# Design of Small Test Facility for Engineering Safety Feature Air Clean-up System

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## 1. Introduction

USNRC (United State Nuclear Regulatory Committee) issued Regulatory Guide 1.52, Rev. 3 (RG. 1.52 Rev.3) in 2006, and the major changes of Rev. 3 with respect to Rev.2 are[1]:

1) the test time was reduced from 10 hours to 15 minutes,
2) instead of DOP (Dioctyl Phthalate) , an alternative challenge agent for the In-place aerosol leak tests of the HEPA (high-efficiency particulate air) filters is also viable, and
3) extension of the test period from 18 months to 24 months for the In-place aerosol leak tests.

It is clear that the revised guideline can provide benefits for the licensees without degrading safety standards, and Korean nuclear industry initiated a project to accumulate the background information of these changes and examine if similar changes can be taken places in domestic plants since it is believed that the revised guidance can be applicable if sufficient justifications are provided. As a part of these activities manufacturing the small test facility and testing the performance of ESF ACS (Engineering Safety Feature Air Clean-up System) is required.

This paper deals with the design principle and actual design methodology. At first the theoretical review on the filtration mechanism was carried out and then the substantial strategy for test facility design was setup. Actual verification for the goodness of test facility design was conducted using CFD (Computational Fluid Dynamic) analysis. These CFD analyses provide the flow field information both the plant ESF ACS and test facility, and these velocity fields are key parameters for the filtration efficiency.

## 2. Filter Theory

Particle can be defined as a small material in the orfer of μ m, whose scale is larger than molecule and smaller than cluster. Especially, the particles of solid or liquid in air are called as 'aerosol'. The filtration mechanism can be classified as:

- Interception
- Inertia Impact
- Diffusion
- Gravitational Settling, Sedimentation
- Electronic Deposition

Electric deposition is very complicated and this mechanism is ruled out for the design analysis of test facility. Fig. 1 shows these typical mechanisms of filtration

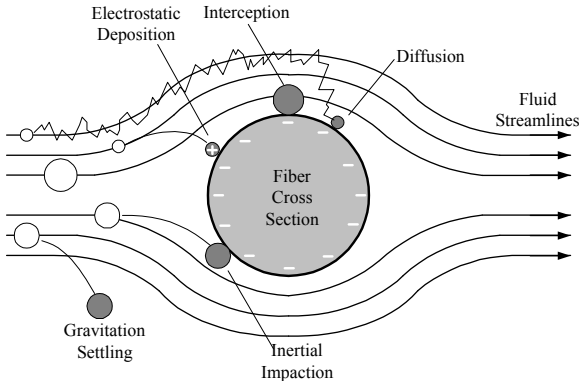


Figure 1. Filtration Mechanism

Filtration efficiency by interception is only dependent on the properties of filter fiber and particle, not dependent on the flow field. The other mechanisms are strongly dependent on the approach velocity.

## 3. Strategy of Test Facility Design

From the theoretical review on the principles of filtration following strategies for the design of test facility and test conditions can be derived;

- Conservation of filter properties
- Conservation of flow fields
- Conservation of test aerosol

Conserving above three items we can get following design and test guides

- Same filter should be used
- Same flow field (verification or justification for the distorted geometry is required)
- Same aerosol should be used
- Only flow area should be reduced

Considering the configuration of filters of YGN 5&6 [2,3], a reference plant, the flow area was reduced as a ratio of 1/9. And the inlet of air is located at the side part of the test facility. The effect of such geometric distortion was evaluated using CFD code, CFX11[4].

## 4. Flow Field Analysis for Reference Plant

### *4.1 Geometry and Domain*

Fig.2 shows the 3-dimensional shape of MCR (Main Control Room) ACS in YGN 5&6. For the CFD

analysis a half of the geometry was modeled because of the symmetry as shown in Fig.3.

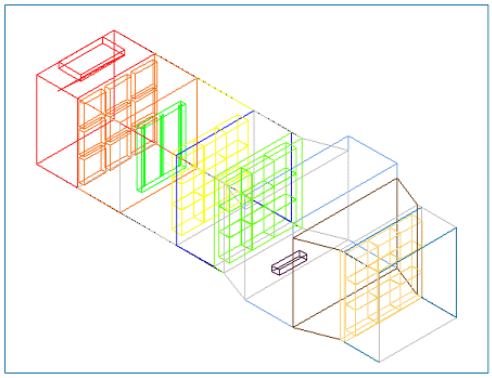

Figure 2 3-dimensional shape of ACS in YGN 5&6.

