IAEA-TECDOC-1544

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Structure of Nuclear Power Plant Design Characteristics in the IAEA Power Reactor Information System (PRIS)

International Atomic Energy Agency

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The originating Section of this publication in the IAEA was:

Nuclear Power Engineering Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

NUCLEAR POWER PLANT DESIGN CHARACTERISTICS: STRUCTURE OF NUCLEAR POWER PLANT DESIGN CHARACTERISTICS IN THE IAEA POWER REACTOR INFORMATION SYSTEM (PRIS)

IAEA, VIENNA, 2007
IAEA-TECDOC-1544
ISBN 92–0–102507–6
ISSN 1011–4289

Printed by the IAEA in Austria
March 2007

FOREWORD

One of the IAEA's priorities has been to maintain the Power Reactor Information System (PRIS) database as a viable and useful source of information on nuclear reactors worldwide. To satisfy the needs of PRIS users as much as possible, the PRIS database has included also a set of nuclear power plant (NPP) design characteristics.

Accordingly, the PRIS Technical Meeting, organized in Vienna 4–7 October 2004, initiated a thorough revision of the design data area of the PRIS database to establish the actual status of the data and make improvements. The revision first concentrated on a detailed review of the design data completion and the composition of the design characteristics. Based on the results of the review, a modified set and structure of the unit design characteristics for the PRIS database has been developed. The main objective of the development has been to cover all significant plant systems adequately and provide an even more comprehensive overview of NPP unit designs stored in the PRIS database.

The IAEA wishes to express its gratitude to all experts who participated in the drafting and reviewing of this publication and to all those contributing with case studies. Particular thanks are due to M. Cihlar (Czech Republic) and C.R. Chapman (United Kingdom) for their assistance in the compilation of this publication.

The IAEA officer responsible for this publication was J. Mandula of the Division of Nuclear Power.

EDITORIAL NOTE

CONTENTS

1. INTRODUCTION

The nuclear power plant (NPP) design characteristics represent a fundamental part of the Power Reactor Information System (PRIS) database. They provide important information on the main components of an NPP unit, such as the reactor or turbine, briefly describe safety and essential auxiliary systems, and list technical specifications of significant plant equipment. In addition to the design specification data, the PRIS database can also accommodate other descriptive data, such as unit systems schematics and flow diagrams, local maps and photographs of the unit site. These characteristics can provide a comprehensive picture of unit design, technology and system configuration and also give a clear idea of unit location, appearance and nearby setting. The characteristics can also be used as basic criteria to select reactors with similar or identical design features.

However, although the Member States regularly provide actual plant performance data to the PRIS database, it has not been always easy to keep the specification data up-to-date or even ensure that all the characteristics of individual units are complete.

The set of unit design characteristics held in the Power Reactor Information System (PRIS) database has been reviewed in conjunction with the general revision and upgrade of the PRIS database and associated applications.

The reviewers initially concentrated on how individual items of the design characteristics originally stored in the PRIS database had been completed for the reactor units. The results of the review showed that most specific design data were missing for many reactor units, while some design characteristics had no data for any units.

Inadequate composition and selection of the characteristic items were identified as possible reasons for this unsatisfactory situation. No clear concept of the design characteristics had been established as to what kind of information should be provided. No definitions or instructions for the data providers had been available, which was discouraging from reporting. Some items were not clearly expressed and no options were provided. Some items were too detailed and it was difficult to obtain them. Other items varied with reactor core design changes or with operation and fuel cycle strategy, for example fuel enrichment, so it was difficult to enter just a single value.

The structure itself was not fully consistent with typical or most significant NPP systems and the characteristics were of unequal detail, level or nature for different plant systems included in the database. Some items were specific for particular types of reactors, not applicable to other types, so some data fields had to be left blank. If a data field had been left blank, it was not clear why the data were missing (whether the characteristic was not applicable to the unit or the data provider failed to enter them). Some characteristics were of a questionnaire type suggesting yes/no answers. Such characteristics would provide only qualitative information on a particular system, equipment or practice used at the NPP, whereas no specific parameters of the equipment had been provided.

Although the PRIS database was supposed to include basic schematics of reactor units, no clear criteria or requirements of the type of character of the schematics were established.

The deficiencies that were revealed, both in the design characteristic completion and structure, prompted discussions about the need for a revision of the characteristics. The discussions were formalized at a PRIS technical meeting that took place in Vienna, 4–7 October 2004. The meeting participants recommended revising the original structure of unit design characteristics with the following particular requirements and suggestions:

- Compare the current design characteristic structure in the PRIS database with other available databases.
- Consider NPP systems layout in the design characteristic structure.
- Include a clear concept of further use of unit design characteristics, with data collection and periodical updates.
- Collect missing data from published data before the completed data are made available in the PRIS database.
- Consider implementation of unit schematics into the PRIS database within the framework of the design characteristic revision process.

A new set and structure of the existing design characteristics was proposed, based on a preliminary analysis of the original characteristics and a consideration of suggestions put forward at the technical meeting. New design characteristics were discussed and accepted at a consultants meeting, held in February 2005 in Vienna. The changes to the original set of characteristics are summarised in the annex. The new structure for design characteristics was discussed and approved at the PRIS technical meeting held in Vienna in October 2006.

This report presents the revised set and structure of unit design characteristics, as they are currently implemented in the PRIS database. Each individual design characteristic is accompanied by a definition and explanations for data providers. Also, the characteristics have been classified according to their significance and applicability as selection criteria. For the qualitative characteristics, multiple choice options have been proposed to facilitate data entry. For the quantitative characteristics, acceptance criteria have been suggested to enable automated database checks of data appropriateness. This report also summarises the significance of the design characteristics in the PRIS database and suggests possible applications. Finally, it highlights changes in the new structure compared with the previous structure.

2. DESCRIPTION OF THE PRIS DATABASE DESIGN CHARACTERISTICS

The objective of the unit design characteristics in the PRIS database has been to provide a consistent overview of design features and technical specifications of the reactor units stored in the PRIS database. The structure of the characteristics has been based on a general configuration of a nuclear power plant, so that all common reactors and plant systems are included. When selecting individual characteristics for system groups, a similar level of detail has been kept. In comparison with the original set of characteristics, features of lower significance or specifications with data difficult to obtain, as well as those of the “Yes/No” type, have been omitted. In their place, specific system characteristics or important characteristics previously missing have been included. For compatibility with simultaneous PRIS developments, design characteristics of the systems for Non-Electrical Applications have been included in the database.

The characteristics have been organised in four main groups: primary systems, secondary systems, spent fuel storage and non-electrical applications. In these main groups, systems subgroups have been arranged and named according to usual plant equipment configuration and terminology.

2.1. Main features of the design characteristics

2.1.1. Multiple choices

Wherever possible, multiple choices of the design characteristics (based on existing or known design features) have been included. The choices are primarily intended as hints for data providers as to what kind of data should be provided. Secondarily, the choices have been selected to facilitate data entry. Instead of typing the data in a text window, the user providing the data can simply select the most appropriate option from a pop-up menu and the choice will be automatically stored in the respective database field.

Because of the variety of possible designs, the multiple choices are not meant as the only possible choices. The list is open, and it is expected that while completing the database, other options may be found missing. In such cases, the data providers can make comments to the database administrator proposing or requiring new options, and the administrator can amend the multiple-choice menu.

2.1.2. "Not applicable" option

For an easy review of characteristic completeness, no blank data fields are acceptable in the database. Accordingly, the "Not applicable" (N/A) option has been introduced into the PRIS design characteristic system. If particular equipment or parameters that have been defined in the PRIS database do not exist at the NPP, "N/A" is entered in the related field or text box. This entry will give a user positive information that such a feature is not present at the plant, unlike a blank field, where relevant data may be missing in the database.

"N/A" has been also included in all "multiple choice" characteristics, where it has the same meaning as mentioned above. "N/A", however, should not be used if no applicable option could be found in the multiple-choice menu for a plant specific system or feature. In such a case, the procedure would be as described in Section 2.1.1 (comment will be made to the PRIS administrator and an appropriate option will be added to the menu). Then the appropriate option can be selected.

2.1.3. Classification

To indicate the significance of individual characteristics and to select possible grouping / selecting criteria for statistical processing of unit performance data, one of the classification codes from Table 1 has been assigned to each design characteristic. The current assignment of classification codes to individual characteristics, as indicated in Table 2, is not irrevocable. The classification can be modified, if experience shows it to be desirable.

Table 1. Design Characteristic Classification

Code	Classification	Description
1	Essential data	The most important (basic) unit parameters or features
2	Complementary data	Rated parameters or design features of individual systems
3	Technical detail	Technical specifications of system components; could be removed from the structure if a reduction was required

Classification 1 has been assigned to the most important unit design characteristics determining basic reactor types (PWR, BWR, GCR, PHWR, etc). Classification 1 characteristics would be used as primary filtering criteria for searching information on particular reactor types or for grouping reactors with comparable design features for unit performance analysis.

Classification 2 has been assigned to basic system parameters or design features specific to a particular NPP. Parameters with this classification may determine various models or designs within a particular reactor type (for example Westinghouse, Siemens, B&W, VVER within PWRs, or Magnox, AGR and HTGR within gas-cooled reactors). These parameters would be used as secondary (supplementary) criteria for more detailed searching and grouping.

Classification 3 has been assigned to particular technical specifications of systems and components. If these characteristics prove difficult to obtain or are of no use in the database completion process, they would be eligible for elimination from the database.

2.1.4. Data validity criteria, units

To ensure that all design characteristic data provided in the PRIS database are consistent and comparable, the required unit for each numerical parameter has been explicitly included in the database.

To help the database system to recognise or eliminate invalid/irrelevant data, validity criteria have been introduced. These criteria specify either the normal range of a particular parameter for most reactors or a required data format (text, numerical value, date, etc.) for the design characteristics that do not offer a multiple choice. Using these criteria, the system would notify data providers of a possible data entry error, if the entered data exceeded its usual range or had an undefined format.

As the proposed criteria have been based on the design values of available operating NPPs, they may not reflect other possible values that might be valid for NPPs that are permanently shutdown, under construction or planned. Therefore, these criteria could be also modified in the early stages of completing the design characteristic database.

2.2. List of the unit design characteristics

The latest revision of the PRIS database design characteristics is shown in Table 2. The individual characteristics are organised into logical groups corresponding to main plant equipment, so that all reactor types are covered. Most of the groups of characteristics are applicable to all reactor types but some, such as pressurizer or steam generators groups, are applicable only to the specific reactor types that use these components.

In the left-hand column, the subgroups of main groups are set out according to system and component significance, considering also the actual physical layout and functional relationships of the systems.

In the second column, the classification of the individual characteristics is indicated. The third column includes the required measurement units of numerical parameters as entered in the PRIS database. In the right-hand column, validity check criteria are suggested.

