UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 15, 2022

Mr. Kevin Cimorelli
Site Vice President
Susquehanna Nuclear, LLC
769 Salem Boulevard
NUCSB3
Berwick, PA 18603-0467

SUBJECT: SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2 - ISSUANCE OF AMENDMENT NOS. 281 AND 264 RE: REVISE TECHNICAL SPECIFICATIONS TO ADOPT TSTF-564, "SAFETY LIMIT MCPR" (EPID L-2022-LLA-0005)

Dear Mr. Cimorelli:

The U.S. Nuclear Regulatory Commission has issued the enclosed Amendment No. 281 to Renewed Facility Operating License No. NPF-14 and Amendment No. 264 to Renewed Facility Operating License No. NPF-22 for the Susquehanna Steam Electric Station, Units 1 and 2, respectively. These amendments consist of changes to the technical specifications (TSs) in response to your application dated January 5, 2022 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML22005A183).

These amendments revise the TS to adopt Technical Specifications Task Force (TSTF) Traveler TSTF-564, Revision 2, "Safety Limit MCPR [Minimum Critical Power Ratio]," dated October 24, 2018 (ML18297A361) as described in the enclosed safety evaluation. The proposed amendments revise the TS safety limit on minimum critical power ratio to reduce the need for cycle-specific changes to the value while still meeting the regulatory requirement for a safety limit. The amendments revise the TS safety limit 2.1.1.2 and TS 5.6.5, "Core Operating Limits Report (COLR)."

Enclosure 3 to this letter contains proprietary information. When separated from Enclosure 3, this document is DECONTROLLED.

A copy of the related safety evaluation is also enclosed. Notice of Issuance will be included in the Commission's monthly *Federal Register* Notice.

Sincerely,

/RA/

Audrey L. Klett, Senior Project Manager
Plant Licensing Branch I
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-387 and 50-388

Enclosures:
1. Amendment No. 281 to License No. NPF-14
2. Amendment No. 264 to License No. NPF-22
3. Safety Evaluation (proprietary)
4. Safety Evaluation (redacted version)

cc: w/Enclosures, 1, 2, and 4:
Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SUSQUEHANNA NUCLEAR, LLC

ALLEGHENY ELECTRIC COOPERATIVE, INC.

DOCKET NO. 50-387

SUSQUEHANNA STEAM ELECTRIC STATION, UNIT 1

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 281
Renewed License No. NPF-14

1. The U.S. Nuclear Regulatory Commission (NRC or the Commission) has found that:

   A. The application for the amendment filed by Susquehanna Nuclear, LLC, dated January 5, 2022, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the regulations of the Commission;

   C. There is reasonable assurance: (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations set forth in 10 CFR Chapter I;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment and paragraph 2.C.(2) of Renewed Facility Operating License No. NPF-14 is hereby amended to read as follows:

2.C.(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 281, and the Environmental Protection Plan contained in Appendix B are hereby incorporated in the license. Susquehanna Nuclear, LLC shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. This license amendment is effective as of its date of issuance and shall be implemented prior to startup from the Spring 2024 refueling outage.

FOR THE NUCLEAR REGULATORY COMMISSION

James G. Danna

Digitally signed by James G. Danna
Date: 2022 07.15 16:13:45 -04'00'

James G. Danna, Chief
Plant Licensing Branch I
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Attachment:
Changes to the Renewed Facility Operating License and Technical Specifications

Date of Issuance: July 15, 2022

ATTACHMENT TO LICENSE AMENDMENT NO. 281

SUSQUEHANNA STEAM ELECTRIC STATION, UNIT 1

RENEWED FACILITY OPERATING LICENSE NO. NPF-14

DOCKET NO. 50-387

Replace the following page of the Renewed Facility Operating License with the attached revised page. The revised page is identified by amendment number and contains a marginal line indicating the area of change.

REMOVE	INSERT
Page 3	Page 3

Replace the following pages of the Appendix A Technical Specifications with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

REMOVE	INSERT
2.0-1	2.0-1
5.0-21	5.0-21

(3) Susquehanna Nuclear, LLC, pursuant to the Act and 10 CFR Parts 30, 40, and 70, to receive, posses, and use at any time any byproduct, source and special nuclear material as sealed neutron sources for reactor startup, sealed neutron sources for reactor instrumentation and radiation monitoring equipment calibration, and as fission detectors in amounts as required;

(4) Susquehanna Nuclear, LLC, pursuant to the Act and 10 CFR Parts 30, 40, and 70 to receive, posses, and use in amounts as required any byproduct, source or special nuclear material without restriction to chemical or physical form, for sample analysis or instrument calibration or associated with radioactive apparatus or components; and

(5) Susquehanna Nuclear, LLC, pursuant to the Act and 10 CFR Parts 30, 40, and 70 to possess, but not separate, such byproduct and special nuclear materials as may be produced by the operation of the facility.

C. This license shall be deemed to contain and is subject to the conditions specified in the Commission's regulations set forth in 10 CFR Chapter I and is subject to all applicable provisions of the Act and to the rules, regulations and orders of the Commission nor or hereafter in effect; and is subject to the additional conditions specified or incorporated below:

(1) Maximum Power Level

Susquehanna Nuclear, LLC is authorized to operate the facility at reactor core power levels not in excess of 3952 megawatts thermal in accordance with the conditions specified herein. The preoperational tests, startup tests and other items identified in License Conditions 2.C.(36), 2.C.(37), 2.C.(38), and 2.C.(39) to this license shall be completed as specified.

