# ENCLOSURE 2

# MFN 09-694

# TRACG-LOCA Presentation Slides

# Non-Proprietary Information

**IMPORTANT NOTICE**

This is a non-proprietary version of Enclosure 1 to MFN 09-694, from which the proprietary information has been removed. Portions of the enclosure that have been removed are indicated by an open and closed bracket as shown here [[ ]]

GE Hitachi
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# TRACG LOCA Application


Kurshad Muftuoglu
10/26/09

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# Outline

# Outline

- Participants
- Objectives
- NEDE-33005P Contents
  - Application Scope
  - PIRT
  - Code Applicability
  - Model Uncertainties and Biases
  - Application Uncertainties and Biases
  - Combination of Uncertainties
  - Demonstration Analyses
  - Methodology Application
- Conclusions
- Submittal Schedule

# Participants

# Participants

- Kurshad Muftuoglu – GEH
- Charlie Heck – GEH
- Jens Andersen – GEH
- Fran Bolger – GEH
- Jim Harrison – GEH

# Objectives

# Objectives

- Provide staff with an overview of the topical report for TRACG Application to BWR ECCS/LOCA Licensing Analyses
- Present our licensing plan and strategy for review
  - Leverage of prior TRACG review
  - Expected schedule
- Receive feedback from the staff.

# NEDE-33005P Contents

# NEDE-33005P Contents

**TRACG Application for BWR/2-6 Emergency Core Cooling Systems / Loss-of-Coolant-Accident Analysis**

# Application Scope

# Application Scope

- BWR/2 through BWR/6 (external pump and jet pump plants – existing U.S. BWRs) (TRACG is separately approved for ESBWR and a separate submittal for ABWR when needed)
- Conformance with GDC 35, 10 CFR 50.46 and RG 1.157
- Follows CSAU Methodology
- Using TRACG04 code

# PIRT

# PIRT

- Separate PIRT's for external and jet pump plants
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- Rankings: H – M – L importance, or N/A

# PIRT (cont.)

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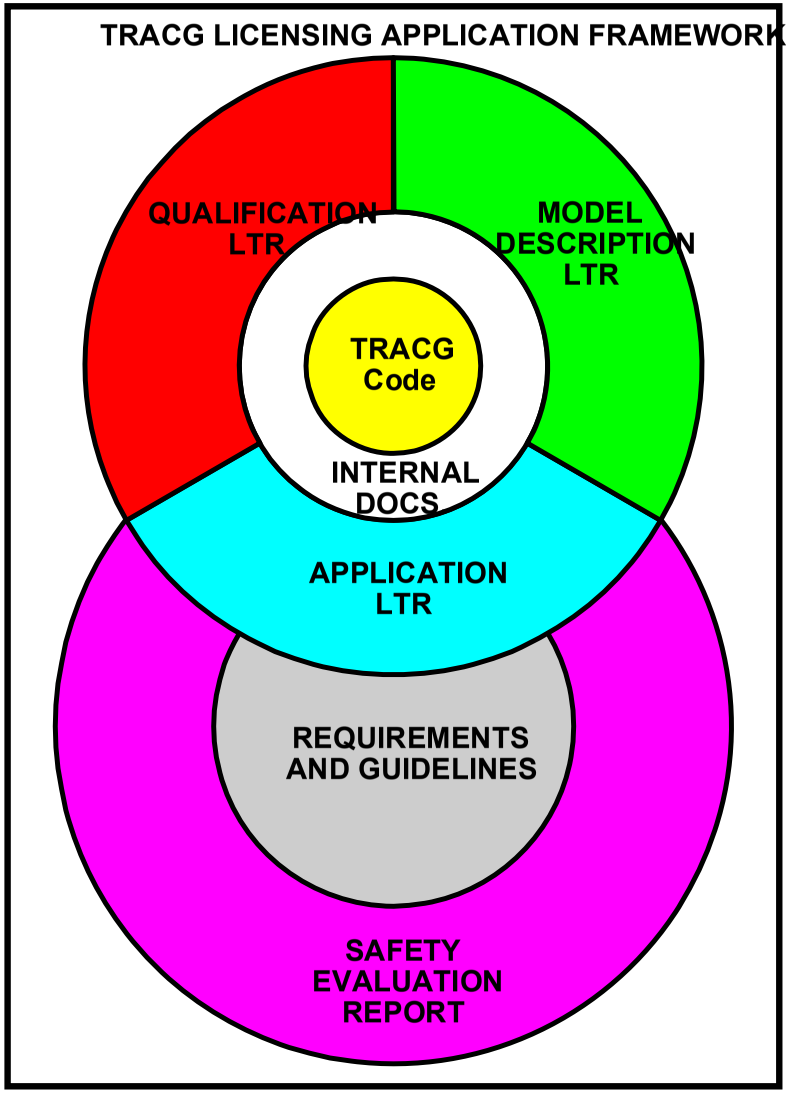
# Code Applicability

