Analysis on the LORHR Event during Refueling Operation

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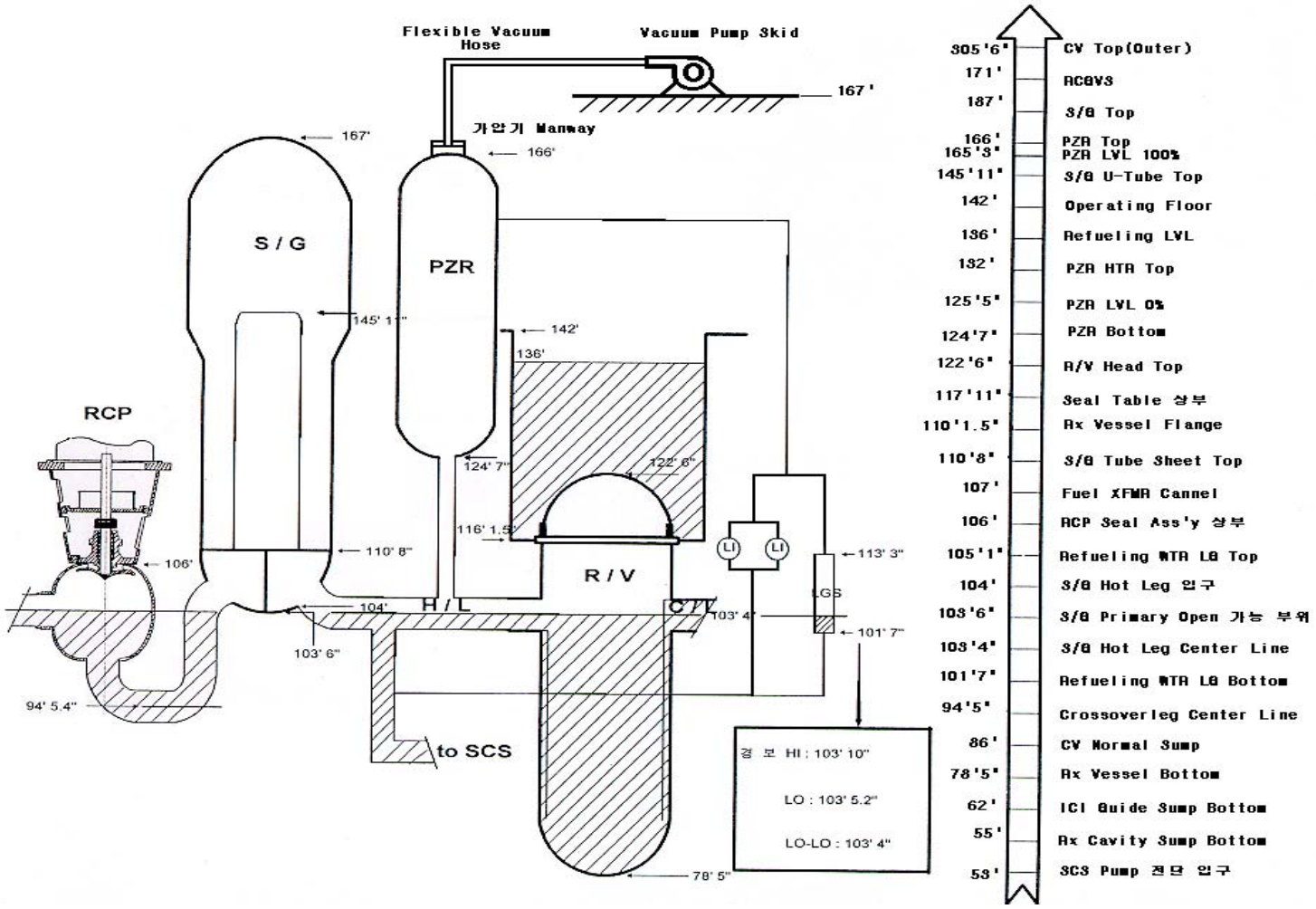
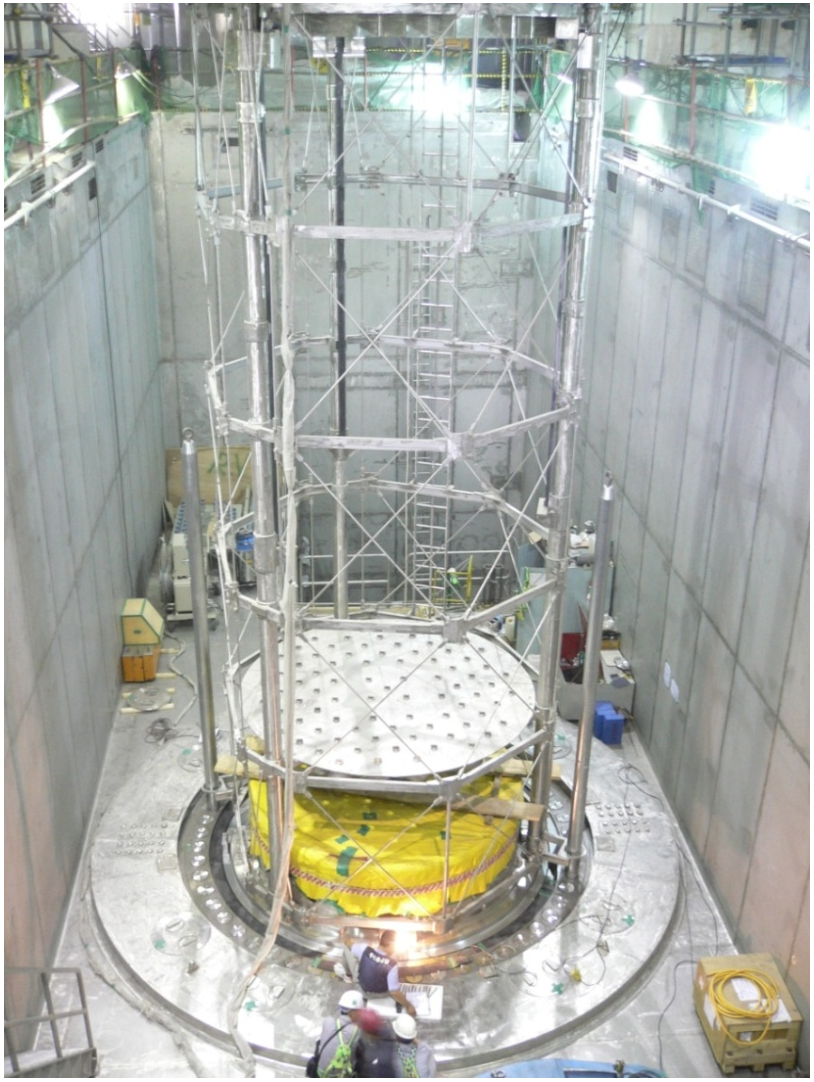
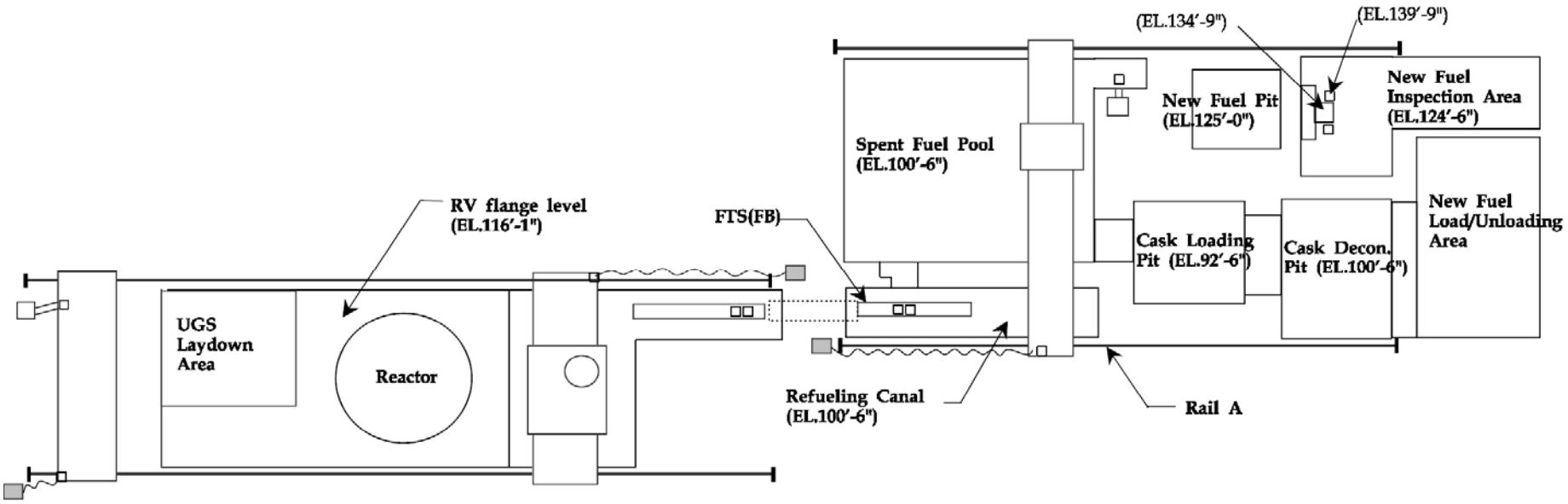
Introduction (POS)



