IAEA
International Atomic Energy Agency

Manual for IRS Coding

Joint IAEA/NEA International Reporting System for Operating Experience

IAEA

AEN NEA

Vienna, February 2011

Services Series 20

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MANUAL FOR IRS CODING

JOINT IAEA/NEA
INTERNATIONAL REPORTING SYSTEM
FOR OPERATING EXPERIENCE

Services Series No. 20

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

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For further information on this publication, please contact:

Operational Safety Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
email: Official.Mail@iaea.org

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FOREWORD

The fundamental objective of the International Reporting System for Operating Experience (IRS) is to contribute to improving the safety of commercial nuclear power plants which are operated worldwide. This objective can be achieved by providing timely and detailed information on lessons learned at the international level from operating and construction experience. This information may be related to issues and events that have safety aspects.

In March 2010, the IAEA issued the IRS Guidelines, IAEA Services Series publication No. 19, jointly with the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development.

This Manual for IRS coding is intended as a companion manual to the IRS Guidelines: the present manual explains the individual coding fields in detail and their proper application in preparing the IRS reports. This manual is the outcome of two consultants meetings in October 2009 and March 2010; it harmonizes closely with IAEA Safety Standards Series No. NS-G-2.11, A System for the Feedback of Experience from Events in Nuclear Installations.

The IAEA officer responsible for this publication was X. Bernard-Bruls of the Division of Nuclear Safety.

EDITORIAL NOTE

CONTENTS

I. INTRODUCTION

The International Reporting System for Operating Experience (IRS) is jointly operated by the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA).

In early 2010, the IAEA and OECD/NEA jointly issued the IRS Guidelines [1], which described the reporting system and process and gave users the necessary elements to enable them to produce IRS reports to a high standard of quality while retaining the effectiveness of the system expected by all Member States operating nuclear power plants.

The purpose of the present Manual for IRS Coding is to provide supplementary guidance specifically on the coding element of IRS reports to ensure uniform coding of events that are reported through IRS. This Coding Manual does not supersede the IRS Guidelines, but rather, supports users and preparers in achieving a consistent and high level of quality in their IRS reports. Consistency and high quality in the IRS reports allow stakeholders to search and retrieve specific event information with ease. In addition, well-structured reports also enhance the efficient management of the IRS database.

This Coding Manual will give specific guidance on the application of each section of the IRS codes, with examples where necessary, of when and how these codes are to be applied. As this reporting system is owned by the Member States, this manual has been developed and approved by the IRS National Coordinators with the assistance of the IAEA and NEA secretariats.

II. OUTLINE AND EXPLANATION OF THE INDIVIDUAL CODING FIELDS

The IRS Guidelines identifies the following coding fields for use when preparing IRS reports[1]:

(1) Reporting categories;
(2) Plant status prior to the event;
(3) Failed/affected systems;
(4) Failed/affected components;
(5) Cause of the event;
(6) Effects on operation;
(7) Characteristics of the event/issue;
(8) Nature of failure or error;
(9) Recovery actions.

The following sections provide explanation and information on each coding field and the individual codes used in each field. Where it is necessary, examples of how the individual codes need to be applied are given. It is possible that more than one individual code in each field may be applied to a single IRS report. For the completion of all IRS reports to be submitted, at least one entry is desirable for each coding field.

A report may be prepared not only because an event has occurred, but also because lessons learned have been identified which may assist in avoiding recurrence of events elsewhere. It is

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[1] For purposes of consistency, the numbering of the coding fields in the present guidance is the same as that in Appendix C of Ref. [1].

important to note that the examples used in this manual are for illustration purposes to provide additional guidance for the preparation of IRS reports.

1. REPORTING CATEGORIES

The categories are intended to provide a basis for identifying safety related events and other information to be reported to the IRS. Complex events may fall and be coded into more than one category.

1.1 Unanticipated releases of radioactive material or exposure to radiation

This category is intended to report the events involving unanticipated releases of radioactive material or exposures that may occur to plant personnel, the public and the environment due to actual or potential weaknesses in operational controls, design, etc.

1.1.1 Unanticipated releases of radioactive material

Examples:

Any releases of radioactive material that exceed prescribed limits whether they are confined to the site or extend beyond it such as:

- Unplanned release that exceeds prescribed limits due to operational errors;
- Release of radioactive material due to failure of a storage tank for gaseous or liquid waste that exceeds prescribed limits for off-site or on-site releases;
- Release of radioactive material or spread of contamination rendering an on-site area inaccessible, with the result that items important to safety cannot be controlled, tested or maintained, and which has to be declared inoperable;
- Release of radioactive material or spread of contamination posing a problem for safety of plant personnel;
- Release of radioactive materials to the environment through unidentified routes which could not be monitored by the plant equipment and procedural inadequacies in the management of radioactive waste, e.g. failure of underground pipework.

1.1.2 Exposure to radiation that exceeds prescribed dose limits for members of the public

Example:

- Exposures to members of the public from sources of direct radiation at the site, from unplanned releases due to failure of barriers, or from an unexpected concentration of radioactive material from controlled releases due to inadequacies in waste management systems and/or operations.

1.1.3 Unanticipated exposure to radiation for site personnel

Example:

- Exposure to site personnel due to failures in access control procedures, degradation of protection equipment, inadequacies in administrative controls or due to unplanned on-site releases.

Note:

These codes (1.1.2 and 1.1.3) are also selected in case the event led to an unanticipated release of radioactivity in the plant or the environment or resulted in an unanticipated exposure to plant personnel or the public, even if the release or the radiation dose did not exceed the prescribed limits.

1.2 Degradation of barriers and safety related systems

This category is intended to include events and issues where actual or potential serious degradation has occurred in the systems affecting the fundamental safety functions of (i) Reactivity control, (ii) Radioactive material cooling and (iii) Confinement of the radioactive material.

This code is only used when the appropriate code(s) among 1.2.1–1.2.6 cannot be identified. When the failure was found during a periodical inspection, even without an actual effect, the appropriate code 1.2.1–1.2.6 is indicated.

1.2.1 Fuel cladding failure

Examples:

- Fuel cladding failure requiring plant shutdown;
- Spent fuel cladding failure while handling and storing in the storage pool;
- Fuel assembly failure (detachment of a fuel rod, spacer grid, etc. from the assembly);
- Fuel failure noticed during off-line and on-line refuelling operations.

Note:

Fuel cladding is the first barrier to prevent release of radioactive material. Reporting of limited anticipated leaks which do not prevent continued operation is not necessary. Fuel cladding failure or challenge caused by unexpected factors/failure mechanisms with or without significant release of fission products is also included.

1.2.2 Degradation of the primary coolant pressure boundary, main steam or feedwater line or other high energy systems

1.2.2.1 Degradation of primary coolant pressure boundary

Examples:

- Through-wall failure of the piping or the significant components of the primary coolant circuit;
- Welding or material related defects in the primary coolant circuits;
- Loss of relief and/or safety valve functions during tests or operation;
- Reactor system coolant leakage exceeding the technical specification limits or defeating the ‘leak before break’ criteria;
- Rapid pressure and temperature transient exceeding the authorized limits and may be jeopardizing the integrity of the reactor pressure vessel.

Note:

The reactor vessel and the reactor coolant system, including all the connected equipment (pumps, valves, steam generators, branch pipes up to isolation valves) that are exposed to reactor pressure, form a second barrier to the escape of fission products.

1.2.2.2 Degradation of main steam or feedwater lines

Examples:

- Through-wall failure of the piping or the significant components of the steam or feedwater lines affecting the decay heat removal capacity, containment function or release of radioactivity.
- Welding or material related defects in steam or feedwater lines.
- Loss of relief and/or safety valve functions during tests or operation.
- Failure of Steam Generator.

1.2.2.3 Degradation of other high energy systems

Examples:

- Through-wall failure of the piping or the significant components of the of steam generator blowdown, letdown lines prior to heat exchange and pressure reduction devices, auxiliary steam system, etc.
- Welding or material related defects in high energy system pipe lines.
- Loss of relief and/or safety valve functions during tests or operation affecting the adjacent safety related equipments.
- Failure of high pressure fluid system of turbine-generator affecting fire safety.

1.2.3 Degradation of containment function or integrity

Examples:

- Containment leakage rates exceeding the Technical Specification limits.
- Loss of containment isolation valve functions during tests or operation.
- Loss of containment cooling/spray capability.
- Loss of pressure suppression/wetwell functioning capability.
- Loss of containment function during refuelling operations.

Note:

This code is also selected in case of:

1. Containment relief valve opens due to high pressure in the containment vessel.
2. Containment liner degradation is observed.
3. Failure of primary or secondary containment function.

1.2.4 Degradation of systems required to control reactivity

Examples:

- Failures of the control rod system (fully or partially).
- Accidental criticality and control rod ejection.
- Failures or dilution of the boron injection system.

- Failure/inadequacies/dilution of burnable poison.
- Failures of recirculation system and/or addition of coldwater affecting the reactivity (check also applicability to 1.2.5).
- Reactivity anomaly or discrepancy in shutdown margin observed.
- Failure of primary/secondary shutdown and liquid poison system.
- Failure of demineralizer/ion exchanger affecting the reactivity.
- Failure of regulating system including liquid zone control, local power control and moderator level control.
- Failures of flux tilt control and local power distribution.
- Uncontrolled reactivity oscillation.
- Failure in administrative and operational controls (errors in core loading, defects in fuel manufacturing, mistakes in estimation of isotopic concentration of uranium in the fuel, etc.)
- Discrepancies observed in calculated and measured values of critical boron concentration.

1.2.5 Degradation of systems required to assure primary coolant inventory and core cooling

Examples:

- Failures of the emergency core cooling systems such as the high/low pressure core injection system and the core spray system.
- Failure of the primary coolant pump and system.
- Loss of auxiliary/emergency feedwater system.
- Loss of residual decay heat system, shutdown cooling system, etc.
- Failure of the pressure control system and the relief valves.
- Failure of the recirculation flow system (check also applicability to 1.2.4).
- Loss of moderator cooling and failure of moderator system.
- Flow blockage of coolant (full or partial) affecting the fuel integrity.

Notes:

1. Failure to remove core power or residual heat may result in uncontrolled primary coolant and fuel temperature increases putting fuel integrity at risk. Failures of such related systems are to be covered under this code.
2. Uncontrolled primary coolant system pressure increases may also challenge or jeopardize the integrity of pressure barriers. Failures of such devices are to be covered under this code.

1.2.6 Degradation of essential support systems

Examples:

- Loss of essential AC/DC power to safety related buses including control power supply.
- Failures of the emergency diesel generator system.
- Loss of essential service water, instrument air, fuel oil, gas, ventilation and air conditioning, etc.
- Loss of backup fire water systems used for decay heat removal.
- Loss of fire protection system affecting essential equipment/safety systems.
- Loss of non-safety system affecting the essential support systems.

1.3 Deficiencies in design, construction (including manufacturing), installation and commissioning, operation, (including maintenance and surveillance), safety management/quality assurance system, safety evaluation and decommissioning

Deficiencies related to the above key elements show the weakness in maintaining the highest safety standards that may lead to loss of safety functions unless rectified. Some of these deficiencies may be plant life limiting.

1.3.1 Deficiencies in design

Examples:

- Deficiencies in the design could result in loss of a safety function/ system, common mode failures affecting the plant safety.
- Degradation observed due to material incompatibility, environmental or operating conditions, layout, sizing and computational errors which are not properly considered during design.

1.3.2 Deficiencies in construction (including manufacturing), installation and commissioning

Examples:

- Degradation of materials due to environmental conditions not sufficiently considered or anticipated in the design stage.
- Errors made during construction or installation that could influence the performance of the system or component if not detected during testing, maintenance or otherwise.
- Deficiencies observed during construction, manufacturing, initial installation and back fitting of equipment.
- Deficiencies detected during commissioning.
- Latent deficiencies which have lead to events during operation.
- Degradation observed in civil structures due to inadequate construction quality/ supervision.
- Quality assurance weaknesses observed in manufacturing, installation and commissioning.

1.3.3 Deficiencies in operation (including maintenance or surveillance)

Personnel errors (including that of contract personnel) occurring during maintenance work are also coded here.

Examples:

- Loss of plant capability to perform safety functions due to personnel errors, procedural deficiencies/non-adherence and shortcomings in design of man-machine interfaces.
- Non-adherence to licence conditions/operational limits and conditions or other provisions.
- Inadequacies noticed in diagnostic systems.
- Inadequate training.

1.3.4 Deficiencies in safety management/quality assurance system

Examples:

- Wrong documents used for maintenance.

- Component does not meet the design requirement.
- Insufficient verification of completed work.
- Deficiencies in quality assurance program/measures.
- Quality assurance deficiencies in non-safety related systems that may affect safety related systems.
- Tools and devices used for testing during commissioning and operation that were unable to detect deterioration.

1.3.5 Deficiencies in the safety evaluation

Examples:

- Any event caused by a failure, condition, or action that demonstrates a dependence of essential structures, systems and components that was not previously identified for accomplishing the safety functions.
- Any event that results in the nuclear power plant not being in a controlled condition or that results in an unanalysed condition that compromises plant safety.
- Deficiencies in the scope of the safety evaluation, event sequences and operating conditions considered in the design analysis.
- Environmental conditions not considered properly, unforeseen system interactions, non-conservative calculations and deficiencies in the safety evaluation.

1.3.6 Deficiencies in decommissioning

Examples:

Deficiencies/failures that result in:

- Generation of radioactive waste being unable to meet the acceptance criteria for storage and disposal.
- Unacceptable quantities of pollutants and/or hazardous waste.
- Spread of contamination due to breach of safety barriers.
- Unacceptable radiation exposure to occupational workers, the public and the environment.
- Inadequacies observed in the decommissioning plan and in implementation of the activities.

1.4 Generic problems of safety interest

Deficiencies affecting several plant systems or components, or having implications for other plants, or indicating the existence of generic problems of safety significance are to be reported.

Examples:

- Series of events where individual events are not of significant importance.
- Recurring events.
- Events with implications for similar facilities.
- Generic problems not adequately addressed by operation experience feedback, research and regulation.

1.5 Consequential actions taken by the regulatory body

Changes made by the regulatory body for licensing/license conditions of nuclear power plants based on the lessons learned from reported events.

Examples:

Warning notices, prohibitions, prosecutions, etc., resulting from reported events taken by the competent safety authority on:

- Licensing/license conditions.
- Design/safety assessment/safety analysis.
- Construction.
- Commissioning.
- Operation.
- Emergency planning.
- Training and qualification.
- Decommissioning.

1.6 Events of potential safety significance

Events/near-misses having no actual significant consequences but which may have the potential to become safety significant.

Examples:

- Events that could lead to potential loss of a safety function.
- Failure of mid-loop operation, header level control or loss of natural circulation.
- Loss of water in spent fuel storage facility that may lead to uncovering of spent fuel elements.
- Loss of shielding capability.
- Fall of spent fuel assembly during refuelling without any consequences.
- Radioactive material container/shipment accident during transportation without any consequences.

