ACTIVITY PLAN

PARAMETRIC STUDIES OF METAL DEGRADATION AND MICROSTRUCTURE: Measurement of Threshold Stress Intensity for Stress Corrosion Cracking.

Sub-Activity E-20-18d of Activity E-20-18 of the scientific investigation "Metal Barrier Selection and Testing"
WBS # 1.2.2.3.2

Harkirat S. Ahluwalia

Revision 0

Aug 1, 1989

10/16/89
. J. Jardine, YMP Project Leader — Date

10/11/89
D. W. Short, YMP QA Manager — Date

10/4/89
W. L. Clarke, Technical Area Leader — Date

October 4, 1989
R. D. McCright, Task Leader — Date

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1.0 INTRODUCTION

1 Identification of activity

This activity plan for sub-activity E-20-18d and is written pursuant to quality procedure 033-YMP-QP 3.0, [1]. Sub-activity E-20-18d is part of activity E-20-18 which is known as "Parametric studies of metal degradation and microstructure". Activity E-20-18 is a part of the scientific investigation known as "Metal Barrier Selection and Testing" which is identified with WBS # 1.2.2.3.2. and published in UCID-21262.

1.2 Quality Assurance Level Assignment

A quality assurance level of QA-II has been assigned to this activity (E-20-18).

1.3 Responsibilities

Harkirat S. Ahluwalia, John Estill, Greg E. Gdowski and Joseph C. Farmer are the Principal Investigators for this activity and are responsible for the conduct of this work. R. Daniel McCright is the Task Leader for the Metal Barrier Selection and Testing Investigation. Willis L. Clarke is the Technical Area Leader for Container Materials, Modeling and Testing.

2.0 PURPOSE AND OBJECTIVES

The objective of this sub-activity is to provide specific stress corrosion cracking data needed for material selection and model development.

3.0 ACTIVITY DESCRIPTION

This activity will be used to access the threshold stress intensity for stress corrosion cracking, (K_{Iscc}) of the candidate materials. Slow stress corrosion crack growth does not occur at all values of stress intensity and the minimum initial value at which environmental sensitive crack growth occurs is designated K_{Iscc}. The value of K_{Iscc} determined by this activity and the value for K_{Ic} (plane-strain fracture toughness) determined by activity E-20-18c will be used to rank the candidate alloys in terms of the embrittlement index, K_{Ic}/K_{Iscc}. This activity will also be used to monitor stress corrosion crack propagation rates using the reversing D.C. instrument (Crack monitoring system).

One of two testing techniques may be used for the determination of K_{Iscc}; the Rising Load testing method or/and Wedge-Opening-Loading technique.

Rising load K_{Iscc} testing method. The testing technique used to determine K_{Iscc} is essentially identical to the procedure used for K_{Ic} fracture testing (ASTM E399-83) [2] except that a slower rate of loading is involved normally, and the specimen is exposed to the environment while ing loaded. The slower rate of loading is essentially to allow for .vironmentally induced crack initiation and to cause time-dependent sub-critical propagation. This technique is often referred to as the Rising load K_{Iscc} testing method [3]. In this technique stress corrosion characteristics are measured in terms of crack growth rate. The specimen is fixed in a holding device and the environment applied to the tip of the :hined notch. The test environment should be brought into contact with e specimen before it is stressed. This enhances access of the corrodent to the crack tip to promote earlier initiation of stress corrosion cracking and to decrease the variability of the test method. If the specimen has been pre-cracked, it is deflected , in the presence of the corrodent, to a predetermined K_I value. Crack length using the reversing DC potential drop method is measured and the crack opening displacement, v, is also measured along the line of load application when the load is maintained at the same level for the duration of the test. Once the environment is applied to the specimen, the crack length is monitored as a function of time elapsed from deflection. The overall result of this procedure is to cause the stress intensity factor to decrease as the crack extends under the influence of the corrodent. The slope of the crack length versus time curve at any crack length provides crack growth rate. From the K-calibration the stress intensity level is determined.

The data are plotted as logarithms crack growth rate or crack velocity versus stress intensity factor. Generally, three stages of crack growth rate may be identified in stress-corrosion results presented in this manner. Stage I occurs at low stress intensities where crack growth rate is strongly stress-intensity dependent and the crack may eventually arrest, thus indicating K_{Iscc}. Stage II occurs at intermediate stress intensities where crack growth rate is independent of stress intensity. Stage III occurs at stress intensities close to K_{Ic} where crack growth rate again becomes dependent upon stress intensity. The reversing D C.potential drop method will also be used to monitor crack propagation :es.

Wedge-Opening-Loaded Technique. Figure 1 shows a schematic illustration of the loading technique and instrumentation involved. The bolt loaded specimen is loaded initially to relatively high stress-intensity levels (K_{Ii}), exposed to the environment of interest for a predetermined length of time, and unloaded. Since the test is conducted under constant displacement conditions, the load on the specimen and, consequently , the nominal stress intensity factor decreases as the crack grows, leading to crack arrest as the decreasing K_I level approaches the threshold for cracking, K_{Iscc}. From knowledge of the initial loading conditions and the final crack length at the end of the test, the stress intensity level associated with crack arrest can be computed [4].

3.1 Technical Reviews

A formal surveillance will be held before any experimental work begins. This review will insure that:

1. Measurement and test equipment (M&TE) are properly calibrated as specified in quality procedure 033-YMP-QP-12.0.

2. Test samples are procured as specified in quality procedure 3-YMP-QP-4.0 and controlled as specified in quality procedure 3-YMP-QP-8.0.

3. Collected data will be controlled as specified in quality procedure 033-YMP-8.0.

4. Laboratory notebooks are being maintained as specified in quality procedure 033-YMP-QP-3.4.

After completion of an experiment or a series of experiments, a UCID report will be written. The UCID report will undergo review as specified in quality procedure 033-YMP-QP-3.3.

3.2 Hold Points

There are no formal hold points associated with this activity, but the results will be evaluated on a continuous basis by the Principal Investigators to insure that work is proceeding according to plan. If significant unanticipated problems arise, the Principal Investigators will inform the Task Leader. A joint decision will be made about corrective actions.

Progress will be reported to the Task Leader in monthly report. If changes in project scope require that experimental work change direction, it is the responsibility of the Task Leader to communicate this to the Principal Investigator in writing.

3.3 Equipment

Required M&TE include: Constant extension rate testing machine (CERT), specifically Cortest Series 34000 Floor Model; Load cell, Sensotec model D/3971-01, identification no: 5015939; Controller, Cortest model SC12, identification no: 4403461. These instruments are found on the list of calibrated equipment (see Appendix I). The Reversing d.c. potential drop instrument and the Instron testing machine Model 8500 are on order. Displacement gages and Caliper or micrometers are also required and are in the process of being acquired. The identification numbers and calibration records of all M&TE used will be identified in the scientific notebook.

