



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION**

REGION I  
475 ALLENDALE RD, STE 102  
KING OF PRUSSIA, PENNSYLVANIA 19406-1415

November 7, 2022

EA-22-089

David P. Rhoades  
Senior Vice President  
Constellation Energy Generation, LLC  
President & Chief Nuclear Officer (CNO)  
Constellation Nuclear  
4300 Winfield Road  
Warrenville, IL 60555

**SUBJECT: CALVERT CLIFFS NUCLEAR POWER PLANT, UNITS 1 AND 2 –  
INTEGRATED INSPECTION REPORT 05000317/2022003 AND  
05000318/2022003 AND PRELIMINARY WHITE FINDING AND APPARENT  
VIOLATION**

Dear David Rhoades:

On September 30, 2022, the U.S. Nuclear Regulatory Commission (NRC) completed an inspection at Calvert Cliffs Nuclear Power Plant. On October 12, 2022, the NRC inspectors discussed the results of this inspection with Patrick D. Navin, Site Vice President, and other members of your staff. The results of this inspection are documented in the enclosed report.

Section 71152A of the enclosed report documents a finding with an associated apparent violation that the NRC has preliminarily determined to be White with low-to-moderate safety significance. This finding is associated with an apparent violation of Calvert Cliffs Unit 1 Technical Specification 5.4.1, "Procedures," as covered in Regulatory Guide 1.33, and implemented by site procedure MA-AA-716-008, "Foreign Material Exclusion Program," for not adequately implementing foreign material exclusion (FME) practices. Specifically, it involved not adequately implementing FME practices which allowed the introduction of foreign material into the 1A emergency diesel generator (EDG) that led to an EDG automatic trip and consequential failure on February 20, 2022, during routine testing.

The basis for the NRC's preliminary significance determination is described in the enclosed report. We assessed the significance of the finding using the significance determination process (SDP) and readily available information. We are considering escalated enforcement for the

apparent violation consistent with our Enforcement Policy, which can be found at <http://www.nrc.gov/about-nrc/regulatory/enforcement/enforce-pol.html>. Because we have not made a final determination, no notice of violation is being issued at this time. Please be aware that further NRC review may prompt us to modify the number and characterization of the apparent violations.

We intend to issue our final significance determination and enforcement decision, in writing, within 90 days from the date of this letter. The NRC's SDP is designed to encourage an open dialogue between your staff and the NRC; however, neither the dialogue nor the written information you provide should affect the timeliness of our final determination.

Before we make a final decision, you may choose to communicate your position on the facts and assumptions used to arrive at the finding and assess its significance by either (1) attending and presenting at a regulatory conference or (2) submitting your position in writing.

If you request a regulatory conference, it should be held within 40 days of your receipt of this letter. Please provide information you would like us to consider or discuss with you at least 10 days prior to any scheduled conference. The focus of a regulatory conference is to discuss the significance of the finding and not necessarily the root cause or corrective actions associated with the finding. If you choose to attend a regulatory conference, it will be open for public observation.

If you decide to submit only a written response, it should be sent to the NRC within 40 days of your receipt of this letter. Written responses should reference the inspection report number and enforcement action number associated with this letter in the subject line. Your response should be sent to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Center, Washington, DC 20555-0001 with a copy to Brice Bickett, Branch Chief, U.S. Nuclear Regulatory Commission, Region 1, 475 Allendale Road, King of Prussia, PA 19406. If you choose not to request a regulatory conference or to submit a written response, you will not be allowed to appeal the NRC's final significance determination.

Please contact Brice A. Bickett at 610-337-5312, or in writing at [brice.bickett@nrc.gov](mailto:brice.bickett@nrc.gov), within 10 days from the issue date of this letter to notify the NRC of your intentions. If we have not heard from you within 10 days, we will continue with our significance determination and enforcement decision.

This letter, its enclosure, and your response (if any) will be made available for public inspection and copying at <http://www.nrc.gov/reading-rm/adams.html> and at the NRC Public Document Room in accordance with Title 10 of the *Code of Federal Regulations* (CFR) 2.390 , “Public Inspections, Exemptions, Requests for Withholding.”

Sincerely,

Daniel S. Collins, Director  
Division of Operating Reactor Safety

Docket Nos. 05000317 and 05000318  
License Nos. DPR-53 and DPR-69

Enclosure:  
Inspection Report 05000317/2022003 and  
05000318/2022003 w/Attachment: Detailed  
Risk Evaluation

cc w/ encl: Distribution via LISTSERV

SUBJECT: CALVERT CLIFFS NUCLEAR POWER PLANT – INTEGRATED INSPECTION REPORT 05000317/2022003 AND 05000318/2022003 AND PRELIMINARY WHITE AND APPARENT VIOLATION DATED NOVEMBER 7, 2022

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**U.S. NUCLEAR REGULATORY COMMISSION  
Inspection Report**

Docket Numbers: 05000317 and 05000318

License Numbers: DPR-53 and DPR-69

Report Numbers: 05000317/2022003 and 05000318/2022003

Enterprise Identifier: I-2022-003-0030

Licensee: Constellation Energy Generation, LLC

Facility: Calvert Cliffs Nuclear Power Plant

Location: Lusby, MD

Inspection Dates: July 1, 2022 to September 30, 2022

Inspectors: G. DiPaolo, Senior Resident Inspector  
L. Dumont, Senior Reactor Inspector  
B. Dyke, Operations Engineer  
N. Eckhoff, Health Physicist  
P. Finney, Senior Project Engineer  
M. Henrion, Health Physicist  
D. Kern, Senior Reactor Inspector  
E. Miller, Senior Resident Inspector  
K. Murphy, Operations Engineer  
S. Obadina, Resident Inspector

Approved By: Brice A. Bickett, Branch Chief  
Projects Branch 3  
Division of Operating Reactor Safety

Enclosure

## SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) continued monitoring the licensee's performance by conducting an integrated inspection at Calvert Cliffs Nuclear Power Plant, in accordance with the Reactor Oversight Process. The Reactor Oversight Process is the NRC's program for overseeing the safe operation of commercial nuclear power reactors. Refer to <https://www.nrc.gov/reactors/operating/oversight.html> for more information.

### List of Findings and Violations

Failure to Prevent Introduction of Foreign Material into Emergency Diesel Generator			
Cornerstone	Significance	Cross-Cutting Aspect	Report Section
Mitigating Systems	Preliminary White AV 05000317/2022003-01 Open EA-22-089	[H.12] - Avoid Complacency	71152A
The inspectors identified a finding and apparent violation of Calvert Cliffs Unit 1 Technical Specification 5.4.1, "Procedures," as covered in Regulatory Guide 1.33, and implemented by site procedure MA-AA-716-008, "Foreign Material Exclusion Program," for not adequately implementing foreign material exclusion (FME) practices. Specifically, Constellation failed to prevent the introduction of foreign material into the 1A emergency diesel generator (EDG) that led to an EDG automatic trip and consequential failure on February 20, 2022, during routine testing.			

### Additional Tracking Items

None.

## PLANT STATUS

Unit 1 operated at or near rated thermal power for the entire inspection period.

Unit 2 began the inspection period at rated thermal power. On August 5, 2022, the unit was down powered to 65 percent power to support main condenser water box cleaning. The unit returned to rated thermal power on August 7, 2022. Operators commenced reducing power for maintenance outage CC2M2201 on September 14, 2022, and returned the unit to 100 percent power on September 22, 2022. The unit remained at or near rated thermal power for the remainder of the inspection period.

## INSPECTION SCOPES

Inspections were conducted using the appropriate portions of the inspection procedures (IPs) in effect at the beginning of the inspection unless otherwise noted. Currently approved IPs with their attached revision histories are located on the public website at <http://www.nrc.gov/reading-rm/doc-collections/insp-manual/inspection-procedure/index.html>. Samples were declared complete when the IP requirements most appropriate to the inspection activity were met consistent with Inspection Manual Chapter (IMC) 2515, "Light-Water Reactor Inspection Program - Operations Phase." The inspectors performed activities described in IMC 2515, Appendix D, "Plant Status," observed risk significant activities, and completed on-site portions of IPs. The inspectors reviewed selected procedures and records, observed activities, and interviewed personnel to assess licensee performance and compliance with Commission rules and regulations, license conditions, site procedures, and standards.

