KOREA ELECTRIC POWER CORPORATION

56
60

Korea Nuclear Units 9 & 10

최종안전성 분석보고서

Final Safety Analysis Report

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VOLUME 11

Chapter 11

RADIOACTIVE WASTE MANAGEMENT

CHAPTER 11 : RADIOACTIVE WASTE MANAGEMENT

TABLES

11.1. SOURCE TERMS

Two sets of source terms are presented in this Section. The first set is based on a realistic model used to predict expected Plant radioactive releases over the life-time of the Plant.

The second set of source terms is a conservative design base which serves as a basis for design of radwaste treatment systems calculated.

11.1.1. Models used to calculate source terms

The radiation sources set out in this Subsection are using the parameters summarized in Table T-11.1-1.

These numeric data concern the reactor core, the reactor coolant system providing pertinent information to assess reactor coolant fission and corrosion product specific activities.

11.1.1.1. Fission products

The phenomena that govern the production of fission products and subsequent release from the fuel into the reactor coolant via fuel clad defects, are complex and can only be clearly apprehended by use of a calculation code. In this purpose, the PROFIP Code was devised and qualified at the CEA/DRE/SEN, on the basis of feedback from experience on French PWR Plants.

The modelling of fission production within the fuel and subsequent passage to the reactor coolant can be split up into four consecutive sequences.

a) The actual creation of the products through fission, radioactive decay or neutron capture.

b) Their release from the fuel due to various mechanisms such as intergranular diffusion and trapping, withdrawal and ejection.

c) Diffusion into the fuel cladding assembly and release into the reactor coolant via cladding defects.

d) An overall assessment of the reactor coolant system which takes into account the reactor operating parameters (purification rate, partition in the RCV system and the pressurizer, leakrate etc.).

Contamination of the reactor coolant system largely depends on the characteristics of the cladding defects and of the phenomena which cause the passage of fission products from the fuel cladding assembly to the reactor coolant.

Feedback from French operating and testing experience has made it possible to model the process of fission product release into reactor coolant, for different types of clad failure (PROFIP Code).

Each type of failure was combined with a given reactor coolant system activity spectrum, both under power operation and transient conditions. The phenomenon of activity peak during transient conditions was assumed for iodines, cesiums and noble gases. The code also computes reactor coolant activity resulting from cladding contamination.

As will be seen further in this section, it was decided to characterize the reactor coolant system activity by the concentration of activity in I 131 equivalent. Activity in I 131 equivalent is the activity which corresponds to the concentration of I 131, which, alone could produce the same dose to the thyroid as the concentration of isotopic iodine mixture contained in the reactor coolant.

11.1.1.2. Activation and corrosion products

A calculation code, known as the PACTOLE Code has been devised and qualified on the basis of fundamental studies conducted concurrently with measures on reactors in operation and experiments on ex-pile test loops.

This code describes and uses the basic mechanisms that actually occur and exclades empirical relations insofar as possible. The main mechanisms involved and therefore postulated, are indicated below :

- oxidation of the parent metal, corrosion and release, precipitation, particulation, deposits, erosion, adhesion probability.

All the above mentioned phenomena are related to one another by equation systems. There is at least one equation per element, per nucleide and per area considered, the reactor coolant being divided into soluble phase and particle phase.

Each area is characterized by the temperatures of the coolant and walls, the coolant speed and hydraulic diameter, the surface rugosity and composition of the material employed, the neutron flux, etc. Use of the code also demands knowledge of the power output records and the evolution with time of the chemical conditions.

The PACTOLE Code resolves the above-mentioned equation system and calculates the activity of nuclides in solution, under stable power operation.

Activity of nuclides in solution, under transient conditions are deduced from operating experience.

11.1.2. Basic assumptions

All data refer to a single Unit, operating on the basis of 8 000 hr/year at rated power, with annual refueling.

The number of postulated transients corresponds to the following scheme of annual Unit operation :

- two 8 hours hot shutdowns with start-up during xenon peak,
- two 90 hours hot shutdowns with start-up during xenon equilibrium,
- four cold shutdowns,
- one shutdown for refueling,
- eight transients of a 50 % magnitude (from 100 % to 50 % of the rated power) and nine reactor trips.

The postulated fuel is divided into 3 parts of equal weight with respective irradiation rates of 5 000, 16 000 and 28 000 MW days/ton. The core represents a weight of 72,5 tons of uranium.

The two sets of assumptions postulated for the waste calculations are as follows :

Case A :

Normal operating conditions. In this case, the assumptions are based on operating feedback from French Power Plants. The waste values are known as "anticipated values".

Case B :

Abnormal operating conditions which correspond to limit conditions and involve waste values known as "design basis values".

The main difference between these two sets of assumptions concerns reactor coolant activity.

For Case A, we shall take a reactor coolant activity concentration of 0,03 Ci/t in I 131 equivalent over the full cycle. This value deducted from the FRAGEMA results (feedback from fuel experience) is the envelope of the mean activities recorded on the total number of French Power Plants in operation.

The total activity spectrum for the operating period normalized at 0,03 Ci/t in I 131 equivalent is given in Table T-11.1-2.

In Case B, we shall analyse a design case which corresponds to a significant reactor coolant activity likely to have been caused by a greater degree of clad failure. The assumptions for such reactor coolant activity are as follows :

0 Ci/t I 131 equivalent over a $\frac{1}{4}$ cycle

0,12 Ci/t I 131 equivalent over a $\frac{1}{2}$ cycle

1 Ci/t I 131 equivalent over a $\frac{1}{4}$ cycle

Corrosion product activities during the operating period 0 Ci/t and 0.12 Ci/t are the same as those of case A.

Fission product activities during the operating period 0,12 Ci/t are deducted from those of Case A by a multiplying factor equal to 0,12/0,03.

To keep within a conservative estimate, the activity spectrum of corrosion products during the operating period at 1 Ci/t is deducted from that of Case A by a multiplying factor equal to 3.

During this period, the activities of noble gases, iodines and cesiums in reactor coolant under stable power and transient operating conditions, are deducted from Case A by a multiplying factor equal to 1/0,03.

The activities of other fission products are the same as those given by the spectrum equal to 0,12 Ci/t.

The total activity spectrum for the operating period at 1 Ci/t is given in Table T-11.1-3.

This activity spectrum is consistent with the one used for the treatment system design.

11.1.3. Activities in the secondary system

Contamination of the secondary system is due to leaks occurring on the tube bundle of the steam generators.

These leaks are modelled using a leak assumed to evolve linearly on a steam generator over a 2 months period within the year, (the other generators being assumed without leaks). The reactor coolant secondary leak develops from 0 to 72 kg/hr in 2 months.

Wastes caused by the secondary system are generated by non-recycled steam generator blowdowns and secondary system leaks.

Under normal operating conditions, except startup and shutdown, the steam generator blowdown (APG system) is recycled in the secondary system after treatment on ion-exchanger resins. They do not produce any waste.

In order to postulate a more adverse situation, it was assumed that twice during the period when the reactor coolant primary to secondary leak was present (at 1 month and 2 months following onset of the leak) the total activity contained in the secondary steam generator system (GV) was released without treatment via the APG system to the SEK system.

Despite the fact these 2 assumptions (leak rate and SG total blowdown) are too conservative to be representitive of Case A, they have been adopted for both cases since the corresponding radioactive waste levels are low.

Thus the assumptions taken into account are as follows :

- the carry-over factor of solid fission products into steam was considered equal to the moisture level of the steam, that is : 0.25%, a level of 1% was assumed for iodine,
- the gas carry-over factor is 100%,
- weight of water in an SG : 44 t,
- secondary system leakrate : 22t/h,
- blowdown rate of each SG : 10 t/h.

11.1.4. Assumptions with regard to tritium production

Production of tritium in the reactor coolant system is mainly due to partial scattering through the cladding of the tritium generated in the fuel and its production in the reactor coolant from the boron used for controlling reactivity.

Under normal circumstances, the annual production of tritium in the reactor coolant is estimated at 660 Ci, and under normal Plant operating conditions, approximately 600 Ci/year of tritium are released into the liquid effluents (waste release value confirmed by operating experience).

Under the most adverse conditions, the annual production may rise to 750 Ci, the total amount of which can be released into the liquid effluents.

TABLE T-11.1-1 (1/2)

PARAMETERS USED TO CALCULATE SOURCE TERMS

1. Reactor core

- Design core thermal power : 2905 MW
- Effective dimensions, cold conditions :
  - height of the active part : 365.76 cm
  - equivalent diameter : 304.03 cm
- Number of assemblies : 157
- 116 Cladding of fuel rods : Zircaloy-4/ZIRLO
- Core volume fractions
  - UO_2 : 0.3029
  - Zircaloy 4 : 0.0945
  - Water : 0.5923
  - Stainless steel : 0.0056
  - Inconel 718 : 0.0047
- Duration of a cycle (at full power) : 11 months

2. Reactor coolant system

a) Mass of water in the reactor coolant system, including the pressurizer during normal operation : $184.1 \times 10^{+3}$ kg

b) Effective wetted areas

- in the core
  - 116 Zircaloy-4/ZIRLO : $5.37 \times 10^{+7}$ ㎠
  - stainless steel : $3.03 \times 10^{+6}$ ㎠
  - inconel 718 : $5.35 \times 10^{+6}$ ㎠

TABLE T-11.1-1 (2/2)

PARAMETERS USED TO CALCULATE SOURCE TERMS

- outside the core
  - Inconel 600 : 1,32 x 10^{+8} cm2
  - stainless steel : 1,49 x 10^{+7} cm2

c) Pressurizer

- liquid mass : 14,1 tons
- steam volume : 15,86 m3
- wetted area : 4,90 x 10^{+5} cm2
- continuous spray flow : 92,12 g/s

d) Composition of alloys

- cobalt
  - Inconel 600 : 0,1 %
  - Inconel 718 : 0,1 %
- nickel
  - Inconel 600 : 72 %
  - Inconel 718 : 55 %

TABLE T-11.1-2 (1/3)

THE ACTIVITY SPECTRUM FOR THE OPERATING PERIOD NORMALIZED AT 0,03 Ci/t* IN I 131 EQUIVALENT

NOBLE GAS, IODINE AND CESIUMS ACTIVITY SPECTRUM

Isotope	Activity (Ci*/t)	
	Steady-state operation	Transient
Kr 85 m	1,74 E-02	4,06 E-02
Kr 85	1,17 E-03	1,17 E-03
Kr 87	2,78 E-02	6,82 E-02
Kr 88	4,46 E-02	1,00 E-01
Xe 133 m	1,01 E-02	2,50 E-02
Xe 133	4,52 E-01	8,49 E-01
Xe 135	1,03 E-01	1,36 E-01
Xe 138	7,33 E-02	2,08 E-01
TOTAL noble gas	7,29 E-01	1,43 E+00
I 131	1,48 E-02	3,76 E-01
I 132	2,89 E-02	3,24 E-01
I 133	4,69 E-02	3,66 E-01
I 134	1,87 E-02	1,90 E-01
I 135	3,22 E-02	2,34 E-01
TOTAL iodine	1,41 E-01	1,49 E+00
Equivalent I131	0,03	0,5
Cs 134	1,26 E-04	6,30 E-02
Cs 136	0,0	1,10 E-02
Cs 137	1,26 E-04	5,10 E-02

(*) 1 Ci = 3,7 10^{10} Bq

TABLE T-11.1-2 (2/3)

THE ACTIVITY SPECTRUM FOR THE OPERATING PERIOD NORMALIZED AT 0,03 Ci/t* IN I 131 EQUIVALENT

SOLID FISSION PRODUCTS ACTIVITY SPECTRUM

Isotope	Activity (Ci*/t)
Sr 89	1,27 E-03
Sr 90	1,18 E-05
Y 90	1,11 E-05
Y 91	2,56 E-03
Sr 91	4,58 E-03
Sr 92	4,77 E-03
Zr 95	1,74 E-03
Nb 95	9,02 E-04
Mo 99	3,94 E-03
Tc 99 m	3,50 E-03
Ru 103	1,89 E-03
Ru 106	2,12 E-04
Te 131 m	2,21 E-04
Te 131	3,57 E-03
Te 132	3,31 E-03
Te 134	7,36 E-03
Ba 137 m	5,10 E-02
Ba 140	3,79 E-03
La 140	3,69 E-03
Ce 141	2,46 E-03
Ce 143	3,71 E-03
Pr 143	3,31 E-03
Ce 144	4,83 E-04
Pr 144	4,83 E-04
TOTAL	1,09 E-01

(*) 1 Ci = 3,7 10^{10} Bq

TABLE T-11.1-2(3/3)

THE ACTIVITY SPECTRUM FOR OPERATING PERIOD NORMALIZED
AT 0.03 Ci/t★ IN I 131 EQUIVALENT

CORROSION PRODUCTS ACTIVITY SPECTRUM

Isotope	Activity (Ci★/t)		
	Steady-state operation	Transient	Cold shutdown
Cr 51	1.1 E-03	3.2 E-03	3.3 E-03
Mn 54	2.8 E-04	1.4 E-04	2.6 E-01
Fe 59	1.2 E-04	6.6 E-04	3.2 E-02
Co 58	3.0 E-03	3.0 E-02(unit 1) 7.2 E-03(unit 2)	4.2
Co 60	2.3 E-03	4.4 E-03	1.6 E-01
Zn 65 (only unit 1)	1.0 E-03	1.0 E-03	1.0 E-02

227

(★) 1 Ci = 3.7 10^{10} Bq

TABLE T-11.1-3 (1/3)

THE ACTIVITY SPECTRUM FOR THE OPERATING PERIOD NORMALIZED AT 1 Ci/t* IN I 131 EQUIVALENT

NOBLE GAS, IODINE AND CESIUMS ACTIVITY SPECTRUM

Isotope	Activity (Ci*/t)	
	Steady-state operation	Transient
Kr 85 m	5,90 E-01	1,34 E+00
Kr 85	3,93 E-02	4,01 E-02
Kr 87	9,42 E-01	2,28 E+00
Kr 88	1,50 E+00	3,42 E+00
Xe 133 m	3,42 E-01	7,42 E-01
Xe 133	1,50 E+01	2,83 E+01
Xe 135	3,40 E+00	4,59 E+00
Xe 138	2,42 E+00	6,96 E+00
TOTAL noble gas	2,42 E+01	4,76 E+01
I 131	5,02 E-01	1,27 E+01
I 132	9,76 E-01	1,09 E+01
I 133	1,61 E+00	1,23 E+01
I 134	6,27 E-01	8,18 E+00
I 135	1,08 E+00	7,86 E+00
TOTAL iodine	4,80 E+00	5,19 E+01
Equivalent I 131	1,00 E 00	1,6 E+01
Cs 134	4,20 E-03	2,07 E+00
Cs 136	0	4,74 E-01
Cs 137	4,20 E-03	1,74 E+00

(*) 1 Ci = 3,7 10^{10} Bq

TABLE T-11.1-3 (2/3)

THE ACTIVITY SPECTRUM FOR THE OPERATING PERIOD NORMALIZED AT 1 Ci/t* IN I 131 EQUIVALENT

FISSION PRODUCTS ACTIVITY SPECTRUM

Isotope	Activity (Ci*/t)
Sr 89	5,12 E-03
Sr 90	4,78 E-05
Y 90	4,42 E-05
Y 91	1,04 E-02
Sr 91	1,86 E-02
Sr 92	1,93 E-03
Zr 95	7,05 E-03
Nb 95	3,61 E-03
Mo 99	1,58 E-02
Tc 99 m	1,41 E-02
Ru 103	7,62 E-03
Ru 106	8,45 E-04
Te 131 m	8,94 E-04
Te 131	1,43 E-02
Te 132	1,32 E-02
Te 134	2,96 E-02
Ba 137 m	2,04 E-01
Ba 140	1,53 E-02
La 140	1,49 E-02
Ce 141	1,00 E-02
Ce 143	1,49 E-02
Pr 143	1,32 E-02
Ce 144	1,93 E-03
Pr 144	1,93 E-03
TOTAL	4,36 E-01

(*) 1 Ci = 3,7 10^{10} Bq

TABLE T-11.1-3 (3/3)

THE ACTIVITY SPECTRUM FOR THE OPERATING PERIOD NORMALIZED AT 1 Ci/t* IN I 131 EQUIVALENT

CORROSION PRODUCTS ACTIVITY SPECTRUM

Isotope	Activity (Ci*/t)		
	Steady-state operation	Transient	Cold shutdown
Cr 51	3,3 E-03	9,6 E-03	9,9 E-02
Mn 54	8,4 E-04	5,2 E-03	7,8 E-01
Fe 59	3,9 E-04	2,0 E-03	9,6 E-02
Co 58	9,0 E-03	2,2 E-02	1,3 E+01
Co 60	6,9 E-03	1,3 E-02	4,8 E-01

(*) 1 Ci = 3,7 10^{10} Bq

TABLES

FIGURES

11.2. LIQUID WASTE MANAGEMENT SYSTEMS

This section describes the capabilities of the plant to collect, handle, store, recycle, control and dispose of liquid radioactive waste generated as the result of normal operation, including anticipated operational occurrences. The liquid waste management systems are listed below :

- boron recycle system (TEP),
- liquid waste treatment system (TEU),
- liquid waste discharge system (TER),
- drain system (workshops) SRE,
- vent and drain system (RPE).

Other contaminated or potentially contaminated liquids are also treated by the : 320

- chemical and volume control system (RCV),
- reactor cavity and spent fuel pit cooling system (PTR),
- steam generator blowdown system (APG).

11.2.1. Design bases (Ref. 1)

The design objectives of the liquid waste management systems are to collect and process radioactive liquid wastes generated during plant operation and to reduce their radioactivity and chemical concentrations to levels acceptable for discharge or plant recycle.

The design bases for the TEP, RPE, RCV, PTR, and APG are discussed in Paragraphs or Subsections 9.3.4.3, 9.3.3, 9.3.4.1, 9.1.3, and 10.4.8, respectively.

The design bases for the TEU, TER, and SRE are :

- the liquid waste systems perform no safety-related function and therefore are designated non-nuclear-safety (NC),

- codes and standards applicable to the radioactive liquid waste systems are specified in Section 3.2,

- the liquid waste systems collect the plant wastes which may contain a significant level of activity relative to plant discharge limits,

- the liquid waste management system processing capability is sufficient to ensure that all anticipated normal operating conditions liquid effluent may be discharged to the environment at concentration below the regulatory limits, as indicated in the rules relating to process (RCC-P, Subparagraph 1.1.2.2.1). Radioactivity design values are given in Section 11.2.

- the TEU, TER, and SRE are shared by both Units,

- the liquid waste management systems are designed in accordance with the RCC-P (Subsection 2.3.7).

- the following specific requirements apply to the systems design :

  . Pressure retaining components of the system utilize welded construction to the maximum practicable extent. Flanged joints or suitable quick-disconnect fittings are used only where maintenance or operational requirements clearly indicate that such construction is preferable. Screwed connections in which threads provide the only seals are not used except for instrumentation connections where welded connections are not always suitable.

    All welding constituting the pressure boundary of pressure retaining components (when classified RCC-M 3) are performed in accordance with RCC-M C 3600.

  . The test pressure for the process piping is held for at least 30 minutes and for such additional time as may be necessary to conduct the examination for leakage.

  . Materials for pressure retaining components are selected from those covered by the material specifications listed in Parts I and II of the second volume of the RCC-M. The components meet the requirements of the material specifications regarding manufacture, examination, repair, testing, identification, and certification.

  . Plastic pipes are not used for radioactive service.

  . It is possible to monitor the TEU and shut it down to a safe condition from the radwaste control panel located in the nuclear auxiliary building (NAB). The radwaste panel contains all required process alarms. Activation of any alarm on the NAB radwaste panel causes annunciation of a single alarm in the main control room.

  . The TER and SRE are locally monitored. Alarms are announced in the main control room.

  . Atmospheric tanks are provided with adequately sized vents and overflows to prevent tank overpressure or vacuum conditions from occuring.

  . Pumps are equipped with reliable, high quality mechanical seals. All pumps drawing suction from a tank or vessel are protected from loss of suction by the use of a low-level pump shutoff control.

  . Retention devices are provided around all tanks so that in the event of a tank leakage the liquid will be confined to the immediate area to minimize contamination and facilitate cleanup.

11.2.1.1. Average annual radionuclide design release objectives

The equipment, instrumentation, and operating procedures utilized in the liquid waste management system are designed to ensure that radwastes are safely processed for plant recycle or discharge, and that releases from the plant are at concentrations and a level of radio activity below the limits set forth in RCC-P Section 5.4.

11.2.1.2. Radionuclide release control capability

Design controls incorporated into the liquid waste systems to prevent inadvertent releases to the environment include strict administrative procedures, operator training, discharge radiation monitors which provide alarms and automatic discharge valve closure (See Section 11.5), and a single plant radioactive discharge line which minimizes the potential for operator error.

During normal operation, effluent is routed around the TER tanks via a bypass which is fitted with redundant volume integrated flowmeters and high radioactivity detectors.

Released radioactivity is measured conservatively by taking the product of the volume of waste released, times the radioactivity threshold.

In the event the predetermined threshold is exceeded, release is interrupted and effluent is switched automatically to TER collection tanks. The operator is alerted to this condition. Waste is then monitored, measured, and released directly from the tanks until the cause of the off-normal condition is remedied.

The release rate is determined to take into account the dilution capacity of the environment and to meet the regulations and standards in force for the site.

The release of waste from either TER tanks or TEU tanks is automatically stopped if the radiation level of the waste is too high. The radiation level is monitored by a KRT system which closes automatically an isolation valve if the preset threshold is exceeded. This system acts as a safety backup in case of possible operator error.

11.2.1.3. Radioactive liquid waste system equipment parameters

The component list and design parameters of the TEU, TER, and SRE are presented in Table T-11.2-1.

11.2.1.4. Equipment design margin

The liquid waste management systems are designed to meet the anticipated processing requirements of the plant. Adequate storage capacity (TER) is provided to handle liquid waste during periods when major processing equipment may be down for maintenance and during periods of excessive waste generation.

A tabulation of the maximum and daily inputs to the liquid waste system is shown in Table T-11.2-2.

11.2.1.5. Seismic and quality group classifications

The seismic design classification of structures housing liquid waste management systems, and the quality group classification of liquid radwaste treatment equipment are specified in Section 3.2.

The TEU is located in the NAB which is designed to seismic Category I. The TEU collects and contains any leakage which may occur during a seismic event.

The TER tank are not seismic classified. However, TER leak tanks are able to contain the volume of two storage tanks and are designed to withstand seismic stresses.

The equipment which is capable of releasing gases or aerosols are seismic classified.

11.2.1.6. Design features for radwaste operation and maintenance

The nuclear auxiliary building radwaste equipment layout provides design features capable of minimizing operator exposure. Components of high activity are segregated and shielded in separate compartments. Those of intermediate and low radioactivity are grouped such that doses are minimized during operator entry for inspection or maintenance. The NAB layout provides for remote radwaste system operation from control panels which also provide process instrumentation readout and alarms. Process support equipment, such as pumps and valves, are located, when necessary, outside process component cells in their own shielded areas.

11.2.1.7. Equipment layout and shielding design

The equipment layout of the liquid waste systems is identified in Figures F-12.3-1 to F-12.3-10. The bases for shielding design are described in Subsection 12.3.2.

11.2.1.8. Equipment overflow protection

Protective measures are provided for tanks containing potentially radioactive liquid to prevent the release of significant quantities of radioactive materials which could result from tank overfilling. The design provisions to control radioactive releases due to overflows from all liquid waste tanks containing potentially radioactive materials are listed in Table T-11.2-3.

11.2.1.9. Single failure analysis

Some liquid waste treatment systems equipment is backed up by redundant equipment within the system itself. For example, holdup tanks in TEU, sump pumps in RPE, or storage tanks in TER are redundant. 320

The storage functions of the liquid waste treatment systems are entirely backed up by the liquid waste discharge system TER. The three TER storage tanks insure a backup storage for TEU, and SRE systems.

Each of the 3 TER tanks can play the role of a TER extra holdup tank.

When the TEU holdup tanks become available the waste stored in TER tanks is routed back to TEU tanks and the process can resume.

11.2.2. System description

This subsection includes a description of each liquid waste system and the process flow diagrams indicating processing equipment, normal system operation, equipment capacities (See Table T-11.2-1), and redundancy of equipment. Estimated quantities and flowrates to the system from radioactive liquid waste sources are given in Table T-11.2-2. Minimum expected factors are listed in Table T-11.2-4. 320

11.2.2.1. Boron recycle system (TEP)

The TEP is discussed fully in Paragraph 9.3.4.3.

The TEP decontaminates (by demineralization and gas stripping) the unpolluted (hydrogenated) reactor coolant effluents which are then separated (by evaporation) into boric acid solution and reactor grade demineralized water to be then reused as makeup to the reactor coolant system or discharged. The system a also allows direct deboration of the letdown flow from the chemical and volume control system (RCV). 320

11.2.2.2. Liquid waste treatment system (TEU)

The TEU monitors and processes three different types of liquid waste : process-drains, floor drains and chemical waste. The function of collecting the liquid waste is performed by the vent and drain system (RPE).

In case of a high radioactive level the service drains collected by the drain system (SRE) can be routed to the TEU floor drains tanks.

The process drains and chemical effluent are both directed to the front holdup tanks TEU 01 BA and TEU 02 BA.

The floor drains are directed to the front holdup tanks TEU 03, 04, 05 or 06 BA. One of four holdup tanks is always on line for collection of incoming effluent. Another one is on stirring sampling mode or processing 174
duty. The two others are on standby.

Once these wastes have been treated and monitored for radioactivity, they are transferred to the TER for release to the outfall canal (see Figures 320
F-11.2-1, F-11.2-2 and F-11.2-3)

The system TEU is also designed to treat effluent from other sources (as TEP collection tank wastes)

11.2.2.2.1. Description

The liquid wastes collected in process drain and floor drain tanks are processed by either the evaporator or the selective ion exchange system
96 (SIES).

a) the evaporator

In the event of treatment by evaporator, a neutralization station comprising acid and base tanks with associated metering pump is provided to adjust effluent PH in the front holdup tanks.

Downstream of the collection tank, headers are connected to feed pump 005 PO (on evaporator 001 EV) via a filter. Evaporation concentrate is sent to the TES collection tank. From this tank, concentrate can be reinjected into the evaporator or drummed.

After being decontaminated in a mixed bed demineralizer if necessary, 174
distillates are monitored in either one of the two monitor tanks. A pump maintains monitor tank contents in constants in constant circulation for accurate radioactivity reading. The pump also serves to drain off effluent for release. Waste return to upstream of the evaporator is possible with 005 PO.

The evaporator includes antifoam reagent blending/injection equipment. This reagent is valved into the evaporator when there are detergent in the effluent treated.

Sampling points are provided in the downstream collection and monitor tanks. Samples are delivered to the REN for verification of effluent characteristics and process efficiency.

Local sampling points are provided on the evaporator.

Equipment which comes in contact with process fluid is constructed of austentic stainless steel which shows excellent resistance to chemical (including descaling and decontamination products) attack.

Equipment in contact with service fluid and gases is carbon steel. Certain portions of the system where a high corrosion risk exists are constructed of austenic stainless steel.

b) The selective ion exchange system (SIES).

If the evaporator is not available or SIES is required to treat liquid wastes instead of the evaporator, the liquid wastes could be fed to SIES for treatment.
The SIES consists of one six-vessel processing train to remove radionuclides from liquid wastes and one plant connection/control module to provide remote monitoring and control capabilities which acts as the interface between the SIES and the existing plant equipment.

Downstream of the collection tank, headers are connected to feed pump 005 PO (on SIES) via a filter.

The spent resin is sent to the TES collection tank.

Prior to being processed by the processing train, the liquid wastes are pretreated to enhance the processing capability by a chemical addition skid, which is contained as a part of the plant connection/control module. 320

The first two vessels in the processing train, adsorption beds, provide deep bed filtration to remove dirt, turbidity, oil and colloidal particulates from liquid wastes, thus increasing the radionuclide removal capacity and the life of downstream organic and ion exchange media. the last four vessels are a series of cesium specific, cation, anion and polishing ion exchange vessel to remove dissolved ions from the liquid wastes.

After removing radionuclides, the effluent quality is continuously monitored with an in-line pipe radiation monitor or sampling to confirm the effluent activity. Off-spec effluent shall be automatically recycled to the SIES before being routed to the monitoring tank.

Local sampling point is provided on the SIES control module.

c) SIES pretreatment system(SPS)

This system is designed for improving the treatment performance of SIES. This system consists of two processes and one remote monitoring/control system.

Two processes consist of :

- one microfiltration membrane process

  This process consists of one microfiltration solid-liquid separating basin(041CW) with a hollow fiber type microfiltration unit(040FF), two suction pump(042PO A/B), one NF feed basin(043CW) and one backwash pump(044PO).

- one nanofiltration membrane process

  This process consists of one nanofiltration unit(046FF), two NF feed pumps(045PO A/B), one treated water storage tank(047CW) and three treated water SIES feed tanks(049CW A/B/C). 174

This system receives liquid waste from the evaporator feed pump(TEU 005PO) and processes this liquid waste to remove suspended solid(SS) and radionuclides including corrosion products(Ag-110m etc) and to increase the life span of ion exchange media. The treated water from this system is fed through SIES booster pump to SIES.

The concentration of SS, conductivity of liquid waste and pressure of each membrane process are continuously monitored with each on-line instrument to confirm whether this system is under normal operating condition or not. This system is automatically stopped when it is under abnormal operating conditions.

The final concentrate of nanofiltation membrane is delivered through the recycle line to the microfiltration solid-liquid separating basin(041 CW), whereas the final concentrate of the microfiltration solid-liquid separating basin(041CW) are collected to one of the TEU floor drain tanks via RPE sump, treated by the evaporator and then disposed by the concentrated waste drying system(CWDS).

11.2.2.2.2. Operation

Operating principles are as follows :

- the TEU is manually controlled: the operator uses a mimic panel to supervise operation.
- headers feeding upstream collection tanks are valved in with at least one tank available per type of effluent.
- once a tank is full (indication in control room), the tank is isolated and the stirring/sampling mode initiated locally : headers are then valved into standby tanks. 320
- depending on sampling results, effluent is either transferred to the TER via the filtration unit for subsequent release or transferred to the front holdup tanks upstream of the evaporator(and demineralizer, if necessary)
- the evaporator is started manually, Once evaporation becomes stables, operation is automatic.
- the SIES is operated remotely from the SIES operator console. The SPS is not only remotely operated from the SPS operator console but also directly from the local control panel.

11.2.2.3. Liquid waste discharge system (TER) (See Figure F-11.2-4)

The liquid waste discharge system provides holdup capacity for conventional and nuclear liquid wastes produced by the plant. These tanks are only used under abnormal waste production, or prolongated unavailability of the liquid waste treatment system. 320

The system also provides for counting and monitoring of all the conventional liquid waste and the nuclear liquid waste from SRE and RPE systems discharged from the plant.

The liquid waste collected into the sump can be filtrated out by Bag Filter installed at discharged of the transfer pump.

11.2.2.3.1. Description

The system is located in an area close to the outfall outside the nuclear island Effluent handled by the TER system includes :

a) The nuclear liquid wastes

- TEP evaporator distillate,
- TEU evaporator distillate,
- unprocessed TEU upstream collection tank drains (process and floor drains),
- SRE laundry, chemical hot workshop effluent, floor drains,
- RPE liquid drains,
- TES liquid drains from the waste auxiliary building,
- SIES effluent.

b) The conventional liquid wastes

- SEK liquid waste,
- APG steam generator blowdowns.

