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*G. P. Moner (GRS) – G. Lerchl*

# STRUCTURAL MECHANICAL AND THERMAL HYDRAULIC ASPECTS ON THE BEHAVIOUR OF CRACK LIKE LEAKS IN PIPING

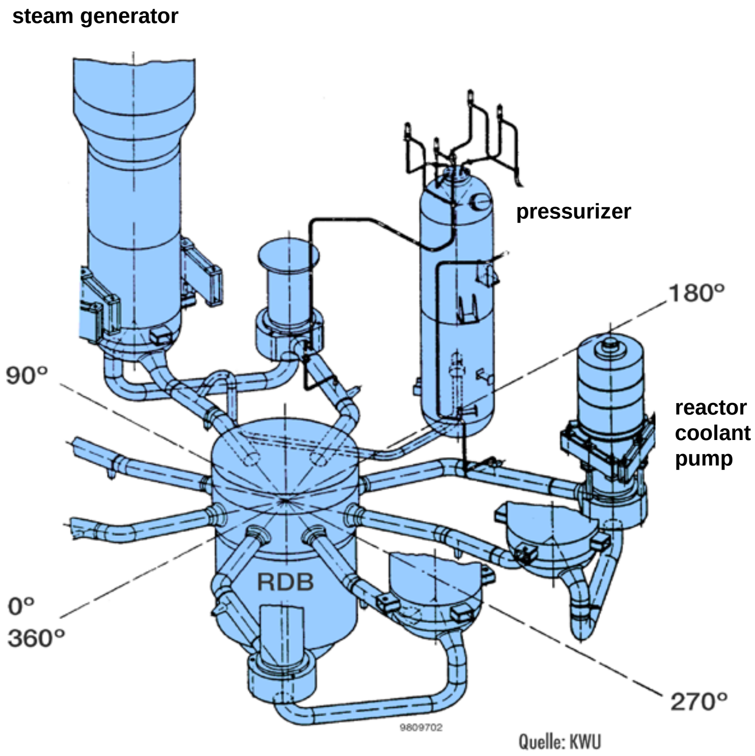
# OUTLINE

- Introduction
- Basics for leak rate calculation
- Investigations on leak rate calculation
- Summary and outlook

# INTRODUCTION

- Safety relevance of investigations of leak behaviour in primary circuit components
- Assessment of break preclusion of a pipe (KTA 3206)
  - Leak-before-Break assessment
  - Leakrate calculation with respect of measuring range of leak detection system

Primary circuit of German PWR




**Application case**

To ensure leak detection calculated leak rate has to underestimate the real leak rate with respect to the measuring range of a leak detection system

# INTRODUCTION

- Objectives of research work
  - Investigations on the accuracy of leak rate calculation by
    - simplified analysis methods
    - complex analysis methods
  - Validation of analysis methods on leak rate experiments

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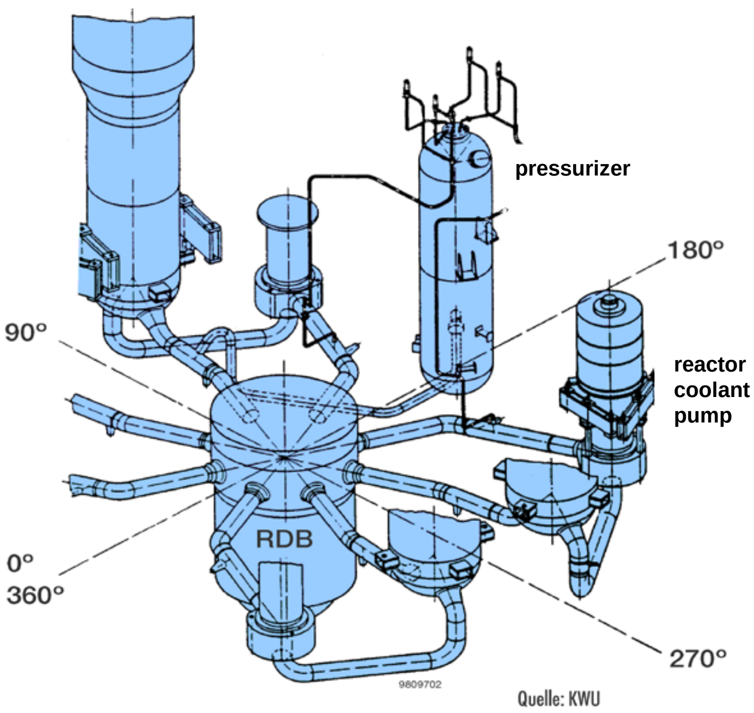
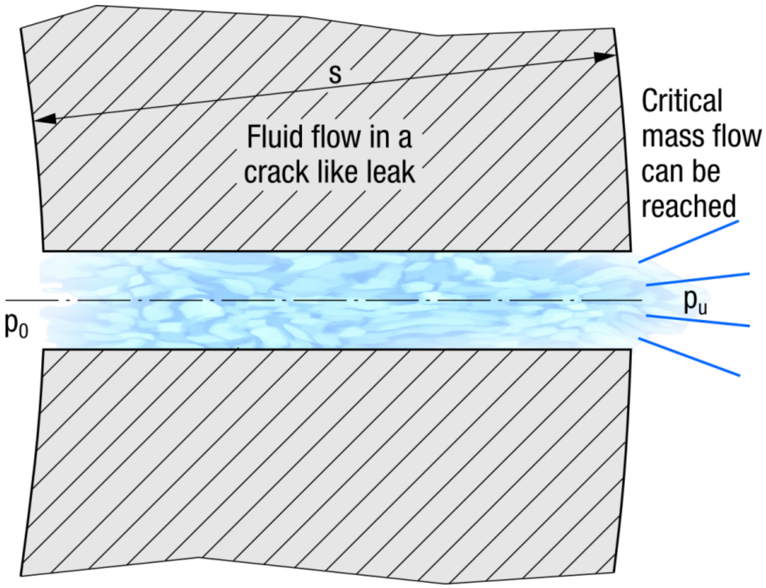


