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01	Integration of technical and co-applicant comments	29-04-2008
02	PCSR June 2009 update including - Text clarifications - Addition of references - Technical update to account for December 2008 design freeze notably CCWS consumers and CCWS inlet temperature (section 2)	29-06-2009
03	Consolidated PCSR update: - Minor editorial changes - Text clarifications - References updated or added - Clarification of cross-references - Addition of a new paragraph related to protection to prevent risk of Reactor Pressure Vessel fragile rupture (§2.5.2.5)	26-03-2011
04	Consolidated PCSR update: - References listed under each numbered section or sub-section heading numbered [Ref-1], [Ref-2], [Ref-3], etc - Minor editorial changes - Update and addition of references - Summary of design changes to be implemented for RRI [CCWS] added, with cross-reference to Sub-chapter 16.4 (§2) - Clarification of text (§2, §2.1, §2.3.1, §2.3.2.2, §2.3.2.3, §2.4.1, §2.5.2, §3.1, §3.2.1, §3.3, §3.6)	23-11-2012

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SUB-CHAPTER 9.2 – WATER SYSTEMS

1. ESSENTIAL SERVICE WATER SYSTEM - SEC [ESWS]

1.0. SAFETY REQUIREMENTS

1.0.1. Safety function

The SEC [ESWS] system cools the nuclear island component cooling water system (RRI [CCWS]) and as such contributes to the following:

- decay heat removal from the primary system (RIS/RRA [SIS/RHRS])
- decay heat removal from the PTR [FPPS/FPCS] spent fuel pool cooling system
- heat removal from the Safety Chilled Water System (DEL [SCWS]) refrigeration units of Divisions 2 and 3.

The SEC [ESWS] indirectly contributes to maintain of the primary fluid inventory by cooling, via RRI [CCWS], the thermal barriers of the primary pumps which ensure the integrity of the pump seals.

1.0.2. Functional criteria

The SEC [ESWS] must ensure sufficient heat transfer from the component cooling system. A permanent minimum flow rate of filtered cold water to the RRI [CCWS]/SEC [ESWS] heat exchangers must thus be ensured.

1.0.3. Design-related requirements

1.0.3.1. Requirements of safety classification

- Safety classification

The SEC [ESWS] is safety-classified in accordance with the classification principles given in Sub-chapter 3.2.

- Single failure criterion (active and passive)

For components performing F1 functions, the single failure criterion must be applied in order to ensure a sufficient level of redundancy.

- Emergency power supplies

The electrical components of the SEC [ESWS] part performing the F1 function must be supplied by backed-up electrical supplies.

- Qualification to operating conditions

See Sub-chapter 3.6.

- Mechanical, electrical and instrumentation and control classifications

Classifications relating to the SEC [ESWS] comply with classification principles given in Sub-chapter 3.2.

- Seismic classification

The SEC [ESWS] fulfils its safety functions during and after earthquake in accordance with the classification principles given in Sub-chapter 3.2.

- Periodic tests

In operation, periodic tests are performed to check availability of the system.

1.0.3.2. Other regulatory requirements

- Technical Guidelines

Chapter B 2.4.2 of the Technical Guidelines (see also Sub-chapter 3.1).

- Specific EPR texts

There is no text specific to the SEC [ESWS].

1.0.3.3. Hazards

In accordance with Sub-chapter 13.1, the list of external hazards to be considered at the design stage is as follows: earthquake, aircraft crash, explosion shock wave, external flood, extreme meteorological conditions and electromagnetic conditions.

Through its direct link with the natural heat sink, the SEC [ESWS] may be affected by specific potential hazards of the marine environment affecting the CFI [CWFS] (or Raw Water Filter System SFI) filtering. These include clogging by floating objects, hydrocarbon pollution and massive intake of seaweed or marine organisms.

In accordance with Sub-chapter 13.2, the list of internal hazards to be considered at the design stage is as follows: pipe rupture, failure of vessels, pumps and valves, internal missiles, dropped loads, internal explosion, fire and internal flood.

1.1. ROLE OF THE SYSTEM

The essential service-water system (SEC [ESWS]) cools the heat exchangers of the component cooling system (RRI [CCWS]) using sea water from the heat sink (downstream of CFI [CWFS] (or SFI) filtering).

1.2. BASIS OF DESIGN [REF-1] TO [REF-7]

1.2.1. Operating assumptions

1.2.1.1. Normal PCC-1 operation

The operating regimes of the SEC [ESWS] system are similar to those of the RRI [CCWS] system.

When the reactor is in operation, two RRI [CCWS] trains are in service. The allocation of use of the RRI [CCWS] to the four SEC [ESWS] trains requires that one of the trains belongs to one pair (train 1, train 2) and the other belongs to the other pair (train 3, train 4).

For normal cool down to the cold shutdown state, four SEC [ESWS] trains are used to ensure the required shutdown time schedule.

When the core is fully unloaded into the fuel building, both PTR [FPPS/FPCS] trains are needed to maintain a PTR [FPPS/FPCS] temperature of 50°C (in the pool) and thus two RRI [CCWS]/SEC [ESWS] trains are required (1 or 2 and 3 or 4).

1.2.1.2. Incident or accident situations (PCC-2 to PCC-4)

All incident and accident conditions and their consequences are described in section 2. The configuration of the SEC [ESWS] system is dependent on the RRI [CCWS] system (number of trains in service).

For LOCA situations leading to start-up of safety injection, the pumps in the SEC [ESWS] trains which are initially shut down are automatically started to cool the RIS [SIS].

1.2.1.3. RRC-A and -B situations

In certain RRC situations, the SEC [ESWS] system must be available to support the RRI [CCWS] to cool the pumps and RIS [SIS] heat exchangers required in these conditions.

1.2.2. Design assumptions

1.2.2.1. Thermal design of the RRI [CCWS]/SEC [ESWS] systems

The maximum SEC [ESWS] temperatures, assumed in designing the equipment, are given in the table below:

	PCC-1 conditions	PCC-2 conditions	PCC-3/PCC-4 conditions (APRP [LOCA])	RRC-A / RRC-B
SEC [ESWS] temperatures	26°C	30°C	30°C	26°C

The heat transfer capacity of the RRI [CCWS]/SEC [ESWS] heat exchangers is determined by the cooling requirements of the reactor with a single RIS [SIS] train available (PCC-2) and by the requirements of the cold shutdown time schedule defined for start of fuel unloading 71 hours after shutdown of the reactor (PCC-1) (see section 2 of this subchapter).

1.2.2.2. Hydraulic sizing

The equipment, in particular the pumps, is sized to ensure the minimum flow rate necessary for cooling the RRI [CCWS] via the SEC [ESWS]/RRI [CCWS] heat exchangers for the maximum low water level (known as PBES) and the maximum fouling considered for design of the cooling water supply.

1.2.2.3. Specific assumptions

a) Redundancy of trains

The four trains of the SEC [ESWS] system are independent and physically separated.

b) Header

Communication by headers between the SEC [ESWS] trains (on the suction side of SEC [ESWS] pumps) downstream of the filtering systems is provided. These headers allow re-supply of an SEC [ESWS] train when the filtering system to which it is normally aligned is unavailable (due to maintenance or failure).

c) Diversification

Diversification by the heat sink discharge structure is not required, according to the safety studies.

d) Filtering

SEC (ESWS) water is filtered by the drum screens and the chain filters of the CFI [CWSF] system or the chain filters of the SFI system (see Sub-chapter 9.2, section 4).

The filtered water supply to the SEC [ESWS] pumps is shared with the CRF (water circulation) for the SEC [ESWS] pumps aligned to the drum screens and shared with the SEN (conventional service water) for the SEC [ESWS] pumps aligned to the chain filters.

The SEC [ESWS] system is also equipped with shellfish filters upstream of the RRI [CCWS]/SEC [ESWS] heat exchangers.

e) Permanent availability of the heat sink (see Sub-chapter 9.2, section 1.4).

f) Maintenance

No specific configuration is required to perform maintenance operations on the SEC [ESWS] system. Maintenance of an SEC [ESWS]/RRI [CCWS] train is permitted during unit operation.

g) Loss of power supplies

The electrical supplies for each SEC [ESWS] train are backed up by diesels, each one dedicated to an electrical supply train. This configuration helps ensure the independence of the power supplies for each of the SEC [ESWS] trains.

h) Accessibility

The pumps, motors, valves, filters and heat exchangers are located in rooms with permanent access.

Pipework downstream of the pumps is installed in tunnels ensuring access for staff to SEC [ESWS] intake and discharge pipes.

1.3. DESCRIPTION OF THE SYSTEM

The SEC [ESWS] system comprises four trains. The four SEC [ESWS] pumps are installed in pits located in four separate compartments in the pumping station. The connecting pipes between pumps, RRI [CCWS]/SEC [ESWS] heat exchangers and the discharge structure are installed in independent tunnels. [Ref-1] to [Ref-3]

Composition of a SEC [ESWS] train:

Each train comprises the following equipment:

- An electric pump powered by backed-up 10kV switchboards
- a RRI [CCWS] active shellfish filter and washing pipe
- a RRI [CCWS]/SEC [ESWS] heat exchanger with a continuous cleaning system
- a SEC [ESWS] weir located in the upper section of the CRF (water circulation) discharge pond

Suction header of SEC [ESWS] pumps:

Case of water filtration performed by CFI [CWFS] system (see Sub-chapter 9.2, section 4):

- In normal operation, trains 1 and 4 are preferentially supplied with filtered water by side water inlets fitted with CFI [CWFS] chain filters; trains 2 and 3 are supplied by central water inlets fitted with CFI [CWFS] drum screens.

Case of water filtration performed by SFI system (see Sub-chapter 9.2, section 4):

- In normal operation, each SEC [ESWS] train is supplied by the waterway and the chain filter which belongs to the same SFI train.

If a water channel is unavailable (due to CFI [CWFS] or SFI maintenance or a random event), the suction of each SEC [ESWS] train may be directed to another available water inlet via header pipwork upstream of the SEC [ESWS] pumps.

This alignment is performed by realigning the manual isolation valves located on the suction header pipes.

Diversification of SEC [ESWS] pumps suction:

For some situations of total loss of the pumping station, each SEC [ESWS] pump may be supplied by water directly by the discharge structure via a diverse suction pipe.

This alignment is performed by realigning the manual isolation valves located on the diverse suction pipes.

See Section 9.2.1 - Figure 1 functional flow diagram.

1.4. OPERATING PRINCIPLES

Each train of the SEC [ESWS] system is allocated to an RRI [CCWS]/SEC [ESWS] heat exchanger. Equipment cooled by each of the RRI [CCWS] trains is specified in Sub-chapter 9.2 section 2.

The operation of the SEC [ESWS] is linked to that of the RRI [CCWS]. When an RRI [CCWS]/SEC [ESWS] train (heat exchanger) is in operation, the SEC [ESWS] pump corresponding to this heat exchanger is in operation.

The different operating modes and the number of trains needed for each of these modes are given in section 2 of this sub-chapter.

- Normal operation

The RRI [CCWS] different operating modes are given in section 2 of this sub-chapter.

- Degraded heat sink operation

When the filtering system on which an SEC [ESWS] train is normally aligned is unavailable (for maintenance), a header pipe is used to re-supply the SEC [ESWS] train via another available filter.

In the event of clogging of the CFI [CWFS] (or SFI) system filters, a high pressure loss threshold may be reached.

However, the filtered water supply to the SEC [ESWS] train remains operable due to the following:

  - o tripping of the CRF (circulation water) and SEN (conventional service water) pumps on reaching a high differential pressure threshold across the drum screens or the chain filters
  - o over-sizing of the filtering surface of the drum screens and the chain filters in relation to the SEC [ESWS] safety flow rate.

- Operation in the event of electrical loss

In the event of loss of external electrical supplies, emergency supply is provided by the main diesel generators (also referred to as the emergency diesel generators within the PCSR).

1.5. PRELIMINARY SAFETY ANALYSIS

1.5.1. Compliance with regulations

Not applicable.

1.5.2. Compliance with functional criteria

To ensure the continuous flow rate of cold filtered water to the RRI [CCWS]/SEC [ESWS] heat exchangers, the SEC [ESWS] has four independent trains connected by headers. The SEC [ESWS] system is designed so that, in all operating configurations, the loss of one or two trains does not compromise the cooling of the nuclear auxiliaries and particularly the safeguard auxiliaries.

The switching from one SEC [ESWS] train to another is coordinated via the corresponding RRI [CCWS] line.

In the event of a leak in the system, the operator is alerted by a sump alarm enabling him to locate and isolate the leak.

1.5.3. Compliance with design requirements

1.5.3.1. Safety classification

The compliance of design and manufacture of materials and equipment with requirements derived from classification rules is detailed in Sub-chapter 3.2.

1.5.3.2. Single failure criterion

During power operation, the 4-train architecture of the SEC [ESWS] system enables consideration, in the analysis of PCC situations, the non-availability of a train for maintenance and the occurrence of a single failure in a second train.

1.5.3.3. Qualification

The equipment is qualified in accordance with the requirements described in Sub-chapter 3.6.

1.5.3.4. Instrumentation and control

The compliance of design and manufacture of materials and equipment with requirements derived from instrumentation and control classification rules is detailed in Sub-chapter 3.2.

1.5.3.5. Emergency power supplies

Each of the four SEC [ESWS] trains is backed up by a diesel dedicated to the electrical train in question. The F1A-classified pumps are powered by the LH electrical switchboards backed up by the main diesels. The other classified low-voltage equipment of the SEC [ESWS] system is powered by the LJ- or LL-classified switchboards backed up by the main diesels.

1.5.3.6. Hazards

External hazards

External hazards are taken into account in the design. Protection against these hazards is assured by either specific design measures (dimensions, structural resistance), or by redundancy and geographical separation.

- Earthquake

The civil engineering structures (water intake channel, pumping station, intake tunnels to the Safeguard Buildings and tunnels to the discharge structure) and other SEC [ESWS] equipment (pumps and piping), is designed to ensure operability during and after an earthquake.

- Aircraft crash

The SEC [ESWS] system is protected in the event of aircraft crash by geographic separation and location in bunkers.

The SEC [ESWS] discharge is also protected against the risk of aircraft crash by the discharge structure location in bunkers.

- External explosion

The buildings housing the SEC [ESWS] system are sized to withstand airborne explosion shock waves.

- External flooding

The pumping station and the SEC [ESWS] system equipment are protected from the consequences of external flooding in accordance with Sub-chapter 13.1.

