Event Inquiry into the Nuclear Regulatory Commission's Oversight of the Auxiliary Feedwater System at Diablo Canyon Nuclear Power Plant

OIG CASE No. 20-025

March 25, 2022

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MEMORANDUM

DATE: March 25, 2022

TO: Christopher T. Hanson
Chairman, Nuclear Regulatory Commission

FROM: Robert J. Feitel
Inspector General

Robert J. Feitel Digitally signed by Robert J. Feitel
Date: 2022.03.25 08:49:37 -04'00'

SUBJECT: THE NRC'S OVERSIGHT OF THE AUXILIARY FEEDWATER SYSTEM AT DIABLO CANYON NUCLEAR POWER PLANT (OIG CASE NO. 20-025)

Attached is an Office of the Inspector General (OIG), U.S. Nuclear Regulatory Commission (NRC), Event Inquiry that addresses the NRC's oversight pertaining to the auxiliary feedwater system at Diablo Canyon Nuclear Power Plant prior to the leak that occurred on July 23, 2020.

We report findings and observations in this inquiry for the NRC's consideration. Although this report is furnished for whatever action you deem appropriate, please notify us by June 10, 2022, confirming the agency's review of applicable policies and procedures and what action(s), if any, you decide to take based on the results of this inquiry.

Attachment: As stated

cc w/attachment:
Commissioner Baran
Commissioner Wright
Daniel H. Dorman, Executive Director for Operations
David A. Castelveter, Director, Office of Public Affairs

Results in Brief

The NRC's Oversight of the Auxiliary Feedwater System at Diablo Canyon Nuclear Power Plant

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Why We Conducted This Event Inquiry

Since 1978, NRC resident inspectors have been stationed at commercial nuclear power plants to provide first-hand, independent assessments of plant conditions and performance. In 2001, the NRC implemented the Reactor Oversight Process (ROP), a process created to inspect, measure, and assess the safety and security performance of operating commercial nuclear power plants, and to respond to any decline in plant performance. The ROP requires inspectors to follow guidance in the NRC Inspection Manual, which specifies the objectives and procedures for each type of inspection. Inspections are an important element of the NRC's oversight of its licensees, and when licensees meet the NRC's requirements and the NRC implements the ROP effectively, commercial nuclear power plants operate in a manner that reasonably assures the public and the environment are protected from undue nuclear risk.

In the last few years, we reviewed multiple allegations reported to us regarding the NRC's oversight at Diablo Canyon Nuclear Power Plant (DCNPP), a plant with two reactors in Avila Beach, California. Several of those concerns involved the NRC's oversight of safety-related structures, systems, and components (SSCs). One such SSC is the auxiliary feedwater (AFW) system, which is important to a commercial nuclear power plant because it is a backup water supply that can be used to cool the reactor if normal feedwater is out of service.

After a July 2020 AFW system failure that required Unit 2, one of DCNPP's nuclear reactors, to shut down for 8 days, we received specific allegations that the NRC had inadequately inspected the AFW system prior to the event. These allegations further raised questions as to whether there is a lack of NRC oversight at the DCNPP. Therefore, we initiated this event inquiry to review the adequacy of the NRC's inspections of the AFW system prior to the July 2020 event. We initiated this event inquiry in accordance with the OIG's Annual Plan, under which the OIG conducts event inquiries to determine if staff actions may have contributed to the occurrence of an event, and to assess the public's concerns.

Since the event, which we describe in our Background section on page 1, the licensee has remedied the AFW system failure and made improvements to the system, and DCNPP continues to operate safely. Additionally, the NRC has since verified that the AFW system complies with regulatory requirements.

What We Found

1. During ROP inspections, the NRC failed to identify piping insulation that had long been in a degraded condition. This degradation led to a leak in the Unit 2 AFW system piping. As a result, the licensee was required to shut down the unit. At no time during the NRC's January and April 2020 AFW system inspections or during weekly plant status inspections did the NRC report findings regarding any SSCs that exhibited defects, such as degraded insulation on the AFW system, that would impact function.

