UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION

WASHINGTON, DC 20555-0001

August 11, 2021

NRC INFORMATION NOTICE 2021-03: OPERATING EXPERIENCE RELATED TO THE DUANE ARNOLD ENERGY CENTER DERECHO EVENT ON AUGUST 10, 2020

ADDRESSEES

All holders of and applicants for an operating license or construction permit for a nuclear power reactor issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic licensing of production and utilization facilities," including those that have permanently ceased operations and certified that fuel has been permanently removed from the reactor vessel.

All holders of and applicants for a power reactor combined license, standard design approval, or manufacturing license under 10 CFR Part 52, "Licenses, certifications, and approvals for nuclear power plants." All applicants for a standard design certification, including such applicants after initial issuance of a design certification rule.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform the addressees of operating experience following the Duane Arnold Energy Center (DAEC) derecho event on August 10, 2020.

The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar issues. INs may not impose new requirements, and nothing in this IN should be interpreted to require specific action.

DESCRIPTION OF CIRCUMSTANCES

On August 10, 2020, the DAEC experienced severe thunderstorms and high winds associated with a derecho, a widespread, long-lived, straight-line windstorm associated with a band of rapidly moving thunderstorms. This storm included wind gusts of 80–100 miles per hour (mph), with the most extreme winds in the area measured at approximately 130 mph.

At 1202 local time, a severe thunderstorm watch (previously issued at 1138) was upgraded to a warning. The senior responsible manager directed in-progress fuel handling operations at the facility to be placed in a safe condition and secured. As severe thunderstorms and high winds associated with the derecho moved through the area, at 1235 (33 minutes after issuance of the severe thunderstorm warning), a grid perturbation caused the site's two emergency diesel generators (EDGs) to automatically start and run unloaded. A short time later, while operating at 82-percent reactor power, the DAEC experienced a loss of offsite power (LOOP), resulting in a main turbine trip on reverse power and a subsequent automatic reactor scram. Since the EDGs were already running, the diesel output breakers immediately closed to maintain power to

ML21139A091

the plant's two electrical safety buses. The flywheels on the 120-volt alternating current (AC) reactor protection system (RPS) motor-generators stabilized RPS voltage and frequency during the power transfer. The reactor unit did not lose the RPS, and since this system is the power supply to the main steam isolation valve solenoids, these valves remained open following the LOOP, which allowed the unit continued access to the normal heat sink for cooldown for the duration of the event. After the automatic reactor scram, the reactor water level initially lowered rapidly because of the loss of feedwater. The reactor core isolation cooling and high-pressure coolant injection systems automatically initiated and were used to restore and maintain the reactor water level. At 1258, the licensee declared a Notification of Unusual Event due to the loss of all offsite AC power to both safety buses for more than 15 minutes.

About 10 hours after the storm, but before the restoration of offsite power, the emergency service water (ESW) system that provides cooling water to the EDGs showed signs of degradation as the differential pressure across the strainers in both ESW trains began increasing. The high winds resulted in increased debris loads at the intake to the ESW system, which caused clogging of the train “B” strainer and subsequent decrease of ESW flow below the value at which adequate cooling to the “B” EDG was assured by Technical Specifications (TS). Although the DAEC operators declared EDG “B” inoperable according to the TS, they successfully bypassed the train “B” strainer in accordance with operating procedures, and EDG “B” did not experience any degradation. The “A” train of ESW also experienced some degradation at the strainer, but not to the point of requiring the strainer to be bypassed. The first of six offsite power lines (Vinton 161-kilovolt line) was restored on August 11, 2020, at approximately 1200, more than 23 hours after the LOOP. The licensee was then able to energize the startup transformer and energize the essential buses. The licensee terminated the Notification of Unusual Event at 1600 that day. All six offsite power lines were restored by August 17, 2020.

In addition to the degradation of the ESW system described above, a small cut as a result of storm damage was discovered on August 12 in the fifth-floor wall of the DAEC reactor building. A subsequent test of the secondary containment boundary identified that the vacuum of 0.24 inches of water was less that the TS requirement of 0.25 inches of water. At the time of discovery, the plant was in Mode 4, which does not require secondary containment to be operable. However, it is very likely that the cut in the reactor building wall existed while the plant was in Mode 3 after the automatic reactor scram and, therefore, secondary containment was inoperable during this period. Although the secondary containment was considered inoperable, the licensee determined that a vacuum of 0.24 inches of water was sufficient to maintain the safety function of the DAEC secondary containment.

