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LONG-TERM STABILITY AND FIRE RESISTANCE OF NEUTRON SHIELDING MATERIALS, TN™ RESIN VYAL-B AND KOBESH EPR RESIN

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ABSTRACT

Transnuclear, Ltd. designs transport and storage casks for the Asian market, using technological resources of neutron shielding materials of both TN International and Kobe Steel, Ltd. A series of tests were performed for two types of neutron shielding materials, TN™ resin Vyal-B and kobesh EPR resin, considering cask design approval in Japan. TN™ resin Vyal-B is vinylester resin based and was developed by TN International. And kobesh EPR is Ethylene-Propylene-Rubber based and was developed by Kobe steel, Ltd.

These materials were heated under 140°C, 160°C, and 170°C, up to 10000hours to evaluate thermal properties under transport and long-term storage conditions by means of Arrhenius equation. The hydrogen content and density of these neutron shielding materials have been stable under test conditions and it is confirmed that these shielding materials have high stability at such elevated temperatures as 160°C for transport and long-term storage conditions for more than 60 years.

The fire resistance tests were performed at 800°C/30minutes for these materials in order to know their behavior under fire accident, using partial models simulating actual cask. After removal from the fire, these neutron shielding materials were instantaneously self-extinguished and most material remains in its previous shape. The remaining weight of these materials after the fire resistance test were more than 90% for TN™ resin Vyal-B, and more than 75% for kobesh EPR respectively. It is confirmed that TN™ resin Vyal-B and kobesh EPR have excellent fire resistant properties.

1. INTRODUCTION

Neutron shielding materials used in transport and/or storage casks is one of the most important materials for radiation safety. And they are usually used under severe thermal conditions, such as long-term usage under high temperature in transport and storage conditions.

To examine the performance of neutron shielding materials TN™ Vyal-B[1] and kobesh EPR, a series of tests were performed. And they were reported in previous PATRAM.
Additional long-term heating tests and fire resistance tests for these materials were performed in order to obtain thermal properties, which are necessary for Japanese design approval. This paper presents the results of these tests.

2. TN™ VYAL-B AND KOBESH EPR

TN™ Vyal-B resin developed by TN International, is composed of vinylester resin in a solution of styrene, aluminum hydrate, and zinc borate. And kobesh EPR resin developed by Kobe Steel, Ltd., is an Ethylene-Propylene-Rubber based resin.

3. LONG-TERM HEATING TEST

To examine the thermal resistance of TN™ Vyal-B and kobesh EPR, long-term heating tests were performed at three different temperatures.

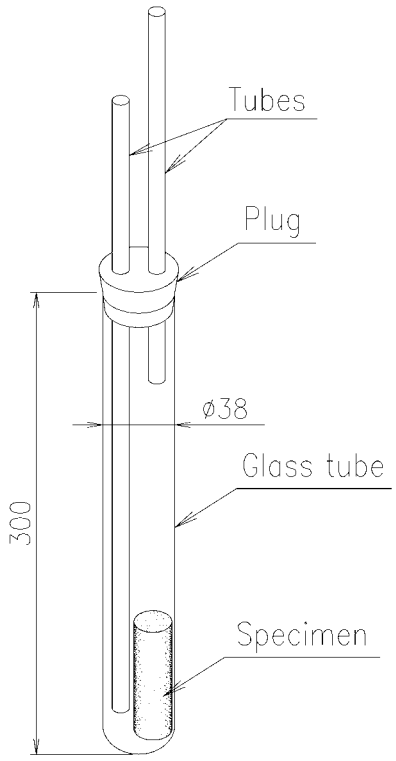
3.1 Test conditions

Figure 1 shows test specimens of TN™ Vyal-B and kobesh EPR, whose diameters are 20mm and lengths are 70mm.
Test specimens of those resins were heated at three different temperatures: 140°C, 160°C, and 170°C. Heat durations were from 500h to 10000h for each temperature. These test conditions were decided to evaluate weight loss of these resins after 60 years by means of Arrhenius equation.

Test specimens of TN™ Vyal-B were heated without envelope in an oven. Consequently, the heating condition for TN™ Vyal-B was conservatively open to atmosphere.
On the other hand, test specimens of kobesh EPR were heated in a glass tube in compliance with the test condition of JIS K6257(Accelerated aging test methods for vulcanized rubber), to simulate actual situation for casks. Figure 2 shows the test apparatus for kobesh EPR. The heating condition for kobesh EPR was closed in the tube, but air could go in and out from two tubes freely.
Because both test specimens were not sealed in the oven, heating conditions were severer than in the actual situation for casks, where resins are sealed by steel, and so on.