1.7 Effects of unusual events of either human — induced or natural origin

Events (internal and external) that could challenge the ability of the plant to operate, shut down or to maintain shutdown conditions in a safe manner.

Examples:

- An earthquake observed at the plant.
- A flood requiring countermeasures.
- Natural events (tsunami, Cyclone, ice-formation, pollution of river/sea water, lightening, heavy snowfall, etc.).
- Human-induced events such as an aircraft crash, fire, explosion, transport accident, breach of security, terrorist attack, sabotage, etc.
- Electromagnetic/radio frequency interference.

1.8 Other findings and operating experience information

New perspectives, industry initiatives, operating experience feedback from other industries are to be reported.

Examples:

- Failures in other industry applicable to nuclear industry.
- New safety requirements due to Severe Accident Management Guidelines.
- Risk based and risk informed insights.

2. PLANT STATUS PRIOR TO THE EVENT

The plant status at the time of the event is indicated in the IRS report even if it has no relation to the sequence of the event. In this case the code ‘2.0 Not Applicable’ is also used along with the appropriate plant status code.

2.0 Not Applicable

2.1 On power

2.1.1 Full allowable power

This code covers the stable operation above 90 percent power.

2.1.2 Reduced power (including zero power)

This code covers the stable operation from criticality to 90 percent power.

2.1.3 Raising power or starting up

This code covers starting of the unit from cold or hot shutdown to power rise. This code also covers reactor startup for shutdown margin test or low power physics tests or cold criticality tests, etc.

2.1.4 Reducing power

This code covers the period of power reduction of the unit.

2.1.5 Refuelling on power

Some reactors, for example CANDU and GCR, can be refuelled during power operation. For these types of reactors, this code can be selected. This code may also be used in case the refuelling is done in these units during unit shutdown.

2.2 Hot shutdown conditions

2.2.1 Hot standby (coolant at normal operating temperature)

In this state, primary coolant is around normal operating temperature and with the reactor subcritical.

2.2.2 Hot shutdown (coolant at or below normal operating temperature)

In this state, primary coolant temperature is less than the normal operating temperature (but greater than cold shutdown temperature limit depending on reactor design) and with the reactor subcritical and the vessel closed.

2.2.3 Natural circulation cooling

This code covers the effect of natural circulation cooling during hot shutdown conditions.

2.3 Cold shutdown

2.3.1 Cold shutdown with closed reactor vessel

In this state, primary coolant temperature is lower than the hot shutdown temperature limit depending on reactor design with reactor vessel closed.

2.3.2 Refuelling or open vessel (for maintenance)

For reactors (PWR, BWR, etc.) where the reactor vessel needs to be opened for refuelling this code is selected in addition to other relevant codes. The reactor vessel is also opened for inspection or maintenance.

2.3.2.1 Refuelling or open vessel — all or some fuel inside the core

This code covers vessel in flooded condition for fuel movement and also for inspection and maintenance.

2.3.2.2 Refuelling or open vessel — all fuel out of the core

This code covers vessel in flooded or drained condition for inspection and maintenance with fuel removed fully from the core.

2.3.3 Mid-loop operation and other reduced primary coolant inventory conditions

This code covers mid-loop operation or header level control with reduced primary coolant inventory for special maintenance works.

2.3.4 Natural circulation cooling

This code covers decay heat removal capabilities during cold shutdown through natural means.

2.4 Pre-operational

2.4.1 Construction, installation

The plant is under construction and equipment installation.

2.4.2 Commissioning

This covers the time span between the completion of construction and the beginning of commercial operation. Preoperational and commissioning phases are marked with this code. This code can be applied together with other codes in Section 2.

2.5 Testing or maintenance being performed

This code covers only the case where the test or maintenance work has a direct relation to the event, including the case where the failure was discovered during a period of testing or maintenance. It will always be used together with other codes in this section.

2.6 Post-operational (decommissioning/dismantling/decontamination)

This code indicates the plant status during decommissioning, etc.

3. FAILED/AFFECTED SYSTEMS

This field identifies:

(a) The systems that failed or lost their normal function, thereby initiating, or triggering the event;
(b) The systems that lost their normal function or were damaged as a direct result of the event;
(c) The systems of safety importance that were damaged or affected during or as a result of the event.

Systems distinguished with subdivisions under this code are:

A. Primary systems
B. Essential reactor auxiliary systems
C. Essential service systems
D. Essential auxiliary systems
E. Electrical systems
F. Feed water, steam and power conversion systems
H. Heating, ventilation and air conditioning systems (HVAC)
I. Instrumentation and control systems
K. Service auxiliary systems
S. Structural systems
W. Waste management systems
Z. No system involved

Some components or sub-components in a system can be categorized in more than one code particularly if it has two or more functions (activating or de-energizing other systems). In such cases select all codes that represent the dependency of those systems on that component or sub-component which have lost their normal function or were affected.

Only those systems are coded that play a direct role in the cause of the event, either because the system failed or lost its normal function, thereby triggering the event or because the system lost its function, was damaged or affected during or as a result of the event.

Although many systems may be affected by the event or are actuated to function, they are not selected for coding if the system functions as designed or if the functional loss is not safety related (see the examples with explanations in this chapter).

In the following sections a detailed description of systems is given along with the constituting parts or components.

3.A Primary systems

Primary systems are systems and components that specifically confine and control nuclear reaction and provide safety functions that cool and shut the reactor down during normal operations and in the case of a failure or malfunction. Primary systems include the components and sub-components of fuel, moderators, steam generators, heat exchangers, coolant systems, control rods, pressure vessel/tubes, etc.

3.AA Reactor core (fuel assemblies, control and poison rods, guide thimbles, …)

Reactor core system (AA) may consist of fuel assemblies, spacer grids, control rods or control assemblies, burnable poison rods, neutron startup sources and thimble guide tubes.

The moderator system of the GCR, AGR and RBMK type reactors is included in (AA).

The fuel assemblies consist of the fuel rods, spacer grids and plates, guide thimbles and plugs, burnable poison rods and all other parts needed for a complete fuel bundle.

The control assemblies consist of the control rods, shutoff rods, adjusters, zone controllers, etc., and the assembly structure up to and including the coupling socket. (This code basically covers reactor trip and control elements.)

Notes:

1. Even if the fuel assembly, control rod was damaged in the storage pool or during transportation inside the plant, (AA) is to be selected.
2. The control rod drive system is to be coded in (AB).
3. Baffle plates, core support plates, core barrel and other reactor internals is to be coded in (AC).
4. In PHWRs, the adjusters comprise absorber rods, regulating rods and shim rods.

3.AB Systems for reactor control and protection e.g. control rod drive mechanism, accumulator… (Motor power supply, hydraulic system, other shutdown systems)

Systems for reactor control (AB) provide means of controlling the reactor power level by changing the position of the control rod assemblies in the reactor core system (AA). These systems also provide the principal means of quickly and safely shutting down the reactor in response to a trip signal. The electronic system that is a part of the motor assembly is included in (AB).

In PWRs, the control rod drive system (AB) consists of control rod drive mechanisms and associated electrical power supplies. This system includes motor assembly, coil stack assembly, reed switch assemblies, extension shaft assembly, etc.

In BWRs, the control rod drive system (AB) consists of the control rod drive mechanisms, a hydraulic control unit for each control rod drive mechanism, a common hydraulic power supply, scram discharge volume tank, etc.

In PHWRs, primary/secondary shutdown system (AB) consists of moderator dumping/shutoff rods /liquid poison, etc. and supported auxiliaries such as clutches, tanks, valves etc.

Notes:

1. Control rod drive cooling water is included in (CA).
2. Normal control rod drive control signal is included in (IK).
3. Scram signal is included in (IN).
4. Guide plates, assemblies and the pressure housings for the upper and lower control rod drive mechanisms are part of the reactor vessel system (AC).
5. Control rod position indicators in the main control room is included in (IE), its detector reed switch is included in (AB).
6. Reactor trip breaker is included in (IN).
7. Required nitrogen for accumulators of (AB) is included in (KC).

3.AC Reactor Vessel (with core internals, PHWR or LWGR pressure tubes, …)

The reactor vessel (AC) houses the reactor core.

For PWRs, it consists of the reactor pressure vessel, head, core support plates, core barrel, baffles, pressure tubes for control rod assemblies and thimbles, stand pipes, support castings, all nozzles (on vessel) and other internals except those included in the reactor core system, (AA).

For BWRs, it includes the reactor pressure vessel and level instrumentation taps, support plates, core shroud, core plate, internal standby liquid control piping, core spray sparger, feedwater sparger, jet pumps and risers and all other internals not included in the reactor core system (AA).

For CANDU and HWLWR, the pressure tubes and associated components are (AC), and the calandria tank and tubes are (AD).

For GCRs it includes the penetrations.

3.AD Moderator and auxiliaries including neutron poison removal system (PHWR)

This code is used for the reactors that have a liquid moderator system, for example PHWR and HWLWR.

The moderator and auxiliaries system (AD) consists of the moderator (Calandria) tank and tubes, moderator cover gas system, moderator make-up system, neutron poison removal system/ion exchange and other moderator-related systems.

Notes:

1. Moderator dump system for emergency scram is included in (AB). However the rest of the moderator system and its auxiliaries are included in (AD).
2. The moderator system of GCR, AGR and RBMK is included in the reactor core (AA).

3. AE Primary coolant system (pumps and associated materials, loop piping, …)

This code is used for reactor types that have a secondary circuit, i.e. PWR, AGR, GCR, PHWR. Primary coolant system (AE) circulates the cooling fluid through the reactor vessel (AC), removes heat from the reactor core (AA) and internals, transferring it to the secondary system via the steam generators or heat exchangers (AH). For GCR and AGR, the coolant circulation pump, fan and guide vane are included in (AE). The primary coolant drains and vents up to the second isolation valves are also to be coded in (AE).

The major components of this system are the reactor coolant pumps, lube oil pumps and coolers, associated loop piping, insulation and pipe supports.

Notes:

1. Pressurizer and related relief valve are included in (AF).
2. Primary pump seal water supply system is included in (BF).
3. Drainage components including piping, valves, drain tank, pipe supports and hangers are included in (WG).

3.AF Pressure control (includes primary safety and relief valves)

Pressure control system (AF) provides a means of controlling the pressure in the primary coolant system. The pressurizer spray actuation signal is included in (AF). Pressure control system (AF) consists of the pressurizer, pressurizer heaters and sprays, safety and relief valves, block valves, feed and bleed control valves, surge tank, pipes, insulation and pipe supports and hangers.

Notes:

1. The indicator of relief valve position is included in (IE).
2. Pressure relief/safety valve of the primary circuit of a BWR is included in (BK).

3.AG Recirculating water system (BWR)

Recirculating water system (AG) provides forced cooling through the reactor vessel to remove the heat generated by the nuclear reaction. BWR power control is included in (AG).

The system consists of internal/external recirculation pumps, some designs also have a flow control valve, motor operated gate valves for pump isolation, pipes, insulation and pipe supports. This system also includes lube oil pumps and coolers.

Notes:

1. Jet pump assembly needs to be included in (AC).
2. Some parts of the ATWS (Anticipated Transient Without Scram) function that trips recirculation pumps as a secondary unit shutdown system needs to be included in (IN).

3.AH Steam generator, boiler steam drum

This code is used for the reactor types that have secondary loops.

The primary function of (AH) is to transfer heat from the primary coolant system to the secondary coolant system while maintaining separation between these systems.

Steam generator system (AH) consists of the steam generators, their internals and nozzles, and related supports. For AGR and GCR, (AH) is the boiler system.

3.AK At power fuel handling systems (PHWR, LWGR, GCR)

At power fuel handling systems (AK) include the refuelling machines, spent fuel transfer system and components that ensure the integrity of the fuel and pressure boundary. These systems include such indicators that provide assurance of leak tightness of the pressure boundary before and after refuelling operations and integrity of the fuel.

Note:

1. This does not include fuel assemblies, etc., which are part of the reactor core (AA)

3.AL Annulus gas

The primary function of the annulus gas system (AL) is to monitor ‘leak before break’ (LBB) of pressure tubes of PHWR units. This system includes tubing, diagnostic systems, and associated equipment.

3.B Essential reactor auxiliary systems

Essential reactor auxiliary systems provide support to the safety functions necessary to mitigate the consequences of an accident which could lead to core damage and to the release of radioactivity to the environment. The consequences of failure of these auxiliary systems needs only to be considered after an initial failure of a safety function.

3.BA Reactor core isolation cooling (BWR)

Reactor core isolation cooling system (BA) includes the two following systems:

a) Reactor core cooling system

This system provides cooling water to the reactor vessel during a loss of normal feed water flow. Components of this system may include steam-driven turbine, pump, condenser, condensate pump, vacuum pump, valves and actuators, pipes, pipe supports and hangers.

b) Isolation/emergency condenser system

The isolation condenser system provides cooling by natural circulation for the reactor in the event that feed water capability is lost and heat removal systems which require electric power for operation are not available. This system may consist of the condensers, the condenser make-up tank, valves and actuators, pipes, pipe supports and hangers and miscellaneous drains.

Note:

1. In some BWRs, the residual heat removal systems have the reactor isolation cooling function. In such a case, this function is included in both (BA) and in (BE).

3.BB Auxiliary and emergency feedwater

The auxiliary and emergency feedwater system (BB) provides emergency cooling capability for the steam generators (AH) so that the primary coolant system (AE) can be cooled. In some units, this system supplies feedwater during startup, shutdown, and low power operation.

Components for this system include turbine driven pumps, electric motor driven pumps, valves and actuators, pipes, pipe supports and hangers.

3.BC Emergency poisoning function (PWR mainly with the boron injection tank, chemical and volume control system participation)

Soluble poisons (Boron) are used in emergency shutdown systems in PWRs. In PHWRs soluble poison (Boron or Gadolinium) is used to enhance the shutdown system capabilities. The poison solution can be injected into the coolant to decrease the reactivity either automatically or manually by the operator. The main components of (BC) are the boron injection tank and associated valves, etc.

In PWRs this tank is the source of water initially injected by the high pressure safety injection pumps (BF)/(BG). This system consists of the tank, pipes, pipe supports and insulation.

Notes:

1. Isolation valves, recirculation piping to and from the chemical and volume control system are included in (BF).
2. The safety injection system is included in (BG).

3.BD Standby liquid control (BWR)

The standby liquid control system (BD) provides a means of shutting the reactor down by injecting boron solution into the reactor vessel (AC). This system is used only in the unlikely event that the control rods cannot be inserted into the reactor core (ATWS).

The system primarily consists of a boron solution storage tank, positive displacement pumps, test tanks, accumulators, valves and actuators, pipes, pipe supports and hangers.

3.BE Residual Heat Removal (PWR and BWR except emergency core cooling functions)

The residual heat removal system consists of pumps, heat exchangers, valves, pipes, insulation, pipe supports and hangers and any drain lines. The system has both normal and emergency modes of operation. During emergency mode, the residual heat removal system can be used for low pressure safety injection. The emergency core cooling function is included in (BG).

