IAEA SAFETY STANDARDS

for protecting people and the environment

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Protection against Internal and External Hazards in the Operation of Nuclear Power Plants

DS 503

DRAFT SAFETY GUIDE

Revision of NS-G-2.1 and enhanced scope

FOREWORD

[To be added]

EDITORIAL NOTE

An appendix, when included, is considered to form an integral part of the standard and to have the same status as the main text. Annexes, footnotes and bibliographies, if included, are used to provide additional information or practical examples that might be helpful to the user.

The safety standards use the form 'shall' in making statements about requirements, responsibilities and obligations. Use of the form 'should' denotes recommendations of a desired option.

The English version of the text is the authoritative version.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. Requirements for the operation of nuclear power plants are established in IAEA Safety Standards Series No. SSR-2/2 (Rev. 1), Safety of Nuclear Power Plants: Commissioning and Operation [1], while requirements for the design of nuclear power plants are established in IAEA Safety Standards Series No SSR-2/1 (Rev. 1), Safety of Nuclear Power Plants: Design [2].

1.2. This Safety Guide provides specific recommendations on ~~the~~ protection against internal and external hazards in the operation of nuclear power plants. This Safety Guide provides new or updated recommendations derived from enhanced understanding of operational aspects of hazards and combinations of hazards.

1.3. This Safety Guide incorporates the following:

(a) Progress in regulatory practice in Member States, feedback from safety review missions and the results of recent research on the effects of external events;

(b) Progress in the operation of nuclear power plants in Member States, considering lessons identified from external events;

(c) Operating experience gained from incidents and accidents;

(d) Insights on plant- and site-specific features relating to internal and external hazards and improvements in the protection measures against such hazards identified in various hazard analyses of internal and external ~~hazard analyses~~hazards and probabilistic safety assessments.

1.4. The terms used in this Safety Guide are to be understood as defined and explained in the IAEA Safety Glossary [3].

1.5. Other Safety Guides provide recommendations on protection against internal and external hazards in the design of nuclear power plants and are complementary to this Safety Guide. These include IAEA Safety Standards Series Nos~~.~~ SSG-64, Protection against Internal Hazards in the Design of Nuclear Power Plants ~~(under publication) [4], DS498,~~[4], SSG-67, Seismic Design for Nuclear Installations [5] and SSG-68, Design of Nuclear Installations against External Events Excluding Earthquakes ~~in the Design of Nuclear Installations [5] and DS490, Seismic Design of Nuclear Installations~~ [6].

~~1.6. This Safety Guide supersedes IAEA Safety Standards Series No. NS-G-2.1, Fire Safety in the Operation of Nuclear Power Plants[1].~~

~~1.7.~~1.6. Operating experience gained from incidents and accidents in nuclear power plants around the world has continued to demonstrate that fire continues to be an important risk contributor in many Member States. However, a number of other internal and external hazards also have to be taken into account in the design and operation of nuclear power plants. This Safety Guide supersedes and expands the scope of IAEA Safety Standards Series No. NS-G-2.1, Fire Safety in the Operation of Nuclear Power Plants[2] to include recommendations on these other hazards.

OBJECTIVE

~~1.8.~~1.7. The ~~purpose~~objective of this Safety Guide is to provide recommendations on the ~~management~~operation of nuclear power plants in relation to ~~preparing~~preparation for, prevention of, protection against, mitigation of, and coping with internal and external hazards, as well as with the impacts of those hazards, to meet the ~~safety~~ requirements established in SSR-2/2 (Rev. 1) [1].

~~1.9.~~1.8. The recommendations in this Safety Guide are aimed primarily at operating organizations of nuclear power plants and at regulatory bodies. They may also be of interest to other organizations involved in the design, construction, commissioning, operation and decommissioning of nuclear power plants, including technical support organizations, vendor companies (e.g. designers, engineering contractors, manufacturers), research establishments and universities providing services in support of a nuclear power plant, as well as organizations involved in mitigating such hazards.

~~[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Fire Safety in the Operation of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.1, IAEA, Vienna (2000).~~

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Fire Safety in the Operation of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.1, IAEA, Vienna (2000).

SCOPE

~~1.10.~~1.9. This Safety Guide applies to water cooled nuclear power plants designed and operated in accordance with the requirements ~~provided~~established in ~~IAEA~~ SSR-2/1 (Rev. 1) [2] and SSR-2/2 (Rev. 1) [1], and with the recommendations ~~complemented by IAEA~~provided in SSG-64 [4], ~~DS498~~SSG-67 [5] and ~~DS490~~SSG-68 [6]. For reactors cooled by other media, some of the recommendations in this Safety Guide might not be fully applicable, as application of these recommendations depends on the particular reactor technology and the risks associated with internal and external hazards.

~~1.11.~~1.10. This Safety Guide provides detailed recommendations for the internal fire hazard, which is common ~~in~~for most nuclear power plants. As detailed application of recommendations for other hazards ~~will~~would be site specific, this Safety Guide also provides high-level recommendations applicable to a broad range of internal and external hazards~~, water cooled reactor types, and different operating phases~~.

~~1.12.~~1.11. The recommendations provided in this Safety Guide are targeted at new and existing nuclear power plants. For water cooled nuclear power plants designed or operated in accordance with earlier standards, it is expected that in their safety assessments a comparison will be made with the current standards to determine whether the safe operation of the plant could be further enhanced by means of reasonably practicable safety improvements: see para. 1.3 of SSR-2/1 (Rev. 1) [2].

~~1.13.~~1.12. This Safety Guide does not specifically address ~~conventional aspects of operating personnel safety, or property protection~~safety related risks associated with non-radiation-related hazards to personnel, or conventional industrial safety, except where this could affect the safety of the nuclear power plant.

~~1.14.~~1.13. This ~~guide~~Safety Guide does not address societal hazards or pathological hazards (e.g. ~~pandemic~~ pandemics) that do not directly impact the safety of the nuclear power plant[3].

~~1.15.~~1.14. This Safety Guide ~~excludes~~does not address postulated internal and external initiating events induced by deliberate human acts of malicious intent ~~(~~, either by on-site

[3] ~~Recommendation~~Recommendations to ensure the safety of personnel and the ~~continuous~~safe operation of nuclear power plants during situations in which a large number of personnel might be unavailable, such as during an epidemic ~~is~~or pandemic, are provided in IAEA Safety Standards Series No. DS497C ~~[12~~, The Operating Organization for Nuclear Power Plants [7].

personnel or by ~~third parties).~~external adversaries. Guidance on this issue is provided in ~~the~~ IAEA Nuclear Security Series Nos~~.~~ 13, 4~~,~~ and 35-G [~~21-23~~8-10].

~~1.16.~~1.15. ~~In the protection of nuclear power plants against internal and external hazards, safety measures~~ Paragraph 5.1 of SSR-2/2 (Rev. 1) [1] states that "Safety and security measures ~~should~~shall be designed and ~~applied~~implemented in ~~an integrated~~ such a manner, ~~and as far as possible in a complementary manner, so that safety measures~~that they do not compromise ~~security, and vice versa.~~each other". This Safety Guide ~~includes~~ addresses the interfaces between ~~nuclear~~ safety and nuclear security~~. In dealing with these interfaces, it should be borne~~ in ~~mind that~~respect of protection of nuclear ~~safety~~power plants against internal and ~~nuclear security are equally important, and measures to be taken should be mutually acceptable in both areas.~~external hazards..

STRUCTURE

~~1.17.~~1.16. Section 2 provides general considerations for the management of internal and external hazards in nuclear power plants. Section 3 focuses on the ~~organization and responsibilities of~~ management system for hazard management. Sections 4 and 5 provide recommendations for ensuring safety for internal hazards and external hazards, respectively. Section 6 provides recommendations on the combination of internal and external hazards. Section 7 provides recommendations on updating hazard management. Section 8 provides recommendations on material control and housekeeping ~~on~~in hazard management. Section 9 provides recommendations on maintenance and testing of equipment for hazard prevention, protection~~,~~ and mitigation ~~and coping~~. Section 10 provides recommendations on training of personnel ~~for hazards~~on hazard management. Appendices I and II provide detailed information on technical aspects to be considered in internal hazards and external hazards, respectively.

2. GENERAL CONSIDERATIONS FOR THE MANAGEMENT OF INTERNAL AND EXTERNAL HAZARDS IN NUCLEAR POWER PLANTS

2.1. Internal hazards are those hazards to the safety of the nuclear power plant that originate from within the site boundary and are associated with failures of facilities and activities that are under the control of the operating organization. External hazards ~~include natural or human induced events unconnected with the operation of a facility or~~ are those hazards that originate from outside the site boundary and outside the ~~conduct of an activity that~~activities that are under the control of the operating organization, for which the operating organization has very little or no control, but which could have an effect on the safety of the facility or activity. ~~Such events are not connected to the operation of the site or conduct of an activity on the site, but could have an adverse effect on the safety of the site or activity.~~ In this Safety Guide, the ~~word "hazard" or "hazards"~~term 'hazard' refers to both internal and external hazards, and to the combination of these hazards unless where specifically noted. Examples of internal hazards and external hazards are provided in paras 5.16 and 5.17 of SSR-2/1 (Rev. ~~1) [2~~1) [2] and for combinations of hazards in Appendix I of SSG-64 [4].

2.2. The term 'hazard management' is used to refer to a set of operational processes and measures for prevention, protection~~,~~ and mitigation of hazards, and strategies for coping with the impact of these hazards to ensure the safe operation of nuclear power plants. Hazard prevention, protection~~,~~ and mitigation features in a nuclear power plant are typically ~~refer to~~ safety systems and safety features, but might also include systems and features that were not originally installed or designed as safety systems or safety features. Hazard management also includes hazard preparedness, response~~,~~ and recovery actions.

2.3. The requirements relevant to hazard management in the operation of nuclear power plants are established in SSR-2/2 (Rev. 1) [1].

2.4. Requirement 2 of SSR-2/2 (Rev. 1) ~~on the management system~~ [1] states:

"The operating organization shall establish, implement, assess and continually improve an integrated management system."

The integrated management system should incorporate hazard management. Hazard management should aim at preventing, mitigating~~,~~ and coping with hazards and reducing the potential for common cause failure~~ and thus reducing threats to safety. The consideration~~. Considerations for ~~the~~ integration of hazard management ~~processes and~~within the plant's management ~~programmes~~system are presented in Section 3.

2.5. Requirement 11 of SSR-2/2 (Rev. 1) [1] states:

"The operating organization shall establish and implement a programme to manage modifications."

The operating organization should ~~update~~maintain up to date, as necessary, all features for prevention, protection and mitigation of hazards as part of the programme for managing modifications. Recommendations for hazard management and its review regarding modifications are provided in Sections 3 and 7. Operational provisions for hazard management should be consistent with the recommendations IAEA Safety Standards Series No. DS497B, Modifications to Nuclear Power Plants [11][4].

2.6. Requirement 12 of SSR-2/2 (Rev. 1) [1] states:

"Systematic safety assessments of the plant, in accordance with the regulatory requirements, shall be performed by the operating organization throughout the plant's operating lifetime, with due account taken of operating experience and significant new safety related information from all relevant sources."

Recommendations for the review and update of the hazard analysis ~~method~~ and the development of hazard management through the periodic safety review are provided in ~~section~~Section 7. Operational provisions for hazard management should be consistent with the recommendations provided in IAEA Safety Standards Series No. SSG-25, Periodic Safety Review for Nuclear Power Plants [12].

2.7. Requirement 18 of SSR-2/2 (Rev. 1) [1] states:

"The operating organization shall prepare an emergency plan for preparedness for, and response to, a nuclear or radiological emergency."

Requirement 19 of SSR-2/2 (Rev. 1) [1] states:

"The operating organization shall establish, and shall periodically review and as necessary revise, an accident management programme."

2.8. Hazard management and decision making in hazard management should be harmonized with the plant's arrangements for emergency ~~plan~~preparedness and response and with the accident management programme, to ensure ~~coping~~that the plant can cope with events arising from internal or external hazards and mitigation of the consequences of these events ~~in case of a nuclear or radiological emergency.~~. Requirements for emergency

[4] DS497B [11] provides specific recommendations for the programme for plant modifications, including processes relevant to the hazard management measures, such as specific safety consideration for industrial hazards and temporary emergency procedures during modifications.

preparedness and response are established in IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [~~7~~]. ~~Recommendations on accident management~~13], and recommendations on preparedness for a nuclear or radiological emergency are provided in IAEA Safety Standards Series ~~Nos. SSG-54, Accident Management Programmes in Nuclear Power Plants [8] and~~No. GS-G-2.1, Arrangements for a Nuclear or Radiological Emergency [~~9~~14], and recommendations on occupational radiation protection in a nuclear or radiological emergency are provided in IAEA Safety Standards Series No. GSG-7, Occupational Radiation Protection [~~10]. While these IAEA Safety Standards provide recommendations on the radiation-related hazards in a severe accident or radiological emergency management, this Safety Guide covers all the other means that assist the operating organization in coping with hazards to ensure minimal consequences.~~15]. Operational provisions for hazard management should be consistent with the recommendations provided in IAEA Safety Standards Series No. SSG-54, Accident Management Programmes in Nuclear Power Plants [16]. Hazard prevention, protection and mitigation features include fixed or non-permanent equipment used to restore the safety functions and to reach and maintain a safe state, during an accident caused by external hazards [16].

~~2.9.~~ Requirement 22 of SSR-2/2 (Rev. 1) [1] states~~:~~

2.9. that **"The operating organization shall make arrangements for ensuring fire safety."** Paragraph 5.21 of SSR-2/2 (Rev. 1) [1] further states:

> "The arrangements for ensuring fire safety made by the operating organization shall cover the following: adequate management for fire safety; preventing fires from starting; detecting and extinguishing quickly any fires that do start; preventing the spread of those fires that have not been extinguished; and providing protection from fire for structures, systems and components that are necessary to shut down the plant safely. Such arrangements shall include, but are not limited to:
>
> (a) Application of the principle of defence in depth;
> (b) Control of combustible materials and ignition sources, in particular during outages;
> (c) Inspection, maintenance and testing of fire protection measures;
> (d) Establishment of a manual firefighting capability;
> (e) Assignment of responsibilities and training and exercising of plant personnel;
> (f) Assessment of the impact of plant modifications on fire safety measures."
> ~~(para. 5.21 of SSR-2/2 (Rev. 1) [1]).~~

The recommendations for hazard management specifically relating to fire safety are ~~presented~~provided in Appendix I. Special attention should be paid for the application of the principle of defence in depth for fire safety (see para. 2.~~24.).~~23).

2.10. Requirement 23 of SSR-2/2 (Rev. 1) [1] states:

> **"The operating organization shall establish and implement a programme to ensure that safety related risks associated with non-radiation-related hazards to personnel involved in activities at the plant are kept as low as reasonably achievable."**
>
> Paragraph 5.26 of SSR-2/2 (Rev. 1) [1] further states [footnote omitted]:
>
> "The non-radiation-related safety programme ~~[footnote omitted]~~ shall include arrangements for the planning, implementation, monitoring and review of the relevant preventive and protective measures, and it shall be integrated with the nuclear and radiation safety programme~~" (para. 5.26. of SSR-2/2 (Rev. 1) [1]).~~."

The operating organization should consider ~~hazard management~~industrial hazards when implementing ~~industrial safety measures for plant personnel~~hazard management.

2.11. Requirement 26 of SSR-2/2 (Rev. 1) [1] states:

> **"Operating procedures shall be developed that apply comprehensively (for the reactor and its associated facilities) for normal operation, anticipated operational occurrences and accident conditions, in accordance with the policy of the operating organization and the requirements of the regulatory body."**

The operating procedures for hazard management should be developed in accordance with the requirements established in paras 7.1–7.6. of SSR-2/2 (Rev. 1) [1]. Operational provisions for hazard management should be consistent with the recommendations provided in IAEA Safety Standards Series No DS497A, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants [17]

2.12. Requirement 28 of SSR-2/2 (Rev. 1) [1] states:

> **"The operating organization shall develop and implement programmes to maintain a high standard of material conditions, housekeeping and cleanliness in all working areas."**
>
> Paragraph 7.10 of SSR-2/2 (Rev. 1) [1] further states:
>
> "Administrative controls shall be established to ensure that operational premises and equipment are maintained, well-lit and accessible, and that temporary storage is controlled and limited. Equipment that is degraded (owing to leaks, corrosion spots,

loose parts or damaged thermal insulation, for example) shall be identified and reported and deficiencies shall be corrected in a timely manner~~" (para. 7.10 of SSR-2/2 (Rev. 1) [1]).~~".

The operating organization should consider the potential for hazards, hazard progression~~,~~ and hazard consequences when developing and implementing programmes to maintain proper material conditions and housekeeping. The operating organization should maintain proper housekeeping at all times, even if some actions are ~~particularly~~ important only at times when ~~an~~a particular external hazard is forecasted. Operational provisions for hazard management should be consistent with the recommendations provided in IAEA Safety Standards Series No. DS497G, Conduct of Operations at Nuclear Power Plants [18][5].

2.13. Requirement 31 of SSR-2/2 (Rev. 1) [1] states:

> **"The operating organization shall ensure that effective programmes for maintenance, testing, surveillance and inspection are established and implemented."**

The operating organization should identify ~~the potential~~ internal hazards that might arise during maintenance, testing, surveillance~~,~~ and inspection activities. These internal hazards should be taken into account when developing ~~the programme for~~ hazard management. Hazard management ~~issues~~for both internal and external hazards should be considered when developing programmes for maintenance, testing, surveillance and inspection. Operational provisions for hazard management should be consistent with the recommendations provided in IAEA Safety Standards Series No. DS497E, Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants [19][6].

2.14. Requirement 32 of SSR-2/2 (Rev. 1) [1] states:

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[5] DS497G [18] provides specific recommendations for the management programme for plant operations, including processes relevant to hazard management such as operational limits and conditions and/or procedures for hazards, formal communication systems with plant organizations during hazards, shift rounds to monitor indication of hazards, deviations in fire protection, condition of protection features for flooding, seismic constraints, unsecured components, and housekeeping.

[6] DS497E [19] provides specific recommendations for the programme for maintenance, testing, surveillance and inspections, including processes relevant to hazard management, such as work control and administrative procedures for fire hazard control; surveillance programmes for equipment for mitigation and coping with hazards; and management for limiting the risk of fire, flooding, earthquake, missiles and release of hazardous substances.

> **"The operating organization shall establish and implement arrangements to ensure the effective performance, planning and control of work activities during outages."**

The operating organization should identify ~~the potential~~ hazards that might arise during outages, including low power and shutdown modes. Hazard management should take into account the dynamic changes in plant conditions, including changes in structures, systems~~,~~ and components ~~during outages,~~ and factors such as availability of safety systems or safety features ~~during shutdown, protection zones (e.g. containment vessel),~~ and increased resource needs (e.g. additional workers, combustibles, scaffoldings, vehicles~~). ~~) during outages and shutdown. In this regard, hazard management should also take into account the long term shutdown for refurbishment for long term operation.

