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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 rule[1] was developed at the Oak Ridge Y-12 Plant to aid in the response to several pos-

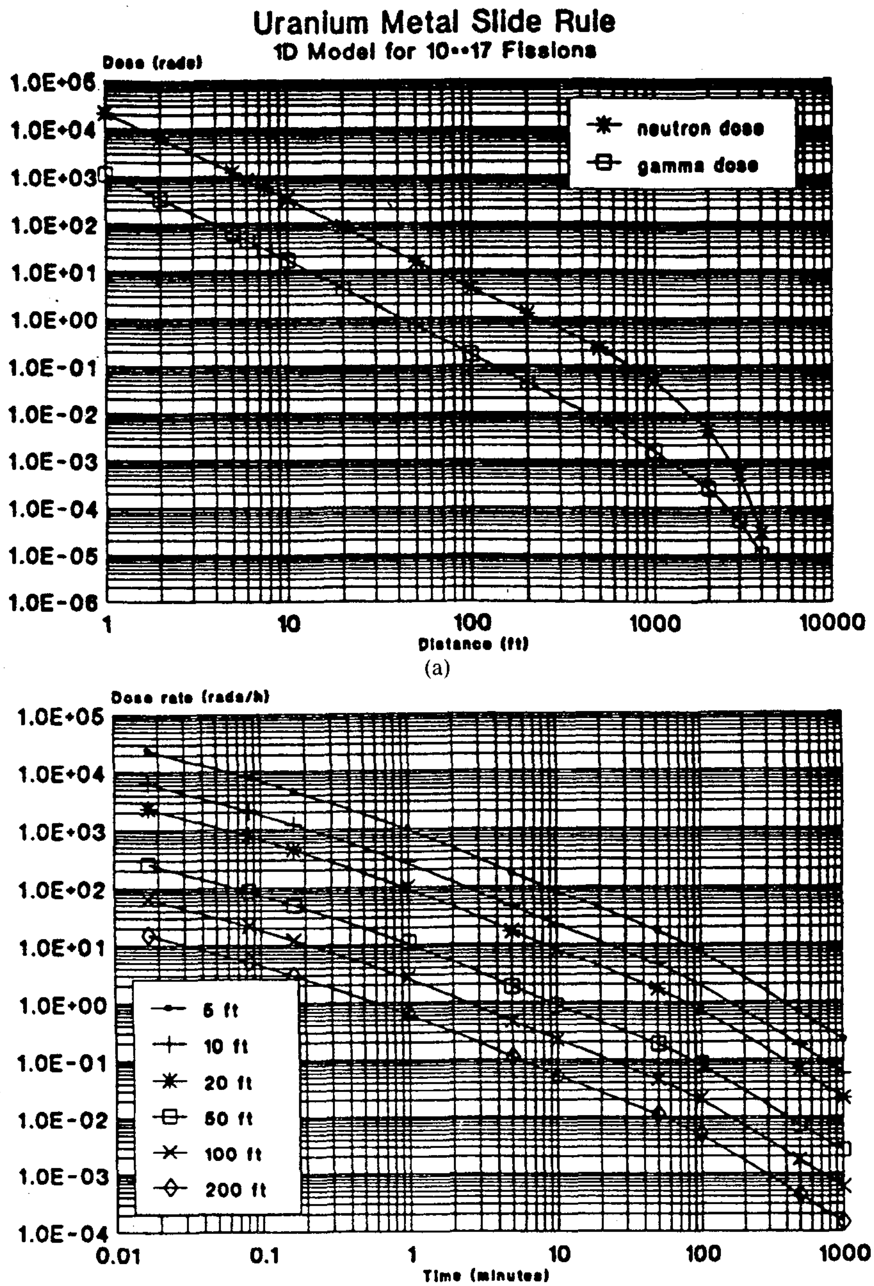

Fig. 1. Slide rule for U(93.2) metal: (a) prompt dose as a function of distance and (b) fission product gamma dose rate as a function of elapsed time.

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[2] relationship to express the time dependence of the dose. The simple prescriptions were tied to actual dose measurements from similar sys-