3.4 Materials

All samples tested will be procured as specified in quality procedure 033-YMP-QP-4.0. and controlled as specified in quality procedure 033-YMP-QP-8.0.

3.5 Special Environmental Conditions

Electrolytes used for testing will be prepared so as to maintain the same relative concentrations of ions as found in water from well J-13, if possible. Absolute concentrations may be greater or less than those found in water from J-13 (reference condition). Measurements in other aqueous environments (NaCl solutions, etc) will be made if necessary. Tests may also be conducted in a vapor-phase environment containing NO_x species; the environmental variables will include temperature, partial pressure of water and partial pressure of NO_x species. Solutions may be refreshed when necessary.

3.6 Special Training/Qualification Requirements

No special training/qualification are required.

3.7 Activity Closeout

The final product of this sub-activity will be a UCID report documenting all results. Supporting documentation such as laboratory notebooks and technical review comments will be retained by the responsible individual until the document package is transferred to the local records center at the conclusion of the sub-activity.

) PRECISION AND ACCURACY

The precision of a K_{Iscc} determination is a function of the accuracy and bias of the various measurements of linear dimensions of the specimen and testing fixtures, the precision of the displacement measurements, and the bias of the load measurement as well as the bias of the recording devices used to produce the load displacement record and the precision of the constructions made on this record. The accuracy of the various measurements will be recorded in the scientific notebook.

4.1 Calibration requirements

All M&TE must be calibrated as specified in quality procedure 033-YMP-QP-12.0. Identification numbers of equipment used for this sub-activity will be found on the approved list of M&TE for the Yucca Mountain Program.

4.2 Conditions Which May Adversely Affect Results

In order for a result for K_{Ic} to be considered valid it is required that both the specimen thickness, B, and the crack length, a, exceed $2.5(K_Q/\sigma_{ys})^2$, where σ_{ys} is the 0.2% offset yield strength of the material for the temperature and loading rate of the test and K_Q is the conditional result used to establish if a valid K_{Ic} has been measured. However, it is not clear whether the same criteria should be applied during the designed of pre-cracked specimens for stress-corrosion testing. It is recommended that the dimensions of the plastic zone be kept at a minimum compared with the thickness dimension of the specimen and the relationship for the validity of K_{Ic} be used as a guide to test the validity of K_{Iscc}.

5.0 IN-PROCESS DOCUMENTATION

In process documentation will include stress-strain curves, optical and electron micrographs. Such records will be kept in a controlled laboratory notebook identified as Metal Barrier Selection and Testing Task Controlled Notebook No.00079. Copies of all in-process documents will be kept by all the principal investigators identified in Section 1.3. Results will be periodically transmitted to the Task Leader in the monthly report and the Task Leader is responsible for transferring the document package to the local records center at the conclusion of this sub-activity..

` Data Recording and Data Reduction

All relevant data for the determination of K_{Iscc} shall be kept in a bound, scientific notebook, as well as an appropriate data base. The data from the x-y recorder and any construction on that record will be pasted in the scientific notebook. Data collected from computers will be stored on magnetic media and a hard copy will also be presented in the scientific notebook.

5.2 Analysis

The interpretation of test records and calculation of K_{Iscc} shall be conducted according to the Technical Implementing Procedures [5,6].

6.0 INTERFACES

This sub-activity can proceed independent of any other activity, however activity E-20-19 ("Metal Barrier Selection") cannot proceed without this activity.

7.0 SCHEDULE

The readiness review for this sub-activity was scheduled for the July 31, 1989. The final UCID report will summarize all of the data and a draft copy will be completed prior to the first week in April of 1990.

8.0 TECHNICAL IMPLEMENTING PROCEDURES

A TIP for the determination of plane-strain fracture toughness (K_{IC}) and the threshold stress intensity for stress corrosion cracking (K_{ISCC}) will be prepared in accordance with Quality Procedure No. 033-YMP-QP 5.0, "Technical Implementing Procedures". [5,6]

9.0 SPECIAL CASES (PROCUREMENT)

Technical services provided by Hira Ahluwalia are provided by contract and meet the requirements of 033-YMP-QP 4.0 "Procurement Control and Documentation"[1]. All such services will be performed under the LLNL YMP Quality Assurance Plan.

9.1 QA Requirements Specification

Not applicable

9.2 Statement of work

The statement of work for technical support for this activity is to provide technical support for electrochemical corrosion experiments. An example of service contract statement of work is provided in Appendix II.

9.3 Subcontractor Interface Control

The technical contacts at LLNL for the contracts discussed in Section 9.0 are Joseph C. Farmer, William Halsey, R.Daniel McCright and Willis Clarke.

9.4 Materials/Equipment Provided

Access to laboratory space is provided so that work on this sub-activity can be accomplished.

9.5 Deliverables

Deliverables for the technical support contractor will include a UCID report documenting the results and scientific notebooks and data accumulated on magnetic media.

10.0 REFERENCES

[1] Yucca Mountain Project, Quality Procedures Manual.

[2] Standard test method for plane-strain fracture toughness of Metallic Materials: E399-83, ASTM Philadelphia, p680-701. 1983.

[3] W.G.Clark Jr. and J.D.Landes. `An evaluation of Rising Load Testing' Stress corrosion- New Approaches, ASTM STP 610, p108-127, 1976.

[4] S.R.Novak and S.T.Rolfe, Journal of Materials, JMLSA,Vol.4, No.3, Sept. 1969, pp701-728.

[5] Technical Implementing Procedure for K_{Ic} and K_{Iscc}.(TIP-CM-1)

[6] Technical Implementing Procedure for K_{Iscc} determination using WOL specimens (TIP-CM-5).

11.0 APPENDIXES

[I] Current list of calibrated equipment p2.
[II] Example statement of work.

APPENDIX I

Current list of calibrated equipment.

