APR1000 EUR Assessment :

Project General and Lessons Learned

May 17, 2023
KNS Workshop

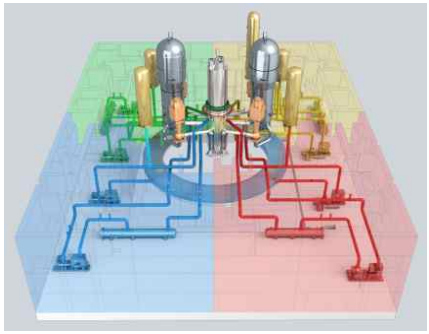
KHNP
KOREA HYDRO & NUCLEAR POWER CO., LTD

Overview of APR 1000

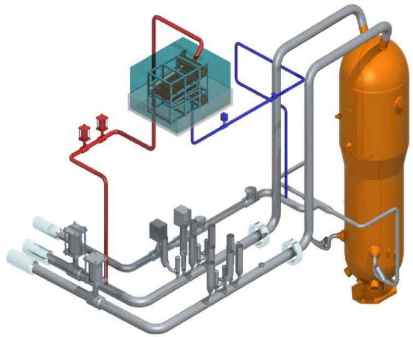
APR1000

- The APR1000 is a medium size capacity Gen III+ pressurized water reactor, generating 1000MW of electrical power.
- The APR1000 design incorporates up-to-date advanced design technologies to enhance plant safety with excellent performance, based on the proven design and operating experience of the OPR1000 and the APR1400

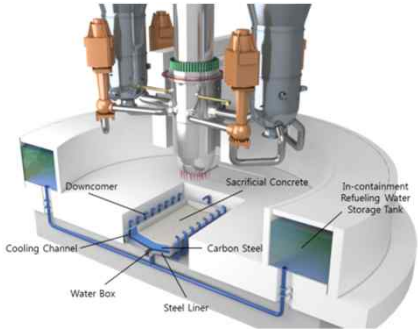
Redundancy & Diversity



Passivity



Severe Accident Mitigation

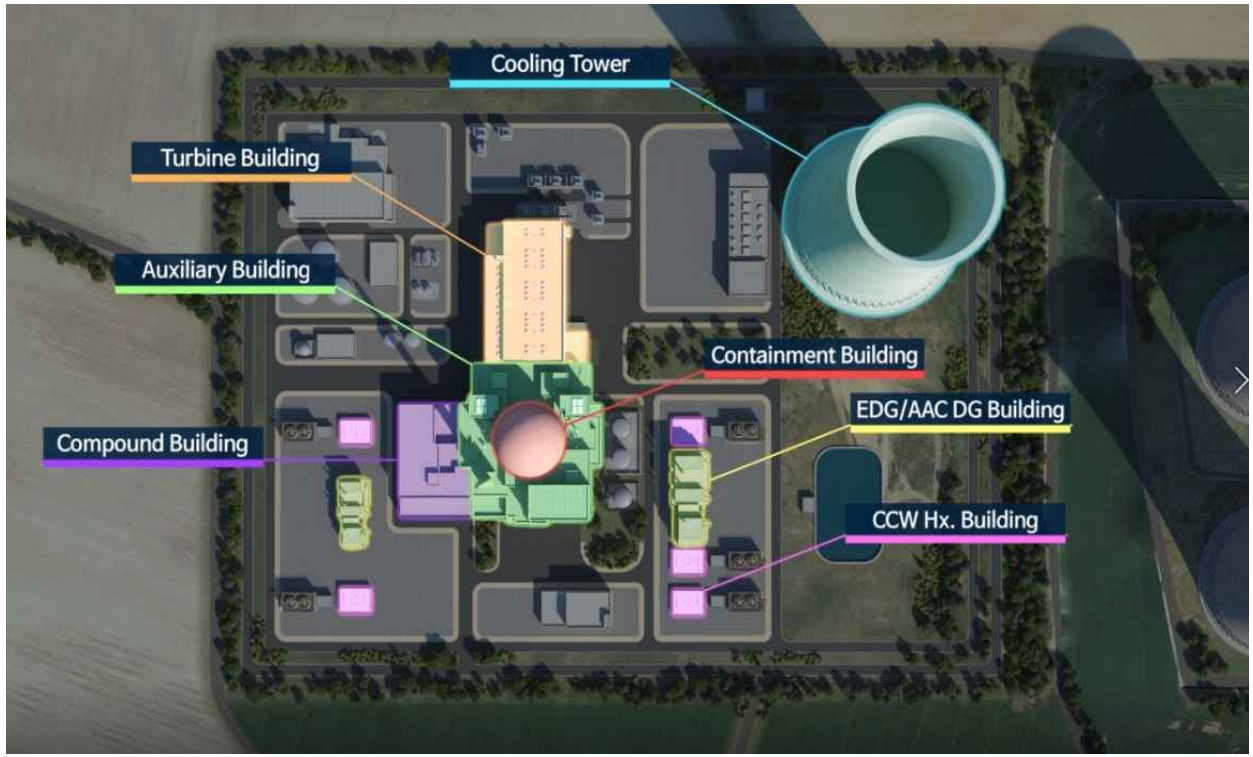


Aircraft Crash Protection

Key Design Features (Layout)

Plant Layout

- Power Block
- Containment Building
- Auxiliary Building
- Compound Building



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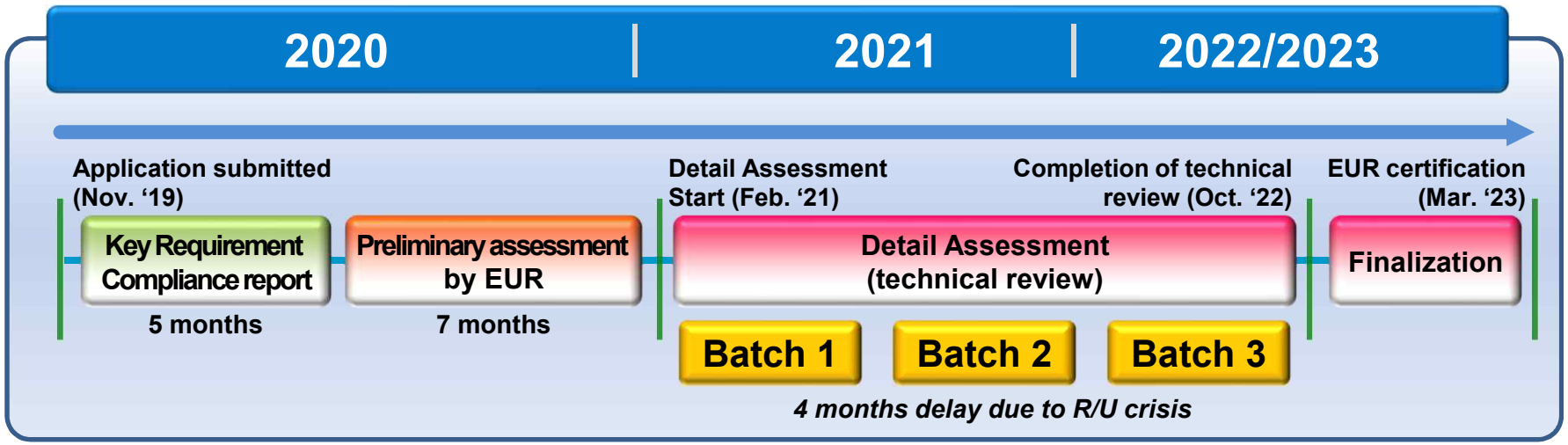
APR1000 EUR Assessment

