From Mark Leyse: Additional Information for the September 6, 2012 Public Meeting Regarding the Filtration of BWR Mark I and Mark II Containment Vents

Nuclear Regulatory Commission ("NRC") needs to consider the limitations of the MELCOR and MAAP codes for predicting the rates of hydrogen production that would occur in a severe accident—especially the rates of hydrogen production that would occur if there were a reflooding of an overheated core.

Below is information regarding the limitations of the MELCOR and MAAP codes. This information is pertinent to NRC's policy paper on the filtration of BWR Mark I and Mark II containment vents, which NRC plans to send to the Commission in November 2012.

In an August 17, 2012 e-mail, Robert Fretz stated:

> The September 6th meeting is essentially a follow-up to the meeting the staff recently held with representatives from the Electric Power Research Institute (EPRI) on August 8th. During the August 8th meeting, the NRC heard from industry representatives on research and analysis being conducted on possible alternatives to installing external filtration devices on BWR Mark I and Mark II containment vents. The September 6th meeting will allow the NRC staff an opportunity to present initial results from similar computer modeling that it has performed on certain Fukushima-like (severe accident) scenarios. These computer model (MELCOR) runs are intended to provide consequence information that will be used to inform the staff's regulatory analysis (RA) on various filtered venting options. The staff's regulatory analysis will serve as one piece of the policy paper that it plans to send to the Commission in November.

(Most likely, EPRI's calculations were done with the MAAP code and NRC's calculations were done with the MELCOR code.)

NRC and EPRI's calculations are non-conservative: the MELCOR and MAAP codes under-predict the rates of hydrogen production that would occur in a severe accident—especially the rates of hydrogen production that would occur if there were a reflooding of an overheated core.

In a July 2012 report, I wrote for Natural Resources Defense Council, "Post-Fukushima Hardened Vents with High-Capacity Filters for BWR Mark Is and Mark IIs" (http://docs.nrdc.org/nuclear/files/nuc_12070201a.pdf), I point out (on page 6) that a high-capacity filter would be needed for scenarios in which there was a reflooding of an overheated reactor core, which would rapidly generate hydrogen, thereby possibly threatening containment integrity and increasing the risk of radioactive fission product releases. And in the same report (on page 5), I point out that early venting would require installing a high-capacity filter to help protect the surrounding population, who would not have time to evacuate and prevent becoming exposed to radioactive releases.

Clearly, it is important that *all* safety analyses conducted by NRC and EPRI, regarding filtered vents for BWR Mark I and Mark IIs are conservative—not non-conservative.

Below are two quotes with information on the limitations of the MELCOR and MAAP codes for predicting the rates of hydrogen production that would occur in a severe accident:

First, a July 2011 IAEA report, "Mitigation of Hydrogen Hazards in Severe Accidents in Nuclear Power Plants" (http://www-pub.iaea.org/MTCD/publications/PDF/TE_1661_Web.pdf), states that 1D severe accident codes, *such as MELCOR and MAAP*, predict less hydrogen release than 2D severe accident codes, such as ICARE/CATHARE, for a given severe accident scenario.

"Mitigation of Hydrogen Hazards in Severe Accidents in Nuclear Power Plants" states (pages 10-11):

> The 1D or 2D thermohydraulic modelling approach of this event will give very different results in terms of hydrogen release, because of the very different flow redistribution scheme and associated heat transfer in the core. For example, very preliminary calculations using a 2D thermohydraulic model versus a 1D thermohydraulic model in the same code have been performed by IRSN with the ICARE/CATHARE code. *Results show a large discrepancy between the calculated hydrogen releases, the 2D production giving the greater one* [emphasis added]. Nevertheless, validation of such 2D flow redistribution models is difficult because of a lack of dedicated tests.
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> *When using a 1D code and running calculations to check if no possible "cliff edge effect" could exist in the plant regarding the hydrogen risk mitigation*, the potential consequences of this lack of 2D modelling of the code need to be kept in mind [emphasis added].

Second, an October 2001 OECD Nuclear Energy Agency report, "In-Vessel and Ex-Vessel Hydrogen Sources" (https://www.oecd-nea.org/nsd/docs/2001/csni-r2001-15.pdf), states that the available Zircaloy-steam oxidation correlations, such as Cathcart-Pawel, under-predict hydrogen production in severe accident scenarios, in which there would be the reflooding of an overheated core.

"In-Vessel and Ex-Vessel Hydrogen Sources" states (page 9):

> Reflooding and quenching of the uncovered core is the most important accident management measure to terminate a severe accident transient. If the core is overheated, this measure can lead to increased oxidation of the Zircaloy cladding which in turn can trigger a temperature escalation. Relatively short flooding and quenching times can thereby lead to high hydrogen source rates which must be taken into account in risk analysis and in the design of hydrogen mitigation systems.
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> Until recently, the experimental database on quenching phenomena was rather scarce. *The available Zircaloy-steam oxidation correlations were not suitable to determine the increased hydrogen production in the few available tests (CORA, LOFT LP-FP-2)* [emphasis added].

(It is noteworthy that the July 2011 IAEA report and October 2001 OECD Nuclear Energy Agency report refer to the "lack of dedicated tests" and "few available tests," respectively.)