# BASICS OF LEAK RATE CALCULATION

- Various calculation methods depending on the thermal hydraulic conditions of the fluid flowing through the leak
- A simplified method for critical discharge of **cold water**
  - mass flow (leak rate / leak area) due to *Bernoulli-equation*

$$G = \sqrt{\frac{2 \cdot \left[p_0 - p_U\right] \cdot \rho_0}{1 + \zeta}}$$




$p_U$ – ambient pressure

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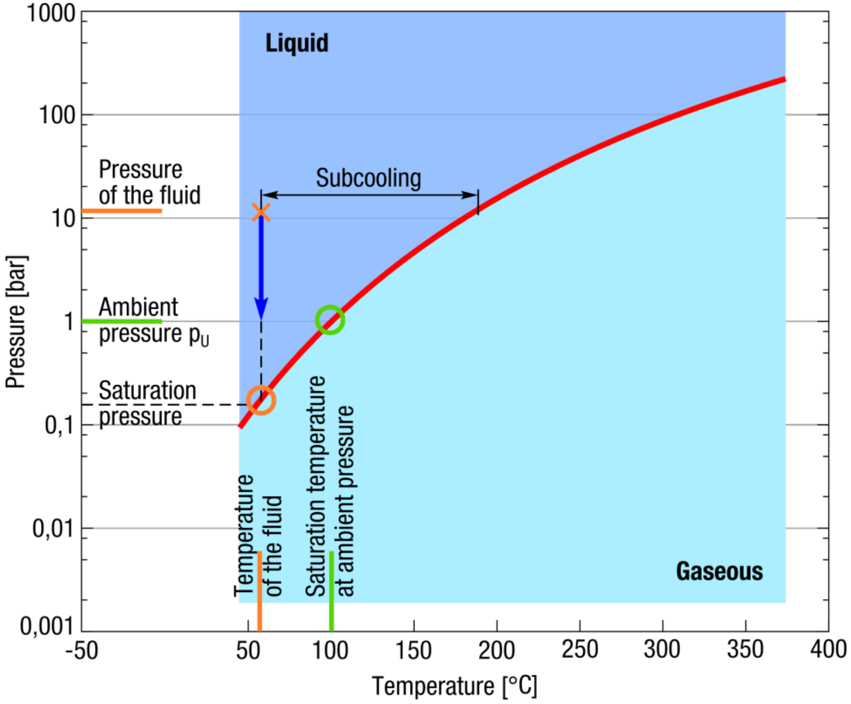


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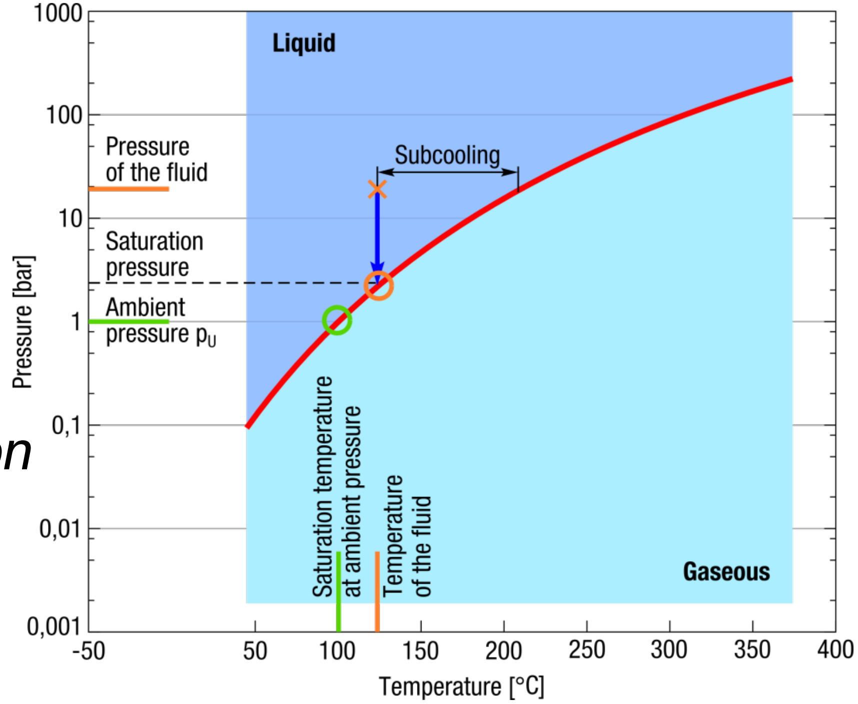


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$p_S(T_0)$ – saturation pressure at stagnation temperature