2. The NRC had not inspected the area where the leak occurred, even though its inspection report indicated that inspectors had conducted a complete walkdown of the AFW system in April 2020. A complete walkdown is a physical inspection that verifies that the selected system is correctly aligned and able to perform its intended safety function.

3. The number of hours NRC staff spent directly inspecting both reactors'—Units 1 and 2—AFW systems was fewer (5 hours) than recommended in the applicable NRC inspection procedure (12 hours) for the complete walkdown in April 2020. Senior regional officials acknowledged that the inspection was inadequate.

What We Observed as Potential Areas of Concern

During this inquiry, we identified potential areas of concern that could give the appearance of less than optimal regulatory oversight. The NRC should consider whether it needs to act to ensure:

1. NRC inspectors are trained to identify corrosion under insulation and that insulation does not unnecessarily limit their ability to identify such corrosion;
2. NRC inspection procedures are sufficiently clear and otherwise adequate regarding the expectations for walkdowns, especially with a single unit versus a multiple unit plant;
3. NRC inspectors are aware of these expectations;
4. NRC managers are appropriately involved in reviewing whether inspectors follow inspection procedures; and,
5. NRC managers are appropriately involved in helping select systems, as well as structures and components within the systems, for inspection.

I. BACKGROUND

Basis and Scope

The NRC inspects commercial nuclear power plants consistent with its mission of protecting public health and safety. NRC inspections assess whether licensees are properly conducting operations and maintaining equipment to ensure safe operations. If an inspection shows that a licensee is not safely conducting an activity or safely operating a facility, the NRC informs the licensee of any problems found and ensures they are addressed. The ROP is the NRC's program to inspect, measure, and assess the safety and security performance of operating commercial nuclear power plants, and to respond to any decline in their performance.

We initiated this event inquiry based on concerns reported to us after the July 2020 AFW system failure when a DCNPP operator found water leaking from under pipe insulation. The licensee removed the insulation and found a 1/16-inch diameter hole in the pipe leaking feedwater. The location and magnitude of the leak required Unit 2 to shut down.

In this event inquiry, we reviewed the adequacy of the NRC's oversight provided to the AFW system and the appropriateness of completed inspections. This report provides background information regarding the AFW system, describes the NRC's actions related to the AFW system prior to the July 2020 leak, and explores the NRC's ROP relative to this incident. We also include our observations of potential areas of concern identified during this review for the NRC to consider.

Event Details

On July 23, 2020, a DCNPP operator noticed water coming down from the Unit 2 AFW pipe gallery, an area of the plant commonly called the "pipe rack." The operator identified water leaking from under the insulation covering the 3-inch, carbon steel AFW pipe. DCNPP maintenance staff removed the degraded pipe insulation and found a 1/16-inch diameter hole leaking 3.9 gallons per minute of feedwater (see Figure 1).

Figure 1: AFW Leak at DCNPP

This photo shows the July 2020 leak and the corrosion that appears to be far more long-standing.
Source: DCNPP

The licensee identified that the AFW piping had long-standing damage to the insulation and its aluminum covering, which allowed moisture and contaminants to be absorbed by the insulation and caused corrosion on the outside of the pipe.

At the time of discovery, Unit 2 was not producing electricity because the licensee was addressing a hydrogen leak in the Unit 2 Main Generator, but the AFW system was in service providing coolant to the unit.

Post-Event

On July 31, 2020, 8 days after the AFW pipe leak, the licensee restarted Unit 2. Prior to restart, the licensee had remedied the leak with numerous actions, such as inspecting 40 pipe sections and repairing piping in 7 locations to ensure pipe thickness met requirements. Significantly, the licensee also determined that the AFW piping located outdoors—including the piping where the leak occurred—did not need to be insulated, and it therefore removed the insulation.

After the event, the NRC issued the licensee a notice of violation for its "failure to appropriately screen relevant operating experience." Part of the basis for the violation was that the licensee had received industry information in 2009 and 2010 relating to corrosion of carbon steel piping under insulation, but it did not identify the AFW as being susceptible to corrosion under insulation.[1] This oversight prevented actions from being identified and implemented that may have eliminated vulnerabilities and prevented corrosion under insulation from occurring at the DCNPP.