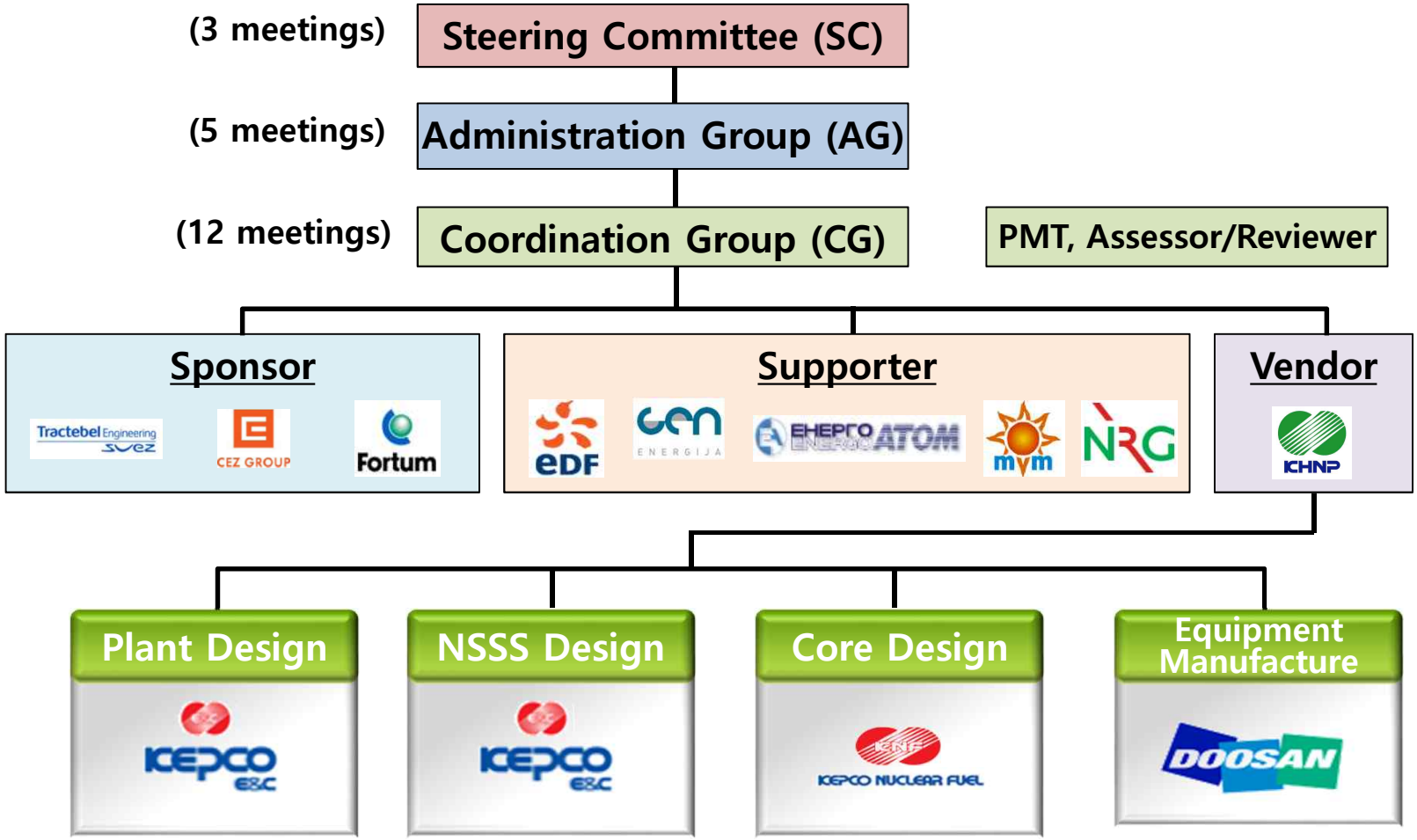
- (Nov. 2019) Submittal of the Application of APR1000 EUR Certification
- (Mar. 2020) Confirmation on assessment start by EUR organization
  - Sponsors (3): CEZ, Tractebel, Fortum
  - Supporters (5): EDF, EnergoAtom, EUASS, GEN Energija, NRG,

    ※ Rosenergoatom was excluded in March 2022
- (Jan. 2021) Completion of Preliminary Assessment (53 key issues)
- (Feb. 2021) Start of Detailed Assessment (20 chapters)
- (Oct. 2022) Completion of Technical Review (20 chapters)
- (Mar. 2023) Final EUR certificate was issued



APR1000 EUR Assessment

The EUR and Team Korea Organization



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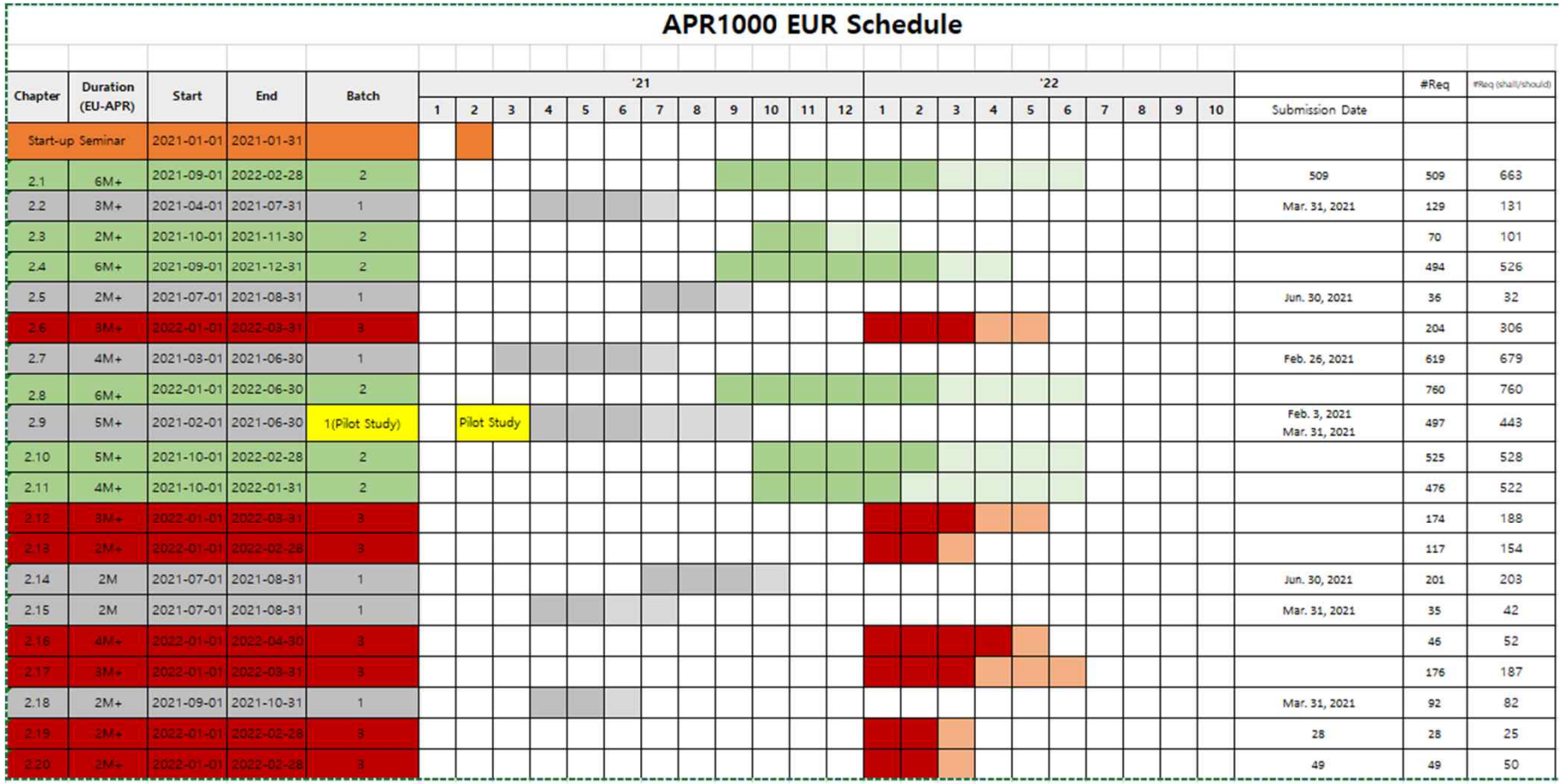
APR1000 EUR Assessment

- **Project Schedule (original) (Vendor)**
  - Delayed(4 months) due to Russia-Ukraine crisis