## REACTOR SAFETY

### 71111.01 - Adverse Weather Protection

#### External Flooding (IP Section 03.03) (1 Sample)

- (1) The inspectors evaluated that flood protection barriers, mitigation plans, procedures, and equipment were consistent with the licensee's design requirements and risk analysis assumptions for coping with external flooding in the Units 1 and 2 intake structure and in the Unit 1A EDG building on September 30, 2022.

### 71111.04 - Equipment Alignment

#### Partial Walkdown (IP Section 03.01) (3 Samples)

The inspectors evaluated system configurations during partial walkdowns of the following systems/trains:

- (1) Unit 1, 11 containment spray pump during maintenance on the 13 high pressure safety injection pump, July 7, 2022
- (2) Unit 1, 12 auxiliary feedwater pump following being aligned for automatic operation, July 11, 2022
- (3) Unit 2, 23 high pressure safety injection pump during surveillance testing of 21 high pressure safety injection pump, August 9, 2022

## 71111.05 - Fire Protection

### Fire Area Walkdown and Inspection (IP Section 03.01) (5 Samples)

The inspectors evaluated the implementation of the fire protection program by conducting a walkdown and performing a review to verify program compliance, equipment functionality, material condition, and operational readiness of the following fire areas:

- (1) Units 1 and 2, EDG rooms, fire areas 28, 30, and 31, July 13, 2022
- (2) Units 1 and 2, refueling water tank rooms, fire areas 44 and 29, July 13, 2022
- (3) Unit 1, emergency core cooling system rooms 12 and 11, fire areas 3 and 4, July 14, 2022
- (4) Unit 1, service water pump room, fire area 39, August 30, 2022
- (5) Unit 2, containment, fire area 2CNMT, September 15, 2022

## 71111.06 - Flood Protection Measures

### Inspection Activities - Internal Flooding (IP Section 03.01) (3 Samples)

The inspectors evaluated internal flooding mitigation protections in the:

- (1) Units 1 and 2, electrical manholes 0MH72, 0MH73, 1MH22 and 1MH23 associated with the 1A and/or 0C EDGs, August 3, 2022
- (2) Unit 1, component cooling water room, September 26, 2022
- (3) Unit 2, switchgear rooms, September 26, 2022

## 71111.07A - Heat Exchanger/Sink Performance

### Annual Review (IP Section 03.01) (1 Sample)

The inspectors evaluated readiness and performance of:

- (1) Unit 2, 22A and 22B service water heat exchangers, July 29, 2022

## 71111.11Q - Licensed Operator Regualification Program and Licensed Operator Performance

### Licensed Operator Performance in the Actual Plant/Main Control Room (IP Section 03.01) (1 Sample)

- (1) The inspectors observed and evaluated licensed operator performance in the control room during Unit 2 power ascension following main condenser water box cleaning on August 7, 2022.

### Licensed Operator Regualification Training/Examinations (IP Section 03.02) (1 Sample)

- (1) The inspectors observed and evaluated a licensed operator simulator scenario involving intake cooling water fouling, a steam generator tube rupture, and a station blackout resulting in a declaration of a Site Area Emergency on July 26, 2022.

### 71111.12 - Maintenance Effectiveness

#### Maintenance Effectiveness (IP Section 03.01) (3 Samples)

The inspectors evaluated the effectiveness of maintenance to ensure the following structures, systems, and components (SSCs) remain capable of performing their intended function:

- (1) Unit 1, AR 4501867, inverter 14/inverter 2 failed due to high frequency, September 29, 2022
- (2) Unit 1, AR 4494041, 12 auxiliary feedwater pump outboard bearing oil sample post flush remains cloudy, September 30, 2022
- (3) Unit 1, AR 4479267, 1A EDG tripped on February 20, 2022, due to high crankcase pressure, September 30, 2022

#### Quality Control (IP Section 03.02) (1 Sample)

The inspectors evaluated the effectiveness of maintenance and quality control activities to ensure the following SSC remains capable of performing its intended function:

- (1) Unit 2, work order (WO) C93799039 and WO C93799058, 2RV-200 and 2RV-201 pressurizer safety relief valve replacements, September 20, 2022

### 71111.13 - Maintenance Risk Assessments and Emergent Work Control

#### Risk Assessment and Management (IP Section 03.01) (4 Samples)

The inspectors evaluated the accuracy and completeness of risk assessments for the following planned and emergent work activities to ensure configuration changes and appropriate work controls were addressed:

- (1) Unit 1, elevated risk condition due to 13 high pressure safety injection pump out of service for maintenance, July 7, 2022
- (2) Unit 2, elevated risk condition due to 22B service water heat exchanger out of service for maintenance, August 24, 2022
- (3) Units 1 and 2, elevated risk condition due to emergent steam train auxiliary feedwater flow control valve (1CV4511) failed closed to 11 steam generator with 0C EDG out of service for maintenance, August 29, 2022
- (4) Unit 2, risk informed completion time implementation due to issues with wide range nuclear instrumentation channel 'D', September 13, 2022

### 71111.15 - Operability Determinations and Functionality Assessments

#### Operability Determination or Functionality Assessment (IP Section 03.01) (7 Samples)

The inspectors evaluated the licensee's justifications and actions associated with the following operability determinations and functionality assessments:

- (1) Unit 1, AR 4514436, 12 atmospheric dump valve isolated due to cyclic partial lifting, August 2, 2022
- (2) Unit 2, AR 4516468, 2B EDG drip tray under west end full, August 30, 2022

- (3) Unit 1, AR 4506005, 1B EDG jacket water cooling leak, September 1, 2022
- (4) Unit 2, AR 4485638, pressurizer safety valves 2RV-200 and 2RV-201 seat leakage during Mode 1 operation, September 12, 2022
- (5) Unit 2, AR 4521739, wide range nuclear instrument channel 'D' momentarily failed low, September 17, 2022
- (6) Unit 1, AR 4501867, inverter 14/inverter 2 for the 120 volt alternating current system failed on high frequency, September 19, 2022
- (7) Unit 1, AR 4494041, 12 auxiliary feedwater pump inoperable due to oil ring misalignment, September 30, 2022

#### 71111.18 - Plant Modifications

##### Temporary Modifications and/or Permanent Modifications (IP Section 03.01 and/or 03.02) (1 Sample)

The inspectors evaluated the following temporary or permanent modifications:

- (1) Unit 2, ECP-22-000268, revise pressurizer relief quench tank normal operating parameters, September 8, 2022

#### 71111.19 - Post-Maintenance Testing

##### Post-Maintenance Test (IP Section 03.01) (5 Samples)

The inspectors evaluated the following post-maintenance testing activities to verify system operability and/or functionality:

- (1) Unit 2, WO C93857924, 1A2 EDG maintenance and testing, August 22, 2022
- (2) Unit 1, WO C93864931, 12B service water heat exchanger leak repair and testing, August 30, 2022
- (3) Unit 2, WO C93789435, 21 shutdown cooling heat exchanger maintenance and testing, August 30, 2022
- (4) Unit 2, WO C93799058, 2RV-201 pressurizer relief valve replacement, September 18, 2022
- (5) Unit 2, WO C93730418, 2CHGR-23 battery charger control card replacement/refurbishment, September 29, 2022

#### 71111.20 - Refueling and Other Outage Activities

##### Refueling/Other Outage (IP Section 03.01) (1 Sample)

- (1) The inspectors evaluated Unit 2 maintenance outage CC2M2201 activities from September 14, 2022 to September 21, 2022.

#### 71111.22 - Surveillance Testing

The inspectors evaluated the following surveillance testing activities to verify system operability and/or functionality:

Surveillance Tests (other) (IP Section 03.01) (2 Samples)

- (1) Unit 2, STP-O-008B-2, "Test of 2B Diesel Generator and 4kV Bus 24 Undervoltage," Revision 03600, August 16, 2022
- (2) Unit 2, STP-O-73CB-1, "'B' Train Component Cooling Pump Quarterly Test," Revision 2, August 17, 2022

FLEX Testing (IP Section 03.02) (1 Sample)

- (1) Units 1 and 2, WO C93799444, two-year maintenance of FLEX 100KW generators, and C93801791, FLEX auxiliary feedwater pumps annual maintenance, September 14, 2022

71114.06 - Drill Evaluation

Drill/Training Evolution Observation (IP Section 03.02) (1 Sample)

The inspectors evaluated:

- (1) The conduct of a simulator training evolution involving loss of condenser vacuum, reactor trip, loss of offsite power, and initiation of once through core cooling resulting in a Site Area Emergency declaration on September 27, 2022.

