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REVISION HISTORY

Issue	Description	Date
00	First issue for INSA review	14.01.08
01	Integration of technical, co-applicant and INSA review comments	26.04.08
02	PSCR June 2009 update: - inclusion of references, - clarification of text, - section 1: the criteria to define an iodine and/or an aerosol risk and the associated zoning are detailed, - section 2: the radiation protection requirements are updated and the walls thickness are set in accordance with the PDMS 3D model (April 2009 extract), - section 4: inclusion of design modification.	23.06.09
03	Consolidated Step 4 PCSR update: - Minor editorial changes, corrections and clarification of text, - Section 1.1: removal of the realistic value classification, - Section 2.1: removal of the energy spectra; section 2.3: correction of material densities; section 2.4: clarification of the calculation method; section 2.5: removal of computer code references; sections 2.6, 2.7, 2.8, 2.9 and 2.10: addition of contaminated systems present in the buildings, correction of the main shielding structures, - Section 3: clarification of the design of ventilation systems, - Section 4: removal of the first paragraph; section 4.2: addition of text on controllers for large objects, - Section 5.3: removal of text on small LOCA with the TAM open; addition of another channel (KRT RCV), - Minor modifications to tables; figures updated (Appendix 1.3, 1.4).	27.03.11

Continued on next page

REVISION HISTORY (Cont'd)

Issue	Description	Date
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 - Addition of a new reference in section 2.4: UK EPR – Overview of the radiological zoning of the nuclear island. ECEIG111267 Revision B - Cross-reference to figures corrected (§2.5) - Section 5.1 renumbered 5.0 "Safety requirements" - Table 1 updated to reflect continuous monitoring of primary circuit activity	29.06.12

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TABLE OF CONTENTS

SUB-CHAPTER 12.3 - RADIATION PROTECTION MEASURES

1. RADIATION PROTECTION RULES

1.1. RADIATION PROTECTION CLASSIFICATION AND ZONING

UK Regulatory control procedures require the Operators of Nuclear Licensed sites to ensure that adequate protection measures are in place to restrict the radiation exposure of site radiation workers, workers on site whose primary occupation is not radiation work and members of the public. In the UK, the primary statutory instrument to regulate radiation exposure to persons is the Ionising Radiations Regulations 1999, SI3232, (IRR99) [Ref-1] which implements EC Euratom Directive 96/29 [Ref-2].

Established within the regulatory framework of IRR99 is a hierarchy of controls. First and foremost are engineering controls. These engineered controls are the provision of adequate shielding, interlocks and trapped key systems and appropriate warning devices. Only after these have been applied can procedural controls such as zoning and special precautions be used to control exposure.

The primary procedural control measure is the designation and establishment of controlled and supervised areas. Under Regulation 16(1) of IRR99, there is a clear requirement for a radiation Employer to designate an area as controlled on the basis of a projected, or potential, dose to a worker in excess of 6 mSv in a calendar year. This limit is taken from the European Basic Safety Standard (BSS) in Euratom Directive 96/29.

Further to the definition of a controlled area in IRR99, there is also a separate definition of a supervised area. This is defined as an area in which workers are projected to receive in excess of 1 mSv per year but less than 6 mSv. This zone is identified as a monitored area. There is a definition of a further procedural area which is neither controlled nor monitored, where projected doses are less than 1 mSv per year. Whilst this is the statutory definition and basis for a supervised area, in actual practice, an NPP will have a single, overall designated area generically known as the RCA, or Radiation Controlled Area. In the UK an area outside the RCA where work is being carried out on a temporary basis, may be designated as controlled whereas by strict definition of the IRRs, this designation should be as a supervised area. Designation is usually done on the basis of a worst case scenario for dose uptake due to a possible internal dose and not necessarily just on measured external dose rates or contamination levels.

Provision of washing and changing facilities is also a regulatory requirement. The areas within the NPP which will require designation as active areas have been identified and it is ensured that these areas are adequately supported by changing room facilities.

The controlled area mainly covers the Reactor Building, the Fuel Building, the Nuclear Auxiliary Building, the access tower (from the control point for controlled area workers), the Safeguard Buildings and the Effluent Treatment Building. Within the EPR design, access to a controlled area is limited to designated category A or B workers as defined in Article 21 of the Euratom Directive 96/29 - Categorisation of exposed Workers, Under Regulation 20(1)-(2) of IRR99, there is a direct alignment between Category A workers and Classified workers and Category B workers and Non classified workers

Both categorisations are based on risk assessments of the projected, or potential, radiation dose an individual worker may receive in a calendar year; this is the 6 mSv threshold above which a worker must be classified under the European BSS. Regulations 20(1)-(2) of IRR99 also require that a worker must be over 18 years of age and have successfully completed a medical examination. A Radiation Employer must have in place additional restrictions for female employees who have declared their pregnancy.

Active systems and radioactive materials, or those likely to become so, are installed in controlled areas.

In order to assess the required radiation protection provisions for a room, the area dose rate is estimated from calculations and/or from operational data. The required shielding provisions and the room's accessibility restrictions are thus defined and justified. This is in line with the requirements of Part IV of IRR99.

The following information is specified for each room:

- Radiation protection zoning: supervised area, controlled area (green, yellow, orange or red). The colour code of the radiation protection zone provides information on the overall dose rate value and on the room accessibility restrictions.

- classification of the rooms using alphanumeric coding (design basis, typical and specific operating conditions): this classification enables more precise information to be provided than that provided by the radiation protection zoning. For example, the green area encloses two sub-areas: A and 2.5A. For an A area, the dose rate level is above 7.5 µSv/hr and must not exceed 10 µSv/hr whereas for a 2.5A area, the dose rate level must not exceed 25 µSv/hr.

Designation is usually done on the basis of a worst case scenario for dose uptake due to a possible internal dose and not necessarily just on measured external dose rates or contamination levels. Designation is also based on the risk of significant spread of contamination.

A diagram defining the radiation protection zoning and classification of rooms is provided in Sub-chapter 12.3 – Figure 1.

It is normal UK practice for areas with a significant potential for surface or airborne contamination to be separately identified. Iodine and aerosol hazards have been identified in specific zones and the specific requirements for new plants have been described. Historical data is also available from existing PWR plants on areas in the plants which are designated on the basis of iodine and aerosol hazard. Various isotopes of iodine are produced during the fission process, which exist mainly in dissolved form in the primary coolant circuit. Iodine and other aerosol hazards are only considered a major issue during outage. The room classification for radiological controlled areas has been defined considering that external radiation and shielding provisions provide the main protection measures. The external radiation requirements are completed by a contamination classification which takes into account the iodine and aerosol risks.

The areas at risk from iodine have been identified as follows:

- rooms with installed equipment which could contain iodine in a gaseous form.

- rooms containing active liquids if they meet both the following criteria simultaneously: the fluid temperature in normal operation is above 60°C and the specific activity of the liquid is greater than 1% of that of the primary coolant.

A threshold level of 3.7×10^{-8} GBq/m^3 of species that may form aerosols is stated above which the room is defined as an Aerosol Risk Room. Again, this hazard is heightened during an outage. The areas at risk from aerosols have been identified as follows:

- Primary system openings, accessed during outage,
- Tools in contact with fuel,
- Any maintenance linked with the primary circuit or connected systems.

Specific engineering controls such as ventilation, monitoring and shielding may be required for these zones, designated on the basis of iodine or aerosol hazard. Regulation 19 of IRR 99, requires that operators of a facility monitor all their designated areas to ensure that they continue to be appropriately designated/zoned. These survey data is an important component of ongoing ALARA assessments based on operational experience feedback. Establishing an adequate monitoring regime is a requirement of Regulation 19(1).

Further operational requirements mainly in respect of monitoring and operational controls will be implemented.

One classification has been defined and is used as a design parameter: Biological Protection Design Source Value Classification

These values are used to design shielding provisions. Calculations are carried out 50 cm from the surface of equipment and 150 cm above the floor or platform assuming nominal operating conditions of the unit.

In any case, the dose rate levels of a room may vary widely over specific operating phases, requiring a different classification to be specified for a given room over time. For example, during refuelling, the transfer tube compartment is classified as a red zone whereas during normal working conditions it is classified as a green or yellow zone.

Limited access zones

Rooms in the controlled zone in which the area dose rate level is higher than 2 mSv/hr (orange zone, red zone) belong to the limited access zone.

General rules for equipment design and installation and room design ensure that radiation protection is taken into account at the design stage, as described below.

1.2. DESIGN RULES FOR EQUIPMENT

The main equipment design rules are the following ones:

- systems likely to be contaminated are designed to avoid occurrence of hot spots (avoidance of particle traps, use of sufficiently large pipework gradients);
- the main primary (up to the second isolating valve) and secondary systems pipework is fitted with heat insulation which can be installed and removed rapidly;
- use of cobalt-based hard coatings in valves is reduced;
- the use of socket-welded connections is reduced lowering the number of hot spots near valves;

- pump bearings made of Antimony alloy are avoided.

1.3. EQUIPMENT INSTALLATION RULES

The main rules for equipment installation applied at the design stage are the following ones:

- non-contaminated equipment is physically separated by a biological protection from systems and equipments which could become contaminated;
- heat exchangers and tanks are installed in separate rooms. Note that the area dose rate of a room containing a tank (or a heat exchanger) can be high (greater than 2 mSv/hr) and may influence dose rate levels in adjacent rooms;
- pumps and valves are installed in separate rooms. Generally, such equipment is not installed near tanks or heat exchangers;
- instrumentation and control equipment (sensors) are separated from other equipment which could become contaminated;
- equipment installed in a controlled zone is made easily accessible in order to reduce exposure time during maintenance and inspection;
- network cables are separated from potentially contaminated equipment;
- equipment and materials installed off the ground are designed to be carried out easily during maintenance.
- worksite ergonomics, security and Human Factors are considered for equipment installation;
- the layout of equipment installed inside a room takes account of the dose rate level expected in the room.

1.4. DESIGN RULES FOR ROOMS

The rules followed for the design of the rooms are the following ones:

- rooms such as the hot workshop or the decontamination room are separated from passageways;
- good accessibility to the rooms containing equipment requiring regular maintenance is provided;
- rooms containing tanks are accessible via rooms containing the associated valves and pumps use protected access points (labyrinths);
- access zones for rooms containing equipment which could become contaminated are designed as labyrinths or fitted with shield doors in order to minimise their influence on adjacent rooms;
- access zones for service rooms are designed in such a way that the equipment can be easily removed;

- storage zones for logistics equipment (heat insulation, shielding devices) are foreseen at the design stage;
- a sufficiently large space is allowed for:
  - work preparation and monitoring from low dose rate level zones;
  - equipment maintenance inside the rooms;
  - mobile protection devices;
  - the dismantling of radioactive equipment;
- a hot room is designated for maintaining equipment which cannot be maintained *in-situ*.

2. SHIELDING PROVISIONS

The required parameters for sizing shielding provisions are:

- the normal state of the reactor unit;
- the geometry and nature of equipment, rooms and radioactive sources.

Depending on the complexity of the above parameters specifications, calculations and modelling may be required for a given configuration.

The shielding provisions have been derived for normal operation source terms in most cases. Post-accident source terms, based on anticipated inventories post LOCA / Severe Accident have only been considered in shielding dimensioning for rooms / areas where post accidental inventories might arise or which will require post-accident access, as specified further in Sub-chapter 12.5.

2.1. SOURCE TERMS

2.1.1. Source terms and energy spectra in the Reactor Building

<u>Full power conditions</u>

When the unit is in operation, the source term in the reactor building is different from that at shutdown. Under normal operating conditions, the main radioactive sources responsible for external radiation near the primary circuit are nitrogen-16 (gamma emitter), nitrogen-17 (neutron emitter) and the core (gamma rays and neutrons).

Reactor Shutdown

During reactor shutdown, modelling methods used for the other buildings of the nuclear island are applicable (see following paragraphs).

2.1.2. Source terms in the other buildings of the nuclear island

The spectrum used to estimate the required shielding thickness is solely based on gamma emitting radioactive nuclides. It is considered that only gamma radiation contributes to the dose rate levels inside the buildings of the nuclear island except in the Reactor Building during power operation where neutrons are also contributing to dose rate. Source terms for the systems are derived from the primary source term, taking into account measures to control and reduce the radioactive nuclides activities (see Sub-chapter 12.2 – section 3).

2.2. OBJECTIVES

The contribution of the dose rate from one room containing active components to that of a room free of active components cannot exceed 20%.

There are individual specifications regarding the shielding design:

- Corridors, floors, stairwells and elevators: frequently used passageways are shielded so that they do not exceed the criteria of 10 µSv/h.
- Secured corridors and emergency stairwells: such compartments are shielded so that they can be specified not higher than 25 µSv/h.
- During fuel handling operations, the area dose rates at the side of the pool must be lower than 25 µSv/hr.

Particular attention has been paid to the design of shielding provisions in the Reactor Building rooms to which accessibility is required during power operation [Ref-1]. The operating floor and the annular zone above +1.50 m are designed to be accessible in operation, particularly in the period seven days before shut-down and three days after restart. Because of this, these zones are designed to have low dose rate levels when the reactor is operating (neutron dose rate lower than 2.5 µSv/hr and total dose rate (gamma and neutron) lower than 25 µSv/hr) and to fulfil an objective of no airborne contamination. This also concerns accessible stairwells and elevators (with a specific total dose rate of 10 µSv/h).

2.3. SHIELDING MATERIALS

Standard concrete aggregate is the main shielding material. Other materials of higher density or of different properties (neutron absorbing for example) are also used.

For shielding calculations, a density of 2.35 g/cm^3 is used for standard concrete aggregate. This density is a conservative value: operational feedback indicates that achieved values are closer to 2.4 g/cm^3 (reinforcement is not taken into account).

The secondary shielding material is water (primary pipework, steam generators, spent fuel pool).

The water density assumed at a pressure of 155 bar, is as follows:

- Steam Generator inlet (330°C): 0.651 g/cm^3,
- Steam Generator outlet (292.5°C): 0.741 g/cm^3,

Other materials may be used:

- steel (assumed density 7.8 g/cm^3), is used for the shielding of boxes or small cells. The reinforced shield doors and specific shielding around pipes may also be made of steel. In exceptional circumstances, for small rooms, steel may replace concrete;
- lead (assumed density 11.34 g/cm^3) may be used for room shielding, in the form of thin sheets (as shielding measure) or in the form of bricks. The reinforced shield doors may also be made partially of lead. However, lead is prohibited in elements that may be in contact with the primary coolant and in elements constituting the primary system;
- anti-radiation shielding glass (density between 2.5 and 4.5 g/cm^3) is used when a worker is required to directly observe an operation in a highly radioactive room;
- a neutron shield material, for example hydrogenated material such as polyethylene or boron material, is used for shielding. The material density is around 1 g/cm^3.

2.4. CALCULATION METHODS

The design of the room shielding provisions and the establishment of the design radiation protection zoning [Ref-1] are carried out using computer codes recognised in the radiation protection field (e.g. PANTHERE and MCNP codes described below).

In some cases, the design is established by analogy with other areas (symmetry of rooms and systems) or on the basis of feedback from the French nuclear power plants.

For the reactor building during reactor operation, the calculations are performed for direct neutron and gamma contributions (also arising from neutron capture) in the primary compartments and foreseen access areas, and other reflected contributions.

2.5. COMPUTER CODES

Different radiation protection computer codes are used to calculate the shielding thickness. The choice of a code is based on the operating conditions, the geometry of the rooms and the radioactive sources involved.

- The computer codes and mathematical models used to perform the shielding design are: the PANTHERE code, which has been developed by EDF, is used for gamma radiation propagation modelling to calculate equivalent dose rates or radiation flux from radioactive sources. The code can model complex 3-D geometries. Data and results can be visualised directly on these 3-D models.
- The MICROSHIELD computer code is used to evaluate a shielding and to estimate exposure from gamma radiations. This code is used for the biological shielding design around a radioactive source in 2D configurations: punctual, line, disk…..

- The MCNP code is used to perform gamma and neutron calculations around the reactor vessel (in the reactor pit out of the RPV and at the level of the primary pipes). It is based on Monte Carlo method. The dose rate around the Steam Generators (SG) and the Main Coolant Pumps (MCP) are determined by 3D calculations.

Examples of the geometries used are given in Sub-chapter 12.3 - Figures 2 and 3.

For the EPR, the reference calculation point is located 50 cm from the source and 150 cm from the ground. The choice of a calculation reference point gives consistency to calculation results obtained using different codes.

2.6. SHIELDING MEASURES FOR THE REACTOR BUILDING

The Reactor Building shielding is designed considering that working in the accessible zone of the Reactor Building during power operation is allowed. The Reactor Building accessible zone consists mainly of the operating floor, the annular zone (levels from +1.50 m) and the polar crane.

A first type of protective measure isolates the accessible zone from atmospheric contamination (see section 3 of this sub-chapter).

A second type of protective measures to achieve satisfactory radiological conditions are foreseen: total dose rate level below 25 µSv/hr and neutron dose rate level below 2.5 µSv/hr, see section 2.2 above:

- neutron shields around primary pipework, implemented near the reactor pit penetrations (hydrogenated material);
- mazes and shield doors (neutron and gamma shield doors) at the exits of the Steam Generator and Primary Pump bunkers for example;
- shield wall sized to allow accessibility during power operation in the required rooms (annular spaces and operating floor);
- use of thick concrete slabs above primary equipments, for example 120 cm above the Reactor Building pool;
- use of gamma or neutron shielding in specific area(s) of the building.

2.7. SHIELDING MEASURES FOR THE FUEL BUILDING

Under normal operating conditions, the contaminated systems are:

- the RCV [CVCS]: Chemical and Volume Control System (pumps, tanks and valves),
- the REA [RBWMS]: Reactor Boron and Water Make-up System,
- the PTR [FPC(P)S]: Fuel Pool Cooling and Purification System,
- the REN [NSS]: Nuclear Sampling System,
- the RPE [NVDS]: Nuclear Island Vent and Drain System,

- the TEG [GWPS]: Gaseous Waste Processing System.

The zones requiring special shielding provisions are:

- the pool,
- the fuel transfer compartment,.

The thicknesses of the most representative shield walls are:

- the walls of the RCV [CVCS] tank room: from 70 cm to 80 cm,
- the walls of the spent fuel pool : from 120 to 150 cm,
- the walls of the transfer compartment: from 110 cm to 150 cm,
- the walls of the loading pit: from 110 cm to 150 cm.

2.8. SHIELDING MEASURES FOR THE NUCLEAR AUXILIARY BUILDING

Under normal operating conditions, the contaminated systems are:

- the PTR [FPC(P)S]: Fuel Pool Cooling and Purification System (filters and demineralisers),
- the RCV [CVCS]: Chemical and Volume Control System (filters and demineralisers),
- the TEP [CSTS]: Coolant Storage and Treatment System (tanks and demineralisers),
- the TEG [GWPS]: Gaseous Waste Processing System (exchangers).
- the REN [NSS]: Nuclear Sampling System,
- the RPE [NVDS]: Nuclear Island Vent and Drain System.

