Work Performed Under Contract DE-AC09-79 ET 47921

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Printed in the United States of America
Available from
National Technical Information Service, U. S. Department of Commerce
5825 Port Royal Road, Springfield, Virginia 22151

Price: Printed Copy \$ 4.00 ; Microfiche \$3.00

AGNS
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AGNS-47921-TPR-5

Distribution
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AFR SPENT FUEL STORAGE PROGRAM

TECHNICAL PROGRESS REPORT

July 1980 - September 1980

MASTER

October 24, 1980

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PREPARED FOR THE
DEPARTMENT OF ENERGY
WASTE AND FUEL CYCLE TECHNOLOGY OFFICE
UNDER CONTRACT DE-AC09-79ET47921

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ABSTRACT

AFR SPENT FUEL STORAGE PROGRAM

Work on this project is focused on developing design and licensing information for the model facility. The subcontracts for soils and structural design and the security system design have been completed. The rack design subcontract is progressing satisfactorily. Design of facility modifications have been completed and draft reports are underway.

Licensing documentation is approximately 65% complete and progressing at a satisfactory pace to meet scheduled projections.

FOREWORD

This Quarterly Report describes the technical status of work performed by Allied-General Nuclear Services (AGNS) in providing design and licensing information preparatory to conversion of a nuclear fuel reprocessing plant's fuel receiving and storage facility to an away-from-reactor (AFR) spent fuel storage facility using the Barnwell Nuclear Fuel Plant as a model.

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TECHNICAL PROGRESS REPORT
July 1980 - September 1980

TASK OBJECTIVES

The contractor shall furnish design and licensing information preparatory to conversion of a nuclear fuel reprocessing plant's fuel receiving and storage facility to an Away-From-Reactor (AFR) spent fuel storage facility using the Barnwell Nuclear Fuel Plant as a model.

SUB-TASK 1.1 - FACILITY MODIFICATIONS

Principal Areas of Investigation

Preparation of a design package for fuel receiving modifications to the model facility.

Status Summary

The major effort this report period was to complete the engineering designs for the various facility modifications. A total of 44 designs and 7 studies have been completed. The structural modification and seismic study with Bechtel are 98% complete. Final reports on their soils investigation is due in November 1980.

Technical Progress

Implementation Concepts

- Provide detail design packages for modifications to the existing FRSS Facility which are required to adapt the model facility to an AFR mode and/or improve the operation of the existing facility.
- Engineering studies and designs will be developed for the building extension structure, crane extension, transfer canal connections, and soils studies required for proposed expansion pools.
- Other major design jobs will involve the crane systems, cask working platform, leaker can handling system, HVAC, pool water, and waste handling systems.
- A report will be provided summarizing the jobs included, documents developed, estimated cost, construction approach, major procurement required, and the schedule for material delivery and installation.

Progress to Date

Sub-Task 1.1.1 - Modifications to Model Facility

- All items in this portion of the modifications design effort have been completed.
- Cost estimates, procurement, and construction packages are complete.
- Draft of deliverable report underway.

Sub-Task 1.1.2 - Subsystem Designs within FRSS

- All items in this portion of the modifications design effort have been completed.
- Cost estimates, procurement, and construction packages are complete.
- Draft of deliverable report underway.

Sub-Task 1.1.3 - FRSS Structure Modifications

- Bechtel has completed the seismic analysis work.
- Law Engineering has completed all test borings at the plant site.
- Soils study to be completed in November 1980.
- Canal extension detail design has been completed.
- Draft of deliverable report underway.

SUB-TASK 1.2 - HIGH-DENSITY FUEL STORAGE RACKS

Principal Areas of Investigation

Preparation of a design package for high-density fuel storage rack configuration for the model storage facility.

Status Summary

The work performed during this quarter has been directed towards a scoping study of the applicability of the movable PWR rack concept for utilization with canned-leaker fuel, canned-disassembled fuel, assembled (normal configuration PWR) fuel, and for possible double-tiering in the deep areas in the BNFP pool.

Technical Progress

Implementation Concepts

- Prepare a specification package for high-density storage racks.
- Evaluate vendor-provided data on specific high-density storage rack designs and configurations.
- Develop engineering data on high-density storage racks suitable for Nuclear Regulatory Commission (NRC) licensing actions.
- Identify, develop, and report on a design for existing pool modifications required to accommodate high-density racks using currently licensed technology.
- Develop a planning schedule for high-density storage rack utilization.
- Submit final report to the Savannah River Spent Fuel Project Office.

