THERMAL SHIELDING OF THE WOOD SHOCK ABSORBER

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Introduction

Introduction

- **To safely transport the radioactive waste arising from a hot test of ACP (Advanced spent fuel Conditioning Process).**
  - **KAERI is developing a shipping package.**
  - **Regulatory guidelines classify the hot cell cask as a Type B.**
- **Type B package should be able to withstand a test sequence as follows;**
  - **9 m drop onto an unyielding surface**
  - **1 m drop onto a puncture bar**
  - **30 minutes under a thermal condition of 800 °C**
- **In particular, the containment of the package must be maintained at the conclusion of this sequence.**

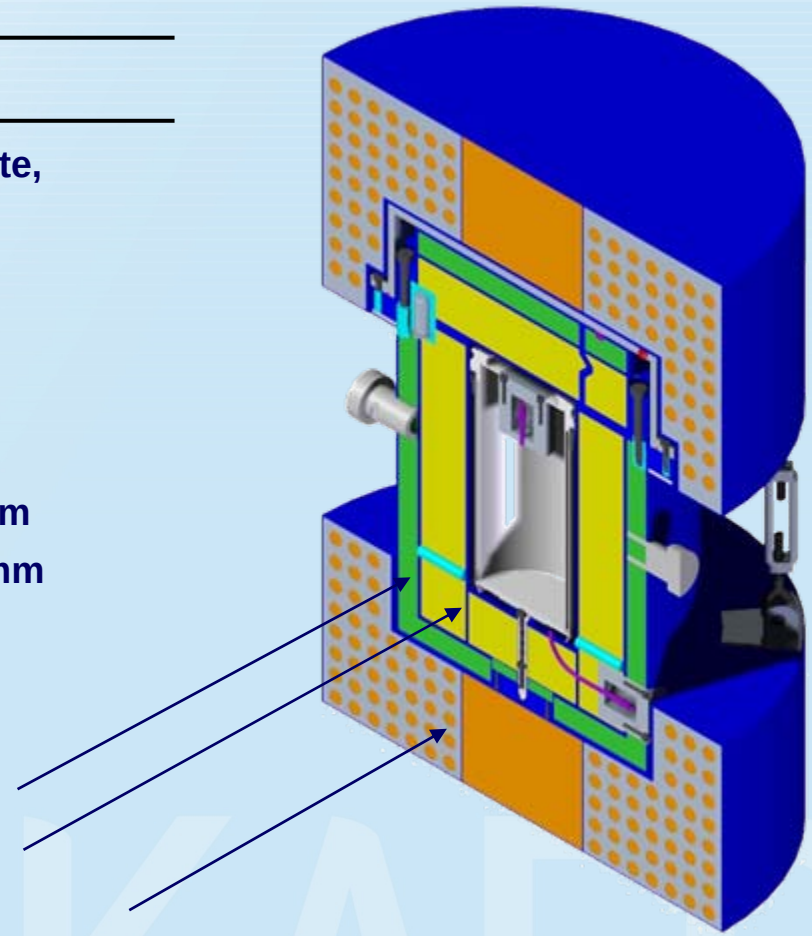
- Greiner investigated the thermal protection provided by shock absorbers to a containment seal of a legal-weight-truck package using the CAFE code.
  - No-shock absorber package : 0.7 h
  - Intact package : roughly 2 h
- This paper discusses the experimental approach used to simulate the response of a hot cell cask to a furnace fire using a 1/2 scale model.

Thermal Test

Thermal Test

Description of a Hot Cell Cask

Item	Description
Components	Shell(Outer, Intermediate, Inner) Neutron Shield Gamma Shield Shock Absorber
Dimension	Outer Diameter : 800 mm Overall Height : 1,140 mm
Weight	4.4 tons
Material	Shell : Stainless Steel Neutron Shield : Resin Gamma Shield : Lead Shock Absorber : Balsa Wood



