THERMAL-HYDRAULIC AND SAFETY ANALYSIS OF NUCLEAR REACTORS

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Keywords: nuclear power; research reactors; thermal-hydraulic analysis; accident analysis; nuclear fuel design; LOCA.

Introduction: Thermal-hydraulic and safety analyses of nuclear reactors comprise the core thermal analyses to determine the fluid and fuel temperatures, the thermal and safety margins; and also the cooling systems ability to remove the nuclear heat during any plant condition. Experimental activities also have been developed in order to supply support information for theoretical calculations.

IEA-R1 Research Reactor: The thermal and safety limits established to this reactor, are in accordance with the TEC-DOC 233, with Safety Series 35 from the International Atomic Energy Agency (IAEA). Some specifications, such as , coolant temperature; average clad temperature limited to corrosion reasons; peak clad surface temperature ; coolant velocity ; peak heat flux should be observed for safety reasons. To check all of these limits, different analyses should be performed, including experimental ones when computer codes are no longer reliable. The calculation procedure for IEA-R1 is performed with the CITATION and LEOPARD neutronic codes; COBRA3C/RERTR and PARET thermal-hydraulic codes. Geometric parameters, materials properties and water flow rate must be known, as well as the associated uncertainties. Experimental research performed at IPEN has shown that current understanding of thermal-hydraulic analysis in not enough to provide the desired safety margins. Several studies on the primary flow measurement system were conducted. Additional investigations were performed with a sub-aquatic visual inspection system. The uncertainties found in the flow rate between fuel elements have imposed the need of a new fuel element design, with a lower fuel concentration in the external plates.

Contract Research Project (CRP - IAEA): This project entitled "Safety Significance of Postulated Initiating Events for Different Research Reactor Types and Assessment of Analytical Tools". Thermal-hydraulics division members have been working in this project in activities concerning to the design and construction of an instrumented MTR fuel element for IEA-R1 research reactor.

IRIS Power Plant: The International Reactor Innovative and Secure (IRIS) concept is being developed by an international consortium led by Westinghouse Electric Company. The pressurizer design and transient analysis are under the responsibility of Brazil as part of an agreement established with Westinghouse. The IRIS pressurizer is housed within the vessel head. Its configuration is quite different from that of conventional pressurizers. A specific nodalization for RELAP5/Mod3.3 code was developed to reproduce the main phenomena involved within this component. The objective of this work was to check the control logic actuation as well as to describe the nodalization scheme proposed for the thermal-hydraulics analyses of the IRIS pressurizer. Only the model of the pressurizer is considered. Boundary conditions as well as controls are supplied. Although the nodalization is still in development, the results showed to be very consistent. An experimental device is being designed to investigate the use of a honeycomb type insulation to reduce the heat exchange between pressurizer and core regions . Another experimental activity is concerning to the development of a probe to measure the level in the pressurizer region.

LABGENE Reactor: The Brazilian Navy has a program, started in the early beginning of the 80s, with the objective of developing an advanced small reactor that can be used for nuclear propulsion. INAP is an advanced loop-type pressurized water reactor. Most of the thermal-hydraulics division members have been working in this program since its beginning. At this moment we are providing a technical assistance in the development of the reactor protection curves, which involves the core analyses beyond the operational conditions.

Nuclear Power Plants: Eletrobrás Termonuclear S.A. (Eletronuclear) operates two nuclear power plants: Angra 1 and 2. Angra 1 is Westinghouse 626MW PWR. Angra 2 is a Kraftwerk Union A.G. (KWU) 1309MW PWR. The performance evaluation of these plants requires the use of many different thermal codes (computer programs). Since 2001 the Thermal Hydraulic Division of IPEN provides technical assistance to the Eletronuclear with the performance evaluation of Angra 2. The Safety Analysis involve the activities related to the licensing process of Angra 2. These activities have been developed through cooperation among CNEN´s Institutes and also Pisa University. In this cooperation the safety analysis group is responsible for activities related to accident analyses such as LBLOCA (Large Break Loss of Coolant Accident) and SBLOCA (Small Break Loss of Coolant Accident). RELAP5/MOD3 code is the tool used for the analyses. Results obtained from the simulations were compared to the ones from Angra 2 Final Safety Analysis Report (FSAR). The accidents simulated considered the new detailed core nodalization which showed to be much better compared to the simple core nodalization. The process of qualification taking into account the new nodalization is in progress.