ROKKASHO REPROCESSING PLANT

JAPAN NUCLEAR FUEL LIMITED

Introduction

There exists a system by which Japan, country scarce in energy resources, can extract reusable uranium and plutonium from fuels spent in nuclear power plants that valuable uranium resources can be more effectively utilized. Such system is called "reprocessing". Because recycle of reprocessed uranium and plutonium as nuclear fuel allows to multiply the efficiency of natural uranium utilization by several times, or possibly by several tens of times, reprocessing will play a significant role in ensuring more stable supply of energy for Japan.

In addition, reprocessing separates fission products (FP) contained in spent fuel and also it is an essential treatment in terms of safety management and disposal measures.

Rokkasho Reprocessing Plant is first commercial plant in Japan, adopting the technology developed on the basis of more than 40years of operation results in both France and United Kingdom, as well as operating experience gained by Atomic Energy Agency (JAEA).

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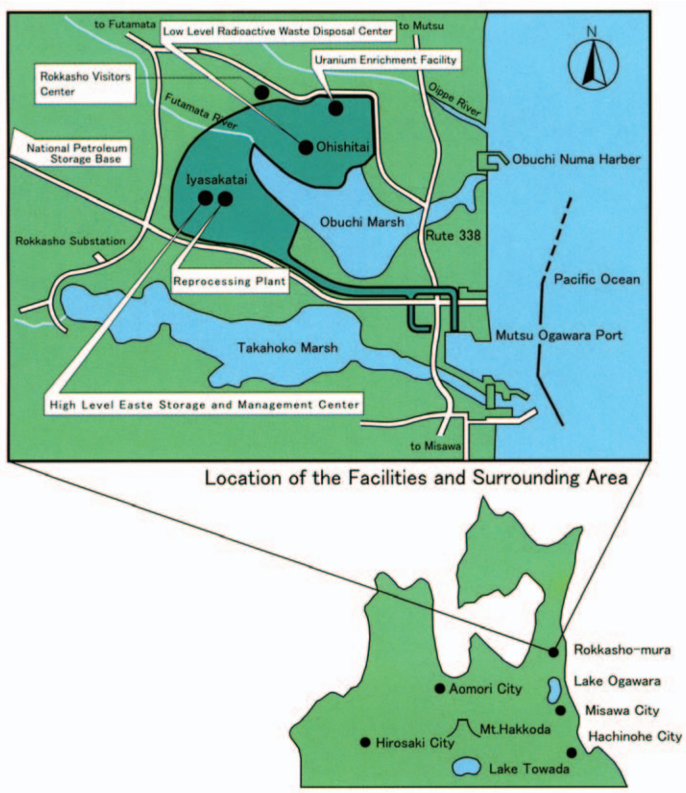
I Outline of the Plant



1. Location

   Oaza Obuchi, Rokkasho-mura,Kamikita-gun, Aomori Prefecture

2. Site Area

   Approx. 3,800,000m^2

3. Reprocessing Capacity

   ● Maximum Annual Reprocessing Capacity

   800t・U_{Pr}

   ● Maximum Daily Reprocessing Capacity

   4.8t・U_{Pr}

4. Maximum Storage Capacity of Spent Fuel Storage Facility

   3,000t・U_{Pr}

5. Schedule

   Mar. 1989:Applied license for the reprocessing business
   Dec. 1992:Approval was granted on the reprocessing business
   Apr. 1993:Staeted construction
   The first half of FY2018:Commissioning

＊ : t・U_{Pr} means converted mass in ton of metallic uranium before irradiation. Because uranium fuel loses its quantity during irradiation in nuclear reactor, its weight before irradiation is generally used.

The uranium necessary to keep a 1,000MWe nuclear power plant in operation for 1 year corresponds to:
Approx. 18t・U_{Pr} for Pressurized Water Reactor
Approx. 23t・U_{Pr} for Boiling Water Reactor
(Source : Nuclear Pocketbook, 2007)

● Rokkasho Reprocessing Plant

II Nuclear Fuel Cycle and Reprocessing Plants in the World

1. Nuclear Fuel Cycle

Uranium ore exploited from mines is transformed into fuel assembly after a number of processes, including refining, conversion, enrichment, reconversion and fabrication. After having produced thermal energy as fuel in a nuclear power plant, fuel assemblies are taken out as spent fuel.

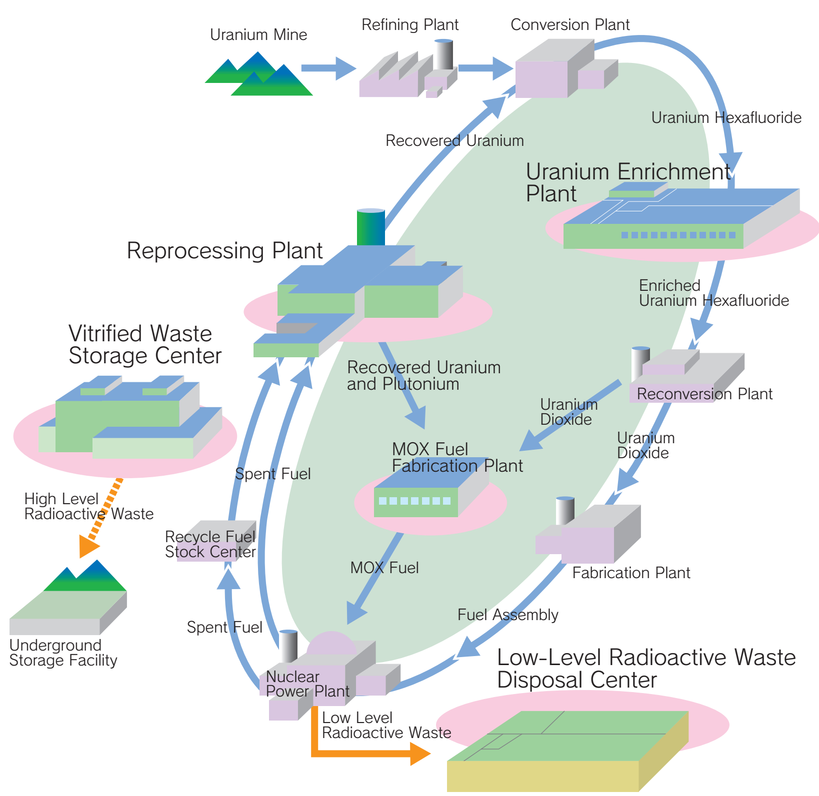
Then, the spent fuel is reprocessed to extract residual uranium as well as plutonium which has been produced during irradiation, in order to use them once more to feed nuclear power plants. This stream is called ″nuclear fuel cycle″.

Japan is scarce in energy resources. To secure a stable supply of energy for the future, development of nuclear power plays a significant role. Japan has determined on peaceful use of nuclear energy and, on one hand, will balance the structure of energy supply through full exploitation of nuclear energy, and on the other will make full use of uranium resources by employing newly produced energy resource, which is plutonium.