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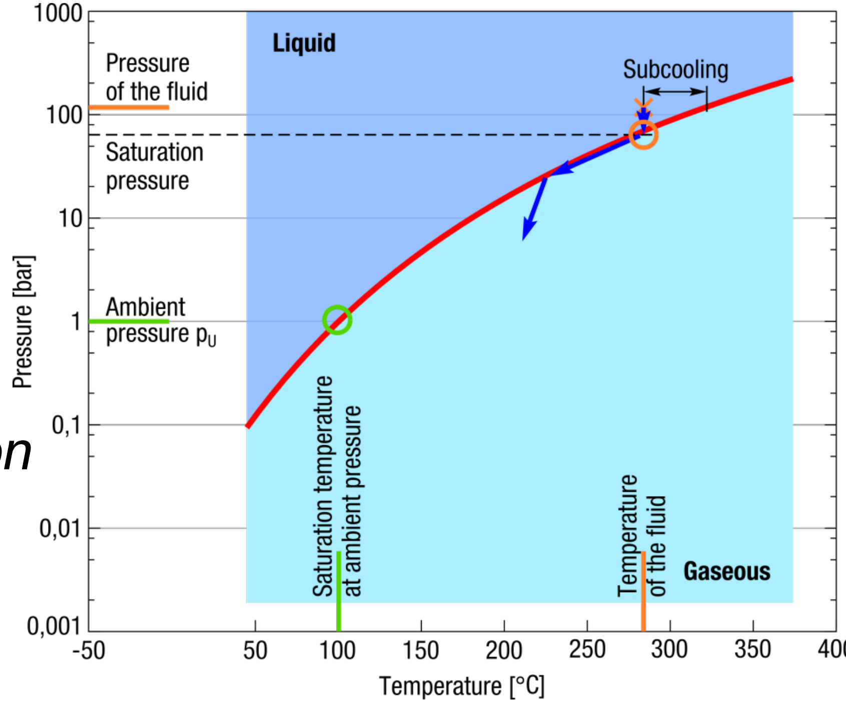


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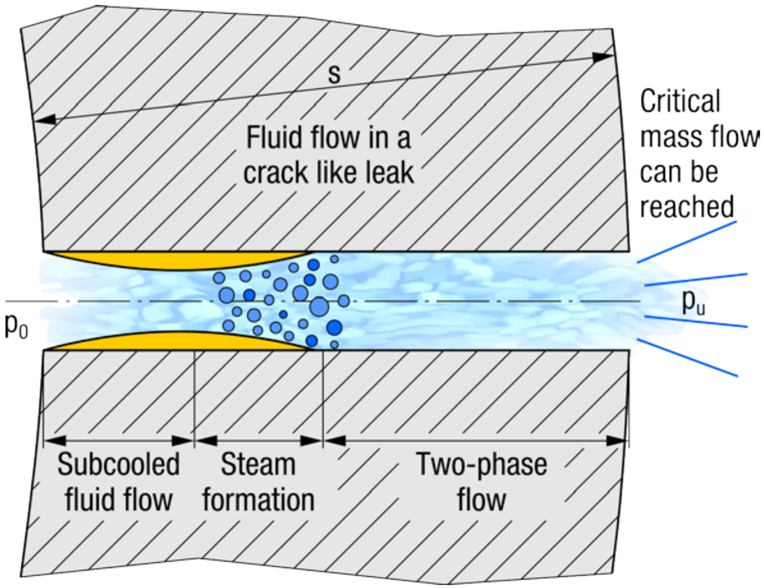


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# BASICS OF LEAK RATE CALCULATION

- Flow resistance

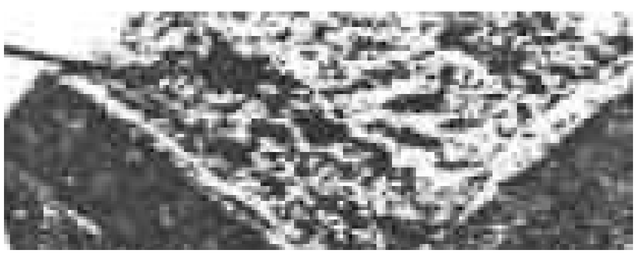
$$\zeta = \zeta_{in} + \lambda \cdot \frac{t}{d_h} + \zeta_{out}$$