The thicknesses of the most representative shield walls are:

- around the PTR [FPCS], TEP [CSTS] and RCV [CVCS] filter demineraliser rooms: between 80 and 100 cm,
- between the rooms containing the TEP [CSTS] storage tanks and the corridor: 80 cm,
- between the TEP [CSTS] storage tank rooms and the outside (supervised zone): 90 cm,
- between the filter rooms and the adjacent rooms (classified green zone or monitored area): 90 cm and 110 cm.

2.9. SHIELDING MEASURES FOR THE SAFEGUARD BUILDING

The largest part of a Safeguard Building is assigned to the area outside the controlled area/outside the supervised area. The part which contains the main components of the Component Cooling Water System (RRI [CCWS]) is arranged in such a way that it can be assigned to the controlled area in case of a radioactive leakage into the system when required.

Under normal operating conditions, the contaminated systems are:

- the PTR [FPC(P)S]: Fuel Pool Cooling and Purification System (filters and demineralisers),
- the REN [NSS]: Nuclear Sampling System,
- the RPE [NVDS]: Nuclear Island Vent and Drain System,
- the TEG [GWPS]: Gaseous Waste Processing System (exchangers),
- the EVU [CHRS]: Containment Heat Removal System,
- the APG [SGBS]: Steam Generator Blowdown System,
- the RIS [SIS] (LHSI) : Safety Injection System.

The thicknesses of the most representative shield walls are:

- in divisions 1 and 4, between the rooms housing the RIS [SIS] (LHSI) and EVU [CHRS] : 50 cm,
- between the EVU [CHRS] rooms and the corridors: 110 cm.

During normal operation within the Safeguard Buildings only the RIS [SIS] (LHSI) trains of the Safety Injection System can be contaminated on a relatively higher dose rate level. These parts of the system will be used also for reactor heat removal after regular shutdowns.

The other parts of the Safety Injection System as well as the Containment Heat Removal System (EVU [CHRS]) could be contaminated during normal operation only due to test operation with IRWST water.

2.10. SHIELDING MEASURES FOR THE EFFLUENT TREATMENT BUILDING

Under normal operating conditions, the contaminated systems are:

- the REN [NSS]: Nuclear Sampling System,
- the TEU [LWTS]: Liquid Waste Treatment System,
- the TES [SWTS]: Solid Waste Treatment System.

The definition of the Effluent Treatment Building shielding provisions considers the analysis of operational feedback from the best operating units (see section 2.3.2.7 of Sub-chapter 12.4). The other development in the EPR design, in relationship to the N4 plant series, is the relocation of the Effluent Treatment Building next to the Nuclear Auxiliary Building.

The most representative shield wall thickness is between the control room and the drumming cell which measures 70 cm.

3. VENTILATION

The ventilation systems are designed to guarantee a low working exposure to contamination. The systems are described in Sub-chapter 9.4.

3.1. FUEL BUILDING, NUCLEAR AUXILIARY BUILDING, SAFEGUARD BUILDINGS, EFFLUENT TREATMENT BUILDING

Two of the objectives of the design of the ventilation systems for the Nuclear Auxiliary Building, the Fuel Building (see section 2 of Sub-chapter 9.4), the mechanical part of the Safeguard Buildings (see section 6 of Sub-chapter 9.4) and the Effluent Treatment Building are:

- to limit aerosols and radioactive gases concentrations in the atmosphere by ensuring the necessary air renewal;
- to ensure, under normal operating conditions, air transfer from the potentially less contaminated rooms to the potentially more contaminated rooms.

Some rooms are considered to be iodine risk rooms. The specific ventilation requirements for these rooms are described in section 1 of Sub-chapter 9.4.

3.2. REACTOR BUILDING

Radiation exposure arising from access to the Reactor Building during power operation is influenced by airborne activity levels.

The containment airborne concentration of radioactive nuclides when the reactor is in operation is based on the concentration of these nuclides in the primary coolant and by the primary coolant leak rate. The production of argon-41 by neutron activation near the reactor vessel also contributes to airborne contamination.

In order to limit internal exposure, the Reactor Building is divided into an equipment compartment (enclosing the main primary system elements) and a service space where the atmosphere is compatible with the presence of personnel during operation (“two-room concept”).

The Reactor Building ventilation systems are designed to maintain a dynamic containment between the equipment compartment and the service space by pressure barrier that forbids transfer of activity from the equipment compartment to the service space.

This design addresses the absence of interior contamination objective.

The internal filtration system (see section 4 of Sub-chapter 9.4) is permanently operational to limit the activity level in the Reactor Building. It maintains a dynamic containment between the equipment compartment and the service space when the Containment Sweeping Ventilation System (EBA [CSVS]) is not operating. It also reduces aerosols and iodine contamination in the equipment compartment via the HEPA (very high efficiency) filters and iodine traps.

While preparing access to the Reactor Building during power operation and during the access period, the Reactor Building Purge Ventilation System EBA [CSVS] low flow system (see section 5 of Sub-chapter 9.4), maintains a dynamic containment between the equipment compartment and the service space. This enables airborne activity levels due to noble gases (krypton-85 and xenon-133 in particular) and tritium (steam from water-containing tritium) to be reduced.

Air extracted from the equipment compartment is discharged via the stack after passing through the HEPA filters and iodine traps.

During an outage, the high flow rate system of the Reactor Building Purge Ventilation System EBA [CSVS], (see section 5 of Sub-chapter 9.4), carries out a purge and ventilation of the equipment compartment in order to reduce the airborne concentration of fission and activation products. Then, access is allowed under optimum safety conditions

No containment is required between the equipment compartment and the service space.

The Containment Continuous Ventilation System (EVR [CCVS]) (see section 3 of Sub-chapter 9.4) does not have a dynamic containment function. It contributes however to limit workers' radiation exposure by circulating air independently in the equipment compartment and the service space thus reducing the amount of tritium by condensing atmospheric humidity in its cooling coils.

4. ROOMS AND STAFF MONITORING

The body contamination and dosimetry control and irradiation of rooms system (KRC) provides personnel radiation protection by monitoring and measuring the ambient dose rate levels in some rooms. The system monitors activity levels for iodine, aerosols and rare gases in the Reactor Building (equipment compartment and in service compartment), and monitors gamma and neutron dose rate levels for the accessible rooms in the Reactor Building.

4.1. MONITORING OF ROOMS

The monitoring devices measure the equivalent dose rate values in a room or a working zone. They are used to produce survey maps and measure the equivalent dose rate level at locations where work is to be carried out, in particular to ensure it is in line with predicted levels.

4.1.1. Rooms in the Reactor Building

The devices in the Reactor Building are used to monitor:

- the atmospheric contamination of the service floor (reactor in operation),
- the atmospheric contamination of the equipment compartment (reactor in operation),

- the neutron dose rate in the personal access (reactor in operation)
- the gamma dose rate in the personal access,
- the gamma dose rate in aeroball room,
- the atmospheric contamination fuel handling area.

4.1.2. Rooms in the Nuclear Auxiliary Building

The devices in the Nuclear Auxiliary Building are used to monitor:

- the gamma dose rate in RCV [CVCS] filters,
- the gamma dose rate in PTR [FPCS] filters,
- the gamma dose rate in RPE [NVDS] filter.

4.1.3. Rooms in the Effluent Treatment Building

The devices in the Effluent Treatment building are used to monitor:

- the gamma dose rate in the header TEU [LWPS] filter,
- the gamma dose rate in the concrete shell storage room,
- the gamma dose rate in the waste conditioning room,
- the atmospheric contamination (aerosol activity concentration) in the waste cutout and conditioning room.

4.1.4. Rooms in specific working zones

Further monitoring devices will be provided for the different work zones: these are portable monitors.

4.2. MONITORING OF STAFF

The radiological monitoring devices check for the absence of contamination on a worker when leaving the controlled zone and site: they act as successive barriers preventing workers from spreading contamination. They include:

- hand and foot monitoring equipment

This detects any potential contamination on the hands or feet.

- equipment for scanning turnstiles between the controlled zone and the supervised area (changing rooms) or at the Reactor Building exit:

The role of this equipment is to detect contamination on clothes.

- objects scanner

The CPO monitor checks small objects for contamination. The CGO monitor checks large objects or waste for contamination. They both use gamma radiation sensitive detectors.

- site exit scanning turnstile

Contamination spread outside the site is controlled using X-ray and gamma radiation sensitive detectors.

5. MONITORING OF THE UNIT

5.0. SAFETY REQUIREMENTS

5.0.1. Safety functions

The Plant Radiation Monitoring System KRT [PRMS] [Ref-1] to [Ref-3] contributes to the basic safety function of containment of all radioactive substances, by contributing to the following three functions:

- containing activity in the steam generators,
- ensuring containment integrity,
- containing radioactive substances in sensitive zones outside the containment.

5.0.2. Functional criteria

The KRT [PRMS] monitors the integrity of the containment barriers and initiates the actions needed to control the activity levels.

5.0.3. Design Requirements

5.0.3.1. Requirements resulting from safety classification

<u>Safety classification</u>

The functional classification of the KRT [PRMS] must comply with the requirements given in Sub-chapter 3.2. Each KRT [PRMS] channel has its own functional classification.

<u>Single failure criterion</u>

The single failure criterion is applied to active components supplying an F1 function in order to ensure a sufficient degree of redundancy.

<u>Emergency-supplied power supplies</u>

The F1 classified KRT [PRMS] channels must be backed up by an uninterruptible electrical power supply.

Qualification for operating conditions

The system equipment must be qualified to remain operational and carry out its safety duty under normal and accident conditions, in compliance with the requirements given in Sub-chapter 3.6.

Mechanical, electrical, instrumentation and control classifications

The system must be classified mechanically, electrically, and in terms of instrumentation and control, in line with the classification described in Sub-chapter 3.2.

Seismic classification

Refer to Sub-chapter 3.2.

Periodic tests

Periodic tests are carried out on components providing safety functions (F1 and F2) in order to ensure their availability is sufficient.

5.0.3.2. Other regulatory requirements

The system is required to comply with the Technical Directives (see section 2 of Sub-chapter 3.1).

The KRT [PRMS] is designed to monitor all site effluents to ensure that the various measurements required in the site discharge authorisations, for gaseous and liquid waste, can be provided.

5.0.3.3. Hazards

The KRT [PRMS] must be protected from internal and external hazards, in compliance with the requirements of Sub-chapters 13.1 and 13.2.

5.1. ROLE OF THE SYSTEM

The KRT [PRMS] contributes to the safety of the station, both under normal operating conditions and in accident situations. It also ensures the safety of operating personnel.

The operational duties of the KRT [PRMS] fixed monitoring installations are mainly as follows:

- process monitoring (containment barriers survey),
- use for diagnostics during accident situations,
- monitoring of radioactive gaseous and liquid effluents.

The monitoring of zones and personnel is carried out by fixed and portable systems (See section 4, “Monitoring of rooms”).

5.2. DESIGN BASIS

In order to confirm that operational duties, functional criteria and regulatory requirements are achieved, the KRT [PRMS] is divided into channels that cover the monitoring of the whole process.

In general, one KRT [PRMS] channel fulfils one assignment.

The main functions carried out by KRT [PRMS] channels, to meet the various safety requirements are the following ones:

Monitoring activity within the CS ventilation system:

The KRT [PRMS] measures the activity in the low-flow EBA [CSVS] exhaust. In case of a radioactive release inside the containment when this ventilation system is operating, the KRT [PRMS] initiates automatic actions to isolate these ventilation systems. KRT [PRMS] monitoring of the EBA [CSVS] ensures the isolation of the Reactor Building following a radioactive release inside the containment.

Monitoring of the Fuel Building fuel handling area:

KRT [PRMS] channels will detect an activity release in the fuel handling area of the Fuel Building and initiate automatic actions required to limit the radioactive release in case of a fuel handling accident.

Monitoring of the Reactor Building fuel handling area:

KRT [PRMS] channels will detect an activity release in the fuel handling area of the Reactor Building and initiate the automatic actions required to limit the radioactive release in the case of a fuel handling accident.

Steam Generator Monitoring:

KRT [PRMS] channels monitoring activity levels in the secondary system will detect a SG leak via:

- measurements of activity levels in the SG blowdown water via the sampling circuit (these channels will also identify the SG containing the leak),
- measurements of activity levels in the main steam system (these systems can also quantify the leak in litre per hour during power operation),
- measurements of the activity levels of non-condensable gas extracted from the condenser vacuum (CVI).

Monitoring of activity levels in the Nuclear Auxiliary Building, Fuel Building and Safeguard Building ventilation systems:

KRT [PRMS] channels can detect an increasing activity level in the area concerned and initiate an automatic switchover to the Nuclear Auxiliary Building ventilation extraction system iodine filters before discharge via the stack.

Monitoring of the dose rate level in the main control room:

KRT [PRMS] channels monitor the main control room air inlet and activate, if required, the Control Room and Electrical Equipment Rooms Atmospheric Conditioning system filters, to maintain the habitability of the control room.

Isolation of the Reactor Building enclosure:

Where the KRT [PRMS] ducts pass through the walls of the Reactor Building containment, the KRT [PRMS] isolation valves will close as soon as "containment isolation" instructions are received.

Discharge Monitoring:

KRT [PRMS] channels check compliance with the regulatory discharge limits and with the EPR specific limits (gaseous discharges). Discharge arrangements are described in Chapter 7 of the PCER.

Monitoring of the Nuclear Auxiliary Building, Fuel Building, Safeguard Building sumps:

KRT [PRMS] channels monitor the activity levels in the sumps by detection of contaminated effluents and will automatically isolate their discharge to the non-recycled liquid waste treatment system TEP [CSTS].

Monitoring of the activity levels in the Reactor Building:

These channels, called “high activity” channels, evaluate activity levels in the containment in important accident conditions (post-TMI action). These channels do not operate automatically but are used for post-accident operation.

Primary coolant sampling activity monitoring:

These channels aim at monitoring primary coolant activity trends in order to detect any significant degradation of the first barrier and to limit its consequences (post-TMI action). In addition, if high activity is detected, these channels participate in the automatic isolation of lines that could transport primary coolant outside the containment (automatic isolation on primary side high activity detection).

Sub-chapter 12.3 – Table 1 outlines the main KRT [PRMS] channels foreseen to meet the main functional and regulatory requirements. The channels fulfilling area radiation monitoring functions only are discussed in section 4.

5.3. SYSTEM DESCRIPTION – EQUIPMENT CHARACTERISTICS

The KRT [PRMS] equipment is detailed in section 9 of Sub-chapter 7.6.

The equipment is designed to be easy to handle, install and dismantle.

Components installed in controlled zones are arranged in such a way that any necessary inspections, maintenance, repairs or, if required, replacements are possible without breaching radiation protection principles.

Components and component parts are arranged so as to be readily accessible for servicing and maintenance. Sufficient space is made available so that this work can be performed unhindered and without undue exposure (space will be provided for temporary shielding and auxiliary equipment).

The fixed channels are composed of the following main characteristics:

Locally:

- the detector is adapted to the type of radioactive product that the process is likely to generate,
- the channel is protected against background noise or this is taken into account,
- when necessary, the channel is fitted with a local radiation source to allow the correct behaviour of the whole KRT [PRMS] channel to be verified, from detection to display of information in the Main Control Room,
- when necessary, the flow rate through the detectors is controlled in order to initiate an alarm when the sampling is not high enough to give an accurate measurement,
- feedback concerning the installation of KRT [PRMS] gas and aerosol channels is used.

In the electrical building and the access tower, are provided:

- electrical power supplies,
- a signal processing module,
- an indicator giving the value of the signal and the exceeded threshold when the Main Control Room displays are unavailable is provided.

In the Main Control Room:

- measured values and alarms are indicated in the control room; when necessary, the failure of a KRT [PRMS] channel is clearly displayed in the control room,
- control graphics, controls and measurement related data are available,
- the measurements are registered and archived.

5.4. PHYSICAL PHENOMENA DETERMINING OPERATION

5.4.1. Normal operation

A radiation monitoring system channel must carry out its detection, alarming, measurement or monitoring functions in every plant configuration for which it is designed: this defines the channel "normal operation mode".

Depending on the channel, the "normal operation mode" may be any of the different plant configurations:

- power operation,
- hot or cold shutdown,
- plant outages,
- post-accident situations.

5.4.2. Operation under degraded conditions

So called “degraded conditions" operating modes correspond to KRT [PRMS] operation in the event of a loss of power supplies, loss of I&C system or loss of monitored fluid.

- With regards to power supply failure:
    - F1 class channels are backed up by an uninterruptible power supply,
    - when a KRT [PRMS] measurement channel has lost accuracy due to a loss of power, the affected KRT [PRMS] channel alarm thresholds and eventually related automatic actions will be inhibited.
- With regard to loss of EE2 and NC Instrumentation and Control:
    - the measurements, functional alarms and information transmitted to the Control Room via EE2 and NC Instrumentation and Control equipment are unavailable in the Control Room.
    - the measurements and "activity threshold exceeded" alarms remain available locally (notably in the access tower room),
    - F1 functions are backed up by an uninterruptible electrical power supply.
- With regards to monitored fluid flow failure:
    - Activity measurements are declared as non-representative when the sampled fluid flow rate is low. Such degraded conditions may be the consequence of a material failure or a power source failure.

5.5. PRELIMINARY SAFETY ANALYSIS

5.5.1. Compliance with regulations

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

5.5.2. Compliance with operational requirements

The KRT [PRMS] contributes to the containment of radioactive materials by:

- supplying information which allows the plant state to be evaluated under normal and accident operating conditions,

- supplying information to record process related data,
- triggering automatic or manual actions when thresholds are exceeded.

5.5.3. Compliance with design requirements

5.5.3.1. Safety classification

The materials and equipment design and installation comply with the requirements of the classification rules given in Sub-chapter 3.2.

5.5.3.2. SFC or Redundancy

The construction arrangements address the requirements given in section 5.0.3.1 above.

5.5.3.3. Qualification

Materials are qualified in compliance with the requirements of Sub-chapter 3.6.

5.5.3.4. Instrumentation and control

The design and installation of the instrumentation and control system comply with the classification rules in Sub-chapter 3.2.

5.5.3.5. Uninterruptible power supplies

All F1A class electrical consumers are supplied by uninterruptible electrical switchboards.

5.5.3.6. Other regulatory requirements

KRT [PRMS] channels, which will be further specified during the detailed design stage, will enable compliance to be verified with respect to EPR authorised discharges and regulatory limits (gaseous discharges). The monitoring of the radioactive discharges is described in Sub-chapter 7.3 of the PCER.

5.5.3.7. Hazards

The inclusion of F1 function related requirements is detailed in Sub-chapter 12.3 - Table 2.

The inclusion of F2 function related requirements will be detailed on a case-by-case basis during the detailed design stage.

5.5.3.8. Tests, monitoring and maintenance

The detectors are mounted such that they are easily accessible for periodic in-service inspections.

