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Bending Observed on the Carbon Steel Liner of the Pre-stressed Concrete Primary Containment of a Nuclear Reactor: Safety Assessment

BEL V

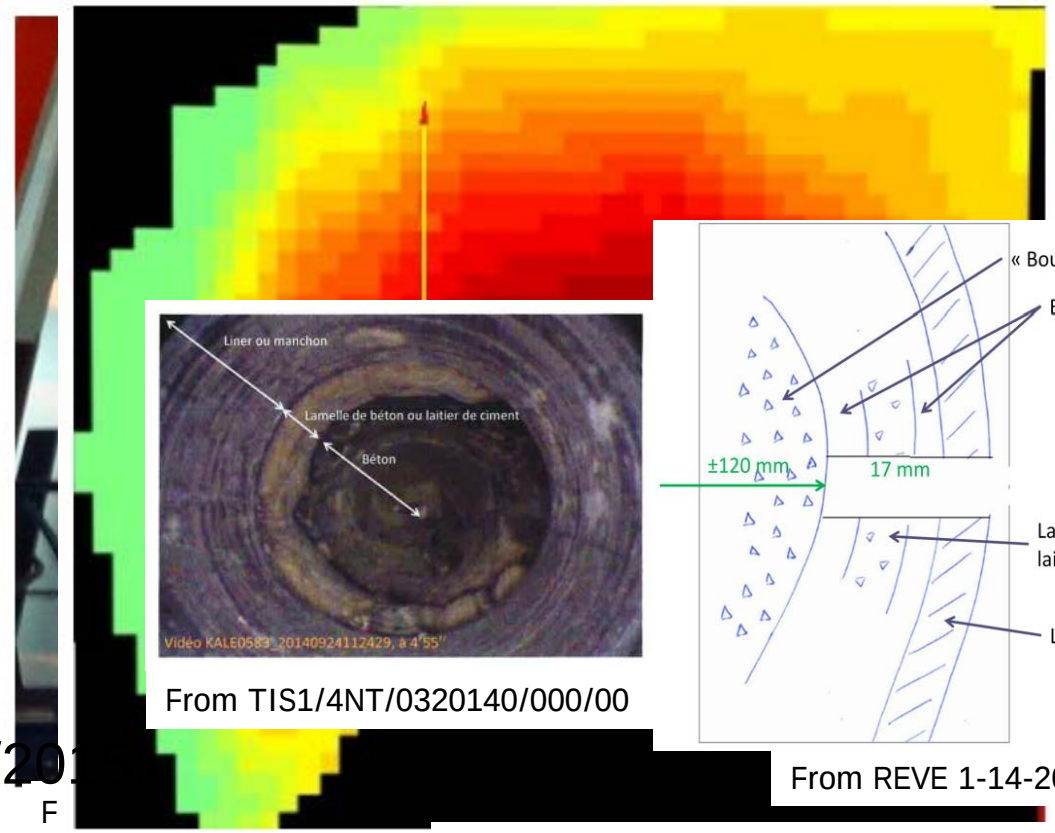
EUROSAFE 2016

SUMMARY

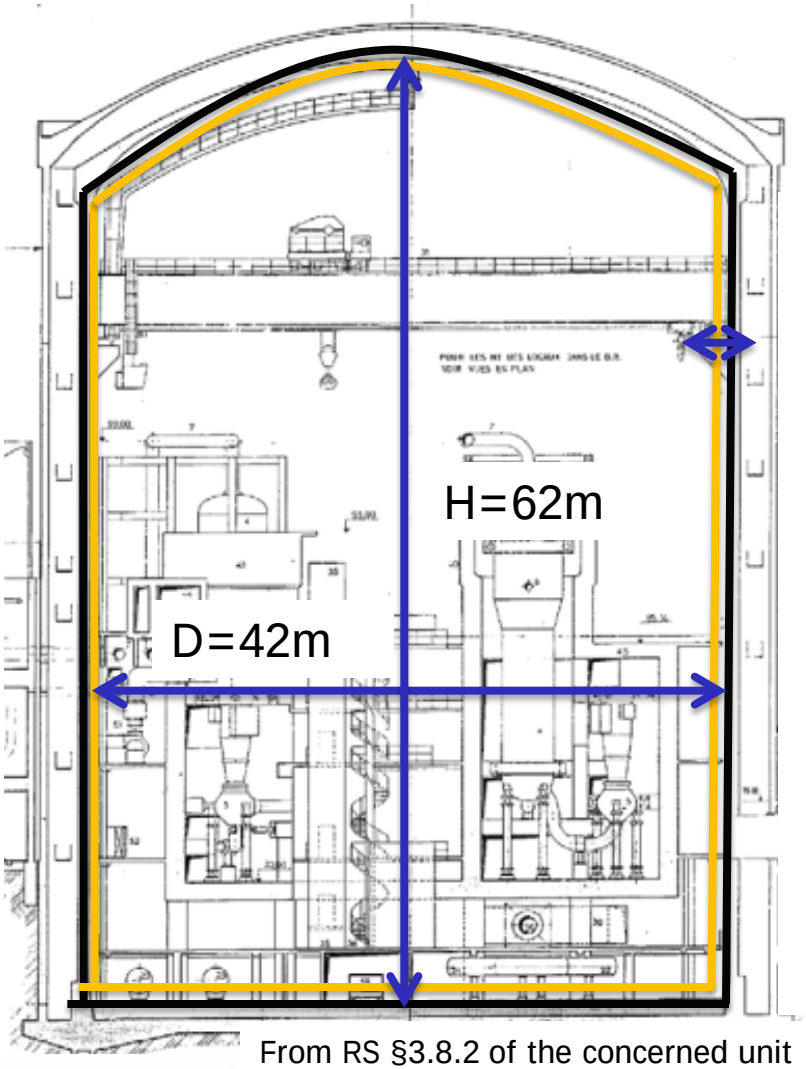
- Introduction
- Historic information
- Experience feedback
- Technical analysis
  - Historical