The SEC [ESWS] building consists of four independent compartments from the foundation up to the upper floor, with no intermediate openings. The first outlet onto the upper floor is above the design maximum high water level (PHES).

- Extreme cold

All SEC [ESWS] equipment is protected against extreme cold (see Sub-chapter 9.4, section 1.2).

- Other hazards

In the event of arrival of sea borne hydrocarbon layers, warning procedures and preventive shutdown of the CRF (water circulation) pumps help avoid pollution of the pumping station. These measures protect the SEC [ESWS] system. In particular the RRI [CCWS]/SEC [ESWS] heat exchangers, are protected against pollution from hydrocarbons due to their installation downstream of the CFI [CWFS] filters.

Massive intake of seaweed or marine organisms is a condition that is taken into account in designing the CFI [CWFS] (or SFI) system, which protects the SEC [ESWS] system located downstream.

External hazards	**Protection required in principle**	**General protection**	**Specific protection introduced in the design of the system**
Earthquake	Yes	Installation in protected buildings (Pumping station, tunnels, Safeguard Buildings and discharge)	Seismic design
Aircraft crash	Yes	Bunker of Pumping station Tunnels: underground structures and protected discharge	Protection of SEC [ESWS] discharge

External hazards	Protection required in principle	General protection	Specific protection introduced in the design of the system
External explosion	Yes	Pumping station, Safeguard Buildings and discharge: protection by tunnels: underground structures	-
External flooding	Yes	Pumping station design and discharge structure	Protection of SEC [ESWS] pit up to the level required
Snow and wind (and wind-generated missiles)	Yes	Pumping station design and discharge structure	-
Extreme cold	Yes	Installation in heated buildings (Pumping station, tunnels, Safeguard Buildings)	Possible protection of SEC [ESWS] discharge
Electromagnetic interference	Yes	Electrical equipment installed in protected buildings (Pumping station and Safeguard Buildings)	-

Internal hazards

All of the following internal hazards are taken into account: leaks and pipe ruptures; tank failure; failure of vessels, pumps and valves; internal missiles; dropped loads; internal explosion, fire and internal flood.

The design of the SEC [ESWS] system is such that an internal hazard on any piece of equipment impacts only one train. This is ensured by the physical separation of the four trains of the SEC [ESWS] systems.

Internal hazards	Protection required in principle	General protection	Specific protection introduced in the design of the system
Rupture of piping	No loss of more than one train	- Pumping station, tunnels and Safeguard Buildings: installation in the four separate divisions - Discharge: risk averted	-
Failures of vessels, pumps and valves		- Pumping station, tunnels and Safeguard Buildings: installation in the four separate divisions - Discharge: risk averted	-
Internal missiles		- Pumping station, tunnels and Safeguard Buildings: installation in the four separate divisions - Discharge: risk averted	-
Dropped loads		- Pumping station, tunnels and Safeguard Buildings: installation in the four separate divisions - Discharge: Protected discharge	Protection of SEC [ESWS] discharge
Internal explosion		- Pumping station, tunnels and Safeguard Buildings: installation in the four separate divisions - Discharge: risk averted	-

Internal hazards	Protection required in principle	General protection	Specific protection introduced in the design of the system
Fire		- Pumping station, tunnels and Safeguard Buildings: installation in the four separate divisions - Discharge: risk averted	-
Internal flooding		- Pumping station, tunnels and: installation in the four separate divisions - Discharge: risk averted	-

1.6. TESTING AND MAINTENANCE

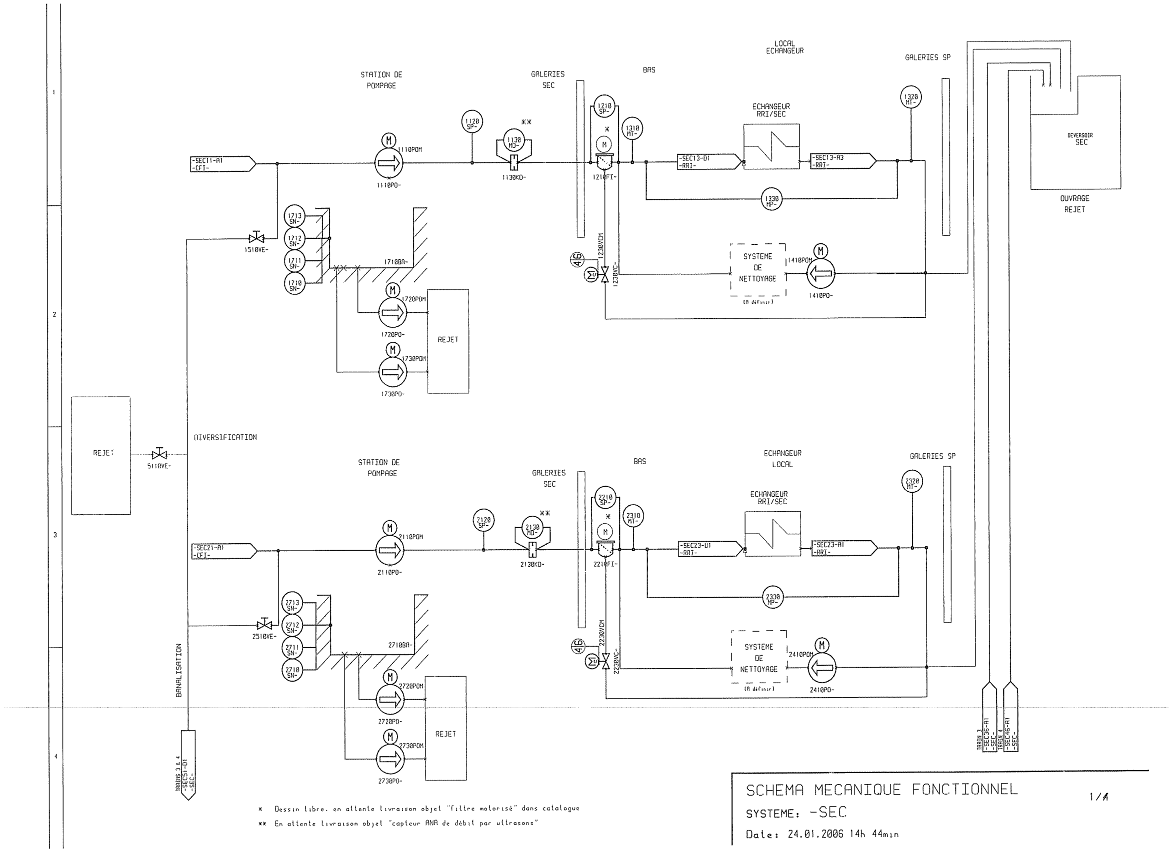
Periodic tests are carried out to check safety criteria and the system ability to fulfil its safety functions.

1.7. FUNCTIONAL FLOW DIAGRAMS

See Section 9.2.1 - Figure 1.

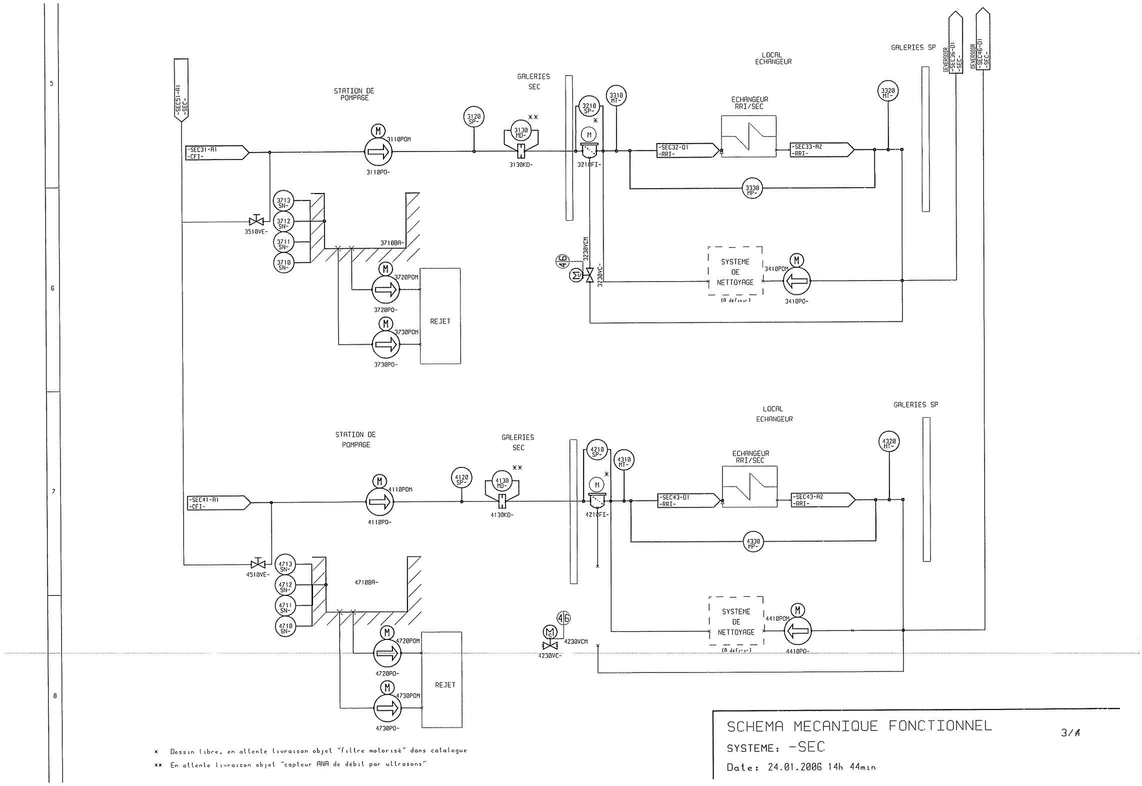
SECTION 9.2.1 – FIGURE 1 (PAGE 1/2) [REF-1]

FUNCTIONAL FLOW DIAGRAM OF ESSENTIAL SERVICE WATER SYSTEM (SEC [ESWS])



SECTION 9.2.1 – FIGURE 1 (PAGE 2/2)

FUNCTIONAL FLOW DIAGRAM OF ESSENTIAL SERVICE WATER SYSTEM (SEC [ESWS])



2. COMPONENT COOLING WATER SYSTEM FOR THE NUCLEAR ISLAND (RRI [CCWS])

Several design changes will be implemented for the RRI [CCWS] systems as follows:

- In order to ensure the cooling of safety classified systems in the event of partial loss of the RRI [CCWS], the safety features performing an automatic switchover of the cooling of the RRI [CCWS] common loads “b” to the stand-by RRI/SEC [CCWS/ESWS] train will be upgraded from Class 2 to Class 1.

- The function of isolation of the faulty RRI [CCWS] train will also be upgraded from Class 2 to Class 1.

- In addition, a common header will be added on the RRI [CCWS] side to allow cooling of the four thermal barriers in the event of loss of one of the trains of RRI/SEC [CCWS/ESWS] cooling.

These design changes are not included in the description of the RRI [CCWS] provided in this section. The incorporation of these design changes into the safety case is described in Sub-chapter 16.4, and the design changes will be fully incorporated into this sub-chapter as part of the detailed design during the site licensing phase.

2.0. SAFETY REQUIREMENTS

2.0.1. Safety functions

The RRI [CCWS] contribution to the three fundamental safety functions is described below:

a) Control of reactivity:

Not applicable

b) Decay heat removal:

The RRI [CCWS] must contribute to the following main functions:

- decay heat removal from the primary system: cooling of RIS [SIS] pumps and heat exchangers in the reactor normal cooling phase (Residual Heat Removal (RHR)) or during incident or accident conditions (PCC-2 to PCC-4 and RRC-A)

- decay heat removal from the spent fuel pool: cooling of PTR [FPCS] heat exchangers in normal operation or accidents (PCC-1 to PCC-4)

- heat removal from the safety chilled water system (DEL [SCWS]) refrigeration plants of divisions 2 and 3.

c) Containment of radioactive substances:

The RRI [CCWS] must contribute to the following main functions:

- ensuring the integrity of the containment: closure of the RRI [CCWS] containment isolation valves
- containment of radioactive substances in sensitive areas outside the containment: the RRI [CCWS] must maintain segregation of all equipment containing contaminated or contaminable fluids used in heat exchangers between radioactive fluids and service water discharged outside the plant (SEC [ESWS]) in order to protect the environment in the event of a heat exchanger leak
- indirectly contributing to maintaining the primary coolant inventory: cooling of the thermal barriers of the primary pumps which ensure their integrity.

2.0.2. Functional criteria

In order to fulfil its safety functions, the RRI [CCWS] must perform the following:

- Provide an appropriate flow for cooling the different loads
- Ensure acceptable temperatures of the RRI [CCWS] in the different operating conditions

The design of heat exchangers must ensure segregation of the radioactive fluids from the SEC [ESWS].

2.0.3. Design-related requirements

2.0.3.1. Requirements from safety classifications

Safety classification

In order to fulfil its safety functions, the RRI [CCWS] must be safety-classified in accordance with the requirements given in Sub-chapter 3.2.

Single failure criterion

Components performing an F1 function must be subject to the single failure criterion to ensure a sufficient level of redundancy.

Uninterruptible power supplies

The electrical power supply to active components must be provided by the electrical trains, backed up by the main diesel generators.

Qualification in operating conditions

Equipment fulfilling an F1 or F2 safety function must be qualified to remain functional in normal or post-accident operating conditions in accordance with Sub-chapter 3.6.

Mechanical, electrical and instrumentation and control classifications

The equipment of the RRI [CCWS] must be classified in accordance with Sub-chapter 3.2.

Seismic classification

The RRI [CCWS] must be able to fulfil its safety functions in the event of an earthquake in accordance with the classification described in Sub-chapter 3.2.

2.0.3.2. Other regulatory requirements

Basic safety rules

The RRI [CCWS] must comply with the applicable national regulatory requirements.

Technical guidelines specific to the RRI [CCWS]

The provisions specific to the RRI [CCWS] are presented in chapters B 1.4.2 and B 2.4.2 of the Technical Guidelines (see also Sub-chapter 3.1).

2.0.3.3. Hazards

The general installation provisions must enable protection of the RRI [CCWS] against external and internal hazards in accordance with Chapter 13.

2.0.4. Tests

Pre-operational testing

The system must be designed to allow the performance of commissioning tests to check that the system can fulfil its safety functions.