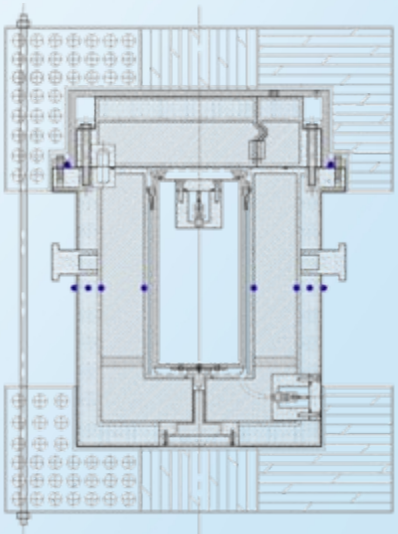
▲ Configuration of a Hot Cell Cask

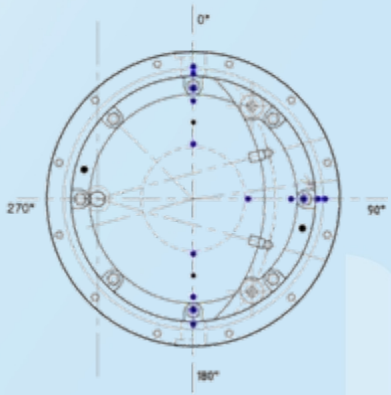
Before the Thermal Test

- 9 m drop test
- 1 m puncture test
- Upper shock absorber was removed
- Accelerometers were removed
- Strain gages were removed
- 16 thermocouples were installed
- Upper shock absorber was re-installed

▲ Drop impact instance

▼ Deformed shape of shock absorber

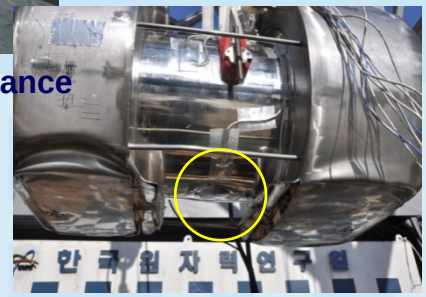




• Thermocouple Location

▲ Puncture impact instance

▼ Deformation of outer shell



Scale Model Heat Input

Specific heat input for the full scale cask

$$Q_P = (\pi DL + 2 \times \frac{\pi D^2}{4}) \sigma F \frac{T_R^4}{M_P} \tau_R$$

- Q_P : full scale specific heat input
- D : full scale package diameter
- L : full scale package length
- σ : Stefan-Boltzmann constant
- F : view factor
- T_F : fire temperature
- M_P : mass of the full scale package
- τ_R : regulatory fire duration

Fire duration for the scale model

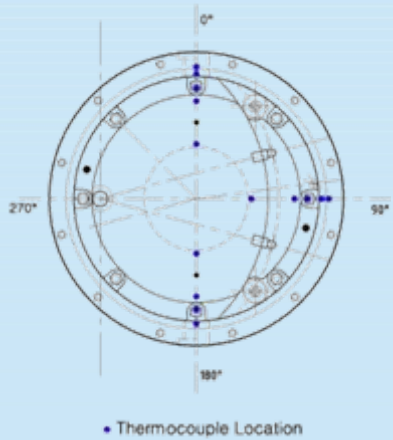
$$\tau_T = \frac{Q_P M_M}{(\pi D_M L_M + 2 \times \frac{\pi D_M^2}{4}) \sigma F T_F^4}$$

- D_M : test model diameter
- L : test model length
- F : view factor for a package in a furnace
- T_F : furnace temperature
- M_M : mass of the test model

- Measurement System
  - Temp. DAS : up to 160 thermocouples
    - Thermocouple scanner
    - Signal conditioner
    - A/D converter
    - Personal computer