Notes:

1. Borated/refuelling water storage tank is included in (CD).
2. Cooling water for the heat exchanger is included in (CA).
3. The BWR Containment spray and torus/wetwell spray system is included in (DD).
4. Code (BE) is selected up to the last isolation valve between systems (BE) and (DD).

3.BF Chemical and volume control (PWR with main pumps seal water…)

The chemical and volume control system (CVCS) (BF) serves many functions, including:

1. Maintaining the primary coolant system (AE) boron concentration.
2. Maintaining the proper water inventory for the primary coolant system.
3. Providing seal water to the primary coolant pump shaft seals.
4. Maintaining the proper concentration of corrosion inhibiting chemicals in the primary coolant.
5. Purifying the coolant.
6. Degassing the primary coolant system.
7. In some designs it provides borated water for emergency core cooling at reactor pressure (high pressure safety injection function).

Components for the chemical and volume control system may include charging pumps, let-down chillers, let down reheater, seal water and regenerative heat exchangers, ion exchangers, demineralizers, volume control tank, boric acid storage tanks, boric acid transfer pumps, mixing and holdup tanks, blenders, chillers, filters and strainers, valves and actuators, pressure reducing orifices, pipes, insulation and pipe supports and hangers.

Notes:

1. Seal water supply system to primary pump is included in (BF).
2. Nitrogen supplies for various tanks of (BF) are included in (KC).
3. Boron recovery system is included in (WA).
4. High pressure safety injection function of the chemical and volume control system is included in both (BF) and (BG).
5. The purification system of GCR and AGR are included in (BF).

3. BG Emergency core cooling

The emergency core cooling system may include the following systems:

a) High or intermediate pressure coolant injection system (PWR, PHWR)

The high or intermediate pressure injection system provides borated water to the primary coolant system (AE) for flooding and cooling of the reactor core (AA) following a LOCA.

This system also assures decay heat removal and injection of borated water to increase the shutdown margin following a rapid cooldown of the reactor due to a steam-line rupture.

In PHWR, if the reactor pressure drops below the set pressure during a LOCA, depending on the reactor design, heavy water/light water is forced into the primary coolant system of the reactor vessel

The components are accumulator, tanks, pumps, lube oil pumps and coolers, valves and actuators, pipes, insulation and pipe supports and hangers.

b) Low pressure core cooling system (PWR, PHWR)

The primary purpose of the low pressure core cooling system is to supply emergency coolant during large breaks in order to flood the uncovered core of the depressurized reactor and to provide long-term decay heat removal, both in the injection mode from borated water storage tank (CD), and in the recirculation mode from the sump on the floor of the primary reactor containment building (SA).

The major components of the system are pumps, fuel oil pumps and coolers, valves and actuators, associated pipes, insulation and pipe supports and hangers.

c) High pressure coolant injection system (mainly BWR)

The high pressure coolant injection system provides high pressure emergency core cooling capability. The flow rate of the system will ensure the reactor core is adequately cooled until the reactor pressure drops sufficiently to permit the low pressure core cooling system to inject into the reactor.

The system's components may include injection pump, booster pump, steam driven turbine, valves, turbine and pump lubrication system, drains, gland seal condenser and pump, associated pipes, pipe supports and hangers.

d) High pressure core spray system (mainly BWR)

The primary purpose of the high pressure core spray system is to maintain reactor vessel inventory after small breaks which do not depressurize the reactor. The system also provides spray cooling heat transfer during breaks in which the core might be uncovered. The primary source of water for this system is the condensate storage tank (CE). The suppression pool (SA) serves as the secondary water source.

The high pressure core spray system may include spray pumps, line-fill pumps, valves, lubrication components, drains and vents, pipes and pipe supports and hangers.

The core spray sparger ring and spray nozzles are part of the reactor vessel system (AC).

e) Low pressure core spray system (mainly BWR)

The primary purpose of the low pressure core spray system is to provide inventory make-up and spray cooling during large breaks in which the core is uncovered. It also provides inventory make-up for small breaks. Primary and secondary sources of water are the suppression pool (SA) and the condensate storage tank (CE).

The low pressure core spray system may include spray pumps, line-fill pumps, valves, drains and vents, lubrication components, pipes and pipe supports and hangers.

The core spray sparger ring and spray nozzles are part of the reactor vessel system (AC).

Notes:

1. Coolant injection by accumulators (PWR) is included in (BL) and for PHWR is included in (BG).
2. Low pressure core cooling, if provided by the residual heat removal system, is included in (BG).
3. The emergency core cooling function of the chemical and volume control system (BF) is included in (BF) and/or (BG) depending on the affected function.
4. The emergency core cooling function of the residual heat removal system (BE), i.e. low pressure and safety/coolant injection function, is included in (BE) and/or (BG) depending on the affected function.

5. The ‘keep fill’ system which keeps pipes full of water to prevent water hammer is also to be included in (BG).
6. The air supply system to control valves of (BG) is included in (CC).

3.BH Main steam pressure relief (reactors which have secondary loops)

The main steam pressure relief system (BH) provides pressure relief for the main steam system (FA) in the event of load change or turbine trip. The method of pressure relief is steam discharge to the atmosphere through relief and safety valves.

The relief and safety valves are usually used only when steam dump to the main condenser via the turbine bypass system (FE) is unavailable or has insufficient capacity.

The system mainly consists of the relief and safety valves, control valves, piping from the main steam line to the valves, vent pipes, pipe supports and hangers and drains.

3.BK Nuclear boiler overpressure protection (mainly BWR)

Nuclear boiler overpressure protection system (BK) prevents over pressurization of the nuclear system by venting steam to the suppression pool for condensation. The safety/relief valves vent steam in the event that the turbine bypass system (FE) is unavailable.

This system mainly consists of safety/relief valves, control valves, piping from the main steam line (FA) to the suppression pool (SA), automatic depressurization system (ADS) accumulators, pipes, insulation, pipe support and hangers.

3.BL Core flooding accumulator (PWR)

Core flooding accumulator system (BL) may include two types of systems:

a) Core flooding accumulator system

This system has the accumulators that are filled with borated water and are pressurized with nitrogen gas. If the reactor pressure drops below the accumulator's pressure, the borated water is forced into the primary coolant system or the reactor vessel. This system consists of the accumulators, valves, piping from the accumulators to the emergency cooling system injection header or to the reactor vessel, it also includes pipes and pipe supports and hangers.

b) Upper head injection system

This system has two large accumulators. One of the accumulators is filled with borated water, the other is filled with pressurized nitrogen which provides a cover gas that propels the contents of the water-filled accumulator into the reactor vessel. This system mainly consists of the two large accumulators, a surge tank, valves, pipes and pipe supports and hangers.

Note:

1. Nitrogen cover gas for the accumulators of (BL) is included in (KC).

3.BP Failed fuel detection (off-line detection system)

Failed fuel refers to the breach in the fuel-clad of an irradiated fuel assembly in a nuclear reactor. Neutron detection, gamma detection or fission product monitoring (such as Iodine) are commonly used in the identification of failed fuel detection. The identification of the location of the failed fuel is normally done out of the core.

This code is used for failure of the detection system employed or of the failure of any subsidiary component of the detection system.

3.BQ Gas cleanup system (LWGR, PHWR)

Normally cover gas (helium) cleanup system is used in some designs to maintain the moderator system operability.

3.BR End shields and associated cooling system (PHWR)

The end shields are surrounded by a shield cooling tank which are designed to allow access to the fuelling machine area and to the reactor face and to fulfil any structural and support function. The space between the calandria shell and the shield cooling tank shell is filled with light water, which serves as a thermal and biological shield. The light water in the shield tank and the end shield cavities is circulated and cooled. The end shield and the shield cooling systems are designed to remove heat from the shielding material as well as heat transferred from the Reactor Coolant System (RCS).

This code is used for main components and sub-components of the end shields and the associated cooling system.

3.C Essential service systems

Essential service systems are those systems that are mainly used to provide cooling or back up to safety-related equipment that must function during and following an accident.

Redundant flow paths are normally available to assure that no single failure would cause a system failure.

3.CA Component cooling water

The component cooling water system (CA) acts as an intermediate heat sink for heat removal from potentially radioactive heat loads during both normal and emergency conditions. Thus, the component cooling water system acts as a barrier between radioactive systems and the environment. The heat is transferred to the cooling service system (CB) for release to the environment.

This system consists of the following major components: component cooling pumps, lube oil pumps and coolers, heat exchangers, surge tanks, valves, pipes and pipe supports and hangers.

Note:

1. The control rod (adjuster rod) cooling system is included in (CA).

3.CB Essential raw water cooling or service water

The essential raw water cooling/service water system (CB) is an open or closed system, using water from the environment and discharging heat to the environment in an open system or recirculation water by dissipating heat to the environment e.g. cooling towers in a closed system, which acts as the final heat sink for primary system components.

This system (CB) provides the cooling water to the heat exchangers of (CA).

The major components in this system are: heat exchangers, centrifugal pumps, travelling screens, screen wash pumps, backwash strainers, valves and their operators, pipes and pipe supports and hangers.

3.CC Essential compressed air (e.g. instrument air…)

The essential compressed air system (CC) supplies dry, filtered air to operate safety-related components such as valves and seals.

The system mainly consists of air compressors, heat exchangers, air receivers, strainers, filters, driers, accumulators, valves and actuators, pipes and pipe supports and hangers.

3.CD Borated or refuelling water storage (PWR)

Borated or refuelling water storage system (CD) is the borated refuelling water storage tank that supplies reactor-grade, borated water to fill the pool during fuel transfer between the reactor vessel and the spent fuel pool. In some designs it also provides water to the emergency cooling system (BG) during emergency operation.

3.CE Condensate storage

The condensate storage system (CE) provides a means of controlling the water inventory in the turbine cycle by supplying water to or accepting water from the main condenser (FC). The condensate storage system usually supplies water to the seal water system (FG) or to the condensate and feed water system (FG), auxiliary feed water system (BB), reactor core isolation cooling system (BA), residual heat removal system (BE), high pressure coolant injection system (BG), high pressure core spray system (BG) and low pressure core spray system (BG) (depending on the plant's design).

Components for this system include condensate storage tank, transfer pumps, valves and actuators, pipes and pipe supports and hangers.

Note:

1. (CE) is used only in the case of failure to supply water to safety related systems.

3.CF CO_2 injection and storage (GCR)

The CO_2 injection and storage system for GCRs supplies purified CO_2 gas to the main circulating circuit. It includes the storage tanks, pumps, valves, pipes and pipe supports and hangers.

3.D Essential auxiliary systems

Essential auxiliary systems are those systems that provide necessary services to ensure the continued operation of the nuclear power plant and which also provide radiological protection to personnel, plant equipment and the environment.

3.DA Spent fuel pool or refuelling pool cooling and cleanup

The purpose of the spent fuel pool/refuelling pool cooling and cleanup system (DA) is to remove the decay heat from the spent fuel elements, to keep the pool clean for good visibility during fuel handling and to minimize contaminants in the fuel pool. The Spent Fuel Inspection bay receiving the spent fuel before transferring to spent fuel pool/refuelling pool should also be included in (DA).

The major components of the system are pumps, heat exchangers, filters, demineralizers, valves and associated pipes and pipe supports and hangers.

Note:

1. In some designs, this system uses the filters and demineralizers of the suppression pool and cleanup system (WH).

3.DB Containment isolation (including penetrations and air lock door seals)

The containment isolation system (DB) may consist of the following two systems:

(a) Containment isolation system:

The containment isolation system (DB) may provide a means for:

1. Isolating the various fluid, pneumatic, heating, ventilation and air conditioning systems which penetrate the containment.
2. Isolating instrument line penetrations.
3. Isolating personnel airlocks/hatches and equipment access airlocks/hatches.
4. Isolating fuel handling penetrations.

The major components are valves and actuators, pipes, pipe sleeves, seals, doors, penetrations, dampers and ductwork.

(b) Containment isolation leak control system:

The system serves to prevent the possible release to the environment of potentially radioactive material through closed isolations (other than main steam isolation valves) and containment air lock door seals after the occurrence of a LOCA.

Upon operation, the system supplies air or water to the various valves and the containment air lock door seals at a pressure greater than the containment pressure. This system consists of a compressor, separator, heat exchanger, air receiver, valves and actuators, pipes and pipe supports and hangers.

Notes:

1. The main steam isolation valves are included in (DC).
2. The reactor building/suppression chamber vacuum breakers are included in (DB).

3.DC Main steam or feedwater isolation function

3.DC.1 Main steam isolation function

Main steam isolation valve system (DC.1) consists of the two following parts:

(a) Main steam isolation valves:

This part includes the valves, related pilot valves, pipes and pipe sleeves.

(b) Main steam isolation valves leakage control:

This part of the system prevents the release of radioactivity to the plant environment from leakage of the main steam isolation valves following a LOCA. It consists of valves and actuators, pipes and pipe support and hangers.

3.DC.2 Feedwater Isolation

In some designs, the main feedwater isolation system (DC.2*)* plays an important role in an emergency shutdown by preventing the reactor from losing its protective cooling water. The system includes valves and actuators, pipes and pipe supports and hangers.

3.DD Containment atmosphere clean up/treatment systems (e.g. spray, iodine removal…)

Containment pressure reduction systems (DD) may include the following three systems:

(a) Containment spray system

The containment spray system functions to reduce containment pressure and airborne fission products in the containment atmosphere following a LOCA or steam line break.

The major components may include containment spray pumps, spray additive tank, liquid jet ejector, spray headers and nozzles, isolation valves, pipes and pipe supports and hangers.

Note:

1. In some BWRs the containment spray system is an integral part of the residual heat removal system or ECCS. In case of degradation of this function, (DD) and/or (BE/BG) are (is) selected depending on the affected function.

(b) Containment ice condenser system.

The containment ice condenser system limits the containment atmospheric pressure to an acceptable value by cooling and condensing the steam with ice following a LOCA. The ice condenser is filled with borated ice which, when it melts, will maintain the boron concentration in the containment sump.

Components for the containment ice condenser system may include the ice condenser structure, an ice-making machine, borated ice, ice baskets and doors leading to the ice condenser compartment.

c) Compartment spray system

In some VVER reactor types the main components (primary pumps. pipes. steam generators, etc.) are housed in steam generator compartment. The spray system for this compartment is included in (DD).

3.DE Containment pressure suppression

Containment pressure suppression system (DE) makes up the suppression pool water in order to maintain the suppression pool dynamic loading. The main components are valves and actuators, pipes, ducts, pipe supports and hangers. This system includes the suppression pool water cooling system.

Notes:

1. The passive pressure suppression system of some VVER reactor types e.g. the bubble steam condenser tower, is included in (DE). Pressure suppression systems in any other reactor types should also be included in (DE).
2. In some designs the ventilation system has also the function of pressure reduction (suppression). This is included in (HA).

3.DF Containment combustible gas control

In order to eliminate the possibility of an in-containment post accident hydrogen explosion, the containment combustible gas control system (DF) controls the hydrogen concentration in the containment atmosphere by recombination, air mixing and/or dilution with nitrogen.