Introduction (POS)



Introduction (POS)



Introduction

Loss of Residual Heat Removal Event (LORHR)

- During plant overhaul, shutdown cooling system is operating to remove core decay heat
- Assume that the decay heat removal function is lost

Introduction

LORHR Analysis of Refueling Operation

- **Background :**
  - **Only SFP TH analysis has been performed representing Refueling Period to support LPSD PSA Model**
  - **The TH analysis results show sufficient time margin until core is damaged**
  - **However, Absence of the TH analysis results about RFP during Refueling Period**

Introduction

LORHR Analysis of Refueling Operation

- **Purpose :**
  - **Provide TH analysis results about RFP during Refueling Period**
  - **Predict the general behaviors of plant parameters for the LORHR event**
  - **Investigate about core boiling, core uncovery and core damage time without an operator mitigating action**
- **Reference Plant :**
  - **OPR1000 : Hanbit Nuclear Power Plant Units 3&4 (HBN 3&4)**

Analysis Method

Case Analyzed

- Realistic and Best Estimate Analysis Method (KINS/RG-N16.03 and KINS/RG-N16.07)
- Computer Code : RELAP5/MOD3.3 Patch 4
- Operating Condition : RFP is filled up to 140 ft
- Cases : LORHR event

Analysis Method

Major Assumptions and Initial Condition (1)

- Initial event : LORHR
- RV closure head : taken off
- RV internal structures : in place
- Fuel : not unloaded (all fuels are rested in the core)
- Decay Heat Curve : ANS5.1-1979 + 2σ
- Time after shutdown : 95.7 hours (Decay Heat Curve)

Analysis Method

Major Assumptions and Initial Condition (2)

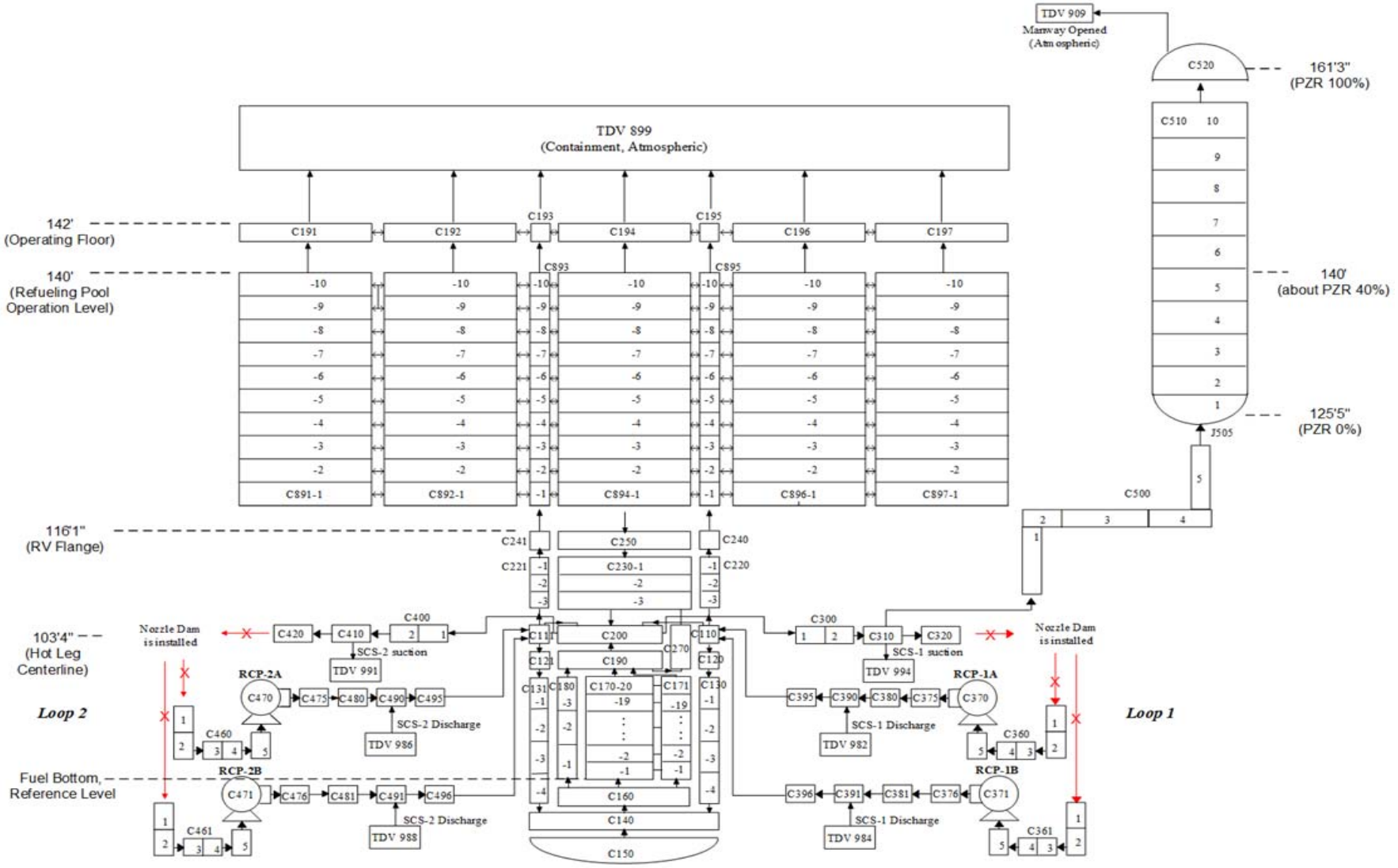
- Nozzle dam : installed
- PZR manway : opened
- RFP volume : only above the RV flange
- Other initial conditions : Refueling Operation Condition (Operating Procedures of HBN 3&4)
- Operator Action : Not performed

