SEVERE ACCIDENT MANAGEMENT

REGULATORY CHALLENGES AND FIXING OF PRIORITIES

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Overview of the Presentation

- Indian nuclear power program
- Structure and functions of AERB
- Approach followed by India
- Session Specific Issues

Indian Nuclear Power Program

Details of Reactor Units

Operating Reactors	: 20	Units generating	4760 Mwe
Reactors Under Construction	: 7	Units of capacity	5300 Mwe
Planned (PHWRs, LWRs)	: 38	Units	~ 39000 Mwe

Additional : FBRs, AWWR:

Reactor Years of Operation: Around 360 years

- Additional Research Reactor experience

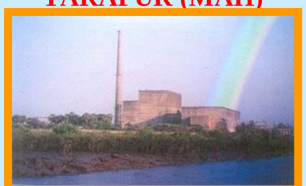
Operating Plants & On-going Projects

- 4780 MW - 18 PHWR & 2 BWR
- 5300 MW - 2 LWR, 1 PFBR, 4 PHWR

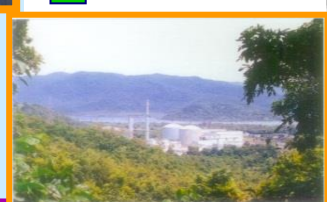
NARORA (UP)
2x 220 MW

RAWATBHATA (RAJ)
1x 200 MW
2 x 220 MW
2 x 220 MW
2× 700MW

KAKRAPAR (GUJ)
2x 220 MW
2 x 700MW



TARAPUR (MAH)
2x 160 MW
2x 540 MW

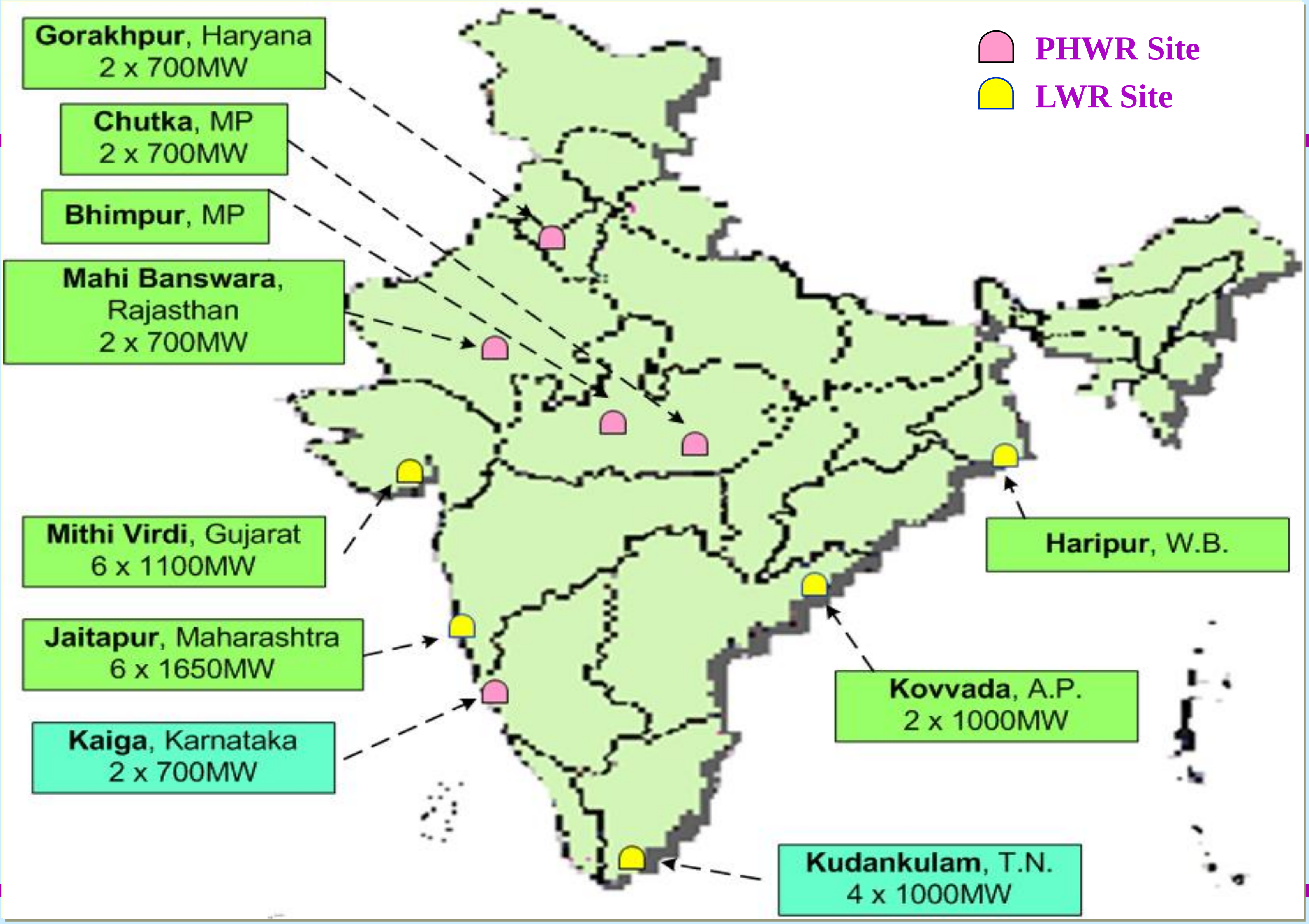


KAIGA (KAR)
4x 220 MW

KALPAKKAM (TN)
2x 220 MW
500 MW (PFBR)

KUDANKULAM (TN)
2x 1000 MW

Sites for Future Projects



Age of the operating reactors

Age		Induction of Reactors	
More than 30 years :	4	After 2002:	6
Between 20 and 30 years :	5	Between 1992-2002:	5
Between 10 and 20 years :	5	Between 1982-1992:	5
Less than 10 years :	6	Between 1972-1982:	1
		Between 1962-1972:	3

On an average of 5 reactors are being inducted in a decade and plans are in place for expanding nuclear base

This calls for strong infrastructure, supporting organizations, research and development and huge investment

With so much investment in nuclear power the safety of the nuclear reactor is of paramount importance.

Atomic Energy Regulatory Board

- Established in 1983, Under Atomic Energy Act 1962
  - ✓ Control of Radioactive Substances
  - ✓ Safety in Nuclear and Radiation Installations
  - ✓ Industrial Safety in DAE Installations

- The Board: Chairman + 4 Members
- Eight Technical Divisions including SRI
- Staff Strength - >400 (Scientific & Technical)

- ISO 9001:2008 Certification for areas:
  - ✓ Consenting Process
  - ✓ Preparation of Regulatory Documents
  - ✓ Regulatory Inspections

Mission of AERB

To ensure the use of ionizing radiation and nuclear energy in India does not cause unacceptable impact on health of workers and the members of the public and on the environment

Compliance/ Enforcement through:

- Codes and Guides
- Granting of Licenses:

  Siting, Construction, Commissioning, Operation, Decommissioning design provisions requirement at the initial approval of the project.

