

STANDARD PROBLEM EXERCISE ON PERFORMANCE OF  
CONTAINMENT VESSEL UNDER SEVERE ACCIDENT CONDITIONS  
SPE Analysis Meeting #3, March 27-29, 2012, Washington DC

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**Scanscot Technology ISP 48 (2004)**  
**Pressure + Temperature Analysis**

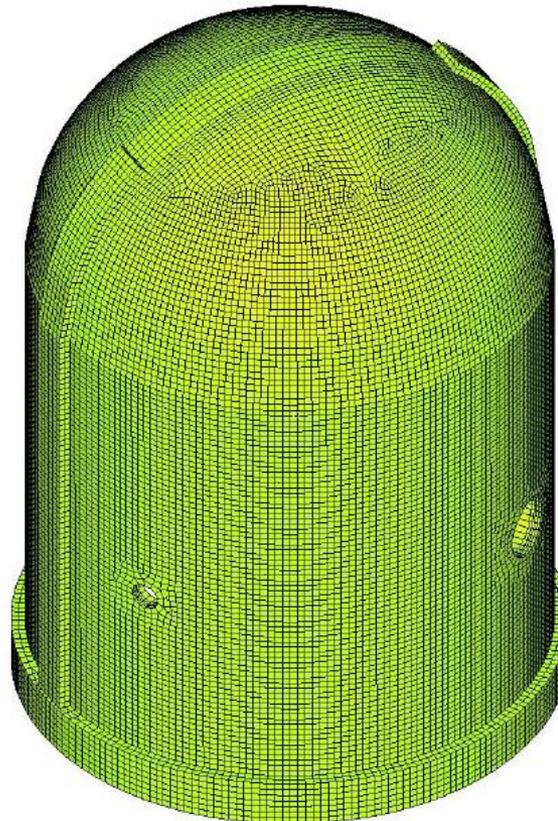
**corresponding to**

**SPE Model 4 – Case 1 and Case 2**

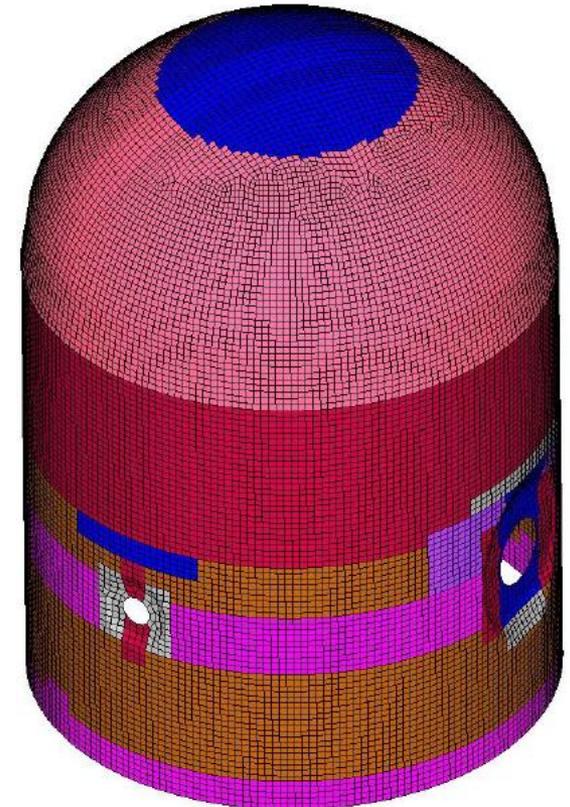
Ola Jovall – Scanscot Technology, Lund, Sweden