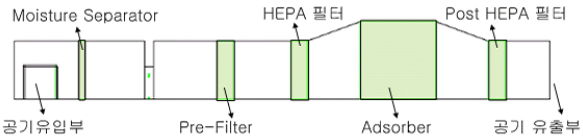


Figure 3 Top View of Analysis Domain

*4.2 Mesh and Modeling*

Mesh was generated using ICEM and Fig. 4 shows the mesh of the analysis domain. Filter was modeled using porous media method. About 1 million tetra-hedral mesh were generated.

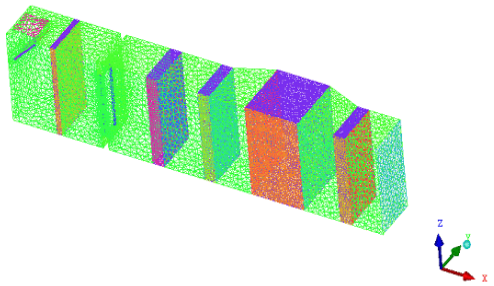

Figure 4 Generated Mesh

*4.3 Results*

One of the calculation result, velocity vector field, is shown in Fig. 5

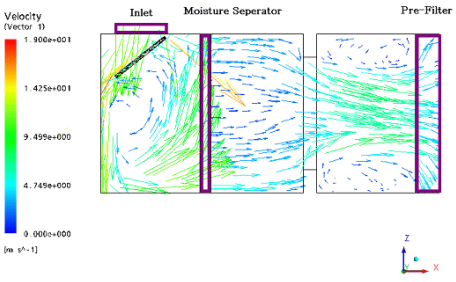


Figure 5 Side View of Velocity Vector

## 5. Flow Field Analysis for Test Facility

The shape of test facility is shown in Fig. 6

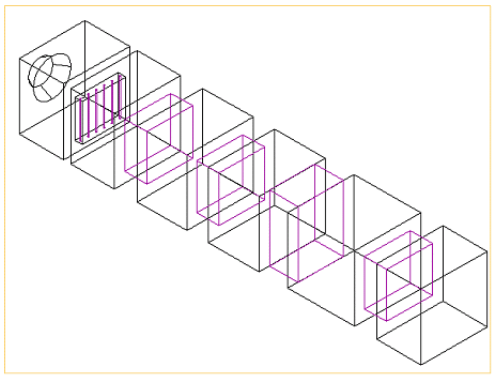

Figure 6 Shape of Test Facility

CFD analysis was also conducted. Comparison of filtration efficiency is given in table 1

Table 1 Comparison of filtration efficiency

| Part | | ACS Velocity (m/s) | Test Facility Velocity (m/s) | Error (%) | |
|---|---|---|---|---|---|
| | | | | Inertia Impact | Diffusion |
| Pre-Filter | Inlet | 1.856561 | 1.87 | 0.59 | 0.39 |
| | Outle | 1.893354 | 1.902 | | |
| HEPA Filter | Inlet | 1.910098 | 1.895 | 0.18 | 0.12 |
| | Outle | 1.900868 | 1.909 | | |
| Adsorber | Inlet | 0.981615 | 0.901 | 8.39 | 6.01 |
| | Outle | 0.992973 | 0.908 | | |
| Post-Filter | Inlet | 1.910098 | 1.897 | 0.54 | 0.36 |
| | Outle | 1.918698 | 1.911 | | |

## 6. Concluding Remarks

This paper provides the design method for the construction of .ESF ACS test facility. And CFD analysis shows the effectiveness of the designed facility in the view point of filtration efficiency.

## REFERENCES

[1] USNRC, Regulatory Guide 1.52 (Rev3), "Design, Inspection, and Testing Criteria For Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants", 2001
[2] KHNP, YGN 5&6 FSAR
[3] Manufacture's Manual for YGN 5&6 ESF ACS
[4] CFX11 Code