5.5.4. Tests

Safety class channels are subject to Periodic Tests.

Tests carried out during plant operation must not disturb the unit normal operation and they must not prevent the successful implementation of any safeguard actions that may be necessary.

The aim of the periodic tests is to check measuring channel availability.

Some parameters will be checked during quality or maintenance inspection in accordance with the Periodic Test strategy.

KRT [PRMS] channels measuring Reactor Building activity levels during normal conditions may be installed outside the Reactor Building. Such channels will be required to have their own containment isolation valves, which will be tested in accordance with the general containment isolation testing procedure.

5.5.5. Inspections and maintenance

The detectors are mounted such that they are easily accessible for periodic in-service inspections.

Maintenance operations can be carried out either when the plant is in operation or during outages. Maintenance operations carried out during plant operation must not disrupt the unit's normal operation of the unit, or prevent the successful implementation of any safeguard action that may be necessary.

Maintenance operations will be carried out in accordance with instructions and guidelines set out in the Maintenance and Operating Manuals.

5.6. FUNCTIONAL FLOW DIAGRAMS

See Appendix 1 of this sub-chapter. The schematics and locations are provided for indication only as these may be further developed during the site licensing phase.

SUB-CHAPTER 12.3 - TABLE 1

KRT [PRMS] Channels

Functional designation of monitored process systems		**Objective of measurement**	**Information, Treatment, Action initiated by a high level alarm**
Isolation valves, safety valves and piping for the Main Steam system.	VVP [MSSS]	Monitoring main steam system radioactivity – detection and quantification of primary-secondary leaks	Alarms recorded
Nuclear sampling system, secondary samples	RES	Measurement of the steam generator liquid activity – leak detection on each SG	Alarms recorded
Condenser	CVI	Measurement of the activity of the gas extracted from the condenser – detection of primary secondary leaks	Alarms recorded
Component cooling system	RRI [CCWS]	Monitoring for leakage in the component cooling system	Alarms recorded
Gaseous waste system	TEG [GWPS]	Monitoring radioactivity upstream of the gas delay bed Monitoring radioactivity downstream of the gas delay bed	Alarms recorded
Fuel Building pool hall	Fuel Building	Monitoring the activity of the fuel handling area – containment of the activity in case of accident	Alarms recorded, automatic isolation of the DWK ventilation system at the air supply and extraction
Reactor Building pool hall	Reactor Building	Monitoring the activity of the fuel handling area – containment of the activity in case of accident	Alarms recorded, automatic isolation: of the EBA [CSVS],high flow, of the EBA [CSVS] low flow ventilation, of the EBA [CSVS] opposite the Equipment Access Hatch (EAH), of the CSBVS air supply opposite the emergency and personnel air locks and operation management of the EBA [CSVS] low flow exhaust (depending on the primary side temperature)
Authorised releases from Reactor Building (equipments and service vaults)	EVR [CCVS]	Tracking and monitoring of authorised releases from the Reactor Building (prior to personnel access during unit operation or shutdown): measurements and sampling of the noble gases, sampling of aerosols, of iodine and of tritium,	Alarms recorded (only the noble gases measurement)
Containment “High activity” measurement	Reactor Building	Monitoring high activity in the containment atmosphere in accident conditions	Alarms recorded

Functional designation of monitored process systems		**Objective of measurement**	**Information, Treatment, Action initiated by a high level alarm**
Containment purge ventilation system	Low Flow EBA [CSVS]	Monitoring activity released outside the containment - – Reactor Building containment isolation in case of high activity detection	Alarms recorded, automatic isolation: of the EBA [CSVS] high flow, of the EBA [CSVS] low flow ventilation, of the EBA [CSVS] opposite the Equipment Access Hatch (TAM), of the EBA [CSVS] air supply opposite the emergency and personnel air locks and operation management of the EBA [CSVS] low flow exhaust (depending on the primary side temperature)
Annulus ventilation system	EDE [AVS]	Monitoring activity released out of the annulus	Recorded
Nuclear Auxiliary Building ventilation system (cell 1, cell 2, cell 3)	Nuclear Auxiliary Building Ventilation system	Monitoring air activity in the ventilation ducts	Alarms recorded and automatic switching to iodine train
Fuel Building and Safeguard Building ventilation system (cell 4, cell 5, cell 6)	Fuel Building and Safeguard Building ventilation systems	Monitoring air activity in the ventilation ducts	Alarms recorded and automatic switching to iodine train
Nuclear Auxiliary Building stack	Nuclear Auxiliary Building Ventilation system	Monitoring of the gaseous releases from the nuclear buildings (noble gases) in normal operation and in the event of an accident	Alarms recorded
		Sampling of gaseous releases from the nuclear buildings (iodine, aerosols, Tritium, Carbon 14)	Not applicable
Sampling of the primary coolant	REN [NSS] RCV [CVCS]	Measurement of the activity of the primary coolant	Alarms recorded Automatic isolation of discharge RCV [CVCS], primary side REN [NSS] and RPE [NVDS] of the Reactor Building
Sumps	Nuclear Auxiliary Building, Fuel Building , Safeguard Building	Measurement of the liquid effluent activity levels in the sumps	Alarms recorded, automatic isolation of discharge to LWPS
SIS and CHRS pump rooms	Safeguard Building	Dose rate measurements (monitoring of access conditions in post-accident conditions)	Alarms recorded
Control Room	Control Room and Electrical Equipment Rooms Atmospheric Conditioning system	Measurement of air inlet activity	Alarms recorded, automatic activation of the Control Room and Electrical Equipment Rooms Atmospheric Conditioning system iodine trap

Functional designation of monitored process systems		**Objective of measurement**	**Information, Treatment, Action initiated by a high level alarm**
Ventilation of the Effluent Treatment Building (cells 1 and 2)	Effluent Treatment Building Ventilation system	Monitoring of the air activity in the ventilation ducts	Alarms recorded, automatic switching to iodine line
Component cooling effluent treatment system of the Effluent Treatment Building	Component cooling effluent treatment system	Activity monitoring downstream the exchangers	Alarms recorded
Non-recyclable liquid waste treatment system	TEU [LWPS]	Checking the operation of the TEU [LWPS], activity measurement of the distillates from the TEU [LWPS]evaporator	Alarms recorded, automatic closing of the transfers to TEP [CSTS] and re-circulation of the distillates to the evaporation unit in case of high activity
		Checking the operation of the TEU[LWPS], activity measurement of the condensed TEU[LWPS] steam	Alarms recorded Automatic isolation of the bleed back flow, pumps shutdown and routing of bleed lines to the TEU [LWPS] floor tanks following high activity

SUB-CHAPTER 12.3 - TABLE 2

Hazards – KRT [PRMS] channels relating to F1 Functions

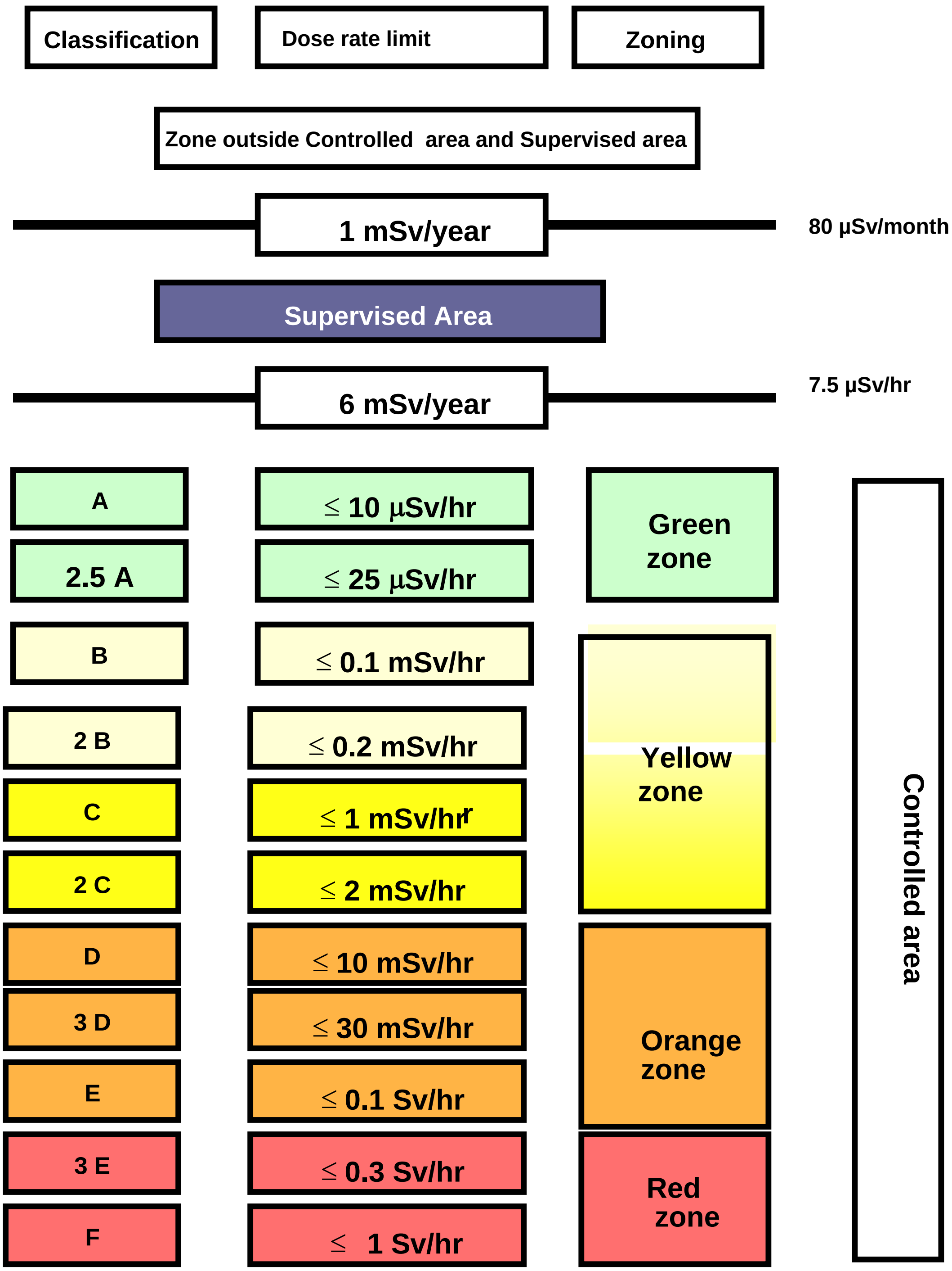
Internal hazards	Protection required in principle	General protection (1)	Specific protection introduced in the design of the system
Pipe leaks and breaks	Yes	Geographical separation of redundant equipment	-
Failure of vessels, tanks, pumps and valves	Yes	Geographical separation of redundant equipment	-
Internal missiles	Yes	Geographical separation of redundant equipment	-
Load drop	Yes	Geographical separation of redundant equipment	-
Internal explosion	Yes	Geographical separation of redundant equipment	-
Fire	Yes	Fire compartments	
Internal flooding	Yes	Geographical separation of redundant equipment	-

External hazards	Protection required in principle	General protection	Specific protection introduced in the design of the system
Earthquake	Yes	-	Seismic design
Aircraft crash	Yes	-	Seismic design
External explosion	Yes	-	Anti-shock wave checking valves
External flooding	Yes	-	Channels located in the upper levels
Snow and wind	Yes	-	-
Extreme cold	Yes	-	Electric heaters allowing the correct operation of the other systems
Electro-magnetic interference	Yes	-	-

(1) The geographical separation of redundant equipment cannot be applied to KRT [PRMS]-VVP [MSSS] channels. Nevertheless, it is demonstrated that this separation is not necessary to meet the safety requirements [Ref-1].

SUB-CHAPTER 12.3 - FIGURE 1

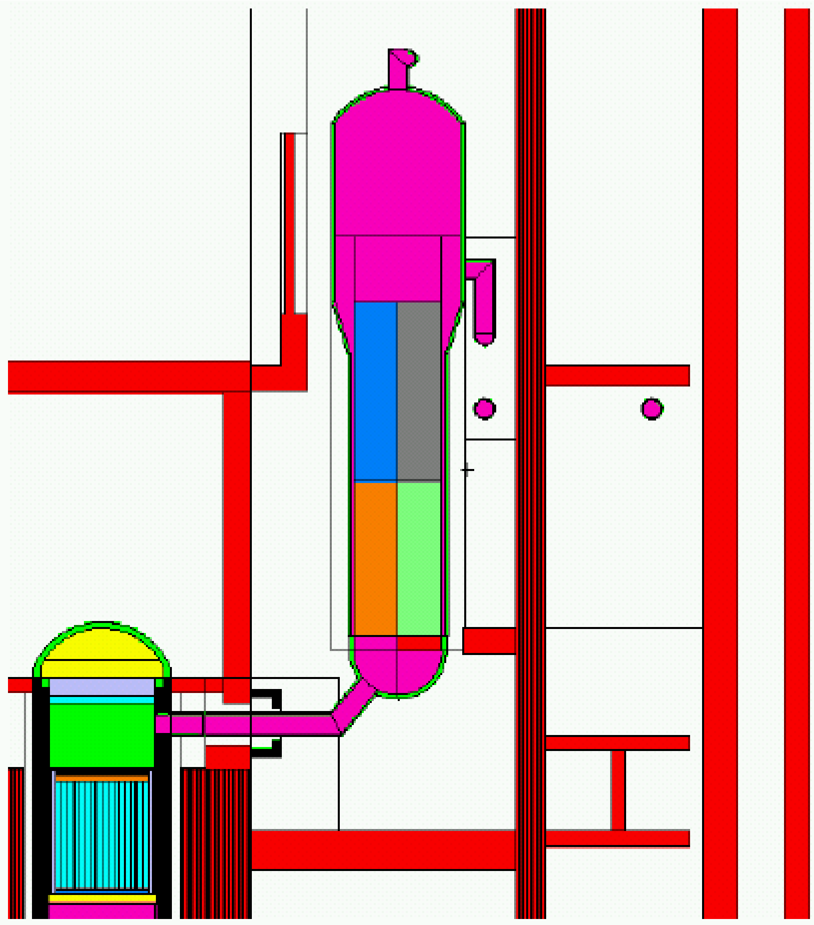
EPR Zoning and Classification of Rooms



Note 1 : This is the French regulatory classification. It is likely to change depending on the final zoning limits used by the operator for the UK EPR

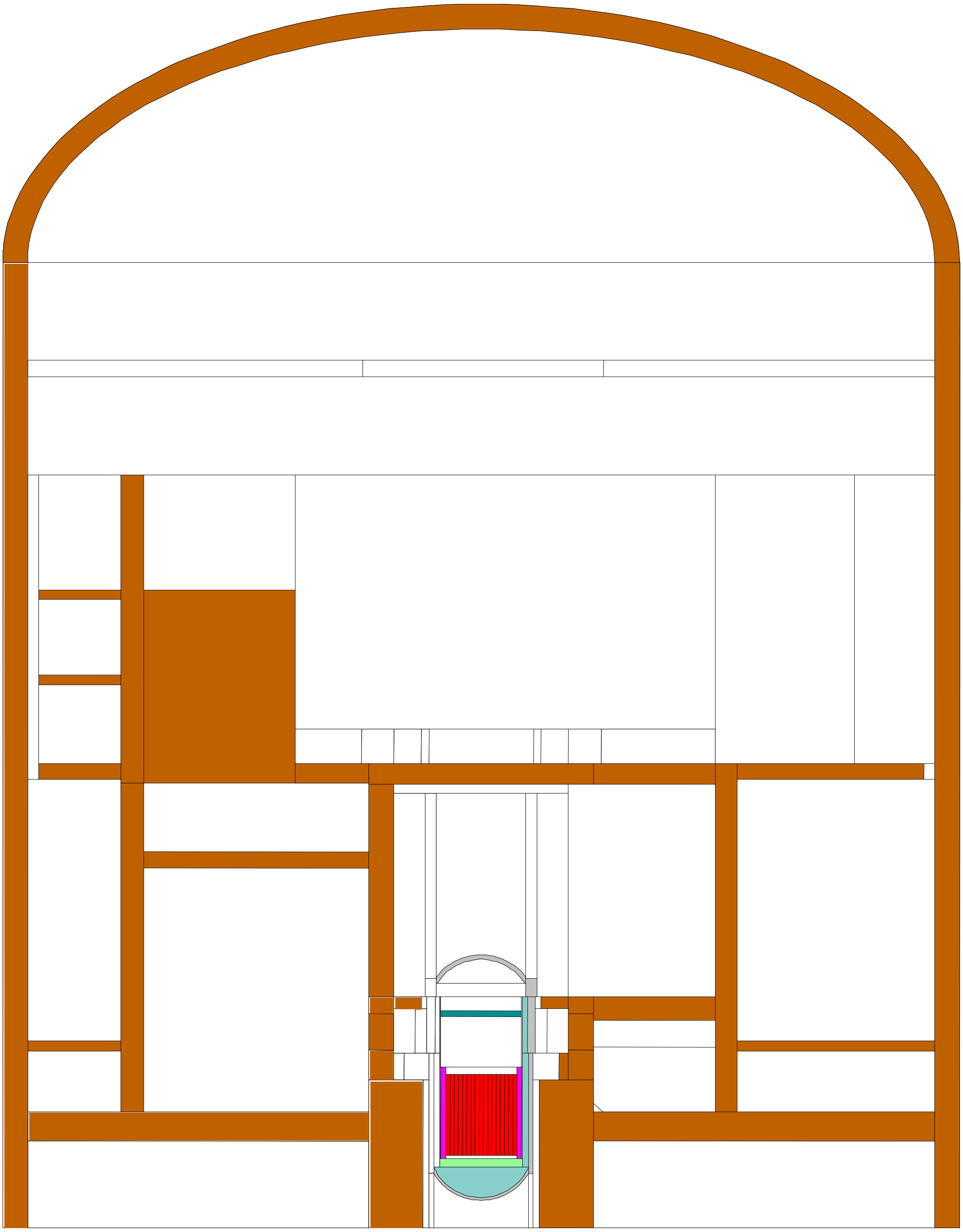
SUB-CHAPTER 12.3 - FIGURE 2

Modelling of a Steam Generator



SUB-CHAPTER 12.3 - FIGURE 3

MCNP Modelling of the reactor Building



SUB-CHAPTER 12.3 – APPENDIX 1

Operational Principles Diagrams of the main KRT [PRMS] Channels

Appendix 1.1: KRT [PRMS]/SG Secondary Sampling System Channels

Appendix 1.2: KRT [PRMS]/Condenser Vacuum System Channel

Appendix 1.3: KRT [PRMS]/VVP [MSSS] Channels

Appendix 1.4: KRT [PRMS]/EBA [CSVS] Channels (shutdown conditions)

Appendix 1.5: KRT [PRMS]/RRI [CCWS] Channels

Appendix 1.6: KRT [PRMS]/Nuclear Auxiliary Building ventilation system Channels (ventilation ducts)