Notes:

1. The hydrogen-oxygen analyser is included in (IQ).
2. Nitrogen supply facility for inerting is included in (DF).

3.DG Essential auxiliary steam (GCR)

Essential auxiliary steam is used to provide steam for reactor start up and to provide steam when main steam is unavailable e.g. post accident. This code may also be applicable to other reactor types.

3.E Electrical systems

3.EA High voltage AC (greater than 15 kV)

The high voltage AC system (EA) includes all electrical Systems and components of voltage greater than 15kV, including all on-site (EA.1) and off-site power sources (EA.2).

3.EA.1 High voltage AC — onsite

This system includes the electrical generators of output rating greater than 15 KV, generator transformer/main transformer (GT), bus ducts, transmission lines from GT to switchyard including generator circuit breaker (GCB), generator and transformer control systems, protective relays, buses, startup transformers primary side and the switchyard equipments like towers/gantries, disconnect switches, power circuit breakers, lightning arrestors, current and potential transformers, etc.

Notes:

1. Loss of partial on-site power including the switchyard is included in (EA.1).
2. Related breakers are also included in (EA.1).
3. The insulating oil in the transformers is also to be included in (EA.1).

4. If the Generator output is less than 15 KV then GT low voltage side and station service transformer and associated equipment are to be included in (EB)

3.EA.2 High voltage AC — Offsite (including grid & transmission lines)

This system mainly includes the electrical grid supplying power, transmission lines (power evacuation and receiving) and their control systems, protective relays, buses, disconnect switches, power circuit breakers, lightning arrestors, and current and potential transformers.

Notes:

1. Loss of off-site power including a partial loss of electrical grid is included in (EA.2).
2. Related breakers and equipment required in power transmission are also included in (EA.2).

3.EB Medium voltage AC (600V to 15kV)

Medium voltage AC system (EB) includes all electrical systems and components of voltage equal to or greater than 600 V AC but less than or equal to 15 kV AC.

This system includes the Electrical Generators of output rating of less than or equal to 15 KV and associated GT & GCB, bus ducts, transmission lines from GT to switchyard, generator and transformer control systems, protective relays, buses, etc.

Startup transformers secondary side and associated equipment are to be included in (EB). The primary side more than 15 KV is included in (EA.1).

The power sources of secondary side (startup transformer, station service transformer, house-load transformer, etc.) between 600 V to 15 KV are to be included in (EB). Emergency power supply of 600 V to 15 kV (diesel generator or gas turbines, etc.) are also to be included in (EB).

The major components are transformers, buses, cables, relays, circuit breakers and other associated electrical equipment.

Note:

1. If the Generator output is more than 15 KV then GT and station service (auxiliary) transformer and associated equipment are to be included in (EA.1).

3.EC Low voltage AC (less than 600V — mainly 480V)

Low voltage AC system (EC) includes all electrical systems of voltages less than 600V. The major components of the system are the bus bars, emergency bus bars, transformers, protective relays, relays, buses, breakers, cables, motor control centres and other associated electrical equipment.

Notes:

1. Power for the instrumentation, control and computer system is included in (ED).
2. Power for the electrical heat tracing system that provides heat to equipment containing liquid is included in (ED).

3. Power for the lighting and motive power is included in (EC), while the system itself is included in (Z).

3.ED Vital instrumentation AC and, control AC

Vital instrument control including computer AC power supply system provides power to all instrumentation and equipment which requires uninterruptible power supply. The power sources for the vital instrumentation, control and computer system are bus bars (EC) and the DC battery boards (EE), which feed the inverters (ED). Typical voltages would be 120V or 240V.

The major components are inverters, relays, circuit breakers, cables, distribution panels and other associated electrical equipment.

Notes:

1. Power for the engineered safety features actuation system (IP) is included in (ED).
2. Power for the in-core and ex-core neutron monitoring system (IF) is also included in (ED).
3. Power for the instrumentation, control and computer system is included in (ED).

3.EE DC power (e.g., UPS, batteries, rectifiers …)

The DC system (EE) provides power to all loads that have to function after a loss of AC power.

The major components are: Uninterruptible Power Supplies (UPS), batteries, battery chargers, rectifiers, circuit breakers, cables and distribution boards.

3.EF Emergency power generation and associated auxiliaries (including fuel oil)

The emergency power generation system (EF) supplies medium voltage AC to essential loads during emergency conditions of loss of normal on-site and off-site power. Essential loads are the loads that are required for reactor shutdown, containment isolation, core cooling, heat removal, etc.

Typically, emergency power is provided by diesel generators, although gas turbines and hydroelectric plants are also used.

The major components are diesel engine (or gas turbine or hydroelectric plant), generator, fuel supply, governors, relays and cables.

Notes:

1. Emergency generator lube oil system is included in (EF). The system that supplies water to lube oil cooler is the essential raw cooling/service water system (CB).
2. Emergency fuel system, fuel oil, jacket cooling, etc. are included in (EF).
3. Emergency generator starting system, which provides compressed air or batteries to assist in rapid starting of the engine, is included in (EF).
4. Emergency generator building ventilation is included in (SE) and the fire detection system is included in (IB)
5. Emergency generator instrumentation and control system is included in (EF).

3.EG Security and access control

The security and access control system (EG) is used to control general access to the site as well as vital and radiation control areas to prevent unauthorized access.

The major components are closed circuit television, microwave and motion detection systems, identification systems (eye, hand, voice, card, etc.), and the associated instrumentation control, etc.

Note:

1. Security and access control system is usually powered by vital instrument AC and control AC system (ED). This system is normally independent of plant power supply systems.

3.EH Communication and alarm annunciation

Communication and alarm annunciation system (EH) could include the following two systems.

The communication system is provided for internal plant and off-site location communication. The system includes radio communications, normal telephone systems, hot-lines to outside authorities, fax machines and other communication systems, etc.

The alarm annunciation system provides the plant personnel with alarms which indicate the onset of an abnormal condition inside the plant with respect to the safety of personnel and/or the public (on-site and off-site emergencies). The system consists of alarms, annunciations, operator interface hardware and miscellaneous equipment.

Notes:

1. (EH) does not include the main control board indication and/or annunciation system; this is included in the plant monitoring system (IE).
2. The communication system between computer equipment is not included in (EH) but is included in (IA).
3. The fire detection system is included in (IB) and the environmental monitoring system in (IC).

3.F Feedwater, steam and power conversion systems

3.FA Main steam and auxiliaries (including auxiliary steam)

The main steam system (FA) delivers steam to the high pressure turbine (FB). In addition, the system also supplies steam to main feedwater turbine driven pumps (FG), the turbine steam sealing system (FB), moisture separator reheaters (FB), steam jet air ejectors (FC), high pressure coolant injection steam driven turbine (BG), reactor core isolation cooling steam driven turbine (BA) and the auxiliary feedwater turbine driven pumps (BB) (depending on the plant design), etc.

Components for this system include flow restrictors, drains, vents, pipes, insulation and pipe supports.

Notes:

1. Main steam pressure relief system for reactors which have secondary loops is included in (BH).
2. Nuclear boiler overpressure protection system (BWR) is included in (BK).
3. Turbine bypass system is included in (FE).
4. Auxiliary steam system is included in (FA). This system generates and delivers auxiliary steam to various systems when they cannot obtain steam from the main steam system.

3.FB Turbines (main, feedwater and auxiliary feedwater turbines and associated auxiliaries)

Turbines (FB) may consist of the following systems:

a) Turbine generator system

The turbine generator system includes the high pressure and low pressure turbines, generator, generator seal oil subsystem, exciter, generator stator cooling subsystem, generator hydrogen cooling subsystem, lubrication oil supply system, valves, pipes, pipe supports and insulation.

b) Turbine steam sealing system

The steam sealing system provides low pressure steam to the turbine shaft seals (FB), feedwater turbine shaft seals (FG), and turbine control valve seals (FB).

Components for this system mainly include steam pressure reducers, valves and actuators, steam condensers, blowers, pipes, pipe supports and hangers, and insulation.

c) Moisture separator reheater system

The moisture separator reheater system receives exhaust steam from the high pressure turbine (FB) and removes the moisture by passing the steam through a series of baffle plates. The steam then flows over reheater tubes where it is heated by extraction steam. The dry, superheated steam is supplied to the low pressure turbines (FB).

Components in this system are the moisture separator reheaters, pipes, pipe supports and hangers and insulation.

Notes:

1. The related part of the steam extraction system and associated auxiliaries is included in (FB).
2. The turbine trip signal is included in (ID).

3.FC Main condenser and auxiliaries (non-condensable gases extraction and treatment)

The main condenser serves to condense the steam exhaust from the low-pressure turbines (FB) and the feedwater turbine driven pumps (FG). The main condenser also serves as a heat sink for steam flow from the turbine bypass system (FE).

Notes:

1. The non-condensable gases extraction system (air ejector) is included in (FC).
2. The cooling water for the main condenser is included in (FN).
3. The water level of the main condenser is properly maintained by an automatic level control system (FC) that may send water from/to the condensate storage tank (CE).

3.FE Turbine steam by-pass to condenser

The turbine bypass system (FE) reduces the magnitude of a nuclear system transient following large turbine load reductions by diverting throttled steam directly to the main condenser (FC).

This system mainly consists of the condenser steam discharge valves, other valves, pipes from the main steam header up to the condenser, pipe supports and hangers.

Note:

1. Steam discharges to atmosphere through relief devices from reactors which have secondary loops are also used to reduce the magnitude of a nuclear system transient following large turbine load reductions. This system is to be included in (BH).

3.FG Feedwater and condensate (including pumps, heat exchangers, tanks, etc.)

The condensate and feedwater system (FG) supplies preheated feedwater to the steam generators (AH) or to the reactor vessel (AC).

Components for this system mainly include pumps (condensate, booster and main feedwater), feedwater pump turbine (for those plants that have turbine driven pumps), feedwater heaters, deaerators, drain tanks, valve and actuators, pipes, insulation and pipe supports and hangers.

Notes:

1. Seal water system used for sealing is included in (FG).
2. The related part of the steam extraction system is included in (FG).
3. The thermal cycle drains and vents that accept drainage from various components in the feedwater, steam and power conversion system which vents non-condensable gases is included in (WG).

3.FM Condensate demineralizer

The condensate demineralizer system (FM) maintains the quality of the feedwater by removing suspended impurities.

Components of this system mainly include demineralizers, resin trap strainers, chemical storage tanks, cation and anion regeneration tanks, waste and crud storage tanks, resin transfer pumps, valves and actuators, pipes, pipe supports and hangers and insulation.

3. FN Circulating or condenser cooling water (including raw cooling and service water)

The primary purpose of the circulating water system (FN) is to supply cooling water to the condensers (FC). In addition, this code includes the non-essential raw cooling water and service water system.

The major components of the circulating water system are the circulating water pumps, motors, cooling towers, large butterfly valves, travelling screens, pipes, pipe supports and hangers.

The non-essential raw cooling water system provides heat removal for turbine building loads, as well as a few non-essential loads in the auxiliary building.

The non-essential service water system supplies a source of water for yard watering. washdown services and for the fire protection system.

Notes:

1. The circulating water system includes the cooling tower blowdown system which removes solids that concentrate in the circulating water system (FN) due to evaporation.
2. Essential raw cooling water and service water system are included in (CB).

3.H Heating, ventilation and air conditioning systems (HVAC)

Heating, ventilation and air conditioning (HVAC) systems are used for assuring and maintaining consistent operable environments for both personnel and equipment by providing ventilation, air quality and temperature control. The ventilation system also helps in maintaining the radiological conditions by pressure gradient and use of appropriate filters, etc.

3.HA Primary reactor containment building HVAC

The primary reactor containment building ventilation system (HA) provides ventilation and temperature and air contamination control in the reactor building (primary containment in a PWR or secondary containment in a BWR or primary and secondary containments in double containment NPPs such as PHWRs, etc.).

The system mainly consists of air handling units, valves and actuators, dampers, ductwork, filters and fans.

Notes:

1. Reactor building fan cooler units are included in (HA).
2. Building atmospheric condition monitors are included in (IE) or for radiation purposes in (IH).
3. In some designs the ventilation system has also the function of pressure reduction (suppression). This is included in (HA).

3.HB Primary containment vacuum and pressure relief

The primary containment vacuum and pressure relief system (HB) controls the pressure in the containment vessel, i.e. the differential pressure between the containment vessel and either the outside air or the torus (wetwell)/drywell.

The main components of this system are penetrations, vacuum breakers connected to outside, diaphragms, dampers, blow-out panels and valves.

Notes:

1. In BWRs. this system is called the primary containment relief system. This system protects the primary containment from exceeding the maximum external pressure and prevents the backflow of suppression pool (torus) water into the drywell. The torus (wetwell)/drywell vacuum breakers are included in (HB).
2. The reactor building/suppression chamber vacuum breakers are included in (DB).
3. In PWRs, this system is called the pressure and vacuum relief system.
4. In PHWRs, the pressure relief function to the vacuum building is included in (HB).
5. The pressure relief and filtration system for severe accident conditions is to be included in (HB).

3.HC Secondary containment recirculation, exhaust and gas treatment (includes BWR standby gas treatment)

The secondary containment recirculation exhaust and gas treatment system (HC) controls the atmosphere within the annulus of double containment NPPs and maintain these annulus areas or the secondary containment (BWR) at a negative pressure relative to the outside atmosphere.

Components mainly include fans, ductwork, and dampers, absolute and charcoal filters and associated equipment.

Notes:

1. Emergency gas treatment system in PWRs is included in (HC).
2. Standby gas treatment system in BWRs is included in (HC).
3. Secondary containment recirculation and purge system in PHWR is included in (HC)

3.HD Drywell or wetwell HVAC and purge inerting (BWR)

The drywell or wetwell HVAC and purge inerting system (HD) provides ventilation and temperature control to the reactor drywell and reactor wetwell/suppression pool system (SA).

The system mainly consists of fans, heat exchangers, ductwork, valves and actuators.

Notes:

1. The containment combustible gas control system (DF) is independent of this system.
2. The cooling water to the heat exchanger used for cooling the containment atmosphere is supplied by the component cooling water system (CA) or chilled water cooling system (HN).

3.HE Reactor or nuclear auxiliary building HVAC

Reactor/Nuclear auxiliary building HVAC system (HE) provides ventilation and temperature control to various sections of the reactor/nuclear auxiliary building (SC).

The system mainly consists of fans, ductwork, air handling units, cooling coils, electric heaters and filters.

Note:

1. The cooling water for air handling units is supplied by the chilled water system (HN).

3.HF Control building HVAC (including main control room HVAC)

The control building HVAC system (HF) provides ventilation, heating and cooling to the control building (SD*)* including the main control room (MCR).

In case of failure of normal ventilation system to MCR, the necessary ventilation requirements for personnel occupancy is provided by emergency/survival ventilation system and this system should also be included in (HF).

