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Introduction to State-of-the-Art Test Results on PAR Performance of THAI Project

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1. Introduction

OECD/NEA THAI (Thermal hydraulics, Hydrogen, Aerosol and Iodine) Project was conducted from 2007 for three years to address open questions concerning the behavior of hydrogen, iodine and aerosols in the containment of water cooled reactors during severe accidents. In the project nine OECD member countries joined including Korea (KAERI and KINS). Recently the final report of the project was published to provide information on research results relevant to the open hydrogen and fission product issues [1].

In this paper, major experimental results of HR (hydrogen recombiner) test series for passive autocatalytic recombiners (PARs) that can be referred to or considered in domestic R&D projects, are introduced. We quote the OECD report to obviously transfer the facts found in test series. Since new or refurbished nuclear power plants (NPPs) in Korea are considering the installation of PARs, the results obtained from HR test series may also give useful information to the licensees as well as the regulators. Therefore this paper aims for sharing the fruitful PAR related findings with Korean Nuclear Society members.

2. Objectives of HR Tests

The test vessel is a 9.2 m-high cylindrical one made of stainless steel with total free volume of about 60 m^3

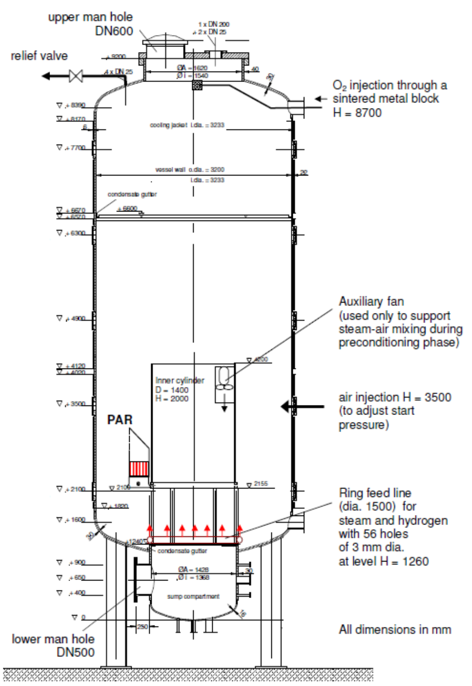


Fig. 1. THAI test vessel configuration (a PAR equipped) [2].

and its configuration is seen in Fig. 1. In test series, the operation behavior of three commercial PAR designs (NIS, AREVA, AECL) were used.

HR test series consisted in PAR performance tests, metal iodine/PAR interaction test and PAR poisoning test. The objectives of the tests are to reduce the gap especially on:

- Condition for the onset of recombination
- Recombination rate
- PAR operation with oxygen starvation
- Conditions for ignition by PAR
- Gas distribution under PAR operation
- Conversion of particle iodine to gaseous one
- Performance under extremely adverse conditions.

3. Major Results of HR Tests

3.1 PAR Performance

Total 30 tests listed in Table 1 were conducted using three PAR designs to achieve the first five objectives mentioned above. Thermal-hydraulic test conditions were varied including ignition potential by a PAR.

For onset of recombination and recombination rate, no significant influence of steam was found and the recombination rate developed after onset as hydrogen concentration and/or atmospheric pressure increased.

Related to the oxygen starvation issue, the test resulted in significant advancement of knowledge base. Tests showed that the hydrogen recombination rate decreases below 50% of the value for unimpaired PAR operation for stoichiometric H_2:O_2 ratio of 2:1 ($2H_2 + O_2 \rightarrow 2H_2O + Heat$), that sufficient oxygen at least the ratio between 2:2 and 2:3 as minimum is required for unimpaired PAR operation, and that recombination rate,

