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Nuclear criticality safety — Emergency preparedness and response

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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ISO 11320 was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 5, *Nuclear fuel cycle*.

Introduction

Criticality safety programmes at facilities that might use significant quantities and concentrations of fissile material are primarily directed at avoiding nuclear criticality accidents. However, the possibility of such accidents exists and the consequences can be life-threatening. For facilities that are judged to have a credible criticality accident risk, this necessitates advance planning, practice in planned emergency responses, and verification of readiness. Two distinct phases are identified:

— the emergency preparedness phase, which needs to be enforced continuously, and

— the emergency response phase, which needs only to be activated when it is indicated that a criticality accident could be developing, could be occurring or could have occurred.

INTERNATIONAL STANDARD ISO 11320:2011(E)

Nuclear criticality safety — Emergency preparedness and response

1 Scope

This International Standard provides criteria for emergency preparedness and response to minimize consequences due to a nuclear criticality accident. The criticality safety of operations are evaluated in accordance with ISO 1709.

This International Standard applies to a site with one or more facilities which might contain significant quantities and concentrations of fissile material. The extent to which this International Standard needs to be applied depends on the overall criticality risk presented by the facilities at the site.

This International Standard does not apply to off-site transport and transit storage of packages with fissile material.

This International Standard does not apply to sites with operating nuclear power plants or to facilities with research reactors which are licensed to become critical or near-critical, provided that there are no operations with fissile material external to the reactor for which a credible criticality accident risk exists. This International Standard can be applied to such sites and facilities in specific cases, if supported by site management and by licensing authorities.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 921, *Nuclear energy — Vocabulary*

ISO 1709, *Nuclear energy — Fissile materials — Principles of criticality safety in storing, handling and processing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 921 and the following apply.

3.1
drill
supervised instruction intended to test, develop, maintain and practise the skills required in a particular emergency response activity

NOTE A drill can be a component of an exercise.

3.2
emergency
non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment

NOTE 1 This includes nuclear and radiological emergencies, and conventional emergencies such as fires, release of hazardous chemicals, storms or earthquakes. It includes situations for which prompt action is warranted to mitigate the consequences of a perceived hazard.

NOTE 2 A criticality emergency is considered to be both a nuclear and a radiological emergency. It is an emergency in which there is, or is perceived to be, a hazard due to the following:

— the energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction;

— radiation exposure.

NOTE 3 Adapted from the IAEA Safety Glossary, 2007 Edition.

3.3
emergency coordinator
person authorized to direct the overall emergency response

3.4
emergency plan
description of the objectives, policy and concept of operations for the response to an emergency, and of the structure, authorities and responsibilities for a systematic, coordinated and effective response

NOTE 1 The emergency plan serves as the basis for development of other plans, procedures and checklists.

NOTE 2 Adapted from the IAEA Safety Glossary, 2007 Edition.

3.5
emergency preparedness
capability to take actions that will effectively mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment

NOTE Adapted from the IAEA Safety Glossary, 2007 Edition.

3.6
emergency response
performance of actions to mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment

NOTE 1 It can also provide a basis for the resumption of normal social and economic activity.

NOTE 2 Criticality emergency response consists of actions taken from the time of identification of a suspected, imminent or actual criticality accident to permanent shutdown of the event.

NOTE 3 Adapted from the IAEA Safety Glossary, 2007 Edition.

3.7
exercise
activity that tests one or more portions of the integrated capability of emergency response plans, equipment and organizations

3.8
facility
defined area within a defined site where fissile material can be located

3.9
immediate evacuation zone
area surrounding a potential criticality accident location that must be evacuated without hesitation if a criticality accident alarm signal is activated

3.10
risk
product of probability and consequences for an undesired event or action

3.11
site
defined area containing one or more facilities under a single management

3.12
technical staff
personnel with specific skills and experience who can assist in the implementation of the requirements defined in this International Standard

NOTE Such personnel can include, but are not limited to, criticality safety, health and safety, and facility process support personnel.

