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|---------------------------------|--|-----------|------|
| ENGINEERING CHANGE NOTICE (ECN) | | ECR No. : | 1399 |
| ECR Title: | Reactor Plenum Flow Meters License Amendment | | |
| System: | Primary Coolant System (Reactor Vessel & internals, drains, etc) | Date: | |

Design Description

Introduction

The NBSR utilizes a double plenum coolant inlet at the bottom of the vessel to provide optimized cooling to the core. The inner six fuel positions and the central thimble are fed by the inner plenum, while the remaining 24 fuel elements and thimbles are fed by the outer plenum. The inner plenum is located within and is concentric to the outer plenum. Coolant exits the vessel through two outlet pipes which are welded to the vessel bottom on either side of the outer plenum pipe. The lower grid plate is bolted to both the inner and the outer plenums forming a watertight seal. The primary coolant flow is distributed between these two plenums by the inherent flow resistance of the two different paths. After the recent replacement of primary pumps (ECN 834, 2018), the total flow is measured (with one σ (standard deviation) less than 1 %) up to 8700 GPM, where approximately 2300 GPM is for the inner plenum and 6400 GPM is for the outer plenum, respectively. Approximately 4% of the flow bypasses the core (National Bureau of Standards, 1966A). Until Amendment 11 (May 1984), NBSR Technical Specifications did require both plenum channels. The changes in the technical specifications (May 1984) for the operability requirements of the inner and outer plenum flow channels do not have any technical basis and lack the necessary safety analysis.

Problem Statement

In all current safety analysis scenarios and technical basis, it is assumed that “the scram occurs 0.4 s after the flow has reached the trip value taking into account instrumentation delays.”. Therefore, there is no technical basis or corresponding safety analysis that would allow the operation of the reactor if any of the primary flow channels is bypassed.

However, Technical Specifications (Amendment 15, March 2, 2023) Table 3.2.2 (Figure 1) and Table 4.2.2 (Figure 2) does allow the NBSR to operate when either one of the inner or outer plenum flow channels is bypassed. Hence, the existing text does not comply with the available technical basis and safety analysis.

From 1984 to now, a review of Shift Supervisor Logs does not have any records that the reactor was operated when one of the inner or outer plenum flow channels was bypassed. O.I. 1.1.0 “Reactor Startup Checklist” “This procedure is used to ensure that the Reactor Safety System (RSS) equipment and components are operable in accordance with NBSR Technical Specification 4.1.1(1).” O.I 1.1. step 2.2.2 requires operators to perform Alarm operability of process instruments listed in Table 11 of the procedure. Table 11 lists all primary coolant flow channels including inner and outer plenum flow meters. “

Nevertheless, although not practiced, there are no clear restrictions on the operations of the reactor when either of the plenum flow meters is bypassed. If either plenum flow channel (FRC-3 and FRC-4) was not operational and there was an inadvertent corresponding closure of either primary inlet valve DWV-1 (FRC-3) or DWV-2 (FRC-4), the consequences of such incident could result in fuel damage to one or more of the fuel elements. See the attachment “DWVClosureMemo.pdf”(NCNR-RE-TM-000651) providing detailed thermal hydraulic analysis for both scenarios using the current RELAP-5 model. Based on the analyses in the report, when one of these flow meters is bypassed and if the primary coolant flow is lost (due to inadvertent valve closure, or a similar event that would cause loss of primary coolant flow), the scram initiation is found to happen after boiling occurs in one or many of the fuel element channels.

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The reactor shall not be operated unless the channels described in Table 3.2.2 are operable and the information is displayed in the reactor Control Room.

Table 3.2.2 Reactor Safety System Channels
Minimum Nuclear and Process Channels Required

| <u>Channel</u> | <u>Scram</u> | <u>Major Scram</u> | <u>Rundown</u> |
|--|--------------|--------------------|----------------|
| (1) High Flux level | 2 | | |
| (2) Short period below 5% rated power | 2 | | |
| (3) Low reactor vessel D ₂ O level ^{1,3} | 2 | | |
| (4) Low flow reactor outlet ^{2,3} | 1 | | |
| (5) Low flow reactor inner or outer plenum ^{2,3} | 1 | | |
| (6) Manual (outside of the Control Room) | 1 | | |
| (7) Manual | 1 | 1 | |
| (8) Reactor Outlet Temperature ³ | | | 1 |
| (9) Gaseous Effluent Monitor ⁴ | | 2 | |

¹ One (1) of two (2) channels may be bypassed for tests or during the time maintenance involving the replacement of components and modules or calibrations and repairs are actually being performed.

² One (1) of these two (2) flow channels may be bypassed during tests, or during the time maintenance involving the replacement of components and modules or calibrations and minor repairs are actually being performed. However, outlet low flow may not be bypassed unless both inner and outer low flow reactor inlet safety systems are operating.

³ May be bypassed during periods of reactor operation when a reduction in Limiting Safety System Settings are permitted by the specifications of Sections 2.2(4) and 3.3.1(1).

⁴ See specifications of Section 3.7.1

Figure 1. Technical Specifications Table 3.2.2

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Table 4.2.2
Surveillance Requirements for the Scram and Confinement Channels

| <u>Channel</u> | <u>Action Required</u> | <u>Surveillance Required</u> |
|---|------------------------|------------------------------|
| (1) High Flux level | Scram | X, A |
| (2) Short period below 5% rated power | Scram | X, A |
| (3) Low reactor vessel D ₂ O level | Scram | X, A |
| (4) Low flow reactor outlet | Scram | X, A |
| (5) Low flow reactor inner or outer plenum | Scram | X, A |
| (6) Manual (outside of the Control Room) | Scram | X, A |
| (7) Manual | Scram | X, A |
| (8) Normal Air Exhaust Activity High | Major Scram | X, A |
| (9) Irradiated Air Activity High | Major Scram | X, A |
| (10) Stack Air Activity High | Major Scram | X, A |
| (11) Reactor Coolant Outlet Temperature | Rundown | X, A |

X - Channel test before startup after a shutdown of longer than 24 hours, or quarterly.
A - Annual Channel Calibration.

