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March 8, 2010

L-10-045

10 CFR 50.90

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001**SUBJECT:**

Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
Response to Request for Additional Information on the ASTRUM Best-Estimate
Large-Break Loss of Coolant Accident (LOCA) Methodology License Amendment Request
(TAC No. ME1776)

By correspondence dated July 6, 2009 (Accession No. ML091890844), FirstEnergy Nuclear Operating Company (FENOC) submitted an amendment request to revise Technical Specification 5.6.3, "Core Operating Limits Report," to allow use of the generically approved report, WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment Of Uncertainty Method (ASTRUM)."

By correspondence dated January 26, 2010, the Nuclear Regulatory Commission (NRC) staff requested additional information to complete its review of the amendment request. The attachment provides responses to the NRC staff's requests.

There are no regulatory commitments contained in this submittal. If there are any questions or additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at (330) 761-6071.

I declare under penalty of perjury that the foregoing is true and correct. Executed on March 8, 2010.

Sincerely,



Paul A. Harden

Attachment:

Response to January 26, 2010 Request for Additional Information - License Amendment
Request for ASTRUM Best-Estimate Large-Break Loss-of-Coolant Accident (LOCA) Methodology

cc: NRC Region I Administrator
NRC Resident Inspector
NRC Project Manager
Director BRP/DEP
Site Representative (BRP/DEP)

A001
NRR

Response to January 26, 2010 Request for Additional Information
License Amendment Request for ASTRUM Best-Estimate Large-Break
Loss-of-Coolant Accident (LOCA) Methodology
Page 1 of 9

By letter dated July 6, 2009, FirstEnergy Nuclear Operating Company (FENOC) submitted for Nuclear Regulatory Commission (NRC) staff review and approval a license amendment request for Beaver Valley Power Station, Unit No. 1 (BVPS-1). The proposed amendment would revise Technical Specification 5.6.3, "Core Operating Limits Report," to allow use of the generically approved report, WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment Of Uncertainty Method (ASTRUM)."

By letter dated January 26, 2010, the NRC staff requested additional information. The NRC staff requests are presented in bold type, followed by the FENOC response.

1. Please clarify the above statement ["WCAP-16009-P-A uses a double-ended guillotine break for plant-specific confirmatory analysis."]. According to WCAP-16009-P-A, and subsequent applications of it, limiting split breaks can also result in a higher peak cladding temperature (PCT) than the double-ended guillotined break. This is also true for the BVPS-1 analysis of record (AOR), which predicts that the limiting break is split geometry.

Response:

On page 11-7, WCAP-16009-P-A states "The most limiting split break and the most limiting double-ended guillotine break have comparable PCTs for both 3-loop and 4-loop plants."

WCAP-16009-P-A, Table 11-1, page 11-22, summarizes break spectrum results for multiple plants. The limiting split break PCT was 2017 degrees Fahrenheit and the limiting double-ended guillotine break PCT was 2011 degrees Fahrenheit for the three-loop plants.

On page 11-7, WCAP-16009-P-A states "Based on these results, it is reasonable to sample [double-ended cold-leg guillotine] DECLG and split breaks equally, and to vary the break flow rate contributors and the axial power distribution simultaneously."

In other words, the limiting break type cannot be predicted prior to the analysis because it depends on the sampling of many random variables. Therefore, in ASTRUM it is appropriate to vary all of the sampled parameters at the same time.

In the ASTRUM analysis, many random variables impact the results in addition to the break type, as detailed in the response to request for additional information (RAI) item 6. The limiting ASTRUM case was a double-ended guillotine break with a low accumulator volume (912.15 cubic feet versus a nominal 957.5 cubic feet) and a low accumulator line resistance multiplier (0.8604 versus a nominal of 1). The accumulator mass flow rate for this case reaches a higher peak than other runs because of the low resistance. The accumulators empty at about 35 seconds after the break, which is significantly earlier than in other runs. This occurs because of the low accumulator line resistance and low accumulator water volume. The vessel liquid mass declines markedly when the accumulators stop providing water. In other cases, the accumulators continue to discharge and the vessel fluid mass continues to rise, enabling water

to enter the core. For the limiting ASTRUM case, there is insufficient water in the core at the accumulator empty time to stop the increase in PCT. Effective core reflood heat transfer is delayed, so the PCT continues to increase to a much higher value for this case than the other cases.