The system mainly consists of fans, ductwork, air handling units, cooling coils, electric heaters and filters.

3.HG Fuel and spent fuel buildings HVAC

The fuel and spent fuel building HVAC system (HG) provides ventilation and temperature control to the fuel and spent fuel building (SF). The system also filters the air through absolute and charcoal filters before discharging to the atmosphere.

The system mainly consists of fan motors, heaters, air handling units, filters, ductwork, pipes and pipe supports.

Note:

1. The cooling water to the air handling units is supplied by the chilled water system (HN) or component cooling water system (CA).

3. HH Turbine building HVAC

The turbine building HVAC system (HH) provides ventilation and temperature control to the turbine building (SG).

The system mainly consists of air handling units, heaters, ductwork, fans, dampers, valves and actuators, pipes, duct and pipe hangers.

Note:

1. The cooling water to the air handling units is supplied by the chilled water system (HN).

3. HK Waste management building HVAC

The waste management building HVAC system (HK) provides ventilation, cooling, heating and air contamination control to the waste management building (SH).

The system mainly consists of fans, ductwork, duct hangers, air handling units, heaters, pumps, valves and actuators.

Note:

1. The cooling water to the air handling units is supplied by the chilled water system (HN).

3.HM Miscellaneous structures HVAC (e.g. laboratories…)

The miscellaneous structures HVAC system (HM) cools, heats or ventilates all structures not specifically identified with other ventilation systems (HA to HK).

The system mainly consists of exhaust fans, air conditioning units, air handling units, ductwork, valves and actuators, dampers, pipes and pipe hangers and supports.

3.HN Chilled water

The chilled water system (HN) provides chilled water to various air cooling coils in the ventilation systems of the drywell or wetwell (HD) reactor or nuclear auxiliary building (HE), control building (HF), fuel handling building (HG), the turbine building (HH), and waste management building (HK).

The main components are pumps, motors, valves and actuators, water chiller packages, tanks, cooling coils, pipes, pipe supports and hangers, insulation, etc.

3.HP Plant stack

Exhaust air from various building ventilation systems is collected and discharged through a common plant stack (HP) to the atmosphere.

The system mainly consists of the stack, ductwork and supports.

Note:

1. The radiation monitoring system used in the plant stack is included in (IH).

3.HQ Emergency generator building HVAC

Emergency generators (diesel, gas) provide essential electrical power supply to safety related systems in case of failure of normal power supply. Emergency generator building HVAC (HQ), independent of other building ventilation is used to maintain the area temperatures. This HVAC is started automatically along with the generators.

3.HR Seismic/Bunkered emergency control building HVAC

In case of inhabitability of Main Control Room (MCR), the minimum safety functions are accomplished from the emergency control building. HVAC of this building (HR) is provided by a separate set of equipment (fan, filters, duct, etc).

3.I Instrumentation and control systems

Instrumentation and control (I&C) systems are important to the safety, particularly if a malfunction or failure could lead to radiation exposure of site personnel or members of the public. Examples of such I&C systems are:

- The reactor protection system.
- Reactor control systems.
- Systems to monitor and control normal reactor cooling.
- Systems to monitor and control emergency power supplies.
- Containment isolation systems.

I&C Systems provide protection, control, monitoring and display and testing of safety functions. They may be either analog or digital systems or a mixture of both (hybrid).

3.I.1 Analog I & C systems

All instrument and control systems that use a continuous variable signal and range of values to represent the information displayed are analog. This code would be used along with other codes in this section that identifies the system that fails or malfunctions.

3.I.2 Digital I & C systems

All instrument and control systems that use discrete discontinuous values to represent the information displayed are digital. This code would be used along with other codes in this section that identifies the system that fails or malfunctions.

3.IA Plant/process computer *(*including main and auxiliary computers)

The purpose of the plant/process computer system (IA) is to provide a means for quick and accurate determination of plant performance by monitoring, calculating, storing and retrieving information collected from plant instrumentation and alarms.

Note:

1. Reactor control and protection is included in (IK) and (IM) respectively.

3.IB Fire detection

The fire detection system (IB) provides an event recording and annunciation system for fire alarms. The system mainly consists of fire detectors, alarms, annunciations, display and recording devices.

Note:

1. The fire protection system is included in (KH).

3.IC Environment monitoring

The environment monitoring system (IC) provides meteorological information of plant site atmospheric conditions and detects, records, annunciates hazardous gases and radiological conditions.

The system mainly consists of gas detectors, recording devices, alarms and annunciators, other miscellaneous hardware, remote sensors, signal boxes, instrument racks with associated electronic equipment and meteorological towers with instrumentation.

3.ID Turbine generator instrumentation and control

The turbine generator instrumentation and control system (ID) provides all monitoring and control for continuous operation of the turbine generator (FB). This includes speed/load control, regulation of the magnetic field in the rotor of the main generator (control of the exciter), and the electro-hydraulic control system.

The system's components mainly include all instrumentation, controls and wiring.

3.IE Plant and process monitoring (including main and remote/supplementary control room equipment and various remote control functions)

The plant/process monitoring system (IE) including the whole panel system of the control room, acquires data from the plant. It provides calculation logs, trends and historical data without any automatic control or protective action. The plant monitoring system also includes the vibration monitoring or loose part monitoring system within the primary coolant pressure boundary. This system consists of display and recording devices, operator interface hardware, vessel mounted sensors, charge converters, logic control, and miscellaneous instrumentation and equipment not covered by the other codes in (3I).

Notes:

1. Individual indication panels are not included in (IE). These panels are included in the closest related code.
2. Radiation monitors, including post accident radiation monitors, are included in (IH).

3.IF In-core and ex-core neutron monitoring (including BWR reactor stability monitoring)

This system mainly consists of an in-core nuclear instrumentation subsystem and an ex-core nuclear instrumentation subsystem.

(a) In-core instrumentation subsystem

The in-core nuclear instrumentation subsystem provides information on the neutron flux distribution, used for flux tilt control and local power monitoring/control.

Special neutron monitoring provided for low-power physics experiments, refuelling and criticality tests should also be included in (IF).

The main components of this system are neutron detectors (including self-powered), stability monitoring instrumentation, helical drive cable, seal table, high pressure seals, isolation valves, rotary transfer, drive wheel, drive motor, storage reel, thimbles, interface hardware, etc.

(b) Ex-core instrumentation subsystem

The ex-core nuclear instrumentation subsystem monitors the neutron flux outside the reactor vessel at all conditions from shutdown to full power or over-power excursions.

These instruments are also used for reactor power monitoring and/or for reactor protection.

The main components included in this subsystem are detectors, related electric circuits and wiring.

Note:

1. Electric power for (IF) is included in (ED).

3.IG Leak monitoring (reactor coolant boundary, containment and auxiliary buildings)

The leak monitoring system (IG) provides a means of detecting abnormal leaks in the reactor coolant pressure boundary and in the containment and auxiliary buildings. The leak detection system is made up of different types of instrumentation that gives indications in the control room (IE).

Note:

1. Containment isolation leak control is included in (DB).

3.IH Radiation monitoring

The radiation monitoring system (IH) monitors the radiation levels in plant areas/systems (IH.1) and for personnel (IH.2).

The radiation monitors that are used as reactor pressure boundary leak detectors are included in the leak monitoring system (IG).

Note:

1. Vital instrument AC, and control AC system (ED) supplies the power to (IH).

3.IH.1 Plant radiation monitoring

The plant radiation monitoring system (IH.1) monitors radiation or radioactivity levels on-site in specific plant areas and plant systems. It provides process information and annunciates a warning signal and an isolation signal.

3.IH.2 Personnel monitoring (dosimetry and contamination detection)

The personnel monitoring system (IH.2) detects contamination and records dosimetry information for plant personnel.

3.IK Reactor power control (e.g. control rods and boration/dilution systems)

The reactor power control system mainly includes the plant control systems, such as those for control rod position, primary coolant temperature, primary coolant pressure, feedwater flow, steam flow, etc.

The system (IK) mainly consists of electrical circuitry, switches, indicators, alarm devices, operator interface hardware, instrumentation and controls and miscellaneous equipment.

Notes:

1. Feedwater control system is included in (IM),
2. The recirculation flow for BWR is included in (IL).
3. The turbine generator control is included in (ID).
4. Indicators in the main control room are included in (IE).
5. The control element assembly is included in (IK).
6. Electric power to this system is included in(ED).
7. The post-shutdown cooling/monitoring of AGRs is included in (IK).

3.IL Recirculation flow control (BWR)

The recirculation flow control system (IL) controls the position of the recirculation flow rate regulation valves (or the speed of the variable-frequency generator), the system adjusts the reactor power level by changing the recirculation flow through the reactor core.

The system mainly consists of electrical circuitry, switchgear, electrical modules, and other instrumentation and controls.

Note:

1. The electric power to this system is included in (ED).

3.IM Feedwater control

The feedwater control system (IM) maintains the steam generator water level (in PWR/PHWR) and the reactor vessel coolant level (BWR) within the appropriate limits.

The system components mainly include electrical circuitry, controllers, instrumentation and controls and miscellaneous equipment.

Note:

1. Electric power to this system is included in (ED).

3.IN Reactor protection

The reactor protection system (IN) detects conditions that threaten the integrity of fuel and/or primary coolant pressure boundary and initiates a rapid automatic power reduction or reactor shutdown.

The system mainly consists of logic circuitry, remote instrumentation and operator interface hardware.

Notes:

1. The reactor trip breaker is included in (IN).
2. Electric power to this system is included in (ED).
3. Some part of the ATWS (Anticipated Transient Without Scram) system that trips recirculating pumps as a secondary unit shutdown system is included in(IN).
4. In-core and ex-core nuclear instrumentation in the reactor protection are included in (IN).
5. Manual actuation of the system is also included in (IM).

3.IP Engineered safety features actuation (including emergency systems actuation)

The engineered safety features actuation system (IP) monitors selected parameters and initiates automatic actuation of the system to prevent exceeding safety limits.

The monitored parameter signals are connected to a logic system and when a logic condition is met, an actuation signal automatically initiates the safety systems (core flooding system, containment isolation system, etc.).

Note:

1. Electric power to this system is included in (ED).

3.IQ Non-nuclear instrumentation

This system coding should only be used if a system cannot be readily categorized into one of the other instrument systems.

3.IR Meteorological instrumentation

The meteorological instrumentation system (IR) provides information on meteorological conditions on and around the plant.

The system mainly consists of remote instrumentation, logic circuitry and operator interface hardware.

3.IS Seismic instrumentation

The seismic instrumentation system (IS) provides information on seismic conditions on and around the plant.

The system mainly consists of remote instrumentation, logic circuitry and operator interface hardware.

3.IT Vibration monitoring

The vibration monitoring system (IT) provides a means of detecting abnormal vibration conditions on plant equipment and infrastructure. Loose parts monitoring system should also be included in (IT).

3.K Service auxiliary systems

Service auxiliary systems are those systems and services which are essential to the continued operation of the plant but are not critical safety systems. Failure of any of these systems may cause an event.

3.KB Sampling (normal and accident conditions)

The sampling system (KB) collects suitable samples (during normal and accident conditions) from the reactor coolant system, recirculating water system, steam power conversion system and related systems for chemical and radiological analyses.

The system mainly consists of sample nozzles, pipes, valves and sample stations.

3.KC Control and service air (non-essential) and compressed gas

The control and service air and compressed gas system (KC) may consist of the following two systems:

The control and service air system provides dry, filtered air to non safety-related components.

Components for this system mainly include intake filters, air compressors, after coolers, receiver tanks, dryers, valves and actuators, pipes and pipe hangers.

The compressed gas system supplies compressed gases (nitrogen, hydrogen, etc.) for both safety-related and non-safety related functions.

Components for this system mainly include gas cylinders, valve banks, compressors, dryers, filters, coolers, valves and actuators, pipes and pipe hangers.

Notes:

1. Compressed air to safety-related components is included in (CC).
2. Electric power to this system is included in (EC).

3.KD Demineralized water

The demineralized water system (KD) serves as the source for all demineralized makeup water.

Components for this system mainly include cation and anion removal tanks, chemical storage tanks, water storage tanks, degasifiers, resin traps, pumps, valves and actuators, pipes and pipe supports and hangers.

Note:

1. The primary coolant purifying system is not included in (KD). For BWRs it is included in (WK), for PWR, GCR and AGR it is included in (BF).

3.KE Material and equipment handling

The material and equipment handling (KE) mainly consists of all hoists, cranes, elevators, platforms/scaffolding and miscellaneous machinery for general maintenance work, loading and unloading of material, erection and dismantling of equipment, or transport and handling of materials or equipment on the plant site.

Note:

1. Mobile cranes, hoists, and so on should also be included in (KE).

3.KG Nuclear fuel handling and storage (both fresh and spent fuel)

The machines and equipment necessary for loading, handling and taking out the new or spent fuel assemblies are included in (KG). The equipment for storing the new or spent fuel assemblies and control assemblies in the spent fuel pool and handling equipment for spent fuel transport in casks are also included in (KG).

3.KH Fire protection

The fire protection system (KH) serves to control and extinguish fires.

Notes:

1. The source of water for the fire system is included in (FN).
2. The fire detection system is included in (IB).

3.KP Chemical additive injection

The chemical additive injection system (KP) stores, transfers and injects special chemicals (ammonium hydroxide, hydrazine, sodium hypochlorite, etc.) in order to prevent corrosion, fouling, etc.

The main components are pumps, motors, valves and actuators, tanks, cables and associated pipes, etc.

Note:

1. Boric acid injection is included in (BF).

3.S Structural systems

Structural systems within these codes are the shells/buildings, walls, ceilings, floors, supports, joists, etc.

Any process equipment and pipes with associated hangers, supports, snubbers, insulation, electrical penetrations, , heating ventilation or air conditioning, ductwork, cable trays in the buildings are not included in these codes.

Note:

The building/structure names are given based on the major equipment that are located in those buildings and hence the title of code is self-explanatory. Further explanation is provided where necessary.

3. SA Primary reactor containment building

The primary reactor containment building (SA) houses the primary structural systems enclosing the reactor installation or the main parts of it and which confine the radioactive materials that are released during a LOCA.

Notes:

1. For PWRs, this can be defined as the containment building and its internal structures.
2. (SA) is limited to the structural system. The containment spray system, the bubble steam condenser system and containment ice condenser system are included in (DD).
3. For BWRs drywell, reactor wetwell/suppression pool and the venting system (that connects the former two parts) are the main elements of this system (SA).
4. If the reactor building forms a secondary containment, it is included in (SB).
5. The containment pressure relief valve is included in (HB).
6. The structural part of personnel equipment transport hatches e.g. door frames is included in (SA) or (SB) depending on whether it is part of the primary or secondary containment. The isolation function of personnel and equipment hatches e.g. doors and hydraulics is included in (DB).
7. For PHWRs, the primary containment housing the reactor and its auxiliaries and steam generator is part of SA.