Surveillance in operation

The RRI [CCWS] must be designed to allow inspections to be carried out during operation.

Periodic tests

The RRI [CCWS] must be designed to allow periodic tests to be performed to ensure its ability to fulfil its safety function.

2.1. ROLE OF THE SYSTEM

The RRI [CCWS] operational role is to cool the various components as follows:

- the bearings and motors of the Low head safety injection (LHSI), Medium head safety injection (MHSI), RCP [RCS], RCV [CVCS], REA [RBWMS] and RRI [CCWS] pumps
- the LHSI heat exchangers
- the PTR [FPCS] heat exchangers

- the thermal barriers of the Reactor Coolant Pumps
- the heat exchangers of the REN [NSS], RES, RCV [CVCS], EVR [CCVS], TEP [CSTS], RPE [NVDS], REA [RBWMS], operational chilled water system (DER) and safety chilled water system (DEL [SCWS]) of divisions 2 and 3 systems

2.2. DESIGN BASES [REF-1] TO [REF-3]

2.2.1. General assumption

The RRI [CCWS] comprises four safety-classified trains corresponding to the four electrical trains and two separate common loop sets, known as common loads 1 and common loads 2.

The common loads 1 loop is connected to train 1 or train 2 and the common loads 2 loop is connected to train 3 or train 4.

Two separate loops, one belonging to the common loads 1 and the other to common loads 2, known respectively as common loads 1a and common loads 2a, provide cooling to the PTR [FPCS] heat exchangers. The PTR [FPCS] heat exchangers are separated from the other common load equipment cooled by the RRI [CCWS] in order to maintain the cooling capacity of the PTR [FPCS] during maintenance operations carried out during plant outages.

Two other RRI [CCWS] loops, one belonging to the common loads 1 and the other to the common loads 2, known respectively as common loads 1b and common loads 2b, provide cooling to the other equipments cooled by the RRI [CCWS].

The equipment cooled by the RRI [CCWS] is classified in four groups:

<u>Group 1</u>

Heat exchangers and components classified F1A (safeguard systems using RRI [CCWS] cooling supplied by each RRI [CCWS] train) comprising the following:

- the LHSI heat exchangers located on the low-pressure safety injection lines, which may be used in RHR system mode
- the LHSI and MHSI pump motor coolers
- the RRI [CCWS] pump motor coolers

<u>Group 2</u>

Heat exchangers and components classified F1B which are redundant and which are cooled by the RRI [CCWS] common header.

This group includes the following:

- the DEL [SCWS] refrigeration plant condensers of divisions 2 and 3
- the PTR [FPCS] pool cooling heat exchangers and pump motor coolers
- the thermal barriers of the Reactor Coolant Pumps

Group 3

Heat exchangers and components classified F2, or not classified, and which can or cannot be isolated, which may be used, if available, during certain PCC-3 and PCC-4 category events, during cold shutdown of the reactor, or in the event of internal or external hazards.

This group includes the following:

- Heat exchangers used to cool the Reactor Coolant Pumps (bearings, thrust bearings and motor).
- Heat exchangers in the volume control system (non-regenerative RCV [CVCS] heat exchangers, RCV [CVCS] charging pumps).
- Heat exchangers in the nuclear sampling system (primary and secondary coolant sampling REN [NSS] and RES.
- Heat exchangers in the REA [RBWMS] in the Fuel Building

Group 4

The non-safety-classified equipment cooled by the RRI [CCWS] common header: heat exchangers and components that can be isolated from other equipment cooled by the RRI [CCWS] which are used in normal operating conditions and are not necessary in the event of incidents, accidents or hazards.

This group includes the following:

- the heat exchangers in the containment ventilation system (EVR [CCVS])
- the primary system vent and drain coolers (RPE [NVDS])
- the TEP [CSTS] heat exchangers (evaporator, degasser, vacuum degasser)
- the DER refrigeration plant condensers
- the REA [RBWMS] heat exchangers in the Nuclear Auxiliary Building

RRI [CCWS] temperatures

The maximum RRI [CCWS] temperatures at inlet to the various heat exchangers and condensers, assumed for equipment design, are given in the table below:

	PCC-1 conditions	**PCC-2 conditions**	**PCC-3/PCC-4 conditions (LOCA)**	**RRC-A / RRC-B**
EVR [CCVS] heat exchangers RPE [NVDS] heat exchangers TEP [CSTS] heat exchangers DER condensers REA [RBWMS] heat exchangers in Nuclear Auxiliary Building	35°C	40°C		

	PCC-1 conditions	PCC-2 conditions	PCC-3/PCC-4 conditions (LOCA)	RRC-A / RRC-B
RCP [RCS] thermal barriers RCP [RCS] pumps heat exchangers Non-regenerating RCV [CVCS] heat exchangers and RCV [CVCS] pumps REN [NSS] and RES heat exchangers REA [RBWMS] heat exchangers in Fuel Building	35°C*	40°C	45°C	
DEL [SCWS] condensers (Divisions 2 and 3) PTR [FPCS] heat exchangers PTR [FPCS] pumps heat exchangers	35°C*	40°C	45°C	45°C
LHSI heat exchangers Heat exchangers of the RIS [SIS] pumps Heat exchangers of the RRI [CCWS] pumps	40°C	45°C	45°C	45°C

** : these components /exchangers are designed with a RRI [CCWS] temperature of 38°C.*

Ultimate heat sink temperatures

The maximum SEC [ESWS] temperatures, considered for equipment design, are given in the table below:

	PCC-1 conditions	PCC-2 conditions	PCC-3/PCC-4 conditions (LOCA)	RRC-A / RRC-B
SEC [ESWS] temperatures	26°C	30°C	30°C	26°C

2.2.2. Independence of the system

The RRI [CCWS] is specific to each unit.

2.2.3. Availability

The RRI [CCWS] shall be available in all operating states.

2.2.4. Choice of materials

The RRI [CCWS] operating fluid is demineralised water which is chemically treated by the SIR (chemical reagents injection system [Ref-1] to [Ref-6]) to prevent corrosion of equipment. For this reason, the equipment of the RRI [CCWS] is made from carbon steel. The RRI / SEC [CCWS / ESWS] heat exchanger tubes are made from titanium for all sites (coastal or river).

2.3. DESCRIPTION OF THE SYSTEM AND CHARACTERISTICS OF EQUIPMENT [REF-1] TO [REF-7]

2.3.1. General description

The RRI [CCWS] comprises four trains attached to four independent electrical trains that supply two common load loops, see Section 9.2.2 – Figure 1.

Composition of a RRI [CCWS] train

Each train comprises the following equipment:

- an electric pump powered from uninterruptible 10kV switchboards
- a minimum flow rate line
- a RRI / SEC [CCWS / ESWS] heat exchanger equipped with a by-pass on the RRI [CCWS] side and an adjustment valve which may be partially open in winter to prevent the RRI [CCWS] outlet temperature from falling too low.
- an expansion tank connected to the pump suction and located above the highest equipment supplied by RRI [CCWS].
- an activity measuring line (KRT [PRMS])
- a demineralised water supply line
- a chemical additive supply line
- a cooling line for RRI [CCWS], RIS [SIS] pumps and pump motors and for the RIS [SIS] heat exchanger
- inter-train isolation valves to allow RRI [CCWS] trains to be connected to or isolated from the common header

Composition of the common loads

The equipment cooled by the RRI [CCWS] common loads is located on two separate loops called common loads 1 and common loads 2.

The common loads 1 and 2 loops contain the following equipment:

- piping for the supply and return lines to the heat exchangers cooled by the RRI [CCWS]
- isolation valves to allow RRI [CCWS] trains to be connected to or isolated from the common loads loops
- containment isolation valves for the part of the common loads located in the Reactor Building
- isolation valves for parts of the common loads that are not seismically classified (loads in Nuclear Auxiliary Building and Effluent (Waste) Treatment Building)

2.3.2. Characteristics of equipment

The characteristics below are preliminary values and are to be confirmed by future detailed studies.

2.3.2.1. Main pumps

The RRI [CCWS] pumps are direct-driven centrifugal pumps, installed horizontally and equipped with a simple mechanical seal.

The pump motors are powered from 10KV switchboards backed up by main diesel generators and are cooled by the RRI [CCWS] fluid itself.

The maximum flow rate of the RRI [CCWS] pumps is based on the configuration used in cold shutdown, when the RRI [CCWS] pump supplies the LHSI heat exchanger and the common loads at the same time.

In this configuration, the main required characteristics of the pumps are:

- flow rate: 3050 m^3/h
- discharge head: 58.1 m

2.3.2.2. RRI / SEC [CCWS / ESWS] heat exchangers

The RRI / SEC [CCWS / ESWS] heat exchangers are tube heat exchangers installed horizontally. The RRI [CCWS] water circulates outside the tubes with the SEC [ESWS] water inside.

Each RRI / SEC [CCWS / ESWS] heat exchanger is equipped with a continuous tube cleaning system (SEC [ESWS] side). This cleaning system, using circulating balls inside the tubes of the exchanger, is used in order to avoid the formation of sediment inside the tubes.

The capacity of the RRI / SEC [CCWS / ESWS] heat exchangers is based on the requirements of cold shutdown assuming the start of fuel unloading 71 hours after shutdown of the reactor.

In this configuration, RRI [CCWS] heat exchangers characteristics are:

- Cold coolant: SEC [ESWS]
    - minimal required flow rate: 950 kg/s
    - inlet temperature: 26°C
- Hot coolant: RRI [CCWS]
    - flow rate: 900 kg/s
    - outlet temperature: 35°C
    - heat removal: 36 MW

During an accident, each RRI [CCWS] train can be connected to the RCP [RCS] at a temperature of 180°C. In this situation, a single RRI [CCWS] train must be able to extract the decay heat maintaining a RRI [CCWS] temperature at the inlet of the loads below 45°C. In this configuration, RRI [CCWS] heat exchanger characteristics are:

- Cold coolant: SEC [ESWS]
  - minimal required flow rate: 950 kg/s
  - inlet temperature: 30°C
- Hot coolant: RRI [CCWS]
  - flow rate: 390 kg/s
  - outlet temperature: < 45°C
  - heat removal: 70.9 MW

2.3.2.3. Valves

The inter-train valves (valves for isolation between the RRI [CCWS] trains and the RRI [CCWS] common loads) must operate in less than 10 seconds.

The isolation valves for common loads which are not seismically classified must operate in less than 8 seconds to avoid complete emptying of the RRI [CCWS] tank in the event of leaks from non-classified sections of the common loads.

The isolation valves of the RIS [SIS] heat exchanger must operate within 10 seconds.

The containment isolation valves must operate within 60 seconds and must fulfil the leaktightness requirements.

2.3.2.4. Expansion tank

Useable volume: 27 m^3.

2.4. PHYSICAL PHENOMENA DETERMINING OPERATION

2.4.1. Normal operating conditions of the system

The normal operating conditions correspond to all normal operating configurations of the RRI [CCWS] during plant operation (State A).

Two RRI [CCWS] trains are in operation and cool the common loads: train 1 (or train 2) cools common loads 1a and 1b and train 3 (or train 4) cools common loads 2b:

a) the isolation valves of the LHSI heat exchangers are closed

b) the associated inter-train valves are open

The following equipment is thus cooled by the RRI [CCWS]:

- on the trains in operation:
  - the RRI [CCWS] and RIS [SIS] pump coolers (except LHSI pump seals)
- on the common loads:
  - the non-regenerative RCV [CVCS] heat exchangers
  - the PTR [FPCS] heat exchangers
  - the DEL [SCWS] refrigeration units
  - the RCP [RCS] coolers (motors, bearings, thermal barriers)
  - the REN [NSS] and RES heat exchangers
  - the EVR [CCVS] containment ventilation cooling coil heat exchangers
  - the RPE [NVDS] heat exchanger inside the Reactor Building
  - the coolers of the TEP [CSTS]
  - the DER chilled water production unit heat exchangers
  - the REA [RBWMS] heat exchangers inside the Fuel Building and the Nuclear Auxiliary Building

The other two trains are not in operation and are isolated from the common loads:

a) the isolation valves of the LHSI heat exchangers are closed

b) the associated inter-train valves are closed

In normal operating conditions, three RRI [CCWS] trains are required to be operable by the Technical Specifications [Ref-1] (two trains required to ensure cooling of the RIS [SIS] in the event of SI, one train is considered unavailable to satisfy the single failure criterion). The fourth train may be in preventive maintenance.

2.4.2. Permanent system operating conditions

2.4.2.1. Operation during normal shutdown of the reactor

<u>State B (normal shutdown, SG cooling, T° RCP [RCS] > 120°C)</u>

The RRI [CCWS] configurations are identical to those of normal plant operating conditions.

Two RRI [CCWS] trains are in operation:

- train 2 is in operation to cool common loads 1a and 1b
- train 3 is in operation to cool common loads 2b

Trains 1 and 4 are in operation on the LHSI exchangers (the isolation valves of the LHSI heat exchangers are open) in order to be ready to remove the residual heat via LHSI trains 1 and 4 following their connection at 120°C.

State C (normal shutdown, RHR cooling), 55°C < T° RCP [RCS] < 120°C)

The four RRI [CCWS] trains must be available to ensure the outage schedule can be met. There are three operational phases:

- Two LHSI low pressure trains in RHR mode (initial mode):

  During this phase, four RRI [CCWS] trains are in operation:

  - Train 1 and train 4 cool the LHSI heat exchangers in RHR mode and are isolated from the common loads (inter-train valves closed)
  - Train 2 cools common loads 1a and 1b (LHSI heat exchanger isolation valves closed)
  - Train 3 cools common loads 2b (LHSI heat exchanger isolation valves closed)

- Four LHSI trains in RHR mode (final mode)

  When the temperature of the RCP [RCS] is lower than 100°C, trains 2 and 3 are also aligned on the LHSI heat exchangers to accelerate cooling of the primary system.

- Stabilisation of the primary temperature with three LHSI trains in RHR mode

  Three RRI [CCWS] trains are aligned on the LHSI heat exchangers in order to maintain the primary temperature below 55°C.

State D (shutdown for maintenance, T° RCP [RCS] < 55°C)

Three RRI [CCWS] trains are in operation on the LHSI heat exchangers and on the common load loops.

The two PTR [FPCS] heat exchangers are cooled, in anticipation of the shutdown for refuelling.

Train 2 cools the LHSI heat exchanger and common loads 1a and 1b. Train 3 cools the LHSI heat exchanger and common loads 2b. Train 4 cools the LHSI heat exchanger and common loads 2a.

