FPL/W/NRC Interface Technical Meeting

Proposed Increase in St. Lucie Unit 2
Steam Generator Tube Plugging Limit

July 13, 2005

Agenda

- Purpose of meeting
- Recap of upcoming submittal
  - Approach to analyses
  - Proposed Tech Spec/COLR changes
- System parameters (as requested by NRC at last meeting)
  - Current cycle predictions and actual values
  - Projections for 42% tube plugging
- Analyses update
  - Applicability of methods and correlations
  - Status of event analysis

Agenda (cont.)

- Feedback from NRC on issues to address in submittal if different from current design bases
- Discussion on partial submittals
- Feedback and comments

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Purpose of Meeting

- To brief the NRC on upcoming plant license amendment for 42% tube plugging to facilitate NRC review
- To address issues/requests from the last meeting of May 2005
- To provide an update on ongoing analyses
- To discuss and obtain NRC feedback on potential partial submittal

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Approach to Analyses

- Submittal will use the same methods already approved by the NRC in Amendment 138
- Submittal will use the same analysis assumptions as recently approved by the NRC for 30% SGTP, except for
  - Inputs and operating parameters changed to be consistent with plant configuration for increased SGTP, reduced flow and reduced power, and
  - As required to achieve acceptable margins (reduced COLR limits, etc.)

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Approach to Analyses (Contd.)

- Submittal will include re-analysis of all limiting non-LOCA events
- Submittal will include re-analysis of LOCA events
- Since a single operating point is identified for Cycle 16, a range of temperatures will not be addressed as done for 30% SGTP
  - Confirmation of continued applicability of the temperature range (535°F to 549°F T_{cold}) for DNB will be provided for the DNB Tech Spec (TS 3.2-5 and TS/COLR Table 3.2-2)

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Proposed Tech Spec/COLR Changes

- TS LCO 3.2.5, DNB Parameters: Include additional footnote in Tech Spec Table 3.2-2 for 335,000 gpm RCS flow rate:
  - "If the Reactor Coolant System Flow Rate is less than 335,000 gpm but greater than or equal to 300,000 gpm, then the maximum reactor THERMAL POWER shall not exceed 89% of RATED THERMAL POWER of 2700 MWth."
- TS SR 4.2.5.2: Modify footnote on Tech Spec page 3/4 2-14 to replace "≥ 90%" with "≥ 80%"
- Definition of RATED THERMAL POWER unchanged
- COLR changes as required to achieve acceptable margins (e.g. Fr, PLHR, ASI Bands)

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System Parameters for 30% Tube Plugging

Parameter	Analysis	Actual	Projection for 18.9%
Tube Plugging	30%	18.9%	18.9 %
RCS Flow (gpm)	335,000	~376,000	~372,000
SG Pressure (psia)	790	837	836
Cold Leg Temp (F)	549	~548.5	

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NRC Requested System Parameter Projections for 42% Tube Plugging

THERMAL DESIGN PARAMETERS	Case 1	Case 2
NSSS Power, %	89	89
MWt	2424	2424
Reactor Power, MWt	2404	2404
Thermal Design Flow, Loop gpm	150,000	150,000
Reactor 10^6 lb/hr	113.5	113.5
Reactor Coolant Pressure, psia	2250	2250
Core Bypass, %	3.7	3.7
Reactor Coolant Temperature, °F		
Core Outlet	602.8	603.9
Vessel Outlet	600.8	601.9
Core Average	575.5	576.6
Vessel Average	573.4	576.6
Vessel/Core Inlet	546.0	547.1
Steam Generator Outlet	545.5	546.6
Steam Generator		
Steam Temperature, °F	506.9	508.0
Steam Pressure, psia	724	732
Steam Flow, 10^6 lb/hr total	10.32	10.32
Feed Temperature, °F	420.8	420.8
Moisture, % max.	0.25	0.25
Design F'F', hr. sq. ft. °F/BTU	0.00017	0.00017
Tube Plugging, %	42.0	42.0
Zero Load Temperature, °F	532	532

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Applicability of methods and correlations

- Each analysis will include a determination of the applicability of methods and correlations as applied to 42% SGTP and 89% power to ensure validity of the results.
- The results of the applicability determination will be summarized in the submittal.
- No method or correlation has been identified to be outside the bounds of applicability for the revised operating conditions.