# Code Applicability

- Model Capability Matrix provides cross-references to the TRACG Model Report (NEDE-32176P, Rev. 4)

- Model Assessment Matrix provides cross-references to the TRACG Qualification Report (NEDE-32177P, Rev. 3) for
  - Separate effects,
  - Component performance,
  - Integral system, and
  - Plant data qualification.

# TRACG LOCA Application Framework



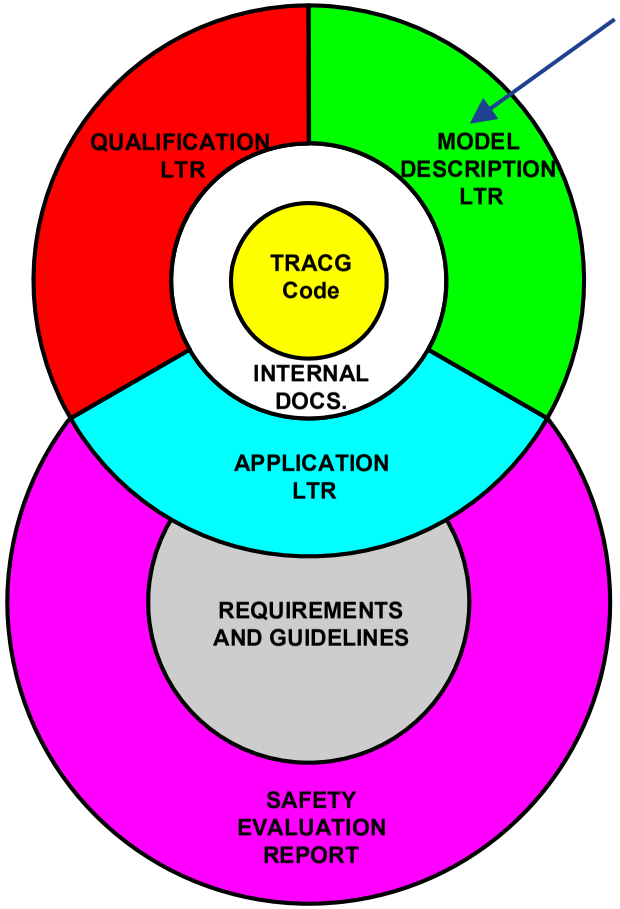
# Licensing/Review Approach

| Model LTR<br>NEDE-32176P | Qualification LTR<br>NEDE-32177P | Application LTR<br>NEDE-33005 |
|---|---|---|
| **Rev. 2**<br>Reviewed by NRC for AOOs | **Rev. 2**<br>Reviewed by NRC for AOOs | **Rev. 0**<br>Will document ECCS/LOCA Application Methodology 11/2009 |
| **Rev. 3**<br>Incorporates LOCA models | **Rev. 3**<br>Issued 08/2007<br>Incorporates additional LOCA-specific Qualification Studies | Approach similar to AOO<br>Follows CSAU/RG1.157 |
| **Rev. 4**<br>Issued 08/2007<br>Minor changes | | |

**Primary review is Application Methodology**

# TRACG Model Capability

- Structure
  - Capability to model plant geometry
- Basic Equations
  - Capability to address global processes
- Models and Correlations
  - Capability to model and scale individual processes
- Numerical Methods
  - Capability to perform efficient and reliable calculations



