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SUB-CHAPTER 10.4 – OTHER FEATURES OF STEAM AND POWER CONVERSION SYSTEMS

The secondary cooling system is described in Sub-chapter 10.1 (role, design basis, safety analysis).

The secondary cooling systems consist principally of the main feedwater system, the main steam supply system and the turbine.

The present sub-chapter contains a brief description of the steam-water system. The main steam-water systems are:

- The condenser and the condensate extraction systems (CEX). These systems are outside the scope of GDA.
- The turbine by-pass systems (GCT [MSB])
- The feedwater plant (ABP-ADG-APA [MFWPS]-AHP-AAD [SSS])
- The cooling water system (CRF)
- The turbine gland system (CET). This system is outside the scope of GDA.
- The steam generator blowdown system (APG [SGBS])

1. CONDENSER (CEX)

The condenser is outside the scope of GDA.

2. CONDENSER EXTRACTION SYSTEM (CEX)

The condenser extraction system is outside the scope of GDA.

3. TURBINE BY-PASS (GCT [MSB])

3.1. ROLE AND DESCRIPTION

The role of the GCT [MSB] is to discharge the steam flow to the condenser when the turbine is unavailable. During normal operation, the power provided by the nuclear steam supply system is matched by the power consumed by the turbine.

However, during rapid transient conditions or power variations at low load, the power imbalance between the turbine and the reactor is compensated for by the opening of the GCT [MSB].

3.2. DESIGN BASIS [REF]

The turbine bypass to the condenser accommodates the discharge of excess steam from the nuclear steam supply system during transient conditions (house load operation, large load decrease, turbine trip, and so on). It is therefore designed to handle approximately 60% of the nominal steam flow produced by the reactor.

- Following reactor trip, it prevents primary circuit heat-up and a demand on the atmospheric bypass (VDA) [MSRT],
- It also allows, during start-up and shutdown phases, control of either the SG temperature rise or of SG cooling for the switch to RIS [SIS] in Residual Heat Removal mode,
- It controls the secondary pressure during turbine start-up and at synchronisation.

3.3. PRELIMINARY SAFETY ANALYSIS

The GCT [MSB] system is not safety classified.

The pressure reducing valves close on loss of fluid or the absence of a control signal.

Failure to open of a bypass valve can cause the VDA [MSRT] to open.

Should a GCT [MSB] valve be left open, causing cooling of the primary circuit, the reactor protection system initiates a demand for steam isolation.

4. FEEDWATER PLANT

The feedwater plant consists of:

- Low pressure feedwater and feed heating plant (ABP). This system is outside the scope of GDA.
- Feedwater tank (ADG). This system is outside the scope of GDA.
- Main feedwater pump system (APA [MFWPS]) [Ref]
- High and medium pressure feedwater and feed heating plant (AHP). This system is outside the scope of GDA.
- Start-up and shutdown feedwater system (AAD [SSS]) [Ref]

4.1. MAIN FEEDWATER PUMP SYSTEM (APA [MFWPS])

4.1.1. Role and description

The role of the APA [MFWPS] is to supply water to the steam generators under all 'reactor at power' and 'normal shutdown on the steam generators' situations encountered during operation of the unit.

During the start-up and shutdown phases of the unit (phases where the thermal power of the reactor is below approximately 4% of rated power), the start-up and shutdown feedwater system (AAD [SSS]) supplies water to the steam generators. Nevertheless, each APA [MFWPS] pump set can supply water to the steam generators via the AAD [SSS] system if the AAD1 sub-function fails.

4.1.2. Design basis [Ref]

The APA [MFWPS] system has four identical motor-driven feedwater pump sets installed in parallel between the feedwater tank (ADG) and the high pressure heating station (AHP). Each pump set can be isolated and is fitted with a non-return valve at its outlet. Three pump sets are required for unit operation at rated power; the fourth provides back-up for the operational pumps.

To meet the requirement for pump set maintenance with the unit in operation, each pump set can be isolated at intake and discharge by a valve-based "double isolation" system.

Each pump set has a priming pump, a main pump, a hydrodynamic variable-speed drive, and an induction motor. The priming pump is driven directly by the motor. The main pump is driven by the other end of the motor shaft via a hydrodynamic variable-speed drive.

The pump set recirculation system provides a minimum flow through the pumps, especially at low load. This system has two parallel independent lines connecting the main feedwater pump discharge to the deaerator tank. Control valves regulate the recirculation flow rate.

4.1.3. Preliminary safety analysis

The APA [MFWPS] is not safety classified.

4.2. START-UP AND SHUTDOWN FEEDWATER SYSTEM (AAD [SSS])

4.2.1. Role and description

The role of the AAD [SSS] is to supply water to the Steam Generators (SG) in all normal start-up and shutdown phases of the unit:

- at start-up, from the moment the reactor coolant is approximately 120°C, up to 4% rated power,
- at shutdown, from 4% rated power until the average reactor coolant temperature reaches 80°C.

The function of the AAD [SSS] system is also to supply water to the steam generators in the event of a step-down transformer/auxiliary transformer changeover (total loss of the 4 motor-driven feedwater pumps).

4.2.2. Design basis [Ref]

The system is designed to allow a flow rate equivalent to 4.35% nominal flow when the pressure in the steam generators is 92 bar (or 4% nominal flow for SG pressure of 97.5 bar) in order to avoid using the ASG [EFWS] with the steam generators at very low levels.

4.2.3. Preliminary safety analysis

The AAD [SSS] is not safety classified.

5. COOLING WATER SYSTEM (CRF- FOR A COASTAL SITE)

5.1. ROLE AND DESCRIPTION

The main role of the Circulating Water System (CRF) is to condense the exhaust steam from the three LP cylinders or the condenser turbine bypass system (GCT [MSB]). The circulating water goes through six modules (two per LP cylinder).