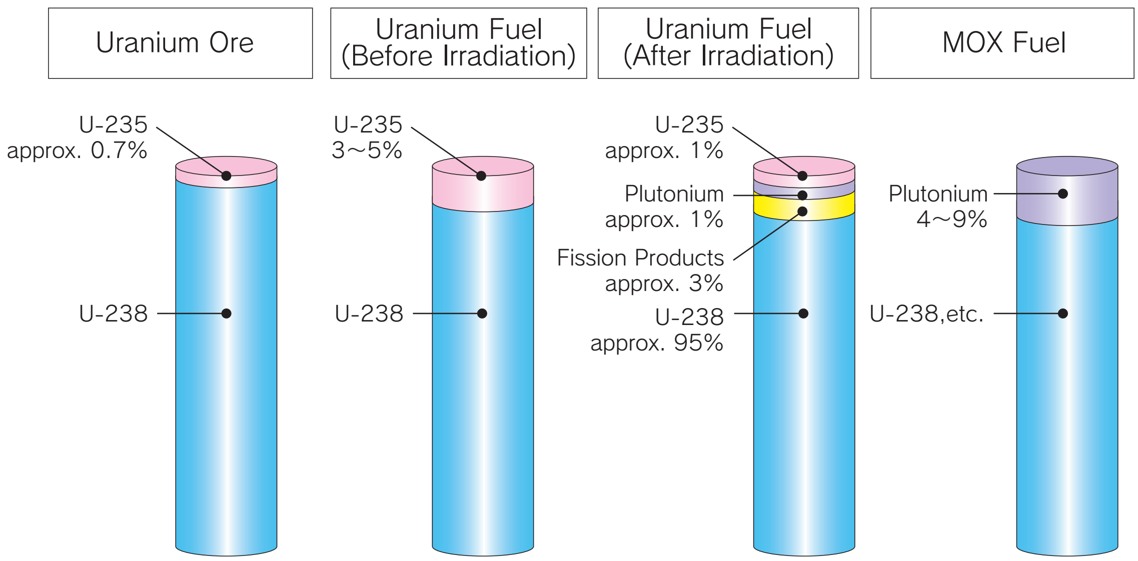
Uranium fuel for light water reactors contains 3 ～ 5 % of fissionable uranium, U-235. The rest is non-fissionable uranium, U-238. There remains still about 1 % of U-235 in spent fuel after 3 ～ 4 years of service in a reactor. 1 % represents substantial quantity, compared with the initial quantity which is 3 ～ 5 %. And the non-fissionable U-238 does not release any energy, but it can absorb a neutron to transform into plutonium 239, which is fissionable.

The use of plutonium permits more effective exploitation of uranium resources. Plutonium can feed not only light water reactor when mixed with uranium to fabricate mixed oxide fuel (MOX), but also fast breeder reactor which is expected to be the leading reactor in the future. Reprocessing is the operation to extract residual uranium and produced plutonium from spent fuel.

Nuclear Fuel Cycle



The Composition of Uranium Fuel for Light Water Reacter and MOX Fuel



2.Reprocessing Plant in the World

France and United Kingdom the energy condition of which is similar to Japanese one have reprocessed spent fuel for more than 40 years. In Japan, Japan Atomic Energy Agency (JAEA) has operated of reprocessing plant with research and development of technology since 1977.

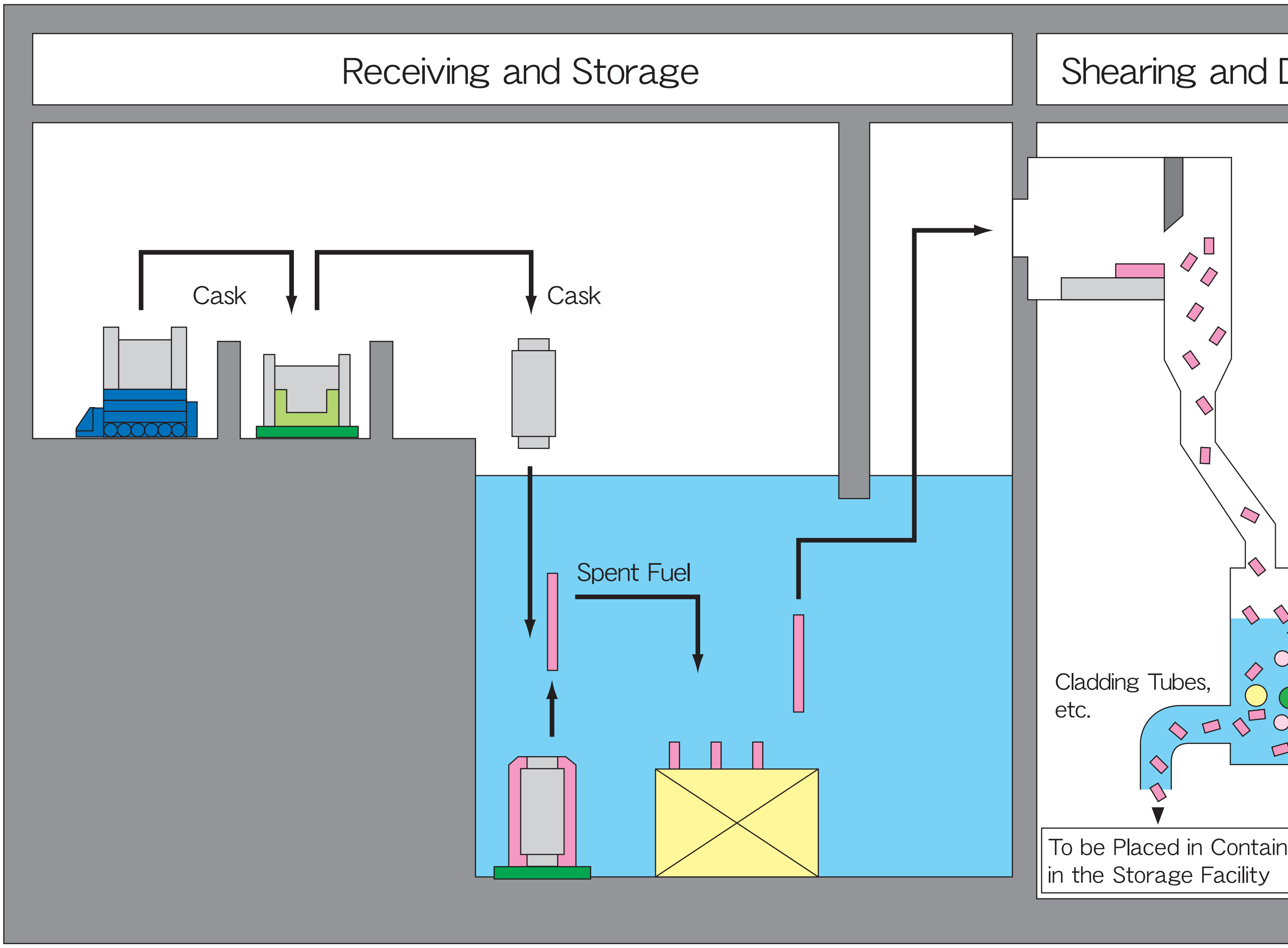
Rokkasho Reprocessing Plant adopted the technology and the experience of JAEA, France, United Kingdom and Germany.

