SEVERE ACCIDENT MANAGEMENT; THE APPROACH IN THE USA.

Applications of US methods in Europe
Other approaches in Europe

Presentation to the Workshop on Development and Validation of EOP/AMG for Effective Prevention/Mitigation of Severe Core Damage,
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About NSC

Dutch consultancy company

Start 1995

Main fields:

- nuclear safety assessments
- modernisation of nuclear power plants (reg. side)
- on-site (severe) accident management
- emergency preparedness organisation, on-site/off-site
- advanced reactors (High Temperature Gas cooled)

Main activities:

- advice to Swiss regulator on SAMG in Swiss plants
- project of EC on SAMG in EU
- support of IAEA tasks

Strengths:

- independent of major vendors/utilties
- wide network with US industry
- 20 years experience in industry and regulatory activities

Weaknesses:

- nuclear basis in NL deteriorating
- small staff

SUBJECTS

1. Introduction

2. Historical perspective

3. US industry position to core melt accidents

4. Method of Westinghouse Owners Group (WOG)

5. Method of Combustion Engineering Owners Group (CEOG)

6. Method of Babcock und Wilcox Owners Group (B&WOG)

7. Method of Boiling Water Reactor Owners group (BWROG)

8. Interaction with/inspection by the USNRC

9. Assessment of US SAMG methods

1. INTRODUCTION

- CORE MELT ACCIDENTS, operator procedures/guidance, technical support at the plant, NOT: emergency preparedness (i.e. response to protect the public/environment

- All US nuclear power plants have - voluntarily - decided to have severe accident management procedures/guidance in place by the end of 1998

- Procedures/guidance are verified & validated, trained, institutionalized

- Also implemented elsewhere: Belgium, Netherlands, Spain, Slovenia, Switzerland, South Africa, work ongoing elsewhere

)EFINITION OF A/M AND SEVERE A/M (SAM)

\CCIDENT MANAGEMENT encompasses all those actions taken luring the course of an accident by the plant operating and technical staff to:

- prevent the accident from progressing to core damage,
- terminate core damage progression once it begins,
- maintain the capability of the containment as long as possible, and
- minimize on-site and off-site releases and their effects.

The latter three actions constitute a subset of accident management (A/M) referred to as *SEVERE ACCIDENT MANAGEMENT* (SAM), or more specifically, severe accident mitigation.

Definition used by all utilities in the USA, represented in the NEI (Nuclear Energy Institute).

HENCE: SAM ARE ACTIONS AFTER CORE DAMAGE HAS BEGUN

2. HISTORICAL PERSPECTIVE

- after TMI: severe accidents defined as 'unresolved safety issues'

- NRC announced rulemaking; defined policy in SECY 88-147, sent out Generic Letter 88-20

- licensee actions were required in four areas:

  a. individual plant examination (IPE)

  b. containment performance improvement (CPI)

  c. IPE of external events (IPEEE)

  d. accident management

- NRC worked on an Accident Management Programme that contained the necessary elements.

Elements of the Accident Management Programme:

- developing *technically sound strategies* and ensuring that procedures and guidance were in place to implement these strategies;

- assuring that *instrumentation and equipment* called for diagnosis and response are identified and that their availability and capabilities are assessed and, where needed, incremental improvements to relevant systems are assessed;

- assuring that well-established, *clear lines of communication and authority* exist, as well as *assigned responsibility* for key decisions, and authority for procedural overrides and ad-hoc modifications;

- assuring that operators, plant technical staff and plant management are *well trained* in the procedures and guidance;

- providing a *technical basis* for the assessment of the effectiveness of the severe accident management strategies and capabilities.

This was further elaborated by EG&G in NUREG/CR 6009:

1. Adequate information to *understand the capabilities and potential limitations of the plant*, including both equipment and personnel.

2. A clearly identified set of *accident management strategies* that will effectively prevent or mitigate undesirable accident consequences.