Holdup capacity is provided by three identical tanks TER 01, 02, 03 BA each one equipped with a pump used for mixing tank content (through ejectors) prior to sampling and analysis, for discharge from the plant or for recycling the waste to the liquid waste treatment system (TEU) for processing.

The release line is common to all the tanks and is equipped with a flow regulation valve, and a totalizer.

The TEU liquid waste is either non radioactive or monitored in the liquid waste treatment system. It is normally directly discharged to the plant spillway through a bypass line connected to the common discharge line of the TER system. The common part of the tank release line and the TEU bypass line is fitted with a radiation monitoring (KRT) to prevent a human error when releasing TEU or TER tank content.

The other listed liquid waste is normally discharged to the plant spillway through a second bypass line connected to the common discharge line of the TER system. This bypass line is equipped with redundant radiation monitoring (KRT), integrator flowmeters and isolation valves. In addition to manual tank feed valves, an automatic tank feedline is provided, equipped with redundant valves in parallel to assure opening of the flow path.

All equipment is of carbon steel construction.

11.2.2.3.2. Operation

During normal operation the TEU liquid waste is monitored in the TEU tanks before release, and the other liquid waste bypasses the TER tanks.

According to monitoring, the TEU liquid waste can be manually directed to the TER tanks for storage.

The redundant totalizing counters measure the volume of waste released having a specific radioactivity reading equal to or less than threshold. When this setpoint is exceeded effluent is automatically routed into the TER tanks and release through the bypass is stopped.

TER tanks are filled and drained on an alternate basis to enable monitoring and radioactivity measurement.

By lining up feed valves upstream of the tanks, the operator can continue to run non radioactive effluent through the bypass line in order to decrease tanks monitoring frequency.

Tank contents are stirred to uniformly distribute radioactivity throughout. Once the volume of waste to be released has been sampled for radioactivity and if the radiation level of the waste is low enough (below the threshold) effluent can be discharged.

If necessary, release of effluent can be modulated to take into account variations in the dilution capacity of the environment.

11.2.2.4. Drain system (Workshops) (SRE) (See Figures F-11.2-5.1, F-11.2-5.2)

The SRE system consists of the following main waste handling subsystems, each of which includes a collection tank from which effluent is subsequently pumped to the TEU, TER or TES :

- hot laundry drain subsystem,
- chemical, hot workshop effluent subsystem (hot workshop, hot laboratory and hot changing room effluent),
- floor drain subsystem.
- The liquid wastes collected into the sump and tanks can be filtrated out by Bag Filter installed at discharge of the transfer pump. 93

11.2.2.4.1. Description

a) Hot laundry subsystem

The hot laundry is quipped with washing-spindrying machines and drying machines.

After a rough filtering, the effluents from washing and initial rinsing are routed by gravity to the tank SRE 001 BA before being drawn off by the pump 001 PO, through the RPE, to the floor drain front holdup tank of the TEU to be tested, and, if necessary, treated before discharge.

The effluents from showers and sinks of the cloak rooms are also collected in the tank 001 BA.

The effluents from the last rinsings are routed by gravity to the tank SRE 002 BA before being drawn off by pump 002 PO to the TER system.

A link between the outputs of the two pumps makes it possible to route the SRE effluents directly to the TEU.

If the radioactivity of hot laundry effluents is high, the effuents are routed to the TEU system or released directly after decontaminated by SRE 001~004DE. 60

b) Chemical hot workshop effluent subsystem

The active and contaminated effluents of the decontamination workshop are chemical effluents coming from the decontamination vats, the ultrasonic vat or the glove-box.

These effluents flow by gravity into tank SRE 003 BA, are transferred by pump 003 PO to the TES concentrate tank for drumming, or to the TEU floor drain hot front holdup tanks.

A link between the pump outlet and the tank makes it possible to mix the effluents for sampling.

c) Floor drain subsystem

This subsystem receives slightly active and slightly contaminated effluents from the chemical laboratories, mechanical decontamination hot workshop and hot area drains into tank SRE 004 BA. All the effluents collected in this way are automatically transferred from tank 004 BA to the TEU floor drain head tanks SRE with pump 004 PO.

A link between the pump outlet and the tank makes it possible, when necessary, to mix the effluents for sampling before discharge.

The sump 002 PS collects the hot workshop floor drains and the "hot" washing facilities effluents. Pump 006 PO transfers these effluents to tank SRE 004 BA or into the TEU floor drain heak tanks or into the concentrate TES tank.

11.2.2.4.2. Operation

a) Hot laundry subsystem

Pumps 001 PO and 002 PO are started up automatically when water is at the high level of tanks SRE 001 BA and 002 BA. The pumps are stopped once the low level of the tanks is reached. A local sampling is possible on each tank to test the radioactivity of the effluents.

60 If the radioactivity of hot laundry efluents is high, the effluents are routed to the TEU system or released directly after decontaminated by SRE 001~004DE.

b) Chemical hot workshop effluent subsystem

All the operations are manual and are performed upon request.

Tank SRE 003 BA is filled by gravity and, at will, by draining one or several decontamination vats. An alarm warns of high level in the tank.

Then the operator can, at will, perform the necessary operations :

mixing, sampling, and draining the tank to the TES tank. The pump shutdown is automatically actuated by low level and starts a local alarm which warns the operator of the necessity of rinsing the circuit by the demineralized water system (SED).

Before transferring the effluents from tank SRE 003 BA to the TES concentrate tank, the pH is adjusted by injecting reagents in the decontamination vats. The pH adjustment and the brisk mixing are necessary to prevent deposit of precipitates in the circuit.

c) Floor drain subsystem

The floor drain tank SRE 004 BA is drained automatically by pumping actuated by high level of the tank. The draining is stopped automatically by low level in the tank.

11.2.2.5. Vent and drain system (RPE)

The RPE is discussed fully in Subsection 9.3.3.

The function of the system is to collect all radioactive fluids generated by both Units, as well as floor drains taken off from various nuclear island buildings.

The liquid wastes are delivered to the TEP or the TEU systems.

11.2.2.6. Chemical and volume control system (RCV)

The RCV is discussed fully in Paragraph 9.3.4.1.

The RCV mainly controls the volume, the chemical characteristics and the reactivity (as a complement of the control rods of the reactor coolant system RCP). It also makes it possible to maintain the reactor coolant inventory in case of a small break in the RCP. As such, it takes part in the reactor safe shutdown.

11.2.2.7. Reactor cavity and spent fuel pit cooling system (PTR)

The PTR is discussed fully in Subsection 9.1.3.

The PTR performs the following functions with regard to the spent fuel and reactor pools : maintenance of fuel in subcritical conditions, biological protection of personnel, cooling (only for the spent fuel pit), control of fluid levels and chemical characteristics. In addition to these functions, the PTR tank provides the storage of the borated water necessary for spraying the containment and for safety injection (direct injection phase).

11.2.2.8. Steam generator blowdown system (APG)

The APG is discussed fully in Subsection 10.4.8.

The APG is provided to treat the secondary water in order to maintain its chemical and physical characteristics within permissible limits.

11.2.3. Radioactive releases

The purpose of the liquid waste treatment systems is to remove radioactivity so that the bulk of the liquid processed is restored to clean water. The removed radioactivity is captured in filters or in demineralizer resins or concentrated in evaporator concentrate.

11.2.3.1. Criteria for disposal of liquid radwaste

All liquid wastes are discharged after processing and/or monitoring except primary effluents handled by the TEP which are normally recycled in the plant in the form of primary coolant quality boric acid and water.

However, TEP evaporators distillate can be discharged if required to maintain primary coolant tritium concentration below 1 Ci/m3.

All the liquid discharged must have a radioactivity level consistant with the guidelines set forth in RCC-P Subsection 5.4.3.

11.2.3.2. Estimated liquid releases

The source term used to predict expected long term average concentrations of radionuclides in the primary and secondary fluids stream is described in Section 11.1. The resulting radionuclides concentrations are also tabulated in Section 11.1.

The releases are calculated for two types of operations and source terms :

- mean normal operation which includes anticipated operational occurrences and allows the computation of the average release over the life of the Plant (Case A), called in here after "expected values",

- exceptional operation at design basis fuel leakage which is used to evaluate maximum possible release levels (Case B), called here after "design values".

All figures given below are for one Unit.

11.2.3.2.1. Releases from TEP system

The reactor coolant effluents are treated by the TEP, which decontaminates them before separation (by evaporation) of boron free water and a boric acid solution (7 000 ppm boron). Both of these are, for the most part, re-utilized as makeup in the reactor coolant system.

To keep the H-3 concentration in the reactor coolant below 1 Ci/m3, a voluntary release of 1 000 m3/year is made after the TEP system treatment.

The amount of liquid releases is 5500 m3 and as follows :

- 1 750 m3 during base load operation,
- 1 725 m3 during hot shutdowns (8 hours),
- 295 m3 during hot shutdowns (90 hours),
- 1 740 m3 during cold shutdowns.

The corresponding H3 concentration in the reactor coolant is 0,3 Ci/m3.

This system ensures a 10 days minimum storage time and an overall decontamination factor, without gas, of 10^4.

This decontamination, mainly carried out by filters and demineralizers and then partly supplemented by evaporation, treats almost constant quality effluents which have already been treated by RCV decontamination system with a decontamination factor of 10 compared to the reactor coolant.

The annual releases from this source are summarized in Table T-11.2-5.

11.2.3.2.2. Releases from TEU system

a) Drains which are estimated at 6 750 m3/year are mainly due to reactor coolant leakage (120 kg/h). These drains include :

   - floor drains, including those originating in the waste auxiliary building representing 4 500 m3/year with production spread over the year,

   - process drains, especially those originating from equipment drains, representing 2 250 m3/year with peak production.

   These drains are discharged after treatment by the liquid waste treatment system (TEU), which ensures a minimum storage of five days and overall decontamination factor of 10^3.

   This decontamination is carried out by filtration and evaporation, followed by demineralization if necessary.

The annual releases from this source are summarized in Table T-11.2-6.

b) The chemical called also micellaneous liquid waste, which mainly comes from the REA and RRI drains represents 2 000 m3/year. The radioactivity of this waste is negligible.

Chemical waste is TEU treated with process drains, which ensures a minimum decay of 5 days (including storage time before decontamination) and overall decontamination factor identical to the one mentioned above.

It should be noted that the decontamination effluents produced by the site decontamination installations (a few m3/year) are, due to their high salinity, sent directly to the solid waste treatment system (TES) and are, therefore, not to be taken into account for release evaluation purposes.

Since the releases from chemical waste are negligible, they are not considered for releases evaluation.

c) Service effluent is the water from both showers and laundries (1 000 m3/year). It is generally released directly. In case of high radioactivity it is routed to the TEU floor drains tanks.

As explained hereabove, the radioactivity originates mainly in the floor and process drains. To evaluate the radioactivity contained in the waste treated by TEU it facilitates to use an equivalent volume of deaerated reactor coolant (DRC).

The radioactivity contained in 4 500 m3/year floor drains and 2 250 m3/year process drains is equivalent to the one contained in 1 100 m3 of deaerated reactor coolant (DRC).

The treatment by TEU during case A and case B is given in Tables T-11.2-2.b and T-11.2-2.c.

11.2.3.2.3. Releases from secondary side

As a result of reactor coolant leakage into the secondary system, there is contamination of the steam generator blowdown system as well as of leakage from the secondary system (see Subsection 11.1.3.).

The steam generator liquid phase is treated by the steam generator blowdown system (APG) with an overall decontamination factor of 100 and then re-utilized through the condenser except after certain shutdowns.

The decontamination is carried out by filters and demineralizers. They do not produce any liquid radioactive waste.

During startups, these blowdowns are released without being treated. It is assumed that this situation occurs after a shutdown lasting a long time, i.e., at the time of the 4 hot shutdowns with startups at xenon equilibrium and at the time of the 5 cold shutdowns, i.e., 9 times per year. Radioactive decay of the secondary coolant for 90 h is thus taken into account. In each case, the blowdown is carried out for about 10 hours, at the rate of about 50 t/h.

It is to be noted that at the time of startup after refuelling, blowdown is carried out without treatment, but activity concentration of the water is still too low to affect the overall release balance.

In order to postulate an adverse situation, it is assumed that twice during the period when the reactor coolant secondary leak is present (at 1 month and 2 months following onset of the leak) the total activity contained in the secondary steam generator system (GV) is released without treatment via the APG system.

It is also assumed that the secondary system samples are re-cycled and that secondary system leakrate is 22 t/h. The annual releases from this source are summarized in Table T-11.2-8.

11.2.3.2.4. Tritium releases

The release of tritium is 600 to 750 Ci/year as per Subsection 11.1.4.

11.2.3.2.5. Total annual liquid release

In brief, there are two sources of liquid release :

a) the nuclear island, which releases 15 250 m^3/year of effluents (5 500 m^3 from the TEP, 6 750 m^3 from drains, 1000 m^3 of service effluents, 2 000 m^3 of chemical or miscellaneous effluents),

b) the conventional island, which releases 106 000 m^3/year (100 000 m^3 pumped out of the turbine hall, 6 000 m^3 from the steam generator blowdowns).

The latter source only figures as a source of released radioactivity in the event of a leak from the reactor coolant system to the secondary system.

The total annual radioactive liquid releases and the effluent concentrations are summarized in Table T-11.2-9.

Comparison with the release during exceptional operation and concentration limit guidelines set forth in RCC-P, Subsection 5.4.3. is made in Table T-11.2-10.a. Releases and concentrations are small fraction of these limits.

Comparison with concentration limit guidelines set forth in the French regulation applying to protection applying to protection against ionizing radiation is made in Table T-11.2-10.b. Concentrations are small fraction of these limits.

11.2.3.2.6 Release Points

There is a single release point of the liquid radioactive waste situated in the essential service water system (SEC) Pipe at about 35 m from the common discharge of SEC and circulating water (CRF) of both units in the outfall canal. The liquid radioactive waste is routed to the single release point via the liquid waste discharge system TER discharge pipe.

The discharge point is shown on the general sit plant Figure.

11.2.3.2.7. Flow dilution factor

The annual average discharge flow rate is 27 m^3/h. Dilution comes from the circulating water whose flow rate is 60 m^3/s per unit.

The subsequent average dilution factor is then greater than 8 000.

11.2.3.2.8. Estimated liquid release resulting from operation of the SIES.

In case of the liquid radwastes are processed by the SIES, the estimated liquid release from the plant is described in this section for normal operation, including anticipated operational occurrences. The annual liquid releases are estimated by using the PWR-GALE (Rev.1) computer program. Fundamental parameters are the same as those used in estimation of expected release
96 from operation of the waste evaporator, which are described in section 11.2.3.2.

The decontamination factors for the SIES are shown in Table T-11.2-4.
Expected annual average releases of radionuclides in the liquid effluents are shown in the Table T-11.2-9.a.

Expectd liquid effluent concentrations and comparison of concentrations in liquid effluents to the MOST Notice, Concentration Limits (for unrestricted aras) are presented in Table T-11.2-10.c.

11.2.3.3. Radiological consequences of liquid radwaste release

11.2.3.3.1. Dilution and sea water contamination

Radioactive effluents are released in circulating water before discharge in the environment.

Calculation of radioactivity concentration resulting in circulating water takes into account the following assessments: 320

96

- expected values for releases of radioactive materials in liquid effluent resulting from normal operation. including anticipated operational occurrences, of 2 units operating during 8 000 h/year,

- a circulating flow - rate of 60 m^3/s per unit.

The total annual releases and the radioactivity concentration in circulating water are given in Table T-11.2-11 (l/5).

The release of circulating water into the sea causes a in radio activity concentration of the water in the marine habitat and in the work and recreational areas. Local activity concentration is deduced from circulating water radioactivity by applying a dilution factor.

For the radiological consequences studies the following assessments are considered :

- the seaweed places, shellfish habitats, swimming and sunbathing areas are located near the site and seawater is assumed to have the same level of contamination as station circulating water. The dilution factor is taken as equal to 1, which is thus a conservative value.

- the fish population is found at 6 km sea area from beach, also the dilution factor is taken equal to 0,1 in fish habitats, which is a conservative value (see Environmental Report for Uljin Nuclear Power Plant).

11.2.3.3.2. Radiological doses model

The following irradiation pathways are taken into account in dose evaluation :

- internal irradiation due to consumption of seafood,

- external irradiation from :

  . swimming,
  . sunbathing on the shore,
  . handling on the shore,
  . boating.

The ways in which these liquid pathways can cause doses are summarized in Table T-11.2.11 (2/5).

In the following, radiological doses are computed for critical groups defined as fisherman and local population of which habits and sea-food consumption are given in Table T-11.2.11 (3/5).

Local population data are the average values for usage factors given in the Environmental Report, completed by a sunbathing on shore line time chosen equal to twice the swimming time. Fisherman consumption data are twice the local population data, and other fisherman usage factors are deduced from international practice.

As indicated by ICRP 30, actual doses received by individuals vary depending on factors such as differences in their age, size, metabolism and customs. Nevertheless, the same limit doses have been derived for application in average situation for all adult ages and for both sexes because variation in risk with age will not influence the total risk from a lifetime exposure, unless the total risk is limited to a special group, and because of the maximizing assumptions used. The dose equivalent actually received will be lower than the estimated dose equivalent whatever the individual innate variability within a group will be.

Thus, in this study of effects of radioactive releases, only the radiological consequences on adults of critical groups are computed.

Furthermore, considering that the ICRP Commission no longer proposes for stochastic effects separate annual dose equivalent limits for individual tissues and organs irradiated singly, and recommends a dose equivalent based on the total risk of all tissues irradiated (whole body dose) whether the whole body is irradiated uniformly or whether there is non-uniform irradiation.

The dose values presented inhere are only whole body doses.

Doses are computed according to the following relations :

- $H_{wb} = \Sigma_T \ W_T \ H_T$

where H_{wb} is the whole body dose equivalent, W_T is the weighting factor recommended by ICRP Commission, H_T is the annual dose equivalent in Tissue (T).

- $H_{wb} = \Sigma_j \dfrac{Ij}{ALI_j} \times H_{wb},L$

where I_j is the annual intake of radionuclide J, ALI_j is, for the public, the annual limit of intake for radionuclide J given by ICRP 30 and $H_{wb,L}$ is the annual dose equivalent limit (5m Sv per year).

11.2.3.3.3. Internal irradiation doses

All effluents from the plant are discharged into the sea, but it is not reasonable to expect that the plant liquid effluents will reach the well water and contaminate it, because the beach area is lower than the area human habitation and the underground water place.

For this reason no effects are expected from the drinking water and from the irrigation water (no irrigation water system drawn from the sea).

Internal irradiation doses result of seafood consumption. They are evaluated for the 2 population critical groups of which habits are given in Table T-11.2-11 (3/5).

Published values for biological transfer factors are used to estimate concentrations of radioactive materials in the various human food chains. These factors are applied to the local sea water concentrations, as defined in 11.2.3.3.1., to obtain estimates of the concentration in fish, seaweed and shellfish. Transfer factors used are given in Table T-11.2-11 (4/5).

The annual amount of radionuclides ingested are translated in whole body dose equivalents using dose model defined in 11.2.3.3.2.

The resulting annual whole body doses expressed in μ Sv and (μ rem) are the following :

- fishermen : 0,92 (92)
- local population : 0,46 (46)

Details of local population doses are given in Table T-11.2-12 (1/2), fisherman doses are twice the local population doses.

Calculation indicates that for normal operation releases critical nuclides and food are iodines and seaweeds.

Nevertheless, maximum doses are very low.

11.2.3.3.4. External irradiation doses

This dose results from the following activities :

- swimming,
- sunbathing on the seashore,
- boating.

Fishermen receive an additional dose from handling fishing tackle.

The uses of seawater and beach are given in Table T-11.2-11 (3/5).

Doses are calculated only to the whole body and not to the skin, because skin is no longer considered as a critical organ, β radiations are not therefore considered.

Doses due to boating are only a few part of doses to other nautic activities and are neglected in the following. 320

Whole body doses due to swimming and sunbathing on shoreline are calculated using the following expression:

$$Di = Ci\ (C_{bi} \cdot T_b + C_{si}\ T_s)$$

where :

- index b is related to swimming,
- index s is related to sunbathing,
- index i is associated with radionuclide i,
- Di (μ rem/yr) is the annual dose,
- Ci (Ci/m^3) is the concentration of radionuclide i in the local seawater.
- T_x (h/yr) is the usage time,
- C_x is the dose rate conversion factor resulting from usage x, this factor takes into account the transfer factors between water and sediment or sand given in Table T-11.2-11 (4/5).

The dose rate conversion factors are given in Table T-11.2-11 (5/5), the usage times in Table T-11.2-11 (3/5) and the activity concentration and dilution factors in Table T-11.2-11 (1/5) and Paragraph 11.2.3.3.1.

The whole body doses due to sunbathing on shoreline are about a thousand time the doses due to swimming, because the transfer factors between water and sediments or sand are very conservative. Nevertheless doses are very low. 320

The total annual whole body doses expressed in μ Sv and (μ rem) are the following:

- Fishermen : 3,23 (323)
- Local population : 0,50 (50)

Details of doses are given in Table T-11.2-12 (2/2).

Critical nuclides are corrosion products, notably Fe 59 and Zr 89.

Irradiation due to fishing tackle is considered to be 1/10 of that due to the sediment bed with which fishing tackle comes into contact.

So if we assume that fishes are caught in sea water for which the dilution factor is 0,1, the whole body dose D_h due to the handling of fishing tackle and the whole body dose D_s , due to the irradiation by sediments (sunbathing dose) are related by the following equation :

$$D_h = D_s \times \frac{1}{10} \times 0{,}1 \times \frac{T_h}{T_s}$$

where T_x is the usage time, T_x is given in Table T-11.2-11 (3/5).

$$D_h = D_s \times \frac{1}{10} \times 0{,}1 \times \frac{2\,000}{100} = \frac{1}{5} D_s$$

D_h = 0,65 μ Sv (65μ rem)

The total annual whole body doses due to external irradiation, expressed in μ Sv and (μ rem) are as follows :

- Fishermen : 3,88 (388)
- Local population: 0,50 (50)

11.2.3.3.5. Total annual doses resulting from liquid release

The dose is calculated making the following assumptions :

- normal operating conditions,
- 2 population groups, fishermen and local population,
- internal irradiation due to consumption of sea food,
- external irradiation from swimming sunbathing and handling fishing tackle.

On these bases, the following total whole body annual doses due to liquid releases are obtained μ Sv and (μ rem).

- Fishermen : 4.8 (480)
- Local population : 0.96 (96)

Off site doses resulting from normal plant liquid release are only a very small fraction of the Korean maximum permissible dose.

11.2.3.3.6. Radiological consequences of liquid radwaste release from SIES processing

When the liquid radwastes are processed through SIES, the radiological doses from liquid effluents are calculated using the LADTAP - II computer code. This code are based on the model provided in USNRC Regulatory Guide 1.109. 96

Basic data used in the calculation and the resultant dose to the public are described in the Table T-11.2-11 to T-11.2-12

11.2.3.4. Reference

1 - System Design Report
09 MDR 02
Radioactive waste treatment systems

2000. 8. 16

TABLE T-11.2-1(1/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(TEU, SRE, TER)

- TEU-Process drain chemical effluent head storge tank (001 - 002 BA)	
Quantity	2
Type	Vertical, cylindrical
Capacity, m³	35
Design pressure, bar (top of tank)	0.96
Design temperature, ℃	70
Material	Stainless steel
- TEU-floor drain head storage tank (003 - 004 - 005 - 006 BA)	
Quantity	4
Type	Vertical, cylindrical
Capacity, m³	20
Design pressure, bar (top of tank)	Atmospheric
Design temperature, ℃	50
Material	Stainless steel
- TEU-distillate monitoring tank (009 010 BA)	
Quantity	2
Type	Vertical, cylindrical
Capacity, m³	35
Design pressure, bar (top of tank)	Atmospheric
Design temperature, ℃	50
Material	Stainless steel
- TEU-anti foam (011 BA)	
Quantity	1
Type	Vertical, cylindrical
Capacity, l	170
Design pressure, bar (top of tank)	Atmospheric
Design temperature, ℃	Ambient
Material	Stainless steel .
- TEU-distillate decontamination demineralizer (003 DE)	
Quantity	1
Type	Vertical, cylindrical
Resin volume, m³	1.5
Design pressure, bar	7.5
Design temperature, ℃	60
Material	Staniless steel
Bed type	Mixed bed

TABLE T-11.2-1 (2/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(TEU, SRE, TER)

- TEU-evaporator filter (001 FI)	
Quantity	1
Type	Cartridge
Design flowrate m3/h	4
Pressure drop (fouled), bar	1,5
Design temperature, °C	80
Filtration mesh, micrometer	5
Filtration efficiency, %	98
Material	Stainless steel
- TEU-direct discharge filter (002 FI)	
Quantity	1
Type	Cartridge
Design flowrate, m3/h	10
Pressure drop (fouled), bar	1,5
Design temperature, °C	80
Filtration mesh, micrometer	5
Filtration efficiency, %	98
Material	Stainless steel
- TEU-distillate decontamination filter (005 FI)	
Quantity	1
Type	Cartridge
Design flowrate, m3/h	10
Pressure drop (fouled), bar	1,5
Design temperature, °C	80
Filtration mesh, micrometer	25
Filtration efficiency, %	98
Material	Stainless steel
- TEU-process drain and chemical effluent pump (001 PO)	
Quantity	1
Type	Centrifugal
Design flowrate, m3/h	10
Design outlet pressure, bar	5,5
Design temperature, °C	70
Material	Stainless steel

TABLE T-11.2-1 (3/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(TEU, SRE, TER)

- TEU-floor drain pump (002 PO, 003 PO)	
Quantity	2
Type	Centrifugal
Design flowrate, m3/h	10
Design outlet pressure, bar	5,5
Design temperature, °C	70
Material	Stainless steel
- TEU-evaporator feeding pump (005 PO)	
Quantity	1
Type	Centrifugal
Design flowrate, m3/h	5
Design outlet pressure, bar	5
Design temperature, °C	70
Material	Stainless steel
- TEU-evaporator recirculation pump (006 PO)	
Quantity	1
Type	Centrifugal
Design flowrate, m3/h	500
Design outlet pressure, bar	2,35
Design temperature, °C	155
Material	Stainless steel
- TEU-evaporator distillate draining pump (007 PO)	
Quantity	1
Type	Centrifugal
Design flowrate, m3/h	4
Design outlet pressure, bar	7,5
Design temperature, °C	155
Material	Stainless steel
- TEU-distillate pump (008 PO)	
Quantity	1
Type	Centrifugal
Design flowrate, m3/h	10
Design outlet pressure, bar	4,5
Design temperature, °C	70
Material	Stainless steel

TABLE T-11.2-1 (4/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(TEU, SRE, TER)

- TEU-anti-foam pump (009 PO)	
Quantity	1
Type	Volumetric
Design flowrate, l/h	0-15
Design temperature, °C	100
Material	Stainless steel
- TEU-soda pump (010 PO)	
Quantity	1
Type	Volumetric
Design flowrate, l/h	0-150
Design temperature, °C	40
Material	Stainless steel
- TEU-acid pump (011 PO)	
Quantity	1
Type	Volumetric
Design flowrate, l/h	0-150
Design temperature, °C	40
Material	Stainless steel
- TEU-evaporator column (001 EV)	
Quantity	1
Design flowrate, m3/h	3,5
Design pressure, bar	6,2
Design temperature, °C	160
Material	Stainless steel

TABLE T-11.2-1 (5/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(TEU, SRE, TER)

- SRE-hot laundry service effluent tank (001 - 002 BA)	
Quantity	2
Type	Horizontal
Capacity, m3	20
Design pressure, bar	Atmospheric
Design temperature, °C	80
Material	Carbon steel
- SRE-decontamination workshop effluent tank (003 BA)	
Quantity	1
Type	Vertical, cylindrical
Capacity, m3	5
Design pressure, bar	Atmospheric
Design temperature, °C	70
Material	Stainless steel
- SRE-hot workshop floor drain tank (004 BA)	
Quantity	1
Type	Horizontal
Capacity, m3	20
Design pressure, bar	Atmospheric
Design temperature, °C	70
Material	Stainless steel
- SRE-service effluent pump (001 - 002 PO)	
Quantity	2
Type	Centrifugal
Design flowrate, m3/h	10
Design pressure, bar	7
Design temperature, °C	50
Material	Carbon steel

TABLE T-11.2-1(6/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(TEU, SRE, TER)

- SRE-hot workshop chemical drains pump (003 PO)	
Quantity	1
Type	Centrifugal
Design flowrate, m^3/h	5
Design pressure, bar	7.0
Design temperature, ℃	50
Material	Stainless steel
- SRE-hot workshop floor drains pump (004 PO)	
Quantity	1
Type	Centrifugal
Design flowrate, m^3/h	5
Design pressure, bar	7.0
Design temperature, ℃	50
Material	Stainless steel
- SRE-site laboratory sump pump (005 PO and 007 PO)	
Quantity	2
Type	Immerged sump pump
Design flowrate, m^3/h	5
Design pressure, bar	4.0
Design temperature, ℃	50
Material	Stainless steel
- SRE-hot workshop sump pump (006 PO)	
Quantity	1
Type	Centrifugal axis vertical immerged sump pump
Design flowrate, m^3/h	5
Design pressure, bar	4.0
Design temperature, ℃	70
Material	Stainless steel

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TABLE T-11.2-1(7/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(TEU, SRE, TER)

- SRE-laundry sump pump (008 PO)	
Quantity	1
Type	Centrifugal, axis vertical immerged sump pump
Design flowrate, m^3/h	5
Design pressure, bar	4
Design temperature, ℃	50
Material	Stainless steel
- SRE-Bag filter (SRE 001~005FI)	
Quantity	5
Type	Bag filter
90 Design flowrate, m^3/h	10
Design pressure, bar	6
Design temperature, °C	80
Filtration efficiency, %	98 320
Filtration mesh, μm	5(002, 004FI) ≤25(001, 003, 005Fl)
Material	Stainless steel
	320
- SRE-Decontamination Demineralizer	
60 (001-004 DE)	
Type	Bag filter
Quantity	4
Nominal flowrate, m^3/hr	10
Resin Volume, ℓ	104
Maximum pressure, kg/cm^2	9
Maximum Temperature, ℃	90
Maximum pressure drop, kg/cm^2	0.2

TABLE T-11.2-1 (7/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(TEU, SRE, TER)

- TER-storage tank (001, 002, 003 BA)	
Quantity	3
Type	Vertical, cylindrical
Capacity, m3	500
Design pressure, bar	Atmospheric
Design temperature, °C	50
Material	Carbon steel
- TER-discharge pump (001, 002, 003 PO)	
Quantity	3
Type	Centrifugal
Design flowrate, m3/h	170
Design pressure, bar	5,0
Design temperature, °C	50
Material	Carbon steel
- TER-sump pump (004, 005 PO)	
Quantity	2
Type	Immersed impeller
Design flowrate, m3/h	10
Design pressure, bar	3,2
Design temperature, °C	70
Material	Cast Alu

TABLE T-11.2-1(8/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(TEU, SRE, TER)

