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Preliminary Feasibility Study on the Construction of Steel Hot Cell Facility for Precise Manipulated Examinations

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1. Introduction

Hot laboratory is essential facility to research and develop in the nuclear industries to examine radioactive materials. The post irradiation examinations for irradiated fuels and materials should be mainly conducted in the hot cell facility to protect radiations to operators. Hot cells are divided into a concrete hot cell and a steel hot cell according to the wall materials. Usually a concrete hot cell is applied to test for high level radioactive materials like as a fuel assembly, rods, and large structure specimens, and a steel hot cell for comparatively lower level activity materials in fuel fragments, and small structural materials. A steel hot cell has many benefits in a specimen manipulation, construction and maintenance costs. In recent the test for the irradiated materials is more frequently required a small and precise manipulating examination for higher degree tests of research and developments. Unfortunately hot laboratory facilities in domestics have mainly constituted of concrete hot cells, and not ready for techniques in steel hot cells. In this paper the construction feasibility of steel hot cell facility is preliminary reviewed in the points of the status of domestic facilities, the test demand prospect and detailed plans.

2. Status of Hot Cell Facilities

In this section the status of hot cell facilities, the related techniques development, and the future prospect of hot test demands are described.

2.1 Characteristics of Hot Cell Facility

A hot cell is a specialized facility to perform examinations for radioactive materials like as the irradiated nuclear fuels and structural components. A facility can be parted in hot cells and operation utilities to maintain required environmental conditions. A hot cell is basically composed of shielding walls to radiation protect, windows to shield radiation and investigate specimens, and manipulators to control specimens. The operation of hot cells is required high costs to protect the pollution of radioactive materials to environments. Usually the amount of hot cell facility is a level tool to measure the development of nuclear industry in country. Hot cells are divided into two groups by the shielding wall materials. One is a concrete hot cell and the other is a steel hot cell using lead, or iron. The thickness of a concrete hot cell to be more than 800 mm, is thicker than it in an iron steel hot cell wall, and high radioactive materials like as units of fuel rod, structural parts, and assemblies are examined in there. On the other hand the thickness of a steel hot cell wall is thin (~ 200 mm), and low radioactive materials like as fuel fragments, small specimen for structural materials are examined in there. It has many benefits which are low cost to construct and maintenance, convenience to handle specimens, and control the leak of radioactive pollutions. Therefore steel hot cell is growing to use to examine irradiated materials, and indispensable to tests required precise manipulations, severe atmosphere conditions.

2.2 Status of Domestic and Oversee Facilities

In domestic two facilities for the post irradiation examination for nuclear fuels and structural materials are operated in KAERI. One is Post Irradiation Examination Facility (PIEF) which was constructed to test PWR fuels in 1985. It has 3 large pools in a depth of 10 m, 4 concrete hot cells in a floor area of about 33 m^2, and 2 lead hot cells having 3 m^2. It has been mainly performed underwater examinations for PWR spent fuel assemblies and rods in pool, non-destructive and destructive examinations in concrete hot cells, and metallurgy and precise test in lead hot cells. The other is Irradiated Material Examination Facility (IMEF) constructed in 1993, to test specimens for nuclear fuels and material capsules irradiated in the HANARO research reactor. It has 1 small pool in a depth of 10 m, 7 concrete hot cells in a floor area of about 138 m^2, 2 lead cells in 3 m^2. It performed non-destructive, destructive tests for the irradiated fuels, mechanical tests for the structural materials, processing tests in concrete hot cells, and metallurgy, a micro-hardness, and a density measurement in lead hot cells. According to reviews the iron steel hot cells in domestic facilities, which have many benefits in tests and maintenances, are insufficient to compare to the concrete hot cells. In future the demand for steel hot cells to test precise controls and high techniques shall be increased with nuclear technological developments.

2.3 Demand Prospect of Steel Hot Cells

In domestic the demands of test in hot cell are predicted to be growing with regard to review the R&D projects and the operating commercial nuclear reactors.

According to Nuclear Technical Road Map (Nu-TRM) planned in 2005 there are many projects to require hot laboratory facility like as DUPIC, AFC, SMART, APR Reactor, Hydrogen Production.

