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Dominion®

August 23, 2013

10 CFR 2.202
EA-12-049

Attention: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Serial No.: 12-160C
NL&OS/MAE: R0
Docket No.: 50-305
License No.: DPR-43

DOMINION ENERGY KEWAUNEE, INC.
KEWAUNEE POWER STATION (KPS)
REQUEST TO RESCIND ORDER MODIFYING LICENSES WITH REGARD TO REQUIREMENTS FOR MITIGATION STRATEGIES FOR BEYOND-DESIGN-BASIS EXTERNAL EVENTS (ORDER NUMBER EA-12-049)

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Order EA-12-049, "Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (the Order) to Dominion Energy Kewaunee, Inc. (DEK). DEK responded to the Order by letters dated March 26, 2012, October 25, 2012, and February 28, 2013 (Serial Nos. 12-160, 12-160A and 12-160B, respectively).

In a February 25, 2013 letter (Serial No. 13-107), DEK certified to the NRC that it had decided to permanently cease power operations of KPS on May 7, 2013. On May 7, 2013 KPS was shut down. The certification of permanent removal of the fuel from the reactor vessel was submitted to the NRC on May 14, 2013 (Serial No. 13-293). Therefore, pursuant to 10 CFR 50.82(a)(2), the 10 CFR Part 50 license for KPS no longer authorizes operation of the reactor or emplacement or retention of fuel into the reactor vessel.

In accordance with Section IV, Condition C.2, of the Order, DEK is required to submit status reports at six (6)-month intervals following submittal of the overall integrated plan (which was submitted on February 28, 2013). This letter fulfills that requirement. In accordance with Section IV of the Order, and considering that KPS is a permanently shutdown and defueled facility, DEK requests that the NRC rescind the Order in its entirety. A demonstration of good cause to support this request is provided as Attachment 1 to this letter. Separately, DEK is committing to enhance existing strategies related to SFP makeup as discussed in Attachment 2 to this letter.

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DEK requests approval of this request by January 28, 2014. If you have any questions, please contact Ms. Margaret Earle at (804) 273-2768.

Sincerely,

Eugene S. Grecheck
Vice President – Nuclear Engineering and Development
Dominion Energy Kewaunee, Inc.

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me today, in and for the County and Commonwealth aforesaid, by Eugene S. Grecheck who is Vice President – Nuclear Engineering and Development for Dominion Energy Kewaunee, Inc. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of the Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 23rd day of August, 2013.

My Commission Expires: December 31, 2016

CRAIG D SLY
Notary Public
Commonwealth of Virginia
Reg. # 7518653
My Commission Expires December 31, 2016

Notary Public

Attachments:

1. Basis for Request to Rescind Order EA-12-049
2. Enhanced Strategies for Spent Fuel Pool Makeup

Commitments made by this letter: As discussed in Attachment 2

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NRC Senior Resident Inspector
Kewaunee Power Station

Attachment 1

Basis for Request to Rescind Order EA-12-049

Mitigation Strategies for Beyond-Design-Basis External Events

Kewaunee Power Station
Dominion Energy Kewaunee, Inc.

Basis for Request to Rescind Order EA-12-049

Request to Rescind Order

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Order EA-12-049, "Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (the Order) to Dominion Energy Kewaunee, Inc. (DEK). DEK responded to the Order for Kewaunee Power Station (KPS) by letters dated March 26, 2012, October 25, 2012, and February 28, 2013 (Serial Nos. 12-160, 12-160A and 12-160B, respectively).

In a February 25, 2013 letter (Serial No. 13-107), DEK certified to the NRC that it had decided to permanently cease power operations of Kewaunee Power Station on May 7, 2013. On May 7, 2013 KPS was shut down. The certification of permanent removal of the fuel from the reactor vessel was submitted to the NRC on May 14, 2013 (Serial No. 13-293). Therefore, pursuant to 10 CFR 50.82(a)(2), the 10 CFR Part 50 license for KPS no longer authorizes operation of the reactor or emplacement or retention of fuel into the reactor vessel.

In accordance with Section IV of the Order, and considering that KPS is a permanently shutdown and defueled facility, DEK is requesting that the NRC rescind the Order in its entirety. Good cause for this request is provided below.

Basis for Rescission Request

DEK is requesting that the requirements of the Order for a three-phased approach to mitigate BDBEEs for core cooling and containment be rescinded. DEK has performed analyses (discussed below) of the consequences of unanticipated events beyond the design basis related to storage of spent fuel in the SFP. These analyses show that, within 17 months after shutdown, the analyzed event is either not credible, is capable of being mitigated, or the event's radiological consequences will not exceed the limits of the Environmental Protection Agency (EPA) Protective Action Guides at the exclusion area boundary (EAB). These analyses support this request that the Order requirements be rescinded in their entirety. KPS was shutdown on May 7, 2013, therefore "17 months after shutdown" will occur on October 7, 2014. The fuel in the SFP will have decayed for an additional 26 months beyond October 7, 2014 before the requirements of the Order must be implemented.

Section IV, Condition A.2. of the Order states, "The Licensees shall promptly start implementation of the requirements in Attachment 2 to the Order and shall complete full implementation no later than two (2) refueling cycles after submittal of the overall integrated plan, as required in Condition C.1.a, or December 31, 2016, whichever comes first." For KPS, since there will be no refueling cycles in the future, the implementation date of the Order is December 31, 2016.