- TER-Gallery sump pump (006PO)		
Quantity	1	
Type	Immersed impeller	
Design flowrate, m^3/h	5	
Design pressure, bar	3.25	
Design temperature, ℃	70	
Material	Cast Alu	
- TER-Setting tank sump pump (007PO)		
Quantity	1	
Type	Immersed impeller	
Design flowrate, m^3/h	5	
Design pressure, bar	3.2	
Design temperature, ℃	50	
Material	Cast Alu	
- TER-Bag filter (TER 001-003FI)		
Quantity	3	
Type	Bag filter	
Design flowrate, m^3/h	10(001, 003FI) 20(002FI)	93
Design pressure, bar	5.5	
Design temperature, ℃	70	
Filtration efficiency, %	98	320
Filtration mesh, μm	≤ 25	
Material	Stainless steel	

TABLE T-11.2-1(8a/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(SIES)

Selective Ion Exchange System		
- Adsorber		
Quantity	2	
Type	Activated Carbon	
Design Flow(m^3/h)	7.95 (35gpm)	
Total Adsorber Volume (m^3)	1(40ft^3)×2(Vessel)	
Vessel Designing Parameters :		320
1) Pressure (bar)	10.34 (150psig)	
2) Temperature (℃)	93.3 (200°F)	
3) Bed Depth/Diameter (cm)	132/107	
Internal Screen :		
1) Type	Wedge Wire	
2) Design Pressure (bar)	10.34	
3) Material	304L S/S	
4) Size (cm)	0.018±0.005	
		96
- Each Ion Exchanger		
Quantity	4	
Type	Organic Bead/Dow	
Design Flow(m^3/h)	7.95 (35gpm)	320
Total Resin Volume (m^3)	0.85(30ft^3)×4(Vessel)	
Ion Exchange Value (kg/m^3)	706.7 - 2120	
Vessel Design Parameters :		
1) Pressure (bar)	10.34 (150psig)	
2) Temperature (℃)	93.3 (200°F)	
3) Bed Depth/Diameter (cm)	132.1/91.4	
Internal Screen :		
1) Type	Wedge Wire	
2) Design Pressure (bar)	93.3	
3) Material	304L S/S	
4) Size (cm)	0.018±0.005	

TABLE T-11.2-1(8b/8)

LIQUID RADWASTE SYSTEMS EQUIPMENT PARAMETERS
(SIES)

- Booster Pump	
Quantity	1
Type	Centrifugal
Pressure (design/operating)(bar)	10.34/6.89
Temperature (design/operating)(℃)	65.6 (150 ℉)
Capacity(m^3/h)	>7.95 (35 gpm)
Speed(RPM)	3,600
Materials	Stainless Steel
- New Resin and Spent Resin Sluice Pump	
Quantity	2
Type	Dual Diaphragm, Air operated
Pressure (design/operating)(bar)	8.62/6.89
Temperature (design/operating)(℃)	100 (212 ℉)
Capacity(m^3/h)	22.7 (100 gpm)
Speed(RPM)	N/A
- Control Panel	
Quantity	1
Size (L × W × H)(cm)	76.2×40.64×76.2
Weight(kg)	22.7 (50 lb)
HVAC heat load (kcal/hr)	252
Power requirements...AC (Voltage/VA)	120
DC (Voltage/Watt)	N/A
- Radiation Monitoring System	
Quantity	1
Radiation type	In-Ling Pipe Radiation Monitor
Range	>1.0 E-07 μCi/CC
Detector Collector Type	γ - SCINT/ON-LINE
Check Source	Cs-137

96

Table T-11.2-1(8c/8)

LIQUID RADWASTE SYSTEM EQUIPMENT PARAMETERS

(SIES Pretreatment System)

SIES Pretreatment System	
- Process MF Solid Liquid Separating Basin (041CW)	
Quantity	1
Type	Rectangular Con.
Capacity, ㎥	2.2
Design Pressure, kg/㎠	ATM
Design Temperature, ℃	70
Material	Stainless steel
- NF Feed Basin (043CW)	
Quantity	1
Type	Rectangular Con.
Capacity, ㎥	0.96
Design Pressure, kg/㎠	ATM
Design Temperature, ℃	70
Material	Stainless steel
- Treated Water Storage Tank (047CW)	
Quantity	1
Type	Rectangular
Capacity, ㎥	0.25
Design Pressure, kg/㎠	ATM
Design Temperature, ℃	70
Material	Stainless steel
- Treated Water SIES Feed Tank (049CW A/B/C)	
Quantity	3
Type	Cylindrical
Capacity, ㎥	4.0
Design Pressure, kg/㎠	ATM
Design Temperature, ℃	70
Material	Stainless steel

174

Table T-11.2-1(8d/8)

LIQUID RADWASTE SYSTEM EQUIPMENT PARAMETERS

(SIES Pretreatment System)

- Process Micro filtration Unit	
(040FF)	
Quantity	1
Type	Hollow Fiber
Design Flowrate, m^3/h	2
Design Pressure, kg/cm^2	Vaccum 60cmHg
Design Temperature, ℃	70
Filtration mesh, ㎛	0.4
Efficiency, %	95
Material	PVDF, PE
- Process Nano filtration Unit	
(046FF)	
Quantity	1
Type	Spiral Wound
Design Flowrate, m^3/h	2
Design Pressure, kg/cm^2	31
Design Temperature, ℃	45
Filtration mesh, ㎛	10^{-3}
Efficiency, %	95
Material	Polyamide

174

Table T-11.2-1(8e/8)

LIQUID RADWASTE SYSTEM EQUIPMENT PARAMETERS

(SIES Pretreatment System)

- Process Micro filtration Unit Suction Pump	
(042PO A/B)	
Quantity	2
Type	Centrifugal, Vertical
Design Flowrate, m³/hr	3
Design Outlet Pressure, kg/cm²	3
Design Temperature, ℃	70
Material, Pump housing	Cast iron, ASTM B A48-30
Material, Pump Impeller	Stainless steel
Piping Design Pressure , kg/cm²	10
- Process Micro filtration Unit Back Wash Pump	
(044PO)	
Quantity	1
Type	Centrifugal, Vertical
Design Flowrate, m³/hr	2
Design Outlet Pressure, kg/cm²	1.5
Design Temperature, ℃	70
Material, Pump housing	Cast iron, ASTM B A48-30
Material, Pump Impeller	Stainless steel
Piping Design Pressure , kg/cm²	10
- Process Nano filtration Unit Feed Pump	
(045PO A/B)	
Quantity	2
Type	Centrifugal, Vertical
Design Flowrate, m³/hr	5
Design Outlet Pressure, kg/cm²	15
Design Temperature, ℃	70
Material, Pump housing	Cast iron, ASTM B A48-30
Material, Pump Impeller	Stainless steel
Piping Design Pressure , kg/cm²	20

1174

Table T-11.2-1(8f/8)

LIQUID RADWASTE SYSTEM EQUIPMENT PARAMETERS

(SIES Pretreatment System)

- Process Treated Water Transfer Pump	
(048PO)	
Quantity	1
Type	Centrifugal, Vertical
Design Flowrate, ㎥/hr	2
Design Outlet Pressure, kg/㎠	4
Design Temperature, ℃	70
Material, Pump housing	Cast iron, ASTM B A48-30
Material, Pump impeller	Stainless steel
Piping Design Pressure , kg/㎠	10

m4

Table T-11.2-1(8g/8)
LIQUID RADWASTE SYSTEM EQUIPMENT PARAMETERS
(SIES Pretreatment System)

Channel Number	Location of Primary Flow Senser	Design Pressure	Design Temp	Range	Location of Readout
		Psig (kg/㎠)	°F (℃)	㎥/hr	
FE-900	SPS Influent	142 (10)	140 (60)	20	Local, Local Control Panel, Operator Console
FE-901	Micro filtration Unit Suction Pump Outlet	142 (10)	140 (60)	20	Local, Local Control Panel, Operator Console
FI-903	Nano Filtration Feed Pump Inlet	142 (10)	140 (60)	10	Local
FI-904	Nano Filtration Recycle Outlet	142 (10)	140 (60)	2	Local
FE-905	Treated Water Transfer Pump Outlet	142 (10)	140 (60)	20	Local, Local Control Panel, Operator Console

174

Table T-11.2-1(8h/8)

LIQUID RADWASTE SYSTEM EQUIPMENT PARAMETERS

(SIES Pretreatment System)

Channel Number	Location of Primary Pressure Senser	Design Pressure Psig (kg/㎠)	Design Temp °F (℃)	Range kg/㎠	Location of Readout
PT-900	Nano Filtration Unit Outlet	284 (20)	140 (60)	0~100	Local Control Panel, Operator Console
CVT-900	Micro filtration Suction Pump Intlet	142 (10)	140 (60)	0 ~ 760mmHg	Local Control Panel, Operator Console
PG-900	Service Air Inlet	142 (10)	140 (60)	0~10	Local
PG-901	Micro filtration Suction Pump /A Outlet	142 (10)	140 (60)	0~10	Local
PG-902	Micro filtration Suction Pump /B Outlet	142 (10)	140 (60)	0~10	Local
PG-903	Micro filtration Back-wash Pump Outlet	142 (10)	140 (60)	0~10	Local
PG-904	Nano filtration Feed Pump /A Outlet	284 (20)	140 (60)	0~20	Local
PG-905	Nano filtration Feed Pump /B Outlet	284 (20)	140 (60)	0~20	Local
PG-906	Treated Water Transfer Pump Outlet	142 (10)	140 (60)	0~10	Local

174

Table T-11.2-1(8i/8)

LIQUID RADWASTE SYSTEM EQUIPMENT PARAMETERS

(SIES Pretreatment System)

Channel Number	Location of Primary Process Senser	Design Pressure	Design Temp	Range	Location of Readout
		Psig (kg/㎠)	°F (℃)	NTU	
AE-900	SPS Influent Turbidity	87 (6)	-41~122 (-5~50)	0~9999	Local Control Panel, Operator Console
AE-901	Micro filtration Suction Pump Outlet Turbidity	87 (6)	-41~122 (-5~50)	0~9999	Local Control Panel, Operator Console
AE-902	Nano filtration Feed Pump Inlet Conductivity	232 (16)	-4~302 (-15~150)	10μs/cm~ 20ms/cm	Local Control Panel, Operator Console
AE-903	Nano Filtration Treated Water Outlet Conductivity	232 (16)	-4~302 (-15~150)	10μs/cm~ 20ms/cm	Local Control Panel, Operator Console

174

TABLE T-11.2-2.a

LIQUID WASTE SYSTEM INPUT
(m^3/year - for 1 Unit)

TEU sources	Volume	Radioactivity (equivalent volume of deaerated reactor coolant contained)
Floor drains	4 500	) 1 100
Process drains	2 250	)
Chemical waste	2 000	negligible
Service effluents	1 000	negligible

TABLE T-11.2-2.b

ASSESSMENTS OF TEU WASTE TREATMENT
DURING NORMAL PLANT OPERATION
(FOR 1 UNIT)

Equivalent of volume DRC *	1 100 m3/yr
- Handled on evaporator	1 045 m3/yr
- Released without treatment	55 m3/yr

* DRC : deaerated reactor coolant

TABLE T-11.2-2.c

ASSESSMENTS OF TEU WASTE TREATMENT
DURING EXCEPTIONAL PLANT OPERATION

	1/4 cycle (0 Ci/t equivalent I 131)	1/2 cycle (0,12 Ci/t equivalent I 131)	1/4 cycle (1 Ci/t equivalent I 131)
Overall equivalent volume of DRC *	1 100 m3		
Handled on evaporator	235	535	300
Released without treatment	15	15	0

DRC : deaerated reactor coolant

TABLE T-11.2-3 (1/2)

TANK OVERFLOW COLLECTION PROVISIONS

Tanks	Hi level alarm	Leak tank or dike	Disposition of tank overflow	Comments
<u>Nuclear auxiliary building</u>				
Floor drain tanks (TEU) (capacity = 20 m3)	Yes	Yes (storage volume = 2 x 20 m3)	Tank overflow to tank compartment	4 tanks - location : 0,00 m ; NC 240 5,00 m ; NA 383
Process drain tanks (TEU) (capacity = 35 m3)	Yes	Yes (storage volume = 35 m3)	Tank overflow to tank compartment	2 tanks - location : 0,00 m ; NC 240
Distillate monitoring tanks (TEU) (capacity = 35 m3)	Yes	No	Tank overflow to tank compartment	2 tanks - ground sill to hold leaks
Head storage tanks (TEP) (capacity = 80 m3)	Yes	Yes (storage volume = 80 m3)	These tanks have no overflow	2 tanks - location : 5,00 m ; NC 316 NC 320. Tank relief valve discharges to tank compartment
Concentrate monitoring tank (TEP) (capacity = 10 m3)	Yes	No	This tank has no overflow	Location : 0,00 m ; ND 239 Membrane - sealed tank
Distillate monitoring tanks (TEP) (capacity = 70 m3)	Yes	No	These tanks have no overflow	2 tanks - location : 5,00 m ; NB 380 Membrane - sealed tank

TABLE T-11.2-3 (2/2)

TANK OVERFLOW COLLECTION PROVISIONS

Tanks	Hi level alarm	Leak tank or dike	Disposition of tank overflow	Comments
Intermediate storage tanks (TEP) (capacity = 350 m3)	Yes	Yes (storage volume = 700 m3)	These tanks have no overflows	3 tanks - location : 0,00 m ; NE 204 Tank relief valve discharges to tank compartment
Volumetric control tanks (RCV)(inside capacity=8,9m3)	Yes	No	These tanks have no overflows	2 tanks - location : 5,00 m ; NA 315 NB 325. Tank safety relief valve discharges to equipment drain tank
PTR tanks (capacity = 1 600 m3)	No	Yes (storage volume = 1600 m3)	These tanks have no overflows (an overflowing never occurs)	2 tanks - location : 0,00 m ; W 211 W 251
<u>Yard area</u>				
TER tanks (capacity = 500 m3)	Yes (Hi and hi-hi levels)	Yes (1 000 m3)	An overflow is provided for each tank and connected to the TER pump room sump	3 tanks - location : XA
<u>Connection building</u>				
SRE tanks (capacity = 20 m3)	Yes	Yes (storage volume = 20 m3)	An overflow is provided from tanks to the recirculation line downstream from discharge pump	2 tanks

TABLE T-11.2-4

LIQUID WASTE SYSTEMS DECONTAMINATION FACTORS (DF)

Equipment	Decontamination factor		
Evaporator	Iodine		Others
TEU	1000		100
TEP	100		100
SIES(Selective Ion Exchange System)		Cesium	
TEU	500	1000	100
Filters			
All systems		1	
Demineralizer			
All systems		10	

96

$$\text{Decontamination} = \frac{\text{inlet specific radioactivity}}{\text{outlet specific radioactivity}}$$

TABLE T-11.2-5

ANNUAL RADIOACTIVE LIQUID RELEASES OF REACTOR COOLANT WASTE
(per Unit)

Isotope	Expected valve (Ci)* case (A)	Design valve (Ci)* case (B)
Sr 89	3.82 E-04	1.15 E-03
Sr 90	4.10 E-06	1.24 E-05
Y 90	3.85 E-06	1.15 E-05
Y 91	7.88 E-04	2.40 E-03
Zr 95	5.41 E-04	1.64 E-03
Nb 95	2.55 E-04	7.65 E-04
Mo 99	1.01 E-04	3.02 E-04
Tc 99m	8.94 E-04	2.70 E-04
Ru 103	5.48 E-04	1.66 E-03
Ru 106	7.22 E-05	2.16 E-04
Te 131m	1.87 E-07	5.65 E-07
Te 132	1.23 E-04	3.70 E-04
I 131	2.75 E-02	2.87 E-01
I 133	1.71 E-05	1.79 E-04
Cs 134	1.08 E-02	1.10 E-01
Cs 136	1.09 E-03	1.15 E-02
Cs 137	8.82 E-03	9.34 E-02
Ba 137m	8.82 E-03	2.72 E-02
Ba 140	7.49 E-04	2.26 E-03
La 140	1.72 E-05	5.22 E-05
Ce 141	6.85 E-04	2.09 E-03
Ce 143	6.43 E-06	1.94 E-05
Pr 143	1.12 E-03	3.36 E-03
Ce 144	1.64 E-04	4.91 E-04
Pr 144	1.64 E-04	4.91 E-04
Cr 51	5.77 E-04	3.65 E-04
Mn 54	3.19 E-04	5.22 E-04
Fe 59	1.20 E-04	1.81 E-04
Co 58	2.11 E-03	3.20 E-03
Co 60	1.18 E-03	1.76 E-03
TOTAL	6.72 E-02	5.53 E-01

(*) 1 C i = 3.7 E 10 Bq

TABLE T-11.2-6

ANNUAL RADIOACTIVE RELEASES OF LIQUID DRAINS
(per Unit)

Isotope	Expected value (Ci)* case (A)	Design value (Ci)* case (B)
Sr 90	6,62 E-02	7,51 E-02
Sr 90	6,60 E-04	7,51 E-04
Y 90	6,20 E-04	6,95 E-04
Y 91	1,35 E-01	1,54 E-01
Sr 91	3,74 E-05	4,82 E-05
Zr 95	9,23 E-02	1,05 E-01
Nb 95	4,57 E-02	5,13 E-02
Mo 99	6,23 E-02	7,00 E-02
Tc 99m	5,54 E-02	6,29 E-02
Ru 103	9,68 E-02	1,10 E-01
Ru 106	1,17 E-02	1,31 E-02
Te 131m	6,74 E-04	7,66 E-04
Te 132	6,29 E-02	7,06 E-02
I 131	5,43 E-01	7,72 E-01
I 133	4,67 E-02	6,15 E-02
I 135	6,81 E-06	8,54 E-06
Cs 134	8,60 E-03	3,69 E-02
Cs 136	2,00 E-04	3,67 E-03
Cs 137	8,33 E-03	3,27 E-02
Ba 137m	8,33 E-03	1,24 E-02
Ba 140	1,61 E-01	1,83 E-01
La 140	2,57 E-02	2,92 E-02
Ce 141	1,24 E-01	1,42 E-01
Ce 143	1,60 E-02	1,81 E-02
Pr 143	1,83 E-01	2,06 E-01
Ce 144	2,67 E-02	3,01 E-02
Pr 144	2,67 E-02	3,01 E-02
Cr 51	5,86 E-02	3,92 E-02
Mn 54	5,40 E-02	8,57 E-02
Fe 59	1,12 E-02	1,27 E-02
Co 58	7,59 E-01	1,32 E-00
Co 60	1,52 E-01	1,20 E-01
TOTAL	2,84 E+00	3,85 E+00

(*) 1 Ci = 3,7 E 10 Bq

TABLE T-11.2-7

ANNUAL RELEASE OF LIQUID SERVICE WASTE
(per Unit)

LIQUID SERVICE WASTES ARE INCLUDED IN LIQUID DRAINS
(SEE TABLE T-11.2-6)

TABLE T-11.2-8

ANNUAL RADIOACTIVE LIQUID RELEASES DUE TO SECONDARY SYSTEM
(per Unit)

Isotope	Expected value (Ci)* case (A)	Design value (Ci)* case (B)
Sr 89	1,05 E-03	3,19 E-03
Sr 90	1,01 E-05	3,07 E-05
Y 90	9,48 E-06	2,83 E-05
Y 91	2,14 E-03	6,51 E-03
Sr 91	1,35 E-03	4,11 E-03
Sr 92	8,77 E-04	2,65 E-03
Zr 95	1,45 E-03	4,42 E-03
Nb 95	7,39 E-04	2,22 E-03
Mo 99	2,15 E-03	6,47 E-03
Tc 99m	1,92 E-03	5,78 E-03
Ru 103	1,46 E-03	4,70 E-03
Ru 106	1,80 E-04	5,40 E-04
Te 131m	8,87 E-05	2,68 E-04
Te 131	1,69 E-04	5,06 E-04
Te 132	1,91 E-03	5,72 E-03
Te 134	5,49 E-04	1,66 E-03
I 131	1,06 E-02	1,11 E-01
I 132	4,86 E-03	5,07 E-02
I 133	1,69 E-02	1,79 E-01
I 134	1,64 E-03	1,70 E-02
I 135	8,62 E-03	8,93 E-02
Cs 134	1,08 E-04	1,11 E-03
Cs 137	1,08 E-04	1,12 E-03
Ba 137m	1,08 E-04	3,27 E-04
Ba 140	2,89 E-03	8,77 E-03
La 140	1,68 E-03	5,08 E-03
Ce 141	2,01 E-03	6,13 E-03
Ce 143	1,56 E-03	4,70 E-03
Pr 143	2,82 E-03	8,47 E-03
Ce 144	4,11 E-04	1,23 E-03
Pr 144	4,11 E-04	1,23 E-03
Cr 51	8,91 E-04	1,34 E-03
Mn 54	2,38 E-04	3,57 E-04
Fe 59	1,08 E-04	1,62 E-04
Co 58	2,51 E-03	3,76 E-03
Co 60	1,97 E-03	2,95 E-03
TOTAL	7,66 E-02	5,42 E-01

(*) 1 Ci = 3,7 E 10 Bq

TABLE T-11.2-9

TOTAL ANNUAL RADIOACTIVE LIQUID RELEASES
(per Unit)

Isotope	Expected value (Ci)* case (A)	Design value (Ci)* case (B)
Sr 89	6,76 E-02	7,94 E-02
Sr 90	6,74 E-04	7,94 E-04
Y 90	6,33 E-04	7,35 E-04
Y 91	1,38 E-01	1,63 E-01
Sr 91	1,39 E-03	4,16 E-03
Sr 92	8,77 E-04	2,65 E-03
Zr 95	9,43 E-02	1,11 E-01
Nb 95	4,66 E-02	5,43 E-02
Mo 99	6,46 E-02	7,68 E-02
Tc 99m	5,74 E-02	6,90 E-02
Ru 103	6,89 E-02	1,16 E-01
Ru 106	1,20 E-02	1,39 E-02
Te 131m	7,63 E-04	1,03 E-03
Te 131	1,69 E 04	5,06 E 04
Te 132	6,49 E-02	7,67 E-02
Te 134	5,49 E-04	1,66 E-03
I 131	5,81 E-01	1,17 E+00
I 132	4,86 E-03	5,07 E-02
I 133	6,36 E-02	2,41 E-01
I 134	1,64 E-03	1,70 E-02
I 135	8,63 E-03	8,93 E-02
Cs 134	1,95 E-02	1,48 E-01
Cs 136	1,29 E-03	1,52 E-02
Cs 137	1,73 E-02	1,27 E-01
Ba 137m	1,73 E-02	3,99 E-02
Ba 140	1,65 E-01	1,94 E-01
La 140	2,74 E-02	3,43 E-02
Ce 141	1,26 E-01	1,50 E-01
Ce 143	1,76 E-02	2,28 E-02
Pr 143	1,87 E-01	2,18 E-01
Ce 144	2,73 E-02	3,18 E-02
Pr 144	2,73 E-02	3,18 E-02
Cr 51	6,01 E-02	4,14 E-02
Mn 54	5,45 E-02	8,66 E-02
Fe 59	1,14 E-02	1,30 E-02
Co 58	7,64 E-01	1,32 E+00
Co 60	1,55 E-01	1,25 E-01
TOTAL	2,99 E+00	4,95 E+00
H3	600	750

(*) 1 Ci = 3.7 E 10 Bq

TABLE T-11.2-9.a (1/2)

EXPECTED RELEASES OF RADIONUCLIDES IN LIQUID EFFLUENTS FOR SIES
(ONE UNIT OPERATION)

		Coolant Concentrations		Annual Release to Discharge Canal							
Nuclide	Half-Life (days)	Primary (μCi/ml)	Secondary (μCi/ml)	Boron Rs (Ci)	Misc. Waste (Ci)	Secondary (Ci)	Trub Bldg (Ci)	Total Lws (Ci)	Adjusted Total (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
Na 24	6.25E-01	5.14E-02	1.28E-06	4.07E-04	7.81E-04	0.00E+00	4.83E-05	1.24E-03	1.31E-03	0.00E+00	1.30E-03
P 32	1.43E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-04	1.80E-04
Cr 51	2.78E+01	3.27E-03	9.64E-08	1.04E-02	2.08E-02	0.00E+00	4.77E-06	3.13E-02	3.30E-02	4.70E-03	3.80E-02
Mn 54	3.03E+02	1.68E-03	4.80E-08	6.11E-03	1.22E-02	0.00E+00	2.39E-06	1.83E-02	1.93E-02	3.80E-03	2.30E-02
Fe 59	9.50E+02	1.26E-03	3.62E-08	4.62E-03	9.24E-03	0.00E+00	1.80E-06	1.39E-02	1.46E-02	7.20E-03	2.20E-02
Fe 59	4.50E+01	3.16E-04	8.88E-09	1.06E-03	2.13E-03	0.00E+00	4.40E-07	3.19E-03	3.37E-03	2.20E-03	5.60E-03
Co 58	7.13E+01	4.85E-03	1.41E-07	1.68E-02	3.37E-02	0.00E+00	6.98E-06	5.05E-02	5.33E-02	7.90E-03	6.10E-02
Co 60	1.92E+03	5.58E-04	1.62E-08	2.05E-03	4.09E-03	0.00E+00	8.09E-07	6.13E-03	6.47E-03	1.40E-02	2.00E-02
Ni 63	3.36E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-03	1.70E-03
Zn 65	2.45E+02	5.37E-04	1.55E-08	1.94E-03	3.88E-03	0.00E+00	7.72E-07	5.82E-03	6.14E-03	0.00E+00	6.10E-03
W 187	9.96E-01	2.71E-03	7.10E-08	2.07E-04	4.03E-04	0.00E+00	2.97E-06	6.13E-03	6.47E-04	0.00E+00	6.50E-04
Np 239	2.35E+00	2.35E-03	6.50E-08	1.66E-03	3.28E-03	0.00E+00	3.01E-06	4.94E-03	5.22E-03	0.00E+00	5.20E-03
Sr 89	5.20E+01	1.48E-04	4.22E-09	5.03E-04	1.00E-03	0.00E+00	2.09E-07	1.51E-03	1.59E-03	8.80E-05	1.70E-03
Sr 90	1.03E+04	1.26E-05	3.62E-10	4.64E-05	9.27E-05	0.00E+00	1.80E-08	1.39E-04	1.47E-04	1.30E-05	1.60E-04
Y 90	2.67E+00	0.00E+00	0.00E+00	3.55E-05	7.13E-05	0.00E+00	1.13E-09	1.07E-04	1.13E-04	0.00E+00	1.10E-04
Y 91	5.88E+01	5.48E-06	1.55E-10	4.55E-05	9.09E-05	0.00E+00	1.05E-08	1.36E-04	1.44E-04	8.40E-05	2.30E-03
Y 93	4.25E-01	4.64E-03	1.07E-07	2.14E-06	4.06E-06	0.00E+00	3.56E-06	9.76E-06	1.03E-05	0.00E+00	1.00E-05
Zr 95	6.50E+01	4.11E-04	2.30E-07	1.42E-03	2.84E-03	0.00E+00	5.88E-07	4.26E-03	4.50E-03	1.10E-03	5.60E-03
Nb 95m	3.75E+00	0.00E+00	0.00E+00	1.88E-05	3.77E-05	0.00E+00	5.31E-10	5.65E-05	5.96E-05	0.00E+00	6.00E-05
Nb 95	3.50E+01	2.95E-04	8.15E-09	1.12E-03	2.24E-03	0.00E+00	4.06E-07	3.36E-03	3.55E-03	1.90E-03	5.50E-03
Mo 99	2.79E+00	6.82E-03	1.92E-07	6.26E-03	1.24E-02	0.00E+00	8.99E-06	1.86E-02	1.97E-02	6.00E-05	2.00E-02
Tc 99m	2.50E-01	5.25E-03	1.07E-07	5.98E-03	1.18E-02	0.00E+00	6.67E-06	1.78E-02	1.88E-02	0.00E+00	1.90E-02
Ru 103	3.96E+01	7.91E-03	2.30E-07	2.63E-02	5.26E-02	0.00E+00	1.14E-05	7.89E-02	8.32E-02	2.90E-04	8.40E-02
Ru 103m	3.96E-02	0.00E+00	0.00E+00	2.63E-02	5.26E-02	0.00E+00	1.12E-05	7.90E-02	8.33E-02	0.00E+00	8.30E-02
Ru 106	3.67E+02	9.48E-02	2.73E-06	3.44E-01	6.88E-01	0.00E+00	1.36E-04	1.03E+00	1.09E+00	8.90E-03	1.10E+00
Rh 106	3.47E-04	0.00E+00	0.00E+00	3.44E-01	6.88E-01	0.00E+00	1.36E-04	1.03E+00	1.09E+00	0.00E+00	1.10E+00
Ag 110m	2.53E+02	1.37E-03	3.92E-08	4.95E-03	9.89E-03	0.00E+00	1.95E-06	1.48E-02	1.57E-02	1.20E-03	1.70E-02

2000. 8. 16

TABLE 11.2-9.a (2/2)

EXPECTED RELEASES OF RADIONUCLIDES IN LIQUID EFFLUENTS FOR SIES
(ONE-UNIT OPERATION)

		Coolant Concentrations		Annual Release to Discharge Canal							
Nuclide	Half-Life (days)	Primary (μCi/ml)	Secondary (μCi/ml)	Boron Rs (Ci)	Misc. Waste (Ci)	Secondary (Ci)	Trub Bldg (Ci)	Total Lws (Ci)	Adjusted Total (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
Ag 110	2.82E−04	0.00E+00	0.00E+00	6.44E−04	1.29E−03	0.00E+00	2.53E−07	1.93E−03	2.04E−03	0.00E+00	2.00E−03
Sb 124	6.00E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.30E−04	4.30E−04
Te 129m	3.40E+00	2.00E−04	5.78E−09	6.56E−04	1.31E−03	0.00E+00	2.86E−07	1.97E−03	2.08E−03	0.00E+00	2.10E−03
Te 129	4.79E−02	2.75E−02	2.81E−07	4.20E−04	8.40E−04	0.00E+00	5.54E−07	1.26E−03	1.33E−03	0.00E+00	1.30E−03
Te 131m	1.25E+00	1.62E−03	4.33E−08	2.71E−04	5.29E−04	0.00E+00	1.88E−06	8.01E−04	8.46E−04	0.00E+00	8.50E−04
Te 131	1.74E−02	8.88E−03	4.12E−08	4.94E−05	9.65E−05	0.00E+00	3.42E−07	1.46E−04	1.54E−04	0.00E+00	1.50E−04
I 131	8.05E+00	4.79E−02	1.36E−06	2.22E−02	4.43E−02	0.00E+00	1.32E−04	6.67E−02	7.03E−02	1.60E−03	7.20E−02
Te 131	3.25E+00	1.81E−03	5.04E−08	2.02E−03	3.99E−03	0.00E+00	2.38E−06	6.01E−03	6.35E−03	0.00E+00	6.30E−03
I 132	9.58E−02	2.39E−01	3.55E−06	2.08E−03	4.11E−03	0.00E+00	6.00E−05	6.25E−03	6.60E−03	0.00E+00	6.30E−03
I 133	8.75E−01	1.53E−01	3.98E−06	1.38E−03	2.67E−03	0.00E+00	3.25E−04	4.37E−03	4.61E−03	0.00E+00	4.60E−03
Cs 136	7.49E+02	7.35E−03	2.11E−07	3.08E−03	5.37E−03	0.00E+00	1.05E−05	8.45E−03	8.92E−03	1.10E−02	2.00E−02
Cs 137	2.79E−01	2.91E−01	6.30E−06	2.76E−07	5.15E−07	0.00E+00	3.37E−04	3.38E−04	3.57E−04	0.00E+00	3.60E−04
Ba 137m	1.30E+01	9.06E−04	2.60E−08	2.58E−04	4.92E−04	0.00E+00	1.28E−06	7.51E−04	7.93E−04	3.70E−04	1.20E−03
Ba 137	1.10E+04	9.73E−03	2.82E−07	4.10E−03	7.14E−03	0.00E+00	1.40E−05	1.13E−02	1.19E−02	1.60E−02	2.80E−02
Ce 140	1.77E−03	0.00E+00	0.00E+00	3.84E−03	6.68E−03	0.00E+00	1.31E−05	1.05E−02	1.11E−01	0.00E+00	1.10E−02
Ce 141	1.28E+01	1.37E−02	3.87E−07	3.72E−02	7.42E−02	0.00E+00	1.90E−05	1.11E−01	1.18E−01	9.10E−04	1.20E−01
Ce 143	1.67E+00	2.67E−02	7.32E−07	4.68E−02	9.33E−02	0.00E+00	3.47E−05	1.40E−01	1.48E−01	0.00E+00	1.50E−01
Pr 143	3.24E+01	1.58E−04	4.52E−09	5.15E−04	1.03E−03	0.00E+00	2.24E−07	1.54E−03	1.63E−03	2.30E−04	1.90E−01
Ce 144	1.38E+00	3.01E−03	7.96E−08	6.67E−04	1.30E−03	0.00E+00	3.49E−06	1.98E−03	2.09E−03	0.00E+00	2.10E−03
Pr 144	1.37E+01	0.00E+00	0.00E+00	8.55E−04	1.71E−03	0.00E+00	4.68E−08	2.56E−03	2.71E−03	0.00E+00	2.70E−03
	2.84E+02	4.11E−03	1.18E−07	1.49E−02	2.97E−02	0.00E+00	5.88E−06	4.46E−02	4.71E−02	3.90E−03	5.10E−02
	1.20E−02	0.00E+00	0.00E+00	1.49E−02	2.97E−02	0.00E+00	5.88E−06	4.46E−02	4.71E−02	0.00E+00	4.70E−02
All Others		6.30E−01	4.07E−06	4.77E−07	9.57E−07	0.00E+00	4.14E−06	5.72E−06	5.72E−06	0.00E+00	5.72E−06
Total (Except Tritium)		1.66E+00	2.67E−05	9.64E−01	1.92E+00	0.00E+00	1.36E−03	2.89E+00	3.50E+00	8.98E−02	3.20E+00

TABLE T-11.2-10.a

COMPARISON OF DESIGN VALUE OF RADIOACTIVITY RELEASES
WITH RCC-P RELEASE AND CONCENTRATION LIMITS**

Isotope	RCC-P release limit	Fraction of release limit	RCC-P concentration limit	Fraction of concentration limit
Beta and gamma emitters (tritium, potassium and radium excluded)	40 Ci*/year	1,24 x 10^{-1}	2 10^{-7} Ci/m3	1,43 x 10^{-2}
Tritium	2 000 Ci/year	3,75 x 10^{-1}	2 10^{-5} Ci/m3	2,17 x 10^{-2}

(*) 1 Ci = 3,7 E 10 Bq

(**) Taken from RCC-P, Table 5.4.3.