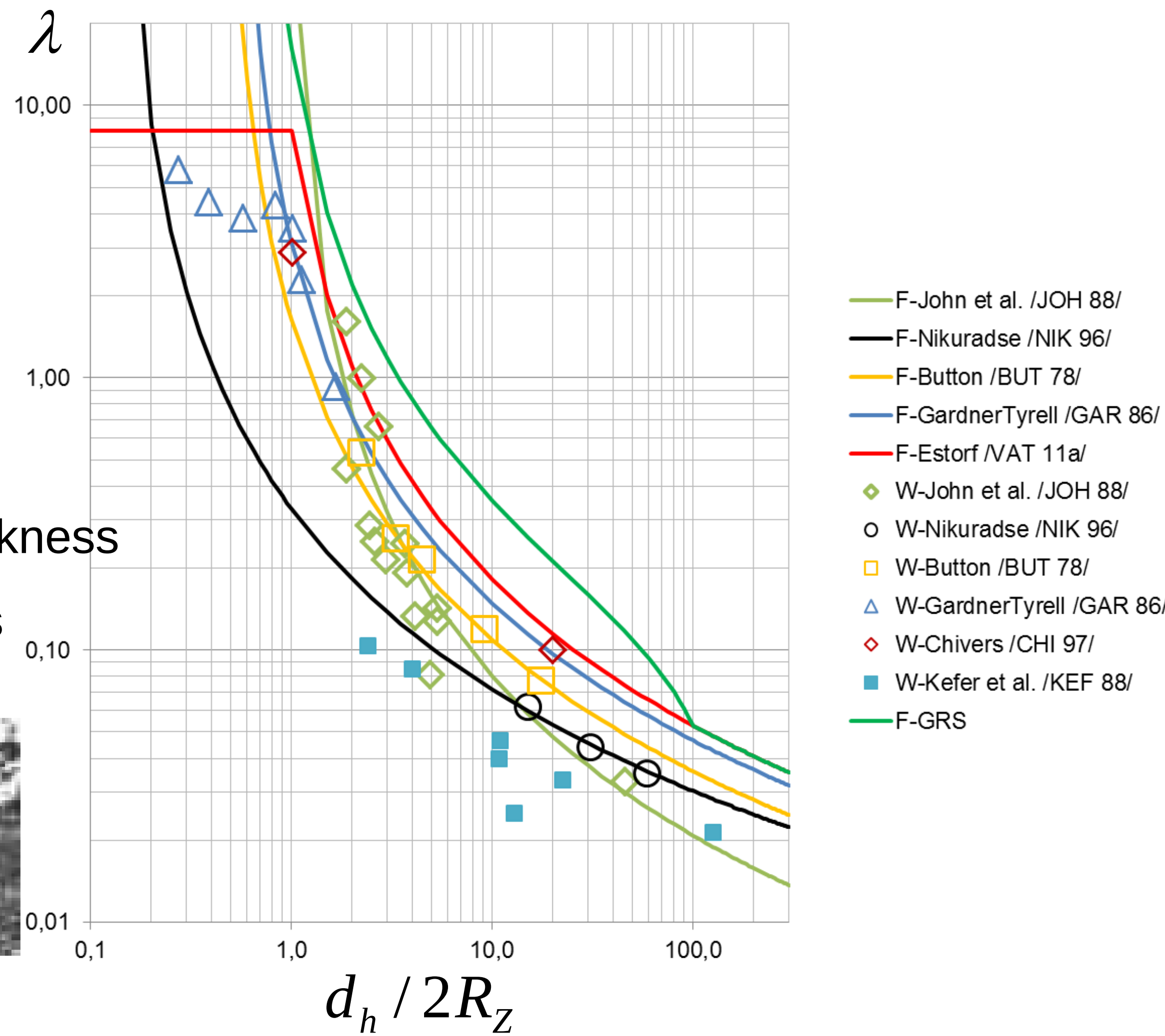
$\lambda$ – resistance coefficient

$d_h$ – hydraulic diameter

$t$ – flow length ≥ wall thickness

$R_Z$ – crack face roughness





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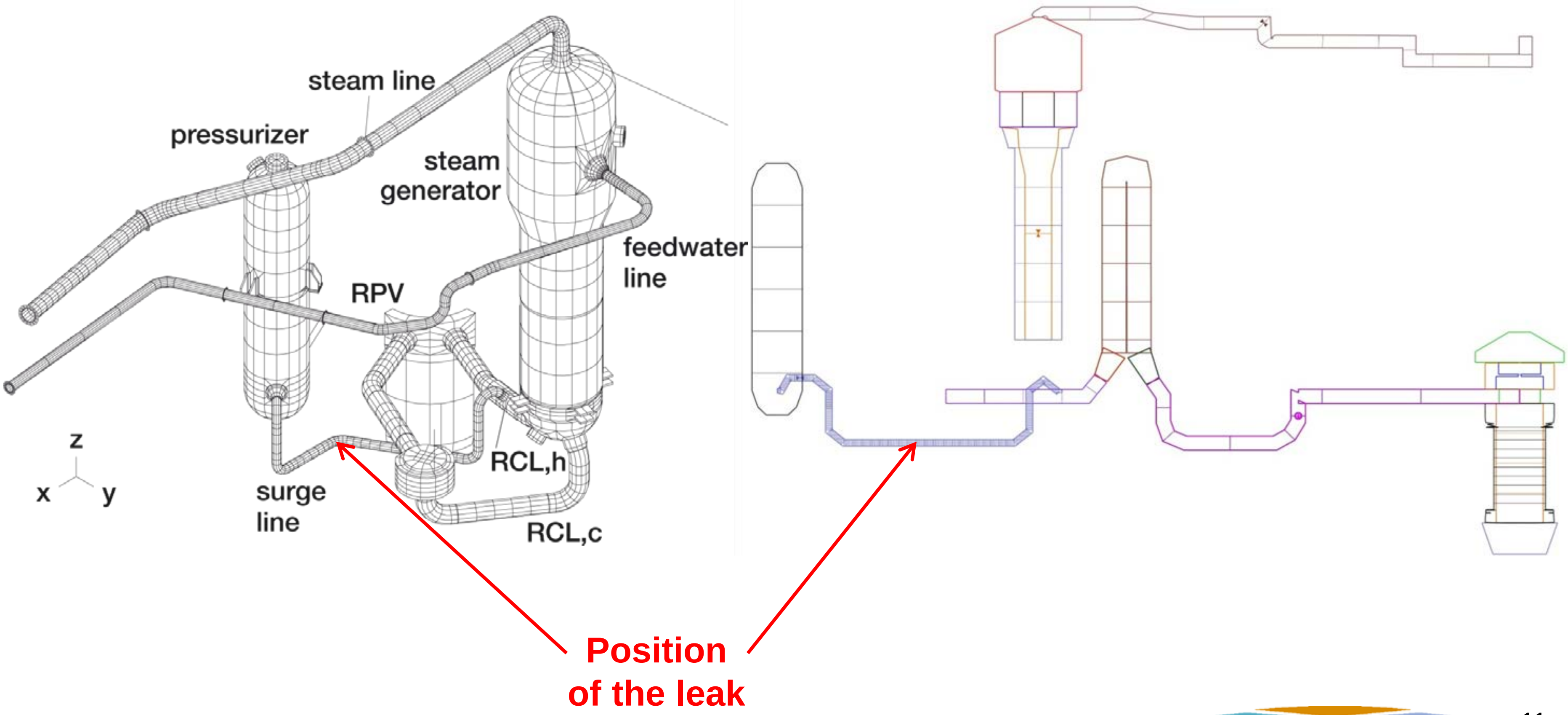
Structure mechanics analysis (ADINA)

Thermal hydraulic analysis (ATHLET)