KPS is a single unit station. The spent fuel at KPS is stored in either the spent fuel pool (SFP) or the Independent Spent Fuel Storage Installation (ISFSI). The safety functions of core cooling and containment are not required since fuel has been permanently removed from the reactor vessel. Since the ISFSI is a passive system, the only remaining safety function necessary to be maintained during a beyond–design–basis external event (BDBEE) is SFP water level and cooling.

The safety focus of personnel at KPS after a BDBEE (or any other unanticipated event) is to protect the spent fuel in the SFP. The relatively low decay heat load in the KPS SFP provides adequate time after an unanticipated event (the time for the SFP temperature to reach 200°F after one year of decay time is calculated to be more than 111 hours, assuming an initial SFP temperature of 80°F) for responders to restore and maintain SFP cooling and level. Separately, DEK is committing to enhance existing strategies related to SFP makeup as described in Attachment 2 to this letter, commensurate with the low risk of fuel being uncovered.

For these reasons, DEK believes that the requirements in Attachment 2 of the Order are unnecessary in its specific circumstances and that the analyses described below demonstrate good cause to support rescission of the Order.

Consequences of Unanticipated Events Beyond the Design Basis

1. Spent Fuel Pool Assessment – Complete Loss of Cooling Water Inventory With Air Cooling

DEK performed a comparison of the heatup characteristics of the KPS spent fuel that would result from a beyond design basis event involving the complete loss of spent fuel pool (SFP) water (when cooling depends on the natural circulation of air through the spent fuel racks), against the results documented in NUREG/CR-6451, "A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants" (August 1997) (Reference 8), for the reference pressurized water reactor (PWR). The results of this comparison are shown in Table 1 and conclude that as of October 2014, decay heat cannot heat the spent fuel cladding sufficiently to cause clad failure (565°C) if all water is drained from the SFP. Since fuel cladding would remain intact at this temperature, a complete loss of water from the KPS SFP would not result in an offsite release exceeding the early-phase Environmental Protection Agency (EPA) Protective Action Guidelines (PAGs).

A comparison of the reference PWR used in the staff's study to KPS shows that KPS has a smaller core power and associated core inventory and smaller heat load in the spent fuel pool. Therefore, KPS would have smaller consequences from a SFP event. During its final operating cycle, the KPS reactor operated for only 12 months (instead of a normal PWR cycle of 18 months). Therefore, the fuel assemblies off-loaded from the reactor vessel after the final operating cycle experienced lower burnup and possess lower decay heat than assemblies from a typical PWR operating cycle. Fuel assembly decay heat rate is dependent on assembly power during its final cycle of operation, total assembly burnup, and decay time since shutdown.

NUREG/CR-4982, "Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82," (July 1987) (Reference 7) and NUREG/CR-6451 contain evaluations of the potential for zircaloy oxidation in the event of a spent fuel pool draindown event. Both of these NUREGs assumed that:

- The spent fuel pool was completely drained of water and only air cooling is available.
- The likelihood of cladding fire initiation is most sensitive to assembly decay heat rate and assembly storage rack configuration which controls the extent of natural convection cooling.

Table 1 below provides a comparison of Kewaunee fuel and spent fuel pool design against the reference PWRs used in the NUREG/CR-4982 and NUREG/CR-6451 evaluations. In Table 1:

- NUREG/CR-4982 provides information for the PWR high-density rack case with a rack bottom inlet orifice that bounds Kewaunee's rack configuration. This case also happens to be the longest time to prevent cladding fire initiation of all the cases analyzed.
- NUREG/CR-6451 provides information for the configuration entitled, "Hot Fuel in Spent Fuel Pool," which covers the period from permanent shutdown and reactor vessel defueling until the hottest assemblies are cool enough such that no substantial zircaloy oxidation occurs and cladding remains intact. At the end of the configuration, the decay time (that is necessary to ensure that the fuel cladding remains intact given the loss of all spent fuel pool water) is about 17 months for the representative PWR that was analyzed.

From Table 1, parameters pertinent to a zirconium/zircaloy fire in the spent fuel pool (SFP) are compared between Kewaunee and the reference PWR data used in the NUREG evaluations. Based upon an analysis of this table, a minimum decay time to prevent a zirconium/zircaloy fire with the SFP completely drained is less than 17 months for Kewaunee.

TABLE 1

Spent Fuel Pool Zirconium Fire Comparison

Parameter	NUREG/CR-4982 1987	NUREG/CR-6451 1997	Kewaunee
Plant Data			
Power	Typical PWR	1130 MWe (~3330 MWt*)	590 MWe (1772 MWt)
Assemblies		193	121
MWt per Assembly		17.3	14.6
SPF Rack Design			
Design	High Density	High Density	High Density
Material	Stainless Steel	Stainless Steel	Stainless Steel
Pitch	N/A	10.4"	10"
Bottom Orifice Opening per Cell	5" diameter 10" diameter	5" diameter	8.14" equivalent diameter***
Fuel			
Design	Typical PWR	17 x 17	14 x 14
Max Assembly Burnup	High Burnup	60 GWD/MTU *Last Cycle*	55.302 GWD/MTU *Cycle 30*** 55.255 GWD/MTU *Cycle 31*** 46.219 GWD/MTU *Cycle 32***
Source Term			
Decay	700 days *(23 months)* 5" dia. 360 days *(12 months)* 10" dia.	17 months	< 17 months****
Zirconium Oxidation Ignition Temperature	650 °C	565 °C	565 °C

* Based on a 34% thermal efficiency.
** As of end of cycle: Cycle 30 02/26/2011, Cycle 31 04/05/2012, Cycle 32 05/07/2013.
*** Derived equivalent diameter.
**** Based on above KPS rack opening & burnup parameters being bounded by associated NUREG PWR parameters.