3.13
individual
person involved in developing, or who can be affected by, the emergency plan

4 Emergency preparedness

4.1 Responsibilities

4.1.1 Management responsibilities

Management shall ensure the following:

a) staff with relevant expertise are provided;

b) an emergency response plan is established, exercised and maintained;

c) immediate evacuation zones and evacuation routes are established;

d) evacuation routes are clearly identified for evacuees and are unambiguous;

e) a personnel assembly station (or stations) is designated;

f) a method is provided for timely accounting of all individuals who were within the immediate evacuation zone at the time of the evacuation;

g) instrumentation and equipment needed to respond to a criticality accident is provided;

h) the level of readiness (including training) needed for response to a criticality accident is adequate;

i) the capability to perform radiological dose assessments for response to criticality accidents is provided;

j) a communication system for central coordination of criticality site emergency activities is provided;

k) a nuclear criticality accident dosimetry system is provided;

l) equipment (e.g. a criticality accident alarm system complying with ISO 7753) and procedures are in place to instigate the emergency response when needed.

4.1.2 Technical staff responsibilities

The technical staff, as formally instructed by management, shall do the following:

a) identify credible criticality accident locations;

b) evaluate and characterize credible criticality accidents, including radiological dose prediction;

c) determine the instrumentation and equipment requirements for emergency response activities;

d) define the immediate evacuation zone around the potential criticality accident locations;

e) participate in the planning, conduct, and evaluation of exercises and drills.

4.1.3 Responsibilities of individuals

Individuals such as managers, technical staff, other employees, temporary staff, visitors and regulators may have emergency preparedness responsibilities. Before entering the site and a facility, each individual shall understand and agree to their responsibilities that are specific to the site and facility, respectively.

4.2 Evaluation

Credible criticality accident locations and predicted accident characteristics shall be evaluated and documented in sufficient detail to assist emergency planning. Criticality safety evaluations for the area or process considered, which shall be prepared in accordance with ISO 1709, will be a key resource in determining the accident locations.

This evaluation should be based on professional judgment or, if practical, a more detailed analysis, as specified in ISO 27467.

The description shall include the estimated number of fissions for each postulated accident and for the entire duration of each accident.

The possibility of recurrence of criticality should be considered.

4.3 Location and design of operations

Emergency preparedness shall be a factor in the selection of the location and design of an operation that may involve fissile material.

Before any planned change to an operation and/or facility leading to a modification of the safety evaluation, the potential impacts on arrangements for emergency preparedness shall be considered.

4.4 Immediate evacuation zone

An immediate evacuation zone shall be established, with the priority of protecting those individuals in a location where they are most likely to be threatened by serious harm.

Shielding should be considered in establishing the immediate evacuation zone.

The localized effects of a criticality accident, and the fact that rapid evacuation is not without risk, may result in an immediate evacuation zone that is significantly smaller than an entire site.

Sufficient exits from the immediate evacuation zone shall be provided to enable rapid and unobstructed evacuation of individuals. An activated evacuation zone should be made visually or audibly obvious from the outside, to warn individuals against entering the zone.

Assembly stations shall be clearly identified or posted.

Accountability of individuals at the site or at a specific facility should be supported by unambiguous registration of entry and exit.

Evacuation routes should be planned to minimize the total risk considering all potential hazards, e.g. chemical, industrial and radiation. Where practical, criticality evacuation routes should be common with other evacuation routes in order to minimize potential confusion.

Consideration should be given to minimizing the spread of radioactive contamination.

4.5 Emergency response plan

An emergency response plan, consistent with the documented accident evaluation required in 4.2 shall be established and maintained. The emergency response plan may form an integral part of, or be separate from, other plans (e.g. fire, radiological release).

The emergency response plan should consider all relevant risks, including the risks of abandoned processes and facilities. The plan should consider overall risk reduction. A balance of the benefits and harms of potential actions

and countermeasures should be taken into account when formulating the plan. This may comprise removal of the risk entirely or use of pre-accident countermeasures (e.g. increased shielding or reduced occupancy), as well as actions and responses identified as minimizing overall risk at the time of an accident occurring.