3. *Procedures and guidelines* implemented at all appropriate levels in the organization for executing the strategies.

4. *Engineered methods* (necessary systems and equipment) identified for the proper implementation of strategies.

5. Indication that adequate plant status information is available to *monitor all plant safety functions* and is available to select and to assess the effectiveness of all strategies.

6. Clearly delineated lines of decision making *authority and responsibility.*

7. Provision for *adequate training* of all personnel involved in accident management.

8. *Validation* of the performance of the implemented accident management plan.

9. A formal mechanism in place to identify and *incorporate new information* into the implemented accident management plan as it becomes available.

FURTHER DEVELOPMENTS.

- NRC set up a research programme

  a. short term issues for closure of severe accidents

  b. long term issues for confirmation

- INDUSTRY TOOK A/M INITIATIVE (NUMARC, later NEI)

- NEI developed a formal industry position, which was binding for all US utilities

- position: all US plants have severe A/M guidance (SAMG) in place end of 1998

- goal was to enhance Emergency Response Organization (ERO)

- objectives:

  a. re-establish core cooling

  b. protect fission product boundaries

  c. focus on existing plant capabilities

FURTHER ACTIVITIES

- NRC accepted the US industry position

- EPRI developed the technical basis for A/M strategies (Technical Basis Report, EPRI TR 101869, vols. 1 and 2.); EPRI did not: develop strategies itself.

- US Owners Groups reviewed all severe accident information sources (TBR, IPEs, IPEEEs, research results) and developed generic insights for their plants, examples:

  - a BWR in-vessel steam explosion is unlikely due to the internals

  - ex-vessel steam explosion will damage all BWR containments, irrespective of pressure suppression capability

  - MCCI can generate 4 to 5 times as much gas as is already in the containment

  - submerging core debris will retain it in the vessel

  - onset of core melting will not be identified by control room or TSC staff

  - a debris-bed will not become critical when submerged with water

  - flooding debris above core support plate is more effective than spraying

FURTHER ACTIVITIES (cont'd)

- US Owners Groups developed generic strategies (at first OGs combined, later individually)
- Utilities developed plant specific guidance from the generic material
- INPO developed training insights
- Templates were developed (by INPO, OGs, utilities) to validate guidance and to train staff
- Utilities organized SAMG verification & validation workshops, with peers
- Utilities organized SAMG demonstrations, watched by peers and NRC
- By October 1998, about 40 plants had already installed SAMG

3. US INDUSTRY POSITION WITH RESPECT TO SEVERE ACCIDENTS

Verbatim, the industry position reads as follows (ref. NEI 91-04, rev.1):

Each licensee will:

- *Assess current capabilities to respond to severe accident conditions using Section 5 of NEI 91-04, rev. 1 "Severe Accident Issue Closure Guidelines";*

- *implement appropriate improvements identified in the assessment, within the constraint of existing personnel and hardware, on a schedule to be determined by each licensee and communicated to the NRC, but in any event no later than December 31, 1998.*

SAM CLOSURE PROCESS

NEI 91-04, rev. 1, sec. 5, specifies the closure process for a given licensee in the following four steps

- Evaluate industry-developed bases and Owners Group severe accident management guidance (SAMG), along with the plant IPE, IPEEE and current capabilities, to develop *severe accident management guidance* for accidents found to be important in the plants as screened *with pre-specified criteria* and consider other generic and plant-specific information (e.g. NRC and industry studies, PSA results, etc.) as appropriate;

- Interface SAMG with the plant's *Emergency Plan (EP)*;

- Incorporate severe accident material into *appropriate training* programmes; and

- Establish a means to consider and possibly adopt *new severe accident information* from licensee self assessments, applicable NRC generic communications, PRA studies, etc.