Basis

To ensure that instrument failures do not go undetected, frequent surveillance of the listed channels is required and operating experience has shown these frequencies to be adequate to ensure channel operability.

Figure 2. Technical Specifications Table 4.2.2

Licensing Basis

The NBSR Technical Specifications (TS) section 2.2 specifies the Limiting Safety System Settings (LSSS) for power, flow, and temperature parameters, which reads as follows.

2.2 *Limiting Safety System Settings*

Applicability: Power, flow, and temperature parameters

Objective: To ensure protective action if any combination of the principal process variables should approach the safety limit.

Specifications

- (1) Reactor power shall not exceed 130% of full power.
- (2) Reactor outlet temperature shall not exceed 147 °F.
- (3) Forced coolant flow shall not be less than 60 gpm/MW for the inner plenum and not less than 235 gpm/MW for the outer plenum.

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(4) Reactor power, with natural circulation cooling flow, shall not exceed 10 kW. Operation in this mode shall only be made with a core that has been previously analyzed and shown to be within the envelope of conditions described in the SAR.

”

NBSR-9 Addendum 1

The NBSR Addendum 1 was completed as part of the NBSR power increase from 10 MW to 20 MW. In NBSR Addendum 1 section 3, the safety analysis was introduced. The Burnout analysis was used to determine the NBSR safety limits, which are those limiting combinations of reactor power, coolant flow, and temperature that define the limiting conditions for safe operation. The NBSR safety limits are shown in Figure 1 and Figure 2 for the inner and outer plena. Table 1 presents the NBSR safety limits for the inner and outer plena at different inlet temperatures (T_{in}).

Table 1. Safety limits of inner and outer plena according to NBSR-9 Addendum 1.

| Safety Limits (SL) for One Variable with the Other Two at the LSSS | | | | | | |
|---|---------------|------------|-----------|---------------|------------|-----------|
| Inner plenum | | | | Outer plenum | | |
| | T_{in} , °F | Flow, gpm | Power, MW | T_{in} , °F | Flow, gpm | Power, MW |
| SL Power | 130 (LSSS) | 1200 (SSS) | 36 (SL) | 130 (SSS) | 4500 (SSS) | 36 (SL) |
| SL Flow | 130 (LSSS) | 860 (SL) | 26 (SSS) | 130 (SSS) | 3200 (SL) | 26 (SSS) |
| SL T_{in} | >150 (SL) | 1200 (SSS) | 26 (SSS) | >150 (SL) | 4500 (SSS) | 26 (SSS) |
| Safety Limits (SL) for One Variable with the Other Two at the Normal Settings (N) | | | | | | |
| SL Power | 115 (N) | 1450 (N) | 50 (SL) | 115 (N) | 6850 (N) | 48 (SL) |
| SL Flow | 115 (N) | 580 (SL) | 20 (N) | 115 (N) | 2200 (SL) | 20 (N) |
| SL T_{in} | >170 (SL) | 1450 (N) | 20 (N) | >170 (SL) | 6850 (N) | 20 (N) |

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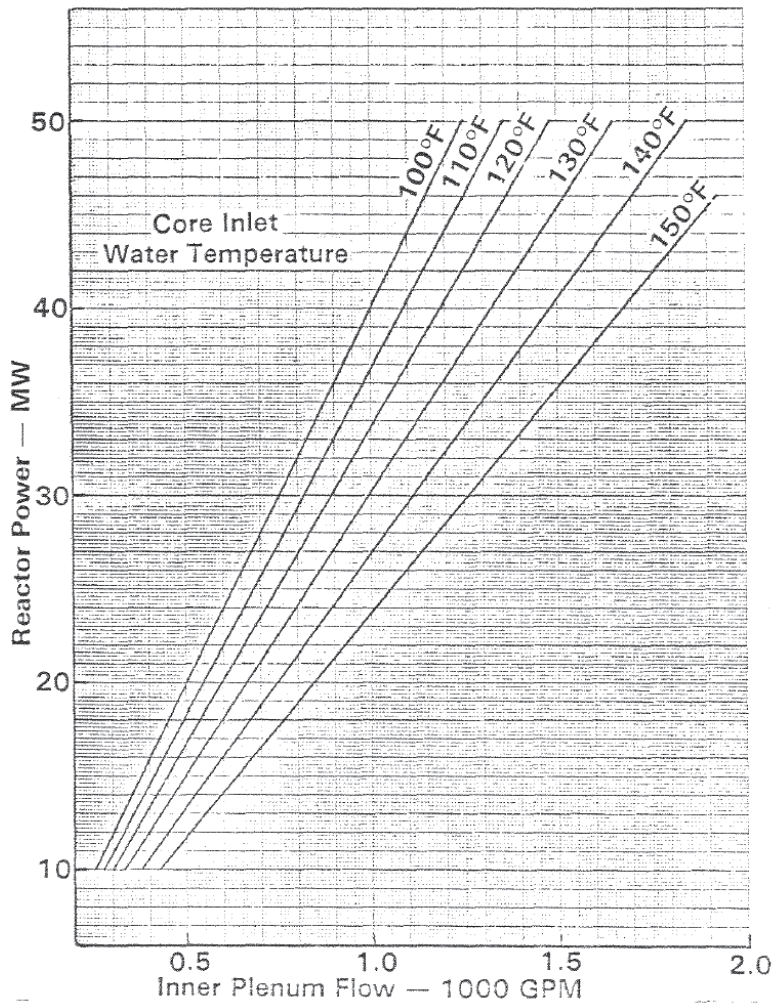


Figure 3. Safety limits - inner plenum according to NBSR-9 Addendum 1.