INSTRUMENT	MODEL	MFG	IDENT NO	LAST CAL	CAL EXP	RECALL	ACTIVITY	BLDG	ROOM	TAL	TL
THERMOCOUP	TYPE K	OMEGA	34	8/09/88	8/09/89	6/28/89	B-20-4	281	1160	WILDER	GLASSLEY
THF' 'OUP	TYPE K	OMEGA	17	8/09/88	8/09/89	6/28/89	B-20-4	281	1160	WILDER	GLASSLEY
STR. GAU	5550	PRECISE SE	23479	8/09/88	8/09/89	6/28/89	B-20-4	281	1160	WILDER	GLASSLEY
STRAIN GAU	5550	PRECISE SE	24380	8/09/88	8/09/89	6/28/89	B-20-4	281	1160	WILDER	GLASSLEY
STRAIN GAU	5550 V5	PRECISE SE	23342	8/09/88	8/09/89	6/28/89	B-20-4	281	1160	WILDER	GLASSLEY
STRAIN GAU	5550 V6	PRECISE SE	23341	8/09/88	8/09/89	6/28/89	B-20-4	281	1160	WILDER	GLASSLEY
STRAIN GAU	2105	TABER	721223	8/09/88	8/09/89	6/28/89	B-20-4	281	1160	WILDER	GLASSLEY
WEIGHT SET	NONE	TROEMNER	4935825	9/14/88	9/15/89		D-20-31	243	2026	SHAW	RYERSON
WEIGHT SET	6137/1540	TROEMNER	4935832	9/15/88	9/15/89		D-20-31	243	2026	SHAW	RYERSON
CONTROLLER	SC12	CORTEST	4403461	CAL LAB		INITIAL	E-20-23	241	1878	CLARKE	McCRIGHT
STRIP CHAR	585/11/13	OMEGA	4347352	CAL LAB		INITIAL	E-20-23	241	1877	CLARKE	McCRIGHT
STRIP CHAR	585/11/13	OMEGA	4414849	CAL LAB		INITIAL	E-20-23	241	1877	CLARKE	McCRIGHT
STRIP CHAR	585/11/13	OMEGA	4076603	CAL LAB		INITIAL	E-20-23	241	1877	CLARKE	McCRIGHT
STRIP CHAR	585/11/13	OMEGA	4350130	CAL LAB		INITIAL	E-20-23	241	1877	CLARKE	McCRIGHT
POTENTIOST	173	PAR	4015329	4/28/89	10/28/89		E-20-23	241	1878	CLARKE	McCRIGHT
POTENTIOST	173	PAR	4369149	CAL LAB		INITIAL	E-20-23	241	1877	CLARKE	McCRIGHT
CONTROLLER	175	PAR	3676767	4/28/89	10/28/89		E-20-23	241	1878	CLARKE	McCRIGHT
POTENTIOST	273	PAR	4053581	4/21/89	10/20/89		E-20-23	241	1877	CLARKE	McCRIGHT
'OTENTIOST	273	PAR	4066826	CAL LAB		INITIAL	E-20-23	241	1878	CLARKE	McCRIGHT
'OTENTIOST	362	PAR	4272227	3/13/89	9/13/89		E-20-23	241	1878	CLARKE	McCRIGHT
POTENTIOST	363	PAR	4345822	1/09/89	7/09/89	6/5/89	E-20-23	241	1878	CLARKE	McCRIGHT
POTENTIOST	363	PAR	4277185	3/07/89	9/07/89		E-20-23	241	1878	CLARKE	McCRIGHT
POTENTIOST	363	PAR	3328949	3/07/89	9/07/89		E-20-23	241	1878	CLARKE	McCRIGHT
POTENTIOST	363	PAR	3711963	3/06/89	9/06/89		E-20-23	241	1878	CLARKE	McCRIGHT
POTENTIOST	363	PAR	3329106	CAL LAB			E-20-23	241	1878	CLARKE	McCRIGHT
CT TER	376	PAR	4764128	4/29/89	10/29/89		E-20-23	241	1878	CLARKE	McCRIGHT
LOA. CELL	D/3971-01	SENSOTEC	5015939	4/28/89	10/28/89		E-20-23	241	1878	CLARKE	McCRIGHT
LVDT	351-000	TRANS-TEK	4764111	CAL LAB		INITIAL	E-20-23	241	1878	CLARKE	McCRIGHT
WEIGHT SET	NONE	TROEMNER	4935818	9/15/88	9/15/89		E-20-23	241	1883	CLARKE	McCRIGHT
PROFILEOME	DEKTAK IIA	SLOAN	88503	1/12/89	1/12/90		G-20-3.1	151	1034A	SHAW	RYERSON
OSCILLOSCO	2465	TEKTRONIX	4160616	9/01/88	9/10/89		H-20-6	327		CLARKE	RUSSELL
WATT TRANS	S73-25-230	AME	4763411	10/07/88	10/07/90		S-20-1	G	TNL	WILDER	RAMIREZ
WATT TRANS	S73-25-230	AME	4763428	10/07/88	10/07/90		S-20-1	G	TNL	WILDER	RAMIREZ
DEPTH PROB	5010R	CPN	4737900	7/28/88	7/28/89	6/5/89	S-20-1	G	TNL	WILDER	RAMIREZ
DA CONTROL	3497A	HP	3854172	9/26/88	9/26/89		S-20-1	G	TNL	WILDER	RAMIREZ
PRES TRAN	2279-1	ASHCROFT	5038761	4/12/89	4/12/90		S-20-1	G	TNL	WILDER	RAMIREZ
PRES TRAN	2279-2	ASHCROFT	5038785	4/12/89	4/12/90		S-20-1	G	TNL	WILDER	RAMIREZ
PRES TRAN	2279-3	ASHCROFT	5038792	4/12/89	4/12/90		S-20-1	G	TNL	WILDER	RAMIREZ
PRES TRAN	2279-4	ASHCROFT	5038761	4/12/89	4/12/90		S-20-1	G	TNL	WILDER	RAMIREZ
BALANCE	2404	SARTORIUS	3792559	CAL LAB		INITIAL	J-20-8	281		AINES	SILVA
BALANCE	MG5D	METTLER	3559879	CAL LAB		INITIAL	J-20-8	281		AINES	SILVA
OSCILLOSCO	11402	TEKTRONIX	4928490	CAL LAB		INITIAL	J-20-8	281		AINES	SILVA
OSCILLOSCO	2335	TEKTRONIX	4728496	CAL LAB		INITIAL	J-20-8	281		AINES	SILVA
PULSE GEN	DG535	SRS	4778699	CAL LAB		INITIAL	J-20-8	281		AINES	SILVA
:RX THERM	2804A	HP	5038655	CAL LAB		INITIAL	J-20-8	281		AINES	SILVA
VERT AMP	11A34	TEKTRONIX	4921767	CAL LAB		INITIAL	J-20-8	281		AINES	SILVA
THERMOCOUP	TYPE K	OMEGA	3977512	3/15/89	3/15/90		B-20-4	281		WILDER	GLASSLEY
THERMOCOUP	TYPE K	OMEGA	3977529	3/15/89	3/15/90		B-20-4	281		WILDER	GLASSLEY
THE?HOCOUP	TYPE K	OMEGA	3977536	3/15/89	3/15/90		B-20-4	281		WILDER	GLASSLEY
. OCCUP	TYPE K	OMEGA	3977543	3/15/89	3/15/90		B-20-4	281		WILDER	GLASSLEY

APPENDIX II

Example statement of work.