Additional comparisons between Kewaunee and generic PWR SFP considerations are discussed below.

2. Spent Fuel Pool Assessment – Loss of All Heat Removal Capability

The KPS spent fuel pool has a large capacity for heat absorption. As documented in the USAR, alternate cooling capability can be made available under anticipated malfunctions or failures. Sufficient time exists to either repair a failed SFP cooling pump or to connect a temporary pump in the system. Both temperature and level indicators in the pool would alert personnel to a loss of cooling. Remote alarms are provided. This allows personnel to take corrective measures in a timely manner to restore cooling capability to the spent fuel pool cooling loop.

In the event of a loss of both SFP pumps and/or SFP heat exchanger, alternate cooling is provided by the evaporative cooling process. On-site water sources, including a service water emergency connection, are available to provide cooling water make-up until failed components are repaired or replaced and placed into service.

Because the Spent Fuel Pool Cooling (SFPC) pumps suction connections are approximately two feet below normal pool water level, there is no possibility of inadvertently draining pool water below that level via a line failure in the SFPC suction lines. This design feature ensures a margin of 23 feet above the top of the fuel assemblies is maintained. Also, the SFPC system water return lines that provide cooling water to the pool enter the pool above the top of the fuel assemblies. The return lines have check valves installed near their penetration into the spent fuel pool wall to prevent siphoning of water from the pool in the unlikely event of a line failure. The check valves and the return lines, like the pool itself, are designed to withstand design basis earthquake loads. Therefore, the probability of inadvertently draining any operationally or radiologically significant volume of water from the spent fuel pool is low.

If heat removal and makeup capabilities for the SFP (SFP cooling system) are lost for an extended period, decay heat produced by the spent fuel will heat the SFP coolant to a point of boiling and then boil the coolant down to the top of the fuel. DEK assessed the decay heat load over time and calculated the times required for boiling to occur in the SFP and the time available to take actions before fuel uncovery occurs. This assessment was based on the fuel assembly characteristics following permanent shutdown of the reactor.

The SFP contains 805.3 gallons of water per inch of height above the top of the fuel assemblies. Technical Specification (TS) 4.3.2 specifies water level in the SFP shall be maintained to prevent inadvertent draining below plant elevation 645 ft 2 inches, which corresponds to a minimum of 23 feet of water above the top of the fuel assemblies in the SFP. A worst case boil-off rate documented in the USAR for the operational facility (freshly discharged core) was about 42 gallons/min.

Table 2 below shows the amount of time required for the water in the SFP to reach saturation temperature (212°F) and begin to boil following a loss heat removal capability (loss of cooling) that was not recovered. A starting SFP water temperature of 100°F was chosen because SFP temperature is annunciated when temperature rises to 100°F, requiring an operator response. These time values are calculated for several dates following permanent shutdown on May 7, 2013 (the calculation is based on the loss of cooling occurring on the stated date). The time to boil values (hours) list truncated whole numbers for conservatism (day values are rounded).

The column titled "Decay Period" lists the elapsed period since shutdown for its associated date. As the fission products in the fuel decay over time, the decay heat being produced continuously decreases and the length of time required to achieve boiling in the SFP increases correspondingly. The final column shows the time required for water in the SFP to boil off until only three feet of water remains above the top of the fuel assemblies. This time period begins with the loss of cooling and thus includes the time (shown in Column 4) needed to reach saturation temperature. Sufficient heat is removed from the fuel during the boiling process such that no fuel damage occurs. Although no fuel damage is expected while the water level remains above the top of the fuel, a level of three feet above the top of the fuel was chosen for ease of comparison to the corresponding information contained in NUREG-1738 (Reference 6). Three feet of water continues to provide sufficient shielding from radiation to any personnel involved in responding to the event.

TABLE 2

KPS SFP Times to Boil and Fuel Uncovery Following Loss of Cooling

Date	Decay Period	Decay Heat	Time to Boil	Time to 3' From Fuel Uncovery
May 8, 2013	1 day	30.9 Mbtu/hr	11 hours	60 hours (3 days)
May 19, 2013	12 days	15.3 Mbtu/hr	24 hours	122 hours (5 days)
July 19, 2013	73 days	7.6 Mbtu/hr	48 hours	247 hours (10 days)
November 1, 2013	178 days	5.1 Mbtu/hr	72 hours	369 hours (15 days)
September 20, 2014	1.4 years	3.1 Mbtu/hr	120 hours	612 hours (26 days)

As shown in the above table, after the spent fuel has decayed 6 months (November 1, 2013), approximately 15 days are available to restore cooling to the SFP before cooling water level reaches three feet above the top of the fuel (additional time would be available before fuel is uncovered). Makeup water capacity from onsite sources can significantly increase the time available to fuel uncovery.

Because of the relative ease with which alternative means of supplying cooling water to the SFP can be established, it is not reasonable to postulate that fuel damage can occur due to loss of normal cooling capability to the SFP.