Table 2. Unit Design Characteristics Included in the PRIS Database

System			Class	Unit of measure	Validity criteria
Primary systems					
	Reactor vessel/ pressure channels				
		Reactor vessel shape (multiple choice: cylindrical-hemispherical end, cylindrical-flat end, spherical)	1		
		Reactor vessel centreline orientation (multiple choice: vertical, horizontal)	1		
		Reactor vessel material (multiple choice: carbon steel, alloyed steel, stainless steel, concrete)	1		
		Reactor vessel material specification	2		text
		Reactor vessel cladding material (multiple choice: alloyed steel, stainless steel, N/A)	2		
		Reactor vessel cladding material specification	2		text
		Reactor vessel overall length/height (including vessel head)	2	m	1 - 25
		Inner shell diameter	2	m	1 - 25
		Shell thickness	2	mm	10 - 7000
		Number of pressure channels	2		300 - 6300
		Pressure channel material (multiple-choice menu: carbon steel, stainless steel, manganese steel, Zircaloy, Zr+Nb(2.5%), N/A)	3		text
		Pressure channel wall thickness	3	mm	1 – 50
	Reactor Core				
		Fuel assembly geometry (multiple choice: square, hexagonal, circular, spherical)	1		
		Fuel form (multiple choice: pellets, rods, coated particles)	1		
		Fuel material (multiple choice: U metallic, UO_2, UO_2/PuO_2, UO_2/ThO_2, UO_2/MOX, UO2/Er2O3)	1		
		Refuelling type (multiple choice: on-line, off-line)	1		
		Moderator material (multiple choice: H_2O, D_2O, C, N/A)	1		
		Fuel clad material (multiple choice: magnesium alloy, stainless steel, zirconium alloy, zirconium-magnesium alloy, carbide compound)	2		
		Fuel clad material specification	2		text
		Average fuel enrichment	2	%	0 - 15[1]
		Refuelling frequency	2	month	1 – 70
		Part of the core refuelled	2	%	1 - 100
		Average discharge burnup	2	MWd/tU	3000 – 120 000
		Active core diameter	2	m	1 – 20
		Active core height/length	2	m	1 – 10
		Number of fissile fuel assemblies/bundles	2		100 – 6300
		Number of fertile fuel assemblies	2		1 – 200
		Fuel weight	3	tons m (t)	1 – 350
		Moderator weight	3	tons m (t)	1 – 2000
		Number of fuel rods per assembly/bundle	3		1 – 100
		Fuel clad thickness	3	mm	0 – 1
		Average core power density	3	kW/dm^3	1 – 150

[1] There are a few reactors with much higher enrichment (HTGR, FBR), which should be treated separately.

System			Class	Unit of measure	Validity criteria
		Average fuel power density	3	kW/kgU	1 – 150
		Fuel linear heat generation rate	3	kW/m	10 – 50
	Reactivity control				
		Control rod material (multiple choice: boron stainless steel (SS), cadmium SS, boron carbide SS, carbon steel, boron carbide, boron carbide/hafnium, boron carbide/cadmium alloy, cadmium alloy, Ag-In-Cd alloy)	1		
		Burnable neutron absorber material (multiple-choice: gadolinium, boron, gadolinium/boron, boron/hafnium, other, N/A)	1		
		Burnable neutron absorber material specification	2		text
		Soluble neutron absorber material (multiple-choice: H_3BO_3, N/A)	1		
		Secondary reactivity control system (multiple choice: H_3BO_3 injection, N_2 injection, Gd injection, liquid zone control, N/A)	2		
		Number of control rod assemblies	2		1 - 220
	Reactor coolant system				
		Number of external reactor coolant loops	1		2 - 8
		Coolant type (multiple choice: carbon dioxide, light water, heavy water, sodium, helium)	1		
		Coolant weight	**2**	tons m (t)	50 – 500
		Operating coolant pressure	2	MPa	1 – 20
		Reactor outlet temperature	2	°C	250 - 850
		Reactor inlet temperature	3	°C	200 - 450
		Coolant mass flow at the rated power	3	t/h	3000 – 70000
	Steam generators (SG)/drum separators				
		Type of SG (multiple choice: vertical, horizontal, modular, N/A)	1		
		SG output (multiple choice: saturated steam, superheated steam, N/A)	1		
		Number of SG	1		2 – 8
		Number of drum separators (multiple choice: 4, 6, N/A)	1		2 – 8
		Tube shape (multiple choice: U-tube, straight, mushroom, finned, helical, N/A)	2		
		Tube material	2		text
		SG shell material	2		text
		Drum separator shell material	2		text
		Design thermal capacity	3	MW	10 - 1000
		Design heat transfer surface	3	m^2	1000 – 10000
	Main coolant pumps/circulators				
		Number of pumps/circulators	1		2 – 8
		Number of pumps per RCS loop	1		1 – 8
		Pump/circulator motor rating	2	MW	1 – 10
		Design pressure difference	3	MPa	0.1 – 2
	Pressurizer				
		Total volume	1	m^3	10 - 100
		Number of safety valves	1		1 – 15
		Number of relief valves	1		1 – 15
		Installed heater power	3	kW	500 – 5000

System			Class	Unit of measure	Validity criteria
	Containment systems				
		Containment type (multiple choice: single, double, partially double, confinement, N/A)	1		
		Containment shape (multiple choice: spherical, cylindrical, N/A)	1		
		Containment structure (multiple choice: pre-stressed concrete, reinforced concrete, steel, pre-stressed concrete + steel, reinforced concrete + steel, reinforced + pre-stressed concrete, steel + concrete, N/A)	1		
		Pressure suppression system (multiple choice: ice condenser, water condenser, pressure suppression pools, containment spray, vacuum building, N/A)	1		
		Additional pressure suppression system (multiple choice: same as for the pressure suppression system)	1		
		Total containment volume	2	m^3	10000 – 100000
		Number of containment spray pumps	2		1 – 6
		Containment design pressure	2	MPa	0.1 – 5
		Design leakage rate	2	% / day	0 – 15
		Type of H_2 recombiner (multiple choice – active, passive, active+passive, N/A)	3		
	Emergency core cooling systems				
		Number of HPSI systems	1		1 – 15
		Number of LPSI systems	1		1 – 6
		Number of hydroaccumulators	1		1 – 16
		Number of core spray pumps	1		1 – 5
		HPSI system pressure	2	MPa	5 – 18
		LPSI system pressure	2	MPa	0.1 – 5
		HPSI system flowrate	2	t/h	10 – 300
		LPSI systems flowrate	2	t/h	10 – 1000
	Reactor protection system				
		Control equipment technology (multiple choice: digital, analogue)	1		
		Number of independent system divisions	2		1 – 5
	Engineered Safeguard Feature Actuation System				
		Control equipment technology (multiple choice: digital, analogue)	1		
		Number of independent system divisions	2		1 – 5
Balance-of-plant systems					
	Turbine				
		Type (multiple choice: saturated steam condensing turbine, superheated steam condensing turbine)	1		
		Number of turbine-generators per unit/reactor	1		1 – 5
		Turbine speed (multiple choice: 1500, 1800, 3000, 3600)	1	rpm	
		Number of HP cylinders per turbine	2		1 – 5
		Number of IP cylinders per turbine	2		1 – 5
		Number of LP cylinders per turbine	2		1 – 5
		HP cylinder inlet steam temperature	3	°C	200 – 600
		HP cylinder inlet steam moisture	3	%	0 – 1
		HP cylinder inlet steam pressure	3	MPa	2 – 17

System			Class	Unit of measure	Validity criteria
		HP cylinder inlet steam flow rate	3	t/h	100 – 10000
	Main generator				
		Rated active power	1	MW(e)	10 – 1600
		Rated apparent power	1	MVA	10 – 1600
		Output voltage	2	kV	5 – 50
		Output frequency (multiple choice: 50, 60)	2	Hz	
	Main condenser				
		Primary means of condenser cooling (multiple choice: cooling towers, lake, river, sea)	1		
		Number of condensers per turbine-generator	1		1 – 5
		Condenser tube material (multiple choice: copper, brass, stainless steel, titanium)	2		
		Number of main condensate pumps	2		1 – 5
		Number of main condensate pumps required for full power	3		1 – 5
		Condenser vacuum at full power	3	kPa (abs.)	0 – 10
	Feedwater system				
		Number of turbine-driven main feedwater pumps	1		1 – 5
		Number of motor-driven main feedwater pumps	1		1 – 5
		Number of start-up feedwater pumps (if different from the auxiliary FWP)	1		1 – 5
		Number of feedwater pumps required for full power operation	3		1 – 5
		Feedwater discharge pressure	3	MPa	1 – 10
		Steam generator inlet feedwater temperature	3	°C	100 – 500
	Auxiliary/emergency feedwater				
		Number of electrical motor-driven pumps	1		1 – 6
		Number of diesel-driven pumps	1		1 – 5
		Number of turbine-driven pumps	1		1 – 5
	Fire protection system				
		On-site fire suppression/extinguishing system (multiple choice: water sprinkler only, water+supplementary chemical systems)	1		
		Fire retardant cable coating (multiple choice: no cables, safety-related cables, safety-related + other systems)	2		
		Cable segregation within the unit (multiple choice: no cables, safety-related cables, safety-related + other systems)	3		
		On-site fire brigade (multiple choice: extra-duty plant personnel, dedicated full time fire brigade)	3		
		Off-site fire brigade response time (multiple choice: less than 30 minutes, more than 30 minutes)	3		
	Emergency power supply systems				
		Number of alternative power sources from the neighbouring units (available per unit)	1		1 – 5
		Number of alternative power sources from the transmission grid (standby transformers available per unit)	1		1 – 5
		Number of on-site safety-related diesel generators (available per unit)	1		1 – 6
		Number of on-site safety-related gas turbines (available per unit)	1		1 – 6
		Number of on-site non-safety-related diesel generators (available per unit)	2		1 – 6
		Number of on-site non-safety-related gas turbines (available per unit)	2		1 – 6
		Other on-site emergency AC power sources	3		text

System			Class	Unit of measure	Validity criteria
		Estimated time reserve of the batteries at full load	3	hours	1 – 5
		Total installed capacity of the on-site emergency power sources per unit	3	MW	1 – 20
		Total battery capacity (per vital power train)	3	Ah	1000 - 50000
Spent fuel storage					
		Reactor building spent fuel pool capacity (number of spent fuel assemblies)	1		100 - 5000
		Interim storage facility type (multiple choice: wet, dry, N/A)	1		
		Interim storage facility capacity (number of spent fuel assemblies)	3		10000 - 200000
Non-electrical applications					
		Primary heat connection (multiple choice: main steam, turbine extraction, N/A)	1		
		Number of heat connection points per unit	1		1 – 5
		Number of intermediate circuits/heat exchangers	1		1 – 5
		Total capacity of heat connections	2	MW	10 - 1000
		Extraction steam pressure	2	MPa	0.5 - 7

2.3. Explanations of individual characteristics in the new structure

In the following sections, explanations are provided of the individual characteristics together with comments on data entry.

2.3.1. Primary systems

This main group of characteristics provides information on the design and parameters of the reactor, the main components of the reactor coolant systems and important nuclear safety systems.