# ISP 48 (2004) Pressure + Temperature Analysis

## 3D MODEL



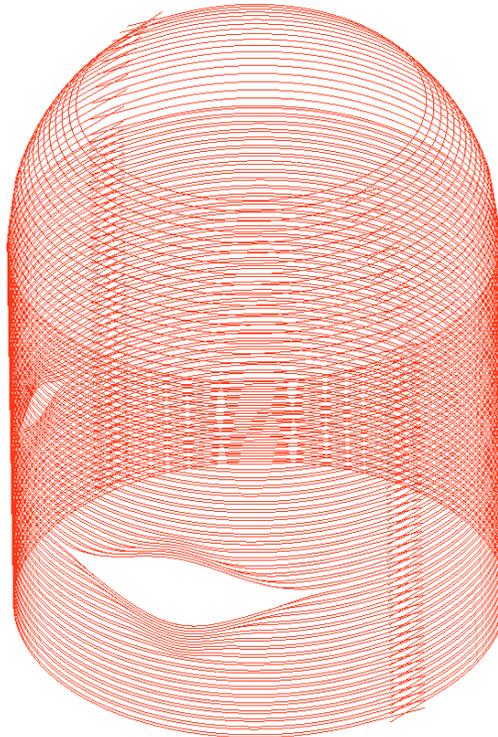
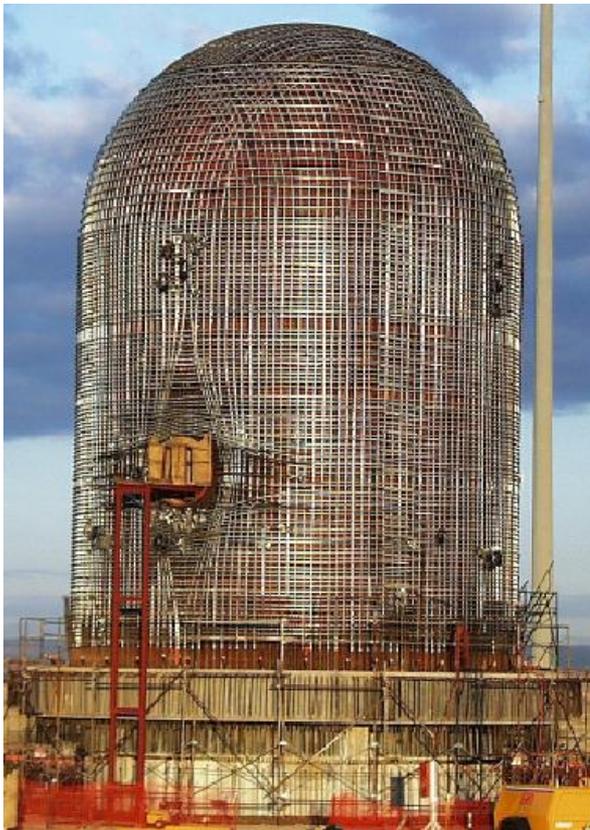
Concrete (solid elements)



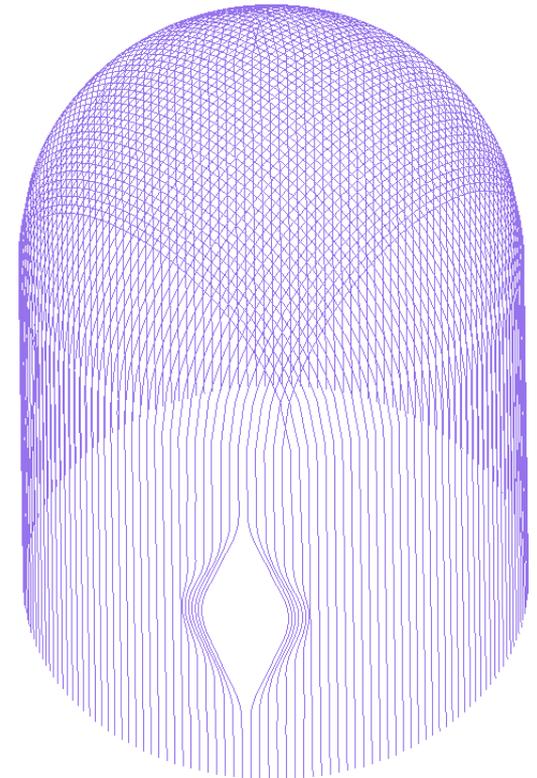
Rebars (embedded shells)

# ISP 48 (2004) Pressure + Temperature Analysis

## 3D MODEL



Hoop tendons (truss)



Hairpin tendons (truss)

# ISP 48 (2004) Pressure + Temperature Analysis

## 3D MODEL

- FEA Software

- Abaqus Explicit

- Material models

- Concrete: Brittle cracking (linear compression, non-linear tension)
- Steel: Plastic with hardening

