Government of India

STATUS OF POST FUKUSHIMA IDENTIFIED SAFETY ENHANCEMENT OF INDIAN NPPs

Atomic Energy Regulatory Board
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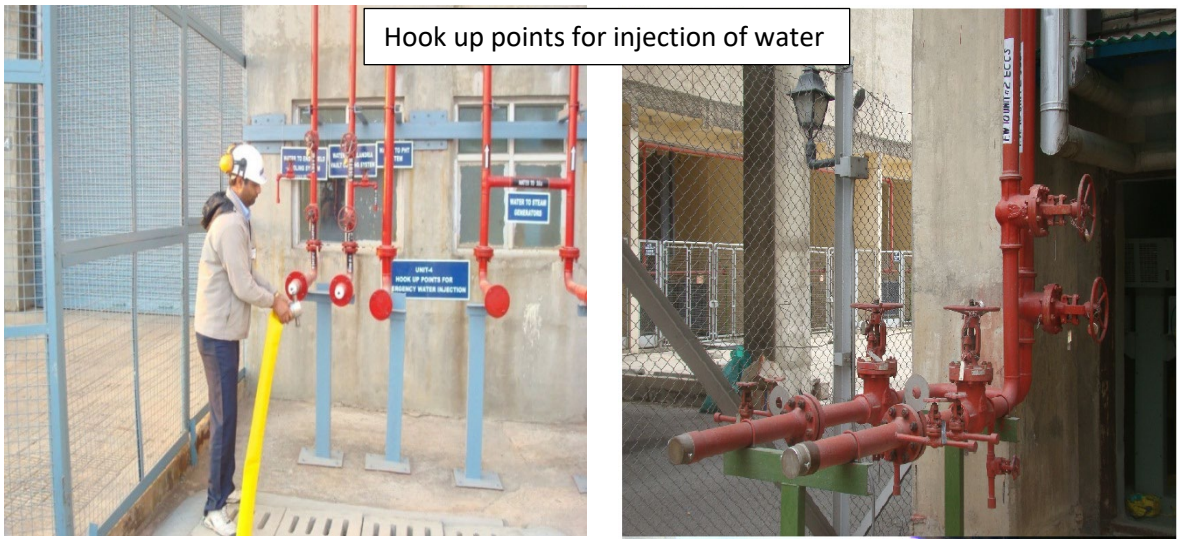
March 2023

Immediately after the accident at Fukushima Daiichi NPPs, safety re-assessment of all Indian NPPs was carried out by AERB and NPCIL to assess capabilities of Indian NPPs to withstand currently defined levels of external events and to deal with the extreme external events. The findings of both AERB and NPCIL reviews have reconfirmed the inherent strengths in design, practices and safety regulation followed in India. However, based on the assessment, certain safety enhancements were identified for strengthening the defences against the extreme external events and enhancing severe accident mitigation capabilities. The identified safety enhancements were classified as short term, medium term and long-term measures taking account of aspects such as feasibility for implementation, need for assessments/analysis/development, engineering & procurement and scheduling of planned outages for implementation. Implementation of the short term and medium-term safety enhancements have been completed. The severe accident management guidelines for different operating NPPs were developed based on technical bases reviewed & accepted by AERB and are now in place at all operating NPPs. The activities related to R&D, engineering, testing & qualification related to the remaining long-term enhancements have been completed and their on-site implementation is now in progress. These safety enhancements have been made part of the regulatory requirements for new NPPs. Complete implementation of these safety enhancements is no longer a challenge.