Appendix 1.7: KRT [PRMS]/TEG [GWPS] Channels

Appendix 1.8: KRT [PRMS]/RPE [NVDS] Channel (Nuclear Auxiliary Building floor drain tank DP3)

Appendix 1.9: Channels KRT [PRMS]/RPE [NVDS] (Nuclear Auxiliary Building chemical drain tank DC and NAB residual drain tank DR)

Appendix 1.10: KRT [PRMS]/ RPE [NVDS] Channels (Nuclear Auxiliary Building floor drain sump DP1)

Appendix 1.11: KRT [PRMS]/ NAB ventilation system Channels (Nuclear Auxiliary Building stack)

Appendix 1.12: KRT [PRMS]/Reactor Building Channels (Reactor Building authorised releases)

Appendix 1.13: KRT [PRMS]/EVU [CHRS] Channels (Safeguard Building monitoring)

Appendix 1.14: KRT [PRMS]/RIS-RA [SIS-RHS] Channels (Safeguard Building monitoring)

Appendix 1.15: KRT [PRMS]/ Effluent Treatment Ventilation System Channels

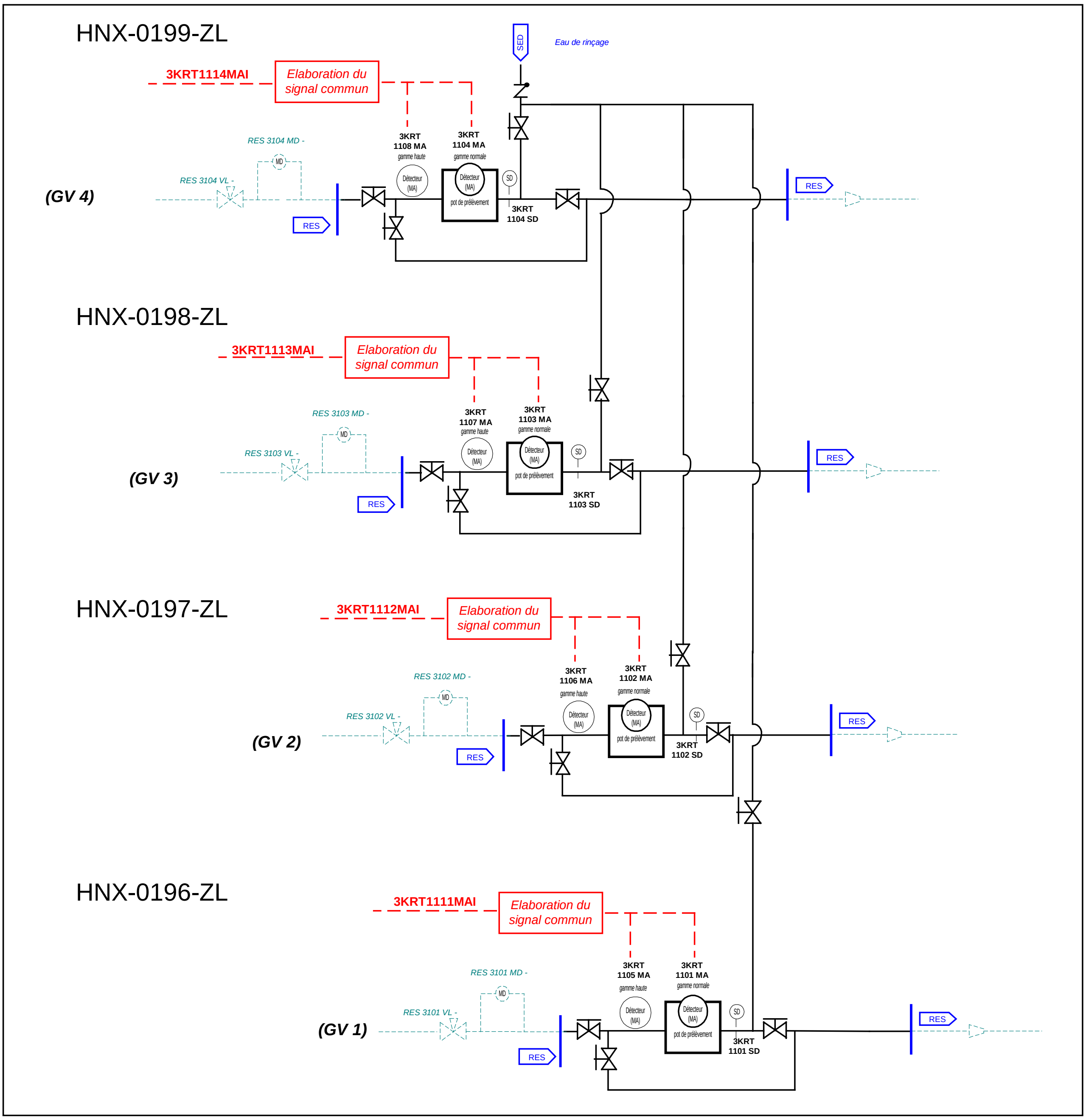
Appendix 1.16: KRT [PRMS]/Component Cooling Effluent Treatment System Channels

Appendix 1.17: KRT [PRMS]/TEU [LWPS] Channels (LWPS evaporator distillates)

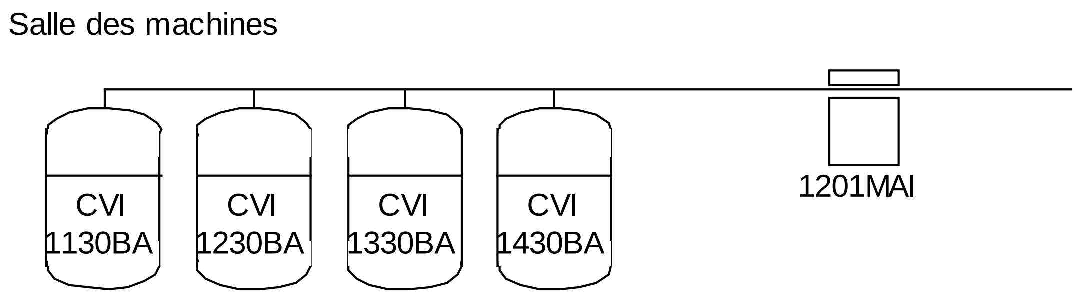
<u>Note</u>:

On the following figures, the Channels have been given a « MAI » identification. The detectors are identified by « MA » references.

Appendix 1.1: KRT [PRMS]/ SG Secondary Sampling System Channels

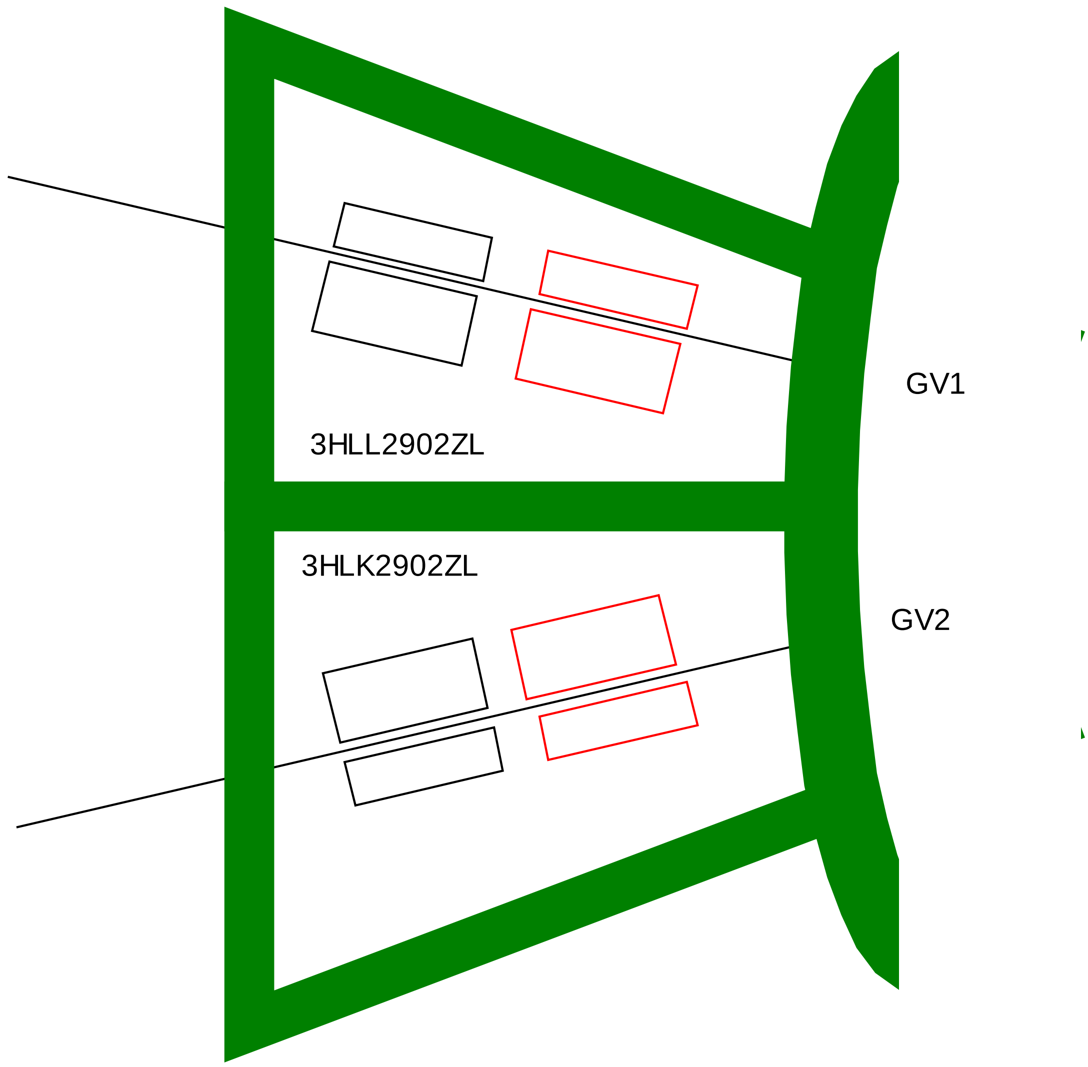


Appendix 1.2: KRT [PRMS]/ Condenser Vacuum System Channel

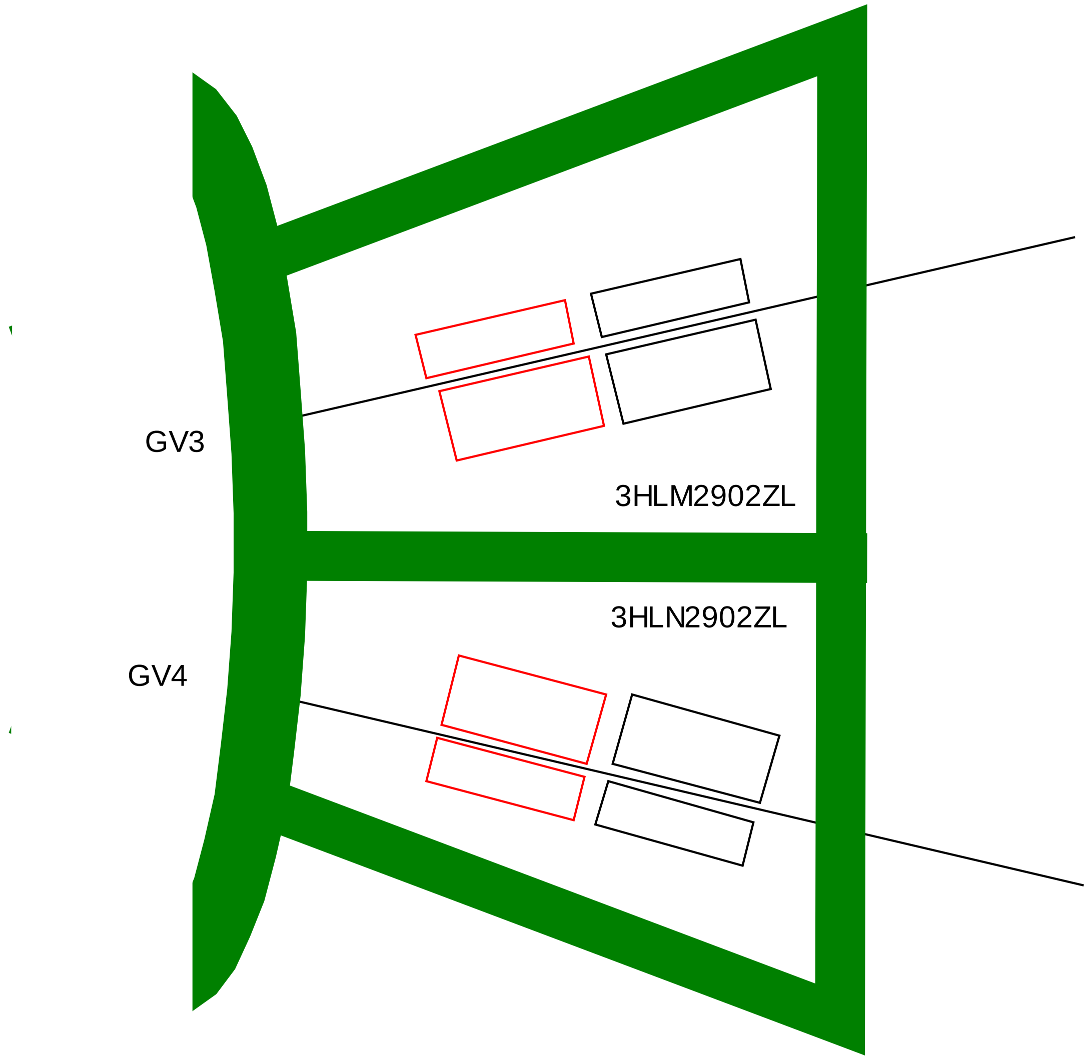


Appendix 1.3: KRT [PRMS]/ VVP [MSSS] Channels

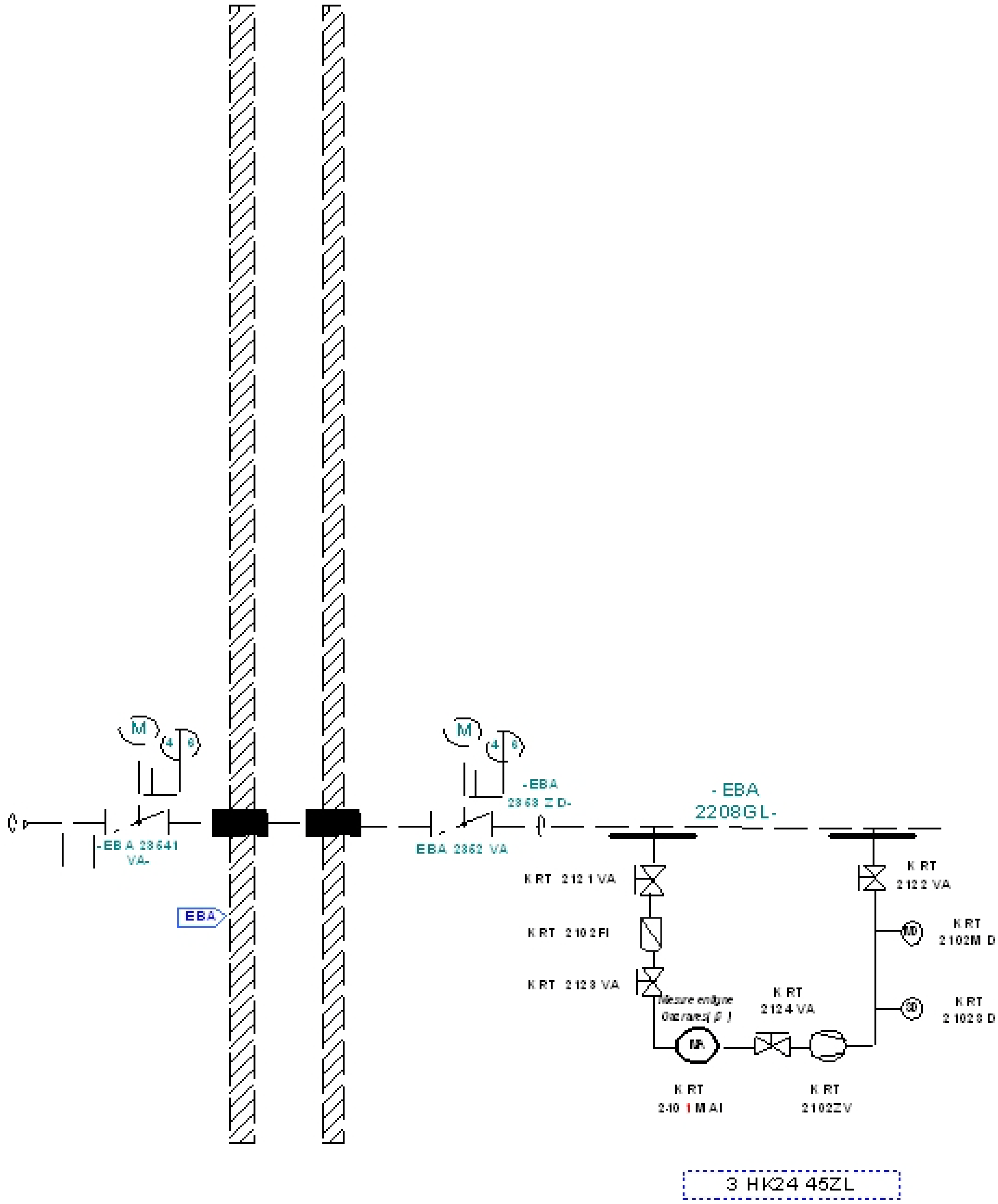
VVP Channels SG1/ SG2



VVP Channels SG3/ SG4

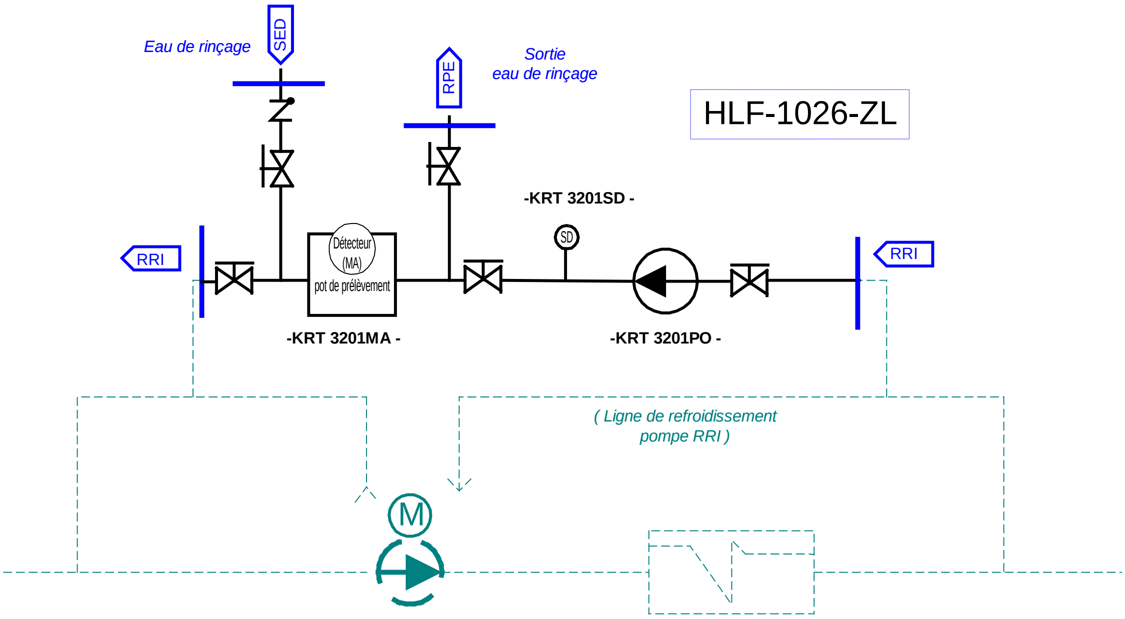


Appendix 1.4: KRT [PRMS]/EBA [CSVS] Channels (shutdown conditions)