TABLE T-11.2-10.b

COMPARISON OF DESIGN VALUE RADIOACTIVITY RELEASES
WITH HEALTH PHYSIC CONCENTRATION LIMITS

Isotope	Release (Ci*) (2 units)	Concentration after dilution (Ci/m3**)	MCP*** Water Ci/m3
Sr 89	1,59 E-01	4,60 E-11	1 E-5
Sr 90	1,59 E-03	4,60 E-13	4 E-7
Y 90	1,47 E-03	4,25 E-13	2 E-5
Y 91	3,26 E-01	9,43 E-11	3 E-5
Sr 91	8,32 E-03	2,41 E-12	7 E-5
Sr 92	5,3 E-03	1,53 E-12	7 E-5
Zr 95	2,22 E-01	6,42 E-11	6 E-5
Nb 95	1,09 E-01	3,15 E-11	1 E-4
Mo 99	1,54 E-01	4,46 E-11	2 E-9
Tc 99m	1,38 E-01	3,99 E-11	6 E-3
Ru 103	2,32 E-01	6,71 E-11	8 E-5
Ru 106	2,78 E-02	8,04 E-12	1 E-5
Te 131m	2,06 E-03	5,96 E-13	6 E-5
Te 131	1,01 E-03	2,92 E-13	no bound
Te 132	1,53 E-01	4,43 E-11	3 E-5
Te 134	3,32 E-03	9,61 E-13	no bound
I 131	2,34 E+00	6,77 E-10	1 E-6
I 132	1,01 E-01	2,92 E-11	3 E-5
I 133	4,82 E-01	1,39 E-10	4 E-6
I 134	3,4 E-02	9,84 E-12	5 E-5
I 135	1,79 E-01	5,18 E-11	1 E-5
Cs 134	2,96 E-01	8,56 E-11	9 E-6
Cs 136	3,04 E-02	8,80 E-12	9 E-5
Cs 137	2,54 E-01	7,35 E-11	2 E-5
Ba 137m	7,98 E-02	2,31 E-11	no bound
Ba 140	3,88 E-01	1,12 E-10	3 E-5
La 140	6,86 E-02	1,98 E-11	2 E-5
Ce 141	3,00 E-01	8,68 E-11	3 E-5
Ce 143	4,56 E-01	1,32 E-10	4 E-5
Pr 143	4,36 E-01	1,26 E-10	5 E-5
Ce 144	6,36 E-02	1,84 E-11	1 E-5
Pr 144	6,36 E-02	1,84 E-11	no bound
Cr 51	8,28 E-02	2,40 E-11	2 E-3
Mn 54	1,73 E-01	5,01 E-11	1 E-4
Fe 59	2,60 E-02	7,52 E-12	6 E-5
Co 58	2,64 E+00	7,64 E-10	1 E-4
Co 60	2,50 E+01	7,23 E-11	5 E-5
TOTAL	9,90 E+00	2,86 E-09	
H3	1500	4,34 E-07	3 E-5

(*) 1 Ci = 3,7 E 10 Bq
(**) assumes dilution in circulating water (unit operating time : 8 000 h per year, unit circulating water flowrate 60 m3/h)
(***) MCP : maximum permissible concentration of radionuclides in water for the Public-French Decree n° 66-450 of June 20 1966

TABLE T-11.2-10.c

COMPARISON OF DESIGN VALVE RADIOACTIVITY RELEASES
WITH HEALTH PHYSIC CONCENTRATION LIMITS FOR SIES
(per Unit)

ISOTOPE	Release 1 Unit (μ Ci)	Concentration in Circulating Water Discharge (μ Ci/cc)	Maximum Permissible Concentration (μ Ci/cc)	Fraction of MPC
Na-24	1.30E+03	7.52E−13	3.00E−05	2.51E−08
P-32	1.80E+02	1.04E−13	2.00E−05	5.21E−09
Cr-51	3.80E+04	2.20E−11	2.00E−03	1.10E−08
Mn-54	2.30E+04	1.33E−11	1.00E−04	1.33E−07
Fe-59	2.20E+04	1.27E−11	8.00E−04	1.59E−08
Fe-59	5.60E+03	3.24E−12	5.00E−05	6.48E−08
Co-58	6.10E+04	3.53E−11	9.00E−05	3.92E−07
Co-60	2.00E+04	1.16E−11	3.00E−05	3.86E−07
Ni-63	1.70E+03	9.84E−13	3.00E−05	3.28E−08
Zn-65	6.10E+03	3.53E−12	1.00E−04	3.53E−08
W-187	6.50E+02	3.76E−13	6.00E−05	6.27E−09
Np-239	5.20E+03	3.01E−12	1.00E−04	3.01E−08
Sr-89	1.70E+03	9.84E−13	3.00E−06	3.28E−07
Sr-90	1.60E+02	9.26E−14	3.00E−07	3.09E−07
Y-90	1.10E+02	6.37E−14	2.00E−05	3.18E−09
Sr-91	1.10E+02	6.37E−14	5.00E−05	1.27E−09
Y-91	2.30E+02	1.32E−13	3.00E−05	4.44E−09
Y-93	1.00E+01	5.79E−15	3.00E−05	1.93E−10
Zr-95	5.60E+03	3.24E−12	6.00E−05	5.40E−08
Nb-95	5.50E+03	3.18E−12	2.00E−05	1.59E−07
Mo-99	2.00E+04	1.16E−11	4.00E−05	2.89E−07
Tc-99m	1.90E+04	1.10E−11	3.00E−03	3.67E−09
Ru-103	8.40E+04	4.86E−11	8.00E−05	6.08E−07
Rh-103m	8.30E+04	4.80E−11	1.00E−02	4.80E−09
Ru-106	1.10E+06	6.37E−10	1.00E−05	6.37E−05
Rh-106	1.10E+06	6.37E−10	—	—
Ag-110m	1.70E+04	9.84E−12	3.00E−05	3.28E−07
Ag-110	2.00E+03	1.16E−12	—	—
Sb-124	4.30E+02	2.49E−13	2.00E−05	1.24E−08
Te-129m	2.10E+03	1.22E−12	2.00E−05	6.08E−08
Te-129	1.30E+03	7.52E−13	8.00E−04	9.40E−10
Te-131m	8.50E+02	4.92E−13	4.00E−05	1.23E−08
Te-131	1.50E+02	8.68E−14	—	—
I-131	7.20E+04	4.17E−11	3.00E−07	1.39E−04
Te-132	6.30E+03	3.65E−12	2.00E−05	1.82E−07
I-132	6.60E+03	3.82E−12	8.00E−06	4.77E−07
I-133	4.60E+03	2.66E−12	1.00E−06	2.66E−06
Cs-134	2.00E+04	1.16E−11	7.00E−06	1.65E−06
I-135	3.60E+02	2.08E−13	4.00E−06	5.21E−08
Cs-136	1.20E+03	6.91E−13	6.00E−05	1.16E−08
Cs-137	2.80E+04	1.62E−11	2.00E−05	8.10E−07
Ba-137m	1.10E+04	6.37E−12	—	—
Ba-140	1.20E+05	6.94E−11	2.00E−05	3.47E−06
La-140	1.50E+05	8.68E−11	2.00E−05	4.34E−06
Ce-141	1.90E+03	1.10E−12	9.00E−05	1.22E−08
Ce-143	2.10E+03	1.22E−12	4.00E−05	3.04E−08
Pr-143	2.70E+03	1.56E−12	5.00E−05	3.13E−08
Ce-144	5.10E+04	2.95E−11	1.00E−05	2.95E−06
Pr-144	4.70E+04	2.72E−11	—	—
H-3	6.00E+08	3.47E−07	3.00E−03	1.16E−04

2000. 8. 16

TABLE T-11.2-11 (1/5)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS

Isotope	Release (Ci/year) (2 units)	Concentration after dilution (Ci/m³) in circulating water
Sr 89	1.35 E-01	3.91 E-11
Sr 90	1.35 E-03	3.91 E-13
Y 90	1.26 E-03	3.65 E-13
Y 91	2.76 E-01	7.99 E-11
Sr 91	2.78 E-03	8.04 E-13
Sr 92	1.75 E-03	5.06 E-13
Zr 91	1.88 E-01	5.44 E-11
Nb 95	9.30 E-02	2.69 E-11
Mo 99	1.29 E-01	3.73 E-11
Tc 99m	1.15 E-01	3.33 E-11
Ru 103	1.97 E-01	5.70 E-11
Ru 106	2.40 E-02	6.94 E-12
Te 131m	1.52 E-03	4.40 E-13
Te 131	3.38 E-04	9.78 E-14
Te 132	1.30 E-01	3.76 E-11
Te 134	1.10 E-03	3.18 E-13
I 131	1.16 E+00	3.36 E+10
I 132	9.72 E-03	2.81 E-12
I 133	1.27 E-01	3.67 E-11
I 134	3.28 E-03	9.49 E-13
I 135	1.72 E-02	4.98 E-12
Cs 134	3.90 E-02	1.12 E-11
Cs 136	2.58 E-03	7.47 E-13
Cs 137	3.74 E-02	1.08 E-11
Ba 137m	3.74 E-02	1.08 E-11
Ba 140	3.30 E-01	9.55 E-11
La 140	5.48 E-02	1.59 E-11
Ce 141	2.52 E-01	7.29 E-11
Ce 143	3.50 E-02	1.01 E-11
Pr 143	3.74 E-01	1.08 E-10
Ce 144	5.44 E-02	1.57 E-11
Pr 144	5.44 E-02	1.57 E-11
Cr 51	1.20 E-01	3.47 E-11
Mn 54	1.09 E-01	3.15 E-11
Fe 59	2.26 E-02	6.54 E+12
Co 58	1.53 E+00	4.43 E-10
Co 59	3.10 E-01	8.97 E-11
TOTAL	5.96 E+00	1.72 E-09
H3	1 200	3.47 E-07

(*) 1 C i = 3.7 E 10 Bq

2000. 8. 16

TABLE T-11.2-11 (1a/5)

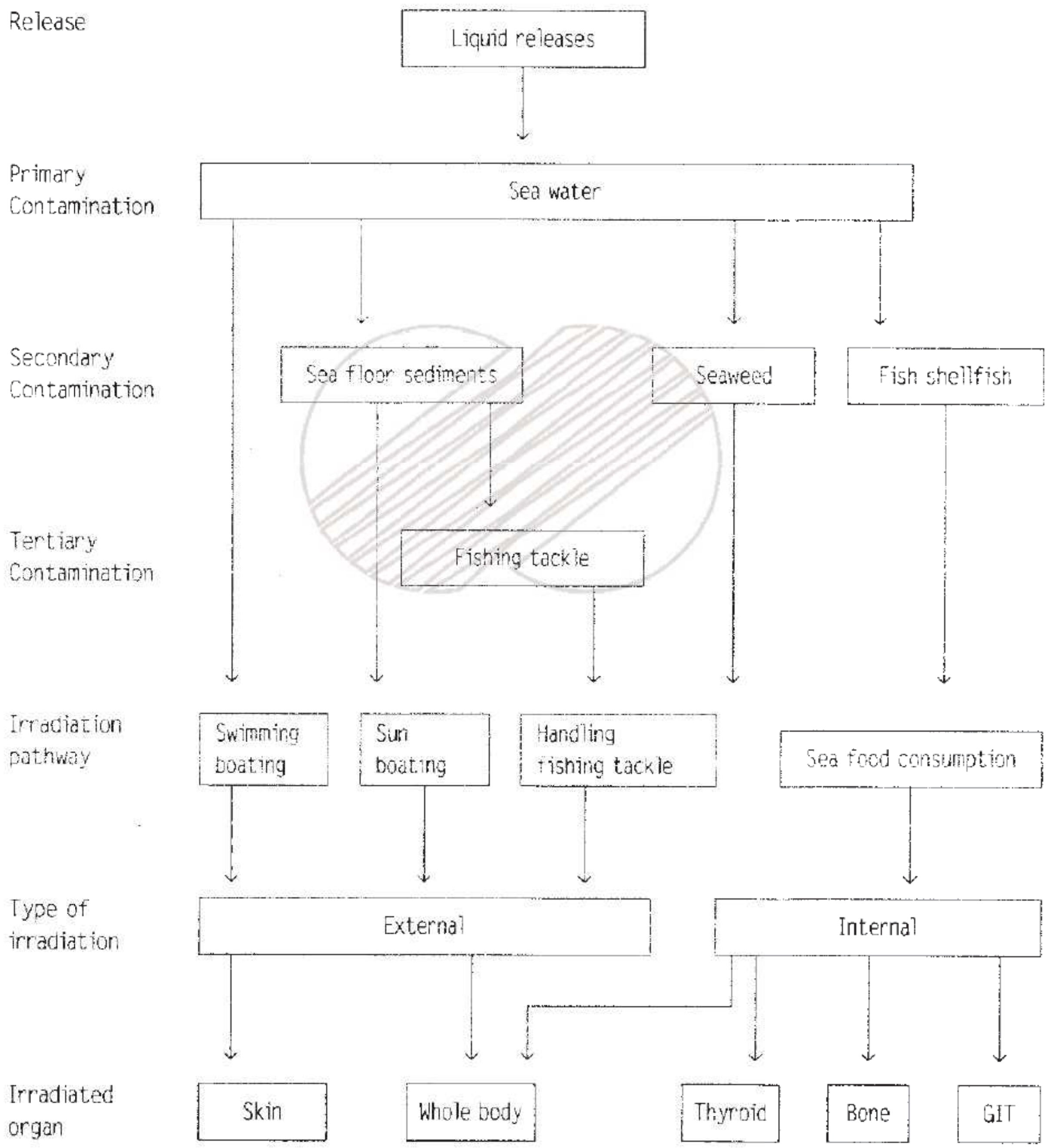
ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS FOR SIES

96

Isotope	Release (2 units) (μCi)	Concentration in circulating water Discharge (μCi/cc)
Na-24	2.60E+03	1.50E−12
P-32	3.60E+02	2.08E−13
Cr-51	7.60E+04	4.40E−11
Mn-54	4.60E+04	2.66E−11
Fe-55	4.40E+04	2.55E−11
Fe-59	1.12E+04	6.48E−12
Co-58	1.22E+05	7.06E−11
Co-60	4.00E+04	2.31E−11
Ni-63	3.40E+03	1.97E−12
Zn-65	1.22E+04	7.06E−12
W-187	1.30E+03	7.52E−13
Np-239	1.04E+04	6.02E−12
Sr-89	3.40E+03	1.97E−12
Sr-90	3.20E+02	1.85E−12
Y-90	2.20E+02	1.27E−13
Sr-91	2.20E+02	1.27E−13
Y-91	4.60E+02	2.66E−13
Y-93	2.00E+01	1.16E−14
Zr-95	1.12E+04	6.48E−12
Nb-95	1.10E+04	6.37E−12
Mo-99	4.00E+04	2.31E−11
Tc-99m	3.80E+04	2.20E−11
Ru-103	1.68E+05	9.72E−11
Rh-103m	1.66E+05	9.61E−11
Ru-106	2.20E+06	1.27E−09
RH-106	2.20E+06	1.27E−09
Ag-110m	3.40E+04	1.97E−11
Ag-110	4.00E+03	2.31E−12
Sb-124	8.60E+02	4.98E−13
Te-129m	4.20E+03	2.43E−12
Te-129	2.60E+03	1.50E−12
Te-131m	1.70E+03	9.84E−13
Te-131	3.00E+02	1.74E−13
I-131	1.44E+05	8.33E−11
Te-132	1.26E+04	7.29E−12
I-132	1.32E+04	7.64E−12
I-133	9.20E+03	5.32E−12
Cs-134	4.00E+04	2.31E−11
I-135	7.20E+02	4.17E−13
Cs-136	2.40E+03	1.39E−12
Cs-137	5.60E+04	3.24E−11
Ba-137m	2.20E+04	1.27E−11
Ba-140	2.40E+05	1.39E−10
La-140	3.00E+05	1.74E−10
Ce-141	3.80E+03	2.20E−12
Ce-143	4.20E+03	2.43E−12
Pr-143	5.40E+03	3.13E−12
Ce-144	1.02E+05	5.90E−11
Pr-144	9.40E+04	5.44E−11
H-3	1.20E+09	6.94E−07

TABLE T-11.2-11 (2/5)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS



GIT : Gastrointestinal tract

2000. 8. 16

TABLE T-11.2-11 (3/5)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS
CRITICAL GROUPS HABITS

	Local population average value	Fishermen
· Fish consumption (kg/yr)	15.5	31
· Shell fish consumption (kg/yr)	5.5	11
· Seaweed consumption (kg/yr)	1.5	3
· Swimming time (h/yr)	8.4	50
· Sunbathing on shoreling (h/yr)	17	100
· Boating time (h/yr)	45	2 000
· Handling fishing (h/yr)	0	2 000

TABLE T-11.2-11 (3a/5)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS FOR SIES
MAXIMUM AND AVERAGE INDIVIDUAL CONSUMPTION RATES FOR SIES

	MAXIMUM INDIVIDUAL			AVERAGE INDIVIDUAL		
	Child	Teen	Adult	Child	Teen	Adult
FISH (kg/yr)	52.9	82.8	79.3	22.1	43.2	41.4
INVETERBRATE (kg/yr)	11.8	18.4	17.6	4.0	7.8	7.5
ALGAE (kg/yr)	10.6	16.6	15.8	3.2	6.2	5.9
SHORELINE ACTIVITY (hr/yr)	14.0	67.0	12.0	–	–	–
SWINNING (hr/yr)	300	240.0	60.0	–	–	–
BOATING (hr/yr)	–	–	3,100	–	–	–

96

2000. 8. 15

TABLE T-11.2-11 (4/5)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS
TRANSFER FACTORS

Irradiation	External	Internal		
	Sediment or sand	Seaweed	Fish	Shellfish
Transfer factor	$Ci.l^{-1}/Ci.l^{-1}$	$Ci.kg^{-1}/Ci.kg^{-1}$	$Ci.kg^{-1}/Ci.l^{-1}$	$Ci.kg^{-1}/Ci.l^{-1}$
Sr	30	100	5	10
Nb	10^5	1 000	50	100
Mo	1 000	100	20	100
Tc	-	5	5	10
Ru	1 000	1 000	10	100
I	1 000	300	15	30
Cs	1 000	100	15	50
Ce	1 000	5 000	30	200
Cr	5 000	5 000	10	200
Mn	-	5 000	10	100
Fe	10^5	20 000	100	5 000
Co	3 000	1 000	10	100
H3	1	1	1	1

TABLE T-11.2-11 (4a/5)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS FOR SIES
TRANSFER FACTORS

	SALTWATER (pCi/kg per pCi/l)		
	FISH	INVERTEBRATE	ALGAE
NA	6.7E−02	1.9E−01	9.5E−01
P	2.9E+04	3.0E+04	3.0E+03
CR	4.0E+02	2.0E+03	2.0E+03
MN	5.5E+02	1.0E+04	2.0E+04
FE	3.0E+03	2.0E+04	5.0E+04
CO	1.0E+02	2.0E+03	1.0E+03
NI	1.0E+02	2.5E+02	2.5E+02
ZN	2.0E+03	1.0E+05	1.0E+03
W	3.0E+01	3.0E+01	3.0E+01
NP	1.0E+01	1.0E+01	6.0E+00
SR	2.0E+00	6.3E+00	1.3E+01
Y	2.5E+01	1.0E+03	5.0E+03
ZR	2.0E+02	2.0E+01	2.0E+03
NB	3.0E+04	1.0E+02	5.0E+02
MO	1.0E+01	1.0E+01	1.0E+01
TC	1.0E+01	5.0E+01	4.0E+03
RU	3.0E+00	2.0E+00	2.0E+03
RH	1.0E+01	2.0E+03	2.0E+03
AG	3.3E+03	3.3E+03	2.0E+02
SB	5.0E+00	5.0E+00	1.5E+03
TE	1.0E+01	1.0E+05	1.0E+03
I	5.0E+01	5.0E+00	4.0E+03
CS	2.0E+01	2.0E+01	4.0E+01
BA	1.0E+02	1.0E+02	5.0E+02
LA	1.0E+03	1.0E+03	5.0E+03
CE	1.0E+03	1.0E+03	5.0E+03
PR	1.0E+03	1.0E+03	5.0E+03
CE	1.0E+03	1.0E+03	5.0E+03
H	9.0E−01	9.3E−01	9.3E−01

96

2000. 8. 16

TABLE T-11.2-11 (5/5)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS

WHOLE BODY DOSE RATE CONVERSION FACTORS RELATEVE TO SWIMMING (b)
SUNBATHING ON SHORE (s)

$\frac{\mu \text{ rem/h}}{\text{Ci/m}^3}$

Nuclide	Whole body dose rate conversion factor	
	Cb	Cs
Fe 59	2.3 E 6	2.38 E 11
Co 58	1.73 E 6	5.62 E 8
Co 60	4.90 E 6	1.47 E 9
Mo 99	5.19 E 5	4.62 E 7
I 131	7.20 E 5	7.35 E 7
I 133	1.07 E 6	1.08 E 8
Cs 134	2.74 E 6	2.74 E 8
Cs 137	1.18 E 6	1.20 E 8
La 140	4.03 E 6	4.47 E 9
Ce 141	1.99 E 5	9.65 E 7
Ce 144	2.68 E 4	1.27 E 7
Sr 89	3.46 E 4	1.18 E 5
Y 90	6.63 E 2	6.48 E 5
Zr 95	1.41 E 6	1.41 E 10
Ru 103	9.51 E 5	9.51 E 7
Ru 106	3.17 E 5	3.46 E 7
Nb 95	1.50 E 6	1.51 E 10
Mn 54	1.64 E 6	1.58 E 8

TABLE T-11.2-11 (5a/5)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS FOR SIES
DOSE CONVERSION FACTOR FOR ADULT

	INGESTION (mrem/pCi)		EXTERNAL (mrem/hr)/(pCi/㎡)	
	W.BODY	THYROID	SKIN	W.BODY
NA 24	1.70E−06	1.70E−06	2.90E−08	2.50E−08
P 32	7.46E−06	0.00E+00	0.00E+00	0.00E+00
CR 51	2.66E−09	1.59E−09	2.60E−10	2.20E−10
MN 54	8.72E−07	0.00E+00	6.80E−09	5.80E−09
FE 55	4.43E−07	0.00E+00	0.00E+00	0.00E+00
FE 56	3.91E−06	0.00E+00	9.40E−09	8.00E−09
CO 58	1.67E−06	0.00E+00	8.20E−09	7.00E−09
CO 60	4.72E−06	0.00E+00	2.00E−08	1.70E−08
NI 63	4.36E−06	0.00E+00	0.00E+00	0.00E+00
ZN 65	6.96E−06	3.56E−07	4.60E−09	4.00E−09
W 187	3.01E−08	0.00E+00	3.60E−09	3.10E−09
NP 239	6.45E−11	0.00E+00	1.10E−09	9.50E−10
SR 89	8.84E−06	0.00E+00	6.50E−13	5.60E−13
SR 90	1.75E−04	0.00E+00	0.00E+00	0.00E+00
Y 90	2.58E−10	0.00E+00	2.60E−12	2.20E−12
Y 91	3.77E−09	0.00E+00	2.70E−11	2.40E−11
Y 93	7.40E−11	0.00E+00	7.80E−10	5.70E−10
ZR 95	6.60E−09	0.00E+00	5.80E−09	5.00E−09
NB 95	1.86E−09	0.00E+00	5.10E−09	6.00E−09
MO 99	8.20E−07	0.00E+00	1.90E−09	2.20E−09
TC 99M	8.89E−09	9.26E−09	1.10E−09	9.60E−10
RU 103	7.97E−08	0.00E+00	3.60E−09	4.20E−09
RU 106	3.48E−07	0.00E+00	1.50E−09	1.80E−09
AG 110M	8.79E−08	0.00E+00	2.10E−08	1.80E−08
SB 124	1.11E−06	6.79E−09	1.50E−08	1.30E−08
TE 129M	1.82E−06	3.95E−06	9.00E−10	7.70E−10
TE 129	7.65E−09	2.41E−08	8.40E−10	7.10E−10
TE 131M	7.05E−07	1.34E−08	9.90E−09	8.40E−09
TE 131	6.22E−09	4.81E−07	2.60E−06	2.20E−09
I 131	3.41E−06	5.19E−05	3.40E−09	2.80E−09
TE 132	1.53E−06	6.67E−06	2.00E−09	1.70E−09
I 132	1.90E−07	4.44E−07	1.70E−08	2.00E−08
I 133	7.53E−06	1.00E−05	4.50E−09	3.70E−09
CS 134	1.21E−04	1.96E−06	1.40E−08	1.20E−08
I 135	4.28E−07	2.06E−06	1.20E−08	1.40E−08
CS 136	1.85E−05	3.04E−07	1.70E−08	1.50E−08
CS 137	7.14E−05	1.41E−06	4.90E−09	4.20E−09
BA 140	1.33E−06	0.00E+00	2.40E−09	2.10E−09
LA 140	3.33E−10	0.00E+00	1.50E−08	1.70E−08
CE 141	7.18E−10	0.00E+00	6.20E−10	5.50E−10
CE 143	1.35E−10	0.00E+00	2.50E−09	2.20E−09
PR 143	4.56E−10	0.00E+00	0.00E+00	0.00E+00
CE 144	2.62E−08	0.00E+00	3.70E−10	3.20E−10
PR 144	1.53E−12	0.00E+00	2.30E−10	2.00E−10
H 3	6.60E−08	6.30E−08	0.00E+00	0.00E+00

96

TABLE T-11.2-12 (1/2)

OFFSITE DOSES RESULTING FROM NORMAL PLANT LIQUID RELEASES
LOCAL POPULATION WHOLE BODY INGESTION DOSES

Nuclide	Ingestions (Ci/year)*	Dose conversion factors**(rem/Ci)	Doses (μ rem/year)
Sr 89	7.77 E−12	9.31 E+3	7.23 E−2
Sr 90	8.31 E−14	1.86 E+5	1.55 E−2
Sr 91	5.04 E−14	3.09 E+3	1.56 E−4
Sr 92	3.17 E−14	1.86 E+3	5.90 E−5
Nb 95	5.20 E−11	2.33 E+3	1.21 E−1
Mo 99	2.26 E−11	4.65 E+3	1.05 E−1
Tc 99m	2.13 E−12	6.12 E+1	1.30 E−4
Ru 103	1.08 E−10	2.64 E+3	2.85 E−1
Ru 106	1.41 E−11	2.64 E+4	3.72 E−1
I 131	1.46 E−10	1.86 E+5	2.72 E−1
I 132	5.29 E−13	1.86 E+3	1.10 E−3
I 133	6.90 E−12	3.72 E+4	2.57 E−1
I 134	1.79 E−12	2.33 E+2	4.17 E−5
I 135	9.35 E−13	6.33 E+3	5.92 E−3
Cs 134	5.21 E−12	6.33 E+4	3.29 E−1
Cs 136	2.99 E−13	9.31 E+3	2.78 E−3
Cs 137	4.84 E−12	4.65 E+4	2.25 E−1
Ce 141	8.50 E−10	3.09 E+3	2.63 E−0
Ce 143	1.37 E−11	4.65 E+3	6.38 E−2
Ce 144	1.33 E−10	2.33 E+4	3.10 E−0
Cr 51	3.88 E−10	1.86 E+2	7.22 E−2
Mn 54	2.48 E−10	2.64 E+3	6.55 E−1
Fe 59	3.57 E−10	6.34 E+3	2.26 E−0
Co 58	8.69 E−10	3.72 E+3	3.23 E−0
Co 60	1.86 E−10	2.66 E+4	4.95 E−0
TOTAL			45.9 μ rem/yr (0.46 μ Sv/yr)
H3	2.96 E−09	6.66 E+1	1.97 E−1

(*) 1 Ci = 3.7 E 10 Bq · rem = 1 E-2 Sv

(**) assumed from ICRP 30

TABLE T-11.2-12 (1a/2)

OFFSITE DOSES FROM NORMAL PLANT LIQUID RELEASES FOR SIES
DOSES TO MAXIMUM INDIVIDUAL
(1 Unit Operation)

