1. INTRODUCTION

The Specialists' Meeting on "Coolant Chemistry, Plate-out and Decontamination in Gas-cooled Reactors" was held at the Kernforschungsanlage Juelich GmbH., Juelich, Federal Republic of Germany, 2-4 December 1980. The meeting was sponsored by the International Atomic Energy Agency (IAEA) on the recommendation of the International Working Group on Gas-cooled Reactors (IWGGCR) and was attended by 38 participants and observers from France, Federal Republic of Germany, Italy, Japan, Poland, Switzerland, the United Kingdom of Great Britain and Northern Ireland and the United States of America.

The purpose of the meeting was to provide a forum for exchange of information on experimental and theoretical results of fission product behaviour in primary loops of gas-cooled reeactors in order to provide comprehensive review of the present status and of directions for future applications and development.

The meeting was divided into five sessions:

A. Fission Product Plate-out I
B. Fission Product Plate-out II
C. Decontamination of Activity
D. Coolant Chemistry
E. Round Table Discussion

During the meeting papers were presented by the participants on behalf of their countries or organizations. Each presentation was followed by an open discussion in the general area covered by the paper.

2. SUMMARY AND CONCLUSIONS

2A. FISSION PRODUCT PLATE-OUT 1 & 2

Session chairmen:

Fission product plate out 1: Mr. Blanchard

Fission product plate out 2: Mr. Baba

Prediction of distribution of fission products which are deposited on surfaces in primary circuits of gas-cooled reactors depends on knowledge of the value of a large number of parameters. These parameters are being estimated by experiments in various test facilities.

Two categories of test-facilities are used:

- in-pile loops
- out-of-pile loops

Specimens of irradiated fuel from gas-cooled reactors are used as the source of fission products in the in-pile loops. The fuel is irradiated further during the test by neutrons produced in test reactors. In order to get an appropriate fission product source burnt-up fuel or, in case of coated particles, fuel with a certain amount of defect particles is used. Fission products are then carried by the heated coolant gas through the plate-out section where some deposit on various material samples to be examined later. Subsequently, the gas is filtered, purified and flows back to the fuel section.

In-pile experiments have been performed or are planned in the following loops:

- Saphir (Pegase reactor) CEA, Cadarache, France
- Comedie (Siloë reactor) CEA, Grenoble, France
- Vampyr I (AVR reactor) KFA, Jülich, Federal Republic of Germany
- Vampyr II (AVR reactor) KFA, Jülich, Federal Republic of Germany
- OGL 1 (JMTR reactor) JAERI, Tokai Mura, Japan.

In addition to these in-pile loops, samples of materials that have been loaded with fission products in main circuits of gas-cooled reactors such as in the Dragon Reactor, Peach-Bottom and FSV have been examined.

Concerning the out-of-pile loops, single ion sources such as Cesium, Iodine and Silver are used instead of reactor fuel. These loops allow the study of interaction of selected isotopes with various reactor materials.

Out-of-pile experiments are performed in, or planned for the following loops:

- Scafex (KFA, Jülich, Federal Republic of Germany)
- Smoc (KFA, Federal Republic of Germany)
- Lift-off experiments (CEA, Grenoble, France)
- Iodine sorption/desorption test facility (ORNL, Oak Ridge, USA)
- Helium loop (EIR, Würenlingen, Switzerland)

Experiments are performed under various combinations of several parameters such as flow rate, time, temperature, fission product concentration and composition of coolant gas.

Results demonstrated that fission product deposition does not only depend on adsorption and desorption mechanisms at the surface but also on irreversible mechanisms such as diffusion into the wall-material. Adsorption and desorption are of main importance at lower temperatures than 300°C, but at temperature above 500° diffusion is dominant more and more with increasing temperature and operation time.

Experimental results together with power plant design parameters are the input for computer codes that have been developed for the prediction of fission product behaviour. Codes are available in the Federal Republic of Germany (KFA/IRB), Japan (JAERI), UK (UKAEA) and USA (GAC).

In addition to Iodine the main fission products to be considered are Ag 110 m, Cs 134, Cs 137 and Ba/La 140. The influence of dust as a transport mechanism for fission products must be taken into account for the prediction of fission product plate-out.

2B. DECONTAMINATION OF ACTIVITY

Session chairman: E. Obryk

Radiation levels caused by fission and activation products deposited in primary circuits of nuclear power plants require decontamination of reactor components in order to conduct inspection and repair. The basic concept of decontamination by wet chemical treatment is that the activity near the surface boundary is removed as the surface itself is dissolved away by the decontaminating fluid. Comparison of experimental and theoretical results have proved that the extent of penetration of radioactive material into the wall material of reactor components can be predicted. Thus, the depth of the surface material to be dissolved can be determined. Chemical solutions have been developed in order to remove the desired surface layer. These substances have been tested successfully on samples loaded with fission products and on components of the Arbeitsgemeinschaft Versuchsreaktor (AVR) in Jülich.