2.15. Requirement 33 of SSR-2/2 (Rev. 1) [1] states:

> **"The operating organization shall prepare a decommissioning plan and shall maintain it throughout the lifetime of the plant, unless otherwise approved by the regulatory body, to demonstrate that decommissioning can be accomplished safely and in such a way as to meet the specified end state."**

The operating organization should ensure that hazard management is included in the decommissioning plan, ~~taking into account~~and any changes in the assessed hazards during decommissioning should be taken into account.

2.16. Hazard management should consider the hazards occurring at each reactor unit at a multiple unit site. It should also include consideration of hazards at co-located or nearby nuclear power plants, even if operated by ~~a~~ different operating ~~organization. This includes~~organizations. Hazard management should also address hazards relating to the use of shared spent fuel pools.

2.17. Hazards might lead to ~~releases~~a release of radioactive material and associated hazardous material by inducing ~~initiating~~internal or external events that might~~: (1)~~ cause equipment failures~~; (2),~~ degrade the performance of barriers~~;~~, or ~~(3)~~ degrade means for preventing harmful effects.

2.18. While it might not be practical or possible to prevent a hazard or its impacts from triggering an ~~unanticipated~~anticipated operational occurrence, hazard management should ensure that, to the extent practicable, ~~hazards do~~a hazard does not trigger a more severe plant state, leading to accident conditions. For example, hazard management could help to prevent a single fire event from causing multiple safety system failures.

2.19. Hazards should be considered in the planning and conduct of inspections. Inspections should be implemented for equipment and features for~~: (1)~~ hazard detection~~; (2)~~ for hazard prevention or mitigation~~; or (3)~~, and for coping with hazards or hazard impacts.

~~2.20.~~ Operational provisions for hazard management should be also consistent with the recommendations provided in ~~the following safety guides:~~

- ~~—~~DS497C [7] and IAEA Safety Standards Series No. ~~NS-G-2.3, Modifications to Nuclear Power Plants [11][7];~~
- ~~IAEA Safety Standards Series No. NS-G-2.4, The Operating Organization for Nuclear Power Plants [12];~~
- ~~IAEA Safety Standards Series No. NS-G-2.6, Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants [13][8];~~
- ~~IAEA Safety Standards Series No. NS-G-2.8~~DS497F, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants [~~14];~~
- ~~IAEA Safety Standards Series No. NS-G-2.14, Conduct of Operations at Nuclear Power Plants [15][9];~~
- ~~IAEA Safety Standards Series No. SSG-25, Periodic Safety Review for Nuclear Power Plants [16];~~

~~2.21.~~2.20. ~~IAEA Safety Standards Series No. SSG-54, Accident Management Programmes in Nuclear Power Plants [8~~20].

APPLICATION OF DEFENCE IN DEPTH FOR HAZARD MANAGEMENT

~~2.22.~~2.21. In accordance with the objectives of defence in depth, the operating organization should establish procedures to operate the features for prevention, protection

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~~[7] NS-G-2.3 provides specific recommendations for the management programme for plant modifications, including processes relevant to the hazard management measures such as specific safety consideration for industrial hazards and temporary emergency procedures during modifications.~~

~~[8] NS-G-2.6 provides specific recommendations for the management programme for maintenance, testing, surveillance and inspections, including processes relevant to hazard management such as work control and administrative procedures for fire hazard control; surveillance programmes for equipment for mitigation and coping with hazards; and management for limiting the risk of fire, flooding, earthquake, missiles and release of hazardous substances at storage facilities.~~

~~[9] NS-G-2.14 provides specific recommendations for the management programme for plant operations, including processes relevant to hazard management such as operational limits and conditions and/or procedures for hazards, formal communication systems with plant organizations during hazards, shift rounds to monitor indication of hazards, deviations in fire protection, condition of protection features for flooding, seismic constraints, unsecured components, and housekeeping.~~

and mitigation ~~for~~of all hazards and should implement strategies for coping with ~~hazard~~the impact of hazards to ensure that the fundamental safety functions are maintained for all plant ~~operational~~ states.

~~2.23.~~2.22. The operating organization should ~~consider following an~~ follow the approach ~~for~~to defence in depth applicable during operation by a combination of maintaining engineered features, ensuring automatic actuation of safety systems and proper operator actions and maintaining systems, structures and components, as presented in Requirement 7 of ~~IAEA~~ SSR-2/1 (Rev. 1) [2] and by implementing ~~procedural measures~~operating procedures, as presented in Requirement 26 of ~~IAEA~~ SSR-2/2 (Rev. 1) [1~~]~~], to protect the plant from hazards. The operating procedures provide additional assurance to the engineered features ~~primarily complement~~in the implementation of defence in depth ~~and the procedural measures~~ against hazards ~~provide additional assurance to engineered features,~~ by monitoring, warning~~,~~ and alerting~~,~~ plant personnel to unanticipated failures, and in post event management and assessment ~~of unanticipated plant failures.~~.

~~2.24.~~2.23. In accordance with Requirement 22 of ~~IAEA~~ SSR-2/2 (Rev. 1) [1] and Requirement 7 of ~~IAEA~~ SSR-2/1 (Rev. 1) [2~~] on the application of defence in depth,~~], the operating organization should verify that the concept of defence in depth for internal fire hazards ~~in line~~is applied in accordance with the corresponding operational limits and conditions (~~See~~see Appendix I~~.1.~~).

3. ~~RESPONSIBILITIES~~APPLICATION OF THE ~~OPERATING ORGANIZATION~~MANAGEMENT SYSTEM TO HAZARD MANAGEMENT

MANAGEMENT RESPONSIBILITY FOR HAZARD MANAGEMENT

3.1. The operating organization should establish a set of hazard management measures to ensure that the plant can be protected against hazards by suitable design and operational activities, including prevention and mitigation of the impact of, and coping with the consequences of hazards or credible combinations thereof, according to SSR-64 [4], in an integrated management system.

3.2. The operating organization should be able to maintain the fundamental safety functions of the nuclear power plant during and after the impact ~~from~~of individual hazards or a credible combination of these hazards. The operating organization should utilize all available resources to cope with hazard impacts and reduce the likelihood that these impacts would propagate, become more severe or jeopardize the fundamental safety functions.

3.3. In accordance with IAEA Safety Standards Series No. GSR Part 2 ~~[17~~, Leadership and Management for Safety [21], defined roles and responsibilities of ~~the~~ personnel involved in the establishment, implementation~~,~~ and administration of hazard management are required to be identified, documented and maintained up to date in the management system. The arrangements for the delegation of authority for these responsibilities should also be documented, implemented~~,~~ and maintained up to date. Further recommendations on the management system for nuclear installations are provided in ~~GS-G-3.5 [18~~IAEA Safety Standards Series No. GS-G-3.5, The Management System for Nuclear Installations [22].

3.4. The operating organization should identify the organizational structures, processes, specific responsibilities~~, level~~ and levels of authority of personnel, and interfaces of personnel involved in hazard management within the organization and with external organizations, if necessary. These external organizations should be identified taking into account specific site challenges, plant design aspects, and regional and national governmental structure.

3.5. The plant management is responsible for deploying protective measures in a timely manner when hazardous conditions are forecasted. ~~The~~Before any event occurs, the operating organization should identify and establish the necessary staffing levels, capabilities of the personnel, and personnel roles and responsibilities ~~before an event,~~ to mitigate and cope with hazards.

3.6. The operating organization should establish ~~documented~~and document plans and protocols for ~~preventing hazards and for mitigating and coping with the impacts of hazards and their consequences~~hazard management and should ensure that ~~the~~ plant personnel ~~is~~are

trained and qualified in these plans and protocols. ~~In these plans and protocols, the~~The operating organization should ~~include~~involve a combination of personnel from the various site sections or departments ~~such as~~ in the development and application of these plans and protocols, including engineering, operations, maintenance, technical support, ~~vendor,~~ and emergency response~~.~~ personnel, with considering insights from external organizations such as vendor as appropriate. The operating organization should also ensure that an adequate number of competent and qualified staff are available at all times to operate the plant safely in operational states and ~~abnormal~~accident conditions in case of hazards and induced effects [~~15~~18].

3.7. The operating organization should organize a response team with the appropriate qualifications, skills and training in the use of equipment for hazard mitigation and coping with consequences (~~See~~see Section 10).

PROCESS IMPLEMENTATION AND RESOURCE MANAGEMENT FOR HAZARD MANAGEMENT

3.8. Hazard management is required to be integrated with the nuclear and radiation safety programme ~~(See Requirement~~of the nuclear power plant (see Requirements 8 and ~~23~~17-24 of ~~IAEA~~ SSR-2/2 (Rev.1) [1]).

3.9. The set of hazard management measures should be structured, documented and associated ~~to~~with the plant's management ~~programmes and processes~~system based on the safety assessment, in accordance with the requirements established in SSR-2/2 (Rev. 1) [1]. Further recommendations on the management of plant operations are provided in ~~NS-G-2.4 [12])~~DS497C [7] and recommendations on the development of operational procedures for hazard management measures are provided in ~~NS-G-2.14 [15~~DS497G [18].

3.10. The incorporation of measures for protection against hazards into the ~~plant~~plant's management ~~programmes and processes can~~system should be based on a graded approach in ~~line~~accordance with the ~~risk significance of the~~ hazards ~~(see GSR Part 4 (Rev. 1) [19]).~~and the magnitude of their potential impact [21]. Factors to be taken into consideration also include the ~~degree of safety significance of the~~ site specific hazards and the magnitude of their potential impact, the extent and difficulty of the efforts needed to implement a protection activity against those hazards, the number of related processes, the overlap of the processes, and the ~~resource~~ optimization of resources.

3.11. Hazard management and ~~the~~ decision making for hazard management should be harmonized with the guidance and actions included in the ~~plant~~ plant's arrangements for emergency preparedness and response ~~programme~~ and the accident management programme ~~for mitigating and coping with the event progress from hazard occurrence to a~~

nuclear or radiological emergency.. Requirements and recommendations on the preparedness for a nuclear or radiological emergency are established in GSR Part 7 [713] and recommendations are provided in GS-G-2.1 [9], and recommendations14]. Recommendations on accident management are provided in SSG-54 [816].

3.12. Hazard management should consider and include the processes, procedures, and measures required for:

- Hazard prevention;
- Prevention of hazards;
- Detection of hazards;
- Protection against and mitigation of the impact of hazards or credible combinations thereofof hazards;
- Strategies for coping with hazard impacts: the methodsthe impact of hazards, including measures to be implemented to deal with an adverse situation for an indefinite period of time.

3.13. Hazard management should be maintained applicable and relevant to the plant throughout the plant's entire plant lifetime. Hazard management should be reviewed periodically and updated as necessary to consider any changes in the plant state, including plant modifications, changes in the site characteristics, results of research and development, new scientific knowledge, and lessons learned, and best practices from industry operating experience at the plant or at other plants. The results of this periodic review should be used to identify and implement in a timely manner any practicable design modifications and changes to hazard management, including organizational arrangements, strategies and measures.

3.14. The operating procedures for hazard management should set out the roles, responsibilities, and tasks of the operatingplant personnel in relation to the roles of any external organizations (e.g. law enforcement organizations, off-site firefighters).

3.15. Strategies for coping with hazard impact should be developed taking into account the civil infrastructure such as electric power, watering, communications, transportation, and the collections of buildings that make up communities around the plant,impacts should be developed as a part of hazard management. These strategies should take into account the infrastructure of the region around athe site, such as roads, railways, electrical grid interfaces, communications, the presence of sources of water and proximity to water ways, regional population centres and local industries, with special. Particular consideration should be given to the infrastructure that might present challenges to the site or that might itself be affected by the hazard if it is being relied upon as part of the hazard management strategy.strategies for coping with the impact of hazards.

3.16. Hazard management should identify relevant external resources and organizations, such as local government, emergency services and response organizations, and the type and amount of support that these regional external organizations can provide, as well as the points of contact and methods of communication with these organizations.

3.17. ~~The early~~Early warning protocols should be established and the co-operation with ~~the~~ external ~~authority network~~organizations should be planned and drilled~~. The function of communication~~ (see Section 10). Communication with external organizations should be tested and communication protocols should be updated periodically by the operating organization.

3.18. The operating organization should establish separate (or integrated where appropriate) procedures for different types of hazards. These procedures should provide clear instructions to the ~~operating~~ personnel on actions to be implemented if precursors or indications of hazards are observed, or if hazard-induced precursors to initiating ~~event precursors~~events occur.

3.19. The emergency arrangements of the operating organization and of external organizations should ensure that special consideration is given to cases where there is a risk of radioactive releases as a consequence of an event caused by a hazard. The aim should be to meet the goals of emergency response ~~goals,~~ as ~~given~~stated in GSR ~~part~~Part 7 [~~7~~13].

3.20. Hazard management should be performance-based ~~and~~, i.e. the approach should define a desired outcome and clear, objective and measurable criteria to determine whether that outcome has been reached ~~[4]. This Safety Guide provides recommendations on developing performance-based measures for hazard management.~~.

3.21. Hazard management should include provisions to ensure the ~~safety~~protection of those personnel responsible for implementing the measures for hazard protection, and mitigation~~,~~ and the strategies for coping with hazard impact. These provisions should ~~also~~ cover the radiation protection of ~~the~~ personnel of both the operating organization and ~~of~~ external organizations ~~operating on~~implementing actions at the plant (e.g. off-site firefighters). Recommendations ~~for occupational~~ on protection of workers ~~in a nuclear or radiological emergency~~ is provided in GSG-7 [~~10~~15].

DECISION- MAKING FOR HAZARD MANAGEMENT

3.22. In accordance with the requirements established in GSR Part 2 [~~17~~21], the operating organization is required to develop and maintain an understanding of the ~~safety significance of~~radiation risks and hazards associated with the nuclear power plant.

3.23. The plant management should have an understanding of how ~~nuclear~~safety systems and safety features and hazard prevention, protection~~,~~ and mitigation features could be adversely affected by hazards, taking into consideration the safety assessment and a graded approach [~~19~~23]. This includes an understanding of hazard management measures to increase the plant's resilience to hazards.

3.24. The plant management should have an understanding that certain nuclear security features ~~of the nuclear power plant~~ might also be adversely affected by the impact of hazards or the activation of hazard mitigation measures.

3.25. ~~In accordance with~~To meet the requirements established in GSR Part 2 [17], the operating organization ~~is required to~~should ensure that the plant management ~~can activate~~remains capable of activating established programmes, processes and procedures to protect the plant against ~~potential~~ hazards, and ~~to be~~is prepared to implement hazard mitigation measures and~~/or~~ strategies for coping with hazard impact[10]. The following aspects should be taken into consideration, as appropriate:

- Cooperation with regional and national external organizations: The operating organization should establish communication arrangements with appropriate external organizations as early as possible, to allow timely predictions of ~~potential~~ hazards that could be used as input for the decision-making process and to ~~activate~~ensure that hazard management measures such as firefighting organization or transporting equipment (e.g. drainage pumps~~)),~~ which might be stored off-site, can be activated. Sections 4 and 5 of this Safety Guide provide further examples of such equipment.
- Nuclear security aspects: Hazard management should be developed in consultation with ~~physical protection~~ experts in nuclear security and should include procedures to inform nuclear security personnel of any modifications to the ~~physical protection~~nuclear security features and of the occurrence of any hazard to ensure required actions are implemented. Further guidance on nuclear security is provided in Refs~~. [20–23~~ [8-10, 24].
- ~~Multi-~~Multiple unit plant sites: For multiple reactor units co-located ~~at~~on the same site or at adjacent sites, ~~either~~whether they are operated by the

[10] ~~The~~ To do this, the operating organization can create an overview document of the processes contained in each management programme and add appropriate information to these programmes that will allow for efficient decision making. An example of such an overview document or check list for a tropical storm is presented in ~~Appendix~~para. II.32.

same or by different operating organizations, the operating organization should consider how the site and the organizational configuration affect the hazard mitigation measures and strategies for coping with hazard impact, especially for hazards with an increased predictability. The operating organizations should ensure appropriate cooperation with other operating organizations at the same site or at adjacent sites.

3.26. When a hazardous event has occurred or hazardous conditions have been forecasted, a hazard response procedure should be initiated by the operating organization to ensure the following:

- ~~Actuation~~Timely actuation of ~~a timely~~the appropriate level of response ~~level~~;
- The performance of time-sensitive actions and confirmation of these actions to manage the risk imposed by the hazard;
- Identification of any support needed (e.g. ~~from internal organizations,~~ from external organizations, emergency support equipment, specialized personnel);
- Maintaining the fundamental safety functions required for the corresponding plant conditions~~.~~;
- Identification of alternative actions if a specific action cannot be performed.

4. ENSURING SAFETY AGAINST INTERNAL HAZARDS IN THE OPERATION OF NUCLEAR POWER PLANTS

4.1. Internal hazards are required to be taken into account in the design (SSR-2/1 (Rev.1) [2]) and the operation (SSR-2/2 (Rev. 1) [1]) of a nuclear power plant.

4.2. In accordance with Requirement 10 of IAEA Safety Standards Series No. GSR Part 4 ~~[19~~(Rev. 1), Safety Assessment for Facilities and Activities [23], an initial hazard analysis is required to be part of the ~~basic~~ design ~~phase~~stage. The frequency of occurrence ~~frequency~~ of internal hazards can be reduced and their effect can be mitigated to a large extent by the design and construction of engineered features. This initial hazard analysis should be supplemented to take into account the operational procedures for preventing, protecting~~,~~ and mitigating and coping with internal hazards. Site-specific aspects (especially for ~~multi-~~multiple unit ~~or multi-source~~ sites or sites on which multiple radiation sources are located) are also required to be considered in the plant design and safety assessment against internal hazards (see Requirement 17 of SSR-2/1 (Rev. 1) [2~~]),~~] and IAEA Safety Standards Series No. SSG-3, Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants [25]) and in the operation of the plant ~~(see Requirement 23 of SSR-2/2 (Rev. 1) [1]) and SSG-3 [XX].~~.

4.3. The hazard analysis and the operating procedures for ~~preventing, protecting, and mitigating~~hazard management for internal hazards should be updated regularly over the lifetime of the plant to reflect lessons from operating experience (See Section 7).

4.4. The hazard analysis should consider the impact of all credible internal hazards on ~~SSCs.~~structures, systems and components. This hazard analysis will be a part of hazard management (see Section 3~~) process.~~). Further recommendations on protection against internal hazards in the design and safety assessment of nuclear power plants are given in SSG-64 [4] and SSG-3 [~~XX~~25].

4.5. Hazard management should include ~~deployment~~ strategies for ~~operating~~deployment of personnel and equipment, and the procedural implementation of these strategies. Where additional personnel or equipment need to be deployed for hazard mitigation, hazard management should specify the means of communication with external organizations and should include training and practice drills for ~~the~~ personnel (see Section 10).

