APPENDIX 23
CONFIGURATION C9

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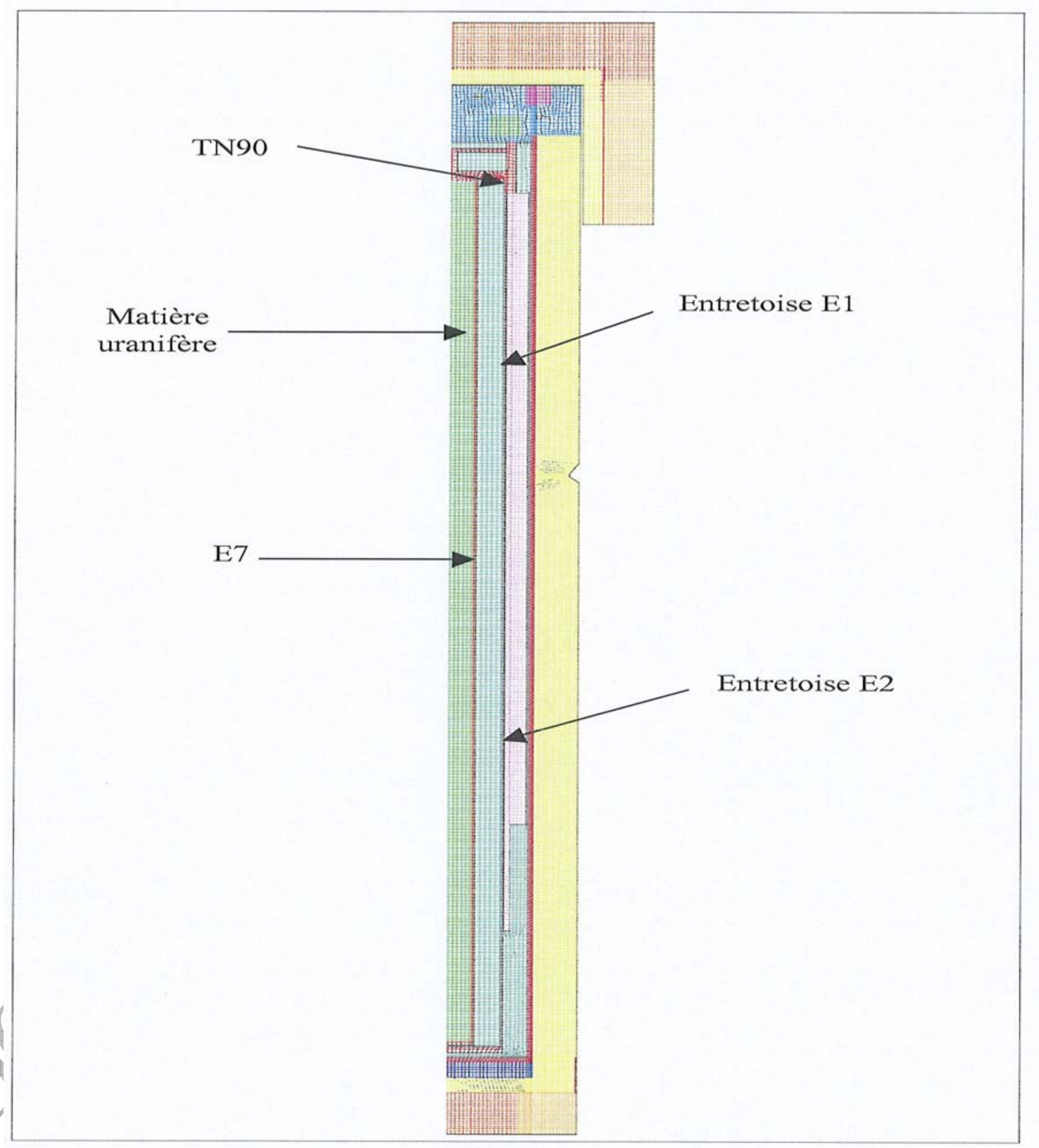
APPENDIX 23

CONFIGURATION C9

PRESENTATION OF MODEL



TN 90	TN 90
Matière uranifère	Uraniferous matter
Entretoise E1	E1 spacer
E7	E7
Entretoise E2	E2 spacer

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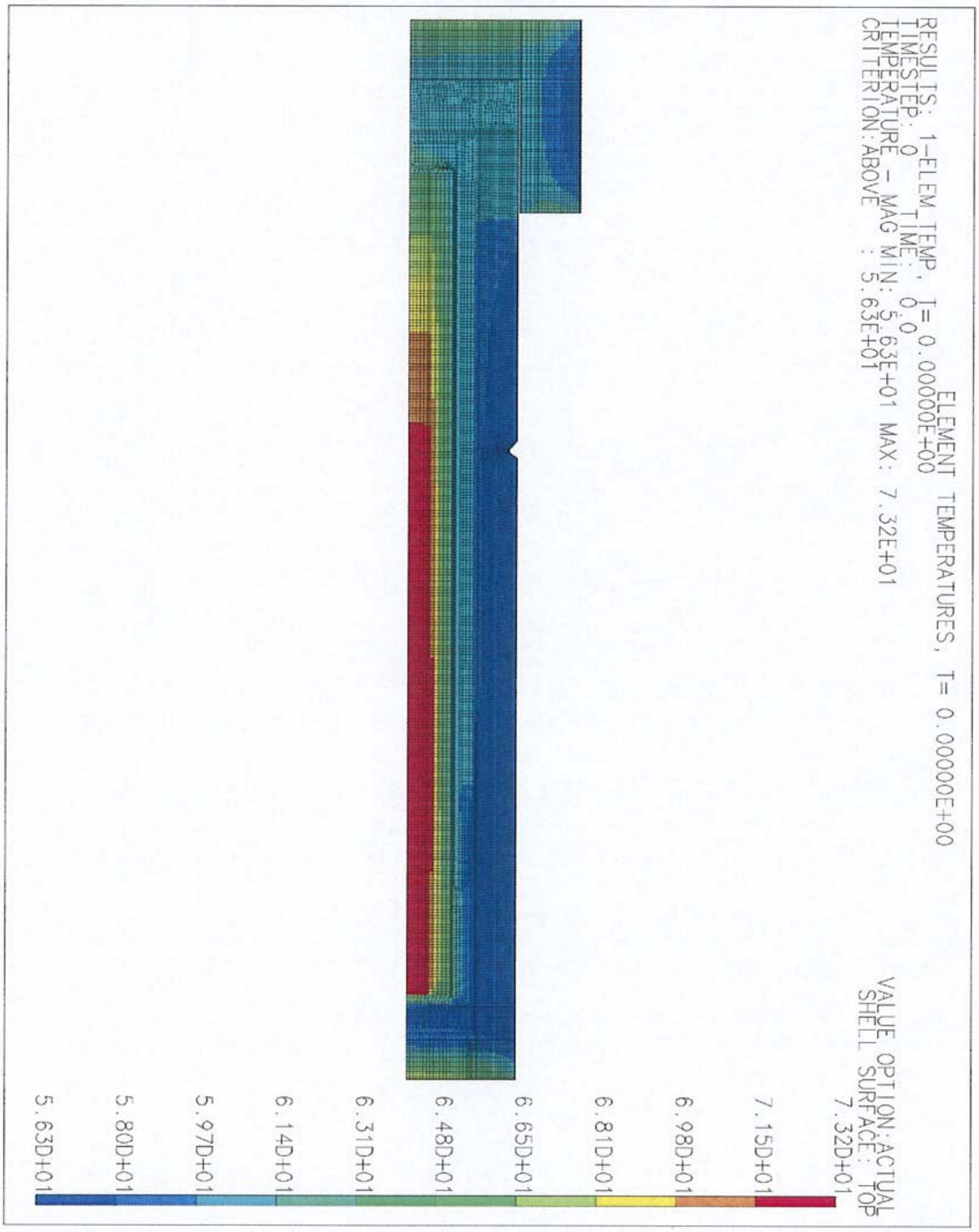
APPENDIX 23

CONFIGURATION C9

ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire



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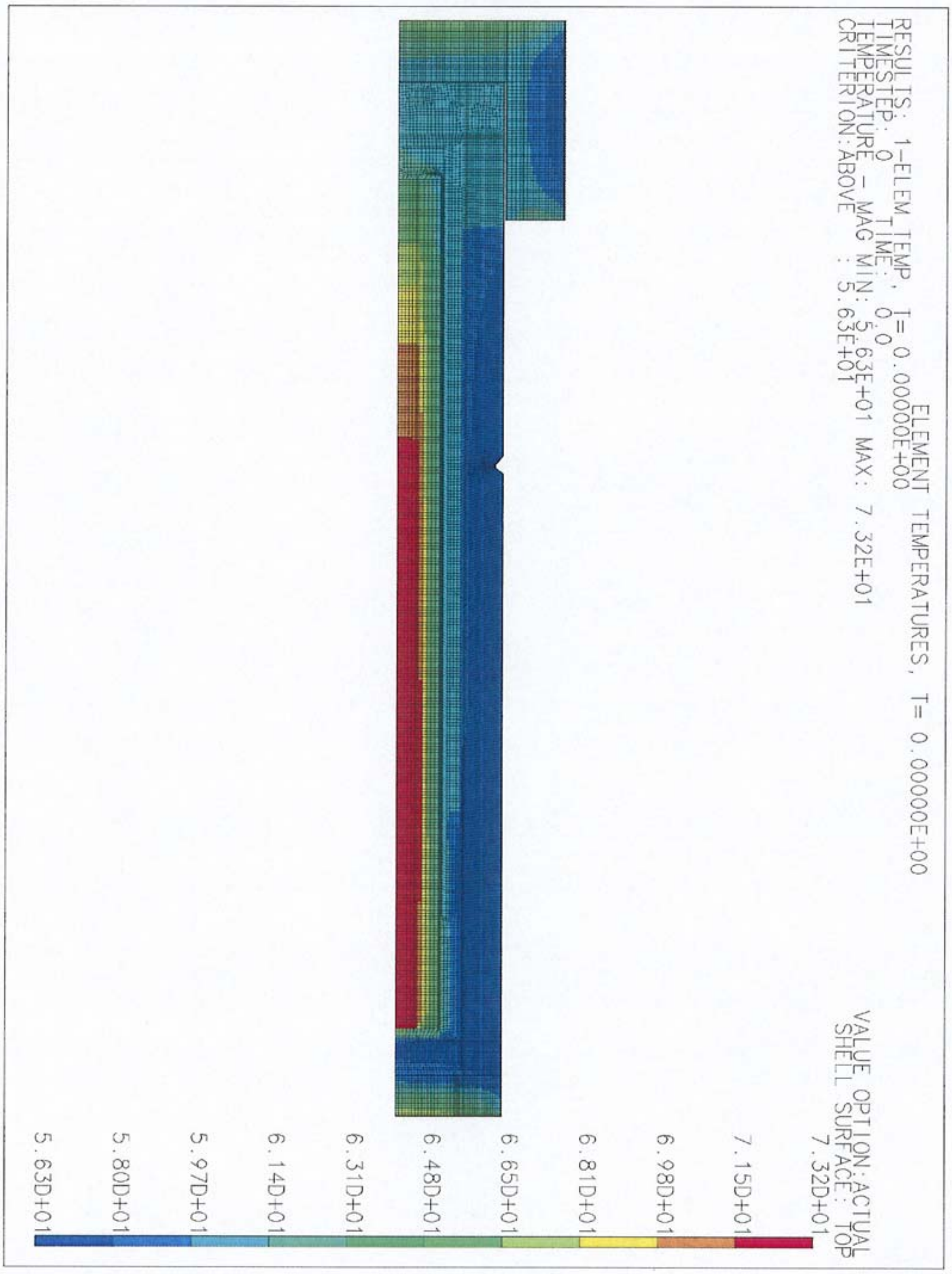
APPENDIX 23

CONFIGURATION C9

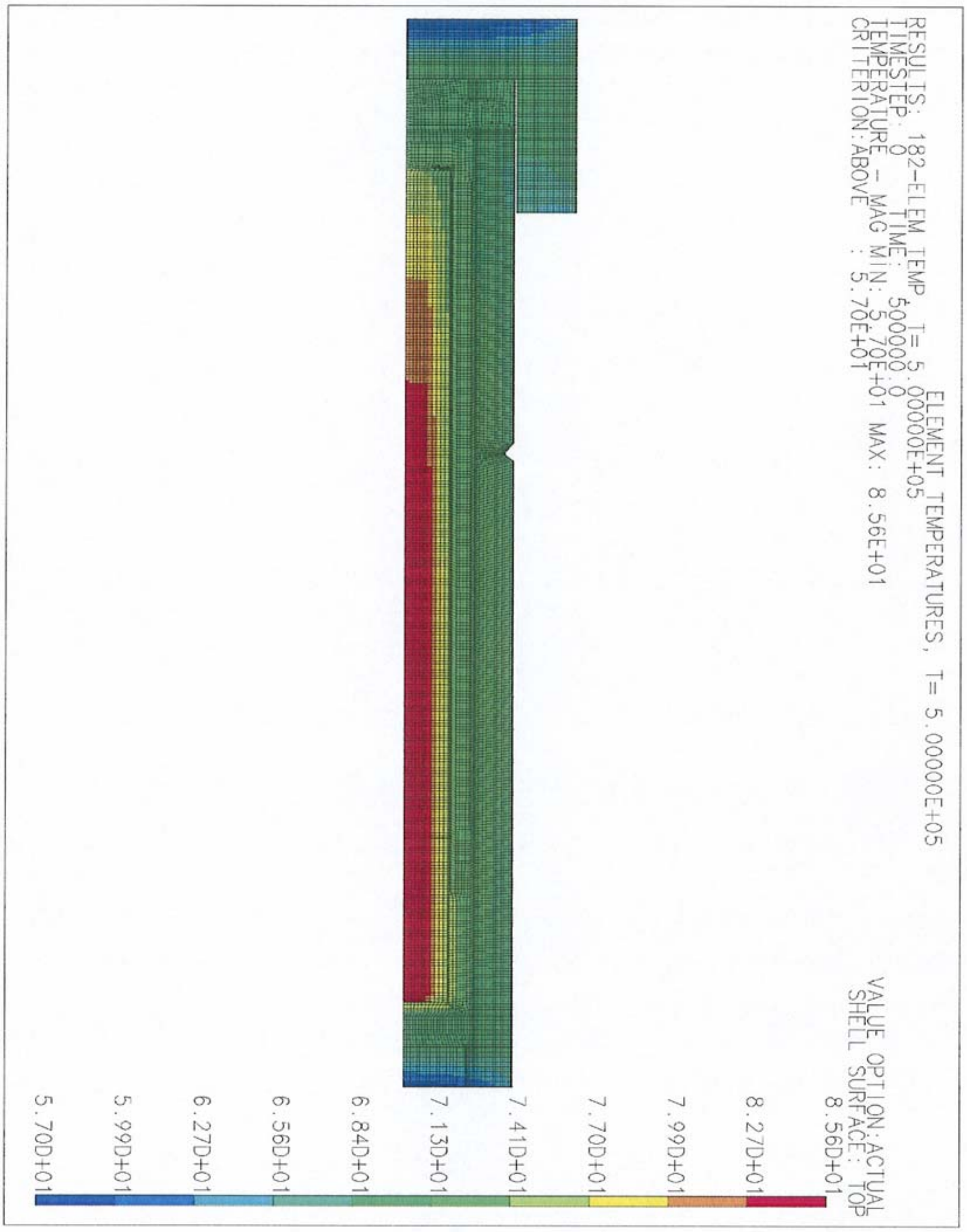
ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 23

CONFIGURATION C9

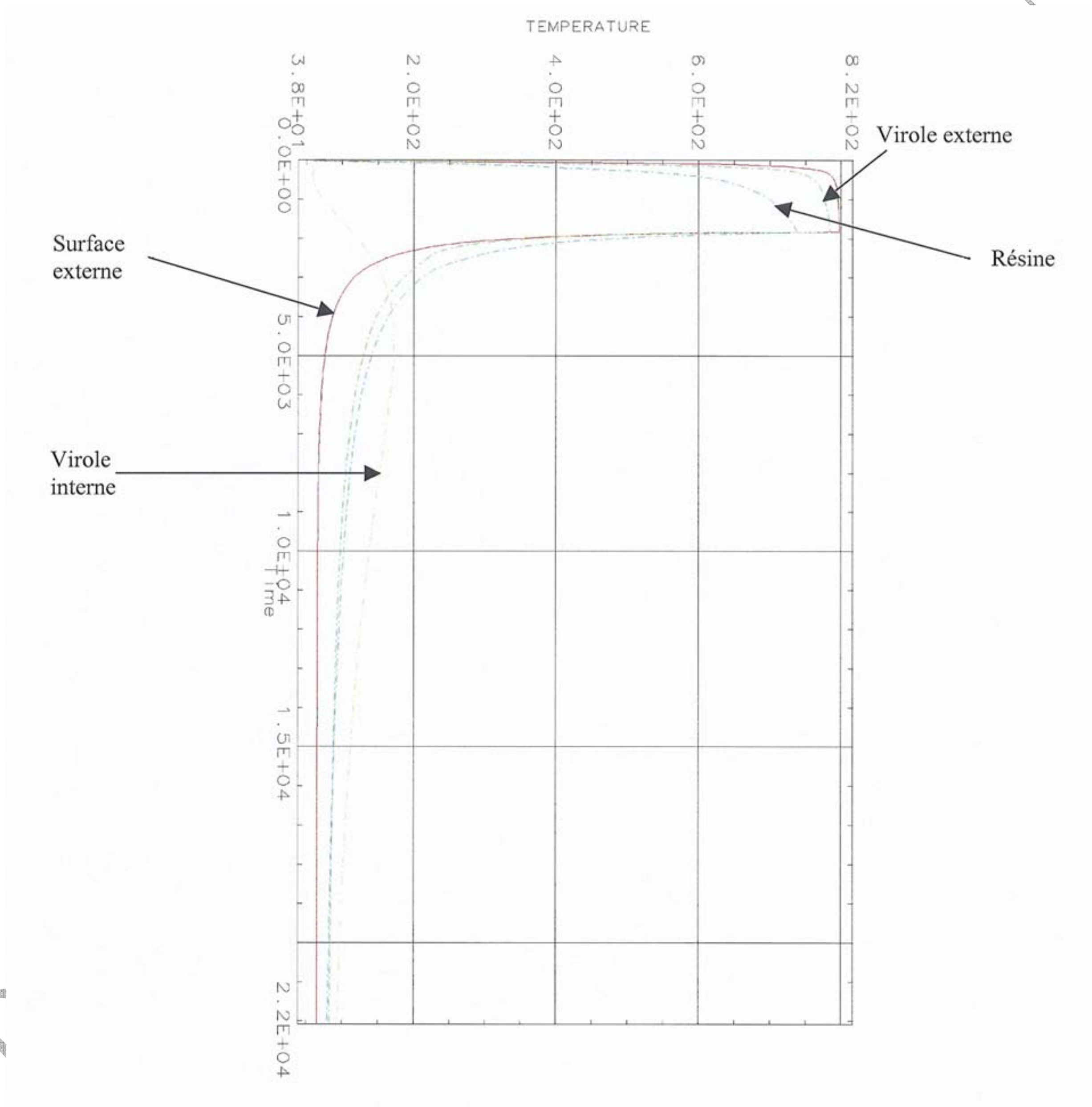
ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



APPENDIX 23

CONFIGURATION C9

PACKAGING TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

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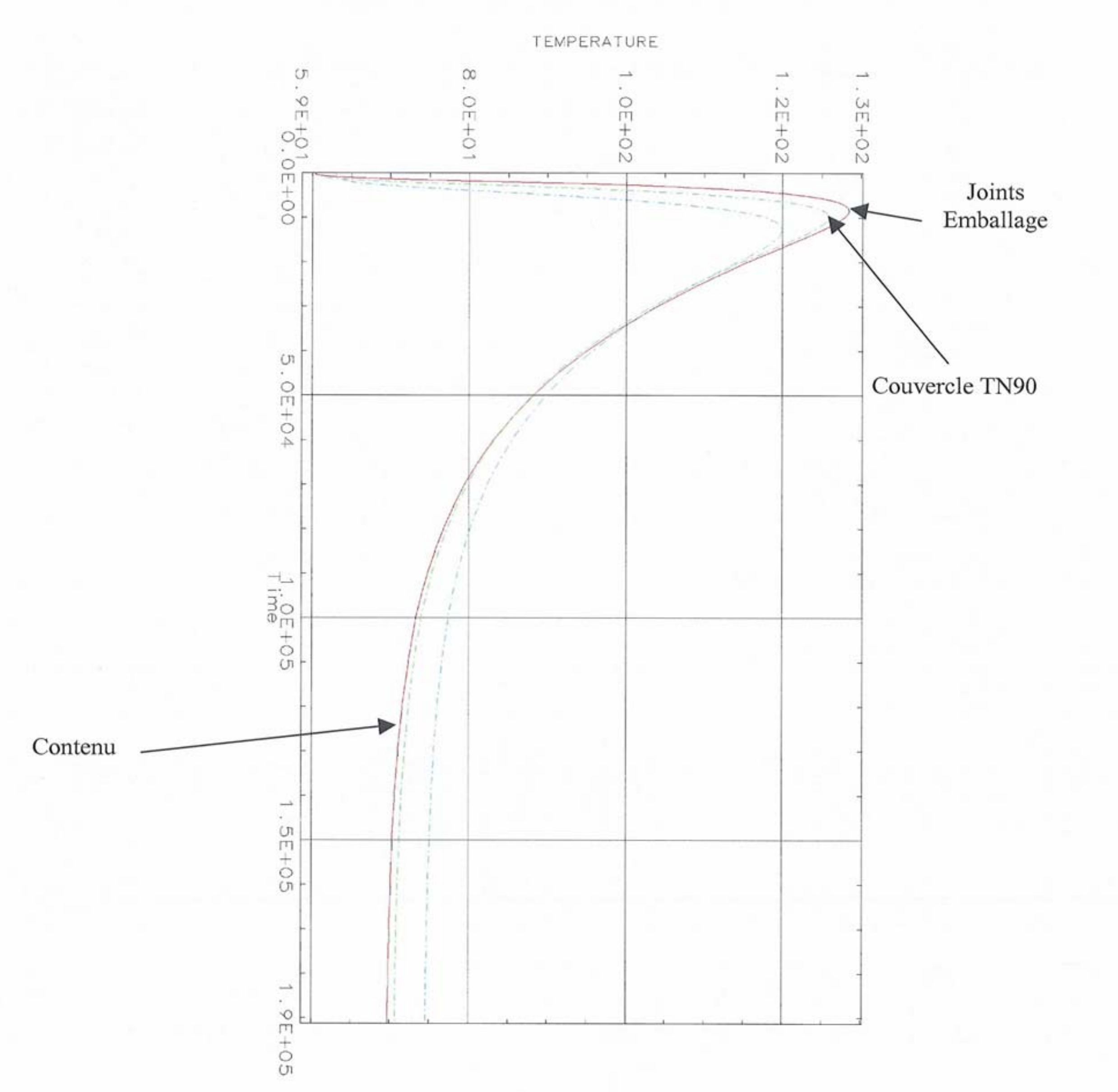
APPENDIX 23

CONFIGURATION C9

SEALS AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Contenu	Contents
Joints Emballage	Packaging seals
Couvercle TN90	TN90 cover

APPENDIX 24
CONFIGURATION C10.1

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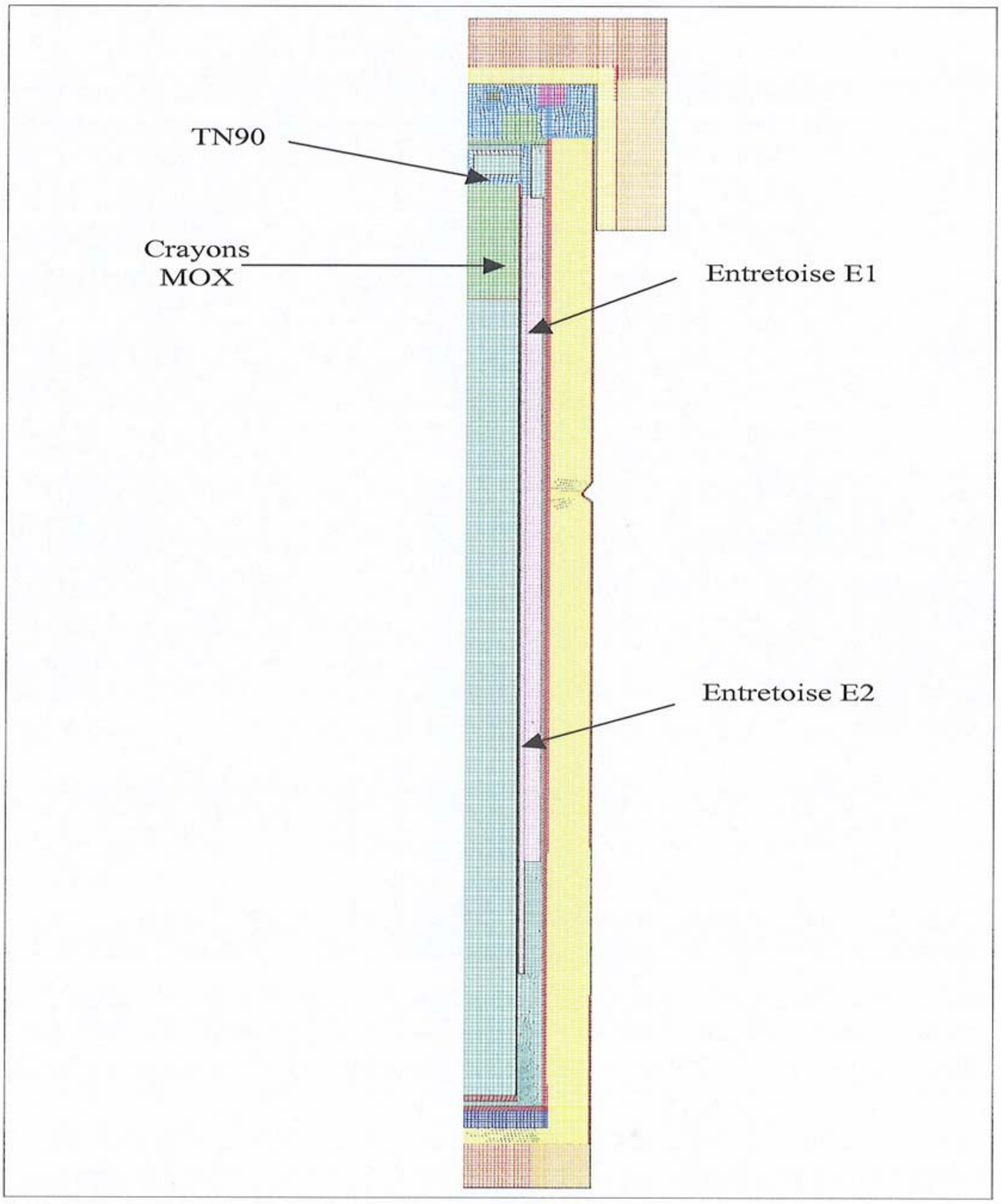
APPENDIX 24

CONFIGURATION C10.1
PRESENTATION OF MODEL



TN 90	TN 90
Crayons MOX	MOX pencils
Entretoise E1	E1 spacer
Entretoise E2	E2 spacer

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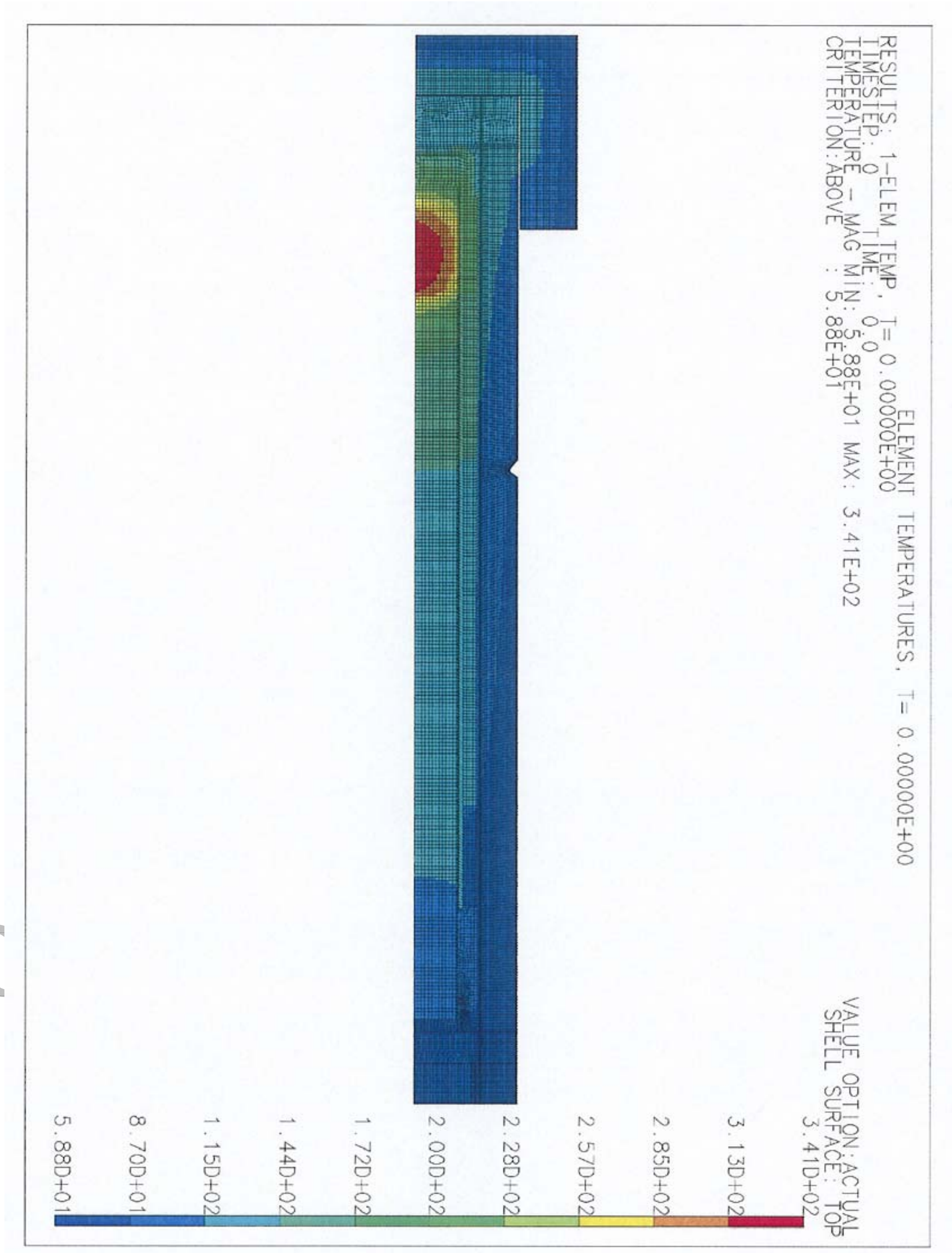
APPENDIX 24

CONFIGURATION C10.1

ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire



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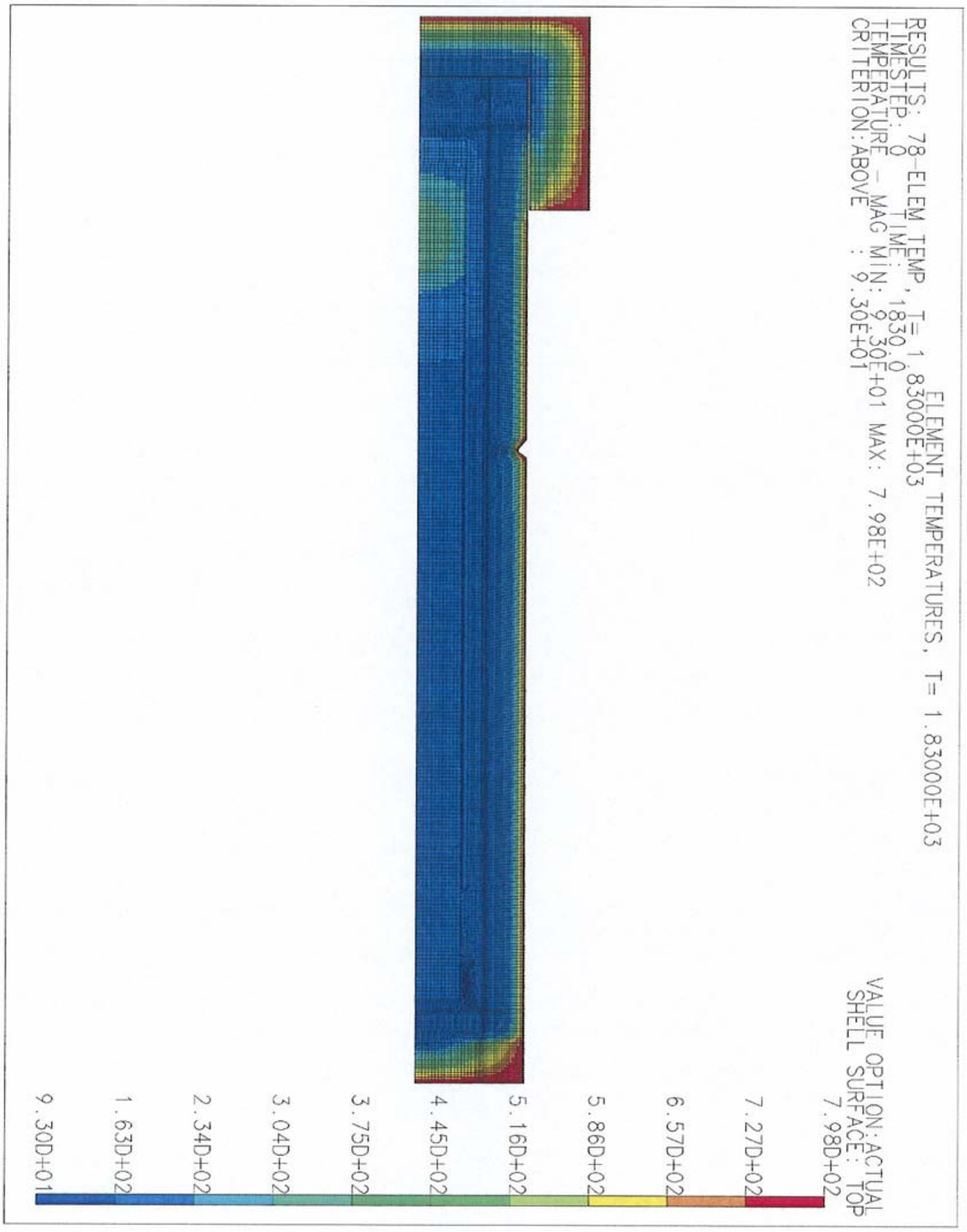
APPENDIX 24

CONFIGURATION C10.1

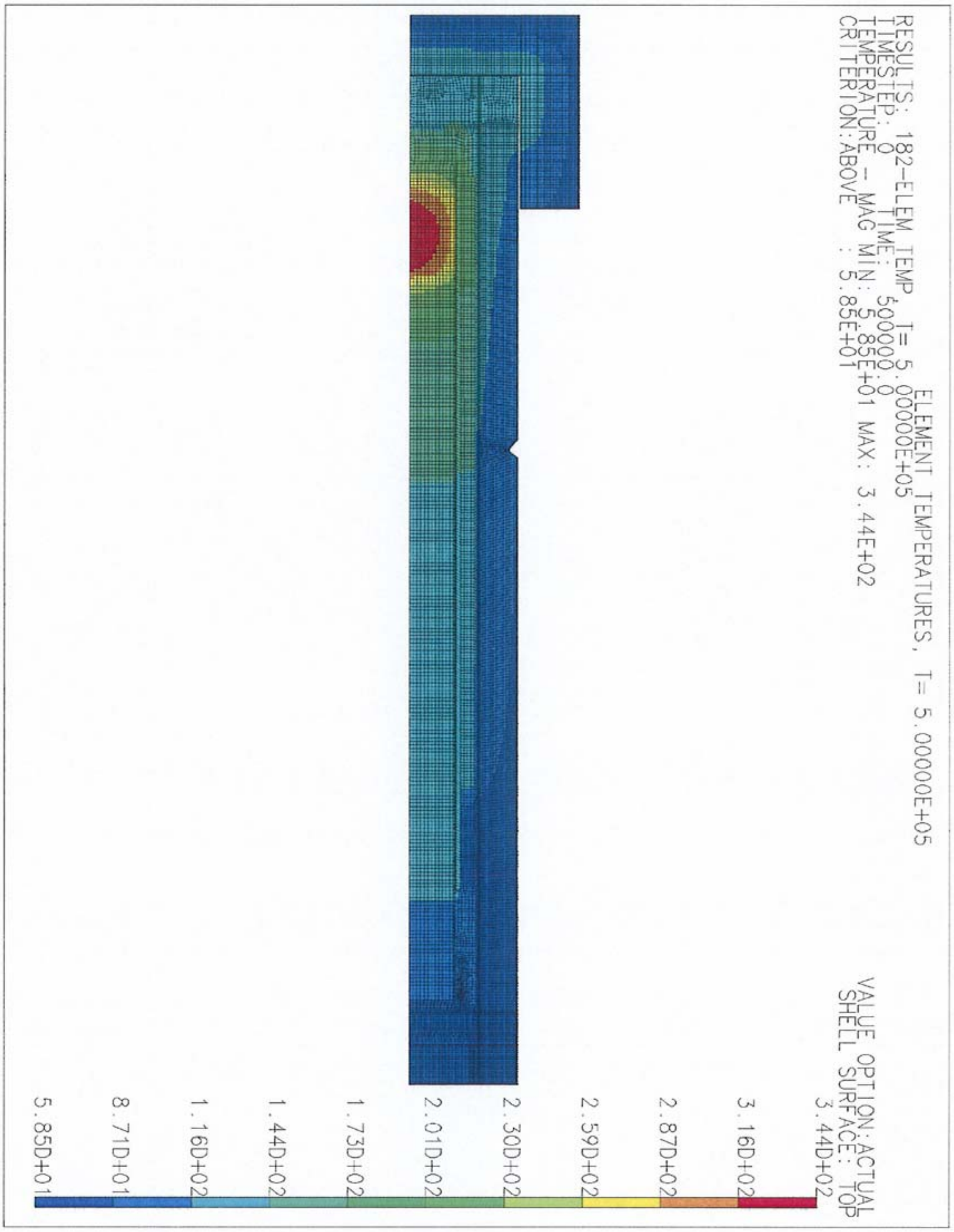
ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 24

