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1. Development of a Computational Program to Planning and Control of the IEA-R1 Reactor Maintenance

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ABSTRACT

Maintenance is an essential activity in nuclear reactors. The components of safety systems of an industrial plant should have a low probability of failure, especially if there is a high risk of accidents that may cause environmental damage. In nuclear facilities, the presence of security systems is a technical specification and a requirement for their license and operation. In order to manage the entire information flow from the maintenance of the IEA-R1, a computational program (software) was developed, which not only plans and control all the maintenance, but also updates the documents and records to safeguard the quality, ensuring the safe operation of the reactor. The software has access levels and provides detailed reports of all maintenance planned and implemented, together with an individual history of the equipment during its lifetime in the facility. This work presents all the stages of the software development, description, compatibility, application, advantages and results obtained experimentally.

Keywords: Research Reactor, Maintenance, Software.

1. INTRODUCTION

The nuclear research reactor IEA-R1 of the Instituto de Pesquisas Energéticas e Nucleares, managed and administered by the Comissão Nacional de Energia Nuclear (IPEN / CNEN-SP) is located in the campus of the São Paulo University. The pool type reactor was designed by "Babcock & Wilcox Company," having reached its first criticality on September 16, 1957.

The purposes of the reactor are: radioisotopes production for applications in medicine, industry, agriculture and research, serving as an intense source of neutrons in scientific experiments for nuclear physics, chemistry, radiochemical samples analysis by the neutron activation analysis method, engineering and biology. The reactor is also used for the training of IPEN-CNEN/SP scientific staff in reactor physics, projects, development of nuclear instrumentation and reactor safety. Another important application is its employment in education and training of operators and supervisors.

With the increasing demand of the radioisotopes usage in medicine, such as ^{153}Sm, ^{125}I and ^{99}Mo, it was necessary to change the operating regime and raise the power to 5 MW. Aiming at this new rhythm of work and installation adjustment for this power growth, a project of continual modernization of its facilities was started [1] . As a result of this effort, it became

the only ISO 9001:2008 certified reactor, throughout Latin America, undergoing routine inspections by CNEN, IAEA and the ABNT [3].

2. OBJECTIVE

The aim of this work is to accomplish the development and installation of a computer system for Maintenance Planning and Control of the Reactor IEA-R1.

The software, besides planning and managing the maintenance, should maintain updated registration of documents and safeguard the quality, ensuring the safe operation of the IEA-R1 reactor [2].

3. COMPUTER SYSTEM FOR PLANNING AND CONTROL MAINTENANCE of the REACTOR IEA-R1

3.1. Basic Functions of the Computer System for Maintenance Planning and Control of the IEA-R1. The computer system has the basic functions of managing the storage and the control of the research reactor components maintenance and calibration. It is also prepared to storage the engineering technical data related to these components. The system should process the information in order to provide various reports to the user.

3.2. General Characteristics of the Computer Program. The computer system will be developed in DELPHI, which is a declarative search language for relational databases. DELPHI programming language is being used in the development of applications that allow the user to perform tasks such as: data entry and updating, reporting and control of maintenance and calibrations performed.

3.3. Operating System. The program was designed with the capacity to be installed in an internal computer network (Intranet), operating in a Windows environment, so that it can be accessed by multiple users, simultaneously. Thus, the access will be accomplished by a single central database on a computer called "server" [4]. In addition, each user should be registered in the system, to have a given level of access to the database, depending on the tasks that will be allowed to be executed (examples: 1. consulting the records of maintenance or calibration and reporting; 2. generating the maintenance and calibration records, adding, updating, modifying and deleting records of maintenance or calibration of the database, and 3. controlling the registration and the level of users access).

4. METHOD

The model used in the computer system of the reactor was the Cascade Development. Fig [1]. In the cascade model, the project follows a series of ordered steps. At the end of each phase, a review is carried out.