Analysis Method

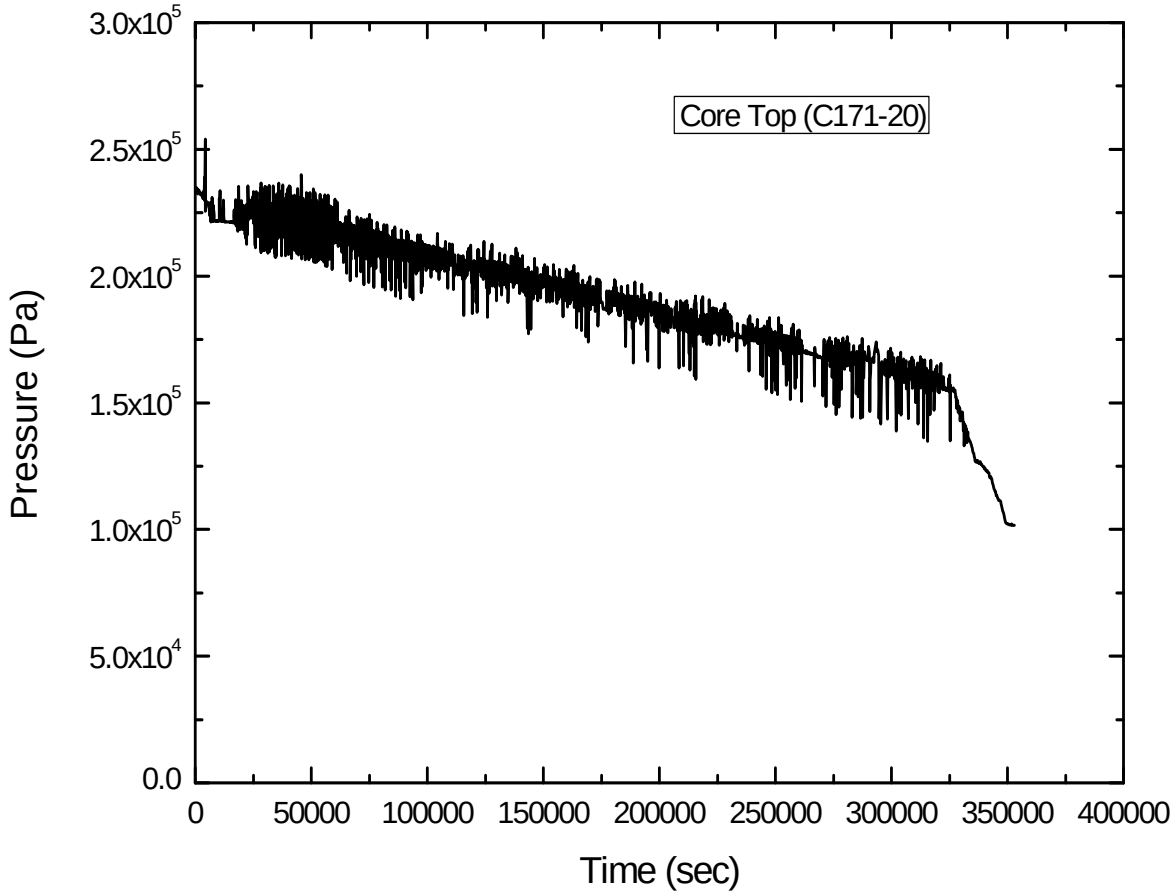
Major Assumptions and Initial Condition (3)

- Core boiling : instant void in the core region
- Core uncovery : the top of the core
- Core damage : 10CFR50.46
- RFP boiling : saturated at the RFP surface
- RFP emtpy : the RFP bottom

Analysis Method (Nodalization)