MATERIAL SCIENCE SUPPORT FOR THE
YUCCA MOUNTAIN PROJECT.

STATEMENT OF WORK PROPOSAL.

Introduction

The Metal Barrier Selection and Testing (MBST) Task of the Yucca Mountain Project at Lawrence Livermore National Laboratory (LLNL) is responsible for the selection of the metal barrier material for application in the high-level nuclear waste repository being designed for the Yucca Mountain Site in Nevada. The Scientific Investigation Plan (SIP) for the MBST task includes : (i) development of models for degradation modes, mechanical properties and microstructure (E-20-16); (ii) experimental technique development (E-20-17); (iii) parametric studies of degradation and microstructure (E-20-18); (iv) degradation mode surveys (E-20-13).

It is proposed that Science and Engineering Associates, Inc. continue to provide significant scientific and engineering support to: (i) evaluate existing mechanistically based models of stress corrosion cracking and crevice corrosion in alloy 825 and CDA 715 under repository conditions; ·i) perform constant extension rate testing with simultaneous measurement . acoustic emissions and electrochemical noise; (iii) provide technica support for electrochemical corrosion experiments including accessment of plane-strain fracture toughness (K_{1c}) and threshold stress intensity for stress corrosion cracking, (K_{1scc}) of the candidate materials; (iv) complete an evaluation of the suitability of titanium, zirconium and monel as corrosion resistant materials for high-level Nuclear Waste Containers for emplacement at the Yucca Mountain repository.

All of these tasks, which are described in detail below, will be completed in accordance with the Quality Assurance Program Plan for YMP (033-YMP) at the Quality Assurance level assigned in the Scientific Investigation Plan.

This procurement action deals with the acquisition of support personnel only. The scientist, who is required due to his technical expertise, will support the activities of the Yucca Mountain Project. The scientific personnel will work under the direct supervision of LLNL-YMP staff. This work will be completed in accordance with approved QA procedures as defined in the YMP Quality Assurance Program Plan. The qualifications of personnel assigned to work on this subcontract has been documented and submitted to the YMP QA staff.

TECHNICAL SUPPORT OF WORK.

eller will provide a Ph.D. Scientist to support the Nuclear Waste Management Program at Lawrence Livermore National Laboratory.

Task 1 Complete an evaluation of the availability and applicability of existing mechanistically based models of stress corrosion cracking and crevice corrosion, adapt these models or develop new models to help predict the effects of stress corrosion cracking and crevice corrosion in alloy 825 and CDA 715 under repository conditions. This task includes completion of a survey of the technical literature to identify mechanistically based models of localized corrosion, crevice corrosion, and stress corrosion cracking and modifying these models to aid in the prediction of the effects of crevice corrosion and stress corrosion cracking on alloy 825 and CDA 715 in a repository environment. This task is an important element of activity E-20-16, building upon already existing data and information previously identified in E-20-13. This task, which will provide significant input to activity E-20-19 (metal barrier material selection), will be performed at a quality assurance level QA II.

Task 2 Conduct constant extension rate testing with simultaneous measurement of acoustic emissions and electrochemical noise. Current transients correlated with acoustic emissions can be used to determine repassivation rates at crack tips. Repassivation rates may also be determined with the strained electrode technique. Additionally provide technical assistance with other experimental technique development activities. This task is an element of activity E-20-17, "Experimental technique development" and will be performed at a quality assurance level QA III.

Task 3 Provide technical support for electrochemical corrosion experiments including accessment of plane-strain fracture toughness (K_{Ic}) and threshold stress intensity for stress corrosion cracking, (K_{Iscc}) of the candidate materials. The values of K_{Ic} and K_{Iscc} will be used to rank the candidate alloys in terms of the embrittlement index, K_{Ic}/K_{Iscc}. This task is an element of activity E-20-18, "Parametric studies of degradation and microstructure" and will be performed at a quality assurance level of QA I.

Task 4 Complete an evaluation of the suitability of titanium, zirconium and monel as corrosion resistant materials for high-level Nuclear Waste Containers for emplacement at the Yucca Mountain Repository. The overall project schedule is such that the container material must be chosen before the environmental conditions at the site are fully characterized by tests conducted in exploratory shafts. There is, therefore, some potential that the actual site conditions may prove to be too aggressive for successful employment of the alloys currently being evaluated as metal container materials. There is also some potential that performance assessment models will predict metal container degradation rates that are not consistent with meeting the goal of "substantially complete containment" included in the NRC regulations for the repository.

While both of these potentials are small, it is prudent to consider other loys as a backup to the alloys currently being considered. This tas' .ll be performed at a quality assurance level of QA III.

<u>Reports</u> The seller will submit monthly progress reports.

TABLE OF CONTENTS

1.0 INTRODUCTION

The LLNL-YMP Scientific Investigation Plan for Spent Fuel Waste Form Testing YMP WBS Element 1.2.2.3.1.1 [1] identifies an activity for oxidation tests on spent fuel and UO_2 by measuring the weight gained during the oxidation process in a low-temperature oven over long time periods. This activity will be performed at the Pacific Northwest Laboratories (PNL) of Battelle in Richland, WA. This activity plan describes performance details for this activity according to the guidelines prescribed in LLNL-YMP Quality Procedure 033-YMP-QP 3.0.

1.1 Activity Identity

The activity number assigned in the SIP (Spent Fuel Waste Form Testing) [1] for the oxidation tests on spent fuel and UO_2 using a low-temperature oven method is D-20-45.

1.2 Quality Assurance Level Assignment

Activity D-20-45 is assigned as QA Level I (see Appendix A).

1.3 Responsibilities

Key personnel responsible for performing the work in this activity are identified below:

Technical Area Leader:	Dr. Henry F. Shaw (LLNL)
Task Leader:	Dr. Ray B. Stout (LLNL)
Principal Investigator:	Dr. Robert E. Einziger (PNL)

Dr. Einziger will be supported by his colleagues, H. C. Buchanan (PNL), who has co-authored several papers on oxidation testing apparatus and the oxidation data measured [3-8] and Dr. W. J. Gray (PNL).

