SUB-CHAPTER E.1. DESCRIPTION OF THE REACTOR COOLANT SYSTEM

1. FUNCTIONAL ROLE

The Reactor Coolant System (RCP) [RCS] fulfils the following functions:

a) Radioactivity boundary

The RCP [RCS] serves as a boundary against leaks of radioactive products in the event of fuel cladding failure.

b) Heat transfer from the reactor - core cooling

The main function of the RCP [RCS] is to transfer heat from the reactor core to the secondary system to produce steam used for turbine operation.

Heat is transferred from the core to the steam generators by the reactor coolant.

Heat is exchanged with the feedwater in the steam generators generates steam which is then routed to the turbine by the main steam lines.

The Reactor Coolant Pumps (GMPP) [RCPs] provide a reactor coolant flow rate that is sufficient to cool the reactor core and limit the temperature of the fuel rods in order to maintain the integrity of the fuel cladding.

The systems involved in the core cooling function are:

- the main steam system, the turbine bypass system, the steam generator feedwater system, the start-up and shutdown feedwater systems (these systems are used under normal operation)
- the residual heat removal system (used during shutdown)
- the emergency feedwater system, in the event of loss of feedwater or of the start-up and shutdown feedwater system
- the chemical and volume control system, to maintain the inventory of reactor coolant water and compensate for minor leakage from the RCP [RCS]
- the safety injection system:
  - o to maintain the inventory of the reactor coolant in the event of a reactor coolant system break
  - o to remove heat in back-up of the residual heat removal system
  - o to remove heat in the event of complete loss of the heat removal functions

c) Neutron moderator

The reactor coolant contained within the RCP [RCS], is used as a neutron moderator in order to slow the neutron velocity to thermal ranges

d) Reactivity control

The reactor coolant fluid serves as a solvent for boric acid (demineralised water is used). Boric acid is used for reactivity control to compensate for the effects of xenon transients, fuel burn-up and to ensure sub-criticality during plant shutdown.

The systems involved in the reactivity control function are:

- the Rod Cluster Control Assemblies [RCCAs]
- the chemical and volume control system (in conjunction with the water and boron-make-up system) to adjust the boric acid concentration under normal operation.
- the safety injection system
- the extra boration system

e) Reactor coolant pressure control

The reactor coolant pressure must be greater than the saturation pressure corresponding to the temperature of the hot leg in order to prevent departure from nucleate boiling which has adverse effects on the heat transfer and reactivity.

The subcooling corresponding to the cold leg temperature of the reactor coolant must be sufficiently small to minimise the loads imposed on the vessel’s internal equipment in the event of a RCP [RCS] pipe rupture.

Control of reactor coolant pressure is carried out by the pressuriser connected to one of the hot legs of the RCP [RCS] by means of the surge line.

2. DESIGN ASSUMPTIONS AND FLUID CHARACTERISTICS

2.1. GENERAL ASSUMPTIONS FOR SYSTEM DESIGN

a) Heat transfer from the reactor - core cooling function

Under normal operation, the core cooling function is provided through the circulation of reactor coolant fluid and heat transfer to the steam generators.

The system is designed with four loops to ensure the reactor coolant flow, each loop being connected to the Reactor Pressure Vessel [RPV]. The core is located inside the vessel.

Within each loop, the reactor coolant circulates:

- from the reactor pressure vessel to the steam generator GV [SG] via the “hot leg” pipework

- from the GV [SG] to the reactor coolant pump (GMPP) [RCP] via the “crossover leg” pipework

- from the reactor coolant pump (GMPP) [RCP] to the vessel via the “cold leg” pipework

Under normal conditions, forced circulation is provided by the four reactor coolant pumps, but in the event that the pumps are totally unavailable, the residual heat is removed by natural circulation through the core.

During shutdown, when the steam generators are unable to operate, the core cooling function is provided by the RIS/RRA [SIS/RHRS]. The reactor coolant fluid is pumped from the hot leg and re-injected into the cold leg after cooling.

