UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
WASHINGTON, DC 20555-0001

October 7, 2009

NRC INFORMATION NOTICE 2009-20: DEGRADATION OF WIRE ROPE USED IN FUEL HANDLING APPLICATIONS

ADDRESSEES

All holders of operating licenses or construction permits for nuclear power reactors. All licensees who store spent fuel under Title 10 of the *Code of Federal Regulations*, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste."

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to possible degradation mechanisms affecting wire rope that may have an adverse impact on safe fuel handling operations. The NRC expects recipients to review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

<u>LaSalle Refueling Machine</u>

In January 2009, during the twelfth refueling outage at the LaSalle County Station, Unit 2, Exelon Generation Company (the licensee) noted that one of the two redundant wire ropes in the main hoist of the refueling machine had broken wire strands at the entry to a terminal end fitting. A refueling operator had noted a sudden movement in the refueling machine while hoisting a fuel assembly to near the full up position. The refueling staff placed the fuel assembly in a safe location, inspected the refueling machine, and identified the damaged wire rope. The licensee quarantined the damaged rope for analysis, replaced the two wire ropes in the main hoist, and resumed refueling operations.

The licensee conducted an evaluation of the damaged main hoist wire rope. The main hoist raises and lowers the fuel grapple mounted on the bottom of a telescoping mast. Two separate wire ropes run from the hoist drum, over equalizer sheaves, and down the inside of the mast, where they terminate at the inner mast section. The two wire ropes normally share the load, but the design of the hoist allows either wire rope to independently support a fully-loaded mast with substantial reserve capacity. The broken wire strands occurred at one of the terminal connections. The wire rope had a rotation-resistant construction, where the inner core strands are twisted in the opposite direction from the outer strands. The licensee had previously noted that the wire rope may be subject to side (bending) forces at the terminal fitting when the mast was stowed in the full up position for maintenance. Analysis of the damaged rope section revealed that fatigue caused the wire strands to fail. The rotation-resistant construction of the wire rope used at LaSalle and the presence of the end fitting made inspection of the wire rope at the damaged location particularly difficult. The licensee's corrective actions included fleet-wide inspection of wire rope in similar use and establishment of a program to replace these wire ropes on a set frequency.

Beaver Valley Fuel Up-Ender

In October 2007, during a refueling outage at the Beaver Valley Power Station, Unit 1, First Energy Nuclear Operating Company (the licensee) noted that a stainless steel wire rope failed completely (all wire strands broken) on the fuel building up-ender. At the time of failure, a new fuel assembly was in the up-ender. When the supporting wire rope failed, the up-ender pivoted from a slightly inclined position to a fully horizontal position.

The fuel building up-ender consists of a stainless steel frame that supports one fuel assembly at a time. The frame pivots from vertical to horizontal positions around a pin support on one end of the frame. To raise and lower the up-ender, operators use an electric winch connected by a wire rope through a series of three sheaves to the up-ender frame; thus, within a short distance, a section of the wire rope undergoes bending cycles in three different directions during each movement of the up-ender.

The licensee determined that fatigue caused the wire rope to fail completely. The failure occurred between two offsetting sheaves, when the wire rope was near its peak loading. The licensee found the wire rope had been in service for 24 years, and the failure occurred in a section of the wire rope that, because of interference from the sheaves, may not have received a complete underwater visual inspection. Since the failure was limited to the wire rope, the licensee replaced the failed rope and resumed refueling operations but did not load the new fuel assembly into the reactor core. Other corrective actions included establishing new repetitive preventive-maintenance tasks to perform fuel transfer equipment cable and sheave inspections at both Beaver Valley Power Station Unit No. 1 and Unit No. 2.

Browns Ferry Reactor Building Crane

On October 4, 2007, while making preparations for dry run activities related to dry cask storage at Browns Ferry, the Tennessee Valley Authority (the licensee) identified the degradation of one of the main hoist cables for the overhead crane in the reactor building. The degradation involved the partial untwisting of the wire rope strands within the stationary section of one wire rope.