2.3.1.1. Reactor vessel

This group of characteristics describes the reactor component that is generally regarded as the reactor vessel. Depending on the reactor type, it could be a pressure vessel containing a pressurized coolant, as in the case of the PWR, BWR or GCR. It could also be a moderator-containing tank, such as the calandria of CANDU reactors. Or it could be a steel shell containing the reactor core and protecting the graphite moderator from oxidation, as with RBMK reactors. The pressure channels are not considered as a reactor vessel. Nevertheless, some characteristics of pressure channels are listed separately with the reactor vessel characteristics.

Reactor vessel shape – the basic form of the vessel. Most vessels are cylindrical, with flat or hemispherical ends/heads, but some (e.g. Magnox) reactors may have a spherical vessel. Data providers should choose the appropriate option from the following multiple-choice menu: cylindrical-hemispherical end, cylindrical-flat end, spherical.

Reactor vessel centreline orientation – the basic orientation of the reactor vessel, usually corresponding to that of the fuel assemblies. Most reactors are vertical cylinders, although the calandria in the CANDU reactor is a horizontally-oriented cylinder. Data providers should choose the appropriate option from the multiple-choice menu: vertical, horizontal.

Reactor vessel material – typically this is either carbon steel, various kinds of alloyed steel or pre-stressed concrete. Data providers should choose the appropriate option from the following multiple-choice menu: carbon steel, alloyed steel, stainless steel, concrete.

Reactor vessel material specification – data providers should specify precisely the composition of the reactor vessel by stating the percentage of the alloying elements added to the basic carbon steel. The specification should not include the inner cladding.

Reactor vessel cladding material – the material that has been used for cladding the inner surface of the reactor vessel. Cladding is usually used for concrete or carbon steel pressure vessels to improve their leak tightness or their resistance to corrosion. Data providers should choose the appropriate option from the following multiple-choice menu: alloyed steel, stainless steel, N/A.

Reactor vessel cladding material specification - data providers should specify the cladding material either by a commonly-used name (e.g. Inconel, Incaloy) or by stating the percentage of the alloying elements. If no inner surface cladding has been used, "N/A" should be entered.

Reactor vessel overall length/height – the longest dimension of the reactor vessel, measured either horizontally (length) or vertically (height) from one end/top to the other/bottom, including any removable vessel head. Data providers should enter the dimension in metres.

Inside shell diameter – the diameter of the cylinder described by the internal surface of the reactor vessel. The diameter should be entered in metres.

Shell thickness – the total thickness of the rector vessel wall, including cladding. The thickness should apply to the vessel already specified. The dimension should be entered in millimetres, even where vessel shells are up to several metres thick.

The following three characteristics concerning pressure channels apply only to CANDU, RBMK and few other reactors. For most reactors, data providers should enter "N/A".

Number of pressure channels – the total number of pressure channels in the reactor. This characteristic is applicable to reactors where pressure channels are inside the reactor vessel to maintain the coolant under pressure and contain the nuclear fuel. Where applicable, a dimensionless number should be entered.

Pressure channel material – the specification of the material (alloy) used for the pressure channel wall. Data providers should choose the appropriate option from the following multiple-choice menu: carbon steel, stainless steel, manganese steel, Zircaloy, Zr+Nb(2.5%), N/A.

Pressure channel wall thickness – the thickness of the pressure channel itself, not including another channels or tubes that may cover the pressure channel, as for example CANDU calandria channels. Where applicable, dimensions in millimetres should be entered.

2.3.1.2. Reactor core

This group of characteristics gives basic information on reactor core features, parameters and materials, including the nuclear fuel and moderator.

Fuel assembly geometry – the arrangement of individual fuel rods in a single assembly. There are three basic types of fuel geometry: square (in most reactors), hexagonal (in VVER reactors) and cylindrical (in CANDU and RBMK reactors). Some high temperature reactors (pebble bed) use spherical fuel geometry. Data providers should choose the appropriate option from the multiple-choice menu: square, hexagonal, circular, spherical.

Fuel form – the basic shape of the elementary fuel elements. Basically, the fuel is produced as relatively long rods or small flat cylinders (pellets). Data providers should choose the appropriate option from the multiple-choice menu: pellets, rods, coated particles.

Fuel material – the material from which the fuel elements are made. Typical fuel materials are uranium metal and uranium dioxide; however, the material could also be a mixture of uranium dioxide and plutonium dioxide or thorium dioxide. Data providers should choose the appropriate option from the multiple-choice menu: U metal, UO_2, UO_2/PuO_2, UO_2/ThO_2, UO_2/MOX, UO_2/Er_2O_3.

Refuelling type – the method by which the used fuel assemblies in the core are replaced by fresh ones. Basically, the fuel may be replaced either individually, or in small groups during reactor operation on load (at rated or reduced power), or with significant portions of the core off load while the reactor is shut down (during refuelling outages). On-load refuelling is typical for the RBMK, CANDU or GCR (Magnox) reactors. AGR reactors may be refuelled either at a reduced load (still on-load) or when shut down. Other reactors (e.g. PWR, BWR, FBR) are refuelled off-load. Data providers should choose the appropriate option from the multiple-choice menu: on-line, off-line.

Moderator material – data providers should specify the moderator used to slow down fission neutrons. There are three basic moderators: light water (H_2O), heavy water (D_2O) and carbon (C). This characteristic does not apply to the FBR. Data providers should choose the appropriate option from the multiple-choice menu: H_2O, D_2O, C, N/A.

Fuel clad material - the material of the tube containing the fuel pellets or rods. Basically, there are three types of cladding – magnesium alloys (e.g. Magnox), stainless steel, or various zirconium alloys. HTGR reactors use fuel particles coated with pyrolitic carbon and silicon carbide in two layers. Data providers should choose the appropriate option from the multiple-choice menu: magnesium alloy, stainless steel, zirconium alloy, zirconium-magnesium alloy, carbide compound.

Fuel clad material specification - Data providers should specify the fuel cladding material either by a commonly-used name (e.g. Magnox, Zircaloy 2, Zircaloy 4), or by stating the percentage of the alloying elements.

Average fuel enrichment – the average content of the fissile ^{235}U isotope in fresh fuel, expressed as a percentage. This characteristic does not apply to reactors (Magnox, CANDU) using unenriched fuel – natural uranium. In natural uranium, the standard content of the ^{235}U isotope is 0.7%. The actual enrichment may vary with fuel cycles, core designs or may be different in various parts of the core. Data providers should, therefore, enter the average enrichment of the fresh fuel being loaded during the most recent refuelling. For reactors with natural uranium, "N/A" should be entered.

Refuelling frequency – the time period in which a significant part of the core is refuelled (usually called a fuel cycle). This characteristic applies only to reactors with off-load refuelling. Where applicable, data providers should enter the average time period in months from the end of one refuelling to the end of the next one (the fuel cycle length). Shifts in refuelling outage dates, due to fuel management strategies or to varying outage lengths, should not be considered. Most common refuelling frequencies are 12, 18 or 24 months. For reactors with on-load refuelling, "N/A" should be entered.

Part of the core refuelled – the portion of the entire fuel load that is discharged from the core and replaced by fresh fuel during refuelling. Fuel reloads should not be considered. The usual refuelled fraction is 1/3 of the core. This characteristic applies only to reactors with off-load refuelling. Data providers should enter the actual value as a percentage. For reactors with on-load refuelling, "N/A" should be entered.

Average discharge burnup – the average burnup of the fuel when it is considered spent. Fuel not intended for further use in the reactor without reprocessing is discharged (removed) from the core and transported to a spent fuel facility. Burnup is defined as the energy (power multiplied by time) obtained from a specific weight of fuel and represents a fuel utilisation rate. In general, it is lower for natural uranium fuel in reactors having on-load refuelling. The actual average burnup depends on fuel type, enrichment and fuel management strategy, so it may change with time. Data providers should enter the most recent average values expressed in megawatt-days per metric ton of uranium (MWd/MTU).

Active core diameter – the diameter of a circle encompassing the active fuel assemblies in the core (both fissile and fertile), excluding any kind of reflector or reactor vessel shielding. Usually, the active core diameter varies from 2 to 10 metres, but it may also be more than 10 m at some GCR (Magnox) or RBMK reactors. Data providers should enter the most appropriate value in metres.

Active core height/length – the vertical or horizontal (depending on the actual fuel orientation) dimension of the active part of the core, excluding structural components and supports. Most appropriately, the dimension should correspond approximately to the overall length of a fuel assembly rod from the top to the bottom. For pressure channel reactors (RBMK, CANDU) the total length of all fuel assemblies inserted in a pressure channel should be entered instead. Normally, the core height varies from 2 to 5 metres, but it may be also between 5 and 7 metres and some GCR (AGR) reactors have a core up to 8 metres high. Data providers should enter the actual value.

Number of fissile fuel assemblies/bundles – for most reactors, the total number of fuel assemblies in the core. For RBMK and CANDU reactors this is the product of the number of pressure channels and the number of fuel assemblies per channel. For FBRs it is the number of fuel assemblies designed to maintain the fission chain reaction (heat and neutron production).

Number of fertile fuel assemblies – the number of fuel assemblies surrounding the fissile assemblies in the breeding zone. These assemblies, containing mainly depleted ^{238}U (or possibly ^{232}Th), are designed for the production of new fissile material through nuclear transmutation. This characteristic applies to FBRs only. For other reactors, the data providers should enter "N/A".

Fuel weight – the total weight of all nuclear fuel loaded in a reactor core. The value should be roughly a product of fuel rod weight, the number of rods per assembly and the total number of fuel assemblies. Data providers should enter the appropriate value in metric tons.

Moderator weight – the total weight of the reactor moderator. For graphite-moderated reactors, this is the total weight of the graphite. For heavy water moderated reactors, it is the total weight of heavy water in the reactor. For PHWR - CANDU reactors it is the weight of the moderator contained in the calandria. For light water moderated reactors (PWRs and BWRs), the characteristic value should be equal to the total reactor coolant inventory (see 2.3.1.4). Data providers should enter the appropriate value in metric tons.

Number of fuel rods per assembly/bundle – the total number of fuelled rods in a single fuel assembly.

Fuel clad thickness – the wall thickness of the metal tube containing the fuel elements (pellets or rods). Data providers should enter the actual value in millimetres.

Average core power density – the amount of energy generated by specific volume of the core. It can be calculated as a quotient of the rated thermal reactor power and the volume of the core. Data providers should enter the actual value in kW/dm^3.

Average fuel power density – the amount of energy produced by a specific mass of fuel. It can be calculated as a quotient of the thermal reactor power and the total fuel weight. Data providers should enter the actual value in kW/kgU.

Fuel linear heat generation rate – the measurement of achievable heat per linear unit of fuel rod. It is one of the basic technical specifications of the nuclear fuel and may be included also in Limiting Conditions of Operation. Data providers should enter the actual value for fresh fuel in kW/m of rod length.

2.3.1.3. Reactivity control

This group of characteristics basically describes equipment designed to control reactor reactivity and power.

