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GESAM Computer Program Error

Incorrect Reseeding of Pseudo-Random Number Generator

May 9, 2018



Purpose

- Describe GESAM computer program error involving Pseudo-Random Number Generator (PRNG) discovered in November 2017.
- Review conclusions of GEH Potential Reportable Condition (PRC) evaluation completed in January 2018 where impact was concluded not reportable under 10 CFR Part 21.



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What is GESAM?

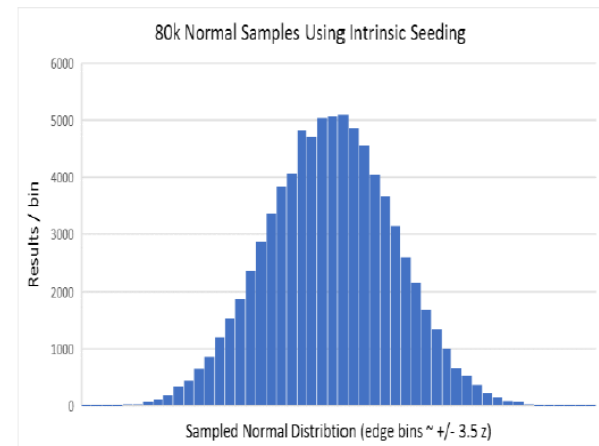
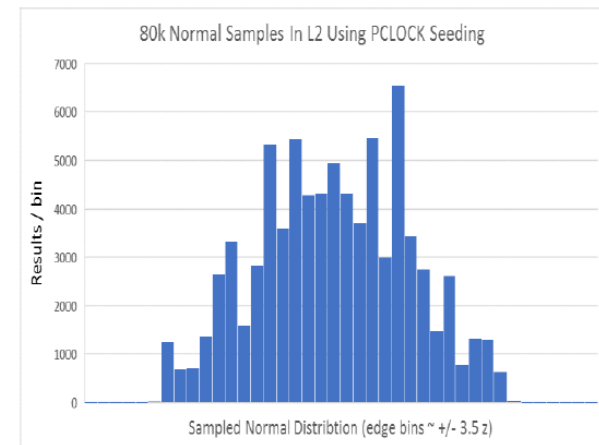
- GESAM is an engineering computer program that performs the Monte Carlo statistical analysis to calculate:
 - Cycle-specific SLMCPR
(NRC Approved Methodologies 1-2)
 - Cycle-specific TRACG AOO OLMCPR
(NRC Approved Methodologies 3-6)
 - GS3 & DSS-CD Stability Solution Generic MCPR Margin Criteria
(NRC Approved Methodologies 7-9)



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Error Description

- The GESAM Monte Carlo method involves sampling a normal distribution in order to perturb operating parameters that affect uncertainties in critical power.
- Sampling of normal distribution is performed using calls to a pseudo-random number generator (PRNG).
- Due to a logic flaw when seeding the PRNG, the population did not reflect a normal distribution. In addition, the random number sequence could be unintentionally short.
- Error has existed in GESAM for >30 years.



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Evaluation Results: SLMCPR

- GESAM is used to define the SLMCPR such that 99.9% of the rods in the core must be expected to avoid boiling transition including methodology-defined uncertainties.
- TLO & SLO SLMCPR recalculated for all operating cycles and in-progress reloads.
- No significant impact on calculated SLMCPR (within nominal uncertainty of methodology).
- No change to TLO/SLO TS SLMCPR value for 62 of 64 limiting SLMCPR cases evaluated.
- Due to rounding, SLO TS SLMCPR increased by 0.01 for two plants (Hatch 2 Cycle 25 & Cooper Cycle 30).

In the PRC evaluation, this impact is considered not reportable due to change in unrounded result being within the nominal uncertainty of methodology of ± 0.005 .



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Evaluation Results: Hatch 2 Cycle 25

- TS SLO SLMCPR impacted by GESAM error.

	Original Value with GESAM Error	Value with Corrected GESAM	Difference
Calculated	1.13498	1.13526	0.00028
TS	1.13	1.14	0.01

- SLO SLMCPR and Rated Equivalent SLO Pump Seizure OLMCPR increase by 0.01 in SRLR.

Evaluation Results: Cooper Cycle 30

- TS SLO SLMCPR impacted by GESAM error.

	Original Value with GESAM Error	Value with Corrected GESAM¹	Difference
Calculated	1.14360	1.14581	0.00221
TS	1.14	1.15	0.01

¹ Change to Revised Methodology (NEDC-32601P-A)

- SLO SLMCPR and Rated Equivalent SLO Pump Seizure OLMCPR increase by 0.01 in SRLR.



Evaluation Results: Transient OLMCPR

ODYN AOO Methodology & Slow Transients

- ODYN based and slow transient OLMCPRs calculated using standard approach: $OLMCPR = SLMCPR + \text{Transient DCPR}$
- These OLMCPRs not impacted when TS SLMCPR values are unchanged.

TRACG AOO Methodology

- GESAM is used to directly calculate OLMCPR such that 99.9% of the rods in the core must be expected to avoid boiling transition including methodology-defined uncertainties and bias.
- TRACG based OLMCPRs recalculated for all operating cycles and in-progress reloads.
- OLMCPRs reported in plant/cycle specific SRLRs confirmed adequate.



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Evaluation Results: Stability OLMCPR

DIVOM Methodology

- Stability DIVOM based OLMCPRs not impacted when TS SLMCPR values are unchanged.

DSS-CD & GS3 Methodology

- GESAM is used to define generic MCPR margin criteria presented in terms of DCPR/ICPR (as a function of setpoint) to protect the SLMCPR.
- Evaluation confirmed adequate margin exists in the generic MCPR margin criteria.
- OLMCPRs reported in plant/cycle specific SRLRs confirmed adequate.



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Summary

- PRC evaluation concluded the impact of the GESAM computer program error was not reportable under 10 CFR Part 21.
- TS SLMCPRs confirmed adequate with the exception of:
 - (1) Cooper Cycle 30 SLO SLMCPR increase by 0.01
 - (2) Hatch 2 Cycle 25 SLO SLMCPR increase by 0.01
- Transient and Stability OLMCPRs reported in plant/cycle specific SRLRs confirmed adequate
- GESAM02 error correction completed in March 2018.



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NRC Approved Methodologies

1. *Methodology and Uncertainties for Safety Limit MCPR Evaluation*, NEDC-32601P-A, August 1999.
2. *Power Distribution Uncertainties for Safety Limit MCPR Evaluations*, NEDC-32694P-A, August 1999.
3. *TRACG Application for Anticipated Operational Occurrences Transient Analyses*, NEDE-32906P-A, Revision 3, September 2006.
4. *TRACG Application for Anticipated Transients without Scram Overpressure Transient Analyses*, NEDE-32906P, Supplement 1-A, November 2003.
5. *TRACG Application for Anticipated Operational Occurrences Transient Analyses*, NEDE-32906P, Supplement 2-A, March 2006.
6. *Migration to TRACG04 / PANAC11 from TRACG02 / PANAC10 for TRACG AOO and ATWS Overpressure Transients*, NEDE-32906P, Supplement 3-A, Revision 1, April 2010.
7. *GEH Simplified Stability Solution (GS3)*, NEDC-33766P-A, Revision 1, March 2015.
8. *GE Hitachi Boiling Water Reactor Detect and Suppress Solution – Confirmation Density*, NEDC-33075P-A, Revision 8, November 2013.
9. *DSS-CD TRACG Application*, NEDE-33147P-A, Revision 4, August 2013.



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