(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 281, and the Environmental Protection Plan contained in Appendix B are hereby incorporated in the license. Susquehanna Nuclear, LLC shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

For Surveillance Requirements (SRs) that are new in Amendment 178 to Facility Operating License No. NPF-14, the first performance is due at the end of the first surveillance interval that begins at implementation of Amendment 178. For SRs that existed prior to Amendment 178, including SRs with modified acceptance criteria and SRs whose frequency of performance is being extended, the first performance is due at the end of the first surveillance interval that begins on the date the Surveillance was last performed prior to implementation of Amendment 178.

2.0 SAFETY LIMITS (SLs)

2.1 SLs

2.1.1 Reactor Core SL

2.1.1.1 With the reactor steam dome pressure < 575 psig or core flow < 10 million lbm/hr:

THERMAL POWER shall be ≤ 23% RTP.

2.1.1.2 With the reactor steam dome pressure ≥ 575 psig and core flow ≥ 10 million lbm/hr:

MCPR shall be ≥ 1.05.

2.1.1.3 Reactor vessel water level shall be greater than the top of active irradiated fuel.

2.1.2 Reactor Coolant System Pressure SL

Reactor steam dome pressure shall be ≤ 1325 psig.

2.2 SL Violations

With any SL violation, the following actions shall be completed within 2 hours:

2.2.1 Restore compliance with all SLs; and

2.2.2 Insert all insertable control rods.

5.6 Reporting Requirements

5.6.4 Not Used

5.6.5 CORE OPERATING LIMITS REPORT (COLR)

a. Core operating limits shall be established prior to each reload cycle, or prior to any remaining portion of a reload cycle, and shall be documented in the COLR for the following:

1. The Average Planar Linear Heat Generation Rate for Specification 3.2.1;

2. The Minimum Critical Power Ratio (MCPR) and $MCPR_{99.9\%}$ for Specification 3.2.2;

3. The Linear Heat Generation Rate for Specification 3.2.3;

4. The Shutdown Margin for Specification 3.1.1;

5. Oscillation Power Range Monitor (OPRM) Trip Setpoints, for Specification 3.3.1.1; and

6. The Allowable Values and power range setpoints for Rod Block Monitor Upscale Functions for Specification 3.3.2.1, Table 3.3.2.1-1.

b. The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC.

UNITED STATES
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WASHINGTON, D.C. 20555-0001

SUSQUEHANNA NUCLEAR, LLC

ALLEGHENY ELECTRIC COOPERATIVE, INC.

DOCKET NO. 50-388

SUSQUEHANNA STEAM ELECTRIC STATION, UNIT 2

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 264
Renewed License No. NPF-22

1. The U.S. Nuclear Regulatory Commission (NRC or the Commission) has found that:

   A. The application for the amendment filed by Susquehanna Nuclear, LLC, dated January 5, 2022, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the regulations of the Commission;

   C. There is reasonable assurance: (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment and paragraph 2.C.(2) of Renewed Facility Operating License No. NPF-22 is hereby amended to read as follows:

2.C.(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 264, and the Environmental Protection Plan contained in Appendix B are hereby incorporated in the license. Susquehanna Nuclear, LLC shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. This license amendment is effective as of its date of issuance and shall be implemented prior to startup from the Spring 2023 refueling outage.

FOR THE NUCLEAR REGULATORY COMMISSION

James G. Danna

Digitally signed by James G. Danna
Date: 2022 07.15 16:14:19 -04'00'

James G. Danna, Chief
Plant Licensing Branch I
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Attachment:
Changes to the Renewed Facility Operating License and Technical Specifications

Date of Issuance: July 15, 2022

ATTACHMENT TO LICENSE AMENDMENT NO. 264

SUSQUEHANNA STEAM ELECTRIC STATION, UNIT 2

RENEWED FACILITY OPERATING LICENSE NO. NPF-22

DOCKET NO. 50-388

Replace the following page of the Renewed Facility Operating License with the attached revised page. The revised page is identified by amendment number and contains a marginal line indicating the area of change.

REMOVE	INSERT
Page 3	Page 3

Replace the following pages of the Appendix A Technical Specifications with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

REMOVE	INSERT
2.0-1	2.0-1
5.0-21	5.0-21

(3) Susquehanna Nuclear, LLC, pursuant to the Act and 10 CFR Parts 30, 40, and 70, to receive, posses, and use at any time any byproduct, source and special nuclear material as sealed neutron sources for reactor startup, sealed neutron sources for reactor instrumentation and radiation monitoring equipment calibration, and as fission detectors in amounts as required;

(4) Susquehanna Nuclear, LLC, pursuant to the Act and 10 CFR Parts 30, 40, and 70 to receive, posses, and use in amounts as required any byproduct, source or special nuclear material without restriction to chemical or physical form, for sample analysis or instrument calibration or associated with radioactive apparatus or components; and

(5) Susquehanna Nuclear, LLC, pursuant to the Act and 10 CFR Parts 30, 40, and 70 to possess, but not separate, such byproduct and special nuclear materials as may be produced by the operation of the facility.

C. This license shall be deemed to contain and is subject to the conditions specified in the Commission's regulations set forth in 10 CFR Chapter I and is subject to all applicable provisions of the Act and to the rules, regulations and orders of the Commission nor or hereafter in effect; and is subject to the additional conditions specified or incorporated below:

(1) Maximum Power Level

Susquehanna Nuclear, LLC is authorized to operate the facility at reactor core power levels not in excess of 3952 megawatts thermal in accordance with the conditions specified herein. The preoperational tests, startup tests and other items identified in License Conditions 2.C.(20), 2.C.(21), 2.C.(22), and 2.C.(23) to this license shall be completed as specified.