In the event of a reactor coolant system break or long-term removal of residual heat in the event of an accident, the core cooling function is provided by the RIS/RRA [SIS/RHRS].

In the event of total loss of heat removal functions, core cooling may be provided by the safety injection system in conjunction with pressuriser bleed to the reactor building (the pressuriser discharge system is described in Section E.4.5).

Under normal operation, the inventory of the reactor coolant fluid is controlled by the chemical and volume control system (RCV) [CVCS]. In the event of a break of the reactor coolant system this is performed by the (RIS) [SIS]. .

In the event of loss of external power, the inertia of the reactor coolant pumps provides a flow transient maintaining the integrity of the fuel cladding.

b) Neutron deceleration function (moderator)

This function is provided by the reactor coolant fluid contained in the RCP [RCS].

The total reactor coolant mass is controlled by the RCV [CVCS] (letdown line and charging line). The pressuriser accommodates changes in reactor coolant volume during transients.

c) Reactivity control function

Reactivity is controlled by:

- the Rod Cluster Control Assemblies [RCCAs]

- The coolant’s boric acid concentration, controlled by the RCV [CVCS] (in conjunction with the reactor boron and water make-up system (REA) [RBWMS]

- the safety injection system (RIS) [SIS] in the event of a reactor coolant system break or secondary system ruptures (by using ISMP [MHSI] pumps)

- the extra boration system, which provides a safe boration method in order to reach safe shutdown state

d) Radioactivity boundary function

The whole Reactor Coolant System serves as a boundary against leaks of radioactive products.

In particular, leaks along the reactor coolant pumps' shaft are controlled by a specific sealing system comprising:

- the RCV [CVCS], to provide seal water injection which ensures the leak resistance of the seals and seal leakage recovery for the leak-off.
- the RRI [CCWS] to cool down the reactor coolant fluid flowing towards the seals
- a shutdown sealing mechanism that can be activated when the pumps are stopped

e) Reactor coolant pressure control function

Reactor coolant pressure is controlled by the pressuriser connected to a hot leg by the surge line.

In the pressuriser, water and steam are kept at saturation point.

Pressure control in the pressuriser is achieved by:

- electric heaters to produce steam and increase the reactor coolant pressure.
- two cold water spray lines in the pressuriser steam phase in order to condense the steam and reduce reactor coolant pressure.

The spray lines are connected to two of the cold legs (the spray flow rate is provided by the reactor coolant pumps and controlled by the spray valves).

If the two normal spray lines are insufficient to control the reactor coolant pressure, or in the event of loss or shutdown of the GMPP [RCPs], an auxiliary spray line, using the RCV [CVCS] pumps, is connected to the pressuriser.

A discharge system, comprising relief valves, is mounted on the pressuriser; this is described in SectionE.4.5.

2.2. RCP [RCS] FLUID CHARACTERISTICS

The data for the Reactor Coolant system is as follows:

- RCP [RCS] operating pressure = 155 bar abs in the pressuriser
- RCP [RCS] design pressure = 176 bar abs
- RCP [RCS] vessel flow rates: three values are used for the various studies (without plugging and with clean tubes):
    - best estimate flow (BE): nominal flow corresponding to the intersection between the performance curve of the GMPP [RCPs] (head-flow) and the RCP [RCS] characteristic curve, without margin
    - thermo-hydraulic flow (TH): minimum flow, used in studying core performance, taking into account the uncertainties on the GMPP [RCP] head-flow curve and the accuracy of the measurement of the reactor coolant flow
    - mechanical design flow (ME): maximum flow, used for the mechanical design basis of the vessel's internal equipment and fuel assemblies.

BE flow per loop = 23124 kg/s.

TH flow per loop = 22225 kg/s.

ME flow per loop = 24925 kg/s.

RCP [RCS] loop temperature at hot standby (0% power) = 303.3°C.

