THE APPLICATION OF THE LBB CONCEPT AT TEMELIN NPP

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The LBB application history

- **NPP Jaslovské Bohunice**
  - **2 units of WWER 440/V-230**
  - **2 units of WWER 440/V-213**
- **NPP Dukovany**
  - **4 units of WWER 440/V-213**

- **NPP Temelín**
  - 2 units of WWER 1000/V-320
- **NPP Mochovce**
  - 4 units of WWER 440/V-213
- **NPP Medzamor**
  - 1 units of WWER 440/V-230
- **NPP Kola**
  - 2 units of WWER 440/V-230
- **NPP Novovoronezh**
  - 2 units of WWER 440/V-230

The LBB concept legal history in the territory of Czechoslovakia

- **"Requirements for compiling and contents of safety reports and their amendments:**
  Leak before break analysis procedure.
  Leak detection system from reactor pressure cooling circuit."
  ČSKAE 1/1991

This document was accepted by Regulatory Bodies of the Czech and Slovak republic.

The SONS issued:
"Requirement on reactor primary circuit leak detection system for the purpose of the LBB application"
SONS 1998

The LBB application benefits

- **The removal of pipe whips restraints and jet impingement shields.**
- **The removal of snubbers on steam generators and reactor coolant pumps whose only design function is the mitigation of thrust loads associated with the pipe break.**
- **Reduction of cost**
- **Increase of inspection effectiveness**

Reduction of staff dose

LBB principle

The basic idea of the LBB is to exclude any potential for pipe break and then prove that the critical crack - which occurred in spite of the exclusion of all detrimental mechanisms - will be safely detectable within 1 hour. The early detection enables to shut down the reactor

The LBB evaluation procedure

- **An evaluation over the entire plant life:**
  - **Water hammer**
  - **Creep damage**
  - **Erosion, corrosion**
  - **Fatigue**
  - **Environmental conditions**

- **Material data collection respecting all types of materials and welding procedures**

- **Piping stress evaluation both for NOC and SSE**
- **Identification of the critical section: Sections with less favourable combination of stress and material properties**
- **Evaluation of detectable crack length**
- **Evaluation of critical crack length**

Detection systems

- **Three independent detection systems**
- **Response time one hour**

Sensitivity better than 3.8 liters

Loading conditions

- **Detectable crack length evaluated under NOC for each critical section**
- **Critical crack length evaluated under NOC + SSE conditions for each critical section**
- **Loading component absolute values summation is used**

Safety margins

- **The margin of 10 is prescribed on leak detection sensitivity.**
- **The ratio limit-load critical crack length / detectable crack length ≥ 2.**
- **Detectable crack length should remain stable under NOC + SSE conditions**

Crack stability evaluation method

- **Limit-load approach**

  - F^{ll} = critical crack size / leakage crack size
  $F^{ll} \geq 2$

- **EPFM approach**

  - F^{EPFM} = instability moment / superimp. mom.
  $F^{EPFM} \geq 1$

Method references

- **Assessment of the Integrity of Structures Containing Defects-R6, I. Milne, R. A. Ainsworth, A. R. Dowling, A. T. Stuart, CEGB 1987**
- **NRC Leak-Before-Break (LBB.NRC) Analysis Method for Circumferentially Through wall Cracked Pipes Under Axial Plus Bending Loads, NUREG/CR-4572**
- **Assessment of Large Scale Pipe Tests by Fracture Mechanics, E. Ros, K.-Herter, P. Julisch, G. Bartholomé, and G. Senski**
- **Approximation Procedures with Regard to Leak-Before-Break, Nuclear Engineering and Design 112 (1989), p.183-195**

Method references (continuing)

- **Ausschluβ des Doppelendigen Rundabrisses der Hauptkühlmittelleitung, 7. MPA-Seminar, 9.10.1981, G. Bartholomé, R. Steinbuch, R. Welein**

- **A. Zahoor: Ductile Fracture Handbook, vol. 1, EPRI 1989**

NPP Temelín main features

- **WWER 1000/320**
- **Four MCL**
- **No isolation valves on MCL**
- **Cladded ferritic and austenitic steels**

Leak detection systems

- **LEMOP**

- **- Leaking coolant acoustic effects monitoring**

  - Quantification, localization

- **HUMOS**

  - Air humidity inside the container

  - Quantification, partial localization

- **Radioactivity monitoring system**
  - **- Depends on time from startup**
  - **- Auxiliary system, difficult quantification**

- **Mass balance**
  - **- Long term evaluation**
  - **- Global information**

NPP Temelín – Evaluated piping

- **Main circulation piping, ∅ 995 (cladded ferrite)**
- **Pressurizer surge line, ∅ 426 (cladded ferrite)**
- **High pressure ECCS, ∅ 159 (austenite)**
  - **TQ 13, TQ 23, TQ 33**
- **Low pressure ECCS, ∅ 351 (cladded ferrite and austenite)**
  - **TQ 12, TQ 22, TQ 32**
- **Accumulator lines**
  - **YT 11, YT 12, YT 13, YT 14**

- **Residual heat removal system, ∅ 351 (cladded ferrite and austenite)**

  - TQ 40

- **Purification line - ∅ 133 (austenite)**

  - TC 10, TC 20, TC 30, TC 40

Evaluation results

- **Piping meeting the LBB requirements**
  - **MCP**
  - **Surge line**
  - **Low pressure ECCS**
  - **Accumulator lines**
  - **Residual heat removal systém**

- **Piping not meeting the LBB requirements**
  - **Purification line**
  - **High pressure ECCS**

Accumulator lines

- **Primary conditions to the isolation valve**
- **Behind the isolation valve**
  - **- Pressure 6 MPa**
    - *** Nitrogen in accumulator tank**
  - **- Temperature 60^{o}C**
- **Detection systems behind the isolation valve**
  - **- Boric acid level in the accumulator tank**
  - **- Nitrogen pressure**
  - **- Acoustic emission**

Evaluation of postulated pipe break effects

- ¨HP ECCS & Purification line
- Modified methodology of SRP 3.6.2.
- "Division principle"
  - Redundancy 3×100% of safety systems
  - Partial isolation of each train in a room
    - * Trains coincidence identification
    - * Rupture effects transfer evaluation

- **The definition of a sub room**

  - The sub room is a room or part of a room isolated in such a way that the effects of pipe break, occurred in the sub room, remain localized in the sub room

Evaluation results

- **The pipe lines**
  - **TC 10, TC 20, TC 30, TC 40**
  - **TQ 13, TQ 23, TQ 33**

- **can break on any location of pipe runs resulting in destruction of all equipment located in the sub room, without effect on safe reactor shutdown**