**RADIATION SAFETY**

71124.03 - In-Plant Airborne Radioactivity Control and Mitigation

Permanent Ventilation Systems (IP Section 03.01) (2 Samples)

The inspectors evaluated the configuration of the following permanently installed ventilation systems:

- (1) Unit 1 main vent
- (2) Unit 2 main vent

Temporary Ventilation Systems (IP Section 03.02) (2 Samples)

The inspectors evaluated the configuration of the following temporary ventilation systems:

- (1) Units 1 and Unit 2, high-efficiency particulate air (HEPA) unit on spent fuel floor during independent spent fuel storage installation welding operations
- (2) Unit 2, HEPA unit in pressurizer doghouse during replacement of pressurizer safety valves 2RV-200 and 2RV-201 during Unit 2 maintenance outage CC2M2201 in September 2022

Use of Respiratory Protection Devices (IP Section 03.03) (1 Sample)

- (1) The inspectors evaluated the licensee's use of the site's respiratory protection devices.

Self-Contained Breathing Apparatus for Emergency Use (IP Section 03.04) (1 Sample)

- (1) The inspectors evaluated the licensee's use and maintenance of the site's self-contained breathing apparatuses.

71124.04 - Occupational Dose Assessment

Source Term Characterization (IP Section 03.01) (1 Sample)

- (1) The inspectors evaluated licensee performance as it pertains to radioactive source term characterization.

External Dosimetry (IP Section 03.02) (1 Sample)

- (1) The inspectors evaluated how the licensee processes, stores, and uses external dosimetry.

Internal Dosimetry (IP Section 03.03) (3 Samples)

The inspectors evaluated the following internal dose assessments:

- (1) Whole body count from unplanned intake in March 2020
- (2) Routine whole body count from March 2021
- (3) Routine whole body count from March 2022

Special Dosimetric Situations (IP Section 03.04) (1 Sample)

The inspectors evaluated the following special dosimetric situations:

- (1) Licensee's implementation of requirements to manage radiation protection of four declared pregnant workers

**OTHER ACTIVITIES – BASELINE**

71151 - Performance Indicator Verification

The inspectors verified licensee performance indicators submittals listed below:

IE01: Unplanned Scrams per 7000 Critical Hours (IP Section 02.01) (2 Samples)

- (1) Unit 1, October 1, 2021 through June 30, 2022
- (2) Unit 2, October 1, 2021 through June 30, 2022

IE04: Unplanned Scrams with Complications (IP Section 02.03) (2 Samples)

- (1) Unit 1, October 1, 2021 through June 30, 2022
- (2) Unit 2, October 1, 2021 through June 30, 2022

MS06: Emergency AC Power Systems (IP Section 02.05) (2 Samples)

- (1) Unit 1, July 1, 2021 through June 30, 2022

- (2) Unit 2, July 1, 2021 through June 30, 2022

MS08: Heat Removal Systems (IP Section 02.07) (2 Samples)

- (1) Unit 1, July 1, 2021 through June 30, 2022
- (2) Unit 2, July 1, 2021 through June 30, 2022

OR01: Occupational Exposure Control Effectiveness (IP Section 02.15) (1 Sample)

- (1) September 2021 through August 2022

PR01: Radiological Effluent Technical Specifications/Offsite Dose Calculation Manual  
Radiological Effluent Occurrences (RETS/ODCM) Radiological Effluent Occurrences (IP Section  
02.16) (1 Sample)

- (1) September 2021 through August 2022

71152A - Annual Follow-up Problem Identification and Resolution

Annual Follow-up of Selected Issues (Section 03.03) (3 Samples)

The inspectors reviewed the licensee's implementation of its corrective action program related to the following issues:

- (1) The documentation, evaluation, disposition, and corrective actions associated with the February 2022, Unit 1, 1A EDG failure on July 22, 2022.
- (2) Review of licensee evaluation and corrective action to address Calvert Cliffs, Unit 2, automatic high reactor coolant system pressure trip.
- (3) The documentation, evaluation, disposition, and corrective actions associated with three action requests involving human performance/configuration control conditions: Unit Common, control element assembly swaps performed in improper orientation (AR 4472803, January 20, 2022); level 3 configuration control - Unit 2, 2A EDG low starting air pressure alarm received (AR 4448267, September 23, 2021); and level 3 configuration control event - Unit Common, 14 EDG fire pump (AR 4441204, August 17, 2021), on August 31, 2022.

71153 - Follow-Up of Events and Notices of Enforcement Discretion

Personnel Performance (IP Section 03.03) (1 Sample)

- (1) The inspectors evaluated the Unit 2, AR 4522477, inadvertent safety injection actuation signal during cooldown to Mode 5 for maintenance outage CC2M2201 and licensee's performance on September 14, 2022.

## INSPECTION RESULTS

Failure to Prevent Introduction of Foreign Material into Emergency Diesel Generator			
Cornerstone	Significance	Cross-Cutting Aspect	Report Section
Mitigating Systems	Preliminary White AV 05000317/2022003-01 Open EA-22-089	[H.12] - Avoid Complacency	71152A
<p>The inspectors identified a finding and apparent violation of Calvert Cliffs Unit 1 Technical Specification 5.4.1, "Procedures," as covered in Regulatory Guide 1.33, and implemented by site procedure MA-AA-716-008, "Foreign Material Exclusion Program," for not adequately implementing foreign material exclusion (FME) practices. Specifically, Constellation failed to prevent the introduction of foreign material into the 1A emergency diesel generator (EDG) that led to an EDG automatic trip and consequential failure on February 20, 2022, during routine testing.</p>			
<p><u>Description:</u> The Calvert Cliffs Unit 1, 1A EDG is a tandem-engine Societe Alsacienne de Constructions Mecaniques de Mulhouse (SACM) EDG that consists of two diesel engines (1A1 and 1A2) connected to a common generator. During refueling outage activities, at 11:17 p.m. on February 19, 2022, the 1A EDG was slow-speed started for power factor testing. The EDG breaker was closed at 11:32 p.m. and fully loaded at 00:05 a.m. on February 20, 2022. At approximately 01:02 a.m., the 1A EDG step-changed load from 5.2 to 4.8 Mwe and then ramped back to 5.2 Mwe. Two minutes later, the 1A1 engine alarmed for high exhaust gas temperature and, two minutes after that, the 1A EDG tripped on 1A1 engine high crankcase pressure. Large amounts of lube oil were reported coming from a 1A1 engine block relief valve as well as smoke from the engine.</p> <p>Constellation borescoped the 1A1 engine and identified damage to the 1A1 engine 3A cylinder including a melted piston. Lube oil sump sample results showed elevated levels of aluminum and iron, presumably from scuffing of the 3A piston head and cylinder liner. SACM EDG melted pistons are historically due to insufficient piston cooling or inadequate fuel delivery. The 1A1 engine 3A fuel injector was removed and failed an as-found pressure calibration test. It also exhibited a poor spray pattern during a pressure pop test. Constellation disassembled the injector and discovered three pieces of foreign material within the injector nozzle. The 1A1 EDG 3A cylinder and injector were replaced and the EDG was returned to service and declared operable on February 24, 2022, at 4:58 p.m.</p> <p>Following repairs and returning the 1A EDG to service, Constellation performed a Corrective Action Program Evaluation (CAPE), as documented in AR 4479267 on the event. Constellation determined that foreign material was the direct cause as it was directly responsible for the improper fuel injector spray into the EDG cylinder. Constellation submitted the foreign material for laboratory analyses where it was determined the foreign material was ethylene propylene diene monomer, a rubber O-ring-like material that is not germane to, nor compatible with, the EDG fuel oil system. Constellation also concluded that the foreign material was introduced at some point when the system was disassembled, either during manufacturing, shipping, or maintenance. FME program practices and parts/vendor quality were considered plausible causes. However, Constellation did not specifically identify any program gaps in those areas based on their review as documented in the CAPE.</p>			