(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 264, and the Environmental Protection Plan contained in Appendix B are hereby incorporated in the license. Susquehanna Nuclear, LLC shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

For Surveillance Requirements (SRs) that are new in Amendment 151 to Facility Operating License No. NPF-22, the first performance is due at the end of the first surveillance interval that begins at implementation of Amendment 151. For SRs that existed prior to Amendment 151, including SRs with modified acceptance criteria and SRs whose frequency of performance is being extended, the first performance is due at the end of the first surveillance interval that begins on the date the Surveillance was last performed prior to implementation of Amendment 151.

2.0 SAFETY LIMITS (SLs)

2.1 SLs

2.1.1 Reactor Core SLs

2.1.1.1 With the reactor steam dome pressure < 575 psig or core flow < 10 million lbm/hr:

THERMAL POWER shall be ≤ 23% RTP.

2.1.1.2 With the reactor steam dome pressure ≥ 575 psig and core flow ≥ 10 million lbm/hr:

MCPR shall be ≥ 1.05.

2.1.1.3 Reactor vessel water level shall be greater than the top of active irradiated fuel.

2.1.2 Reactor Coolant System Pressure SL

Reactor steam dome pressure shall be ≤ 1325 psig.

2.2 SL Violations

With any SL violation, the following actions shall be completed within 2 hours:

2.2.1 Restore compliance with all SLs; and

2.2.2 Insert all insertable control rods.

5.6 Reporting Requirements

5.6.4 Not Used

5.6.5 CORE OPERATING LIMITS REPORT (COLR)

a. Core operating limits shall be established prior to each reload cycle, or prior to any remaining portion of a reload cycle, and shall be documented in the COLR for the following:

1. The Average Planar Linear Heat Generation Rate for Specification 3.2.1;

2. The Minimum Critical Power Ratio (MCPR) and $MCPR_{99.9\%}$ for Specification 3.2.2;

3. The Linear Heat Generation Rate for Specification 3.2.3;

4. The Shutdown Margin for Specification 3.1.1;

5. Oscillation Power Range Monitor (OPRM) Trip setpoints, for Specification 3.3.1.1; and

6. The Allowable Values and power range setpoints for Rod Block Monitor Upscale Functions for Specification 3.3.2.1, Table 3.3.2.1-1.

b. The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 281 TO RENEWED FACILITY OPERATING

LICENSE NO. NPF-14

AND AMENDMENT NO. 264 TO RENEWED FACILITY OPERATING

LICENSE NO. NPF-22

SUSQUEHANNA NUCLEAR, LLC

ALLEGHENY ELECTRIC COOPERATIVE, INC.

SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2

DOCKET NOS. 50-387 AND 50-388

1.0 INTRODUCTION

By letter dated January 5, 2022 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML22005A183) to the U.S. Nuclear Regulatory Commission (NRC), Susquehanna Nuclear, LLC, (the licensee) submitted a license amendment request (LAR) for Susquehanna Steam Electric Station, Units 1 and 2 (Susquehanna).

The LAR proposes to revise technical specification (TS) safety limit (SL) 2.1.1.2, the reactor core safety limit for the minimum critical power ratio (MCPR). The MCPR ensures protection against boiling transition on the fuel rods in the reactor core. The current MCPR safety limit for Susquehanna ensures that 99.9 percent of the fuel rods would not be susceptible to boiling transition (i.e., reduced heat transfer) during normal operation and anticipated operational occurrences and is referred to as $MCPR_{99.9\%}$. The revised MCPR safety limit will ensure that there is a 95 percent probability at a 95 percent confidence level that no fuel rods will be susceptible to boiling transition using an SL based on critical power ratio (CPR) data statistics and is referred to as the $MCPR_{95/95}$. The revised MCPR would also delete reference to single- and two-loop operation because $MCPR_{95/95}$ is not dependent on the number of recirculation loops in operation. Susquehanna TS 5.6.5, “Core Operating Limits Report (COLR),” is also proposed to be modified to require the $MCPR_{99.9\%}$ value to be included in the cycle-specific COLR.

The proposed changes are based on Technical Specifications Task Force (TSTF) traveler TSTF-564, Revision 2, “Safety Limit MCPR [Minimum Critical Power Ratio],” dated October 24, 2018 (ML18297A361). The NRC issued a final safety evaluation (SE) approving traveler TSTF-564, Revision 2, on November 16, 2018 (ML18299A069).

The licensee proposes variations from the traveler TSTF-564, Revision 2 that are described in the LAR. Susquehanna is currently using Framatome ATRIUM 10 and ATRIUM 11 fuel types, which are not explicitly identified in TSTF-564 Table 1. The Susquehanna TSs also specify a different dome pressure value rather than the value specified in the Standard Technical Specifications (STS). In addition, the Susquehanna TSs use different numbering than the STS for the COLR; specifically, Susquehanna uses TS 5.6.5 versus STS 5.6.3. These variations are described and evaluated in Section 3.6 of the SE.

As addressed in Section 3.5 of this SE, Susquehanna followed the methodology described in traveler TSTF-564 to demonstrate the $MCPR_{95/95}$ for the Framatome ATRIUM 10 and ATRIUM 11 fuel types are acceptable. This SE contains proprietary information, which is marked with double brackets and bold font such as **[[Example]]**.

1.1 Background on Boiling Transition

During steady-state operation in a boiling-water reactor (BWR), most of the coolant in the core is in a flow regime known as annular flow. In this flow regime, a thin liquid film is pushed up to the surface of the fuel rod cladding by the bulk coolant flow, which is mostly water vapor with some liquid water droplets. This provides effective heat removal from the cladding surface; however, under certain conditions, the annular film may dissipate, which reduces the heat transfer and results in an increase in fuel cladding surface temperature. This phenomenon is known as boiling transition or dryout. The elevated surface temperatures resulting from dryout may cause fuel cladding damage or failure.