State E (shutdown for refuelling)

At the start of core unloading, the RRI [CCWS] trains are in operation to remove heat from the core and to cool the PTR [FPCS] and the necessary common load equipment.

One train may be in maintenance.

State F (core completely unloaded)

With the core fully unloaded, two non-associated RRI [CCWS] trains are in operation to cool the PTR [FPCS] and the required common loads.

The two other trains may be in maintenance.

2.4.2.2. Operation in the case of PCC-2 events

- In this case, one LHSI train may be connected in RHR mode at an RCP [RCS] temperature of 180°C

- Loss of one RIS / RRI [SIS / CCWS] train in state C3 or D (“3/4 loop" operations): only two LHSI trains are in operation in RHR mode (see Sub-chapter 14.3).

2.4.2.3. Operation following PCC-3/PCC-4 events

Small break LOCA (PCC-3) or large break LOCA (PCC-4)

When an RRI [CCWS] train is in operation, the LHSI and MHSI pumps of the same train are cooled by the RRI [CCWS].

On receipt of the safety injection signal, the pumps of the RRI [CCWS] trains on stand-by are automatically switched on to cool the RIS [SIS] pumps which have started up, and the LHSI heat exchanger of the corresponding trains.

On receipt of the safety injection signal, the non-classified equipment cooled by the RRI [CCWS] common loads is isolated from the trains in operation.

On a phase-2 containment isolation signal, the RRI [CCWS] common load equipment located inside the Reactor Building is isolated by closure of the containment isolation valves, with the exception of the thermal barriers which must continue to ensure the leak tightness of the Reactor Coolant Pump seals.

2.4.3. RRC-A and RRC-B situations

In certain RRC situations, the RRI [CCWS] must be available to cool the required pumps and LHSI heat exchangers required in these conditions, or to cool the REN [NSS] heat exchangers in the event of sampling of the primary system.

2.4.4. Transient system operating conditions

Loss of one RRI [CCWS] pump (loss of an RRI [CCWS] train)

Following loss of one RRI [CCWS] pump, the pump of the associated train is automatically switched on and the automatic switchover of the common loads to the corresponding train is triggered.

In the event of loss of one RRI [CCWS] train if one train is in maintenance, only two LHSI / RRI [CCWS] trains are available. The plant is then shut down normally using the SG cooling until the conditions for connection of the RRA [RHRS] are reached.

Switchover of common loads

The switchover of common loads from one train to the associated train is activated either automatically or on demand from the operator.

The automatic switchover takes place in the following cases:

- loss of a RRI [CCWS] pump

- loss of a SEC [ESWS] pump
- loss of flow to the common F1B RRI [CCWS] loads (PTR [FPCS] or DEL [SCWS] heat exchangers)
- temperature on a RRI [CCWS] train higher than 45°C

Failure of the automatic switchover of the common loads

Failure to switchover the common loads (1 or 2) causes shutdown of one RCV [CVCS] pump and two reactor coolant pumps followed by shutdown of the reactor.

Leaks on the RRI [CCWS]

- Small leaks from the RRI [CCWS]

The RRI [CCWS] train may remain in service as long as the level in the tank is maintained by automatic make-up of water.

The reactor remains at power if the leak is located:

  - on one of the four redundant RRI [CCWS] trains
  - on a piece of equipment cooled by the RRI [CCWS] that can be temporarily taken out of service
  - on a header of a redundant piece of equipment cooled by the RRI [CCWS]

- Major leakage from the RRI [CCWS]

An automatic control system enables initial isolation of the common loads that are not safety classified and, if the leak persists, isolation of the common loads or the RRI [CCWS] train affected by the leak.

SEC [ESWS] failure

The loss of a SEC [ESWS] train leads to the non-availability of the corresponding RRI [CCWS] train and the switchover of common loads to the associated train.

Total Loss of Heat Sink

The total loss of the SEC [ESWS] causes loss of the RRI [CCWS] shortly afterwards.

2.5. SAFETY ANALYSIS

2.5.1. Compliance with regulations

The system will be compliant with applicable national regulations in force.

2.5.2. Achievement of functional criteria

The RRI [CCWS] must be able to cool systems that are important for safety and must successfully contain radioactive substances either inside the containment (by closure of containment isolation valves) or in sensitive areas outside the containment, in the event of a leak from a heat exchanger containing contaminated fluid.

Sections 2.2, 2.3 and 2.4 present the design assumptions for the RRI [CCWS], to ensure compliance with the above requirements.

Protection against component failure is described below:

2.5.2.1. Protection against excess pressure (rupture of a heat exchanger tube)

The RRI [CCWS] cools certain heat exchangers which are at a pressure higher than that of the RRI [CCWS]. The rupture of a tube leads to a risk of over-filling of the tank and excess pressure on the RRI [CCWS] side which may lead to loss of primary fluid outside the containment.

- Heat exchangers with high-energy piping

<u>Thermal barriers</u>

In the event of rupture of a thermal barrier, a pressure or temperature measurement is used to initiate automatic isolation of the affected pipe section. The system is subjected to primary pressure between the motor-driven valve located upstream of the thermal barrier and the automatic valve downstream. A safety valve downstream of this section protects the RRI [CCWS] from the pressure wave.

<u>Non-regenerative RCV [CVCS] heat exchanger</u>

In the event of rupture of a tube of this heat exchanger, two rupture disks upstream and downstream of the heat exchanger and a pressure relief valve, protect the RRI [CCWS] from the pressure wave. Using the information passed to the control room (activity measurements, temperature and flow rate measurements, RRI [CCWS] tank level measurements), the operator is able to identify and isolate the defective heat exchanger.

- Heat exchangers with medium-energy pipes with pressures above the RRI [CCWS] pressure

<u>LHSI heat exchanger</u>

In the event of rupture of a LHSI heat exchanger tube, the RRI [CCWS] is designed to contain the water from the leak for a period of 30 minutes.

Using the information passed to the control room (activity measurements, temperature and flow rate measurements, RRI [CCWS] tank level measurements), the operator is able to identify and isolate the defective heat exchanger.

2.5.2.2. Protection against risks of dilution

The RRI [CCWS] cools the heat exchangers containing primary fluid (RIS [SIS], RCV [CVCS], REN [NSS] heat exchangers, thermal barriers). In certain configurations, the RRI [CCWS] pressure may be higher than that of the primary fluid in these heat exchangers. Specific means for detection and protection are being developed to avoid risks of boron dilution in the event of a leak in a heat exchanger.

2.5.2.3. Protection against thermal overpressurisation risk

Sections of the RRI [CCWS] loops which can be isolated between two valves and which can be subjected to a heat source (heat exchanger or ambient temperature conditions) are protected from overpressurisation by a relief valve.

2.5.2.4. RRI [CCWS] leaks

Besides the leak detection and isolation process, the operator has other means for identification of leaks (lowering of the water level in the RRI [CCWS] tank, increased level in the building sumps) and is provided with procedures to help locate and isolate leaks.

2.5.2.5. Protection to prevent risk of RPV fragile rupture

The RRI [CCWS] temperature needs to be maintained in the range 18°C to 32°C in order to prevent the risk of Reactor Pressure Vessel (RPV) fragile rupture in the case of safety injection.

The RRI [CCWS] temperature is maintained in the authorised range (18°C to 32°C) by automatic control. In the case of the RRI [CCWS] temperature being out of range combined with a safety injection signal, F1A signals are sent to the RRI [CCWS] in order to bring the RRI [CCWS] temperature back into its normal range.

2.5.3. Compliance with design requirements

2.5.3.1. Safety classification

The design and manufacture of materials and equipment comply with requirements derived from classification rules detailed in Sub-chapter 3.2.

2.5.3.2. SF(C) or “redundancy”

The four RRI [CCWS] trains needed for safeguard functions (cooling of RIS [SIS] heat exchangers) comply with the single failure criterion by design. Each train is in a separate building, and is protected from aircraft crashes by an aircraft shell or by geographical separation.

Common loads 1, supported by RRI [CCWS] train 1 or 2, cool the following classified systems:

- PTR [FPCS] train 1
- DEL [SCWS] train 2
- RCV [CVCS] line 1
- Reactor Coolant Pump 1 and 2 thermal barriers

Common loads 2, supported by the RRI [CCWS] train 3 or 4, cool the following classified systems:

- PTR [FPCS] train 2
- DEL [SCWS] train 3
- RCV [CVCS] line 2
- Reactor Coolant Pump 3 and 4 thermal barriers

In the event of loss of cooling of a RRI [CCWS] common load loop, the trains of systems served are redundant.

In the event of loss of cooling of the thermal barriers, the protection of Reactor Coolant Pump seals is taken over by the Standstill Sealing System of the Reactor Coolant Pump.

The RRI [CCWS] containment isolation valves are duplicated and powered by different electrical trains.

2.5.3.3. Qualification

The equipment is qualified in accordance with the requirements described in Sub-chapter 3.6.

2.5.3.4. Instrumentation and control

The design and manufacture of materials and equipments comply with requirements derived from instrumentation and control classification rules detailed in Sub-chapter 3.2.

2.5.3.5. Emergency power supplies

In the event of Loss Of Offsite Power (LOOP), the RRI [CCWS] pumps supplies are backed up by the main diesel generators.

The general loss of electrical power (station blackout) leads to loss of the four RRI [CCWS] pumps.

2.5.3.6. Hazards

The following tables summarise the consideration of hazards for the RRI [CCWS]:

Internal hazards	**Protection required in principle**	**General protection**	**Specific protection introduced in the design of the system**
Rupture of piping	No loss of more than one train or one common load loop	Physical separation	Isolation of non safety classified common loads on delta-flow measurement and/or low RRI [CCWS] tank level (MIN2) and then of common loads impacted if the leak persists (MIN3)
Failures of tanks, pumps and valves		Physical separation	-
Internal missiles		Physical separation	-
Dropped Load		Physical separation	-
Internal explosion		Physical separation	-
Fire		Physical separation in the four safeguards buildings Fire zoning in the reactor building and the fuel building	-
Internal flooding		Physical separation	-

External hazards	**Protection required in principle**	**General protection**	**Specific protection introduced in the design of the system**
Earthquake	Yes	Installation in the safeguards building, fuel building, reactor building Installation in the nuclear auxiliary building and the reactor building (for non-safety classified loads)	Seismic design Isolation of non-safety classified common loads on delta-flow measurement and/or low RRI [CCWS] tank level (MIN2) and then of impacted common loads if the leak persists (MIN3)

External hazards	Protection required in principle	General protection	Specific protection introduced in the design of the system
Aircraft crash	Yes	Installation in the safeguards building, fuel building, reactor building Installation in the nuclear auxiliary building	Seismic design Isolation of non-safety classified common loads on delta-flow measurement and/or low RRI [CCWS] tank level (MIN2) and then of impacted common loads if the leak persists (MIN3)
External explosions	Yes	Installation in the safeguards building, fuel building, reactor building Installation in the nuclear auxiliary building	Isolation of non-safety classified common loads on delta-flow measurement and/or low RRI [CCWS] tank level (MIN2) and then of common loads impacted if the leak persists (MIN3)
External flooding	Yes	Installation in the safeguards building, fuel building, reactor building and the nuclear auxiliary building (volume protection)	-
Snow and wind	Yes	Installation in the safeguards building, fuel building, reactor building and the nuclear auxiliary building	-
Extreme cold	Yes	Installation in the safeguards building, fuel building, reactor building and the nuclear auxiliary building	-
Electromagnetic interference	Yes	Installation in the safeguards building, fuel building, reactor building and the nuclear auxiliary building	-

2.5.3.7. Other requirements

This system is considered in the demonstration of the practical elimination of the risk of containment bypass (see Sub-chapter 16.3).

2.6. TESTING, INSPECTION AND MAINTENANCE

2.6.1. Maintenance

The design of the part of the system located outside the reactor building facilitates access for preventive maintenance with the plant in operation. For other equipment, the design will facilitate preventive maintenance in a timescale compatible with the duration of the plant outage.

The system design will also allow visual inspections to facilitate the search for leaks.

The design of the four-train RRI [CCWS] permits preventive maintenance on one train with plant in operation.

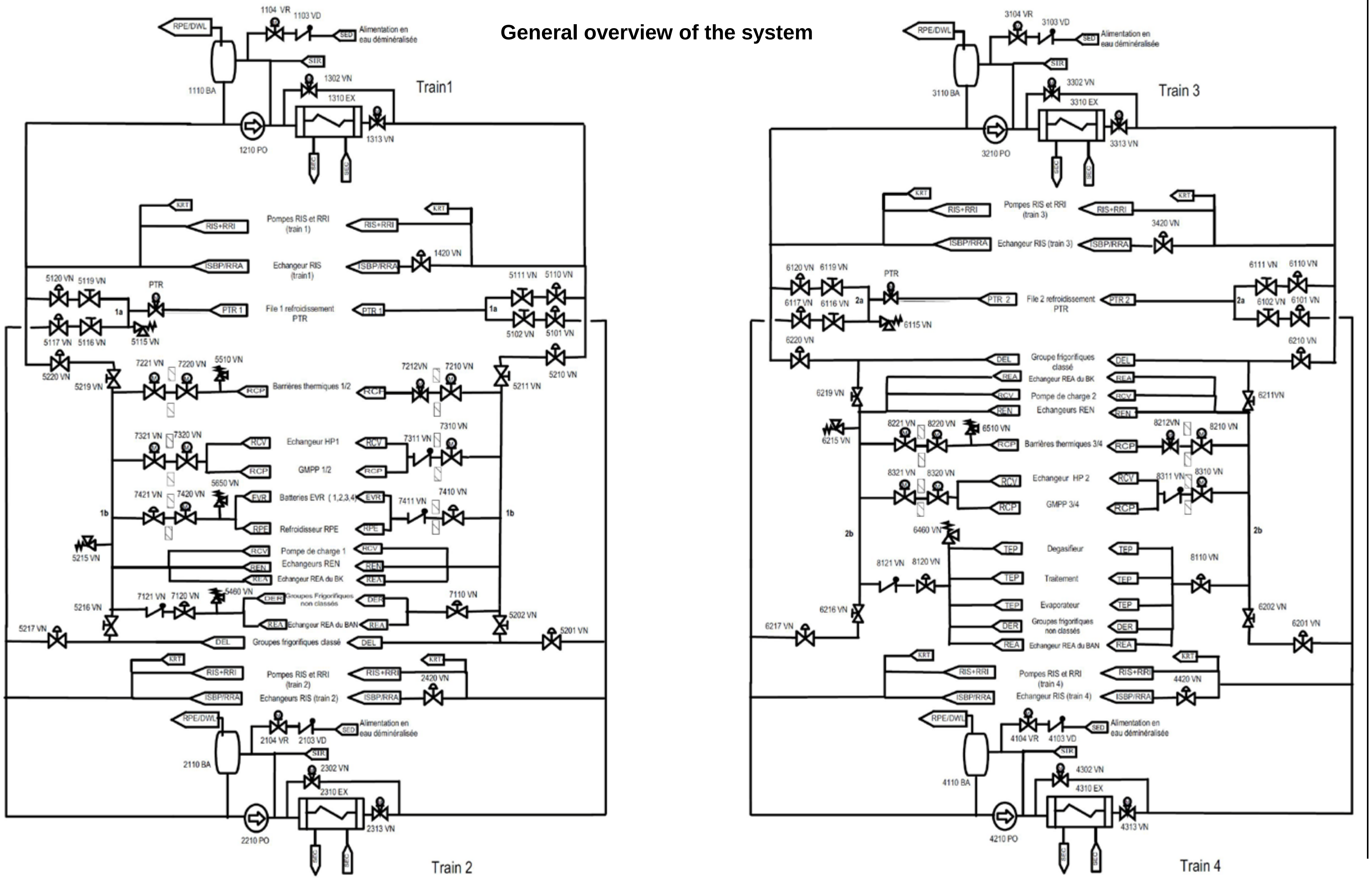
The re-qualification of equipment will be the subject of future detailed studies.