The inspectors conducted interviews and reviewed the CAPE, work orders and procedures to include MA-AA-716-008, "Foreign Material Exclusion Program," Revision 14. They noted that while the station unanimously concluded in the CAPE that the foreign material was introduced during manufacturing, shipping or maintenance activities and documented that these were plausible causes, the station did not identify a most probable cause nor perform the associated risk assessment and other relevant corrective action program-driven processes given the uncertainty of a probable cause. The inspectors determined the CAPE lacked rigor in investigating station maintenance and foreign material practices. Further, the inspectors found no credible information or evidence to suggest the foreign material was introduced via shipping or manufacturing given the components for the 3A cylinder (fuel pump, gooseneck, fuel injector) were installed since at least the year 2000. This also supported the inspectors' conclusion that it was unlikely the foreign material (ethylene propylene diene monomer rubber) would have existed in the high pressure, fuel oil environment for an extended period of time and foreign material introduction reasonably occurred during a maintenance outage when the system was opened. The inspectors noted Constellation's conclusion was that the foreign material was likely introduced at some point between the 3A fuel injection pump and injector nozzle because the size of the foreign material was too large to pass through the tight clearances within the fuel injection pump if the foreign material had been introduced to the fuel oil system upstream of the 3A fuel injector pump. The inspectors identified that the last 1A EDG maintenance window, specific to the 1A1 engine 3A cylinder, occurred in August 2020, and was the most likely opportunity for foreign material to be introduced and detected. This was based on consideration that the fuel line between the 3A fuel injection pump and fuel injector was disassembled for shop testing at that time, thereby creating the most recent opportunity for foreign material introduction. Additionally, Constellation was not able to provide the inspectors documentation regarding FME closeout activities that would have occurred during the August 2020 maintenance activities.

Corrective Actions: Constellation replaced the 1A EDG 3A cylinder and fuel injector (including other damaged components) and returned the EDG to service and declared it operable on February 24, 2022, at 4:58 p.m. Constellation also completed a prompt investigation and a CAPE under AR 4479267 in April 2022.

Corrective Action References: ARs 4479267 and 4518072

Performance Assessment:

Performance Deficiency: MA-AA-716-008, "Foreign Material Exclusion Program," Revision 14, as stated in step 1.1, provides the requirements to maintain FME integrity by preventing the introduction of foreign material into systems, structures, and components. Step 1.5 establishes that its attachments govern the specific steps necessary to establish and maintain FME areas to prevent foreign material intrusion. Step 4.5.1 establishes FME Zone 2 for standard risk work activities. Attachment 5 provides the FME requirements and implementation. The inspectors determined inadequate FME work practices and controls allowed introduction of foreign material without detection into the 1A EDG during previous maintenance activities, likely during August 2020 EDG maintenance outage, and were within Constellation's ability to foresee and correct, should have been prevented, and was a performance deficiency.

Screening: The inspectors determined the performance deficiency was more than minor because it was associated with the Equipment Performance attribute of the Mitigating Systems cornerstone and adversely affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent

undesirable consequences. Specifically, the failure to prevent the introduction of foreign material resulted in the 1A1 engine 3A piston damage and mechanical failure of the 1A EDG.

Significance: The inspectors reviewed Inspection Manual Chapter (IMC) 0609, Attachment 4, "Initial Characterization of Findings," and determined the finding affects the Mitigating System cornerstone. Although the finding was self-revealed during a refueling outage, the risk was best represented by assessing the significance of the finding using IMC 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power." Inspectors used IMC 0609, Exhibit 2, for Mitigating Systems and determined a Detailed Risk Evaluation (DRE) was required since the finding was a deficiency affecting the design or qualification of a mitigating system, structure, and component that did not maintain its probabilistic risk assessment (PRA) functionality, and the degraded condition represented a loss of the PRA function of one train of a multi-train technical specification system for greater than its technical specification allowed outage time.

A Region I Senior Reactor Analyst (SRA) performed a DRE. The finding was preliminarily determined to be of low-to-moderate safety significance (White). The risk important core damage sequences were dominated by internal events and loss of offsite power events. The dominant sequences involved loss of offsite power events with failure of both EDGs (or variations of common cause failure), failure to align the 0C station blackout EDG to supply power to the safety busses, failure to recover an EDG / declare extended loss of AC power, and subsequent failure to recover offsite power leading to core damage. Fire (external events) was also a major contributor and dominated by scenarios associated with fires in the 45' level switchgear room (fire area 430). See Attachment, "1A EDG Failure Detailed Risk Evaluation," for a detailed review of the quantitative and qualitative criteria considered in the preliminary risk determination.

Cross-Cutting Aspect: H.12 - Avoid Complacency: Individuals recognize and plan for the possibility of mistakes, latent issues, and inherent risk, even while expecting successful outcomes. Individuals implement appropriate error reduction tools. Specifically, Constellation did not implement appropriate error reduction tools to prevent the introduction of foreign material into the 1A EDG fuel oil system.

Enforcement:

Violation: Calvert Cliffs Unit 1, Technical Specification 5.4.1, "Procedures," requires, in part, that written procedures shall be established, implemented, and maintained as covered in Regulatory Guide 1.33, Revision 2, Appendix A, February 1978. Regulatory Guide 1.33, section 9, covers procedures for performing maintenance that can affect the performance of safety-related equipment and states it should be properly pre-planned and performed in accordance with written procedures, documented instructions, or drawings. Procedure MA-AA-716-008, "Foreign Material Exclusion Program," Revision 14, as stated in step 1.1, is to provide the requirements to maintaining FME integrity by preventing the introduction of foreign material into systems, structures, and components. Further, step 1.5 establishes that its attachments govern the specific steps necessary to establish and maintain FME areas to prevent foreign material intrusion and step 4.5.1 establishes FME Zone 2 for standard risk work activities such as would be applicable to the EDG maintenance performed in August 2020.

Contrary to the this, Constellation failed to implement adequate FME procedure and practices such that during prior EDG maintenance on the 1A EDG, likely during the most recent maintenance activity in August 2020, foreign material was introduced in the 1A EDG fuel oil

system and remained undetected. Consequently, on February 20, 2022, the 1A EDG experienced a 1A1 engine, 3A cylinder failure and tripped during surveillance testing.

Enforcement Action: This violation is being treated as an apparent violation pending a final significance (enforcement) determination.

Observation: Review of Licensee Evaluation and Corrective Action to Address the January 22, 2022, Unit 2 Automatic High Reactor Coolant System Pressure Trip, September 23, 2022	71152A
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On January 3, 2022, a ground fault on a switchyard transformer feeder breaker and the resulting electrical grid frequency transient caused Unit 2 turbine speed to rise. The turbine control system sensed a turbine overspeed and closed the turbine control valves and intercept valves. As a result, the reactor coolant system heated up, causing high reactor coolant system pressure and an automatic reactor trip [LER 05000318/2022001 (Agencywide Documents Access and Management System (ADAMS) ML22063A703)]. Constellation subsequently determined the cause was a misconfigured megawatt transducer circuit, which activated the load drop anticipator function of the turbine control system at a lower turbine speed than designed.

The inspectors selected this issue as an annual sample for focused problem identification and resolution review, because the event was an unintended consequence of a 2017 plant modification (upgrade to digital turbine control system), and the extent-of-condition was unknown. Inspectors interviewed plant staff and reviewed issue documentation and prioritization, causal evaluation, corrective actions, and assessment of the extent-of-condition (AR 4469662).

The root cause evaluation included a 5-year extent-of-condition review of plant modifications and developed immediate and long-term corrective actions. Constellation identified no similar deficiencies through their plant modification review and determined no other Constellation plants were susceptible to the same turbine control system configuration issue. While not the root cause, engineers informed the inspectors that assignment 4469662-36 was initiated to verify appropriate measures have been implemented to mitigate the occurrence of environment-induced switchyard faults at Calvert Cliffs. Constellation's evaluation and corrective actions included case study seminars on lessons learned from this event.

