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RECENT ADVANCES IN RADIATION MONITORING SYSTEMS FOR NUCLEAR POWER STATIONS

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1. INTRODUCTION

Present projections indicate that by 1990 a minimum of 600 nuclear power plants will be in operation in over 40 different countries. As a result, the health physics' profession is confronted with a massive responsibility to control the radiological consequences of these operations. Regulations have been adopted or are being considered by the various governments to guide the health physicist. It is apparent that the necessary radiological measurements will become increasingly complex, require improved sensitivity and accuracy, increase in frequency, and demand more attention from the health physics staff. There must be an expanded scope assigned to health physics instrumentation in order that available personnel will be able to cope with these new responsibilities. The discussion at this poster session will describe the integration of available instrumentation into a sophisticated system which will fulfill this new role in a cost-effective fashion.

2. HEALTH PHYSICS REQUIREMENTS

Based on the actual regulations and anticipating current attitudes of regulatory bodies in the United States, it is possible to summarize in general terms the health physics requirements to receive major emphasis over the next decade. Without a doubt one of these requirements will be the collection and documentation of data with more sensitive techniques and with improved error terms.

A second requirement will be the periodic determination of isotopic content of the various radioactive effluents, streams and processes which lead to personnel exposures. These data combined with the measurement of concentration, occupancy factors, internal retention patterns, significant environmental pathways and meteorological parameters will be necessary to provide estimates of dose. In the final analysis it will be these dosage calculations which control regulatory compliance rather than any of the individual elements in the equations.

All operations will be conducted in conformance with the philosophy of maintaining personal dosage history as-low-as-reasonably-achievable (ALARA). In the U.S. ALARA has been quantified in terms of its allowable environmental impact from light water reactors. However, there are many improvements to be realized in the application of ALARA to the occupational environment. A comprehensive basis for achieving ALARA will be a natural evolution from the evaluation of the data generated by fulfilling the two requirements above.

Obviously the health physicist must be given the tools in the form of authority, personnel and equipment to discharge his responsibilities. It should be evident that one of these essential tools will be the management and reporting of data in an intelligent manner readily assimulated into the decision-making process.

3. HEALTH PHYSICS INSTRUMENTATION REQUIREMENTS

Having established this background of operational and regulatory considerations impacting on the health physicist in a nuclear power plant, it is necessary that his supporting instrumentation be designed within the same parameters. The first recommendation is that a systems approach be adopted. Each source of data should be evaluated not as an isolated bit of information but rather in terms of its importance to overall operational significance. The author prefers to start with the concept of a Health Physics Operations Center controlling the flow and evaluation of data into and out of the Center. This concept is based on the utilization of microcomputer technology as the most cost-effective technique to meet reliably the health physics requirements of an expanding nuclear power economy.

Microcomputers or microprocessors are available in varying degrees of capacity and intelligence -- often classified from "dumb" to "smart"! Fortunately most radiation measurements already exist in the digital mode so as to be compatible with the data collection, manipulation and storage features of a microprocessor. Digital counting is inherently more sensitive and statistically accurate, both necessary ingredients in future systems. A data base may be maintained at the individual detector as well as transmitted conveniently to the Main Control Room and/or Health Physics Operations Center. High resolution gamma spectrometry and other laboratory analyses may be interconnected to provide for the routine updating of isotopic content from collected samples. At these information centers there will be a merging of peripheral data, e.g., meteorology, in order that higher level dosage calculations may be computed. The historical file of personnel dose can also be kept current and available for immediate recall.

Probably the most convenient form of data presentation will be on a CRT terminal, again with its own microprocessor intelligence. These presentations may be tabular, graphic or multi-color graphic. Historical information should be retained in a format identical to reporting requirements in order to facilitate report preparation essentially instantaneously and at the prescribed frequency. It is the conviction of instrument designers that system limitations are only the imagination of the health physicist and not in his demands on hardware/software.

Other features to be retained in system development are flexibility and expandability. Significantly, about 80% of the personnel radiation dose from the power reactor program is received during plant shutdown. This fact implies a physical redistribution of radiation monitors between operational and non-operational periods consistent with the shift of radiological problems within the areas of a reactor facility. It is feasible to incorporate these features into a microprocessor-based system without significant cost because of the capacity and distribution built-in to interconnecting cables.

As one envisions the advantages of a fully computer-based system it is only natural to apply these advantages to the evaluation of radiological conditions caused by a variety of emergency situations. At the present time it is questionable whether this application will be permitted under all conditions. The testing of microcomputers throughout the entire cycle of radiation, aging and seismic environments has not been completed in order to qualify the entire system during the post-LOCA. This is considered to be a temporary situation which will be corrected as time and effort are devoted to a solution. In the interim less sophisticated techniques, previously tested and qualified, are available for those few radiation monitoring channels critical to a LOCA response.

4. SYSTEM COSTS

There is a general rule for estimating purposes in the United States that installation costs of an analog radiation monitoring system equal the cost of the hardware. Most of this cost of installation is associated with the engineering, procurement, routing, isolation, interconnection and checkout of system cabling. Since it does represent a significant cost factor, reduction in cable requirements offers a fruitful area for cost savings. Digital, microprocessor-based systems are interconnected in a drop-loop, i.e., a single loop of cable from the Main Control Room to the monitoring stations and terminating at the most distant detector. This loop may be duplicated for redundancy and isolation. An analog system requires individual cabling between the Main Control Room and each monitoring station. Ideally, a drop-loop has the capacity for 192 channels but to preserve system flexibility and expandability perhaps only 50% are committed in a given design configuration. To add a monitoring station(s) or to re-configure existing stations it is only necessary to tie into the drop-loop, and not to re-wire between the station and the Main Control Room. Costs are reduced between 75% and 85% when compared with the cabling requirements of an analog system. However, the hardware/software costs of a microprocessor-based system exceed similar analog hardware costs so that total installed system cost savings amount to approximately 25% in favor of microprocessor-based systems.

Because data gathering, management and reporting are automatically processed, personnel devoted to these functions are either eliminated or assigned to other health physics' duties. Estimates vary as to the magnitude of this workload but it is on the order of a savings of two man-years per year per nuclear power plant.

It is more difficult to quantify the importance of the improved operator interface with the available data in an intelligent format. The ability to make a proper decision without undue delay is certainly enhanced. If this decision avoids a single shutdown unnecessarily or damage to expensive equipment, it will return system cost.

5. CONCLUSION

Faced with extraordinary growth in nuclear power, the health physicist is being confronted with expanded responsibilities to control these radiological consequences. It represents, however, an opportunity for the profession to discharge its responsibilities in a manner which will reflect favorably on the environmental and public acceptance of nuclear power. A Health Physics Operations Center, fed by the data generated from a microprocessor-based radiation monitoring system, is recommended as a vital contributor to this objective while realizing significant savings in costs and personnel.