Duke Energy®
Carolinas

DUKE ENERGY CAROLINAS, LLC
Catawba Nuclear Station
4800 Concord Road
York, SC 29745

June 4, 2012

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

Subject: Duke Energy Carolinas, LLC (Duke Energy)
Catawba Nuclear Station, Units 1 and 2
Docket Nos. 50-413 and 50-414
Licensee Event Report 413/2012-001

Pursuant to 10 CFR 50.73(a)(1) and (d), attached is Licensee Event Report 413/2012-001, Revision 0 entitled, "Unit 1 Automatic Reactor Trip Due to Faulted Reactor Coolant Pump Motor Cable Resulted in Zone G Relay Lockout and Subsequent Loss of Offsite Power and Emergency Diesel Generator Automatic Start for Both Units".

This report is being submitted in accordance with 10 CFR 50.73(a)(2)(iv)(A).

There are no regulatory commitments contained in this letter or its attachment.

This event is considered to be of no significance with respect to the health and safety of the public.

If there are any questions on this report, please contact L.J. Rudy at (803) 701-3084.

Sincerely,

George T. Hamrick

George T. Hamrick
Site Vice President

LJR/s

Attachment

IE22
NRR

xc (with attachment):

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NRC FORM 366 (10-2010) U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

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4. TITLE

Unit 1 Automatic Reactor Trip Due to Faulted Reactor Coolant Pump Motor Cable Resulted in Zone G Relay Lockout and Subsequent Loss of Offsite Power and Emergency Diesel Generator Automatic Start for Both Units

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
04	04	2012	2012	- 001	- 0	06	04	2012	Catawba Unit 2	05000414
									FACILITY NAME	DOCKET NUMBER

9. OPERATING MODE
1

10. POWER LEVEL
100%

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check all that apply)*

☐ 20.2201(b)	☐ 20.2203(a)(3)(i)	☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(vii)
☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☒ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(C)	☐ OTHER
☐ 20.2203(a)(2)(vi)	☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(D)	Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER (Include Area Code)
L.J. Rudy, Regulatory Compliance	(803) 701-3084

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
E	AB	NCPUDCLG	W120	Yes					

14. SUPPLEMENTAL REPORT EXPECTED

☒ YES (If yes, complete EXPECTED SUBMISSION DATE) ☐ NO

15. EXPECTED SUBMISSION DATE	MONTH	DAY	YEAR
	08	31	2012

16. ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)

On 04/04/12 at 2003 hours, Unit 1 tripped from 100% power following a trip of reactor coolant pump 1D. Shortly after the Unit 1 generator power circuit breakers opened, the Zone G protective relaying system unexpectedly actuated on an instantaneous underfrequency condition as a result of an error in the relay logic. This opened the switchyard breakers thereby isolating Unit 1 from the grid and resulting in a Loss of Offsite Power (LOOP). At the time of the trip, Unit 2 was in Mode 5 during its End-of-Cycle 18 Refueling Outage with both of its essential busses aligned to Unit 1 offsite power. Therefore, Unit 2's essential busses lost power as a result of the LOOP. Both emergency diesel generators (EDGs) on each unit automatically started and powered their respective essential busses as designed. A Notification of Unusual Event (NOUE) was declared as a result of the LOOP and the Catawba Emergency Response Organization was activated. Approximately five and one-half hours later, after confirming that the sources of the fault were cleared, offsite power was restored to one essential bus on each unit and the NOUE was terminated. The root causes of this event and the planned corrective actions in response to this event are described in detail in the respective sections of this LER. All plant safety related systems required to mitigate the event were operable and capable of performing their required safety related functions. These systems functioned as designed in response to this event. Therefore, the health and safety of the public were not adversely affected by this event.

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NARRATIVE

BACKGROUND

This event is being reported under the following criterion:

10 CFR 50.73(a)(2)(iv)(A), any event or condition that resulted in manual or automatic actuation of the Reactor Protection System (RPS) including: reactor scram or reactor trip; PWR auxiliary or emergency feedwater system; and emergency ac electrical power systems, including: emergency diesel generators (EDGs).

