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Criticality safety

<p>
From: thomas P. McLaughliin <i>tpm@lanl.gov</i>
Date: 2/2/99 8:29:32
Thread ID: 5.1
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Since I consider this proposed Rule and SRP important to not only the NRC community, but also the DOE, DoD, and the worldwide community,

I submitted comments thereon which were read at the 12/3/98 NRC open meeting by George Bidinger and are posted on this website. Having now

read the more recent postings, this message is a short update of how I

see the developments in this arena. First let me compliment the NRC for this website as I could never have devoted the time to attend all the public meetings but I can read about them and submit comments on them efficiently in this manner. My comments will be provided in two categories, General and Specific.

GENERAL

The discussions during the 12/3,4 and 1/13,14 public meetings were refreshingly open and showed a high degree of agreement between the parties represented. I’m optimistic that the NEI’s proposed revisions

will be adopted essentially as is by the NRC. I would also hope that the discussions that are now documented in the transcripts of these public meetings could be retained as evidence of the understanding and

interpretation of the intent and flavor that the NRC intends for the words in the Rule and SRP.

SPECIFIC

There are still a few areas of disagreement and misunderstanding, but they seem to be largely with the understanding of the ANS-8 standards or the energetics of criticality accidents. Let me comment on the two

which seem most important and then conclude with a grammatical point o
n
the use of the word "criticality."

Double Contingency Principle. This concept has been badly misunderstood and misapplied over the years and this seems to grow as the original authors who understood quite clearly what they meant are no longer active criticality practitioners. I addressed this briefly in my letter and I note that Calvin Hopper addressed this in his comments at the 1/13 public meeting. A careful reading of ANSI/ANS-8.
1
makes it clear that what is really important is maintaining subcriticality and that the DCP is simply an aid or guide to achieving

this ultimate goal. Section 4.1.2 of ANS-8.1 is the overriding SHALL statement while 4.2.2(DCP) is simply a SHOULD statement. It is essentially unanimous among the experienced practitioners nationwide that the NRC, and now the DOE, are misguided in their attempts to "better?" control criticality risks by making the DCP a SHALL statement. Effort which could be better spent on the floor understanding process upsets and their likelihoods is being diverted t
o
counting contingencies and documenting double contingency. Whenever I

hear people ask "What are your two contingencies?" I cringe because it

tells me there is a gross misunderstanding of (1) the relative importance of 4.1.2 vs 4.2.2 and (2) the intent of 4.2.2 itself.

NCS Limits(Section 5.4.5.2). I support completely the NEI revision to

the SRP for this Section. This discussion ties directly in to that above where the mandate to remain subcritical, as stated in ANS-8.1, Section 4.1.2, is seemingly deemphasized in the SRP in favor of the DCP. Perhaps the NRC is attempting to strengthen the assurance of subcriticality by defining Failure Limits and Safety limits, etc. Thi
s
approach will lead to much effort and paperwork only to the detriment of thorough reviews of process operations and a true understanding of the range of credible upset conditions The DOE has funded the International Criticality Safety Benchmark Evaluation Project for the last several years and it is bearing tremendous fruit. Relatedly, both

the DOE and the NRC are funding "Range of Applicability" research at ORNL.The former effort provides high quality benchmarks for the criticality engineer so that he can perform his task as intended, namely to work with line personnel to achieve safe, efficient

operations. The latter will permit yet further improvements in safety
and eficiency. Let me provide an example of where these additional
limit definitions could add significant paperwork and reduce
operational flexibility but not enhance real safety. Consider the
common university subcritical reactor made of normal uranium rods and
light water. It is understood that this system can not credibly be
made critical, thus there are no Failure limits, Safety Limits,
Subcritical Limits etc. The calculation of these various limits,
however, would limit such subcritical operations without benefit to th
e
maintenance of subcriticality. Thus it is the proper role of the
criticality engineer to assure himself that for those worst case, but
still credible, upset conditions that subcriticality is assured. The
margins of subcriticality may be specified in terms of fraction of a
critical dimension, fraction of a critical mass, fraction of a critica
l
spacing, or, as is commonly done, in terms of the calculated
multiplication factor. The exact value of the multiplication factor
which assures subcriticality for the stated upset conditions, but at
the same time maximizes process efficiency, will be different for each

operation based on the use of different ISCBEP benchmarks. It is
misguided and likely dangerous to attempt to specify either a single,
subcritical k-eff, such as 0.95, or a single delta k-eff such as 0.02,

that is intended to be applied to all situations

To address my second issue, namely accident magnitudes, frequencies,
and consequences, let me first repeat some words from Dennis Damon fro
m
the transcript of the 1/13 public meeting:

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MR. DAMON: My name is Dennis Damon, with the NRC.

We accepted the industry’s idea that criticality should not be called
out in a special sense as a high-consequence event, even though one
normally, in an unprotected case, can’t preclude that it would be, but

the idea was we realize that one of the major reasons for not
automatically categorizing an event -- criticality as a high
consequence is that there are facilities, not at these licensees, but

there are facilities -- shielded facilities exist where criticality
could happen behind engineered shielding, and therefore, no one would
get a dose exceeding any of those limits, and we recognize that that’s

possible.

We also recognize that the Commission has specifically issued a
strategic safety performance goal of not having inadvertent
criticalities.

Therefore, we recognize that the rule language as it was originally
structured had a regulatory gap, namely a shielded criticality that di
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not produce a dose exceeding any of the limits stated in the rule woul
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be simply not addressed at all by the rule, it would have been -- ther
e
would have been no requirement, and we realize that that was not what
the Commission intended.

