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Project Report

Deterministic Safety Technology for RBI

F. D'Auria,[1] S. Soloviev,[2] D. Mazzini,[1] and C. Sollima[1]

[1]Mechanical, Nuclear and Production Department (DIMNP), Univers
Diotisalvi 2, 56122 Pisa, Italy
[2]N. A. Dollezhal Research and Development Institute of Power Eng

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Abstract

The present paper deals with the description of the technical activ
2 EC Contract no. 30303, related to RBMK. The project activitie
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brittle failure of the pressure tube and of graphite bricks with
reference scenario for the project. However, a series of expected
of the individual codes or chains of code in simulating the envis
activities performed at NIKIET in Moscow and at University of Pisa
structuring the executive summary that includes the following sec
the roadmap, (iii) the adopted computational tools, (iv) key findir
tube rupture (MPTR) issue and the individual channel monitoring (I

1. Introduction

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The result of 30 man-years effort is summarized hereafter includi
University of Pisa (UNIPI) in Pisa. A top-down approach is pursued
the following sections.

(i) The safety needed for the RBMK NPP is described first:
and the key findings from the execution of the project.
(ii) The roadmap is discussed that gives an idea of the inter
complexity.
(iii) The adopted computational tools are presented in the t
nodalization. In this section, the transient scenarios establish
chains are discussed.
(iv) Key findings are presented per each logical block of activ
(v) Emphasis is given to the multiple pressure tube ru
monitoring (ICM) proposal.

2. RBMK Safety Needs, Status, and Key Conclusion a

RBMK safety technologists in Russia are well aware of safety nee
cooperation involving EC, US DOE, and IAEA in the last twenty
summarized and was used to identify the priorities of the project
safety technology was found as well as established and no remark
process. However, related to the development and the improvem
are described that brought to the characterization of priority area
be concentrated. Examples of this, related to the KORSAR code
pump performance as well as the need for a three-dimensional the

The main difference from the safety standpoint, primarily in the dc
other water-cooled reactor lies in the allowance in the case of RE
design basis conditions (design basis accident (DBA)), to break th
pressure boundary. In facts, the rupture of fuel channel caused
contamination of parts of the confinement system, but no real ha
are not expected to overpass the thresholds applicable to other w
apply.

(i) The potentially involved core inventory is less than 0.1%
(ii) The radioactivity is expected to remain primarily in th
accident localization system and basically no contamination for
(iii) Notwithstanding the above, the expected breaking of
events Leningrad NPP 1 and 3 (1975 and 1992) and Chernoby
or by the regulatory authorities) as a lack of capability of contr
(iv) The individual channel monitoring (ICM) proposal and
below, might substantially contribute in preventing the possibil

The deterministic analyses performed within the project did not
situations that can harm the public or the environment to an ext
purpose of the project to evaluate the RBMK safety, however th
calculations). Nevertheless, computational tools are the outcome c
conclusion and the ICM proposal has been formulated in the attem

3. The Roadmap of the Project

The roadmap of the project has been finalized based on two mai matrices, where the computational tools are related to the safety b NPP and the technological areas, Figure 1, (b) the flow diagram o accident scenarios goes through the technological subjects and enc

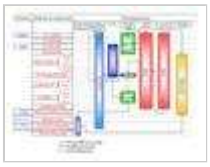

Figure 1: Connection between topological sub the conduct of the project by NIKIET.

Matrices of Activities

Two matrices have been developed for codes adopted by NIKI subjects, relevant to the nuclear technology, were distinguished in

(i) five barriers (5Bs) to the release of fission products to clad, pressure boundary, reactor cavity, ALS, and (various) rea
(ii) sixteen RBMK system (16S) hardware or material par assembly, coolant in power channel (high pressure) and in CP absorber and displacer tube, graphite of power channels a circulation circuit, reactor cavity, accident localization system a
(iii) seven nuclear technology (7T) sectors or computational thermalhydraulics in main circulation circuit (including fuel structural mechanics including fuel behavior, three-dimensior and fission product release and transport.