2.6.2. Periodic tests

Periodic tests are planned to check safety criteria and the ability of the RRI [CCWS] to fulfil its safety functions.

SECTION 9.2.2 - FIGURE 1 [REF-1]

General overview of the system



3. DEMINERALISED WATER (PRODUCTION – STORAGE – DISTRIBUTION)

3.1. ROLE OF THE DEMINERALISED WATER SYSTEMS (SDA, SDS, SED AND SER SYSTEMS)

The role of the demineralised seawater production system (SDS) is to take seawater supplies and desalinate them to obtain demineralised water see Section 9.2.3 – Figure 1.

Additional to the demineralised seawater production system, the role of the SDA (demineralised water production system) is to filter and demineralise potable water.

The role of the SED-SER systems is to store and distribute demineralised water with pH7 (SED) and pH>9 (SER).

3.2. BASIS OF DESIGN [REF-1]

3.2.1. Safety Role

The SDA (demineralised water production system), SDS (demineralised seawater production system) and SER systems play no part in the safety case.

3.2.2. Design

The chemical specification of the demineralised water to be used for supply of systems is as follows:

- conductivity lower than 0.2×10^{-6} S/cm (at 25°C)
- silica (Si02) content lower than 20×10^{-6} g/l
- sodium content lower than 10^{-5} g/l (average value on one cycle)
- suspended solids content 50×10^{-6} g/l (after heat treatment)

Storage of demineralised water must be sufficient for the supply of nuclear and conventional systems for two days in normal operation.

3.3. DESCRIPTION - SUPPLY, PRODUCTION AND DISTRIBUTION [REF-1] TO [REF-9]

SDS

Water is pumped from downstream of a drum screen at the pumping station and is channelled towards the SDS (demineralised seawater production system) treatment station, which includes the following:

- a pre-treatment station using filtering and ultra-filtering membranes
- a demineralisation station using reverse osmosis with two trains and storage for the reagents associated with pre-treatment and cleaning of the osmosis membranes

SDA (demineralised water production system)

In the event of non-availability of the SDS (demineralised seawater production system), the SDA (demineralised water production facilities) will be used.

SED

The SED system supplies non-degassed water make-up for the primary system and the nuclear auxiliary systems (pH7).

SER

The SER system supplies conditioned demineralised water for filling and make-up of conventional systems (pH>9) and the ASG [EFWS] tanks.

3.4. OPERATING PRINCIPLES

Not applicable

3.5. PRELIMINARY SAFETY ANALYSIS

The networks, supplied with demineralised water and performing a safety role have their own reserves which are earthquake resistant and allow them to fulfil their safety function independently.

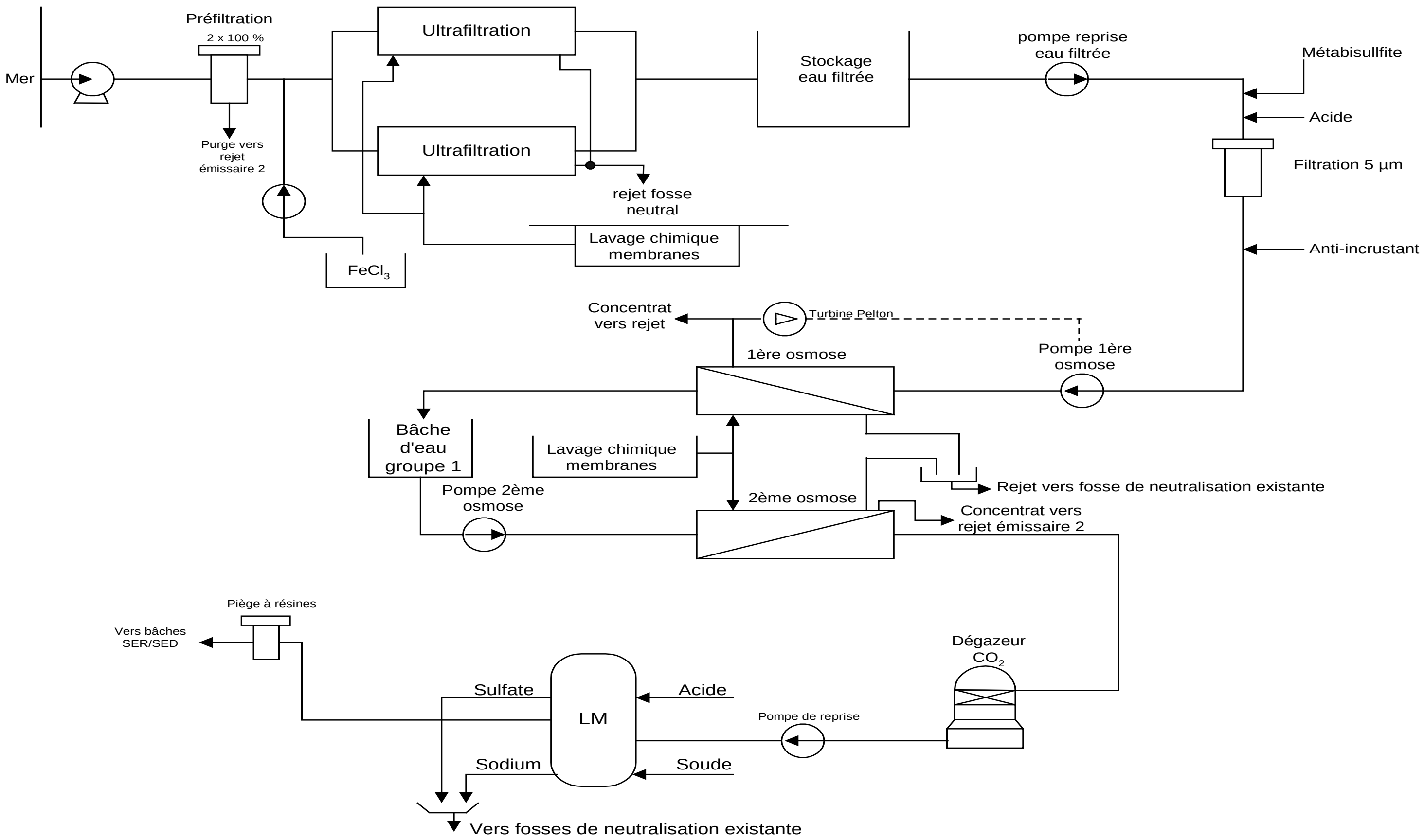
The role of the demineralised water production system is limited to the replenishment of these reserves after they are used.

3.6. TESTING AND MAINTENANCE

The SDS (demineralised seawater production system), SDA (demineralised water production system) and SER systems are not subject to periodic tests.

SECTION 9.2.3 – FIGURE 1

BLOCK DIAGRAM



4. WATER INTAKE AND FILTERING OF SERVICE WATER

The design of the water intake and filtering of service water is directly related to the power plant location and to the specification of the cold water. Therefore design studies have not been completed.

The following chapter provides the safety requirements applied to water intake and filtering of service water for the UK-EPR. It describes the possible design choices, consistent with the FA3 reference design and/or other French nuclear power plants.

Two design orientations are possible for these systems: cooling the condenser by means of open circuits or closed circuits (atmospheric cooling towers).

For open circuits, filtering of service water is fulfilled by drum screens and chain filters (CFI [CFWS] system). The CFI [CFWS] performs the filtering of the water for cooling the nuclear and conventional auxiliaries (SEC [ESWS] – SRU [UCWS] ultimate cooling water, SEN [raw water cooling]) and circulation water (CRF).

For closed circuits, filtering of service water is fulfilled by chain filters (SFI system). The SFI performs the filtering of the water for cooling the nuclear and conventional auxiliaries (SEC [ESWS] – SRU [UCWS] ultimate cooling water, SEN [raw water cooling]) and the water for supplying the atmospheric cooler.

In every case, the seawater is supplied either via an intake channel (similar to FA3) or via an offshore water intake with submarine tunnels driving to an equalising pond.

4.0. SAFETY REQUIREMENTS

4.0.1. Safety function

The pre-filtering (SEF) and filtering (CFI [CWFS] or SFI) systems for service water do not play a direct role in fulfilling the three basic safety functions.

However, the SEF pre-filtering and CFI [CWFS] (or SFI) filtering systems must supply the SEC [ESWS] and SRU [UCWS] ultimate heat sink systems with enough high-quality water to ensure cooling of the intermediate RRI [CCWS] and EVU [CHRS] systems.

4.0.2. Functional criteria

The CFI [CWFS] (or SFI) [filtering] system must perform service-water filtering for the required flow rates of the SEC [ESWS] and SRU [UCWS] ultimate heat sink systems.

The SEF pre-filtering system must protect the CFI [CWFS] (or SFI) filtering system at the required flow rates of the SEC [ESWS] and SRU [UCWS] ultimate heat sink systems.

4.0.3. Design-related requirements

4.0.3.1. Requirements resulting from safety classifications

- Safety classification

The CFI [CWFS] (or SFI) filtering function helps achieve and maintain a safe state. The components of the CFI [CWFS] (or SFI) filtering system helping to perform the filtering function must be F1B classified in accordance with Sub-chapter 3.2.

The SEF pre-filtering function helps protect the CFI [CWFS] (or SFI) filtering system. The components of the SEF pre-filtering system helping to perform the pre-filtering function must be F2 classified in accordance with Sub-chapter 3.2.

- Single failure criterion (active and passive)

For components performing F1 functions, the single failure criterion must be applied in order to ensure a sufficient level of redundancy.

- Emergency power supplies

The power supply to F1 classified equipment must be backed up (supplied from switchboards backed up by main diesel generators).

- Qualification for operating conditions

See Sub-chapter 3.6.

- Mechanical, electrical and instrumentation and control classifications

Classifications relating to the CFI [CWFS] (or SFI) filtering system are given in Sub-chapter 3.2.

- Seismic classification

The F1 filtering equipment of the CFI [CWFS] (or SFI) filtering system must be seismically classified in accordance with Sub-chapter 3.2.

- Periodic tests

Periodic tests must enable checking of safety criteria and the ability of the system to fulfil its safety functions.

4.0.3.2. Other regulatory requirements

- Technical Guidelines

No specific requirements (see Sub-chapter 3.1).

- Specific EPR texts

No specific texts.

- Notification of cooling towers and atmospheric cooling regulations 1992.

(Required in the case of closed circuit atmospheric cooling towers)

4.0.3.3. Hazards

In accordance with Sub-chapter 13.1, the external hazards to be considered at the design stage are as follows: earthquakes, aircraft crashes, explosion shock waves, external floods, extreme meteorological conditions and electromagnetic interference. Through its direct link with the natural heat sink, the SEC [ESWS] and CFI [CWFS] (or SFI) filtering systems may be affected by specific potential hazards associated with the marine environment, including clogging of the cooling water intakes with floating objects, freezing, hydrocarbon pollution and the massive intake of seaweed or marine organisms.

In accordance with Sub-chapter 13.2, the list of internal hazards to be considered at the design stage is as follows: leaks and pipe rupture, vessel leaks, pump and valve failure, internal missiles, dropped loads, internal explosions, fire and internal floods.

4.1. ROLE OF THE SYSTEMS

The CFI [CWFS] (or SFI) filtering system filters all the service water used for the unit; the main consumers are as follows:

- In the case of an open circuit: the CRF water circulation system (non-classified) for cooling the condenser
- In the case of a closed circuit: the CVF system (non-classified) of an atmospheric cooling tower.
- the SEC [ESWS] system (classified F1A) for cooling the nuclear auxiliaries
- the SRU [UCWS] ultimate cooling water system (classified F2) for final cooling of the EVU [CHRS] system and the 3rd PTR [FPCS] train
- the CFI [CWFS] (or SFI) filtering system itself for supply of the chain filter and drum screen washing systems
- the SEN system (non-classified) for cooling the conventional island auxiliaries

The SEF system pre-filters all the service water used for the unit. It protects the CFI [CWFS] (or SFI) filtering system intake by trapping marine debris likely to hinder the smooth operation of the CFI [CWFS] (or SFI) filters.

4.2. BASES OF DESIGN [REF-1] TO [REF-6]

<u>Open circuit:</u>

- The CFI [CWFS] filtering system comprises four independent filtering trains with:
    - o two chain filters arranged in lateral trains
    - o two drum screens arranged in central trains

Closed circuit with atmospheric cooling tower:

- The SFI system comprises four independent filtering trains with a chain filter in each train.

If a drum screen or chain filter is heavily clogged, the non-classified (SEN conventional service water and CRF [water circulation]) pumps are tripped to quickly reduce the head loss and thus preserve the integrity of the filter panels and guarantee a sufficient safety flow rate.

The choice of construction materials is dictated by the seawater content.

