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Safety Important Functions and Components Classification Criteria and Methodology

The ITER safety functions are listed, and the criteria presented for safety importance classification of structures, systems and components.
The rationale for a graduated approach is laid out, and the classification at system and sub-system level are tabulated.
Some implications of safety importance classification are discussed.

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Change Log				
Title (Uid)	***Version***	***Latest Status***	***Issue Date***	***Description of Change***
Safety Important Functions and Components Classification Criteria and Methodology (347SF3_v1_8)	v1.8	Approved	25 Jan 2012	Change to Annex A for PBS62 to clarify that fire detection and extinguishing systems may be SIC-1 or SIC-2.
Safety Important Functions and Components Classification Criteria and Methodology (347SF3_v1_7)	v1.7	Approved	20 Dec 2011	Changes in response to comments from reviewers of V1.6. Changes to Annex A: Cryostat support columns are SIC-2 (previously omitted). LAC in TCWS vault are SR, not SIC-2 (due to PCR-391). Other wording changes for clarification only.
Safety Important Functions and Components Classification Criteria and Methodology (347SF3_v1_6)	v1.6	Signed	25 Nov 2011	Changes approved by PCR-393. 1. Clarification that the label "Safety Relevant (SR)" is not a SIC class, and does not in itself imply any general requirements. To emphasize this the table of systems containing SR items has been separated from the table giving SIC-1 and SIC-2 classifications by system. 2. Principles and guidelines for layout of safety systems (e.g. segregation of SIC cubicles) have been added. 3. Several changes and corrections to the table of SIC classifications by system: PBS11: Parts of the TF coil terminal box which now provide a confinement function are SIC-2, as a result of PCR-245. PBS24: The cryostat pedestal ring is SIC-1 for its support of the vacuum vessel (first confinement system). This was previously overlooked but was recognized during the study for PCR-210. PBS26: The part of the Component Cooling Water System pipes between the PHTS heat exchangers and the isolation valves, before exiting the TCWS Vault, provide confinement and are SIC-2. This is not new, but was previously omitted from the table in this document. PBS34: Parts of cryolines that provide confinement where they penetrate a confinement barrier are SIC-2. This was a change as a result of PCR-225. PBS23, 58, 62 and 66: Several items are SIC-1 or SIC-2. These are not new classifications but a rearrangement of the table following the elimination of PBS67, which was done by PCR-M0026. 4. Add additional earthquake level, SMHV, is to be considered in the design, less severe than SL-2. 5. Various editorial changes, corrections and clarifications.
Safety Important Functions and Components Classification Criteria and Methodology (347SF3_v1_5)	v1.5	Approved	04 May 2010	This version considers the comments (minor) from P.Cortes and J.Goff and remains fully consistent with RPrS rev.2, March 2010.
Safety Important Functions and Components Classification Criteria and Methodology	v1.4	Signed	22 Apr 2010	The version 1.4 considers comments from QA, in particular a closer reference to Quality Classification Determination. A further clarification about the access control system to red, orange and yellow zones (SIC-2) performed by PBS-48 (CSS)

(347SF3_v1_4)				is included too. This version remains fully consistent with RPrS, rev2, March 2010.
Safety Important Functions and Components Classification Criteria and Methodology (347SF3_v1_3)	v1.3	Signed	18 Mar 2010	The previous version, v1.3, was an uncorrect word file
Safety Important Functions and Components Classification Criteria and Methodology (347SF3_v1_2)	v1.2	Signed	18 Mar 2010	Further refinement of the safety classification of few systems, particularly PBS 31, PBS 66 and PBS 67. The document is consistent with the rev.2 of RPrS (March 2010).
Safety Important Functions and Components Classification Criteria and Methodology (347SF3_v1_1)	v1.1	Signed	04 Feb 2010	This version takes into account the comments on the first version including some indications coming from January 2010 review of RPrS. The latter modifications are mainly relevant to the Annex 1 "Safety Important Systems, Structures and Components, Safety Function and SIC Class" considering the update of PBS structure and graduating the classification of few systems as HVAC and fire protection systems to better answer the ASN questions.
Safety Important Functions and Components Classification Criteria and Methodology (347SF3_v1_0)	v1.0	Approved	11 Dec 2009	

Safety Important Functions and Components Classification and Methodology

Abstract

The ITER safety functions are listed, and the criteria presented for safety importance classification of structures, systems and components. The rationale for a graduated approach is laid out, and the classification at system and sub-system level is tabulated. Some implications of safety importance classification are discussed.

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1 Scope

The scope of this document is:

- identification of safety functions
- criteria for identifying structures, systems and components as important for safety,
- rationale for a safety graduation approach for structures, systems and components important for safety,
- implications for design, construction, commissioning and operation when a system, structure or component has been identified as important for safety.

2 ITER Safety Functions

Safety functions are defined as a group of specific actions that prevent or mitigate against radiological hazards. These actions can therefore prevent or mitigate dose uptake to on-site personnel and members of the public.

There are two fundamental safety functions required for the ITER facility as described in [1]:

- radioactive material confinement: ensuring the personnel, public and the environment are protected against radioactive material releases. This function is achieved with confinement barriers and associated confinement systems;
- limitation of internal and external exposure to ionizing radiation.

Table 1 reports the main safety functions of ITER (confinement of radioactivity and limitation of exposure) and those functions supporting the main ones.

Table 1 ITER Safety Functions

Safety Function		**Detailed Safety Functions**	
1	Confinement of radioactivity	1a)	Process confinement barriers
		1b)	Building confinement barriers including systems for maintaining depression and filtering/detritiating effluents
2	Limitation of exposure	2a)	Shielding to limit exposure and ALARA principle
		2b)	Access control

Supporting Functions		**Detailed Supporting Functions**	
3	Protection of systems for confinement and limiting exposure	3a)	Management of pressure
		3b)	Management of chemical energy
		3c)	Management of magnetic energy
		3d)	Management of heat removal and long term temperatures
		3e)	Fire detection/mitigation
		3f)	Mechanical impact (including seismic, dropped load, etc.)
		3g)	Management of mobilizable radioactive inventory
		3h)	Management of activated and contaminated material
		3i)	Control of safety protection and mitigation systems

4	Supporting functions	4a)	Providing auxiliaries essential for implementing safety functions (electrical power supply, I&C, compressed air, etc…)
		4b)	Monitoring plant status: safety functions, radiation monitoring, etc…
		4c)	Providing protection of important to safety systems (e.g. earthing, lightning, etc…)
		4d)	Provide transport/lifting of radioactive components/materials
		4e)	Providing support to operator intervention (lighting, communications, etc..)