Therefore, the limiting case for the BVPS-1 ASTRUM analysis is a double-ended guillotine break because of the poor accumulator performance (low accumulator water volume and high accumulator mass flow rate) resulting from the sampled parameter values in that particular case, as indicated above.

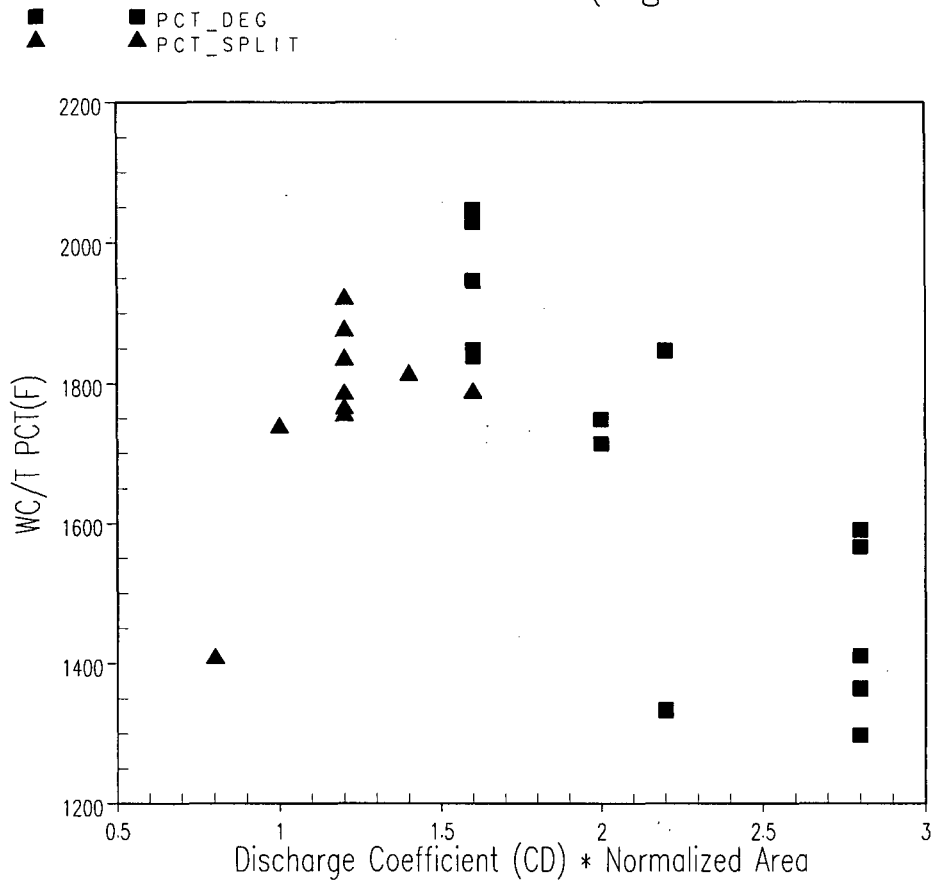
2. For the current AOR (Code Qualification Document (CQD) method), provide a scatter plot of PCT vs. break characteristics (normalized area and discharge coefficient) that distinguishes between slot breaks and double-ended breaks.

Response:

Figure 2.1 presents the results in terms of WCOBRA/TRAC-calculated PCT of cases from the BVPS-1 CQD analysis of the double-ended cold leg guillotine (DECLG), and slot (split) breaks. A normalized area (Break Area/Cold Leg Area) of 2.0 applies to guillotine breaks, and a normalized area of 1.0 applies to slot breaks. In the CQD methodology, the discharge coefficient (CD) sensitivity study is performed first for the split break to determine the limiting break size. Once the limiting split break CD is determined, the augmented split break matrix is performed with variation in broken cold leg nozzle resistance and downcomer condensation multiplier. The response to RAI item 6 contains additional details.