CONFIGURATION C10.1

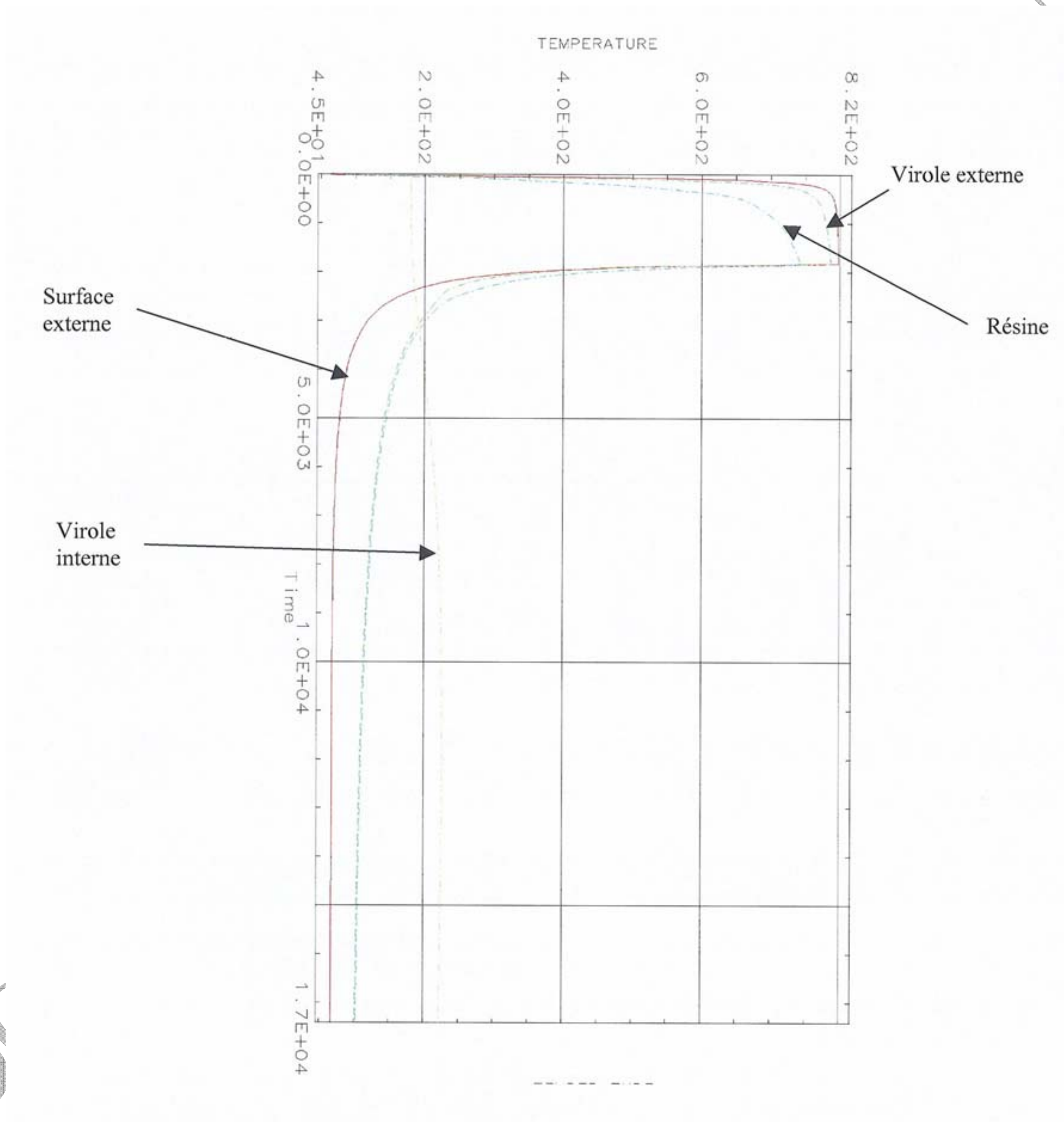
ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



APPENDIX 24

CONFIGURATION C10.1

PACKAGING TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT

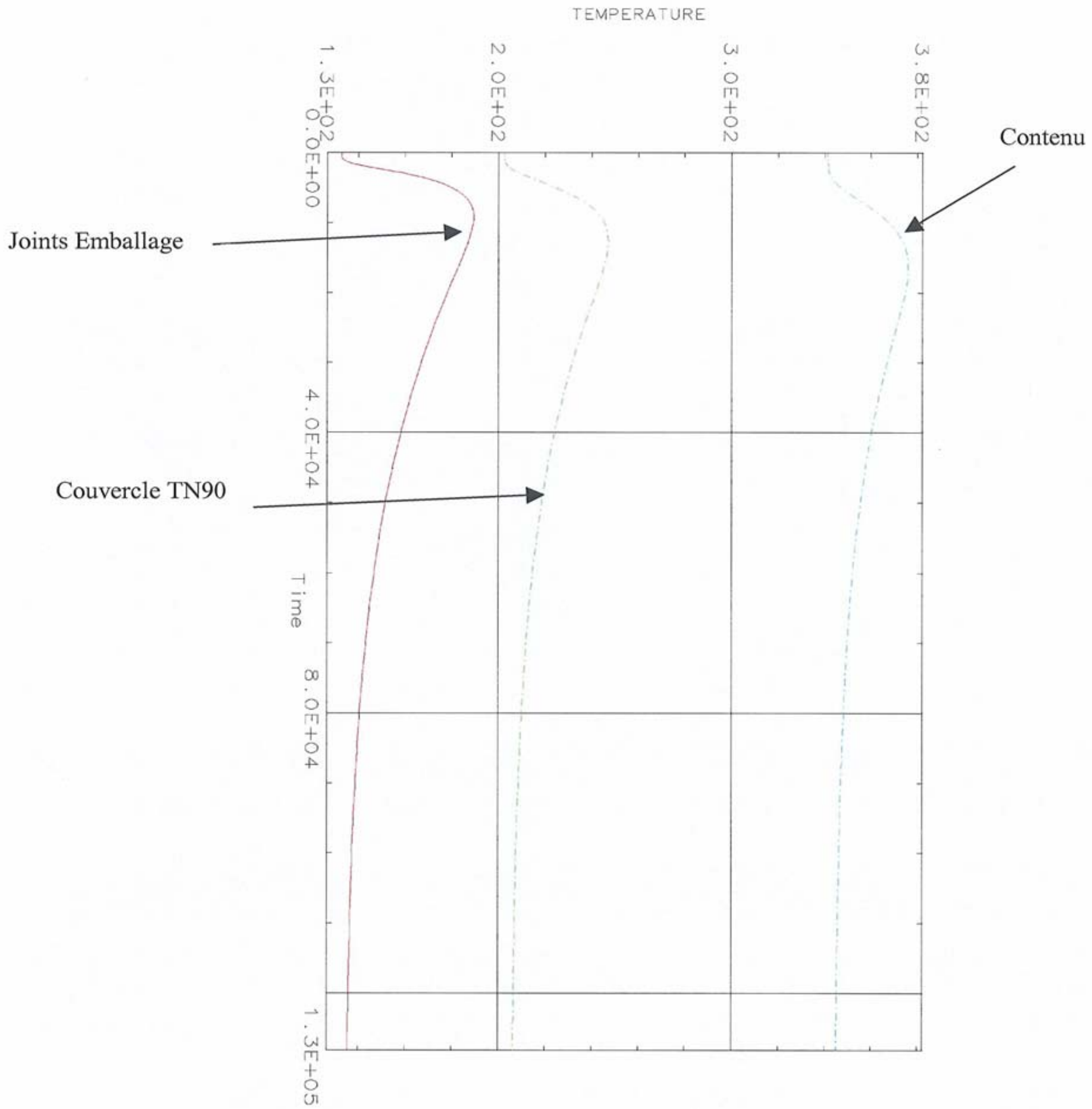


Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

APPENDIX 24

CONFIGURATION C10.1

SEALS AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Contenu	Contents
Joints Emballage	Packaging seals
Couvercle TN90	TN90 cover

APPENDIX 25
CONFIGURATION C10.2

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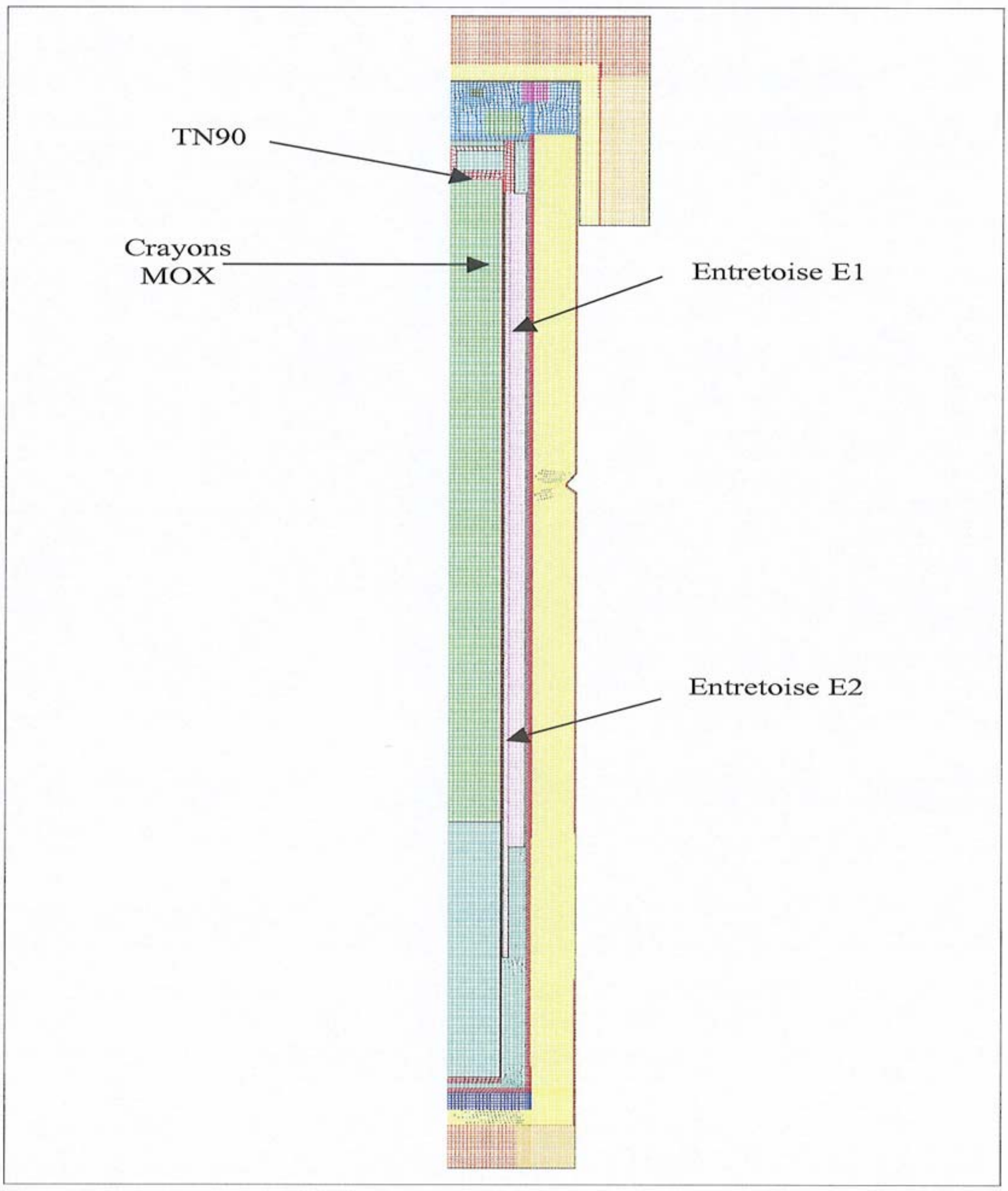
APPENDIX 25

CONFIGURATION C10.2
PRESENTATION OF MODEL

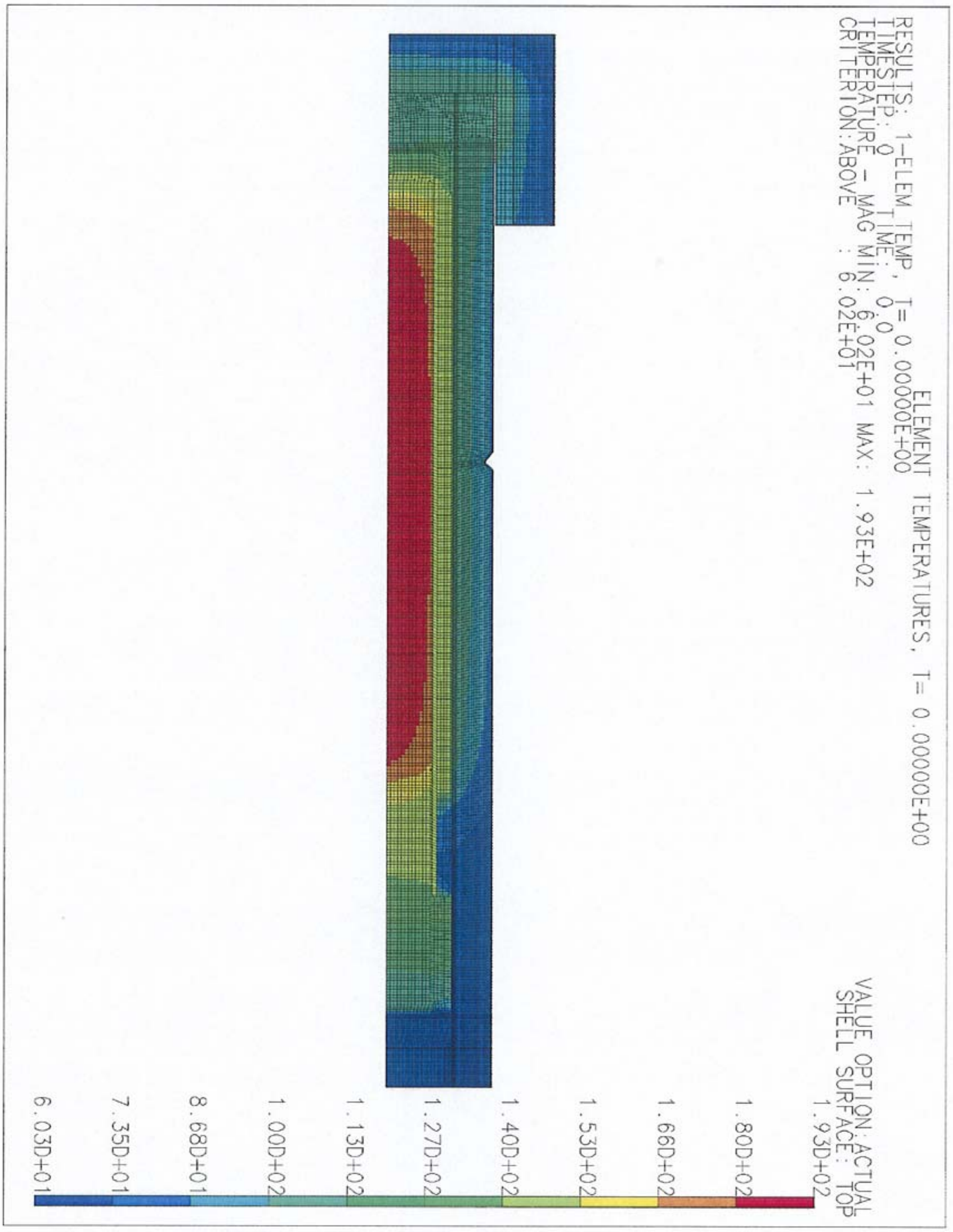


TN90	TN90
Crayons MOX	MOX pencils
Entretoise E1	E1 spacer
Entretoise E2	E2 spacer

APPENDIX 25

CONFIGURATION C10.2

ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire



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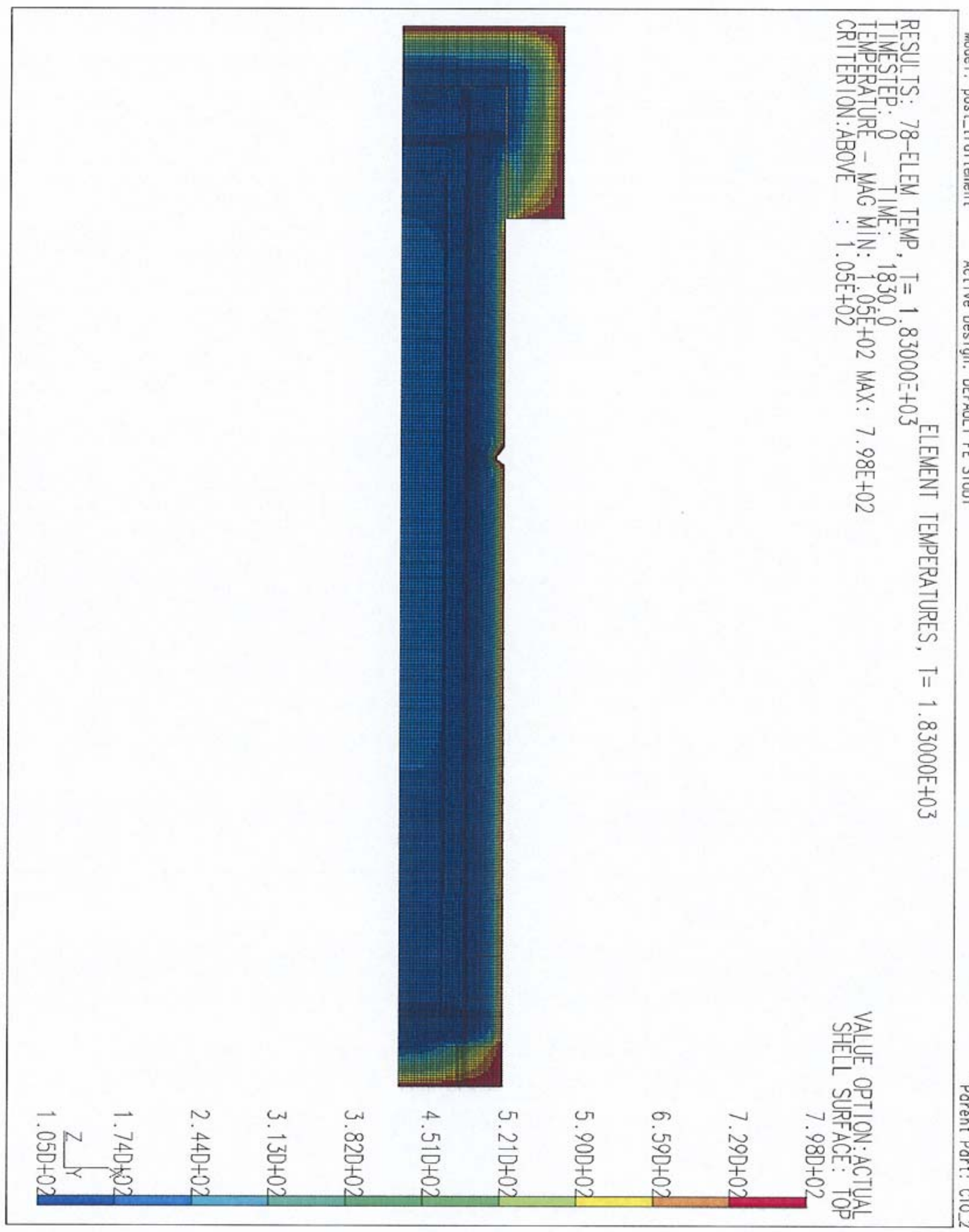
APPENDIX 25

CONFIGURATION C10.2

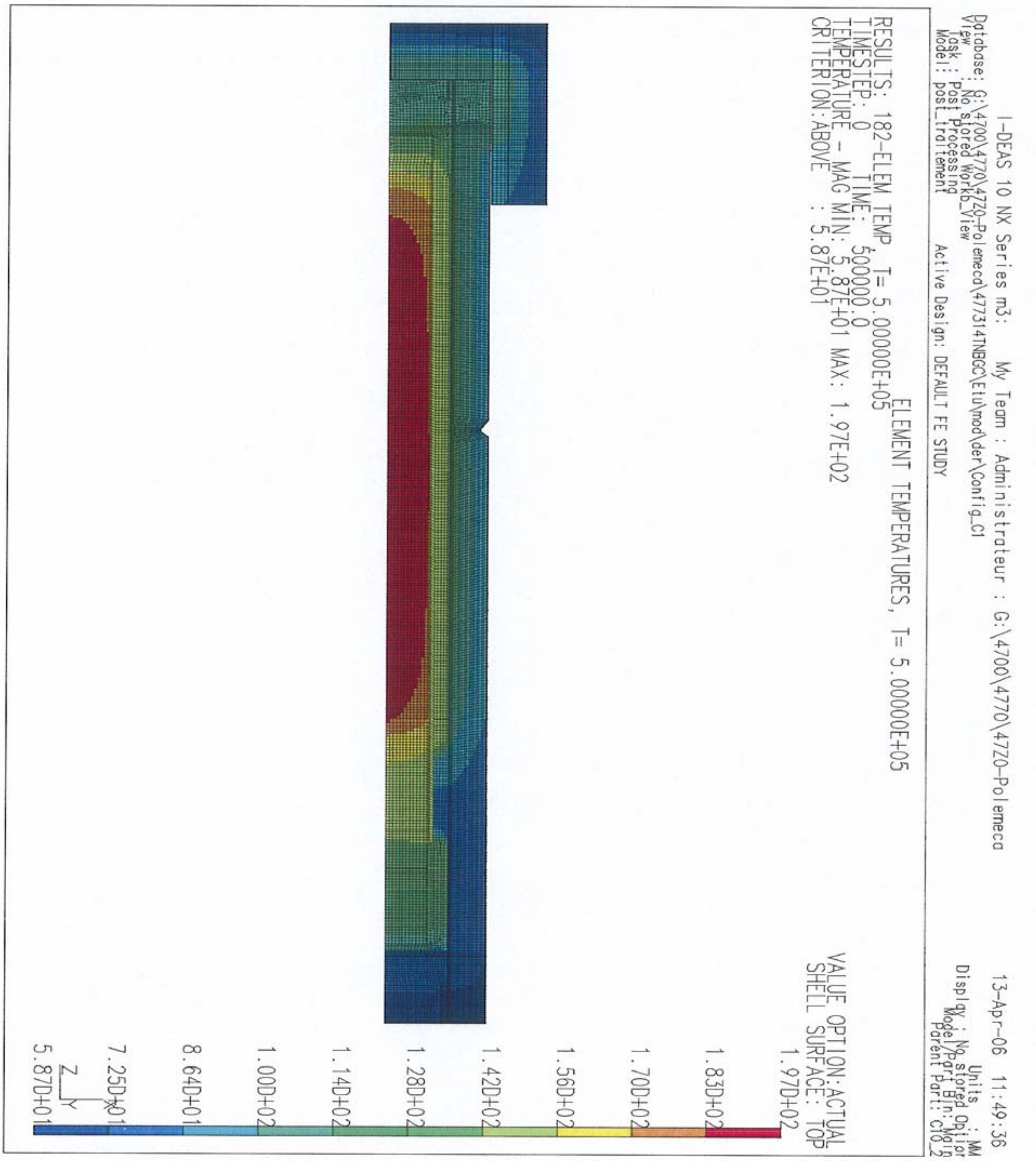
ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 25

CONFIGURATION C10.2

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



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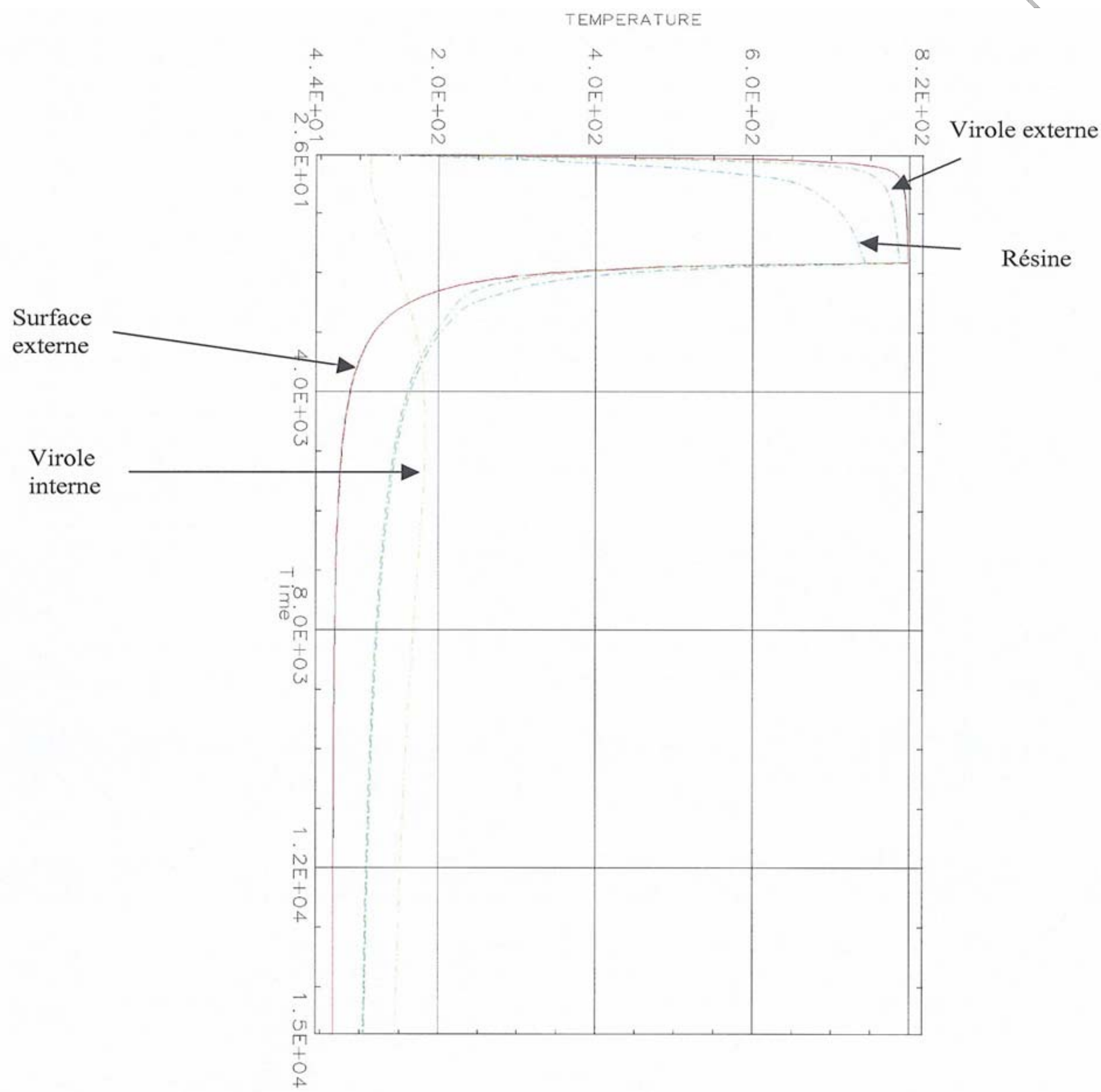
APPENDIX 25

CONFIGURATION C10.2

PACKAGING TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT

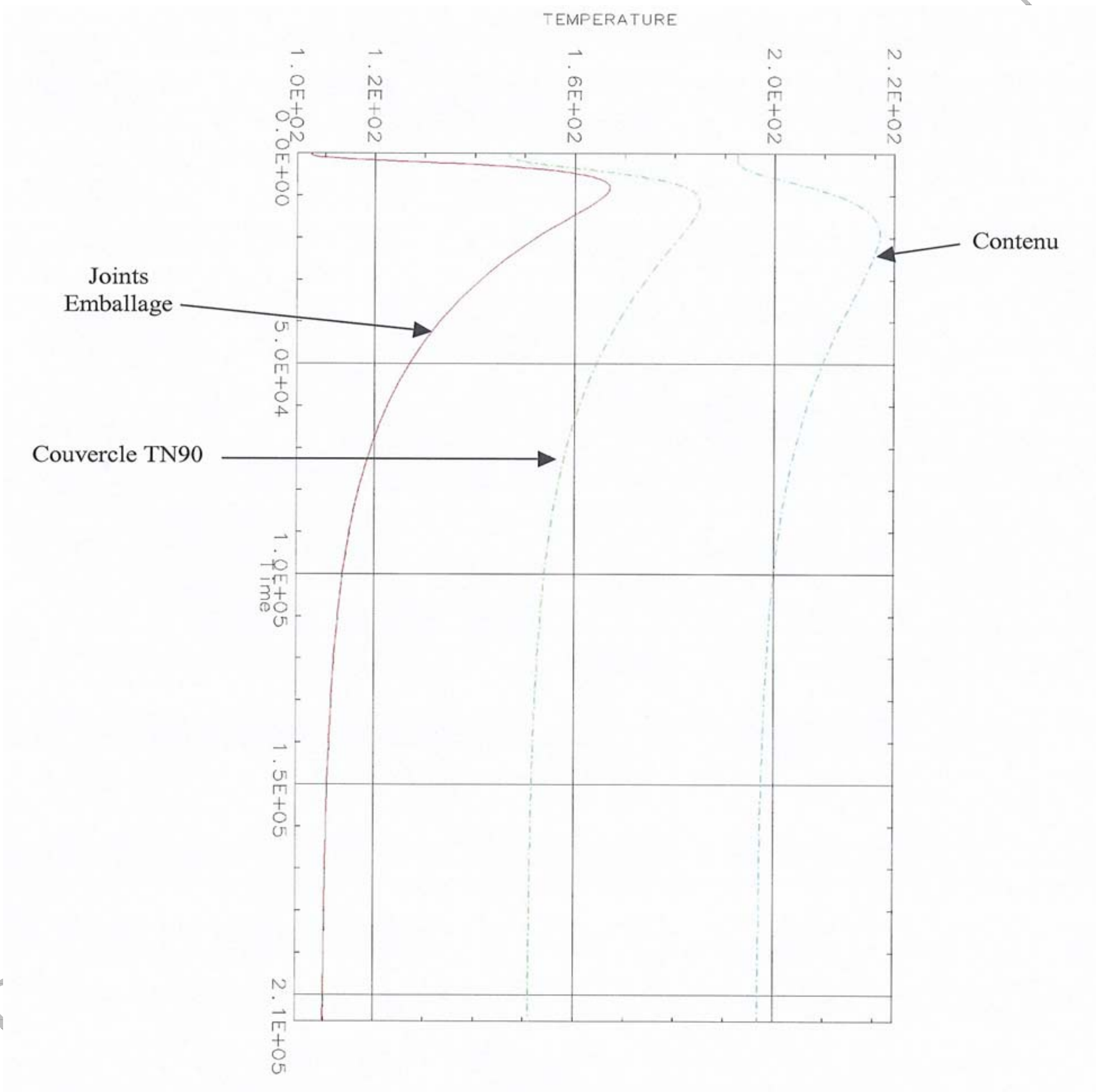


Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

APPENDIX 25

CONFIGURATION C10.2

SEALS AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT

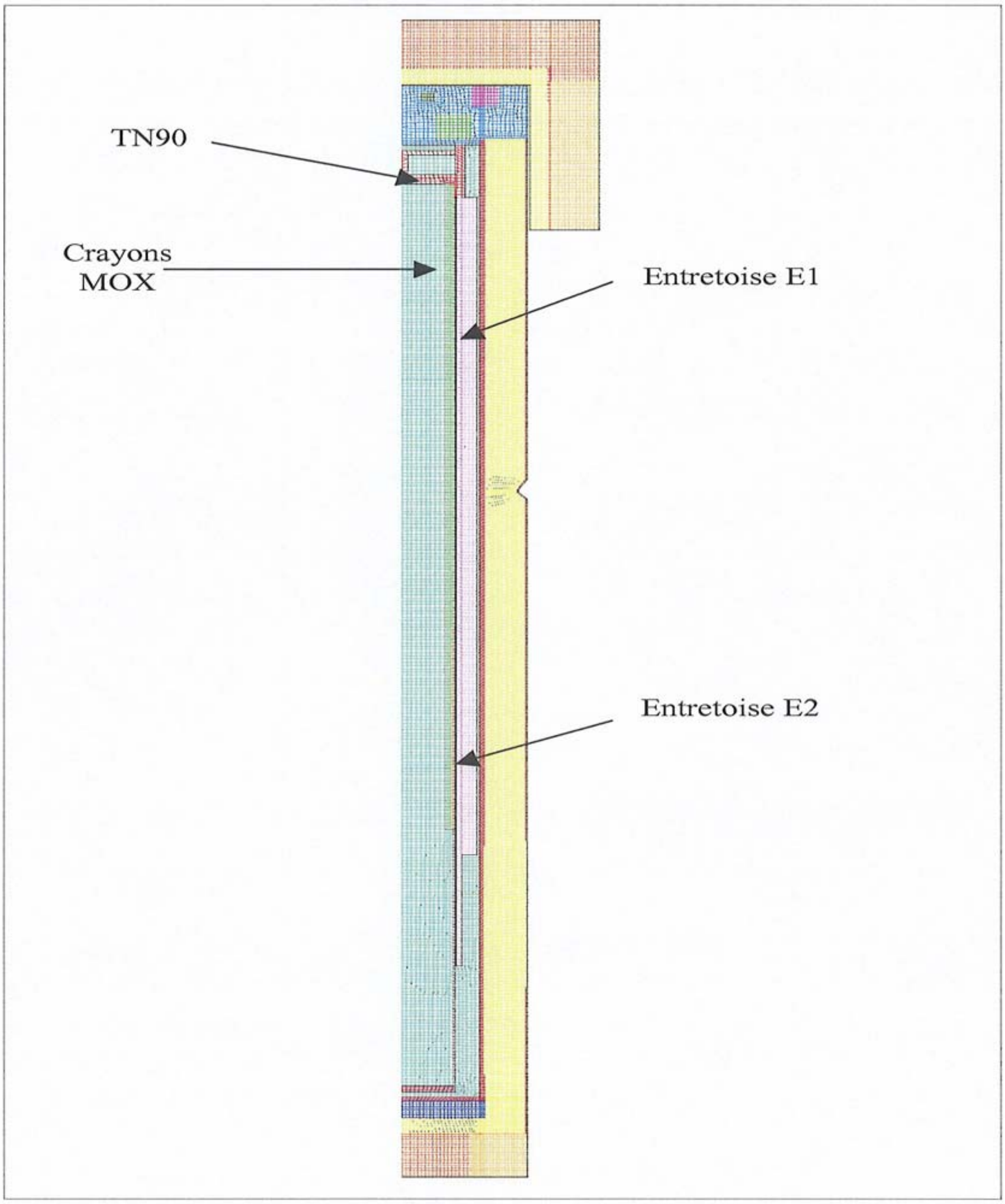


Contenu	Contents
Joints Emballage	Packaging seals
Couvercle TN90	TN90 cover

APPENDIX 26
CONFIGURATION C10.3

APPENDIX 26

CONFIGURATION C10.3
PRESENTATION OF MODEL



TN 90	TN 90
Crayons MOX	MOX pencils
Entretoise E1	E1 spacer
Entretoise E2	E2 spacer