AGE	Pathway	Doses (mrem/yr)						
		BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
ADULT	FISH	9.99E−03	1.43E−02	1.08E−02	1.75E−03	6.88E−03	2.15E−03	1.59E−02
	INVERTEBRATE	3.46E−02	3.52E−02	2.41E−02	2.32E−02	1.39E−01	2.75E−03	1.51E−01
	ALGAE	3.55E−02	4.21E−03	7.89E−03	1.61E−02	5.94E−02	3.91E−04	3.75E−01
	SHORELING	3.47E−04	3.47E−04	3.47E−04	3.47E−04	3.47E−04	3.47E−04	3.47E−04
	SWIMMING	1.02E−05	1.02E−05	1.02E−05	1.02E−05	1.02E−05	1.02E−05	1.02E−05
	BOATING	2.63E−04	2.63E−04	2.63E−04	2.63E−04	2.63E−04	2.63E−04	2.63E−04
	TOTAL	8.07E−02	5.43E−02	4.33E−02	4.17E−02	2.06E−01	5.90E−03	5.43E−01
TEEN	FISH	4.97E−02	2.86E−02	1.24E−02	3.87E−02	9.07E−03	6.17E−03	2.02E−01
	INVERTEBRATE	8.33E−02	6.24E−02	3.39E−02	5.47E−02	2.01E−01	6.83E−03	1.53E+00
	ALGAE	5.44E−02	1.02E−02	1.07E−02	7.60E−01	8.84E−02	6.42E−04	2.29E+00
	SHORELINE	1.94E−03	1.94E−03	1.94E−03	1.94E−03	1.94E−03	1.94E−03	1.94E−03
	SWIMMING	4.07E−05	4.07E−05	4.07E−05	4.07E−05	4.07E−05	4.07E−05	4.07E−05
	TOTAL	1.89E−01	1.03E−01	5.89E−02	8.55E−01	3.00E−01	1.56E−02	4.03E+00
CHILD	FISH	9.38E−02	3.67E−02	1.68E−02	5.90E−02	1.09E−02	7.55E−03	1.09E−01
	INVERTEBRATE	1.55E−01	7.85E−02	5.57E−02	8.80E−02	2.61E−01	8.47E−03	9.08E−01
	ALGAE	1.03E−01	1.27E−02	1.75E−02	1.16E+00	1.17E−01	7.74E−04	1.42E+00
	SHORELINE	4.05E−04	4.05E−04	4.05E−04	4.05E−04	4.05E−04	4.05E−004	4.05E−04
	SWIMMING	5.09E−05	5.09E−05	5.09E−05	5.09E−05	5.09E−05	5.09E−05	5.09E−05
	TOTAL	3.52E−01	1.28E−01	9.04E−02	9.04E−02	3.89E−01	1.73E−02	2.43E+00

96

2000. 8. 16

TABLE T-11.2-12 (2/2)

OFFSITE DOSES RESULTING FROM NORMAL PLANT LIQUID RELEASES
SWIMMING AND SUNBATHING WHOLE BODY DOSES (μ rem*/year)

Isotope	Local population	Fishermen
Sr 89	8.90 E−05	5.29 E−04
Y 90	4.11 E−06	2.42 E−05
Zr 95	1.31 E+01	7.68 E+01
Nb 95	6.92 E+00	4.07 E+01
Mo 99	2.94 E−02	1.73 E−01
Ru 103	9.26 E−02	5.44 E−01
Ru 106	4.10 E−03	2.41 E−02
I 131	4.13 E−01	2.43 E+00
I 133	6.69 E−02	3.94 E−01
Cs 134	5.27 E−02	3.10 E−01
Cs 137	2.18 E−02	1.29 E−01
La 140	1.20 E+00	7.08 E−00
Ce 141	1.20 E−01	7.06 E−01
Ce 144	3.39 E−03	1.99 E−02
Mn 54	8.19 E−02	5.02 E−01
Fe 59	2.20 E+01	1.55 E+02
Co 58	4.11 E+00	2.49 E+01
Co 60	2.18 E+00	1.32 E+01
Total	5.04 E+01	3.23 E+02
	μ rem/year	μ re,/year
Total	(0.50 μ Sv/yr)	(3.2 μ Sv/yr)

(*) 1 rem = 1 E-2 Sv

TABLE T-11.2-12 (2a/2)

OFFSITE DOSES FROM NORMAL PLANT LIQUID RELEASES FOR SIES
DOSES TO POPULATION
(1 Unit Operation)

Fish		Doses (man-rem/yr)							
		BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI	SKIN
Fish	Sport	3.16E−01	2.30E−01	1.35E−01	1.67E−01	9.00E−02	4.22E−02	7.45E−01	0.00E+00
	Commercial	1.08E−02	8.36E−03	4.89E−03	4.78E−03	3.31E−03	1.56E−03	2.59E−02	0.00E+00
	Total	3.27E−01	2.38E−01	1.40E−01	1.72E−01	9.33E−02	4.38E−02	7.71E−01	0.00E+00
Invertebrate	Sport	1.39E+01	1.09E+01	7.00E+00	8.47E+00	3.85E+01	1.03E+00	1.26E+02	0.00E+00
	Commercial	3.12E−02	2.54E−02	1.58E−02	1.33E−02	7.81E−02	2.57E−03	2.80E−01	0.00E+00
	Total	1.39E+01	1.09E+01	7.02E+00	8.48E+00	3.86E+01	1.03E+00	1.26E+02	0.00E+00
Algae	Sport	3.86E−03	8.69E−04	1.37E−03	3.27E−02	1.07E−02	7.38E−05	1.13E−01	0.00E+00
	Commercial	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Total	6.86E−03	8.69E−04	1.37E−03	3.27E−02	1.07E−02	7.38E−05	1.13E−01	0.00E+00
Shoreline		0.00E+00	0.00E+00	1.37E−02	1.37E−02	0.00E+00	0.00E+00	0.00E+00	1.44E−02
Swimming		0.00E+00	0.00E+00	2.99E−04	2.99E−04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Boating		0.00E+00	0.00E+00	2.26E−04	2.26E−04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL		2.85E+01	2.23E+01	1.43E+01	1.74E+01	7.74E+01	2.15E+00	2.54E+02	1.44E−02

96

2000. 8. 16

Ulchin Nuclear Power Plant 1, 2

Final Safety Analysis Report

Figure 11.2−1

Liquid waste treatment system

9TEU Sheet 1/5 | 174

ULCHIN NUCLEAR UNIT 1 and 2

Final Safety Analysis Report

Figure 11.2－2

Liquid waste treatment system

9TEU Sheet 2/6

Ulchin Nuclear Power Plant 1, 2

Final Safety Analysis Report

Figure 11.2-3

Liquid waste treatment system

9TEU Sheet 3/6

Ulchin Nuclear Power Plant 1, 2

Final Safety Analysis Report

Figure 11.2–3a

Liquid waste treatment system

9TEU Sheet 4/6

Ulchin Nuclear Power Plant 1, 2

Final Safety Analysis Report

Figure 11.2-3b

Liquid waste treatment system

9TEU Sheet 5/6

Ulchin Nuclear Power Plant 1, 2

Final Safety Analysis Report

Figure 11.2-3c

Liquid waste treatment system

9TEU Sheet 6/6

ULCHIN NUCLEAR UNIT 1 and 2

Final Safety Analysis Report

FIGURE 11.2-4

Liquid waste discharge system(storage)

Ulchin Nuclear Power Plant 1, 2

Final Safety Analysis Report

Figure 11.2－5.1

Drain system (workshops)

ULCHIN NUCLEAR UNITS 1 and 2

Final Safety Analysis Report

FIGURE 11.2－5.2

Drain system (workshops)

No. Page

TABLES

FIGURE

11.3. GASEOUS WASTE MANAGEMENT SYSTEMS

This section describes the capabilities of the Plant to control, collect, process, store, and dispose of gaseous radioactive waste generated from normal operation and anticipated operational occurrences. Process and radiological monitoring systems are described in Section 11.5. The gaseous waste management systems consist of :

- gaseous waste treatment system (TEG),
- condenser vacuum system (CVI),
- building ventilation systems.

The condenser vacuum system is described in Subsection 10.4.2. The building ventilation systems are described in Section 9.4. They are not discussed in this section except for portions relating to radiation management.

11.3.1. Design bases (Ref.1)

The purpose of the gaseous waste treatment system is to collect and process the airborne radioactive noble gases, halogens, and particulates in order to reduce the anticipated annual releases and personnel exposure in restricted and unrestricted areas to levels as low as practicable.

The design bases for the TEG are :

- the TEG performs no safety-related function but its hydrogenated subsystem is designated safety Class 3 since its failure would result in a release of radioactive gases normally held for decay (RCC-P Subparagraph 4.1.2.2.3.),
- codes and standards applicable to the gaseous waste treatment systems are specified in Section 3.2,
- the gaseous waste treatment system provides for the collection of gaseous waste generated during plant operation which is potentially radioactive,
- the gaseous waste treatment system provides sufficient processing capability so that gaseous effluents may be discharged to the environment at concentrations below the regulatory limits as indicated in RCC-P, Subsection 1.1.2.2.1,
- the TEG system is shared by both units,

- the TEG consists of independent subsystems :

3 . the hydrogenated gaseous waste subsystem,

. the aerated gaseous waste subsystem,

. the oxygen analyzer subsystem.

- the TEG is designed in accordance with RCC-P Subsection 2.3.7,

- the following specific requirements apply to the system design :

. Pressure retaining components of the system utilize welded construction to the maximum practicable extent. Flanged joints are used only where maintenance or operational requirements clearly indicate that such construction is preferable. Screwed connections in which threads provide the only seals are not used except for instrumentation connections where welded connections are not always suitable.

All welding constituting the pressure boundary of pressure retaining components (when classified RCC-M 3) will be performed in accordance with RCC-M C 3 600.

. The test pressure for the process piping is held for at least 30 minutes and for such additional time as may be necessary to conduct the examination for leakage.

. Materials for pressure retaining components are selected from those covered by the material specifications listed in Parts I and II of the second volume of the RCC-M. The components meet the requirements of the material specifications with regard to manufacture, examination, repair, testing, identification, and certification.

. It is possible to monitor the TEG from the TEG control panel located in the nuclear auxiliary building (NAB). The radwaste panel contains all required process alarms. Activation of any alarm on the NAB radwaste panel causes annunciation of a single alarm in the main control room.

11.3.1.1. Average annual radionuclide design release objectives

The equipment, instrumentation, and operating procedures utilized in the gaseous waste management system are designed to ensure that radwastes are safely processed and that releases from the plant are at concentrations below the limits set forth in RCC-P Section 5.4.

11.3.1.2. Equipment design margin

The gaseous waste system is designed to meet the usual anticipated processing requirements of the Plant.

Adequate capacity is provided to process gaseous waste during periods when major processing equipment may be down for maintenance (single failures) and during periods of excessive waste generation. The design parameters for the hydrogenated gaseous waste subsystem are tabulated in Table T-11.3-1.

11.3.1.3. Gaseous waste system equipment parameters

The component list and design parameters of the gaseous waste system are listed in Table T-11.3-2.

11.3.1.4. Seismic and quality group classification

The seismic classification of components used in the gaseous waste system, and structures housing system, are specified in Section 3.2.

The TEG is located in the NAB which is designed for Seismic Category I.

The equipment which processes active gaseous waste is seismically classified.

11.3.1.5. Design features for radwaste operation and maintenance

The nuclear auxiliary building radwaste equipment layout provides design features capable to minimize operator exposure. Components of high radioactivity are segregated and shielded in separate compartments. Those of intermediate and low activity are grouped such that doses are minimized during operator entry for inspection or maintenance.

The NAB layout provides for remote radwaste system operation from control panels which also provide process instrumentation readout and alarms. Process support equipment, such as compressors and valves, are located, when necessary, outside process components cells in their own shielded areas.

11.3.1.6. Equipment layout and shielding parameters

The equipment layout of the gaseous waste system is identified in Figures F-12.3-5 and 7. The geometry and shielding parameters of components containing radioactive materials are described in Subsection 12.3.2.

11.3.1.7. Single failure analysis

Active gaseous waste system equipment is backed up by redundant equipment within the system itself :

- 2 x 50 % capacity for compression (hydrogenated subsystem),
- 2 x 100 % capacity for heaters, iodine traps and fans (aerated subsystem).
- 2 x 100% capacity for oxygen analyzers.

3 11.3.1.8. Design consideration for potential explosions

The hydrogenated gaseous waste subsystem is designed to prevent any internal hydrogen explosion risk. All systems which feed the hydrogenated subsystem are maintained at a positive gauge pressure to prevent the occurrence of air inleakage.

The following measures have been taken to prevent explosions :

- the entire system is of welded joint construction with the exception of a few connections that are flanged,
- a thorough leak test is performed on the system before startup,
- all tank bunkers are ventilated when in service,
- the temperature throughout the system remains at less than 50 °C, except for the compressors discharge lines up to gas coolers,
- all electrical equipment within the hydrogenated gaseous waste subsystem rooms is explosion proofed,
- air scavenging of tank rooms is designed so that air inflow is through the bottom and air outflow through the top of the rooms ; this prevents leaking hydrogen from accumulating in rooms,
- the maximum tank drain rate is set to ensure that the dilute hydrogen concentration does not exceed the lower hydrogen flammability limit in air (4 % H_2).
- 3 the dilute oxygen concentration does not exceed the lower oxygen flammability limit in the surge tank (001BA, 4% O)

11.3.2. System descriptions

Figure F-11.3-1 is a flow diagram of the TEG system.

11.3.2.1. Subsystem descriptions

The entire TEG facility is housed in the nuclear auxiliary building (NAB).

11.3.2.1.1. Hydrogenated gaseous waste subsystem

Hydrogenated gaseous waste is made up principally of hydrogen and nitrogen contaminated with fission gas products generated in the reactor coolant system.

Hydrogenated gaseous waste comes from two sources :

- degasing of the reactor coolant in TEP gas strippers ; the flow of these streams is low but can be frequent,
- flushing of gas blankets established in controlled atmosphere tanks (either as a result of liquid level variations in the tank or intentional blanket removal) ; these streams have high flows but only occur one or two times a month.

After being collected by the RPE, waste is routed to upstream buffer tank 001 BA which is connected to a header, feeding two compressor lines (001 CO ; 002 CO) mounted in parallel.

The gas compressors deliver compressed gas mixtures to one of the six decay tanks (manually selected).

Compressed gas is cooled by heat exchangers 001 RF and/or 002 RF. Compressors are cooled by the RRI system.

The six decay tanks (002, 003, 004, 005, 006, 007 BA) are linked to a vent network.

This vent network consists of two redundant trains sized to enable a decay tank to be drained at a preset constant flowrate within a period of 5 to 84 hours. A flowmeter/counter measures the flowrate and volume of gas released to the atmosphere. Release takes place upstream of the DVN iodine filter.

A hookup is provided for transfer of the content of one tank to another via a gas compressor. The upstream surge tank as well as the decay tanks are protected against overpressure by means of safety valves discharging directly to the stack (downstream of the DVN iodine filters).

The inlet nozzle on each decay tank is tapped for sampling. Sampling lines are routed to a fume chamber (primary sampling room NA 293).

Main components characteristics are given in Table T-11.3-2.

11.3.2.1.2. Aerated gaseous waste subsystem

The entire facility is housed in the nuclear auxiliary building.

The corresponding RPE header connects to the suction leg of two leak-tight fans, 001 ZV and 002 ZV, parallel mounted.

An adjustable flap type check valve on the air intake maintains a preset constant negative pressure in the header.

Two air reheaters, placed in series on the header upstream of the iodine traps and fans, reduce the relative humidity of the gas to a level suitable for trap operation.

Each suction line of the relevant fan has a iodine trap.

Fan discharge lines are linked to a common header connected to the DVN.

Main component characteristics are listed in Table T-11.3-2.

11.3.2.1.3 Oxygen analyzer subsystem

This subsystem consists of two oxygen analyzer which are in operation
3 and continuously analyze the oxygen concentration when TEG system is in 320
137 operation. One oxygen analyzer (101RK) sucks the gas from surge tank
(001BA) and discharges it to gas surge tank (001BA) and the other one
7 (201RK) is connected with two compressors (001, 002 CO) in parallel.
Main component characteristics are listed in table T-11.3-2.

11.3.2.2. System operation

11.3.2.2.1. Hydrogenated gaseous waste subsystem

Prior to system operation, the TEG is purged with nitrogen. The gas collection header directs all high-activity gases to the waste gas surge tank. 001 BA serves as a buffer tank to cushion pressure variations that result from irregular effluent inflow. The tank also delivers an even flow of gas to compressors and separates gas-entrained condensate.

If no gas is fed into the surge tank, pressure in the tank does not exceed 0,05 bar gauge and the compressors are shutdown.

As gas is generated and fed through the RPE, pressure in the surge tank rises. When tank pressure reaches 0,25 bar gauge, the first compressor starts.

A further pressure rise to 0,30 bar gauge, starts the standby compressor.

Upon startup of the second compressor, pressure in the buffer tank falls back below 0,05 bar gauge, and the two compressors shut down.

Normal operation is automatically controlled by means of a pressure switch on the surge tank. Compressors startup priority selection is done by means of a switch on the TEG control panel.

Tank lineup (fill, decay and release mode) is manual. Radioactivity level is measured in monitor tanks (by sampling) before the tank content is released to the atmosphere. No release is possible unless at least two remote series valves have been manually opened.

Release is stopped automatically if DVN iodine ventilation subsystem fails, stack radioactivity threshold is exceeded, or if pressure in a storage tank being drained falls under 0,20 bar gauge. The latter 3
arrangement prevents backflow of outside air into the processed storage tank.

The pump of the oxygen analyzer in started up after opening the root, valven which are connected to the oxygen analyzer.

11.3.2.2.2. Aerated gaseous waste subsystem

During normal operation one reheater, one iodine trap and one fan are on line. The standby fan starts up automatically upon reception of a signal indicating the outage of the first fan. Negative pressure in the vent air header is adjusted by a check valve, which closes automatically as soon as underpressure is no longer maintained. The degree of negative pressure is controlled by adjusting manually the valve flap counterweight.

Both vent gas and air are diluted by the main DVN vent air stream before being released through the stack.

11.3.3. Radioactive releases

Gaseous radioactive releases originate from the discharge of gaseous waste treatment system output gases and from the discharge of building ventilation systems exhaust gases, including the main condenser evacuation system.

11.3.3.1. Criteria for releasing radioactive gases

All gaseous wastes are discharged after processing and/or monitoring. Their radioactivity level must conform with the guidelines set forth in RCC-P Subsection 5.4.3.

11.3.3.2. Estimated gaseous releases

The source term used to predict expected long term average concentration of radionuclides in the primary and secondary fluids stream is described in Section 11.1. The resulting radionuclide concentrations are also tabulated in Section 11.1.

Like in Section 11.2., the gaseous releases are calculated for two types of operation and source terms :

- Mean normal operation which includes anticipated operational occurrences and allows to compute the average release over the life of the plant (case A), called here after "expected values".

- Exceptional operation at design basis fuel leakage, which is used to evaluate maximum possible release levels (case B), called here after "design values".

11.3.3.2.1. Hydrogenated effluent releases

These effluents are produced principally by gas stripping of the 5500 m3/year reactor coolant effluents treated by the TEP system. The gas strippers in this system treat effluents whose noble gas radioactivity is identical to that of the reactor coolant, whereas their iodine radioactivity is only 10 % of that of the reactor coolant. This is because these effluents are extracted from the reactor coolant system after passing through the RCV and TEP demineralizers, for which a decontamination factor of 100 is taken into consideration.

In the gas strippers all the noble gases are removed, whereas the iodine separation factor is only 10^{-3}.

Assuming an average filling time of about 12 days, the TEG decay tanks are designed for an average storage capacity of 60 days.

These values take into account the sweeping or venting time of certain storage tanks.

The annual releases from this source are summarized in Table T-11.3-3.

11.3.3.2.2. Aerated effluents releases

Aerated effluents come principally from Nuclear Island tanks containing slightly radioactive water and from extraction of gases in the condenser in the case of leakage from the reactor coolant system to the secondary system.

As far as reactor coolant leaks in the nuclear auxiliary building are concerned, (See Subparagraph 11.2.3.2.2) all the gases and a fraction of the iodine contained in this leakage are released to the atmosphere of the building.

The separation factor for the iodine contained in hot leakage ($t > 60$ °C) is taken as 10 % and for cold leakage as 0,01 %.

The buildings ventilation systems release these radioactive products to the environment without decay. Iodine traps in the ventilation systems processing potentially contaminated rooms have a 99,99 % design efficiency for I2 and 99,5 % for methyl iodine (ICH_3), at 25 °C and 40 % relative humidity. Nevertheless for release calculation a factor 90 % is assumed.

As far as reactor coolant leakage in the reactor building is concerned (See Subparagraph 11.2.3.2.2), all the gases and a fraction of the iodine contained in the leakage are released to the atmosphere of the building, due to the leak temperature, the design iodine separation factor is taken as 10 %.

An internal filtration (EVF system) of 20 000 m3/h and a sweeping (ETY system) of 1 500 m3/h during 180 h/year make possible the reduction of the ambient radioactivity level in the reactor building. The iodine traps in these two systems have a decontamination factor of 10.

In the case of leakage from the reactor coolant system to the secondary system the noble gases drawn out are completely removed by the ejectors or the condenser vacuum pumps and released directly to the atmosphere.

A separation factor of 5×10^{-3} is assumed for iodines passing through the condenser.

The activity released by leaks in the form of steam which is not re-condensed in the secondary system escapes directly to the atmosphere with a separation factor of 1.

Finally, for aerosol and argon releases, the values given in NUREG 0017 are used. These values are 25 mCi/year of aerosols and 25 Ci of argon (Ar 41).

The annual releases from these sources are summarized in Tables T-11.3-4 to T-11.3-6.

11.3.3.2.3. Tritium releases

Production of tritium in the reactor coolant system is mainly due to partial scattering through the cladding of the tritium generated in the fuel, and its production in the reactor coolant from the boron used for controlling reactivity.

On the basis of the various annual tritium production estimates, which give a range of 660 to 750 Ci/year the value for tritium releases may vary between :

- 60 and 90 Ci in the form of gas.

11.3.3.2.4. Total annual gaseous releases

The total annual gaseous releases are summarized in Table T-11.3-8.

Comparison of design value releases with the release and concentration limit guidelines set forth in RCC-P, Subsection 5.4.3 is made in Table T-11.3-9. Releases and concentration are small fraction of this limits.

11.3.3.3. Release point

All the radioactive gaseous release are done through the NAB stack.

The minimum flow rate is 278 000 m3/h which corresponds to an air exit velocity of 12 m/second.

The stack height is 62,30 m above ground level.

11.3.3.4. Radiological consequences of gaseous releases

11.3.3.4.1. Atmospheric dispersion and contamination

Gaseous radioactive nuclides are released along with gaseous effluents and ventilation exhausts through the stack. The transfer of these effluents to the environment involves the atmospheric dispersion and the fall-out phenomena. The knowledge of those making it possible to evaluate the activities in the environment and on the basis of this data making it possible to estimate the effects of the radioactive releases on the public.

Calculation of air radioactivity concentration takes into account the following assessments :

- the quantity of gaseous radioactivity released,

- the atmospheric dispersion coefficient.

The gaseous releases consequences are calculated with the "expected values" resulting from normal operation.

The total annual gaseous releases are given in Table T-11.3-8.

The atmospheric dispersion coefficients are suited to the meteorological and topographical conditions of the region taking into account :

- the wind frequency for each wind directions, given by the wind rose,

- the distance between the release point and the point of calculation,

- the atmospheric stability and other meteorological conditions like rain days ...

In the following, radioactivity concentrations are computed for critical areas defined as local population area and agricultural area. The location of these areas is established using the meteorological input data (see Chapter 2) and the map of the site.

The most exposed individual is assumed to live all year round at the most exposed place determined on the basis of atmosphere diffusion.

The highest dispersion factor corresponds to the nearest offsite habitation located 1,0 km to the SSE from containment, and its value is 1,45 x 10^{-6} sec/m3.

The most exposed agricultural area is assumed to be situated adjacent to the site boundary.

To keep within a conservative estimate, the highest dispersion factor for the site exclusion boundary is chosen, that is 5,79 x 10^{-6} sec/m3, which matches an agricultural area located 0,7 km to the SW and during the most unfavourable season (82,6 - 82,8).

The air radioactivity can contaminate a ground surface through a phenomenon which may be compared with sedimentation in absence of rain and with washing in the event of rainfall. The only fallout radioactivity is due to iodines, aerosols and tritium - but through different phenomena.

Iodine deposit rate depends on the intensity of precipitations, and is more significant in rainy weather. Moreover, the iodine fallout radioactivity concentration is calculated with two deposit rates :

- rainy weather : 4 x 10^{-2} m/s
- dry weather : 4 x 10^{-3} m/s

Tritium is assumed to be released in the form of tritiated water and behaves as water. It is possible to estimate the average concentration of tritium in water rain on the basis of the following assumptions :

- tritium concentration release,
- mass of water in atmosphere,
- the CHAMBERLAIN transfer factor, between atmospherique tritiated water and rain water.

All assumptions are summarized in Table T-11.3-10 (1/6).

11.3.3.4.2. Radiological doses model

The ways in which radioactive airborne substances can irradiate are summarized in Table T-11.3-10 (2/6) and are as follows :

- external irradiation by exposition to the plume and ground deposit,
- internal irradiation by inhaling radioactive iodine or tritium,
- internal irradiation by ingestion of contaminated products containing iodine or tritium.

Other radioactive airborne substances are not taken into account because the amounts released are very small and their radiological consequences are negligible.

General assessments on the dose model are given in Paragraph 11.2.3.3.

As indicated in this paragraph the critical group includes only adults, and the doses calculated for the persons of critical groups are the equivalent whole body doses.

A critical group is defined as adults whose habits are given in Table T-11.3-10 (3/6).

These habits are those indicated in the Uljin environmental report completed by international data.

The consumption of milk is not regarded as a radioactive pathway because only 4 cows are reported to be bred within a 10 mile radius of the site.

To postulate the most conservative consequences of gaseous releases, it is assumed that infants raised locally, drink the milk of the cows that graze in the most exposed agricultural area. This calculation is given only as indicative data.

11.3.3.4.3. Internal irradiation dose by ingestion

a) Iodine contamination

In view of the short timelife of radioactive iodines, it appears that the only way by which vegetation can be contaminated is through fall-out on leaves, the contamination pathway through the soil being negligible. The main foods liable to produce human contamination are fresh foods such as crops, market gardening products or products from cattle or dairy products.

The activity concentration in vegetables and fruit is calculated by using fall-out activity concentration surfaces, the retention factor (between fall-out and vegetable), translocation factors and productivity. The calculation method is illustrated in Table T-11.3-10 (4/6).

Crops

It is assumed that the vegetables consumed by the critical group are from fields located in the critical agricultural area.

The total activity ingested depends on food consumption and the amount of radionuclides ingested are converted into doses using the dose model defined in 11.2.3.3.2.

Meat

It is assumed that cows and oxen feed on the critical agricultural area.

The radioactivity concentration in meat is calculated by using grass radioactivity concentration, consumption of grass (by cows, oxen), and transfer factor (between radionuclide and meat).

The total radioactivity ingested depends on meat consumption and the amount of radionuclides ingested are converted into doses using the dose model defined in 11.2.3.3.2.

b) Tritium contamination

Tritium concentration in vegetation and grass is evaluated by using root absorption of soil water.

Taking into account that the plants contain 85 % water and assuming that :

. the soil water comes only from rain water,

. the water of plants is in isotopic equilibrium with the soil water.

The factor of transfer from rain water to plants used to calculated activity concentration in vegetation and grass is 0,85.

The calculation method is illustrated in Table T-11.3.10 (5/6).

Crops

The total radioactivity ingested (from critical agricultural area) depends on food consumption and the amount of radionuclide ingested is converted into doses using the value defined in 11.2.3.3.2.

Meat

The total radioactivity ingested depends on meat consumption and the amount of tritium ingested is converted into dose using the value defined in 11.2.3.3.2.

The total annual dose due to ingestion is : $5{,}2 \times 10^{-5}$ m Sv.

c) Milk ingestion for infants

The radioactivity concentration in milk is calculated by the same method as the radioactivity concentration in meat.

The total radioactivity ingested depends on milk consumption (see in Table T-11.3-10 (3/6)) and dose rate conversion factors (see in Table T-11.3-10 (6/6)).

The total annual thyroid dose due to milk ingestion for an infant is : $6{,}2 \times 10^{-2}$ m Sv.

11.3.3.4.4. Internal irradiation dose by inhalation

Atmospheric contamination from iodine and tritium results in internal irradiation of the body through inhalation (compared to the dose from external irradiation, the dose from noble gas inhalation is negligible).

Inhalation is assumed to be of long duration ; contamination of the whole body reaches an equilibrium when the absorption of the contamining element is equal to the loss due to radioactive decay and biological elimination.

The ICRP 30 has used this assumption in determining the maximum annual limit of inhalation intake. This figure is determined for an adult breathing rate of 20 m3/24 h.

The dose is calculated assuming that the person remains within the area of his home all the year round.

The dose rate conversion factors are given in Table T-11.3-10 (6/6).

The total annual dose due to inhalation is : $1{,}2 \times 10^{-5}$ m Sv.

11.3.3.4.5. External irradiation dose

The calculation for the whole body takes into account only the action of gamma rays in view of the limited path of β-rays in the tissues.

The dose by immersion is calculated assuming that :

- the person is located at the centre of the hemisphere,

- the atmosphere of the hemisphere is contaminated uniformly and this contamination is equal to that present at the centre of the hemisphere where the dose is calculated,

- the person remains all the year round within the area of his home.

The total annual dose due to plume is : $6{,}5 \times 10^{-4}$ m Sv.

The total annual dose due to ground deposit is : $1{,}1 \times 10^{-5}$ m Sv.

11.3.3.4.6. Total annual dose resulting from gaseous releases

The dose is calculated using the following assumptions :

- normal operating conditions,

- local population area and agricultural area,
- internal irradiation by ingestion of contaminated products,
- internal irradiation by inhalation,
- external irradiation by plume and ground deposit.

On these bases, the total annual doses due to gaseous releases are summarized in Table T-11.3-11.