The above safety functions have been derived from the systematic safety analysis of ITER baseline reference design as presented in the ITER Preliminary Safety Report (RPrS) [2], and take into account normal, incidental and accidental situations in all plant states.

3 Purpose of Safety Classification

Safety Importance Class (SIC) describes a classification scheme for structures, systems and components (SSC) of ITER that perform a safety function and contribute towards meeting the General Safety Objectives at ITER during incident/accident situations.

Those SSCs assigned a Safety Importance Class will receive adequate attention during the design, fabrication, installation, commissioning and operational stages. The objective is to ensure and demonstrate that they will meet the minimum performance and reliability requirements throughout their intended lifecycle so that the safety function is provided when required.

4 Identification of Safety Importance Class for Structures Systems and Components

4.1 Criteria

Structures, systems and components (SSC) are assigned a particular Safety Importance Class (SIC) that is based on the consequences of their failure. The top-level criteria for the identification are:

Criterion A their failure can directly initiate an incident or accident, leading to significant risks of exposure or contamination,

Criterion B: their operation is required to limit the consequences of an incident or accident that would lead to significant risks of exposure or contamination, or

Criterion C: their operation is required to ensure the functioning of other SIC components.

4.2 Identification of SIC SSCs

As mentioned above, the identification of SIC SSCs has been derived from the comprehensive safety analyses performed for the ITER facility. The components have been identified by the application of the criteria as defined in the paragraph 4.1. In particular, FMEA analyses have been previously performed for most ITER systems with safety importance, followed by a systematic safety analysis of reference incident/accident scenarios [3]. The systems that provide mitigation against these scenarios could then be identified.

The following documentation was consulted to ensure all the relevant safety functions were identified for further assessment:

- review of the Plant Breakdown Structure,
- review of the Accident Analysis Report [3] to ensure all systems, structures and components that could potentially initiate a fault sequence were included.

Earlier FMEA studies were also taken into account and the current design documents including Systems Requirements Documents (SRDs), Design Description Documents (DDDs), process flow diagrams and I&C diagrams, where available. Following this process, a review and finalisation of the functions listed in table 1 was carried out.

4.3 Grading of Safety Importance Classification

A system of classification of SIC systems and components in ITER has been under development since the early 1990s with the initiation of the ITER Engineering Design Activities (EDA). At that time, classification schemes in use throughout nuclear and non-nuclear industries were examined. These were found to be not fully applicable to ITER, due to the unique nature of many ITER systems. For example, safety classification schemes at nuclear fission facilities are mainly concerned with criticality and emergency cooling that are not relevant for fusion facilities.

The safety analysis of ITER has consistently shown that the design is robust to failures and no single component failure leads to significant consequences. Results also show that no single event can simultaneously damage the multiple confinement barriers, and hence the ITER design provides a high level of public protection.

The following provides a rationale for the adopted methodology:

- a detailed, multi-level graduation of safety classes based upon the consequences of a particular failure is not applicable to ITER. The approach led to an over-complex and confusing approach, mainly due to ITER being a relatively low hazard facility (e.g. when compared to a nuclear power plant),
- an approach that defines a series of required functions and assigns these to the systems and components at ITER was adopted,
- the implementation of the functions at the system / component level has been assessed on an individual basis by Suitably Qualified Experienced Personnel (SQEP) experts,

- guidelines would be produced for developing system/component specifications to ensure consistency and comprehensiveness (see Annex C).

From the above considerations a simplified graduation was introduced in the overall SIC classification. This allows an appropriate level of requirements (e.g. design, quality, functional, integrity, redundancy, monitoring) dependent on the safety function required. These requirements aim to ensure that all systems and components are of sufficient quality and perform their function under normal and incident/accident conditions as credited in the safety analysis in order to meet the safety design target.

Two classes of SIC (SIC-1 and SIC-2) were defined in order to graduate the SIC components derived from the application of the criteria A, B and C defined in section 4.1. The graduation was directly related to the function provided in preventing/mitigating the impact. Also inventories, energies and consequences to the public and the staff were taken into account.

Components classified SIC are divided into:

SIC-1 SSCs are those required to bring to and to maintain ITER in a safe state;

SIC-2 SSCs are those used to prevent, detect or mitigate incidents or accidents, but not SIC-1 (not required for ITER to reach a safe state).

All other components are described as "**non-SIC**". However, some components, while not being SIC, may have some relevance to safety. These components are labelled "**Safety Relevant**", **SR**. They are not credited in the safety analysis and their failure would not impact any safety function. **Concerning the design phase**, no safety requirements are defined for these SR components. **In operation**, some requirements, such as periodical maintenance, could be defined.

Any unintended operation or failure of active components in any system (whether SIC or non-SIC) must not prevent safety functions from being provided by SIC components when required. Design solutions such as SIC isolation equipment (e.g. circuit breaker, valve) or a specific design feature (e.g. separation, seismic design) must be implemented if necessary to satisfy this criterion.

The SIC classification at a system and subsystem level is presented in Annex A. The table identifies the main Safety Important systems, subsystems, safety function, safety category and a justification of the classification chosen. Relevant quantitative data (e.g. inventories, energies, dose consequence data) has been used wherever possible in order to justify each classification. The level of SIC classification in the table, SIC-1 or SIC-2, is that of the highest classified component in the system or subsystem. Where no classification is given, all components in the system are non-SIC, although in some cases there may be SR components in these systems. A list of systems that contain SR components is given in Annex B.