Progress to Date

- (1) The mechanical design of the movable BWR rack has been completed. This design is interchangeable with the PWR fuel rack pool mountings. It incorporates the capability of accommodating 25 BWR assemblies.
- (2) Continuing design studies were made of the rack latching device which permits an attachment of the movable rack to the pool floor mounting. The devices permit the remote locking operation to be performed after each rack transfer. The latch will be located on each of the four corners exterior to the casing of the rack itself. The design studies have attempted to optimize the conditions related to visibility, simplified remote handling tool access, and possible maintenance (in the event of a "jammed" engagement). The key design parameter is the rack to mounting structural loading under seismic conditions. This loading is high under worst case design conditions and requires a large mounting block.
- (3) Horizontal seismic response spectrum for the various pool areas were formulated by Bechtel in accordance with NRC Regulatory Guides 1.60 and 1.61. The spectrum was utilized to evaluate the dynamic loadings of the fuel rack and mounting components. The preliminary results indicate that the components are structurally adequate.
- (4) A scope study utilizing the PWR movable rack concept for possible disassembled fuel and leak-control application (in addition to assembled fuel) is currently underway at NES. This study was initiated in mid-August, at DOE request, and is expected to be completed by late October. The conceptual study envisions the

utilization of movable racks for both shallow and deep pool areas. The resulting operational and procurement flexibility does result in a slight loss in total pool storage capacity.

(5) Detailed studies of the movable PWR rack were performed which evaluated criticality and structural aspects.

(a) Table 1 presents the results of a parametric study of criticality which optimizes the necessary poison concentration for disassembled fuel. In all cases, the criticality concerns are less for disassembled than normal fuel. However, this study permits possible optimization for poison on two sides of the fuel tube, if an "L-shaped" insert is required for assembled fuel. The study also indicates the poison level acceptable for the design basis - disassembled fuel.

(b) Table 2 presents the results of various structural evaluations of the rack and mounting. The heavy wall outer casing of the rack module in combination with the "tension straps" which attach the fuel tubes to the structure permit the rack and fuel to accommodate a variety of hypothetical handling accidents. In addition, the rigidity of the rack is increased. This results in a higher natural frequency for the structure. Also, the outer casing increases the axial strength of the module sufficiently to permit possible "double-tiering" of the modules in deep pool areas. The feasibility of this will be examined in greater detail as the scoping study progresses.

Table 2 also illustrates the increased loadings associated with disassembled fuel. As a result, it was necessary to increase the strength of the mounting structures to keep the component stresses at permissible levels. It was also necessary to include more mounting stubs in the pool floor to distribute these loads in a more uniform manner.

(c) Continuing studies on the all movable rack concept will emphasize:

- possible reduction in facility storage space
- possible increased (or decreased) rack cost
- feasibility of "double-tiering" in deep pools
- optimum power concentration for normal and disassembled fuel
- resolution of all areas of structural/seismic difficulty and problems
- presentation of results to project management to determine a future course of action with regard to fixed versus movable racks.

SUB-TASK 1.3 - SECURITY SYSTEM

Principal Areas of Investigation

Preparation of a security system design package for a model AFR Facility.

Status Summary

The conceptual system design has been completed. The three plans required for license submittal have been completed.

Technical Progress

Implementation Concepts

- Identify governmental regulations applicable to security system requirements for AFR spent fuel storage.
- Develop design criteria for an AFR security system that conforms to the governmental regulations identified above.
- Prepare a design of an AFR security system that meets the design criteria specified above.
- Provide a report covering preliminary plans and programs for safeguards contingency, site security, and security personnel training. These items are presently required for licensing action by NRC.

Progress to Date

- The system design and required plans have been received from IEAL.
- Documentation is now undergoing internal AGNS review. To date no major problems have been identified.

SUB-TASK 1.4 - LICENSING DOCUMENTATION

Principle Areas of Investigation

Preparation of licensing-related documents required by the NRC for a spent fuel storage application.

Status Summary

Satisfactory progress is being made on preparing the required licensing documents. The owner/operator/applicant relationship will have to be defined before portions of the documents can be finalized for submittal to NRC.

Technical Progress

Implementation Concepts

- Prepare and refine basic licensing-related documentation required by NRC for an AFR Spent Fuel Storage Facility. Five major subsystems will be evaluated:
  - (a) Application for Licensing
  - (b) Technical Description
  - (c) Environmental Report
  - (d) Emergency Plan
  - (e) Decommissioning Plan.
- Provide a report incorporating all of the above documents to the Savannah River Spent Fuel Project Office.

Progress to Date

The safeguards contingency and physical security plans have been drafted and submitted to DOE.

The quality assurance, decommissioning, and training plans have been drafted and incorporated in the Safety Analysis Report.

The Safety Analysis Report, emergency plan, and Environmental Report are each 60 to 65% drafted.

TABLE 1

SUMMARY OF CRITICALITY CALCULATIONS TO DATE - FEASIBILITY
STUDY FOR HIGH-DENSITY PWR FUEL STORAGE - DISASSEMBLED FUEL

Summary of Results

1. Flux Trap Rack with Disassembled Fuel - No Poison

Properties

Cell Array	Infinite
Cell Pitch	10.912 in.
Cell O.D.	9.925 in.
Cell I.D.	9.625 in.
Cell Wall Thickness	0.150 in. (S.S.)
Fuel Array	21x21

$$K_{eff} = 1.22$$

Composite PWR Fuel Assembly

Clad I.D., in.	0.388
Clad O.D., in.	0.439
Clad Thickness, in.	0.0255
# of fuel rods	208
# of guide tube spaces	17
Arrangement	15x15
Guide tube layout	As in B&W 15x15
Linear loading UO ₂ , per rod, lbs./in.	0.04152
Pitch, in.	0.591
Assembly width, in.	8.865
Clad Material	Zr-4
Enrichment, w/o	4.1