RCP [RCS] loop temperature at nominal power:

- Cold leg:
  - BE = 296.1°C
  - TH = 295.7°C
  - ME = 296.8°C.
- Hot leg:
  - BE = 329.0°C
  - TH = 329.9°C
  - ME = 327.4°C.
- Core outlet:
  - BE = 330.1°C
  - TH = 331.7°C
  - ME = 327.9°C.

  For closed warm dome configuration.

Pressuriser temperature in operation = saturation temperature for 155 bar abs = 345 °C.

RCP RCS] loop design temperature = 351 °C.

Pressuriser design temperature = 362 °C.

3. FLOW DIAGRAMS AND MAIN EQUIPMENT CHARACTERISTICS

3.1. SAFETY CLASSIFICATION

The detailed classification is given in the construction, components and systems classification chapter (see Section C.2.2).

3.2. REACTOR PRESSURE VESSEL

The reactor vessel is cylindrical with a welded lower hemispherical end and a removable flanged upper hemispherical head including a seal. The reactor vessel is designed to hold the reactor core (sufficient volume), the Rod Cluster Control Assemblies [RCCAs], the heavy reflector and internal equipment. The reactor vessel has four inlet and four outlet nozzles located horizontally just below the reactor vessel flange but above the top of the core. The reactor coolant from the cold legs enters the reactor vessel through the inlet nozzle and flows down through the annular space between the core barrel and the reactor vessel wall. The coolant turns at the bottom of the reactor vessel and then flows upwards inside the core towards the outlet nozzles and thence towards the hot legs.

The reactor vessel head supports the mechanisms of the Rod Cluster Control Assemblies [RCCAs] and the core monitoring systems.

The reactor vessel flange and head are sealed by means of two metal seals. Any seal leaks that may occur are detected by means of a leakoff connection between the internal and external seals.

The vent in the reactor vessel head can be connected to the RPE [VDS] vacuum pump for filling of the reactor vessel.

It is possible to inject nitrogen via the reactor vessel vent to drain the RCP [RCS] before opening.

3.3. REACTOR COOLANT SYSTEM PIPEWORK

The Reactor Coolant system pipework comprises:

- four heat transfer loops, each comprising a hot leg connecting the reactor vessel to the GV [SG], a crossover leg connecting the GV [SG] to the GMPP [RCP] and a cold leg connecting the GMPP [RCP] to the reactor vessel

- one pressuriser surge line connecting the pressuriser to one hot leg pipe

- two pressuriser spray lines connecting the pressuriser normal spray nozzles to two cold legs

Pressuriser discharge is discussed in Section E.4.5.

<u>Connections to auxiliary systems</u>

- RIS/RRA [SIS/RHRS]:
    - o 4 nozzles on the hot legs (also used for RRA [RHRS] suction)
    - o 4 nozzles on the cold legs (also used for accumulator, ISMP [MHSI] and ISBP/RRA [LHSI/RHRS] injection on 4 loops, with a nozzle combination including emergency boration system injection in the 4 loops)
- (RCV) [CVCS]
    - o 2 nozzles on the cold legs (RCV [CVCS] make-up on 2 loops)
    - o 1 nozzle on the crossover leg (RCV [CVCS] letdown on 1 loop)

- 1 nozzle on the pressuriser for the auxiliary spray line

- Other connections:
  - vent and drain connections
  - nitrogen supply to the pressuriser and reactor coolant pumps
  - vacuum pump connection on the pressuriser for filling and purging of the Reactor Coolant system
  - connections to the sampling system
  - reactor vessel seal leak-off connection
  - instrument nozzles

3.4. PRESSURISER

a) General description

The pressuriser is a vertical cylindrical chamber, with hemispherical upper and lower ends.

The lower end holds the heaters, installed vertically in the vessel.

A nozzle for the surge line is positioned axially, in the centre of the lower end.

The surge line is connected to the hot leg of loop 3.

