A MICROCOMPUTER CONTROLLED THERMOLUMINESCENCE DOSIMETRY SYSTEM

Chris J. Huyskens, Pierre J.H. Kicken

Health Physics Division, Eindhoven University of Technology, Eindhoven, Netherlands

INTRODUCTION

Using a microcomputer, we have developed an automatic thermoluminescence dosimetry system for personal dosimetry and thermoluminescence detector (TLD) research. Process automation, statistical computation and dose calculation are provided by this microcomputer. Recording of measurement data, as well as dose record keeping for radiological workers is carried out with floppy disk. The microcomputer also provides a human/system interface by means of a video display and a printer.

The main features of this dosimetry system are its low costs, high degree of flexibility, high degree of automation and the feasibility for using in routine dosimetry as well as in TLD-research. The system is in use for personal dosimetry, environmental dosimetry and for TL-research work. Because of its modular set-up several components of the system are in use for other applications, too. The system seems suited for medium sized Health Physics groups.

FEATURES

Some of the benefits of a local personal dosimetry system by authorized health physicists are:

- the time interval between exposure and dose determination is short; in case of extreme radiation hazards this may be very important.
- the measurement data can be interpreted very well because of the knowledge about the working conditions and radiation qualities.
- if necessary the composition of the TLD-badge can be modified to fit in with the working conditions, by changing the filtertype and the TL-material.

The dosimetry system described here, is designed to function as a stand alone system. The automated TLD read-out and the complete data processing has been worked out locally. Other main features are:

- automatic dosimeter badge identification.
- reliability in read-out operation with built-in self-checking functions and error messages.
- possibility of simultaneous dose determination in mixed fields.
- the initiation of a number of read-out cycles is easy and personnel not familiar with computers is able to operate the system.
- switching from dosimetry to TLD-research takes little effort.

SYSTEM SET-UP

In 1978 we started developing our dosimetry system. To reduce the time for development, we used commercially available components. The modular set-up of the system is sketched in fig. 1. The thermo-

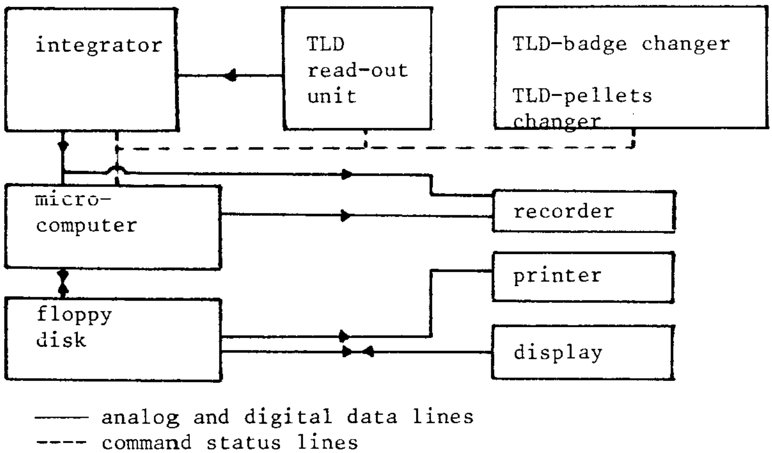

Fig. 1

luminescence analyzer consists of the Harshaw TL-reader (2000-A) and the integrating pico-amperemeter (2000-B). We have chosen a non-automatic analyzer because of the relative low system flexibility of the available semi-automatic systems. The read-out component has been completed with an external TLD sample changer. The TL-signal is detected by a photomultiplier tube and amplified and then integrated. These components are connected with the microcomputer which has full control over all the active and moving system parts. The differential as well as integrated TL-signal are connected with the A/D-convertor and a TTY-interface to the computer. The temperature window by which the current integrator is switched, is set manually or by means of two variable DC-levels, available on D/A-convertors in the computer. In all cases of active control a feedback signal is added to provide a so called self-control feature.
Nowadays the complete software is written in BASIC. Although programming in BASIC is not the most advanced way, in view of the large occupied memory space and the slow execution time, we used BASIC instead of an assembly language for the following reason. Learning in BASIC is really easy. Therefore not only program development time can be short, but afterwards non-specialized personnel is able to update parts of the program. As soon as the system fulfils our expectations some parts will be transferred into assembly to speed up the system. During execution the program is stored in RAM-memory and directly accessible to the operator for changing program lines or variables in case of function errors or control problems. The measurement and the calculated data are stored in the computer memory and are also stored immediately on a floppy diskette. If problems occur and the program has to be aborted there will be no loss of information.
For heating of the TLD a so called planchet heater is used. The sample heating can be controlled hardware by the Harshaw 2000-A after manual presetting or software by the microcomputer. Especially for TLD-research purposes this feature saves time, since it is possible to program more than one heating function for groups of TLDs in a batch (100 pellets). When glow curve characteristics are investigated the digitalized TL-

