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02	Addition of section 5 “Systems for treating solid and liquid radioactive effluents – other utilities” and minor modifications	20-11-2008
03	PCSR June 2009 update: - Inclusion of references; - Consistency achieved with December 2008 design freeze; - Clarification of text	23-06-2009
04	Consolidated Step 4 PCSR update: - Minor editorial changes - Clarification of text - Update and addition of references - Clarification of number of tanks (section 1.1.3.1) - Additional information included in sections 1.1.2, 1.1.3, 4.2.4.1.5, 6.4.2.3 - Figures 1 and 2, 6.4.2.4 - Figure 1 and 6.4.2.5 - Figure 1. - Minor editorial changes in sections 2.1.2.3, 2.1.3.1.1, 2.1.3.1.3, 2.1.3.1.4, 2.1.4.1.1, 2.1.4.1.3 and 6.4.4.2 - Figures 1, 2 and 4. - New sub-section 1.1.3.2 “Laundry facilities” added, covering laundry arrangements and discharges - New section 2.6 " Inter-stage refrigeration circuits (RRI [CCWS] and TRI)" added, with references for ETB closed cooling water system - Update of figures	30-03-2011

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REVISION HISTORY (Cont'd)

Issue	Description	Date
05	Consolidated PCSR update: - References listed under each numbered section or sub-section heading numbered [Ref-1], [Ref-2], [Ref-3], etc - Minor editorial and typographical changes for consistency / clarification - Text added to take into account electrical and C&I issues (§1) - Clarification of text or text added for consistency (§1, §1.1, §2.1.3.1.2, §2.2.0.2, §2.2.3, §2.3.3.1, §2.4.3, §2.5.1), - Text added regarding the conditioning / treatment of sludge and concentrates (§1.3.2, §4.2) - Statements added regarding proportional sampling (§2.3.2, §2.3.3.1, §2.4.3.1, §2.5.2, §2.5.3.1) - Updates to reactor chemistry aspects – source term reference updated in active inventory table (§3.4.1.2) - References updated (§2.1, §2.2, §2.3, §2.5, §2.6, §3, §4) - Cross-references to the PCER added (§1.1.3, §2.3.1, §2.4.1, §2.5.1) - Update for modification of HVAC systems, regarding connections of the TEG [GWPS] containment to the EBA [CSVS] ventilation system (§3)	22-10-12

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5. SYSTEMS FOR TREATING SOLID AND LIQUID RADIOACTIVE EFFLUENT – OPTIONS TO THE REFERENCE CASE

SUB-CHAPTER 11.4 - EFFLUENT AND WASTE TREATMENT SYSTEMS DESIGN ARCHITECTURE

This sub-chapter deals with the requirements 1.2, 1.4, 2.1 and 3.2 of the EA P&I Document [Ref-1].

1. THE ROLE OF EFFLUENT TREATMENT SYSTEMS

During normal operation of the unit, some systems convey primary coolant with a normal level of contamination. Some systems, normally separated from the primary coolant by a barrier, may be accidentally contaminated by a failure in the leak tightness of the barrier.

During normal operation of the EPR, the release of radioactive substances outside the plant is monitored and controlled within the limits set by regulations and effluent discharge authorisations.

The role of effluent treatment systems, in normal operation, involves the following:

- collecting effluent produced in the unit and in the site facilities; this effluent comes from draining, bleeding, venting and leaks from systems that are normally or accidentally contaminated;
- treating, if necessary, the effluent, i.e. reducing the level of contamination in order to meet regulatory discharge limits; and
- discharging effluent outside the site following monitoring and accounting of the levels of activity discharged under regulatory conditions.

In some accident situations that may lead to significant transfer of contamination to the buildings adjacent to the Reactor Building, the effluent treatment systems operate to ensure contamination is contained, in order to limit the release of radioactivity to the environment by re-injection inside the Reactor Building.

The following description of the effluent and waste treatment systems is organised according to the effluent phase: liquid, gaseous or solid.

Smart devices may be required for class 1, 2 or 3 systems. For the effluent and waste treatment systems, this will be identified when suppliers are chosen and appropriate substantiation will be provided as part of the detailed design.

In addition, the detailed implementation of the electrical design in the effluent and waste treatment systems will be performed as part of the detailed design.

1.1. LIQUID EFFLUENT TREATMENT SYSTEMS

The treatment of liquid effluent can be divided between reactor systems, EPR Effluent Treatment Building (ETB) [Ref-1] systems and the site systems.

Note: In this sub-chapter, the treatment of liquid effluent organisation is based on the assumption that the site is a coastal site, and that there are storage tanks as described below (the description is based on Flamanville 3).

The liquid and gaseous effluent of the nuclear island is collected by the Nuclear Vent and Drain System (RPE [NVDS]). The treatment of liquid effluent is described below; the treatment of gaseous effluent is described in section 3.

The Coolant Storage and Treatment System (TEP [CSTS]), which is the primary coolant treatment system, is described in Sub-chapter 9.3 of the PCSR and is considered as an auxiliary system. It is excluded from the following description.

The Effluent Treatment Building comprises the non-recycled Liquid Waste Processing System (8TEU [LWPS]).

The site systems are as follows:

- Liquid Radwaste Monitoring and Discharge System (0KER [LRMDS], system for monitoring and discharge of effluent from the nuclear island);
- Additional Liquid Waste Discharge System (0TER [ExLWDS], residual liquid effluent system); and
- Site Liquid Waste Discharge System (0SEK [SiteLWDS], system for collecting, monitoring and discharging waste from the turbine hall).

1.1.1. Unit systems

The liquid effluent treatment systems of the unit are described in section 2.1. The RPE [NVDS] is the only system in this section.

The RPE [NVDS] collects the liquid effluent and transfers it to various systems according to the ability of the effluent to be recycled or according to its radiological characteristics.

The RPE [NVDS] collects the hydrogenated or aerated liquid effluent from the primary system for recycling in the TEP [CSTS].

The RPE [NVDS] collects the non-recyclable liquid effluent to transfer it to the following:

- 8TEU [LWPS]:
    - process drains: primary coolant more or less diluted and/or polluted;
    - chemical drains: fluid from sampling or transfer of resins;
    - floor drains 1: contaminated fluid from leaks, floor washing, drainage of contaminated equipment;
    - floor drains 2: fluid normally uncontaminated from leaks, floor washing in regulated work area, drainage of equipment that does not treat primary coolant.

- 0SEK [SiteLWDS] :
    - o floor drains 3: uncontaminated fluid from leaks, floor washing, drainage of equipment in uncontrolled areas.

1.1.2. Effluent Treatment Building System

The 8TEU [LWPS] treatment system (non-recycled liquid waste treatment system) is located in the Effluent Treatment Building and has a treatment capacity for two units.

The 8TEU [LWPS] system is described in section 2.2 of this sub-chapter.

The 8TEU [LWPS] treats process drains, chemical drains and floor drains from the RPE [NVDS] of the EPR unit(s). The treatment performed to reduce the radioactivity discharged consists of the following:

- filtering of all effluent;
- demineralisation of chemically clean radioactive effluent (process drains);
- evaporation of liquid effluent from chemical drains, radioactive floor drains and chemically polluted process drains that cannot be treated by one of the processes above because of its chemical characteristics.

After treatment, the liquid effluent is transferred to the 0KER [LRMDS] or, exceptionally, to the 0TER [ExLWDS] (site systems) for storage.

The concentrates resulting from evaporation are stored in the Solid Waste Treatment System 8TES [SWTS] (system for treating solid effluent).

Each 8TEU [LWPS] sub-system is composed of two tanks and the volumes are shown in the table below:

8TEU [LWPS] sub-system	Volumes
8TEU [LWPS] floor drain tank volume	2 x 75 m^3
8TEU [LWPS] process drain tank volume	2 x 100 m^3
8TEU [LWPS] chemical drain tank volume	2 x 160 m^3

The tanks are made of stainless steel, design standard EN 14015, and have high level alarms. There is a common bund for all the 8TEU [LWPS] tanks with a volume of approximately 440 m^3. The drainage system routes leak effluents from the bunds to the relevant 8RPE [NVDS], i.e. the chemical, process or floor drains. These are then analysed and sent to the relevant 8TEU [LWPS] tanks. There is level monitoring in each tank with direct feedback of levels to the Effluent Treatment Building control room, and a level monitoring alarm in the bund.

1.1.3. Site Systems

1.1.3.1. Systems for storage before discharge

The site systems (systems which would be common to several units on the same site) for storage before discharge comprise:

- 0KER [LRMDS] (system for monitoring and discharge of effluent from the nuclear island);
- 0TER [ExLWDS] (system for residual liquid effluent);
- 0SEK [SiteLWDS] (system for collection, monitoring and discharge of waste from the turbine hall).

The contents of the 0KER [LRMDS], 0TER [ExLWDS] and 0SEK [SiteLWDS] tanks may be transferred to the 8TEU [LWPS] for re-treatment via the 0TER [ExLWDS] if a regulatory limit is threatened.

The 0KER [LRMDS] liquid effluent monitoring and discharge system is described in section 2.3.

It stores the following:

- blowdown from the APG [SGBS] (SG Blowdown System) of each EPR unit when not recycled;
- liquid effluent treated and / or stored in the 8TEU [LWPS];
- washing and decontamination effluent;

and, following measurement (see PCER Chapter 7), controls discharge to the environment via a dilution system.

The 0TER [ExLWDS] additional liquid waste storage and discharge system is described in section 2.4.

The storage tanks of the 0TER [ExLWDS] are used only in exceptional circumstances.

They can store effluent from the APG [SGBS] and the PTR [FPPS] of EPR unit(s), and effluent from the 8TEU [LWPS], 0KER [LRMDS] and 0SEK [siteLWDS] tanks.

The 0SEK [SiteLWDS] for collection, monitoring and discharge of waste from the turbine hall is described in section 2.5.

It stores the following:

- liquid effluent from the turbine hall and the general auxiliary building that may be slightly contaminated as a result of primary to secondary leaks in the steam generators;
- RPE [NVDS] floor drains 3 if they are not contaminated;
- and, following measurement (see PCER Chapter 7), controls the discharge of this effluent to the environment.

The 0KER [LRMDS], 0TER [ExLWDS] and 0SEK [SiteLWDS] tanks are site specific and their volume is 750 m^3 per tank. They are made of reinforced concrete with a leak tight and reinforced liner, and are fitted with high level alarms and with overflow pipes to the other discharge tanks. For example, for the Flamanville site, the tanks for two EPR units and the two existing 1300 MW(e) units include six 0KER [LRMDS], three 0TER [ExLWDS] and four 0SEK [SiteLWDS].

For two UK EPR units, the tanks will include three 0KER [LRMDS], three 0TER [ExLWDS] and two 0SEK [SiteLWDS]. Section 11.4.2.3 - Figure 1 shows the overall 0KER [LRMDS]-0SEK [SiteLWDS]-0TER [ExLWDS] diagram.

1.1.3.2. .Laundry facilities

1.1.3.2.1. Arrangement for a laundry

The laundry is a site specific facility, and it will be the choice of the operator to have a laundry on or off-site. The design and layout of the laundry, together with the arrangements for operation of an on-site laundry, are also operator specific.

The purpose of the laundry is to clean the clothes (overalls, underwear, socks, gloves, towels, masks, shoes and protection shoes) used in the maintenance activities. Clothes slightly contaminated in the controlled area are brought and washed separately from the non-contaminated clothes. Radioactivity controls are performed after drying to decide whether the clothes can be brought back to the changing rooms or need to be discarded as waste.

If the laundry is on-site, piping will be needed to send the water and detergent to the 0KER [LRMDS] tanks together with the plant discharge before release.

The laundry equipment comprises washing machines and driers as well as activity control equipment. The building will comprise several rooms and associated services (rooms for sorting, washing, drying, activity monitoring, storage of clothes, etc).

1.1.3.2.2. Discharges from a laundry

Discharges from the laundry are included in the EPR estimates and maximum discharges presented in Sub-chapter 3.4 of the PCER.

These discharges, as explained in Sub-chapter 3.4 of the PCER, are based on the feedback from the operation of the current French fleet 1300 MW(e) PWRs, which include an on-site laundry.

Regarding chemical discharges associated with radioactive discharges, PCER Sub-chapter 3.4 provide estimates and maximum expected discharges for detergents.

Regarding detergents it is noted, in PCER Sub-chapter 3.4, that detergents which will be used for the EPR laundry are biodegradable products which contain neither EDTA (ethylene diamine tetra-acetic acid) nor phosphate. The detergents which would be used in a UK EPR laundry would have to comply with the water framework discharges requirements regarding non-radioactive discharges in force at the time of start of operation.

1.2. GASEOUS EFFLUENT TREATMENT SYSTEMS

The gaseous effluent treatment systems are divided into systems for primary gaseous effluent treatment (RPE [NVDS] gaseous effluent portion and TEG [GWPS]) and the system for treating other gaseous effluent which is carried out by the ventilation systems (e.g. DWN [NABVS], EBA [CSVS], DWL [CSBVS]).

1.2.1. Treatment of primary gaseous effluent

The RPE [NVDS] is described in section 2.1. It comprises a gaseous effluent portion which collects gases from the RPE [NVDS] tanks of the Reactor Building, the Nuclear Auxiliary Building (NAB), Safety Auxiliary Buildings and Fuel Building that receive recyclable bleeds and venting from safety valves, primary leaks and degassing of the pressuriser.

During plant shutdown, and depending on its radiochemical characteristics, the gaseous effluent from flushing the Reactor Coolant System (RCP [RCS]) is routed to either the TEG [GWPS] or the EBA [CSVS].

During plant start-up, the collection from the Reactor Building also enables venting and filling of the primary system under vacuum.

The TEG [GWPS] is based on the system used on the German units.

The TEG [GWPS] is described in section 3 and fulfils the following functions:

- offsetting the variations in the level of cover gas in the connected tanks by bleeding or feeding the required volume of gas;
- preventing leaks of radioactive gases from connected components into the building by keeping the system under negative pressure;
- nitrogen purging of the components in which the primary coolant is degassed in order to treat the gaseous effluent;
- limiting the hydrogen content in the systems and the swept components to less than 4% volume, and the oxygen content to less than 0.1% to prevent the formation of a combustible mixture and avoid absorption of oxygen by the primary coolant, thus preventing corrosion in the primary system;
- absorbing the excess gas produced during the start-up and shutdown phases by the systems connected to the TEG [GWPS];
- hold-up of radioactive noble gases (in particular xenon and krypton) for a sufficient decay time in order to achieve an acceptable level of activity before their discharge to the environment.

1.2.2. Treatment of other gaseous effluent

The ventilation systems are described in Sub-chapter 9.4 of the PCSR.

The extracted air is treated through HEPA filters and iodine absorbers if needed.

The following provide protection for the public by reducing the level of contamination before discharge to the stack and then the environment:

- Nuclear Auxiliary Building Ventilation System (DWN [NABVS]) and low-capacity Containment Sweep Ventilation System (EBA [CSVS]): during normal operation of the unit, unit shutdown or following a fuel handling accident in the Reactor Building;

- Controlled Safeguard Building Ventilation System (DWL [CSBVS]): following a fuel handling accident in the Fuel Building or Safety Injection.

1.3. SOLID WASTE TREATMENT SYSTEMS

The treatment of solid waste is divided between the TES [SWTS] unit system and the 8TES [SWTS] located in the EPR Effluent Treatment Building [Ref-1].

1.3.1. Unit system

The TES [SWTS] unit system for treatment of solid waste is described in section 4.1.

It handles the filter replacement and the transfer of resins from the Nuclear Auxiliary Building to the EPR Effluent Treatment Building.

The filter handling machine removes the used filter and places it in a concrete enclosure.

The spent resins of the RCV [CVCS], TEP [CSTS], PTR [FPPS] and APG [SGBS] are flushed to the 8TES [SWTS] storage tanks in the Effluent Treatment Building by the 8TES [SWTS] handling system.

1.3.2. Effluent Treatment Building System

The 8TES [SWTS] system for treatment of solid waste is described in section 4.2.

It is located in the Effluent Treatment Building and treats the solid waste produced by the EPR unit(s).

It comprises effluent storage facilities and conditioning facilities.

The storage of spent ion-exchange resins includes the site manifold and two storage tanks.

The system also stores, in two tanks, the concentrates produced by the 8TEU [LWPS] evaporator.

The facility for conditioning of resins mainly involves a mobile encapsulating machine [Ref-1].

The other conditioning facilities are:

- the facility for encapsulation of filter contents and other operational radioactive waste in concrete enclosures [Ref-1];

- the facility for conditioning of sludge and concentrates;

- the installation for compacting low-activity operational waste.

2. SYSTEMS FOR TREATING RADIOACTIVE LIQUID EFFLUENTS

2.1. NUCLEAR ISLAND VENT AND DRAIN SYSTEM (RPE [NVDS]) [REF-1] TO [REF-4]

2.1.0. Safety requirements

2.1.0.1. Safety functions

The contribution of the system to the three basic safety functions is described below:

Control of reactivity

None.

Decay Heat Removal

None.

Containment of Radioactivity

The system helps to limit the retention of activity in the nuclear island buildings and to limit discharge to the environment by monitoring of activity during normal operation.

It can also perform containment penetration isolation for the RPE [NVDS] tanks and sumps of the Reactor Building.

2.1.0.2. Functional requirements

To ensure its role in basic safety functions during reactor normal operation, the system must fulfil the following functions:

- monitoring of leak-tightness of the primary system and the primary coolant inventory using means of detection, leak measurement and activity monitoring;
- limitation of discharge to the environment via recovery of all effluents and by optimisation of effluent discharge versus effluent treatment;
- monitoring of leakage via the floor drain sumps, to avoid flooding of safety classified equipment.

On detection of high levels of activity in the RPE [NVDS] sumps in the Nuclear Auxiliary Building, in the event of an accident, the drains collected in the auxiliary buildings can be re-injected into the Reactor Building for treatment at a later time. However, this function is not essential for accident management.

2.1.0.3. Design-related requirements

2.1.0.3.1. Requirements related to safety classification

Safety classification

The RPE [NVDS] is safety classified as defined in Sub-chapter 3.2 of the PCSR.

Single failure criterion (active and passive)

The single failure criterion is applied to the active components of the part of the RPE [NVDS] system that performs an F1 function.

Emergency electrical supplies

All the F1A electrical components of the system are supplied from the emergency electrical switchboards.

Qualification for operating conditions

The system equipment is specified according to its safety role and the ambient conditions to which it is subjected during fulfilment of its function.

The requirements given in Sub-chapter 3.6 of the PCSR apply to some parts of the RPE [NVDS].

Mechanical, Electrical and Control and Instrumentation classification

The system has mechanical, electrical and control and instrumentation classification in accordance with the classification set out in Sub-chapter 3.2 of the PCSR.

Seismic classification

The system is classified in accordance with Sub-chapter 3.2 of the PCSR.

Periodic tests

Periodic testing of safety functions and individual components (F1 and F2) demonstrate their availability with a sufficient degree of confidence.

2.1.0.3.2. Other regulatory requirements

Not applicable for the UK EPR.

2.1.0.3.3. Hazards

See Section 13.1.1 - Table 1 and Sub-chapter 13.2.1 - Table 1 within Chapter 13 of the PCSR, which present the lists of internal and external hazards considered for the RPE [NVDS].

2.1.1. Role of the system

The operational functions of the system are as follows:

- selective collection:
  - of the different categories of liquid and gaseous effluent defined according to the appropriate treatment method, produced by the primary system, the reactor auxiliary systems and the nuclear auxiliary systems of the nuclear island;
  - of the different categories of liquid effluent, defined according to the appropriate treatment method, produced by the decontamination facilities (e.g. showers, floor washing);
- selection of primary system effluent (hydrogenated or aerated) to recycle the boron therein as far as possible;
- channel the liquid effluent collected to the storage tanks dedicated to each effluent category, before treatment in the effluent treatment system;
- channel the gaseous effluent collected towards the appropriate treatment;
- purging of the primary system before it is opened for de-fuelling for example, and venting before and during filling after refitting of the vessel head;
- collection of effluent discharged by the safety valves of systems containing primary coolant and channelling to the primary coolant tanks.

2.1.2. Design bases

The effluents are classified into different groups depending on whether or not they can be recycled and on the appropriate treatment. They are collected according to their phase (liquid or gaseous) and their origin (process drains, chemical drains, floor drains, or primary effluents).

2.1.2.1. Recyclable liquid effluents

- Collection of primary liquid effluents

These come from the aerated or hydrogenated primary coolant and are produced mainly by the following:

- discharge of primary coolant linked to operation of the unit;
- leaks and bleeds of primary coolant;
- transfer of primary coolant;
- discharge of safety valves.

Note: Some bleeds and safety valve releases are transferred to the IRWST due to their characteristics (i.e. low activity, no need for degassing).

Improvements in design of the RPE [NVDS] enable boron recycling to be maximised.

- Transfer of primary liquid effluent

The chemical characteristics of the primary effluent enable it to be recycled in the TEP [CSTS].

Recycling of aerated primary effluent, which was habitually discharged, is an improvement in the EPR compared to previous designs.

The primary effluent transfer systems are available during the following operating phases:

  - in the Reactor Building: all operating phases including at the end of shutdown and before filling of the primary system;
  - other buildings: all the operating phases particularly during unit shutdown.

2.1.2.2. Non-recyclable liquid effluents

- Collection of effluents:
  - Process Drains (PD): these contain polluted primary coolant from flushing of systems which are not recycled because they have a low boron content and may potentially have the wrong chemical properties or too much suspended material. Generally speaking, their low pollution level means they may be treated in a different way to chemical drains;
  - Chemical Drains (CD) produced in the Nuclear Auxiliary Building: these consist of water from the REN [NSS] laboratory and the primary coolant decontamination systems that is more polluted than water from the process drains;
  - Floor Drains 1 (FD1): these are potentially contaminated and come from exceptional leaks from equipment carrying primary coolant and from floor washing. The sumps and the connected floor drains are installed in areas containing equipment transporting primary coolant;
  - Floor Drains 2 (FD2): these are slightly contaminated or uncontaminated and come from leaks, from floor washing and from the bleeding of equipment (feedwater or RRI [CCWS]). The sumps and the connected floor drains are installed in controlled areas that do not contain equipment transporting primary coolant;
  - Floor Drains 3 (FD3): these effluents are produced solely in uncontrolled zones. They are usually uncontaminated and come from bleeding of equipment (feedwater or RRI [CCWS]), from leaks and from floor washing.
- Transfer of effluents:
  - after mixing, and analysis of the corresponding relay sumps or tanks, non-recycled effluents are routed to the 8TEU [LWPS] in the Effluent Treatment Building or to the 0SEK [SiteLWDS] according to the analysis results:
    - 8TEU [LWPS] PD if effluents are active and not chemically polluted;

– 8TEU [LWPS] CD if effluents are active and chemically polluted;

– 8TEU [LWPS] FD if effluents are slightly active;

– FD3 may be sent towards the 0SEK [SiteLWDS].

The PD, CD, FD1, FD2 and FD3 transfer systems are available during all operating phases, particularly in unit shutdown.

2.1.2.3. Gaseous effluents

Gaseous primary effluent has two origins:

- Primary gaseous effluents from processes:

These gases are extracted from the primary coolant in the RPE [NVDS] primary effluent tanks in the different buildings by the TEG [GWPS] and originate from the discharge of safety valves, leaks from the primary system, permanent degassing of the pressuriser or draining of primary coolant. The gases are mainly nitrogen, hydrogen, oxygen, water vapour and radioactive noble gases (xenon, krypton and helium), and are transferred to the TEG [GWPS] by continuous nitrogen purging.

The gaseous effluent transfer system is available during all operating phases, including unit shutdown.

- Venting of effluents in the Reactor Building during shutdown and start-up:

During start-up, the primary circuit is subjected to a partial vacuum during its filling using a vacuum pump.

During shutdown the vacuum pump is used to sweep the primary circuit with nitrogen then air before opening of the closure head. During sweeping with nitrogen, any gaseous effluents are sent to the TEG [GWPS], whereas during sweeping with air, gases are sent to the EBA [CSVS].

2.1.3. System description

2.1.3.1. Description

The RPE [NVDS] system handles the following different categories of effluent collected in the various buildings (Reactor Building, Safeguard Building, Fuel Building and Nuclear Auxiliary Building):

- liquid and gaseous primary effluents;
- chemical drains;
- process drains;
- floor drains 1, 2 and 3.

The functional diagrams (see Section 11.4.2.1 - Figure 1, page 1 to page 9) are attached at the end of this sub-chapter.

The design of the RPE [NVDS] enables sorting of effluent enabling optimum treatment of each type of effluent.

The principles for the routing of effluents within the RPE [NVDS], and the rules for the channelling of effluents to the 8TEU [LWPS] are given at the end of this sub-chapter, in Section 11.4.2.1 - Figure 2.

2.1.3.1.1. Recyclable liquid effluent

Primary liquid effluent in the Reactor Building

These effluents are primary coolant originating from the following:

- leaks from the primary system (seal 2 and static seal of the reactor coolant pump);
- leaks from the inside seal of the tank;
- the degassing line of the pressuriser;
- the bleeding of the phase separator by the vacuum pump;
- discharge of safety valves;
- bleeding and venting of piping and equipment on the primary system.

These effluents are collected in the main RPE [NVDS] primary effluent tank, swept by the TEG [GWPS] system. It is degassed and cooled via a heat exchanger (to a temperature below the maximum authorised temperature for TEP [CSTS] resins). The liquid part, after cooling and filtering, is transferred to the TEP [CSTS]. The gaseous part is pumped to the TEG [GWPS].

Primary liquid effluent in the Nuclear Auxiliary Building

The following effluents are collected in a tank and swept by the TEG [GWPS] before being transferred to the TEP [CSTS] after filtering:

- bleeding of equipment and piping conveying primary coolant;
- safety valve discharge.

Safety valve discharges end up in a special device comprising wide-diameter pipes connected to the following:

- two TEP [CSTS] tanks in the upper part, to handle high flow rates (pipes filled);
- the primary effluent tank via the primary leakage measurement bottle in the Nuclear Auxiliary Building to handle low flow rates (in the event that, following a response, a safety valve does not completely close).

A safety valve, located in the upper part, protects the system from excess pressure.

Primary effluents of the Safeguard Building and Fuel Building

These tanks are mainly used during maintenance; they collect mainly RIS [SIS], EVU [CHRS] and PTR [FPPS] effluents.

2.1.3.1.2. Non-recyclable liquid effluents

It is possible, by design, to switch effluents towards the various treatment lines (filtering, demineralisation, evaporation) to enable the necessary flexibility during operation to meet to technical, environmental and economical constraints.

- Process drains

The water used to flush and decontaminate the pipes and equipment of the system that contained primary coolant (including sumps) is collected in the process drain tanks.

Most of the connections for bleeding of equipment and tanks are fixed and equipment is drained via gravity.

The process drain tanks are connected to the ventilation system and are equipped with submerged pumps.

The process drain tanks in the Safeguard Buildings and Fuel Building transfer their effluents to the relay tank which is located in the Nuclear Auxiliary Building.

Depending on the chemical characteristics of the PD relay tank and the results of a technical and economic assessment, the PDs may be transferred either to the 8TEU [LWPS] PD (for treatment on demineralisers) or to the 8TEU [LWPS] CD (for treatment in the evaporator).

- Chemical drains

The chemical drain tanks located in the Fuel Building and in the Nuclear Auxiliary Building collect the chemically polluted radioactive effluent from sampling and primary coolant decontamination systems, in particular.

The chemical drain tanks are connected to the ventilation system.

Pumps in the chemical drain tank transfer the chemical drains to the 8TEU [LWPS] CD for treatment in the evaporator.

- Floor drains 1

These effluents are potentially contaminated and are collected in the Reactor Building and the auxiliary buildings. They come from leaks and floor washing in contaminated areas in controlled zones such as:

  - uncontrolled consequences of contaminated water;
  - cleaning of potentially contaminated premises.

The sumps are equipped with submerged pumps which transfer the effluents to the relay sump in the Nuclear Auxiliary Building.

Depending upon the activity of the relay sump (compared to a pre-defined threshold), effluents are transferred either to the 8TEU [LWPS] CD (for treatment in the evaporator) or to the 8TEU [LWPS] FD (for treatment by filtering).

The effluent is collected by gravity via gutters and drains.

- Floor drains 2

These effluents are slightly contaminated or uncontaminated and are collected in the Reactor Building, the annulus space and the Nuclear Auxiliary Building. They come from bleeding of components, leaks and floor washing in slightly contaminated areas of controlled zones such as:

  - steam generator blowdown system (APG [SGBS]);
  - RRI [CCWS] exchangers;
  - rinsing and counter-current washing of APG [SGBS] resins;
  - cooling coils of the ventilation and air-conditioning systems.

The sumps are equipped with submerged pumps which pump the effluent into the relay sump in the Nuclear Auxiliary Building.

Following analysis of the contents of the relay sump, effluents are transferred to the 8TEU [LWPS] FD.

The effluents are collected by gravity via gutters and drains.

- Floor drains 3

These effluents are normally uncontaminated and are collected in the auxiliary buildings. They come from bleeding of equipment, leaks and floor washing in premises in uncontrolled zones such as:

  - emergency supply of the SG (ASG [EFWS]) pumps;
  - RRI [CCWS] pumps and exchangers;
  - VVP [MSSS].

The sumps are equipped with submerged pumps discharging into the relay sump of the Nuclear Auxiliary Building.

Following analysis of the content of the relay sump, effluents are transferred to the 0SEK [SiteLWDS] or to the 8TEU [LWPS] FD for filtering.