4.6. Enhanced administrative and procedural controls over material housekeeping and operations should be put ~~into~~in place (see Section 8) as part of hazard management for periods of increased risk (for example, during outages or during the implementation of modifications), ~~in order~~ to ensure that the hazard prevention, protection~~,~~ and mitigation ~~measures~~features are not reduced.

4.7. Hazard management should define the role of the ~~operating~~ personnel in controlling actions to respond to the challenges of hazards. The ~~operating~~ personnel should be able to implement protection measures, to reduce the extent of the effects of specific hazards by ~~plant~~ re-alignment of systems or equipment, or to address impacts from the hazard by initiating on-site actions as part of strategies for coping with the impact of the hazard on the plant.

4.8. Hazard management for internal hazards should include the following elements ~~that~~, which should be adapted to the specific ~~hazard~~ characteristics~~,~~ of each hazard as appropriate:

- Identification of a response level commensurate with the ~~internal~~ hazard and the potential consequences;
- Identification of appropriate warning or monitoring systems and equipment for the hazard;
- Identification and assessment of the ~~nuclear~~ safety challenges and functional challenges caused by the hazard, e.g. challenges to specific equipment ~~that are required~~needed for protection from the hazard;
- Development and implementation of procedures for maintenance and inspection of equipment needed to cope with and mitigate the impact of the hazard;
- Development and implementation of ~~communication~~ standards and protocols for communication with external organizations;
- Training of personnel to ensure development of necessary skills for implementing hazard mitigation measures~~.~~;
- Identification ~~on~~of equipment and tools that are needed to mitigate the effect of the hazard.

RECOMMENDATIONS FOR SPECIFIC INTERNAL HAZARDS

4.9. Recommendations for design related aspects of internal hazards are provided in ~~IAEA~~ SSG-64 [4]. For all credible internal hazards~~,~~ including combined ones (see Section 6), the general recommendations ~~given~~provided in ~~paragraphs~~paras 4.1–4.8 are applicable.

4.10. Appendix I is not exhaustive but provides detailed recommendations for hazard management of the following commonly considered internal hazards:

- Internal fires;
- Internal explosions;
- Internal missiles;

- Pipe breaks (including secondary consequences such as pipe whip, jet effect, flooding and pressure build up);
- Internal flooding;
- ~~Dropped Load and Falling Objects and impact of these on SSCs;~~Heavy load drop;
- Electromagnetic interference;
- Release of hazardous substances inside the plant.

5. ENSURING SAFETY AGAINST EXTERNAL HAZARDS IN THE OPERATION OF NUCLEAR POWER PLANTS

5.1. Hazard management for protection against external hazards should be based on the identification of site-specific external hazards and plant vulnerabilities. These are identified, for example, in connection with site ~~evaluations~~evaluation, plant design, periodic safety reviews, evaluation of operating experience, and if applicable, probabilistic safety assessments for external hazards. Levels of hazards more severe than those considered in the design should also be considered in hazard management as an interface with accident management, ~~based on~~in accordance with the evaluation of the impact of these hazards. ~~IAEA DS498~~SSG-67 [5] and ~~DS490~~SSG-68 [6] provide general recommendations on the design aspects of external hazards including hazard analysis. Further recommendations on safety ~~assessments~~assessment for external hazards are ~~given~~provided in SSG-3 [~~XX]. These~~25]. Results of the design and safety assessment for external hazards should be ~~used to inform~~taken into account by the operating organization, and any changes in ~~this guidance~~safety assessment should be reviewed as part of the periodic updating process for hazard management (see ~~section~~Section 7).

5.2. Based on the external hazard impacts ~~on~~evaluated in hazard management, ~~potential~~ measures for protection and mitigation should be identified for each hazard that can increase the viability of a strategy for coping with external hazards. ~~See para 7.1 on the periodic monitoring of external hazards.~~

5.3. ~~Prior to~~Before establishing processes and procedures for protection against ~~potential~~external hazards, the operating organization should ~~also~~ put in place processes and procedures to ensure that meteorological forecasts are monitored and that appropriate actions ~~are~~will be taken in ~~due time~~a timely manner when weather-related hazardous conditions are forecasted (e.g. coastal flooding, severe storms, tornadoes). For predictable or partially predictable hazards[11], the operating organization should undertake the ~~decision making process described~~hazard response procedure set out in para. 3.26~~.~~ to ensure that the site is prepared in a timely manner. In order to reflect ~~the sensitivities of~~ local conditions, the operating organization should ~~be encouraged to~~ record and maintain data on on-site

[11] The basis of a valid forecast or prediction ~~is formed by~~comprises facts that are collected using formalized methods and ~~forecast~~forecasting technologies to create data. ~~Resulting~~The resulting predictions are available from national and regional organizations ~~which~~that are specialized in ~~their~~the production and provision~~.~~ of such forecasts. On-site monitoring can support the information. On this basis, decisions then can be made with a certain confidence.

meteorological conditions and water ~~level data~~levels to provide enhanced prediction and forecasting at a local level.

5.4. The operating organization should establish protocols for effective notification ~~protocols with~~of external organizations in advance, taking into consideration events at ~~or near~~ the site ~~boundary area~~or external zone (e.g. temporary increases in population and traffic, the dispatch plan of the external organizations, third-party activities such as rally groups or demonstrations). This notification protocol ~~can~~should provide clear guidance for both the operating organization and the external organizations to implement pre- and post-event actions.

5.5. Hazard management should include strategies for the deployment of ~~operating~~ personnel and equipment, and the procedural implementation of these strategies.

5.6. Enhanced administrative and procedural controls over material housekeeping and operations should be put ~~into~~in place (see Section 8) for periods of increased risk (for example, during outages or during the implementation of modifications), in order to ensure that the hazard protection and mitigation measures are not reduced.

5.7. Hazard management for external hazards should include the following elements ~~that~~, which should be adapted to the specific ~~hazard~~ characteristics of each hazard and especially the predictability of the hazard:

- Identification of a realistic predictability or warning time for the hazard, and response criteria commensurate with the ~~external hazards~~hazard identified and the potential consequences;
- Identification of appropriate warning or monitoring systems and equipment for the hazard;
- Identification and assessment of the potential challenges to the fundamental safety functions caused by the hazard (e.g. specific items of equipment that might need to be protected against the hazard);
- Development and implementation of an operational strategy for responding to events with warning (e.g. procedures to support anticipatory actions~~)~~), taking into consideration the seasonal patterns of frequency and/or magnitude of the hazard, for certain natural external hazards;
- Development and implementation of procedures for maintenance and inspection of equipment needed to cope with and mitigate the hazard and ~~post hazard~~ demonstration of the continued functional capability of ~~SSCs~~structures, systems and components after the hazardous conditions have passed;

- Development and implementation of a ~~plant~~ strategy for responding to events without warning (e.g. ~~response actions for a specific hazard such as~~ debris removal following a seismic event);
- Development and implementation of protocols for communication ~~protocols~~ with external organizations;
- Training of personnel to ensure development of the necessary skills for implementing hazard mitigation measures.

5.8. The operating organization should establish operating procedures that describe actions before, during and after the event corresponding to each external hazard, including any preparatory actions before the hazard impacts the site, as appropriate. The operating organization should define and take into account all additional hazards that can be generated by an original hazard~~,~~ and should also define credible combinations of hazards according to SSG-64 [4] (see Section 6).

5.9. The operating organization should take actions to prevent or mitigate the propagation of hazard effects throughout the entire site before the event (for a forecasted event) or during the event for an external hazard that impacts a vulnerable or sensitive part of the site. These actions should include ensuring that site access routes are available and useable or providing alternative means of site access (e.g. by boat or helicopter) if the site access routes are impacted by the hazard. For ensuring this, protocols for effective communication with and notification ~~protocols with~~of external organizations should be established by the operating organization. Adverse working conditions of ~~the operating~~ personnel because of the hazard should be taken into consideration when developing the operating procedures for hazard management. The safety of ~~the operating~~ personnel should be taken into account, particularly during an event.

5.10. There is a wide range in the capability to forecast external hazards. Some external hazards such as seismic events, aircraft crashes~~,~~ and industrial accidents are generally unpredictable and hazard management should assume that there will be no warning. For other hazards, there can be a forecast capability, depending on the ~~phenomena~~phenomenon and the forecast lead time. For example, external ~~flood~~floods on certain large river systems can be forecasted with considerable accuracy days to weeks in advance. Coastal flooding due to tropical and extratropical storms can be forecasted hours to days in advance. Conditions favourable for formation of severe storms and tornadoes can be forecasted using the distribution of atmospheric pressure hours in advance, but there can be very little warning for the precise location and intensity of such phenomena. Hazard management should consider the forecast capability for each credible external hazard and ~~develop~~ measures should be developed for hazard protection and mitigation and strategies for coping with hazard impact that are consistent with the respective forecast capability. These

measures should include actions to secure loose materials or unsecured equipment to minimize the hazard impact (e.g. for high winds, tornadoes~~),~~) and the removal of items that could prevent proper site drainage (e.g. in the event of heavy rainfall, storm surges). Communication and notification protocols should ensure that the ~~operating~~ personnel are aware of the likelihood of a specific hazard.

5.11. Depending on the predictability of the external hazard (including combined ~~ones~~hazards) and the communications with external organizations and agencies, plant shutdown or power reduction should be considered as a pre-event action, especially if there is potential for a station blackout or loss of the ultimate heat sink.

5.12. Depending on the expected severity of the external hazards and the available time, the operating ~~organisation~~organization should consider evacuating all non-essential plant personnel ~~within the estimated~~in accordance with established evacuation ~~time~~procedures.

5.13. After the cancellation of a national or regional hazard warning, the operating organization should take any necessary actions to return the plant to ~~operational states~~normal operation including, as appropriate, inspection and remedial actions to ensure sufficient protection is reinstated. This includes returning any personnel temporarily assigned to coping with the ~~potential~~ hazard to their normal duties in a controlled manner.

RECOMMENDATIONS FOR SPECIFIC EXTERNAL HAZARDS

5.14. For all external hazards, the recommendations provided in ~~sections~~paras 5.1– 5.13 are applicable. Appendix II is not exhaustive but provides more detailed recommendations ~~that should be incorporated into~~ for hazard management ~~for protection against external hazards for~~of the following common external hazards:

- Seismic hazards;
- External floods (storm surges and tsunamis);
- External floods (flooding of rivers and streams, and floods due to extreme precipitation events);
- Extreme winds;
- Other extreme meteorological conditions;
- Volcanism;
- External fires;
- External explosions;
- Hazardous substances (toxic, radioactive, flammable, corrosive or asphyxiant chemicals, and their air and liquid mixtures, including inadvertent releases from neighboring nuclear installations or from other plants on ~~multi-~~multiple unit ~~plant~~ sites);

- Aircraft crash;
- Electromagnetic ~~interferences~~interference, including solar storms;
- Biological phenomena;
- Hazards by floating objects and hazardous liquid on water intakes and components of the ultimate heat sink;

6. COMBINATION OF HAZARDS

6.1. This Safety Guide provides recommendations on developing a performance-based approach to management of hazard combinations, i.e. it does not prescribe steps for each specific combination, nor how to combine hazards.

~~6.1.~~6.2. Hazard management should take into consideration the effects of combined hazards according to SSG-64 [4] and mitigation strategies against these combined hazards. Some examples of the considerations for combinations of hazards in hazard management are given in Appendices I and II.

~~6.2.~~6.3. Any consequential effects from credible hazard combinations of external-external events, external-internal~~,~~ events and internal-internal events, including unrelated combinations, as defined by plant design and applicable regulations, should be considered in hazard management.

~~6.3. This Safety Guide provides recommendations on developing performance-based measures for hazard combinations, but does not prescribe steps for each specific combination, nor on how to combine hazards.~~

6.4. The goal of hazard management should be to ensure that the plant can withstand the impact of any credible combination of hazards and their effects. Hazard management should include information on how combinations of hazards could alter the overall situation of the plant and how this is handled. Combinations of hazards can alter hazard mitigation measures and strategies for coping with hazard impact, operating procedures, special hazard mitigation equipment, the internal and external organizations that need to be involved, communication protocols, and post-accident management ~~considering~~, including any deterioration of or damage to hazard mitigation features.

6.5. The operating organization should review the applicability of operating procedures and deployment of the necessary mitigation equipment for each individual hazard taking into account the potential effects of the credible combinations of hazards applicable at the site. Operating procedures for separate hazards should not contain conflicting instructions that might lead to confusion if the hazards were to occur in combination. For example, hazard mitigation equipment for a certain hazard should not be stored in an area that ~~is~~could be affected by another subsequent hazard, so that equipment can be used in cases ~~than~~where both hazards ~~already occurred~~occur in combination.

6.6. If ~~a~~ combined ~~hazard event occurs~~events occur that ~~has~~have not been anticipated in the safety assessment, then the precautionary conservative ~~decision-making principles~~hazard response procedure should apply (see para. 3.26). For ~~reactors~~plants that are in operation at the time of occurrence of ~~the~~ combined ~~hazard~~events, shutdown or power

reduction should be considered by the operating organization. The ~~operating~~ personnel should then follow the ~~site~~ accident management programme for the site as a whole, in accordance with Requirement ~~18 in IAEA~~19 of SSR-2/2 (Rev. 1) [1~~],~~] and the recommendations provided in SSG-54 [~~8~~16]. For example, anticipation and consideration for a combination of hazards categorized as unrelated (independent) events [4] might not be ~~recommended~~established unless the combination of events is shown to have a sufficient probability ~~[5].~~in the safety assessment [6]. The operating organization should maintain situational awareness when responding to ~~those unrelated~~such events that have not been anticipated in the safety assessment and should use judgment to ensure the fundamental safety functions ~~based on~~are maintained. Such situational awareness should also include consideration of the performance of response organizations and the conditions in which they are operating at the time of response.

6.7. The operating organization should be aware of the potential for the mitigation of ~~combinations of hazards, i.e., of a~~one hazard causing the initiation of other hazards (consequential or correlated hazards).

6.8. ~~Communication protocols~~Protocols for communication with ~~internal~~plant personnel or communication with external organizations ~~might need to~~should take hazard combinations into account. These communication protocols should be developed considering the effects of hazard combinations based on specific plant conditions. For example, different external organizations might need to be involved in the response for certain hazards. If there are multiple hazards, there might be more organizations involved in the response with different roles and responsibilities. It should be envisaged and assessed that these roles and responsibilities do not overlap or conflict with each other.

6.9. The performance-based approach should be developed using a systematic process to identify and categorize hazard combinations, and should then screen the hazard mitigation measures and strategies for coping with hazard impact based on ~~the basis of~~ the significance of effects on the plant and the frequency of occurrence. ~~IAEA~~ SSG-64 [4] provides three categories of hazard combination: consequent (subsequent) events, correlated events and unrelated (independent) events. For example, the hazard mitigation measures and coping strategies for hazards that ~~rise~~arise from consequent events should receive more ~~special~~ attention~~,~~ than hazards that ~~rise~~arise from independent events.

6.10. For all defined hazard combinations, the operating organization should consider the duration of the consequential effects of each hazard, rather than the duration of the hazard itself. For example, a seismic event might last a few tens of seconds, but the overall measures for hazard management implemented by personnel for the response could last several days or weeks. If a severe rainfall event occurs during the repair period after the

seismic event, the measures for mitigation ~~measures~~ of the rainfall event could be different than when the plant is operating in normal conditions. The response by plant personnel ~~response~~ for these cases should be based not only on the response criteria for both individual hazards, but on specific management measures that relate to ~~a~~the combination of these hazards.

7. PERIODIC UPDATING OF HAZARD MANAGEMENT

7.1. The understanding of the potential effects of hazards on the plant and the importance of maintaining the fundamental safety functions should be continuously sustained ~~while periodically updating hazard management throughout the lifetime of the plant.~~ . Continuous or frequent periodic monitoring of external hazards should be considered, and hazard management should be periodically updated, throughout the lifetime of the plant. ~~Further recommendations on management of plant operations are provided in NS-G-2.4 [12].~~

7.2. The method for hazard analysis and the ~~development of~~ hazard management should be consistent with the plant design bases and the design assumptions. ~~–~~ Hazard management should be reviewed and updated in the following cases:

- If additional hazards or hazard combinations are identified~~;~~ according to SSG-64 [4];
- If there is a reassessment of the severity of an initially considered ~~hazards~~hazard or the ability to withstand this hazard in the specific stage of ~~plant life~~the plant's lifetime;
- As a part of the ageing management and programme for long term operation, as described in SSG-48 [26]
- As part of a re-licensing application;
- As part of a ~~Periodic Safety Review~~periodic safety review, as described in SSG-25 [~~16~~12];
- If new or updated information for a site-specific event shows that the current design basis and design assumptions for hazard mitigation measures or strategies might be inadequate, including information on cliff edge effects or challenges to multiple layers of defence in depth that were not previously identified or addressed.

An update of hazard management should include harmonization with other plant programmes ~~at the plant site~~, such as monitoring programmes or emergency ~~preparedness programmes~~arrangements.

7.3. Hazard management should be considered as an important contributor to the overall safety assessment for the plant and should be used as an input to operational decision making.

7.4. The operating organization should also take into consideration operating experience from ~~hazard~~ events that have already occurred at the ~~installation~~plant or elsewhere. Further recommendations on implementing an operating experience programme to improve plant

equipment, procedures and training are provided in ~~SSG-50 [24].~~IAEA Safety Standards Series No. SSG-50, Operating Experience Feedback for Nuclear Installations [27].

7.5. The operating organization should identify and implement design and procedural recommendations based on initial and periodic safety assessments~~, where~~ if conditions of low margin to external hazard mitigation and cliff edge effects ~~can be~~are identified.

7.6. In the periodic updating of hazard management processes and procedures, the operating organization should consider and address ~~SSCs~~structures, systems and components important for hazard prevention, protection~~,~~ and mitigation, including portable emergency equipment and passive design features. The effect of ageing of ~~SSCs~~structures, systems and components should also be taken into account.

7.7. Procedures, training, drills~~,~~ and exercises for hazard ~~coping and mitigation strategies and measures~~management should be periodically validated to ensure that they remain consistent with updated design assumptions or design bases from safety assessments or safety analysis. Any changes in the procedures or in the use of the procedures should be communicated to all personnel involved and, if necessary, reflected in the training programme.

7.8. Strategies for coping with hazard impact should be examined and updated if there are any changes to the civil infrastructure around the plant site. Such changes include the contact information of external organizations, changes in regional population sizes and the proximity of these populations to the site, changes in electrical grid interfaces, changes in transportation routes, and changes in local industries.

7.9. The potential effects from changes in hazards should be identified and updated based on the results of the periodic site hazard reassessment and the periodic safety assessment ~~results~~ (as needed). ~~The guidance for the periodical~~Recommendations on periodic update ~~on~~ of information on the potential impacts of climate change ~~information is~~are provided in IAEA Safety Standards Series No. SSG-18~~ [XX].~~, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations [28]. Additional considerations might be needed for multiple ~~units. The~~unit sites. For example, a change of the anticipated highest speed of extreme wind might ~~cause~~affect the evaluation for the potential loss of off-site power of multiple units sharing the same switchyard. In this case, it is also necessary to evaluate the operating state of both plants, ~~e.g.~~for example if one unit is undergoing an outage while the other is in full-power operation.