The relief valves and the discharge line used for severe accident mitigation (the relief valves and the discharge line used in the event of a severe accident are described in Section E.4.5) are connected to the upper end. The spray lines are connected laterally to the upper section of the pressuriser's cylindrical shell.

Cold water spraying occurs in the steam phase via spray nozzles located at the end of the spray lines.

b) Pressuriser heaters

The total heater power is shared between:

- the continuously controlled heaters
- the emergency on/off heaters
- the fixed heaters

c) Pressuriser spray system

The pressuriser is fitted with three separate spray nozzles:

- two for normal spraying
- one for auxiliary spraying

The normal spraying nozzles are connected to the normal spray lines that are connected to the cold legs of loops 2 and 3.

The spray rate for each normal spray line may be actuated by a spray valve which is able to operate in automatic mode or in on/off mode.

A continuous spray rate is ensured in each normal spray line (when the reactor coolant pumps are operating) by dedicated control valves.

An auxiliary spray line is connected to the RCV [CVCS].

d) Pressuriser venting and degassing system

A vent line connects the pressuriser to the RPE [VDS].

A vacuum line to the RPE [VDS] and a degassing line (to the RPE [VDS]) are connected to this vent line. A nitrogen supply line is also connected to this line.

The connection to the RPE [VDS] is used to reduce pressure in the (RCP) [RCS] to a value below atmospheric pressure using a dedicated vacuum pump during initial filling (the pump belongs to the RPE [VDS] system). This connection and the vacuum pump are also used for nitrogen draining of the RCP [RCS] during PTB-RRA (operation with reduced RCP [RCS] water level) (extraction of noble gases before opening of the RCP [RCS]).

The pressuriser degassing line can be used:

- running at low capacity, permanently, to avoid a significant build-up of hydrogen in the pressuriser plenum.

- running at high capacity to eliminate gases trapped in the pressuriser just before running pressuriser relief valve testing.

Gases are sent to the gaseous waste treatment system (TEG) [GWTS] via the RPE [VDS] system.

The nitrogen supply line is used during the shutdown procedure, to maintain a gas cover in the pressuriser during and after returning the reactor coolant system to sub-saturated conditions.

3.5. REACTOR COOLANT PUMPS

a) General description

The reactor coolant pump is a vertical, single stage pump designed to circulate large flow of reactor coolant at high temperature.

The shaft sealing system is designed to avoid any reactor coolant system leaks into the containment area. The motor is an air-cooled three-phase motor.

The full unit is a vertical assembly comprising (from top to bottom) a flywheel, a motor, a seal assembly and a hydraulic unit.

The reactor coolant is pumped by an impeller attached to the base of the rotor shaft. The reactor coolant is drawn up into the suction nozzle of the casing, directed towards the impeller by the suction adapter, pumped through the impeller then discharged through the diffuser to the discharge nozzle.

The reactor coolant pumps are designed to supply a sufficient flow rate to obtain satisfactory cooling of the core.

The total head of the pumps is designed by the pressure drop in the reactor coolant system loops (vessel, steam generators and pipework).

The reactor coolant pumps are described in Section E.4.1.

b) Shaft sealing system

The water injected at the reactor coolant pump seal no.1 is supplied by the RCV [CVCS].

Seal No. 1 leakage is also recovered by the RCV [CVCS].

Pressure upstream and downstream of seal no.1 can be equalised using the seal bypass line. The bypass line is only open during RCP [RCS] vacuum filling to protect the no.1 seal against negative pressure differences.

Seal No. 2 leakage is drained into the reactor coolant drains (part of the RPE [VDS]).

Seal No.3 is permanently flushed with demineralised water from the demineralised water system.

Seal No. 3 leakage is drained to the process drains (part of the RPE [VDS]).

The “standstill seal system” is the ultimate leaktightness mechanism of the shaft sealing system (when the GMPP [RCP] is stopped). The standstill seal system is pneumatically controlled (nitrogen). The standstill seal system is open during normal pump operation.