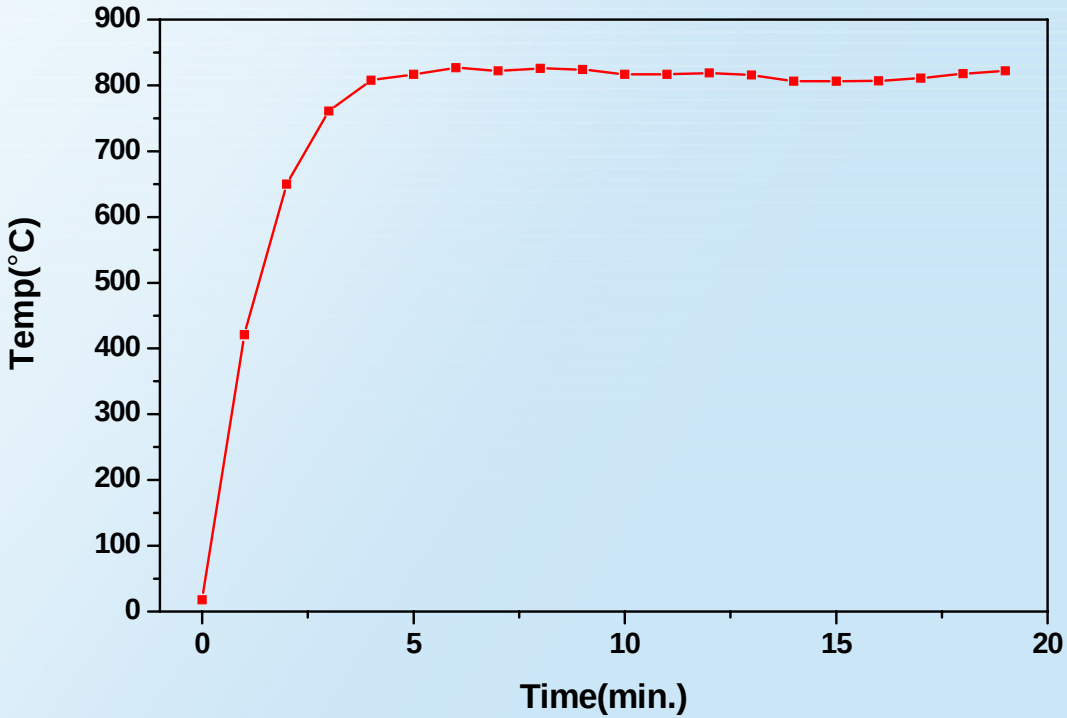
Thermal Test

- Carried out in a furnace of Fire Insurers Laboratories of Korea(FILK)
- Furnace roof was opened by using the overhead crane
- Test model was lowered into the furnace
- Thermocouples were connected to Temp. -DAS
- Furnace roof was closed
- After the required duration, furnace roof was opened
- Thermocouples were removed from Temp. -DAS
- Test model was lifted out of the furnace
- Transferred to cooling area



Results & Discussion

Flame Temperature

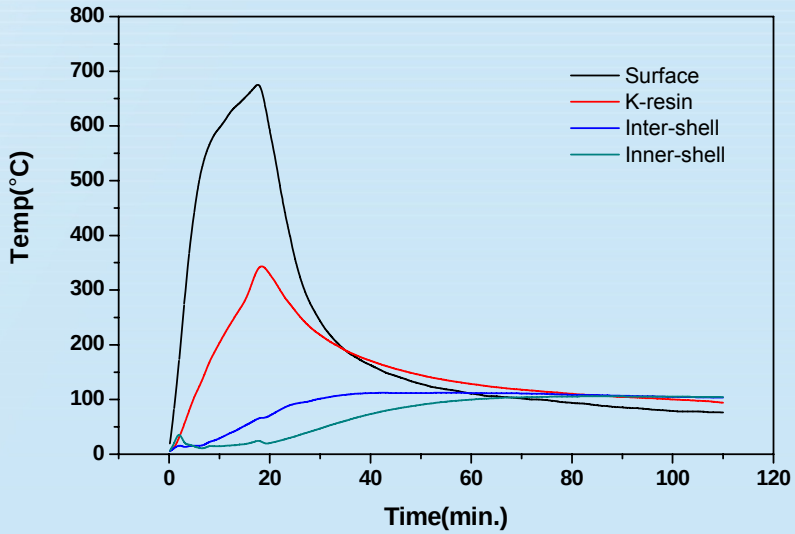


▲ Average flame temperature

- Average flame temperature in the thermal test : 813 °C
  - ➔ Thermal condition was Satisfied.

