

Application of Personal Computers to the Control System for the Liquid Waste Treatment Station at the Dalat Nuclear Research Institute

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Abstract

The radioactive liquid waste treatment station of the Nuclear Research Institute (NRI – Dalat) was established and put into operation in July 1984, four months after the completion of the Dalat nuclear research reactor's reconstruction. The previous control system of this station was designed and manufactured by the former Soviet Union and had generally good reliability and had proven its ability to ensure the operating regimes. However, due to using discrete and low-level integrated electronic components of 1970 s generation, the system's technology was somewhat obsolete. After ten years of operation, the system's reliability was degraded because of ageing effects on equipment and electronic components. In the framework of a national project on the nuclear research reactor general inspection and refurbishment, of the renovation and modernization tasks for the control system of the radioactive liquid waste treatment station was implemented as part of the project.

The design and construction of a new PC-based control system for the liquid waste treatment station of the NRI were imperative for improving its reliability and measurement accuracy and for increasing the system functions.

This paper describes the application of PC-based electronic systems to the liquid waste treatment station's control.

The level measurement system has the function of monitoring, measuring, displaying and storing information on liquid radioactive waste level for 24 vessels and automatically controlling valves and pumps when required. The system was built upon add-on interface cards to a PC/AT computer.

The design and construction of the dosimetry system were performed. The electronic blocks of this system were also built upon add-on cards to PC. The system is used for monitoring the radioactivity level at different positions in the liquid waste treatment station. Information on radioactivity is displayed digitally and graphically on a computer monitor and saved continuously on the PC's hard disk. The system can also give warning signals (visual and audial) whenever the radioactivity level at any observed position exceeds the set limit.

Software programs for both level measurement and dosimetry systems were written in Turbo Pascal and Assembler languages.

The new control system for the liquid waste treatment station was checked, commissioned and put into operation in May 1997.

1 Radioactive liquid waste treatment station

The radioactive liquid waste treatment station is a part of the radioactive waste management system [1]. The station consists of 4 storage tanks (5 m³ each) for waste collection and precipitation; 6 ion-exchange and 2 mechanical filters; 4 sludge reservoirs; 6 storage tanks containing alkaline-acid solution; 2 purified water tanks; electric pumps and valves and other accessories. The diagram, *Fig. 1*, shows the main part of the station. The designed capacity of this station is 5 m³ per day. Annually 100 – 150 m³ of radioactive liquid waste can be treated by this station.

As the Dalat nuclear research reactor is used for radioisotope production, scientific research and training purposes, the main waste sources collected by this station are from reactor operation and radioisotope production activities.

The most significant quantity of the collected waste is in liquid form. Every month, the Institute generates about 10 – 15 m³ of liquid waste. The quantity and radiochemical composition of the waste greatly depends on the activities of the reactor and radioisotope production laboratories. The produced radioisotopes are mainly those serving nuclear medicine needs, industry applications, sedimentology and hydrology studies and other scientific research. Several types of isotopes are produced, such as ³²P in injectable solution and applicator, ¹³¹I solution and capsule, ^{99m}Tc generator, ⁵¹Cr in injectable solution. Other isotopes such as ⁶⁰Co, ⁶⁵Zn, ⁶⁴Cu, ²⁴Na, ⁸⁶Rb, ⁴⁶Sc, ¹⁹²Ir, ⁷¹Ge, ⁵⁵Fe, etc. are produced in small amount when requested. The liquid waste in the collection tanks consist principally of ¹³¹I, ⁵¹Cr, ⁶⁰Co, ¹³⁹Ce, ¹³⁴Cs, ⁵⁴Mn with radioactivity between 3.7 – 37 KBq/l. The chemical and radiochemical composition of waste in these tanks are classified in two types. The first type, having "simple" composition, is the result of reactor operation, and the second type, with more "complicated" composition, is from radioisotope production laboratories.

2 Description of the control system

The control system for the liquid waste treatment station consists of 3 main parts:

- System for measurement of technological parameters, such as liquid level in various tanks of the treatment lines, the liquid waste's pH and conductivity values before and after treatment, flow rates of filtering unit, etc.

- Dosimetry system for measurement of radioactivity at various positions in the treatment station.

- Control panels and control console for installing electronic equipment, indicators and others.

