

# **Accident Management Programme for Indian Pressurized Heavy Water Reactors**

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# Presentation Contents

- **Indian nuclear power programme**
- **Operation experience feedback**
- **Safety upgrades in Indian PHWRs**
- **Accident management guidelines for Indian PHWRs**

# Indian Nuclear Power Programme



Operating Units

18 PHWRs  
2 BWRs

4680 MW



Units under  
Commissioning

2 VVERs

2000 MW



Units under  
Construction

4 PHWRs

2800 MW

# Operation Experience Feedback

- An established OEF mechanism in the country
- Reviews and safety upgrades carried out post TMI-2 and Chernobyl-4 accidents
- Accident management programme was under finalization at the time of Fukushima accident
- Appropriate feedback from Fukushima accident and outcome of safety review post Fukushima were accounted in the accident management programme
- Safety review post Fukushima focused on
  - Unavailability of designed power supplies
  - Unavailability of designed water sources
- This presentation is on Indian Pressurized Heavy Water Reactors (PHWRs)

# PHWRs: Safety Upgrades

- PHWRs by design have large water heat sinks around the core, which can slow down accident progression and delay core damage
  - 'Preventive' measures are further augmented
  - 'Mitigating' measures are introduced
- To implement these preventive and mitigating measures, actions were categorized into short term, medium term and long term

# PHWRs: Safety Upgrades

## ▪ Identified safety upgrade measures

### Short Term

- Installation of external hook up points for addition of water to plant systems and spent fuel bay.
- Provision of additional emergency lighting
- Emergency Operating Procedure (for SBO) reviewed and revised for all Indian nuclear power plants
- Training and mock-up exercises of operating personnel completed

# PHWRs: Safety Upgrades

## ▪ Identified safety upgrade measures

### Medium Term

- Introduction of seismic trip in NPPs where it does not exist
- Provision of additional backup DGs (air cooled mobile/installed at higher elevation)
- Strengthening provision for monitoring of critical parameters under prolonged loss of power
- Provision of diesel driven pumps for transfer of water from deaerator storage tank to steam generators
- Additional mobile pumps and fire tenders
- Augmentation of onsite water storage, wherever required

# PHWRs: Safety Upgrades

- **Identified safety upgrade measures**

Long Term

- **Strengthening hydrogen management provisions**
- **Provision for venting of containment**
- **Creation of an On-site Emergency Support Centre capable of withstanding severe flood, cyclone and earthquake**



# PHWRs: Safety Upgrades

- **Selected plant systems provided with ‘hook-up’ arrangements, from where water can be supplied for cooling. These hook-ups are in addition to the water backup existing in the design**
  - **from outside reactor building**
  - **Independent of station power supplies**
- **Hook-ups also include spent fuel storage pools**
- **Hook-ups for plant systems are completed at all PHWR units**

# PHWRs: Safety Upgrades

- Hook-ups to selected plant systems



# PHWRs: Safety Upgrades

- **Station power supplies**
  - **Off-site (grid)**
  - **On-site emergency diesel generators**
  - **Battery backup**
  
- **Further augmented**
  - **Mobile air cooled diesel generators**
  - **Fixed air cooled diesel generator**