5 Relation to Other Classifications

5.1 Quality Classification

Systems, structures and components are classified into one of four quality classes based on:

- the Safety Importance Class (SIC) assigned to the item,
- anticipated impact of item failure or malfunction on machine availability,
- maturity and complexity related to a risk of failure or malfunction.

SIC-1 components are assigned to Quality Class 1 [4].

SIC-2 and SR components are assigned to a Quality Class as determined by the attachment 1 in the Quality Class Determination document [4].

5.2 Seismic Classification

Those SIC components that are required to perform functions important for safety in the event of an earthquake have been identified. These shall be designed to withstand the event and maintain the required capability. The collapse, falling, dislodgement or other spatial response of a component as a result of an earthquake shall not jeopardise the functioning of other components providing a safety function.

Reference [5], provides a guide for seismic classification and qualification that:

- defines the safety objectives in case of an earthquake,
- assesses the expected or desired response of ITER to earthquakes,
- defines seismic requirements for seismically classified components and structures.

The seismic assessment level corresponds to a reference earthquake spectra for the ITER Cadarache site in compliance with the Basic safety rule RFS 2001-01: the reference earthquakes for the design are defined by two seismic levels. The more severe is called Safe Shutdown Earthquake (SSE), defined as SL-2. A second (lower) level called SMHV also needs to be considered in the design. Moreover, ITER defines a less intense earthquake (SL-1) addressed in the facility design for investment protection.

In addition, the document defines seismic classes for the buildings and components:

- SC1 (SF): Structural stability and required functional seismic safety performance maintained in the event of an earthquake,
- SC1 (S): Structural stability maintained in the event of an earthquake,
- SC2: No damage to SC1 equipment; absence of damage to SC1 equipment for buildings and structures housing and protecting components that are safety importance classified, or to buildings that can potentially damage such structures in the event of collapse,
- NSC: Non seismic class.

6 Implementation

6.1 Guidelines

Rules and standards shall be selected for SIC components/systems using the guidelines reported in this section.

SIC components should be designed, fabricated, qualified, inspected and maintained in accordance with the selected codes and standards, or properly justified specifications specific for application to ITER. This shall include quality requirements (refer to above) and technical requirements for materials, design, fabrication, examination and testing, inspection, repair and replacement, packaging and transportation as appropriate.

Annex C provides general criteria and guidance to be applied for each safety category defined above.

Specific requirements for SIC components will need to be developed on an individual basis due to the diverse range of technologies and associated potential hazards. For ITER, operational and investment protection requirements may be more restrictive than safety requirements and hence may drive the design and quality assurance. However, minimum acceptable requirements based on safety shall be determined to confirm that restrictive requirements are determined.

Table 3 Guidelines Related to Safety Importance Class Components

Issue	Guideline for SIC
Design (use of codes and standards, degree of conservatism, margins, etc.)	• If an appropriate design code exists, the code requirements for design, fabrication, testing etc. should be followed. Deviations from code requirements must be justified. • Where an appropriate design code does not exist, an agreed surrogate developed specifically for ITER may be used • Prototype/non-code items require testing, proven and documented manufacturing process, control of materials, etc. • Standard commercial components acceptable if appropriate to conditions of use and if compliance with appropriate design codes can be verified.
Materials (restrictions on which materials can be used, extent of testing, sources of data, margins in data, etc.)	• Materials to be specified and compliance ensured. • Materials in standard commercial component may be acceptable if appropriate to conditions of use.
Fabrication and Installation (manufacturing process qualification, weld types, welding procedures and welder qualification, etc.)	• Manufacturing, assembly and installation process/procedures to be specified and compliance ensured. • Compliance with design code requirements (if applicable). • Standard, proven, commercial component fabrication may be acceptable, provided compliance with appropriate design codes can be verified where applicable..

Issue	Guideline for SIC
Examination (extent of inspection, third party or owner, non-destructive examination, etc prior to operation.)	• Examination and acceptance tests during fabrication/construction as needed to ensure safety function to be specified and compliance ensured. • Compliance with design code and regulatory requirements (if applicable).
Testing (pressure testing, performance testing, etc prior to operation)	• Testing required to demonstrate safety function to be specified and compliance ensured. • Compliance with design code requirements (if applicable).
In-Service or Periodic Inspection (inaugural, frequency and extent of in-service tests)	• In-service inspections, monitoring and/or tests or compensatory measures taken to ensure that the equipment can continue to provide its safety functions with the required level of reliability. • Test records, calibration records, personnel training requirements, etc. to be specified as part of the normal maintenance procedures.
Equipment qualification	• Justification to be provided that component can withstand the normal and abnormal environmental conditions that may arise from an accident at the end of their service life for which their operation is needed. Qualification against aging (e.g. operating cycles, radiation integrated doses, magnetic field) followed by an accident such as loss of coolant and by seismic event.
Reliability	• System to perform safety function even with single active fault/failure (or alternative system available to provide the safety function). • Use of proven, good industrial quality components may suffice as a justification.
Independence, physical separation	• As required to ensure safety function cannot be undermined by underlying common cause or cascading failures. • Protective I&C for a system should be separate and functionally isolated from process instrumentation for that system (separate signal channels appropriately de-coupled and shielded), and with physical separation between redundant channels.
Equipment status indication	• Status under normal conditions and functioning of system under emergency use as appropriate available to operators, possibly at remote location.

6.2 Mechanical components

A set of Codes & Standards have been defined for ITER Mechanical Components [6] establishing the design requirements and service conditions for ITER. The most important loads are defined in the documents ''Load Specifications'' [7] and ''Guidelines for ITER System Load Specifications'' [8].

For SIC components, appropriate recognised codes and standards, or where not available, specific technical specifications, shall be used and justified. Specific requirements for some systems/components may need to be developed on a case-by-case basis.

6.3 Electrical Components

The SIC classification of electrical equipment is related to that of the system to which they provide electrical power (SIC-1 or SIC-2), where electrical power is needed to provide the safety function. The Steady-State Electric Power Network (SSEN) is organised in several classes to accommodate the needs of ITER electrical equipment.

The relevant Categories are as follows:

- Class I: Uninterruptible DC,
- Class II: Uninterruptible AC,
- Class III: Emergency AC power (temporarily interruptible).

