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August 14, 1985

Prof. W. Kerr
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Dear Bill:

Enclosed are my corrected and revised comments for the August 1st Meeting. I am sorry I still do not have my comments done for the IDCOR presentation but I am a little overwhelmed here. We are moving from one house to another and everything is a mess. I will get these IDCOR comments to you as soon as possible.

Sincerely,

Mike

Mike Corradini
Associate Professor

MLC:rb

Enclosure

xc: D. Houston, ACRS Staff

Comments
on
NUREG-0956 Presentation
8-1-85

The stated purpose of NUREG-0956 is to explain the RES staff's source term methodology. This explanation had three specific purposes as stated in the report and as discussed at the May 2nd meeting:

(a) display the improvements in the source term methodology;

(b) show that it is superior to past work, e.g. WASH-1400;

(c) show that it can be used in regulatory environment.

The report does a credible job of the first two objectives. In Chapter 2 the history is discussed and in Chapter 3 the current Battelle code 'suite' is discussed. In Chapter 4 the current important accident sequences and assumed containment failure modes were reviewed as performed by the BCL 'suite' of codes in BMI-2104. Finally, in Chapter 5 the source term review process is discussed and Chapter 6 discusses an example of how one would construct a risk perspective using the results of BMI-2104 along with other information from the SARRP research. This chapter and the associated information in the Appendices (especially Appendix D) is probably the most illustrative and informative part of the report. Also the presentation by J. Mitchell was quite understandable. This part of the report indicates quite well the interconnection necessary for a risk perspective:

(a) accident sequence definition and probabilities (WASH-1400 as example)

(b) containment event tree probabilities (SARRP Surry results best estimate example)

(c) source term calculation using designated accident/containment failure sequences (BMI-2104 and source term bins)

(d) consequence calculation

(CRAC2 Surry specific meteorology example)

The last objective of the report is not so clearly discussed for a number of reasons. The RES staff makes an initial attempt at how it could be used in the regulatory context but I think their thoughts have not been formulated completely. One reason may be that they have only recently begun thinking in these terms of how the research is to be used. The ten items discussed by NRR (Aug. 2nd Mtg for example) seems to be a good initial attempt at this. However, a number of them could have been done without the new source term work. There could be a better illustration of this use of such a methodology by taking the Surry 'risk appraisal' that is summarized in Chapter 6 (detailed in App. D) and discuss how this risk appraisal could be used in some of the ten areas outlined by NRR for illustrative purposes. This would go one step further to illustrate possible uses for the methodology.

One problem I have with the report is that the methodology is sometimes mixed up with the current computer programs (identified as the Battelle 'suite') used in the methodology. The computer programs should not be the methodology. The two are quite distinct. The methodology should be something which can be used as a set of guidelines or procedures that assists one in the estimate of the source term. These guidelines may assist in doing hand-calculations or they may assist in the Battelle code 'suite'. But the two things are not synonymous. The methodology should consist of guidelines made up of assumptions, criteria, and constraints that one might follow regardless of the codes used. This is partially identified but does not come through clearly in the report.

Another point that is confusing in the report is the use of the words sensitivity and uncertainty. The 'uncertainty' estimtes mentioned are really

sensitivity estimates. In NUREG-0956 central estimates are used in the Surry 'risk appraisal' with no attempt to identify the sensitivities. This, I feel, could be improved using the SARRP's own optimistic and pessimistic results as well as the central estimates. In this way the Surry 'risk appraisal' would also give some insight into the important sensitivities which control the risk from a severe accident in the plant.

Finally, I would suggest that the QA procedure for developing the input to these calculations be as rigorous as that required by the NRC for its licensees. In this way errors can be detected in input and methodology consistency. This does not appear to have been done in the past but should be in the future.

There were some things that were not in NUREG-0956 <u>at all</u>. I am not sure how useful these things would be at this present time but they are missing. These issues should be specifically identified as missing and a rationale given as to why they were neglected or should be included in a later draft of NUREG-0956.

(a) No discussion of external events was included and evidently will not be included in NUREG-1150. I am not an expert in siesmic events but it appears it could be important for certain plants and should be addressed in some way.

(b) No inclusion of a BWR-Mark II plant in any of the IDCOR or NRC analyses. This I think may be a serious error. I would think a MARK-II might be considered because (1) it is structurally quite different from other Mark I & II; (2) the accident sequences could be different in dominance; (3) containment analysis could be different.

(c) No extension to other types of LWR's by other vendors -- e.g. there are no combustion or B&W plants. Now this may not be a problem but the document should state this and give the rationale. The IDCOR presentation on August 2nd indicated that their analysis is being extended to a BW and CE plant.

