NORTHERN STATES POWER COMPANY

MONTICELLO NUCLEAR GENERATING PLANT

REPORT TO THE
UNITED STATES ATOMIC ENERGY COMMISSION
DIRECTORATE OF LICENSING

Docket No. 50-263 License No. DPR-22

PRELIMINARY REPORT OF FUEL CASK DROP ACCIDENT ANALYSIS

Dated October 1, 1974

INTRODUCTION

The Regulatory Staff of the Directorate of Licensing, USAEC, is currently considering possible accident conditions and postulated events which result from a spent fuel shipping cask drop.

A detailed assessment of the effects of a spent fuel shipping cask drop accident for the Monticello plant involved the determination of possible plant damage incurred including:

- Spent Fuel Pool Integrity
- Spent Fuel Integrity
- Safety of Vital Equipment and Systems
- Cask Lifting Systems Operations and Safety

The structural, mechanical systems and cask handling equipment at the Monticello plant have been subjected to a detailed safety evaluation in response to the subject AEC request for information (1). A summary of the results of these evaluations are presented in this preliminary report.

For a description of the cask used in this analysis refer to reference (6).

SPENT FUEL POOL INTEGRITY

The fuel storage and handling systems are described in Section 10.2.1 of the Monticello FSAR. The pool and its support systems are designed to Seismic Class I conditions.

An analysis was conducted to determine possible structural damage to the spent fuel pool floor that could result from dropping a fuel shipping cask from various heights. The method used to determine the impact loading of the dropped cask can be found in reference (2). Once the impact loading was determined, standard beam deflection methods were used to evaluate the effects on the structures. The effects of buoyancy and friction were taken into consideration in the analysis.

The FSAR analysis of the cask drop accident, using the fuel shipping cask design envisioned at that time, demonstrated that minor cracking of the fuel pool would result. Based upon the results of a conservative analysis of the spent fuel pool floor structure, using the IF-300 shipping cask, only minor cracking cannot be assumed from all possible drop heights.

SPENT FUEL INTEGRITY

Fuel cask handling precautions have been imposed in the Monticello FSAR which require that the shipping cask not be moved over the reactor vessel or spent fuel in the storage pool. Furthermore, the cask will not be lifted above the spent fuel pool except in the designated area above the cask laydown pad on the fuel pool floor.

In the event that the spent fuel cask were to be tipped over or deflected into the fuel pool, the cask size is adequate to reach spent fuel stored in close proximity to the cask laydown pad. However, a cask drop on the pool edge is expected to spall the impact area and force the cask into the pool nearly vertically. Thus, a horizontal cask drop is considered highly unlikely due to the mass and size of the cask. Direct fuel damage from a cask drop is thereby limited to fuel stored in close proximity to the cask laydown pad.

INTEGRITY OF CRITICAL SYSTEMS AND COMPONENTS

An assessment has been conducted to determine the mechanical equipment and systems affected by a cask drop while being transported across the reactor building operating floor or while being lifted in the building equipment hatch from the rail shipping car. By means of a structural analysis identical to that used for the spent fuel pool floor it can be concluded that, with the use of proper administrative controls, the reactor building operating floor has sufficient structural strength to withstand a fuel cask drop while sustaining only minor damage. All equipment and systems below the reactor building operating floor would be protected from damage in this case.

A cask drop from the maximum drop height in the equipment hatch area could cause structural and possibly cask damage. Cask handling procedures are being evaluated to provide adequate protection to plant structures and equipment in this area.

DESCRIPTION OF THE HANDLING EQUIPMENT FOR THE SPENT FUEL CASK

REACTOR BUILDING CRANE

The Reactor Building Crane is an indoor, electric powered traveling bridge crane, with a single trolley cab or pendent controlled 85 ton main hoist. The crane was constructed by the Crane Manufacturing and Service Corporation to the requirements for a Class A crane established by the Electrical Overhead Crane Institute Specification 61 (3), and Bechtel Design Specification 5828-M-3 (4). The Reactor Building Crane was designed to the following safety factors.

COMPONENT	SAFETY FACTOR
Main Hoist	6
Cables	6
Main Hook	6 for tension in stem 5 for combined bending and tension
Welds	5 based on ultimate strength of metal in welds

MAIN HOIST DRIVE

The main hoist motor is a shunt wound, DC motor, rated at 40 h.p. In addition to the shunt field, the motor has a separate series winding for use during dynamic braking. Power for the hoist motor is supplied by an AC driven motor-generator set installed on the crane. The generator is a shunt wound DC machine. The hoist motor is controlled by a General Electric Maxspeed 320 Crane Drive unit. The drive unit varies motor field and armature currents to control the speed and torque of the motor along a constant horsepower characteristic. Consequently, the speed of the hoist motor is a function of the weight of the load being lifted. At full load the hoist motor rated speed is 850 rpm which is equivalent to a drum speed of 5 fpm. With an empty hook, the hoist motor speed is approximately 2720 rpm which is equivalent to a drum speed of 16 fpm. These are maximum speeds for their load condition. However, the crane operator may vary the speed of the hoist from a creep rate up to these maximum speeds.