Electrical equipment categories I, II and III are classified SIC-1 as all the three classes have to supply loads classified as SIC-1 (as well as some SIC-2).

The other classes are not SIC, but the SR components may be supplied by Investment Protection classes in selected cases:

- Class I-IP, II-IP and III-IP: Uninterruptible AC and Emergency AC power (temporarily interruptible) for components classified as "Investment Protection'',
- Class IV: AC grid power (indefinitely interruptible).

SIC classes are organized on 2 redundant trains. The routing of the trains supplying a SIC-1 or redundant SIC-2 system are physically separated and must not be located in the same fire sector.

Electrical components that are designated as SIC shall be designed to recognised codes and standards, and the selection of these justified for appropriateness taking into account the above guidelines.

Environmental conditions (normal, incidental and accidental) within which these components operate while providing the functions important to safety shall be identified, considering:

Environmental conditions during normal operation:

- Radiation dose (end of life): Gy

- Temperature (maximum excursion range in the room)
- Humidity (maximum excursion range in the room)
- Pressure
- Electromagnetic Interference (EMI)
- Magnetic Field

Environmental conditions during incidents/accidents:

- Radiation dose rate (Gy/h) and integrated dose (Gy) during an accident
- Seismic floor response spectra
- Temperature (peak and duration)
- Humidity (peak and duration)
- Pressure (peak and duration)

6.4 Instrumentation and Control Components

Instrumentation and control components that are designated as SIC will be designed to recognised codes and standards, and the selection of these justified for appropriateness taking into account the above guidelines.

Instrumentation and control components that are designated as SIC will be of the best available technology, respecting the requirements for category A, B or C functions according to IEC 61226 [9].

Environmental conditions (normal, incident and accident) within which these components operate while providing the functions important to safety will be identified as above in Section 6.3.

6.5 Buildings and Civil Components

Buildings and civil structures important for safety can be considered as those that:

- participate in a confinement function for radioactive materials under incident or accident conditions,
- house, support or protect SIC components/systems,
- provide shielding from ionising radiation.

For building or civil structures important for safety, specific requirements for design and construction have been developed and applied [10].

6.6 Structural Design

The design of SIC components shall take into account the loading conditions to which the component is subjected in performing the relevant safety function.

The following table indicates the relationship between Load Combination Category (loads and likelihood categories defined in the Load Specification document [7]) and acceptable damage limit as a function of the component safety class (SIC-1, SIC-2 or non-SIC).

Table 4 Damage Limits for Loading Condition Categories

Loading Event Category		Category I: Operational/ Design Loading	Category II: Likely Loading	Category III: Unlikely Loading	Category IV: Extremely Unlikely Loading	Test Loading
Plant Level		Normal	Normal	Emergency	Faulted	Normal
Component	SIC-1	Normal	Normal (4)	Emergency (3)	Faulted (1), (3)	Normal
	SIC-2 (5)	Normal	Normal (4)	Emergency (3)	Faulted (3)	Normal
	Non-SIC	Normal	Upset (3)	Emergency (2), (3)	Faulted (2), (3)	Normal

Notes
(1) Faulted for passive components with no deformation limits. Emergency for active SIC-1 components and some passive components in which general deformations should be limited.
(2) Events need not be considered from the safety point of view, but only for investment protection if required.
(3) Damage limits can be made more stringent for investment protection. Normal for some SIC-1 active components and some passive ones which are required to function following Category III and IV accident (e.g. fire dampers and detritiation system)
(4) Normal damage limits are assumed to have a robust design for SIC components not only for category I event, but also for category II.
(5) Case by case considerations (this system is not credited for bringing the plant into a safe state)

6.7 Pressure Equipment

The classification of mechanical equipment as SIC does not imply any requirement in respect of pressure equipment classification.

- The pressure-retaining components, whether or not they are designated as SIC, will comply with the decree n° 99-1046 (13th December 1999), relating to pressure equipments and introducing the Pressure Equipment Directive EC 97/23 in France.
- The Nuclear Pressure Equipment, whether or not they are designated as SIC, will comply with the French Order dated 12th December 2005 concerning nuclear pressure equipment. A list of such equipment is given in ref. [11].
- Appropriate codes and standards shall be used and justified, such as RCC-MR Class 2 or ASME Section VIII. ITER will define specific design criteria for non-standard SIC components (e.g. windows in lines penetrating the vacuum vessel).

6.8 Equipment layout

Concerning the layout of safety systems the following principles are applied:

- Segregation principle: The two electrical and I&C trains of redundant safety systems are not implemented in the same room. Their routings are located within distinct and independent fire sectors; exceptions have to be very limited and supported by detailed analysis.

- Radiological protection principle: Safety systems and their components are located to comply with the radiological and ventilation zonings. This means that the routing of ducts or pipes containing radioactive fluids is prohibited within white, blue and green radiological zones and C1 and C2 ventilation zones. For exceptional cases, specific and local protections for the workers shall be given. The ALARA principle should be applied to the maximum extent in order to make as low as reasonably achievable the dose to staff during maintenance and inspection activities.

- Magnetic field protection principle: The routing of safety I&C cables carrying safety data and the racks containing Safety Control Systems are placed in locations chosen to minimize the effects of magnetic fields.

- Specific requirements for HVAC and Detritiation Systems:

    - pipe routing is such that no contamination propagation from high contaminated rooms to low contaminated level is possible;
    - penetration within red zones are protected against irradiation (e.g. by use of a labyrinth);
    - fire dampers must be installed against or inside a wall;
    - exhaust ducts must not be located close to an ignition source.

- Specific requirements for the layout of safety systems within the rooms containing high pressurized pipes of cooling water systems: this solution shall be limited and if needed specific precautions against whip piping shall be taken to protect them such as
    - segregation;
    - the use of pipes with diameter and thickness no less than those of the high pressure pipes;
    - adoption of restraints according to a dynamic analysis.