PRIMARY IPE CORE DAMAGE EVALUATION PROCESS

Mean CDF per sequence group (per reactor year)		Licensee response
Greater than 1E-4	1.	find a cost-effective plant administrative procedural or hardware modification with emphasis on eliminating or reducing the likelihood of the source of the accident sequence initiator
or		
greater than 50 percent of total CDF	2.	If unable to satisfy above response, treat in EOPs or other plants procedure with emphasis on prevention of core damage
	3.	If unable to satisfy above responses, ensure SAMG is in place with emphasis on prevention/mitigation of core damage or vessel failure, and containment failure
1E-5 to 1E-4	1.	Find a cost effective treatment in EOPs or other plant procedure or minor hardware change with emphasis on prevention of core damage
or		
20 percent to 50 percent of total CDF	2.	If unable to satisfy above response, ensure SAMG is in place with emphasis on prevention.mitigation of core damage or vessel failure, and containment failure
1E-6 to 1E-5		Ensure SAMG is in place with emphasis on prevention/mitigation of core damage or vessel failure, and containment failure
Less than 1E-6		No specific action required

PRIMARY IPE CONTAINMENT BYPASS EVALUATION PROCESS

Mean containment bypass frequency (per reactor year)		Licensee response
Greater than 1E-5 or greater than 20 percent of total bypass frequency	1. 2. 3.	find a cost-effective plant administrative procedural or hardware modification with emphasis on eliminating or reducing the likelihood of the source of the accident sequence initiator If unable to satisfy above response, treat in EOPs or other plants procedure with emphasis on prevention of core damage If unable to satisfy above responses, ensure SAMG is in place with emphasis on prevention/mitigation of core damage or vessel failure, and containment failure
1E-6 to 1E-5 or 5 to 20 percent of total bypass frequency	-1. 2.	Find a cost effective treatment in EOPs or other plant procedure or <u>minor</u> hardware change with emphasis on prevention of core damage If unable to satisfy above response, ensure SAMG is in place with emphasis on prevention.mitigation of core damage or vessel failure, and containment failure
1E-7 to 1E-6		Ensure SAMG is in place with emphasis on prevention/mitigation of core damage or vessel failure, and containment failure
Less than 1E-7		No specific action required

IN PRACTICE, US UTILITIES DEVELOPED SAM GUIDANCE

FOR ALL *MECHANISTICALLY POSSIBLE* CORE AND CONTAINMENT CONDITIONS,

IRRESPECTIVE OF THEIR PROBABILITY,

FOR WHICH SUCH GUIDANCE COULD BE DEVELOPED.

SAMG DEVELOPMENT: ON THE BASIS OF EPRI TBR (TECHNICAL BASIS REPORT)

Principal investigator: dr. R.E. Henry, of Fauske and Associates (FAI)

Industry-wide common technical basis from which the SAMGs can be developed.

Recognizes a number of plant damage states:

- 3 RCS damage states: OX, BD, EX (oxidized fuel, badly damaged core, debris ex-vessel)

- 1 intact containment and 3 containment damage states: CC, CH, I, B (closed and cooled, challenged, impaired, bypassed)

Structure of TBR

2 volumes: I and II.

Vol I:

describes the RCS and containment damage conditions

describes all relevant accident management actions during each of the phases OX, BD, EX and CC, CH, CB and presents the impact of the actions

Vol. II:

describes physics of all processes

ACTIONS THAT ARE CANDIDATES FOR ACCIDENT MANAGEMENT STRATEGIES:

'CANDIDATE HIGH LEVEL ACTIONS' (CHLAs, "chilla's")

1. Inject into RPV/RCS
2. Depressurize the RPV/RCS
3. Spray within the RPV (BWR)
4. Restart reactor cooling pumps

5. Depressurize steam generators (PWRs)
6. Inject into (feed) steam generators

7. Spray into containment
8. Inject into the containment
9. Operate fan coolers
10. Operate recombiners
11. Operate igniters
12. Inert containment with non-condensibles
13. Vent containment

14. Spray secondary containment
15. Flood secondary containment

SPECIAL CONSIDERATIONS:

1. External cooling of RPV/RCS
2. Steam inerting of the containment