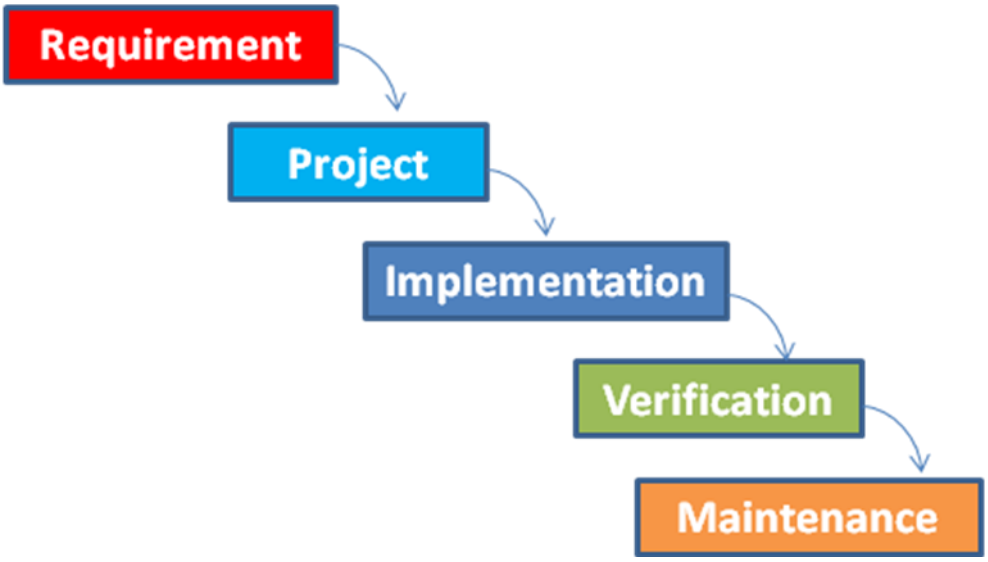

Figure 1 - Cascade Model Development

The cascade model is based on documents and, certainly, has a huge amount of reports and outputs which are nothing more than documents.

The cascade model works well when the user requirements are strict (rules, procedures) and may be known in advance, as in the research reactor.

The cascade development methodology also works well in rigid and strongly controlled environments. This model is especially indicated for projects that have components of high risk, such as projects for medical and nuclear purposes or public security. This computer system was developed as a software process, or process of software engineering, which is a coherent sequence of steps, aiming at the development or evolution of software systems [5][6].

These steps include the activities of requirement, project, implementation, verification and maintenance (fig. 1) and are characterized by the interaction of tools, methods and people [7].

In the stage of requirement, all aspects related to the needs of the reactor were raised: the legal aspects (standards) to be achieved by the system. A feasibility study for the proposed computer system was performed.

In the project phase, the sequence of steps that were completed for the implementation of the system was detailed: initiation, planning, execution, monitoring / controlling and closing.

In the implementation stage, the computer system was coded and executed.

In the verification step, operational tests and the validation of the new software were carried out, as well as the preparation of the internal project documentation for the software (user manual), with the purpose of future maintenance and enhancements.

In the maintenance phase, the necessary corrections of failures or errors during the software validation were carried out .

5. STRUCTURE AND CONTENT OF THE COMPUTER SYSTEM FOR PLANNING AND CONTROL MAINTENANCE OF THE IEA-R1 REACTOR

The Computational System for the Planning and Maintenance Control of the IEA-R1 Research Reactor of IPEN / CNEN-SP is structured to provide the following modules below.

Preventive Maintenance module. The preventive maintenance module is divided into three sub-modules:

Register. The sub-module of Registration is where the information in the installation equipment databases, maintenance plans and tasks to be performed during preventive maintenance are stored.

All equipment registered receives an identification (tag), which recognizes the system to which it belongs, the type of equipment and the existing quantity.