5.2. DESIGN BASIS [REF]

The Circulating Water System (CRF) is designed to optimise the CRF flow rate, passing through the condenser with a 12°C increase in temperature, taking into account the temperature of the raw water and air, and mean monthly humidity values.

The two circulating pumps are located in the pumping station. The sea water passes through the drum screens (5 mm mesh), the circulating pumps (approximately 30 m³/s/pump) on the 3,500 mm diameter steel cylinder concrete pipe, and the condenser modules (three per pump), and finally enters the discharge basin, through the 3,500 mm diameter steel cylinder concrete pipe.

5.3. PRELIMINARY SAFETY ANALYSIS

The Circulating Water System (CRF) is not directly safety-related. However, the following functions are classified:

- Automatic initiation of the CRF pump in the event of a significant pressure difference between the piping upstream and downstream of the sea water filtration system (CFI [CWFS]) screening drum, which is F1B classified. Start-up of the CRF pumps protects the filtration devices and recovers sufficient margin for operation of the Essential Service Water System (SEC [ESWS]).

6. GLAND SYSTEM (CET)

The gland system is outside the scope of GDA.

7. STEAM GENERATOR BLOWDOWN SYSTEM (APG [SGBS])

7.0. SAFETY REQUIREMENTS

7.0.1. Safety functions

Containment of radioactive substances

The steam generator blowdown system (APG [SGBS]) performs the basic safety function "containment of radioactive substances" in the event of a steam generator tube rupture (SGTR).

Residual heat removal

In case of loss of operational feedwater supply, SG isolation has to be ensured to prevent loss of emergency feedwater.

7.0.2. Functional criteria

The functional criteria relating to the APG [SGBS] safety function are as follows:

- retain radioactive materials in the affected SG in the event of an SGTR.
- transfer part of the affected steam generator (SG) water inventory to another SG in the event of an SGTR (PCC-3 and PCC-4), to avoid SG overfilling and the ensuing discharge of contaminated water into the environment;
- isolate the containment.

The APG [SGBS] will likewise meet the following criteria, which are indirectly associated with a safety function:

- isolate the secondary system, i.e.:
 - prevent excessive mass flow during a leak or an APG [SGBS] pipe break, to prevent unacceptable rise in containment pressure,
 - prevent flashing of the unaffected SGs in the event of a un-isolatable rupture of a main feedwater system pipe in the containment,
- prevent excessive mass flow from the feedwater tank into the containment (mitigation of internal hazards),
- prevent excessive mass flow of secondary water into the containment following a regenerative blowdown cooler (APG [SGBS]/CEX) or pipe rupture, to preclude containment flooding and, consequently, dilution of boron in the IRWST (mitigation of internal hazards).

7.0.3. Design requirements

7.0.3.1. Requirements arising from safety classification

1. Safety classification

APG [SGBS] safety classification will comply with the requirements of Sub-chapter 3.2.

2. Single failure criterion

Active APG [SGBS] components performing an F1 function are subject to the single failure criterion.

3. Emergency power sources

F1 class components will be powered by emergency power-supplied switchboards. The motor-operated, inside containment, isolation valves and the SG isolation valves will be supplied by an uninterrupted AC power supply.

4. Qualification to operating conditions

APG [SGBS] equipment must be qualified according to its safety role, under the ambient conditions to which it is subjected in performing its safety functions (see Sub-chapter 3.6).

5. Mechanical, electrical and instrumentation and control (I&C) classifications

The mechanical, electrical and I&C classifications of the APG [SGBS] will comply with the provisions of Sub-chapter 3.2.

6. Earthquake classification

The seismic classification of the APG [SGBS] will comply with the provisions of Sub-chapter 3.2.

7. Periodic testing

Periodic tests will be carried out on safety class (F1 and F2) APG [SGBS] components to verify their availability with a suitable degree of confidence.

7.0.3.2. Other regulatory requirements

The APG [SGBS] compliance with regulations in force is dealt with in Sub-chapter 1.4.

7.0.3.3. Hazards

The requirements set in Chapter 13 (for external and internal hazards) are applicable.

7.0.4. Testing

Pre-operational tests

Following installation, the system will undergo a program of tests defined in accordance with its safety functions.

Periodic tests

The system is designed for periodic testing.

7.1. ROLE OF THE SYSTEM

The Steam Generator Blowdown System (APG [SGBS]) is used to maintain the necessary quality of the water/steam cycle in conjunction with the Nuclear Sampling System (REN [NSS]). The radioactive and chemical characteristics of secondary-side water will be kept within permissible limits during all plant operating conditions. Steam Generator secondary water is removed continuously because the secondary side may contain impurities in the form of corrosion products, condenser tube leakage or primary-to-secondary leakage.

The APG [SGBS] is also used to:

- partially or completely drain secondary side water from the SG,
- bubble the SG secondary side water via the nuclear island nitrogen distribution system, following chemical reagent injection in cold shutdown,
- reprocess secondary water samples from the REN [NSS],
- enable SG isolation under SGTR conditions and, where appropriate, transfer excess water from an affected SG to another SG.

After treatment in the Steam Generator Blowdown Demineralising System, the blowdown water is normally recycled to the condenser, in exceptional cases to the Liquid Waste Discharge System.

7.2. DESIGN BASES [REF]

7.2.1. Blowdown rate

In the normal operating configuration, the nominal blowdown rate for all SGs is 1% of the total feedwater flow rate and amounts to 23 t/h/SG.

In the special operating configuration, with three SGs isolated or with reduced blowdown flow rate, the maximum continuous blowdown rate for the fourth SG is approximately 2% of total feedwater flow rate and amounts to 46 t/h.

7.2.2. Blowdown collection

Steam flashing must be avoided by minimising pressure losses and providing a continuous slope between the SG drain taps and the flash tank.

Each of the 4 blowdown line essentially comprises:

- the first SG isolation valves which are located in the reactor building inside the missile shield (one each on the SG hot leg side blowdown line and cold leg side blowdown line respectively).

