Thermal Analysis of HI-STAR 100 MPC-24 & Overpack Under NCT and Enhanced HAC Conditions Using ANSYS

April 11, 2002

PNNL

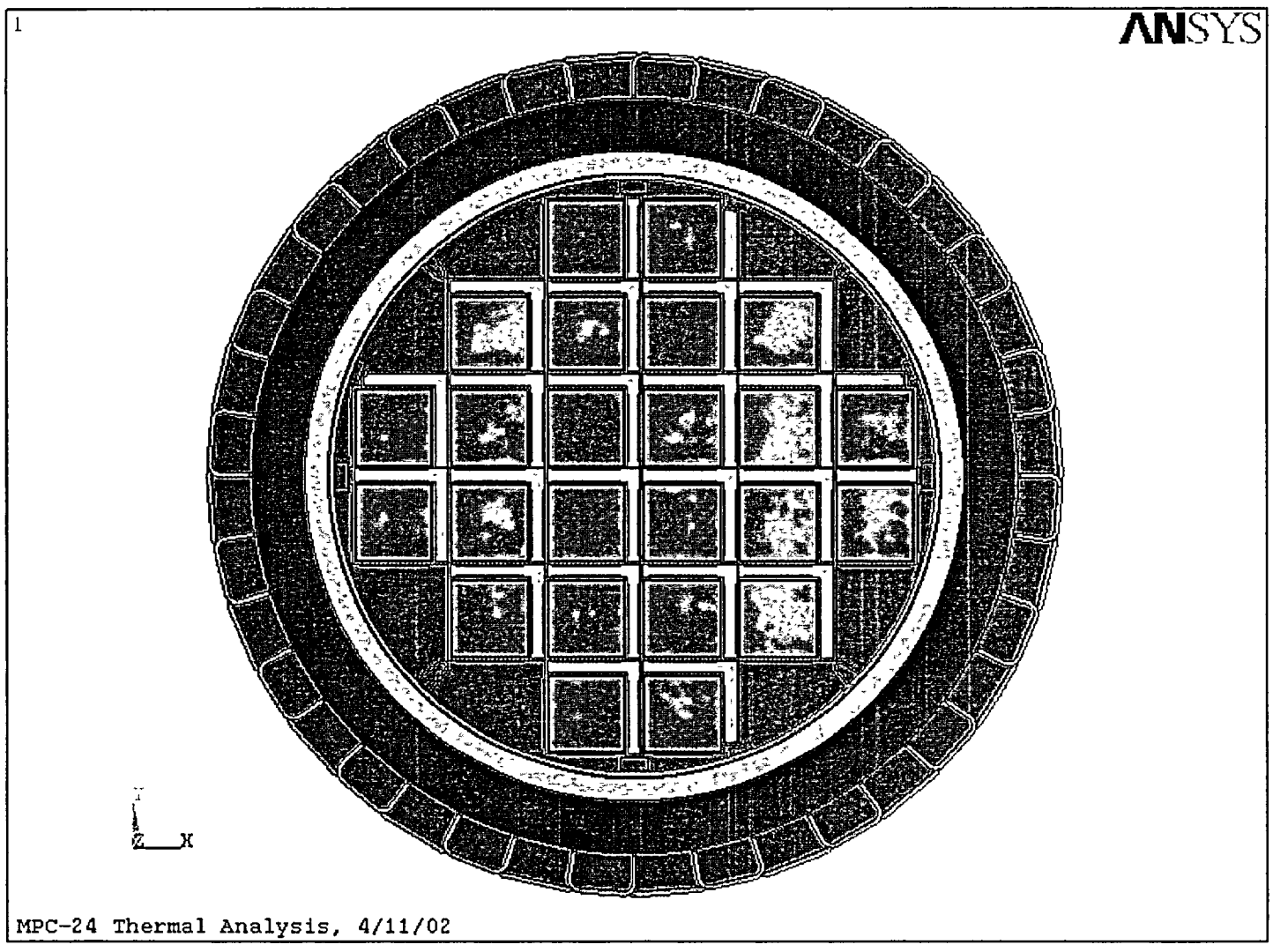
(PRELIMINARY)

Model Geometry Details

- 2D cross-section of basket at hottest axial location
- Full representation of basket plates, basket supports, MPC shell, overpack inner shell, neutron shield, radial channels, and enclosure shells
- Equivalent conductors used for fuel assembly, boral sheathing, and gamma shield shells