1.2 Background on Critical Power Correlations

For a given set of reactor operating conditions (pressure, flow, etc.), dryout will occur on a fuel assembly at a certain power, known as the critical power. Because the phenomena associated with boiling transition are complex and difficult to model purely mechanistically, thermal-hydraulic test campaigns are undertaken using electrically heated prototypical fuel bundles to establish a comprehensive database of critical power measurements for each BWR fuel product. These data are then used to develop a critical power correlation that can be used to predict the critical power for assemblies in operating reactors. This prediction is usually expressed as the ratio of the actual assembly power to the critical power predicted using the correlation, known as the CPR.

One measure of the correlation's predictive capability is based on its validation relative to the test data. For each point j in a correlation's test database, the experimental critical power ratio (ECPR) is defined as the ratio of the measured critical power to the calculated critical power, or:

$$ECPR_j \quad \frac{\text{Measured Critical Power}_j}{\text{Calculated Critical Power}_j}$$

For ECPR values less than or equal to 1, the calculated critical power is greater than or equal to the measured critical power and the prediction is considered to be non-conservative. Because the measured critical power includes random variations due to various uncertainties, evaluating the ECPR for all of the points in the dataset (or, ideally, a subset of points that were not used in the correlation's development) results in a probability distribution. This ECPR distribution allows the predictive uncertainty of the correlation to be determined. This uncertainty can then be used

to establish a limit above which there can be assumed that boiling transition will not occur (with a certain probability and confidence level).

Per TSTF-564, Revision 2, fuel vendors may determine the $MCPR_{95/95}$ for other fuel designs using the methodology described in References 1 and 2. The licensee provided the necessary detail of derivation of the $MCPR_{95/95}$ for both ATRIUM 10 and ATRIUM 11 fuel types. The information provided is based on NRC-approved CPR correlations for each fuel type. This is consistent with Susquehanna TS 5.6.5.b. Framatome defines ECPR as the ratio of the calculated critical power to the measured critical power which is the inverse of the TSTF-564 definition. The TSTF-564, Revision 2 95/95 formulation presumes a mean ECPR of one. The licensee stated that the form of the equation used by Framatome and the form presented in TSTF-564, Revision 2, are equal when the mean of the ECPR is equal to one.

1.3 Background on Thermal-Hydraulic Safety Limits

To protect against boiling transition, BWRs have implemented an SL on the CPR, known as the MCPR SL. As discussed in NUREG-1433 (Reference 3) and NUREG-1434 (Reference 4), the STS at the time TSTF-564 was approved for General Electric BWR designs, the basis of the MCPR SL for the licensee's facility is to prevent 99.9 percent of the fuel in the core from being susceptible to boiling transition. This limit is typically developed by considering various cycle-specific power distributions and uncertainties and is highly dependent on the cycle-specific radial power distribution in the core. As such, the limit may need to be updated as frequently as every cycle.

The fuel cladding SL for pressurized-water reactor (PWR) designs, described in the STS for Babcock & Wilcox, Westinghouse, and Combustion Engineering[1] plants in NUREG-1430, NUREG-1431, and NUREG-1432 (Reference 5), respectively, correspond to a 95 percent probability at a 95 percent confidence level that departure from nucleate boiling will not occur. As a result of the overall approach taken in developing the PWR limits, they are only dependent on the fuel type(s) in the reactor and the corresponding departure from nucleate boiling ratio (DNBR) correlations. The limits are not cycle-dependent and are typically only updated when new fuel types are inserted in the reactor.

The TSs for the licensee's facility also have a limiting condition for operation (LCO) that governs MCPR, known as the MCPR operating limit (OL). The OL on MCPR is an LCO which must be met to ensure that anticipated operational occurrences do not result in fuel damage. The current MCPR OL is calculated by combining the largest change in CPR from all analyzed transients, also known as the ΔCPR, with the MCPR SL.

2.0 REGULATORY EVALUATION

The applicable regulatory requirements and the appropriate guidance is provided in the following subsections.

[1] Denotes applicability to Combustion Engineering plants with digital control systems only

2.1 Description of TS Sections

TSTF-564 modifies STS 2.1.1, "Reactor Core SLs". SLs ensure that specified acceptable fuel design limits are not exceeded during steady-state operation, normal operational transients, and anticipated operational occurrences (AOOs).

Susquehanna Unit 1 TS 2.1.1.2 currently requires that:

> "With the reactor steam dome pressure ≥ 575 pounds psig [pounds per square inch gauge] and core flow ≥ 10 million lbm/hr:
>
> MCPR shall be ≥ 1.09 for two recirculation loop operation or ≥ 1.12 for single recirculation loop operation."

Susquehanna Unit 2 TS 2.1.1.2 currently requires that:

> "With the reactor steam dome pressure ≥ 575 pounds psig and core flow ≥ 10 million lbm/hr:
>
> MCPR shall be ≥ 1.08 for two recirculation loop operation or ≥ 1.11 for single recirculation loop operation."

The MCPR SL ($MCPR_{99.9\%}$) ensures that 99.9 percent of the fuel in the core is not susceptible to boiling transition.

TSTF-564 also modifies STS 5.6.3, "Core Operating Limits Report (COLR)". STS 5.6.3 corresponds to Susquehanna Unit 1 and Unit 2, TS 5.6.5.

Susquehanna Unit 1 and Unit 2, TS 5.6.5.a requires that:

> "Core operating limits shall be established prior to each reload cycle, or prior to any remaining portion of a reload cycle, and shall be documented in the COLR …"

2.2 Proposed Changes to the TS

The licensee proposes to revise the MCPR SL, consistent with the method described in traveler TSTF-564, Revision 2, to make it cycle-independent.

