



## PROJECT AND BUDGET PROPOSAL FOR NRC WORK

July 1983

☒ NEW☐ REVISION NO.

## PROJECT TITLE

Examination of TMI-2 Fuel Specimens

PIN NUMBER

A2220

## NRC OFFICE

Nuclear Regulatory Research

NRC SAR NUMBER

60-19-01-03

## DOE CONTRACTOR

Argonne National Laboratory

CONTRACTOR ACCOUNT  
NUMBER 3M475

## SITE

Argonne, Illinois

DOE SAR NUMBER

40-10-01-06

## COGNIZANT PERSONNEL

## ORGANIZATION

## FTE PHONE NUMBER

## PERIOD OF PERFORMANCE

## NRC PROJECT MANAGER

R. Foulds

DAE-FBB

427-4582

## STARTING DATE

10/1/81

## OTHER NRC TECHNICAL STAFF

## COMPLETION DATE

open

## DOE PROJECT MANAGER

R. J. Dalton

DOE-CH

972-2229

## CONTRACTOR-PROJECT MANAGER

B. R. T. Frost

ANL/MST

972-4928

## PRINCIPAL INVESTIGATOR(S)

L. A. Neimark

ANL/MST

972-5177

## STAFF YEARS OF EFFORT (Round to nearest tenth of a year)

FY 1983

FY 1984

FY 1985

FY 1986

FY 1987

Direct Scientific/Technical

0.6

1.2

1.8

Other Direct (Graded)

0.3

0.8

1.0

## TOTAL DIRECT STAFF YEARS

0.9

2.0

2.8

## COST PROPOSAL

Direct Salaries

\$40K

\$92K

\$146K

Material and Services (Excluding ADP)

30

50

70

ADP Support

—

—

5

Subcontracts

—

—

—

Travel Expenses

Foreign

—

—

—

Domestic

3

5

5

Indirect Labor Costs Division Overhead

20

47

73

Other (Specify) Reactor Program Administration

2

5

7

General and Administrative (17.3 %)

20

42

64

## TOTAL OPERATING COST

\$115K

\$241K

\$370K

\$504K

\$207K

## CAPITAL EQUIPMENT

PIN CHARGED: 2220

23

## TOTAL PROJECT COST

\$115K

\$264K\*

\$370K

\$504K

\$207K

FY 1984

OCTOBER

NOVEMBER

DECEMBER

JANUARY

FEBRUARY

MARCH

MONTHLY FORECAST  
EXPENSE

\$20K

\$25K

\$25K

\$25K

\$20K

\$20K

APRIL

MAY

JUNE

JULY

AUGUST

SEPTEMBER

\$20K

\$20K

\$20K

\$20K

\$20K

\$29K

## PROJECT AND BUDGET PROPOSAL FOR NRC WORK

A2220

DATE

July 1983

## PROJECT TITLE

Examination of TMI-2 Fuel Specimens

## OGE PROPOSING ORGANIZATION

Argonne National Laboratory

FORECAST MILESTONE CHART: Scheduled to Start —  — Completed (Shown in Quarter Year)  
PROVIDE ESTIMATED DOLLAR COST FOR EACH TASK FOR EACH FISCAL YEAR

TASK		FY 1983				FY 1984				FY 1985				FY 1986				FY 1987			
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Examination Planning	SCHEDULE																				
	COST		\$10K				\$10K														
Examination Preparation	SCHEDULE																				
	COST		\$30K				\$30K														
Materials Examination	SCHEDULE																				
	COST		\$75K				\$201K			\$370K				\$504K							\$150K
Equipment Procurement	SCHEDULE																				
	COST						\$23K														
Material Disposal	SCHEDULE																				
	COST																				\$57K
TOTAL ESTIMATED PROJECT COST			\$115K				\$264K*			\$370K				\$504K							\$207K

PROJECT DESCRIPTION: (Provide narrative descriptions of the following topics in the order listed. Attach on plain paper to this NRC Form 189, if an item is not applicable, so note.) See attached sheets. \*Includes \$74K carryover from FY 83.

