# Official Transcript of Proceedings ACRST-3193

# NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
491st Meeting - OPEN SESSION

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TR04

1 UNITED STATES OF AMERICA

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3 NUCLEAR REGULATORY COMMISSION

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5 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

6 (ACRS)

7 MEETING #491

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9 Friday

10 April 12, 2002

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12 ROCKVILLE, MARYLAND

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14 The ACRS met at the Nuclear Regulatory

15 Commission, Two White Flint North, Room T2B3, 11545

16 Rockville Pike, at 8:30 a.m., Mario V. Bonaca, Vice

17 Chairman, presiding.

18 COMMITTEE MEMBERS:

19 MARIO V. BONACA, Vice Chairman

20 THOMAS S. KRESS, Member-at-Large

21 F. PETER FORD, Member

22 GRAHAM M. LEITCH, Member

23 DANA A. POWERS, Member

24 VICTOR H. RANSOM, Member

25 STEPHEN L. ROSEN, Member

1 COMMITTEE MEMBERS (cont.):

2 WILLIAM J. SHACK, Member

3 JOHN D. SIEBER, Member

4 ACRS STAFF PRESENT:

5 SHER BAHADUR, Associate Director ACRS/ACNW

6 PAUL A. BOEHNERT, ACRS Staff

7 RALPH CARUSO, ACRS Staff

8 JOE DONOGHUE, ACRS Staff

9 SAM DURAISWAMY, Technical Assistant ACRS/ACNW

10 ED KENDRICK, ACRS Staff

11 HOWARD J. LARSON, Special Assistant ACRS/ACNW

12 TAD MARSH, ACRS Staff

13 ALSO PRESENT:

14 FRAN BOLGER, GE

15 ISRAEL NIR, GE

16 DAN PAPPONE, GE

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C-O-N-T-E-N-T-S

1 P-R-O-C-E-E-D-I-N-G-S

2 (8:32 a.m.)

3 VICE CHAIR BONACA: On the record. The
4 meeting will now come to order.

5 This is the second day of the 491st
6 meeting of the Advisory Committee on Reactor
7 Safeguards. During today's meeting the Committee will
8 consider the following: General Electric Nuclear
9 Energy topical report Constant Pressure Power Uprate,
10 future ACRS activities, report of the Planning and
11 Procedure Sub-Committee, reconciliation of ACRS
12 comments and recommendations, and proposed ACRS
13 reports. A portion of the meeting may be closed to
14 discuss General Electric proprietary information.

15 This meeting is being conducted in
16 accordance with the provisions of the Federal Advisory
17 Committee Act. Mr. Sam Duraiswamy is the designated
18 Federal Official for the initial portion of the
19 meeting.

20 We have received no written comments or
21 requests for time to make oral statements from members
22 of the public regarding today's sessions. A
23 transcript of a portion of the meeting is being kept.
24 It is requested that the speakers use one of the
25 microphones, identify themselves and speak with

1 sufficient clarity and volume so that they can be
2 readily heard.
3 We have two new additions to our staff.
4 Mr. Rob Elliott, could you please stand up? You will
5 be with us for two years. Right?
6 MR. ELLIOTT: It's going to be on the
7 30th.
8 VICE CHAIR BONACA: Yes. He has been with
9 the NRC for almost 11 and a half years. His most
10 recent position was as a Technical Reviewer in NRR's
11 Plant Systems Branch. He has also had the lead roles
12 in both the Hatch and Duke Power Licensing UL
13 Application Reviews. He's well qualified to be with
14 us.
15 The other person is Tim Kobetz who is also
16 going to be with us for two years. His most recent
17 job with the Agency was as Project Manager with the
18 Spent Pure Project Office in NMSS. Before that he was
19 Senior Resident Inspector for two years at the Point
20 Beach Nuclear Plant. So he's also very well qualified
21 to be with us. Welcome to both of you.
22 We are ready to start. The first topic is
23 the General Electric Nuclear Energy topical report,
24 Constant Pressure Power Uprate. The cognizant member
25 is Mr. Sieber.

1 MEMBER SIEBER: Thank you, Mr. Chairman.
2 I think before we begin we have two members with
3 potentially conflicts of interest, Dr. Ford and Dr.
4 Ransom who would like to make a statement for the
5 record to recuse yourself.
6 MR. BOLGER: I'm a GE retiree. Therefore
7 I declare a conflict of interest.
8 MEMBER RANSOM: I'm Victor Ransom. I own
9 700 shares of GE stock. Until I get rid of those I
10 guess I should go. Right now I don't want to get rid
11 of them.
12 MEMBER SIEBER: Okay. Thank you. I also
13 note from the slides that there is proprietary
14 information. I would request General Electric to let
15 me know so that we can close the session and mark the
16 transcript accordingly. Those persons in the room who
17 should not have access to proprietary information will
18 be requested to step outside for that period of time.
19 As we begin the session, I would note that
20 the Thermal Hydrolic Phenomenon Sub-Committee met
21 twice to discuss specifically General Electric's
22 constant pressure power operate topical report first
23 on January 16 through 18 and second on March 6. We
24 have all had some experience at least with the
25 concepts because Clinton came very close in its Uprate

1 to strictly following what was in the topical report
2 and Dresden Quad Cities also used elements of it.
3 From our Sub-Committee meetings, we had a
4 couple of issues that we have asked be further
5 discussed today so that we can clarify and fill in
6 some detail. The first of those would be directed to
7 General Electric which talks about core spray
8 effectiveness. So that we would get a better and
9 stronger feel of whether it's adequate or not.
10 The second issue that has come up in
11 various power uprates and also in the discussion here
12 is more directed to the staff. It has to do with
13 oversight of the reload analysis methodology. The
14 licensee usually through its integral supplier or its
15 fuel vendor is required to perform a Reload Safety
16 Analysis for every reload and every cycle.
17 So that they first of all can establish
18 and demonstrate that the core as designed and operated
19 will meet all the regulatory constraints. The outcome
20 of that is a Reload Safety Analysis and a Core
21 Operating Wellness Report. The Core Operating
22 Wellness Report is used in the control room by the
23 operators and reactor engineers in order to properly
24 operate the core.
25 On the other hand, neither of these

1 documents are submitted to the staff prior to the
2 start-up after a refueling outage. The practice of
3 the staff right now is not to audit these reports
4 either.
5 The Constant Pressure Power Uprate places
6 a greater demand on core performance than previously
7 existed. In that we're trying to achieve flux
8 flattening to get a higher average power output from
9 a core without increasing the peak rod power. Also in
10 a lot of cases it involves a change in the style or
11 model of the fuel. So that you may end up with a
12 mixed core of two different types of fuel or a new
13 type of fuel for a given cycle.
14 We are concerned that these Core Operating
15 Wellness Reports and the Reload Safety Analysis are
16 not being reviewed. We feel that it would be more
17 appropriate given the higher demands of the core and
18 changes that are occurring during an uprate that the
19 staff pay closer attention to these reports for
20 transitional cores.
21 With that I think that's enough of an
22 introduction, I'll end up using everybody's time.
23 Then we'll have to have a break. I really don't want
24 to do that. So what I'd like to do now is introduce
25 Joe Donoghue.

1 MR. BOEHNERT: He's not in there.

2 MEMBER SIEBER: Okay.

3 MR. BOEHNERT: GE is going first. He's

4 coming later.

5 MEMBER SIEBER: Okay.

6 MR. NIR: Good morning. My name is Israel

7 Nir. I'm representing General Electric. I'll cover

8 the GE BWR Constant Pressure Power Uprate Program.

9 We're also going to cover the core spray topic and

10 also some general information on the reload scope just

11 to give the Committee maybe a sense of what is

12 involved in a standard BWR reload campaign.

13 I have a short open session. It provides

14 some introductory remarks. Then we'll go into the

15 closed session which I'll provide more detail on the

16 Constant Pressure Power Uprate Program.

17 Most of the slides that I will present was

18 presented to the Thermal Hydrolic Phenomenon Sub-

19 Committee. So bear with me. That's actually per

20 their request. Hopefully the second time around will

21 be better.