Fukushima Accident Review & Challenges Surfaced

- **Phase I - Review of Plant Conditions**
- Disseminating the accident and unearthing latent weaknesses
- Arriving at a figure for the magnitude of the external events to be considered
- Review of design basis with respect to the revised values of the external events
- Carrying out Stress Tests to evaluate the robustness of the plant /SSCs against external events
- Check for cliff edge effects that may be latent
- Review of the Severe Accident analysis and mitigating measures
- Spent fuel safety during external events of severe nature
- Review of emergency handling at site and at public domain
- Requirement of Radiological emergency situations in a multi unit site
- **Development of regulatory requirements for severe accident management**

Fukushima Accident Review & Challenges Surfaced

- **Phase II – Handling of SAs**
- Provision of preventive and mitigation hardware for Accident Handling
- Aspects of accident handling during a natural disaster when access and resources are restricted
- Communication during accident handling
- Training of manpower with special emphasis on handling stress while handling severe accidents
- Sharing of resources for handling natural emergency
- Stabilising the reactor after accident

- **Phase III – Actions to be taken after coming out of the SA**
- Handling of high active and huge quantities of radioactive waste generated during a severe accident
- Recovery from the after effects of the accident at plant site and at the public domain
- **Restart of other units in a multi unit site ?**

Review Process

External Events - Challenges

- Importance of External Events (EE):

  – Normal practices that enhance the safety of the NPPs – Robust Design (Reliability, Diversity Redundancy, Equipment Qualification etc.)
- EE can be the single common cause leading to failure of redundant systems – Fukushima
- Evaluation of the magnitude of the EEs difficult due to many uncertainties
- External events can trigger secondary phenomena like fire, create inaccessibility, degrade the infrastructure for handling incidents etc.
- Multi unit sites will be affected by the external events simultaneously – Sharing of resources may be helpful but also put stress on handling the events by diversion of attention
- Changes in design basis levels can be expected due to development of advanced models – global conditions, availability of historical data etc.
- Change in the design basis values of external events – impact on the design of the old NPPs.
- Whether Engineering solutions can address the problems fully? – how to evaluate?