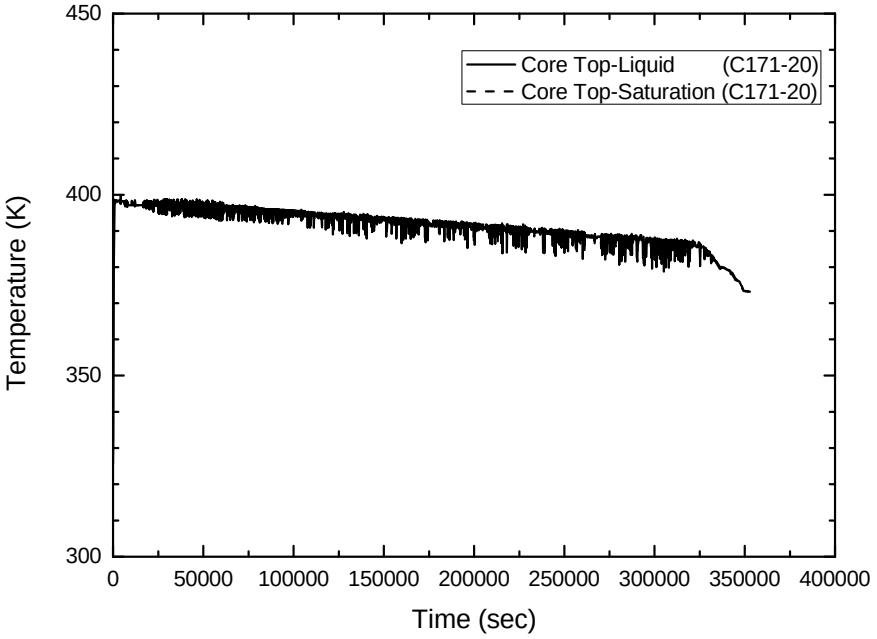


Analysis Results

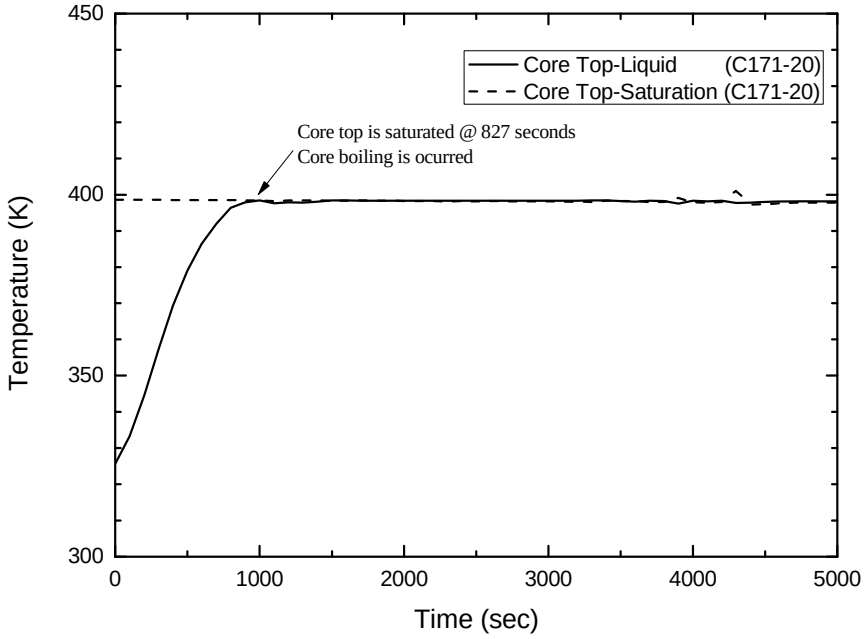


[Core Top Pressure]