The NRC inspectors did not identify any findings or violations of more than minor significance.

Observation: 1A Emergency Diesel Generator Failure to Run in February 2022	71152A
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On February 20, 2022, during power factor testing, the 1A EDG tripped on high crankcase pressure. During troubleshooting, Constellation identified foreign material in the 3A cylinder of the 1A1 engine that damaged the 3A cylinder piston. Following repairs and returning the 1A EDG to service, Constellation performed a CAPE (AR 4479267) on the event. Inspectors reviewed this CAPE in accordance with IP 71152 and developed the following observations in the areas of determination of cause and corrective actions.

Determination of Cause

1) Inspectors determined that Constellation had not followed its CAPE process when they determined the event's direct cause (foreign material) but not an apparent or probable cause.

The inspectors noted the CAPE charter directed staff to “determine the apparent cause.” Additionally, as documented in the CAPE, the station unanimously concluded that the foreign material was introduced during manufacturing, shipping or maintenance and documented that these were plausible causes. However, the station did not choose the most probable cause and perform the associated risk assessment and other corrective action program-driven processes as required by PI-AA-125-1003, “Corrective Action Program Evaluation Manual,” step 4.4.1.5.

2) Constellation’s CAPE and FME guidance documents direct the generation of an issue report for a newly discovered condition adverse to quality (CAQ) and drive efforts to identify where it originated. (PI-AA-125-1003, step 4.1.2 and MA-AA-716-008, “FME Program,” Attachment 5, “FME Requirements & Implementation,” step 1.1.25 and Attachment 9, “Recovery from a Loss of FME Integrity,” step 1.8.) While Constellation determined the 1A EDG failure was a CAQ and captured this in their corrective action program, the presence of foreign material and loss of FME integrity was also a CAQ and should have been captured in their corrective action program.

3) Constellation’s Maintenance Rule 10 CFR 50.65(a)(1) evaluation determined that “this failure was not caused by not performing preventative maintenance activities as planned and was not caused by incorrect implementation of maintenance. It was also not caused by inadequate preventative maintenance. Therefore, the system should stay (a)(2).” The inspectors determined Constellation’s basis for these statements conflicted with its CAPE statements that maintenance was a plausible cause and “the unanimous conclusion is that this foreign material was introduced at some point when the system was disassembled either during shipping, maintenance, or manufacturing.”

#### Corrective actions

1) The inspectors noted that the only CAPE-documented corrective action was the 1A EDG repair. Given the station did not identify an apparent or probable cause per corrective action program guidance, as previously discussed, the inspectors determined that corrective actions in the areas of shipping, maintenance, or manufacturing were warranted for consideration or further evaluation.

2) Inspectors noted the lack of corrective actions for foreign material controls despite the likelihood that this barrier would have prevented foreign material introduction. The inspectors further noted an absence of actions to critically assess or alter the station’s FME program in a comprehensive manner. Considering this foreign material event and the Spent Fuel Pool breaker foreign material event in November 2021 (as documented in Inspection Report 05000317;318/2022002), and the associated consequences, the CAPE was a missed opportunity to reflect on the FME program.

Constellation initiated a root cause analysis under AR 4518072 to re-examine the EDG failure, the foreign material issue, and NRC observations on Constellation’s CAPE. The results of the EDG failure are documented in the Results section of this report. The inspectors determined these observations did not constitute separate, more than minor performance deficiencies in addition to the Apparent Violation documented in the Results section.

Observation: Review of Evaluations and Corrective Actions in Response to Three Human Performance/Configuration Control Related Conditions	71152A
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The inspector reviewed Constellation's evaluations and corrective actions in response to three human performance/configuration control related conditions.

Two of the three Level 3 configuration control action requests (AR 4448267 and AR 4441204) involved conditions where maintenance personnel interfaced with Operations to complete their assigned tasks. AR 4448267 contained 33 corrective actions, five of which were assigned to Operations. These five corrective actions were to perform cross functional observations of maintenance-related activities. AR 4441204 contained 17 corrective actions, none of which were assigned to Operations. While shortfalls in maintenance personnel's use of human performance tools were direct contributors to the conditions, the identification and documentation of corrective actions that were appropriately focused to correct the problem, which were associated with Operations, were limited. However, Operations did initiate some corrective actions, which were not directly linked to the initiating action requests. The corrective actions associated with the remaining human performance event (AR 4472803) were reviewed for completeness and did not interface with Operations.

The inspector reviewed the remedial training and actions associated with each of the three events. Additionally, dynamic learning activities, out-of-the-box evaluations, and oral boards for maintenance personnel were also reviewed. Multiple maintenance groups which included technicians, lead technicians, and first-line supervisors were interviewed to review the applicable conditions.

The NRC inspectors did not identify any findings or violations of more than minor significance.

## **EXIT MEETINGS AND DEBRIEFS**

The inspectors verified no proprietary information was retained or documented in this report.

- On September 16, 2022, the inspectors presented the in-plant airborne radioactivity control and mitigation and occupational dose assessment inspection results to Patrick Navin, Site Vice President, and other members of the licensee staff.
- On October 12, 2022, the inspectors presented the integrated inspection results to Patrick Navin, Site Vice President, and other members of the licensee staff.

## DOCUMENTS REVIEWED

Inspection Procedure	Type	Designation	Description or Title	Revision or Date
71111.04	Procedures	OI-32A	Auxiliary Feedwater System	04400
71111.06	Work Orders	C93791738		
71111.11Q	Procedures	NEOP-23	Technical Data Book	38
		OP-3-2	Normal Power Operation	5700
71111.12	Miscellaneous	Purchase Order 816876	Valve, Safety Relief, Dresser Industries Consolidated, Closed Bonnet Maxiflow, 2 1/2 Inch Safety Valve	
		ST-M-002-2	Pressurizer Safety Valves Setpoint Adjustment	03/26/2021
	Work Orders	C93799039	Replace 2RV200	
		C93799058	Replace 2RV201	
71111.20	Procedures	NEOP-302	Estimated Critical Condition	00902
		OP-1-2	Plant Startup from Cold Shutdown	03400
		OP-2-2	Plant Startup from Hot Standby to Minimum Load	04900
71111.22	Procedures	OI-21A-2	2A Diesel Generator	03100
		OI-21B-2	2A Diesel Generator	03000
71152A	Corrective Action Documents	04469629		
		04469633		
		04469662		
		04469872		
		04469922		
		04469968		
		04473144		
		04474017		
	Corrective Action Documents Resulting from Inspection	4505246*		
		4510614*		
		4512132*		
		4512180*		
		4512183*		
71152A	Engineering Changes Changes	ECP-15-00566	Ovation Digital Control System	Revision 0
		ECP-22-00002	U2 TCS Tuning Change for F(X) TCS1942 on CBS 3/402	Revision 0
		SR 0197	Unit 2 Main Turbine Control System Requirements Document	Revision 0

Inspection Procedure	Type	Designation	Description or Title	Revision or Date
	Engineering Evaluations	CA-SDP-005	SDP Analysis of February 2022 1A Diesel Generator Failure	Revision 0
	Miscellaneous	IEEE Std C37.017-2020	IEEE Standard for Bushings for High-Voltage (Over 1000 Vac) Circuit Breakers and Gas-Insulated Switchgear	Revision 0
		IEEE Std C37.100.1-2018	IEEE Standard for Common Requirements for High-Voltage Power Switchgear Rated Above 1000 V	Revision 0
		PWROG-18042-NP	FLEX Equipment Data Collection and Analysis, February 2022	Revision 1
		UFSAR 7.4.7.2	Unit 2 Turbine Control System	Revision 50
	Work Orders	C93612354		

## ATTACHMENT: 1A EDG FAILURE DETAILED RISK EVALUATION

The SRA evaluated the finding using the Calvert Cliffs Standardized Plant Analysis Risk (SPAR) model, version 8.80, and System Analysis Program for Hands-On Integrated Reliability Evaluations (SAPHIRE), version 8.2.6. This model incorporates the most recent 2020 failure probability and initiating event data, incorporates internal events all-hazards, and models post-Fukushima diverse and flexible coping strategies (i.e., FLEX). The SPAR model was not used to evaluate the fire risk.

