CEA CADARACHE

DESIGN REPORT

THERMAL ANALYSIS OF TN-BGC 1 PACKAGE

Summary: The purpose of this thermal study is to determine the temperature span in the TN BGC package in normal and accident conditions of transport.

Keywords: Thermal, TN BGC 1, Transport, Normal and accident conditions, Caisson.

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A	BPO	27/04/2006	S. MELTZHEIM	A. DUMONT	Initial distribution	L. QUENARD
Iss.	Status	Date	Author	Reviewer	Type of modifications	Approval

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REVISION HISTORY

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SUMMARY

The aim of this study is to define the temperature distribution within a package consisting of the TN BGC 1 package in the different possible configurations for fittings and content. These configurations are defined according to possible fittings for this package (containers, content, frames with or without covers, spacers, shims, etc.).

The purpose of this service is to justify the resistance of:
- the model consisting of the TN-BGC1 package loaded with its different contents in general,
- containment joints in particular, in accident conditions of transport after the fire test.

Objectives:
OBJECTIVE 1: Thermal design **in accident conditions of transport with an isolated package** to determine the temperature for the different package components.

OBJECTIVE 2: Thermal design **in a caisson in accident conditions of transport** to determine the temperature for the different package components.

This study was carried out using the finite difference method I-DEAS/TMG <2> to simulate thermal phenomena. Digital models implemented:
- axisymmetric for the design of isolated packages,
- 3D for the design of packages in caissons.

The calculations demonstrated that the temperatures reached by the different package components are acceptable and are not likely to endanger the properties of the components. In particular, joint temperatures remain below their operating limit and the extrusion temperature.

0. PURPOSE

The aim of this study is to define the temperature distribution within a package consisting of the TN BGC 1 package in various configurations and with the different possible contents. These configurations are defined according to possible fittings for this package (containers, content, frames with or without covers, spacers, shims, etc.).

The purpose of this service is to justify the resistance of:
the model consisting of the TN-BGC 1 package loaded with its different contents in general, containment joints in particular, in accident conditions of transport after the fire test.

This study was carried out using the finite difference method I-DEAS/TMG <2> to simulate thermal phenomena. The digital model used is axisymmetric (package design only) and 3D (caisson design).

1. REFERENCE DOCUMENTATION

<1> IAEA Safety standards collection – Regulations for the safe transport of radioactive materials – 1996 Edition amended (ST-1 amended)

<2> Finite element calculation software: I-DEAS Master Series V10 developed by EDS associated with TMG Thermal Analysis Module

<3> Transferts thermiques (Thermal transfers), J. TAINE & J.P. PETIT Edition DUNOD, 1995.

<4> Certificate of approval and authorisation for the dispatch of a package model DGSNR/SD1/0440/2004 dated 28/07/04

<5> TN BGC 1 package safety analysis report - Chapter 3 Ann. 0 - Description of internal fittings.

<6> Transnuclear plan ref 9990-65, 9990-117,9990-118

<7> DEMA note - 172C3W01 Iss. F of 30/06/03 "Thermal analysis of the TN-BGC 1 package".

<8> Heat transmission - WH Me A dams - Chapter VII.

2. DESIGN CODE

The model will be produced using the I-DEAS software <2>. The thermal design will be carried out based on the finite difference method using the TMG module interfaced with I-DEAS.

3. NOMENCLATURE

The main parameters of the study are as follows:

a: Absorptivity

C_p: Specific heat (J/kg.K)

E: Sunlight (W/m)

F_{gij}: Grey form factor of surface i to the surface j

h: Coefficient of thermal exchange ($W/m^2.K$)

H: Height (m)

L: Length (m)

P: Dissipated thermal power (W or kW)

r: Radius (m)

S: Surface area (m^2)

T: Temperature (°C or K)

V: Volume (m^3)

ε: Emissivity

λ: Thermal conductivity (W/m.K)

ρ: Density (kg/m^3)

σ: Stefan Boltzmann constant ($5.674.\ 10^{-8}\ W/m^2.K^4$)

ΔT: Temperature difference (°C or K)

4. TYPE OF CALCULATIONS

The following transport conditions are studied:

- **Design under normal conditions of transport (NCT)**

- The package is located in an environment at 38°C,
- The solar flux is applied to the external surfaces of the package under normal conditions of transport as defined in regulations <1>,
- The package is transported vertically,
- Heat exchanges by conduction, radiation and convection are considered, in particular:
  - convective and radiative exchange between the external surface of the package and ambient air,
  - convective and radiative exchange taken into consideration in all gaps and air zones in the package,

- **Design under accident conditions of transport (ACT)**

- The package is placed in an environment at 800°C for 30 minutes according to the fire conditions defined in regulations <1>, followed by the outstanding period in an environment at 38°C under regulatory sunlight <1>,
- The package is transported horizontally,
- The initial conditions of the package, prior to the application of fire conditions, correspond to those determined under normal conditions of transport.
- Heat exchanges by conduction, radiation and convection are considered,
- The design model is identical to that used for normal conditions of transport.

- **Design under accident conditions of transport in a caisson:**

- The caisson can transport 12 or 24 packages in a vertical position,
- Outside temperature: 38°C,
- The solar flux is applied to the external surfaces of the caisson under normal conditions of transport as defined in regulations <1>,
- Heat exchanges by conduction, radiation and convection are considered,
- The exchange surfaces are considered as straight, corrugations are not taken into consideration for convective and radiative exchanges,
- However, the solar flux applied for the caisson walls integrates actual exchange surfaces.

5. METHODOLOGY

The following methodology was used for caisson design:

- Caisson design

The caisson transports the packages in a vertical position. Only the external surfaces of the shell and wood covers are modelled. The distances between each package, considered as the smallest possible (the same applies to package/internal caisson wall distances), are taken with reference to the cage dimensions.
As a worst-case scenario, the thermal load is applied to the outer shell of the package.

- 2D NCT axisymmetric design

The maximum temperature of the hottest generator in the outer shell of the package (based on caisson design) is applied as limit conditions for the axisymmetric 2D model in order to determine the temperature span within the package.
Calculations are carried out based on steady-state conditions.

- 2D ACT axisymmetric design

The initial temperature span is based on the previous calculations.
Calculations are carried out based on transient conditions.

The methodology applied can be used to carry out axisymmetric calculations based on a 3D design in a caisson with simplified modelling of the package in the caisson (outer shell only). Caisson design, followed by two axisymmetric calculations, is required to obtain the temperature span for the package in accident conditions of transport in a caisson.

6. DESIGN CONFIGURATION

6.1. ISOLATED PACKAGE

Config..	Primary packaging	Frames, Spacers, Covers	Secondary packaging	Frame, spacer, shims	Tertiary packaging	Outer spacers	Content	Power	Power density	Comments
C1.1	Housing x4	covers	AA213 x 4	-	AA226	E1	PuO2 powder	4 x 20 W	20 W/Kg	
C1.2	Housing x4	-	AA213 x 4	-	AA226	E1	PuO2 powder	4 x 85 W 340 W	20 W/Kg	
C2.1	Housing x4	-	AA303	Spacers	AA227	E1	PuO2 powder	4 x 85 W 340 W	20 W/Kg	shim replaced with an air gap
C2.2	Housing x5	-	AA236	shims	AA227	E1	PuO2 powder	5 x 68 W 340 W	20 W/Kg	shim replaced with an air gap
C3.1	Housing x4	-	AA99 x 4	Frame P1	TN90	E1 + E2	PuO2 powder	4 x 85 W 340 W	20 W/Kg	
C3.1bis	Housing x4	-	AA99 x 4	Frame P1	TN90	E1 + E2	PuO2 powder	4x 100 W 400 W	20 W/Kg	
C3.2	Housing x4	covers	AA99 x 4	Frame P1	TN90	E1 +E2	PuO2 powder	4 x 20 W	15 W/Kg	
C3.2bis	Housing x4	covers	AA99 x 4	Frame P1	TN90	E1 + E2	PuO2 powder	4x 15 W	15 W/Kg	
C3.3	Housing x4	covers	AA99 x 4	Frame P1	TN90	E1 +E2	PuO2 powder	4 x 20 W	20 W/Kg	
C3.3bis	Housing x4	covers	AA99 x 4	Frame P1	TN90	E1 + E2	PuO2 powder	4 X 25 W	20 W/Kg	
C4.1	Housing x4	-	AAS9 x 4	-	AA204	E1+E10	PuO2 powder	170 W 4 X 42.5 W	20 W/Kg	
C4.2	Housing x4	covers	AA99 x4	-	AA204	E1+E10	PuO2 powder	4 x 20 W	20 W/Kg	
C4.3	Housing x2	-	AA99 x 2	-	AA203	E1* E8	PuO2 powder	170 W	20 W/Kg	
C4.4	Housing x2	covers	AA99 x 2	-	AA203	E1+E8	PuO2 powder	2x20 W	20 W/Kg	
C4.5	Housing x1	-	AA99 x 1	-	AA41 x 1	E1+ E11	PuO2 powder	100 W	20 W/Kg	
C4.6	Housing x1	covers	AA99 x 1	-	AA41 x 1	E1+E11	PuO2 powder	1 X20W	20 W/Kg	
C4.7	Housing x2	-	AA99 x 2	-	AA41 x 2	E1+E12 + E13	PuO2 powder	170 W 2 x 85 W	20 W/Kg	
C4.8	Housing x2	covers	AA99 x 2	-	AA41 x 2	E1+ E12 + E13	PuO2 powder	2 x 20 W	20 W/Kg	
C4.9	Housing x3	-	AA99 x 3	-	AA41 X 3	E1+E9 + E13	PuO2 powder	170 W 3 x 56.6 W	20 W/Kg	
C4.10	Housing x3	covers	AA99 x 3	-	AA41 X 3	E1+E9 + E13	PuO2 powder	3 x 20 W	20 W/Kg	
C5.1	AA97 x2	Frame P2	TN 90	-	.-	E3	U02 powder	2x2 W	0.1 W/Kg	complete fill
C7.1	Serv. syst. E4	-	TN 90	Frame P4	-	E1 + E2	U ingot	4 W	-	8 compartments filled, 1 empty
C7.2	Serv. Syst. E4	-	TN 90	Frame P4	.	E1 + E2	Pu ingot	340 W	-	8 compartments filled, 1 empty
C8	Serv. syst. E5	-	TN 90	-	-	E1 + E2	Pu Zebra plate	150 W 6x 25 W	-	complete filling of each stage
C9	E7	-	TN 90	-	-	E1 + E2	Uranium substance	16 W	0.11 W/Kg	power surrounded by a stainless steel shell
C10.1	Rack R1	-	TN 90	-	-	E1 +E2	MOX rod	340 W	340/20 i.e. 17 W/Kg	Rod packing head side
C10.2	Rack R1	-	TN 90	-	•	E1 + E2	MOX rod	340 W	Height 1 *m*	homogeneous distribution 60 rods
C10.3		-	TN 90	-	-	E1 +E2	MOX rod	340 W	Height 1 m	homogeneous distribution 10 rods

6.2. PACKAGE IN CAISSON

Config.	Power per packaging	Power in the caisson	distribution	Package configuration
CA1	4 x 20 W	12x80 W	12 packages in the base of the caisson	Config. C4.2
CA2	100W	12 x100 W	12 packages in the base of the caisson	Config. C4.5
CA3	4 x 50 W	12 x 200 W	12 packages in the base of the caisson	config C3.1 (at 200 W)
CA4	4 x 20 W	24 x 80 W	24 packages in the base of the caisson	Config. C4.2
CA5	100 W	24 x 100 W	24 packages in the base of the caisson	Config. C4.5
CA6	340 W	7 x 340 W	7 packages in the base of the caisson	Config. C2.1

7. MODELLING

7.1. ASSUMPTIONS

The design model is created in accordance with the plans provided by the CEA ref. <4>, <5> and <6>, with the software I-DEAS ref. <2>.

Main modelling assumptions:

- The TN-BGC package will be modelled axisymmetrically with a vertical axis, and 3D modelling will be used for the caisson,
- The vertical position in normal conditions of transport and horizontal position in accident conditions of transport represent worst-case scenarios while reflecting actual transport conditions (loaded package secured vertically),
- Sources of heat are modelled using cylindrical volumes,
- The following package dimensions are used for modelling purposes (ref <6>):

- Cavity radius: 181 mm,
- Resin thickness: 49.5 mm,
- Internal and external shell thicknesses are 6 mm and 1.5 mm respectively.
- Package length (including the cover): 1794 mm (covers in contact with the casing),
- Working height of the package: 1475 mm.

- Caisson dimensions:

	External	Interior	Wall thickness es
Length (m)	6.13	5.91	0,11
Width (m)	2.50	2.28	
Height (m)	2.26	2.04	

Note: The exchange surfaces are considered as straight, corrugations are not taken into consideration for convective and radiative exchanges. However, the solar flux applied for the caisson walls integrates actual exchange surfaces.

- The different axial and radial gaps are considered cold (the thermal expansion of materials is not taken into consideration),
- The aluminium cage and perforated sheets are not taken into consideration,
- Axial and radial clearance between the plug and package are zero (perfect thermal contact),
- Internal packaging, shims, frames, spacers and power zones are located towards the head of the package (plug side) to maximise thermal transfers for the plug joints,
- Clearance modelled between the covers and the package is zero (perfect thermal contact),
- The deformation assumptions taken into account to model the package in accident conditions of transport (from reference note <7>) are as follows:

During the fire phase (30 minutes):

- The shock-absorbing cover is reduced by 42 mm along the longitudinal axis (the balsa is assumed to be compressed by approx. 60%). This packing corresponds to an axial fall on the shock-absorbing cover. The physical properties of the balsa and poplar used for this cover are modified: the density and thermal conductivity are multiplied by 2.5,
- The shock-absorbing cover is reduced by 33 mm along the radius simulating a fall on the centre line, The physical properties of the balsa and poplar used for this cover are modified: the density and conductivity are multiplied by 2.5,
- Part of the outer shell of the casing is depressed, simulating the impact of a punch. The thermal flux of the fire are applied to all internal surfaces of this deformation,
- The "shock-absorbing" part of the casing is reduced by 39 mm along the longitudinal axis. This packing corresponds to an axial fall on the casing base. The physical properties of the balsa and poplar are modified: the density and conductivity are multiplied by 2.5.

During the cooling phase (after 30 minutes).

- The initial geometry with better insulation can be simulated by dividing the initial thermal conductivity of the balsa and poplar by 2.5.

To create a worst-case scenario, design models for packages in normal conditions of transport are identical to those in accident conditions of transport (consideration of deformation caused by the impact of the punch).

7.2. MESHING

Axisymmetric modelling will be used for isolated packages and elements will be linear quadrilateral and linear shell type.
3D modelling will be used for caisson design and elements will be linear hexahedral and linear quadrilateral shell type.

7.3. MATERIALS

Material: Stainless steel 304 L□(Z2CN18-10).
Package components: Package casing, Internal containers, Frame, Housings.

Operational temperature range (°C)	Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Masse Density (kg/m^3)	Emissivity	Solar absorption capacity
20°C	14.7	454.3	7930	0.5 for external surfaces 0.5 before fire 0.9 during and after fire	0.3 before fire 0.9 after fire
100°C	15.8	492			
200°C	17.2	525.2			
300°C	18.6	541.7			
400°C	20	553.1			
500°C	21.1	560.2			
600°C	22.2	566.7			
800°C	24.1	587.8			

Material: Aluminium (AG3 and AU4G).
Package components: Spacer E1, +shim E10.

Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Density (kg/m^3)	Emissivity	Solar absorption capacity
134	950	2790	0.5	-

Materials: Neutron-absorbing resin/air equivalent environment.
Package components: Package resin layer.

Operational temperature range (°C)	Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Density (kg/m^3)	Emissivity	Solar absorption capacity
20°C	0.66	1173	1600	-	-
50°C	0.66	1257			
100°C	0.66	1397			
150°C	0.66	1536			
200°C	0.47	1533			
250°C	0.28	1515			
300°C	0.09'	1415			
400°C	0.09'	764			
500°C	0.09'	615			
600°C	0.09'	543			

Area of neutron-absorbing resin damaged after the fire;

Material: Plastic;
Package components: Plug disc, AA97 flask, covers, E3 rings.

Plastic	Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Density (kg/m^3)
PEHD	0.46	1881	950
PEBD	0.334	2299	920
PVC-C	0.166	1000	1380
PUR	0.2	1000	1230
PA 6.6	0.25	1045	1140
PTFE	0.23	1000	2200

NOTE: the emissivity of the covers is taken as 0.8.

Materials: Air/steel equivalent material
Components: Caisson wall

Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Density (kg/m^3)	Emissivity	Solar absorption capacity
0.1749	-	-	0.7	0.3

Material: Air.
Components: Caisson and package filling gas.

Operational temperature range	Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Density (kg/m^3)	Emissivity	Solar absorption capacity
27°C	0.0262	1006	1.177	-	-
127°C	0.0337	1014	0.883		
227°C	0.0404	1030	0.705		
327°C	0.0466	1055	0.588		
427°C	0.0523	1075	0.503		
527°C	0.0578	1098	0.441		
627°C	0.0628	1121	0.392		
827°C	0.0723	1161	0.32		
1027°C	0.0823	1197	0.271		

Material: Bronze.
Package components: Plug locknut.

Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Density (kg/m^3)	Emissivity	Solar absorption capacity
50.2	370	8800	-	-

Material: Copper-Aluminium.
Package components: Clamp ring.

Operational temperature range (°C)	Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Density (kg/m^3)	Emissivity	Solar absorption capacity
20°C	32.8	473.2	7850	-	-
100°C	32.5	484.9	7820		
200°C	32.2	523.6	7785		
300°C	31.9	554.7	7750		
400°C	31.6	594.7	7780		
500°C	31.3	658.6	7690		
600°C	31	739.5	7663		
800°C	-	-	7610		

Material: Wood
Package components: Shock-absorbing covers

Wood species	Operational temperature range (°C)	Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Density (kg/m^3)
Balsa wood	20	0.051	1100	150
	270	0.086		
ACT balsa	20	0.128		375
	270	0.215		
Poplar	20	0.13	450	460
	270	0.22		
ACT balsa	20	0.325		1150
	270	0.55		

Note: In accident conditions of transport, in damaged areas, densities and thermal conductivities are multiplied by 2.5 (compressed areas).

Materials: PuO2 (powder), U, Pu, MOX (rods).
Package components**: content**

Content	Thermal conductivity (W/m·K)	Specific heat (J/kg·K)	Density (kg/m^3)
PuO2	0.2	250	3500
Pu ingot	6.3	130	19840
U ingot	24.3	125	18950
MOX	2.1	366	10450

8. LIMIT CONDITIONS

Figures showing all limit conditions for the package and caisson are shown in appendix 1.

8.1. CONDUCTION

Conductive exchanges in the package are calculated on the basis of the thermal conductivity of each material. Meshing of the filling gas (air) can be used to integrate the conductive effects of clearance between the different package components.

8.2. CONVECTION

Calculations for an isolated package:

✓ Under normal conditions of transport:

Generally, it is assumed that the laws on the smooth outer surfaces of the package "at ordinary ambient temperature and under atmospheric pressure" taken from <8> are as follows:

$h = 1.28\ (\Delta T)^{0.33}$ for flat vertical surfaces,
$h = 1.22\ (\Delta T)^{0.33}$ for cylindrical horizontal surfaces,
$h = 1.51\ (AT)^{0.33}$ for flat horizontal surfaces (ascending flux),
$h = 0.96\ (AT)^{0.33}$ for flat horizontal surfaces (descending flux).

✓ In accident conditions of transport:

During the fire phase, on the outer surfaces of the package: $h = 10\ W/m^2 \cdot K$

Caisson design

Convective exchange coefficients are calculated based on the following correlations (taken from <3>):

for a vertical cylinder or plate:

$Nu = 0.59 \times Ra^{1/4}$ if $10^4 < Ra < 10^9$ Correlations by Me Adams,
$Nu = 0.13 \times Ra^{1/3}$ if $10^9 < Ra < 10^{12}$ Correlations by Me Adams,

for a horizontal plate heating downwards or cooling upwards:

$Nu = 0.27 \times Ra^{1/4}$ if $3x10^5 < Ra < 3x10^9$ Correlations by Me Adams,
$Nu = 0.58 \times Ra^{/5}$ if $10^6 < Ra < 10^n$ Correlations by Fujii et Imura,

for a horizontal plate heating upwards or cooling downwards:

$Nu = 0.54 \times Ra^{1/4}$ if $10^5 < Ra < 10^7$ Correlations by Fischender et Saunder,
$Nu = 0.14 x Ra^{1/3}$ if $10^7 < Ra < 3x10^{10}$ Correlations by Fischender et Saunder,

The numbers of Nusselt & Rayleigh are assessed with the air properties taken at film temperature. The following convective exchange coefficients are assessed at these temperature levels after several iterations.

Caisson	Lateral walls	Base	Door	Top panel	Floor
Internal walls	$h = 1.4 \times (\Delta T)^{0.33}$	$h = 1.4 \times (\Delta T)^{0.33}$	$h = 1.4 \times (\Delta T)^{0.33}$	$h = 1,5 \times (\Delta T)^{0,33}$	$h = 1,5 \times (\Delta T)^{0,33}$
External walls	$h = 1.5 \times (\Delta T)^{0.33}$	$h = 1.5 \times (\Delta T)^{0.33}$	$h = 1.5 \times (\Delta T)^{0.33}$	$h = 1,6 \times (\Delta T)^{0,33}$	-
Packages	Vertical surfaces	Horizontal surfaces (lower part of the cover)		Horizontal surfaces (upper part of the cover)	
Outer shell and cover	$h = 1.35 \times (\Delta T)^{0.33}$	$h = 0.66 \times (\Delta T)^{0.25}$		$h = 1.35 \times (\Delta T)^{0.25}$	

8.3. RADIATION

The software automatically calculates radiative exchanges. Simply define the radiating surfaces, their orientation and emissivity levels beforehand in order to calculate the form factor.
With clearance modelled inside the shell and for all package surfaces in contact with ambient air (excluding adiabatic surfaces), the net radiative flux exchanged between two surfaces i and j (or between a surface and the ambient air) is expressed as follows:

, where ε_i and ε_j are the emissivity levels of the surfaces present

Where $$Fgij = \frac{1}{\left(\frac{1}{\varepsilon i} + \frac{1}{\varepsilon j} - 1\right)}$$

During the fire phase, the radiative flux leads to an emissivity flux caused by the flames (800°C) with an emissivity coefficient equal to 1 (worst case scenario with reference to an emissivity of 0.9 (taken from ref. <2>)).

8.4. AMBIENT AIR

The ambient temperature is defined as 38°C in normal conditions of transport according to regulations <1>.

During the entire fire phase (30 minutes), this temperatures increases to 800°C:

t = 0 s	T = 38°C
t = 30 s	T = 800°C
t = 1830 s	T = 800°C
t = 1860 s	T = 38°C
t = ∞	T = 38°C

8.5. THERMAL POWER

The internal power will be applied to solid components and positioned in the upper part of the internal fittings (plug side) in order to maximise the temperature of plug joints.
The maximum residual power and the type of content are indicated in section 6.
For caisson design, the thermal load is applied to the outer shell of the package.

8.6. SUNLIGHT

Regulatory sunlight conditions <1> correspond to 800 W/m^2 for horizontal surfaces, 400 W/m^2 for curved surfaces, 200 W/m^2 for flat vertical surfaces, and are applied continuously, 24 hours per day, before and after the fire scenario.

The density of the solar flux applied to a surface is given as:

$\varphi = a \times E$

The solar flux densities reaching the surfaces before the fire are:

$\varphi_0 = 0.30 \times 200 = 60$ W/m², on vertical stainless steel surfaces,

$\varphi_0 = 0.30 \times 400 = 120$ W/m², on cylindrical stainless steel surfaces,

$\varphi_0 = 0.30 \times 800 = 240$ W/m², on horizontal stainless steel surfaces,

The solar flux densities reaching the surfaces after the fire are:
$\varphi_1 = 0.90 \times 200 = 180$ W/m², on vertical stainless steel surfaces,
$\varphi_1 = 0.90 \times 400 = 360$ W/m², on cylindrical stainless steel surfaces,
$\varphi_1 = 0.90 \times 800 = 720$ W/m², on horizontal stainless steel surfaces,

During accident conditions of transport, the density of the flux applied to the outer surfaces of the model will vary over time and take the following values successively:

At t = 0 s	$\varphi = \varphi_0$
At t = 30 s	$\varphi = 0$ (start of fire)
At t = 1830 s	$\varphi = 0$ (end of fire)
At t = 1860 s	$\varphi = \varphi_1$
At t = ∞	$\varphi = \varphi_1$

9. RESULTS

The following tables summarise all of the results obtained according to the different design cases.
The exact position of the internal fitting joints is difficult to estimate using drawings <6>, therefore their temperature is assimilated as that of the top of the container head.

9.1. CONFIGURATION C1.1

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**739**	**1830**
Package inner shell	**171**	**4500**
Clamp ring.	**134**	**8000**
Package joints	**135**	**7500**
Package head internal surface	**134**	**8500**
Package cavity gas	**169**	**4500**
Base of the package	**171**	**4500**
AA226 container shell	**129**	**12000**
Spacer	**122**	**17000**
AA226 container head	**129**	**12000**
AA213 shell	**135**	**17000**
AA213 head	**135**	**17000**
Container cavity gas	**201**	**17000**
Housings	**148**	**17000**
Content	**242**	**19000**

9.2. CONFIGURATION C1.2

The figures showing isotherms and variation graphs are provided in appendix 4.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**742**	**1830**
Package inner shell	**187**	**4500**
Clamp ring.	**156**	**8000**
Package joints	**156**	**7500**
Package head internal surface	**158**	**12000**
Package cavity gas	**186**	**4500**
Base of the package	**187**	**4500**
AA226 container shell	**189**	**11000**
Spacer	**172**	**8500**
AA226 container head	**165**	**14000**
AA213 shell	**216**	**12000**
AA213 head	**210**	**15000**
Container cavity gas	**284**	**14000**
Housings	**282**	**14000**
Content	**453**	**18000**

9.3. CONFIGURATION C2.1

The figures showing isotherms and variation graphs are provided in appendix 4.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**787**	**1830**
Resin	**746**	**1830**
Package inner shell	**177**	**5000**
Clamp ring.	**163**	**8500**
Package joints	**164**	**9500**
Package head internal surface	**170**	**11000**
Package cavity gas	**188**	**10000**
Base of the package	**176**	**4500**
Spacer	**181**	**9000**
AA227 container shell	**195**	**10000**
AA227 container head	**184**	**13000**
Container cavity gas	**339**	**16000**
AA303 shell	**242**	**15000**
Housings	**303**	**15000**
Content	**518**	**18000**

9.4. CONFIGURATION C2.2

The figures showing isotherms and variation graphs are provided in appendix 5.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**787**	**1830**
Resin	**742**	**1830**
Package inner shell	**153**	**9500**
Clamp ring.	**150**	**8000**
Package joints	**150**	**8000**
Package head internal surface	**151**	**10000**
Package cavity gas	**153**	**9500**
Base of the package	**142**	**5500**
Spacer	**152**	**7500**
AA227 container shell	**154**	**9500**
AA227 container head	**154**	**9500**
Container cavity gas	**155**	**9500**
AA236 shell	**155**	**10000**
AA236 head	**155**	**10000**
Housings	**155**	**10000**
Content	**357**	**13000**

9.5. CONFIGURATION C3.1

The figures showing isotherms and variation graphs are provided in appendix 6.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**787**	**1830**
Resin	**743**	**1830**
Package inner shell	**179**	**5000**
Clamp ring.	**165**	**8500**
Package joints	**165**	**9500**
Package head internal surface	**171**	**9500**
Package cavity gas	**196**	**9500**
Base of the package	**179**	**5000**
Spacer	**187**	**9000**
TN90 container shell	**205**	**10000**
TN90 container head	**188**	**11000**
Container cavity gas	**341**	**13000**
AA 99	**282**	**12000**
Housings	**336**	**13000**
Content	**522**	**16000**

9.6. CONFIGURATION C3.1BIS

The figures showing isotherms and variation graphs are provided in appendix 6.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**787**	**1830**
Resin	**744**	**1830**
Package inner shell	**186**	**5000**
Clamp ring.	**170**	**8500**
Package joints	**171**	**9500**
Package head internal surface	**178**	**9500**
Package cavity gas	**208**	**9500**
Base of the package	**180**	**5000**
Spacer	**199**	**8500**
TN90 container shell	**218**	**9500**
TN90 container head	**197**	**11000**
Container cavity gas	**373**	**13000**
AA 99	**301**	**12000**
Housings	**350**	**12000**
Content	**540**	**15000**

9.7. CONFIGURATION C3.2

The figures showing isotherms and variation graphs are provided in appendix 7.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	Accident conditions of transport	
	Temperature (°C)	Time (s)
External surfaces	798	1830
Outer shell	785	1830
Resin	739	1830
Package inner shell	174	4500
Clamp ring.	136	8500
Package joints	137	8500
Package head internal surface	137	9000
Package cavity gas	172	5000
Base of the package	174	4500
Spacer	136	11000
TN90 container shell	152	7500
TN90 container head	139	11000
Container cavity gas	227	15000
AA 99	183	14000
Housings and covers	195	14000
Content	282	16000

9.8. CONFIGURATION C3.2BIS

The figures showing isotherms and variation graphs are provided in appendix 7.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**174**	**4500**
Clamp ring.	**136**	**8500**
Package joints	**137**	**8500**
Package head internal surface	**137**	**9000**
Package cavity gas	**172**	**5000**
Base of the package	**174**	**4500**
Spacer	**136**	**11000**
TN90 container shell	**152**	**7500**
TN90 container head	**139**	**11000**
Container cavity gas	**227**	**15000**
AA 99	**183**	**14000**
Housings and covers	**195**	**14000**
Content	**282**	**16000**

9.9. CONFIGURATION C3.3

The figures showing isotherms and variation graphs are provided in appendix 8.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**174**	**4500**
Clamp ring.	**137**	**8500**
Package joints	**137**	**8500**
Package head internal surface	**137**	**9000**
Package cavity gas	**172**	**5000**
Base of the package	**174**	**4500**
Spacer	**136**	**11000**
TN90 container shell	**152**	**7500**
TN90 container head	**140**	**11000**
Container cavity gas	**237**	**15000**
AA 99	**192**	**14000**
Housings and covers	**196**	**14000**
Content	**286**	**15000**

9.10.CONFIGURATION C3.3BIS

The figures showing isotherms and variation graphs are provided in appendix 8.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**739**	**1830**
Package inner shell	**174**	**4500**
Clamp ring.	**139**	**8500**
Package joints	**139**	**8500**
Package head internal surface	**140**	**9000**
Package cavity gas	**172**	**5000**
Base of the package	**174**	**4500**
Spacer	**140**	**10000**
TN90 container shell	**153**	**7500**
TN90 container head	**145**	**11000**
Container cavity gas	**252**	**15000**
AA 99	**204**	**14000**
Housings and covers	**213**	**14000**
Content	**322**	**15000**

9.11.CONFIGURATION C4.1

The figures showing isotherms and variation graphs are provided in appendix 9.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	Accident conditions of transport	
	Temperature (°C)	Time (s)
External surfaces	798	1830
Outer shell	786	1830
Resin	739	1830
Package inner shell	168	4500
Clamp ring.	154	9000
Package joints	154	9500
Package head internal surface	159	10000
Package cavity gas	188	10000
Base of the package	168	4500
AA204 container shell	195	11000
Spacer	158	9000
AA204 container head	180	11000
AA 99	250	13000
Container cavity gas	302	14000
Housings	284	14000
Content	435	16000

9.12.CONFIGURATION C4.2

The figures showing isotherms and variation graphs are provided in appendix 10.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**166**	**4500**
Clamp ring.	**139**	**9000**
Package joints	**139**	**9000**
Package head internal surface	**142**	**10000**
Package cavity gas	**164**	**4500**
Base of the package	**166**	**4500**
AA204 container shell	**157**	**12000**
Spacer	**141**	**9500**
AA204 container head	**155**	**11000**
Container cavity gas	**246**	**15000**
AA 99	**204**	**14000**
Housings and covers	**207**	**14000**
Content	**295**	**15000**

9.13.CONFIGURATION C4.3

The figures showing isotherms and variation graphs are provided in appendix 11.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**739**	**1830**
Package inner shell	**168**	**4500**
Clamp ring.	**160**	**9000**
Package joints	**161**	**9500**
Package head internal surface	**167**	**10000**
Package cavity gas	**211**	**11000**
Base of the package	**168**	**4500**
AA203 container shell	**223**	**11000**
Spacer	**165**	**9000**
AA203 container head	**194**	**11000**
Container cavity gas	**344**	**14000**
AA 99	**289**	**14000**
Housings	**336**	**14000**
Content	**521**	**17000**

9.14.CONFIGURATION C4.4

The figures showing isotherms and variation graphs are provided in appendix 12.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**165**	**4500**
Clamp ring.	**134**	**9000**
Package joints	**134**	**9000**
Package head internal surface	**136**	**10000**
Package cavity gas	**163**	**4500**
Base of the package	**165**	**4500**
AA203 container shell	**149**	**12000**
Spacer	**135**	**9500**
AA203 container head	**149**	**12000**
Container cavity gas	**234**	**15000**
AA 99	**194**	**15000**
Housings and covers	**196**	**150000**
Content	**285**	**16000**

9.15.CONFIGURATION C4.5

The figures showing isotherms and variation graphs are provided in appendix 13.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**166**	**4500**
Clamp ring.	**150**	**9000**
Package joints	**151**	**10000**
Package head internal surface	**158**	**10000**
Package cavity gas	**190**	**11000**
Base of the package	**166**	**4500**
AA41 container shell	**203**	**11000**
Spacer	**153**	**9500**
AA41 container head	**199**	**11000**
Container cavity gas	**358**	**14000**
AA 99	**267**	**13000**
Housings	**346**	**13000**
Content	**640**	**16000**

9.16.CONFIGURATION C4.6

The figures showing isotherms and variation graphs are provided in appendix 14.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**164**	**4500**
Clamp ring.	**130**	**9000**
Package joints	**130**	**9000**
Package head internal surface	**132**	**10000**
Package cavity gas	**161**	**4500**
Base of the package	**164**	**4500**
AA41 container shell	**143**	**12000**
Spacer	**130**	**9500**
AA41 container head	**143**	**12000**
AA 99	**146**	**13000**
Container cavity gas	**217**	**14000**
Housings	**171**	**13000**
Content	**256**	**14000**

9.17.CONFIGURATION C4.7

The figures showing isotherms and variation graphs are provided in appendix 15.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**739**	**1830**
Package inner shell	**165**	**7000**
Clamp ring.	**158**	**9000**
Package joints	**159**	**9500**
Package head internal surface	**164**	**10000**
Package cavity gas	**198**	**11000**
Base of the package	**137**	**6500**
AA41 container shell	**208**	**12000**
Spacer	**162**	**9500**
AA41 container head	**204**	**13000**
AA 99	**262**	**13000**
Container cavity gas	**322**	**15000**
Housings	**318**	**14000**
Content	**501**	**17000**

9.18.CONFIGURATION C4.8

The figures showing isotherms and variation graphs are provided in appendix 16.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**145**	**6000**
Clamp ring.	**133**	**9000**
Package joints	**134**	**9000**
Package head internal surface	**135**	**10000**
Package cavity gas	**220**	**14000**
Base of the package	**129**	**6500**
AA41 container shell	**147**	**14000**
Spacer	**134**	**9500**
AA41 container head	**147**	**14000**
AA 99	**150**	**13000**
Container cavity gas	**142**	**5000**
Housings and covers	**175**	**13000**
Content	**260**	**14000**

9.19.CONFIGURATION C4.9

The figures showing isotherms and variation graphs are provided in appendix 17.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**739**	**1830**
Package inner shell	**172**	**4500**
Clamp ring.	**154**	**9000**
Package joints	**155**	**9500**
Package head internal surface	**160**	**9500**
Package cavity gas	**183**	**12000**
Base of the package	**172**	**4500**
AA41 container shell	**194**	**13000**
Spacer	**158**	**9000**
AA41 container head	**194**	**13000**
AA 99	**229**	**14000**
Container cavity gas	**296**	**15000**
Housings	**283**	**15000**
Content	**449**	**17000**

9.20.CONFIGURATION C4.10

The figures showing isotherms and variation graphs are provided in appendix 18.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**170**	**4500**
Clamp ring.	**136**	**9000**
Package joints	**136**	**8500**
Package head internal surface	**138**	**10000**
Package cavity gas	**169**	**4500**
Base of the package	**170**	**4500**
AA41 container shell	**151**	**14000**
Spacer	**145**	**7000**
AA41 container head	**151**	**14000**
AA 99	**153**	**14000**
Container cavity gas	**222**	**14000**
Housings and covers	**178**	**15000**
Content	**263**	**16000**

9.21.CONFIGURATION C5.1

The figures showing isotherms and variation graphs are provided in appendix 19.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**797**	**1830**
Resin	**739**	**1830**
Package inner shell	**172**	**4500**
Clamp ring.	**129**	**9000**
Package joints	**129**	**9000**
Package head internal surface	**131**	**9500**
Package cavity gas	**171**	**4500**
Base of the package	**172**	**4500**
Spacer	**142**	**5500**
TN90 container shell	**145**	**7500**
TN90 container head	**135**	**8000**
Container cavity gas	**144**	**7500**
Content	**131**	**10000**
AA97 flasks	**132**	**10000**

9.22.CONFIGURATION C7.1

The figures showing isotherms and variation graphs are provided in appendix 20.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**171**	**4500**
Clamp ring.	**125**	**8000**
Package joints	**125**	**8000**
Package head internal surface	**124**	**8500**
Package cavity gas	**170**	**4500**
Base of the package	**171**	**4500**
Spacer	**108**	**10000**
TN90 container shell	**126**	**7000**
TN90 container head	**118**	**10000**
Container cavity gas	**125**	**7000**
Content	**105**	**16000**

9.23.CONFIGURATION C7.2

The figures showing isotherms and variation graphs are provided in appendix 21.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**742**	**1830**
Package inner shell	**186**	**5000**
Clamp ring.	**167**	**8500**
Package joints	**167**	**8500**
Package head internal surface	**172**	**9500**
Package cavity gas	**185**	**5000**
Base of the package	**186**	**5000**
Spacer	**207**	**16000**
TN90 container shell	**193**	**14000**
TN90 container head	**193**	**14000**
Container cavity gas	**201**	**16000**
Content	**216**	**16000**

9.24.CONFIGURATION C8

The figures showing isotherms and variation graphs are provided in appendix 22.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**740**	**1830**
Package inner shell	**184**	**5000**
Clamp ring.	**142**	**8500**
Package joints	**142**	**8500**
Package head internal surface	**143**	**8500**
Package cavity gas	**182**	**7000**
Base of the package	**184**	**5000**
Spacer	**194**	**16000**
TN90 container shell	**183**	**7000**
TN90 container head	**145**	**10000**
Container cavity gas	**243**	**11000**
Housings	**249**	**12000**
Content	**252**	**12000**

9.25.CONFIGURATION C9

The figures showing isotherms and variation graphs are provided in appendix 23.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**785**	**1830**
Resin	**739**	**1830**
Package inner shell	**173**	**4500**
Clamp ring.	**128**	**8500**
Package joints	**129**	**8500**
Package head internal surface	**128**	**9000**
Package cavity gas	**172**	**4500**
Base of the package	**173**	**4500**
Spacer	**120**	**9000**
TN90 container shell	**138**	**7500**
TN90 container head	**126**	**10000**
Container cavity gas	**137**	**7500**
Shell E7	**120**	**12000**
Content	**120**	**13000**

9.26.CONFIGURATION C10.1

The figures showing isotherms and variation graphs are provided in appendix 24.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**787**	**1830**
Resin	**743**	**1830**
Package inner shell	**226**	**12000**
Clamp ring.	**188**	**8500**
Package joints	**189**	**9500**
Package head internal surface	**217**	**11000**
Package cavity gas	**268**	**13000**
Base of the package	**176**	**4500**
Spacer	**228**	**12000**
TN90 container shell	**312**	**15000**
TN90 container head	**247**	**13000**
Container cavity gas	**335**	**16000**
Content	**376**	**17000**

9.27.CONFIGURATION C10.2

The figures showing isotherms and variation graphs are provided in appendix 25.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**787**	**1830**
Resin	**743**	**1830**
Package inner shell	**183**	**4500**
Clamp ring.	**167**	**8500**
Package joints	**167**	**8000**
Package head internal surface	**177**	**10000**
Package cavity gas	**195**	**14000**
Base of the package	**179**	**4500**
Spacer	**185**	**11000**
TN90 container shell	**208**	**17000**
TN90 container head	**185**	**12000**
Container cavity gas	**206**	**16000**
Content	**221**	**20000**

9.28.CONFIGURATION C10.3

The figures showing isotherms and variation graphs are provided in appendix 26.

DESIGN OF AN ISOLATED PACKAGE Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**797**	**1830**
Resin	**743**	**1830**
Package inner shell	**188**	**11000**
Clamp ring.	**170**	**8500**
Package joints	**171**	**8000**
Package head internal surface	**182**	**11000**
Package cavity gas	**205**	**12000**
Base of the package	**179**	**4500**
Spacer	**193**	**12000**
TN90 container shell	**218**	**13000**
TN90 container head	**193**	**12000**
Container cavity gas	**220**	**13000**
Content	**220**	**13000**

9.29.CONFIGURATION CA1 (12×80W)

Configuration C4.2 for an isolated package was adopted for this caisson design.
The figures showing isotherms and variation graphs are provided in appendix 27.

CAISSON DESIGN Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**741**	**1830**
Package inner shell	**176**	**4500**
Clamp ring.	**150**	**8500**
Package joints	**150**	**8000**
Package head internal surface	**152**	**10000**
Package cavity gas	**174**	**4500**
Base of the package	**176**	**4500**
AA204 container shell	**166**	**11000**
Spacer	**152**	**9000**
AA204 container head	**165**	**11000**
Container cavity gas	**252**	**14000**
AA 99	**212**	**13000**
Housings	**214**	**13000**
Content	**302**	**14000**
CONTAINMENT	**Normal conditions of transport Maximum temperatures**	
	Temperature (°C)	
Side Wall	**69**	
Top panel	**70**	
Door	**65**	
Base	**70**	
Floor	**74**	
Package	**81**	
Air	**70**	

9.30.CONFIGURATION CA2 (12×100W)

Configuration C4.5bis for an isolated package was adopted for this caisson design.
The figures showing isotherms and variation graphs are provided in appendix 28.

CAISSON DESIGN Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**786**	**1830**
Resin	**742**	**1830**
Package inner shell	**179**	**4500**
Clamp ring.	**164**	**8500**
Package joints	**165**	**9000**
Package head internal surface	**171**	**9500**
Package cavity gas	**201**	**10000**
Base of the package	**179**	**4500**
AA41 container shell	**214**	**11000**
Spacer	**167**	**9000**
AA41 container head	**211**	**10000**
Container cavity gas	**364**	**13000**
AA 99	**276**	**12000**
Housings	**354**	**12000**
Content	**647**	**15000**
CONTAINMENT	**Normal conditions of transport Maximum temperatures**	
	Temperature (°C)	
Side Wall	**74**	
Top panel	**74**	
Door	**68**	
Base	**75**	
Floor	**79**	
Package	**88**	
Air	**74**	

9.31.CONFIGURATION CA3 (12×200W)

Configuration C3.1 at 4 ×50 W per package for an isolated package was adopted for this caisson design. The figures showing isotherms and variation graphs are provided in appendix 29.

CAISSON DESIGN Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**788**	**1830**
Resin	**747**	**1830**
Package inner shell	**201**	**5000**
Clamp ring.	**182**	**7500**
Package joints	**182**	**7000**
Package head internal surface	**184**	**8500**
Package cavity gas	**200**	**5000**
Base of the package	**201**	**5000**
Spacer	**187**	**9000**
TN90 container shell	**199**	**10000**
TN90 container head	**192**	**10000**
Container cavity gas	**313**	**11000**
AA 99	**260**	**10000**
Housings	**302**	**11000**
Content	**464**	**13000**
CONTAINMENT	**Normal conditions of transport Maximum temperatures**	
	Temperature (°C)	
Side Wall	**95**	
Top panel	**92**	
Door	**85**	
Base	**97**	
Floor	**103**	
Package	**117**	
Air	**95**	

9.32.CONFIGURATION CA4 (24 ×80 W)

Configuration C4.2 for an isolated package was adopted for this caisson design.
The figures showing isotherms and variation graphs are provided in appendix 30.

CAISSON DESIGN Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**787**	**1830**
Resin	**743**	**1830**
Package inner shell	**184**	**4500**
Clamp ring.	**162**	**8000**
Package joints	**162**	**7500**
Package head internal surface	**163**	**9500**
Package cavity gas	**182**	**4500**
Base of the package	**184**	**4500**
Spacer	**162**	**8500**
AA204 container shell	**175**	**10000**
AA204 container head	**175**	**10000**
Container cavity gas	**258**	**13000**
AA 99	**219**	**12000**
Housings	**222**	**12000**
Content	**309**	**13000**
CONTAINMENT	**Normal conditions of transport Maximum temperatures**	
	Temperature (°C)	
Side Wall	**76**	
Top panel	**80**	
Door	**72**	
Base	**75**	
Floor	**90**	
Package	**97**	
Air	**86**	

9.33.CONFIGURATION CA5 (24 x 100W)

Configuration C4.5bis for an isolated package was adopted for this caisson design.
The figures showing isotherms and variation graphs are provided in appendix 31.

CAISSON DESIGN Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**787**	**1830**
Resin	**744**	**1830**
Package inner shell	**188**	**4500**
Clamp ring.	**177**	**8000**
Package joints	**178**	**8500**
Package head internal surface	**184**	**9000**
Package cavity gas	**212**	**9500**
Base of the package	**188**	**4500**
Spacer	**179**	**8500**
AA41 container shell	**226**	**10000**
AA41 container head	**222**	**10000**
Container cavity gas	**369**	**12000**
AA 99	**284**	**11000**
Housings	**360**	**12000**
Content	**654**	**14000**
CONTAINMENT	**Normal conditions of transport Maximum temperatures**	
	Temperature (°C)	
Side Wall	**82**	
Top panel	**85**	
Door	**78**	
Base	**81**	
Floor	**98**	
Package	**106**	
Air	**94**	

9.34.CONFIGURATION CA6 (7 x 340W)

Configuration C2.1 for an isolated package was adopted for this caisson design.
The figures showing isotherms and variation graphs are provided in appendix 32.

CAISSON DESIGN Maximum temperatures		
TN/BGC 1 PACKAGE	**Accident conditions of transport**	
	Temperature (°C)	**Time (s)**
External surfaces	**798**	**1830**
Outer shell	**788**	**1830**
Resin	**752**	**1830**
Package inner shell	**205**	**5000**
Clamp ring.	**195**	**7000**
Package joints	**196**	**8000**
Package head internal surface	**200**	**10000**
Package cavity gas	**216**	**8500**
Base of the package	**204**	**4500**
Spacer	**210**	**7500**
AA227 container shell	**223**	**9000**
AA227 container head	**213**	**11000**
Container cavity gas	**355**	**12000**
AA303 shell	**265**	**12000**
Housings	**322**	**12000**
Content	**536**	**15000**
CONTAINMENT	**Normal conditions of transport Maximum temperatures**	
	Temperature (°C)	
Side Wall	**95**	
Top panel	**92**	
Door	**84**	
Base	**101**	
Floor	**104**	
Package	**127**	
Air	**94**	

9.35.CONCLUSION

Table summarising results

Packaging components	C1.1	C1.2	C2.1	C2.2	C3.1	C3.2	C3.3	C4.1	C4.2	C4.3	C4.4	C4.5
Total power dissipated (W)	80	340	340	340	340	80	80	170	80	170	40	100
Type of contents	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder
Package:												
External surfaces	798	798	798	798	798	798	798	798	798	798	798	798
Outer shell	786	786	787	787	787	785	785	786	785	786	785	785
Resin	739	742	746	742	743	739	739	739	739	739	739	739
Inner shell	171	187	177	153	179	174	174	168	166	168	165	166
Clamp ring	134	156	163	150	165	136	137	154	139	160	134	150
Package joint	135	156	164	150	165	137	137	154	139	161	134	151
Head internal surface	134	158	170	151	171	137	137	159	142	167	136	158
Package cavity gas	169	186	188	153	196	172	172	188	164	211	163	190
Base of the package	171	187	176	142	179	174	174	168	166	168	165	166
Internal fittings and content:												
Tertiary container shell	129	189	195	154	205	152	152	195	157	223	149	203
Spacer	122	172	181	152	187	136	136	158	141	165	135	153
Tertiary container head	129	165	184	154	188	139	140	180	155	194	149	199
Secondary container shell	135	216	242	155	282	186	192	250	204	289	194	267
Secondary container head	135	210	242	155	282	186	192	250	204	289	194	267
Container cavity gas	201	284	339	155	341	227	237	302	246	344	234	358
Housings and covers*	148	282	303	155	336	195	196	284	207	336	196	346
Content	242	453	518	357	522	282	286	435	295	521	285	640

* the following configurations include covers: C3.2, C3.3, C4.2, C4.4.

Table summarising results (continued)

Packaging components	C4.6	C4.7	C4.8	C4.9	C4.10	C5.1	C7.1	C7.2	C8	C9	C10.1	C10.2	C10.3
Total power dissipated (W)	20	170	40	170	60	4	4	340	150	16	340	340	340
Type of contents	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	U ingot	U ingot	Zebra Pu plates	Uranium substance	MOX rod	MOX rod	MOX rod
Package:													
External surfaces	798	798	798	798	798	798	798	798	798	798	798	798	798
Outer shell	785	786	785	786	785	797	785	786	786	785	787	787	797
Resin	739	739	739	739	739	739	739	742	740	739	743	743	743
Inner shell	164	165	145	172	170	172	171	186	184	173	226	183	188
Clamp ring	130	158	133	154	136	129	125	167	142	128	188	167	170
Package joint	130	154	134	155	136	129	125	167	142	129	189	167	171
Head internal surface	132	164	135	160	138	131	124	172	143	128	217	177	182
Package cavity gas	161	198	220	183	169	171	170	185	182	172	268	195	205
Base of the package	164	137	129	172	170	172	171	186	184	173	176	179	179
Internal fittings and content:													
Tertiary container shell	143	208	147	194	151	-	-	-	-	-	-	-	-
Spacer	130	162	134	158	145	142	108	207	194	120	228	185	193
Tertiary container head	143	204	147	194	151	-	-	-	-	-	-	-	-
Secondary container shell	146	262	150	229	153	145	126	193	183	138	312	208	218
Secondary container head	146	262	150	229	153	135	118	193	145	126	247	185	193
Container cavity gas	217	322	142	296	222	144	125	201	243	137	335	206	220
Housings and covers*	171	318	175	283	178	132 (AA97)	-	-	249	120 (Shell E7)	-	-	-
Content	256	501	260	449	263	131	105	216	252	120	376	221	220

* the following configurations include covers: C4.6, C4.8, C4.10.

Table summarising results (final part)

Packaging components	C3.1bis	C3.2bis	C3.3bis	CA1	CA2	CA3	CA4	CA5	CA6
Total power dissipated (W)	400	60	100	12 × 80W (C4.2)	12 × 100W (C4.5)	12 × 200W (C3.1 at 4 ×	24 × 80W (C4.2)	24 × 100W (C4.5)	7 × 340W (C2.1)
Type of contents	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder	PuO_2 powder
Package:									
External surfaces	798	798	798	798	798	798	798	798	798
Outer shell	787	785	786	786	786	788	787	787	788
Resin	744	739	739	741	742	747	743	744	752
Inner shell	186	173	174	176	179	201	184	188	205
Clamp ring	170	134	139	150	164	182	162	177	195
Package joint	171	134	139	150	165	182	162	178	196
Head internal surface	178	134	140	152	171	184	163	184	200
Package cavity gas	208	172	172	174	201	200	182	212	216
Base of the package	180	173	174	176	179	201	184	188	204
Internal fittings and content:									
Tertiary container shell	218	151	153	166	214	199	175	226	223
Spacer	199	132	140	152	167	187	162	179	210
Tertiary container head	197	135	145	165	211	192	175	222	213
Secondary container shell	301	173	204	212	276	260	219	284	265
Secondary container head	301	173	204	212	276	260	219	284	265
Container cavity gas	373	209	252	252	364	313	258	369	355
Housings and covers*	350	176	213	214	354	302	222	360	322
Content	540	276	322	302	647	464	309	654	536

* the following configurations include covers: C3.2bis, C3.3bis, CA1, CA4.

This study demonstrated that the temperatures reached by the different package components are acceptable and are not likely to endanger the properties of the components. In particular, joint temperatures remain below their operating limit and the extrusion temperature.
If covers are used, the temperatures reached demonstrate that it is not feasible to remove the risk of thermolysis in ACT.
With regard the temperatures reached by the filling gas, either in the package cavity or in the internal fittings, the values calculated are approximately of the same order of magnitude as those defined in the previous studies (and even below these in most cases) and do not modify the results of studies for which this temperature is used as input data (release of H2, tightness maintained at high temperatures, release). Finally, the temperatures reached by the different content components are not likely to downgrade the components (in particular, the maximum temperature reached by the cladding of the zebra plates or Mox rods remains allowable)

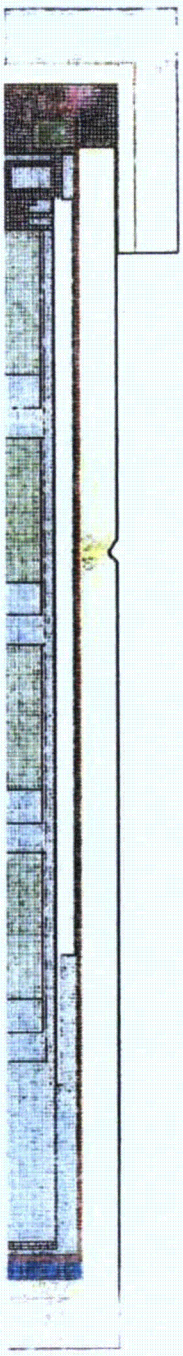
APPENDIX 1

PRESENTATION OF THE MODEL

APPENDIX 1

PACKAGE MESHING

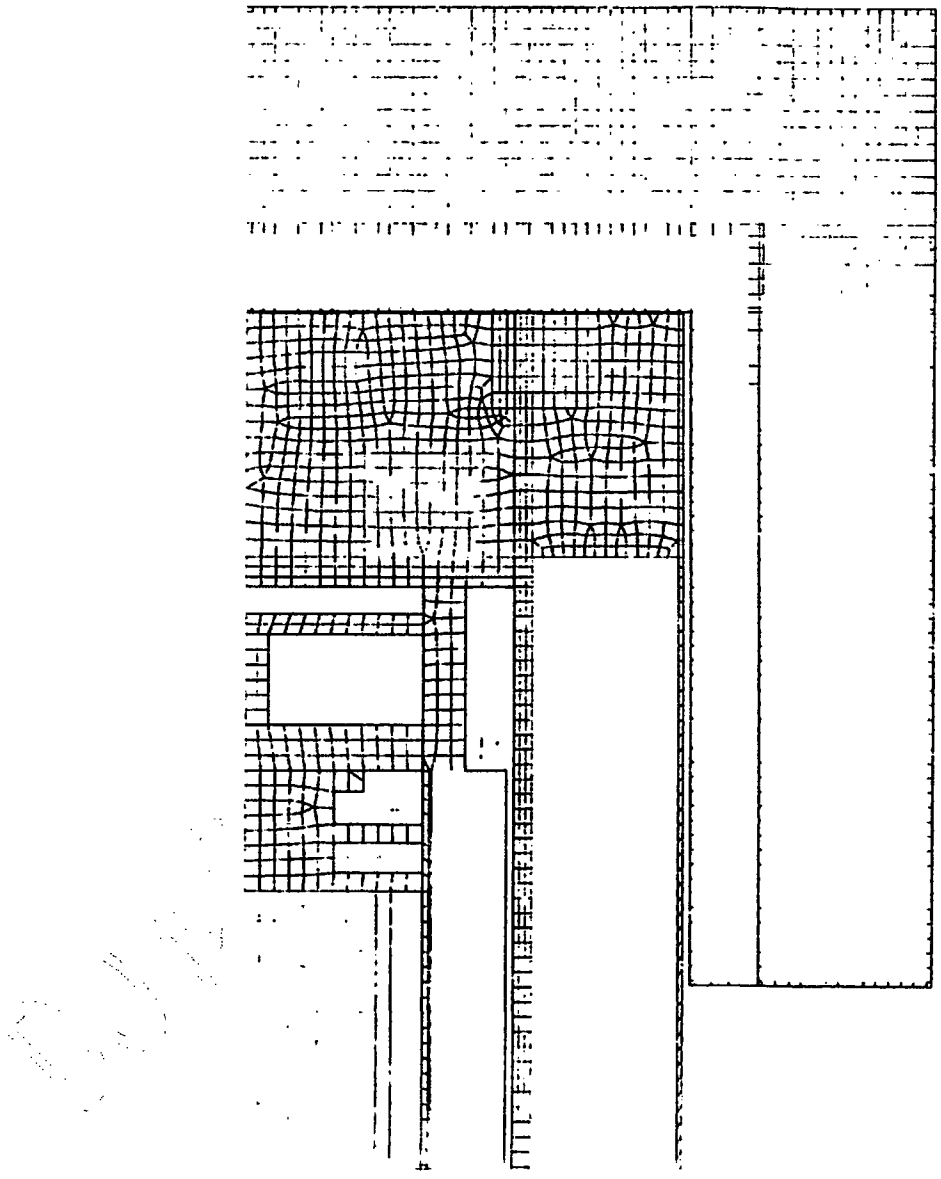
PACKAGE



APPENDIX 1

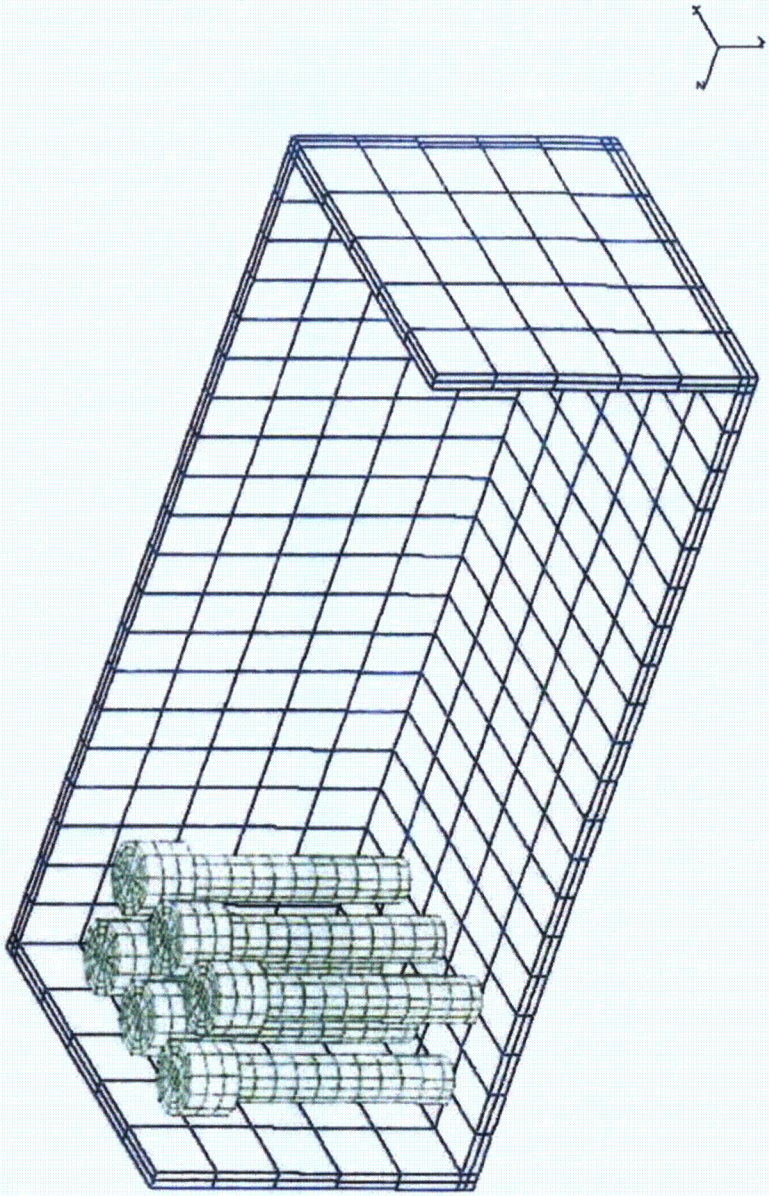
PACKAGE MESHING

PACKAGE (UPPER SECTION)