1. OBJECTIVE OF PROPOSED WORK
2. SUMMARY OF PRIOR EFFORTS
3. WORK TO BE PERFORMED AND EXPECTED RESULTS
4. DESCRIPTION OF ANY FOLLOW-ON EFFORTS
5. RELATIONSHIP TO OTHER PROJECTS
6. REPORTING SCHEDULE
7. SUBCONTRACTOR INFORMATION
8. LIST NEW CAPITAL EQUIPMENT REQUIRED
9. DESCRIBE SPECIAL FACILITIES REQUIRED
10. CONFLICT OF INTEREST INFORMATION

SEE NRC MANUAL CHAPTER 1102 FOR ADDITIONAL INFORMATION

APPROVAL AUTHORITY—SIGNATURE

DATE

## 1. Objective of Proposed Work

The objective of the proposed work is to determine, through detailed hot-cell examinations, the physical, metallurgical, and chemical changes that occurred in TMI-2 core materials during the accident of March 28, 1979. These determinations will be used to supply the data needs for 1) reconstruction of the accident sequence, 2) analytical tool development, 3) establishment of future licensing criteria, 4) methods for accident mitigation and safety, and 5) future designs, operation, or maintenance. The hot-cell examinations will be preceded by extensive planning to assure that the correct data are obtained and that the capability is in hand to obtain that data. Such plans will derive from interfacing with pertinent NRC/DOE/EPRI planning committees. This proposal addresses the planning and preparation activities that will lead to the later examinations in the Argonne hot-cells.

## 2. Summary of Prior Efforts

### Past Years

Argonne has had extensive interaction with the NRC/DOE/EPRI 7.4 Subcommittee responsible for reviewing and recommending analytical techniques for examining the TMI-2 fuel and core components. Much of the methodology included in the subcommittee's final report was derived from ANL's recommendations. Argonne's experience in this area comes from many years of examining severely damaged fast reactor safety tests conducted in the TREAT and ETR reactors. In the LWR area, we have conducted materials research programs for NRC and EPRI on fission-gas behavior during accident situations, mechanical property studies of irradiated and unirradiated Zircaloy cladding, the analysis of fission products released to the fuel/cladding gap, the susceptibility of Zircaloy to stress-corrosion failure owing to these fission products, and the examination of  $\text{UO}_2$ -Zircaloy reactions in irradiated specimens from tests conducted at ORNL. The personnel expertise and hot-cell capabilities developed through these programs will constitute a firm foundation for the examination and evaluation of the TMI-2 core materials at ANL.

In FY 1982 an interface was established with EG&G, the lead DOE contractor in the TMI-2 core evaluation. This interface led to ANL having input to the EG&G draft plan for the examination of the core materials. Also, ANL arranged with EG&G to examine samples of the filtrate recovered from TMI-2's filtering system shortly after the accident. This examination was coordinated with the examinations performed at EG&G and LANL.

An evaluation was made of ANL's capabilities in the area of irradiated materials characterization. Because of ANL's existing strong base of sophisticated equipment (SEM, TEM, scanning and ESCA Auger analysis, and electron and ion microprobe analysis), only a computer to control Auger data collection and analysis was identified now as a necessary new equipment item.

ANL was requested by NRC-RSR to prepare a number of samples of synthetic core debris that might resemble similar combinations of materials in the TMI-2 core debris. The intent of this limited effort was to see if

configurations could be generated by induction heating that resemble debris observed in the mid-summer TV examination of the core. Effort was devoted to obtaining specimen materials and readying an induction furnace.

In FY 1983 three samples of filter debris received from EG&G were examined to characterize the debris by size, shape and chemical composition. Examinations carried out included visual inspections, metallography, SEM, and gamma spectroscopy. The filtrate was found to contain particles of  $UO_2$ , oxidized and unoxidized Zr, Ag-In-Cd, stainless steel (control rod cladding), and Inconel 718 (bundle straps). Fission products were present in relatively small quantities. The results of the examinations were combined with those of EG&G and LANL in a joint report.

The effort to generate synthetic core debris was completed. Combinations of materials investigated were stainless steel/Zircaloy, Zircaloy/Inconel 718, Ag-In-Cd/stainless steel, and Zircaloy/ $UO_2$ . The environment for the tests was flowing argon; no attempt was made to simulate the more likely environment during the accident. However, in the first test with stainless steel/Zircaloy, perhaps because of incomplete system purging, the Zircaloy underwent a rapid exothermic reaction at  $\sim 1700^\circ C$ . Subsequent tests only resulted in the expected eutectic formation. The Zircaloy/ $UO_2$  tests resulted in eutectic reaction with the reaction product escaping along grain boundaries through the cladding.

A continuing dialogue was maintained with EG&G on obtaining one or more grab samples of core debris. Originally scheduled for May, obtaining the grab samples from the core was delayed until the end of FY 1983.