The effluents are collected by gravity via gutters and drains.

2.1.3.1.3. Gaseous effluents

- Venting and filling of primary circuits

Before filling of the primary system, vacuum suction is performed by start-up of the vacuum pump. The gases are transferred to the EBA [CSVS] during this phase.

The vacuum pump is also used during shutdown in order to perform the nitrogen then air sweeping of the reactor coolant system at ¾ loop. The gases are transferred to the TEG [GWPS], then to the EBA [CSVS].

- Gaseous effluents from processes

The gaseous effluents in the RPE [NVDS] primary effluent tanks are swept by the TEG [GWPS], whereas process or chemical drain tanks are connected to the ventilation system.

2.1.3.1.4. System design parameters

The design flow rate and temperature of the RPE [NVDS] are based on the maximum leak rates for drained and bled equipment.

The design temperature of the primary liquid effluent of the Reactor Building corresponds to the saturation temperature at maximum permitted pressure.

The RPE [NVDS] equipment is mainly constructed from stainless steel in accordance with the fluid characteristics of the systems which must be drained. Some of the floor drains 2 and 3 components are made of chloride resistant austenitic steel to prevent corrosion.

2.1.4. Operating conditions

2.1.4.1. Normal operation

2.1.4.1.1. Recyclable liquid effluents

- Primary liquid effluents in the Reactor Building

These effluents are collected in the Reactor Building main primary effluent tank.

They are transferred and cooled by two redundant pumps and a heat exchanger located at the discharge of the pumps.

A network of pipes and motor-driven valves downstream of the exchanger direct the liquid effluent to one of the following:

  - recirculation to the RPE [NVDS] tank, with a manual regulating valve and a motor-driven valve;
  - recirculation to the pressuriser discharge tank, via a check valve to prevent the transfer of effluents from the pressuriser to the RPE [NVDS] tank or IRWST;
  - to the TEP [CSTS] head tank, which is equipped with two lines to adjust the flow rate. The high flow rate line can be used for the draining of the pressuriser discharge tank. Each of these lines comprises a motor-driven valve and a flow-limiting diaphragm. The shared collector includes a check valve outside the Reactor Building to prevent the transfer of effluents from another tank or sump to the Reactor Building.

The temperature and level are controlled by start-up of one of the two pumps and opening or closing of the three shut-off valves on the cooling loop and on the two parallel lines routed to the TEP [CSTS] tanks (at high or low flow rate).

Transfer to the TEP [CSTS] is only possible if the temperature is below 48°C, so as to protect the TEP [CSTS] resins.

- Liquid primary effluents outside the Reactor Building

These cold effluents, which do not need further cooling, are routed to the TEP [CSTS] tanks via the relay tank in the Nuclear Auxiliary Building.

This transfer is controlled to meet level limits.

- Measurement of leaks from primary loops

The configurations of the RCP [RCS] and RCV [CVCS] systems do not allow distinction between a leak occurring on the RCP [RCS] and a leak occurring on the non-isolable part of the RCV [CVCS] in normal operation. As a result, the leaks occurring on the two RCP [RCS] and RCV [CVCS] systems are taken into account in assessing the leak tightness of the primary system.

Among the primary leaks distinction is made between:

- o quantified leaks: these leaks are collected and routed towards an identified tank and the total flow is measured and monitored;
- o un-quantified leaks: leaks that are not collected, not identified or identified without flow measurement;
- o inter-system leaks: internal leaks not collected but not detectable or directly measurable.

<u>Quantified leaks</u>

Leaks from safety valves of the systems conveying primary fluid are collected in the Reactor Building primary effluent tank and in the Nuclear Auxiliary Building dedicated tank.

They comprise normal leaks occurring during normal operation (leaks from RCP [RCS] seals) and leaks that may occur on the bleed shut-off valves, the safety valves and other shut-off components of the RCP [RCS]-RCV [CVCS] connected to the RPE [NVDS].

The leak flow rate is measurable either directly or by level increases measured in the tanks mentioned above.

<u>Un-quantified leaks</u>

By definition, these are uncollected leaks that are discharged into the containment atmosphere.

They are normally detected by an increase in the level within the floor drain 1 sump, or, with the appropriate measuring methods. They may also be detected and identified visually by the presence of boron, steam jets or low water flow rates.

<u>Inter-system leaks</u>

These include all leaks from the RCP [RCS] and RCV [CVCS] to the following:

- APG [SGBS] and CVI for leaks from SG tubes;
- RRI [CCWS] for leaks through the heat exchangers;
- RIS [SIS] for leaks through the primary shut-off valves;

- the other systems connectible by shut-off valves to the RCP [RCS] and RCV [CVCS].

They can be detected by changes in activity, temperature, pressure or level in the system receiving the leak, but cannot normally be quantified.

Total leakage

The total leakage includes the three types defined above and may be evaluated from the level decrease in the RCV [CVCS] tank.

2.1.4.1.2. Non-recyclable liquid effluents

These effluents are collected in the tank or sump dedicated to their category and are transferred to the relay tank or sump.

Evacuation to the relay sump is controlled to meet level limits.

After mixing and analysis, the content of the relay tank or sump is transferred to the appropriate treatment depending on the results of a chemical and/or radio-chemical and/or technical and economic analysis.

2.1.4.1.3. Gaseous effluents

A dedicated line enables degassing of the pressuriser at a fixed flow rate by directing the effluents in the Reactor Building main primary effluent tank for cooling and evacuation.

2.1.4.2. Transient operation

2.1.4.2.1. Cooling of the tank and discharge of the pressuriser

The Reactor Building primary effluent tank cooling loop is also designed to cool the pressuriser discharge tank following pressuriser safety valve testing.

This can only be done when the Reactor Building primary effluent tank does not require cooling or draining because its temperature and level are low enough. The sequences for switching between pressuriser discharge tank cooling operation and normal operation of the system are initiated manually with the pumps shut down.

2.1.4.2.2. Vacuum procedure for filling the primary system

After a cold shutdown for refuelling and before filling of the primary system, a vacuum pump connected to the pressuriser (and temporarily to the vent of the vessel) places the primary system in negative pressure at 200 mbar abs (preliminary value) in order to limit the venting operations (in dynamic mode by primary pumps) required after filling, and thus accelerate filling and venting of the primary system.

2.1.4.2.3. Nitrogen purging of the primary system in ¾ loop

When the level of primary system reaches ¾ loop, nitrogen sweeping is performed before opening of the vessel head.

Nitrogen is injected at the vessel vent and the casing of the primary pumps (via the seal injection line); effluents are extracted by the vacuum pump and routed to the TEG [GWPS].

Opening of the primary system is possible after final purging with air which is then sent to the ventilation system, EBA [CSVS].

2.1.5. Preliminary safety analysis

2.1.5.1. Compliance with regulations

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

2.1.5.2. Compliance with functional requirements

Faults in the RPE [NVDS] system have no impact on the safety of the nuclear steam supply system.

The system plays no part in the basic safety functions for controlling reactivity and removing decay heat.

Concerning the basic safety function for containment of radioactive materials, the system plays an active part in retention of activity in the nuclear island buildings and in limiting discharge to the environment:

- monitoring of leak tightness of the primary system and the primary coolant inventory is performed by detection of primary leaks via the primary effluent tank in the Reactor Building and using the dedicated cylinder located in the Nuclear Auxiliary Building;
- discharge to the environment is limited by recovering all effluents and by ensuring appropriate treatment methods with respect to the characteristics of the effluent collected;
- leakage is monitored by measuring the volume collected in the floor drain sumps in the Reactor Building and the auxiliary buildings;
- re-injection of effluents in the Reactor Building: in the event of an accident, the samples of contaminated fluid and the drains collected in the auxiliary buildings may be re-injected in the Reactor Building for treatment at a later time. Specific means are implemented to re-inject highly-contaminated effluents in the Reactor Building in order to cover the case of a leak from the RIS [SIS] or EVU [CHRS] in the Safeguard Building after a Loss Of Coolant Accident (LOCA).

2.1.5.3. Compliance with design requirements

Safety classification

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

Single Failure Criterion or Redundancy

The construction provisions satisfy the requirements presented in Sub-chapter 11.0 of the PCSR.

Containment isolation is achieved for each penetration by a set of two valves; one inside and one outside the containment (see Sub-chapter 6.2 of the PCSR). The containment isolation valves are powered by two different electrical divisions.

Qualification

The system equipment is specified in accordance with its safety role and the ambient conditions to which it is subjected during fulfilment of its function.

Components involved in protection against accidents are qualified in accordance with the requirements of Sub-chapter 3.6 of the PCSR.

Control and Instrumentation

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

Emergency electrical supplies

All the F1A electrical components of the system are supplied by emergency electrical switchboards.

Other requirements

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

2.1.5.4. Hazards

With the exception of the containment penetrations, the RPE [NVDS] is not required to be protected against hazards.

The protection requirement is generic for the containment penetrations.

2.1.6. Maintenance inspections and testing

System analysis will be performed to define the required periodic testing.

2.2. LIQUID WASTE PROCESSING SYSTEM (8TEU [LWPS]) [REF-1] TO [REF-6]

The 8TEU [LWPS] is installed in the Effluent Treatment Building. It is provided for storage and treatment of spent, non-recyclable liquid effluent collected by the vent and drain system (RPE [NVDS]).

2.2.0. Safety requirements

2.2.0.1. Safety functions

The contribution of the system to the three basic safety functions is described below:

Control of reactivity

None.

Decay heat removal

None.

Containment of radioactivity

Concerning the basic safety function of radioactive material containment, it has an active role in limiting discharge and protecting the environment as it enables monitoring and treatment of the liquid radioactive effluent before transfer to the 0KER [LRMDS], and thus ensures compliance with site specific discharge limits.

There are provisions for double containment and directing overflows back to the storage and treatment systems.

2.2.0.2. Functional requirements

To ensure its participation in the basic safety functions during normal operation of the unit, the 8TEU [LWPS] system must facilitate compliance with the site specific authorised liquid discharge limits.

2.2.0.3. Design-related requirements

2.2.0.3.1. Requirements related to safety classification

Safety classification

The 8TEU [LWPS] is safety classified in accordance with the classification given in Sub-chapter 3.2 of the PCSR.

Single failure criterion (active and passive)

Not applicable.

Emergency electrical supplies

Not applicable.

Qualification for operating conditions

Since the 8TEU [LWPS] is not essential for the maintenance of safety functions in post-accident operating conditions, it is not subject to any requirements concerning accident environmental qualification.

Mechanical, Electrical and Control and Instrumentation classification

The system has mechanical, electrical and Control and Instrumentation classification in accordance with the classification described in Sub-chapter 3.2 of the PCSR.

Seismic classification

The system is classified in accordance with Sub-chapter 3.2 of the PCSR.

Periodic tests

Periodic tests will be performed on safety functions and components to confirm their availability with a sufficient degree of confidence.

2.2.0.3.2. Other regulatory requirements

Not applicable for the UK EPR.

2.2.0.3.3. Hazards

See Section 13.1.1 - Table 1 and Sub-chapter 13.2.1 - Table 1 within Chapter 13 of the PCSR, which present the lists of internal and external hazards considered for the 8TEU [LWPS] system.

2.2.1. Role of the system

The 8TEU [LWPS] shared by the EPR units is provided for storage, treatment and monitoring of the non-reusable spent liquid effluent collected by the vent and drain system (RPE [NVDS]), before transfer to the discharge system (0KER [LRMDS] or exceptionally the 0TER [ExLWDS]).

The system also treats effluent from the 0TER [ExLWDS], 0KER [LRMDS] and 0SEK [SiteLWDS], if re-treatment is needed.

The 8TEU [LWPS] performs the following functions:

- in conjunction with the 8TEN (Effluent Treatment Building Sampling System, [Ref-1] to [Ref-6]), analysis of the content of each head storage tank and direction to the appropriate treatment facility;
- treatment of the spent effluent so as to achieve an acceptable quality for discharge to the environment;
- discharge of the treated effluent after monitoring;
- transfer of waste produced by treatment to the solid waste treatment system (concentrates, ion-exchanging resins, used filters, etc.).

The effluent treated by this system is classified into five categories (process drains, chemical drains, floor drains 1, 2 and 3). Its characteristics are given in section 2.1.

The purpose of the treatment is to limit discharge to the environment by:

- filtering of effluent at 5 µm;
- demineralisation of chemically clean and active effluent from the process drains;

- evaporation of effluent whose poor quality does not allow the preceding treatment (chemical drains, active floors or chemically polluted process drains), or for which the result of a technical and economic analysis shows that it is appropriate to treat effluent in an evaporator rather than with a demineraliser.

2.2.2. Design bases

The role of the 8TEU [LWPS] is to use the most suitable treatment for the characteristics of the effluent to be treated.

2.2.2.1. Categories of effluent

The spent, non-recyclable liquid effluent is categorised according to its activity and chemical properties. It comes from the vent and drain system (RPE [NVDS]) of each unit and from the EPR Effluent Treatment Building.

The effluent is divided into four categories as follows:

- Process Drains (PD)

This effluent contains polluted primary coolant from the flushing of systems; it is not recycled due to its low boron content and potential to have the wrong chemical properties, or too much suspended material. Generally speaking, the moderate pollution level means it may be treated in a different way to chemical drains.

- Chemical Drains (CD)

This effluent, produced in the Nuclear Auxiliary Building, consists of water that is more polluted than water from the process drains, the REN [NSS] laboratory and the primary coolant decontamination systems.

- Floor Drains (FD)

This effluent is from Floor Drains 1 (FD1), Floor Drains 2 (FD2) and, exceptionally, Floor Drains 3 (FD3).

The characteristics of each of these floor drains are given in section 2.1.

- TEP [CSTS] Distillates

This effluent is from the TEP [CSTS] tritiated distillates (see Sub-chapter 9.3 of the PCSR).

2.2.2.2. Treatment of effluent

Each type of effluent is characterised in terms of the presence of suspended matter, its radioactivity and chemical pollution.

<u>Details of treatment methods</u>

- Filtering

This retains materials (active or not) in suspension but has no effect on chemical composition. It thus enables reduction of the activity in insoluble form.

- Demineraliser

Treatment in a demineraliser involves passing the effluent through resin beds that fix the radioactive elements present in ionic form in the effluent. It thus retains materials (active or not) in solution, but lets boron pass through. Chemical pollution considerably reduces its life.

- Evaporator

This involves evaporating the liquid effluent and then condensing the purified distillate in order to discharge it, with the condensate constituting the treated waste. It thus concentrates the activity and chemical elements present in the treated effluent into a reduced volume. The distillate has a significantly reduced concentration of radioactive products (with the exception of tritium).

Routing of effluent

Each type of effluent can be treated in the way most suited to its characteristics.

Generally speaking, the chosen treatments are as follows:

- filtering for floor drains;
- filtering and demineralisation for chemically clean and active effluent (process drains);
- evaporation for chemical effluent and other effluent according to their chemical characteristics;
- filtering for non-radioactive chemical effluent.

However, to improve operating flexibility, the treatment paths are not fixed and routing of effluent downstream of the tanks is possible so that a range of treatment methods is available.

Only the floor drains 1 and floor drains 2 are treated by the 8TEU [LWPS]. The floor drains 3 are transferred to 0SEK [SiteLWDS] as they are normally uncontaminated; however, it is possible to transfer them to 8TEU [LWPS].

In addition, the design of the EPR enables greater recycling of primary effluent; in contrast to the aerated primary effluent in previous designs, which was considered to be process drains, aerated primary effluent can now be recycled.

The treated effluent is transferred into the 0KER [LRMDS] and 0TER [ExLWDS].

2.2.3. System description

The functional diagram is presented in Section 11.4.2.2 - Figure 1 and the functional diagram for routing effluent in the 8TEU [LWPS] can be found in Section 11.4.2.2 - Figure 2.

The system comprises the following:

- a system for storage, mixing, sampling and transfer of effluent (floor drains, process drains, chemical drains) according to its activity, towards the appropriate treatment (filtering, demineralisation or evaporation);

- a system for storage and injection of sodium hydroxide as well as an acid injection system for neutralising effluent;
- a system for transferring the distillates from the treatment by evaporation to the 0KER [LRMDS];
- a transfer line to the 0KER [LRMDS] shared by all effluent, equipped with a flow rate accumulator and an automatic activity measurement (8KRT [PRMS]) to control the effectiveness of treatment;
- a line shared by all effluent enabling it to be directed as back-up to the S tanks (0TER [ExLWDS]);
- a sampling of each type of effluent by sampling points directed towards the Effluent Treatment Building sampling system (see PCSR Sub-chapter 9.3 – section 1). The sampling is always performed after mixing of the effluent in the tank.

For each category of effluent, a tank is permanently available to receive the effluent collected by the RPE [NVDS]. The other tank is either awaiting filling, or in the mixing process or appropriate treatment, or in transfer to the 0KER [LRMDS].

2.2.3.1. Treatment of floor drains

This effluent has low levels of activity, chemical pollution and aeration. The treatment chosen is filtering.

The treatment system comprises the following:

- two head tanks (one in filling and the other in mixing/sampling then chemical adjustment if necessary);
- a pump for mixing and draining tanks;
- a large-mesh filter for mixing of tanks;
- and:
    - a line for transfer to the evaporator;
    - a line for transfer to the demineraliser;
    - a line for direct transfer to the 0KER [LRMDS] / 0TER [ExLWDS] after filtering to 5 μm.

2.2.3.2. Treatment of process drains

This effluent is active, chemically clean, aerated and borated.

The treatment system comprises the following:

- two head tanks;
- a pump;

- a large-mesh filter for mixing of tanks and a 5 μm filter downstream of the demineraliser;
- three standard demineralisers (equipped with systems for backwash and evacuation of resins to the 8TES [SWTS]); they may be equipped with the following:
  - strong high-capacity anionic or macro-porous resins;
  - strong high-capacity gel-type cationic resins;
  - mixed-bed type resins;
- a recirculation line on the treated drain tanks (recirculation of effluent through the demineraliser significantly increases the effectiveness of the treatment).

Depending on the activity and chemical characteristics of the effluent, re-routing is possible. The following alternatives exist:

- a direct transfer line after filtering (demineraliser bypass) to the 0KER [LRMDS], if the effluent has low activity and low chemical pollution;
- a line for transfer to the evaporator upstream of the demineraliser, if the effluent is active and chemically polluted.

2.2.3.3. Treatment of chemical drains

The chemical effluent is active, aerated and chemically polluted. The treatment chosen for the EPR units is treatment by the evaporator.

The distillate obtained has low salinity and low activity (it will then be discharged to the environment).

The concentrate contains almost all the activity and the majority of the salts: it is transferred to the solid waste treatment system (8TES [SWTS]) for encapsulation.

The treatment system comprises the following:

- two head tanks;
- a mixing/filtering pump;
- a pump for transfer to the evaporator;
- a line with large-mesh filter for mixing of tanks;
- a complete evaporation station;
- a single filtering line if the effluent has low chemical pollution and activity;
- a tank for collecting distillates and a line for transfer of distillates to the 0KER [LRMDS] or to the head tanks of chemical drains for possible treatment in an evaporator;
- a line for transfer of concentrates to the 8TES [SWTS].

Neutralisation of effluent in the evaporator is necessary to comply with a limit on the ratio between sodium hydroxide and constant boron concentrations (and thus avoid crystallisation of insoluble forms of boron).

A tank for preparation of sodium hydroxide, involving neutralisation of boric acid with sodium hydroxide, is designed to neutralise a chemical drain tank.

The evaporation station is equipped with the following:

- a steam-supplied heater;
- an evaporation column with counter-wash flange;
- an anti-foam station with tank and metering pump;
- a density meter for monitoring the density of concentrates;
- a heat exchanger to cool the distillates;
- a 8KRT [PRMS] probe to monitor the distillates continuously. In the event of high activity levels, the transfer of distillates to the buffer tank is suspended.

The components of the evaporation station that are at a temperature above 60°C are thermally insulated. The line for transferring concentrates to the 8TES [SWTS] is electrically trace heated and thermally insulated.

The vent from the evaporation station is connected to the iodine ventilation plant.

2.2.3.4. System design features

Components in contact with the effluent are made from stainless steel X2 Cr Ni 18 10, with the exception of the reagent injection system and the part of the evaporation station whose temperature is above 80°C and is in contact with the effluent to be treated or with the concentrates, which are made from stainless steel X2 Cr Ni Mo 17 12 2.

The tanks of the process drains, the floor drains and the chemical effluent, the demineraliser, the associated pumps and filters and the evaporation station are shielded.

No valves or measuring devices are installed in the evaporation column compartment.

Components are generally welded, to avoid leaks of contaminated fluid.

2.2.4. Operating conditions

2.2.4.1. Normal operation

2.2.4.1.1. Normal configuration

A chemical effluent tank, a floor drain tank and a process drain tank are permanently available to receive the effluent collected by the RPE [NVDS] network.

The other chemical effluent tank is either in use in the mixing process or the process of discharge to the 0KER [LRMDS] (or 0TER [ExLWDS], exceptionally), or is supplying the evaporation station or awaiting filling. It may also be treated by simple filtering before discharge to the 0KER [LRMDS].

The other process drain tank is either in use in the mixing process, the treatment by demineraliser process, the process of discharge to the 0KER [LRMDS] (or 0TER [ExLWDS], exceptionally), or the process of transfer to the evaporator, or is awaiting filling. It may also be treated by filtering alone.

The other floor drain tank is either in use in the mixing process, the process of discharge to the 0KER [LRMDS] (or 0TER [ExLWDS], exceptionally), the process of transfer to the evaporator, or transfer to the demineraliser, or is awaiting filling.

Discharge to the 0KER [LRMDS] of a chemical effluent, floor drain or process drain tank is decided after measurement of the activity level following mixing and filtering. A level of activity which is too high requires treatment by evaporation (or demineraliser for the process drains).

Treatment by the evaporator requires prior neutralisation of the contents of the tank to be treated in order to obtain a determined Na OH/H_3 BO_3 concentration ratio and thus avoid crystallisation of insoluble forms of boron.

The evaporation station operates in batches. Outside of the operating periods, this station is kept in a standby state characterised by the maintenance of a minimum temperature of 80°C and by permanent circulation of concentrates. Start-up of the station from the standby state is manual.

The distillates are cooled and transferred permanently to the buffer tank which is automatically drained to the 0KER [LRMDS] to prevent over-filling. The distillate activity is permanently monitored; if the activity is too high the discharge of distillates to the buffer tank is suspended and the evaporation station is placed on standby; the contents of this tank may be transferred to the chemical effluent head tank during filling.

The concentrates are transferred in batches and without cooling to the 8TES [SWTS]. This transfer is manual and depends on the boron content of the effluent to be treated. A density meter enables constant monitoring of the density of concentrates.

Treatment by a demineraliser comprises a recirculation phase and a phase for transfer to the 0KER [LRMDS] during which the effluent activity is permanently monitored. If the activity is too high, the transfer to the 0KER [LRMDS] is automatically suspended and the effluent is recycled for operation in recirculation to the demineralisers.

The 0KRT [PRMS] line located on the line for discharge to the 0KER [LRMDS] closes the 8TEU [LWPS] discharge valve and stops the pumps in discharge configuration if activity levels are too high.

2.2.4.1.2. Man-machine interface

All the following information is displayed in the Effluent Treatment Building control room:

- level of all tanks;
- position of all valves of the evaporation station.

All the alarms are provided in the Effluent Treatment Building control room.

High levels in the head storage tanks trigger an individual alarm in the control room.

2.2.4.2. Transient operation

When the chemical effluent tank to be treated by evaporation contains detergents, anti-foam injection is performed on the upper part of the evaporation column.

2.2.5. Preliminary safety analysis

2.2.5.1. Compliance with regulations

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

2.2.5.2. Compliance with functional requirements

Faults in the 8TEU [LWPS] have no impact on the safety of the nuclear steam supply system.

The system plays no part in the basic safety functions of controlling reactivity and decay heat removal.

Concerning the basic safety function of radioactive material containment, it has an active role in limiting discharge and protecting the environment since it enables monitoring and treatment of the liquid radioactive effluent before transfer to the 0KER [LRMDS].

Activity discharged to the environment is limited by filtering of all effluent at 5 µm and by the use of treatment (filtering, demineralisation, evaporation) appropriate to the characteristics of the effluent.

2.2.5.3. Compliance with design requirements

Safety classification

The compliance of design and manufacture of components with requirements derived from classification rules is detailed in Sub-chapter 3.2. The system is not safety or seismically classified. Its failure does not cause any gaseous radioactive discharge or contamination of the water table.

Single Failure Criterion or Redundancy

The construction provisions satisfy the requirements presented in Sub-chapter 11.0 of the PCSR.

Qualification

The 8TEU [LWPS] does not require qualification for accident conditions.

Control and Instrumentation

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

Emergency electrical supplies

Not applicable.

2.2.5.4. Hazards

The 8TEU [LWPS] is not required to be protected against hazards.

2.2.6. Maintenance, inspection and testing

The system is not subject to periodic testing.

Provision for inspection and maintenance takes into account the need to check the system performance and the effectiveness of effluent treatment.

2.3. NUCLEAR ISLAND LIQUID EFFLUENT MONITORING AND DISCHARGE SYSTEM (0KER [LRMDS]) [REF-1]

The 0KER [LRMDS] is a site system.

2.3.0. Safety requirements

2.3.0.1. Safety functions

The contribution of the 0KER [LRMDS] to the three basic safety functions is described below:

Control of reactivity

None.

Decay heat removal

None.

Containment of radioactivity

Concerning the basic safety function for containment of radioactive substances, it plays an active part in ensuring containment and monitoring of liquid radioactive discharge to the environment. In addition, it protects the public from exposure to radiation.

There are provisions for double containment and directing overflows back to the storage and treatment systems.

2.3.0.2. Functional requirements

The effluent monitoring and discharge systems enable compliance to be demonstrated with the site specific authorised discharge limits.

2.3.0.3. Design-related requirements

2.3.0.3.1. Requirements related to safety classification

Safety classification

The system is safety classified in accordance with the classification given in Sub-chapter 3.2 of the PCSR.

Active and passive single failure criterion

Not applicable.

Emergency electrical supplies

Not applicable.

Qualification for operating conditions

Since the 0KER [LRMDS] is not essential for the maintenance of safety functions in post-accident operating conditions, it is not subject to any requirements for environmental qualification.

Mechanical, Electrical and Control and Instrumentation classification

The collectors have mechanical, electrical and Control and Instrumentation classification in accordance with the classification described in Sub-chapter 3.2 of the PCSR.

Seismic classification

The system is classified in accordance with Sub-chapter 3.2 of the PCSR.

Periodic tests

There is no requirement for periodic tests. The normal use of the system prevents periodic tests, or they are treated according to the 0KRT [PRMS] periodic test procedure.

2.3.0.3.2. Other regulatory requirements

Official texts, laws, orders and decrees

Not applicable for the UK EPR.

2.3.0.3.3. Hazards

See Section 13.1.1 - Table 1 and Sub-chapter 13.2.1 - Table 1 within Chapter 13 of the PCSR, which present the lists of internal and external hazards considered.

2.3.1. Role of the system

This section describes the existing extended system which is relevant to the EPR.

The 0KER [LRMDS] collects liquid radioactive effluent from the nuclear island of each unit and from certain site facilities, monitors and accounts for its activity and its chemical and physical composition, and discharges it in a controlled fashion to the environment via the sea outlet.

The flow rate of the discharge to the environment depends on the level of activity of the effluent and the dilution capacity of the environment, so as to meet the limits set by discharge authorisation.

The various functions are as follows:

- storage for control of the activity and recording of the volume of effluent from the various 0KER [LRMDS] upstream systems;
- monitored discharge to the environment via a dilution system.

Monitoring and recording procedures before discharge (see PCER Chapter 7) check compliance with regulations (water uptake and effluent discharge orders).

In the event of pollution of the 0KER [LRMDS] tanks, it is possible to treat the contents by transferring them via the 0TER [ExLWDS] to the 8TEU [LWPS] in the EPR Effluent Treatment Building.

2.3.2. Design bases

The effluent collected comes from:

- the spent effluent treatment system (8TEU [LWPS]):
  - the process drains after demineralisation;
  - the floor drains after filtering;
  - the distillates of chemical effluent after evaporation;
  - emptying after filtering of the head tanks if the effluent activity permits (process drains, floor drains, chemical effluent);
  - stored distillates from the TEP[CSTS];
- the bleed from the steam generators, when it are not recycled to the condenser after treatment;
- hot laundry.

The system complies with regulations on liquid radioactive discharges, specifically in terms of monitoring and recording of the discharged activity which is performed after mixing.

The 0KER [LRMDS] discharge system enables the following:

- sufficient dilution to comply with volume concentration calculated at 500 m from the sea discharge point as a daily average;
- rapid draining of tanks containing only low-activity bleed from the APG [SGBS] and not requiring pre-dilution by a factor of 500 before discharge;

- flow proportional sampling during discharge.

All effluent collected in the 0KER [LRMDS] is filtered in each system to 5 µm except for the APG [SGBS] where filtering is to 25 µm.

2.3.3. System description

Section 11.4.2.3 - Figure 2 shows the 0KER [LRMDS] collectors.

2.3.3.1. General description

Storage tanks

The system is composed of storage tanks, which are designed to store the effluent produced by the number of units needed for the site chosen for the UK EPR (2 or 4).

Collectors

The EPR system comprises three effluent collection systems comprising the following:

- pipes to which the tapping of the 8TEU [LWPS] in the Effluent Treatment Building is connected;
- pipes collecting bleed from the APG [SGBS];
- pipes collecting effluent from the hot laundry.