  Considering the complexity of the systems and of the layout in ITER, an acceptable approach is the following:
    - Identify systems and pipes that can generate a whip event
    - Analyse the relevant areas that can be involved by the whip event
    - Identify the SIC-1 components performing critical safety functions (e.g. I&C SIC-1 cubicles and signals, SIC-1 isolation valves, SIC-1 fire detection systems), protect these from whip effect (e.g. restraints of pipes to avoid pipe whip or segregation of SIC-1)
    - Apply the separation criteria to the maximum extent for SIC-2

The above safety principles are not normally applied to components classified SR.

Regarding fire, specific requirements are associated with the SIC grade, such as:

a. The components of two redundant **SIC-1** systems are located in independent and separate fire sectors. Their electrical supply and I&C trains (A and B) are routed through independent and separate fire sectors.
The SIC-1 cubicles are located in dedicated rooms (which do not contain SIC-2, SR or non-SIC cubicles). The SIC-1 cubicles are equipped with automatic fire detection and suppression systems.

b. The components of **SIC-2 systems for which there is a redundancy requirement** are located in two independent and separate fire sectors. The redundant SIC-2 cubicles can be implemented together with SR and other non-SIC cubicles at dedicated and separate places in the same room. The minimum distance between SIC-2 cubicles and non-SIC cubicles is 2 m. This room (and not the cubicles themselves) is equipped with automatic fire detection and suppression systems. For power and I&C cabling, only one train (A or B) is required to go through a fire sector.

c. Concerning the **SIC-2 cubicles for which there is no redundancy requirement**, their implementation in the same room as SR and non-SIC cubicles is possible if all the cubicles (SIC-2, SR and non-SIC) are equipped with automatic fire detection and suppression systems.

d. In one room, all the SIC-1 cubicles must be on the same Train (A or B) for power supply and I&C cabling. In one room, all the SIC-2 cubicles must be on the same Train (A or B) for power supply and I&C cabling.

6.9 Cable Tray layout

The design of cables and cable trays should guarantee the following points:

a. Signal integrity for SIC cables in a fire of 2 hours duration

b. Avoidance of fire propagation by the cables in critical areas

The signal integrity of the SIC cables is guaranteed by the use of fire-resistant cables according to IEC 60331 or NF 32070 CR1.

The cables in the ITER facility are fire and flame retardant (IEC 60332-3 and IEC 60332-1). According to those standards, the flame is not propagated and they do not release flammable products capable of triggering a second fire. In critical areas, the cable tray configuration is horizontal and not vertical, reducing the risk of fire propagation.

There will be two configurations of cables, one mostly used and the other used in the critical areas. The difference is that the cable trays in critical areas shall be covered by a 2 hours fire protection envelope. All SIC cables will be in the same cable tray, but with a metallic divider between the SIC-1 and SIC-2 cables. The SIC cables will never be mixed with non-SIC cables in the same cable tray.

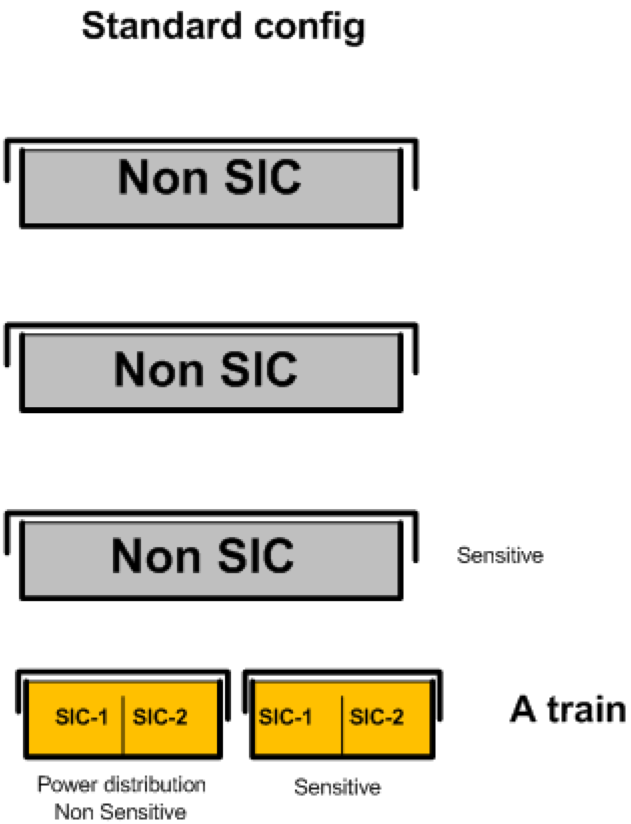

Figure 1. Standard configuration of cable trays, with non-SIC cables and one SIC train ("sensitive" refers to sensitivity to electromagnetic interference).

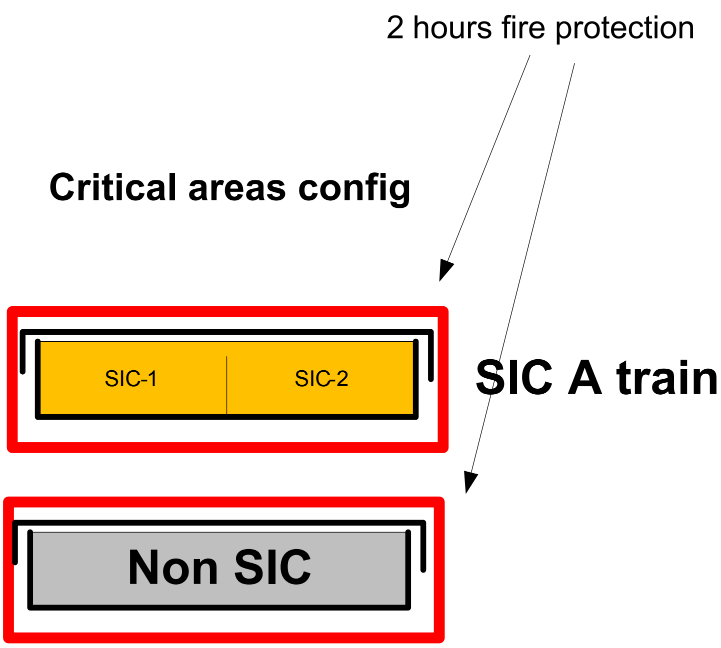

Figure 2. Configuration to be used in the critical areas. In this configuration, each cable trays shall be covered by an enveloped 360 degrees 2 hours fire resistant.

