Stability Analysis of Buffer Storage Large Basket and Temporary Storage Pre-packaging Basket Used in the Type B Radwaste Process Area

Sung-Kyun Kim [a*], Kune-Woo Lee [a], Jei-Kwon Moon[a]

[a]*Korea Atomic Energy Research Institute, Dukjin-Dong, Yuseong-Gu, Daejeon, South Korea*
[*]*Corresponding author: sungkyun@kaeri.re.kr*

1. Introduction

The ITER radioactive waste (radwaste) treatment and storage systems are currently being designed to manage Type B, Type A and dust radwastes generated during the ITER machine operation. The Type B management system is to be in the hot cell building basement with temporary storage and the modular type storages outside the hot cell building for the pre-packed Type B radwaste during the ITER operation of 20 years.

In order to store Type B radwaste components in onsite storage, the waste treatment chain process for Type B radwastes was developed as follows. First, Type B full components filled in a large basket are imported from Tokamak to the hot cell basement and they are stored in the buffer storage before treatment. Second, they are cut properly with a laser cutting machine or band saw machine and sliced waste parts are filled in a pre-packaging basket. Third, the sampling of Type B components is performed and then the tritium removal treatment is done in an oven to remove tritium from the waste surface and then the sampling is performed again. Forth, the characterization is performed by using a gamma spectrometry. Fifth, the pre-packaging operation is done to ensure the final packaging of the radwaste. Sixth, the pre-packaging baskets are stored in the temporary storage for 6 months and then they are sent to the extension storage and stored until export to host country.

One of issues in the waste treatment scheme is to analyze the stacking stability of a stack of large baskets and pre-packaging baskets in the storage system. The baseline plan is to stack the large baskets in two layers in the buffer storage and to stack the pre-packaging baskets in three layers in the temporary storage and extension storage. In this study, the stacking stability analysis for the buffer storage large basket and temporary storage pre-packaging basket was performed for various stack failure modes.

2. Methods and Results

In this section, large baskets containing big components such as vacuum vessel, TBM, and cryopump are stored in the buffer storage before waste treatment. The large baskets will be piled up in two layers and basket size is 3.7 m(L)x3.2 m(W)x2.8 m(H). After waste treatment process, Type B components are stored in pre-packaging baskets (1.4 m(L)x1.4 m(W)x1.4 m(H) and the baskets will be stacked up in three layers in both the temporary storage and the extension storage. In this study, the stacking stability analysis for the large basket and pre-packaging basket was performed for various stack failure modes.

2.1 Maximum floor angle for a basket, No external forces

In the process of analyzing the modes of stacking stability failure, it is necessary to define the number of stacked baskets before tipping over, on a floor having a slope and no external forces. The number of stacked baskets on a floor having a slope can be calculated by the following equilibrium equation.

$$\tan\theta_{cr} = \frac{N \times y}{\frac{x}{2}} \quad \therefore N = \left[\left(\frac{x}{y} \right) \times \tan\theta_{cr} \right] \tag{1}$$

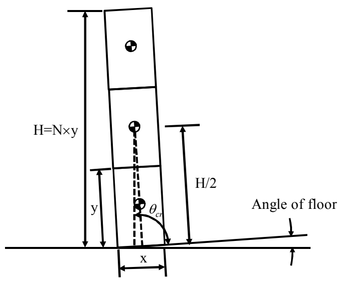


Fig. 1 Layout of stacked baskets on the angled floor

Table 1 shows the maximum number of the large basket and pre-packaging basket with respect to floor angle variation. From the result we can conclude that the floor angle of the buffer storage should be less than 20 degree to stack two baskets and the floor angle of the temporary storage and extension storage should be less than 15 degree to stack three baskets.