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Applicability of Methods – DNB Correlations

- Range of ABB CHF Correlation Conditions (WCAP-14565-P-A)

– Pressure (psia)	1750 to 2415
– Local Mass Velocity (Mlbm/hr-ft^2)	0.8 to 3.16
– Local Quality (Fraction)	-0.14 to 0.22

- DNB codes identify when above parameters are outside of the above ranges of the DNB correlation.

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Applicability of Methods – DNB Correlations

- Range of ABB CHF Correlations in WCAP-14565-P-A

– Pressure (psia)	1750 to 2415

The Thermal Margin / Low Pressure reactor trip and High Pressurizer Pressure Reactor trips ensure that the RCS pressure remains in the range of pressures associated with the DNB correlation. For events analyzed beyond the time of reactor trip resulting in a large RCS pressure drop, such as post-trip steamline break, other approved DNB correlations are used (W-3 correlation).

(TM/LP floor pressure > 1800 psia)

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Applicability of Methods – DNB Correlations

- **Range of ABB CHF Correlations in WCAP-14565-P-A**
  - Local Mass Velocity (Mlbm/hr-ft^2) 0.8 to 3.16

The Low RCS Flow reactor trip ensures that the mass velocity conditions remain in the range associated with the DNB correlation. For events analyzed beyond the time of reactor trip, other approved DNB correlations are applied (W-3 correlation).

(Expected mass velocities in the range of at least 1.0)

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Applicability of Methods – DNB Correlations

- **Range of ABB CHF Correlations in WCAP-14565-P-A**
  - Local Quality (Fraction) -0.14 to 0.22

The Thermal Margin / Low Pressure reactor trip and High Pressurizer Pressure Reactor trips ensure that the local quality remains in the range of pressures associated with the DNB correlation. For events analyzed beyond the time of reactor trip resulting in a large RCS pressure drop, such as post-trip steamline break, other approved DNB correlations are applied (W-3 correlation).

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Applicability of Methods – DNB Correlations

- W-3 Correlation Ranges

  - Pressure (psia) 1000* to 2400
  - Local Mass Velocity (Mlbm/hr-ft^2) 1.0 to 5.0
  - Local Quality (Fraction) -0.15 to 0.15

  * A lower limit of 500 psia has been approved based on a DNBR limit of 1.45 instead of 1.30

- DNB codes identify when above parameters are outside of the above ranges of the DNB correlation.

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Applicability of Methods – SG Models

- SG Models benchmarked against plant data (SG Pressures)
- Adjustments made to fouling factor to match plant data
- Used to define global boundary conditions for the safety analysis models
  - Steam generator pressures
  - Circulation ratios

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Applicability of Methods – SG Models

- SG Models use standard heat transfer correlations
  - Dittus – Boelter for tube side
  - Jens & Lottes for shell side (benchmarked against plant data)
  - SG plugging levels have been successfully analyzed and licensed for Westinghouse-designed plants with conditions similar to St. Lucie Unit 2 42% SGTP.
  - Conditions associated with 42% SGTP are within the ranges of SG model correlations.

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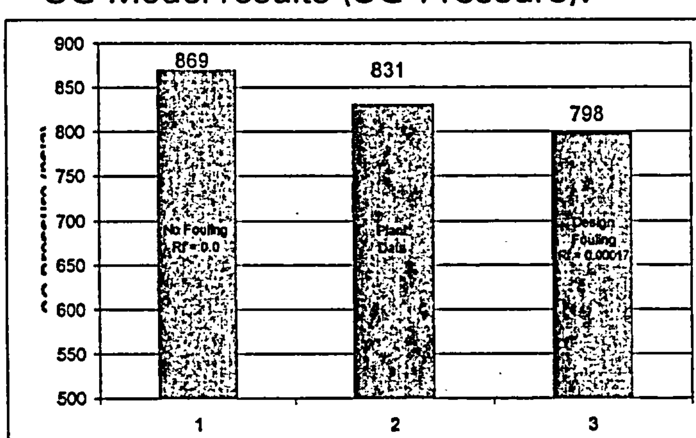
Applicability of Methods – SG Models

- SG Model results (SG Pressure):



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Applicability of Methods – SG Models

- Conclusions:
  - SG Model results compare very favorably to actual plant data for high plugging levels
  - 42% SG Tube Plugging conditions are within the ranges of the SG model heat transfer correlations.