# PHWRs: Safety Upgrades

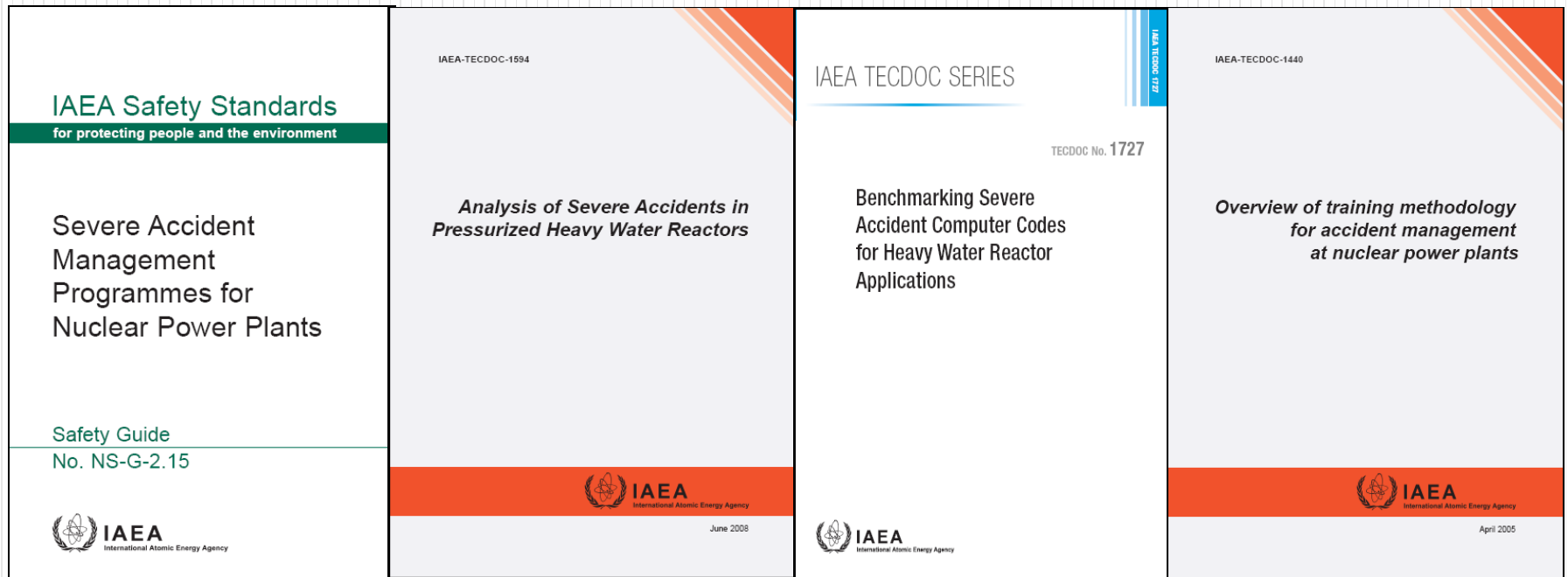
- **Station water sources**
  - Secured water storage for seven days decay heat removal
  - Basins of cooling towers
  - Different storage tanks
- **Further augmented**
  - From nearby water bodies
  - Bore holes
  - Transportation by fire tankers/ fire tenders

# PHWRs: Safety Upgrades

- **Hydrogen management**
  - **Passive hydrogen recombiners**
  - **Containment filtered venting system**
- **On-site emergency support centre at each site**
  - **Robust structure, much above anticipated flood level**
  - **Shielded building**
  - **Survival ventilation**
  - **Independent power supply**
  - **Plant data and information available**
  - **Self sufficient for extended stay of essential personnel**