2.3.3.2. System design features

Storage tanks

The storage tanks are made from concrete.

Collectors

The collectors are made from stainless steel.

2.3.4. Preliminary safety analysis

2.3.4.1. Compliance with regulations

The system complies with general regulations in force.

2.3.4.2. Compliance with functional requirements

The 0KER [LRMDS] plays no part in the basic safety functions for controlling reactivity and decay heat removal.

The system fulfils the basic safety function of containment of radioactivity by ensuring containment and control of liquid radioactive discharge to the environment.

2.3.4.3. Compliance with design requirements

2.3.4.3.1. Storage tanks

The storage tanks installed for the EPR site satisfy the requirements described below.

2.3.4.3.2. Collectors

The collectors installed for the EPR site satisfy the requirements described below.

Safety classification

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

Single Failure Criterion or Redundancy

The design satisfies the requirements presented in Sub-chapter 11.0 of the PCSR.

Qualification

The 0KER [LRMDS] is not subject to any requirement for qualification for accident conditions.

Control and Instrumentation

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

Emergency electrical supplies

Not applicable.

Hazards

The equipment is designed in accordance with the requirements described in Chapter 13 of the PCSR.

2.3.5. Functional flow diagrams

Section 11.4.2.3 - Figure 2 shows the 0KER [LRMDS] collectors.

2.4. RESIDUAL LIQUID EFFLUENT SYSTEM (0TER [EXLWDS]) [REF-1] [REF-2]

The 0TER [ExLWDS] is a site system.

2.4.0. Safety requirements

2.4.0.1. Safety functions

The contribution of the 0TER [ExLWDS] to the three safety functions is described below:

Control of reactivity:

None.

Decay heat removal:

None.

Containment of radioactivity:

In terms of the basic safety function of containment of radioactivity, the system plays an environmental protection role by constituting an additional storage reserve for the radioactive effluent requiring storage during exceptional situations.

There are provisions for double containment and directing overflows back to the storage and treatment systems.

2.4.0.2. Functional requirements

The effluent monitoring and discharge systems enable compliance with site specific authorised discharge limits for liquid effluent.

2.4.0.3. Design requirements

2.4.0.3.1. Requirements related to safety classification

Safety classification

The collectors are safety classified in accordance with the classification given in Sub-chapter 3.2 of the PCSR.

Active and passive single failure criterion

Not applicable.

Emergency electrical supplies

Not applicable.

Qualification to operating conditions

Since the 0TER [ExLWDS] is not essential for the maintenance of safety functions in post-accident operating conditions, it is not subject to any requirements for qualification for accident conditions.

Mechanical, Electrical and Control and Instrumentation classification

The system has mechanical, electrical and Control and Instrumentation classification in accordance with the classification described in Sub-chapter 3.2 of the PCSR.

Seismic classification

It is classified in accordance with Sub-chapter 3.2 of the PCSR.

Periodic tests

There is no requirement for periodic tests. The normal use of the system prevents periodic tests or they are treated according to the 0KRT [PRMS] periodic test procedure.

2.4.0.3.2. Other regulatory requirements

Official texts, laws, orders and decrees

Not applicable for the UK EPR.

2.4.0.3.3. Hazards

See Section 13.1.1 - Table 1 and Sub-chapter 13.2.1 - Table 1 within Chapter 13 of the PCSR, which present the lists of internal and external hazards considered for the EPR.

2.4.1. Role of the system

This system is normally not used. It is kept empty in reserve.

This system may be used exceptionally, when, for example:

- dilution in the natural environment cannot be performed by normal discharge methods due to the unavailability of the 0KER [LRMDS] or 0SEK [SiteLWDS] tanks;
- an unexpected operating incident disrupts the normal operation of a unit preventing direct discharge via normal means.

The role of the 0TER [ExLWDS] is thus to store the site liquid radioactive effluent:

- either to re-treat it using the 8TEU [LWPS];
- or to discharge it later to the environment.

In the event of pollution of the 0TER [ExLWDS] tanks, it is possible to treat the contents by transferring them to the 8TEU [LWPS].

2.4.2. Design bases

These storage capacities are used only during exceptional circumstances in the following situations:

- complete unavailability of the 0KER [LRMDS];

- complete unavailability of the 0SEK [SiteLWDS]; and
- complete saturation of the 8TEU [LWPS] head tanks; and
- the need to drain a high-volume capacity (for maintenance or in the event of failure) containing effluent which cannot be discharged via normal means. These are a PTR [FPPS] tank, RCV [CVCS] tanks for water make-up of the primary system; and
- high activity of effluent from the turbine building which is normally discharged by the 0SEK [SiteLWDS]; and
- difficulties in discharge of effluent to the environment.

2.4.3. System description

Section 11.4.2.4 - Figure 1 presents an outline of the 0TER [ExLWDS] collectors.

The EPR system comprises the following:

- Storage tanks which are designed to store the effluent produced by the number of units needed for the site chosen for the UK EPR (2 or 4);
- a collector that collects effluent from the APG [SGBS], PTR [FPPS], and SEK [CILWDS] via a connector that can be disassembled;
- a collector that collects effluent from the 8TEU [LWPS], 0KER [LRMDS] and 0SEK [siteLWDS];
- a collector to transfer effluent for re-treatment to the EPR 8TEU [LWPS].

Discharge is via the 0KER [LRMDS] discharge line which is equipped with a flow proportional sampling device.

System material

The collectors installed for the EPR are made from stainless steel.

2.4.4. Preliminary safety analysis

2.4.4.1. Compliance with regulations

The system complies with general regulations in force.

2.4.4.2. Compliance with functional requirements

The 0TER [ExLWDS] plays no part in the basic safety functions for controlling reactivity and decay heat removal.

The system fulfils the basic safety function of containment of radioactivity by providing additional storage for radioactive effluent needing to be stored during exceptional situations.

Discharge is via a discharge line of the 0KER [LRMDS].

2.4.4.3. Compliance with design requirements

The collectors installed for the EPR site satisfy the requirements described below.

Safety classification

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

Single Failure Criterion or Redundancy

The design satisfies the requirements presented in Sub-chapter 11.0 of the PCSR.

Qualification

The 0TER [ExLWDS] is not required to be qualified for accident conditions.

Control and Instrumentation

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

Emergency electrical supplies

Not applicable.

Hazards

The equipment is designed in accordance with the requirements described in Chapter 13 of the PCSR.

2.4.5. Functional flow diagram

Section 11.4.2.4 - Figure 1 shows the 0TER [ExLWDS] collectors.

2.5. SYSTEM FOR COLLECTION, MONITORING AND DISCHARGE OF WASTE FROM THE CONVENTIONAL ISLAND (0SEK [SITELWDS]) [REF-1] TO [REF-3]

The 0SEK [SiteLWDS] is a site system.

Collection in the EPR unit performed by the SEK [CILWDS] is backed up by the 0SEK [SiteLWDS] site system including storage and discharge. The 0SEK [SiteLWDS] site system is the subject of this section.

2.5.0. Safety requirements

2.5.0.1. Safety functions

The 0SEK [SiteLWDS] has no direct safety role.

2.5.0.2. Functional requirements

The effluent monitoring and discharge systems enable demonstration of compliance with the site specific authorised discharge limits.

2.5.0.3. Design requirements

2.5.0.3.1. Requirements related to safety classification

Safety classification

The system is safety classified in accordance with Sub-chapter 3.2 of the PCSR.

Active and passive single failure criterion

Not applicable.

Emergency electrical supplies

Not applicable.

Qualification for operating conditions

Since the 0SEK [SiteLWDS] is not essential for the maintenance of safety functions in post-accident operating conditions, it is not subject to any requirements concerning accident environmental qualification.

Mechanical, electrical and Control and Instrumentation classification

The collectors have mechanical, electrical and Control and Instrumentation classification in accordance with the classification described in Sub-chapter 3.2 of the PCSR.

Seismic classification

The effluent handled by the system has nil or negligible activity. The 0SEK [SiteLWDS] is not designed to withstand an earthquake.

The collectors are classified in accordance with Sub-chapter 3.2 of the PCSR.

Periodic tests

Not applicable.

2.5.0.3.2. Other regulatory requirements

Official texts, laws, orders and decrees

Not applicable for the UK EPR.

2.5.0.3.3. Hazards

See Section 13.1.1 - Table 1 and Sub-chapter 13.2.1 - Table 1 within Chapter 13 of the PCSR, which present the lists of internal and external hazards considered for the EPR.

2.5.1. Role of the system

This section describes the existing extended system relevant to the EPR.

The role of the system is as follows:

- to collect waste water from the following:
  - sumps in the uncontrolled area of the plant; and
  - systems in the turbine hall and the auxiliary buildings which may be slightly contaminated in the event of primary/secondary leaks in the steam generators;
- to record the volume of effluent received and monitor its level of activity; and
- to discharge this effluent to the environment.

Monitoring and recording procedures before discharge (see PCER Chapter 7) check compliance with regulations and discharge authorisations.

In the event of pollution of the 0SEK [SiteLWDS] tanks, it is possible to treat the contents by transferring them via the 0TER [ExLWDS] to the 8TEU [LWPS] in the EPR Effluent Treatment Building.

2.5.2. Design basis

The SEK [CILWDS] comprises unit systems (collection, filtering, degreasing and discharge of effluent).

The 0SEK [SiteLWDS] comprises a site installation shared by all units (storage, monitoring and discharge).

Discharge of the effluent to the environment is performed after monitoring the volume and activity of effluent. The discharge line is notably equipped with a flow proportional sampling device.

In the event of unavailability of the site installation or abnormal contamination of effluent, the effluent can be routed to the 0KER [LRMDS] or possibly to the 0TER [ExLWDS].

2.5.3. System description

Section 11.4.2.5 - Figure 1 shows the 0SEK [SiteLWDS] collectors.

2.5.3.1. Description

<u>Storage tanks</u>

The system is composed of storage tanks, which are designed to store the effluent produced by all the site units.

<u>Collectors</u>

The EPR system comprises a collector that collects RPE [NVDS] FD3 and SEK [CILWDS] turbine hall effluent.

2.5.3.2. Component materials

Storage tanks

The storage tanks are made from concrete.

Collectors

The collectors installed for the EPR are made from stainless steel.

2.5.4. Preliminary safety analysis

2.5.4.1. Compliance with regulations

The system complies with regulations in force.

2.5.4.2. Compliance with functional requirements

The 0SEK [SiteLWDS] has no direct safety role.

2.5.4.3. Compliance with design requirements

2.5.4.3.1. Storage tanks

The storage tanks installed for the EPR satisfy the requirements described below.

2.5.4.3.2. Collectors

The collectors installed for the EPR satisfy the requirements described below.

Safety classification

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

Single Failure Criterion or Redundancy

The design provisions satisfy the requirements presented in Sub-chapter 11.0 of the PCSR.

Qualification

The 0SEK [SiteLWDS] is not required to be qualified for accident conditions.

Control and Instrumentation

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

Emergency electrical supplies

Not applicable.

Hazards

The effluent handled by this system has nil or negligible activity. This system therefore requires no shielding. It is not designed to withstand an earthquake.

Leak tightness is ensured by welded design.

In order to satisfy discharge requirements, Control and Instrumentation is provided to prevent any system alignment error that might cause an uncontrolled discharge or an inadvertent mixing of effluent.

2.5.4.4. Functional flow diagram

Section 11.4.2.5 - Figure 1 represents the 0SEK [SiteLWDS] collectors.

2.6. INTER-STAGE REFRIGERATION CIRCUITS (RRI [CCWS] AND TRI)

The TRI (Effluent Treatment Building closed cooling water system [Ref-1] to [Ref-6]) cools the condensation and heat exchangers of the 8TEU [LWPS] evaporation distillates and certain 8TEU [LWPS] pumps. The RRI [CCWS] provides cooling for the nuclear vent and drain system (RPE [NVDS]) heat exchanger.

The water in these systems circulates within a closed circuit and is used to cool circuits carrying radioactive liquids. In normal operation these circuits are not contaminated. The global gamma activity is measured continuously, and an alarm in the control room informs the operator in the case of any failure of the barrier between the radioactive circuit and the RRI [CCWS] or TRI circuits, to enable the operator to isolate the leaking equipment.

If the RRI [CCWS] or TRI circuits are contaminated and the leak occurs at the junction with the untreated water circuit (extremely unlikely, requiring several simultaneous failures), the operator is alerted by the fall in the level of the buffer tank. The faulty heat exchanger is isolated immediately.

3. GASEOUS WASTE PROCESSING SYSTEM (TEG [GWPS]) [REF-1] TO [REF-7]

3.0. SAFETY REQUIREMENTS

3.0.1. Safety functions

The contribution of the system to the three basic safety functions is described below:

Control of reactivity

None.

Decay heat removal

None.

Containment of radioactivity

The system contributes to the retention of activity and limitation of discharge to the environment during normal operation of the plant.

It has the means to isolate the containment penetrations for the purging lines upstream and downstream of the pressuriser relief tank and the reactor coolant drain tank inside the Reactor Building.

In the event of an accident, the TEG [GWPS] contributes to minimisation of radiological releases.

3.0.2. Functional requirements

The TEG [GWPS] system contributes to the following functions:

- containment of radioactivity and limitation of discharge to the environment during normal operation of the plant;
- containment isolation;
- minimisation of radiological releases in the event of an accident.

The system must allow xenon decay for at least 40 days and krypton for 40 hours before discharge.

The functional requirements associated with the safety function of the containment isolation valves are discussed in Sub-chapter 6.2 of the PCSR.

3.0.3. Design-related requirements

3.0.3.1. Requirements arising from safety classification

Safety classification

The TEG [GWPS] system is safety classified in accordance with the classification given in Sub-chapter 3.2 of the PCSR.

Active and passive single failure criterion

The single failure criterion is applied to the active components of the parts of the system that perform an F1A function.

Emergency electrical supplies

All the F1A electrical components are supplied by emergency electrical switchboards.

Qualification to operating conditions

Since the TEG [GWPS] system is not essential for the maintenance of safety functions in post-accident operating conditions, it is not required to be qualified for accident conditions (except for the containment isolation valves).

Mechanical, Electrical and Instrumentation and Control classification

The system has mechanical, electrical and instrumentation and control classification in accordance with the classification described in Sub-chapter 3.2 of the PCSR.

Seismic classification

The system is classified in accordance with Sub-chapter 3.2 of the PCSR.

Periodic tests

Periodic tests are performed on safety functions and their components (F1 and F2) to monitor their availability with a sufficient degree of confidence.

3.0.3.2. Other regulatory requirements

No additional requirements.

3.0.3.3. Hazards

See Section 13.1.1 - Table 1 and Sub-chapter 13.2.1 - Table 1 within Chapter 13 of the PCSR, which present the lists of internal and external hazards considered for the systems.

3.1. ROLE OF THE SYSTEM

Gaseous fission products are generated in the core, including nuclides of xenon and krypton. In particular, a higher fraction of these gases is released into the primary coolant in the event of a defect in the fuel cladding.

Hydrogen is added to the primary coolant via the RCV [CVCS] to control the oxygen in the primary system and thus avoid corrosion.

Since these gases are dissolved in the primary coolant, they are transported to the other systems during fluid transfers.

Given the explosive nature of hydrogen in the presence of oxygen and the radioactivity of the gaseous fission products, the presence of these gases in the various auxiliary systems must be limited. The TEG [GWPS] ensures that these limits are met.

The TEG [GWPS] system performs the following functions:

- it offsets the variations in free gas volume in the tanks caused by liquid transfers into or out of the tanks;
- it contains the radioactive gases by keeping parts of the system under a negative pressure;
- it performs nitrogen purging, and treats the gaseous effluent resulting from the degassing of the primary coolant effluents in the tanks;

- it limits the hydrogen content in the system and in the connected components to 4% by volume to avoid formation of an ignitable mixture, and limits oxygen content to 0.1% by volume to minimise the corrosion effect in the primary system. After recombination, the concentration in the purging gas is lower than 0.3% by volume for hydrogen and 0.1% by volume for oxygen;

- it manages the excess gas produced in the connected system during reactor transients;

- it retains the noble gases during the decay phase to meet authorised limits on discharge to the environment.

Only the containment isolation valves on the purge lines of the pressuriser relief tank and the reactor coolant drain tank of the Reactor Building (RPE [NVDS] system in the Reactor Building) and the motorised valves located on the TEG [GWPS] lines connected to EBA [CSVS] fulfil a safety function. The containment isolation valves are automatically closed by signals from the reactor protection system.

3.2. DESIGN BASES

The system is designed for all normal reactor operating transients.

The various systems connected to the TEG [GWPS] are mainly tanks with variable free volume. In consequence, the TEG [GWPS] fulfils two main functions:

- offsets the variations in free gas volume in the connected tanks and vessels by transferring the corresponding volume in or out;

- performs nitrogen purging, and treats the gaseous effluents resulting from the degassing of the primary coolant effluents in the tanks.

The basic functional requirements are to:

- contain the radioactive gases in the connected systems and tanks; this is ensured by extraction and treatment of the gases resulting from the degassing of the primary coolant effluents and maintaining the major part of the system under a negative pressure;

- minimise discharges of gas to the environment by a closed-loop operation in which purging nitrogen is reused after reduction of the hydrogen and oxygen content to a maximum of 0.3% by volume for hydrogen and 0.1% by volume for oxygen;

- control the purging gas flow rate of the primary system during nitrogen sweeping in ¾ loop configuration (during plant shutdown);

- limit the oxygen content in the system to less than 0.1% by volume to avoid absorption of oxygen by the primary coolant which would cause corrosion in the primary system;

- limit the hydrogen content in the system to less than 4% by volume to prevent formation of an ignitable mixture with oxygen (flammability limit is 4% H_2 and 5% O_2);

- effectively reduce hydrogen and oxygen content in the purging gas by use of a catalytic recombiner unit;
- sufficiently delay the radioactive gases (xenon, krypton) before discharging them to the Nuclear Auxiliary Building Ventilation System (DWN [NABVS]);
- increase pressure in the delay beds to increase the storage capacity of the delay line;
- use activated charcoal to delay the noble gases and reduce the required volume of the delay line.

3.3. SYSTEM DESCRIPTION

3.3.1. General description

The system comprises two functional assemblies; the treatment assembly and the hold-up assembly. The main components of the system are installed in the Nuclear Auxiliary Building.

These functional assemblies are shown on the functional flow diagrams (see Section 11.4.3 - Figure 2):

- assembly for gas preparation recombination and compression of gaseous effluent (pages 3, 4 and 5);
- distribution and collection networks (pages 1, 2 and 6);
- delay line (page 7).

A simplified diagram of the TEG [GWPS] system is attached at the end of the sub-chapter (see Section 11.4.3 - Figure 1).

3.3.1.1. Treatment plant

The treatment plant comprises several sub-systems, described below:

Purging sub-system

The main gas sources (tanks and vessels) connected to the TEG [GWPS] are as follows:

- the pressuriser discharge tank (RCP [RCS]);
- the volume control tank (RCV [CVCS]);
- the Reactor Building primary coolant drain tank (RPE [NVDS]);
- the primary effluent drain tanks inside the Safeguard Buildings and Fuel Building (RPE [NVDS]);
- the Nuclear Auxiliary Building primary effluent tank (RPE [NVDS]);
- the primary effluent storage tanks (TEP [CSTS]);

- the boric acid column (TEP [CSTS]);
- the low- and high-capacity degassers (TEP [CSTS]);
- the boric acid storage tanks (REA [RBWMS]);
- the sample feeding tank (REN [NSS]);
- vents of the primary system during approach to shutdown (RPE [NVDS] in the Reactor Building).

Hydrogen and radioactive gases are degassed in the connected components.

All the tanks except the boric acid storage tanks (REA [RBWMS]) are permanently swept by the TEG [GWPS].

The purging lines are under a negative pressure to contain the gases in the system.

Gas preparation sub-system

The purging gas is dried in a dryer (heat exchanger cooled by the chilled water system (DER)).

Condensate is drained to the RPE [NVDS] system.

A floating ball valve protects the recombiner unit from rising liquid water in the system.

Hydrogen and oxygen are injected, via redundant control valves, to obtain stoechiometric conditions before recombination. For each group of redundant valves, only one is involved in control at a time.

Nitrogen is injected by a control valve when the negative pressure drops too low.

Measurement of the hydrogen and oxygen content upstream of the recombiner unit is performed by sampling the main gas flow by two of the three compressors, with the third on standby. The gas is dried in a dryer. The hydrogen and oxygen concentrations in the gas are measured in redundant cabinets.

Flame suppressers, made up of several energy-absorbing deflectors, protect the other parts of the system in the event of explosion.

Recombination sub-system

The recombiner unit is catalytic.

The formation of water from hydrogen and oxygen begins at ambient temperature in the presence of a catalyst.

Since humidity can impair the efficiency of the catalyst, three heaters maintain a sufficiently high temperature in the recombiner to avoid condensation of water.

The water vapour produced by the recombination of hydrogen and oxygen is condensed in a gas cooler downstream of the recombiner.

Monitoring of combustion of hydrogen and oxygen is performed by the H_2/O_2 measuring cabinets after the gas passes through the measuring gas dryer.

The hydrogen and oxygen content is thus kept below the authorised limits to avoid explosion risk. However, additional flame inhibitors are installed upstream and downstream of the recombiner unit and the H_2/O_2 measuring system, each of them comprising several energy-absorbing deflectors establishing additional explosion protection.

Gaseous effluent compression sub-system

There are redundant compressors.

The compressors are liquid ring compressors (liquid-sealed and encased-rotor type).

As it recirculates in the pump, the sealing fluid (demineralised water) acts as a seal between the pump vanes and the casing. It also lubricates the units and cools the motor.

This type of compressor is able to pump and compress a mixture of oxygen and hydrogen without risk of explosion due to the absence of hot spots (e.g. bearings). The compressor is not sensitive to cavitation; compression is performed without pressure pulsing and with a low noise level.

Furthermore, a high degree of leak tightness is achieved by the encased rotor design.

The sealing fluid and the gas are separated in a separation tank. The sealing fluid is recycled to the compressor after cooling in a heat exchanger.

Gas distribution sub-system

The gas is dried in a pre-dryer and condensate is transferred to the RPE [NVDS] via the collection tank.

Reducing station 1 maintains the pressure at 9 bar absolute in the pressurised section of the system back pressure regulator. Depending on the operating mode of the TEG [GWPS], the compressed gas is expanded and dried in the reducing station 1. There is redundancy between the control valves, with only one operating at a time in the control loop.

Reducing station 2 keeps the pressure at 0.8 bar absolute in the negative pressure section of the system. If the pressure rises or falls, the reducing station 2 closes or opens. At the same time, the pressure monitoring point located in the TEP [CSTS] tanks enables injection of nitrogen, if the pressure falls too low. There is redundancy between the control valves; only one valve is active in the control loop at any one time.

Reducing station 4 maintains a constant purge flow rate to the pressuriser discharge tank in the Reactor Building.

Reducing station 5 maintains a constant purging flow rate to the RPE [NVDS] reactor coolant drain tank in the Reactor Building.

Reducing station 6 maintains a constant purging flow rate in the RCV [CVCS] volume control tank.

Reducing station 7 maintains a constant pressure in the volume control tank RCV [CVCS].

3.3.1.2. Delay sub-system

The delay sub-system is comprised of two sections, described below:

Drying section

The delay beds require the gas to be dry.

Depending on the system operating mode, the gas is dried, either by adiabatic expansion when it passes through reducing station 1 or in the desiccator.

The desiccator is made from austenitic steel and filled with silica gel.

Humidity is removed from the gas flow by reversible absorption on the surface of the silica gel.

Redundant humidity measurements are installed upstream of the delay beds to monitor drying by reducing station 1 or the desiccator.

Delay line section

The delay line comprises three delay beds connected in series.

These are filled with activated charcoal, whose role is to reduce the radioactivity in the gas passing through the delay beds by delaying the noble gases (xenon, krypton).

The noble gases are delayed in relation to the carrier gas (nitrogen) by dynamic adsorption on the surface of the activated carbon. The delay is more than sufficient to ensure decay of the noble gases (xenon and krypton) in the delay line.

The radioactivity of the gas is measured and recorded at the inlet and outlet of the delay line as well as at the stack.

The effectiveness of the delay line can be confirmed by comparing the values recorded for the gaseous local samples upstream, in the middle and downstream of the delay line.

The function of the filter downstream of the delay beds is to protect the control valves of reducing station 3 from the dust particles that may result from mechanical abrasion when the beds are filled with activated carbon.

Reducing station 3 acts in two different ways depending on the operating mode. In steady state operation, it maintains the pressure at 1.5 bar absolute in the delay line. In operation with excess gas, it closes to increase the pressure in the delay line up to 9 bar absolute. At the end of the gas excess mode, the pressure is decreased until the normal pressure of 1.5 bar absolute is reached.

3.3.2. Design features

3.3.2.1. Treatment assembly

Purging lines

The design flow rate for the purging lines is based on the maximum quantity of hydrogen arising from degassing of the tanks and vessels swept, as well as on the maximum flow rate during excess gas operation.

Recombiner unit

The recombiner unit is designed to treat the maximum flow rate of purging gas with a maximum concentration of 4% by volume of hydrogen and 2% by volume of oxygen.

The volume of the catalyser depends on its type and on the maximum flow rate. The catalyser comprises spheres formed from a substrate coated with a catalyst film.

The catalyst is designed for a plant life of 60 years.

Although the reaction begins at ambient temperature, the catalyst is heated to 100°C by the heaters to ensure its proper operation. The heating prevents humidity from condensing on the catalyst. Condensation could reduce the effectiveness of the recombiner unit.

A hydrogen/oxygen ratio of 2.05:1 is maintained by regular injection of oxygen and hydrogen upstream of the recombiner unit. The excess hydrogen ensures complete conversion of the oxygen. The hydrogen and oxygen injection valves are inter-locked against each other to prevent simultaneous injection of oxygen and hydrogen.

After recombination, the concentration in the purging gases is lower than 0.3% by volume for hydrogen and 0.1% by volume for oxygen.

Compressors

The compressor design flow rate is based on the maximum quantity of hydrogen resulting from degassing of the tanks and vessels swept as well as on the maximum flow rate during excess gas operation. Simultaneous operation of the two compressors is possible.

The compressors are encased-rotor and water-seal type. This compressor type features a leak tight seal to outside.

3.3.2.2. Delay assembly

The noble gases (xenon and krypton) are retained in a delay line by dynamic adsorption until radioactive decay allows discharge via the stack.

The activated charcoal is designed for a plant life of 60 years.

The aerosols, iodides and tritium are mainly retained in the liquid phase upstream of the activated carbon beds (on the coolers and in the compressors). They are therefore not taken into account in the design of the hold-up system.

The required mass of activated carbon depends on the following:

1. the required delay for the xenon and the krypton;
2. the gas flow rate for the following modes of operation of the TEG [GWPS] operation:
    - o stable operation;
    - o operation with excess gas;
3. the temperature;
4. the pressure;

5. the humidity of the gas and the activated carbon in operation.

3.3.3. Fluid properties

Purging lines

The main TEG [GWPS] fluid is nitrogen.

The purging gas upstream of the connected components has the following properties:

- oxygen content of < 0.1% by volume;
- nitrogen content of > 96% by volume.

Purging of the connected components, depending on the role of the component, leads to removal of the following gases: hydrogen, oxygen, water vapour and noble gases (xenon, krypton and helium).

Cooling fluid

The temperature of the cooling fluid at the entrance to the TEG [GWPS] coolers and dryers is approximately 6°C to dry the gas. The DER system provides the necessary cold water.

Gas supply

The TEG [GWPS] requires supply of some gases:

- nitrogen, to control negative pressure;
- hydrogen, to recombine oxygen in the effluent;
- oxygen, to recombine hydrogen in the effluent.

3.4. OPERATING CONDITIONS

3.4.1. Normal system operation

The system is designed for all normal transients of the unit.

The system operates in two modes:

- steady-state operation (99% of annual operating time);
- operation with excess gas (see section 3.4.2.1, below):
    - o excess water due to thermal expansion of the primary coolant in the start-up phase leading to excess gas;
    - o reduction of the level in the primary system after unit shutdown leading to excess gas;

- o purging of loops and the space under the vessel head with fresh nitrogen to decrease the activity due to the noble gases before opening the vessel. This purging is carried out by the vents and purging lines inside the Reactor Building via the RPE [NVDS] about one day after shutdown when the primary coolant level is at ¾ loop and generates an excess of gas.

3.4.1.1. Steady-state operation

The TEG [GWPS] system and the connected systems are permanently swept by nitrogen in a quasi-closed loop.

In this configuration, the reducing station 1 expands the gas from 9 bar to 1.5 bar, which dries out the gas. This dry gas is used to regenerate the desiccator before returning to the purging system. A small portion of the dry gas (0.2 Nm^3/hr) is also transferred to the hold-up beds.

Stable operation represents 99% of annual operating time of the TEG [GWPS] system.

3.4.1.2. Active inventory of the TEG [GWPS]

Degassing of the primary coolant enables reduction of its radioactive noble gas content in normal operation and particularly before shutdown.

The quantity of radioactive isotopes in the treatment process and in the delay line depends on the extent of degassing of the primary coolant.

The maximum activity of the main noble gases present in the treatment sub-system during degassing of the primary system at shutdown is listed below.

The carbon-14 produced in the primary coolant has a very long half life. There is no industrially proven retention method. The gaseous carbon-14 produced is discharged.

To determine the activity inventory in the treatment system, three hypotheses are taken:

- during shutdown, total degassing by the high flow rate degasser TEP4 [CDS];
- total degassing during normal operation by the RCV [CVCS];
- gas release to the discharge line at 0.2 m^3/h.