Isolating valves are installed on the 3 seal leakoff connection lines.

c) Interface with the component cooling water system (RRI) [CCWS]

The reactor coolant pumps are fitted with coolers supplied by the RRI [CCWS] for:

- cooling the motor (two air-coolers per pump)
- cooling the motor’s upper and lower bearings (one oil cooler per bearing)

The pump’s thermal barrier, which is also cooled by the RRI [CCWS], provides cooling for the reactor coolant arriving at the seals in the event of failure of No. 1 seal injection.

3.6. STEAM GENERATORS

The steam generators are vertical shell and inverted-U tube evaporators fitted with integral moisture separating equipment. They are also fitted with an axial pre-heater (or economiser) to obtain higher steam pressure.

The reactor coolant is circulated through the inverted-U tubes, entering and leaving by nozzles located in the steam generator' channel head (lower hemispherical end). The lower end is divided (inlet chamber and outlet chamber) by a vertical separation plate (partition plate) extending from the tube sheet. Manholes provide access to both sides of the channel head.

The heat carried by the reactor coolant is transferred to the secondary fluid through the walls of the tube bundle.

On the secondary side, feedwater is directed towards the cold side of the tube sheet by an annular skirt in which the feedwater is injected through a feedwater distribution ring.

The economiser wrapper and the feedwater distribution ring cover only that half of the tube sheet corresponding to the cold side. A separation plate separates the hot leg and the cold leg in the tube bundle (from the tube sheet until the 6th tube support plate). Once the feedwater reaches the bottom of the cold side, the water rises along the cold leg tube bundle and is heated to boiling point. The steam-water mixture rises, crosses the separators and driers and exits the steam generator by the outlet nozzle located on the GV [SGs] elliptical upper end.

Water from the separators and driers is recirculated:

- 90% on the hot side of the tube bundle where it is evaporated
- 10% mixed with the feedwater on the cold leg side of the tube bundle

4. DESCRIPTION OF STATES

4.1. NORMAL OPERATION OF THE REACTOR COOLANT SYSTEM

Normal operation of the RCP [RCS] corresponds to power operation of the plant.

This covers all power levels ranging from 0% to 100% of nominal power.

The temperature of the hot leg, the cold leg and consequently the average temperature, depend on the load in accordance with the chart shown in E.1 FIG 1.

The pressuriser pressure is constant and equals 155 bar abs irrespective of the load.

The pressuriser water level depends on the load as shown in E.1 FIG 2.

The pressure on the secondary side of the steam generator depends on the load as shown in E.1 FIG 1.

The values given in E.1 FIG 1 and E.1 FIG 2 are based on the best estimate [BE] value of the reactor coolant flow with four reactor coolant pumps operating.

In the event that one reactor coolant pump is lost, operation with 3 loops at reduced power output is possible.

4.2. STANDARD STATES OF THE REACTOR COOLANT SYSTEM AT SHUTDOWN

a) Hot shutdown

This is the normal state of the system when the reactor is not critical.

- The four reactor coolant pumps are operating (operation with a reduced number of pumps is possible)
- the pressuriser pressure is 155 bar abs
- the average temperature of the RCP [RCS] loops is 303.3 °C
- the pressuriser is saturated and controls the RCP [RCS] pressure, the level is adjusted to the no-load value

b) Intermediate shutdown

This is an intermediate state, reached during unit start-up and shutdown procedures, corresponding to the heating up and cooling down of the RCP [RCS].

- The average temperature of the reactor coolant loop is between 55°C and 303.3°C (pressure/temperature value pairs remaining within the acceptable limits given by the RCP [RCS] equipment designers).
- Below 120°C, RCP [RCS] temperature control is carried out by the residual heat removal system
- Above 120°C, RCP [RCS] temperature control is carried out by the steam generators
- At least one reactor coolant pump is operating
- The pressuriser pressure is between 15 and 155 bar abs (15 bar being the minimum pressure required for operation of the reactor coolant pumps)
- While the RRA [RHRS] is connected to RCP [RCS], the maximum pressure is limited to 30 bar
- The pressuriser is saturated and controls the RCP [RCS] pressure

c) Normal cold shutdown

This is the normal state of the system when cold.

