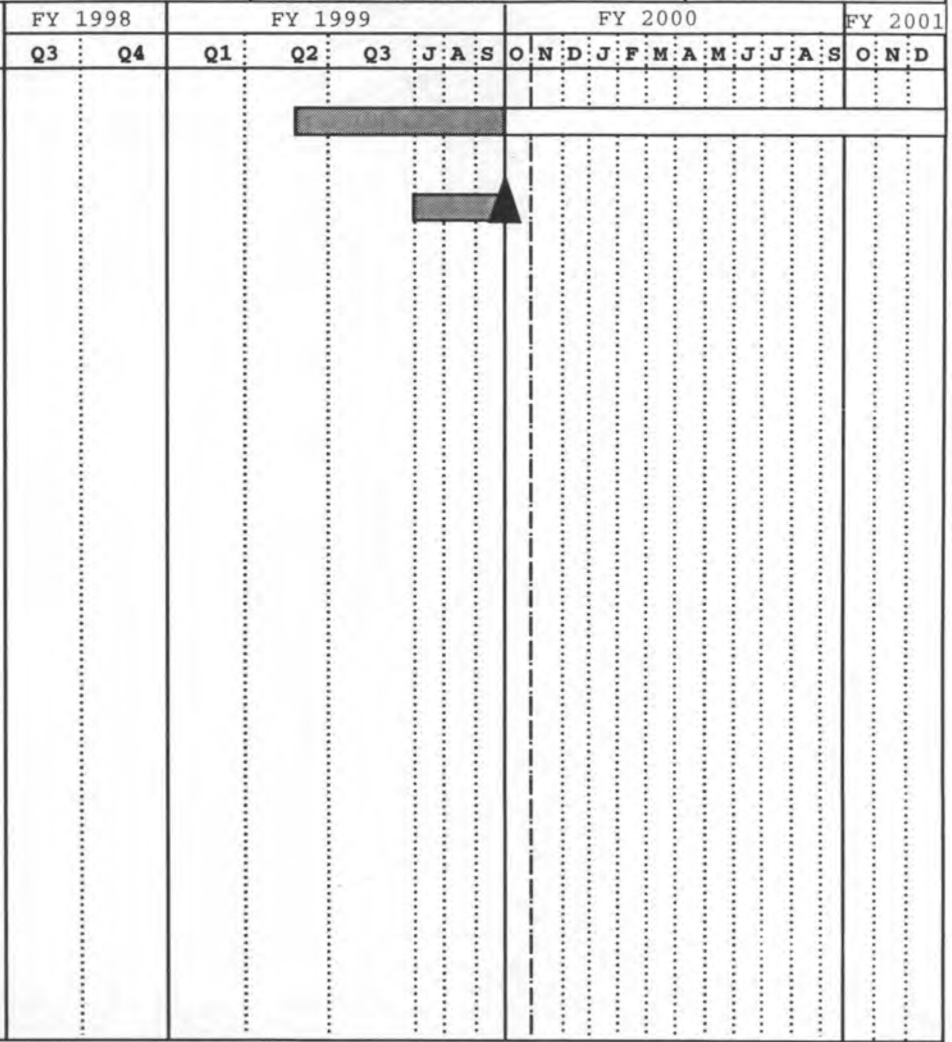
5. CONTRACT PERIOD
FY 1998-2001

6. ACTIVITY NO.
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
7.1.A.	Evaluate and Input Surveillance Reports into Embrittlement Database
7.1.B.	Complete Update 10



11. REMARKS