Control rod material – the material of rods used to control reactor reactivity and power (including coarse and fine power control, burnup compensation and scram rods). Data providers should choose the appropriate option from the multiple-choice menu: boron stainless steel, cadmium stainless steel, boron carbide stainless steel, carbon steel, boron carbide, boron carbide/hafnium, boron carbide/cadmium alloy, cadmium alloy, Ag-In-Cd alloy.

Burnable neutron absorber material – the neutron absorbing material that decreases because of neutron absorption (burnup). The process of absorber decrease results in positive reactivity being inserted into the core. A burnable absorber is incorporated into the fuel in various forms to compensate for decreasing reactivity resulting from burnup of fissile ^{235}U material and increasing fuel poisoning by fission products. A typical burnable poison material is ^{203}Gd. Data providers should choose the appropriate option from the multiple-choice menu: gadolinium, boron, gadolinium/boron, boron/hafnium, other, N/A.

Burnable neutron absorber material specification – data providers should specify the form of the burnable neutron absorber (e.g. B_4C or Al_2O_3-B_4C).

Soluble neutron absorber material – the neutron absorbing material dissolved in the moderator to compensate for fuel burnup or to maintain the required reactor shutdown margin. During reactor operation, the soluble neutron absorber is gradually removed by diluting the moderator. Data providers should choose the appropriate option from the multiple-choice menu: H_3BO_3, N/A.

Secondary reactivity control system – a system, additional to the control or shutdown rods, which is designed to shutdown the reactor or keep it deeply and permanently subcritical after being shut down by the control rods and subsequent cooling down. Data providers should choose the appropriate option from the multiple-choice menu: H_3BO_3 injection, nitrogen injection, Gd injection, liquid zone control, N/A.

Number of control rod assemblies – the total number of all control rod assemblies of any kind (power control, compensation, scram) used in the reactor under consideration. If the control rods are arranged in clusters, the entire clusters should be counted as a whole, rather than counting individual rods in the cluster. Basically, the characteristic value should agree with the number of control rod drives.

2.3.1.4. Reactor coolant system

This group of characteristics provides information on the basic arrangement and parameters of the system designed to remove heat from the reactor core.

Number of external reactor coolant loops – the number of separate pipeline loops externally attached to the reactor that are used to recirculate reactor coolant through the reactor. Each loop includes at least one reactor coolant (recirculation) pump. For boiling water reactors, it is the number of loops recirculating coolant through the reactor or returning reactor coolant from the steam separators to the reactor. For reactors with a primary circuit (including reactor coolant pumps and steam generators/boilers) integrated in the reactor pressure vessel, such as an AGR or some FBRs, data providers should enter "N/A".

Coolant type – the liquid used primarily to remove heat from the reactor fuel. This does not include separate fluids used to cool the moderator. Data providers should choose the appropriate option from the multiple-choice menu: carbon dioxide, light water, heavy water, sodium, helium.

Coolant weight – the total weight of coolant in the primary circuit at standard ambient temperature 20°C. For light water reactors (PWR and BWR), this value equals the moderator weight. Data providers should enter the actual value in metric tons.

Operating coolant pressure – the overall coolant pressure at which the reactor is operated, while critical. For pressurized water reactors, the operating pressure in the pressurizer should be entered. For other reactors, the coolant pressure at the reactor/pressure channel outlet should be entered. Data providers should enter the actual value in MPa (1MPa = 10 bar = 10.19 kg/cm^2).

Reactor outlet temperature – the coolant temperature at the outlet of the reactor core. If such a value is not available (measured), the average temperature in the hot leg of the coolant loops should be used instead. The actual value should be expressed in °C.

Reactor inlet temperature – the coolant temperature at the inlet to the reactor core. If this specific value is not available (measured), the average temperature in the cold leg of the coolant loops (at the reactor coolant pump discharge) should be used instead. The actual value should be expressed in °C.

Coolant mass flow at the rated power – the total mass flow of the coolant through the reactor when operating at the rated power[2]. It can be roughly determined according to the following equation:

$$F = \frac{P_{th}}{c_p \cdot \Delta T},$$

where

P_{th} = the rated thermal power of the reactor.
C_p = the specific heat of water at the operating pressure and temperature.
ΔT = the difference between the reactor outlet and inlet temperature (core heatup).
The value entered should be indicated in metric tons per hour (t/h).

2.3.1.5. Steam generators (SG)/drum separators

This group of characteristics identifies the components designed to generate non-nuclear steam or to separate moisture from the steam produced in the reactor. These characteristics do not apply to boiling light water reactors (BWRs); accordingly, for all characteristics concerning SGs at BWRs, data providers should enter "N/A".

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[2] The volumetric flowrate at the operating coolant temperature will be higher due to the water density decreasing with temperature

Type of SG – this characteristic is related to the basic orientation of the SG shell and tubes. Most steam generators are in the form of a vertical cylinder with hemispherical heads, horizontal flat tubesheet(s) and vertically-oriented straight or bent tubes in the shape of the letter "U" (U-tubes). VVER reactors have horizontally-oriented steam generators with vertical cylindrical tubesheets and horizontally-oriented U-tubes. For other reactors, e.g. FBRs, HTGRs or GCRs, other special steam generators may be used. Data providers should choose the appropriate option from the multiple-choice menu: vertical, horizontal, modular, N/A.

SG output – the nature of steam generated by the steam generator. Most SGs generate dry saturated steam, but the GCR or HTGR may generate superheated steam having parameters comparable to those of conventional coal or gas-fired power plants. Data providers should choose the appropriate option from the multiple-choice menu: saturated steam, superheated steam, N/A.

Number of SGs – the number of steam generators per primary/secondary circuit. For a loop configuration, the number of SGs should be equal to the number of primary (secondary for FBRs) circuit loops. For FBRs, the characteristic should be entered in the following form: "number of primary-to-secondary heat exchangers/number of steam generators". For modular steam generators, the number should be entered in the following form: "number of steam generators/number of modules per steam generator".

Number of drum separators – the number of components of RBMK (or possibly some other minor type) reactors used to separate moisture from the steam produced in the reactor. For reactors other than RBMK, data providers should enter "N/A". Data providers should choose the appropriate option from the multiple-choice menu: 4, 6, N/A.

Tube shape – the prevailing or typical form of the SG heat exchanging tubes. The majority of steam generators have either straight tubes or U-tubes. Data providers should choose the appropriate option from the multiple-choice menu: U-tube, straight, mushroom, finned, helical, N/A.

Tube material - the material of the heat exchanging tubes. Usually, it is a stainless steel. Data providers should enter either the common name of the material (e.g. stainless steel) including the alloying elements (e.g. Cr-Ni-Ti) or a commonly-used commercial name (e.g. Inconel 600, 690, Incaloy 800).

SG shell material – the material of the SG outer shell (vessel). It is usually made of carbon steel. If the vessel includes an inner cladding, the characteristic should be entered in the following form: "base material/cladding material".

Drum separator shell material – the material of the RBMK steam drum outer shell (vessel). For reactors other than RBMK, data providers should enter "N/A".

Design thermal capacity – the maximum thermal power that may be transferred from the primary to secondary circuit by one steam generator. It is approximately equal to the rated reactor thermal power divided by the number of steam generators. The actual SG capacity may be lower due to plugged heat exchanging tubes that had been leaking. The original (as manufactured) value should be entered in MW.

Design heat transfer surface – the total surface of all the heat exchanging tubes in one steam generator. It is the product of the total number of tubes in a new SG and the lateral area of a tube (cylinder). The actual value may decrease during plant service as a result of successive plugging of leaking tubes. The original (as manufactured) value should be entered in m^2.

2.3.1.6. Main coolant pumps/circulators

This group of characteristics concerns the components of the reactor coolant system that are designed to circulate coolant through the reactor to remove heat from the core. Based on the type of coolant, they include both liquid pumps and gas circulators (blowers).

Number of pumps/circulators – the total number of reactor coolant pumps, recirculation pumps or gas circulators (blowers) in the reactor coolant system (RCS).

Number of pumps per RCS loop - the number of reactor coolant pumps, recirculation pumps or gas circulators (blowers) in one external RCS loop. For units with no external coolant loops data providers should enter “N/A”.

Pump/circulator motor rating – the electric power input to the reactor coolant pump or circulator motor at the normal operating parameters of the coolant. The actual value should be entered in MW. For units that use steam driven pumps or circulators, data providers should enter "N/A".

Design pressure difference – the difference between the reactor coolant pump discharge pressure and suction pressure. This is usually one of the basic technical specifications of the pump/blower. Unlike pump head pressure, it is independent of the overall system pressure or medium flowrate. The actual value should be entered in MPa.

2.3.1.7. Pressurizer

These characteristics relate to the RCS component of a PWR that is designed to maintain the RCS operating pressure and to compensate for any changes in reactor coolant volume and pressure with temperature. The pressurizer is the only component of the RCS of a PWR which contains steam. For all reactors that do not use a pressurizer, data providers should enter "N/A".

Total volume – the total internal volume of the pressurizer vessel. This value should be the sum of the steam and water volume of the pressurizer. The actual value should be indicated in m^3.

Number of safety valves – the number of valves on the pressurizer designed to open, in the event of an unacceptable increase of reactor coolant pressure, to protect the RCS from damage by overpressure.

Number of relief valves – the number of valves on the pressurizer designed to relieve the pressurizer (RCS) pressure to the relief tank, to prevent the safety valves from opening. The relief valves usually open at a lower pressure (earlier) than the safety valves and may have a lower flowrate capacity.

Installed heater power – the power rating (total input power) of all the electrical heaters installed in the pressurizer to increase the pressure by warming the water. The actual value should be entered in kW.

2.3.1.8. Containment systems

This group of characteristics specifies the structure around a reactor, designed to protect the reactor from outside intrusion and protect the outside from radiation effects, in case of a malfunction inside the structure. Except for the reactor, the containment usually contains all the reactor coolant system components. They are either designed to withstand the maximum pressure expected after a design basis accident (DBA), in which case they are termed full-pressure containments, or they may have installed systems to reduce the DBA containment pressure, when they are termed pressure-suppression containments. The containment must be sufficiently tight to keep any released radioactive gases inside the structure.

Containment type – the overall configuration of the containment. The basic type of containment is a cylindrical concrete or steel structure. Concrete structures may have their inner surface covered by a steel lining to reduce the leak rate. This type is termed single containment. To improve the safety function of the containment, a steel structure containing the reactor and the entire RCS may be installed within an outer concrete containment, and gases accumulating in the gap between the two containments are filtered and released through a ventilation stack. The internal steel structure, which may be either spherical or cylindrical, is called the primary containment, while the outer concrete structure is called the secondary containment. This configuration is termed a double type of containment. Double containment with the primary containment containing only a part of the RCS is termed partially double. Some older reactor types may have only the RCS installed within a structure designed to maintain the coolant pressure after a loss of coolant accident, while the reactor is housed solely in a conventional reactor building structure. Such a type of "partial" containment is termed confinement. For this characteristic, data providers should choose the appropriate option from the multiple-choice menu: single, double, partially double, confinement, N/A.