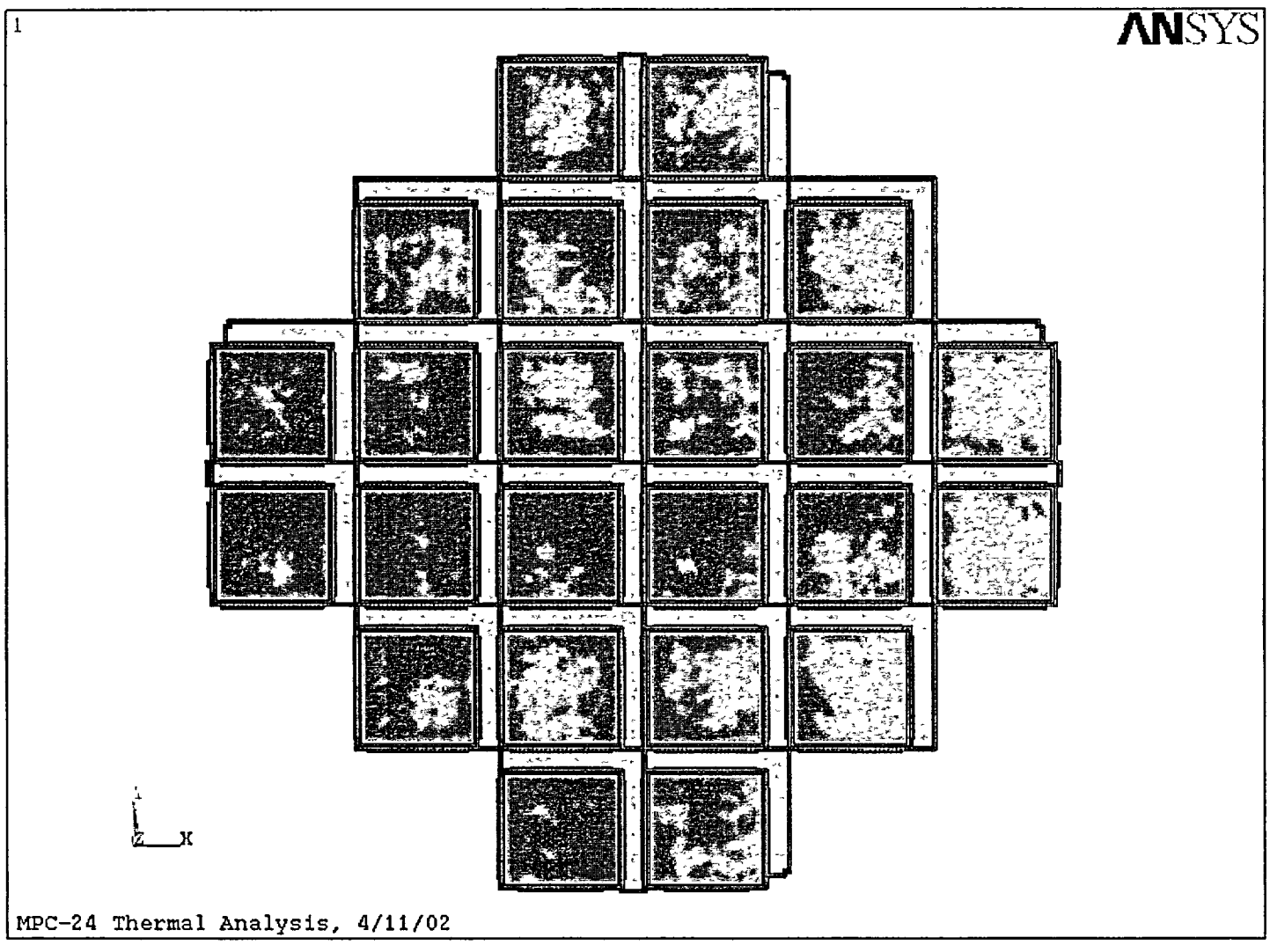
MPC/Overpack Geometry

Entire Cross-Section



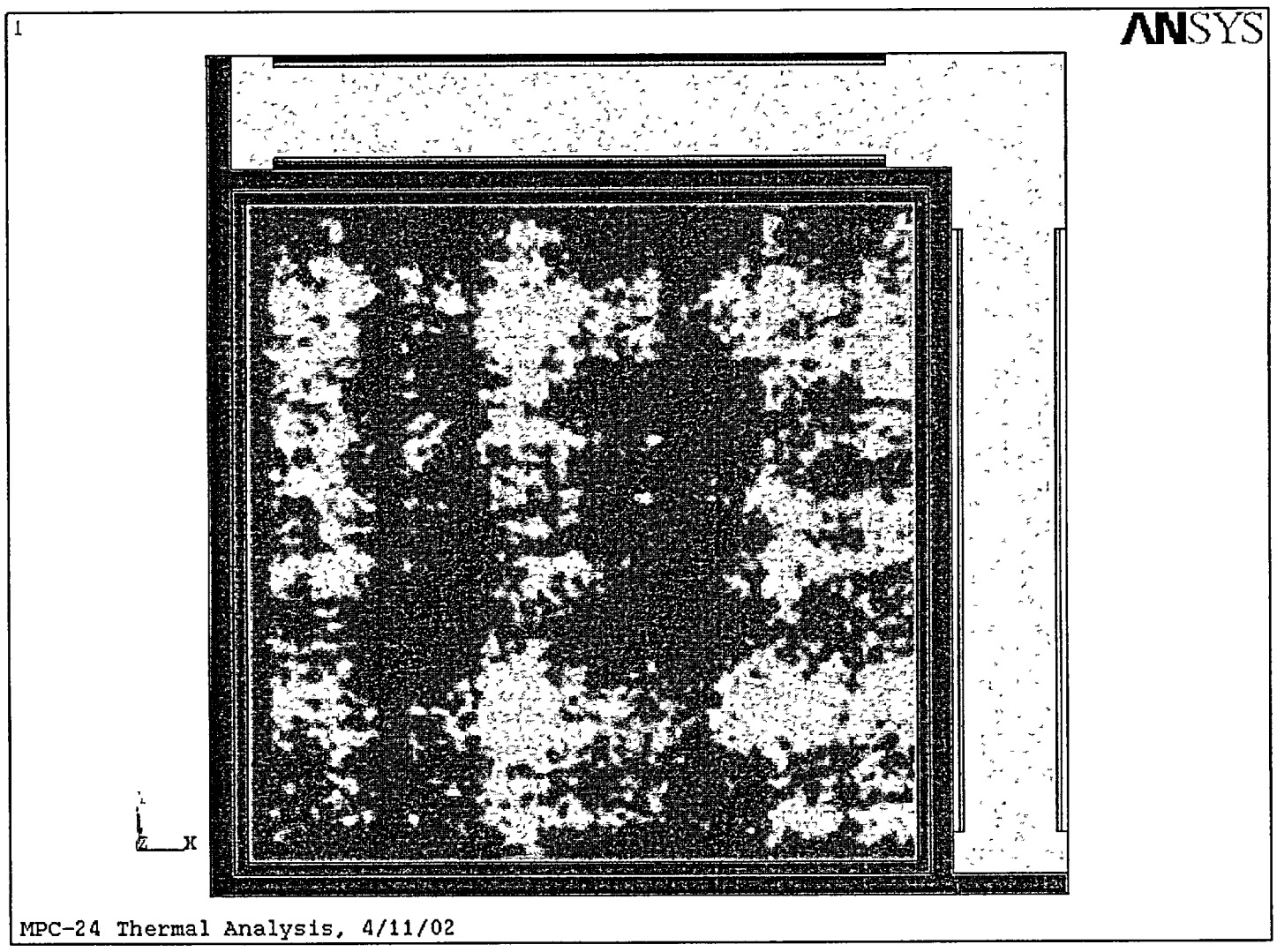
MPC/Overpack Geometry

Basket



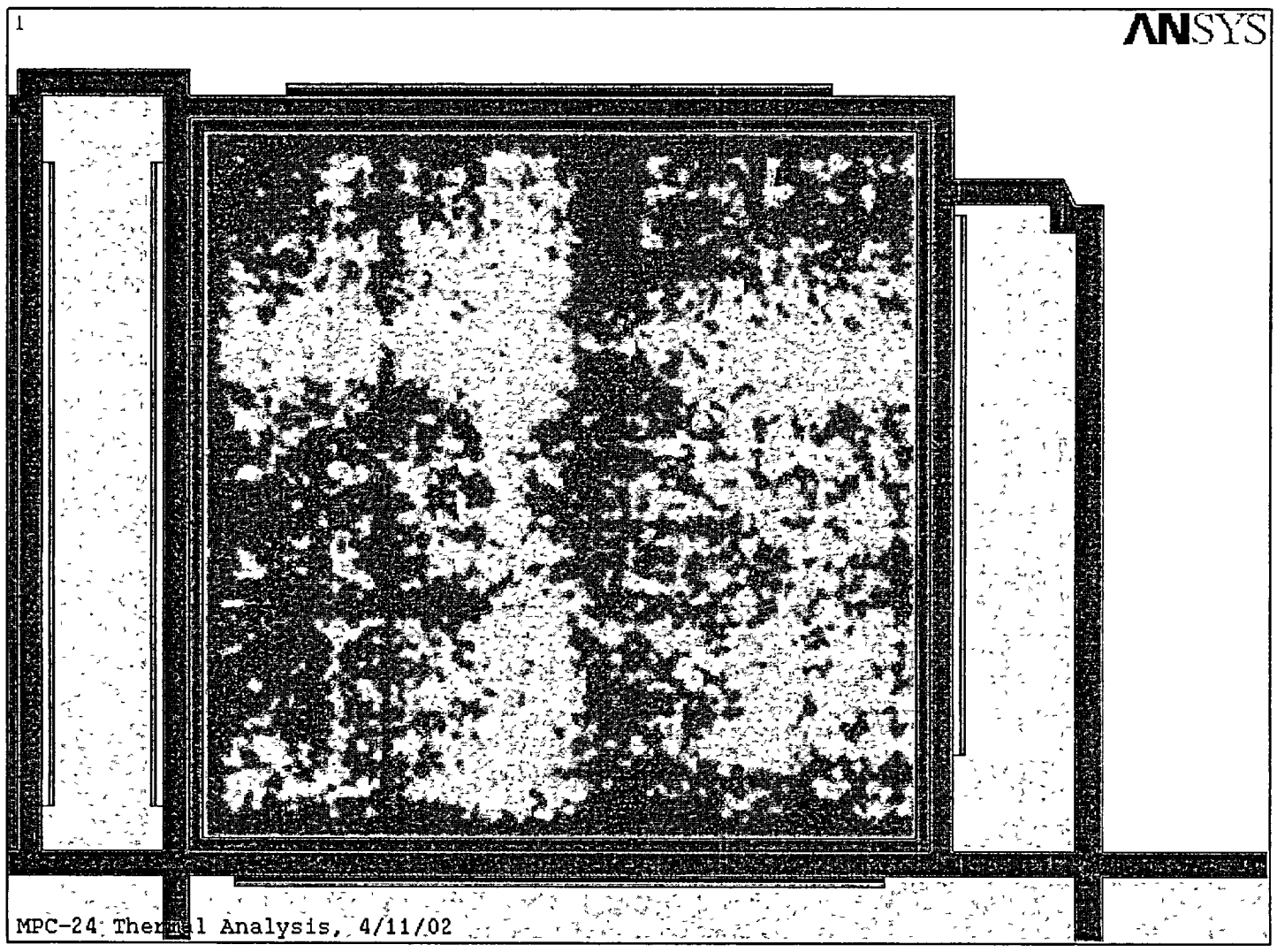
MPC/Overpack Geometry

Detail of Basket Cell



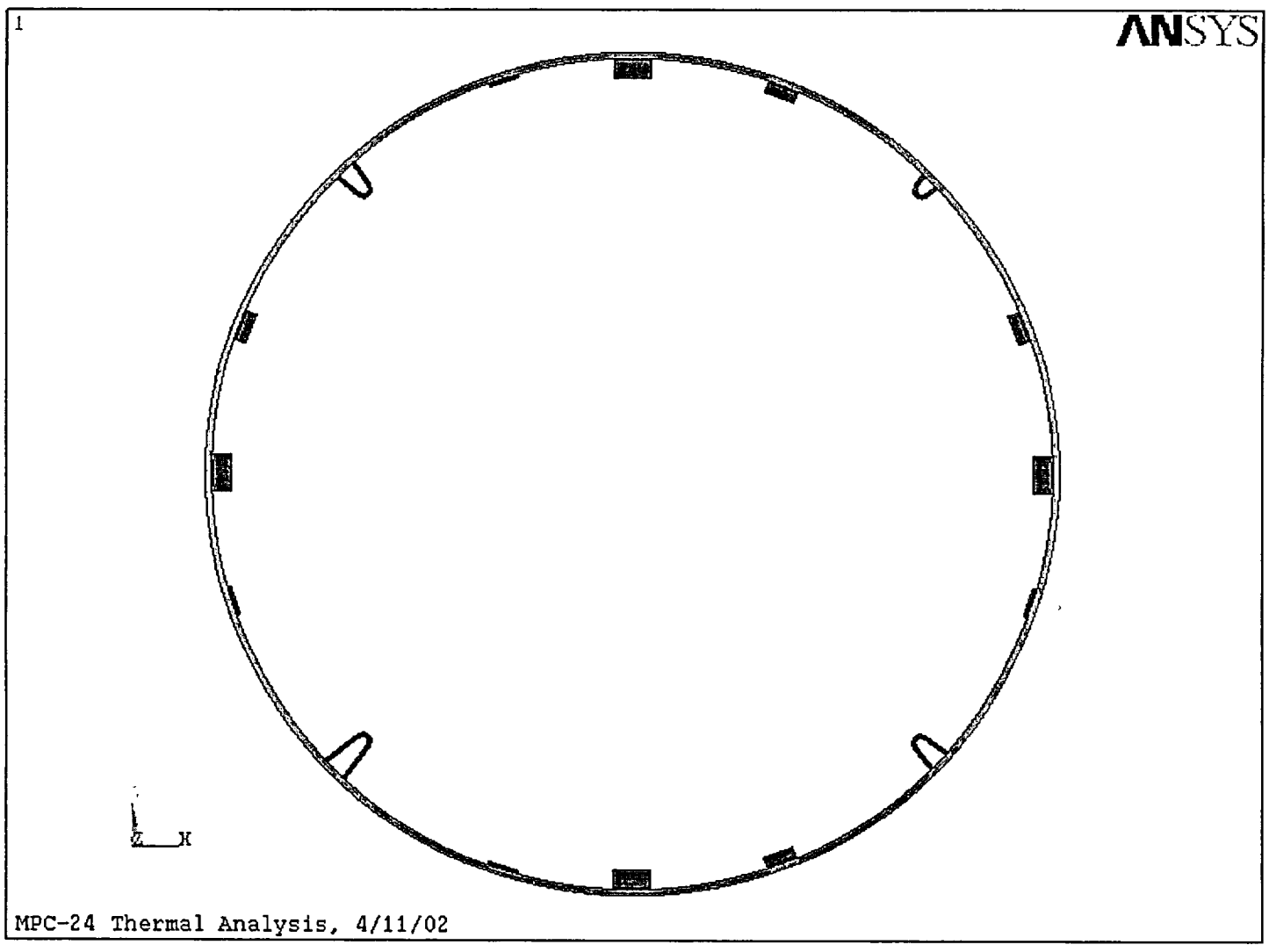
MPC/Overpack Geometry