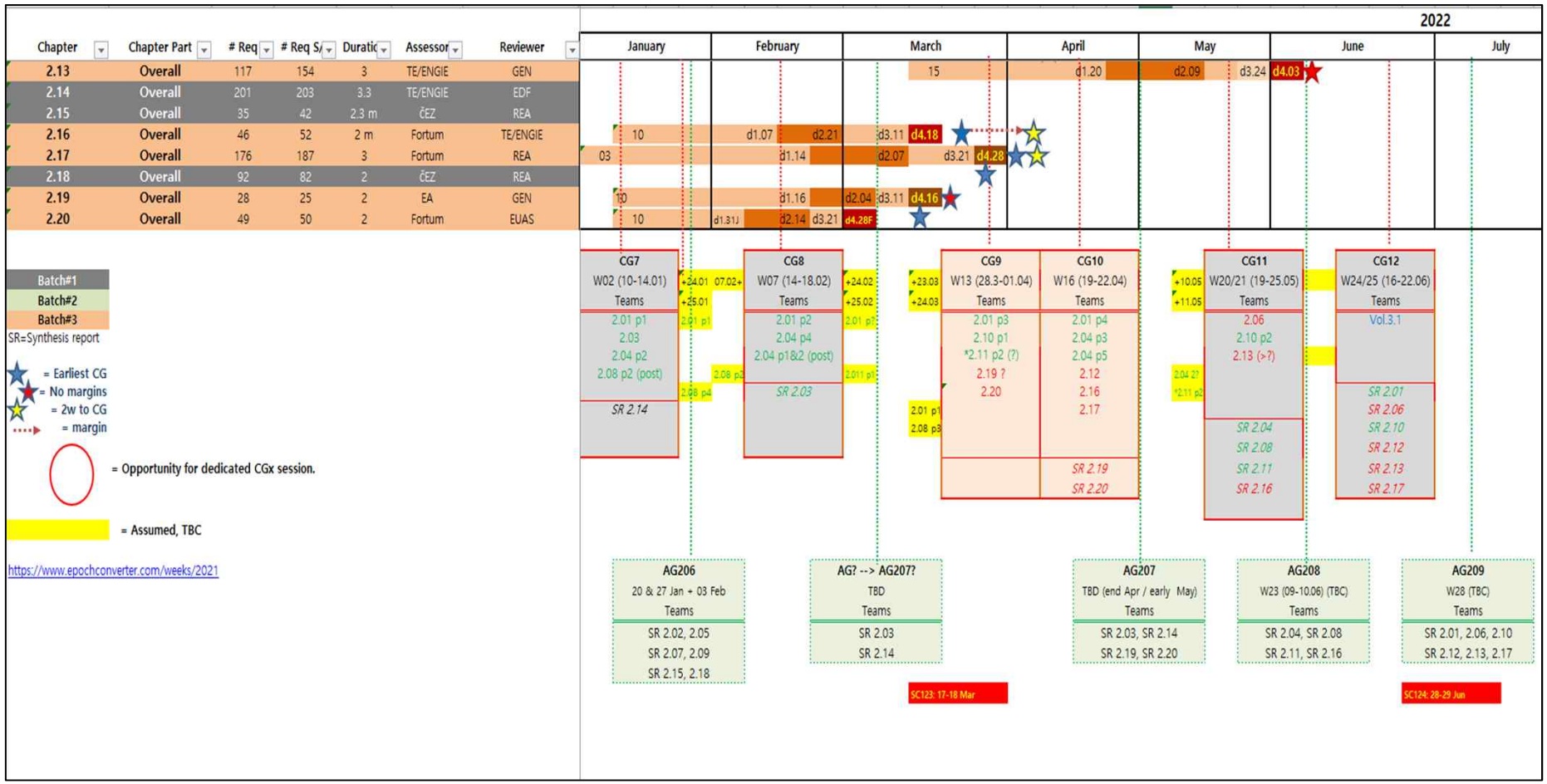
APR1000 EUR Schedule

Chapter	Duration (EU-APR)	Start	End	Batch	'21												'22										Submission Date	#Req	#Req (shall/should)
					1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10			
Start-up Seminar		2021-01-01	2021-01-31																										
2.1	6M+	2021-09-01	2022-02-28	2																							509	509	663
2.2	3M+	2021-04-01	2021-07-31	1																							Mar. 31, 2021	129	131
2.3	2M+	2021-10-01	2021-11-30	2																								70	101
2.4	6M+	2021-09-01	2021-12-31	2																								494	526
2.5	2M+	2021-07-01	2021-08-31	1																							Jun. 30, 2021	36	32
2.6	3M+	2022-01-01	2022-03-31	3																								204	306
2.7	4M+	2021-03-01	2021-06-30	1																							Feb. 26, 2021	619	679
2.8	6M+	2022-01-01	2022-06-30	2																								760	760
2.9	5M+	2021-02-01	2021-06-30	1(Pilot Study)		Pilot Study																					Feb. 3, 2021 Mar. 31, 2021	497	443
2.10	5M+	2021-10-01	2022-02-28	2																								525	528
2.11	4M+	2021-10-01	2022-01-31	2																								476	522
2.12	3M+	2022-01-01	2022-03-31	3																								174	188
2.13	2M+	2022-01-01	2022-02-28	3																								117	154
2.14	2M	2021-07-01	2021-08-31	1																							Jun. 30, 2021	201	203
2.15	2M	2021-07-01	2021-08-31	1																							Mar. 31, 2021	35	42
2.16	4M+	2022-01-01	2022-04-30	3																								46	52
2.17	3M+	2022-01-01	2022-03-31	3																								176	187
2.18	2M+	2021-09-01	2021-10-31	1																							Mar. 31, 2021	92	82
2.19	2M+	2022-01-01	2022-02-28	3																							28	28	25
2.20	2M+	2022-01-01	2022-02-28	3																							49	49	50

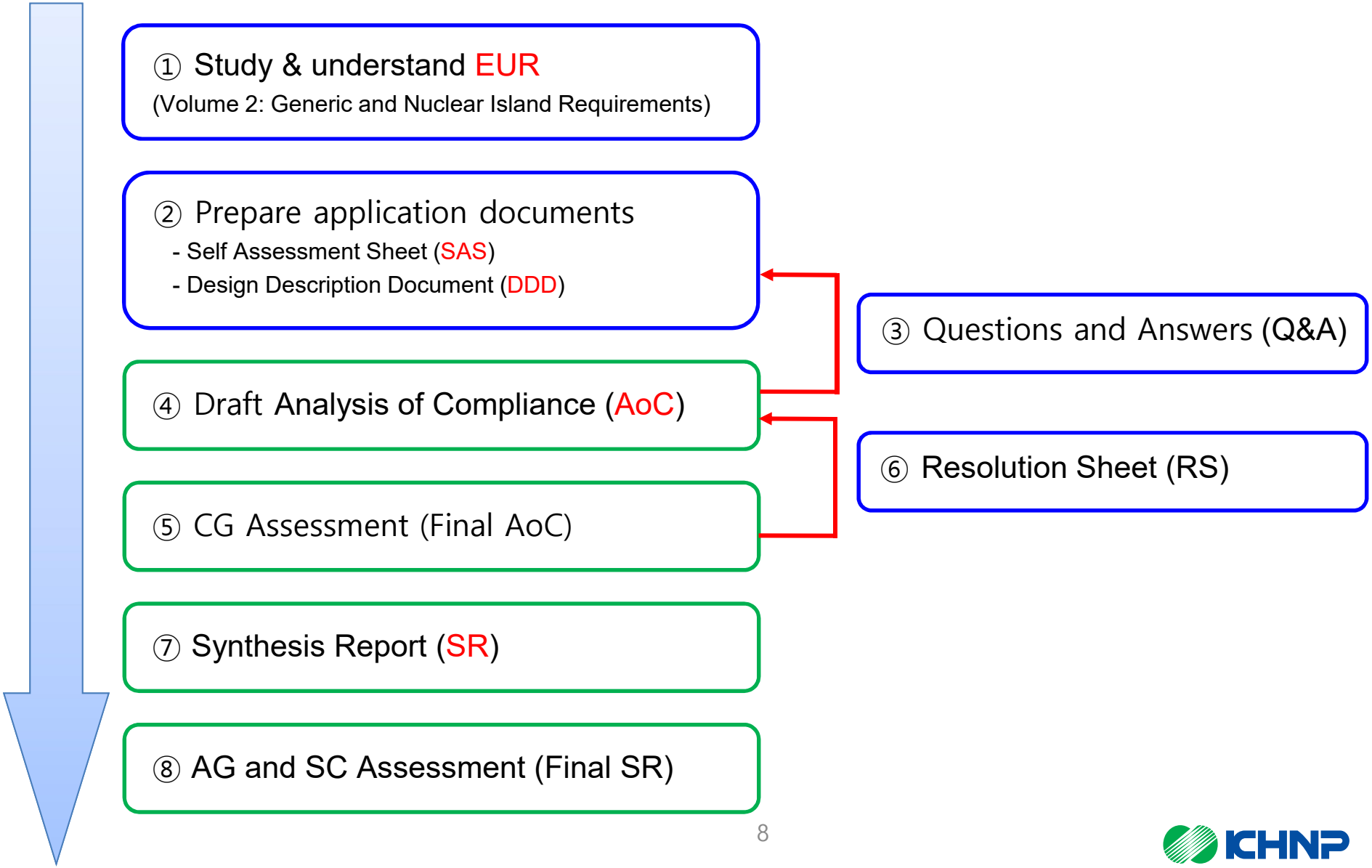
APR1000 EUR Assessment

Project Schedule (EUR)

Chapter	Chapter Part	# Req	# Req S/	Duratic	Assessor	Reviewer
2.13	Overall	117	154	3	TE/ENGIE	GEN
2.14	Overall	201	203	3.3	TE/ENGIE	EDF
2.15	Overall	35	42	2.3 m	ČEZ	REA
2.16	Overall	46	52	2 m	Fortum	TE/ENGIE
2.17	Overall	176	187	3	Fortum	REA
2.18	Overall	92	82	2	ČEZ	REA
2.19	Overall	28	25	2	EA	GEN
2.20	Overall	49	50	2	Fortum	EUAS