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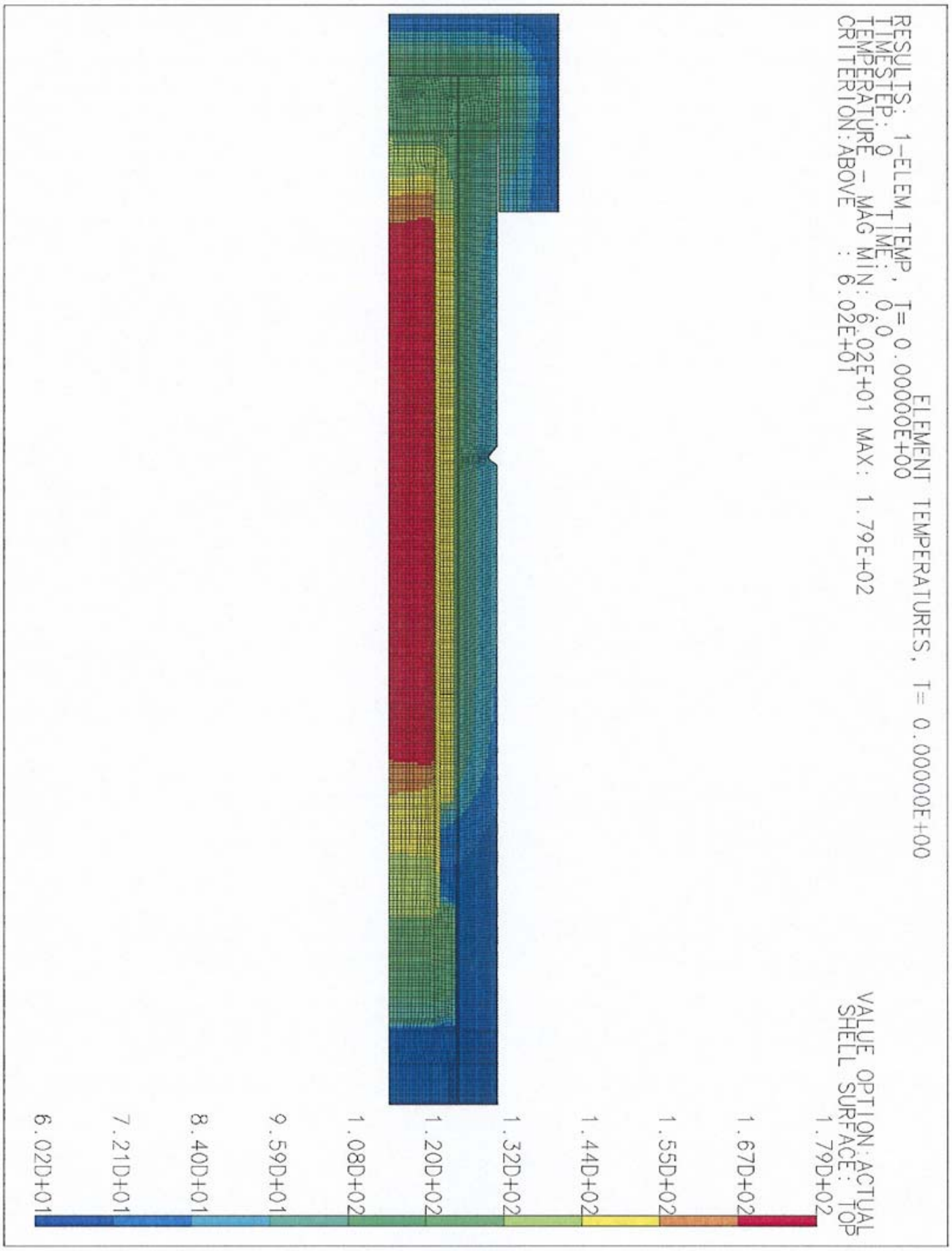
APPENDIX 26

CONFIGURATION C10.3

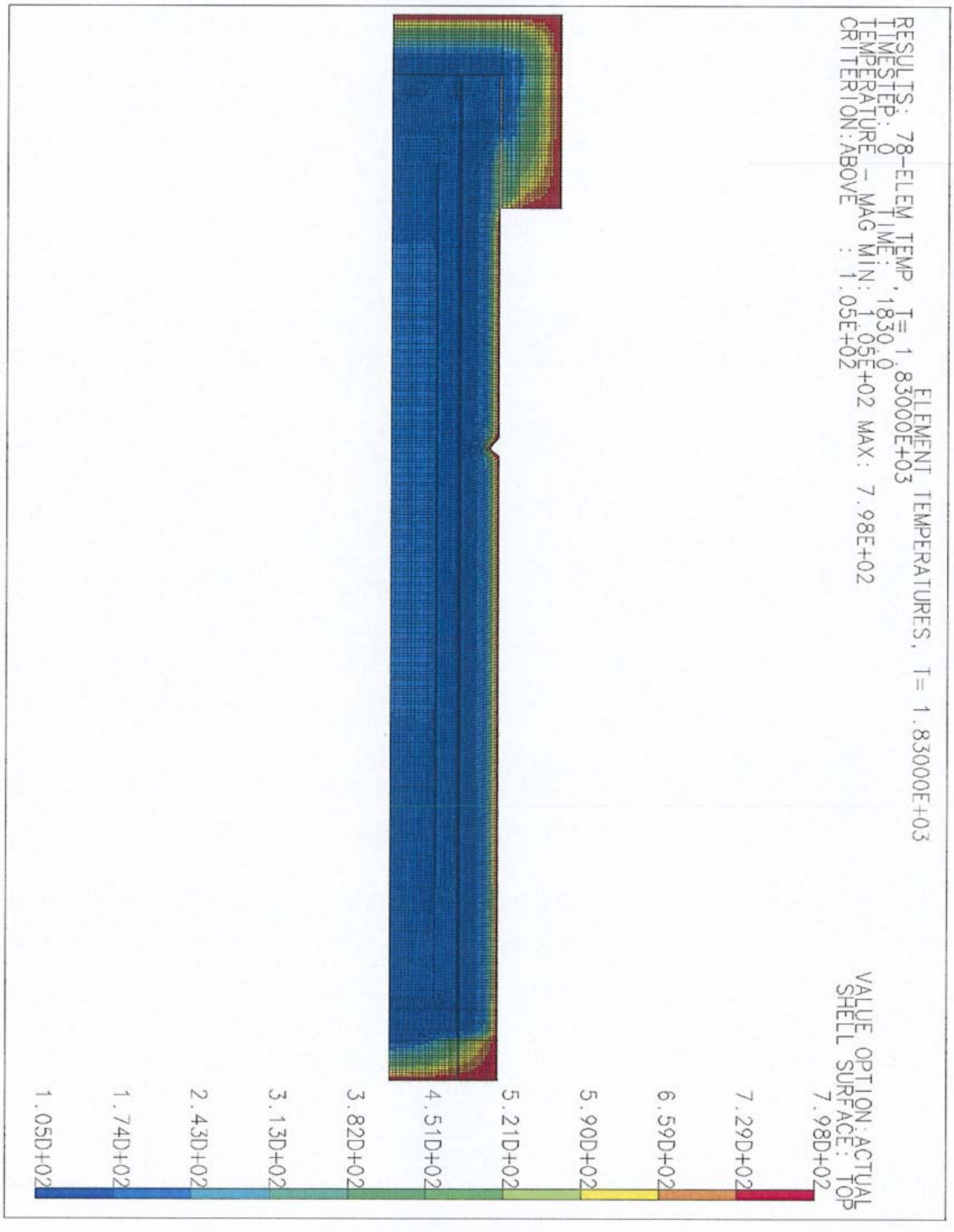
ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire



APPENDIX 26

CONFIGURATION C10.3

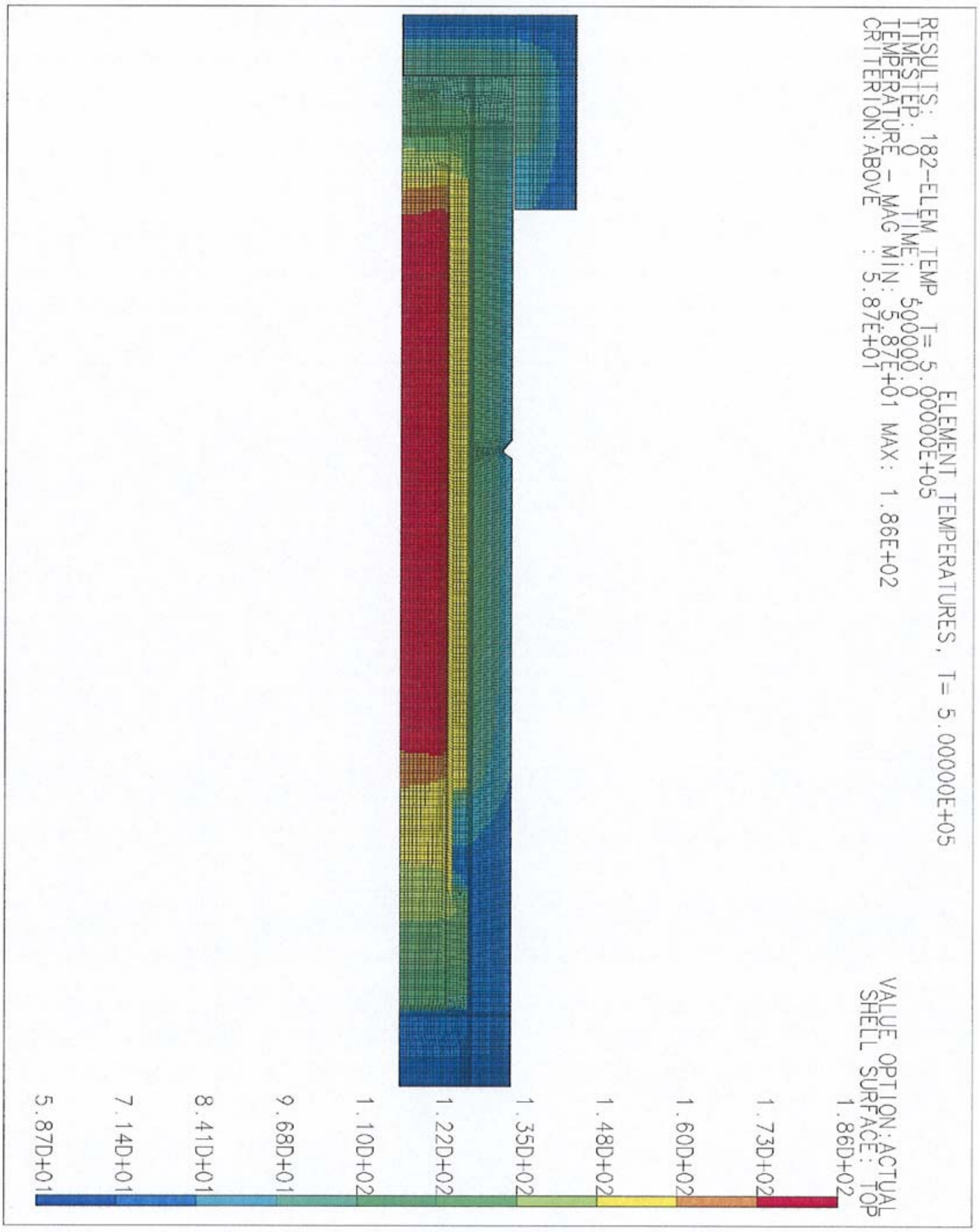
ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 26

CONFIGURATION C10.3

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



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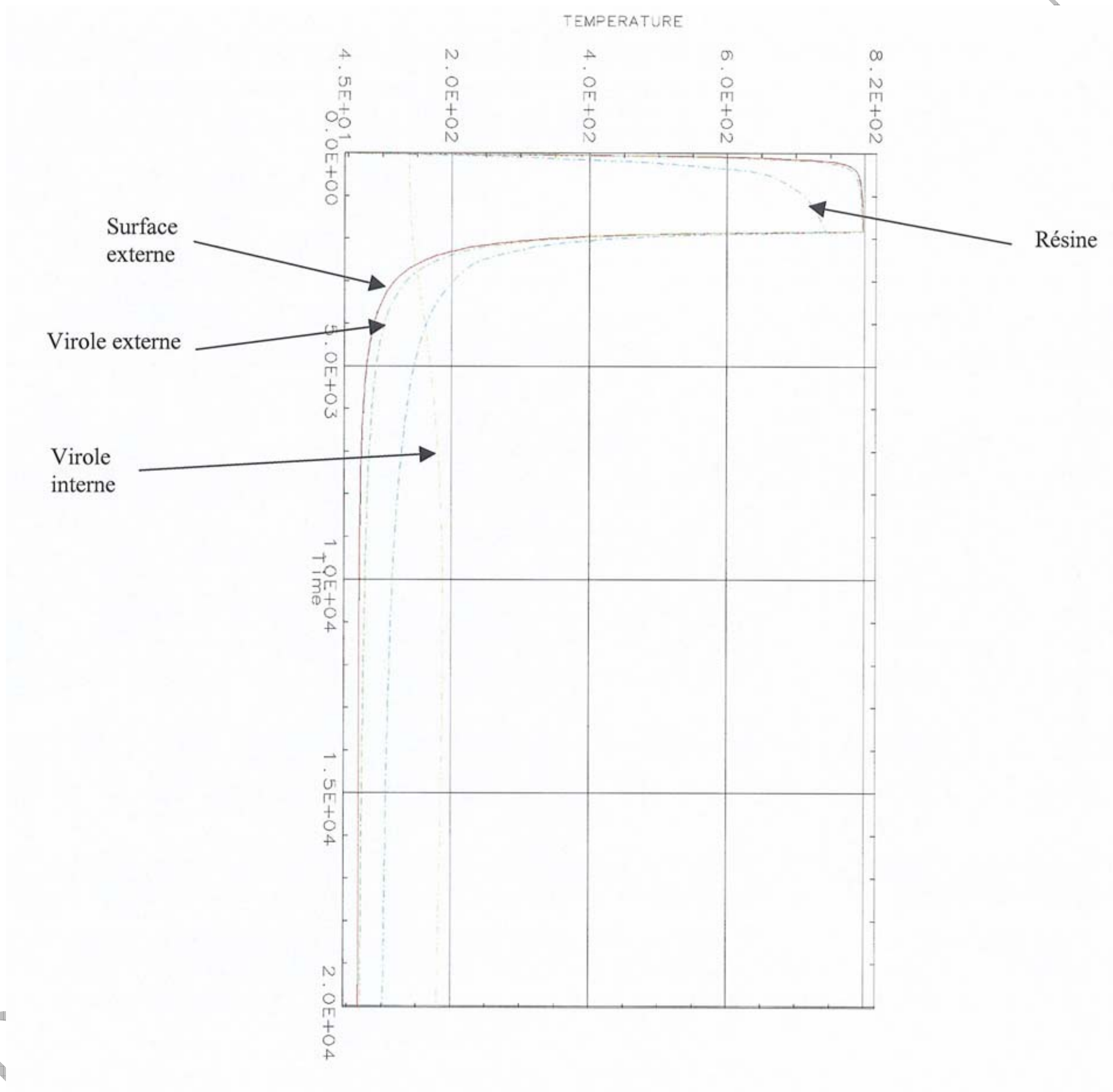
APPENDIX 26

CONFIGURATION C10.3

PACKAGING TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

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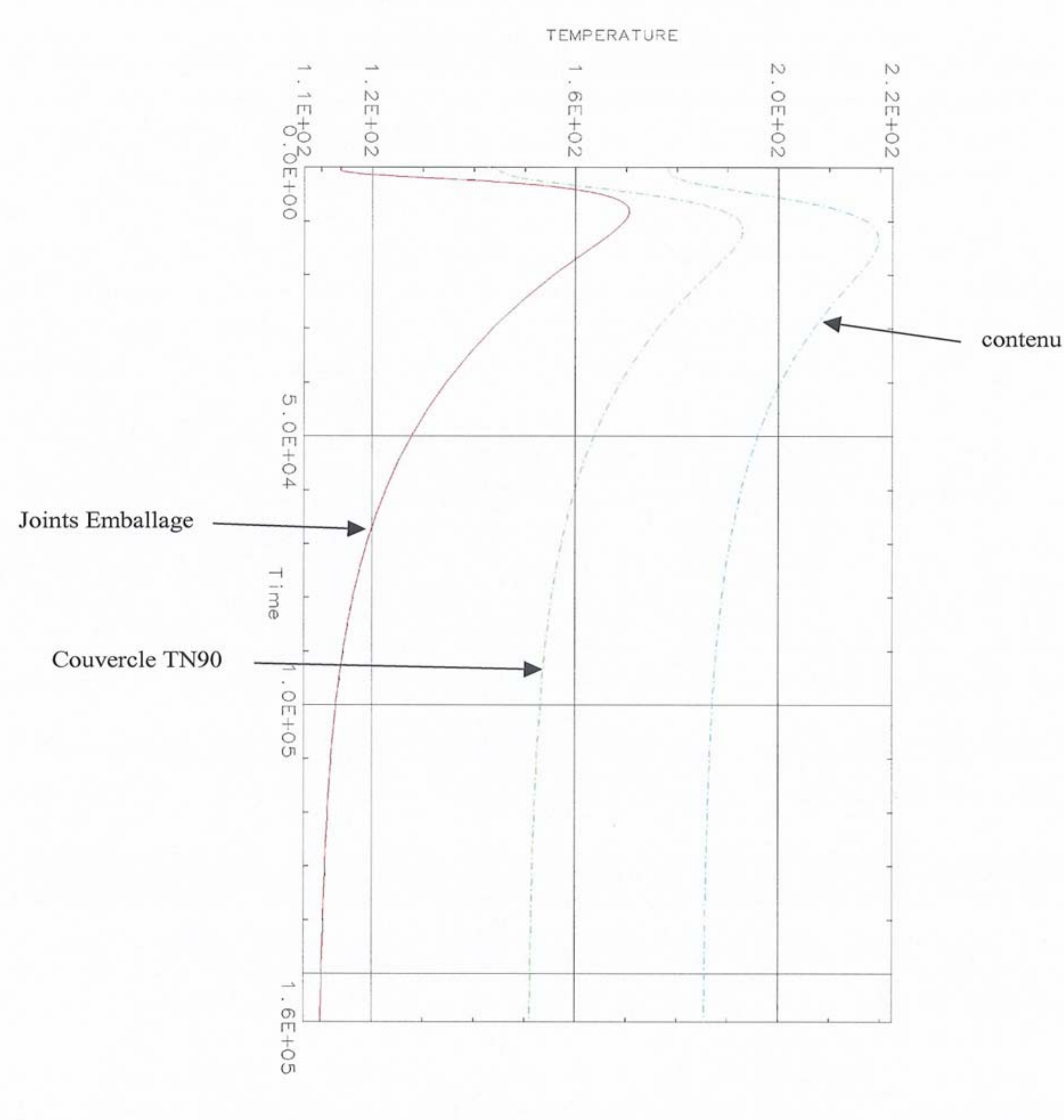
APPENDIX 26

CONFIGURATION C10.3

SEALS AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Contenu	Contents
Joints Emballage	Packaging seals
Couvercle TN90	TN90 cover

APPENDIX 27
CONFIGURATION CA1

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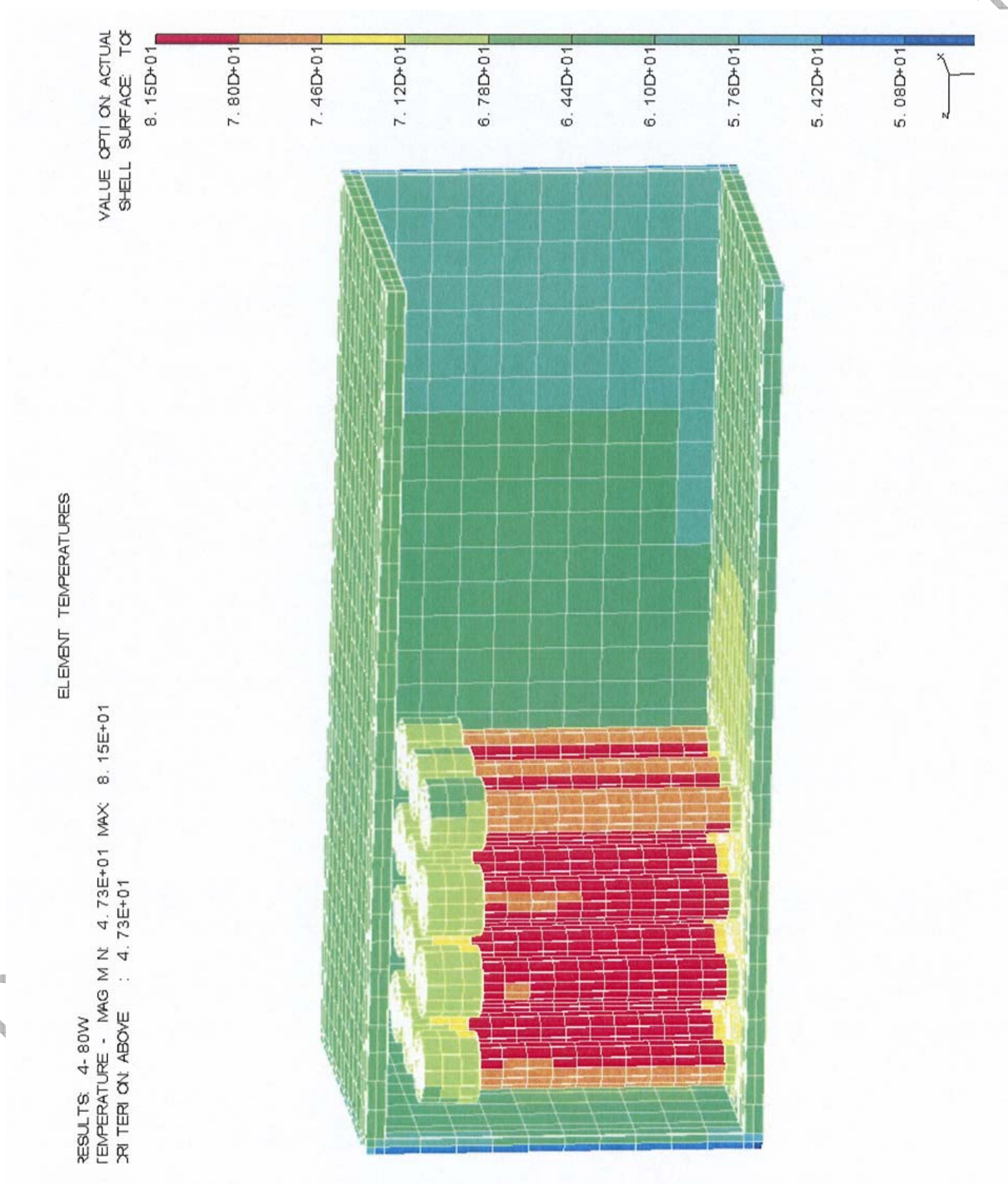
APPENDIX 27

CONFIGURATION CA1

ISOTHERMS OF CASING



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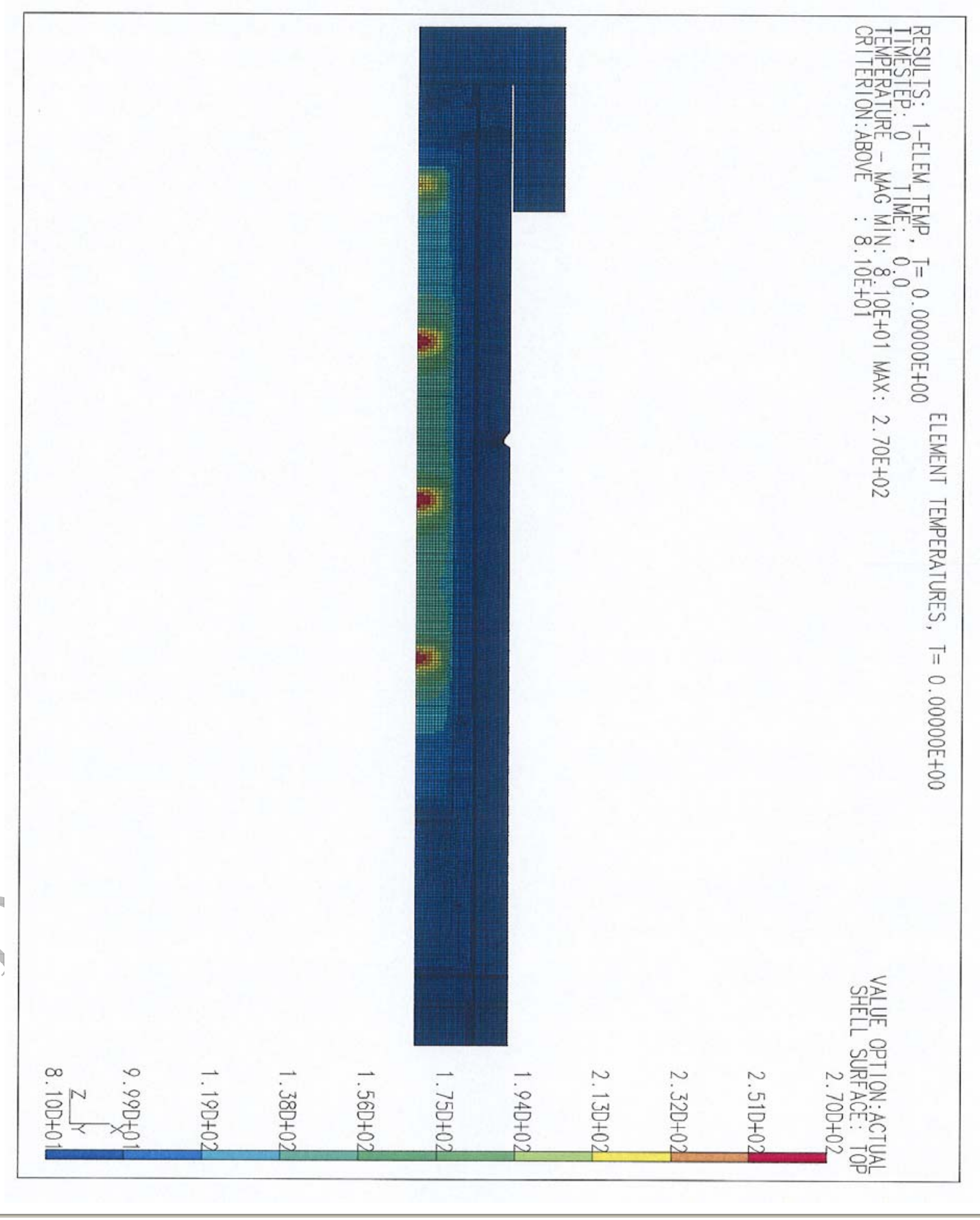
APPENDIX 27

CONFIGURATION CA1

ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire



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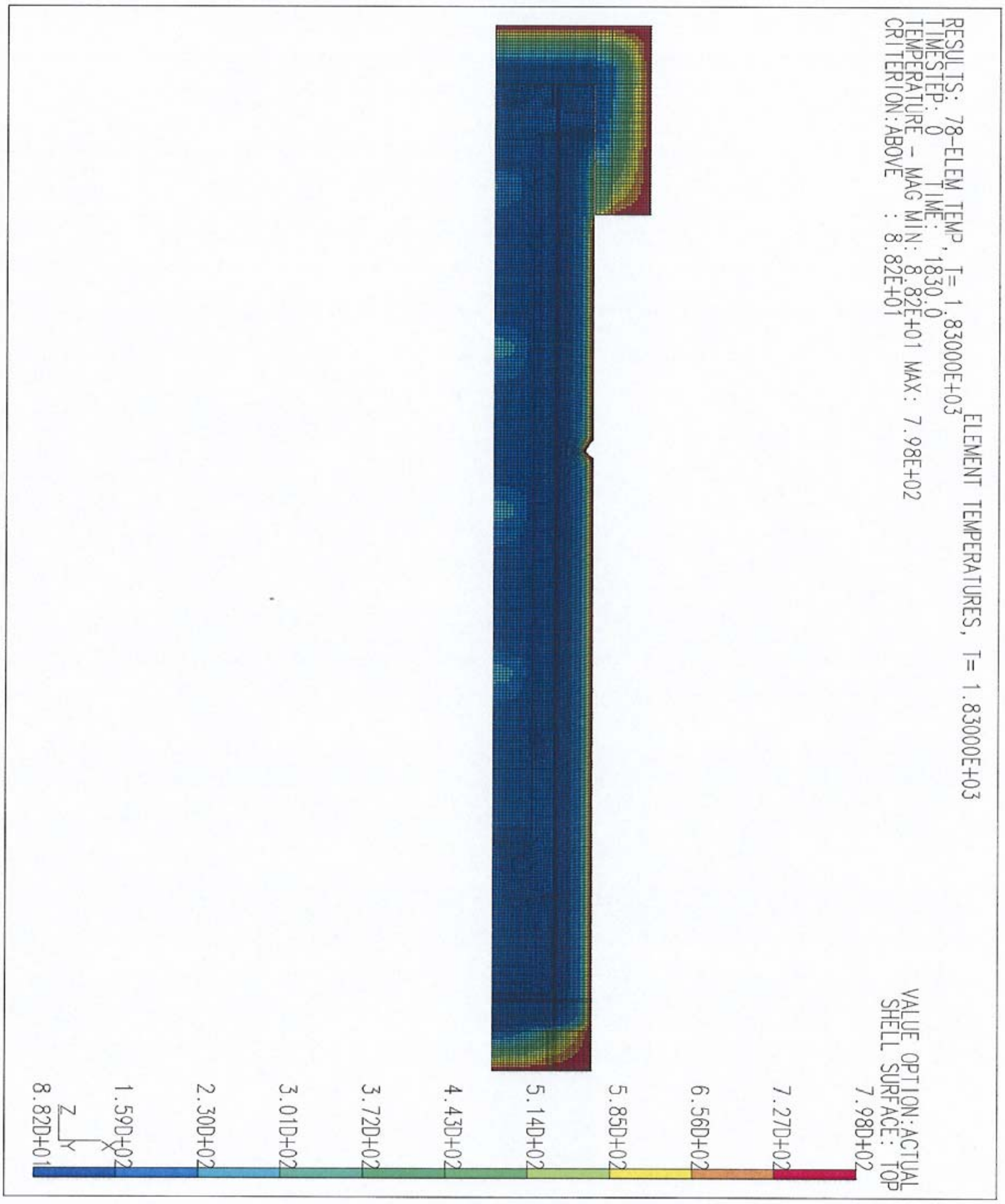
APPENDIX 27

CONFIGURATION CA1

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



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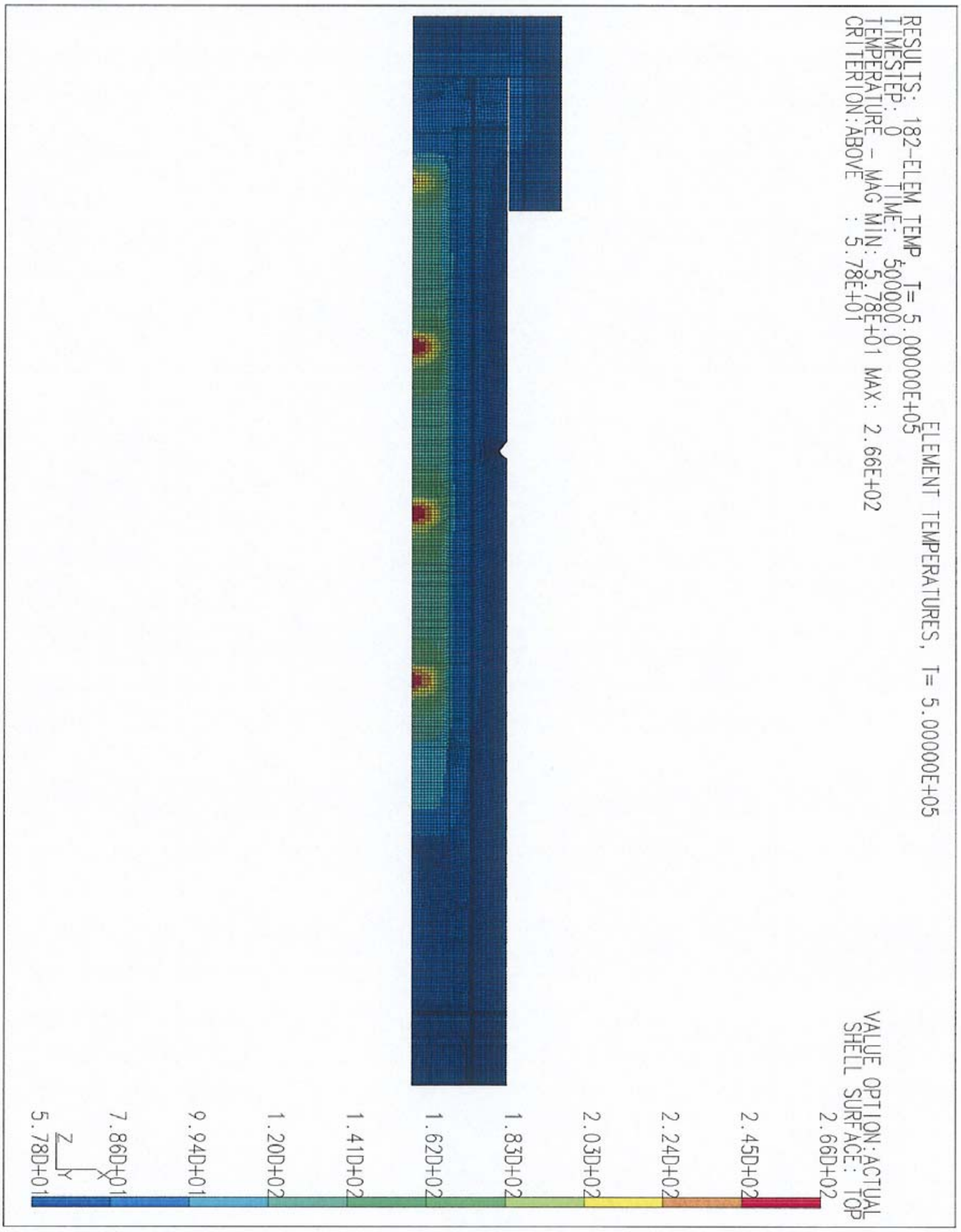
APPENDIX 27

CONFIGURATION CA1

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



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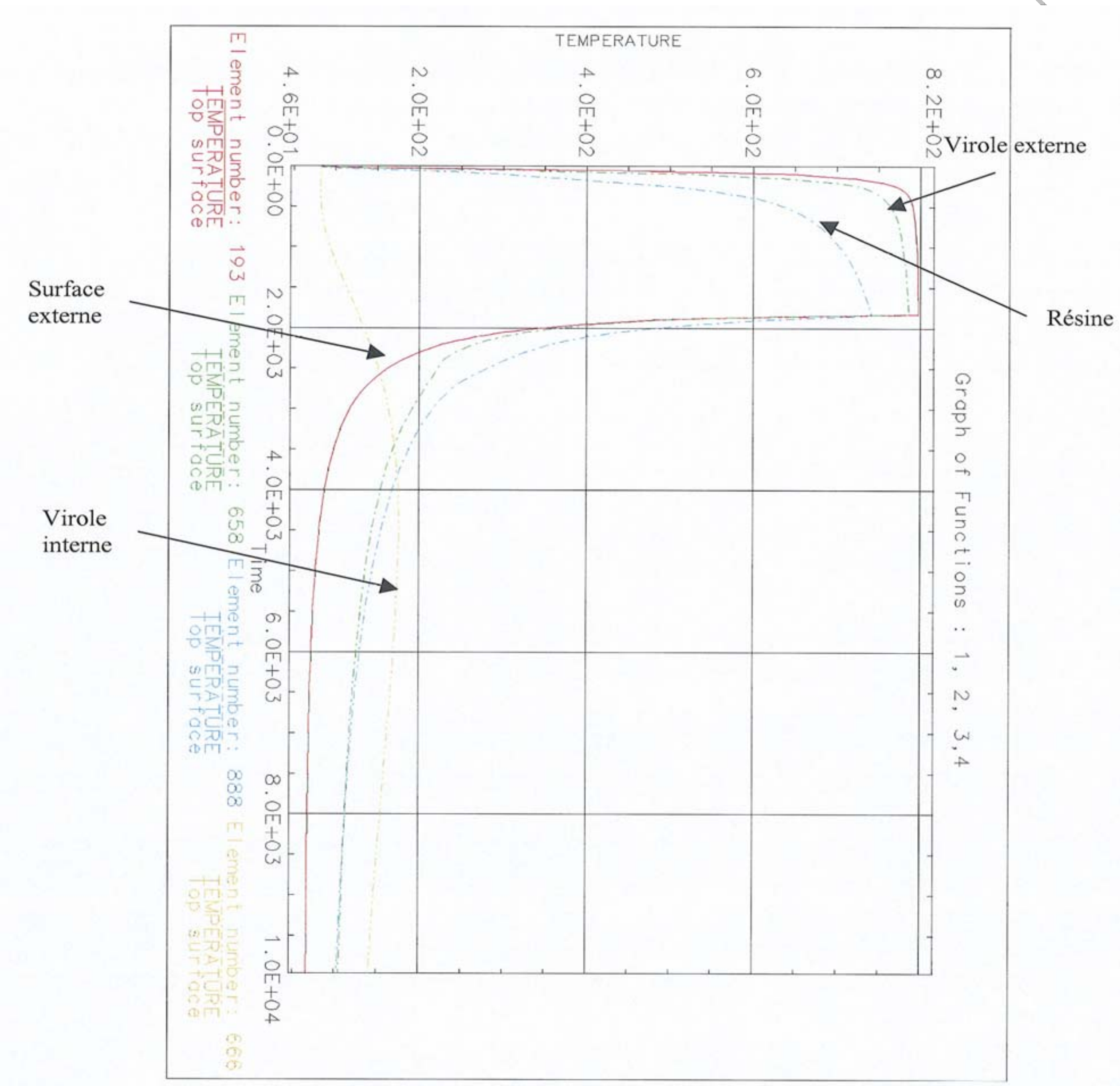
APPENDIX 27

