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System for monitoring Cyclotron CV-28 safety parameters

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1. Introduction

In a cyclotron facility, there are numerous possible dangers. Extreme voltage, radiation, high temperatures, and the transportation of big pieces of equipment are all common risks. All of these hazards should be properly marked on signs, and employees should be trained to be aware of them. Furthermore, the interlock protection should be set up such that the machine cannot be used while it is not protected. Local regulations could decide the specific layout. Nureg 0800 [1] indicates that in the main control room, a set of displays and controls for manual system-level actuation of essential safety functions and monitoring of parameters that support safety functions should be provided. Displays and controls should be separate and distinct from facility safety systems. This work summarizes the framework for monitoring safety parameters that is currently being developed to Cyclotron CV-28, a circular multi-particle accelerator in operation at Instituto de Engenharia Nuclear (IEN).

2. Methodology

Originally dedicated to nuclear physics science, CV-28 has increasingly shifted its focus to commercial radioisotope manufacturing, owing to the demand for radiopharmaceuticals with short half-lives in nuclear medicine over the decades. The CV-28 has required several updates over the years to remain operational for so long. One of these updates was to ensure that the cyclotron control panel could display all safety-related parameters. Two 32-inch video monitors were installed on the cyclotron operating console. Human-system interfaces make safety information available, following human factor requirements [2]. Human factors refers to a collection of scientific knowledge about human traits that includes biological, psychological, and psychosocial concerns, as well as concepts and applications in people selection, training, and work performance assistance technologies [3][4].

Figure 1 shows the ergonomics studies for the installation of these screens in the cyclotron control room. These analyses are backed up by the group's experience designing and modernizing research reactor control rooms [2]. Nuclear control room studies, particularly those undertaken as part of attempts to modernize control rooms, present distinct issues. A standard quantitative technique is often not possible or appropriate due to the difficulty of sampling large numbers of operators, the interface enhancement aims of a usability review, and the restricted resources available for study analyses [5]. Ergonomics is a multidisciplinary study subject that focuses on enhancing the human-technology interaction's safety performance. This is achieved by taking into consideration human performance's strengths and shortcomings. Ergonomics' objective is to establish the best possible fit between goods and users in the context of the job at hand [6]. The inclusion of ergonomics into system design, interfaces, and equipment provides several options for system effectiveness, efficiency, dependability, and safety.

3. System developed

The following are the safety-related parameters and information that are already available on the monitors in the control room of the CV-28 cyclotron:

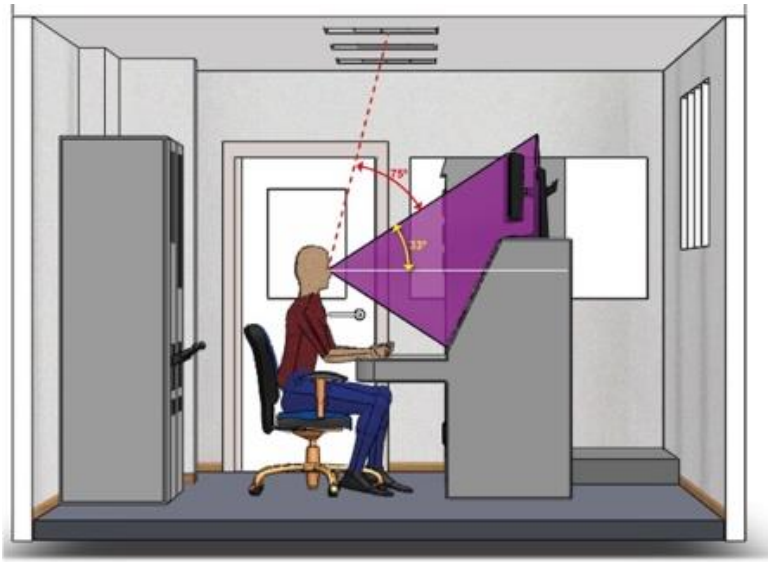

Figure 1 - Sketch for the positioning of the screens.

1. Confirmation that the round at the designated locations was completed: this subsystem captures the information of the round carried out, before the start of the operation, and records in file the time when each round button was pressed, as well as the time when the tour was completed. Figure 2 shows this information on the application screen. The criterion of a safe start-up of the operation is better met with information recorded in the operator's round that all cave entrances are closed, and nothing is obstructing vital regions of the installation.

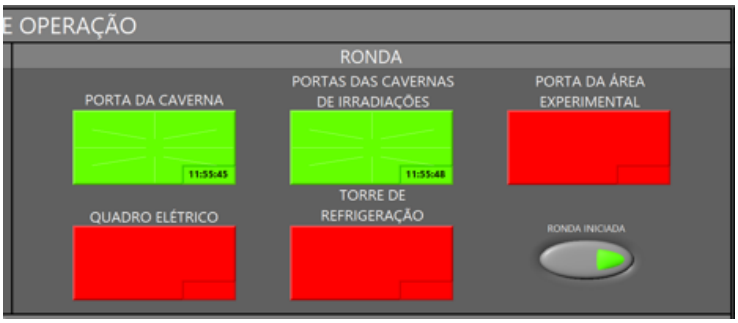

Figure 2 - Information about the round.

2. Details on the opening of fluorine processing cells [7]: a magnetic lock has been mounted on the cell's door that is directly controlled by a radiation monitor. If dose rate measurement surpasses its alarm threshold, the lock is instantly energized. Such threshold is set by the supervisory computer. This is clearly a critical safety criterion throughout the cell opening procedure since it prevents the worker from being exposed involuntarily and unnecessarily.

3. Data on the status of material transfer from the cyclotron to the hot cells. This information is displayed on video monitors in the control room and is also accessible remotely via cloud computing, as shown in figure 3. Before everyone in the plant, including cyclotron operators and irradiated material processing cell operators, had access to this information, a call from the operator to the processing sector was required to notify that the material was in transit. In the event that this transit fails, the worker may be exposed for not knowing what material passed through or was detained at some site. The dose rate monitored by the monitor during irradiation is also used to provide the operator with another indicator of the correct cyclotron functioning.

Figure 3. Monitoring data in cloud.

Figure 4 displays the system's video monitors placed on the CV-28 cyclotron console for examining safety-related parameters. More parameters can be added to the system in the future, depending on the demands of the operation. Despite the limitations imposed by the control table, such as the height of the panel for placing the monitors, the study provided comfort for the operator to observe the parameters, and guaranteed that this operator could read the information and conditions of safety parameters during cyclotron operation, by using curved video monitors and appropriately sized indicators in the supervisory software.


Figure 4. Video monitors on the CV-28 console.

4. Conclusions

In a control room at a nuclear facility, the operator monitors and controls the process, recognizes disturbances that affect safety, and keeps the plant in a safe condition. Many nuclear facilities around the world are being modernized and computer-based systems are being introduced. Despite careful recommendations from

international regulators around the world to use the human factors engineering aspects of design in control room modernization, most modernization processes were driven in large part by technology. This work showed the framework for monitoring safety parameters that is currently being developed to Cyclotron CV-28. The research to modernize the control rooms of nuclear facilities with the human factors and ergonomics approach, adding new technologies with the approval of multidisciplinary teams in the project, will allow greater safety and reliability in the validation process of these facilities.

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