Progress of implementation of pending enhancement is being followed up by AERB through regulatory instruments such as safety review & assessment, licensing and regulatory inspections. Current status of identified safety enhancement is as below:

Short Term Safety Enhancements (completed)

- **External hook up connection for addition of water to safety systems such as Steam Generator, Primary Heat Transport (PHT) System, End-shield, Calandria, Calandria vault and Spent Fuel Bay**



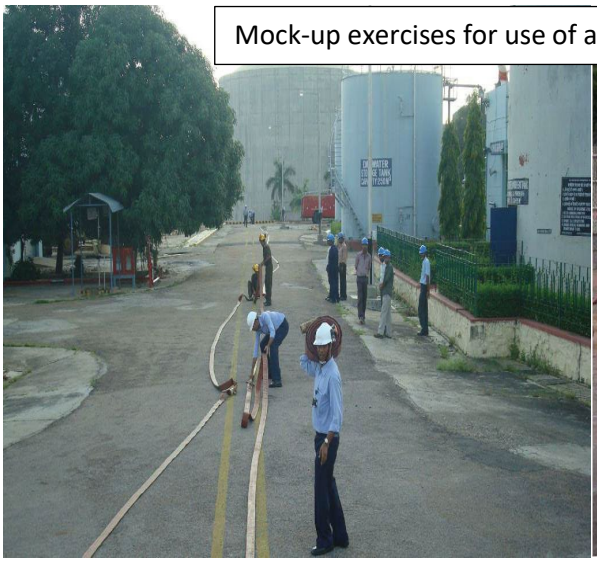
Hook up points for injection of water

- **Provision of emergency lighting backed up by solar cells**

Solar powered emergency lighting

- **Training and mock-up exercises of operating personnel**

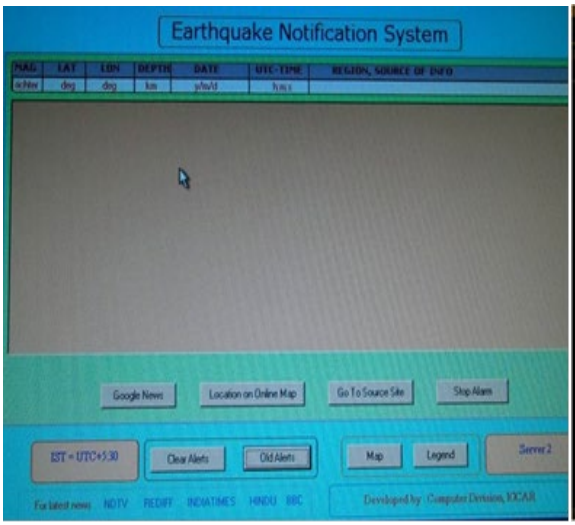
Mock-up exercises for use of accident management measures



- **Review and revision of Emergency Operating Procedures (EOPs) for handling the accident condition**

Medium Term Safety Enhancement (completed)

❖ Introduction of automatic reactor trip on seismic event



❖ Provision of additional backup Diesel Generators (air cooled mobile / fixed at higher elevation)