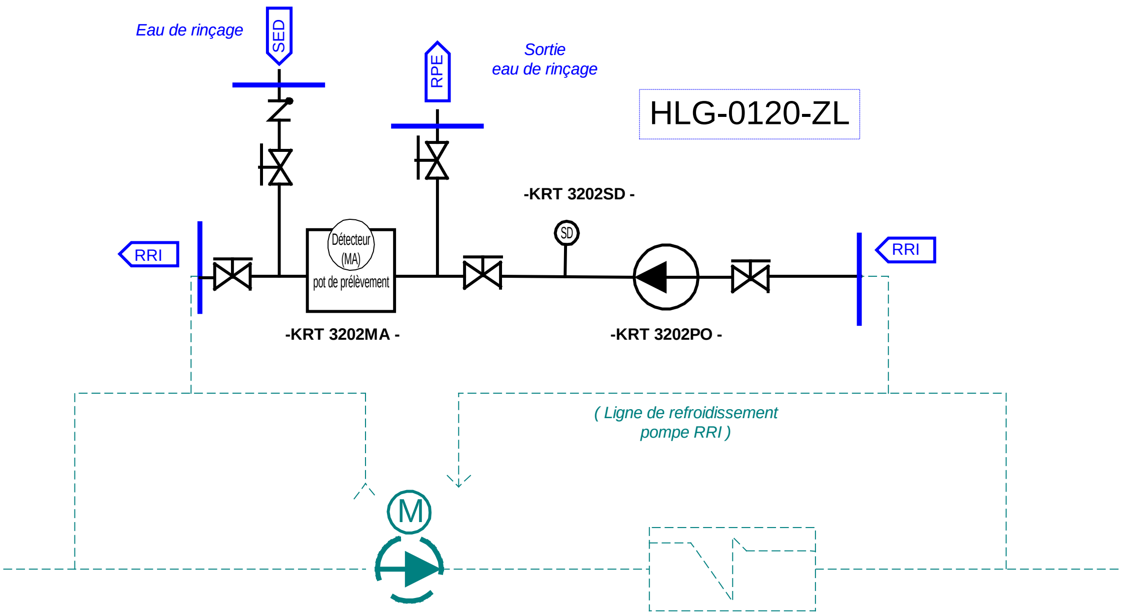


Appendix 1.5: KRT [PRMS]/RRI [CCWS] Channels

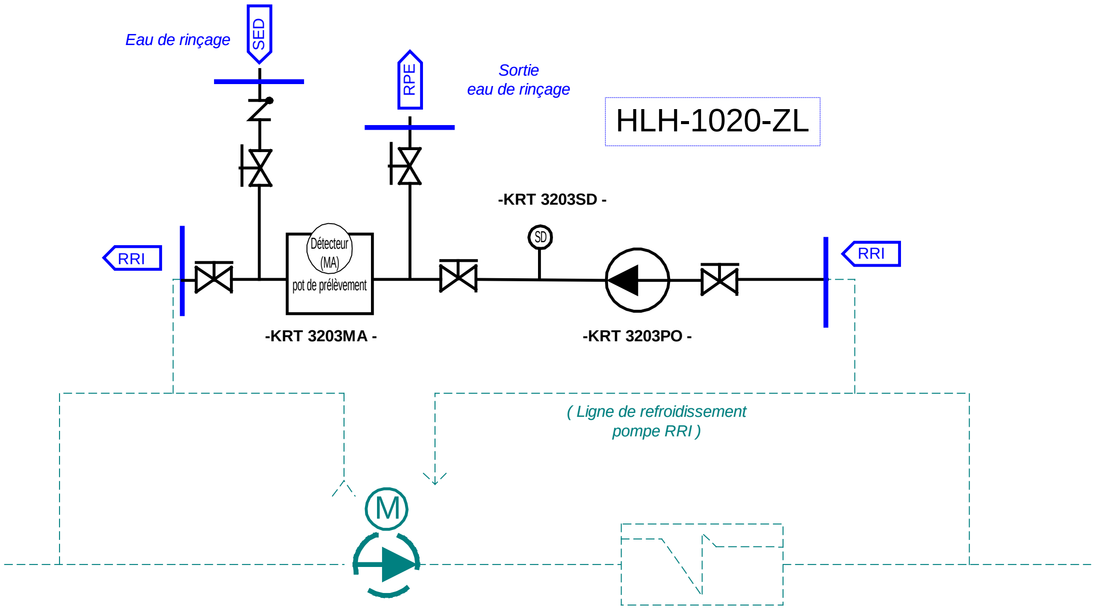
Safeguard Building 1



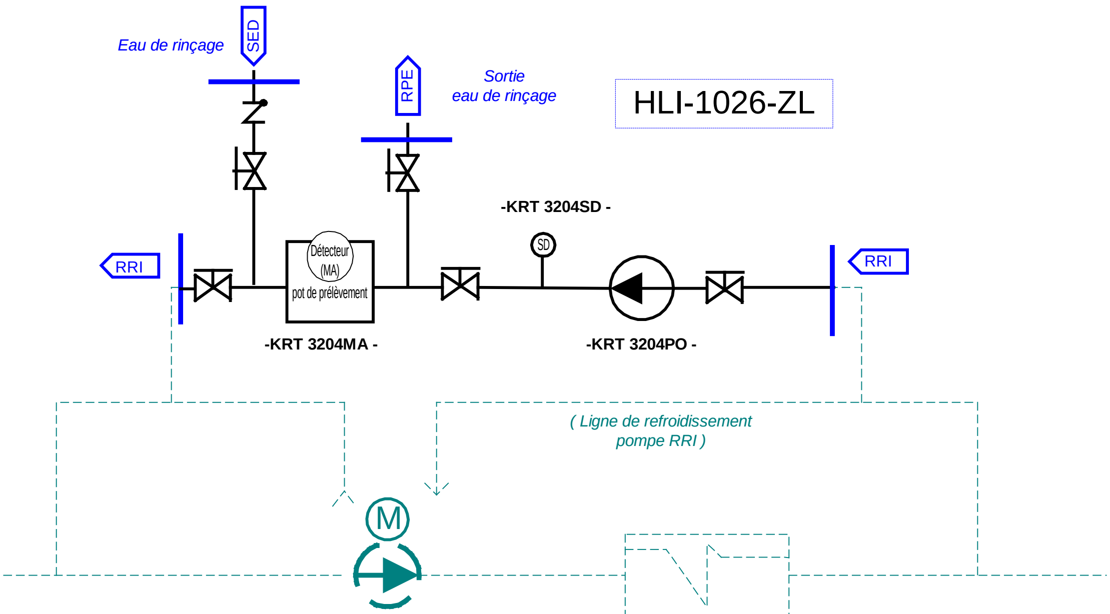
Safeguard Building 2



Safeguard Building 3

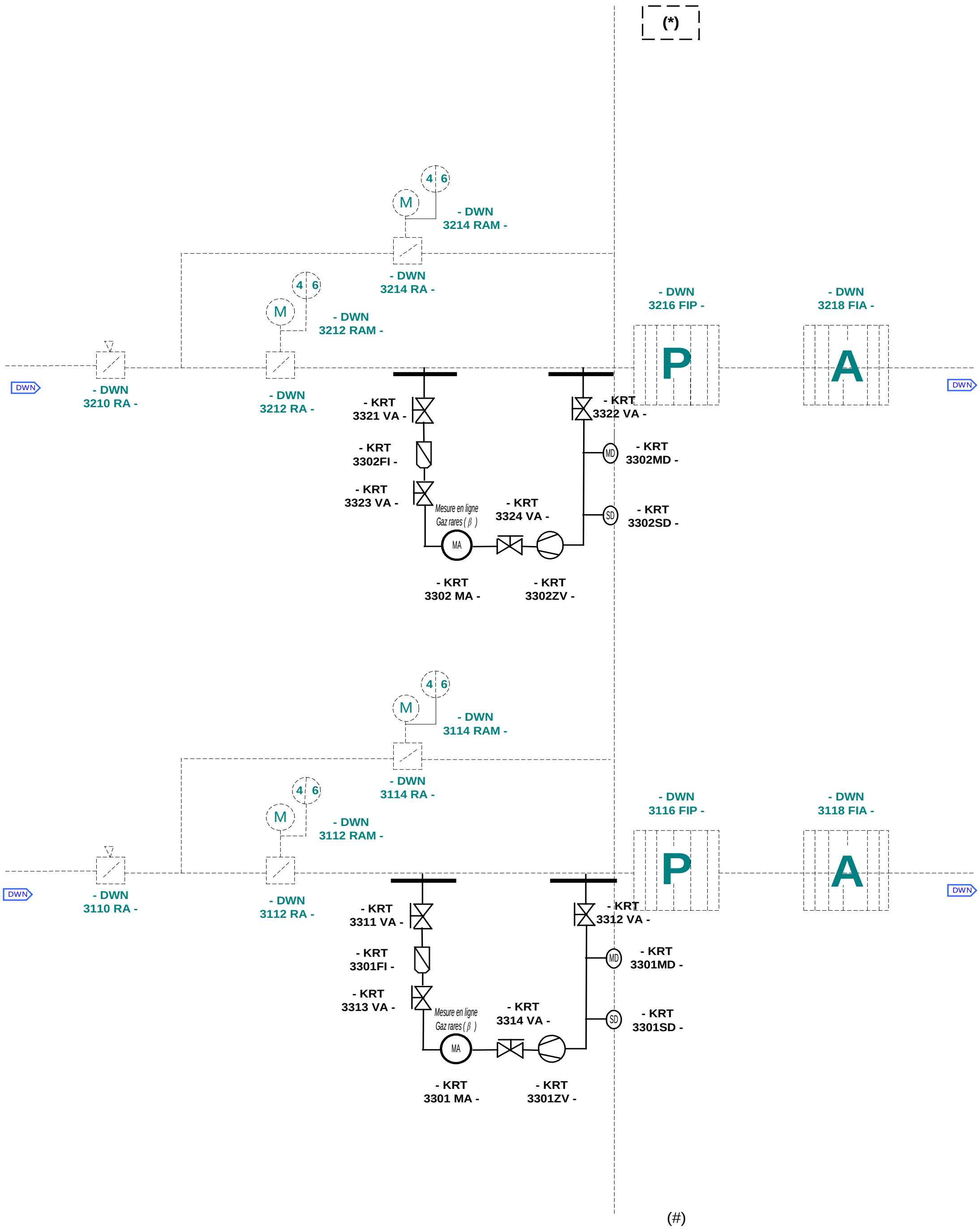


Safeguard Building 4

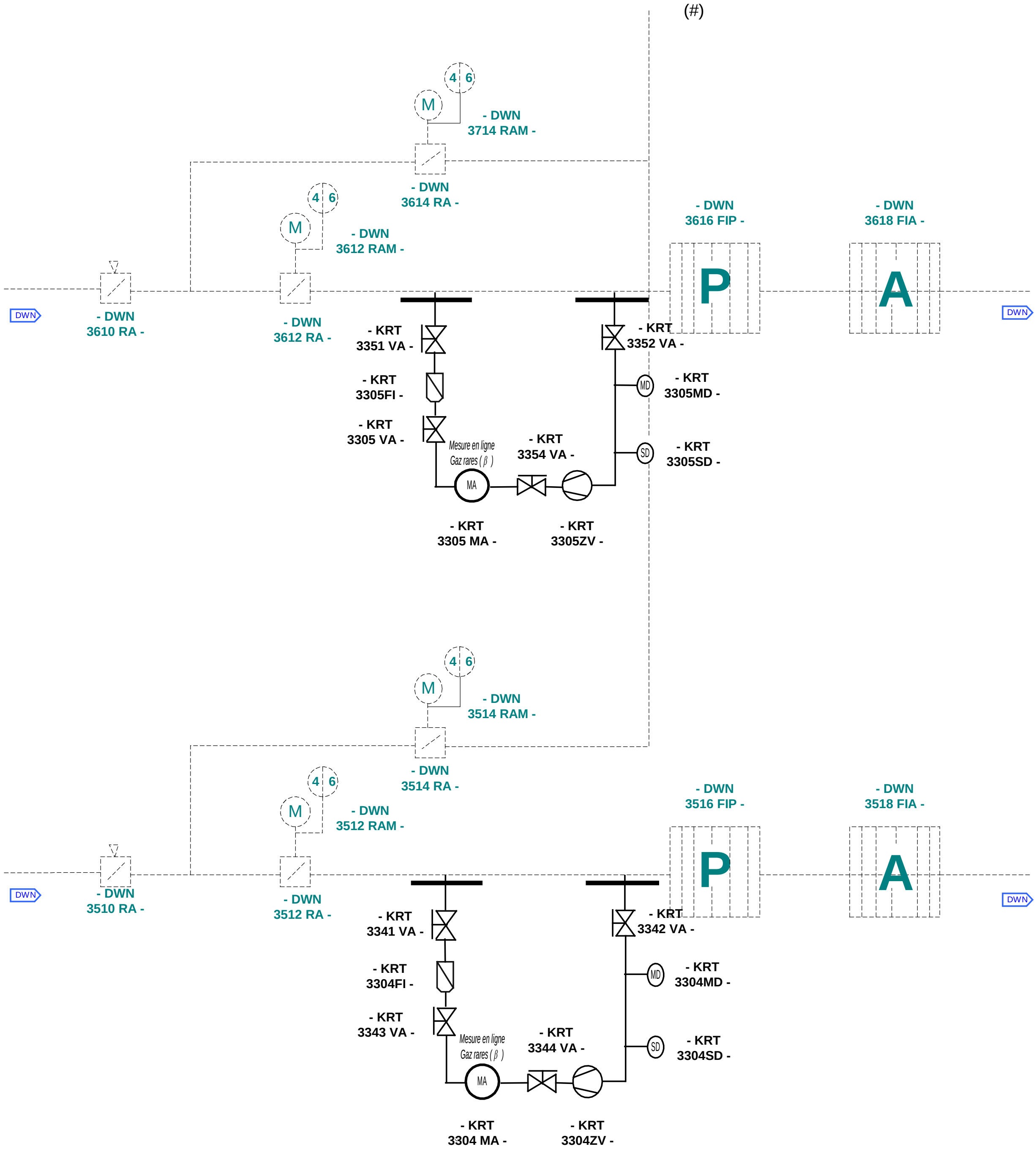


Appendix 1.6: KRT [PRMS]/ Nuclear Auxiliary Building Ventilation System Channels (ventilation ducts)