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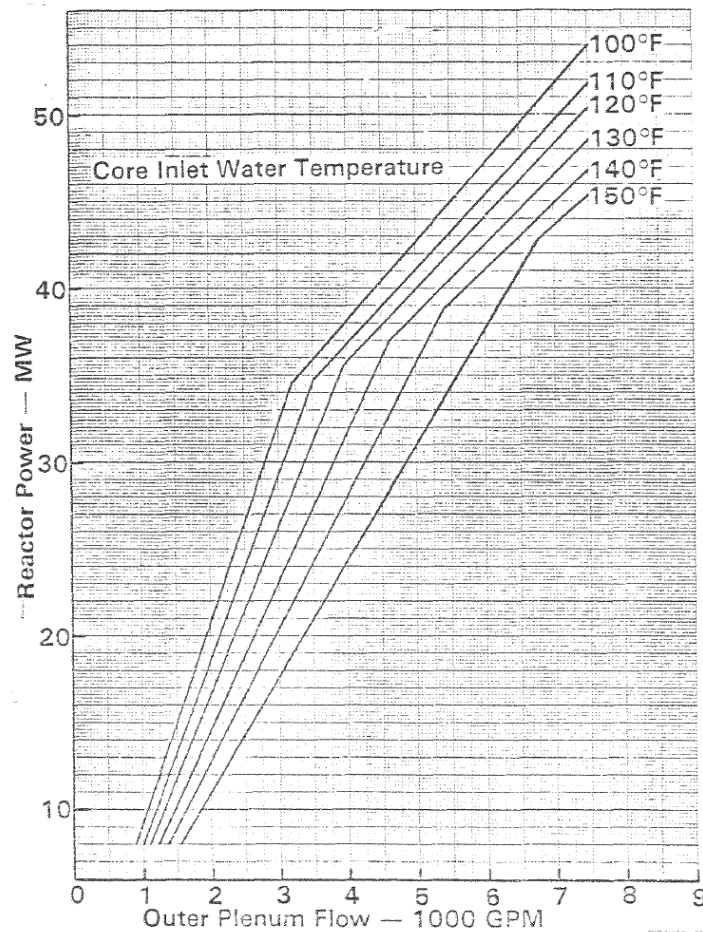


Figure 4. Safety limits - outer plenum according to NBSR-9 Addendum 1.

NBSR Addendum 1 Methodology

The NBSR Addendum 1 uses the same methods and correlation which were introduced in NBSR 9. The safety limits (Figure 3 and Figure 4) are computed by considering the excursive (hydraulic) instability and stable burnout conditions. The excursive instability condition is computed using Maulbetsch and Griffity [1] while stable burnout condition is computed using the Mirshak correlation [2]. Another way to describe the excursive instability is the currently recognized onset of flow instability. The inner plenum uses the excursive instability as the limiting condition. The outer plenum uses excursive instability as the limiting condition for low flow rates, whereas higher flow rates rely on stable burnout as the limiting condition. This is how Figure 3 and Figure 4 were derived, which are the basis for the values in Table 1.

It is notable to consider that the hot spot temperature was used as the bulk temperature for determining the safety limits, which was essentially calculated as 1.34 times the nominal hot spot bulk temperature (as shown in NBSR-9 Addendum 1, page 3-6). It is not clear how the nominal bulk temperature for the hot spot was computed, but presumably, it was computed as shown in the equation below.

$$T_{HS}^S = T_{in} + \Delta T_{HS}^b$$

Where,

- T_{HS}^S ; Temperature of the fuel plate surface at the hot spot.
- T_{in} ; bulk inlet coolant temperature including any uncertainties in temperature measurement.

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- ΔT_{HS}^b ; bulk temperature rise at hot spot.

The ΔT_{HS}^b is computed in °F as shown in the equation below.

$$\Delta T_{HS}^b = \frac{K_b F_b F_{HC} F_P P_e}{V}$$

Where,

- $K_b = 0.9786 \frac{BTU}{kW \cdot s}$ (unit conversion and geometry constraints constant)
- $F_b = 1.34$, bulk hot channel factor
- $F_{HC} = 1.21$, ratio of power in hot channel to average power per channel
- $F_P = 0.71$ [inner plenum], 0.75 [outer plenum], fraction of fuel element power between water inlet and the hot spot
- $P_e = 730 kW$ [inner], 685 kW [outer], fuel element power (at 20 MW core power)
- V = water velocity through the channels in ft/s

The Excursive instability burnout would occur when the slope of the core pressure drops vs flow rate curve becomes more negative than that of the external forced convection system [NBSR Addendum 1 section 3.2.2.2]. This can be expressed by the following relation, where the inputs are explained in addendum 1 page 3-7.

$$\frac{\partial(\Delta P_{ext})}{\partial Q} - \frac{\partial}{\partial Q} [\Delta P_{0-1} + \Delta P_{1-2} + \Delta P_{2-3}] \geq 0$$

Where,

- Q ; coolant flow rate
- ΔP_{ext} ; pressure drop in external supply system.
- ΔP_{0-1} ; pressure drop across inlet to fuel plate heated portion.
- ΔP_{1-2} ; pressure drop across heated portion of fuel plates.
- ΔP_{2-3} ; pressure drop across outlet of fuel plates.

For the NBSR core where several coolant channels are in parallel, it is conservatively assumed that the external system provides a constant differential pressure across the core. In this case, the flow changes in one channel have a negligible effect on the flow in the other channels. The onset of an excursive instability could be expected for conditions causing the core pressure drop vs flow rate curve to pass through a minimum. As the flow decreases in a heated coolant channel, a point can be reached at which the pressure drop across the channel begins to increase.

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Updated FSAR (June 2023) Safety Limits

The Updated FSAR (and current technical basis) was determined during the relicensing of the NBSR in 2009. A similar analytical calculation was performed, but it yielded different results that are shown in Table 2, Figure 5 and Figure 6.