Radio-nuclides	Activity inventory of the treatment system (MBq) [Ref-1]	
	Realistic	Biological protection design
Kr-85m	6.2E+03	8.6E+04
Kr-85	2.2E+04	1.8E+05
Kr-87	4.5E+00	9.3E+01
Kr-88	2.7E+03	4.0E+04
Xe-131m	1.5E+04	1.2E+05
Xe-133m	6.0E+04	3.9E+05
Xe-133	2.6E+06	2.1E+07
Xe-135	1.2E+05	1.3E+06
Xe-138		
Ar-41	7.1E+01	2.2E+02

3.4.2. Transient system states

3.4.2.1. Operation with excess gas

Operation with excess gas occurs during the shutdown and start-up phases of the unit when there is a relatively large movement of water in the connected systems and during the nitrogen purging of the loops and the space under the vessel head.

The large transfers of water to the connected tanks generate large volumes of gaseous effluent in the TEG [GWPS] system by reduction of their free volumes. This excess of gas generates a pressure increase in the part which is at negative pressure and which is then maintained by closing the reducing station 2. This involves a flow rate increase in the delay line and discharge to the environment (after treatment in the delay beds).

If the flow rate at the reducing station 3 becomes too high, the system switches from steady-state operating mode to operating mode with excess gas. The set point of the reducing station 3 then switches from 1.5 bar absolute to 9 bar absolute. This pressure increase in the delay beds leads to an increase in the storage capacity of the delay line.

Furthermore, the gel drier is switched from “stand-by” mode to “drying” mode by reversing the gas flow. The gaseous effluent is then dried in the desiccator before it enters the delay beds (the adiabatic depressurisation in the regulating station 1 is no longer operational since it is open).

Operation with excess gas is followed, after a certain period, by a gradual reduction of pressure from 9 bar absolute to 1.5 bar absolute. The system then returns to steady-state operation.

3.4.2.2. System failures and consequences

To avoid the intake of air into the system, the components of the part at negative pressure are designed with a leak flow rate of 10^{-3} mbar.l.s^{-1} with the exception of the H_2/O_2 measuring systems which are designed with a leak flow rate of 10^{-6} mbar.l.s^{-1}. This lower leak flow rate reduces the probability of failure of one of these measuring systems.

To avoid any leak of gaseous effluents, the components of the pressurised part are designed with a leak flow rate of 10^{-6} mbar.l.s^{-1}.

For reasons of system availability, there are redundant compressors.

To check the smooth operation of the system, there are H_2/O_2 measuring assemblies upstream and downstream of the recombiner unit. If the hydrogen content is higher than 4% or the oxygen content is higher than 2% upstream of the recombiner unit, this is bypassed; the hydrogen and oxygen injections are closed. Nitrogen can be injected to dilute hydrogen/oxygen concentration.

The formation of an explosive gaseous H_2/O_2 mixture in the system is practically eliminated by the following:

- effective nitrogen purging of all connected components;
- bypass of the recombiner unit, isolation of components and shutdown of the systems that provide hydrogen to the TEG [GWPS] in the event of loss of purging.

The same actions are initiated if the oxygen or hydrogen content is excessive or if the H_2/O_2 measuring system is faulty.

Shutdown of the TEG [GWPS] may be caused by the following:

- shutdown of the compressors;
- reversible or irreversible poisoning of the recombiner unit catalyst.

Reversible contamination can be caused by liquid water. A floating ball valve upstream protects the recombiner unit from any rising water in the system. Three heating elements ensure a sufficiently high temperature to avoid water condensation on the catalyser.

Irreversible pollution of the catalyst may be caused by elements such as sulphur, phosphorus, arsenic or oil. These substances are not present and cannot enter the system.

Before shutdown of the TEG [GWPS] system, it is necessary to inject nitrogen into the section under negative pressure to achieve atmospheric pressure so as to prevent air ingress and creation of an explosive mixture.

During and after shutdown of the TEG [GWPS] system, no operation generating significant quantities of hydrogen may be performed since recombination is no longer possible. Thus the following operations are prohibited:

- a power increase in the reactor since the increase in volume caused by thermal expansion of the primary fluid would generate a flow of primary effluents to the TEP [CSTS] and produce hydrogen in the TEG [GWPS] by degasification;
- use of the degasser TEP [CSTS] for degassing the primary coolant.

Additionally, the pressuriser relief tank and reactor coolant drain tank inside the Reactor Building (RPE [NVDS]) are isolated to prevent a build-up of hydrogen associated with a possible leak of primary coolant into these tanks.

3.5. PRELIMINARY SAFETY ANALYSIS

3.5.1. Compliance with regulations

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

3.5.2. Compliance with functional requirements

The TEG [GWPS] contributes to the following functions:

- containment isolation;
- containment of radioactivity in the installation and limitation of discharge to the environment (in normal operation);
- minimisation of radiological releases in the event of an accident.

The functions and functional requirements for containment isolation are described in Sub-chapter 6.2 of the PCSR.

Containment of radioactivity in the installation is ensured by the leak tight welded design of the TEG [GWPS]. Only equipment requiring maintenance is connected by flanges and bolting.

The use of delay beds limits discharge to the environment while allowing radioactive decay of noble gases.

Minimisation of radiological releases in the event of an accident is ensured by connecting the TEG [GWPS] containment penetrations to the EBA [CSVS] iodine filters to avoid gaseous releases even in the case of valve leakages which would lead to Fuel Building contamination increase and uncontrolled releases.

Faults in the TEG [GWPS] leading to discharge are considered in the safety assessment (PCC-3 event, see Sub-chapter 14.4 of the PCSR).

3.5.3. Compliance with design requirements

3.5.3.1. Safety classification

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

3.5.3.2. Redundancy

Although they are F2 classified, the following components are redundant:

- compressors;
- some reducing stations;
- H_2/O_2 measurements upstream of the recombiner unit and the associated compressors;
- humidity measurement upstream of the delay beds.

These redundancies ensure the tolerance of the system to failures in service and also enable maintenance during operation (which is a consideration for plant availability).

3.5.3.3. Qualification

The TEG [GWPS] system is not required to be qualified for accident conditions. The containment shut-off valves must comply with Sub-chapter 3.6 of the PCSR.

3.5.3.4. Instrumentation and Control

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

3.5.3.5. Emergency electrical supplies

All electrical components are connected to the emergency electrical supply to ensure their availability.

3.5.3.6. Hazards

Only the containment shut-off valves are designed to withstand internal and external hazards.

3.6. MAINTENANCE, INSPECTION AND TESTING

3.6.1. Commissioning tests

The commissioning tests must show that the TEG [GWPS] functional requirements are met.

3.6.2. Monitoring in operation

The system operates continuously; however, maintenance or inspection during operation of some components is taken into account in the design.

3.6.3. Periodic tests

The design requires periodic tests to confirm the functional capability of the following components:

- containment shut-off valves;
- delay line.

4. SYSTEMS FOR TREATING SOLID RADIOACTIVE EFFLUENTS (TES [SWTS]) [REF-1] TO [REF-8]

In accordance with the waste strategy of Sub-chapter 11.2, the treatment and conditioning processes are based on Flamanville 3 (FA3) EPR processes. FA3 is considered as the reference case.

4.1. SOLID WASTE TREATMENT SYSTEMS (TES [SWTS])

The TES [SWTS] system of the EPR unit is installed in the Nuclear Auxiliary Building and partly in the Effluent Treatment Building. It treats the solid waste from operation of the unit (filters and ion-exchanging resins). It comprises a filter loading/unloading machine and a spent resin collector. This solid waste is then conditioned by the 8TES [SWTS] system installed in the Effluent Treatment Building before being despatched.

4.1.0. Safety requirements

4.1.0.1. Safety functions

Control of reactivity

Not applicable.

Decay heat removal

Not applicable.

Containment of radioactivity

The system must ensure containment during transfer of spent and active resins from the Nuclear Auxiliary Building to the 8TES [SWTS] collection tanks located in the Effluent Treatment Building.

The filter loading/unloading machine must ensure containment during transfer of used filters to the Effluent Treatment Building.

4.1.0.2. Functional requirements

The pipes and valves associated with the transfer of spent active resins from the Nuclear Auxiliary Building to the 8TES [SWTS] collection tanks must ensure containment. This is ensured by the leak tightness of this equipment.

The filter loading/unloading machine must ensure containment. This is ensured by the leak tightness of the handling machine.

4.1.0.3. Design-related requirements

4.1.0.3.1. Requirements related to safety classification

Safety classification

The TES [SWTS] is safety classified in accordance with Sub-chapter 3.2 of the PCSR.

Single failure criterion (active and passive)

Not applicable.

Emergency electrical supplies

Not applicable.

Qualification for operating conditions

Since the TES [SWTS] is not essential for the maintenance of safety functions in post-accident operating conditions, it is not subject to any requirements for qualification for post-accident conditions.

Mechanical, Electrical and Control and Instrumentation classification

The mechanical, electrical and Control and Instrumentation classification of the TES [SWTS] is set out in Sub-chapter 3.2 of the PCSR.

Seismic classification

The system is not seismically classified.

Periodic tests

Normal use of the system avoids the need for periodic tests.

4.1.0.3.2. Other regulatory requirements

The system is subject to the following:

- UK regulations;
- the ICRP recommendations, the aim of which is to reduce exposure of exposed individuals and populations according to the ALARP principle.

4.1.0.4. Hazards

There is no requirement for protection against internal and external hazards for TES [SWTS] equipment.

4.1.1. Role of the system

The system performs the following functions:

- selective collection of active and inactive resins and transfer to the 8TES [SWTS] in the Effluent Treatment Building;
- transfer of used filters to the 8TES [SWTS] in the Effluent Treatment Building for encapsulation.

These two functions are independent of one another.

4.1.2. Design bases

The system is installed in the Nuclear Auxiliary Building of the EPR unit and partly in the Effluent Treatment Building.

It is operated during transfer of spent resins from the unit to one of the 8TES [SWTS] resin storage tanks via the TES [SWTS] collector. These resins are as follows:

- the active resins contained in the RCV [CVCS], PTR [FPPS] and TEP [CSTS] demineralisers;
- the inactive resins contained in the APG [SGBS] demineraliser.

It is also used for unloading used filter cartridges from the unit to the 8TES [SWTS] in the Effluent Treatment Building for encapsulation in concrete (this operation is performed in the Effluent Treatment Building).

The operational waste (contaminated paper, clothing) produced in the Nuclear Auxiliary Building is stored in the Nuclear Auxiliary Building and then transferred to the Effluent Treatment Building for conditioning.

The design of the TES [SWTS] includes consideration of radiological protection.

4.1.3. System description

4.1.3.1. Description

4.1.3.1.1. Transfer of the filter cartridge holders

The transfer of used filter cartridges from the Nuclear Auxiliary Building to the Effluent Treatment Building is performed using a handling machine which enables unloading of the used filter and its replacement with a new filter in the same operation (header system). This machine is also used for replacement of the 8TEU [LWPS] used filters. This handling is performed in a bay shared by the Nuclear Auxiliary Building and the Effluent Treatment Building and the encapsulation is performed in the Effluent Treatment Building.

The transfer of cartridges is designed to ensure continuous radiological protection for operators.

The handling machine also enables recovery of drip-off from the used filter cartridges. This drip-off is then bled to the RPE [NVDS].

4.1.3.1.2. Transfer of resins from the Nuclear Auxiliary Building to the Effluent Treatment Building

The RCV [CVCS], TEP [CSTS], PTR [FPPS] and APG [SGBS] spent resins are transferred via flushing to one of the 8TES [SWTS] resin storage tanks installed in the Effluent Treatment Building via the TES [SWTS] collector.

4.1.3.2. System functions

4.1.3.2.1. Transfer of used filters

The handling machine unloads a used filter and replaces it with a new filter.

It also provides shielding for operators during all operations.

4.1.3.2.2. Transfer of spent resins

The equipment chosen must facilitate the transfer of resins and not be subject to corrosion in the presence of water and spent resins in the piping. It is therefore made from austenitic stainless steel.

The piping has a suitable geometry (radius of curvature, diameter) to facilitate the flow of a water and resin mix.

4.1.4. Operating conditions

4.1.4.1. Normal operation

4.1.4.1.1. Active resins

The spent resins contained in the unit demineralisers (RCV [CVCS], PTR [FPPS], TEP [CSTS]) are drained using special piping (the TES [SWTS] collector connected to the EPR Nuclear Auxiliary Building) in the Nuclear Auxiliary Building - Effluent Treatment Building tunnel. The tunnel is not accessible during normal operation, to limit operator dose. Therefore no handling is performed and any risk of contamination or radiation exposure is excluded.

The resins may be separated depending on their activity and decay of the most radioactive.

4.1.4.1.2. Filter cartridge baskets

All operations are controlled manually, but using remote control. A filter is replaced using three spindles mounted at 120° on a revolving turret on the handling machine head. Each spindle is assigned a specific function:

- spindle no.1: manoeuvring of the biological plug;
- spindle no.2: handling of the used filter;
- spindle no.3: handling of the new filter.

Given the operations to be carried out, each spindle must perform two movements: one rotation and one translation. Each movement is performed by an electrical motor.

The replacement of a used filter and unloading to the 8TES [SWTS] involves the following sequence of operations:

1. loading of a new filter in the handling machine;
2. positioning of the machine above the used filter;
3. extraction of the shield plug above the filter;
4. unloading of the used filter;
5. loading of the new filter;
6. replacement of the shield plug;
7. positioning of the machine above the transfer tube;
8. unloading of the used filter to the 8TES [SWTS] for encapsulation.

The handling machine provides shielding for staff. Containment of the filter is guaranteed at each stage.

The shield plug is positioned by rotation of the spindle.

A KRT [PRMS] instrument monitors radioactivity in the bay during all operations.

4.1.4.2. Transient operation

Not applicable.

4.1.5. Preliminary safety analysis

4.1.5.1. Compliance with regulations

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

4.1.5.2. Functional requirements

The TES [SWTS] plays no part in the basic safety functions related to control of reactivity and decay heat removal.

It has a role in protecting the public and operators against radioactive waste and transport thereof (containment of radioactive materials).

4.1.5.3. Compliance with design requirements

4.1.5.3.1. Safety classification

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

4.1.5.3.2. Single failure criterion

Not applicable.

4.1.5.3.3. Qualification

The TES [SWTS] is not required to be qualified for accident conditions.

4.1.5.3.4. Control and Instrumentation

The handling machine has its own specific Control and Instrumentation.

4.1.5.3.5. Emergency electrical supplies

Not applicable.

4.1.5.3.6. Hazards

Not applicable.

4.1.6. Maintenance, inspection and testing

Normal use of the system avoids the need for periodic testing. Provision is made for inspection and maintenance to ensure the system operation remains satisfactory.

4.2. EFFLUENT TREATMENT BUILDING SOLID WASTE TREATMENT SYSTEM (8TES [SWTS])

The 8TES [SWTS] is installed in the Effluent Treatment Building. It is associated with the TES [SWTS] (section 4.1) of the unit located in the Nuclear Auxiliary Building.

The 8TES [SWTS] solid waste treatment system conditions the low level activity waste (LLW) and very low level activity waste (VLLW). The VLLW storage area is shared by the whole site.

The waste is conditioned to enable the following:

- safe transport off the site in accordance with the transport regulations in force;
- safe storage off-site on a surface site in accordance with regulations.

It also encapsulates the following in concrete:

- filter cartridges;
- resins;
- concentrates;
- sludge.

4.2.0. Safety requirements

4.2.0.1. Safety functions

Control of reactivity

Not applicable.

Decay heat removal

Not applicable.

Containment of radioactivity

The 8TES [SWTS] has a role in protecting the public and operators against radioactive waste and their transport. In this respect, only spent resin and concentrate storage and encapsulation of active waste are safety classified in accordance with design rules.

There are provisions for double containment and directing overflows back to the storage and treatment systems.

4.2.0.2. Functional requirements

Transport of these packages will comply with UK regulations.

4.2.0.3. Design-related requirements

4.2.0.3.1. Requirements related to safety classification

Safety classification

The 8TES [SWTS] is not safety classified under the design rules, with the exception of spent resin and concentrate storage and encapsulation of active waste, which is F2 classified.

Single failure criterion (active and passive)

Not applicable.

Emergency electrical supplies

Not applicable.

Qualification for operating conditions

Since the 8TES [SWTS] is not essential for the maintenance of safety functions in post-accident operating conditions, it is not subject to any requirements for qualification for accident conditions.

Mechanical, Electrical and Control and Instrumentation classification

The mechanical, electrical and Control and Instrumentation classification of the 8TES [SWTS] is described in Sub-chapter 3.2 of the PCSR.

Seismic classification

The system is not seismically classified.

Periodic tests

Normal use of the system avoids the need for periodic tests.

4.2.0.3.2. Other regulatory requirements

Not applicable.

4.2.0.3.3. Hazards

Not applicable.

4.2.1. Role of the system

The waste is conditioned to enable the following:

- safe interim storage on site;

- safe transport on and off site in accordance with the relevant regulations;
- safe storage and ultimate disposal off-site in accordance with the Low Level Waste Repository (LLWR) near Drigg, the NDA repository and other waste acceptance criteria.

The 8TES [SWTS] facility performs the following functions:

- selective collection of all solid radioactive waste produced by the EPR unit, including:
  - spent resins;
  - evaporator concentrates;
  - used filter cartridges;
- buffer waste storage (tanks and metal drums);
- conditioning of solid waste for consignment off site (filters, concentrates, operational waste);
- intermediate storage of empty and full waste containers.

4.2.2. Design bases

The solid waste treated by 8TES [SWTS] is as follows:

- evaporation concentrates from the 8TEU [LWPS];
- the active resins contained in the RCV [CVCS], PTR [FPPS], TEP [CSTS] and 8TEU [LWPS] demineralisers;
- the APG [SGBS] resins;
- sludge;
- the filter cartridge baskets of the RCV [CVCS], PTR [FPPS], TEP [CSTS] and 8TEU [LWPS] radioactive liquid systems;
- the ventilation system filters (possibly);
- sundry low-activity operational waste (<2 mSv/hr on contact) produced (clothes, vinyl, etc.);
- special high-activity operational waste.

The French basic principle is to condition all solid waste in drums or containers so that their transfer from the site to a final approved storage centre or another treatment system (e.g. the CENTRACO incinerator) is compatible with the following:

- regulations on transport of radioactive materials, as stipulated in the orders relating to transport of radioactive materials;

- specifications required for radioactive waste storage.

4.2.3. System description

4.2.3.1. Description

Section 11.4.4.2 - Figures 1 to 4, provide conditioning block diagrams for the different types of solid waste concerned.

4.2.3.1.1. Conditioning of spent resins

The active resins are transferred from each demineraliser by flushing in one of the two temporary storage tanks according to their activity via the piping network and the valves of the TES [SWTS]. Spent resins may also come from the 8TEU [LWPS] demineralisers. They are also removed by flushing via a piping and valve network specific to the 8TES [SWTS].

The active resins are then conditioned in C1 type concrete containers (after radioactive decay if necessary), by a mobile coating unit (MERCURE process).

The resins are transferred from the tanks to the mobile station by pumping from the mobile station.

The active resins are conditioned and encapsulated in a mobile treatment plant that moves from site to site, which is named the MERCURE mobile encapsulating unit.

The MERCURE process mixes the resins with an epoxy polymer inside the concrete container. The epoxy polymer is hardened during the polymerisation process with the use of a hardener.

A temporary steel plug is placed in the container after mixing. The packages are then finally sealed with a concrete plug in the storage bay.

The MERCURE machine features an "open-tunnel" design and comprises the following:

- a container loading and identification station;
- a container weighing station;
- a steel cover coating, removal and replacement station;
- a station for sealing the cover (cold welding on the ferrule) and unloading of containers.

The machine is located in a controlled area and is connected to the 8TES [SWTS] fixed facilities by hoses. It is equipped with a membrane pump supplying spent resins to a hopper for weighing and measuring activity by gamma spectrometry. The pump flows directly into the concrete container.

The machine is also connected by hoses to a mobile tank located outside the building which is used for storage of the epoxy resin and the hardener.

4.2.3.1.2. Conditioning of evaporator concentrates

The evaporation concentrates are collected in the 8TEU [LWPS] evaporators then temporarily stored in one of the two storage tanks.

Two treatment systems are currently possible:

- transport in a mobile tank to a nuclear incineration facility;
- placement in a concrete container using a mobile unit before evacuation to a storage centre.

Given the high concentration of boric acid, all pipes conveying concentrates are thermally insulated and electrically trace heated to prevent crystallisation.

The concentrates are transferred from the tanks to the mobile station by pumping from the mobile station.

The mobile machine installed in the Effluent Treatment Building principally comprises a packaging module featuring the following:

- a sack-opening hopper;
- a mechanical arm for handling sacks;
- a concentrate dosage system;
- a reinforced sealed mixer;
- a trolley for transferring containers.

This machine is connected to the 8TES [SWTS] fixed installations by hoses for supply of fluid and energy. The concentrates from the 8TEU [LWPS] evaporators are thus solidified in a cement- and sand-based mortar prepared in pre-dosed sacks in a C1-type concrete container. Slaked lime is added to neutralise the sodium borates.

It does not seal the packages. This function is performed in the storage bay.

4.2.3.1.3. Conditioning of used filters

The used filters from the unit and the 8TEU [LWPS] system are directed by the 8TES [SWTS] handling machine above a transfer tube which ends in the encapsulation cell. The filter descends inside the transfer tube to be conditioned in a concrete container.

The packaging formulation (known as F37) is used for the used filter packaging process. The mortar is poured into the container using a vibrating chute. The container is then transferred to a storage area for a period of drying.

After the drying period, the containers are plugged with concrete (F44 formulation) whose composition and characteristics are identical to those of the container.

4.2.3.1.4. Conditioning of low-activity operational waste

Low-activity operational waste is first conditioned in airtight vinyl sacks and stored temporarily in the Nuclear Auxiliary Building or the Effluent Treatment Building. It is then sorted, ground or compacted then conditioned in metal or 200 L PEHD (high-density polyethylene) drums. Compacting is performed in the Effluent Treatment Building.

The press used for compacting is equipped with a suction hood to prevent the spreading of dust, and a shield placed in the drum to prevent its deformation.

4.2.3.1.5. Storage of concrete containers

Once filled, the concrete containers conditioned in the Effluent Treatment Building cell are stored for around one month in the main storage area of the Effluent Treatment Building for hardening.

The storage capacity is at least one month, corresponding to the hardening period for the filters. The capacity is dependent on the production of packages by the mobile encapsulating machine, for one packaging campaign.

4.2.3.2. System design features

The equipment used for storing resins and concentrates and for encapsulating active waste is F2 classified.

The equipment in contact with concentrates and spent resins is made from austenitic stainless steel.

The design parameters of containers are given in Section 11.4.4.2 - Table 1.

4.2.4. Operating conditions

4.2.4.1. Normal operation

4.2.4.1.1. Active resins

These resins are removed from the demineralisers by flushing; then channelled by collectors to storage tanks, enabling distribution of resins according to their volume activity and the radioactive decay of the most active resins.

The resins are stored under a fixed level of water.

There are two storage tanks located in the Effluent Treatment Building.

The resins are transferred to the MERCURE coating machine and treated as follows:

- granular and radiological homogenisation of the storage tank by circulating resins in a closed circuit using the pump located on the machine;
- underwater transfer of the resins to the dosing hopper using the same pump;
- removal of excess water from the resins in the dosing hopper by a strainer system;

- the resins are introduced into the concrete packages after addition of resin and hardener. This is all mixed by a bladeless mixer.

Final plugging is performed after drying of the coating in the storage bay.

4.2.4.1.2. Evaporation concentrates

The treatment of concentrates by the mobile packaging machine is performed in operations that may be 2 to 3 years apart.

Homogenisation of the content of the storage tank is obtained by air mixing for 24 hours before pumping starts.

The concentrates are pumped into the storage tank by the mobile machine and dosed in the mixer. A specified quantity of demineralised water and the contents of a pre-dosed sack (sand + cement + slaked lime) are then introduced. After a mixing cycle of 6 to 8 minutes, the contents of the mixer are emptied by gravity into the container. Four identical successive batches are needed to fill a C1 container.

The containers are then transferred by an overhead crane in the Effluent Treatment Building storage bay for drying within 24 hours following mixing. Drying takes 7 days, during which time the package is not moved.

Plugging is performed in the storage bay. After plugging, the containers are stored temporarily before being transferred to the final storage centre.

4.2.4.1.3. Filter cartridge baskets

All operations are performed manually via remote control.

The used filter cartridge baskets arrive from the TES [SWTS] via a transfer tube.

The filter cartridge basket is placed in a concrete container. For particularly active filters, additional shielding in the container may be necessary to comply with regulatory limits.

During filter encapsulation operations, the cells are not accessible to staff. The containers are inserted, before filling, into the cell using a motor-driven trolley.

The containers waiting to be filled are closed using a temporary cover then transported via a remote-controlled trolley and stored in the Effluent Treatment Building storage bay.

The trolley is moved via remote control. The trolley stops automatically in pre-selected positions which are determined by the different stations.

When the concrete container is full, it is transferred by a remote-controlled trolley to a position under the concrete unit. The concrete is poured directly into the container via the mixer.

The container is then transferred to the Effluent Treatment Building storage bay for drying within 24 hours following mixing. Drying takes 7 days, during which time the package is not moved.

Plugging is performed in the storage bay.

After plugging, the containers are stored temporarily before being transferred to the final storage centre.

4.2.4.1.4. Low-activity operational waste

The low-activity operational waste is compacted by the press in the 200 litre metal or PEHD (high-density polyethylene) drums and are stored temporarily in transport containers in the Effluent Treatment Building.

The compacting cylinder comes down at the same time as the hood connected to the suction of the room ventilation system. The hood/drum seal does not require additional equipment and helps avoid contamination of the room by dust.

4.2.4.1.5. Storage and transfer of finished packages off site

The unplugged waste packages are stored between 2 plugging campaigns. The plugged packages are temporarily stored before being transferred to an approved storage location.

The Effluent Treatment Building includes two separate areas. One area is dedicated to storage, and also includes the "shipment" room where LLW is loaded into ISO 20-foot containers, and a few packaging rooms. The other area is dedicated to the treatment of the solid and liquid effluents and is also used as a buffer storage zone.

The storage capacity of the reference Effluent Treatment Building has been designed based on feedback from operation of the N4 Effluent Treatment Building and operations foreseen for the EPR. It is sufficient to ensure buffer storage for more than one year of operation including maintenance operations, even in the case where two EPR units share the Effluent Treatment Building. By adding the packaging zones as extra buffer storage, there is sufficient space to cover the potential for extended delays in shipment, as well as larger quantities of waste (than usual) from maintenance operations.

The transport of concrete shells and containers off the site is governed by regulations on the transport of radioactive materials which limit the maximum dose rate on contact with the container and 2 m from the transport vehicle.

4.2.4.2. Transient operation

Not applicable.

4.2.5. Preliminary safety analysis

4.2.5.1. Compliance with regulations

The system complies with the general regulations in force

4.2.5.2. Compliance with functional requirements

The 8TES [SWTS] plays no part in the basic safety functions related to control of reactivity and decay heat removal.

It has a role in protecting the public and operators against radioactive waste and their transport (containment of radioactive materials).

4.2.5.3. Compliance with design requirements

4.2.5.3.1. Safety classification

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

4.2.5.3.2. Single Failure Criterion or redundancy

Not applicable.

4.2.5.3.3. Qualification

Not applicable.

4.2.5.3.4. Control and Instrumentation

Not applicable.

4.2.5.3.5. Emergency electrical supplies

Not applicable.

4.2.5.3.6. Hazards

Not applicable.