Catawba Nuclear Station Units 1 and 2 are Westinghouse four-loop Pressurized Water Reactors (PWRs) [EIIS: RCT].

Systems Description:

The Main Power System [EIIS: EL] for each Catawba nuclear unit includes the main generator [EIIS: GEN] and a switchyard [EIIS: FK] common to both nuclear units. A protective relaying network [EIIS: FK] is provided for the Main Power System for each Catawba nuclear unit. It is the function of the protective relaying to detect faults and other abnormal conditions affecting equipment in the switchyard or associated with the main generator and isolate the affected equipment from the remaining equipment while reducing to a minimum the impact of the fault or isolation on the remaining equipment. The protective relaying system is partitioned into three zones: Zones A and B for that portion of the switchyard associated with a nuclear unit and the main generator of that unit, and Zone G for the main generator itself.

Zone G encloses the main generator, generator exciter [EIIS: EXC], the generator isolated phase bus [EIIS: IPBU], neutral grounding cubicle [EIIS: None], and the main generator power circuit breakers (PCBs) [EIIS: 52]. Most of the Zone G protective relaying schemes cause the main generator PCBs to open, isolating Zone G from the other two zones. Some of the relaying schemes trip the exciter or the exciter and turbine [EIIS: TRB]. Other protective relaying schemes block the closing of the motor operated disconnects (MODs) [EIIS: MOD] for the main generator PCBs until the generator approaches operating speed, block the auto synchronizer [EIIS: None] if a potential transformer (PT) [EIIS: IPT] is lost, and trip the switchyard breakers in case of generator breaker failure or faults in the switchyard that are not cleared by switchyard relaying.

The Catawba 230kV switchyard is designed in a breaker-and-a-half scheme which allows any one of the switchyard PCBs to be isolated from the grid without deenergizing any transmission line or affecting the integrity of the switchyard. Six double-circuit transmission lines from the primary transmission system terminate in the switchyard. Additionally, each Catawba unit is tied to the 230kV switchyard by two separate and independent overhead lines. The entire switchyard, including the PCBs, cabling system, ac and dc auxiliary power systems, protective relaying system, and control system is also divided into two power trains. Additionally, the incoming transmission lines are also assigned to power trains in such a way as to separate the associated cabling, protective relaying, and controls for each circuit of the double-circuit transmission lines into two distinct sources of offsite power. The Catawba 230kV switchyard design assures the independence of the redundant offsite power feeders to each nuclear unit.

The 4160VAC Essential Auxiliary Power System [EIIS: EB] supplies power to those Class 1E loads required to safely shut down the unit following a design basis accident. This system is divided into two completely redundant and independent trains, each consisting of one 4160V switchgear assembly [EIIS: SWGR], three 4160V/600V

transformers [EIIS: XFMR], two 600V load centers [EIIS: None], and associated loads. Normally, each Class 1E 4160V switchgear is powered from its associated non-Class 1E train of the 6900VAC Normal Auxiliary Power System [EIIS: EA]. Additionally, an alternate source of power to each 4160V essential switchgear is provided from the 6900V system via two separate and independent 6900V/4160V transformers. These transformers are shared between units and provide the capability to supply an alternate source of preferred power to each unit's 4160V essential switchgear from either unit's 6900V system. A key interlock scheme is provided to preclude the possibility of connecting the two units together at either the 6900V level or the 4160V level. Each train of the 4160VAC Essential Auxiliary Power System is also provided with a separate and independent emergency diesel generator [EIIS: EK] to supply the Class 1E loads required to safely shut down the unit following a design basis accident.