Table 2. Safety limits of inner and outer plena according to the Updated FSAR.

| Safety Limits (SL) for One Variable with the Other Two at the LSSS | | | | | | |
|---|----------------------|------------|-----------|----------------------|------------|-----------|
| Inner plenum | | | | Outer plenum | | |
| | T _{in} , °F | Flow, gpm | Power, MW | T _{in} , °F | Flow, gpm | Power, MW |
| SL Power | 130 (SSS) | 1200 (SSS) | 45 (SL) | 130 (SSS) | 4700 (SSS) | 39 (SL) |
| SL Flow | 130 (SSS) | 500 (SL) | 26 (SSS) | 130 (SSS) | 2800 (SL) | 26 (SSS) |
| SL Tin | >170 (SL) | 1200 (SSS) | 26 (SSS) | >150 (SL) | 4700 (SSS) | 26 (SSS) |
| Safety Limits (SL) for One Variable with the Other Two at the Normal Settings (N) | | | | | | |
| SL Power | 115 (N) | 1450 (N) | 52 (SL) | 115 (N) | 6850 (N) | 49 (SL) |
| SL Flow | 115 (N) | 350 (SL) | 20 (N) | 115 (N) | 1850 (SL) | 20 (N) |
| SL Tin | >170 (SL) | 1450 (N) | 20 (N) | >170 (SL) | 6850 (N) | 20 (N) |

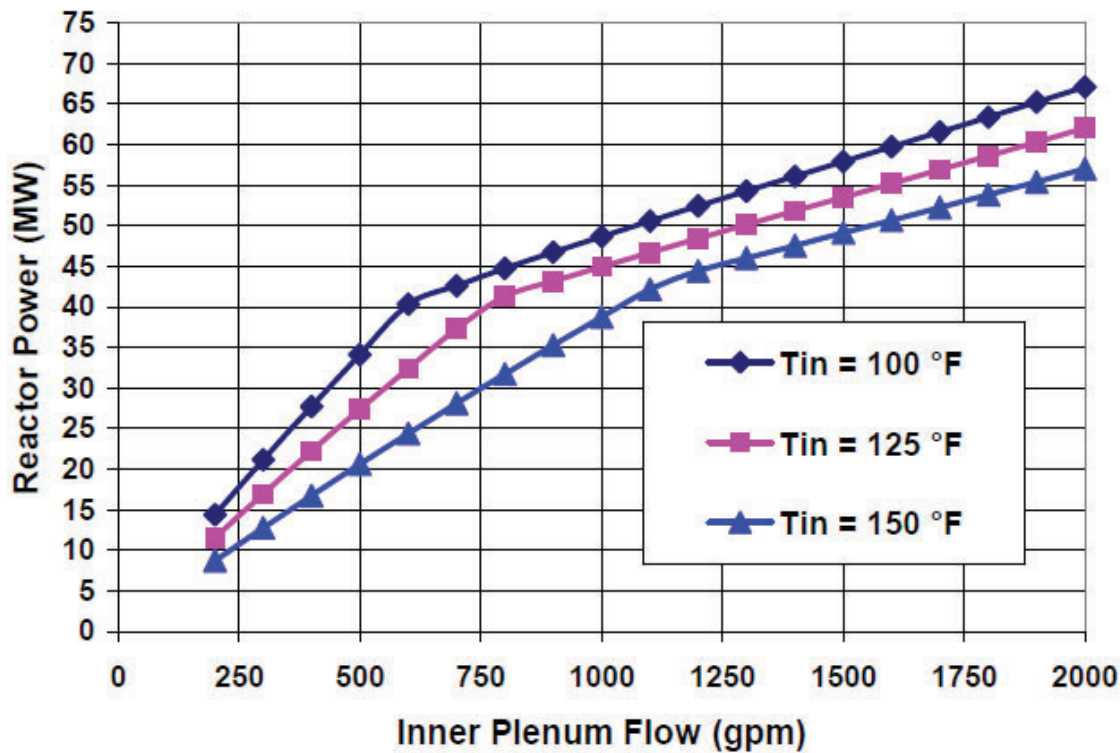


Figure 5. Safety limits - inner plenum according to the Updated FSAR (Figure 4.6.1 in the SAR).

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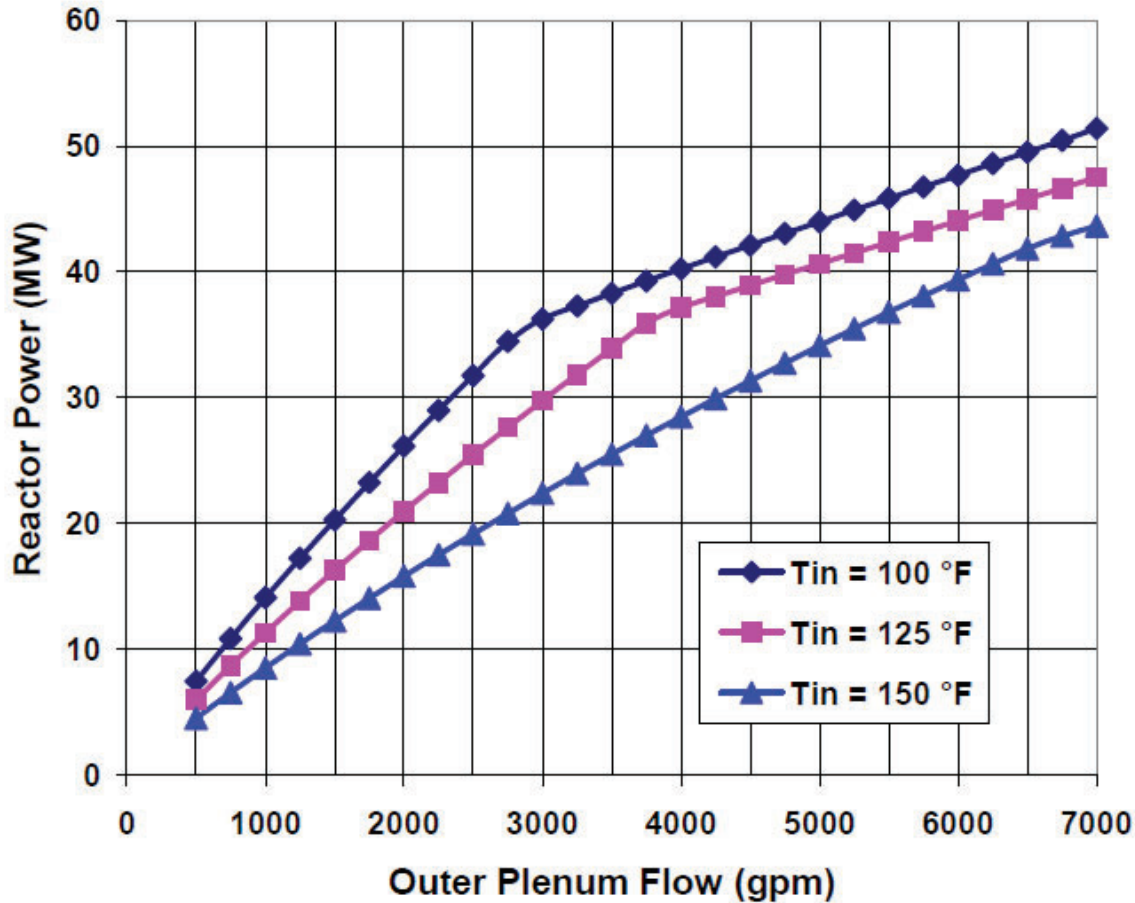