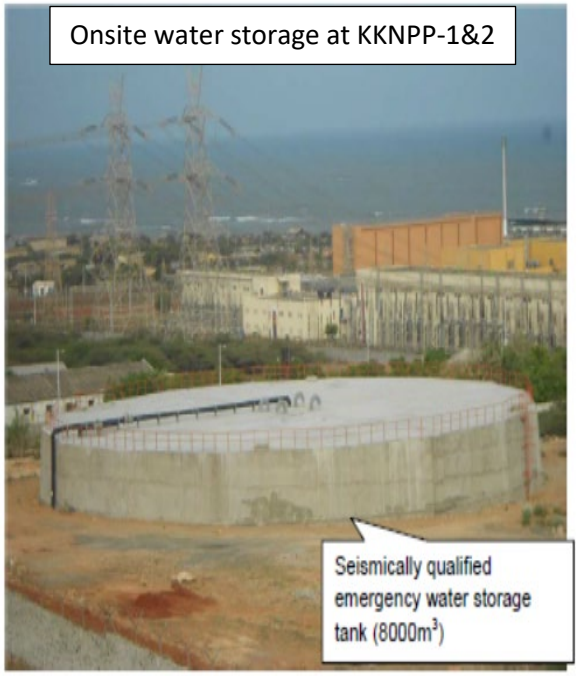
Mobile Diesel Generator

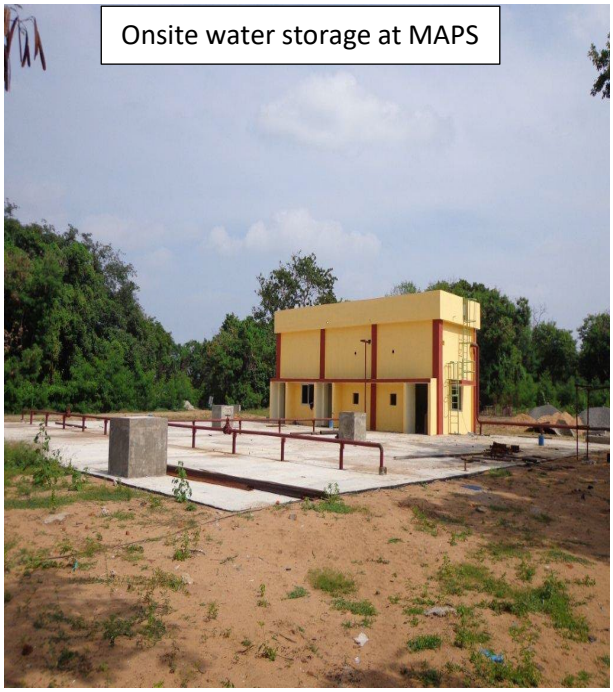
Fixed Diesel Generator

Diesel generator and its auxiliaries at higher elevation

- **Additional mobile pumps and fire tenders**

- **Augmentation of onsite water storage in seismically qualified tanks**



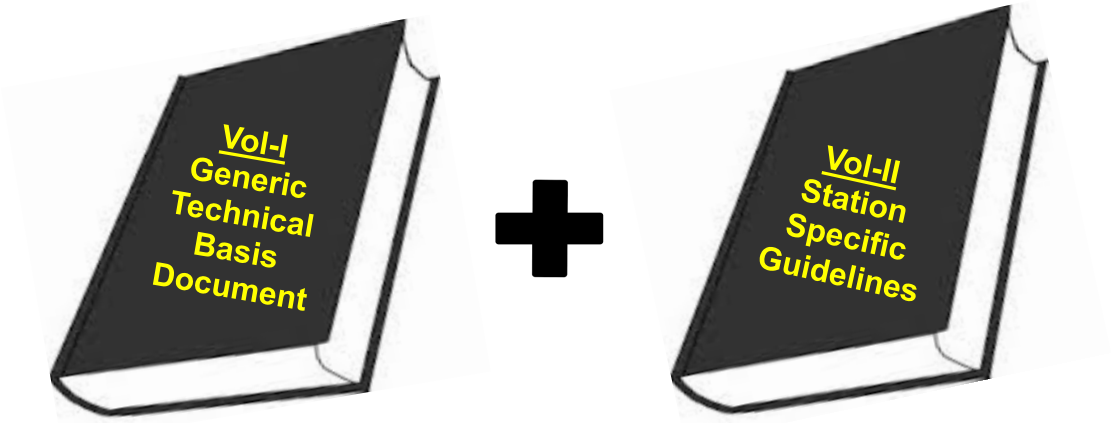


- **Strengthening provision for monitoring of critical parameter under prolonged loss of power**

- **Provision of diesel driven pumps for transfer of water from deaerator storage tank to steam generators**

Long Term Safety Enhancement (in progress)

❖ **Enhancement of Severe Accident Management programme:**
The severe accident management guidelines for PHWR, BWR and PWR have been developed based on technical bases reviewed and accepted by AERB. Accident Management Guidelines developed based on these have been implemented at all the operating NPPs, including implementation of the necessary hardware enhancements, training of the operating personnel, mock up tests and periodic surveillance. In addition to regular drills on utilising accident management provisions, exercises are being conducted at all stations. Apart from this, table top exercises are being carried out linking on-site accident management actions with off-site actions making use of decision support system.



Common to all stations **Station Specific**

❖ **Provision of Containment Filtered Venting System (CFVS):**
Technology development of CFVS has been completed and detailed engineering of the system has been finalized after analysis and testing. CFVS has been installed in TAPS-1&2 (BWR). Installation of CFVS is in progress in PHWR based NPPs, where the requirement has been envisaged.