The 4160VAC Blackout Auxiliary Power System [EIIS: EA] supplies power to those non-Class 1E loads that may be required following a Loss of Offsite Power (LOOP). This system consists of two separate and independent 4160V switchgear assemblies, 4160V/600V transformers, 600V load centers, and their associated loads. This system is divided into two trains, with each train normally powered from its corresponding train of the 6900VAC Normal Auxiliary Power System via a separate 6900V/4160V transformer and feeder breaker. Each 6900V/4160V transformer also serves as the normal source to its associated 4160V essential switchgear. In the event that the normal source is not available, each blackout switchgear assembly can be supplied from the emergency diesel generator through a connection with its associated 4160V essential switchgear. Upon the loss of the normal source to each 4160V blackout switchgear, all loads are shed and the associated emergency diesel generator is started and automatically connected to its 4160V essential switchgear. All essential loads required during the blackout and all loads on the blackout switchgear that are required are then sequenced onto the emergency diesel generator.

Zone G Modification Description:

In May - June 2011, during the Unit 1 End-of-Cycle 19 Refueling Outage, the protective relaying system for Zone G was replaced. A similar replacement was subsequently performed during the Unit 2 End-of-Cycle 18 Refueling Outage. The purpose of the modification was to maximize the reliability of the protective function while minimizing the likelihood of spurious actuation. The modification consisted, in part, of adding a redundant train of protective relays for each function. Within each train, the protective relays are arranged in either a one-out-of-one (1/1) or a two-out-of-two (2/2) scheme for each function. In addition, the modification added two new protective relaying functions. Of all of the functions affected by the modification, the following function is the one of importance relative to this event:

- Generator Underfrequency (81L1/L2/L3/L4/L5). This function trips the switchyard unit tie breakers, separating the turbine generator from the grid. The previous (pre-modification) protection was provided by a series of relays and timers in a stepped protective relaying scheme at various settings at different frequencies. The initial design of the revised (post-modification) protection was to incorporate a blocking scheme when the generator is not connected to the grid. However, this blocking scheme was not fully incorporated into the Zone G digital relay upgrades. The effect of this error was that during an unanticipated event such as a reactor trip, generator voltage remains above the voltage block setpoint and the underfrequency trip will actuate, isolating the nuclear unit from the switchyard. In contrast, during a planned event such as a normal reactor shutdown, generator voltage decays below the voltage blocking setpoint, preventing the undervoltage trip from actuating.

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NARRATIVE

When this event occurred on 04/04/12, Unit 1 was in Mode 1 at 100% power and Unit 2 was in Mode 5 during its End-of-Cycle 18 Refueling Outage. No structures, systems, or components were out of service that had any effect on the event.

EVENT DESCRIPTION

Date/Time Event
(Some event times are approximate.)

05/11-06/11 Zone G relay modification installed on Unit 1 during the End-of-Cycle 19 Refueling Outage.

03/12-04/12 Zone G relay modification installed on Unit 2 during the End-of-Cycle 18 Refueling Outage.

04/04/12/1943 Unit 2 entered Mode 5.

2003 EDG 1B started due to trip of reactor coolant pump 1D and opening of feeder breaker 1ATD. The opening of feeder breaker 1ATD was unexpected and was due to a breaker coordination issue. This issue was evaluated under the Catawba Corrective Action Program.

Unit 1 reactor tripped on low reactor coolant system flow. Unit 1 generator PCBs opened following the reactor trip. Zone G protective relaying system actuated on the underfrequency condition and opened the switchyard breakers, isolating Unit 1 from the grid and resulting in a LOOP on Unit 1. (At the time of the trip, Unit 2's essential busses were aligned to Unit 1 offsite power.) LOOP resulted in loss of residual heat removal and spent fuel cooling on Unit 2.

EDGs 1A, 2A, and 2B started due to LOOP.

EDGs were powering all essential busses on both units.

Turbine-driven and both motor-driven auxiliary feedwater pumps automatically started for Unit 1.

