

Technology and Organization: Two key factors in achieving nuclear safety

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What needs to change to make nuclear power safer?

- Technology: What key safety-related issues can be addressed by known technology?
- Organization: What are the key characteristics of an organization that operates nuclear power safely?



First - technology

- All past catastrophic nuclear accidents have involved the failure to maintain a cooled nuclear reactor core: Chernobyl, 3-Mile Island, Fukushima ...
 - Is there a technological answer to this issue?
- My answer: yes – passively safe designs that rely on basic physics principles, not complex manual or automatic backup systems
 - “Natural” shut-down of chain reaction (‘natural scram’)
 - “Natural” core cooling, even for long-term total station blackout



Example #1: Physics-based 'scram'

- Core expands as core temperature rises, based on simple physical principle that the core structural materials expand with temperature
 - Examples: HTGC pebble-bed reactors, Toshiba 4S ...
- Core expansion reduces probability of neutron scattering, bringing core below critical and shutting off chain reaction



Example #2: Natural cooling

- Once core is below critical, only the residual heat needs to be removed ...
- If the reactor vessel geometry and volume are properly designed, the core can be cooled without recourse to (electric) pumps by simple thermally-driven convection of the heat transfer fluid (viz., water for LWRs)
 - Examples: LWR SMR designs by mPower, nuScale, Holtec, Westinghouse ... ; liquid metal SMR designs by GE/Hitachi, Toshiba 4S, ...



Second: Organization

- Nuclear power is unique among energy technologies in that it requires a uniquely high level of technical expertise on the part of the operator
 - On-site workforce needs to be highly trained, and must have expertise on-site sufficient to deal with ‘unexpected’ events
 - Senior management must trust on-site experts to deal with emergencies – no ‘second-guessing’ – because time is often of the essence



Thus: The critical organizational ingredients

- Highly **trained** and **trusted** workforce in place
- Extensive **preparation and training** for emergencies
- **Transparent** chain of command & responsibilities
- **Independent verification** and **validation** of workforce status, general safety and security, and preparation for emergencies
- Operator culture change that **couples safety with operational efficiency** (and thus, profit)



Can all this be achieved? YES!

- Example #1: the U.S. nuclear navy
 - All ‘key ingredients’ in place ...
 - No accidents and no deaths in > 50 years of service
- Example #2: the post-3-Mile-Island U.S. nuclear industry
 - All ‘key ingredients’ in place (including independent oversight by the Nuclear Regulatory Commission [NRC] **and** industry self-regulation [INPO: <http://www.inpo.info>] ...)
 - No significant accidents, no deaths since 3-Mile-Island **AND** significantly increased operator efficiency



How might this apply to present-day Japan?

- Focus of *all new* construction on Gen III+ and yet more modern designs
 - Passive safety by design, not retrofit ...
- Changed safety culture ...
 - Government supervision of safety and security via *independent* oversight: separation of promotion and supervision of civilian nuclear power
 - Changed operator culture: recognition that good safety practices and efficient operation (and therefore profitable operations) are strongly coupled



On to the discussion!



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