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•*Technical note*

Design of a PLC system for automatic I-123 production

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Background: Design of the production system for Iodine-123 has begun recently in nuclear research centre of agricultural and medicine (NRCAM). The production system consists of pipes for xenon gas transfer, equipped with 10 valves, 3 heaters, fluid nitrogen and 2 vacuum pumps. In the first prototype the function of elements was being done manually by an operator. Because dispensing radiopharmaceuticals manually involves receiving radiation dose by operators, therefore, automation is very important step in radiopharmaceutical production. ***Materials and Methods:*** The automatic system for production of Iodine-123 is PLC /135u Siemens, which is designed and installed for the first time in Iran. The PLC was connected to the production system through relays. By programming the CPU of the PLC, start up and control of the production procedure was executed automatically. ***Results:*** Automation leads to reduced presence of operator for Iodine-123 production. We were also able to record storage and transfer of materials and minimize risk of error. ***Conclusion:*** Automation in production of radiopharmaceutical may lead to reduced radiation dose to personnel and achieved better dispensing precision. **Iran. J. Radiat. Res., 2005; 3 (1): 49-51**

Keywords: *Automation, programmable logic controller, Iodine-123.*

INTRODUCTION

Radioisotopes are being used increasingly in a range of processes associated with food preparation, agriculture, and water supply, as well as biological and industrial researches. One of the most important applications of these radionuclides is in nuclear medicine. The risks of exposure to radiation are well known; therefore, an automated PLC system was designed to reduce radiation exposure to staff.

MATERIALS AND METHODS

Production system of Iodine-123 is consisted of two sections. The first section is the target section, and the second is the chemical one. In this project, automation has been done for the first section, which is the target section. In this section xenon gas was being bombarded with proton beam. Target section was consisted of 10 digital valves, thermometer (PT100), pressure gauge (Pisoelectric), vacuum gauge (Pirani), heater and vacuum pump.

Production of Iodine-123 in target section involves in 8 stages. These 8 stages are as follow[1]:

1) Vacuuming the target system,
2) Transferring xenon gas to target,
3) Transfer remaining xenon gas in cold finger and pipes to xenon bottle,
4) Bombarding target with proton beam,
5) Transferring xenon gas to decay vessel,
6) Transferring xenon gas from decay vessel to xenon bottle,
7) Transferring warm water to decay vessel in order to solve Iodine-123,
8) Transferring Iodine-123 to chemical stage.

For automation of production process, PLC 135U/Siemens was used[2]. In order to ensure that automation works properly, the automated system was set up in parallel with manual system, and was assumed to work in this same mode, at least for one year after completion.

The PLC system

The PLC utilized for this application represented a cost-efficient way to implement small control system. The modules which were used in this PLC are as follows[3, 4]:

- CPU 922
- Digital input card 432
- Digital output card 482
- Analog input card 465

Each one of these modules had the following characteristics:

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CPU 922

- Suitable for word processing (closed loop control and arithmetic calculation),
- Programming levels are: cyclic, time-controlled (1 time base), interrupt driven (hardware interrupt),
- 2048 flags,
- 128 Timers,
- 128 Counters,
- Maximum size of user memory was 67 × 210 words,
- DB RAM 22 × 210 bytes,
- Transmission rate of serial PG interface 9600 bit/s,
- 256 Program Block (PB),
- Sequence Block (SB),
- Function Block (FB).

Digital input module 432

- Rated input voltage: 24 VDC,
- Number of inputs: 32,
- Isolation for 4 groups of 8 inputs,
- Input frequency 100 Hz/300Hz/,
- 1 kHz max.

Digital output module 458

- Rated supply voltage: 24 VDC,
- Number of outputs: 16,
- Isolation for 16 outputs,
- Output: Relay contacts.

Analog input module 465

Input analog module was used to measure the pressure rate analog, vacuum gauges and thermometers. Each of these measurements can be done by specific Range Cards which are connected to module and convert the analogue value to digital numbers. The number of Range Cards and the sensors, which were used, are shown in table 1.

Table 1. Range cards for converting analog to digital values.