Major Identified Actions and their status

- Review of the safety status against perceived external events with review basis levels/ magitudes
  - Strengthening the SSCs against these levels
  - Dry protection preferred against Wet protections
- Provision of hook up arrangements for core cooling, emergency power supply and sources, instrumentation
  - Design based on SA analysis to satisfy minimum requirements
  - Combination of Flexible arrangements with fixed provisions

Protection of Containment Structure (ultimate barrier) against over pressurisation

-H2 Management issues (Analysis, Monitoring, PARs provision etc,.)

- Provision of filtered containment venting system (System Dsig under review)

Interim SAMG in place – operator training, surveillance of systems

Preparation of generic severe accident management guidelines – Prepared under review

Generic Document on Severe Accident Management

- Prior to Fkushima accident, SA analysis were in progress and the process of drawing guidelines was on (Core cooling, disintegration, H2 gen & distribution)
- A generic document on Accident Management for PHWRs has been prepared. Reference documents - IAEA-NS-G-2.15 (SAMP for NPPs)

  -IAEA Tec.Doc 1594 - IAEA Safety reports series no.32

  -IAEA Tec.Doc (under preparation) Coordinated Research Project on benchmarking SAA comp codes
- Objectives and strategies
- Strengths and vulnerabilities of PHWRs (with PSA inputs)
- SA scenario for PHWRs
- Analysis of SA with & without mitigation measures
- Description of SAM measures
- Organisational aspects of AM and integration with Emergency Plans

Formulation of an action plan for handling Severe Accidents

- Identifying events that can lead to severe accident and formulate preventive and mitigation strategy based on severe accident analysis (PRA studies on seismic and fire aspects, PSA level II results)
- Identification of short term and long term measures for handling severe accidents

  - experimental set ups to simulate severe accident progressions,
  - mock ups to prove the minimum acceptable efficiency of proposed mitigating systems
  - identification of long term measures
- Review of the proposals from the point of view of their effectiveness, complexity, interference with normal operation, approach and ease of operation during severe accidents etc.
- Requirement of special qualification for the instruments to be used during the severe accident
- Review of dose to public with the SA mitigation system vs design basis criteria
- Establishment of Hardened Emergency Response/ Control Centre for handling Severe Accident
- Review of the emergency plans and integration with National Emergency Procedures
- **Review of codes and guides**
- Communication during severe accident handling

Review of Regulatory Requirements

- The Safety code on NPP design describes the SA sequences and prescribes requirements to be considered in the design. The containment design requirement includes factoring Severe Accident situations.
- However no set guidelines/ acceptance criteria with respect to Severe Accident Handling in the design has been prescribed (on par with international practices)
- The dose limits to the public prescribed by the siting and design codes set the boundary conditions for design, operation and accident management.
- Post Fukushima Accident, the subject of SAM and its requirement in codes and guides on design, operation and emergency preparedness are being reviewed.
- Dose limits to the general public beyond the exclusion zone area includes dose limits due to possible elevated dose levels for occupation / reoccupation and also accidents in multi unit site. (Dose limit per accident – Life time impact?)

Emergency Handling

- Emergency response procedures have been reviewed. Assessment of emergency and initiating actions based on plant conditions in addition to the prevalent dose criteria are being evolved.
- Indian Real Time On Line Decision Support System based on measuring of radiation levels by array of radiation monitors for calculating source term and formulating emergency action plans are being established.
- Operational Intervention Level Criteria is being established from the plant status assessment. The guides on emergency handling are being revised to include the above criteria.
- Integrated crisis management exercises at the national level with National Disaster Management Agency and Reaction Force carried out with perceived nuclear emergencies
- Design document on Hardened Offsite Emergency Support Centre prepared and their establishment for NPPs at coastal sites taken up at a priority level
- **Regulatory level emergency response centre established with regulators being trained in the emergency response actions** (License in Operation of NPPs)

International Interaction

- Comparison of Indian Nuclear Safety status with other countries through Convention of Nuclear Safety conferences

  - elaborate study and constant updating of status in progress
- Taken part in Convex-3 exercises in communication, identification of areas of international support etc.
- AERB has applied of undergoing the IRRS process of IAEA with special module on Fukushima (concerns SAM)

Session Specific Issues

Type of regulatory controls required (Licensed – Voluntary)

-Training, Equipment Qualification, Inspection

SAM provisions should be prescribed?

- Mobile or hardened onsite

Independent oversight of the technical basis

-mission time, performance

Instrumentation

Involvement of the regulators in emergency handling

- parallel pre-planning

Multi unit sites- Resource sharing

Regulatory Controls on Severe Accident Management

- Nuclear Safety is being improved constantly through generations of NPPs – While the safety principles essentially remain same, the safety objectives may become stringent based on impact on man, environment and history.