3.SB Secondary reactor containment building or vacuum building (PHWR)

The secondary reactor containment building or vacuum building or the reactor building (SB) houses the structural systems enclosing the primary reactor containment building (SA) which is used as an additional barrier to confine radioactive materials.

This mainly consists of the containment building, ventilation system to maintain negative pressure and associated filters/auxiliaries to limit the radioactive discharges to environment.

Notes:

1. The secondary reactor containment building includes the annulus region between the primary reactor containment building and the reactor building in double containment NPPs, and reactor building structure in PWRs and BWRs.
2. For PHWRs, the vacuum building is also included in (SB). The pressure relief function is included in (HB).

3.SC Reactor or nuclear auxiliary building

The reactor or nuclear auxiliary building is an enclosed reinforced concrete building that mainly houses:

- Support systems and components that may contain radioactive liquid and gases and chemical and volume control (CVCS).
- High and low pressure emergency core cooling systems (safety injection and RHR) and containment spray.
- Emergency ventilation and filter systems.
- Primary coolant polishing systems.

3.SD Control building

This building houses the main control room and instrumentation cabinets, cable spread room and control equipment room, etc.

3.SE Emergency generator building

This building may house the emergency diesel or gas turbine generators.

3.SF Fresh and spent fuel buildings

3.SG Turbine building

3.SH Waste management building

3.SK Pumping station (e.g. cooling, make-up water, fire water...)

3.SL Backup ultimate heat sink building

The ultimate sink is provided by various means to remove the decay heat when normal and emergency heat sinks have been lost. The structures containing ultimate heat sinks are included in (SL).

3.SM Cooling towers & /or intake structure

3.SN Switchyard (enclosed/open)

3.SP Seismic/bunkered emergency control building

3.SQ Heavy water up-gradation building (PHWR)

Heavy water spilled from the system equipments is downgraded and hence sent for up-grading before utilizing for system make-up.

3. W Waste management system

Radioactive waste occurs in a variety of forms with very different physical and chemical characteristics. In addition to radioactive waste other non-radiological wastes are also produced. Both these types of wastes may occur in gaseous form, in liquid form or in solid form.

The systems described in the codes below are those systems specifically designed to deal with each particular type of waste either radiological or non-radiological which ensure protection of personnel and the environment.

3.WA Liquid radwaste processing, hold-up & discharge

The liquid radioactive waste system (WA) collects radioactive liquid wastes from various plant systems and then processes them for recycle, hold-up for decay of radioactivity, discharge or disposal.

The system mainly processes the primary coolant for the reuse of boric acid and reactor make-up water.

This system mainly includes pumps, tanks, pipes, filters and ion exchange columns.

3.WB Solid radwaste

The solid radioactive waste system (WB) collects and processes solid radioactive wastes for on-site or off-site storage or disposal.

This system mainly includes centrifuge, hopper, drums and bailing machines.

Note:

1. Spent fuel elements are included in (KG).

3.WC Gaseous radwaste hold-up & discharge

The gaseous radioactive waste system (WC) collects radioactive gases from various systems, stores them in decay tanks and processes them for recycle or release.

This system mainly includes pumps, hold-up tanks, pipes and filters.

Notes:

1. The plant stack system that vents processed radioactive gases to the atmosphere is included in (HP).
2. Control and process air for this system is included in (KC).

3.WD Non-radioactive waste (liquid, solid and gaseous)

The non-radioactive waste system (WD) handles all wastes generated at plant site that are not radioactive.

3.WE Steam generator blowdown

The steam generator blowdown system (WE) provides a method of removing contaminants and crud from the steam generators. In addition to the normal, continuous blowdown, this system provides periodic high capacity blowdown.

3.WF Plant drainage (floor, roof, …)

The plant drainage system (WF) collects the surface runoff and roof drainage, mainly precipitation.

Notes:

1. Roof drainage system is included in (WF).
2. This system does not handle radioactive wastes.

3.WG Equipment drainage (including vents)

The equipment drainage system (WG) collects radioactive and non-radioactive drainage from various sources including floor drains throughout the plant, and transports this drainage to the liquid radioactive waste system (WA) or the non-radioactive wastes system (WD).

3.WH Suppression pool cleanup

The suppression pool cleanup system (WH) provides a means for purifying the suppression pool water by removing radioactive iodine and other impurities. During normal power operation, it maintains the suppression pool water quality within prescribed limits. Following any evolution which releases reactor coolant to the suppression pool, the system runs continuously to reduce radiation levels inside the containment.

Notes

1. In some designs, spent fuel pool/refuelling pool cooling/cleaning up system (DA) uses the suppression pool cleanup filters and demineralizers, this is included in (DA).
2. The pressure suppression water cooling system is included in (DE).

3.WK Reactor water cleanup (BWR, PHWR, LWGR, ...)

The reactor water cleanup system (WK) maintains the purity of the water in the reactor vessel (AC) and recirculation lines (AG). Water purity is necessary to reduce the deposition of impurities on fuel, pipes and other surfaces. In addition, this system removes water from the reactor vessel during plant startups or during level transients following a reactor scram.

The main components of this system include pumps, heat exchangers, filter/demineralizer units, precoat tanks, receiving tanks, valves and actuators, pipes, pipe supports and hangers and insulation.

3.Z No system involved

This code is used where no specific system is involved e.g. human performance issues or where a system can not be identified and does not belong to any other code.

3.ZA Other systems (specified in text of IRS report)

This code is for any system that does not belong to any other code.

Any failure of any system, equipment, plant, structure or component that cannot be identified in the codes (AA to WK) is included in (ZA).

4. FAILED/AFFECTED COMPONENTS

This field identifies:

(a) The component(s) of the failed or affected system that failed or lost their normal function, thereby initiating or triggering further steps of the event;

(b) The important component(s) of the failed or affected systems that failed or lost their normal function as a result of or during the event.

The components of a nuclear power plant are divided into four main categories:

1. Instrumentation
2. Mechanical
3. Electrical
4. Computers

The appropriate code is mentioned for the failed component from the listed coding. Some failed or affected components can be categorized in more than one code. In such cases, code all that are of importance.

Suspected but not identified as the failed or affected components should also be coded according to their category.

4.0 No specific component involved

The code 4.0 is only to be used if no component is involved or no specific component can be identified.

4.1 Instrumentation (gauges, transmitters, sensors, controllers, detectors, displays…)

4.1.0 Other (specified in text of IRS report)

The code 4.1.0 is used for the instrument components that cannot be coded in any code from 4.1.1 to 4.1.15.

4.1.1 Pressure
4.1.2 Temperature
4.1.3 Level
4.1.4 Flow
4.1.5 Radiation/contamination

4.1.6 Chemical concentration
4.1.7 Position
4.1.8 Dew point, moisture
4.1.9 Neutron flux (detectors, ion chambers and associated components)
4.1.10 Speed (e.g. rotational speed of equipment, wind speed…)
4.1.11 Fire (smoke, flames, heat...)
4.1.12 Hydrogen concentration
4.1.13 Electrical (current, voltage, power...)
4.1.14 Vibration
4.1.15 Seismic motion

4.2 Mechanical

4.2.0 Other (specified in text of IRS report)

The code 4.2.0 is used for the mechanical components that cannot be coded in any code from 4.2.1 to 4.2.12.

Notes:

1. Welding parts is coded under 4.2.6 and/or 4.2.7.
2. 4.2.6 does not include fuel tubes; they belong to 4.2.10.

4.2.1 Pumps, compressors, fans
4.2.2 Turbines (steam, gas, hydro), engines (diesel, gasoline…)
4.2.2.1 Turbines (steam, gas, hydro)
4.2.2.2 Engines (diesel, gasoline…)
4.2.3 Valves (including safety/relief/check/solenoid valves), valve operators, controllers, dampers and fire breakers, seals and packing
4.2.4 Steam generators and heat exchangers including internals
4.2.4.1 Steam generators including internals
4.2.4.2 Heat exchangers including internals
4.2.4.3 BWR vessel internals
4.2.5 Tanks, pressure vessels (e.g. reactor vessel and internals, accumulators)
4.2.6 Tubes, pipes, ducts
4.2.7 Fittings, couplings (including transmissions and gear boxes), hangers, supports, bearings, thermal sleeves, snubbers.
4.2.8 Strainers, screens, filters, ion exchange columns
4.2.9 Penetration (personnel access, equipment access, fuel handling…)
4.2.10 Control or protective rods and associated components or mechanisms, fuel elements
4.2.11 Fuel storage racks, fuel storage casks and fuel transport containers
4.2.12 Nuclear assemblies (absorber, bunrnable, breeder, reflectors, neutron sources, shielding equipment)

4.3 Electrical

4.3.0 Other (specified in text of IRS report)

The code 4.3.0 is used for the Electrical components that cannot be coded in any code from 4.3.1 to 4.3.8.

4.3.1 Switchyard equipment (switchgear, transformer, buses, line isolators…)
4.3.2 Circuit breakers, power breakers, fuses.
4.3.3 Alarms
4.3.4 Motors (for pumps, fans, compressors, valves, motor generators…)
4.3.5 Generators of emergency and stand-by power
4.3.6 Main generators and auxiliaries
4.3.7 Relays, connectors, hand switches, push buttons, contacts
4.3.8 Wiring controllers, starters, electrical cables

4.4 Computers

This code is used for partial or total failure of the computer hardware or software that has impaired the safety or safety related functions of NPP. Computer failures that have led to loss of assistance to the operator in handling the event or retaining the data of safety significance should also be included.

4.4.1 Computer hardware
4.4.2 Computer software

5. CAUSE OF THE EVENT

This field identifies the causes of the event. Any event unfolds in stages and for each stage of the event the appropriate cause is identified. The ‘direct/observed cause’ is the cause that is the direct initiator of the event and/or the direct trigger of the next step(s) in the event. Short term remedial actions are usually based on the direct/observed cause.

The ‘root cause’ of the event is the cause that played a significant part in the event occurring; primarily, it is the fundamental cause or causes that if corrected will prevent recurrence of the event or adverse condition. In many (or most cases) the root cause may be basically connected with human performance, management and equipment. The root cause is usually the basis for long(er) term remedial actions.

In many cases the root cause will fall in Section 5.5 ‘Human performance related causal factors and root causes’. These human performance codes will usually be considered along with other root cause codes 5.6 and 5.7. For further information and guidance on how the codes in Section 5 (particularly 5.3, 5.5, 5.6 and 5.7) can relate to human factors as direct and root causes of an incident/event, please refer to IAEA document J4-01CT02184-CS-14/02 ‘Guidelines for Describing of Human Factors in the Incident Reporting System (IRS) Reports’.

In some cases it may be difficult to determine between the direct/observed cause and the root cause, in such cases both codes are used.

To help distinguish between direct/observed cause and root cause the following examples are given to illustrate:

Example 1: Primary coolant leakage due to stress corrosion cracking in a pipe:

Direct/observed causes:

5.1.1.1 Corrosion, cracking, fouling
5.1.1.6 Leak
5.1.1.7 Break, rupture, crack, weld failure.

Root causes:

5.7.1.2 Materials selection (wrong material has been chosen).

This can include the following causal factors:

- Component/material selection inadequate

5.7.2 Equipment (procurement) specification, manufacture, storage and installation.

This can include the following causal factors:

- Material used inadequate
- Specifications provided to manufacturer inadequate
- Substitute parts/material used do not meet specifications
- Installation workmanship inadequate
- QA requirements not used or met during procurement

Example 2: Primary coolant pump trip due to a bad contact in the breaker of the pump circuit due to insufficient maintenance.

Direct/observed cause:

5.1.2.4 Bad contact, disconnection

Root causes:

5.7.3 Maintenance, testing or surveillance.

This can include the following causal factors:

- Corrective maintenance did not correct problem
- Preventative maintenance inadequate
- Maintenance performed incorrectly
- Post maintenance testing inadequate
- Incorrect restoration of plant following maintenance /isolation/testing

However, if the maintenance failure was due to deficiencies in maintenance procedures or deficiencies in work planning during the planned /preventive maintenance then the following codes could be used.

5.4.5 Planned/preventive maintenance.
5.5.7 Written procedures and documents.

Example 3: A control valve fails to open due to dust from the compressed air system.

Direct/observed cause:

5.1.1.8 Blockage, restriction, etc.

Although the foreign material (dust) might have been indicated as the direct cause of the valve failure, the more 'up-stream' cause might be a deficiency in the maintenance of the compressed air system.

In this case blockage/restriction due to foreign material is a direct/observed cause, the root cause has to be identified specifically.

Root causes:

5.7.3 Maintenance, testing or surveillance.

This can include the following causal factors:

- Corrective maintenance did not correct problem
- Preventative maintenance inadequate
- Maintenance performed incorrectly
- Surveillance schedule not followed
- Situational surveillance not performed
- Failure to exclude foreign material

The full list of codes/fields under the CAUSE OF THE EVENT is the following:

5.1 Direct cause

5.1.0 Unknown
5.1.0.1 Other (specified in text of IRS report)
5.1.1 Mechanical failure
5.1.1.0 Other mechanical failure
5.1.1.1 Corrosion, erosion, fouling
5.1.1.2 Wear, fretting, lubrication problem
5.1.1.3 Fatigue
5.1.1.4 Overloading (including mechanical stress and overspeed)
5.1.1.5 Vibration
5.1.1.6 Leak
5.1.1.7 Break, rupture, crack, weld failure
5.1.1.8 Blockage, restriction, obstruction, binding, foreign material
5.1.1.9 Deformation, distortion, displacement, spurious movement, loosening, loose parts
5.1.2 Electrical failure
5.1.2.0 Other electrical failure
5.1.2.1 Short-circuit, arcing
5.1.2.2 Overheating

5.1.2.3 Overvoltage
5.1.2.4 Bad contact, disconnection
5.1.2.5 Circuit failure, open circuit
5.1.2.6 Ground fault
5.1.2.7 Under voltage, voltage breakdown
5.1.2.8 Faulty insulation
5.1.2.9 Failure to change state

5.1.3 Chemical or core physics failure

5.1.3.0 Other chemical failure/problem (specified in text of IRS report)
5.1.3.1 Chemical contamination (including corrosion products, anionic impurities), deposition
5.1.3.2 Uncontrolled chemical reaction
5.1.3.3 Core physics problems (operation outside core physics limits, e.g., shutdown margins, reduction in reactivity worth of reactivity devices…)
5.1.3.4 Poor chemistry or inadequate chemical control

5.1.4 Hydraulic/pneumatic failure

5.1.4.0 Other hydraulic/pneumatic failure (specified in text of IRS report)
5.1.4.1 Water hammer, pressure fluctuations, over pressure *(5.1.4.1 is pressure acting from the inside on the equipment)*
5.1.4.1.1 Water hammer
5.1.4.1.2 Pressure fluctuations, over pressure
5.1.4.2 Loss of fluid flow
5.1.4.3 Loss of pressure
5.1.4.4 Cavitation
5.1.4.5 Gas binding and pressure locking
5.1.4.6 Moisture in air systems
5.1.4.7 Vibration due to fluid flow