Detail of Cell on Basket Boundary

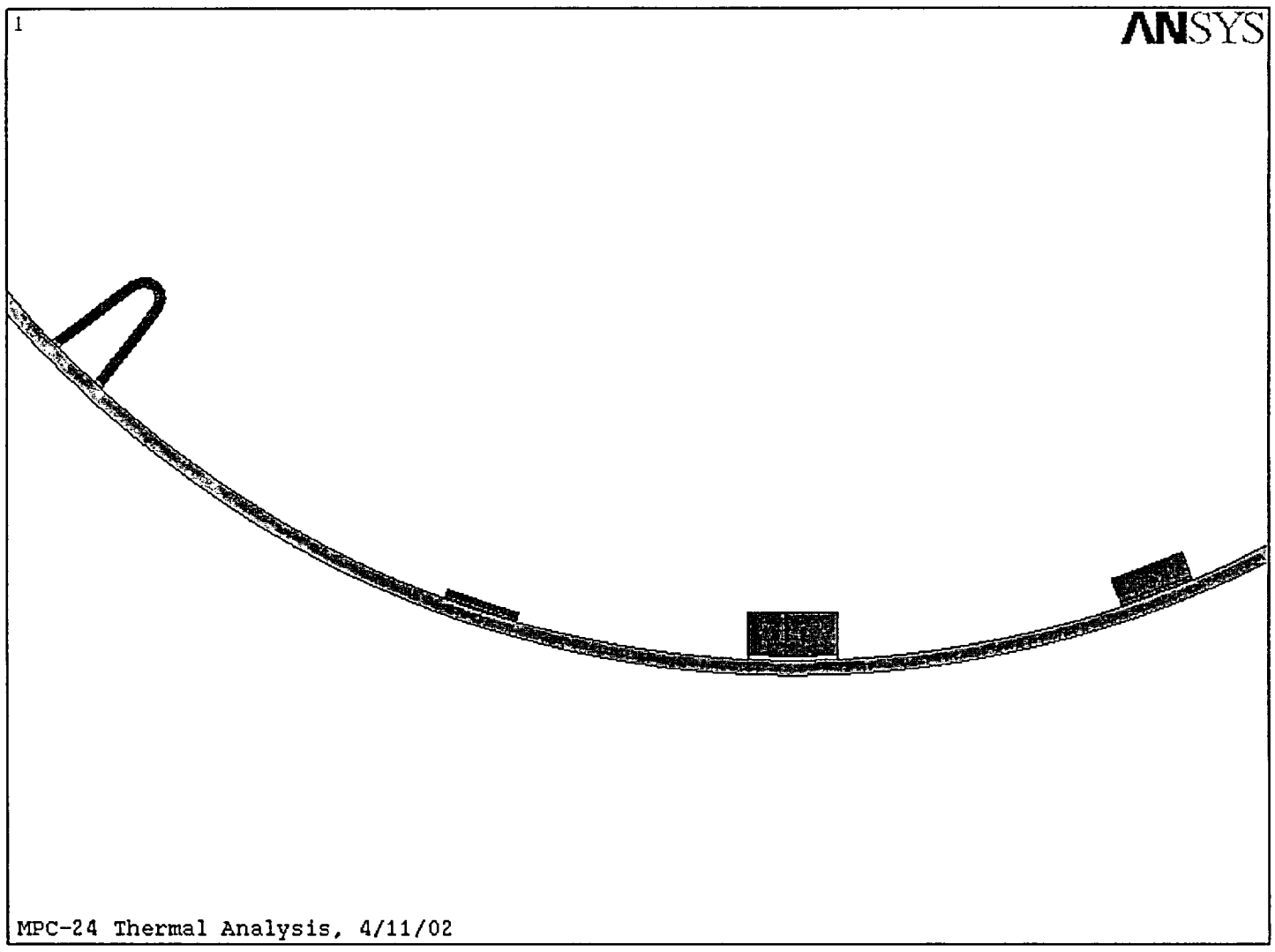


MPC/Overpack Geometry

MPC

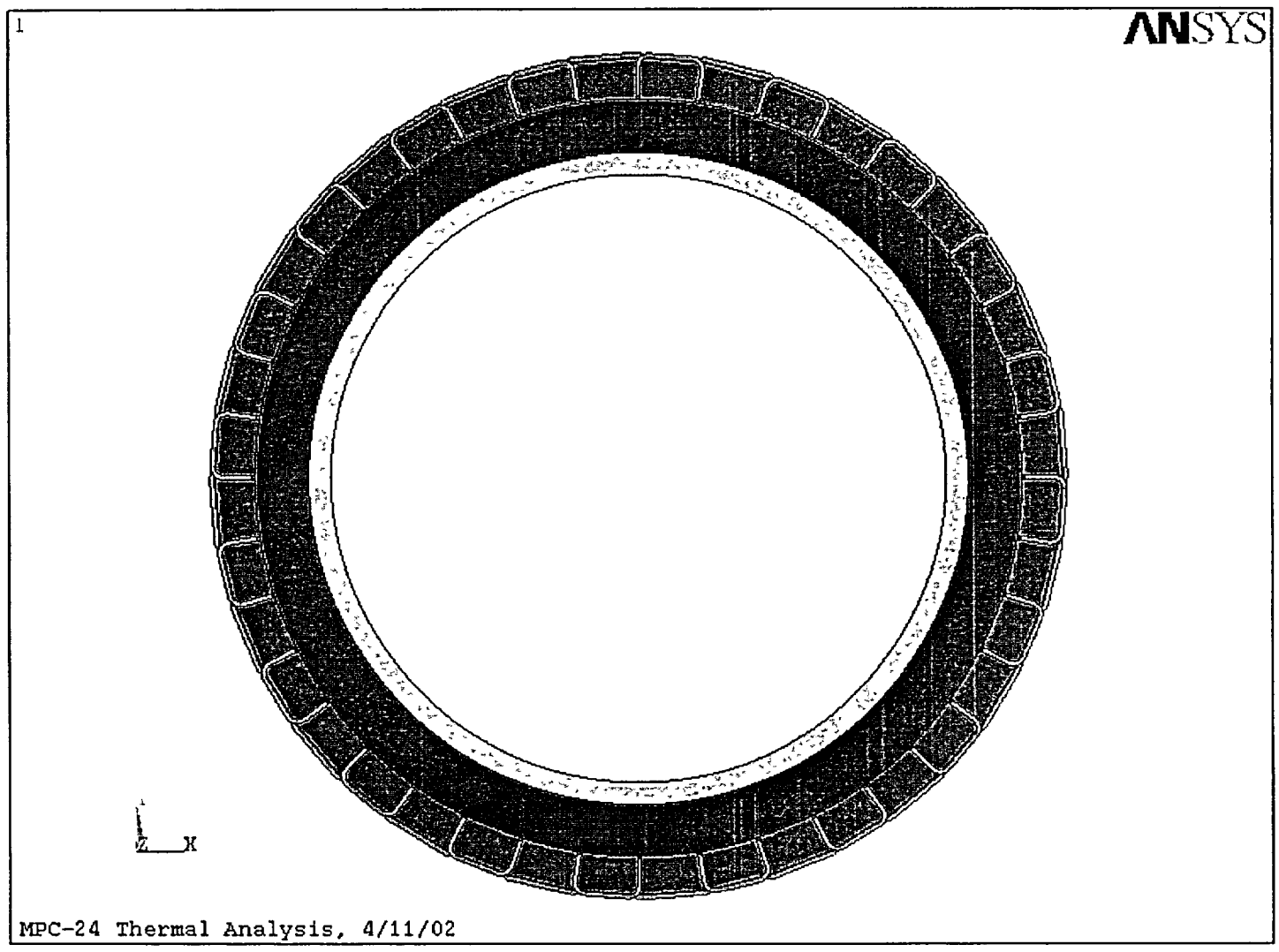


MPC/Overpack Geometry
Detail of Basket Supports

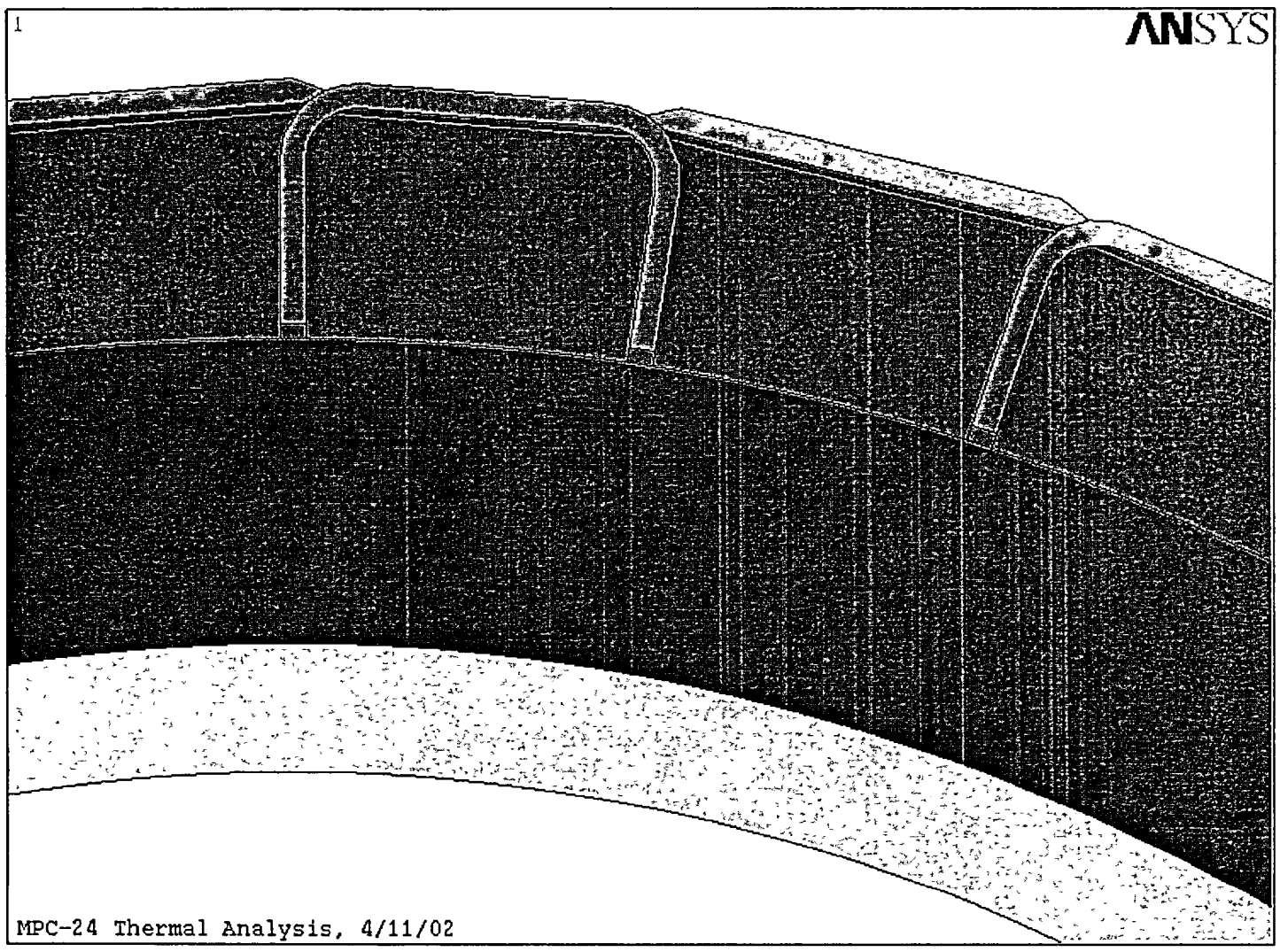


MPC/Overpack Geometry

Overpack



MPC/Overpack Geometry
Detail of Enclosure Channels



Thermal Transport Mechanisms