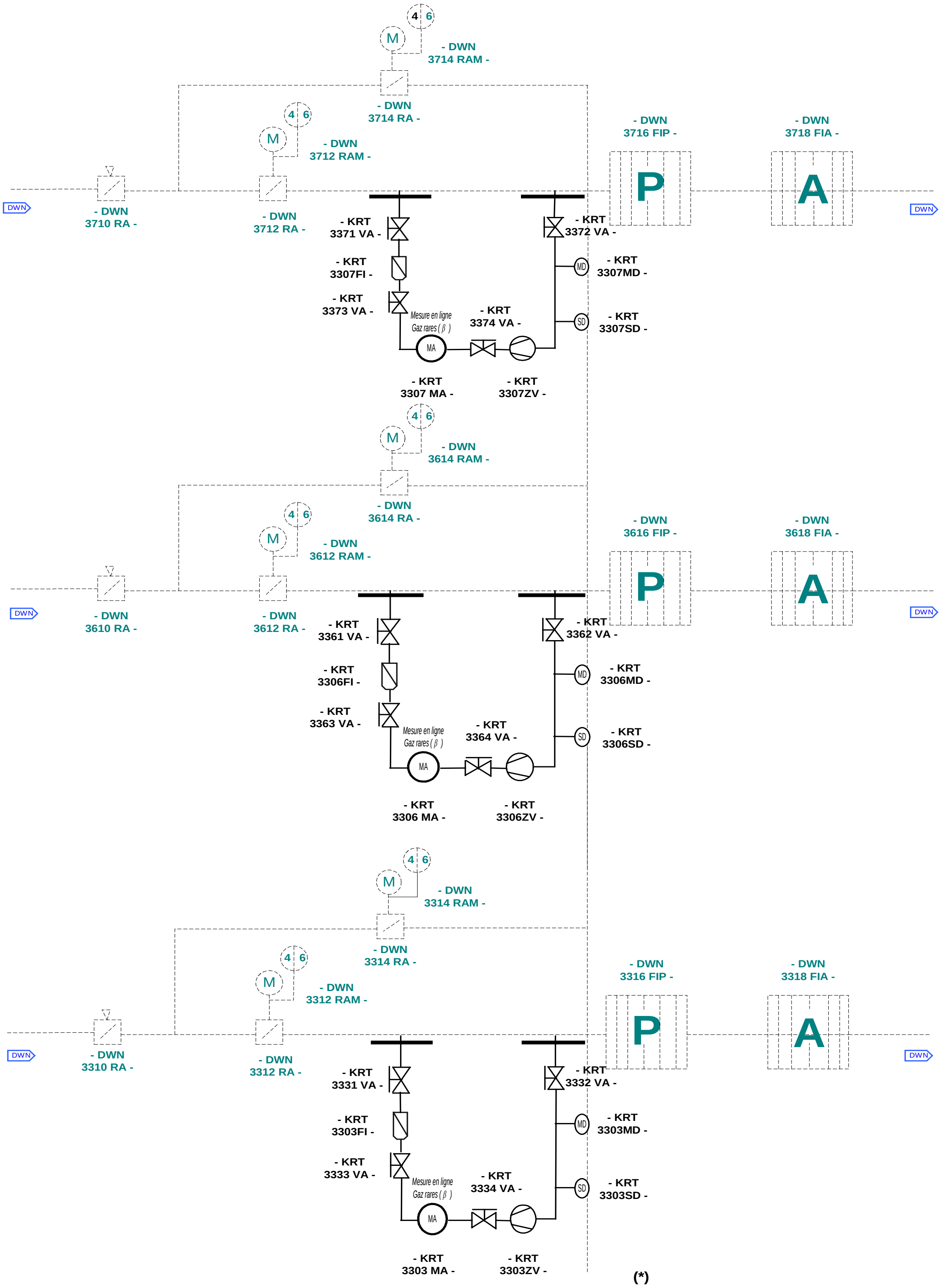
Cell 2 and 1



Cell 4 and 5

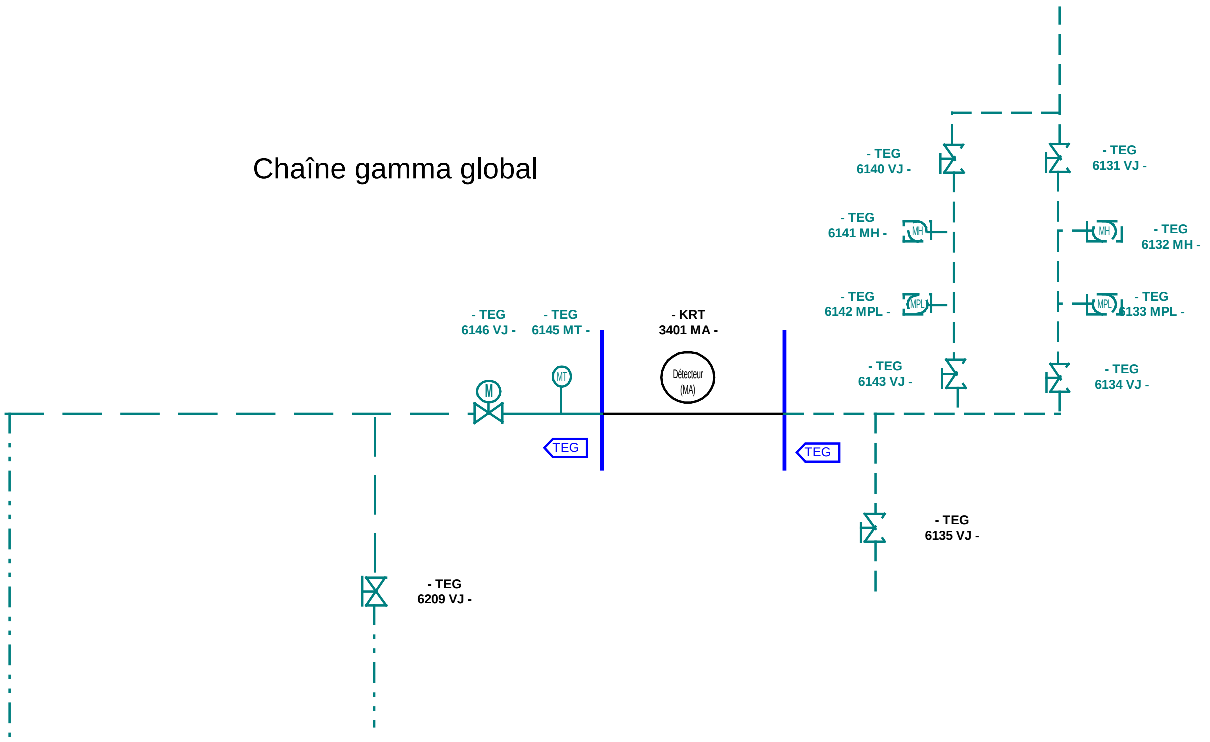

(#)
- DWN
3714 RAM -
- DWN
3614 RA -
- DWN
3612 RAM -
- DWN
3616 FIP -
- DWN
3618 FIA -
P
A
DWN
- DWN
3610 RA -
- DWN
3612 RA -
- KRT
3351 VA -
- KRT
3352 VA -
- KRT
3305FI -
- KRT
3305MD -
- KRT
3305 VA -
Mesure en ligne
Gaz rares (β)
- KRT
3354 VA -
- KRT
3305SD -
MA
MD
SD
- KRT
3305 MA -
- KRT
3305ZV -
- DWN
3514 RAM -
- DWN
3514 RA -
- DWN
3512 RAM -
- DWN
3516 FIP -
- DWN
3518 FIA -
- DWN
3510 RA -
- DWN
3512 RA -
- KRT
3341 VA -
- KRT
3342 VA -
- KRT
3304FI -
- KRT
3304MD -
- KRT
3343 VA -
- KRT
3344 VA -
- KRT
3304SD -
- KRT
3304 MA -
- KRT
3304ZV -

Cell 7, 6, 3

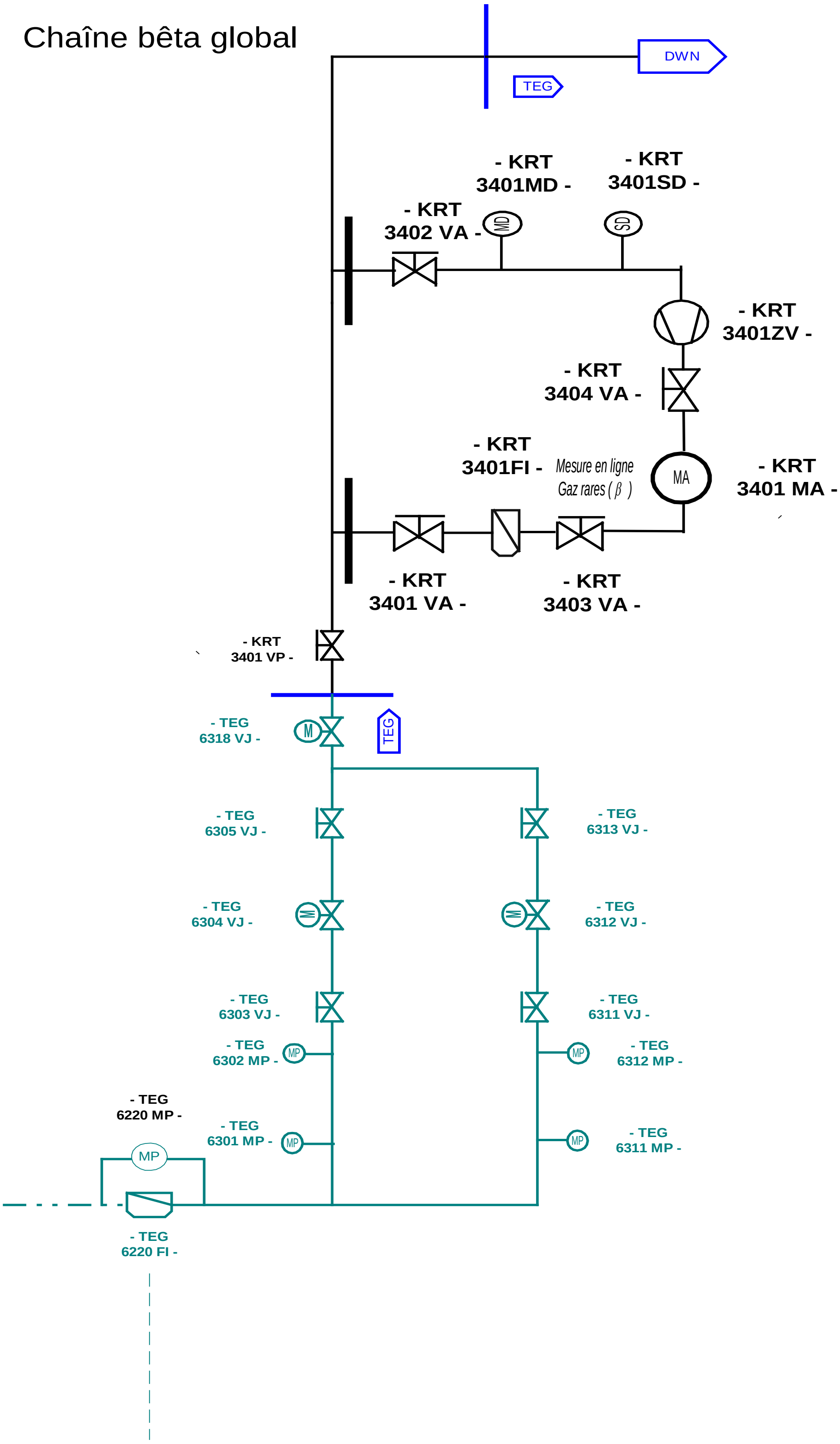

- DWN 3714 RAM -
- DWN 3714 RA -
- DWN 3712 RAM -
- DWN 3716 FIP -
- DWN 3718 FIA -
- DWN 3710 RA -
- DWN 3712 RA -
- KRT 3371 VA -
- KRT 3372 VA -
- KRT 3307FI -
- KRT 3307MD -
- KRT 3373 VA -
Mesure en ligne Gaz rares (β)
- KRT 3374 VA -
- KRT 3307SD -
- KRT 3307 MA -
- KRT 3307ZV -
- DWN 3614 RAM -
- DWN 3614 RA -
- DWN 3612 RAM -
- DWN 3616 FIP -
- DWN 3618 FIA -
- DWN 3610 RA -
- DWN 3612 RA -
- KRT 3361 VA -
- KRT 3362 VA -
- KRT 3306FI -
- KRT 3306MD -
- KRT 3363 VA -
- KRT 3364 VA -
- KRT 3306SD -
- KRT 3306 MA -
- KRT 3306ZV -
- DWN 3314 RAM -
- DWN 3314 RA -
- DWN 3312 RAM -
- DWN 3316 FIP -
- DWN 3318 FIA -
- DWN 3310 RA -
- DWN 3312 RA -
- KRT 3331 VA -
- KRT 3332 VA -
- KRT 3303FI -
- KRT 3303MD -
- KRT 3333 VA -
- KRT 3334 VA -
- KRT 3303SD -
- KRT 3303 MA -
- KRT 3303ZV -
(*)

Appendix 1.7: KRT [PRMS]/TEG [GWPS] Channels

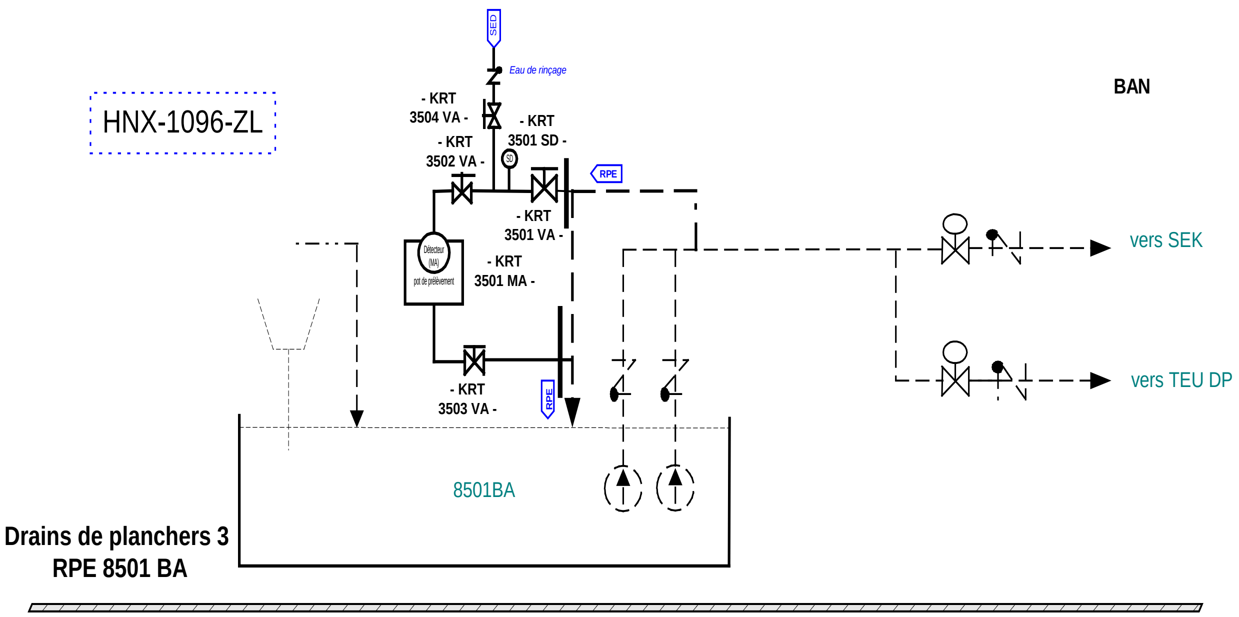
Detection upstream of the TEG beds



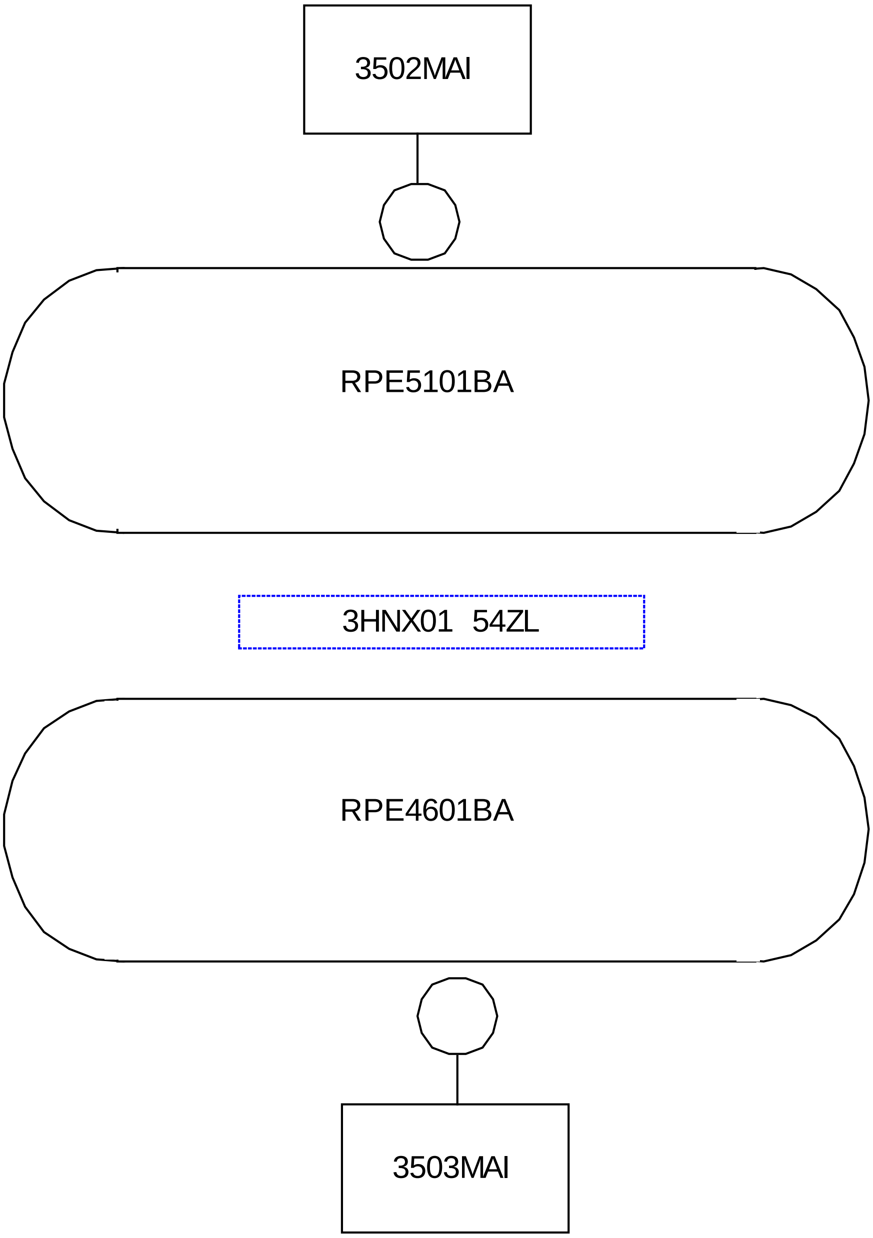
Detection downstream of the TEG beds



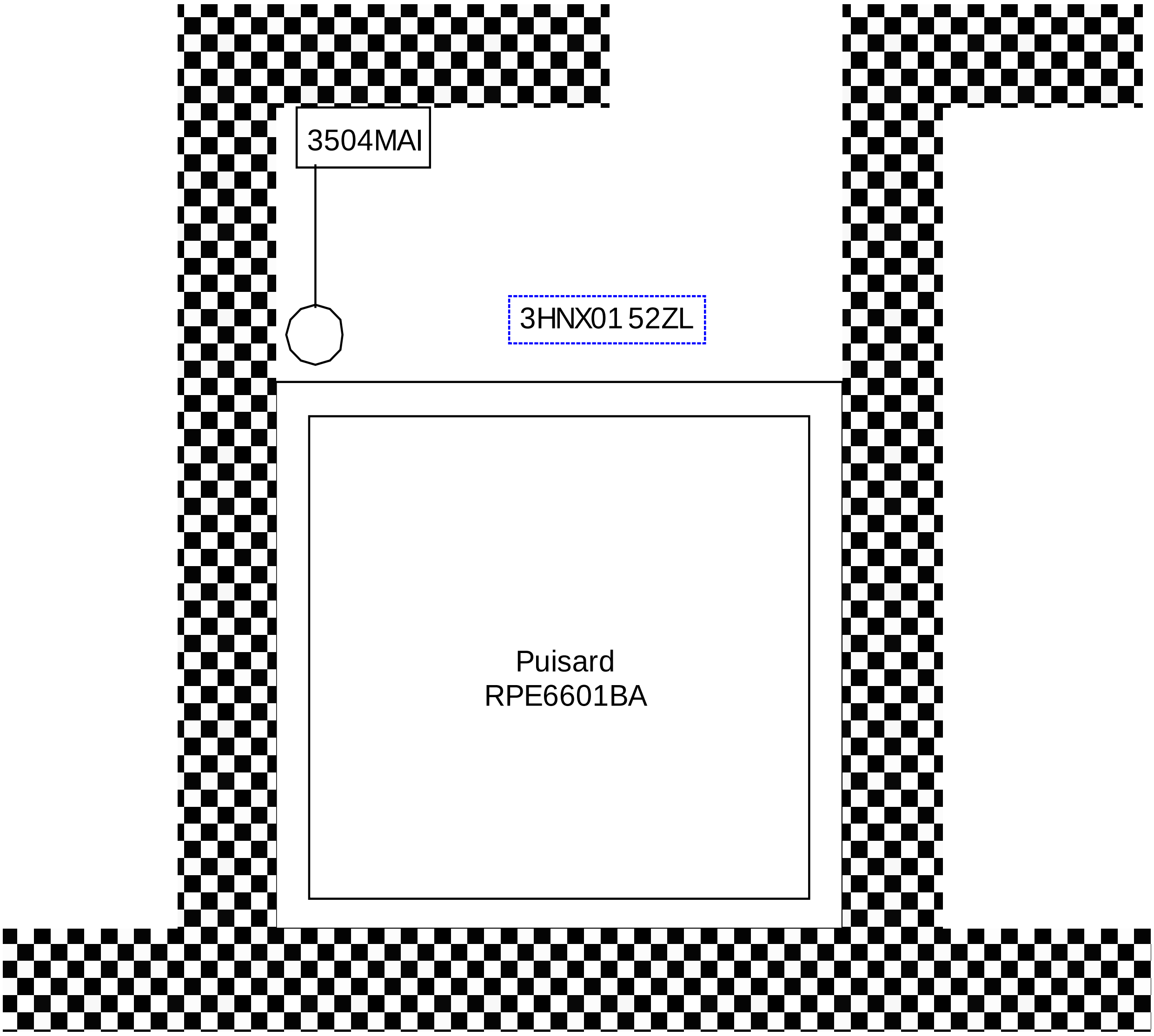
Appendix 1.8: KRT [PRMS]/RPE [NVDS] Channel (Nuclear Auxiliary Building floor drain tank DP3)