  - Causes of the bending
  - Safety issues
- Conclusions

INTRODUCTION

- 7/09/2014:
  - Auth… …pending loca…
- Licens…
  - Dete… …ng
  - Veri… …right behi…
  - Veri… …er Belg…
  - Eva… …on
- 30/01/20…
  - Bel V started a safety assessment

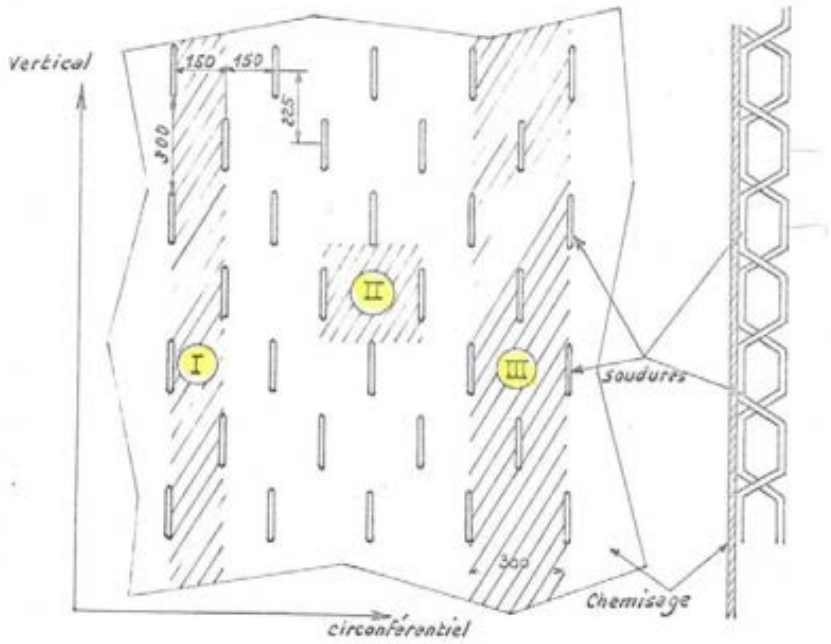


HISTORIC INFORMATION



From RS §3.8.2 of the concerned unit

FIGURE 2 : DISPOSITION DES ANCRAGES DANS LE LINER.



