

GUIDE NO. AERB/NPP/SG/S-8



GOVERNMENT OF INDIA

GUIDE NO. AERB/NPP/SG/S-8

AERB SAFETY GUIDE

**SITE CONSIDERATIONS
OF
NUCLEAR POWER PLANTS
FOR
OFF-SITE EMERGENCY PREPAREDNESS**



ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY GUIDE NO. AERB/NPP/SG/S-8

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FOR
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**Atomic Energy Regulatory Board
Mumbai-400 094
India**

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Price

Orders for this guide should be addressed to:

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FOREWORD

Activities concerning the establishment and utilisation of nuclear facilities and the use of radioactive sources are to be carried out in India in accordance with the provisions of the Atomic Energy Act 1962. In pursuance of the objective to ensure safety of members of the public and occupational workers as well as the protection of environment, the Atomic Energy Regulatory Board has been entrusted with the responsibility of laying down safety standards and framing rules and regulations for such activities. The Board has, therefore, undertaken a programme of developing safety standards, codes of practice and related guides and manuals for the purpose. While some of these documents cover aspects such as siting, design, construction, operation, quality assurance and decommissioning of nuclear and radiation facilities, other documents cover regulation aspects of these facilities.

Codes of practice and safety standards are formulated on the basis of internationally accepted safety criteria for design, construction and operation of specific equipment, systems, structures and components of nuclear and radiation facilities. Safety codes establish the objectives and set minimum requirements that shall be fulfilled to provide adequate assurance for safety. Safety guides elaborate various requirements and furnish approaches for their implementation. Safety manuals deal with specific topics and contain detailed scientific and technical information on the topic. These documents are prepared by experts in the relevant fields and are extensively reviewed by advisory committees of the Board before they are published. The documents are revised when necessary, in the light of experience and feedback from users as well as new developments in the field.

The code of practice on 'Safety in Nuclear Power Plant Siting (AERB/SC/S)' states the minimum requirements to be met during siting of nuclear power plants in India. This safety guide provides guidance on siting considerations for off-site emergency preparedness of nuclear power plants for implementing the relevant parts of the code.

Consistent with the accepted practice, 'shall', 'should' and 'may' are used in the guide to distinguish between a firm requirement, a recommendation and a desirable option, respectively. Bibliography and list of applicants are included to provide information that might be helpful to the user. Approaches for implementation different to those set out in the guide may be acceptable, if they provide comparable assurance against undue risk to the health and safety of the occupational workers and the general public, and the protection of the environment.

For aspects not covered in this guide, applicable and acceptable national and international standards, codes and guides should be followed. Non-radiological aspects of industrial safety and environmental protection are not explicitly considered. Industrial safety is to be ensured through compliance with the applicable provisions of the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996.

This guide has been prepared by specialists in the field drawn from Atomic Energy Regulatory Board, Bhabha Atomic Research Center, Nuclear Power Corporation of India Limited and other consultants. It has been reviewed by the relevant AERB Committee on Codes and Guides and the Advisory Committee on Nuclear Safety.

AERB wishes to thank all individuals and organisations, who have prepared and reviewed the draft and helped in its finalisation. The list of persons, who have participated in this task, along with their affiliations, is included for information.

A handwritten signature in black ink, appearing to be 'S.K. Sharma', written in a cursive style.

(S.K.Sharma)
Chairman, AERB

DEFINITIONS

Atomic Energy Regulatory Board (AERB)

A national authority designated by the Government of India having the legal authority for issuing regulatory consent for various activities related to the nuclear and radiation facility and to perform safety and regulatory functions including enforcement for the protection of the site personnel, the public and the environment from undue radiation hazards.

Avertable Dose

The dose that could be prevented if a countermeasure or set of countermeasures was (were) to be applied.

Countermeasures

An action aimed at alleviating or mitigating the consequences of accidental release of radioactive material into the environment.