The proposed changes to the Susquehanna Unit 1 and Unit 2 TS would revise the value of the MCPR SL in TS 2.1.1.2 to ≥ 1.05, with corresponding changes to the associated bases.

The change to TS 2.1.1.2 replaces the existing separate limits for single- and two-recirculation loop operation, respectively, with a single limit since the revised SL is no longer dependent on the number of recirculation loops in operation.

The current MCPR SL (i.e., $MCPR_{99.9\%}$) is an input to the MCPR OL in LCO 3.2.2, "Minimum Critical Power Ratio (MCPR)". The proposed TS changes include revisions to TS 5.6.5, to require the $MCPR_{99.9\%}$ value used in calculating the LCO 3.2.2 MCPR OL to be included in the cycle-specific COLR. The definition and method of calculation of both the $MCPR_{99.9\%}$ and the LCO 3.2.2 MCPR OL remains unchanged.

2.3 Applicable Regulatory Requirements and Guidance

The regulation at Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.36(a)(1), requires an applicant for an operating license to include in the application proposed TSs in accordance with the requirements of 10 CFR 50.36. The applicant must include in the application, a "summary statement of the bases or reasons for such specifications, other than those covering administrative controls." However, per 10 CFR 50.36(a)(1), these TS bases "shall not become part of the technical specifications."

As required by 10 CFR 50.36(c)(1), TSs will include items for *Safety limits, limiting safety system settings, and limiting control settings*. As required by 10 CFR 50.36(c)(1)(i)(A), safety limits for nuclear reactors are "limits upon important process variables that are found to be necessary to reasonably protect the integrity of certain physical barriers that guard against the uncontrolled release of radioactivity. If any safety limit is exceeded, the reactor must be shut down. The licensee shall notify the Commission, review the matter, and record the results of the review, including the cause of the condition and the basis for corrective action taken to preclude recurrence. Operation must not be resumed until authorized by the Commission."

As required by 10 CFR 50.36(c)(2)(i), the TSs will include LCOs, which are the lowest functional capability or performance levels of equipment required for safe operation of the facility. When an LCO of a nuclear reactor is not met, the licensee shall shut down the reactor or follow any remedial action permitted by the TSs until the condition can be met. Additionally, as required by 10 CFR 50.36(c)(5), TSs must include administrative controls, which are "the provisions relating to organization and management, procedures, recordkeeping, review and audit, and reporting necessary to assure operation of the facility in a safe manner."

General Design Criterion 10 (GDC), "Reactor design," of 10 CFR Part 50 Appendix A, "General Design Criteria of Nuclear Power Plants," states:

"The reactor core and associated coolant control and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences."

The limits placed on the MCPR act as a specified acceptable fuel design limit to prevent boiling transition, which has the potential to result in fuel rod cladding failure and are used to meet GDC 10.

The NRC staff's review guidance contained in Revision 2 of NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [Light Water Reactor] Edition", Section 4.4, "Thermal and Hydraulic Design," (Reference 6) provides the following two examples of acceptable approaches to meeting the SRP acceptance criteria for establishing fuel design limits (as stated in SRP Acceptance Criterion 1):

A. For departure from nucleate boiling ratio (DNBR), CHFR [critical heat flux ratio] or CPR correlations, there should be a 95 percent probability at the 95 percent confidence level that the hot rod in the core does not experience a DNB [departure from nucleate boiling] or boiling transition condition during normal operation or AOOs.

B. The limiting (minimum) value of DNBR, CHFR, or CPR correlations is to be established such that at least 99.9 percent of the fuel rods in the core will not experience a DNB or boiling transition during normal operation or AOOs.

The NRC staff's guidance for the review of TSs is in Chapter 16.0, Revision 3, "Technical Specifications," of the SRP (NUREG-0800), dated March 2010 (ML100351425). As described therein, as part of the regulatory standardization effort, the NRC staff has prepared STSs for each of the LWR nuclear designs. Accordingly, the NRC staff's review considers whether the proposed changes are consistent with the applicable reference STSs (i.e., the current STSs), as modified by NRC-approved travelers. The STS applicable to Susquehanna is NUREG-1433, Revision 5.0, "Standard Technical Specifications, General Electric Plants BWR/4," Volume 1, "Specifications," and Volume 2, "Bases," September 2021 (ML21272A357 and ML21272A358, respectively). Revision 5 to the STS incorporates NRC-approved changes from traveler TSTF-564.

3.0 TECHNICAL EVALUATION

3.1 Basis for Proposed Changes

As discussed in Section 1.3 of this SE, the current MCPR SL (i.e., the $MCPR_{99.9\%}$), is affected by the plant's cycle-specific core design, especially including the core power distribution, fuel type(s) in the reactor, and the power-to-flow operating domain for the plant. As such, it is frequently necessary to change the MCPR SL to accommodate new core designs. Changes to the MCPR SL are usually determined late in the design process and necessitate an accelerated NRC review (i.e., license amendment request) to support the subsequent fuel cycle.

The licensee proposed to change the basis for the MCPR SL for Susquehanna so that it is no longer cycle-dependent, reducing the frequency of revisions and eliminating the need for the NRC's review on an accelerated schedule. The proposed revised basis for the MCPR SL aligns it with that of the DNBR SL used in PWRs, which provides a 95 percent probability at a 95 percent confidence level that no fuel rods will experience a DNB.

The NRC staff finds the proposed basis for the revised MCPR SL calculation is acceptable based on the discussion in SRP Section 4.4, SRP Acceptance Criterion 1. The remainder of this SE evaluates the methodology for determining the revised MCPR SL to determine if it provides the intended results and if the revised MCPR SL can be adequately determined in the core using various types of fuel. The SE also evaluates the proposed SL to determine if it continues to fulfil the necessary functions of an SL without unintended consequences and assesses if the proposed changes have been adequately implemented in the Susquehanna TS.

