POST-ACCIDENT RECOVERY COST STUDY OF THE LACROSSE BOILING WATER REACTOR

Prepared for

DAIRYLAND POWER COOPERATIVE

LACROSSE, WI

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TO

POST-ACCIDENT RECOVERY

COST STUDY

OF THE

LACROSSE BOILING WATER REACTOR

ESTIMATED COST IMPACT

OF ADDING FUEL

MELTING TO BASE STUDY

ACCIDENT SCENARIO

PREPARED FOR
DAIRYLAND POWER COOPERATIVE
LACROSSE, WI

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I. SUMMARY

This report is Addendum 1 to the report "Post-Accident Recovery Cost Study Of The LaCrosse Boiling Water Reactor", NES Document 81A1087, Revision 3, published on December 20, 1984. The report (hereinafter referred to as the "base study") consisted of the analysis and cost estimate of a post-LOCA recovery project at the subject plant. The accident scenario involved a below-core complete break in the primary coolant piping system and included 100% fuel cladding failure without fuel melting.

This addendum report reflects the impact of adding a 50% fuel melt criterion to the accident scenario of the base study and estimates the resultant increased costs. All other criteria and the cost estimating methodology of the base study were maintained in the preparation of this report.

A comparison of post-accident recovery costs of the base study and the recovery cost estimate of this report is shown in Table A-1. These data show that the impact of 50% fuel melting would add an estimated $27,282,950 to the costs estimated in the base study.

Thus, it is estimated that property damage insurance coverage of approximately $180 million would be adequate for the LaCrosse Boiling Water Reactor plant.

TABLE A-1

SUMMARY OF POST-ACCIDENT RECOVERY COSTS*

ITEM	COST OF RECOVERY BASE STUDY	COST OF RECOVERY ADDENDUM 1
Plant Structures, Systems, and Components	$115,155,000	$142,437,950
Cost Increase For Disposal of Damaged Fuel	$17,716,400	$17,716,400
Increased Cost Of Reactor Decommissioning	$19,170,800	$19,170,800
Total Recovery Cost	$152,042,200	$179,325,150

TOTAL COST INCREASE = $27,282,950
DUE TO FUEL MELTING

* COSTS INCLUDE A 25% CONTINGENCY AND ARE STATED IN 1984 DOLLARS

2. EXPLANATION OF COST INCREASES TO THE BASE STUDY

The base study attempted to accurately estimate the maximum reasonable costs of recovery from a LOCA at the LACBWR plant. Three scenarios of accident criteria were presented in NUREG/CR-2601. The NUREG study presents three accident scenarios. Of these scenarios, Scenario 2 and Scenario 3 equate to the accident scenario of the base study and this addendum, respectively.

The preparation of the base study incorporated many of the unit cost factors developed in the NUREG study. In order to provide of reasonable maximum cost estimate, many cost factors related to Scenario 3 of the NUREG study were used in the base study cost estimate. Thus, while the total recovery cost estimate presented in this addendum depict the total impact of a LOCA, with 50% fuel melting, the differential cost of $27,282,950 reflects only the difference in the cost estimate of this addendum and that of the base study - not the total differential costs of the two accident scenarios.

The cost estimate differential between the base study and this addendum are attributed primarily to five areas of the accident recovery plan.

2.1 RADIOLOGICAL CONSEQUENCES

A major cost element in an accident recovery project results from the contamination of the containment structure. A comparison of the expected source term and contamination levels in the base study and this addendum is shown in Table A-2. The principle areas of added costs due to contamination are in Plant Structures, Systems and Components. Of the total added costs of $27.2 million, approximately $4.3 million is attributed to increased efforts in recovery plan development, preparation of activity specifications and detailed procedures, supplies, health physics and recovery plan implementation.

