Is an ANS-8.3 Compliant CAAS Justifiable: Time to Acknowledge Reality?

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INTRODUCTION

Since the first version of ANS-8.3 was published in 1969 the goal has always been to alert personnel of a possible criticality accident such that they might take immediate protective action and thereby possibly avoid an injurious or lethal radiation exposure. It has also always been recognized that the dose to nearby personnel associated with the first spike from a prompt or near-prompt critical, unshielded excursion could not be prevented by a CAAS. On the other end of the kinetics spectrum, it was also recognized that a facility might not be able to economically detect a near-delayed critical excursion that might fission at a very low level for an extended period and, over several hours, possibly result in a lethal exposure. A CAAS is not required per ANS-8.3, regardless of likelihood, if personnel are not at risk of injurious or lethal radiation exposure.

The goal has always been to detect the large majority of potential accidental excursions. It was recognized that this required a balance between the cost and the benefit of: 1) a more costly CAAS that had more detectors throughout a facility and could thus detect smaller excursions, but also be possibly more prone to false alarms and 2) a simpler, less-costly, and possibly less prone to false alarms, CAAS that had fewer detectors but might not be able to detect very small, sub-prompt-critical excursions.

For nearly 50 years now, the standard has had guidance that was thought capable of detecting excursions down to a few cents above delayed critical, the so-called Minimum Accident of Concern (MAC). This size excursion was thought to be consistent with an unshielded dose rate of 20 rad/minute at 2 meters from the fission source, i.e., the current MAC. Recent analyses indicate that this dose rate may in fact correspond to excursions about 50 to 70 cents above delayed critical (Ref 1,2). If accurate, this would mean that to be in compliance with the standard, namely to detect excursions of only a few cents above delayed critical, might require that many additional detectors be installed, likely at great cost.

It is proposed that the MAC be revisited and that perhaps it is no longer cost/risk-effective to detect such smaller, slower excursions. Arguments defining and supporting such a new MAC are presented in this paper. Additional arguments are also presented on the need for an ANS-8.3-compliant CAAS regardless of the kinetics of the excursion. Discussions on these topics have been ongoing at ANS-8.3 Working Group (WG) meetings and among concerned professionals.

DISCUSSION

Long before the development of the first version of ANS-8.3, which began in 1966, it was recognized that a CAAS would possibly prevent injurious or lethal radiation exposures. In fact, installed CAAS's had already likely saved lives associated with two of the four unshielded accidents in the US. These four all occurred before 1965. The codification of this awareness in the form of administrative and technical guidance for a CAAS was completed in 1969 with the first issuance of ANS-8.3. Criticality accident information shared by Russian colleagues has confirmed that CAAS's developed and installed in the early 1960's in their facilities also saved lives (Ref 3).

The MAC defined in ANS-8.3 has been redefined slightly over the last 50 years, but always with the expectation that it was consistent with the detection of an excursion of a few cents above delayed critical. Members of the current ANS-8.3 WG have, over the last several years, performed calculations that indicate that the current MAC might only detect excursions consistent with reactivity insertions about 50-70 cents above delayed critical.

If this is indeed the case, then facilities in the US and possibly worldwide may be faced with very costly CAAS retrofits or replacements in order to comply with the Standard. It is suggested that this may be unnecessary if one considers the likelihood of a few-cent excursion in light of criticality safety practices that were initiated in the late 50's and early 60's and largely implemented throughout the major fissile material processing countries before the end of that decade.

Prior to the late 1950's, fissile material processing practices in both countries (and probably others) were judged to provide adequate personnel safety with (largely administrative) controls on fissile mass or concentration, while working with unfavorable geometry vessels. However, by the early1960's it became apparent in both the US and Russia (then the USSR) that the control of fissile mass or concentration in unfavorable geometry vessels for rich solution processing was not as low a risk as had been thought. Nearly one criticality accident per year in both countries from the late 1950's through the mid-1960's led to the replacement of unfavorable geometry vessels (for rich solution processing) with favorable geometry options such that mass/concentration control was no longer relied upon. This was done at considerable expense, but deemed appropriate for the perceived risk and benefit.