CONFIGURATION CA1

PACKAGING TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT

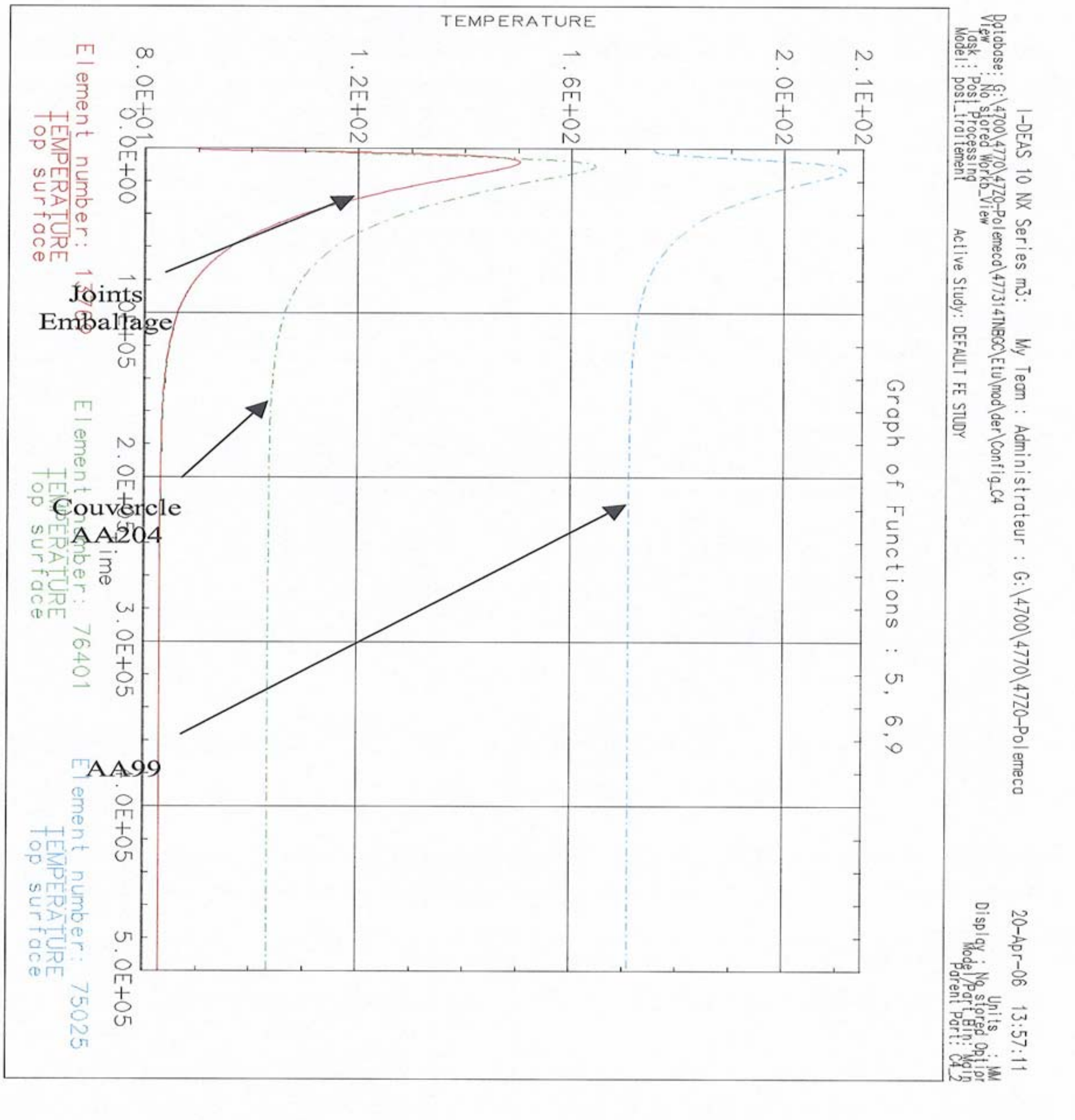


Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

APPENDIX 27

CONFIGURATION CA1

SEAL TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Joints Emballage	Packaging seals
Couvercle AA204	AA204 cover
AA99	AA99

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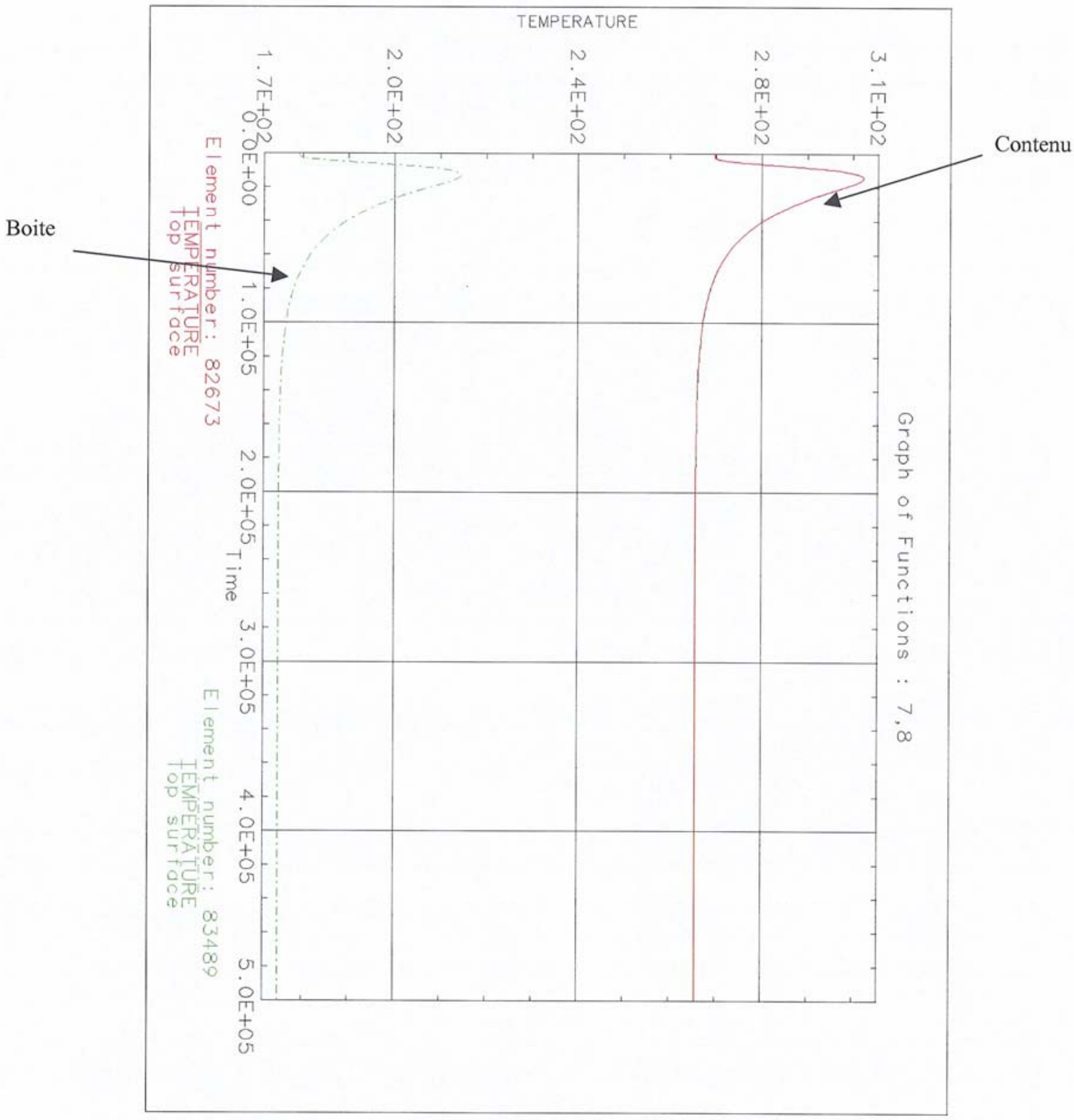
APPENDIX 27

CONFIGURATION CA1

BOXES AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Contenu	Contents
Boite	Box

APPENDIX 28
CONFIGURATION CA2

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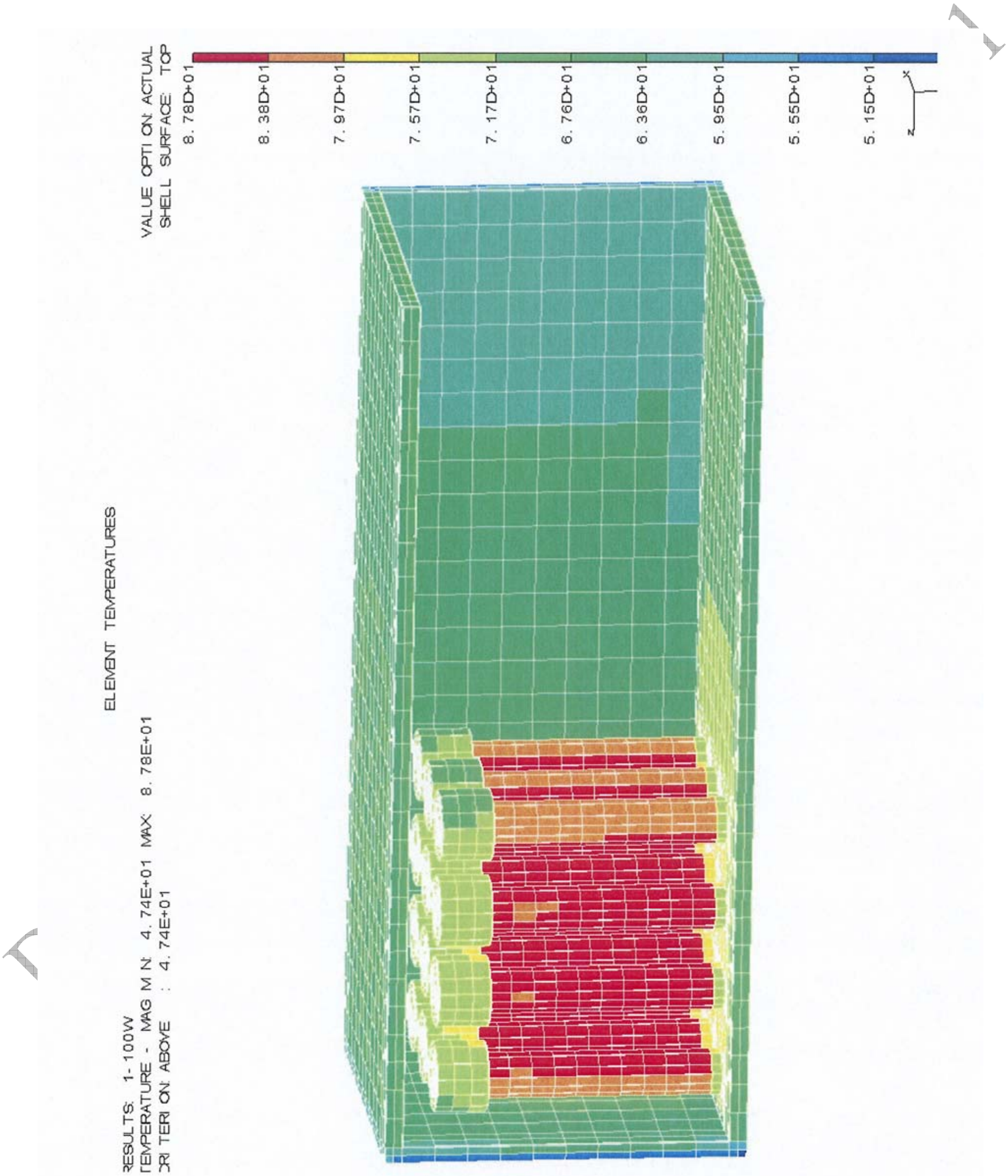
APPENDIX 28

CONFIGURATION CA2

ISOTHERMS OF CASING



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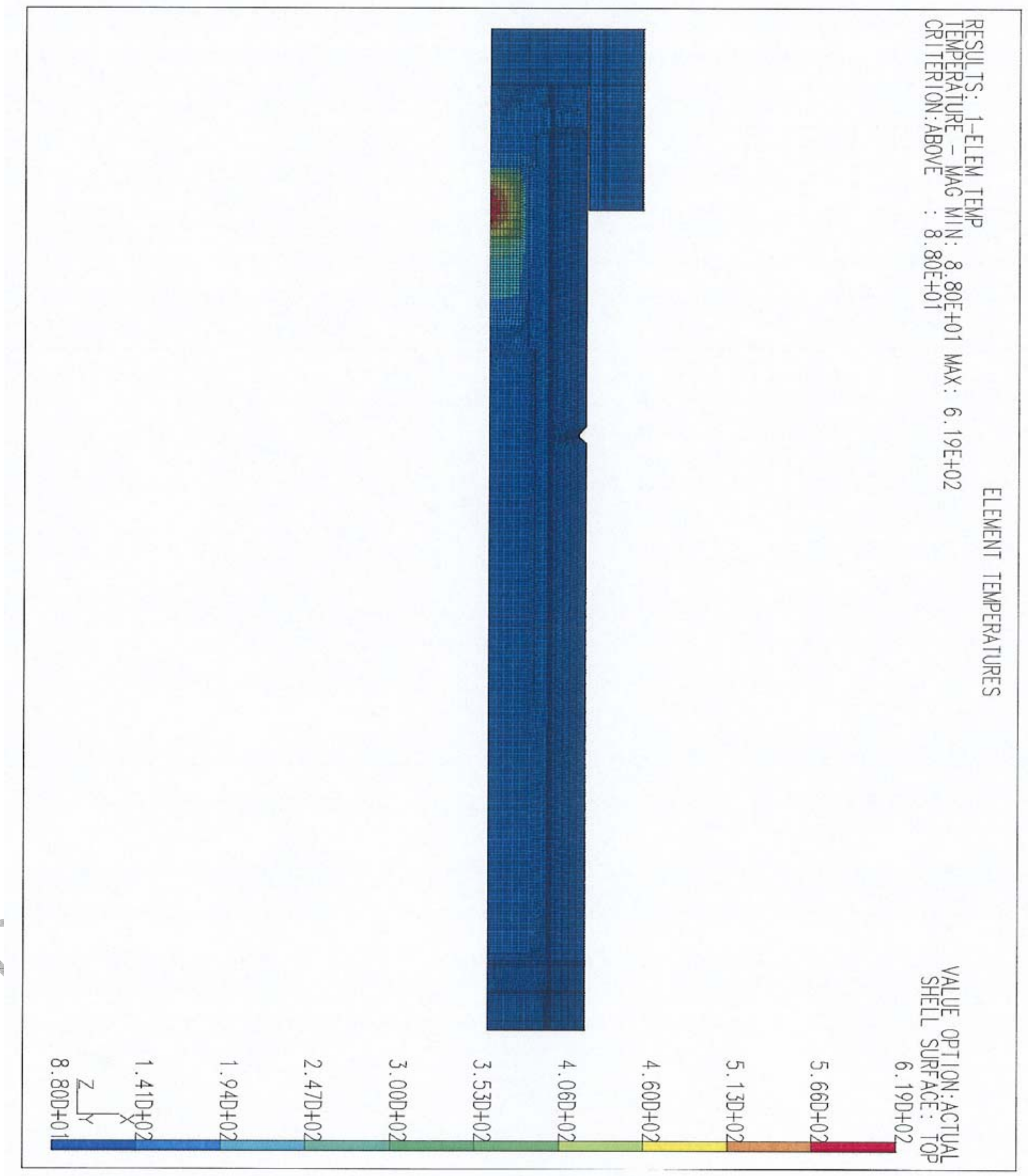
APPENDIX 28

CONFIGURATION CA2

ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire



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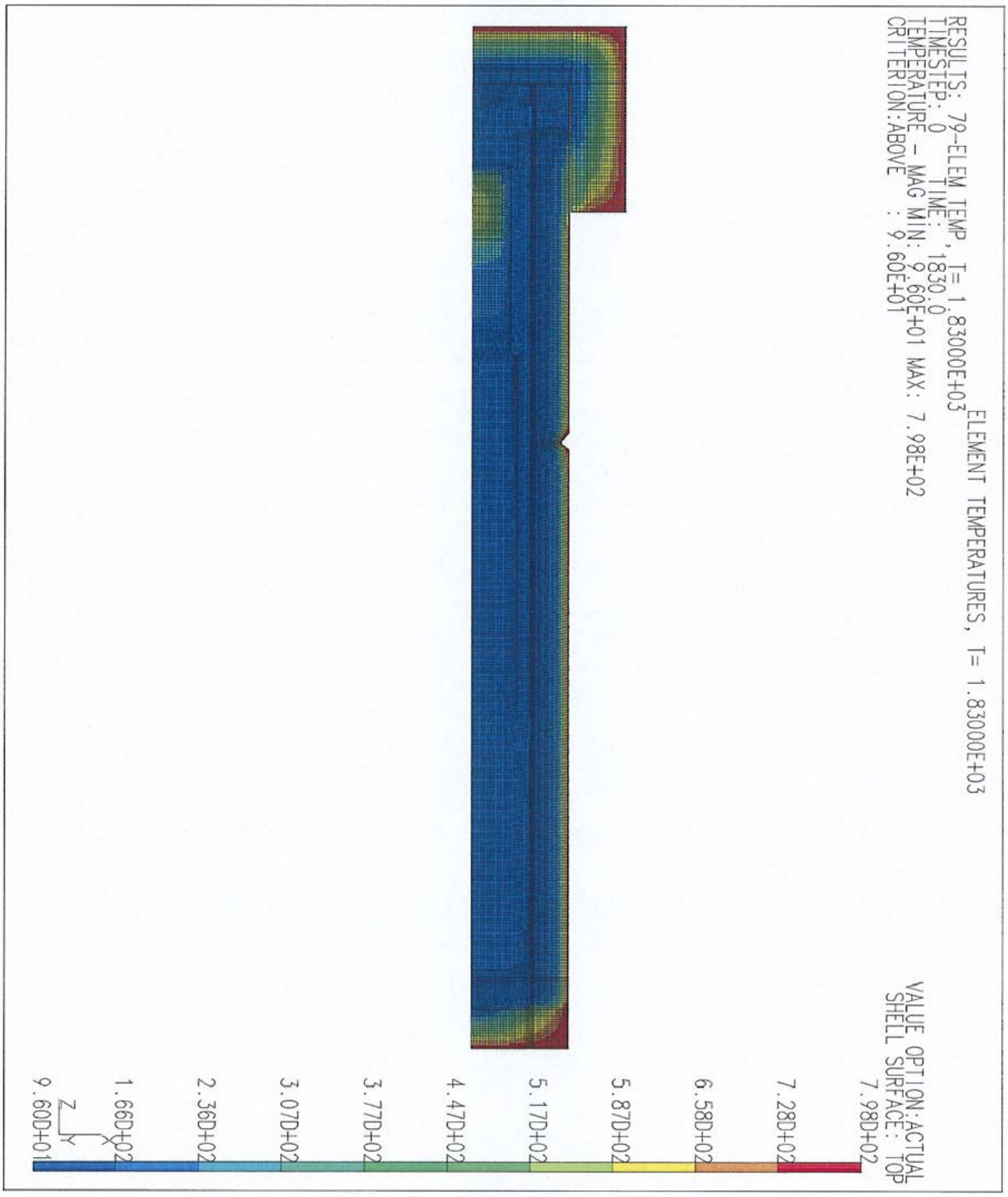
APPENDIX 28

CONFIGURATION CA2

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



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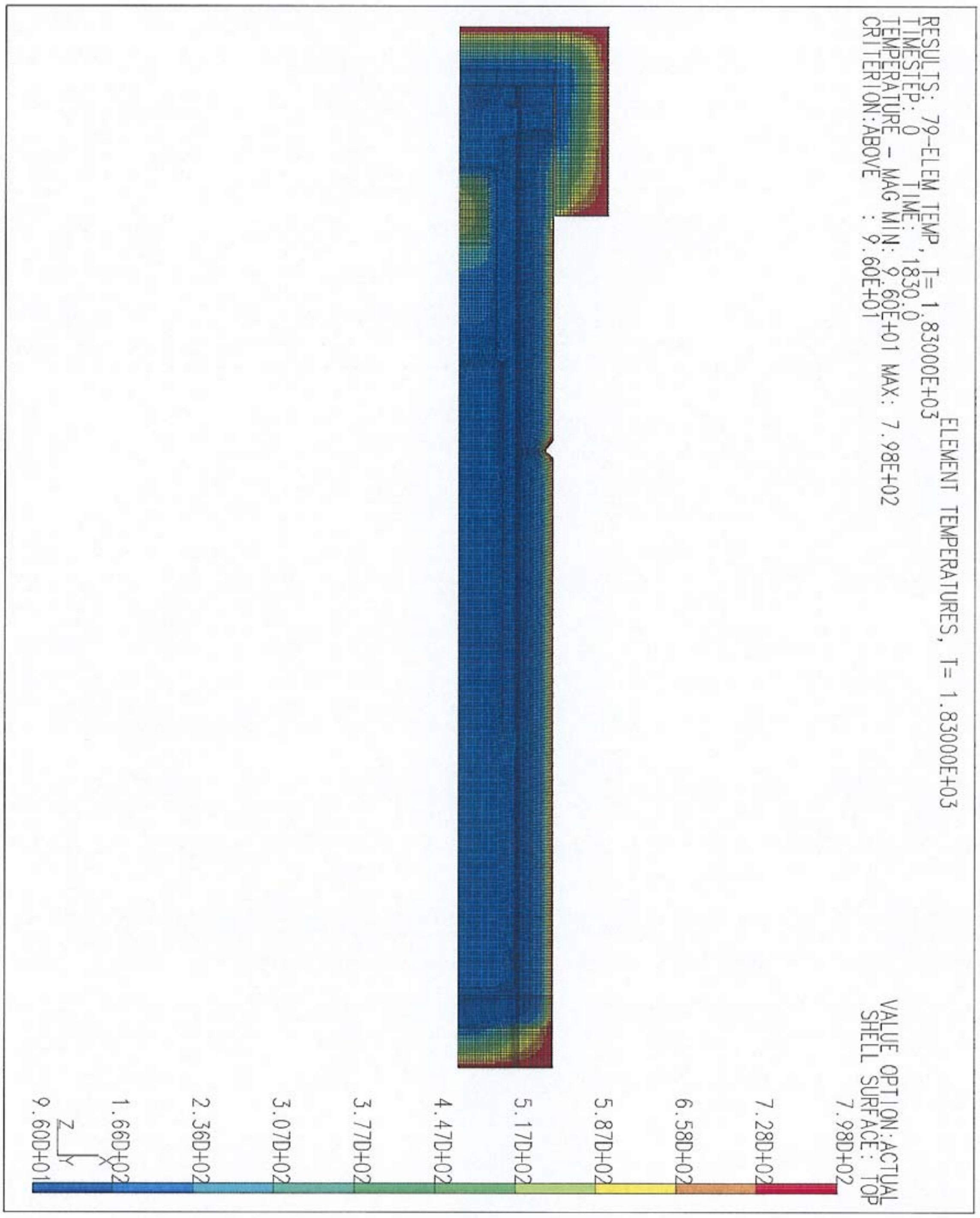
APPENDIX 28

CONFIGURATION CA2

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



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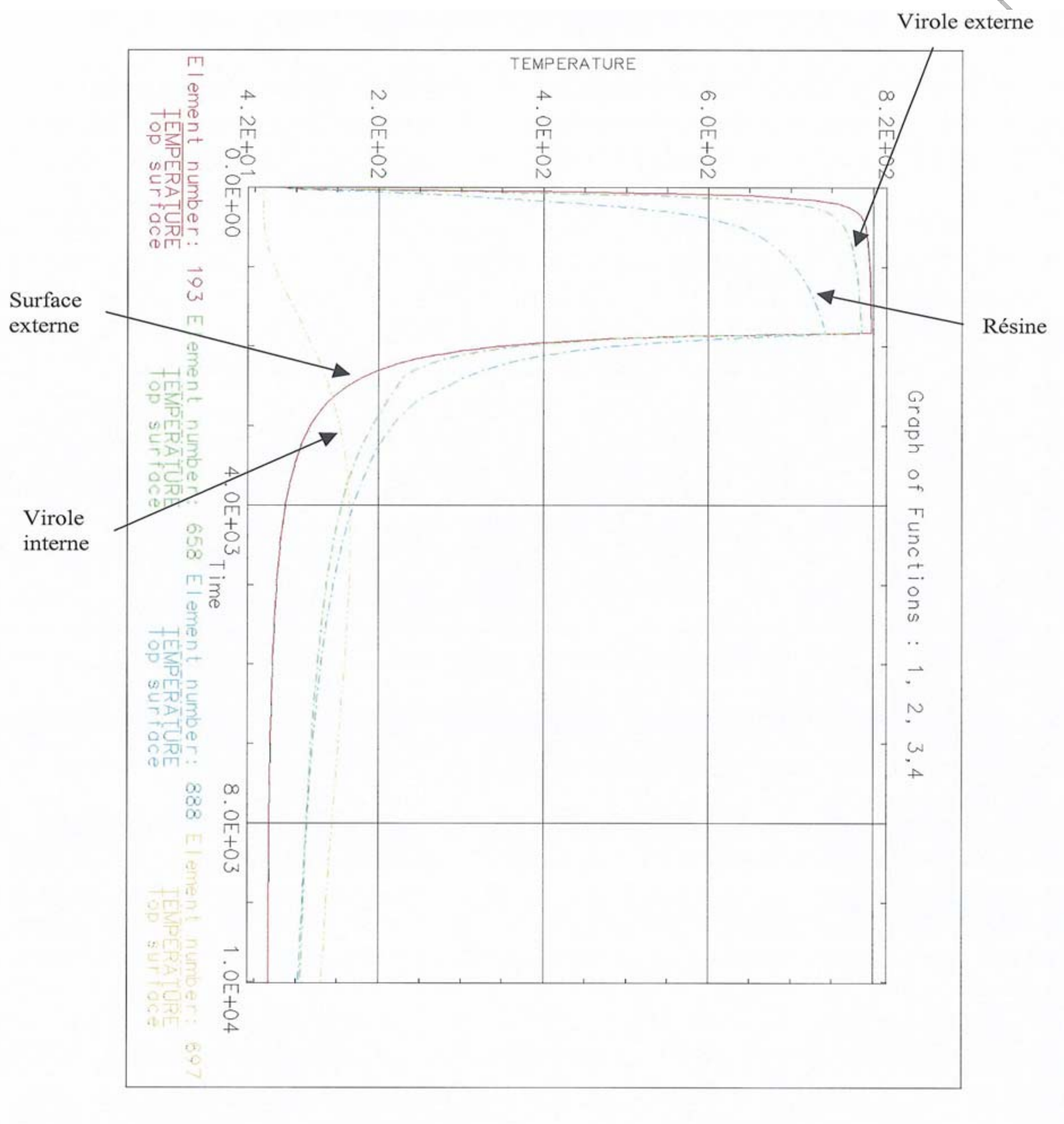
APPENDIX 28

CONFIGURATION CA2

PACKAGING TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

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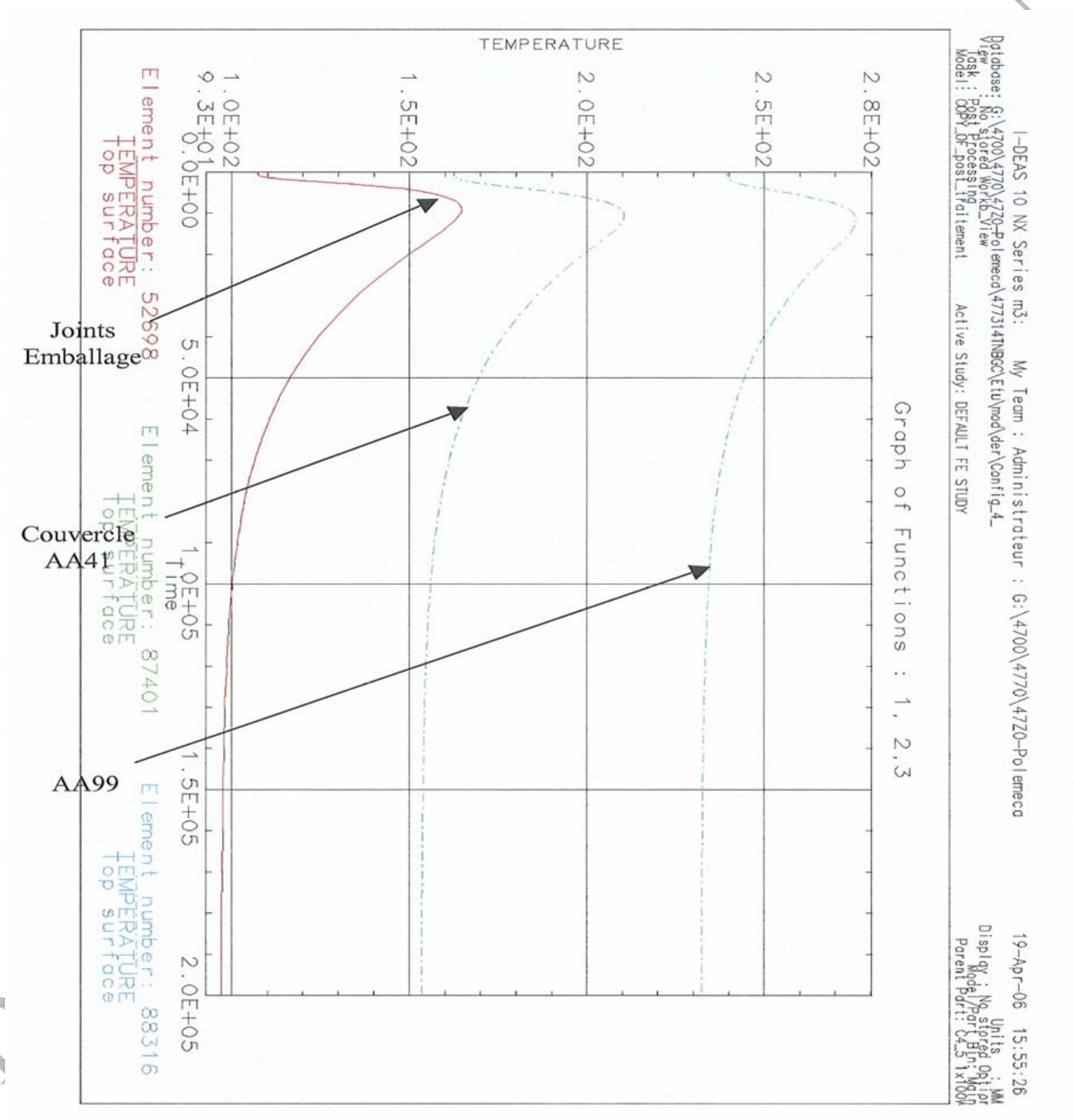
APPENDIX 28

CONFIGURATION CA2

SEAL TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Joints Emballage	Packaging seals
Couvercle AA41	AA41 cover
AA99	AA99

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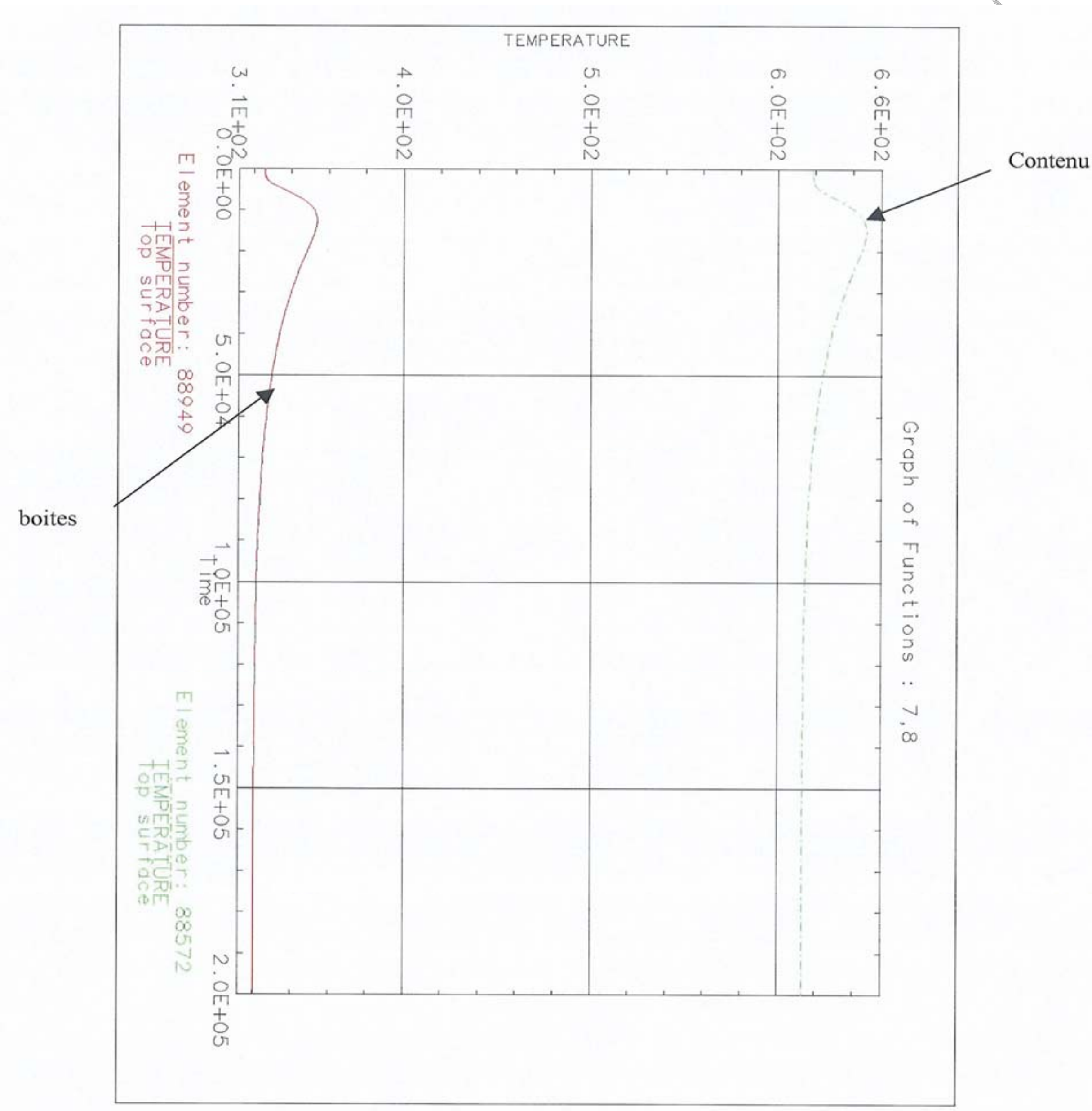
APPENDIX 28

CONFIGURATION CA2

BOXES AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Contenu	Contents
Boites	Boxes