2.2 SPENT FUEL HANDLING EQUIPMENT

The largest single cost increase to the base cost estimate is attributable to the $12.5 million added costs for spent fuel handling equipment. This cost increase

TABLE A-2

COMPARISON OF SOURCE TERM AND CONTAMINATION LEVELS

	BASE STUDY	ADDENDUM 1
Activity Released During Accident (Ci)	1.3×10^6	29.6×10^6
Activity Remaining After Two Year Decay (Ci)	6.9×10^4	64.4×10^4
Average Area Dose Rate in Containment Building After Two Year Decay (mr/hr)	64	279

is the difference between the estimated equipment costs in Scenario 2 and Scenario 3 of $1.0 million and $11.0 million, respectively, escalated to 1984 dollars.

2.3 WASTE DISPOSAL

The second largest cost increase is due to the impact upon waste disposal. The estimated cost increase of $6.0 million is due largely to burial site charges for disposal of the 64 million curies estimated in this addendum study as opposed to only 6.9 million curies estimated in the base study.

2.4 REACTOR MOCK-UP

An added cost of $2.5 million results from the need for more extensive use of more complex reactor mock-up equipment for training in spent fuel handling and packaging for off-site disposal.

2.5 SUPPLIES, HEALTH PHYSICS AND MISCELLANEOUS

A cost increase of $1.9 million results from the need for additional supplies and expendable tools to support health physics coverage and contamination removal.

3. COST ESTIMATE - EFFECTS OF FUEL MELTING UPON BASE STUDY

Detailed elements of the recovery cost estimate for Plant Structures, Systems and Components for this addendum accident scenario are shown in Table A-3. The total cost estimate shown in Table A-3 is $142,437,950.

The total recovery cost estimate for the accident scenario of this addendum report is obtained by adding the above costs to the $17,716,400 estimated cost increase for disposal of damaged fuel (Table 4-2) and the $19,170,800 estimated increased cost of reactor decommissioning (Table 4-3). Therefore, the total recovery cost estimate for this addendum accident scenario is $179,325,150.

Thus, the impact of adding 50% fuel melting to the accident scenario of the base study results in a total increased cost of $27,282,950 or a 17.9% increase to the base study cost estimate.

TABLE A-3
LACBWR POST-ACCIDENT RECOVERY COSTS - INCLUDING EFFECTS OF FUEL MELTING

Major Activities	Cost ($)
I. Phase I - Recovery Planning	
1. Post Accident Monitoring & Maintenance	Note A
2. Interface with NRC	Note A
2.1 Establish Accident Licensing Staff	
3. Evaluate/Select Engineering Support Contractor	$ 221,800
3.1 Write Specification	
3.2 Answer Questions	
3.3 Select Bidder	
4. Construct Temporary Offices	$ 301,300
4.1 Turbine Building	
4.2 Yard	
5. Develop Recovery Conceptual Plan	$ 312,520
5.1 Obtain & Review Plant Drawings	
5.2 Prepare End Product Description	
5.3 Calculate Containment Radioactive Inventory	
5.4 Define Major Sequence of Work Activities	
5.5 Develop Conceptual Plan	

TABLE A-3
(Continued)

	Major Activities	Cost ($)
6.	Develop Accident Recovery Reports	$ 550,400
	6.1 Safety Analysis Reports	
	6.2 Environmental Impact Statement	
	6.3 Final Report	
7.	Prepare Integrated Recovery Sequence	$ 78,650
8.	Design Temporary Support Facilities	$ 332,640
9.	Design, Fabricate and/or Purchase Recovery Equipment/Systems	
	9.1 Containment Ventilation System	$ 102,400
	9.2 Containment Vent System Contamination Control Envelope	$ 70,400
	9.3 Breathing Air Compressor (2 each)	$ 70,000
	9.4 Containment Water Processing System	$ 330,600
	9.5 Concrete Scabblers	$ 58,000
	9.6 HEPA Filter Attachments for Scabblers	$ 100,200
	9.7 High Pressure Water Wash Equipment	$ 186,500
	9.8 Hand Operated Pallet Trucks	$ 1,400
	9.9 Spider Work Platform	$ 52,200
	9.10 In-Containment Communication Systems	$ 25,000
	9.11 Containment Closed Circuit TV Monitoring System	$ 258,500
	9.12 High Reach Scissors Platform	$ 15,000
	9.13 Application Equipment for Strippable Paint	$ 5,000
	9.14 Strippable Paint	$ 250,800

