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On the evolution of safety culture thinking TMI – Chernobyl - Fukushima

Nordic perspectives of Fukushima: Where are we now and where do we go?
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It all started from human error

- Three Mile Island (TMI-2) nuclear accident in 1979 was rated five on the INES scale
- The partial nuclear meltdown occurred only a few months after the plant was commissioned
- The initial cause of the accident was an error made in maintenance in the secondary circuit => this error eventually tripped the turbine and caused a scram
- A number of errors happened before & during the event:
  - A pilot-operated relief valve opened in the pressurizer and stuck open
  - Operators did not realize the open valve due to e.g. bad interface design
  - The operators misdiagnosed the level of water in the pressurizer and turned off the emergency core cooling pumps
  - Operators turned off the four main reactor coolant pumps because of cavitation => this further increased the formation of steam and exposed the core

⇒ **At the time, the accident was largely seen as a result of human errors and lack of operator competence**

In fact, the official investigation already showed a more nuanced picture of the accident

The Kemeny report 1979

"To prevent nuclear accidents as serious as Three Mile Island, fundamental changes will be necessary in the organization, procedures, and practices - and above all - in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions we investigated are typical, of the nuclear industry."

"Most serious mindset is the pre-occupation of everyone with the safety of equipment, resulting in the down-playing of the importance of the human element in nuclear power generation."

In fact, the official investigation already showed a more nuanced picture of the accident

The Kemeny report 1979

"When we say that the basic problems are people-related, we do not mean to limit this term to shortcomings of individual human beings -- although those do exist. We mean more generally that our investigation has revealed problems with the "system" that manufactures, operates, and regulates nuclear power plants. There are structural problems in the various organizations, there are deficiencies in various processes, and there is a lack of communication among key individuals and groups."

Systemic explanations for accidents have been given since the 70s

- Barry Turner (1978): ‘slow build-up of resident pathogens in the system during so called incubation period followed by an initiating event’
- Charles Perrow (1984): ‘complexity and tight couplings among sociotechnical system components increases the probability of major accidents’ ‘complex high risk systems will inevitably experience a “normal accident“’
- Jens Rasmussen (1997): ‘economic pressures and scarcity of resources drive sociotechnical systems closer to their safety boundaries’
- Scott Snook (2000): ‘complex systems exhibit “practical drift” where local goals override system level goals’
- Hollnagel (2004, 2009): ‘a unique combination of ordinary events causes an accident, trade-off between efficiency and thoroughness contributes to accidents (but also normally to efficient work)’
- Sidney Dekker (2011): ‘complexity and variability create unpredictability where the organization can drift into an accident‘

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⇒ **Complexity and change as challenges to safety**

⇒ **Emphasis on the system, not only on the components (safe system is more than a sum of safe components)**

⇒ **Major accidents have a social and cultural context and a history (Pidgeon 2012)**

Chernobyl, the birth of ”safety culture”, and Fukushima

- Safety culture as a concept was first used to explain the Chernobyl nuclear accident in 1986
- IAEA’s International Nuclear Safety Advisory Group (INSAG) reviewed the evidence concerning the accident and concluded that the “root cause of the Chernobyl accident … is to be found in the so-called human element” (IAEA 1986, p. 76), and that “formal procedures must be properly reviewed, approved and supplemented by the creation and maintenance of a ‘nuclear safety culture’” (Ibid., p. 77).
- No formal definition of the concept was proposed at that time; the concept strived to capture the human and organizational aspects of accidents but did not fully succeed (Reiman & Rollenhagen 2014)
- In fact it has taken us 30 years to integrate the concept of safety culture with other safety concepts, accident theories as well as engineering principles (and we are still in progress)
- Fukushima disaster demonstrated once again the systemic nature of accidents, but so far has not revealed any new social accident mechanisms

Evolution of the concept of safety culture

- There is an increased recognition concerning the common contributing causes of all three accidents
  - All the accidents are systemic in origin, they have a history and a context
- The common contributing factors include
  - belief in the inherent safety of nuclear power and safety of the specific power plant
  - lack of operating experience concerning similar previous incidents / lack of continuous improvement
  - lack of (training on) emergency situation competence of the operators,
  - inadequate procedures for dealing with emergency situations
  - problems in human-machine interface,
  - ineffective regulation

Evolution of the concept of safety culture

- Safety culture concept is associated with shared norms, values and basic assumptions directly or indirectly related to safety
  - ***The ability and willingness of the organization to manage the systemic nature of nuclear safety***
- When developing safety culture it is necessary to go beyond individual attitudes to the level of shared thinking and the administrative structures and resources that embed ideas of what is means to be safe, and how safe we are now
  - Improving safety culture means constantly building organizational capacity for increased risk perception and risk management
- During 30 years of safety culture development, we have increased our understanding of how and why accidents happen
  - But, are we also better at preventing them?