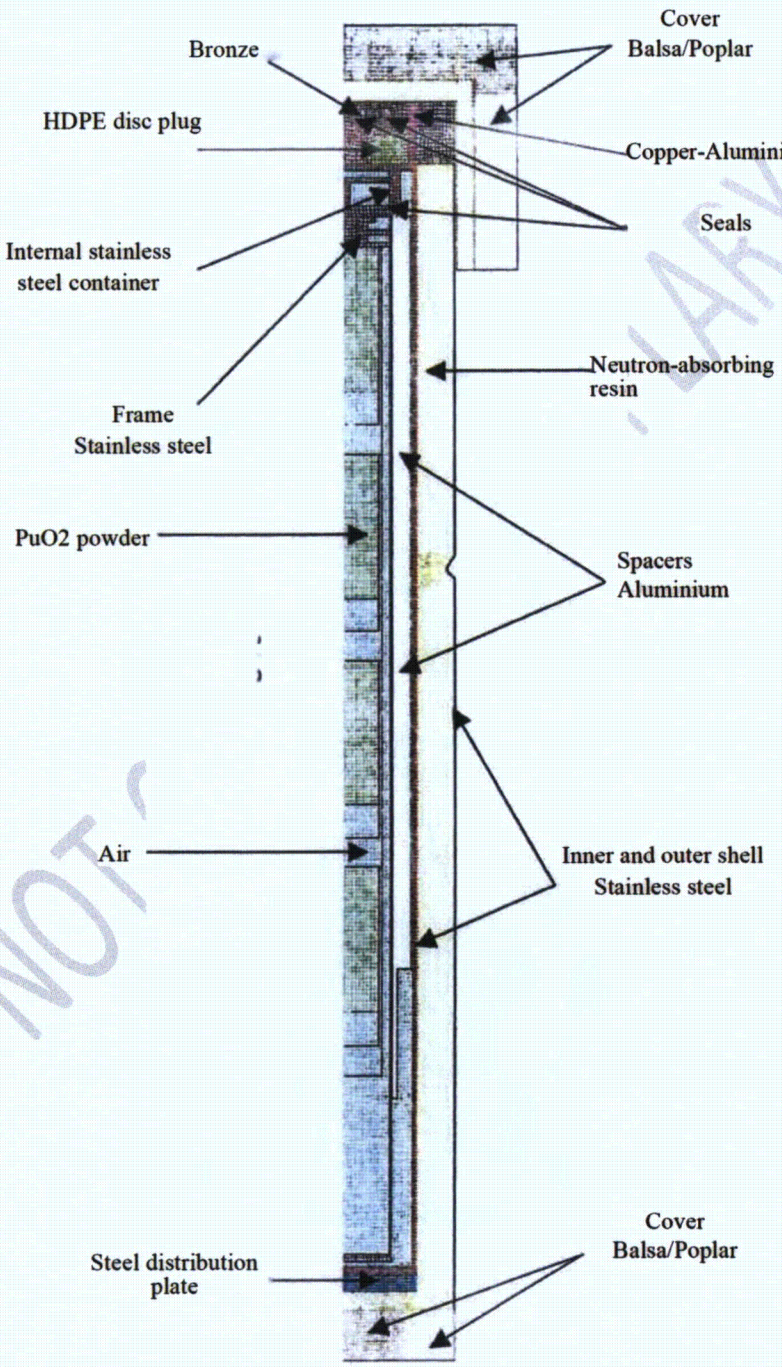
APPENDIX 1

CAISSON MESHING



APPENDIX 1

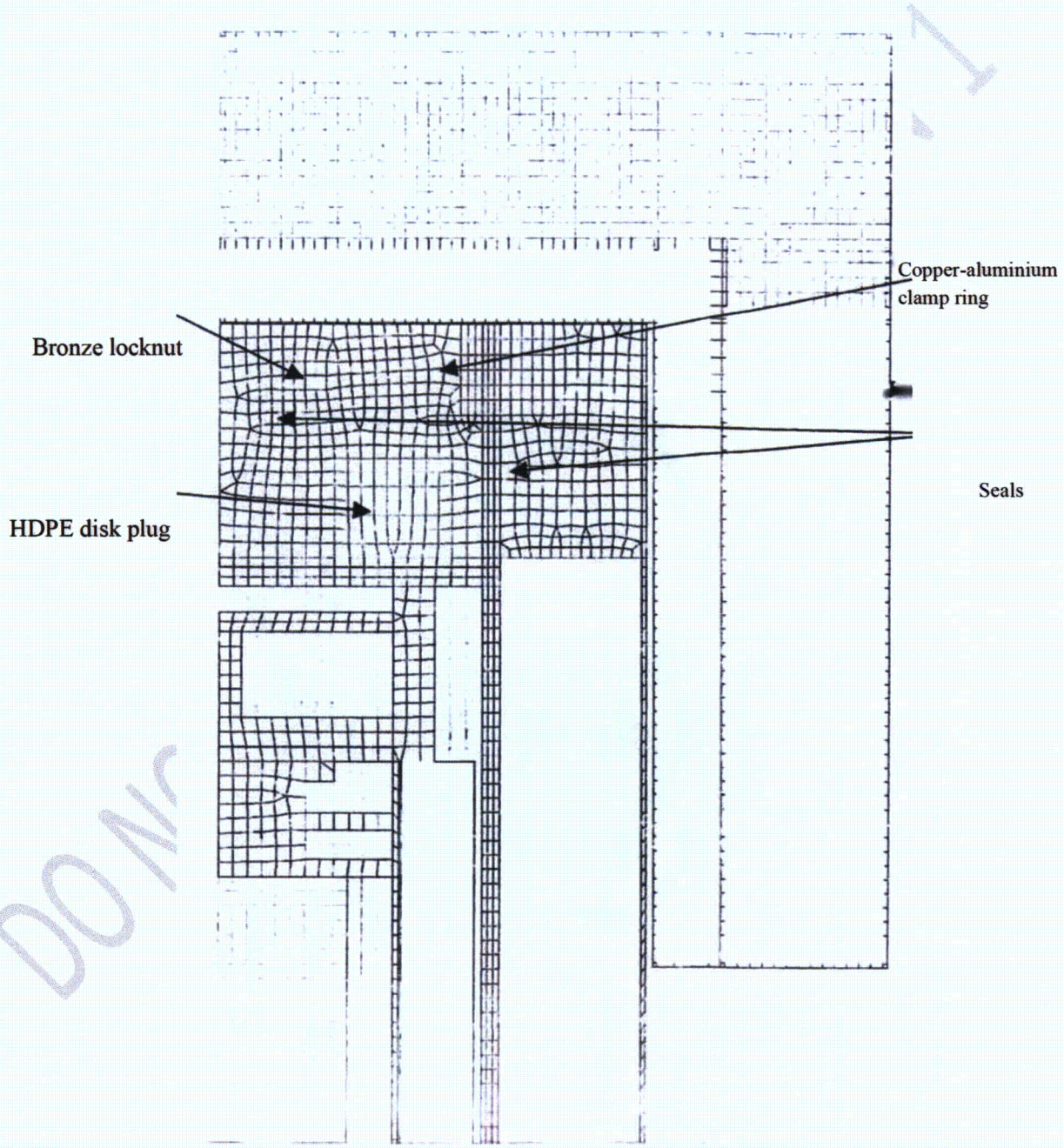
PACKAGE MATERIALS



APPENDIX 1

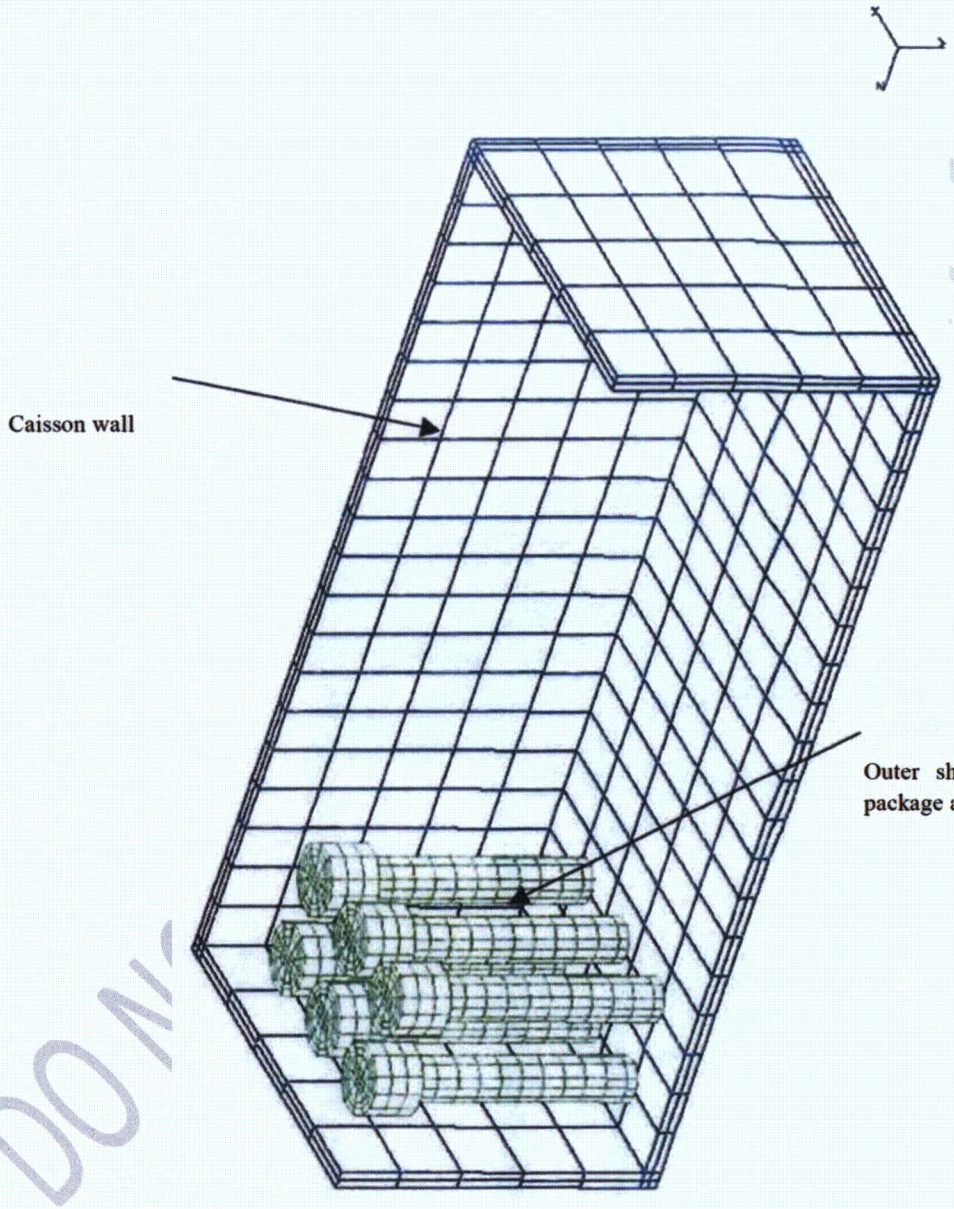
PACKAGE MATERIALS

PACKAGE (UPPER SECTION)



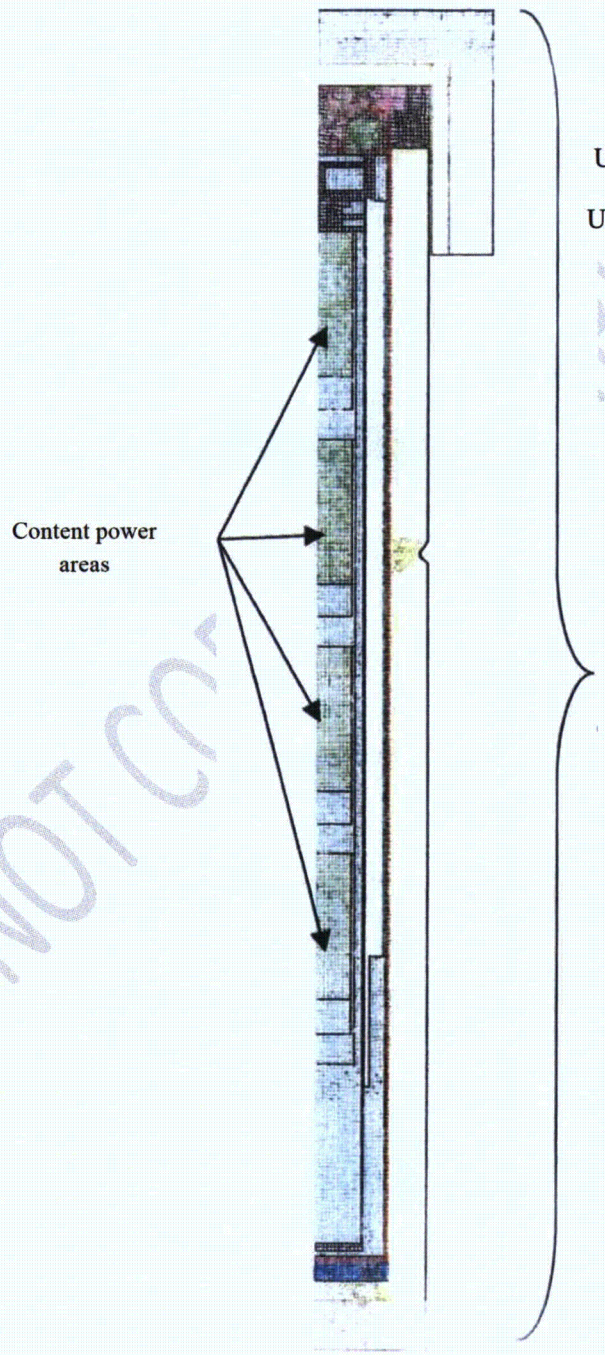
APPENDIX 1

CAISSON DESCRIPTION



APPENDIX 1

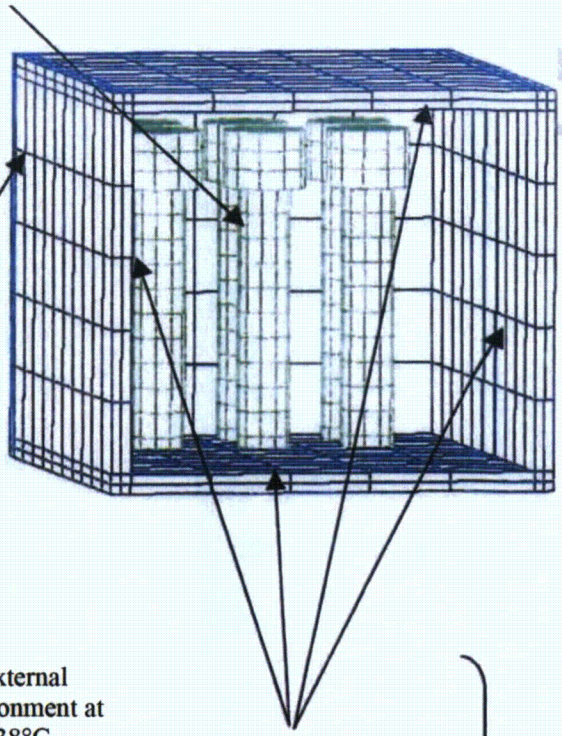
LIMIT CONDITIONS PACKAGE



APPENDIX 1

LIMIT CONDITIONS
CONTAINMENT

Internal power applied to the outer shell of each package
P = 80, 100, 200 W/packages
For 12 or 24 packages



Convective exchange
+
Radiative exchange
+
Regulatory sunlight

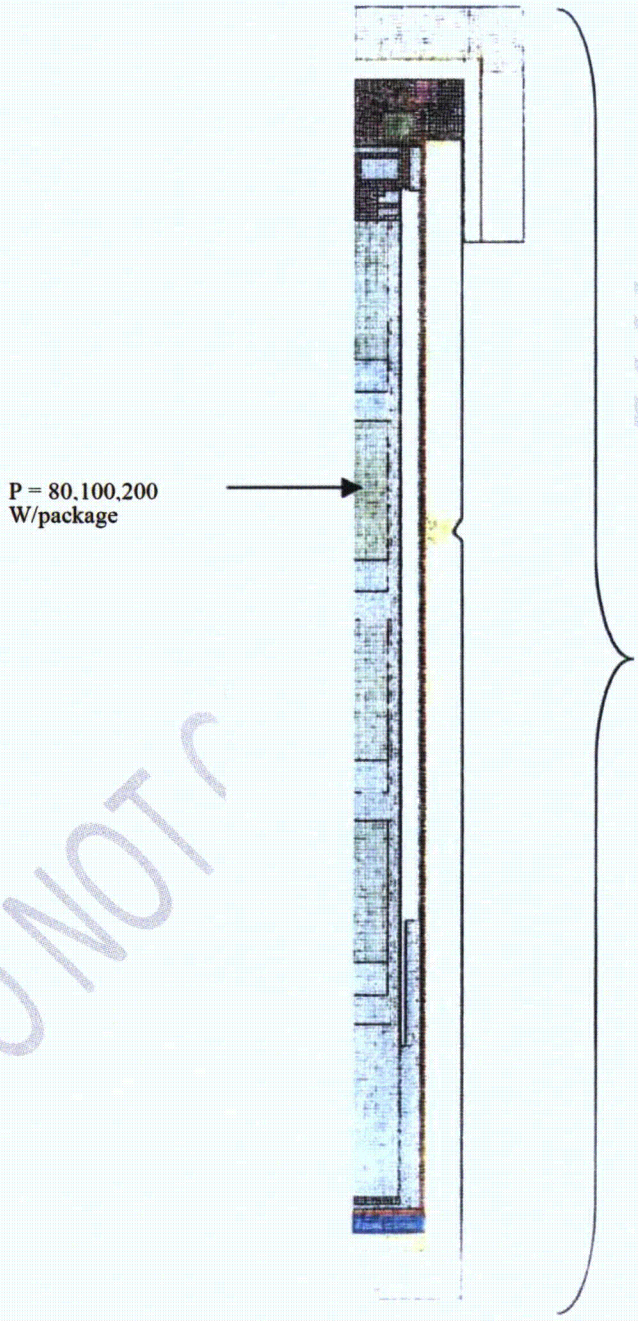
External environment at 38°C

Convective exchange
+
Radiative exchange

Interior environment

APPENDIX 1

LIMIT CONDITIONS
PACKAGE IN CAISSON



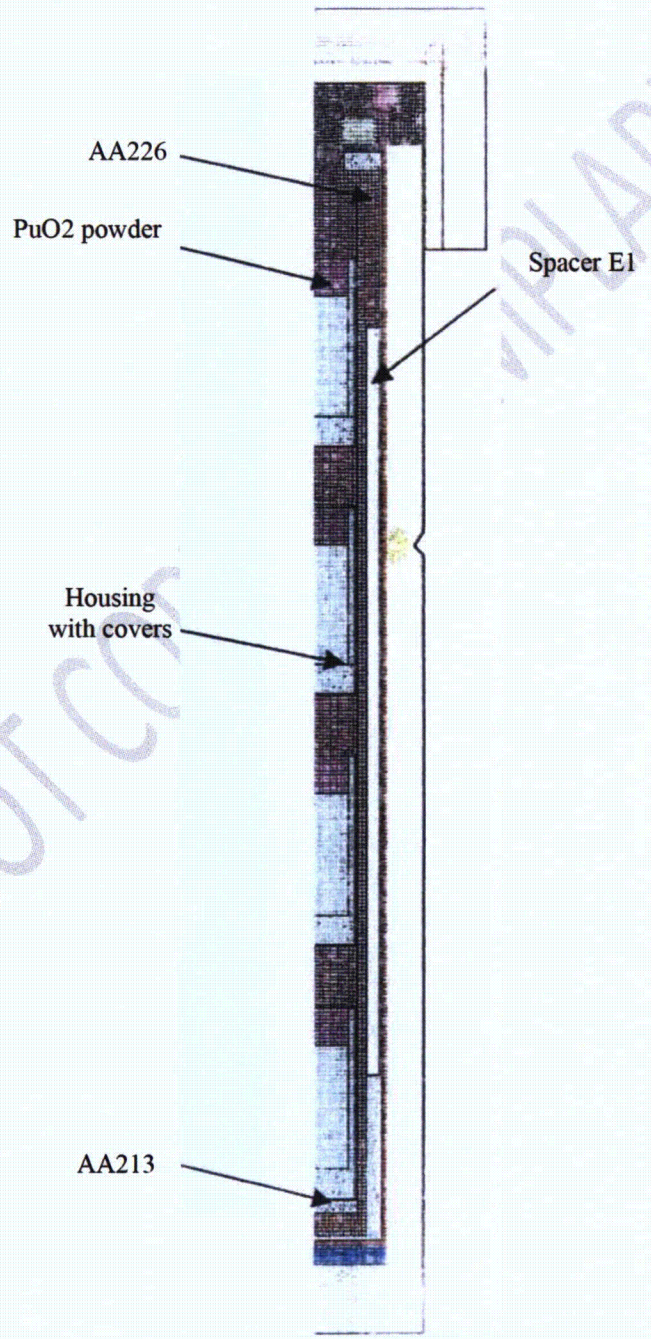
APPENDIX 2

CONFIGURATION C1.1

APPENDIX 2

CONFIGURATION C1.1

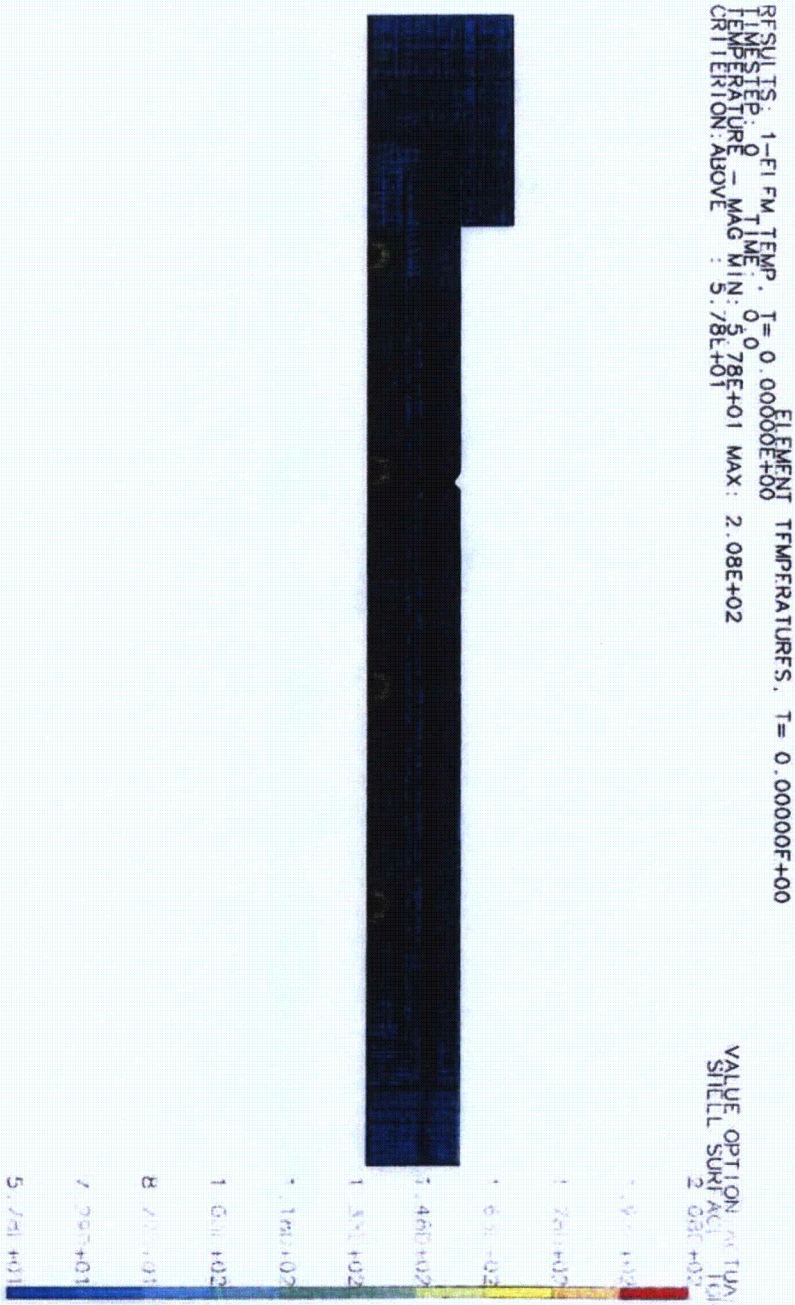
PRESENTATION OF THE MODEL



APPENDIX 2

CONFIGURATION C1.1

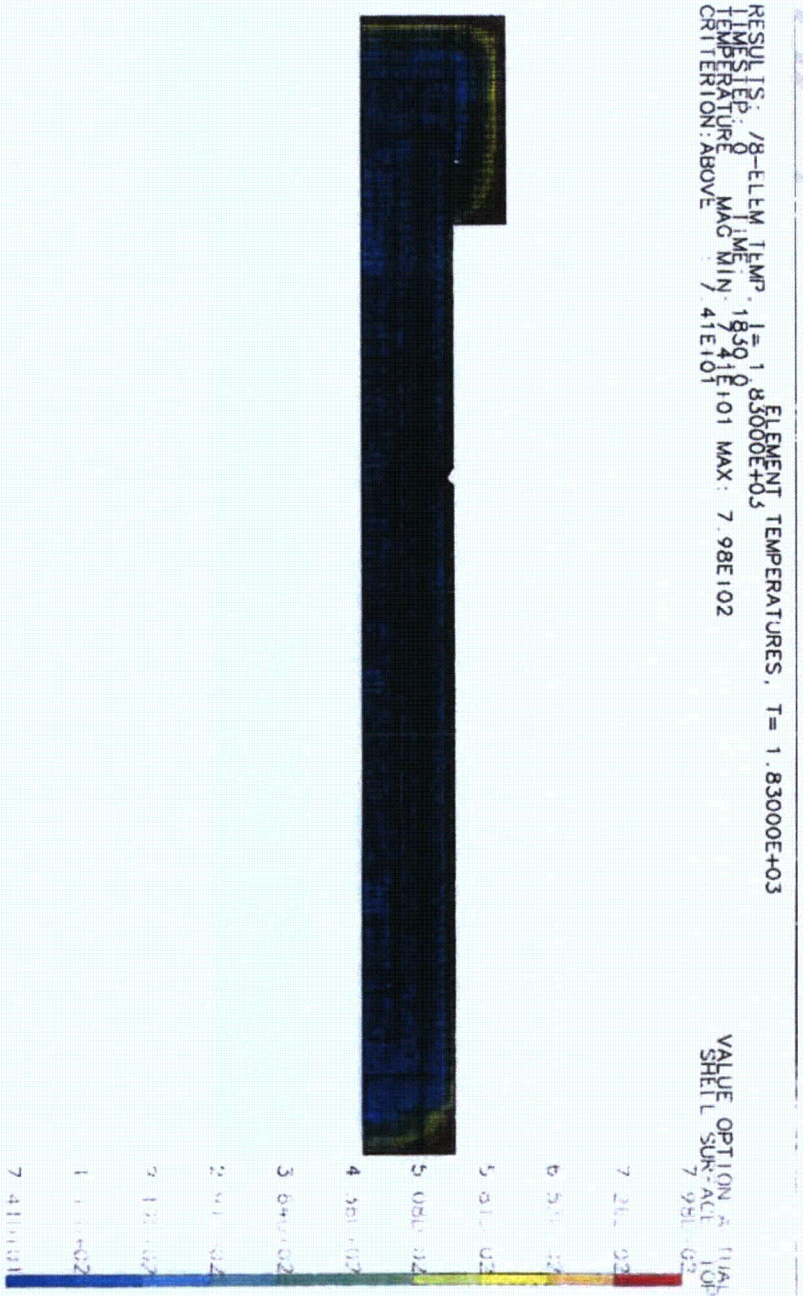
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 2

CONFIGURATION C1.1

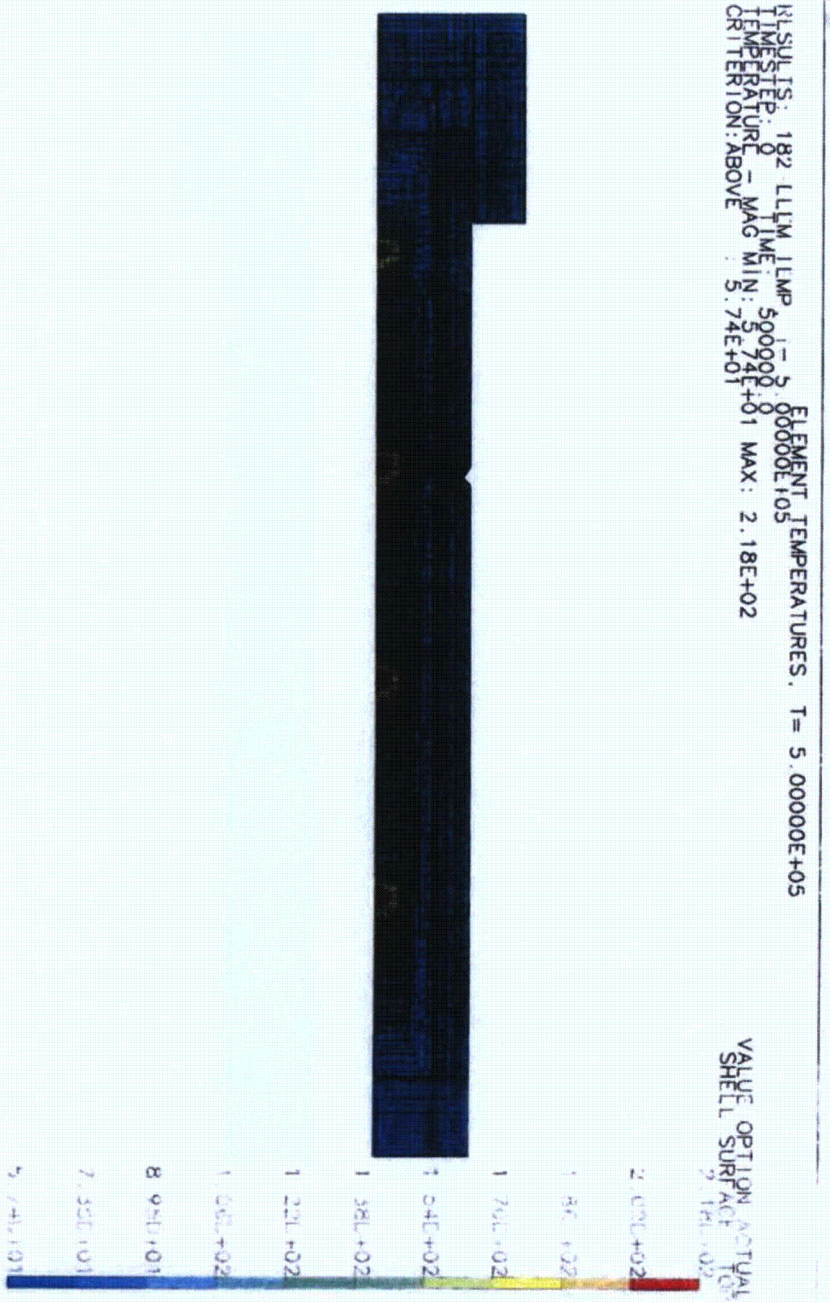
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 2

CONFIGURATION C1.1

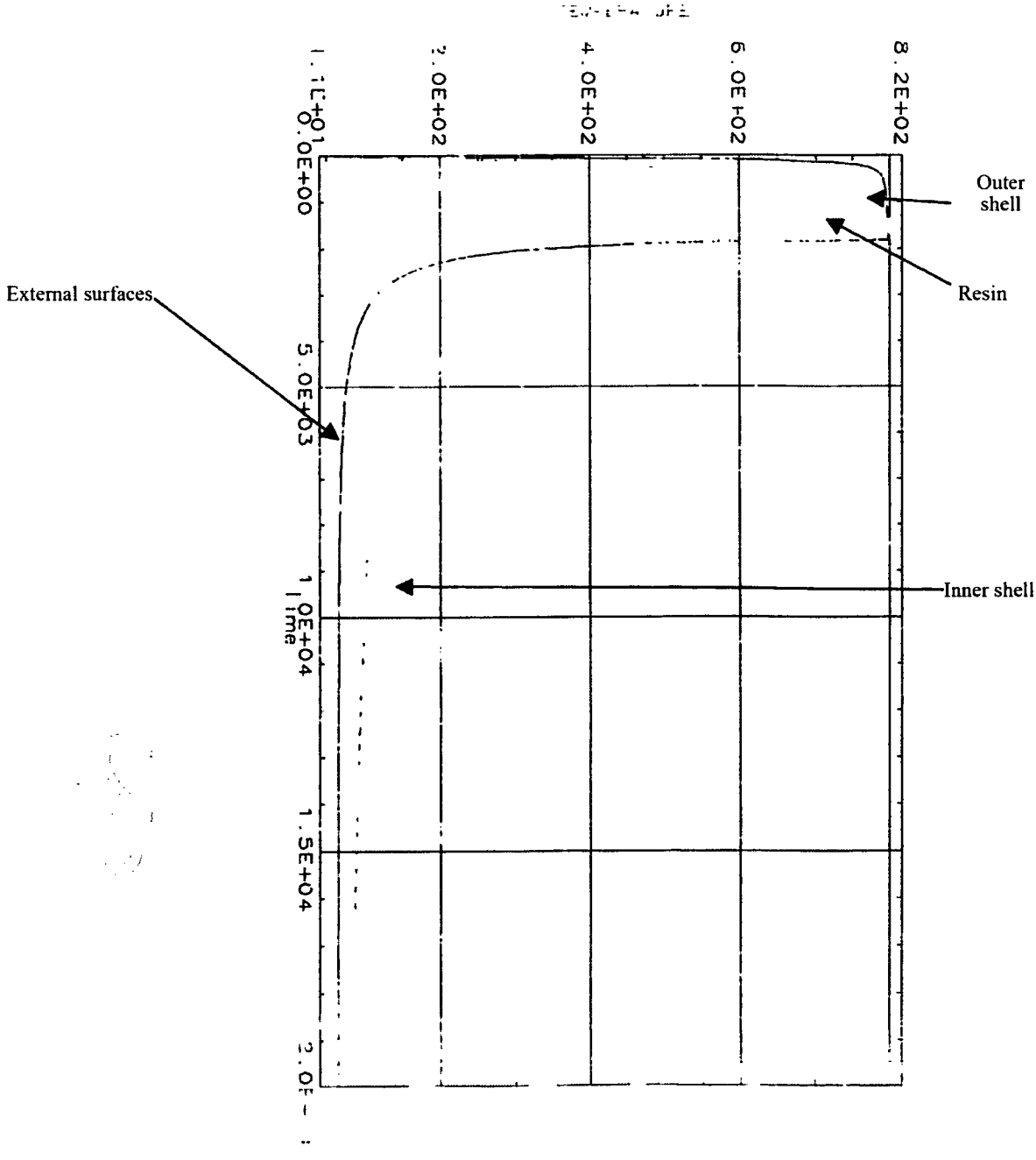
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 2

CONFIGURATION C1.1

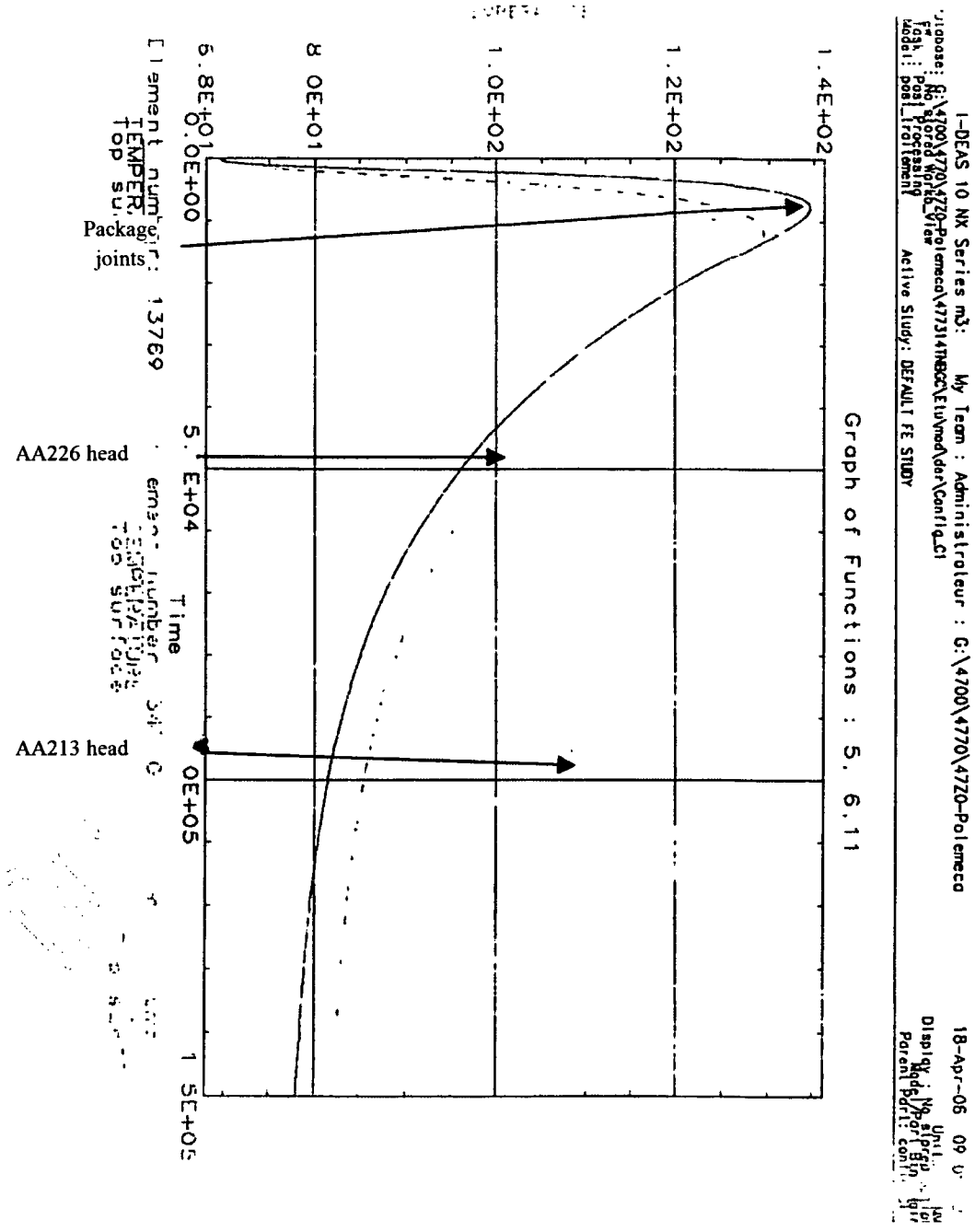
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 2

CONFIGURATION C1.1

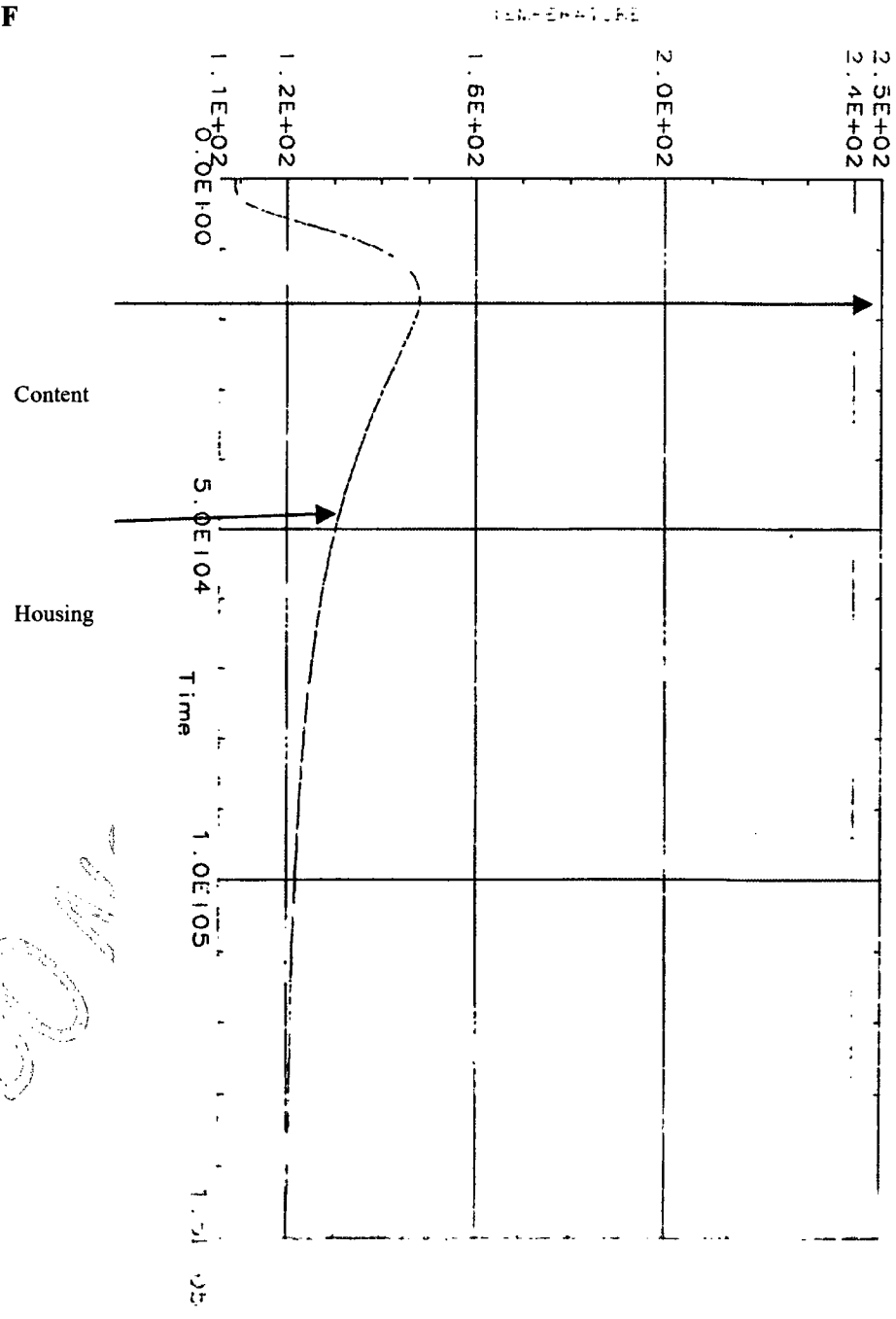
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 2

CONFIGURATION C1.1

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT

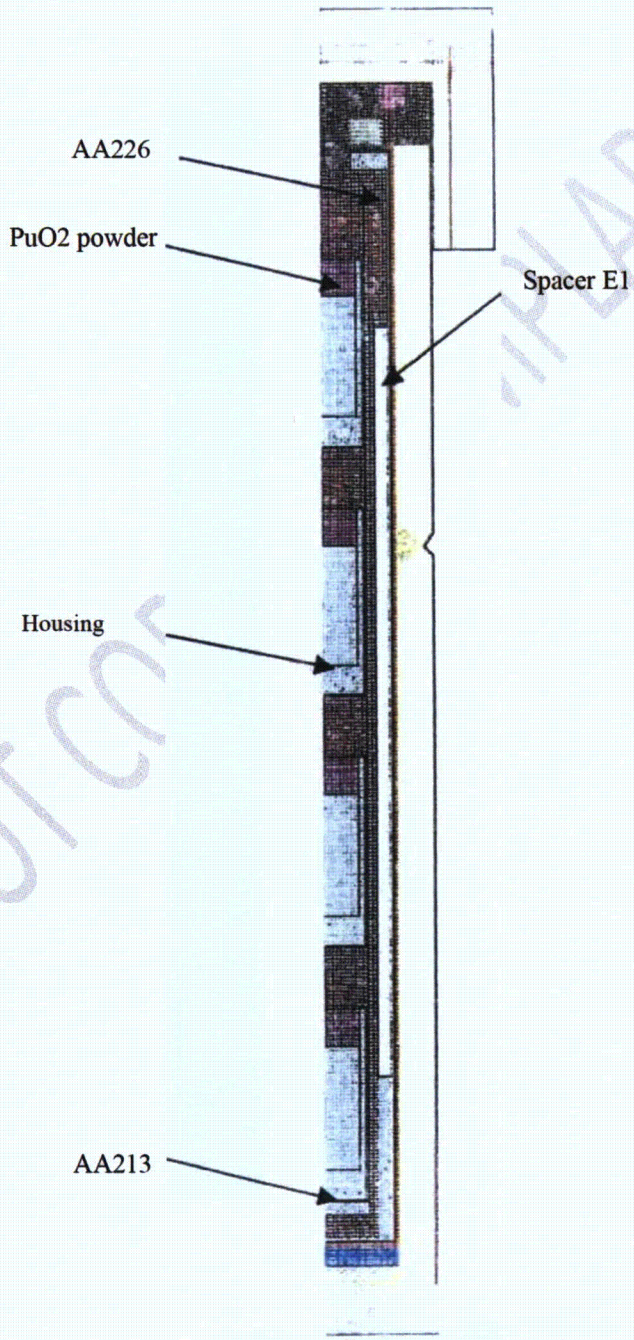


APPENDIX 3
CONFIGURATION C1.2

APPENDIX 3

CONFIGURATION C1.2

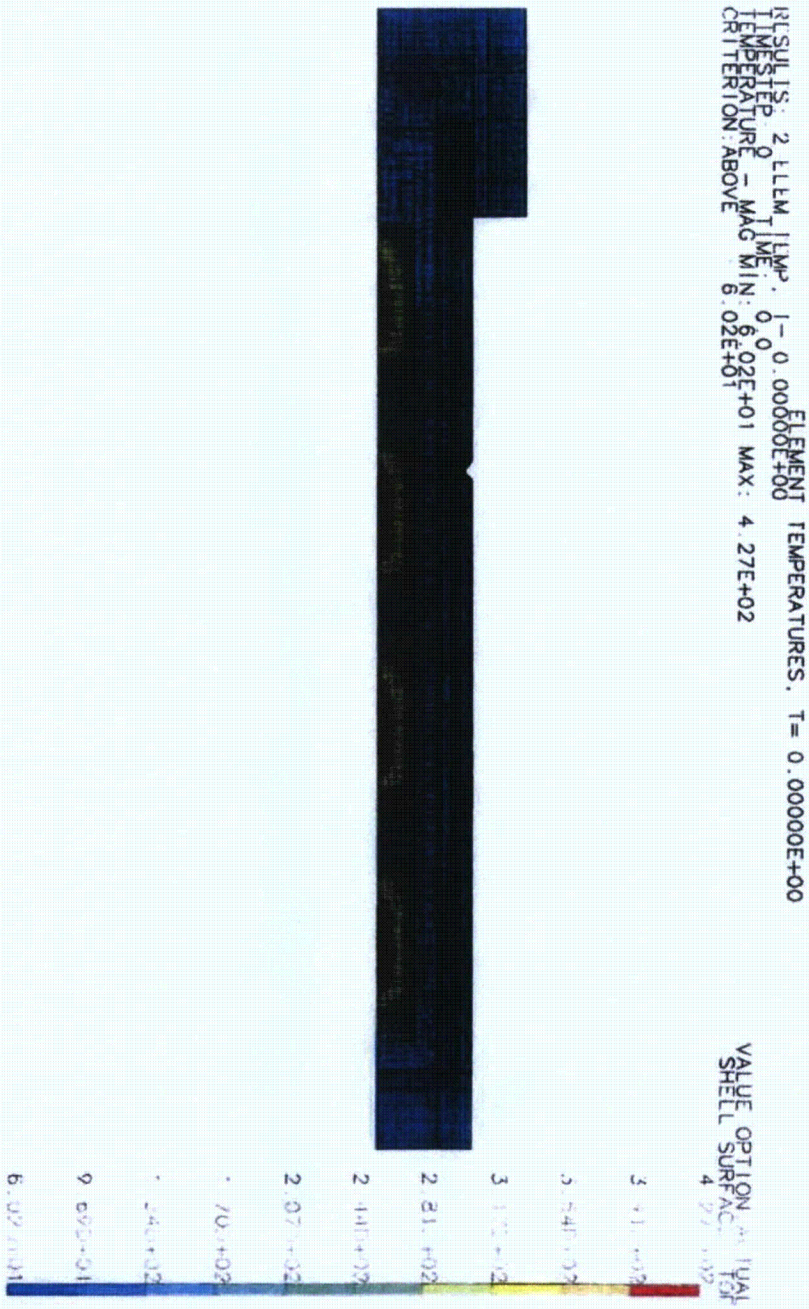
PRESENTATION OF THE MODEL



APPENDIX 3

CONFIGURATION C1.2

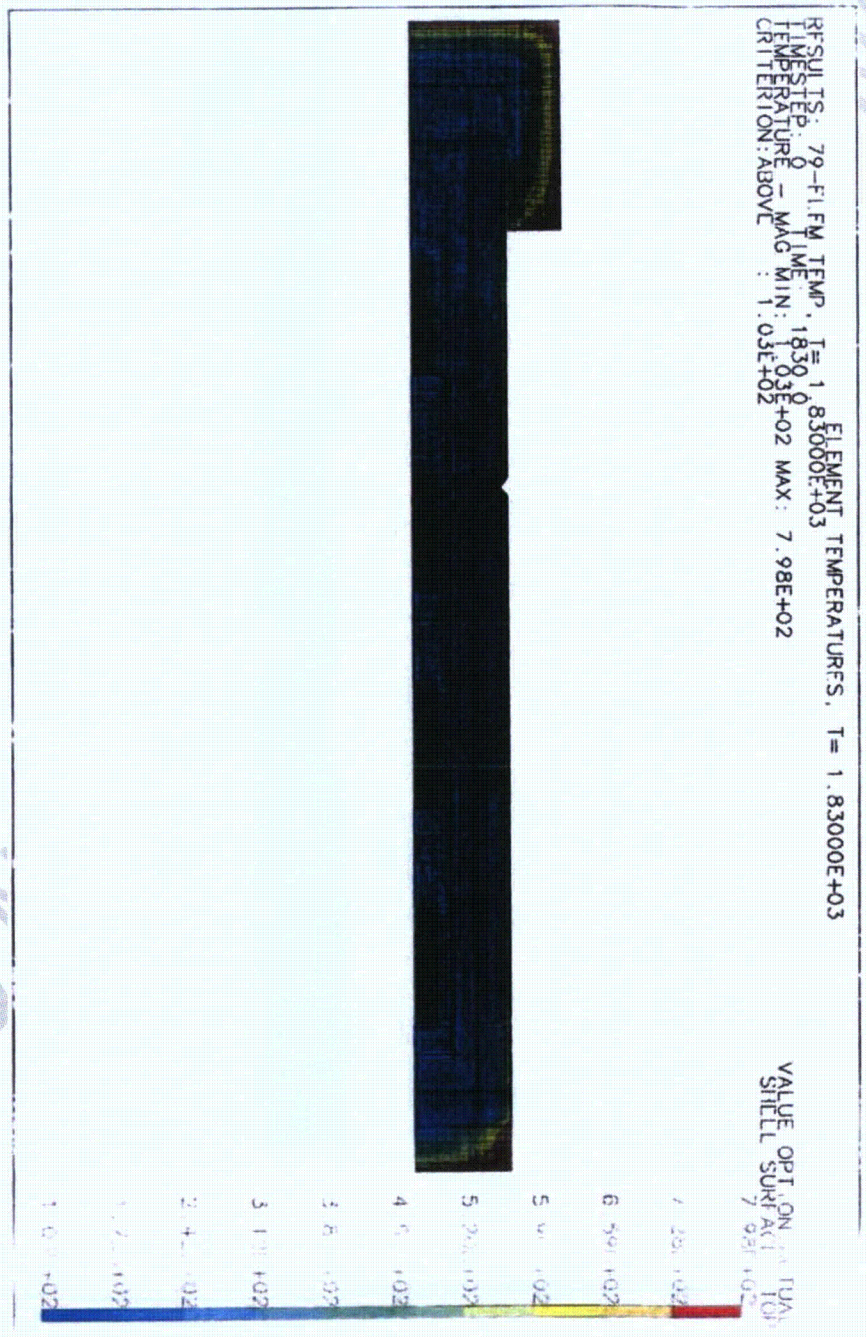
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 3

CONFIGURATION C1.2

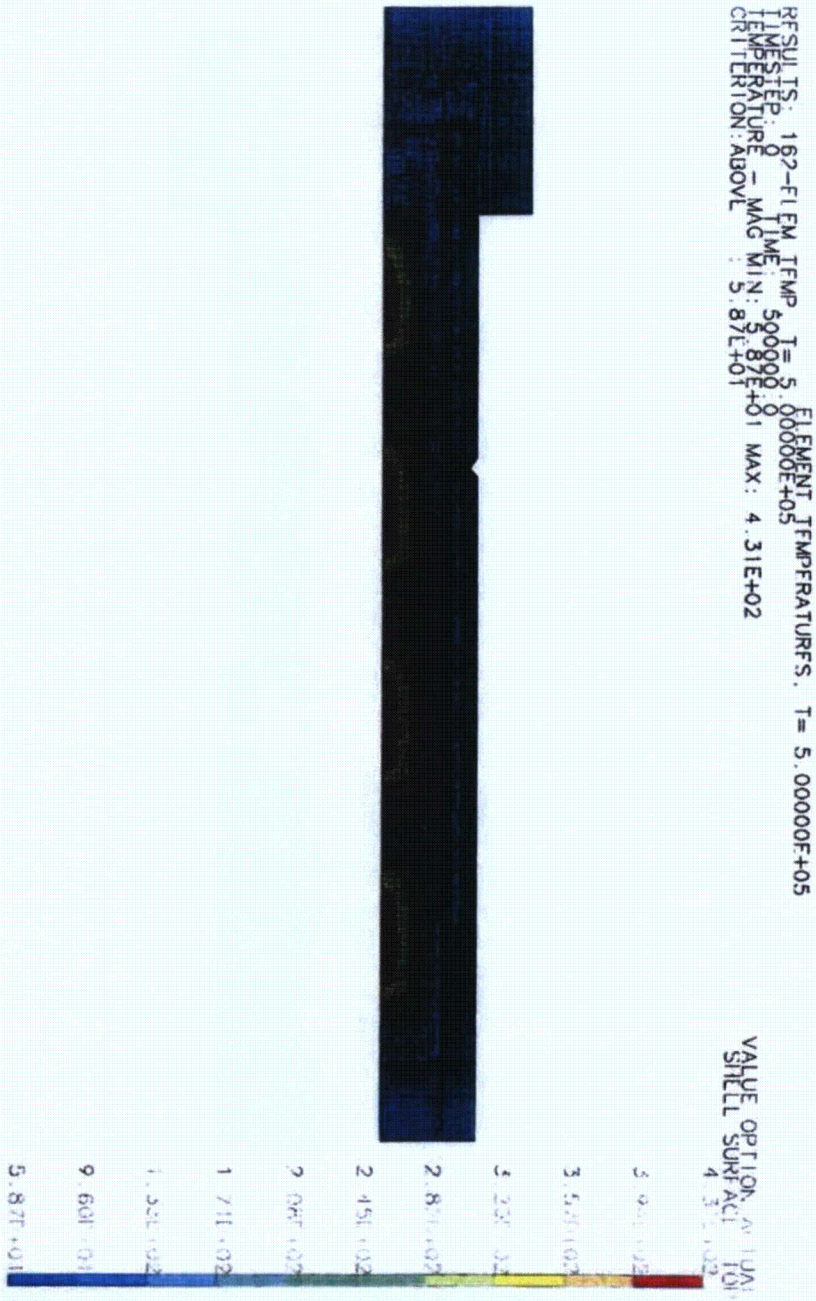
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 3

CONFIGURATION C1.2

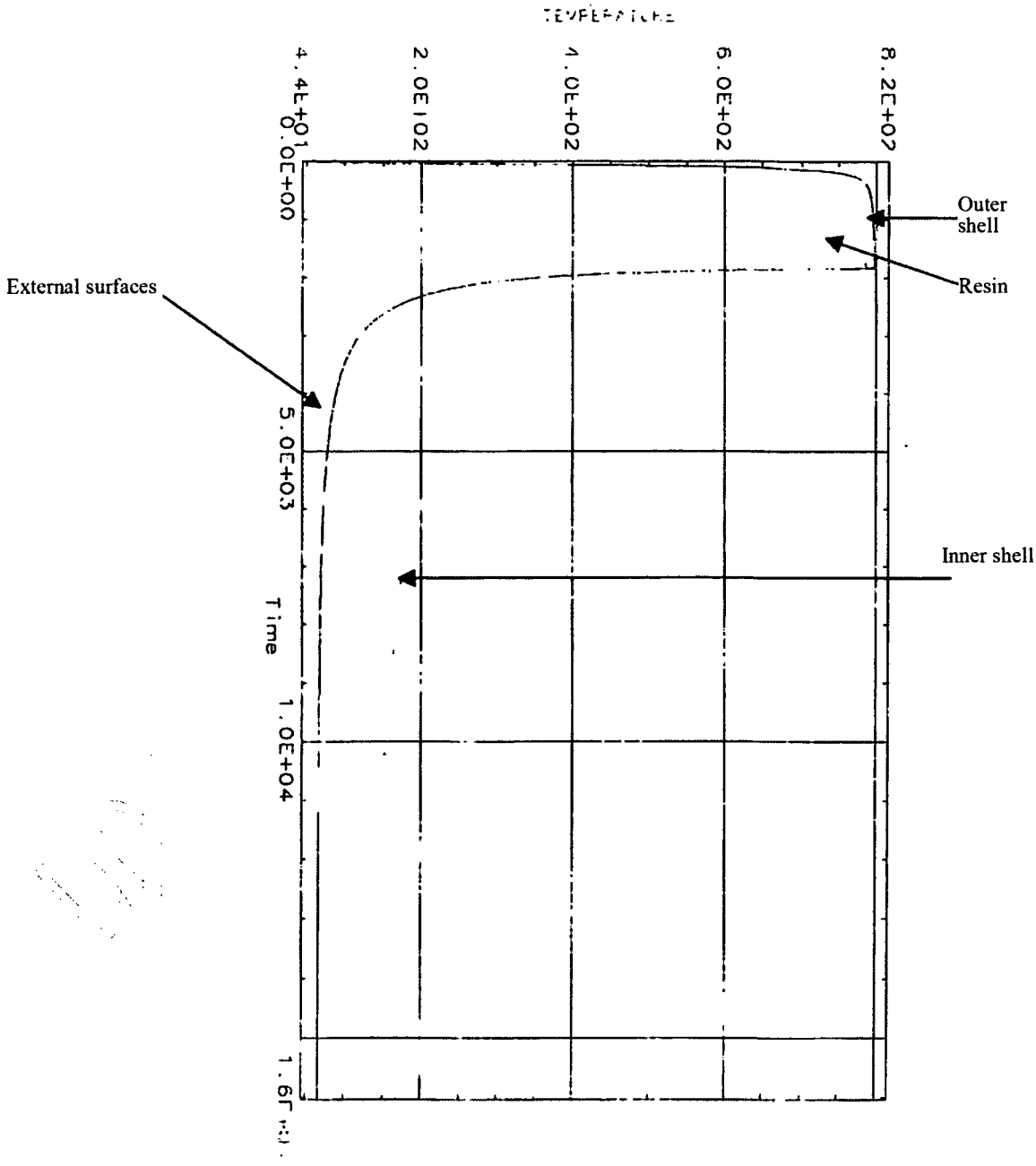
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 3

CONFIGURATION C1.2

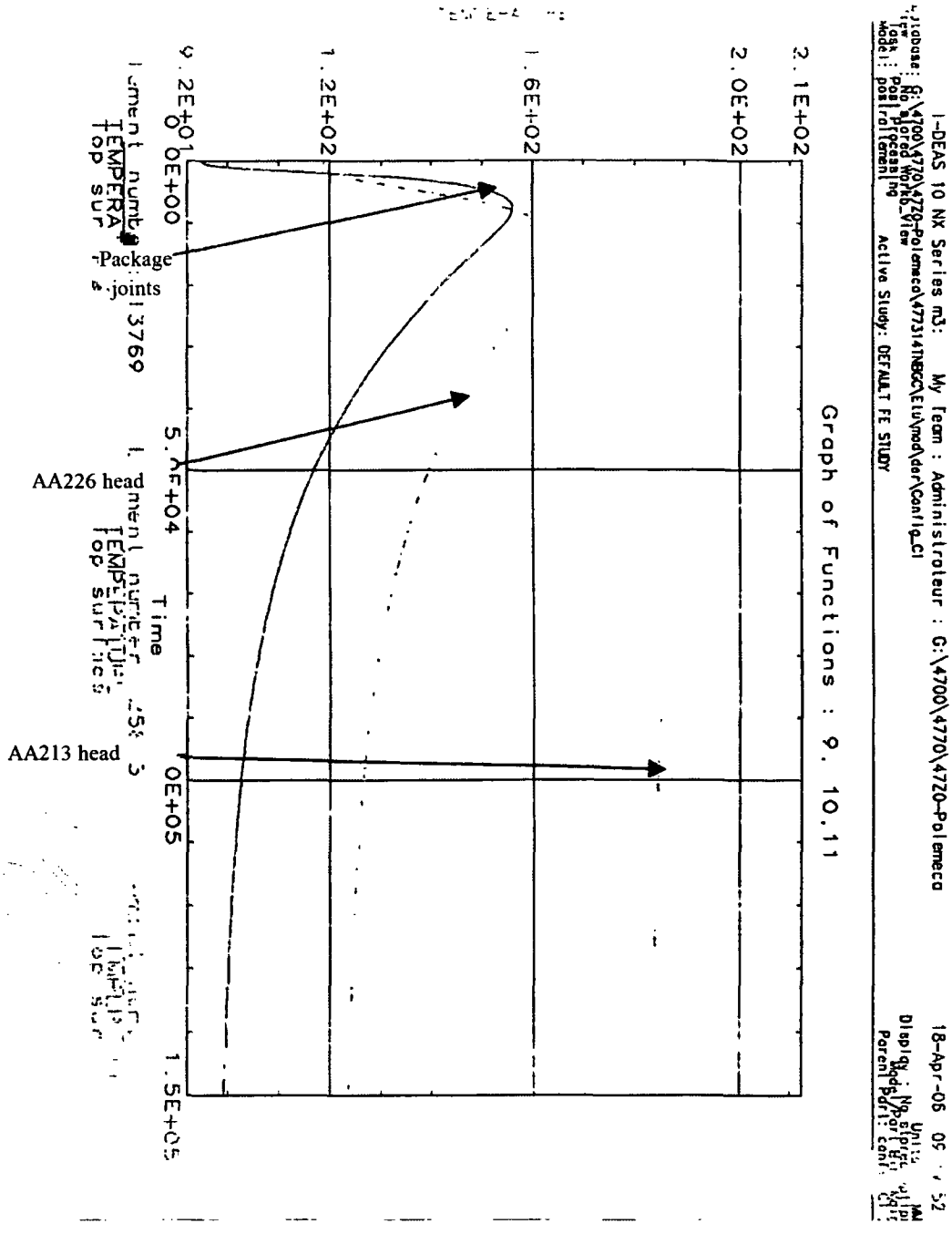
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 3

CONFIGURATION C1.2

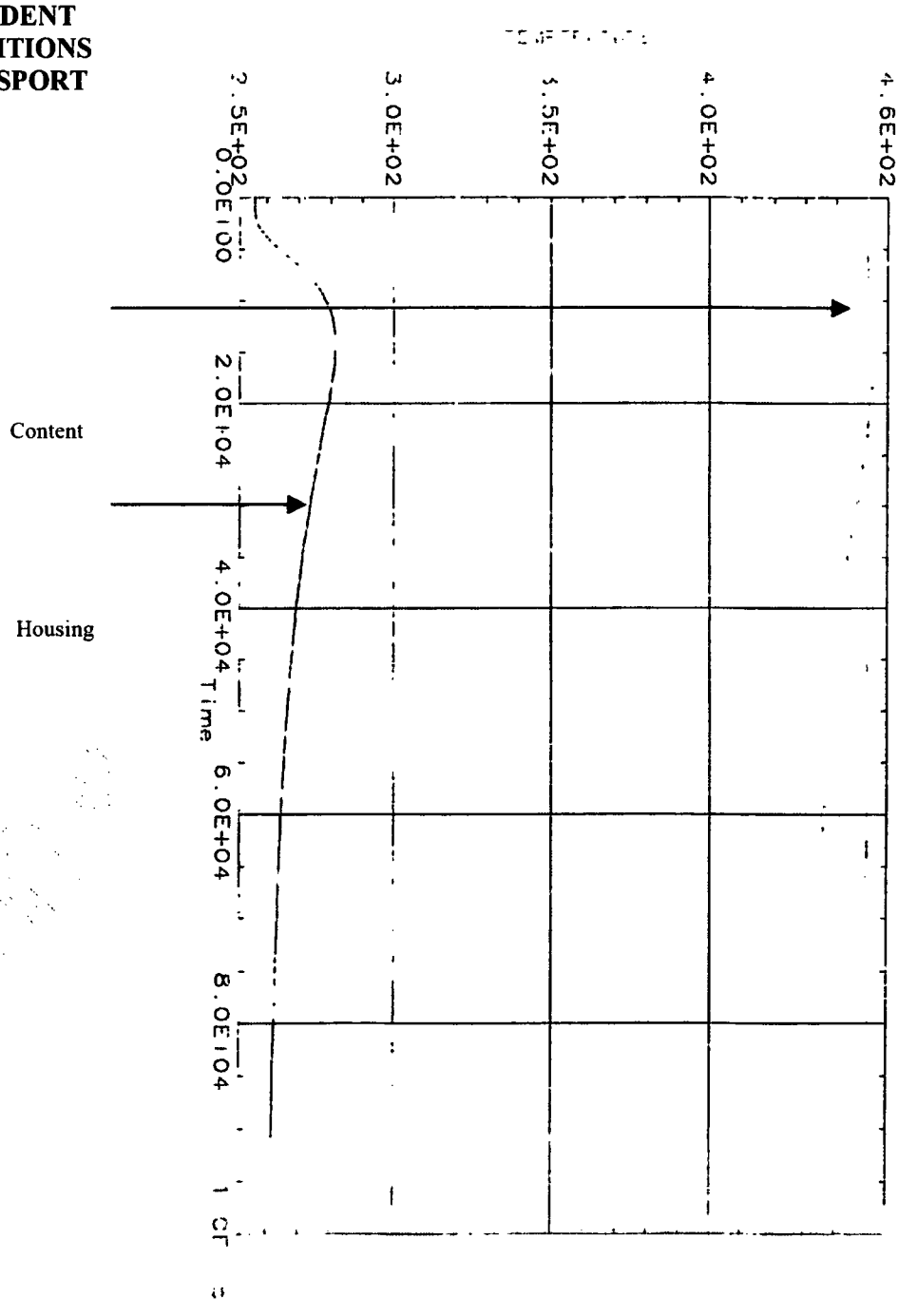
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 3