Figure 2.1

CQD cases DEG and SPLIT, RAI Q2
PCT vs. CD * Normalized Area (Highest PCT Cases)



3. Compare input parameters between the CQD and ASTRUM analyses.

Response:

In developing the RAI responses, the values presented as part of the CQD analysis refer to the AOR as presented in the current revision of the Updated Final Safety Analysis Report with a PCT of 2144 degrees Fahrenheit. Downstream evaluations as captured in the 10 CFR 50.46 annual report that now form the licensing basis are not taken into account in this RAI response in order to facilitate a more direct comparison with ASTRUM results.

Differences exist in the containment and containment heat sink data resulting from implementation of plant changes associated with steam generator replacement and containment sump strainer modifications, as well as more detailed modeling of the containment spray systems. The containment pressure analysis code (COCO) containment model was updated as part of the ASTRUM analysis to account for these changes. Other differences are summarized in Table 3.1. In addition, differences are noted by comparing the information provided in Tables 4.1 and 4.2. The response to RAI item 4 contains additional information.

Table 3.1

Parameter	CQD Value	ASTRUM Value
Baseload FQ	2.1	2.2
Accumulator Temperature Range (°F)	70-105	70-108
Nominal SI Temperature (°F)	75	55
SI Temperature Range (°F)	45-105	45-65
Steam Generator Model	OSG-51*	RSG-54F**
Initial Containment Pressure, Full Power Operation (psia)	14.3	12.8

* Model 51 original steam generators (OSG-51) were analyzed since they were evaluated to be bounding.

** Model 54F replacement steam generator (RSG-54F).

Degrees Fahrenheit (°F)

Pounds per square inch absolute (psia)

Safety injection (SI)

Maximum Steady State Depletion FQ (Baseload FQ)

4. For both the AOR and the ASTRUM analyses, provide the reference values, nominal values, and ranges for the following parameters:

- a. Reactor Coolant System (RCS) T_{avg}
- b. RCS Pressure
- c. Accumulator Pressure, Volume, and Temperature
- d. Safety Injection Temperature
- e. Peaking Factors
- f. Hot Assembly, Hot Rod, and Average Linear Heat Rates

Response:

The values for these items are listed within Tables 4.1 and 4.2 for the AOR (CQD) and ASTRUM analyses, respectively. For the non-power related parameters and FQ the nominal value is the midpoint of the range.

For the CQD analysis, the reference transient is a base case used to define the initial conditions bias and uncertainty to be included in the final total uncertainty assessment. For the ASTRUM methodology reference transient, most of the parameters assume the nominal value, while some assume a bounding or conservative value (Reference 1, section 12-3). The reference transient in ASTRUM does not provide a base case for or carryover into the uncertainty assessment in the same way as in the CQD methodology. Each case that is executed in an ASTRUM analysis uses its own set of sampled variables, and the limiting PCT (or local maximum oxidation (LMO) and core-wide oxidation (CWO)) result among the 124 cases executed establishes the 95th percentile PCT (and also LMO/CWO) value at a 95 percent confidence level.

Table 4.1: CQD Parameters

Parameter	Reference	Minimum	Maximum
RCS Tavg (°F)	580.1 *	575.9	584.1
RCS Pressure (psia)	2237	2200	2300
Accumulator Pressure (psia)	649.7	575	716
Accumulator Volume (ft ³)	957	893	1022
Accumulator Temperature (°F)	87.5	70	105
SI Temperature (°F)	75	45	105
FQ ****	2.2615	2.1	2.33 **
FdH ****	1.779 ***	1.75	
HR Peak Linear Heat Rate (kw/ft)	12.74	12.17	13.67
HA Peak Linear Heat Rate (kw/ft)	12.25	11.7	13.14
Peak Channel Avg. Linear Heat Rate (kw/ft)	10.02 ***	9.75	9.87

* Confirmatory runs determined high average temperature (Tavg) to be limiting.

