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IGORR-II Meeting
May 18-19, 1992
Saclay, FRANCE

REFURBISHMENT PROGRAMME

FOR THE BR2-REACTOR

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I. Introduction

BR2 is a high flux engineering test reactor, which differs from comparable material testing reactors by its specific core array (fig. 1).

It is a heterogeneous, thermal, tank-in-pool type reactor, moderated by beryllium and light water, which serves also as coolant. The fuel elements consist of cylindrical assemblies loaded in channels materialized by hexagonal beryllium prisms. The central 200 mm channel is vertical, while all others are inclined and form a hyperbolical arrangement around the central one. This feature combines a very compact core with the requirement of sufficient space for individual access to all channels through penetrations in the top cover of the aluminium pressure vessel. Each channel may hold a fuel element, a control rod, an experiment, an irradiation device or a beryllium plug.

II. The refurbishment programme

According to the present programme of C.E.N./S.C.K., BR2 will be in operation until 1996. At that time, the beryllium matrix will reach its foreseen end-of-life. In order to continue operation beyond this point, a thorough refurbishment of the reactor is foreseen, in addition to the unavoidable replacement of the matrix, to ensure quality of the installation and compliance with modern standards.

Some fundamental options have been taken as a starting point: BR2 will continue to be used as a classical MTR, i.e. fuel and material irradiations and safety experiments with some additional service-activities. The present configuration is optimized for that use and there is no specific experimental requirement to change the basic concepts and performance characteristics. From the customers viewpoint, it is desirable to go ahead with the well-known features of BR2, to maintain a high degree of availability and reliability and to minimize the duration of the

long shutdown. It is also important to limit the amount of nuclear liabilities.

So the objective of the refurbishment programme is the life extension of BR2 for about 15 years, corresponding to the expected life of a new beryllium matrix with the present operation mode.

The underlying assumption is that the extent of refurbishment-work should be consistently minimized with maintaining a reliably operating reactor and without, in any way, prejudicing safety standards.

III. The phase 1 study

A phased approach has been adapted as outlined in fig. 2. The objectives of phase 1 were:

- to give an overview of the refurbishment needs, i.e., compile a comprehensive list of plant items, identify the critical items and carry out a preliminary assessment of them against some agreed on criteria of aging, safety and upgrading,

- to provide confidence that by making commitments towards operating beyond 1996, the investment will not be jeopardized by the need for supplementary work or major failures,

- to define a schedule of work for all plant items to be assessed and inspected in phase 2, and to provide an estimate of costs and timescale for the overall refurbishment programme.

The approach chosen was to comment on all systems, but concentrate on items or sub-systems, that are most fundamental.

Fundamental critical items are the safety-critical ones, and those whose failure, or if refurbishment requirements dictate replacement or major intervention, could lead to significant cost or prolonged shutdown of the reactor.

According to these criteria, some items could be excluded from consideration in this context. At the first stage, the depth of consideration in subsidiary systems is limited. Actually those items and systems are adressed by the preventive maintenance programme.

The requirements on the critical items were determined by aging considerations, possible needs for safety improvements and opportunities to upgrade particular features.

Aging criteria are essentially the same as the ones used in the prevention maintenance in use since 1988. Maintenance staff are in the best position to judge the reliability of the equipment, yet they may lack best judgement on long-term fitness. For that reason, some additional inspections by external specialists will be foreseen in phase 2.

Safety criteria concern comparisons against "modern thinking" in the broad sense. Besides the official requirements written down in the operating license, a review on international criteria (e.g. IAEA), requirements for other MTR´s and power reactors has been done and some supplementary requirements have been adopted in accordance with the licensing authority. A general theme seems to be the link between PSA and modern criteria.

Concerning upgrading activities, the possibility will be considered and a cost/benefit balance will be made. Although the assumption is made that there are no requirements to change the basic concepts, there may be other reasons for upgrading, like availability of modern technology, reduction of operating costs, ergonomic and "presentational" improvements ...

The Phase 1 study has been undertaken with the assistance of AEA Technology Engineering Business and took about 4 months. The licensing authority has been closely involved from the start.

IV. Phase 1 conclusions:

The conclusion of the phase 1 study was that BR2 is in good physical condition, but some significant items of work have been identified and will be required for operation after 1996. A list of the phase 2 work packages is given in fig. 3. Some urgent actions which will determine options and refurbishment/ replacement work are presently being undertaken. They concern major components of the reactor:

- the question whether or not to replace the pressure vessel will have to be answered definitely. Although there is some concern about embrittlement under irradiation, some arguments have been put forward which tend to indicate that the vessel is in a good state of conservation and will not have to be replaced.

- whether a new matrix is needed or the matrix of the zero power nuclear model BRO2 can be used, is another question which will have to be answered as soon as possible.

A probabilistic safety assessment (PSA) will be carried out to determine if there are any system weaknesses and because such an assessment is considered an emerging requirement for all types of reactors. Possible design changes will be deferred until the preliminary conclusions of the PSA are known.

Other areas, like control-room arrangements and fire mitigation, will also be considered as to their compliance with "accepted" modern standards.

Finally, some specific areas, like spent fuel storage, will have to be adressed by long-term solutions in order to secure the future.

V. Future programme

The phase 2 work items, i.e. assessments and inspections listed in fig. 3, are foreseen to be accomplished in about 1.5 years on a project management basis.

The outcome of phase 2 will be:

- a clear definition of the actual refurbishment needs,
- a definite decision on issues still left open at the end of phase 1,
- a precise estimation of the overall costs,
- a planning and organization scheme for phases 3 and 4.

It is important that phase 2 is executed without delay as it is not only desirable to remove the existing uncertainties as soon as possible, but also to leave sufficient time in phase 3 to procure any major items of hardware that may be required.