A comparison was made of the times to boil and to uncover fuel, which were calculated for KPS (Table 2 above), against the corresponding times contained in NUREG-1738, Table 2.1, "Time to Heatup and Boiloff SFP Inventory Down to 3 Feet Above Top of Fuel (60 GWD/MTU)," for the reference PWR. The NUREG-1738 data show that about 11 days are required (after 2 years of decay time) to heat the SFP coolant in the reference PWR to a point of boiling and then boil the coolant down to 3 feet above the top of the fuel. In contrast, Table 2 above shows that the corresponding time to boil the coolant down to 3 feet above the top of the fuel in the KPS SFP (after 18 months of decay time) is about 26 days. This information is summarized in Table 3 below for ease of comparison.

TABLE 3

Comparison of NUREG-1738 Reference PWR Data to KPS SFP

	Decay Time	Time to Boil Coolant Down to 3 Feet above the Top of Fuel
Reference PWR	2 years	11 days
KPS	1.5 years	26 days

The results show that KPS has more time available for personnel to take actions to restore cooling (and thus prevent reaching zirconium ignition temperature) than was analyzed in NUREG-1738.

The longer period to boil away the SFP cooling water is expected based on the smaller decay heat load in the KPS SFP (which results from KPS being a relatively small sized reactor facility and having operated for an abbreviated period during its final operating cycle) as compared to the reference PWR in NUREG-1738. As such, the analysis contained in NUREG-1738 is considered conservative (and therefore bounding) for KPS.

The ample time available, coupled with the simplicity of obtaining makeup water, further reinforce the conclusion that it is not reasonable to postulate that fuel damage can occur due to loss of normal cooling capability to the SFP.

3. Spent Fuel Pool Assessment – Partial Loss of Cooling Water Inventory with No Air Cooling

Although a partial loss of SFP cooling water inventory with no air cooling is unlikely, DEK performed a comparison of the reference PWR used in the NRC staff's study against KPS to assess the postulated consequences of a partial loss of cooling water inventory with no air cooling. This comparison considered the maximum Zircaloy cladding temperature that may occur in the spent fuel pool (SFP) with the fuel exposed to an air environment, as well as the potential upper limit radiation fields at the exclusion area boundary. This assessment was based on the information contained in NUREG-1738, which evaluated the thermal-hydraulic characteristics of spent fuel stored in the spent fuel pools of decommissioning plants and determined the time available for plant operators to take actions to prevent a zirconium fire. The NUREG-1738 results are based on obstructed airflow (adiabatic heatup) of the spent fuel (due to a geometry change or partial draining of the spent fuel pool that inhibits upward air flow through the fuel assemblies).

DEK also performed a site-specific adiabatic heatup analysis to address a partial draindown of the SFP, assuming no air-cooling. The purpose of the analysis was to conservatively evaluate the length of time it takes for uncovered spent fuel assemblies to reach a temperature of 565 degrees Centigrade (°C) assuming no air-cooling. Per NUREG-CR/6451, 565°C is the lowest temperature where incipient cladding failure might occur and is appropriate to be used as the critical cladding temperature. Based on 17 months of decay time after permanent shutdown of KPS, the time necessary for the hottest fuel assembly to reach the critical temperature of 565°C is 6 hours after the fuel rods have become uncovered. Six hours is sufficient time for personnel at the station to respond with additional resources, equipment, and capability to regain cooling to the spent fuel pool, even after the most non-credible, catastrophic draindown event. For an event involving draindown of the SFP, the response time would increase significantly due to mitigative actions to regain spent fuel pool level and heat loss from the fuel to the remaining water and steam in the pool prior to draindown.

DEK has developed Guidance for mitigating the loss of water inventory prior to the onset of Zirconium cladding damage in the event of a loss of spent fuel pool water inventory. The guidance includes multiple strategies for providing makeup to the Spent Fuel Pool. Strategies include using existing plant systems for makeup; supplying water via hoses to a spool piece connection to the existing SFP piping; or using a diesel-driven portable pump to take suction from Lake Michigan and provide makeup or spray to the Spent Fuel Pool (external makeup). Special tools and equipment needed to perform these actions are located on site. The external makeup strategy (using the diesel driven portable pump) has been demonstrated to be capable of being deployed within two hours. These diverse strategies provide defense-in-depth and ample time to provide makeup or spray to the SFP prior to the onset of Zirconium cladding ignition.

Furthermore, NUREG-1738 found that the event sequences important to risk at decommissioning plants (that could possibly result in a rapid draindown of the SFP) are limited to large earthquakes and cask drop events. These two event sequences are discussed below.

4. Spent Fuel Pool Assessment - Rapid Draindown Due to Seismic Events

Given the robust structural design of SFPs, it is expected that a seismic event with peak spectral acceleration several times larger than the safe shutdown earthquake (SSE) would be required to produce catastrophic failure of the structure. The estimated frequency of seismic events sufficiently large to result in structural failure of the SFP is given in NUREG-1738, Table 3.7-4, and is based on the Lawrence Livermore National Laboratory (LLNL) and Electric Power Research Institute (EPRI) seismic hazard estimates. Both the LLNL and EPRI hazard estimates were developed as best estimates and are considered valid by the NRC.

KPS is located in a geologically stable region whose seismic hazard risk is very low as documented in recent seismic hazard estimates (based on U.S. Geological Survey (USGS) of 2008). Geologic investigations throughout the Lake Michigan basin have not found any indication of fault movement in the recent geologic past. As shown in Figure 2 of GI-199 (Reference 1), the peak horizontal acceleration (%g) for 2-percent probability of exceedance in 50 years, for the geographic region where KPS is located, is in the second lowest region of the conterminous United States (between 0.02 and 0.03 g).