** Values reported are without standard uncertainty.

*** FdH for the reference transient is set consistent with Reference 2, Section 26-3-2, Item 2.1c.

**** Treatment of FQ and FdH is based on Technical Specification values with distributions assigned in accordance with the methodology described in Reference 2, Section 21.

Degrees Fahrenheit (°F)

Pounds per square inch absolute (psia)

Kilowatt per foot (kw/ft)

Safety injection (SI)

Cubic feet (ft³)

Reactor coolant system (RCS)

Hot Assembly (HA)

Hot Rod (HR)

Hot Rod Peak Linear Heat Rate Peaking Factor (FQ)

Hot Rod Average Linear Heat Rate Peaking Factor (FdH)

Table 4.2: ASTRUM Parameters

Parameter	Reference	Minimum	Maximum
RCS Tavg (°F)	580 *	576	584
RCS Pressure (psia)	2250	2200	2300
Accumulator Pressure (psia)	645.5	575	716
Accumulator Volume (ft ³)	957.5	893	1022
Accumulator Temperature (°F)	89	70	108
SI Temperature (°F)	55	45	65
FQ ****	2.31	2.20	2.33 **
FdH ****	1.779 ***	1.75	
HR Peak Linear Heat Rate (kw/ft)	13.03	12.75	13.67
HA Peak Linear Heat Rate (kw/ft)	12.53	12.26	13.14
Peak Channel Avg. Linear Heat Rate (kw/ft)	10.02 ***	9.75	9.87

* Confirmatory runs determined high average temperature (Tavg) to be limiting.

** Values reported are without standard uncertainty.

*** FdH for the reference transient is set consistent with Reference 1, Section 12-3-2, Item c.

**** Treatment of FQ and FdH is based on Technical Specification values with distributions assigned in accordance with the methodology described in Reference 1, Table 1-10.

Degrees Fahrenheit (°F)

Pounds per square inch absolute (psia)

Kilowatt per foot (kw/ft)

Safety injection (SI)

Cubic feet (ft³)

Reactor coolant system (RCS)

Hot Assembly (HA)

Hot Rod (HR)

Hot Rod Peak Linear Heat Rate Peaking Factor (FQ)

Hot Rod Average Linear Heat Rate Peaking Factor (FdH)

5. Are there any rackup items incorporated in the new analysis?

Response:

No. None of the line items on the current rackup are applicable to the ASTRUM analysis.

6. For both the CQD AOR and the ASTRUM analysis, provide a table of sampled input parameters and their case-specific values for the four highest PCT cases for each of the split and the double-ended guillotine breaks.

Response:

The values for the AOR (CQD) and ASTRUM analyses are listed within Tables 6.1 and 6.2, respectively. The tables compare global variables that affect the WCOBRA/TRAC computation. Local variables considered in the peak cladding temperature (HOTSPOT) calculation, while potentially significant factors in defining the calculated PCT, are not included because the differing treatment of local uncertainty in the two methodologies precludes any meaningful comparison. A single value of each local variable is sampled and implemented in each ASTRUM case, as indicated in Table 12-7 of Reference 1. In the AOR (CQD) methodology, HOTSPOT is executed in a large matrix of variations in the local variables, which then feeds into a Monte Carlo response surface simulation to identify a 95th percentile PCT value.

Overall, in the CQD methodology response surfaces are generated to identify the PCT impact of variations in different classes of global variables (initial condition, power distribution, code modeling) and combined with the HOTSPOT local variables function to identify the 95th percentile PCT. In contrast, in ASTRUM individual cases are executed with sampled values of each pertinent parameter. This accounts for the wider difference in the ASTRUM parameters shown in the tables relative to CQD parameters.