Country	Plant	Capacity
France	UP2	1,000 tU/y
	UP3	1,000 tU/y
United Kingdom	THORP	900 tU/y
Russia	RT-1	400 tU/y
Japan	Tokai Reprocessing Plant (JAEA)	210tU/y
Japan	Rokkasho Reprocessing Plant	800 tU/y

Source: White Paper on Nuclear Energy 2006 (Publisher: Japan Atomic Energy Commission)

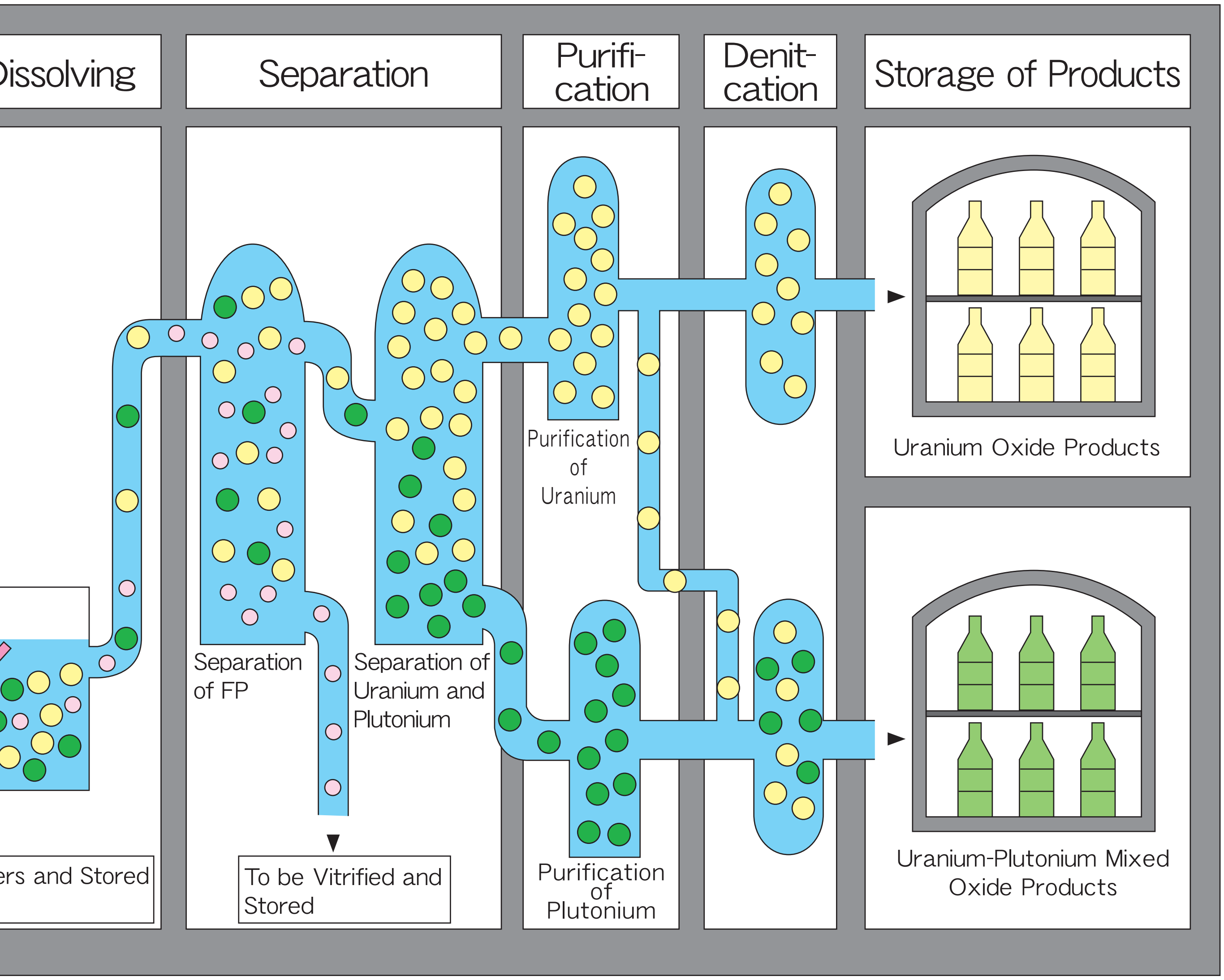
III Reprocessing Plant

Process Outline



In the receiving and storage process, spent fuel is received, then cooled and stored in the fuel storage pool to reduce radioactivity.
In the shearing and dissolving process, spent fuel is sheared into small pieces and only fuel is dissolved by nitric acid, leaving the cladding tubes.
In the separation process, the nitric acid is brought into contact with an oily solution called "solvent" to separate fission products from uranium and plutonium. Then uranium is chemically separated from plutonium.
The uranium and plutonium solutions then go through purification processes to remove small quantity of fission products still contained in the solutions.
In the denitration process, the nitric acid is vaporized to transform the purified uranium solution and uranium-plutonium mixed solution into powder.
The method of separating uranium, plutonium and fission products is a wet process called the "Purex process", which allows to recover highly pure products with high recovery rate and has proved high performance in Japan and abroad.

* Purex Process stands for Plutonium Uranium Reduction Extraction.



Specifications of Spent Fuel to be Reprocessed

a. Enrichment of U-235
Maximum Enrichment before Irradiation : 5 wt %
Average Enrichment of Spent Fuel Assembly : less than 3.5wt %

b. Cooling Time after Shutting Down the Reactor
Cooling Time before Receiving at the Reprocessing Plant : more than 1 year
Cooling Time before Shearing : more than 4 years

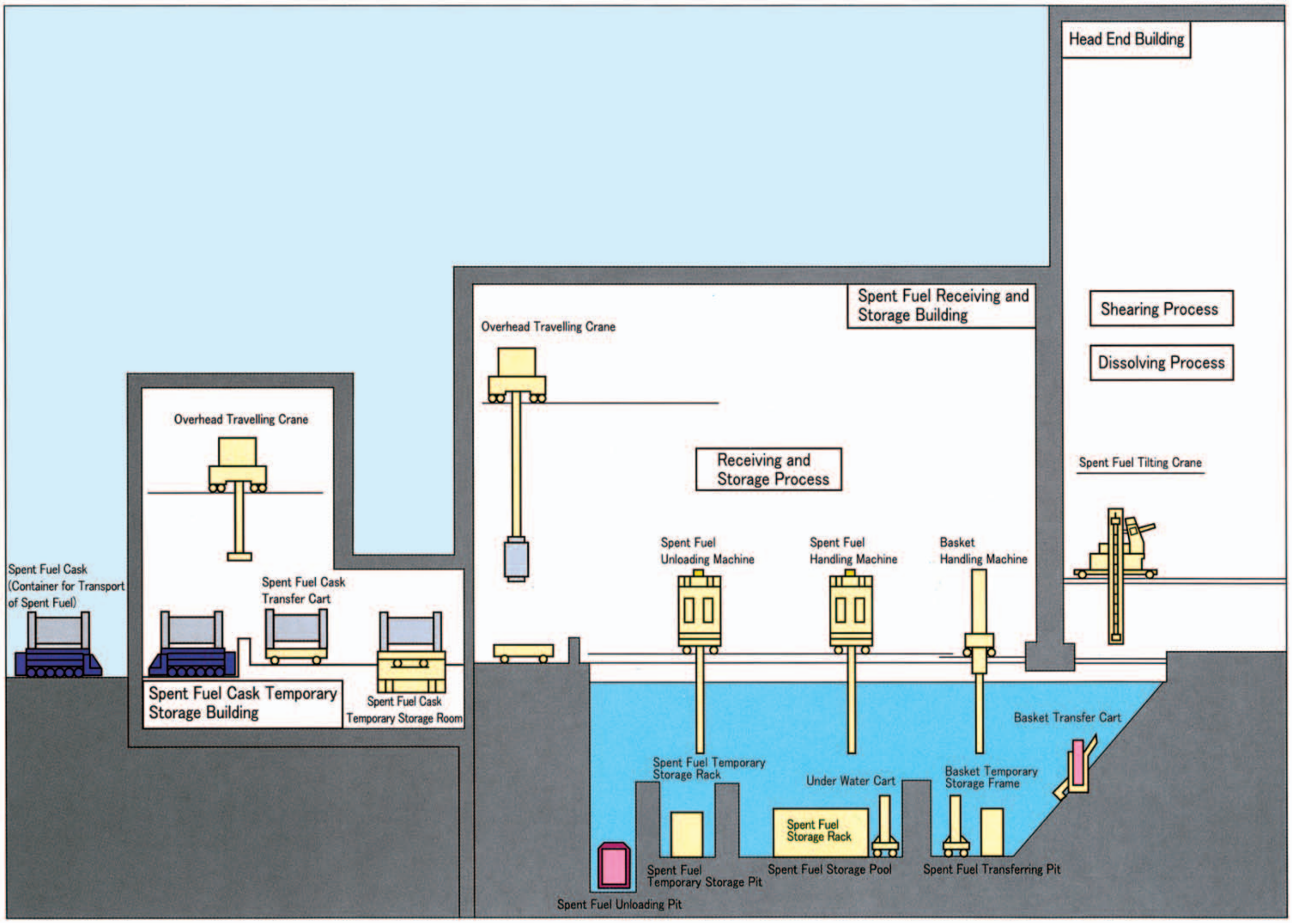
c. Maximum Burn Up of Spent Fuel Assembly : 55,000 MWd/t・U_{Pr}
The average burn up of spent fuel reprocessed per day should not exceed 45,000 MWd/t・U_{Pr}

＊: wt % stand for mass percent.