2.0 PURPOSE AND OBJECTIVES

Low-temperature experimental data on UO_2 spent fuel oxidation kinetics are necessary to develop performance assessment models that describe the behavior of the spent fuel in a repository. The objective of these spent fuel experimental tests will be to evaluate the effects of variables such as moisture, temperature, burnup, and various other spent fuel characteristics on oxidation rate and phase formation, to evaluate and identify the various operative oxidation mechanisms, and to confirm results of an alternative short-term thermogravimetric testing method [4,5]. Results from these experimental tests will be used to develop a mechanistic model for the oxidation of UO_2 activity D-20-50.1, "Generate Models for Release of Radionuclides from the Spent Fuel Waste Form."

3.0 ACTIVITY DESCRIPTION

This low-temperature oven oxidation testing activity will be performed under the current LLNL-YMP QA Program Plan (QAPP) 033-YMP-R [2]. Some initial oxidation testing and scoping studies of spent fuel was conducted under the previous LLNL Nuclear Waste Management Program QAPP. This experience has been incorporated into this activity plan.

The sequence of steps in the activity and the connections with model development and leaching activities in the spent fuel task WBS 1.2.2.3.1.1 are illustrated in Figure 1.1 (pp 1.2) of the test plan entitled, "Test Plan for Thermogravimetric Analyses of BWR Spent Fuel Oxidation" document no. PNL-6745 [5]. Defining a set of precise decision points that identify completion of the activity is difficult because the activity for obtaining experimental data of oxidation kinetics and the activity for model development of oxidation kinetics are complementary, iterative and continuously coupled. However, at this stage in activity planning for low-temperature oven oxidation tests, decision points occur when:

i sufficient experimental data are provided to support or refute a proposed two stage mechanism of an initially rapid grain boundary oxidation process and then a slower grain volume oxidation process;

ii the proposed two stage mechanism is refuted, therefore, consideration needs to be given in possibly developing an alternative model for spent fuel oxidation kinetics with the available experimental data;

iii sufficient experimental data are provided to analytically represent, through a parallel model development activity, the temperature, moisture, and description parameters of spent fuel characteristics (burnup, grain size, fission gas content, etc) effects on spent fuel oxidation kinetics over the expected range of environmental history conditions expected in a repository.

3.1 Technical Reviews

At this time, no technical reviews are planned for this activity. However, at least two meetings per year between PNL and LLNL personnel are planned to discuss and report the status and future plans for low-temperature oven oxidation tests and, at which time, the need for technical reviews will be re-examined. These meetings will be in addition to the anticipated formal reports and papers that will be written to document the results and to distribute spent fuel oxidation data amongst all the related activities in YMP and the scientific community for review and comment by peers. The timing of these meetings will be determined, in part, by the progress of the experimental work.

3.2 Hold Points

No hold points for directional changes in testing are currently identified. However, the need for establishing hold points will be considered during each meeting described in Section 3.1 of this activity plan.

3.3 Equipment

The experimental equipment required for this activity is identified and described in Section 2.0 of the test plan entitled, "Test Plan for Long-Term, Low-Temperature Oxidation of BWR Spent Fuel" document no. PNL-6427. This test plan is attached as Appendix B.

3.4 Materials

Initial oxidation tests have been conducted and are still continuing for PWR fuel samples (Series Test 1) and BWR fuel samples (Series Test 2) which are described in sections 1.2 and 2.0 of Appendix B. New samples of UO_2 spent fuel used in this activity are identified and described in the addendum to Test Plan for Long-Term, Low-Temperature Oxidation of High Burnup Spent Fuel. This addendum is attached as Appendix C. These samples are obtained from the Material Characterization Center (MCC) [9] which has been assigned the responsibility by DOE-HQ of providing QA Level I specimens for spent fuel oxidation testing by YMP. Additional samples of different fuel types will be added to the test matrix as they become available. This will greatly increase the amount of data that can be acquired for use in oxidation modeling development activities and performance assessments.

3.5 Special Environmental Conditions

The test specimens are radioactive and the oxidation testing conditions require temperature and moisture control. The environmental testing conditions are described in Sections 2.1.3, 2.1.5, and 2.3 of Appendix B.

3.6 Special Training/Qualification Requirements

Training will be required for personnel performing work in this activity relative to the procedure for low-temperature oven oxidation tests, technical implementing procedures listed in Section 8.0 of this activity plan, and appropriate examination procedures discussed in Section 2.7 of Appendix B. Training will be accomplished through reading assignments and on-the-job supervision, as appropriate, to gain and demonstrate proficiency. Training documentation will be included in the Personnel Qualification Records at PNL.

3.7 Activity Closeout

At the completion of the low-temperature oven oxidation testing, any remaining QA records such as scientific notebooks and technical reports will be submitted to the LLNL-YMP Local Records Center.

4.0 PRECISION AND ACCURACY

The overall measurement error of the low-temperature oven oxidation testing is specified at less than 20% in Section 1.2 of Appendix B.

4.1 Calibration Requirements

All measurement instrumentation (i.e., balances, thermocouples, and data recorders) will be calibrated against National Institute of Standards and Technology (NIST) traceable reference standards. Calibration procedures and requirements are given in PNL

Technical Implementing Procedure (TIP) No. SFO-2-1. This section supersedes the fourth sentence in section 2.4.1 of Appendix B.

4.2 Conditions That May Adversely Affect Results

Progress and results may be adversely affected by understaffing and personnel changes during the course of an experiment in progress. Also, as discussed under model evaluation in section 2.F of the test plan entitled, "Test Plan for Series 2 Thermogravimetric Analyses of Spent Fuel Oxidation", HEDL-7556 [4], there exist uncertainties in the current understanding of low temperature UO_2 spent fuel oxidation kinetics which make these tests non-routine and developmental in nature. Thus, changes and updates in experimental procedures and directions should not come as future surprises, although none are currently anticipated. Uncertainties in mechanistic interpretations for oxidation kinetics have been discussed in the report entitled, "Technical Test Description of Activities to Determine the Potential for Spent Fuel Oxidation in a Tuff Repository", HEDL-7540 [3].

4.3 Sources of Uncertainty and Error to be Controlled and Measured.

Once the test specimens are provided, sources of experimental error are moisture measurements, temperature measurements, weight measurements, and elapsed time measurements. The temperature and weight measurements are the most critical for this test procedure. The temperature control limit of ± 3°C at temperatures up to 300°C and weight change limit of ± 0.01% are given as controllable measurements in the Section 2.3 of Appendix B.

5.0 IN-PROCESS DOCUMENTATION

Documentation to be generated during the conduct of this activity include: scientific notebooks; magnetic computer disks, and photographs. Scientific notebooks are controlled and maintained in accordance with PNL's Act Now Directive 89-1 entitled, "Use of Laboratory Record Books (MG 4.3, Research Records)." Records will be transferred to the PNL Records Center for storage and maintenance prior to turnover to LLNL-YMP on an annual basis.