Design Basis Accidents (DBAs)

A set of postulated accidents which are analysed to arrive at conservative limits on pressure, temperature and other parameters which are then used to set specifications that must be met by plant structures, systems and components, and fission product barriers.

Emergency

A situation which endangers or is likely to endanger safety of the site personnel, the nuclear/radiation facility or the public and the environment.

Emergency Plan

A set of procedures to be implemented in the event of an emergency.

Emergency Planning Zone (EPZ)

The zone defined around the plant upto 16 km radius providing a basic geographic framework for decision making on implementing measures as part of a graded response in the event of an off-site emergency.

Emergency Shelters

Rooms/buildings where personnel can be sheltered during emergencies.

Evacuation

The temporary removal of persons from locations where dose rates or projected doses arising in an emergency situation are unacceptably high, or where the avertable dose exceeds the relevant intervention level.

Intervention Level

A level of avertable dose at which a specific protective or remedial action is taken in an emergency or chronic exposure situation.

Nuclear Power Plant (NPP)

A nuclear reactor or group of reactors together with all the associated structures, systems, equipment and components necessary for safe generation of electricity.

Nuclear Safety

The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of site personnel, the public and the environment from undue radiation hazards.

Off-site Emergency

Accident condition/emergency situation involving excessive release of radioactive materials/hazardous chemicals from the plant to the public domain calling for intervention.

Prophylaxis

The intake of specific stable chemical compounds which have a reducing or blocking effect on uptake of certain radionuclides, e.g., the use of stable Potassium Iodide (KI) or Potassium Iodate (KIO_3) to reduce the uptake of radionuclides (particularly I-131) in thyroid gland.

Relocation (Off-site Emergency)

The removal of members of public from their homes, for an extended period or time, as a protective action in a chronic exposure situation.

Site

The area containing the facility defined by a boundary and under effective control of facility management.

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1. INTRODUCTION

1.1 General

Nuclear power plants (NPPs) are designed, constructed, commissioned and operated in conformity with nuclear safety standards. During the operating life of these plants, prevention, control and mitigation of various postulated accidents have been considered which form the design basis [1]. Further, every NPP is also required to formulate comprehensive emergency plans which will help ensure public safety during those low frequency events which will have a significant radiological impact in public domain. These plans should provide for appropriate action, by way of protective measures [2], for implementation in proper time so that radiation exposures to members of the general public would remain within the intervention levels specified by the regulatory body.

1.2 Objective

The purpose of the present guide is to highlight the relevant site features that have a bearing on the various protective measures that may need to be initiated following an off-site emergency condition. It describes the principal site related provisions to facilitate carrying out emergency plan action to restrict population exposures in such a case.

1.3 Scope

The guide deals with parameters which influence the implementation of off-site emergency plans if such plans are required to be implemented during the life time of the nuclear power plants. In general, there are several desirable features for a site for locating an NPP, which can simplify the emergency plans. The guide is applicable to land based nuclear power plants and covers aspects such as advance projection of environmental radiation levels, quick assessment of radiological status, issue of prompt warning to the general public regarding the protective measures like intake of prophylaxis, sheltering, evacuation etc., if needed, and the effective implementation of such measures.

2. DATA REQUIREMENTS

2.1 General

2.1.1 Population Data

As the emergency plans are directed principally towards protection of the general population from avoidable exposures to radiation, demographic data about the site and its immediate neighborhood assume importance. Sites with low population densities are to be preferred. It is expected that population data upto a radial distance of 30 km would have been collected as indicated in the safety guide titled 'Population Distribution and Analysis in Relation to Siting of Nuclear Power Plants' [10] which stipulates inclusion of data on both permanent and temporary population. Population data should be based on the latest available census information prior to and during operating life of the NPP, and should be updated periodically. Full details of population distribution sector wise (16 sectors of 22.5 degrees in EPZ) should be obtained. Population data should also take into account all people employed at site including construction workers, if any.