Burn up indicates the total energy released by nuclear fuel.Usually, it is expressed in heat quantity MW (megawatt) multiplied by number of days of operation per ton of fuel (MWd/t). The quantity of fission products and heat release of spent fuel depend on its burn up.

Uranium
Plutonium
Fission Products(FP)
(High Level Radioactive Waste)
Metal Pieces, such as Cladding Tubes

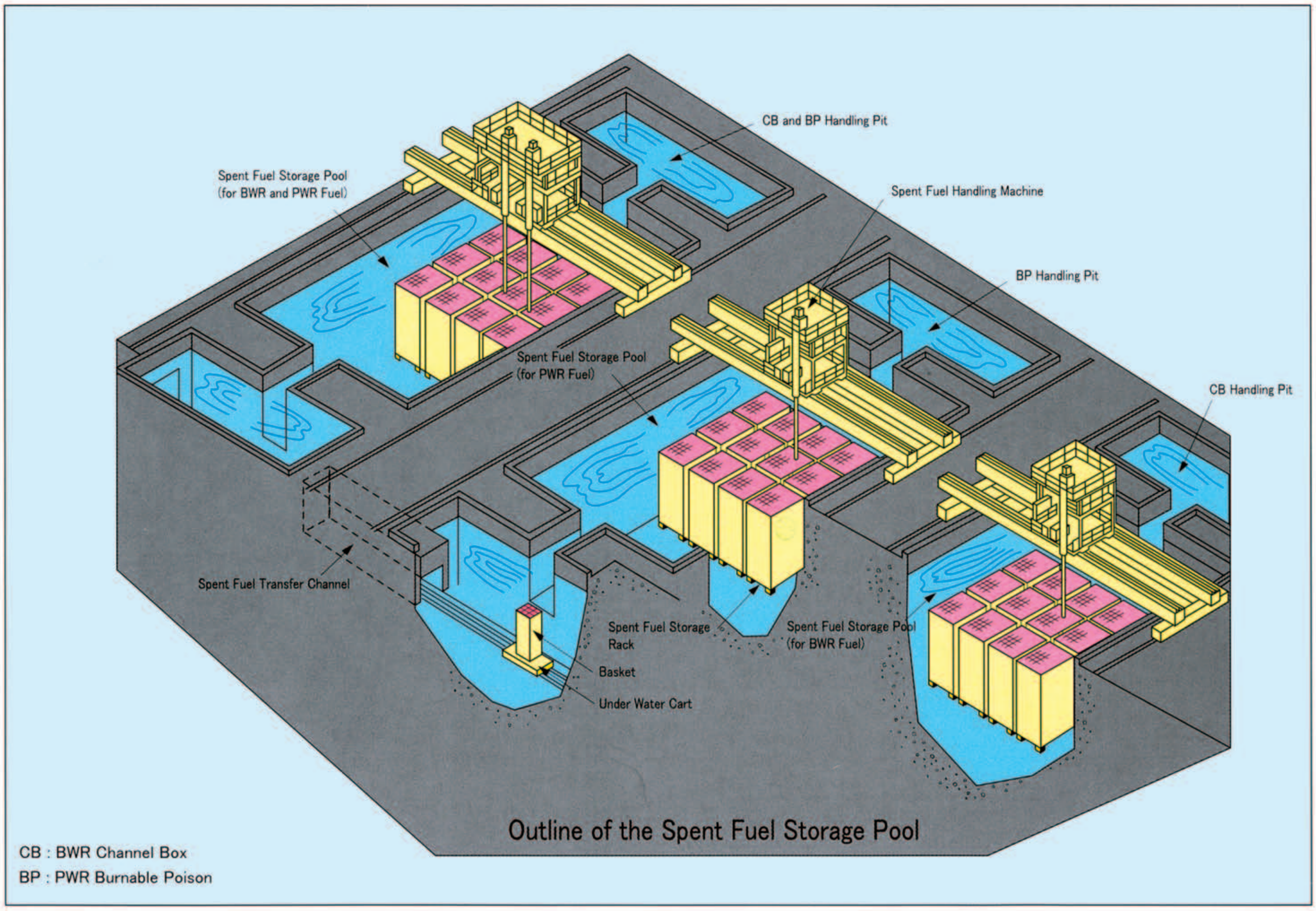
Receiving and Storage of Spent Fuel



Spent fuel assemblies (spent fuel) are transported in containers (spent fuel casks) from nuclear power plants by sea.

In the Reprocessing Plant, the casks are received in the Spent Fuel Cask Temporary Storage Building and carried to the Spent Fuel Cask Temporary Storage Room using the Overhead Travelling Crane and the Spent Fuel Cask Transfer Cart. After temporary storage, the casks are transferred to the Spent Fuel Receiving and Storage Building, where the casks are moved by using another Overhead Travelling Crane before placed in the Spent Fuel Unloading Pit filled with water. Here, the cask lid is removed and the Spent Fuel Unloading Machine takes out the spent fuel out of the cask one by one and places it on the Spent Fuel Temporary Storage Rack. Then, the Spent Fuel Unloading Machine places the spent fuel in the basket on the Under Water Cart. Then, the spent fuel is removed from the basket one by one by the Spent Fuel Handling Machine to be stored in the Spent Fuel Storage Rack.

In the Spent Fuel Storage Pool, spent fuel will be cooled and stored for more than four years counting from the cooling and storage period in the pool at nuclear power plant. Then the spent fuel is placed in the basket on the Under Water Cart by the Spent Fuel Handling Machine and carried to the Spent Fuel Transferring Pit. The basket that contains the spent fuel will be temporarily stored and then sent to the shearing process by the Basket Transfer Cart.



