RESPONSES TO REQUESTS FOR ADDITIONAL INFORMATION RAJ-II PACKAGE DSU/SSTC/2007-331

Presented to ASN and IRSN

23 June, 2009

Global Nuclear Fuel

A Joint Venture of GE, Toshiba, & Hitachi

Fire Analysis Questions

IRSN/ASN Questions:

The requesting party did not allow for:

- **Combustion of the polyethylene components in contact with the fuels: foam on the walls of the inner container, inserts and rod separators.**
- **The parcel (fuel rods) had not been heated before this test. The temperatures reached by the rods were therefore not representative of the maximum temperatures reached under accident transport conditions.**
- **The thermal calculation carried out to simulate the fire test but without simulating the internal combustion of the combustible materials in the parcel indicates that the maximum temperature reached by the fuel rod cladding could exceed 705°C, Since the confinement of radioactive material in the rods is only provided if their temperature does not exceed 650°C for 9x9 and 10x10 type fuel rods, there would be a risk of the rods of this type breaking under hot pressure.**

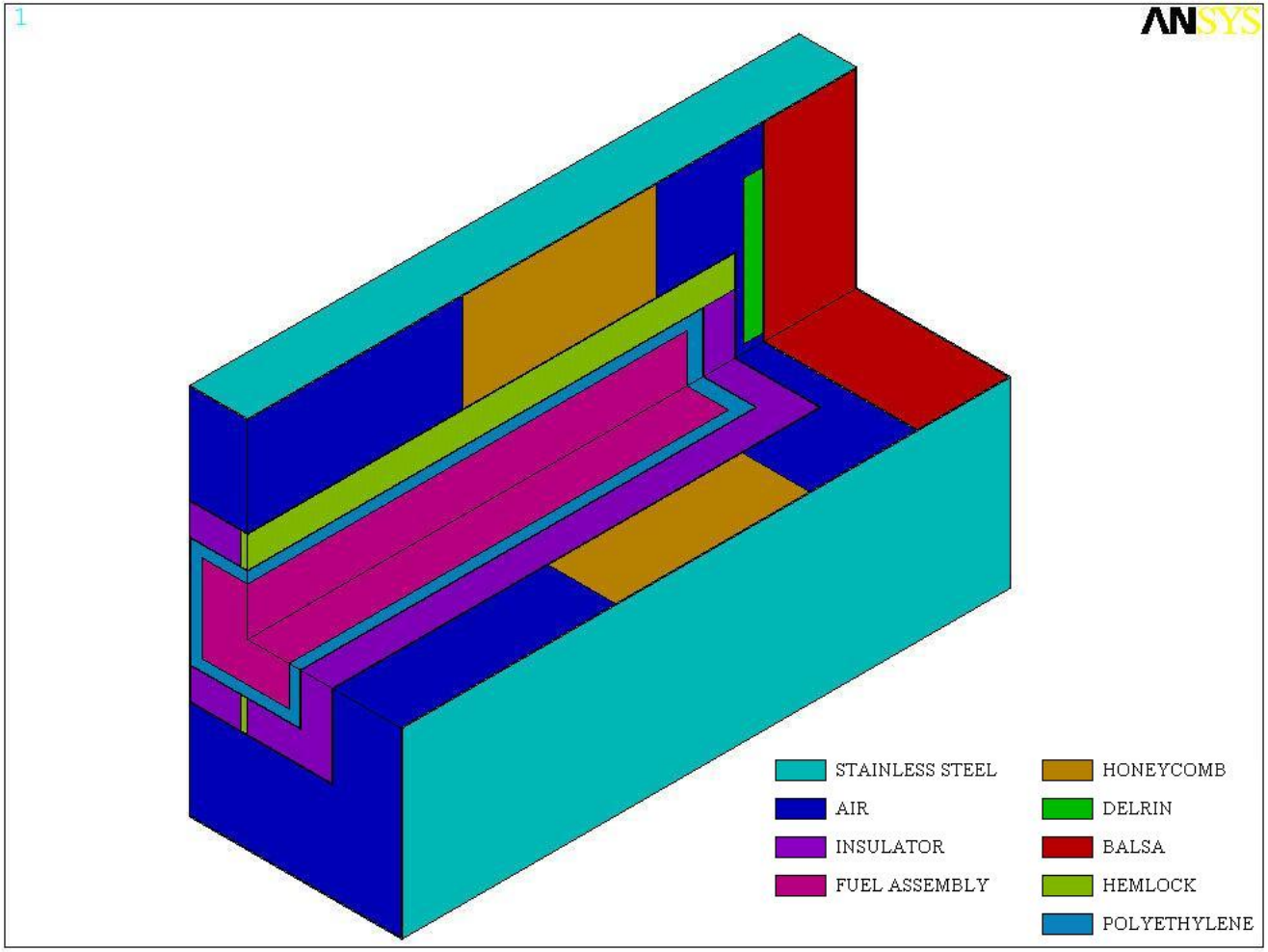
Fire Analysis Details

1. A new 3-D finite element was developed to evaluate the performance of the RAJ-II when exposed to the NRC/IAEA regulatory fire conditions. The new model includes the complete geometry of the RAJ-II outer and inner containers.
2. Boundary conditions include preheating of the container; combustion of the honeycomb paper, charring of the balsawood, charring of hemlock and the phase change of the polyethylene foam (both melting and vaporizing) within the inner container. Also included are the combustible materials (e.g. Delrin) located at the ends of the RAJ-II package.
3. The initial condition of the assembly was found by solving the steady-state case for exposure to ambient solar radiation and 38°C environment. The transient case was then solved for exposure to an 800°C external fire for 30 minutes, followed by exposure to a 38°C environment.
4. Radiation heat transfer between the outer container wall and the surrounding environment is modeled.

Fire Analysis Details

5. Radiation heat transfer between the outer container wall and the inner container wall is modeled.
6. The ANSYS program internally calculates view factors between components. Emissivity in all radiation cases is conservatively chosen as 1.
7. The convection heat transfer from the outer container wall to the environment is also modeled.
8. The mixing effects of convection are included in the enclosure between the outer container wall and the inner container wall, equalizing temperature in all air elements.