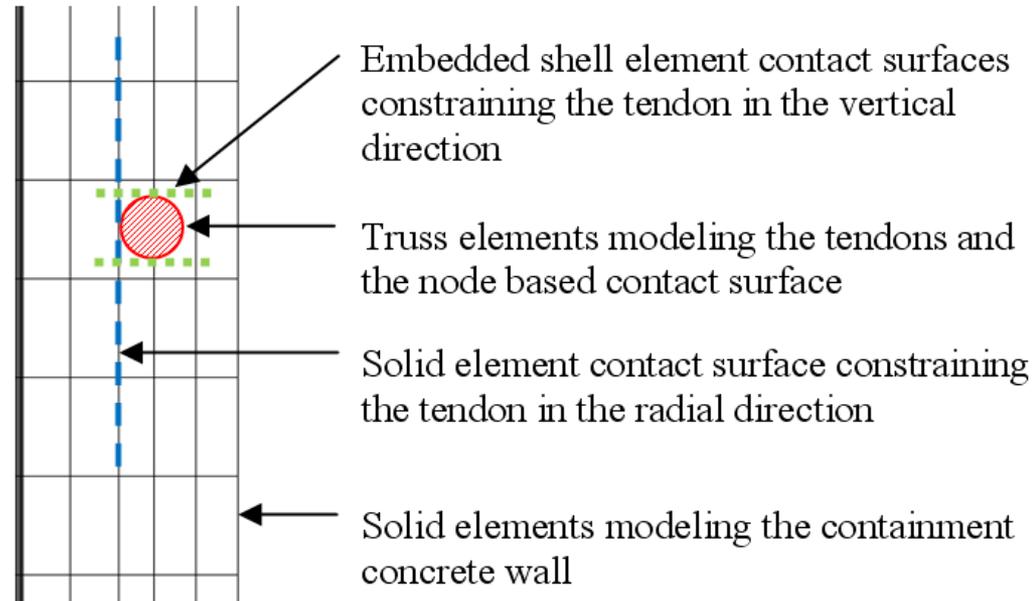
- FE-model

- Concrete: Solid elements
- Reinforcement: Membrane elements, orthotropic, embedded
- Liner: Shell elements
- Tendons: Truss elements (each tendon modeled separately)

# ISP 48 (2004) Pressure + Temperature Analysis

## KEY MODEL FEATURES

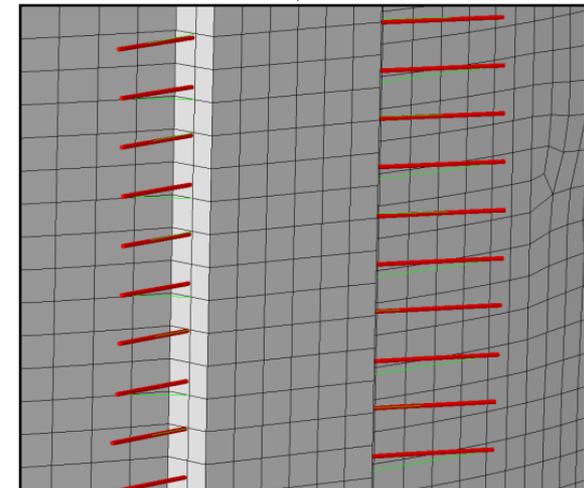
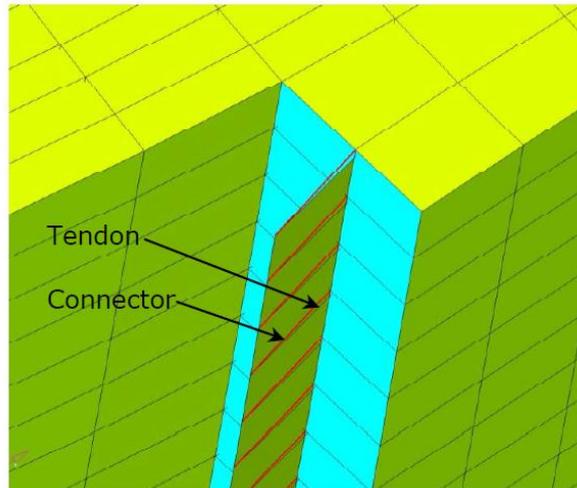
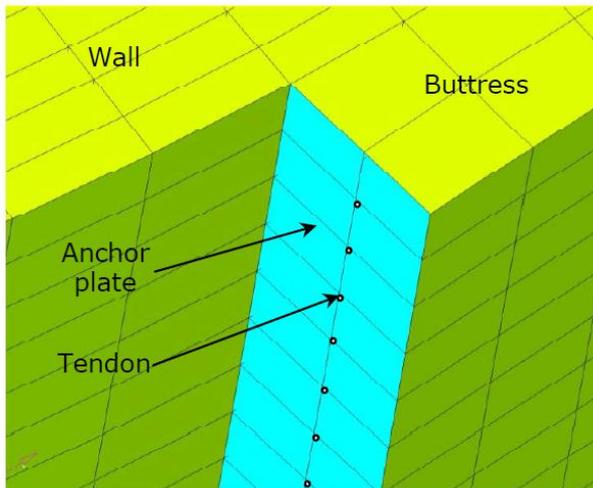
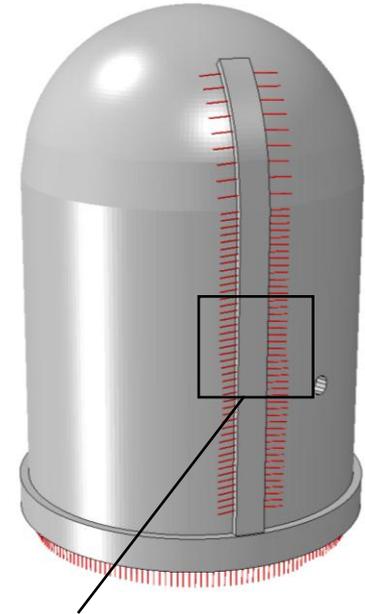
- Pre-stressing tendons
  - **Interaction** with concrete modeled using contact
  - Allow **slippage** between tendons and concrete
  - **Friction** between tendon and concrete included