In phase 3, design, procurement and some installation work compatible with normal shutdowns will take place.

Phase 4 work covers everything to be done during the long refurbishment shutdown, including recommissioning.

VI. Conclusions

The refurbishment needs for the BR2 reactor, if it is to operate beyond the end of life of its current beryllium matrix, have been investigated.

A phased refurbishment programme is envisaged. The first phase of this programme has been executed and produced quite encouraging results.

Phase 2 inspections and assessments are presently being undertaken in order to define more precisely the extent of actual refurbishment work needed. A definite decision to operate BR2 beyond 1996 is expected on completion of phase 2, after the key assessments have been completed and when overall costing can be given with a higher degree of confidence.

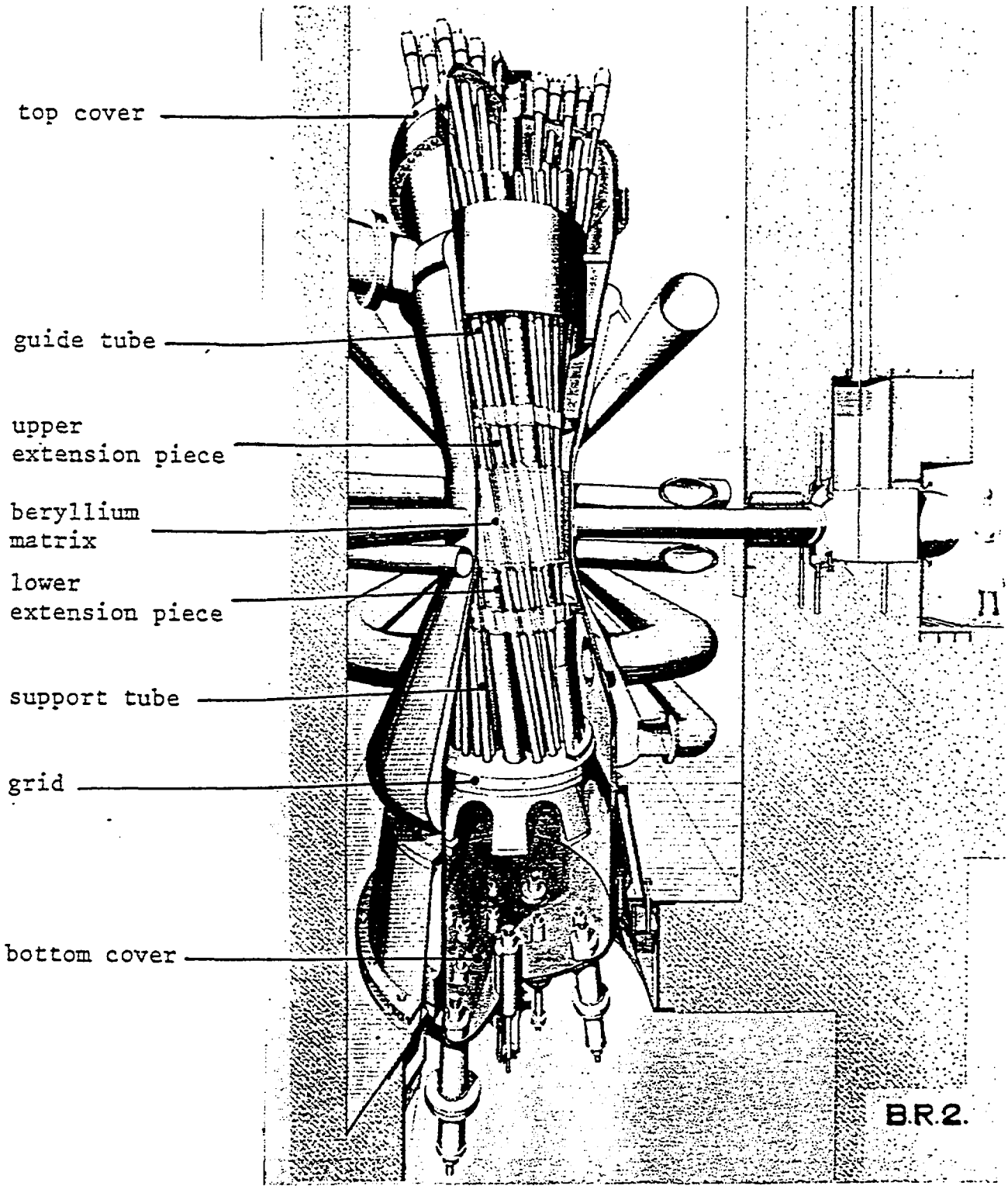

FIG.1: General view of the BR2 reactor

Fig. 2: BR2 REFURBISHMENT STUDY

Overall Objective

'to carry out the studies and refurbishment necessary to keep BR2 operational beyond 1996 and to approximately 2010'.

PHASE 1

list areas of further work, preliminary programme and costing

PHASE 2

detailded inspections, assessments, planning and costing

PHASE 3

design, procurement and some installation

PHASE 4

long shutdown-replacement, installation and recommissioning

Fig. 3: PHASE 2 Work Packages

1.	Probalistic Safety Assessment	Assessment
2.	Structural Inspection of Buildings	Inspection
3.	Fatigue Analysis of Vessel	Assessment
4.	Early Inspection of Vessel	Inspection
5.	Assessment of BR02 Matrix	Dismantle, inspect & assessment
6.	Inspection of Reactor Pool	Inspection
7.	Inspection of Pipework	Inspection
8.	Inspection of Storage Pool	Inspection
9.	New Spent Fuel Store Study	Study
10.	Control Room Study	Study
11.	Electrical Inspection	Inspection
12.	Fire Protection Study	Study
13.	Seismic Assessment	Assessment