2.1.2 Land Use and Water Use

Information on agricultural produce, dairy products, grazing grounds etc. and location and amount of water including ground water used for drinking, industrial and agricultural purposes, dietary and dwelling habits of population, fishing and hobbies like swimming etc. should be collected. These data are required to establish the limiting discharge rate for radioactive effluents into surface waters, and for effective monitoring and implementation of countermeasures.

2.1.3 Maintenance and Updating of Data

With regard to emergency plan it is necessary that all related data is collected in a timely manner in a form that is readily retrievable. It is also necessary that the data which are liable to change during operating life of NPP, such as population, land use etc. should be regularly updated.

2.2 Availability of State Government Machinery

The responsibility for declaration of an emergency vests with the Off-site Emergency Director. The state government personnel are expected to carry out the task of communicating the decisions on countermeasures along with necessary instructions to the general public. Information on the evacuation routes, communication facilities, buildings for sheltering etc. within the EPZ is needed for effective planning of this task. The tasks of public announcements and regulation of access to and from EPZ are to be distributed among different

government agencies as per the responsibilities identified in emergency plans. If there are limited facilities present within the EPZ and outside EPZ, action would have to be taken to identify/augment these facilities, by quick deployment of personnel.

2.3 Sheltering

2.3.1 Data on Types of Residential Dwellings

Sheltering is one of the first steps to be taken to protect the population from avoidable exposure to radiation in the event of environmental release of radioactive substances in accidents. The effectiveness of this measure depends on the type of the dwellings in the neighborhood. Information should be collected regarding the type of residential houses and public buildings existing in the emergency planning zone (EPZ). More specifically information should be available as to whether the houses and public buildings are of concrete, brick or mud structures, whether they have doors and windows with shutters and whether their roofs are of concrete slabs or tiles or are of the thatched type. A survey of pucca buildings in the EPZ, whether used for residential/commercial purposes or meant for public purposes, their exact locations, areas, amenities available etc. should be undertaken and the data is to be used to determine ways and means to direct people to these shelters if required during an off-site emergency. The designation of such areas as emergency shelter will need prior arrangements.

2.3.2 Public Institutions within EPZ

The demographic data for the site should also include details of sensitive population from hospitals and nursing homes, orphanages and old age homes, schools and other educational institutions, temples and other places of worship, archaeological sites, hotels and tourist resorts, fair sites as well as prisons present in the EPZ. The data is important for drawing up plans for sheltering and/or evacuation, should the situation warrant such an action.

2.3.3 Floating Population

Besides the statistics on the population permanently resident in the EPZ, information should also be available on seasonal variations in the populations. Such variations could occur for a variety of reasons. Movement of agricultural labourers seeking work during harvest seasons occurs in many parts of the country. Various types of festivals, church fairs and darga anniversaries attract visitors from far and wide. While these outside visitors are likely to spend no more than a few days, their presence influences availability of public facilities. Hence data on dates of festivals, location and estimation of population the festival attracts, duration of the festival etc. should be available and updated.

2.4 Medical Facilities (Prophylaxis)

Prophylaxis forms one of the protective measures to be considered when radioactive isotopes of iodine are suspected to be present in the environmental releases following an off-site emergency. It calls for distribution of potassium iodide tablets of prescribed dosage to those sections of the population present in the downwind direction. Since early administration of the prophylactic is the key to its effectiveness, to facilitate distribution, the tablets in required numbers shall be stored in multiple locations within the EPZ, preferably in primary health centres (PHCs), hospitals and other health care facilities or other similar organisations of the district. Administration of these tablets should be done under proper medical supervision. Information should be collected on the locations of the PHCs within the EPZ, along with details of staff employed there.

2.5 Cattle Population

Data on cattle population in rural areas is another input in the preparation of emergency plans for nuclear power plants. Cattle milk forms an intermediate pathway in the ingestion route for children. In situations where radioactive iodine is present in the environment at levels likely to cause undue thyroid exposure by the ingestion route, bringing uncontaminated cattle fodder and milk from outside the EPZ should be planned. Information should therefore be gathered about the possible alternative sources of stored or fresh uncontaminated fodder and the time frame of its availability, bearing in mind the quantities that could be required.