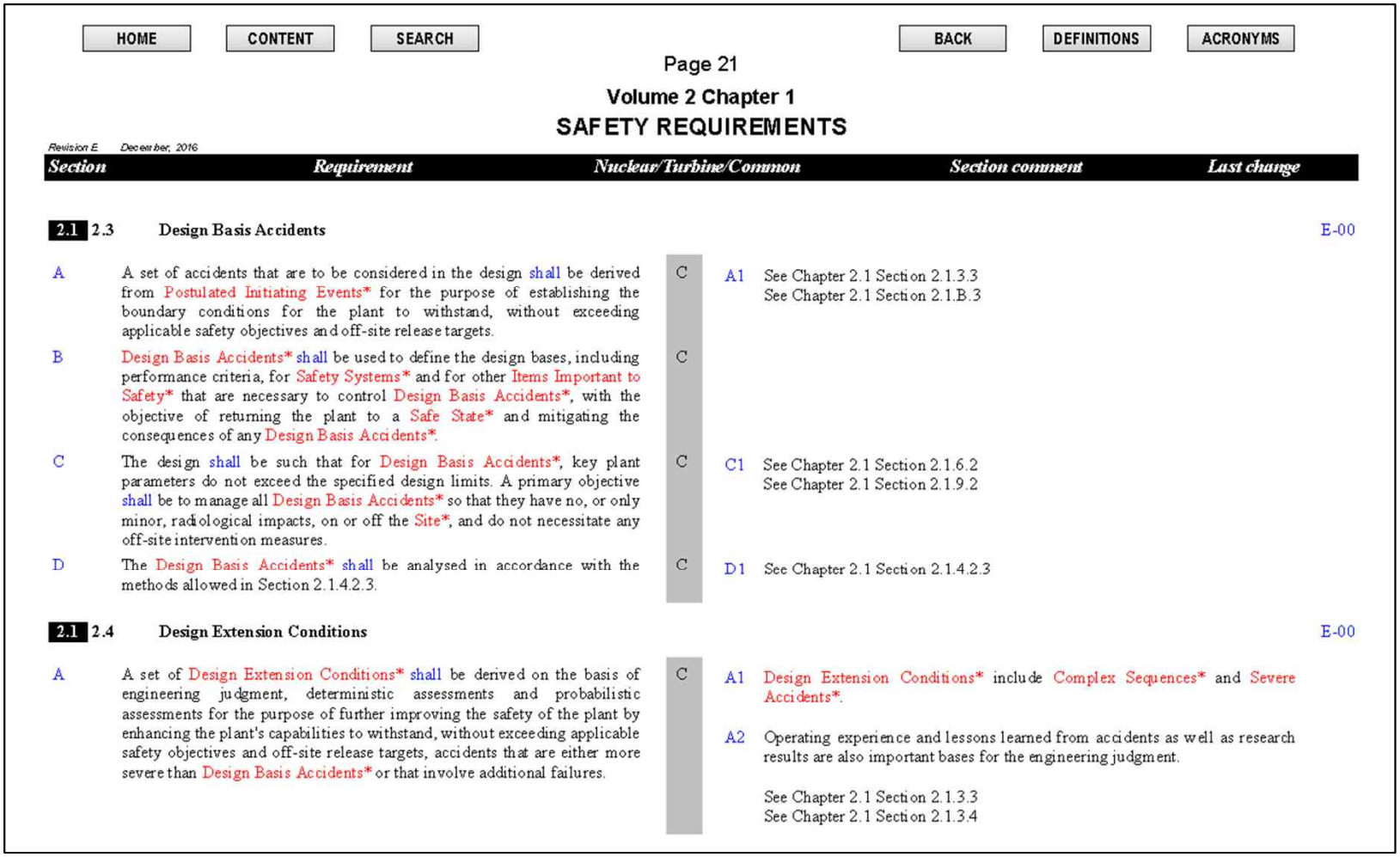
APR1000 EUR Assessment



ICHNP

APR1000 EUR Assessment

- **EUR (Volume 2: Generic and Nuclear Island Requirements)**



HOME | CONTENT | SEARCH | BACK | DEFINITIONS | ACRONYMS

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Volume 2 Chapter 1

SAFETY REQUIREMENTS

Revision E December, 2016

Section	Requirement	Nuclear/Turbine/Common	Section comment	Last change
2.1 2.3	**Design Basis Accidents**			E-00
A	A set of accidents that are to be considered in the design shall be derived from Postulated Initiating Events* for the purpose of establishing the boundary conditions for the plant to withstand, without exceeding applicable safety objectives and off-site release targets.	C	A1 See Chapter 2.1 Section 2.1.3.3 See Chapter 2.1 Section 2.1.B.3	
B	Design Basis Accidents* shall be used to define the design bases, including performance criteria, for Safety Systems* and for other Items Important to Safety* that are necessary to control Design Basis Accidents*, with the objective of returning the plant to a Safe State* and mitigating the consequences of any Design Basis Accidents*.	C		
C	The design shall be such that for Design Basis Accidents*, key plant parameters do not exceed the specified design limits. A primary objective shall be to manage all Design Basis Accidents* so that they have no, or only minor, radiological impacts, on or off the Site*, and do not necessitate any off-site intervention measures.	C	C1 See Chapter 2.1 Section 2.1.6.2 See Chapter 2.1 Section 2.1.9.2	
D	The Design Basis Accidents* shall be analysed in accordance with the methods allowed in Section 2.1.4.2.3.	C	D1 See Chapter 2.1 Section 2.1.4.2.3	
2.1 2.4	**Design Extension Conditions**			E-00
A	A set of Design Extension Conditions* shall be derived on the basis of engineering judgment, deterministic assessments and probabilistic assessments for the purpose of further improving the safety of the plant by enhancing the plant's capabilities to withstand, without exceeding applicable safety objectives and off-site release targets, accidents that are either more severe than Design Basis Accidents* or that involve additional failures.	C	A1 Design Extension Conditions* include Complex Sequences* and Severe Accidents*. A2 Operating experience and lessons learned from accidents as well as research results are also important bases for the engineering judgment. See Chapter 2.1 Section 2.1.3.3 See Chapter 2.1 Section 2.1.3.4	

APR1000 EUR Assessment

Self Assessment Sheet (SAS)

No.	Section No.	EUR Rev. E Requirements	Reference (Name)	Reference Section	Rationale (English)	Scale of Compliance
		EUR Vol. 2 Chapter 1 Safety Requirement				
32	EUR 2.1 2.3	B Design Basis Accidents* shall be used to define the design bases, including performance criteria, for Safety Systems* and for other Items Important to Safety* that are necessary to control Design Basis Accidents*, with the objective of returning the plant to a Safe State* and mitigating the consequences of any Design Basis	DDD → [I-04] NSSS Design Bases → [I-01] Plant Design Description of APR1000	[I-04] 5.1.1 [I-01] 5.1, 5.2	DBAs are postulated for the purpose of establishing the design bases of the safety systems. DBAs are accident conditions and divided into DBA 1 and DBA 2. The safety systems and supporting system are used to mitigate the associated DBAs within the acceptable level, returning the plant to Safe State without exceeding the acceptance criteria.	COM
33	EUR 2.1 2.3	C The design shall be such that for Design Basis Accidents*, key plant parameters do not exceed the specified design limits. A primary objective shall be to manage all Design Basis Accidents* so that they have no, or only minor, radiological impacts, on or off the Site*, and do not necessitate any off-site intervention measures.	DDD → [VII-60] Summary of Safety Analysis on AOOs, DBA 1, and DBA 2 → [VII-20] APR1000 Radiation Safety Analysis Report_Rev.1	[VII-60] 5.0 [VII-20] 2.0, 6.0	Acceptance Criteria for the AOOs and DBAs are provided with respect to fuel, primary and secondary system barrier integrity. The performance criteria of safety equipment are determined so that for Design Basis Accidents, key plant parameters do not exceed the specified design limits. The radiological consequence analyses for the representative events of AOOs and DBAs meet the off-site release targets. The following radiological release targets are met for DBA 1 and DBA 2: - No evacuation action - No sheltering action - No iodine prophylaxis action - No or only minor off-site radiological impact beyond 800m - Very limited restrictions on foodstuff consumption	COM
34	EUR 2.1 2.3	D The Design Basis Accidents* shall be analysed in accordance with the methods allowed in Section 2.1.4.2.3.	N/A	N/A	See the self-assessment for EUR 2.1.4.2.3	COM
35	EUR 2.1 2.4	**2.4 Design Extension Conditions** A A set of Design Extension Conditions* shall be derived on the basis of engineering judgment, deterministic assessments and probabilistic assessments for the purpose of further improving the safety of the plant by enhancing: the plant's capabilities to withstand, without exceeding applicable safety objectives and off-site release targets, accidents that are either more severe than Design Basis Accidents* or that involve additional failures.	DDD → [I-05] Safety Classification of SSCs for APR1000 → [VII-57] Severe Accident Analysis Report for APR1000_Rev.1	[I-05] 2.2.1, Table 8 [VII-57] 5.2	For APR1000, DEC-A events have been identified, based on several regulatory guidance such as from IAEA, US, Korean, and also EUR. In accordance with the IAEA SSR-2/1, engineering judgment, deterministic assessment and probabilistic assessment were used in the selection of the multiple failure events. In addition to this principle, available references of and the event lists considered in other NPPs have been collected to include all foreseeable events. DEC-B events involving core melt accident are identified based on preliminary results of Level 1 PSA for APR1000 and deterministic severe accident sequences. The deterministic sequences that represent the bounding progress of accident in deterministic viewpoint are assumed to have no engineered safety system activation except the passive systems, so the containment conditions can envelop that driven by PSA Level 1 results.	COM
36	EUR 2.1 2.4	B Design Extension Conditions* shall be used to identify, and define the design bases and performance criteria for, the dedicated Safety Features for Design Extension Conditions* and other Items Important to Safety*, as well as Accident Management Procedures*, needed to control	DDD → [I-01] Plant Design Description of APR1000 → [I-05] Safety Classification of	[I-01] 2.3.2, Table 2-1, Table 2-2 [I-05] 2.2, Table 8	Lists of DEC-A and DEC-B events are considered to identify the dedicated safety features and to define the design bases and performance criteria for DEC safety features. As indicated in Table 2-1 of [I-01], DiD Levels for 3b and 4, of which conditions exceed the capability of safety systems designed for DiD Levels 2 and 3, are explicitly defined for ensuring robust defense-in-depth concept. Independent safety features designed to control and/or mitigate the events in DiD Levels 3b and 4	

APR1000 EUR Assessment

Design Description Document (DDD)