# Model Additions for ECCS/LOCA

- Re-implementation of model for axial conduction quenching
  - Established model (TRACG, CORECOOL, SAFER)
  - Important for quenching of channel by spray (BWR/2)
- PANAC11 Kinetics
  - Insignificant for LOCA
  - Primarily for transient applications
  - Separate informational update on AOO applications

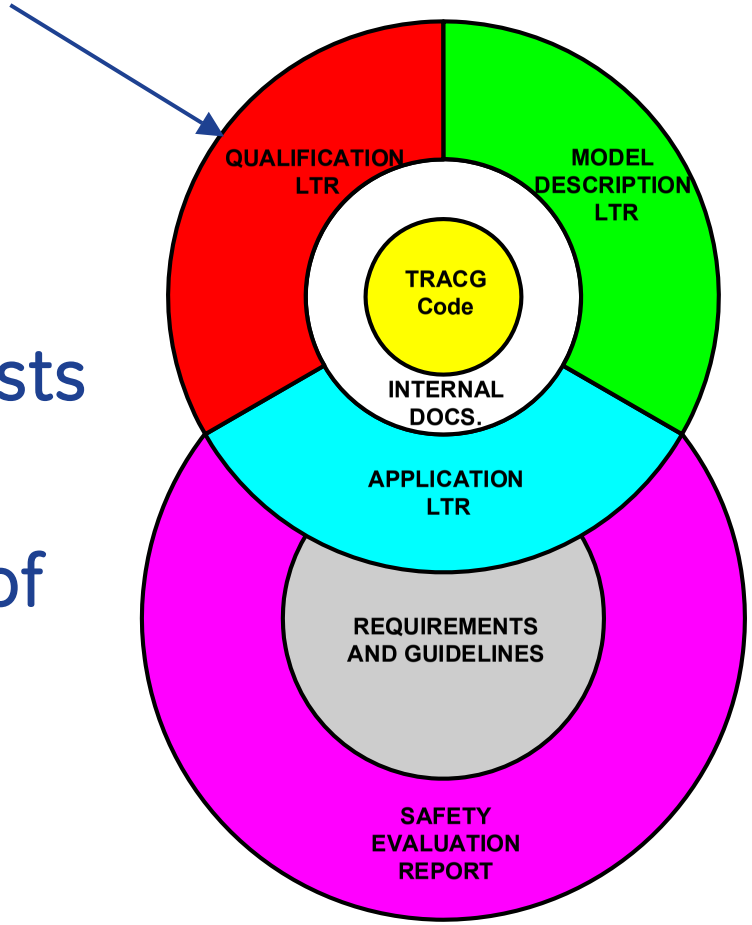
  TRACG Application Methodology for AOO, NEDE-32906P, Section 2.6
- ANS 5.1 (1979) Decay Heat Standard

# Models not Previously Reviewed (many models reviewed for ESBWR)

- Core heatup models
  - Film boiling, thermal radiation, axial conduction controlled quenching, metal-water reaction, rod perforation
- Upper plenum models
  - ECC distribution at top of core

# TRACG Qualification

- Qualification Strategy
  - Separate Effects Tests
  - Component Performance Data
  - Integral System Effects Tests
  - Full Scale Plant Data
- Determination of Adequacy of TRACG Models
- Determination of Model and Experimental Uncertainty *




* A section defining model biases and uncertainties for all highly and medium ranked PIRT parameters will be contained in Application Methodology LTR

# Qualification for LOCA

- **Separate Effects Tests**
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- **Component Performance Tests**
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- **Integral System Effects Tests**
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+ Nodalization and Sensitivity Studies for LOCA

# Model Uncertainties and Biases

# Model Uncertainties and Biases

- Assessments based on comparisons between SETs data and best-estimate TRACG calculations
- The biases and uncertainties derived from the data comparisons are used to establish PDF's.
- *PIRT* multipliers on TRACG parameters and correlations for high and medium-ranked phenomena

# Model Uncertainties and Biases (cont.)

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# Application Uncertainties and Biases

# Application Uncertainties and Biases

- Uncertainties introduced by the application are considered.
- Initial Conditions:
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- Plant Parameters:
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# Combination of Uncertainties

# Combination of Uncertainties

- Use of statistics to determine the analysis results for 50.46 acceptance criteria with *high probability* in conformance with RG 1.157
- Uncertainty parameters are sampled from their respective PDF's for each run
- At least 59 cases to generate output distribution
- If normal distribution,
  - then one-sided upper tolerance limit (OSUTL) computed from mean and standard deviation;
  - else, use non-parametric order statistics to determine OSUTL

# Combination of Uncertainties (cont.)

- Method applied to qualification tests
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- Results confirm applicability of the overall methodology and the statistical technique as well as the degree of conservatism.