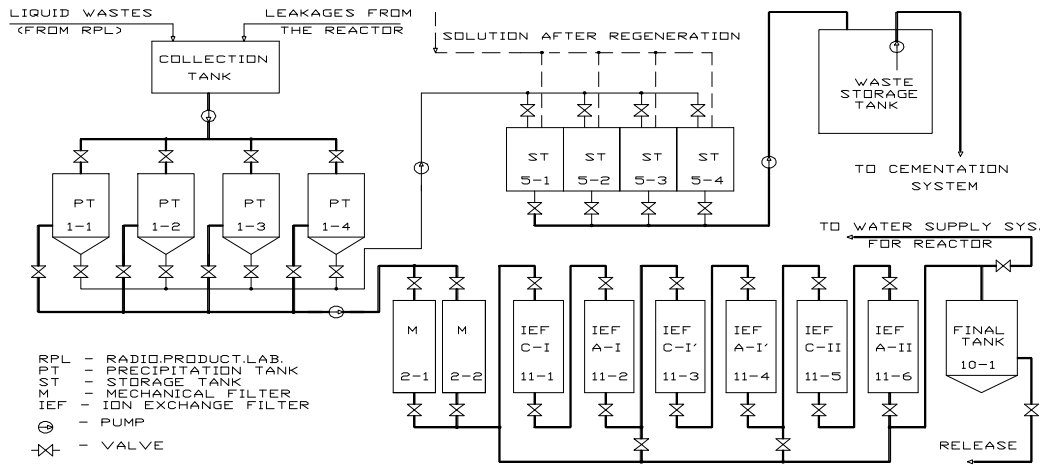


Fig. 1. overview of the radioactive liquid waste treatment station of the NRI

The most important renovation task was to re-design and construct a number of systems/blocks which might play a key role in enhancing the reliability of the whole control system. The main results obtained from the renovation and modernization work are the following:

- Replacement of the old system for technological parameter measurement with the new one. This system was built using a PC and advanced multi-purpose add-on cards. The designed system allows the operators to measure simultaneously various parameters of the treatment station. Measured as well as alarm setting values are displayed on a PC monitor in digital and graphical modes.

- Redesign and construction of a new PC-based 8-channel dosimetry system. The electronic part of this system was also built upon PC interface standard. The information on the radioactivity level is displayed digitally and graphically on the PC monitor. Data can be saved on the PC's hard disk.

- Redesign and rearrangement of the control panels and the control console in the control room. Due to using modern components and equipment, the size and number of control panels were significantly reduced: 4 out of 7 panels were removed but all the control and monitoring functions of the old system were kept unchanged.

As a consequence, the new control system contains two separate PC systems for information acquisition and processing, data storage and display, as well as for sending alarm signals in order to control automatically secondary devices such as electric pumps and valves.

2.1 PC-based level measurement system

In general, the storage tank's liquid level has to be monitored. In total, there are more than 20 measuring channels for the storage tanks in the station. The front-end electronic blocks of each channel consist of three parts. The first one is the sensor unit based on either a float or capacitance method. The second part consists of voltage buffer or converter and some amplifier stages in order to supply a voltage value in relation with the liquid level of

the storage tank to the PC interface card. The third part is a control driver and motor for moving a potentiometer whenever the liquid level changes. The front-end electronic blocks are installed on the outside of the storage tank, at a distance of about 100 m from the control room, where the PC system with add-on interface cards is located. The block diagram of the 8-channel add-on interface card is shown in Fig. 2. There are a total of 3 such interface cards used in the designed system. The level measurement system is used for monitoring, measuring and displaying information from 24 storage tanks, as well as for sending control commands to output devices. There are different units in each card. In the address decoder unit, a switching method with a digital comparator on IC 74LS688 is used that permits easy change using address range. The switching 8-channel 8-bit ADC type ADC0809 has enough accuracy for this purpose. The 24-bit digital I/O port on IC 8255 and other buffers are used for controlling the status of the interface and sending alarm signals on lower and upper levels.

Application software of the system permits the operators to display both in graphical and digital modes. The monitor of the PC is divided into various windows. The main window in the upper area is for displaying 24 liquid level measurement channels both alphanumerically

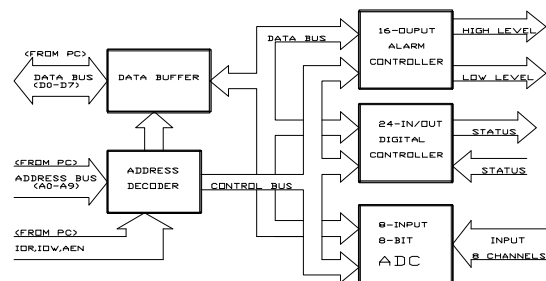


Fig. 2. Block diagram of the interface card for level measurement system

and using vertical bar-graphs with separate columns. The upper and lower level alarm set of each channel are also indicated on the window. The alarm set values can be defined by the operator from his PC keyboard when needed. When any level measurement value exceeds the preset value, a visual alarm indication appears on the corresponding column and at the same time a control signal is sent to output devices for switching on or off an electric pump and/or a valve. The remaining windows in the lower area of the PC monitor are used to display pH and conductivity measurement values of the liquid waste before and after treatment, flow rates of filters, etc. alphanumerically and using horizontal bar-graphs.