About the Plant

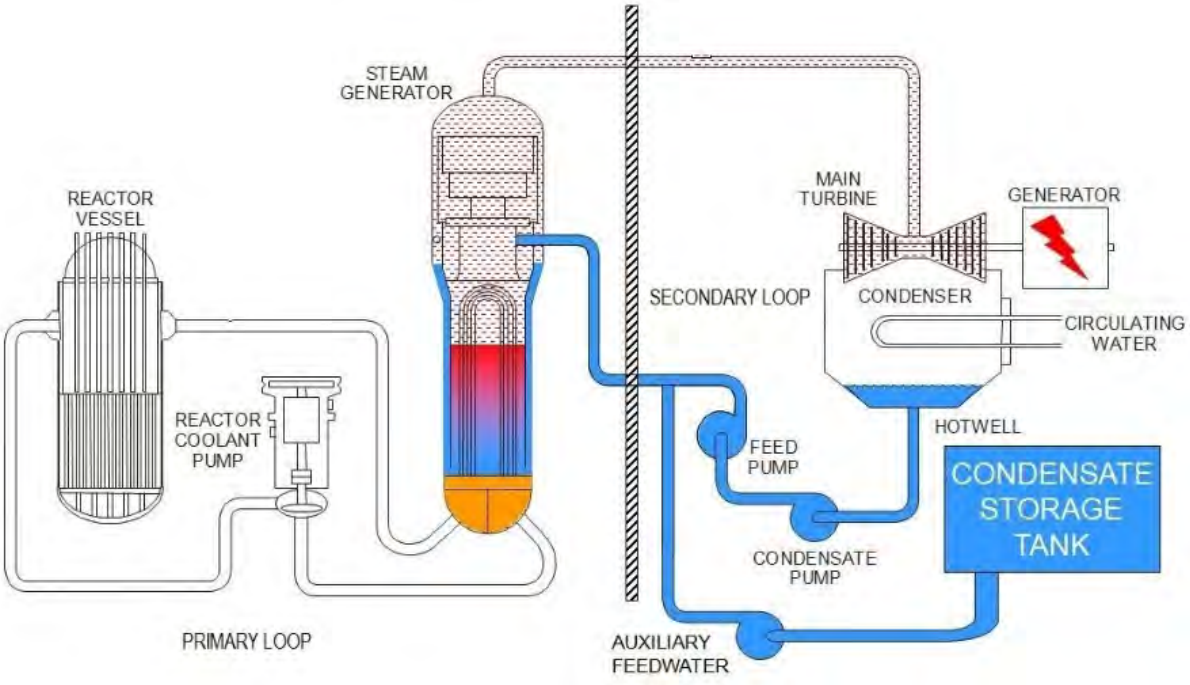
DCNPP is an electricity-generating nuclear power plant in San Luis Obispo County, California, that is operated by Pacific Gas & Electric. The plant has two Westinghouse-designed, four-loop, pressurized-water nuclear reactors, each of which is capable of producing 1,100 megawatts of electricity.

According to the NRC's and licensee's risk information, the AFW system at DCNPP—one of dozens of systems at DCNPP—is ranked among the top 10 most risk important systems by achievement worth. Achievement worth is the increase in risk if the system were assumed not to be there or failed.[2] For each unit, the AFW system is comprised of approximately 175 components that plant operators must verify are correctly aligned prior to use. Of the 175 components, more than 50 are classified as sealed, or locked in their current positions,[3] according to plant quality procedures.[4]

All AFW piping is considered a risk-significant SSC designed to transport feedwater. The AFW system flow and emergency water supply capacity must be sufficient to remove heat. The AFW system must be capable of functioning for extended periods, and is directly relied upon to prevent core damage and reactor coolant system overpressurization in the event of transients—changes in the reactor's coolant system temperature, pressure, or both—attributed to a change in the reactor's power output.