# ISP 48 (2004) Pressure + Temperature Analysis

## KEY MODEL FEATURES

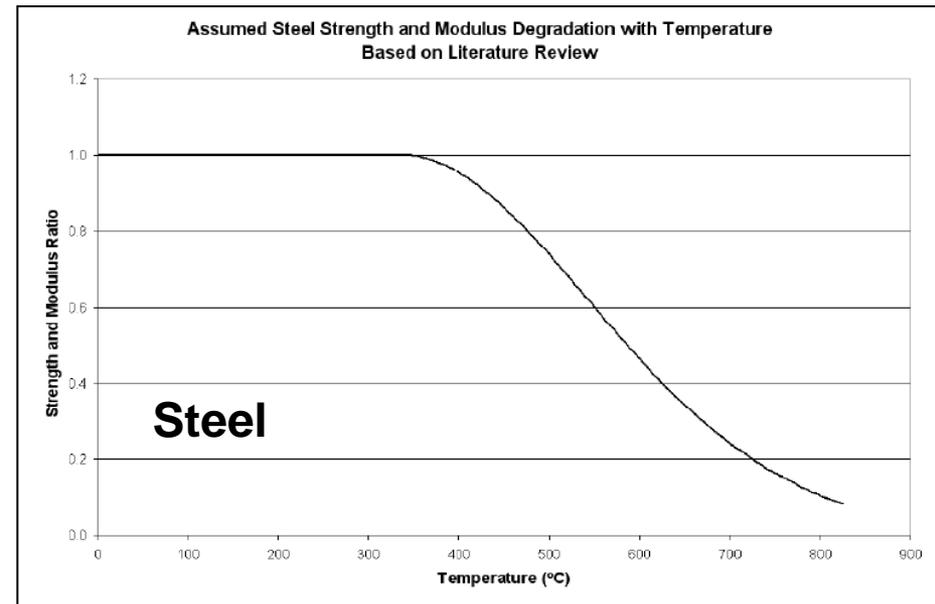
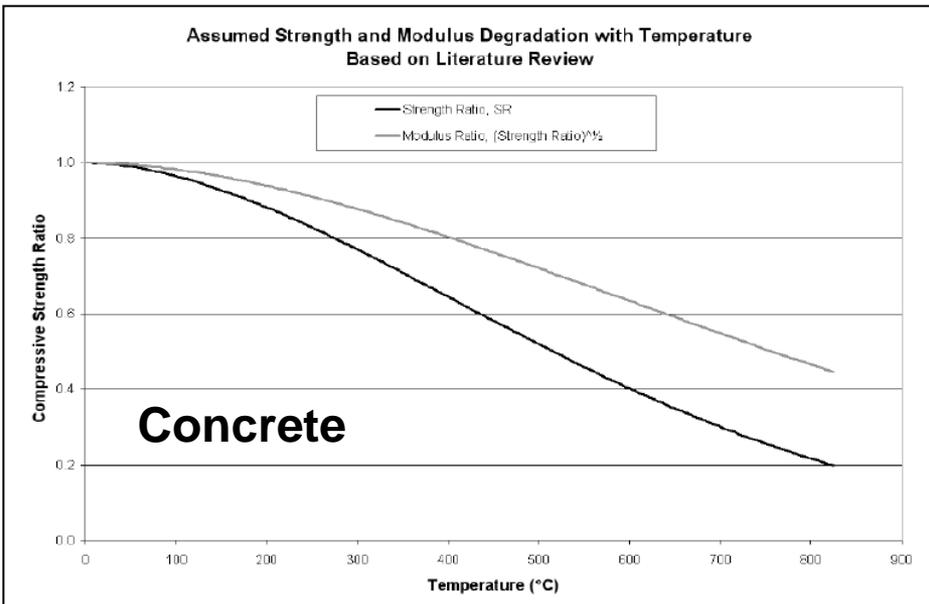
- Pre-stressing tendons
  - Tensioning of tendons simulated
  - Connector elements