❖ **Strengthening Hydrogen Management Provisions:**

The hydrogen management scheme in Indian PHWRs includes provision of suitable number of Passive Catalytic Recombiner Devices (PCRD) along with provisions for homogenizing the containment atmosphere and maintenance of the inert steam atmosphere. Installation of PCRDs and implementation of automatic provision for maintenance of the inert steam atmosphere inside primary containment have been completed in all operating PHWRs. Installation of equipment and instrument of Post-Accident Hydrogen Management System (PAHMS) is in progress. For the PWR units of KKNPP-1&2, the Passive Autocatalytic Recombiners (PARs) for hydrogen management are already incorporated as part of the design. In TAPS-1&2, containment inerting system has been indigenously refurbished and the refurbished system is put in operation.

Installed PCRD in containment

Containment Inerting System at TAPS-1&2

- **Creation of On-Site Emergency Support Centre (OESC):**
  AERB has framed requirements and guidelines for establishing On-Site Emergency Support Centres (OESCs) at all NPPs, which takes into account the NPPs at the given site and the accident scenarios. OESCs are designed to remain functional under radiological conditions following a severe accident and should be capable of withstanding extreme external events (flood, cyclone, earthquake, etc.). These facilities will be in addition to the existing emergency control centres. After regulatory approvals, construction of the OESCs at all NPP sites is in progress.

OESC construction at KAPS site

OESC construction at KGS site

Emergency Preparedness and Response

AERB is currently in the process of consolidating & revising its requirements and guidance for Emergency Preparedness & Response, which are addressed in a number of documents and were developed in different timelines over many years. As a step towards holistic revision, the existing requirements are being consolidated/updated through a dedicated safety code and safety guides for management of nuclear and radiological emergencies. Safety code and guides for EPR are being developed taking into account existing EPR requirements, developments including the change in approach to public protection during emergency conditions as elaborated in ICRP publications, IAEA General Safety Requirements, lessons learned from the accident at Fukushima Daiichi NPP. Towards this, Safety Code on 'Management of Nuclear and Radiological Emergencies' has been issued and safety guide are in advance stage of preparation.

In the wake of accident at Fukushima Daiichi NPPs, a comprehensive review of the emergency preparedness and response plans, infrastructure required and the roles & responsibilities of the agencies involved in emergency response was carried out. In order to address the various aspects such as early phase decision making, capability for providing technical support / response in accordance to phases of emergency, co-ordination among response agencies and effective testing of preparedness, AERB has developed various technical documents covering guidance for preparing plant specific

emergency action levels (EAL), formulating a protections strategy, template for EPR plan with a revised response framework and new methodology for conduct of off-site emergency exercise. AERB has approved the revised overall framework for off-site emergency exercises taking into consideration the feedback from conduct of exercises with new methodologies and stakeholder consultation. As per revised framework, following exercises are to be conducted to check the EPR plans.

S. No.	Type of Exercise	Objective
1.	Table Top Exercise (TT)	To check the decision-making capability / response of plant personnel & management
2.	Integrated Command Control and Response (ICCR)Exercise	Testing of command control functions, operation of response facilities, early warning & field response in realistic environment, inter-agency co-ordination, communication and preparing public information
3.	Field Exercise and Demonstration (FED)	To check resources according to required field response and demonstrating relevant protective measures in public domain

Revision of Regulatory Requirements

In parallel to safety enhancement, AERB carried out review of its existing regulatory documents with regard to the lessons learned from the accident at Fukushima Daiichi NPPs. Based on this review, AERB is progressively revising the identified documents, as per its established process, for incorporating the lessons learned from the accident at Fukushima Daiichi NPPs, as well as to take account of the aspect in the latest IAEA documents. AERB has issued the Safety Code on 'Site Evaluation of Nuclear Facilities' 'Design of Light Water Reactor based NPPs' and Safety Code 'Management of Nuclear and Radiological Emergencies', which are in line with the latest requirements specified in the IAEA documents and incorporate the lessons learned from the accident at Fukushima Daiichi NPP. Thus, the requirements are in place for all the reactor technologies which India intends to deploy.