5.1 Data Recording and Data Reduction

The data acquisition system and data reduction techniques are described in PNL TIP No. SFO-2-1.

5.2 Analysis

Section II.F of Reference 4 discusses existing references, phenomenological models, and correlation functions to obtain empirically fitted models. This approach will be augmented with the model development for the oxidation of UO_2 activity D-20-50.1 as described in the LLNL-YMP Scientific Investigation Plan for Spent Fuel Waste Form Testing YMP WBS Element 1.2.2.3.1.1 [1]. The experimental testing and the model development activities will be carried out in parallel with close and continuous technical interchanges to maintain consistent and contiguous data input quality and model prediction capability.

6.0 INTERFACES

Activity D-20-45 involves experimental tests for obtaining data on oxidation rates and the various oxidation states of UO_2. These data will be used in activity D-20-50.1 which is the activity for developing a mechanistic model of oxidation kinetics that can be extrapolated to the time domain for repository environmenal conditions. Activity D-20-45 is planned to be conducted in parallel with activity D-20-50.1. This will allow information to be "continuously" interchanged between the two activities. The Technical Area Leader for both of these activities is Dr. Henry F. Shaw, of LLNL. The Task Leader for both of these activities is Dr. Ray B. Stout, of LLNL. Thus, two levels of activity managers have direct technical information and budget control over the coordination between these activities.

Within the Spent Fuel Waste Form Testing YMP WBS Element 1.2.2.3.1.1, data and specimens at various oxidized states will be provided to activities for dissolution/leach testing. These activities are D-20-42, D-20-43, and D-20-53; and the Task Leader is Dr. Herman Leider, of LLNL. Other information, in terms of both experimental data and models developed, are provided to activities under the control of the LLNL-YMP Waste Package Performance Assessment WBS 1.2.2.5.1.

7.0 SCHEDULE

7.1 Duration

The duration of this activity is governed by the model development activity D-20-50.1 since this activity is planned to be an ongoing activity where data collected will be continuously provided to update and improve this model and provide input in future performance assessments. The duration of activity D-20-50.1 is approximately 7 years where the final model development will be provided into the final Licensing Application Design Performance Assessment.

The estimated test durations for the currently planned Series 3 oven oxidation testing are listed in Table 2.2 of Appendix C.

7.2 Staffing Requirements

Estimated staffing requirements are shown in Appendix D. Staffing requirements are based on the currently planned Series 3 oven oxidation tests described in Appendix C. As more fuel samples become available and are added to the test matrix, these estimates will be revised accordingly.

8.0 TECHNICAL IMPLEMENTING PROCEDURES

Procedures for performing the tests are discussed in Section 2.7 of Appendix B. In addition, the following TIPs will also be used:

- PNL TIP No. SFO-2-1.

1-2-7

9.0 SPECIAL CASES (PROCUREMENT)

The experimental testing, data acquisition/storage and some preliminary data analyses are performed and managed by the Principal Investigator, Dr. Robert Einziger of Pacific Northwest Laboratories (PNL) in Richland, WA 99352 as described in Appendix B.

9.1 QA Requirements Specifications

Work to be performed under this activity plan will be in accordance with the latest revision of PNL-MA-70 QA Plan No. WTC-018, which is consistent with the requirements of LLNL-YMP QA Requirements Specification No. QARS-001C. This section supersedes the second sentence in section 2.9 of Appendix B.

9.2 Statement of Work

The description of the work to be performed by the Principal Investigator, Dr. Robert Einziger of PNL, is provided in Appendix B.

9.3 Subcontractor Interface Control

The technical contacts and interfaces between LLNL-YMP and PNL are described in the Special Client Requirements Section, Part B16.0 of the PNL-MA-70 QA Plan No. WTC-018. This section also describes the documents/reports (i.e., Technical Procedures, Reports and Test Plans) to be submitted by PNL to LLNL-YMP for review and approval. Informal memo and telephone exchanges will be documented in LLNL-YMP controlled scientific notebooks assigned to this activity.

9.4 Materials/Equipment Provided

At present, no materials and equipment are expected to be provided directly from LLNL-YMP to PNL for TGA oxidation testing under activity D-20-45. The UO_2 spent fuel specimens will be obtained from MCC [9] as previously discussed in Section 3.4 of this activity plan. All other testing equipment is currently available at PNL.

9.5 Deliverables

As described in Section 2.8 of Appendix B, periodic progress reports, formal reports, and journal papers will be provided as warranted. Currently, monthly progress reports, test plans, formal reports, and papers for journal publication are submitted by PNL to LLNL-YMP for review and approval.

10. REFERENCES

1. LLNL-YMP Scientific Investigation Plan for Spent Fuel Waste Form Testing - Rev. 1 (1989), Lawrence Livermore National Laboratory, Livermore, CA.

2. LLNL-YMP QA Program Plan (QAPP) 033-YMP-R (1989), Lawrence Livermore National Laboratory, Livermore, CA.

3. Einziger, R. E., (1985), Technical Test Description of Activities to Determine the Potential for Spent Fuel Oxidation in a Tuff Repository, HEDL-7540, Westinghouse Hanford Co., Richland, WA.

4. Einziger, R. E., (1986), Test Plan for Series 2 Thermogravimetric Analyses of Spent Fuel Oxidation, HEDL-7556, Westinghouse Hanford Co., Richland, WA.

5. Einziger, R. E., (1988), Test Plan for Thermogravimetric Analyses of BWR Spent Fuel Oxidation, PNL-6745, Pacific Northwest Laboratory, Richland, WA.

6. Einziger, R. E., and Woodley, R. E., (1985), Evaluation for the Potential for Spent Fuel Oxidation Under Tuff Repository Conditions, HEDL-7452, Westinghouse Hanford Co., Richland, WA.

7. Einziger, R. E., and Buchanan, H. C. (1988), Long-Term, Low-Temperature Oxidation of PWR Spent Fuel: Interim Transition Report, WHC-EP-0070, Westinghouse Hanford Co., Richland, WA.

8. Thomas, L. E., Einziger, R. E., and Woodley, R. E., (1989), Microstructural Examination of Oxidized PWR Fuel by Transmission Electron Microscopy, J. Nuclear Materials (in press).

9. MCC - Characterization Plan for MCC Approved Testing Materials - Draft Copy, (1989), Pacific Northwest Laboratory, Richland, WA.

