ANALYSIS OF THE REPLACEMENT NEED FOR THE CONTAINMENT ANCHORING BOLTS OF THE LOVIISA NPP ESTIMATED BY THE STRENGTH ASSESSMENT

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1. INTRODUCTION

The type of the containment building is a double-containment, the purpose of which is to produce the isolating protection between the processes of the reactor building and the environment. The outer concrete shell of the containment building gives the external protection to the process and to the inner steel shell against the future effects of the environment.

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1. INTRODUCTION (continuation)

The purpose of the inner steel shell is to prevent the emissions from getting directly into the environment in any process situation.

The free-standing inner steel shell has been anchored from its bottom on the ring plate on the elevation +9.60 which from the middle part extends downwards as the reactor pit reaching the reactor pit base slab on the bedrock.

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2. DESCRIPTION OF THE STRUCTURE

The containment material in the first unit of the plant is RAEX 385 P structural steel sheet and in the second unit of the plant the containment material is RAEX 305 AV steel. The total height of the containment building is 66.850 meters. The internal diameter of the containment building is 44.400 m. The steel parts of the containment building form the welded sheet metal structure.

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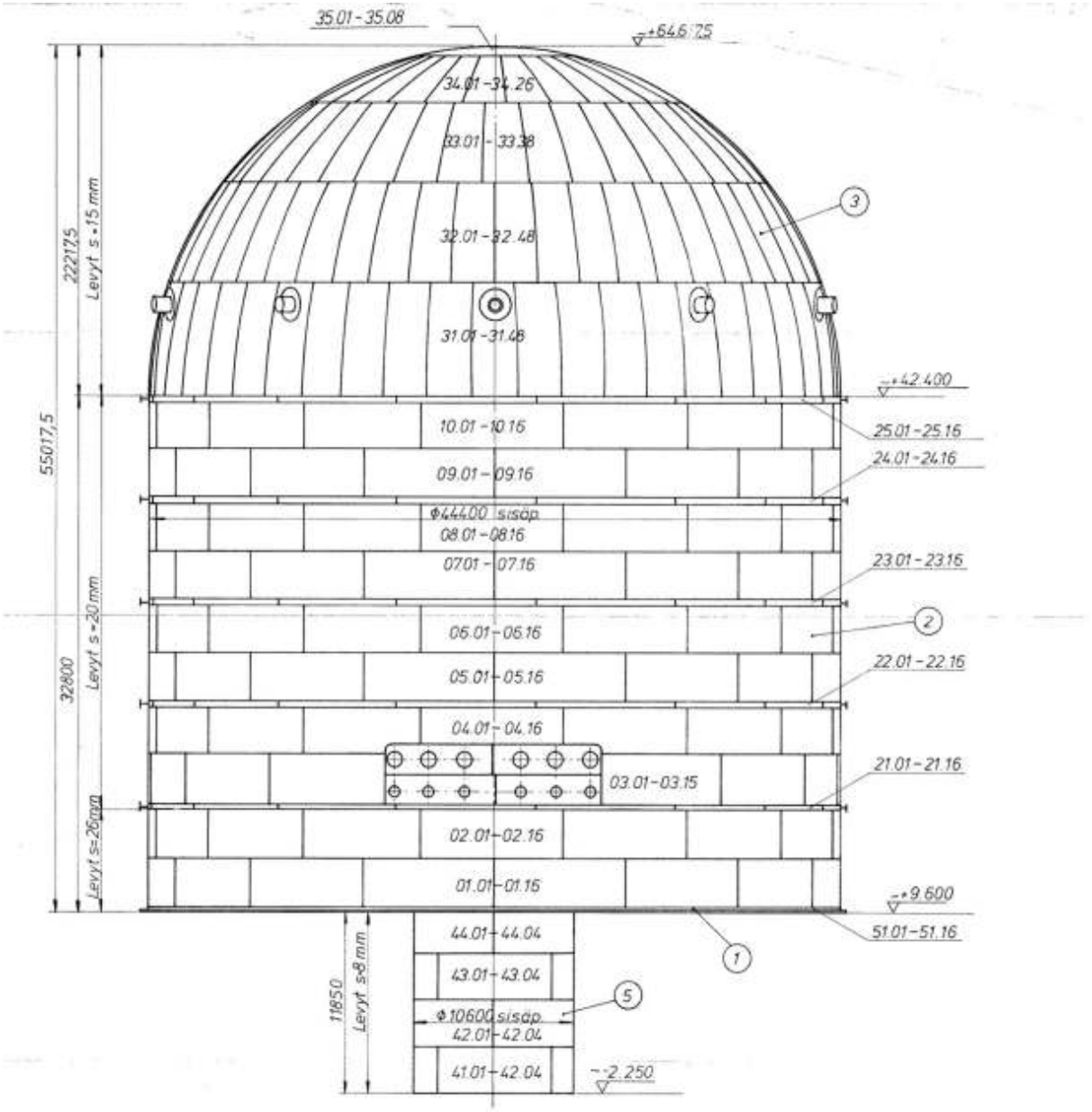

