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The Operational Parameter Electronic Database of the IPR-R1 TRIGA Research Reactor

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ABSTRACT

Nuclear reactor operators need to know the basic behaviour of reactors in order to understand and safely operate them. In the last four years, the main operational parameters of the IPR-R1 TRIGA Mark I Reactor of Nuclear Technology Development Center (CDTN) at Belo Horizonte, Brazil, have been monitored and displayed on-line by using a data acquisition system developed for this reactor. Besides showing the real-time performance of the plant, the system stores the information in a computer hard disk, with an accessible historical database, in order to make the chronological information on reactor performance and its behaviour available to users. Some of the parameters stored are: the control rod positions and its reactivity, the reactor power, the fuel and water temperatures, the radiation levels, the primary cooling system flow, the water pool level and so on. Records of process variables of the reactor are important for immediate or subsequent safety analyses to show the short and long term trends, and to report the reactor operations to the organization and external authorities. This paper describes the data acquisition system, the developed electronic database and operational procedure used by the IPR-R1 TRIGA reactor staff to storage the operational parameter.

1. INTRODUCTION

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The IPR-R1 TRIGA Research Reactor, located at the Nuclear Technology Development Center - CDTN, has been operating for 48 years. The operational parameters are monitored and displayed by analog meters located at reactor console. The reactor operators registered the most important operational parameters manually in a logbook. This process is quite useful, but it can involve some human errors, parallax error, time delay, etc. It is also impossible for the operators to take notes of all variables involving the process mainly during fast power transients. Due to the experiments on neutronics, thermohydraulics and reactor power calibrations, it was necessary the development of a data acquisition system to make possible the tests [1, 2, 3, 4]. Now, this system is part of the IPR-R1 reactor operational procedures, and it is used to register the operational parameters and to maintain the electronic files. The system responds to the International Atomic Energy Agency - IAEA recommendations on the monitoring and registration of the operational variables [5]. The Figure 1 shows the reactor cooling system diagram and the localization of the instrumentation used to monitor the operational parameter.