5.1.5 Instrumentation and control failure

5.1.5.0 Other instrumentation and control failure (specified in text of IRS report)
5.1.5.2 False response, loss of signal, spurious signal
5.1.5.3 Oscillation
5.1.5.4 Set point drift, parameter drift
5.1.5.5 Computer hardware deficiency
5.1.5.6 Computer software deficiency
5.1.5.7 Electromagnetic and/or radiofrequency interference

5.1.6 Environmental (abnormal conditions Inside plant)

5.1.6.0 Other internal environmental cause (specified in text of IRS report)
5.1.6.1 High temperature
5.1.6.2 Pressure (5.1.6.2 is pressure acting from the outside on the equipment).
5.1.6.3 Humidity
5.1.6.4 Flooding, water ingress

5.1.6.5 Low temperature, freezing
5.1.6.6 Radiation, contamination, irradiation of parts
5.1.6.7 Dropped loads, missiles, high energy impacts
5.1.6.8 Fire, burning, smoke, explosion

5.1.7 Environmental (external to the plant)

5.1.7.0 Other external environmental cause (fire, toxic/explosive gasses,...)
5.1.7.1 Lightning strikes
5.1.7.2 Flooding
5.1.7.3 Storm, wind loading
5.1.7.4 Earthquake
5.1.7.5 Freezing
5.1.7.6 High ambient temperature
5.1.7.7 Heavy rain or snow

5.1.10 Human factors (*(IAEA document J4-01CT02184-CS-14/02 covers the details)*)[2]
5.1.10.1 Slip or lapse
5.1.10.2 Mistake
5.1.10.3 Violation
5.1.10.4 Sabotage

5.3 Plant staff involved

5.3.1 Maintenance
5.3.2 Operations
5.3.3 Technical and engineering
5.3.4 Management and administration
5.3.5 Control of contractor/sub-contractor

5.4 Type of activity

5.4.1 Not relevant
5.4.2 Normal operations
5.4.3 Shutdown operations
5.4.4 Equipment startup
5.4.5 Planned/preventive maintenance
5.4.6 Isolating/de-isolating (e.g., clearance & tagging of electrical & piping systems)
5.4.7 Repair (unplanned/breakdown maintenance)
5.4.8 Routine testing with existing procedures/documents *(This code is used for routine testing either performed frequently or infrequently where procedures already exist)*

[2] Working Material - Guidelines for Describing of Human Factors in the Incident Reporting System (IRS) Reports, IAEA Document J4-01CT02184-CS-14/02, Vienna (2003).

5.4.9 Special testing with one-off special procedure *(this code is used where a procedure is specifically produced to perform the testing even if the testing may be carried out regularly)*
5.4.10 Post-modification testing
5.4.11 Post-maintenance testing
5.4.12 Fault finding
5.4.13 Construction, installation and commissioning (of new equipment system, or complete plant)
5.4.14 Return to service (of existing equipment)
5.4.15 Decommissioning
5.4.16 Fuel handling/refuelling operations
5.4.17 Inspection
5.4.18 Abnormal operation (due to external or internal constraints)
5.4.19 Engineering (design or field engineering) review
5.4.20 Modification implementation
5.4.21 Training
5.4.22 Actions taken under emergency conditions
5.4.23 Other activity (specified in text of IRS report)
5.4.24 Inspections, Tests, Analysis, Acceptance Criteria (ITAAC) — for new reactor construction

5.5 Human performance related causal factors and root causes

5.5.1 Verbal communications
5.5.2 Personnel work practices
5.5.2.0 Others (specified in text of IRS report)
5.5.2.1 Control of task/independent verification
5.5.2.2 Complacency/lack of motivation/inappropriate habits
5.5.2.3 Use of improper tools and equipment
5.5.2.4 Self-check practices (e.g. Stop, Think, Act, Review (STAR)…)
5.5.2.5 Questioning attitude, dealing with uncertainty (e.g. assumption of competence of more experienced personnel)
5.5.3 Personnel work scheduling (including workload, work time provided)
5.5.4 Environmental conditions
5.5.5 Man-machine interface
5.5.5.1 Alarm control & maintenance practices
5.5.5.2 Equipment/controls labelling
5.5.6 Training/qualification
5.5.7 Written procedures and documents
5.5.7.1 Procedure availability
5.5.7.2 Procedure completeness/accuracy
5.5.7.3 Procedure compliance
5.5.8 Supervisory methods (e.g., standard setting, emphasis of safe work practices & questioning attitude, self-checks...)
5.5.9 Work organization
5.5.9.0 Others (specified in text of IRS report)
5.5.9.1 Shift/team size or composition

5.5.9.2 Planning/preparation of work (e.g., work package planning, pre-job briefings, shift turnover practices)
5.5.10 Personal factors
5.5.10.0 Others
5.5.10.1 Fitness for work (e.g., fatigue…)
5.5.10.2 Stress/perceived lack of time/boredom (including imposition of parallel &/or unexpected tasks)
5.5.10.3 Skill of the craft less than adequate/not familiar with job performance standards (including task difficulty)
5.5.11 Use of operating experience

5.6 Management related causal factors and root causes

5.6.0 Other (specified in text of IRS report)
5.6.1 Management direction
5.6.1.1 Existence of policies, standards, expectations
5.6.1.2 Communication/Enforcement of policies, standards, expectations
5.6.1.3 Production pressure/perceived pressure
5.6.1.4 Clarity of responsibility
5.6.2 Communication or co-ordination
5.6.3 Management involvement, monitoring and assessment
5.6.4 Decision process
5.6.5 Allocation of resources (e.g., planning & prioritization relative to safety…)
5.6.6 Change management
5.6.7 Safety culture
5.6.8 Management of contingencies (e.g., alternate plans of action…)
5.6.9 Management of contracted work (e.g., qualification, training, supervision and guidance…)
5.6.10 Management of staff training and qualification
5.6.11 Knowledge management

5.7 Equipment related causal factors and root causes

5.7.0 Others (specified in text of IRS report)
5.7.1 Design configuration and analysis
5.7.1.1 Design analysis quality
5.7.1.2 Materials selection
5.7.1.3 Modifications engineering quality
5.7.1.4 Modifications engineering review process
5.7.2 Equipment (procurement) specification, manufacture, storage and installation
5.7.2.1 Receipt inspection
5.7.2.2 Parts/consumables shelf life/storage controls
5.7.2.3 Installation and commissioning
5.7.3 Maintenance, testing or surveillance
5.7.3.1 Foreign material exclusion controls
5.7.3.2 Parts & consumables selection/use

5.7.4 Equipment environmental qualification
5.7.5 Equipment aging

6. EFFECTS ON OPERATION

This field identifies the results of a manual or automatic response on operation of the plant such as a scram or a load reduction due to the occurrence of an event. It also identifies the activation of any safety system, the challenge of safety or relief valves, the release of radioactivity or the exposure of people and the exceeding of technical specifications or operational limits as a result of an event.

The fields given are mostly self-explanatory like Reactor scram (Auto/Manual), Controlled shutdown, etc. Explanation is provided where necessary.

6.0 No significant effect on operation or not relevant

6.1 Reactor scram

6.1.1 Automatic reactor scram

6.1.2 Manual reactor scram

6.2 Controlled shutdown

6.3 Load reduction

6.3.1 Automatic load reduction

6.3.2 Manual load reduction

6.4 Activation of engineered safety features

This code includes not only the activation of a safety feature but also the actuation of safety related signals (safety injection, containment isolation, etc.).

6.5 Challenge to safety or relief valve

6.5.1 Challenge to safety or relief valve in the primary circuit

6.5.2 Challenge to safety or relief valve in the steam or condensate cycle

Codes 6.5.1 and 6.5.2 are used only when a real challenge to safety or relief valve occurred during the transient/operation.

6.6 Unanticipated or significant release of radioactive materials

6.6.1 Unanticipated or significant release of radioactive materials outside the plant

Code 6.6.1 is selected, even if the release level of radioactive material is lower than the regulatory limits if the release occurred as a result of an event rather than as a result of planned operation.

6.6.2 Unanticipated or significant release of radioactive materials inside the plant

Code 6.6.2 is selected if a certain amount of radioactive material leaked but the radioactivity remained confined inside the plant.

6.7 Unplanned or significant radiation exposure of personnel or public

Code 6.7 is selected, even if the exposure level is lower than the regulatory limits.

6.8 **Personnel or public injuries**

6.9 **Outage extension**

6.10 **Exceeding technical specification limits**

6.11 **House load operation (plant continues to operate supplying only its own loads)**

7. CHARACTERISTICS OF THE EVENT/ISSUE

This field identifies the nature of the event in relation to the reporting categories; similar to the relation between direct/observed causes and root causes.

The characteristic of the event describes in a few words the trigger or nature of the event as often found in the title of the event, whereas the reporting categories indicate the areas of concern, where lessons can be learnt or the results of the event.

The codes given are mostly self-explanatory, such as fuel handling event. Explanation is provided where necessary.

7.0 **Other characteristics**

This code is to be used if the event can not be coded in any other code from 7.1 to 7.16.

7.1 **Degraded fuel**

Even if the fuel cladding has not ruptured but the fuel is affected 7.1 needs to be selected

7.2 **Degraded reactor coolant boundary**

Any abnormal leak or crack in the pressure boundary, even if small, is coded in 7.2.

If there is a failure inside the pressure boundary, but the integrity of the boundary is not affected, code 7.2 is not appropriate.

7.3 **Degraded reactor containment**

This code is used for any failure of the containment function e.g. ventilation, airlocks/hatches, isolation valves, etc.

7.4 **Loss of safety function**

Loss of safety function means the total loss of one safety function. Total loss of a safety function means the complete failure of all redundant and diverse safety systems associated with that function.

7.5 **Significant degradation of safety function**

This code is to be used only when significant degradation of safety function is noticed due to partial or full failure without affecting the safety function fully.

7.6 **Failure or significant degradation of the reactivity control**

This code is mainly related to failure or degradation of the control rod drives (primary shutdown system) or secondary shutdown system. For

BWRs, the recirculation system failure is included in 7.6 together with 7.7.

7.7 Failure or significant degradation of plant control

This code includes all kinds of events in which the plant control was affected which caused the plant to be shutdown either automatically or manually.

7.8 Failure or significant degradation of heat removal capability

This code includes all kinds of events in which the heat removal capacity from the reactor core was affected significantly A small leak in the primary coolant pressure boundary should not be included in 7.8 but should be included in 7.2.

7.9 Loss of off-site power

This code means the loss of all high voltage power supply from external lines. In such a situation the power supply from the generator to station auxiliaries through station auxiliary transformer and/or from emergency diesel generators will be available.

7.10 Loss of on-site power

This code includes loss of, or significant degradation of on-site power. The power loss in only one bus should also be coded with 7.10. Partial loss of emergency diesel generator power supply or battery power supply, even if it is not necessary in the situation, should also be coded in 7.10.

7.11 Transient

Transients regardless as to whether they originate from the primary or secondary side is included in the following codes.

7.11.0 Other transient

7.11.1 Power transient

Code 7.11.1 implies a power excursion.

7.11.2 Temperature transient

7.11.3 Pressure transient

7.11.4 Flow transient

7.12 Physical hazards (internal or external to the plant)

Hazards like flooding, fire, etc. are to be included here. Security related events are included in 7.16.

7.13 Discovery of major condition not previously considered or analysed

7.14 Fuel handling event

7.15 Radwaste event

7.16 Security, safeguards, sabotage or tampering event

8. NATURE OF FAILURE OR ERROR

This field identifies the failure mode(s) that played the major role in the event. Failure can include physical impairment and/or functional loss. The terms: 'single failure' or 'common cause failure' are not limited to redundant systems only. The field also includes significant or unforeseen interactions between systems or between a system and its environment.

'Failure' refers to physical impairment and/or unavailability of plant equipment. 'Error' refers to human error or inadequate human action.

8.0 Not relevant

This code is used where no specific component failure can be identified and where no other code in this section is relevant.

8.1 Single failure or single error

This code is used for a random failure which results in the loss of capability of a component to perform its intended function.

8.2 Multiple failure or multiple error

This code is used for the failure of several components to perform their intended function even if this is caused initially by the failure of one single component. Multiple failures may be either independent or dependent multiple failures**.**

8.2.1 Independent multiple failures or errors

This code is used if within one event, two or more occurrences (failures, errors) took place with different causes and where one occurrence is not a (logical or technical) consequence of the another one.

8.2.2 Dependent multiple failures or errors

This code is used if within one event, two or more occurrences (failures, errors) took place with different causes but where one occurrence is a consequence of another occurrence, such as:

- Shared equipment dependencies where one system is a support system for other systems.
- Functional dependencies where the function of one system depends on the function of another system.
- Physical interaction dependencies where environmental effects caused by a failure (e.g. flooding after a pipe break) results in failing of other equipment.

8.2.3 Recurrent failure or error

This code is used if the same or similar failure occurred due to the same cause in more than one event in either the same plant or different plants.

8.3 Common cause failure (including potential for CCF)

This code is used when the same single cause gives rise to multiple failures, i.e. two or more identical or similar components fail due to the same cause. Consequential failures from a single cause are coded as multiple failures (8.2).

8.4 Significant or unforeseen interaction between systems

This code is used when there is a significant or unforeseen interaction between several systems e.g. the operation of an emulsifier system which may cause a short circuit in another safety system required to control the event. Interactions between systems include the interaction between the environment and plant equipment, i.e. due to frost, condensation, humidity, etc.

9. RECOVERY ACTIONS

This field identifies the activities taken to terminate/recover the event and to bring the plant to a safe state. More than one code can be used

'Failure' means physical impairment and/or unavailability of plant equipment. 'Error' means human error or inadequate human action.

9.0 Not relevant

This code is used where no specific recovery action can be identified and/or where no other code in this section is relevant**.**

9.1 Recovery by human action

Human recovery actions are those effective actions taken by plant staff in response to equipment failures, inadequate human actions and plant transients in order to terminate the event. Recovery may be by foreseen or unforeseen human actions as explained below**.**

9.1.1 Recovery by foreseen human action (e.g., procedures and instructions/guidelines available and used, training prepared the operators to respond…)

Foreseen human recovery actions means recovery actions taken by plant staff, which are directed by operating procedures, (e.g. planned surveillance, transient response procedures, etc.) guidance, training, etc.

9.1.2 Recovery by unforeseen human action (e.g., new actions or actions outside the procedures required, inadequate or non existent training)

Unforeseen human recovery actions are those recovery actions taken by plant staff in response to observed failures, errors, transients, etc., which are not prescribed/directed by operating procedures, documents, instructions, guidance or training.

9.2 Recovery by automatic plant action or by design

Recovery by automatic plant action or by design is where the event has been halted or where the plant has been returned to a safe state by means of automatic plant response or by system plant design e.g. automatic operation of emulsifier fire protection system.

9.3 No recovery

This code is to be used along where no recovery of the event has been made either by automatic plant action or by human intervention. In this case the event has usually been allowed to run its course. This code can also be used when the report has been issued prior to recovery of the event.