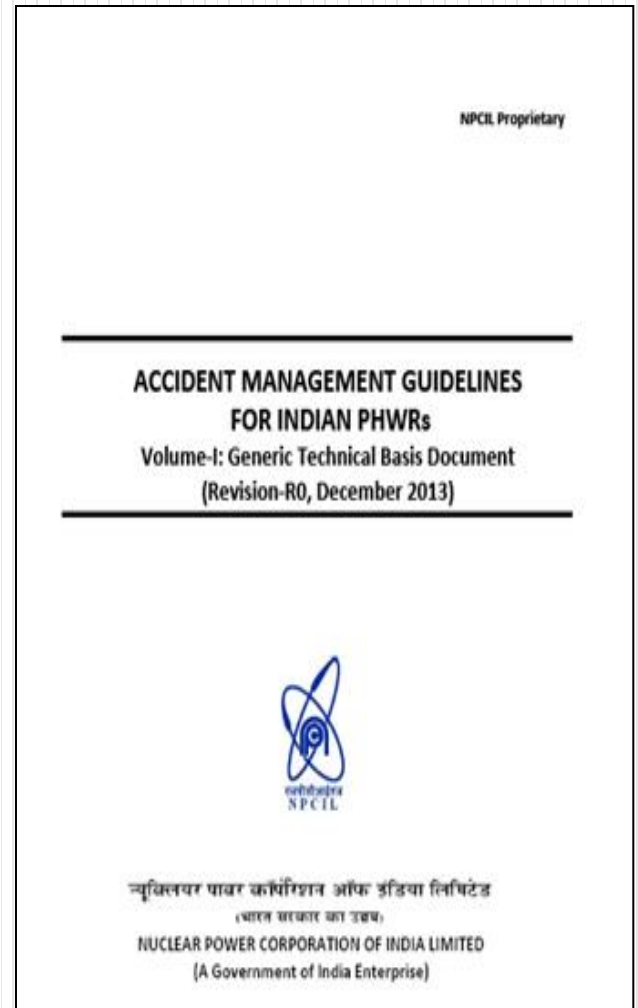
# PHWRs: Accident Management Guidelines

- Stations are having interim document for handling beyond design basis events, covering both preventive and mitigating guidelines
- Generic accident management guidelines have been made available to all stations, and are being converted into final station specific accident management guidelines



# PHWRs: Accident Management Guidelines

- **Design basis of generic accident management guidelines**
  - **Technical basis document, that can be used as training resource**
  - **Analysis of severe accident scenario**
  - **Design basis of SSCs considered in accident management**
  - **Basis of actions in guidelines**
  - **Basis for computational aids**
  - **Basis for surveillance and functional tests of SSCs considered in accident management**



# PHWRs: Accident Management Guidelines

## ■ Training

- All licensed and qualified station personnel covered in training, including station management
- Training module designed based on SAT
- Graded training
- Class room training with plant walk downs
- Discussion on scenario and escalation of accident, as part of table top exercise
- In general on-site actions are rehearsed –off-site emergency programme have different agencies and actions – severe accident scenario can be rehearsed with off-site emergency exercise
- Frequency of training in line with licensing renewal



# PHWRs: Accident Management Guidelines

- **Surveillance and Functional Testing**
  - **Surveillance testing methodology and frequency specified for individual equipment**
  - **Functional testing methodology and frequency specified for the systems**
  - **Equipment storage in secured location**
  - **Drills to arrange water / diesel oil**
  - **Monitoring of important plant parameters**

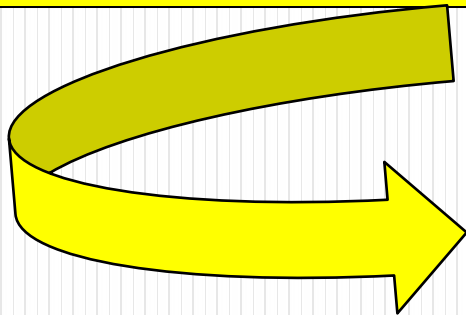
# PHWRs: Testing of hook-ups



# PHWRs: Accident Management Guidelines

## **IAEA NS G 2.15**

**"The capabilities of plant personnel to contribute to unconventional measures to mitigate plant vulnerabilities, including the behaviour and reliability of personnel under adverse environmental conditions, should also be investigated. Where necessary, protective measures should be provided and training should be specified for the execution of such tasks. It should be noted that work that poses risks to the health or even the life of plant personnel is always voluntary in nature and can never be demanded of the individual; the guidance should be developed accordingly".**