BRAKING

Mechanical braking is provided by two solenoid operated disc and shoe brakes on the main hoist, one installed on the free end of the hoist motor and one on the gear reducer input shaft. The brakes are spring loaded and automatically set whenever electrical power is removed from the armatures. The brakes are released (armature energized) simultaneously with the energization of the main hoist motor. The brakes are energized by direct current from a static exciter/transformer system off the input power to the main hoist motor-generator set. Each brake is designed to hold 150% rated full load hoist torque at base speed.

Regenerative braking is used to provide control braking when lowering heavy loads and to decelerate the motor from fast speeds before applying the mechanical brakes. The hoist motor drive unit controls the amount of braking by means of a polarity reversing power amplifier in the shunt field of the generator. Emergency braking action is effected by immediate application of both mechanical holding brakes when: (1) the hoist motor voltage decreases to 70 volts, (2) upper or lower hoist travel limit switches are activated or (3) upon loss of power to the main hoist motor. In addition, dynamic braking is provided to assist the mechanical brakes in the event regenerative braking is unavailable due to a power failure. Upon interruption of power, the series field is automatically inserted in the motor DC power loop, driving the motor as a self-excited generator. The generated current is dissipated in a load resistor providing mechanical braking torque. Although dynamic braking will prevent free-fall of the load during an emergency, operation of one mechanical brake is necessary to bring the load to a stop. Based upon an anlysis of the dynamic braking capability for the motor-drive system, load descent speed under this condition would be limited to 10.5 feet per minute. Fuel cask descent at this speed to the floor levels would not result in loss of floor structural integrity.

LIMIT SWITCHES

There are three main hoist travel limit switches, two for upper-hoist-travel and one for lower-hoist travel. One of the two upper-hoist-travel limit switches is located on the top block assembly and is activated by the cable.

The other upper-hoist-travel limit switch is directly coupled to the hoist drum and is activated by drum rotation. Each upper-hoist-travel limit switch de-energizes a mechanical brake and the hoisting motor. The upper-hoist-travel limit switch electrical control circuit is designed so that both mechanical brakes and hoist motor will be deenergized by one limit switch on loss of one limit switch. The lower-hoist travel limit switch is directly coupled to the hoist drum and is activated by drum rotation. The lower-hoist-travel limit switch de-energizes both mechanical brakes and the hoisting motor when the main hook is three feet above the ground floor elevation.

HOIST MECHANISMS

A four series gear reducer decreases the hoisting motor speed to the drum speed by a ratio of 139 to 1. The first reduction gear and pinion is a herring-bone gear arrangement and the remaining reduction gears and pinions are spur gears.

The hoisting drum is constructed of all welded steel. The drum is machine threaded with righthand and left hand cable grooves and is flanged to prevent the cable from slipping off the drum. The diameter of the drum was designed so that two complete wraps of cable remain on the drum when the hook is in its lowest position. The cable is a 12 part 6x37 improved plow steel wire with a hemp core. The main hook is a twin sister type with safety latches. A six inch diameter shackle hole is provided in the center of the hook. This shackle hole is used for lifting the spent fuel cask. The hook will remain fixed in any selected direction during lowering or raising.

The spent fuel shipping cask lifting yoke is a steel structure which consists of two yoke legs, two cross members, and a retractable six inch diameter heat treated pin for insertion in the main hook shackle hole. The two yoke legs engage the cask lifting trunnions, the six inch diameter pin is inserted through the two yoke leg crossmembers and the main hook shackle hole. The cask lifting yoke is designed for a minimum load safety factor of 3.

CRANE BRIDGE AND TROLLEY

The bridge of the crane consists of two welded box section girders rigidly attached to the bridge trucks. The bridge drive consists of two 7.5 h.p. direct current motors each coupled to a drive wheel axle through a gear reducer. The drive systems are located on opposite sides of the box girders. The drive motors receive electrical power from their own motor-generator set. The bridge drive has regenerative braking similar to that described in the Main Hoist section.

The bridge parking brake is a solenoid operated disc and shoe brake which is set and released as described in the Main Hoist section for the mechanical brakes. The parking brake is designed to hold 150% of the rated full load drive motor torque and sets automatically on loss of power to the brake or drive motor. The truck wheels are double flanged machine steel. The end truck has safety lugs to limit the drop of the truck in the event of a wheel or axle failure. The bridge has two end-of-travel limit switches which, when activated, de-energize the drive motors and brake solenoids. The bridge has four polyurethane bumpers and runway stops to prevent over-travel of the bridge.