# ISP 48 (2004) Pressure + Temperature Analysis

## KEY MODEL FEATURES

- Material degradation due to increased temperature
  - Strength and stiffness reduction automatically adjusted during analysis

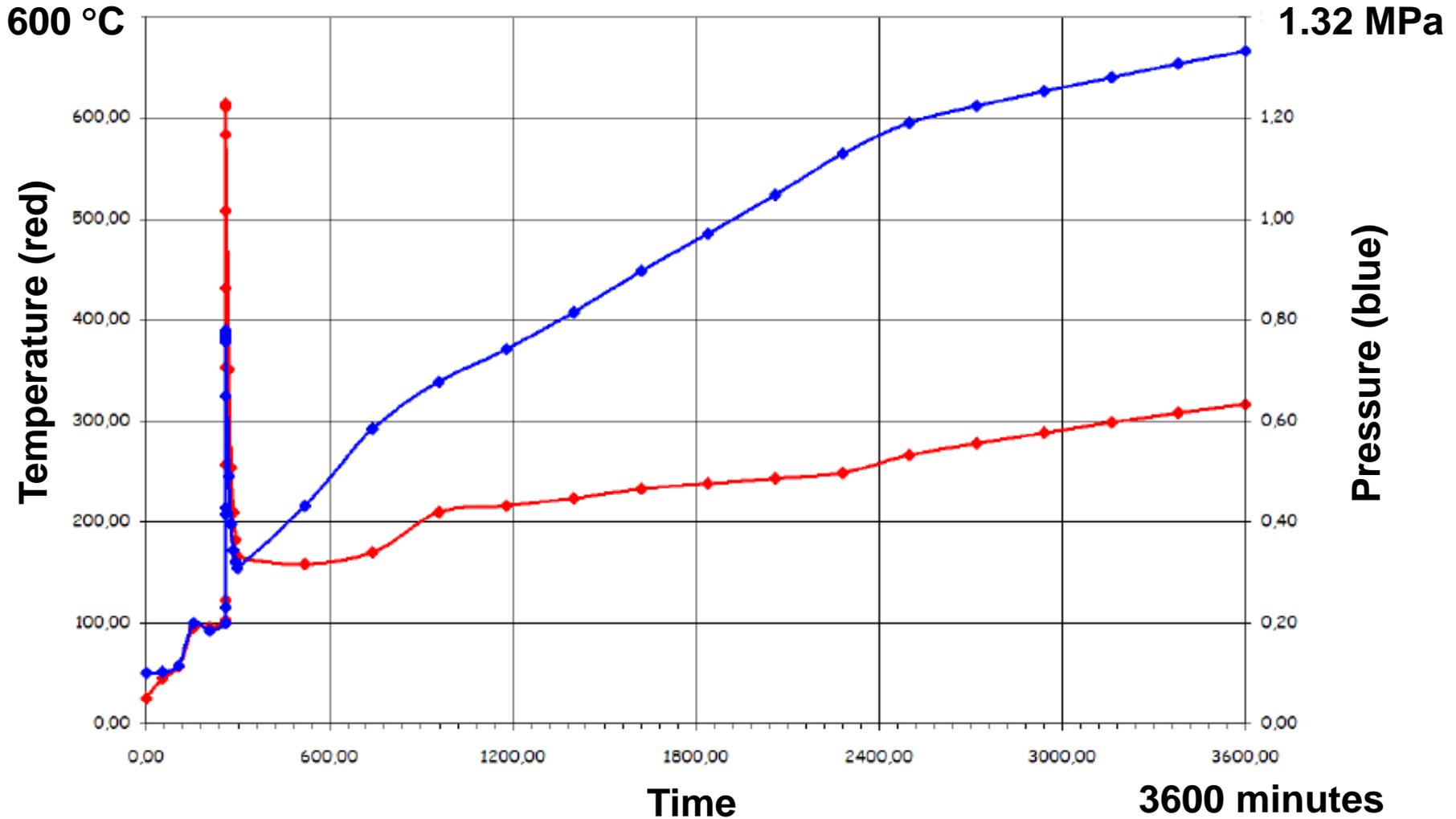
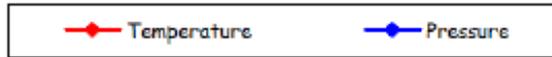