11.3.4. Reference

1 - Design Report
09 MDR 02
Gaseous waste treatment system

2 - Oxygen Analyzer Manual 3

1991. 7. 08

TABLE T-11.3-1

HYDROGENATED GASEOUS WASTE SUBSYSTEM DESIGN PARAMETERS

Holdup time, days	60
Nominal flowrate for two units, m3/h (STP)	2 x 38
Relative humidity	saturated
Design pressure, bar (gage)	7,0
Design temperature, °C	50
Number of decay tanks	6
Input radionuclide concentrations	(*)

(*) Reactor coolant fission gases activity :

Case A <u>Expected value</u> 0,03 Ci/t (I-131 equivalent)

Case B <u>Design value</u>
1/4 cycle at 0 Ci/t (I-131 equivalent)
1/2 cycle at 0,12 Ci/t (I-131 equivalent)
1/4 cycle at 1 Ci/t (I-131 equivalent)

TABLE T-11.3-2 (1/2)

GASEOUS WASTE SYSTEM PROCESS EQUIPMENT PARAMETERS

- Buffer tank (001 BA)	
Quantity	1
Type	horizontal, cylindrical
Capacity, m3	5
Design pressure, bar (gage)	3,5
Design temperature, °C	50
Material	stainless steel
- TEG compressor (001, 002 CO)	
Quantity	2
Type	diaphragm
Nominal flowrate, m3/h (STP)	38 per unit
Design pressure, bar (gage)	10
Service temperature, °C	50
Material	stainless and carbon steel
- Compressed gas cooler (001, 002 RF)	
Quantity	2
Type	vertical, cylindrical
Design pressure, bar (gage) (tube side)	7,0
Design pressure, bar (gage) (shell side)	8,5
Service temperature, °C (tube side)	120
Material	stainless steel
- Storage tank (002, 003, 004, 005, 006, 007 BA)	
Quantity	6
Type	vertical, cylindrical
Capacity, m3 (STP)	18
Design pressure, bar (gage)	7,0
Design temperature, °C	50
Material	carbon steel
-TEG fan (001, 002 ZV)	
Quantity	2
Type	horizontal
Design flowrate, m3/h (STP)	2 000 per unit
Design temperature, °C	-
Material	carbon steel

TABLE T-11.3-2 (2/2)

GASEOUS WASTE SYSTEM PROCESS EQUIPMENT PARAMETERS

- Iodine traps (001, 002 PI)	
Quantity	2
Design flowrate, m3/h (STP)	2 000 per unit
Design temperature, °C	50
Material	carbon steel
Efficiency : elemental iodine	99,9 %
methyle iodine	90 %
- Heaters (001, 002 RS)	
Quantity	2
Design flowrate, m3/h (STP)	2 000 per unit
Material	carbon steel
- Oxygen Analyzer (101, 102 RK)	
3 Quantity	2
Cell flow rate	0.65 SCFH
System flow rate	4.0 ± 0.2 SCFH

TABLE T-11.3-3

ANNUAL GASEOUS RELEASES OF HYDROGENATED EFFLUENTS (per Unit)

Isotope	Expected value (Ci)* Case A	Design value (Ci) Case B
Kr 85 m	7,09 E-01	7,35 E+00
Kr 85	7,46 E+00	7,88 E+01
Kr 87	1,14 E+00	1,19 E+01
Kr 88	1,76 E+00	1,85 E+01
Xe 133 m	1,17 E+00	1,11 E+01
Xe 133	7,02 E+01	7,25 E+02
Xe 135	3,35 E+00	3,45 E+01
Xe 138	3,26 E+00	3,38 E+01
I 131	8,85 E-03	9,22 E-02
I 132	3,13 E-03	3,25 E-02
I 133	3,92 E-03	4,06 E-02
I 134	2,36 E-03	6,86 E-02
I 135	2,40 E-03	2,48 E-02
Total gases	8,90 E+01	9,21 E+02
Total iodines	2,07 E-02	2,59 E-01

* 1 Ci = 3,7 E 10 Bq

TABLE T-11.3-4

ANNUAL GASEOUS RELEASES DUE TO REACTOR COOLANT LEAKS IN THE REACTOR BUILDING (per Unit)

Isotope	Expected value (Ci)* Case A	Design value (Ci) Case B
Kr 85 m	1,03 E-01	1,08 E+00
Kr 85	8,38 E-01	8,74 E+00
Kr 87	4,87 E-02	5,11 E-01
Kr 88	1,68 E-01	1,75 E+00
Xe 133 m	6,94 E-01	7,28 E+00
Xe 133	6,55 E+01	6,73 E+02
Xe 135	1,26 E+00	1,30 E+01
Xe 138	2,80 E-02	2,87 E-01
I 131	3,81 E-04	3,99 E-03
I 132	4,10 E-04	4,27 E-03
I 133	1,11 E-03	1,19 E-02
I 134	1,51 E-04	1,57 E-03
I 135	6,47 E-04	6,70 E-03
Total gases	6,87 E+01	7,07 E+02
Total iodines	2,70 E-03	2,84 E-02

* 1 Ci = 3,7 E 10 Bq

TABLE T-11.3-5

ANNUAL GASEOUS RELEASES DUE TO REACTOR COOLANT LEAKS IN THE NUCLEAR AUXILIARY BUILDING (per Unit)

Isotope	Expected value (Ci)* Case A	Design value (Ci) Case B
Kr 85 m	4,60 E+00	4,83 E+01
Kr 85	3,09 E-01	3,23 E+00
Kr 87	7,34 E+00	7,71 E+01
Kr 88	1,18 E+01	1,23 E+02
Xe 133 m	2,66 E+00	2,79 E+01
Xe 133	1,19 E+02	1,23 E+03
Xe 135	2,71 E+01	2,79 E+02
Xe 138	1,94 E+01	1,98 E+02
I 131	2,41 E-03	2,52 E-02
I 132	4,70 E-03	4,91 E-02
I 133	7,62 E-03	8,10 E-02
I 134	3,04 E-03	3,16 E-02
I 135	5,23 E-03	5,43 E-02
Total gases	1,93 E+02	1,98 E+03
Total iodines	2,30 E-02	2,41 E-01

* 1 Ci = 3,7 E 10 Bq

TABLE T-11.3-6

ANNUAL GASEOUS RELEASES DUE TO SECONDARY SYSTEM (per Unit)

Isotope	Expected value (Ci)* Case A	Design value (Ci) Case B
Kr 85 m	9,40 E-01	9,85 E+00
Kr 85	6,30 E-02	6,57 E-01
Kr 87	1,50 E+00	1,57 E+01
Kr 88	2,41 E+00	2,51 E+01
Xe 133 m	5,43 E-01	5,71 E+00
Xe 133	2,44 E+01	2,51 E+02
Xe 135	5,55 E+00	5,69 E+01
Xe 138	3,95 E+00	4,06 E+01
I 131	7,78 E-04	8,13 E-03
I 132	6,70 E-04	6,99 E-03
I 133	2,18 E-03	2,33 E-02
I 134	2,24 E-04	2,33 E-03
I 135	1,18 E-03	1,22 E-02
Total gases	3,94 E+01	4,06 E+02
Total iodines	5,04 E-03	5,30 E-02

* 1 Ci = 3,7 E 10 Bq

TABLE T-11.3-8

TOTAL ANNUAL GASEOUS RELEASES (per Unit)

Isotope	Expected value (Ci)* Case A	Design value (Ci) Case B
Kr 85 m	6,35 E+00	6,66 E+01
Kr 85	8,67 E+00	9,13 E+01
Kr 87	1,00 E+01	1,05 E+02
Kr 88	1,61 E+01	1,68 E+02
Xe 133 m	5,07 E+00	5,20 E+01
Xe 133	2,79 E+02	2,88 E+03
Xe 135	3,73 E+01	3,82 E+02
Xe 138	2,66 E+01	2,73 E+02
I 131	1,24 E-02	1,30 E-01
I 132	8,90 E-03	9,28 E-02
I 133	1,48 E-02	1,57 E-01
I 134	5,77 E-03	1,04 E-01
I 135	9,46 E-03	9,80 E-02
Total gases	3,90 E+02	4,01 E+03
Total iodines	5,14 E-02	5,81 E-01
Tritium	60	90
Aerosols	25 E-3	
Ar 41	25	

* 1 Ci = 3,7 E 10 Bq

TABLE T-11.3-9

COMPARISON OF DESIGN VALUE RELEASES WITH RELEASE AND CONCENTRATION LIMITS *

Isotope	Fraction of release limit	Fraction of ** concentration limit
Noble gases	$5{,}0 \times 10^{-2}$	$4{,}7 \times 10^{-2}$
Halogens and aerosols	$1{,}2 \times 10^{-1}$	$6{,}8 \times 10^{-1}$

(*) Taken from RCC-P Subsection 5.4.3.

(**) The concentration is calculated with pessimistic dispersion factor X/Q = $6{,}71\ 10^{-6}$ s/m3 at 1000 m to SE from the release point, i.e. the higher seasonal factor for the land and for ground release.

TABLE T-11.3-10 (1/6)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS

Maximum exposed habitat and pasture or field, and garden locations with highest effluent concentrations :

	nearest habitation	most exposed offsite land
sector	SSE	SW
distance (m)	1 000	700
X/Q (sec/m3) (ground releases)	$1,45 \times 10^{-6}$	$5,79 \times 10^{-6}$
rainy weather (proportion)	0,2	0,2
dry weather (proportion)	0,8	0,8
deposition rate (m/s) :		
rainy weather	4×10^{-2}	4×10^{-2}
dry weather	4×10^{-3}	4×10^{-3}
air-water concentration (g/m3)	8	8
Chamberlain factor	0,25	0,25

Retaining factors on vegetation : rainy weather 0,10
: dry weather 0,25

TABLE T-11.3-10 (2/6)

GASEOUS RELEASE IRRADIATION PATHWAYS

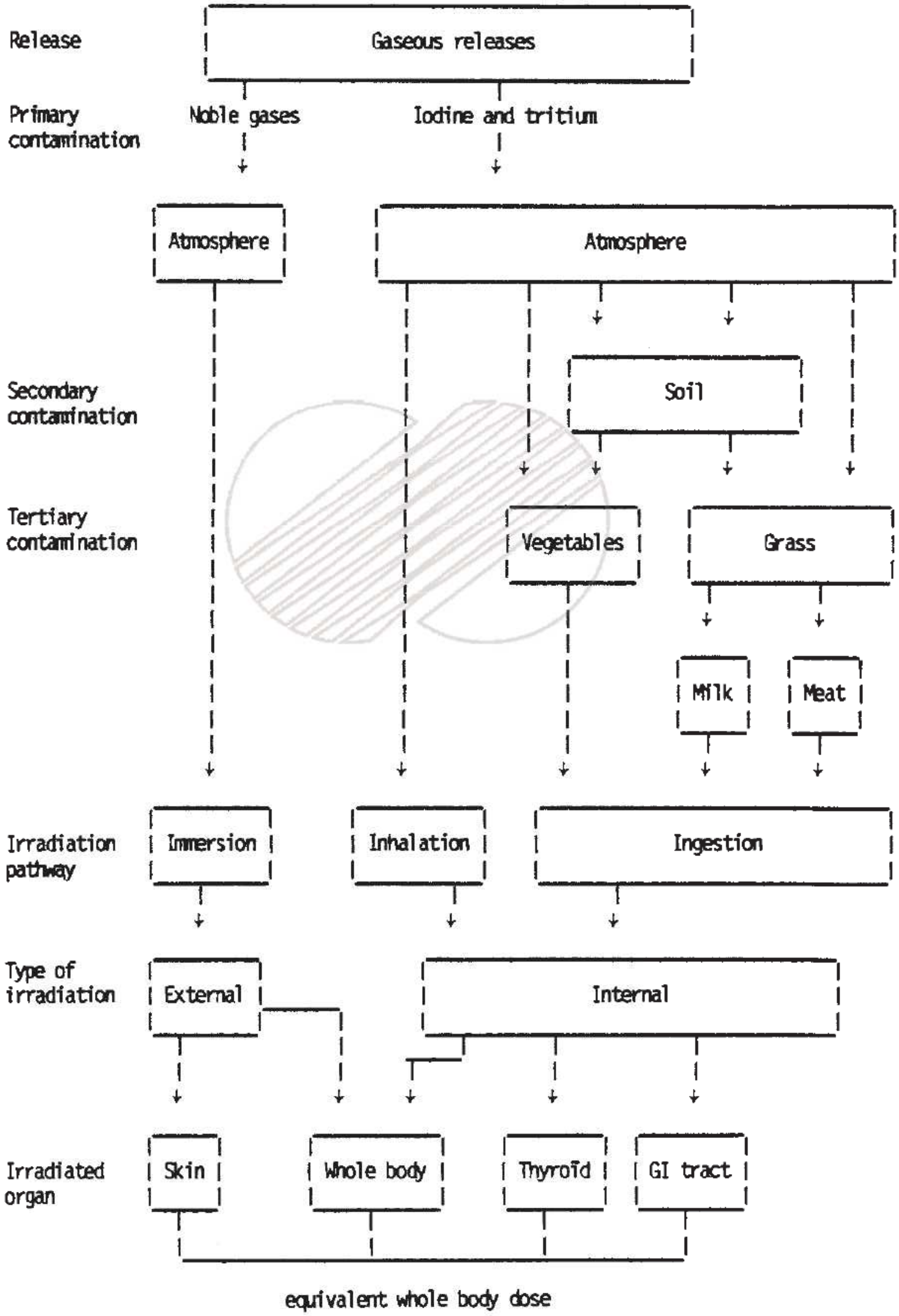


TABLE T-11.3-10 (3/6)

ASSUMPTIONS USED IN NORMAL RELEASE DOSE ANALYSIS

Adult consumption :

	Time (months)	Consumption (g/d)	Productivity (kg/m2)	Storage (months)
leafy vegetable	6	90	2,5	0
	6	90	2,5	3
fruit	5	22	3,0	0
	7	22	3,0	3
root vegetable	5	90	2,5	0
	7	90	2,5	3
grain	0	500	2,0	1
milk	0	0	-	-
meat	12	23	-	0,1

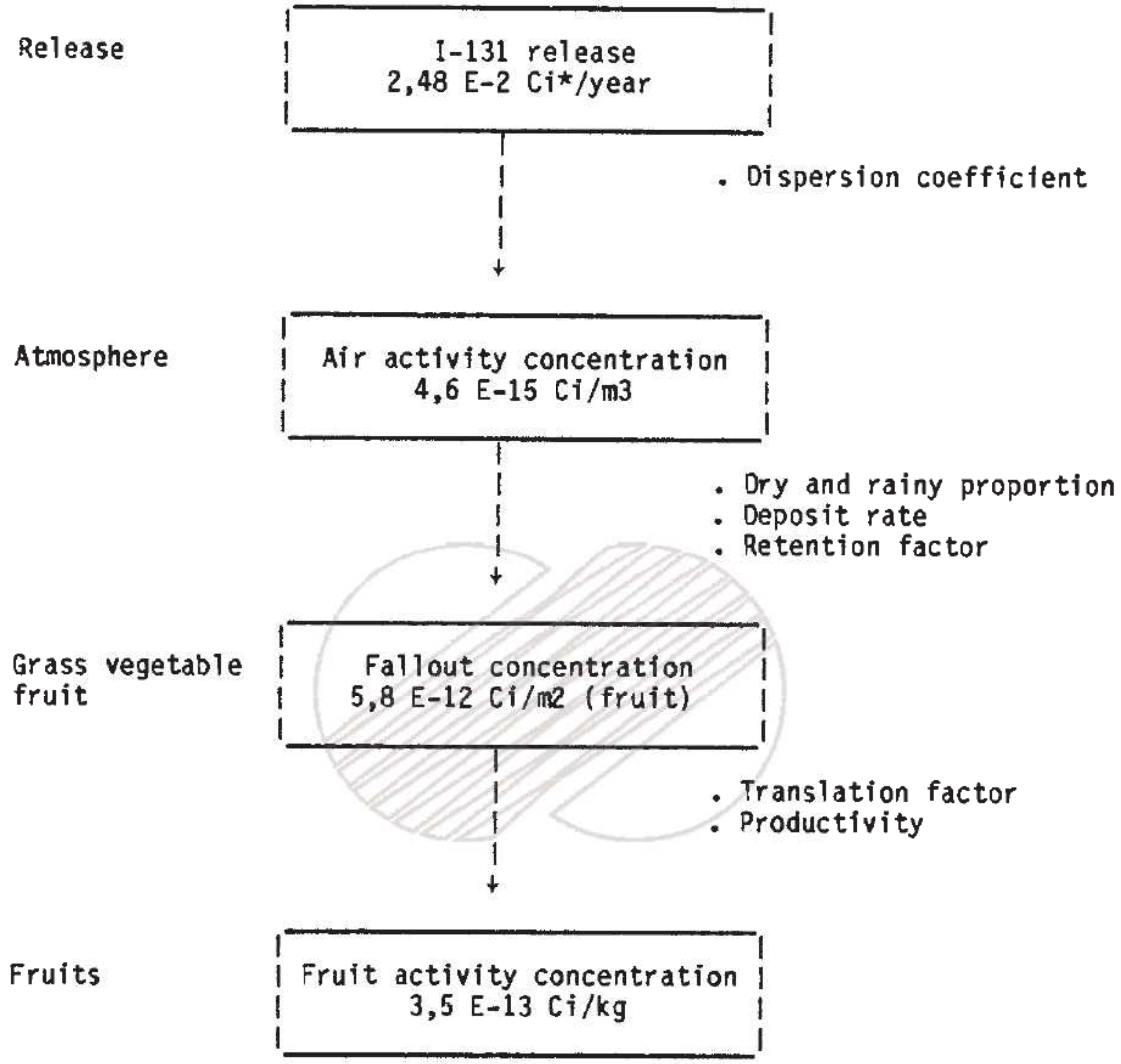
Nursing child's consumption

	Time (months)	Consumption (g/d)	Storage (months)
Milk	12	700	0

Cow feed :

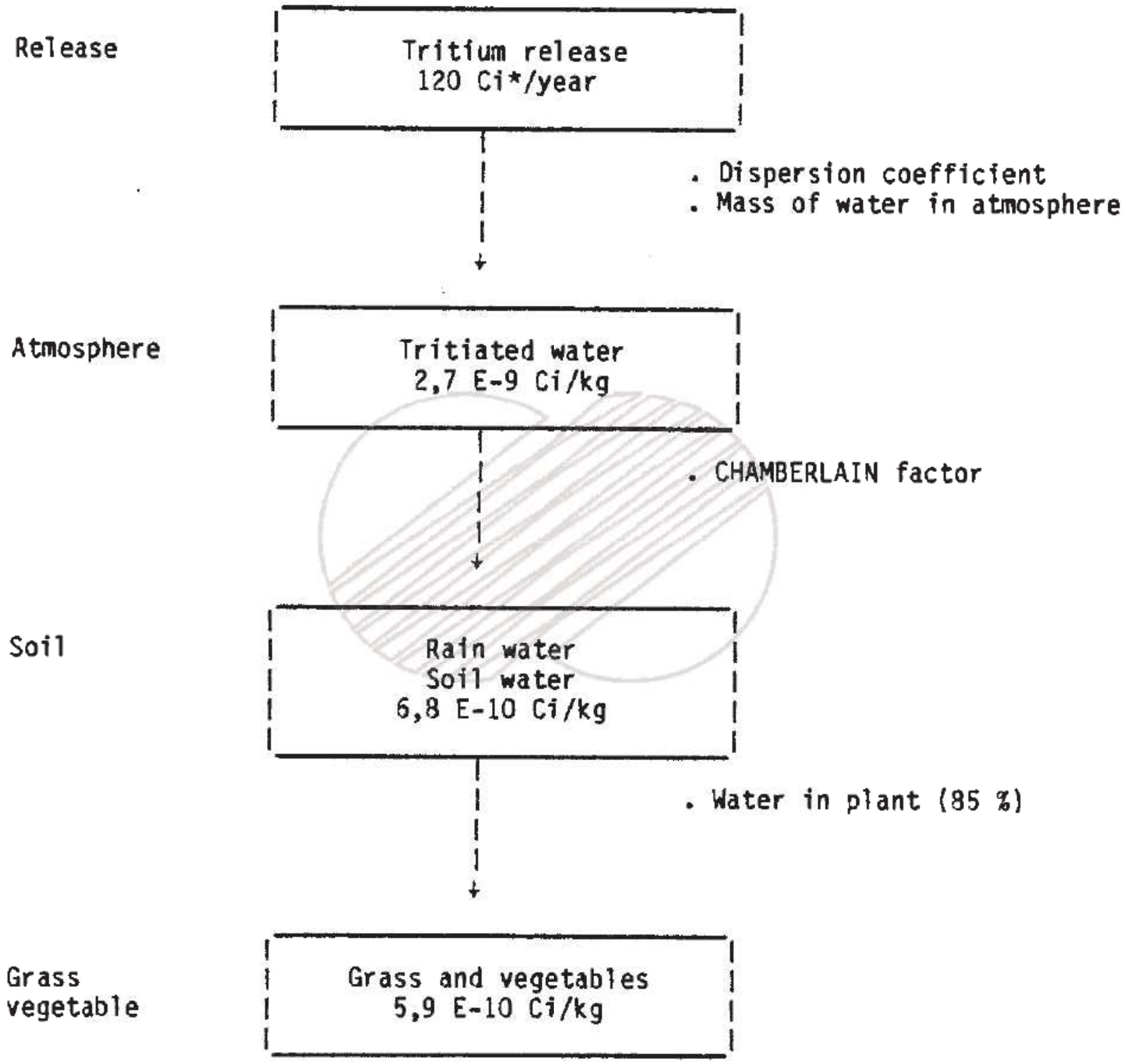
	Time (months)	Consumption (g/d)	Productivity (kg/m2)	Storage (months)
pasture feed	8	64	0,8	0
stored feed	4	20	0,3	6

TABLE T-11.3-10 (4/6)



(*) 1 Ci = 3,7 E 10 Bq.

TABLE T-11.3-10 (5/6)



(*) 1 Ci = 3,7 E 10 Bq.

TABLE T-11.3-10 (6/6)

CONVERSION FACTOR FOR INHALATION

$\frac{(Rem/s)}{(Ci/m3)}$

H 3	1,54 E-3
I 131	2,14 E+1
I 132	1,43 E-1
I 133	4,28 E 0
I 134	2,14 E-2
I 135	7,14 E-1

CONVERSION FACTOR FOR MILK INGESTION (nursing child)

$\frac{Rem}{Ci}$

H 3	6,3 E+1
I 131	1,3 E+7
I 132	1,3 E+5
I 133	3,1 E+5
I 134	2,1 E+3
I 135	6,7 E+4

TABLE T-11.3-11

RADIOLOGICAL DOSES FOR PERSONS OF CRITICAL GROUPS

1. Whole body dose (rem/year) and ratio to maximum permissible dose (MPD)*	
	Dose (rem/year)
Exposition to the plume	$6,5 \times 10^{-5}$
Exposition to ground deposit	$1,1 \times 10^{-6}$
Food ingestion	$5,2 \times 10^{-6}$
Inhalation	$1,2 \times 10^{-6}$
Total	$7,3 \times 10^{-5}$
TOTAL DOSE/MPD	$1,5 \times 10^{-4}$

* MPD = Maximum permissible whole body equivalent dose : 5 m Sv (0,5 rem)

ULCHIN NUCLEAR UNITS 1 and 2

Final Safety Analysis Report

Figure 11.3-1

TEG gaseous waste treatment system

11.4 SOLID WASTE MANAGEMENT SYSTEM

The solid waste management system(TES) is designed to provide collection, holdup storage, treatment, packaging and temporary storage prior to subsequent off site disposal of radioactive waste generated by Plant operation and maintenance. 102

11.4.1 Design bases(Ref. 1)

The TES is common to both Unit.

The design bases for the TES are the following :

a) The TES is not safety related and is classified as non nuclear safety(NC).

b) The TES handles for types of waste.
- Evaporator concentrates from liquid waste treatment system(TEU) and boron recycle system(TEP) and chemical waste from TEU and workshop drain system(SRE).
- Spent demineralizers resin.
- Spent filter cartridges.
- Miscellaneous dry waste.

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c) Solid wastes are treated according to their nature : 10

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- Packing of the spent resins is performed in a HIC after drying process by the SRDS(Spent Resin Drying System).
- Packing of the evaporator concentrates is performed in a 55-gallon drum after drying process by the CWDS. 10
- Miscellaneous dry active wastes are sorted, compacted or vitrified to reduce volume. 260
  (The vitrification process is performed in Vitrification Facility operating in the Ulchin Nuclear Power Units 5&6)
- Packing of the compressible dry active waste and low radioactive spent resin is performed in metal drums.

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d) In the Waste Auxiliary Building(WAB) there is a drum storage area(900 m^2). This design provides a storage for 140 concrete drums and 3 140 metal drums(on four layers).

e) The system is designed to process, handle, and store the waste types, and quantities described in Paragraph 11.4.1.2. below, generated as a result of Plant operation and maintenance.

f) The system design parameters are based on a radionuclide concentrations and volumes consistent with reactor operating experience for similar designs and with the source terms of Sections 11.1 and 12.2.

102 10 g) All wet solid waste types are solidified/dried or stabilized prior to shipment offsite.

h) Codes and standards applicable to the TES are specified in Section 3.2.

i) The TES is designed in accordance with the RCC-P(Subsection 2.3.7).

j) The TES is locally monitored from local control rooms associated with the equipment and shielded to prevent radiation exposure of operating personnel.

k) Atmospheric tanks are provided with adequately sized vents and overflow to prevent tank overpressure or vacuum conditions from occurring.

l) Curbs are provided around TES tanks so that in the event of tank leakage the waste will be confined to the immediate area to minimize contamination and facilitate cleanup.

m) Plastic pipes are not used for radioactive service. 245

n) Piping is designed to minimize crud pockets where radioactivity (resin, concentrate...) could accumulate; for example, the pipes routing resin from demineralizers to resin storage tanks must have an adequate bending radius to avoid clogging.

o) valves are chosen to minimize pockets where radioactivity could accumulate; for example, valves dealing with resin routing are the globe valve type.

p) Pressure retaining components of the system utilize welded construction to the maximum practicable extent. Flanged joints or suitable quick-disconnect fittings are used only where maintenance or operational requirements clearly indicate that such construction is preferable. Screwed connections in which threads provide the only seals are not used except for instrumentation connections where welded connections are not always suitable.

All welding constituting the pressure boundary of pressure retaining components (when classified RCC-M 3) will be performed in accordance with RCC-M C 3600.

- The test pressure for the process piping is held for at least 30 minutes and for such additional time as maybe necessary to conduct the examination for leakage.

- Materials for pressure retaining components are selected from those covered by the material specifications listed in Parts I and II of the second volume of the RCC-M. The components meet the requirements of the material specifications with regard to manufacture, examination, repair, testing, identification, and certification.

11.4.1.1. Design criteria for solid waste processing facilities

a) Seismic and quality group classified

The TES is mainly located in the NAB which is designed to Seismic Category I to collect and contain any leakage which may occur during a seismic event. However, the TES equipment is not seismic classified.

b) Equipment layout and shielding parameters

The equipment layout of the TES is identified in Figures F-12.3-3, F-12.3-5, F-12.3-6, F-12.3-7, and F-12.3-8. The geometry and shielding parameters of components containing radioactive materials are described in Section 12.3.2.

c) Design features for TES operation and maintenance

The radwaste building equipment layout provides design features to minimize operator exposure. Components of high radioactivity are segregated and shielded in separate compartments. Those of intermediate and low activity are grouped such that doses are minimized during operator entry for inspection or maintenance. Storage and loading of waste drums is accomplished in the shielded solid waste area. Filter cartridges are removed from the filter housing via floor hatches under the biological protection of a lead cask.

The building layout provides for remote radwaste system operation from control panels which also provide process instrumentation readout and alarms, Throughout the building, process support equipment, such as valves, are located outside process component cells in their own shielded areas. Piping runs are located in shielded piping chases.

11.4.1.2. Types of wastes to be processed by the TES

The waste types to be processed by the TES are as follows:

a) Spent resin

The sources of spent resin are the demineralizers of the following systems: RCV, TEP, APG, PTR, TEU.

The spent resin of the demineralizers is collected in the TES storage tanks by means of water flushing.

A breakdown of the volume and types of the resin produced yearly is noted in Table T-11.4-1.

Estimated overall volume and isotopic inventories of TES input streams are given in Table T-11.4-3.

b) Evaporator bottom concentrate

The concentrate will consist of an aqueous solution containing mainly sodium borates, boric acid or any combination.

The maximum concentration will be 40,000ppm. The concentrate temperature will be maintained at about 55°C to avoid risk of crystallization.

The concentrate sources are the evaporators of the TEU system and under exceptional circumstances, the TEP system.

Concentrate is collected in the TES concentrate tank.

Estimated overall volume and isotopic inventories of TES input streams are given in Table T-11.4-3.

c) Chemical waste

The chemical waste sources are the TEU and the SRE systems.

Chemical waste is collected in the TES concentrate tank (See Table T-11.4-3 for an yearly estimate of the volume).

d) Spent filter cartridges

Filter cartridges are used throughout the Plant to maintain water quality and remove radioactivated corrosion and wear products.

The systems incorporating these filters are the APG, PTR, RCV, TEP and TEU.

Spent filter cartridge are removed through the upper portion of the bunker in the NAB inside a shielded transfer cask or transported to the temporary 184
storage area in the NAB for the decay of short-lived radionuclides. If the 245
radioactivity of these cartridges is low or nil (APG for example) the cartridges are removed manually and disposed of in metallic drums. A detailed list of these filters giving a yearly estimate of their number is noted in Table T-11.4-2 and isotopic inventories is given in Table T-11.4-3.

Ventilation filters are not encapsulated in the TES system. They can be compacted if necessary, in the WAB.

e) Miscellaneous dry active waste

The dry active waste consist of low contaminated compressible wastes 10
such as rags, vinyls, paper, disposable protective shoe coverings, masks, gloves, clothings, small metal parts, incompressible small solid parts.

Table T-11.4-3 lists the expected volume of dry active waste to be 10
processed on an annual and for a two Unit Plant.

11.4.2 System description

The TES is shown in the process flow diagram Figures F-11.4-1 and F-11.4-2. The equipment parameters of major process components are listed in Table T-11.4-4.

11.4.2.1. NAB equipment

The NAB equipment performs the following functions :
- storage and treatment of waste,
- drumming of waste,
- handling cask for filter cartridges. 10
- compacting press for miscellaneous dry active waste.

a) Spent resin treatment station

Spent resin is removed from the demineralizers and stored temporarily in tanks 002 BA or 003 BA. The spent resin tanks are supplied with demineralized water from the nuclear island demineralized water distribution system (SED) and with compressed air from the service compressed air distribution system (SAT).

The tank drain is connected to HICs for drying process.

The drum fill pipe has an antisplash nozzle with drip tray.

Near tanks 002 BA and 003 BA, activity is measured by the KRT system.

b) Concentrate and chemical waste treatment station

Evaporator bottom concentrate is collected in concentrate storage tank 001 BA. Tank contents are continuously circulated by means of an agitator.

The tank drain is connected to vacuum/dryer of the CWDS via a pipe with an antisplash nozzle with drip tray.

An electrical heat tracing circuit maintains the tank, header, drain pipes, and metering pot within a set temperature range.

c) Filters

Spent filter cartridges are removed through the upper portion of filter bunkers.

Cartridges are removed under the bio logical protection of a lead handling cask. The cask is fitted with a locator assembly, sliding bottom for linkup with the spent cartridge transfer tube, and built-in hoist.

A flexible skirt protects against the spread of contamination.

Cartridges are lowered to the temporary storage area in the NAB. Cartridges are lowered into the tube by the cask hoist and transferred to drums for conditioning. The lower end of the spent cartridge transfer tube is equipped with a valve : the upper end is fitted with a locating adaptor for cask linkup.

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11.4.2.2 WAB equipment

The waste auxiliary (WAB) building is located on the site and houses the following equipment :

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- temporary drum storage,

- compacting press for spent Hvac filter waste

Miscellaneous contaminated dry waste is collected in a sorting room and compacted in metal drums.

The compactor is equipped with a dust screen, suction nozzle, and fine mesh dust filter.

The mobile supercompactor is common unit for all plants which is a single stroke compactor to deliver an adjustable compaction force of 2,000 metric tons at maximum to the dry low-level radioactive waste package of a 55 gallon drum. The supercompacted 55 gallon DAW drums are packaged in the 80 gallon overpack drum, and the gap inside the overpack drum is filled up with filter material to prevent the movement of the supercompacked 55 gallon drums.

b) Drum storage - drum characteristic

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Five types of drums are utilized for solid waste disposal, depending on the radioactivity level of the effluent. They are :

- metal drums(*) for slightly radioactive miscellaneous dry active waste, and for mixture of concentrate waste power and binding material.