Specification

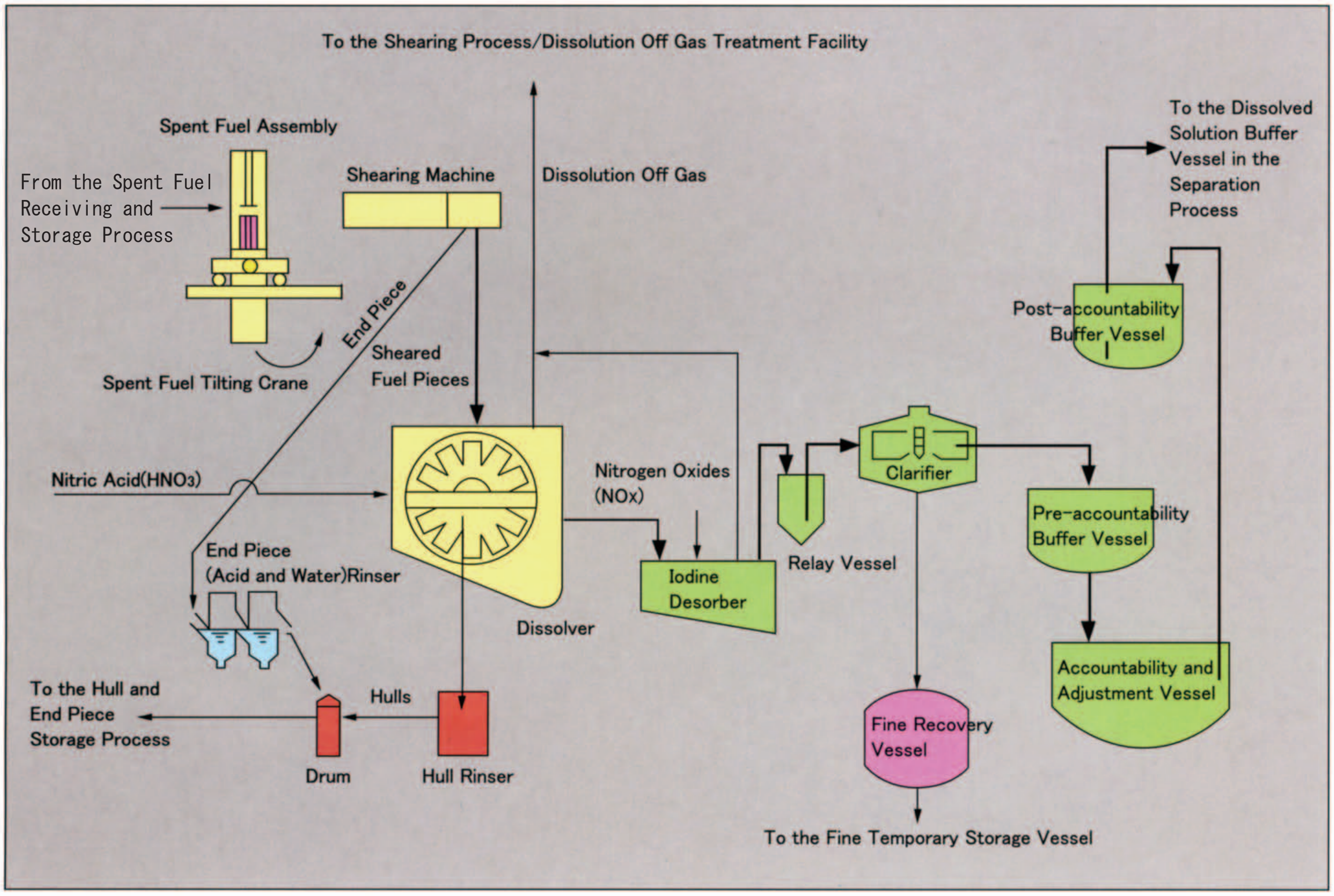
- ○ Spent Fuel Storage Pool : 3 units
- ○ Maximum Storage capacity
  - For BWR Spent Fuel Assembly : 1,500t・U_{Pr} (approx. 8,600 assemblies)
  - For PWR Spent Fuel Assembly : 1,500t・U_{Pr} (approx. 3,600 assemblies)
- ○ Specifications of Spent Fuel to be Received and Stored
  - (a) U-235 enrichment
    - Maximum Fuel Enrichment before Irradiation : 5 wt %
    - Average Enrichment of Spent Fuel Assembly : less than 3.5 wt %
  - (b) Cooling Time : more than 1 year
  - (c) Maximum Burnup of Spent Fuel Assembly : 55,000 MWd/t・U_{Pr}

＊:

Channel Box : metallic tubes(zirconium alloy) with square section (approx. 13 cm each side, and length of tube is approx. 4 meters), which encircle the BWR fuel assembly

Burnable Poison : it consists of metallic rods (stainless steel, approx. 1 cm diameter and approx. 4 meters long) inserted in the PWR fuel assembly and a structure which supports the rods from the upper part of the fuel assembly. The rods contain neutron absorbing materials such as bolosilicate glass.

Shearing and Dissolution



The shearing and dissolution process is located in the Head End Building where spent fuel is sheared and then dissolved in nitric acid and sent to the separation process.

In the shearing process, the Spent Fuel Tilting Crane removes spent fuel assembly from the Basket Transfer Cart arriving from the receiving and storage process and transfers them to the Shearing Machine. Then, sheared fuel pieces are sent out to the Dissolver.

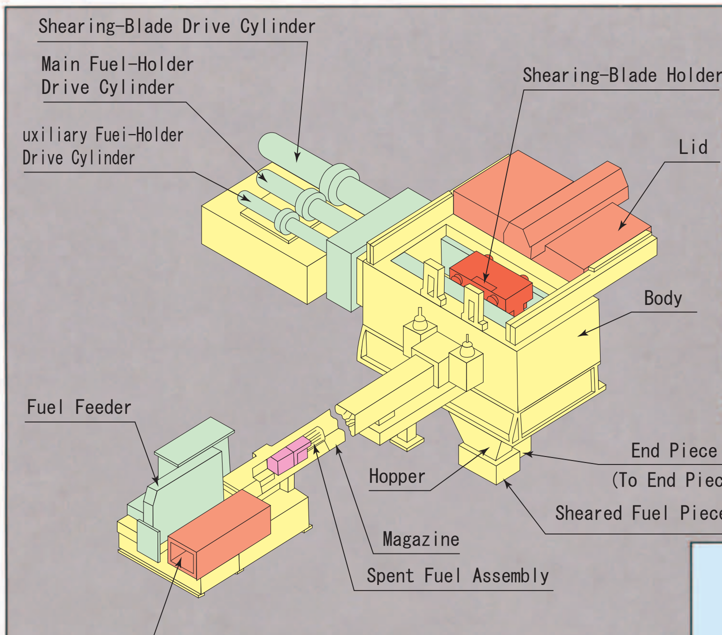
The dissolution process consists of Dissolution Facility and Clarification and Accountability Facility. In the Dissolution Facility, sheared fuel pieces are placed in the bucket in the Dissolver, where the fuel is dissolved with nitric acid (HNO_3). In the Iodine Desorber, iodine in the dissolved solution is purged to the Shearing Off Gas and Dissolution Off Gas Treatment Facility. In the Clarification and Accountability Facility, the clarifier removes the fines from the dissolved solution, which is then accounted in the Accountability and Adjustment Vessel. If necessary, the acid concentration is adjusted, Finally, the dissolved solution is transferred to the Dissolved Solution Buffer Vessel in the separation process.

* : Fines are particles which remain undissolved after the sheared fuel pieces are dissolved in the Dissolver. The main components are elements of platinum group (ruthenium and palladium) and molybdenum.