## ISP 48 (2004) Pressure + Temperature Analysis

### ANALYSIS STEPS (CASE 2 EXAMPLE)

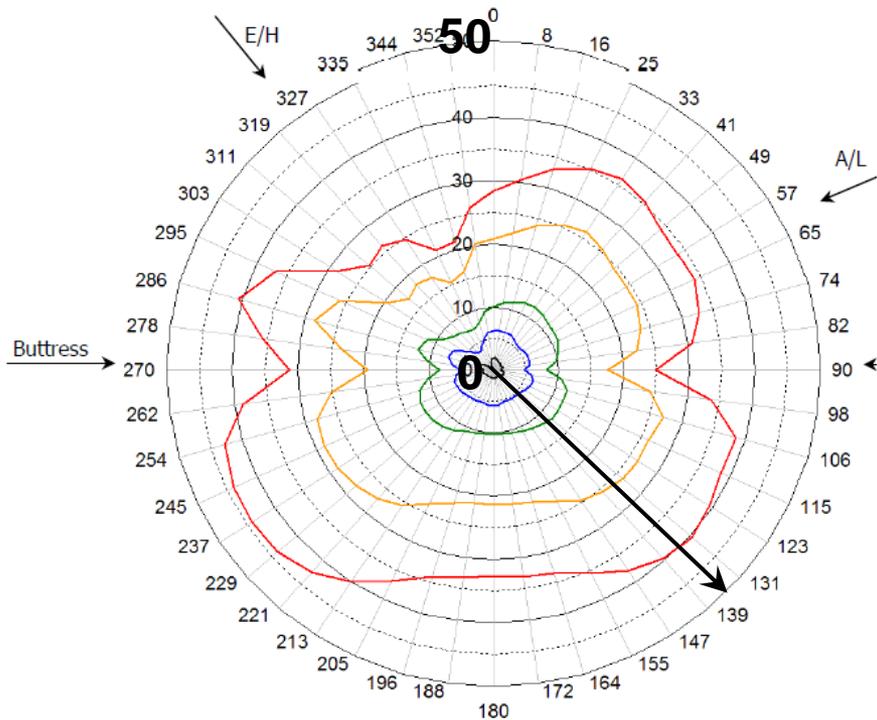
- Step 1: Temperature analysis
  - Temperature field is calculated in a separate analysis
  - 3600 minutes according to case 2 temperature scenario
- Step 2: Time scale is compressed
  - 3600 minutes is “compressed” to 9 seconds
  - 9 seconds is long enough to avoid dynamic structural response
- Step 3: Stress analysis with imported temperature field
  - Pressure and temperature load stress analysis
  - Temperature imported from separate analysis (previous steps)