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Applicability of Methods – RETRAN Model

- RETRAN SG Model
  - Currently used for conditions that bound the expected conditions associated with the 42% SGTP program
    - Low RCS flow conditions analyzed for Loss of Flow events, Loss of Offsite Power event, Feedline Break without offsite power event, etc.
      - Although total RCS flow tends to drop with increased plugging levels, mass velocity on tube side tends to increase
    - Low secondary side flow conditions analyzed for part-power CEA withdrawal event, zero-power events, etc.

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Applicability of Methods – RETRAN Model

- RETRAN SG Model
  - Uses standard well behaved and well known heat transfer correlations
  - SG Model successfully used to model SG plugging levels for Westinghouse-designed PWR plants
  - CE RETRAN SG Model essentially the same as the SG model used for numerous Westinghouse plant designs which cover a wide range of operating and accident conditions.
  - RETRAN SG model is the same model as used in the 30% SGTP safety analyses.

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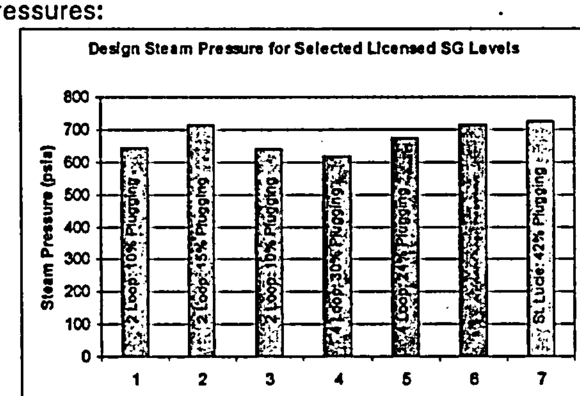
Applicability of Methods – Licensed SG Plugging Levels

- Examples of Licensed SG Plugging Levels and Associated SG Pressures:



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Applicability of Methods – Licensed SG Plugging Levels

- Examples of Licensed Westinghouse SG Designs

Parameters	Westinghouse	St. Lucie 2
Tube OD (inches)	0.688 to 0.875	0.75
Number of Tubes per SG	5,626 to 10,025	8,411
Heat Transfer Area (ft^2)	55,000 to 123,538	90,232
RCS Flow/SG (gpm)	93,600 to 157,500	167,000 – 30% 150,000 – 42%
Power Level/SG (MWt)	894 to 1707	1360 – 100% 1212 – 89%
Plugging Levels (%)	0 to 30	42

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Analysis Update

- Fuel Performance:
  - Analyses are on-going
  - Preliminary indications:
    - Most of the fuel performance results are expected to be bounded by the 30% case due to power reduction
    - Corrosion characteristics for fuel are also expected to be better at lower power level
- Fuel Mechanical Design:
  - Reduced flow impacts are being analyzed
  - Analyses are on-going
- No issues are expected in meeting applicable acceptance criteria.

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Analysis Update

- Fuels Thermal and Hydraulic Design
  - Currently licensed VIPER-W model is being used to generate departure from nuclear boiling analyses to support the 42% SGTP
  - Analyses are on-going
- Steam Generator Tube Rupture
  - Analysis of SGTR is on-going
  - Results of SGTR analysis will be used in the radiological dose calculations using AST methodology
  - Same method as used in the 30% SGTP analysis.

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Analysis Update

- LOCA Analysis:
  - Analyses are on going
  - Employing the same methods as used for 30% tube plugging
    - LBLOCA - 99EM
    - SBLOCA - S2M
    - Post LOCA long term cooling - CENPD-254-P-A
  - Full reanalysis is being performed
    - Full spectrum of cases are being analyzed
  - All fuel types for Cycle 16 are being analyzed
  - Preliminary Results indicate need for changing some COLR parameter limits (PLHGR decrease from 12.5 to 12 kw/ft)

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Analysis Update

- Post LOCA LTC-Boron Precipitation: An issue was raised by the NRC during the Waterford EPU review
  - Issue relates to impact of voids in core on post-LOCA boron precipitation
  - Additional analyses were performed to show conservatism of the model.
  - The issue was resolved for Waterford
  - Similar additional analysis will be performed for the 42% tube plugging.