- The RCP [RCS] is closed
- No reactor coolant pump is operating
- The pressuriser pressure is between 1 and 30 bar abs
- The average temperature of the reactor coolant loop is between 15°C and 65°C (pressure/temperature value pairs remaining within the acceptable limits given by the RCP [RCS] equipment designers)

- The pressuriser is two-phase and controls the RCP [RCS] pressure

- The pressuriser gaseous phase contains either nitrogen or steam

d) Cold shutdown for maintenance

This is the RCP [RCS] state necessary to prepare for and carry out maintenance of the RCP [RCS] or RCP [RCS]-related equipment, with a depressurised and partially drained system.

- The RCP [RCS] is depressurised: the reactor vessel may be closed but the integrity of the reactor coolant pressure boundary is not ensured, consequently, the system cannot be pressurised (the GV [SGs] are not available for heat removal)

- No reactor coolant pump is operating

- The average reactor coolant temperature is between 15°C and approximately 55°C

- The reactor coolant level is greater than or equal to that defined as the minimum level for RRA [RHRS] operation with a reduced RCP [RCS] water level (PTB-RRA)

The lower working range of the RRA [RHRS] (PTB-RRA) is applied in particular:

- before filling the RCP [RCS] (upon plant start-up), the RPE [VDS] vacuum pump being connected to the pressuriser vent line to adjust the RCP [RCS] pressure at approximately 0.2 bar abs

- for RCP [RCS] gas draining (during shutdown), the RCP [RCS] is firstly drained under nitrogen pressure, to minimise degassing in the GV [SG] tubes. Next, the RPE [VDS] vacuum pump is used to evacuate the nitrogen or air injected into the RCP [RCS] through the reactor vessel head vent and the GMPP [RCP] No. 1 seal injection lines

e) Re-fuelling shutdown

The re-fuelling shutdown state corresponds to the RCP [RCS] state required to prepare for and carry out all fuel handling operations.

- The RCP [RCS] is at the containment pressure and the vessel is open (no reactor coolant pump is operating).

- The average reactor coolant temperature is between 15°C and approximately 55°C.

- The refuelling cavity has been filled with water from the IRWST (or filling or draining of the refuelling cavity is being carried out).

5. RCP [RCS] CONTROL FUNCTIONS

5.1. RCP [RCS] PRESSURE CONTROL

Control of RCP [RCS] pressure contributes to:

- the RCP [RCS] overpressure protection safety function by preventing the activation of the pressuriser relief valves.
- the reactor heat transfer safety functions, core cooling and reactivity control by maintaining the RCP [RCS] pressure above saturation pressure.

Control of RCP [RCS] pressure is based on the comparison between the measured pressuriser pressure and the reference pressure setpoint and the sending of a control signal to the control actuators to:

- activate the pressuriser heaters to increase pressure by heating the liquid phase of the pressuriser
- introduce spray water in the steam phase of the pressuriser to reduce pressure.

Only continuously controlled heaters and spray control valves in automatic mode are involved in controlling the RCP [RCS] pressure during minor variations relative to the reference pressure setpoint.

On/off heaters and on/off spray valves are activated only in the event of a significant variation compared with this setpoint.

RCP [RCS] pressure measurements contribute to the establishment of alarm setpoints and automatic actions to prevent the actuation of instrumentation and control functions and automated protection.

These upper and lower RCP [RCS] pressure setpoints generate automatic alarms or limitation measures such as:

- actuation or switch-off of the pressuriser heaters
- opening or isolation of the normal and/or auxiliary spray
- isolation of the RCV [CVCS] charging flow or switch-off of the RCV [CVCS] charging pump (high pressure)

RCP [RCS] pressure measurements are also used to activate the protection instrumentation and control functions (the reactor protection system is described in Section G.3.1).