2.2 PC-based dosimetry system

The multi-channel dosimetry system [2] for area monitoring at the liquid waste treatment station is based on a set of individual measuring probes. The system is used for detection and measurement of ambient gamma radiation as well as for processing, displaying and storing information on radioactivity level at 8 different positions in the station where technological equipment is installed. The hardware of the system consists essentially of three parts: probes, central unit and alarm devices. As sensing elements, 8 GM gamma counters with shaping circuits are used. The electronic blocks of the central unit including a counter/timer board using programmable timer/counter type I8253 were built upon 8-bit add-on standard interface cards to PC through extension slots of the PC. An intermediate relay board to control the alarm devices is located in the same PC crate in order to access the power supplies. The system has the following functions:

- Continuously measuring radioactive level at 8 points
- Displaying count rate/dose rate in digital and graphic form on the PC monitor
- Giving light and sound warning signals whenever the radioactive level exceeds the setting values
- Recording information on count rate/dose rate into PC hard disk.

In the counter/timer board of the central unit, three IC I8253 are used to set up to 9 counting channels and one IC I8253 is used as a programmable timer. Each counting channel has maximum capacity of 2^{16} . 8 channels are simultaneously counting from the "Start command" from the computer and stopped counting by the timer interruption. In our case, a quartz generator 1 MHz is used, therefore the interval range of the timer from $2^0 - 2^{32} \mu\text{s}$ can be set from the PC keyboard. The counter/timer board is connected to the computer via add-on interface cards using either an interrupt function (IRQ3) or a flag setting (DB0 on the data bus of the PC).

Whenever the radioactive level at any monitoring point exceeds a set level, the control programme from the PC sends a signal to the intermediate relay board to warn by lamp and buzzer at the detector as well as in the control room.

Application software permits the system to display both in graphic and digital modes. For this purpose, the screen of the PC is divided into four windows where each one can

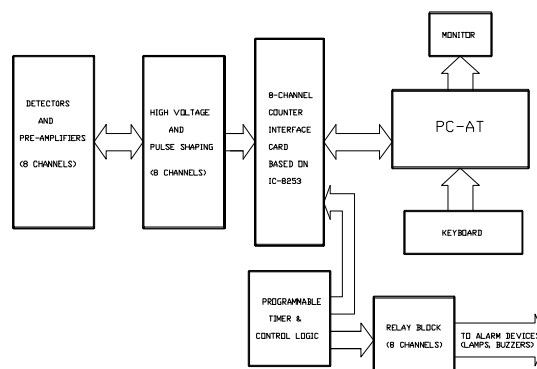


Fig. 3. Block diagram of the dosimetry system

display three channels but only one is visualized at each time. It means that, at any time, four channels are visualized, but the operator can see any other channel by pressing a pre-assigned function key. In each window, the vertical axis indicates the signal amplitude calibrated in counter/dose rate and the time information is indicated on the horizontal axis. As the trace displaying the current radiation value reaches the extreme right end of the window, the display is reset for a fresh record. In the case that the signal value of any of the radiological channels exceeds the preset level, a visual alarm indication appears on the corresponding window. The alarm can be reset by the operator but the visual indication remains as long as the alarm condition persists.

The smoothing technique used in the processing programme is of digital count rate type. It is a combination of the self-adapting and the floating mean techniques.

3 Conclusion

The renovation and modernization of the control system for the liquid waste treatment station were carried out by staff members of the NRI during the past two years. The new system was checked and put into operation in May 1997. Until now the system has been working with high reliability, is convenient for the users and is easy to repair and maintain.

In the past five years, a number of computer and microprocessor-based systems have been designed, developed and used at the NRI for the liquid waste treatment station control system, the reactor control and instrumentation system and other systems for physics experiments [3]. The main configuration of each system contains sensor elements; functional electronic modules, each having a specific application; central computer or microprocessor unit; and output devices. These autonomous systems are working on their separate hardware and software architectures. In the near future, they will be linked for system development, improvement and more efficient utilization in the framework of a local computer network system.

The use of personal computers as an operator aid has been found in NRI to be highly beneficial for operation and

maintenance related tasks and has a potential for application in many different areas.

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