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PEER REVIEW COMMENTS ON NUREG-0956 Vol. I (Draft)

As requested during the January 25 and 26, 1983 peer review meeting on the draft copy of NUREG-0956 Volume I, I am pleased to submit a number of written comments.

The NRC staff and its contractors should be complemented for the great deal of effort which has been and continues to be expended toward the goal of publishing a best estimate interim source term. My colleagues and I at Stone & Webster are committed to providing whatever technical support is required to assist you in meeting your goal.

As the time for review and comment for this first draft has been very brief, our comments are limited to the accident sequences with the highest quoted releases to the environment, i.e., TMLB'-γ, AB-β, and the V sequence.

The attachment to this letter includes a number of comments on the draft report. These comments are briefly summarized below along with some additional comments and observations.

(1). No analyses are presented to support the postulated containment failure for the various sequences.

(2). The mode of containment failure is not described for any sequence.

(3). For the AB-β sequence, the postulated unisolated penetrations in the containment lead into contiguous buildings (e.g. auxiliary or safeguards buildings). Fission product transport and deposition in these buildings must be considered in this sequence in contrast to the draft report analysis which assumes release through such penetrations are directly to the environment.

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(4). Cesium iodide and tellurium are erroneously assumed to be released only after core melt begins. When the fuel temperature data in the draft are combined with the well documented release rate data in Figure 5.2, the release of CsI and Te from the fuel prior to core melt is directly demonstrated. Thus the data in the report do not support the assumptions of the time of release of these fission products from the fuel. This error has important ramifications in the remainder of the analyses.

(5). The graph presented by Dana Powers of Sandia at the peer review meeting should be incorporated into and used in the report.* This graph addresses the release rate of aerosol as a function of fuel temperature. Use of this graph in conjunction with the stated core melt temperature and duration of core melt, results in release of a substantial amount of aerosol before core slump begins. Aerosols released while the reactor pressure vessel is intact must be analyzed relative to their behavior in the reactor vessel internals and other portions of plant systems and buildings.

(6). The release of specific radionuclides, in addition to CsI and Te, should be analyzed using the release rate fractions presented in Figure 5.2.

(7). The simplified model of the reactor vessel internals does not adequately represent the physical situation as it affects fission product transport and deposition.

(8). A single zone representation of the containment is not adequate to realistically address fission product transport and deposition in the containment. As an example, the AB-β sequence analysis assumes a hot leg break. Such a break would have to occur within the reactor cavity or the steam generator compartment. As no subcompartments have been analyzed, the practical effect, in the present draft, is to have a direct leakage path out the postulated unisolated containment penetration. Such modeling is unrealistic and does not lead to "best estimate" releases.

(9). The CsI and Te from the fuel can be readily demonstrated to be released into the reactor vessel internals, the reactor coolant piping, the pressurizer and the quench tank, in the TMLB'-γ sequence. In the draft report, such is not the case. A set of very questionable assumptions are combined to result in the conclusion that these fission products are released during core slump. The entire release scenario for this sequence is questionable.

(10). The solubility of the approximately 50 pounds of CsI in terms of the thousands of pounds of condensed water in the containment atmosphere has not been adequately treated.

* See Attachment 3

(11). The solubility of CsI in the liquid present in the RCS and ECCS piping is not addressed in the V sequence. Similarly, the transport and deposition of aerosol in the reactor vessel internals, RCS piping and circuitous ECCS piping, including reaction of Te with RCS metals are far from adequately analyzed. The effects of aerosol depletion in the circuitous piping with right angle bends is not analyzed in the model.

Based on the above comments and those included in the Attachment 1, we strongly urge that more rigorous analyses be performed for each of the major release sequences. We do not believe effort should be expended on the other sequences at this time.

As noted above, we at Stone & Webster Engineering Corporation share your commitment to the goal of developing best estimate interim source terms. We would be pleased to offer any technical information which we can, to further your investigations in a timely manner.

If we can be of any assistance please contact the undersigned at (617) 589-6510.

Sincerely,

John M. Otto FOR

E. A. Warman
Chief Engineer
Nuclear Technology Division

Attachments

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ATTACHMENT 1

COMMENTS ON NUREG-0956 DRAFT VOL. I

1. TMLB'-γ Sequence

A. CsI Transport and Retention

The Cs and I core release rates and fractions of retained CsI in the reactor coolant system, as reported in Tables 6.10, 7.7 and 7.8 unrealistically show that no CsI is considered to have been released before the start of core melt. Core melt is reported to start at 201 minutes (3.35 hours). This apparently correlates with the fuel region temperatures in Figure 6.5 which remain unrealistically low for up to 180 minutes (3 hours) for region TRO (1,7) and up to 200 minutes (3.33 hours) for region TRO (1,2). The data in Figure 6.5 appear to be in conflict with the temperature data in both Figures 6.6 and 6.7, which show upper grid structure and gas temperatures significantly higher than the fuel region temperatures, for the same time period. In addition, Table 6.3 indicates core heating commences at 60 minutes.