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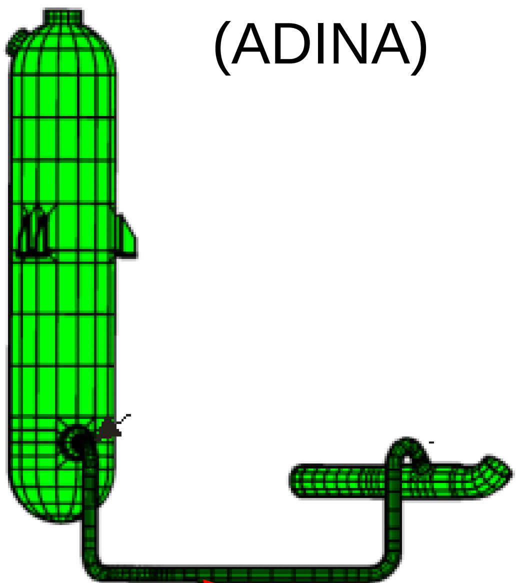

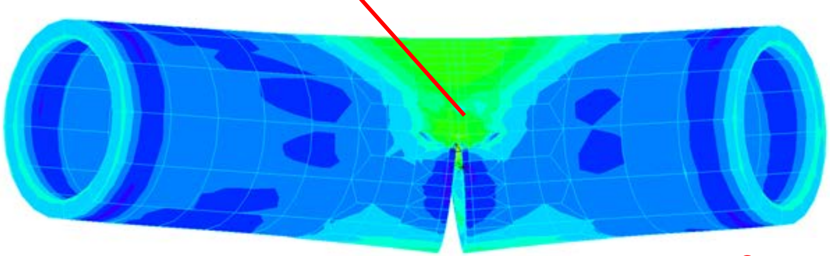

Deformation
factor 20

**Leak area inside $A_i$ = 14.2 $cm^2$**
**due to normal operation conditions**

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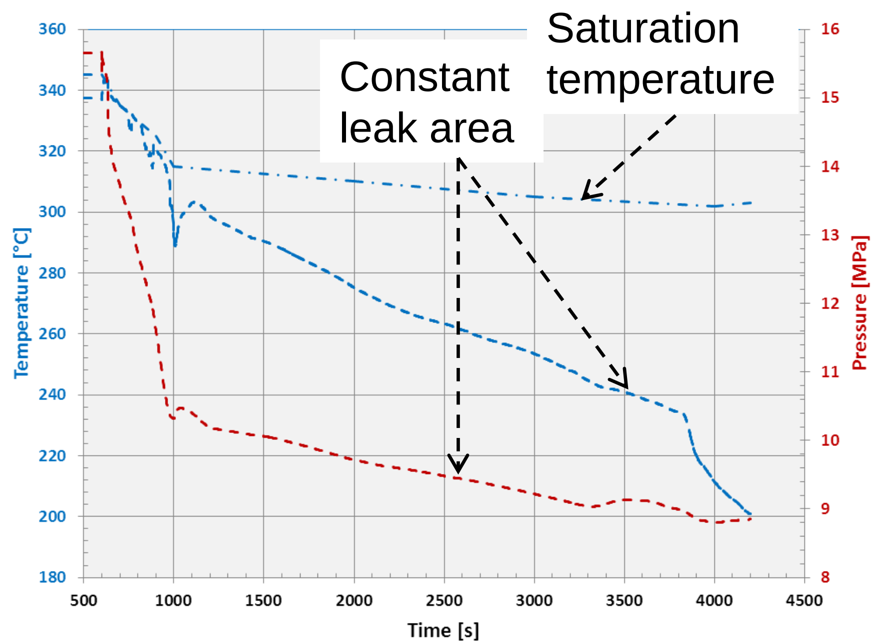

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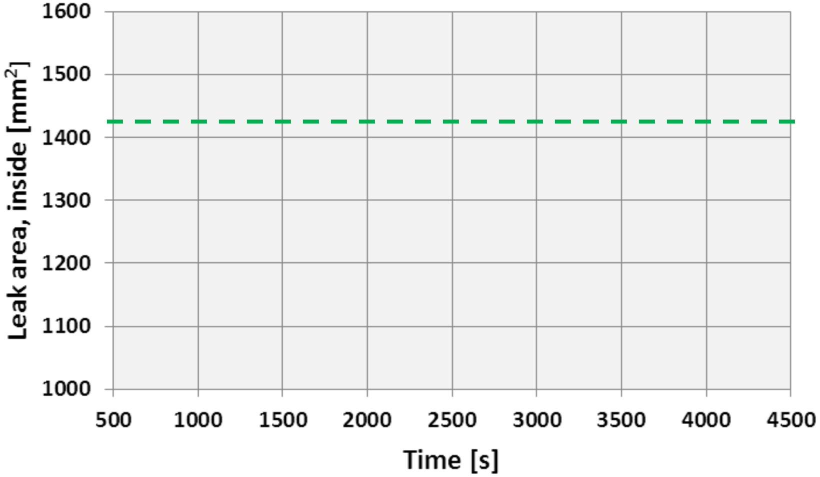


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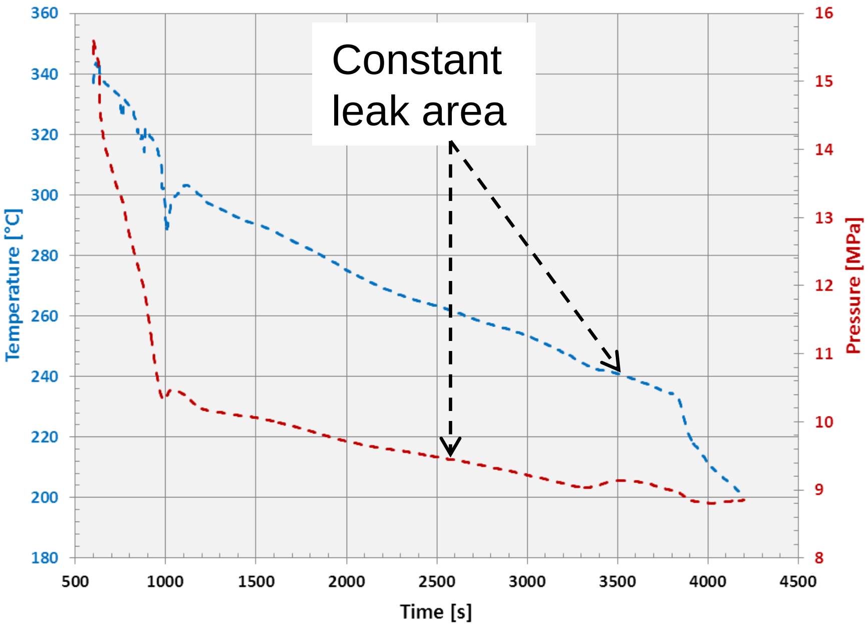