### Summary of Significance Determination:

#### a. Screening and Detailed Risk Evaluation (DRE), Logic Process, and Results

The inspectors evaluated the finding in accordance with IMC 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power," Exhibit 2. The inspectors concluded the finding required a DRE because 1A EDG was determined not to be able to perform its 24-hour PRA function for greater than its technical specification allowed outage time. The DRE results indicate the finding has a preliminary White safety significance.

#### b. Influential Assumptions

- Though the high crankcase pressure trip would be bypassed during an emergency start signal, the EDG would not continue to run for its mission time based on observed damage.
- The 1A EDG was not recoverable based on observed sustained damage.
- The assumed exposure time for 1A EDG functionality was based upon successful operation of the EDG for a mission time of 24 hours. Calculation of the exposure time (179 days; 161 days at-power, 18 days shutdown) was determined by summing the past successful run times. The basis for this approach was the assumption that the foreign material interfering with the fuel oil stream in the 3A fuel injector, resulting in a high cylinder temperature and subsequent piston melting, was highly run time dependent.
- The assumed exposure time for 1A EDG functionality was 179 days for Unit 2.
- Consistent with the above assumption, offsite power non-recovery probabilities were adjusted for each run segment to reflect the duration of successful EDG operation over the past 24-hour runtime. Appropriate SPAR model changes were made with the assistance of the Idaho National Laboratory staff.
- SPAR model adjustments of EDG common cause failure (CCF) probability were left unchanged. All station EDGs (and 0C station blackout EDG) are controlled under the same maintenance staff / FME program.
- The 1A EDG and 0C EDG are SACM EDGs with aluminum pistons. The other EDGs (1B, 2A, and 2B) are Fairbanks Morse EDGs and considered susceptible to foreign material induced damage, though under potentially different failure phenomena.

#### Exposure Time

The SRA reviewed Constellation's evaluation (AR 04479267) which documented the 1A EDG timeline and response during the event. It also included descriptions of the engine damage, the repairs/replacements made over the 6-day repair window, troubleshooting of the cause and analysis of the foreign material identified in the fuel injector line nozzle to cylinder 3A. Three pieces of foreign material, determined to be similar to an organic O-ring type material (ethylene propylene diene monomer), were identified as the cause of the issue. This material is not used in fuel oil systems. The material had lodged in the injector nozzle ports causing an improper spray resulting in overheating the cylinder and melting of the aluminum piston. Calvert Cliffs experienced a similar issue (melted piston) in 2007. Based on the 2007

experience, Calvert Cliffs learned SACM diesels have a low margin between piston operating temperature and the melting point of aluminum. The 0C and 1A EDGs are SACM air-cooled and have aluminum-crowned piston heads. The Fairbanks Morse EDGs (1B, 2A, 2B) do not have aluminum-crowned pistons and are not susceptible to the same failure as exhibited by the FM in the 1A EDG.

It was determined by inspection that the most probable cause of the foreign material introduction was during a maintenance outage window in August 2020. Based on the ethylene propylene diene monomer material found and its as-found appearance of expansion from exposure to fuel oil, the SRA considered the degradation mechanism to be primarily dormant while in standby and active when high pressure fuel oil was agitating and exposing the ethylene propylene diene monomer rubber. The exposure time was best represented from engine failure (2/20/2022) back to when it could operate for its PRA mission time (i.e., 24 hours) (8/30/21). This was consistent with Risk Assessment Standardized Project (RASP) Volume I, Section 2.5, "Exposure Time for Component Run Failures," example A.

The EDGs at Calvert Cliffs are operated approximately 3 hours every 30 days. A review of plant computer logs and information from the licensee identified the exposure to lead back to August 30, 2021, as the time when the 24-hour mission time would have been satisfied. Unit 1 entered a refueling outage and entered Mode 4 on February 7, 2022. Unit 1 exposure was broken into two operating modes, at-power (8/30/21 – 2/7/22, ~161 days) evaluated under IMC 0609, Appendix A, using SAPHIRE and shutdown (2/7/22 – 2/24/22, ~18 days) evaluated under IMC 0609, Appendix G. The shutdown evaluation period ended when the 1A EDG became functional on February 24, 2022, and included the 4-day repair time. Unit 2 risk was evaluated from the approximately 24-hour success until 1A EDG was functional (8/30/21 – 2/24/22, 179 days).

#### SPAR Model Modifications

Consistent with RASP, Volume 1, for Component Run Failures, the SRA modified the Unit 1 SPAR model to account for the successful EDG run times by revising the offsite power non-recovery probabilities and was developed in consultation with Idaho National Laboratory. The method used involved convolution and maintained the potential for random EDG failures during the 24-hour mission time.

Model adjustments were made to account for diminished decay heat following successful EDG operation. With decay heat rates lowering with time after shutdown there are lower demands on mitigating equipment over time. To partially account for this condition, SPAR model post-processing rules were written for each interval between surveillance test runs. The rules were invoked for the dominant sequences which included offsite power non-recovery events at 1 hour, 2 hours, 4 hours, and 6 hours.

The 1A EDG surveillance tests completed prior to the February 20 failure, were broken into exposure time intervals. These intervals were then added up until the 24-hour mission time was met. For exposure Interval 1, 1A EDG was assumed to operate for 1.8 hours and then fail. Recovery rules and fault tree logic modifications were made to credit this 1.8 hour of operation. Separate change in core damage frequency ( $\Delta$ CDF) risk calculations were performed for all the eight intervals, comprising the cumulative exposure time back to when 1A EDG would have been capable of completing its 24-hour mission time (8/30/21). Each of these exposure intervals had revised basic events, rules written to reflect adjustments to offsite power non-recovery, and fault tree revisions. This was incorporated in sensitivity Case 4 and the best estimate cases.

**Table 1:** (At-Power) 1A EDG Run Time Intervals for Calculated 24-hour Mission Time

Interval	Dates	Duration (days)	Runtime (hours)	Cumulative run time (hours)
1	2/7/22 to 1/25/22	12.72	1.82	1.82
2	1/25/22 to 12/20/21	36.04	3.1	4.92
3	12/20/21 to 11/23/21	27.04	3.0	7.92
4	11/23/21 to 10/31/21	23.05	3.6	11.52
5	10/31/21 to 10/25/21	5.96	3.1	14.62
6	10/25/21 to 9/25/21	30.36	3.5	18.12
7	9/25/21 to 9/24/21	0.1	3.5	21.62
8	9/24/21 to 8/30/21	25.42	0.3	21.92
9	8/30/21	N/A	3.0	24.92

**Common Cause Failure Assumption**

The Calvert Cliff EDGs are of two types, 0C and 1A are SACM air-cooled and the remaining (1B, 2A, 2B) are water-cooled Fairbanks Morse (FBM). The SPAR model has four common cause control groups (CCCGs), and SAPHIRE uses the alpha factor method to automatically adjust CCF factors depending on the number and type of failures of components in each CCCG. Below is a summary of the version 8.80 model CCCGs and their nominal and values for 1A EDG fail-to-run (FTR) set to TRUE, including parameters used by the SRA for Sensitivity Case 1:

**Table 2:** CCCGs and CCF factors Related to EDGs in Calvert Cliffs SPAR Model 8.80

Group	Description	Nominal Value	CCF Value with 1A EDG Failed to Run	Sensitivity Case 1 (Only SACM EDGs)
CCCG1 FR1AB	Unit 1 EDGs Only (1 SACM, 1 FBM)	3.696E-04	1.380E-02	3.696E-04
CCCG2 FR1AB0C	Unit 1 EDGs + 0C (2 SACM, 1 FBM)	1.049E-04	3.914E-03	1.049E-04
CCCG3 FR1A0C	SACM EDGs Only (1A, 0C)	3.696E-04	1.380E-02	1.380E-02
CCCG4 ALL5FR	Unit 1 & 2 EDGs + 0C (2 SACM, 3 FBM)	1.357E-05	5.064E-04	1.357E-05

RASP, Volume I, Section 5.2, provides CCF Ground Rules and suggests that if the performance deficiency results in a failure of a component in the CCCG and that observed failure has the potential for CCF then it should be allowed to propagate through the CCF logic unmodified. The SRAs conducted a sensitivity (Case 1) as a point estimate to assess the risk impact comparable to Constellation's estimate (only SACM EDG CCF increase) and to provide a range with respect to CCF impact.