22 We now have extensive analysis experience

23 with Extended Power Uprate and growing experience with

24 implementation. The 12 BWRs are now in different

25 phases of implementing EPU. They all were approved to

1 implement the EPU. NRC is now in the process of
2 reviewing two additional BWRs.
3 We expect to see additional requests for
4 Extended Power Uprate in the coming years. In
5 anticipation for that load, we propose this Constant
6 Pressure Power Uprate approach, the CPPU. It is based
7 on our growing experience. It is focused on the
8 potential impacts of the power increase, maintain
9 safety margin, facilitate the review and focus the
10 documentation of the power increase effects.
11 We met first with the Thermal Hydrolic
12 Phenomenon Sub-Committee back in June 2001 to describe
13 the approach. We initiated the interface with the NRC
14 back in March 2001. We submitted the Constant
15 Pressure Power Uprate LTR which I will refer to as
16 CLTR.
17 We received significant feedback on the
18 approach in the level of detail. We then resubmitted
19 the CLTR in July 2001. We received a significant
20 number of RAIs that provided I believe some
21 significant clarifications on the CLTR. We submitted
22 a RAI Addenda (PH) to the CLTR in December 2001.
23 We met with the Sub-Committee again in
24 January to describe the approach. Clinton made a
25 presentation on their program which included some

1 elements of CPPU to the Sub-Committee and as a matter
2 of fact in March to the full Committee. We met again
3 in March with the Sub-Committee to review the CLTR/CR.
4 I have just a few words on GE Power Uprate
5 Program. It started with a 5 percent Power Uprate
6 Program which is a Stretch Power Uprate. We then
7 moved back in '98 to Extended Power Uprate, up to 20
8 percent above original license thermal power.
9 We also have what we call Thermal Power
10 Optimization Uprate which is based on the improved
11 feedwater flow measurement uncertainty. It involves
12 Power Uprate up to about one and a half percent, not
13 exceeding two percent.
14 Finally the last element is the Constant
15 Pressure Power Uprate which is associated with no
16 pressure increase but as you will see it is actually
17 more than that. It's a more streamlined and
18 simplified approach.
19 This is a summary of our Power Uprate
20 experience. You can see on the left hand side that
21 initially the Power Uprates were associated with a
22 dome pressure increase. As we move to the right hand
23 side, some of the latest five percent Power Uprates
24 were associated with no pressure increase. All of the
25 subsequent EPUs are associated with no pressure, dome

1 pressure increase.

2 I noted at the bottom that Brunswick Unit

3 1 and 2, the effort is in progress. Actually it's

4 under NRC review. Browns Ferry Units 2 and 3 are also

5 in progress. It will submit in the middle of the

6 year. I believe the target right now is July.

7 Finally this is just a summary of what the

8 program has contributed to the electrical grade. This

9 is a summary of the Megawatt Electric added as a

10 result of GE BWR Power Uprates. You can see that the

11 light gray is the five percent power, the Stretch.

12 This is a past contribution of 1,000 or so Megawatt

13 Electric.

14 You can see that the EPU contribution.

15 This is the licensed EPU still in different phases of

16 implementation but it will reach the level equivalent

17 of what we've achieved with the Stretch. In progress

18 we have another 540. What is still on top and

19 potentially used in the years to come is about 46

20 percent or an additional 2,000 Megawatt Electric.

21 Overall that is as indicated here the

22 equivalent of five relatively large BWR plants. The

23 program definitely contributes significant Megawatt

24 Electric to electrical grid. That concludes my

25 comments for the open session. I'm ready now to go to

1 the closed session.

2 MEMBER SIEBER: Can we go to the closed

3 session now?

4 (Discussion off the microphones.)

5 MR. BOEHNERT: Let's go to closed session.

6 No one has to leave apparently.

7 (Whereupon, at 8:47 a.m., the proceedings

8 went into Closed Session.)

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**CERTIFICATE**

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards

Docket Number: 491st Meeting (Open Session)

Location: Rockville, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

/s/ Debra Wilensky
Debra Wilensky
Official Reporter
Neal R. Gross & Co., Inc.

GE Nuclear Energy

# Advisory Committee on Reactor Safeguards Full Committee Meeting

## *GE BWR Constant Pressure Power Uprate Program*

*Open Session*

April 12, 2002

## Outline

- **Opening Remarks (Open Session)**
- **Introduction**
  - **Past EPU briefing to ACRS**
  - **Key elements of GE CPPU program**
  - **BWR PU Implementation status and grid MWe time line**
- GE CPPU Program (Closed Session)
- Concluding Remarks

## Opening Remarks

- Extensive experience with EPUs
  - EPU being implemented at 12 BWRs
  - NRC review on-going for 2 additional BWRs
- High volume of power uprate review requests anticipated
  - Expect 4 BWR submittals per year
- CPPU approach proposed by GE
  - Experience based
  - Focus on potential impacts
  - Maintain safety margins
  - Facilitate regulatory review



## Past CPPU briefing to ACRS

- June 12, 2001 described CPPU approach
  - CPPU LTR (CLTR) submitted for NRC review in 3/01
  - CLTR Rev. 1 submitted in 7/01 to address NRC feedback
  - CLTR E&A submitted 12/01 to address NRC RAIs
- January 16, 2002 described CPPU/CLTR approach
- February 13-14, 2002 CPS EPU selected CPPU topics
- March 6, 2002 reviewed CLTR SER (GE/NRC Staff)
- March 7, 2002 CPS EPU selected CPPU topics (full committee)

# GE PU Program Key Elements

- **Power Uprate licensing**
  - **Stretch Power Uprate (SPU)**
    - Up to 105% of original licensed thermal power (OLTP)
  - **Extended Power Uprate (EPU)**
    - Up to 120% OLTP
  - **Thermal Power Optimization (TPO)**
    - Improved feedwater flow measurement uncertainty
  - **Constant Pressure Power Uprate (CPPU)**
    - Up to 120% OLTP, no maximum operating reactor dome pressure increase

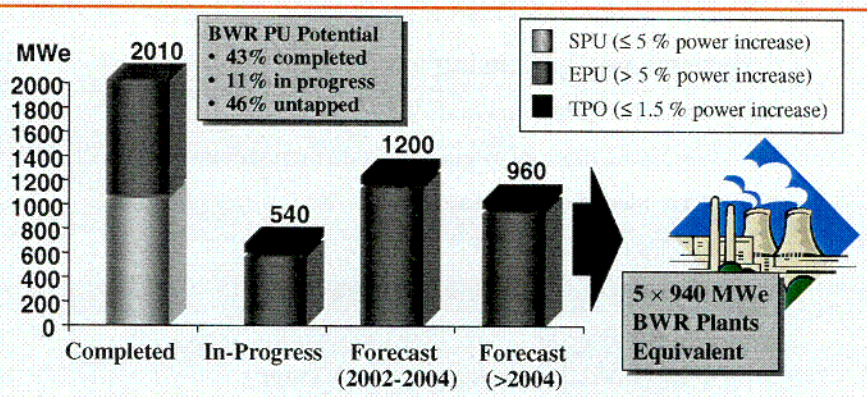


# GE PU Experience/Status

| Plant | PU (~% OLTP) | Dome Pr Increased | Plant | PU (~% OLTP) | Dome Pr Increased |
|---|---|---|---|---|---|
| Duane Arnold | 105 | Yes | Laguna Verde - 1, 2 | 105 | No |
| Cofrentes | 105 | Yes | LaSalle - 1, 2 | 105 | No |
| Hatch - 1, 2 | 105 | Yes | Perry | 105 | No |
| Susquehanna - 1, 2 | 105 | Yes | KKL | 120 | No |
| WNP-2 | 105 | Yes | Hatch - 1, 2 | 113 | No |
| Limerick - 1, 2 | 105 | Yes | Monticello | 106 | No |
| Peach Bottom - 2, 3 | 105 | Yes | Cofrentes | 110 | No |
| Fermi 2 | 105 | Yes | Duane Arnold | 120 | No |
| FitzPatrick | 105 | Yes | Dresden - 2, 3 | 117 | No |
| Brunswick - 1, 2 | 105 | Yes | Quad Cities - 1, 2 | 117 | No |
| NMP-2 | 105 | Yes | Clinton | 120 | No |
| Browns Ferry - 2, 3 | 105 | Yes | Brunswick - 1, 2 * | 120 | No |
| KKM | 114 | Yes | Browns Ferry - 2, 3* | 120 | No |
| KKL | 105 | Yes | | | |
| River Bend | 105 | Yes | | | |