Additionally, all spent fuel is expected to be removed from the KPS SFP and placed into the onsite ISFSI by 2020, as documented in KPS Post Shutdown Decommissioning Activities Report submitted to NRC on February 26, 2013 (Reference 2). As such, the seismic exposure period for the SFP is expected to be limited to approximately 7 years after plant shutdown.

Based on the low probability of a seismic event of sufficient magnitude to cause failure of the SFP in the geographic region where KPS is located, a seismic event as an initiator of a rapid SFP draindown event is not considered credible at KPS.

5. Spent Fuel Pool Assessment - Rapid Draindown Due to Cask Drop Event

KPS has a single-failure proof auxiliary building crane that is used for lifting heavy loads over the SFP. This upgraded crane was analyzed using a method that assessed the crane when subjected to seismic loading. This method was approved by NRC in License Amendment 205 (Reference 3), which included an independent third party review. DEK uses the auxiliary building crane for spent fuel cask loading operations in the spent fuel pool. The NRC safety evaluation approving KPS License Amendment 205 stated that this method of analysis demonstrates that the crane will not lower its load in an uncontrolled fashion and that the trolley and bridge wheels will remain on their respective rails during a seismic event. Amendment 205 incorporated the seismic analysis methodology for the auxiliary building crane into the KPS License as License Condition 2.C.(11). This license condition is being maintained in the KPS license. Because the auxiliary building crane will not lower its load in an uncontrolled fashion during a seismic event, a cask drop event is not considered a credible initiator of a rapid SFP draindown event at KPS.

The analysis of heavy load drops discussed in NUREG-1738 exclusively considered loads that were severe enough to catastrophically damage the SFP so that pool inventory would be lost rapidly and it would be impossible to refill the pool using onsite or offsite resources. The NUREG-1738 analysis assumption is based on no possibility of mitigating the damage, only preventing it. Only spent fuel casks are heavy enough to catastrophically damage the pool if dropped. The NRC staff assumes a very low likelihood that other heavy loads will be moved over the SFP and that if one of these lighter loads over the SFP is dropped, it is unlikely to cause catastrophic damage to the pool.

The potential for a catastrophic pool draindown event, as discussed above, has not changed from what existed at KPS during power operations. No specific response capability was needed for such an event because resolution of Generic Issue (GI) 82, "Beyond Design Basis Accidents in Spent Fuel Pools," and other studies of operating reactor SFPs concluded that existing requirements for operating reactor SFPs were sufficient. The risk for SFPs at operating plants is limited by a lower expected frequency of heavy load lifts than at decommissioning plants. However, as documented in License Amendment 205, measures in place at KPS are adequate to prevent the occurrence of a spent fuel cask drop. As such, a cask drop event as the initiator of a rapid draindown of the SFP is not credible at KPS.

6. Assessment of Shine from an Empty Spent Fuel Pool

Although a significant release of radioactive material from the spent fuel is not possible in the absence of water cooling after approximately 17 months, the potential exists for radiation exposure to an offsite individual in the event that shielding of the fuel is lost (a beyond-design-basis event). Water and the concrete pool structure serve as radiation shielding. A loss of water shielding above the fuel could increase the offsite radiation levels because of the gamma rays streaming up out of the pool being scattered back to a receptor at the site boundary.

The offsite radiological impact of a postulated complete loss of SFP water was assessed. It was determined that the gamma radiation dose rate at the exclusion area boundary would be sufficiently low, such that it would take more than a month for the event to exceed the EPA early-phase Protective Action Guidelines (PAG) of 1 Rem. The EPA early-phase PAG is defined as the period beginning at the projected or actual initiation of a release and extending a few days later. The PAGs were developed to respond to a mobile airborne plume that could transport and deposit radioactive material over a large area. In contrast, the radiation field formed by scatter from a drained SFP would be stationary rather than moving and would not cause transport or deposition of radioactive materials. The extended period required to exceed the integrated PAG limit of 1 Rem TEDE would allow sufficient time to develop and implement on-site mitigative actions and provide confidence that additional offsite measures could be taken without planning if efforts to reestablish shielding over the fuel are delayed.

Recent NRC Analyses Regarding Storage of Spent Nuclear Fuel in SFPs

In a 2008 denial of petitions for rulemaking (73FR46204, Reference 4), the NRC discussed the results of additional studies of spent fuel pool risk conducted subsequent to NUREG-1738. The NRC denial of rulemaking addressed the Petitioners assertion that spent fuel stored in high density SFPs is more vulnerable to a zirconium fire than the NRC concluded in its analysis for the renewal of nuclear power plant licenses.

Specifically, the Petitioners asserted that an accident or a malicious act, such as a terrorist attack, could result in an SFP being drained, either partially or completely, of its cooling water. The Petitioners further asserted that this drainage would then cause the stored spent fuel assemblies to heat up and then ignite, with the resulting zirconium fire releasing a substantial amount of radioactive material into the environment.

The staff's denial of the petition for rulemaking was based on numerous factors. These factors included the physical robustness of SFPs, the enhanced physical security measures required for their protection, the very low risk of an accident causing a zirconium fire in an SFP, and evaluations performed by NRC at every SFP in the United States.