The emergency response plan shall include guidance to management, technical staff and response personnel for response to a criticality accident. The plan shall address recommended protective actions, functions of response personnel, and equipment needed for criticality accident response. Methods for making safe or shutting down a criticality accident may be included in the plan. Exceptions to prompt evacuation shall be clearly planned and documented.

The emergency response plan shall identify potential criticality accident locations and include appropriate facility descriptions (e.g. facility layouts or floor plans).

The emergency response plan shall include provisions for the following:

a) providing an emergency coordinator;

b) instigating emergency response;

c) responding to concurrent emergencies (e.g. fire, personnel injury, or security incidents);

d) identifying exposed individuals and estimating their radiation doses;

e) providing appropriate medical care for exposed individuals;

f) evaluating the consequences of the criticality accident, including those from radioactive and non-radioactive hazardous materials that might be released as a result of the accident;

g) determining when the emergency condition no longer exists;

h) coordinating with emergency organizations expected to provide emergency response assistance, which may be on-site or off-site;

i) assembly and accountability of individuals (taking into account the possibility for inclement weather).

The emergency response plan may be activated on any indication that a criticality accident is developing, is occurring, or has occurred.

Consideration should be given to the provisions for adjacent facilities not in the immediate evacuation zone (e.g. shielding, reduced occupancy, supplemental evacuation). This may include a consideration of the benefits and harms to determine the optimum response. The plan should provide for overall risk reduction, including risks from abandoned processes and potential countermeasures.

4.6 Equipment and materials

Appropriate protective clothing and equipment shall be provided for response personnel. This clothing and equipment may include respiratory protection equipment, anticontamination suits, both high-range and low-range gamma radiation detection equipment, neutron detection equipment, communications equipment, and personal monitoring devices (e.g. self-reading pocket dosimeters).

Appropriate monitoring equipment, to determine if further evacuation is needed and to identify exposed individuals, shall be provided for use at personnel assembly stations.

If use of neutron absorbers is required to terminate or stabilize a postulated critical system (see 5.3), a sufficient quantity of absorbers shall be readily available or readily obtainable. Prior to being selected for use, the effect of the neutron absorbers under accident conditions shall be evaluated with respect to

a) material effectiveness and compatibility (e.g. temperature conditions, pressure conditions, solubility in the system, chemical interaction with the system), and

b) cases under which addition of the neutron absorber can increase system neutron multiplication.

Additional relevant information may be obtained from References [3] and [6].

4.7 Classroom training, exercises, and evacuation drills

4.7.1 Classroom training

A programme of training for response to a criticality accident shall be developed and provided periodically. This training shall be reviewed periodically, and as needed, to ensure that appropriate changes or modifications are incorporated into the training programme. Other instructional formats than classroom training, e.g. computer-based training, may be used to satisfy these requirements.

a) Facility personnel, who shall respond to a criticality accident alarm, shall be trained to recognize the alarm and to know the facility's layout, evacuation routes, personnel assembly station locations, and personnel accountability and monitoring methods. Training should emphasize that emergency actions, including evacuation, should be performed in a manner that reduces the potential for injury.

b) Emergency response personnel shall be trained on their specific duties and responsibilities to respond to a criticality accident. This training shall include procedures, facility layout, and characteristics of a criticality accident.

c) Visitors shall be briefed on their responsibilities in responding to a criticality accident alarm or criticality accident.

d) Training on re-entry procedures and facility hazards shall be provided periodically for re-entry team personnel.

e) Technical staff shall be trained in their duties and responsibilities in the event of a criticality accident.

4.7.2 Exercises

A criticality accident response exercise should be conducted periodically to test the capabilities of the emergency organizations and communication system and to reinforce emergency training. Exercises may include a drill. If exercises are conducted, the following provisions apply:

a) exercises should include a realistic scenario involving a simulated criticality accident, and shall have defined objectives that specify the aspects of emergency response selected for testing or reinforcing;

b) exercises should include a post-exercise critique involving observers, controllers, and representative participants;

c) exercises should be planned and controlled by personnel who are not direct participants (players) in the exercise;

d) emergency response personnel should participate in nuclear criticality accident exercises to update and reinforce their previous response training.