TN™ Vyal-B kobesh EPR

Figure 1. Test specimens for long-term heating



Test tube Test tubes in the oven

Figure 2. Heating apparatus for kobesh EPR

3.2 Test results for long-term heating test

Figure 3 and Figure 4 show the trends of weight loss for the resins during long-term heating. Although the weight loss of the resins increased as heating time and temperature, the maximum weight loss of both resins was less than 4% after 10000 hours heating.

It is known that the relation between heating temperature and duration can be expressed by so-called Arrhenius equation:

$$\ln(t) = A + \frac{E}{R \cdot T}$$

t : time
A : constant
E : activation energy(J/mol)
R : gas constant(J/mol/K)
T : temperature(K)

The weight loss during long-term heating for TN™ Vyal-B and kobesh EPR were evaluated by means of Arrhenius equation above. Figure 5 shows the relation between heating temperature and duration for TN™ Vyal-B assuming 4% of weight loss, and Figure 6 shows the relation for kobesh EPR assuming 5% weight loss.
Consequently, in this case, maximum temperatures for 60 years usage are evaluated as 160°C for TN™ Vyal-B and kobesh EPR.

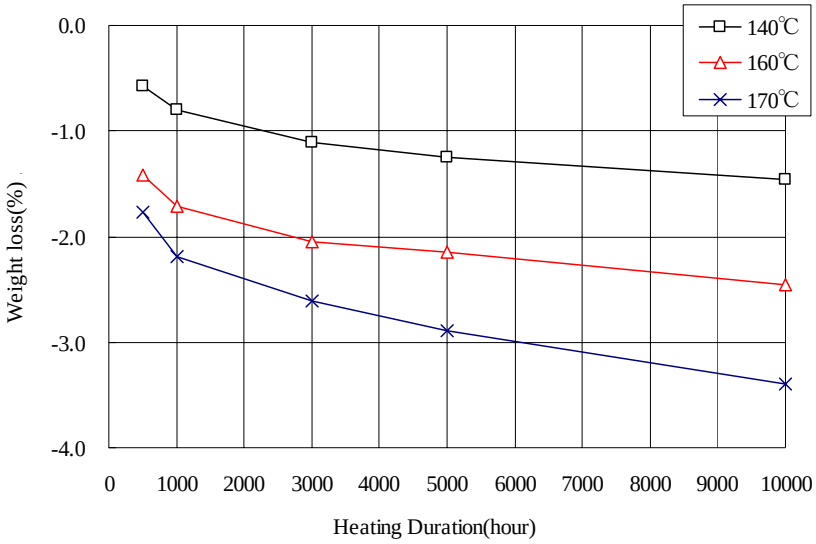


Figure 3. Weight loss of TN™ Vyal-B resin during long-term heating

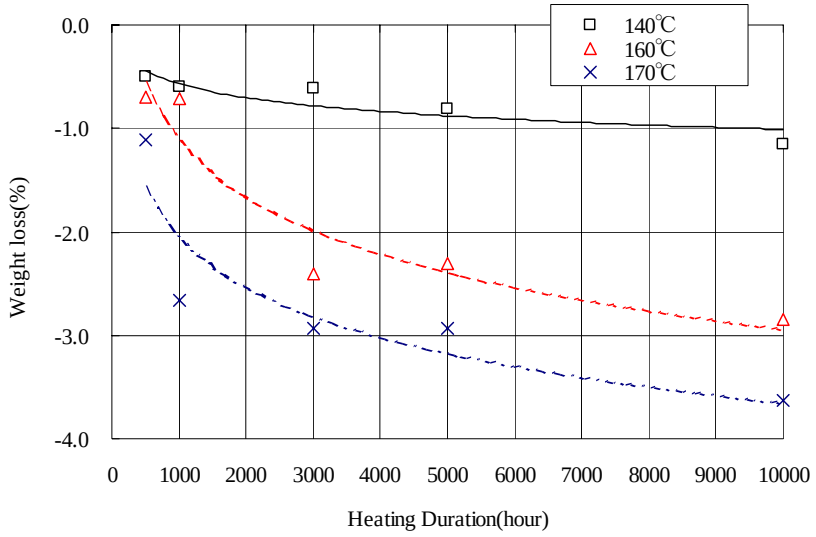


Figure 4. Weight loss of kobesh EPR resin during long-term heating

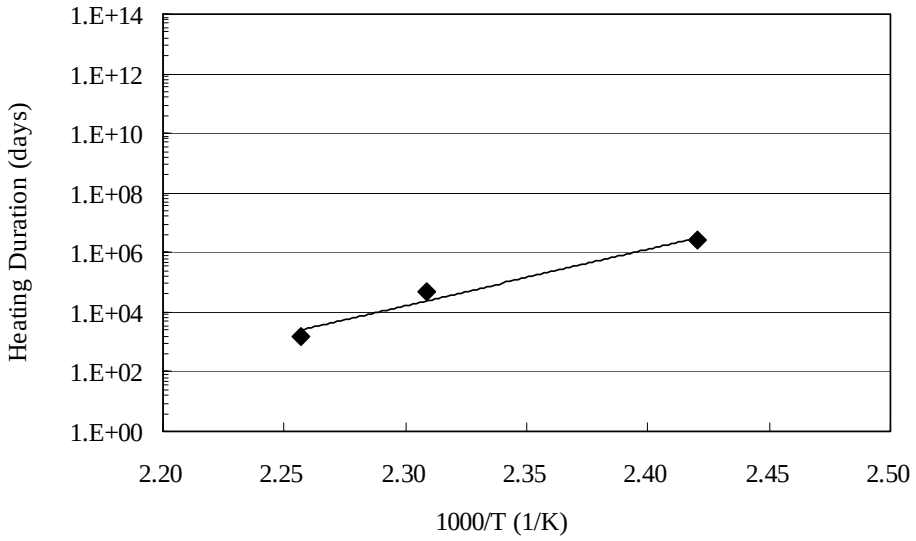


Figure 5. Relation between heating temperature and duration for TN™ Vyal-B (In case of 4% weight loss)

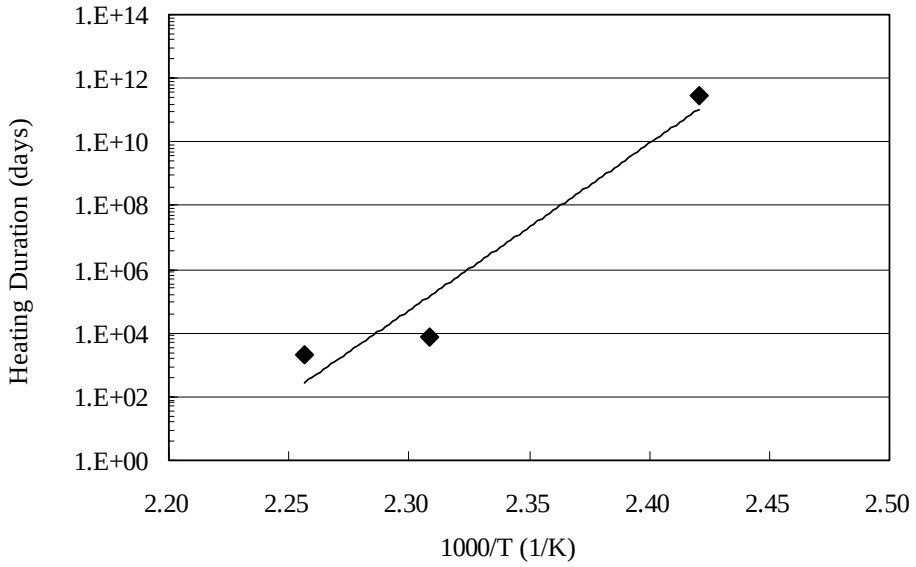


Figure 6. Relation between heating temperature and duration for kobesh EPR (In case of 5% weight loss)

4. FIRE RESISTANCE TEST

Fire resistance tests for TN™ Vyal-B and kobesh EPR were performed at 800°C in order to know their behavior under fire accident, using partial models simulating an actual cask.