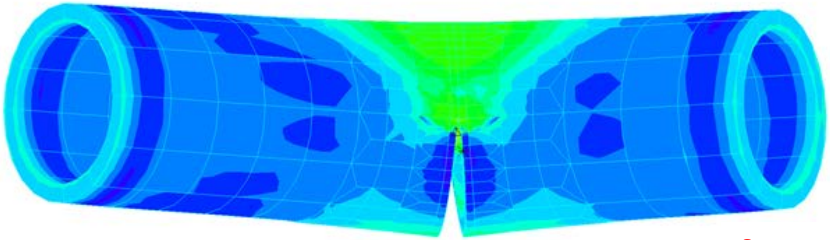

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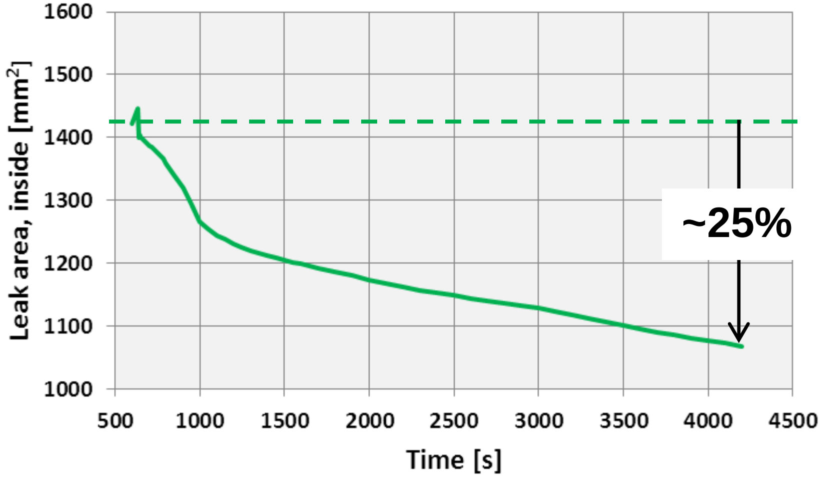


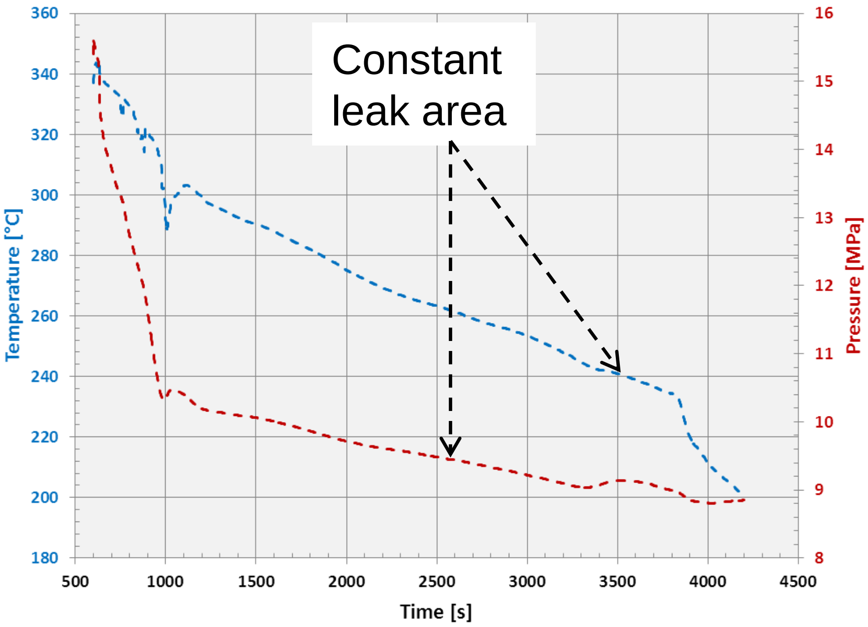


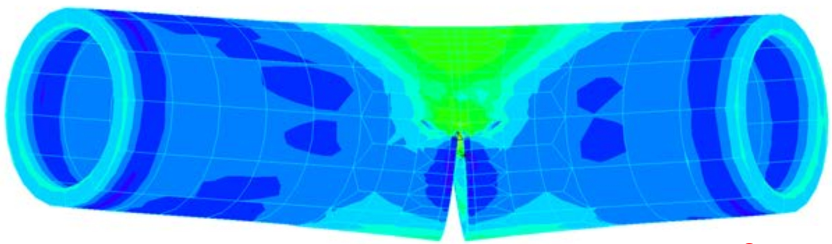

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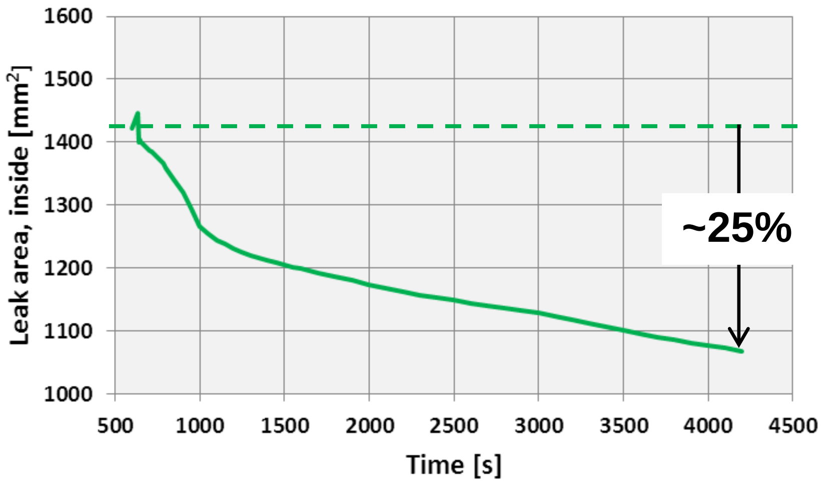