[1] Corrosion under insulation can exacerbate otherwise known and managed corrosion mechanisms, such as general surface corrosion of carbon steels. If insulation is damaged, water can become trapped while maintaining access to the surrounding environment (e.g., air and corrosion contaminants, such as chlorides or sulfates).
[2] NUREG/CR-3385.
[3] NRC IN 86-61.
[4] DCNPP Operating Procedure OP D-1:II.

Figure 2: Auxiliary Feedwater System



Source: Union of Concerned Scientists

II. DETAILS

The NRC's Oversight of the DCNPP Unit 2 AFW System

Finding 1. Degraded Insulation

During routine inspections, the NRC failed to identify rain-soaked, long-degraded insulation. The resulting moisture caused surface corrosion that led to a leak in the Unit 2 AFW system piping. This phenomenon is called corrosion under insulation. The licensee was required to shut down the unit on July 23, 2020, because two AFW pumps were inoperable.

Prior to the leak, NRC staff performed many plant tours in accordance with Inspection Manual Chapter (IMC) 2515. Plant tours are described in IMC 2515,[5] Appendix D, which instructs inspectors to conduct weekly tours of the accessible areas of the plant containing SSCs, areas that contain significant radiological hazards, and areas with important physical security equipment. Appendix D also instructs inspectors to focus their weekly inspections on areas of the plant they have not entered while performing other inspections.

Additionally, in early 2020, NRC staff performed an inspection procedure[6] that requires inspectors to verify that SSCs do not exhibit defects, such as degraded insulation, that would impact function. In January, staff conducted a partial walkdown of the Unit 2 AFW system. Furthermore, in April, approximately 3 months prior to the leak being discovered, staff conducted a complete walkdown of both the Unit 1 and 2 AFW systems. For both walkdowns, the NRC reported no findings in its respective integrated inspection reports.

Upon viewing pictures of the degraded insulation, well-placed NRC principals said that "dented" insulation is not a safety issue they would identify during an inspection because it would have looked like an operator had stepped on the insulation and it was still "intact" (see Figure 3).

[5] IMC 2515, Light-Water Reactor Inspection Program-Operations Phase, Appendix D, Plant Status, effective July 1, 2016.
[6] Inspection Procedure 71111.04, Equipment Alignment.

Figure 3: Degraded Insulation

Source: DCNPP

One principal said that if insulation is degraded, it will be "loose" or easily ripped off, such that it could go into a drain and clog it, therefore not allowing the drain to perform its function. In other words, the principal suggested that because the insulation on the Unit 2 AFW system piping was not loose, he would not have identified its degraded condition. Another principal said there was no way the corrosion could have been identified because it was under insulation.

One principal told us that degraded insulation is not an area in which NRC inspectors are trained, and another said that after this incident, this is an area he looks at more carefully now. A senior regional official told us that "probably" the inspector should have questioned whether the insulation was degraded and informed operations of the potential condition because the insulation's outer jacket was crushed, and it was not in the same condition it was when installed. The official added that "maybe" he would have looked to see if any corrective action reports had been written on it. Another senior regional official told us that there is a lot of this type of insulation degradation in most power plants, and that

this type of deformation can lead to an event such as the DCNPP AFW system leak. The senior regional official added that the expectation was for the inspectors to report what they see no matter how minor it may seem.

Finding 2: Inadequate Inspection of the Pipe Rack

Our review of plant access records[7] revealed that the Unit 2 AFW pipe rack area where the leak occurred was not accessed during the inspection period, despite NRC inspectors reporting a complete walkdown. For each unit, there are more than 25 components in the pipe rack area, including 5 sealed devices. The leak occurred downstream of sealed level control valve #111 and between sealed valves FW-2-142 and FW-2-176. A well-placed NRC principal told us that [Inspection Procedure] IP 71111.04 requires a walkdown of all the accessible portions of the system, and that DCNPP's AFW system was mostly accessible in both the radiologically controlled area and the pipe racks, which were not inside containment. The principal added, "the whole point of the procedure…is you're physically walking down the system to make sure everything is the way it should be." The principal said the neglect of the pipe rack area bothered him because "there are components in that area you definitely want to see," but also said there is "probably not a textbook way to do the procedure."