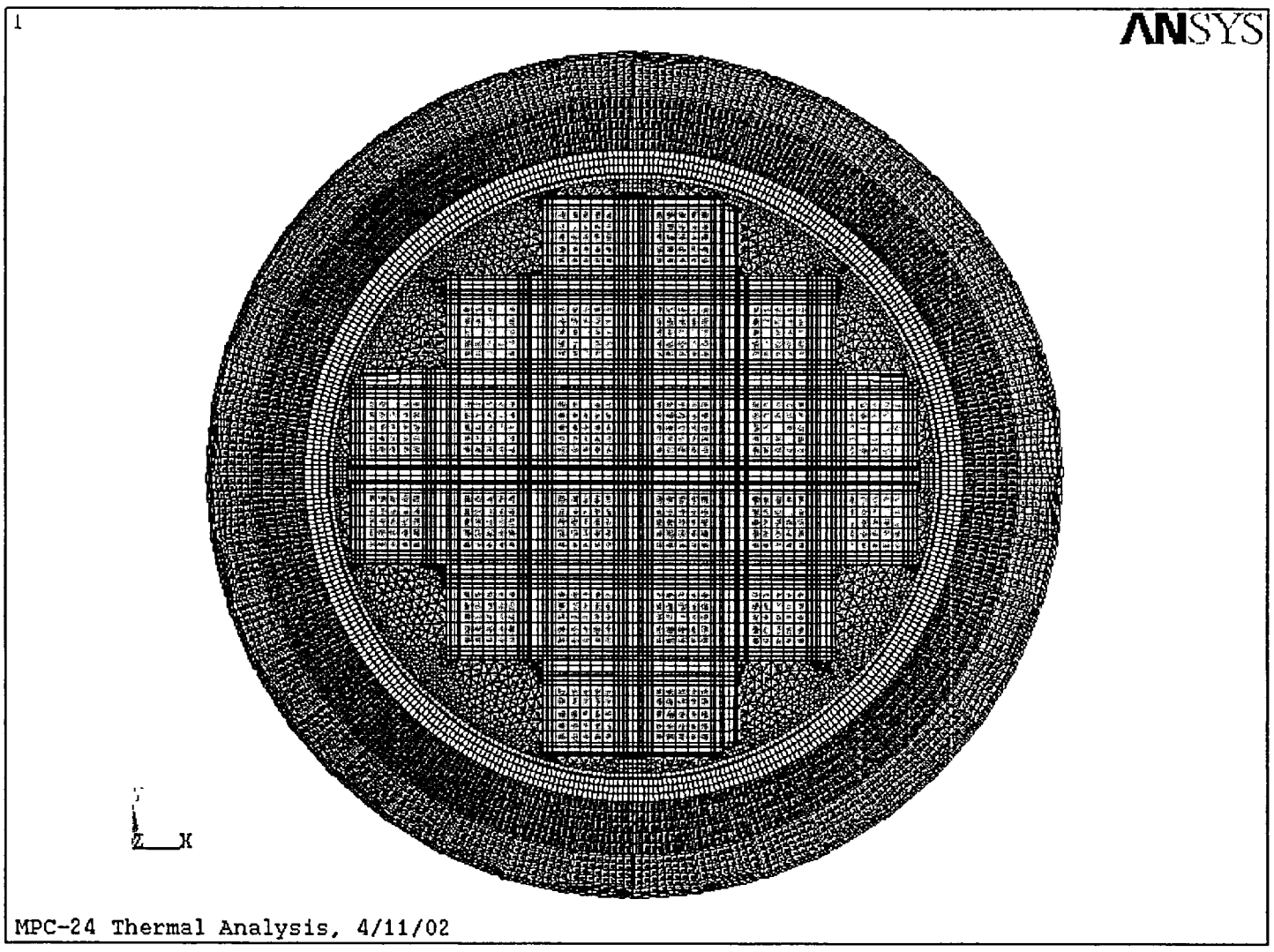
- Heat generation within fuel assembly
- Conduction within fuel assembly, all structural members, and helium backfill in MPC and between MPC and overpack
- Radiation between fuel assembly and guide tube, guide tube and basket, basket and MPC shell, MPC shell and overpack, overpack and ambient