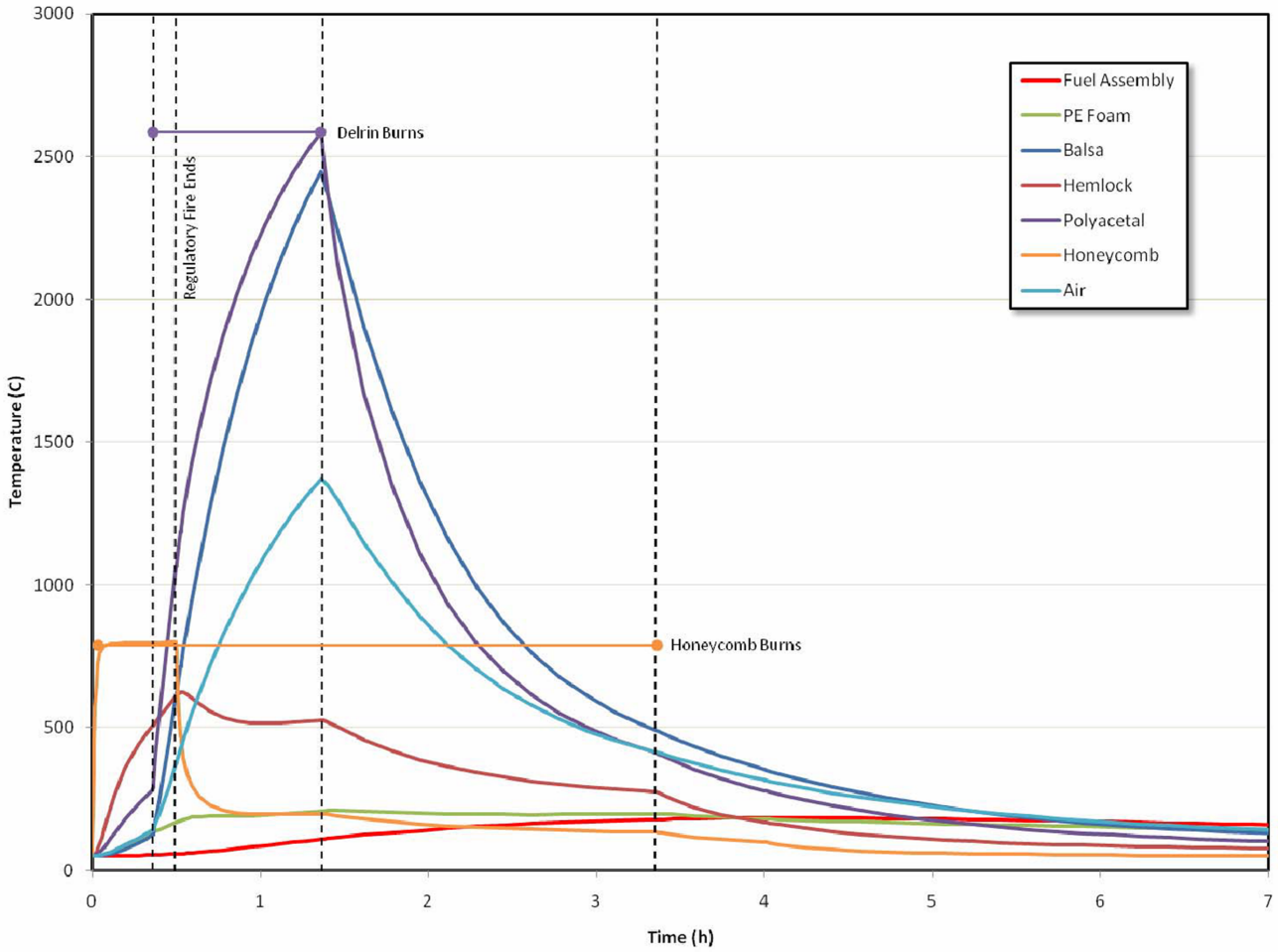
- **The 3-D finite element model includes both transverse and longitudinal heat transfer and end effects, e.g., burning of Delrin. In order to decrease computing time, geometric symmetries were used, requiring only one-half of the transverse cross section to be modeled. Similarly, only a portion of the overall length was required.**



Results Summary

1. Results of the transient analysis shows that the temperatures inside of the inner container reached the melting point of the polyethylene foam but not the combustion temperature.
2. The melting and vaporization of the polyethylene foam and combustion of the Delrin contributes to the internal temperature of the fuel bundle.
3. Burning of the honeycomb paper has little effect on final fuel bundle temperature.
4. The maximum fuel bundle temperature is approximately 200°C.