* In progress

# GE BWR PU MWe Time Line




**Supports NRC Staff Requirements memo on additional PU**

**High power uprate volume for NRC review is anticipated**



C01

**GE Nuclear Energy**

# Advisory Committee on Reactor Safeguards Full Committee Meeting

## *GE BWR Constant Pressure Power Uprate Program*

*Closed Session*

April 12, 2002

# Outline

- **CPPU/CLTR** - I. Nir
  - CPPU approach
  - Heat balance, power/flow map
  - Relation to ELTR
  - CPPU process simplification
  - CLTR dispositions
  - CLTR format
  - Plant specific submittal
- **Specific Topics**
  - Standard BWR reload analysis scope - F. Bolger
  - Core Spray Distribution - D. Pappone
- **Concluding Remarks** - I. Nir

# CPPU Approach

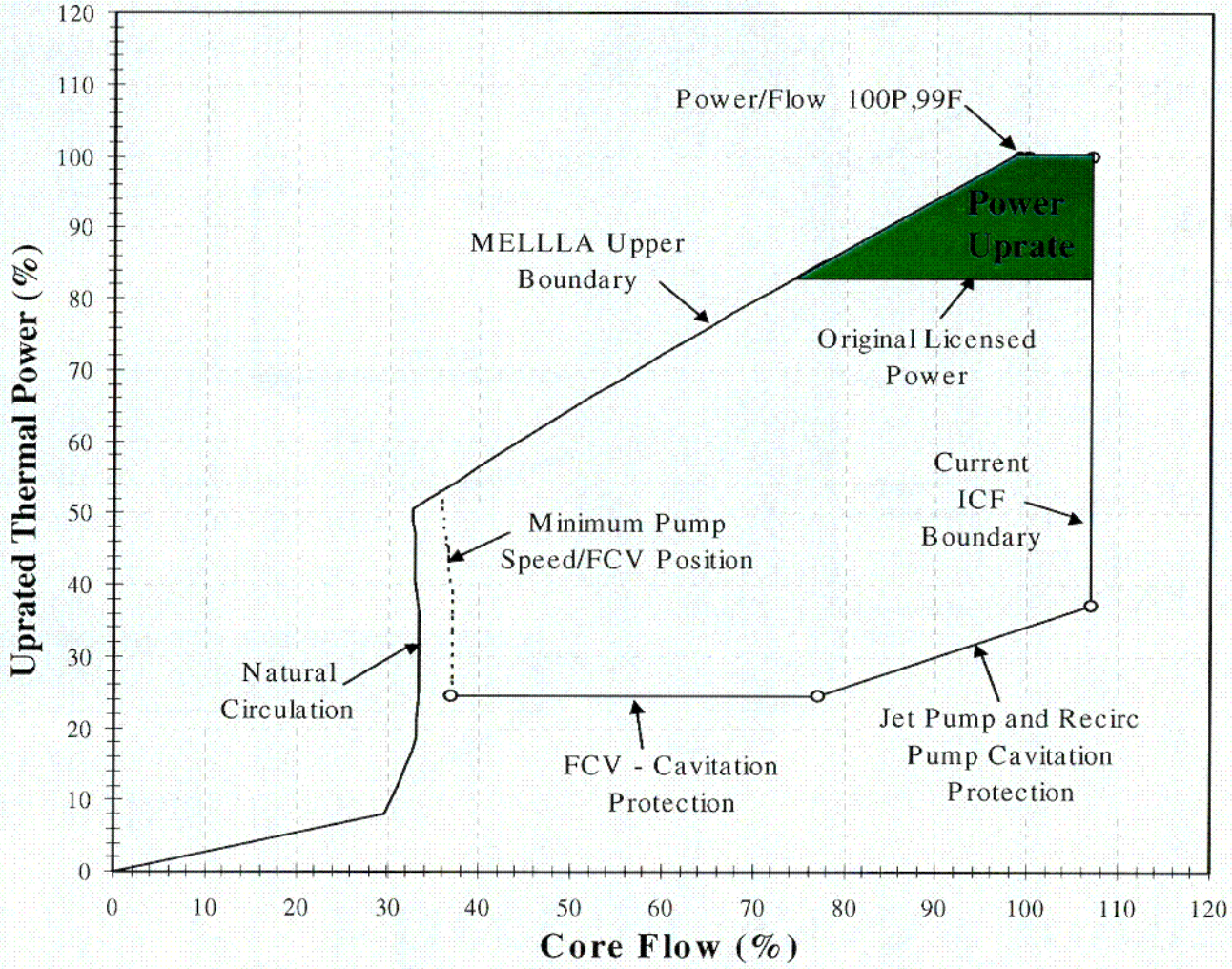
- **Transition to efficient and effective power uprate evaluation and NRC review processes**
  - **Uprate aspects not significantly affected by power increase should not dilute effort and priorities**
- **Introduce approach and process simplifications to facilitate focus on aspects affected by power increase**
  - **Separate changes not related to power increase**
    - Quantify direct uprate effect
  - **Separate aspects not affected by power increase**
    - Build on SPU and EPU experience

**A streamlined process maintaining full assurance of safety**

# CPPU Changes

- **Limit power increase to 20% of Original Licensed Thermal Power (OLTP)**
  - **Increased steam flow**
  - **Increased feedwater flow**
  - **Increased feedwater temperature**
  - **Increased radiation source and levels**
  - **Increased decay heat**
- **Results in limited effect on safety related systems and performance**
- **Some modifications to non-safety related power cycle and balance of plant system required**

# CPPU Operating Map






C02

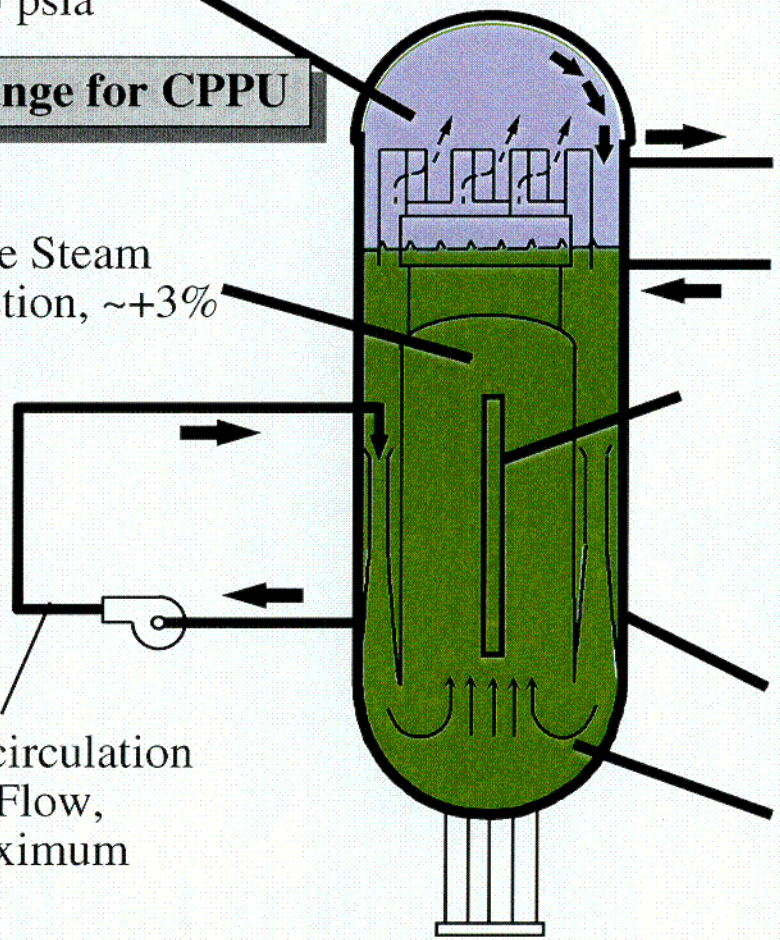
# ≤ 20% PU Effect on NSSS Conditions

ELTR Dome Pressure
1020 to 1095 psia

**No pressure change for CPPU**

Average Core Steam
Volume Fraction, ~+3%

Average Recirculation
Drive Loop Flow,
≤~+3%; Maximum
Unchanged



Steam & FW Flows,
≤~+24%
FW Temperature, ≤~+10 °F

Average Channel Power
Increase ≤20%;
No Significant Change in
Hot Channel Conditions
(~Same operating limits)