- Convection on external overpack surface
- Solar insolation on external overpack surface per 10CFR71

ANSYS Model Details

- ANSYS 5.7.1
- Elements: 26177 PLANE55
  880 SURF151
  72 MATRIX50
- Nodes: 23737
- Degrees of Freedom: 23737

ANSYS Model

Element Plot

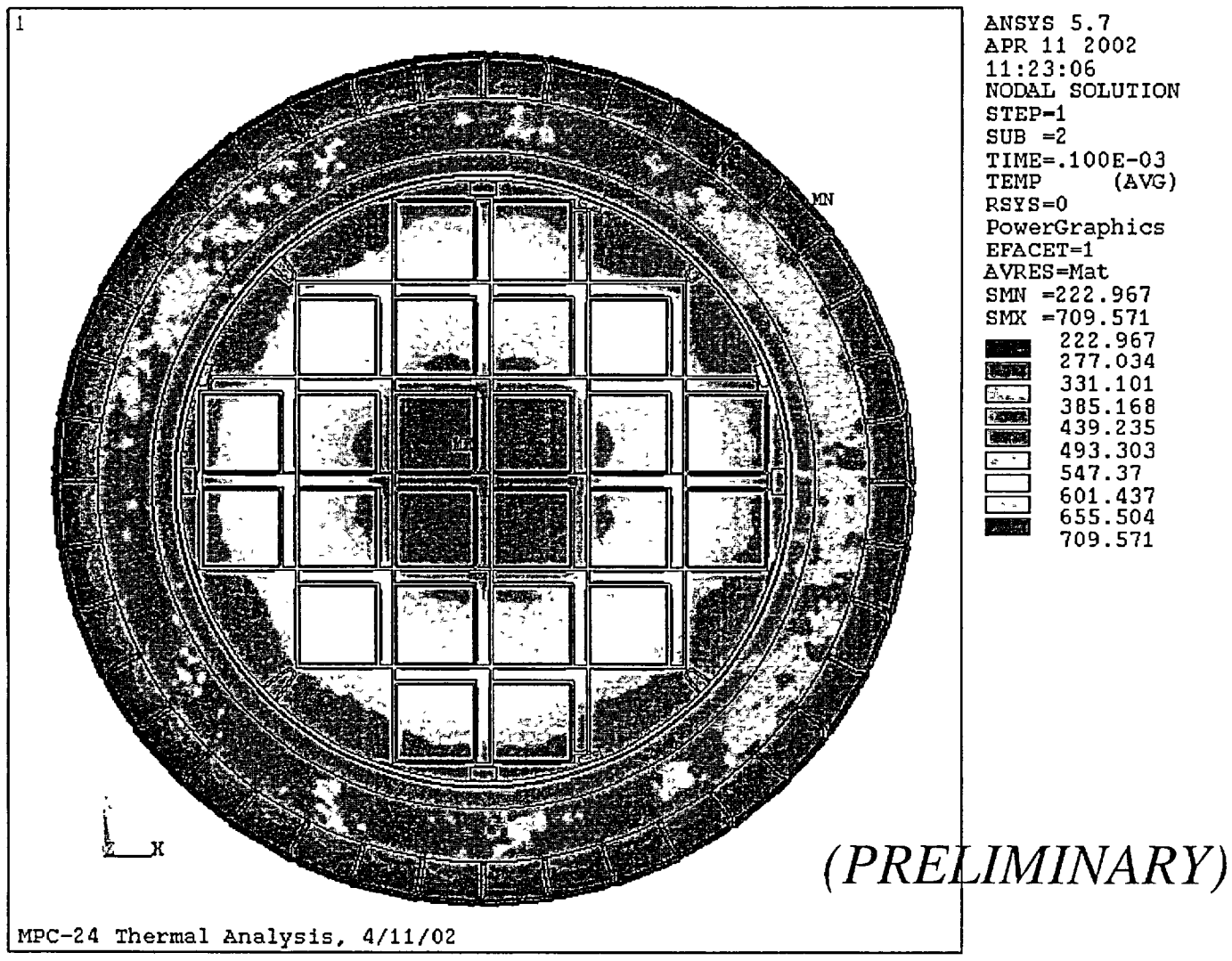


Thermal Loading
Normal Conditions of Transport

- Fuel heat generation of 20 kW
- Solar insolation of 1475 BTU/ft^2 averaged over 24 hours and absorptivity of 0.9
- External free convection to 100°F ambient with film coefficient of 0.891 BTU/ft^2-hr-°F
- External radiation to 100°F ambient with emissivity of 0.85 and view factor of 1.0