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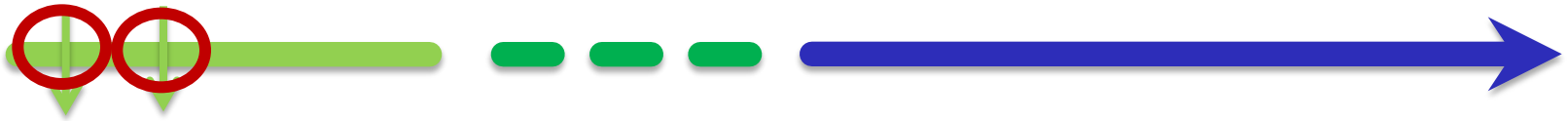
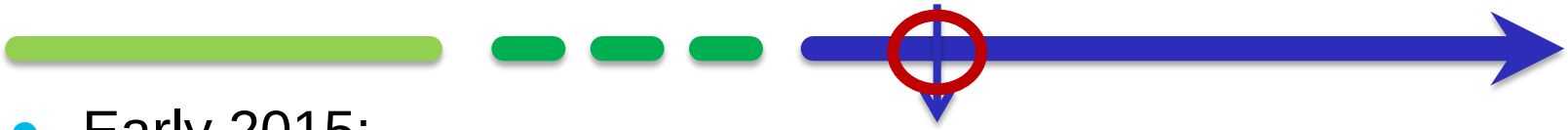


- Design of the concerned unit
  - Loads considered (primary containment)
- Construction of the concerned unit
  - Carbon steel liner used as a lost formwork
- Regarding CONFINEMENT safety function
  - Carbon steel liner: “tightness” safety function
  - Pre-stressed reinforced concrete: “structural” safety function

→ Both are key elements when talking about nuclear safety

EXPERIENCE FEEDBACK



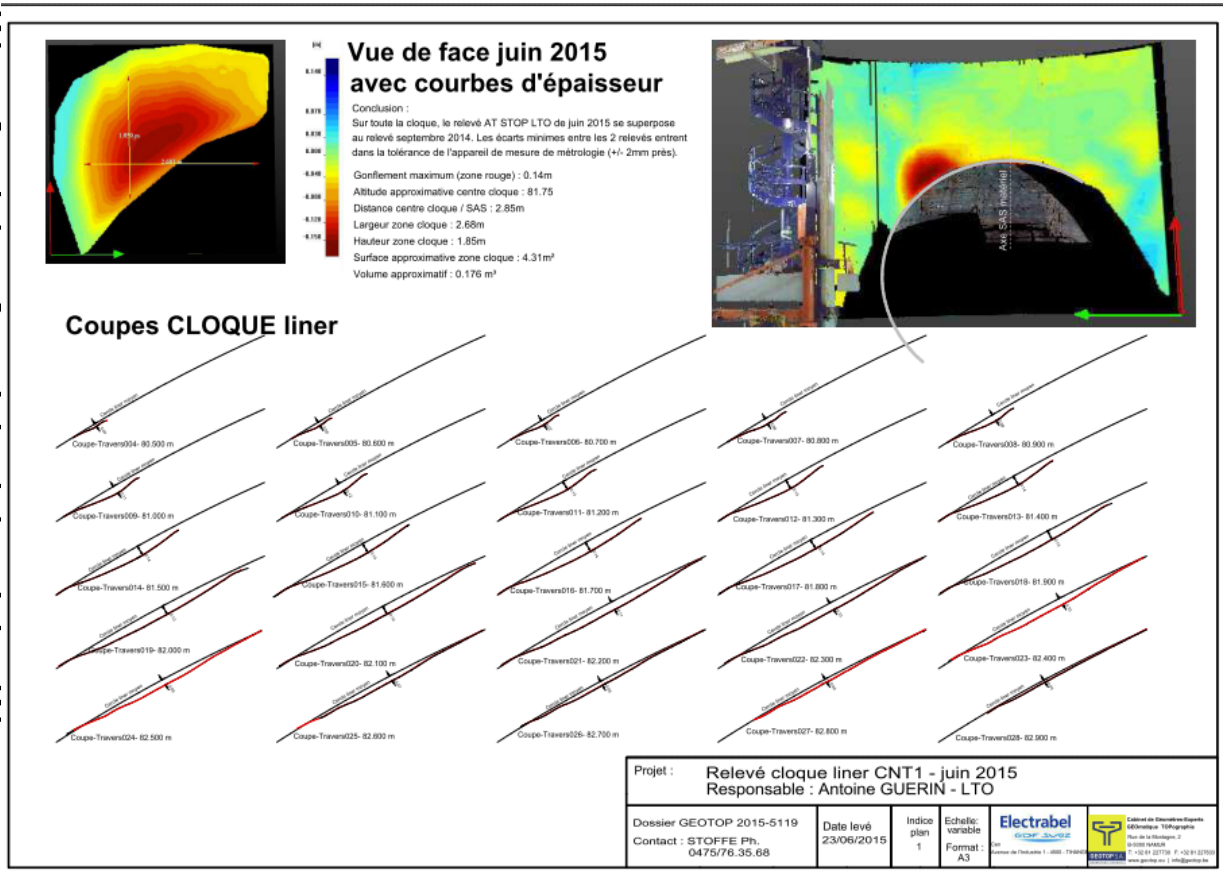
- Early 2015:
  - Bel V checked the existence of similar events worldwide and in Belgium
    - International return of experience: bending reported had a maximal surface of around 1 m^2
    - National experience: local deformation (bending 1m long and 50 cm to 60 cm high) of the carbon steel liner observed in its lower part (1992)