$RT_{NDT}$ Shift ≤~10 °F

Max Licensed Core Flow
Unchanged; Smaller Full
Power Core Flow Range



C03

# CPPU Relation to ELTR

- **Analysis methods evaluated and approved for PU up to 20% OLTP as part of the ELTR generic licensing**
  - **Addressed significant reactor pressure increase**
- **CPPU represents a subset of the ELTR scope considering CLTR exclusions**
  - **ELTR methods applicability identified in CLTR**
- **Methods subsequently approved by NRC and applicable to PU may be used**

# CPPU Process Simplification

- **Significant CLTR scope reduction relative to ELTR**
- **Changes to the following require separate submittal**
  - **No increase in maximum operating reactor dome pressure**
  - **No increase to maximum licensed core flow**
  - **No increase to MELLLA/MEOD upper boundary**
  - **No change to source term methodology**
  - **No new fuel mechanical design**
  - **No change to operating cycle length**
  - **No introduction of/additions to licensed operational enhancements**

**NRC review focused on power increase effects only**

# CLTR Dispositions (Process Completeness)

- **Systematic disposition of all power uprate topics in CPPU LTR**
  - **SPU/EPU experience based scope**
  - **~ 200 separate topics**
- **Two Types of Dispositions**
  - **Generic (~ 50%)**
  - **Plant specific (~ 50%)**

# **Generic Assessments** (Process Efficiency)

- **Justified as either:**
  - **Bounding analysis**
    - Previous ELTR bounding assessments applicable to CPPU
    - Additional generic studies
  - **Negligible effect due to CPPU**
  - **Selected fuel dependent evaluations**
    - PU effect small and comparable to cycle specific variations
    - Address by standard reload process
      - Cycle specific analysis required prior to CPPU implementation
- **All generically dispositioned topics must be confirmed in plant specific submittal**

# Generic Assessments (ELTR deviations)

- **Selected fuel dependent evaluations**

| Phase | ELTR Approach | CLTR Approach |
|---|---|---|
| PU Analysis | • Based on representative equilibrium cycle<br>– Provides indication of changes expected for actual cores<br>– Not applied for actual design | • Based on knowledge and experience<br>– Change is small and similar to cycle-to-cycle variations<br>– Not applied for actual design |
| Reload | • Standard reload process requires prescribed cycle specific analysis | • Standard reload process requires prescribed cycle specific analysis |

- **Reload results not available at the time of PU submittal**

# Selected fuel dependent evaluations (examples)

- **Power Uprate analysis phase (including submittal)**

| Topic | ELTR Approach | CLTR Approach |
|---|---|---|
| SLMCPR | • Based on representative equilibrium cycle<br>– Small effect not applied to actual design | • Knowledge/experience base quantification<br>– Small effect not applied to actual design |
| Thermal Margin AOOs | " | " |
| Stability (AOO) | " | " |

- **Reload phase**
  - Required standard reload demonstrates compliance for actual design
  - Recent Clinton EPU review successfully demonstrated process

# Generic Assessments (ELTR deviations)

- **Negligible effect due to CPPU (examples)**

| Topic | ELTR Approach | CLTR Approach |
|---|---|---|
| General | • Plant specific analysis | • Limiting scenarios or knowledge/ experience base |
| Large Break LOCA | • Full scope analysis of limiting events | • Limiting event to quantify PCT change (< ~ 20°F) |
| ATWS PCT | • Plant specific analysis | • Knowledge, experience base (< 1500 vs. 2200°F limit) |

- **Small break LOCA spectrum analysis required (decay heat effect)**
- **Recent Clinton EPU review successfully demonstrated ECCS-LOCA disposition**

# Generic Assessments (ELTR deviations)

- **Bounding analyses (examples)**

| Topic | ELTR Approach | CLTR Approach |
|---|---|---|
| General | • Plant specific analysis | • Eliminate non-limiting events<br>• Establish bounding analyses |
| ATWS Events | • 4 events (MSIVC, PRFO, IORV, LOOP) | • Eliminate non-limiting IORV and LOOP (bounded by MSIVC and PRFO) |
| Radiation Sources in Rx Core | • Plant specific analysis | • Bounding scenario established<br>– Bounding values for key parameters specified |

# Plant Specific Evaluations (Focused Review)

- **Require plant specific input**
- **CPPU will evaluate key plant specific PU aspects**
  - **Pressure relief system**
  - **Reactor vessel fluence**
  - **Reactor vessel and internals structural performance**
  - **Containment temperature, pressure and loads response**
  - **ECCS LOCA performance**
  - **Emergency service water systems**
  - **Loss of Feedwater**
  - **SLCS ATWS requirement**
  - **Radiation source and accident radiological consequences**
  - **ATWS, SBO, fire protection, HELB, PSA, EQ**
- **Relative effect of PU known**
- **Allows focused, standardized plant specific analysis**

# CLTR Format

- CLTR sections and technical areas outline follow recent EPU plant specific submittals
- Summary disposition at beginning of each section
  - Topic disposition at the beginning of each subsections
  - Evaluations provide CPPU effect and basis for each topic disposition

# CPPU Plant Specific Submittal

- **Maintain existing EPU plant specific submittal general approach**
  - Similar format and content for CPPU based submittal
- **Content depends on CLTR disposition**
  - Generic ➡ Disposition basis/plant specific confirmation
  - Plant specific ➡ Same level of detail as recent EPU submittal
    - Including applicable input, assumptions, methods and results
- **Integrate applicable past RAIs as appropriate**
- **Document/justify any CLTR basis deviations/exceptions**
  - Include a summary in Section 1 of the plant specific submittal

# Outline

- CPPU/CLTR - I. Nir
  - CPPU approach
  - Heat balance, power/flow map
  - Relation to ELTR
  - CPPU process simplification
  - CLTR dispositions
  - CLTR format
  - Plant specific submittal
- **Specific Topics**
  - **Standard BWR reload analysis scope - F. Bolger**
  - ECCS Core Spray Distribution - D. Pappone
- Concluding Remarks - I. Nir

# Standard BWR Reload Analysis Scope

## Review of Supplemental Reload Licensing Report

- **SRLR primary deliverable resulting from reload licensing process**
- **The data in SRLR covers critical output from the licensing process**
- **SRLR sections are described in GESTAR as follows:**

1. Plant-unique items
2. Reload Fuel Bundles
3. Reference Core Loading Pattern
4. Calculated Core Effective Multiplication and Control System Worth - No Voids, 20°C
5. Standby Liquid Control System Shutdown Capability
6. Reload Unique GETAB Anticipated Operational Occurrences (AOO) Analysis Initial Condition Parameters
7. Selected Margin Improvement Options
8. Operating Flexibility Options
9. Core-wide AOO Analysis Results
10. Local Rod Withdrawal Error (w/ Limiting Instrument Failure) AOO Summary
11. Cycle MCPR Values
12. Overpressurization Analysis Summary
13. Loading Error Results
14. Control Rod Drop Analysis Results
15. Stability Analysis Results
16. Loss-of-Coolant Accident Results