4.2.6. Maintenance, inspection and testing

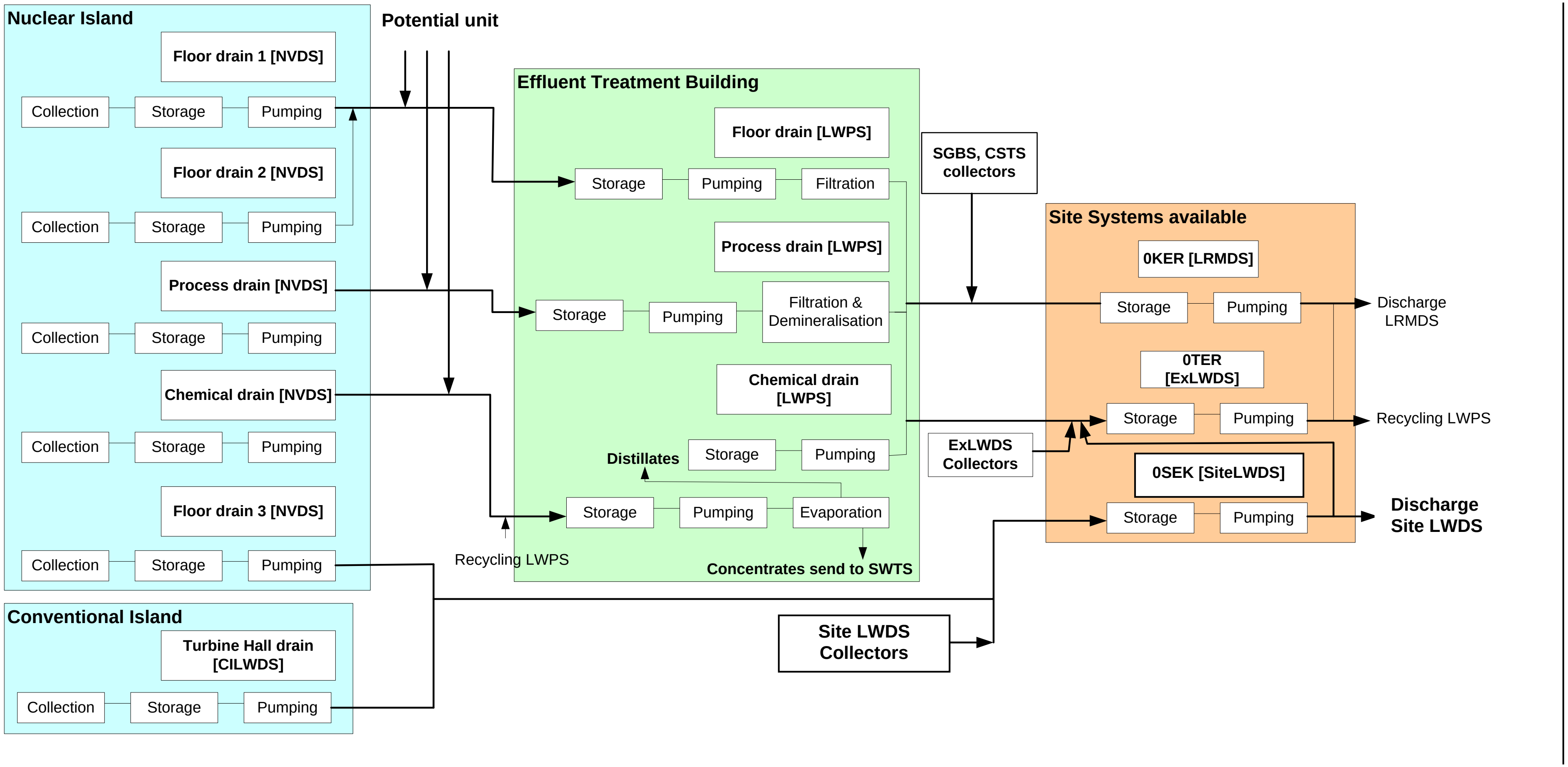
Normal use of the system avoids the need for periodic tests. Provision is made for inspection and maintenance to ensure the system operation remains satisfactory.

5. SYSTEMS FOR TREATING SOLID AND LIQUID RADIOACTIVE EFFLUENT – OPTIONS TO THE REFERENCE CASE

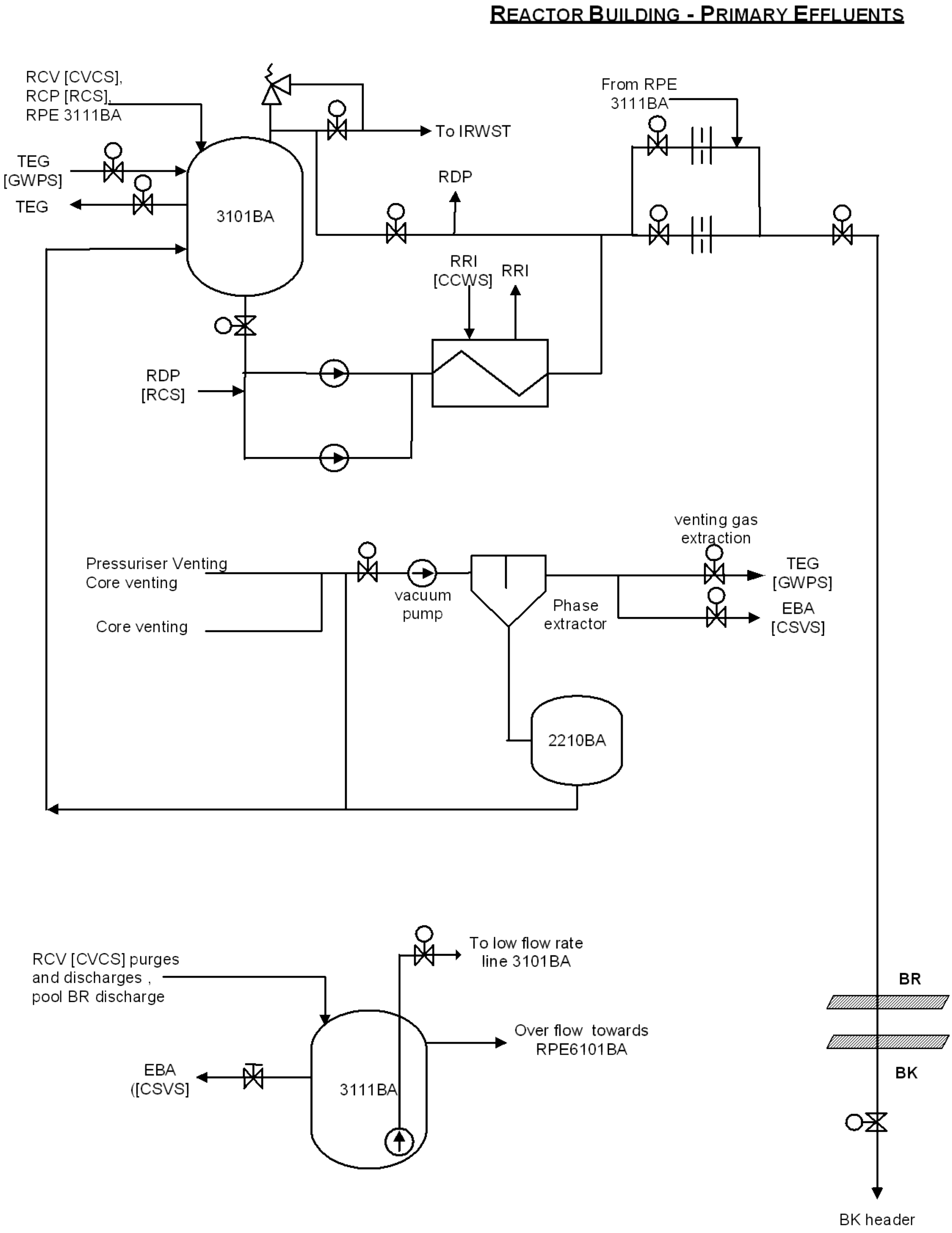
Process options and facilities for the treatment and conditioning of liquid and solid radioactive waste are described in the Solid Radioactive Waste Strategy Report (SRWSR) [Ref-1].

SECTION 11.4.1 - FIGURE 1

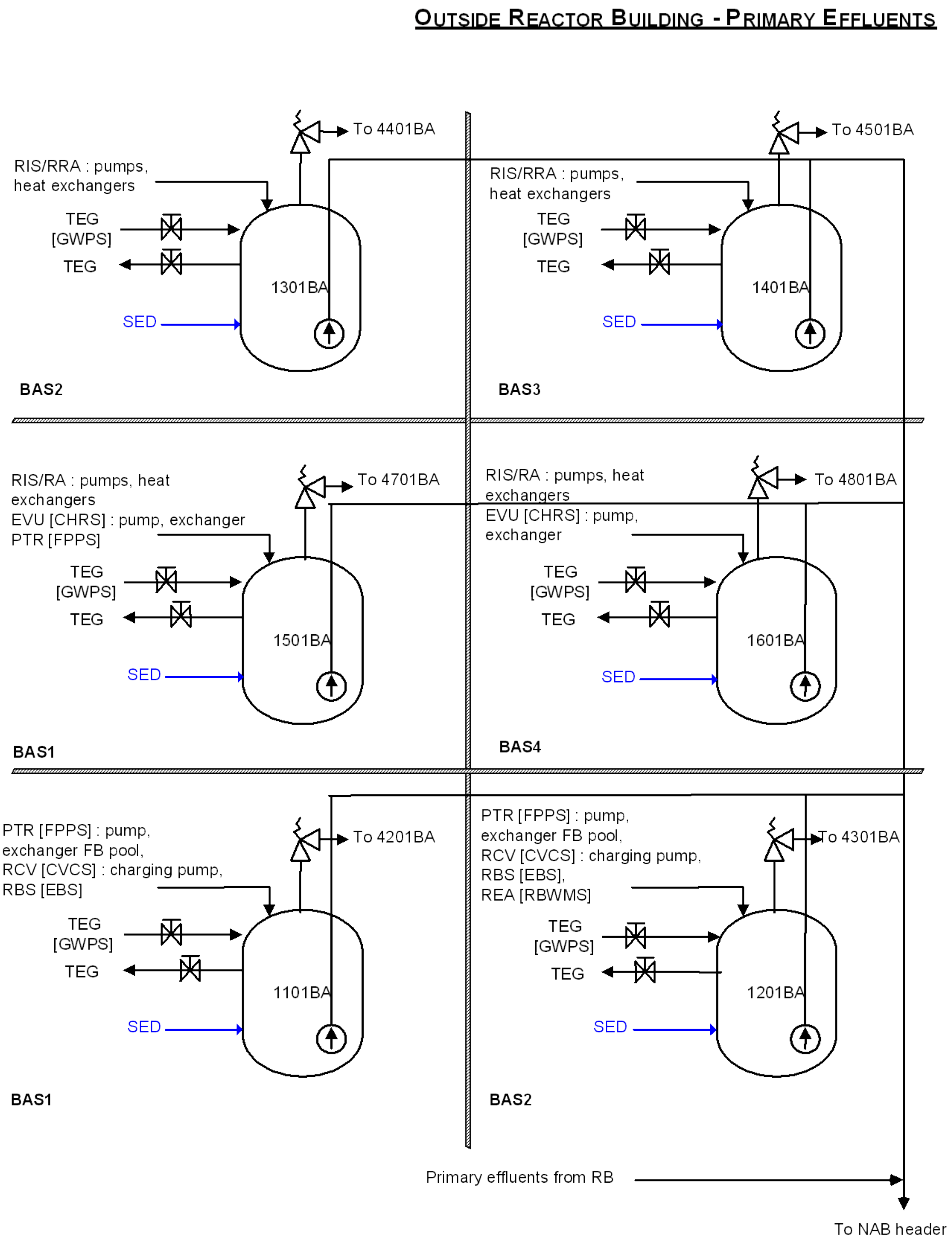
OVERALL DIAGRAM FOR NON-RECYCLED LIQUID EFFLUENT (Example of the Flamanville site)