4.3. DESCRIPTION OF THE FACILITIES [REF-1] TO [REF-5]

The pumping station, described in Sub-chapter 3.3, is located on the seafront and protected from swell by an appropriate device. The seawater is supplied via an intake channel or directly via an offshore water intake with submarine tunnels driving to an equalising pond.

The pumping station has four separate hydraulic trains.

The water comes from the intake channel or the equalising pond, via the pre-filtering waterways for each hydraulic train of the pumping station.

Open circuit, filtration performed by CFI [CWFS] system:

- The lateral trains supplying the chain filters each have one waterway. The central trains supplying the drum screens each have four waterways.
- In case of an intake channel, each pre-filtering waterway comprises a fixed pre-filtering grid (SEF) and a trash rake (SEF) in order to remove debris and marine organisms trapped in the grids (SEF).
- A central hydraulic train comprises four pre-filtering waterways (SEF) and a drum screen which performs the filtering of the water for cooling the nuclear auxiliaries (SEC [ESWS] – SRU [UCWS] ultimate cooling water system) and circulation water (CRF). Each waterway can be isolated by a sluice gate for maintenance of the drum screens and pumps.
- A lateral hydraulic train comprises a pre-filtering waterway (SEF) and a chain filter which performs the filtering of the water for cooling the nuclear auxiliaries (SEC [ESWS] – SRU [UCWS] ultimate cooling water system) and water for cooling the conventional auxiliaries (SEN [raw water cooling]). The waterway can be isolated by a sluice gate for maintenance of the chain filters and the pumps.

Closed circuit, filtration performed by SFI system:

- All the trains supplying the chain filters, each have one waterway.
- In the case of an intake channel, each pre-filtering waterway comprises a fixed pre-filtering grid (SEF) and a trash rake (SEF) in order to remove debris and marine organisms trapped in the grids (SEF).

- Each hydraulic train performs the filtering of the water for cooling the nuclear and conventional auxiliaries (SEC [ESWS] – SRU [UCWS] ultimate cooling water system - SEN [raw water cooling]). It performs also filtration of water for supplying the atmospheric cooler (CVF).

- Each waterway can be isolated by a sluice gate for maintenance of chain filters and pumps.

The CFI [CWFS] filtering drum screens are equipped with a three-speed rotating drive device:

- low speed (classified F1B)

- high speed (non-classified)

- very high speed (non-classified)

The CFI [CWFS] (or SFI) chain filters are equipped with a two-speed rotating drive device:

- low speed (classified F1B)

- high speed (non-classified)

The filter panels of the CFI [CWFS] (or SFI) drum screens and chain filters are cleaned by two washing stations, supplied by two pumps with two pressure levels:

- a low-pressure pump (classified F1B) associated with low speed

- a high-pressure pump (non-classified) associated with high speed for the chain filters or very high speed for the drum screens

The CFI [CWFS] (or SFI) drum screens and chain filters are also equipped with a device for measuring the level of filtered water inside filter (classified F2).

The SEF pre-filtering grids are equipped with a device for measuring the head loss (classified F2).

4.4. OPERATING PRINCIPLES

Under normal operation:

- the drum screens are in permanent rotation at low speed with low-pressure washing

- the chain filters are normally shutdown, without washing. A rotation sequence is however performed periodically (timed).

Rotation speed (low and high speed) and the start-up of washing (high and low pressure) are controlled by sensors measuring the head loss across the drum screens.

In the event of massive clogging of a filter (drum screen or chain filter), a trip signal is issued to the downstream pumps (not important for safety):

- CRF [circulation water] pump for a drum screen,

- SEN [conventional service water] pump for a chain filter.

The head loss through the filtering element and thus the flow limit that is achieved, helps preserve the mechanical integrity of the filter consistent with the flow rates required for safety systems (SEC [ESWS] and SRU [UCWS] ultimate cooling water systems).

4.5. PRELIMINARY SAFETY ANALYSIS

4.5.1. Compliance with regulations

Not applicable.

4.5.2. Compliance with functional criteria

The CFI [CWFS] (or SFI) system filters the water for the SEC [ESWS] system and the SRU [UCWS] ultimate cooling water system, which are linked to the safeguards systems.

The CFI [CWFS} (or SFI) filtering system thus plays a part in safety, through availability of the following equipment:

- a low-pressure washing device pump feeding two spray headers
- a low-speed rotation drive device consisting of a speed reducer and a motor
- a mechanism for automatic tripping of the non-classified downstream pumps (SEN pump for a chain filter, CRF pump for a drum screen): two classified head loss measuring trains powered and operated by the centralised instrumentation and control system
- measurement of the water level downstream of the filtering elements allows a further line of protection for detecting an external hazard leading to massive clogging.

The pre-filtering function is performed passively by the SEF [water intake] grids situated on the waterways positioned in front of the drum screens and chain filters. These grids protect the CFI [CWFS] (or SFI) filtering system against the arrival of large debris. The grids are thus classified F2.

Measurement of head loss is performed at each grid and informs the operator of any accumulation of debris in front of the grid concerned. These measurements are classified F2 (instrumentation and alarm).

Regular cleaning of the grids is performed by using trash rakes (one per grid) activated by a timer (about every 8 hours), an alarm, or on manual start-up. The failure of one or more trash rakes does not compromise the protective functions of the CFI [CWFS] (or SFI) filters and the service water transit function due to the spacing of grids and the passage surface. The trash rakes and their start-up control systems are therefore not classified.

4.5.3. Compliance with design requirements

4.5.3.1. Safety classification

The compliance of the design and manufacture of equipment with requirements derived from classification rules is detailed in Sub-chapter 3.2.

4.5.3.2. Redundancy

The single failure criterion is applied to the elements of the CFI [CWFS] (or SFI) system (filtering) that perform an F1 function. It does not apply to the elements of the SEF system (pre-filtering).

4.5.3.3. Qualification

The equipment is qualified in accordance with the requirements described in Sub-chapter 3.6.

4.5.3.4. Instrumentation and control

The design and manufacture of equipment comply with requirements derived from instrumentation and control classification rules is detailed in Sub-chapter 3.2.

4.5.3.5. Emergency power supplies

The power supplies for equipment in the CFI [CWFS] (or SFI) filtering system are classified as F1, (low-speed rotation motors and low-pressure washing pump motors for the drum screens and chain filters) are backed up by the main diesel generators.

4.5.3.6. Hazards

<u>External hazards</u>

External hazards are taken into account in the design. Protection against these hazards is assured by either specific design measures (dimensions, specific resistance), or by redundancy and geographic separation.

- Earthquakes

The civil engineering structures (water intake channel, pumping station and waterways, intake tunnels to the Safeguard Building and tunnels to the discharge structure) as well as CFI filtering equipment (drum screens, chain filters, low-pressure washing), is designed to remain operable during and after an earthquake. For the SEF [water intake] equipment (floating cranes, grids and trash rakes), checks are made that any damage suffered in the earthquake will not hinder the transit of service water required by classified systems.

- Aircraft crash

The CFI [CWFS] (or SFI) filtering system is protected in the event of aircraft crash by geographic separation and location in bunkers.

- External explosion

The building housing the CFI [CWFS] (or SFI) filtering system is designed to withstand airborne explosion shock waves.

- External flooding

The pumping station and the CFI [CWFS] (or SFI) filtering system equipment are protected from effects of external flooding in accordance with Sub-chapter 13.1.

- Extreme cold

All classified CFI [CWFS] (or SFI) filtering equipment is protected against extreme cold (see section 12 of Sub-chapter 9.4). The characterisation and consequences of possible sea-ice and freeze-up phenomena will be detailed in future studies.

- Other hazards

In the event of the intake of sea borne hydrocarbon layers, alert procedures and the preventive shutdown of the CRF [water circulation] pumps will help avoid pollution of the pumping station. The massive intake of seaweed or marine organisms is taken into account in designing the CFI [CWFS] filtering system.

External hazards	Protection required in principle	General protection	Specific protection introduced in the design of the system
Earthquake	Yes	Installation in pumping station SC1	SC1 design for CFI (or SFI) filtering F1B equipment SC2 design for SEF pre-filtering grids and trash rakes
Aircraft crash	Yes	pumping station: geographic separation and use of bunkers	-
External explosion	Yes	Installation in pumping station protected	SEF pre-filtering: Submerged grids
External flooding	Yes	pumping station design	Equipment installation level
Snow and wind	Yes	Installation in pumping station protected	-
Extreme cold (frazil ice, freeze-up)	Yes	Installation in pumping station protected	-
Electromagnetic interference	Yes	Installation in pumping station protected	-
Blockage by marine foreign bodies	Yes		Global design of the SEF and CFI (or SFI) filtering systems
Hydrocarbons	Yes		SEF floating cranes (in case of intake channel) and global design of SEF and CFI [CWFS] (or SFI) systems

Internal hazards

The following internal hazards are taken into account: leaks and pipe ruptures, failures of vessels, pumps and valves, internal missiles, dropped loads, internal explosions, fire and internal floods.

The design of the SEF and CFI [CWFS] (or SFI) filtering systems is such that an internal hazard on any piece of equipment affects only one train. This is ensured by the physical separation of the four pre-filtering and filtering channels.

Internal hazards	**Protection required in principle**	**General protection**	**Specific protection introduced in the design of the system**
Rupture of piping	No loss of more than one train	installation in the four separate divisions of the pumping station	-
Failure of tanks, pumps and valves		installation in the four separate divisions of the pumping station	-
Internal missiles		installation in the four separate divisions of the pumping station	-
Dropped loads		installation in the four separate divisions of the pumping station	
Internal explosion		installation in the four separate divisions of the pumping station	
Fire		installation in the four separate divisions of the pumping station	
Internal flooding		installation in the four separate divisions of the pumping station	-

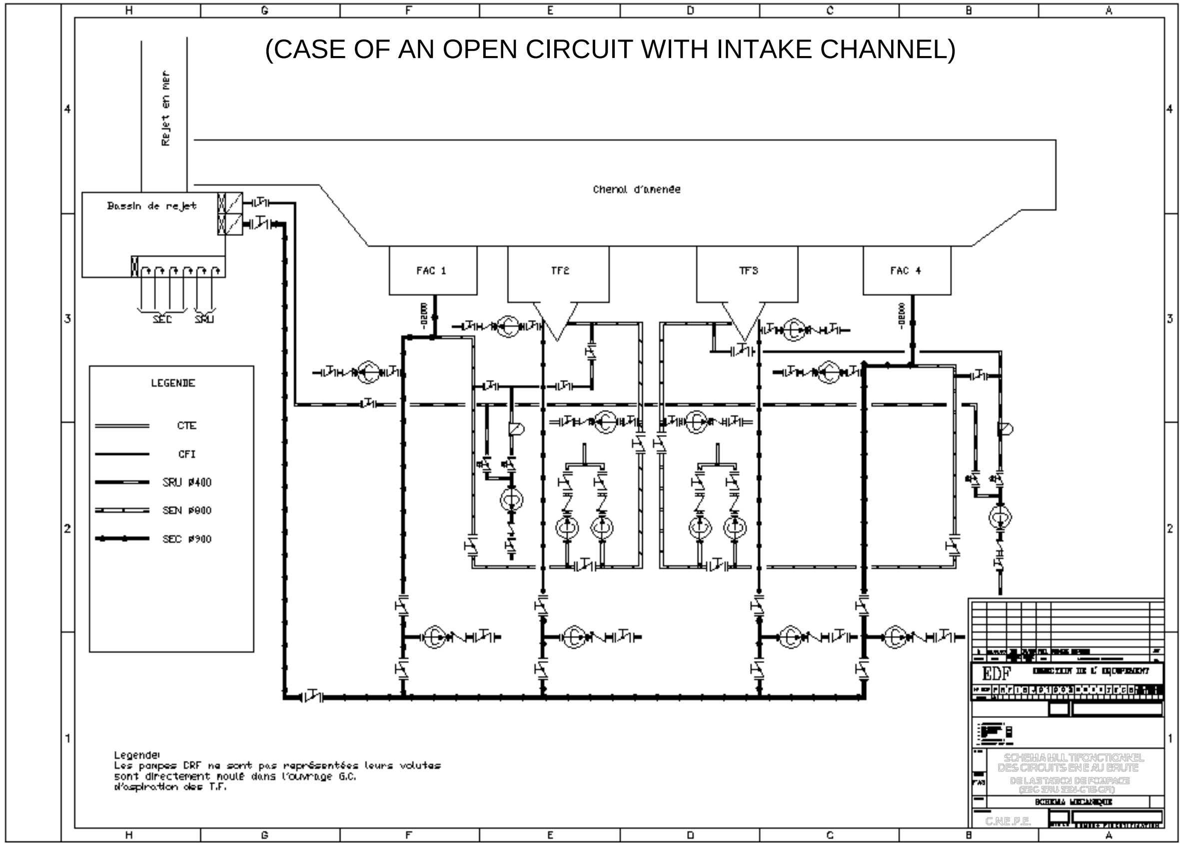
4.6. TESTS AND MAINTENANCE

The 4-train structure allows maintenance and periodic tests on each chain filter during unit operation (SEC[ESWS]/SRU [UCWS] ultimate cooling water system/SEN [conventional service water] water supply on the other chain filter, or even on the drum screens through use of headers).

Since each drum screen is required continuously during unit operation for the CRF (50% of the CRF filtering flow rate per drum screen), maintenance and periodic tests can be performed only during unit shutdown, one drum screen at a time.

SECTION 9.2.4 - FIGURE 1 [REF-1]

BLOCK DIAGRAM



5. POTABLE WATER SYSTEM

5.1. ROLE OF THE SYSTEM

The potable water system distributes potable water throughout the plant site for the needs of staff and for certain industrial uses.

5.2. DESIGN BASIS

5.2.1. Safety Role

This system has no safety role.

5.2.2. Design

The drinking water needs of the EPR are of two types:

1. Personal needs
    - Operational Service Centre
    - safeguard building / electrical building & control rooms
    - access tower
    - Turbine hall
    - pumping station
    - electrical building for the conventional island
2. Industrial needs
    - maintenance premises – laundry– laboratory
    - Operational Service Centre

5.3. DESCRIPTION OF THE FACILITIES

Potable water supply for the site is provided by the external supply network.

5.4. OPERATING PRINCIPLES

Not applicable.

5.5. SAFETY EVALUATION

The potable water production and distribution facility has no safety role.

The SEP potable water system network has no link with any other system.

5.6. TESTS AND MAINTENANCE

The SEP drinking water system is not subject to periodic tests.