Sensor	Number of Range Card	Channel and Board Number
Thermometer (PT100)	6E55.498- 1AA11	Channel 1 and 3 Analog board 1,2
Vacuum Gauge	6E55-498-1AA31	Channel 2 Analog board 1
Pressure Gauge	6E55-498-1AA51	Channel 2 Analog board 2

System operation

For operation, the manual and automated systems were connected to valves, temperature and pressure sensors, and were vacuumed by relays (figure 1). As shown in figure1 the inputs of relays were connected to

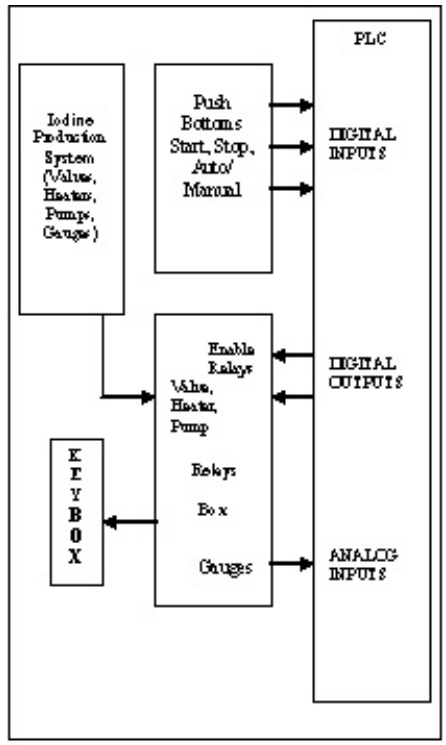

Figure 1. The automation system

the Iodine production system and the outputs of each relay was connected to manual and automatic systems separately. First the whole system was connected to manual system until the PLC receives the automatic command from the two state switches. At this moment PLC would enable the relays and all of the production system would be connected to the PLC. In the intermediate circuit, there are 9 LEDs. 8 LEDs represented each steps of Iodine production and one LED was for showing any error happens during the production. There were also 3 switches, 2 of them were push bottoms and due to starting for each steps of production and stop manually, which was for emergency stop, and switch 2 state for manual or automatic production.

Software structure

In this project the user program was executed in cyclic way. In this mode first OB1 (Organization Block) run cyclically and calling the blocks programmed in the user program[4, 5] as shown as figure 2.

In the user program the 8 process stages of Iodine production were programmed in PBs (Program Block) and FBs (Function Block). After finishing each stage the related LED

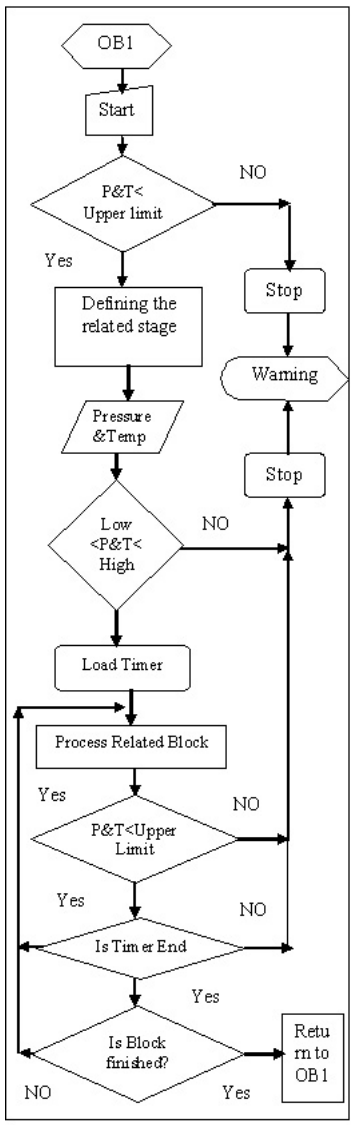

Figure 2. Flowchart of program

was set on and PLC comes back to OB1, waiting for start command from the operator. At the beginning of each stage the amount of pressure and temperature of system is checked and if one of them were over the standard level of system, the PLC would stop the operation and warn for any problem in the system. After checking pressure and temperature PLC entered the operation level. For each stages of production, there was an estimated time, which was considered in the user program. When PLC runs the operation level, it checked the time of operation with that threshold time; if it was exceeded from that time the PLC would go to stop state. In stop state all the valves, heaters, pumps and fluid nitrogen flow were off.

CONCLUSION

The aims of the APD system were to:

- Reduce radiation dose to personnel,
- Limit contamination risks during aseptic handling,
- Achieve better dispensing precision,
- Record storage and transfer of materials,
- Minimizing risk of error,
- Increase efficiency[6].

In this project 8 stages of I-123 production in target section have been done automatically. This level was performed manually before, which was not accurate and accompanied with receiving dose by operators. As this production system is under test situation, for calculation of the precision of production and comparing with manual system needs that production to reach to final situation.

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