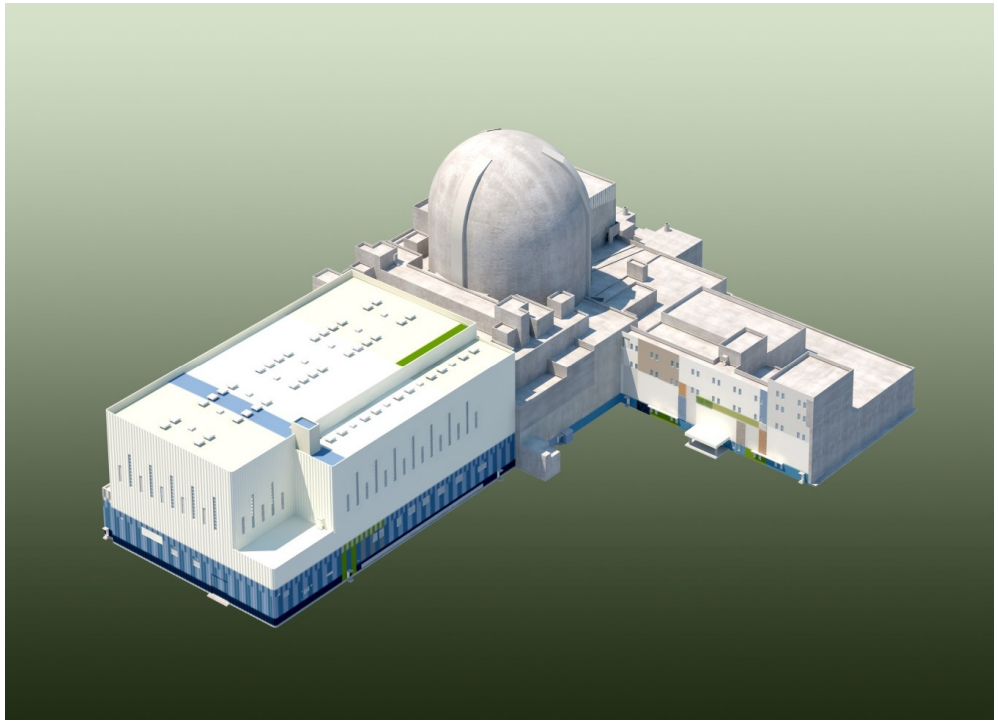
APR1400 Piping Design (Hazard Analysis)
- High Energy Line Break Analysis -



KEPCO/KHNP

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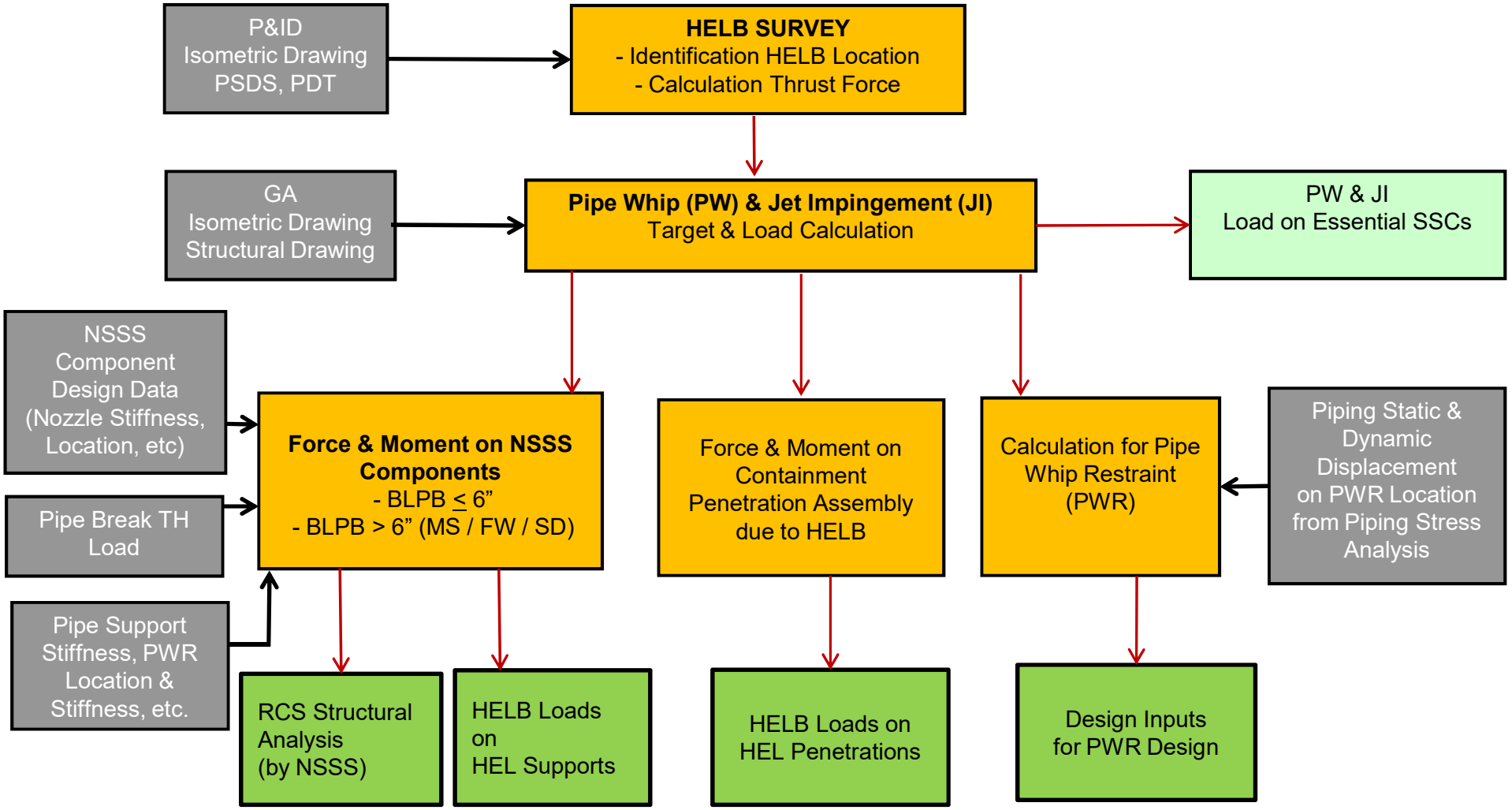
Introduction