11. APPENDICES

11.1 Appendix A - QA Level Assignment Sheets for Low-Temperature Oven Oxidation Tests.

11.2 Appendix B - Test Plan for Long-Term, Low-Temperature Oxidation of BWR Spent Fuel, PNL-6427 by Robert E. Einziger, December 1988.

11.3 Appendix C - Addendum to Test Plan for Long-Term, Low-Temperature Oxidation of High Burnup Spent Fuel by Robert E. Einziger, August 4, 1989.

11.4 Appendix D - Estimated Staffing Requirements for Series 3 Oven Oxidation Tests.

Appendix A - QA Level Assignment Sheets for Low-Temperature Oven Oxidation Tests

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Lawrence Livermore National Laboratory

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Page______
Of______

SUMMARY SHEET

QALA Record: __________ Rev. No.: ______

Planning Reference: __________

Item/Activity	QA Level	Justification
D-20-45	I	~~II.H~~ II.C2 HFS 8/22/89

Upper Tier QALA Record:

WBS	Description	QA Level
1.2.2.3.1.1	Oven oxidation tests, spent fuel and UO_2	I

Approvals:

LLNL YMP		DOE PROJECT OFFICE	
Task Leader: Ray B. Stout	Date: May 15, 1989	DD:	Date:
Technical Area Leader: [signature]	Date: 5/15/89	PQM:	Date:
QA Manager: [signature]	Date: 5/15/89		
YMP Leader: [signature]	Date: 5/15/89		

YMP 037 REV 0

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QA LEVEL ASSIGNMENT & GRADING APPROVAL SHEET

Upper Tier
QALA Record No.________________ Rev:______ Dated:__________

Lower Tier

WBS No. 1.2.2.3.1.1 Activity No. D-20-45

S.I.P. Identification: WASTE FORM - SPENT FUEL

Activity Description: OVEN OXIDATION TESTS, SPENT FUEL AND UO_2

Quality Assurance Level: I QALA Meeting Date: 4/26/89

Additional Comments:

Meeting Attendees:

R. SCHWARTZ
L. JARDINE
H. LEIDER
R. STOUT
H. SHAW

SIGNATURES INDICATE APPROVAL OF LEVEL OF QUALITY ASSURANCE & GRADED SELECTION OF APPLICABLE REQUIREMENTS

Technical Area Leader	Date 5/8/89	YMP QA Manager	Date 5/8/89
YMP Project Leader	Date 5/16/89		

AFTER PROJ LEADER APPROVAL. RETURN TO QA MGR W/COPY TO TASK LEADER

DOE (YMP) Proj Office	Date	DOE Proj Office QA Mgr	Date

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Lawrence Livermore National Laboratory

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DECISION CRITERIA RECORD

Upper Tier
QALA Record No.________________ Rev:________ Dated:________________

Lower Tier

WBS No. 1.2.2.3.1.1 Activity No. D-20-45

S.I.P. Identification: WASTE FORM - SPENT FUEL

Activity Description: OVEN OXIDATION TESTS, SPENT FUEL AND UO_2

Decision Criteria	Applicability
I	NO HARDWARE (ENGINEERED ITEMS)
II.A	INDETERMINATE
II.B	NO SOFTWARE DESIGN
II.C.1	INDETERMINATE
II.C.2	APPLICABLE
II.D.1	APPLICABLE
II.E	NOT APPLICABLE - NO HISTORICAL REPORTS
II.F	NOT APPLICABLE - NO ENVIRONMENTAL/SOCIOECONOMIC STUDIES
II.G.1	APPLICABLE
II.H	NOT APPLICABLE

Additional Considerations:

Quality Assurance Level: I

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Lawrence Livermore National Laboratory

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GRADED QA CONTROL SPECIFICATION RECORD

Upper Tier
QALA Record No.________________ Rev:________ Dated:________________

Lower Tier

WBS No. 1.2.2.3.1.1 Activity No. D-20-45

S.I.P. Identification: WASTE FORM - SPENT FUEL

Activity Description: OVEN OXIDATION TESTS, SPENT FUEL AND UO_2

LLNL QUALITY ASSURANCE PROGRAM PLAN (QAPP) STRUCTURE

APPLICABLE (YES/NO)		DESCRIPTION	JUSTIFICATION OR CONTROL PROCEDURE(S)
YES		Section I - ORGANIZATION	033-YMP-QP 1.0
YES		Section II - QA PROGRAM	033-YMP-QP 2.series
YES		Section III - SCIENTIFIC INVESTIGATION & DESIGN CONTROL	
YES		1.0 Scientific Investigation Control	
	YES	1.1 Preparation of Plans	
	YES	1.2 Assignment of QA Levels	
	YES	1.3 Review & Approval Process	
	YES	1.4 Scientific Investigation Data Interpretation and Analysis	
	YES	1.5 Use of Computer Programs	
	YES	1.6 The Use of Scientific Notebooks Versus the Use of Technical Implementing Procedures	
	YES	1.7 Change Control	
	YES	1.8 Interface Control	
	YES	1.9 Verification of Scientific Investigations	
	YES	1.10 Surveillance of Scientific Investigations	
	YES	and Experiments	
	YES	1.11 Reports, Conclusions and Recommendations	
	YES	1.12 Close-Out Verification	
NO		2.0 Design Control - NO ENGINEERED ITEMS INVOLVED	
	NO	2.1 General	
	NO	2.2 Design Input	
	NO	2.3 Design Analysis	
	NO	2.4 Design Verification	
	NO	2.5 Design Change Control	
	NO	2.6 Design Interface Control	
	NO	2.7 Design Output Requirements	
	NO	2.8 Design Documents as QA Records	
NO		3.0 Software Quality Assurance and Control - NO SOFTWARE DESIGNS	
	NO	3.1 Computer Software Documentationand Contrc:	
	NO	3.2 Documentation of Computer Software	
	NO	3.3 Software Configuration Management	
YES		4.0 Peer Reviews	
YES		5.0 Technical Reviews	

GRADED QA CONTROL SPECIFICATION RECORD (CONTINUED)