7 Conclusions

This document provides the criteria for identification and for graduation into classes 1 and 2 of SIC. The simplification of the classification was aided by the relatively low hazard and favourable safety features of ITER.

Two SIC classes have been defined, dependent on whether the system is required to bring the facility to a safe state following an incident/accident.

Among systems not classified as SIC, a Safety Relevant category was introduced in order to identify systems contributing to nuclear safety, but not credited in the safety analyses.

The SIC classes are consistent with other ITER classifications, and ensure each SIC structure, system and component receives appropriate attention during the design, fabrication, installation, commissioning and operational phases.

The overall objective will be to ensure that all SIC structures, systems and components will meet the safety performance and reliability requirements throughout their intended lifecycle in any of the incident and accident situations where they are credited in the safety analysis.

The systems and subsystems (level 1 and 2 of PBS) have been classified from the safety point of view and criteria have been defined for further level of classification up to the component level.

8 References

1. Project Requirements (PR) (ITER_D_27ZRW8)
2. Preliminary Safety Report (Rapport Préliminaire de Sûreté, RPrS), (ITER_D_3ZR2NC)
3. Accident Analysis Report (ITER_D_2DLLRM)
4. Quality Classification Determination (ITER_D_24VQES)
5. ITER Seismic Nuclear Safety Approach (ITER_D_2DRVPE)
6. Codes and Standards for ITER Mechanical Components (ITER_D_25EW4K)
7. Load Specifications (LS) (ITER_D_222QGL)
8. Guideline for ITER System Load Specifications (ITER_D_33TTPJ)
9. IEC-61226 Nuclear power plants - Instrumentation and control important to safety - Classification of instrumentation and control functions
10. Safety Requirements for ITER Facility Buildings (ITER_D_2E4KSJ)
11. List of the ITER Nuclear Pressure Equipment (ITER_D_34MZKE)

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Annex A – Safety Important Systems, Structures and Components, Safety Functions and SIC Class

PBS	System	Subsystems	Safety function provided	SIC class	Rationale
11	Magnet	Safety-class TF quench detection system	Magnetic energy management	SIC-2	Trigger fast energy discharge resistors preventing possible break of confinement
		Coil terminal boxes (L3)	Confinement	SIC-2	Parts of boxes at level L3 which form part of the second confinement boundary
15	Vacuum Vessel	Main vessel	1st confinement barrier	SIC-1	Confinement barrier of the main radioactive inventories
		Ports	1st confinement barrier	SIC-1	Confinement barrier of the main radioactive inventories
		VV supports	Support SIC system (1st confinement barrier)	SIC-1	Support SIC system
		ELMs & VS Coils	1st confinement barrier	SIC-1	ELMs & VS don't have a safety function, only the VV penetrations (part of the confinement barrier)
18	Fuelling and Wall Conditioning	Disruption mitigation	Components providing the 1st confinement barrier	SIC-1	Confinement barrier of the main radioactive inventories
		Gas injection	Components providing the 1st confinement barrier	SIC-1	Tritium confinement process barrier
		Pellet Injection	Components providing the 1st confinement barrier	SIC-1	Tritium confinement process barrier
		Glow discharge cleaning	Components providing the 1st confinement barrier	SIC-1	Confinement barrier of the main radioactive inventories
		Fusion plasma termination	Components providing the 1st confinement barrier	SIC-1	Confinement barrier of the main radioactive inventories
			Management of chemical energy in case of ex VV cooling failure	SIC-2	Mitigation system
23	Remote Handling Equipment	Cask RH	Provide a confinement function during in-vessel RH	SIC-1	Confinement barrier

PBS	System	Subsystems	Safety function provided	SIC class	Rationale
			Provide a confinement function during cask Handling	SIC-2	Transport of radioactive material without shielding and with confinement of low mobilizable inventory
		Viewing and metrology RH	Provide confinement	SIC-1	Part of the VV boundary
		Docking station in Hot Cell Facility	Confinement and shielding	SIC-1 SIC-2	First confinement and shielding of in-vessel components, including shielding doors. For hot workshop
24	Cryostat and VVPSS	Vacuum Vessel Pressure Suppression System	Components providing confinement function	SIC-1	After intervention of bleed lines/rupture disk, VVPSS is and remains 1st confinement barrier
		Cryostat pedestal ring	Support of vacuum vessel	SIC-1	Provide support of the 1st confinement system (VV)
		Cryostat support columns	Support of vacuum vessel	SIC-2	
26	Cooling Water Systems	Primary VV HTS	Components providing confinement function Management of heat removal and long term temperatures	SIC-2 SIC-2	Low T and ACP inventory The only cooling system to control long term temperatures of all vessel components. Very slow transient and has a redundant-diversified system.
		Primary Blanket HTS	Provide confinement	SIC-1	High T and ACP
		Primary Divertor HTS	Provide confinement	SIC-1	High T and ACP
		Primary NBI HTS	Provide confinement	SIC-2	Low T and ACP (tbc)
		CVCS	Provide confinement	SIC-1	High ACP
		Component CWS	Provide confinement	SIC-2	Up to isolation valve; in case of leaks in PHTS heat exchanger
		Chilled WCS	Services for functioning of systems implementing safety functions	SIC-2	SIC-2 is the highest class of chilled WCS class (e.g. VDS)
		Draining and refilling	Confinement	SIC-2	High ACP and T, very low risk of accident