While the high winds also resulted in minor damage to the DAEC reactor, turbine, and diverse and flexible coping strategies (FLEX) buildings, the FLEX equipment was not impacted and remained available. High winds, however, caused more severe damage to the nonsafety-related cooling towers, which collapsed, thus demonstrating a derecho’s potential to introduce widespread damage to systems, structures, and components that are not designed to withstand effects of sustained high winds.

The NRC conducted followup inspection activities to review the facts surrounding the derecho event as documented in “Duane Arnold Energy Center—NRC Integrated Inspection Report 05000331/2020003 and 07200032/2020001,” dated November 6, 2020 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML20314A150).

Additional information appears in "Duane Arnold Energy Center LIC-504 Team Recommendations," dated March 30, 2021 (ADAMS Accession No. ML21084A010), and "Final ASP [Accident Sequence Precursor] Analysis]—Precursor," dated March 4, 2021 (ADAMS Accession No. ML21056A382).

DISCUSSION

Main Conclusions of the Accident Sequence Precursor Analysis

The NRC staff's ASP analysis revealed that risk of core damage for this weather-related LOOP was driven by the potential risk of both EDGs failing, along with both the high-pressure coolant injection and reactor core isolation cooling systems. Although the mean conditional core damage probability of 8×10^{-4} for this event was high, the risk of core damage was mitigated and plantwide safety margins were maintained.

The overall risk of this event was significantly impacted by the station blackout scenarios. The risk associated with these scenarios is particularly high for this plant as there were only two safety-related EDGs. In addition, as the DAEC is a single-unit site, there was no ability to crosstie safety-related buses from another unit.

FLEX mitigation strategies implemented in accordance with Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012, and codified in 10 CFR 50.155, "Mitigation of beyond-design-basis events," were credited in the DAEC ASP analysis and significantly affected the results. Specifically, without the mitigation capabilities of the FLEX strategies, the conditional core damage probability would have been approximately a factor of 10 higher for this event.

Main Conclusions of the LIC-504 Evaluation

In accordance with the Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-504, "Integrated Risk-Informed Decisionmaking Process for Emergent Issues," Revision 5, dated March 4, 2020 (ADAMS Accession No. ML19253D401), the NRC staff assessed the DAEC derecho event to evaluate potential safety impacts to other nuclear power plant (NPP) licensees.

The NRC staff analyzed eight sample NPPs with different design characteristics that estimated the risk increases due to a similar combined event (i.e., concurrent challenges to offsite power supplies and the functionality of the ESW system due to a sudden inrush of debris to the intake structure) and concluded that the safety implications can vary significantly based on site, plant design, and plant operating characteristics. Risk analyses for this group of eight sample NPPs confirmed that the potential increases in risk associated with the issue were below the value for which the NRC would consider taking immediate regulatory action, such as issuing shutdown orders or imposing compensatory measures to ensure public health and safety.

The NRC staff gleaned additional risk insights from the ASP analysis and LIC-504 evaluation including the following site design and operating characteristics that would reduce the risk exposure at the plants analyzed for a similar combined event and that could, when present, influence the magnitude of the risk impact from this type of event.