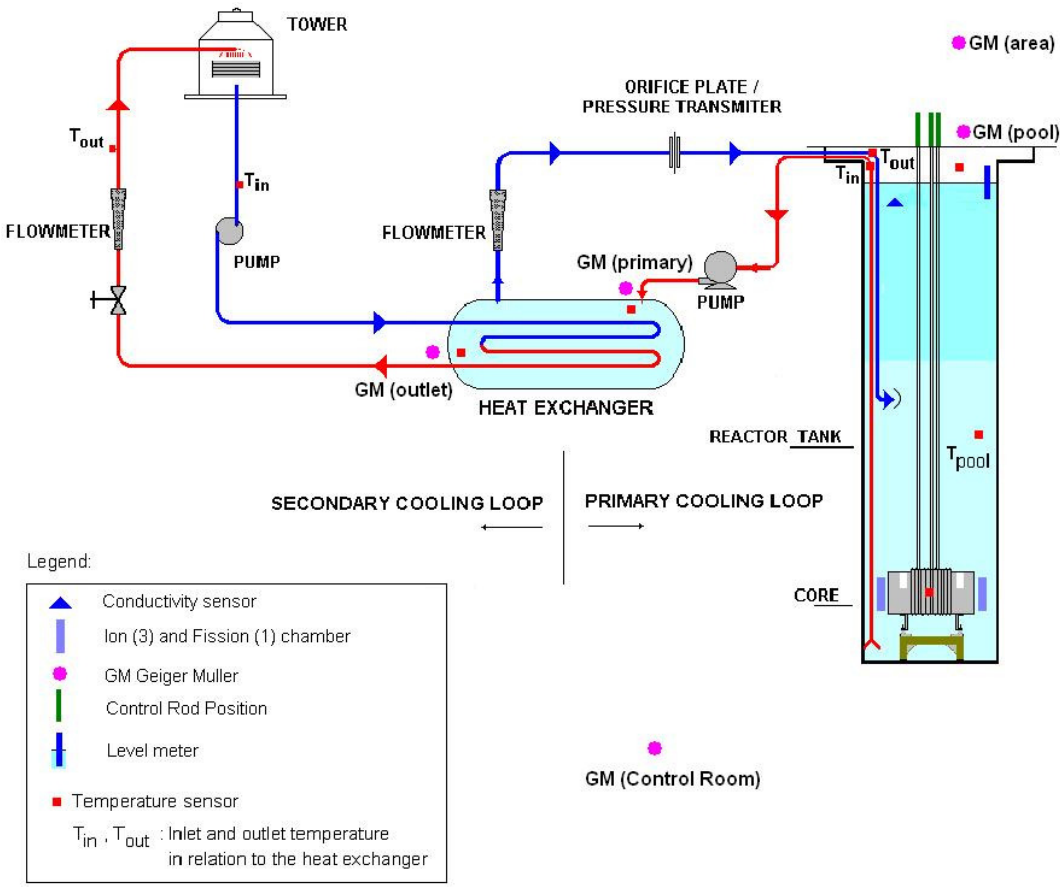

Figure 1 – Cooling System and Instrumentation Distribution

2. HARDWARE DESCRIPTION

The reactor instrumentation includes four neutron channels that are fed by three neutron-sensitive ion chambers (two compensated and one uncompensated), and by one fission chamber located around the core The detector´s signals are amplified in a voltage amplifier. The amplified output voltage is between 0 to ± 10V which is the input sign of the Multiplexing Board and to the Analog to Digital Converter card of the PC with the associated software. The other analog signs, collected by the data acquisition system**,** are outputs of the reactor control console and from some digital indicators or directly from the thermocouples. The measure data are shown in the LCD computer video monitor. The main components of the instrumentation are described in the next sections.

3. DATA ACQUISITION CARDS

3.1. Amplifier and Multiplexing Cards

The analogical signs are received in three cards model PCLD-789 by Advantech Co [6] connected in cascade, each one with 16 channels which totalize 48 inputs. These cards prepare the signs amplifying and filtering the noises, and make the connection for a unique analogical output (multiplex action). One of the cards receives the signs directly from the thermocouples (range of ± 100 mV). It has a sensor that measures the temperature and makes the compensation of the cold junction adjusting the measured value. The other cards receive the signs from the control console (range of ±10 V).

3.2. Analog to Digital Conversion Card

The outputs of the three conditioning cards are addressed to the analog input plug of the data acquisition card, model PCL-818hd by Advantech Co [6]. This is a high-speed data transference card installed in the computer case, which transforms the analog input signs into digital sign.

4. DATA ACQUISITION SOFTWARE

The data acquisition system is programmed with a set of icons that represents controls and functions, available in the menu of the software. Such a programming is called *visual programming*. The user interface consists of two parts - a *front panel* and a *diagram*. The front panel is used for input, output controls, and to display the data whereas the circuit resides on the circuit board**.** The front panel has buttons, indicators and graphics and display functions. This interface also calculates mean and standard deviation of the data and plots it.

The main indications of the control console are collected by the data acquisition system, including the positions of the three control rods. These signs come from the rack of the instruments and from the reactor control console and they input in channels 1 to 15 of the Card 2. A description of all signs collected from the control console is not presented in this paper. It was accomplished all the answers of the parameters collected and the equations used to transform the signals of Volt into engineering units were introduced in the data acquisition program**.** The program presents four screens; one of them is shown in Fig. 2 (Control, Start up Channel, Period and Reactivity). The other screens are: Radiation Levels, Power Channels and Cooling System and Temperatures.

4.1 Control, Start up Channel, Period and Reactivity

On the screen, shown in Fig. 2, the start up of the reactor can be accompanied through the neutron evolution counting rate. The positions of the three control rods of the reactor can be visualized in graphics and in digital indicators. The evolution of the control rods position and its reactivity, in the last 60 minutes, are shown in three graphics**.** The reactivity of the reactor, in [pcm] and in [dollar], is given by digital counters. This screen also shows the loss of reactivity as a function of power and time, the positive period of the reactor (T) in [s] and the start up rate (SUR) in [dpm].

4.2. Radiation Levels

The gamma radiation levels at the reactor area are measured in the following positions: in the Control Room (*AEROSSOIS*); at about 30 cm above the reactor pool (*POÇO*); at 2 m above the reactor pool (*AREA*); at the inlet piping of the primary cooling loop heat exchanger (*ENTRADA PRIMÁRIO*); in the ion exchanger system (*RESINAS*); and at the outlet piping of the secondary cooling loop heat exchanger (*SAÍDA SECUNDÁRIO*). These radiation levels of the monitoring channels are shown on the screen in analog and digital indicators and their evolution, in the last 60 minutes, are presented in graphic ways.

4.3. Power Channels

This screen shows the evolution of the reactor powers supplied by three conventional neutron channels of measurement: Logarithmic Channel, Linear Channel and Percent Power Channel. Digital indication and graphics show the last 60 minutes values. The evolution of the power dissipated in the primary and secondary cooling systems is also shown. After several hours of reactor operation, when it is reached the thermal balance with the environment, the power of the reactor will be closer to the power dissipated in the primary coolant loop, and the thermal losses will be smaller. Those losses value are indicated on the screen. The reactor power is monitored also by the increase of the temperature in the center of the instrumented fuel.

