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FOR POSITIONING GAMMA AND NEUTRON CALIBRATION SOURCES

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AN AUTOMATIC, PNEUMATIC SOURCE-CONTROL SYSTEM
FOR POSITIONING GAMMA AND NEUTRON CALIBRATION SOURCES*

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We developed a microcomputer-based source-control system to move gamma and neutron calibration sources into position for sample irradiation. In addition to monitoring interlocks and system status, the computer calculates for gamma sources the time required for a requested exposure at a specified distance. All system use data is stored, and monthly reports are generated.

Introduction

A pneumatic source-handling system, which moves one of four neutron sources or one of four gamma sources or one of each to an irradiation position, was installed in our calibration facility in 1969. Because the controller became unreliable, we replaced it with a microcomputer-based controller and added several features. The resulting system, based on the LSI-11 microcomputer, has the following features:

- A hardware-interlock string, which for safety reasons is not dependent on microcomputer operation.
- A control panel that includes an interlock string and other system status.
- A capability for calculating exposure time for a requested gamma dose at a given distance.
- A capability for accumulating use data and generating monthly reports.
- The ability to recover from a power failure without loss of time by using an internal clock.
- The capability to also control an x-ray generator.

System Description

General Features

Figure 1 shows the block diagram of the system. The LSI-11 has 4K of core memory and 8K of erasable programmable read-only memory (EPROM) to provide the necessary nonvolatility for power-fail recovery. The EPROM module used contains ultraviolet (UV) erasable EPROM and all the necessary logic for programming.¹ A modified absolute loader and temporarily attached paper tape reader are all that is necessary to transfer the software code to the EPROM module.

The time-of-day clock includes month, day, hour, minutes, and fractional minutes with resolution of 0.001 min. The module used was Digital Pathways model TCU-50Q. This is a quad-height board and the spare space was used to add the necessary logic to convert it to readout in fractional minutes instead of the standard seconds. We did this because the exposure values are mR/min. The clock also includes battery backup to prevent loss of time during a power failure.

The floppy disk provides nonvolatile storage of system use data from which monthly reports are generated. This data includes the date, user identification, source identification, and exposure time.

The interface to the pneumatic system includes switching control voltages, circuits to convert the

position-sensing contact closures to logic levels, and logic to prevent moving a source at unauthorized times. The control voltages select a specific source, switch an air valve to move the source from its storage cask to an irradiation point, and control another air valve to return the source. Position-sensing microswitches sense which source has been selected, if the pneumatic tube is properly connected to the storage cask, and if the shielded door to the irradiation cell is closed. There are interlock switches that must be closed in order to obtain the power used to move a source to the irradiation cell. These switches are 1) Run/Safe switches inside the irradiation cell, 2) the door-closed switch indicating the shielded door to the irradiation cell is closed, and 3) the Standby/Operate key switch on the operators panel. Also, there are air pressure switches that indicate there is sufficient pressure to move a source throughout the system.

The remaining type of sensing switches are the source-position switches. There is an optical switch that senses the source at the irradiation position and there are Geiger tubes in each storage cask that operate switches to sense when each source is in storage.

There are a maximum of eight sources--four neutron and four gamma sources. The system is divided so the neutron and gamma sources travel in different pneumatic lines to separate irradiation

FIG. 1. Block diagram of pneumatic source control system.

*Work performed under the auspices of the U.S. Department of Energy, contract No. W-7405-Eng-48.

points located nearby in a low-scatter room. This allows simultaneous irradiation of a material by both a neutron and gamma source. There is also an x-ray generator, located in a separate irradiation cell, which may be timed by the system.

Operation

An operator is first required to log on the system. Figure 2 shows an operator at the system controls. Users fall into one of two categories, public and controlled users. The public may print the current date and time, calculate the exposure time for a requested exposure given a distance from a specified gamma source, and check the pressure integrity of the pneumatic system as each of the eight sources are selected. Also, the public may, with possession of the required keys, fire sources to the irradiation cell or operate the x-ray generator. In addition to all of the above, the controlled user may 1) modify the controlled user list, 2) set the date and time, 3) generate monthly use reports, 4) update the sources activity data on the calibration date, 5) enter the calibration date offset to January 1 of the current year, and 6) zero the diskette.

Gamma Sources

Gamma sources may be fired for a specified exposure, a specified time, or a manually controlled period of time. In the timed mode, a neutron source may also be fired with a gamma source.

The operator first selects the source via the console terminal. In the automatic timing mode, the operator will specify exposure desired in mR, or specify the exposure time. In the manual timing mode, the operator controls the time the source is returned.

The machine then physically selects the source and checks, via position-sensing switches, if that source was indeed selected. The pneumatic tube is checked to see if it is properly connected to the source storage cask, and the source return air pressure is tested. Then the interlocks associated with the irradiation cell are tested. These include the Run/Safe switches inside the cell, the closed-door sensing switch, and the Standby/Operate switch. To activate this last switch requires the key that is used to open the door to the irradiation cell. If any of these conditions are not met, the operator is notified and the machine aborts any attempt to fire a source.

FIG. 2. The meters and front panel controls are easily accessible by the operator.

The interlocks associated with the irradiation cell must all be closed to provide the power that will be used to fire the source. If all the interlocks are closed, the computer enables the source fire logic, and the operator is then able to fire the source. When the source arrives in the irradiation cell, the machine prints the time the exposure will end. While the source is in the irradiation cell, all the interlocks are monitored and, if one is opened, the source is returned and the operator is notified which interlock was opened. There is a 'Return Source' button on the control panel that will return the source at any time.

When the source is returned, the data associated with that exposure is recorded on floppy diskette. This data includes the date, source number, user identification, and exposure period.

If a power failure occurs during a run, all data in volatile memory is stored in nonvolatile memory. When power is restored, the data is restored, and the program is continued. Since the clock with its battery backup does not lose the time-of-day, the source would be returned at the correct time. If the exposure period was to have ended during the period power was down, the source will be returned when power is restored and the actual exposure time recorded.

Neutron Sources

The operation of the neutron source is identical to the gamma sources except the capability to calculate the exposure time for a given exposure is not included because of the complexity of converting neutrons per second to mRem per minute with various moderators at the required accuracies.

X-Ray

There is an x-ray generator in a separate irradiation cell which may be controlled by the system for timed exposures. This irradiation cell contains interlocks similar to those previously discussed. When all the interlocks are closed, the operator starts the exposure by an 'X-ray Operate' key switch. The system terminates the exposure when the requested time expires. In addition, there is a 'Set-Up' mode, which requires another key, that by-passes all interlocks except the Run/Safe switch inside the cell.

Conclusion

The replacement of the control electronics of an existing pneumatic source-handling system has greatly improved both reliability and functional capability. The new system informs the user which interlock is open, calculates exposure times, and generates monthly reports.

The pneumatic system is a noisy environment for the ILSI-11 microcomputer, and some trouble was encountered with the system failing after installation. It seems that noise transients were generating false interrupts. The fix was to ground all unused interrupts, filter the interrupt lines that are used, install filters on the power input, and disable the interrupt when not in use.

References

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