Analysis Results

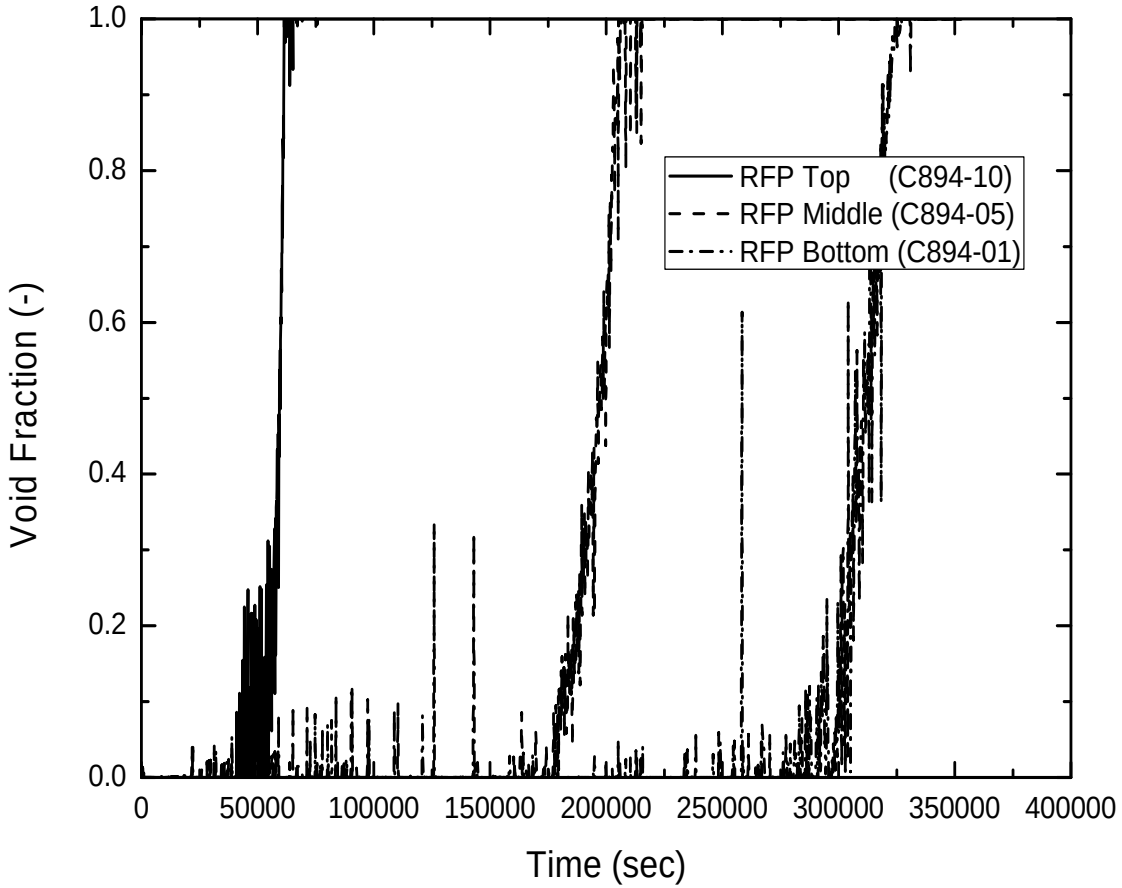


[Core Top Temperature – long term]



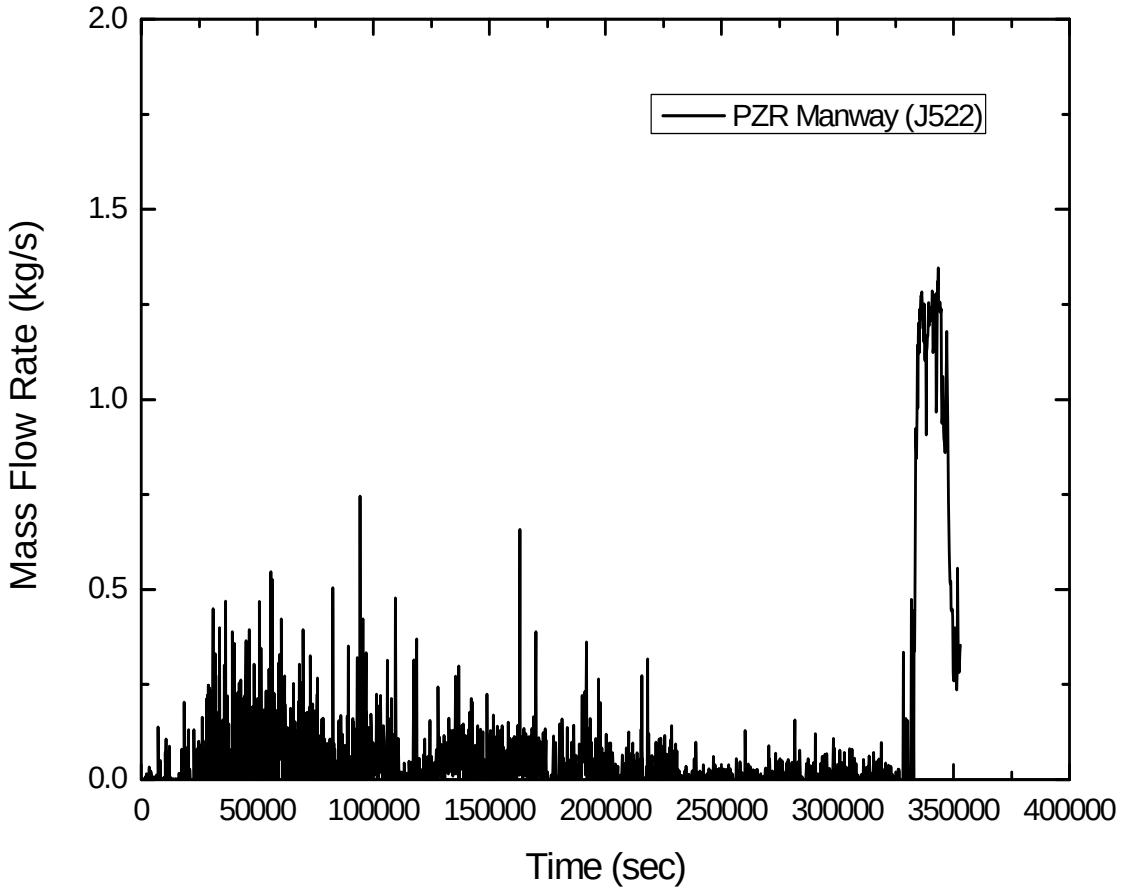
[Core Top Temperature – short term]