4.7.3 Evacuation drills

Evacuation drills shall be conducted periodically. The frequency should be set to maintain sufficient familiarity with the required response, with due respect to complacency that could arise from excessively frequent drills.

NOTE An annual drill is often sufficient to fulfil this requirement.

Drills should be scheduled to include the maximum number of personnel who routinely work within the immediate evacuation zone.

The drills should be preannounced (e.g. by written notice, posted signs, or public address announcement) to minimize the possibility of accident or injury. Before planning any non-preannounced drills, consideration of the overall risks shall be taken to evaluate whether the risk from performing such a drill is tolerable, and provisions shall be made in order to minimize the risks when triggering the evacuation drill.

If the response tests the same evacuation practices as used for a criticality accident, an evacuation drill may involve a scenario other than a criticality accident.

False alarms should not be substituted for drills. Such occurrences shall, however, be evaluated for any conclusions about the current state of the emergency preparedness.

5 Emergency response

5.1 Responsibilities

5.1.1 Emergency coordinator

The responsibility of the emergency coordinator is to supervise the response actions.

5.1.2 Management

Management shall ensure that the emergency coordinator is supported appropriately. Management shall ensure that individuals are made aware of

— their required actions and responses when entering the site or facility,

— any requirements and regulations that apply to criticality emergency arrangements, and

— directions from the emergency coordinator.

5.1.3 Technical staff

During an emergency response the technical staff shall be available to advise and assist the emergency coordinator in responding to the criticality accident. This should include assistance in determining the location of the criticality accident and include a consideration of the nature of materials and the process conditions to use all available information in order to qualitatively

a) evaluate the likelihood of continuation or recurrence of the criticality accident, and

b) identify and evaluate the methods available to end an on-going criticality accident or prevent a recurrence of a criticality accident when such a development is considered credible; other risks that may arise from any such actions should be considered and taken into account.

5.2 Evacuation

Appropriate response shall be given to a criticality alarm.

Accountability of all individuals who were registered as present at the facility (or site when facility registration is not required) shall be verified.

Radiation levels shall be monitored periodically at the assembly station (or stations) after initiation of the emergency response.

If the monitoring indicates that the dose rate exceeds a predetermined threshold for mitigation of the dose to individuals in areas adjacent to the immediate evacuation zone, non-emergency-response individuals shall be evacuated from those areas unless otherwise justified in the interests of overall risk reduction.

5.3 Re-entry, rescue, and stabilization

All activities associated with re-entry, rescue and stabilization shall be coordinated and authorized by the emergency coordinator. The emergency coordinator may delegate authority to other qualified individuals.

Re-entry shall be planned to minimize risks to re-entry personnel. The possibility of a continuing or recurring criticality shall be considered.

Re-entry during the emergency shall only be made by personnel trained in emergency response and re-entry.

Personnel who volunteer to re-enter the immediate evacuation zone during the emergency shall be informed of the potential hazards. Re-entry should be performed by more than one person.

Re-entry should be made only after an assessment of the preliminary radiological survey indicates that the radiation levels are acceptable for re-entry. Existing instrumentation or temporary sensors with remote readouts may be used.

All re-entries shall be made with continuous radiation monitoring. Both neutron and gamma instruments should be used.

If members of personnel need to be rescued, the rescue shall be planned so as not to expose rescuers to life-threatening radiation doses.

If the system remains critical and is possibly causing excessive damage or significant releases of radioactive material, an early re-entry effort to disable the system may be permitted. The method for disabling the system shall be carefully planned and implemented to minimize risks to the re-entry team.

The technical staff shall determine if the system is subcritical and shall advise management of methods to ensure stabilization of affected equipment and safe conditions for personnel. This may include placing the fissile material in a favourable geometry, diluting the fissile solution below a critical concentration, modifying the reflection conditions or using neutron absorbers to facilitate/maintain subcriticality. The overall risks of these methods to ensure stabilization of affected equipment shall be evaluated before choosing one over another.

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