- the second SG isolation valve which is located in the reactor building outside the missile shield.

All these valves ensure containment of radioactivity in the event of an SGTR, while preventing partial and simultaneous blowdown of two SGs. They likewise allow isolation of three of the four SGs to enable a higher blowdown rate from the fourth SG.

7.2.3. Blowdown expansion and cooling

The blowdown from each Steam Generator is routed to its dedicated flash valve, which adjusts the blowdown flow rate and allows an expansion of the blowdown. The four flash valves are linked to the flash tank, which ensures a liquid/gas phase separation.

Subsequently, the liquid phase of the Steam Generator blowdown is cooled to a temperature below 50°C to be consistent with the operating conditions for the demineralisers in the Steam Generator Blowdown Demineralising System. A regenerative heat exchanger (blowdown cooler), located downstream of the blowdown flash tank and cooled by the Condensate Extraction System (CEX), cools the flashed liquid down to the required temperature.

The steam phase is routed to the feedwater tank.

The flash tank and the blowdown cooler are located in the reactor building.

7.2.4. Blowdown demineralising system

Following pressure reduction and cooling, the blowdown is routed outside the containment to the blowdown demineralising system, where it is first filtered, then demineralised before being recycled to the condenser.

7.2.5. Sampling lines

The radioactive characteristics and chemistry of SG blowdown flows are monitored by the Nuclear Sampling/Plant Radiation Monitoring System (REN [NSS]/KRT [PRMS]).

Connections with the REN [NSS] are therefore provided:

- at SG output, on the SG hot and cold leg side blowdown lines (since the concentration of impurities may differ from one side to the other),
- downstream the cartridges filters of each demineraliser in the blowdown demineralising system.

All secondary water samples from the REN [NSS] are re-injected downstream of the blowdown cooler.

The sampling lines connected to SG outlets are located upstream of the SG isolation valves so that, even when the SGs are isolated, their secondary water can be sampled and its chemical and radioactive characteristics measured.

7.2.6. SG transfer lines

Transfer lines link Steam Generators 1 and 2, and Steam Generators 3 and 4, to avoid Steam Generator overfilling and liquid water release in case of Steam Generator Tube Rupture with loss of offsite power (LOOP). They permit transfer of water from the affected Steam Generator to the neighbouring unaffected Steam Generator.

Two transfer lines, each with one dedicated valve, are installed between a pair of Steam Generators, in case of a single failure.

7.2.7. Fluid characteristics

The APG [SGBS] controls and maintains the quality of SG secondary side water.

Water quality is monitored by the REN [NSS].

The main parameters measured are:

- cationic conductivity (on-line)
- sodium content (on-line).

Other secondary water parameters include pH, total conductivity and its content of ammonia, morpholine, calcium, suspended solids, silica and chlorides, that can be measured by grab sampling.

These measurements are used to:

- adjust the blowdown rate of each SG (up to maximum value, so that secondary water characteristics remain acceptable); and
- verify the efficiency of the blowdown demineralising system with respect to secondary water quality requirements.

7.2.8. Interfaces with conventional systems

The requirements stated here are preliminary and will be confirmed in the Conventional Island (CI) detail design phase.

Blowdown discharge to the condenser

- Maximum blowdown rate (at fully opened control valve): 92 t/h
- Design blowdown rate: 76 t/h
- Maximum blowdown temperature (limit to protect demineralising system): 60°C
- Normal blowdown temperature: < 50 °C
- Maximum blowdown pressure (at response of flash tank safety valve): 19 bar a
- Normal operation pressure: 15 bar a

Flashed steam release to the feedwater storage tank

- maximum steam flow: to be confirmed in the CI detailed design phase
- maximum steam temperature: to be confirmed in the CI detailed design phase
- maximum steam pressure: 19 bar a

CEX cooling water entering the APG [SGBS] regenerative heat exchanger

- CEX inlet temperature (nominal): 35°C
- CEX inlet temperature (max at normal operation): 43 °C
- CEX inlet pressure (nominal): to be confirmed in the CI detailed design phase
- CEX inlet pressure (system design): 41 bar a
- CEX inlet flow rate (nominal): < 41 kg/s

CEX cooling water leaving the APG [SGBS] regenerative heat exchanger

- CEX outlet flow (nominal): < 41 kg/s
- Heat exchanger duty : approx. 13 MW
- CEX outlet temperature: < 120°C

7.3. SYSTEM DESCRIPTION – EQUIPMENT CHARACTERISTICS

7.3.1. System description

7.3.1.1. Functional interfaces

The APG [SGBS] interfaces with the following systems:

- RCP [RCS]: on the SG secondary side,
- Feedwater tank: for flashed steam release from the APG [SGBS] flash tank.
- Condensate extraction system:
 - for return of blowdown water to the condenser after the treatment in demineralising system, and
 - for blowdown condensate cooling.
- Nuclear sampling system (REN [NSS]):
 - for blowdown sampling and chemical control of the blowdown demineralising system,

- for recycling uncontaminated blowdown samples.
- Solid waste treatment system (TES [SWTS]):
 - for discharge of spent resins from the demineralisers.
- Liquid waste discharge system (KER [LRMDS]/TER [ExLWDS]):
 - for discharge of blowdown water that cannot be recycled to the condenser.
- Nuclear island nitrogen distribution system:
 - for nitrogen injection to the SGs (used to bubble secondary water during shutdown, thus ensuring a homogeneous mixture before sampling or after chemical reagent injection).
- Nuclear island demineralised water distribution system:
 - for demineraliser flushing and draining,
 - for water makeup.
- Nuclear island vent and drain system:
 - for APG [SGBS] vent and drain collection.

7.3.1.2. Blowdown collection

See Section 10.4.7 – Figure 1.

Each EPR SG is equipped with blowdown collection lines made up of two nozzles on the hot leg and a third one on the cold leg side of each SG. These three nozzles are located at the SG tube sheet.