2.6 Evacuation

2.6.1 General

Evacuation of the population inevitably involves some disruption of normal life. It is therefore a protective measure generally to be considered only as a final means of minimising exposures to individual member of public.

2.6.2 Road and Railway Network in EPZ

Information on the accessibility, by motorable roads, canals or other possible routes of all the villages in the EPZ needs to be collected. The viability of such access needs to be assessed in different seasons with particular attention given to the monsoon periods, when rivers in the country may be in spate. Alternative routes need to be identified in the event of non-availability of culverts, bridges or other tracks.

2.6.3 Transport Facilities

The following should be considered for transport:

- Bus depots in the vicinity of the NPP and the availability of public buses in required numbers for evacuation at short notices.
- Locations for assembly of these buses before proceeding to the various villages on the evacuation mission.
- Adequate measures for evacuation of cattle along with the people.
- Where it is proposed to requisition other private vehicles for completion of evacuation of men and cattle, the mode and means of communication with the agencies that could provide the vehicles should be identified.
- Requirements for prompt and precise briefing of the crew of the buses and other vehicles.

2.6.4 Shelters Outside the EPZ

Availability of suitable shelters for temporary relocation of the population being moved out of the EPZ is an aspect that could be kept in view for implementing evacuation as a protective measure. The emergency plans should be anticipative in character and consider the need to initiate evacuation action at the appropriate point of time. Besides shelter, resources for other essential amenities such as food and medical attention should also be available at these locations.

3. FACILITIES FOR OFF-SITE EMERGENCY MONITORING AND CLEAN-UP OPERATIONS

3.1 Meteorological Features and Data for Dose Projection

With information available about the site meteorological features, possible atmospheric dispersion/deposition characteristics, aspects of the plant design and anticipated releases of different radionuclides during the off-site emergency, environmental radiation levels can be estimated. Each NPP should also establish the needed facilities to continuously monitor the wind and weather conditions and to obtain dose projections in the public domain that could form the basis for determining the suitable protective measures. This calls for provisions for constant telemetering of weather information from the local meteorological station to the emergency control centre. Provisions should also be available for establishing the source term for the release either by actual measurement or through correlation of data transmitted from a detector network around the site. Such a network of detectors shall be set up to obtain environmental radiation levels due to normal operation of the plant as well as in emergencies. In the case of sites with complex terrain, sufficient attention should be given to achieve reasonable accuracy for inverse calculation of the source term from measured levels at a distance from the point of release.

3.2 Quick Assessment by Aerial Survey

Techniques are now available for rapid survey of the EPZ with airborne radiation detectors for obtaining precise estimates of the spatial spread of the contamination consequent to environmental releases in an accident. Modalities for interaction with the relevant wings of state government and central government should be established by the NPP for quick deployment of aircrafts fitted out with the detectors for aerial surveys. It may be necessary to rely on estimates of environmental doses from dose projection algorithms until results from the aerial survey become available.

3.3 Facilities for Environmental Sample Analysis

Large numbers of environmental samples would also need to be collected and analysed following accidental releases to the environment. Availability of instruments/ equipment and personnel for monitoring and analysis on a large scale is required to be ensured. It is important that the location for carrying out these operations is well outside the contaminated area and should be free from background interference for reliable results. This requirement becomes significant in cases where the environmental survey laboratory attached to the NPP is situated at or within the boundary of the exclusion zone itself. In addition mobile environmental survey facility should be available.

3.4 Facilities for Storage of Radioactive Wastes

Even for situations that are limited to a site emergency without warranting an off-site emergency, the post-accident operations may call for clean-up of plant areas. As these operations are likely to generate very large volumes of solid and liquid wastes, the site should have feasibility for installing additional provisions to process these and store them at site.