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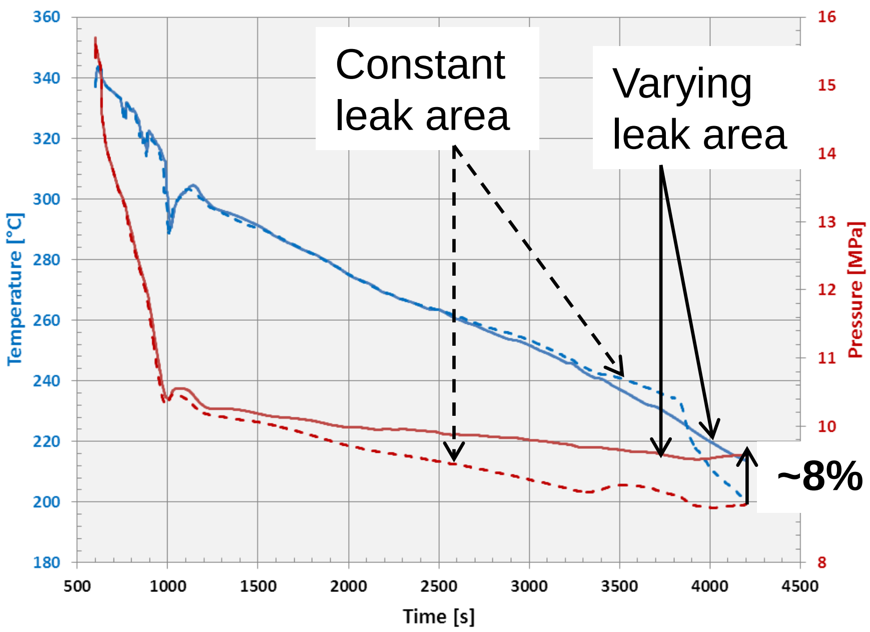


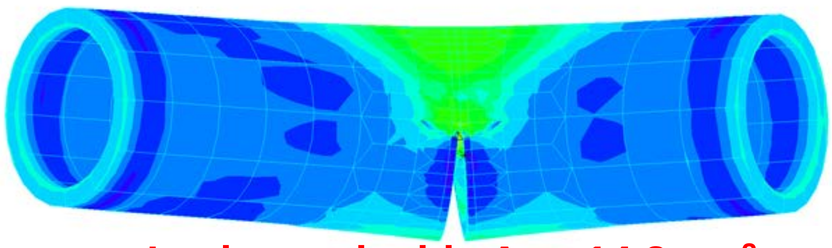

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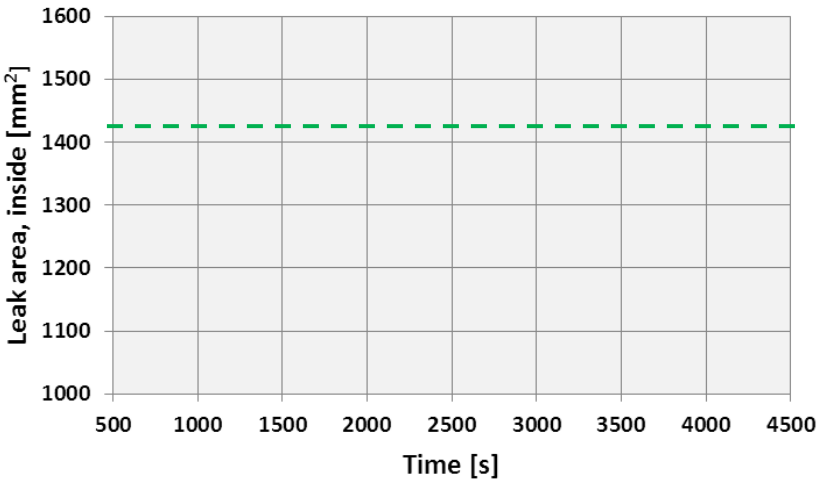