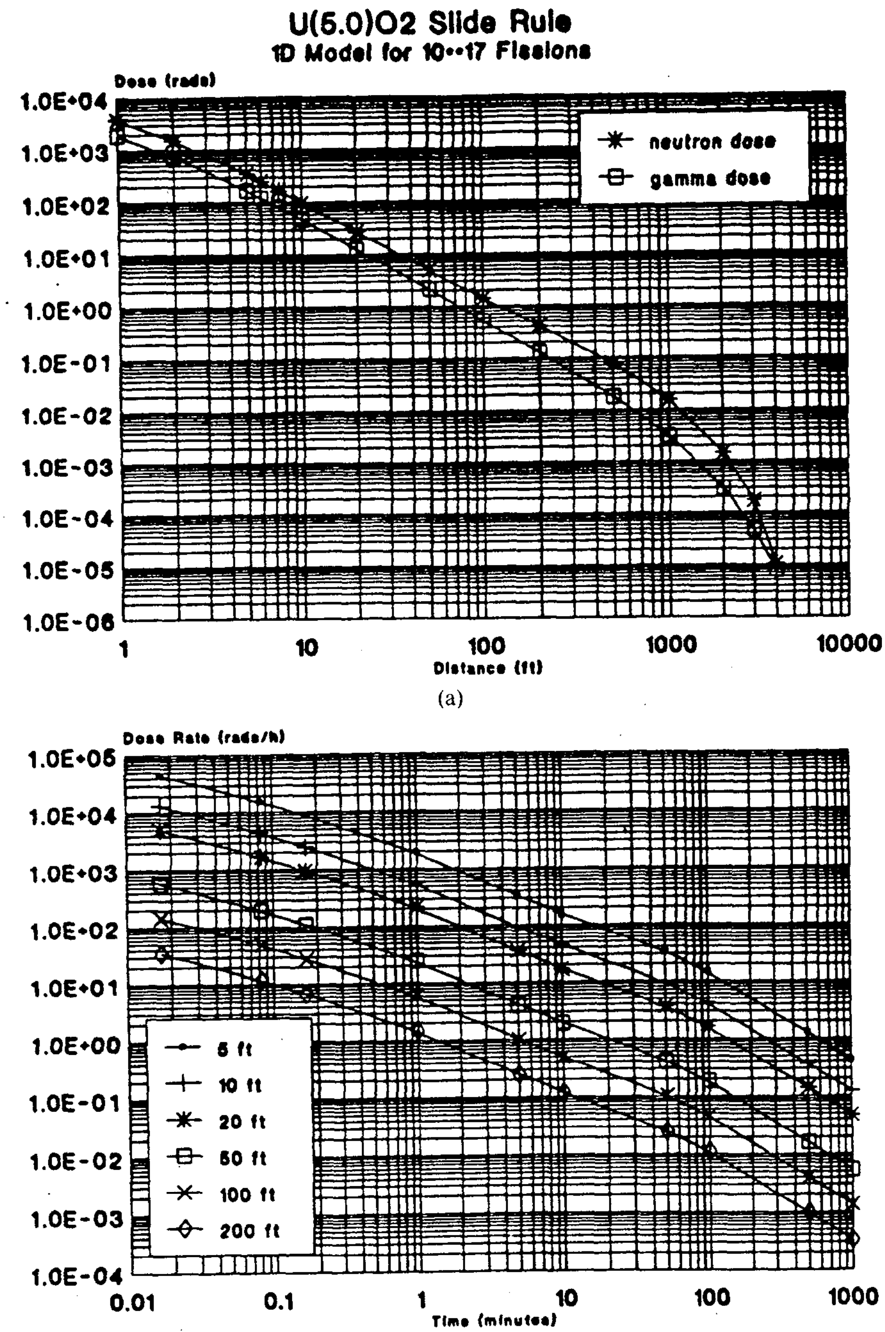

Fig. 2. Slide rule for U(5.0)O_2: (a) prompt dose as a function of distance and (b) fission product gamma dose rate as a function of elapsed time.

tems 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[3] 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 application of an advanced procedure to the updating of the original slide rule for five critical systems. These five systems include (a) an unreflected sphere of 93.2 wt% enriched uranium metal, (b) an unreflected sphere of 93.2 wt% enriched uranyl nitrate solution with a $H/^{235}U$ ratio of 500, (c) an unreflected sphere of damp 93.2 wt% enriched uranium oxide with a $H/^{235}U$ ratio of 10, (d) an unreflected sphere of 4.95 wt% enriched uranyl fluoride solution having a $H/^{235}U$ ratio of 410, and (e) an unreflected sphere of damp 5 wt% enriched uranium dioxide having a $H/^{235}U$ ratio of 200.

APPROACH

The first phase of this slide rule update procedure used one-dimensional (1-D) geometry models along with the SCALE system[4] methodology to develop the dose-versus-distance-and-time relationships. Later phases will investigate ground effects via several two-dimensional air/ground calculations. In addition, the attenuation characteristics of several common shielding materials will be estimated for inclusion along with multidimensional effects into a final updated slide rule package. This package will include development of a decision-tree procedure for quick fission yield estimation based on input information about postulated homogeneous solution system conditions. This information will be provided in a readily adaptable form for inclusion into the U.S. Nuclear Regulatory Commission's Response Technical Manual.

The procedures followed for this first phase follow closely those in Ref. 3, which included the determination of a critical system leakage with the XSDRNPM 1-D discrete ordinates transport code with subsequent 1-D shielding analysis and with XSDRNPM to determine the dose-versus-distance relationships. This entire calculational sequence is automated via the SAS1X control module in SCALE. The dose-rate-versus-time relationships were generated in a similar procedure that involved the use of the point depletion code ORIGEN-S for the time-dependent radioisotope inventories that were input into the SAS1 control module in SCALE to obtain the dose-rate-versus-distance relationships.

RESULTS

The U(93.2) metal slide rule is shown in Fig. 1, and the $U(5.0)O_2$ slide rule is shown in Fig. 2. The prompt neutron and gamma dose versus distance are given in part a, and the delayed fission product gamma dose rates versus distance and time are given in part b for both figures. Comparison of the prompt neutron and gamma dose in Figs. 1a and 2a shows the enhanced neutron leakage for the metal system and the enhanced gamma leakage for the damp UO_2 system. The overall shapes are very similar to each other 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.

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6. Emergency Planning Lessons Learned from TMI-2: Potential Applications for Fuel Facilities, *Ronald A. Knief (Ogden EES)*

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[1] provided many valuable lessons to be learned in the area of emergency preparedness. A workshop[2] 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 overconservatism (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 to all levels of government, the news media, and the general public. During the TMI-2 accident, lack of effective communication led to perceptions of an accident far more serious than it really was (leading, for example, to evacuation two days *after* the accident essentially was over). For nuclear criticality safety, preplanning can ensure common terminology (e.g., *accident* versus *loss of a control*) and more appropriate expected responses among all involved.

Several lessons related to response readiness included the need to (a) develop a keener appreciation by corporate and unit personnel of the purpose and need for emergency planning and