3.2 Revised MCPR SL Definition

Framatome defines ECPR as the ratio of the calculated critical power to the measured critical power, which is inverse of the definition in TSTF-564. As discussed in Section 1.2 of this SE, a critical power correlation's ECPR distribution quantifies the uncertainty associated with the correlation. Traveler TSTF-564, Revision 2, provides a definition for a limit that bounds 95 percent of a correlation's ECPR distribution at a 95 percent confidence level, according to the following formula:

$$MCPR_{95/95}(i) \quad \mu_i + K_i\sigma_i$$

Where μ_i is the correlation's mean ECPR, σ_i is the standard deviation of the correlation's ECPR distribution, and K_i is a statistical parameter chosen to provide "95% probability at 95% confidence (95/95) for the one-sided upper tolerance limit that depends on the number of samples (N_i) in the critical power database." This formula is commonly used to determine a 95/95 one-sided upper tolerance limit for a normal distribution, which is appropriate for the situation under consideration. The factor κ is generally attributed to D. B. Owen (Reference 7) and was also reported by M. G. Natrella (Reference 8), as referenced in traveler TSTF-564, Revision 2.

The licensee proposes variations from the TS changes described in TSTF-564. Susquehanna is transitioning from ATRIUM 10 to ATRIUM 11 fuel, neither of which are identified in Table 1 of traveler TSTF-564. As discussed in TSTF-564, other fuel vendors may determine the $MCPR_{95/95}$ for other fuel designs using the methodology described in the TSTF. The licensee in the LAR provided the required description of the deviations of the $MCPR_{95/95}$ for ATRIUM 10 and ATRIUM 11, which is based on the information contained in each fuel type's NRC-approved CPR correlation as stated in Susquehanna TS 5.6.5.b. The NRC staff finds that the difference does not affect the applicability of traveler TSTF-564 to the Susquehanna TS.

As discussed by Piepel and Cuta (Reference 9) for DNBR correlations, the acceptability of this approach is predicated on a variety of assumptions, including the assumptions that the correlation data comes from a common population and that the correlation's population is distributed normally. These assumptions are typically addressed generically when a critical power or critical heat flux correlation is reviewed by the NRC staff, who may apply penalties to the correlation to account for any issues identified. The traveler TSTF-564, Revision 2, states that such penalties applied during the NRC's review of the critical power correlation would be imposed on the mean or standard deviation used in the calculating the $MCPR_{95/95}$ (ML20132A260). These penalties would also continue to be imposed in the determination of the $MCPR_{99.9\%}$, along with any other penalties associated with the process of (or other inputs used in) determining the $MCPR_{99.9\%}$ (e.g., penalties applied to the $MCPR_{99.9\%}$ SL for operation in the Maximum Extended Load Limit Line Analysis Plus (MELLLA+) operating domain).

In the SE approving TSTF-564, Revision 2, the NRC staff found that the definition of the $MCPR_{95/95}$ will appropriately establish a 95/95 upper tolerance limit on the critical power correlation and that any issues in the underlying correlation will be addressed through penalties on the correlation mean and standard deviation, as necessary. Therefore, the NRC staff concludes that the method for determining $MCPR_{95/95}$, as proposed, can be used to establish acceptable fuel design limits in the Susquehanna TSs.

3.3 Determination of Revised MCPR SL for Mixed Cores

The Susquehanna Unit 1 reactor is currently fueled with Framatome ATRIUM 10 fuel bundles and ATRIUM 11 fuel bundles will be introduced during the spring 2022 refueling outage. The Susquehanna Unit 2 reactor is currently fueled with Framatome ATRIUM 10 and ATRIUM 11 fuel bundles.

Traveler TSTF-564, Revision 2, proposed that a core containing a variety of fuel types would evaluate the $MCPR_{95/95}$ for all of the fresh and once-burnt fuel in the core and apply the most

limiting (i.e., the largest) value of $MCPR_{95/95}$ for each of the applicable fuel types as the MCPR SL. As stated in Section 3.1 of traveler TSTF-564, Revision 2, this is because bundles that are twice-burnt or more at the beginning of the cycle have significant MCPR margin relative to the fresh and once-burnt fuel. The justification is that the MCPR for twice-burnt and greater fuel is far enough from the MCPR for the limiting bundle that its probability of boiling transition is very small compared to the limiting bundle and it can be neglected in determining the SL. Results of a study provided in the traveler indicate that this is the case even for fuel operated on short (12-month) reload cycles. As discussed in the traveler, twice-burnt or greater fuel bundles are included in the cycle-specific evaluation of the $MCPR_{99.9\%}$ and the MCPR OL. If a twice-burnt or greater fuel bundle is found to be limiting, it would be governed by the MCPR OL, which will always be more restrictive than both the $MCPR_{95/95}$ and the $MCPR_{99.9\%}$. The NRC staff found this justification to be appropriate and determined that it is acceptable to determine the $MCPR_{95/95}$ SL for the core based on the most limiting value of the $MCPR_{95/95}$ for the fresh and once-burnt fuel in the core.

In the LAR, the licensee proposed safety limit value in SL 2.1.1.2 as 1.05, which is the most limiting value for ATRIUM 10 and ATRIUM 11 fuel types. The licensee states that ATRIUM 11 is identified as the fuel type the SL is based upon since it is most limiting and will be the dominant fuel type at Susquehanna going forward. The NRC staff finds the justification provided for use of SL value for mixed core consistent with the guidance provided in traveler TSTF-564, Revision 2 and acceptable for the Susquehanna TS.

