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TITLE: *American National Standard ANSI/ANS-8.6, Safety in Conducting Subcritical Neutron - Multiplication Measurements In Situ*

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SUMMARY

ANS TRANSACTIONS

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TITLE: **American National Standard ANSI/ANS-8.6, Safety in Conducting Subcritical Neutron - Multiplication Measurements In Situ**

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INTRODUCTION:

Safe and economical operations with fissile materials require knowledge of the subcriticality of configurations that arise in material processing, storage, and transportation. Data from critical experiments have been a principal source of information with which to establish safety margins. However, the lesser cost and the expediency of performing confirmatory, subcritical measurements on the process floor or in the storage vault resulted in much of the early criticality safety guidance being based on subcritical, in situ experiments.[1,2]

In the middle 1960's the in situ standard, ANS-8.6, was developed. While reported applications of this potentially valuable standard are scarce, a few examples from the past 10 years will be presented. This scarcity is probably driven by the difficulty in providing well characterized conditions (suitable for validations) in the process areas as well as a hesitancy among regulatory personnel to permit "approach to critical" experiments at work sites even though there is no intention of going beyond accepted "hands on" practices at critical experiments facilities.

Although the early subcritical measurements provided valuable data, to take advantage of refinements in safety margins which may be afforded by the application of current computer codes it will be necessary to have more accurate measurements of the sub-critical state than often exist today. The criticality specialist is basing safety margins for far subcritical operations on validations made against data gathered at the critical point.

In situ measurements, in addition to possibly providing more expeditious and less costly information about safety margins than may be available from experiments at critical, may also be applied to the task of providing identification information. Finally, with the increasing interest in site restoration and the possible desire to exhume material which may have been buried for decades, in situ techniques may offer the only practical means of characterizing a situation before it is disturbed.

EARLY APPLICATIONS

Extensive critical measurements were performed at the several critical experiments facilities which existed from the 1940's into the 1960's. The majority of these experiments were with single units due partly to the cost, time, and complexity of large array measurements. However, guidance for storage of weapons and weapons components and early reactor fuel storage configurations was based largely on subcritical measurements. The major reason being that it was not always practical to perform critical experiments since necessary facilities did not always exist where the bulk of the material of interest was stored.

Subcritical, in situ measurements in the 1945-1955 years on weapons and weapons components at Rocky Flats and at weapons assembly and storage sites provided criticality safety guidance which is still valuable today! C. L. Schuske of Rocky Flats and H. C. Paxton of Los Alamos were instrumental in the instigation of these measurements, an example of which is illustrated in Figure 1. The safety guidance from most of these early subcritical experiments was derived from inverse multiplication plots with the limit for safe storage chosen as, for example, a cross-multiplication of two.

Exemplifying the efficiency and timeliness of in situ measurements for unique applications is the proof test conducted on a compact, poisoned fuel storage rack for the PM-2A reactor.[3] This Portable Medium Power Reactor was located at Camp Century, Greenland and the multiplication measurements were conducted on site.

ANSI/ANS-8.6

The standard development effort leading to ANS-8.6 was largely due to the efforts of Lee Schuske of Rocky Flats. He was associated with many beneficial in situ measurements on process vessels and storage configurations within the facility as well as participated in or instigated many others at sites within the AEC and the military.

While this standard should facilitate the application of measurements which can better define safety margins and hence enhance safety and economy of operations, few reported in situ measurements are noted since the 1960's. Perhaps the difficulty and expense of critical experiments as well as developments in subcritical measurement techniques will reverse this trend. On the other hand, as stated in section 4.1 of the Standard, "Primary responsibility for safety shall be assigned to one individual experienced in the performance of subcritical or critical experiments." Such personnel are becoming as scarce as critical facilities.