- 140 ℓ, 350 ℓ, and 950 ℓ concrete drums for resin and concentrate ; thickness of drums increases with effluent radioactivity (see characteristics belows),

(*) ANS 55 - Gallon (208 liter) Full - removable - Head universal steel Drums.

	Outside diameter	Wall thickness	Inside diameter	Service capacity	Full weight
Type Ⅰ	1.40m	0.15m	1.10m	950 ℓ	5t approx.
Type Ⅱ	1.40m	0.30m	0.80m	350 ℓ	5t approx.
Type Ⅲ	1.40m	0.40m	0.60m	140 ℓ	5t approx.

For the three types of drum here above a metal liner is inserted into the drum to account for a possible expansion of the solidified concrete waste during setting time (specially for the resin) and to avoid thermal shocks on concrete drums{specially for the concentrate).

- 500 ℓ concrete drums for filter cartridge (350 t drums may be used if more biological protection is necessary).

	Outside diameter	Wall thickness	Inside diameter	Service capacity	Full weight
Type Ⅳ	1.10m	0.15m	0.80m	500 ℓ	3.5t approx.

- High Integrity Containers (HICs) for dried spent resins.

	Outside diameter	Wall thickness	Inside diameter	Service capacity	Full weight	Material
HIC	1.2m	0.018m	1.18m	1,160 ℓ	1.9t	polyethylene

102

- SRDS control panel provides a central location to start and stop the system equipment and includes indications for container level, system temperatures, valve positions, fillhead position indication and system alarms.

Table T-11.4-3 lists the expected annual drum output for two Units. Table T-11.4-5 gives detailed specifications of concrete drum manufacturing.

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c) Equipment characteristics

The characteristics of main components are listed in Table T-11.4-4.

All equipment in contact with concentrate and spent resin is of stain less steel construction.

11.4.3. System operation

a) Resin handling

Resin is flushed from demineralizers with demineralized water (SED system) and fed through headers to either one of the two spent resin storage tanks.

The water bleed valve is open while the tank is being filled.

A water blanket is re-established once filling is complete.

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The resin is removed for drying process as follows :

- after the SRDS setup, integrity of all connections to the system is verified,
- resin flushing commences,
- drain valve opens,
- waste inlet valve in the SRDS opens remotely, waste transfer is initiated,
- as waste level rises in the HIC, the dewatering pump is started,
- during filling of the HIC, waste inlet valve as required to maintain water level in the HIC below the high level is remotely controlled and, 102
- the dewatering pump is also operated to maintain water level at the level of waste in the HIC,
- when the HIC is filled to desired level with resins, the waste supply valve is remotely closed,
- the resins in the HIC are fully dewatered and dried, and then HIC is capped remotely.

The flushed water is collected and treated through the process drains of vent and drain system (RPE).

b) <u>Concentrate handling</u>

The heat tracing circuit, which maintains the concentrate within a predetermined temperature range, operates automatically. 245
The concentrate wastes are processed by the CWDS as follows :

- agitator mixes evaporator bottom in the concentrate tank, 10
- tank drain valve opens, and transfers evaporator bottoms to the vacuum/dryer in the CWDS,
- the vacuum/dryer boils down to low level,
- above procedure is repeated three(3) times,
- evaporator bottoms are dried out and become waste powder, 265
- [DELETE]
- waste powder is loaded and capped.

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c) Filter cartridge handing (NAB level 13,15 m)

The filter cell head is removed and placed on the room floor using the overhead crane. These operations are performed both manually and remotely by the operator.

The lead handling cask is attached to the crane and lined up over the filter cell.

The cask hoist lowers a gripper into the cell. The gripper latches onto and raises the cartridge or the cartridge basket into the cask.

The cask bottom slides are closed, and the cask is moved to the spent cartridge transfer tube. A vinyl bag is raised and lowered with the gripper, preventing dripping or splashing of contamination in or over the filter cell, cask, transfer tube, or floor. After being positioned in the tube by the hoist, the cartridge is lowered to the temporary storage area in the NAB.

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d) Concreting

The solidification method used cement as solidification agent during the cement solidification facility operation.

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Table T-11.4-6 gives mixing ratio for solidification.

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e) Removal

Drums, which are routed to the storage area at the waste auxiliary building, are removed to the on site temporary storage vaults. 23 The Ulchin 1 temporary storage vault accommodates 7,400 drums and 2 temporary storage vault accommodates 10,000 drums.(See Table T-11.4-8 and Figure F-11.4-4) 367

Old Steam Generator Storage Facility only stores six(6) old steam generators of Ulchin units 1&2 224

f) Sorting and compacting 245

Miscellaneous dry active wastes(DAW) are collected at appropriate locations throughout the plant, as dictated by the waste volumes generated during operation or maintenance. As necessary, these waste are taken to the DAW sorting room in the auxiliary building for sorting and packaging. The DAW can be carried outside at ground level to the DAW sorting room. When the DAW is received, it is sorted decontaminated for uncontrolled disposal, if appropriate and then the compactible waste is compressed in drums by the compacting press to reduce shipping volume.
Additional compressible material is added, and the drum contents are recompacted until a drum is filled. The drums are then sealed and moved to the waste drum storage area. During pre-compaction, the airflow in the vicinity of the compactor is directed by the compactor exhaust fan 10 through a HEPA filter before it is discharged to the building ventilation exhaust. The precompacted DAW drums are supercompacted to reduce volumes before eventual offsite disposal by a mobile super-compactor. The supercompacted drums are packaged into overpack drums for offsite disposal.
Large or highly radioactive components and equipment that have been contaminated during reactor operation and that are not amenable to compaction or decontamination by plant personnel are packaged in shipping containers of an appropriate size and design.

11.4.3.1 Radioactive Waste Assay System(RAS)

The Radioactive Waste Assay System (RAS) is used to identify and measure activity of radionuclides in radioactive drums stored in the waste drum storage area prior to shipping offsite to a licensed burial site.
Also, the Scaling Factor is applied in order to measure and identify 195 activity of radionuclides such as alpha or beta-emitter because the RAS measures only gamma- emitting nuclides. 242 The Scaling Factor for two units is presented in T-11.4-7.
The function of the RAS is to identify and measure activity, specially activity of radionuclides in waste drums generated in all Ulchin units using the NDA(Non-Destructive Assay) method.
The RAS is commonly used for all Ulchin units and installed in the Radioactive Waste Storage Building. The system is composed of the following major components :

1. Radioactive Waste Assay System 164

   a. Detector Assembly
      The Detector Assembly is used to identify and measure gamma-emitting

nuclides in radioactive drums. This assembly has scanning modes to support both Segmented Gamma Scanner (SGS) for high density drum and Tomographic Gamma Scanner (TGS) for low density drums. This assembly is composed of an HPGe detector, a detector shield & collimator, an attenuator, and a detector drive.

b. Transmission Source Assembly

For high quality analysis of radionuclides in radioactive drums, the Transmission Source Assembly is used. The Transmission Source Assembly uses a tungsten shutter and a lead storage shield. The storage shield and shutter can accommodate a source strength of up to 15 mCi Eu-152.

c. Drum Loading & Rotator Assembly

The Drum Loading & Rotator Assembly is used to move the radioactive drums to the detector and to rotate the drums. The assembly can accommodate drums of up to 1,000 kg to measure various waste drums. 164

d. Data Acquisition Hardware Assembly

The Data Acquisition Hardware Assembly consists of system operation and analysis software, a PC, and acquisition electronics. The assembly can assay the radioactive drums and create an image of the drum matrix. The assembly is installed in a shielded control room to protect the operator from the radiation.

e. Automatic Conveyor System

The Automatic Conveyor System can accommodate drums of up to 1,000 kg to handle the various waste drums. The system is integrated with the RAS and can be operated automatically to ensure proper operation of radioactive drums.

2. In-Situ Object Counting System

The In-Situ Object Counting System (ISOCS) is a portable Radioactive Waste Assay System. The ISOCS can be used to assay gamma-emitting nuclides in the special radioactive waste containers, such as High Integrated Containers (HIC), which cannot be measured by the RAS. This system is shared by all Korean nuclear power plants.

11.4.4 Radioactive spent oil and sludge solidification

The spent oil is collected from radioactive areas and the sludge is collected from radioactive sumps and tanks. These wastes are solidified by using the mobile solidification equipment which uses the solidification agent and additives to enhance the solidification.

11.4.5. Reference

System design report
09 MDR 02
Radioactive waste treatment systems.

TABLE T-11.4-1 (1/3)

ESTIMATE OF RESIN VOLUME AND RADIOACTIVITIES PER YEAR FOR TWO UNITS

Number	Type of resin	Unit volume m3	Level activity	Comments	Yearly average production m3
1 APG 01 DE	Cationic	1,5	Nil or low	Two files 50 % of normal flow (50 t/h).	6
02 DE	Cationic	1,5	Nil or low		
03 DE	Mixed bed	1,5	Nil or low	These resins last about one year if nominal feedwater used and no SG leak.	
04 DE	Mixed bed	1,5	Nil or low		
2 APG 01 DE	Cationic	1,5	Nil or low		6
02 DE	Cationic	1,5	Nil or low		
03 DE	Mixed bed	1,5	Nil or low		
04 DE	Mixed bed	1,5	Nil or low		

TABLE T-11.4-1 (2/3)

ESTIMATE OF RESIN VOLUME AND RADIOACTIVITIES PER YEAR FOR TWO UNITS

Number	Type of resin	Unit volume m3	Level activity	Comments	Yearly average production m3
1 PTR 01 DE	Mixed bed	1,5	high	Permanent run - draining preferably when there is no spent fuel in the pit. They last about one year.	3
2 PTR 01 DE	Mixed bed	1,5	high		
1 RCV 01 DE	Mixed bed	1	high	) About one demineralizer a year	1
02 DE	Mixed bed	1	high		
03 DE	Cationic	0,5	high	) About one demineralizer a year	0,5
2 RCV 01 DE	Mixed bed	1	high	) About one demineralizer a year	1
02 DE	Mixed bed	1	high		
03 DE	Cationic	0,5	high	) About one demineralizer a year	0,5

TABLE T-11.4-1 (3/3)

ESTIMATE OF RESIN VOLUME AND RADIOACTIVITIES PER YEAR FOR TWO UNITS

Number	Type of resin	Unit volume ㎥	Level activity	Comments	Yearly average production ㎥
TEP 01 DE	Cationic	1.5	medium	Two filter 01-03 and 02-04. One per Unit of 900 MW, intermittent run resin is changed each year.	3
02 DE	Cationic	1.5	medium		
03 DE	Mixed bed	1.5	low		
04 DE	Mixed bed	1.5	low		
TEP 05 DE	Anion or Mixed bed	1.5	low or high	Intermittent run (back-up RCV). These resin lasts more than two years.	4.5
06 DE	Anionic	1.5	low		
07 DE	Anion or Mixed bed	1.5	low or high	- idem 05 DE -	
TEU 03 DE	Mixed bed	1.5	low		0.5
	Total	32		Total	26

TABLE T-11 .4-2
ESTIMATE OF THE NUMBER OF FILTER CARTRIDGES USED PER YEAR FOR TWO UNITS

Filter Identification	Dose rate ≤ 200 mRem/h on outside surface	Dose rate ≥ 200 mRem/h on outside surface
1 APG 01 FI	12	
1 APG 02 FI	6	
1 APG 03 FI	1	
2 APG 01 FI	12	
2 APG 02 FI	6	
2 APG 03 FI	1	
1 PTR 01 FI		1
1 PTR 02 FI		0.5
1 PTR 05 FI		1
1 PTR 06 FI	1	
2 PTR 01 FI		1
2 PTR 02 FI		0.5
2 PTR 05 FI		1
2 PTR 06 FI	1	
9 PTR 03 FI		3
9 PTR 04 FI		3
1 RCV 01 FI		4
1 RCV 02 FI		0.5
1 RCV 03 FI		2.5
1 RCV 04 FI		2.5
1 RCV 05 FI		1
2 RCV 01 FI		4
2 RCV 02 FI		0.5
2 RCV 03 FI		2.5
2 RCV 04 FI		2.5
2 RCV 05 FI		1
9 TEP 01 FI		1
9 TEP 02 FI		1
9 TEP 03 FI		1
9 TEP 04 FI		1
9 TEP 05 FI		1
9 TEP 06 FI		1
9 TEU 01 FI	13	37
9 TEU 02 FI	46	24
9 TEU 05 FI	1	1
9 TEU 040 FF		1
9 TEU 046 FF		1
Total	100	102
	Compacted in metal drums	Encapsulated with concrete in concrete drum

TABLE T-11.4-3 (1/2)

VOLUME OF WASTE TO BE PROCESSED FOR ONE YEAR AND TWO UNITS

Estimated overall volume of TES input streams

Source	Input to TES	
	TEU Evaporator operation only	TEU SIES operation only
Filter cartridges	100 units	100 units
Spent resin	26 ㎥	40.44 ㎥
Concentrate	50 ㎥	-
Chemical easte	negligible	negligible
Compacted miscellaneous dry waste	300 ㎥	300 ㎥

184

DROMS OUTPUT FOR TWO UNITS

		Total concrete drums output (1998.08 ~ 2006.04)				Average annual drums output for one year two units	
		TYPE Ⅰ	TYPE Ⅱ	TYPE Ⅲ	TYPE Ⅳ	ANS55 gallon metal drum	HIC
Spent resin	C	413	426	-	-	-	-
	H	-	-	-			22/35*
Concentrate		789	24	-	-	50/-*	-
Filters		-	10	-	506	100	-
Miscellaneous Waste		-	-	-	-	1400(724)	-
Total		1202	460	-	506	1550/1500*	22/35*
		2168					

245 260

* Note : (TEU Evaporator operation only) / (TEU SIES operation only)
( ) : Using Vitrification facility
C : Concrete Drum only, H : HIC only 260

Spent resin or concentrate volumes in the different concrete drums and spent resin volumes in the HICs
Type Ⅰ : 342 L of concentrate or 305 L of spent resin
Type Ⅱ : 128 L of concentrate or 131 L of spent resin
Type Ⅲ : 44 L of spent resin
HIC : 1,160 L of spent resin

Estimated input and discharge volume of the radioactive spent oil and sludge

Source	Annual volume	
	Input	Output
Spent oil	0.7 ㎥	1.2 ㎥
Sludge	2.0 ㎥	3.5 ㎥

184

* Output volume bases upon 75 % increase of input volume using the solidification agent and additives.

11.4-17a

Estimated input and output volume of the flammable miscellaneous dry waste using the vitrification facility.

Source	Annual volume	
	Input	Output
Flammable miscellaneous dry waste	135.2 ㎥	4.4 ㎥

260

TABLE T-11.4-3 (2/2)

ACTIVITIES OF WASTE TO BE PROCESSED FOR ONE YEAR AND TWO UNITS

Design isotopic inventories of radwaste solidification system input streams (ci/year/2 Units)

Nuclide	Activity (Ci(*)/year/2 Units)			
	Spent resin			Evaporation concentrates TEP + TEU
	RCV	TEP	APG	
Cs 134	9000	900	Nil	100
Cs 137	8000	750	Nil	90
Co 60	2100	160	Nil	25

Design isotopic inventories of RCV filters (ci/year/2 Units)

Nuclide	Activity (Ci/year/2 Units)
Cr 51	70
Mn 54	260
Co 58	4200
Fe 59	35
Co 60	220

Remark : RCV filters are the most highly radioactive filters.
Radioactive levels in other filters are lower.

(*) 1 Ci = 3.7×10^{10} Bq

TABLE T-11.4-4 (1/4)

SOLID WASTE SYSTEM EQUIPMENT PARAMETERS

Concentrate tank 001 BA	
Quantity	1
Type	Vertical
Capacity, m^3	5
Design pressure, bar	3
Design temperature, °C	140
Material	316 L stainless steel
Spent resin tanks 002 BA and 003 BA	
Quantity	2
Type	Vertical
Capacity, m^3	9
Design pressure, bar	1,2
Design temperature, °C	50
Material	316 L stainless steel
Resin ejector 001, 002 EJ	
Motive fluid, pressure, bar	SED, water, 4
Motive fluid, flow, m^3/h	SED, water, 7,5
Sucked fluid, flow, m^3/h	SED, water + resins, 2,5

TABLE T-11.4-4 (2/4)

SOLID WASTE SYSTEM EQUIPMENT PARAMETERS

Concentrate stirrer 001 AG	
Motor power, kW	2.2
Rotating stirrer speed, rpm	140
DELETE	DELETE
Compacting press 001 PQ	
Capacity, ton	30
Operating power, kW	7.3
Lead cask 001 DM	
Lead thickness, m	0.1
DELETE	DELETE
Compaciting press 002 PQ	
Capacity, ton	28(V), 20(H)
Operating power, kW	7.5

164

TABLE T-11.4-4 (3/4)
SOLID WASTE SYSTEM EQUIPMENT PARAMETERS

DELETE	DELETE	154
<u>Waste Shredder</u>		
Quantity	1	
Type	Electric Cutter	
Motor, hp	10	10
DELETE	DELETE	154
<u>Mobile Supercompactor</u>		
Quantity	1 (a common unit for all plants)	
Type	Hydraulic	
Compaction pressure, psi	3,626 (2,000)	
Disposable container	55-gallon drum	
Hydraulic pump motor, hp	84.4	
Material	carbon steel	
<u>SRDS Dewatering Fillhead</u>		
Quantity	1	
Type	Stainless steel	
<u>SRDS Piping Skid</u>		
Quantity	1	
Capacity		
<u>- Entrainment separator</u>	$15 ft^3$	102
- Dewatering pump	20 - 35 gpm	
- Material	Stainless steel	
<u>SRDS Blower Skid</u>		
Quantity	1	
Blower Capacity	317 CFM	
Material	Stainless steel	

Table T-11.4-4 (4/4)

SOLID WASTE SYSTEM EQUIPMENT PARAMETERS

Radioactive Waste Assay System	
Quantity	1
Type	HPGe detector
Measurement Range (keV)	3 ~ 3,000
Assay Mode	TGS and SGS
Max. Measurable Drum Size	85 gallon drum
Max. Drum Load (kg)	1,000
Automatic Conveyor System	
Quantity	1
Type	Roller Conveyor
Conveying Speed (m/min)	3.05
Max. Conveying Drum Size	85 gallon drum
Max. Drum Load (kg)	1,000
Conveyor Roller Material	Stainless Steel
Motor (hp)	1
In-Situ Object Counting System	
Quantity	1
Type	HPGe detector
Measurement Range (keV)	3 ~ 3,000
Mobile Radioactive Spent Oil and Sludge Solidification System	
Quantity	1
Capacity	200~300 ℓ / Batch
Material	Stainless Steel
Packing Container	55 gallon drum

TABLE T-11.4-5

REQUIREMENTS FOR CONCRETE DRUMS MANUFACTURING

The materials used for the manufacturing of concrete drums are as follows :

- concrete constituents (cement, aggregates, water, admixtures),

- metal parts (handling belts, reinforcements).

The concrete mix (French practice), to manufacture the drum is designed to meet the following requirements :

- minimum cement	≥ 370 kg/m^3
- density	≥ 2,3
- nominal compressive strength at 28 days	≥ 500 bar
- nominal tensile strength at 28 days	≥ 45 bar
- slump test	≥ 4 cm
- shrinkage	≤ 600 micron/m
- nitrogen tightness	≤ 5×10^{-18} m^2

TABLE T-11.4-6 (1/2)

APPROPRIATE MIXING PROPORTION Of INGREDIENTS AND WASTE FOR A GOOD SOLIDIFICATION

Concentrate

Drum	Metering-pot number	Concentrate volume (liter)	cement weight kg	sand weight kg	Lime weight kg
Type I	8	342	790	270	53
Type II	3	128	296	101	20

Cement : Type V
Lime : hydrated lime (92 % Ca $(OH)_2$)
Chemical analysis : boron concentration 40 000 ppm

$$K = \frac{[Na]}{[B]} = 0,23$$

Resin

Drum	Metering-pot number	Wet resin volume (liter)	Cover water* volume (liter)	cement weight kg	sand weight kg	Lime weight kg
C I	7	305	31	546	512	14
C II	3	131	13	240	230	6
C III	1	44	4	80	77	2

* Water trapped between the strainer and the metering tank wall

Cement : Type V

Lime : hydrated lime (92 % Ca $(OH)_2$)

TABLE T-11.4-6 (2/2)

APPROPRIATE MIXING PROPORTION OF INGREDIENTS AND WASTE FOR A GOOD SOLIDIFICATION

Filters : 1 cartridge in drum C IV

Proportions per one filter drum

Cement Type V	: 200 Kg
Sand	: 400 kg
Gravel	: 400 kg
Water	: 95 ℓ

Final sealing

The same proportions as for filter encapsulation are used (to improve workability of the fresh concrete, a plasticizer may be used).

TABLE T-11.4-7

Scaling Factor for two units

Types of Wastes	DTM Nuclides	Key Nuclides	Geometric Mean	Linear Regression	
			SF	c	d
Miscellaneous Dry Active Waste	H-3	Co-60	2.01 E +00		
	C-14	Co-60	1.06 E -02		
	Fe-55	Co-60	4.39 E +00		
	Ni-59	Co-60	2.49 E -02		
	Ni-63	Co-60	9.05 E -01		
	Nb-94	Co-60	1.59 E -03		
	Sr-90	Cs-137	1.61 E -02		
	Tc-99	Cs-137	3.40 E -02		
	I-129	Cs-137	3.90 E -04		
	Gross α	Co-60	1.70 E -03		

○ **Geometric Mean**

: $A_{DTM\_N} = SF \times A_{KEY\_N}$

○ **Linear Regression**

: $\log(A_{DTM\_N}) = \log(c) + d \times \log(A_{KEY\_N})$

[Terms Definition]

A : Activity per unit mass of wastes(Bq/g)

DTM : Difficult To Measure

KEY : The index of DTM

SF, c, d : The constants applied to two units

TABLE T-11.4-8

Design characteristics of radioactive waste temporary storage vault

General characteristic	
Classification	
Safety class	Non-Safety
Electrical class	Non-Class 1E
Seismic category	III
Quality class	S
Range of uses	Ulchin units 1,2,3,4,5,6
Storage of capacity (Standard : 200L drum)	1 temporary storage vault 7,400 drums 2 temporary storage vault 10,000 drums
Storage objects	Miscellaneous dry active waste, Spent resin, Spent filter cartridge, Evaporator bottom concentrate etc
Basic composition	
Structure	Reinforced-concrete structure of radiation shielding function Boundary fence and entrance separated from power plant
Wall thickness/Height	1 temporary storage vault 40cm/6.6m 2 temporary storage vault 50cm,70cm,90cm /9.3m,15.8m
System	Radioactive waste assay system, HVAC system, Fire protection system, Radiation monitoring system etc

367

FIGURE 11.4-1 ~ 11.4-3

SAP 참조

ULCHIN NUCLEAR UNIT 1 and 2

Final Safety Analysis Report

FIGURE 11.4-4(1/2)
Floor plan of radioactive waste 1 temporary storage vault

ULCHIN NUCLEAR UNIT 1 and 2

Final Safety Analysis Report

FIGURE 11.4-4(2/2)

Floor plan of radioactive waste 2 temporary storage vault

218

No. Page

TABLES

11.5. PROCESS AND EFFLUENT RADIOLOGICAL MONITORING AND SAMPLING SUBSYSTEM

The process and effluent radiological monitoring subsystem monitors activity levels in selected process systems and Plant effluents. The system initiates Plant actions when limits are exceeded. The sampling system ensures that representative samples are drawn for monitoring and for laboratory analyses. The systems are used to determine system/component performance and the quantity of activity released in effluents.

The process sampling system is described further in Subsection 9.3.2. The process and effluent radiological monitoring subsystem is part of the radiation monitoring system (KRT). A complementary description of the KRT system is given in Section 12.3, area radiation monitoring subsystem.

11.5.1. Design basis

The principal design objectives of the process and effluent radiological monitoring and sampling subsystem are to :

- prevent excessive irradiation of the public,

- indirectly prevent exposure of station personnel and of the public by monitoring the integrity of protective barriers and ascertaining that Unit design provisions and operating instructions are respected.

The design basis are the following :

- continuously monitor all major and potentially significant paths for release of radioactive materials during normal reactor operation, including anticipated operational occurrences, in order to determine if releases to unrestricted areas exceed permissible limits. This monitoring is required by French Decree No. 66-450 of June 20, 1966 ; and the corresponding Implementing Orders of August 10, 1976, and of Article 13, Section 18 of the Decree of February 5, 1980 authorizing the construction of the Reference Plant,

- provide information on containment atmosphere activity to detect leaks from reactor coolant boundary,

- provide information on the activity of fluid circuits connected to the reactor coolant boundary in order to detect leaks,

- provide signals to selected systems to initiate automatic system action to terminate discharging of effluents and to initiate emergency ventilation systems, as appropriate, upon detection of high activity,

- provide sufficient information to Plant personnel to assess functional performance of selected systems and components,

- provide the capability of sampling for laboratory analysis of gases, aerosols, particulates and tritium to ensure that effluent releases do not result in exceeding the Plant offsite dose objectives,

- comply with Article 31 of Decree No. 75-306 of April 28, 1975, that requires the monitoring system continue to function efficiently in the event of a loss of electrical power,

- warn of abnormal conditions in the Plant,

- provide monitoring assuring that solidified radwaste drums meet the requirements of shipping and storage,

- monitoring channels used to provide information on containment atmosphere activity are qualified to withstand corresponding environmental conditions and seismic loads,

- monitoring channels used to provide information to the post-accident monitoring system PAMS complies with PAMS safety requirements (refer to Section 7.5), i.e. :

  . application of single failure criterion,

  . physical and electrical reparation (electrical power supplied from reactor protection system power supplies),

  . signal protection,

  . qualification to environment and seismic conditions,

  . tests.

- The process and effluent radiological monitoring and sampling subsystems comply with the following requirements (NUREG 578) :

  . Noble gas effluent monitors have an extended range to function during accident conditions, as well as during normal operating conditions,

  . iodine effluent continuous sampling is tailored to cope with accident conditions,

  . sample nozzle entry velocity of particulate and iodine sampling system is approximately isokinetic,

  . in containment radiation level monitors have a maximum range of 10^5 Gy/h (10^7rad/h) ; there are two monitors in each contaiment (PAMS channels).

11.5.1.1. Design criteria for radiological monitoring of effluents

To ensure compliance with Regulation in force, normal and potential paths for release of radioactive materials, during normal operation and during anticipated operational occurrences, are continuously monitored. Furthermore, potential paths for releases of radioactive materials during accident conditions are also continuously monitored.

During normal operation, as well as during accident conditions, all gaseous effluents are released to the environment through the stack (except secondary steam safety valve and dump valve discharge lines which discharge directly to the outside).

Monitoring of stack air activity allows monitoring of all gaseous releases.

All potentially radioactive liquids are collected and released to the environment through two pathways, both are monitored.

11.5.2. System description

Process and effluent radiological monitoring subsystems consist of multiple channels that continuously monitor radioactivity levels in various Plant operating systems and effluent streams.

The output from each channel detector is transmitted to the respective ratemeter of the radiation monitoring system cabinets located in the electrical building. Alarms and main parameters are transmitted to the control room and recorded.

The ratemeter has three level trip alarm functions. One level alarm trip is set to alarm for detector signal failure and power failure or circuit failure. The two other alarm trips are set to alert that a specified radioactivity level has been exceeded. The alarm trips initiate the alarm lights on the front panel of the ratemeter and the alarm lights on the KRT panel in the control room. The alarm trip of the radwaste discharge header monitors terminates the discharge upon monitoring a high preset radioactive level. Strip-chart recorders are provided in the control room.

The function of the radioactivity monitoring channels in the systems with which they are associated is given in Paragraphs 11.5.3.1 and 11.5.3.2. A tabulation of the process and effluent radioactivity monitoring channels and of the various samplers is contained in Table T-11.5-1 for liquids and in Table T-11.5-2 for gases. Some of the tabulated monitors are used for in-Plant airborne radioactivity monitors as discussed in Subsection 12.3.4.

Selection of measurement locations and equipment specifications takes facility features into account, however physical measurement condition impose certain practical limitations. 320

The minimum sensitivities, equipment ranges, and alarm setpoints will bases on :

- site boundary concentration limits and atmospheric dilution factors for continuous and intermittent gaseous releases,

- applicable regulation enforce,

- the isotopes present at the detector and their comparative abundances, detectabilities, and half-lives,

- expected process concentrations during normal operation plus anticipated operational occurrences,

- expected activity concentrations in monitored streams for postulated incidents.

Equipment setpoints are provided in Table T-11.5-2.

The airborne radioactivity monitoring system obtains representative samples of airborne concentration by :

- sampling isokinetically the stack which is the pathway for gaseous radwastes and the exhaust for all ventilation,

- sampling at a constant flow from the condenser evacuation system exhaust and from the containment atmosphere.

Monitoring channels used to provide information to the Post Accidental Monitoring Systems (PAMS) are similar to non-PAMS channels. nevertheless PAMS channels are classified safety 1E and seismic 1 and they comply with single failure criterion. Furthermore they are physically and electrically separated and protected, and they are qualified.

The following channels are included in PAMS :

- steam generator blowdown water activity measurement,

- stack discharge air noble gases activity measurement (low and high activity channels),

- post accident containment atmosphere activity measurement.

Good operation of monitors is continuously checked by measuring background dose rate created by an internal source or periodically checked by measuring external source (see Subparagraph 11.5.2.1.2.).

11.5.2.1. Components

Monitoring channels include various components. Descriptions of these components are given below.

11.5.2.1.1. Detector

Liquid process and effluent monitor channels which measure low activity liquids use gamma scintillation detectors. Condenser off-gas monitor channels use beta scintillation detectors. Aerosol and particulate monitor channels use beta Geiger-Mueller tubes. Gas monitor channels use beta differential ionization chambers. High activity gas monitoring channel uses beta ionization chamber. High activity liquid monitor channels use gamma ionization chambers.

11.5.2.1.2. Complementary devices

- Lead casing makes it possible to reduce background radiation. Depending on the type of channel, this shielding is integral with the detector or the detection subsystem.

- In most cases the detector is connected to a monitoring device making it possible to place an incorporated radioactive source in front of the detector. Channel monitoring control is carried out by remote control from the KRT centralized cabinets.

11.5.2.1.3. Measurement boxes

These boxes installed near detectors are tailored to the type of detector.

- Measurement boxes for photomultiplier detectors have the following functions :

  . convert charged impulses coming from photo-scintillation detectors into voltage pulses which transmit the signal to the processing module (INR),

  . to supply the detector with high voltage.

  This device is connected to a scintillator NaI TL gamma probe or to a plastic scintillator beta probe provided a few modifications be made to the preamplifier and amplifier.

- Measurement boxes for Geiger-Mueller counters have the following functions :

  . to ensure the amplification, editing, and transmission of physical pulses coming from Geiger-Mueller counters to the INR,

  . to supply the detector with high voltage.

- Measurement boxes for ionization chambers have the following functions :

  . to convert very weak electrical charges coming from an ionisation chamber into voltage pulses to be sent to the INR,

  . to supply the detector with high voltage.