Spent nuclear fuel offloaded from a reactor is stored in a SFP. The SFPs at nuclear plants in the United States are massive, robust structures designed to safely contain the spent fuel discharged from a nuclear reactor under a variety of normal, off-normal, and hypothetical accident conditions (e.g., loss of electrical power, floods, earthquakes, or tornadoes). SFPs are made of thick, reinforced, concrete walls and floors lined with welded, stainless-steel plates to form a leak-tight barrier. Racks fitted in the SFPs store the fuel assemblies in a controlled configuration (i.e., so that the fuel is both sub-critical and in a coolable geometry). These structural features, complemented by the deployment of effective and visible physical security protection measures, are deterrents to terrorist activities.

The NRC has determined that the security and mitigation measures NRC has imposed upon its licensees since September 11, 2001, and national anti-terrorist measures to prevent, for example, aircraft hijackings, coupled with the robust nature of SFPs, make the probability of a successful terrorist attack, though numerically indeterminable, very low. In addition, reactor physical security systems use a defense-in-depth concept, involving internal and external barriers, intrusion assessment systems, armed responders, local law enforcement authority's response to the site, and other measures. The staff has determined that, taken as a whole, these systems, personnel, and procedures provide reasonable assurance that public health and safety, the environment, and the common defense and security will be adequately protected.

The staff noted that studies conducted over the last three decades have consistently shown that the probability of an accident causing a zirconium fire in an SFP to be lower than that for severe reactor accidents.

The staff's assessment discussed the conservatisms in NUREG-1738, including the assumption that if the water level in the SFP dropped below the top of the spent fuel, a zirconium fire involving all of the spent fuel would occur. The staff concluded NUREG-1738 bounded those conditions associated with air cooling of the fuel. The study found the risk of an SFP fire to be low and well within the Commission's Safety Goals even when all events leading to the spent fuel assemblies becoming uncovered were assumed to result in a zirconium fire.

Furthermore, the staff noted that significant additional analyses have been performed since September 11, 2001, which support the view that the risk of a successful terrorist attack (i.e., one that results in an SFP zirconium fire) is very low. These analyses were conducted by the Sandia National Laboratories and are collectively referred to as the "Sandia studies." The Sandia studies indicated that there may be a significant amount of time between the initiating event (i.e., the event that causes the SFP water level to drop) and the spent fuel assemblies becoming partially or completely uncovered. In addition, the Sandia studies indicated that for those hypothetical conditions where air cooling may not be effective in preventing a zirconium fire, there is a significant amount of time between the spent fuel becoming uncovered and the possible onset of such a zirconium fire, thereby providing a substantial opportunity for both operator and system event mitigation.

The Sandia studies, which more fully account for relevant heat transfer and fluid flow mechanisms, also indicated that air-cooling of spent fuel would be sufficient to prevent SFP zirconium fires at a point much earlier following fuel offload from the reactor than previously considered in NUREG–1738. Thus, the fuel is more easily cooled, and the likelihood of an SFP fire is therefore reduced.

Additional mitigation strategies implemented subsequent to September 11, 2001, enhance spent fuel coolability and the potential to recover SFP water level and cooling prior to a potential SFP zirconium fire. The Sandia studies also confirmed the effectiveness of additional mitigation strategies to maintain spent fuel cooling in the event the pool is drained and its initial water inventory is reduced or lost entirely. Based on this more recent information, and the implementation of additional strategies following September 11, 2001, the probability, and accordingly, the risk, of a SFP zirconium fire initiation is expected to be less than reported in NUREG–1738 and previous studies.

The staff concluded that a zirconium fire requires a number of conditions that are extremely unlikely to occur together. The Sandia studies provide a more realistic assessment of the coolability of spent fuel under a range of conditions and a better understanding of the actual safety margins than was indicated in NUREG–1738. The Sandia studies show that the safety margins are much larger than indicated by previous studies such as NUREG–1738.

Past NRC studies of spent fuel heatup and zirconium fire initiation conservatively did not consider certain natural heat transfer mechanisms, which would serve to limit heatup of the spent fuel assemblies and prevent a zirconium fire. In particular, these studies, including NUREG–1738, did not consider heat transfer from higher decay assemblies to older, lower decay fuel assemblies in the SFP. This heat transfer would substantially increase the effectiveness of air cooling in the event the SFP is drained, beyond the effectiveness of air cooling cited in past studies. The Sandia studies confirm the NRC conclusion that such heat transfer mechanisms allow rapid heat transfer away from the higher powered assemblies. Such heat transfer could air-cool the assemblies sufficiently to prevent a zirconium fire within a relatively short time after the assemblies are discharged from the reactor to the SFP. Thus, air cooling is an effective, passive mechanism for cooling spent fuel assemblies in the pool.

In summary, within a few days after reactor shutdown for boil-down type events, there is considerable time (>100 hours) to take action to preclude a fission product release or zirconium fire before uncovering the top of the fuel. Although the NUREG-1738 analysis shows that a zirconium fire could still be possible after 2 years for cases involving unsuccessful accident management measures, the ample time and diverse measures available to mitigate such accidents makes the likelihood of a zirconium fire extremely low. Furthermore, subsequent studies have shown that the safety margins are much larger than indicated by the studies documented in NUREG–1738.

Studies documented in NUREG/CR-6451, "A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants" (August 1997), showed the results of spent fuel heatup under conditions where air cooling of the fuel assemblies remains available (i.e., the seismic or cask drop event resulted in draining the SFP, but did not result in obstructed air flow of the coolant channels within the fuel assemblies). These studies showed that the reference PWR would not produce sufficient decay heat to cause clad failure after about 17 months of decay time.