CONFIGURATION C1.2

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES OF ACCIDENT CONDITIONS TRANSPORT

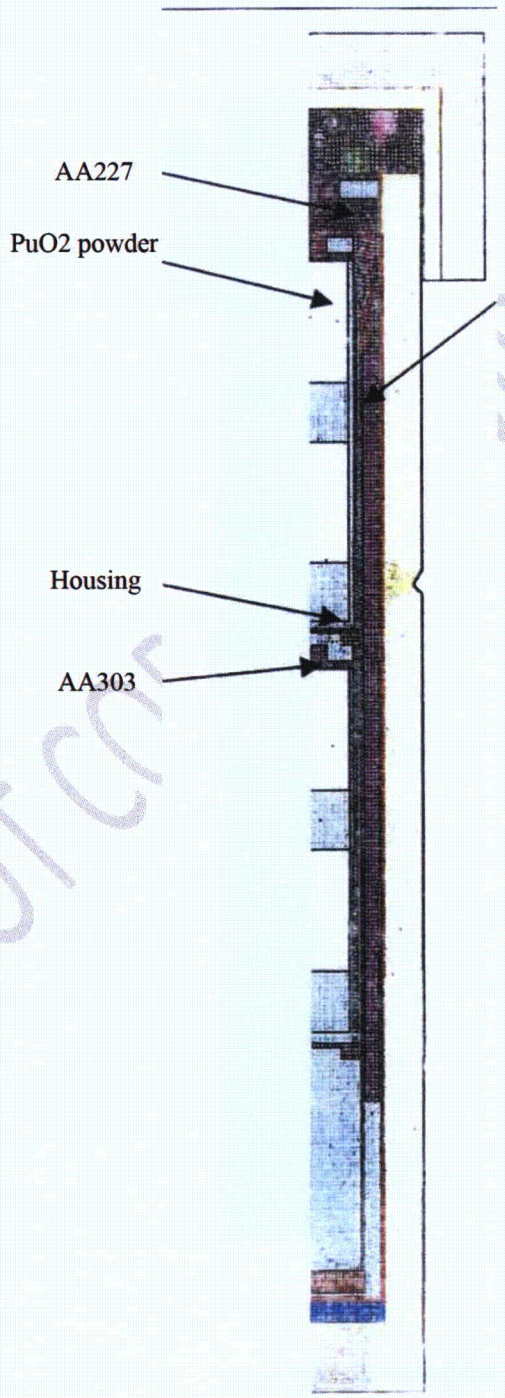


APPENDIX 4
CONFIGURATION C2.1

APPENDIX 4

CONFIGURATION C2.1

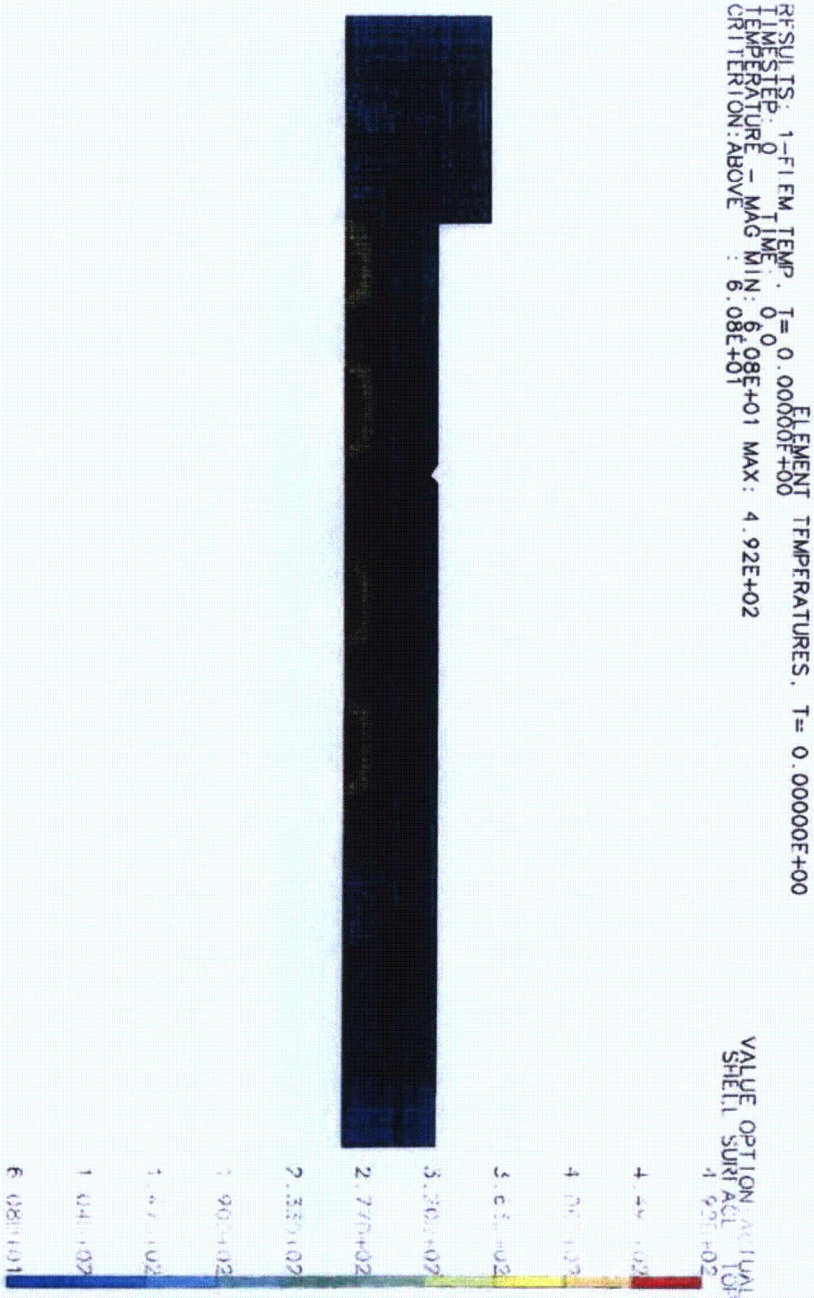
PRESENTATION OF THE MODEL



APPENDIX 4

CONFIGURATION C2.1

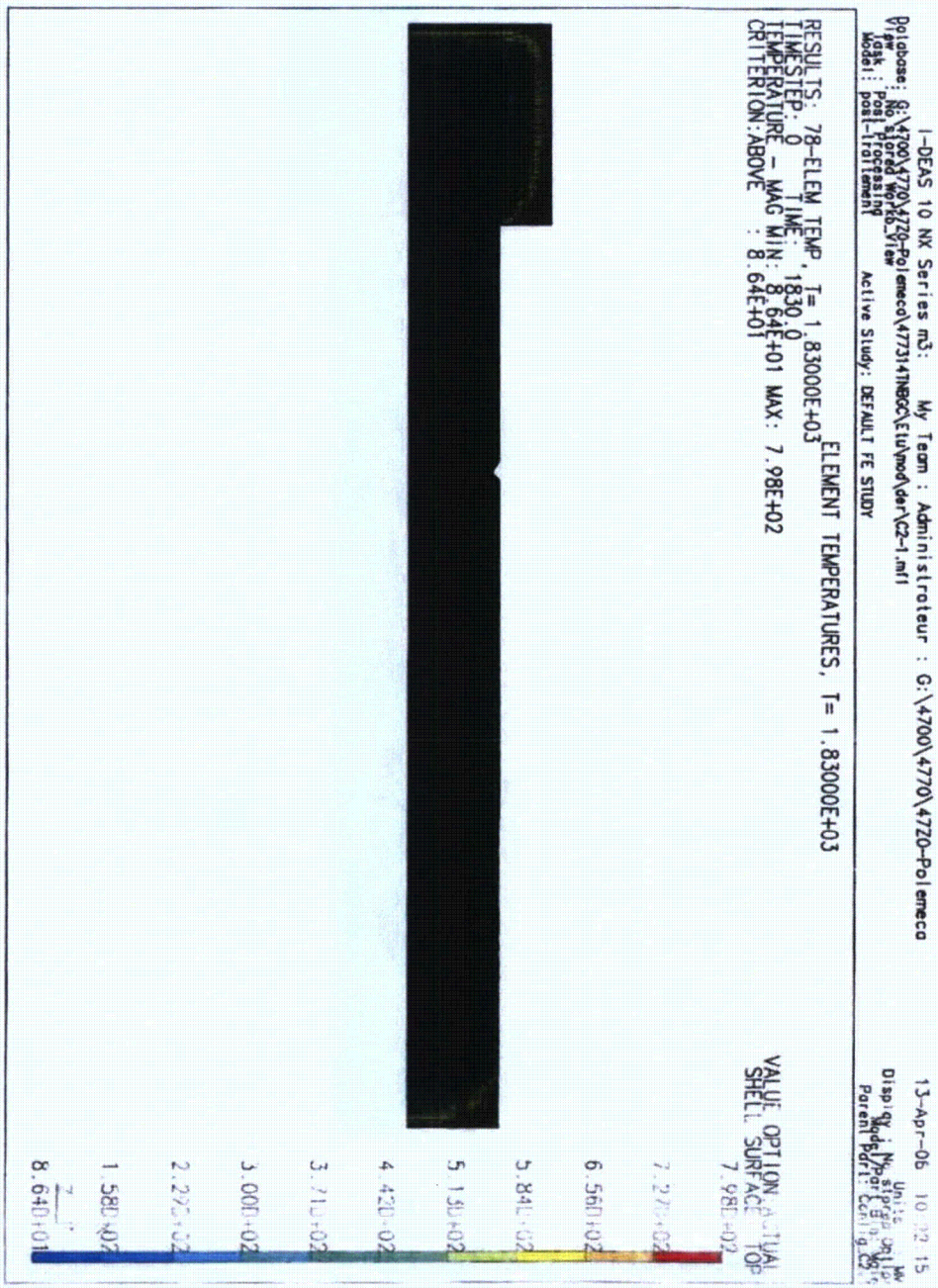
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 4

CONFIGURATION C2.1

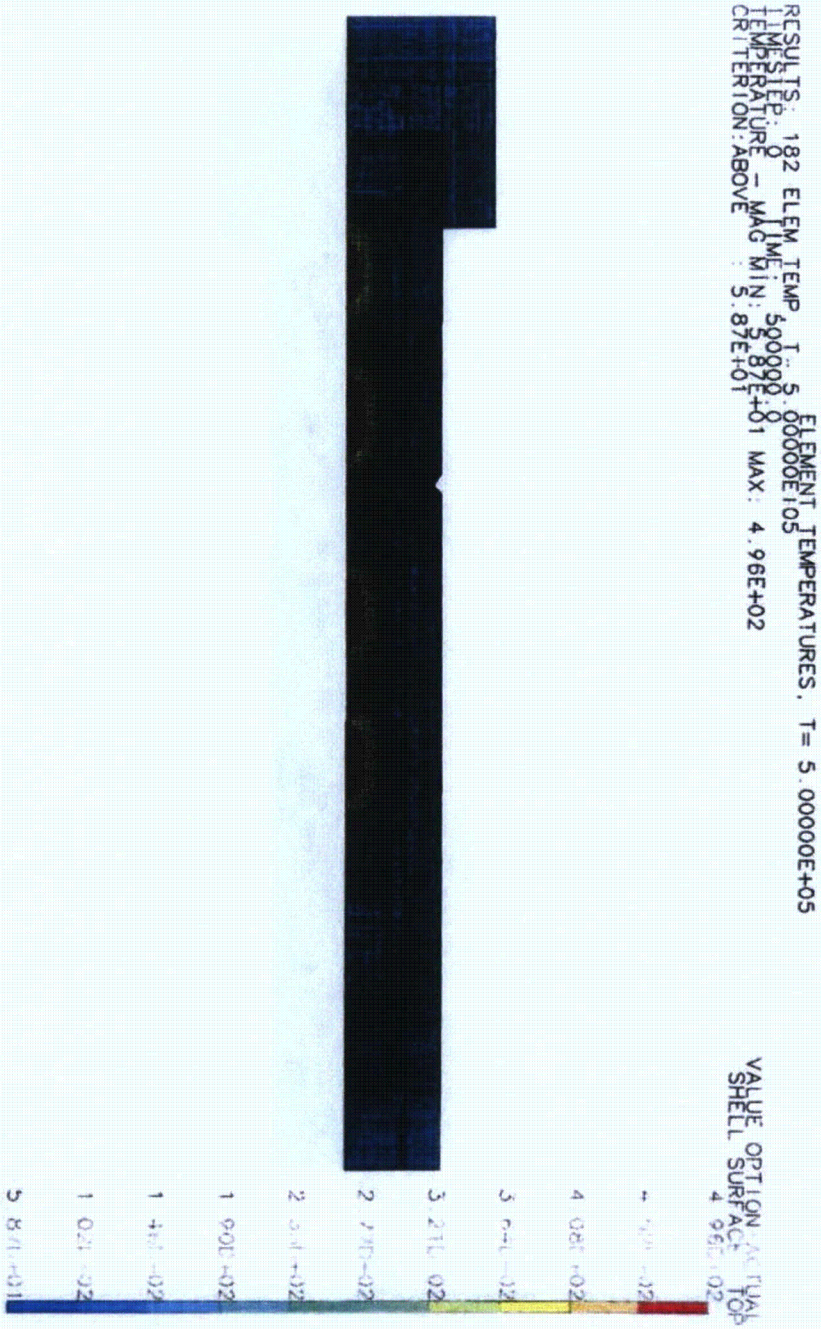
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 4

CONFIGURATION C2.1

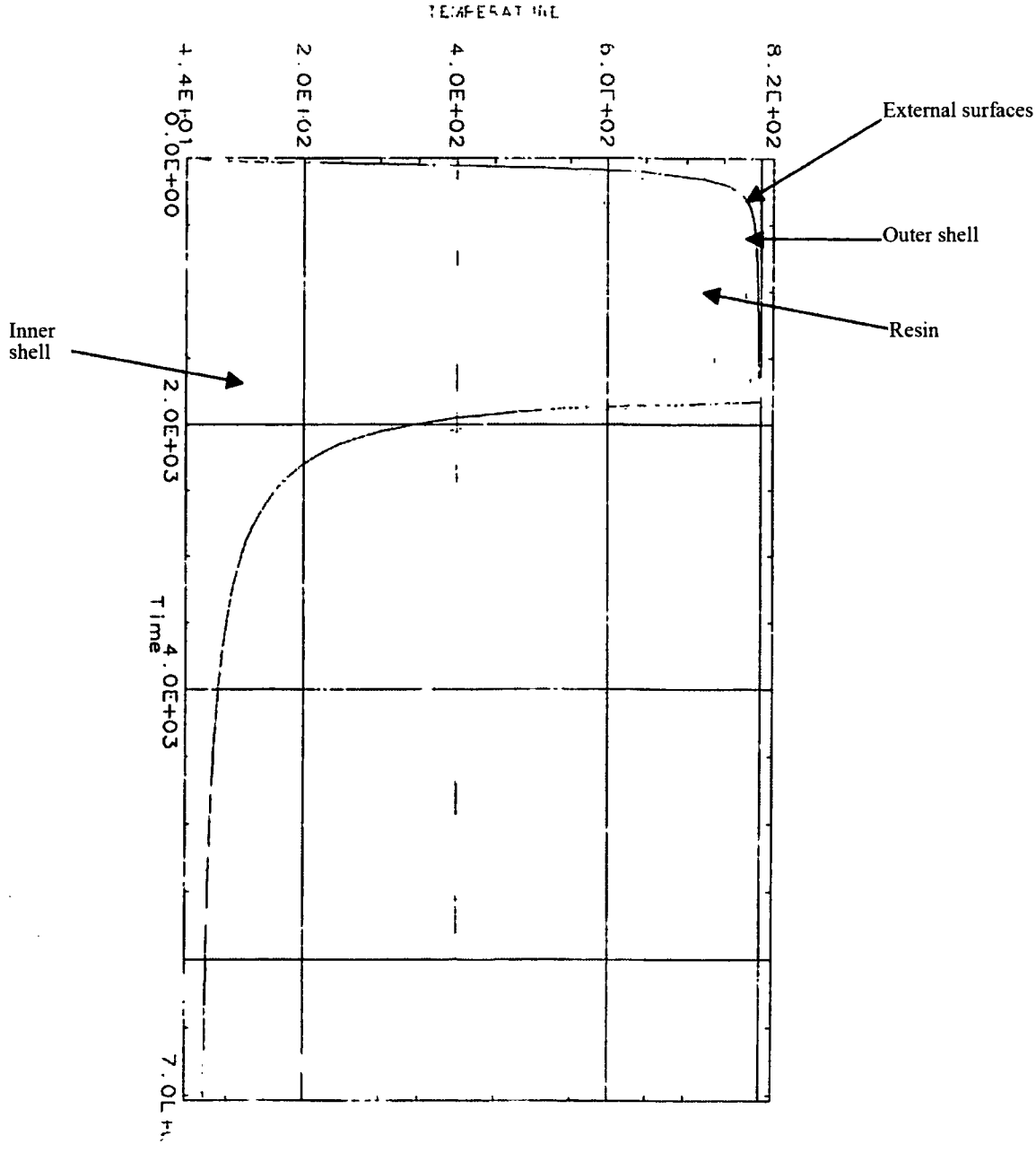
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 4

CONFIGURATION C2.1

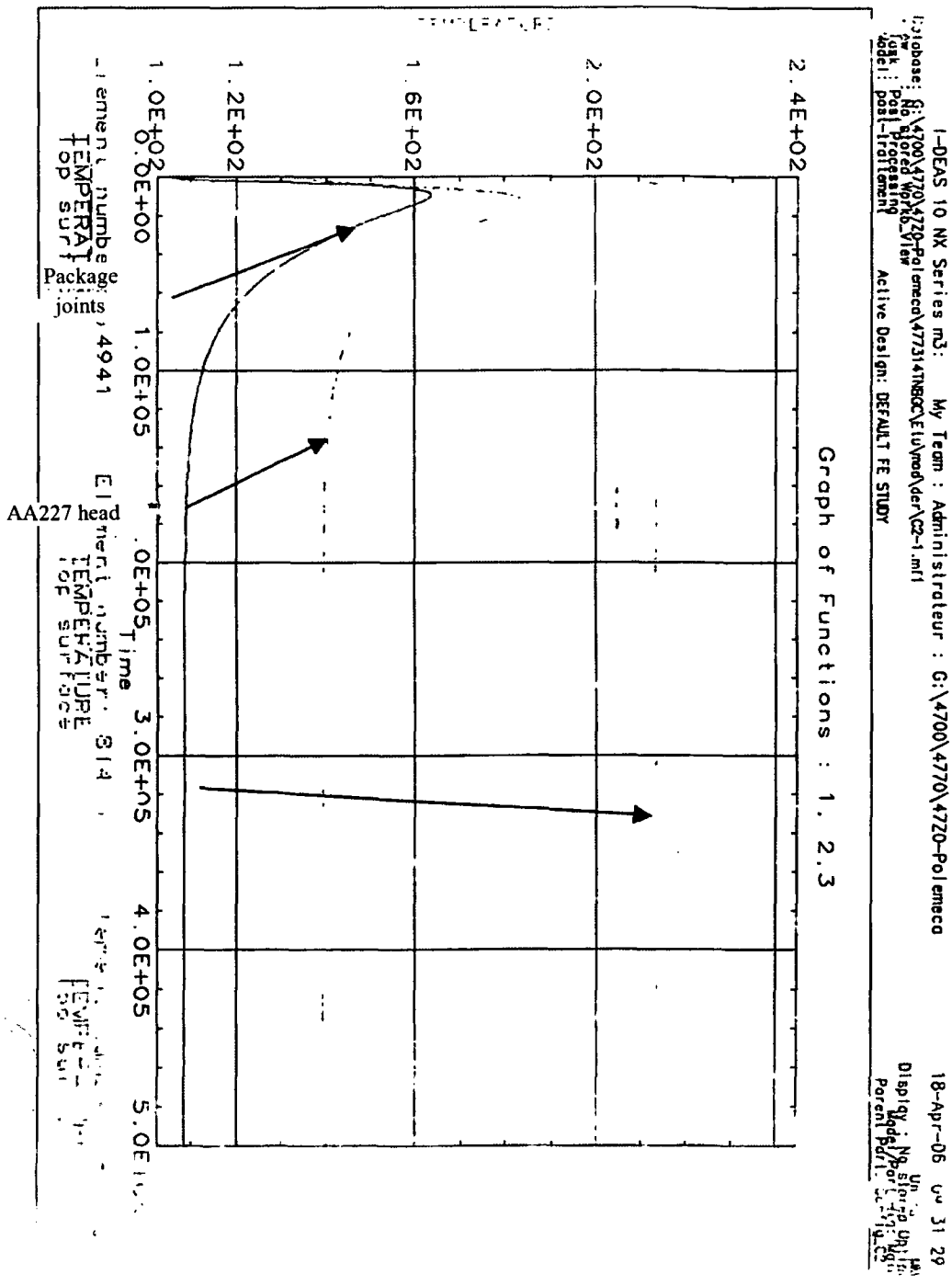
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 4

CONFIGURATION C2.1

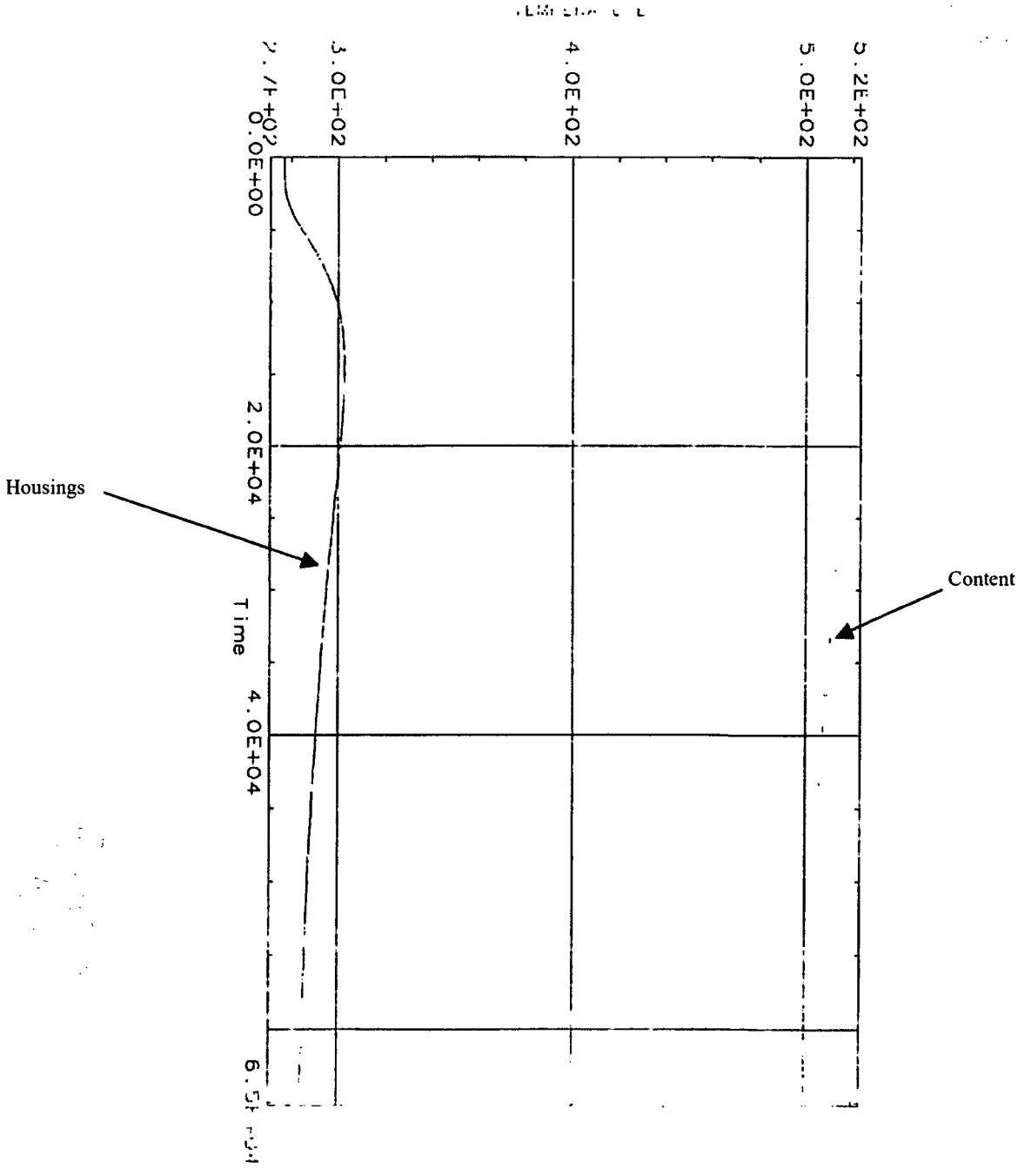
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 4

CONFIGURATION C2.1

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



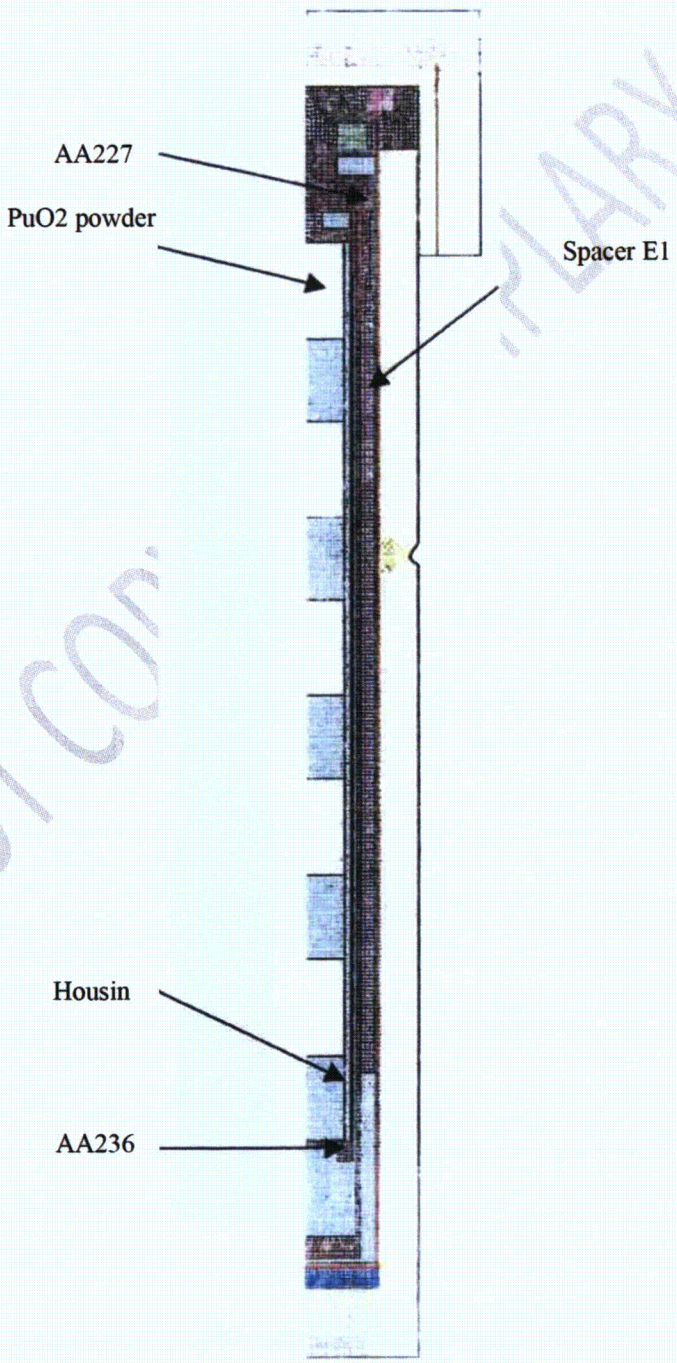
APPENDIX 5

CONFIGURATION C2.2

APPENDIX 5

CONFIGURATION C2.2

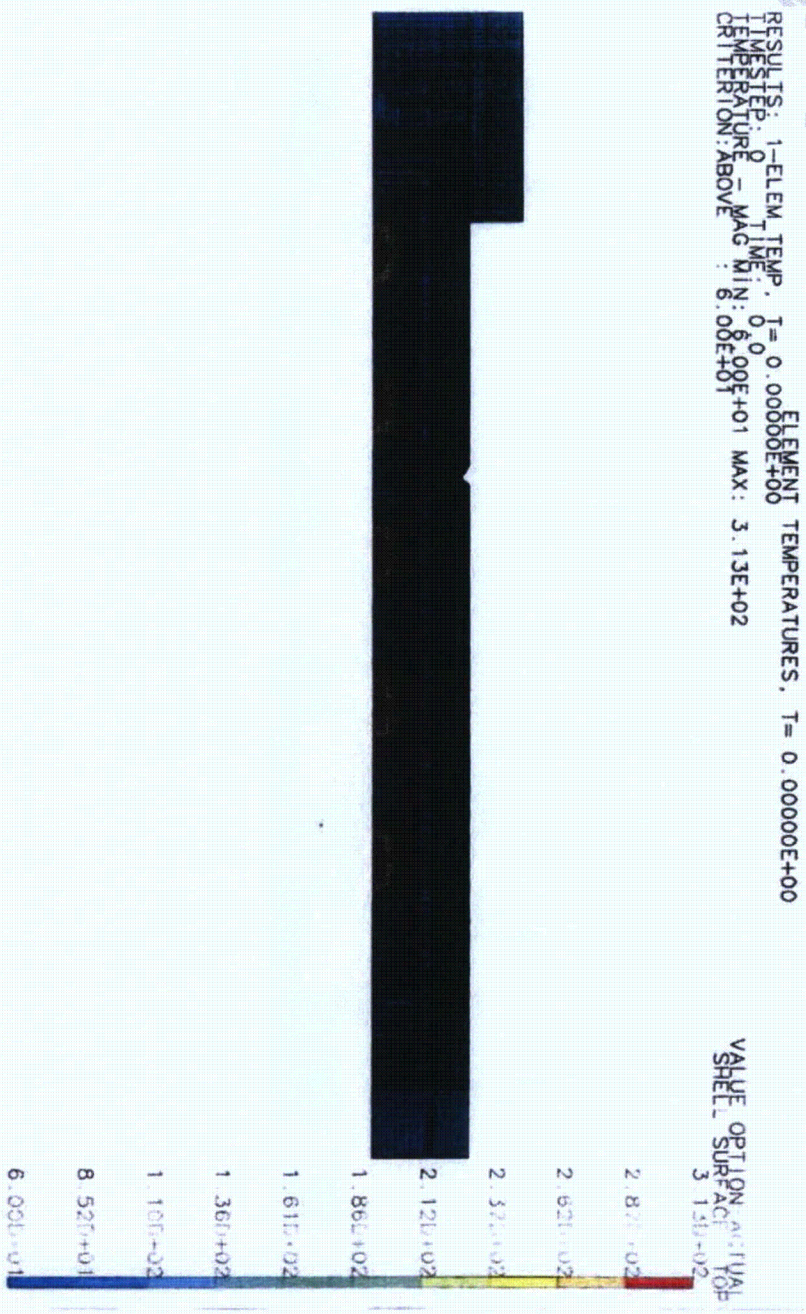
PRESENTATION OF THE MODEL



APPENDIX 5

CONFIGURATION C2.2

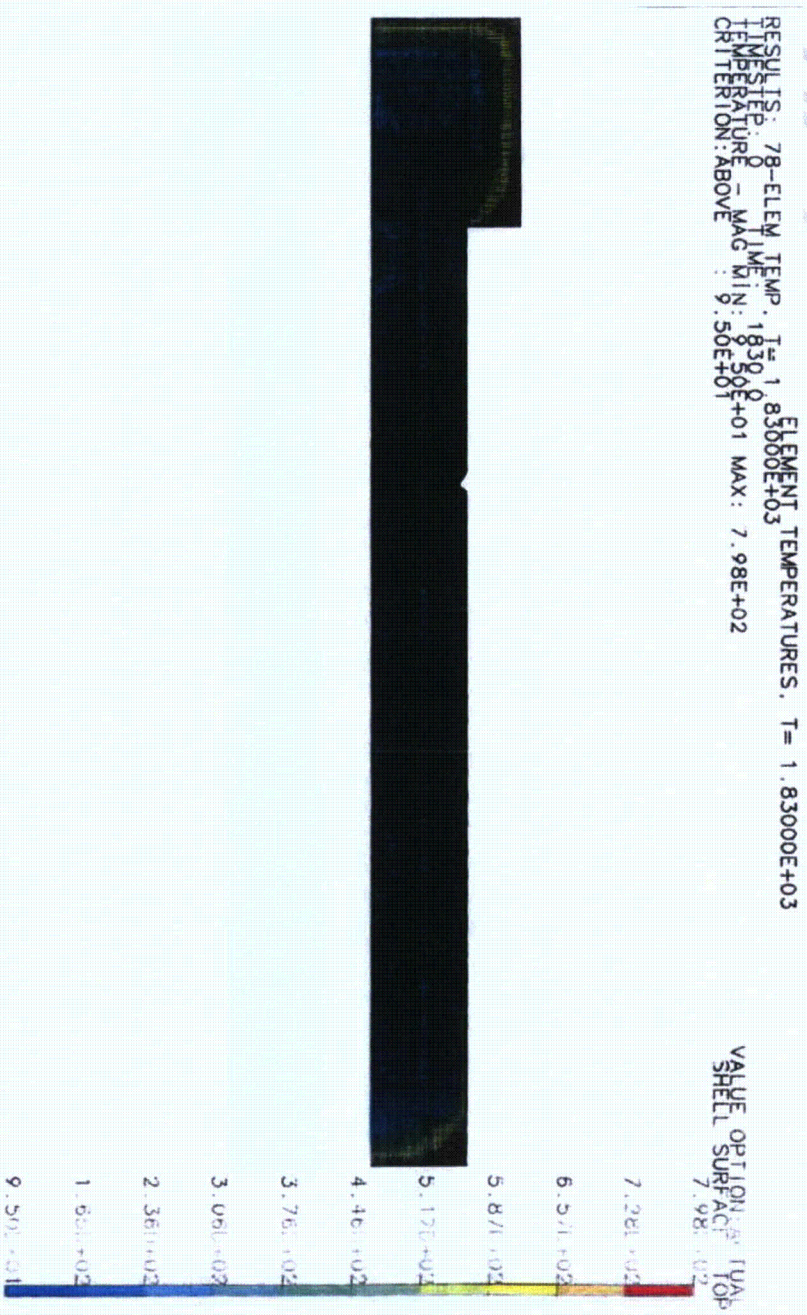
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 5

CONFIGURATION C2.2

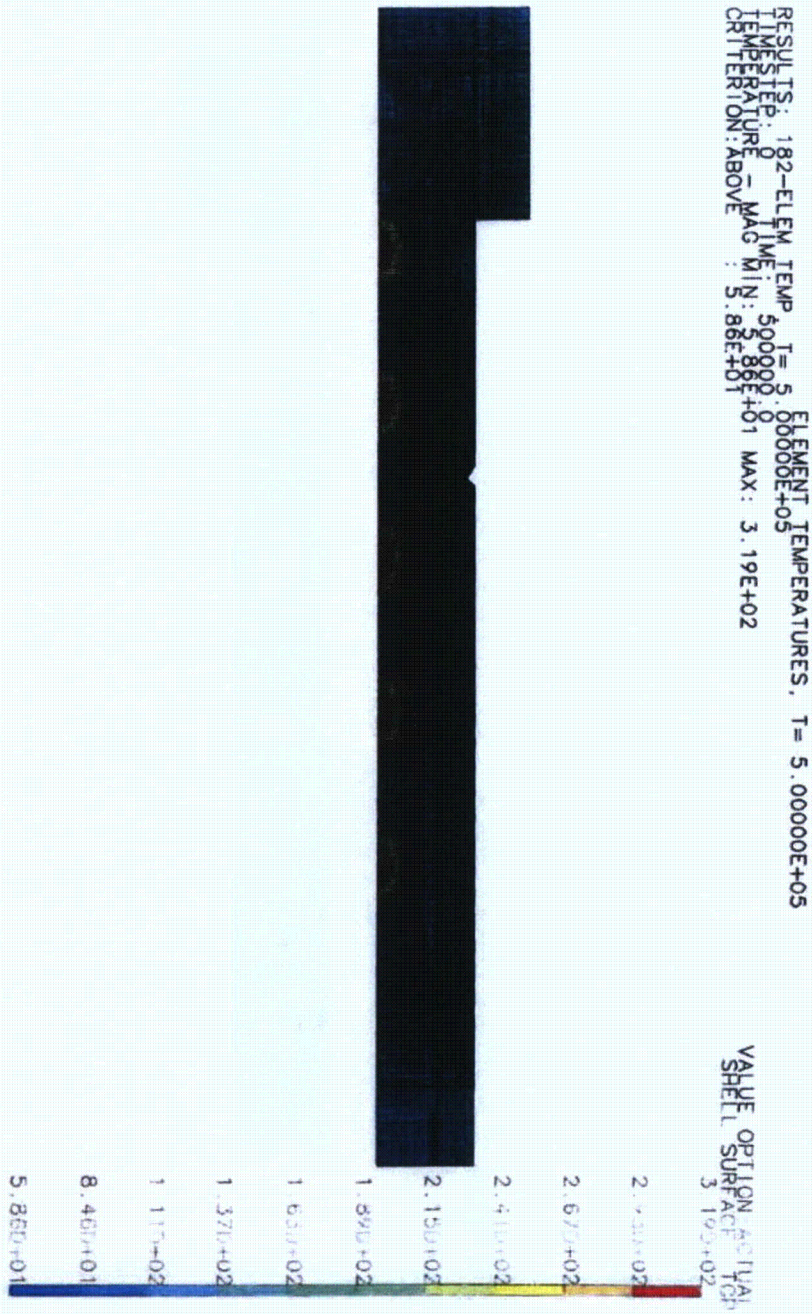
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 5

CONFIGURATION C2.2

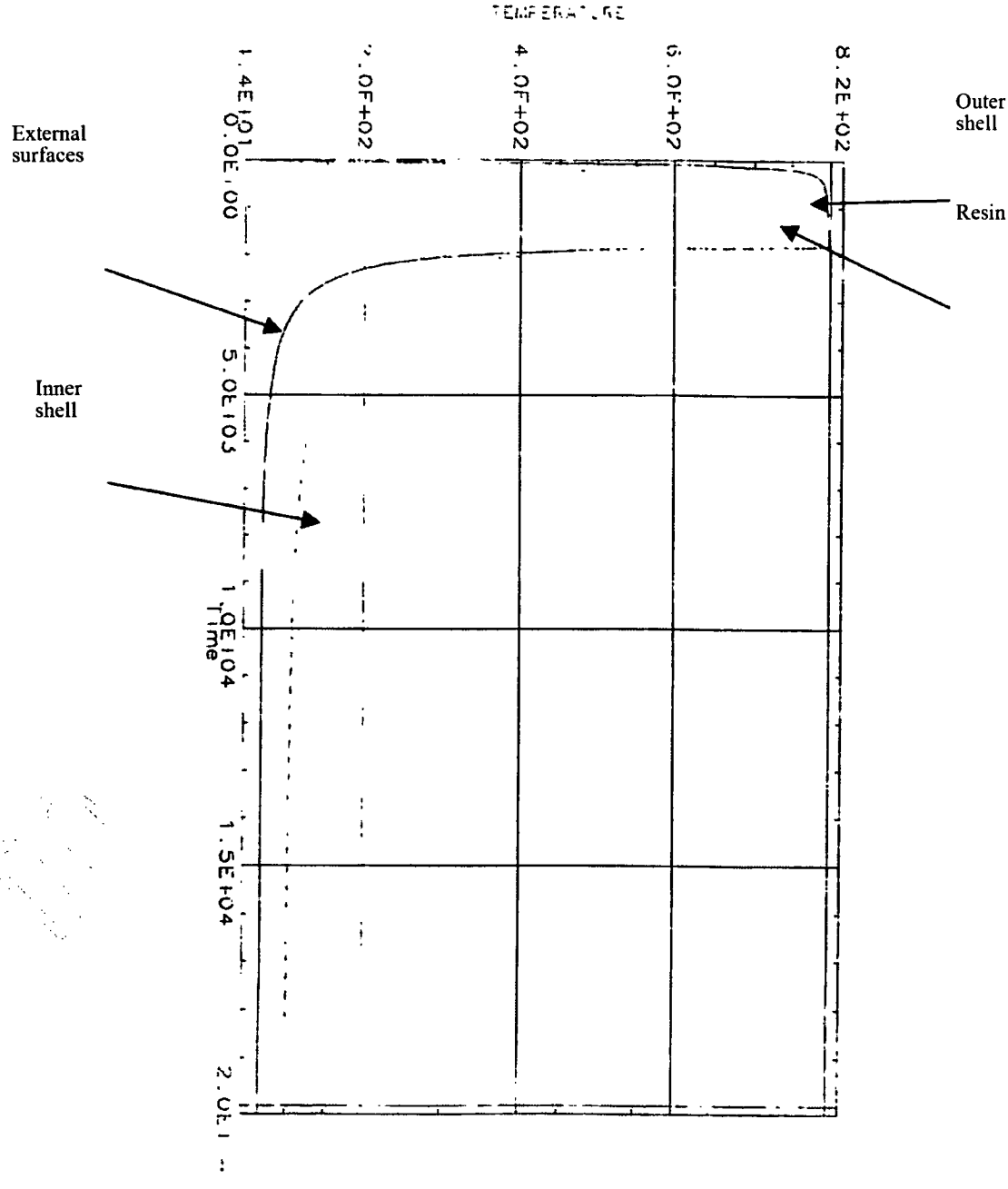
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 5

CONFIGURATION C2.2

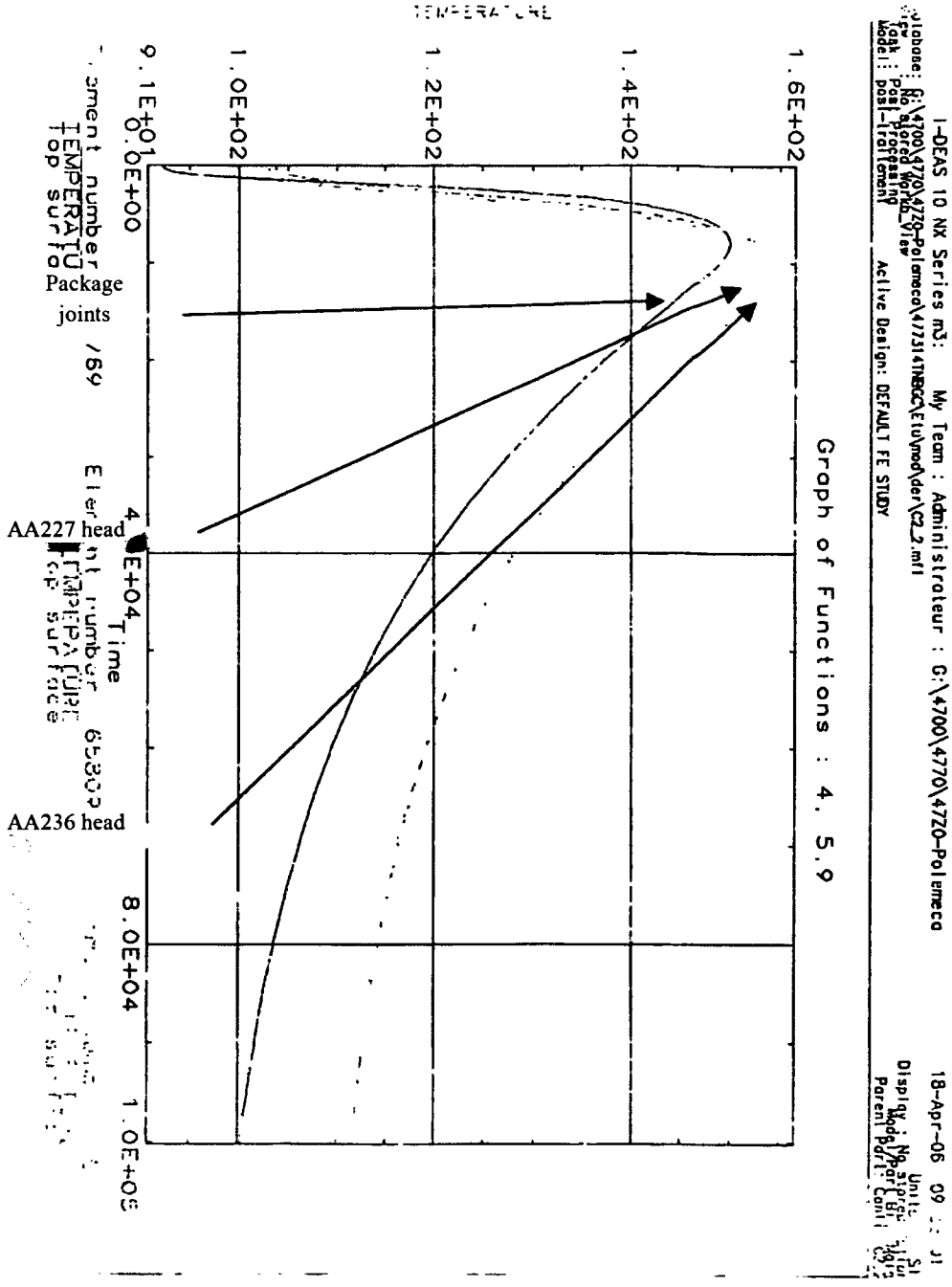
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 5

CONFIGURATION C2.2

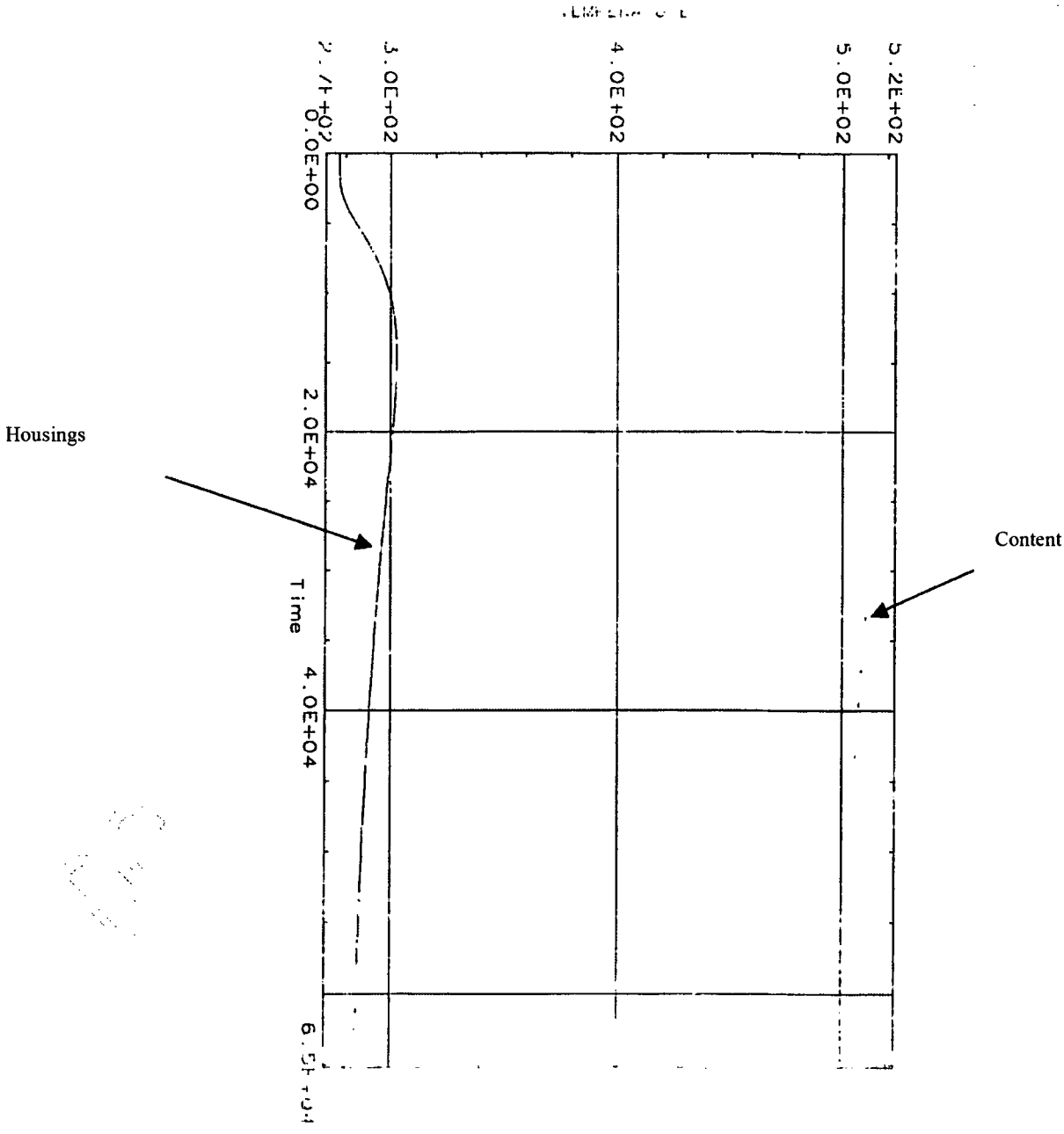
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 5

CONFIGURATION C2.2

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



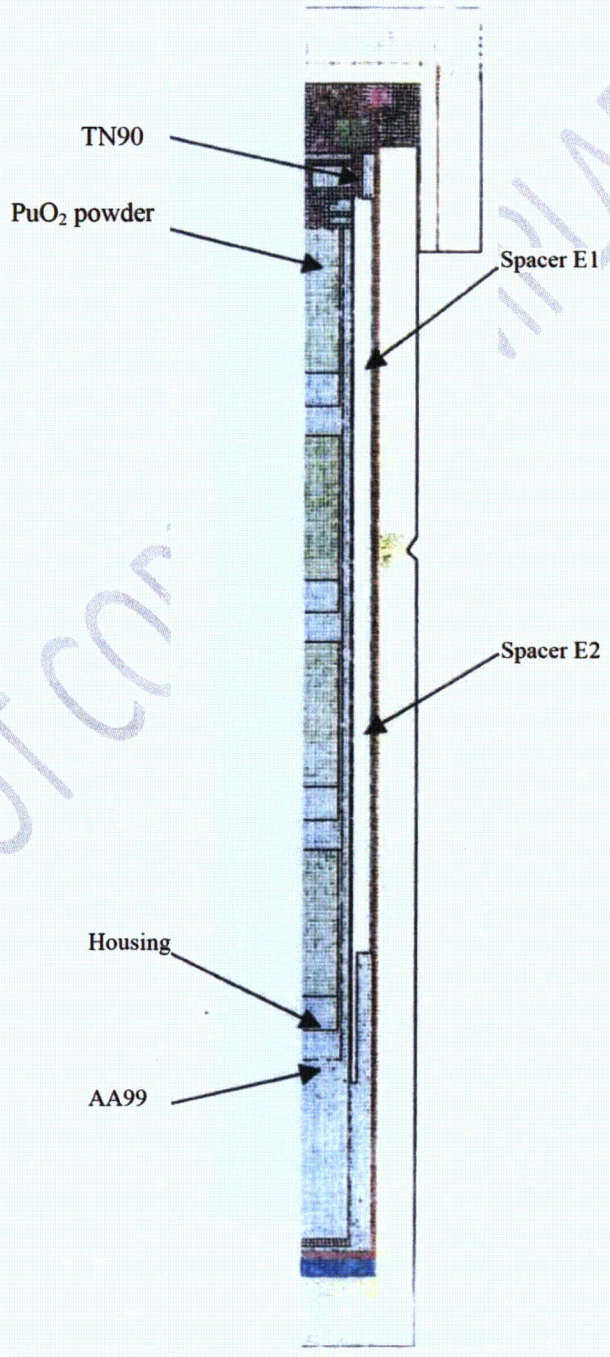
APPENDIX 6

CONFIGURATIONS C3.1 and C3.1 bis

APPENDIX 6

CONFIGURATION C3.1

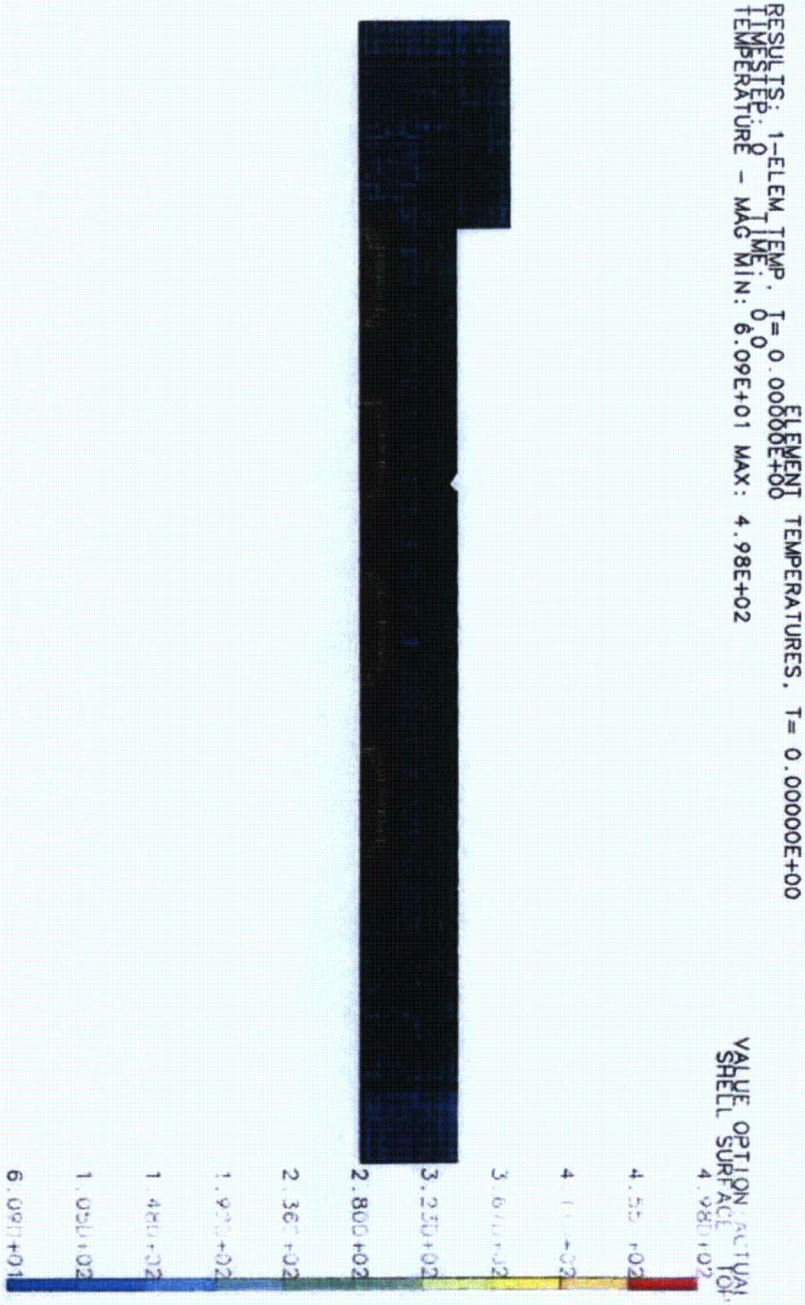
PRESENTATION OF THE MODEL



APPENDIX 6

CONFIGURATION C3.1

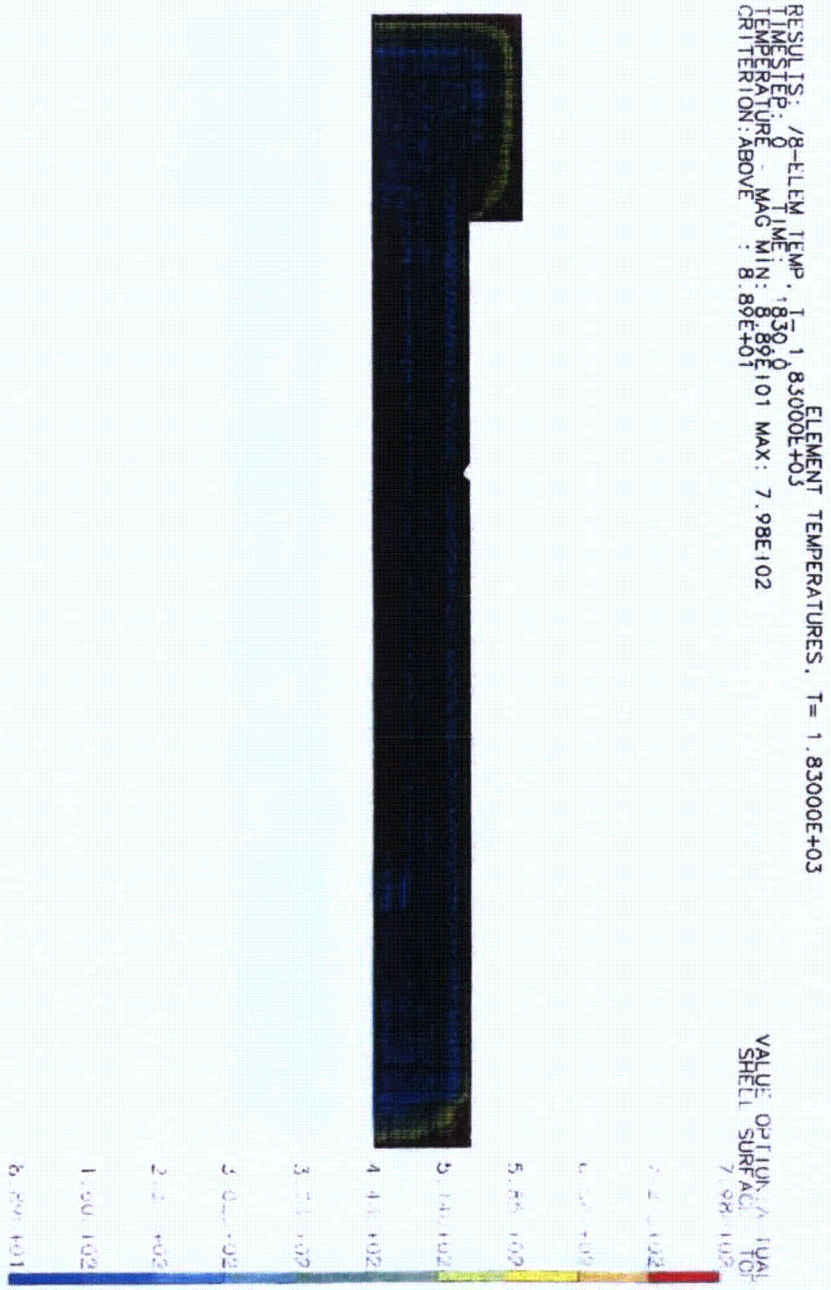
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 6

CONFIGURATION C3.1

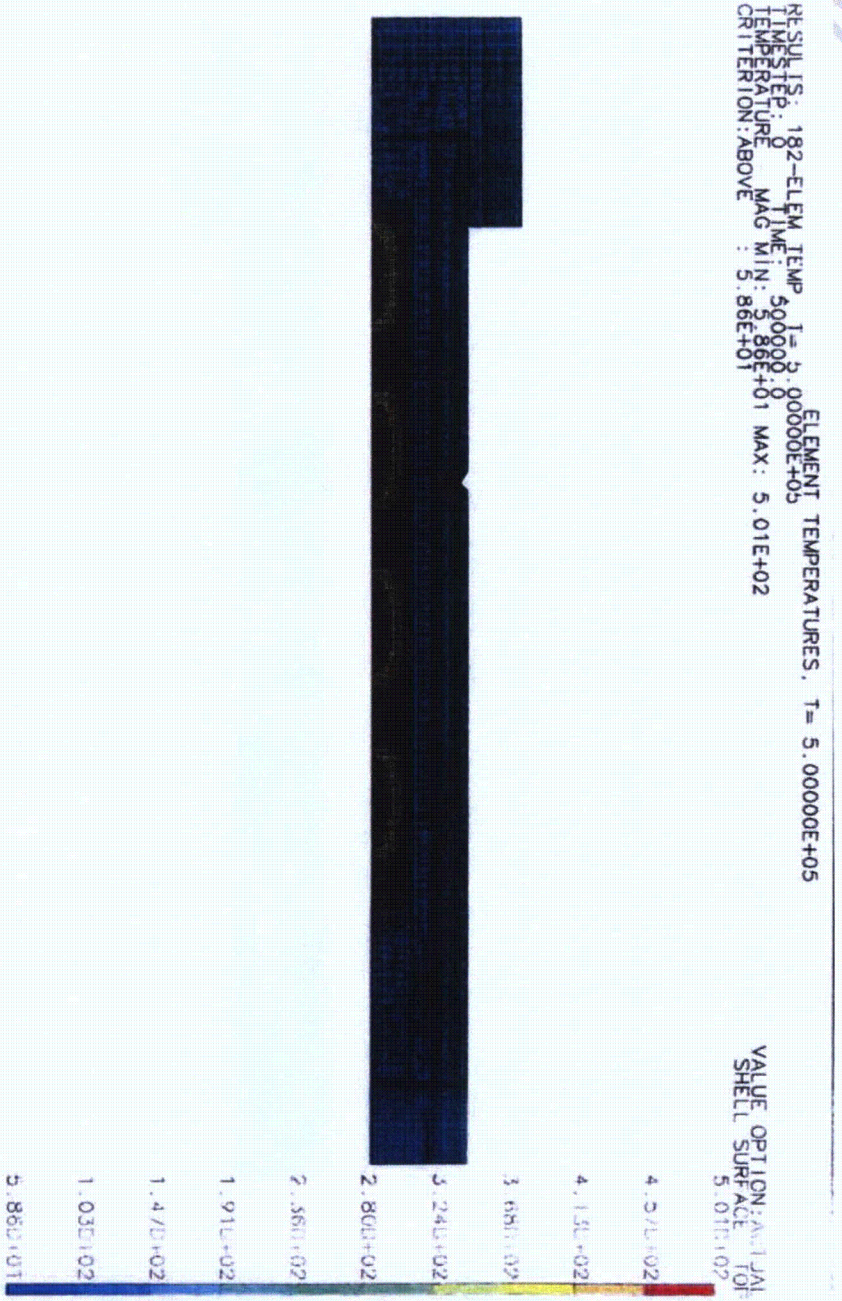
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 6