Figure 1. Steel containment assembly drawing

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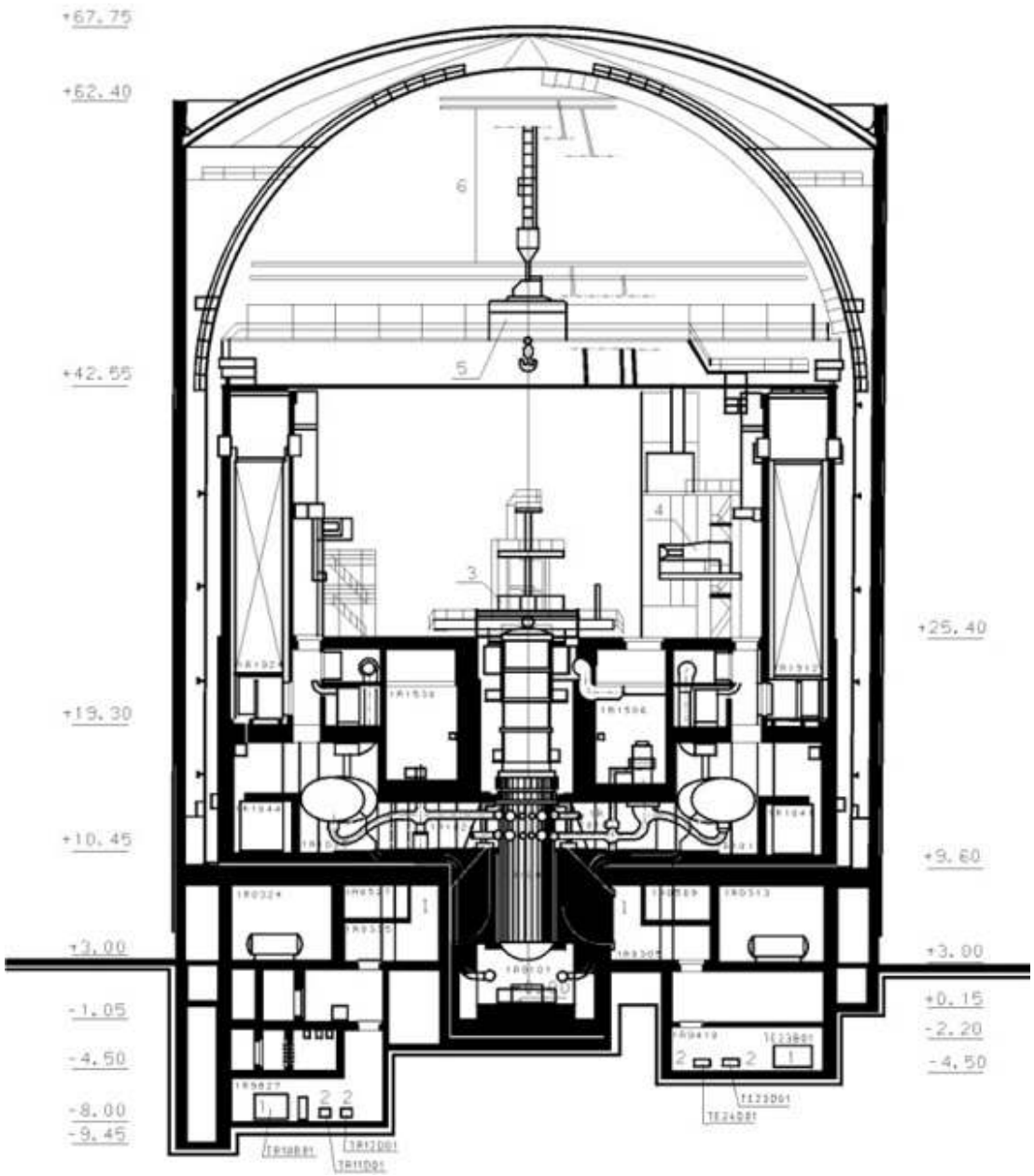

Figure 2. Reactor building section

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3. STRUCTURAL LOADS

DESIGN CONDITION	
Design Internal Pressure P_D	0.70 kp/cm^2
Design Temperature T_D	70 °C
Design External Pressure Pc	0.035kp/cm^2
TEST CONDITION (Pneumatic Test)	
Test Pressure P_T	0.875 kp/cm^2
Test Temperature T_T	0 ^{o}C
MAXIMUM OPERATING CONDITION	
Max. internal pressure $P_{MA.X}$	0.70 kp/cm^2
Max. wall temperature T_{MAX}	70 ^{o}C