6. ULTIMATE COOLING WATER SYSTEM – SRU [UCWS]

6.0. SAFETY REQUIREMENTS

6.0.1. Safety function

The ultimate cooling water system is required to remove decay heat from the following:

- the containment, via the EVU [CHRS] system for RRC-B situations and certain RRC-A and PCC conditions
- the fuel building pool via the third PTR [FPCS] train for certain accidents involving loss of cooling of the fuel assembly storage pool

6.0.2. Functional criteria

The SRU [UCWS] must have a sufficient heat removal capacity to meet the requirements of the EVU [CHRS] system or the third PTR [FPCS] train.

The SRU [UCWS] acts as a diversified system for the SEC [ESWS], meaning that the system must remain operational in the event of loss of the SEC [ESWS] function.

6.0.3. Design-related requirements

6.0.3.1. Requirements due to safety classification

Safety classification

The SRU [UCWS] is F2 safety-classified in accordance with the classification given in Sub-chapter 3.2.

Single failure criterion (active and passive)

The single failure criterion does not apply to the F2-classified SRU [UCWS]. There is therefore no redundancy requirement.

Emergency power supplies

The electrical power must be provided for the pumps of the two trains of the SRU [UCWS], which are active components (main diesel generators and ultimate diesel generators in states D, E and F).

Qualification to operating conditions

See Sub-chapter 3.6.

Mechanical, electrical and instrumentation and control classifications

Classifications relating to the system are given in Sub-chapter 3.2.

Seismic classification

The SRU [UCWS] seismic classification must be defined according to the classification rules presented in Sub-chapter 3.2.

Periodic tests

The system is subject to periodic tests to check its availability since it is not in continuous service.

6.0.3.2. Other regulatory requirements

Technical guidelines

The Technical Guideline sections applicable and specific to the system are sections B2.3.5, E2.3.2 (see Sub-chapter 3.1).

6.0.3.3. Hazards

As an F2 system, the SRU [UCWS] is not subject to the analysis of all internal and external hazards. For these situations, the protection requirements must be analysed on a case-by-case basis in accordance with Chapter 13. In particular, the design of the SRU [UCWS] must take account of the hazards that may lead to loss of the pumping station (particularly situations involving clogging).

6.1. ROLE OF THE SYSTEM

The SRU [UCWS] cools the heat exchangers of the intermediate EVU [CHRS]. The intermediate EVU [CHRS] cools the containment heat removal system (EVU [CHRS]) in RRC-A and B conditions and the 3rd train of the spent fuel pool (PTR [FPCS]) cooling system.

6.2. DESIGN BASIS [REF-1] TO [REF-4]

6.2.1. Design assumptions

All the operating conditions and their consequences are described in Sub-chapter 6.2 (EVU [CHRS]) and section 3 of Sub-chapter 9.1(PTR [FPCS]).

6.2.2. Specific assumptions

Two operating assumptions are considered:

- As long as the supply of service water filtered via the pumping station is available, the SRU [UCWS] is supplied by the pumping station and the SRU [UCWS] discharge is aligned to the discharge culverts. In this case, the cold source temperature taken into account for designing the cooling train is 26°C.

- In the event of loss of normal supply from the pumping station, the SRU [UCWS] is supplied via the sea discharge tunnel. The discharge from SRU [UCWS] pumps is thus aligned to the intake channel. In this case, transients associated with various accident situations are analysed, taking into account the initial temperature of the water in this structure at the time of the event, which depends on the temperature of the main heat sink and on the operating situation when the initiating event occurs.

6.3. DESCRIPTION OF THE SYSTEM [REF-1] TO [REF-4]

The SRU [UCWS] comprises two 50% trains which are both necessary to supply the cooling needs of the EVU [CHRS] in the first 15 days after the beginning of the RRC-B situations. Beyond this time one train is sufficient.

The two SRU [UCWS] trains cool the two trains of the EVU [CHRS] via the intermediate EVU [CHRS]. Train 1 of the SRU [UCWS] also cools the third PTR [FPCS] train via the intermediate EVU [CHRS].

The two SRU [UCWS] trains (pumps, piping) are installed in the pumping station and the tunnel respectively with two trains of the SEC [ESWS].

Composition of an SRU [UCWS] train:

Each train comprises the following equipment:

- a motor driven pump supplied from a 690 V LJ switchboard backed up by a main diesel generator and an ultimate diesel generator
- an active shellfish filter and its wash pipe upstream of the pump
- an intermediate SRU/EVU [UCWS / CHRS] heat exchanger
- an SRU [UCWS] seal weir located in the upper section of the CRF [water circulation] discharge pond

Suction header of SRU [UCWS] pumps:

In the case of water filtration performed by CFI [CWFS] system (see section 4 of this sub-chapter):

- The suction of the SRU [UCWS] pumps can be aligned on a chain filter or a drum screen using a header pipe.

Case of water filtration performed by SFI system (see section 4 of this sub-chapter):

- The suction of the SRU [UCWS] pumps can be aligned on any chain filter using a header pipe.

Diversification of SRU [UCWS] pumps suction:

For some situations of total loss of the pumping station, each SRU [UCWS] pump may be supplied with water directly by the discharge culvert via diverse piping.

This alignment is performed by realigning the manual isolation valves located on the suction and diverse piping. The SRU [UCWS] discharge is then redirected to the intake channel by closing a sluice gate valve at the level of the discharge culvert.

The SRU [UCWS] suction in the discharge culvert is equipped with a grid to protect the SRU [UCWS] system from debris liable to be present in the discharge pond at the time of the event requiring start-up of the SRU [UCWS]. For SBO (station blackout) or LUHS (loss of ultimate heat sink) situations, any debris present in the discharge structure would be small and limited in quantity given the shutdown of the other systems.

See principle diagram, Section 9.2.6 - Figure 1.

6.4. OPERATING PRINCIPLES

The different operating modes of the SRU [UCWS] derive from the operating principles given in Sub-chapter 6.2 for the EVU [CHRS] and Sub-chapter 9.1, section 3 for the PTR [FPCS].

6.4.1. Normal operating conditions

The SRU [UCWS] is normally shut down.

However, for situations involving maintenance on a main PTR [FPCS] train or one of its support systems, train 1 of the SRU [UCWS] is started up as a preventive measure to ensure cooling of the third PTR [FPCS] train.

6.4.2. Loss of the pumping station,

For situations involving total loss of the final cold source and station blackout SBO in states E and F, the water supply of the SRU [UCWS] can be provided by a connection to the discharge pond. In this case, this means pumping seawater through the discharge tunnel. The discharge of the SRU [UCWS] is always performed in the part of the structure that is dedicated to the SEC [ESWS]-SRU [UCWS]. However, the water heated in the intermediate EVU [CHRS] heat exchanger is no longer channelled towards the CRF [water circulation] discharge area but towards the intake channel or toward the equalising pond of water intake* (by using a sluice gate valve).

** design is related to power plant location (see section 4 of this sub-chapter).*

Switchover to the diverse heat sink is manual. If an SRU [UCWS] train is already operating at the time of the event, the intake of clogging material following loss of the pumping station (the massive intake of clogging material may be one of the causes of the loss of filtering) will cause a pressure drop to occur at the SRU [UCWS] filter protecting the pump. On detection of this pressure drop, the pump in operation is automatically switched off. Realignment to the diverse device is performed by local manual alignment and the time taken for this operation is compatible with the grace period authorised for these events.

6.5. PRELIMINARY SAFETY ANALYSIS

6.5.1. Compliance with regulations

The system complies with the general regulations in force (see Sub-chapter 1.4).

6.5.2. Compliance with functional criteria

The SRU [UCWS] has a sufficient heat exchange capacity with the EVU [CHRS] or the third PTR [FPCS] train, even in the event of loss of supply by the pumping station, due to diversity of the discharge culvert.

6.5.3. Compliance with design requirements

6.5.3.1. Safety classification

The SRU [UCWS] is designed in accordance with the safety classifications given in Sub-chapter 3.2.

6.5.3.2. Redundancy

The single failure criterion does not apply to the SRU [UCWS]. However, the system comprises two identical trains to ensure, in the long term, that the failure of a train does not jeopardise the functional requirements.

6.5.3.3. Qualification

The equipment is qualified in accordance with the requirements described in Sub-chapter 3.6.

6.5.3.4. Instrumentation and control

The compliance of design and manufacture of materials and equipment with requirements derived from instrumentation and control classification rules is detailed in Sub-chapter 3.2.

6.5.3.5. Emergency power supplies

Electrical power is provided for the pumps of the two trains of the SRU [UCWS], these are active components (emergency power is provided by the main diesel generators and ultimate diesel generators in states D, E and F).

6.5.3.6. Hazards

External hazards:

Earthquake, explosion, aircraft crash, external flooding, climatic loads: protection against these hazards is provided for the SRU [UCWS] by the pumping station building (see Sub-chapter 13.1).

In an extreme situation which could lead to loss of the pumping station (massive intake of seaweed, marine organisms or hydrocarbon), diversity of the discharge culvert enables supply of the SRU [UCWS] pumps to be maintained.

In terms of the seismic classification, the two main SRU [UCWS] trains will be operational during and after an earthquake. For the rest of the SRU [UCWS] (including the diversity), it is ensured that balance of equipment cannot have an impact on the F1 equipment particularly considering an internal hazard which may result from the earthquake (internal flooding, drooped loads, toppling, missiles, etc.).

External Hazards	Protection required in principle	General protection	Specific protection introduced in the design of the system
Earthquake	Yes	Installation in SC1 buildings (pump house, tunnels, Safeguard Buildings and discharge)	Seismic design (SC1) for equipment in lines 1 and 2 (SC2 for the diversity).
Aircraft crash	No	Installation in protected buildings	-
External explosion	Yes	Installation in protected buildings	-
External flooding	Yes	pump house design and discharge culvert	- Protection of SEC [ESWS] pit up to the level required
Snow and wind (projectiles)	Yes	pump house design and discharge culvert	-
Extreme cold	Yes	Installation in heated buildings (pump house, tunnels, Safeguard Buildings)	- Possible protection of SRU [UCWS] discharge
Electromagnetic interference	No	Electrical equipment installed in protected buildings (pump house, tunnels and Safeguard Buildings)	-
Clogging by marine foreign bodies	Yes		- Diversity of the discharge culvert.
Hydrocarbons	Yes		- Diversity of the discharge culvert.

Internal hazards

Internal Hazards	Protection required in principle	General protection	Specific protection introduced in the design of the system
Rupture of piping	no	-	-
Failures of vessels, pumps and valves	no	-	-
Internal missiles	no	-	-
Dropped loads	no	-	-
Internal explosion	no	-	-
Fire	no	-	-
Internal flooding	no	-	-

6.6. TESTS AND MAINTENANCE

6.6.1. Periodic tests

The periodic tests aim to check safety criteria and the system ability to fulfil its safety functions.

6.6.2. Maintenance

Preventive maintenance

The SRU [UCWS] is maintained with the unit in operation, with the exception of the two isolation valves of the headers on the drum screens.

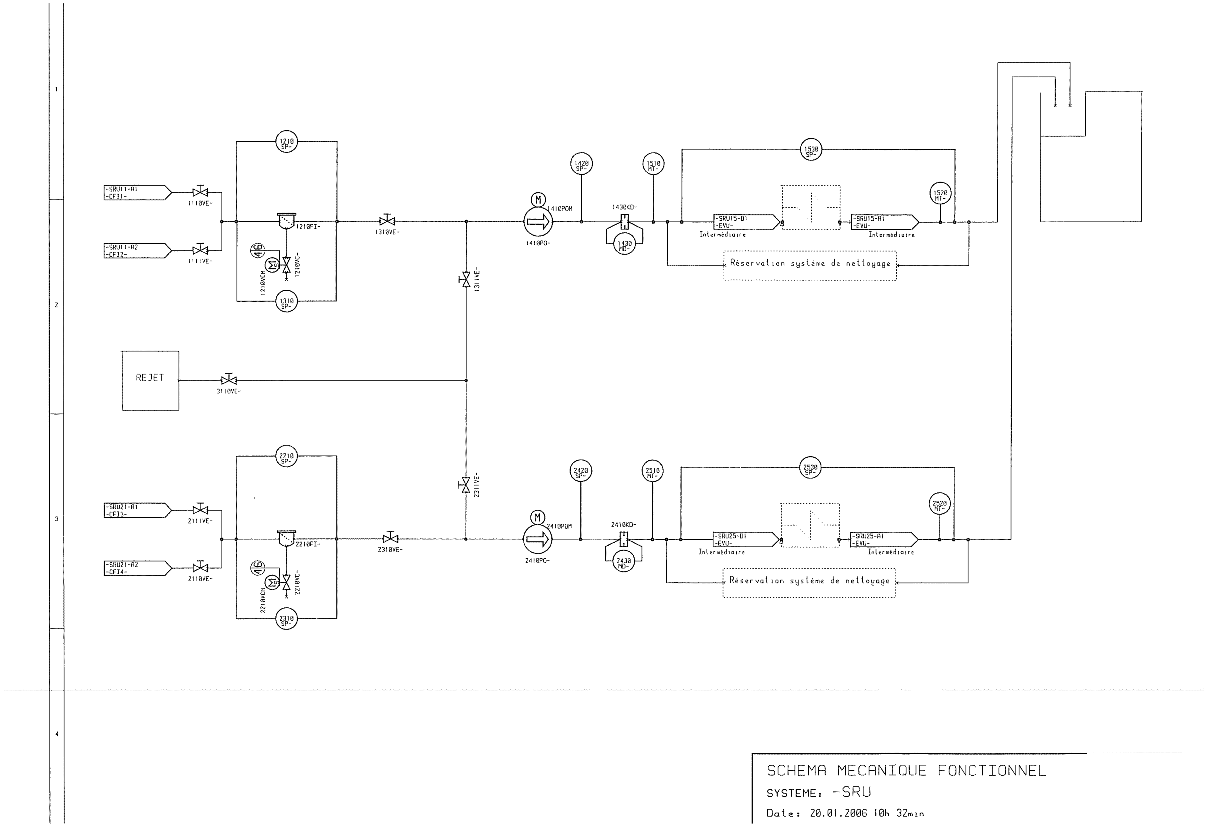
The third PTR [FPCS] train is put into operation as a preventive measure during maintenance of the main PTR [FPCS] trains or their support systems (i.e. the SEC [ESWS], the electric trains, etc.). Maintenance of the SRU [UCWS] 1 train must be performed in a sequence with that of the main PTR [FPCS] trains or their support systems and will be performed during maintenance of the 3rd PTR [FPCS] train.