PBS	System	Subsystems	Safety function provided	SIC class	Rationale
					(no pressure-no significant temperature)
31	Vacuum Pumping Systems	Roughing Pump System	Providing confinement function	SIC-1	1st confinement
		Torus Vacuum Cryopumping	Providing confinement function	SIC-1	1st confinement
		Type 2 Diagnostic System	Providing confinement function	SIC-1	1st confinement
		NB Vacuum Cryopumping	Providing confinement function	SIC-1	1st confinement
		Front-end Cryopump Cryogenic Distribution	o Protection of systems for confinement (management of pressure). o Confinement function	SIC-2	Limit of incondensable gas that can reach VVPSS (50 kg He) Confinement of tritium in case of cryopanel rupture
		Service Vacuum	Providing protection function of first confinement barriers	SIC-2	Monitoring interspaces of double containment spaces protecting against in-VV air ingress (classification level depends on the maximum inventory of air entering the vacuum vessel)
		Leak Detection	Providing confinement function	SIC-1	1st confinement
		Venting	Providing confinement function Other parts	SIC-1	1st confinement
		Vacuum Instrumentation, Control and Interlock	Protection of systems for confinement	SIC-2	Control of vacuum isolation valves of systems connected with the VV in case of air leak detection from one of the systems. Level of SIC depends on the maximum inventory of air can enter VV
		Torus and NBI cryopump regeneration lines	Confinement function	SIC-1	1st confinement
32	Tritium Plant	Tritium Depot	Confinement function	SIC-1	High tritium inventory
		Storage and Delivery	Confinement function	SIC-1	High tritium inventory
		Tokamak Exhaust	Confinement function	SIC-1	High tritium inventory

PBS	System	Subsystems	Safety function provided	SIC class	Rationale
		Processing			
		Hydrogen Isotope Separation	Confinement function	SIC-1	High tritium inventory
		Detritiation Systems	Management of mobilizable radioactive inventory	SIC-1	For Hot Cell provides 1st confinement barrier of components with significant tritium. Fundamental mitigation system for all the other buildings with tritium. Necessary to bring the plant into a safe status.
		Water Detritiation	Confinement function	SIC-1 / SIC-2	Tritium inventory Tank containing HTO
		Tritium Plant Automated Control	Services for functioning of systems implementing safety functions 4a)	SIC-1 / SIC-2	control and interlocking for tritium related safety
		Ventilation Air Tritium Detectors	Monitoring plant status	SIC-1	Trigger HVAC isolation valves to close and S-VD isolation valves to close
		Glove boxes	Protection of confinement function and limiting exposure, management of chemical energy	SIC-2	Protection through tritium and O2 detectors and depression (leak) control (except in case of fire and seismic events)
34	Cryoplant and cryo-distribution	Cryolines.	Confinement	SIC-2	Components providing confinement where second confinement barrier is penetrated
41	Coil PS and distribution	TF coil energy discharge	Management of magnet energy	SIC-2	Prevent possible electrical arcs (that could challenge confinement)
43	Steady State Electrical PS	Emergency PS (Class III)	Services for functioning of systems implementing safety functions	SIC-1/ SIC-2	Provide electrical power supply to SIC components (including SIC-1)
		Emergency PS (Class II)		SIC-1	
		Uninterruptible PS (class I)		SIC-1	
48	Central Safety System		Protection of systems for confinement and limiting exposure Protection of workers	SIC-1 / SIC-2	Control of SIC protection/mitigation systems. Control of access for the radiological zones red, orange and yellow is SIC-2.
51	Ion Cyclotron	VV port interfaces	Confinement function	SIC-1	High tritium and dust inventory

PBS	System	Subsystems	Safety function provided	SIC class	Rationale
	H&CD				
52	Electron Cyclotron H&CD	VV port interfaces	Confinement function	SIC-1	High tritium and dust inventory
53	Neutral Beam H&CD DNB	o Beam source vessel o Beam Line Vessel o Transmission Lines and High Voltage Decks	Confinement function	SIC-1	VV first barrier, High tritium and dust inventory
		HV Bushing	Confinement function	SIC-2	Confinement
55	Diagnostics	VV port interfaces	Confinement function	SIC-1	1st confinement barrier (VV)
56	Test Blanket	TBM port plug	Confinement function on port	SIC-1	VV first barrier
		TBM T-Removal System	Management of overpressure Confinement	SIC-1 SIC-2	Isolation of the system from TBM module Low inventory of tritium
		Liquid Metal System	Management of overpressure Confinement	SIC-1 SIC-2	Isolation of the system from TBM module Tritium and activated products
		Auxiliary circuits	Confinement function	SIC-2	Tritium and activated products in the cooling and auxiliary systems
58	Port Plug Test Facility	Test tank facilities	Confinement	SIC-2	Confinement
61, 62, 63	Buildings & site	Reinforced Concrete Buildings	Provide confinement and contain SIC systems	SIC-1 / SIC-2	Secondary confinement or/and protection of SIC systems from external/internal events
		Hot Cell Facility shielding doors	Limitation of exposure	SIC-1	Confinement
		Steel liners in Hot Cell Facility	Confinement	SIC-1	Confinement of tritium
		Steel frame Buildings	Contain SIC systems	SIC-1 / SIC-2	Protection of SIC systems from external/internal events

PBS	System	Subsystems	Safety function provided	SIC class	Rationale
		HVAC for control rooms and areas with SIC systems sensitive to environmental conditions and where human presence is required	Provide auxiliary functions to SIC (Maintain environmental conditions suitable for SIC components performances) Limitation of exposure (Provide inlet filtration for the rooms needed to be permanently occupied after an accident for the back-up control room)	SIC-2	For the main and back-up control rooms and other areas with SIC cubicles present
		HVAC for Radwaste building	Provide confinement function for Radwaste building	SIC-2	Ensuring air pressure cascade
		HVAC for the other buildings served by DS system (Isolation)	Support confinement function	SIC-1 / SIC-2	Isolation of HVAC (dampers and relevant actuators): o SIC-1 for areas with significant tritium inventory o SIC-2 for areas with no significant tritium inventory Provide HEPA filtration
		LAC in Hot Cells (if necessary)	Support to confinement function (heat removal, homogenization of tritium concentration)	SIC-2	Control of the temperature
		Fire Detection and Extinguishing Systems	Management of thermal and chemical energy	SIC-1	In area containing components with significant tritium inventory
				SIC-2	In area containing components with low tritium inventory
		Lift	Transport of activated material	SIC-1	Cask transporter with high activated contaminated material with limited confinement capacity in time