**FLEX Credit, Nominal x3 versus PWROG Failure Data (Case 2 / 3)**

When FLEX credit was appropriate and applied, it was toggled via a change set and increased by a factor of three to account for the quality of the failure data (Case 2). In 2022, the NRC received, and reviewed, FLEX failure information provided by the pressurized water reactor owners group (PWROG) documented in report PWROG-18042-NP, Revision 1, "FLEX Equipment Data Collection and Analysis" (NRC ADAMS Accession

ML22123A259). This failure information updated failure to 'start' and 'run' for various FLEX related equipment and was incorporated into a separate change set (Case 3). This data does not have information for 'load run' failure probabilities. The SRAs used the default x3 SPAR nominal values for these basic events.

c. Internal Risk Calculation

Unit 1 At-Power Internal Risk

The base case was set for each interval consistent with each case (FLEX and/or offsite power adjustments). For the condition case EPS-DGN-1A-FR was set TRUE for 161 days.

Main Case\* - 1A FTR / Full CCF / No FLEX / No Offsite Power Adjustment (Ref Point)

Sensitivity Case 1\* – CCF increase only for SACM EDGs

Sensitivity Case 2\* – FLEX Credit with x3 nominal probabilities

Sensitivity Case 3\* – FLEX Credit with PWROG failure data

Sensitivity Case 4\* – Offsite Power Non-Recovery Adjustment for EDG runtime

Best Estimate – 1A EDG FTR / Full CCF / FLEX PWROG / Offsite Power Adjustment

Best Estimate / Sens 1 – Best Estimate with Case 1 CCF

Best Estimate / Sens 2 – Best Estimate with Case 2 FLEX

**Table 3** -  $\Delta$ CDF/year for At-Power Exposure Period for Internal Events for 1A EDG FTR

Main Case*	Sens 1*	Sens 2*	Sens 3*	Sens 4*	Best Est (Table 4)	Best Est Sens 1	Best Est Sens 2
1.90E-5	1.15E-5	5.67E-6	1.44E-5	1.24E-5	<b>4.32E-6</b>	2.83E-6	2.98E-6

\* point estimates for sensitivity assessment only

**Table 4** – Best Estimate  $\Delta$ CDF/year (per Interval) for At-Power Internal Events (1A FTR)

Period No. (Runtime prior to FTR)	Duration (Days)	Base Case (per year)	Cond Case (per year)	Delta CDF (per year)	Delta CDF (per interval)
1 (1.8 hours)	12.72	1.76E-05	3.14E-05	1.38E-05	4.81E-07
2 (4.9 hours)	36.04	1.78E-05	2.90E-05	1.12E-05	1.11E-06
3 (7.9 hours)	27.04	1.79E-05	2.78E-05	9.87E-06	7.31E-07
4 (11.5 hours)	23.05	1.80E-05	2.71E-05	9.05E-06	5.72E-07
5 (14.6 hours)	5.96	1.81E-05	2.65E-05	8.35E-06	1.36E-07
6 (18.1 hours)	30.36	1.83E-05	2.63E-05	8.03E-06	6.68E-07
7 (21.6 hours)	0.1	1.84E-05	2.74E-05	8.95E-06	2.45E-09
8 (21.9 hours)	25.42	1.84E-05	2.74E-05	8.96E-06	6.24E-07

Unit 1 Shutdown Risk and Repair Interval

Unit 1 entered Mode 4 on February 7, 2022, and ended the exposure period when the EDG failed on February 20. The repair interval continued until February 24 when the 1A EDG was repaired and considered functional. For ease of calculation, this period was added to the Appendix G shutdown SDP window since Unit 1 was still in Mode 5. The issue was considered a condition finding per Appendix G, Attachment 2, section 4.4. Loss of offsite power worksheets were used with initiating event likelihood set equal to '2' for plant operating states 1 and 2. The dominant sequence was loss of offsite power, loss of emergency AC (EDGs) and failure to recover offsite power in 18 hours given unsuccessful gravity drain. The estimated shutdown risk contribution for Unit 1 was 1E-7/year (yr) for 18 days.

Unit 2 At-Power Internal Risk

Though the finding is assigned to Unit 1, the 1A EDG is modeled in Unit 2's SPAR. In accordance with RASP guidance, a screening SDP was conducted on Unit 2 to determine the limiting unit risk. The base and condition cases were established as in Unit 1, but no offsite power recovery adjustments were made. Also, exposure was set to 179 days. This screening determined that risk from this finding was bounded by Unit 1.

Unit 2: Full CCF, No FLEX (bounding case):

5%	Point Est.	Mean	95%
2.29E-07	2.72E-06	<b>2.38E-06</b>	8.79E-06

d. Dominant Cutsets

For internal events, the dominant sequences involve loss of offsite power events with failure of both EDGs (or variations of CCFs), failure to align the 0C station blackout EDG to supply power to the safety busses, failure to recover an EDG / declare extended loss of AC power and subsequent failure to recover offsite power leading to core damage.

For external events, a dominant scenario involves fires associated with the 45' level switchgear room (fire area 430). The dominant sequence involves the loss of component cooling water and failure of operators to trip reactor coolant pumps resulting in a reactor coolant pump seal loss of coolant accident.

e. Risk-Insights

Events resulting in a loss of offsite power constitute most of the risk associated with EDG operations. The Calvert Cliff units are highly cross-tied and capable of flexible alignments to support the other unit. The station does have a station blackout (0C) EDG that is credited as a backup AC power source which is very reliable and does result in a significant reduction in overall risk since it can be aligned to any of the units' safety busses. Since the 0C EDG is a SACM EDG and part of the directly affected CCGG that includes the 1A and 0C EDGs; results are sensitive to its CCF increase, and more importantly, the basic events related to its alignment and/or recovery. The flexibility of the 0C station blackout EDG alignment does affect internal risk to both units and reflected in the CCF increase when any of the EDGs fail.

f. Uncertainty and Sensitivity Studies

The SRAs evaluated sensitivities related to increases in CCFs for only the SACM EDGs versus all EDGs, FLEX credit, and the reduction of offsite power non-recovery failure as the 1A EDG culminated 24-hour runtime. All the sensitivities highlighted a reduction of risk against the main case. The results were sensitive to EDG CCF and FLEX credit based on loss of offsite power / station blackout dominant sequences. A case which included full CCF increases for each CCCG, FLEX credit using PWROG failure data, and offsite power non-recovery adjustments was considered a 'best estimate.'

CCF Sensitivity (Case 1)

Sensitivity Case 1 determined that the risk results are sensitive to CCF application. A 39 percent reduction in risk was realized by using only CCF related to the SACM EDGs. There was merit that the SACM EDGs have smaller operating margin to piston failure (as related to Fairbank Morse engines). Based on the key assumption that foreign material could impact the other EDGs in a different manner and that all engines are controlled by the same maintenance personnel, the SRAs did not incorporate this into the best estimate. The sensitivity case indicates that with the credit applied, the risk would remain White risk significance.

FLEX Sensitivity (Case 2 / 3)

Sensitivity Case 2 determined that the risk results are sensitive to FLEX credit. A 70 percent reduction in risk was indicated by the NRC default method of implementing FLEX and x3 nominal failure rates. Using failure data from the PWROG report reduced those values by 24 percent by comparison. The SRAs considered the PWROG failure data to be best available information and incorporated that data into the best estimate.

Offsite Power Non-Recovery Adjustments (Case 4)

The analyst reviewed the effect of adjusting offsite power non-recovery probabilities to reflect the duration of successful EDG operation and associated decay heat reduction. This involved model changes for each interval between surveillance test runs and applying post-processing rules for changing non-recovery probabilities for offsite power. This method resulted in a calculated decrease in the risk estimation by 35 percent, for the intervals that were sampled. This indicates a reasonable effect that this method has on calculating a best estimate risk increase due to an EDG failure to run event.

g. Contributions from External Events (Fire, Flood, and Seismic)

External fire risk was determined to be the dominant external risk contributor for this performance deficiency. High winds, tornados, hurricanes, and seismic were evaluated. Only hurricane contribution was noteworthy but minor in comparison to fire risk.