Two REN [NSS] lines are connected to the blowdown collection lines:

- one to the cold leg side line and
- the other to the (common) hot leg side line.

Each of the blowdown collection lines on the hot and cold leg sides is equipped with a motor-operated SG secondary side isolation valve, i.e. the first SG isolation valve. Each common SG blowdown line is equipped with a motor-operated SG secondary side isolation valve, i.e. the second isolation device.

A nitrogen distribution line (nitrogen distribution system) is connected to each blowdown line for secondary water bubbling.

The SG transfer lines connecting SG1 to SG2 and SG3 to SG4 are connected to the hot side blowdown collection lines for transferring excess water from an affected SG to the neighbouring unaffected SG following an SGTR under LOOP conditions.

7.3.1.3. Blowdown expansion and cooling

See Section 10.4.7 – Figures 1 and 2.

Each SG blowdown line is routed via the blowdown adjusting valve to the blowdown flash tank.

The resulting flows are then expanded in the flash tank (located in the reactor building).

The blowdown rate from each SG is adjusted using the blowdown adjusting valves APG 5131 VL to APG 5134 VL located upstream of and as close as possible to the flash tank.

The flash tank pressure is controlled by the valve APG 5360 VL, located on the line that removes the flash steam to the feedwater tank.

The water level in the flash tank is controlled by valve APG 5240 VL located downstream of the blowdown cooler.

The blowdown water is cooled in the blowdown cooler (cooled by main condensate system CEX), which is located in the reactor building.

Once CEX cooling water has passed once through the heat exchanger, it returns to the main condensate line in the turbine building.

The subsystem comprising the flash tank and the blowdown cooler is protected against overpressure by the safety valve APG 5310 VL.

Uncontaminated secondary water samples from the REN [NSS] are reprocessed to the APG [SGBS], by re-injecting them downstream of the blowdown cooler and upstream of the demineralising system.

7.3.1.4. Blowdown treatment

See Section 10.4.7 – Figure 3.

The SG blowdown demineralising system is isolatable and is protected against excess temperatures by containment isolation valves APG 6320 VL and APG 6330 VL.

The system purifies the blowdown water, which is cooled by the blowdown cooler.

Following the mechanical filtration, the blowdown flow can be directed either to the demineralisers or via the demineralisers bypass to

- the turbine condenser or
- to the liquid waste treatment system, if recycling to the condenser is not possible.

Normally the purified blowdown flow is recycled to the condenser via a loop.

7.3.2. Equipment characteristics

(to be supplemented and confirmed during the detail design phase).

The pipework and equipment located upstream of the flash tank and between blowdown cooler and demineralising system is made of ferritic steel. For the steam line between the flash tank and the feedwater tank, ferritic steel with high chromium content and austenitic steel is used. The demineralising system is, made of austenitic steel.

Pipework and equipment downstream of the demineralisers are made of austenitic stainless steel, as the blowdown water has a pH of 6 to 8.

The blowdown demineralising system relies on two 50% lines with (2 x 100%) cartridge filters and non-regenerative demineralisers.

7.4. OPERATING CONDITIONS

7.4.1. Normal operating conditions

P ≥ 15% FP

Normal APG [SGBS] service conditions (P ≥ 15% FP) are defined as follows:

- continuous blowdown of the four SGs takes place only on the hot leg side,
- normal blowdown rate can be adjusted up to 23 t/h per SG at full power or part load.
- blowdown pressure is reduced using the blowdown adjusting valves. Blowdown is then separated into two phases (liquid and steam) in the flash tank. The flash tank pressure is controlled to about 15 bar a, which enables steam flow to the feedwater tank at a pressure of about 11 bar a.
- The flashed steam flows to the feedwater tank.
- The flash tank blowdown condensate flows to the turbine condenser via the blowdown cooler and the demineraliser.
- The flash tank blowdown condensate is cooled using main condensate to a temperature below 50°C.

P < 15% FP

Under normal service conditions, with P < 15% Full Power (FP), blowdown of the four SGs takes place continuously and simultaneously on both the hot and cold leg sides; blowdown treatment is the same as for the previously described normal operating scenario ≥ 15% FP.

Use of the blowdown cooler under the above-mentioned conditions requires the availability of at least the condenser, one main condensate pump and the feedwater tank.

7.4.2. Normal start-up

The feedwater tank and at least one main condensate pump are available.

The blowdown system components are available and the system is ready to start

After the inside and outside containment isolation valves are opened, the main condensate flow via the blowdown cooler has to be adjusted and the required pressure and temperature are reached by opening the SG secondary side isolation valves and the blowdown adjusting valves upstream of the flash tank.

The blowdown adjusting valves are then opened until the required total blowdown rate (92 t/h at 100% FP) is achieved.

The level control valve APG 5240 VL controls the required water level in the flash tank.

The pressure control valve APG 5360 VL controls the flash tank pressure.

Blowdown water is routed to the blowdown cooler and from there to the blowdown demineralising system or to the liquid waste discharge system.

7.4.3. Normal shutdown

For shutdown of the system the blowdown rate adjusting valves upstream of the flash tank are gradually closed. The flash tank level control valve closes automatically to keep the set point level in the flash tank. The flash tank pressure control valve closes because the working pressure in the flash tank drops below its setpoint. When the plant is shutdown, the inside and outside containment isolation valves and SG secondary side isolation valves are closed.

7.4.4. Other steady state conditions

During other steady state conditions such as hot standby or the power transients preceding or following a cold shutdown, reactor service conditions may require:

- realignment of blowdown collection: the total blowdown rate from the SGs is limited according to the design of the flash tank (normal admissible mass flow up to approximately 101 t/h) and the blow down cooler (normal admissible mass flow up to approximately 76 t/h). The blowdown rate of one SG is limited according to the design of the blowdown adjusting valve (up to 46 t/h). If required, the blowdown of three SGs will be reduced or interrupted and the fourth SG is blown down with a maximum flow rate of 2 % of the feedwater flow. This configuration may occur if a pre-determined limit of radioactivity in one SG is exceeded or in the event of large power transients generating significant quantities of suspended solids in the SGs and the feedwater plant.
- realignment of blowdown discharge for removal to the liquid waste discharge system rather than recycling to the condenser. This configuration may occur:
 - during plant start-up or cold shutdown,
 - in the event of internal condenser leakage,and is necessary following an SGTR.