2. Poison Rack with Disassembled Fuel in Basket-D array; $B_{10} = 0.03 \text{ gm/cm}^2$

Properties:

Cell Array	-	Infinite
Fuel Array	-	20x20
Basket O.D.	-	9.250 in.
Basket Wall Thickness	-	0.003 in. (S.S.)

$$K_{eff} = 0.84$$

TABLE 1 (CONTINUED)

3. Poison Rack with Disassembled Fuel in 3/16 in. Thick Stainless Steel Basket

Properties:

Array	-	Infinite
Fuel Array	-	20x20
Basket O.D.	-	9.25 in.
Basket Wall Thickness	-	3/16 in. (S.S.)

$$K_{eff} = 0.74$$

4. Reduced Poison Concentration (0.020 gms B_{10} /cm²) with Disassembled 20x20 Fuel

Properties:

Cell Properties	-	Same as 3 except B_{10} Areal Density = 0.020 gms/cm ²
Basket Properties	-	Same as 3
Fuel Array	-	20x20

$$K_{eff} = 0.763$$

5. Reduced Poison Concentration (0.010 gms B_{10} /cm²) with Disassembled Fuel

Properties:

Cell Properties	-	Same as 3 with B_{10} Areal Density = 0.010 gms/cm ²
Basket Properties	-	Same as 3
Fuel Array	-	20x20

$$K_{eff} = 0.80$$

6. Poison Rack with all Poison Removed with Disassembled Fuel

Properties:

Fuel Rack Properties	-	Same as 3 with no poison
Basket Properties	-	Same as 3
Fuel Array	-	20x20

$$K_{eff} = 0.979$$

TABLE 1 (CONTINUED)

7. Poison Rack with 0.05 inch Stainless Steel Substituted for Poison with Disassembled Fuel

Properties:

All properties same as 3 with 0.050 stainless steel plates substituted for poison plates

$$K_{eff} = 0.97$$

8. Poison Rack Containing 0.010 gm B_{10}/cm^2 with Two Poison Plates Removed with Disassembled Fuel

Properties:

All properties same as 5 except that poison plate width = 5.7 in., and two adjacent plates are removed.

$$K_{eff} = 0.946$$

TABLE 2

SUMMARY OF STRUCTURAL/SEISMIC ANALYSES RESULTS

		<u>Assembled Fuel</u>		<u>Disassembled⁽¹⁾</u>
		<u>BWR</u>	<u>PWR</u>	<u>(Canned) Fuel Racks</u>
I.	<u>31 Feet Drop Analysis</u>			
	Max. Velocity of Impact (ft/sec)	36.5	36.5	36.5
	Max. Elongation of Strap (in.)	10.0	10.0	15.75
	Max. Reaction Load of Impact (k)	802.8	802.8	845.2
	Max. Stress in Casing (ksi)	11.77	11.77	12.4
	Percent of Ultimate Strain (%)	12.1	12.1	18.8
II.	<u>Frequency Analysis</u>			
	14 Mass Model (Excluding the Flexibility of Base)			
	Frequency (CPS) Lateral	10.4	11.2	8.52
	Vertical	27.24	29.4	20.82
	All Racks (Including the Flexibility of Base Structure)			
	Frequency (CPS) Lateral	5.22	5.22	5.40
	Vertical	15.95	15.95	13.03
III.	<u>Seismic Response</u>			
	1. Mass Model (Excluding the Flexibility of Base)			
	Max. Horizontal OBE	0.06	0.06	0.097
	Deflection (inches) DBE	0.10	0.10	0.155
	All Racks (Including the Flexibility of Base) OBE	0.422	0.422	0.4005
	DBE	0.675	0.675	0.641
	2. Max. Stress in OBE	3.37	3.37	4.52
	Casing (ksi) DBE	5.39	5.39	7.23
	3. Max. Reaction on Each Latch			
	OBE Horizontal (k)	7.94	7.94	12.01
	Vertical (k)	50.16	50.16	93.56
	DBE Horizontal (k)	12.7	12.7	18.82
	Vertical (k)	73.4	73.4	152.54

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(1) With modified mounting structure.

TABLE 2 (CONTINUED)

SUMMARY OF STRUCTURAL/SEISMIC ANALYSES RESULTS

		<u>Assembled Fuel</u>		<u>Disassembled⁽¹⁾</u>
		<u>BWR</u>	<u>PWR</u>	<u>(Canned)</u>
				<u>Fuel Racks</u>
4.	Max. Stress in Base OBE	20.3	20.3	14.7
	Structure (ksi) DBE	29.0	29.0	23.52
5.	Max. Reaction Load on Post			
	OBE Horizontal (k)	27	27	65
	Vertical (k)	91	91	135
	DBE Horizontal (k)	43.2	43.2	104
	Vertical (k)	145.6	145.6	216

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(1) With modified mounting structure.

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