Table 1. Maximum number of baskets in stack with respect to floor angle

Floor angle (degree)	Number of baskets in stack=N					
	3	5	10	15	20	25
Large basket	16	10	4	3	2	1
Pre-packaging basket	19	11	5	3	2	2

2.2 Sliding failure mode

The force required to slide a basket can be calculated following equation.

$$F = \mu_s \times P = \mu_s \times (n \times W)$$

using $\mu_s = 0.74$ for steel on steel

$$F = \mu_s \times \left[\left(\frac{H}{y} \right) - \left(\frac{h}{y} \right) \right] \times W$$

where F = required force, n = number of baskets above the slip plane, P = normal force to slip plane, W = weight of individual basket, y = height of individual basket, μ_s = static friction coefficient, [ ] = quantity inside the brackets must be truncated to a whole number (e.g., 1, 2, 3,…, etc.). Table 2 shows the required sliding forces for occurring sliding failure. From the analysis results it is known that as the distance acting the contact force increases the required sliding force decreases.

Table 2. Required forces for occurring sliding failure

h	Sliding force F_{slide}	
	Large basket (y=2.8 m, W=30 ton)	Pre-packaging basket (y=0.7 m, W=11 ton)
3y/2	0.74*W	1.48*W
5y/2	-	0.74*W

2.3 Tip over failure mode

In this section the force required to tip over a stack of baskets is calculated. Fig. 2 shows the required force for occurring tipping with respect to applying force location for the large basket and pre-packaging basket. From this result, it is concluded that as the applying force location increases, the tipping failure can occur with quite small applying force. And it is also known that the required force for sidling is less than the tipping force under the same condition.

$$\sum M_{Tipping} = h \times F, \quad \sum M_{Sliding} = \left(\frac{x}{2} \right) \times (N \times W)$$

Equilibrium condition

$$\sum M_{Tipping} = \sum M_{Sliding} \Rightarrow h \times F = \left(\frac{x}{2} \right) \times (N \times W)$$

Substituting for "N"

$$F = \left(\frac{x}{2h} \right) \times W \times \left[\frac{H}{y} \right]$$

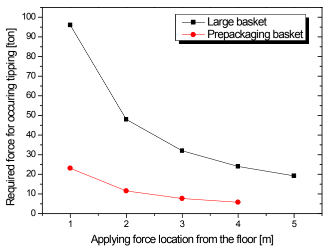
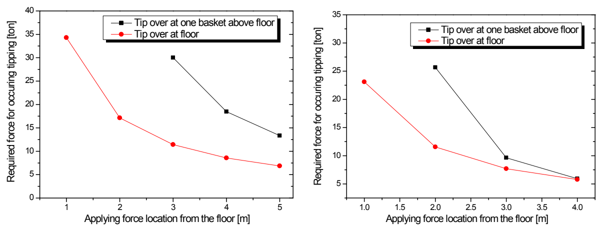


Fig. 2 Required force for occurring tipping vs. applying force location

2.4 Tip over location for a stack of baskets with the force applied any distance above the floor

From the previous section, it has been noted that with the use of stacking interlocking features, tip over will be the dominant mode of failure. The next part of this study compares the amount of force to tip over a stack pivoting at the floor versus a pivot point within the stack. As shown in Fig 3 it is concluded that, when applied F above the floor, force required to tip over the stack at floor level is less than tipping from one basket level above the floor.



(a) large basket (b) pre-packaging basket

Fig. 3 Comparison of required forces for tip over at one basket above floor and. tip over at floor

2.5 Tip over location for a stack of baskets with the force applied near the top of the column

This section presents a series of figures and calculations simulating a moving basket operated by a crane contact force being applied at an elevation near the top of a stack. Each of the calculations uses a stack of two buffer storage large baskets and three temporary storage pre-packaging baskets. Table 3 shows the required forces occurring tip over for both large basket and pre-packaging basket. The results indicate that the lowest required force occurs when the three baskets are pivoted as a group at the floor level.

Table 3 Required forces occurring tip over for both large basket and pre-packaging basket

Large basket		Pre-packaging basket	
Tip location from top	Required force	Tip location from top	Required force
0.5	96	0.5	32
3.3	29.1	1.9	8.1
-	-	3.3	7

3. Conclusions

In this paper the stacking analysis for the large basket and pre-packaging basket was performed and the results showed that the stacking number of both basket types is reasonable. This stacking analysis technique is practically applicable when 200L waste packaging drums and containers are stored in a confined area or yard.