Main Equipmemts

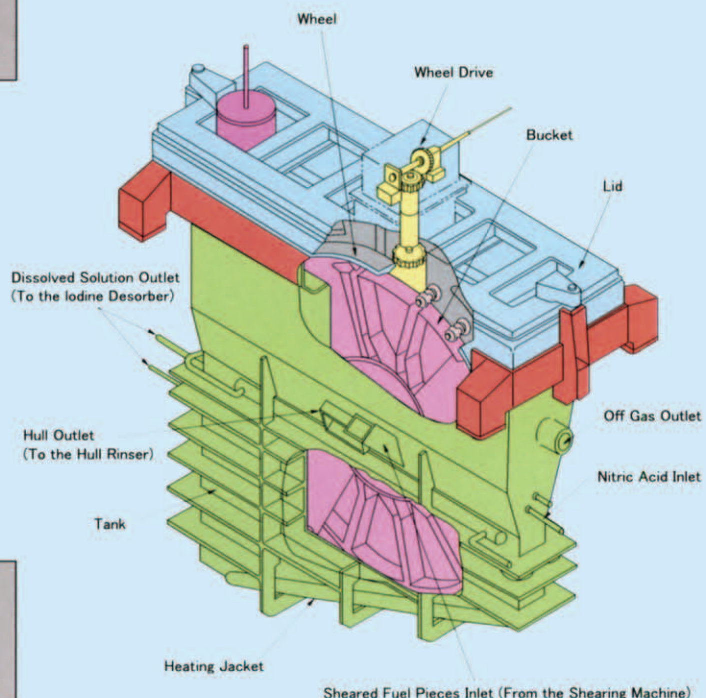
Shearing machine	: 2 sets (1 set/system)
Dissolver (continuous type)	: 2 sets (1 set/system)
Material	: Zirconium
Clarifier (centrifugal type)	: 2 sets (1 set/system)
Material	: Titanium

In the Shearing Machine, spent fuel assembly are changed into the Magazine and intermittently sent to the shearing part by the Fuel Feeder.The spent fuel assembly is sheared into small pieces, 3〜4 cm in length.Sheared fuel pieces are transferred to the Dissolver and end pieces are transferred to the End Pieace Acid Rinser, both by gravity through special chutes.

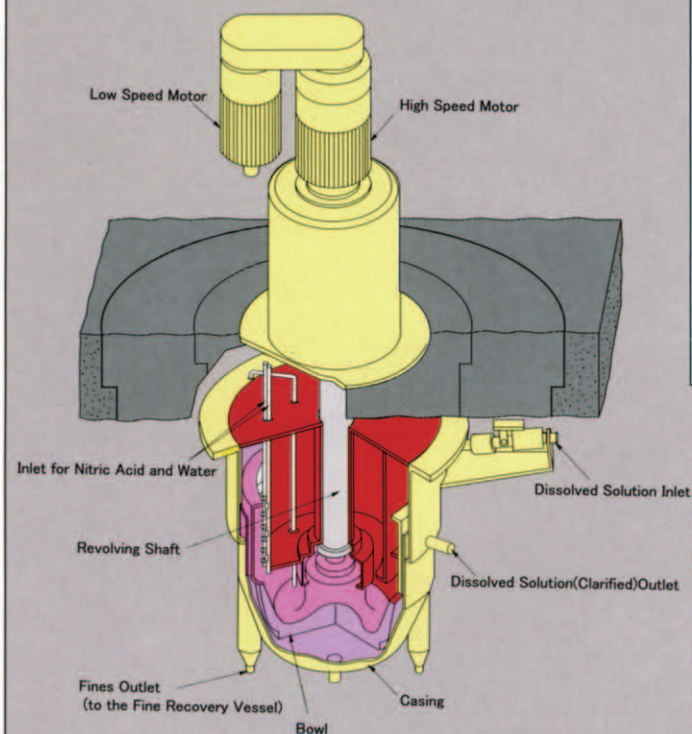


Outline of Shearing Machine

The Dissolver consists of tank and a wheel containing 12 Buckets. sheared fuel pieces loaded in the Buckets are soaked in hot nitric acid for a specified time Through this process, a portion of the fuel dissolves and only the sheared fuel cladding tubes (hulls) remain in the Buckets. Then, the hulls are discharged to the Hull Rinser from the Hull Outlet when the Bucket faces the outlet by rotation of the wheel.



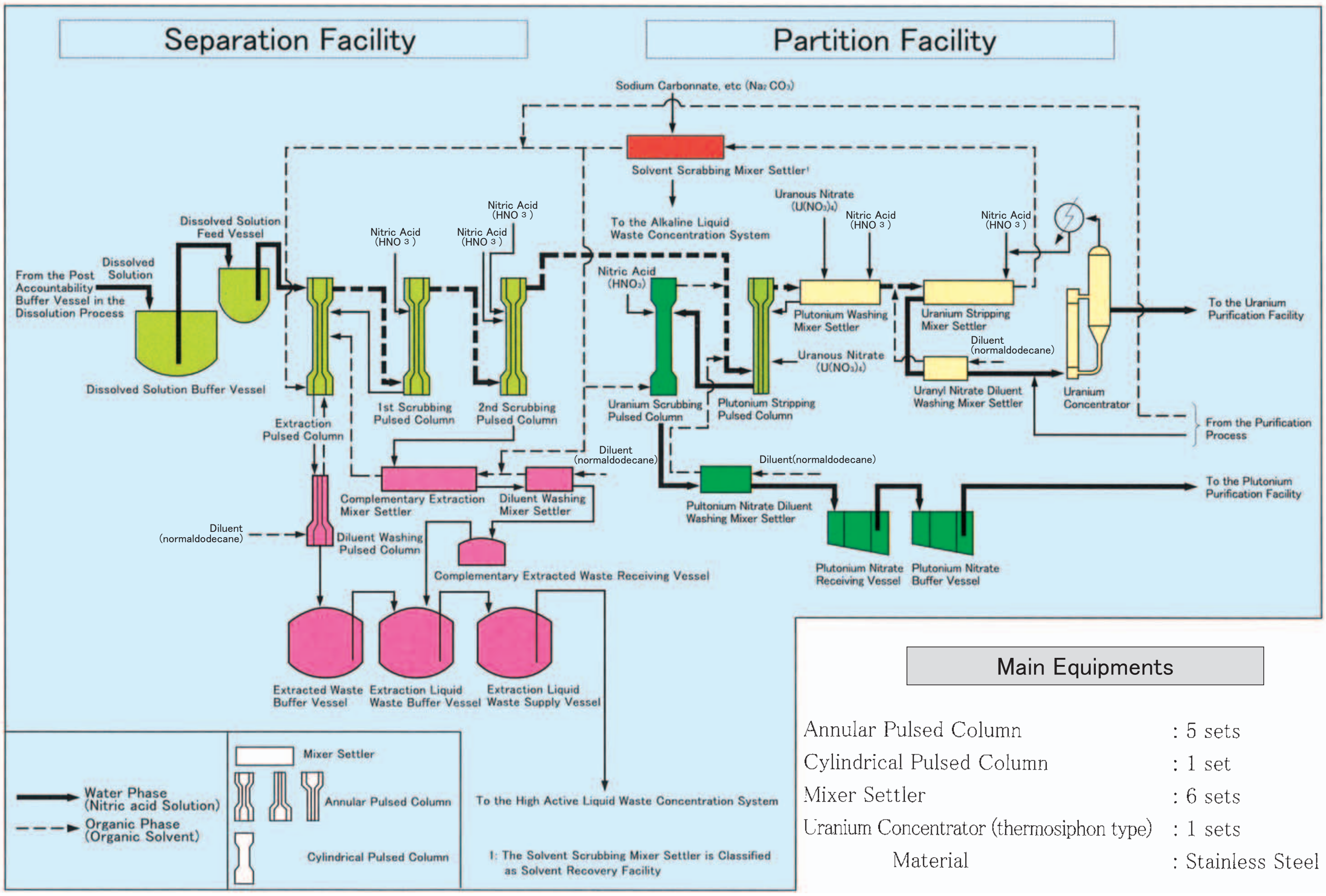
Outline of Dissolver



Outline of Clarifier

The Clarifier is a centrifugal type system containing a bowl that rotates at high speed. Fines in the dissolved solution are collected in the bowl by centrifugal force. After a specified amount of the dissolved solution is clarified, the collected fines are washed with nitric acid through low speed rotation then discharged to the Fine Recovery Vessel with water.