Under all these conditions, blowdown may exhibit poor chemical or radioactive properties that preclude its recycling to the condenser.

Preferential blowdown of one SG

Blowdown takes place in a single SG, with the other three SGs isolated or blowdown flow reduced to a smaller value.

Maximum blowdown rate for the selected SG is approximately 46 t/h.

Discharge without treatment in the demineralising system

If the SG water does not meet the required specifications, it can be directed to the liquid waste treatment system instead of to the condenser. This water is mechanically filtered. The demineralisers can be used or bypassed.

The maximum blowdown rate for such discharge is 92 t/h for a period to be specified in the detailed design phase.

The various chemical and radioactivity limits for this discharge will be defined in the detailed design phase in special reports.

SG draining

The SGs can be drained via the APG [SGBS] when cold, wet lay-up or dry lay-up of the SGs is required.

This drainage, which takes place by gravity, may be partial or total.

The water drained in this way is routed to the condenser or, where this is not possible, to the nuclear island vent and drain system.

7.4.5. Special transient conditions**SG blowdown isolation after ASG [EFWS] actuation on SG level < Min 2**

In case of loss of main feedwater, the ASG [EFWS] is actuated as a safety classified system to remove residual heat via the secondary side. The selected detection signal is based on a SG level, which characterises a loss of SG water inventory.

The SG blowdown isolation valves are closed in case of ASG [EFWS] signal to limit the reduction in emergency feedwater volume.

SG blowdown isolation after ASG [EFWS] actuation on LOOP signal in conjunction with RIS [SIS] Signal

The loss of offsite power (LOOP) induces a turbine trip and switches off the reactor coolant pumps and ARE [MFWS] pumps. The heat is removed via MSRT and ASG [EFWS].

The steam generator blowdown isolation valves of the affected SG are closed in case of ASG [EFWS] signal to limit the reduction in emergency feedwater volume.

SG blowdown isolation after activation of the containment isolation signal

APG [SGBS] lines run through the containment. For this reason, they are included in containment isolation.

On receipt of a safety injection signal, all APG [SGBS] containment isolation valves are closed.

7.4.6. APG [SGBS] protection – detection of radioactivity in blowdown water

This event can cause secondary water contamination.

If radioactivity is detected in the samples taken on the hot or cold leg sides of an SG, the affected SG is isolated by manual closing of its isolation valves.

7.4.7. Transfer of SG water in the event of an SGTR under LOOP conditions

To avoid liquid discharge resulting from a rise in the water level of an SG affected by an SGTR under LOOP conditions, the APG [SGBS] is used to transfer water from the affected SG to the neighbouring unaffected SG.

Not more than one APG [SGBS] transfer line may be used between two SGs, and the blowdown lines of both must be isolated from the flash tank. This is followed by opening the transfer line isolation valve.

7.5. PRELIMINARY SAFETY ANALYSIS

7.5.1. Compliance with regulations

The APG [SGBS] will comply with the applicable general regulations (see Sub-chapter 1.4).

7.5.2. Compliance with functional criteria

The safety function performed by the APG [SGBS] is containment of the radioactive substances released in the secondary system in the event of an SGTR. Such containment (isolation of the secondary barrier) is performed by closing the isolation valves of each SG. These isolation valves also prevent excessive mass flow during a leak or an APG [SGBS] pipe break, to preclude unacceptable rise in containment pressure. They also prevent flashing of the unaffected SGs due to a non-isolatable break in a main feedwater system pipe.

Moreover, following an SGTR, part of the water inventory of the affected (i.e. isolated) SG can be transferred to another SG to avoid overflowing of the affected SG and then discharge of contaminated water into the environment.

Containment isolation for the APG [SGBS] is achieved at three levels, see Section 10.4.7 – Figures 1 and 2:

- downstream the blowdown (liquid phase) outlet of the blowdown cooler, where isolation is obtained by closing valves 6320 and 6330 VL;
- at the flash tank steam line to the feedwater tank, where isolation is achieved by closing valves 6120 and 6130 VL;
- at the blowdown cooler main condensate cooling water inlet and outlet, where isolation is achieved by closing valve 6230 VL and check valve 6240 VL (at inlet) and valves 6250 and 6260 VL (at outlet).

The following measures are taken to limit the risk of containment flooding (and IRWST dilution) by water from the APG [SGBS]:

- a check valve 5340 VL is installed on the steam discharge line to the feedwater tank, to prevent backflow from the feedwater tank from entering into the containment in the event of a line break;
- at the main condensate water inlet to the containment, excessive secondary water flow into the containment is prevented in the event of a blowdown cooler tube rupture or pipe rupture. This is afforded by a check valve on the main condensate outlet line, the motor-operated outside containment isolation valves, and the safeguard building isolation valves located in the APG [SGBS] valve chamber.

7.5.3. Compliance with design requirements

7.5.3.1. Safety classification

Compliance of equipment design and construction with rules for safety classification is detailed in Sub-Chapter 3.2.

7.5.3.2. Single Failure Criterion - SFC (redundancy)

Active APG [SGBS] components performing an F1 function are subject to the single failure criterion. Therefore:

- all SG isolation valves are redundant. This includes SG hot and cold leg side valves for blowdown collection, which are redundant to the valve on the common blowdown collection line. It also applies to the REN [NSS] collection valves on SG cold and hot leg sides (the second valve belongs to the REN [NSS] system).
- All containment isolation valves are redundant.
- The SG transfer lines are redundant.