The maintenance concepts for the gas turbine for a 1640 MW direct cycle HTR were reported and extensively discussed. The maintenance concepts foresee minor inspections at two years intervals and major inspection every six years. The major inspections require disassembling and dismantling of the turbo-machine and the inspection of the individual parts. The turbo-machine will be transferred by a traction machine into a dismantling cell. The machine will be dismantled by remote-handling. For the disassembling of the machine blades two variants were reported:

- remote controlled disassembly of machine blades
- manual disassembly of machine blades with pre-decontamination.

After having disassembled the blades they will be decontaminated separately and examined using a special inspection procedure.

After having inspected all components of the turbo-machine it will be re-assembled, mounted and connected into the primary circuit. The power plant shut down time for the major inspection is expected to be 50-60 days.

2C. COOLANT CHEMISTRY

Session chairman: R. Wichner

The operation of the Peach Bottom and Fort St. Vrain (FSV) HTRs has provided valuable data and experience on the coolant chemistry of primary ciruits. In Peach Bottom oil contamination was the main source of chemical impurities, while in FSV moisture ingress and subsequent long term component outgassing occurred. In addition, a hydrogen injection experiment was performed in Peach Bottom. Impurities of the Peach Bottom reactor mainly consist of hydrogen and methane due to the oil ingress, which led to a coating of virtually all metallic surfaces with carbon deposits. The deposits caused no untoward effects on reactor operation nor on the metallurgy of the underlying materials.

A water ingress from the heat exchanger of the AVR experimental power station into the primary circuit led to a shut down period of about one zear. During this time the defective heat exchanger was repaired and the entire plant was inspected. 30 tons of water entered through a small leak in the super-heater of the steam generator into the primary circuit while the reactor was shut down. Because of the low temperature of about 500 °C–600 °C only an extremely small part of the water reacted with the graphite of the fuel elements. The water was removed through the valves by evacuation and by stepwise nuclear heating of the core and the reactor is now again in operation.

In the British Advanced Gas-cooled Reactors (AGR) carbon monoxide and methane are added to the coolant gas (carbon dioxide) in order to reduce moderator corrosion. Since additions of methane increase the possibility of producing carbonaceous deposits on hot surfaces, such as fuel pins, a special coolant strategy has been developed and successfully supplied.

The primary circuits of HTRs will continuously be contaminated by a large number of minor sources, such as hydrogen diffusion processes from the steam circuit, methane production by a radiolytic reaction with hydrogen and carbon monoxide from minor air ingresses. The composition of the coolant gas also influences fission product behaviour in addition to the influence of materials properties and must also be taken into account in the design of experiments.

The behaviour of Tritium in HTRs is of major importance because it is the only radioactive isotope which diffuses from primary into secondary circuits. In order to reduce the amount of Tritium in the produced gas of process heat plants, oxide layers for the steam side of the heat exchanger and duplex tubes are being developed.

2D. DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

Session chairman: C. B. von der Decken

Safe prediction of fission product behaviour in primary circuits of gas-cooled reactors is an important aspect in the lay-out of reactor plants. Deposition of fission products in components of primary circuits will influence the plant concepts of maintenance and repair and could be a potential danger to the environment in case of severe accidents.

Fission product plate-out strongly depends on several parameters, such as choice of material, coolant gas composition, flow rate, gas and wall temperature and time.

Influence of these parameters needs to be studied in various experiments. In order to limit future effort the recommendation was made to make as much use as possible of the already available results in participating countries. This mainly concerns the experience gained by the operation of the British Magnox and Advanced Gas-cooled Reactors. The Representatives from the United Kingdom offered design parameters of a GCR-power plant in order to compare their own fission product predictions with those made by using the German computer code PATRAS.

A general comparison of all assumptions and analytical methods made in computer codes for plate-out prediction was suggested. The Federal Republic of Germany will take the lead and invite a group of experts in this area and report its meeting results to the IAEA.

Participants recommended to emphasize in future programmes the following activities:

- the influence of dust on the deposition
- of fission products in reactor components
- fission product behaviour in the reactor containment
- accident analysis with specific regard to fission products in order to safely predict fission product behaviour.

The participants recommended to publish a summary of this meeting in an international journal in order to disseminate information to a wider range of interested readers.