Containment shape – the geometric form of the hermetic internal structure containing the reactor and primary circuit. For NPPs with confinement or without any type of containment, “N/A” should be entered. Data providers should choose the appropriate option from the multiple-choice menu: spherical, cylindrical, N/A.

Containment structure – the material of the containment: A single containment or confinement is usually made of pre-stressed or reinforced concrete, a double containment is made of concrete and steel. Data providers should choose the appropriate option from the multiple-choice menu: pre-stressed concrete, reinforced concrete, steel, pre-stressed concrete + steel, reinforced concrete + steel, reinforced + pre-stressed concrete, steel + concrete, N/A.

Pressure-suppression system – this characteristic applies to pressure-suppression containments only. It specifies the system used for reducing containment or confinement pressure after a loss of coolant accident. Typical pressure suppression systems include passive ice or water condensers of various designs, or active containment spray systems. Some reactors may also use pressure suppression pools designed for both steam condensation and containment spray. Other reactors may use vacuum buildings designed to suck in the leaking coolant as it expands to steam. Data providers should choose the appropriate option from the multiple-choice menu: ice condenser, water condenser, pressure suppression pools, containment spray, vacuum building, N/A.

Additional pressure suppression system – this characteristic applies to reactor units having a containment pressure suppression system additional to the one above one. Data providers should choose the appropriate option from the same multiple-choice menu: ice condenser, water condenser, pressure suppression pools, containment spray, N/A.

Total containment volume – the total internal (void) volume of the containment without the internal equipment. For double containment, the volume of the primary containment should be entered. For confinement, the total volume of the confinement (hermetically sealed - hermetic) areas should be entered. The appropriate value should be indicated in m^3.

Number of containment spray pumps – this characteristic applies to reactor units with an active containment/confinement spray system. Thus this characteristic identifies units using this active containment pressure suppression system, and also specifies the number of containment spray pumps. For units with no active containment spray system data providers should enter "N/A".

Containment design pressure – a maximum internal overpressure (above atmospheric pressure) that the containment is able to withstand at a designed leak rate. The actual value should be indicated in MPa (0.1 MPa = 1 bar = 1.019 kg/cm^2). For reactors without any containment or confinement, data providers should enter "N/A".

Design leakage rate – the portion of the containment air volume that leaks from the containment over a 24 hour period. This parameter is periodically tested and is usually calculated from the confinement pressure decrease over a time period. The actual value should be entered as a percentage per day.

Type of H2 recombiner – equipment used to recombine (burn) any hydrogen that may be generated by the reaction of the zirconium fuel cladding with steam (at temperatures above 600°C) during a serious loss of coolant accident. The recombiner may be either passive (a hydrogen-oxygen reaction catalyzer) or active (e.g., a sparking device continually igniting small amounts of hydrogen). Data providers should choose the appropriate option from the multiple-choice menu: active, passive, active+passive, N/A.

2.3.1.9. Emergency core cooling systems

The characteristics in this group identify the systems used to maintain reactor core cooling if there is a loss of the normal reactor coolant. These systems usually include both active and passive systems (safety injection pumps and core flooding hydroaccumulators). Safety injection pumps should be considered as such pumps if they can be automatically started by an Engineered Safeguard Feature Actuation System (ESFAS) or a similar safety signal.

Number of HPSI systems – the number of high-pressure safety injection systems designed to make up for reactor coolant losses in the case of a relatively small leakage, when the pressure drop is small. For reactors without a HPSI system, data providers should enter "N/A".

Number of LPSI systems – the number of low-pressure safety injection systems designed to remove residual heat from the reactor core in the case of a considerable loss of coolant, when the coolant pressure drops significantly. Such LPSI systems with a high flowrate may also be used for residual heat removal after normal reactor shutdown. For reactors without an LPSI system, data providers should enter "N/A".

Number of hydroaccumulators – the number of pressurized water tanks designed to flood the reactor core once the reactor coolant pressure drops below the hydroaccumulator pressure. For reactors without hydroaccumulators, data providers should enter "N/A".

Number of core spray system pumps – this characteristic applies only to BWRs. For other reactors, data providers should enter "N/A".

HPSI system pressure – means the water pressure delivered by the HPSI system to the reactor. Normally, HPSI pump head pressure at the rated HPSI pump flowrate will be entered. Units using other systems of high pressure safety injection (e.g. a gas-driven water injection used at CANDU reactors) should enter the maximum attainable pressure of water being injected by HPSI to the core. The appropriate value should be expressed in MPa.

LPSI system pressure – means the water pressure delivered by the LPSI system to the reactor. Normally, LPSI head pressure at the rated LPSI pump flowrate should be entered. For other systems of low pressure safety injection, the maximum attainable pressure of water being injected by LPSI to the core should be entered. The appropriate value should be expressed in MPa.

HPSI system flowrate – means the flowrate of water delivered by the HPSI system to the reactor. Normally, rated value of HPSI pump flowrate will be entered. Units using other systems of high pressure safety injection (e.g. a gas-driven water injection used at CANDU reactors) should enter maximum attainable flowrate of water being injected to the core. The appropriate value should be expressed in metric tons/hour.

LPSI system flowrate – means the flowrate of water delivered by the LPSI system to the reactor. Normally, rated value of LPSI pump flowrate will be entered. For other systems of low pressure safety injection, the maximum attainable flowrate of water being injected by LPSI to the core should be entered. The appropriate value should be expressed in metric tons/hour.

2.3.1.10. Reactor protection system

This group of characteristics generally specifies the system designed to scram the reactor.

Control equipment technology – the main control component on which the reactor protection system (RPS) is based. Typically, the reactor protection system may be computer controlled with the reactor trip signals being processed and generated by software (a digital system), or the reactor trip signals are processed by analogue gauges and generated by analogue relays (an analogue system). Data providers should choose the appropriate option from the multiple-choice menu: digital, analogue.

Number of independent system divisions – the RPS redundancy. Each of such independent divisions is fully capable of performing all RPS functions on its own.

2.3.1.11. Engineered Safeguard Feature Actuation System (ESFAS)

This group of characteristics specifies the ESFAS designed to control the safety injection, containment isolation and other major components (reactor coolant pumps, service water pumps, HVAC system) in the case of an emergency situation at the unit.

Control equipment technology – the main control component on which the ESFAS is based. Typically, the ESFAS may be computer controlled with ESF actuation signals being processed and generated by software (a digital system), or the ESF actuation signals are processed by analogue gauges and generated by analogue relays (an analogue system). Data providers should choose the appropriate option from the multiple-choice menu: digital, analogue.

Number of independent system divisions – the ESFAS redundancy. Each of such independent divisions is fully capable of performing all RPS functions on its own.

2.3.2. Balance-of-plant systems

This main group of characteristics provides information on conventional plant systems used to generate electricity.

2.3.2.1. Turbine

This group of characteristics specifies the main component of the conventional plant, the steam turbine used to drive the electrical generator.

Type – the turbine type, based on the main steam parameters at the turbine inlet. Data providers should choose the appropriate option from the multiple-choice menu: saturated steam condensing turbine, superheated steam condensing turbine.

Number of turbine-generators per unit/reactor – the number of turbines installed at the reactor unit to generate the rated unit power.

Turbine speed – the speed of turbine rotation in revolutions per minute (rpm) at power operation when connected to the grid. The actual value depends on the generator design and its output voltage frequency. Data providers should choose the appropriate option from the multiple-choice menu: 1500, 1800, 3000, 3600.

Number of HP cylinders per turbine – the number of high-pressure parts of the turbine. The HP cylinder (turbine) is the "introductory" part of the main turbine closest to the main steam inlet. It consists of a set of HP wheels, usually in a double-flow configuration.

Number of IP cylinders per turbine - the number of intermediate-pressure parts of the turbine. The IP cylinder is the part of a turbine between the high-pressure and low-pressure cylinders. It consists of a set of IP wheels, usually in a double-flow configuration. This characteristic may apply only to units with superheated steam turbines. For units that do not have IP cylinder turbines, data providers should enter "N/A".

Number of LP cylinders per turbine - the number of low-pressure parts of the turbine. The low-pressure cylinders are the final parts of a turbine closest to the generator and with the main condenser attached. They consist of a set of LP wheels, usually in a double-flow configuration.

HP cylinder inlet steam temperature – the main steam temperature before the turbine stop valves (or in the main steam line) at the rated turbine power. The actual value should be indicated in °C.

HP cylinder inlet steam moisture – the approximate water content of the saturated steam before the turbine stop valves. If this value is not available, the steam moisture at the SG or reactor outlet should be used instead. The actual value should be indicated as a percentage of water in a unit amount of steam. For units producing superheated steam, data providers should enter 0%.

HP cylinder inlet steam pressure - the main steam pressure before the turbine stop valves (or in the main steam line) at the rated turbine power. The actual value should be indicated in MPa.

HP cylinder inlet steam flow rate - the total main steam flowrate in all the main steam lines to the turbine (or at the associated steam generator outlets) at the rated turbine power. The actual value should be indicated in metric tons per hour (t/h).

2.3.2.2. Main generator

This group of characteristics specifies the major unit component attached to the turbine and designed to produce electric power from the unit.

Rated active power – the maximum active (real) power the generator can produce (if measured at its outlet terminals) without any risk of damaging the generator. This value is used primarily for generator design calculations. The active power is defined by the following formula:

$$P = U_{rms} \cdot I_{rms} \cdot \cos\phi ,$$

where

U_{rms} = root mean square (effective) voltage at the generator output
I_{rms} = root mean square (effective) current at the generator output
cos ϕ = power factor
ϕ = phase angle between the AC voltage and the current sinusoidal waveforms.

The actual rated active power value should be indicated in megawatts (electrical) MW(e).

Rated apparent power - a measure of the alternating current (AC) power that is computed by multiplying the root-mean-square (rms) current by the root-mean-square voltage. It is determined by the following formula:

$$P = U_{rms} \cdot I_{rms}$$

The actual rated apparent power is one of basic technical specifications of the generator. The actual value for the unit should be expressed in megavolt-amperes (MVA).

Rated output voltage – the effective (root mean square) voltage for which the generator is designed. The actual generator output voltage is adjusted to this value. The appropriate rated voltage value should be expressed in kilovolts (kV).

Rated output frequency – the standard frequency of the generator output voltage in Hertz (Hz). Data providers should choose the appropriate option from the multiple-choice menu: 50, 60.

2.3.2.3. Main condenser

This group of characteristics specifies the component designed to maintain a pressure drop along the turbine, and to condense the turbine outlet steam.

Primary means of condenser cooling – the predominant ultimate heat sink from where the cooling water is taken. Data providers should choose the appropriate option from the multiple-choice menu: cooling towers, lake, river, sea. If, for example, the condenser is normally cooled by river water, but during a hot summer, the cooling is supported by using a cooling tower, the river should be chosen as the appropriate option.