The following definitions are applicable for this response:

WCT PCT = Peak Clad Temperature, as determined by WCOBRA/TRAC

TAVG or Tavg = Vessel Average Temperature

PLOW = Rod Relative Power in Low Power Region

CD = Discharge Coefficient of the Break

KN = Broken Cold Leg Nozzle Resistance

XC = Downcomer Condensation Multiplier

FQ = Hot Rod Peak Linear Heat Rate Peaking Factor

FdH = Hot Rod Average Linear Heat Rate Peaking Factor

TSI = Safety Injection Water Temperature

PACC = Accumulator Gas Pressure

VACC = Accumulator Water Volume

TACC = Accumulator Water Temperature

KACC = Accumulator Delivery Piping Flow Resistance

RCS = Reactor Coolant System

PSIA = Pounds Per Square Inch Absolute

°F = Degrees Fahrenheit

FT³ = Cubic feet

Table 6.1: CQD Parameters

DOUBLE-ENDED GUILLOTINE													
Run	WCT PCT(°F)	TAVG (°F)	PLOW	CD	KN	XC	FQ	FdH	TSI (°F)	PACC (psia)	VACC (ft3)	TACC (°F)	KACC
G2	2047	580	0.6	0.8	1.58	1	2.2615	1.779	75	649.7	957	87.5	1
G3	2029	580	0.6	0.8	2.4	1	2.2615	1.779	75	649.7	957	87.5	1
G14	1946	580	0.6	0.8	0.77	0.5	2.2615	1.779	75	649.7	957	87.5	1
G11	1848	580	0.6	0.8	2.4	0.5	2.2615	1.779	75	649.7	957	87.5	1
SPLIT													
Run	WCT PCT(°F)	TAVG (°F)	PLOW	CD	KN	XC	FQ	FdH	TSI (°F)	PACC (psia)	VACC (ft3)	TACC (°F)	KACC
D4	1920	580	0.6	1.2	1.58	0.5	2.2615	1.779	75	649.7	957	87.5	1
D3	1875	580	0.6	1.2	0.77	1	2.2615	1.779	75	649.7	957	87.5	1
10A	1834	580	0.6	1.2	1.58	1	2.2615	1.779	75	649.7	957	87.5	1
11A	1812	580	0.6	1.4	1.58	1	2.2615	1.779	75	649.7	957	87.5	1

Table 6.2: ASTRUM Parameters

DOUBLE-ENDED GUILLOTINE													
Run	WCT PCT(°F)	TAVG (°F)	PLOW	CD	KN	XC	FQ	FdH	TSI (°F)	PACC (psia)	VACC (ft3)	TACC (°F)	KACC
9	2025	578.5	0.2	0.99	1.67	0.96	2.28	1.67	50.06	631.40	912.15	71.49	0.86
121	1965	582.93	0.2	0.89	1.35	0.55	2.35	1.64	50.15	666.32	1008.62	100.03	0.83
59	1822	577.3	0.2	0.93	1.36	0.52	2.16	1.74	45.65	605.42	993.45	71.84	0.95
122	1800	580.86	0.2	0.96	1.39	0.72	2.24	1.68	48.07	620.78	947.35	84.70	1.14
SPLIT													
Run	WCT PCT(°F)	TAVG (°F)	PLOW	CD	KN	XC	FQ	FdH	TSI (°F)	PACC (psia)	VACC (ft3)	TACC (°F)	KACC
106	1844	582.61	0.2	0.91	2.19	0.68	2.18	1.64	48.84	704.65	1001.64	76.49	1.06
78	1804	576.349	0.2	1.00	1.86	0.99	2.26	1.70	59.08	621.32	939.43	91.43	1.14
2	1727	577.24	0.2	0.90	2.17	0.86	2.20	1.69	45.32	587.58	951.58	105.05	1.00
63	1726	581.01	0.2	0.95	1.85	0.65	2.34	1.74	47.50	695.06	943.76	77.15	1.11

References:

1. Westinghouse Electric, WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)," January 2005.
2. Westinghouse Electric, WCAP-12945-P-A, "Code Qualification Document for Best Estimate LOCA Analysis," 1998.