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4. STRUCTURAL MODELING

STRENGTH PROPERTIES OF STEEL SHEET MATERIAL

QUALITY CLASSES	Thickness mm	σ_B kp/mm^2	σ_{SU} kp/mm^2	σ_{SO} kp/mm^2	δ_5 %	Charpy test		Bending test 180° Φ
						T °C	KV kpm	
RAEX 383 P RAEX 384 P RAEX 385 P	5-60	52–62	36	38	22	0 -20 -40	2.8 2.8 2.8	2a

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Anchor bolt material properties

TEMP.	Y.S.	Sm	E	alfa	Cp	lambda
°C	kp/cm^2	kp/cm^2	kp/cm^2	$cm/cm°C$	$J/kg°C$	$W/m°C$
-40	-	-	-	-	-	-
-20	-	-	-	-	-	-
0	-	-	-	-	-	-
+20	7382	1758	$2.1x10^6$	$1.11x10^{-5}$	488	50.0
+40	-	1758	$2.08x10^6$	$1.12x10^{-5}$	-	49.1
+60	-	1758	$2.06x10^6$	$1.13x10^{-5}$	-	48.2
+80	-	1758	$2.04x10^6$	$1.14x10^{-5}$	-	47.4
+100	-	1758	$2.02x10^6$	$1.15x10^{-5}$	-	46.5

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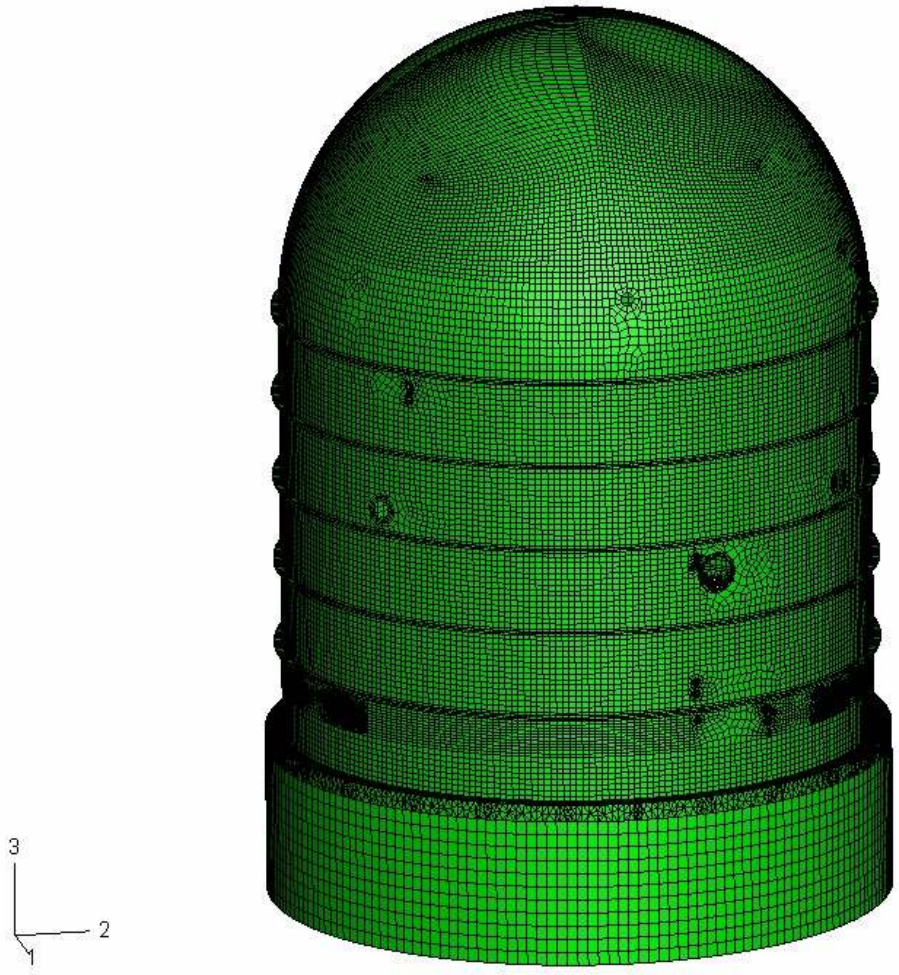

Figure 3 The finite element model of the containment building

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5. RESULTS

The limit capacity of anchor bolts in Abaqus analysis was 0.5 MN/m^2 of internal overpressure, and 185 ^{o}C of internal temperature. In that case the most stressed bolt had been reached the yield stress of 700 MN/m^2 and the tension of the least stressed bolt was 662 MN/m^2.