APPENDIX 29
CONFIGURATION CA3

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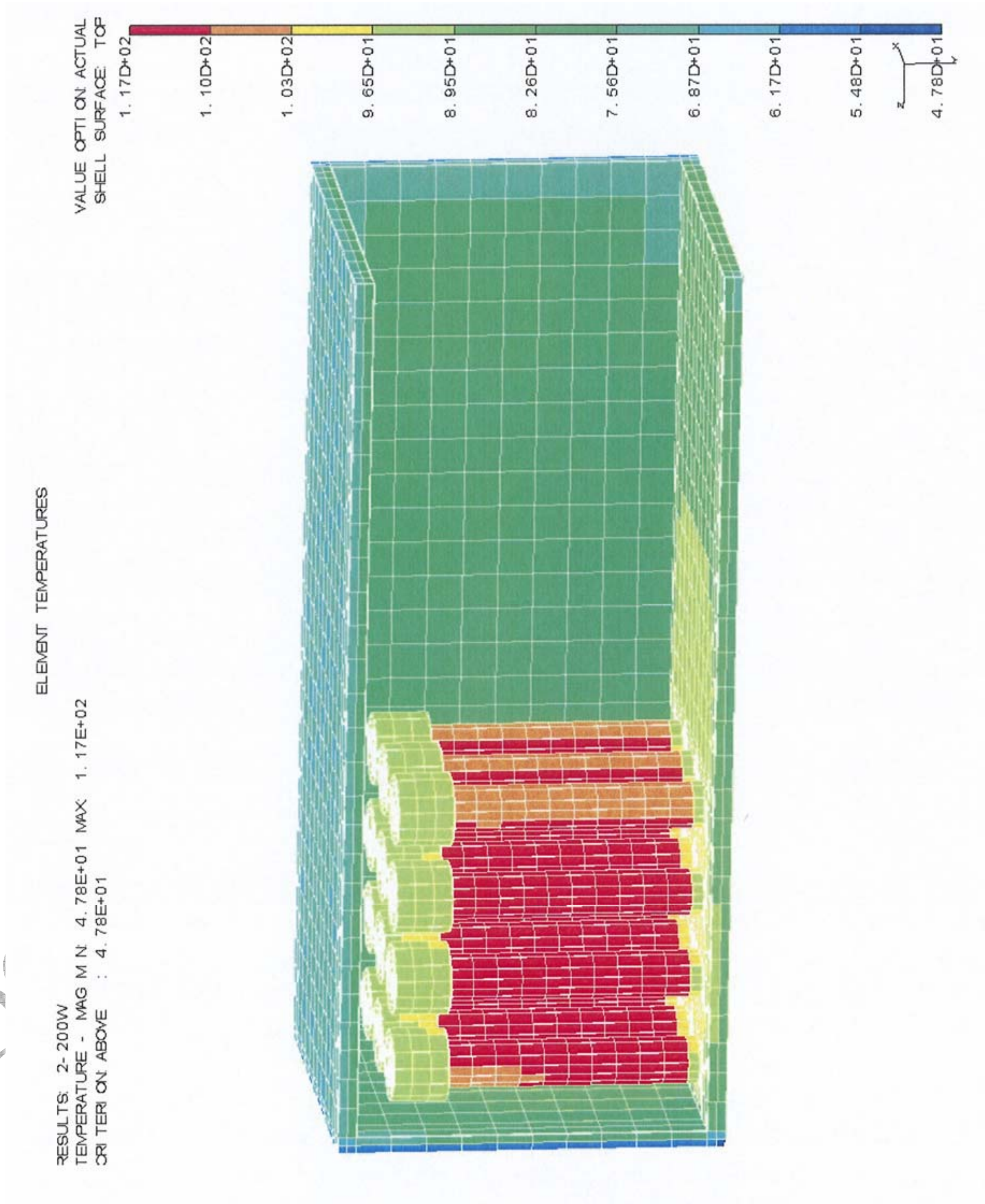
APPENDIX 29

CONFIGURATION CA3

ISOTHERMS OF CASING



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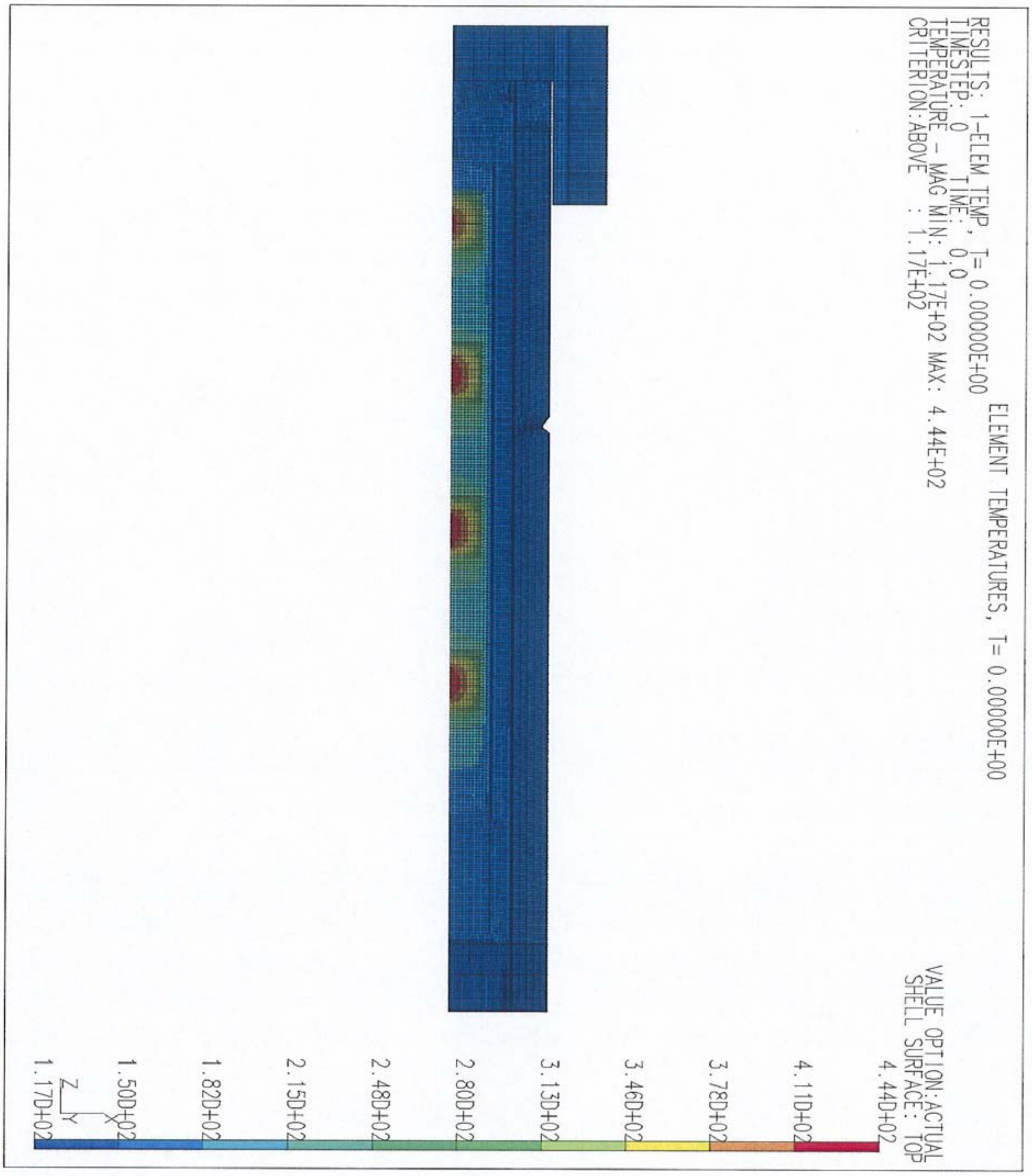
CONFIGURATION CA3

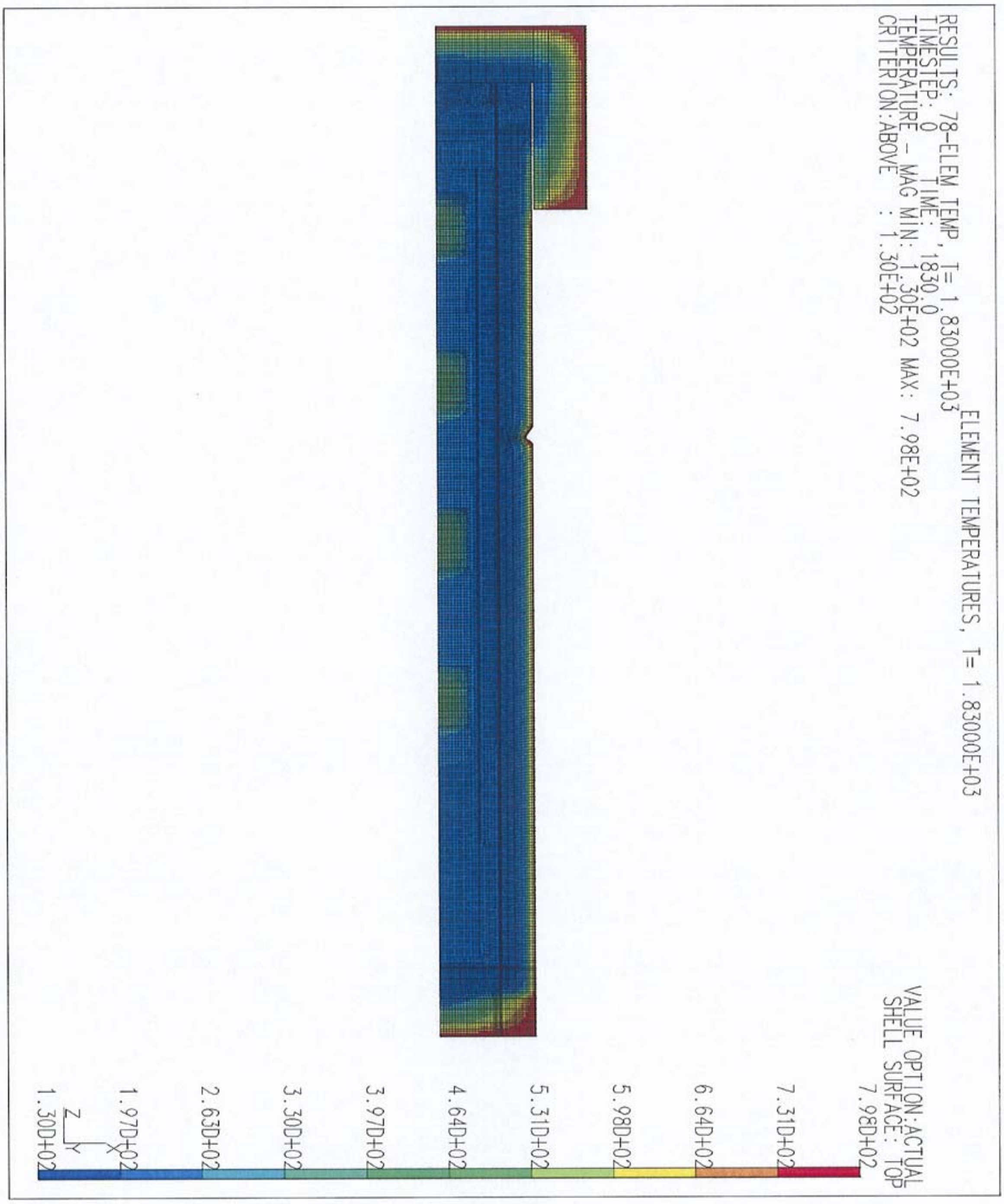
ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire



APPENDIX 29

CONFIGURATION CA3

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



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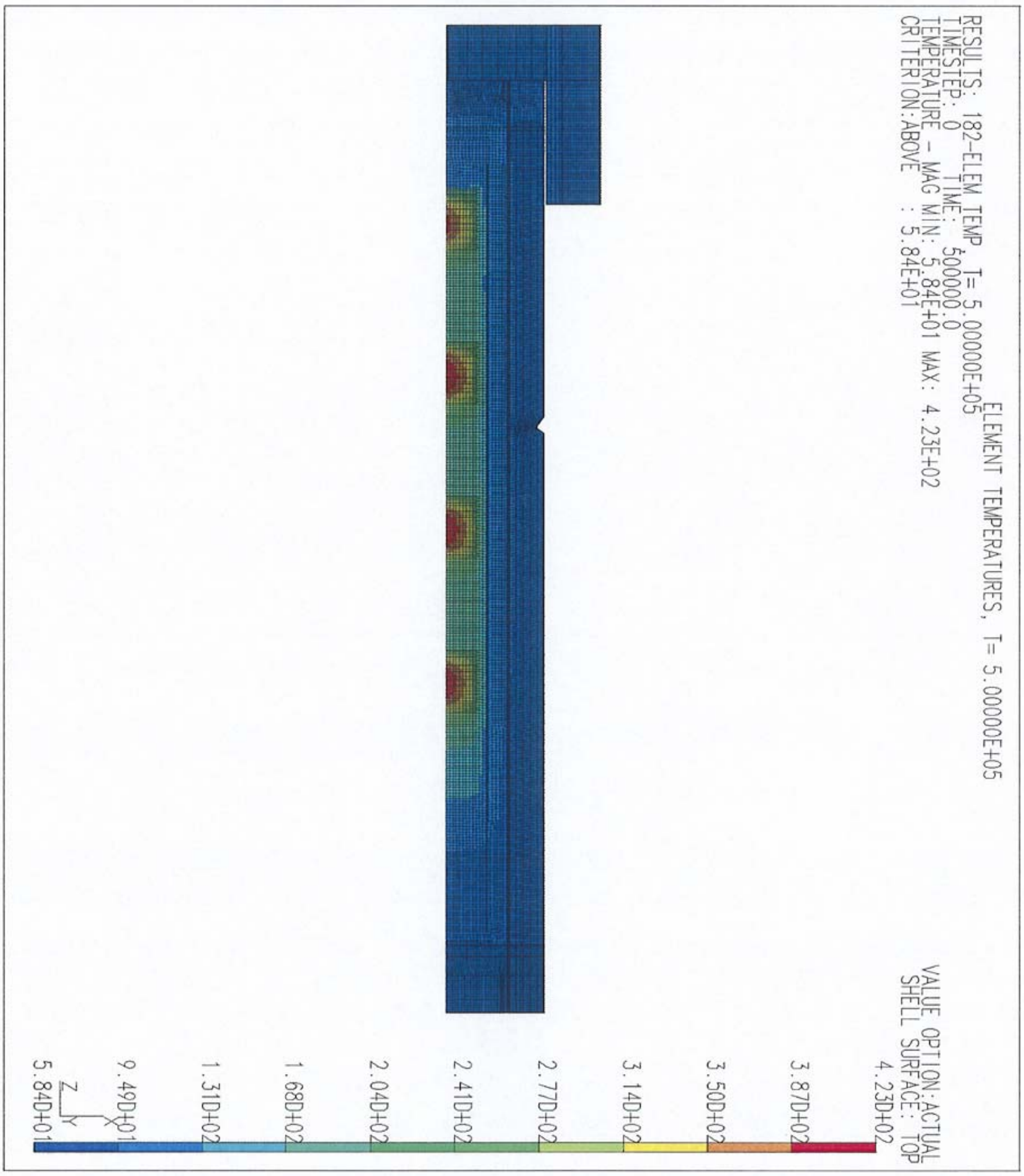
APPENDIX 29

CONFIGURATION CA3

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



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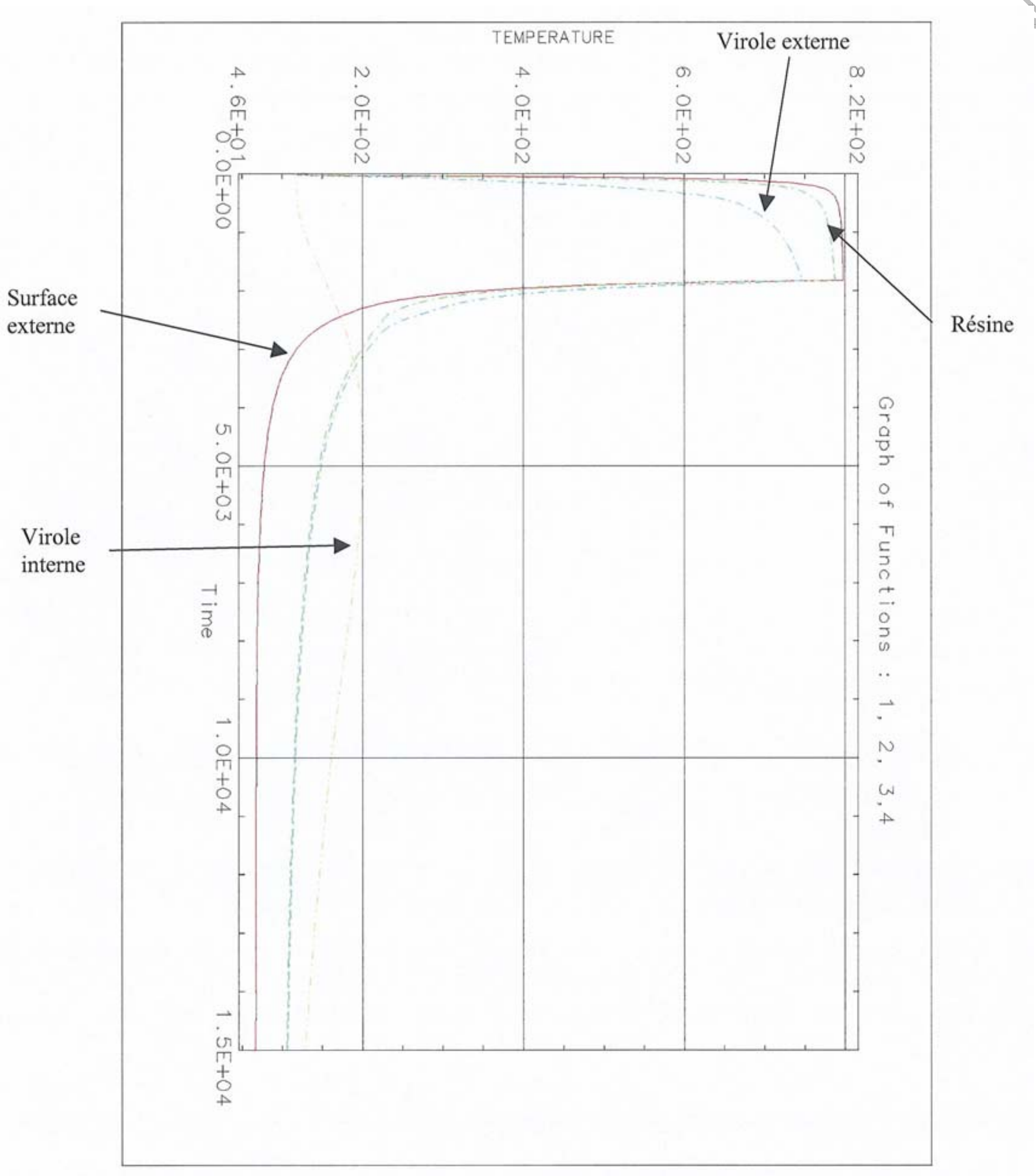
APPENDIX 29

CONFIGURATION CA3

PACKAGING TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

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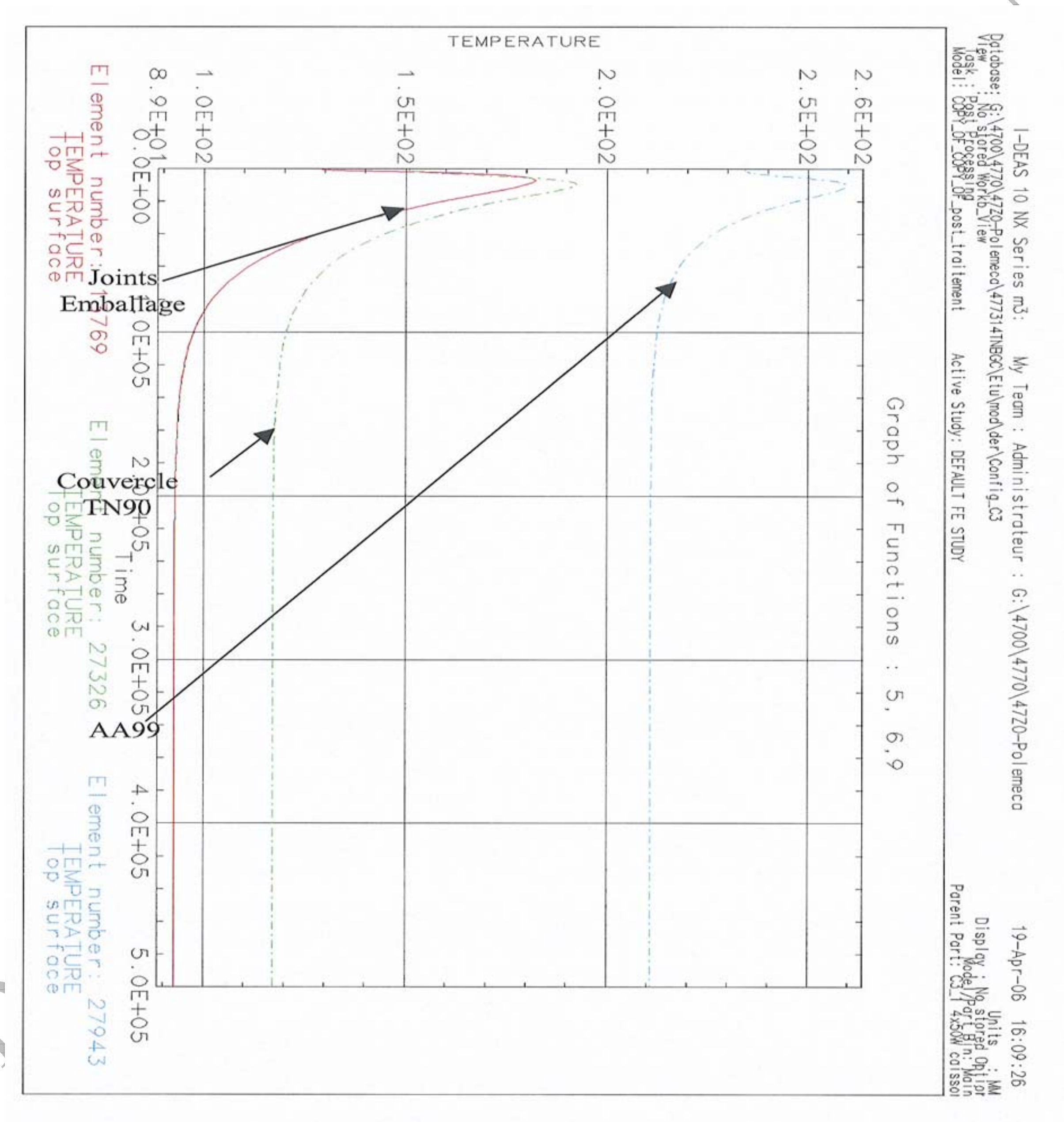
APPENDIX 29

CONFIGURATION CA3

SEAL TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT

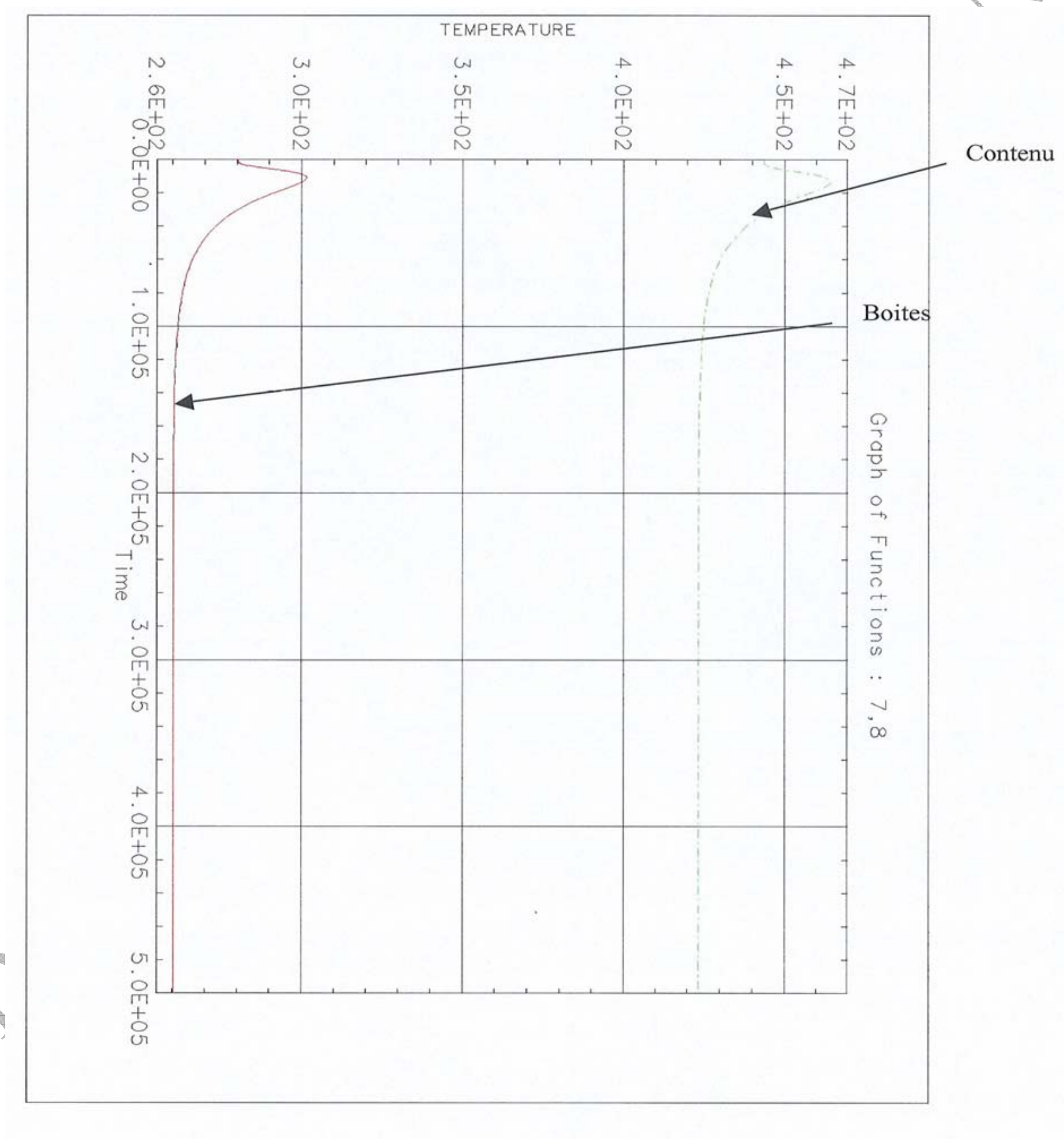


Joints Emballage	Packaging seals
Couvercle TN90	TN90 cover
AA99	AA99

APPENDIX 29

CONFIGURATION CA3

BOXES AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Contenu	Contents
Boites	Boxes

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CONFIGURATION CA4

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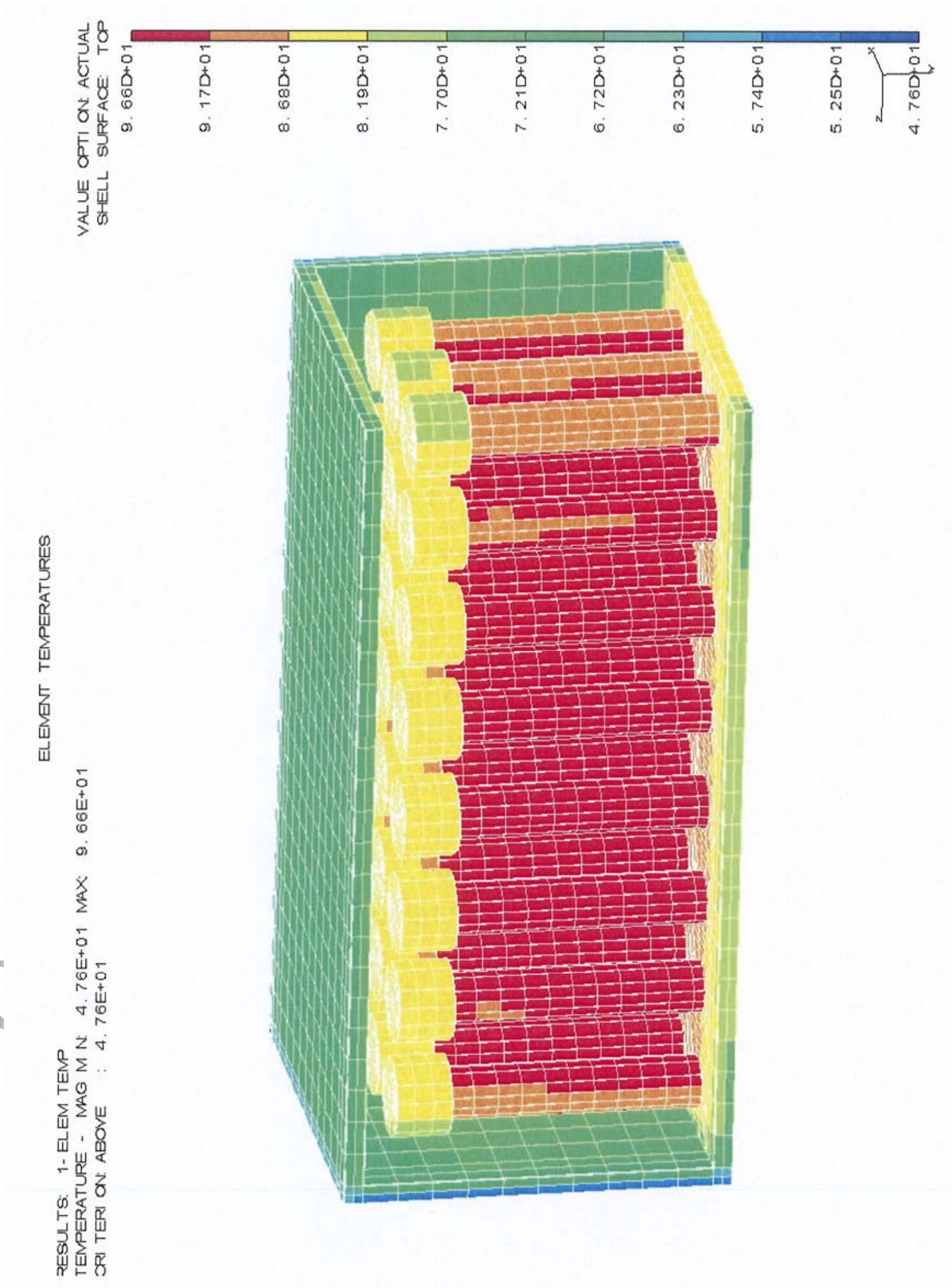
APPENDIX 30

CONFIGURATION CA4

ISOTHERMS OF CASING



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APPENDIX 30

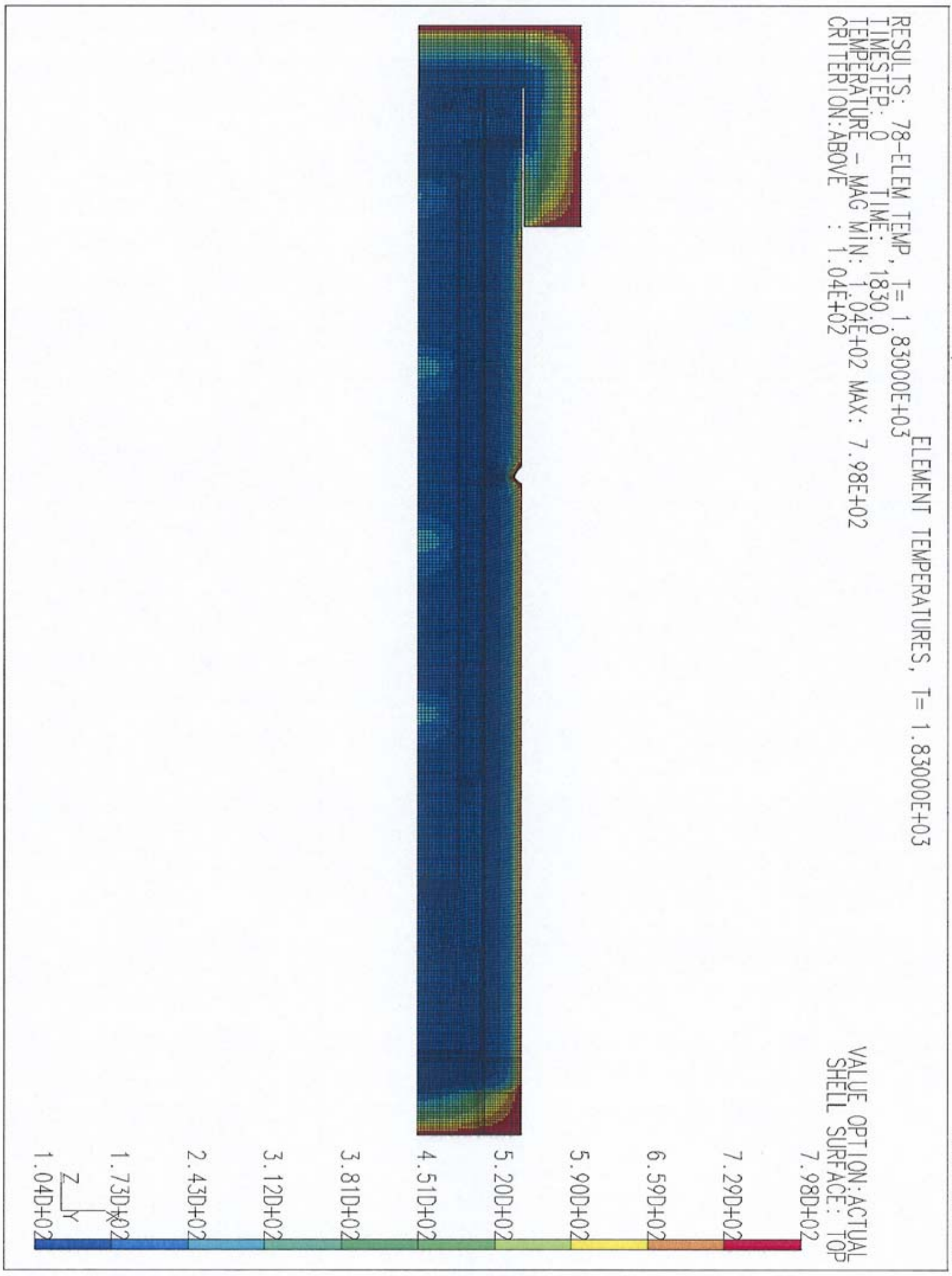
CONFIGURATION CA4

ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire

APPENDIX 30

CONFIGURATION CA4

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



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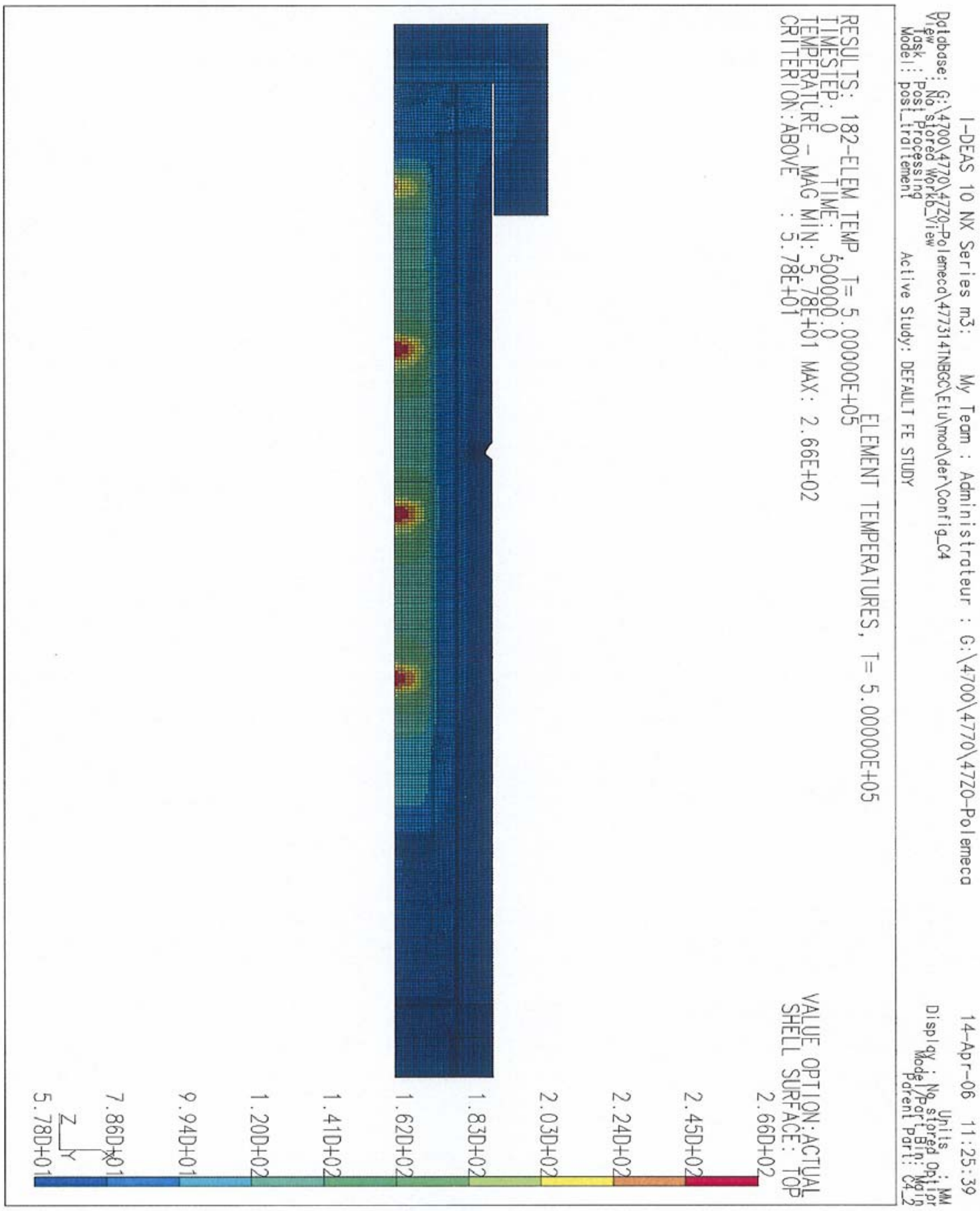
APPENDIX 30