CONFIGURATION C3.1

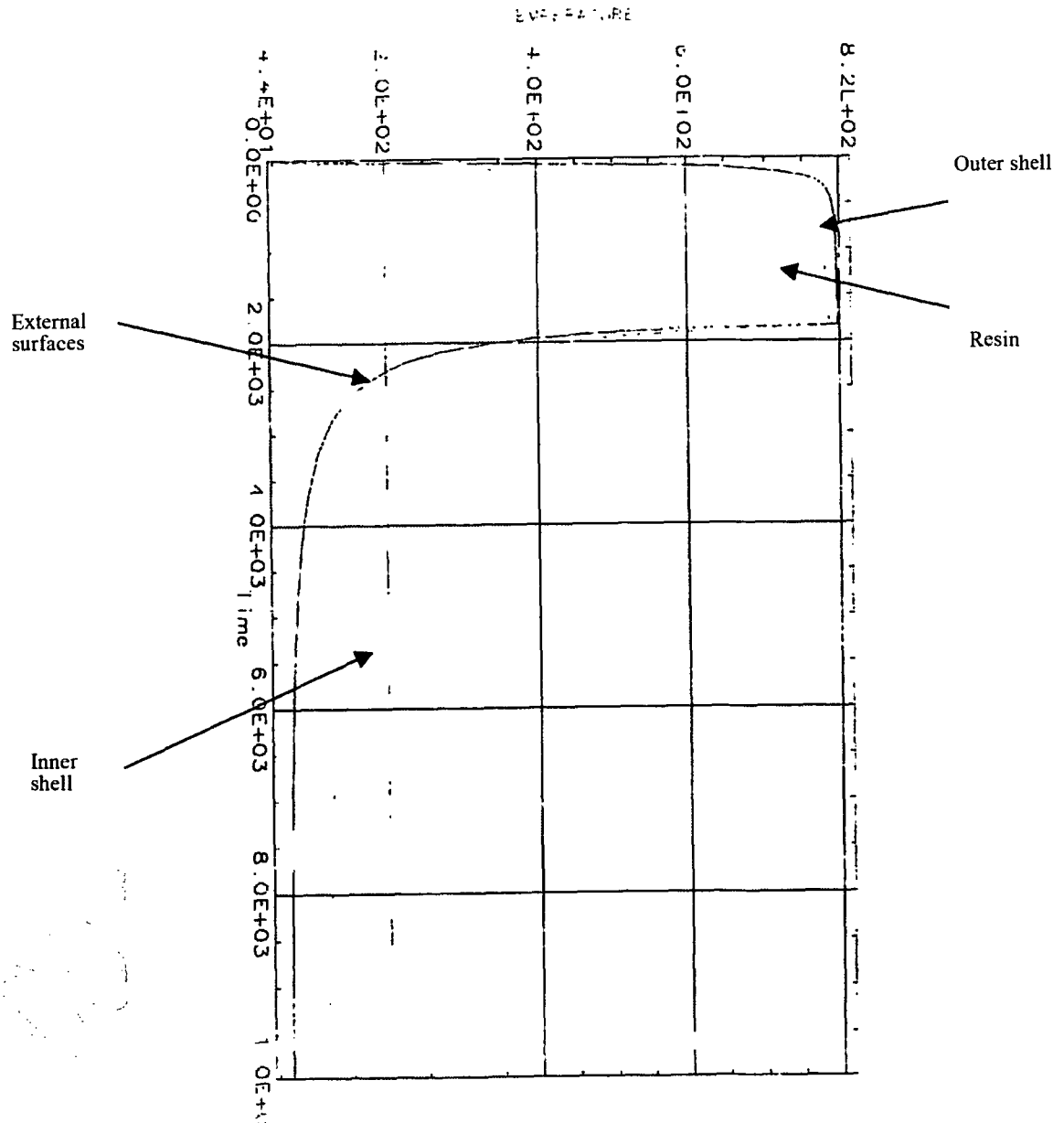
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 6

CONFIGURATION C3.1

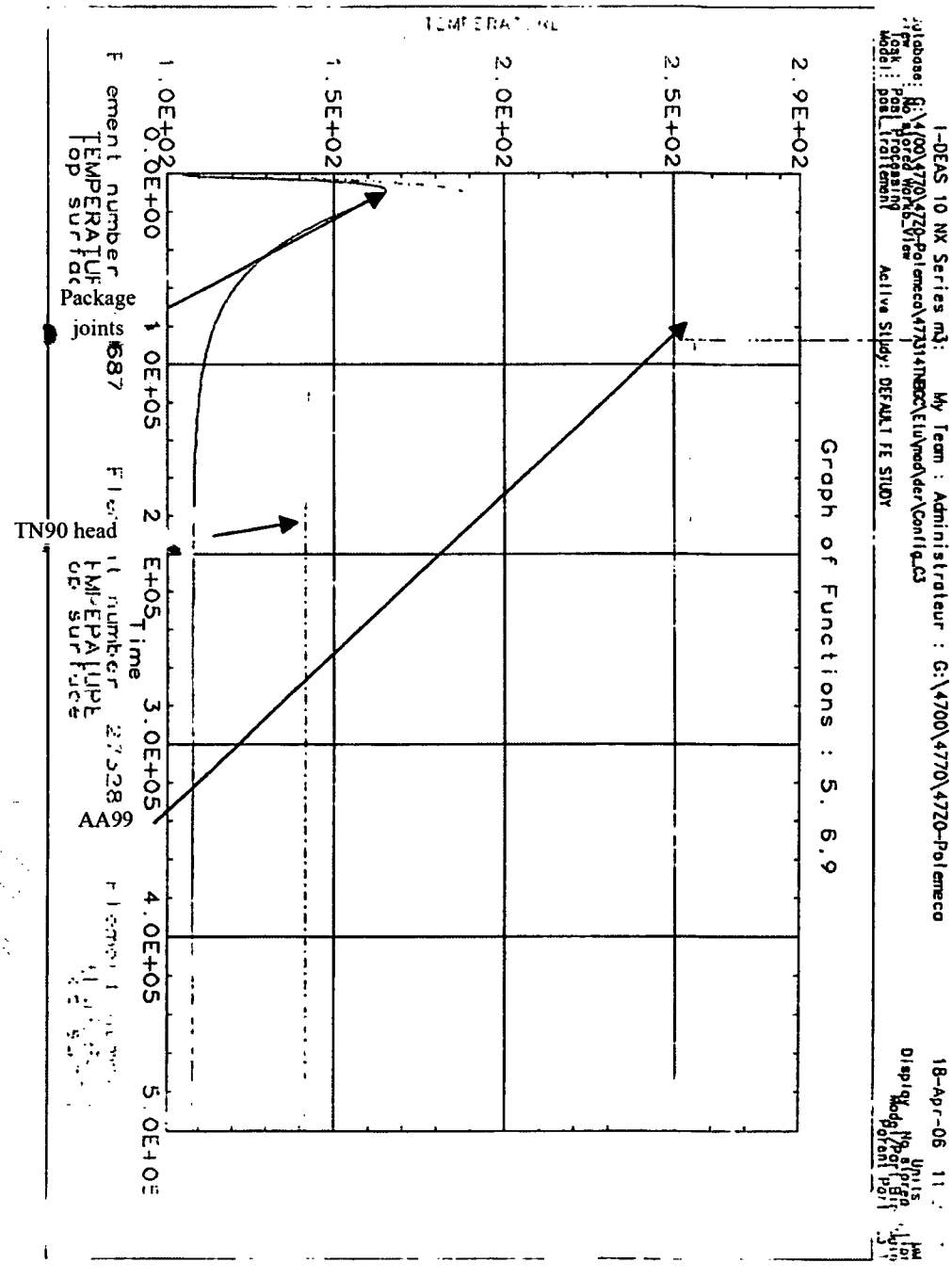
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 6

CONFIGURATION C3.1

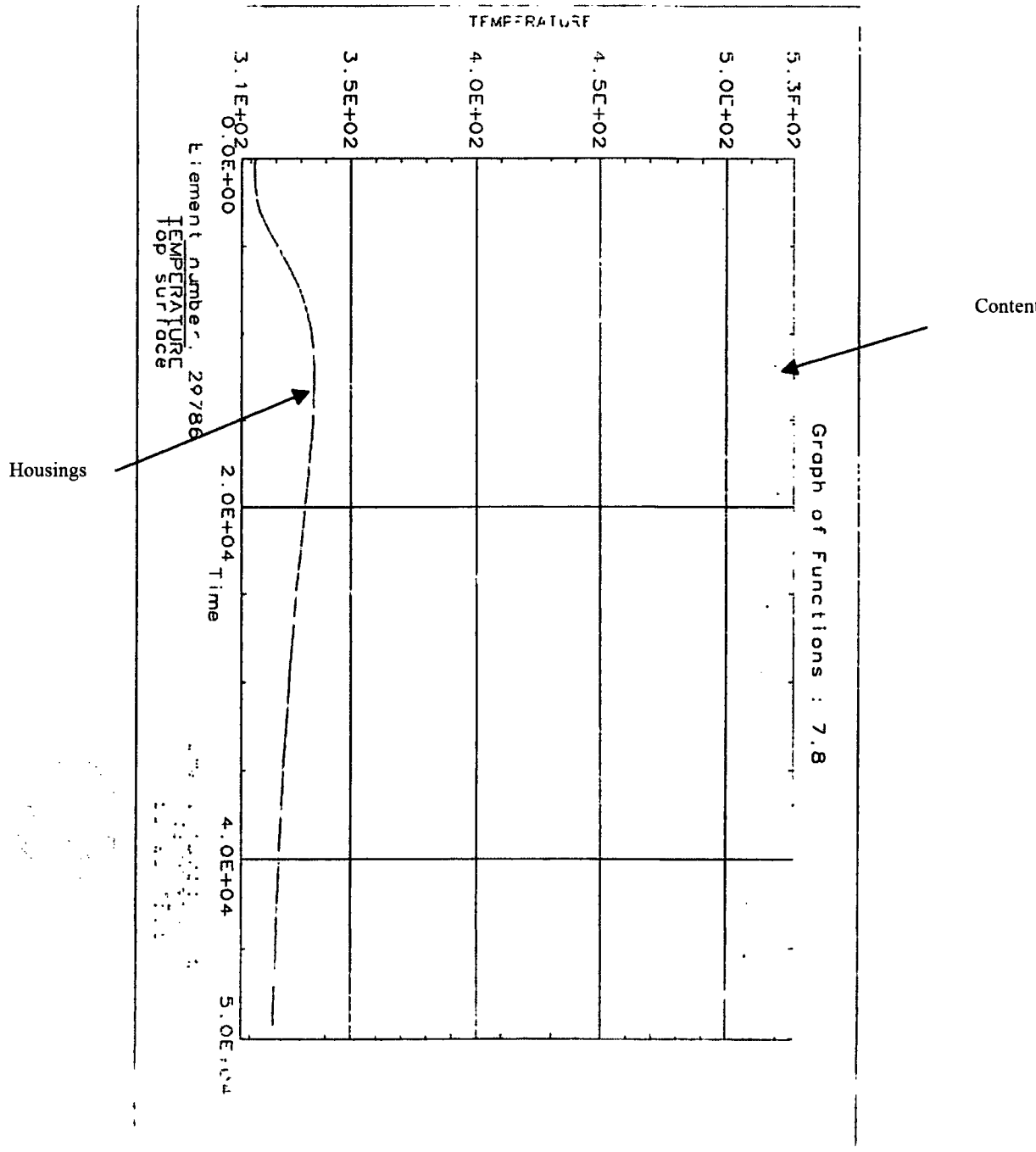
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 6

CONFIGURATION C3.1

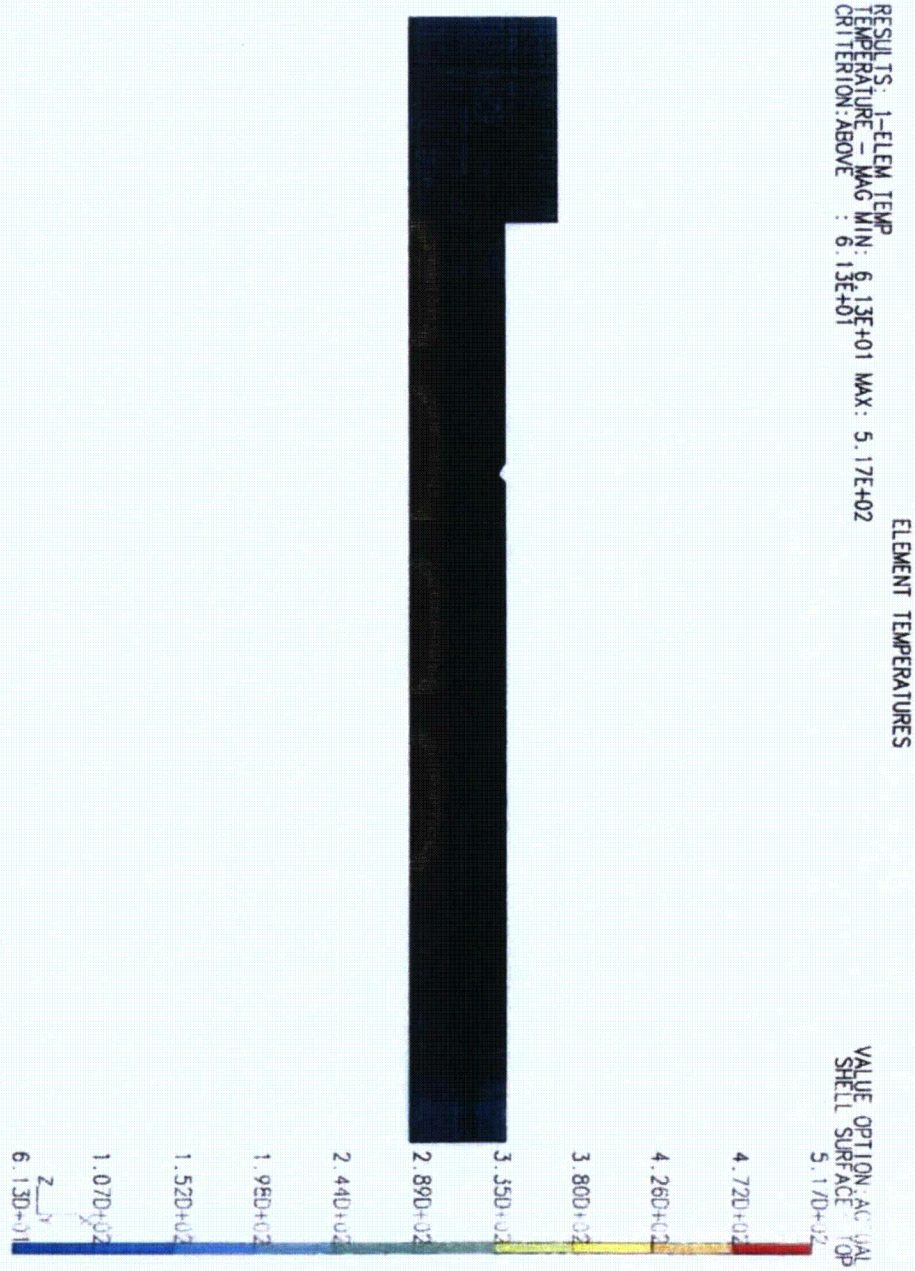
GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 6

CONFIGURATION C3.1bis

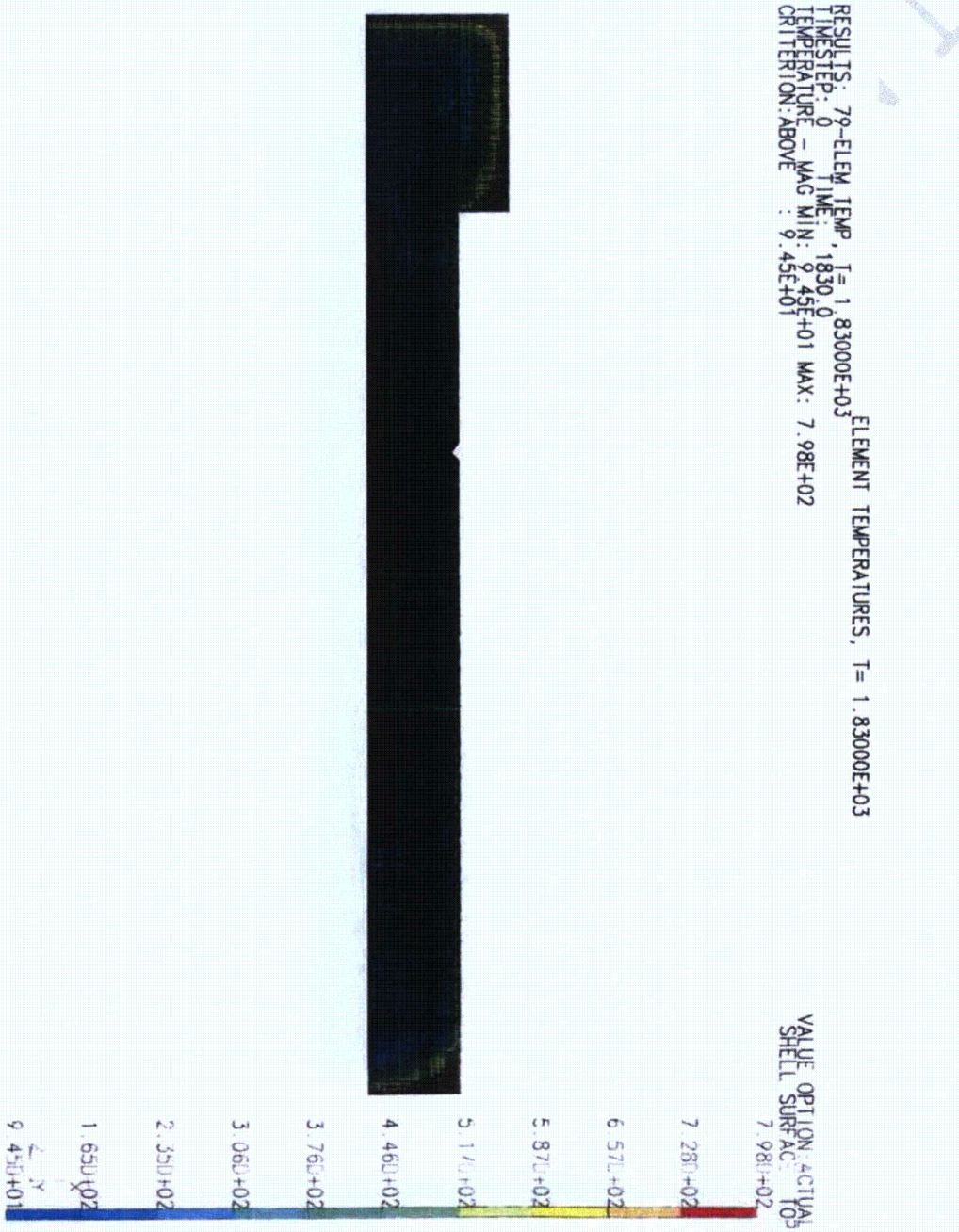
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 6

CONFIGURATION C3.1bis

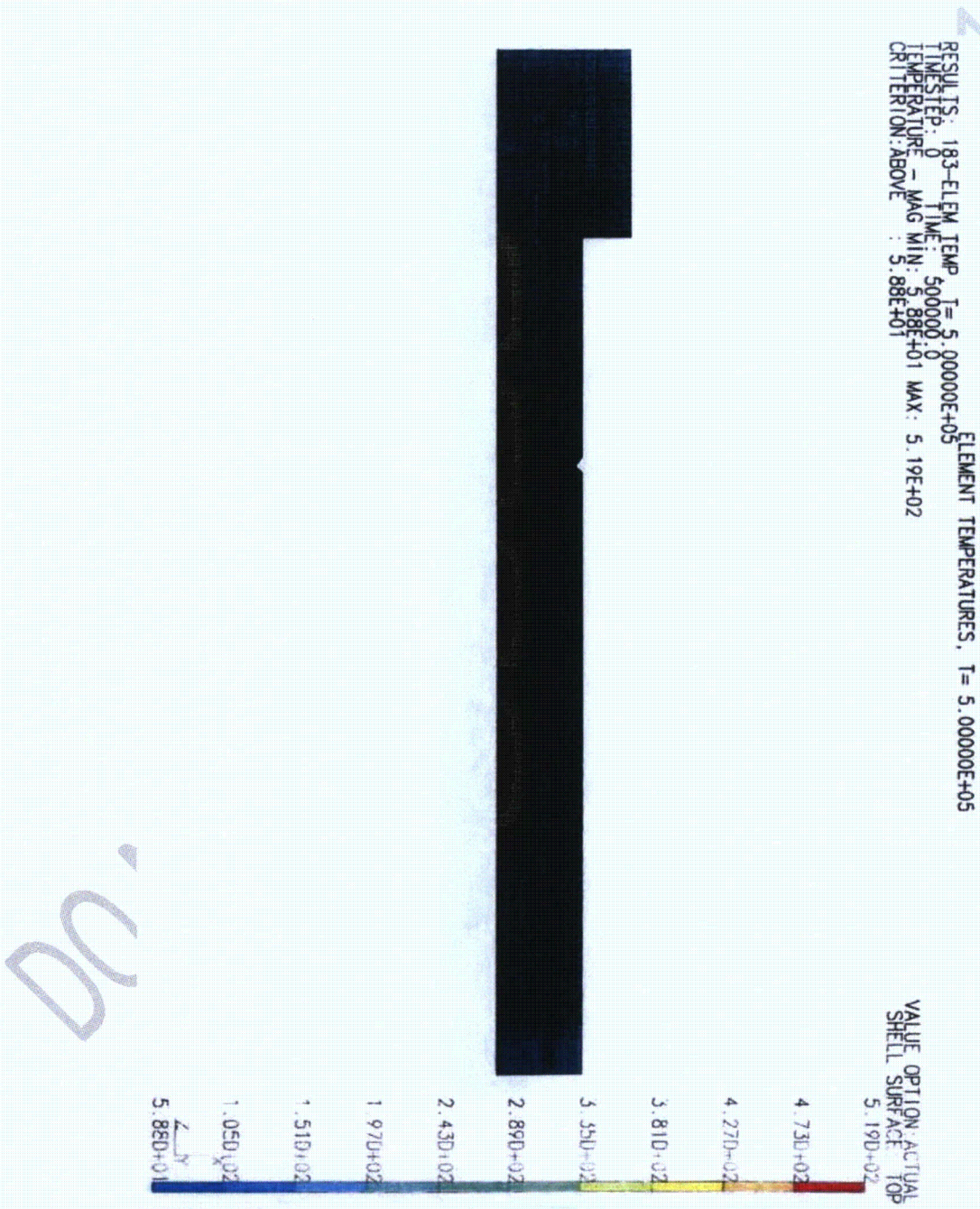
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 6

CONFIGURATION C3.1bis

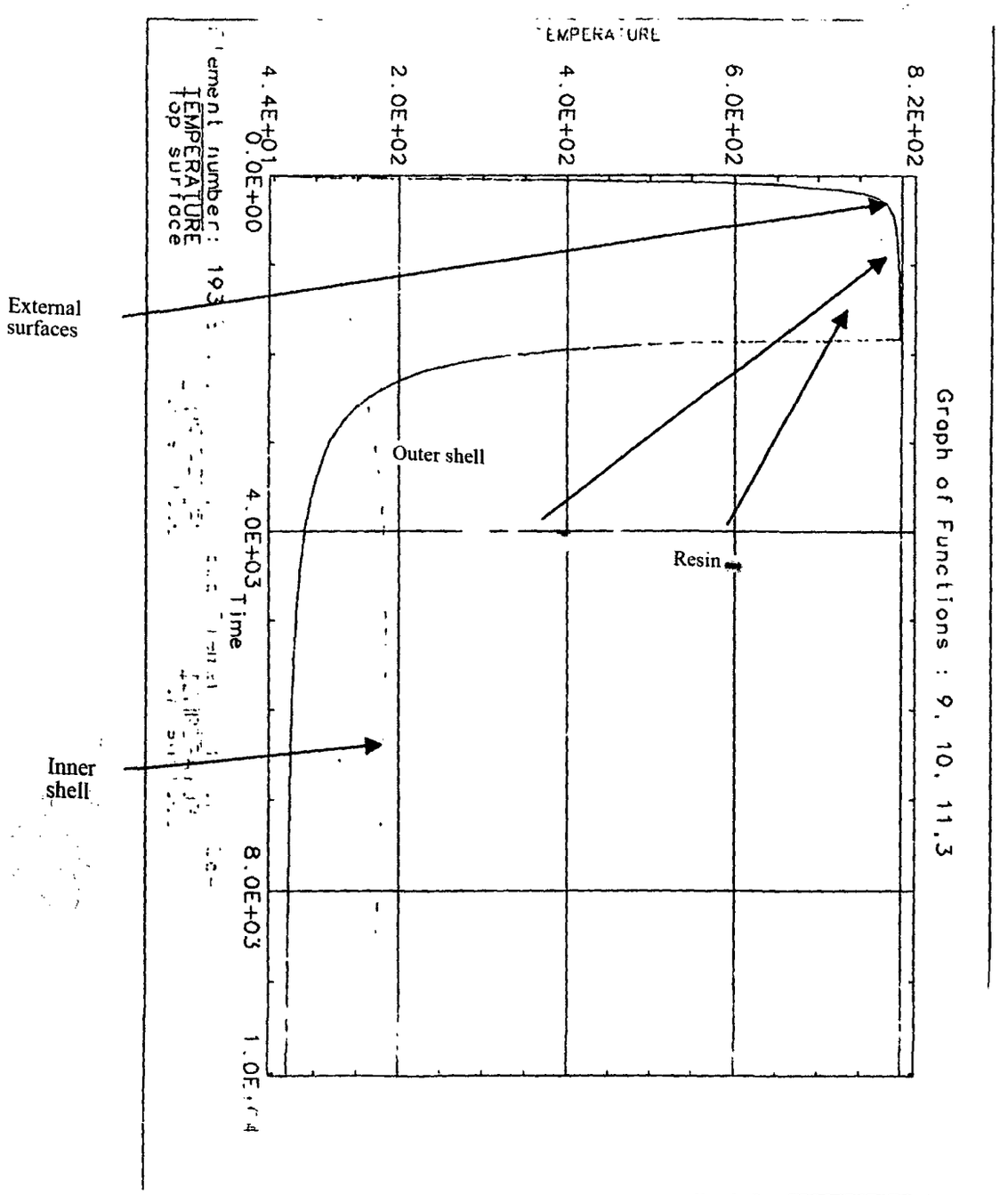
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 6

CONFIGURATION C3.1bis

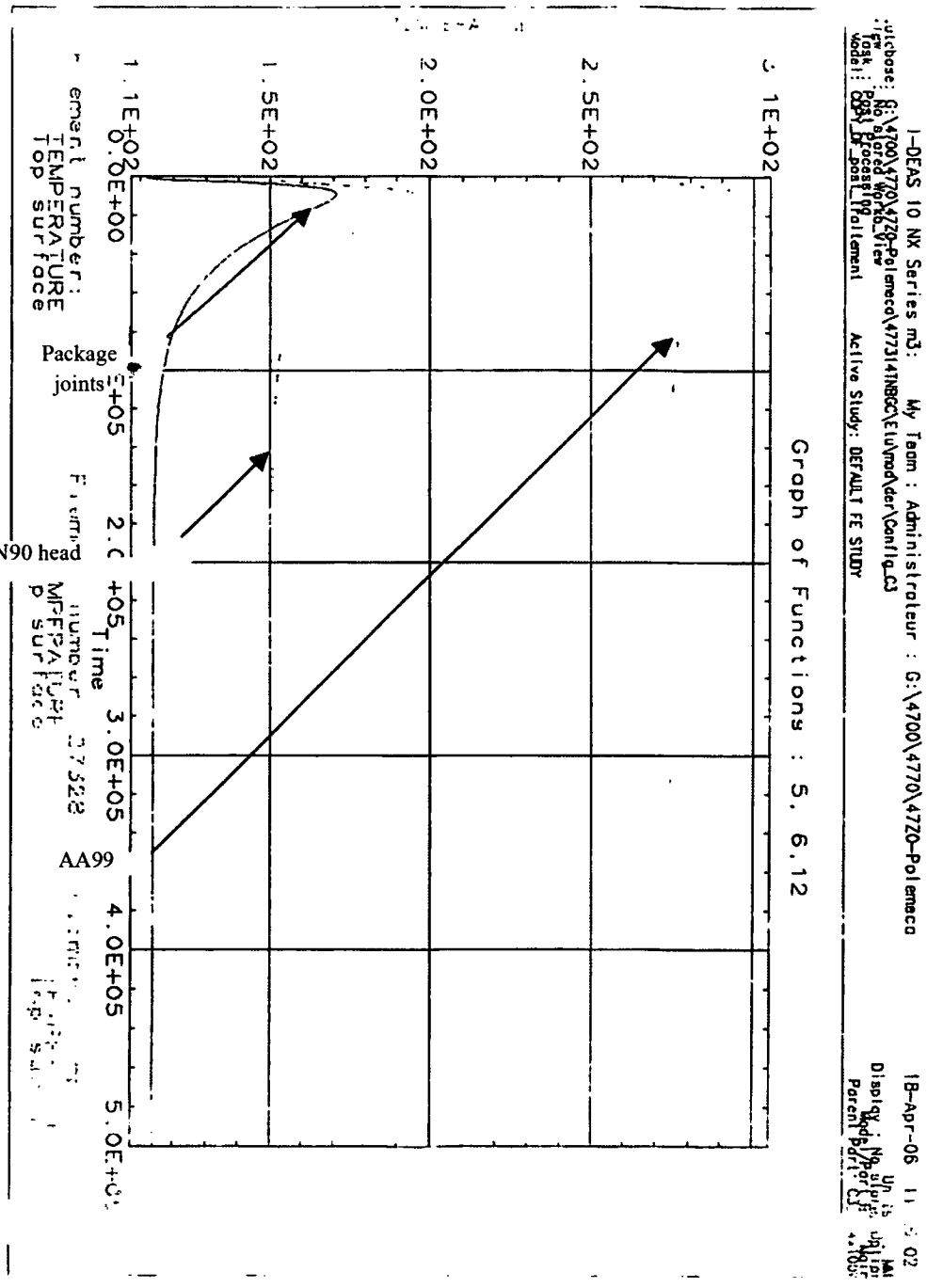
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 6

CONFIGURATION C3.1bis

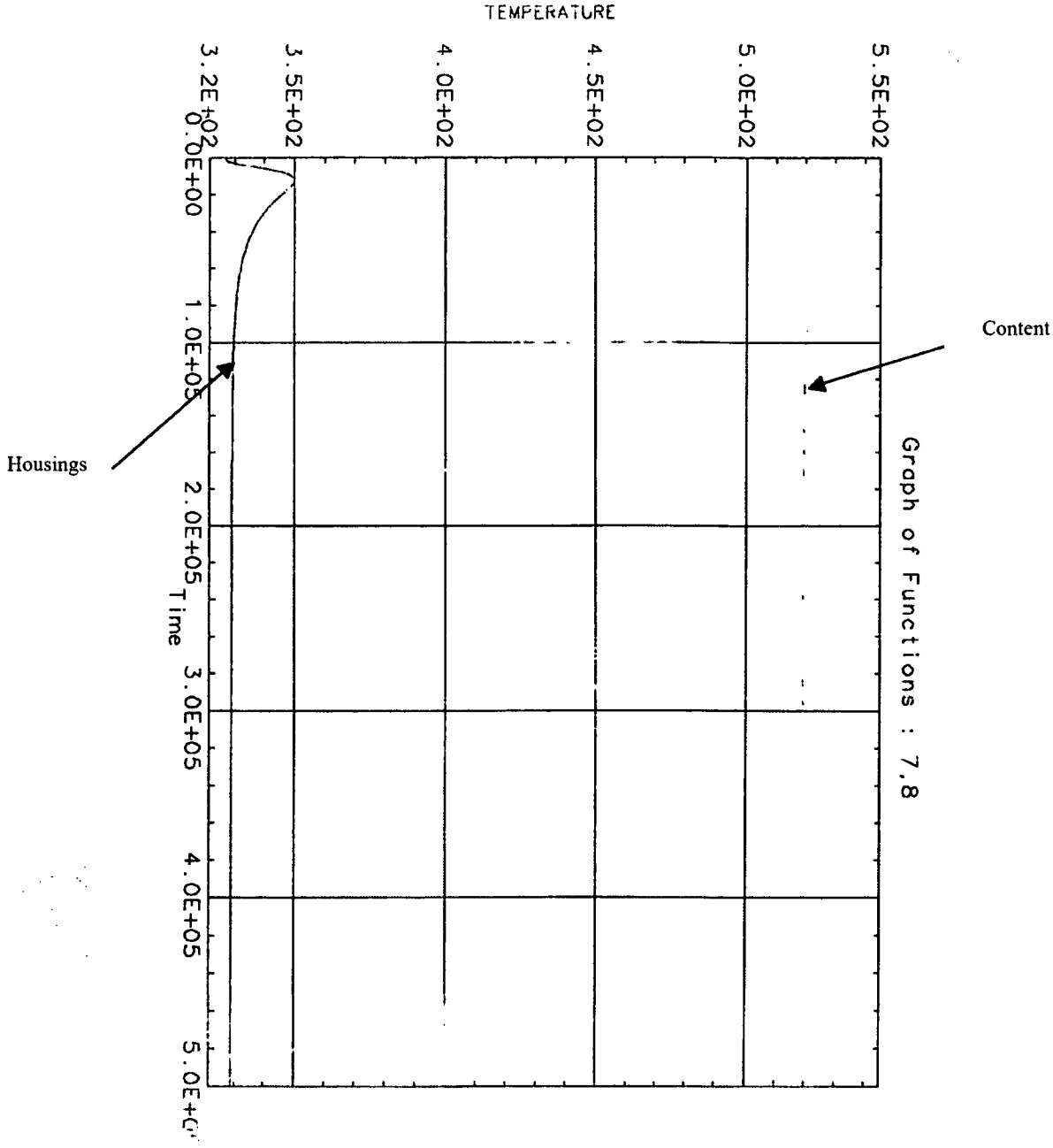
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 6

CONFIGURATION C3.1bis

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



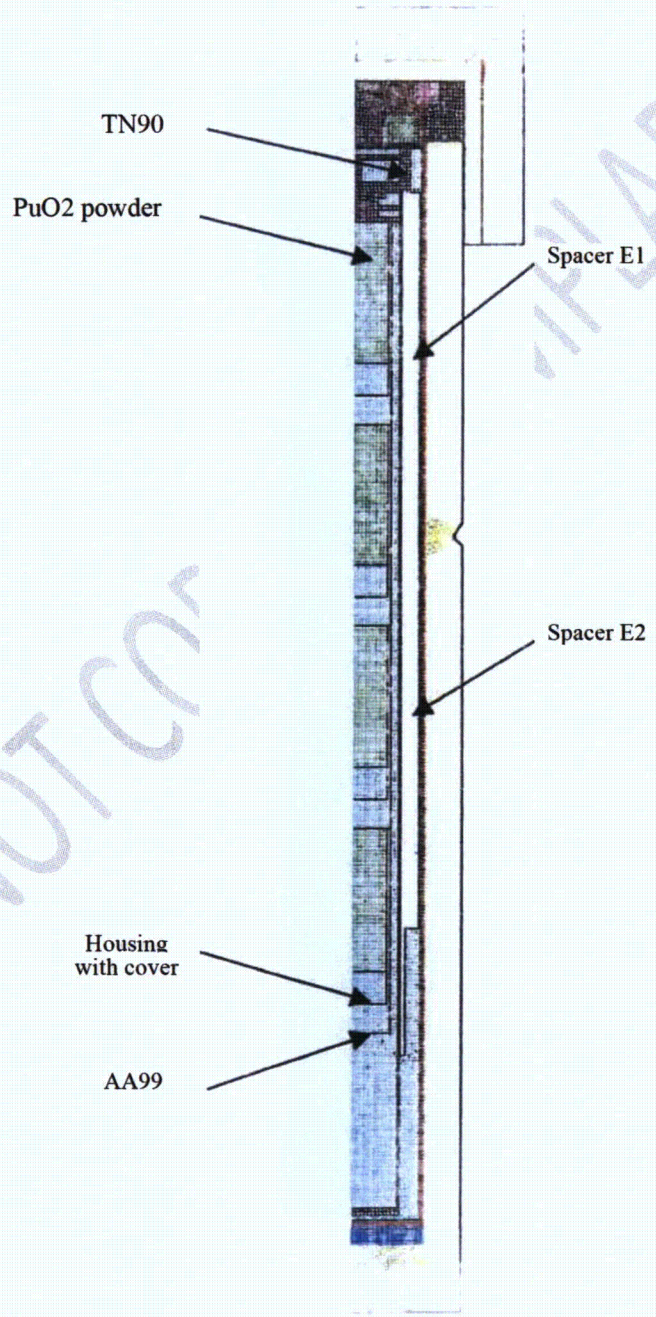
APPENDIX 7

CONFIGURATIONS C3.2 and C3.2 bis

APPENDIX 7

CONFIGURATION C3.2

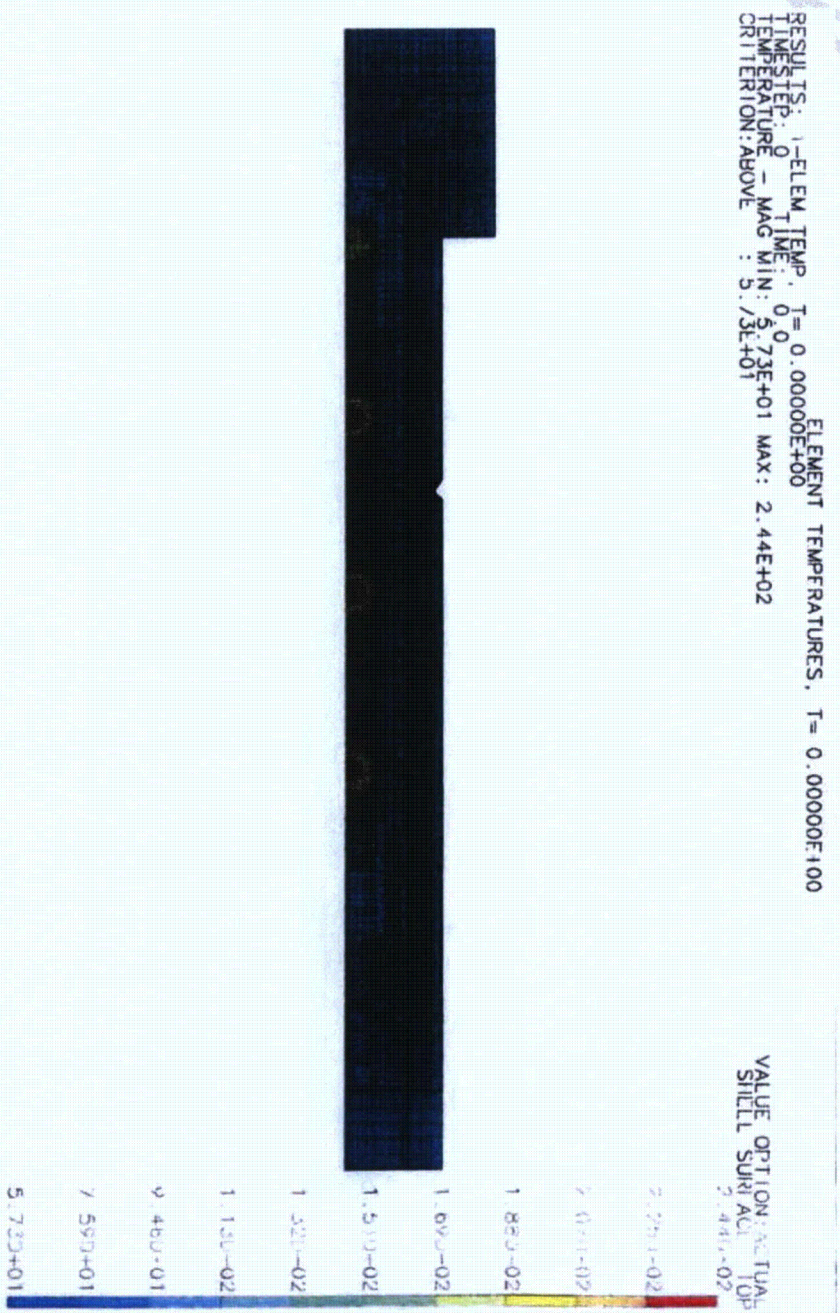
PRESENTATION OF THE MODEL



APPENDIX 7

CONFIGURATION C3.2

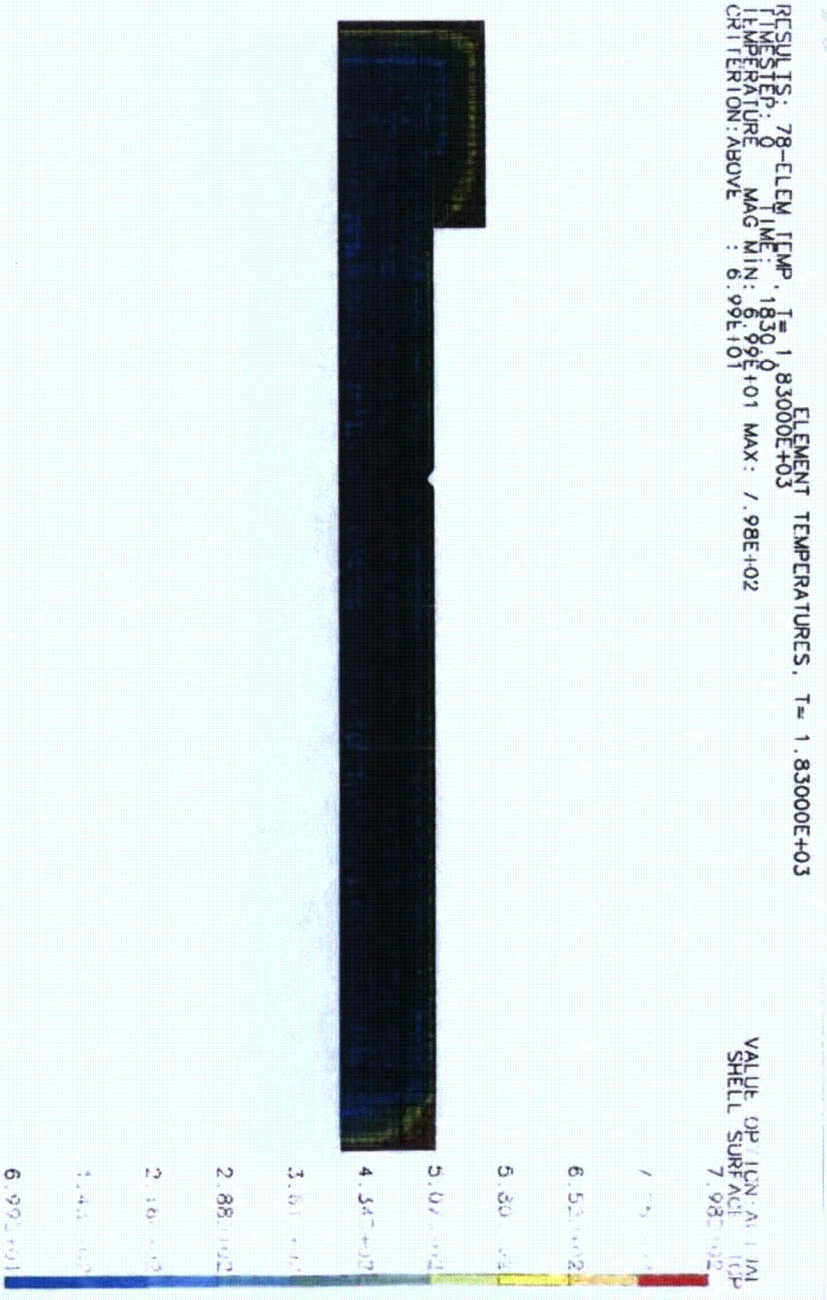
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 7

CONFIGURATION C3.2

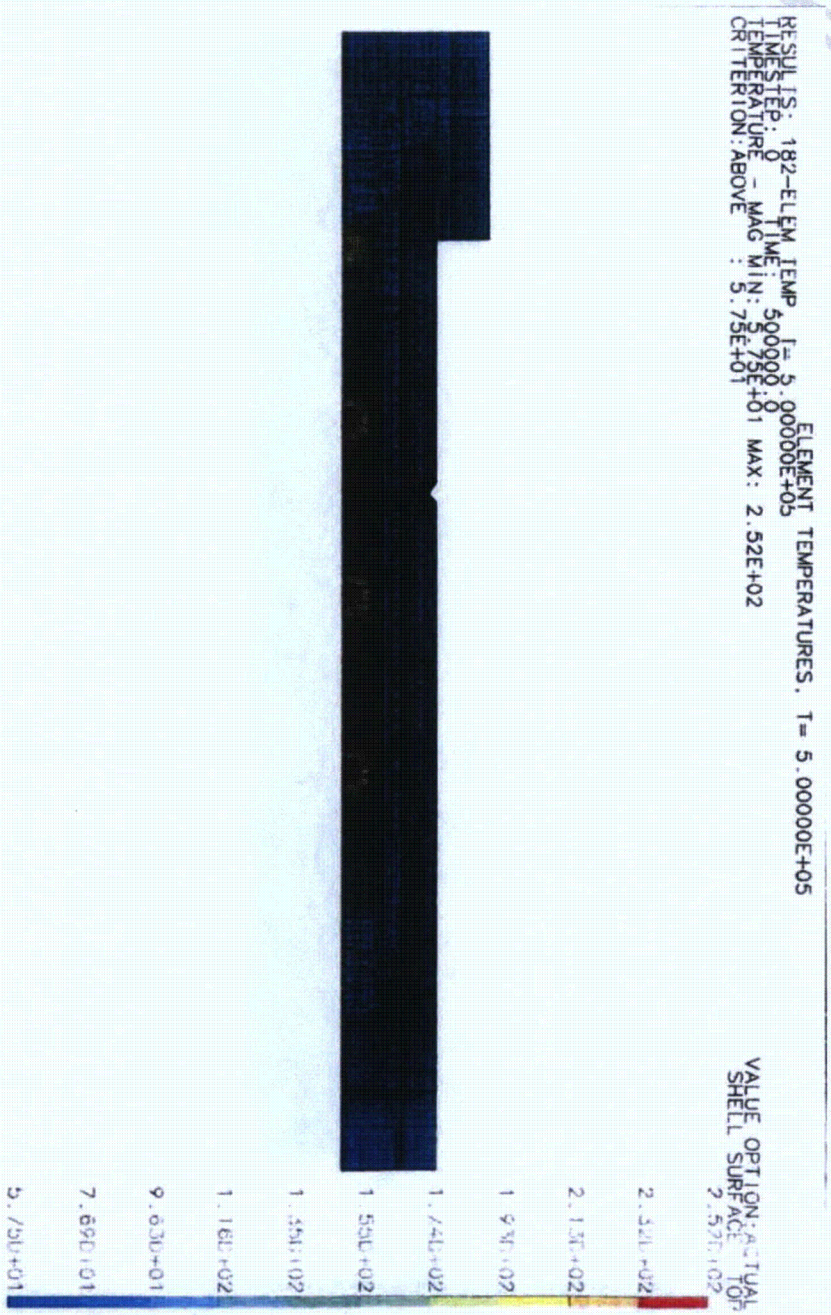
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 7

CONFIGURATION C3.2

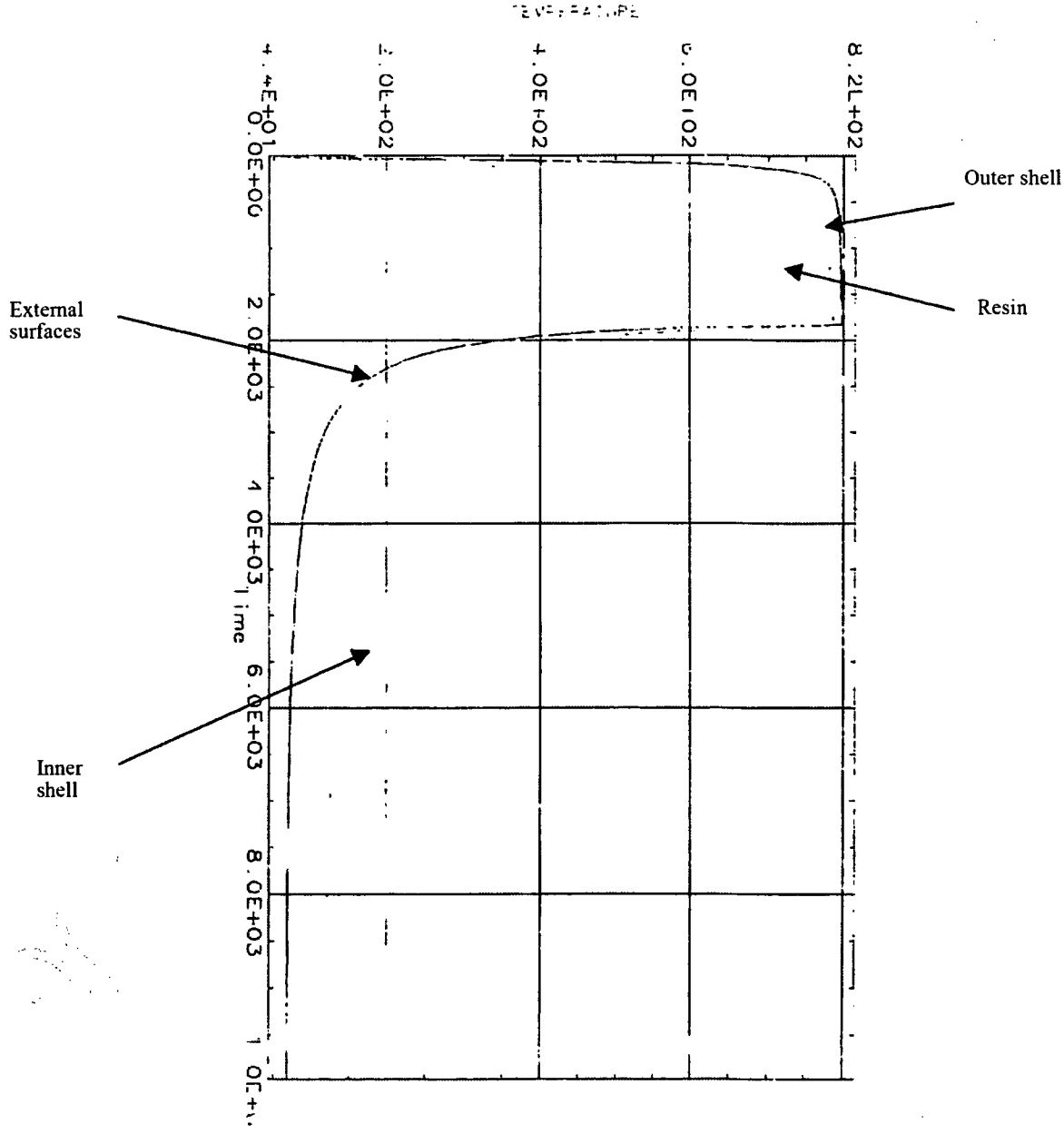
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 7

CONFIGURATION C3.2

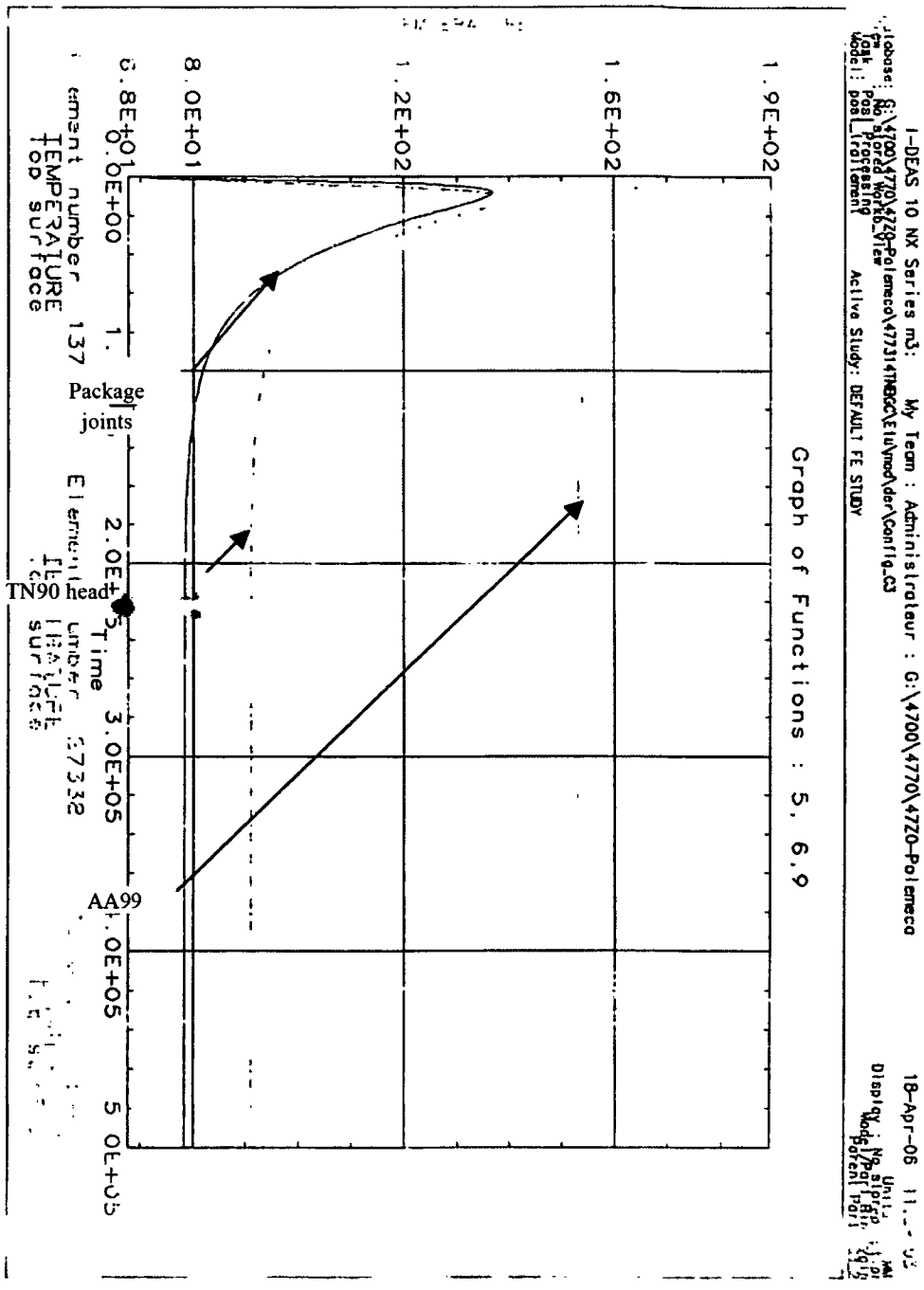
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 7

CONFIGURATION C3.2

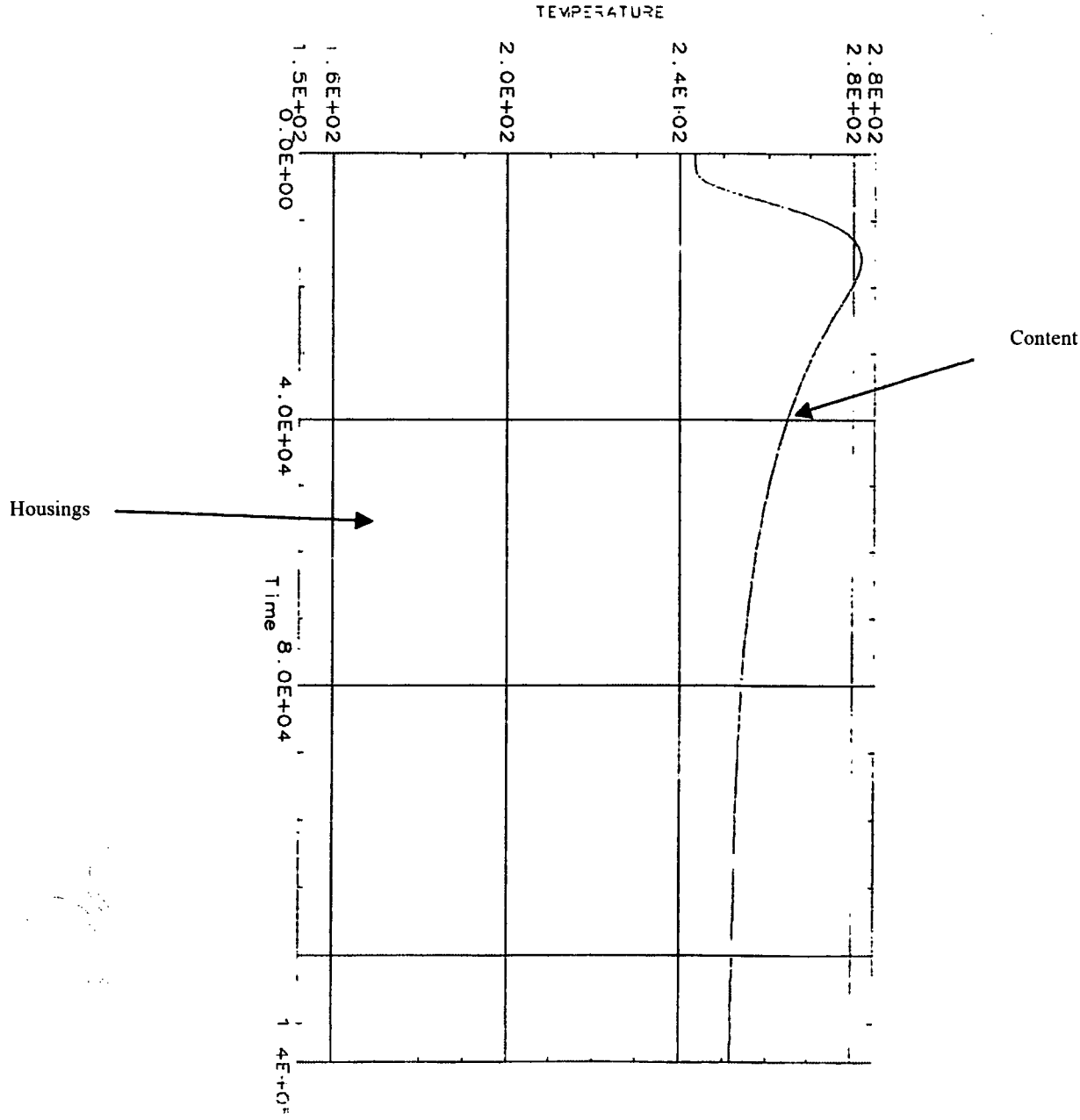
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 7

CONFIGURATION C3.2

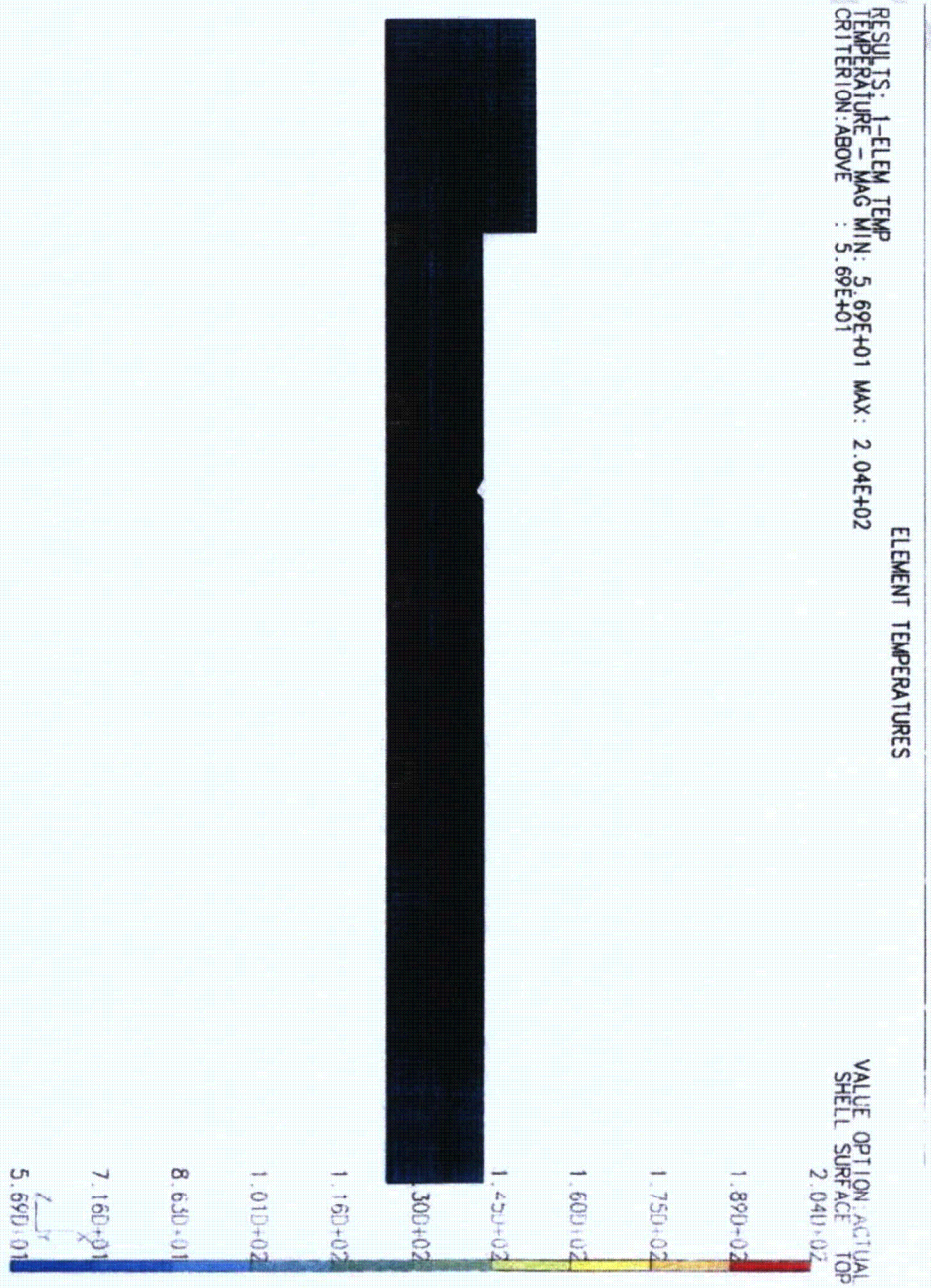
GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 7