7.10. Modifications in the ~~nuclear power plant~~ design and/or operation of the plant during its lifetime (with regard to both equipment and organization) should be reflected in hazard management. Hazard management processes and procedures should be reviewed and updated following any plant modification~~, and periodically~~.

7.11. If proposed solutions to potential hazard impacts are not implemented, ~~the~~a technical justification for not implementing the solutions should be provided, and this should be reviewed and documented by the operating organization. The technical justification should describe any compensatory features provided to maintain an acceptable level of safety, where applicable. The proposed solutions also include the effect on ~~SSCs~~structures, systems and components important to safety ~~during performing~~while the modification ~~of~~to the ~~installation~~plant is being carried out.

8. CONTROL OF MATERIALS AND HOUSEKEEPING IN HAZARD MANAGEMENT

8.1. The management and control of materials ~~and housekeeping~~ on a routine basis and housekeeping can impact the progression of hazards and their consequences.

8.2. Hazard management should include specific plant walkdown procedures to be conducted periodically, and before and after an event. The results of these walkdowns should be properly documented. These walkdowns should ensure that the ~~SSCs~~structures, systems and components needed for prevention, protection~~,~~ and mitigation of ~~events due to~~ hazards and for coping with ~~effects from~~the impact of hazards are in place and maintained operational. Some examples of walkdowns are the following:

- Ensuring that non-essential flammable materials ~~are removed from the vicinity of activities~~, including ignition sources (flame cutting, welding~~);~~), are removed from the vicinity of activities;
- Ensuring that fire ~~extinguishers are~~extinguishing equipment is present on site and operable;
- Ensuring that culverts are kept clear, as they can have a significant impact on the ability of the site drainage systems to dewater the site;
- Ensuring that loose materials (especially heavy objects) are cleared away or tied down, as they ~~can~~could create ~~potential~~ airborne missiles if extreme wind occurs.

Some of these actions are of particular importance when an external hazard (such as extreme winds or flooding) is forecasted, but proper housekeeping is required to be in effect at all times even if some actions are particularly important only at times when an external hazard is forecasted (see Requirement 28 of SSR-2/2 (Rev. 1) [1]). Further examples of actions that need to be taken~~,~~ and checked during ~~these~~ walkdowns~~,~~ are given in Appendices I and II.

8.3. Hazard management should identify the measures needed for the management of materials and enhanced housekeeping in accordance with Requirement 28 of SSR-2/2 (Rev. 1) [1].

8.4. Control of materials at the various working areas should be enhanced at times of increased risk, for example if a hazardous event is predicted.

8.5. Housekeeping procedures for working areas should include specific activities to increase resilience to hazards by protecting essential areas and equipment.

8.6. Housekeeping should be enhanced at different times throughout the lifetime of the nuclear power plant, including periods of increased risk (e.g. just before returning from an outage or after the implementation of a modification).

9. INSPECTION, MAINTENANCE~~,~~ AND TESTING OF HAZARD PREVENTION, PROTECTION AND MITIGATION MEASURES

9.1. In accordance with Requirement 31 ~~in IAEA~~of SSR-2/2 (Rev. 1) [1], the operating organization is required to establish and implement a comprehensive programme to perform maintenance, testing~~,~~ and inspections of hazard prevention, protection~~,~~ and mitigation measures. Further recommendations on such programmes are provided in ~~IAEA Safety Standards Series No. NS-G-2.6, Maintenance, Testing, Surveillance and In-Service Inspection in Nuclear Power Plants [13~~DS497E [19].

9.2. The maintenance of design features for hazard prevention, protection~~,~~ and mitigation should be included in surveillance programmes ~~to ensure protection against and mitigation of internal and external hazards~~. The operating organization should perform regularly scheduled inspections and maintenance activities to preserve the integrity and functional availability of all ~~SSCs~~structures, systems and components important to safety designed to prevent~~, as applicable~~, protect against and mitigate hazards.

9.3. The operating organization should develop and maintain a list of hazard protection measures for the site and plant and should implement inspection, maintenance and testing activities to ensure their availability. ~~The operating organization should set the~~The conditions for the use of these hazard protection measures ~~in their operability requirements.~~should be documented. If the protection measures are ~~associated with~~derived from the safety analysis, the ~~operability specifications~~conditions for the use of the hazard protection measures should be set in accordance with the results or assumptions of the analysis. If these ~~operability specifications~~conditions cannot be met, alternative measures should be specified and implemented to ~~reduce the risk~~maintain an adequate level of safety (see para 9.5), and the time allowed to complete these alternative measures should be indicated.

9.4. The inspection, maintenance~~,~~ and testing for the site and plant should include general hazard protection measures and ~~protection~~ measures for protection against specific hazards. Hazard protection ~~measures~~and mitigation features that should be inspected, maintained~~,~~ and tested include the following:

- Hazard detection and alarm systems;
- Communication systems for use in the occurrence of a hazard;
- Emergency lighting systems;
- On-site mobile equipment and features for mitigating hazard effects, such as emergency vehicles, ~~submerged~~submersible pumps, mobile diesel generators with adequate fuels;

- Engineered structures, fittings and barriers such as fire doors, watertight doors, dampers and penetrations;
- Access ~~routes~~ and escape routes for hazard response personnel;
- ~~Respirators and~~ Respiratory protective ~~clothing for radiological applications~~equipment and other personal protective equipment.

9.5. Inspection, maintenance~~, or~~ and testing activities can be conducted during outages or on-line states of the plant. The on-site hazard protection measures should be complemented by alternative measures so that an adequate level of safety is continuously maintained during the off-line states of those original measures ~~by~~due to inspection, maintenance or testing. Some examples of alternative measures are the following:

- Sustaining fire barriers, and monitoring and firefighting equipment (e.g. ~~placing watchmen~~assigning a fire watch [12] during fire sensor repairs, securing water lines or fire extinguishers while fire water systems are partially isolated);
- Ensuring that flood doors or flooding hazard mitigation measures are not compromised by ~~the~~a lack of sealing ~~for the~~on drill holes or by ~~the~~a lack of alternative barriers during ~~the~~ maintenance;
- Deploying alternative mobile equipment for spray water for the reactor or for the spent fuel ~~pit~~pool and electrical power supply;
- Deploying emergency response personnel.

9.6. Special consideration should be given to off-site equipment dedicated to hazard mitigation, such as the following:

- Protective barriers and other hazard protection measure not located on site (e.g. dykes). Such protective barriers and hazard protection measures might not be under the direct control of the operating organization and their maintenance might therefore ~~require~~necessitate special arrangements.
- Equipment provided by external organizations or stored in an off-site location, and additional off-site engineered equipment that might be utilized in hazard mitigation measures and strategies for coping with hazard impact.

[12] A fire watch is one or more persons responsible for providing additional monitoring of plant activities or areas for the purpose of detecting fires or identifying activities and conditions that present a fire hazard, and trained in identifying conditions or activities that present potential fire hazards, as well as in the use of firefighting equipment and the proper fire notification procedures.

Such equipment ~~needs to~~should be included in inspection, maintenance and testing procedures.

– Hazard mitigation equipment. For predictable or partially predictable hazards, the operating organization should consider pre-event inspection and/or testing of this equipment to ensure its availability when the ~~hazard~~ event occurs.

9.7. The operating organization should consider additional combustibles such as fire loads during the maintenance periods (~~See~~see Appendix I).

10. TRAINING OF PERSONNEL ON HAZARD MANAGEMENT

10.1. Before starting work, all personnel of the operating organization and any contractor personnel temporarily assigned to the plant should receive training on hazards that might affect the operation of the plant. Training of personnel is required to be performed in accordance with Requirement 7 of ~~IAEA~~ SSR-2/2 (Rev. 1) [1]. Recommendations on the training of personnel are provided in ~~IAEA Safety Standards Series No. NS-G-2.8, Qualification and Training of Personnel for Nuclear Power Plants [14~~DS497F [20].

10.2. Specialized training on hazards should be established for those personnel involved in operations, maintenance activities~~,~~ and hazard mitigation activities at the plant, including contractor personnel temporarily assigned to the plant, where applicable. The level of training provided should be tailored to the role undertaken by the individual or group; differing training courses can be provided to different individuals or groups.

10.3. In accordance with Requirement 7 of ~~IAEA~~ SSR-2/2 (Rev. 1) [1], the operating organization is required to ensure that the personnel have adequate skills commensurate with their roles in hazard management and ~~familiarity~~are familiar with the procedures to be followed.

10.4. Training should be sufficient to ensure that individuals understand the significance of their duties and the consequences of errors arising from misconceptions or lack of diligence, and that individuals understand and follow the evolution of the plant status, including unanticipated evolution of the hazards. Records of training and qualification should be maintained. Also, training materials should be updated, as appropriate, and should reflect the current plant configuration and hazards.

10.5. The training of all personnel on hazard management should include the following topics:

- Hazard ~~safety principles~~management approaches at the plant;
- General awareness of specific hazards (see para. 10.7);
- Roles and responsibilities of ~~the~~ personnel for hazard management before, during and after ~~hazard~~ events;
- Recognition of audible and visual alarm signals, including fire alarms, tsunami warnings, and other alarms as applicable to the site;
- Exits and emergency evacuation routes ~~in the event of an internal or external hazard;~~
- The need to delay or discontinue certain plant activities in case specific external hazards are predicted such as extreme ambient temperatures,

flooding~~,~~ or extreme wind~~;~~, including the means of reporting hazards and actions to be taken to make work safe;

– The different types of portable or resilience equipment provided and their use in mitigating hazard effects in the initial stage~~. This~~; this might include firefighting equipment, flood barriers and communication equipment (e.g. satellite phones).

10.6. The training for personnel who authorize relevant work activities and for personnel who may be assigned ~~the~~ duties for prevention, protection~~,~~ or mitigation ~~on~~of hazards should cover the following topics, which are common for all hazards:

– The importance of maintaining the integrity and operability of hazard prevention, protection~~,~~ and mitigation features (both passive and active) and performing regularly scheduled inspections, routine and emergency maintenance of equipment, and periodic functional tests of equipment and systems;
– The design and operation of the specific hazard prevention, protection~~,~~ and mitigation features installed in the plant to permit effective maintenance of equipment for operability, and the results and assumptions of the hazard analysis, if applicable;
– The significance of planned design changes and plant modifications with respect to hazards ~~without~~, including those changes and modifications not affecting equipment qualification and safety classification, ~~including both~~as well as direct and indirect impacts on ~~nuclear~~ safety and any effects on the integrity or operability of the hazard prevention, protection, and mitigation features (both passive and active) as a result of these modifications;
– Familiarization with the physical location of ~~SSCs contributing to protection and~~structures, systems and components important to safety, preferably through a plant walkdown;
– Familiarization with the physical location of hazard prevention, protection~~,~~ and mitigation features of the plant;
– Detailed knowledge of the design and testing requirements of hardware for hazard protection and knowledge of specific design objectives for those features in each area of the plant, as specified in the safety assessment or similar documentation to ensure that the personnel responsible for the review of planned design changes and plant modifications are sufficiently knowledgeable to recognize issues that might have implications ~~on~~for hazard prevention, protection and mitigation features.

10.7. Familiarization ~~with~~ and training for personnel responsible for the initiation or authorization of relevant work activities should cover specific topics regarding prevention, protection or mitigation ~~on hazards which might include, but are not necessarily limited to,~~of hazards, including the following:

For fire hazards:

- How to control combustibles and ~~to~~ ensure that area limitations on fire ~~loadings~~loads are met;
- Awareness of potential ignition sources, and their limitation and control ~~– e.g.~~, for example by using a special system of permits for hot work ~~procedures~~;
- ~~Maintenance, inspection,~~Inspection, maintenance and ~~controls~~testing of passive fire protection ~~means~~measures, including ~~of~~ fire barriers ~~with~~and their active elements such as doors, dampers~~,~~ and other penetrations, as well as consideration of the corresponding relevant working practices;
- ~~Maintenance, inspection,~~Inspection, maintenance and ~~controls~~testing of fire detection, alarm~~,~~ and reporting means~~,~~ including actions to be taken;
- Recognition of audible and visual fire alarm signals;
- ~~Maintenance~~Inspection, maintenance and ~~controls~~testing of means ~~for~~of access and escape as well as emergency evacuation routes in the event of fire;
- The designated assembly point for evacuation;
- Preventing adverse effects from flooding caused by fire extinguishing media;
- Manual firefighting capability and automatic fire extinguishing by the different types of fire extinguishing systems and equipment provided, and their use, ~~maintenance,~~ inspection, maintenance and ~~controls~~testing;
- ~~Fire~~The fire safety policy at the plant;
- Awareness of specific fire hazards (including combined hazards), including limitations on ~~area~~the fire ~~loading~~load and, where necessary, associated ~~radiological~~radiation protection concerns;
- Significance of the control of combustible materials and ignition sources and its potential impact on the permissible fire ~~loading~~load in an area;
- The hazards associated with hot work activities such as cutting ~~and~~or welding that could ~~produce~~be a potential ignition source;

- The stipulations of the work permit system, specific situations in which a fire watch is necessary, and the risk of introducing potential ignition sources into fire ~~areas~~compartments [13] containing structures, systems, and components ~~identified as~~ important to safety;
- Instructions on work implementation and general fire safety training so that the personnel can readily recognize various fire hazards in the plant and can understand the implications of introducing combustible materials or ignition sources into ~~safety related areas~~areas containing components important to safety;
- ~~Hot~~Controls on hot work ~~controls~~ and ~~their~~the significance of hot work for fire safety, as well as instructions and procedures for taking appropriate additional or alternative fire prevention, protection~~,~~ and mitigation measures to sustain protective barriers (e.g. fire watches ~~during~~for fire detection, safety measures in confined spaces, area ventilation systems, and ~~extinguishing features~~ inspection, maintenance and repair of fire extinguishing features)

For internal flooding:

- Reliable ~~function~~functioning of barrier elements (e.g. doors~~,~~ and other penetrations) in walls, floors~~,~~ and ceilings, and drainage systems for protection against adverse effects from spreading of flooding media in the event of internal flooding, including their control, inspection~~,~~ and maintenance, as well as floor area control with respect to temporary storage, and the ~~result~~results and assumptions ~~based on~~of the internal flooding hazard analysis;
- The ability to respond (detect and isolate) to leaks in diverse locations within ~~evaluated time~~the time necessary to complete these actions.
- Pumping water from flooded areas or compartments;
- Operation of equipment in flood conditions.

For flooding external to the buildings:

[13] A fire compartment is a building or part of a building that is completely surrounded by fire resistant barriers: all walls, the floor and the ceiling.

- ~~Controls as well as inspections and~~ Inspection, maintenance and testing of doors, gates~~,~~ and penetration seals of buildings ~~which~~that need to remain watertight to withstand external flooding;
- Awareness of extreme precipitation and flood warnings and the approach ~~for~~to taking these into account in protection against external flooding;

For seismic events:

- The significance of ~~field~~ housekeeping to avoid extraneous debris or loose items;
- Awareness of the potential for collapse of temporary platforms and scaffolds (in particular inside buildings and close to ~~SSCs~~structures, systems and components important to safety) and the need to adequately secure ~~them~~such temporary structures;
- Information on drills and exercises including drills in prompt decision-making, notification, communication with external ~~organization~~organizations, shutdown, work control, evacuation~~,~~ and other ~~mitigating~~mitigatory actions in line with the on-site emergency plan (see paras 3.11. and 10.10);

For extreme wind and other meteorological hazards:

- Awareness of extreme precipitation, storm~~,~~ and other meteorological warnings and the approach ~~for~~to taking these into account in protection against extreme wind and other meteorological hazards;
- Awareness of the hazards associated with items not adequately fixed ~~for~~against extreme winds, heavy machinery that might be in danger of collapsing and the potential that ~~they~~these might become wind-borne missiles, as well as the need ~~of restriction~~ for restrictions on vehicle parking and equipment storage;
- The work control and evacuation ~~scheme according to~~procedure, in accordance with the meteorological alert level;
- Awareness of the potential for collapse of temporary platforms and scaffolds and the need to adequately secure ~~them~~such temporary structures;
- Notification of and communication with external organizations.

For explosion hazards:

- Active and passive protection systems (such as gas detectors, blast doors, blowout panels, and room and area ventilation systems);
- Explosion detection, alarm and reporting means and actions to be taken;
- Recognition of audible and visual explosion alarm signals;
- Significance of the control of flammable gas pipes;
- The hazards associated with activities using flammable~~,~~ or compressed gas, or involving batteries charging.

10.8. Certain activities might lead to additional risks involving internal or external hazards; therefore, familiarization and training for personnel in charge of authorizing or performing such activities should be provided. Some examples of these types of additional risk are provided in paragraph 10.9.

10.9. Personnel in charge of authorizing who initiates ~~or authorizes~~ work activities involving handling or management of radioactive material should be trained to ensure they are aware of relevant items ~~which might include, but are not necessarily limited to,~~, including the following:

- Description of the categories of radioactive material; labelling, marking, placarding, and packaging and segregation requirements; the purpose and content of the radioactive material transport ~~document~~documents; and the available emergency response documents;
- The ambient conditions that form part of the safe operating envelope for individual fuel or waste packages and the requirement to ensure that these conditions are not exceeded during ~~movement operations~~handling;
- The means by which the site receives and communicates warnings or information on forecasts for predictable external hazards ~~as~~ (e.g. external flooding, meteorological~~,~~ and other natural hazards) that could affect the ability of the ~~operating~~ personnel to perform the fuel or waste handling safely;
- Actions to take after the occurrence of a seismic ~~hazard~~event during fuel or waste handling to verify ~~that~~ ~~(1)~~ the integrity of the transport package has not been compromised, ~~(2)~~ the receiving facility and ~~SSCs~~structures, systems and components have not been ~~inadmissibly~~unacceptably affected, and ~~(3)~~ the handling process can be successfully completed.

EXERCISES AND DRILLS

10.10. Periodic exercises and drills should be sufficiently realistic so that the personnel have the capability to cope with and respond to situations that might occur in the event of

hazards. Exercises or drills should extend over a time period long enough to realistically represent the plant response and associated information transfer, and, if necessary, they should be developed to practice shift ~~change~~changes and to simulate the strategies for coping with hazard impact. Especially for exercises on external hazards, it should be considered that such hazards might affect simultaneously or sequentially multiple units at the site.

10.11. Training should address the implementation of response actions under adverse environmental conditions and, if necessary, under the influence of stress on the anticipated behaviour of the personnel.

10.12. Results from exercises and drills should be systematically evaluated and documented, to provide feedback for the improvement of the training programme and, if applicable, the procedures and instructions (see para. 7.7~~.~~).).