Analysis Results



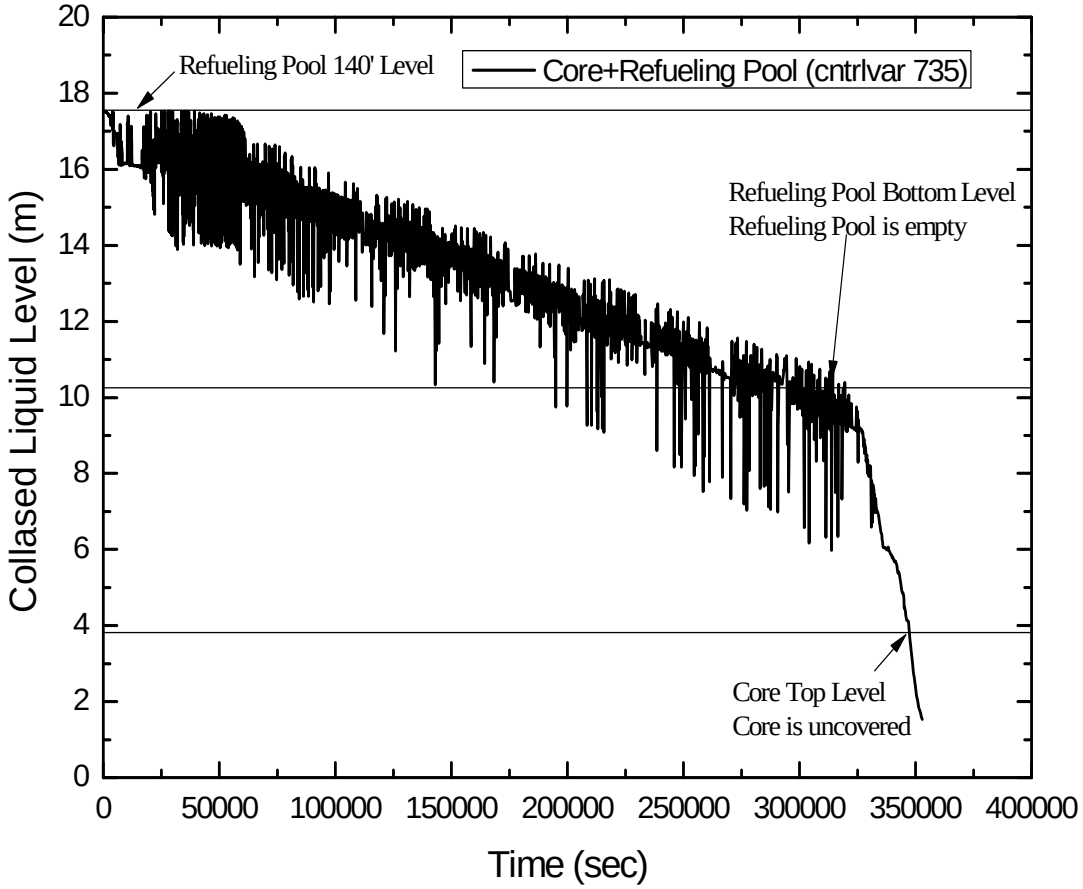
[Refueling Pool Void Fraction]

Analysis Results



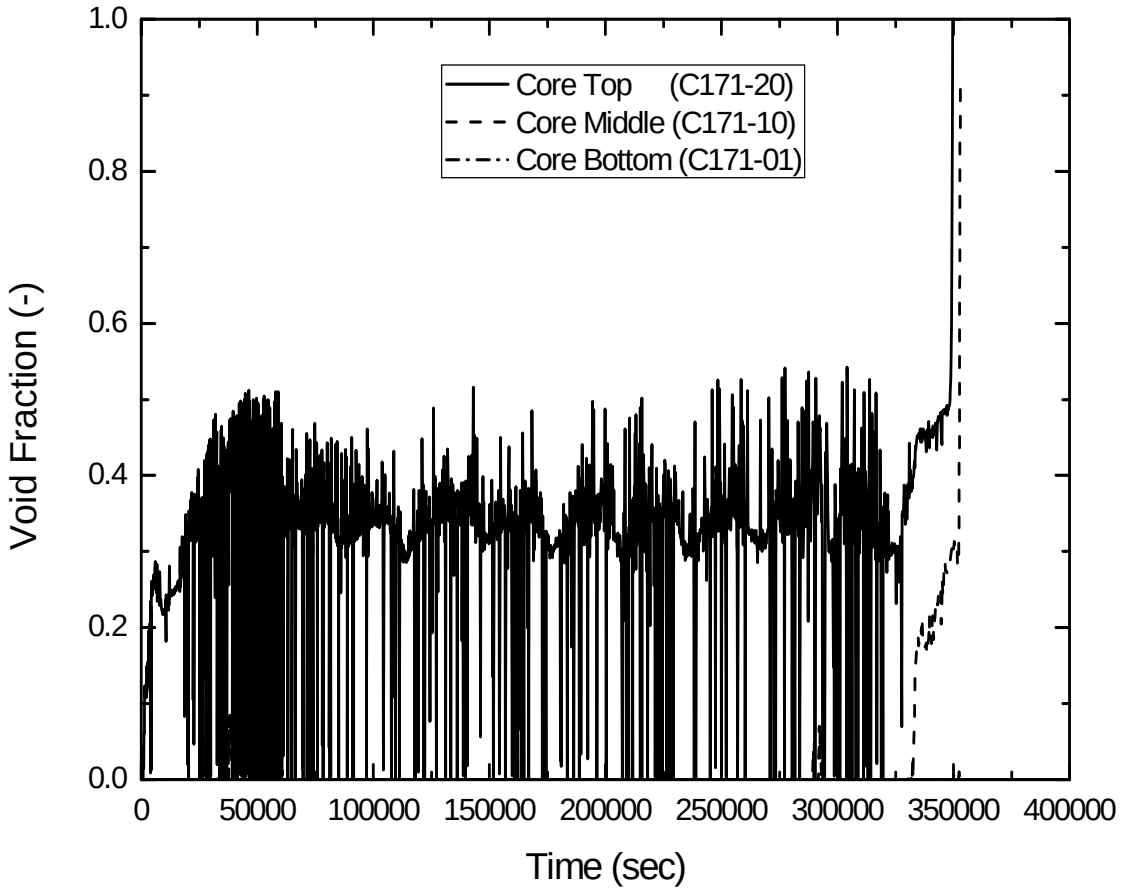
[Mass Flow Rate Through the Pressurizer Manway]