7.5.3.3. Qualification

APG [SGBS] equipment is qualified in accordance with the requirements stated in Sub-chapter 3.6.

7.5.3.4. Instrumentation and Control (I&C)

Compliance of equipment design and construction with rules for I&C safety classification is detailed in Sub-chapter 3.2.

7.5.3.5. Emergency power sources

All class F1 valves have emergency or uninterrupted power supply. The power supply circuits for these devices will be defined at the detailed design stage.

7.5.3.6. Hazards

Section 10.4.7 - Tables 1 and 2 show the type of protection provided against hazards potentially affecting the APG [SGBS] (class F1 equipment):

7.6. TESTING, INSPECTION AND MAINTENANCE

Testing, inspection and maintenance requirements for the APG [SGBS] will be defined in the detail design phase.

SECTION 10.4.7 - TABLE 1

Protection against internal hazards

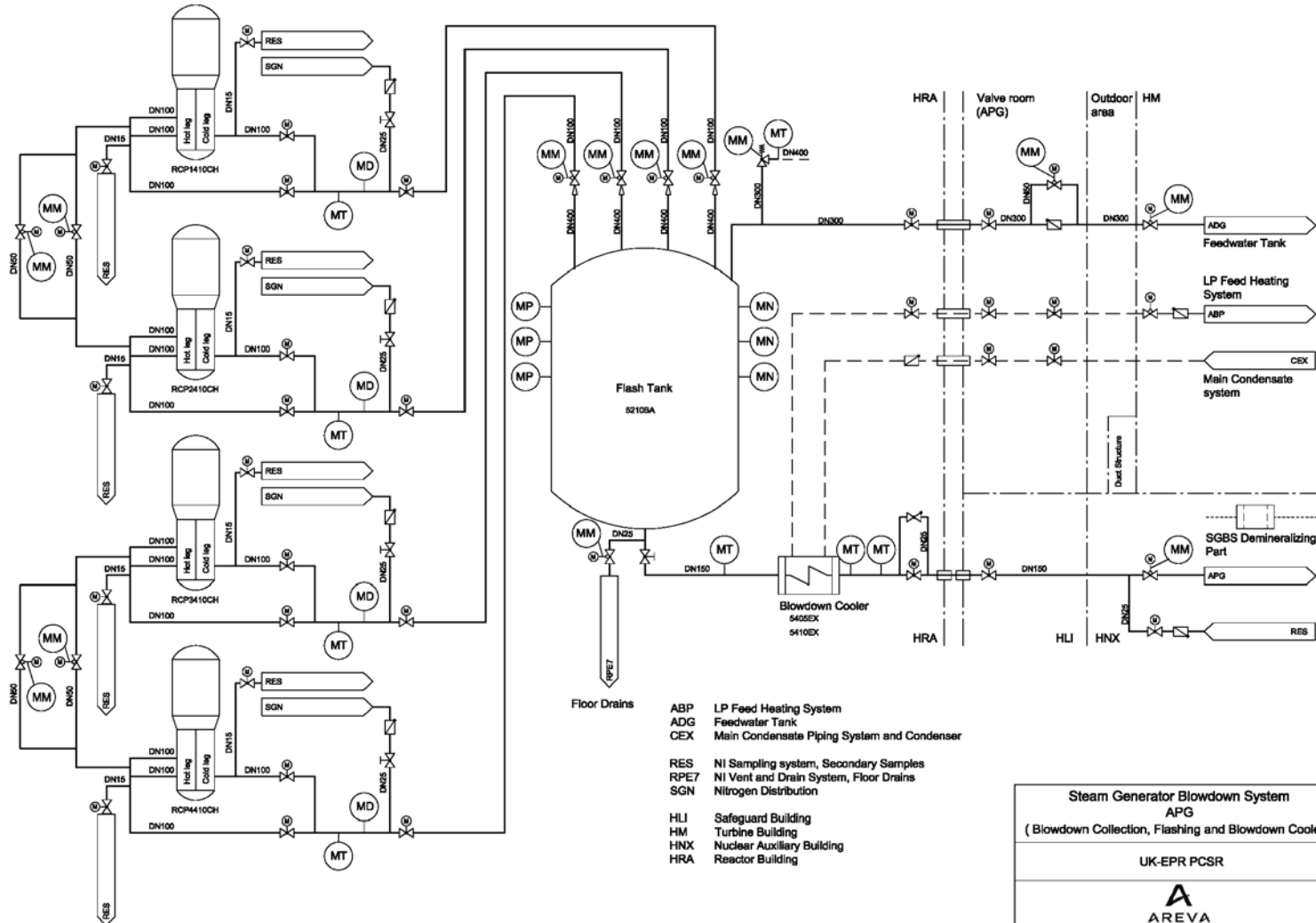
Internal hazards	Protection required in principle	General protection	Specific protection inherent in system design
Pipe rupture	Loss of not more than one train.	Physical separation and fire sectors in the reactor building	Fixed points to protect SG isolation valves and containment isolation valves.
Tank, pump and valve failure			Fixed point at transfer line valves.
Internal missiles			Isolation of a leak inside the safeguard building.
Dropped loads			In case of postulated failure of the flash tank it is ensured that the first SG isolation valves remain operable.
Internal explosion			none
Fire			none
Internal flooding			none
		Geographical separation	