10.13. Specifically, for fire hazards, ~~paragraph~~para. 5.24. of Requirement 22 in SSR-2/~~1~~2 (Rev. 1) [2] states that "Periodic joint fire drills and exercises shall be conducted to assess the effectiveness of the fire response capability." Drills or exercises should be performed with participating site personnel and, as appropriate, ~~the staff of~~ off-site ~~firefighter~~firefighters (see Appendix I).

APPENDIX I – TECHNICAL ASPECTS TO BE CONSIDERED IN HAZARD MANAGEMENT FOR PROTECTION AGAINST INTERNAL HAZARDS

I.1. This Appendix provides recommendations on elements of hazard management for specific internal hazards in addition to the general recommendations for mitigating and coping with internal hazards provided in Section 4.

INTERNAL FIRES

Defence in depth

I.2. To ensure adequate fire safety in a nuclear power plant ~~in operation~~, an appropriate level of defence in depth should be maintained throughout the lifetime of the plant, through the fulfilment of the following three principal objectives:

- Preventing fires from starting;
- Detecting and extinguishing quickly those fires ~~which~~that do start, thus limiting the damage;
- Preventing the spread of those fires ~~which~~that have not been extinguished, thus minimizing their effects on essential plant functions.

I.3. By satisfying these three objectives, it should be ensured that:

- The probability of a fire occurring is reduced to as low as reasonably practicable;
- ~~SSCs~~Structures, systems and components are adequately protected to ensure that the consequences of a single fire will not ~~prevent~~ result in the loss of capabilities of those structures, systems ~~from performing~~and components to perform their ~~required function~~intended safety functions, taking into account the effects of the worst single failure~~.~~ of active fire protection features. Further ~~guidance of~~recommendations on the ~~significance of~~ safety classification of ~~SSCs~~structures, systems and components for fire protection systems are ~~given in the~~ provided in IAEA Safety Standards Series No. SSG-30 ~~[XX, Safety Classification of Structures, Systems and Components in Nuclear Power Plants~~ [29].

I.4. These three objectives of defence in depth should be achieved through a combination of design, installation and operation of fire prevention and protection features; management of fire safety; fire prevention and protection measures; quality assurance; and emergency arrangements. These aspects are addressed in the following paragraphs.

DesignRecommendations on design related aspects of internal fire hazards are provided in IAEA SSG-64 [4].

Fire safety management

I.5. The operating organization should clearly define in writing the responsibilities of all personnel involved in the fire prevention and protection and in the firefighting activities and fire mitigation measures.

I.6. Plant personnel or personnel from outside (e.g. off-site firefighters) engaging in activities relating to fire safety should be appropriately qualified and trained so as to have a clear understanding of their specific areas of responsibility and how these might interface with the responsibilities of other individuals, and appreciate the potential consequences of errorsshould have an understanding of the potential consequences of errors. Also, external personnel (e.g. off-site firefighters) engaging in activities relating to fire safety should be appropriately trained so as to have a clear understanding of specific natures of relevant nuclear power plants.

I.7. Plant personnel orand external personnel from outside (e.g. off-site firefighters) should be encouraged and trained to adopt a rigorous approach to their firefighting activities and responsibilities and a questioning attitude in the performance of their tasks, to foster continual improvement.

I.8. The cause of any fire or of the failure or spurious operation of fire protection features that has the potential to affect safety should be established and corrective actions should be taken to prevent a recurrence. The potential implications for fire prevention and protection of operating experience from fires at other plants should be considered. Communication should be maintained, and information should be exchanged between operating organizations of different nuclear power plants (and with the regulatory body) on nuclear safety related aspects of fire safety.

Fire prevention and protection

I.9. Procedures should be established for the purpose of ensuring that amounts and reaction to fire of combustible materials (the fire load) and ignition sources (number, intensity,

frequency) be minimized in areas containing items important to safety and in adjacent areas that might present a risk of exposure to fire for items important to safety.

I.10. Effective procedures for maintenance, testing, surveillance~~,~~ and inspection should be prepared and implemented throughout the lifetime of the plant with the objective of ensuring continued minimization of fire ~~loads~~load, and the reliability of the features in place for detecting, extinguishing and mitigating the effects of fires, including established fire barriers. The fire mitigation measures should be identified and designed in accordance with their impact on ~~nuclear~~ safety (~~Ref.~~see SSG-30 [~~XX~~29]). The ~~hazard analysis~~operating organization should ~~recognize~~address the ~~limitations~~identified impact of the implementation of fire mitigation systems and of active ~~(~~protection measures (for fire detection and suppression) and passive ~~(~~protection measures (e.g. fire barriers) ~~measures implemented based~~ on ~~risk against nuclear~~ safety.

Organization and responsibilities

I.11. The operational organization should establish an on-site group with the specific responsibility ~~for~~of ensuring the continued effectiveness of the fire safety arrangements. Responsibility for coordinating fire safety activities should be assigned to an individual personnel position, generally referred to as the fire safety coordinator.

I.12. The fire safety coordinator should retain the responsibility for ensuring that all fire safety activities and functions necessary for safety are effectively coordinated to achieve the objectives of the fire prevention and protection.

Fire hazard analysis

I.13. A comprehensive fire hazard analysis should be performed for the plant in order to do the following~~:~~ (see SSG-64 [4]):

- Demonstrate the adequacy of fire protection ~~means~~measures (both passive and active) in place to protect areas ~~identified as~~containing systems, structures and components important to safety for all plant ~~operational~~ states;
- Identify any specific areas where ~~levels of~~ fire protection measures are inadequate and where corrective measures are necessary;
- Provide a technical justification for deviation from the recommended practices ~~(see IAEA SSG-64 [4]) for which~~in cases where no corrective measures are taken~~.~~ (see para I.15).

The fire hazard analysis should be updated regularly over the lifetime of the plant and in case of any plant modifications. Further ~~guidance of~~recommendations on the ~~significance of~~ safety classification of ~~Structures, Systems and Components for~~ fire protection systems are ~~given~~provided in ~~the~~ SSG-30 [~~XX~~29].

Impacts of plant modifications on fire safety

I.14. Any modification that might affect, directly or indirectly, the fire ~~safety means~~protection measures in place, including integrity of fire barriers and the manual firefighting capability, should be subject to a procedure for controlling modifications. ~~Such a~~This procedure ~~for modifications~~ should provide assurance that there will be no detrimental effects on the fire ~~safety means~~protection measures in place or on the ability to provide an effective manual firefighting capability in those areas for which fire ~~safety means~~protection measures are identified as necessary to maintain safety.

I.15. ~~The~~If a technical justification for deviation from the recommended practice ~~(IAEA SSG-64 [4]) that~~ is ~~identified~~provided when the fire hazard analysis is updated, this should include a ~~discussion~~description of the plant modifications that would be necessary to follow ~~accepted~~recommended practice and the reasons why it is not reasonably practicable to implement such modifications. The technical justification should also describe compensatory features provided to maintain an acceptable level of safety, where applicable.

I.16. A review of implications for fire safety should be performed for the following modifications to the plant, if necessary, as part of the update to the fire hazard analysis ~~update~~:

- Modifications to ~~the~~ fire protection features;
- Modifications to ~~the~~ protected items important to safety or systems that could adversely affect the performance of the fire protection features;
- Any other modification that could adversely affect the required performance of ~~the~~ fire protection features, including changes in the fire load from ~~those of~~the fire load identified in the fire hazard analysis.

I.17. Operating ~~licenses~~licences issued to nuclear power plants usually include a requirement for approved, written procedures to be established and implemented for controlling modifications to ~~SSCs.~~structures, systems and components. All proposed plant modifications should be scrutinized for their potential effect on ~~area~~ fire ~~loading~~loads and fire protection features, since a modification involving ~~non-~~structures, systems and components that are not important to safety ~~-related SSCs~~ could conceivably change a fire load or could degrade a fire protection feature whose primary purpose is to protect safety systems.

I.18. A formal review system to evaluate the impacts of modifications on fire safety should be incorporated into the overall modification procedure. Alternatively, a separate procedure should be established and implemented specifically for reviews for fire ~~protection~~safety. Modifications should not be commenced until the review has been completed.

I.19. The personnel assigned the responsibility for performing such reviews for issues of fire safety should be suitably qualified to evaluate the potential effect of any modification on fire safety and should have sufficient authority to prevent or suspend modification work, if necessary, until any issues identified have been satisfactorily resolved.

I.20. Plant modifications should only be carried out ~~on the authority of~~in accordance with a work permit issued by a person who is competent in and knowledgeable of the implications for fire safety~~.~~, and authorized to issue such permits. It also should be ensured that ~~physical protection~~nuclear security personnel are notified of ~~the~~ modifications to the ~~characteristics of the nuclear power~~ plant's physical layout.

I.21. If a modification necessitates the removal from service of any of the fire protection features, careful consideration should be given to the consequent reduced level of protection of ~~item(s)~~items important to safety or of hazard prevention, protection and mitigation features, and appropriate temporary arrangements should be made to maintain adequate protection against ~~fires~~fire. On completion of the modification, the plant as modified should be inspected to confirm its compliance with the modified design. In the case of an active fire protection system, the modified system should be commissioned and the plant as modified should be ~~commissioned and~~ placed into or returned to normal service, as applicable.

I.22. The fire hazard analysis should be reviewed and updated to reflect the modification, as appropriate.

Control of combustible materials and ignition sources

I.23. Administrative procedures should be established in writing and implemented for effective control of combustible materials throughout the plant. The ~~written~~administrative procedures should establish controls for delivery, storage, handling, transport and use of flammable or combustible solids, liquids and gases. Consideration should be given to the prevention of fire related explosions within or adjacent to areas ~~identified as~~containing items important to safety. For such areas ~~identified as important to safety~~, the procedures should establish controls for combustible materials associated with normal plant operations and those ~~which~~that might be introduced in activities ~~related~~relating to maintenance or modifications.

I.24. Written procedures should be established and enforced to minimize the amount of transient (i.e. non-permanent) combustible materials, particularly packaging materials, in areas

~~identified as~~containing items important to safety. Such materials should be removed as soon as the activity is completed (or at regular intervals) or should be temporarily stored in approved containers or storage areas.

I.25. The total fire load in each area ~~identified as~~containing items important to safety should be maintained as low as reasonably practicable, with account taken of the fire resistance rating of the fire compartment boundaries. Records should be maintained that document the estimated or calculated ~~existing~~actual fire load as well as the defined maximum permissible fire load ~~defined~~ for each fire compartment. In addition, combustible materials allowed in ~~the hazard analysis~~each area, in terms of nature, location, and maximum amount, should be defined and documented.

I.26. The use of combustible materials in the furnishings of the plant should be minimized. Combustible materials should not be used for decorative reasons or other non-essential ~~effect~~reasons in areas ~~identified as~~containing items important to safety.

I.27. Administrative controls should be established and implemented to ensure that areas containing items important to safety are inspected periodically in order to evaluate the general fire ~~loading~~load and the plant housekeeping conditions, and to ensure that means of access and escape routes for manual firefighting are not blocked. Administrative controls should also be established and implemented to ensure that the actual fire load is kept within permissible limits.

I.28. Administrative procedures should be established and implemented to provide effective control of temporary fire loads in areas ~~identified as~~containing items important to safety during maintenance and modification activities. These procedures should cover flammable or combustible solids, liquids and gases, their ~~containment~~confinement and their storage locations in relation to other hazardous ~~material~~materials such as oxidizing agents. These administrative procedures should also include a procedure for issuing work permits that necessitate in-plant review and approval of proposed work activities before the start of work to determine the potential effect on fire safety. The on-site personnel responsible for reviewing work activities for the potential for creation of temporary fire loads should determine whether the proposed work activity is permissible and should specify any additional fire protection measures that are needed (such as the provision of portable fire extinguishers or the ~~use~~assignment of a fire watch ~~officer~~, as appropriate).

I.29. Administrative procedures should be established and implemented to control the storage, handling, transport and use of flammable and combustible solids and liquids in areas ~~identified as important to safety. The procedures should be in accordance with national practice and should provide controls for solids and liquids~~containing items important to safety.

I.30. ____ Controls for solids should take into account the following:

- The use of combustible materials (such as wooden scaffolding and polymer joints) should be restricted. Where wooden materials are permitted, they should be chemically treated or coated so as to be fire retardant.
- The storage of combustible materials such as charcoal filters and dry unused ion exchange resins should be restricted; any large stocks of such materials should be placed in a designated storage area with appropriate fire rated compartmentation and fire protection measures provided.
- The storage of combustible materials such as papers and personal protective clothing should be restricted; any large stocks of such materials should be placed in designated storage areas with appropriate fire rated compartment barriers and fire protection measures provided.
- The storage of all other flammable or combustible materials should be prohibited.

I.31. Controls for liquids should take into account the following:

- The amounts of flammable or combustible liquids introduced into fire ~~areas~~compartments during maintenance or modification activities should be limited to the amount needed for daily use. Suitable fire protection measures such as the provision of portable fire extinguishers should be taken, as appropriate.
- Approved containers or dispensers should be used whenever possible for the transport and use of flammable ~~or combustible~~ liquids. Openings in containers should be fitted with spring loaded ~~closures~~caps. Transport of flammable ~~or combustible~~ liquids in open containers should be prohibited.
- If it is necessary to store small amounts of flammable ~~or combustible~~ liquids within a working area, cabinets of an approved design for flammable liquids should be used.
- All containers of flammable ~~or combustible~~ liquids should be clearly and prominently labelled to indicate their contents.
- Stores of large quantities of flammable ~~or combustible~~ liquids should be located and protected such that they ~~should~~do not compromise safety. Such bulk storage areas should be separated from other plant areas by fire rated compartmentation or by spatial separation with suitable fire protection measures taken as appropriate.
- Warning signs should be placed at storage areas for flammable ~~or combustible~~ liquids.

I.32. Administrative procedures should be established and implemented to control the delivery, storage, handling, transport and use of flammable gases ~~through-out~~throughout the

plant. The procedures should ~~be established in accordance with national practice and should be implemented to~~ ensure the following:

- Cylinders of compressed gases that sustain fires, such as oxygen, are properly secured and are stored separately from flammable gases and away from combustible materials and ignition sources;
- Where a supply of flammable gas is needed inside a building for permanent use, it is supplied from cylinders or a bulk storage area safely located outside the building in a dedicated storage area such that a fire affecting the storage area would not compromise safety.

I.33. Administrative procedures should be established and implemented to control potential ignition sources throughout the plant. The procedures should include controls to:

- Restrict personnel smoking to designated safe areas and to prohibit personnel from smoking in all other areas;
- Prohibit the use of open flames for testing heat or smoke sensing devices (such as fire detectors) or for leak testing purposes;
- Prohibit the use of portable heaters, cooking appliances and other such devices in areas ~~identified as~~containing items important to safety;
- Limit the use of temporary wiring;
- ~~Testing~~Limit the testing of portable electronic equipment.

I.34. Administrative procedures should be established and implemented to control maintenance and modification activities that necessitate the use of a potential ignition source or that might themselves create an ignition source. The performance of such work should be controlled by means of formal written procedures, i.e. by means of either the work permit system or a special system of permits for hot work ~~permits~~. In the permit system adopted, procedures should be established to cover management, supervision, authorization and performance of the work, inspection of the work area, assignment of a fire watch (if stipulated) and access for firefighting. All personnel ~~concerned with~~involved in the preparation, issuing and use of permits for hot work should be instructed in the proper use of the permit system and should have a clear understanding of its purpose and application. Whether or not a fire watch is provided, at least one person engaged in ~~the~~hot work should be trained in the use of any fire ~~safety~~protection features provided.

I.35. In areas containing items important to safety, work which involves the use of a potential ignition source or which might create ignition sources should be permitted only after consideration of the possible consequences for safety. For example, such work might be prohibited from occurring simultaneously on functionally redundant items important to safety or in the areas containing such items.

I.36. Procedures should be established to ensure that, before any hot work is attempted, the immediate work area and adjacent areas are inspected for the presence of combustible materials and that the operability of necessary fire protection measures is confirmed. If the configuration and design of the work area might permit the spread of sparks or slag beyond the initial work area, spaces both above and below the work area should be checked, and any combustible materials should be either removed to a safe area or suitably protected.

I.37. During hot work, regular inspections should be performed to ensure that the conditions of the permit are observed, that there are no exposed combustible materials present, and that the fire watch is on duty (if a fire watch has been stipulated in the permit).

I.38. In cases where the permit for hot work ~~permit~~ identifies the need for a fire watch, the following procedures should be followed:

- The fire watch should be on duty in close proximity before any hot work is attempted, the work should be stopped if the fire watch leaves the work area, and the fire watch should remain in the work area for an appropriate period after open flame work is completed.
- While the work is in progress the fire watch should perform no other duties.
- Suitable dedicated firefighting equipment should be readily available and means should be provided by which additional assistance can be readily obtained, if necessary. Adequate access and escape routes for firefighters should be maintained.

I.39. Any equipment or vehicle in use in areas in which a flammable gas could be released should be appropriately qualified for use in explosive atmospheres.

I.40. The use of compressed gas cylinders for cutting or welding operations or other hot work should be controlled by a system of work permits.

I.41. Warning signs should be placed at the entrances to areas containing combustible materials to warn personnel of restrictions or access control measures and of the necessity to permanently control ignition sources.

Inspection, maintenance and testing of fire protection ~~means~~measures

I.42. The maintenance, testing, surveillance~~,~~ and inspection programme should cover the following fire protection ~~means~~measures:

- Passive fire rated compartment barriers and structural elements of buildings, including the seals of barrier penetrations;
- Fire barrier elements with active functions such as fire doors, fire dampers;

- Separating or protective elements such as fire-retardant coatings and qualified cable wraps; fire detection and alarm systems including fire detectors, flammable gas detectors and their electrical support systems;
- Fire extinguishing systems;
- A fire water supply system including a water source, a supply and distribution pipe, sectional and isolation valves, and fire pump assemblies;
- Gaseous and dry powder fire extinguishing systems;
- Portable fire extinguishers;
- Other manual firefighting equipment including emergency vehicles;
- Smoke and heat removal systems and air pressurization systems;
- Emergency lighting systems;
- Communication systems for use in fire incidents;
- ~~Respirators and~~ Respiratory protective ~~clothing for radiological applications~~equipment and other personal protective equipment;
- Access and escape routes;
- Emergency procedures.