Analysis Results



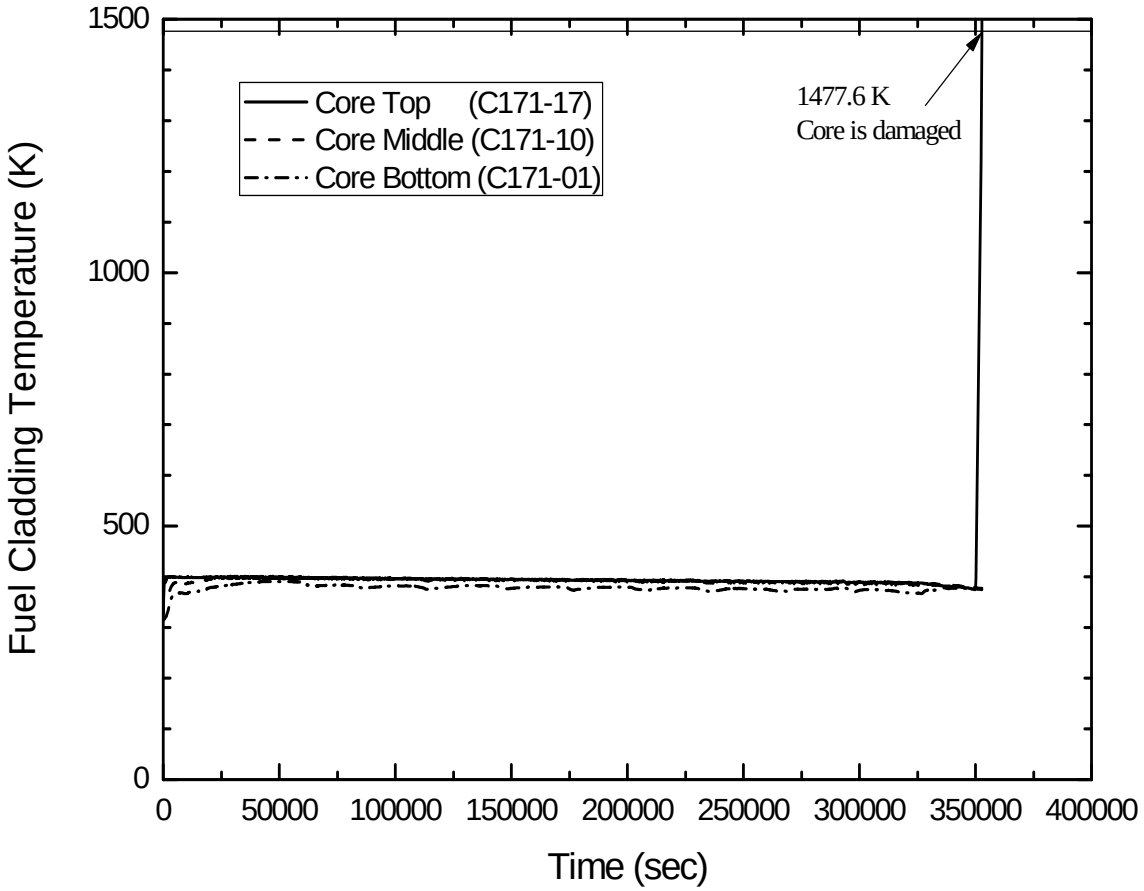
[Reactor Vessel and Refueling Pool Collapsed Level]

Analysis Results



[Core Void Fraction]

Analysis Results



[Fuel Cladding Temperature]

Conclusion

[Summarized LORHR Analysis Results]

Decay Heat	95.7 hours after reactor shutdown
Primary Initial Condition	Pressure : Atmospheric Pressure, Cold Leg Temperature : 40 ℃ (313.15 K) PZR manway : opened
	Initial Elevation : Refueling Operation Level (140')
Secondary Initial Condition	N/A (Nozzle dam is installed)
Initial Event	t=0 sec, LORHR
Core Boiling Time	827 sec (0.23 hr)
Refueling Pool Boiling Time	40900 sec (11.36 hr)
Refueling Pool Empty Time	321000 sec (89.17 hr)
Core Uncovery Time	347348 sec (96.49 hr)
Core Damage Time	352676 sec (97.97 hr)

Conclusion : Sufficient time is expected for an operator action to mitigate LORHR event during refueling operation.