- **Regulatory requirements of high energy line break analysis (HELBA)**
  - 10 CFR 50 Appendix. A, GDC 4
  - US-NRC SRP 3.6.1, 3,6,2, and 3,6.3
  - US-NRC BTP 3-3 and 3-4

HELBA approach for APR1400



HELBA approach for APR1400

- **High-energy line break analysis**
  - ➢ High-energy and moderate-energy piping systems
  - ➢ Methodologies for HELB analyses
    - Rupture types (breaks or cracks), rupture locations (terminal end, intermediate, or crack)
    - Dynamic effects (thrust force, force and moments, jet impingement, pipe whip, BLPB load)
- **Leak-before-break analysis**
  - ➢ Piping systems for LBB application
    - Reactor coolant loop and pressurizer surge line
    - Direct vessel injection and shutdown cooling line
  - ➢ Methodology for LBB analysis
    - Piping Evaluation Diagram (PED) was developed as acceptance criteria for LBB

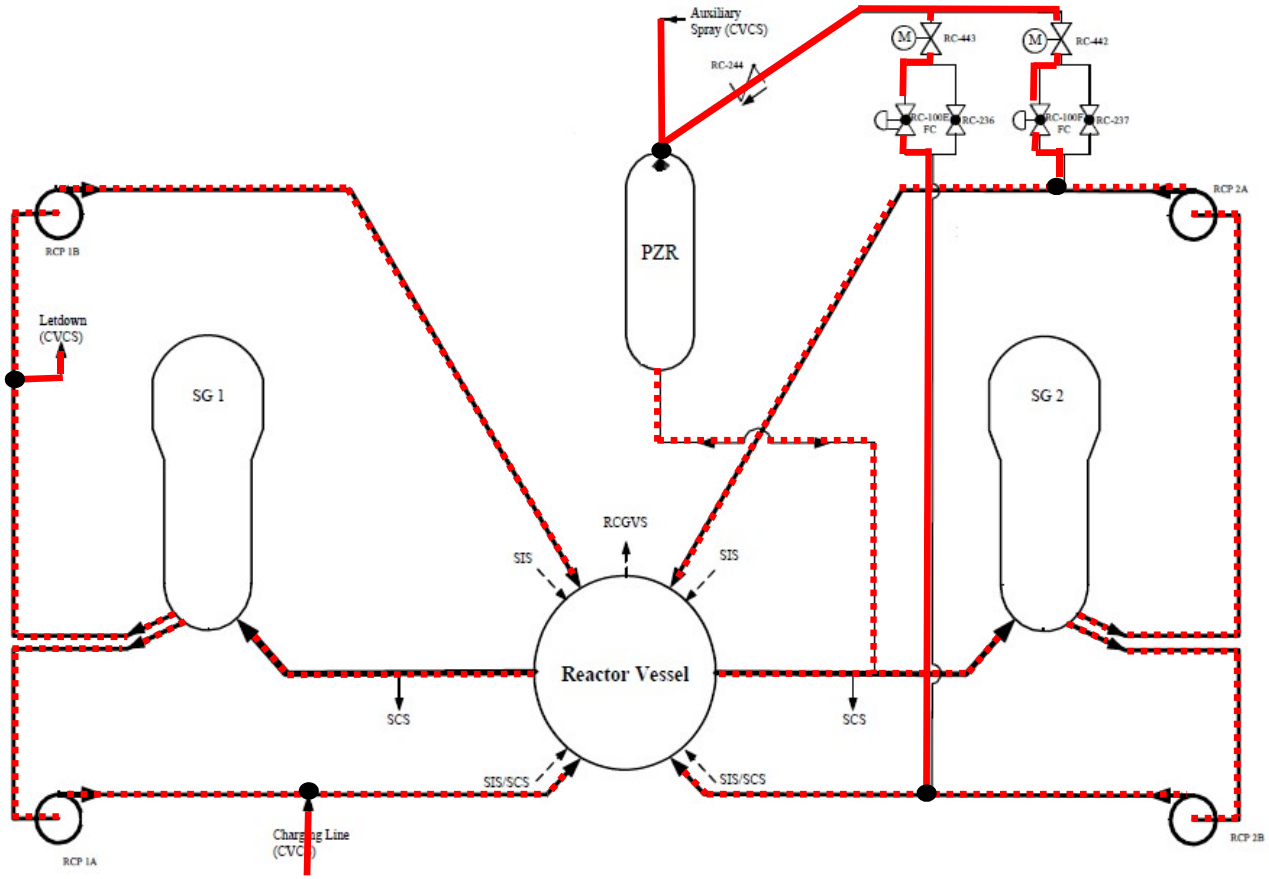
HELBA approach for APR1400

- **KHNP incorporated a graded approach to HELBA for high safety significant piping as follows:**
  - All Class 1 piping
  - Class 2&3 piping inside containment
  - MS & FW lines to the first 6-way rigid restraint beyond the isolation valves
  - Technical report was submitted for NRC review.
    (Summary report of high-energy piping rupture analysis, APR1400-E-N-NR-14004-P, Rev.0)

Location of high-energy line break

- **Identification of break location for high-energy line**
  - Terminal end break location
  - Intermediate break location of the piping system taken to the graded approach as a result of stress analysis and cumulative usage factor analysis.
  - Criteria for selection of break location in piping systems meets the US NRC BTP 3-4.

Location of high-energy line break



High-energy piping

LBB applied piping

Break Location

Evaluation of pipe whip analysis

- **Pipe whip analysis**
  - Calculation of blowdown thrust force is based on simplified methods described in ANSI/ANS 58.2-1988.
- **Protection of essential target**
  - Structure is designed to withstand pipe whip impact load.
    - Pressurizer compartment wall
    - RCP concrete pedestal and floor
    - Secondary shield wall, etc.
  - Pipe whip restraint