PBS	System	Subsystems	Safety function provided	SIC class	Rationale
64	Radiological Protection	Process and Release Radiological Monitoring	Confinement (Safety Tritium Control) and Limit Exposure of Public and Environment	SIC-1	Provide signals to CSS for actuation of SIC systems (e.g. HVAC isolation detritiation system)and monitoring of releases
		Area radiological monitoring and Beryllium Monitoring	Limit exposure of workers	SIC-2	Provide signals for alarms for worker protection
65	Gas Distribution	Compressed Air	Provide auxiliary function to SIC-1, SIC-2	SIC-1, SIC-2	Provide compressed air through dedicated tanks with 32 hours autonomy and the dedicated circuits. The production and distribution of air to the tanks is not SIC
66	Radwaste Treatment & Storage	Type B waste management ○ Tritium Recovery Station	 Provide confinement	 SIC-2	 Medium radioactive inventory
		Type A liquid management ○ Tanks ○ Pipes	Provide confinement	 SIC-2 SIC-2	Low-medium radioactive inventory in liquid form.
		Type A solid management ○ Containers	Provide confinement	 SIC-2	 Medium radioactive inventory in solid form
		Dust canister	Confinement	SIC-2	Confinement and shielding
69	Access Control and Security	Intercom	Supporting protection of workers	SIC-2	It will allow to make distress calls and reliable communications during accident and post-accident conditions.

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Annex B. Systems not classified as SIC, but which contain Safety Relevant components.

PBS	System	Subsystems	Safety relevance	Rationale
23	Remote Handling Equipment	Blanket RH	Management of mobilizable radioactive inventory	Contribution to measurement/removal of in-vessel inventory (dust and tritium)
		Divertor RH	Management of mobilizable radioactive inventory	
		Viewing and metrology RH	Provide in-VV metrology	Overall dust erosion information
		NB RH	Handling of activated components	No drop of activated components/materials
		MPD RH	Management of mobilizable radioactive inventory	Contribution to measurement/removal of in-vessel inventory (dust and tritium)
		Hot Cell RH	Handling of activated components/ Management of mobilizable radioactive inventory	No drop of activated components/materials. Management of dust
		Vacuum cleaner	Management of activated material	Collect dust from VV
26	Cooling Water Systems	CVCS	Management of mobilizable radioactive inventory	Minimization of ACP production and inventory
		Drying	Confinement	Low ACP tritium content
32	Tritium Plant	Tritium Plant Analytical	Monitoring plant status	Accuracy accountancy of inventory (off-line)
		Tritium Extraction from Blanket Test Modules	Provide confinement	Low tritium inventory
34	Cryoplant and cryo-distribution	Cryodistribution	Protection of systems for confinement (management of pressure, 3a)	Limit of incondensable gas that can reach VVPSS (50 kg He)
41	Coil PS and distribution	PF coil PS	Protection: management of magnetic energy	Only part of the circuit dedicated to detect - prevent shorts and arcs and to isolate coils from the power supply
		CS coil PS	Protection: management of magnetic energy	Only part of the circuit dedicated to detect - prevent shorts and arcs and to isolate coils from the power supply

PBS	System	Subsystems	Safety relevance	Rationale
43	Steady State Electrical PS	Earthing	Supporting function	Concur to the functioning of SIC EPS and I&C during electrical failure and lightning
61, 62, 63	Buildings & site	HVAC for the other buildings served by DS system	Maintain pressure depression in normal conditions	Except isolation and filtration functions (SIC). In case of tritium release, DS (SIC) assumes depression function.
		HVAC for Personnel Access Control Building	Support confinement function	Provide HEPA filtration
		LAC in TCWS vault	Support confinement	Accelerate reduction of pressure following LOCA
		Fire Detection System	Management of thermal and chemical energy	In area containing SIC-2 components
		Fire extinguishing systems	Mitigation of thermal and chemical energy	In areas with low tritium inventories and SIC-1, and SIC-2, no segregated components
		Crane (Hot Cells)	Transport of activated material	Avoid drop/blockage of activated components
		Emergency Lightning	Support in emergency situation	Escape routes for Personnel. Support manual intervention during accident
		Communication systems	Support in emergency situation	Provide good communication among operative areas and for general communication to the people on the plant
64	Radiological Protection	Environmental and Individual Radiological Monitoring	Limit exposure of Workers, Public and Environment	Provide further measurements, provides check against safety objectives (e.g. worker dose limits)
		Sampling (for radioactive and toxic effluents)	No safety function	It will done through a safety procedure
66	Radwaste Treatment & Storage	Type A solid management ○ Cementification system ○ Glove boxes and enclosures	Provide confinement	Low radioactive inventory in solid form
		TFA waste management	Management of activated material	Very low radioactivity inventory

PBS	System	Subsystems	Safety relevance	Rationale
69	Access Control and Security	Access control	Supporting protection of workers	SR for the access control of green radiological zones and for areas with conventional risks. The access control of radiological zones red, orange and yellow is SIC-2 and it is provided by PBS48-CSS.
		Information & Warning	Supporting protection of workers	It provides reliable information and warning in emergency situations

Annex C – Main requirements recommended[1] for SIC-1 and SIC-2 SSCs and guidelines for SR SSCs

Safety classified SSCs	Single failure criterion. Separation	Mechanical classification	Safety class power supply	I&C 61226	Periodic tests	Quality Class	Environmental qualification	Design resistant to design basis earthquake	Seismic qualification
SIC-1	Yes	Standards, ITER specification	Yes	Cat A or B	Yes	QC1	Yes	SC1	S and F
SIC-2	Yes or No	Standards, ITER specification	Yes	Cat B or C	Yes	See ref [4].	Yes (by analysis normally) [2]	SC1 or SC2	S normally. F on a case by case basis
SR	No	Standards, ITER specification	No	Cat C or none	Normally yes (case by case)	See ref [4].	No	SC2 or NSC	S

1. Deviations from these recommendations are possible with a case-by-case justification.
2. Except for I&C Class C, for which the need for qualification is decided case-by-case.