Test Results

Location		Temp.(°C)	Time(hr)
Surface	Upper(0°)	682	0.3
	Mid.(90°)	602	0.3
	Lower(180°)	-	-
K-resin	Upper(0°)	346	0.3
	Mid.(90°)	438	0.28
	Lower(180°)	426	0.33
Intermediate-shell	Upper(0°)	112	0.87
	Mid.(90°)	101	1.41
	Lower(180°)	105	0.97
Inner-shell	Upper(0°)	106	1.40
	Mid.(90°)	103	1.43
	Lower(180°)	102	1.45

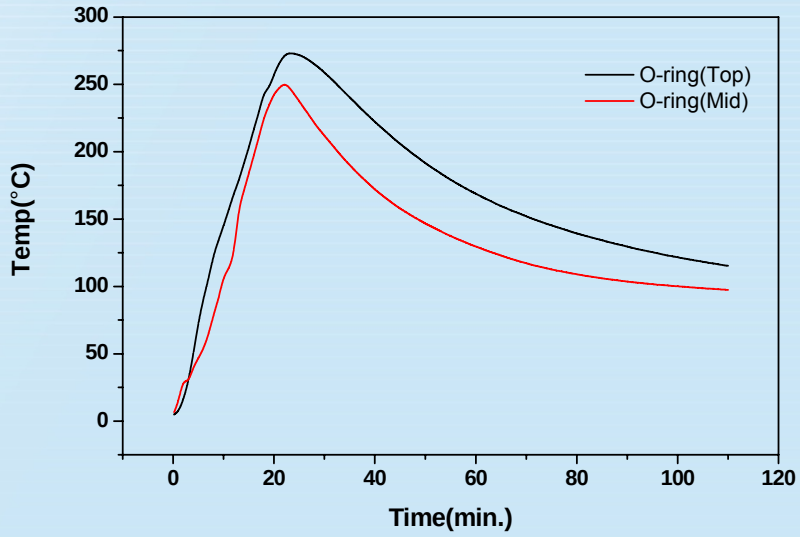


▲ Temperature history during a thermal test

- Maximum temperature
  - Surface of the hot cell cask : 682 °C
  - K-resin : 438 °C after 17 min.
  - Intermediate-shell : 112 °C after 52 min.
  - ❖ Max. temp. of the lead < melting temp.

Test Results

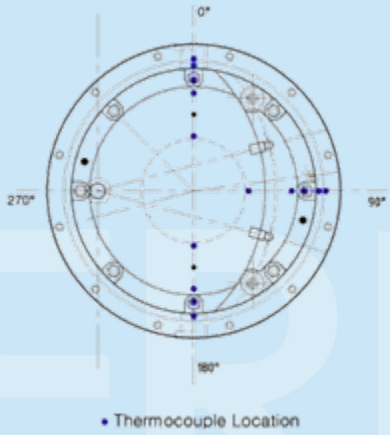
Location		Temp.(˚C)	Time(hr)
O-ring	Upper(0˚)	273	0.38
	Mid.(90˚)	251	0.37



▲ Temperature history at O-ring

- Temp. of the Upper part
  - Higher than that in the lower part
  - ➔ Combustion was initiated from the broken upper part of the shock absorber
- Temp. of the O-ring
  - Higher than manufacture's recommended temp.
  - ➔ Shock absorber, which was broken in the drop test, was burned
- To maintain the containment boundary
  - ➔ Important that the manufacturing of the shock absorber prevent breakage

❖ To ensure thermal integrity, KAERI is currently improving the thermal problem of the hot cell cask



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Conclusion

- Thermal test was carried out to evaluate the thermal integrity of a hot cell cask.
  - The maximum temperature of the containment seal in the upper part was measured as 273 °C, which is higher than the manufacture's recommended maximum temperature.
    - This is because the shock absorber, which was broken in the drop test, was burned.

- Therefore, in order to maintain the containment boundary of the hot cell cask, it is important that the manufacturing of the shock absorber prevents breakage.

Thank You for Your Attention

감사합니다