2006 Residual heat removal pump 2A was started to restore Unit 2 core cooling.

2012 Notification of Unusual Event (NOUE) was declared.

2031 Spent fuel cooling pump 2B was started to restore Unit 2 spent fuel cooling.

2045 Started raising Unit 2 reactor coolant system level. Level increased to approximately 43%.

2122 Operational Support Center (OSC) and Technical Support Center (TSC) were activated.

2232 Emergency Operations Facility (EOF) was activated.

NARRATIVE

04/05/12/0129 Offsite power was restored to Unit 1 essential bus 1ETA.

0137 Offsite power was restored to Unit 2 essential bus 2ETB.

NOUE was terminated.

0138 EDG 1A was shut down.

0143 EDG 2B was shut down.

0236 Offsite power was restored to Unit 2 essential bus 2ETA.

0245 EDG 2A was shut down.

0537 Offsite power was restored to Unit 1 essential bus 1ETB.

0541 EDG 1B was shut down.

1200 It was determined that the LOOP was caused by a Zone G relay programming error.

04/06/12/0000 Reactor coolant pump motor 1D was inspected. No damage to motor was indicated.

CAUSAL FACTORS

Separate root cause analyses were performed for the trip of reactor coolant pump 1D (the initiating event) and for the LOOP (the resultant event).

The trip of reactor coolant pump 1D occurred as a result of a phase to ground fault in the Y phase conductor for the pump motor. The fault occurred in the vicinity of the Elastimold connector. In 2000, reactor coolant pump 1D experienced a similar trip as a result of the pump motor Y phase Elastimold bushing fault to ground. This likely resulted in thermal degradation to the cable which was not replaced at that time. The cause analysis and corrective actions following that event did not sufficiently address the thermal degradation that occurred leading to the failure of the cable on 04/04/12.

The LOOP occurred as a result of inadequate design input specification and insufficient control over vendor outsourcing in conjunction with the Zone G relay modification. As a result, a critical design input was not included in the design change package or confirmed by testing. During preparation of the relay setting calculation, the blocking function for the instantaneous generator underfrequency trip was omitted. The vendor calculation check was performed as a high level review and did not identify the missing blocking function. The calculation was subsequently approved and used for relay setting and factory acceptance testing preparation. In addition to the described vendor issue, Catawba Engineering personnel did not specify all of the critical design inputs required for proper operation of the Zone G relay scheme. As a result, the design error was not detected during site review or post-modification testing.

NARRATIVE

CORRECTIVE ACTIONS

Immediate:

1. Operations entered the appropriate plant response procedures for the reactor trip on Unit 1 and the LOOP on both units.

2. Unit 1 was stabilized on natural circulation, with residual heat removal via auxiliary feedwater and secondary side steam relief.

3. Residual heat removal core cooling was restored on Unit 2.

4. A NOUE was declared in response to the LOOP and the Emergency Response Organization was activated.

5. Spent fuel cooling was restored on both units.

Subsequent:

1. Following the restoration of offsite power, the NOUE was terminated.

2. The faulted reactor coolant pump motor cable was replaced.

3. The Zone G relay modification error was corrected on both units.

4. A modification was implemented to correct the identified breaker coordination issue.

Planned:

1. A formal station process will be developed to direct diagnostic testing of medium voltage cable and connectors on a periodic basis and following identified issues with these components.

2. Power cables and Elastimold connectors associated with reactor coolant pump and other critical pump motors will be incorporated into a more rigorous predictive monitoring program.

3. Processes associated with modification scope description, specification of critical design inputs, specification of vendor services and oversight, and checker responsibilities will be revised as appropriate.

There are no NRC commitments contained in this LER.