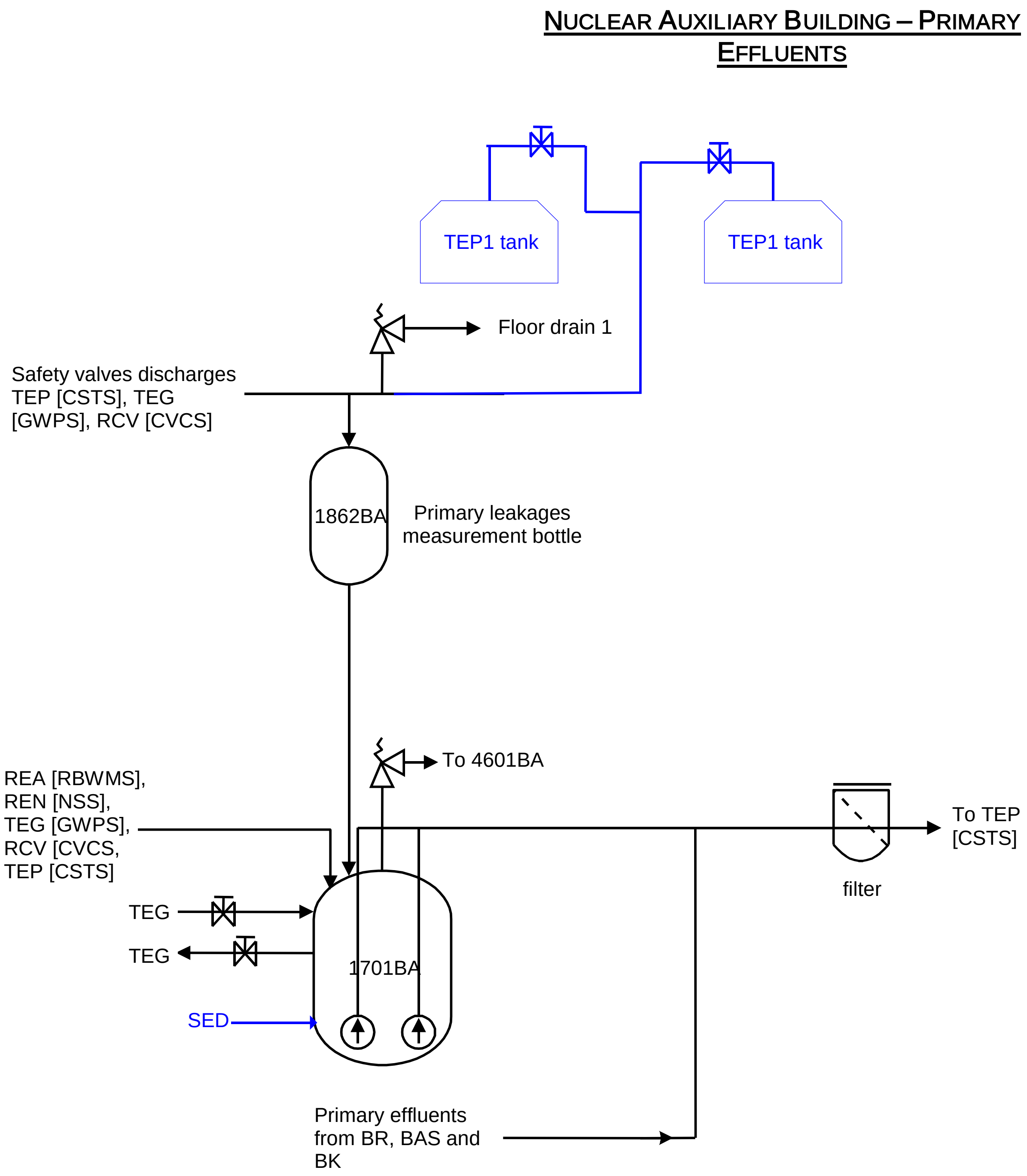
SECTION 11.4.2.1 - FIGURE 1 PAGE 1/9: COLLECTION OF RECYCLED EFFLUENT



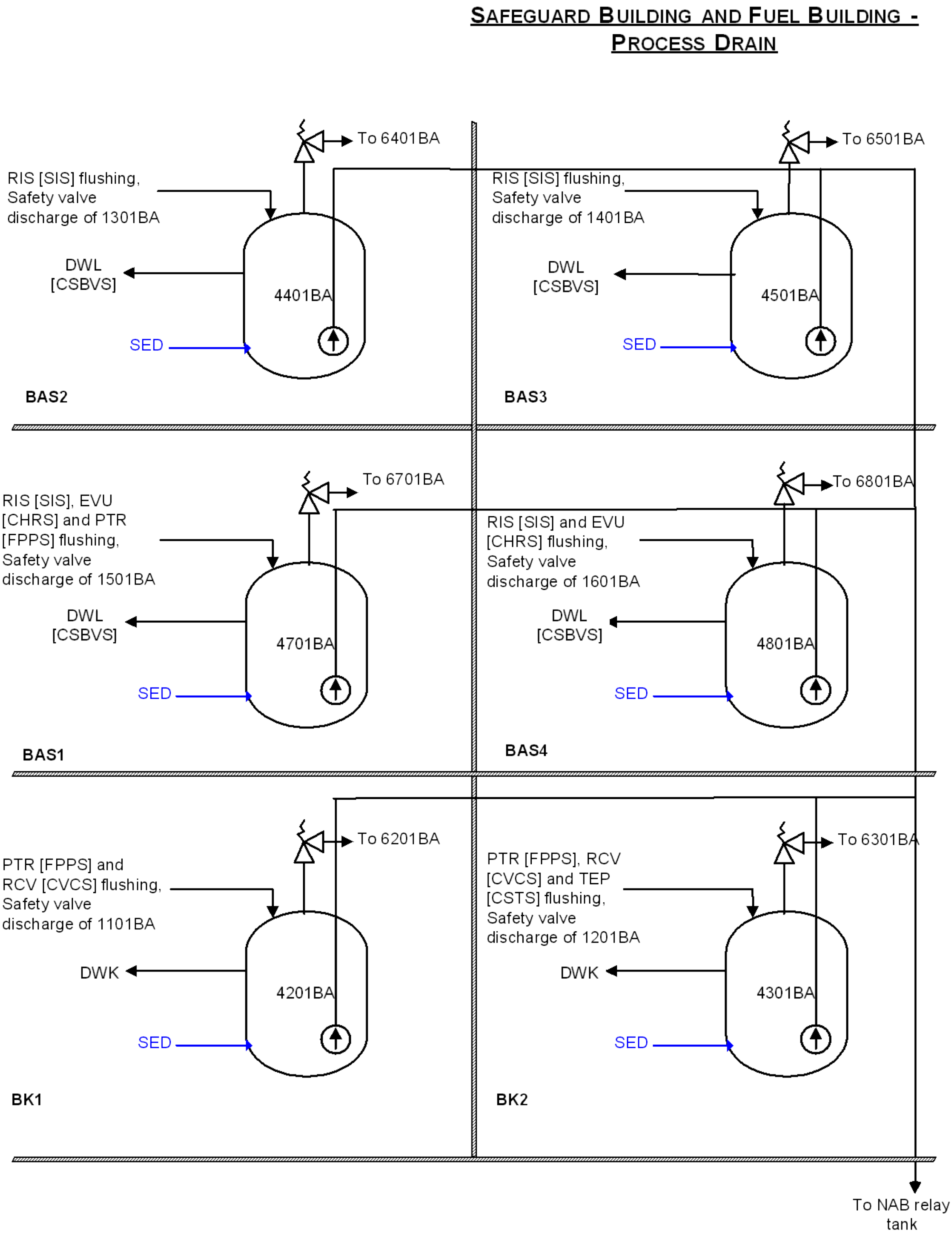
SECTION 11.4.2.1 - FIGURE 1 PAGE 2/9: COLLECTION OF RECYCLED EFFLUENT



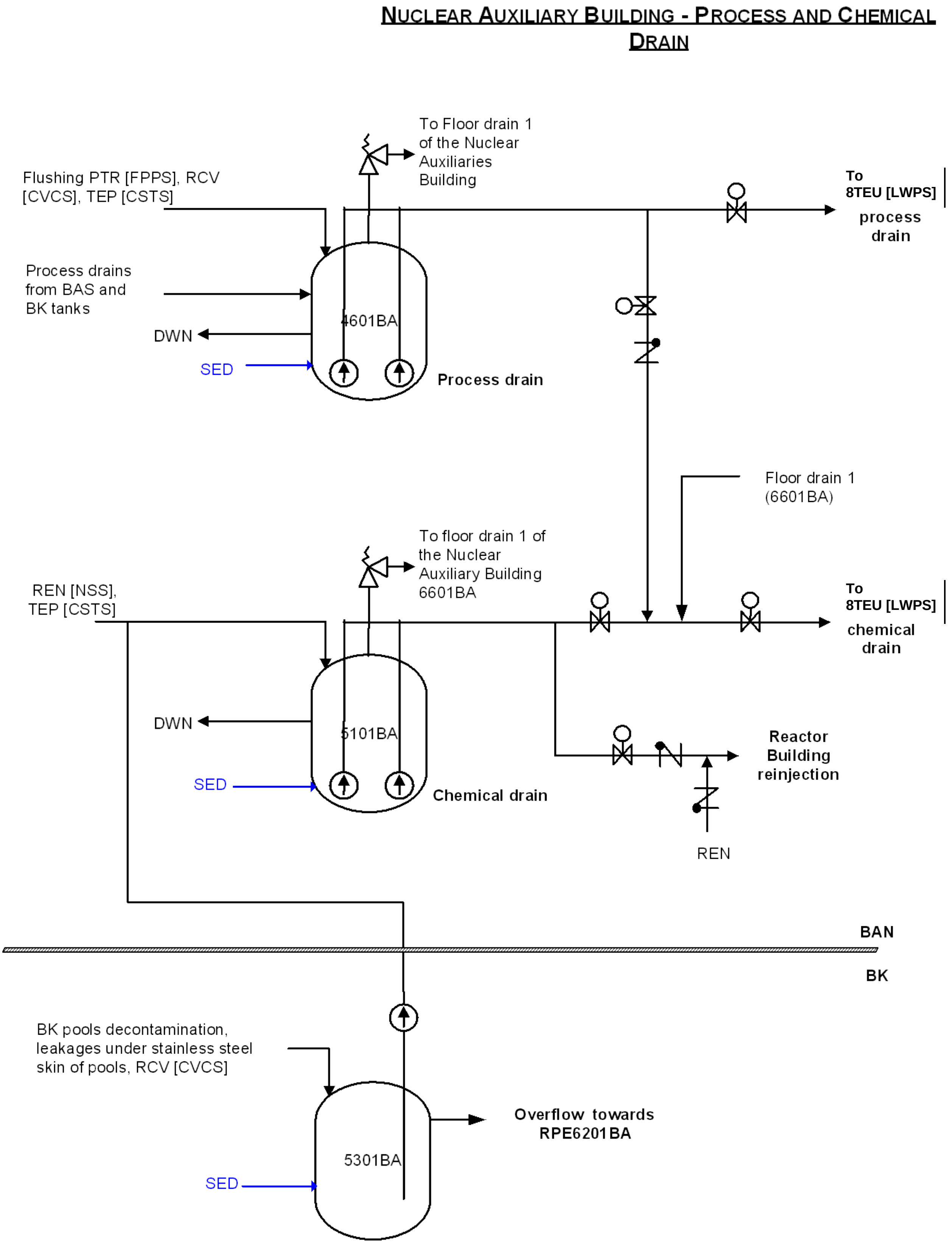
SECTION 11.4.2.1 - FIGURE 1 PAGE 3/9: COLLECTION OF RECYCLED EFFLUENT



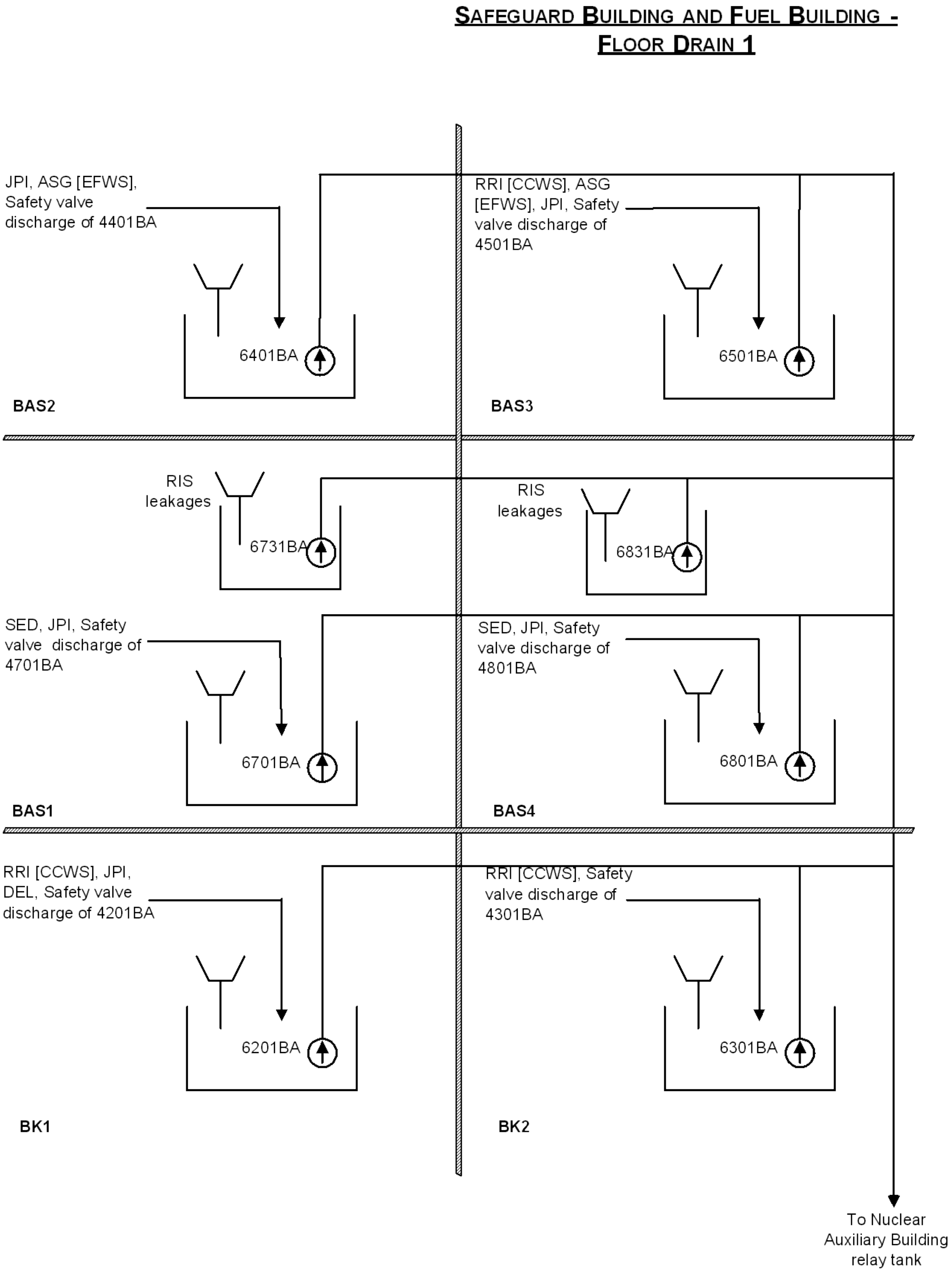
SECTION 11.4.2.1 -FIGURE 1 PAGE 4/9: COLLECTION OF RECYCLED EFFLUENT



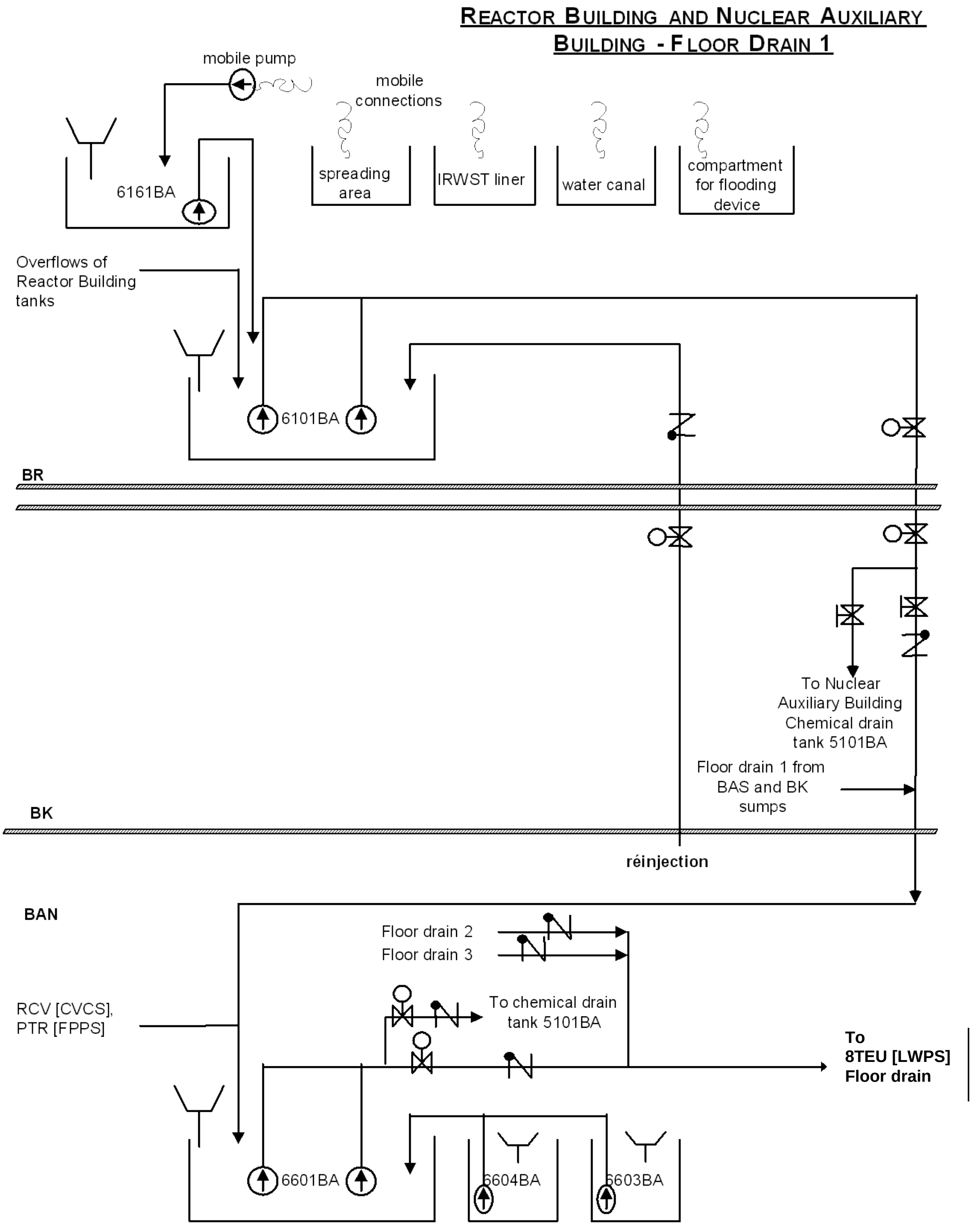
SECTION 11.4.2.1 - FIGURE 1 PAGE 5/9: COLLECTION OF RECYCLED EFFLUENT



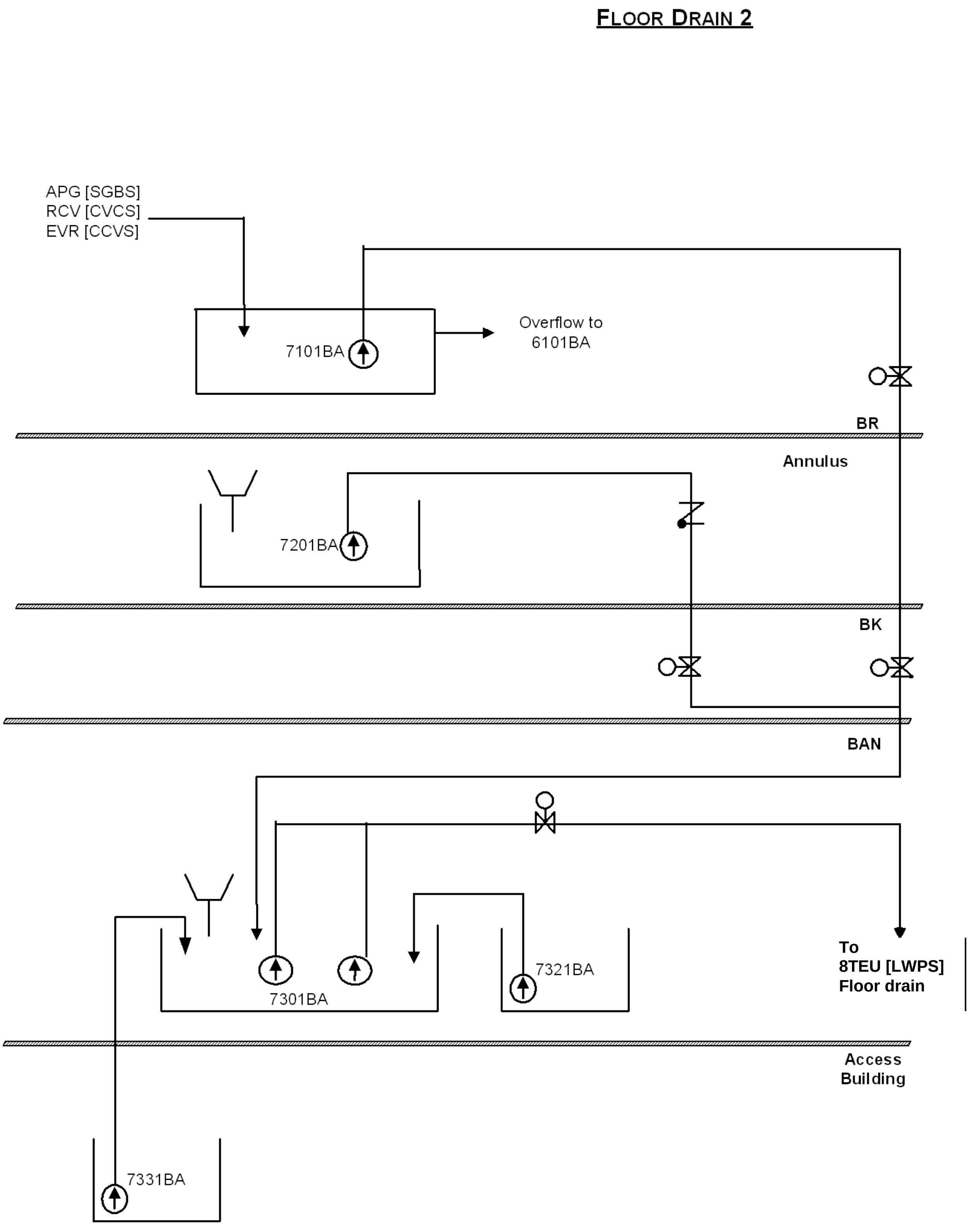
SECTION 11.4.2.1 - FIGURE 1 PAGE 6/9: COLLECTION OF RECYCLED EFFLUENT



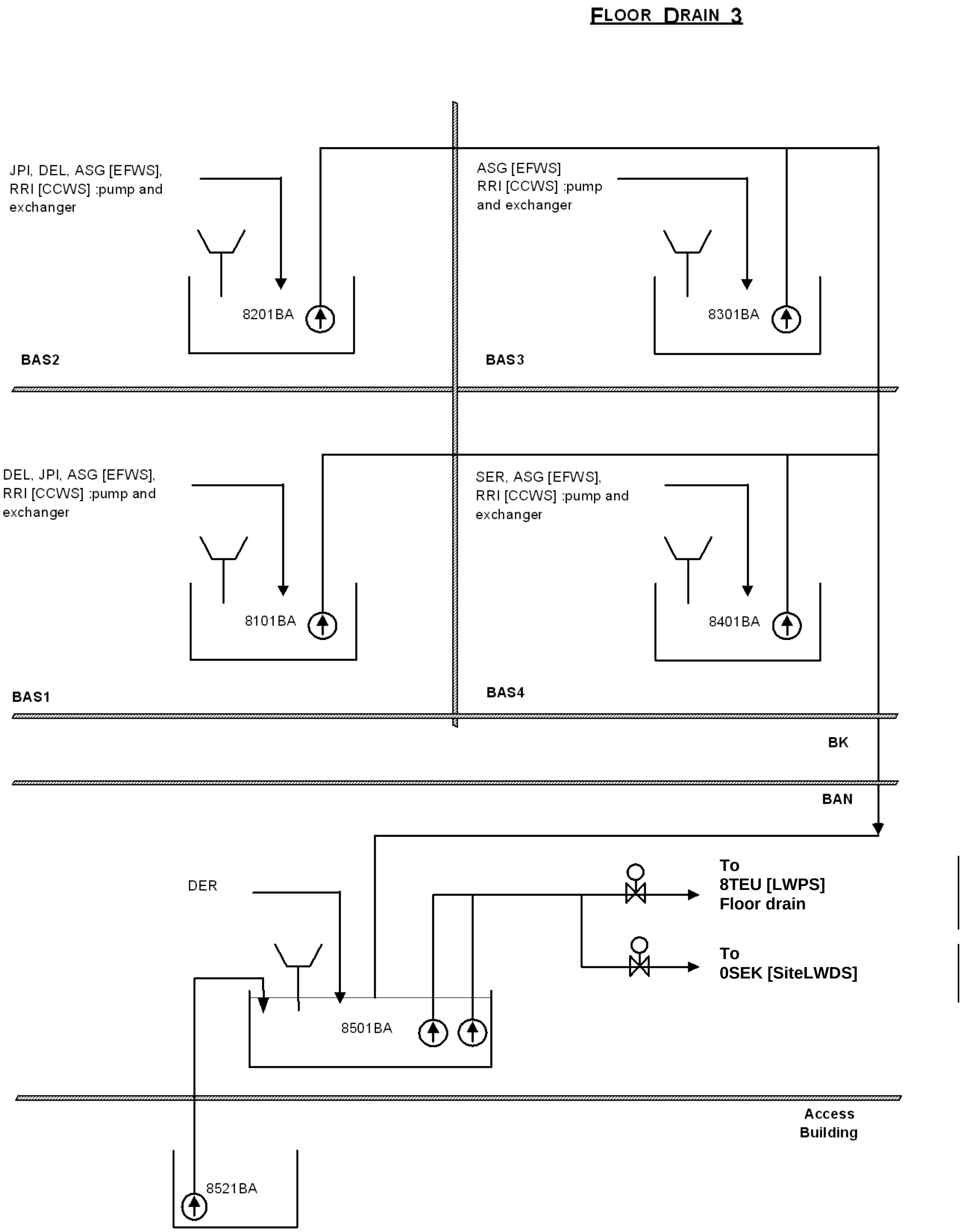
SECTION 11.4.2.1 - FIGURE 1 PAGE 7/9: COLLECTION OF RECYCLED EFFLUENT



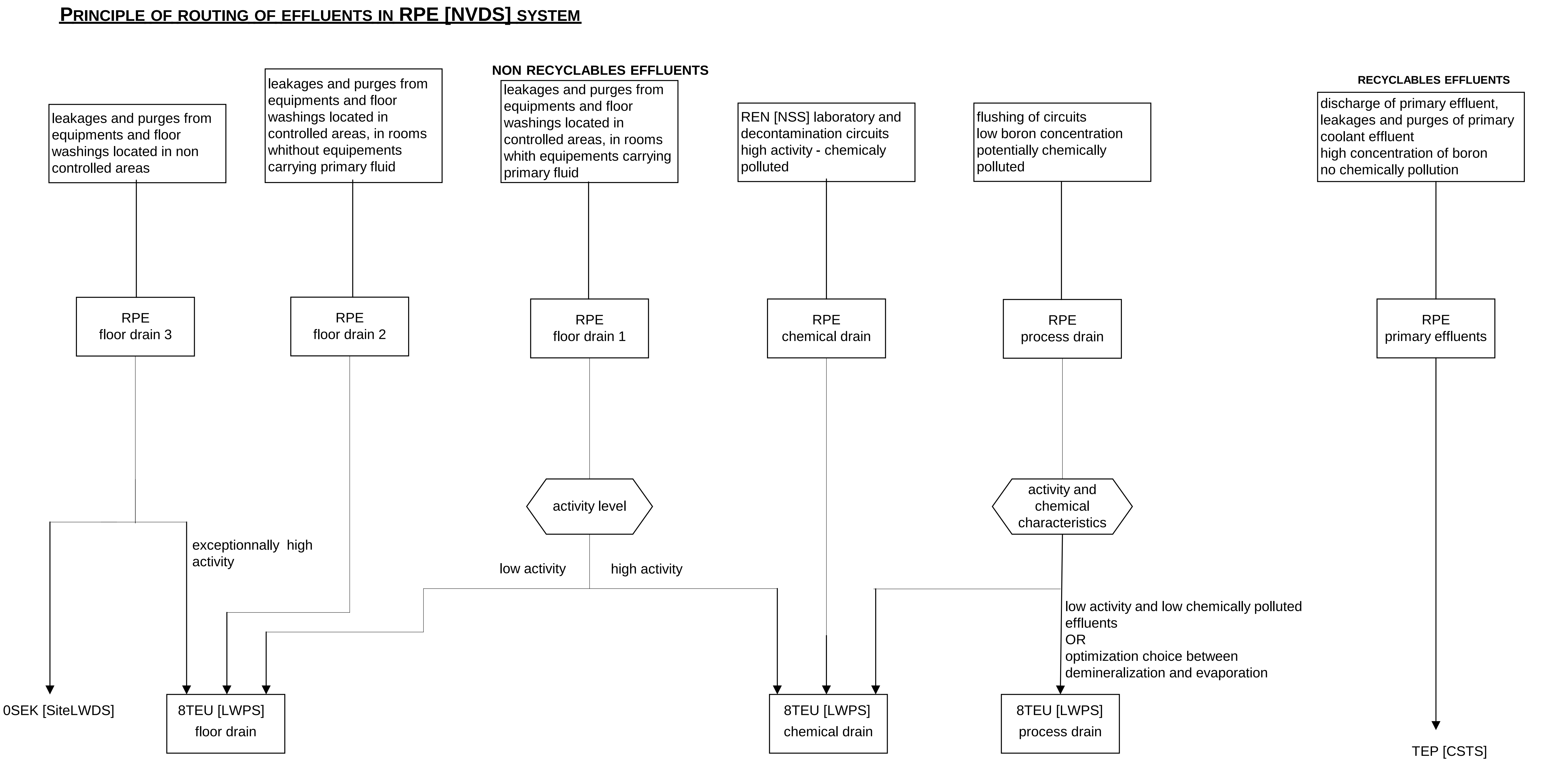
SECTION 11.4.2.1 - FIGURE 1 PAGE 8/9: COLLECTION OF RECYCLED EFFLUENT



SECTION 11.4.2.1 - FIGURE 1 PAGE 9/9: COLLECTION OF RECYCLED EFFLUENT

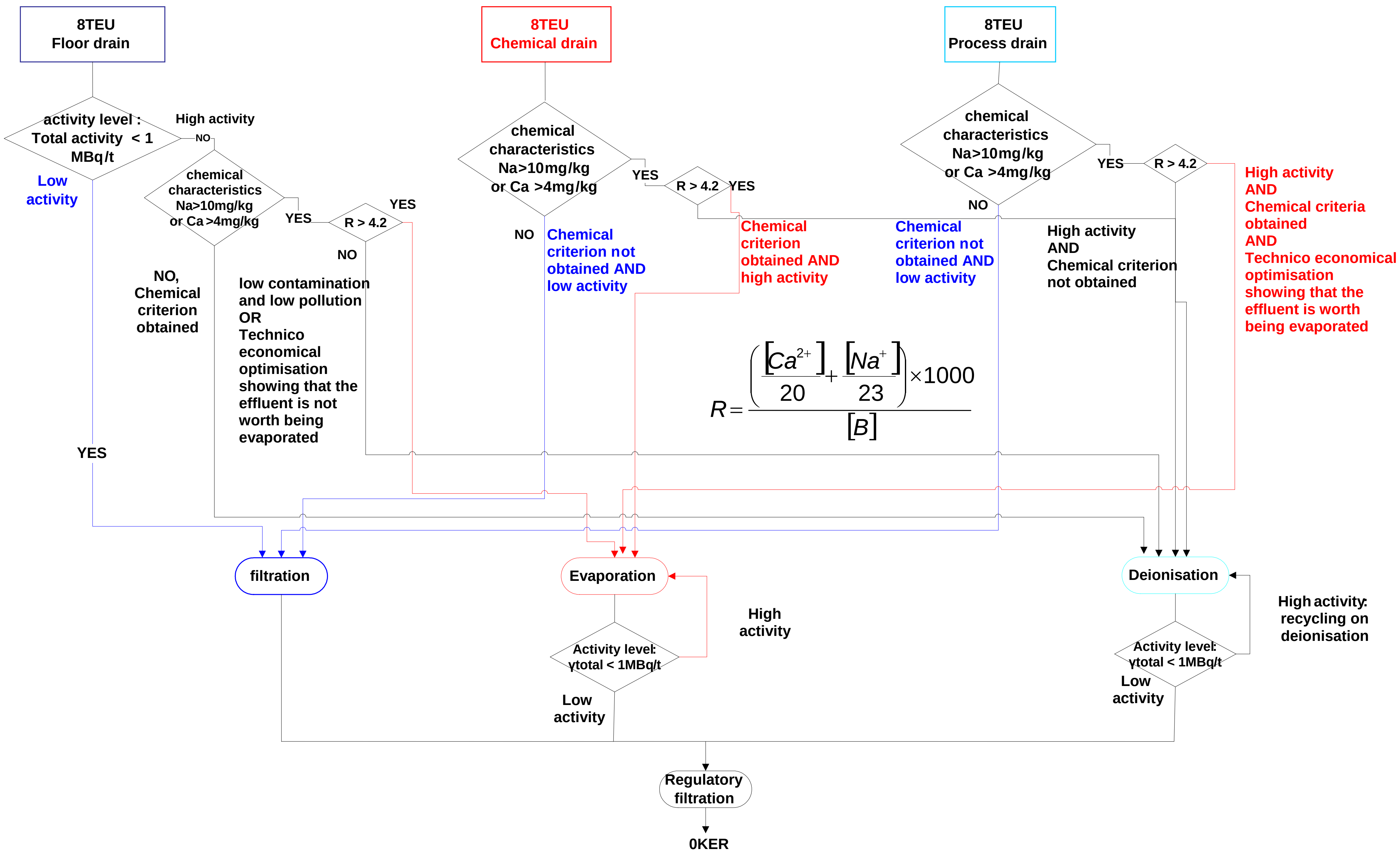


SECTION 11.4.2.1 - FIGURE 2: RULES FOR CHANNELLING EFFLUENT IN THE RPE [NVDS]

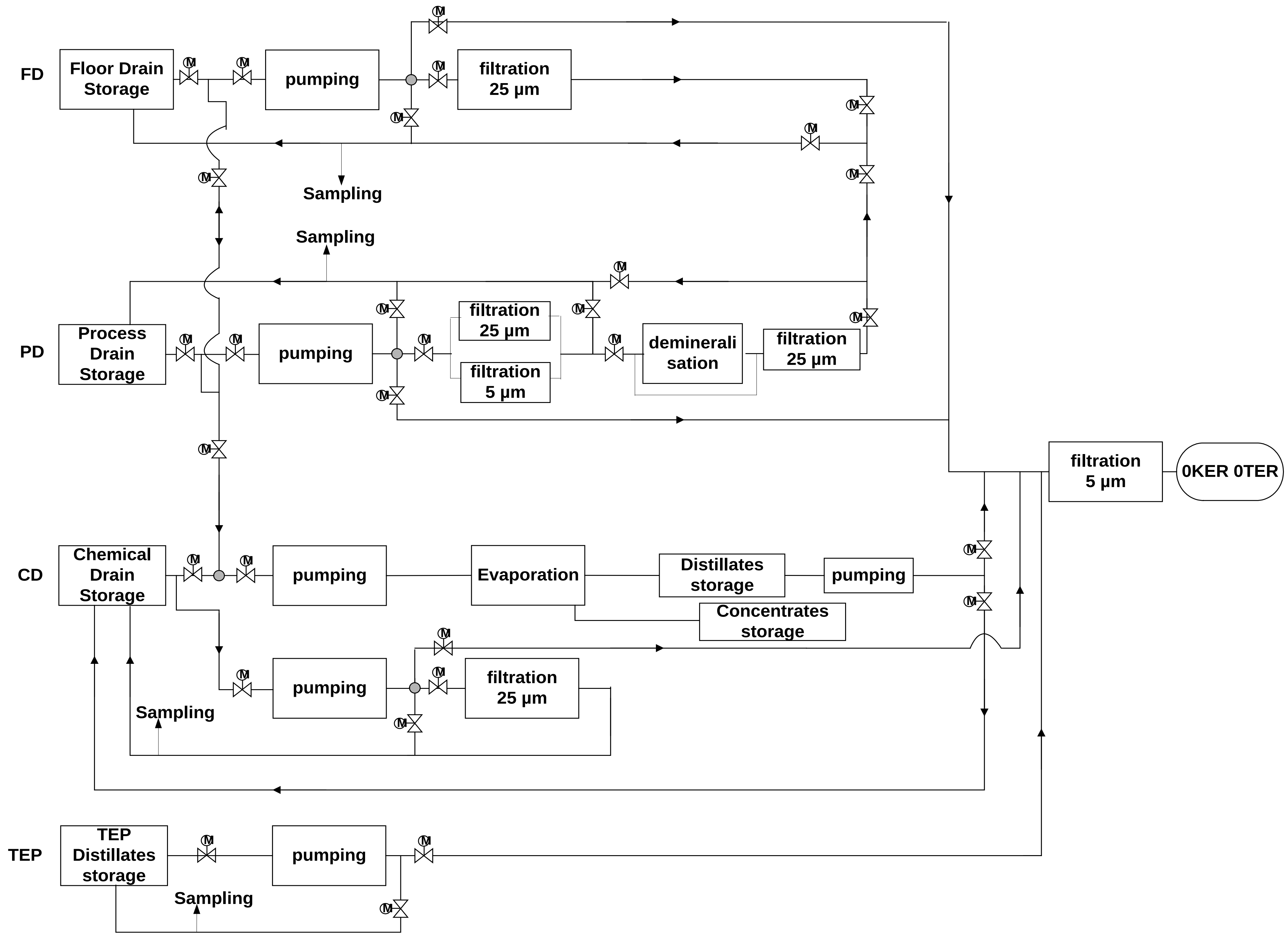


SECTION 11.4.2.2 - FIGURE 1: PRINCIPLE FOR ROUTING OF EFFLUENTS IN 8TEU [LWPS]

NON RECYCLABLE EFFLUENTS

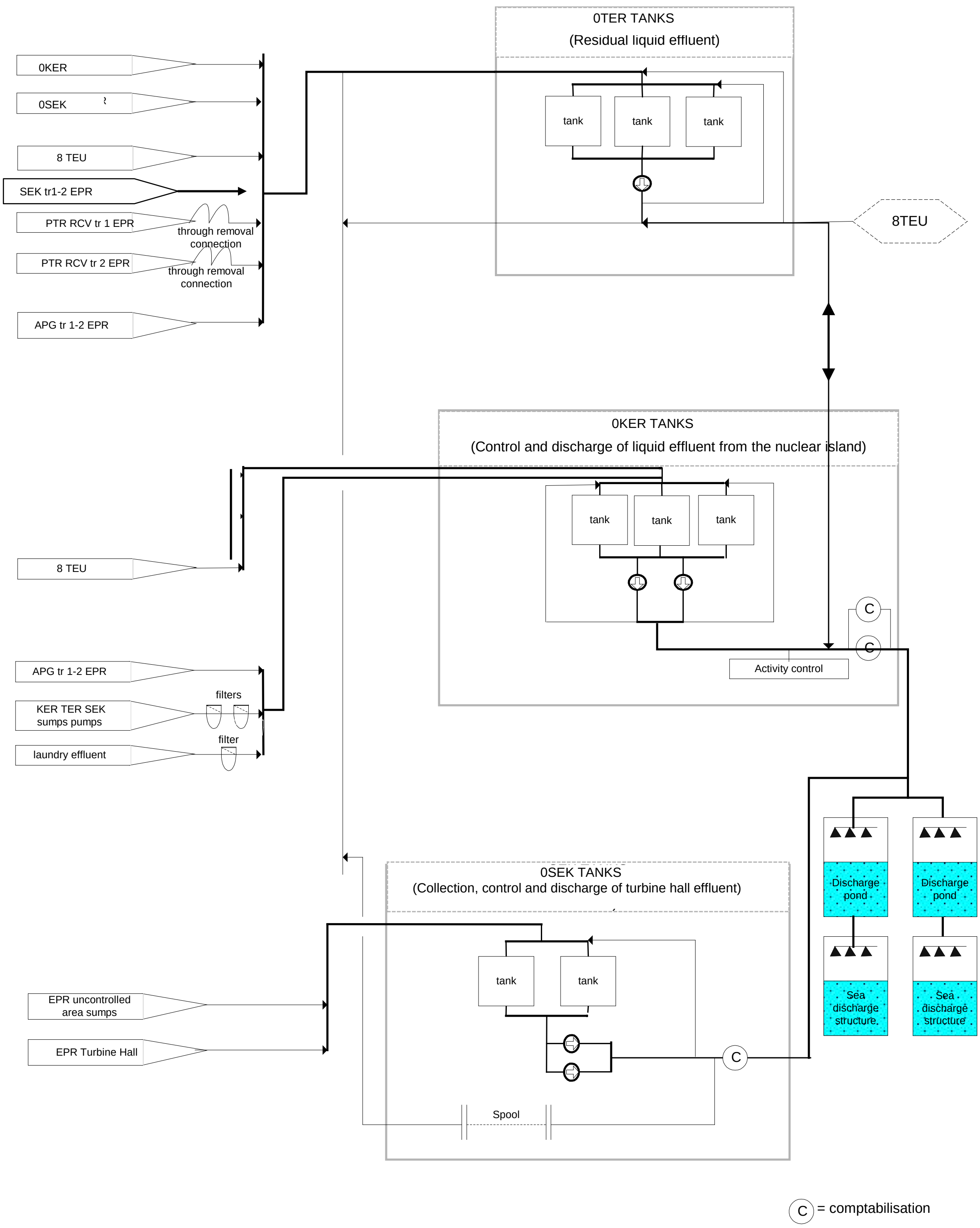


SECTION 11.4.2.2 - FIGURE 2: RULES FOR CHANNELLING EFFLUENT IN THE 8TEU [LWPS]

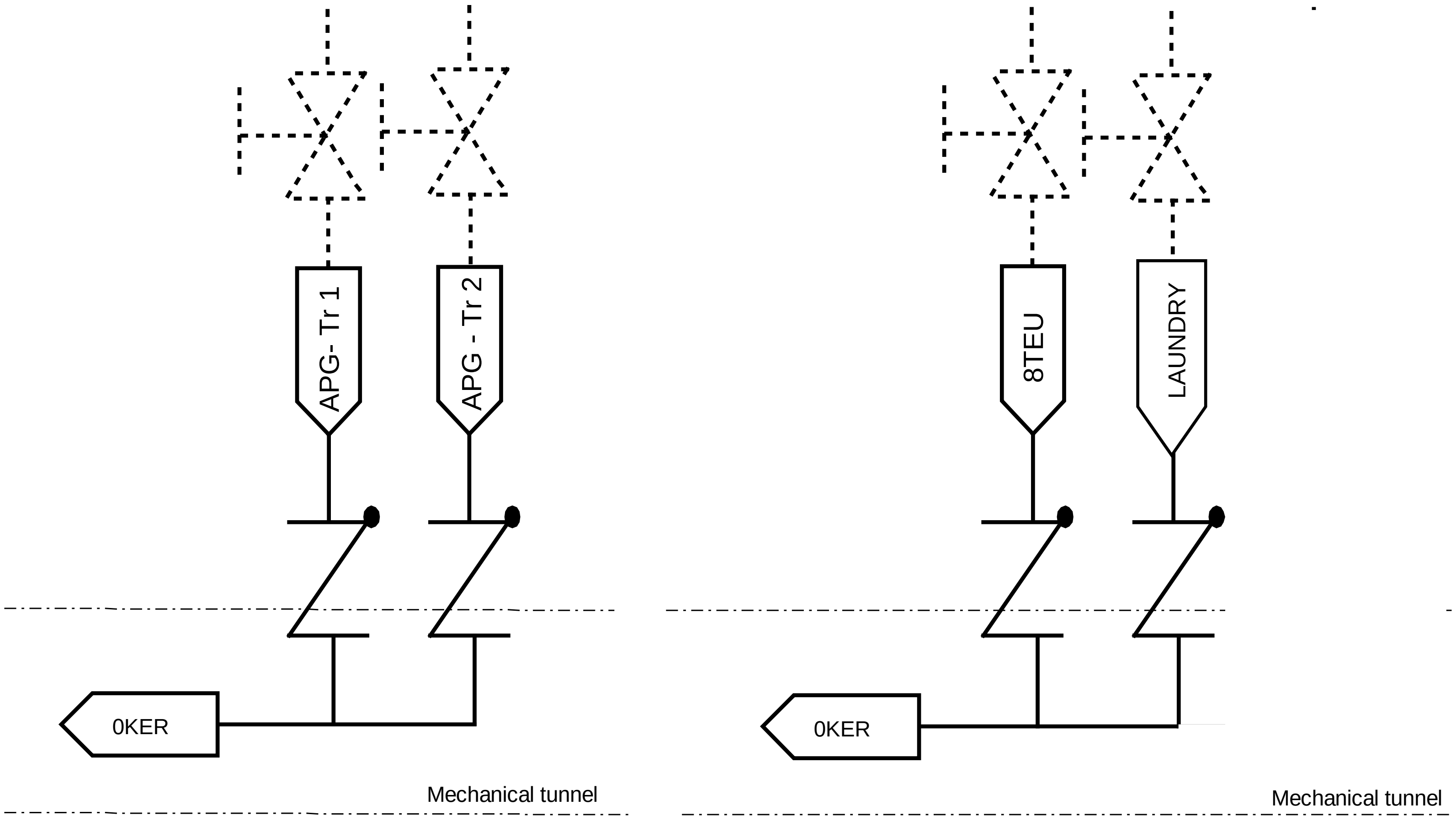


SECTION 11.4.2.3 - FIGURE 1:

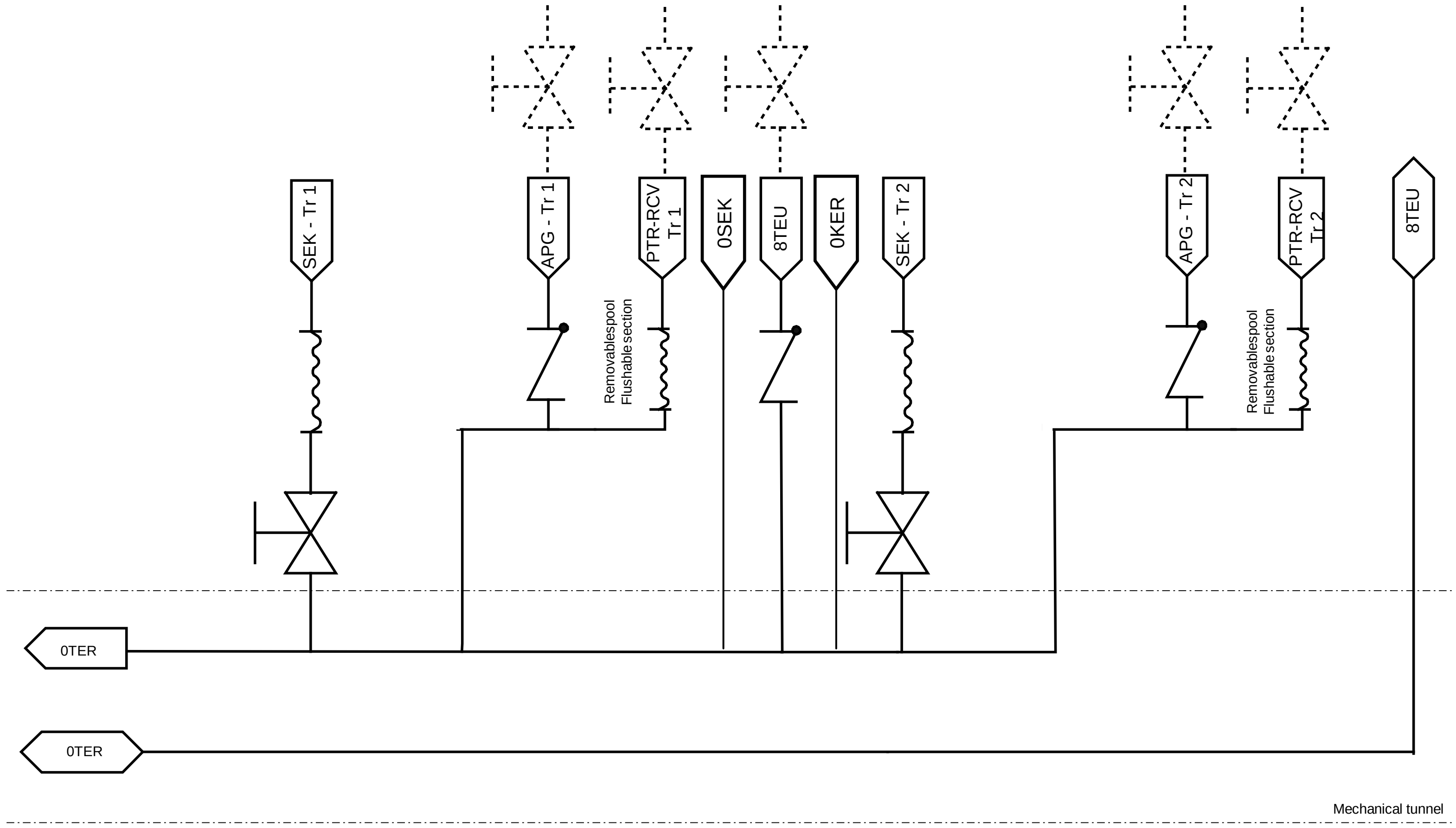
OVERALL 0KER [LRMDS]-0SEK [SiteLWDS]-0TER [ExLWDS] DIAGRAM Available for FA3