# Combination of Uncertainties (cont.)

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# Combination of Uncertainties (cont.)

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# Combination of Uncertainties (cont.)

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# Demonstration Analyses

# Demonstration Analyses

- LOCA Calculations for BWR/2, BWR/4, and BWR/6 are presented.
- Break spectrum analysis covers all break sizes, additional evaluations for non-recirculation breaks.
  - Statistical analysis for multiple break location/size

# BWR/2 Results

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# BWR/2 Results (cont.)

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# BWR/2 Results (cont.)

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# BWR/4 Results

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# BWR/4 Results (cont.)

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# BWR/6 Results

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# BWR/6 Results (cont.)

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# Methodology Application

# Methodology Application

- Chapter 9 provides analysis process summary and additional applicability aspects regarding
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# Conclusions

# Conclusions

- Methodology developed following CSAU principles
- Conforms with RG 1.157 guidelines
- Significant overlap on uncertainty parameters with previous NRC-approved methodologies
- Applicability of TRACG is well established in other analysis methods, LOCA is a natural extension.

- Submittal as a BWR/2-6 ECCS evaluation/LOCA analysis methodology.

# Submittal Plans

# Submittal Plans

- Pre-submittal Meeting – today
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# Questions/Discussion

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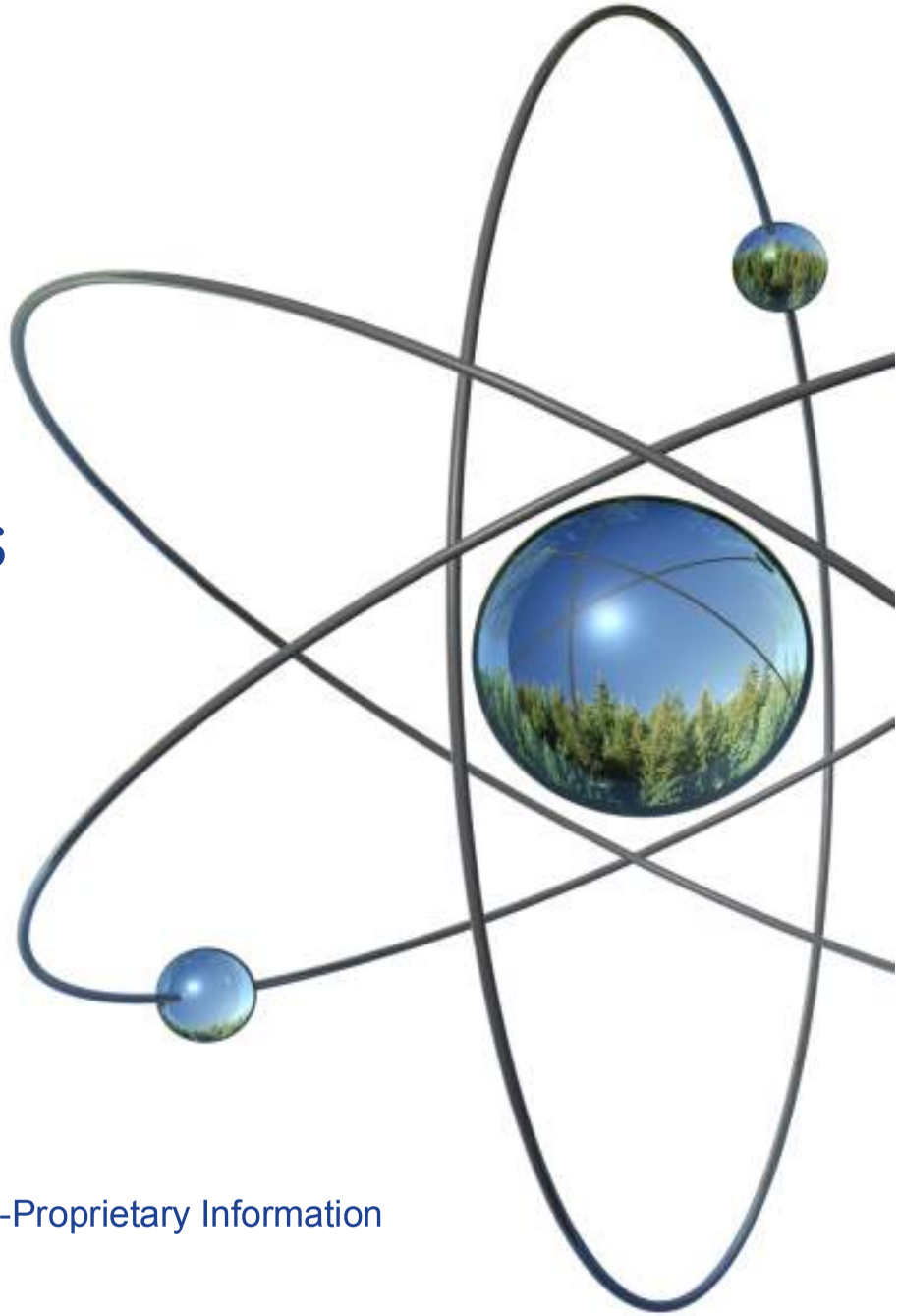
# TRACG for BWR
## Models, Qualification, Applications and Reviews