KHNP
APR1000 Standard Design

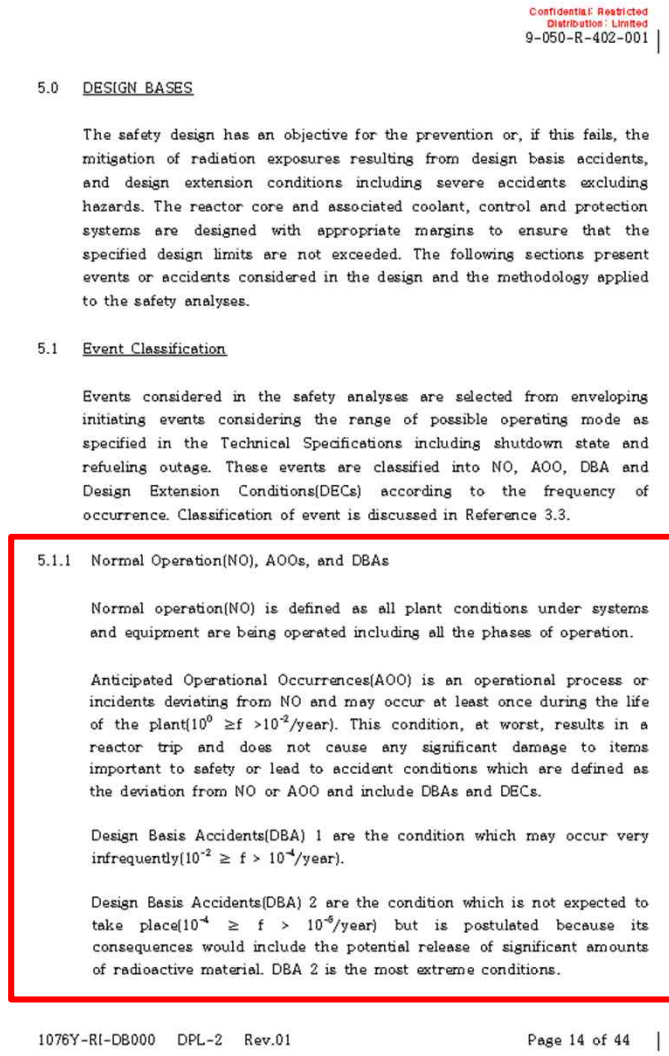
Number:	9-050-Z-402-001	Version:	0
Confidentiality:	Restricted	Doc.Category:	I
Distribution:	Limited	Type:	Design Document

NSSS Design Bases

March 2021

KHNP

Korea Hydro & Nuclear Power Co., Ltd..



5.0 DESIGN BASES

The safety design has an objective for the prevention or, if this fails, the mitigation of radiation exposures resulting from design basis accidents, and design extension conditions including severe accidents excluding hazards. The reactor core and associated coolant, control and protection systems are designed with appropriate margins to ensure that the specified design limits are not exceeded. The following sections present events or accidents considered in the design and the methodology applied to the safety analyses.

5.1 Event Classification

Events considered in the safety analyses are selected from enveloping initiating events considering the range of possible operating mode as specified in the Technical Specifications including shutdown state and refueling outage. These events are classified into NO, AOO, DBA and Design Extension Conditions(DECs) according to the frequency of occurrence. Classification of event is discussed in Reference 3.3.

5.1.1 Normal Operation(NO), AOOs, and DBAs

Normal operation(NO) is defined as all plant conditions under systems and equipment are being operated including all the phases of operation.

Anticipated Operational Occurrences(AOO) is an operational process or incidents deviating from NO and may occur at least once during the life of the plant($10^{0} \geq f > 10^{-2}$/year). This condition, at worst, results in a reactor trip and does not cause any significant damage to items important to safety or lead to accident conditions which are defined as the deviation from NO or AOO and include DBAs and DECs.

Design Basis Accidents(DBA) 1 are the condition which may occur very infrequently($10^{-2} \geq f > 10^{-4}$/year).

Design Basis Accidents(DBA) 2 are the condition which is not expected to take place($10^{-4} \geq f > 10^{-6}$/year) but is postulated because its consequences would include the potential release of significant amounts of radioactive material. DBA 2 is the most extreme conditions.

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APR1000 EUR Assessment

List of References (DDD)

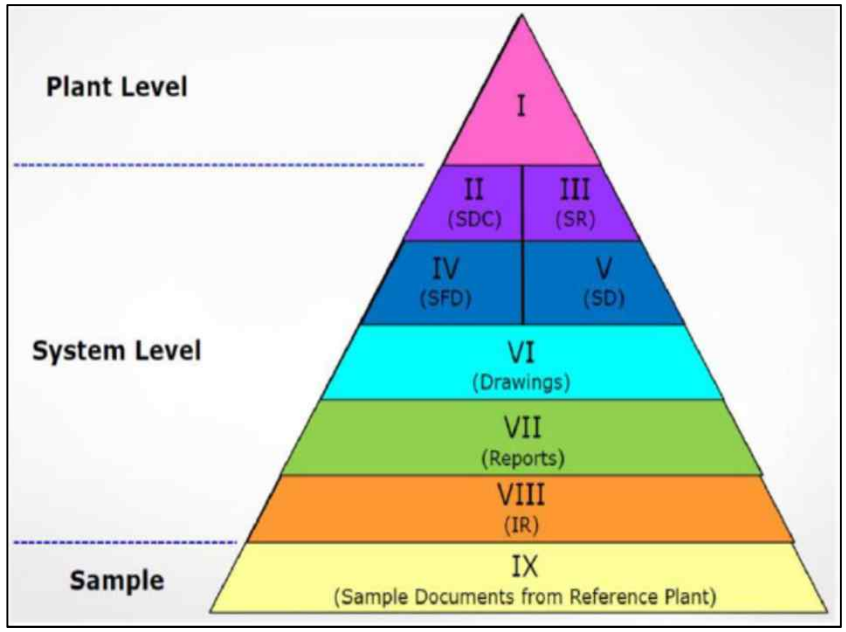
List of References for SAS 2.1

Category	No.	References (SAS)	Document Number	Type	Submission Date
I	I-01	Plant Design Description of APR1000	UB-034-K-464-001	General Description	Aug. 31
I	I-02	Technical Background of Top Tier Requirements	UB-034-K-460-001	Design Document	Aug. 31
I	I-03	Design Criteria Manual Chapter 1&2	1-037-B401-001-CH1-A	Design Document	Aug. 31
I	I-03	Design Criteria Manual Chapter 3	1-037-B401-001-CH3-A	Design Document	Aug. 31
I	I-03	Design Criteria Manual Chapter 4	1-037-B401-001-CH4-A	Design Document	Aug. 31
I	I-03	Design Criteria Manual Chapter 5	1-037-B401-001-CH5-A	Design Document	Aug. 31
I	I-03	Design Criteria Manual Chapter 8	1-037-B401-001-CH8-A	Design Document	Aug. 31
I	I-04	NSSS Design Bases	9-050-R-402-001	Design Document	Aug. 31
I	I-05	Safety Classification of SSCs for APR1000	9-037-Z-462-023	General Description	Aug. 31
I	I-07	General Material Specification for RCS	9-410-R-462-005	Topical Report	Aug. 31
I	I-11	Report on Application of Rules for APR1000	9-037-R-462-043	General Description	Aug. 31
II	II-01	SDC for Alarm System	1-723-J402-001	Design Document	Aug. 31
II	II-02	SDC for AAC Diesel Generator System	1-593-M402-001	Design Document	Aug. 31
II	II-05	SDC for Passive Auxiliary Feedwater System	1-454-N402-001	Design Document	Aug. 31
II	II-06	SDC for Auxiliary Power System	1-820-E402-001	Design Document	Aug. 31
II	II-08	SDC for Component Cooling Water System	1-461-N402-001	Design Document	Aug. 31
II	II-12	SDC for Containment Spray System	1-442-N402-001	Design Document	Aug. 31
II	II-13	SDC for Control Room HVAC System	1-601-M402-001	Design Document	Aug. 31
II	II-14	SDC for DC Distribution System	1-841-E402-001	Design Document	Aug. 31
II	II-15	SDC for Diverse Component Cooling Water System	1-464-N402-001	Design Document	Aug. 31
II	II-16	SDC for Diverse Essential Service Water System	1-465-N402-001	Design Document	Aug. 31
II	II-17	SDC for Diesel Fuel Oil Transfer System	1-585-M402-001-A	Design Document	Aug. 31
II	II-20	SDC for Engineered Safety Features Actuation System	1-712-J402-001	Design Document	Aug. 31
II	II-22	SDC for Emergency Control Room System	1-754-J402-001	Design Document	Aug. 31
II	II-24	SDC for Emergency Diesel Generator System	1-591-M402-001	Design Document	Aug. 31
II	II-25	SDC for Emergency Response Facility	1-758-J402-001	Design Document	Aug. 31
II	II-26	SDC for Engineered Safety Feature-Component Control System	1-745-J402-001	Design Document	Aug. 31
II	II-27	SDC for Essential Service Water System	1-462-N402-001	Design Document	Aug. 31
II	II-31	SDC for Gaseous Radwaste System	1-471-N402-001	Design Document	Aug. 31
II	II-33	SDC for Hoist and Crane	1-683-N402-001	Design Document	Aug. 31
II	II-36	SDC for Information Processing System	1-721-J402-001	Design Document	Aug. 31
II	II-38	SDC for Large Display Panel System	1-757-J402-001	Design Document	Aug. 31
II	II-41	SDC for Liquid Radwaste System	1-472-N402-001	Design Document	Aug. 31
II	II-42	SDC for Main Control Room System	1-751-J402-001	Design Document	Aug. 31
II	II-46	SDC for Primary Containment Building Purge System	1-612-M402-001	Design Document	Aug. 31

2.1 List of References for Ch. 2.1

APR1000 EUR Assessment

Technical Document Hierarchy



- Plant level (I)
  - Top-Tier Requirements (TTR)
  - General Design Criteria (GDC) & NSSS Design Bases (NSSS DB)
  - Safety Classification, Codes & Standards, QA Manual, etc.
- System level
  - System Design Criteria (SDC) (II)
  - System Design Requirements (SR) (III)
  - System Functional Description (SFD) (IV)
  - System Description (SD) (V)
  - Drawings (VI), Topical Reports (VII), Interface Requirements (IR) (VIII)
- Sample documents (IX) of reference plant issued in the detailed design stage