CONFIGURATION C3.2bis

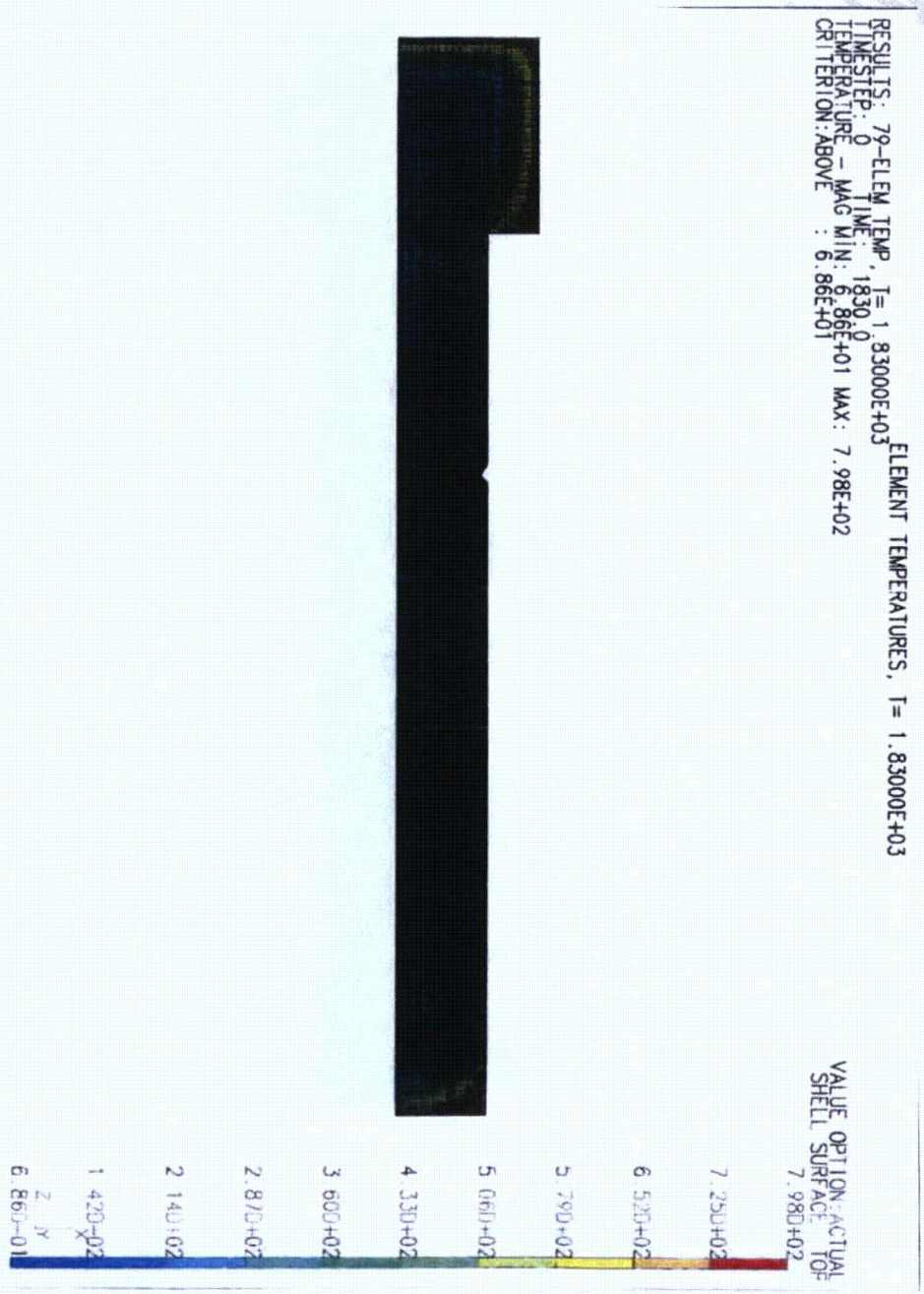
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 7

CONFIGURATION C3.2bis

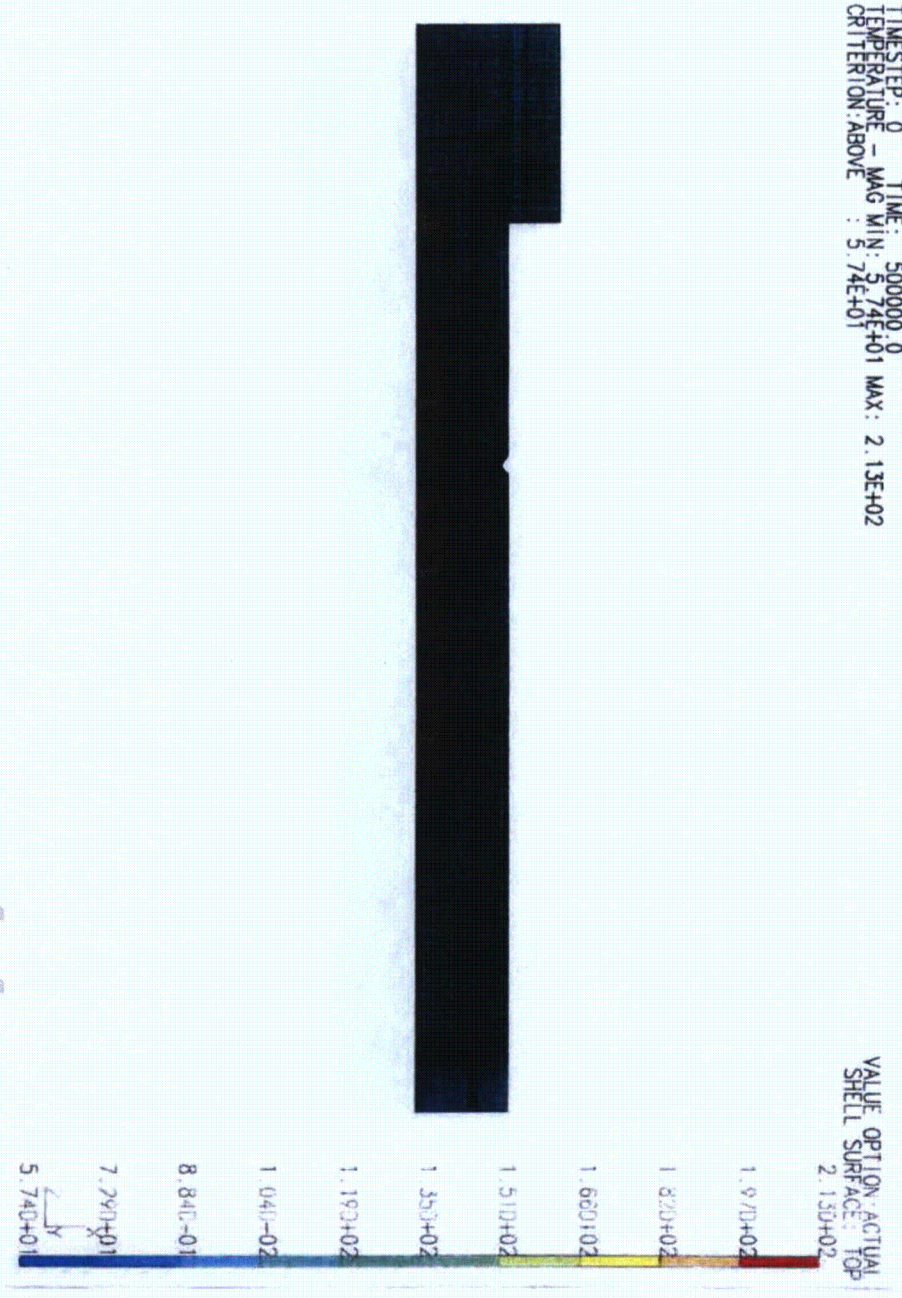
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 7

CONFIGURATION C3.2bis

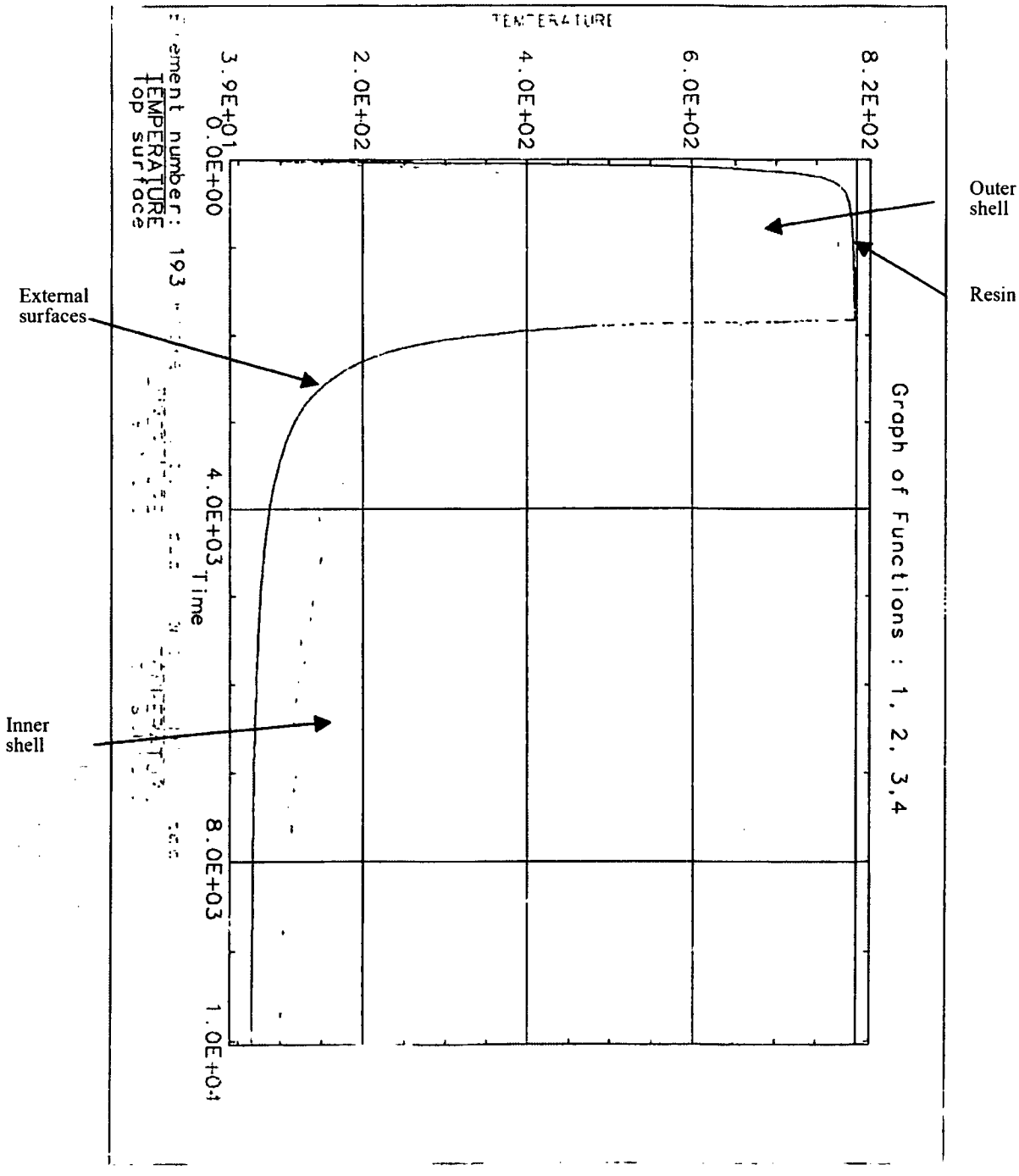
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 7

CONFIGURATION C3.2bis

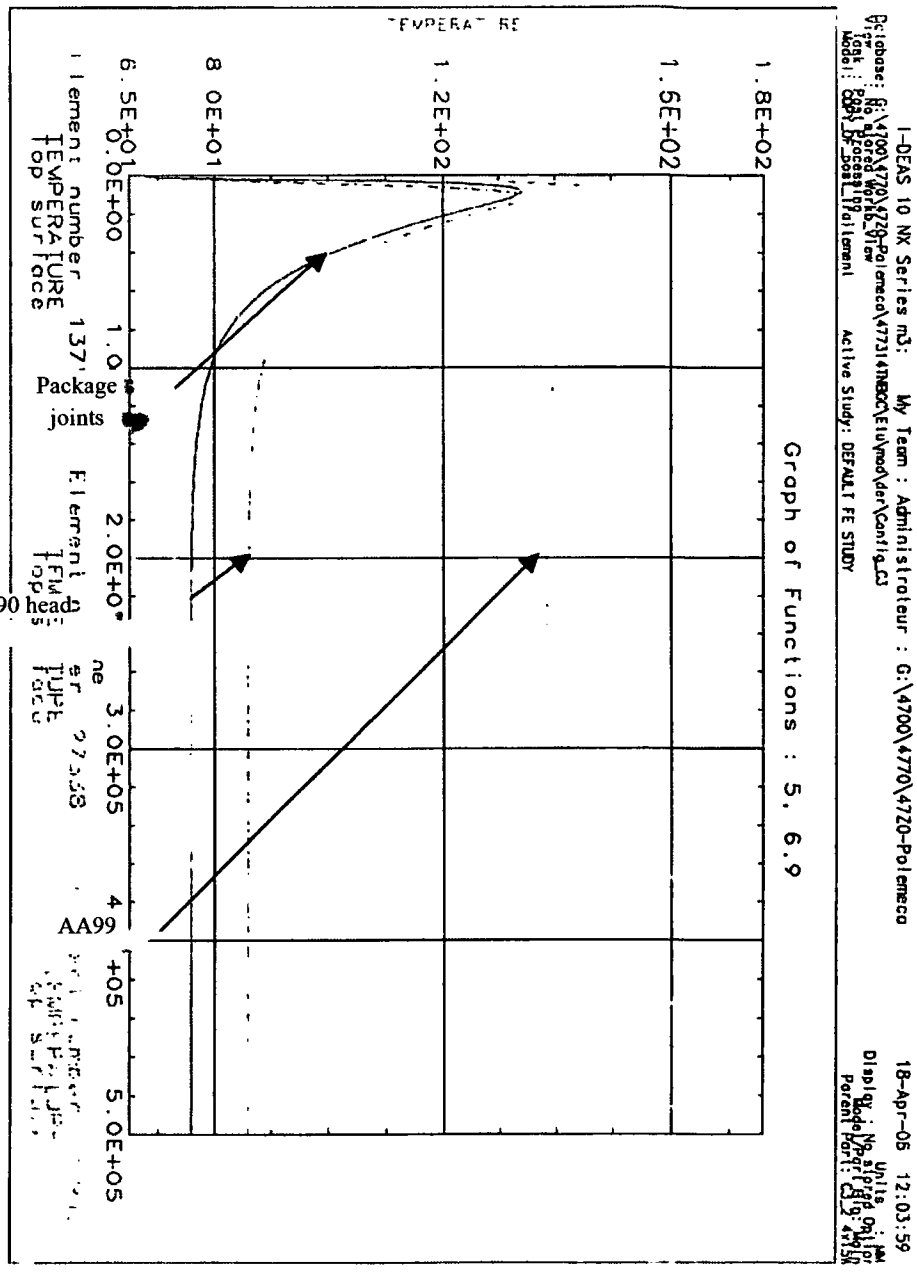
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 7

CONFIGURATION C3.2bis

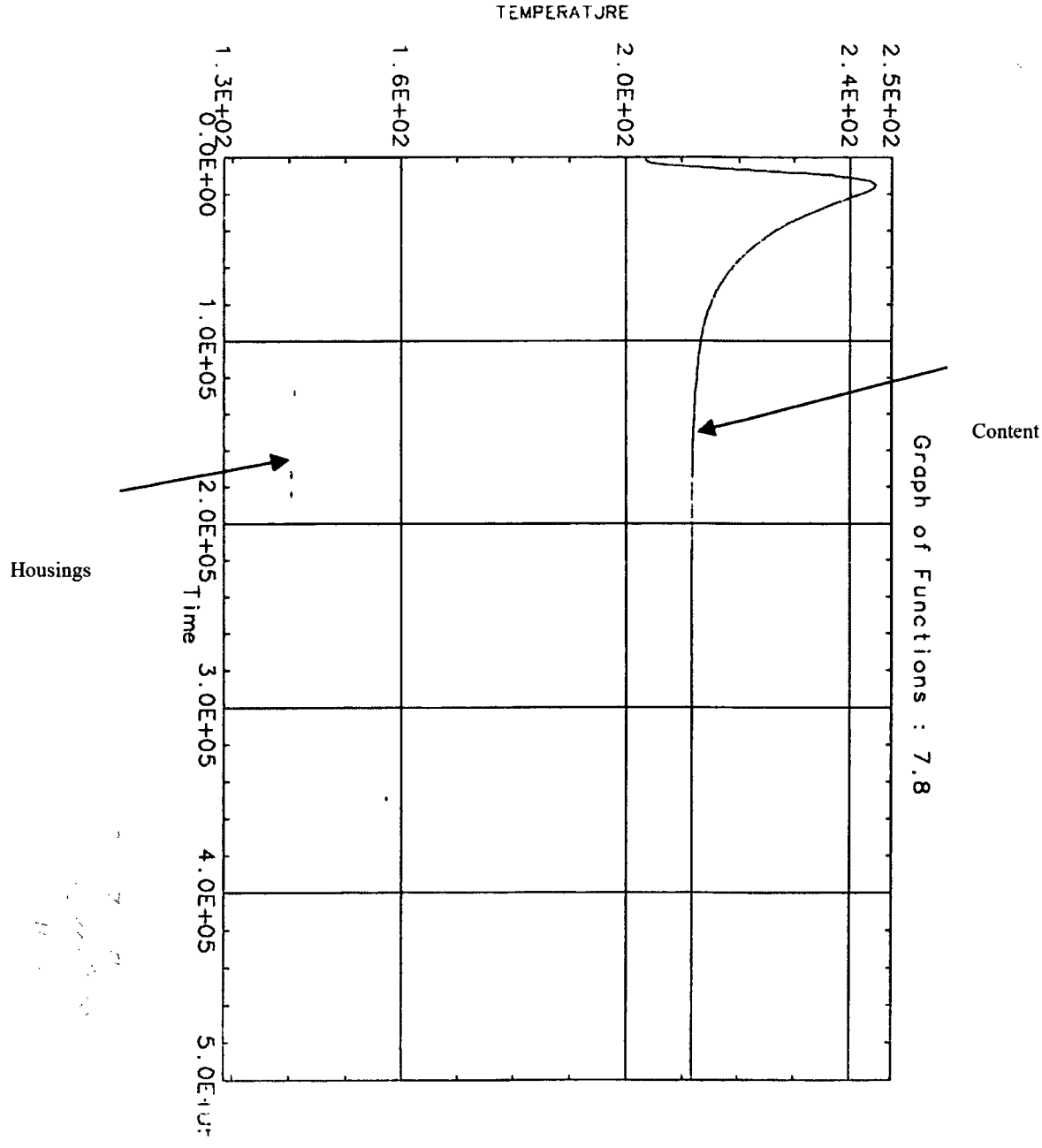
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 7

CONFIGURATION C3.2bis

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



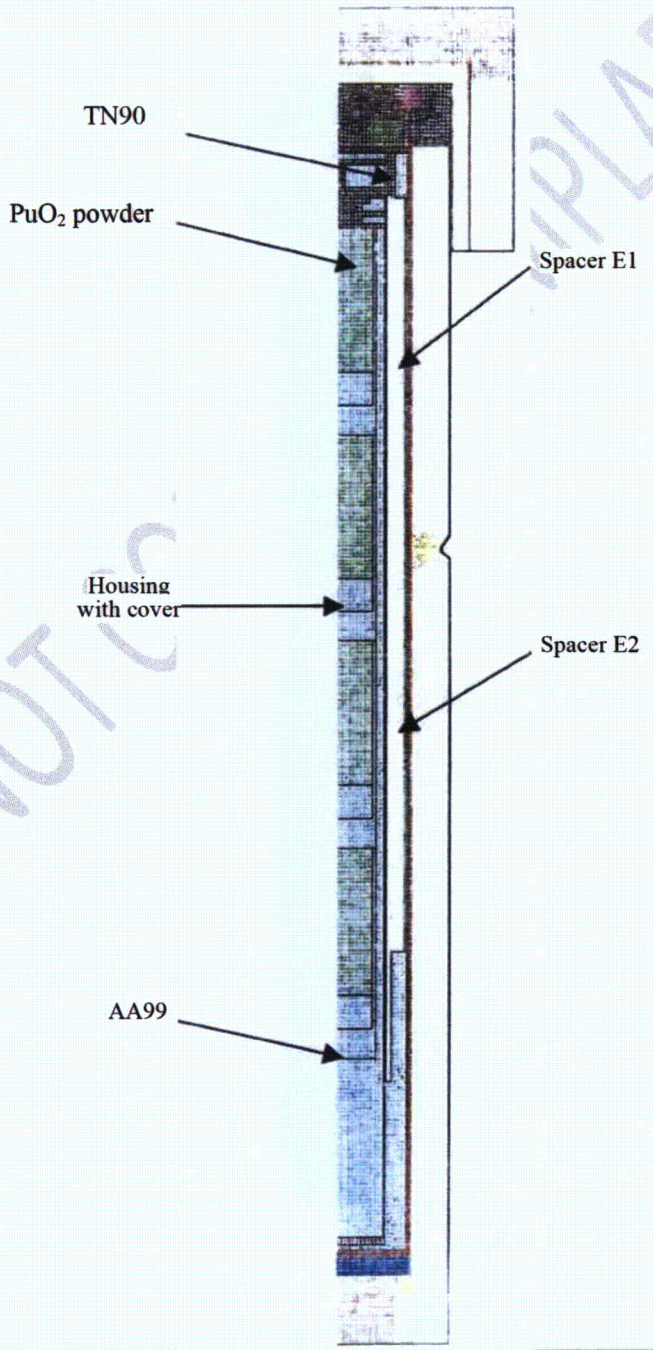
APPENDIX 8

CONFIGURATIONS C3.3 and C3.3 bis

APPENDIX 8

CONFIGURATION C3.3

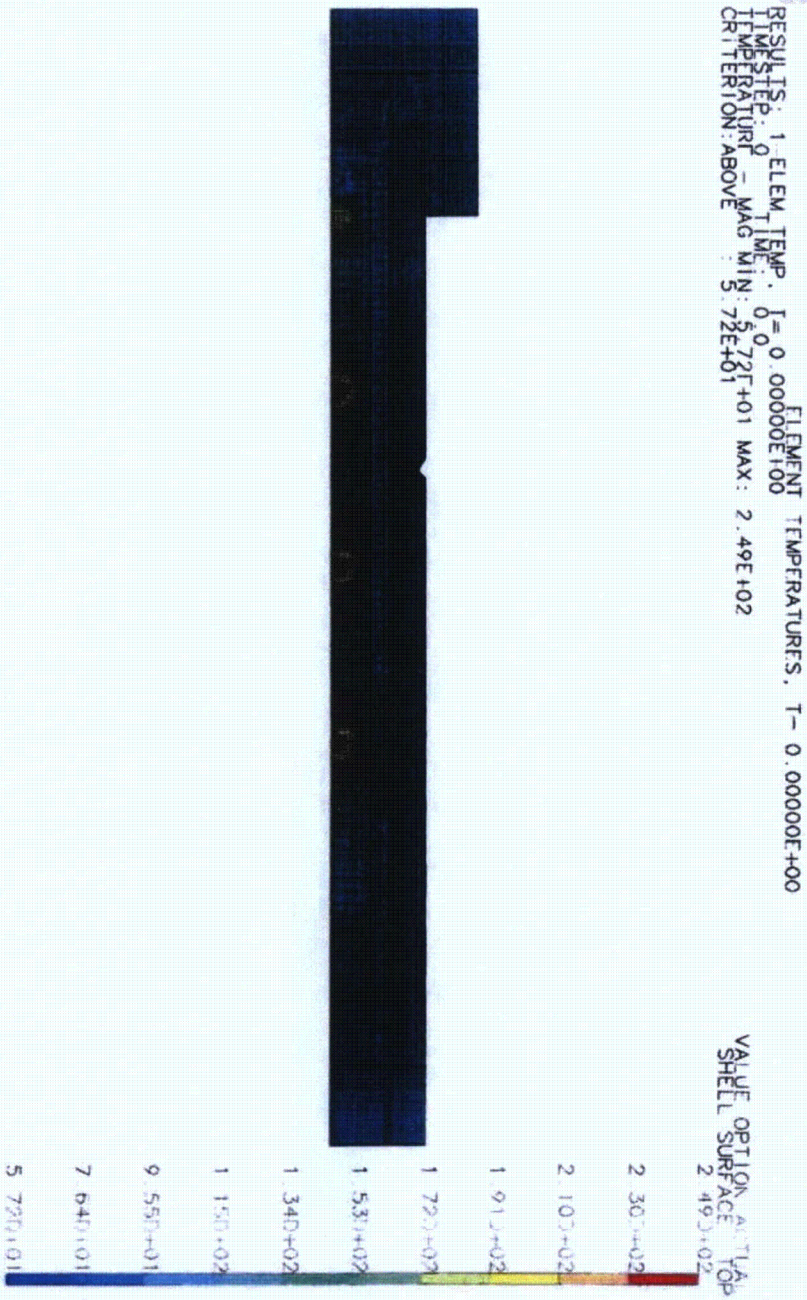
PRESENTATION OF THE MODEL



APPENDIX 8

CONFIGURATION C3.3

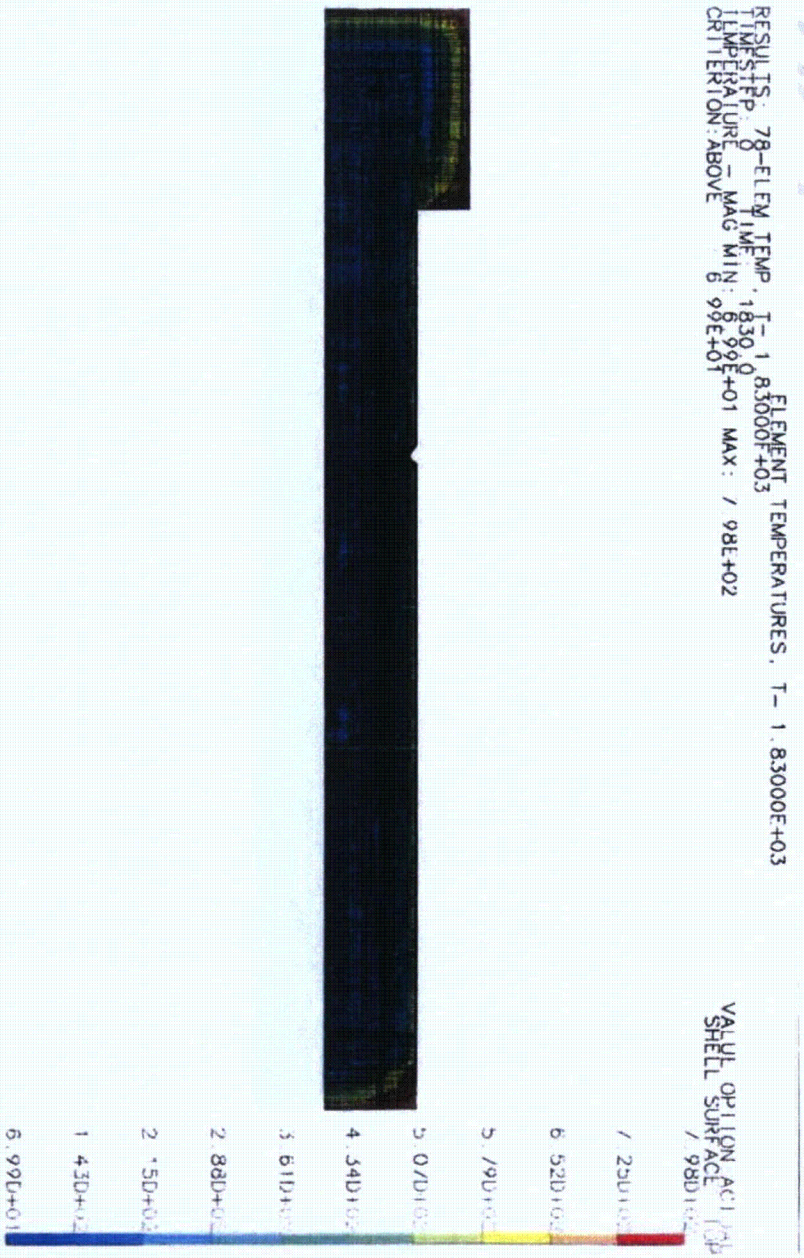
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 8

CONFIGURATION C3.3

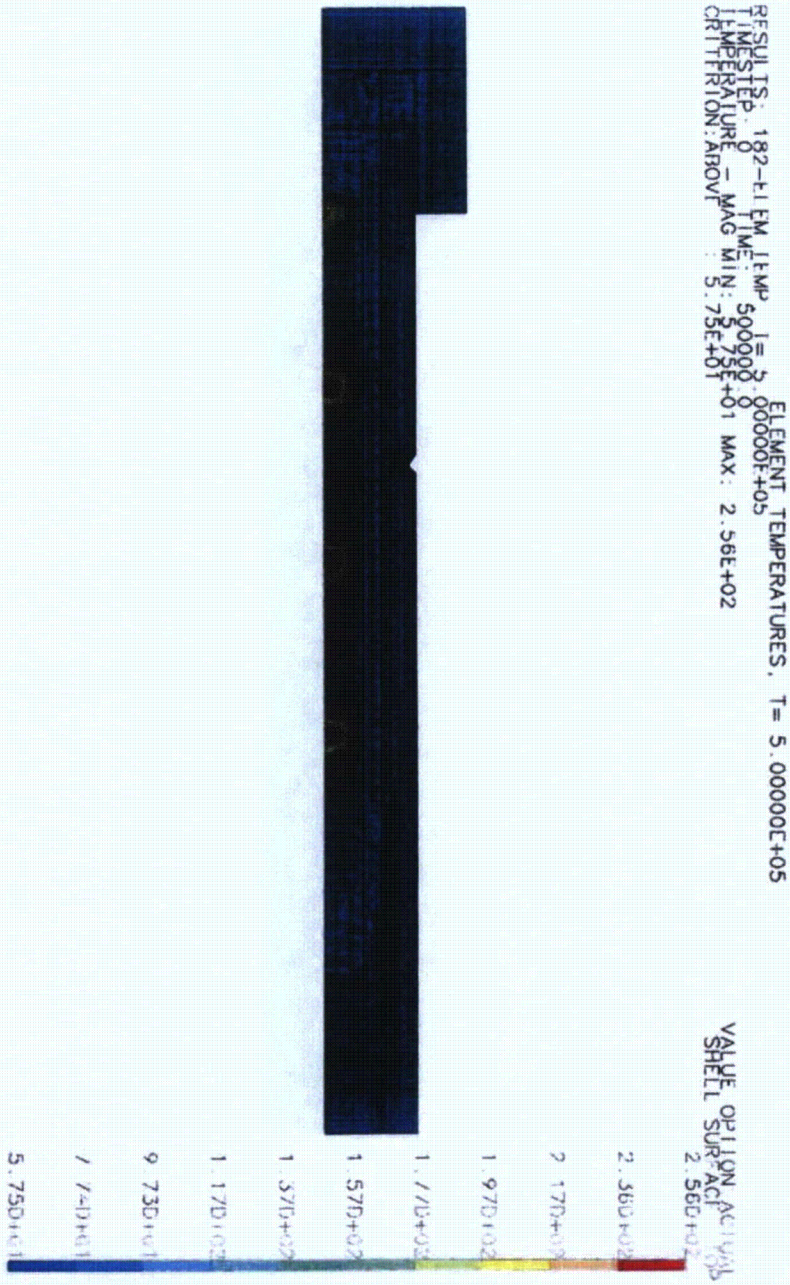
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 8

CONFIGURATION C3.3

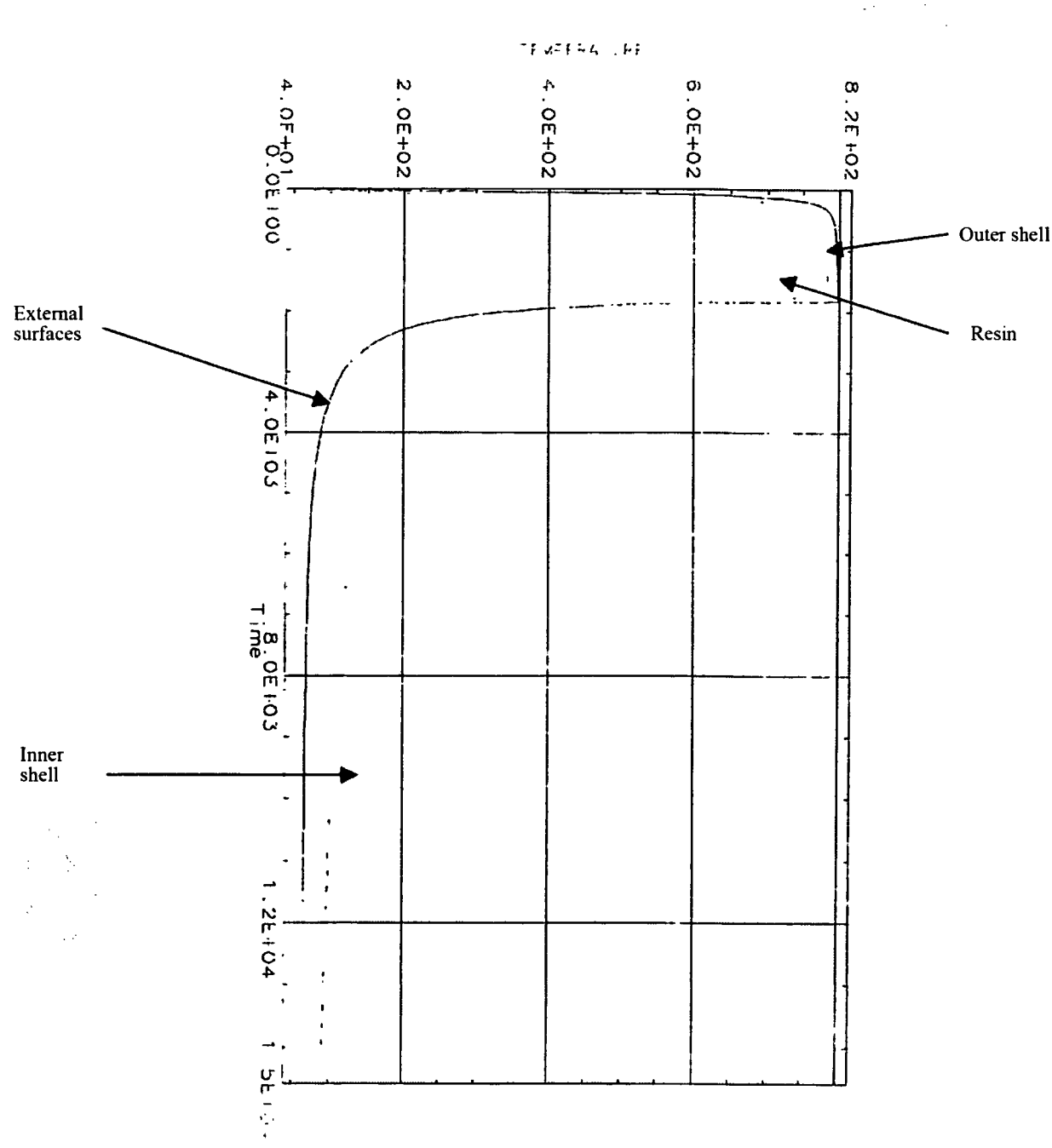
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 8

CONFIGURATION C3.3

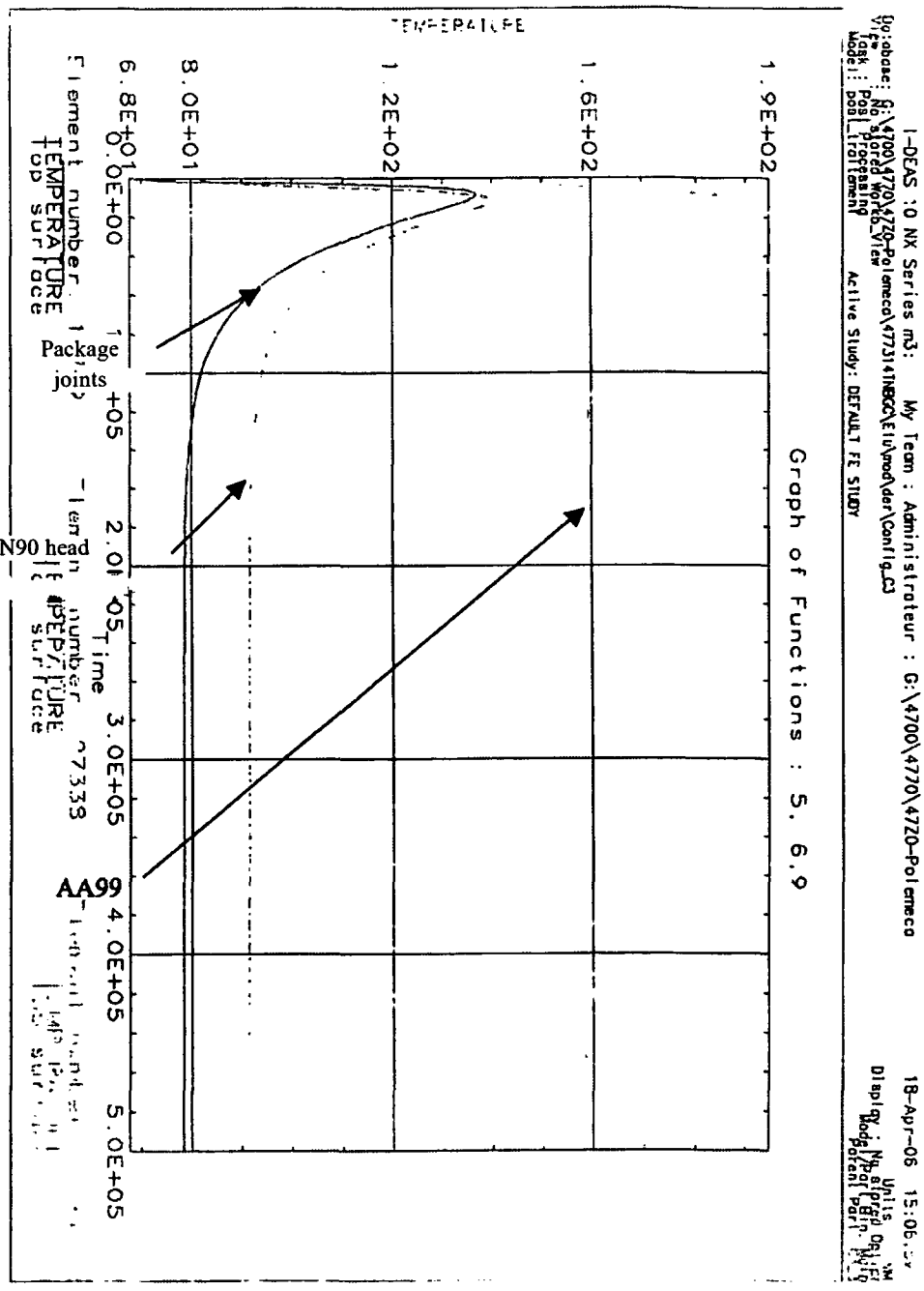
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 8

CONFIGURATION C3.3

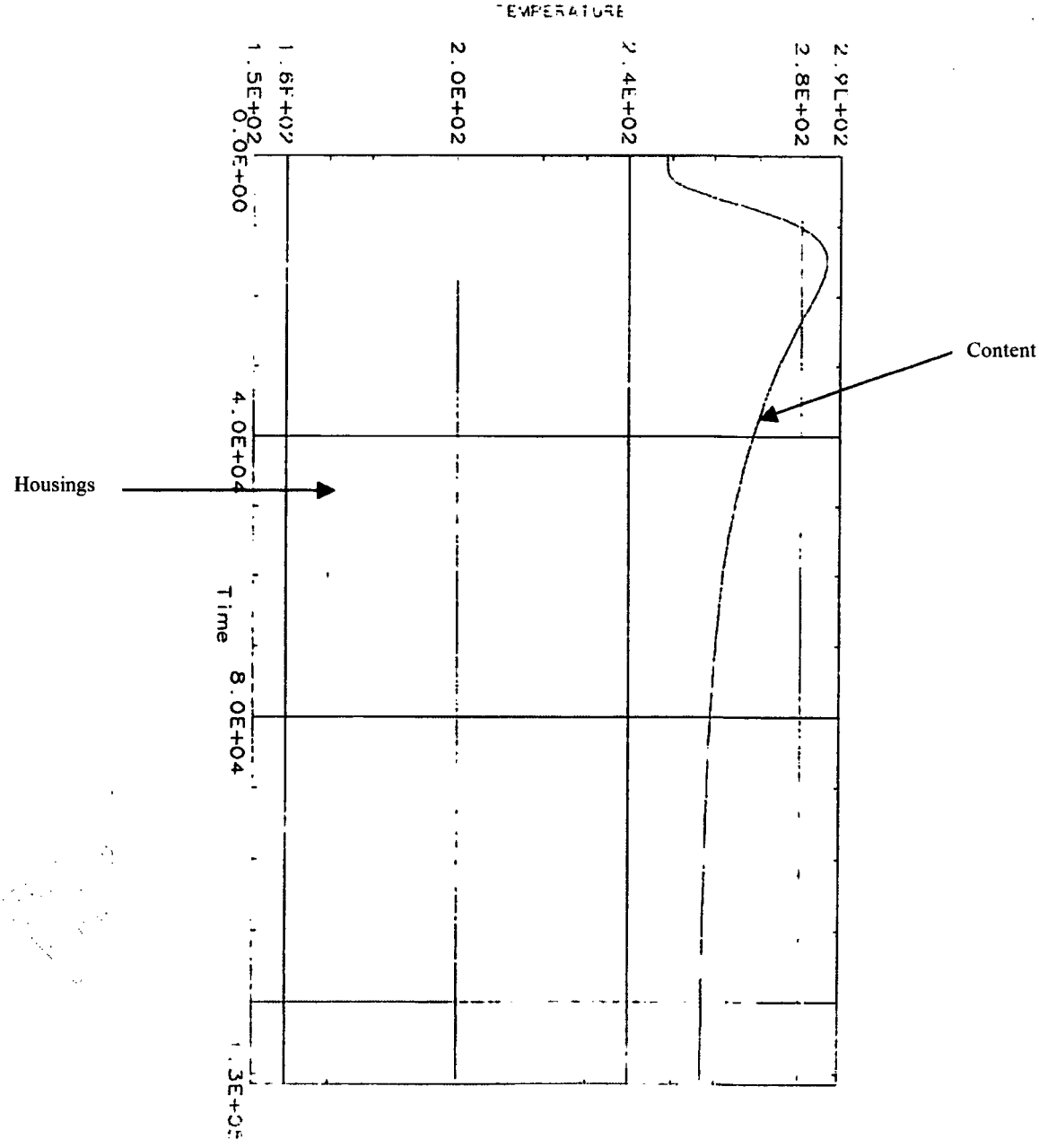
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 8

CONFIGURATION C3.3

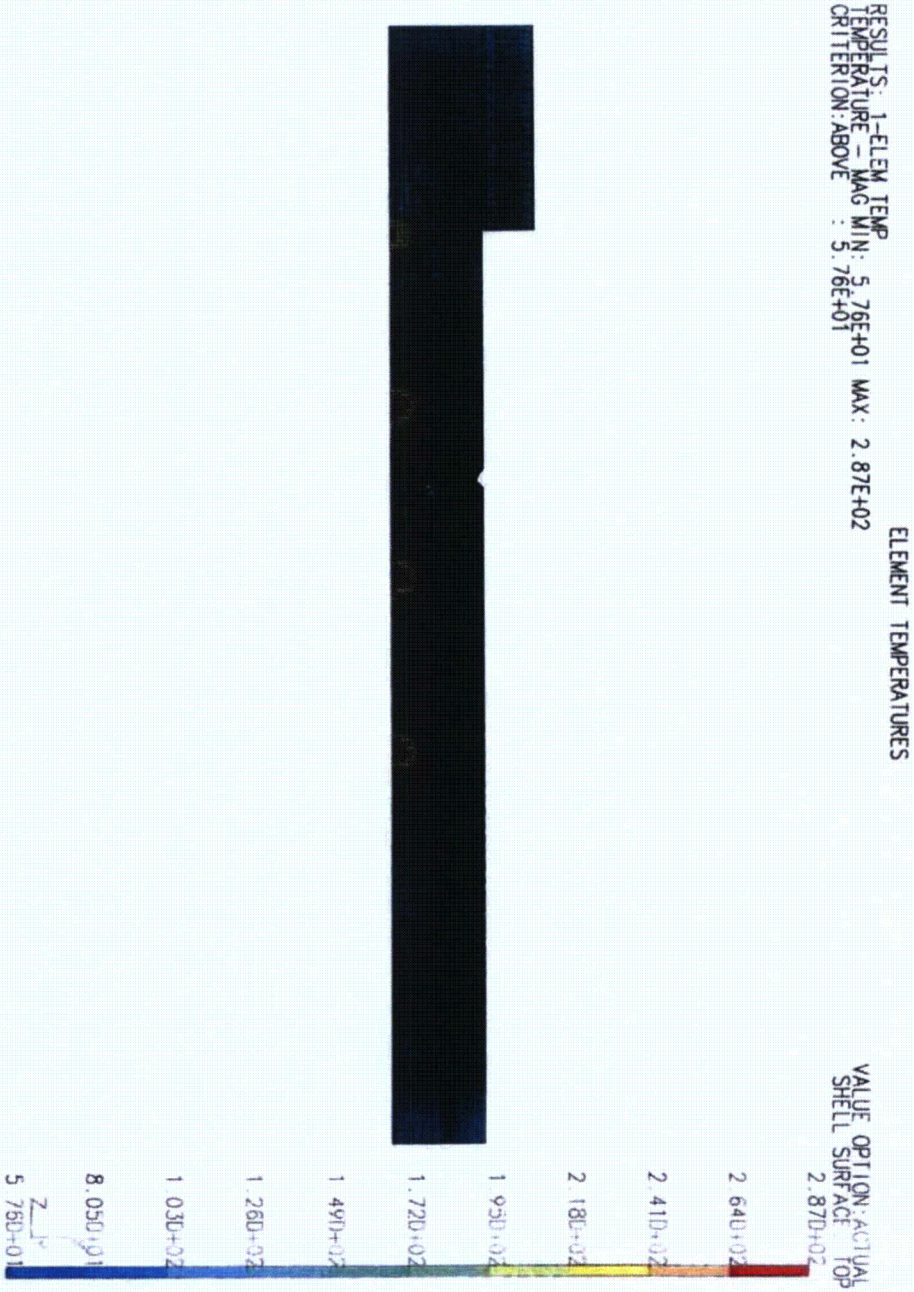
GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 8

CONFIGURATION C3.3bis

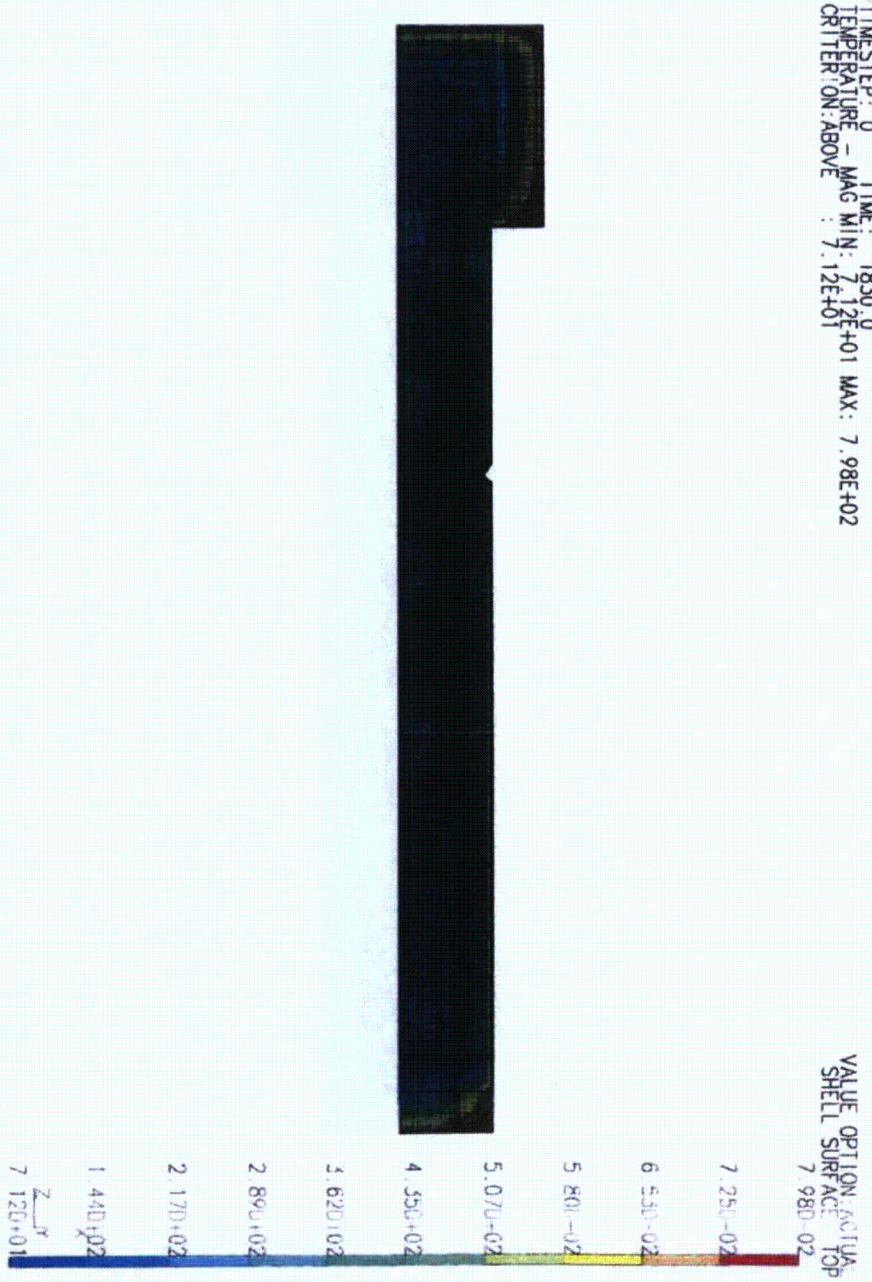
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 8

CONFIGURATION C3.3bis

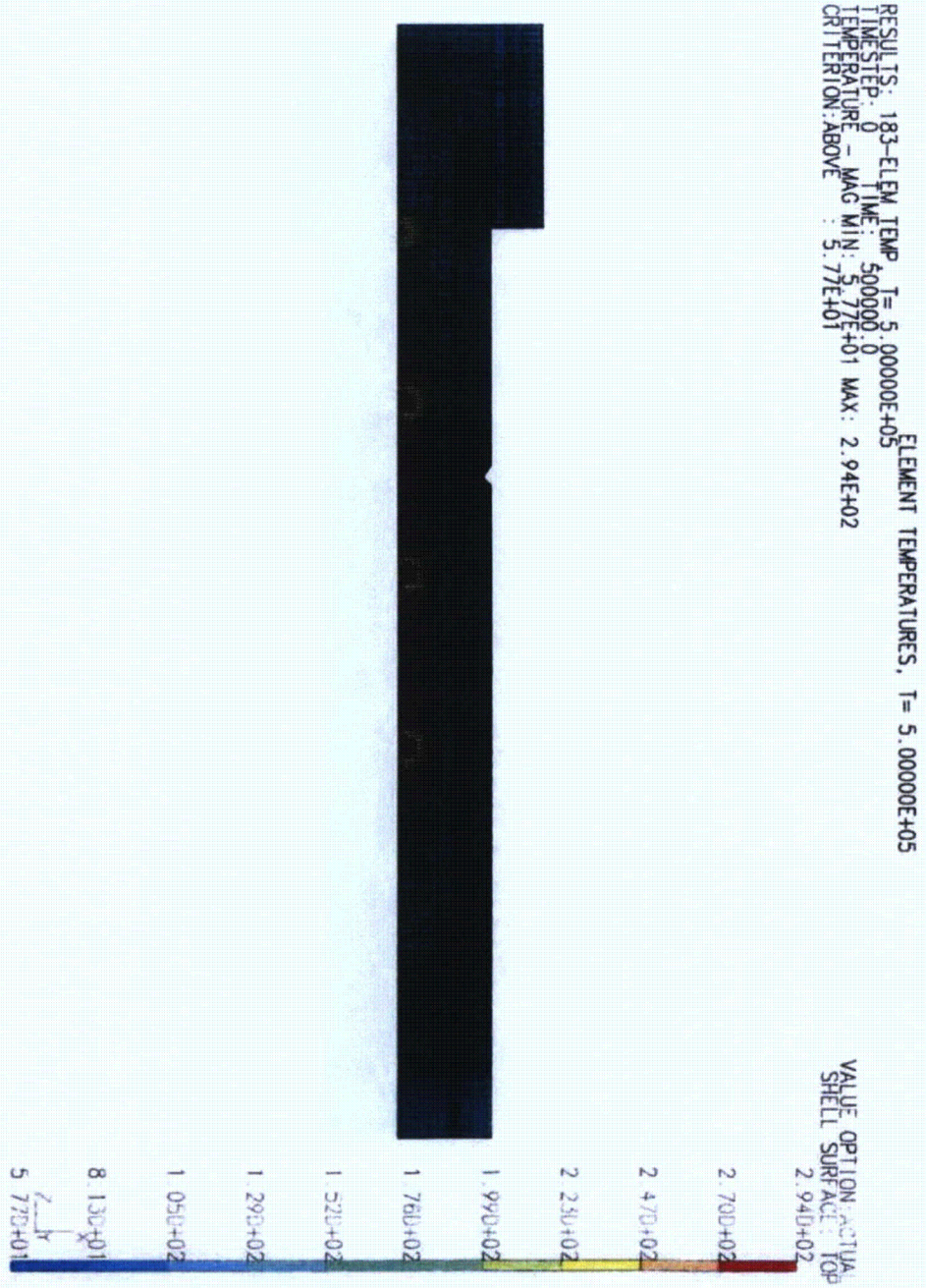
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 8

CONFIGURATION C3.3bis

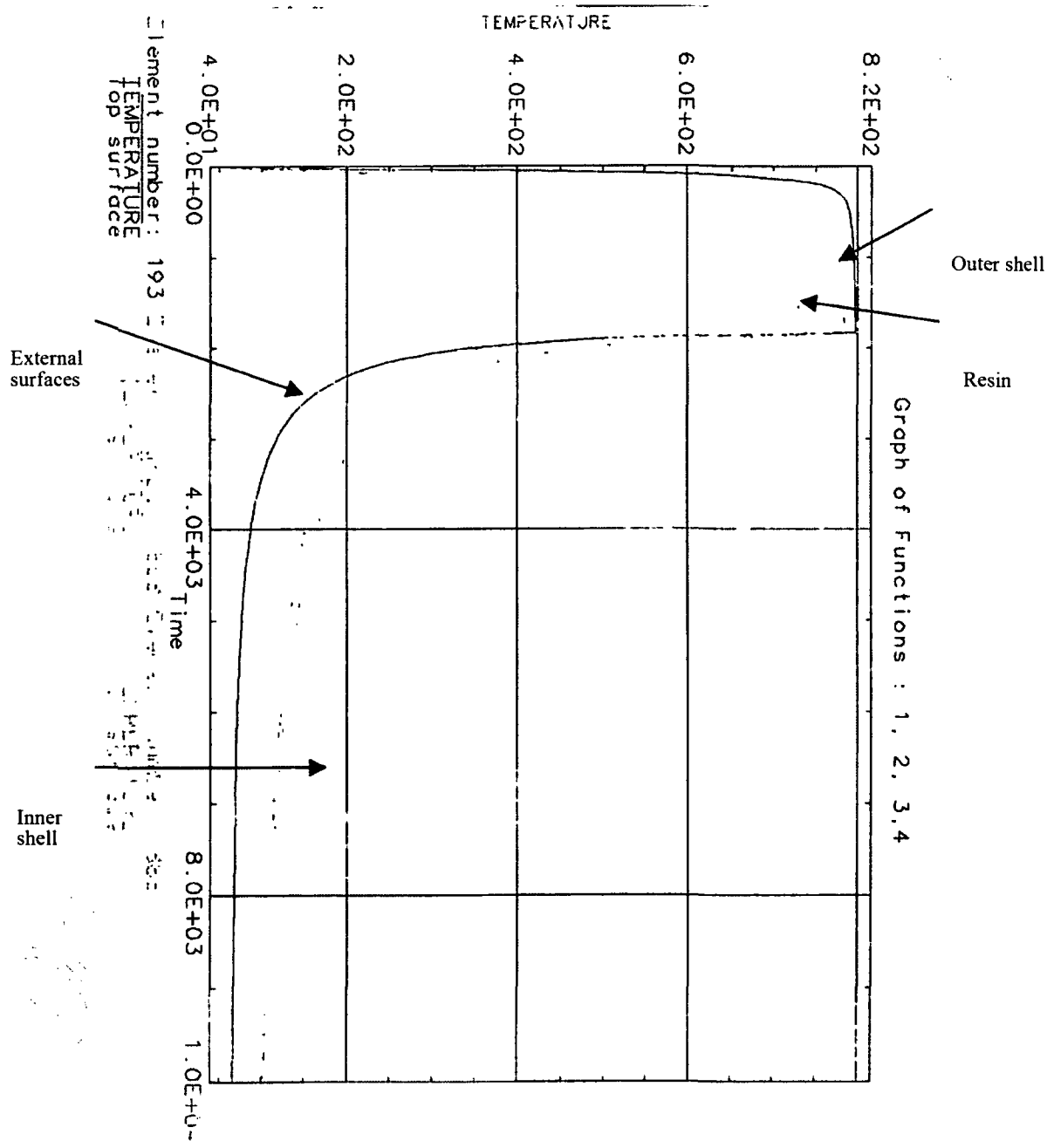
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 8

CONFIGURATION C3.3bis

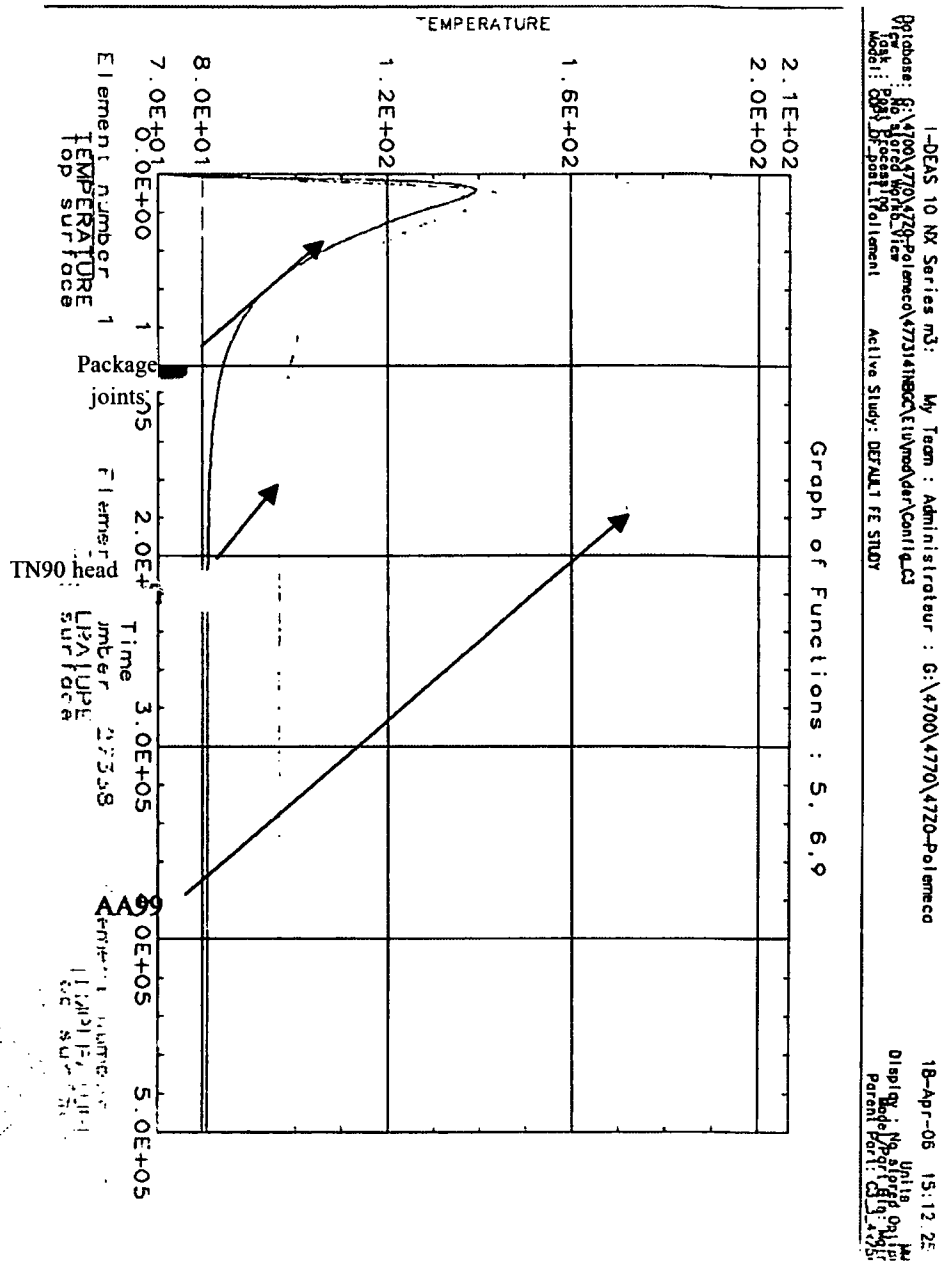
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 8