Figure 6. Safety limits - outer plenum according to the Updated FSAR (Figure 4.6.2 in the SAR).

Updated FSAR Methodology

The Updated FSAR utilizes a similar analytical calculation approach, with the following differences being applied.

- Maulbetsch’s excursive instability correlation is replaced with the Costa correlation for onset of flow instability [3].
- Both inner and outer plena use Mirshak and Costa for the limiting condition, with the more limiting setting being used as the basis for the setpoint.
 - No differentiation between low or high flow rates.
- A hot spot saturation temperature of 110.3 °C is used (based on a pressure of 138.5 kPa).
 - NBSR-9 suggested a saturation temperature of 117.78 °C (NBSR-9 Final SAR page 4-24).
- Different peaking factors are used based on MCNP computations (fission rates, or F7-equivalent tallies) as opposed to analytical calculations from NBSR-9 or NBSR-9 Addendum 1.
 - Startup power profiles were considered in the Updated FSAR due to it being the most limiting cycle state.

The updated FSAR, section 4.6.3 “Determination of Limiting Conditions.” in part mentions:

“The power limits shown on Figures 4.6.1 and 4.6.2 were compared to the values on the Safety Limit curves for power, primary flow, and coolant inlet temperature, calculated in NBSR-9, Addendum I (NBS, 1980). For the bounding primary flows and inlet temperatures, the power limits calculated in the above analysis were greater

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than or equal to those calculated in the 1980 Addendum. The results just derived allow determination of the Safety Limits for the third variable when two are at the Safety System Setting (SSS), and when two variables are at the normal condition These limits are listed in Tables 4.6.2 and 4.6.3. Again, the current results are less limiting than the 1980 values in Tables 3.2-3 and 3.2-4 of Addendum I (NBS, 1980). That is, the allowed power is greater, or the required flow is lower, than the existing Safety Limits.”

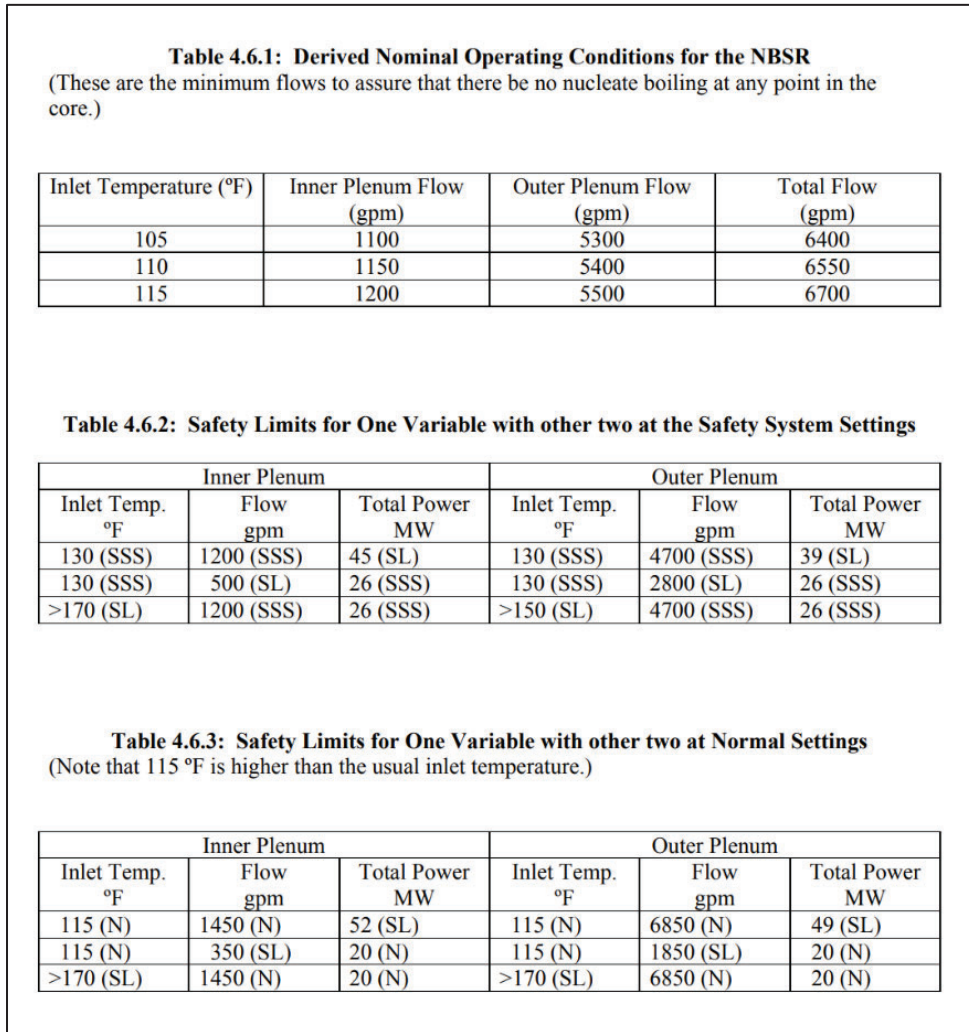


Figure 7. Table 4.6.1, Table 4.6.2 and Table 4.6.3 from updated FSAR, Chapter 4

NCNR License Amendment No. 15 (March 2023), recently updated the Relap-5 thermal-hydraulic model of the reactor and validated current correlations used in evaluations. The amendment included specific analysis for the Throttling of Coolant Flow to the Outer Plenum and Throttling of Coolant Flow to the Inner Plenum and determined limiting thermal hydraulic conditions.