Core melting is reported to start at 201 minutes (3.35 hours). During this 201 minute period, the release of CsI from the core has been unrealistically neglected. The well substantiated data reported in Figure 5.2 indicate that the release of CsI would be completed during approximately the first half of this time period. In any best estimate analysis, with the copious amounts of liquid present in the RCS, it is unrealistic that CsI remains undissolved as assumed in NUREG-0956.

For the TMLB'-γ sequence the location of release is the pressurizer relief valve discharge tank. A best estimate analysis of the transport and retention of releases from the containment would have to include the effects of significant release reductions in the piping from the pressurizer relief valves to the tank, in the tank, and along the pathway volumes and surfaces from the tank to any point of release.

B. Te Transport and Retention

The temperature profiles shown in Figure 6.5 are consistent with the 4130°F core melting temperature in Table 6.1. These temperature profiles show that for the 69 minute period from the start of core melt to core slump (i.e. 201-270 minutes) the core remains at 4130°F or higher. When combined with the release rate data shown in Figure 5.2, the release rate for Te is indicated as approximately 0.1 fractions/minute. Thus, all of the Te should have been released in less than 10 minutes. For the next 59 minute period sensible heat is added to the reactor coolant system from the decay heat in the core, and this heat drives the Te into the various regions of the reactor vessel internals, reactor coolant system piping, pressurizer, and water filled quench tank. To assume that the 25.4 kg (56 lb) of Te are not substantially reacted with these various metal surfaces is grossly unrealistic.

2. AB-β Sequence

A. CsI Transport and Retention

The masses of CsI injected into the containment, as reported in Figure 7.3 and 7.4, unrealistically show that no CsI is considered to have been released before the start of core melt. Core melt is assumed to start at 1620 sec (27 min.) as reported in the material provided at the peer review meeting. This apparently correlates with the fuel region temperatures depicted in Figure 6.1, which remain unrealistically low for up to eighteen minutes for Region TRO (1,7) and up to thirty five minutes for Region TRO (1,2). The data in Figure 6.1 also appear to be in conflict with temperature data in Figure 6.2, which shows upper grid plate structure and gas temperatures significantly higher than the fuel region temperatures, for the same time period. In addition, Table 6.3 indicates core heating commences at time 0.52 minutes.

Core uncovery is reported to start at 30 seconds (0.5 min.) and core melt is reported to occur at 1620 seconds (27 minutes) in the material provided at the peer review meeting. In this 0.5 to 27 minutes period, the release of CsI from the core is unrealistically neglected. The well substantiated data reported in Figure 5.2 indicate that the release of CsI would be completed during this time period.

Concurrent with the release of CsI from the core during heatup several hundred thousand pounds of coolant inventory are also released. As the 50 lbs of CsI are highly soluble in water, it will substantially dissolve while still in the reactor coolant system. It is also noted that in any best estimate analysis, two phase conditions will exist in the vicinity of the postulated pipe break.

Our calculations indicate that approximately 33,000 lbs of water condense in the containment during this 0.5 to 27 minute period as shown in the Figure labeled Attachment 2. Aprroximately 53,000 lbs of CsI are soluble in 33,000 of hot water (approximately 14,000 lbs CsI are soluble in 33,000 lbs of cold water). As the total inventory of CsI is only approximately 50 lbs, there is over 1000 times as much relatively hot water available to dissolve all the CsI in the core than required.

The large LOCA pipe break location, for the AB sequences, is the reactor cavity or steam generator cubicle. A best estimate analysis of the transport and retention of releases from the containment would have to include the effects of significant release reductions along pathway volumes and surfaces from the reactor cavity or steam generator cubicle to any point of release.

In Table 7.1 the containment failure time is reported to be 0 minutes. This apparently is based on the β designation which is failure to isolate the containment. Containment penetrations lead into contiguous buildings (e.g. auxiliary and safeguards buildings). Therefore any analysis of releases via these penetrations must consider the aerosol transport and depositions in these buildings. When these effects are properly incorporated in the anlaysis, substantial reductions in the releases to the environment result.