The NRC recently published a report that documents the Office of Nuclear Regulatory Research's consequence study that continues the NRC's examination of the risks and consequences of postulated spent fuel pool accidents (Reference 5). This report concluded that "spent fuel is only susceptible to a radiological release within a few months after the fuel is moved from the reactor into the spent fuel pool. After that time, the spent fuel is coolable by air." The report also stated that, "If a leak and radiological release were to occur, this study shows that the individual cancer fatality risk for a member of the public is several orders of magnitude lower than the Commission's Quantitative Health Objective of two in one million ($2x10^{-6}$/year). For such a radiological release, this study shows public and environmental effects are generally the same or smaller than earlier studies." The study considered scenarios where some preplanned and improvised mitigative actions were either not successful or not implemented before three days, at which time the analysis was terminated. In responding to such an event, the site emergency response organization would request support from offsite response organizations to implement improvised additional mitigative measures, such as pumping water into the spent fuel pool using a fire truck. Analysis of these additional mitigative measures was not assessed (or credited by) this study.

Additional margin is available at KPS based on the spent fuel pool rack design. The KPS spent fuel racks contain a rectangular channel that has an area equivalent to an 8.14 inch diameter flow hole, which would serve to provide significantly more cooling capability than the 5 inch diameter orifice of the reference rack flow holes listed in NUREG/CR-6451. Based on comparison of the KPS SFP to the reference PWR SFP (see Table 1 for comparison), fuel in the KPS SFP would likely not produce sufficient decay heat to cause clad failure after a shorter period of decay time than for the reference PWR.

Conclusion

Spent nuclear fuel at KPS is stored either in the SFP or in dry storage at the onsite ISFSI. Since KPS is a permanently shutdown and defueled facility, no additional fission products will be generated at from the plant in the future and the decay heat load of the spent fuel will continue to decline. Since the ISFSI is a passive system, the only remaining safety function necessary to be maintained at KPS during a BDBEE is SFP cooling and water level. Loss of SFP level due to lack of cooling, and the subsequent need for makeup, would occur slowly due to low decay heat load from spent fuel in the SFP. Analyses have been developed for beyond design basis events related to storage of spent fuel at KPS which show that, within 17 months after shutdown, the analyzed event is either not credible, is capable of being mitigated, or the event's radiological consequences will not exceed the limits of the EPA Protective Action Guides at the EAB.

Because the station is permanently shutdown, defueled, and in a state of decommissioning, DEK believes that the requirements of the Order are unnecessary in its specific circumstances. The analyses that DEK has performed demonstrate good cause to support DEK's request that the Order be rescinded in its entirety. Separate from the requirements of the Order, DEK is providing commitments that will enhance existing strategies related to SFP makeup that are commensurate with the low risk of fuel being uncovered. These commitments are described in Attachment 2 to this letter.

References

1. Generic Issue 199 (GI-199), "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants," Safety/Risk Assessment, August 2010.
2. Letter from Daniel G. Stoddard (DEK) to NRC Document Control Desk, "Post-Shutdown Decommissioning Activities Report," dated February 26, 2013 (ADAMS Accession No. ML13063A248).
3. Letter from Peter S. Tam (NRC) to David A. Christian (DEK), "Kewaunee Power Station - Issuance of Amendment RE: Analysis Methodology for the Auxiliary Building Crane (TAC No. MD9221)," dated April 30, 2009 (License Amendment 205).
4. Federal Register, Vol. 73, No. 154, Friday, August 8, 2008 (73 FR 46204); Nuclear Regulatory Commission; Petition for rulemaking; denial.
5. Office of Nuclear Regulatory Research Draft Report, "Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor," June 2013 (ADAMS Accession No. ML13133A132).
6. NUREG-1738, "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants," February 2001.

7. NUREG/CR-4982, "Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82," July 1987.

8. NUREG/CR-6451, "A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants," August 1997.

Attachment 2

Enhanced Strategies for Spent Fuel Pool Makeup

Kewaunee Power Station
Dominion Energy Kewaunee, Inc.

Enhanced Strategies for Spent Fuel Pool Makeup

Dominion Energy Kewaunee, Inc. (DEK) submitted the certification of permanent removal of the fuel from the reactor vessel on May 14, 2013 (Serial No. 13-293). Therefore, per 10 CFR 50.82(a)(2), the 10 CFR Part 50 license no longer authorizes operation of the reactor or emplacement or retention of fuel into the reactor vessel. The spent fuel at Kewaunee Power Station (KPS) is stored either in the spent fuel pool (SFP) or the Independent Spent Fuel Storage Installation (ISFSI). The remaining safety function to be maintained at KPS is the SFP cooling and water level, since the ISFSI is a passive system. Since KPS is a permanently shutdown and defueled facility, no additional fission products will be generated at the site in the future and the decay heat load on the spent fuel will continue to decline. Loss of SFP level due to lack of cooling, and the subsequent need to restore makeup capability to the SFP, would occur slowly due to the low decay heat load from spent fuel in the SFP. Adequate time exists to use onsite equipment to restore the makeup capability to the SFP, obtain necessary equipment from other unaffected fleet sites or procure the necessary equipment.