Appendix 1.9: KRT [PRMS]/RPE [NVDS] Channels (Nuclear Auxiliary Building chemical drain tank DC and Nuclear Auxiliary Building residual drain tank DR)

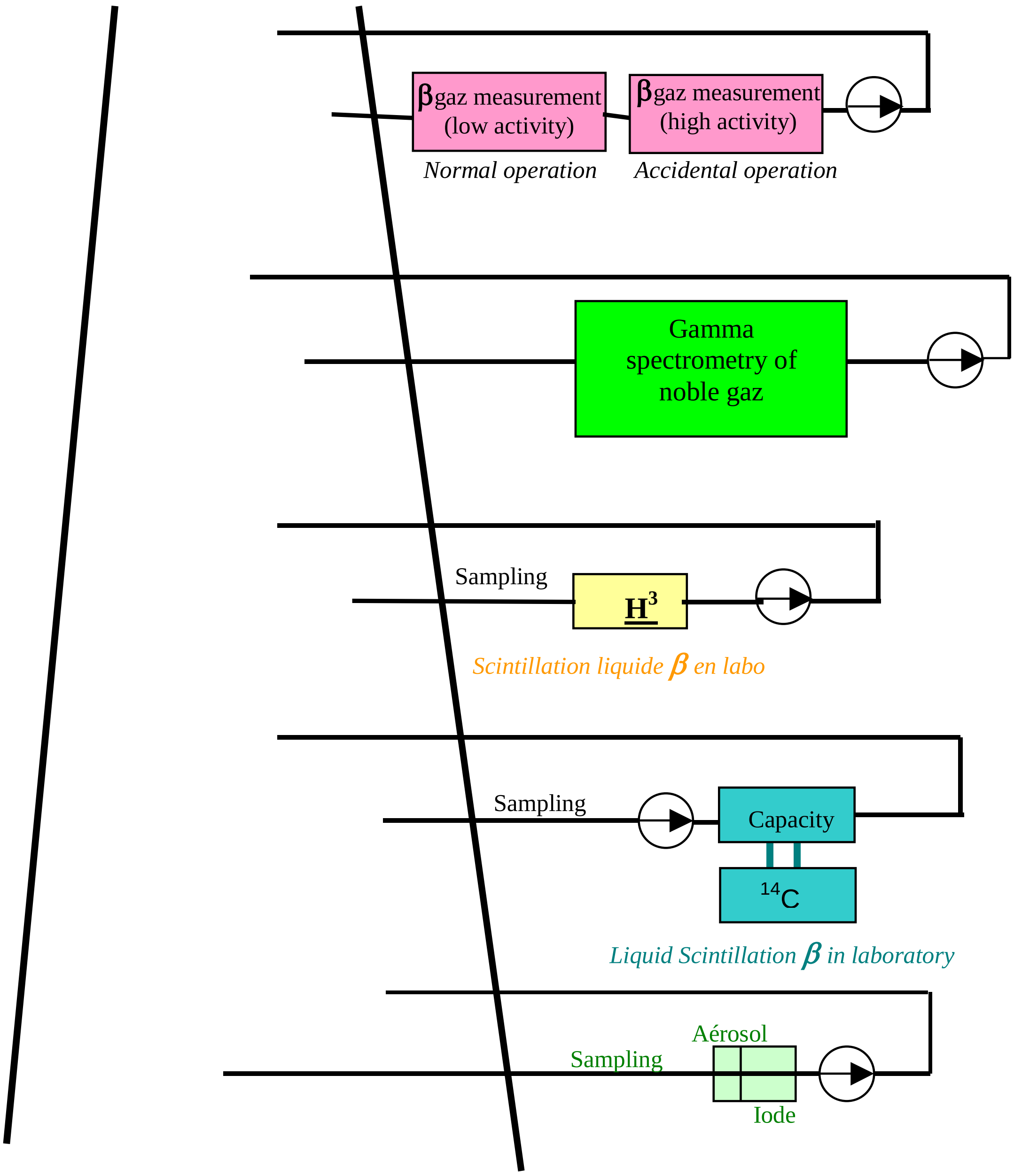


Appendix 1.10: KRT [PRMS]/RPE [NVDS] Channels (Nuclear Auxiliary Building floor drain sump DP1)

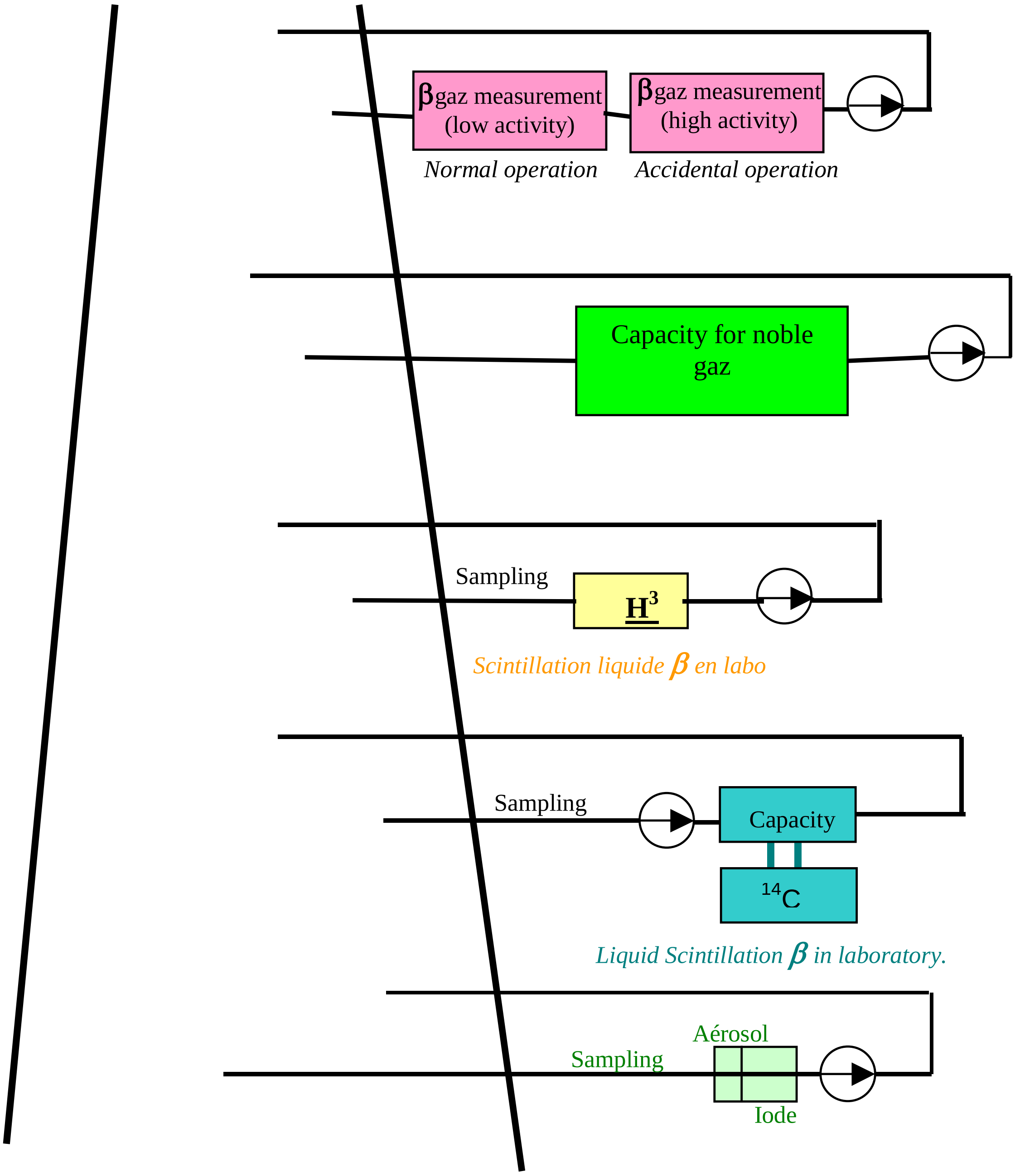


Appendix 1.11: KRT [PRMS]/ Nuclear Auxiliary Building ventilation system Channels (Nuclear Auxiliary Building stack)

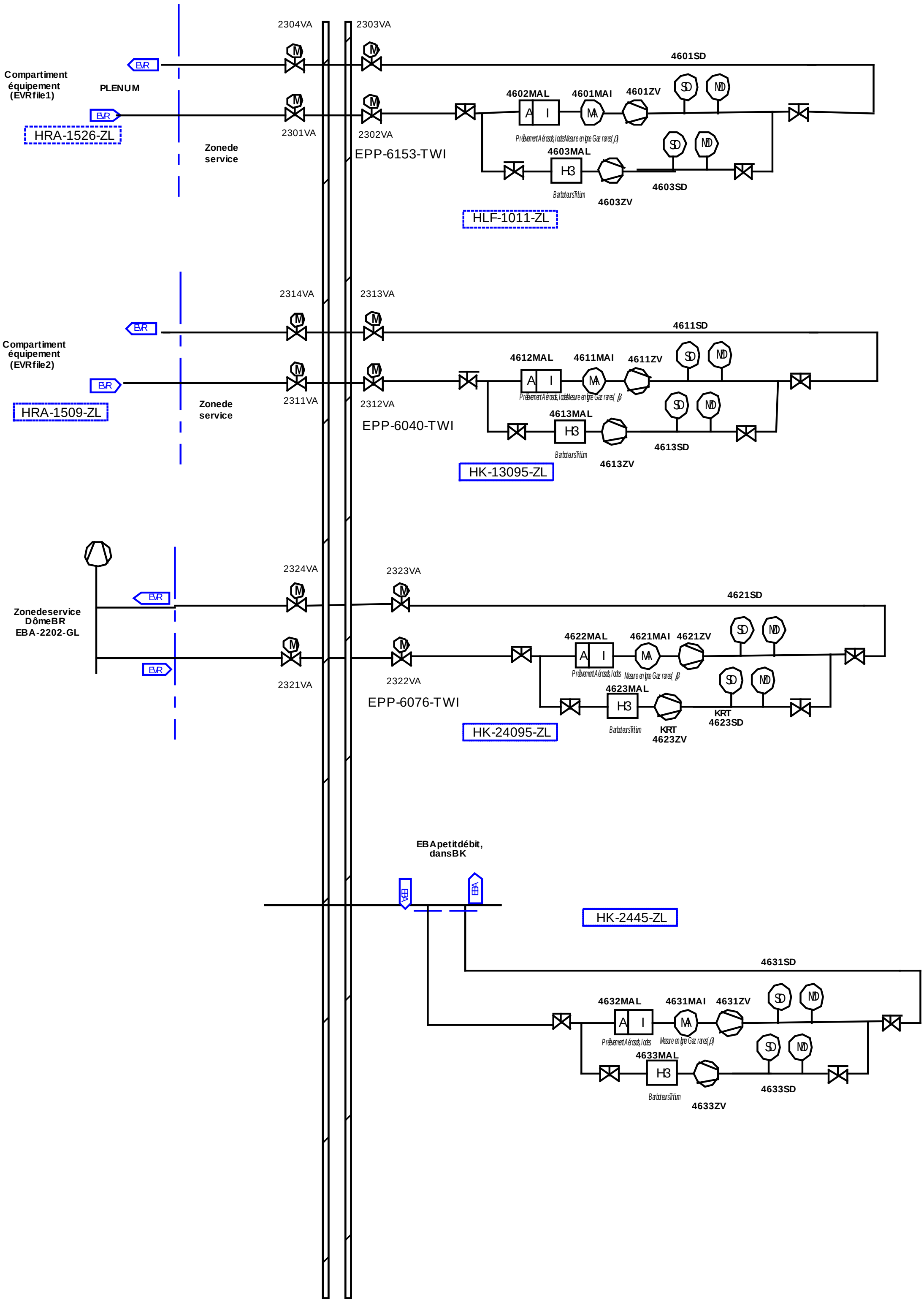
Division 1



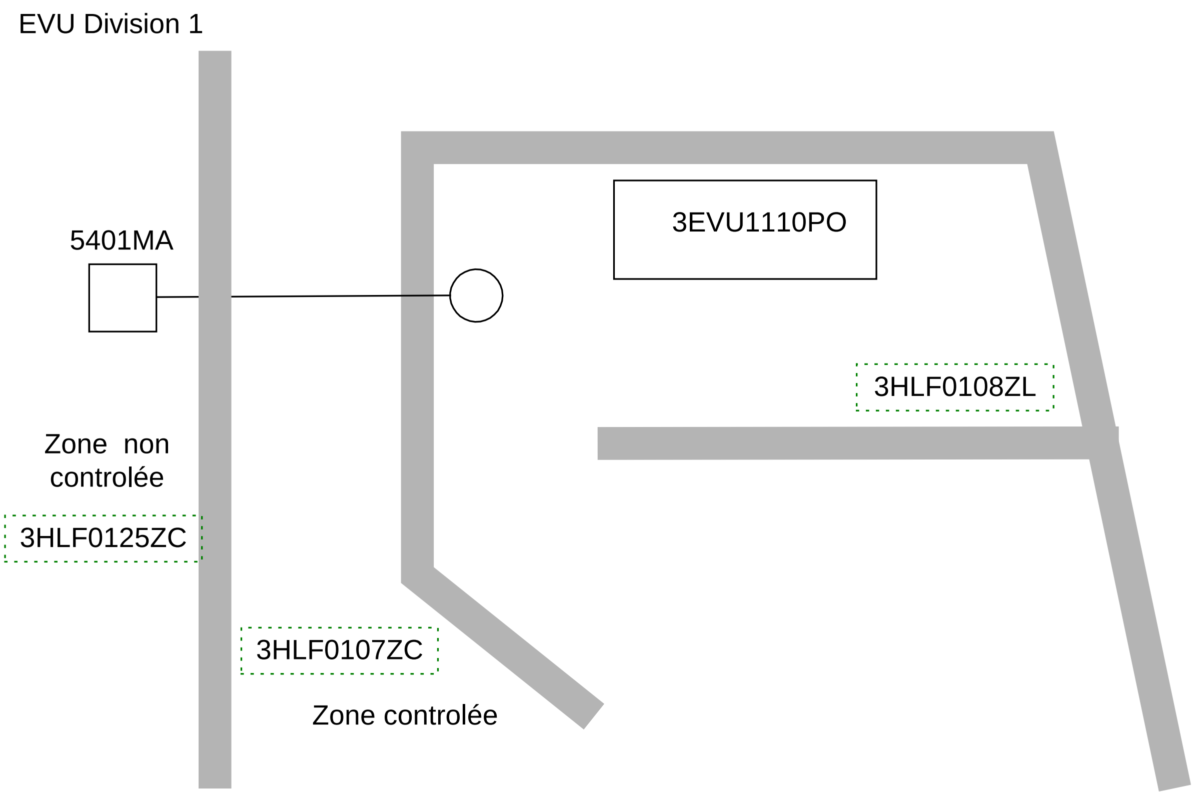
Division 4

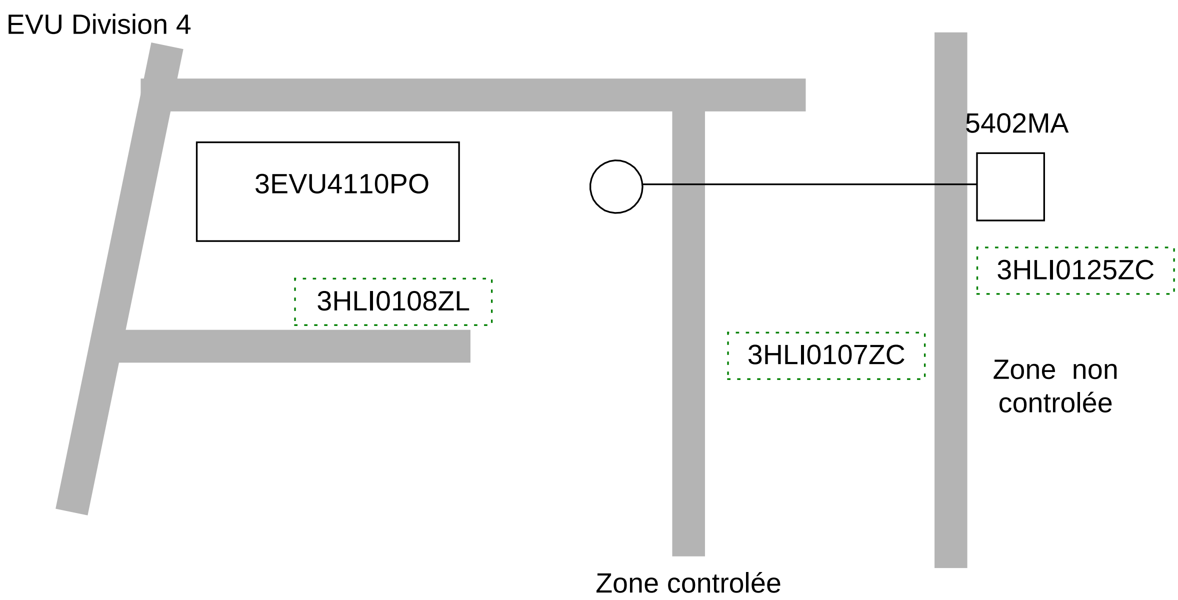

β gaz measurement (low activity)
β gaz measurement (high activity)
Normal operation
Accidental operation
Capacity for noble gaz
Sampling
H3
Scintillation liquide β en labo
Sampling
Capacity
14C
Liquid Scintillation β in laboratory.
Aérosol
Sampling
Iode

Appendix 1.12: KRT [PRMS]/Reactor Building Channels (Reactor Building authorised releases)