Number of condensers per turbine-generator – the number of separate condenser vessels attached to one main turbine. Usually, this number corresponds to the number of low-pressure turbine cylinders.

Condenser tube material – the basic material of the condenser tubes. Data providers should choose from the multiple-choice menu: copper, brass, stainless steel, titanium.

Number of main condensate pumps – the number of pumps per turbine designed to transport the main condensate from the condenser to a feedwater tank. For units that have separate booster condensate pumps installed, data providers should enter the following: "number of main condensate pumps/number of booster pumps".

Number of main condensate pumps required for full power – the number of condensate pumps that are normally in operation at the rated turbine power. It is usual for some of the condensate pumps available to be on standby in case an operating pump trips. The value should be entered in the same form as for the total number of condensate pumps.

Condenser vacuum at full power – the absolute pressure in the condenser at full turbine power (rated steam flowrate) and standard cooling water temperature (usually 20°C). The actual value should be expressed in kPa (1 kPa = 0.01019 kg/cm^2).

2.3.2.4. Feedwater system

This group of characteristics contains basic information on those components of the system that are designed to provide feedwater to the steam generators or to the reactor.

Number of turbine driven main feedwater pumps – the number of main feedwater pumps per unit, for which the driving force is provided by a steam turbine (other than the main turbine). For units without any turbine-driven main feedwater pumps, data providers should enter "N/A".

Number of motor-driven main feedwater pumps - the number of main feedwater pumps per unit, for which the driving force is provided by an electrical motor. For units without any motor-driven main feedwater pumps, data providers should enter "N/A".

Number of start-up feedwater pumps - the number of smaller feedwater pumps that may be used to feed the steam generators or the reactor at low reactor power (usually up to 5% of power), when the main feedwater pumps would be too powerful (would not operate under optimal flowrate conditions). This characteristic applies only to units that have these start-up feedwater pumps in addition to auxiliary feedwater pumps. For units that use auxiliary feedwater pumps to feed the steam generators/reactor at low reactor power, data providers should enter "N/A".

Number of feedwater pumps required for full power operation - the number of main feedwater pumps that are normally in operation at rated unit power. It is usual for some of the available feedwater pumps to be on standby in case an operating pump trips. If turbine-driven and motor-driven feedwater pumps are operated simultaneously, the value should be entered in the following form: "number of operating turbine-driven feedwater pumps/ number of operating motor-driven feedwater pumps".

Feedwater discharge pressure – the typical pressure at the feedwater pump discharge at the rated unit power and standard configuration of the operating feedwater pumps. The appropriate value should be entered in MPa (1 MPa = 10.19 kg/cm^2).

Steam generator inlet feedwater temperature – the feedwater temperature at the steam generator or reactor inlet, after being heated in high-pressure regenerative heaters. The appropriate value should be expressed in °C.

2.3.2.5. Auxiliary/emergency feedwater

This group of characteristics specifies components of a standby feedwater system that is started if the main feedwater system is not available because of a failure. These systems should have an independent power source available after loss-of-offsite-power events. The auxiliary feedwater pumps are usually connected to the main feedwater tank and may also be used as normal start-up feedwater pumps at low reactor power (see above). The emergency feedwater system is usually designed for use in case of a catastrophic failure of the main feedwater system, e.g. if a common feedwater pipeline ruptures, making both main and auxiliary feedwater pumps unavailable. The emergency feedwater pumps and flowpaths should be different to those of the main and auxiliary feedwater.

Number of electrical-motor-driven pumps – the number of auxiliary or emergency feedwater pumps driven by an electrical motor that are installed at the unit. The appropriate value should be entered in the following form: "number of electrical-motor-driven auxiliary feedwater pumps/ number of electrical-motor-driven emergency feedwater pumps"

Number of diesel-driven pumps – the number of auxiliary or emergency feedwater pumps driven by a diesel motor that are installed at the unit. The appropriate value should be entered in the following form: "number of diesel-motor-driven auxiliary feedwater pumps/number of diesel-motor-driven emergency feedwater pumps".

Number of turbine-driven pumps – the number of auxiliary or emergency feedwater pumps driven by a turbine that are installed at the unit. The appropriate value should be entered in the following form: "number of turbine-driven auxiliary feedwater pumps/number of turbine-driven emergency feedwater pumps".

2.3.2.6. Fire protection system

This group of characteristic specifies the means of response to a fire at the NPP.

On-site fire suppression/extinguishing system – the system used to extinguish or suppress a fire in fire-protected plant areas. At some NPPs, a water sprinkler or spray only is used. At other NPPs, fire-extinguishing chemicals can also be used in selected areas, either to increase fire suppression system efficiency, or to protect sensitive electronic equipment from water intrusion. Data providers should choose the appropriate option from the multiple-choice menu: water sprinkler only, water + supplementary chemical systems.

Fire retardant cable coating – the systems and cables that are fire-protected by a special non-flammable coating. At some NPPs only the safety system cables are coated, while at other NPPs other vital systems also have coated cables. Data providers should choose the appropriate option from the multiple-choice menu: no cables, safety-related cables, safety-related + other systems.

Cable segregation within the unit – those systems having cables in individual divisions segregated in order to prevent fire in one division from spreading to a neighbouring division. Data providers should choose the appropriate option from the multiple-choice menu: no cables, safety-related cables, safety-related + other systems.

On-site fire brigade – the staffing of the on-site fire brigade. At some NPPs, the fire brigades consist of specially appointed and trained personnel, who normally perform other duties and are called on, when needed, to deal with a fire. At other NPPs, the brigade consists of full-time dedicated firemen. Data providers should choose the appropriate option from the multiple-choice menu: extra-duty plant personnel, dedicated full-time fire brigade.

Off-site fire brigade response time – the time taken by an off-site fire brigade (e.g. from a neighbouring town) to arrive at the NPP, after a fire alarm is actuated or announced. Data providers should choose the appropriate option from the multiple-choice menu: less than 30 minutes, more than 30 minutes.

2.3.2.7. Emergency power supply systems

This group of characteristics generally specifies power supply systems that are available at the unit in case of a loss of unit auxiliary power caused by a turbine or main generator trip. At some NPPs, dedicated neighbouring power plant units are used as an alternative source of auxiliary power. Most NPPs also have dedicated off-site transmission lines to supply on-site reserve transformers as alternative sources of unit auxiliary power. Units usually have on-site emergency power sources, such as diesel generators, gas turbines and accumulator batteries, in case all off-site power sources are lost.

Number of alternative power sources from neighbouring units - the number of neighbouring dedicated (directly connected) plant units available as an alternative auxiliary power source. If no such dedicated unit is available, "N/A" should be entered.

Number of alternative power sources from the transmission grid – the number of redundant reserve/standby transformers available to the unit as alternative auxiliary power sources. These transformers are usually connected to a separate transmission line, distinct from the unit output transmission line, to provide auxiliary power to the unit in case of an output transmission line failure. If more reserve transformers are needed to power all unit loads, they are counted as a single power source. Reserve transformers common to more than one unit at multi-unit NPPs are counted for each connected unit. If no reserve transformer is available to the unit, "N/A" should be entered.

Number of on-site safety-related diesel generators – the number of diesel generators assigned as emergency power sources to the safety-related equipment of the unit (emergency core cooling pumps, service water pumps etc.). For multi-unit NPPs, only the diesel generators dedicated to the unit should be counted. For units without any safety-related emergency diesel generators, data providers should enter "N/A".

Number of on-site safety-related gas turbines - the number of gas turbines assigned as emergency power sources to the safety-related equipment of the unit (emergency core cooling pumps, service water pumps etc.) instead of the diesel generators. For multi-unit NPPs, only gas turbines dedicated to the unit should be counted. For units without any safety-related gas turbines, data providers should enter "N/A".

Number of on-site non-safety-related diesel generators – some NPPs may have additional emergency diesel generators supplying other important equipment that is not directly safety-related (e.g. RCS makeup pumps, auxiliary feedwater pumps). A load-sequencing logic, different to that of the safety-related diesel generators, may control these diesel generators. For multi-unit NPPs, only those non-safety-related diesel generators dedicated to the unit should be counted. For units without any non-safety-related emergency diesel generators, data providers should enter "N/A".

Number of on-site non-safety-related gas turbines – similarly to the safety-related emergency power sources, this is the number of gas turbines installed at some NPPs instead of non-safety-related diesel generators. For multi-unit NPPs, only those non-safety-related gas turbines dedicated to the unit should be counted. For units without any non-safety-related gas turbines, data providers should enter "N/A".

Other on-site emergency AC power sources – data providers should specify on-site emergency AC power sources additional to the safety-related and non-safety-related diesel generators or gas turbines that may be available for unit safety or for safety-related equipment. For units without any additional on-site emergency AC power sources, data providers should enter "N/A".

Estimated time reserve of the batteries at full load – the time period that the batteries of the above capacity would be able to supply power to all the connected vital plant equipment, if it is the only available power source in the train/division (in the case of a total power blackout). The appropriate value should be indicated in hours.

Total installed capacity of the on-site emergency power sources per unit – the sum of auxiliary AC power available to the unit from all the emergency power sources (both safety-related and non-safety-related diesel generators and gas turbines) installed at the NPP. The appropriate value should be expressed in megawatts electrical (MW(e)).

Total battery capacity (per vital power train) – the capacity of all the accumulator batteries installed as non-interruptible power sources in a redundant vital power supply train (supplying vital unit equipment such as reactor protection, reactor control, ESFAS and other safety-related I&C systems). The capacity is defined as the maximum DC current which the batteries can supply for an hour. The appropriate value should be expressed in ampere-hours (Ah).

2.3.3. Spent fuel storage

This group of characteristics specifies on-site facilities designed to contain the spent fuel assemblies discharged from the reactor. Basically, there can be two types of spent fuel storage facilities available on site to the unit: a spent fuel pool and an interim spent fuel storage facility. The spent fuel pool is usually located in the containment or in the reactor building next to the reactor to facilitate the transport of fuel from the reactor to the pool by a refuelling machine. The spent fuel pool is partially filled with water and the assemblies are left in the water for several years to allow the fuel activity (decay heat) to decrease. After that, it may be transported to an on-site interim storage facility, where it can be stored for several decades before it is placed in a permanent repository.

Reactor building spent fuel pool capacity – the maximum number of spent fuel assemblies that can be placed in the spent fuel pool in the reactor building.

Interim storage facility type – the basic design of the interim storage facility. The facility may be designed as a building with a big pool having a higher capacity than the spent fuel pool where the fuel assemblies are submerged under water. This type of facility is considered wet. In other facilities, the spent fuel assemblies are inserted in hermetically sealed (hermetic) shielded casks which are stored in a conventional building. This type of facility is considered dry. Data providers should choose the appropriate option from the multiple-choice menu: wet, dry, N/A.

Interim storage facility capacity – the maximum number of spent fuel assemblies that can be placed in the interim storage facility. For multiple unit NPPs, data providers should enter the capacity per unit. For units with no on-site interim storage facility, "N/A" should be entered.