TABLE A-3
(Continued)

	Major Activities	Cost ($)
9.15	Procure Containers & Cask Contracts	$ 12,200
9.16	Remote Underwater Monitor and Manipulator for Reactor Vessel	$ 125,000
9.17	Hydraulic Shears for Core Spray Bundle	$ 20,000
9.18	Remote Manual Manipulators	$ 10,000
9.19	Steam Separator In-Vessel Retainer	$ 65,300
9.20	Core Spray Bundle Segment Cans & Pit Rigging	$ 23,000
9.21	Reactor Water Clean-Up & Level Control System	$ 190,300
9.22	Contamination Control Envelope for Internals Segmentation	$ 152,600
9.23	Remote Manipulator & Torch for Internals Segmentation	$1,290,500
9.24	Internals Segment Storage Cans	$ 65,000
9.25	Hydraulic Vacuum System	$ 160,500
9.26	Equipment for Removal and Loading of Damaged Fuel into Transport Containers	$13,772,000
9.27	Damaged Fuel Storage Racks	$ 388,100
9.28	Recirculation Nozzle Plugs & Installation Equipment	$ 320,000
9.29	Containment Silt Pumps & Piping	$ 95,200
9.30	Shielding	$ 450,000
9.31	Underwater Plasma Arc Torch	$ 75,000
9.32	Portable Oxyacetylene Torches	$ 5,000
9.33	Underwater Lights and Viewing Aids	$ 50,000
9.34	Rigging Equipment	$ 62,600
9.35	HEPA Filtered Vacuum	$ 270,000
9.36	Supplied Air Plastic Suits	$ 25,000

TABLE A-3
(Continued)

Major Activities	Cost ($)
10. Develop Activity Specifications, Detailed Procedures & Radiation Work Permits	
10.1 Installation of Containment Vent	$ 181,400
10.2 Installation of Containment Access Structure	$ 302,400
10.3 Design of Temporary Laydown Areas	$ 120,980
10.4 Containment Entry & Initial Survey	$ 141,100
10.5 Containment Decontamination	$ 544,300
10.6 Personnel Training	$ 80,600
10.7 Service Equipment Repair/Maintenance	$ 60,500
10.8 Repairs to Main Crane & Refueling Equipment	$ 131,000
10.9 Install Special Equipment at Elevation 701'	$ 120,980
10.10 Installation of Damaged Fuel Racks	$ 120,920
10.11 Removal of Reactor Vessel Head	$ 151,200
10.12 Fuel and Core Inspection	$ 110,900
10.13 Reactor Water Clean-Up & Level Control System Installation	$ 131,000
10.14 Segmentation of Core Spray Bundle	$ 181,400
10.15 Removal of Damaged Fuel and Core Debris, Container Loading	$ 272,200
10.16 Segmentation and Removal of Internals	$ 211,700
10.17 Installation of Recirculation Nozzle Plugs	$ 60,500
10.18 Containment Water Processing & Drainage	$ 181,400
10.19 Decontamination/Repair of Main Air Lock	$ 50,400
10.20 Solidification of Liquid Wastes	$ 161,300

TABLE A-3
(Continued)

	Major Activities	Cost ($)
10.21	Handling & Storage of Recovery Wastes	$ 181,400
10.22	Disposal of Recovery Wastes	$ 141,200
10.23	Waste Classification	$ 100,800
10.24	Recirculation Pump Cubicle Area Decontamination	$ 136,100
10.25	Removal of Damaged Fuel Racks from Fuel Pool	$ 95,720
10.26	Transfer of Damaged Fuel and Core Rubble into Shipping Casks	$ 241,960
10.27	Installation of Breathing Air Compressor	$ 10,100
10.28	Installation of Temporary Shielding	$ 120,980
10.29	Installation of Containment Utility Panel	$ 80,600
11.	Perform Plant Preparation/Construct Temporary Facilities	
11.1	Install Reactor Mock-Up in Turbine Building	$3,756,000
11.2	Construct Shielded & Unshielded Waste Storage Facilities	$1,020,700
11.3	Construct Containment Water Processing Building	$ 626,000
11.4	Construct Temporary Laydown & Storage Areas	$ 229,200
11.5	Install Augmented Laundry Facility	$ 187,800
11.6	Construct Temporary Employee Processing and Training Center	$ 130,000