CONFIGURATION CA4

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



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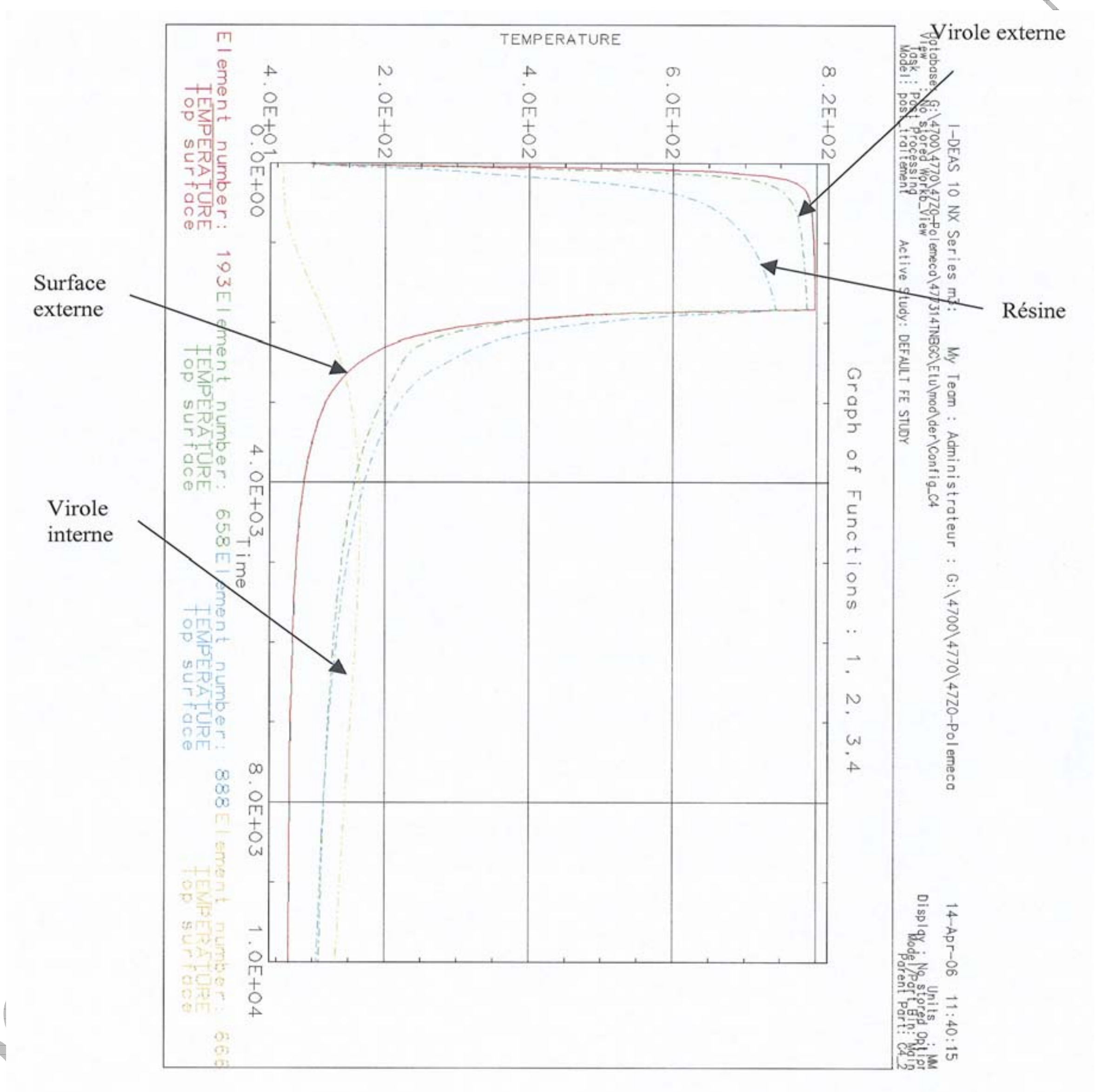
APPENDIX 30

CONFIGURATION CA4

PACKAGING TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

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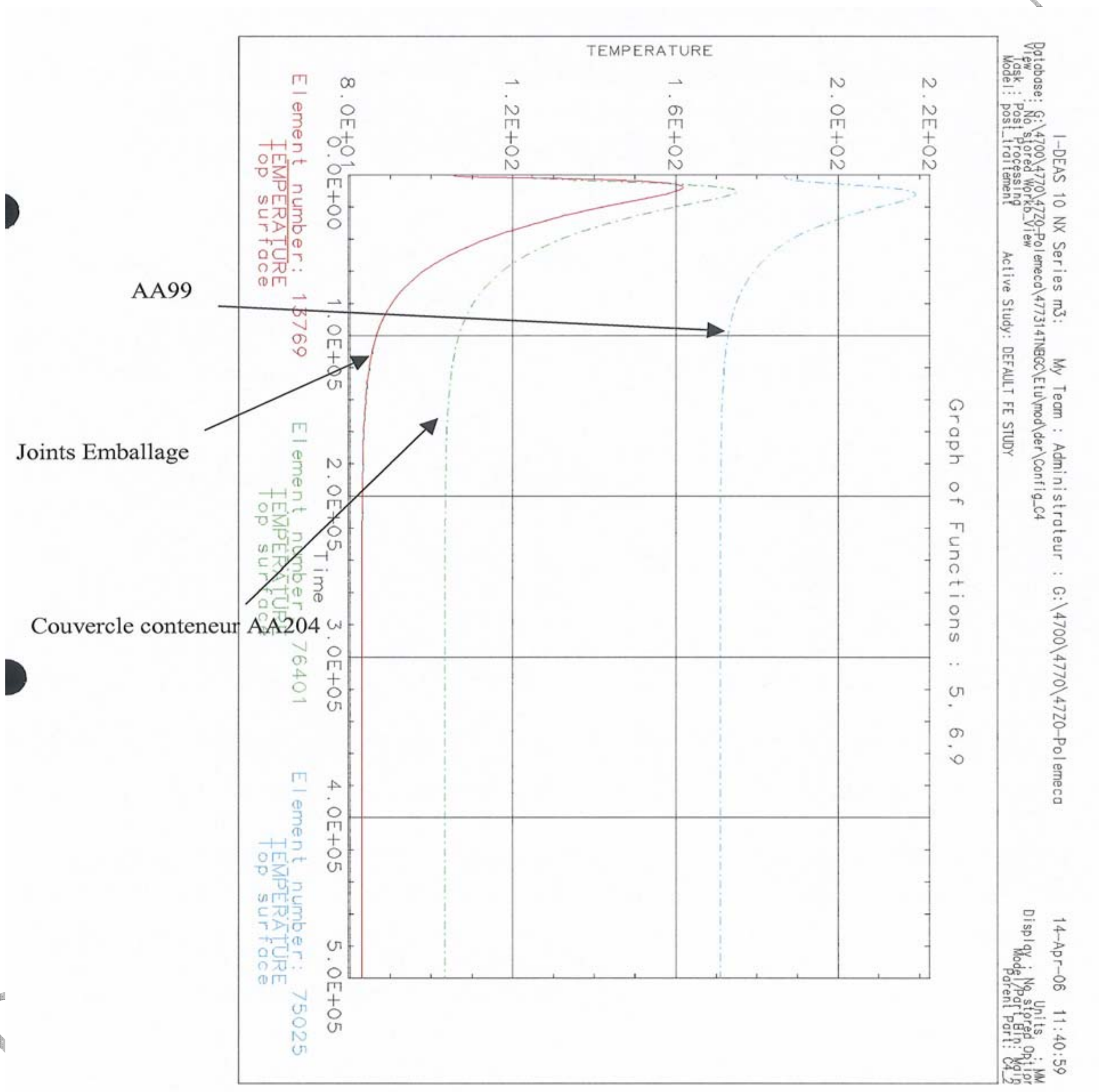
SEAL TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Joints Emballage	Packaging seals
Couvercle conteneur AA204	AA204 container cover
AA99	AA99

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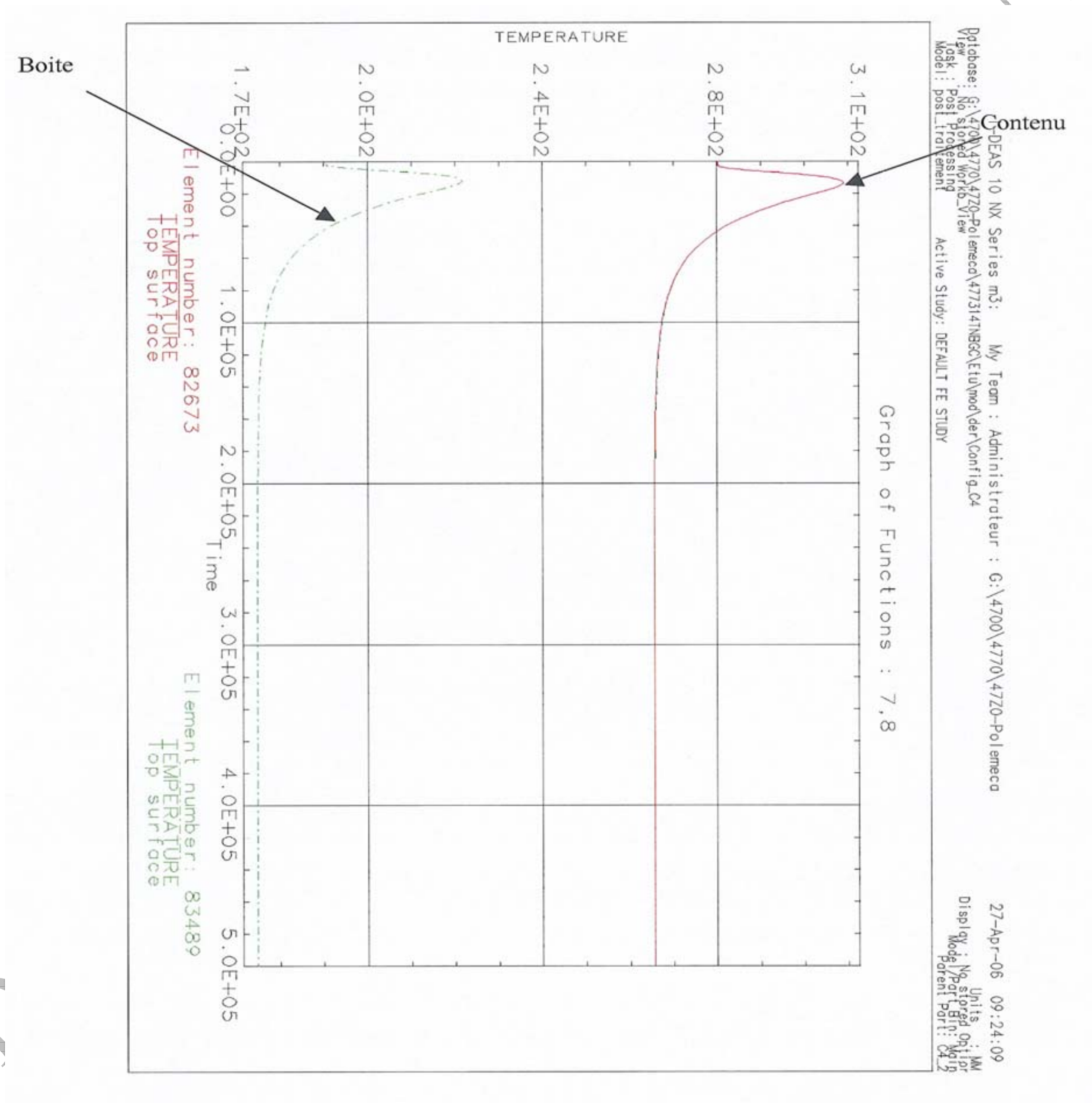
BOXES AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Contenu	Contents
Boite	Box

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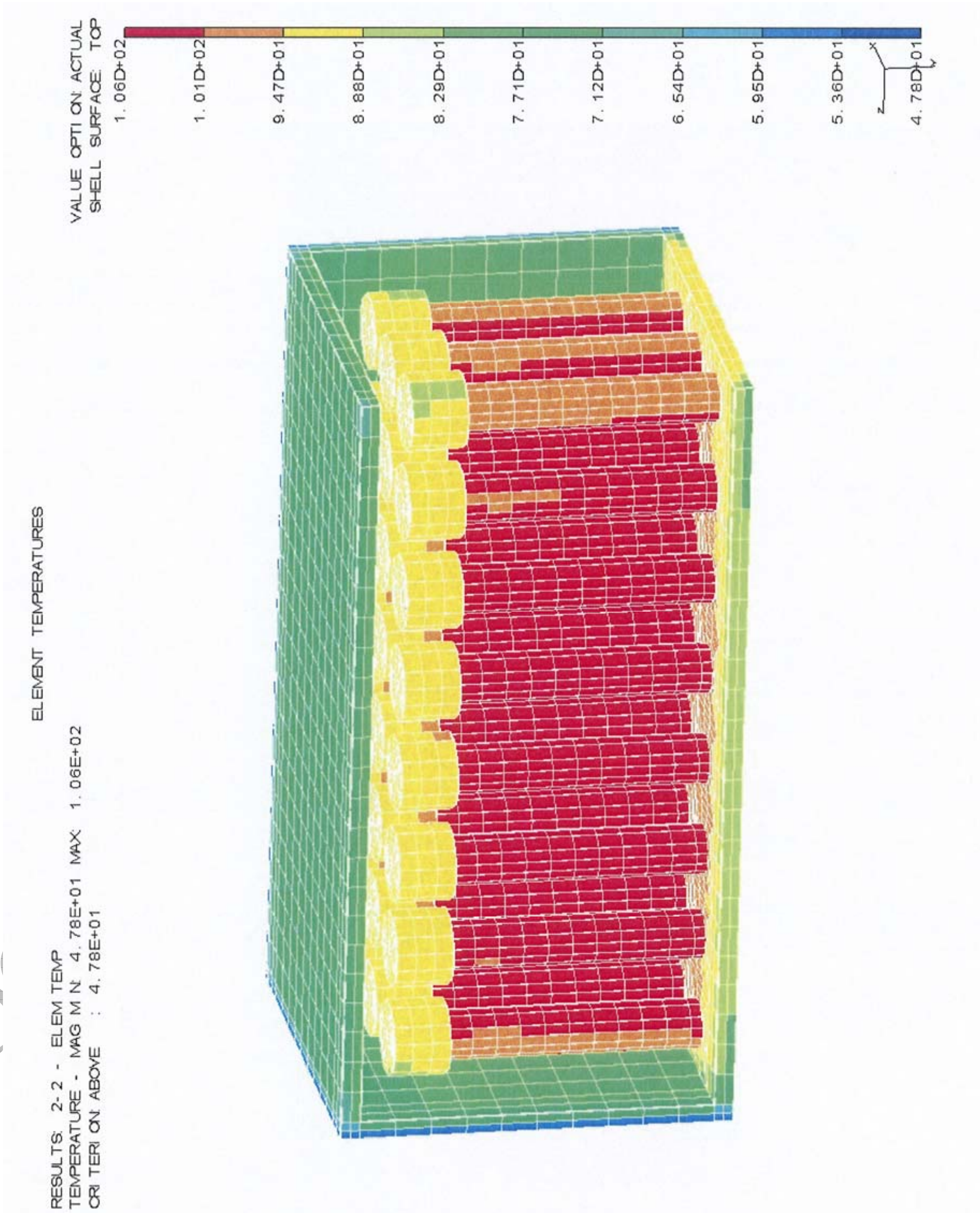
ISOTHERMS OF CASING



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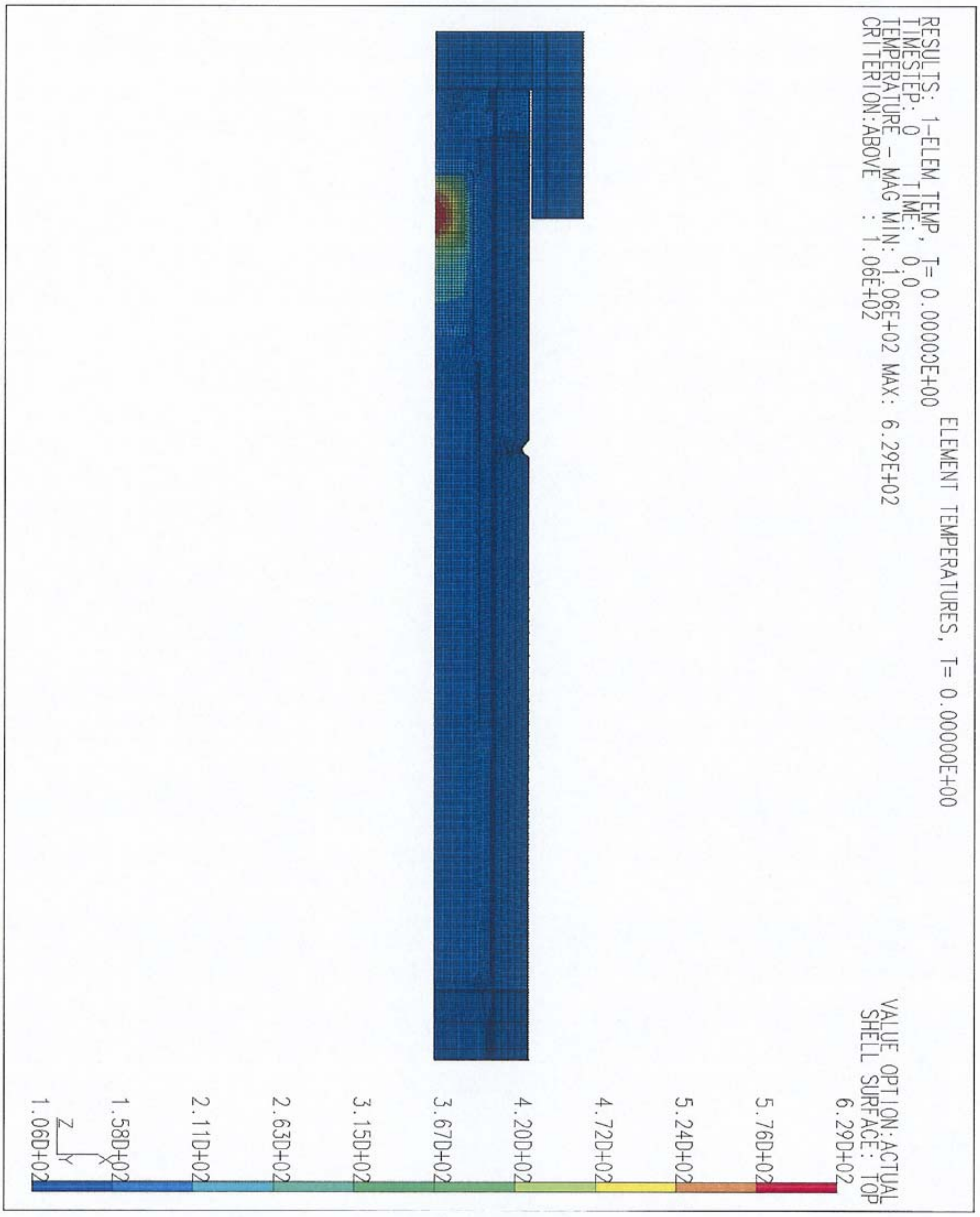
CONFIGURATION CA5

ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire



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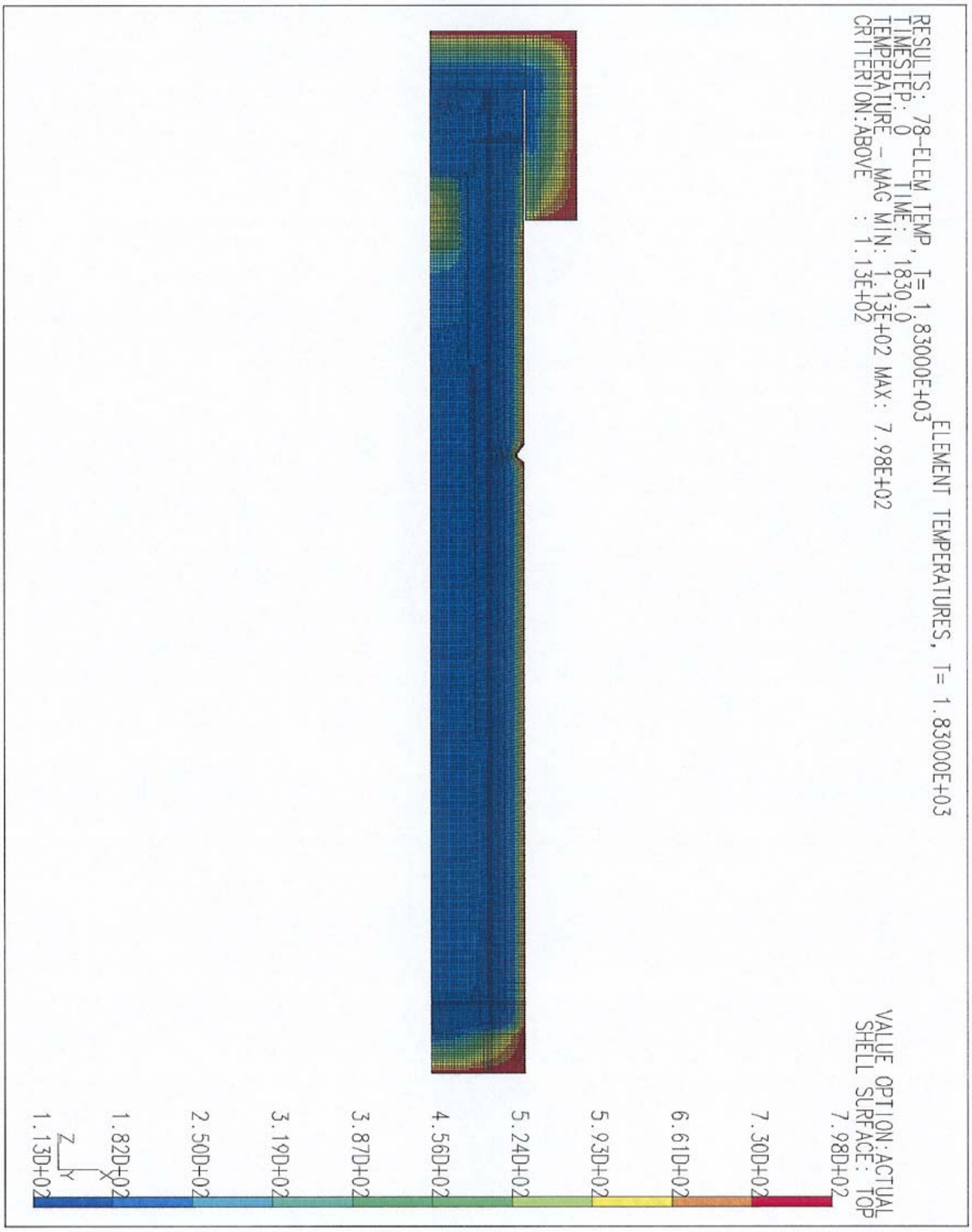
ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



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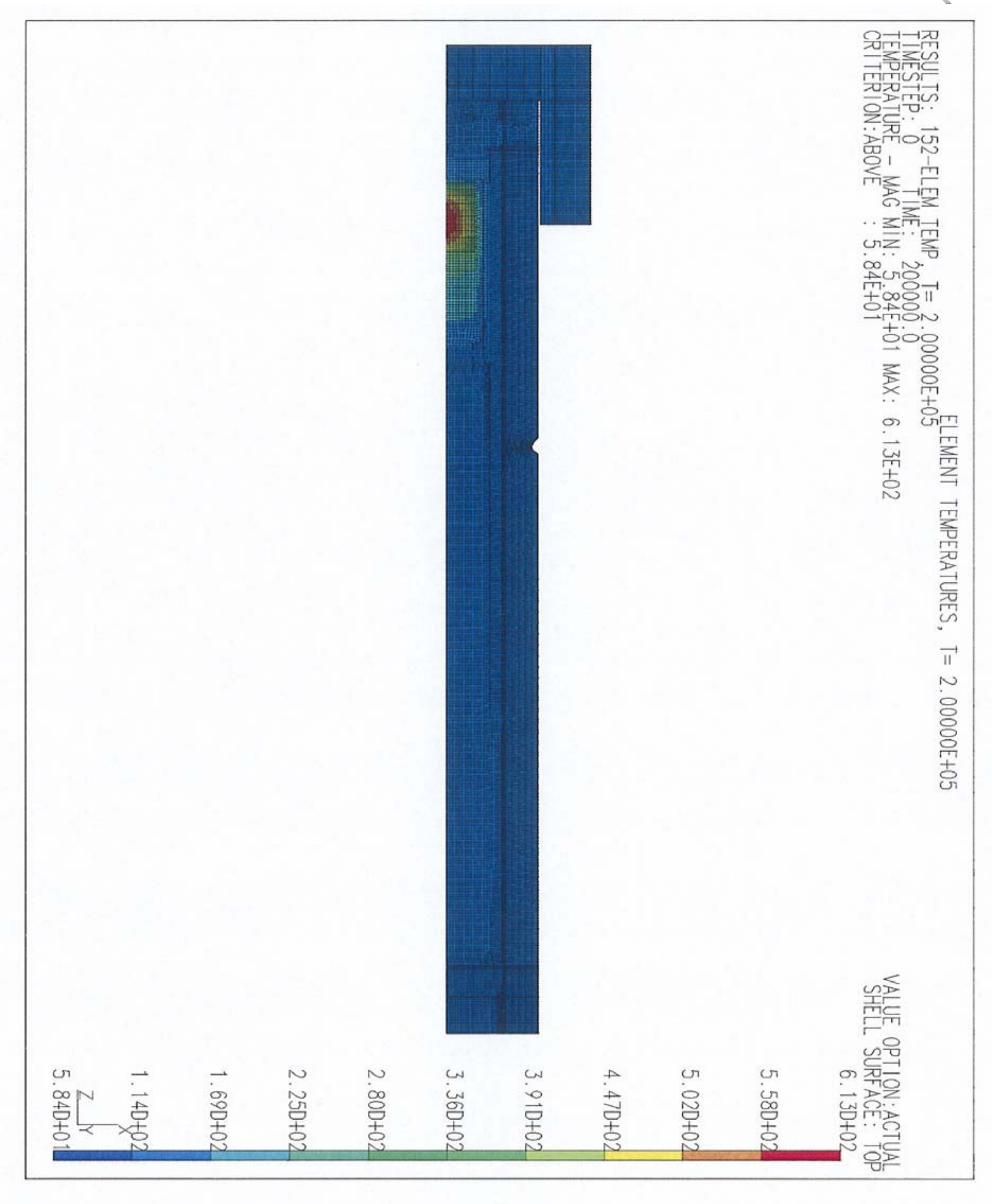
CONFIGURATION CA5

ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



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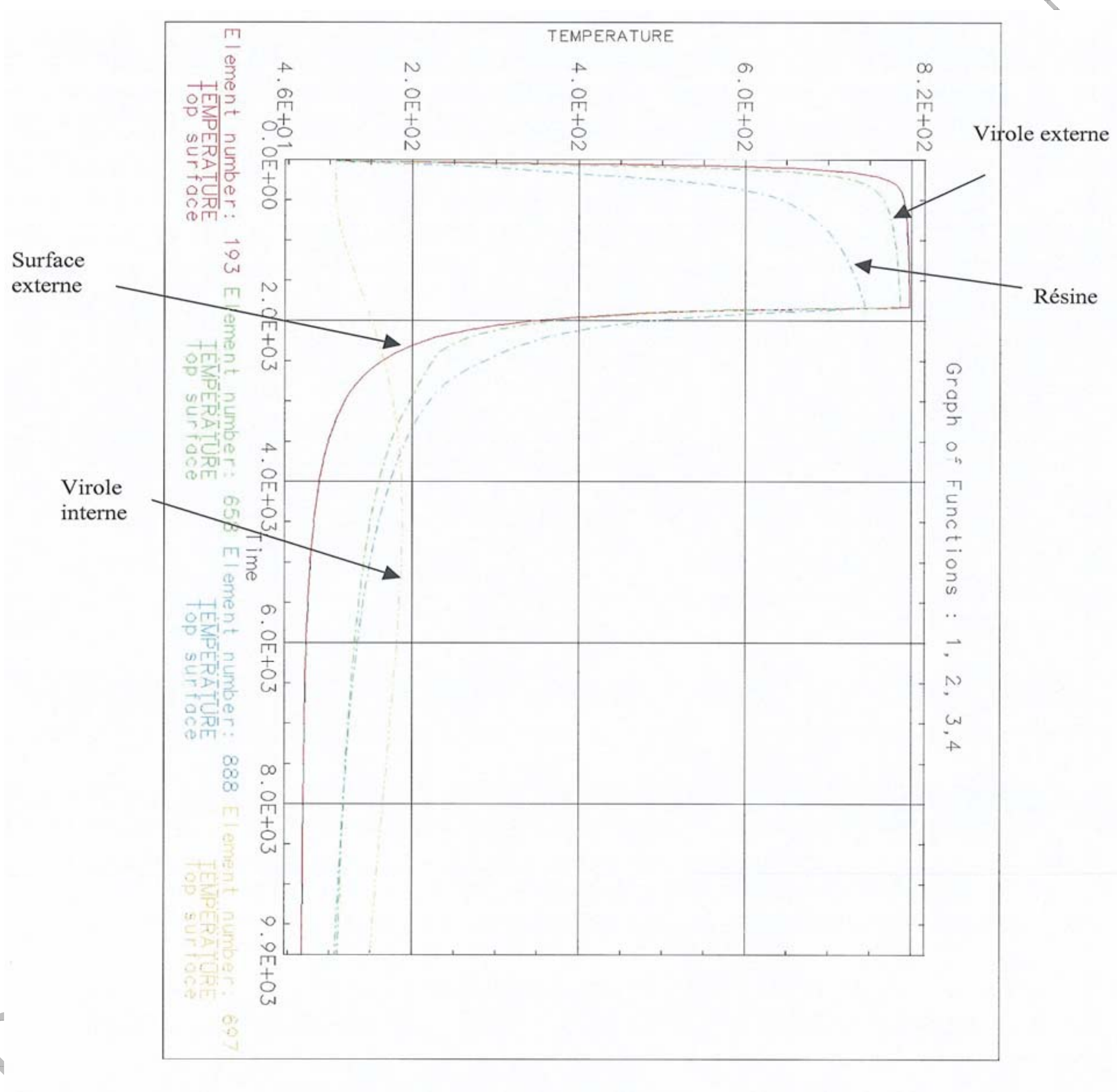
PACKAGING TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

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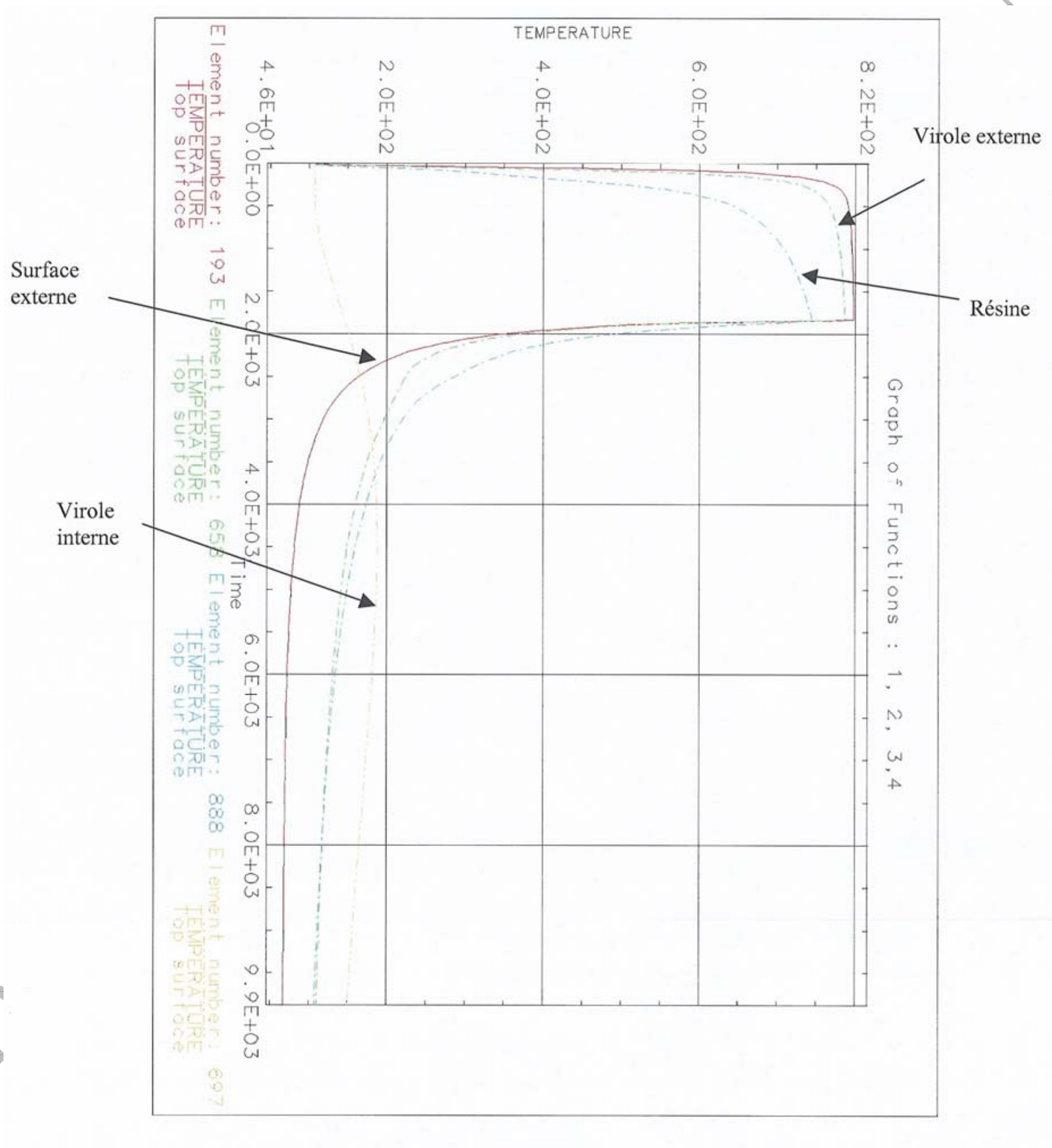
CONFIGURATION CA5

SEAL TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Joints Emballage	Packaging seals
Couvercle AA41	AA41 cover
AA99	AA99

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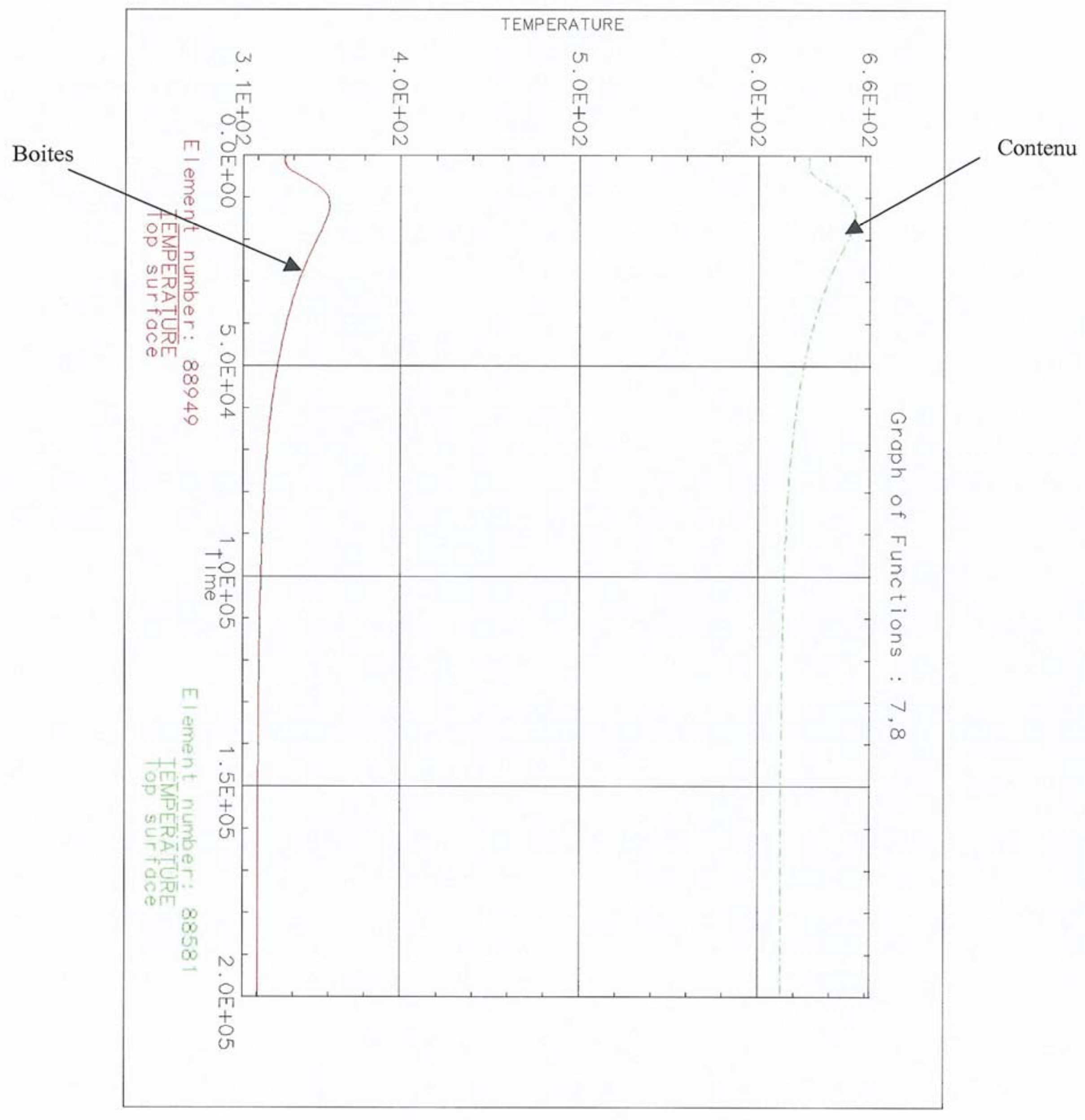
BOXES AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Contenu	Contents
Boites	Boxes