Furthermore commercial nuclear power plants are planned to be operated 27 reactors in the year of 2015. Considering the ability of present hot facility in domestic, the demand of test shall exceed the capabilities of facilities. A new hot cell facility is required to support the increasing demand.

3. Preliminary Construction Plan of Steel Hot Cells.

In this section the detailed preliminary plans are described on budget, test equipments, construction plan, and so on.

3.1 Basic Design

In PIEF there is the reserved space to be 16.2 m in length, 10.8 m in width, which was planed to install steel cells for mechanical test for fuel rods at the time of constructions in the past. At that time the installation plan of steel hot cells had been canceled from the budget problems. To save construction costs the reserved space can be used for this project. In there 12 steel hot cells with two cell lines are inferred to construct, which are 1.5m in width. One line is composed with lead cells for fuel tests and the other is with iron steel cells for structural material tests. This has many favorable sides in construction and maintenance, but some problems in cell arrangement, equipment selection, the interference of existing facility generated from a pre-limited space.

3.2 Equipments in Hot Cell

Test equipments to be installed in steel cells are satisfied to be high-tech items, and met for the future planned R&D projects and complementary for the existing function of PIEF and IMEF. Equipments are categorized into 7 groups with the test function as micro specimen fabrication, micro structure analysis, thermal property measurement, micro compositions analysis, fission product analysis, structural material test, specimen transportation and storage. A detailed equipment list is shown in Table 1.

Table 1 Proposed detailed equipment list in hot cell

Test Function	Equipments	Required Cell
Specimen Fabrication	Precise Milling, Wire EDM, Fuel Specimen Fabrication	S(1), L(1)
Micro Structure Analysis	XRD, TEM, SEM	S(2)
Thermal Property Analysis	TCT, TET, DSC	L(2)
Micro Compound Analysis	EPMA, SIMS	S(1), L(1)
Fission Product Analysis	Ultra Temp. Furnace, Fuel Melt Sys., Micro Gamma Scan	L(2)
Structural Material Test	E-SCC Tester, Burst, RUS, Creep, Small Tensile Tester	S(2)
Specimen Storage	Padirac System, Reserve System	

* L: lead hot cell, S: ferritic steel hot cell

3.3 Budget Review

The budget to construct steel hot cell facility is divided into 5 categories according to action items as design and license, structure installation, purchase of equipments, utilities, labor costs. The total budget is supposed to cost in the amount of 19.5 billions Won. Detailed budgets for each category are 1.5 billions in design, 6.1 billions in the buildup of hot cell walls including windows and manipulators, 7.5 billions in the purchase and installation of test and handling equipments, 2.6 billions in the utilities including HVAC, electric and radiation monitoring systems, and 1.8 billions in the cost of staff's labors. Total cost is inferred to be cheaper than it in the construction of the isolated independent facility system.

3.4 Construction Schedule

The schedule to construct is at least supposed to be 6 years as shown in Fig. 1, but depended on the confirmation of budget strongly. A construction step can be divided 3 phases as a hot cell structure construction, a utility installation, a test equipments installation. Each phase needs 3~4 years individually, it can be progress simultaneously to shorten the period.

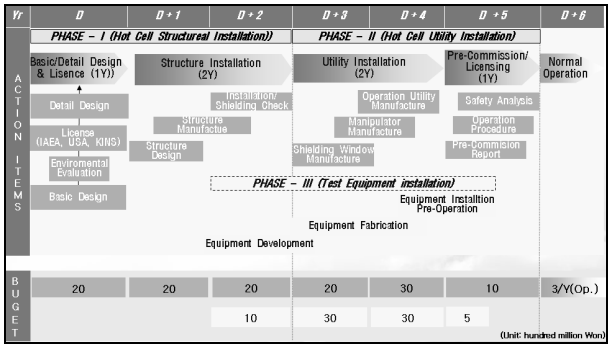

Fig 1 Proposed construction schedule and budgets with year.

4. Conclusion

A construction of steel hot cell facility is preliminary reviewed in the points of domestic status of hot cell facilities, a construction plan. Considering the nuclear R&D plans and the operation plan of nuclear power plants, the test abilities for the irradiated fuels and structural materials should be expanded to support plans. The budget and the period to construct are supposed to be about 21.5 billions Won and 6 years. The steel hot cell facilities to be reviewed in this study can take a valuable role of planning construction in the future.

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