11.5.2.1.4. Terminal boxes

These boxes installed locally near the measurement boxes ensure :

- decoupling of the 220 V supply, sent from the processing module by means of a transformer,

- collecting of data coming from the source monitoring measurement box, the source monitor, and the electrotechnical box.

11.5.2.1.5. Electrotechnical boxes

Each measurement channel equipped with a circulation subsystem has a local electrotechnical box. Power for electrotechnical boxes in the Plant are supplied from actuator boxes, or from actuators located in the centralized cabinets (for PAMS channels).

- Actuator box

  These boxes receive three-phase 480 V AC emergency backed electrical power and distribute it to local boxes through fuse-disconnectors.

  A main selector switch on one of the interunit actuator boxes makes it possible to change over manually from emergency power supply of one Unit to a supply from the other Unit.

- Local electrotechnical box

  These boxes are devices to control and monitor circulation subsystems and are comprised of :

. an isolating switch for 480 V incoming current,(220 V for PAMS circulation subsystems),
. a contactor equipped with a thermal relay,
. on-off push buttons,
. a time meter,
. an inside adjustable 48 V DC, making it possible to transmit data of defect, pressure flow etc., to the centralized module,
. a data inhibition push button.

11.5.2.1.6. Processing module INR

This device is installed in a central cabinet and makes it possible to start up the electronic channel to measure the frequency of the signal provided by a detector and to produce numerical, on-off, and analog data.

It is connected to two types of detectors through a measurement box providing variable frequency electrical pulses :

- a pulse counter of the Geiger-Muller or photomultiplier type,

- a current detector of the ionization chamber type.

The front side of the module consists of monitor devices making it possible to display measurement channel operation :

- on-off switch,

- digital measurement display (W, XY x 10^{Z}),

- unit indicator light (mHz, nGy/h, mGy/h, Bq/m3, MBq/m3, MPL (maximum permissible limite)),

- preselecting switches for the two alarm thresholds,

- voltage indicator light,

- malfunction indicator light,

- threshold overstep indicator lights,

- failure flow indicator light,

- channel monitoring indicator light.

The following data is provided on the rear panel :

- on/off type threshold overstep indication,

- on/off type incorrect operation indication,

- analog type measurement indication for the computer and recorder,

- digital type indication for a local counter if required.

11.5.2.1.7. Centralization cabinets

INR measurement channel processing modules are installed in five seismically qualified cabinets according to whether the channel belongs to a Unit cabinets 001 and 002 AR or is an interunit channel cabinet 501 AR (the site measurement is considered as an interunit measurement) or is a PAMS - cabinet 001 AR (train A) and 004 AR (train B).

These cabinets may content 20 processing modules, they are installed in the electronic room at level +15,50 m. Interunit channel cabinet can be found on odd unit only.

Each non PAMS cabinet has a 220 V AC seismically qualified emergency supply (LNE and LNF) and a 48 V DC continuous supply. PAMS cabinets are supplied by reactor protection systems (220 AC) power supplies (LNA and LND) and generate internally their 48 DC supply. 320

Internal terminal rows located on the back panel make it possible to ensure :

- the distribution of 220 V AC and 48 V DC supplies,

- the transmission of on/off type indications,

- the transmission of analog indications ; PAMS and non PAMS indications are separated owing to isolation modules located inside the PAMS cabinets.

2 keyboards on the cabinet front panel allow to test measurement channels and to inhibit signals emitted by the channels. 320

A transparent lockable door makes it possible to have an overall view of all the data displayed on the front panel of each module.

11.5.2.2. Component design basis

Components of the process and effluent radiological monitoring subsystems are designed to meet the following conditions:

- an ambient temperature range of 5 to 50 ℃ for all monitors,

- relative humidity 0 to 100 %,

- process and effluent radiation monitors are of a non-saturating design so that they register full scale if exposed to radiation levels above full scale indication,

- radiation sampling and monitoring equipment is designed and located so that radiation exposure of electric insulation and other materials does not affect their usefulness over the life of the Plant,

- each radiation monitoring channel is designed so that it can be tested and can be recalibrated at periodic intervals,

- access to the radiation monitoring systems alarm setpoints is under administrative control,

- all alarms from process and effluent radiation monitors are annunciated in the control room ; some process and all effluent radiation monitors are recorded in the control room, additionally, effluents related monitors have local readout (the liquid waste discharge system, sampling room). All process and effluent radiation monitors have readout in the centralization cabinets.

- process and airborne effluent monitors continuously survey radioactivity radiation levels. Airborne effluent samplers continuously draw representative samples for laboratory analysis,

- liquid effluent monitors survey low activity waste discharge work continuously ; the monitor surveys tank batch discharge when liquid is discharged,

- process and effluent monitors and samplers provide instrument failure annunciation in the control room, and the shared rooms where applicable,

- lead shielding is provided as necessary to reduce the effect of background radiation so that it does not interfere with detector sensitivity,

- monitors giving a high radiation level signal used as an alarm signal or to operate automatic actions are fail-safe,

- gaseous airborne monitoring equipment is qualified Seismic I,

- off line liquid monitoring equipment is qualified Seismic I,

- monitors giving PAMS information are designed to meet PAMS requirements.

11.5.2.3. Off-line liquid monitoring equipment

Off-line liquid monitors are listed in Table T-11.5-1.

These monitors are of the sampling chamber type. They are provided with the following components, and they operate as follows :

'93. 5.08.

- the water flows into a waterproof container which houses the detector (gamma scintillation detector) enclosed in a metallic sleeve in the upper part of the container,

- the container-detector set is enclosed in a lead cask on which the box containing the channel monitoring mechanism is fixed,

- connections to sampling systems are made via piping located on the lower part of the container,

- connections to restoration systems are made in the upper part of the container,

- the above mentioned equipment rests on a metal bracket fixed to the floor,

- shutdown valves of external systems are installed close to the equipment and a flow controller is placed on the restoration system,

- one or two optional subsystems can be adjoined to the above mentioned equipment according to the nature of the systems,

  . circulation subsystem

  When the flow is insufficient, a motor pump is connected to the above unit. This equipment is installed on a metallic frame near the sampling container.

  • decontamination subsystem

46 This makes it possible to rinse the sampling container manually with a raw water (SEB)

  In this case a single console fixed to the floor houses :

  waterproof container and lead cask,
  circulation motor pump,
  flow meter,

46

  the various electrical boxes.

11.5.2.4. On-line high activity liquid monitoring equipment

This kind of monitor measures activity contained in a tank or a pipe by measuring radiations emitted outside the tank or the pipe.

- Detection outside tanks and small pipes

  The detector (ionization chamber) is placed in a metallic sleeve embedded in the protecting wall, opposite the tank to be monitored.

On the tank side, the sleeve either penetrates the wall completely or is blocked off (filled by concrete to a variable thickness) according to the degree of activity of the equipment to be monitored.

On the opposite side, the sleeve is blocked off by a lead plug.

The measurement boxes used are tailored to the activity to be measured (high or very high activity).

- Detection outside a pipe

The detector is contained in a cylindrical lead casing. It is placed opposite the pipe to be monitored on a metallic console fixed on the wall.

11.5.2.5. Monitoring equipment for gas with high humidity

The gas passes through a filter before circulating in a measurement chamber opposite which there is a detector (beta scintillation detector) protected by a metallic sleeve.

A frame supports the above mentioned equipment, as well as the related boxes including the channel source test and a differential pressure controller.

A vacuum motor pump installed nearby on a frame collects the gas at the outlet of the measurement chamber and discharges it directly to the stack.

11.5.2.6. Off-line airborne monitoring equipment

Off-line airborne monitoring equipment is either of a fixed device type or a mobile service type.

a) Fixed device type equipment

This equipment operates as follows :

The same sample supplies both the aerosol and iodine channel and the gas channels which are in series. A pump installed on the discharge side of the last channel is common to the various systems. By means of bypass circuits, each system can be taken out of service without disturbing the others.

A compressed air inlet, in front of the channel, makes counter flushing of the sampling system possible.

The design of the stack air sampling system provides for sample nozzle entry velocity which is isokinetic with the instack air velocity (± 20 %, according to the ventilation system configurations). It also provides minimum plateout inside piping ; stainless steel pipes with special connections, steady flowrate and temperature.

- Aerosol and iodine channel

  The sampled air enters a container containing filters. On the first filter (paper filter) aerosols form a deposit. The second filter is an active carbon filter to trap iodine.

  The detector (a beta Geiger-Mueller tube) is placed above the filters.

  The container is protected against the spurious effects of ambient radiation by a lead cask. After an accident with large releases this cask protects Plant personnel from the activity trapped on filters.

  A volumetric recorder records the volume of air at the filter outlets.

  A two-threshold pressure controller is placed upstream and downstream of the filters.

  The whole channel is isolated by two valves.

  The aerosol filter and iodine trap may be taken to the laboratory for analysis.

- Gas channels

  · Low activity gas channel

    The main branch consists of a filter followed by a differential ionisation chamber. The whole channel is monitored by a two-threshold pressure controller placed upstream and downstream.

    A steam trap (scrubber) for super heavy water, fitted with two isolating valves is installed in parallel on this branch. The gas flow crossing through the steam trap may be regulated and measured. The whole channel is isolated by two valves.

    Open aeration is provided upstream of the channel and sampling by bottle is possible.

  · High activity gas channel

    This gas channel may be fitted in series with the on mentioned above. 320

The high activity gas channel consists of a detector (an ionization chamber) located in a lead cask.

b) Mobile device type equipment

Portable type airborne monitoring equipment is adapted for detection of radioactive gas leakage from the ventilation ducts of the nuclear auxiliary building (NAB). This equipment does not give centralized information.

There are two different units, differing in dimensions and in weight :

- Aerosol detection

  This equipment is a sampling device, measurement of aerosol activity is conducted in the laboratory, nevertheless it is assimilated by the radiation monitoring device.

  The air sample from the ventilation ducts is sucked through a filter and an iodine trap by a vacuum pump and is restored to the system after having passed through a volumetric recorder.

- Gas detection

  The air sampled in ducts passed through a fixed filter then a differential ionisation chamber. Measurement value is displayed locally. 320

11.5.3. Continuous monitoring

Normal and potential paths by which liquid or gaseous radioactivity may leave the Plant and selected Plant process systems are sampled and/or monitored continuously. The location, basis of location, type of sampler, type of radiation, type of detector, detector sensitivity. detector range, are given in Tables T-11.5-1 and T-11.5-2. The expected isotopic concentration is either within or below the detector range.

11.5.3.1. Liquid process and effluent radiological monitors

a) The following liquid process and effluents radiation monitors perform no safety functions. They are not seismically qualified. 320

   - Reactor coolant activity measurement

     The continuous monitoring of reactor coolant activity is performed by measurement of dose rate outside of the letdown line of the chemical and volume control system (RCV).

     The channel is an on-line high activity liquid monitoring equipment (see Paragraph 11.5.2.4.).

The purpose of this channel is to give information on the level of contamination of the reactor coolant system and associated auxiliary systems. Any significant variation in dose rate will lead to sampling for laboratory analysis to ascertain the cause of the variation and determine the necessary actions to be taken.

The information is recorded in the control room and also transmitted to the nuclear sampling system (REN) room to warn personnel about activity variations.

- Post accident reactor coolant activity measurement (REN). This channel continuously monitors samples of the reactor coolant during normal operation and in case of an accident which results in fuel clad defects. Sampling is interrupted by the containment isolation signal (second step), but its operation may be renewed just after the accident.

  Furthermore this channel may monitor the reactor containment sump water after an accident when the safety feature systems are operating.

  This channel gives information which is recorded in the control room, and a high activity alarm which automatically terminates the reactor coolant sampling.

  The monitor is an on-line high activity liquid monitoring equipment (very high activity type) (see Paragraph 11.5.2.4.).

- Auxiliary steam condensate activity measurement (SVA)

  This channel monitors gamma activity in the auxiliary steam condensate after it has passed through different nuclear island heat exchangers.

  The monitor is an off-line liquid monitor (see Paragraph 11.5.2.3.), and it is common to both Units.

  Activity in the liquid would indicate a leak in equipment served by the process steam.

- Batch discharged liquid effluent activity measurement

  This monitor is located in the discharge header downstream of the effluent tanks of the liquid waste discharge system (TER), prior to dilution in the station discharge.

  The function of the monitor is to give a confirmation of the accuracy of the laboratory measurements performed on effluent samples before discharging or that the tank on which the measurement was performed has been drained.

  The monitor provides a high activity alarm which automatically terminates the discharge.

The alarm threshold must be adjusted at each release, to take into account the activity which the operator intends to release. Sample measurements enable the rate of release to be determined In relation to the station discharge channel dilution capability.

The monitor is an off-line liquid monitor (see paragraph 11.5.2.3.) fitted with an automatic decontamination subsystem and a circulation subsystem.

- low activity liquid effluent discharge measurement

Two paralleled monitors are located in tile discharge header which conveys the low activity waste from the turbine hall. The purpose discharge for counting and to automatically terminate the discharge in case of high activity level. Monitors are paralleled for availability.

The monitors are off-line liquid monitors (see paragraph 11.5.2.3.) fitted with a circulation subsystem and a local measurement display.

- Condensate demineralizer regeneration waste water activity measurement

This monitor is located in the collection tank(ATE 008BA) in order to monitor gamma activity In the waste water. 339

The monitor provides a high activity alarm which is interlocked with the discharge operation.

- Waste water treatment system inlet activity measurement

This monitor is installed at the discharge of the chemical waste water pumps (SEU 104A/B PO) in order to monitor gamma activity.

The monitor provides a high radiation level signal that is interlocked with chemical waste water pumps.

b) The component cooling water activity measurement do not perform safety functions but the sampling chambers which are a part of these channels are pressure-retaining components for the RRI water, consequently these components are classified RCC-P3 and Seismic 1I.

The component cooling water monitoring subsystem consists of two channels (one channel per train), which continuously measure gamma activity in the component cooling water lines.

Normally there should be no activity in this system. Activity detection means that there is a leak between radioactive systems and the component cooling system. Upon activity detection the affected loop is sampled to determine the defective component.

c) Steam generator blowdown water activity measurements (PAMS channels)

Two paralleled channels monitor the activity of the blowdown water of each steam generators (6 channels per Unit). The water monitored is conveyed by the nuclear sampling system (REN).

The information given by these channels are available to the operator in the PAMS (train A and B).

The monitors are off-line liquid monitors (see Paragraph 11.5.2.3.) fitted with a local measurement display located in the nuclear sampling system (REN) room.

11.5.3.2. Gaseous process and effluent radiological monitors

The containment gas activity monitor and the stack discharge gas activity monitor initiate Plant actions such as terminating discharge and, for the stack discharge gas monitor, monitoring gaseous activity releases during normal operation or accidental conditions. Appropriate redundancy is provided for these monitors taking into consideration the fact that the stack is common to the two Units, and that monitoring may be carried out by other monitors located on the radioactive release path.

Channels are powered by an emergency power supply and are fail-safe.

Gaseous process and effluents radiation monitoring channels are described below and are listed in Table T-11.5-2.

a) Reactor containment air activity measurements

The reactor containment building atmosphere is continuously monitored for aerosols and iodine, and gaseous activity. The sample is drawn from the containment building in a closed system ; is passed through series connected aerosols and iodine monitor, and low activity gas monitors ; and is returned to the containment building.

The equipment is an off-line airborne monitor and is described in Paragraph 11.5.2.6 320

The equipment is seismic category 1. The power supply is an emergency power supply. The signals given by the monitors are fail-safe.

The gas channel gives reliable information on primary coolant leaks. The high radiation level signal of this channel controls the automatic closing of :

- the containment sweeping ventilation system isolation valves (EBA),

- the containment low scavenging system isolation valves (ETY),

- the containment vent and drain system isolation valves (RPE).

Laboratory analysis of aerosols iodines, tritium, and gas may be performed on filters, traps, and gas samples.

b) Stack discharge air activity measurements

These air monitors survey all the Plant air exhausts for release of activity. The stack air discharge is continuously and isokinetically monitored for airborne particulate, iodine, and low and high gaseous activity by two paralleled monitors. One of each of the monitors is power supplied and connected with each Unit.

Low and high gaseous activity measurements are included in PAMS. Equipment of Unit 9 is the PAMS train A equipment of both units, equipment Unit 10 is the PAMS train B. Information from train A and B is sent to the control rooms of Unit 9 and 10.

This equipment is an off-line type airborne monitoring equipment as described in Paragraph 11.5.2.6. It is safety lE, Seismic Category I and 1E supplied. Supplies for pumping and control are produced from 220 V AC in the KRT centralized cabinets. 320

The high radiation level signal given by the low activity gas monitors controls the automatic closing of :

- the containment sweeping ventilation system isolation valves (EBA),
- the containment low scavenging system isolation valves (ETY),
- the gaseous waste treatment system release valves (TEG).

Laboratory analysis of aerosols, iodine, tritium, and gas may be performed on filters, traps, and gas samples. Evaluation of discharge is made using these measurements and the values recorded continuously by the monitors, and taking into account the air flowrate through the stack which is also recorded.

c) Condenser off-gas activity measurement

The activity of gas extracted from the condenser is continuously monitored to detect activity resulting from primary to secondary system leakage.

The equipment is described in Paragraph 11.5.2.5. It is emergency power supplied. The activity level is continuously recorded.

d) Nuclear auxiliary building air activity monitoring

When a variation in the activities measured by the stack air monitor is detected, measurements are made of the activity concentration of the gases and aerosols in the ventilation ducts using the mobile monitors described in Paragraph 11.5.2.6.

Blind flanges for connecting mobile monitors are provided on ventilation ducts in low radiation areas, with the object of identifying, by successive measurements in the various legs of the ventilation systems, the source of contamination.

11.5.4. Monitoring during operational occurences and postulated accidents

All potentially significant paths for the release of radioactive materials are monitored by the process and effluent radiation monitors discussed in Subsection 11.5.3. Provisions for monitoring radiation levels in process and effluent streams during postulated accidents are discussed below.

The containment atmosphere is continuously monitored for air particulate and iodine, and gaseous radioactivity that may be released during normal operation, including anticipated operational occurrences. The air particulate and iodine, and gas monitors are designed to withstand a safe shutdown earthquake and are powered from an emergency power seismically qualified supply. In the event of a LOCA, these monitors are isolated, and, therefore, are not available for monitoring the containment atmosphere until the pressure and temperature are reduced.

When the containment is isolated following an accident, the dose rate level inside the containment is measured by the post accident reactor building monitors described in Section 12.3. The measurement range of these monitors is up to $1x10^7$ rad/h ($1x10^{+5}$ Gy/h) for gamma as required by French and US Authorities.

In the event of a LOCA, containment atmosphere and fluids may be grab sampled for laboratory analysis, reactor coolant and containment sump water may be sampled and monitored continuously for their activity.

The area monitors located near the reactor cavity water surface (See Subsection 12.3.4), the containment air activity monitor, and the stack discharge air activity monitors are available for detecting a fuel handling accident or other accidents which do not have containment isolation as a consequency.

The spent fuel pit area monitors (See Subsection 12.3.4) are available for detecting a fuel handling accident. The activity release following this type of accident is also monitored by the stack discharge air activity monitors.

All gaseous releases from the nuclear buildings due to operational or accidental occurences are monitored by the stack discharge air activity monitors. This equipment has the capability to monitor low and high activity releases. Noble gas effluents monitoring is provided for the total range of concentration extending from a minimum of 10^{-6} Ci/m3 ($4x10^4$ Bq/m3) of Xe 133 to a maximum of $1x10^5$ Ci/m3 ($4x10^{15}$ Bq/m3) of Xe 133 by two monitors of which ranges overlap by a factor of ten.

Since continuous iodine gaseous effluent monitoring for the accident condition is not practical, capability for continuous sampling conducted by adsorption on charcoal traps is provided. Plant personnel is protected against radiation emitted by the samples by a shielding of 5 cm thick lead.

Monitoring and sampling capabilities for gaseous are paralleled, seismically qualified and powered by 1E sources (PAMS channels). The design for the sampling of particulates and iodines includes a sample nozzle entry velocity which is isokinetic (+ 20 %) with the expected intack air velocities (flowrates between 271 000 m3/h and 356 000 m3/h).

Radioactivity in effluents released from the waste treatment systems or from the secondary system due to operational occurences are monitored by the liquid effluent discharge monitors and by the condenser off-gas activity monitor.

Radioactivity released from the reactor coolant to the secondary system through a steam generator tube leak is monitored by the condenser off-gas activity monitor and by the steam generator blowdown water activity monitors (2 monitors per S.G.). The last ones are seismically qualified and powered by 1E sources (PAMS channels).

Radioactivity released to the component cooling water (RRI) or to the auxiliary steam supply (SVA) by a heat exchanger leak is monitored by the corresponding monitors.

11.5.5. <u>Inservice test and calibration</u>

All the radiation monitoring channels (KRT) of the process radiation monitoring subsystem are designed for testing during operation.

Some detectors have an internal radioactive source that makes a continuous background noise. The related signal is used in a way as a "watch dog", meaning that the electronic associated to the detector control the signal on a continuous basis and set off an alarm in the event of any change. The background noise is automatically subtracted from the measurement values but can also be read so as to check that there is no shift.

Proper alarm operation and automatic action triggering can be tested by adjusting the alarm threshold to a value under that of the background noise. 320

The other detectors are equipped with a device constituting a radioactive source that can be shifted in front of the detector from a shielded position to a open one.

This test is performed from the central KRT cabinets, that includes the control of check source displacement.

The background noise created by the source can be compared to the initial values and can also be used to test the alarms and the proper automatic action operation.

KRT activity monitoring devices are not allowed to measure accurately activity of dose rate, this is the purpose of laboratory measurements. The function of these devices is to provide an alarm when levels exceed preselected values to detect the variations not the value perse. As a consequence, inservice calibration of radiation monitors are not required.

Nevertheless, accuracy of effluent activity measurements may be regularly deduced from the comparison between monitors and laboratory measurement results for the same effluents.

Single point calibration is performed by driving the radioactive test sources, it confirms detector sensitivity.

For containment high range monitor calibration see Section 12.3.

11.5.6. Sampling

In addition to continuously monitoring Plant effluent discharge paths as discussed in the preceeding paragraphs, potential liquid and gaseous radioactive effluent discharge paths are sampled periodically for laboratory analysis and an isotopic analysis is performed as required by RCC-P Section 5.6 and in accordance with operating rules established according to the radiation protection program.

Samples are obtained either remotely or locally. Remote samples are connected directly to the sampling system as discussed in Subsection 9.3.2. For local samples, the sample points are as close as possible to the respective process lines to provide the most representative effluent sample.

11.5.6.1. Liquid effluent sampling

The TEU and TER tanks are discharged on a batch basis. Each batch is sampled after stirring before treatment or prior to release. If there is indication of a pathway from the reactor coolant to the secondary side, the turbine building floor drain sump is sampled periodically.

11.5.6.2. Gaseous effluent sampling

The reactor building, fuel buildings, and the nuclear auxiliary building have separate ventilation circuits reaching a common discharge stack. Samples are taken from each circuit and from the discharge stack.

11.5.6.3. Local sampling

The list of local sampling points for radioactivity checks is given in Table T-11.5-3.

Other local sampling points not used during normal operation to monitor activity may be used for this purpose in case of incident.

These sampling points are not included in Table T-11.5-3, for more details see Subsection 9.3.2.

TABLE T-11.5-1 (1/2)

LIQUID PROCESS AND EFFLUENT RADIOACTIVITY MONITORS

Monitor point	Basis for location selection	Quantity per Unit	Detector type	Measurement	Range	. Calibration isotope, . 2 alarm set point	. Information treatment, . Action initiated by high level alarm
Reactor coolant activity measurement (RCV)	monitor reactor coolant activity	1	ionization chamber on-line	gross gamma	$1x10^{-5}$ - $1x10^{-1}$ Gy/h	Cs 137 **	recorded, alarm
Post accident reactor coolant activity measurement (REN)	monitor reactor coolant and sump water activity	1	ionization chamber on-line	gross gamma	$1x10^{-2}$-$1x10^{4}$ Gy/h	Cs 137 1 Gy/h	local display recorded, alarm closes sampling valves
Auxiliary steam condensate activity measurement (SVA)	monitor for leakage from liquid radwaste system	1 (*)	scintillation off-line	gross gamma	$4x10^{4}$ - $4x10^{9}$ Bq/m3	Cs 137 **	alarm
Batch discharged liquid effluent activity measurement	monitor liquid discharge path	1 (*)	scintillation off-line	gross gamma	$4x10^{4}$ - $4x10^{9}$ Bq/m3	Cs 137 8 x 10^{7} Bq/m3	recorded, alarm, closes discharge valves to terminate discharge

(*) shared between Units 9 and 10
(**) set point is chosen according to actual value of the fluid

TABLE T-11.5-1 (2/2)

LIQUID PROCESS AND EFFLUENT RADIOACTIVITY MONITORS

	Monitor point	Basis for location selection	Quantity per Unit	Detector type	Measu-rement	Range	· Calibration isotope · 2 alarm set point	· Information treatment · Action initiated by high level alarm	
	Low activity liquid effluent discharge measurement	monitor second-ary effluent discharge path	2(*)	scintillation off-line	gross gamma	4×10^4 - 4×10^9 Bq/m^3	Cs-137 3.8×10^7 Bq/m^3	recorded, alarm closes discharge valves to terminate discharge	151
	Steam generator blowdown water activity measurement	monitor steam generator liquid activity for primary coolant leakage	6 (2 per steam generator)	scintillation off-line	gross gamma	4×10^4 - 4×10^9 Bq/m^3	Cs-137 **	local display, recorded, alarm (PAMS channels)	
	Component coolant water activity measurement(RRI)	monitor for leakage into RRI	2	scintillation off-line	gross gamma	4×10^4 - 4×10^9 Bq/m^3	Cs-137 **	alarm	
151	Condensate deminer-ralizer regeneration waste water activity measurement	monitor regeneration waste water activity	1	scintillation off-line	gross gamma	3.7×10^3 - 3.7×10^9 Bq/m^3	Cs-137 **	local display, alarm closes discharge valve to terminate discharge	144

218

TABLE T-11.5-1 (2a/2)

LIQUID PROCESS AND EFFLUENT RADIOACTIVITY MONITORS

Monitor point	Basis for location selection	Quantity per Unit	Detector type	Measu-rement	Range	· Calibration isotope · 2 alarm set point	· Information treatment · Action initiated by high level alarm
Waste water treat-ment system inlet activity measurement	Monitor waste water activity	1(*)	scintillation off-line	gross gamma	3.7×10^3 – 3.7×10^9 Bq/m^3	Cs-137 1.0×10^5 Bq/m^3	local display, alarm stops discharge pumps to terminate discharge

(*) shared between Units 9 and 10

(**) set point is chosen according to actual value of the fluid

218

TABLE T-11.5-2 (1/3)

GASEOUS PROCESS AND EFFLUENT CONTINUOUS SAMPLERS AND MONITORS

Sampler/ Monitor point	Basis for location selection	Quantity per Unit	Detector and sample type	Measure ment	Range	· Calibration isotope, · 2 alarm set point	· Information treatment, · Action initiated by high level alarm
Containment air activity measurement	monitor containment building at mosphere	1	paper aerosols filters				
			charcoal cartridge filter				
			beta Geiger Muller	gross beta	4×10^3 – 4×10^6 Bq	Co 60 **	recorded, alarm
			beta differential ionization chamber for gas	gross beta	3.7×10^4 – 3.7×10^9 Bq/m³	Xe 133 1.5×10^7 Bq/m³	recorded, alarm automatic closing of valves of EBA, ETY and RPE systems
			tritium trap				
			gas sample				

(**) set point is chosen according to actual value of the fluid

105

TABLE T-11.5-2 (2/3)

GASEOUS PROCESS AND EFFLUENT CONTINUOUS SAMPLERS AND MONITORS

Sampler/ Monitor point	Basis for location selection	Quantity per Unit	Detector and sample type	Measure ment	Range	· Calibration isotope, · 2 alarm set point	· Information treatment, · Action initiated by high level alarm
Stack discharge air activity measurement	monitor gaseous releases of nuclear buildings	2(*)	paper aerosols filters				
			charcoal cartridge filter				
			beta Geiger Muller	gross beta	4×10^{3} – 4×10^{6} Bq	Co 60 **	recorded, alarm
			beta differential ionization chamber for gas	gross beta	3.7×10^{4} – 3.7×10^{9} Bq/m³	Xe 133 2.3×10^{6} Bq/m³	recorded, alarm automatic closing of valves of EBA, ETY and TEG systems (PAMS channels)
			beta ionization chamber for gas	gross beta	3.7×10^{8} – 3.7×10^{15} Bq/m³	Xe 133 3.7×10^{9} Bq/m³	recorded, alarm (PAMS channels)
			tritium trap gas sample				

(*) shared between UCN 1&2

(**) set point is chosen according to actual value of the fluid

107

TABLE T-11.5-2(3/3)

GASEOUS PROCESS AND EFFLUENT CONTINUOUS SAMPLERS AND MONITORS

Sampler/ Monitor point	Basis for location selection	Quantity per Unit	Detector and sampler type	Measu-rement	Range	· Calibration isotope, · 2 alarm set point	· Information treatment, · Action initiated by high level alarm
Condenser off-gas activity measurement	monitor primary to secondary system leakage	1	beta scintillation	gross beta	3.7×10^{4}–3.7×10^{7} Bq/㎥	Kr 85 **	recorded, alarm
Nuclear auxiliary building gas activity measurement	monitor air activity in ventilation ducts	1(*)	beta ionization chamber	gross beta	3.7×10^{4}–3.7×10^{9} Bq/㎥	Kr-85 **	local recorder
Nuclear auxiliary building aerosol and isodine activity monitors	monitor aerosol and isodine activity in ventilation ducts	1(*)	aerosols paper filter and charcoal cartridge filter		no detector		
Old steam generator storage facility HVAC effluent monitor	monitor particulate, iodine and noble gas activity in ventilation duct	1(*)	beta scintillation gamma scintillation beta scintillation	particulate iodine gross beta	3.7×10^{-7}–3.7×10^{-1} Bq/cc 3.7×10^{-7}–3.7×10^{-1} Bq/cc 3.7×10^{-2}–$3.7\times10^{+7}$ Bq/cc	later	recorded, alarm, stop exhaust ACU

(*) shared between Unit 1 and 2

(**) set point is chosen according to actual value of the fluid

2

224

Amendment 224

2010. 3. 25

TABLE T-11.5-3

RADIOACTIVE LOCAL SAMPLING

System	Sample n°	Sample
9 DVN	YA 001 to 034	Downstream potentially contamined rooms
1 ETY 2	025 LG 027 LG 024 LG 026 LG	001 ZV fan 002 ZV fan
1 EVF 2	103 LG 104 LG	Upstream filtrations Downstream filtrations
1 PTR 2	731 ZG to 735 ZG	Spent fuel pit damaged fuel storage racks
1 REA 2	117 LG	001 BA and 002 BA make-up water storage tanks
0 SRE	010 LG 022 LG 033 LG 050 LG 042 LG	001 BA tank 002 BA tank 003 BA tank 005 BA tank 004 BA tank
9 SVA	237 LG	Condensate activity measurement line
9 TER	130 LG 131 LG 132 LG 133 LG 134 LG to 137 LG 138 LG to 141 LG	By-pass Downstream 001 BA Downstream 002 BA Downstream 003 BA Drain from conventional island Drains from nuclear island