TECHNICAL ANALYSIS

- Bel V carried out a safety assessment to evaluate:
  - the upholding of the **tightness** safety function (and so the upholding of the bending) in accidental conditions
  - the upholding of the **structural** safety function of the pre-stressed reinforced concrete primary containment in accidental conditions
- Determine causes / origin
- Evolving phenomenon

TECHNICAL ANALYSIS - HISTORICAL

- 7/09/2004:
  - E
  - N
  - C
  - N
- 20:
  - C
- 20:
  - E
- No



TECHNICAL ANALYSIS - CAUSES

- Thrust of the fresh concrete on the non-supported carbon steel liner used as formwork
- *Fatigue phenomenon caused by the thermal loads?*
- *Defect in the pre-stressed reinforced concrete primary containment ?*

→ *Bel V asked the Licensee to carry out necessary inspections and investigations*

TECHNICAL ANALYSIS – TIGHTNESS SAFETY FUNCTION

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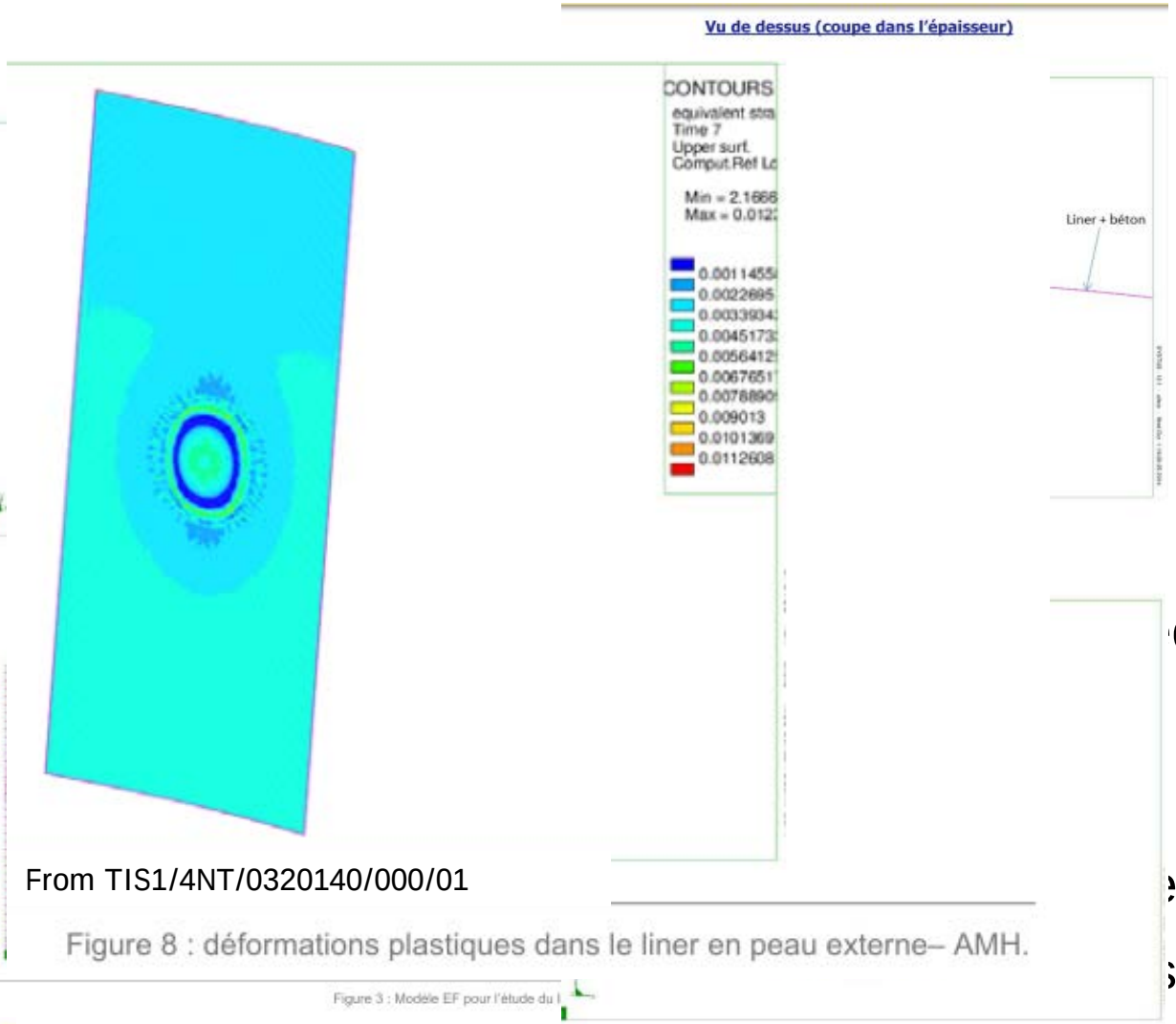

From TIS1/4NT/0320140/000/01

Figure 8 : déformations plastiques dans le liner en peau externe– AMH.

Figure 3 : Modèle EF pour l'étude du l

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TECHNICAL ANALYSIS – STRUCTURAL SAFETY FUNCTION

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02F	4+4	Bossage	ASME III Cl. CC	Sa 105			
01F	4+4	Bouchon	ASME III Cl. CC	Sa 105			
Pos.	Quant.	Description	Norme	Nuance	Matière	Lot n°	

Chanfrein : 1 x 45°	HAQUENNE S.C.S.I. rue de Courrière, 30 5340 Faulx-Les-Tombes Tél: 081/57.86.24 - Fax: 081/57.00.37		Titre: TIH 1 – BR: Injection de coulis derrière Liner métal.	Ech. 1/1	Unité mm	Format A4