CONFIGURATION C3.3bis

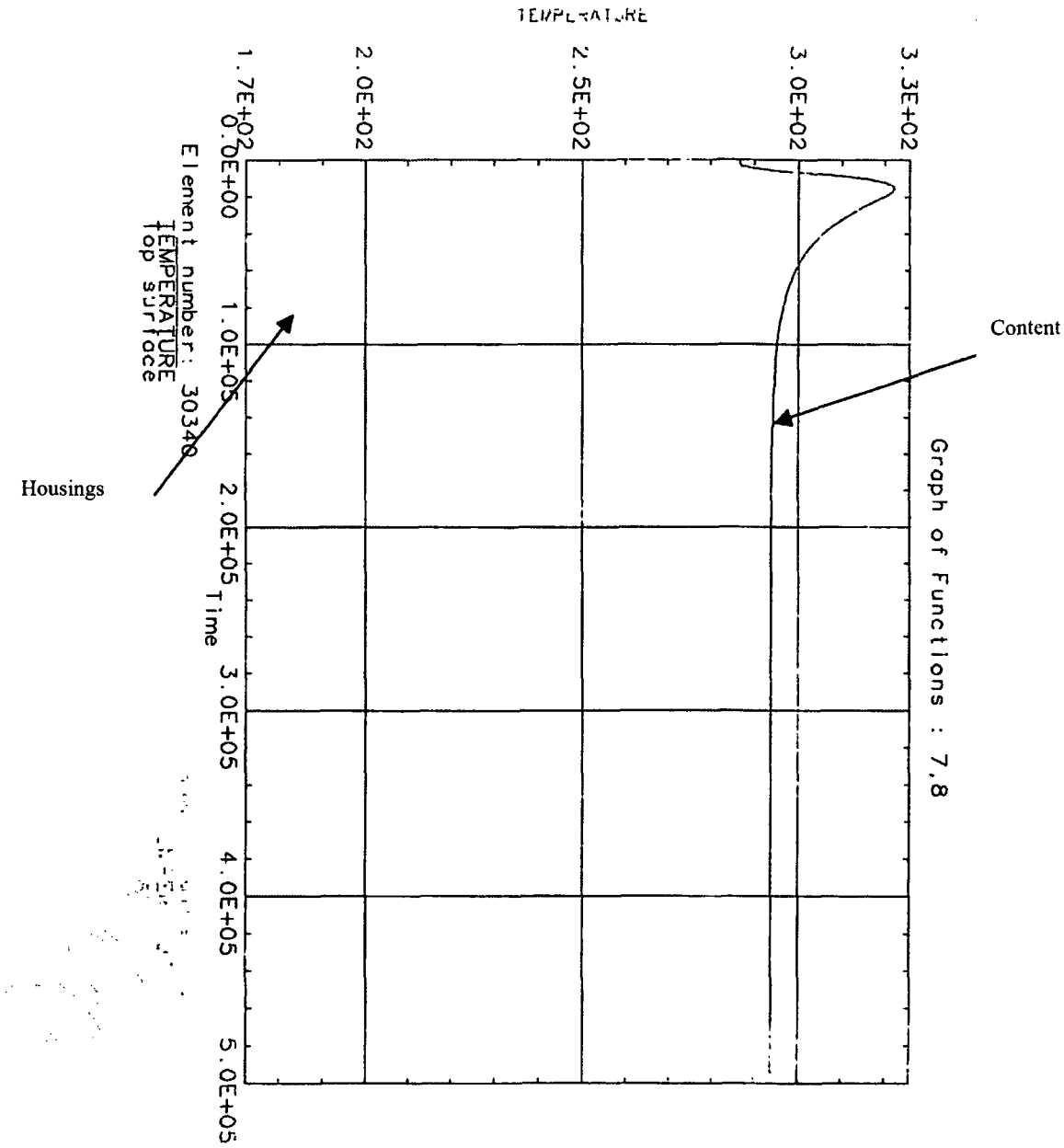
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 8

CONFIGURATION C3.3bis

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



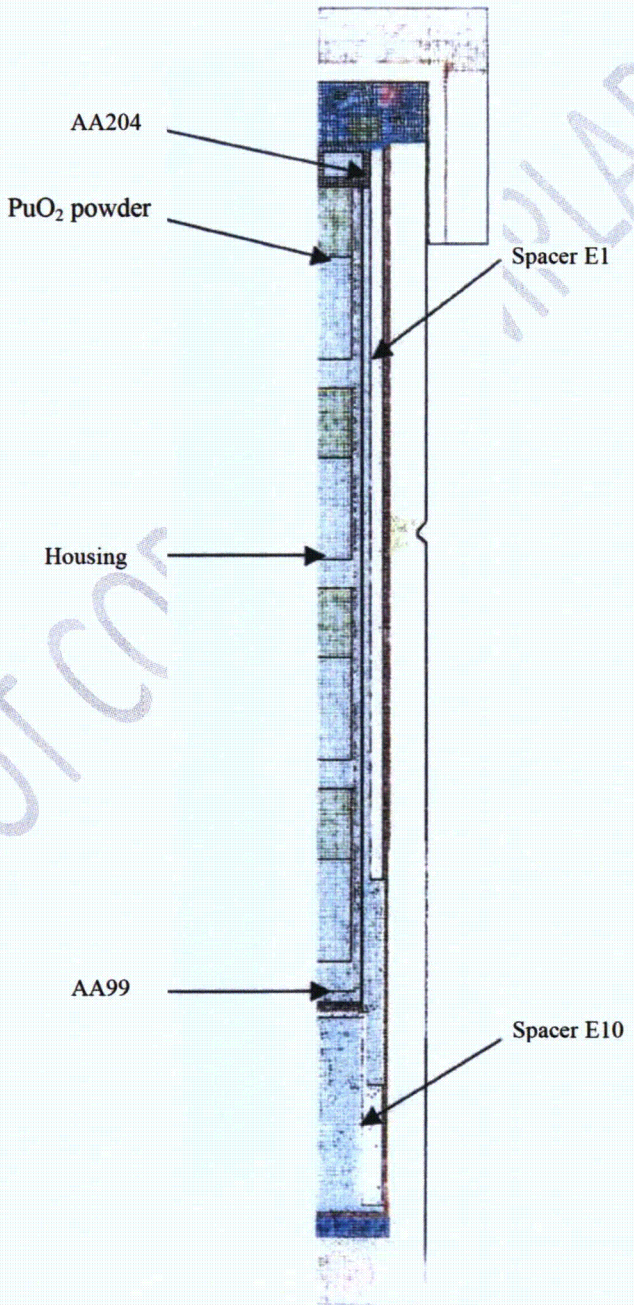
APPENDIX 9

CONFIGURATION C4.1

APPENDIX 9

CONFIGURATION C4.1

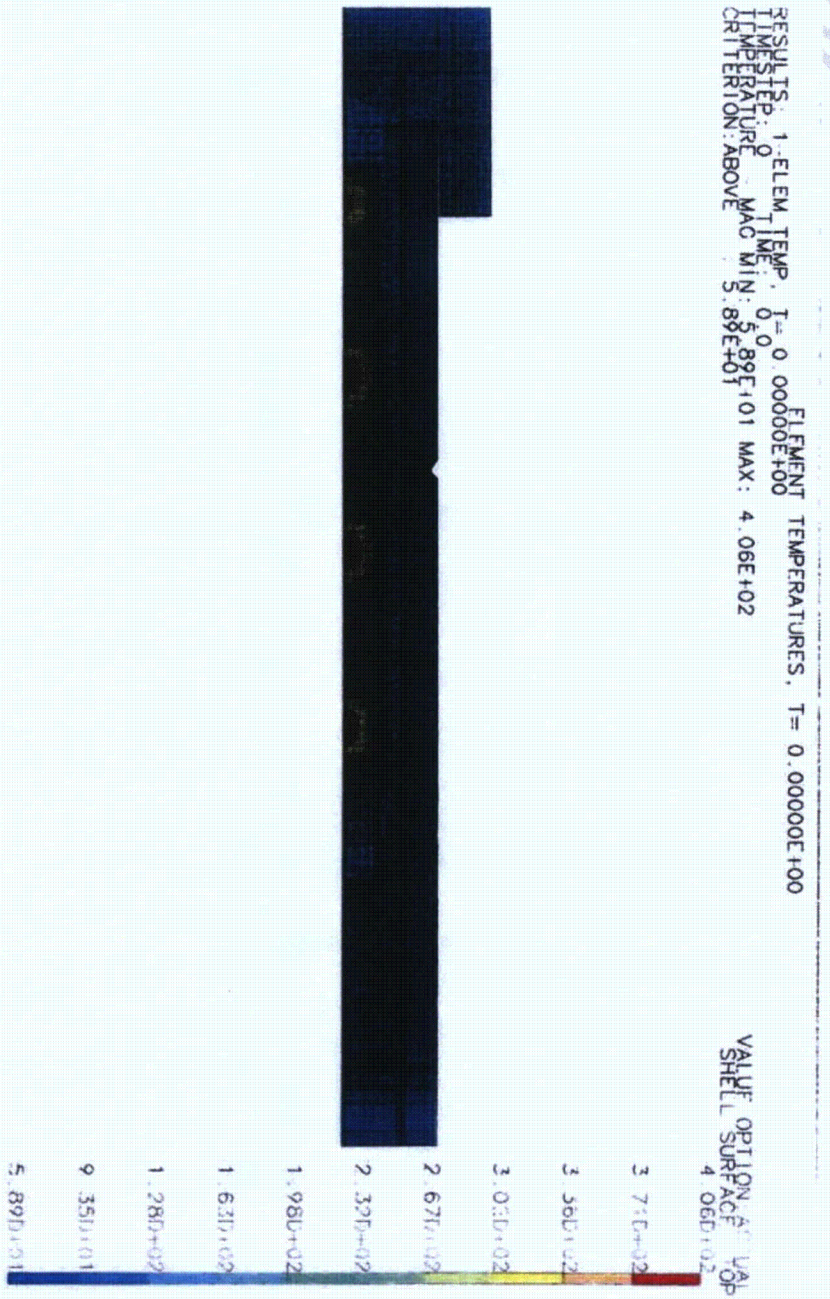
PRESENTATION OF THE MODEL



APPENDIX 9

CONFIGURATION C4.1

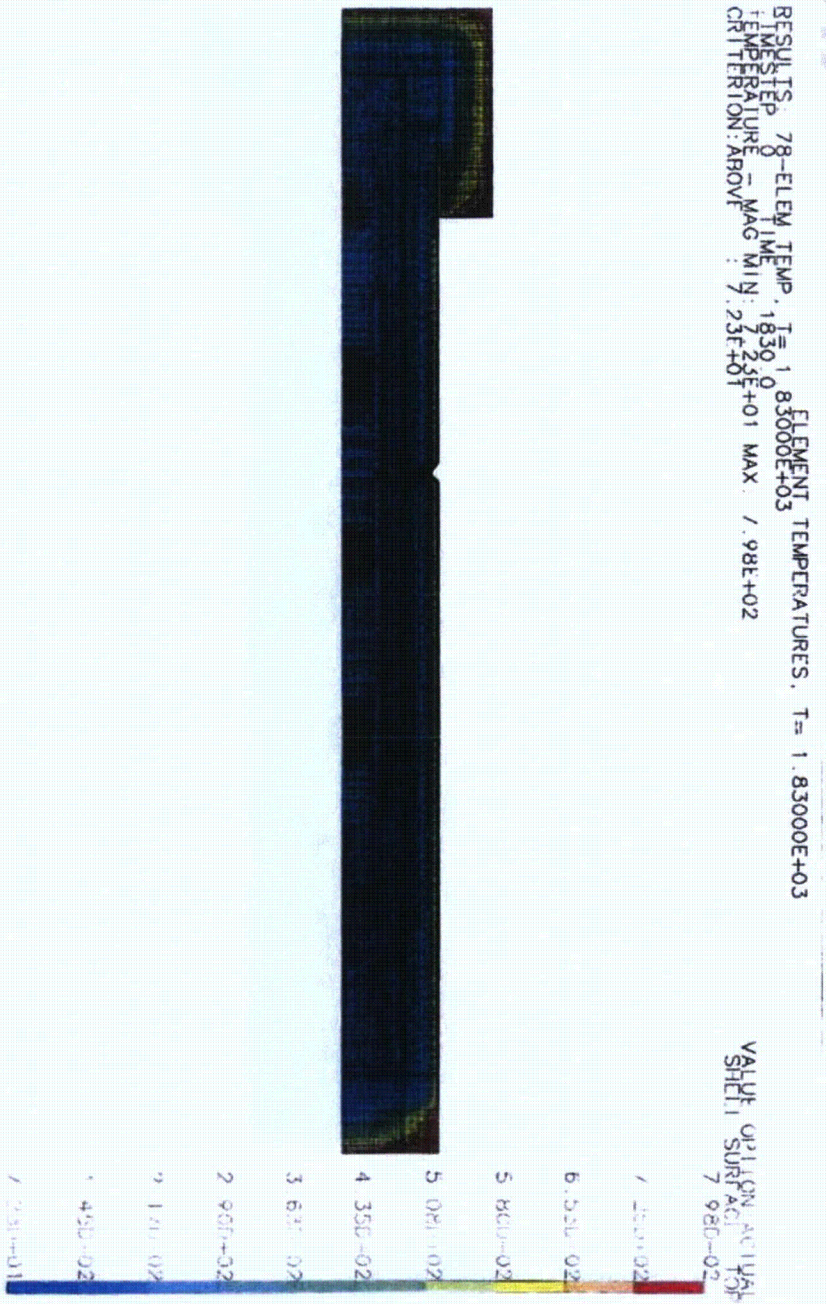
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 9

CONFIGURATION C4.1

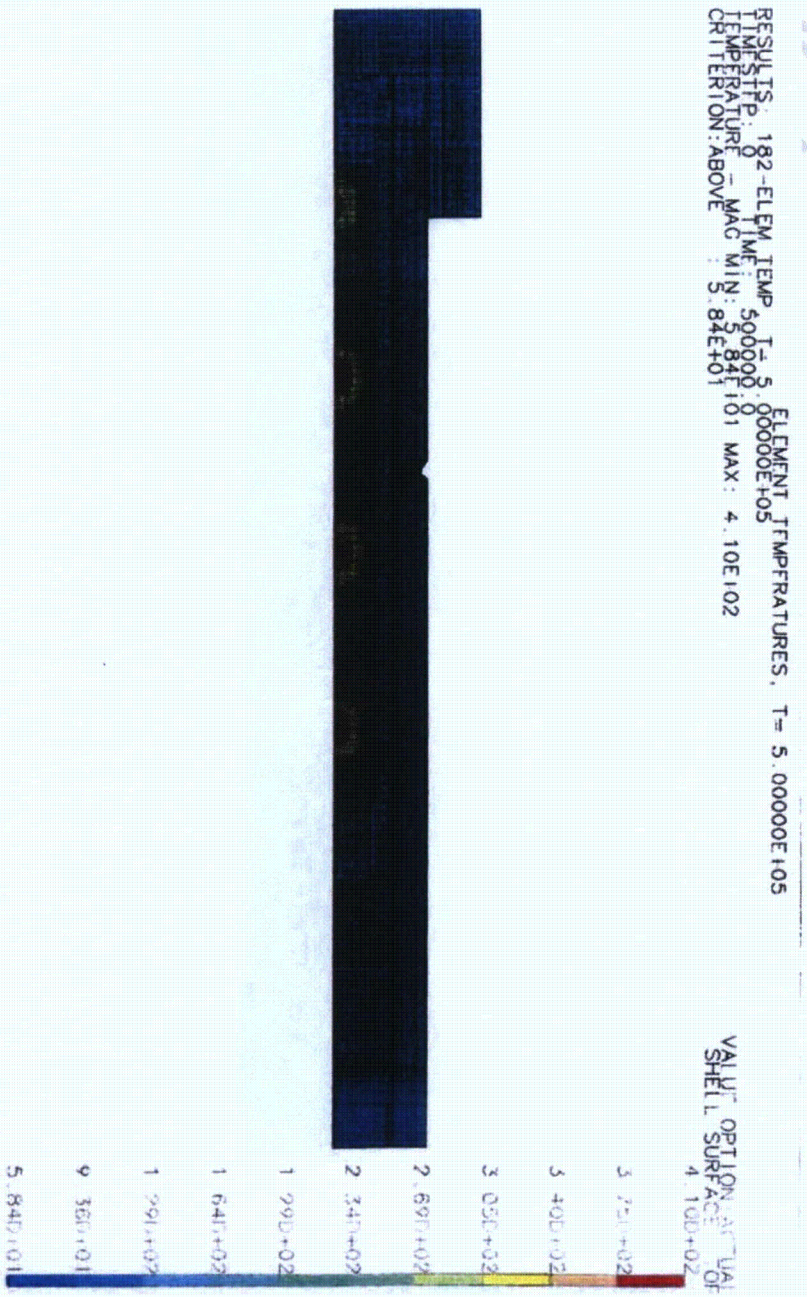
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 9

CONFIGURATION C4.1

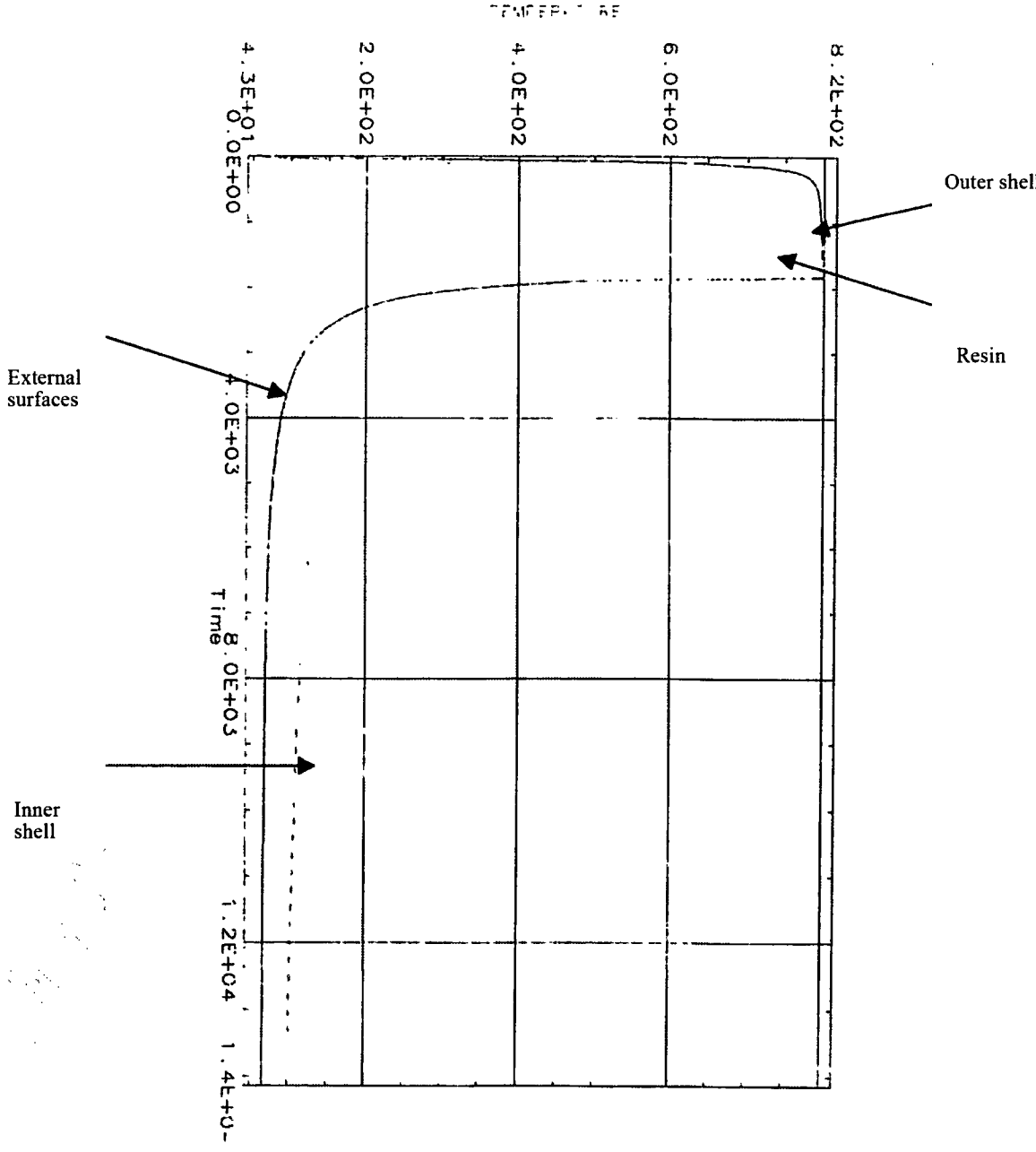
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 9

CONFIGURATION C4.1

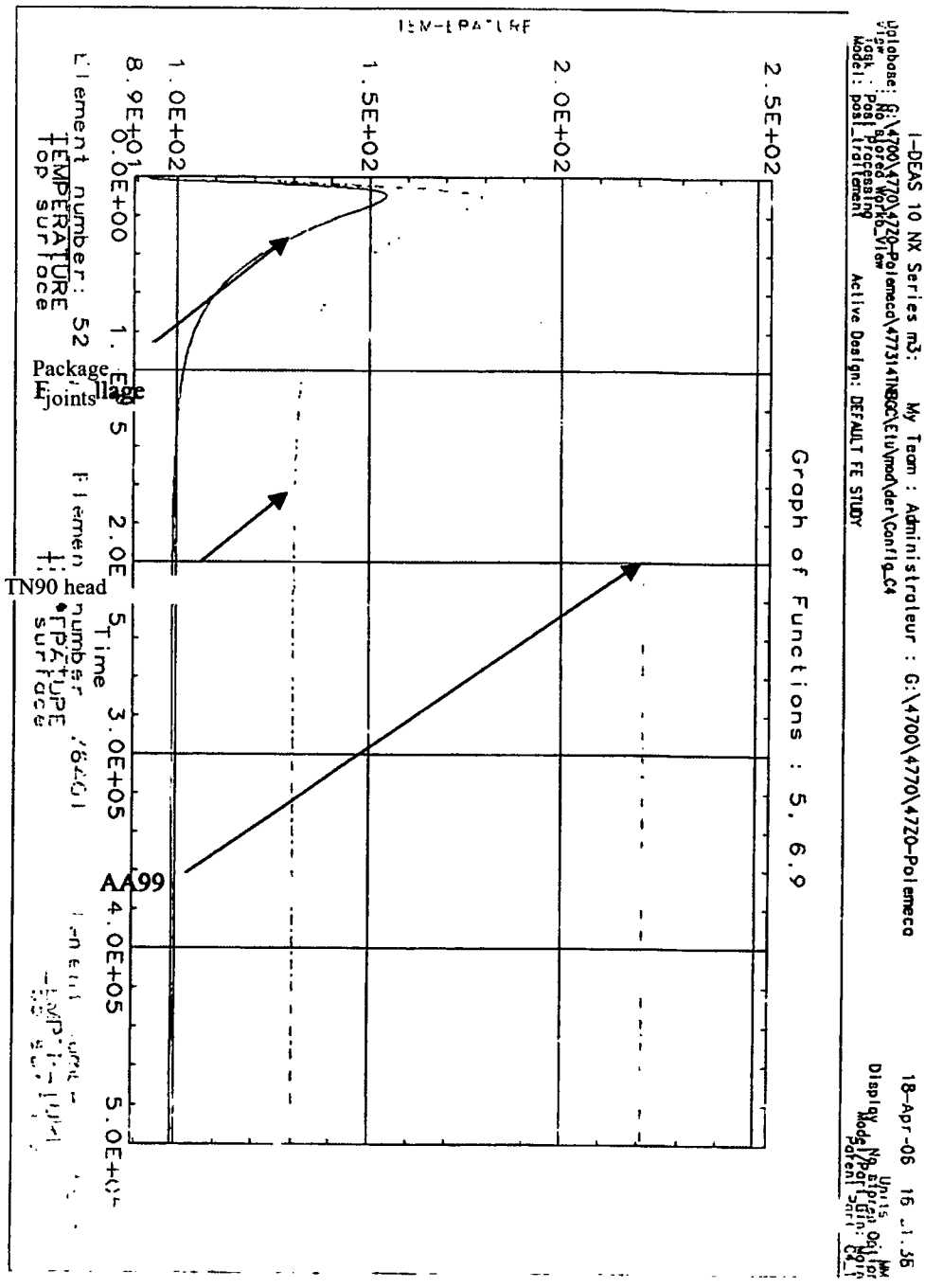
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 9

CONFIGURATION C4.1

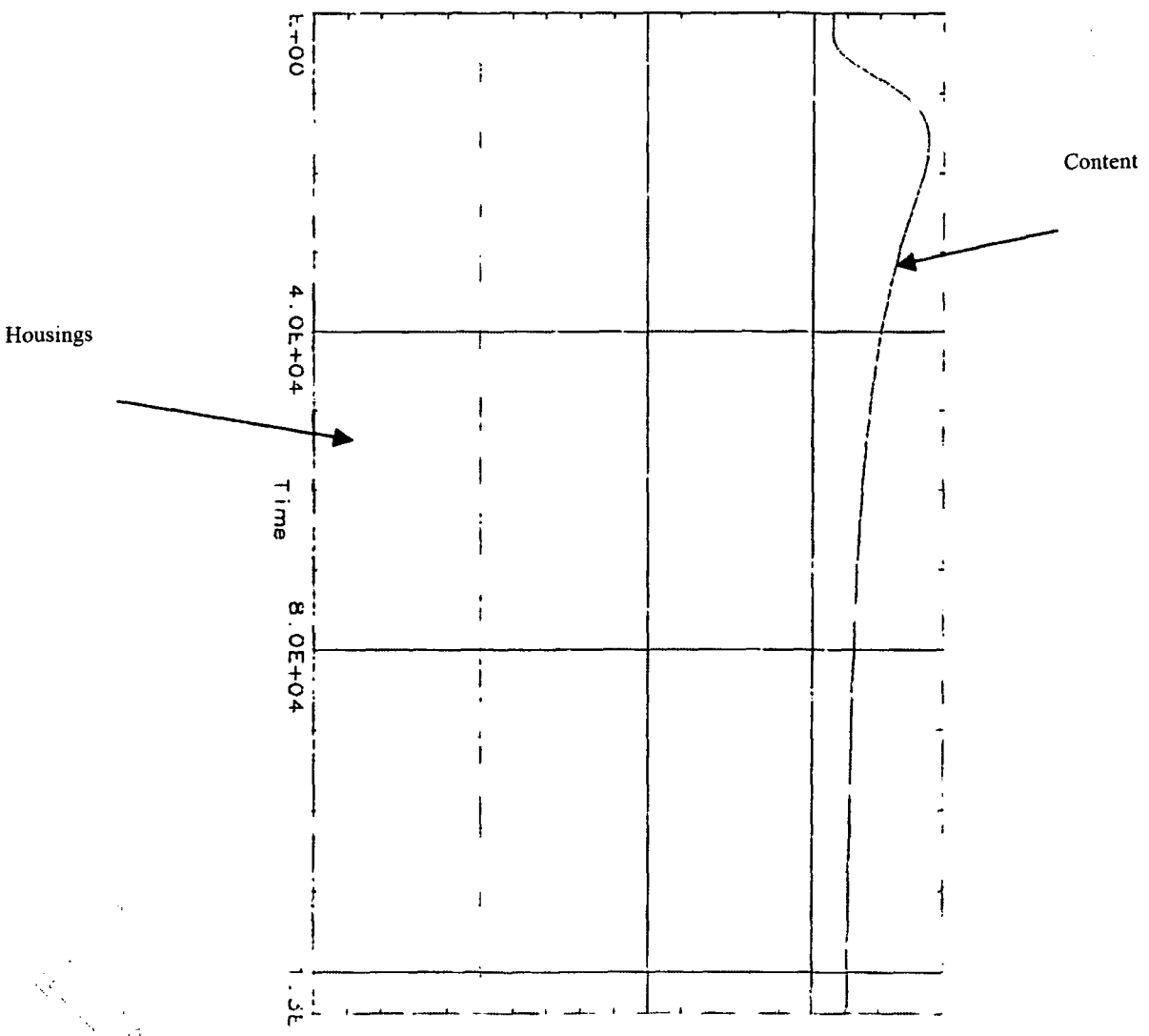
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 9

CONFIGURATION C4.1

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



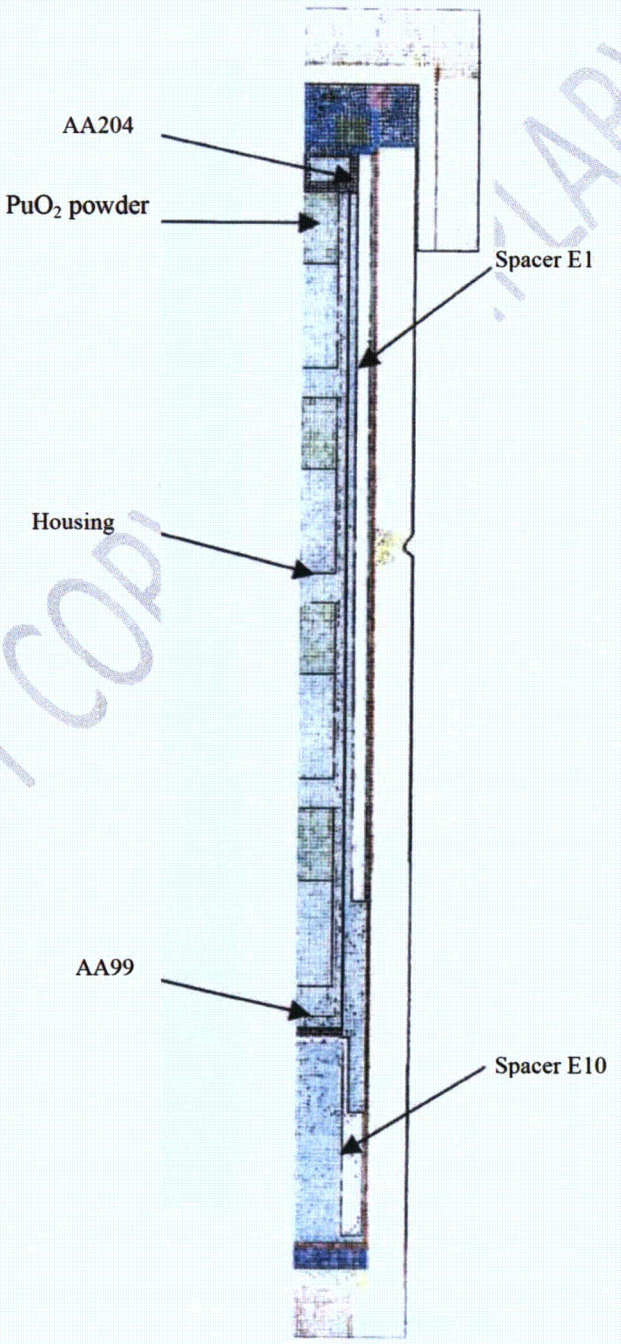
APPENDIX 10

CONFIGURATION C4.2

APPENDIX 10

CONFIGURATION C4.2

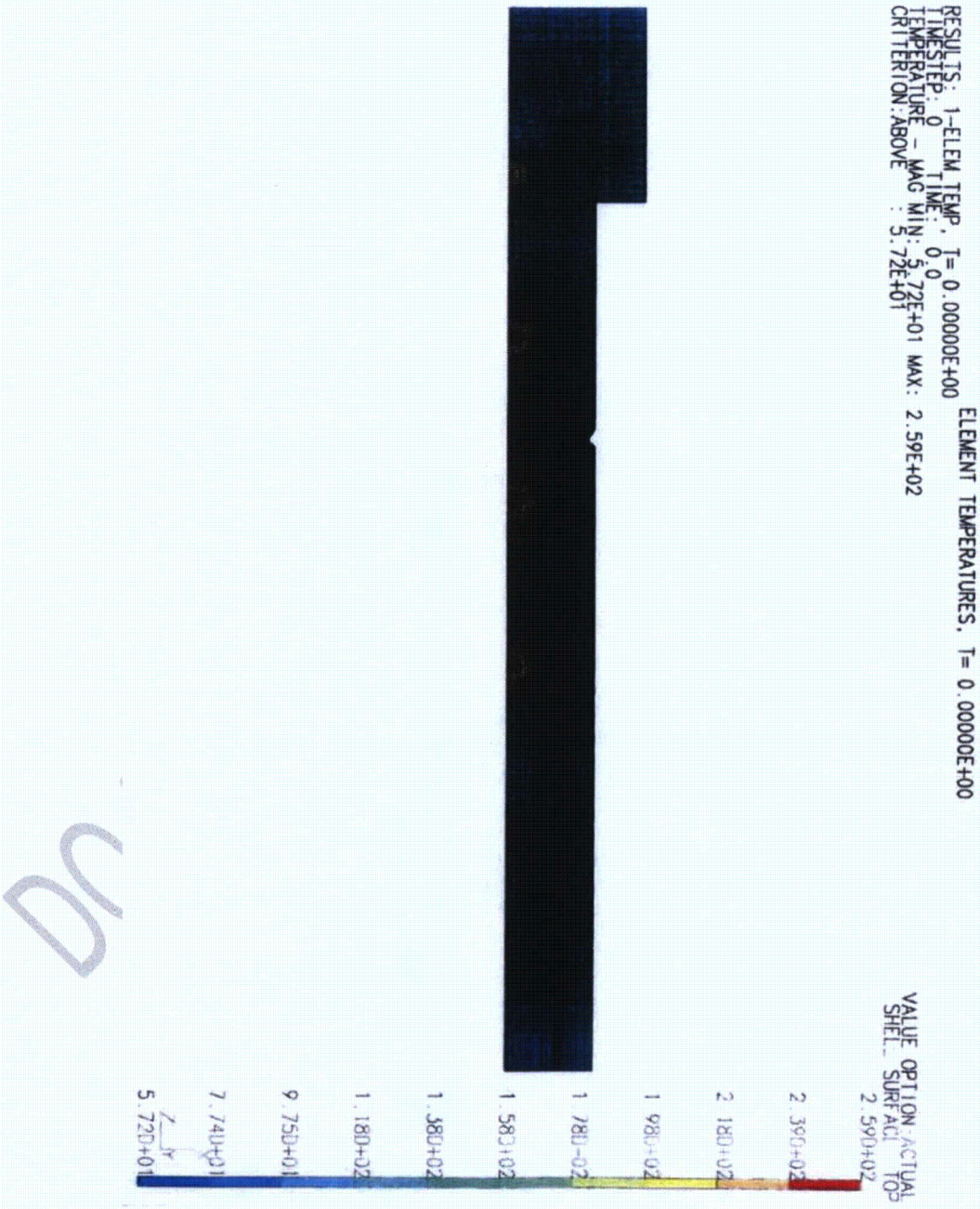
PRESENTATION OF THE MODEL



APPENDIX 10

CONFIGURATION C4.2

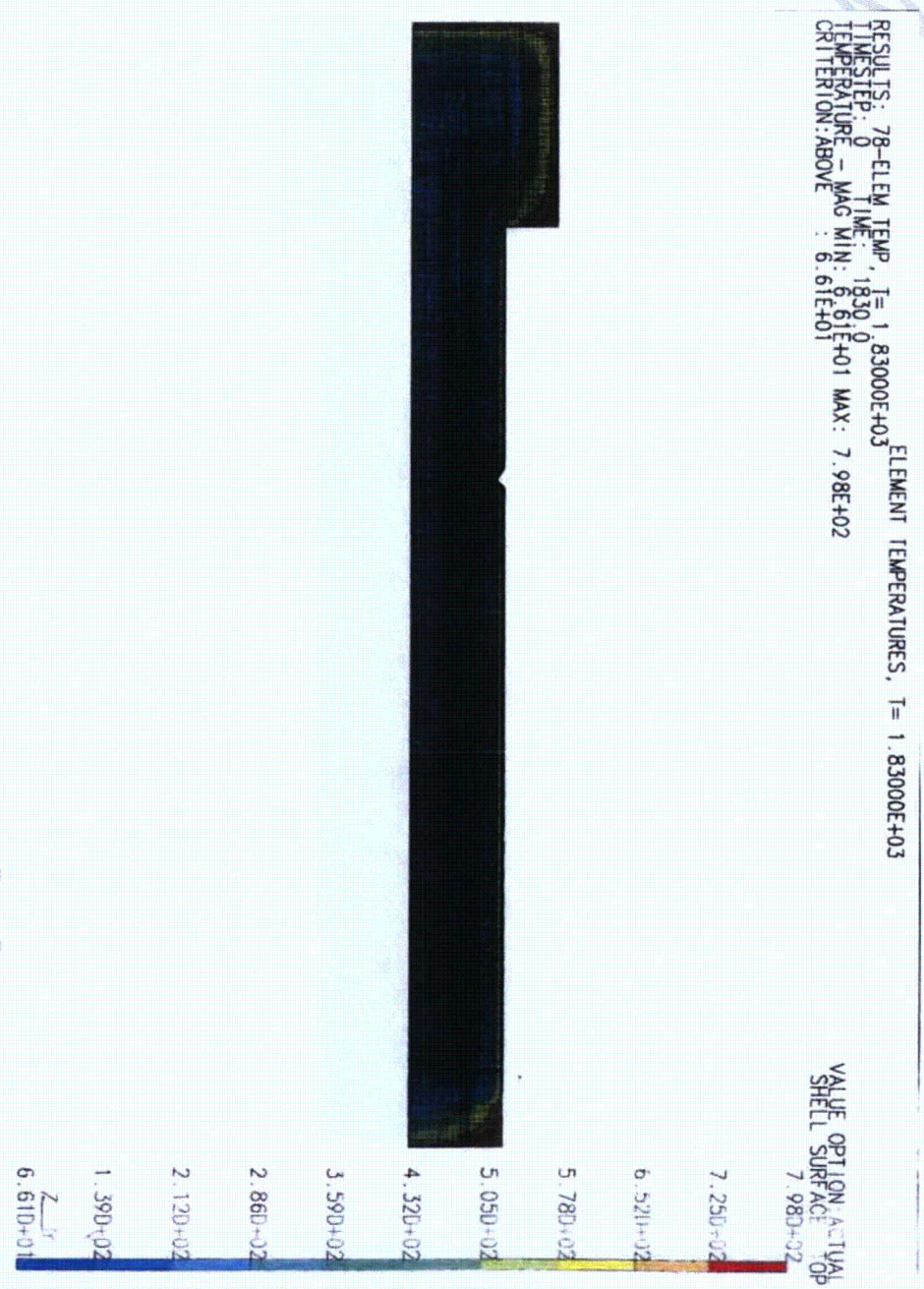
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 10

CONFIGURATION C4.2

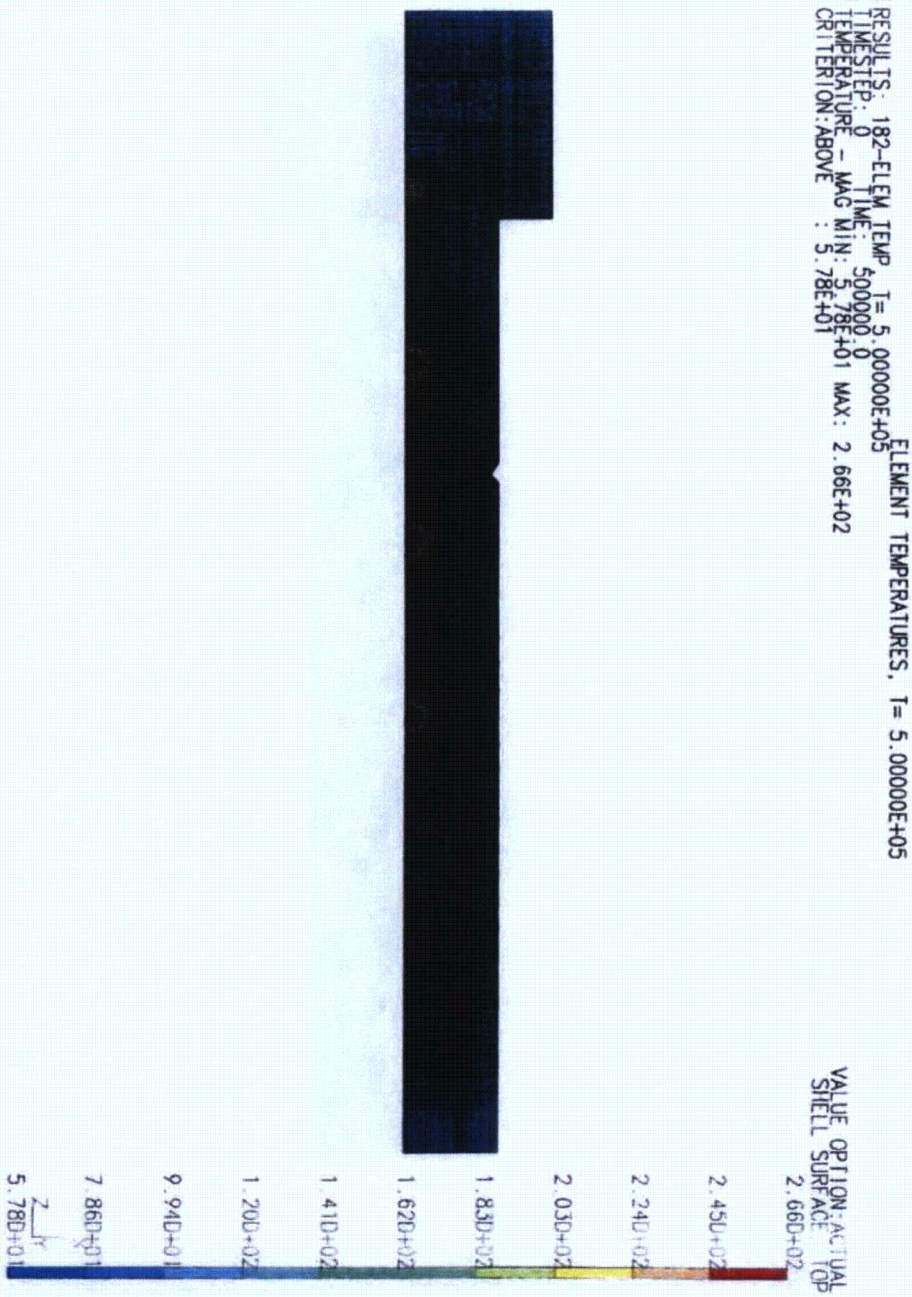
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 10

CONFIGURATION C4.2

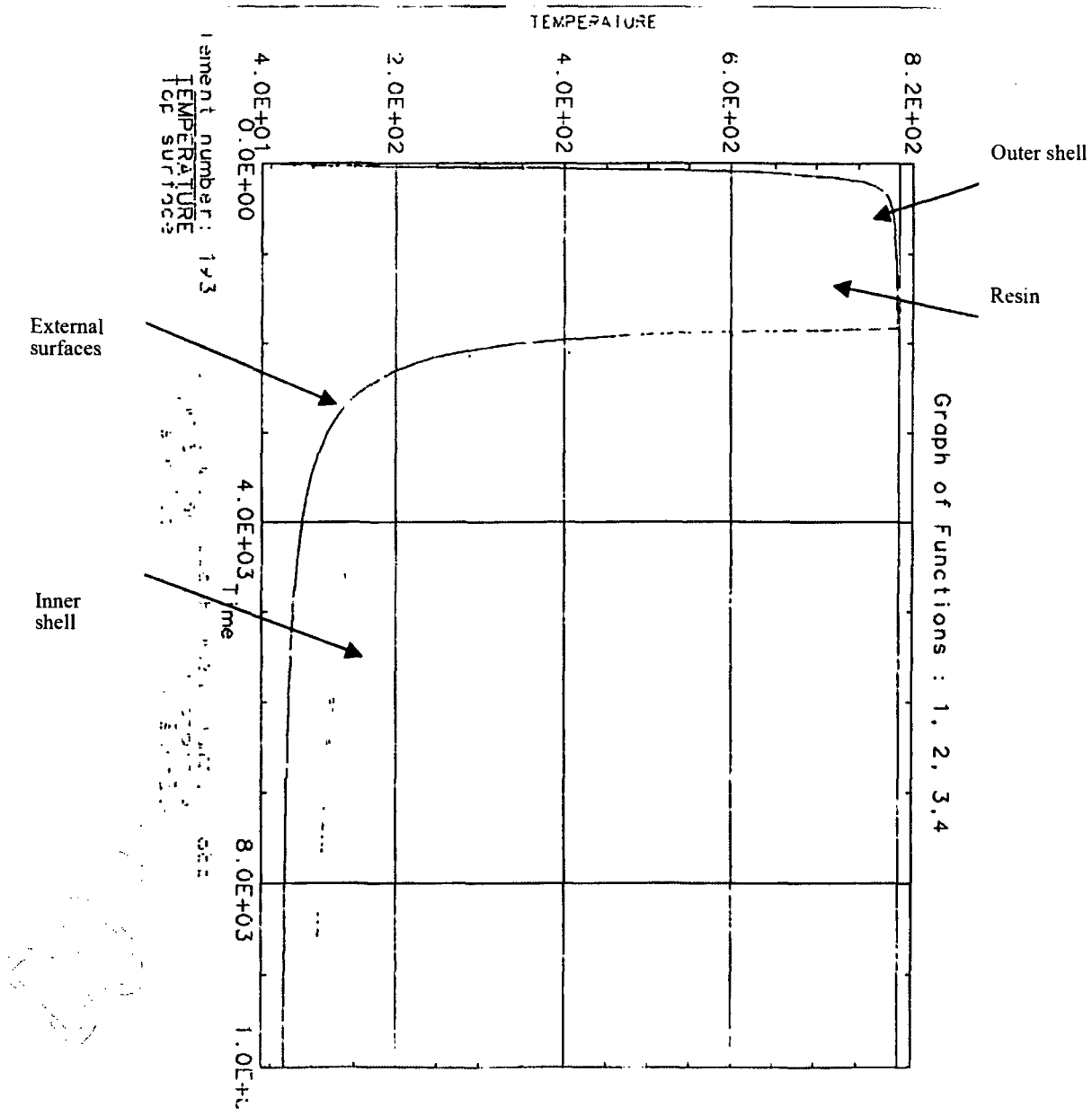
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 10

CONFIGURATION C4.2

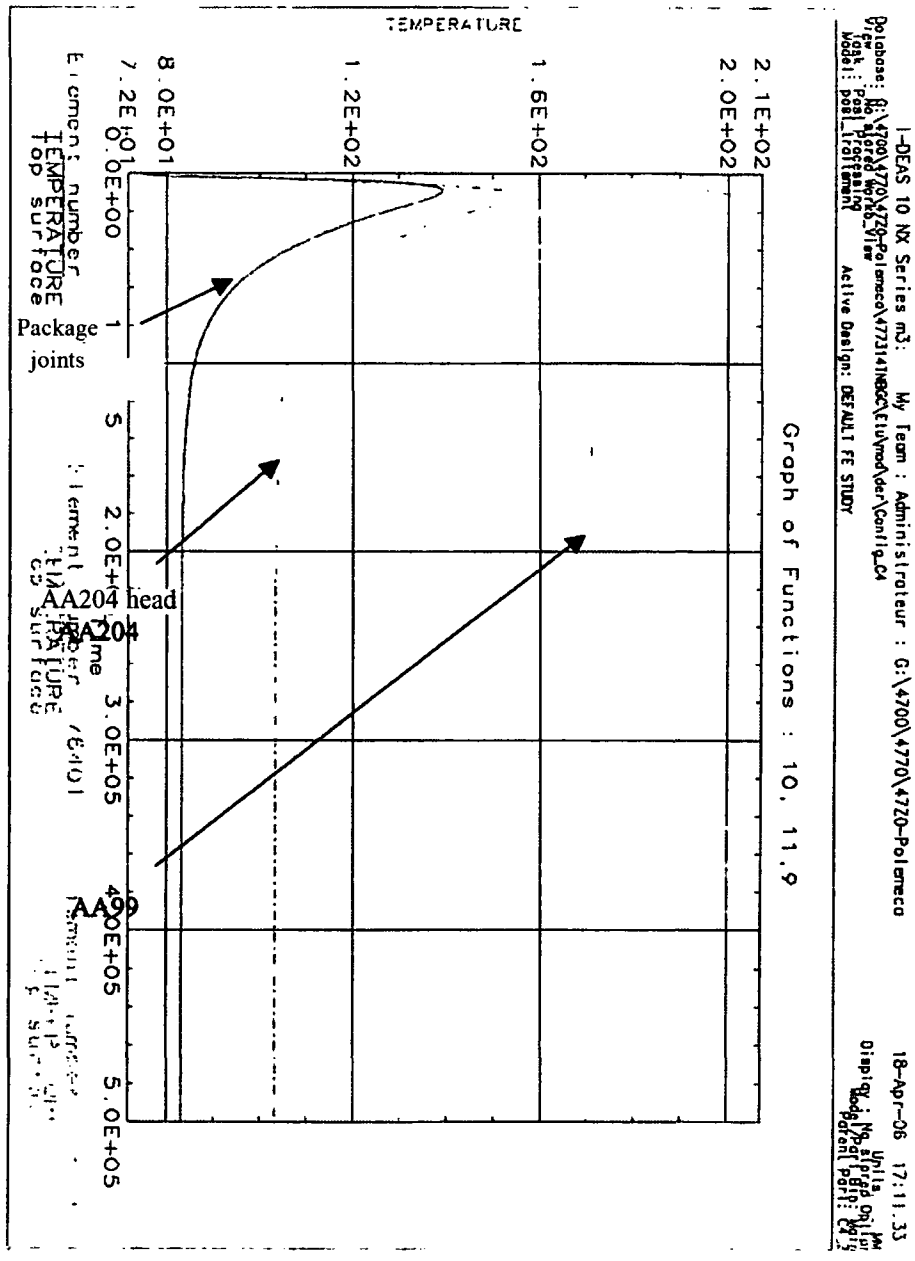
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 10

CONFIGURATION C4.2

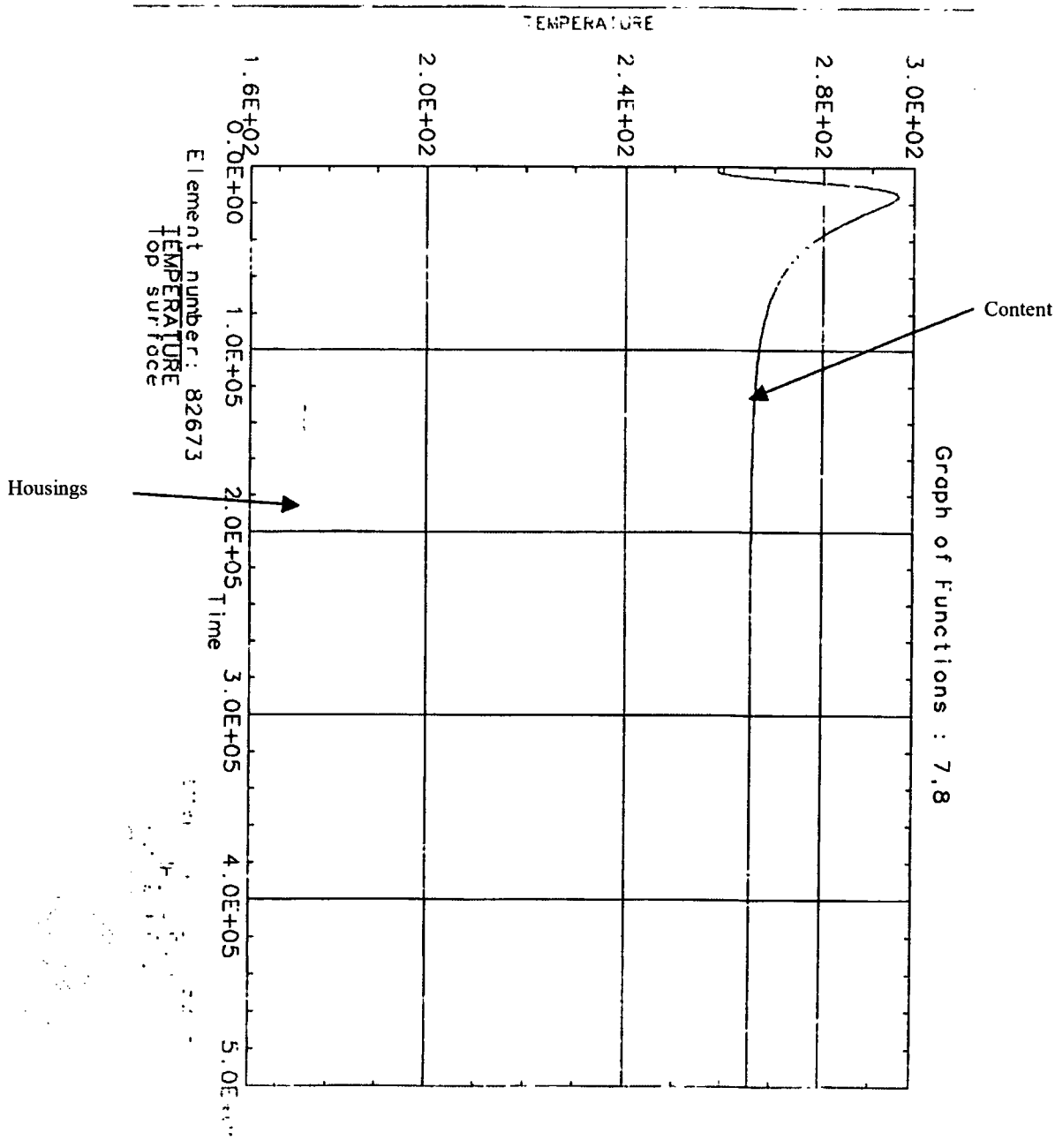
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 10

CONFIGURATION C4.2

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



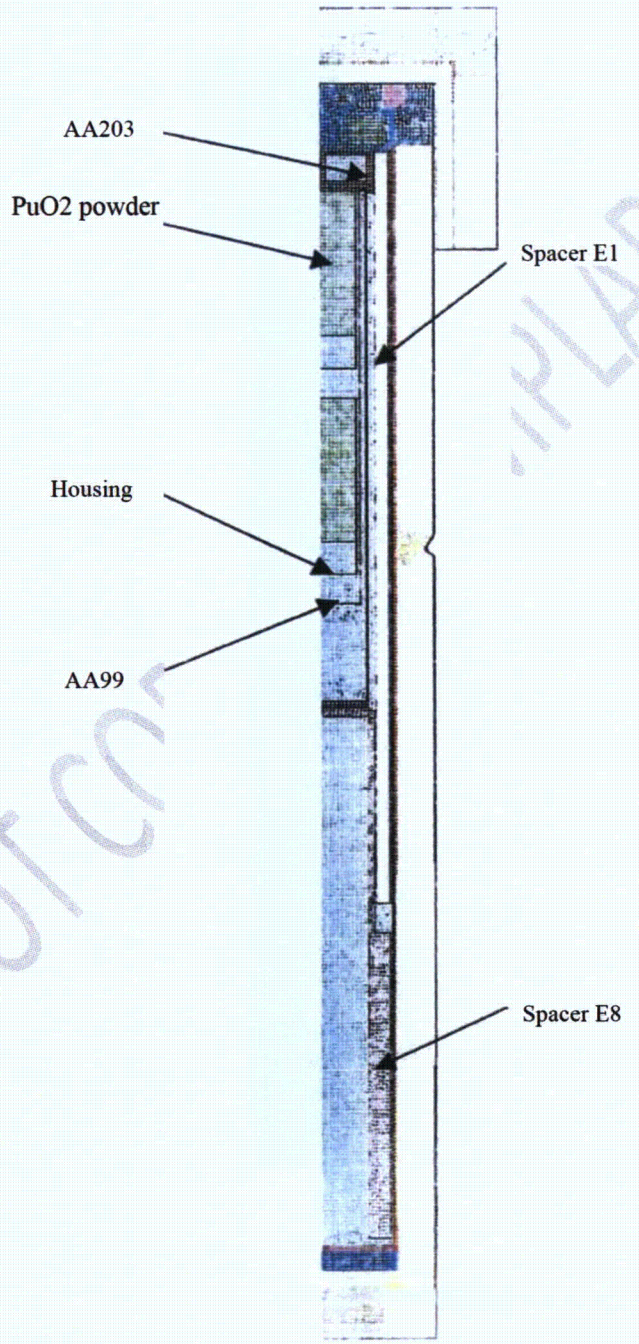
APPENDIX 11

CONFIGURATION C4.3

APPENDIX 11

CONFIGURATION C4.3

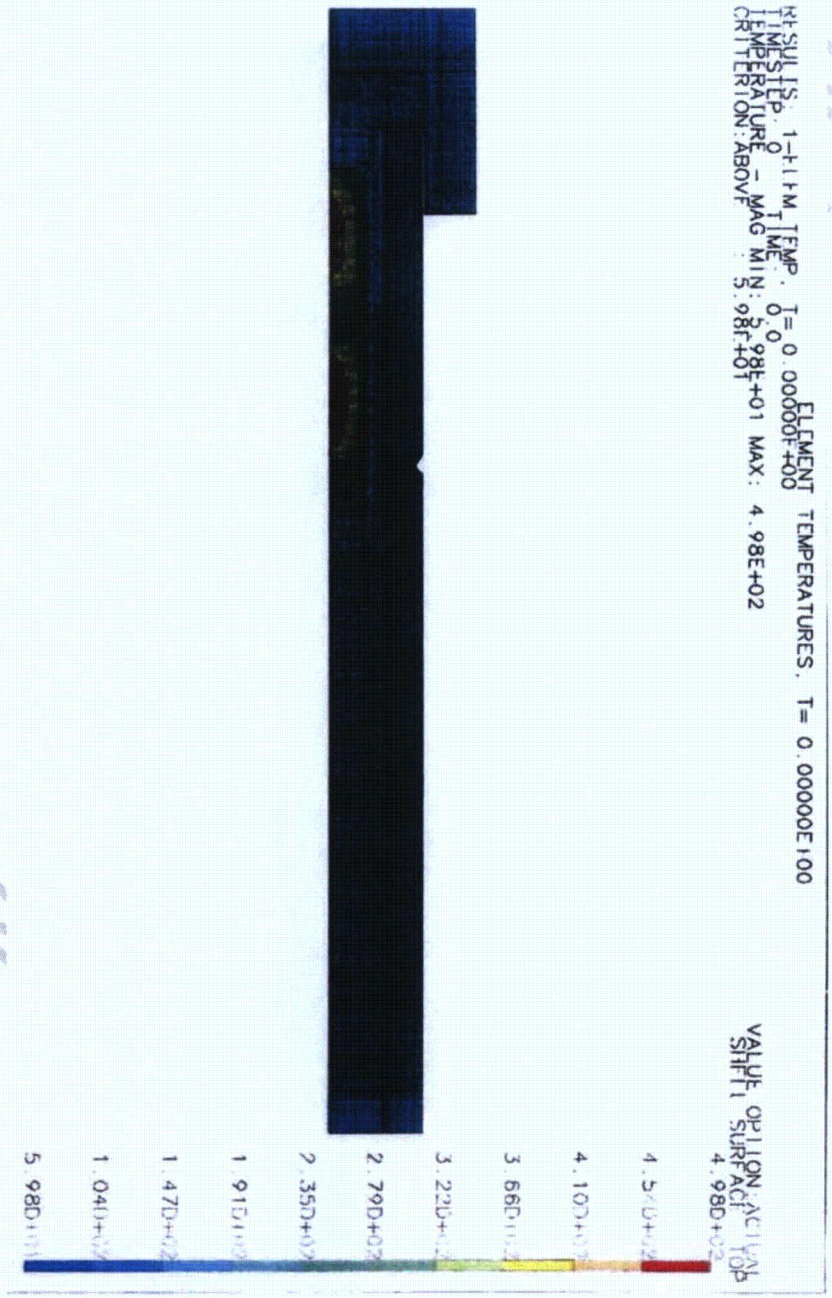
PRESENTATION OF THE MODEL



APPENDIX 11

CONFIGURATION C4.3

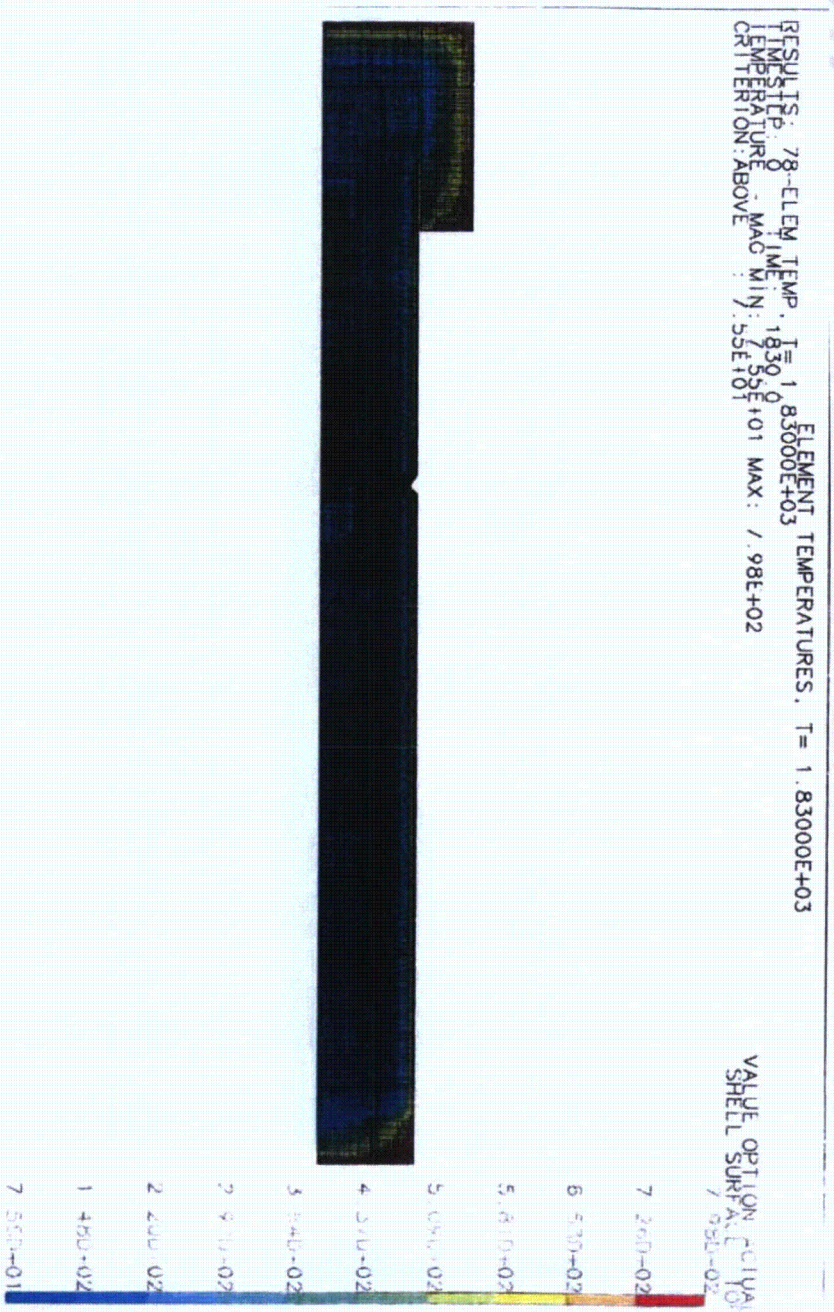
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 11

CONFIGURATION C4.3

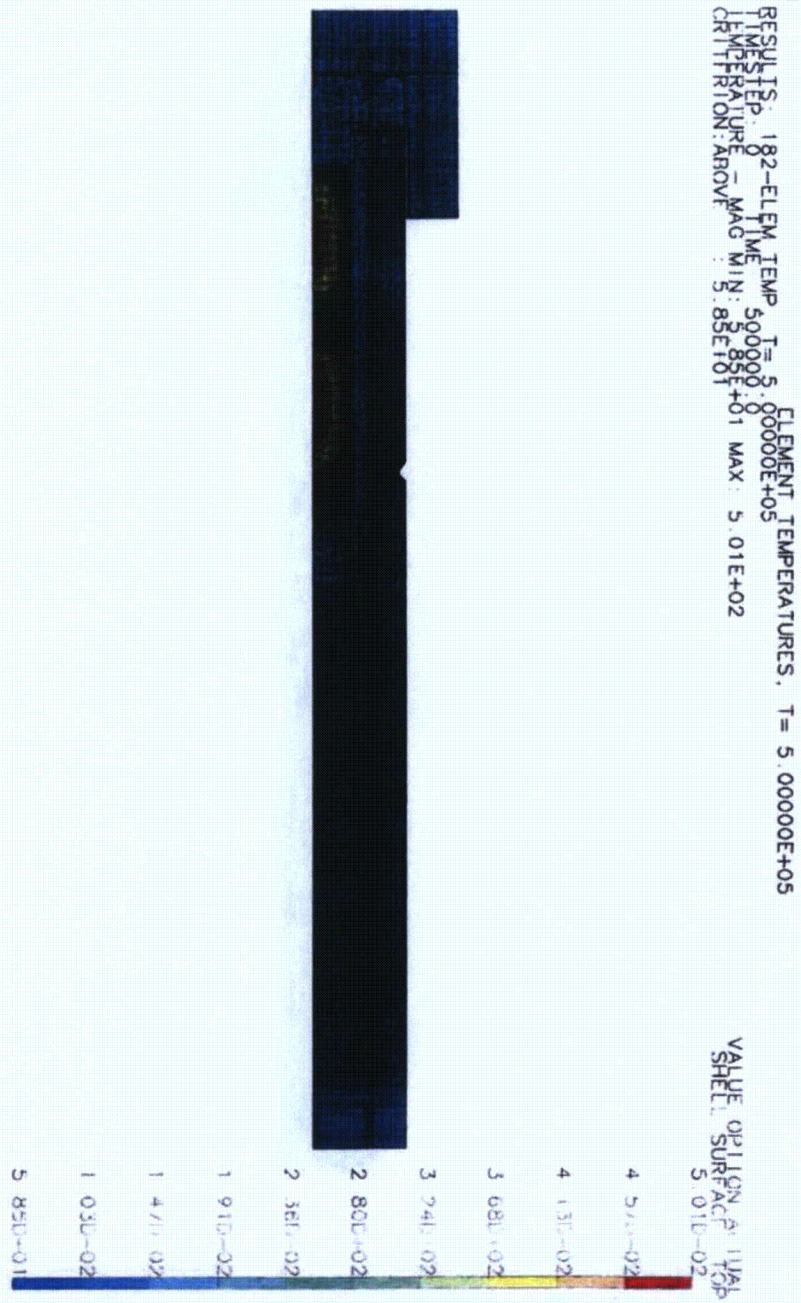
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 11