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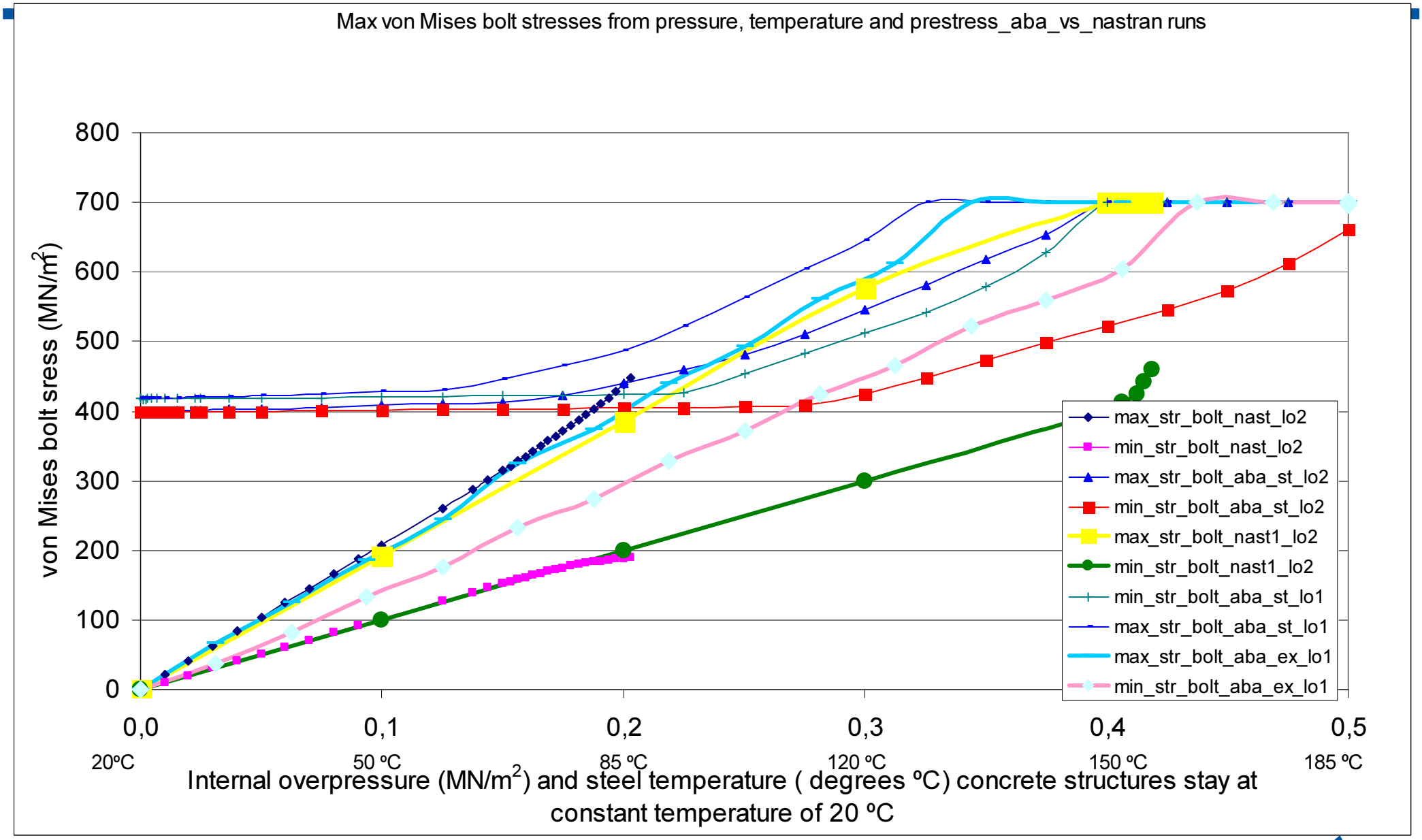

Fig 4 Anchor bolt stress histories

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Capacity check according to ASME

Load case	Pressure/ temperature [bar]/[°C]	Calculated bolt force [kN]	Calculated stress [MPa]	Allowable stress [MPa]	Required min. bolt area [mm^2]	% from orig. cross-section area
Normal- and test loads (mechanical)	0.858/20	297.4	195.6	283.8	1048	69%
Bolt pre-stress	0.0/20	637	419	602	1058	70%
Design Basis Accident-situation(mech.)	0.7/70	248.6	163.5	430	578	38%
Serious reactor accidents	2.25/70	713	469.1	686	1040	68%

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8. CONCLUSION

One can conclude from the results that the limit capacity of the anchor bolts with respect to the containment steel shell can be expressed with the aid of the quotient 0.41785MN/m2/ 0.203125MN/m2 , which equals to 2, in other words the capacity of bolts with respect to the steel shell of the containment is double.

The anchor bolts do not form the weak link of the containment building. Their capacity is twice as large as the capacity of the containment shell steel sheet.

The corrosion allowances that are used in developing the criteria for anchor bolt replacement are deduced with the aid of the results of the performed analysis

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