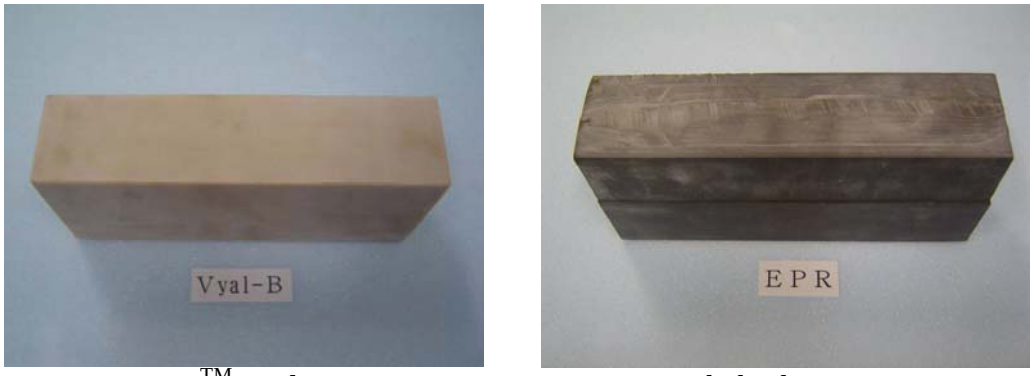
4.1 Test conditions

Table 1 shows the resin block dimensions of both resins for the fire resistance test. And resin blocks are shown in Figure 7. Figure 8 shows the partial model of resin blocks. These models simulate the actual situation of resin of spent fuel transport/storage casks by putting ceramic insulator at the bottom and two side walls in a steel box.

Test blocks were heated at 800°C for 30minutes in a furnace without direct flame contact(Figure9).

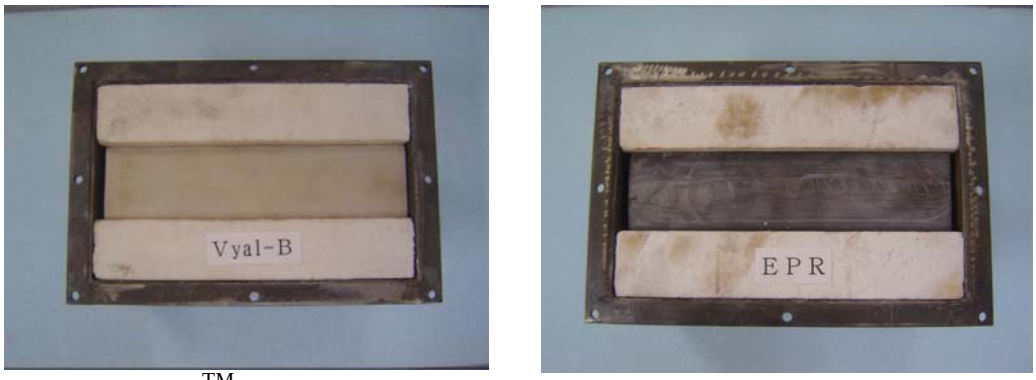
Table 1. Dimension of resins

Resin	Block Dimension (mm)
TN™ Vyal-B	253 x 107 x 62
kobesh EPR	240 x 106 x 62



TN™ Vyal-B kobesh EPR

Figure 7. Test blocks for fire resistance test



TN™ Vyal-B kobesh EPR

Figure 8. Test blocks insulated at the bottom and two side walls in a steel box

Figure 9. Test blocks in a furnace

4.2 Test results for fire resistance test

After removal from the fire, these neutron shielding materials were instantaneously self-extinguished and most material remained in its previous shape.

Figure 10 shows photos of the resins after exposed to the fire. Table 2 shows the weight of the resins before and after the test. The remained weight ratio of these materials after the fire resistance test were more than 90% for TN™ resin Vyal-B, and more than 75% for kobesh EPR respectively.

TN™ Vyal-B kobesh EPR

Figure 10. Resin blocks after fire resistance test

Table 2. Weight of resins before and after the test

Resin	Before test (g)	After test (g)	Remaining ratio (wt%)
TN™ Vyal-B	2997	2790	93
kobesh EPR	1905	1447	76

5. CONCLUSIONS

These tests confirmed that TN™ resin Vyal-B and kobesh EPR resin have excellent properties for thermal resistance and fire resistance.
High performance casks can be designed by employing these neutron shielding materials. Therefore, it makes it possible to meet the customer need for transportation and storage of high burn-up spent fuels.

REFERENCES

[1] P.ABADIE, "Development of a new neutron shielding materials, TN™ resin Vyal for transport/storage casks for radioactive materials", The 14th International Symposium on the Packaging and Transportation of Radioactive Materials(PATRAM 2004), Berlin, Germany, September 20-24, 2004.