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Analysis Update

- Containment Peak Pressure Analysis
  - Evaluation against the current analysis of record based on no increase in core ΔT is ongoing

- Primary Line Break Outside Containment
  - No explicit analysis
  - Event is insensitive to RCS vessel flow rate and tube plugging
  - Evaluation based on existing analysis is ongoing

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Analysis Update: Non-LOCA Impacts

- Reduced RCS flow
  - DNB
  - Peak pressure
- Reduced heat transfer area
  - Heatup events
- Reduced RCS Volume
  - Boron Dilution/Heatup and Cooldown events

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Analysis Update: Assumptions

	Current Analysis	To be Addressed
SGTP	30%	42%
TDF	335,000 gpm	300,000 gpm
MMF	341,400 gpm	314,000 gpm
Target Maximum Power	100%	89%
Target T_{avg}	576.5	574.5

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Analysis Update: Non-LOCA Scope

- Setpoints Confirmation
- Increase in heat removal events
- Decrease in heat removal events
- Decrease in reactor coolant system flow rate
- Reactivity and power distribution anomalies
- Increase in reactor coolant inventory
- Decrease in reactor coolant inventory

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Analysis Update: Tools (Non-LOCA)

- No new analysis tools
- NRC approved codes
  - Same computer code suite as 30% SGTP program
    - RETRAN
    - FACTRAN
    - TWINKLE
    - CESEC (Steam Generator Tube Rupture only)

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Submittal - Safety Analyses (1)

Event	Limiting Case(s)	Notes
Feedwater Malfunction	HFP Increased Flow case	Non-limiting DNB event. Reduced power would yield less limiting results.
Post-Trip Steamline Break	Post-Trip with offsite Power case	**Analyzed for reduced RCS flow.**
Pre-Trip SLB	Breaks for limiting MDC case	**A Limiting DNB event. Failure of the Fast Bus Transfer and Loss of Offsite Power will be addressed.**
Loss of Condenser Vacuum	Primary side pressure case	**A Limiting RCS pressure case**
Asymmetric Steam Generator Transient	DNBR case	Non-limiting DNB event. Reduced power would yield less limiting results. RCS pressure cases also non-limiting.
CVCS Malfunction	Pressurizer Filling case	Non-limiting event and reduced power should provide additional margin
RCS Depressurization	DNBR case	Non-limiting DNB event. Reduced power would yield less limiting results.

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Submittal - Safety Analyses (2)

Event	Limiting Case(s)	Notes
Feedline Break	Peak RCS Pressure for breaks < and > 0.20 Ft²	**A Limiting RCS pressure event. Failure of the FBT will be addressed.**
Loss of Flow	Complete Loss of Flow - DNB case	**A Limiting DNBR event**
Locked Rotor	DNBR and peak pressure case	**A Limiting DNB/RCS pressure event. Failure of FBT & LOOP will be addressed**
Rod Withdrawal from Subcritical	DNBR	Limiting statepoints will be analyzed with lower RCS flow
Rod Ejection	HFP cases	Lower power is non-limiting. Analyzed for confirmation with respect to current licensing basis.
Rod Withdrawal at Power	All DNB cases examined	**Limiting event. Dynamics of trip functions at the lower RCS flow must be examined.**
Dropped Rod	Depends on Core Design	**Limiting DNB event. Transient Statepoints should remain essentially unchanged**

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Submittal - Safety Analyses (3)

Event	Limiting Case(s)	Notes
Boron Dilution	Minimum Operator Action Time for All Cases	Analyzed for reduced RCS volume which minimizes operator action time
Steam Generator Tube Rupture	LOOP	Analyzed with support from FPL for dose considerations.
Large Break LOCA	All cases	
Small Break LOCA	All cases	
Post-LOCA	All cases	
Nuclear Design	Only as required to address Chapter 15 analyses	Cycle-specific reload calculations
Thermal-Hydraulic Analyses	Limiting Transients	To supplement cycle-specific reload calculations
Fuel Performance Analysis	Evaluation	To supplement cycle-specific reload calculations

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Decrease in Feedwater Temperature

Acceptance Criteria
- DNBR

Case(s) for Reanalysis
- HFP (bounds HZP)