Tolérance Générale : +/- 0,1	Dessinateur: FRANÇOIS R.			Plan n° 0309/H15-653/Assemblage		
Etat de Surface Général : /	Vérificateur: DENAMUR A.		PCT	Rev. 1	Date d'émission 10/06/2015	Page 1/1
	Approbateur:					

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CONCLUSIONS

- On 7/09/2014: Bending (2.7 m wide, 1.9 m high, maximum curving of 14 cm) was observed on the liner of the primary containment
- National and international literature did not show similar reported bendings

CONCLUSIONS

- Bel V carried out a safety assessment:
  - Upholding of the tightness safety function of the liner (and so the upholding of the buckling) in accidental conditions:
    - Global type A pressure test in 2005 and 2016
    - Ultrasonic tests on the welds in 2015
    - Magnetic controls of the liner in 2015
    - Finite elements calculation of the liner
    - 3D scan of the liner in 2014, in 2015 and in 2016
  - Bel V concluded that the tightness safety function is ensured

CONCLUSIONS

- Bel V carried out a safety assessment:
  - Upholding of the structural safety function of primary containment in accidental conditions by demonstrating no damage on the primary containment:
    - Two drillings inside of the buckling through the carbon steel liner
    - Post-tensioning losses were checked
  - Bel V concluded that the structural safety function is ensured


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Albert Einstein