The reported criticality accident frequency dropped dramatically with this unfavorable-to-favorable process vessel changeover, from approximately one per year to much less than one per 10 years for unshielded solution operations worldwide. In the US the drop in accident frequency for unshielded accidents has been even more dramatic – there have been **NONE** since 1964. Given this accident-free track record and the known cause and preventive actions taken, it is suggested that not only the few-cent above delayed critical accident, but all criticality accidents with rich solution operations (in favorable geometry vessels) have been "essentially" eliminated.

One can envision criticality accident scenarios that have not been experienced, but it would seem that they are few, very unlikely, and, in addition, unlikely to expose personnel to significant radiation doses. Ones that come to mind are: 1) large liquid waste handling operations and 2) criticality accidents resulting from severe disruptive events such as large fires, floods and earthquakes. In these scenarios it seems self-evident that operations personnel will not likely be close to the fission source were the critical state to be reached. Either distance or shielding or both would seem to be highly likely to be present, although not precisely knowable.

A vigorous debate can and should be had on the topic of the cost-effectiveness of an ANS-8.3-compliant CAAS in any facility that rigorously restricts unfavorable geometry vessels in areas with large-scale, rich solution processing, as is apparent throughout the US today. This debate should take place regardless of the kinetics of the postulated excursion. Other options, more cost-effective, and safer if false alarms are reduced, can surely be implemented. In the near term, it is argued that very slow ("few cent") transients that might occur, be undetected and result in significant radiation exposures are, based on criticality accident experience, current operational practices and the known likelihoods of severe disruptive events, extremely unlikely and arguably much less likely than common perceptions of a "credible" threshold. When these occurrence likelihoods are coupled with the likelihoods of significant radiation exposures when shielding or distance is present, then the risk to operating personnel is judged to be much less than the intended ANS-8.3 risk/cost threshold for a CAAS.

A criticality accident of a few tens of cents, or more, above delayed critical will result in at least a modest first spike fission yield and be readily detected by a CAAS that is capable of responding to the current MAC. If it is judged that a lesser transient is incredible, but that a modest (or larger) first-spike transient with personnel at risk of significant radiation exposure is credible, then an ANS-8.3-compliant CAAS may be justifiable. It is emphasized that the MAC in ANS-8.3 is a "permitted" value. Process-specific accidents with their particular likelihoods and power histories are always preferred.

Thus, a new MAC, based on fission rate, is proposed. Criticality accident simulation experiments for reactivity insertions approaching prompt critical and beyond are known to produce about 1.0+15 fissions/liter in the first spike. Since this is a spike of about one second or less duration, it would appear that a MAC corresponding to a peak fission rate of 1.0+14 fissions/second/liter would be reasonably conservative for fast transients and at the same time provide for a somewhat larger radius of coverage (less costly system) than the current MAC.

CONCLUSIONS

The current MAC has not been significantly changed since the first issuance of ANS-8.3 in 1969. Accident experience and accident simulation experiment results and knowledge has grown significantly and fissile material operating practices with rich solutions have changed dramatically since then. This enhanced knowledge and these changed operating practices are judged to no longer support the credibility of a slow transient, i.e., one that does not exhibit a pronounced first spike, with personnel at risk of injurious radiation exposures. A new, fission rate based MAC of 1.0+14 fissions/second/liter is suggested as a practical, yet still conservative, value.

Further, a vigorous debate should be conducted within both ANS-8 and the larger technical community as to the credibility of any criticality accident with injurious radiation exposure consequences, given today's accident knowledge and experience and operating practices. This will shed important light on the cost/benefit of today's CAAS systems. Can they be justified?

REFERENCES

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