CONFIGURATION C4.3

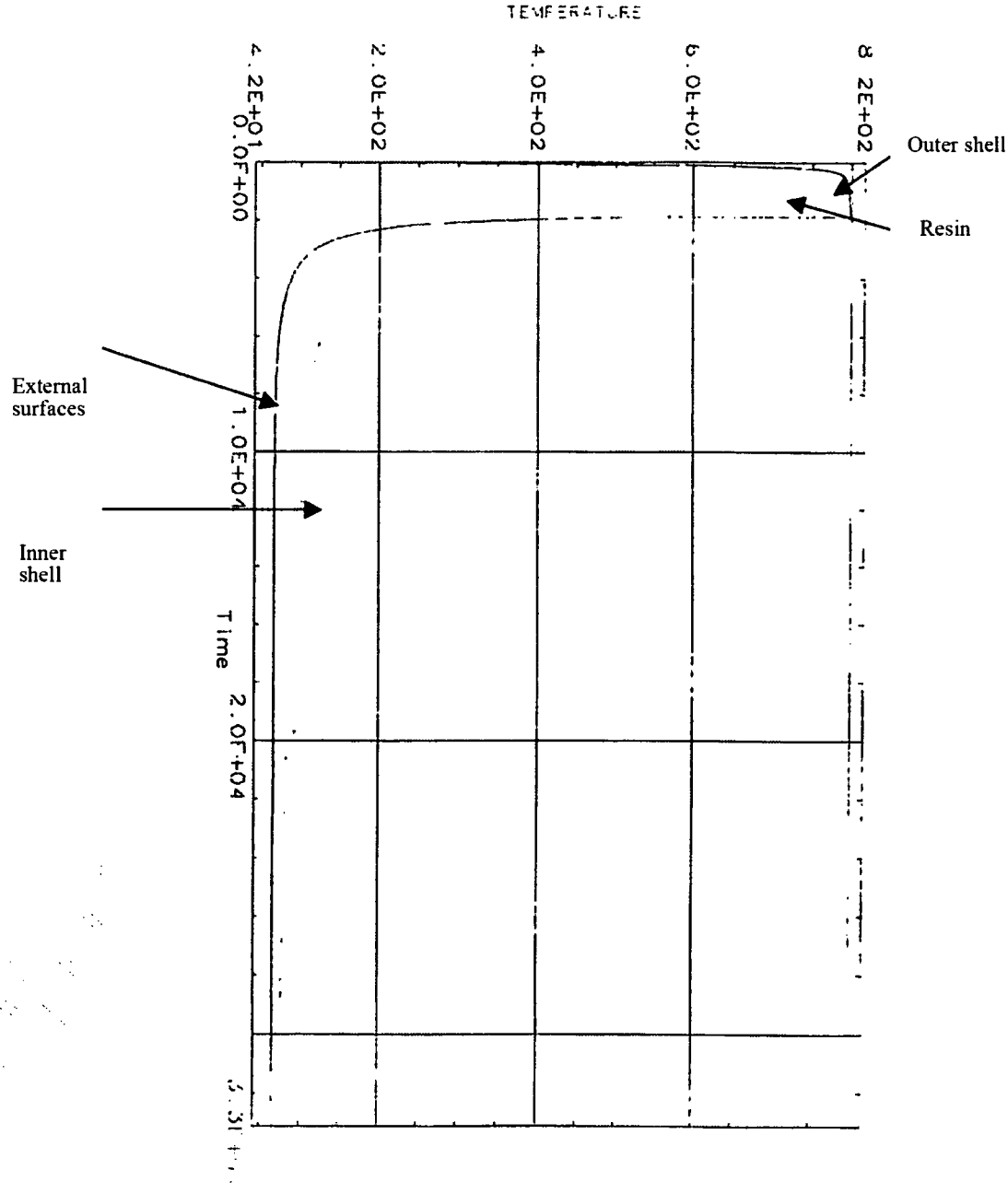
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 11

CONFIGURATION C4.3

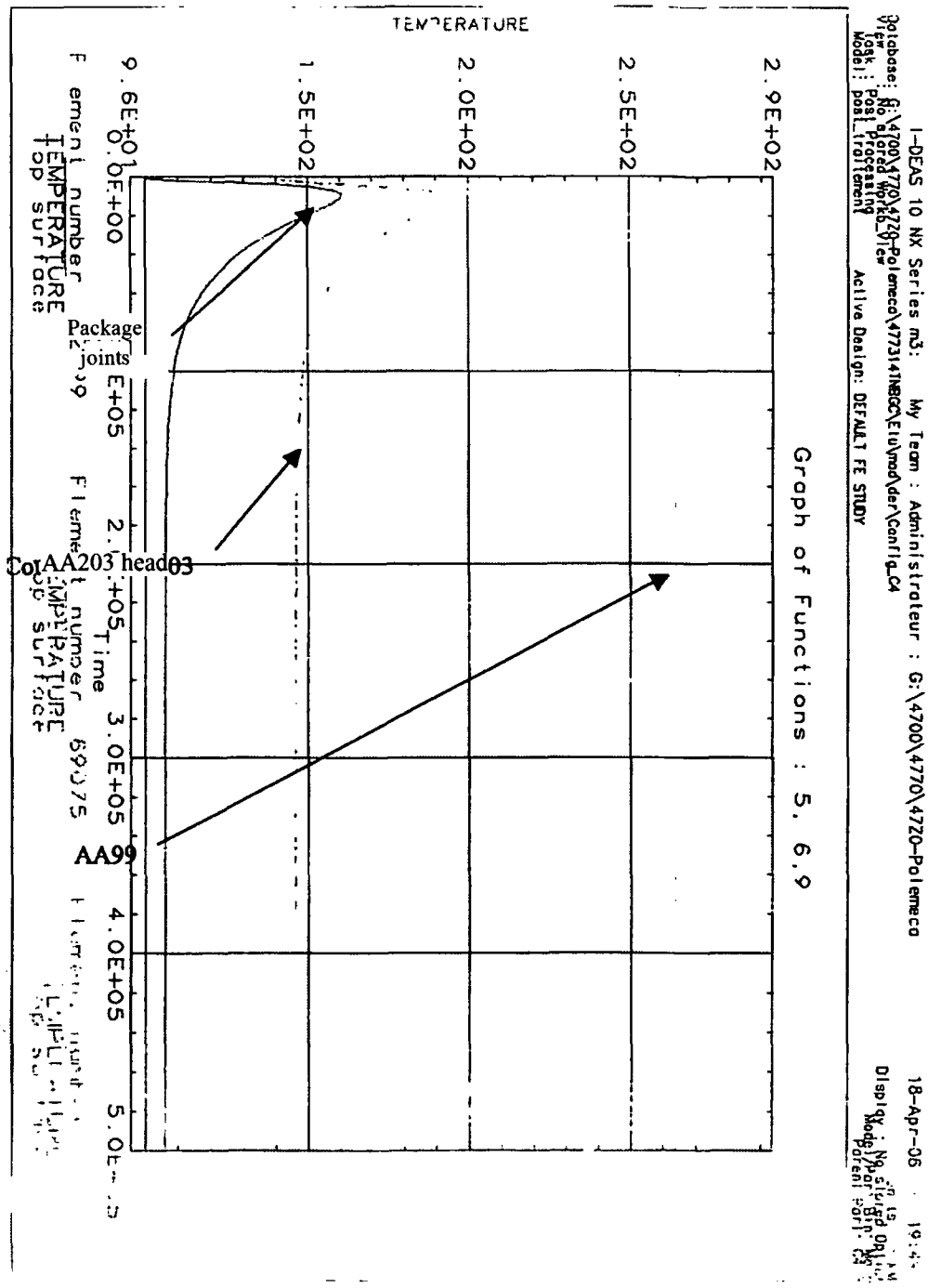
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 11

CONFIGURATION C4.3

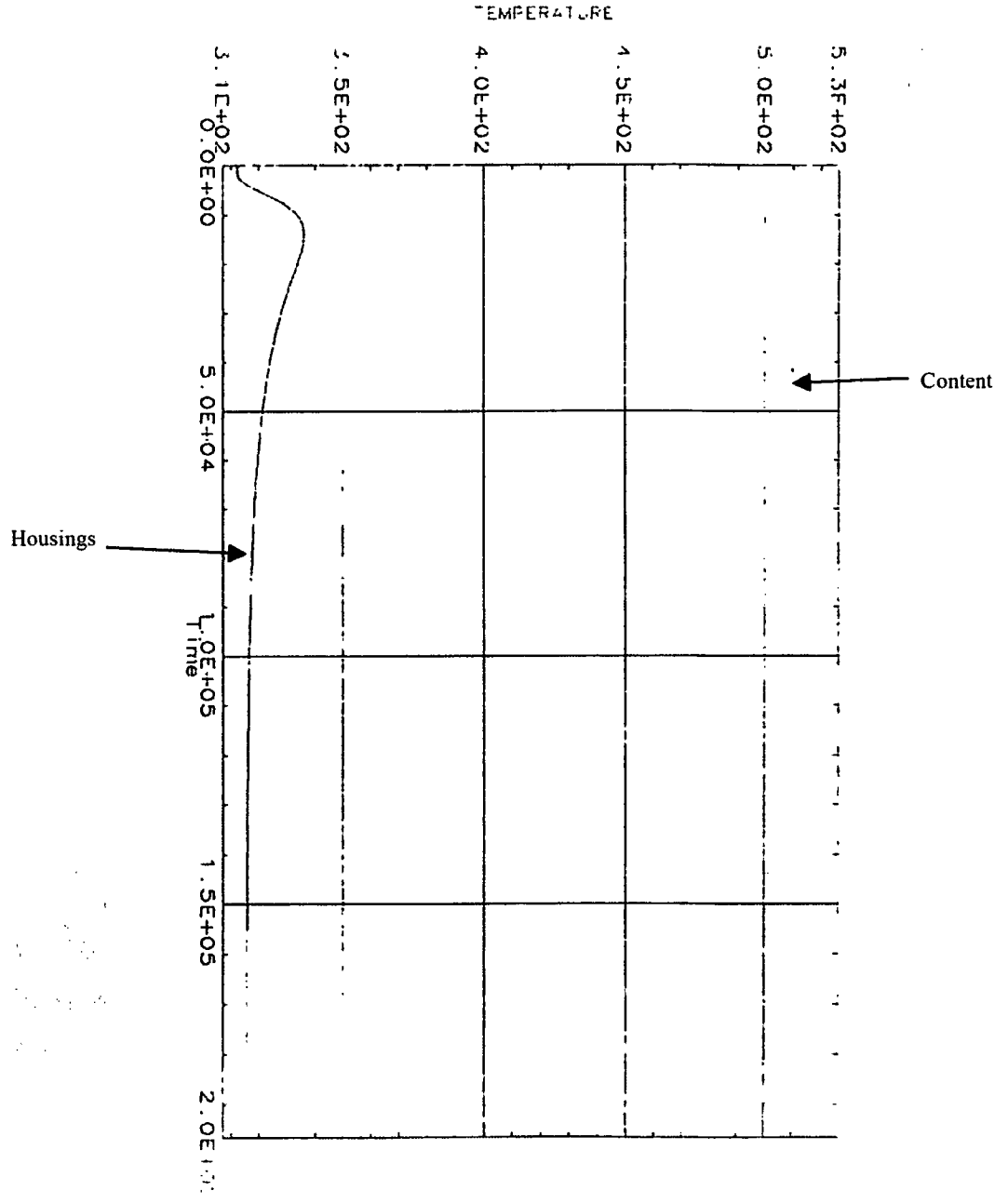
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 11

CONFIGURATION C4.3

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



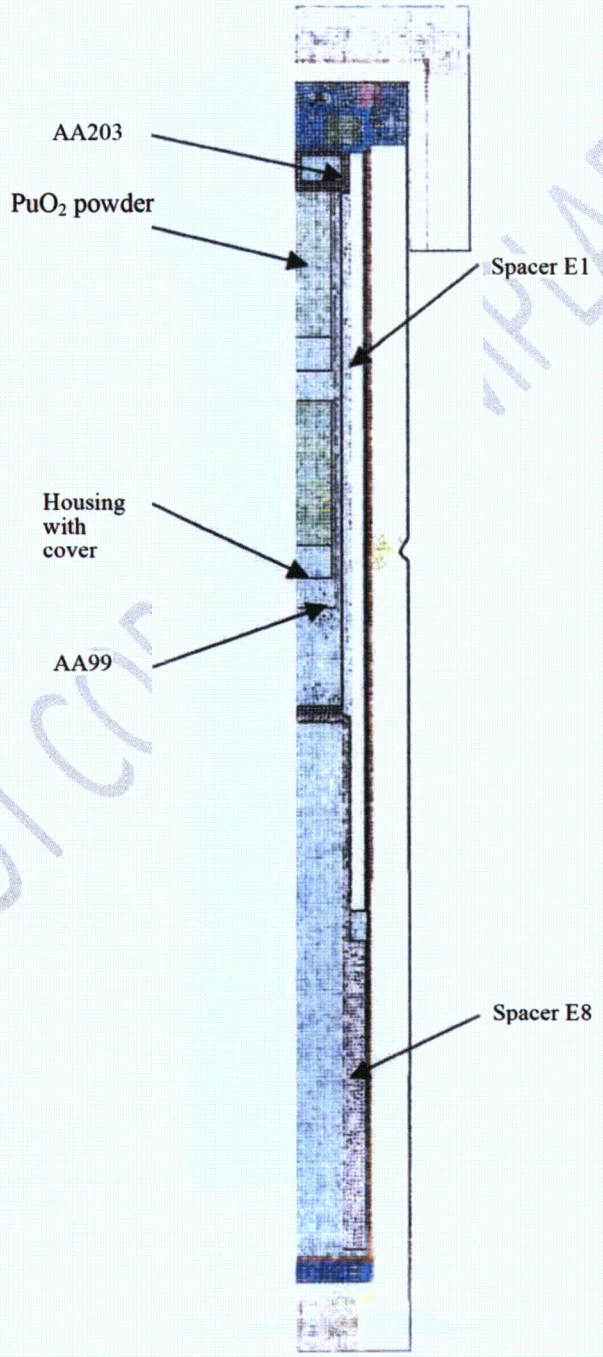
APPENDIX 12

CONFIGURATION C4.4

APPENDIX 12

CONFIGURATION C4.4

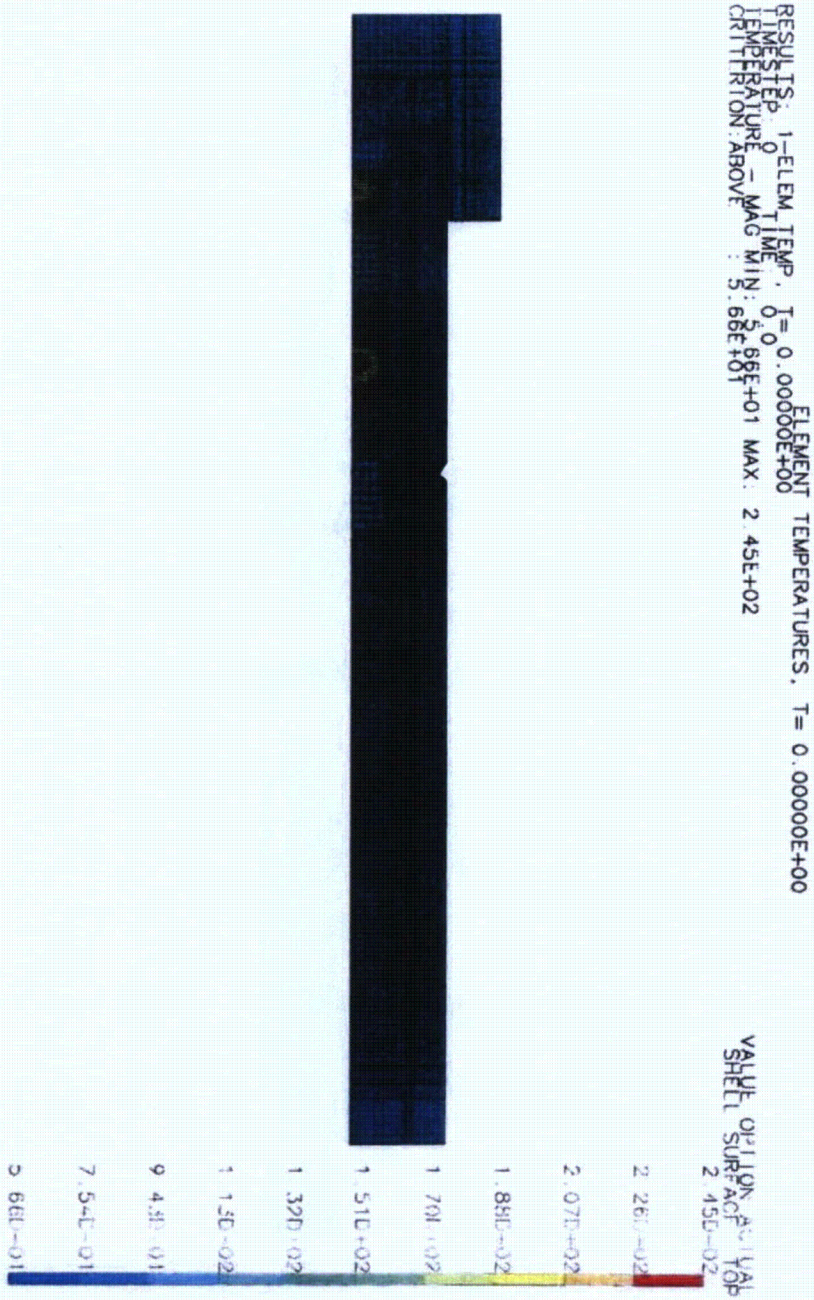
PRESENTATION OF THE MODEL



APPENDIX 12

CONFIGURATION C4.4

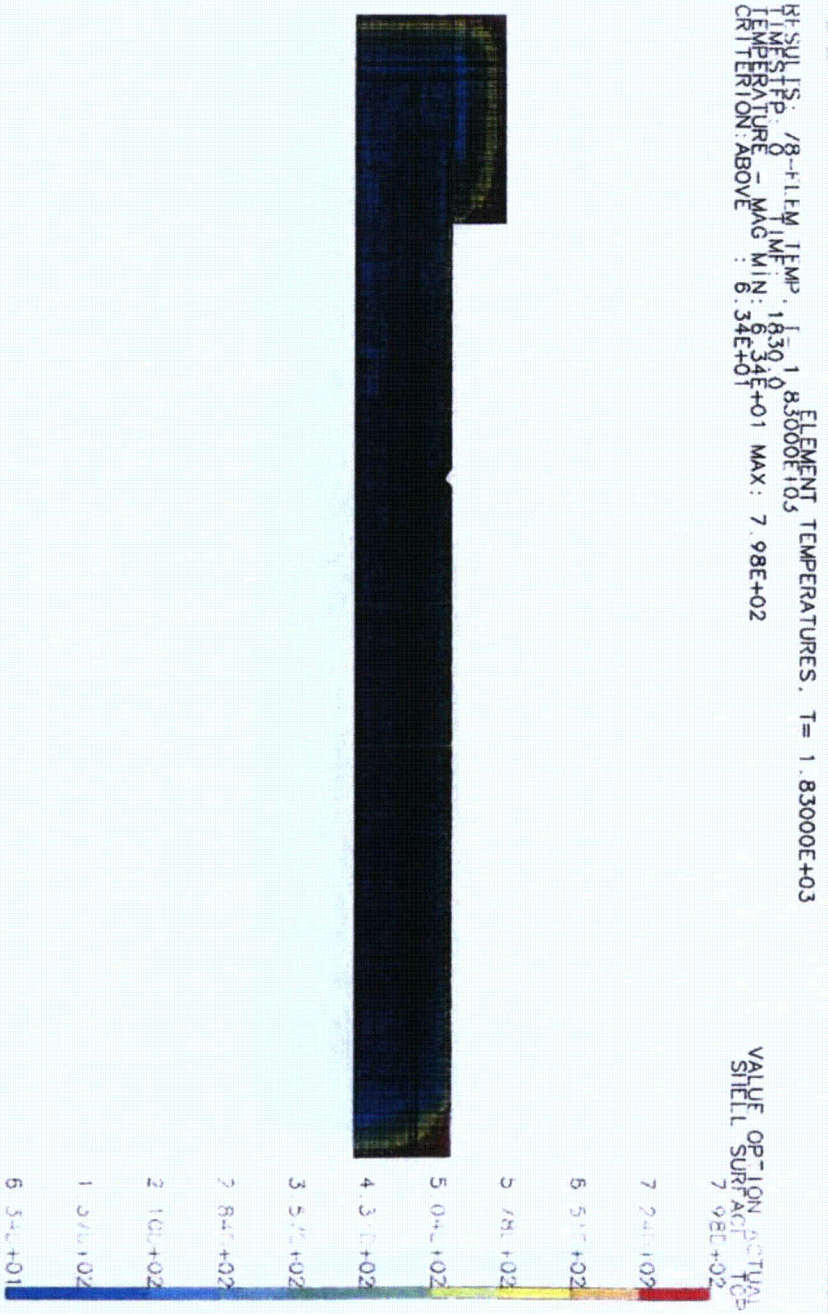
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 12

CONFIGURATION C4.4

PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 12

CONFIGURATION C4.4

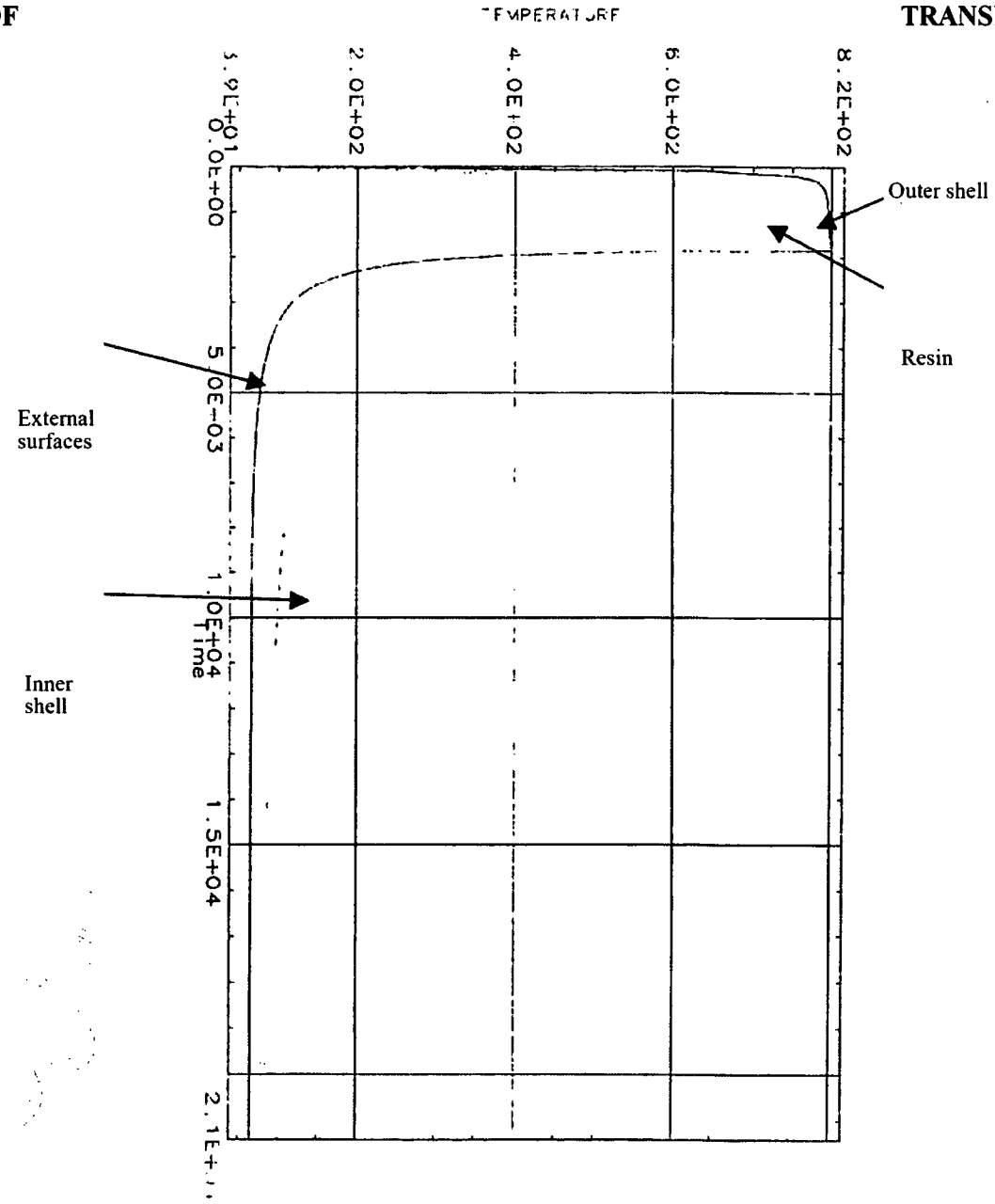
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s

APPENDIX 12

CONFIGURATION C4.4

GRAPH OF VARIATION IN PACKAGE TEMPERATURE

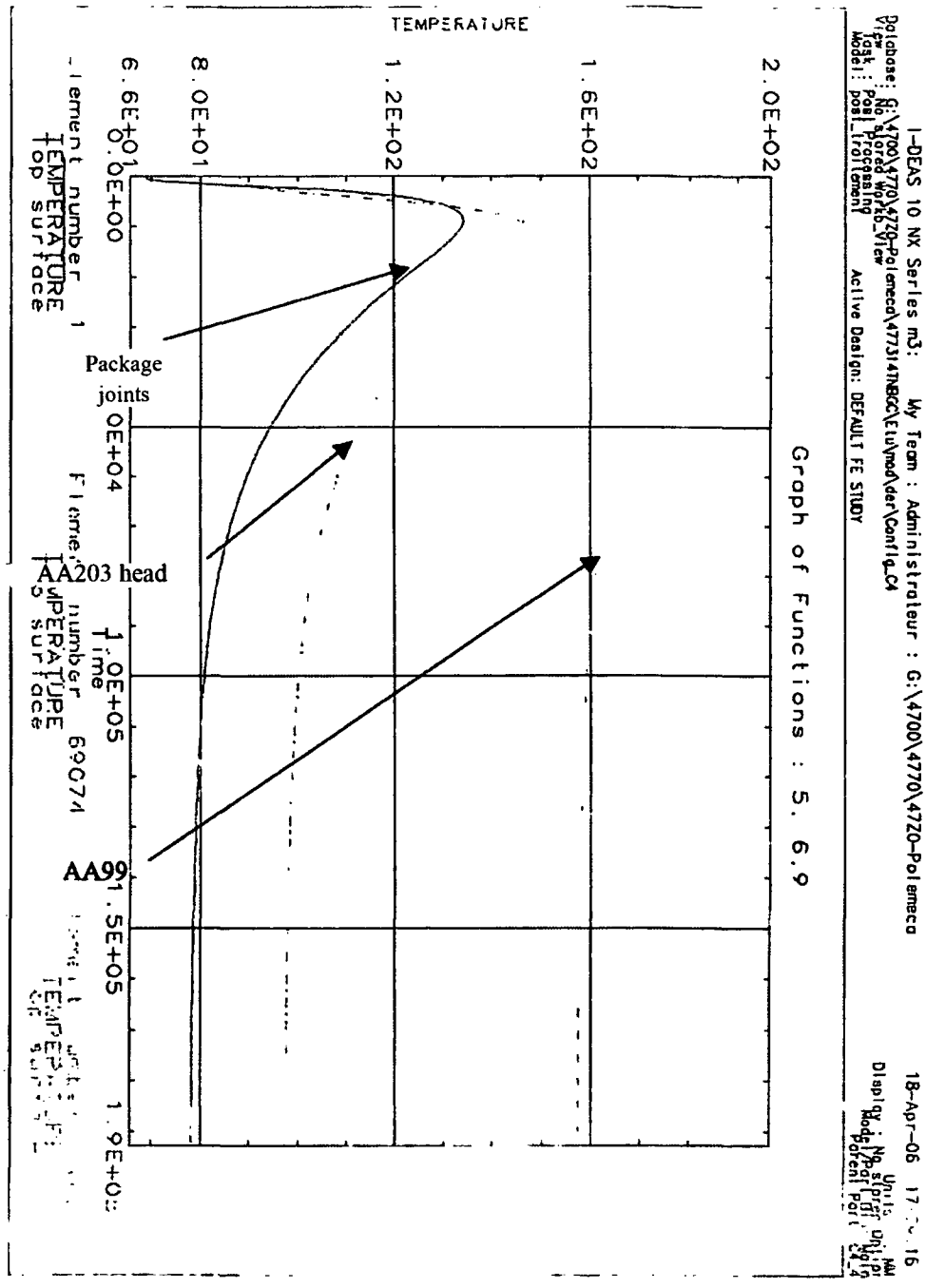
ACCIDENT OF **CONDITIONS TRANSPORT**



APPENDIX 12

CONFIGURATION C4.4

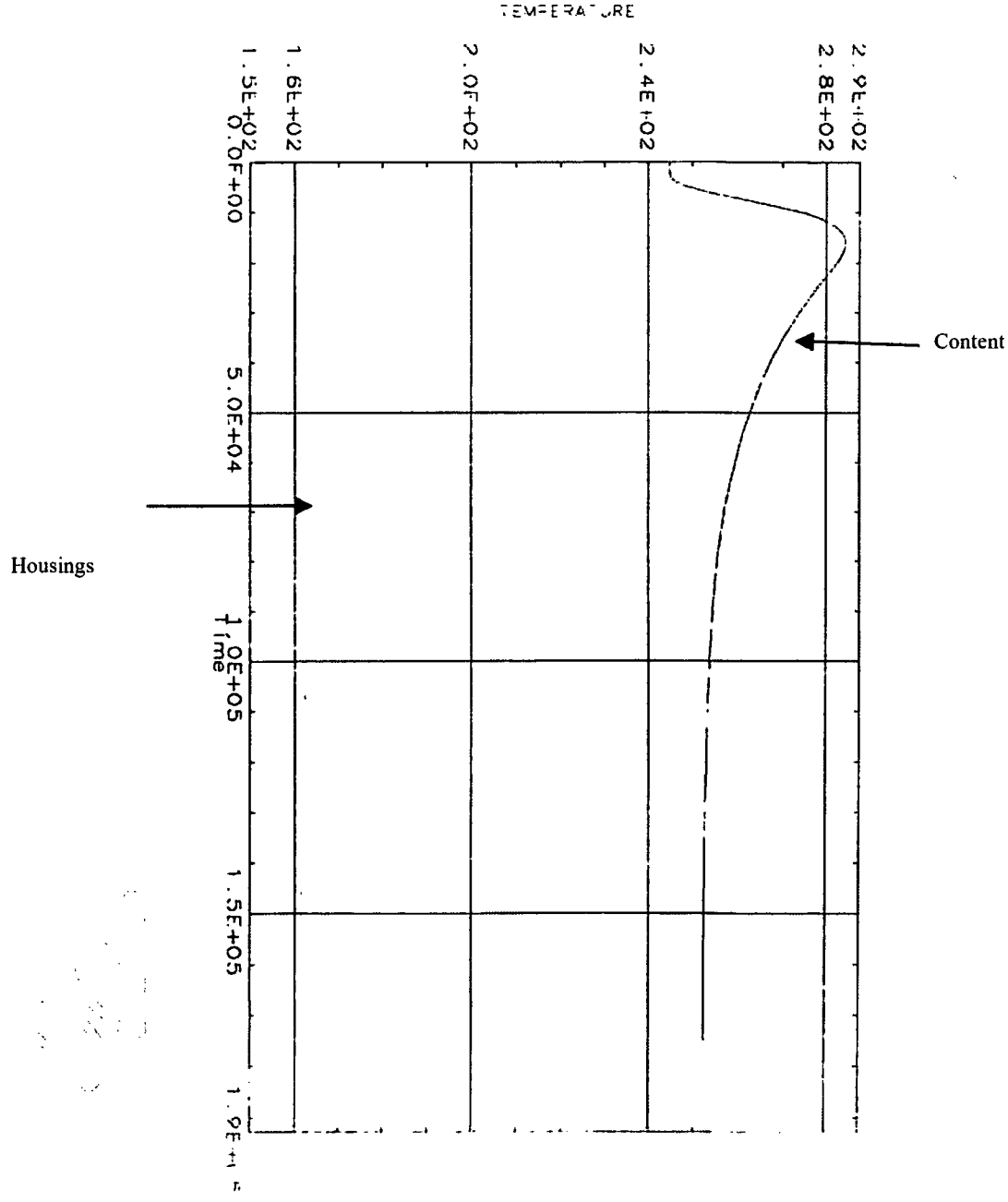
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 12

CONFIGURATION C4.4

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



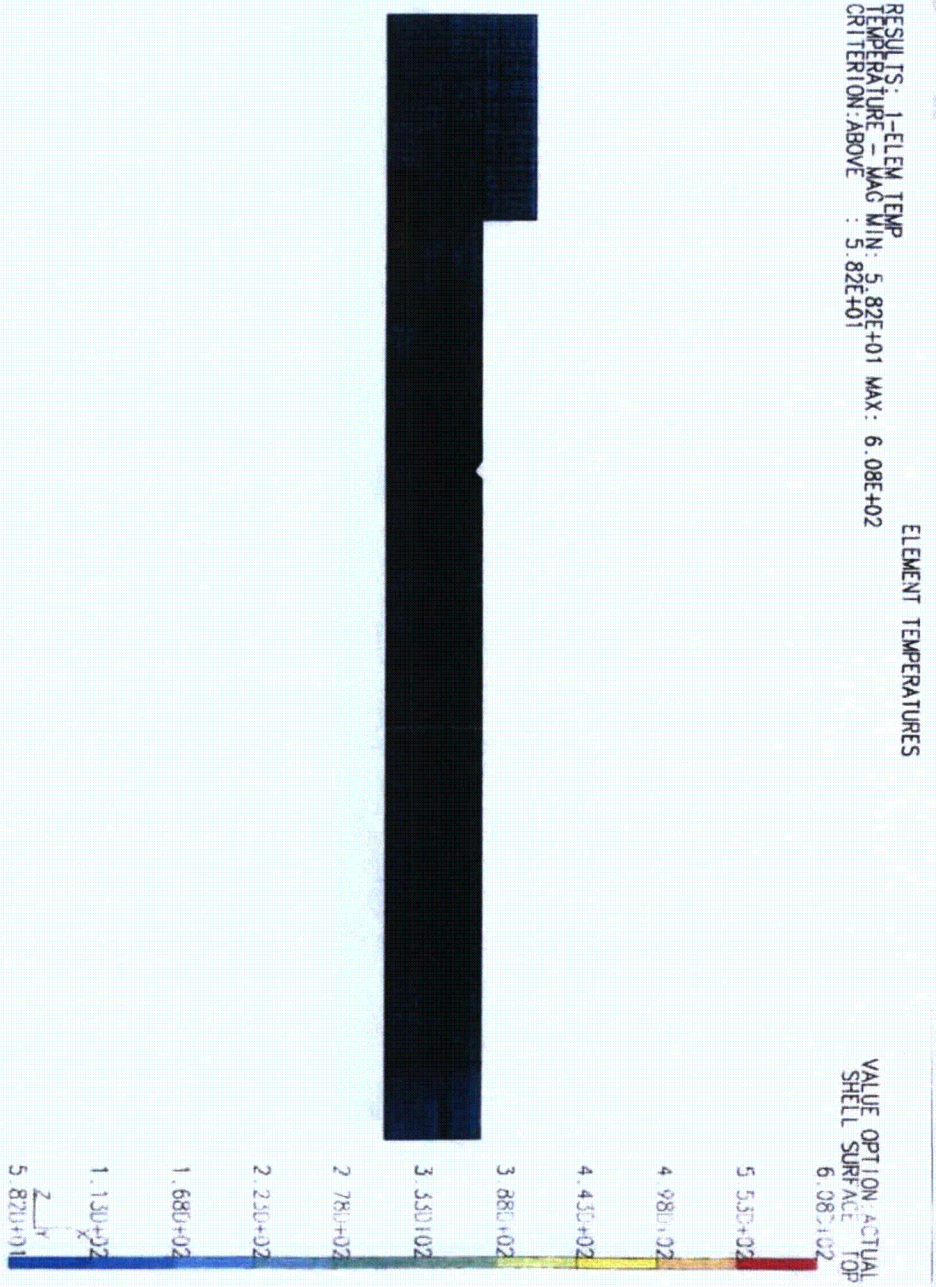
APPENDIX 13

CONFIGURATION C4.5

APPENDIX 13

CONFIGURATION C4.5

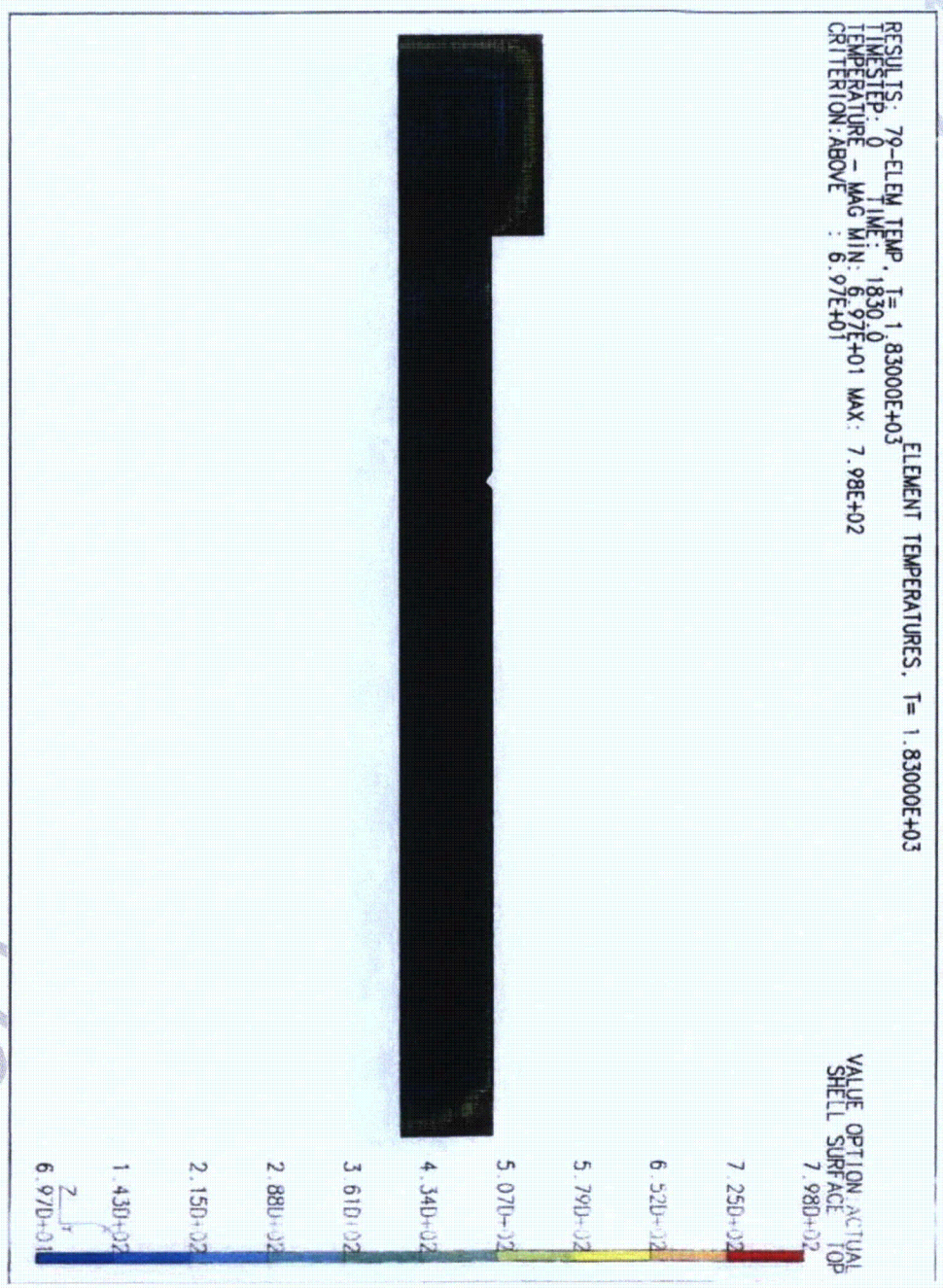
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 13

CONFIGURATION C4.5

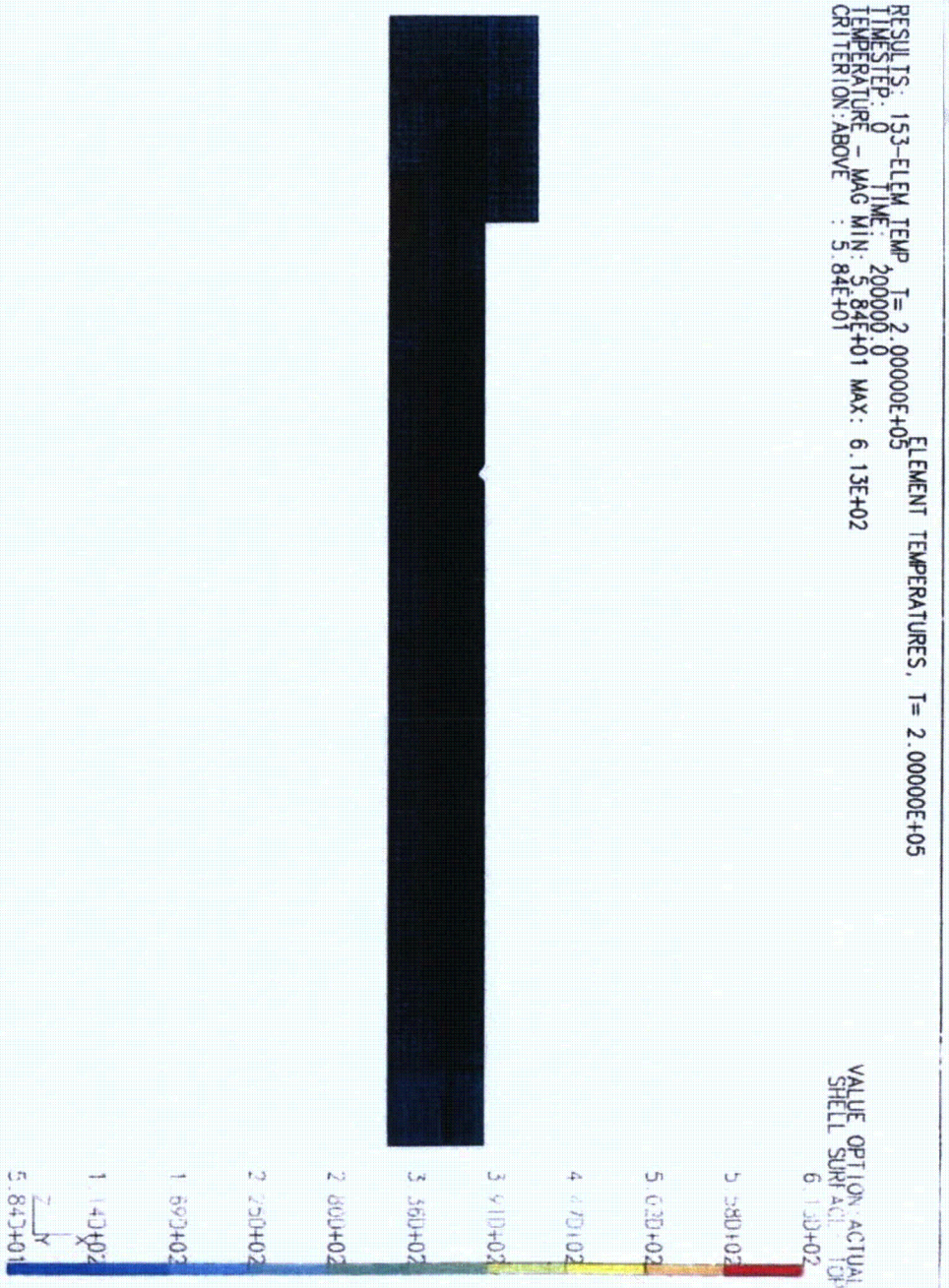
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 13

CONFIGURATION C4.5

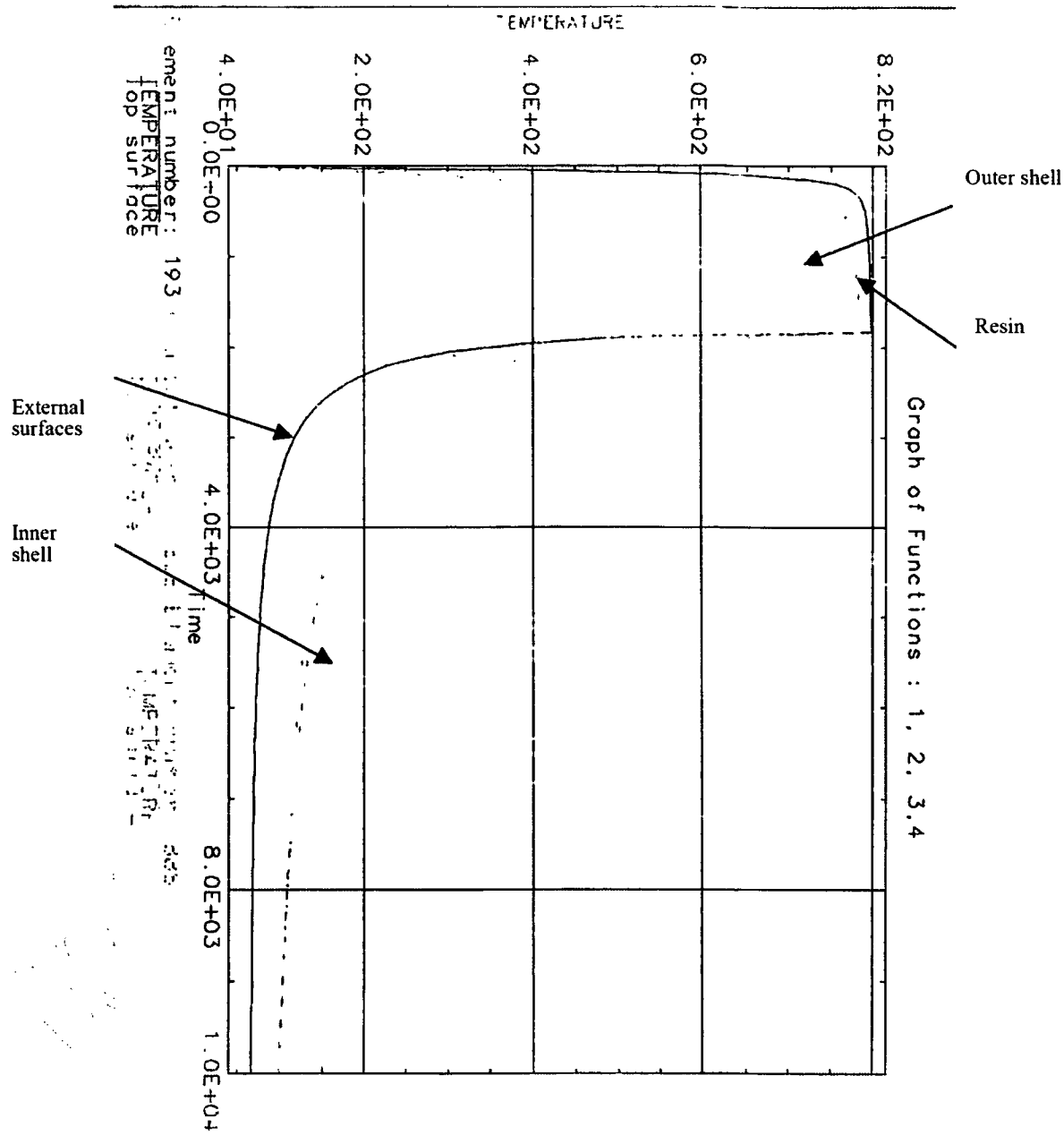
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 200,000 s



APPENDIX 13

CONFIGURATION C4.5

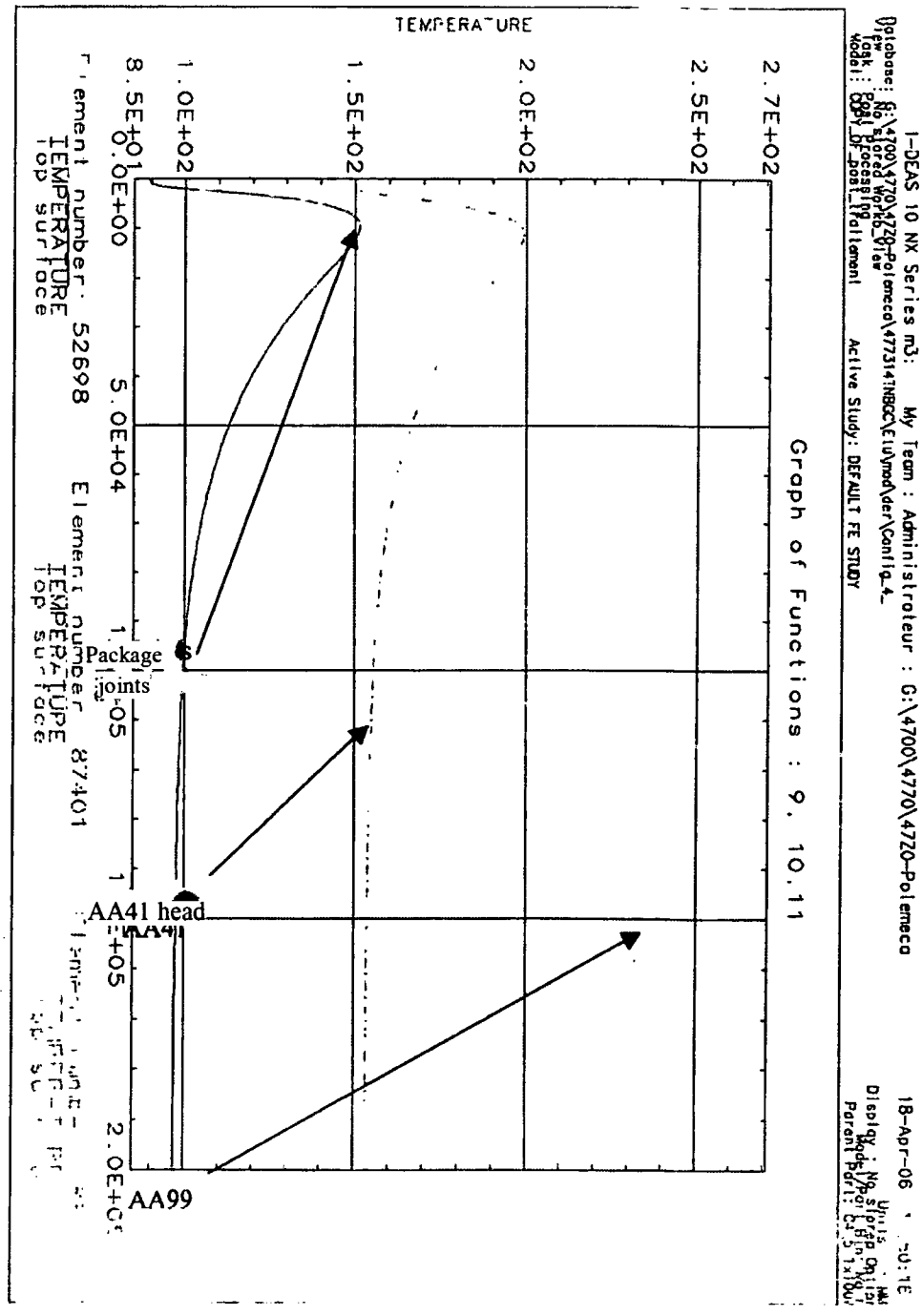
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 13

CONFIGURATION C4.5

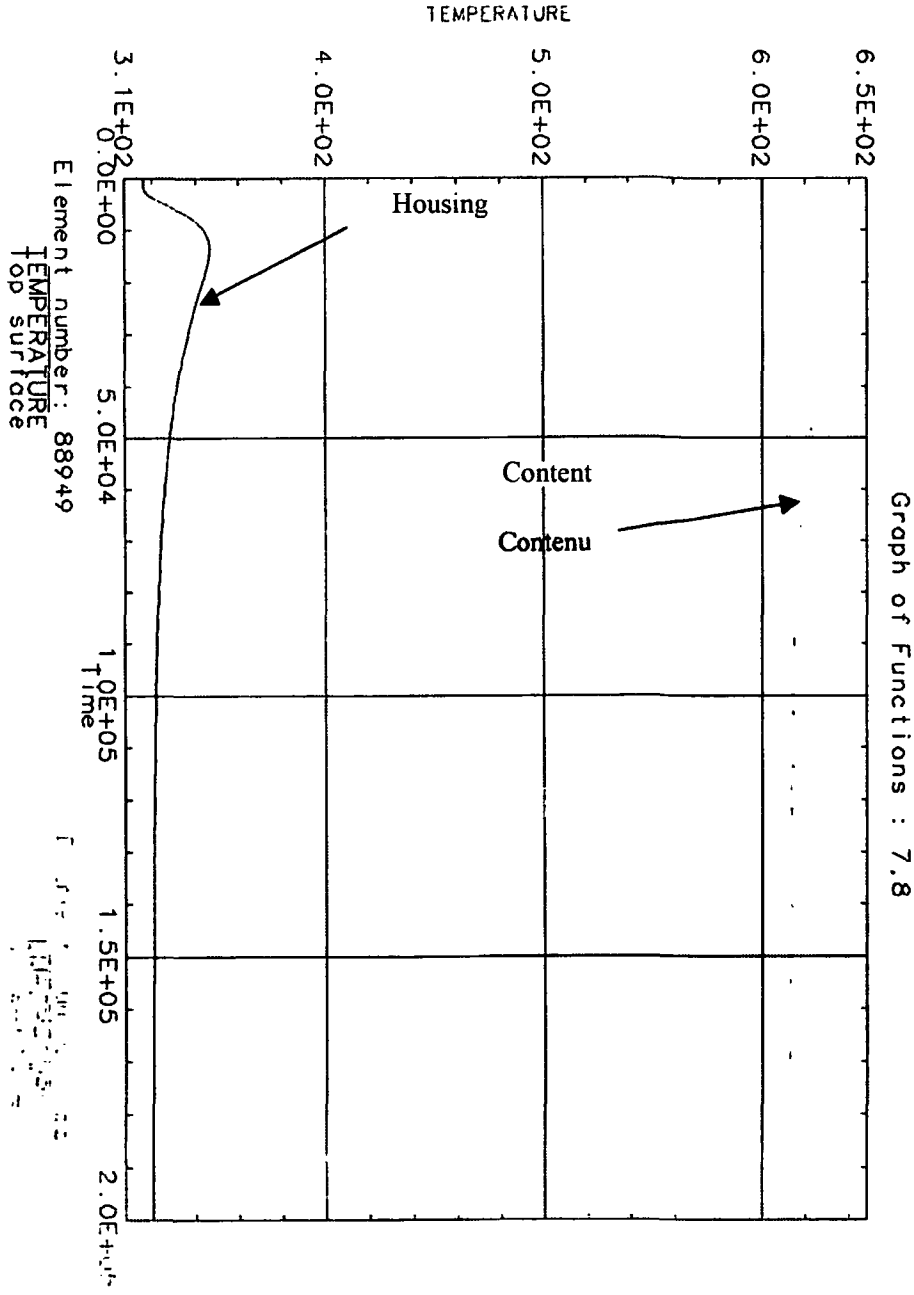
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 13

CONFIGURATION C4.5

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



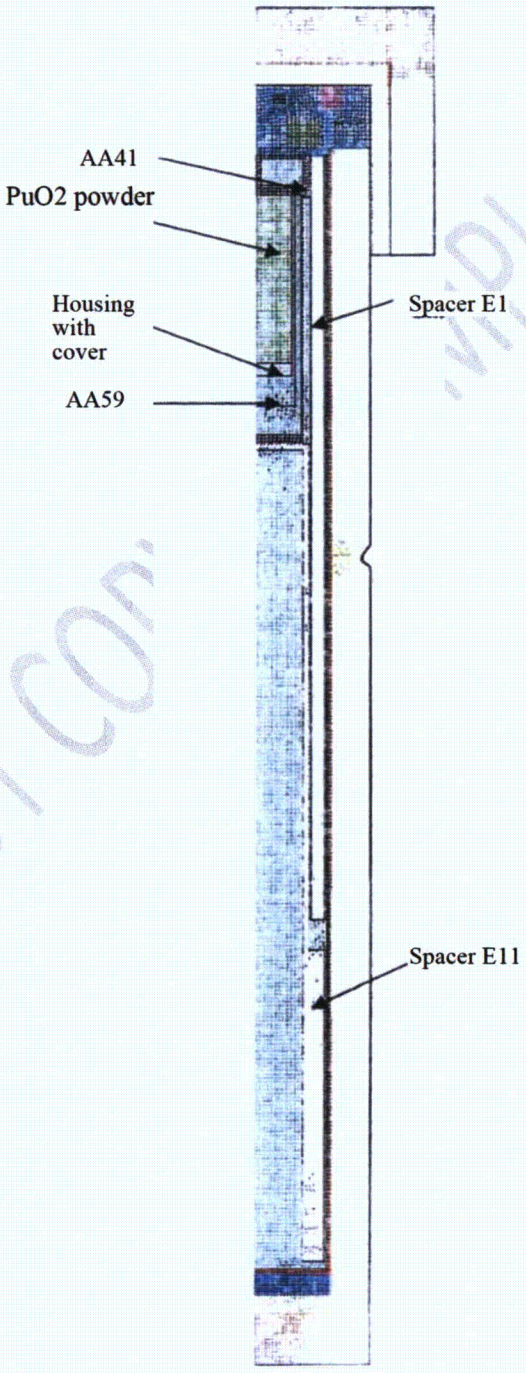
APPENDIX 14

CONFIGURATION C4.6

APPENDIX 14

CONFIGURATION C4.6

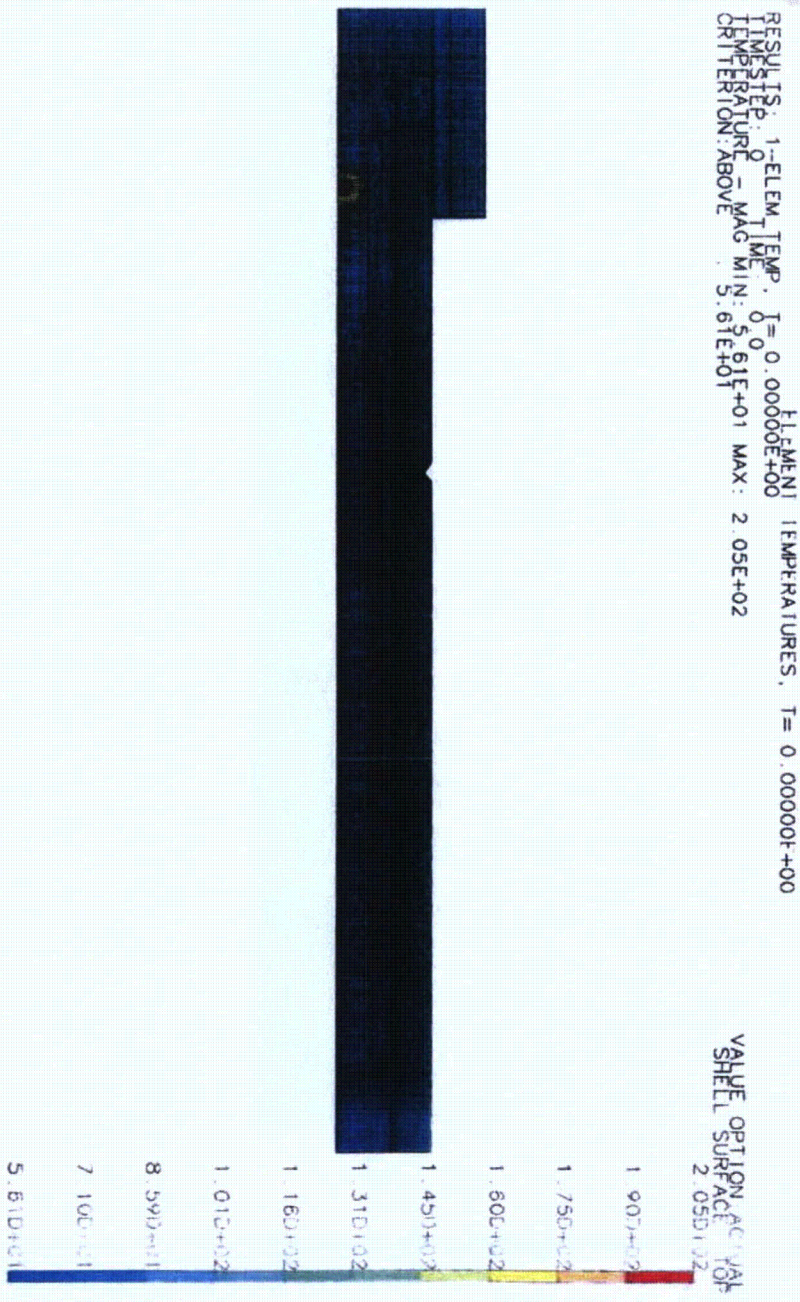
PRESENTATION OF THE MODEL



APPENDIX 14

CONFIGURATION C4.6

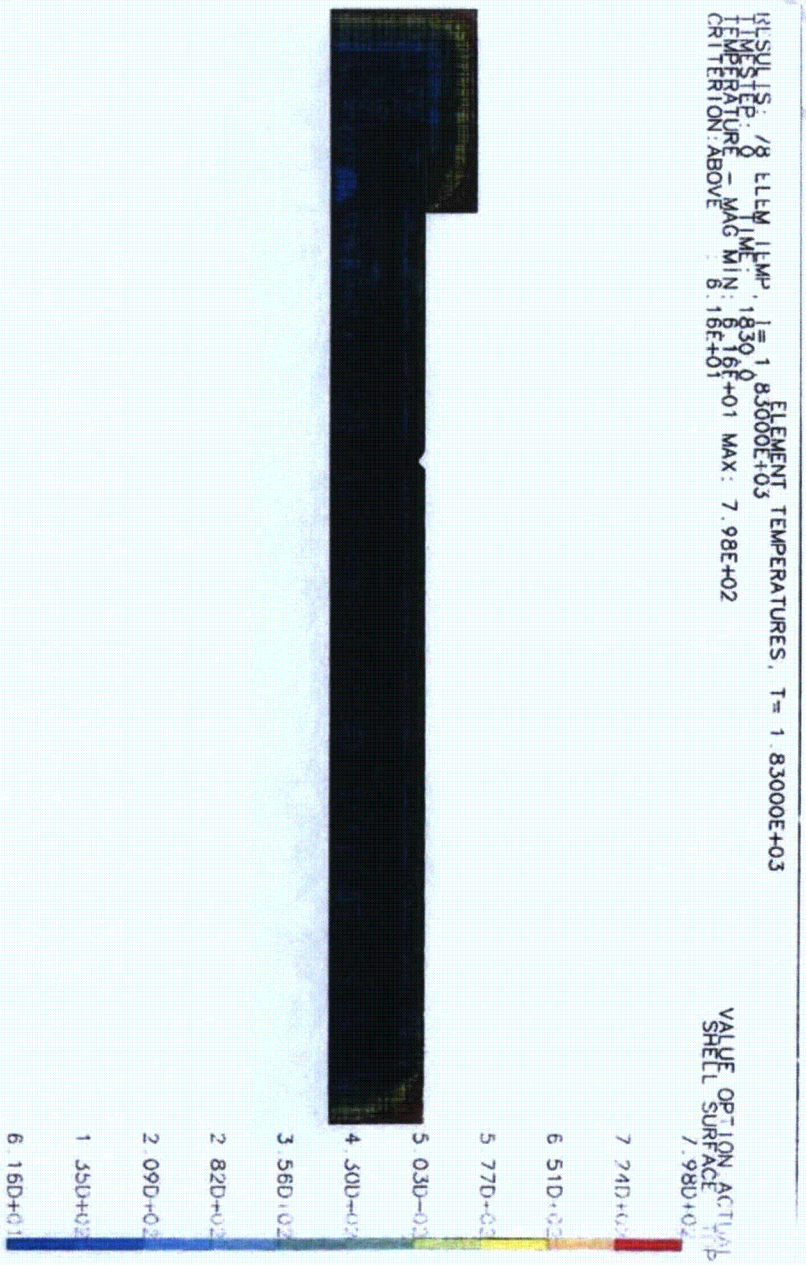
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 14