Separation

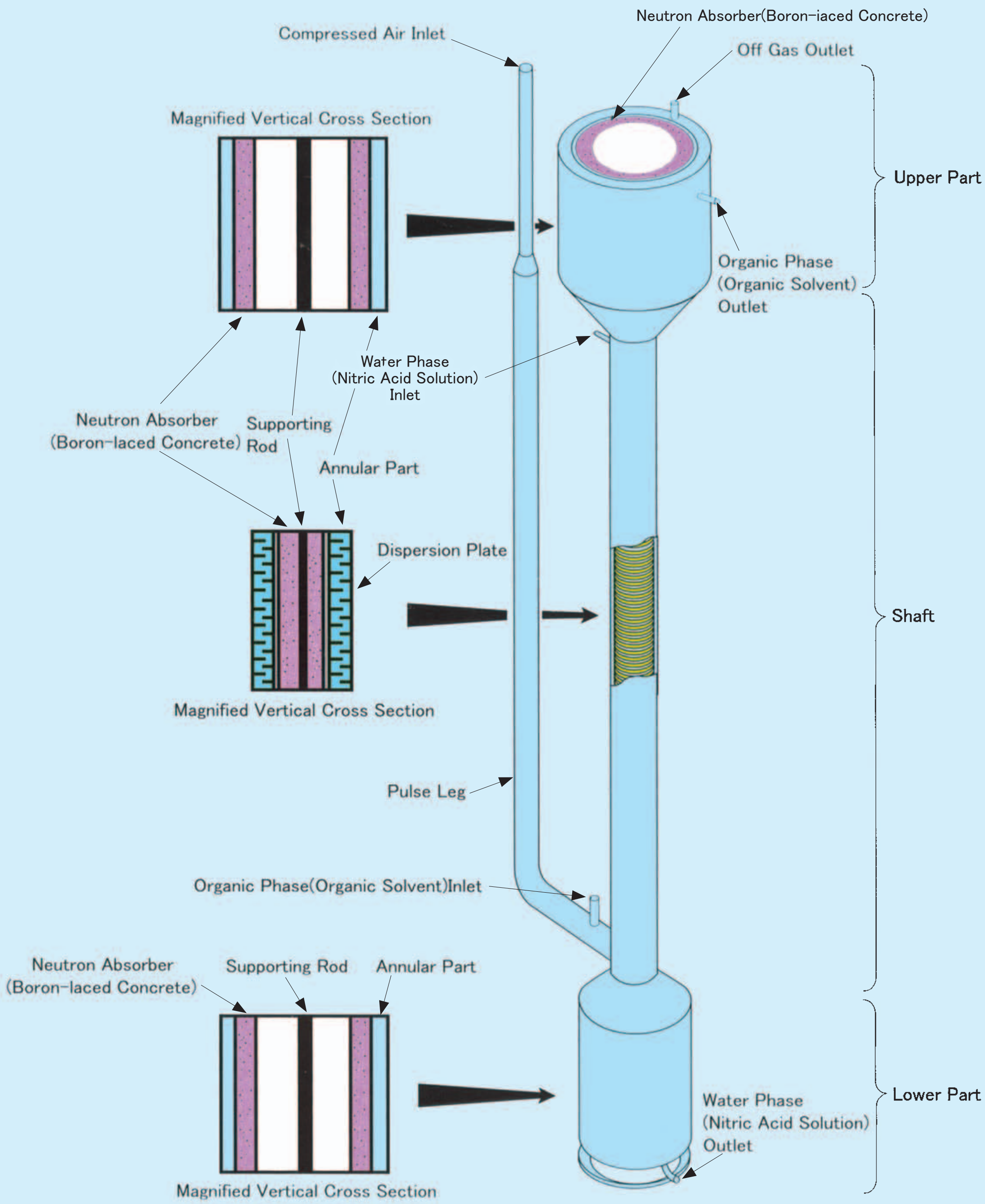


Main Equipments

Annular Pulsed Column	: 5 sets
Cylindrical Pulsed Column	: 1 set
Mixer Settler	: 6 sets
Uranium Concentrator (thermosiphon type)	: 1 sets
Material	: Stainless Steel

The dissolution process supplies nitric acid solution containing uranium, plutonium and fission products (FP) to the separation process.
The separation process, located in the Separation Building, consists of Separation Facility and Partition Facility. The Separation Facility extracts "uranium and plutonium" from the dissolved solution sent from the dissolution process. And the second Facility separates "uranium" and "plutonium".
In the Separation Facility, dissolved solution (nitric acid solution) is brought into contact in counterflow with organic solvent (mixture of TBP used for solvent extraction and diluent) in the Extraction Pulsed Column (annular pulsed column) to extract uranium and plutonium into the organic solvent. Most of the fission products remain in the nitric acid solution. The organic solvent containing extracted uranium and plutonium is sent to the 1st and 2nd Scrubbing Pulsed Columns (both annular pulsed columns) to remove remaining small quantity of fission products through counterflow contact with nitric acid.
In the Partition Facility, the organic solvent from the 2nd Scrubbing Pulsed Column is sent to the Plutonium Stripping Pulsed Column (annular pulsed column) to separate uranium and plutonium through counterflow contact with a nitric acid solution containing uranous nitrate ($U(NO_3)_4$). The separation process of uranium and plutonium takes advantage of the property of plutonium; when uranous nitrate is added, the valence of plutonium reduces from P_u^{4+} to P_u^{3+} in the organic solvent. The P_u^{3+} has the property to shift into the water phases (nitric acid solution).
The organic solvent containing uranium is sent from the Plutonium Stripping Pulsed Column to the Plutonium Washing Mixer Settler to remove the very small amount of plutonium still contained in the organic solvent through contact with nitric acid solution containing uranous nitrate. Then, the organic solvent containing uranium is sent to the Uranium Stripping Mixer Settler to strip the uranium into the water phase (nitric acid solution) through contact with diluted nitric acid. This uranyl nitrate solution (nitrate solution which contains uranium(VI)) is brought into contact with diluent (normaldodecane) in the Uranyl Nitrate Diluent Washing Mixer Settler to remove the very small amount of TBP still contained in the nitric acid solution, before the uranyl nitrate solution is concentrated in the Uranium Concentrator.
Meanwhile, the plutonium nitrate solution (nitrate solution which contains plutonium) separated in the Plutonium Stripping Pulsed Column is sent to the Uranium Scrubbing Pulsed Column (cylindrical pulsed column) to remove small amount of uranium still contained in the nitric acid solution through counterflow contact with organic solvent. Then, the nitric acid solution is sent to the Plutonium Nitrate Diluent Washing Mixer Settler and brought into contact with diluent (normaldodecane) to remove the very small amount of TBP still contained in the solution.