The Browns Ferry reactor building has a single-failure-proof crane with two independent wire ropes. Each wire rope is capable of safely handling the rated 125-ton load. Each wire rope has one end clamped to the hoist drum, unspools from the drum to the first load block sheave, passes several times between the load block sheaves and the upper sheaves attached to the trolley, and travels from the final load block sheave to a terminal end fitting attached to the trolley. The wire rope is stationary (i.e., neither bends around sheaves nor moves with respect to the trolley) at the end between the highest position of the load block and the terminal end fitting. The crane was fitted with two right regular lay wire ropes. One of the wire ropes was installed slightly untwisted to reduce the tendency of the load block to twist. The action of the sheaves as the load block was lowered and raised concentrated the uneven twist in the stationary section of wire rope, causing the strands to untwist in this area.

The licensee evaluated the physical condition of the wire rope, using the guidelines of the 1976 version of American Society of Mechanical Engineers Safety Standard B30.2, "Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)," which the licensee had committed to follow. Consistent with those guidelines, the licensee and the crane vendor determined that, although the wire rope was somewhat distorted, it retained sufficient strength to support continued operation. However, the licensee implemented an enhanced inspection schedule to monitor the condition of the wire rope until the distorted rope could be replaced. The licensee subsequently replaced the wire ropes.

BACKGROUND

Nuclear power plants use wire ropes in a broad range of material handling applications, including fuel handling, refueling, and dry storage. Safe conduct of these activities depends on the retention of adequate strength in the wire rope supporting the load. A wire rope's strength comes from the integration of several individual wire strands into a well-ordered structure. Damage to multiple wire strands in a single location or loss of the well-ordered structure results in a substantial reduction in strength and the potential for rope failure.

Fatigue is a common cause of wire rope damage in nuclear plant fuel handling applications. Each time the wire rope bends and returns to a straight configuration, it undergoes a complete bending cycle. The wire strands on the outside of the bend experience the greatest change in stress, and this stress is concentrated at points where individual wires in the outer wire strands pass over an inner wire strand. Repeated bending cycles lead to hardening and subsequent brittle failure of individual wires. Thus, fatigue failure is more likely to occur in regions of the wire rope subject to the most frequent bending (i.e., wire rope that passes around the most sheaves) during operation.

As multiple wires fail in a single location, the load increases the stress on the remaining intact wires. Eventually, the remaining wires may have insufficient strength to support the load, and tensile overload may cause the last remaining wires to fail in a ductile manner.

DISCUSSION

The LaSalle licensee experienced a partial failure (broken wire strands) of one of two wire ropes supporting the refueling mast at well below the rated load of the wire rope. The broken wire strands occurred at a point that was subject to small-radius bending and was difficult to inspect because it was located at an end fitting. While the redundant wire rope had no broken wire strands, it was subject to similar operating conditions. An installed equalizer assembly provides a means to compensate for variations in the lengths of the two ropes and maintains substantially equal rope loading. Had similar damage existed on the second rope and the first wire rope failed completely, the second wire rope also may have failed because of the sudden increase in its load. Failure of both of the redundant wire ropes could have resulted in a drop of an irradiated fuel assembly and a consequential release of radioactive material. In situations where redundant wire ropes are used and are difficult to inspect, licensees may consider staggered replacement (i.e., replacement of individual wire ropes at widely separated times) or early simultaneous wire rope replacement (i.e., replacement of both ropes well before wire rope replacement criteria are satisfied) to avoid operation with both wire ropes in a severely degraded state.

The Beaver Valley licensee experienced a complete failure of the sole wire rope used to position the fuel up-ender, with a new fuel assembly in the up-ender. The failure occurred at a point that was subject to repeated bending around two closely-spaced sheaves, was under maximum load (i.e., the fuel assembly was near horizontal in the up-ender), and was difficult to inspect because of the underwater location near the sheaves. Had the event occurred with a brittle, irradiated fuel assembly in the up-ender, the event could also have resulted in a release of radioactive material.

The Browns Ferry licensee experienced a distortion (untwisting) of the wire rope structure in one of the two redundant reeving systems that support heavy loads moved on the refueling floor. Distortion of the wire rope structure can increase the potential for failure under load because the individual strands are less likely to share the load evenly. Proper control of the wire rope twist during the reeving process prevents this type of rope distortion.

CONTACT

This information notice requires no specific action or written response. Please direct any questions about this matter to the technical contact listed below or, for reactor licensing issues, to the appropriate project manager in the Office of Nuclear Reactor Regulation (NRR).

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