ANL's thoughts on how NRC's examination objectives could be optimally served within expected budgetary constraints were conveyed by letter to the NRC. This letter contained an examination approach for ANL, how ANL's role fitted with those of other laboratories expected to be involved, and examination cost estimates.

### 3. Work to be Performed and Expected Results

#### FY 1984

The examination of the grab samples that were obtained in FY 1983 will be completed and a report issued. As the core recovery operations gain momentum at TMI, it is anticipated that more samples will be received at ANL for examination. These examinations will be very specific using ANL's capabilities for optical and electron microscopy; X-ray analysis; electron, ion, and Auger microprobe analyses; and chemical analyses. Preparations will continue at ANL for receiving the principal TMI samples in FY 1985 during the major core recovery operations. These preparations will consist of a continued upgrading of our equipment and examination techniques.

#### FY 1985

It is expected that ANL's principal TMI activities will occur in this year when core recovery and examination operations go into full swing. It is anticipated that ANL will receive representative samples of the various core regions of interest, i.e. rubble, portions of partially damaged subassemblies, portions of intact subassemblies, and portions of the upper and lower plenums. ANL's examination of these components will be only a part of the total examination to be conducted by participating laboratories. However, this sampling will allow ANL to provide the NRC with a self-consistent set of data on fission-product distributions, materials interactions, core temperatures, and core damage.

#### 4. Description of Follow-On Efforts

It is anticipated that the detailed TMI-2 examination efforts will continue through FY 1986. This will include data collection, evaluation, reporting, and disposal of radioactive wastes from the hot-cell. In addition, it can be expected the examination results will create spin-off studies of fuel and cladding properties, fission-product behavior under extreme conditions, and phase diagrams. These efforts could carry the program through FY 1988, depending upon when they were started.

#### 5. Relationship to Other Projects

It is expected that the principal TMI-2 core examination will be carried out under DOE auspices at a number of hot-cell facilities in the country to maximize the benefits of the available expertise and capabilities. It is now anticipated that the larger portions of the core will be first sent to the EG&G hot-cell for disassembly and subsequent dissemination of smaller units to satellite hot-cells. We presently view ANL in the role of one of the satellite facilities for the detailed, in-depth examinations. However, some of the smaller samples could be received directly at ANL. The work would be coordinated by EG&G's Technical Integration Office for TMI-2 activities. The ANL activities for the NRC are anticipated to be beyond those required or funded by DOE.

#### 6. Reporting Schedule

##### FY 1983

Examination of TMI-2 Filter Debris, R. V. Strain, J. E. Sanecki, and L. A. Neimark, June 1983 (with EG&G and LANL).

Preparation and Interpretation of Synthetic TMI-2 Core Debris, R. V. Strain and L. A. Neimark, September 1983.

##### FY 1984

Examination of TMI-2 Core Debris "Grab" Sample, R. V. Strain and L. A. Neimark, September 1984.



7. Subcontractor Information

Not applicable.

8. New Capital Equipment Required

A necessary new equipment item is a computer to control data collection and analysis for the scanning Auger microprobe. The present system requires a laborious and time consuming manual data reduction. The computer would control data collection, evaluate the raw data, and present it in a readily understandable format. The total cost is estimated to be \$46,000; however, this cost will also be borne by other programs (including NRC FIN No. A2232, Posttest Fuel Examination (ORNL Fission Product Release Test Specimens)).

9. Special Facilities Required

The TMI-2 core materials examination will be done in the Alpha-Gamma Hot Cell Facility at ANL-East. This facility has been engaged in reactor fuels and materials work for 19 years. Over the years its forte has become the in-depth examination of irradiated materials using a wide variety of examination techniques and sophisticated equipment. The facility's uniqueness derives from three principal sources: 1) a staff of senior materials people with extensive experience in understanding materials behavior; 2) an array of electron beam instruments adapted for interrogating irradiated materials including a scanning electron microscope, a scanning Auger microprobe, and an electron microprobe; and 3) proximity to other analytical instruments at ANL-E such as an ion microprobe and an ESCA Auger unit that are also capable of handling irradiated materials. The facility currently supports programs totaling approximately \$1.7M annually, including the costs to operate the facility and the balance of the programmatic effort. To replace such a facility would cost about \$50M and require about six years.

10. Conflict of Interest Information

Argonne National Laboratory presently conducts research for NRC and no conflict of interest is involved.