Presentation to USNRC
October 2009

Jens G. Munthe Andersen
Chief Consulting Engineer



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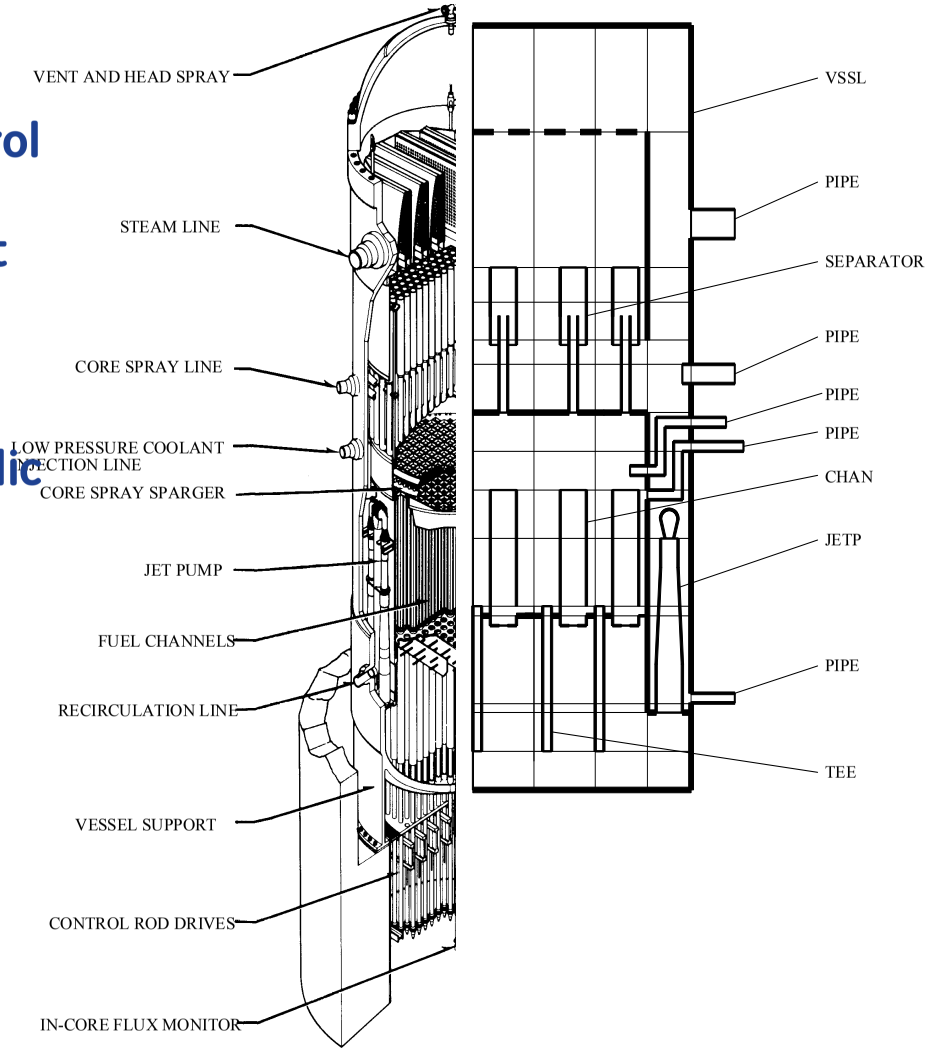
# TRACG Realistic Code for BWR Transients