Temperature Results

Normal Conditions of Transport



(PRELIMINARY)

Thermal Loading
Accident Conditions

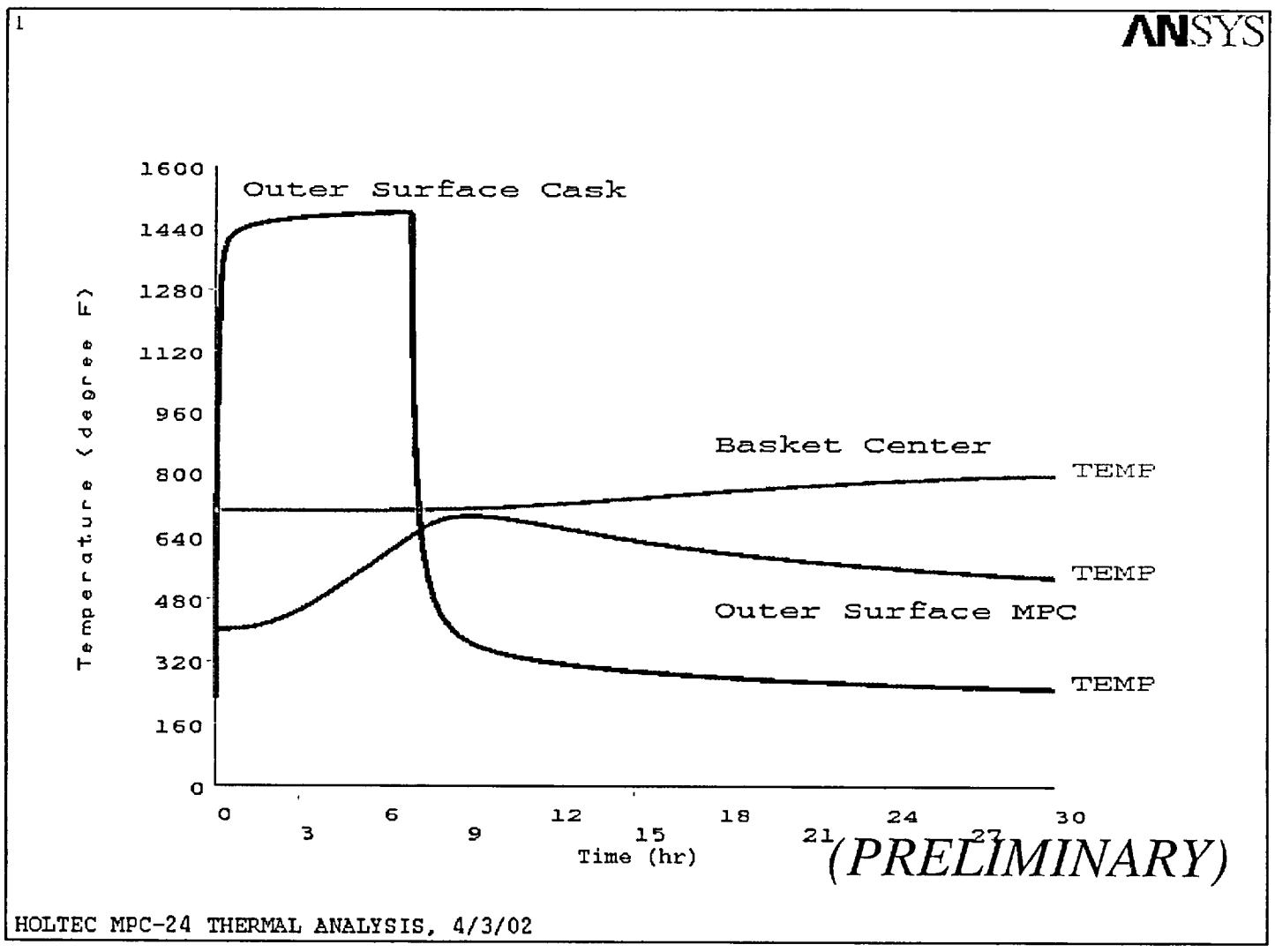
- Fuel heat generation of 20 kW
- No solar insolation
- External forced convection to 1500°F fire with film coefficient of 2.5 BTU/ft^2-hr-°F
- External radiation to 1500°F fire with emissivity of 0.9 and view factor of 1.0
- 7 hour duration of fire