The correct interpretation of data gathered with well understood techniques is clearly dependent on knowledgeable, experienced personnel. Indeed, the incorrect interpretation of data was a factor in the confusion and misunderstanding associated with reactivity measurements of the Z-9 Crib at Hanford.[4] These in situ, pulsed neutron experiments were performed to provide confidence in the expected high degree of subcriticality of the plutonium bearing liquid waste disposal site. Interpretations of initial data however, did not confirm the expected result and indicated a system possibly near critical. Analyses of subsequent data led to the conclusion that indeed the system was highly subcritical and there were no criticality safety concerns. Perhaps noise analysis techniques currently being refined might have enabled a more accurate estimation of how far subcritical the Z-9 Crib really was.

RECENT AND FUTURE APPLICATIONS

Two applications of in situ measurements and the ANS-8.6 standard at Los Alamos in the past decade come to mind. The first is a one of a kind operation calculated to be subcritical by about ten percent when fully assembled, which included thick reflection. Appropriate counting equipment and knowledgeable personnel from the critical experiments facility were brought into the plutonium facility to monitor the assembly operation. The inverse multiplication data coupled with calculational results provided confidence during the assembly process that the unit was subcritical by about the degree predicted and the final multiplication factor was also nearly as expected.

The second application involves inverse multiplication measurements on BWR and PWR assemblies with loadings and enrichments typical of commercial reactors. These assemblies are used by the Safeguards Assay Group at Los Alamos for instrumentation development purposes. Following the administrative and operational practices stated in the Standard provides confidence that no surprises will be encountered even though it is known that individual assemblies in water cannot be made critical for expected loadings and enrichments.

As environmental restoration activities DOE-wide escalate, there will undoubtedly arise situations where the degree of subcriticality of buried material will be desired knowledge prior to its disturbance. The advancement of technologies to handle such situations is certainly a necessary item, but also adherence to the in situ Standard and other professional practices will provide the necessary confidence that margins of subcriticality are maintained acceptably large.

SUMMARY

There are many examples of expeditious and cost effective in situ measurements dating from the 1940's and 50's. These subcritical experiment, upon which the safety of operations were based, were paralleled by numerous critical experiments which provide most of the bases for computer code validations presently. As the capability to expeditiously and cost effectively perform critical experiments withers, in situ subcritical measurements may provide the information necessary to further reduce uncertainties and biases in safety margins and thus incorporate more safety and efficiency into process operations. Finally, certain site restoration activities may demand knowledge of the subcritical state before disturbing the buried material. In situ neutron multiplication measurements may offer the only practical means to this knowledge.

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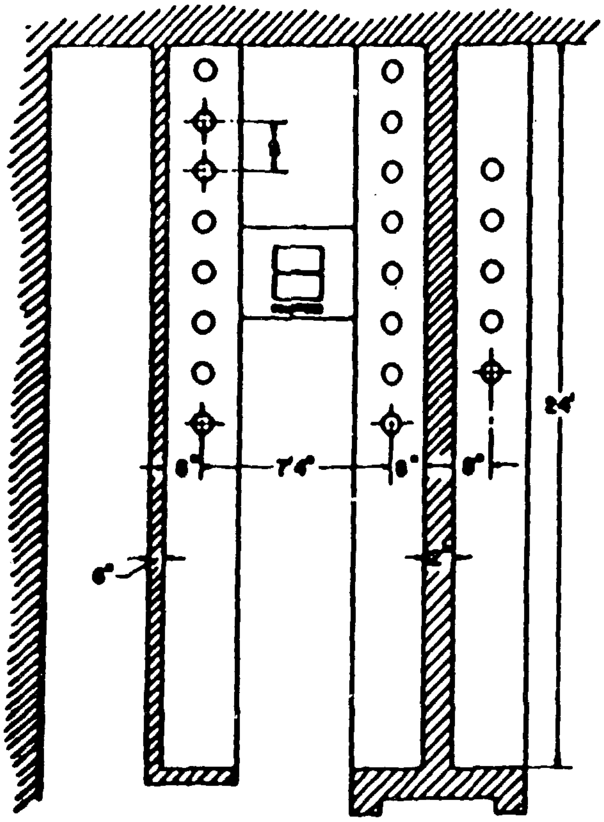