TABLE A-3
(Continued)

Major Activities	Cost ($)
Undistributed Costs	
Utility Administrative and Operations Staff (through Activity 11)	$6,320,300
Engineering Support Contractor (through Activity 11)	$3,093,900
II. Phase II - Containment Recovery Activities	
12. Install Containment Vent System	Note B
12.1 Construct System on Skids	
12.2 Remove Insulation from Containment Dome	
12.3 Install Containment Contamination Control Envelope	
12.4 Install Vent System	
13. Install Containment Water Processing System	
13.1 Install & Test Filtration/Evaporation/ Demineralization System	$ 250,000
13.2 Install Processed Water Storage Tanks	$ 507,000
13.3 Install Waste Solidification System	$ 500,000
14. Construct Containment Access Structure	$ 439,300
14.1 Construct Support Structure & Elevator	
14.2 Construct Contamination Control Envelope & Open Containment	
14.3 Install Prefabricated Air Lock by Crane	
14.4 Weld Air Lock to Support Tube	

TABLE A-3
(Continued)

Major Activities	Cost ($)
15. Enter Containment	Note B
15.1 Perform Initial Radiological & Plant Status Surveys	
15.2 Install Remote T.V. Monitor System	
15.3 Install Containment Utility Panel	
16. Perform Manual Decontamination of Operating Floor Elevation 701' Floor, Walls, & Dome	Note C
16.1 Scabble Concrete Floors & Walls	
16.2 Vacuum Concrete Floors & Walls	
16.3 Paint Scabbled Surfaces with Strippable Coatings	
16.4 Decontaminate Containment Dome with High Pressure Water Hose	
16.5 Paint Dome with Strippable Paint	
16.6 Install Temporary Shielding	
16.7 Decontaminate & Repair Polar Crane and Fuel Service Equipment	$ 250,000
16.8 Remove Reactor Pit Plug, Decon Reactor Pit	
17. Deliver Special Equipment to El. 701' Operating Floor	Note B
17.1 Damaged Fuel and Core Rubble Storage Racks	
17.2 Shielding, Plastic, Small Tools, Misc. Equipment	
17.3 Damaged Fuel and Core Rubble Canisters	

TABLE A-3
(Continued)

Major Activities	Cost ($)
17.4 Reactor Water Clean-Up System	
17.5 Underwater Remote T.V. Camera Equipment	
17.6 Internals Segmentation Equipment	
17.7 Contamination Control Envelope for Internals Segmentation	
17.8 Core Rubble Containers	
17.9 Decontamination Materials	
17.10 Damaged Fuel Removal Tools & Equipment	
18. Install Damaged Fuel Racks	Note B
19. Remove Reactor Vessel Head	Note B
19.1 Unbolt Head	
19.2 Rig & Remove Head	
19.3 Wrap in Plastic, Laydown & Shield	
20. Inspect Core	Note B
20.1 Install Closed Circuit T.V. Camera	
20.2 Inspect Core	
21. Install Reactor Water Clean-Up System	Note B
22. Prepare for Segmentation of the Core Spray Bundle	Note B
22.1 Install Segment Liners in Reactor Pit	
22.2 Install Torch, Manipulators, Cameras, Clamps and Miscellaneous Equipment	
22.3 Install Contamination Control Envelope	

TABLE A-3
(Continued)