The crane trolley consists of a rigid, braced, box steel frame attached to the trolley trucks. The trolley drive consists of a 2 h.p. direct current motor, a gear reducer and two drive shafts, one to each drive wheel. The trolley drive motor receives electric power from its own motor-generator set. The trolley drive motor has regenerative braking as described in the Main Hoist section. The trolley has two solenoid operated disc and shoe brakes which are set and released as described in the Main Hoist Mechanical Braking section. The solenoids are de-energized to engage the brakes. Each parking brake is designed to hold 50% of the rated full motor torque and sets automatically on loss of power to the brakes or trolley drive motor. The trolley truck wheels are double flanged machine steel. The trolley trucks have safety lugs to limit the drop of the trolley in the event of a wheel or axle failure. The trolley movement is controlled by an end-of-travel limit switch, which when activated de-energizes the trolley drive motor and brake solenoids. The trolley has polyurethane bumpers to prevent over-travel.

QUALIFICATION TESTING

Pre-service qualification tests were conducted on the reactor building crane during "Pre-Operational Test No. B-22," March 21, 1970. All limit switches on the hook travel, trolley travel and bridge travel were tested. The trolley and bridge brakes and speed controls were checked. The pendant controls and deadman switch were checked. The main hook was load tested to the maximum rating of the crane (85 ton). The deflection of the bridge at rated load was checked. The mechanical holding brakes were slip tested at rated load. The main hook descent speed at rated load was verified to be 6 feet per minute. Subsequent to load testing, the main hook was Magnafluxed. Additional tests and inspections are conducted in accordance with periodic maintenance and operating procedures. Section 10.2.1 of the Monticello FSAR also describes testing activites planned prior to spent fuel cask handling operations.

A summary table of reactor building crane design parameters as specified by Reference (4) and the Crane Manufacturing and Service Corporation design manual (5) is given in Table 1. A combination of proven engineering practices in the design of the crane and the implementation of special precautions as reported in Section 10.2.1.3 of the Monticello FSAR, to avoid dropping of heavy objects insures crane safety and reliability will be maintained during fuel cask handling operations.

CONCLUSIONS

The results of our analysis of the cask drop accident, while it cannot demonstrate absolute assurance of only minor structural damage in the postulated cask drop, does indicate that the combination of proper administrative controls and the conservatively rated and highly reliable handling equipment do provide reasonable assurance to preclude the cask drop event.

This subject will be a matter of further detailed review and consideration by NSP when fuel shipping plans and schedules are determined and firm decisions are made as to selection of the cask to be utilized for fuel shipping.

A final report on this subject will be submitted, demonstrating that spent fuel handling operations can be safely conducted at Monticello, in sufficient time to prevent disruption of the first anticipated shipment.

TABLE 1

MONTICELLO REACTOR BUILDING CRANE

DESIGN PARAMETER SUMMARY

Parameter		Main Hoist	Auxiliary Hoist
Load Capacity		85 ton	5 ton
Control Station		Trolley Cab	Pendant
Design Speed:	Full Load	5 fpm	20 fpm
	No Load	16 fpm	
Lifting Range		117'-0"	117'-0"
Drive Motor		40 h.p. (240VDC)	7.5 h.p. (240VDC)
Type of Braking Systems:		Holding/Regenerative/Dynamic	
Mechanical (Holding) Brakes:		2 disk and shoe	
	Capacity	150% of motor torque	
Crane Span		98'-9"	
Length of Runway		130'-6"	
Cable		12 part 6 x 37 plowsteel	
Hook		Twin (sister) with 6" shackle hole	
Hook Limit Switches		2 upper-hoist-travel	
		1 lower-hoist-travel	
Motor-Generator Set		50 h.p. (230/240VAC)/33KW	
Trolley Design Speed		10fpm	
Trolley Drive Motor		2 h.p. (240VDC)	
Trolley M-G Set		3 h.p./1.5 KW	
Bridge Design Speed		50 fpm	
Bridge Drive Motors		2-7.5 h.p. (240VDC)	
Bridge M-G Set		20 h.p./13 KW	

REFERENCES

1. D. J. Skovholt, letter to L. O. Mayer, Director of Nuclear Support Services, Northern States Power Company from U.S. Atomic Energy Commission, Directorate of Licensing, Re: License No. DPR-22, February 4, 1974.

2. R. J. Roark, "Formulas for Stress and Strain," McGraw Hill Book Company, 4th Edition, p. 370, 1965.

3. Electric Overhead Crane Institute, "Specification No. 61 for Electric Overhead Traveling Cranes," One Thomas Circle, N.W., Washington D.C.

4. Bechtel Corporation, "Specification No. 5828-M-3 for Reactor Building Bridge Crane for the Monticello Nuclear Generating Plant," San Francisco, Revision 2, March 29, 1968.

5. Crane Manufacturers Service Corporation, "Design Manual 5828-M3-41-1," Crane Serial No. 514, 85/5 Ton Powerhouse Crane for Monticello Nuclear Plant, November 4, 1968.

6. General Electric Company, "Technical Description-IF 300 Irradiated Fuel Shipping Cask," report No. NEDO-10864, July 1972.

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