3.4 Relationship Between MCPR Safety and Operating Limits

As discussed in the traveler TSTF-564, Revision 2, the $MCPR_{99.9\%}$ is expected to always be greater (and thus more conservative) than the $MCPR_{95/95}$ for two reasons. Firstly, because the $MCPR_{99.9\%}$ includes uncertainties not factored into the $MCPR_{95/95}$, and secondly, because the 99.9 percent probability basis for determining the $MCPR_{99.9\%}$ is more conservative than the 95 percent probability at a 95 percent confidence level used in determining the $MCPR_{95/95}$. The level of conservatism in the $MCPR_{95/95}$ SL is appropriate because the lead fuel rod in the core (i.e., the limiting fuel rod with respect to MCPR) is used to evaluate whether any fuel rods in the core are susceptible to boiling transition as discussed in the traveler. This is consistent with evaluations performed for PWRs using a 95/95 upper tolerance limit on the correlation uncertainty as an SL.

Consistent with traveler TSTF-564, Revision 2, the MCPR OL defined in LCO 3.2.2 would continue to be evaluated using the $MCPR_{99.9\%}$ as an input. The $MCPR_{99.9\%}$ will continue to be evaluated in the same way as it is currently, using the whole core. The licensee is not proposing a change to LCO 3.2.2 and will continue to determine the MCPR operating limits for LCO 3.2.2 at Susquehanna.

Consistent with traveler TSTF-564, Revision 2, the licensee proposed to revise the COLR TS (Susquehanna TS 5.6.5) to require the cycle-specific value of the $MCPR_{99.9\%}$ to be included in the COLR. The methods supporting the inclusion of the $MCPR_{99.9\%}$ must also therefore be included in the list of COLR references contained in TS 5.6.5.b. The Susquehanna TS 5.6.5.b states that methods used to determine COLR shall be those reviewed and approved by the NRC and support that the uncertainties being removed from the MCPR SL are still included as part of the MCPR OL and will continue to appropriately inform plant operation.

Based on its review, the NRC staff, therefore, finds that the changes proposed by the licensee

will retain an adequate level of conservatism in the MCPR SL in TS 2.1.1.2 while appropriately ensuring that plant- and cycle-specific uncertainties will be retained in the MCPR OL. The NRC staff notes that the $MCPR_{95/95}$ represents a hard floor on the value of the $MCPR_{99.9\%}$, which should always be higher since it accounts for numerous uncertainties that are not included in the $MCPR_{95/95}$ (as discussed in Section 3.1 of traveler TSTF-564, Revision 2).

3.5 Implementation of the Revised MCPR SL in the TS

The licensee proposes to change the value of the SL in TS 2.1.1.2 for ATRIUM 10 and ATRIUM 11 to ≥ 1.05. The value reported in Susquehanna TS 2.1.1.2 will be the value calculated using Equation 1 from traveler TSTF 564, Revision 2, with the exception that ECPR used was the inverse of the quantity used in TSTF-564, Revision 2, as is discussed further below. The value was reported at a precision of two digits past the decimal point with the hundreds digit rounded up. This is consistent with the current practice for PWR DNBR SLs and is acceptable to the NRC staff.

Consistent with TSTF-564, Revision 2, the licensee also proposes to modify Susquehanna TS 5.6.5 to include the value of the $MCPR_{99.9\%}$ to ensure that the cycle-specific $MCPR_{99.9\%}$ value will continue to be determined for LCO 3.2.2 and reported in the COLR. The COLR, therefore, will continue to report the cycle-specific value of the MCPR OL contained in LCO 3.2.2, and Susquehanna TS 5.6.5.b will continue to use appropriate NRC-approved methodologies for determination of the $MCPR_{99.9\%}$ and the MCPR OL. Therefore, the NRC staff finds the proposed change to TS 5.6.5 to be acceptable.

In attachment 5 to the LAR, the licensee provides the details of the calculation of the $MCPR_{95/95}$ for ATRIUM 10 using the statistics from the SPCB/ATRIUM 10 CPR correlation database contained in Topical Report EMF-2209(P)(A) (Reference 10). The attachment also provides the details of the calculation of the $MCPR_{95/95}$ for ATRIUM 11 using the statistics from the ACE/ATRIUM 11 CPR correlation database contained in ANP-10335P-A, Revision 0 (Reference 11).

The licensee derived the SL consistent with the process described in traveler TSTF-564, Revision 2.The NRC staff, therefore, finds the proposed change to the SL in TS 2.1.1.2 is acceptable.

3.6 Deviations and Variations from TSTF-564

The NRC staff assessed the licensee's deviations from TSTF-564, Revision 2 for ATRIUM 10 and ATRIUM 11 and determined that they are consistent with the process described in traveler TSTF-564, Revision 2. In Attachment 5 to the LAR, the licensee notes that Framatome defines ECPR as the ratio of the calculated critical power to the measured critical power, which is the inverse of the TSTF-564 definition. The licensee stated that the form of the equation used by Framatome and the form presented in TSTF-564, Revision 2, are equal when the mean of the ECPR is equal to one. Section 4 of the Attachment 5 to the LAR shows that Mean ECPR for ATRIUM 10 is **[[ ]]** and ATRIUM 11 is **[[ ]]**. Since the licensee is using Design Limit based on the ATRIUM 11 fuel, which is more conservative, the NRC staff finds this acceptable.