APR1000 EUR Assessment

Analysis of Compliance (AoC)

ANALYSIS OF COMPLIANCE
OF APR1000 DESIGN VERSUS:

VOLUME 2

GENERIC NUCLEAR ISLAND REQUIREMENTS

CHAPTER 10

INSTRUMENTATION & CONTROL AND HUMAN-MACHINE INTERFACE (PART 1)

Revision E
Draft 9
November 2022

ANALYSIS OF COMPLIANCE OF APR1000 DESIGN VERSUS
Volume 2 Chapter 10 Revision E
INSTRUMENTATION & CONTROL AND HUMAN-MACHINE INTERFACE (PART 1)
STATUS

- Revision E Draft 9 November 2022

Revision	Status	Date	Author/Company	Comments
E	Draft 1	29/01/2022	S. Durisotti/Tractebel	First draft including several QA
E	Draft 2	28/02/2022	J.Kurnik/GEN	Review of draft 1
E	Draft 3	02/03/2022	S. Durisotti/Tractebel	Draft 3 including remaining QA and comments from Reviewer
E	Draft 4	11/04/2022	J.Kurnik/GEN	Review of draft 3
E	Draft 5	11/05/2022	R. Dones/Tractebel	CG9 review
E	Draft 6	15/06/2022	S. Durisotti/Tractebel	Draft 6 including resolutions sheets following CG9
E	Draft 7	12/06/2022	J.Kurnik/GEN	Review of draft 6
E	Draft 8	26/09/2022	S. Durisotti/Tractebel	Draft 8 including resolutions sheets in APR1000 references
E	Draft 9	02/11/2022	S. Durisotti/Tractebel	Draft 9 including minor modifications agreed on APR1000_MoM_CG12_d2. Refer to requirements 2.10.6.4.2.5.1.G and 2.10.6.4.2.5.2.A, B, C, D, E.

Q&A

Resolution Sheet

B	However, the control rod system should be designed to be capable of damping any azimuthal oscillation through motion of selected control rod groups.	[VII-28] 2.6 [VII-80] 6.3.8 APR1000_202_QA04 APR1000_202_QA08 APR1000_202_QA10 APR1000_202_QA11 Resolution_Sheet_APR1000_202_SC#125(2.2.3.6.1_B)	In the referred report [VII-28] it is provided the following explanation. "APR1000 core is designed to be self-damping against azimuthal oscillation. The existence of azimuthal oscillations can be recognized through the azimuthal power tilt which is monitored by ICOMS during operation. If measured power tilt is greater than the limit of technical specifications, the power reduction is required to provide the acceptable level of protection from increased power peaking." In addition, in the Vendor's self-assessment it is also stated - The capability of damping any azimuthal oscillation through motion of selected control rod is not required due to the generic self-damping characteristics against azimuthal xenon oscillation of the APR1000 core. From the information provided by the Vendor the Assessor assumes that the APR1000 has not implemented design feature providing selection or automatic initiation of specific control rods or control rod groups to be capable of damping any azimuthal oscillation. Although the Vendor's argumentation about the generic self-damping characteristics seems logical, however, the EUR Requirement says that the control rod system should be capable of damping ANY azimuthal oscillations, not only divergent ones. Although the requirement is expressed as the recommendation (it seems not mandatory), to assure consistency with past assessments the NOC label should be given at this point.	CONNOC

EUROPEAN UTILITY REQUIREMENTS FOR LWR NUCLEAR POWER PLANTS

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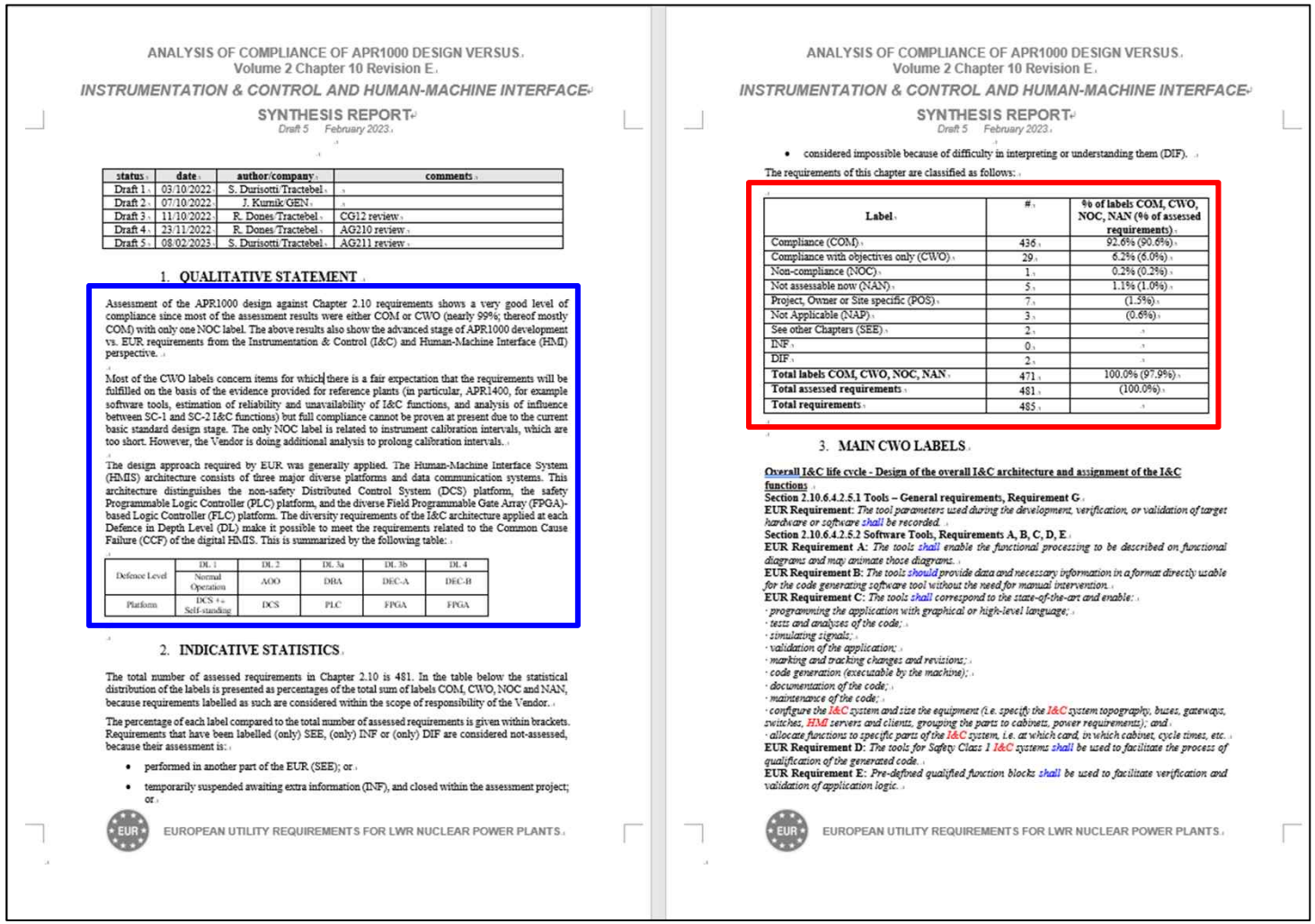
ANALYSIS OF COMPLIANCE OF APR1000 DESIGN VERSUS
Volume 2 Chapter 2 Revision E
PERFORMANCE REQUIREMENTS
DETAILED ANALYSIS OF COMPLIANCE

Revision E Draft 8 July 2022

Section	Requirement	APR1000 References	Compliance Assessment	Result
			After the meeting SC125 KHNP has provided additional information on APR1000 DRCS manual individual mode in Resolution Sheet Resolution_Sheet_APR1000_202_SC#125(2.2.3.6.1_B) and its Attachment_1 (System_Design_Requirements_for_Power_Control System). The Technical Report excerpts indicate the APR1000 DRCS has capability to select control rod groups for manual individual mode and thus it can be deduced that the control rod system is designed to be capable of damping any azimuthal oscillation through motion of selected control rod groups. Therefore, the label is changed to COM.	

APR1000 EUR Assessment

- **Synthesis Report (SR)**



ANALYSIS OF COMPLIANCE OF APR1000 DESIGN VERSUS
Volume 2 Chapter 10 Revision E
INSTRUMENTATION & CONTROL AND HUMAN-MACHINE INTERFACE
SYNTHESIS REPORT
Draft 5 February 2023

status	date	author/company	comments
Draft 1	03/10/2022	S. Durisotti/Tractebel	
Draft 2	07/10/2022	J. Kurnik/GEN	
Draft 3	11/10/2022	R. Dones/Tractebel	CG12 review
Draft 4	23/11/2022	R. Dones/Tractebel	AG210 review
Draft 5	08/02/2023	S. Durisotti/Tractebel	AG211 review

1. QUALITATIVE STATEMENT

Assessment of the APR1000 design against Chapter 2.10 requirements shows a very good level of compliance since most of the assessment results were either COM or CWO (nearly 99%; thereof mostly COM) with only one NOC label. The above results also show the advanced stage of APR1000 development vs. EUR requirements from the Instrumentation & Control (I&C) and Human-Machine Interface (HMI) perspective.