signal is connected to the computer I/O and interpreted directly by software and stored on floppy diskette for further data processing.
The microprocessor in the dual drive floppy disk provides its own intelligence and is used for storage and retrieval of software, experimental data as well as results in personal dosimetry. For communications actions a fast printer and a video display (CRT) are connected. The CRT also has direct access to the computer through the floppy disk.
The frame of the TLD sample changer consists of a modified sample changer of Nuclear Enterprises (type PSC 1) and a modified X-Y plotter. The plotter pen has been replaced by a vacuum needle, which can be moved in directions parallel and perpendicular to the X-Y plotter plateau. Putting it upside down, this component provides a transport of the single TLD-pellets. For personal dosimetry we use Studvic TLD-badges, containing four TLD-pellets per badge. The badge has identification numbers in decimal form as well as in punched binary form for automatic registration. The badges are piled up in the sample changer and transported mechanically one by one to the read-out component. In front of the heating planchet the badges are opened automatically. The pellets are transported from badge to planchet and vice versa with the vacuum needle. The moving parts are driven by steppermotors and a synchrone motor. The air pressure in the vacuum needle is controlled by air valves. By means of an air pressure sensitive relay the transport of the TLD-pellet is checked. For easy programming of the transport functions, the TLDs are for research purposes positioned in a batch on equidistant places (10 by 10 matrix).
It may be emphasized that during processing the TLD-pellets are not exposed to light and that the badge is not opened by the operator. At no time the pellets are touched by bare hands or tweezers.

SYSTEM PERFORMANCE AND APPLICATIONS

A main feature of the system set-up is its high degree of flexibility, owing to the modular way of hardware and software constructions. In future it is possible to change parts by more sophisticated components or add other functions. For example the nitrogen flow is at present only controlled, later on N_2-heating can be built in. After changing some parameters in the transport functions different types of research batches may be used. A β-source can be mounted for calibration purposes or measurement of irradiation damages in the TL-material in a continuous way.
As mentioned before, there may be defined a number of heating functions within one research batch read-out. To eliminate the time influence, the TLD-pick-up sequence can be don randomwise, calling a small subroutine.
In the research mode a standard initiation procedure consists of:
- inputting the read-out sequence by entering numbers or ranges of numbers corresponding with the positions on the matrix. TLDs may by read out more than once.
- inputting data to define groups of TLDs on which statistical calculations will be done. Groups may be nested in other groups. The maximal number of groups is 15. The statistical data output per group consists of the mean, the absolute and relative standard deviation, a group number identification and the number of TLDs on which the calculation has been worked out.
- inputting calibration data. The preselected research batces can have

different sensitivities for radiation. Giving some TLD-pellets well-known doses, it is possible to calculate the dose-TL-signal relation of that particular batch. The identification numbers of the TLDs and the calibration doses have to be entered.

After a complete batch read-out the function between the netto TL-signal and the absorbed dose is calculated by fitting a straight line with the method of least squares. The calculated coefficients are used to compute the absorbed doses of the TLDs on that particular batch. These parameters, the correlation coefficient, the standard deviation of the multiplication coefficient and the degrees of freedom are outputted to inform the operator about the data accuracy.
More sophisticated statistics such as variance-analysis methods are restricted by computer memory. However the data are stored on diskette and can be transmitted to other computer systems. The modular hardware construction is important in case of serious system errors. Within 15 minutes the non-automatic read-out component is disconnected from the other parts and can be used manually. Selecting components we took into account the possibility for multifunctional application. This reduced the specific system costs.

OTHER APPLICATIONS OF SYSTEM COMPONENTS

As argued before the specific system costs were restricted by the modular set-up. Other applications of main system components are:

- Record keeping of radioactive sources. A file system has been designed, containing all relevant data of radioactive sources, in use or used in the Eindhoven University of Technology. Some examples of stored data which are directly accessible to the operator are: nuclide names, irradiation qualities, availability, manager, location and physical forms.
- In gamma and neutron spectrometry the spectra measured by a 4000 channel analyzer can be stored and modified in the "intelligent" floppy disk to fit in with the I/O-specifications of a mainframe computer system (Burroughs B7700) for spectra unfoldings.
- The microcomputer is used for calculations and model simulations, at present for example in risk analyses in radiation protection.
- To support the clerical staff we developed a text editing system by using the microcomputer and its peripherals.

REFERENCE

Kicken, P.J.H., Huyskens, Chr.J. (1979): NVS-nieuws, 4, no. 3, pp. 3-8 (in Dutch)