CONFIGURATION C4.6

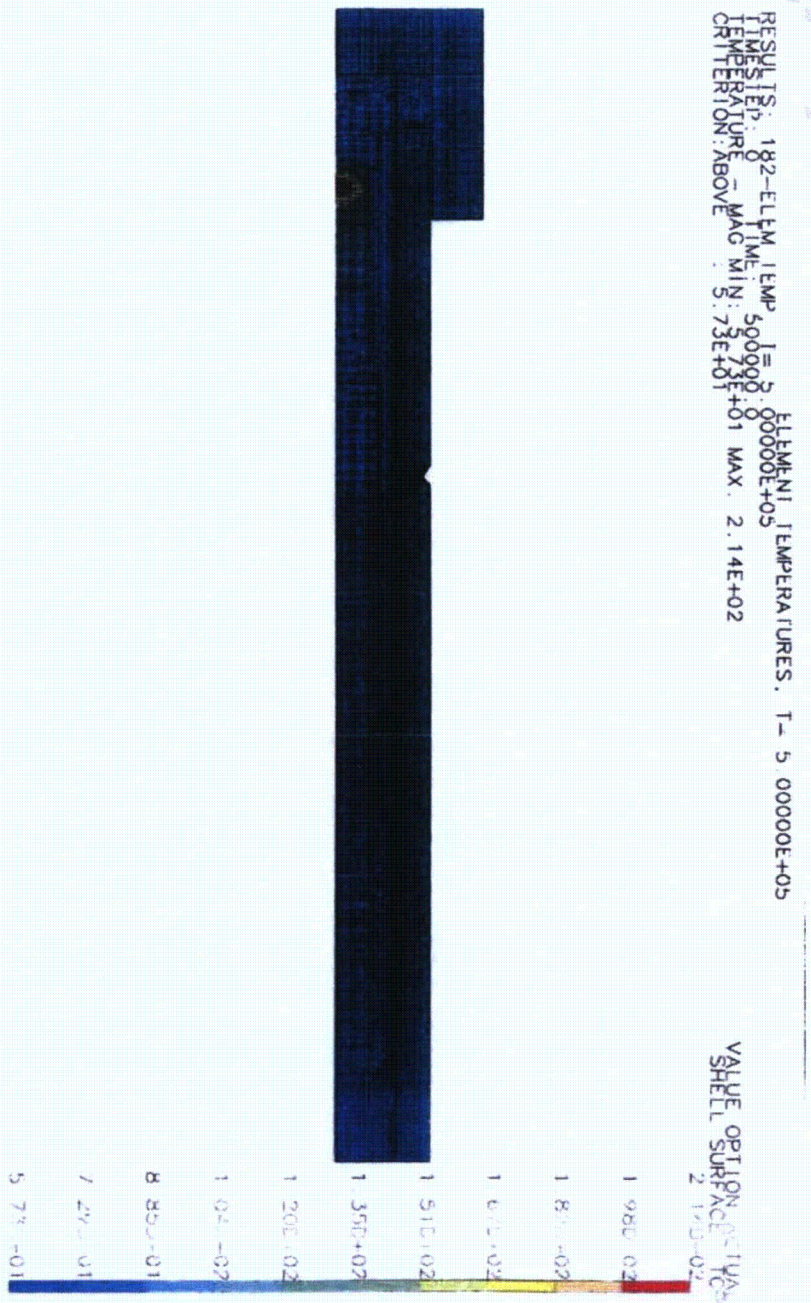
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 14

CONFIGURATION C4.6

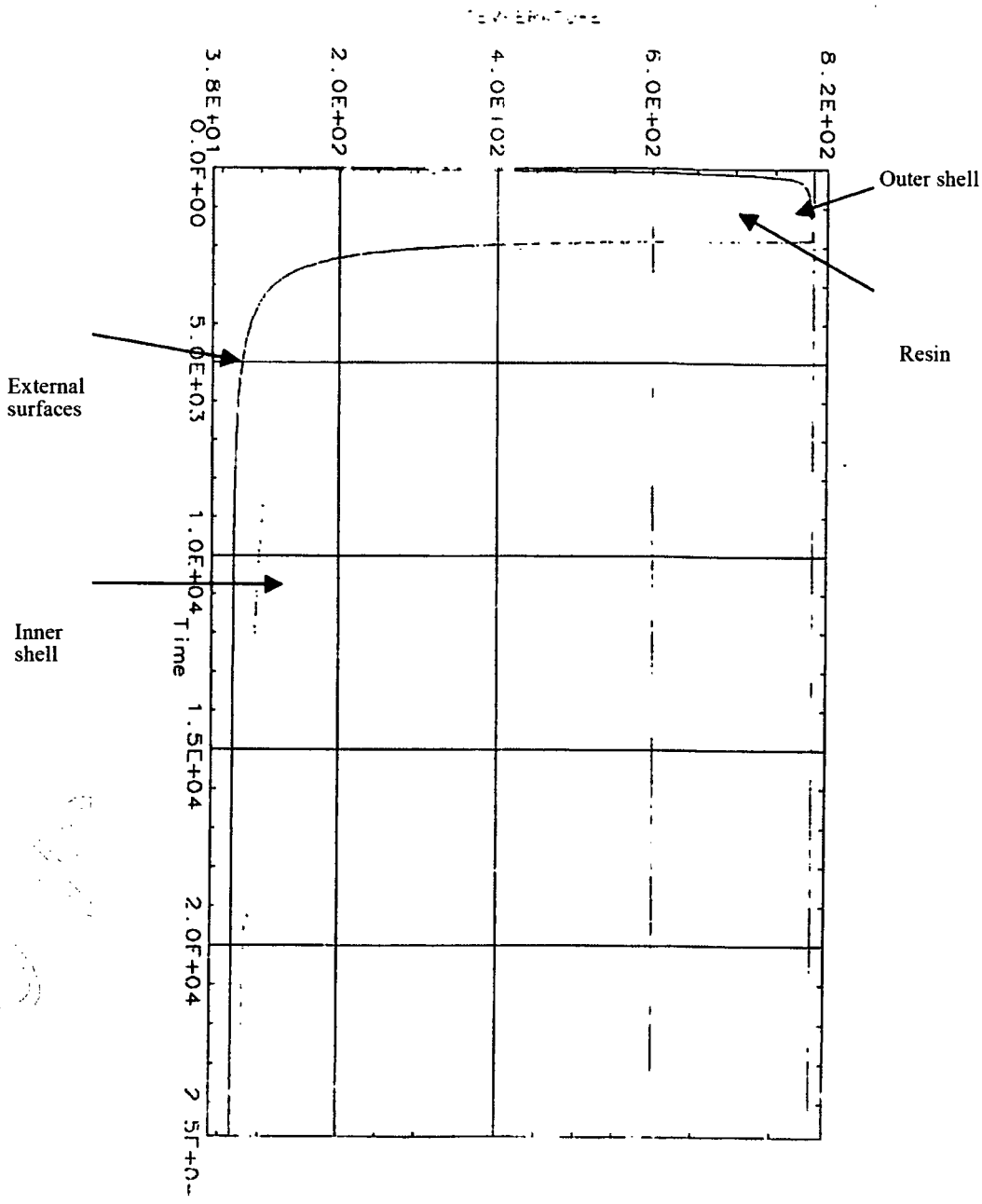
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 14

CONFIGURATION C4.6

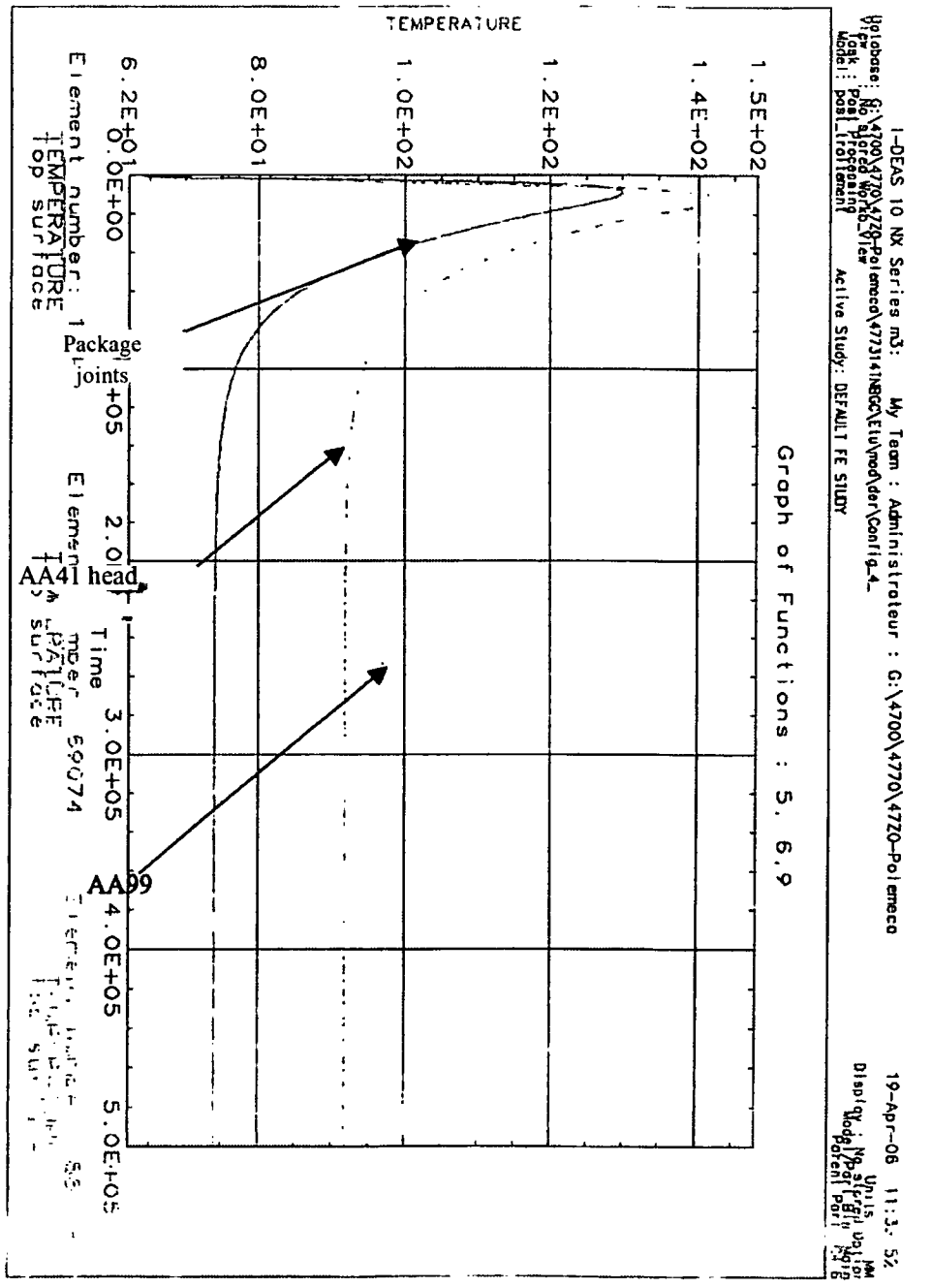
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 14

CONFIGURATION C4.6

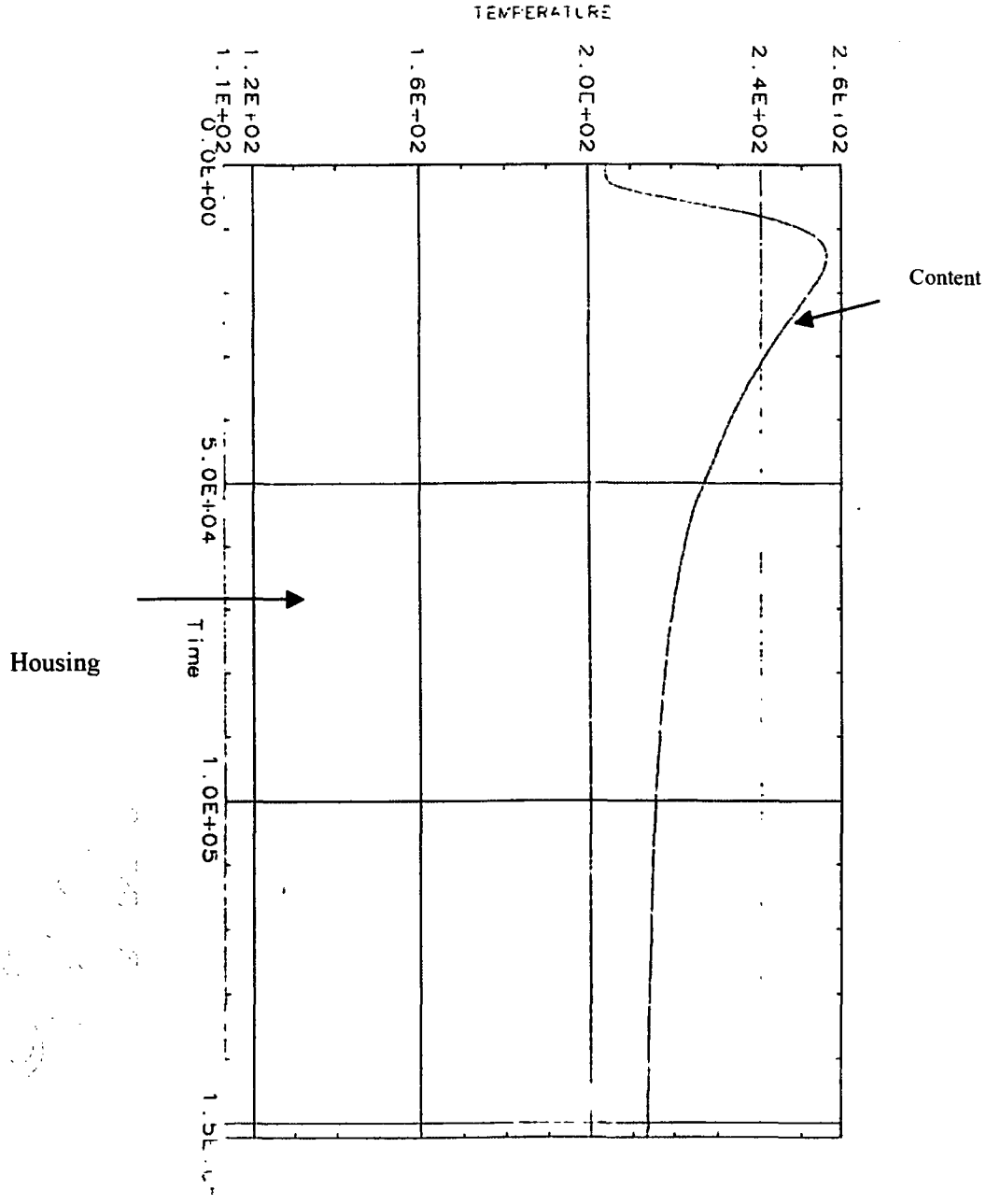
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 14

CONFIGURATION C4.6

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



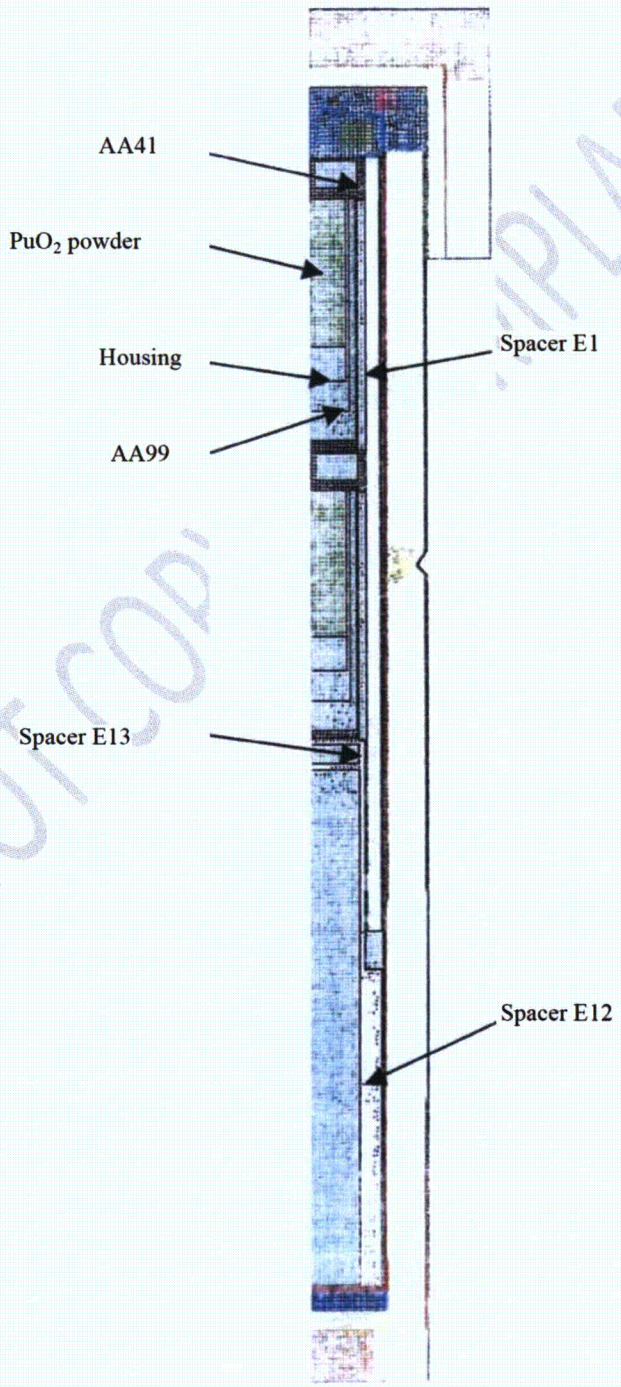
APPENDIX 15

CONFIGURATION C4.7

APPENDIX 15

CONFIGURATION C4.7

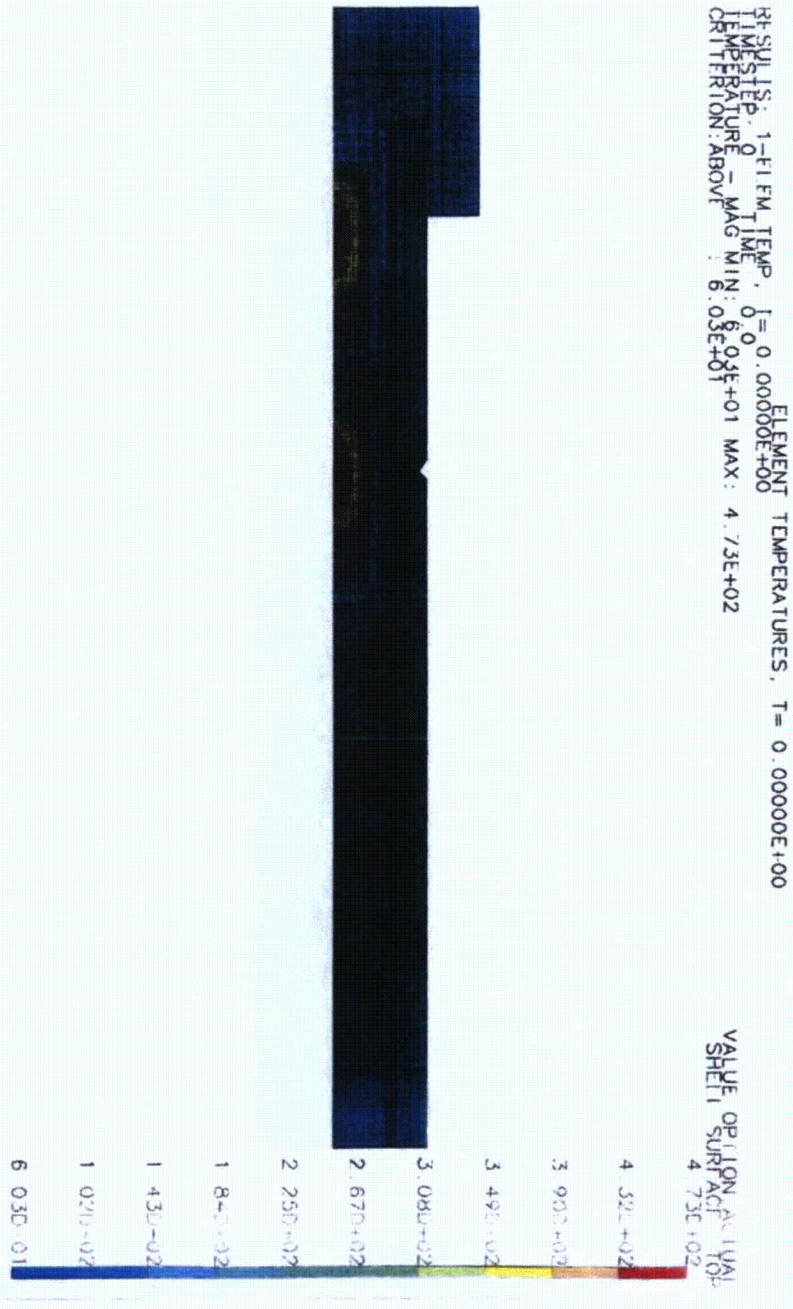
PRESENTATION OF THE MODEL



APPENDIX 15

CONFIGURATION C4.7

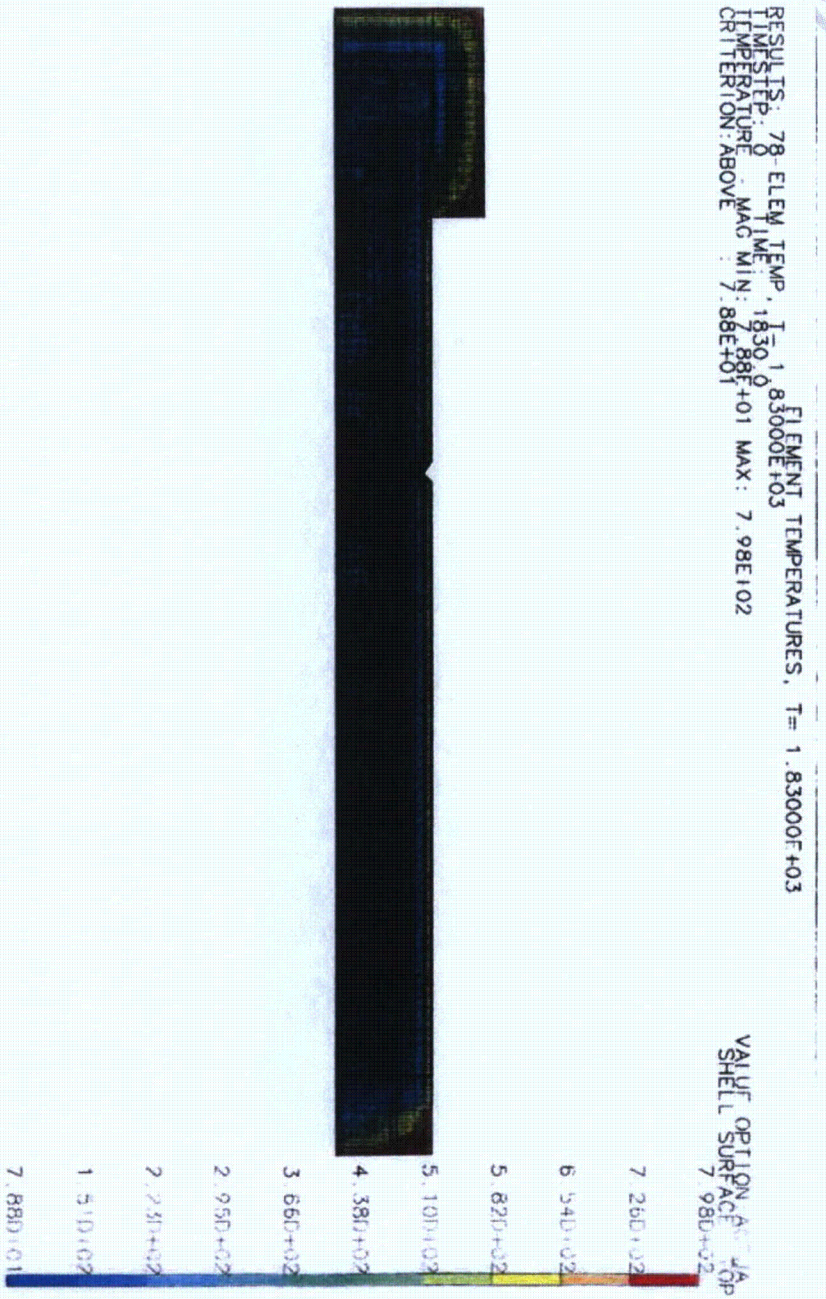
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 15

CONFIGURATION C4.7

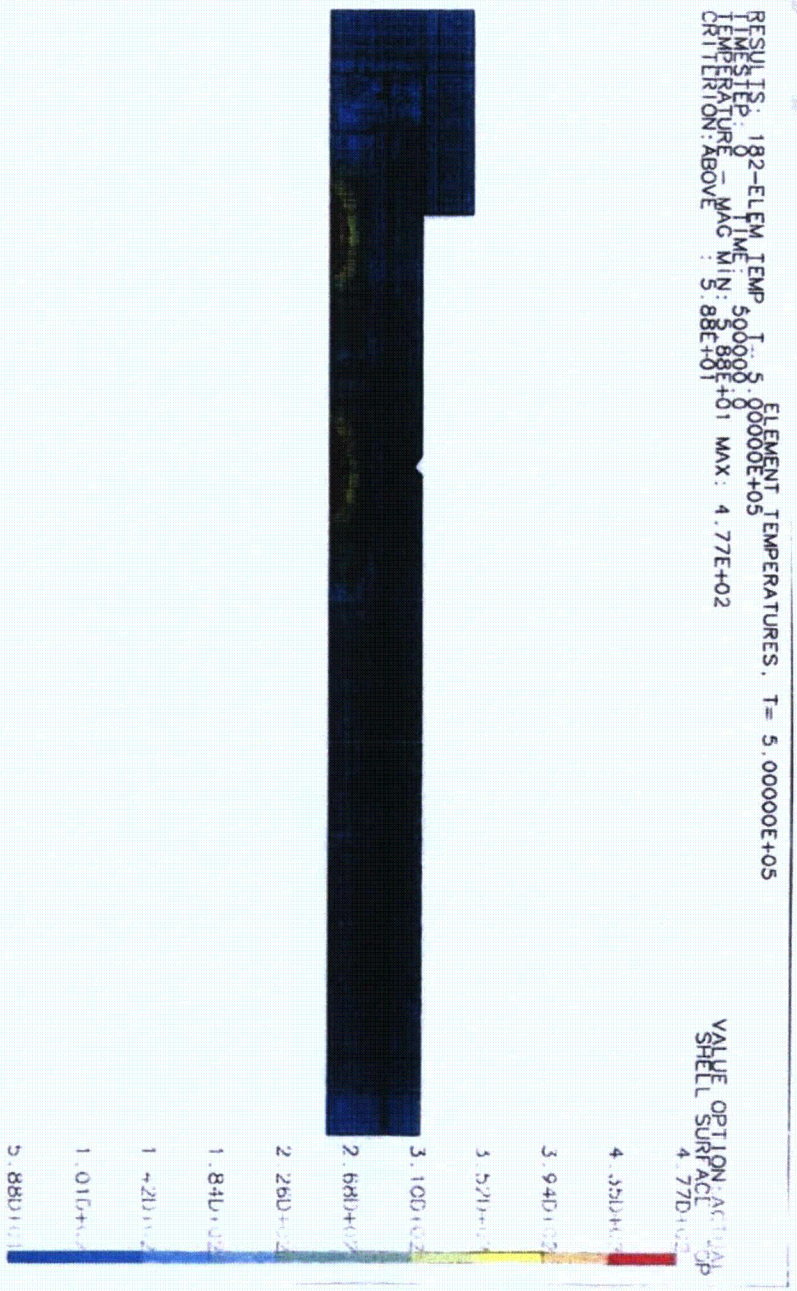
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 15

CONFIGURATION C4.7

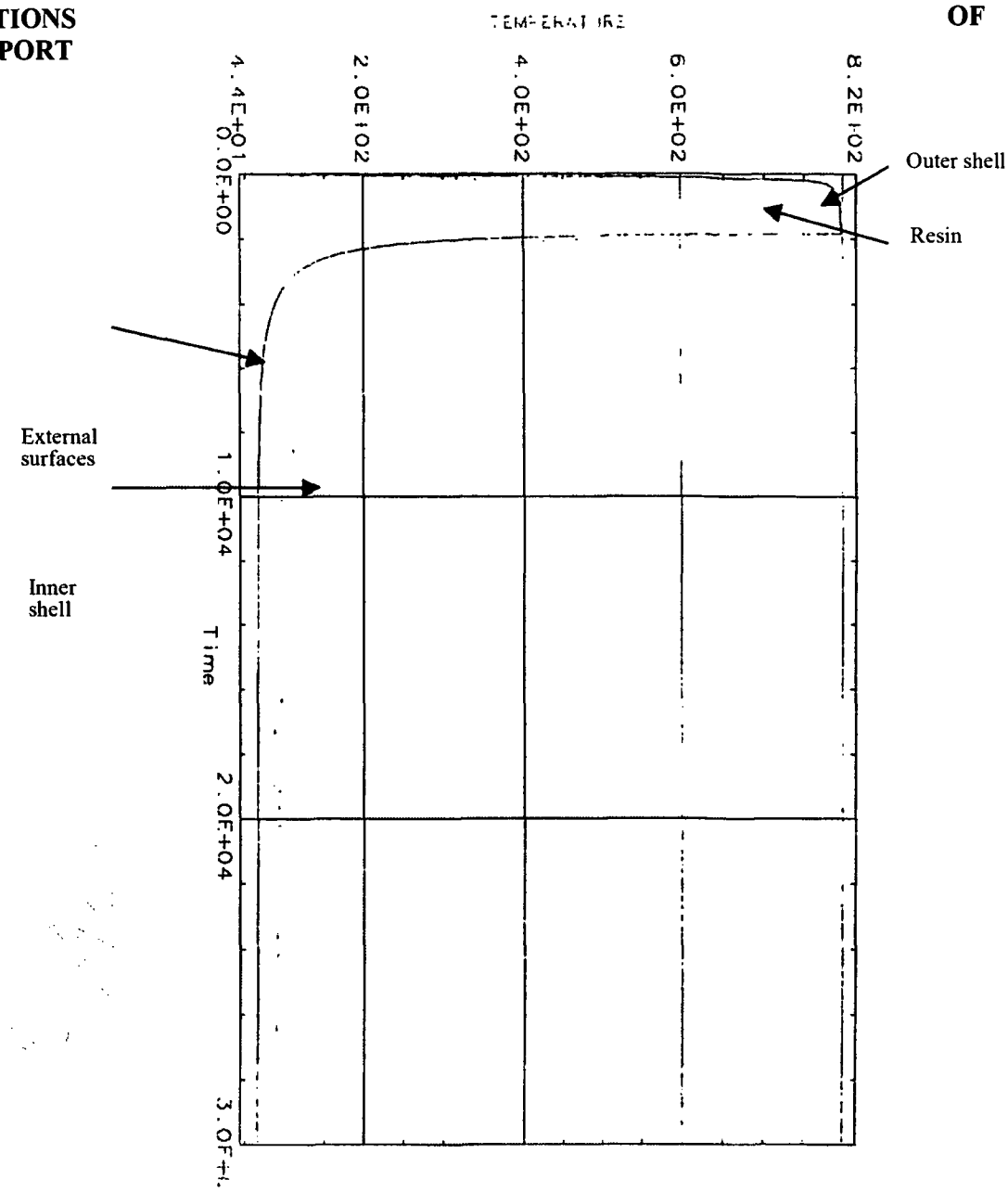
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 15

CONFIGURATION C4.7

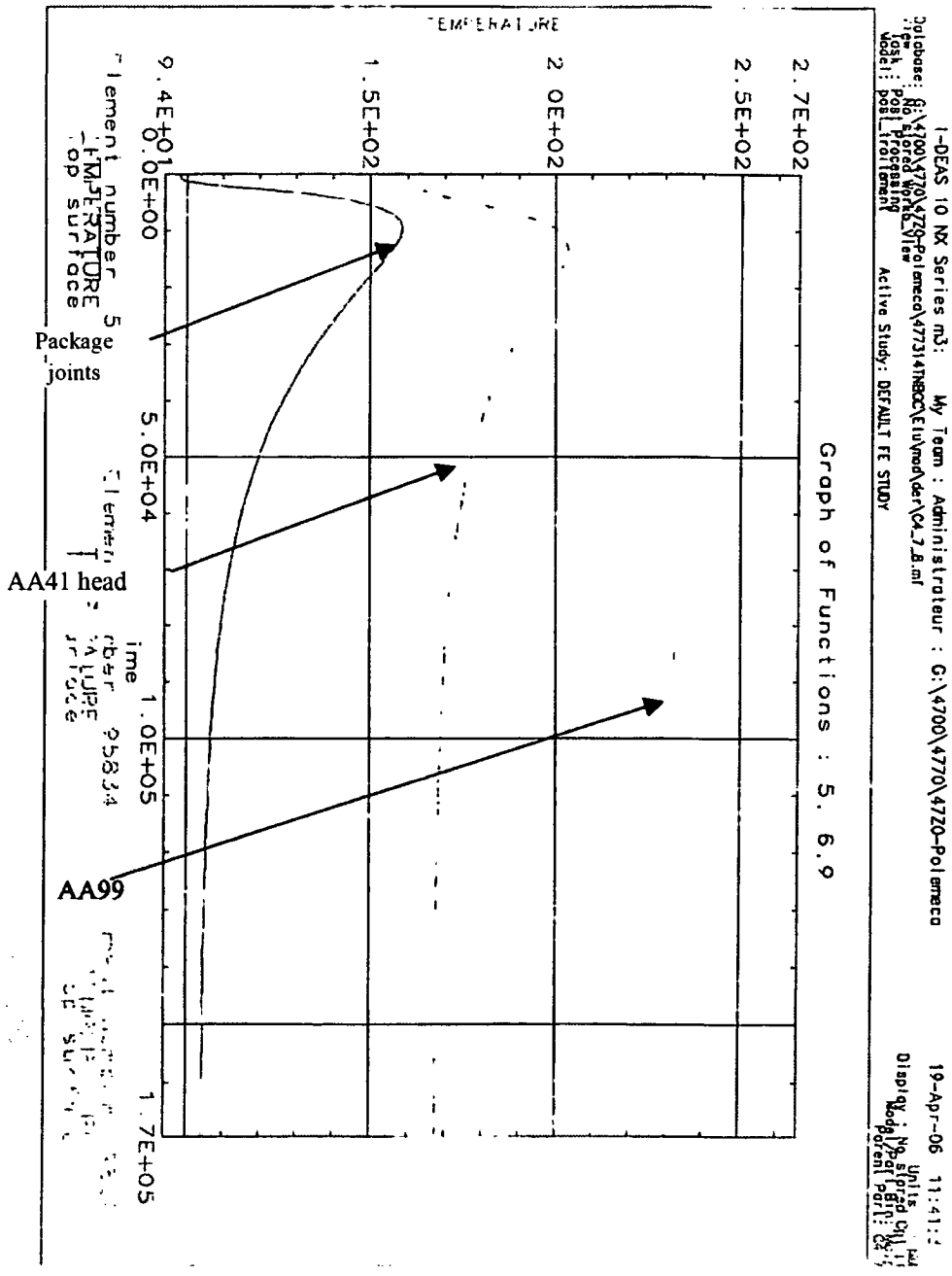
GRAPH OF VARIATION IN PACKAGE TEMPERATURE OF ACCIDENT CONDITIONS TRANSPORT



APPENDIX 15

CONFIGURATION C4.7

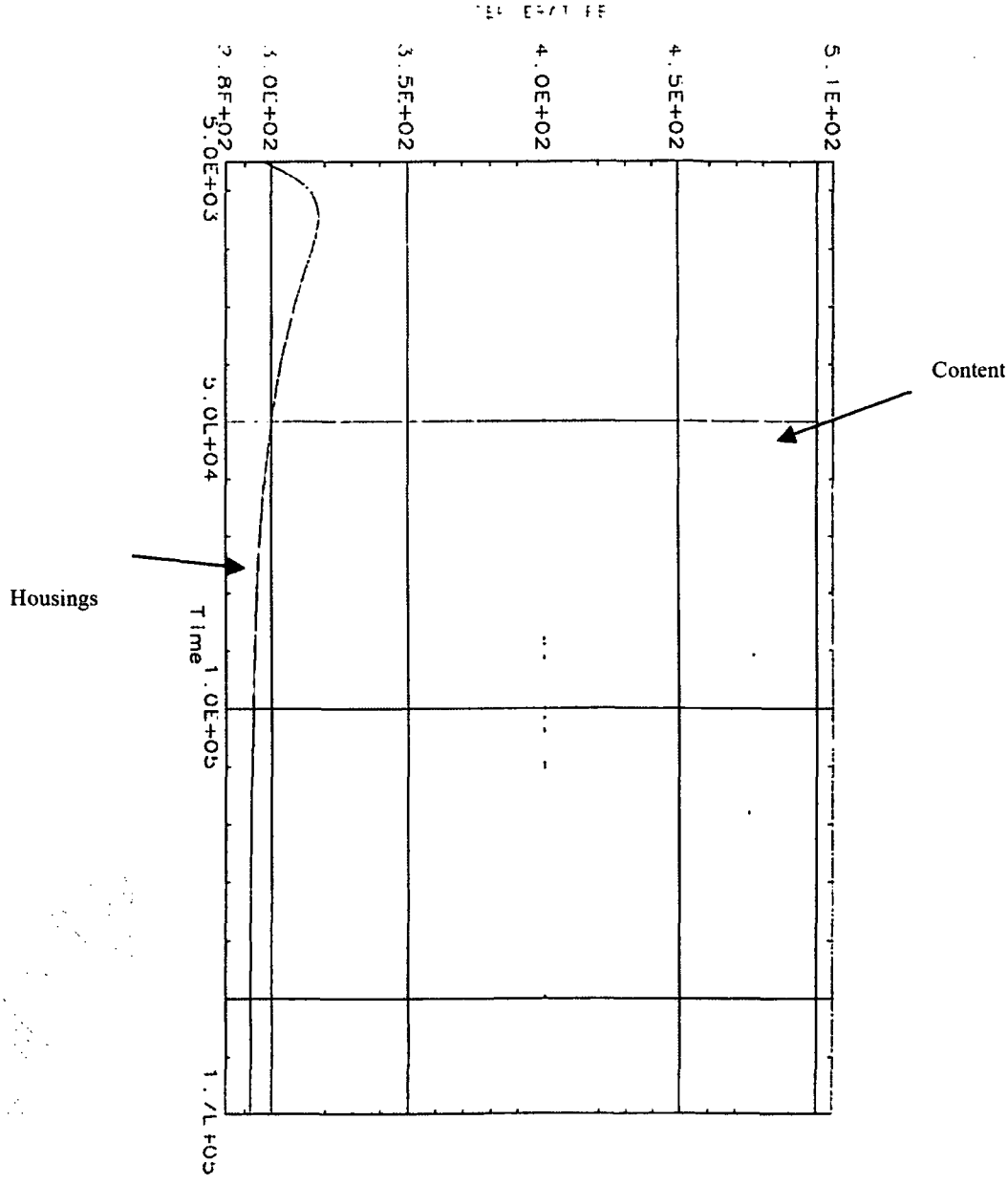
GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 15

CONFIGURATION C4.7

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



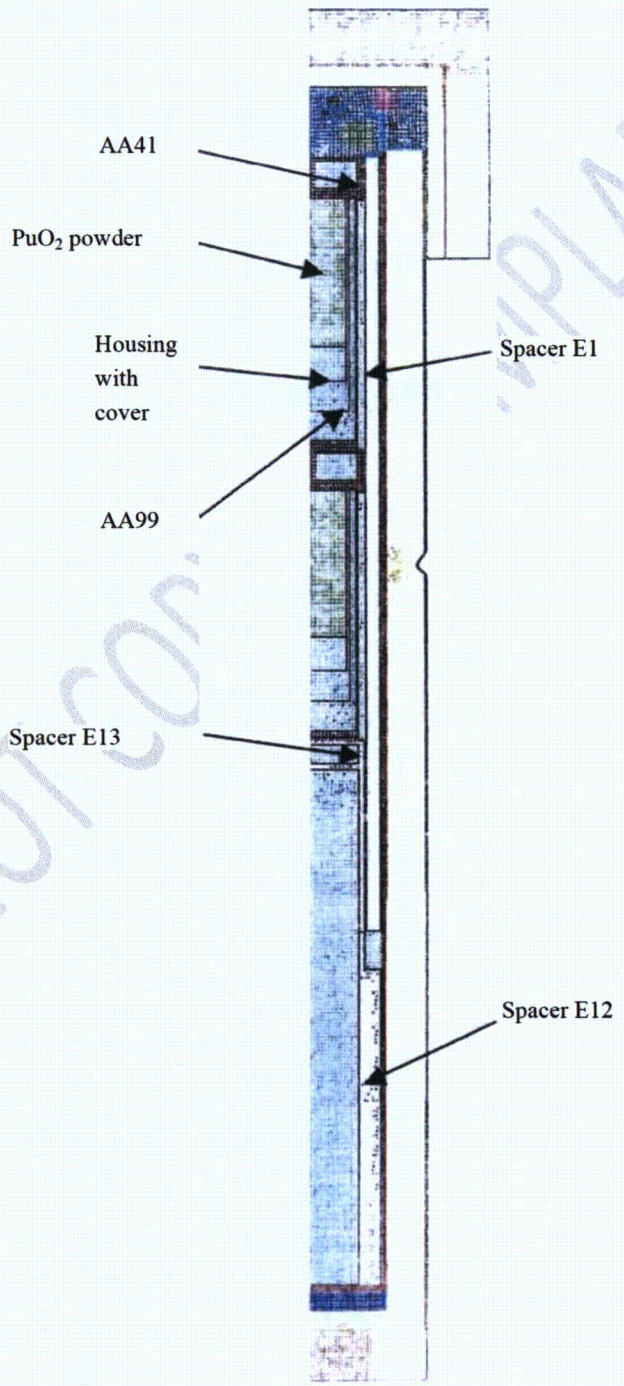
APPENDIX 16

CONFIGURATION C4.8

APPENDIX 16

CONFIGURATION C4.8

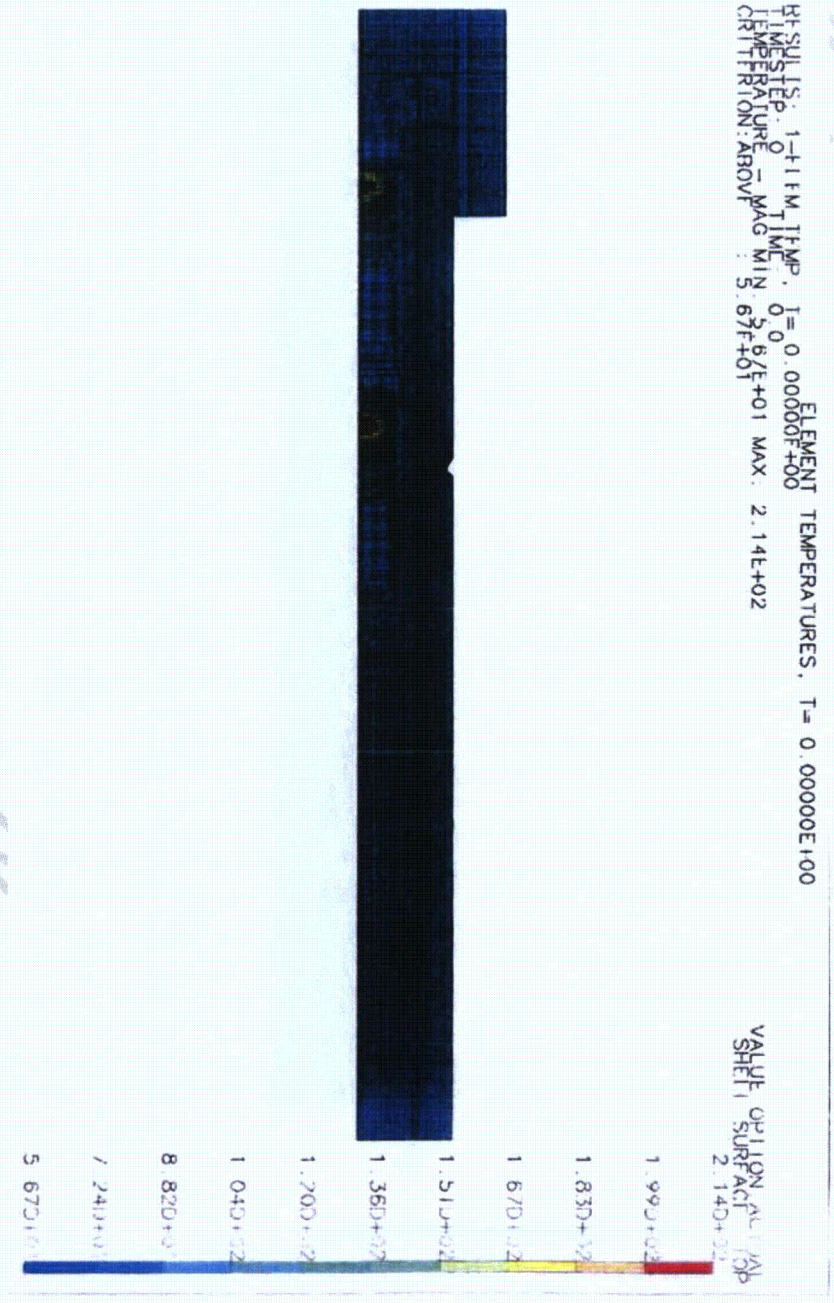
PRESENTATION OF THE MODEL



APPENDIX 16

CONFIGURATION C4.8

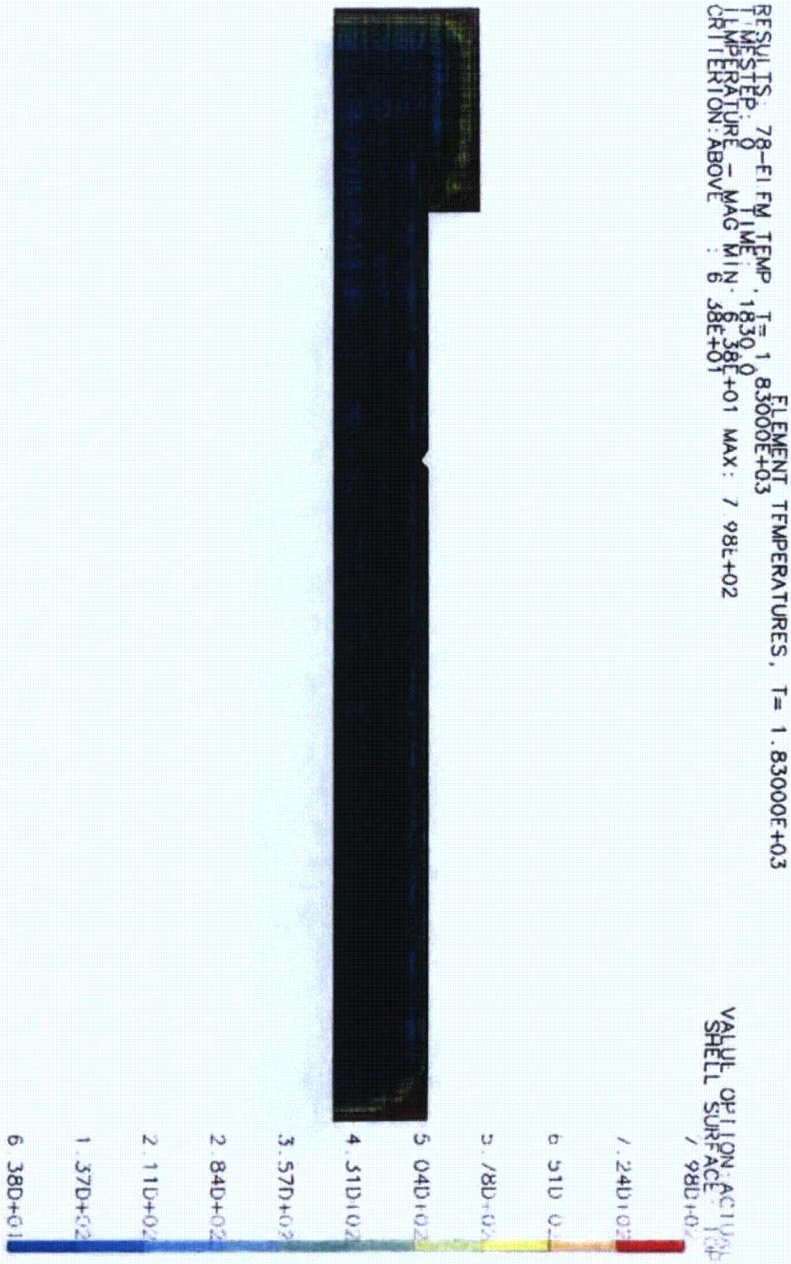
ISOTHERMS FOR THE ISOLATED PACKAGE ACCIDENT CONDITIONS OF TRANSPORT Before fire



APPENDIX 16

CONFIGURATION C4.8

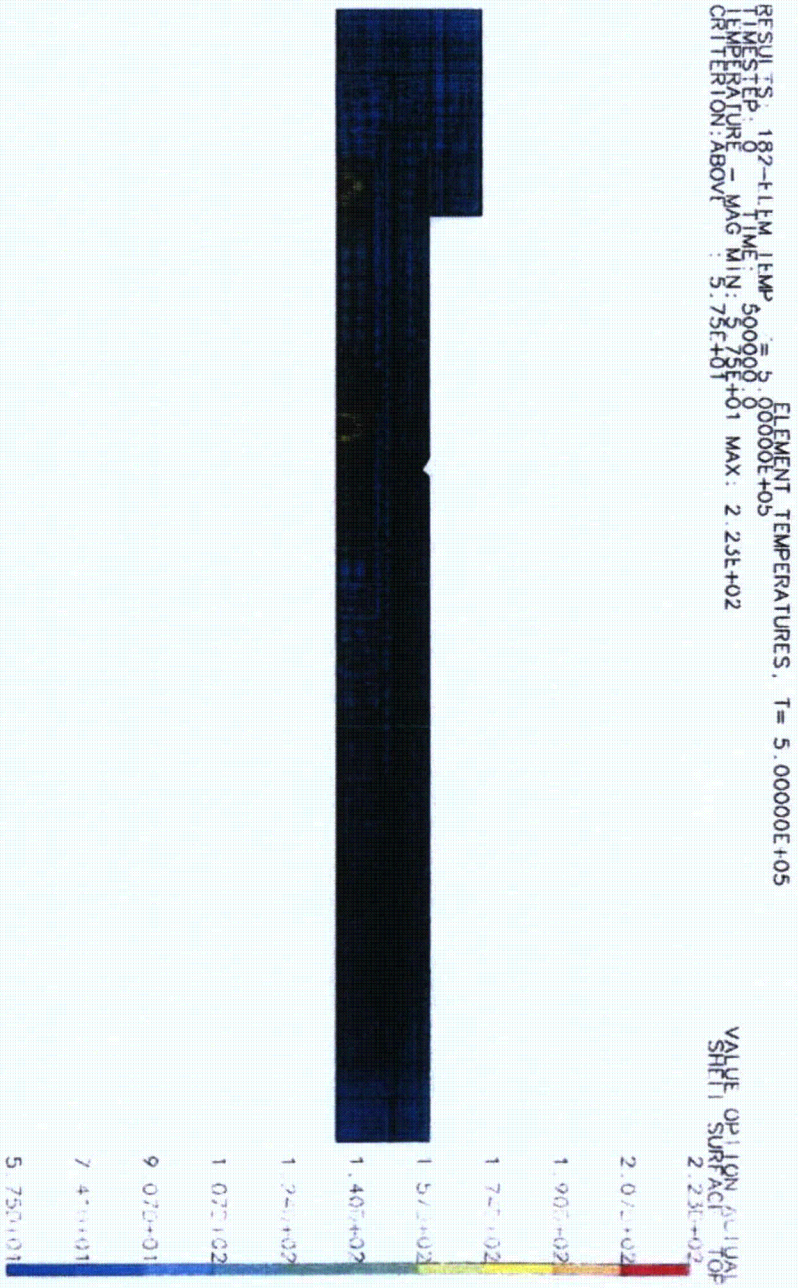
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 1830 s



APPENDIX 16

CONFIGURATION C4.8

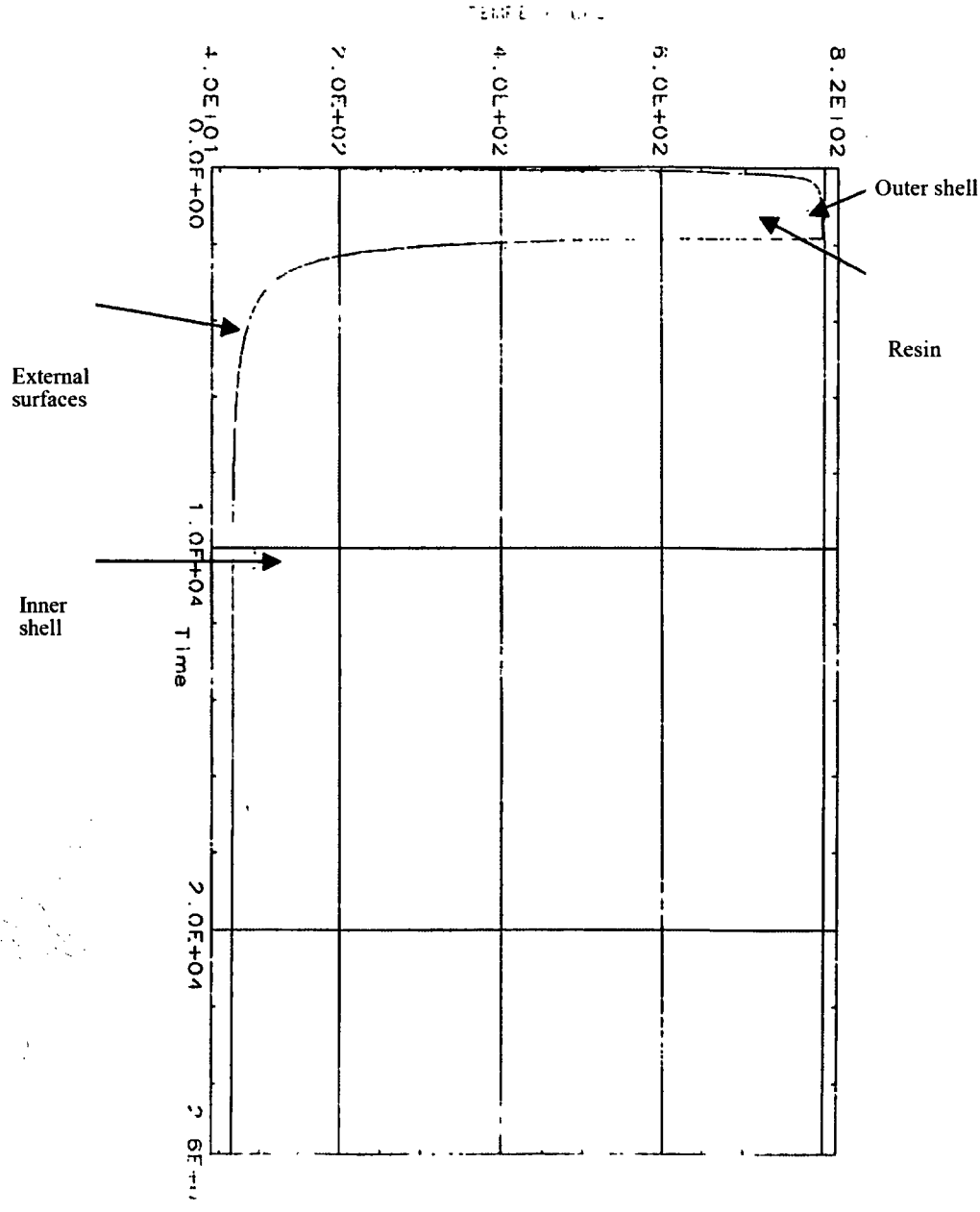
PACKAGE ISOTHERMS
ACCIDENT CONDITIONS OF TRANSPORT
t = 500,000 s



APPENDIX 16

CONFIGURATION C4.8

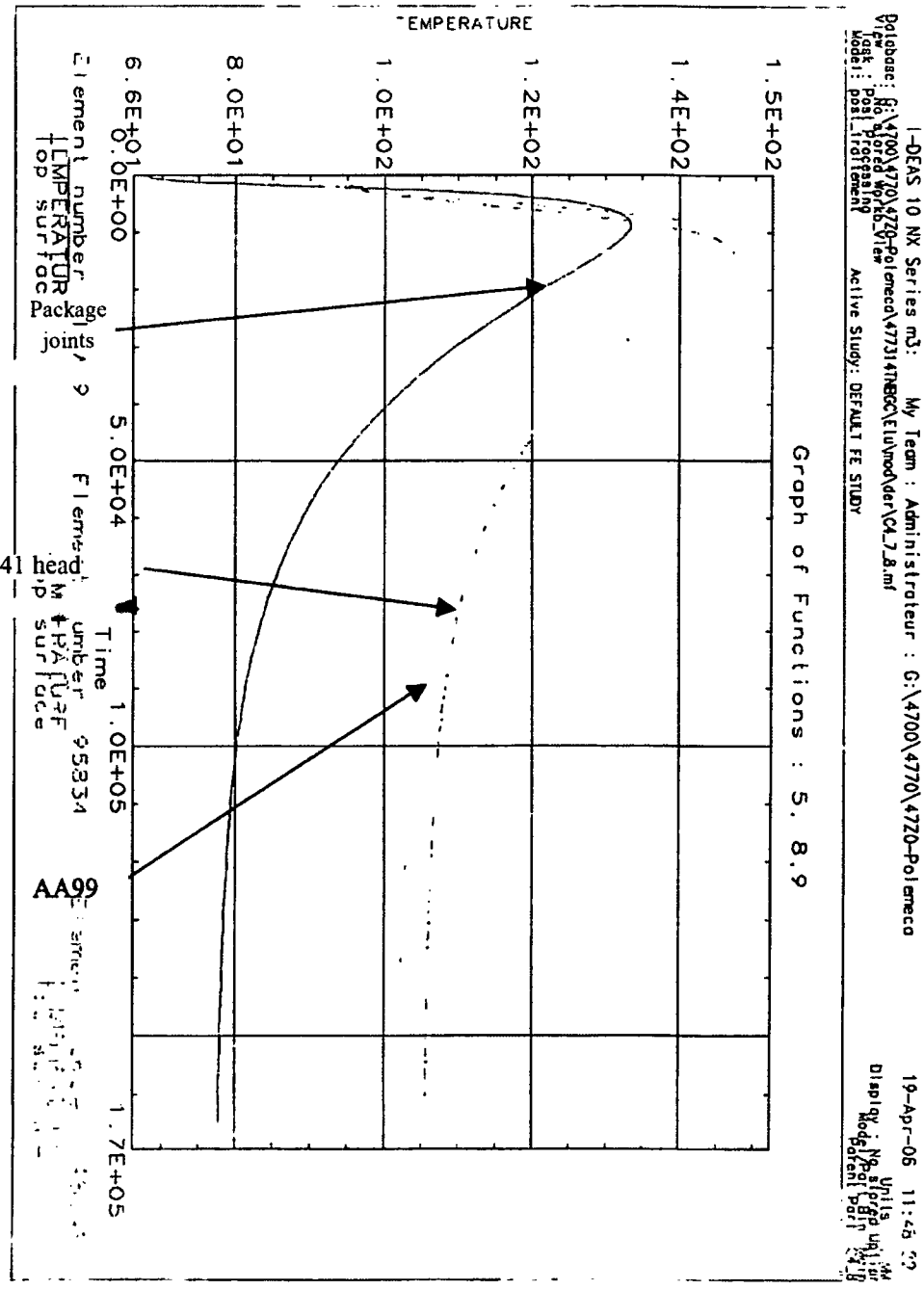
GRAPH OF VARIATION IN PACKAGE TEMPERATURE ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 16

CONFIGURATION C4.8

GRAPH OF VARIATION IN JOINT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT



APPENDIX 16

CONFIGURATION C4.8

GRAPH OF VARIATION IN HOUSING AND CONTENT TEMPERATURES ACCIDENT CONDITIONS OF TRANSPORT