Most of the CWO labels concern items for which there is a fair expectation that the requirements will be fulfilled on the basis of the evidence provided for reference plants (in particular, APR1400, for example software tools, estimation of reliability and unavailability of I&C functions, and analysis of influence between SC-1 and SC-2 I&C functions) but full compliance cannot be proven at present due to the current basic standard design stage. The only NOC label is related to instrument calibration intervals, which are too short. However, the Vendor is doing additional analysis to prolong calibration intervals.

The design approach required by EUR was generally applied. The Human-Machine Interface System (HMIS) architecture consists of three major diverse platforms and data communication systems. This architecture distinguishes the non-safety Distributed Control System (DCS) platform, the safety Programmable Logic Controller (PLC) platform, and the diverse Field Programmable Gate Array (FPGA)-based Logic Controller (FLC) platform. The diversity requirements of the I&C architecture applied at each Defence in Depth Level (DL) make it possible to meet the requirements related to the Common Cause Failure (CCF) of the digital HMIS. This is summarized by the following table:

	DL 1	DL 2	DL 3a	DL 3b	DL 4
Defence Level	Normal Operation	AOO	DBA	DEC-A	DEC-B
Platform	DCS +/- Self-standing	DCS	PLC	FPGA	FPGA

2. INDICATIVE STATISTICS

The total number of assessed requirements in Chapter 2.10 is 481. In the table below the statistical distribution of the labels is presented as percentages of the total sum of labels COM, CWO, NOC and NAN, because requirements labelled as such are considered within the scope of responsibility of the Vendor.

The percentage of each label compared to the total number of assessed requirements is given within brackets. Requirements that have been labelled (only) SEE, (only) INF or (only) DIF are considered not-assessed, because their assessment is:

- performed in another part of the EUR (SEE); or
- temporarily suspended awaiting extra information (INF), and closed within the assessment project; or

EUROPEAN UTILITY REQUIREMENTS FOR LWR NUCLEAR POWER PLANTS

ANALYSIS OF COMPLIANCE OF APR1000 DESIGN VERSUS
Volume 2 Chapter 10 Revision E
INSTRUMENTATION & CONTROL AND HUMAN-MACHINE INTERFACE
SYNTHESIS REPORT
Draft 5 February 2023

- considered impossible because of difficulty in interpreting or understanding them (DIF).

The requirements of this chapter are classified as follows:

Label	#	% of labels COM, CWO, NOC, NAN (% of assessed requirements)
Compliance (COM)	436	92.6% (90.6%)
Compliance with objectives only (CWO)	29	6.2% (6.0%)
Non-compliance (NOC)	1	0.2% (0.2%)
Not assessable now (NAN)	5	1.1% (1.0%)
Project, Owner or Site specific (POS)	7	(1.5%)
Not Applicable (NAP)	3	(0.6%)
See other Chapters (SEE)	2	
INF	0	
DIF	2	
Total labels COM, CWO, NOC, NAN	471	100.0% (97.9%)
Total assessed requirements	481	(100.0%)
Total requirements	485	

3. MAIN CWO LABELS

Overall I&C life cycle - Design of the overall I&C architecture and assignment of the I&C functions
Section 2.10.6.4.2.5.1 Tools – General requirements, Requirement G
EUR Requirement: *The tool parameters used during the development, verification, or validation of target hardware or software shall be recorded.*
Section 2.10.6.4.2.5.2 Software Tools, Requirements A, B, C, D, E
EUR Requirement A: *The tools shall enable the functional processing to be described on functional diagrams and may animate those diagrams.*
EUR Requirement B: *The tools should provide data and necessary information in a format directly usable for the code generating software tool without the need for manual intervention.*
EUR Requirement C: *The tools shall correspond to the state-of-the-art and enable:*
- *programming the application with graphical or high-level language;*
- *tests and analyses of the code;*
- *simulating signals;*
- *validation of the application;*
- *marking and tracking changes and revisions;*
- *code generation (executable by the machine);*
- *documentation of the code;*
- *maintenance of the code;*
- *configure the I&C system and size the equipment (i.e. specify the I&C system topography, buses, gateways, switches, HMI servers and clients, grouping the parts to cabinets, power requirements); and*
- *allocate functions to specific parts of the I&C system, i.e. at which card, in which cabinet, cycle times, etc.*

EUR Requirement D: *The tools for Safety Class 1 I&C systems shall be used to facilitate the process of qualification of the generated code.*
EUR Requirement E: *Pre-defined qualified function blocks shall be used to facilitate verification and validation of application logic.*

EUROPEAN UTILITY REQUIREMENTS FOR LWR NUCLEAR POWER PLANTS

APR1000 EUR Assessment

- Assessment Results

Chapter	COM	CWO	NOC	NAN	POS /NAP	SUM
2.1	359	51	**0**	0	53	463
2.2	78	18	**8**	1	20	125
2.3	31	1	**1**	0	40	73
2.4	333	76	**1**	9	50	469
2.5	22	5	**0**	0	0	27
2.6	137	17	**3**	4	49	210
2.7	409	100	**0**	22	72	603
2.8	513	48	**1**	2	118	682
2.9	290	23	**1**	2	69	385
2.10	436	29	**1**	5	10	481
2.11	415	38	**0**	4	12	469
2.12	157	9	**0**	0	3	169
2.13	101	10	**0**	0	3	114
2.14	151	33	**1**	3	1	189
2.15	29	6	**0**	0	0	35
2.16	33	7	**0**	0	5	45
2.17	97	50	**1**	0	19	167
2.18	66	4	**0**	0	3	73
2.19	22	4	**1**	0	0	27
2.20	37	1	**0**	0	11	49
SUM	3,716	530	**19**	52	538	4,855

Chapters

2.1: Safety Requirements
2.2: Performance Requirements
2.3: Grid Requirements
2.4: Design Basis
2.5: Codes and Standards
2.6: Material-related Requirements
2.7: Functional Requirements (Components)
2.8: Functional Requirements (Systems & Processes)
2.9: Containment System
2.10: I&C and HMI
2.11: Layout
2.12: Design Process and Documentation
2.13: Constructability and Commissioning
2.14: Operation, Maintenance and Procedures
2.15: Quality Assurance
2.16: Decommissioning
2.17: PSA Methodology
2.18: Performance Assessment Methodology
2.19: Cost Assessment Information Requirements
2.20: Environmental Impact

APR1000 EUR Assessment

- Indicative Statistic (APR1000)

Non-Compliance : 0.4%

	TOTAL	%(COM, CWO, NOC, NAN)	%(total assessed requirements)
Compliance (COM)	3716	86.1%	76.5%
Compliance with objectives only (CWO)	530	12.3%	10.9%
Non-compliance (NOC)	19	0.4%	0.4%
Not assessable now (NAN)	52	1.2%	1.1%
Not applicable (NAP)	308		6.3%
Project, Owner or Site specific (POS)	230		4.7%
Total labels (COM, CWO, NOC, NAN)	**4317**	**100.0%**	**88.9%**
Total assessed requirements	**4855**		**100.0%**

Total compliance (COM+CWO): 98.4%

APR1000 EUR Assessment

- Indicative Statistic

Reactor	Country	EUR version	Certification	Ratio of NOC*	Duration**
APR1000	Korea	Rev.E	2023	0.4%	25~26 M
HPR1000	China	Rev.E	2020	< 1%	38 M
VVER-TOI	Russia	Rev.D	2019	< 2%	40 M
EU-APR	Korea	Rev.D	2017	0.8%	24 M
EU-APWR	Japan	Rev.D	2014	< 2%	24 M
EPR Rev.B	France	Rev.C	2009		
VVER AES-92	Russia	Rev.C	2007		
AP1000	USA	Rev.C	2007		
SWR1000	Germany	Rev.B	2002		
ABWR	USA	Rev.B	2001		
EP1000	USA	Rev.B	1999		
EPR Rev. A	France	Rev.B	1999		
BWR90	Sweden	Rev.B	1998		

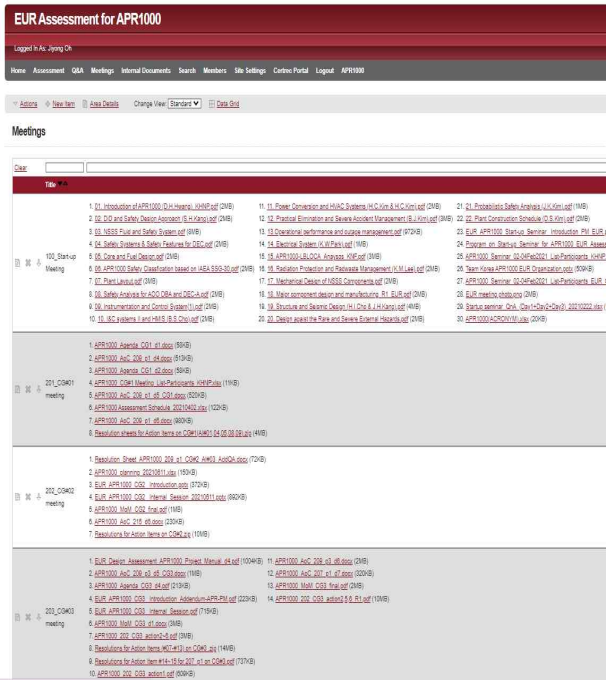
APR1000 EUR Assessment

Non-compliance(NOC) items (19)