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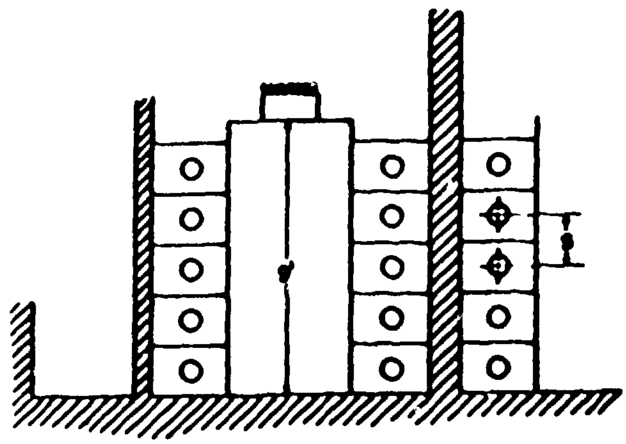

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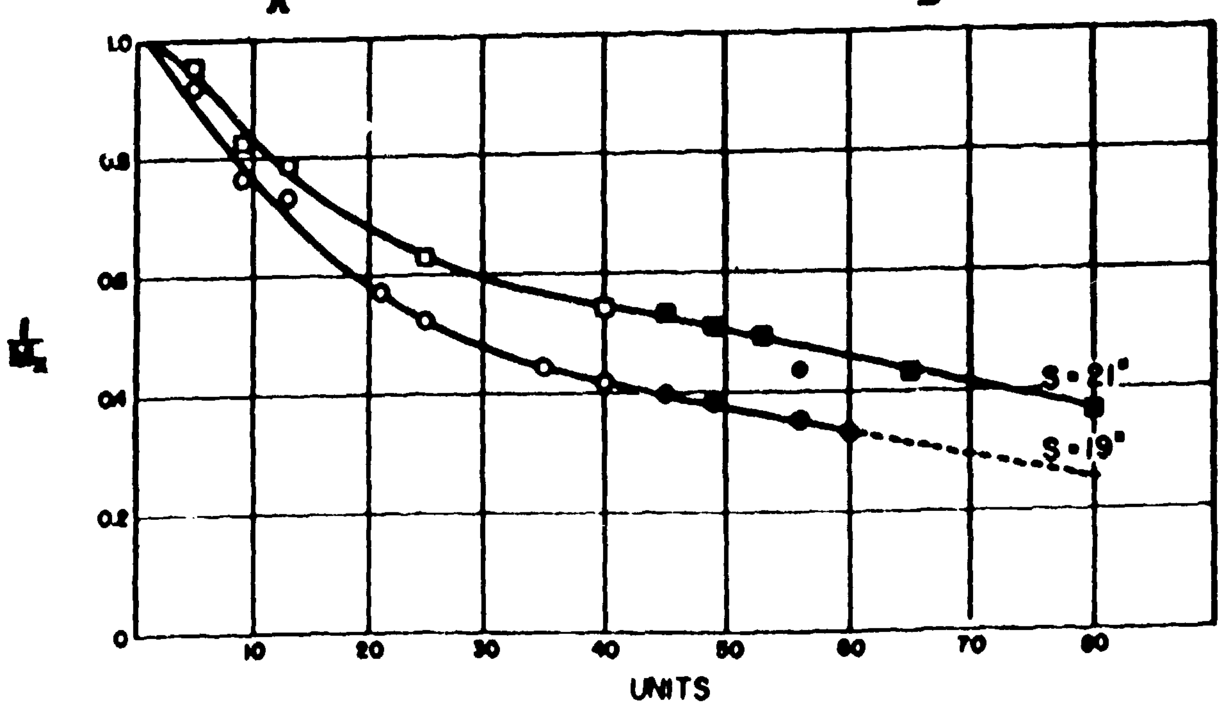

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