In the maintenance plan, all the technical instructions concerning the reactor existent maintenance plan and the frequency these procedures should be performed are stored. The stored information refers both to a single device and to a system composed of multiple devices.

The sub-module allows the inclusion, correction and exclusion of records as well as reporting, for simple conference.

Update. The Update sub-module is where the records of the preventive maintenance are generated, together with the control over these records and their history. All preventive maintenance records receive a sequential control number, which can not be used by another apparatus. In case a complementation or replacement is necessary, this preventive maintenance register can be canceled and a new preventive maintenance register will be generated, according to a numerical sequence. This sub-module is, also, divided into three sub-modules:

Preventive Maintenance Program. In this sub-module, the system relates the equipment with its respective preventive maintenance plan, as well as the frequency, the expected date for completion and the worker in charge of the task.

Generating Maintenance Records. In this sub-module, the system generates the preventative maintenance records of each equipment or system, according to the targeted period. Records are numbered and printed for execution. Once the preventive maintenance is performed and properly filled, the record returns to update the database.

Records Monitoring. In this sub-module, the system updates the database of preventive maintenance records, according to the status of implementation (request / execution / pending / concluded / canceled). It is at this point that the occurrences which were not forecast during maintenance are registered, together with the identification of the executor and the date the preventive maintenance was carried out.

This information is very important since from this step the Maintenance History reports will

be generated, containing all the preventive maintenance performed in each equipment or system. This information is fundamental to forecast preventive actions in the reactor.

Corrective Maintenance module. The corrective maintenance module is divided into two sub-modules:

Register. The Registry sub-module is responsible for the generation of corrective maintenance record of each equipment, according to the modality (equipment / installation), type of service (mechanical / electrical / electronics / instrumentation / hydraulic), the occurrence answer (immediate / urgent / normal), the applicant (the technician who reported the occurrence / failure), the contact (executor) who will perform the corrective maintenance and the description of the occurrence or failure. All corrective maintenance records receive a sequential control number, which can not be used by other equipment or installation. In case a supplement or replacement is needed, this corrective maintenance record may be canceled and a new record of corrective maintenance will be generated, in accordance with the numerical sequence.

The records are numbered and printed for execution. Once you have made the corrective maintenance, and properly filled it out, the record will return for database update.

Query. In this sub-module, the system updates the database records of corrective maintenance, according to the status of implementation (request / execution / pending / completed / canceled). It is at this point that the description of the components used and the services performed during the corrective maintenance are registered, the executor is identified and the date of the corrective maintenance is recorded.

This information is very important since from it the reports of History Maintenance, containing all corrective maintenance performed on each piece of equipment or installation, will be generated. Thus, this information is essential for the prediction of future preventive actions in the reactor.

The sub-module allows the inclusion, correction and deletion of records and, also, the reporting for simple conference.

Calibration Module. The calibration module is divided into two sub-modules:

The sub-module of Registration is responsible for storing information in the database of the instrument or installation meter, which requires periodic calibration. This sub-module is divided into two sub-modules:

Calibration Plan Update. This system generates the calibration records of each instrument or meter, according to the periodicity. Once the calibration has been performed, the record should be updated with the date of execution, the number of the certificate and the laboratory or company that performed the service.

This information is very important because from it the Registration of Calibration report will be generated, containing all the calibrations performed in each instrument or meter.

The sub-module allows the inclusion, correction and deletion of records and, also, reporting for simple conference.

Calibration History. In this sub-module, the system generates the calibration record of each instrument or meter that contains the history of each calibration performed by identifying the instrument or meter through a control number (tag), the calibration parameters and measurement uncertainty, certificate number, when calibration was made, laboratory, the prediction of the next calibration and the member of staff responsible for the instrument or meter.

Query. In this sub-module, the system generates and prints the Calibration Plan of the installation, for control or single conference. The module enables multiple filters for the preparation of reports during the execution of tasks, such as status (completed / not completed) separation by area, application, period (annual / monthly / up to a given month).

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