2.3.4. Non-electrical applications

This group of characteristics applies to units that provide some of the energy generated in the reactor to off-site applications other than the generation of electricity. The energy is usually provided in the form of steam for district heating, or desalination or as process heat to other industrial facilities. For units that do not provide heat to any off-site non-electrical applications, data providers should enter "N/A" for all the following characteristics. Providing heat to any on-site facility is not considered a non-electrical application.

Primary heat connection – the point at the unit from where most of the process steam is taken. Basically, it may be either a main steam line or a turbine extraction pipeline. Data providers should choose the appropriate option from the multiple-choice menu: main steam, turbine extraction, N/A.

Number of heat connection points per unit – the total number of points from where steam used for non-electrical applications is taken. Some units may supply steam with various parameters to several different applications. In such cases more than one connection point may exist at the unit.

Number of intermediate circuits – the total number of heat transferring circuits “in series” that separate the primary heat source (main steam, turbine extraction steam) from the heat consumer (non-electrical application), ensuring no radioactivity gets into the non electrical application product (fresh water or heating system). The number of intermediate circuits may be one or more (for example RBMK or BWR reactors having radioactive steam in turbines). Possible parallel intermediate circuits connected to separate extraction points are not counted separately – they are considered as one intermediate circuit. Some plants may not have installed any intermediate circuits, if the main or extraction steam is directly used to heat the exchangers in the central heating system. For such plants, data providers should enter "N/A".

Total capacity of heat connections – the maximum thermal power that can be diverted from the unit to the non-electrical applications. The maximum capacity should be limited by parameters of the associated heat exchangers. The actual value should be indicated in megawatts thermal (MWt).

Extraction steam pressure – the typical pressure of the steam at the primary heat connection. The actual value should be indicated in MPa.

3. CONCLUSION AND SUGGESTIONS

Reactor unit design characteristics are a significant component of the PRIS database. Significantly, they represent a comprehensive source of information on all reactor units worldwide, whether in operation, under construction or permanently shutdown. In combination with other PRIS data and outputs, such as production data, outage data and performance indicators, design characteristics offer an important tool for various performance analyses. The classification system enables the appropriate characteristics to be used as convenient selection or filtration criteria for choosing reactor units suitable for a particular analysis, thereby improving the relevancy of such analyses.

The complete set of unit design characteristics should provide all significant information on unit parameters, equipment and processes. In the form presented, the design characteristics can be used for the following main purposes:

- As a part of the PRIS database, the characteristics serve as the most comprehensive single source of information on the design of all operating, constructed, and shutdown units worldwide.
- When addressing a technical problem, NPP personnel can use the design characteristics to identify units having the same or a similar design of the pertinent equipment.
- Design characteristics can be used to select groups of units having comparable design or operating conditions for relevant operational performance analyses or performance trends.
- Design characteristics can also be used for various comparative studies performed to identify differences in design of a selected group of reactors. For example, they may be used to study gradual design developments of various models of the same reactor types.

Appropriate unit schematics or drawings would enhance applicability of the design characteristics to the above purposes. The following types of drawing, at least, should be included in the PRIS database:

- A simplified or functional cross-section of the containment/reactor building, including the main components and the pressure suppression system. This kind of drawing is currently available for some reactor types, even on the Internet.
- Operating flow diagrams of the primary system with all the main components (reactor, RCP, loops, steam generators, pressurizer etc.) including the ECCS (pumps, tanks, piping) and connections of the ECCS to the primary circuit. The diagrams should show at least the components included in the primary system design characteristics.
- Any additional diagrams and schematics (for example those of the balance-of-plant systems) can be provided if available or found useful by the NPP personnel.

Annex

CHANGES TO THE ORIGINAL DESIGN CHARACTERISTICS

In the revision of the original set of unit design characteristics in the PRIS database, the following main changes have been made:

- Most of the existing characteristics have been retained, but several new characteristics have been added if they were not included in the original set but are considered significant.
- Characteristics considered too detailed or otherwise problematic have been deleted. Also all the "questionnaire (Yes/No) type" characteristics have been consistently eliminated – their removal has been also justified by their very low completion rate in the past.
- Some of the characteristics have been combined with others or transferred to another group.
- For some characteristics, minor changes in wording or terminology have been made.
- The elimination, transfer or combination of individual characteristics, caused some of the original characteristic groups to be without parameters, so they have been deleted completely.

Table A-1 provides a complete list of the original set of unit design characteristics in the PRIS database, including all changes or modifications made within the current revision.

Table A-1: Changes to the original set of design characteristics

Item Order	Original design characteristic name	Comment on an item change
	Core and reactivity control	Split into two groups: "**Reactor core**" and "**Reactivity control**"
1	Fuel material	Multiple choice included; moved to "Reactor core" group
2	Fuel inventory [t]	Renamed "Fuel weight" and moved to "Reactor core" group
3	Moderator material	Moved to "Reactor core" group
4	Moderator weight [t]	Moved to "Reactor core" group
5	Average core power density [kW/dm^3]	Moved to "Reactor core" group
6	Average fuel power density [kW/kgU]	Moved to "Reactor core" group
7	Average discharge burnup [MWd/t]	Moved to "Reactor core" group
8	Average linear core power density [kW/m]	Renamed "Fuel linear heat generation rate" *(to keep consistency with WANO terms)*; moved to "Reactor core" group
9	Initial enrichments or enrichment range [%]	Changed to "Average fuel enrichment" and moved to "Reactor core" group
10	Reload enrichment at the equilibrium (for GCR and AGR) [%]	Deleted *(combined with the9 above)*
11	Refuelling frequency [month]	Moved to "Reactor core" group
12	Type of refuelling (on/off-power)	Multiple choice included; moved to "Reactor core" group
13	Part of core withdrawn [%]	Renamed "Part of the core refuelled" and moved to "Reactor core" group
14	Active core height [m]	Modified to "Active core height/length" to include also reactors with a horizontal core; moved to "Reactor core" group
15	Core diameter [m]	Modified to "Active core diameter"; moved to "Reactor core" group
16	Number of fuel assemblies	Deleted – combined with the "Number of fissile fuel assemblies/bundles"; moved to "Reactor core" group
17	Number of fissile fuel assemblies and fertile fuel assemblies (for FBR)	Split into two groups "Number of fissile fuel assemblies/bundles" and "Number of fertile fuel assemblies"; moved to "Reactor core" group
18	Number of fuel rods per assembly	Modified to " Number of fuel rods per assembly/bundle"; moved to "Reactor core" group

19	Rod arrays in assembly	Deleted *(unclear meaning, not found at any type of fuel)*
20	Clad material	Renamed “Fuel clad material”; moved to “Reactor core” group
21	Clad thickness [mm]	Renamed “Fuel clad thickness ”; moved to “Reactor core” group
22	Number of control rod assemblies	Moved to “Reactivity control” group
23	Number of control rods (for GCR, AGR)	Combined with “ Number of control rod assemblies”
24	Number of control elements per assembly (for PWR, BWR)	Combined with “ Number of control rod assemblies”
25	Control rod neutron absorber material	Modified to “Control rod material”; multiple choice provided
26	Soluble chemical neutron absorber	Renamed “Soluble neutron absorber material”; multiple choice provided
27	Burnable poison	Renamed “Burnable neutron absorber material”; multiple choice provided
	Reactor coolant system	
28	Reactor core thermal power (for PWR, BWR, CANDU) [MW]	Deleted *(has been included in the “Reactor basic Information”)*
29	Total thermal power [MW]	Deleted *(the core is considered the only power source at the unit)*
30	Coolant type	Multiple choice has been provided
31	Design coolant mass flow through core [kg/s or t/h]	Modified to “Coolant mass flow at the rated power”; units have been unified to “metric tons per hour (t/h)”
32	Operating coolant pressure [kg/cm^2]	Units have been changed to MPa (conversion formula provided)
33	Inlet core temperature [^{o}C]	Modified to “Reactor inlet temperature” *(“core inlet temperature” is usually not measured, but it is about the same at the “reactor inlet temperature”)*
34	Inlet reactor temperature (for GCR) [^{o}C]	Combined with “Reactor inlet temperature”
35	Outlet core (or reactor) temperature [^{o}C]	Renamed “Reactor outlet temperature”
36	Outlet reactor temperature (for GCR) [^{o}C]	Combined with “Reactor outlet temperature” *(unnecessary duplication)*
	Reactor pressure vessel	Modified to “**Reactor vessel/pressure channels**” *(to include all reactor, which may not always include a* ***pressure*** *vessel*
37	Overall length of assembled vessel and closure head [mm]	Modified to “ Reactor vessel overall length/height (including vessel head); unit changed to “metre” *(to avoid big numbers)*
38	Inside shell diameter [mm]	Modified to “ Inner shell diameter”; unit changed to “metre” *(to avoid big numbers)*
39	Average shell thickness [mm]	Modified to “Shell thickness”
40	Vessel material	Modified to “Reactor vessel material"; multiple choice provided
41	Cladding material	Modified to “Reactor vessel cladding material"; multiple choice provided
42	Number of channels	Modified to “Number of pressure channels”
43	Channel material	Modified to “Pressure channel material”
44	Channel wall thickness [mm]	Modified to “Pressure channel wall thickness”
	Steam generator (PWR)	Modified to “**Steam generators (SG)/drum separators”**
45	Number of steam generators	No change
46	Type	Modified to “Type of SG”; multiple choice provided
47	Tube material	No change
48	Shell material	Modified to “SG shell material”
49	Heat transfer surface per steam generator [m2]	Modified to “Design heat transfer surface”
50	Thermal capacity per steam generator [MW]	Modified to “Design thermal capacity”
51	Number of steam drums	Modified to “Number of drum separators”
52	Shell material	Modified to “Drum separator shell material”
	Pressurizer (PWR, CANDU)	
53	Pressurizer total volume [m^3]	Modified to “Total volume”
54	Steam volume at full power [m^3]	Deleted *(marginal parameter)*
55	Steam volume at zero power [m^3]	Deleted *(marginal parameter)*
56	Design temperature [^{o}C]	Deleted *(temperature of saturation at the coolant pressure)*