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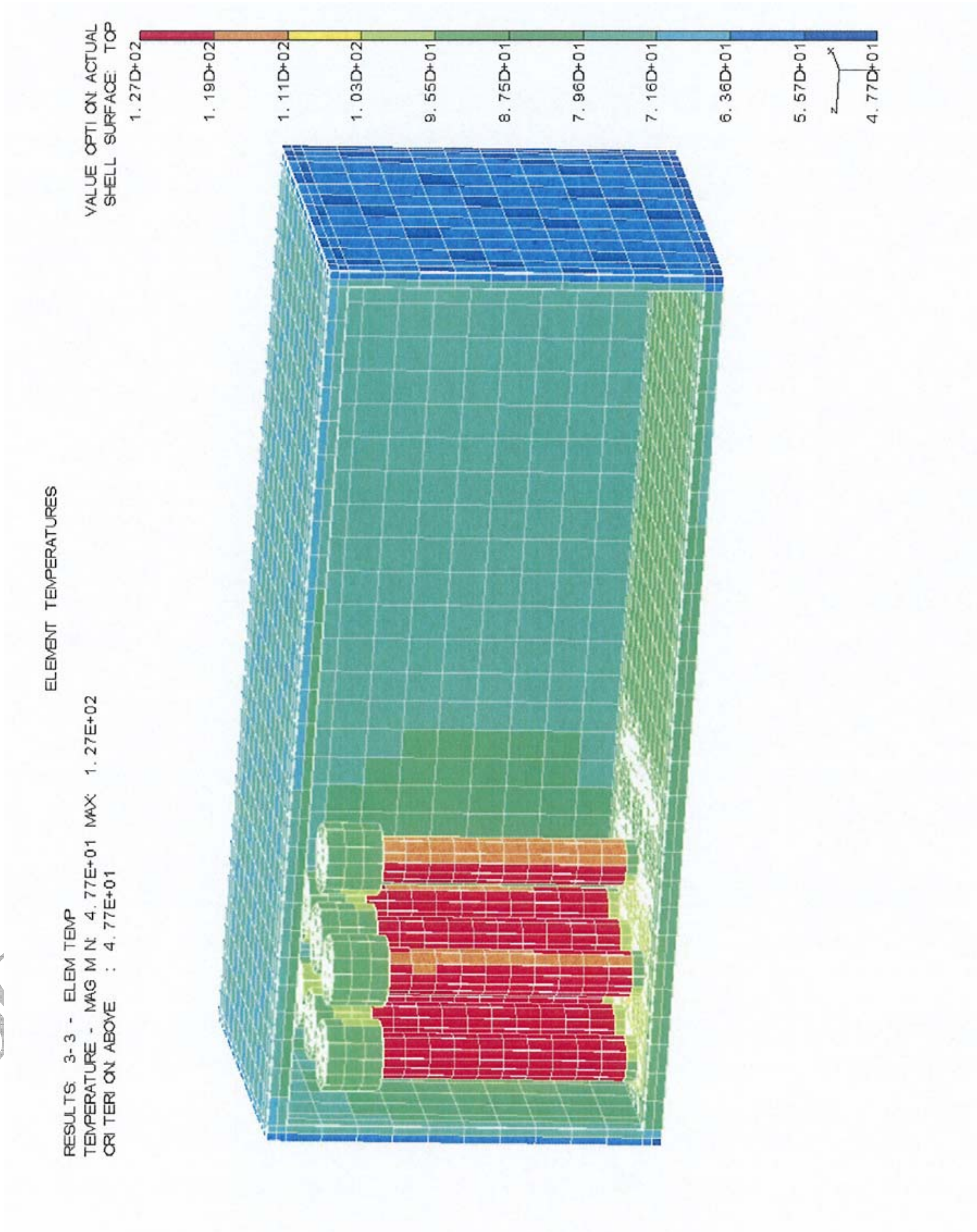
APPENDIX 32

CONFIGURATION CA6

ISOTHERMS OF CASING



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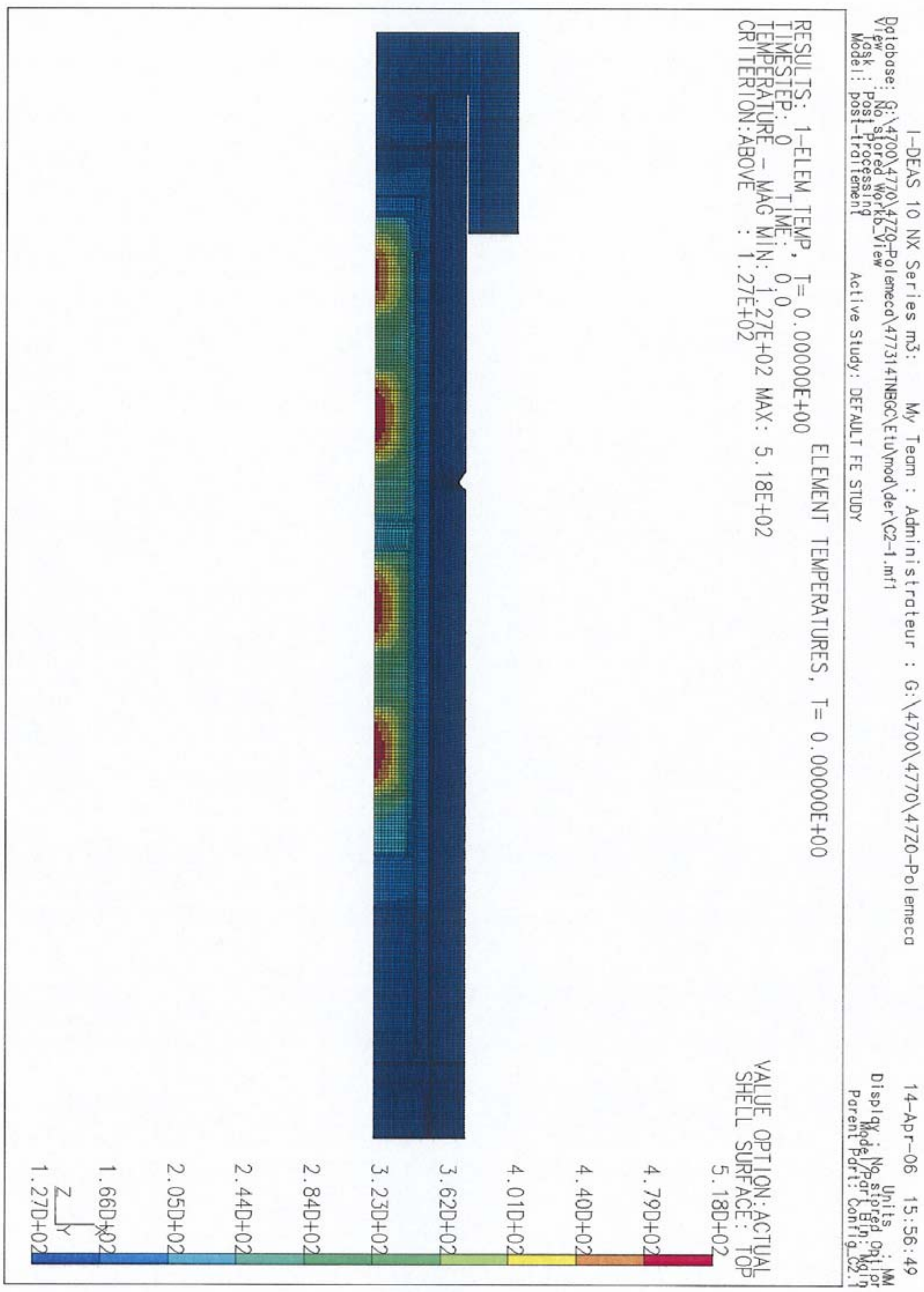
ISOTHERMS OF ISOLATED PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
Before fire



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ISOTHERMS OF PACKAGE
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s

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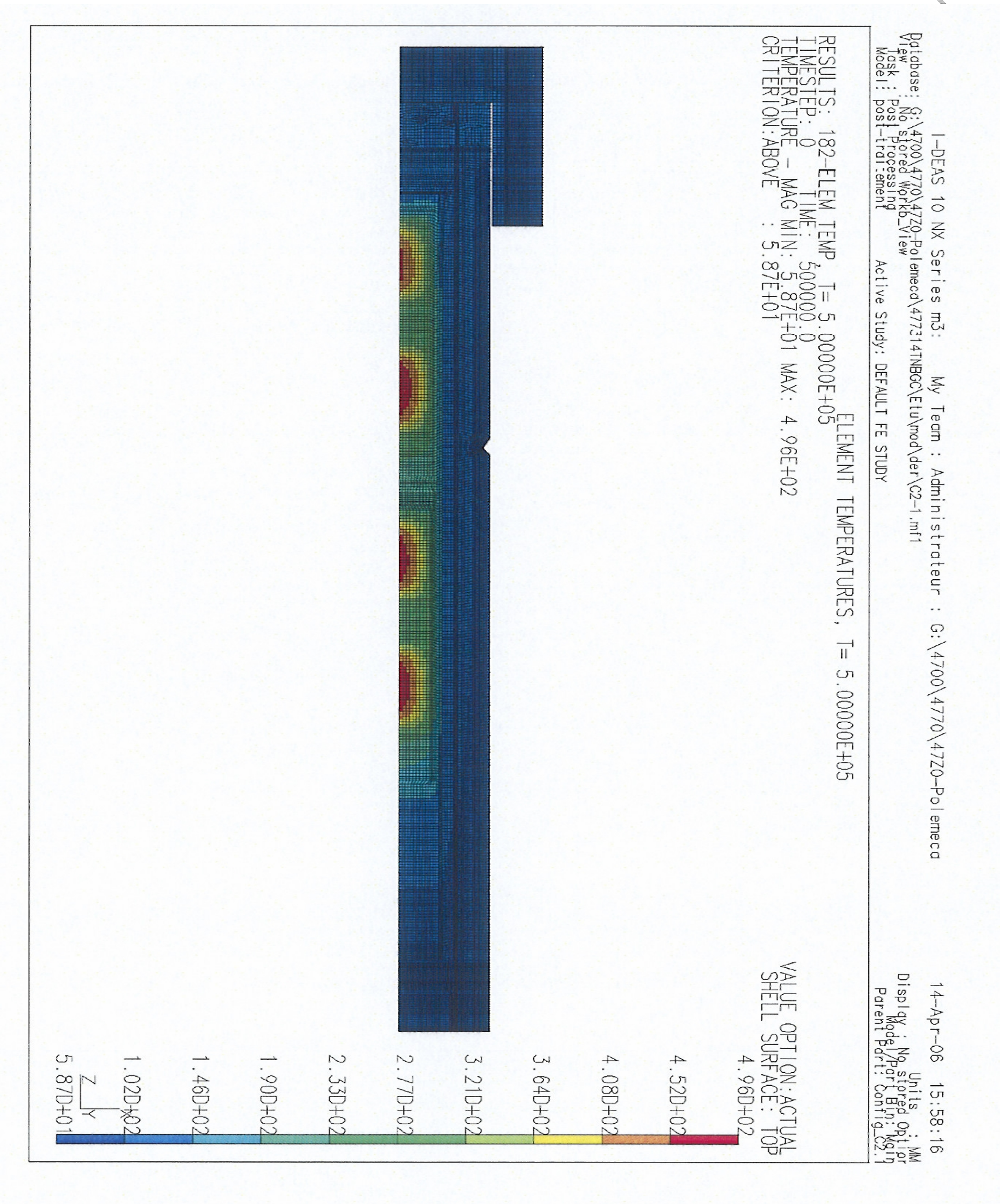
ACCIDENT CONDITIONS OF TRANSPORT
t = 500 000 s



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PACKAGING TEMPERATURE VARIATION CHART
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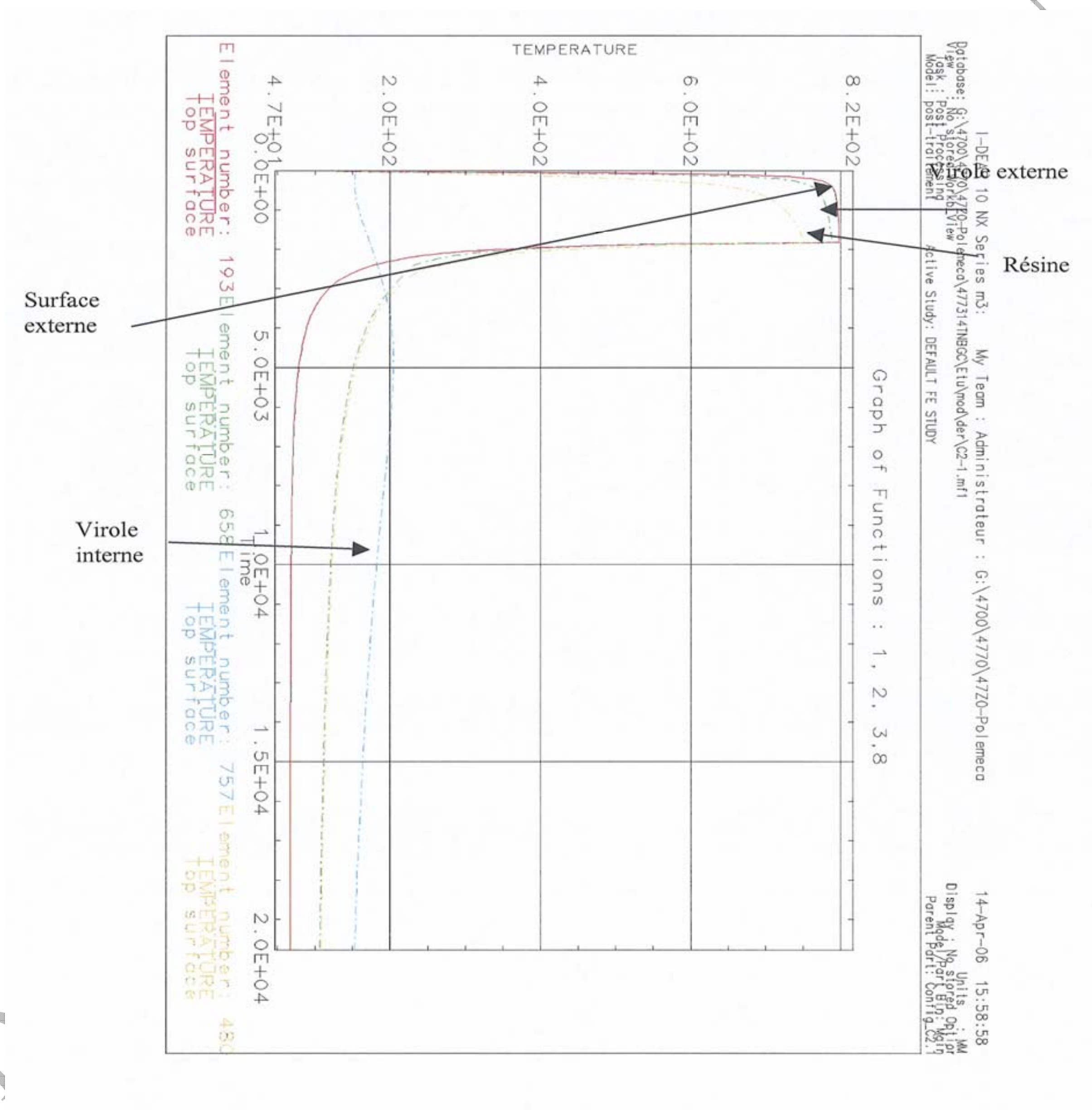

Surface externe	Outer surface
Virole externe	Outer shell
Résine	Resin
Virole interne	Inner shell

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APPENDIX 32

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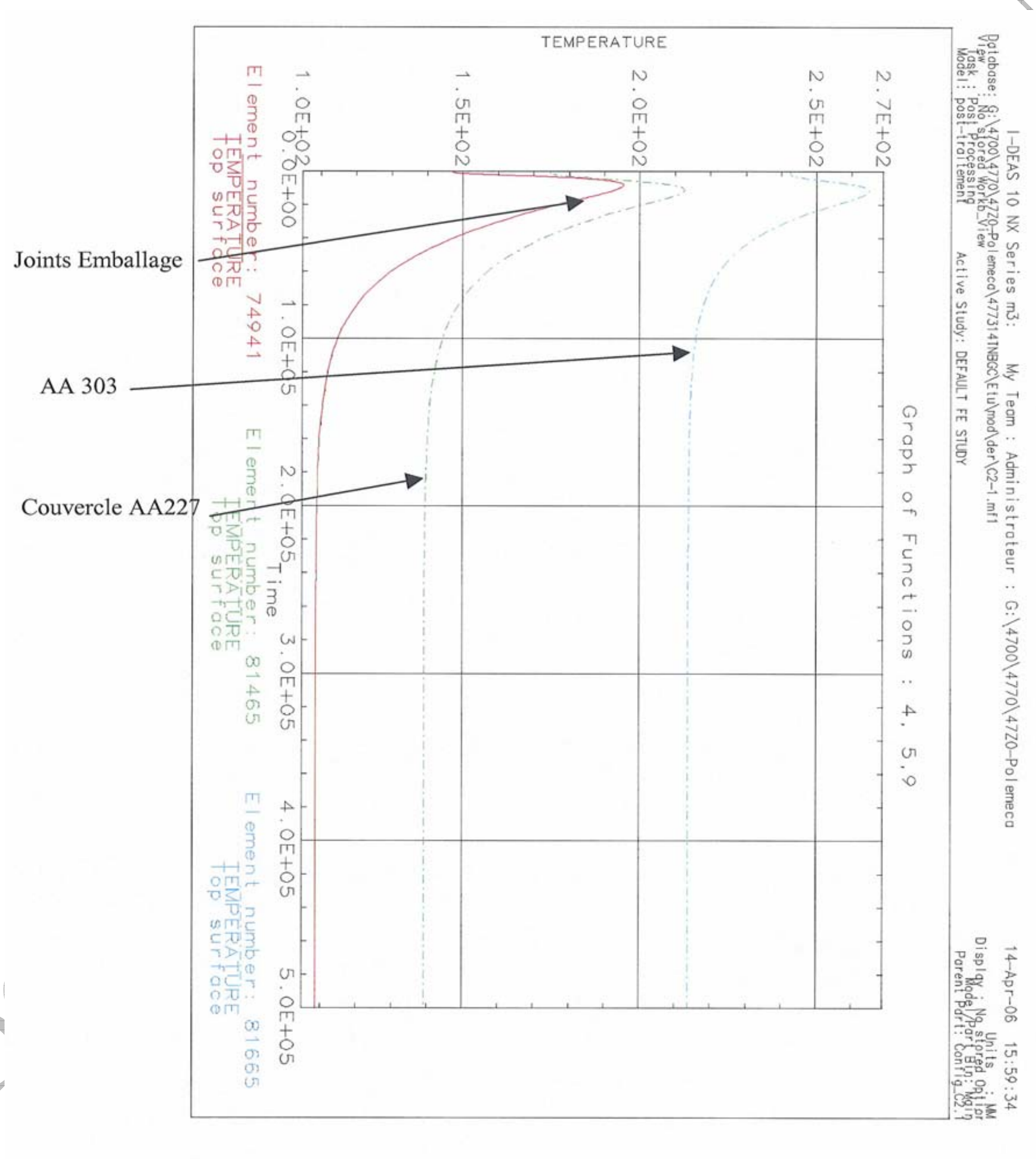
SEAL TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Joints Emballage	Packaging seals
Couvercle AA227	AA227 cover
AA 303	AA 303

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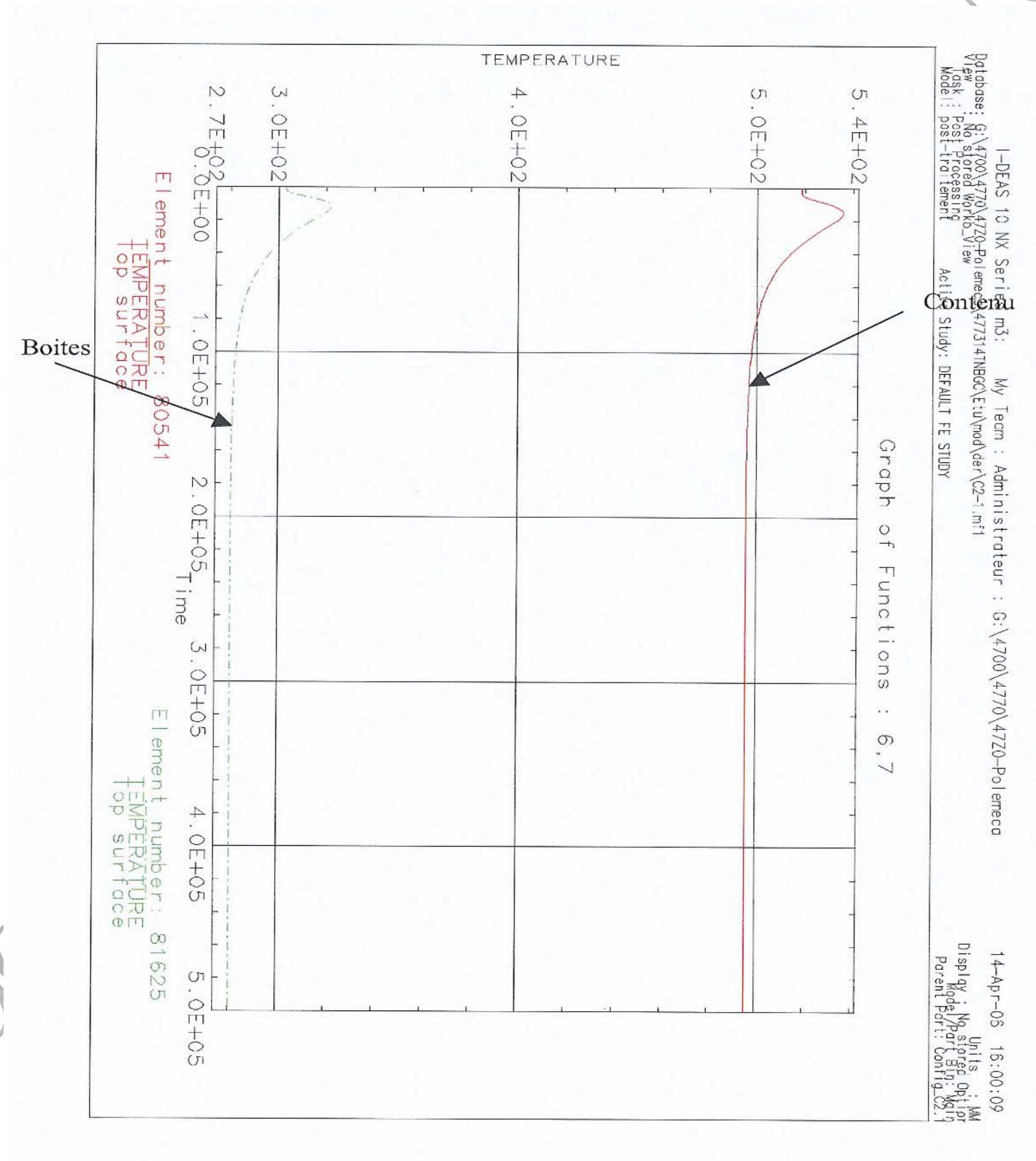
CONFIGURATION CA6

BOXES AND CONTENTS TEMPERATURE VARIATION CHART
ACCIDENT CONDITIONS OF TRANSPORT



Contenu	Contents
Boites	Boxes

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Department of Installation and Packaging projects
CEA Transport package service

Classification: 7.4.1	Page 1/44
Reference: 160 EMBAL PFM DET 08000166	Issue A
Title: Safety file – TN-BGC 1 Chapter 3.4: containment analysis	

Purpose of the document:

This chapter constitutes the containment analysis of the TN-BGC 1 package model

CEA/DEN/CAD/DPIE/SET
DO 85 27/02/08
08PPFM000166

Field of application and summary:

APPENDICES (included in this document and therefore in global page numbers)			ATTACHMENTS (separate page numbers, identification and formal procedures)		
No.	TITLES	N° of pages	No.	TITLES	N° of pages
			3.4-1	Test report on dialometry test on the STACEM joints Ref. D031080 – document CM1/1	40
			3.4-2	Containment analysis ref. NTC-07-00101341-006 of 21/12/07	23

History of changes

Issue	Date	Comments/Purpose of the change of issue
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	S. CLAVERIE-FORGUES (CEA/DEN/DPIE/SET)	

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LIST OF TABLES

1 INTRODUCTION.

This chapter analyses the containment of contents of package TN-BGC 1 under normal and accident conditions in transport.

The special case of contents 1b and 3b is deal with in attachment 3.4-2.

2 REFERENCES

[1] International Atomic Energy Agency Regulations for the transport of radioactive materials, Safety standards collection, no. TS-R-1 - 1996 edition (amended in 2005).

[2] Precision joints manual, ref. 5705 F, Parker company

[3] Safety of transport of radioactive materials. Package leaktightness tests - Standard ISO 12 807 - 1996.

3 CONTAINMENT SYSTEM

The loading of package TN-BGC 1 is contained in an envelope described in Chapter 2. This containment system is closed by a plug held in place by a compression ring. During transport, all access to this system is prohibited by anti-tamper seals.

3.1 DESCRIPTION OF THE CONTAINMENT ENVELOPE

The containment system is described in Chapter 2. Remember however that all the metal parts in the containment system are stainless steel with excellent resilience at -40 .

3.2 CONTAINMENT SYSTEM CLOSURE DEVICE

The containment system is closed by a plug held in place by a compression ring supported by a bayonet device.

The plug itself has a penetration fitted with a quick-connect coupling designed to take gaseous samples in the cavity or to create a negative pressure within in; during transport, this penetration is plugged by the quick-connect cap which is held in place by a compression ring screwed into the plug.

3.3 CONTAINMENT SYSTEM WELDS AND JOINTS

The containment system has the following welded joints:

- longitudinal weld of the shell,
- base weld on the shell,
- flange weld on the shell,
- closing weld on the neutron shielding housing on the plug.

These welds are carried out under a qualified procedure (see Chapter 2). They are liquid penetrant tested and checked for leaktightness during manufacture by a helium test.

The closing system is kept leaktight by O-rings and tested at the end of manufacture during period servicing and at each transport operation.

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4 ANALYSIS OF CONTAINMENT SYSTEM COMPLIANCE FOR NORMAL TRANSPORT CONDITIONS

4.1 COMPATIBILITY OF THE CONTAINMENT SYSTEM MATERIALS WITH EACH OTHER, WITH OTHER PACKAGING COMPONENTS AND WITH THE PACKAGE CONTENTS

The materials in contact with the outside of the containment system are:

- the carbon steel reinforcing plate, fixed to the bottom with welded studs,
- the resin.

These materials are totally compatible with the stainless steel in the containment system.

The following components inside the containment system can be in contact with the walls:

- the internal stainless steel containers,
- the aluminium wedges and spacers,
- the circular isolating shoes adjusted on the space when transporting uranyl nitrate in the internal container TN 90.

The materials used in these internal components (described in Chapter 1) are compatible with the stainless steel of the containment system.

4.2 EFFECTIVENESS OF THE CLOSING DEVICES IN RELATION TO SHOCKS AND VIBRATION

The weight of the plug and the closing device added to the heaviest content of the packaging is 170 kg maximum.

The prestressing imposed on the plug when being closed and before locking by the compression ring is:

F_T = 30 000 N (see Chapter 2).

The flattening force for the two plug joints is F_J = 16 560 N (see Chapter 3.1).

This prestressing force is therefore far greater that the force required to flatten the two plug joints. This gives considerable margins in terms of potential loosening.

In addition, the multiple drop tests and the mechanical calculations performed in Chapter 3.1 show that the closing system remains intact despite major mechanical loading.

Similarly, the quick-connect cap tightening nut is tightened to a torque of 50 N.m, which excludes any risk of loosening through vibration in transport or shocks.

The resistance of the package is therefore guaranteed in these conditions.

5 MAINTAINING LEAKTIGHTNESS AT HIGH AND LOW TEMPERATURE

5.1 NO RISK OF JOINT EXTRUSION AT HIGH TEMPERATURE

The method proposed to ensure there is no risk of joint extrusion involves checking that the volume of the trapezoidal throat remains greater than the volume of the O-ring across the entire temperature range considered. The joint therefore has total latitude to expand inside the throat and not outside it.

The spreadsheet attached to Table 3.4-2 is used to study the risk of extrusion.

Two joints delimit the containment system of the TN-BGC 1 packaging: this involves internal joints in the Staubli

cap and the cover.

Conservatively, the joint dimensions are considered at the maximum tolerances and the throat dimensions are considered at the minimum tolerances. The expansion of the steel delimiting the joint throats is ignored.

In accordance with the note supplied in attachment 3.4-1, the maximum coefficient of linear thermal expansion is:

- 0.000227 $m.K^{-1}$ for the GLT Viton joints,
- 0.000274 m.K-1 for the silicon joints.

The results presented in Table 3.4-2 reveal that the theoretical joint extrusion temperature is 231°C, a value higher than the maximum temperature calculated in Chapter 3.3.

The risk of extrusion of joints delimiting the containment system and fitted to package TN-BGC 1 is therefore excluded.

5.2 MAINTAINING LEAKTIGHTNESS AT LOW TEMPERATURE

An elastomer component loses its elasticity when cooled. We prefer to use joints with a good flexibility at low temperature. The TR10 tests have proved to be more effective in translating and comparing the flexibility of different elastomers when cold. The tests involve cooling a fully drawn test coupon. Held between two jaws, the test coupon is then released on one side and the temperature is increased by a controlled value. The elastomer tends to return to its original value when heating. When 90% of the elongation is reached, the temperature reached is the TR10 point. This means a return of 10% of elasticity. According to [2], the temperature of the TR10 point can be used to determine the minimum service temperature of all the elastomer joints. In practice, a static joint has a minimum service temperature of about 8° less than the TR10 point.

Two types of joints are used in delimiting the containment:

- THT silicon joints, for packaging in configuration B(U).

  The supplier guarantees a service range of [- 70°, + 300°] for these joints.

  However, the value of the TR10 is -45°C, which is lower than the minimum regulatory ambient temperature of -40°C.

- low temperature Viton joints, for packaging in configuration B(M).

  The supplier of these joints guarantees a service range of [- 40°, + 250°].

  However, the value of the TR10 is -28°C. By insisting on the use of packaging fitted with Viton joints only when the ambient temperature is not likely to drop below -20°C, a safety margin is maintained in terms of this potential risk of degradation in leaktightness.

5.3 MAINTAINING THE CONTAINMENT FOLLOWING REGULATORY TESTS UNDER NORMAL AND ACCIDENT CONDITIONS IN TRANSPORT

The tests to be considered in NTC are as follows:

- water spray,
- drop from a height of 1.20 m,
- compression under a distributed load equal to 5 times the natural weight of the package,
- impact on the hemispherical extremity of a 3.2 cm-diameter bar weighing 6 kg falling from a height of 1 m,

and in accident conditions in transport:

- drop from a height of 9 m,
- drop from a height of 1 m onto punch,
- drop of a 500 kg plate from a height of 9 m,
- exposure to a fire at 800°C for thirty minutes,
- immersion test.

In Chapter 3.1 we show that there is no risk of these tests causing loss or dispersion of the packaging content.

6 TEMPERATURES AND PRESSURES IN THE CAVITY

6.1 TEMPERATURES IN THE PACKAGING AND TERTIARY PACKING CAVITY

These temperatures are taken from Chapter 3.3.

6.1.1 Normal transport conditions

For a content with a maximum permitted **thermal power** of **340 W**, regardless of the physico-chemical nature of the content (including for the content made up of mixed uranium-plutonium oxide rods), the maximum gas temperatures in the packaging cavity and in the tertiary packing container cavity are 181°C and 302°C respectively.

For a content with **nil thermal power**, regardless of the physico-chemical nature of the content (including uranyl nitrate), the maximum gas temperatures in the packaging cavity and in the tertiary packing container cavity are 57°C and 55°C respectively.

Note: loading when wrappers are used is not considered as the thermal power of the content is then limited (4 x 20 W) so as to eliminate taking into account the thermolysis of wrappers in normal transport conditions and the temperatures are always less than those obtained with a loading of 340 W. As radiolysis of wrappers can be considered is negligible in an increase in pressure, loading a content is a thermal power of 340 W is therefore considered as envelope for the temperature and pressure reached.

6.1.2 Accident conditions in transport

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The maximum temperatures reached by the gases in the packaging cavity and in the tertiary packing container cavity are determined in attachment 3.3-2.

Without wrappers, for a content with a maximum permitted **thermal power** of **340 W**, the maximum temperatures of gases in the packaging cavity and in the tertiary packing container cavity are 211°C and 344°C respectively.

For the special case of mixed uranium-plutonium oxide rods, for a maximum **thermal power** of **340 W**, the maximum gas temperatures in the packaging cavity and in the tertiary packing container cavity are 268°C and 335°C respectively.

With wrappers, for a content with a maximum permitted **thermal power** of **4 x 20 W**, the maximum temperatures of gases in the packaging cavity and in the tertiary packing container cavity are 164 and 246 respectively.

For a content with **nil thermal power**, the maximum gas temperatures in the packaging cavity and in the tertiary packing container cavity are 171°C and 144°C respectively.

For the special case of uranyl nitrate, the maximum gas temperatures in the packaging cavity and in the tertiary packing container cavity are 183 and 112 respectively.

6.2 PRESSURE IN THE PACKAGING CAVITY

6.2.1 Normal transport conditions

6.2.1.1 Content with a maximum thermal power of 340 W (no wrapper) or 4 x 20 W (with wrappers) - water content less than 0.5%

When loading contents, the packaging cavity and the cartridges are considered to be in equilibrium with the ambient and pressure conditions (25°C, $1.04.10^5$ Pa given the fluctuations estimated at $60.04.10^5$ Pa).

The average temperature in the packaging is written Tme = (Vlc x Tmc + Vlai x Tmai) / (Vlai + Vlc)

Where

Tmc: average maximum temperature of the gas at thermal equilibrium in the packaging cavity = 454 K

Tmai: average maximum temperature of the gas at thermal equilibrium in the tertiary packing container = 575 K

Vlc: free volume in the packaging cavity = 7.4 l

Vlai: free volume in the loaded tertiary packing container cavity = 7.64 l

i.e. **Tme = 515 K**

The average resulting pressure in the containment is therefore expressed as follows:

Pme = $1,04.10^5$ x Tme / 298 = **$1.79.10^5$ Pa**

6.2.1.2 Content with a maximum thermal power of 340 W (no wrapper) or 4 x 20 W (with wrappers) - water content more than 0.5%

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It is considered conservatively that the maximum permitted pressure in this case is the absolute pressure which guarantees that the packaging remains leaktight (statically or in an explosion), i.e. 11.10^5 Pa (the transport time is limited in Chapter 3.7 to avoid exceeding this pressure), from which is subtracted the pressure of the thermolysis gas, i.e. $1.5.10^5$ Pa (as there is never wrapper thermolysis in NTC).

Thus, **Pme = 9.5. 10^5 Pa**.

The average maximum temperature in the packaging blanket remains **Tme** = **515 K**.

6.2.1.3 Content with maximum thermal power of 340 W - special case of mixed uranium-plutonium oxide rods

The maximum internal gas pressure inside the rods (or the cartridges enclosing rod sections) is 2.10^5 Pa absolute at 25°C (see Chapter 1).

Conservatively, and to avoid taking types of rod in isolation, no assumption is made on the gas leaktightness of rods.

It is therefore assumed as initial condition that the interior (assumed empty of its content) of the tertiary packing container is subject to the pressure 2.10^5 Pa absolute at 25°C.

It is assumed that once thermal equilibrium is reached, the gas contained in the tertiary packing container escapes into the packaging cavity.

In these conditions, the average resulting pressure in the containment system is:

$$Pme = (PcVlcTmai + PaiVlaiTmc)/(VlcTmai + VlaiTmc)$$

Pc: maximum pressure in the packaging cavity, given the fluctuations in atmospheric pressure estimated at $\pm$ $0.04.10^5$ Pa = $1.04.10^5$ Pa x 454/298 = $1.6.10^5$ Pa

Pai maximum pressure in the tertiary packing container at thermal equilibrium, i.e. Pai = 2.10^5 Pa x Tmai/298 = 3.86 10^5 Pa

Tmc: average maximum temperature of the gas at thermal equilibrium in the packaging cavity = 454 K

Tmai: average maximum temperature of the gas at thermal equilibrium in the tertiary packing container = 575 K

Vlc: free volume in the packaging cavity = 7.4 l

Vlai: free volume in the empty tertiary packing container cavity = 15.8 l

i.e., **Pme = $3.13.10^5$ Pa**

The average temperature Tme is written **Tme** = (Vlc x Tmc + Vlai x Tmai) / (Vlai + Vlc) = **536 K.**

6.2.1.4 Contents not releasing thermal power - general case

The internal pressure in the cavity is therefore left at atmospheric pressure when the package is closed.