III - EXAMPLES OF CODING

EXAMPLE 1: FAILURE TO CORRECT A TEMPORARY CONFIGURATION

Title: FAILURE TO CORRECT A TEMPORARY (TEST) CONFIGURATION THAT PRECLUDES SAFETY INJECTION SYSTEM SWITCH TO RECIRCULATION MODE

Abstract:

During refuelling outage of PWR unit, a plant operator performed a safety injection (SI) test with the vessel open and the core unloaded. In order to perform this task, it was necessary for the operator to install a temporary shunt and disconnect two wires to simulate closure of the automatic reactor trip breakers (RTBs). One year later, during the next outage, the operator detected a malfunction while testing reactor protection system relays. The two wires that were disconnected to simulate RTB closure during the safety injection test with vessel open/core unloaded had been found to be still disconnected. The original work request contained ambiguities that resulted in a second operator who was returning the system to its initial configuration, failing to identify that the RTB wires, simulating closure, were still disconnected. This temporary configuration performed during the earlier SI test, prevented the 'RTB open' confirmation signal from being initiated as would normally occur in the safety injection sequence. Without receipt of this signal the safety injection signal will not be reset and will prevent the SI system switching to recirculation mode. During this period of disconnection, no accident requiring safety injection had occurred. The temporary configuration which was still in place had no direct impact on safety. However, a large or intermediate-break Loss of Coolant Accident (LOCA) or a Steam Generator Tube Rupture (SGTR) occurring during this period would have had significant impact on safety. It was identified that the probability of core damage should such a incident occur would be severe. This incident was classified level 1 on the INES scale.

Reporting categories

1.2.5 Degradation of systems required to assure primary coolant inventory and core cooling

(Code 1.2.5 has been applied since there was degradation in the safety related system which could have impaired core cooling.)

1.3.3 Deficiencies in operation (including maintenance and surveillance)

(During the original SI test a personnel error resulted in the temporary disconnection not being removed once the work was completed resulting in loss of plant capability to perform a safety functions.)

1.6 Events of potential safety significance

(There was no immediate impact on safety, however should certain plant conditions have required these safety systems to operate, there could have been potentially a significant event.)

Plant status prior to the event

2.3.2.2 Refuelling or open vessel - all fuel out of the core

(The safety injection test was being performed during a refuelling outage with all the fuel unloaded.)

2.5 Testing or maintenance being performed

(The temporary disconnection which was not reconnected was carried out during a safety injection test.)

Failed/affected Systems

3.IN Reactor protection

(The system that failed was the reactor trip breaker (RTB) because the RTB open signal did not operate. The RTB is part of reactor protection. Only those systems that failed or lost their normal function are coded. Code 3.BG (Emergency Core Cooling, Essential Auxiliary Systems) is not applicable as the safety injection system did not fail.)

Failed/affected components

4.3.2 Circuit breakers, power breakers, fuses

(This code is chosen because even though the breaker did not fail it could perform its intended function.)

4.3.8 Wiring, controllers, starters, electrical cables

(Event occurred due to disconnection of electrical wiring in a safety circuit.)

Cause of Event

5.1.2.4 Bad contact, disconnection

(See 4.3.8)

5.3.2 Operations

(This was the plant staff involved who failed to return the system to its normal operational state.)

5.4.8 Routine testing with existing procedures/documents

(Code 5.4.8 was chosen because the event occurred during periodic testing using a existing standard work request. 5.4.9 would be applicable if the procedure was specifically written to perform this as special test.)

5.5.2 Personnel work practices

(The operator failed to check that the reconnection of the RTBs had been made. Other codes in Section 5.5.2 could have also been used, such as 5.5.2.4, if further information had been available to allow for this.)

5.5.7.2 Procedure completeness/accuracy

(Ambiguities in work request)

5.5.9.2 Planning/preparation of work

(e.g., work planning, pre-job briefings, shift turnover practices) (One operator commenced the SI test and a second returned the plant to its original configuration. As no further information was available to allow for coding no code under Section 5.6 has been used.)

5.7.3 Maintenance, testing or surveillance

(The event occurred during periodic testing of safety injection systems.)

Effects on operation

6.0 No significant effect on operation or not relevant

(There was no immediate impact on operation as there was no significant event, however should certain plant conditions have required these safety systems to operate, there could have been potentially a significant event.)

Characteristics of the event/issue

7.5 Significant degradation of safety function

(This code is applicable because only part of the safety function was impaired. Code 7.4 would be used if there was a total loss of the safety functions in one system.)

Nature of failure or error

8.1 Single failure or single error

(Used because the event occurred due to one failure e.g. the RTB signal wires being disconnected.)

Nature of recovery actions

9.1.1 Recovery by foreseen human action

(Manual reconnection of the disconnected wires and amendment of the procedures by the operators in line with normal procedures, instructions, guidance and training.)

EXAMPLE 2: FOREIGN OBJECTS IN STEAM GENERATOR

Title: FOREIGN OBJECTS FOUND IN STEAM GENERATOR ‘COLD’ HEADER DURING SCHEDULED MAINTENANCE OUTAGE

Abstract

During scheduled maintenance outage on the Unit in the course of TV examination of the ‘cold header’ on Steam Generator 2 (SG-2) to check for cleanliness and for subsequent pressurization, the following foreign material was found: M4x8 mm stainless steel bolt; 15x2 mm piece of plastic clamp; two 10x10 mm pieces of black-colour reinforced hose; Undetermined particulate. On completion of examination all the above objects were removed from the header. No breach of safe operation limits and conditions occurred. The foreign objects fell into SG-2 ‘cold’ header from a maintenance platform during SG-2 repair works; no requirement for maintenance plugs for header was identified to avoid foreign material intrusion. Contractors and plant personnel were allowed to work unsupervised during the maintenance work. Maintenance documentation did not identify the actions required and risk assessment to avoid foreign material intrusion into the primary circuit during activities performed on depressurized components of the reactor installation.

Reporting categories

1.3.3 Deficiencies in operation (including maintenance and surveillance)

(This code is applied because the event was caused due to personnel errors during maintenance work.)

1.4 Generic Problems of Safety Interest

(This code indicates the event is of generic interest because of the applicability of foreign material exclusion.)

1.6 Events of potential safety significance

(The event was identified before closing the header which avoided any significant consequences.)

Plant status prior to the event

2.3.1 Cold shutdown with closed reactor vessel

(The unit was undergoing a scheduled maintenance outage)

Failed/affected systems

3.AH Steam generator, boiler, steam drum

Failed/affected components

4.2.4.1 Steam generators including internals

(This code comes under 4.2.4 but specifically is used because the affected component is only the steam generator)

Cause of event

5.1.1.8 Blockage, restriction, obstruction, binding, foreign material

(Direct/observed cause)

5.1.10.1 Slip or lapse

(Contractors and plant personnel failed to maintain a clean work area during the maintenance work to prevent foreign material intrusion)

5.3.1 Maintenance

(Maintenance personnel performed the work)

5.3.4 Management and administration

(Failure of management staff to adequately supervise and control the work)

5.3.5 Control of contractor/sub-contractor

(Failure to adequately supervise and control contractors)

5.4.5 Planned/preventive maintenance

(This was the activity being performed)

5.5.7.2 Procedures completeness and accuracy

(The procedures and work control documents did not identify the actions required to avoid foreign material intrusion)

5.7.3.1 Foreign material exclusion controls

Effects on operation

6.0 No significant effect on operation or not relevant

(The loop was isolated from the rest of the reactor cooling system so therefore there was no effect on general operations.)

Characteristics of the event/issue

7.0 Other characteristics

(The event does not fall in any other code for characteristics of the incident.)

Nature of failure or error

8.1 Single failure or single error

(Used because the event occurred due to one failure e.g. foreign material intrusion into the SG Header even though on four separate occasions foreign material entered the header the cause was the same.)

Nature of recovery actions

9.1.1 Recovery by foreseen human action

(Manual removal of foreign material from SG header was carried out as per procedures and operating procedures amended to include actions required to prevent foreign material intrusion during maintenance in line with plant instructions.)

EXAMPLE 3: REACTIVITY EXCURSION

Title: REACTIVITY EXCURSION AFTER CATION-BED DEMINERALIZER PLACED IN SERVICE BEFORE BEING CONDITIONED

Abstract

The cation-bed demineralizer/ion exchanger on the reactor primary circuit let down line was placed in service for 10 minutes after the PWR Unit was being returned from outage. After 12 minutes the reactor operators noticed that the reactor coolant temperature was higher than normal. The Shift Chemist was contacted and he confirmed that as per his training he had requested the control room to place the demineralizer in service for 10 minutes. At the time he was unaware of a requirement to condition the demineralizer by flushing before placing it in service after a unit outage. The Plant Chemist had anticipated that the demineralizer would only be required to be placed in service later that week and had not left any written instructions for the duty Shift Chemist on the requirements of conditioning should the demineralizer be required to be placed in service. Procedures for the use of the demineralizer/ion exchanger did not identify this requirement also. Although the resultant change in reactor coolant temperature was small the event led to an unexpected reactivity excursion.

Reporting categories

1.2.4 Degradation of systems required to control reactivity

(Event led to a reactivity excursion hence the use of this code. The demineralizer/ion exchanger while part of water chemistry is important for reactivity control.)

Plant status prior to the event

2.1.3 Raising power or starting up

(The unit was under start up.)

Failed/affected systems

3.BF Chemical and volume control (PWR with main pumps, seal water...)

(Code 3.BF is used because it pertains to water chemistry on the let down lines of the primary circuit. Code 3.AA was not chosen because it pertains to the component and not the reactivity.)

Failed/affected components

4.2.8 Strainers, screens, filters, ion exchange columns

(Code 4.2.8 has been used because the ion exchange column/demineralizer was the affected component.)

Cause of event

5.1.3.4 Poor chemistry or inadequate chemical control

(Direct cause: Flushing of the system was not carried out resulting in poor chemistry)

5.1.10.2 Mistake

(The person performing the task made the error because his understanding of the task was inadequate)

5.3.2 Operations

(Shift chemist is part of operations)

5.4.4 Equipment startup

(Demineralizer was put into operation)

5.5.1 Verbal communications

(Failure of the plant chemist to ensure all responsible persons involved with the system were aware of all the necessary requirements)

5.5.6 Training/qualification

(The shift chemists training had not included the requirement to condition the demineralizer/ion exchanger prior to being put into service after a unit outage)

5.5.7.2 Procedure completeness/accuracy

(The need to condition the demineralizer/ion exchanger prior to being put into service after a unit outage was not included in the procedures on operation of the demineralizer/ion exchanger)

5.5.10.3 Skill of the craft less than adequate/not familiar with job performance standards

(The shift chemist was not aware of the requirement to condition the demineralizer/ion exchanger prior to being put into service after a unit outage)

Effects on operation

6.0 No significant effect on operation or not relevant

(Although there was some small reactivity excursion there were no significant effects on any other operation hence this code is. Code 6.10 is chosen if there is evidence of exceeding of a technical specification limit).

Characteristics of the event/issue

7.6 Failure or significant degradation of the reactivity control

(This code is used because of the reactivity excursion due to failure in reactivity control)

Nature of failure or error

8.2.1 Independent multiple failure or errors

(Several failures led to this event hence use of this code. These failures were not connected with each other. i.e. plant chemist not communicating the requirement, training inadequate of shift chemist, etc.)

Nature of recovery actions

9.1.1 Recovery by foreseen human actions

Annex
LIST OF REACTOR TYPES

REACTOR TYPES

BWR	boiling water reactor
FBR	fast breeder reactor
GCR	gas cooled reactor (graphite or heavy water moderated; includes AGR, HTGR and HWGCR)
HWLWR	heavy water moderated, boiling light water cooled reactor
LWGR	light water cooled, graphite moderated reactor (e.g. RBMK)
PHWR	heavy water moderated, pressure tube reactor
PWR	pressurized water reactor (includes WWER)
SGHWR	steam generating heavy water reactor
OTHER	other type of reactor

ABBREVIATIONS

List of abbreviations and their meaning (Abbreviations are to be used in IRS reports only after their meaning has been identified, e.g. Steam Generator 2 (SG2))

ADS	automatic depressurization system
ADV	atmospheric dump valve
A/E	architect engineer
AFW	auxiliary feedwater
APRM	average power range monitor
ASP	accident sequence precursor
ATWS	anticipated transient without scram
BDT	boron dilution tank
BIT	boron injection tank
BOP	balance of plant
CCIAS	concurrent containment isolation actuation signal
CCP	centrifugal charging pump
CCWS	component cooling water system
CIAS	containment isolation actuation signal
CPCS	containment pressure control system
CRD	control rod drive
CRDI	control room distribution inverter
CREF	control room emergency filtration
CRPI	control rod position indicator
CSS	containment spray system
CVCS	chemical and volume control system
DNB	departure from nucleate boiling
ECCS	emergency core cooling system
EDG	emergency diesel generator
ESF	engineered safety feature
ESFAS	engineered safety feature actuation signal
ESW	emergency service water system
FCV	feedwater control valve
FWIV	feedwater isolation valve
FWP	feedwater pump
HPCI	high pressure coolant injection
HPSI	high pressure safety injection
HVAC	heating, ventilation and air conditioning
ICS	integrated control system
I&C	instrumentation and control
IGSCC	intergranular stress corrosion cracking
IPIS	intermediate pressure injection system
ISI	in-service inspection
LCO	limiting conditions for operation

LER	license event report
LPCI	low pressure coolant injection
LPCS	low pressure core spray
LSSF	loss of safety system function
MCP	main coolant pump
MFWP	main feedwater pump
MSIV	main steam isolation valve
MSSV	main steam safety valve
NDT	non-destructive testing
NSSS	nuclear steam supply system
OL	operating licence
OTSG	once through steam generator
PDP	positive displacement pump
PORV	pressure operated relief valve
RCIS	reactor core isolation system
RCP	reactor coolant pump
RCS	reactor coolant system
RFWP	reactor feedwater pump
RHR	residual heat removal
RPS	reactor protection system
RTB	reactor trip breaker
RTS	reactor trip signal
RWCU	reactor water clean up
SBLC	standby liquid control
SDT	steam dump tank
SDV	steam discharge vent
SG	steam generator
SGPR	steam generator pressure relief
SIAS	safety injection actuation signal
SIT	safety injection tank
SJAE	steam jet air ejector
SRV	safety relief valve
SVCP	suction valve for charging pump
TS	technical specifications

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CONTRIBUTORS TO DRAFTING AND REVIEW

Bernard-Bruls, X.	International Atomic Energy Agency
Duchac, A.	European Commission, Petten, Netherlands
Mamani, Y.	National Commission on Nuclear Safety and Safeguards, Mexico
Maqua, M.	Gesellschaft für Anlagen- und Reaktorsicherheit, Germany
Napke, A.	Canadian Nuclear Safety Commission, Canada
Rao, S.N.	Atomic Energy Regulatory Board, India
Shah, Z.	Pakistan Nuclear Regulatory Authority, Pakistan
Small, B.	Consultant, United Kingdom

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