However, the NRC staff notes that this is not the only condition necessary for these equations to be equivalent. In addition to requiring a mean ECPR of one, the NRC staff finds that two other conditions are necessary to achieve the same $MCPR_{95/95}$ using either the ECPR or its inverse: a normal distribution and a small standard deviation. The method described in TSTF-564, Revision 2, is predicated on the assumption of normality, as was discussed in Section 3.2 of this SE. Provided that the data is normally distributed and given the small standard deviations reported in Attachment 5 to the LAR, NRC staff calculations show that the $MCPR_{95/95}$ (which is rounded up at the hundredths digit) is unlikely to change whether the standard deviation of the ECPR or its inverse is used. The NRC staff finds that given the mean value of ECPR near one (i.e. within five ten-thousandths), the assumption of normality, and the relatively small values of standard deviation reported in Attachment 6 to the LAR, there is reasonable assurance that the licensee's definition of ECPR as the ratio of the calculated critical power to the measured critical power (i.e., the inverse of the TSTF-564 definition) will not change the resulting $MCPR_{95/95}$ and is therefore acceptable. The NRC staff, therefore, finds the proposed change to the SL in TS 2.1.1.2 is acceptable. The licensee derived the SL consistent with the process described in traveler TSTF-564, Revision 2.

The staff notes that Susquehanna TS have a different numbering than STS for the COLR; specifically, Susquehanna TS 5.6.5 versus STS 5.6.3. The NRC staff finds that the different TS numbering is acceptable because it does not substantively alter TS requirements.

The licensee states in the LAR that Susquehanna TS specify a different steam dome pressure value (575 psig) in the TS 2.1.1.1 and 2.1.1.2 rather than the value specified in STS (785 psig). The licensee states that this plant-specific value does not affect applicability of TSTF-564. This is not a change in the licensee dome pressure value and the licensee is noting variation from value noted in STS. Therefore, the NRC staff finds that the licensee's applicability statement is acceptable.

3.7 NRC Staff Conclusion

The NRC staff reviewed the licensee's proposed TS changes and determined that the proposed SL associated with TS 2.1.1.2 was calculated in a manner consistent with the process described in traveler TSTF-564, Revision 2, and was therefore acceptably modified to suit the revised definition of the MCPR SL. Under the new definition, the MCPR SL will continue to protect the fuel cladding against the uncontrolled release of radioactivity by preventing the onset of boiling transition, thereby fulfilling the requirements of 10 CFR 50.36(c)(1) for SLs. The MCPR OL in LCO 3.2.2 remains unchanged and will continue to meet the requirements of 10 CFR 50.36(c)(2) and GDC 10, by ensuring that no fuel damage results during normal operation and AOOs. The NRC staff determined that the proposed changes to TS 5.6.5 are acceptable; upon adoption of the revised MCPR SL, the COLR will be required to contain the $MCPR_{99.9\%}$, supporting the determination of the MCPR OL using current methodologies.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Commonwealth of Pennsylvania official was notified of the proposed issuance of the amendments on April 27, 2022. The Commonwealth official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendments change a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendments involve no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration, and there has been no public comment on such finding (87 FR 19719). Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

6.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

7.0 REFERENCES

1. Letter from Brian R. Moore, Global Nuclear Fuel, to U.S. NRC, “Information Supporting TSTF-564 Safety Limit Minimum Critical Power Ratio,” June 16, 2017 (ML17167A108).

2. Letter from James A. Gresham, Westinghouse Electric Company, to U.S. NRC, “Submittal of 'Calculation for Technical Specification SLM CPR Values Applying to Westinghouse Fuel in Support of TSTF-564',” May 16, 2017 (ML17142A319).

3. U.S. Nuclear Regulatory Commission, “Standard Technical Specifications, General Electric Plants BWR/4,” NUREG-1433, Volume 1, “Specifications,” and Volume 2 “Bases,” Revision 4.0, April 2012 (ML12104A192 and ML12104A193).

4. U.S. Nuclear Regulatory Commission, “Standard Technical Specifications, General Electric Plants BWR/6,” NUREG-1434, Volume 1, “Specifications,” and Volume “Bases,” Revision 4.0, April 2012 (ML12104A195 and ML12104A196). (Does not apply to Susquehanna – a BWR/4 plant).

5. U.S. Nuclear Regulatory Commission, “Standard Technical Specifications, Babcock and Wilcox Plants,” NUREG-1430, Volume 1, Specifications,” and Volume 2, “Bases,” Revision 5.0, September 2021 (ML21272A363 and ML21272A370).

   U.S. Nuclear Regulatory Commission, “Standard Technical Specifications, Westinghouse Plants,” NUREG-1431, Volume 1, “Specifications,” and Volume 2, “Bases,” Revision 5.0, September 2021 (ML21259A155 and ML21259A159).

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6. U.S. Nuclear Regulatory Commission, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [Light-Water Reactor] Edition,” NUREG-0800, Section 4.4, “Thermal and Hydraulic Design, Revision 2, March 2007 (ML070550060).

7. D. B. Owen, “Factors for One-Sided Tolerance Limits and for Variables Sampling Plans,” Sandia Corporation, SCR-607, March 1963 (ML14031A495).

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9. G. F. Piepel and J. M. Cuta, “Statistical Concepts and Techniques for Developing, Evaluating, and Validating CHF Models and Corresponding Fuel Design Limits,” SKI Technical Report, 93:46, 1993.

10. AREVA Topical Report EMF-2209(P)(A), “SPCB Critical Power Correlation.”

11. Framatome Topical Report ANP-10335P-A, “ACE/ATRIUM-11 Critical Power Correlation.”

Principal Contributor(s): SBhatt, NRR/DSS/SNSB

Date: July 15, 2022

SUBJECT: SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2 - ISSUANCE OF AMENDMENT NOS. 281 AND 264 RE: REVISE TECHNICAL SPECIFICATIONS TO ADOPT TSTF-564, "SAFETY LIMIT MCPR" (EPID L-2022-LLA-0005) DATED JULY 15, 2022

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