To ensure adequate makeup capability to the SFP is available after an unanticipated event, DEK is committing to enhance existing mitigation strategies. These mitigation strategies will be evaluated for seismic considerations, external flooding, storms with high winds, snow, ice, and low temperature, as well as extreme high temperature. Mitigation strategies will be met with one piece of equipment on site and a redundant piece of equipment available from another unaffected fleet power station. This equipment will be stored in existing plant structures. Procedures will provide programmatic controls for the strategies.

Strategy Assumptions

- The SFP contains a full core discharge, decayed 12 months, producing a calculated time to reach 200°F of more than 111 hours. Inventory loss from seismically-induced SFP water sloshing does not preclude access to the SFP area.
- Spent fuel pool level is greater than 23 ft of water over the top of irradiated fuel seated in the storage racks.
- Plant is initially at minimum required operating staff. Offsite support personnel are assumed to begin arriving after 6 hours and response is fully staffed after 24 hours.
- SFP cooling system pressure and temperature are within normal operating parameters.
- Loss of all AC power and loss of ultimate heat sink.
- No independent failures other than those causing the Extended Loss of AC Power/Loss of Ultimate Heat Sink (ELAP/LUHS) event are assumed to occur during the course of the event.
- The Technical Support Center diesel-generator is maintained functional with fuel oil in its fuel oil tank.

Description of Mitigation Strategies

Because the SFP water level instrumentation will be powered by a battery backed instrument bus, it will be functional after an ELAP/LUHS. SFP level is currently available by visual observation locally at the SFP using a "ruler" gauge attached to the SFP wall. KPS will be adding additional SFP level instrumentation. The control room annunciators are assumed to be unavailable after the ELAP/LUHS event because they are not seismically qualified. Once the SFP water reaches boiling point temperature, several additional days are available before make-up capability to the SFP is required (i.e., before the water level approaches the top of the stored fuel). The KPS objective is to have SFP makeup capability before SFP level drops to ten feet above the top of the stored fuel in order to maintain radiation shielding for personnel who may have to access the SFP operating deck.

When responders determine the ELAP/LUHS will last for an extended period of time, personnel would be summoned to the site as required. Actions would then be initiated to provide back-up power to the SFP level instrumentation and establish the capability to provide makeup to the spent fuel pool from a sustained water source.

A 120VAC portable diesel generator would be retrieved from storage and taken to an accessible location where cables can reach the disconnect/receptacle used to provide back-up power for SFP level instrumentation. Responders would also retrieve the portable diesel-powered low-head/high-flow (LHHF) pump and suction hose from storage and move it to a location near the intake screenhouse. While the pump is readied for operation, responders would retrieve the exterior fire hose from storage and move it to the area adjacent to the Auxiliary Building (AB) north wall. One end of the suction hose would be connected to LHHF pump suction and the other would be dropped into a pit connected to the forebay at the screenhouse. The supply hose is connected between the LHHF pump discharge and fed to an area on the ground near the AB north wall.

Responders would retrieve the interior fire hose and connect one end to a new tie on the service water (SW) emergency SFP makeup system injection line and feed the other end through a new access opening in the AB north wall of the SFP heat exchanger room, and down to the ground outside. Due to the location and construction of the SFP heat exchanger room, it is not expected to be affected radiologically by the lowering SFP level. At this location, the LHHF pump supply hose can be connected to the interior fire hose to complete the SFP make-up flow path. Upon opening permanently installed valves near the SW emergency SFP makeup system injection line and starting the LHHF pump, sustained unlimited makeup capability to the SFP from Lake Michigan would be established.

Depending on the SFP level at the time makeup capability from Lake Michigan is established, responders may need to provide make up to the SFP to restore level to the high-level setpoint. From that point forward, responders make up to the SFP as needed to maintain the desired level. This process can be maintained as long as needed. SFP Level will be monitored using the installed level indication instrumentation.

Support Guidelines will be developed in conjunction with development of procedures to support the permanently defueled condition of the plant.

Modifications

Modifications required (to be integrated with modifications required to place the plant in SAFSTOR):

- New 120VAC disconnect/receptacle with cables and cable trays.
- New permanent hard-pipe connection and valves, in the SW emergency SFP makeup injection line.
- New access opening in the steel plate covering the access port in the north AB wall to the SFP heat exchanger room.

Portable Equipment

Currently, upon loss of all AC power, the only lighting that will remain is the existing battery-operated emergency lighting in the control room and Appendix R lighting throughout the plant. The emergency and Appendix R lighting will be augmented by flashlights and portable battery-powered lights. The portable battery-powered lights will be staged in seismically designed brackets near the areas where responders would take actions and plugged into power outlets to keep the batteries charged.

Schedule for Completion

The modifications discussed above are scheduled to be complete by the end of 2014.

List of Commitments

Number	Commitment
1	Mitigation strategies will be met with one piece of equipment on site and a redundant piece of equipment available from another unaffected fleet power station. This equipment will be stored in existing plant structures. Procedures will provide programmatic controls for the strategies.
2	Support Guidelines will be developed in conjunction with development of procedures to support the permanently defueled condition of the plant.
3	Modifications • New 120VAC disconnect/receptacle with cables and cable trays. • New permanent hard-pipe connection and valves, in the SW emergency SFP makeup injection line. • New access opening in the steel plate covering the access port in the north AB wall to the SFP heat exchanger room.
4	Portable battery-powered lights will be staged in seismically designed brackets near the areas where responders would take actions and plugged into power outlets to keep the batteries charged.