- AOO Transients ← Focus of presentation
  - LOCA, ATWS, Stability, RIA, RIPD
- Multi-dimensional vessel
- Flexible modular structure with control system capability
- Proven 3D nuclear kinetics consistent with PANACEA
- Steam, liquid, boron and non-condensable gases
- Flow regime map covering all hydraulic conditions
- Consistent use of constitutive correlations
  - Shear and heat transfer
- BWR component models
- Extensive qualification
  - Separate effects tests
  - BWR component performance data
  - Integral system effects tests
  - Full scale plant data



# TRACG Application for BWR

**Plants:** BWR/2/3/4/5/6 and ESBWR
**Events:** Anticipated Operational Occurrences (Transients)
Stability
Loss of Coolant Accident (LOCA)
Anticipated Transients without Scram (ATWS)

**Documentation**

- TRACG Model Description LTR, NEDE-32176P, Revision 2 (TRACG02) and 4 (TRACG04)
- TRACG Qualification LTR , NEDE-32177P, Revision 2 (TRACG02) and 3 (TRACG04)
- TRACG Application LTR for AOO Transient Analyses, NEDE-32906P-A, Revision 3
- TRACG Application LTR for Anticipated Transient without Scram Over Pressure Transient Analyses, NEDE-32906P Supplement 1-A
- TRACG Application LTR for AOO Transient Analyses, NEDE-32906P Supplement 2-A
- DSS/CD TRACG Application, NEDE-33147P-A, Revision 2
- Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG02 AOO and ATWS Overpressure Transients, NEDE-32906P Supplement 3 (NRC SE Issued July 10, 2009, ML091751102)
- TRACG02A User's Manual, NEDC-32956P
- TRACG04A,P User's Manual, UM-136
- TRACG Application for ESBWR, NEDO-33083-A and supplements
  - LOCA, transient, stability and ATWS based on TRACG04

# TRACG Application for BWR Transients

**Plants: BWR/2/3/4/5/6 and ESBWR**
**Events: Anticipated Operational Occurrences (AOO Transients)**

**Documentation:**

- **TRACG Application LTR for AOO Transient Analyses, NEDE-32906P-A, Revision 3**
  **Approves TRACG02 for application to BWR/2-6 transients**
  - **TRACG Model Description LTR, NEDE-32176P, Revision 2 approved by reference**
  - **TRACG Qualification LTR , NEDE-32177P, Revision 2 approved by reference**
- **TRACG Application LTR for Anticipated Transient without Scram Over Pressure Transient Analyses, NEDE-32906P Supplement 1-A**
- **TRACG Application LTR for AOO Transient Analyses, NEDE-32906P, Supplement 2-A**
  **Improved Transient CPR calculation**
- **Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG02 AOO and ATWS Overpressure Transients, NEDE-32906P, Supplement 3 (NRC SE Issued July 10, 2009, ML091751102)**
  **Approves TRACG04 for application to BWR/2-6 transients & ATWS overpressure events**
  - **TRACG Model Description LTR, NEDE-32176P, Revision 4 approved by reference**
  - **TRACG Qualification LTR , NEDE-32177P, Revision 3 approved by reference**
  - **TRACG Application for ESBWR, NEDC-33083P, Supplement 3 - Transients**
  - **Submitted to NRC in support of ESBWR DCD. All RAIs addressed.**
  - **TRACG Model Description LTR, NEDE-32176P, Revision 3 reviewed by reference**
  - **TRACG Qualification LTR , NEDE-32177P, Revision 3 reviewed by reference**
  - **TRACG04 used for ESBWR DCD**