Appendix A - Analysis Conditions

# SRLR Analysis Summary

| SRLR Section | Typical Analyses Performed To Support This Section |
|---|---|
| 3. Reference Core Loading Pattern<br>4. Calculated Core Effective Multiplication and Control System Worth - No Voids, 20°C<br>5. Standby Liquid Control System Shutdown Capability | About 15 statepoints are converged with PANACEA (3D simulator) for energy determination and for thermal limits determination. For each statepoint, cold shutdown margin, SLCS shutdown margin, and hot excess reactivity is determined.<br>**≈ 60 Core and Fuel cases** |
| 6. Reload Unique GETAB Anticipated Operational Occurrences (AOO) Analysis Initial Condition Parameters<br>9. Core-wide AOO Analysis Results<br>10. Local Rod Withdrawal Error (With Limiting Instrument Failure) AOO Summary<br>11. Cycle MCPR Values<br>12. Overpressurization Analysis Summary<br>13. Loading Error Results | Three ODYN (1D transient)/TASC (1D hot channel) MCPR transients are analyzed for the maximum and minimum core flow, two feedwater temperatures, two core axial power shapes, two exposures (Section 7), and two operational flexibility conditions (Section 8). One ODYN overpressure transient is analyzed. Three PANACEA exposures are analyzed for Loss of Feedwater Heating. One PANACEA exposure is analyzed for Rod Withdrawal Error. About 15 statepoints are converged with PANACEA for misallocated bundle fuel loading error.<br>**≈ 115 AOO cases** |
| 15. Stability Analysis Results | For Option 1D perform at least 2 ODYSY (1D frequency domain) calculations at 3 exposures on two rod lines. Other stability options vary in scope.<br>**≈ 12 Stability cases** |
| 16. Loss-of-Coolant Accident Results | Confirm reload bundles are bounded by base LOCA analysis unless a new fuel type is being introduced. |

# Outline

- CPPU/CLTR - I. Nir
  - CPPU approach
  - Heat balance, power/flow map
  - Relation to ELTR
  - CPPU process simplification
  - CLTR dispositions
  - CLTR format
  - Plant specific submittal
- **Specific Topics**
  - Standard BWR reload analysis scope - F. Bolger
  - **Core Spray Distribution - D. Pappone**
- Concluding Remarks - I. Nir

# Core Spray Distribution

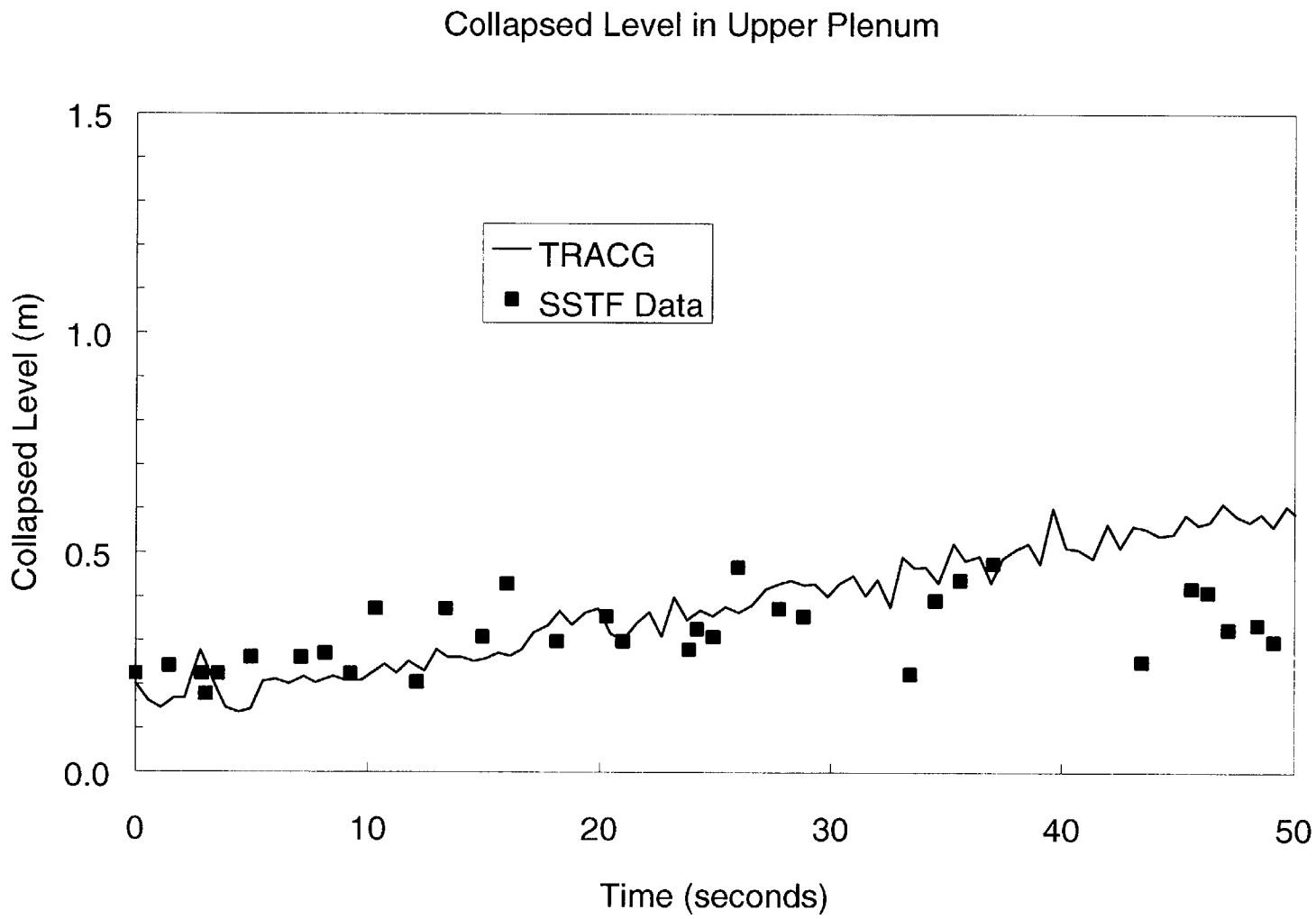
- **Power uprate concerns**
  - **More steam updraft may disrupt spray distribution**
  - **Higher power in peripheral core may lead to more CCFL holdup**
    - May delay CCFL breakdown in peripheral region
    - May delay upper plenum draining and reflooding of core
- **Power uprate effect on spray distribution not a concern**
  - **Steam venting through core center disrupts spray distribution**
    - Steam updraft provides good cooling
  - **No credit for direct spray distribution in analytical models**
- **CCFL holdup in upper plenum is a self-limiting phenomenon**
  - **Governed by subcooling in peripheral region**
  - **More holdup → earlier breakdown**
  - **No net impact due to power uprate**