Protection against excess pressure in the RCP [RCS] using the pressuriser relief valves and the RCP [RCS] depressurization line in the event of a severe accident is described in Section E.4.5.

5.2. PRESSURISER LEVEL CONTROL

Control of the pressuriser level contributes to the safety function of maintaining the RCP [RCS] water inventory.

Control is based on the comparison between the measured pressuriser level and the reference level and provides a control signal to the RCV [CVCS] high pressure letdown flow control valve.

The pressuriser reference level is a function of the RCP [RCS] temperature and is determined so as to keep a constant reactor coolant mass for pressure levels between 0 and 100%.

Pressuriser level measurements contribute to the establishment of alarm setpoints and automatic actions to prevent the actuation of automated instrumentation and control protection functions.

These upper and lower pressuriser level setpoints generate automatic alarms or limitation measures such as:

- opening or closing of the RCV [CVCS] high pressure letdown flow rate control valve
- start up of the second RCV [CVCS] charging pump (low level)
- isolation of the RCV [CVCS] charging flow (high level)
- isolation of the pressuriser normal and/or auxiliary spray (high level)
- switching off the pressuriser heaters (low level)

Pressuriser level measurements are also used to activate the protection instrumentation and control functions (the reactor protection system is described in Section G.3.1).

5.3. RCP [RCS] LOOP LEVEL CONTROL

Controlling the level in the reactor coolant loops contributes to the safety function of controlling the RCP [RCS] water inventory at the lower working range of the RRA [RHRS] (in shutdown).

Control is based on the comparison between the measured level in the loop and the reference level and provides a control signal to the RCV [CVCS] low pressure letdown flow control valve.

The reference level is determined in such a way as to guarantee water inventories are sufficient for operation of the RRA/ISBP [RHRS/LHSI] and are in accordance with maintenance requirements.

Loop level measurements contribute to the establishment of alarm setpoints and limitation functions to prevent the automatic actuation of instrumentation and control protection functions. These upper and lower RCP [RCS] loop level setpoints generate automatic alarms or limitation measures such as the closing of the RCV [CVCS] low pressure letdown flow path (low level).

The loop level measurements are also used to actuate the automated protection function in the event of failure of the above control methods i.e. actuation of the safety injection system when the reactor coolant system loop levels are low. In the event of failure of the protection system, an RRC-A function is designed to actuate the safety injection system.

5.4. STEAM GENERATOR LEVEL CONTROL

Controlling the steam generator level contributes to the safety function of controlling the RCP [RCS] temperature.

Control is based on the comparison between the measured value and a setpoint, and provides a control signal to the feedwater control valves.

The steam generator level setpoint is constant and independent from the power levels exchanged by the steam generators.

On high GV [SG] level, the RCV [CVCS] charging line is isolated. This measure contributes to avoiding overfilling of the GV [SG] in the event of RTGV [SGTR].

Steam generator level measurements are also used to actuate the automated protection control functions (the reactor's protection system is described in Section G.3.1).