57	Design pressure [kg/cm^2]	Deleted *(the same as the coolant pressure)*
58	Number of heaters	Deleted *(irrelevant parameter)*
59	Installed heat power [kW]	Modified to “Installed heater power”
	Main coolant pumps	Modified to “**Main coolant pumps/circulators**”
60	Number of primary cooling or recirculation pumps or gas circulators	Modified to “Number of pumps/circulators”
61	Type	Deleted *(there has been no single criterion to define the “type”)*
62	Pump mass flow rate [t/h or kg/s]	Deleted *(the actual value per one pump can be calculated from the total coolant mass flow and the number of pumps, whereas the rated value provides no relevant information about the unit - the size of the pump can be derived from the pump motor rating)*; replaced by “pressure difference”
63	Pump design head or p (m of H_2O) (for all but AGR, GCR)	Deleted; replaced by “pressure difference”
64	Pump nominal power (cold/hot for PWR) [kW]	Modified to “Pump/circulator motor rating”
65	Pump nominal power (main/auxiliary for GCR, AGR, CANDU) [kW]	Combined with “Pump/circulator motor rating”
	Containment (PWR, BWR, AGR)	Modified to “**Containment systems”**
66	Type	Modified to “Containment type”; multiple choice provided
67	Free volume [m^3]	Replaced by “Total containment volume”
68	Total volume [m^3]	Modified to “Total containment volume”
69	Design pressure [kg/cm^2]	Modified to “Containment design pressure”
70	Drywell design pressure (for BWR) [kg/cm^2]	Deleted *(provides basically the same information as the containment pressure)*
71	Design temperature [^oC]	Deleted *(irrelevant parameter)*
72	Design leakage rate [% per day]	No change
	Accident localization system or confinement (RBMK, WWER)	Included in “Containment type”
73	Free volume [m^3]	Deleted *(replaced by “Total containment volume”)*
74	Total volume [m^3]	Deleted *(covered by “Total containment volume”)*
	Chemical volume control system (CVCS)	Completely deleted *(unnecessary information on an auxiliary system)*
75	Number of extraction lines	Deleted *(unnecessary information)*
75	Safety and safety-related systems	Deleted *(unnecessary information)*
76	Number of pumps	Deleted *(unnecessary information)*
77	Number of feed and bleed connections	Deleted *(unnecessary information)*
	Boron injection system	Completely deleted *(unnecessary information on an auxiliary system)*
78	Volume of boron tank [m^3]	Deleted *(unnecessary information)*
79	Boron concentration [ppm]	Deleted *(unnecessary information)*
80	Is there any boron system? (GCR, AGR) (Y/N)	Deleted *(“questionnaire” type of data)*
	Emergency core cooling systems (ECCS)	
81	H.P. Injection - Number of pumps	Modified to “Number of HPSI pumps”
82	H.P. Injection - Minimum number of pumps for coping with DBA	Deleted *(one redundant ECCS train systems should be able to cope with DBA)*
83	H.P. Injection - Design head or p [m of H2O]	Modified to “HPSI pump rated head pressure”
84	H.P. Injection - Design mass flow rate [kg/s or t/h]	Modified to “HPSI pump rated flowrate”; units unified to t/h
85	L.P. Injection - Number of pumps	Modified to “Number of LPSI pumps”
86	L.P. Injection - Minimum number of pumps for coping with DBA	Deleted *(one redundant ECCS train systems should be able to cope with DBA)*
87	L.P. Injection - Design head or p [m of H_2O]	Modified to “LPSI pump rated head pressure”
88	L.P. Injection - Design mass flow rate [kg/s or t/h]	Modified to “LPSI pump rated flowrate”; units unified to t/h

89	Accumulators - Number of accumulators	Modified to “Number of hydroaccumulators”
	Core Spray System	Combined with the “ **Emergency core cooling systems**”
90	Core Spray System - Number of pumps	Modified to “ Number of core spray system pumps”
91	Core Spray System - Feed and bleed connections	Deleted *(unnecessary information)*
	Component cooling syst.-up to the ultimate heat sink	Completely deleted *(unnecessary information on an auxiliary system)*
92	Number of trains	Deleted *(unnecessary information)*
93	Number of pumps	Deleted *(unnecessary information)*
94	Ultimate heat sink (river, lake or other)	Deleted *(unnecessary information)*
	Containment systems	Incorporated in “**Containment systems**”
95	Spray Systems - Number of trains	Combined with the “Number of containment spray pumps” (*number of trains is determined by the number of pumps)*
96	Spray Systems - Number of pumps	Renamed “ Number of containment spray pumps”
	Other Safety Systems (OSS)	Incorporated in “**Containment systems**”
97	H2 Recombiner/Igniters (Y/N)	Deleted *(“questionnaire” type of data)*
98	OSS- Counter measures againts core melting (Y/N)	Deleted *(“questionnaire” type of data)*
99	OSS- Venting system (Y/N)	Deleted *(“questionnaire” type of data)*
100	OSS- Inertization (Y/N)	Deleted *(“questionnaire” type of data)*
101	OSS- Cooling system- Outside (Y/N)	Deleted *(“questionnaire” type of data)*
102	OSS- Cooling system- Outside- Type	Deleted *(unclear meaning)*
103	OSS- Cooling system- Inside (Y/N)	Deleted *(“questionnaire” type of data)*
104	OSS- Cooling system- Inside- Type	Deleted *(unclear meaning)*
105	OSS- Other	Deleted *(unclear meaning)*
	Emergency feedwater system	Modified to “**Auxiliary/Emergency Feedwater”**
106	Number of pumps	Split into “Number of electrical motor-driven pumps”, “ Number of diesel driven pumps” and “ Number of turbine driven pumps”
107	Number of trains	Deleted *(the same as number of pumps)*
108	Type of energy supply (e.g. diesel, electric motor)	Deleted *(expressed in the number of different type of pumps – above)*
	Fire protection systems	Completely rearranged; multiple choices provided
109	Are the most fire hazard areas (nuclear safety&radiological prot.) identified (Y/N)	Deleted *(“questionnaire” type of data)*
110	Do you have provisions to minimize fire loads in safety-related areas? (Y/N)	Deleted *(“questionnaire” type of data)*
111	Specify	Deleted *(irrelevant)*
112	Storage of combustibles/flammable liquids or gases (Y/N)	Deleted *(“questionnaire” type of data)*
113	Fire ignition sources (e.g. electrical equipment special requirements) (Y/N)	Deleted *(“questionnaire” type of data)*
114	Fire spread (e.g. fire retardant cable coatings) (Y/N)	Modified to “Fire retardant cable coating”; multiple choice provided
115	Do you provide separation between independent trains? (Y/N)	Modified to “Cable segregation within the unit”
116	Do you have fire detection systems available in all the building areas? (Y/N)	Deleted *(“questionnaire” type of data)*
117	Or only in selected rooms? (Y/N)	Deleted *(“questionnaire” type of data)*
118	List of detector types (e.g.optical, ionization chambers, temperature sensors)	Deleted *(irrelevant detailed information)*
119	Do you have automatic fire suppression systems available in all building? (Y/N)	Deleted *(“questionnaire” type of data)*
120	List of fire extinguishing systems types available for fire loads (Y/N)	Modified to “On-site fire suppression/extinguishing system”; multiple choice provided

121	List of fire extinguishing systems types available for special areas (Y/N)	Combined with "On-site fire suppression/extinguishing system"; multiple choice provided
122	Do you have on-site dedicated fire brigade? (Y/N)	Modified to "On-site fire brigade", multiple choice provided
123	Or plant operators are in charge of that duty? (Y/N)	Modified to "On-site fire brigade", multiple choice provided
	Safety-related I&C system	Split into "**Reactor protection system**" and " **Engineered Safeguard Feature Actuation System**"
124	Is the reactor prot.syst.physically&functionally separated and independent? (Y/N)	Deleted *("questionnaire" type of data)*; replaced by "Number of independent system divisions"
125	Specify the hierarchy concept e.g. two steps or three steps	Deleted *(unclear meaning)*
126	Reactor Protection System (RPS)-list of reactor trip signals parameters	Deleted *(unnecessary detailed information; multiple data required)*
127	RPS- general protection logic	Deleted *(unclear meaning)*
128	RPS- application of analogue or digital reactor protection system	Modified to "Control equipment technology"; multiple choice provided
129	RPS- located in the main control room (Y/N)	Deleted *("questionnaire" type of data)*
130	RPS- existence of centralized saf.s/d panel diff. from the main oper. panel (Y/N)	Deleted *("questionnaire" type of data)*
131	RPS- existence of de-centralized safety shutdown panel (Y/N)	Deleted *("questionnaire" type of data)*
	Emergency power supply system	Completely rearranged; multiple choices provided
132	Type (e.g. diesel, gas turbine, grid connections)	Replaced by numbers of particular source types
133	Number of trains	Replaced by numbers of particular source types
134	Number of DG per train	Deleted *(usually used one DG/train)*
135	Other uninterruptible AC emergency sources (e.g. motor-generator)	Deleted
	AC/DC supply system	Incorporated into "**Emergency power supply systems**"
136	Type (e.g. rectifier, converter, battery)	Deleted *(batteries are used along with the rectifiers, converters or motor-generators)*, replaced by " Total battery capacity per vital power train"
137	Estimated time reserve [h]	Modified to "Estimated time reserve of the batteries at full load"
	Conventional thermal cycle	Modified to "**Balance-of-plant system**"
	Turbine system	Modified to "**Turbine**"
138	Type (e.g. saturated steam condensing turbine, superheated condensing turbine)	Multiple choice provided
139	Number of turbines per reactor	No change
140	Turbine rating [MW]	Deleted *(included in the main generator "Rated active power")*
141	Number of turbine sections or cylinders per unit (e.g.H.P/I.P./L.P.)	Split into " Number of HP cylinders per turbine", "Number of IP cylinders per turbine" and "Number of LP cylinders per turbine"
142	Turbine speed [rpm]	No change
143	Steam conditions at H.P.turbine inlet-Temperature [^oC]	Modified to "HP cylinder inlet steam temperature"
144	Steam conditions at H.P.turbine inlet-Pressure [kg/cm^2]	Modified to "HP cylinder inlet steam pressure"
145	Steam conditions at H.P.turbine inlet-Moisture content [%]	Modified to "HP cylinder inlet steam moisture"
146	Steam conditions at H.P.turbine inlet-Flow [kg/s or t/h]	Modified to "HP cylinder inlet steam flowrate"
	Condenser	Modified to "**Main condenser**"
147	Type (e.g. box type surface condenser)	Deleted *(there has been no single criteria to define the "type")*
148	Number of condenser per turbine	No change
149	Condenser vacuum [kg/cm^2]	Modified to "Condenser vacuum at full power"

150	Type of condenser cooling (river, sea, lake, tower)	Modified to "Primary means of condenser cooling"; multiple choice provided
	Main generator	
151	Type (e.g.3-phase synchronous generator, DC generator)	Deleted *(there is no single way to specify the type; there are no DC generators used for power production at NPPs, all main generators are 3-phase synchronous; e.g. number of poles can be determined from the turbine speed and generator frequency)*
152	Apparent power [MVA]	Modified to "Rated apparent power"
153	Active power [MW]	Modified to "Rated active power"
154	Frequency [Hz]	Modified to "Output frequency"; multiple choice provided
	Spent fuel storage	
155	Number of pools	Deleted *(it has been assumed there is always one SFP in the reactor building; the other spent fuel characteristics will provide more specific information)*
156	Capacity [m^3]	Modified to "Reactor building spent fuel pool capacity (number of fuel assemblies)"
157	Maximum number of fuel rods in storage	Combined with "Reactor building spent fuel pool capacity (number of fuel assemblies)"

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CONSULTANTS MEETING

Vienna, Austria: 7–10 February 2005

TECHNICAL MEETINGS

Vienna, Austria: 4–7 October 2004, 9–12 October 2006