The Commission intended that criticalities be prevented, perhaps not
with the same degree of stringency if they were behind shielding than
if they were not but that criticalities had to be addressed and covere
d
no matter where the dose came out in the rule.

So, that’s why this whole section is really in here, and I’m just
saying that so that, when we get wrapped up in this language, that’s
really the objective here, is simply to have a statement in here that
criticality should be addressed or prevented and rely on prevention,
not simply -- shielding alone is not enough.

If you were going to have a criticality every week behind that shield,

the Commission still would not like that, they would want you to
prevent -- if you want to have a criticality every week, go see NRR fo
r
a reactor license, because that’s what you’re building, you know.

MR. SHARKEY: You’re operating a reactor without a license.

MR. DAMON: Exactly. That’s really all this is in here for. It’s not
really to have all the verbiage. It’s simply to say, okay, even if a
criticality does not produce a dose, we still want you to prevent it
adequately.

As long as I’ve got the microphone, I’d like to make a couple other
remarks on two technical points, because they are things which -- we
have a mixed audience here, and some people might understand this and
others not.

There was a discussion by Calvin Hopper and George Bidinger about
frequency of occurrence of events and 10 to the minus 6 per year and
stuff like that.

You have to remember that the numbers that may have arisen in some
other context with respect to reactors are usually a number applied to

a single reactor. So, it’s the likelihood of something happening at th
e
reactor.

The numbers as they are stated and the terms "likely" and "unlikely" -
-
"highly unlikely" and "unlikely" in the rule are referring to
individual accidents, not to the whole plant, and it’s on a
per-accident basis, and as has been mentioned many times before, the
ISAs that are being submitted may have hundreds or thousands of these
potential accidents.

So, unless you take a plant-level numerical goal and divide it by thos
e
hundreds or thousands of accidents, that’s the number you have to get
to. That’s why the number would have to be a low number. It’s because
there’s hundreds and thousands of -- it’s applied at each individual
level and you have to do it that way.

Second point on the consequences of criticality -- some people here ar
e
not really criticality engineers, and the area of consequences of
criticalities is an area that I have worked in in the past.

I wouldn’t be considered the world’s foremost expert, but there is a
reason why -- there is a fundamental physical reason why it is that
almost any criticality would produce a dose sufficient to exceed 100
rem to someone standing close to it.

The physical reason is because in order to turn that criticality aroun
d
and shut it down, it has to be done by inherent feedback mechanisms.

In order to get most feedback mechanisms, you have to do something
macroscopic to that material. Normally what you have to do is to heat
it up or to radiolytically generate bubbles in it or something like
this.

You cannot turn a criticality around with trivial feedback effects. Yo
u
have to use substantial. And that’s why you always get a number like 1
0
to the 17th fissions in a criticality event. It’s because of having to

put enough energy into the system to get the negative feedback
sufficient to shut you down.

So, it is generally a true statement that it’s very difficult to get a

criticality to be small enough that it would not give you a 100-rem
dose if you’re standing right next to it.

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First, I do not have strong disagreement with Dennis’s words; I have a

large degree of agreement. However, let me continue this discussion
that I can only wish I were present to take part in - and let me
encourage anyone to add to this website discussion.

1) I agree with the Commission’s goal of no criticality accidents and
Dennis’s interpretation to mean less frequent than every 10 years. In

fact, if we look at the track record, the frequency does indeed seem t
o
be trending toward much less than once in 10 years; but the statistics

are too large at this time. For manned operations I would certainly
consider a frequency of once in several decades an "acceptably low
risk". As a safety professional one should be able to accept a much
higher frequency of occurrence for operations whereby personnel are
protected by shielding or distance. This may not be practical without

much greater public understanding and acceptance of the nuclear
business in general and radiation in specific.

2) I am also pleased that the NRC has decided that criticality
accidents are not unilaterally to be labeled as high consequence
events. Putting aside the political consequences, the accident track
record has indicated that most have occurred in manned facilities, but

without fatalities. In fact many would not have even resulted in 100
rem from the first spike were personnel in the immediate vicinity.
That is, many of the first spikes have been limited to only 1.0+15 to
1.0+16 fissions, due to the small reactivity insertion rates and small

reacting volumes. Thus I do differ with Dennis on this point. As we
can all agree, it is the specific energy(energy density) that will tur
n

a power spike over and not the total energy. Thus the reacting volume

plays a key role in the magnitude of the first spike. Taking this to the other extreme, in a very large volume, say a multithousand gallon waste tank, there might also be a very small dose to a nearby worker due to internal shielding, this in spite of perhaps a very large total

yield.

As a final specific issue that neither the NRC nor the NEI has picked up on, I must comment on the use of the word "criticality". As Hugh Paxton, one of the original authors of ANS-8.1 and for many years the technical editor of Nuclear Science and Engineering, states in his "Glossary of Nuclear Criticality Terms", report LA-11627-MS, the use o
f
this word in phrases such as "an inadvertent nuclear criticality" is incorrect. I suggest that before the final Rule or SRP is issued that

this grammatical point be understood and applied to the text of both documents.

Again, I thank the NRC for making this valuable forum available and I welcome others’ comments on my submission.

Tom McLaughlin, Group Leader, Nuclear Criticality Safety, Los Alamos

505-667-7626(T); 505-665-4970(F) tpm@lanl.gov(email)

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