Manual firefighting capability

I.43. A firefighting strategy (if necessary, ~~as~~ pre-planned) should be developed for each area of the plant ~~identified as~~containing items important to safety ~~(including those areas, which present a fire exposure risk to areas important to safety).~~. These strategies should provide information to supplement the information provided in the general plant emergency plan. The strategies should provide all appropriate information needed by firefighters to use safe and effective firefighting techniques in each fire ~~area~~compartment. The strategies should be kept up to date and should be used in routine classroom training and in actual fire drills at the plant. The firefighting strategy developed for each fire ~~area~~compartment of the plant should cover the following:

- Access and escape routes;
- Locations of structures, systems or components ~~identified as~~ important to safety;
- ~~Area fire loadings;~~
- Fire loads;
- Particular fire hazards, including the possibly reduced capability for firefighting due to fire hazard combinations, in particular with external hazards (e.g. seismic or extreme wind hazards);
- Special radiological, toxic, high voltage and high pressure hazards, including the potential for explosions;

- Fire protection features provided (both passive and active);
- Restrictions on the use of specific fire extinguishing media because of concerns about ~~nuclear~~ criticality safety or other particular concerns~~,~~ and the alternative extinguishing media to be used;
- Locations of heat and/or smoke sensitive items important to safety;
- Location of fixed and portable extinguishing equipment;
- Water supplies for manual firefighting;
- ~~Containment~~Confinement of fire water run-off from firefighting activities;
- Communication systems (not affecting items important to safety) for use by firefighting personnel;
- ~~Physical protection~~Nuclear security features and notification procedures for ~~plant physical protection~~nuclear security personnel;
- Consideration for ~~inadmissible~~unacceptable effects of firefighting (e.g. the use of water or other extinguishing media) for ~~SSCs~~structures, systems and components important to safety (e.g. measuring converters on the bottom level of the reactor annulus), when the subsequent internal flooding is defined as credible combination of hazards~~.~~ according to SSG-64 [4].

I.44. ~~Plant~~The plant documentation should provide a clear description of the manual firefighting capability provided for those areas of the plant ~~identified as~~containing items important to safety. The manual firefighting capability might be provided by ~~a~~ suitably trained and equipped on-site firefighters, by a qualified off-site service or by a co-ordinated combination of the two, as appropriate for the plant and in accordance with national practice.

I.45. If reliance is placed on off-site response, a well-balanced notification protocol for reliability and rapidness should be established between the ~~plant~~operating organization and ~~the~~ off-site ~~firefighter~~firefighters. Designated ~~operating~~plant personnel in each shift should be assigned the responsibility to coordinate and liaise with the off-site ~~firefighter~~firefighters and to establish a clear line of authority at the fire scene. Appropriate plant personnel should be designated even in situations in which the off-site response is supplementary to a primary response by ~~a~~ qualified on-site ~~firefighter~~firefighters. A possible delay in the off-site response should be taken into account in the fire hazard ~~assessment~~analysis.

I.46. Where full or partial reliance for manual firefighting capability is placed on off-site resources, there should be proper coordination between the plant personnel and the off-site response group in order to ensure that the latter is familiar with the hazards of the plant. The responsibilities and lines of authority for manual firefighting personnel should be documented in a firefighting plan.

I.47. If an on-site ~~firefighter~~firefighting organization is established to provide a manual firefighting capability, the firefighter's organization, minimum staffing level, equipment (including self-contained breathing apparatus) and training should be documented, and their adequacy should be confirmed by a competent person.

I.48. ~~Members~~Member of the ~~firefighter~~on-site firefighting organization should be physically capable of performing firefighting duties and should attend a formal programme of firefighting training prior to assignment to the ~~plant~~on-site firefighters. Regular training (i.e. routine classroom training, firefighting practice and fire drills) should be provided for all on-site ~~firefighter members.~~firefighters. Special training should be provided for ~~firefighter leaders~~firefighters in leadership positions to ensure that they are competent to assess the potential safety consequences of a fire and provide advice to control room personnel.

I.49. If manual firefighting represents the primary means of fire protection, ~~it should be ensured, as far as possible, that the necessary actions in the event of fire can be carried out safely in terms of radiological protection~~radiation protection of firefighters and other personnel should be ensured.

Fire related training of plant personnel

I.50. All plant personnel and ~~contractors'~~contractor personnel temporarily assigned to the plant should receive training in plant fire safety, including their responsibilities in fire incidents, before starting work at the plant. These topics for training are provided in para. 10.7.

I.51. Selection and appointment procedures for plant ~~staff~~personnel should establish minimum initial qualifications for all personnel involved in fire safety functions and activities ~~which~~that might affect safety. These minimum qualifications should be based on an evaluation of the necessary education, technical competence and practical experience for the job concerned.

Quality assurance for matters relating to fire safety

I.52. Fire protection features (including preventive features) are not generally classified as hazard prevention, protection and mitigation features and thus they might not be subject to the rigorous qualification requirements and the associated quality assurance programme applied to hazard prevention, protection and mitigation features. However, fire has the potential to ~~fail~~cause multiple systems ~~and thus to pose a threat to safety~~to fail, and therefore the operating organization should apply an appropriate level of quality assurance to active and passive fire

protection measures ~~according to~~in accordance with their ~~influence on plant~~ safety significance.

INTERNAL EXPLOSIONS

I.53. The operating organization should consider various explosion sources when ~~preventing, detecting,~~addressing the prevention, detection and ~~mitigating~~mitigation of internal explosions. Potential sources of internal explosions might be related to the use or ~~the~~ generation of explosive gases and compressed gases. There is also a potential for dust or oil mist explosions, although these are ~~judged~~generally less likely. Additionally, events leading to an energy release similar to an explosion might also come from high energy arc flashes in electrical equipment. Explosion events might also occur in conjunction with other hazards~~,~~ such as fire, and a release of fluids stored at high pressure can result in significant overpressure events having effects similar to explosions.

I.54. The potential formation of an explosive atmosphere should be avoided or limited using non-flammable liquids ~~or processes (~~, such as water-based solvents, and by application of suitable processes such as operating contamination monitors with inert gases~~,~~ and recombining hydrogen emissions from battery charging~~).~~.

I.55. Internal fires and internal explosions are similar hazards and, in developing the management for internal explosions, the recommendations provided for internal fires (see paras I.2.–I.52) should be taken into consideration. For explosions, as with fires, there should be enhanced controls over materials and operations during times of increased explosion risks.

I.56. Active and passive protection ~~systems~~means (such as gas detectors, blast doors, blowout panels, room and area ventilation systems~~,~~ and venting safety devices) should be subject to the inspection, maintenance and testing programmes identified in hazard management.

I.57. Operating procedures (e.g. area ventilation procedures, area or system isolation procedures) should ~~play a role in preventing~~be applied to prevent explosion events and ~~in any~~ post-explosion ~~event~~events.

I.58. Administrative procedures should be established and implemented to control the delivery, storage, handling, transport and use of flammable and explosive materials, including the types, quantities and locations of gases throughout the plant. The procedures should ~~be established in accordance with national practice and should be implemented to~~ ensure the following:

- Containers of compressed gases that sustain fires, such as oxygen, ~~are~~should be properly secured and ~~are~~ stored separately from flammable gases and away from combustible materials and ignition sources;
- Where a supply of flammable gas is needed inside a building for permanent use, it ~~is~~should be supplied from cylinders or from a bulk storage area safely located outside the building in a dedicated storage area such that a fire affecting the dedicated storage area would not compromise safety.

I.59. Control of ignition sources is a main ~~prevention~~preventive measure for internal explosions. Therefore, administrative procedures should be established and implemented to control maintenance and modification activities that necessitate the use of a potential ignition source or that might themselves create an ignition source. The performance of such work ~~will~~should be controlled by means of formal written procedures, i.e. by means of either the work permit system ~~discussed earlier~~ or a special system of permits for hot work ~~permits. Since flammable~~. Flammable gases might have the potential to create explosive mixtures, which can cause an explosion ~~with~~if ignition sources ~~being~~are present~~. The recommendations provided for internal fire are also applicable~~.

I.60. In areas containing items important to safety, work ~~which~~that involves the use of a potential ignition or explosion source or ~~which~~that might create ignition sources should be permitted only after consideration of the possible consequences for safety. For example, such work might be prohibited from occurring simultaneously on functionally redundant components important to safety or in ~~the~~ areas containing such components.

I.61. The operating organization should control and/or limit personnel access in areas where explosion hazards could occur, such as main and auxiliary transformer areas. ~~This includes the prevention~~The preventive measures ~~of~~for combustible materials, as described in I.23.-I.41, should also be applied.

INTERNAL MISSILES

I.62. Potential missile sources are present at all nuclear power plants. The operating organization efforts should focus on ensuring that the integrity of potential internal missile sources and of engineered structures is maintained so that internal missile generation and hazard propagation are prevented or unlikely and limited in extent, if the hazard occurs, and is mitigated before it affects essential plant or system functions.

I.63. Operating procedures should be developed and implemented for identified and characterized internal missile sources to prevent internal missile hazards ~~and include~~, including the following:

- Regular plant area walkdowns to detect ~~potential~~ missile hazards;
- Observation of personnel interacting with potential missile sources;
- Rotating machinery inspections, including means to limit ~~the~~ rotational speed and monitoring and surveillance measures;
- Regular turbine blade inspections for turbine blade degradation;
- Inspection of storage areas of high-pressure gas bottles and of the integrity of the gas bottles themselves;
- In the areas where ~~SSCs~~structures, systems and components important to safety are located, inspection of ~~the~~ pressure vessels and of high energy valves to detect possible flaws (~~for example~~e.g. the presence and good tightening of all bolts fastening the cap of the valves on their bodies should be checked and welds inspected).

I.64. The operating organization should control and/or limit personnel access in areas where missile hazards could occur.

I.65. The operating organization should establish operating procedures that describe actions following early identification of ~~potential~~ missile ~~events~~hazards at the site. These indications of a ~~potential~~ missile ~~event~~hazard might include output from vibration monitors or reports of unusual sounds. Indication that an event has occurred might come from direct observation of missile effects by ~~operating~~ personnel~~,~~ or video monitoring of plant areas.

I.66. Operating procedures to be implemented after missile events should include actions such as plant walkdowns to determine the missile impact on the integrity and functionality of ~~SSCs~~structures, systems and components important to safety.

I.67. Much of the protection provided against the effects of missile hazards is from basic layout decisions in design~~,~~ and by passive hazard protection such as engineered barriers. The passive features should be subject to the inspection, maintenance~~,~~ and testing programmes identified in hazard management, and ~~the~~to plant surveillance programmes (see ~~section~~Section 9).

I.68. The integrity of engineered structures and barriers affected by an internal missile hazard should be assessed.

~~PIPE BREAKS (INCLUDING SECONDARY CONSEQUENCES SUCH AS PIPE WHIP, JET EFFECT, FLOODING AND PRESSURE BUILD UP)~~

PIPE BREAKS

I.69. Pipe breaks (or pressure part failure) are associated with a variety of resulting hazard phenomena, including pipe whip impacts, room pressurization, jet effects and flooding. The extent of each of these phenomena depends on the fluid involved, and its temperature and pressure. In accordance with Requirements 10, 14, 24 and 31 of SSR-2/2 (Rev. 1) [1], the actions described in paras I.70–I.74. should be implemented to prevent pipe breaks and mitigate their potential impact.

I.70. The operating organization should ensure the control of plant configuration for the plant piping is maintained at all times, including engineered structures designed to minimize the impact of pipe breaks. Periodic ~~walk-downs~~walkdowns of plant areas should be performed to confirm that the plant conditions correspond to those stated in the design, including identification of items that could hinder or make ineffective leak detection devices, proper closure of compartment doors~~,~~ and proper installation of protective covers. These periodic walkdowns should also include inspections to identify general pipe and piping component degradations~~,~~ and steam and water leaks, and inspections of engineered barrier integrity, pipe whip restraints, pipe hangers, blast doors, blowout panels and drains.

I.71. The ageing management programme should incorporate the appropriate aspects of pipe integrity, including operating experience feedback regarding any new information on the potential degradation of comparable piping systems.

I.72. Maintenance, testing, surveillance~~,~~ and inspection programmes should ensure that any degradation of piping systems is detected and corrected in a timely manner if necessary, thereby preventing pipe failures. Movable engineered structures designed to minimize the impact of pipe breaks like valves, hangers~~,~~ and dampers should be tested regularly to prove they are functional.

I.73. Apart from the operating procedures associated with preventive actions, there should be procedures ~~related to~~for the implementation of ~~mitigating~~mitigatory actions and coping strategies in the event of pipe break impacts ~~that should include implementation of coping strategies~~.

I.74. If a pipe break occurred and the plant has been returned to a safe state, a thorough inspection should be performed to reveal any damage that might have been caused by the different impacts of the break in its surrounding, including, ~~according to the needs and~~depending on the importance of the rupture, the internal depressurization wave, high humidity, spray~~,~~ and high temperature in the room concerned.

INTERNAL FLOODING

I.75. Internal flooding at a nuclear power plant might be caused by leakages, pipe breaks, tank breaches or overflows, open valves or the use of firefighting water. These can also be ~~the~~ indirect effects of challenges from external hazards such as seismic or external flooding events. The operating organization should ensure that the integrity of engineered structures and barriers that are designed to minimize the impact of internal flooding is maintained at ~~any time~~all times.

I.76. Enhanced operational controls during construction, maintenance~~,~~ or inspection activities should be implemented during times of increased flooding risks (e.g. temporary water hoses during outage periods, temporary storage ~~which~~that causes floor area reduction).

I.77. Operational controls should include inspections of water-based systems for integrity before returning them to service and should ensure that any temporary modifications to drains, including temporary covers, have been restored to the pre-work conditions.

I.78. ~~Prevention~~Measures for prevention, protection~~,~~ and mitigation ~~measures~~ against internal flooding hazards should include level detection systems, engineered drainage routes, water proofing measures to prevent flooding~~,~~ and protection covers or embankments around ~~significant~~ structures and components to prevent water spreading to other plant areas in an uncontrolled manner. Mitigation of internal flooding should be achieved in part by design choices with respect to the layout of the plant. Some ~~flood~~flooding scenarios are naturally self-limiting (for example where the flood is limited to the contents of a single tank), whereas others might necessitate short-term actions to be implemented by ~~the operating~~ personnel.

I.79. General housekeeping rules will control debris in drain systems, but inspections and plant ~~walk downs~~walkdowns should check the general good condition of drainage systems. Inspections or ~~walk downs~~walkdowns should also ensure that flood doors are properly closed and secured, flood barriers are in place as designed, and flood mitigation measures are not compromised by ~~the~~a lack of sealing for ~~the~~ drill holes~~,~~ or a lack of alternative barriers during ~~the~~ maintenance.

I.80. ~~When~~For cases when evacuation or retention capacities cannot contain the flow of an internal flood, the operating organization should establish operating procedures for the detection and mitigation of internal flooding. The operating procedures should include instructions for the isolation of leaking systems and flooded rooms~~,~~ and the potential use of deployable pumping equipment to drain flood liquids. The personnel ~~required~~responding to

~~respond to the~~ flooding should be suitably trained ~~to~~in the application of these procedures (~~See~~see para. 10.7).

~~DROPPED LOAD AND FALLING OBJECTS AND IMPACT OF THESE ON SSC~~

HEAVY LOAD DROP

I.81. Analysis of the hazards associated with heavy load drop should be performed in accordance with the recommendations for heavy load drops provided in ~~paras 4.170–4.183 in~~ SSG-64 [4]. The prevention of structural collapses and falling objects from crane lifts is first and foremost ~~realized~~ensured by ~~a demonstrably~~ conservative design. Nevertheless, falling objects impacts from cranes and other lifting equipment should be considered ~~as~~ a ~~potential~~ hazard. Non-crane related load drops from heights might be related to mishandling of other heavy objects at height.

I.82. Hazard protection and mitigation measures should include load following platforms, deployable deformable structures and protective dampers if applicable, as well as load cells on hoists, fall zone controls, and ~~crane~~limit switches on cranes and lifting equipment ~~limit switches~~.

I.83. The operating organization should establish procedures for planning hoisting and lifting activities. Planning of these activities should include involvement of suitably qualified personnel, risk assessments, pre-planned lifting routes, associated lifting equipment, additional supervision, defining of restrictions~~,~~ and interlocking of lifting routes, as applicable. Hazard management should ensure that in appropriate timings after these activities, or periodically, the following items are consistent with design documents, such as the code or standards referenced in licensing documentation or in the design basis:

(i) Calculations for crane and lifting devices~~, or~~;

(ii) Procedures used to implement inspections, such as load testing, visual testing, dimensional testing, non-destructive testing of major load carrying welds, and critical areas for the lifting devices.

I.84. Communication protocols should be established between control room operators and personnel controlling and performing the lifts ~~where needed.~~.

I.85. The operating organization should establish operating procedures to implement hazard management when there is a high risk of damage or multiple hazard impacts (e.g. fire, flooding) following a dropped load.

I.86. The operating organization should establish operating procedures for performing regular walkdowns and inspections of areas and structures where collapses might occur and objects might fall. Those areas ~~which~~that are located outside plant buildings should be included for walkdowns or inspections when there is a high risk of the degradation of objects in the open air or ~~impacts~~the impact of extreme winds. The operating organization should also establish ~~as well operating~~ procedures for performing regular walkdowns and inspections of areas and structures where a load might impact ~~of the load with an SSC~~a structure, system or component during ~~its~~ movement of the load via handling (along the horizontal or/and vertical ~~axis) might happen.~~axes).

I.87. The ageing management programme for the lifting equipment should ~~be established to~~ ensure that the number of load cycles during the lifetime of equipment is consistent with the result of the fatigue analysis.

I.88. Disabling of or changes to active protective measures (e.g. limiters, interlocks, trips) should only be allowed in accordance with pre-planned procedures.

I.89. The scheduling of load movements and lifts in specified modes of plant operation (such as shut-down modes) should be considered as a preventive and mitigative measure.

I.90. The integrity of engineered structures and barriers affected by ~~drop of loads~~a dropped load should be assessed.

ELECTROMAGNETIC INTERFERENCE

I.91. All potential sources of electromagnetic interference ~~(EMI)~~[14] and all items of sensitive equipment in the plant should be identified. Significant sources of electromagnetic interference can be eliminated by suitable design, construction~~,~~ and maintenance of instrumentation and

[14] If the disturbance is in the high or radio frequency ranges, it is sometimes referred to as radio frequency interference ~~(RFI), but in the context of this document, electromagnetic interference is used as the generic term.~~.

control systems and also of power supply systems and their components. Other potential sources of electromagnetic interference might include maintenance or construction equipment and activities such as portable arc welding equipment, portable radio communications or telephones brought into the ~~nuclear~~ plant, and ground penetrating radars used for ground surveys.

I.92. Within hazard management, the identification of ~~potential~~ electromagnetic interference hazards should take into account ~~for~~ all potential sources of electromagnetic interference during regular and specific maintenance periods or other plant activities.

I.93. The identification process for electromagnetic interference hazards should include the ~~potential location~~possible locations of permanent and temporary sources of electromagnetic interference, where possible, and should focus on sources close to sensitive equipment. The integrity of electromagnetic interference prevention or mitigation features should be checked after maintenance operations on electromagnetic interference sources or sensitive equipment (e.g. cable or equipment shielding, cable separation, earthing)

I.94. The identification process for electromagnetic interference hazards should contain ~~controls~~checks for portable or temporary sources of electromagnetic interference ~~sources~~. These ~~controls~~checks should include the location and timing of maintenance and construction activities~~,~~ and exclusion zones or other administrative or operational controls to minimize an electromagnetic interference hazard, ~~including~~as well as the location of sensitive equipment, such as digital instrumentation and control systems, wireless equipment used at the plant, equipment used for maintenance and repair activities~~,~~ and measuring devices.