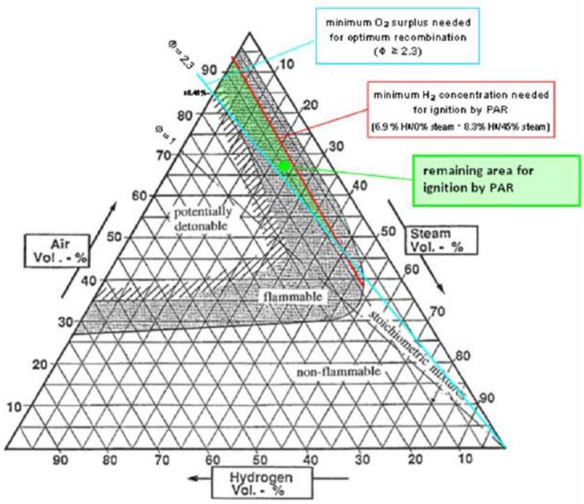
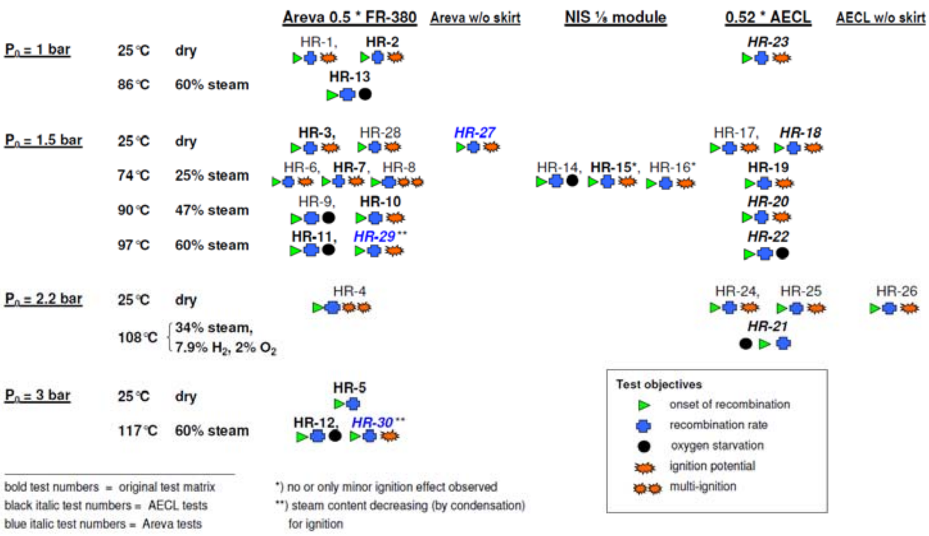


Fig. 2. Example of ternary diagram for ignition possibility of PAR [1].

Table 1. Tests performed in HR series [2].



oxygen ratio decreases.

The question for the ignition potential of PAR was also answered. High hydrogen concentration at the PAR inlet raises catalyst temperature and this directly affects the initiation of deflagration at PAR outlet. Combination of this result with the above findings for the oxygen concentration can provide such a resultant ternary diagram shown in Fig. 2 to give additional information about ignition potential by PAR. The final report describes this finding should be considered in future accident modeling and PSA studies.

3.2 Metal Iodides/PAR Interaction

As one of radiological source term issues in containment, the high temperature higher than about 800℃ on catalyst surface may increase the fraction of gaseous iodine in containment atmosphere by a conversion process from suspended particle iodide including CsI.

HR 31 test was conducted to address this issue. In the test, PAR inlet hydrogen and steam concentration was set to approximately 8% and 60% in volume, respectively, to regulate the catalyst surface temperature to approximately 800℃ not to initiate ignition. Particle diameter of 0.5 to 0.7 μm with residence time about 0.15 sec was achieved. The conversion rates were found in the range of 1% to 3%. According to the report, the result is consistent with previous findings of experiments performed by IRSN where the conversion rates were around 5%.

3.3 PAR Poisoning

In HR 32 test, the influence of adverse conditions on PAR operation under the condition of high aerosol concentration with gaseous iodine during the start-up phase, was investigated. The aerosols used in this test were the solid SnO_2 and the hygroscopic $LiNO_3$ particles of which total amount was in the range of 1.5 to 2.5 g/m^3. estimated in the test was to be in the range of 50% to 70%, which was slightly lower level than that for the case without aerosols and iodine. Therefore the poison effect of aerosols and iodine was resulted to be not significant.

4. Conclusions

Several PAR designs were developed through various R&D programs conducted for a few decades and now this innovative device is being installed in NPPs of many countries including Korea. However there have been some issues concerned about PAR performance in adverse severe accident conditions and about the side effect of ignition. OECD/NEA THAI Project had successfully addressed these issues and also our knowledge base on PAR performance has been much strengthened. We expect that the fruitful results obtained in HR test series might be referred to or considered in R&D projects and licensing process in Korea.

ACKNOWLEDGEMENT

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