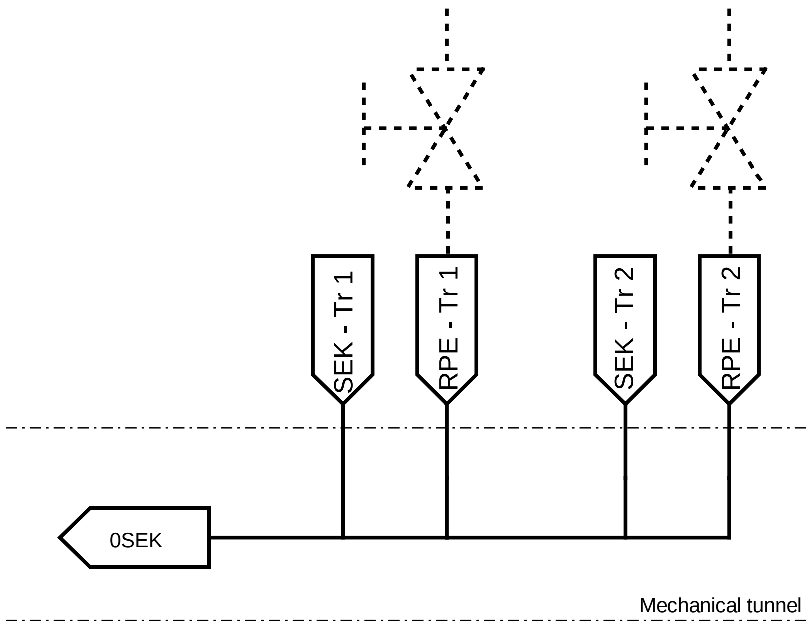
SECTION 11.4.2.3 - FIGURE 2: MECHANICAL DIAGRAM OF 0KER [LRMDS] COLLECTORS



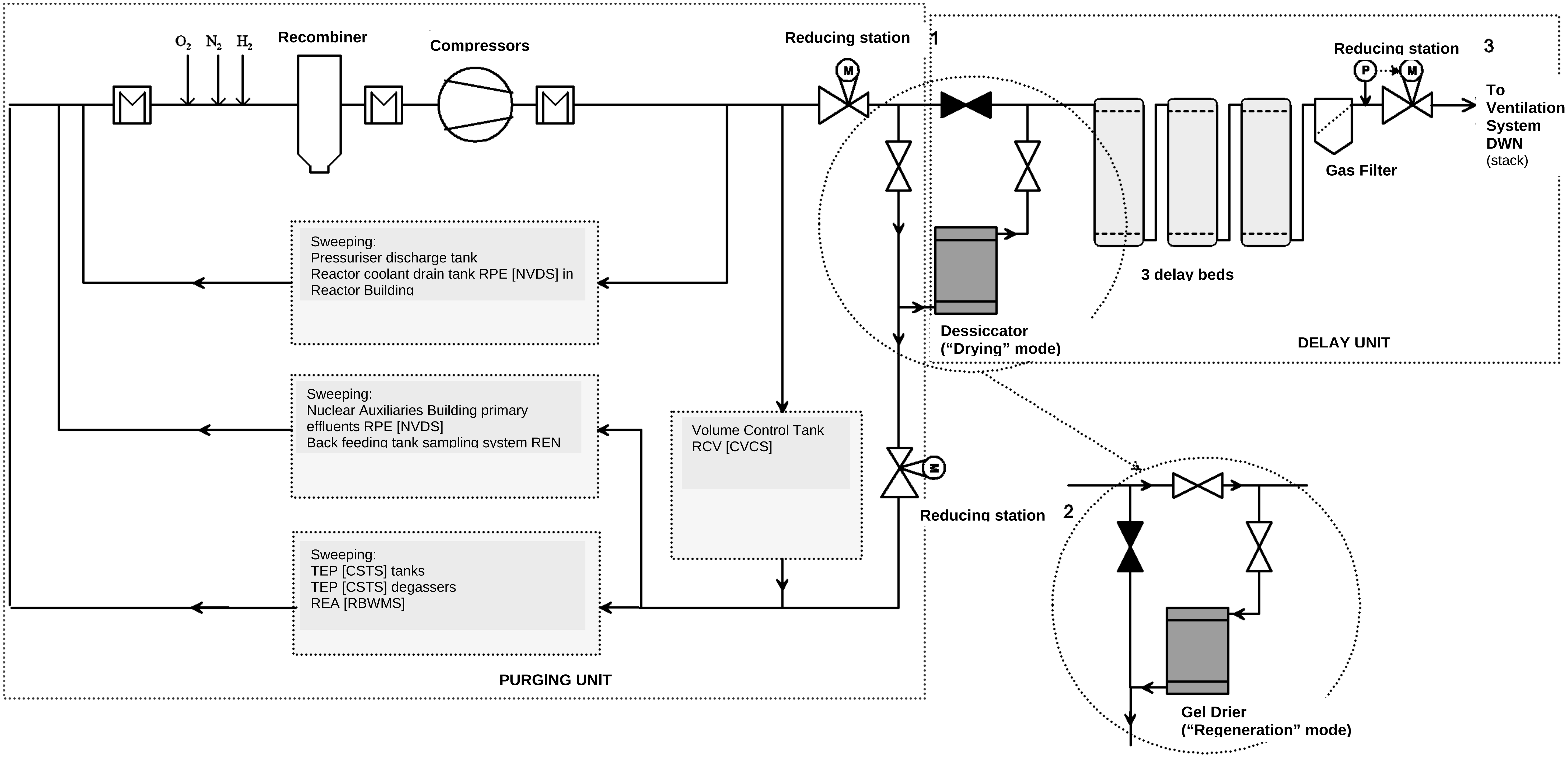
SECTION 11.4.2.4 - FIGURE 1: MECHANICAL DIAGRAM OF 0TER [ExLWDS] COLLECTORS



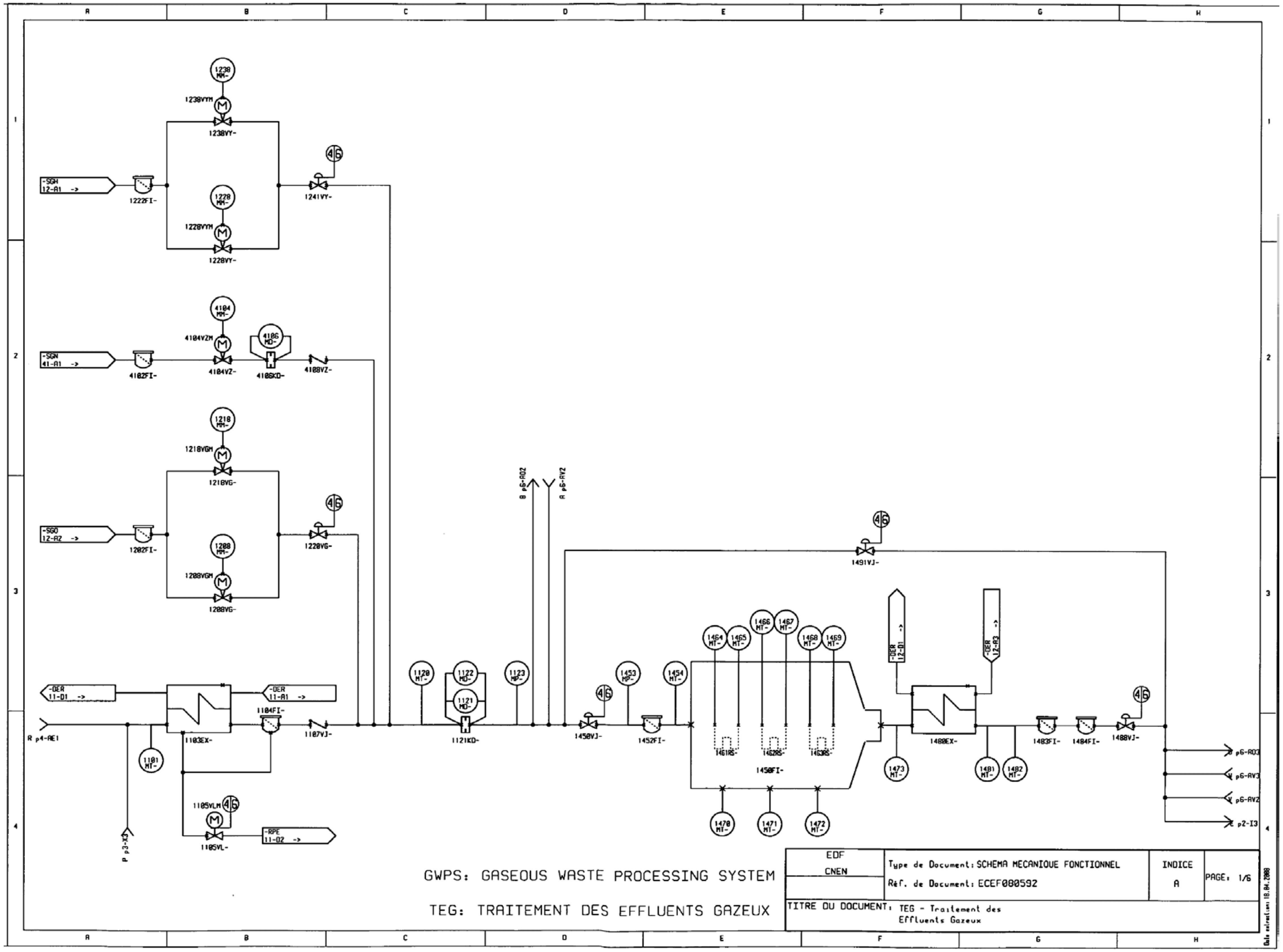
SECTION 11.4.2.5 - FIGURE 1: MECHANICAL DIAGRAM OF 0SEK [SiteLWDS] COLLECTORS



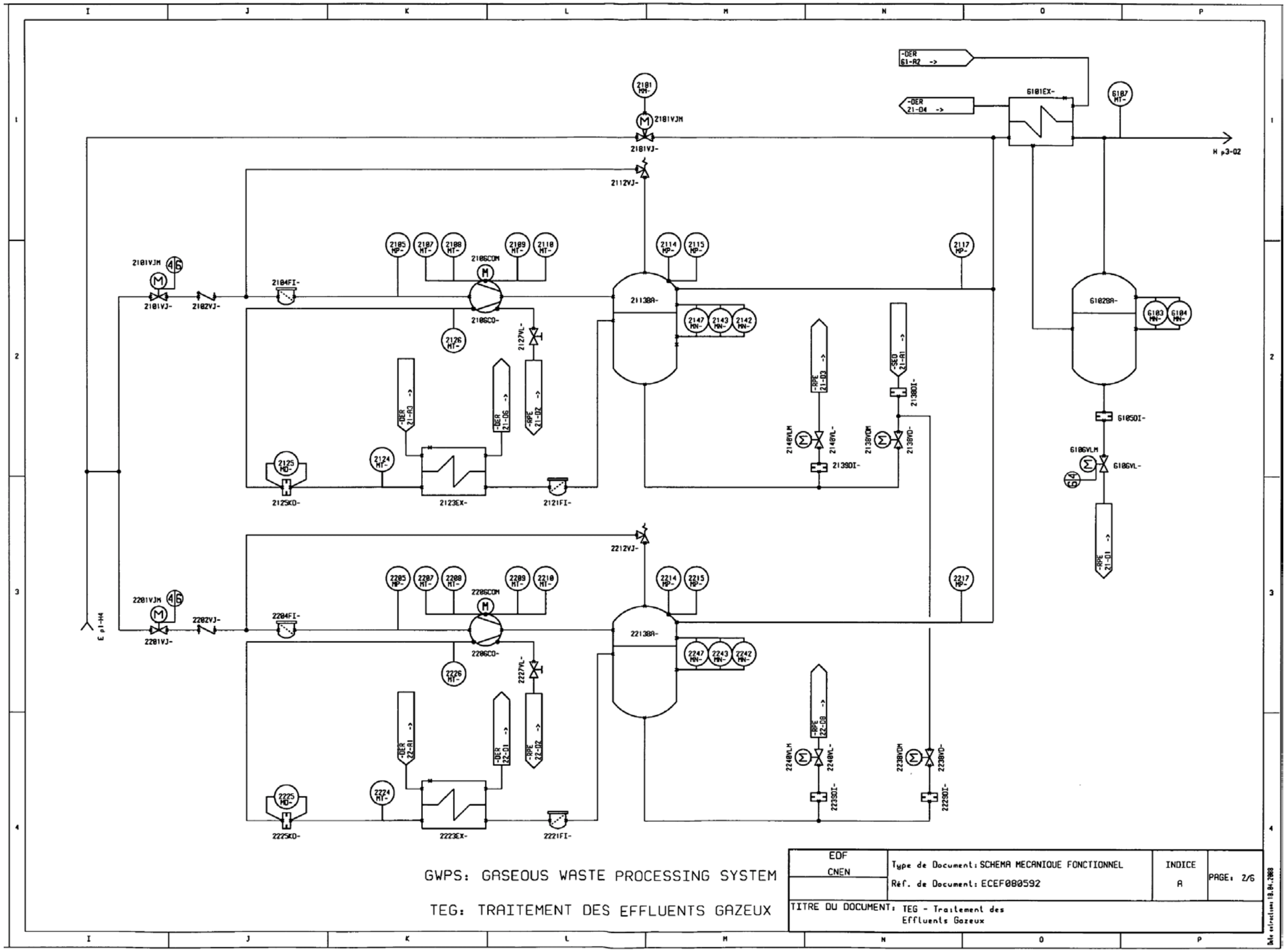
SECTION 11.4.3 - FIGURE 1: SIMPLIFIED DIAGRAM OF THE TEG [GWPS] SYSTEM



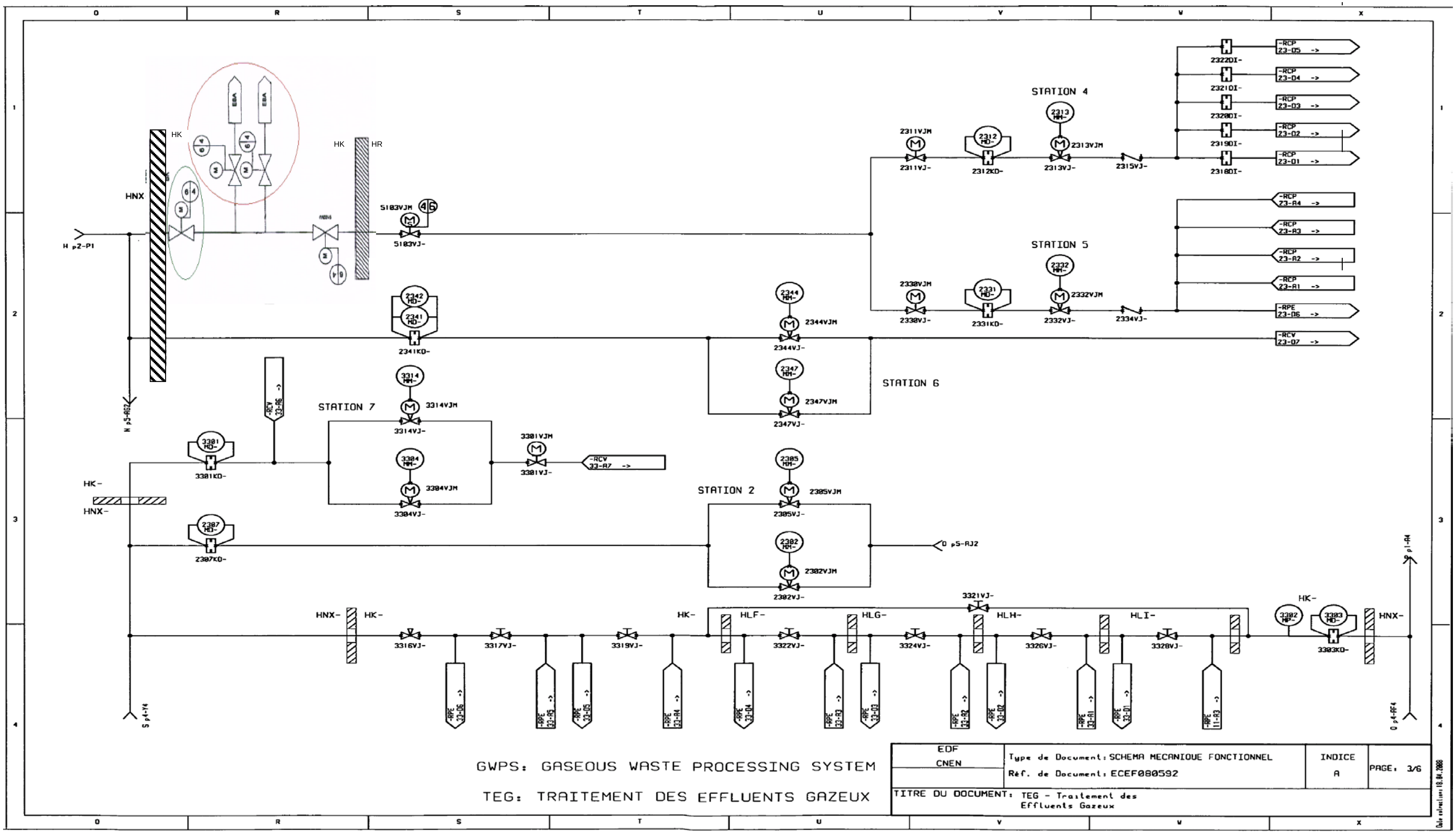
SECTION 11.4.3 - FIGURE 2 PAGE 1/6: TEG [GWPS] FUNCTIONAL FLOW DIAGRAM



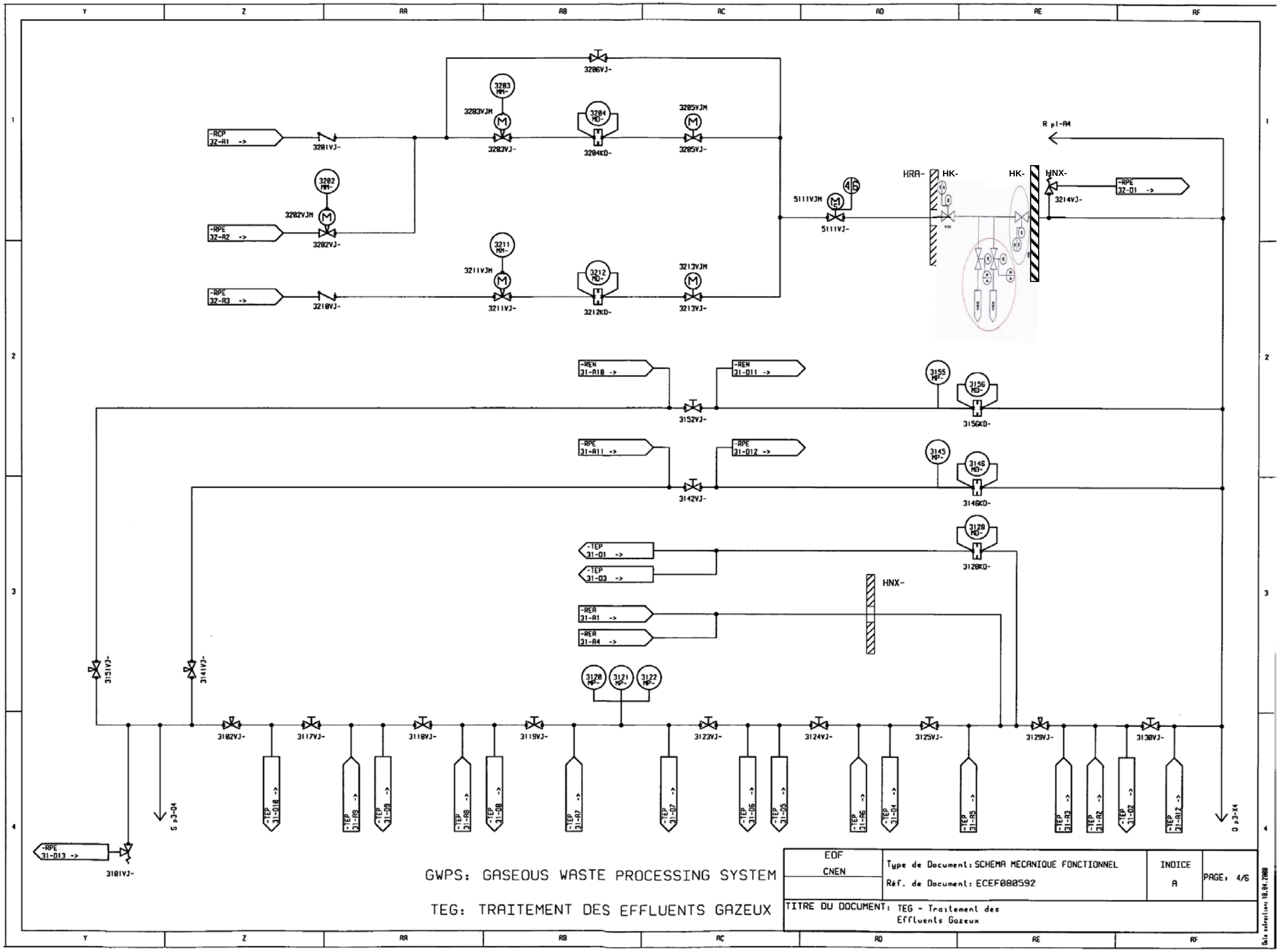
SECTION 11.4.3 - FIGURE 2 PAGE 2/6: TEG [GWPS] FUNCTIONAL FLOW DIAGRAM



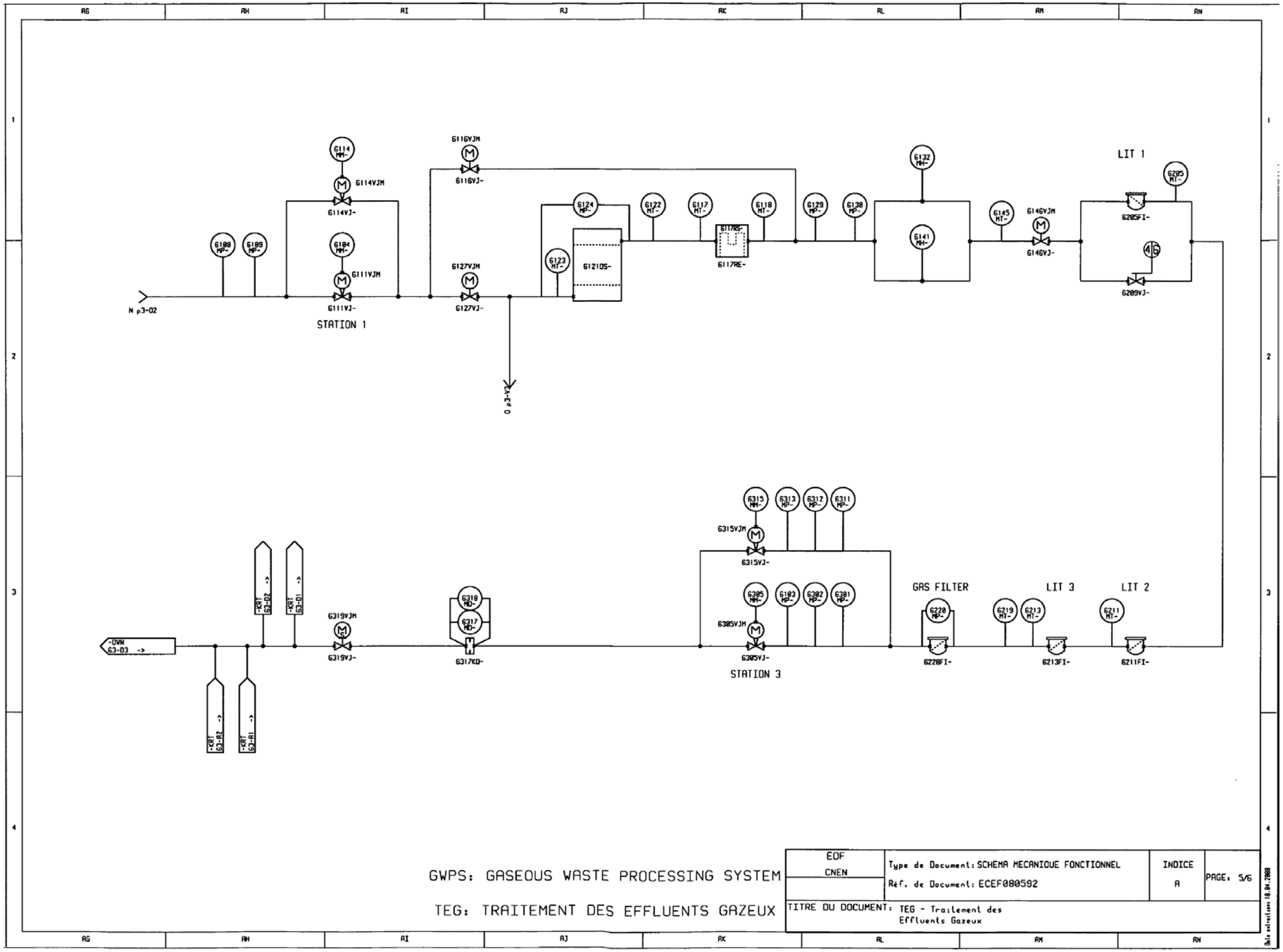
SECTION 11.4.3 - FIGURE 2 PAGE 3/6: TEG [GWPS] FUNCTIONAL FLOW DIAGRAM



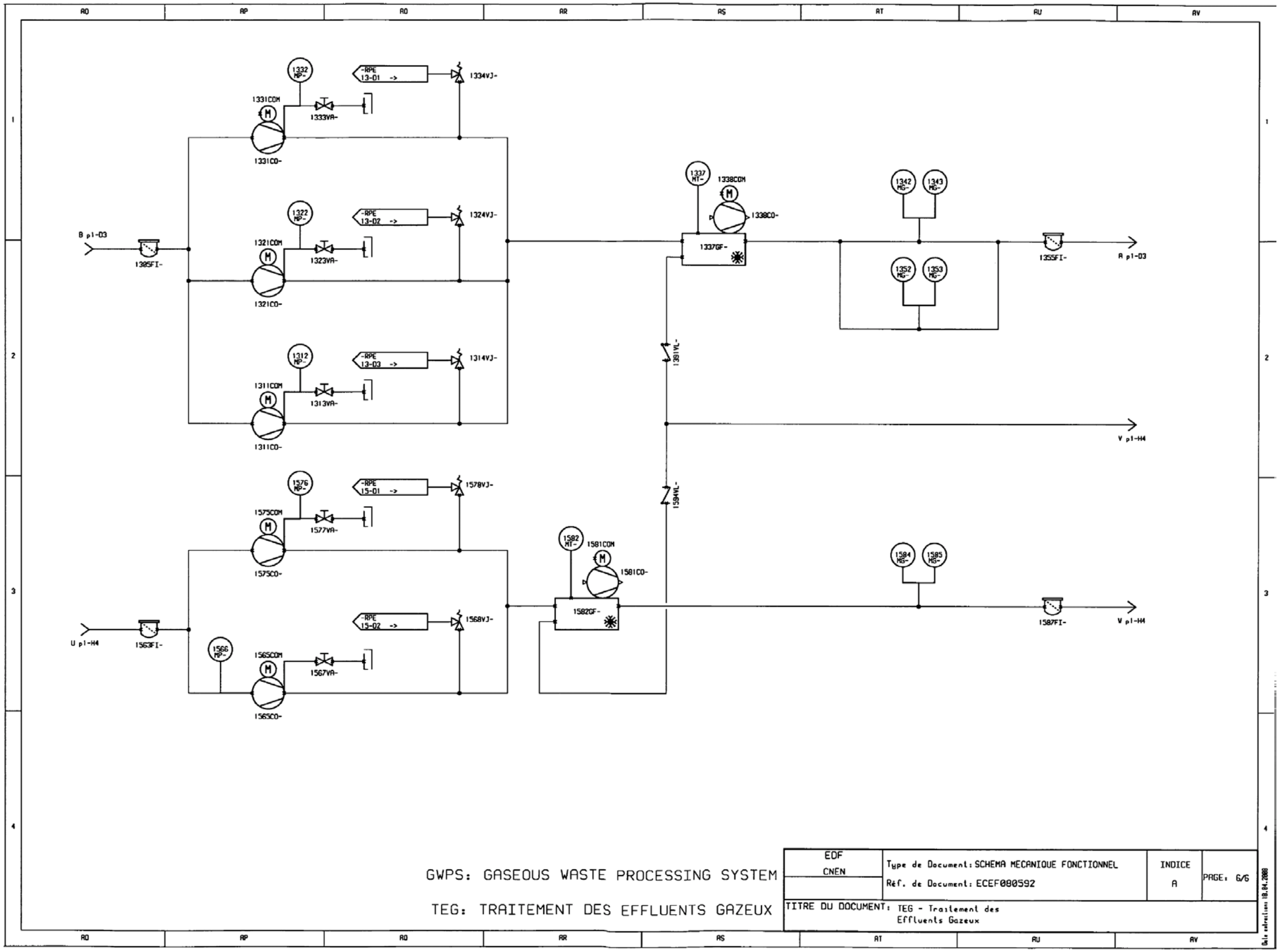
SECTION 11.4.3 - FIGURE 2 PAGE 4/6: TEG [GWPS] FUNCTIONAL FLOW DIAGRAM



SECTION 11.4.3 - FIGURE 2 PAGE 5/6: TEG [GWPS] FUNCTIONAL FLOW DIAGRAM



SECTION 11.4.3 - FIGURE 2 PAGE 6/6: TEG [GWPS] FUNCTIONAL FLOW DIAGRAM



SECTION 11.4.4.2 - TABLE 1

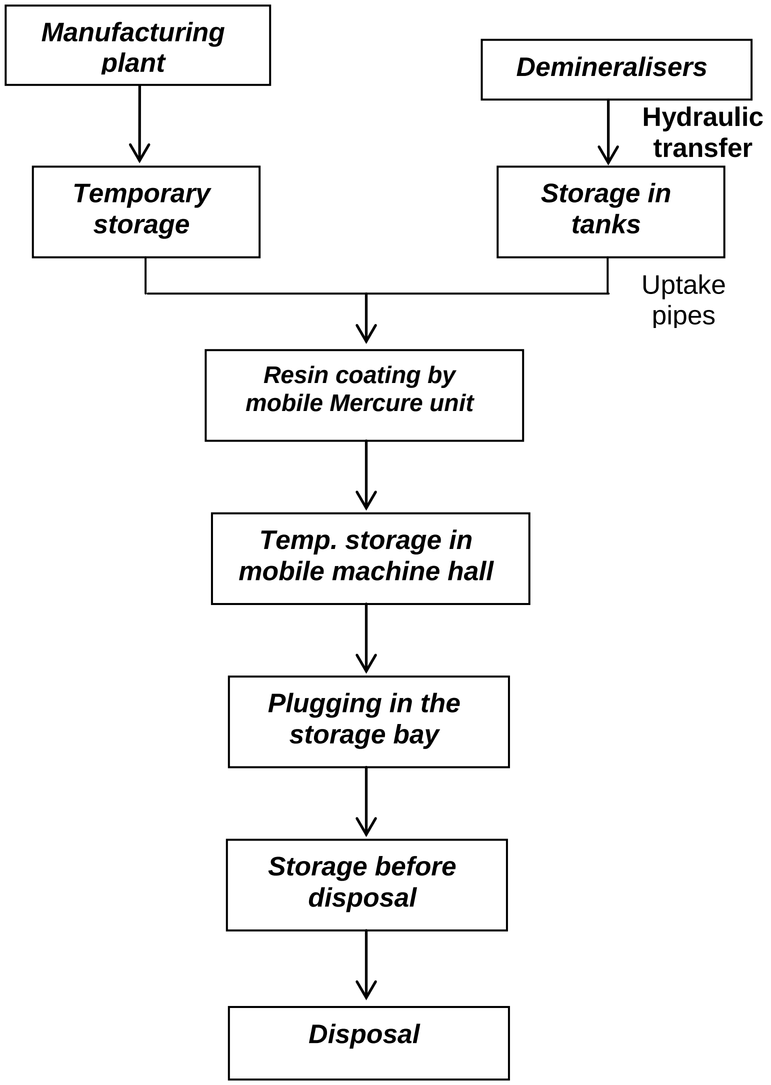
CONTAINERS

The types of containers used to condition the waste are listed below:

Level of radioactivity	Type of waste	Type of container
Slightly active	Technological waste or waste produced by compactable processes	200 L Metal or PEHD drum
Active	Ion-exchanging resins	C1 concrete containers
	Water filters Heterogeneous waste	C1 or C4 concrete containers
	Concentrates	C1 concrete containers with metal skin

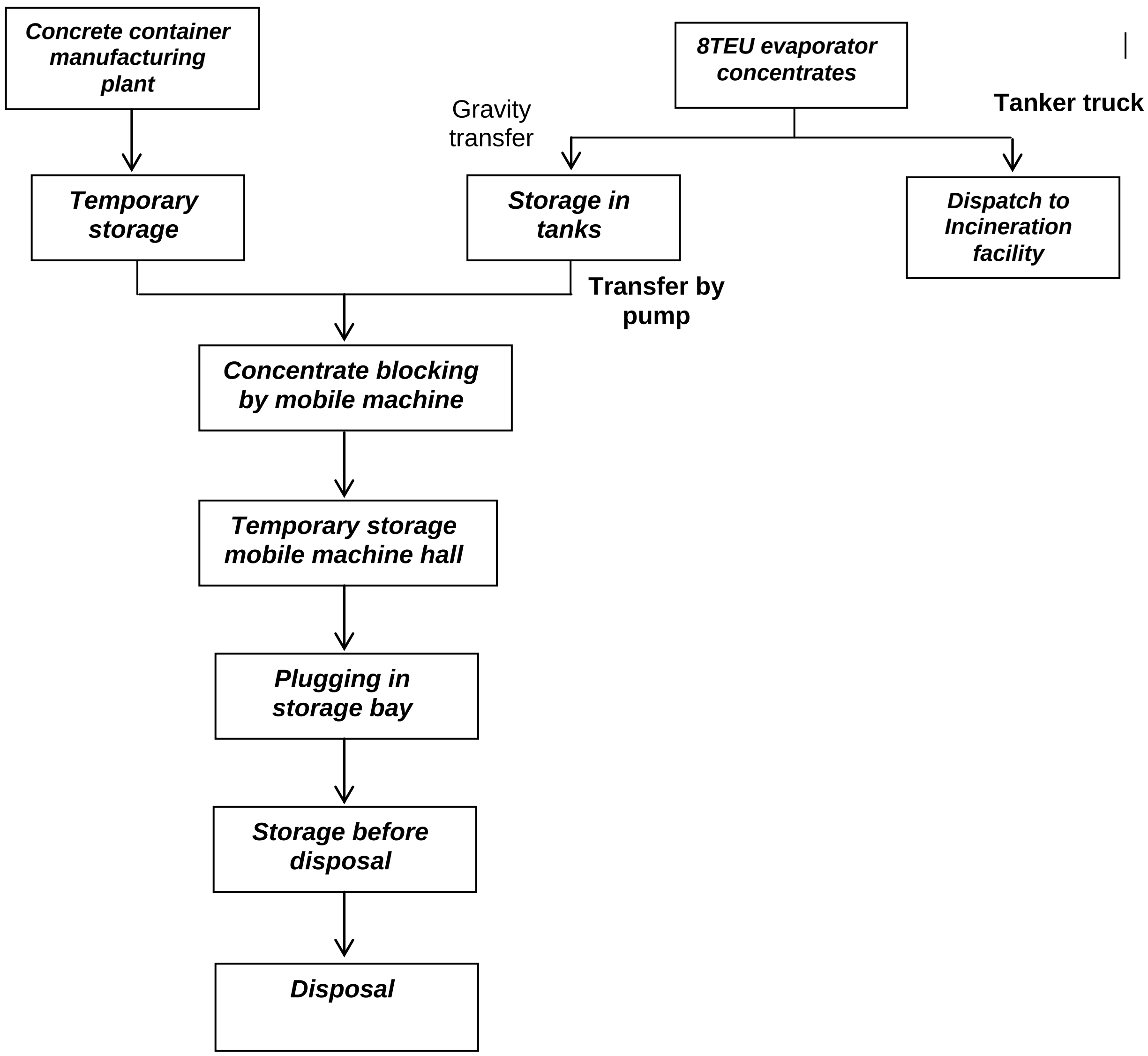
SECTION 11.4.4.2 - FIGURE 1

BLOCK DIAGRAM FOR CONDITIONING OF ACTIVE RESINS



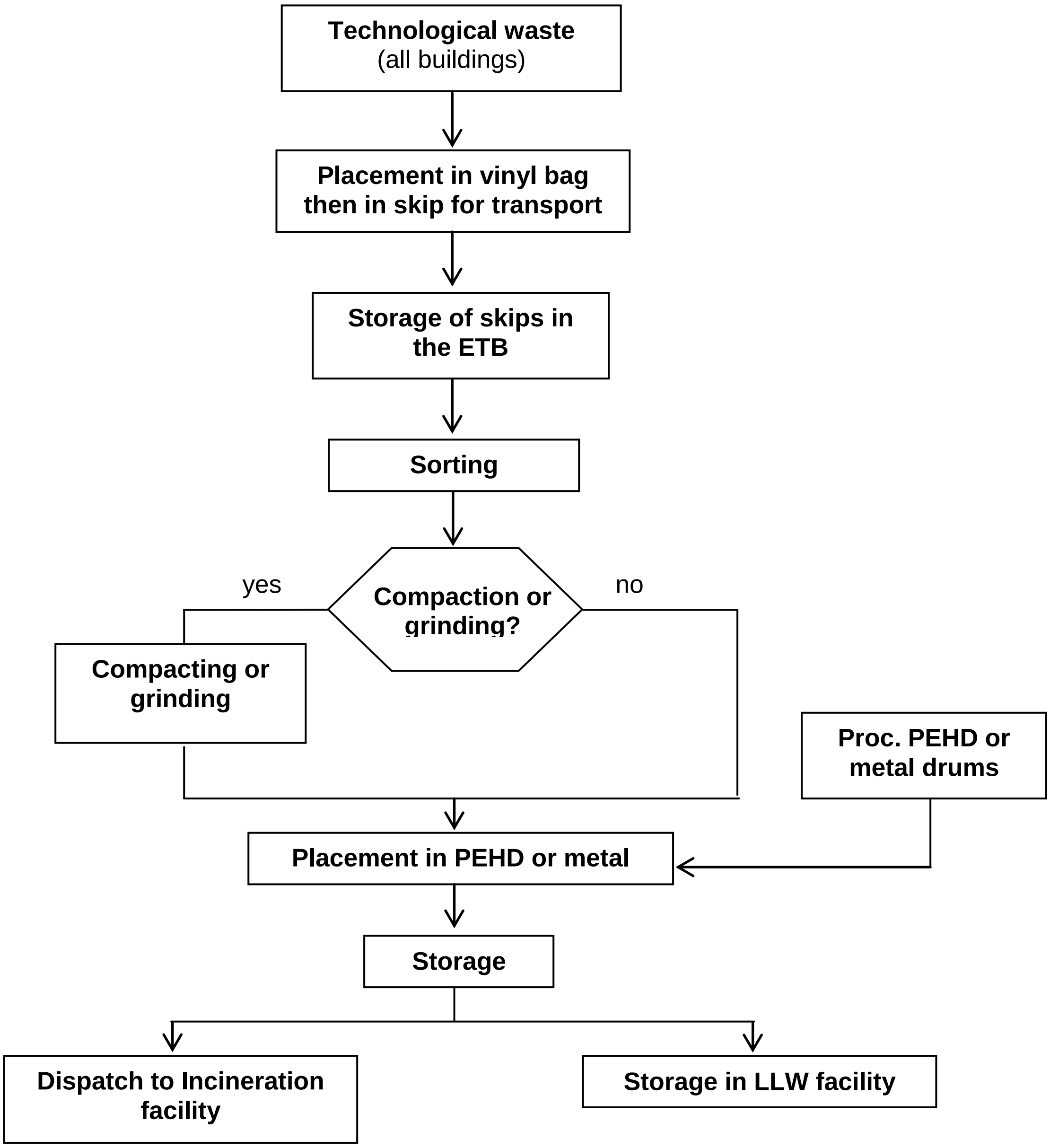
SECTION 11.4.4.2 - FIGURE 2

BLOCK DIAGRAM FOR CONDITIONING OF CONCENTRATES



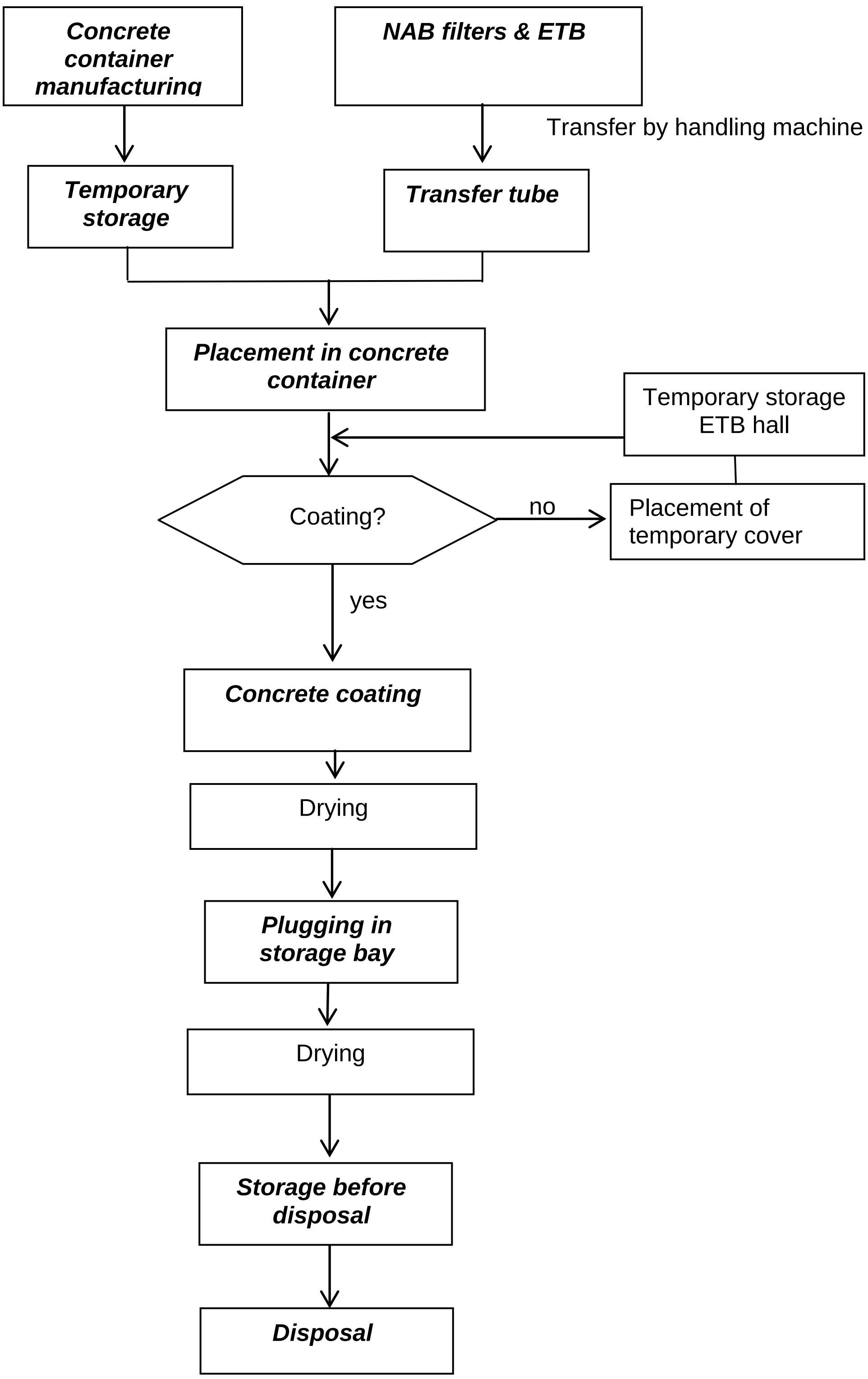
SECTION 11.4.4.2 - FIGURE 3

BLOCK DIAGRAM FOR CONDITIONING OF TECHNOLOGICAL WASTE



SECTION 11.4.4.2 - FIGURE 4

BLOCK DIAGRAM FOR CONDITIONING OF WATER FILTERS



SUB-CHAPTER 11.4 – 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.

[Ref-1] Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs. The Environment Agency. January 2007. (E)

1. THE ROLE OF EFFLUENT TREATMENT SYSTEMS

1.1. LIQUID EFFLUENT TREATMENT SYSTEMS

[Ref-1] EPR - Radioactive waste conditioning. ECUK110016 Revision A. Appendix 4. EDF. January 2011. (E)

1.3. SOLID WASTE TREATMENT SYSTEMS

[Ref-1] EPR - Radioactive waste conditioning. ECUK110016 Revision A. Appendix 4. EDF. January 2011. (E)

1.3.2. Effluent Treatment Building System

[Ref-1] EPR - Radioactive waste conditioning. ECUK110016 Revision A. Appendix 3. EDF. January 2011. (E)

2. SYSTEMS FOR TREATING RADIOACTIVE LIQUID EFFLUENTS

2.1. NUCLEAR ISLAND BLEED AND VENTING SYSTEM (RPE [NVDS])

[Ref-1] System Design Manual – Nuclear Island Vent and Drain System (RPE [NVDS]) P2 - System Operation.

BNI SFLEZS030018 Revision F. SOFINEL. October 2008. (E)
RB NESS-F DC 608 Revision A. AREVA. November 2009. (E)
ETB (8RPE) EYTF2008/fr/0010 Revision A1. EDF. September 2009. (E)

[Ref-2] System Design Manual - Nuclear Island Vent and Drain System (RPE [NVDS]) P3 – Sizing of the System and its Components.

BNI SFLEZS030019 Revision F. SOFINEL. July 2008. (E)
RB NESS-F DC 609 Revision A. AREVA. November 2009. (E)

[Ref-3] System Design Manual - Nuclear Island Vent and Drain System (RPE [NVDS]) P4 – Flow Diagrams.

BNI P4: Flow Diagrams. SFLEZS030020 Revision D. SOFINEL. October 2007. (E)
P4.1: Functional Flow Diagrams. EZS2007EN0021 Revision A. October 2007. (E)
P4.2: Detailed Flow Diagrams: EZS2007EN0022 Revision C. November 2008. (E)

RB NESS-F DC 610 Revision A. AREVA. November 2009. (E)
ETB (8RPE) P4: Flow Diagrams. EYTF2007/fr/0044 Revision C1. EDF. October 2009. (E)
(8RPE) P4.2: Detailed Flow Diagrams. EYTF2007/fr/0043 Revision C. EDF. October 2008.

[Ref-4] System Design Manual - Nuclear Island Vent and Drain System (RPE [NVDS]) P5 – Instrumentation and Control.

BNI SFLEZS030055 Revision F. SOFINEL. November 2008. (E)
RB NESS-F DC 616 Revision A. AREVA. (E)
ETB (8RPE) EYTF2008/fr/0047 Revision B1. EDF. October 2009. (E)

2.2. LIQUID WASTE PROCESSING SYSTEM (TEU [LWPS])

[Ref-1] System Design Manual - Liquid Waste Processing System (TEU [LWPS]) Part 2: Operation of the TEU [LWPS] EPR FA3 system.
ECEF070502 Revision A1. EDF. January 2010. (E)

[Ref-2] System Design Manual – Liquid Waste Processing System (TEU [LWPS]) Part 3: Design basis of the system and its components.
ECEF070503 Revision A1. EDF. January 2010. (E)

[Ref-3] System Design Manual – Liquid Waste Processing System (TEU [LWPS]) Part 4: Mechanical diagrams TEU EPR FA3.
ECEF070504 Revision A1. EDF. January 2010. (E)

[Ref-4] Dossier Système Elémentaire - Traitement Des Effluents Uses, P4.1: Schéma Mécanique Fonctionnel.
[System Design Manual – Liquid Waste Processing System (TEU [LWPS]) P4.1, Functional flow diagram].
ECEF072208 Revision A. EDF. November 2007.

[Ref-5] Dossier Système Elémentaire - Traitement Des Effluents Uses, P4.2: Schéma Mécanique Detaille.
[System Design Manual – Liquid Waste Processing System (TEU [LWPS]) P4.2, Detailed flow diagram].
ECEF071497 Revision B. EDF. January 2008.

[Ref-6] Dossier de Système Elémentaire – TEU DSE P5: Contrôle-commande.
[System Design Manual – Liquid Waste Processing System (TEU [LWPS]) Part 5: Instrumentation and Control]
ECEF071379 Revision A. EDF. December 2008.

2.2.1. Role of the system

[Ref-1] System Design Manual – Effluent Treatment Building Sampling System (TEN), P1. EYTS2008/fr/0016 Revision A1. EDF. August 2009. (E)

[Ref-2] System Design Manual – Effluent Treatment Building Sampling System (TEN)
P2 - System Operation.
EYTS2007/fr/0038 Revision B1. EDF. August 2009. (E)

[Ref-3] System Design Manual - Effluent Treatment Building Sampling System (TEN)
P3 – System and Component Design Basis.
EYTS2007/fr/0174 Revision B1. EDF. August 2009. (E)

[Ref-4] System Design Manual - Effluent Treatment Building Sampling System (TEN)
P4 – Mechanical Diagrams.
EYTS2007/fr/0040 Revision B1. EDF. August 2009. (E)

[Ref-5] Dossier Système Elémentaire – Circuit d'échantillonnage des effluents du BTE (TEN), P4.1 - Schéma Mécanique Fonctionnel.
[System Design Manual – Effluent Treatment Building Sampling System (TEN), P4.1 - Functional flow diagram].
EYTS2007/fr/0101 Revision A. EDF. November 2007.

[Ref-6] Dossier Système Elémentaire – Circuit d'échantillonnage des effluents du BTE (TEN), P4.2 - Schéma Mécanique Detaille.
[System Design Manual – Effluent Treatment Building Sampling System (TEN), P4.2 - Detailed flow diagram.]
EYTS2007/fr/0039 Revision B. EDF. November 2007.

2.3. NUCLEAR ISLAND LIQUID EFFLUENT CONTROL AND DISCHARGE SYSTEM (0KER [LRMDS])

[Ref-1] DARPE FLA (Authorization request for water intake and liquid and gaseous releases of the Flamanville site) Part B Chapter II.3 - Gaseous and liquid radioactive releases. (E)

2.4. RESIDUAL LIQUID EFFLUENT SYSTEM (0TER [EXLWDS])

There are no SDM for 0TER [ExLWDS] tanks - it is directly dealt with by the site as the tanks will be reused from the existing units in France

The reference below is available for Flamanville.

[Ref-1] DARPE FLA (Authorization request for water intake and liquid and gaseous releases of the Flamanville site) Part B Chapter II.3 - Gaseous and liquid radioactive releases. (E)

2.5. SYSTEM FOR COLLECTION, MONITORING AND DISCHARGE OF WASTE FROM THE CONVENTIONAL ISLAND (0SEK [SITELWDS])

[Ref-1] DARPE FLA (Authorization request for water intake and liquid and gaseous releases of the Flamanville site) Part B Chapter II.3 - Gaseous and liquid radioactive releases. (E)

[Ref-2] Dossier de Système Elémentaire – SEK DSE P4.2: Schéma mécanique détaillé.
[System Design Manual – Site Liquid Waste Discharge System (SEK [SiteLWDS]) P4.2 : Detailed Flow Diagrams].
23952 SEK 00014 SH Revision C. Assystem. September 2008.

[Ref-3] System Design Manual – Conventional Island Liquid Waste Discharge System (SEK [CILWDS]) Part 5 : Instrumentation and Control].
23952 SEK 00025 DSE Revision C1. Assystem. December 2008. (E)

2.6. INTER-STAGE REFRIGERATION CIRCUITS (RRI [CCWS] AND TRI)

[Ref-1] System Design Manual - Waste Building Component Cooling System (TRI) - Part 1 History. EYTS/2007/fr/0228 Revision B1. Sofinel. November 2009. (E)

[Ref-2] System Design Manual - Waste Building Component Cooling System (TRI) - Part 2 System Operation. EYTS/2007/fr/0036 Revision B1. November 2009. EDF. (E)

[Ref-3] System Design Manual - Waste Building Component Cooling System (TRI) - Part 3 System and component design basis. EYTS/2007/fr/0037 Revision C1. November 2009. EDF. (E)

[Ref-4] System Design Manual - Waste Building Component Cooling System (TRI) - Part 4 Mechanical diagrams. EYTS/2007/fr/0070 Revision C1. November 2009. EDF. (E)

[Ref-5] Dossier Système Elémentaire – (TRI), P4.2 - Schéma Mécanique Detaille.
[System Design Manual – Waste Building Component Cooling System (TRI), P4.2 - Detailed flow diagram.]
EYTS2007/fr/0069 Revision C. EDF. August 2008.

[Ref-6] System Design Manual - Waste Building Component Cooling System (TRI) - Part 5 Instrumentation and Control. EYTS/2007/fr/0115 Revision D1. November 2009. EDF. (E)

3. GASEOUS WASTE PROCESSING SYSTEM (TEG [GWPS])

[Ref-1] System Design Manual - Gaseous Waste Processing System (TEG [GWPS]), P1 – History of the System Manual.
SFL–EZS 030050 Revision D. SOFINEL. October 2008. (E)

[Ref-2] System Design Manual - Gaseous Waste Processing System (TEG [GWPS]), P2 – System operation.
SFL–EZS 030051 Revision E. SOFINEL. September 2008. (E)

[Ref-3] System Design Manual - Gaseous Waste Processing System (TEG [GWPS]), P3 – System design.
SFL–EZS 030052 Revision E. SOFINEL. September 2008. (E)

[Ref-4] System Design Manual - Gaseous Waste Processing System (TEG [GWPS]), P4 – Flow diagrams.
SFL–EZS 030053 Revision D. SOFINEL. September 2008. (E)

[Ref-5] System Design Manual - Gaseous Waste Processing System (TEG [GWPS]), P4.1 – Functional flow diagrams.
ECEF080592 Revision A. EDF. April 2008. (E)

[Ref-6] System Design Manual - Gaseous Waste Processing System (TEG [GWPS]), P4.2 – Detailed flow diagrams.
EZS/2007/en/0007 Revision D. SOFINEL. September 2008. (E)

[Ref-7] System Design Manual - Gaseous Waste Processing System (TEG [GWPS]), P5 – Instrumentation and Control.
EZS 2007/en/0015 Revision C. SOFINEL. October 2008. (E)

3.4. OPERATING CONDITIONS

3.4.1. Normal system operation

3.4.1.2. Active inventory of the TEG [GWPS]

[Ref-1] EPR: activity concentrations in the TEP, REA, TEG, RPE, TEU and TES auxiliary systems. ENTERP070291 Revision A. EDF. November 2007. (E)

ENTERP070291 Revision A is the English translation of ENTERP070070 Revision A

4. SYSTEMS FOR TREATING SOLID RADIOACTIVE EFFLUENTS (TES [SWTS])

Filter changing equipment:

[Ref-1] System Design Manual – Solid Waste Treatment System (TES [SWTS]) – Filter changing equipment TES11, P2 – System operation.
SFLEZM200118 Revision B. SOFINEL. September 2006. (E)

[Ref-2] System Design Manual – Solid Waste Treatment System (TES [SWTS]) – Filter changing equipment TES11, P3 – Sizing of the system and its components.
SFLEZM200119 Revision B. SOFINEL. September 2006. (E)

Transfer of the spent resins

[Ref-3] System Design Manual – Solid Waste Treatment System (TES [SWTS]) – Transfer of the spent resins (TES21, TES31), P1.
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[Ref-4] System Design Manual – Solid Waste Treatment System (TES [SWTS]) – Transfer of the spent resins (TES21, TES31), P2 – System operation. SFL-EZS030040 Revision D. SOFINEL. March 2007. (E)

[Ref-5] System Design Manual – Solid Waste Treatment System (TES [SWTS]) – Transfer of the spent resins (TES21, TES31), P3 – Sizing of the system and its components. SFL-EZS030041 Revision D. SOFINEL. March 2007. (E)

[Ref-6] System Design Manual – Solid Waste Treatment System (TES [SWTS]) – Transfer of the spent resins (TES21, TES31), P4 – Flow diagrams. SFL-EZS030042 Revision D. SOFINEL. March 2007. (E)

[Ref-7] System Design Manual – Solid Waste Treatment System (TES [SWTS]) – Transfer of the spent resins (TES21, TES31), P4.1 – Simplified flow diagrams. EZS/2006/en/0019 Revision A. SOFINEL. March 2007. (E)

[Ref-8] System Design Manual – Solid Waste Treatment System (TES [SWTS]) – Transfer of the spent resins (TES21, TES31), P4.2 – Detailed flow diagrams. EZS/2006/en/0020 Revision B. SOFINEL. March 2007. (E)

5. SYSTEMS FOR TREATING SOLID AND LIQUID RADIOACTIVE EFFLUENTS – OPTIONS TO THE REFERENCE CASE

[Ref-1] Solid Radioactive Waste Strategy Report (SRWSR). AREVA NP. NESH-G/2008/en/0123 Rev A. November 2008. (E)