I.95. The ~~persons~~personnel responsible for the activities where electromagnetic interference might be generated should have a role in ~~the~~hazard management for electromagnetic interference hazards. Communications between control room operators and the personnel performing the work might be necessary to terminate the ~~generation~~ source generating the interference and stop further effects on the plant.

RELEASE OF HAZARDOUS SUBSTANCES INSIDE THE PLANT

I.96. Releases of hazardous substances inside the plant and on ~~-~~ the site are generally ~~viewed as~~ unlikely, limited in extent if they occur, and can be avoided before they affect essential plant functions. However, the operating organization should consider the effects of hazardous substances on control room operators and the habitability of control ~~room~~rooms.

I.97. The operating organization should establish operating procedures that characterize actions following indications of a release of a hazardous substance ~~release~~ inside the plant.

Entry into these procedures is typically based upon indications from a gas detection system~~,~~ or from direct reports from the ~~operating~~ personnel. The objective of the operating procedures should be to limit exposure of the personnel during the event and ensure timely recovery of personnel after the release has dispersed.

I.98. ~~From~~In the case of an on-site release ~~perspective~~, operating procedures should include the isolation of damaged systems or storage tanks, rooms with non-habitable atmospheres, preservation of habitable atmospheres in the main control rooms, and a process for partial evacuation for personnel involved in activities at the plant. The need ~~for maintaining~~to maintain personal protective equipment on~~-~~ the site (e.g. breathing apparatus, protective clothing) should be considered to allow control room operators to move to safe plant locations or perform safety related actions.

I.99. Protection and mitigation against the effects of an internal release of hazardous substances is largely ensured by passive means (e.g. redundancy of rooms or systems) or administrative procedures. Operating procedures should include provisions to close dampers in the air inlet path of the ventilation system to the main control room if necessary and might also include other controls over ventilation flows.

APPENDIX II – TECHNICAL ASPECTS TO BE CONSIDERED IN HAZARD MANAGEMENT FOR PROTECTION AGAINST EXTERNAL HAZARDS

II.1. This Appendix provides recommendations on elements of hazard management for specific external hazards in addition to the general recommendations for ~~mitigation~~mitigating and coping with external hazards provided in Section 5.

SEISMIC HAZARDS

II.2. To ensure that seismic hazards are included in hazard management, the operating organization should consider and include specific actions derived from the results of the design and assessments performed as recommended in ~~Refs [6, 25]. The operating~~SSG-67 [6] and IAEA Safety Standards Series No. NS-G-2.13, Evaluation of Seismic Safety for Existing Nuclear Installations [30]. The plant personnel should have an understanding of the importance of specific seismic safety design and analyses results and ~~safety related~~ components important to safety and their potential failure modes, interactions~~,~~ and challenges to redundancies.

II.3. The operating organization should develop an earthquake response plan for pre-event and post-event actions. These actions should be documented as procedures that describe short-term and long-term actions and include specific walkdowns for ~~SSCs~~structures, systems and components to determine the status and functionality of hazard protection and mitigation features. Procedures for actions to be taken after hazardous conditions have passed should take into account ~~for~~ challenges introduced by the seismic event such as safe access to site areas and consequential hazards ~~when specifying post hazard actions.~~after an earthquake. The initiation of these procedures should be based upon indications from the seismic monitoring system, information from off-site geological monitoring centres~~,~~ or ground motion experienced by ~~the operating~~ plant personnel. Insights for plant shutdown are provided in Ref. [~~26~~31]. The indications from the seismic monitoring system should be calibrated to highly sensitive seismographs and strong motion accelerographs in regional and/or national monitoring networks ~~to~~as well as worldwide broadband seismograph networks, if necessary, as described in ~~Ref. [27~~IAEA Safety Standards Series No. SSG-9 (Rev. 1), Seismic Hazards in Site Evaluation for Nuclear Installations [32].

II.4. The operating organization should maintain the seismic qualification of equipment required to perform safety functions during and/or after an earthquake. This could be achieved through implementation of an inspection programme in order to identify potential deviations, such as defects due to ageing or inadequate systems configuration following maintenance or modification. ~~As a pre-event action~~Before an earthquake, the operating organization should observe the principles of good housekeeping to ensure that earthquake damage is not

propagated or increased by temporary and/or loose items. This action should include securing items (through seismic restraints) that might cause damage ~~through seismic interactions with~~to items important to safety during a seismic event. If a seismic event and a subsequent tsunami are defined, according to SSG-64 [4], as a credible combination of hazards, the operating organization should consider the response and ensure the plant is adequately protected against the tsunami (for example, flood protection gates being in place).

II.5. If the plant is shut down after an earthquake ~~event~~, the operating organization should ensure long-term safety during the shutdown ~~phase~~. Items to be considered are emergency diesel generator fuel supplies, off-site power supply, auxiliary power supply, control room habitability~~,~~ and the restoration or possible repair of disabled or damaged items important to safety and hazard protection and mitigation features. The operating organization should check the monitoring ~~systems~~systems used to determine the expected type and level of damage to the plant and take appropriate actions for that damage level. If a subsequent tsunami is a credible combined hazard, the operating organization should include criteria for lead time (for the tsunami to reach the plant) and should take into account the severity of seismic damage to the plant~~,~~ in ~~their~~ post-accident management.

II.6. If the plant is surrounded by mountains or hills, the operating organization should consider implementing post-~~-~~event monitoring for the condition of the slopes~~, or~~ and for the sedimentation level of dams that were built to protect the ~~facility~~plant from landslides and should prepare appropriate measures if unacceptable conditions are observed.

II.7. As appropriate, protocols for communication ~~protocols~~ with off-site geological monitoring centres should be established for redundant seismic notifications. The data from regional and/or national monitoring networks described in para II. 3 can be used for periodic updating of hazard management.

EXTERNAL FLOODS (STORM SURGES AND TSUNAMIS)

II.8. To ensure that external floods (storm surges and tsunamis) are included in hazard management, the operating organization should consider and include specific actions derived from the results of the design and the assessments performed on the basis of the recommendations provided in ~~DS498 [5~~SSG-68 [6]. For example, in areas where tsunami hazards could occur, ~~hazard design assessment~~the tsunami flooding analysis might identify risks to SSCs important to safety, e.g. the emergency generators and electrical distribution systems~~. Since, the~~, and sea water system for the ultimate heat sink. The impact of tsunami backrush on sea water system should also be taken into account. The impacts of tsunamis and

storm surges are not limited to flooding, and in coastal areas the extensive and sudden movement of soft sediments or biological material also has the potential to affect the water intake system ~~requiring actions by operating personnel~~.

II.9. Since external floods by storm surges or tsunamis can be forecasted to a certain extent, the operating organization should establish a warning system for external floods, including storm surges and tsunamis~~,~~ and protocols for communication ~~protocols~~ with national and local agencies that provide forecasts, where available. The hazard management for this hazard should take into consideration that the capability and available lead time in these forecasts might differ significantly (e.g. storm surge vs~~.~~ tsunami, far-field tsunami vs~~.~~ near-field tsunami). Where appropriate, the ~~operating organization should ensure that~~ hazard management ~~considers~~should consider evacuation routes and safe refuges for personnel in the event of a tsunami.

II.10. If protocols for communication ~~protocols~~ with national agencies are not available for tsunami warnings, the operating organization should consider the installation of a site-area tsunami warning system.

II.11. The operating organization should establish and implement procedures that describe ~~pre-event~~actions to be taken before, during and ~~post-~~after the event ~~actions~~ corresponding to the estimated height, arrival time~~,~~ and duration of the storm surge or the tsunami.

II.12. Before a flooding or storm surge event, monitoring of sea water levels should be initiated. ~~Status~~The status of water-tight doors, bulkhead openings and water intake structures should be checked as appropriate. If necessary, actions should also be taken for any low water level conditions (e.g. stopping operation of the seawater pump). All site drainage systems and engineered water runoff systems should be checked~~,~~ and their functionality should be ensured. Additional waterproofing measures should also be considered for vulnerable and/or sensitive areas.

II.13. Before the flooding event, the site should be inspected for loose equipment or structures that might become floating debris and cause structural loading if they impact structures or equipment during the event. If possible, these items should be removed from the site~~,~~ or secured so as to minimize hazard propagation during the flood, including restraining items that might become buoyant during an extreme flooding event and block drainage outlets or access routes.

II.14. Before the flooding event, all operation and maintenance activities not related to the flooding hazard mitigation should be completed and equipment and systems should be brought ~~into~~to a safe condition.

II.15. The operating organization should ensure personnel safety during the flooding event by clearly communicating the expected water levels~~,~~ and the potential for overtopping of dykes, dams~~,~~ or seawalls due to the combined effect of sea level variations and wind-generated waves.

II.16. The operating organization should ~~ensure~~establish hazard mitigation measures such as removing debris or isolating damaged ~~SSCs~~structures, systems and components to minimize flooding propagation and to avoid increasing ~~the~~ damage ~~of SSCs~~to structures, systems and components important to safety.

II.17. For sites in cold climates, the operating organization should monitor regional ice conditions (e.g. coverage, thickness, duration) in seas and estuaries to minimize the impact on exposed structures (e.g. water intake) by ~~the~~ flooding.

EXTERNAL FLOODS ~~(FLOODING OF RIVERS AND STREAMS, AND FLOODS DUE TO EXTREME PRECIPITATION EVENTS)~~

II.18. To ensure that external floods (flooding ~~of~~on rivers and streams, and floods due to extreme precipitation events) are included in hazard management, the operating organization should consider and include specific actions derived from the results of the design and assessments performed on the basis of the recommendations provided in ~~DS498 [5~~SSG-68 [6].

II.19. Since external floods by extreme precipitation or flooding ~~of~~on rivers are predictable to a varying extent, the operating organization should establish ~~communication~~ protocols and standards for communication with national and local agencies that predict such phenomena. The wide range in forecast capability for flooding on large rivers, flash flooding on small watersheds or local intense precipitation on the site should be considered.

II.20. The operating organization should establish and implement procedures that describe ~~pre-event~~actions to be taken before, during and ~~post-~~after the event ~~actions~~ corresponding to the expected amount of precipitation or, in the case of river flood, the expected time of the different events ~~which justify putting in place~~ and consequently the different protections that need to be put in place or ~~to implement specific~~ actions that need to be implemented.

II.21. Before the ~~flooding~~flood event, site water levels should be monitored continuously. ~~Status~~The status of water-tight doors, bulkhead openings and water intake structures should be checked as appropriate. The recommendation in para. II.12. for drain and waterproofing measures also should be considered.

II.22. In the case of extreme precipitation, mitigation strategies should include ensuring the site drainage systems are clear of debris and able to handle the expected water runoff. Where

necessary, the operating organization should consider the use of mobile pumps to remove water ~~from vital areas~~.

II.23. The recommendations in paras II.14–16 for the activities of personnel should be considered.

II.24. The operating organization should ensure that there are adequate supplies of mobile pumps and other necessary flood mitigation equipment. Before the flooding event, the ~~operating~~ personnel should ensure all flood protection measures are installed and deployed as intended by design.

II.25. The recommendation in para. II.6 should be considered for extreme precipitation.

EXTREME WINDS

II.26. To ensure that extreme winds, including straight-line winds, tornadoes~~,~~ and extratropical or tropical storms (cyclones, hurricanes and typhoons) are included in hazard management, the operating organization should consider and include specific actions derived from the results of the design and assessments performed on the basis of the recommendations in ~~DS498 [5~~SSG-68 [6].

II.27. The operating organization should establish ~~communication~~ protocols and standards for communication with national and regional meteorological organizations to be properly warned of these hazards, including any rare meteorological ~~phenomenon~~phenomena.

II.28. The operating organization should regularly check the site meteorological systems, where installed, to ensure consistency with measurements by specialized meteorological organizations as well as determining ~~localized~~local weather conditions, if necessary. For example, a plant located in a narrow valley can be affected by a localized extreme wind that cannot be identified by wide-area weather forecasts. There are cases where this extreme wind can be aggravated due to the change of the wind direction. This check can be done in the periodic update of the hazard management ~~programmes~~ (see Section 7).

II.29. Before any predicted extreme wind events, ~~the operating organization should perform~~ walkdowns and inspections of the site should be performed to identify and remove any loose debris and unsecured items or equipment stored around the plant site, especially metallic items. These activities should include reinforcing or removing any temporary scaffolding, securing any unstable equipment~~,~~ and preparatory checks of emergency power systems.

II.30. Before ~~the~~ any predicated extreme wind events, all outdoor operation and maintenance ~~outdoor~~ activities not related to the mitigation of this external hazard ~~mitigation~~ should be

completed and equipment and systems should be brought into a safe condition, such as folding the tall cranes being temporarily brought ~~in~~indoors.

II.31. Depending on the severity of the extreme wind hazard, the operating organization should consider evacuating all non-essential plant personnel.

II.32. Example check lists ~~prepared~~ for ~~the operating organization to associate various management programmes for~~use in case of a tropical storm are the following:

(i) When ~~the~~a tropical storm is approaching the plant:

- Identify the appropriate operating ~~procedure~~procedures for responding to the tropical storm, start frequent weather monitoring, conduct patrolling and, if necessary, housekeeping outside the building ~~according to the plant operation~~in accordance with the plant's operations programme;
- Confirm the availability and testing log of drainage pumps (if the ~~hazards are~~hazard is combined with extreme precipitation) or facilities ~~according to~~in accordance with the surveillance programme;
- Reconfirm the criteria for deciding to stop outdoor work ~~by~~ in accordance with the work management of the maintenance programme (or, if necessary, management of the fuel management programme);
- Establish internal and external communication systems ~~according to~~in accordance with the ~~plant operation~~plant's operations programme[15].

(ii) When the expected alert area of ~~the~~ extreme winds includes the plant:

- Assess whether all works can be continued ~~by~~in accordance with the work management ~~according to~~of the maintenance programme (or, if necessary, management of the fuel management programme);
- Review the list of all work, preparation progress and ~~incorporating~~incorporation of information from other ~~management~~plant programmes, including programmes for plant modification ~~management~~, operating experience feedback~~,~~ and ~~physical protection according to~~nuclear security in accordance with the quality assurance programme (or relevant supporting functions~~)~~[9])[11]
- Establish response teams including control room operators, on-site firefighters~~,~~ and ~~physical protection~~nuclear security personnel in shift

[15] These actions might be taken as part of the emergency preparedness and response programme or independent comprehensive operational hazard management programme.

~~schedule according to~~schedules in accordance with the ~~plant operation programme~~[9]plant's operations programme[11];

– Take ~~the~~ roll calls and confirm the safety of all personnel including absent personnel ~~according to~~in accordance with the industrial safety programme.

(iii) When ~~the~~a storm alert is actually issued for ~~the~~an area ~~including~~that includes the plant:

– Stop all work except essential work for ~~reactor~~ safety and nuclear security, and notify as necessary the external organization ~~according to the plant operation programme~~[9](e.g. local government, emergency services and response organizations) in accordance with the plant's operations programme[11];
– Instruct the evacuation of non-essential plant personnel ~~according to~~in accordance with the industrial safety programme;
– Ensure the stand-by state of the drainage pump ~~according to the plant operation~~in accordance with the plant's operations programme (or if necessary, ~~according to~~in accordance with the maintenance programme);
– Put ~~the SSC and~~ structures, systems and components, including structures, systems and components for managing a severe accident ~~facilities~~, in a stand-by state ~~according to~~in accordance with the accident management programme (or, if evaluated as necessary ~~according to~~, in accordance with the safety assessment).

(iv) When the alert is lifted:

– Instruct ~~the~~ personnel to resume works after the necessary ~~check is~~checks have been completed ~~according to~~ in accordance with the maintenance programme (or, if necessary, the fuel management programme);
– Release the response teams ~~according to the plant operation~~in accordance with the plant's operations programme[159];

II.33. If extreme precipitation is defined as a credible combination of hazards with extreme winds~~,~~ (see also SSG-64 [4] for combinations of hazards), the operating organization should determine whether equipment for flooding should be put in place based on the anticipated severity of the combined hazards.

OTHER EXTREME METEOROLOGICAL CONDITIONS

II.34. To ensure that other extreme meteorological conditions, including extreme air temperature and humidity, extreme water temperature, snowpack, freezing precipitation and frost related phenomena~~,~~ and lightning, are included in hazard management, the operating organization should consider and include specific actions derived from the results of the design and assessments performed on the basis of the recommendations provided in ~~DS498 [5~~SSG-68 [6]. This should include a full consideration of other effects of these extreme meteorological conditions including:

- ~~low~~ Low levels of sea water, which may be caused by ~~an~~ extremes of air pressure;
- ~~sandstorm~~Sandstorms and dust ~~storm as an immediate issue~~storms;
- ~~low~~Low river or lake water levels from a drought from longer term extreme weather fluctuations.

II.35. The operating organization should establish ~~communications~~ protocols and standards for communication with national and regional meteorological organizations to be properly warned of any extreme meteorological conditions, including their possible duration. This information should be supplemented as necessary by the use of the site's meteorological systems, where installed and available. For example, the localized lightning strikes for some plants can be notified by a regional meteorological forecasting service ~~which implement~~that implements credible monitoring of ~~the wide-area~~ atmospheric stability in a wide area.

II.36. In cases of extreme ambient air or water temperatures (hot or cold), analyses or testing of equipment or systems such as pumps, fans, cooling circuits (e.g. emergency cooling, cooling ~~circuit~~ of essential services), should be performed to ensure that the equipment is working properly and determine ~~if~~whether there is sufficient operating margin. Operating procedures should be developed and implemented to perform the necessary testing.

II.37. In cases of extreme ambient air temperatures, procedures should be developed and implemented to enhance area or equipment heating or cooling. Simple measures include opening or closing doors, using dampers~~,~~ and adding additional heating or cooling systems. The operating organization should ensure that these measures do not invalidate the plant's safety analysis for the ~~subject~~ areas or equipment. To ensure adequate energy supply ~~of safety related~~to equipment that is important to safety, diesel fuel composition should be checked and, if necessary, adjusted.

II.38. If there is insufficient operating margin ~~in~~for equipment or systems, appropriate actions such as cleaning of heat exchangers or reducing pump flow should be performed. In some extreme cases, margin might only be gained by reducing the reactor power.

II.39. Snow or large amounts of hail can block inlets or outlets of safety systems and safety features such as safety valves, blowout panels and intakes of heating, ventilation and air

conditioning ~~systems~~systems. These should be cleared during and after the event. Installation of electric heaters ~~in some vital areas~~ should be considered.

II.40. The operating organization should ~~have~~establish procedures ~~in place~~ for storing and moving snow at the site, if applicable. This should include clearing of access routes, as well as removal of snow from buildings to avoid the exceedance of design loads.

