Severe Accident Management – Lessons Still to be Learned from Fukushima-Daiichi

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Progress in SAMG to date

- SAMG programs have been reviewed
  - Example: EU-wide stress test involved SAMG
- Major Technical Basis Document (EPRI TBR reviewed) in 2012, is now an open document
  - Strategies (´CHLAs` added)
- Various features in SAMG added
  - Spent fuel pool, multi-unit aspects
  - Cooling with all available water sources
  - Leakage from containment to other buildings
- On- and off-site support (incl. portable equipment) added /better organised
- But there is still to be learned

Limitations of present SAMG - 1

- Many SAMG tell people to pump water from A to B, reading instruments C and D – but few tell what to do if there is no AC, DC, and/or cooling water.
  - This is a TMI heritage, where all was there except insights; nowadays, we can largely assume severe accidents do not happen if there is AC, DC and cooling water.
  - Telling people – as some SAGs do - to find causes and restore functions may not be very effective in the stress of a severe accident.
- Reading instruments is essential – what to do if no DC is available?
  - Very few SAMG give guidance - some people tell to dismantle I&C and read voltages, using calibrators – is that a realistic option in the stress of the event? If yes, is it trained? Or more mechanical gauges?
  - Impact of severe accident on instrument reading sometimes forgotten

Limitations of present SAMG - 2

- Where portable equipment is specified, time needed AND time available to transport it and hook it on is seldom/not specified, seldom trained in exercises.
  - Often, portable equipment is specified for preventive actions, not for mitigative actions
- SAMG programs often state injection into the RCS is the first priority –
  - Remarkably, as we have a severe accident just due to the lack of RCS injection for extended time
  - Real focus should be **protection of remaining intact fission product boundaries** – few programs do so systematically

Limitations of present SAMG - 3

- Remarkably, only few SAMG programs specify removing decay heat to an ultimate heat sink as a major function
  - Example: ´OSSA` (France)
- Few SAMG programs specify early venting of the containment with the sole purpose to create margin to containment failure, if SAMG tools fail
  - Everybody has venting to protect against containment overpressure, but this may be too late or impossible later on

Limitations of present SAMG - 4

- All SAMG programs tell their SAMG is only guidance, no verbatim following needed
  - But few (if any) programs tell when and why deviations may /should occur
- SAMG programs tell users to balance positive and negative consequences of potential actions
  - But few programs give quantitative information of such possible negative consequences
- There is no guidance how long deliberations in the TSC may last
  - Deliberations may easily be overtaken by the evolution of the accident

Limitations of present SAMG - 5

- Some TSC /ERO are in a building that has no protection against radiation and has no independent power source for its instruments /laptops / cell phones
  - Execution of SAMG at such plants is virtually impossible
- Few SAMG programmes include loss of command and control and restoring an ERO structure
  - There are often detailed instructions for the MCR what to do as long as the TSC is not functional, but there is seldom anything if the TSC does not come at all, or if even the MCR and emergency shutdown rooms are unavailable
    - Exception: US EDMG (but not designed for severe accidents)
    - See also my **poster** on this topic

Limitations of present SAMG - 6

- There is no internationally agreed industry standard for SAMG
  - SAMG approaches vary widely, even within one reactor type, and even where the goal is the same: protect FP boundaries
  - Limited exchange of information between SAMG approaches: proprietary, security arguments
    - Note: PWR SAMG harmonisation in US underway
  - IAEA developed its RAMP service: very few plants have used it
- Type of SAMG not decided by the vendor, but by the utility (as he pays the bill)
  - But often only the vendor has the required knowledge, not the utility
  - ´The patient selects the medicine, not his doctor`

Limitations of present SAMG - 7

- The link between various SAMG programs and severe accident research is weak
  - I found no reference in the new EPRI TBR to 25 years of major EU research (´SARNET` program), or major OECD programmes (RASPLAV, MASCA).
  - And vice versa: EU research (SARNET) did not review the EPRI TBR
  - Worse: I heard some SAMG developers say: SAMG is no research area, it is engineering (´add water`).
  - Few research has been undertaken to the decision making process in the TSC /ERO.

Limitations of present SAMG - 8

- Many SAMG programs have been set up so that the TSC / MCR do not need to be severe accident experts
  - This makes the program ineffective the moment deviations occur from pre-staged and pre-analysed scenarios
  - If they have this knowledge, they could infer needed actions from their understanding of the event
    - Such insights help also if instruments are gone: accidents are no meteorites – they usually develop along a certain path
    - Example: if you know you are in SBO, you have to depressurise the RCS (later if RCIC/AFW still work)

Limitations of present SAMG - 9

- Present A/M is ´Routine Accident Management` i.e. a very big accident, but everybody is aware of his duties and well trained
  - Example: a big traffic accident: big damage and big chaos, but emergency staff knows what to do
- For unknown scenarios, complications, etc. better A/M is ´Emergency Accident Management`
  - Improvisation needed, leadership required
  - There is little or no training on improvisation, leadership in SAMG drills /exercises.
    - (see Herman B. Leonard and Arnold M. Howitt, Kennedy School of Government, Harvard University, 2007; courtesy Bob Lutz, W)

Limitations of present SAMG - 10

- Rulemaking re SAMG varies widely, there is no common regulatory position
  - SAMG can even be outside regulation
- Regulation focuses on public health and safety
  - Societal disruption is not considered
    - ASME initiative on ´New Safety Construct`
- Regulation stays focused on traditional approaches (DBA, LBLOCA, etc.)
  - Risk-informed approaches go very slowly
    - Step forward in IAEA SSR 2/1

Conclusions

- Progress in SAMG has been made
- Some harmonisation underway
- Open items:
  - Adapt SAMG to site disruptive accidents
    - Add restoration of command and control
  - Operate more knowledge-based, incl. training for improvisation, leadership
  - Interface better with research
  - Need for industry standard and more open communication – adapt regulation
  - More peer review needed, RAMP missions (or similar)