Interpretation and Review of Relevant Changes to Technical Specifications

Channel 5 of TS Table 3.2.2 defines that “Low flow reactor inner or outer plenum” produces 1 (one) reactor scram. Note, for instance “Low reactor Vessel D₂O Level” is listed as to have 2 scrams, since there are two sensors. This item has footnotes 2 and 3, to clarify and define the boundaries for the operation of these channels.

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Footnote 2 states that “One (1) of these two (2) flow channels may be bypassed during tests, or during the time maintenance involving the replacement of components and modules or calibrations and minor repairs are actually being performed. However, outlet low flow may not be bypassed unless both inner and outer low flow reactor inlet safety systems are operating.”

Footnote 3 states that “May be bypassed during periods of reactor operation when a reduction in Limiting Safety System Settings are permitted by the specification of Sections 2.2(4) and 3.3.1(1).”

To further clarify the footnote 3, specifications of Sections 2.2(4) and 3.3.1(1) are given below.

Section 2.2(4) states that “Reactor power, with natural circulation cooling flow, shall not exceed 10 kW. Operation in this mode shall only be made with a core that has been previously analyzed and shown to be within the envelope of conditions described in the SAR.”

Section 3.3.1(1) states that “The reactor shall not be operated unless the reactor vessel coolant level is no more than 25 inches below the overflow standpipe.”

Footnote 2 allows deviation from standard operating conditions by allowing bypass of one of the two flow channels only during specific activities: tests, maintenance involving component or module replacement, calibrations, or minor repairs.

Footnote 3 allows bypassing any of the flow channels if the reactor is running in natural convection mode, at which the reactor flow indication is not necessary.

Problem: The problem arises from the interpretation of Table 3.2.2, which states, “(5) *Low flow reactor inner or outer plenum* ^{2,3}”. The “or” is often interpreted as inclusive unless specified otherwise. This means that either one or both conditions can be true. A common interpretation of the phrase “low flow reactor inner or outer plenum” suggests that the reactor must not be operated unless at least one of these channels is operable, and it does not necessarily require both to be operable simultaneously. Since, there is only 1 scram listed, it is understood such.

However, another interpretation of “(5) *Low flow reactor inner **or** outer plenum* ^{2,3}” is that the “or” is used to connect them in a list rather than indicating exclusivity. This usage is less about offering a choice and more about enumerating the flow channels.

The previous versions of the Technical Specification for the NBSR were also reviewed. Technical Specifications dated 07/31/1970 provide one of the previous versions of Table 3.2.2. of the current Technical Specifications, and it is given in Figure 8. A significant difference is that low flow reactor inlet inner plenum and low flow reactor inlet outer plenums are separated, and they are both required to be operable for a normal operation.

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| <u>REACTOR SAFETY SYSTEM</u> | | | |
|--|----------------------------------|--------------------|---|
| <u>Function</u> | <u>MINIMUM OPERABLE CHANNELS</u> | | |
| | <u>Scram</u> | <u>Major Scram</u> | |
| High Flux Level (2 of 3 or 1 of 2 logic only) | 2 | | |
| Short Period Below 10% Rated Power | 2 | | |
| High Activity, Effluent Air Exhaust RD 3-4, 3-5, and 4-1 | | | 2 |
| High Reactor Differential Temperature ⁽¹⁾ | 2 | | |
| Low Reactor Vessel D ₂ O Level ^{(1) (3)} | 2 | | |
| Low Flow Reactor Outlet, gpm ^{(2) (3)} | 1 | | |
| Low Flow Reactor Inlet, Inner Plenum ^{(2) (3)} | 1 | | |
| Low Flow Reactor Inlet, Outer Plenum ^{(2) (3)} | 1 | | |
| Manual in Control Room | 1 | | 1 |

NOTES

(1) One of two channels may be bypassed for tests, or during the time maintenance involving the replacement of components and modules or calibrations and minor repairs are actually being performed.

(2) One of these three flow channels may be bypassed during tests, or during the time maintenance involving the replacement of components and modules or calibrations and minor repairs are actually being performed.

(3) All channels may be bypassed when not required by the exceptions of Sections 2.2 or 3.2 of these specifications.

Figure 8. Reactor Safety System in Technical Specifications (1970)

The modification of low flow reactor inlet channels can be seen in the Technical Specifications (1984) document. The reactor safety system parameters are given in Figure 9. As it can be seen in Figure 9, low flow reactor inlet inner plenum and low flow reactor outer plenum are combined together in a single item and categorized as the low flow reactor inlet, inner or outer plenum.

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Table 3.1 Reactor Safety System

| Function | Minimum Operable Channels | |
|--|---------------------------|-------------|
| | Scram | Major Scram |
| High flux level (2 of 3 or 1 of 2 logic only) | 2 | |
| Short period below 5% rated power | 2 | |
| High activity, effluent air exhaust RD 3-4, 3-5, and 4-1 | | 2 |
| Low reactor vessel D ₂ O level ^{1,3} | 2 | |
| Low flow reactor outlet ^{2,3} | 1 | |
| Low flow reactor inlet, inner or outer plenum ^{2,3} | 1 | |
| Manual in control room | 1 | 1 |

¹One of two channels may be bypassed for tests or during the time maintenance involving the replacement of components and modules or calibrations and minor repairs is actually being performed.

