David L. Hetrick, Ph. D.
8740 E. Dexter Dr.
Tucson, AZ 85715

July 14, 1999

Dr. Thomas McLaughlin
Criticality Safety Group
EHS-6, MS F-691
Los Alamos National Laboratory
Los Alamos, NM 87545

Dear Tom:

Thanks for the opportunity to re-examine the incident of January 25, 1961, at the Idaho Chemical Processing Plant. This excursion is of special interest because the uranium concentration was close to the concentrations (approx. 200 gm/liter) in the largest unreflected excursions seen in both the CRAC and KEWB experiments (2.25 and 7.0 MJ respectively).

The Idaho documents quote 40 liters of solution and a yield of 6.0×10^{17} fissions (16.9 MJ using SILENE's empirical conversion factor of 3.56×10^{16} fissions/MJ). I agree with Dave Smith that the initial criticality occurred in less than 40 liters, and I believe that it is incredible to have this much energy in a single pulse.

The cold leg of the evaporator is too small to hold 40 liters prior to the excursion. Moreover, 40 liters, even if available, would be subcritical as a cylinder 2 feet (60 cm) in diameter. According to Sung Lee's thesis, page 22, criticality in a 2-foot diameter cylinder at this concentration would require 47 liters (9.4 kg critical mass, 16 cm high). More likely, a slug of solution, say 20 liters as a one-foot diameter sphere or optimal cylinder, represented the initial criticality. If we look at CRAC-08 (20 liters), we find 8×10^{16} fissions (2.25 MJ). Additional yield would easily result from splashing and/or wave action following the first pulse.

Such a single-pulse yield appears in the summary paper by Olsen *et al* (Trans. Am. Nucl. Soc., vol. 19, p. 189, 1974). They state 6×10^{16} fissions for the "actual excursion initial burst", which fits the empirical model in their Fig. 1 at a volume of 40 liters. Unfortunately, such a simple empirical model is unable to account for the effects of delayed initiation. For example, their model at a volume of 20 liters predicts less than half of the actual yield in CRAC-08.

Examination of CRAC data with and without extraneous neutron sources suggests that the yield for CRAC-08 was augmented by a factor of three by delayed initiation. For a confidence limit of 98 percent, we calculated an augmentation factor of five. These factors are for ramp rates near one dollar per second, and they might be doubled or tripled for a ramp rate produced by a pulse of compressed air as described for the event under discussion. See the enclosed graph.

If you really want an extreme number, we could take CRAC-08, multiply the yield by 5/3 to push it to 98 percent confidence, and then multiply by three to allow for a higher ramp rate. The result is what I would call an incredible single pulse yield of 4×10^{17} fissions.

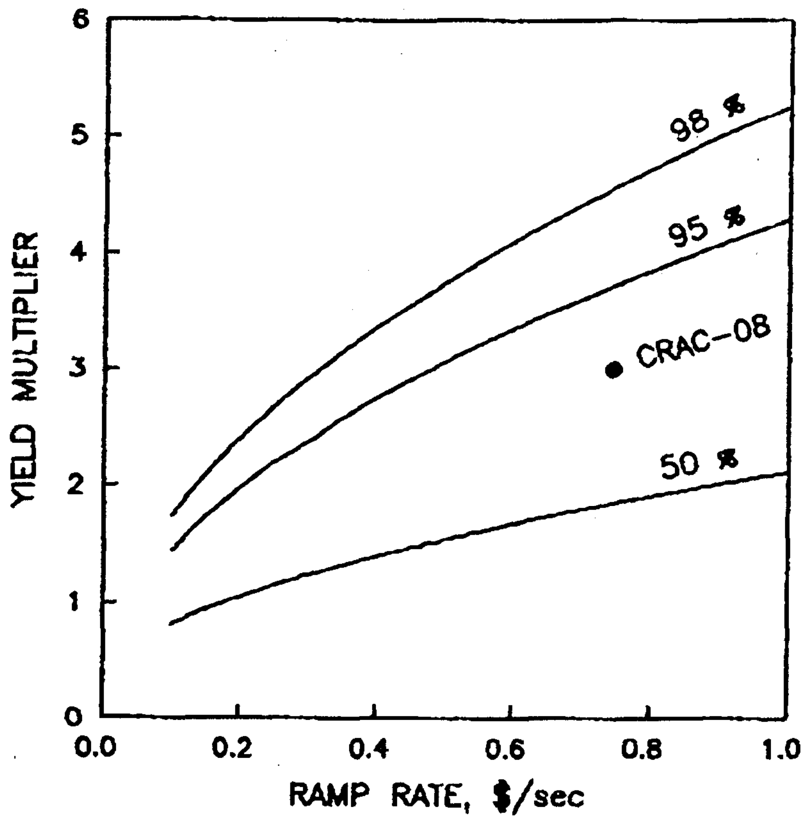
The KEWB excursion of 7 MJ (2.5×10^{17} fissions) is not directly relevant here. It was initiated by a very fast reactivity step of about 4.3 dollars, and had a stable period of 0.56 msec. The unreflected KEWB cylinder solution had a volume of 24 liters, and the model of Olsen *et al* would yield an underestimate by a factor of six. Such a large single pulse could not be produced by fluid motion alone without an incredibly delayed initiation.