Thermal Loading

Post-Fire Conditions

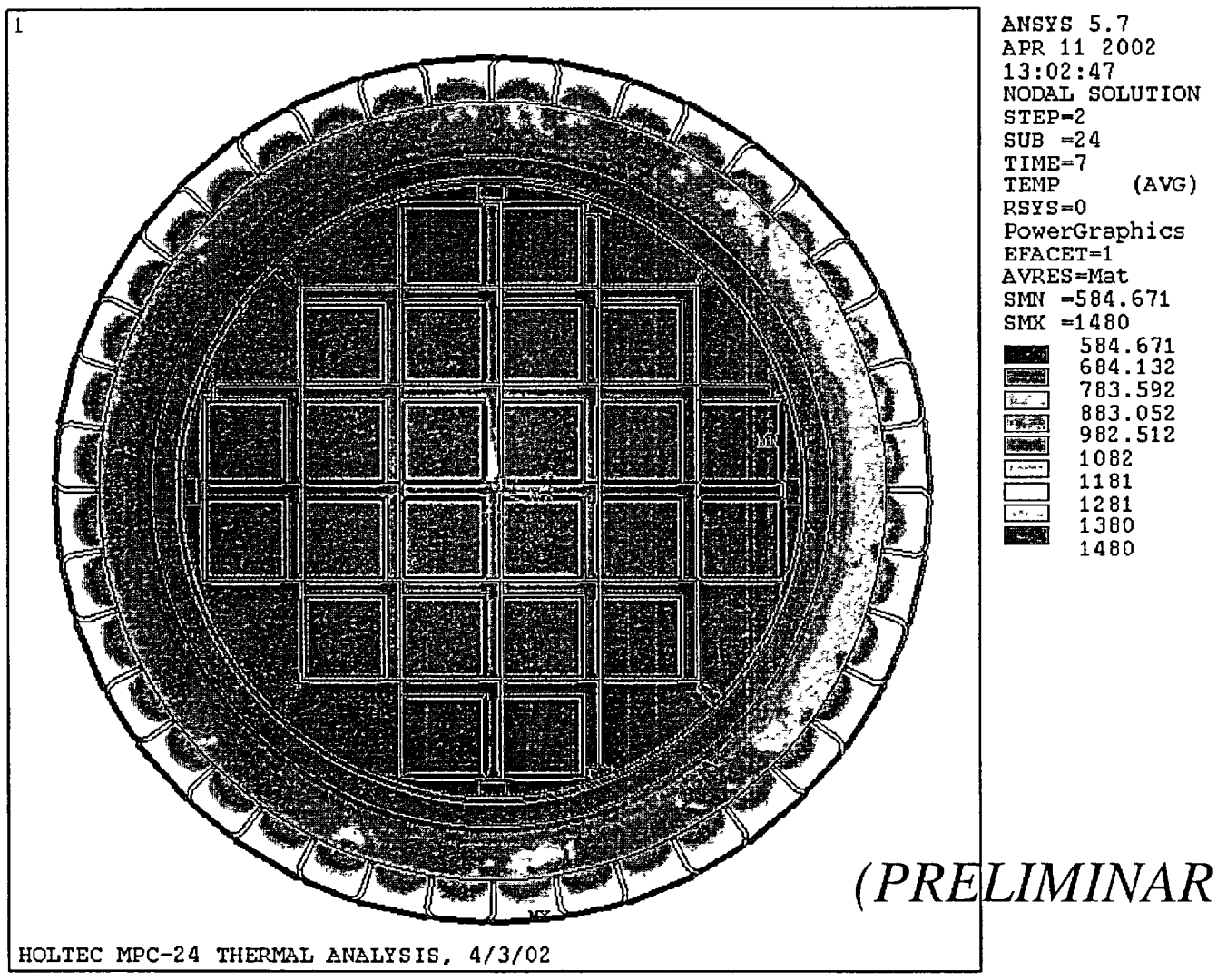
- Fuel heat generation of 20 kW
- No solar insolation
- External free convection to 100°F ambient with film coefficient of 0.891 BTU/ft^2-hr-°F
- External radiation to 100°F ambient with emissivity of 0.9 and view factor of 1.0
- 20 hour duration of cooling period after fire

Temperature Results
Thermal History



Temperature Results

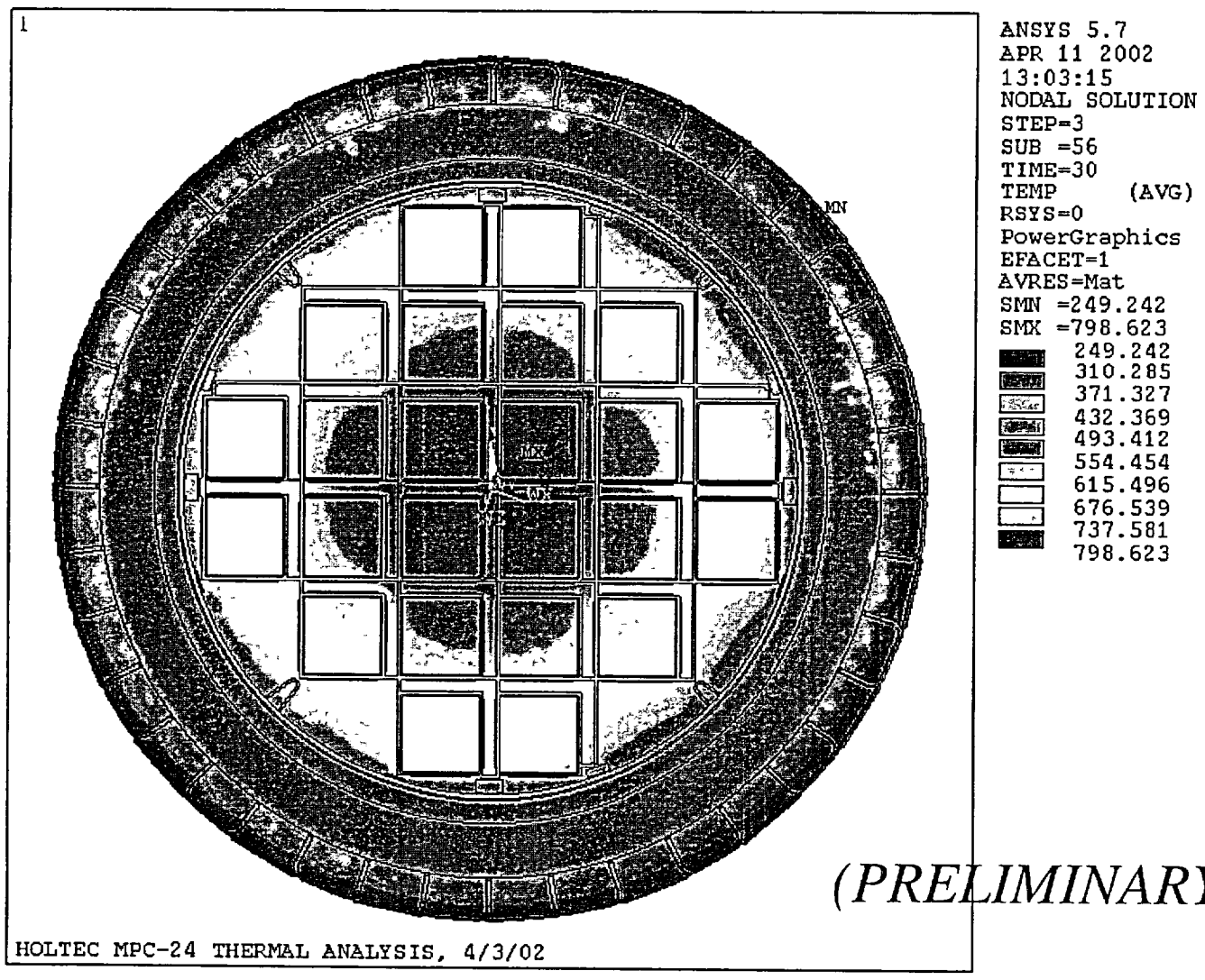
End of Fire



(PRELIMINARY)

Temperature Results

Peak Cladding Temperature After Fire



(PRELIMINARY)