SAFETY ANALYSIS

Prior to the Unit 1 reactor trip, all safety systems were in their normal standby readiness alignments. As a result of the shorted Y-phase cable on reactor coolant pump motor 1D, Unit 1 tripped on low reactor coolant system flow (P-8 permissive). The reactor protection system functioned as designed to trip the reactor within the required response time and all control rods inserted normally. The main turbine tripped as designed following the reactor

trip. Safety injection was not required and did not actuate. Main feedwater was isolated as designed on the reactor trip signal coincident with reactor coolant system average temperature ≤ 564°F. Neither main steam line isolation nor containment isolation was required. Ice condenser actuation was not required. The containment spray system was not required to be actuated. All four EDGs (1A, 1B, 2A, and 2B) started as designed on the blackout logic actuation and energized their respective load groups. (EDG 1B started prior to the other three EDGs due to the trip of reactor coolant pump 1D and the opening of feeder breaker 1ATD.) Offsite power 2A remained available throughout the event. Following the reactor trip, pressurizer power operated relief valve (PORV) 1NC34A cycled four times. The valve was determined to have exhibited acceptable performance. The pressurizer code safety valves were not required to actuate. All four steam generator PORVs (1SV1, 1SV7, 1SV13, and 1SV19) lifted in response to the transient. 1SV1 and 1SV13 were initially determined to have exhibited sluggish response. Nevertheless, core cooling was effectively established via natural circulation. One steam generator code safety valve (1SV14) lifted a total of nine times due to the sluggish PORV response. Subsequent troubleshooting revealed no problems with 1SV1. The valve appeared to have several slow strokes at the onset of the event, but stroked as expected over 200 times beyond the initial strokes. 1SV13's sluggish response was attributed to a solenoid valve porting air incorrectly in two directions. This condition was subsequently corrected. Both main feedwater pumps tripped and the auxiliary feedwater pumps (both motor-driven pumps and the single turbine-driven pump) automatically started in response to this event. The following items were noted during the nuclear safety assessment of the reactor trip:

- Reactor coolant system pressure remained above the setpoint for automatic safety injection actuation.
- Reactor coolant system pressure remained below the setpoint for pressurizer code safety valve actuation.
- Reactor coolant system temperature did not decrease more than 100°F in a one-hour period following the transient initiation (Technical Specification limit).
- Reactor coolant was contained within the reactor coolant system and the pressurizer relief tank.
- Pressurizer level remained on scale.
- The transient response was bounded by the Updated Final Safety Analysis Report (UFSAR) analyses.

When this event occurred, Unit 2 was in Mode 5 during its End-of-Cycle 18 Refueling Outage. As a result of this event, residual heat removal and spent fuel cooling were briefly lost. Residual heat removal capability was restored in approximately three minutes following the LOOP. Spent fuel cooling capability was restored in approximately 28 minutes following the LOOP. There was no significant impact to Unit 2 as a result of this event.

During this event, the Standby Shutdown System (SSS) diesel generator experienced a low voltage condition after it was started. The cause of the low voltage condition was traced back to a latent design error which occurred during the original plant design. This error resulted in a condition where the diesel generator's power factor controller was not disabled during isochronous operation (i.e., separated from the grid). The SSS is designed to mitigate the consequences of certain postulated fire, security, and station blackout incidents by providing the capability to maintain Mode 3 conditions and by controlling and monitoring vital systems from locations external to the main control room. The SSS is not required to function in order to mitigate design basis events analyzed in Chapter 15 of the Catawba UFSAR. Therefore, the issue with the SSS diesel generator had no impact upon the ability to mitigate the LOOP event (a UFSAR Chapter 15 analyzed event), since the EDGs started and operated to supply power to the essential busses. The SSS diesel generator low voltage condition does not constitute a reportable event in itself; however, it is discussed in this LER for completeness. A separate root cause analysis is currently being performed for this issue.

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NARRATIVE

The probabilistic risk analysis information related to this event will be submitted to the NRC in a supplement to this LER.

This event did not affect the health and safety of the public.

ADDITIONAL INFORMATION

Within the previous three years, there have been no other reactor trip events or LOOP events. In addition, there have been no other LER events attributed to similar root causes. Therefore, this event is considered to be non-recurring.

Energy Industry Identification System (EIIS) codes are identified in the text as [EIIS: XX]. This event is considered reportable to the Equipment Performance and Information Exchange (EPIX) program.

This event is not considered to constitute a Safety System Functional Failure. There was no release of radioactive material, radiation overexposure, or personnel injury associated with the event described in this LER.