Results – RAJ-II Inner & Outer Container

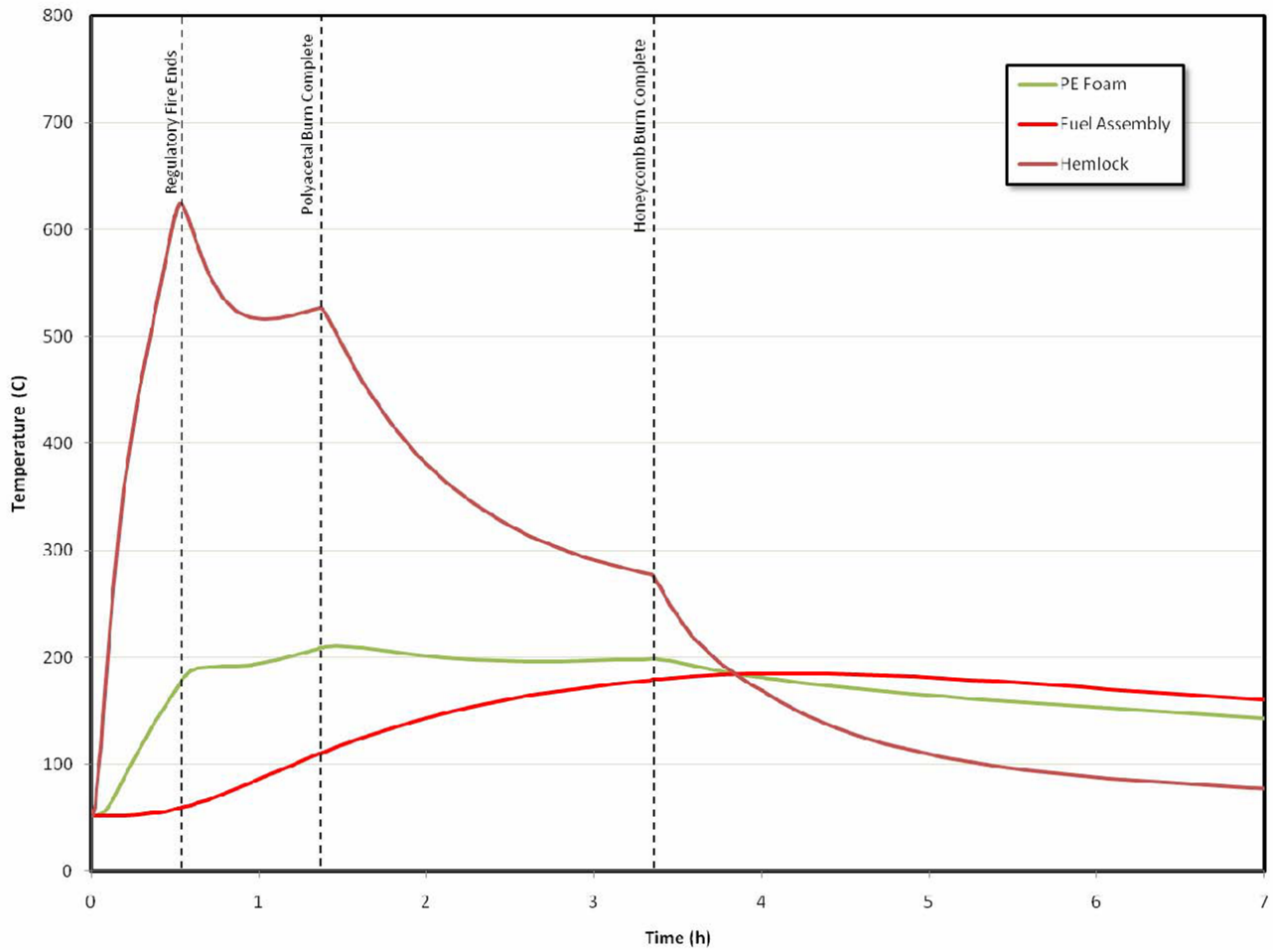


ENUSA INDUSTRIAS AVANZADAS, S.A. GRUPO ENUSA

GNF Global Nuclear Fuel A Joint Venture of GE, Toshiba, & Hitachi

Westinghouse

Results – RAJ-II Inner Container



ENUSA INDUSTRIAS AVANZADAS, S.A. GRUPO ENUSA

GNF Global Nuclear Fuel A Joint Venture of GE, Toshiba, & Hitachi

Westinghouse

Conclusions

- The fuel cladding temperature is below the mechanical limit for the material and the pressure stresses are below the values presented in the safety analysis report.
- The existing 2-D analysis bounds the worst-case thermal conditions and no further analysis is required. The licensing basis does not change.