
**5. Updated Tool for Nuclear Criticality Accident Emergency Response**, B. L. Broadhead, C. M. Hopper (ORNL)

**INTRODUCTION**

Some 20 yr ago a hand-held slide rule¹ was developed at the Oak Ridge Y-12 Plant to aid in the response to several pos-

![Uranium Metal Slide Rule](image)

**Fig. 1.** Slide rule for U(93.2) metal. (a) prompt dose as a function of distance and (b) fission product gamma dose rate as a function of elapsed time.
tulated nuclear criticality accidents. These assumed accidents involved highly enriched uranium in either a bare metal or a uranyl nitrate system. The slide rule consisted of a sliding scale based on the total fission yield and four corresponding dose indicators:

1. a prompt radiation dose relationship as a function of distance
2. a delayed fission product gamma dose rate relationship as a function of time and distance
3. the total dose relationship with time and distance
4. the 1-min integrated dose relationship with time and distance.

The original slide rule was generated assuming very simplistic numerical procedures such as the inverse-square relationship of dose with distance and the Way-Wigner relationship to express the time dependence of the dose. The simple prescriptions were tied to actual dose measurements from similar sys-

Fig. 2. Slide rule for U(5.0)O₂: (a) prompt dose as a function of distance and (b) fission product gamma dose rate as a function of elapsed time.
s comments to yield a meaningful, yet simple approach to emergency planning and response needs.

Extension of these simple procedures to other systems requires the availability of experimental data. A preferred approach was the determination of dose-versus-time and distance relationships using more advanced computational techniques for the original two systems as well as additional systems of interest. A previous study used advanced calculational techniques to obtain the dose variations with distance and time but again normalized the dose curves to measured results. This paper describes the development of an advanced procedure to update the dosimetric results will be updated with multidimensional effects for inclusion in the final slide rule package.


Proposed American National Standard on Nuclear Criticality Accident Emergency Planning and Response, ANSI/ANS-8.23, is being prepared to provide guidance on the important subject area indicated by its title. The accident at the Three Mile Island unit 2 (TMI-2) reactor provided many valuable lessons to be learned in the area of emergency preparedness. A workshop conducted by GPU Nuclear Corporation, the company operating TMI-2, identified a number of lessons, several of which provide insights for nuclear fuel facilities as described in this paper.

For better recognition of an emergency it is necessary to (a) have greater awareness and understanding by operators and management of the real possibility for an accident's occurrence and (b) teach plant staff to recognize what kinds of accidents can occur and how to diagnose and respond. Following the TMI-2 accident, these lessons became well ingrained for reactor personnel. However, in fuel facilities, additional attention may be needed to ensure that criticality accidents are viewed as a real possibility, especially in facilities handling fissile material with a relatively large minimum critical mass, e.g., low-enrichment uranium.

Another lesson is that under uncertain conditions, a conservative approach should be taken in declaring emergency events. While over conservatism (e.g., declaring an unwarranted general emergency) is not appropriate, recognizing "events of potential public interest" and involving regulatory and local authorities early and on an informal basis may be very appropriate.

From the standpoint of communications lessons, there is need to (a) record, analyze, trend, and communicate data in the appropriate form and for the intended audience and (b) maintain training and dialogue with state and local political, regulatory, and emergency response authorities and the local news media under normal and emergency conditions. In addition, the facility operator has the primary responsibility for providing information on plant status as well as the previous results given in Ref. 3 and are characterized by an inverse square portion followed by an air attenuation portion. The fission product gamma dose rate shapes shown in Figs. 1b and 2b are also similar with near-constant slope segments from 1 s to 1 min, 1 to 100 min, and 100 to 1000 min. This behavior is probably caused by the domination of various fission product isotopes during these respective decay periods. Although these results were generated with simple geometric models, the resulting plots are extremely useful for obtaining quick information regarding doses from a criticality accident. These simple geometric results will be updated with multidimensional effects for inclusion in the final slide rule package.