Major Activities	Cost ($)
23. Segment Core Spray Bundle	Note B
23.1 Rig & Lift Bundle from Core	
23.2 Segment Bundle, Load Segments in Liners	
24. Conduct Training & Practice on Reactor Vessel Mock-Up for Defueling	Note B
25. Analyze Core, Reactor Coolant & Crud in Accordance with 10 CFR 61, 49 CFR & NRC Requests	Note B
25.1 Sample Coolant	
25.2 Take Sample Coupons of RV Internals	
25.3 Take Debris Samples	
25.4 Take Crud Scraping Samples	
26. Remove Damaged Fuel	Note B
26.1 Install Damaged Fuel Containers	
26.2 Remove Assemblies & Install in Containers	
26.3 Transfer Damaged Fuel to Fuel Pool & Store in Damaged Fuel Racks	
27. Inspect Core & Perform Debris Removal	Note B
27.1 Perform Inspections	
27.2 Install Underwater Hydraulic Vacuum System & Collection Canisters	
27.3 Vacuum Rubble from Internals into Rubble containers	
27.4 Install Rubble Canisters into Transport Containers	

TABLE A-3
(Continued)

Major Activities	Cost ($)
27.5 Install Long Reach Suction Hose on Reactor Water Clean-Up System. Vacuum internals to Remove Fines & Small Rubble	
28. Prepare for Underwater Segmentation of Internals	Note B
28.1 Install Steam Separator Storage Retainer in Reactor	
28.2 Remove Steam Separators and Store on Top of Core	
28.3 Install Underwater Torch Manipulator	
29. Segment Internals	Note B
29.1 Segment Steam Separator Plate Above Recirculation Nozzles, Remove Segments	
29.2 Segment Steam Separator Support Plates Above Recirculation Nozzles	
29.3 Cut Plenum Separator Plate, Inner Thermal Shield Support Ring and Core Support Skirt Support Ring above Inlet Nozzles. Remove Segments.	
30. Install Recirculation Nozzle Plugs	Note B
30.1 Open Contamination Control Envelope, Remove Cutting Tools	
30.2 Install Nozzle Plugs	
30.3 Drain Containment	
31. Drain Containment	Note B
31.1 Process Containment Water & Release	

TABLE A-3
(Continued)

Major Activities	Cost ($)
32. Decon Containment Below El. 701'	Note B
32.1 High Pressure Water Wash	
32.2 Scabble Concrete	
32.3 Vacuum Concrete	
32.4 Paint Surfaces with Strippable Coating	
33. Decontaminate Recirculation Pump Cubicles	Note C
33.1 Remove Recirculation Pump Access Hatches	
33.2 Install Remote Water Blasting Equipment	
33.3 Manually Decontaminate Recirculation Pump Cubicles	
34. Decontaminate Main Air Lock	Note C
34.1 Decontaminate Exposed Surfaces	
34.2 Open Air Lock & Decontaminate Sealing Surfaces as Necessary	
34.3 Refurbish Air Lock	
35. Turn Over Plant for Decommissioning	Note B
Undistributed Costs	
Utility Administrative and Operating Staff (Activities 12-35)	$29,062,400
Engineering Support contractor (Activities 12-35)	$17,006,400

TABLE A-3
(Continued)

Major Activities	Cost ($)
III. GENERAL UNDISTRIBUTED COSTS	
Supplies; Health Physics and Miscellaneous	$ 6,290,700
Insurance	$ 3,350,000
Heavy Equipment Rental	$ 1,000,800
Lab Fees	$ 100,000
Consulting	$ 3,350,000
Energy	$ 2,114,000
Recovery Waste Disposal	$ 6,050,200
License Fees	$ 586,300
Small Tools and Miscellaneous Supplies	$ 419,400
Rigging, Handling Equipment	$ 132,700
Environmental Surveillance	$ 424,400
Laundry Services	$ 1,377,200
Sub-Total	$113,950,350
25% Contingency	$ 28,487,588
Total Plant Structures Systems and Components Cost	$142,437,950

TABLE A-3
(Continued)

NOTES

A - Work is performed by plant utility staff. Costs are included in Phase I utility staff costs.

B - Work is performed by augmented plant utility staff. Costs are included in Phase II utility staff costs.

C - Work is performed by augmented plant decontamination staff. Costs are included in Phase II utility staff costs and the adjustment to utility operations staff due to exposure limits of 10 CFR 20.