    - PWR installation to protect containment wall due to main steam line break
    - PWR installation to protect Pzr. spray piping due to feedwater line break

Background of jet impingement

- **SRP 3.6.2 Rev. 2 issued March 2007 identified concerns with the modeling of jet impingement forces in ANSI 58.2-1998.**
  - The ANSI/ANS 58.2 standard has been accepted by the NRC. However, based on recent comments from the Advisory Committee on Reactor Safeguards (ACRS) (V. Ransom and G. Wallis), it appears that some assumptions related to jet expansion modeling in the ANSI/ANS 58.2 standard may lead to non-conservative assessments of the jet impingement loads of postulated pipe breaks on neighboring SSCs.
- **Key issues from mPower DSRS Section 3.6.2 Appendix A are as follows:**
  - Blast Wave Effect
  - Jet Plume Expansion and Zone of Influence (ZOI)
  - Distribution of Pressure within the Jet Plume
  - Jet Dynamic Loading including Potential Feedback Amplification and Resonance effects

Evaluation methodology for jet impingement

- KHNP evaluation methodology for blast wave and jet plume distribution

TS

Evaluation methodology for jet impingement

- KHNP evaluation methodology for jet plume expansion and ZOI

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Evaluation methodology for jet impingement

- **KHNP evaluation methodology for distribution of pressure within the jet plume**

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- **KHNP evaluation methodology for feedback amplification resonance effects**

  - Evaluation methodology for feedback amplification resonance effect is under developing.

Summary

- **KHNP expects that KHNP evaluation methodology meets the US-NRC requirement.**
- **SSCs important to safety are designed to withstand dynamic effects associated with postulated pipe rupture.**
- **KHNP evaluation address the non-conservative issues of jet impingement loads.**
- **Technical reports were submitted for NRC review.**
  - Summary report of high-energy piping rupture analysis, APR1400-E-N-NR-14004-P, Rev.0
  - Evaluation methodology of jet impingement loads on SSCs, APR1400-E-N-NR-14003-P, Rev.0