Long-term maintenance

The operation in service of the EVU [CHRS], so-called “long-term” maintenance, is possible after a severe accident.

SECTION 9.2.6 - FIGURE 1 [REF-1]

MECHANICAL FUNCTIONAL DIAGRAM OF THE ULTIMATE COOLING WATER SYSTEM – SRU [UCWS]



SUB-CHAPTER 9.2 – REFERENCES

External references are identified within this sub-chapter by the text [Ref-1], [Ref-2], etc at the appropriate point within the sub-chapter. These references are listed here under the heading of the section or sub-section in which they are quoted.

1. ESSENTIAL SERVICE WATER SYSTEM - SEC [ESWS]

1.2. BASIS OF DESIGN

[Ref-1] System Design Manual – Essential Service Water System (SEC [ESWS]), Part 2 – System operation.ETDOFC080069 Revision A1. EDF. September 2009. (E)

[Ref-2] System Design Manual – Essential Service Water System (SEC [ESWS]), Part 4 – Flow Diagrams. ETDOFC080276 Revision A1. EDF. September 2009. (E)

[Ref-3] Dossier de Système Elémentaire - SEC, P4.2 Circuit d'eau brute secourue.
[System Design Manual – Essential Service Water System (SEC [ESWS]), Part 4.2 – Flow Diagrams.]
ETDOIG070270 Revision C. EDF. May 2008

[Ref-4] System Design Manual – Essential Service Water System (SEC [ESWS]), Part 5 – Instrumentation and Control. ETDOFC070361 Revision A1. EDF. September 2009. (E)

[Ref-5] Dossier de Système Elémentaire - CRF. [System Design Manual – Circulating Water System (CRF)]. ETDOFC050062 Revision B1. EDF. July 2011. (E)

[Ref-6] Dossier de Système Elémentaire - CRF, P4.2 Schémas Mécaniques Detaille.
[System Design Manual – Circulating Water System (CRF), Part 4.2 - Detailed flow diagrams]
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[Ref-7] System Design Manual – Circulating Water System (CRF), Part 5 – Instrumentation and Control. ETDOFC080077 Revision C1. EDF. September 2009. (E)

1.3. DESCRIPTION OF THE SYSTEM

[Ref-1] System Design Manual – Essential Service Water System (SEC [ESWS]), Part 2 – System operation.ETDOFC080069 Revision A1. EDF. September 2009. (E)

[Ref-2] System Design Manual – Essential Service Water System (SEC [ESWS]), Part 4 – Flow Diagrams. ETDOFC080276 Revision A1. EDF. September 2009. (E)

[Ref-3] System Design Manual – Essential Service Water System (SEC [ESWS]), Part 5 – Instrumentation and Control. ETDOFC070361 Revision A1. EDF. September 2009. (E)

SECTION 9.2.1 – FIGURE 1

[Ref-1] System Design Manual – Essential Service Water System (SEC [ESWS]), Part 4 – Flow Diagrams. ETDOFC080276 Revision A1. EDF. September 2009. (E)

2. COMPONENT COOLING WATER SYSTEM FOR THE NUCLEAR ISLAND (RRI [CCWS])

2.2. DESIGN BASES

[Ref-1] System Design Manual - Component Cooling Water System (RRI [CCWS]), P1 - History. EYTS/2007/fr/0155 Revision B1. Sofinel. November 2009. (E)

[Ref-2] System Design Manual – Component Cooling Water System (RRI [CCWS]), P2 – System Operation (Stage 2 EC1). SFL-EF MF 2006.446 Revision F1. Sofinel. August 2009. (E)

[Ref-3] System Design Manual – Component Cooling Water System (RRI [CCWS]), P3 – System and component design (Stage 2 EC1).SFL-EF MF 2006.416 Revision D1. Sofinel. August 2009. (E)

2.2.4. Choice of materials

[Ref-1] System Design Manual - Chemical reagents injection system (SIR) - Plant System File (Stage 1). 23952SIR00010DSE Revision D1. January 2010. EDF. (E)

[Ref-2] System Design Manual Chemical reagents injection system (SIR), Part 1, History of the System Manual. EZS/2008/en/0055 Revision B. December 2008. (E)

[Ref-3] System Design Manual - Chemical reagents injection system (SIR6), Part 2, System Operation. EZS/2008/en/0044 Revision A. November 2008. (E)

[Ref-4] System Design Manual - Chemical reagents injection system (SIR6), Part 3, System Design. EZS/2008/en/0045 Revision A. November 2008. (E)

[Ref-5] System Design Manual - Chemical reagents injection system (SIR6), Part 4, Flow Diagrams. EZS/2008/en/0046 Revision A. November 2008. (E)

[Ref-6] System Design Manual - Chemical reagents injection system (SIR6), Part 5, Instrumentation and Control. EZS/2008/en/0050 Revision A. November 2008. (E)

2.3. DESCRIPTION OF THE SYSTEM AND CHARACTERISTICS OF EQUIPMENT

[Ref-1] System Design Manual - Component Cooling Water System (RRI [CCWS]), P1 - History. EYTS/2007/fr/0155 Revision B1. Sofinel. November 2009. (E)

[Ref-2] System Design Manual – Component Cooling Water System (RRI [CCWS]), P2 – System Operation (Stage 2 EC1). SFL-EF MF 2006.446 Revision F1. Sofinel. August 2009. (E)

[Ref-3] System Design Manual – Component Cooling Water System (RRI [CCWS]), P3 – System and component design (Stage 2 EC1). SFL-EF MF 2006.416 Revision D1. Sofinel. August 2009. (E)

[Ref-4] System Design Manual – Component Cooling Water System (RRI [CCWS]), P4 – Mechanical Diagrams (SMF and SMD). SFL-EF MF 2006.447 Revision E1. Sofinel. August 2009. (E)

[Ref-5] Dossier de Système Elémentaire - RRI, P4.1 – Schéma Mécaniques Fonctionnel. [System Design Manual – Component Cooling Water System (RRI [CCWS]), P4.1 – System flow diagrams.] ECEF071334 Revision A. April 2008.

[Ref-6] Dossier de Système Elémentaire - RRI, P4.2 – Schéma Mécanique Detaille (Stage 2 EC1). [System Design Manual – Component Cooling Water System (RRI [CCWS]), P4.2 – Detailed flow diagrams (Stage 2 EC1).] EYTS2007/fr/0156, EYTS2007/fr/0157, EYTS2007/fr/0158 Revision F. October 2008.

[Ref-7] System Design Manual – Component Cooling Water System (RRI [CCWS]), P5 – Instrumentation and control. SFL-EF MF 2006.448 Revision F1. Sofinel. September 2009. (E)

2.4. PHYSICAL PHENOMENA DETERMINING OPERATION

2.4.1. Normal operating conditions of the system

[Ref-1] System Design Manual – Component Cooling Water System (RRI [CCWS]), P2 – System Operation (Stage 2 EC1). SFL-EF MF 2006.446 Revision F1. Sofinel. August 2009. (E)

SECTION 9.2.2 - FIGURE 1

[Ref-1] System Design Manual – Component Cooling Water System (RRI [CCWS]), P2 – System Operation (Stage 2 EC1). SFL-EF MF 2006.446 Revision F1. Sofinel. August 2009. (E)

3. DEMINERALISED WATER (PRODUCTION – STORAGE – DISTRIBUTION)

3.2. BASIS OF DESIGN

[Ref-1] System Design Manual – Demineralised water distribution system (within nuclear island) (SED), Part 2 – System operation.
EZS 2007/en/0090 Revision C. EDF. November 2008. (E)

3.3. DESCRIPTION - SUPPLY, PRODUCTION AND DISTRIBUTION

[Ref-1] System Design Manual - Demineralised water distribution system (within nuclear island) (SED), Part 1 - History of the System Manual.
EZS/2007/en/0128 Revision C. EDF. December 2008 (E)

[Ref-2] System Design Manual – Demineralised water distribution system (within nuclear island) (SED), Part 2 – System operation.
EZS/2007/en/0090 Revision C. EDF. November 2008. (E)

[Ref-3] System Design Manual – Demineralised water distribution system (within nuclear island) (SED), Part 3 – System sizing.
EZS/2007/en/0091 Revision C. EDF. November 2008. (E)

[Ref-4] System Design Manual – Demineralised water distribution system (within nuclear island) (SED), Part 4 – Flow Diagrams.
EZS/2007/en/0092 Revision C. EDF. October 2008. (E)

[Ref-5] System Design Manual – Demineralised water distribution system (within nuclear island) (SED), Part 5 – Instrumentation and Control.
EZS/2008/en/0010 Revision C. EDF. October 2008. (E)

[Ref-6] System Design Manual – Demineralised pH9 water distribution system (within nuclear island) (SER), Part 2 – System operation.
EZS/2007/en/0111 Revision C. EDF. January 2008. (E)

[Ref-7] System Design Manual – Demineralised pH9 water distribution system (within nuclear island) (SER), Part 3 – System sizing.
EZS/2007/en/0112 Revision D. EDF. January 2008. (E)

[Ref-8] System Design Manual – Demineralised pH9 water distribution system (within nuclear island) (SER), Part 4 – Flow Diagrams.
EZS/2007/en/0113 Revision B. EDF. December 2007. (E)

[Ref-9] System Design Manual – Demineralised pH9 water distribution system (within nuclear island) (SER), Part 5 – Instrumentation and Control.
EZS/2008/en/0059 Revision A. EDF. October 2008. (E)

4. WATER INTAKE AND FILTERING OF SERVICE WATER

4.2. BASES OF DESIGN

[Ref-1] System Design Manual – Auxiliary (raw water) cooling system (SEN). ETDOFC050283 Revision A1. EDF. December 2009. (E)

[Ref-2] System Design Manual – Water Intake Screening and Filtering System (SEF). ETDOFC070015 Revision A1. EDF. December 2009. (E)

[Ref-3] System Design Manual – Circulating Water Filtration System (CFI [CWFS]), Part 2 – System operation. ETDOFC080143 Revision A1. EDF. August 2009. (E)

[Ref-4] System Design Manual – Circulating Water Filtration System (CFI [CWFS]), Part 3 – System sizing. ETDOMA080153 Revision A1. EDF. August 2009. (E)

[Ref-5] Dossier de Système Elémentaire - CFI, P4.2 Schémas Mécaniques Detaille.
[System Design Manual – Circulating Water Filtration System (CFI [CWFS]), Part 4.2 – Detailed Flow Diagrams].
ETDOIG070273 Revision B. EDF. March 2008.

[Ref-6] System Design Manual – Circulating Water Filtration System (CFI [CWFS]), Part 5 – Instrumentation and Control. ETDOFC070338 Revision B1. EDF. August 2009. (E)

4.3. DESCRIPTION OF THE FACILITIES

[Ref-1] System Design Manual – Water Intake Screening and Filtering System (SEF). ETDOFC070015 Revision A1. EDF. December 2009. (E)

[Ref-2] System Design Manual – Circulating Water Filtration System (CFI [CWFS]), Part 2 – System operation. ETDOFC080143 Revision A1. EDF. August 2009. (E)

[Ref-3] System Design Manual – Circulating Water Filtration System (CFI [CWFS]), Part 3 – System sizing. ETDOMA080153 Revision A1. EDF. August 2009. (E)

[Ref-4] Dossier de Système Elémentaire - CFI, P4.2 Schémas Mécaniques Detaille.
[System Design Manual – Circulating Water Filtration System (CFI [CWFS]), Part 4.2 – Detailed Flow Diagrams].
ETDOIG070273 Revision B. EDF. March 2008.

[Ref-5] System Design Manual – Circulating Water Filtration System (CFI [CWFS]), Part 5 – Instrumentation and Control. ETDOFC070338 Revision B1. EDF. August 2009. (E)

SECTION 9.2.4 - FIGURE 1

[Ref-1] Dossier de Système Elémentaire - CFI, P4.2 Schémas Mécaniques Detaille.
[System Design Manual – Circulating Water Filtration System (CFI [CWFS]), Part 4.2 – Detailed Flow Diagrams].
ETDOIG070273 Revision B. EDF. March 2008.

6. ULTIMATE COOLING WATER SYSTEM – SRU [UCWS]

6.2. DESIGN BASIS

[Ref-1] System Design Manual – Ultimate Cooling Water System (SRU [UCWS]), Part 2 – System operation. ETDOFC080149 Revision A1. EDF. September 2009. (E)

[Ref-2] System Design Manual – Ultimate Cooling Water System (SRU [UCWS]), Part 3 – System sizing. ETDOMA080206 Revision A1. EDF. August 2009. (E)

[Ref-3] Dossier de Système Elémentaire - SRU, P4.2 Schémas Mécaniques Detaille [System Design Manual – Ultimate Cooling Water System (SRU [UCWS]), Part 4.2 – Detailed Flow Diagrams].
ETDOIG070266 Revision C. EDF. September 2008.

[Ref-4] System Design Manual – Ultimate Cooling Water System (SRU [UCWS]), Part 5 – Instrumentation and Control. ETDOFC080070 Revision C1. EDF. September 2009. (E)

6.3. DESCRIPTION OF THE SYSTEM

[Ref-1] System Design Manual – Ultimate Cooling Water System (SRU [UCWS]), Part 2 – System operation. ETDOFC080149 Revision A1. EDF. September 2009. (E)

[Ref-2] System Design Manual – Ultimate Cooling Water System (SRU [UCWS]), Part 3 – System sizing. ETDOMA080206 Revision A1. EDF. August 2009. (E)

[Ref-3] Dossier de Système Elémentaire - SRU, P4.2 Schémas Mécaniques Detaille [System Design Manual – Ultimate Cooling Water System (SRU [UCWS]), Part 4.2 – Detailed Flow Diagrams].
ETDOIG070266 Revision C. EDF. September 2008.

[Ref-4] System Design Manual – Ultimate Cooling Water System (SRU [UCWS]), Part 5 – Instrumentation and Control. ETDOFC080070 Revision C1. EDF. September 2009. (E)

SECTION 9.2.6 - FIGURE 1

[Ref-1] Dossier de Système Elémentaire - SRU, P4.2 Schémas Mécaniques Detaille [System Design Manual – Ultimate Cooling Water System (SRU [UCWS]), Part 4.2 – Detailed Flow Diagrams].
ETDOIG070266 Revision C. EDF. September 2008.