Additional Comment (Technical)

As a last item I will include in these typed comments my estimate of the effect on the source term by the MCCI. I still find the pool temperature as the most important variable (by far) that determines the rate of aerosol generation and fission product release. Therefore, I am still confused by the comments of D. Powers of SNL on August 1 about how temperature may not be the most important variable (his suggestion was the gas velocity through the pool). My estimate is that temperature is a factor of four to eight times as important compared to the gas velocity.

ATTACHMENT I

EFFECT ON SOURCE TERM BY MCCI

(ESPECIALLY THE SUPPOSED NON-VOLATILE F.P.)

D. Power says there are three important effects:

a) -- surface area available for chemical reactions

b) -- temperature of the pool as it directly affects the source term; i.e. vapor pressure of the specific fission product species, $P_p = P_{sat}(T_p)$

c) -- gas superficial velocity due to concrete decomposition V_{SUP}

A. Let us assume that thermodynamic equilibrium occurs in the molten corium pool, so that (a) is not an important parameter. This would be a bound to the chemistry results. This bound is much easier to determine than the detailed kinetics of the multiple chemical reaction processes.

B. Aerosol mass flux, $\dot{m}_a''$ (kg/m^{2}s), is a function of the partial pressure of the fission product, P_p, which will condense after it is released from the hot corium pool after its vaporization at temperature of the pool, T_p.

$$\dot{m}_a'' = \rho_a V_{SUP} = \frac{P_p}{RT_p} V_{SUP} = \frac{P_{sat}(T_p)}{RT_p} V_{SUP}$$

Now take the differential

$$\frac{\delta \dot{m}_a''}{\dot{m}_a''} = \left(\frac{\delta P_p}{P_p} + \frac{\delta V_{SUP}}{V_{SUP}} - \frac{\delta T_p}{T_p}\right) \qquad (1)$$

Now these differentials normalized to their base values give the relative importance of pressure, temperature, and velocity

Now generally for $P_p = P_{sat}(T_p)$

$$P_p = C_o \exp\left(A + B/T_p\right) \tag{2}$$

$$\therefore \delta P_{p/P_p} = \frac{-B\,\delta T_p}{T_p^2} \tag{3}$$

- Now for V_{SUP} one recognizes that the gas superficial velocity is dependent on the heat flux from the corium pool to the surface of the decomposing concrete given by

$$q'' = \rho_{CONCRETE}\, V_{ABL}\, i_{ABL} \tag{4}$$

Also from this one gets

$$q'' = \rho_{gas}\, V_{SUP} = h\,(T_p - T_{ABL}) = h\,\Delta T \tag{5}$$

Where

h is the heat transfer coefficient which also is a function of V_{SUP}

ρ_{gas} is the decomposition gas density

T_{ABL} is the concrete ablation temperature

- Now there are two current models for $h = f(V_{SUP})$

- one for a nucleate boiling type of flow regime

$$h \propto V_{SUP}^{2/3} \tag{6a}$$

- one for a film boiling type of flow regime

$$h \propto V_{SUP}^{1/3} \tag{6b}$$

- Therefore if one combines Eqn's 5 and 6

$$V_{SUP} \propto \Delta T^{m} \text{ where } m = \frac{1}{1-n}$$

$$\frac{1}{3} < n < 2/3$$

$$\therefore \frac{\delta V_{SUP}}{V_{SUP}} = \frac{1}{1-n} \frac{\delta \Delta T}{\Delta T}$$

- Now consider a sample case for the MCCI

T_p 2500K typical initial pool temp.

T_{abl} = 1600K typical ablation temp. for conc.

ΔT = 900

let $\delta \Delta T$ = 100

CONSIDER A REFRACTORY RADIONUCLIDE UO_2

ONE FINDS FROM SIMPLE ANALYSIS:

$$\frac{\delta T_p}{T_p} \doteq 0.04$$

$$\frac{\delta P_p}{P_p} \doteq 1.35$$

$$\frac{\delta V_{SUP}}{V_{SUP}} \doteq .167 - .33$$

Therefore for $\dot{m}_a''$

Temperature (and the induced vapor pressure) has the biggest effect

130% effect

Compared to superficial velocity

16-33% effect

The importance of this simple calculation is to show that for the source term from the MCCI due to the release of refractory radioactive material the temperature (and the induced fission product partial pressure) of the pool has a much greater effect than the superficial velocity by a factor of 4 to 8. Therefore temperature is indeed the most important variable in determining the source term released.