SECTION 10.4.7 - TABLE 2

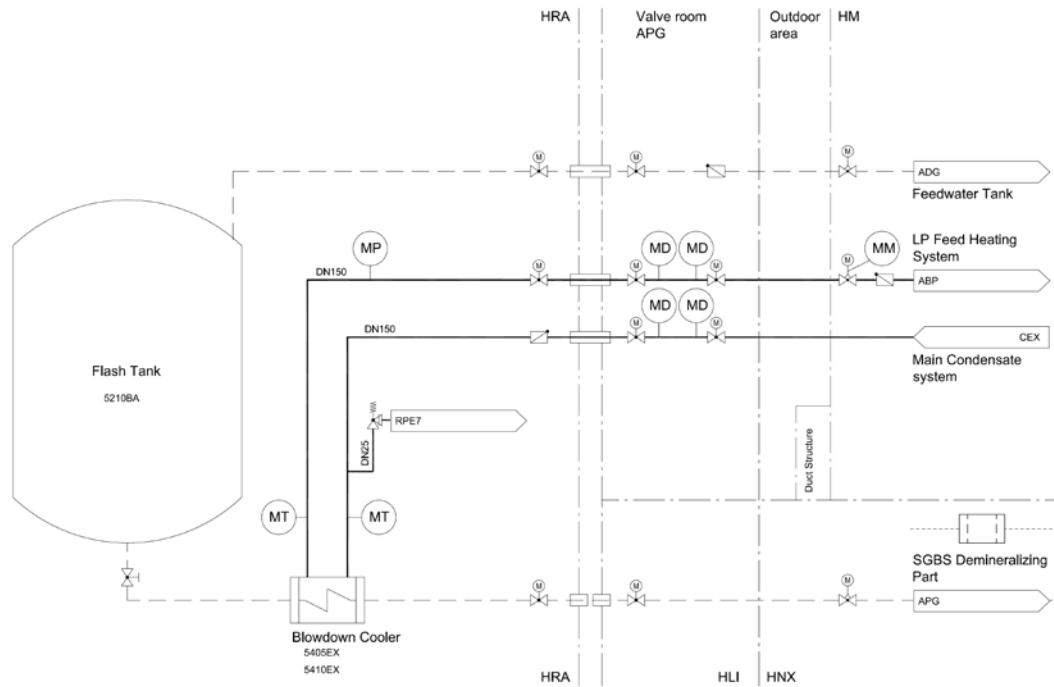
Protection against external hazards

External hazards	Protection required in principle	General protection	Specific protection inherent in system design
Earthquake	Yes	Location in the Safeguard Buildings and the reactor building	Seismic design
Aircraft crash	Yes	Location in the Safeguard Buildings and the reactor building	Seismic design
External explosion	Yes	Location in the Safeguard Buildings and the reactor building	none
External flooding	Yes	Location in the Safeguard Buildings and the reactor building	none
Snow and wind	Yes	Location in the Safeguard Buildings and the reactor building	none
Extreme cold	Yes	Location in the Safeguard Buildings and the reactor building	none
Electromagnetic interference	Yes	Location in the Safeguard Buildings and the reactor building	none