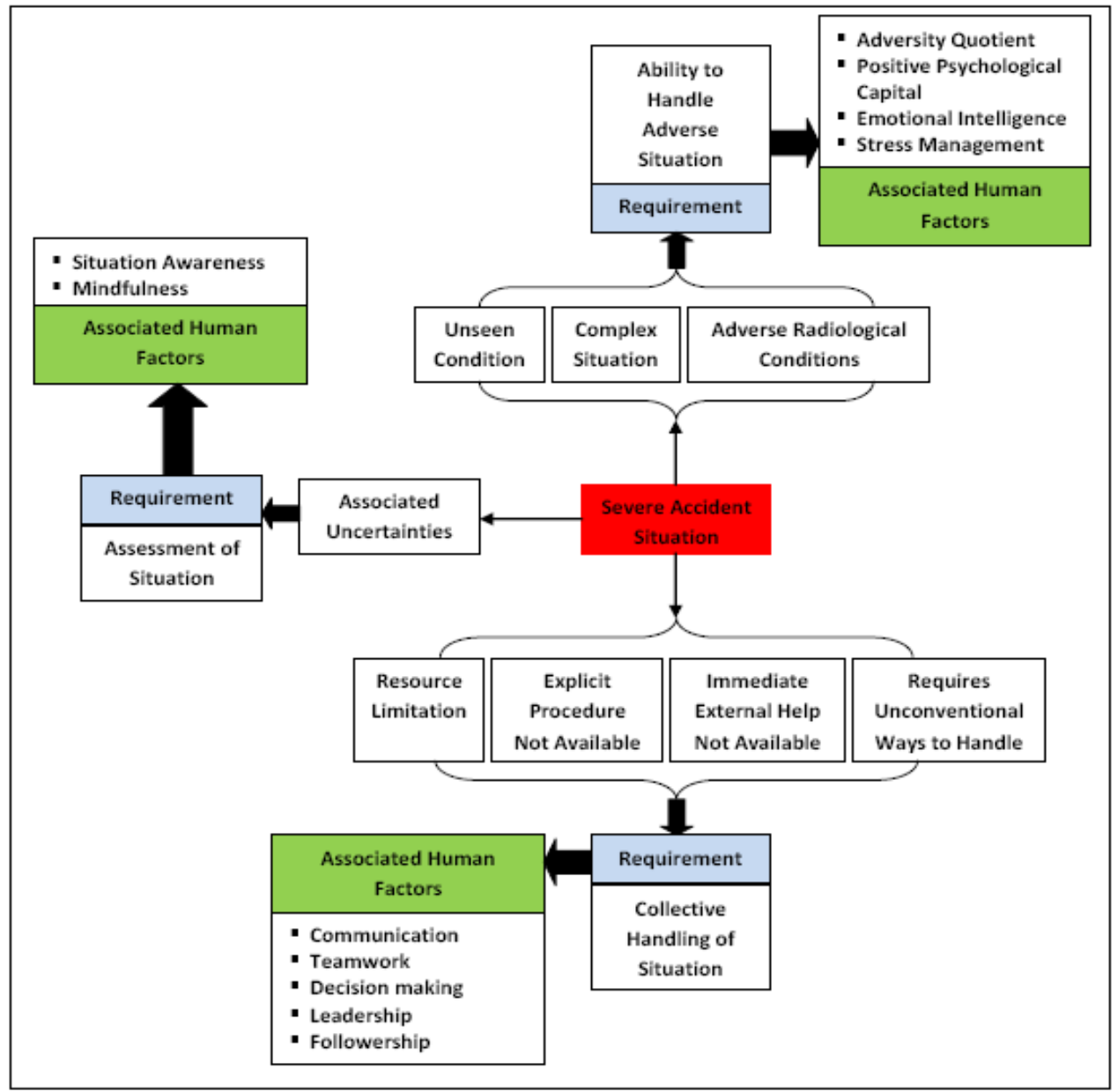


**Training includes consideration of 'human factors' under anticipated adverse situations**

# PHWRs: Accident Management Guidelines

## 'Human Factors' model

- Situation Awareness
- Mindfulness
- Adversity Quotient
- Positive Psychological Capital
- Emotional Intelligence
- Stress Management
- Communication
- Teamwork
- Decision Making
- Leadership and Followership



# Knowledge Sharing

- **Knowledge sharing regarding effective implementation of SAMGs**
  - **Technical meetings**
  - **Workshops dedicated to reactor types**
  - **TECDOCs**

# Conclusions

- **Defined accident management programme for Indian PHWRs is in place**
- **Hardware to implement guidelines are made available at NPPs, some long term items are under progress**
- **Accident management guidelines are available**
- **Training in place for accident management programme**
- **Surveillance and functional testing programme is established for equipment and systems required for accident management**

**Thank you for attention**