ISP 48 Phase 3, Case 2, Loading

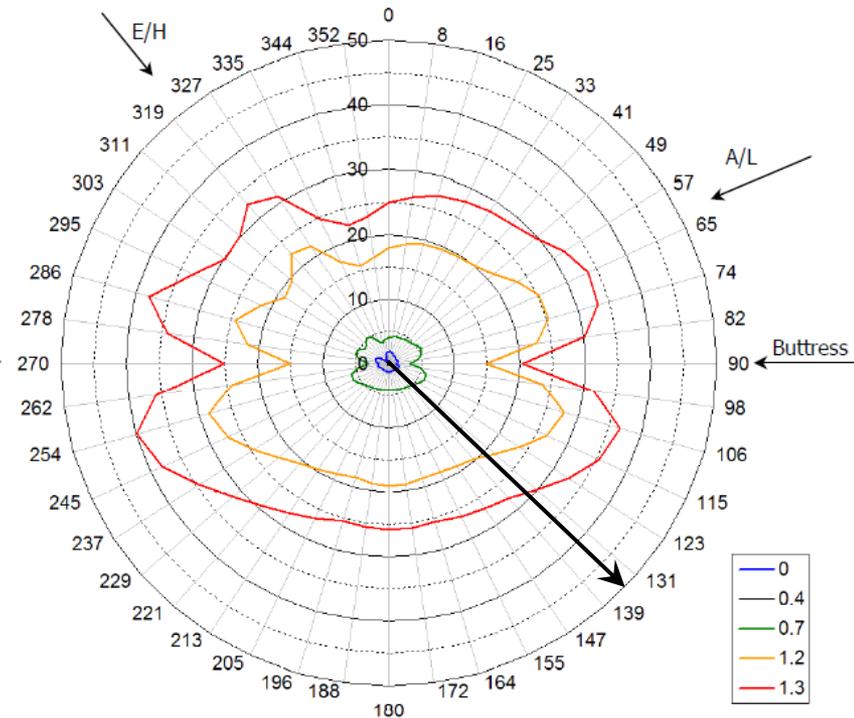


# ISP 48 (2004) Pressure + Temperature Analysis

## RESULTS – RADIAL DEFORMATION



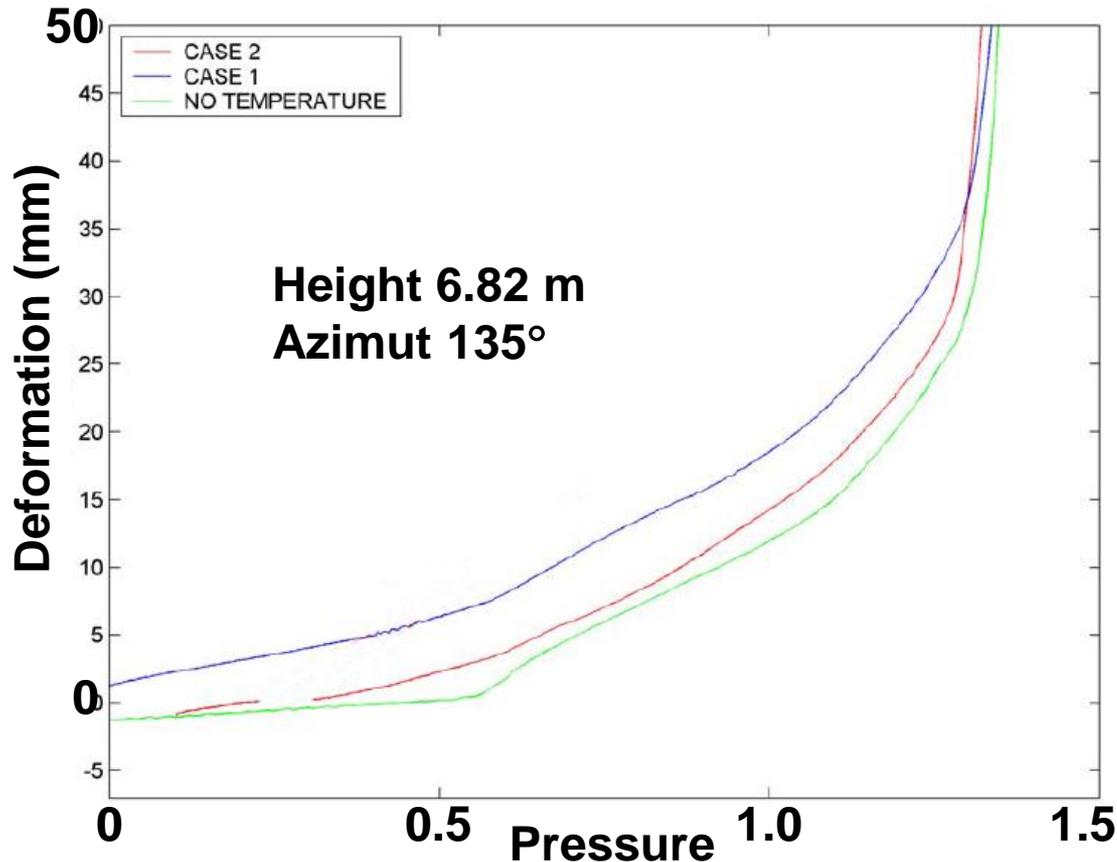
Case 1



No temp.