II.41. In cases of sandstorm and dust storm, the recommendation in para II.53 for HVAC filter change should be considered. In addition, the recommendation in para II.29 for securing equipment outside of buildings in an extreme wind ~~event~~events should be considered to prevent ~~object~~objects from becoming ~~missile~~missiles.

II.42. At sites where frazil ice can occur, the temperature of the cooling water should be carefully monitored to ensure that the inlet of the cooling water circuit does not freeze. Freezing can be prevented by circulating warm water from the outlet circuit to the inlet.

II.43. The operating organization should ensure that the integrity of the plant's lightning protection system is maintained in an operational state.

II.44. When hail is predicted, the operating organization should remove or protect as necessary ~~vital~~ equipment that is located outdoors.

II.45. When an ice storm (a combination of high ~~wind~~winds and super cooled rain, see also SSG-64 [4] for combinations of hazards) is predicted in the area of the external power grid ~~from nuclear power plants~~, the operating organization should be prepared for ~~the~~a loss of external power caused by the rapid building up of an ice layer on overhead line conductors.

II.46. When subsequent persistent precipitation is defined as a credible combination of hazards with extreme low temperatures, the operating organization should ensure that installed drains have been properly cleared to prevent ~~the~~ compound ~~effect, e.g.~~effects, for example due to clogging by ice. Additionally, the operating ~~organisation~~organization should consider the potential effects of blocked drainage channels and how these could be mitigated.

II.47. If a reduction in the installed firefighting capability available to suppress potential internal fires is identified as a credible consequential effect of low temperatures hazards with outside freezing conditions, then the operating organization should maintain the defence in depth by alternative firefighting measures.

VOLCANISM

II.48. Volcanic events can present significant hazards for nuclear power plants. Phenomena associated with volcanic events (volcanism) that might be accommodated by measures for

design and operation are ~~provided in SSG-21 [XX].~~addressed in IAEA Safety Standards Series No. SSG-21, Volcanic Hazards in Site Evaluation for Nuclear Installations [33]. To ensure that volcanism is included in hazard management, the operating organization should consider and include specific actions derived from the results of the design and assessments performed on the basis of the recommendations provided in ~~DS498 [5~~SSG-68 [6].

II.49. The operating organization should establish a warning system for volcanic hazards, if possible and applicable. Additionally, ~~communication~~ protocols and standards for communication with national or local agencies ~~need to~~should be established to receive timely and comprehensive warning of volcanic activity and the potential for transport of volcanic ash and toxic gases.

II.50. The operating organization should develop specific procedures that guide ~~the operating personnel~~control room operators to determine ~~if~~whether a plant shutdown is necessary due to volcanic activity, based on the warning and established reasonable criteria, such as proximity to the volcanic plume or ashes.

II.51. Operating procedures should be developed and implemented for the inspection and removal of volcanic ash on or near ~~SSCs.~~structures, systems and components. Special considerations should include equipment (such as emergency diesel generators) affected by volcanic ash deposition impacting ventilation and structural loading.

II.52. Operating procedures should be developed and implemented to inspect and maintain the functions of ~~automatic screen wash equipment~~the intake screens to prevent blockage of water intake ~~facilities~~structures and pumps.

II.53. Operating procedures should be developed and implemented to monitor the differential pressures of HVAC filters and the air quality in the main control room. These procedures should include cleaning or replacing the filters as needed due to the deposition of volcanic ash.

II.54. Operating procedures should be developed and implemented to inspect and clean electrical insulators for ~~SSC related~~ power cables, auxiliary power supply cables~~,~~ and switchyard connections that are important to safety, if applicable.

II.55. The operating organization should ensure sufficient spare parts are available for ~~vital plant~~ equipment that might be impacted by volcanic ash deposition. Special consideration should be given to the available quantities of ventilation filters.

II.56. The operating organization should consider the removal of volcanic ash from access ways to ensure the safe passage of ~~control room operators and other operating~~ personnel.

EXTERNAL FIRES

II.57. The ~~guidance~~recommendations provided in ~~this appendix~~Appendix I for internal fires ~~is~~are also valid for external fires. Additional specific ~~guidance~~recommendations for external fires ~~is~~are provided in paras II.58–II.66.

II.58. ~~Communication protocols~~Protocols and standards should be established for communication with off-site agencies and organizations to notify the operating organization when activities involving combustible or explosive materials are performed. Because of the potential increase of the risk of external fires during these activities, these protocols and standards ~~will~~should require off-site organizations involved in these activities in relevant proximity to the site to notify the operating organization in sufficient time before the start of such activities and to provide information on the type, route and duration of the intended activities. This ~~allows~~will allow the ~~operating~~ personnel to prepare for an accident that could involve combustible or explosive materials, or ~~inadmissibly~~ impair ~~SSCs~~structures, systems and components and impact the ~~site's~~plant's external fire mitigation strategies.

II.59. ~~Communications protocols~~Protocols and standards should be established for communication with off-site agencies and organizations to notify the operating organization when environmental and/or population conditions are such that external fires could occur (e.g. dry conditions, high winds, local festivals).

II.60. Communications from external organizations should include the notification of the operating organization of the occurrence ~~but~~and also the successful suppression of fires external to the site, but in close proximity to the site ~~boundary~~area.

II.61. In case of a notification ~~on~~of either the potential for or the occurrence of an external fire, the operating organization should notify the on-site ~~firefighter~~firefighters and emergency response personnel of the ~~potential~~ hazard. This could result in the early deployment of on-site emergency ~~on-site~~ response and firefighting equipment to a standby readiness condition.

II.62. If there is an external fire with the potential to ~~inadmissibly~~ affect the site, the on-site firefighters should be in readiness, including performing necessary equipment and personnel preparations.

II.63. Response to external fires will typically ~~necessitate a response from~~involve both on-site and off-site emergency workers. As such, the operating organization should conduct regularly scheduled training, drills or practical exercises with off-site organizations to ensure coordination and response actions are understood by all emergency workers.

II.64. The operating organization should regularly inspect and maintain and repair, if necessary, all engineered structures and barriers (e.g. firebreaks, paved roads, earth mounds, dykes, walls,

surrounding building structures) in place designed to prevent as far as possible the spreading of external fires to the site and to fires of origin external to the site, as appropriate.

II.65. In order to minimize the impact of external fires ~~from inadmissibly affecting the plant site~~, the operating organization should regularly inspect and assess the engineered structures and barriers at the site or in close proximity to the site ~~boundary~~area. The scope of the inspection should include the effect of both permanent and temporary accumulations of combustible material~~,~~ and the presences of vehicles. If appropriate, this should lead to vegetation control or land clearing around buildings and site boundaries.

II.66. Due to the potential for toxic gases and hazardous fumes from external fires, operating procedures should be ~~in place~~established to ensure proper use of air monitoring equipment, and isolation or realignment of ~~plant area~~ ventilation systems in the building to ensure habitability for personnel ~~habitability~~, cooling ~~purposes~~ and operability of emergency diesel generators. These procedures should be updated on a regular basis and in case of ~~any~~relevant plant modifications ~~of relevance for this aspect~~.

EXTERNAL EXPLOSIONS

II.67. To ensure that external explosion (deflagrations and detonations) with or without fire, with or without secondary missiles are included in the hazard management, the operating organization should consider and include specific actions derived from the results of the design and assessments performed on the basis of the recommendations in SSG-68 [6].

~~II.67.~~II.68. In the case of a notification about potential off-site explosions or shockwaves, heat flux, smoke and heated gases, ground and other vibratory motions and blast and missiles from explosions, the operating organization should notify the on-site firefighters and emergency response personnel about the ~~potential~~ hazard. This could result ~~to~~in the deployment of on-site emergency response and firefighting equipment to a standby readiness condition. The recommendation in para. II.58 for communication with off-site organizations for external fires should also be considered for external explosions.

HAZARDOUS SUBSTANCES ~~(TOXIC, RADIOACTIVE, FLAMMABLE, CORROSIVE AND ASPHYXIANT CHEMICALS AND THEIR MIXTURES IN AIR AND LIQUIDS)~~

II.69. To ensure that hazardous substances including toxic, flammable, corrosive and asphyxiant chemicals and their mixtures in air and liquids, as well as radiological hazards from other on-site and collocated installations are included in the hazard management, the operating organization should consider and include specific actions derived from the results of the design and assessments performed on the basis of the recommendations in SSG-68 [6].

~~II.68.~~II.70. The operating organization should establish ~~communication~~ protocols and standards for communication with off-site agencies and organizations when significant movements of or activities with asphyxiants, toxic gases~~,~~ and corrosive and radioactive liquids are planned to take place. Because the ~~potential of the~~ hazard increases during these times, off-site organizations within the ~~site characterization boundaries~~external zone should notify the operating ~~personnel~~organization and emergency ~~managers~~organizations when off-site activities with asphyxiants, toxic gases~~,~~ and corrosive and radioactive liquids occur (i.e. transport or movement of these materials). This ~~allows~~will allow the operating ~~personnel~~organization to prepare for an accident that could involve these substances and could impact the site's external hazard mitigation strategies. Regular and less significant movements might be excluded from these communication protocols but also should form part of the ~~plant~~plant's hazard mitigation strategies.

~~II.69.~~II.71. Operating procedures should be developed and implemented to properly monitor hazardous substances in the air, isolate the affected buildings or areas, ensure ~~personnel~~ habitability for personnel, cooling ~~purposes~~ and operability of emergency diesel generators by ventilation realignments, and protect control room operators. These should cover ~~release~~releases of hazardous materials from the plant ~~being operated~~ and from other units on a ~~multi-~~multiple unit site, as well as any credible external sources of hazardous gaseous ~~release~~releases.

~~II.70.~~II.72. Operating procedures should be developed and implemented to ensure that the hazard will not propagate to unaffected buildings and areas by closing openings to unaffected buildings and areas, including windows and doors.

~~II.71.~~II.73. ~~There should be considerations of the~~ The need ~~for maintaining~~to maintain personal protective equipment on the site (e.g. breathing apparatus, ~~protection suit) on-site~~ protective clothing) should be considered to allow ~~operating~~plant personnel and emergency workers to move to ~~places of safety~~safe locations or to perform safety related actions.

~~II.72.~~II.74. The operating organization should consider sheltering or evacuating non-essential plant personnel and the potential need for ~~the use of~~ external emergency response organizations to organize a safe evacuation from the site.

AIRCRAFT CRASH

II.75. To ensure that accidental aircraft crash is included in the hazard management, the operating organization should consider and include specific actions derived from the results of the design and assessments performed on the basis of the recommendations in SSG-68 [6].

~~II.73.~~II.76. While accidental aircraft crash is protected primarily by the design of the structure against the crash load, the operational organization should consider measures for mitigating the effects of ~~the~~a crash if it occurs and minimizing the likelihood of ~~their~~its occurrence. In this regard, ~~it is important~~as described in paras II.74 to ~~collaborate with external organizations on this hazard. The~~II.77, the operating organization should establish and maintain operating procedures and protocols for communication ~~protocols~~ with national or regional air traffic control organizations for immediate and/or redundant ~~event notifications, as appropriate~~notification of events.

~~II.74.~~II.77. The operating organization should review and apply the site-specific requirements of the site and report any violations of ~~“~~‘no-fly-~~zones”~~zones’ to national or regional air traffic control organizations.

~~II.75.~~II.78. If the safety assessment identifies that aircraft crashes might ~~involve~~necessitate the use of off-site ~~firefighter~~firefighters and emergency response personnel, the operating organization should establish, maintain~~,~~ and implement communication protocols to ensure efficient response by these off-site personnel.

~~II.76.~~II.79. Response to an aircraft crash will typically ~~necessitate a response by~~involve both on-site and off-site emergency workers. The operating organization should conduct routine training, drills or practical exercises with off-site organizations to ensure coordination and response actions are understood by all emergency workers.

~~II.77.~~II.80. The operating organization should develop a specific procedure for action and deployment of alternative mobile equipment for deployment of firefighting water ~~deployment~~ and electrical power supply ~~that~~, which should be available on the site, and of on-site emergency response personnel when notified of this hazard. This includes the prompt relocation of equipment and personnel from any potentially affected location to prevent an ~~inadmissible~~unacceptable loss of emergency response capability.

~~II.78.~~II.81. Since an aircraft accident on site might result in the generation of hazardous substances, emergency workers should consider the recommendations provided in ~~sub-section~~paras II.~~9~~69 to II.72, including the use of air monitoring equipment.

~~II.79.~~II.82. ~~The~~If practicable, the operating organization should develop a specific procedure for returning the ~~reactor~~plant to a safe state ~~when notified by the air traffic control organization of~~following an aircraft crash ~~potentially~~ affecting the site.

~~II.80.~~II.83. ~~The~~If practicable, the operating organization should develop a specific procedure for evacuating, relocating or sheltering non-essential plant personnel and personnel necessary for emergency response when notified with sufficient time by the air traffic control organization of an aircraft crash potentially affecting the site (e.g. to a bunkered supplementary control room ~~instead of an unprotected~~in case the main control room is unprotected).

ELECTROMAGNETIC ~~INTERFERENCES~~INTERFERENCE, INCLUDING SOLAR STORMS

~~II.81.~~II.84. Large solar storms caused by solar flares and electromagnetic pulses can affect the electrical grid, on-site electric equipment and instrumentation and control systems[16]. The operating organization should establish protocols for communication ~~protocols~~ with the appropriate external organizations, so that the operating organization can be informed of predictable solar flares by national agencies~~,~~ and as a result can take appropriate hazard mitigation measures for possible disturbances and notify ~~the plant situation to~~ external ~~organizations.~~organization of the plant's status. If necessary, the hazard mitigation measures should include the protection of telecommunication systems (e.g. by a combination of shielded phone devices and multiple satellite systems) and ~~exercise for using~~exercises in the use of those systems.

[16] Solar storms have a lower perturbation level than electromagnetic pulses, but a wider area of effects. Solar storms will mainly have effects on long conductors as ~~pipeline~~pipelines and electrical ~~line~~lines (and connected transformers~~) where~~), whereas electromagnetic pulses can have effects on other equipment. The effects and the countermeasures for those two hazards might be different.

~~II.82.~~II.85. Large solar storms and electromagnetic pulses might impact the electrical grid, potentially resulting in a loss of ~~plant~~ external power supply~~.~~ to the plant. In order to prepare for a loss of power supply, a sufficient emergency fuel supply should be ~~in place~~kept at the site.

~~II.83.~~II.86. As solar flares and electromagnetic pulses might also impact on-site electric equipment for the emergency power supply, such as transformers, the operating organization should perform proper monitoring, inspections and maintenance for ~~those~~such equipment.

~~II.84.~~II.87. The evolution of instrumentation and control in nuclear power plants includes more digital equipment and tends to increase the ~~plant~~plant's vulnerability to electromagnetic ~~interferences~~interference. The operating organization should perform routine inspections and maintenance on cable shielding for ~~those~~such instrumentation and control systems.

BIOLOGICAL PHENOMENA

~~II.85.~~II.88. The operating organization should consider biological phenomena in hazard management, as appropriate. Biological phenomena encompass the following three types of biological ~~hazards~~hazard:

- Marine or waterborne~~, e.g.~~ biological hazards, such as jellyfish, seaweed, fish, mussels;
- Land-based~~, e.g.~~ biological hazards, such as infestation from mice, rats~~,~~ and rabbits~~,~~ and biological debris such as fallen leaves;
- Airborne~~, e.g.~~ biological hazards, such as swarms of insects, flocks of birds.

II.89. Biological hazards might include slower action degradation such as bacterial induced corrosion in supporting structures and pipework, leading to sudden or premature failure in components made from materials thought to be corrosion resistant. These however should be addressed via ~~programmes of asset~~ inspection, maintenance and testing programmes and ageing management ~~for example~~programmes, including by the periodic reviews described in ~~section~~Section 6 of this ~~guide~~Safety Guide. The ~~remainder of this discussion relates~~recommendations in paras II.87 to II.92 relate to the more immediate effects of biological hazards.

~~II.86.~~II.90. The cooling water and intake structures should be monitored continuously, to ensure that any unusual accumulation of aquatic organisms is noticed in ~~time~~a timely manner and that measures can be taken to avoid clogging of intake structures or unacceptable degradation of cooling water quality. ~~Communication protocols~~Protocols and standards should be established for communication with regional environmental, meteorological~~,~~ and waterways

agencies to identify when biological hazards might be present or expected so ~~the operating~~that personnel can take timely actions to mitigate the hazard.

~~II.87.~~II.91. For waterborne biological hazards, the operating organization should consider:

- The use of chemical controls, where allowed by environmental regulations;
- Regular mechanical cleaning of cooling water and intake structures;
- Complete drainage and dry- storage of cooling water and intake structures.

~~II.88.~~II.92. For infestation of animals, ~~the operating organization should identify the~~ evidence of ingress or equipment damage ~~while performing~~should be sought during plant walkdowns. Where evidence is found, the operating organization should make arrangements to deter animals from entering buildings or provide specific protection against animal induced equipment damage.

~~II.89.~~II.93. For leaves and similar debris~~, the operating organization should perform~~ routine inspections and walkdowns (including along the embankments of rivers, if applicable) should be performed to ensure intake structures and drainage systems ~~or vital plant~~and equipment remain operational.

~~II.90.~~II.94. Swarms of insects might ~~threaten~~endanger heating, ventilation~~,~~ and air conditioning equipment~~,~~ or emergency diesel generators by restricting airflow, thus limiting the operational capability of the equipment. ~~The operating organization should perform inspections~~Inspections and cleaning of the affected equipment should be performed when this hazard occurs.

~~II.91.~~II.95. ~~The operating organization should perform routine~~Routine monitoring and dredging should be performed to ensure that the equipment for ~~silting up~~removing silt in water ~~intake~~intakes remain operational.

HAZARDS BY COLLISIONS OF FLOATING OBJECTS AND HAZARDOUS LIQUID ON WATER INTAKES AND COMPONENTS OF THE ULTIMATE HEAT SINK

~~II.92.~~II.96. The operating organization should establish and implement communication and response protocols with regional or national maritime authorities, as appropriate, to be forewarned of ships adrift in heavy weather~~,~~ and of the possibility of ~~collision with~~ ice masses or large floating debris colliding with the plant, so as to provide the operating organization with sufficient time to prepare for the mitigation of any associated hazards.

~~II.93.~~II.97. For prevention of ~~ship~~ collisions by ships, large pieces of debris and large amounts of waterborne debris, the operating organization should establish and implement notification and response protocols with navigation and coast guard authorities.

~~II.94.~~II.98. If applicable, operating procedures should be developed and implemented to prepare and/or ~~actuate~~implement a diverse ultimate heat sink to accommodate ~~the~~a potential loss of normal cooling and ultimate heat sink systems.

~~II.95.~~II.99. Operating procedures should be developed and implemented for the deployment of floating booms or curtains to intercept oil spills, or surface skimmers to keep any oil at a safe distance from water intake structures to prevent damage to plant equipment and facilitate recovery actions.

~~II.96.~~II.100. Operating procedures should be developed and implemented for the identification of potential debris accumulation in water intake structures and for performing the subsequent cleaning.

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