²One of these two flow channels may be bypassed during tests, or during the time maintenance involving the replacement of components and modules or calibrations and minor repairs is actually being performed. However, outlet low flow may not be bypassed unless both inner and outer low-flow reactor inlet safety systems are operating.

³All channels may be bypassed when not required by the exceptions of Sections 2.2 or 3.2 of these specifications.

Figure 9. Reactor Safety System in Technical Specifications (1984)

The logic and justification behind this modification in 1984 were not documented to the best of the authors' knowledge. However, it can be stated that the representation of inner and outer plenum flow channels as a single reactor inlet flow channel is flawed for two reasons. First, it does not represent the physical plant, as there is two inlet plenums for the NBSR. Second, the usage of "or" seems intentional in the sentence "low flow reactor inlet, inner or outer plenum" because the minimum operable channel for Scram is 1 for the low flow reactor inlet scram input. This implies that the reactor can be operated when at least one of these channels is operable, and it does not necessarily require both to be operable simultaneously. This implication not only contradicts the Technical Specifications (1974) but is also counterintuitive and may not align with best safety practices. A thorough safety analysis was required for such a change, and it is not known if such safety analyses were conducted before this change.

Another modification was done with the Technical Specifications (2009), see Figure 1. An important change is item 5 of Technical Specifications (1984) is changed from "(5) Low flow reactor inlet, inner or outer plenum" to "(5) Low flow reactor inner or outer plenum" in Technical Specification (2009).

Proposed Changes to Technical Specifications

As part of the engineering review, accident scenarios, and thermal hydraulic analysis models used in the Amendment 15 are verified to be in synchronization with TS 2.2, TS Table 3.2.2 (as proposed in this ECN), TS Table 4.2.2 (as proposed in this ECN) and listed scram setpoints in the updated FSAR Table 7.1 (see snapshot in Figure 10). There are no changes proposed to the FSAR Table 7.1.

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Table 7.1: Reactor Scram Inputs

| <u>Scram</u> | <u>Source</u> | <u>Trip Setting</u> | <u>Annunciator No.</u> |
|--------------------------------------|--|---------------------|------------------------|
| Manual Scram | Scram Button on MCP or Manual Scram Stations | | 4-1 |
| Moderator Dump | Moderator Dump on MCP | | 4-2 |
| Safety Sys. Process Instr. Power Off | Process Instr. P/S | | 5-44 |
| High Flux | NC-6, NC-7 and NC-8 | 125% / 13% | 4-3 |
| Period Scram | NC-3 and NC-4 | 5 Sec. | 4-4 |
| Nuclear Instrument Power Off | Nuclear Instrument P/S | | 4-5 |
| Building Exhaust Activity High | RM3-5 | 50k CPM | 4-6 |
| Irradiated Air Activity High | RM3-4 | 50k CPM | 4-7 |
| Stack Activity High | RM4-1 | 50k CPM | 4-8 |
| Outlet Flow Low | FIA-40 | 6,500 gpm | 4-9 |
| 14 In. Inlet Flow Low | FRC-3 | 5,000 gpm | 4-10 |
| 10 In. Inlet Flow Low | FRC-4 | 1,400 gpm | 4-11 |
| Differential Temperature "A" High | TIA-40A | 20 °F | 4-12 |
| Differential Temperature "B" High | TIA-40B | 20 °F | 4-13 |
| Vessel Level "Recorder" Low | LRC-1 | 140 in. | 4-14 |
| Vessel Level "Indicator" Low | LIA-40 | 140 in. | 4-15 |
| Experimental Scram | Not used at this time. | N/a | 4-16 |

Figure 10: Updated FSAR Table 7.1

To eliminate the possibility of such an incident, the NCNR is requesting a License Amendment to modify Technical Specifications 3.2.2 and 4.2.2 to require that the inner plenum flow be operable during reactor operations. This change will ensure Technical Specifications and existing safety analysis are in agreement. Corresponding operating Instructions and Reactor Procedures will also be updated to clearly require the primary flow channels.

Proposed changes to TS Table 3.2.2 and Table 4.2.2 are shown below.

ECR Title: Reactor Plenum Flow Meters License Amendment

System: Primary Coolant System (Reactor Vessel & internals, drains, etc)

Date:

| Channel | Scram | Major Scram | Rundown |
|---|----------|-------------|---------|
| (1) High Flux level | 2 | | |
| (2) Short period below 5% rated power | 2 | | |
| (3) Low reactor vessel D2O level ^{1,23} | 2 | | |
| (4) Low flow reactor outlet ^{2,3} | 1 | | |
| (5) Low flow reactor inner plenum ² | 1 | | |
| (6) Low flow reactor outer plenum ^{2,3} | <u>1</u> | | |
| (7) Manual (outside of the Control Room) | 1 | | |
| (8) Manual | 1 | 1 | |
| (9) Reactor Outlet Temperature ²³ | | | 1 |
| (10) Gaseous Effluent Monitor ³⁴ | | 2 | |

¹ One (1) of two (2) channels may be bypassed for tests or during the time maintenance involving the replacement of components and modules or calibrations and repairs are actually being performed.

~~² One (1) of these two (2) flow channels may be bypassed during tests, or during the time maintenance involving the replacement of components and modules or calibrations and minor repairs are actually being performed. However, outlet low flow may not be bypassed unless both inner and outer low flow reactor inlet safety systems are operating.~~

²³ May be bypassed during periods of reactor operation when a reduction in Limiting Safety System Settings are permitted by the specifications of Sections 2.2(4) and 3.3.1(1).