Site and Design Characteristics	
Characteristic	**Impact of Characteristic on Risk**
Frequency of the combined event that causes a LOOP and a concurrent challenge to the functionality of the ESW and fire protection water systems due to debris	Sites located in areas that have lower likelihood of events such as derechos are at reduced risk.
Susceptibility of the water source for ESW to debris accumulation during a derecho	Sites that have ultimate heat sink sources that are not prone to accumulation of debris have reduced risk.
Relative location of the intake to redundant ESW trains, as well as the location of fire pump suction at plants that use fire protection water as a diverse capability for EDG cooling	Plants with suction sources that are spatially significantly apart are at reduced risk because concurrent blockage of redundant and diverse suction capabilities is reduced.
Availability of additional diesels that do not rely on ESW, in addition to availability of diesels procured and installed as part of FLEX mitigation strategies	Plants with additional AC power sources (often not dependent upon ESW for cooling) that have the ability to provide motive power to essential loads are at reduced risk.
Availability of alternative strategies to provide cooling water to EDGs (including water from the fire protection system or other sources)	Plants with alternative strategies to provide cooling water to EDGs are at reduced risk.
Ability to promptly recognize the increased differential pressure (ΔP) across strainers	Plants that have alarms or annunciators to inform operators of increasing ΔP across the ESW strainer and intake structure screens are at reduced risk.
Ability to bypass the ESW strainers and ability of the EDGs to successfully operate in the bypass mode	Plants that have the capability to bypass the ESW strainers decrease risk since the EDGs may operate successfully in that temporary configuration. However, bypassing the ESW strainers can result in increased risk to downstream components.
Source of AC power to traveling screens	Plants whose traveling screens are powered by emergency AC power are at reduced risk.
Operating Characteristics	
Ability to promptly recognize increased ΔP across strainers	Early detection and procedures that instruct operators to monitor ΔP across the ESW strainer and intake structure screens upon receipt of warnings for severe weather, may decrease risk.
Use of FLEX strategies	With appropriate procedures, testing, and training, FLEX strategies reduce potential risk increases attributed to this event.
Procedures and abnormal operating procedures related to severe weather warnings	Severe weather preparedness procedures and abnormal operating procedures that: (1) recognize and take action to minimize the potential for blockage of intake structures, traveling screens, and strainers decrease risk (2) direct risk management actions for ongoing site activities (e.g., suspension

	of fuel movement activities) decrease risk

Results of the risk analysis performed for the eight NPPs analyzed demonstrate that the availability of the following three mitigation characteristics would significantly reduce plant risk:

(1) the ability of operators to bypass a clogged ESW strainer, if needed

(2) the ability to align an alternate cooling source, such as fire protection water or another source of water, to provide cooling to diesel generators

(3) having additional diesel generators (not including FLEX diesels) that are not dependent on service water for cooling

Of particular note from this derecho event, the debris buildup on the DAEC ESW strainers did not challenge the functionality of ESW until several hours into the event. However, because of the extended duration of the LOOP, EDGs, and therefore, the ESW system, were still required to remain functional to provide AC power. When the ESW system and the EDGs are each dependent on the continuing functionality of the other to remain operable, even as they both serve multiple safety functions, diverse capabilities to mitigate the consequences of the loss of one of these systems can reduce the risk of events that challenge both systems simultaneously.

The NRC staff's evaluation concluded that the derecho at the DAEC demonstrated that the plant's design was adequate to withstand the impacts of high winds and resulting debris-generated missiles. It also demonstrated that there are additional risk insights gained that could benefit plants impacted by similar severe weather events in the future.

CONTACTS

Please direct any questions about this matter to the technical contacts listed below,

/RA/
Christopher G. Miller, Director
Division of Reactor Oversight
Office of Nuclear Reactor Regulation

Technical Contacts: Matthew Leech, NRR
301-415-8312
e-mail: Matthew.Leech@nrc.gov

Rebecca Sigmon, NRR
301-415-0895
e-mail: Rebecca.Sigmon@nrc.gov

INFORMATION NOTICE 2021-03, "OPERATING EXPERIENCE RELATED TO THE DUANE ARNOLD ENERGY CENTER DERECHO EVENT ON AUGUST 10, 2020," DATE: August 11, 2021

ADAMS Accession No.: ML21139A091 **EPIDS No. L-2021-GEN-0003**

OFFICE	Author	QTE	NRR/DRA/BC	NRR/DRA/DD	OE	
NAME	MLeech	JDoughtery	AZoulis	MFranovich	JPeralta	
DATE	6/25/21	6/11/21	6/25/21	7/09/21	5/24/21	
OFFICE	NRR/DRO/IOEB/PM	NRR/DRO/LA	NRR/DRO/IOEB/BC	NRR/DIRS/D		
NAME	BBenney	IBetts	LRegner	CMiller		
DATE	7/29/21	8/3/21	7/29/21	8/11/21		

OFFICIAL RECORD COPY