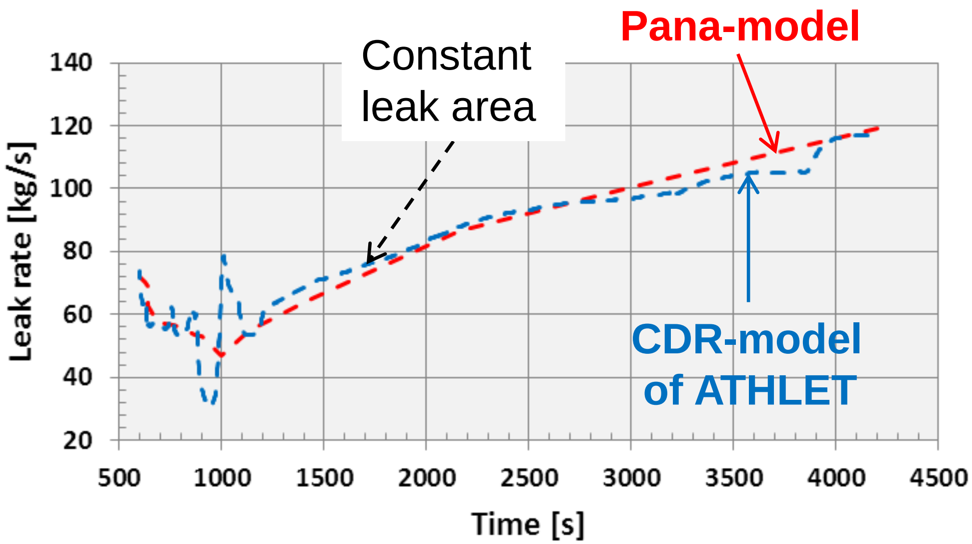


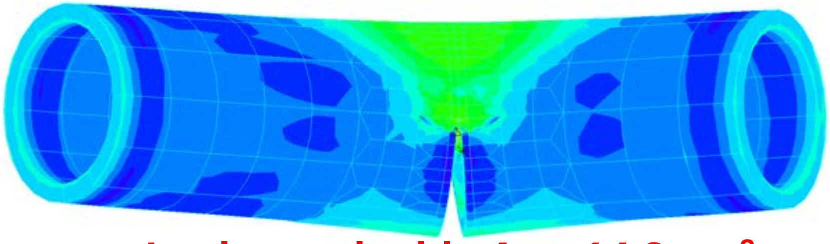

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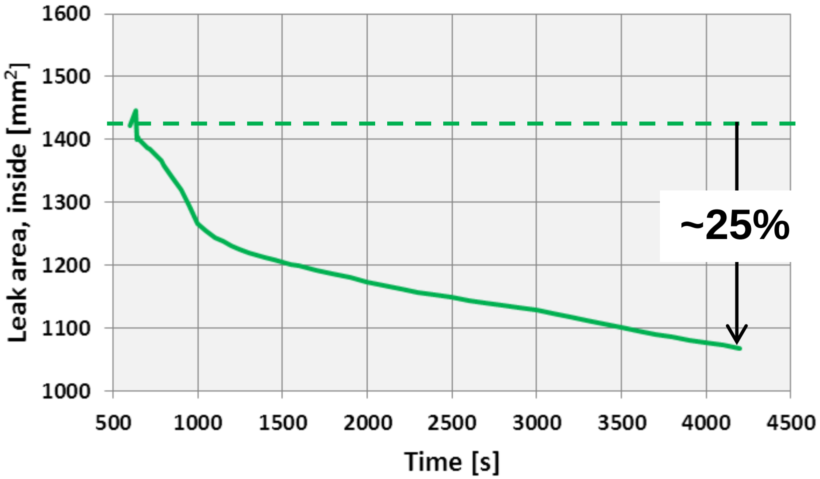


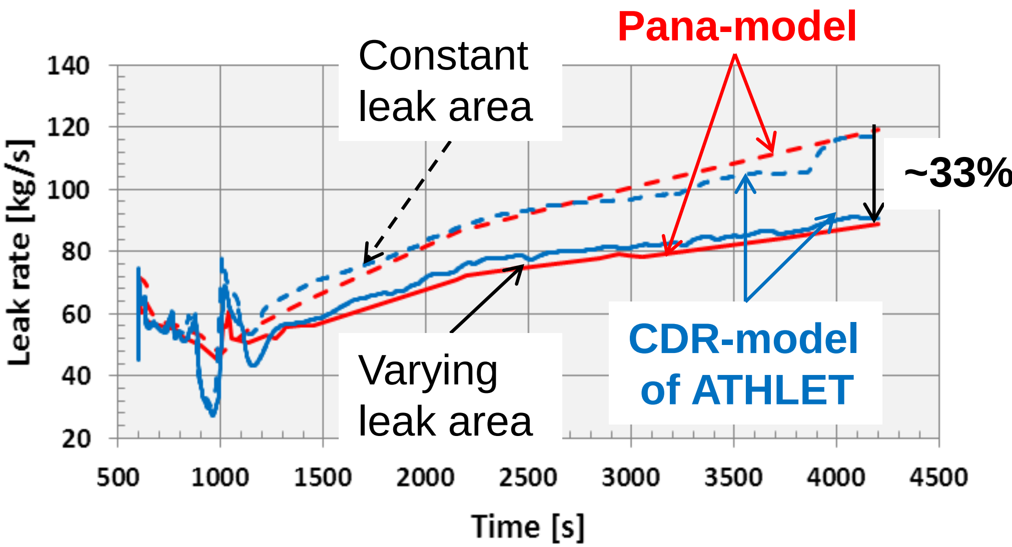


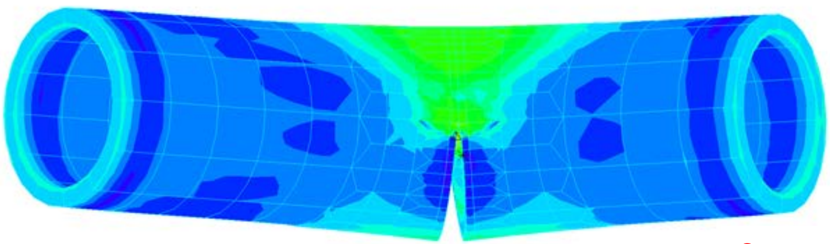

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# SUMMARY AND OUTLOOK

- Evaluation of fluid flow rates through crack-like leaks in piping relevant for leak-before-break assessment
  - Leak rates should be underestimated to ensure leak detection
  - Simplified methods calculate critical mass flow
  - Need for investigations on best estimate methods
- Changing of the leak size during accident scenario should be considered by coupled thermal hydraulic and structural mechanical investigations, if significant.
- In case of severe accident scenarios due to a crack-like leak investigations should be performed on
  - the changing leak size
  - possible leak growth
  - possible break

THANK YOU FOR YOUR ATTENTION