Table 4.2.2
Surveillance Requirements for the Scram and Confinement Channels

| Channel | Action Required | Surveillance Required |
|--|-----------------|-----------------------|
| (1) High Flux level | Scram | X,A |
| (2) Short period below 5% rated power | Scram | X,A |
| (3) Low reactor vessel D2O level | Scram | X,A |
| (4) Low flow reactor outlet | Scram | X,A |
| (5) Low flow reactor inner or outer plenum | Scram | X,A |
| (6) Low flow reactor outer plenum | <u>Scram</u> | <u>X,A</u> |
| (7) Manual (outside of the Control Room) | Scram | X,A |
| (8) Manual | Scram | X,A |
| (9) Normal Air Exhaust Activity High | Major Scram | X,A |
| (10) Irradiated Air Activity High | Major Scram | X,A |
| (11) Stack Air Activity High | Major Scram | X,A |
| (12) Reactor Coolant Outlet Temperature Rundown | Rundown | X,A |

X - Channel test before startup after a shutdown of longer than 24 hours, or quarterly.

A - Annual Channel Calibration.

Basis

To ensure that instrument failures do not go undetected, frequent surveillance of the listed channels is required and operating experience has shown these frequencies to be adequate to ensure channel operability.

| | | | |
|---------------------------------|--|-----------|------|
| ENGINEERING CHANGE NOTICE (ECN) | | ECR No. : | 1399 |
| ECR Title: | Reactor Plenum Flow Meters License Amendment | | |
| System: | Primary Coolant System (Reactor Vessel & internals, drains, etc) | Date: | |

Final Technical Specifications as proposed are shown below

| Table 3.2.2 Reactor Safety System Channels Minimum Nuclear and Process Channels Required | | | |
|--|-------|-------------|---------|
| Channel | Scram | Major Scram | Rundown |
| (1) High Flux level | 2 | | |
| (2) Short period below 5% rated power | 2 | | |
| (3) Low reactor vessel D2O level ^{1,2} | 2 | | |
| (4) Low flow reactor outlet ² | 1 | | |
| (5) Low flow reactor inner plenum ² | 1 | | |
| (6) Low flow reactor outer plenum ² | 1 | | |
| (7) Manual (outside of the Control Room) | 1 | | |
| (8) Manual | 1 | 1 | |
| (9) Reactor Outlet Temperature ² | | | 1 |
| (10) Gaseous Effluent Monitor ³ | | 2 | |

¹ One (1) of two (2) channels may be bypassed for tests or during the time maintenance involving the replacement of components and modules or calibrations and repairs are actually being performed.

² May be bypassed during periods of reactor operation when a reduction in Limiting Safety System Settings are permitted by the specifications of Sections 2.2(4) and 3.3.1(1).

³ See specifications of Section 3.7.1

| | | | |
|---------------------------------|--|-----------|------|
| ENGINEERING CHANGE NOTICE (ECN) | | ECR No. : | 1399 |
| ECR Title: | Reactor Plenum Flow Meters License Amendment | | |
| System: | Primary Coolant System (Reactor Vessel & internals, drains, etc) | Date: | |

Table 4.2.2
Surveillance Requirements for the Scram and Confinement Channels

| <u>Channel</u> | <u>Action Required</u> | <u>Surveillance Required</u> |
|---|------------------------|------------------------------|
| (1) High Flux level | Scram | X,A |
| (2) Short period below 5% rated power | Scram | X,A |
| (3) Low reactor vessel D2O level | Scram | X,A |
| (4) Low flow reactor outlet | Scram | X,A |
| (5) Low flow reactor inner plenum | Scram | X,A |
| (6) Low flow reactor outer plenum | Scram | X,A |
| (7) Manual (outside of the Control Room) | Scram | X,A |
| (8) Manual | Scram | X,A |
| (9) Normal Air Exhaust Activity High | Major Scram | X,A |
| (10) Irradiated Air Activity High | Major Scram | X,A |
| (11) Stack Air Activity High | Major Scram | X,A |
| (12) Reactor Coolant Outlet Temperature Rundown | Rundown | X,A |

X - Channel test before startup after a shutdown of longer than 24 hours, or quarterly.

A - Annual Channel Calibration.

Basis

To ensure that instrument failures do not go undetected, frequent surveillance of the listed channels is required and operating experience has shown these frequencies to be adequate to ensure channel operability.

| | | | |
|---------------------------------|--|----------|------|
| ENGINEERING CHANGE NOTICE (ECN) | | ECR No.: | 1399 |
| ECR Title: | Reactor Plenum Flow Meters License Amendment | | |
| System: | Primary Coolant System (Reactor Vessel & internals, drains, etc) | Date: | |

Proposed Changes to Procedures

Introduce notes to applicable procedures that the “Technical Specifications require all 3 low flow scrams be operational for reactor operations.”

O.I 1.1.0 “Reactor Startup Checklist”

TSP 4.1.1(1) “Operability Test of Reactor Safety System Channels”

Review all relevant procedures and remove statements referring to bypass of primary coolant flow channels (inlet and outer plenum and reactor outlet flow meter)

References

- [1] Maulbetsch JS (1965) A study of system-induced instabilities in forced-convection flows with subcooled boiling.
- [2] Mirshak S, Durant WS, Towell RH (1959) *Heat flux at burnout* (EI du Pont de Nemours & Company, Explosives Department, Atomic Energy ...), Vol. 355.
- [3] Costa J (1969) Friction coefficient measurement in turbulent flow, simple phase with heat transfer, in a rectangular channel. (France), Note CEA-N-1142, p 21. Available at http://inis.iaea.org/search/search.aspx?orig_q=RN:49041845

Safety Considerations, Identification, and/or Analysis

The ECN implements changes to Technical Specification requirements for the operability of the inner and outer plenum flow channels. Proposed changes will ensure TS requirements are in agreement with existing safety analysis and technical basis. There are no safety consequences of the proposed change.

Required Tests, Retests, Surveillances, or Measurements

There are no tests, surveillance or measurement requirements associated with this change. Additional training will be provided to the reactor personnel about the changes in the TS.

Safety Evaluation and Conclusion

Proposed modifications to the TS operability requirements of the inner and outer plenum flow channels are conservative and ensures compliance with existing safety analysis and technical basis.