APPLICABLE (YES/NO)		DESCRIPTION	JUSTIFICATION OR CONTROL PROCEDURE(S)
YES		Section IV - PROCUREMENT DOCUMENT CONTROL	
		1.0 Requirements	
	YES	1.1 Measures to Assure Adequate Quality	
YES		2.0 Additional Requirements for Level I Activities	
	YES	2.1 Content of Procurement Documents	
	YES	2.2 Procurement Document Review	
	YES	2.3 Procurement Document Changes	
	YES	2.4 Distribution of Procurement Documents	
YES		Section V - INSTRUCTIONS, PROCEDURES, PLANS, AND DRAWINGS	033-YMP-QP 5.0
YES		Section VI - DOCUMENT CONTROL	033-YMP-QP 6.0
YES		Section VII - CONTROL OF PURCHASED ITEMS AND SERVICES	
YES		1.0 General Requirements	
	YES	1.1 Procurement Planning	
	YES	1.2 Source Evaluation and Selection	
	YES	1.3 Bid Evaluation	
	YES	1.4 Supplier Performance Evaluation	
	YES	1.5 Control of Documents Generated by Suppliers	
	YES	1.6 Acceptance of Item or Service	
	YES	1.7 Acceptance of Services Only	
	YES	1.8 Control of Supplier Nonconformances	
YES		2.0 Commercial-Grade Items	
	YES	2.1 Alternatives	
YES		Section VIII - IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES AND DATA	
NO		Part A - Identification and Control of Items	– NO ENGINEERED (ITEMS INVOLVED)
	NO	1.0 Identification	
	NO	1.1 General	
	NO	2.0 Control	
YES		Part B - Identification and Control of Samples	
	YES	1.0 Identification	
	YES	1.1 General	
YES		Part C - Identification and Control of Data	
	YES	1.0 Identification	
	YES	1.1 General	
NO		Section IX - CONTROL OF PROCESSES	– NO SPECIAL PROCESSES
NO		1.0 General Requirements	
NO		2.0 Process Control	
	NO	2.1 Method	
	NO	2.2 Identification of Special Processes	
	NO	2.3 Qualification of Special Process Procedures	
	NO	2.4 Qualification of Personnel Performing Special Processes	
	NO	2.5 Special Process Equipment	
	NO	2.6 Special Process Records	

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GRADED QA CONTROL SPECIFICATION RECORD (CONTINUED)

APPLICABLE (YES/NO)		DESCRIPTION	JUSTIFICATION OR CONTROL PROCEDURE(S)
NO		**Section X - INSPECTION**	NO ENGINEERED ITEMS INVOLVED
NO		1.0 General Requirements	
NO		2.0 Personnel	
	NO	2.1 Reporting Independence of Personnel	
	NO	2.2 Qualification	
NO		3.0 Inspection Hold Points	
NO		4.0 Inspection Planning	
	NO	4.1 Sampling	
NO		5.0 In-Process Inspection	
	NO	5.1 Combined Inspection and Monitoring	
	NO	5.2 Controls	
NO		6.0 Final Inspection	
	NO	6.1 Inspection Requirements	
	NO	6.2 Acceptance	
	NO	6.3 Modifications, Repairs or Replacements	
NO		7.0 In-Service Inspection	
	NO	7.1 Methods	
NO		8.0 Qualifications Requirements	
NO		9.0 Records	
	NO	9.1 Inspection Records	
	NO	9.2 Personnel Qualification Records	
NO		**Section XI - TEST CONTROL**	NO ENGINEERED ITEMS INVOLVED
NO		1.0 General Discussion	
NO		2.0 Test Requirements	
NO		3.0 Test Procedures	
	NO	3.1 Test Instructions, Procedures and Drawings	
	NO	3.2 Test Prerequisites	
	NO	3.3 Review of Procedures	
	NO	3.4 Potential Sources of Error	
	NO	3.5 Alternatives	
NO		4.0 Test Results	
NO		5.0 Records	
YES		**Section XII - CONTROL OF MEASURING AND TEST EQUIPMENT**	
YES		1.0 General	
	YES	1.1 Maintaining Accuracy of Equipment	
	YES	1.2 Scope of Control Program	
	YES	1.3 Description of Responsibilities	
YES		2.0 Purpose of Equipment	
	YES	2.1 Selection	
	YES	2.2 Calibration	
	YES	2.3 Control	
	YES	2.4 Commercial Devices	
	YES	2.5 Handling and Storage	
	YES	2.6 Records	

GRADED QA CONTROL SPECIFICATION RECORD (CONTINUED)

APPLICABLE (YES/NO)		DESCRIPTION	JUSTIFICATION OR CONTROL PROCEDURE(S)
YES		Section XIII - HANDLING, SHIPPING AND STORAGE	
YES		1.0 General	
	YES	1.1 Special Equipment and Protective Environments	
	YES	1.2 Specific Procedures	
	YES	1.3 Inspection and Testing of Special Tools	
	YES	1.4 Operators of Special Equipment	
	YES	1.5 Marking and Labeling	
NO		Section XIV - INSPECTION, TEST AND OPERATION STATUS	NO ENGINEERED ITEMS INVOLVED
NO		1.0 Indication of Status	
NO		2.0 Methods of Indicating Status	
NO		3.0 Application and Removal of Status Indicators	
YES		Section XV - CONTROL OF NONCONFORMING ITEMS	033-YMP-QP 15.0
YES		Section XVI - CORRECTIVE ACTION	033-YMP-QP 16.00
YES		Section XVII - QUALITY ASSURANCE RECORDS	033-YMP-QP 17.00
YES		Section XVIII - AUDITS	033-YMP-QP 18.00

Supplemental Controls Required:

NONE

Justification:

Remarks:

NONE

Appendix B - Test Plan for Long-Term, Low-Temperature Oxidation of BWR Spent Fuel

PNL-6427
UC-70

Test Plan for Long-Term, Low-Temperature Oxidation of BWR Spent Fuel

R. E. Einziger

December 1988

Prepared for
Lawrence Livermore National Laboratory
under a Related Services Agreement
with the U.S. Department of Energy
Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

PNL-6427

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PNL-6427
UC-70

TEST PLAN FOR LONG-TERM, LOW-TEMPERATURE OXIDATION OF BWR SPENT FUEL

R. E. Einziger

December 1988

Prepared for
Lawrence Livermore National Laboratory
under a Related Services Agreement
with the U.S. Department of Energy
Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

Preliminary studies indicated the need for more spent fuel oxidation data in order to determine the probable behavior of spent fuel in a tuff repository. Long-term, low-temperature testing was recommended in a comprehensive technical approach to 1) confirm the findings of the short-term thermogravimetric analysis tests; 2) evaluate the effects of variables such as burnup, atmospheric moisture, and fuel type on the oxidation rate; and 3) extend the oxidation data base to representative repository temperatures and better define the temperature dependence of the operative oxidation mechanisms.

This document presents the test plan to study the effects of atmospheric moisture and temperature on oxidation rate and phase formation using a large number of boiling-water reactor fuel samples. Tests will run for up to two years, use characterized fragmented and pulverized fuel samples, cover a temperature range of 110°C to 175°C, and be conducted with an atmospheric moisture content ranging from <-55°C to ~80°C dew point. After testing, the samples will be examined and made available for leaching testing.

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