A senior regional official told us, "If they [inspectors] document that a sample was completed, unless I have some reason to question their integrity, I trust that they performed the module as written, and that they did a complete walkdown." The official added that he trusted inspectors to not only look at the system, but also to pull valve lineups and conduct visual verifications. The official told us that the requirements of the inspection procedure were not met in this case, nor were his expectations that inspectors "are walking the system and verifying that all the valves that are required are in the correct position for the system to be able to perform a safety function."

Finding 3: Insufficient Direct Inspection

We determined that during the April 2020 inspection, the NRC spent approximately 5 direct inspection hours divided between 2 units (see Figure 4). Specifically, analysis of plant access records identified NRC staff spent a little over 1 hour per unit inspecting inside the radiologically controlled area and Auxiliary Building, which is where most non-containment safety components are located. Additionally, staff spent approximately 7 minutes in the Unit 1 pipe rack,

[7] Plant access records are a means to monitor personnel entering and exiting secure rooms with electronic badge readers.

no time at all in the Unit 2 pipe rack, and under an hour in the switchgear areas. An NRC senior regional official told us this amount of inspection time was unacceptably low.

As previously described, there are approximately 175 components in the licensee's AFW startup procedure. Of the 175 components, more than 50 per unit are also contained on the licensee's "sealed" components list. Furthermore, IP 71111.04 contains procedures for verifying equipment alignment, which includes verifying that sealed (locked) valves are in the correct position and identifying any discrepancies that impact system safety functions.

The IP budgets 12 hours for a complete plant walkdown. A well-placed NRC principal told us, however, that DCNPP's AFW system has a high rating as risk significant and ideally required 12 hours to complete a walkdown of the system alone. Upon reviewing the plant access records, the principal said that it did not appear that the inspector spent a lot of time in the plant during April 2020. According to the principal, the inspector probably did "more of a document review" and relied on information from previous walkdowns.

Another well-placed NRC principal added that if an inspector only spends an hour and a half walking down the system, "that's not enough time for a complete system walkdown." Upon seeing plant access records with approximately 5 hours of direct inspection, the principal said it was "not wrong but certainly seemed light." The principal explained that some inspectors like to allot significant inspection hours reviewing databases and finding problems there.

A senior regional official told us that 4 to 5 hours of inspection done for two AFW systems was "not sufficient," and would not be enough to meet the inspection objectives. He said that all inspectors must ensure they are thorough with each inspection they perform: "It is not acceptable to say, 'I've been in there 100 times.'" The official added that ROP inspections were budgeted for a certain number of hours with the expectation that the inspections are completed correctly.

Figure 4: Inspection Times for Two AFW Systems

Inspection Dates	Time in Auxiliary Building	Time in Pipe Rack	Time in Switchgear Area	Time in unknown area
04/13/2020	1 hour and 14 minutes	7 minutes (Unit 1)		
04/20/2020			44 minutes	1 hour (approximately)
04/27/2020	1 hour and 2 minutes			
Total	**2 hours and 16 minutes**	**7 minutes**	**44 minutes**	**1 hour**

Source: OIG generated from plant access records

Reactor Oversight Process

According to NRC Management Directive (MD) 8.13, the ROP was developed to provide tools for inspecting and assessing licensee performance in a more risk-informed, objective, predictable, and understandable way than the previous oversight process. The NRC's inspection program collects information about licensee performance through direct observation by NRC inspectors. The inspectors perform this fundamental function and determine whether licensees are operating their plants safely and in accordance with regulatory requirements and self-imposed standards. Resident inspectors assigned to each site and inspectors from NRC regional and headquarters offices contribute to the inspection program.

The inspection program is intended to provide regional administrators flexibility in the planning and application of inspection resources to deal with risk-significant issues and problems. The regional offices plan inspections up to 24 months in advance, and transmit updated inspection plans semiannually to licensees.