The air temperature at closing is assumed equal to 25°C. During transport under regulatory temperature (38°C) and regulatory insolation, the air temperature in the cavity can be estimated at 57°C at most.

The corresponding pressure is therefore written:

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Pme = $1.04.10^5$ x 330 / 298 = **$1.15.10^5$ Pa** absolute.

6.2.1.5 Contents not releasing thermal power - uranium oxide fuel rods

Adopting similar reasoning as in § 5.2.1.3, the average resulting pressure in the containment is shown to be:

$$Pme = (PcVlcTmai + PaiVlaiTmc)/(VlcTmai + VlaiTmc)$$

Pc: maximum pressure in the packaging cavity, given the fluctuations in atmospheric pressure estimated at $\pm$ $0.04.10^5$ Pa = $1.04.10^5$ Pa x 330/298 = $1.2.10^5$ Pa

Pai maximum pressure in the tertiary packing container at thermal equilibrium, i.e. Pai = 3.10^5 Pa x Tmai/298 = 3.32 10^5 Pa

Tmc: average maximum temperature of the gas at thermal equilibrium in the packaging cavity = 330 K

Tmai: average maximum temperature of the gas at thermal equilibrium in the tertiary packing container = 330 K

Vlc: free volume in the packaging cavity = 7.4 l

Vlai: free volume in the empty tertiary packing container cavity = 15.8 l

i.e., **Pme = $2.63.10^5$ Pa**

6.2.1.6 Contents not releasing thermal power - uranyl nitrate

The maximum pressure reached in the cavity is the pressure calculated in § 6.2.1.4, to which must be added the overpressure generated by any radiolysis of the content (ΔP = $0.31.10^5$ Pa).

The pressure in the cavity is therefore $1.51.10^5$ Pa absolute.

Taking the conservative hypothesis of a saturating vapour pressure of 1.10^5 Pa (reminder: uranyl nitrate does not reach its boiling point in NTC), the total maximum pressure is **Pme = $2.51.10^5$ Pa**.

6.2.2 Accident conditions in transport

6.2.2.1 Content with maximum thermal power of 340 W - water content less than 0.5%

Chapter 3.7 reveals that the average maximum temperature in the packaging cavity blanket **Tme** is **555 K**.

The average resulting pressure in the containment is therefore expressed as follows:

Pme = $1.04.10^5$ x Tme / 298 = **$1.94.10^5$ Pa**

6.2.2.2 Content with maximum thermal power of 340 W - general case - water content more than 0.5%

It is considered conservatively that the maximum permitted pressure in this case is the absolute pressure which guarantees that the packaging remains leaktight (in an explosion), i.e. 11.10^5 Pa.

Thus, **Pme = 11. 10^5 Pa**.

The average maximum temperature in the packaging blanket remains **Tme** = **555 K**.

6.2.2.3 Content of 4 x 20 W (with wrappers) - general case - water content less than 0.5%

Chapter 3.7 reveals that the average maximum temperature in the packaging cavity blanket **Tme** is **490 K**.

The resulting average pressure in the containment due to the increase in temperature from the fire test is therefore expressed as follows:

Pme = $1.04.10^5$ x Tme / 298 = $1.71.10^5$ Pa

Considering the thermolysis and radiolysis of wrappers (see Chapter 3.7), the average maximum pressure in the containment is **Pme = $3.38.\ 10^5$ Pa**.

6.2.2.4 Content of 4 x 20 W (with wrappers) - general case - water content more than 0.5%

We are going to consider conservatively that the maximum permitted pressure in this case is the absolute pressure which guarantees that the packaging remains leaktight (in an explosion), i.e. 11.10^5 Pa.

Thus, **Pme = $11.\ 10^5$ Pa**.

The average maximum temperature in the packaging blanket remains **Tme** = **490 K**.

6.2.2.5 Content of 340 W - special case of mixed uranium-plutonium oxide rods

The pressure in the cavity in normal transport conditions has been assessed at 3.13 10^5 Pa and the temperature at 536 K.

The average maximum temperature in the packaging cavity is written Tme = (Vlc x Tmc + Vlai x Tmai) / (Vlai + Vlc) with Tmc = 541 K and Tmai = 608 K. I.e. **Tme = 587 K**.

The resulting maximum average pressure in the containment is therefore **Pme = $3.43.10^5$ Pa**.

6.2.2.6 Contents not releasing thermal power - general case

The pressure in the cavity in normal transport conditions has been assessed previously at 1.2 0.10^5 Pa.

The average temperature in the packaging is written Tme = (Vlc x Tmc + Vlai x Tmai) / (Vlai + Vlc) Tmc = 515 K, Tmai = 414 K, Vlc - 7.4 l and Vlai = 5.3 l. I.e. **Tme = 474 K**.

The resulting maximum average pressure in the containment is therefore **Pme = $1.72.10^5$ Pa**.

6.2.2.7 Contents not releasing thermal power - uranium oxide fuel rods

The pressure in the cavity in normal transport conditions has been assessed at 2.63 0.10^5 Pa and the temperature at 330 K.

Tme is **474 K**.

The resulting maximum average pressure in the containment is therefore **Pme = $3.78.10^5$ Pa**.

6.2.2.8 Contents not releasing thermal power - uranyl nitrate

The temperature is identical to that determined in § 6.2.2.6, i.e. **Tme = 474 K.** The maximum pressure reached in the cavity is the same as in § 6.2.2.6, except that the overpressure generated by any radiolysis of the content (ΔP = $0.31.10^5$ Pa) must be added.

The maximum pressure in the cavity is **Pme = 3.03.10^5 Pa** (taking into account the saturating vapour pressure, which is increased to 1 bar as the solution never reaches boiling point: 10^5 Pa is therefore added to the calculated pressure without taking this phenomenon into account).

7 RELEASE OF ACTIVITY

7.1 SOURCE OF ACTIVITY RELEASE

As the containment system has no decompression system, any activity potentially released during transport (or post-accident) is due only to leaks at the leaktight joints.

The importance of these leaks relates to the difference in driving head and to the state of the joints and their bearing surfaces.

For this reason the loading operating procedure includes a method for checking joint leaktightness (actual criterion).

7.2 CALCULATION NOTATIONS AND METHODOLOGY

The methodology adopted to calculate the release of activity of various contents in normal and accident conditions in transport is taken from standard ISO 12 807 [3]/

The methodology is based on solving the equation of:

- Knudsen, for the solid contents,
- Poiseuille, for the liquid content.

It is used to define the pairing:

- "maximum specific activity - leak rate checked before transport" in the general case of aerosols,
- "maximum activity - leak rate checked before transport" in the special case of uranyl nitrate.

7.3 RESULTS

The Excel solver is used to solve the problem. The results are presented in Tables 3.4-3 to 3.4-14.

Table 3.4-1 links the calculation scenarios presented below and the contents of Chapter 1 covered by this case study.

7.3.1 Scenario 1

Pre-transport check of X Pa.$m^3.s^{-1}$ SLR guarantees, for all these contents, that:

- the release in normal transport conditions is less than 10^{-6} A_2/hr as long as the content has an

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activity less than **Y(X) A2/g**,

- the release in accident conditions in transport is less than 1 A_2 in one week as long as the content has an activity less than **Z(X) A2/g.**

7.3.1.1 Scenario 1A - Pth = 340 W - general case - water content less than 0.5%

The values obtained for Y and Z(X) based on the criterion checked before transport are as follows: (Tables 3.4-3 to 3.4-6)

Pre-transport check (SLR) in lusec	**Pre-transport check (SLR) in Pa.m^3.s^{-1}**	**Maximum activity (NTC) in A2/g**	**Maximum activity (TAC) in A2/g**
2	2.66E-04	**87**	4307
1	1.33E-04	**175**	8647
0,5	6.65E-05	**352**	17371
0,1	1.33E-05	**1799**	88014

7.3.1.2 Scenario 1B - Pth = 340 W - general case - water content more than 0.5%

The values obtained for Y and Z(X) based on the criterion checked before transport are as follows: (Tables 3.4-7 to 3.4-10)

Pre-transport check (SLR) in lusec	**Pre-transport check (SLR) in Pa.m^3.s^{-1}**	**Maximum activity (NTC) in A2/g**	**Maximum activity (TAC) in A2/g**
2	2.66E-04	**15**	723
1	1.33E-04	**31**	1465
0,5	6.65E-05	**63**	2979
0,1	1.33E-05	**331**	15645

7.3.1.3 Scenario 1C - Pth = 4 x 20 W - general case - water content less than 0.5%

The values obtained for Y and Z(X) based on the criterion checked before transport are as follows: (Tables 3.4-11 to 3.4-14)

Pre-transport check (SLR) in lusec	Pre-transport check (SLR) in $Pa.m^3.s^{-1}$	Maximum activity (NTC) in A2/g	Maximum activity (TAC) in A2/g
2	2.66E-04	**78**	1936
1	1.33E-04	**158**	3915
0,5	6.65E-05	**318**	7930
0,1	1.33E-05	**1635**	41185

7.3.1.4 Scenario 1D - Pth = 4 x 20 W - general case - water content more than 0.5%

The values obtained for Y and Z(X) based on the criterion checked before transport are as follows: (Tables 3.4-15 to 3.4-18)

Pre-transport check (SLR) in lusec	Pre-transport check (SLR) in $Pa.m^3.s^{-1}$	Maximum activity (NTC) in A2/g	Maximum activity (TAC) in A2/g
2	2.66E-04	**14**	590
1	1.33E-04	**28**	1198
0,5	6.65E-05	**56**	2437
0,1	1.33E-05	**296**	12842

7.3.2 Scenario 2

A pre-transport check at $6.65.10^{-4}$ $Pa.m^3.s^{-1}$ (5 lusec) SLR guarantees for these contents (see Table 3.4-19) that:

- the release in normal transport conditions is less than 10^{-6} A_2/hr as long as the content has an activity less than **44 A_2/g**,

- the release in accident conditions in transport is less than 1 A_2 in one week as long as the content has an activity less than **1698 A_2/g**.

This design scenario covers air transport (external pressure taken as equal to 5,000 Pa).

7.3.3 Scenario 3

A pre-transport check at $6.65.10^{-4}$ Pa.m^3.s^{-1} (5 lusec) SLR guarantees (see Table 3.4-20) that:

- the release in normal transport conditions is less than 10^{-6} A_2/hr as long as the content has an activity less than **$1.64.10^{-1}$ A_2/m^3**,
- the release in accident conditions in transport is less than 1 A_2 in one week as long as the content has an activity less than **867 A_2/m^3.**

Generally, the uranium isotopes normally encountered (^{235}U, ^{238}U) have an unlimited A_2.

The activity release criteria are therefore largely respected.

Note: a factor of 2 is taken compared with the regulatory criterion.

7.3.4 Scenario 4

A pre-transport check at **$6.65.10^{-4}$** Pa.m^3.s^{-1} (5 lusec) SLR guarantees for these contents (see Table 3.4-21) that:

- the release in normal transport conditions is less than 10^{-6} A_2/hr as long as the content has an activity less than **22 A_2/g**,
- the release in accident conditions in transport is less than 1 A_2 in one week as long as the content has an activity less than **960 A_2/g**.

7.3.5 Scenario 5

Pre-transport check at X Pa.m^3.s^{-1} SLR guarantees, for all these contents, that:

- the release in normal transport conditions is less than 10^{-6} A_2/hr as long as the content has an activity less than **Y(X) A2/g**,
- the release in accident conditions in transport is less than 1 A_2 in one week as long as the content has an activity less than **Z(X) A2/g**.

The values obtained for Y and Z(X) based on the criterion X checked before transport are as follows: (Tables 3.4-22 to 3.4-25)

Pre-transport check (SLR) in lusec	**Pre-transport check (SLR) in Pa.m^3.s^{-1}**	**Maximum activity (NTC) in A2/g**	**Maximum activity (TAC) in A2/g**
2	2.66E-04	**47**	2200
1	1.33E-04	**94**	4441
0,5	6.65E-05	**191**	8977
0,1	1.33E-05	**987**	46353

8 CONCLUSION

Note that according to the previous analyses, and despite the envisage conservative hypotheses, the release from package model TN-BGC 1 largely satisfies the criteria imposed by the regulations under both normal and accident conditions in transport.

The table below summarises for each family of contents the parameters to be checked before transport to ensure compliance with the regulatory criteria.

Case	Pre-transport check (SLR) in Pa.m^3.s^{-1}	Maximum activity in A2/g or in A2/m^3 (content 3)
1A - contents 1, 3, 5, 8 (pellets only) 9, 10, 15, 18, 19, 20 and 23	2.66E-04	**87**
	1.33E-04	**175**
	6.65E-05	**352**
	1.33E-05	**1799**
1B - contents 1, 3, 5, 8 (pellets only) 9, 10, 15, 18, 19, 20 and 23	2.66E-04	**15**
	1.33E-04	**31**
	6.65E-05	**63**
	1.33E-05	**331**
1C - contents 1, 3, 5, 8 (pellets only) 9, 10, 15, 18, 19, 20 and 23	2.66E-04	**78**
	1.33E-04	**158**
	6.65E-05	**318**
	1.33E-05	**1635**
1D - contents 1, 3, 5, 8 (pellets only) 9, 10, 15, 18, 19, 20 and 23	2.66E-04	**14**
	1.33E-04	**28**
	6.65E-05	**56**
	1.33E-05	**296**
2 - contents 2, 4, 7 (pellets only), 11 and 26	6.65E-05	**44**
3 - content 6	6.65E-05	**0,164**
4 - content 7	6.65E-05	**22**
5 - content 8	2.66E-04	**47**
	1.33E-04	**94**
	6.65E-05	**191**
	1.33E-05	**987**

TABLE 3.4-1: MAIN CHARACTERISTICS OF TRANSPORTED CONTENTS

		CNT			CAT		
Type de cas	**Type de contenu**	**Pression dans la cavité (bar)**	**T (K) joints emballage**	**T (K) cavité**	**Pression dans la cavité (bar)**	**T (K) joints emballage**	**T (K) cavité**
Cas 1a - Pth 340 W - cas général - teneur en eau inférieure à 0,5%	1, 3, 5, 8 (pastilles uniquement) 9, 10, 15, 18, 19, 20 et 23	1,79	400	515	1,93	500	554
Cas 1b - Pth 340 W - cas général - teneur en eau supérieure à 0,5%	1, 3, 5, 8 (pastilles uniquement) 9, 10, 15, 18, 19, 20 et 23	9,5	400	515	11	500	554
Cas 1c - Pth 4x20W (présence de housses) - cas général - teneur en eau inférieure à 0,5%	1, 3, 5, 8 (pastilles uniquement) 9, 10, 15, 18, 19, 20 et 23	1,79	342	515*	3,38	372	490
Cas 1d - Pth 4x20W (présence de housses) - cas général - teneur en eau supérieure à 0,5%	1, 3, 5, 8 (pastilels unqiuement) 9, 10, 15, 18, 19, 20 et 23	9,5	342	515*	11	372	490
Cas 2 - Pth nulle - cas général	2, 4, 7 (pastilles uniquement) 11 et 26	1,2	400	330	1,72	500	474
Cas 3 - Pthnulle - cas du nitrate d'uranyle	6	2,51	400	330	3,03	500	474
Cas 4 - Pth nulle - cas particulier des crayons d'oxyde d'uranium	7 (Crayons)	1,9	400	330	2,73	500	474
Cas 5 - Pth 340 W - cas particlier des crayons d'oxyde mixte d'uranium-plutonium	8 (Crayons)	3	400	536	3,38	462	587

(*) TCNT >TCAT car en CNT, les températures prises en compte sont celles correspondant à un chargement de 340 W

(*) TCNT > TCAT for in NTC, the temperatures taken into account correspond to a load of 340 W

CNT	NCT
CAT	HAC
Type de cas	Type of scenario
Type de contenu	Type of content
Pression dans la cavité	Pressure in the cavity
T (K) joints emballage	T (K) packaging joints
T (K) cavité	T (K) cavity
Pression dans la cavité	Pressure in the cavity
T (K) joints emballage	T (K) packaging joints
T (K) cavité	T (K) cavity
Cas 1a - Pth 340 W - cas général - teneur en eau inférieure à 0.5%	Scenario 1a - Pth 340 W - general case - water content less than 0.5%
Cas 1b - Pth 340 W - cas général - teneur en eau supérieure à 0.5%	Scenario 1a - Pth 340 W - general case - water content more than 0.5%
(pastilles uniquement)	(pellets only)
Cas 1c - Pth 4x20W (présence de housses) - cas général - teneur en eau inférieure à 0.5%	Scenario 1c - Pth 4 x 20 W - general case - water content less than 0.5%
Cas 1d - Pth 4x20W (présence de housses) - cas général - teneur en eau supérieure à 0.5%	Scenario 1d - Pth 4 x 20 W - general case - water content more than 0.5%
Cas 2 - Pth nulle - cas général	Scenario 2 - Pth nil - general case
Cas 3 - Pth nulle - cas du nitrate d'uranyl	Scenario 3 - Pth nil - uranyl nitrate
Cas 4 - Pth nulle - cas particulier des crayons d'oxyde d'uranium	Scenario 4 - Pth nil - uranium oxide rods
Cas 5 - Pth 340 W - cas particulier des crayons d'oxyde mixte d'uranium-plutonium	Scenario 5 - Pth 340 W - special case of mixed uranium-plutonium oxide rods
crayons	rods

TABLE 3.4-2: EXTRUSION TEMPERATURE OF JOINTS DELIMITING THE CONTAINMENT

	Configuration B(U) - THT silicon joints		Configuration B(M) - Viton joints	
COMPONENT:	Vessel head	Staubli plug	Vessel head	Staubli plug
input data for the throat:				
average diameter	203.1	36.45	203.1	36.45
depth	4.78	2.5	4.78	2.5
inlet (in pte)	6.5	3.1	6.5	3.1
bottom radius	0.7	0.3	0.7	0.3
inlet radius	0.3	0.15	0.3	0.15
angle	30	30	30	30
input data for the joint:				
average diameter	197.64	33.27	197.64	33.27
feedring diameter	6.95	3.63	7	3.63
intermediate calculations				
k	6.009734287	2.993375673	6.009734287	2.993375673
h	4.797298721	2.473760431	4.797298721	2.473760431
beta	1.047197551	1.047197551	1.047197551	1.047197551
A	26.28919699	6.926529206	26.28919699	6.926529206
A2	13.26	3.41	13.26	3.41
A	3.014923106	0.710140831	3.014923106	0.710140831
A	1.0262536	0.188495559	1.0262536	0.188495559
A	0.311769145	0.077942286	0.311769145	0.077942286
A	0.188495559	0.04712389	0.188495559	0.04712389
Total area	43.71364729	11.26598399	43.71364729	11.26598399
output data				
throat volume	27891.8191	1290.079681	27891.8191	1290.079681
inlet (in radius)	6.846410162	3.273205081	6.846410162	3.273205081
joint volume	23555.05965	1081.697448	23895.20052	1081.697448
volume ratio	**1.184111588**	**1.192643732**	**1.167256122**	**1.192643732**
stretching ratio	1.027625987	1.095581605	1.027625987	1.095581605
flattening ratio	0.687769784	0.688705234	0.682857143	0.688705234
joint expansion coefficient	0.000274	0.000274	0.000227	0.000227
Extrusion temperature	231.4880604	240.7396795	253.056677	286.4434898

TABLE 3.4-3: SCENARIO 1 - PTH 340 W - GENERAL CASE - WATER CONTENT LESS THAN 0.5% - 1.33.10^{-5} PA.M^{3}.S^{-1} (0.1 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**1799**	**88014**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	179 000	193 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		1,54399E-10	1,49097E-10	*m3/s*
Taux de fuite	**Q**	1,33E-05	2,76E-05	2,88E-05	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	8,68E-06	8,68E-06	8,68E-06	*m*

Conditions de calcul	Calculation conditions
Caractéristiques du contenu	Characteristics of the content
Rapport Am/A2éq	Am/A2eq ratio
Caractéristiques de la cavité	Characteristics of the cavity
Plus petit diamètre de joint de l'emballage	Smallest packaging joint diameter
Température des joints	Joint temperature
Nature du fluide porteur	Type of carrier fluid
Masse molaire du fluide porteur	Molar mass of the carrier fluid
Viscosité du fluide porteur à la temperature	Viscosity of the carrier fluid at temperature
Pression amont	Upstream pressure
Pression aval	Downstream pressure
Activité volumique du fluide porteur	Activity concentration of the carrier fluid
Taux de relâchement d'activité admissible	Permitted activity release rate
Débit volume de fuite	Leak volume flow rate
Taux de fuite	Leak rate
Diamètre de capillaire équivalent D	Equivalent capillary diameter D

TABLE 3.4-4: SCENARIO 1 - PTH 340 W - GENERAL CASE - WATER CONTENT LESS THAN 0.5% - $6.65.10^{-5}$ PA.M^{3}.S^{-1} (0.5 LUSEC) SLR

Conditions de calcul		**SLR**	**CNT**	**CAT**	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**352**	**17371**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	179 000	193 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		7,88605E-10	7,55431E-10	*m3/s*
Taux de fuite	**Q**	6,65E-05	1,41E-04	1,46E-04	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,32E-05	1,32E-05	1,32E-05	*m*

TABLE 3.4-5: SCENARIO 1 - PTH 340 W - GENERAL CASE - WATER CONTENT LESS THAN 0.5% - $1.33.10^{-4}$ PA.M^3.S^{-1} (1 LUSEC) SLR

Conditions de calcul		**SLR**	**CNT**	**CAT**	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**175**	**8647**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	179 000	193 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		1,58856E-09	1,51766E-09	*m3/s*
Taux de fuite	**Q**	1,33E-04	2,84E-04	2,93E-04	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,57E-05	1,57E-05	1,57E-05	*m*

TABLE 3.4-6: SCENARIO 1 - PTH 340 W - GENERAL CASE - WATER CONTENT LESS THAN 0.5% - $2.66.10^{-4}$ PA.M^3.S^{-1} (2 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**87**	**4307**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	*---*
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	179 000	193 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		3,19673E-09	3,04706E-09	*m3/s*
Taux de fuite	**Q**	2,66E-04	5,72E-04	5,88E-04	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,88E-05	1,88E-05	1,88E-05	*m*

TABLE 3.4-7: SCENARIO 1 - PTH 340 W - GENERAL CASE - WATER CONTENT MORE THAN 0.5% - 1.33.10^{-5} PA.M^{3}.S^{-1} (0.1 LUSEC) SLR

Conditions de calcul		**SLR**	**CNT**	**CAT**	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**331**	**15645**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	950 000	1 100 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		8,40403E-10	8,38744E-10	*m3/s*
Taux de fuite	**Q**	1,33E-05	7,98E-04	9,23E-04	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	8,68E-06	8,68E-06	8,68E-06	*m*

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TABLE 3.4-8: SCENARIO 1 - PTH 340 W - GENERAL CASE - WATER CONTENT LESS THAN 0.5% - $6.65.10^{-5}$ PA.M^3.S^{-1} (0.5 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**63**	**2979**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	950 000	1 100 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		4,41964E-09	4,40512E-09	*m3/s*
Taux de fuite	**Q**	6,65E-05	4,20E-03	4,85E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,32E-05	1,32E-05	1,32E-05	*m*

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TABLE 3.4-9: SCENARIO 1 - PTH 340 W - GENERAL CASE - WATER CONTENT MORE THAN 0.5% - 1.33.10^{-4} PA.M^3.S^{-1} (1 LUSEC) SLR

Conditions de calcul		**SLR**	**CNT**	**CAT**	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**31**	**1465**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	950 000	1 100 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		8,98789E-09	8,95461E-09	*m3/s*
Taux de fuite	**Q**	1,33E-04	8,54E-03	9,85E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,57E-05	1,57E-05	1,57E-05	*m*

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TABLE 3.4-10: SCENARIO 1 - PTH 340 W - GENERAL CASE - WATER CONTENT MORE THAN 0.5% - 2.66.10^{-4} PA.M^{3}.S^{-1} (2 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**15**	**723**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	950 000	1 100 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		1,82328E-08	1,81589E-08	*m3/s*
Taux de fuite	**Q**	2,66E-04	1,73E-02	2,00E-02	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,88E-05	1,88E-05	1,88E-05	*m*

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TABLE 3.4-11: SCENARIO 1 - PTH 4 X 20 W - GENERAL CASE - WATER CONTENT LESS THAN 0.5% - $1.33.10^{-5}$ PA.M^{3}.S^{-1} (0.1 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**1635**	**41185**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	342	372	*K*
Nature du fluide porteur		Air	Air	Air	*---*
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,040E-05	2,170E-05	*Pa.s*
Pression amont	**Pu**	101 300	179 000	338 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		1,69878E-10	3,18626E-10	*m3/s*
Taux de fuite	**Q**	1,33E-05	3,04E-05	1,08E-04	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	8,68E-06	8,68E-06	8,68E-06	*m*

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TABLE 3.4-12: SCENARIO 1 - PTH 4 X 20 W - GENERAL CASE - WATER CONTENT LESS THAN 0.5% - 6.65.10^{-5} PA.M^{3}.S^{-1} (0.5 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**318**	**7930**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	342	372	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,040E-05	2,170E-05	*Pa.s*
Pression amont	**Pu**	101 300	179 000	338 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		8,73205E-10	1,65486E-09	*m3/s*
Taux de fuite	**Q**	6,65E-05	1,56E-04	5,59E-04	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,32E-05	1,32E-05	1,32E-05	*m*

TABLE 3.4-13: SCENARIO 1 - PTH 4 X 20 W - GENERAL CASE - WATER CONTENT LESS THAN 0.5% - 1.33.10^{-4} PA.M^{3}.S^{-1} (1 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**158**	**3915**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	342	372	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,040E-05	2,170E-05	*Pa.s*
Pression amont	**Pu**	101 300	179 000	338 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		1,76267E-09	3,35188E-09	*m3/s*
Taux de fuite	**Q**	1,33E-04	3,16E-04	1,13E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,57E-05	1,57E-05	1,57E-05	*m*

TABLE 3.4-14: SCENARIO 1 - PTH 4 X 20 W - GENERAL CASE - WATER CONTENT LESS THAN 0.5% - 2.66.10^{-4} PA.M^{3}.S^{-1} (2 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**78**	**1936**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	342	372	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,040E-05	2,170E-05	*Pa.s*
Pression amont	**Pu**	101 300	179 000	338 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		3,55347E-09	6,77667E-09	*m3/s*
Taux de fuite	**Q**	2,66E-04	6,36E-04	2,29E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,88E-05	1,88E-05	1,88E-05	*m*

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TABLE 3.4-15: SCENARIO 1 - PTH 4 X 20 W - GENERAL CASE - WATER CONTENT MORE THAN 0.5% - 1.33.10^{-5} PA.M^{3}.S^{-1} (0.1 LUSEC) SLR

Conditions de calcul		**SLR**	**CNT**	**CAT**	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**296**	**12842**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	342	372	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,040E-05	2,170E-05	*Pa.s*
Pression amont	**Pu**	101 300	950 000	1 100 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		9,38543E-10	1,02183E-09	*m3/s*
Taux de fuite	**Q**	1,33E-05	8,92E-04	1,12E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	8,68E-06	8,68E-06	8,68E-06	*m*
Marge de sûreté / critère réglementaire			1	1	

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TABLE 3.4-16: SCENARIO 1 - PTH 4 X 20 W - GENERAL CASE - WATER CONTENT MORE THAN 0.5% - 6.65.10^{-5} PA.M^{3}.S^{-1} (0.5 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**56**	**2437**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	342	372	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,040E-05	2,170E-05	*Pa.s*
Pression amont	**Pu**	101 300	950 000	1 100 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		4,94429E-09	5,38453E-09	*m3/s*
Taux de fuite	**Q**	6,65E-05	4,70E-03	5,92E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,32E-05	1,32E-05	1,32E-05	*m*
Marge de sûreté / critère réglementaire			1	1	

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TABLE 3.4-17: SCENARIO 1 - PTH 4 X 20 W - GENERAL CASE - WATER CONTENT MORE THAN 0.5% - 1.33.10^{-4} PA.M^{3}.S^{-1} (1 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**28**	**1198**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	342	372	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,040E-05	2,170E-05	*Pa.s*
Pression amont	**Pu**	101 300	950 000	1 100 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		1,00604E-08	1,09571E-08	*m3/s*
Taux de fuite	**Q**	1,33E-04	9,56E-03	1,21E-02	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,57E-05	1,57E-05	1,57E-05	*m*
Marge de sûreté / critère réglementaire			1	1	

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TABLE 3.4-18: SCENARIO 1 - PTH 4 X 20 W - GENERAL CASE - WATER CONTENT MORE THAN 0.5% - 2.66.10^{-4} PA.M^{3}.S^{-1} (2 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**Am_A2**		**14**	**590**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	342	372	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température	**m**	1,840E-05	2,040E-05	2,170E-05	*Pa.s*
Pression amont	**Pu**	101 300	950 000	1 100 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		2,04179E-08	2,22395E-08	*m3/s*
Taux de fuite	**Q**	2,66E-04	1,94E-02	2,45E-02	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,88E-05	1,88E-05	1,88E-05	*m*
Marge de sûreté / critère réglementaire			1	1	

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TABLE 3.4-19: SCENARIO 2 - NIL PTH - $6.65.10^{-4}$ $PA.M^3.S^{-1}$ (5 LUSEC) SLR

Conditions de calcul		**SLR**	**CNT**	**CAT**	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**A2/g**		**44**	**1698**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température des joints	**m**	1,843E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	120 000	172 000	*Pa*
Pression aval	**Pd**	0	5 000	5 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		6,32121E-09	7,72754E-09	*m3/s*
Taux de fuite	**Q**	6,65E-04	7,59E-04	1,33E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	2,38E-05	2,38E-05	2,38E-05	*m*

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TABLE 3.4-20: SCENARIO 3 - NIL PTH - URANYL NITRATE - 6.65.10^{-4} PA.M^{3}.S^{-1} (5 LUSEC) SLR

Calcul du diamètre de capillaire pour un test en air (Equation de Knudsen)				
	Paramètre	Unité	Valeur	
Pam	Pression atmosphérique	Pa	1,01E+05	
a	Longueur du capllaire de fuite	m	3,53E-03	
µ	Viscosité du gaz à 25°C	Pa.s	1,84E-05	
Pav	Pression = 0	Pa	0,00E+00	
Tj	Température des joints (25°C)	K	298	
M	Masse molaire du gaz	kg/mol	0,029	
D	Diamètre du capillaire de fuite	m	2,38E-05	
Ajustement du diamètre de capillaire équivalent pour atteindre le débit de fuite (Equation de Knudsen)				
	Paramètre	Unité	CNT	CAT
D	Diamètre du capillaire de fuite	m	2,38E-05	2,38E-05
Pam	Pression interne	Pa	2,51E+05	3,03E+05
a	Longueur du capillaire de fuite	m	3,53E-03	3,53E-03
µ	Viscosité de l'eau	Pa.s	2,50E-04	2,82E-04
Pav	Pression externe	Pa	6,00E+04	6,00E+04
Tj	Température	K	400	500
M	Masse molaire du NU	kg/mol	0,029	0,029
L	Flux de fuite de l'emballage	m3.s-1	1,69E-09	1,91E-09
Calcul de l'activité massique du contenu				
R =	A2/h (CNT) ou A2 /semaine (CAT)	1,00E-06	1	
	A2/s	2,78E-10	1,65E-06	
Cmax =	A2/m3	1,64E-01	8,67E+02	
Cmax =	Bq/m3	0,00E+00	0,00E+00	

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Calcul du diamètre de capillaire pour un test en air	Calculating the capillary tube diameter for an air test
Equation de Knudsen	Knudsen equation
Paramètre	Parameter
Unité	Unit
Valeur	Value
Pression atmosphérique	Atmospheric pressure
Longueur de capillaire de fuite	Length of leak capillary
Viscosité du gaz à 25°C	Viscosity of the gas at 25°C
Pression	Pressure
Température des joints	Joint temperature
Masse molaire du gaz	Molar mass of the gas
Diamètre du capillaire de fuite	Diameter of the leak capillary
Ajustement du diamètre de capillaire équivalent pour atteindre le débit de fuite	Adjusting the equivalent capillary diameter to achieve the leak flow rate
Pression interne	Internal pressure
Viscosité de l'eau	Viscosity of the water
Pression externe	External pressure
Température	Temperature
Masse molaire du NU	Molar mass of the NU
Flux de fuite de l'emballage	Packaging leak flux
Calcul de l'activité massique du contenu	Calculating the specific activity of the content
A2/h (CNT) ou A2/semaine (CAT)	A2/hr (NTC) or A2/week (TAC)

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TABLE 3.4-21: SCENARIO 4 - NIL PTH - URANIUM OXIDE RODS - 6.65.10-4 PA.M3.S-1 (5 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**A2/g**		**22**	**960**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	500	*K*
Nature du fluide porteur		Air	Air	Air	*---*
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température des joints	**m**	1,843E-05	2,290E-05	2,670E-05	*Pa.s*
Pression amont	**Pu**	101 300	263 000	328 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		1,24991E-08	1,36703E-08	*m3/s*
Taux de fuite	**Q**	6,65E-04	3,29E-03	4,48E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	2,38E-05	2,38E-05	2,38E-05	*m*

TABLE 3.4-22: SCENARIO 5 - PTH 340 W - URANIUM-PLUTONIUM MIXED OXIDE RODS - $1.33.10^{-5}$ $PA.M^3.S^{-1}$ (0.1 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**A2/g**		**987**	**46353**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	462	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température des joints	**m**	1,843E-05	2,290E-05	2,530E-05	*Pa.s*
Pression amont	**Pu**	101 300	313 000	343 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		2,81511E-10	2,83102E-10	*m3/s*
Taux de fuite	**Q**	1,33E-05	8,81E-05	9,71E-05	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	8,68E-06	8,68E-06	8,68E-06	*m*

TABLE 3.4-23: SCENARIO 5 - PTH 340 W - URANIUM-PLUTONIUM MIXED OXIDE RODS - $6.65.10^{-5}$ $PA.M^3.S^{-1}$ (0.5 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**A2/g**		**191**	**8977**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	462	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température des joints	**m**	1,843E-05	2,290E-05	2,530E-05	*Pa.s*
Pression amont	**Pu**	101 300	313 000	343 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		1,45705E-09	1,46178E-09	*m3/s*
Taux de fuite	**Q**	6,65E-05	4,56E-04	5,01E-04	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,32E-05	1,32E-05	1,32E-05	*m*

TABLE 3.4-24: SCENARIO 5 - PTH 340 W - URANIUM-PLUTONIUM MIXED OXIDE RODS - 1.33.10^{-4} PA.M^{3}.S^{-1} (1 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**A2/g**		**94**	**4441**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	462	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température des joints	**m**	1,843E-05	2,290E-05	2,530E-05	*Pa.s*
Pression amont	**Pu**	101 300	313 000	343 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		2,94792E-09	2,95517E-09	*m3/s*
Taux de fuite	**Q**	1,33E-04	9,23E-04	1,01E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,57E-05	1,57E-05	1,57E-05	*m*

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TABLE 3.4-25: SCENARIO 5 - PTH 340 W - URANIUM-PLUTONIUM MIXED OXIDE RODS - $2.66.10^{-4}$ $PA.M^3.S^{-1}$ (2 LUSEC) SLR

Conditions de calcul		SLR	CNT	CAT	*Unités*
Caractéristiques du contenu					
Rapport Am/A2éq	**A2/g**		**47**	**2200**	*A2/g*
Caractéristiques de la cavité					
Plus petit diamètre de joint de l'emballage	**a**	3,53E-03	3,53E-03	3,53E-03	*m*
Température des joints	**T**	298	400	462	*K*
Nature du fluide porteur		Air	Air	Air	---
Masse molaire du fluide porteur	**M**	0,029	0,029	0,029	*kg/mol*
Viscosité du fluide porteur à la température des joints	**m**	1,843E-05	2,290E-05	2,530E-05	*Pa.s*
Pression amont	**Pu**	101 300	313 000	343 000	*Pa*
Pression aval	**Pd**	0	60 000	60 000	*Pa*
Activité volumique du fluide porteur	**C**				*Bq/m3*
Taux de relâchement d'activité admissible	**R**		2,78E-10	1,65E-06	*A2/s*
Débit volume de fuite	**L**		5,9543E-09	5,96499E-09	*m3/s*
Taux de fuite	**Q**	2,66E-04	1,86E-03	2,05E-03	*Pa.m3/s*
Diamètre de capillaire équivalent D	**D**	1,88E-05	1,88E-05	1,88E-05	*m*