5.5. REACTOR COOLANT PUMP STANDSTILL SEAL SYSTEM ACTUATION

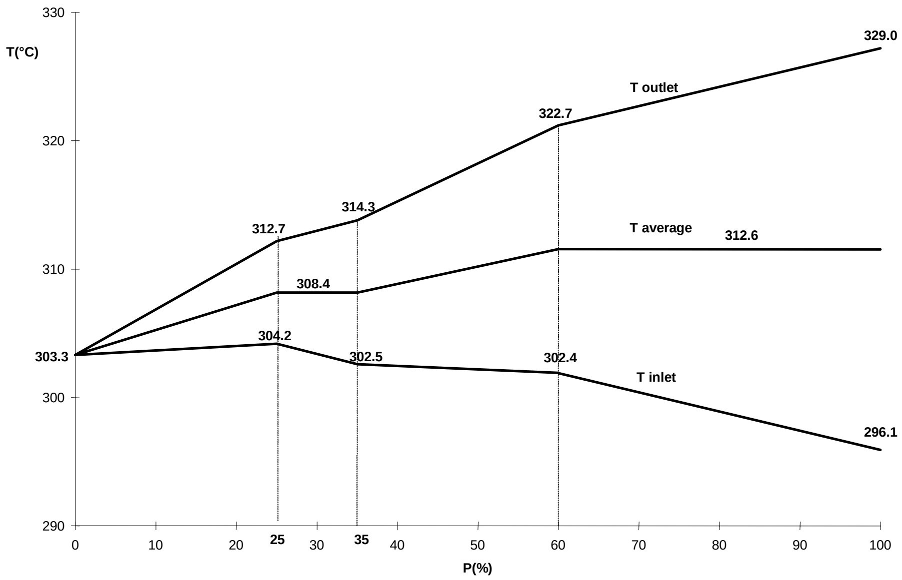
The standstill seal system on reactor coolant pumps prevents excessive loss of coolant along the shaft in case of failure of the normal seals. It contributes to the RCP [RCS] isolation safety function.

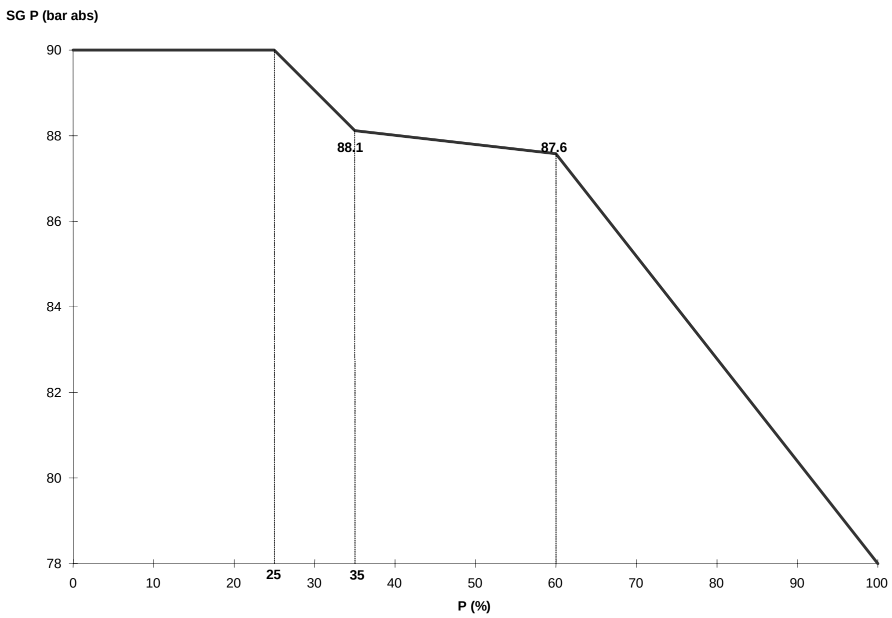
The standstill seal system automatically closes when pump shutdown is detected by pump rotational speed measurement sensors and the seal cooling means are unavailable (RCV [CVCS] injection and RRI [CCWS] supply).

The standstill seal system is actuated with a seal gas supply and disabled with seal gas relief to the Reactor Building atmosphere. Seal gas is nitrogen.

All of the leakoff lines from reactor coolant pumps are automatically isolated by closure of the motorized isolation valves on seal nos. 1, 2 and 3 leakage recovery lines

E.1 FIG 1: PART LOAD DIAGRAM AT BE FLOW RATE FOR PRIMARY TEMPERATURE AND SECONDARY PRESSURE





E.1 FIG 2: PRESSURISER LEVEL VERSUS SECONDARY POWER