# SSTF Upper Plenum Mixing Test

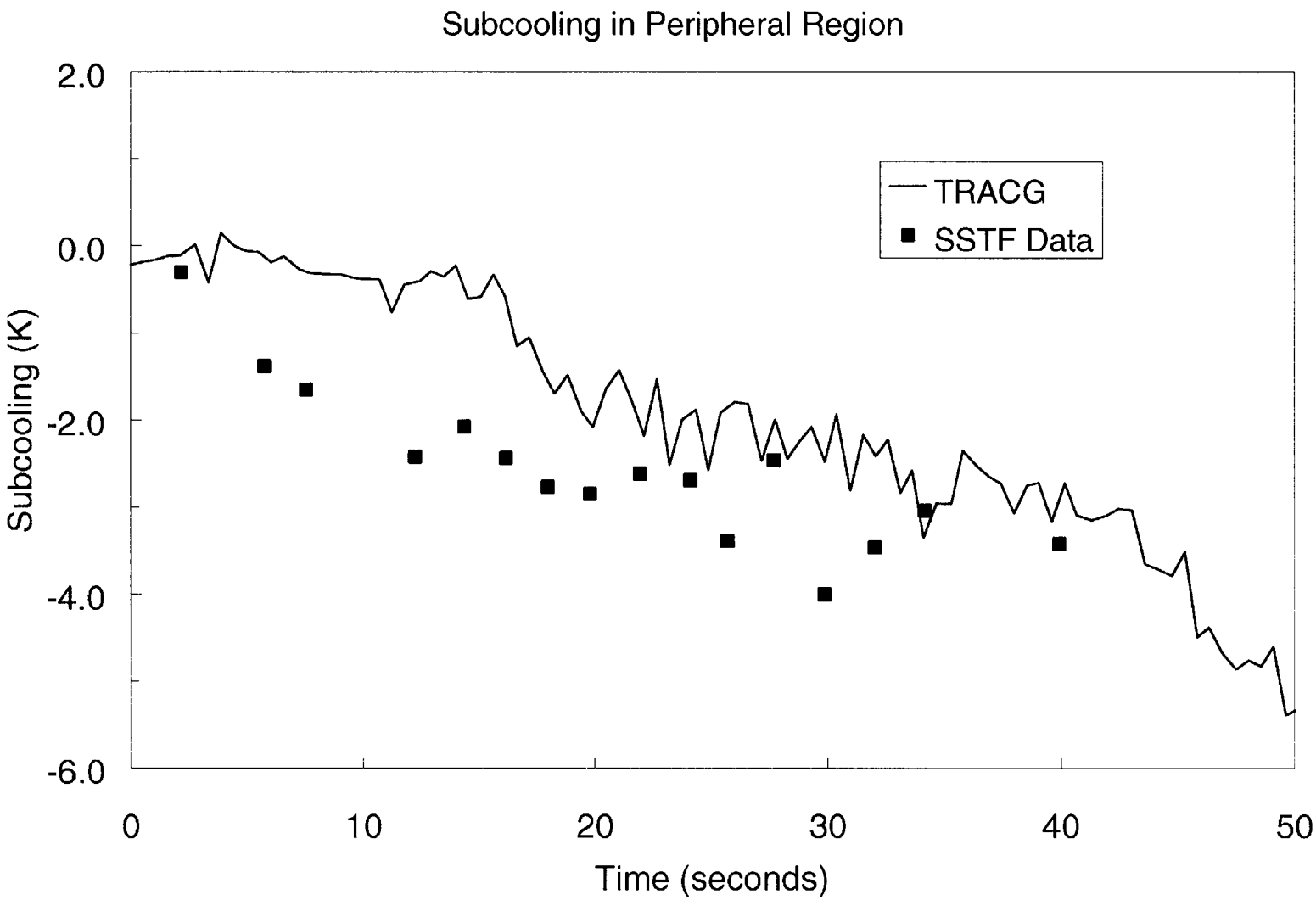
- **SSTF separate effects test**
  - **ECC mixing**
  - **Parallel channel response**
- **Test configured to maximize holdup in upper plenum**
  - **Lower plenum, bypass filled with saturated water**
  - **Level in bundles held above lower tie plate to prevent steam communication between bundles**
- **Test results show**
  - **ECC flow drains through peripheral bundles**
  - **Little downflow in middle and central bundles due to CCFL**
  - **Maximum inventory buildup of ~0.4 m (collapsed level) out of 1.8 m upper plenum height**

**CCFL holdup is self-limiting**

# SSTF Upper Plenum Test (Level)



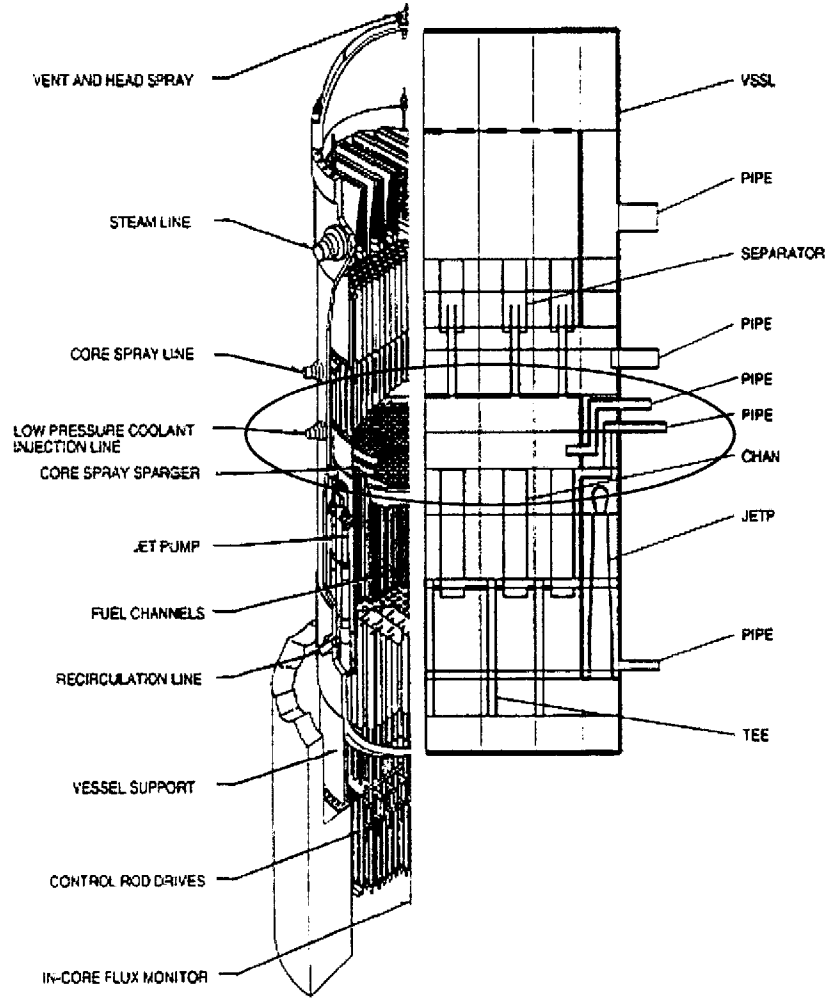
# SSTF Upper Plenum Test (Subcooling)