B. Te Transport and Retention

The temperature profiles shown in Figure 6.1 are consistent with the 4130°F core melting temperature in Table 6.1. These temperature profiles show that for the 30 minute period from the start of core melt to core slump, (i.e. 27 minutes to 57 minutes) the core remains at 4130°F. When combined with the release rate data shown in Figure 5.2 the release rate for Te is indicated as approximately 0.1 fractions/minute. Thus it would take only 10 minutes to release all of the Te inventory at that temperature. As the core is at that temperature for 30 minutes all the Te inventory is released in 10 minutes. For the next 20 minute period, the reactor coolant system and reactor vessel system remain intact with a heat source to drive the aerosol into regions where deposition of Te is known to react with steel.

As there are over a hundred thousand pounds of these materials in the upper plenum alone, a best estimate analysis must address these reactions of Te. Also, as there are only 25.4 kg (56 lbs) of Te and there are over 100,000 lbs of metal and the design of the reactor vessel internals is such that the surface area to volume ratio is large, any reasonable analysis of the fate of the 25.4 kg (56 lbs) of Te will show they substantially react with the steel.

3. V Sequence

A. CsI Transport and Retention

The mass of CsI injected into the auxiliary building as reported in Figure 7.8 for the V sequence unrealistically shows that no CsI is released before the start of core melt. The core was reported to be uncovered at 4.9 minutes, core melt is assumed to start at 37 minutes, and core slump is assumed to start at 64 minutes, as reported in the material provided at the peer review meeting.

For the 32.1 minute period during which the core is uncovering, the release of CsI from the core is unrealistically neglected. The well substantiated data reported in Figure 5.2 indicate that the release of CsI would be completed in this period, for reasons similar to those we stated for the AB-β sequence.

It was not possible for us to perform similar calculationsof CsI release for the V sequence because the necessary data have not been provided in NUREG-0956.

As this period of core uncovery, of 32.1 minutes, is longer than the 26.5 minute period for the AB-β sequence, more opportunity exists for CsI release from the core. The 50 lbs of highly soluble CsI are released during this period together with copious amounts of coolant inventory. These transit the long and circuitous RCS & ECCS piping together providing ample opportunity for the CsI to dissolve.

Upon release from the core region, the CsI (and the other fission products) must transit through the reactor vessel internals, reactor coolant system piping and interfacing small diameter ECCS piping. As the temperature of all this piping is well below the 1148° melting point of CsI, the physical form of any CsI that may escape being dissolved during this transit period will be that of solid particles. The piping in question is wetted surfaces containing a two phase mixture. In addition, the piping has many bends (frequently at right angles in most plants) which would have a major reduction impact during the transport of these CsI particles. The release fraction for CsI for the reactor coolant system, reported in Table 7.20 is only 0.4. As there are only approximately 50 lbs of CsI available from the core, is is unrealistic that a rigorous analysis would support that 20 lbs of CsI inventory was released and that only 30 lbs were retained in the reactor coolant system.

Furthermore, our analysis of the auxiliary building pressure capability shows that the data presented in Table 6.3 which indicate the immediate structural failure of the auxiliary building are incorrect. Structural

integrity of the building, which our analysis shows persists indefinitely, will serve to entrap air-borne fission products entering from the ECCS piping by the various mechanisms of aerosol depletion, including condensation of water from the primary system.

B. Te Transport and Retention

As the V Sequence is stated to be very similar to the AB sequence with regard to thermal hydraulics and core temperature behavior, the arguments above for early Te release will not be repeated.

In addition such arguments would have been difficult to pose in that no temperature profiles have been provided for the V sequence comparable to Figures 6.4 and 6.5.

From the data that were provided at the peer review meeting, the core is reported to be uncovered at 4.9 minutes, the core melt is reported to start at 37 minutes, and the core is reported to slump at 64 minutes. During the period of core melt (27 minutes) the core temperature is assumed to be 4130° F or higher. Using the release rate data from Figure 5.2 For Te, the release fraction of approximately 0.1 fractions/minute will result in the complete release of the available Te in less than 10 minutes. During the more than 17 minutes that remain of the core melt period, the energy from the decay heat generation in the core would act to drive the released Te to interact with the complex reactor vessel internals, reactor coolant system piping, and interfacing small diameter ECCS piping. As there are over a hundred thousand pounds of steel in the upper plenum alone and the surface area to volume ratio is large, a best estimate analysis must address the reaction of Te.

The temperatures of reactor coolant system piping and interfacing small diameter ECCS piping play important roles in determining the fate of any fission products released from the core. The transit path would include approximately 10 feet of reactor coolant system piping and approximately 100 feet of small diameter (e.g., 6 inch) interfacing ECCS piping. A realistic analysis must address the transit of 25.4 kg (56 lbs) of Te in the reactor coolant system and interfacing ECCS piping which contain large surface areas and hundreds of thousands of pounds of steel.