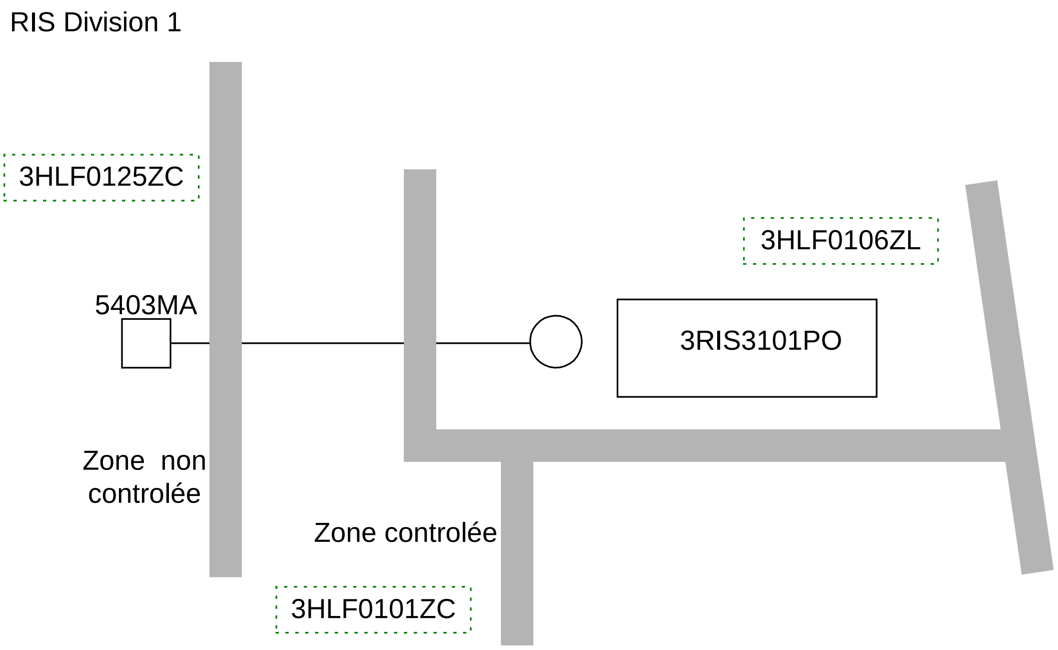


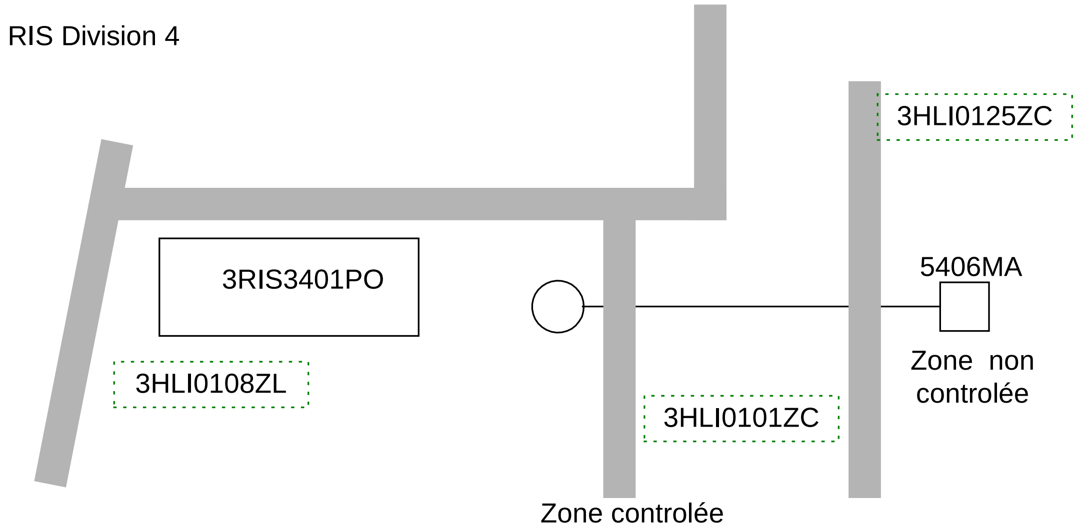
Appendix 1.13: KRT [PRMS]/EVU [CHRS] Channels (Safeguard Building monitoring)

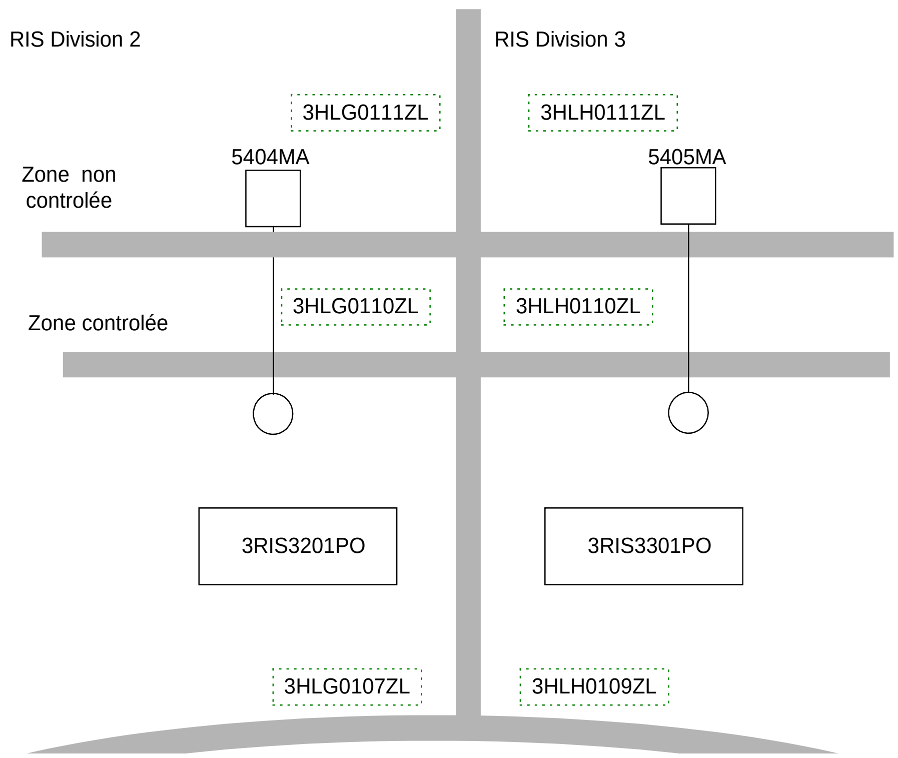




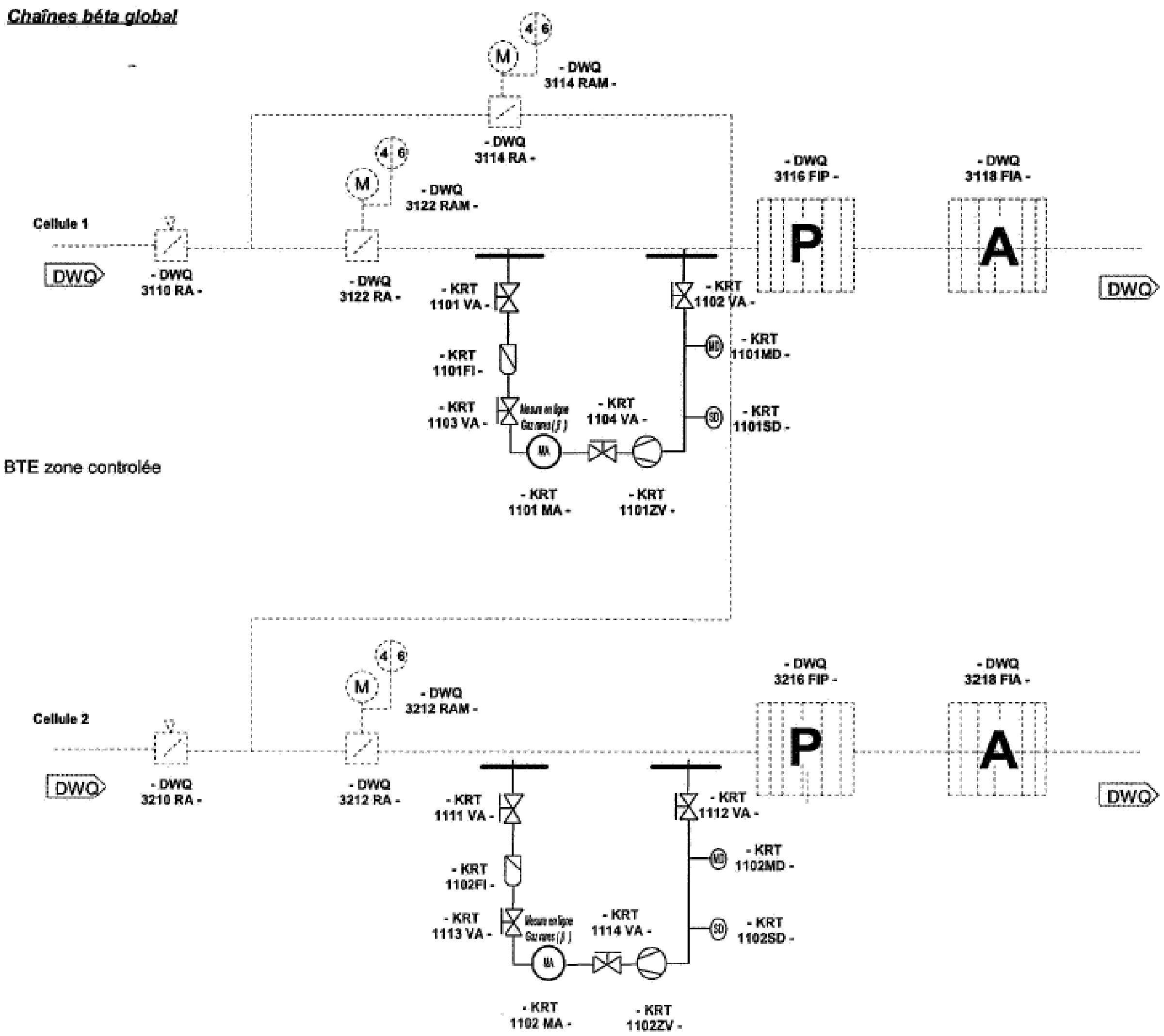
Appendix 1.14: KRT [PRMS]/RIS6RA [SIS-RHRS] Channels (Safeguard Building monitoring)



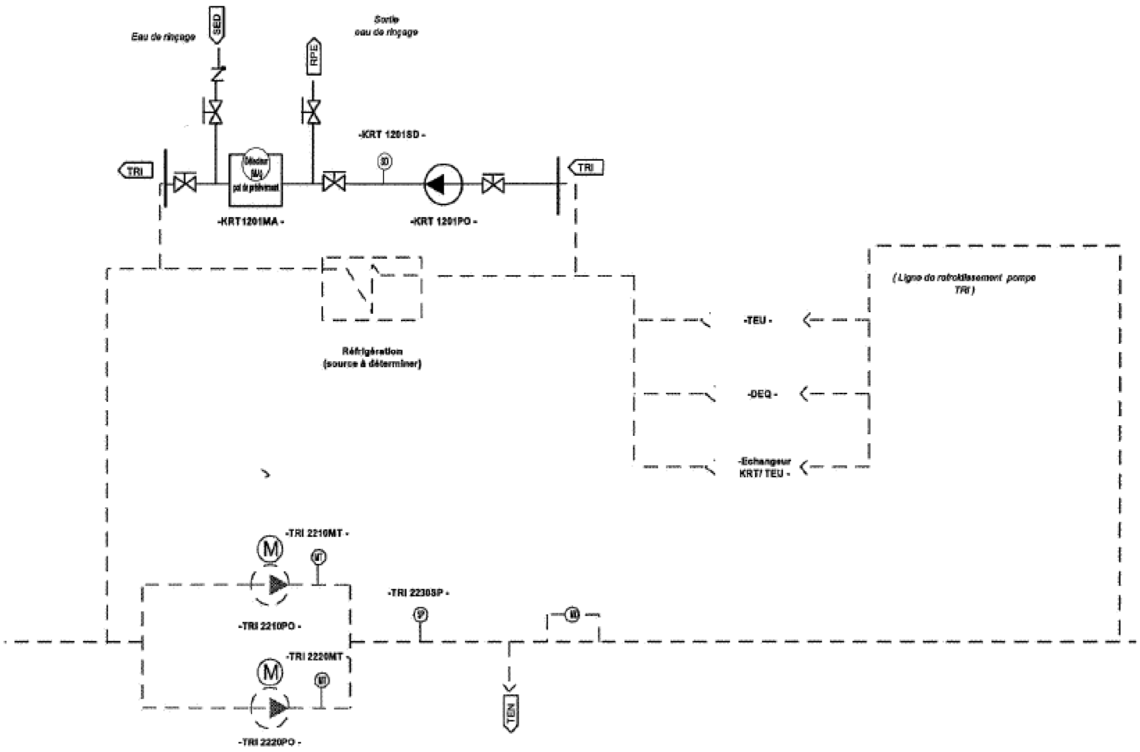



RIS Division 2
RIS Division 3
3HLG0111ZL
3HLH0111ZL
5404MA
5405MA
Zone non controlée
3HLG0110ZL
3HLH0110ZL
Zone controlée
3RIS3201PO
3RIS3301PO
3HLG0107ZL
3HLH0109ZL

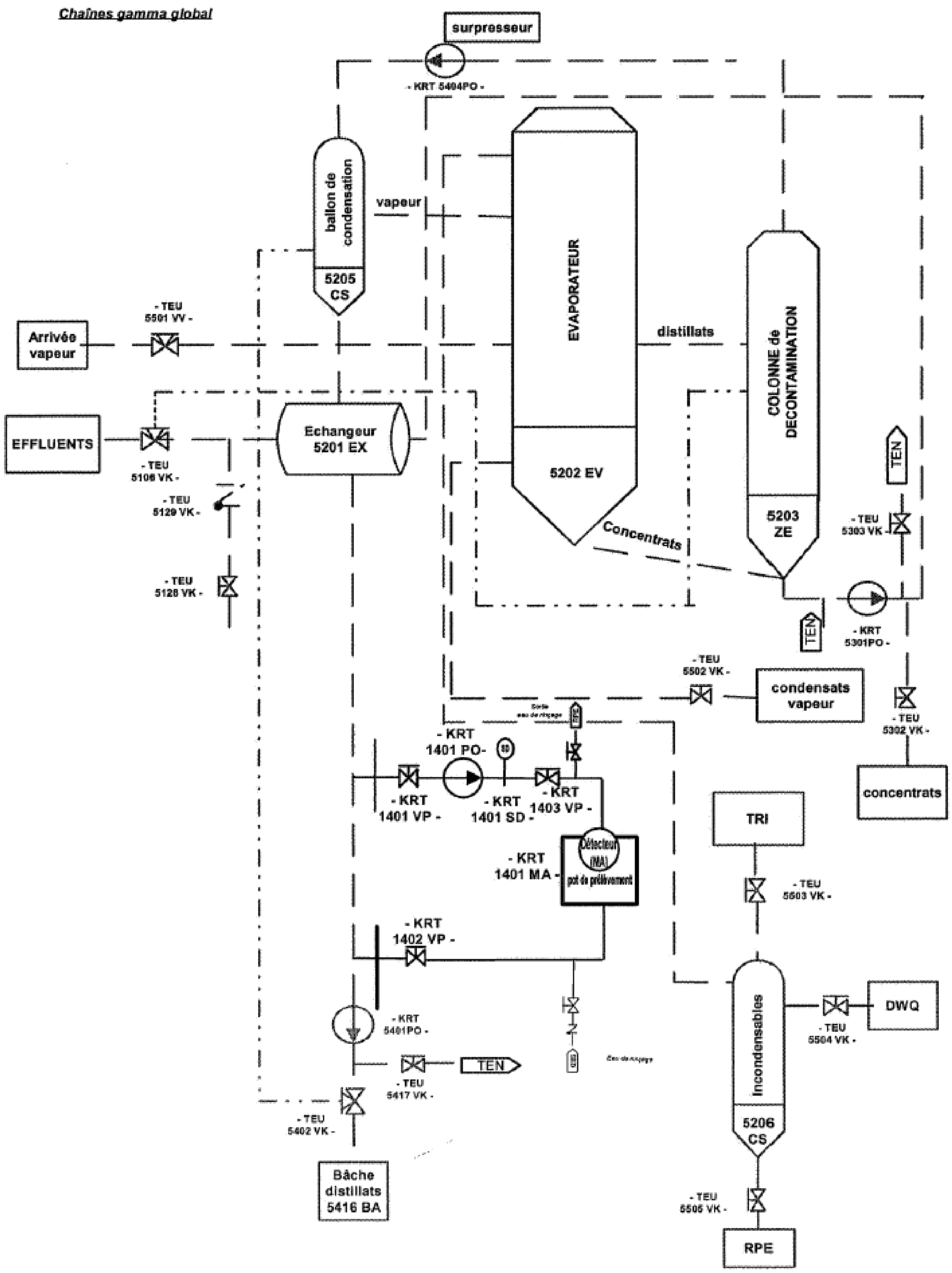
Appendix 1.15: KRT [PRMS]/Effluent Treatment Ventilation System Channels



Appendix 1.16: KRT [PRMS]/ Component Cooling Effluent Treatment system Channels



Appendix 1.17: KRT [PRMS]/CSTS Channels (CSTS evaporator distillates)



SUB-CHAPTER 12.3 – 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. RADIATION PROTECTION RULES

1.1. RADIATION PROTECTION CLASSIFICATION AND ZONING

[Ref-1] The Ionising Radiations Regulations 1999. Statutory Instrument 1999 No. 3232. HM Stationery Office. ISBN 0-11-085614-7. (E)

[Ref-2] Council Directive 96/29/EURATOM of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. Official Journal of the European Communities, L159, Vol. 39. June 1996. (E)

2. SHIELDING PROVISIONS

2.2. OBJECTIVES

[Ref-1] EPR - Optimised dose assessment for unit at power activities planned in the FA3 EPR Reactor Building. ECEIG081619 Revision A1. EDF. November 2009. (E)

ECEIG081619 Revision A1 is the English translation of ECEIG081619 Revision A.

2.4. CALCULATION METHODS

[Ref-1] UK EPR - Overview of the radiological zoning of the nuclear island. ECEIG111267 Revision B. EDF. March 2012. (E)

5. MONITORING OF THE UNIT

5.0. SAFETY REQUIREMENTS

5.0.1. Safety functions

[Ref-1] System Design Manual – Radiation Monitoring System (KRT [PRMS])
P2 - System Operation.
(KRT) EYTS/2007/fr/0042 Revision B1. SOFINEL. November 2009. (E)
(8KRT) EYTS/2007/fr/0224 Revision A1. SOFINEL. August 2009. (E)

[Ref-2] System Design Manual – Radiation Monitoring System (KRT [PRMS])
P3 – System sizing.
(KRT) EYTS/2007/fr/0186 Revision A1. SOFINEL. November 2009. (E)

[Ref-3] System Design Manual – Radiation Monitoring System (KRT [PRMS})
P5 – Instrumentation and Control.
(KRT) EYTS/2008/fr/0011 Revision B1. SOFINEL. November 2009. (E)
(8KRT) EYTS/2008/fr/0052 Revision B1. SOFINEL. August 2009. (E)

SUB-CHAPTER 12.3 - TABLE 2

[Ref-1] Steam Generator Tube Rupture – Mitigation Strategy. PEPR-F DC 38 Revision B. AREVA. February 2012. (E)