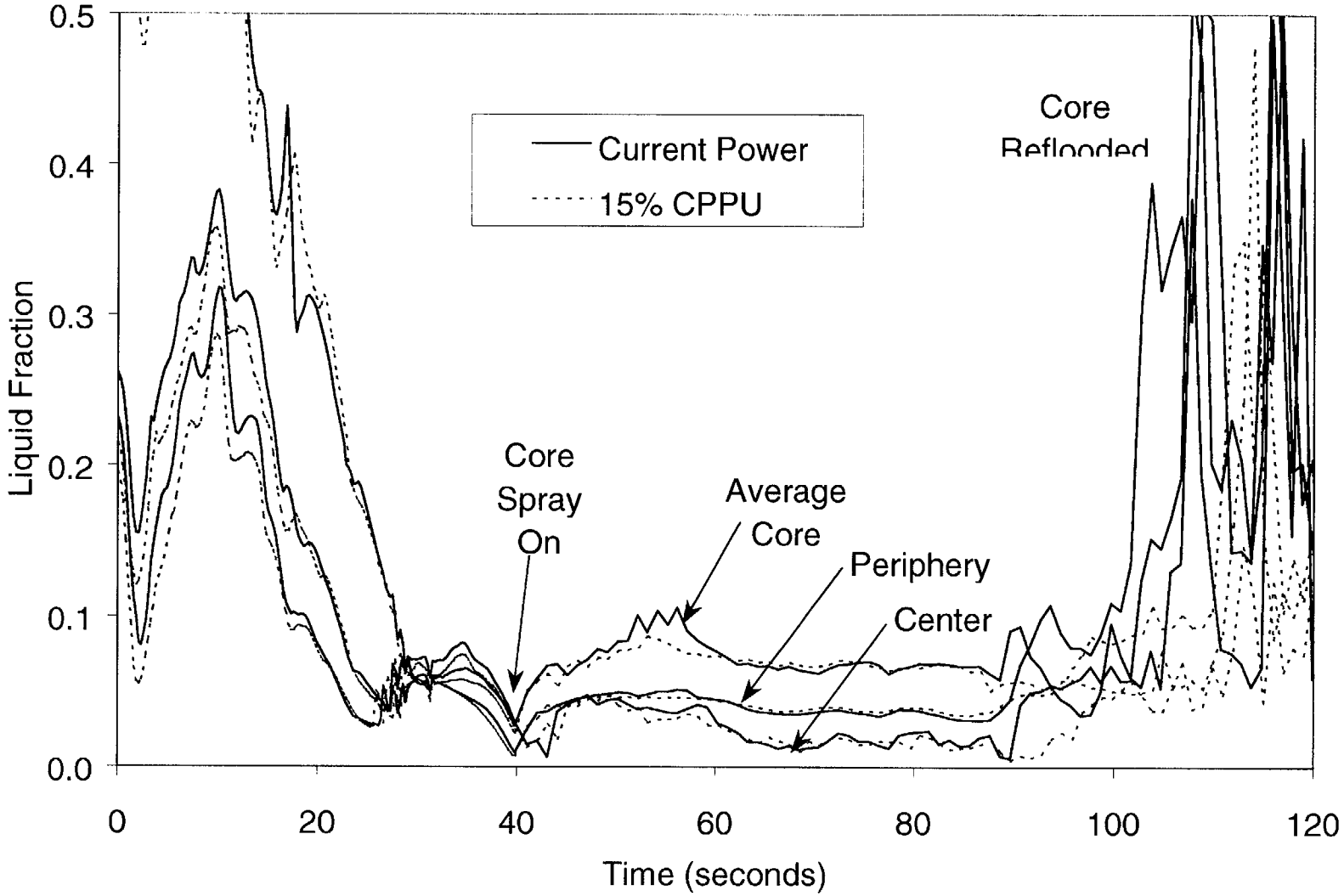
# CPPU TRACG Calculations

- **BWR/4 TRACG calculations for DBA to show effect of CPPU on upper plenum behavior**
  - **Upper plenum modeled using 2 layers with 3 rings**
  - **Average fuel channel power increased ~15%, hot channel power held constant on thermal limits**
- **Core spray distribution**
  - **0% in center ring**
  - **62% in average core ring**
  - **38% in peripheral ring**
- **Results show CPPU has no significant effect on upper plenum behavior**
  - **No change in liquid inventory holdup**
  - **Negligible change in subcooling characteristics**
  - **No CCFL in peripheral bundles**

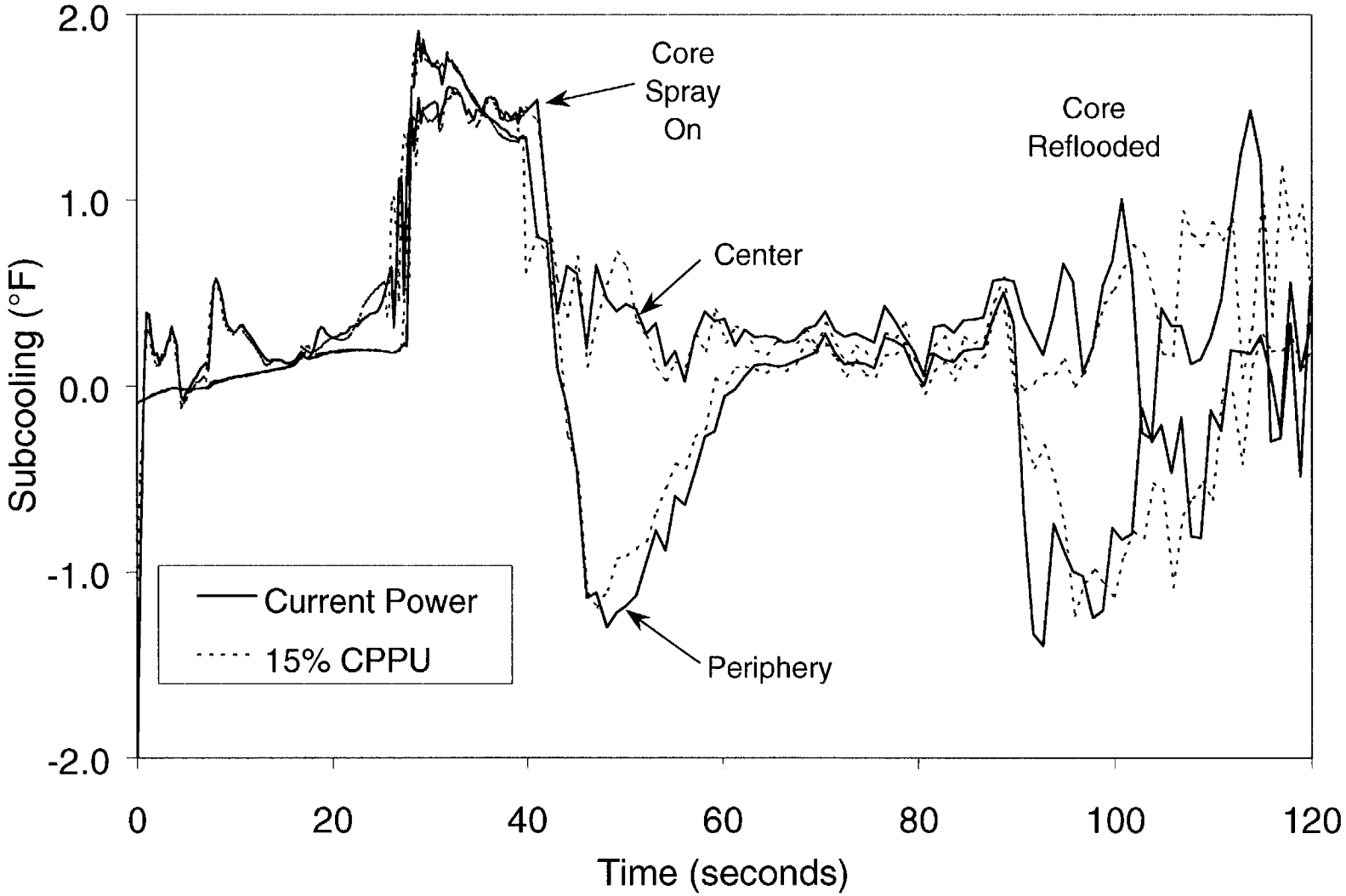
# TRACG Nodalization



# Upper Plenum Liquid – BWR/4 DBA



# Upper Plenum Subcooling – BWR/4 DBA



# Conclusions

- **CCFL holdup in upper plenum is self-limiting phenomenon**
- **TRACG comparisons show no change in upper plenum inventory holdup due to power uprate**

**Power Uprate has no significant effect on upper plenum behavior during LOCA**

# Concluding Remarks

- **Extensive experience with EPUs**
  - **EPU being implemented at 12 BWRs**
  - **NRC review on-going for 2 additional BWRs**
- **High volume of power uprate review requests anticipated**
  - **Expect 4 BWR submittals per year**
- **CPPU approach proposed by GE**
  - **Experience based**
  - **Focus on potential impacts**
  - **Maintain safety margins**
  - **Facilitate regulatory review**

# GE CONSTANT PRESSURE POWER UPRATE

NRC Review of Licensing Topical Report

Briefing to the
Advisory Committee on Reactor Safeguards

April 12, 2002

Joe Donoghue, NRR (301) 415-1131

**Presentation Includes GE Proprietary Information**



## Background: CPPU Topical Report Review

- GENE submitted NEDC-33004P, Rev. 1, "Constant Pressure Power Uprate" in July 2001
- Recent EPU submittals use parts of the CPPU approach (e.g., Clinton, Brunswick)
- NRC staff completed draft safety evaluation in March 2002
- Presentations to ACRS Subcommittee on T-H Phenomena
  - GE on January 16, 2002
  - NRC/GE on March 6, 2002