Nine and eight codes, 9C and 8C, were selected by NIKIET and UN

Diagram of Activities

The first level of the diagram (not given here) is constituted by the level of the diagram is constituted by the disciplines and the re constituted by the main outcomes from the project.

4. The Computational Tools and the Established Sce

The correspondence between the seven nuclear technology (7T) s constituted the background for identifying the classes of accide capabilities of the codes. The classes of accidents, the selected tra codes are given in Table 1.

Table 1: Transient scenarios relevant to RB project and correspondence with adopted code

5. Key Findings within the Identified Safety Techno

Reference is made to the seven safety technological (7T) sectors a chain of codes to the identified accident scenarios. The capability cases.

Thermalhydraulics in Primary Cooling Circuit

Relap (primarily) and Korsar codes were found capable of simulat was found that prevents the application of those codes. Typical re summarized as follows.

(i) Instabilities in parallel channels may originate critical h excursions during the operation of the emergency core cooling
(ii) As a consequence of the group distribution header block tubes, flow reversal may be sufficient to cool the remaining c appears a function of the adopted calculation hypotheses inclu conditions.
(iii) The comparison between system performance in Igna introduced in Ignalina NPP in the recent past create the co dynamic response.

The best estimate analysis of the RBMK primary circuit requires a h

Thermalhydraulics in Confinement

The passive function of mitigating the radioactivity release to hypothetic accident in RBMK is performed by a number of building localization system (ALS) constitute the important ones. Suitable design of reactor cavity and ALS.

Application of CFD

Two main applications were completed within the framework of t former focused on the modeling of a valve located in the inlet reg steam superheating, due to pressure drop in the flow reversal v trigger event for the Chernobyl 4 accident. The latter application rods following the break of the pressure tube.

Structural Mechanics Including Fuel Behavior

Clad ballooning was found as the most important mechanism for from any channel. A damage map for fuel rods derived in the plan channel blockage was derived. In the case of flow blockage, signifi

The graphite rings and the bricks have been modeled by finite ele failure conditions. The important role of graphite rings has been t the radiation damage (fluence) upon the conditions for graphite bri

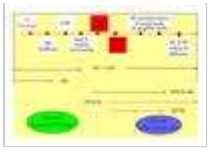

Figure 2: Evolution of the RBMK FC blockage e

Three-Dimensional Neutron Kinetics

A pioneering effort has been made in relation to the applicatior technology. Bars, allowing the 3D representation of the RBMK core suitable "λ-functions" to calculate the local system performance response following local perturbations like the control (and) protect individual control rod, was demonstrated.

Generation of Cross-Sections

The Helios and the Unk codes were adopted to calculate the r respectively.

Fission Product Release and Transport

The technological area of fission product generation,release and tra surface does not present special features compared with the same

5.1. The MPTR Issue and the ICM Proposal

The MPTR Issue

A methodology was proposed for investigating the realism in neighboring pressure tubes, that is, addressing the MPTR issue. Sig

The study emphasized the importance of

(i) modeling the RBMK core channels one-by-one (i.e., the c considering the geometric position within the array, the mater the fluence,
(ii) the stiffness of the tank that constitutes the ultimate cor again depending upon the position of the channel in the core.

As a key conclusion (the generic warning about the applicability c scenarios will be considered), it was found that only a limited nu prone to cause the propagation of the fuel channel rupture.

Figure 3: Results from calculating mechanical of an assigned pressure tube.

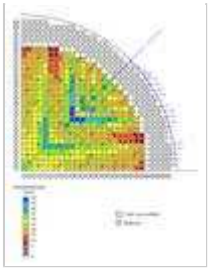

Figure 4: The ICM and the predicted working r

The ICM Proposal

The RBMK safety issue connected with the hydraulic blockage (i. deeply considered within the project. Notwithstanding the recent e rupture to a multiple pressure tube rupture is negligible, the break associated with stop of electricity production for cleaning and stru to personnel (unquantified), and (c) a "residual risk" for MPTR (subject for public acceptance and for regulatory bodies.

The individual channel monitoring (ICM) system has the capability channel blockage. The system generates a devoted scram signal f coolant temperature at FC inlet and outlet, respectively. The perf scram can be actuated early enough to prevent the PT rupture. See

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