4.4. Cooling System and Temperatures

All the following parameters of the primary and secondary cooling loops are monitored and shown on the screen: the average values of the inlet and outlet temperatures of the primary and secondary loops, of the flow rate, and of the temperatures in the reactor pool, and their standard deviations; the power dissipated in the primary and secondary cooling loops; the air temperatures above the reactor pool and in two points of the soil; the average temperature taken from three thermocouples of the instrumented fuel element; and the time elapsed since the program has begun, in [s], [min] and [h].

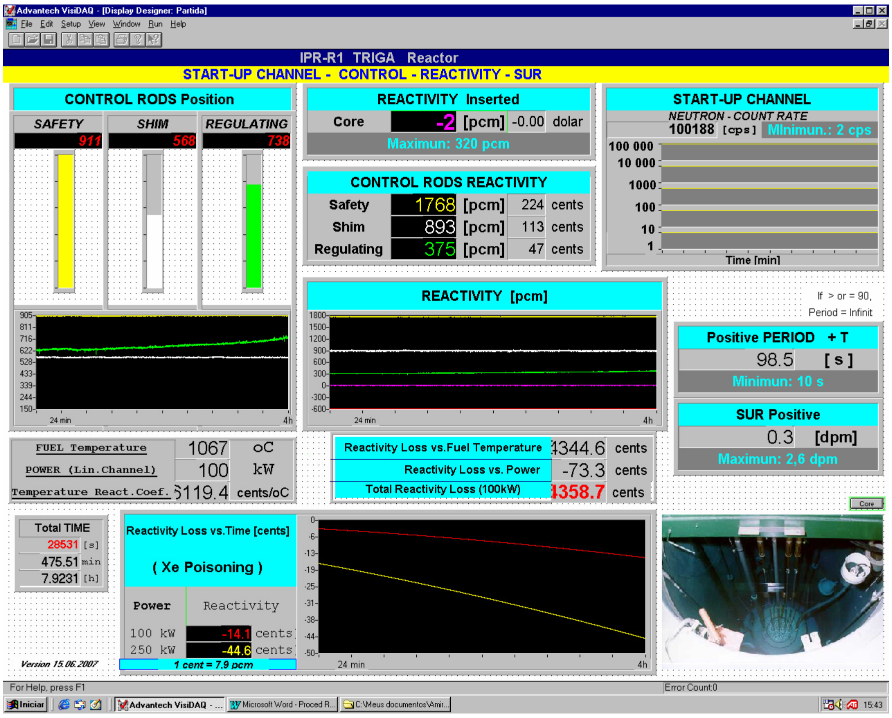

Figure 2. Control, Start up Channel, Period and Reactivity Screen of the IPR-R1 TRIGA Data Acquisition System

DATABASE SYSTEM

The database is a computerized collection of the operational parameters, organized so that it can be expanded, manipulated, and retrieved rapidly for various uses. Within the electronic database, a computer program assists the user in selecting desired pieces of data. The data are recorded in five separated text-files that permit to register 40 parameters. In all files, the first column is always the time registration in [s]. The data collection and recording frequency can be adjusted starting from 1.0 Hz to 1.0 kHz.

The Figure 3 shows the IPR-R1 database with all operation files from the year of 2002 to the last operation at this moment. The data is recorded in text files (.txt) and after it is passed to Excel software to allow the visualization of variables evolution (Fig. 4). Safety backup is made to other computers and also available in the Ethernet.