## Today's Presentation

- Focus on Reactor and Plant Systems Areas of review
- Highlights:
  - Key departures from previous power uprate approach
  - Specific exclusions applicable to CPPU
  - Role of audits conducted by NRC staff



# GE/BWR Constant Pressure Power Uprate Licensing Topical Report

Fuel and Reactor Systems

Ralph Caruso
Section Chief
BWR Systems and Nuclear Performance
Reactor Systems Branch

Presentation Includes GE Proprietary Information

# BACKGROUND

- Constant Pressure Power Uprate approach
  - Thermal power increase (up to 20%) from the original rated thermal power (ORTP),
  - Increased steam and feedwater system flow,
  - [NO increase in licensed maximum core flow,]
  - [NO increase in reactor dome pressure,]
  - [NO increase in power/flow map upper bound, only] [extension along current rod lines]
  - [NO change in fuel product line, maximum fuel burnup,] [or operating fuel cycle length]
  - [NO change to current operational improvement options]





# REVIEW SCOPE/APPROACH

- Reactor Core and Fuel Performance
- Reactor Coolant System and Connected Systems
- ECCS System Function and Performance during LOCA
- Capability of SLC System
- Reactor Safety Performance Features
- Included on-site audits at GENE and GNF

# SRXB AUDITS

- Focused on Specific Areas:
  - Reactor Core and Fuel Performance
  - Transient Analysis
  - Emergency Core Cooling/LOCA Analysis
  - Stability Evaluation

- For example: One audit covered compliance with restrictions and limitations on the NRC-approved methodology related to fuel system design.
  - Focus on experimental data base used to qualify Critical Power (CP) correlation.



# CPPU SAFETY ANALYSES

- Scope of CPPU evaluations generally follow NRC-accepted, generic EPU guidelines and evaluations (ELTR1, ELTR2, and Supplement 1 to ELTR2)

- Exceptions reviewed for specific Transient Analysis, LOCA Analysis, and Stability Analysis areas

- Analyses and evaluations are based on NRC-approved methodologies, analytical methods and codes

# FUEL DESIGN AND OPERATION

- Fuel system design criteria
  - Outlined in Standard Review Plan Section 4.2
    - ensure fuel bundles not damaged during normal operation and Anticipated Operational Occurrences
  - Use of NRC-Approved Fuel Design Methodology
    - verify analytical methods used ensure that the fuel design meets the fuel design acceptance criteria
- New fuel designs must comply with NRC-approved fuel design methodology General Electric Standard Application for Reactor Fuel (GESTAR-II), and are subject to reporting requirements and compliance audits.



# THERMAL LIMITS ASSESSMENT

- Thermal limits are established or confirmed at every reload
- Core Operating Limits Report provides the cycle-specific thermal limits.
- Safety Limit Minimum Critical Power Ratio changes require Technical Specification amendment request with staff review and approval
- Several power uprate transition reload cycle design evaluations were audited at GNF to confirm reload core design process

# REACTOR STABILITY

- Staff On-Site Audits:
  - Reviewed continued applicability of Interim Corrective Action (ICA)
  - Discussed implementation plan for stability long term solution (LTS) for power uprate operation.
  - Reviewed the status of the generic DIVOM (Delta CPR/Initial Vs. Oscillation Magnitude) curve issue for power uprate operation.
  - Reviewed GE response to questions on the applicability of the DIVOM curves for power uprate operation using new fuel with higher bundle powers.
  - Staff concluded from the audit that Long Term Solution options were still applicable to power uprate operation, subject to resolution of Part 21 DIVOM curve issue.



# Anticipated Operational Occurrences

- Licensee will analyze plant limiting transients based on representative core design for power uprate operation
- The transients evaluated are consistent with Appendix E of ELTR1 and are analyzed using NRC-approved methodology and codes
- Limiting transients would be confirmed or reanalyzed based on actual core design and the uprated power level for each transition reload power uprate cycle, as well as for subsequent cycles
- Conclusion
  - Licensee will demonstrate that the cycle-specific transient analyses do not identify any major changes to the basic characteristics of any of the limiting transients

# ECCS PERFORMANCE

- Staff approved methods (SAFER/GESTR) are used
- Limited break "spectrum" analysis is performed to determine PCT
- [Peak Cladding Temperature change typically less than] [20°F for CPPU]
- Reload analysis will include LOCA confirmation
- Reload analysis will follow NRC staff-approved methods
- Conclusion: ECCS-LOCA performance analysis complies with 10 CFR 50.46 and Appendix K requirements and the analyses conform to NRC-approved methods and codes, with applicable SER restrictions.





# Anticipated Transient Without Scram

- CPPU reload designs will meet the ATWS mitigation features specified in 10 CFR 50.62 (ARI, ATWS-RPT, SLC-boron injection capability )
- Licensee will confirm applicability of existing analyses or re-analyze ATWS events for power uprate operating conditions
- Conclusion
  - Licensee will meet the requirements of 10 CFR 50.62 and the ATWS acceptance criteria for the power uprate operation (i.e. limiting peak vessel bottom pressure and peak cladding temperature)
  - Future reload evaluations would confirm that the plant's response to an ATWS event will meet ATWS acceptance criteria.

# Standby Liquid Control System

- Manually initiated system
- SLC system shutdown capability is reconfirmed for every reload
- Boron solution concentration/volume may be increased to meet the ATWS rule
- Adequate margin confirmed for the bypass relief valve to inject against system pressure



# Conclusions

- CPPU plant-specific safety analysis report will be consistent with NRC-accepted guidelines and generic evaluations
- Analyses will use NRC-approved analytical methods and codes
- On-site audits have confirmed compliance to restrictions on staff approved methodology
- Cycle specific thermal limits and the applicable safety analyses would be confirmed or reanalyzed using NRC-approved core reload analysis methodology

# Constant Pressure Power Uprate

Balance of Plant Systems

Steven Jones
Plant Systems Branch, NRR





# Staff Evaluation Methods

- Scope Consistent with Prior Uprates
- Evaluation Methods
  - [Generic (Bounding or Negligible Effect)]
  - Plant Specific
- Generic Evaluations for:
  - [Main Steamline Break]
  - [Moderate Energy Break Flooding]
  - [Standby Gas Treatment System]
  - [Liquid, Solid, and Gaseous Waste Management Systems]
- [Previously Approved Generic Approach to Containment] [System and ECCS NPSH Plant Specific Evaluations]
- [Remainder of BOP Topics Identified for Plant Specific] [Evaluation - No Change in Approach]

# Main Steamline Break Evaluations

Negligible Effect

- Constant Pressure - Negligible Change in Steam Properties
- [Large Break - Flow Restrictor Prevents Increase in Peak] [Flow at Constant Pressure]
- [Small Break - Break Isolation Initiated by Local] [Temperature Sensors]





# Moderate Energy Flooding

[Negligible Effect]

- [Closed Systems - No Change in Fluid Inventory]
- [Open Systems - No Change in Flow Rate]

# Standby Gas Treatment System

[Bounding]

- [Plant Specific Confirmation that Parameter Values from] [Generic Analysis are Bounding]
- [Generic Analysis Demonstrates Satisfactory System] [Performance]
  - [Iodine Loading]
  - [Charcoal Bed Temperature]
- [Plant Specific DBA Radiological Consequence Evaluations]





# Liquid, Solid, and Gaseous Waste Management

[Negligible Effect]

- [Small Increase in Waste Generation]
- [Principal Source of Liquid and Solid Waste is More] [Frequent Condensate Demineralizer Backwashes]
- [Gaseous Waste Production a Function of Cladding] [Performance and Air Inleakage Rate -Effect of Power Level] [Secondary]
- [Bounding Evaluation of Off-Gas System Performance]

# Containment System Performance

- Analyses Methods Defined in Appendix G to ELTR1
  - M3CPT code for short-term response
  - LAMB code for more realistic blowdown
  - SHEX code for long-term response
- NRC Staff Performs Plant Specific Evaluation and Confirmatory Analyses



# Conclusion

- Scope of Overall Evaluation is Acceptable
- Generic Evaluations Adequately Supported