BIBLIOGRAPHY

1. ATOMIC ENERGY REGULATORY BOARD, Radiation Protection Aspects in Design for Pressurised Heavy Water Reactor Based Nuclear Power Plants, AERB/NPP-PHWR/SG/D-12, Mumbai, India (2005)
2. ATOMIC ENERGY REGULATORY BOARD, Preparation of Off-site Emergency Plans for Nuclear Facilities, AERB/SG/EP-2, Mumbai, India (1999)
3. ATOMIC ENERGY REGULATORY BOARD, Code of Practice on Safety in Nuclear Power Plant Siting, AERB/SC/S, Mumbai, India (1990)
4. ATOMIC ENERGY REGULATORY BOARD, Atmospheric Dispersion and Modelling, AERB/SG/S-1, Mumbai, India (Under Preparation)
5. ATOMIC ENERGY REGULATORY BOARD, Hydrological Dispersion of Radioactive Materials in Relation to Nuclear Power Plant Siting, AERB/SG/S-2, Mumbai, India (1998)
6. ATOMIC ENERGY REGULATORY BOARD, Extreme Values of Meteorological Parameters, AERB/SG/S-3, Mumbai, India (Under Preparation)
7. ATOMIC ENERGY REGULATORY BOARD, Hydrogeological Aspects of Siting of Nuclear Power Plants, AERB/SG/S-4, Mumbai, India (2000)
8. ATOMIC ENERGY REGULATORY BOARD, Design Basis Flood for Nuclear Power Plants on Inland Sites, AERB/SG/S-6A, Mumbai, India (1998)
9. ATOMIC ENERGY REGULATORY BOARD, Design Basis Flood for Nuclear Power Plants at Coastal Sites, AERB/SG/S-6B, Mumbai, India (2002)
10. ATOMIC ENERGY REGULATORY BOARD, Population Distribution and Analysis in Relation to Siting of Nuclear Power Plants, AERB/SG/S-9, Mumbai, India (1998)
11. ATOMIC ENERGY REGULATORY BOARD, Seismic Studies and Design Basis Ground Motion for Nuclear Power Plant Sites, AERB/SG/S-11, Mumbai, India (1990)
12. ATOMIC ENERGY REGULATORY BOARD, Intervention Levels and Derived Intervention Levels for Off-Site Radiation Emergency, AERB/SG/HS-1, Mumbai, India (1993)
13. GOVERNMENT OF INDIA, Atomic Energy Act, 1962
14. GOVERNMENT OF INDIA, Factories Act, 1948
15. GOVERNMENT OF INDIA, Atomic Energy (Factories) Rules, 1996

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September 24, 2004

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**PROVISIONAL LIST OF SAFETY GUIDES UNDER
SITING CODE**

Safety Series No.	Title
AERB/SC/S	Code of Practice on Safety in Nuclear Power Plant Siting
SG/S-1	Atmospheric Dispersion and Modelling
SG/S-2	Hydrological Dispersion of Radioactive Materials in Relation to Nuclear Power Plant Siting
SG/S-3	Extreme Values of Meteorological Parameters
SG/S-4	Hydrogeological Aspects of Siting of Nuclear Power Plants
SG/S-5	Methodologies for Environmental Radiation Dose Assessment
SG/S-6A	Design Basis Floods for Nuclear Power Plants on Inland Sites
SG/S-6B	Design Basis Floods for Nuclear Power Plants at Coastal Sites
SG/S-7	Human-Induced Events and Establishment of Design Basis
SG/S-8	Site Considerations of Nuclear Power Plants for Off-site Emergency Preparedness
SG/S-9	Population Distribution and Analysis in Relation to Siting of Nuclear Power Plants
SG/S-10	Quality Assurance in Siting of Nuclear Power Plants
SG/S-11	Seismic Studies and Design Basis Ground Motion for Nuclear Power Plant Sites

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