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Experimental Investigation of the Trapping Efficiency of a Debris Interceptor for ECCS Recirculation Strainers of Korean NPPs

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1. Introduction

The suction head of the safety injection pumps should be maintained after hypothetical loss of coolant accident of the nuclear power plant because the high energy jet force from the break fragments the thermal insulation and protective coatings into particulate pieces and then may block the ECCS recirculation strainer. The fine holes of the fiber insulation pieces can be filled up by particles of coating, which can produce higher head loss. Therefore, most existing strainers should be replaced with larger and more efficient strainers in order to provide sufficient suction flow even when particles accumulate on the strainer. For a cost-effective design change, the concept of debris interceptor, a pre-filter, can be considered. The debris interceptor is installed in a specific location of the flow path over the reactor building floor upstream of the ECCS strainer. It reduces the flow velocity and thus ultimately sinks most of the particles before reaching the strainer. This paper describes an experimental method pertaining to the trapping efficiency of the debris interceptor to verify its performance and to elucidate the trapping mechanism of the coating debris with the plant-specific parameters[1-3.]

2. Experimental Methods

2.1 Test Facility Design

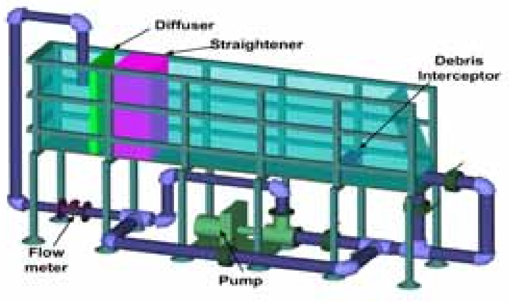

Fig.1 FINA Facility for Interceptor Test

The FINA (FNC INterceptor Assessment test facility) consists of a flume containing diffuser (porous media), a flow straightener, a simulated debris interceptor, a recirculation pump and piping, as shown in Fig. 1. The flume is 6m in length, 0.6m in width and 1.5m in height. The diffuser is installed near the water inlet to make a uniform flow of water over the cross-section of the test flume. The flow straightener is installed directly behind the diffuser to dampen and straighten the flow that is incoming from the diffuser, before it enters the main test region of the flume.

2.2 Test Conditions

The size distributions of the coating stimulants are determined from plant data for three types of Korean NPPs. Four size classes are used. Their percentages in the mixture and quantities are presented in Table 1 and Table 2, respectively.

Table 1. Size Distribution of the Coating Simulant for Each Plants

Silica simulant size(mil)	WH Type	CANDU Type	FRAMATOME Type
5 ~ 10	46.72 %	96.09 %	34.49 %
10 ~ 15	14.30 %	8.45 %	57.72 %
15 ~ 20	38.92 %	5.31 %	0.07 %
>20	0.06 %	2.08 %	0.01 %

Table 2. Quantity of the Coating Simulant

Plant Type	Quantity (Kg)
WH	14
CANDU	28
FRAMATOME	31

2.3 Test Procedure

The trapping efficiency tests are performed according to the following procedure:

a. Determine the amount of coating simulant and prepare the coating simulant mixture according to the ratio presented in Table 1 and Table 2.
b. Spread the coating simulant uniformly through 2.7~3.5 m region on the test flume floor
c. Place the debris interceptor at 4 m downstream on the test flume floor
d. Fill the water up to 1.0~1.1 m height of the test flume
e. Set up a video camera that can easily capture the movement of the simulant
f. Increase the flow rate until it reaches the specified velocities
g. Keep the flow rate constant and observe the movement of the coating simulant (This usually

takes about 16~18 hours)

h. If the coating simulant movement reaches a steady state, drain the water
i. Collect the coating simulant that has accumulated on the flume floor upstream of the debris interceptor and dry the collected simulant in an oven
j. Measure the dried coating simulant mass and calculate the trapping efficiency of the debris interceptor

3. Results and Discussion

Debris interceptor test was carried out with varying mean flow rate of the pool trapping efficiency of each case was measured. In the table 3, test 1 to 3 are for WH type, test 4, 5 are for CANDU type and test 6, 7 are FRAMATOME type debris interceptor tests. Water levels are the lowest flood level of containment at the time of LOCA.

The debris interceptor is 30 cm high, and basic shape is block form passing over the top of debris interceptor, window was equipped on the top of debris interceptor, so overall debris interceptor is T-shaped. The debris interceptor of borehole type was made of stainless steel and diameter of borehole is 2.2 mm, distance between each borehole center is 4 mm and centers of adjacent boreholes take form of triangle.

Table 3. Test Matrix

Test	Silica Quantity (Kg)	Water Level (m)	Flow Velocity (ft/s)	Silica Size (mil)	Interceptor Height (cm)
1	14	1.00	0.3	5.0~20.0	30
2	14	1.00	0.35	5.0~20.0	30
3	14	1.00	0.3	5.0~20.0	30
4	28	1.10	0.3	5.0~20.0	30
5	28	1.10	0.25	5.0~20.0	30
6	31	1.00	0.3	5.0~20.0	30
7	31	1.00	0.25	5.0~20.0	30

Trapping efficiencies of debris interceptor for 3 types of plants are summarized in table 4. Trapping efficiencies become lower as light particles increase, and that if any plant had slow flow and heavy coating material particle, trapping efficiency rate of the plant would be high.

Table 4. Measurement Results for Trapping Efficiency

Plant Type	Velocity (ft/s)	Trapping Efficiency (%)
WH	0.3	80.1
	0.35	68.9
	0.3	74.5
CANDU	0.3	50.7
	0.25	71.9
FRAMATOME	0.3	87.2
	0.25	74.3

In a plant application, the debris interceptor can keep more than 80% of the coating particles from being transported to the ECCS strainer if it is located in a region where the average flow bulk velocity is about or less than 0.3 ft/sec for WH and FRAMATOME plants and 0.2 ft/sec for CANDU plant. These results are currently being referenced in the preparation of the design specifications of a trap for a domestic plant.

4. Conclusions

The purpose of this test is to assess trapping efficiency performance of debris interceptor with measurement of trapping efficiency, and then to increase the efficiency of filtration by blocking some debris which flowing into the strainer with installation of debris interceptor in advance as regards improvement of strainer feature for recirculation sumps of Korean NPPs.

The results of this study are currently being referenced in the preparation of the design specifications of a trap for a domestic plant. Additional uses are expected for the future. The debris interceptor size and the trapping efficiency data obtained from this study can be used for the design of debris interceptor for modifications in various plants.

REFERENCES

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