# ISP 48 (2004) Pressure + Temperature Analysis

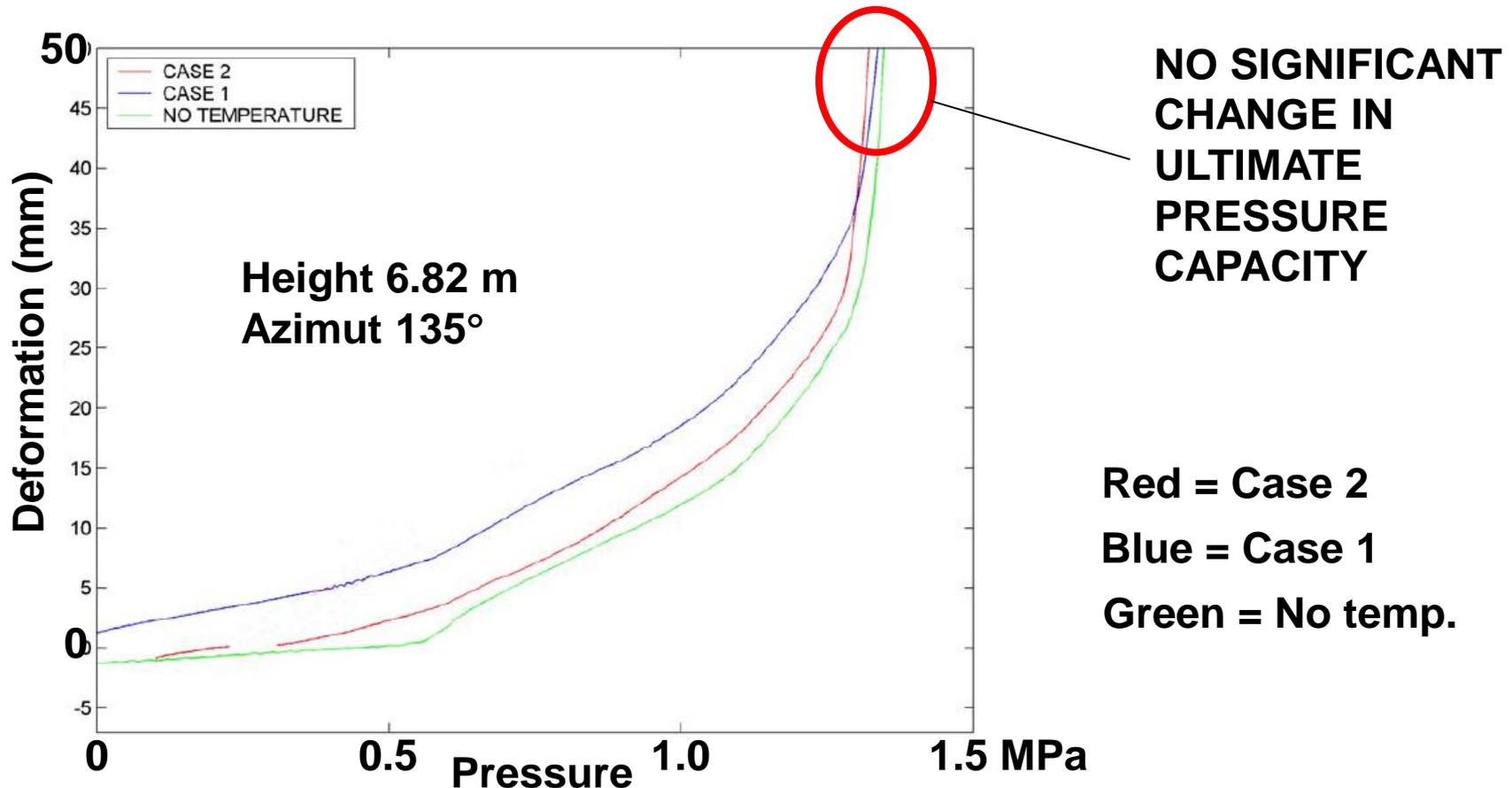
## RESULTS – RADIAL DEFORMATION



**Red = Case 2**  
**Blue = Case 1**  
**Green = No temp.**

# ISP 48 (2004) Pressure + Temperature Analysis

## RESULTS – RADIAL DEFORMATION



# ISP 48 (2004) Pressure + Temperature Analysis

## RESULTS – MILESTONES

Analysis	Concrete cracking	Yield steel liner	Yield tendons	Tendons 2%	Rupture of tendons
No temp.	0.55 – 0.7	0.8	1.12	1.35	1.38
Case 1	0.58 – 0.72 (through wall)	1.01	1.17	Not reported	1.45
Case 2	0.68 (through wall)	0.4* (tension)	1.22	Not reported	> 1.33 (max. load)  Stress 1850 Rupture 1950
Unit	MPa	MPa	MPa	MPa	MPa

\*Due to sudden drop in temperature after peak temperature (600 → 150°C)



# Olkiluoto 3 – New NPP i Finland

New plant under construction

- FE analysis of the reactor containment