# TRACG Application for BWR Stability

**Plants:** BWR/2/3/4/5/6 and ESBWR

**Events:** Stability

**Documentation:**

- TRACG Application for Stability Detect and Suppress Solutions, NEDO-32465-A

  Approves TRACG02 for stability detect and suppress solutions as documented in "BWR Owners Group Reactor Stability Detect and Suppress Solution Licensing Basis Methodology and Reload Applications"
  - TRACG Model Description LTR, NEDE-32176P, Revision 2 (TRACG02) approved by reference
  - TRACG Qualification LTR , NEDE-32177P, Revision 2 (TRACG02) approved by reference
- TRACG Application for ESBWR, NEDC-33083P-A, Supplement 1, Revision 1 - Stability
  - Submitted to NRC in support of ESBWR DCD.
  - TRACG Model Description LTR, NEDE-32176P approved by reference
  - TRACG Qualification LTR , NEDE-32177P approved by reference
  - TRACG04 used for LTR and ESBWR DCD
- DSS/CD TRACG Application, NEDE-33147P-A, Revision 2
  - TRACG Model Description LTR, NEDE-32176P, Revision 2 approved by reference
  - TRACG Qualification LTR , NEDE-32177P, Revision 2 approved by reference

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# TRACG Application for BWR LOCA

**Plants: BWR/2/3/4/5/6 and ESBWR**

**Events: Loss of Coolant Accident (LOCA)**

**Documentation:**

- **The GESTR LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident, NEDE-23785-1-PA**

  **Approves TRACG for the SAFER upper bound PCT calculation for BWR/3-6**
- **SAFER Models for Evaluation of the Loss-of-Coolant Accidents for Jet Pumps and Non Jet Pump Plants, NEDE-30996P-A**

  **Approves TRACG for the SAFER upper bound PCT calculation for BWR/2-6**
- **TRACG Application for ESBWR, NEDC-33083P-A, - LOCA**
  - **Submitted to NRC in support of ESBWR DCD.**
  - **TRACG Model Description LTR, NEDE-32176P approved by reference**
  - **TRACG Qualification LTR , NEDE-32177P approved by reference**
  - **TRACG04 used for LTR and ESBWR DCD**
- **TRACG Application for Emergency Core Cooling Systems / Loss of Coolant Accident Analysis, NEDC-33005P**

  **TRACG LOCA application for BWR/2-6 to be submitted 2009**
  - **TRACG Model Description LTR, NEDE-32176P, Revision 4 included by reference**
  - **TRACG Qualification LTR , NEDE-32177P Revision 3 included by reference**

# TRACG Application for BWR ATWS

**Plants: BWR/2/3/4/5/6 and ESBWR**

**Events: Anticipated Transients without Scram (ATWS)**

**Documentation:**

- **TRACG Application for ESBWR, NEDC-33083P, Supplement 2 - ATWS**
  - **Submitted to NRC in support of ESBWR DCD. All RAIs addressed.**
  - **TRACG Model Description LTR, NEDE-32176P reviewed by reference**
  - **TRACG Qualification LTR , NEDE-32177P, reviewed by reference**
  - **TRACG04 used for LTR and ESBWR DCD**

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# TRACG Models, NEDE-32176P

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# TRACG Models, NEDE-32176P

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# TRACG Qualification, NEDE-32177P

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# TRACG Qualification, NEDE-32177P

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# Models, Qualification, Applications and Reviews

## Summary

TRACG Applications have been reviewed and approved for AOO, LOCA, Stability and ATWS

- TRACG Models and Qualification have been reviewed and approved by reference for the approved applications
- Reviews during the past nine years have involved numerous individuals from NRC and ACRS
- New and or unreviewed models and qualification are unique to post boiling transition LOCA applications.
  - Post boiling transition heat transfer and rewet
  - Thermal radiation heat transfer
  - Metal-water reaction
  - Cladding failure
  - Upper plenum phenomena
  - Parallel channel effects