The baseline inspection program uses a risk-informed approach to develop a comprehensive list of inspectable areas within each cornerstone of safety. These areas are selected based on their risk significance.

Specifically, IMC 2515 states, "The baseline inspections are risk informed through (1) the inspectable areas, which are based on their risk importance in measuring a cornerstone objective; (2) the inspection frequency and sample size for each inspectable area, which are based on risk information; and (3) sample selection of activities and

equipment to inspect in each inspectable area, which is based on risk insights that will be modified by plant-specific information."

Observation 1: Senior Regional Management is Not Involved in System Sample Selections for ROP Inspections.

During this inquiry, we identified that from 2015 through 2020, 50 percent of the total partial walkdowns performed at DCNPP were on only two safety systems. A partial walkdown inspection verifies that the *critical* portions of a selected system are correctly aligned, whereas a complete walkdown verifies that *all* aspects of a system are correctly aligned.

A well-placed NRC principal said that there is a series of inspections that must be done throughout the year, but it is within the discretion of the senior resident inspector at the site as to when and how the inspections are done. Furthermore, the principal said there is a lot of flexibility given to senior resident inspectors. He added that it is the branch chief's job to supervise the senior resident inspector, but not to choose when and how the inspections are done or what systems are inspected. A senior regional official told us that although branch chiefs review yearly inspection plans developed by the senior resident inspectors, the resident inspectors are responsible for selecting, implementing, and documenting which systems they inspect.

When we discussed the fact that a high percentage of the partial walkdowns at DCNPP involved just two systems, a senior regional official told us that regional branch chiefs typically go to each site once a quarter and enter the plant with the inspectors. However, when the branch chiefs are on site, they do not necessarily pull random inspection samples for walkdown verification. The senior regional official stated that although a high percentage of the partial walkdowns involved just two systems, system selection needs to account for the risk significance of the systems at a pressurized-water reactor, such as at DCNPP. Another senior regional official told us it was the regional branch chief's responsibility to ensure the objective of the ROP was met based on what the inspectors were inspecting.

Observation 2: NRC Inspection Procedures Do Not Differentiate between a Single or Multiple Unit Site for Sample Size and Budgeted Hours, which can Lead to Inconsistent Inspection Approaches.

When we observed that NRC policy does not differentiate between single or multiple unit sites for sample size and budgeted hours, an NRC principal said that

sometimes an inspection sample will be for one unit, or sometimes it will be for two units, and the senior resident inspectors have the flexibility to decide if an inspection sample consists of one or two units. The principal added that the guidance in the inspection procedures does not specify whether a sample is one or two units. Furthermore, another NRC principal told us that one complete walkdown sample was a single system, and the 12 budgeted hours was per unit on a multi-unit site.

A senior regional official said that IP 71111.04 not defining a sample size could lead to inconsistencies across power plants and inspectors. The senior official explained that only having two NRC inspectors at each site, whether a single unit or multi-unit site, is a resource constraint; however, at a multi-unit site, the NRC is dealing with the same licensee, processes, and people that can be leveraged to alleviate some of the resource constraint. Furthermore, the senior official said, "There was opportunity to add clarity to the IP by defining what a sample size should be and an opportunity to regularly review the inspector's sample selection."

Conclusion

Through this event inquiry, we learned that the NRC did not identify long-degraded insulation that compromised the integrity of the AFW system piping at DCNPP. We also learned that during an April 2020 inspection, the NRC failed to inspect the Unit 2 AFW pipe rack area, where a leak occurred, and that the NRC's direct-inspection hours during the April 2020 inspection were far fewer than provided for in the applicable inspection procedure. Senior NRC officials acknowledged that the inspections of the AFW system did not meet their expectations, and that the objectives of the NRC's inspection procedures were not met. Additionally, through this event inquiry we identified other areas of concern that potentially give the appearance of less than optimal regulatory oversight.

We have forwarded this report to the NRC's executive leadership for review and response.

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