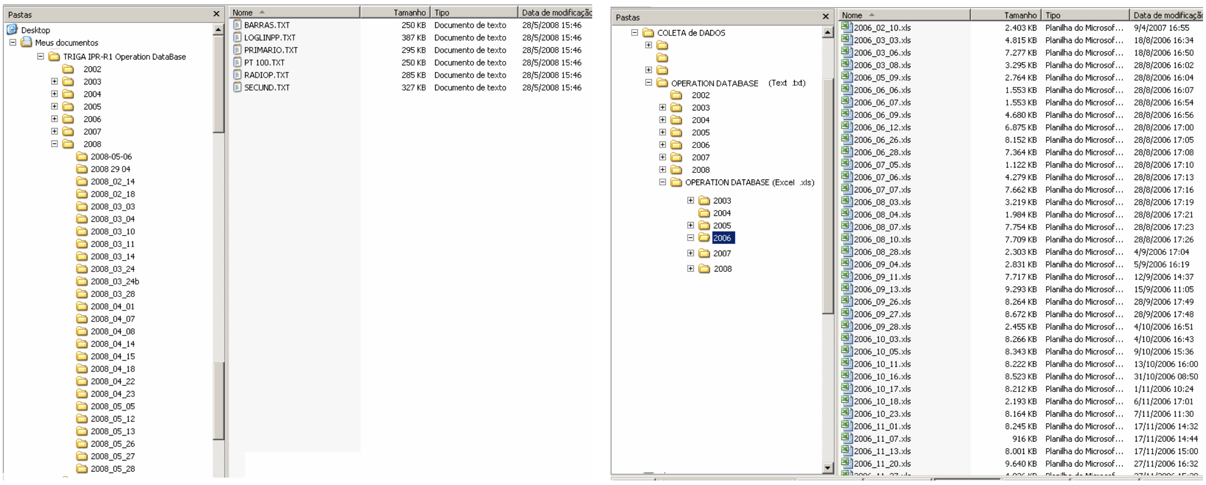

Figure 3 – IPR-R1 TRIGA Operation Database in Microsoft Word Files and Microsoft Excel Files

The trend of a series of data can be analyzed from the curve charts. An example of display pattern of results data are showed in Fig. 4.

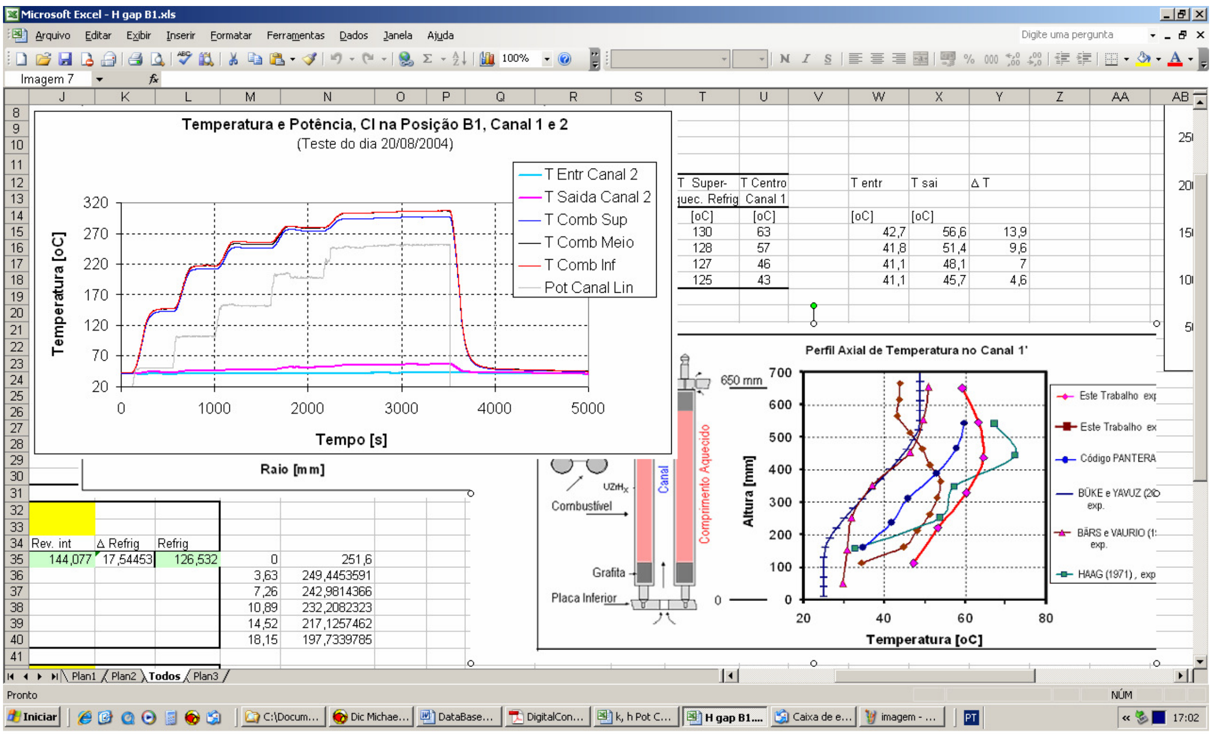

Figure 4 – Example of the Data Display Pattern of Results Data

5. CONCLUSIONS

The new data acquisition based on the microcomputer has been designed and developed to allow the real-time collection of all IPR-R1 TRIGA Reactor operational parameters and information from the reactor console. They are fed into the computer through an interface unit that includes hardware like multiplexer, A/D converter and computer interface. Information on all aspects of reactor operation is displayed on the computer screen. The color graphic monitors can display real-time operation data in concise, accurate, and easily understood formats. Bar graph indicators, and visual and audible enunciators are also provided. Information displayed on the monitor is recorded on hard disk copy. The system collects data during reactor operations and stores it in a historical database. This record is a powerful tool that can be used for operations review and maintenance troubleshooting. In every operation of the research reactor about forty variables are registered by the data acquisition system. The system provides data for the last five years, (since 2004).

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