  - May call for new requirements

- Study on how the new requirements will impact the older plants will need in-depth study. New requirements may set up bench marks which old NPPs may find difficult to comply with.
- Old NPPs need to have back fits within a restricted frame work
- With increase in sophistication in analytical models predictions have become better which can be translated into design requirements
- The requirement on SAM will keep on evolving. The Regulatory body should keep in pace with the developments

Training Needs on Severe Accident Management

- The SA progression depends on so many factors status of reactors, existing leaks etc. Time scales have varied from prediction.
- The SAM intervention guidelines should be based on identifiable parameters/ time scales.
- The operator intervention should not aggravate the situation nor should there be in-ordiante delay in taking actions
- Operator/ Technical Support Group training in SAM plays a major role in handling SAs

-Training should be holistic. / graded

- Knee jerk reactions should be avoided

-Should be able to interpret the situations

- The mitigation measures should not give a false sense of fulfilment and complacency

- The training should also address the psychological aspects of handling SA

The training needs and conduct of drills should be identified and should be verifiable during Licensing of Operators and Regulatory Inspections

Equipment Qualification and Surveillance

- The environment expected during SA may be harsher than that expected during DBAs.
- The components that are a part of original design and taken credit of during the SA phase for preventive and mitigation measures may experience greater stresses than designed for (e-g) ABDS valves in BWRs, Pressurizer Surge line in PWRs – This aspect has been identified and is being looked into with inputs from SA analysis
- The components of the mitigation systems proposed to handle SA also may experience harsher environment / handle harsher fluids (e-g) H_2 mitigation systems, containment de-pressurization system components etc. – Components Qualification should be addressed.
- Instrumentation – Limited, critical information should be available to decide the follow the progress of the accident and the condition of the reactor – Efforts are to be intensified to identify suitable instruments / methodology to address this requirement
- **Surveillance** on these components will ensure the readiness of the systems designed for handling SA . The surveillance program is being evolved. These will be verified during regulatory inspection.

Option of Using of Mobile or Hardening the Site Equipment

- Hardening the site equipment has the advantage of continued surveillance and maintenance and assurance of readiness
- Portable or mobile equipment though can be parked at some hardened shelters have to be mobilised. Access may be limited.
- **It has to be judicious mix of hardened on site and back up mobile equipment**
- Accordingly the regulation on these aspects also need to be a mix of both prescriptive for hardened on site equipment and guideline based for mobile equipment. But the requirements need to be identified and firmed up as far as possible

Independent Oversight of the Technical Basis for mission time and equipment performance needs

- These are design specific, analysis intense requirements
- Severe Accident Analysis is a specialized subject. Regulatory body intends to utilize the expertise of In- house and Technical Support Organization in this aspect.
- Review groups with a judicial mixture of analysts and operational experts are formed to review these requirements and submissions from the utility

Accident Planning by the Regulatory Body

- The SAMG and the Emergency Plans are reviewed by the regulatory body and hence have a good overview of the emergency actions
- The regulatory body staff are also trained in emergency handling in a broad way and are expected to have a good understanding (limited role in accident management measures in the present set up)
- The off-site emergency response falls in the domain of state authorities with team of experts helping in directing the course of emergency actions
- The regulatory body has identified experts within the organization to monitor the emergency situation.

Accident Handling in Multi Unit Sites

- Simultaneous accident in Multi unit sites will put a lot of strain in handling accidents.
- The dose prediction for multi unit sites is being worked out and probably would be the guiding factor in the handling of severe accidents
- Sharing of resources would be possible and was proved beneficial in Unit 5 and 6 of Fukushima
- There should be an action plan in deciding the infrastructure/ resources for accident management which should be acceptable based on the risk involved.
- The requirement of infrastructure and the capacity of the handling equipment were reviewed and the arrangement was arrived at as an initial / essential requirement
- The above will be reviewed based on the generic severe accident management guidelines and the plant specific AM guidelines which are being prepared.

Conclusion

- We learn lessons from accidents – TMI, Chernobyl and formulate action plans based on experience.
- India - learnt lessons from incidents national and international (Narora , Kalpakkam)
- The industry was concentrating on so many things (technology improvement / human and organisational aspects etc.)
- The Fukushima accident came and the industry was forced to turn its attention back to the basics. We will surely address these and go ahead.
- But there may be a new situation/ challenge thrown up at us as a surprise
- Are we ready to face those situations? Can we think of other scenarios and prepare?
- The outcome of these efforts should be translated into sound practices, easy to understand and executable programs as the operator at the controls will be under great stress. He should be trained to be resourceful and adaptive to situations.
- **The Public Confidence on Nuclear Industry Should Not be Allowed to be Eroded**

Thank You