Potential Limiting Modeling Conditions
- None

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Increase in Feedwater Flow

Acceptance Criteria
- DNBR

Case(s) for Reanalysis
- HFP
- HZP

Potential Limiting Modeling Conditions
- None

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Pre-Trip Steam System Piping Failure

Acceptance Criteria
- DNBR
- Peak linear heat rate

Case(s) for Reanalysis
- Limiting MDC cases
  - Failure of fast bus transfer by overlaying flow coastdown onto the with-flow case
  - Break coincident with LOOP at time zero

Potential Limiting Modeling Conditions
- None

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Post-Trip Steam System Piping Failure

Acceptance Criteria
- DNBR

Case(s)
- With offsite power available

Potential Limiting Modeling Conditions
- None

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Loss of Condenser Vacuum

Acceptance Criteria
- DNBR
- Primary and Secondary overpressure

Case(s) for Reanalysis
- DNB
- Primary overpressure
- Secondary overpressure
- Inoperable MSSVs

Potential Limiting Modeling Conditions
- None

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Feedwater System Pipe break

Acceptance Criteria

- Secondary Overpressure
- Primary Overpressure

Case(s) for Reanalysis

- Primary peak pressure < 110% of design pressure
  - Small break with failure of fast bus transfer (FFBT)
  - Large break without FFBT
- Primary peak pressure < 120% of design
  - Large break with FFBT
- Secondary peak pressure
  - Limiting break size (without FFBT)

Potential Limiting Modeling Conditions

- None

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Asymmetric Steam Generator Transients

Acceptance Criteria

- DNBR
- Peak linear heat rate

Case(s)

- Maximum SGTP (42%)

Potential Limiting Modeling Conditions

- None

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Complete Loss of Flow

Acceptance Criteria
- DNBR

Case(s)
- Maximum SGTP

Potential Limiting Modeling Conditions
- Mass flux range associated with the CHF correlation

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Locked Rotor

Acceptance Criteria
- DNBR
- Primary overpressure
- Cladding average temperature

Case(s)
- Rods-In-DNB with failure of fast bus transfer (FFBT) and subsequent Loss of Offsite Power (LOOP)
- Peak pressure / maximum clad average temperature with FFBT and subsequent LOOP

Potential Limiting Modeling Conditions
- Mass flux range associated with the CHF correlation

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Rod Withdrawal from a Subcritical or low Power Condition

Acceptance Criteria
- DNBR and Fuel centerline temperature

Case(s)
- DNBR
- Peak fuel centerline temperature

Potential Limiting Modeling Conditions
- Mass flux range associated with the CHF correlation
- Addressed with the use of other approved CHF correlations (W-3) if necessary.

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Rod Withdrawal at Power

Acceptance Criteria
- DNBR
- Fuel centerline melt
- Primary and secondary overpressure

Case(s)
- DNBR - 89%, 65%, 50% and 20% power at both maximum and minimum feedback
- Overpressure – 100%, minimum feedback

Potential Limiting Modeling Conditions
- None

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Feedback from NRC on New Issues to be Addressed in the Submittal

- Comments on
  - Analysis Approach
  - Proposed Technical Specification changes
- Other issues?

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Discussion on Partial Submittals

- Two Submittal Options were suggested at the previous meeting:
  - Complete Submittal
    - Submittal on November 1, 2005 (similar to 30% SGTP submittal, and subsequent RAIs)
  - 2-Phase Submittal
    - 1st Phase submittal about a month in advance
    - Final submittal on November 1, 2005
    - NRC approval needed prior to the start of Cycle 16 outage, currently scheduled for 4/26/06

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Discussion on Partial Submittals (Contd.)

- 1st Phase submittal
  - Approximately 6 to 7 of the Non-LOCA analyses:
    - RCS Depressurization
    - Loss of Flow
    - Locked Rotor
    - CVCS Malfunction
    - Boron Dilution
    - Rod Withdrawal from Subcritical

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Discussion of Submittal Content

- Same format as 30% SGTP Submittal to facilitate NRC review.
- Summary of changes to the 30% Submittal.
- Comparison of Analysis Results to 30% SGTP submittal results and to the regulatory limits.

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Feedback and Comments

- Open Discussion
- Proposed next meeting

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