Fire Risk Contribution

The SPAR model for Calvert Cliffs does not include fire (external) events. Constellation used their Fire PRA to estimate risk for the 1A EDG FTR SDP risk evaluation. The analyst reviewed the Fire PRA results from their Fire model CC020DFire. The model included several conservatisms the licensee identified during their SDP review but did not modify the model in that further review was necessary. The dominant fire areas that contributed the most were 45' switchgear room (430) and 27' cable spreading room (306) area.

The analyst performed a sensitivity check on the two dominant fire scenarios using the SPAR model internal events as a surrogate for the events. The analyst compared this to the Calvert Cliffs fire model result cutsets for the 1A EDG failure to run. The analyst noted the resulting contribution was close to the licensee’s Fire PRA estimate for the increase in contribution due to this fire scenario. The analyst did not perform the same assessment for Unit 2.

Based on the above reviews, the analyst considered the use of the licensee’s calculated annual change in CDF, given the 1A EDG failure, to appropriately represent a conservative increase in fire risk. The annual change in CDF calculated by Constellation with their fire model was 9.86E-6/yr (Unit 1) and 4.35E-6/yr (Unit 2) for the 1A EDG failure. The conditional increase in CDF calculated by Constellation’s Fire PRA application specific model for the 1A EDG failure was applied to the unit-specific (161-day vs 179-day) exposure time and results in their estimated contribution 4.35E-6/yr (Unit 1), and 2.14E-6/yr (Unit 2).

Flooding

The analyst reviewed the Calvert Cliffs Individual Plant Examination External Events and did not consider flooding to be a significant risk contributor for this performance deficiency.

Seismic and High Winds (including Tornado and Hurricane)

The Calvert Cliffs SPAR models are an all-hazards models and can estimate seismic and high winds. Below is a summary:

Unit 1 Wind/Tor/Hur: 2E-7/yr	Unit 2 Wind/Tor/Hur: 2E-8/yr
Unit 1 Seismic: 6E-8/yr	Unit 2 Seismic: 4E-9/yr

h. Potential Risk Contribution Due to Large Early Release Frequency (LERF)

The SRA used insights from IMC 0609, Appendix H, “Containment Integrity Significance Determination Process,” to evaluate the estimated change in LERF associated with this finding. The failure of 1A EDG to meet its 24-hour mission time was classified as a Type A finding per Appendix H. The SRA screened out LERF based on SAPHIRE LERF estimation <1E-7 based zero delta CDF for events with non-zero LERF factors. However, Calvert Cliffs is a Combustion Engineering plant and hence requires a consequential steam generator tube rupture assessment per IMC 0609, Appendix H, Section 5. With guidance from NUREG-2195, the analyst estimated consequential steam generator tube rupture at Unit 1 at (3.86E-7/yr) x 161/365 = 1.7E-7/yr (for 161 days).

The SRA noted Constellation estimated LERF (Unit 1) = 3E-7/yr, and (Unit 2) = 2E-7/yr. Both NRC and licensee values are consistent with a White risk range based on ΔLERF.

i. Total Estimated Change in Core Damage Frequency (CDF) and LERF and Qualitative Risk Considerations

The ‘best estimate’ total change in **Unit 1 CDF is 7.5E-6/yr – 9.0E-6/yr, (preliminary White)**. The estimated change in **Unit 1 LERF is 1.7E-7/yr, (preliminary White)**. (Consequential Steam Generator Tube Rupture)

	Best Estimate	Best Estimate S1	Best Estimate S2
Internal Risk	4.32E-6/yr	2.83E-6/yr	2.98E-6/yr
Shutdown Risk	1.00E-7/yr	1.00E-7/yr	1.00E-7/yr
Ext. Risk from Winds	1.83E-7/yr	1.83E-7/yr	1.83E-7/yr

Ext. Risk from Seismic	6.09E-8/yr	6.09E-8/yr	6.09E-8/yr
Ext. Risk from Fire	4.35E-6/yr	4.35E-6/yr	4.35E-6/yr
Total Risk for Unit 1	<b>9.0E-6/yr</b>	<b>7.5E-6/yr</b>	<b>7.7E-6/yr</b>

- Sensitivity Case 1 used CCF increase for only the 1A/0C SACM EDGs (similar to licensee’s evaluation) and resulted in total  $\Delta$ CDF for the exposure time of **7.5E-6/yr**.
- Sensitivity Case 2 used the nominal FLEX failure probabilities multiplied by three (FLEX x3) and resulted in total change in CDF for the exposure time of **7.7E-6/yr**.
- Offsite power non-recovery adjustments were made for a partial set of dominant event tree top events (1-hour, 2-hour, 4-hour, 6-hour only). A full 24-hour offsite power non-recovery reduction was not implemented. Only the hours in the dominant sequence top events (loss of offsite power and station blackout). No other adjustments to mitigating systems to account for EDG runtime were made. Making these adjustments would lower risk estimate.
- A review of the licensee’s fire risk evaluation indicated several conservative assumptions regarding zone of influence and cable damage assumption that would further reduce the fire risk contribution.
- Unit 2 risk was evaluated and was considered over-estimated since the offsite power non-recovery adjustment was not used. Unit 2 risk was intended to be a bounding screen for unit comparison.

j. Licensee’s Risk Evaluation

Constellation modeled this event as a ‘failure to run’ of the 1A EDG and determined exposure time based on its history of past (24-hour) runtime capability, similar to the NRC, and documented their SDP evaluation of both Units 1 and 2 in CA-SDP-005, Revision 0. The licensee also used Calvert Cliffs Units 1 and 2 (National Fire Protection Association-805 Plant) Fire PRA (CC020DFire) as part of their assessment. The licensee used 160.7-day exposure for both Units 1 and 2.

Constellation made various changes within their application specific model to represent the plant alignment during the event, including other mitigating system adjustments to account for a successful 1A EDG runtime. Constellation considered CCF only between the SACM EDGs but did perform a subsequent case with CCF increase (internal risk  $\Delta$ CDF = 4E-6/yr; total risk  $\Delta$ CDF ~8E-6/yr). Also, human error probabilities for 0C station blackout EDG realignment (to alternate busses) and component cooling water heat exchanger realignments were reassessed based on additional available time gained by at least 1 hour of 1A EDG runtime. The SRA did not incorporate any specific licensee model adjustment since the SRA application of partial offsite power non-recovery adjustment was reasonably representative of the licensee adjustments. The licensee Internal Events result increase for 1 year, is as follows: Unit 1 CDF = 1.4E-6/yr; Unit 2 CDF = 9.0E-7/yr.

During fire area walkdowns the licensee identified additional conservatisms that could be adjusted in the model related to various cable routing and fire damage assumptions. These adjustments were not incorporated in the licensee’s SDP as additional follow-up and review were needed. The licensee identified them for consideration. These were entered into Calvert Cliff’s PRA configuration control database (URE-DB). The SRA considered the licensee’s fire risk result a realistic bounding estimate and incorporated the licensee’s result into the NRC’s total risk result. The licensee fire risk result increase for 1 year, Unit 1 CDF = 9E-6/yr; Unit 2 CDF = 4E-6/yr.

Seismic, wind, and LERF impacts were determined qualitatively and considered to not significantly change the findings of their result. Licensee did not assess potential shutdown risk on Unit 1.

The total increase in risk estimate (for 160.7 days) determined by licensee:  
Unit 1 CDF =  $5E-6$ /yr, LERF =  $3E-7$ /yr; Unit 2 CDF =  $2E-6$ /yr, LERF =  $2E-7$ /yr

The licensee's risk increase values are also consistent with a preliminary White safety significance.

### **Summary of Results and Impact**

The NRC's preliminary quantitative risk increase assessment (internal and external CDF contributions) for this finding was determined to be  $7.5 - 9.0E-6$ /yr, or of low-to-moderate safety significance, (preliminary White). Sensitivity analyses demonstrated a high confidence in this quantitative risk estimate. Constellation's value was calculated to be  $5E-6$ /yr (low-to-moderate safety significance). The SRAs based the final risk evaluation on Unit 1 and the exposure time assessed by the cumulative EDG run time for its 24-hour mission time.