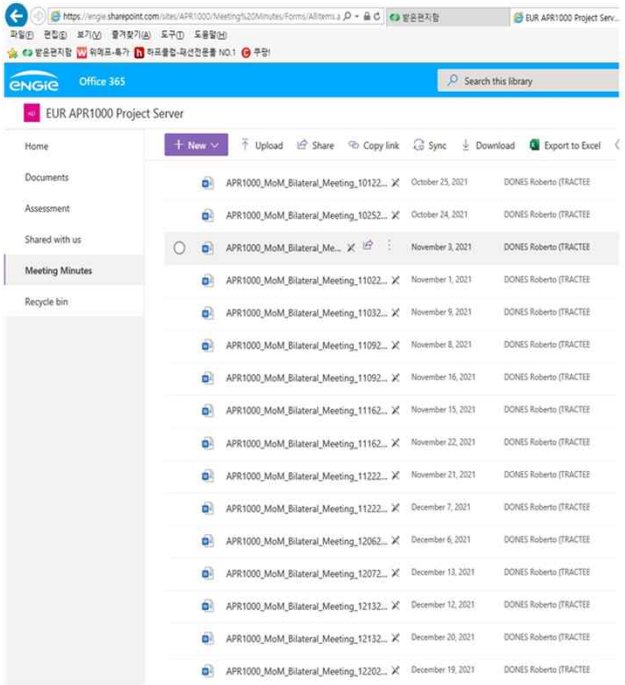
- Duration of start-up and loading (2.2.2.1.2 (3 shalls))
- Response to loss of a running pump (2.2.2.6)
- Secondary control (2.2.2.8.4)
- Load following and maneuvering capability (2.2.3.8)
- MOX fuel maximum assembly burnup (2.2.4.1 A&B)
- Frequency response (primary control) (2.3.3.1.2.1)
- Welded attachments to elbows, tees and other fittings shall not be permitted (2.4.7.7)
- Cobalt free material in RCS (2.6.4.1.2 (3 shalls))
- Negative MTC (2.8.2.1.1.3)
- Backflushing for suction strainer (2.9.4.1.1.1.1)
- Sensor calibration interval > 48 mon (2.10.7.2.2.3.6)
- Emergency Response Facilities shall be protected against RSEH (2.14.3)
- Event tree end states shall include limited release frequency (2.17.3.3.1)
- Economic analysis shall include the impact of load following (2.19.4.2)

APR1000 EUR Assessment

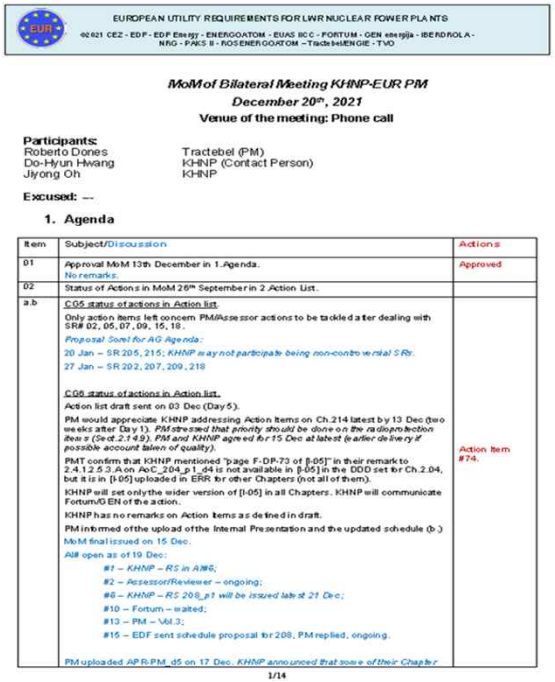
- **Major Communication tools:**
  1. Electronic Reading Room (ERR): Technical Doc./Q&A/Meeting
  2. Project Server : SC/AG/CG results
  3. Weekly Bilateral Meeting (WBM) with PM team (PMT)
  4. Remote (MS teams) and Face to Face meetings



ERR



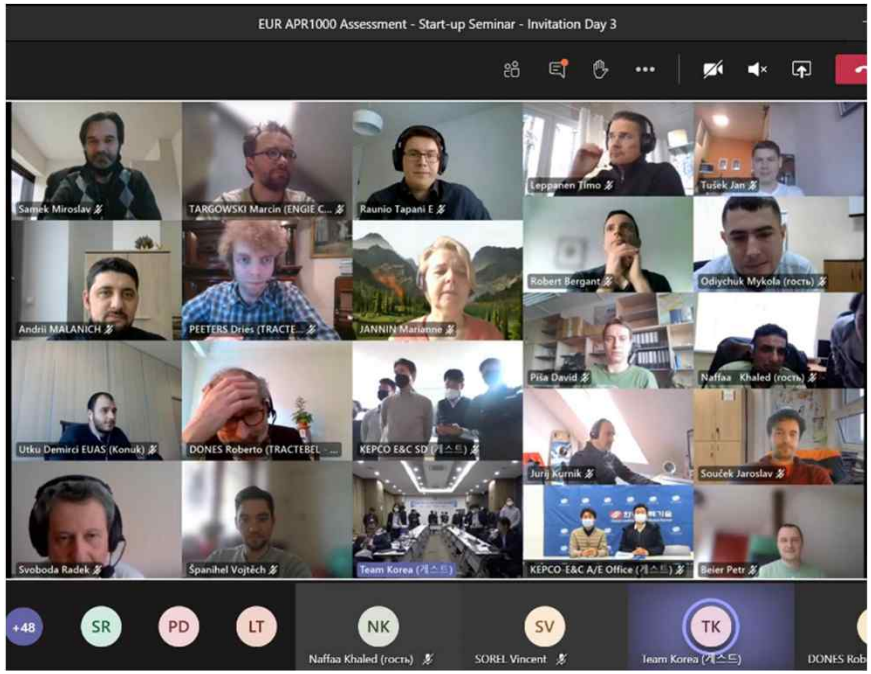
Project Server



WBM

APR1000 EUR Assessment (meetings)

- **Startup Seminar (Feb. 2021)**



APR1000 EUR Assessment (meetings)

CG#1 (Mar. 2021)

CG#2 (Jun. 2021)

CG#3 (Jun. 2021)

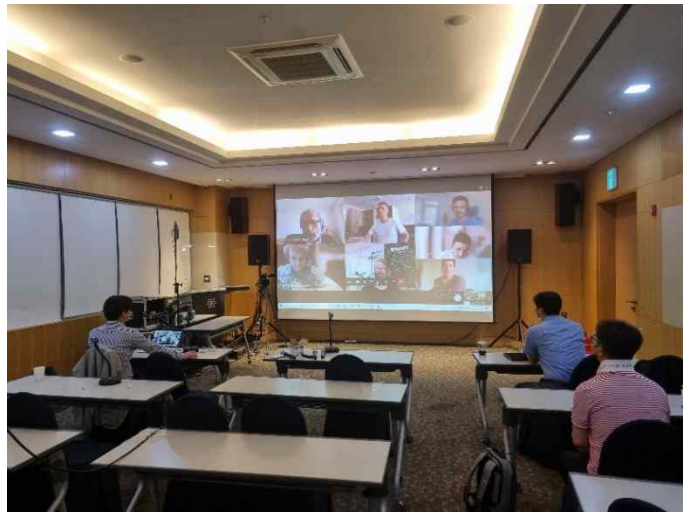
CG#4 (Sep. 2021)

APR1000 EUR Assessment (meetings)

CG#5 (Oct. 2021)

CG#6 (Nov. 2021)

CG#7 (Jan. 2022)



CG#9 (May 2022)

APR1000 EUR Assessment (meetings)

CG#11 (Sep. 2022)

CG#11 (Sep. 2022)

CG#12 (Oct. 2022)

CG#12 (Oct. 2022)

APR1000 EUR Assessment (meetings)

SC#125 (Jun. 2022)

SC#128 (Dec. 2022)

AG#210 (Nov. 2022)

APR1000 EUR Assessment

- **APR1000 EUR Certification (Mar. 2023)**

APR1000 EUR Assessment

APR1000 EUR Chapter Leaders

Jiyong Oh
(Chap 1,2,8,17)

Chewung Ha
(Chap 3)

Wonseok Yang
(Chap 4,5,6,7)

Dohyun Hwang
(Chap 9,16,20)

Sunmi Choi
(Chap 10)

Yongsu Kim
(Chap 11)

Byeungjun Jeong
(Chap 12,14,18)

Sunguk Kwon
(Chap 15)

Deajun Kim
(Chap 13,19)

Lessons Learned, Observations and Feedbacks

Observations

- Thorough and comprehensive assessment process
  (Assessor → Reviewer → CG → AG → SC)
- Clear process control and management by PM manual
- Continuous improvement process (ex. HOLD A,B,C)
- Thorough documentations → contribute to transparency in assessment

Lessons Learned

- Communication effectiveness in video-conference using MS teams under Co-vid 19
  - Clear objective and agenda
  - Use visual aids (sharing screens and files)
  - Importance of moderator/facilitator (stay on track)
  - Follow-up and action items
- Different interpretations for some requirements between EUR and Applicant
  - understand the basis and ground philosophies for the requirements
  - understand the diverse perspectives on nuclear technical basis
    (especially European nuclear industry practices, don't stick on US-based technical viewpoints only)
  - Clear rationale is essential to reach an concrete consensus

KHNP

THANK YOU