SECTION 10.4.7 - FIGURE 1
APG [SGBS] mechanical flow diagrams




SECTION 10.4.7 - FIGURE 2
APG [SGBS] mechanical flow diagrams

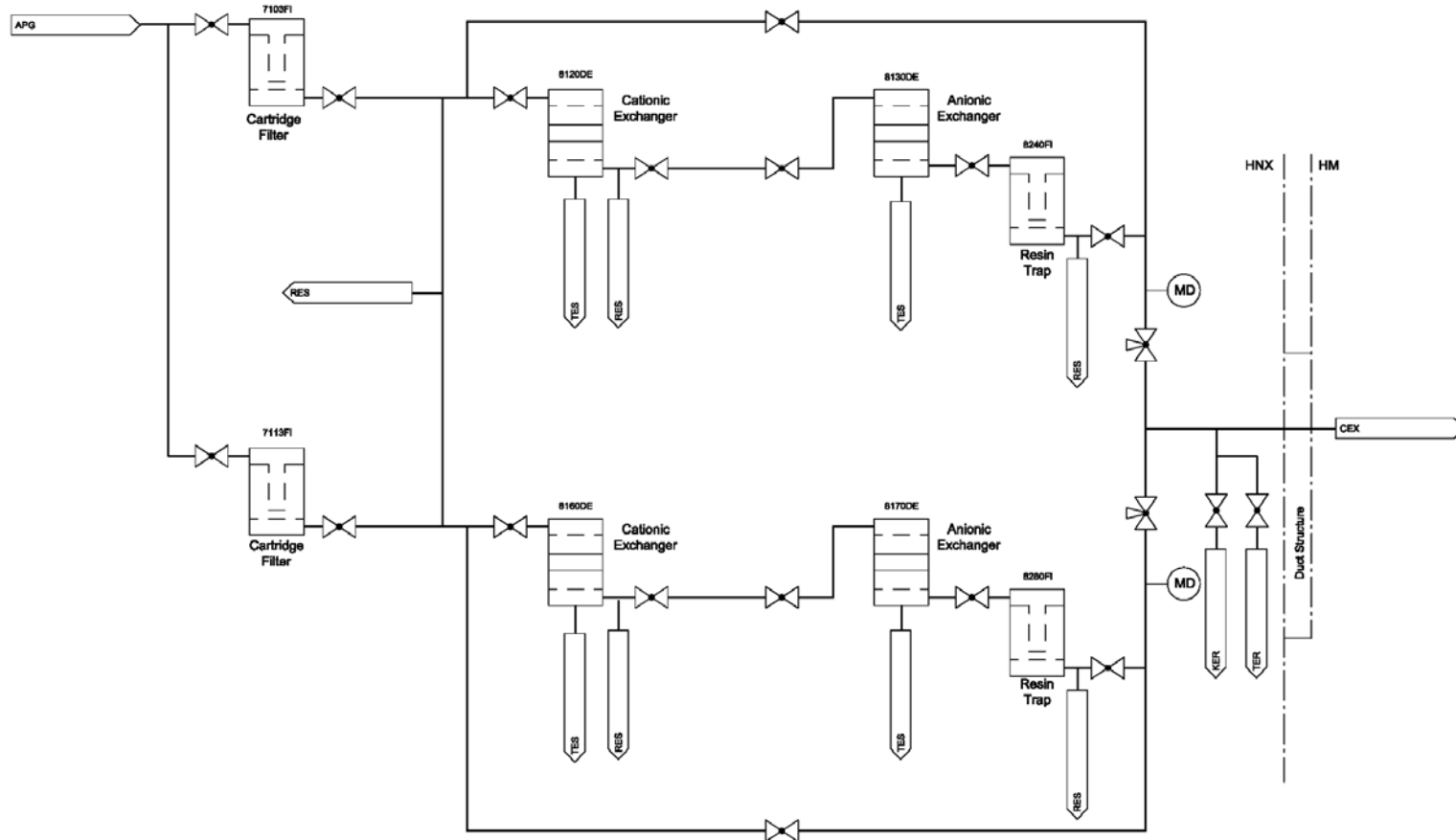


- ABP LP Feed Heating System
- ADG Feedwater Tank
- CEX Main Condensate Piping System and Condenser
- RPE7 NI Vent and Drain System, Floor Drains


- HLI Safeguard Building
- HM Turbine Building
- HNX Nuclear Auxiliary Building
- HRA Reactor Building

Steam Generator Blowdown System (Main Condensate Cooling Part)
UK-EPR PCSR
 AREVA

SECTION 10.4.7 - FIGURE 3
APG [SGBS] mechanical flow diagrams



HNX Nuclear Auxiliary Building
 HM Turbine Building
 KER Nuclear Island Liquid Radwaste Discharge System
 RES Nuclear Sampling System, Secondary Samples
 TES Solid Waste Treatment System
 TER Liquid Waste Discharge System

Steam Generator Blowdown System (Demineralizing Part)
UK-EPR PCSR
 AREVA

SUB-CHAPTER 10.4 – REFERENCES

External references are identified within this sub-chapter by the text **[Ref]** 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.

3. TURBINE BY-PASS (GCT) [MSB]

3.2. DESIGN BASIS

[Ref] System Design Manual – Main Steam Bypass System (to condenser) (GCT)
Part 1 – System operation. ETDOFC080022 Revision A1. EDF. September 2009. (E)

ETDOFC080022 Revision A1 is the English translation of ETDOFC080022 Revision A.

[Ref] System Design Manual – Main Steam Bypass System (to condenser) (GCT)
Part 2 – System sizing. ETDOFC080023 Revision A1. EDF. September 2009. (E)

ETDOFC080023 Revision A1 is the English translation of ETDOFC080023 Revision A.

[Ref] System Design Manual – Main Steam Bypass System (to condenser) (GCT)
Part 3 – Flow diagrams. ETDOFC080024 Revision A1. EDF. December 2009. (E)

ETDOFC080024 Revision A1 is the English translation of ETDOFC080024 Revision A.

[Ref] System Design Manual – Main Steam Bypass System (to condenser) (GCT)
Part 4 - Instrumentation and Control. ETDOFC080025 Revision A1. EDF.
December 2009. (E)

ETDOFC080025 Revision A1 is the English translation of ETDOFC080025 Revision A.

[Ref] Dossier de Système Élémentaire GCT - Pièce 5 - P5 Contrôle-commande.
[System Design Manual – Main Steam Bypass System (to condenser) (GCT), Part 5 -
Instrumentation and Control.].
NESS-F DC 398 Revision B. AREVA.

4. FEEDWATER PLANT

4.1. MAIN FEEDWATER PUMP SYSTEM (APA [MFWPS])

4.1.2. Design basis

[Ref] System Design Manual – Motor driven Feedwater Pump (APA [MFWPS]).
ETDOFC60117 Revision A1. EDF. December 2009. (E).

ETDOFC60117 Revision A1 is the English translation of ETDOFC60117 Revision A.

4.2. START-UP AND SHUTDOWN FEEDWATER SYSTEM (AAD [SSS])

4.2.2. Design basis

[Ref] System Design Manual - Start-Up and Shutdown Feedwater System (AAD [SSS]) - 1st Stage. ETDOFC060129 Revision A1. January 2010. EDF. (E)

ETDOFC060129 Revision A1 is the English translation of ETDOFC060129 Revision A.

5. COOLING WATER SYSTEM (CRF- FOR A COASTAL SITE)

5.2. DESIGN BASIS

[Ref] System Design Manual - Circulating Water System (CRF), Part 2 – System operation. ETDOFC080201 Revision B1. EDF. September 2009. (E)

ETDOFC080201 Revision B1 is the English translation of ETDOFC080201 Revision B

[Ref] Dossier de Système Élémentaire - CRF, P4.2 Schémas Mécaniques Détaillé.
[System Design Manual – Circulating Water System (CRF), Part 4.2 - Detailed flow diagrams]
ETDOIG060274 Revision D. EDF. September 2008.

[Ref] System Design Manual – Circulating Water System (CRF), Part 5 – Instrumentation and Control. ETDOFC080077 Revision C1. EDF. September 2009. (E)

ETDOFC080077 Revision C1 is the English translation of ETDOFC080077 Revision C.

7. STEAM GENERATOR BLOWDOWN SYSTEM (APG) [SGBS]

7.2. DESIGN BASES

[Ref] System Design Manual – Steam Generator Blowdown System (APG [SGBS])
P2 –System Operation.
SFL-EZS-030046 Revision G. SOFINEL. December 2008. (E).

[Ref] M Seiter, M Lenz, Steam Generator Blowdown System (APG [SGBS]) P3 – Sizing of the system and its components. SFL-EZS-030047 Revision G. SOFINEL. 15/12/2008. (E).

[Ref] M Seiter, M Lenz, Steam Generator Blowdown System (APG [SGBS]) P4.2 - Detailed Flow Diagrams (SMD). EZS/2007/en/0013 Revision E. SOFINEL. 17/12/2008. (E).

[Ref] System Design Manual – Steam Generator Blowdown System (APG [SGBS])
P5 – Instrumentation and Control (I&C).
SFL-EZS-030079 Revision G. SOFINEL. November 2008. (E).