Finally, I suggest that Olsen *et al* may have been incredibly lucky to pick 6×10^{16} fissions. In their Fig. 1, that is the yield for 20 liters at 95 percent confidence. Why not go with it?

Very best regards,

Dave

David L. Hetrick



YIELD MULTIPLIER
RAMP RATE, $/sec
98 %
95 %
CRAC-08
50 %
0
1
2
3
4
5
6
0.0
0.2
0.4
0.6
0.8
1.0

Original of Ref. ~~#~~

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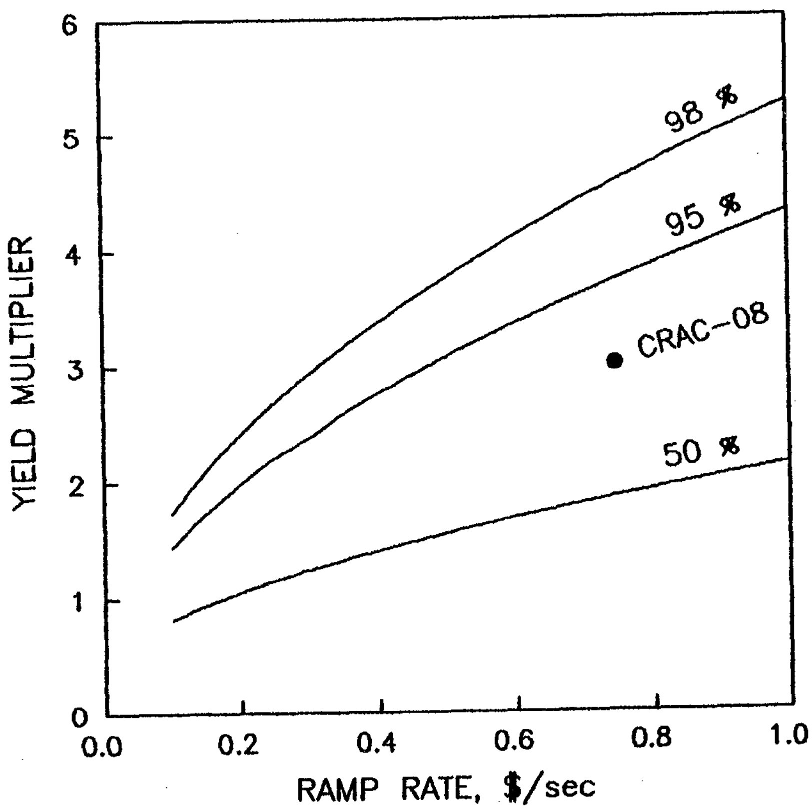

6
5
4
3
2
1
0
0.0
0.2
0.4
0.6
0.8
1.0
YIELD MULTIPLIER
RAMP RATE, $/sec
98 %
95 %
CRAC-08
50 %

To: Dave Hetrick
From: thomas mclaughlin <tpm@lanl.gov>
Subject: ICPP '61 Accident
Cc:
Bcc:
Attached:

Hi Dave,

Thanks for looking at this one. As you will read in the proposed revision to the text, I have removed the single spike scenario as the likely event and replaced it with words which suggest a spike which contains but a fraction of the total yield.

This is largely based on four issues.

1) The discussions in the accident investigation reports about how much liquid was involved and how it might have been injected into the disengagement head and thus the shape it might have had.

2) The specific energy releases of the CRAC experiments - realizing that there were different, but difficult to quantify, ramp rates and neutron backgrounds involved.

3) The radiation monitor strip chart recordings, which are admittedly not strong pieces of evidence.

4) The ANS Transactions article, although I could get no information from those authors I could track down.

Any insight you can provide will be appreciated. Please '"let the chips fall where they may"; we are interested in the best we can do technically.

Warm Regards,

Tom