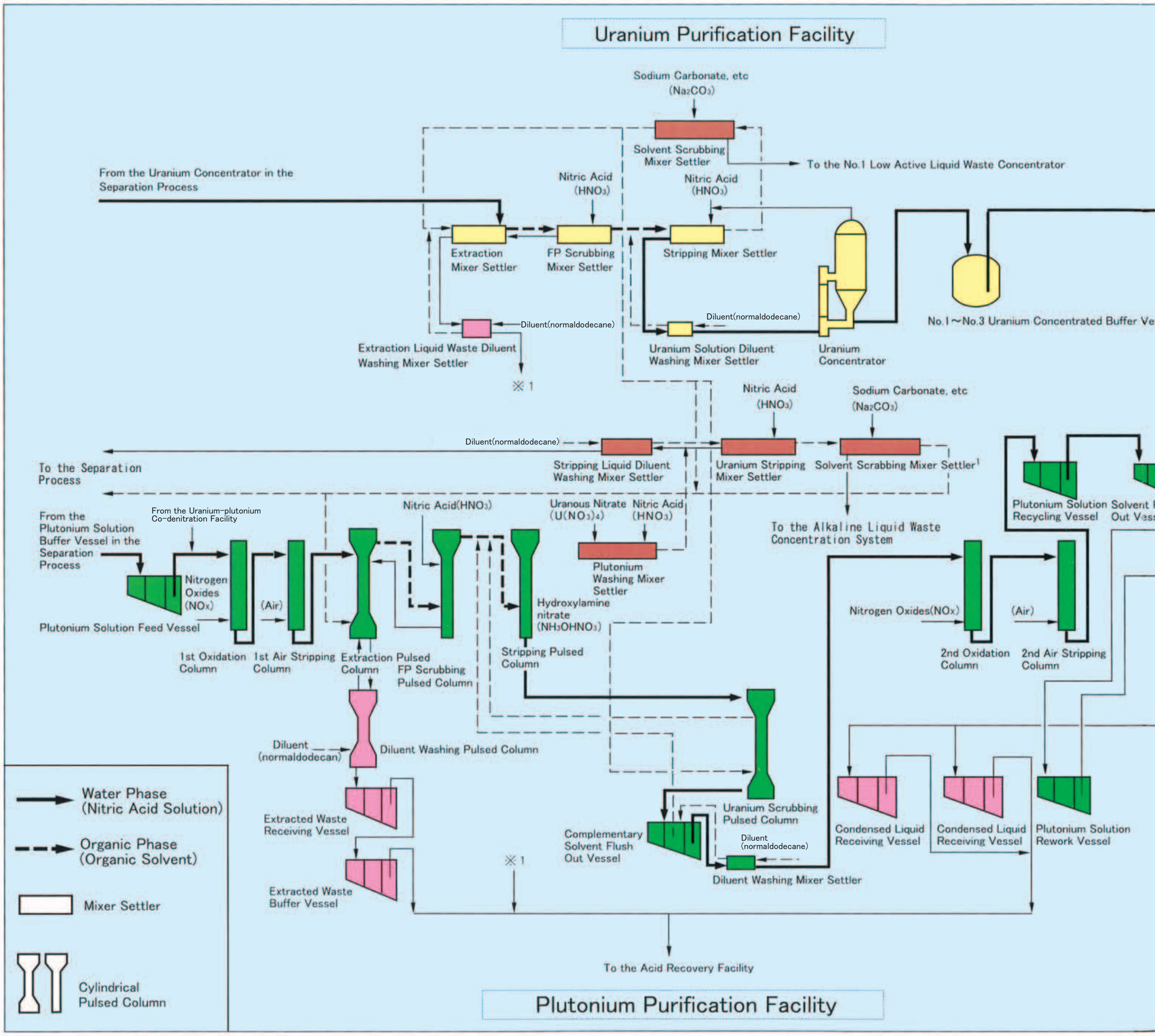
＊ TBP stands for TriButyl Phosphate. It is an extractant used to extract uranium and plutonium in solvent extraction method.



Outline of Annular Pulsed Column

In the pulsed column, the water phase (nitric acid solution) is supplied from the upper part of the Shaft, and the organic phase (organic solvent) is supplied from the lower part of the Shaft. The two phases are brought into contact in counterflow while pulsation is provided by compressed air from the Pulse Leg. Thus, a dispersion phase (liquid droplets) are formed in the continuous phase by pulsation and the dispersion plate to increase efficiency of material movement between the two phases. For example, in the Extraction Pulsed Column, the two phases are brought into contact in counterflow by supplying the dissolved solution (nitric acid solution: water phase) from the upper part, and the organic solvent (organic phase) from the lower part. Thus, nearly all the uranium and plutonium in the dissolved solution can be extracted into the organic solvent.

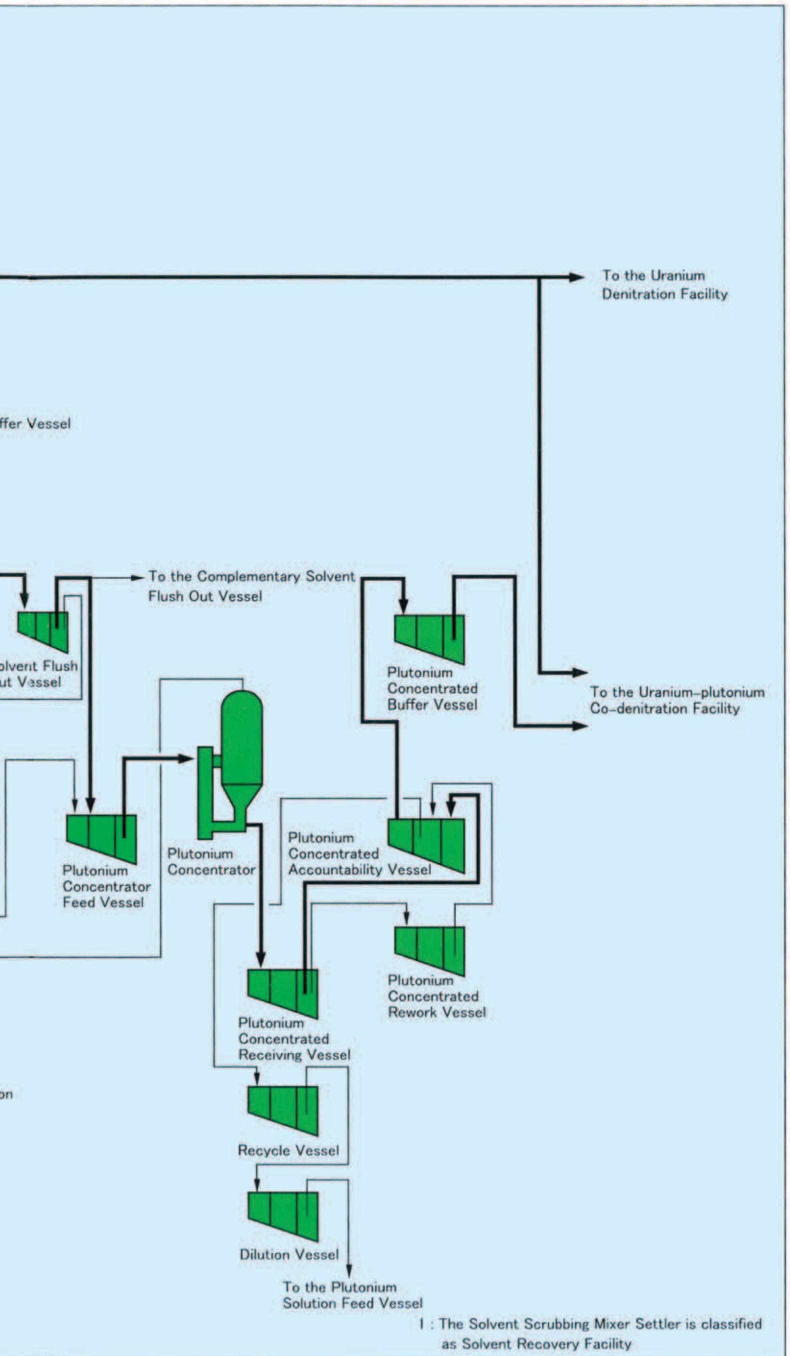
Purification



The purification process, located in the Purification Building, consists of the Uranium Purification Facility and the Plutonium Purification Facility.

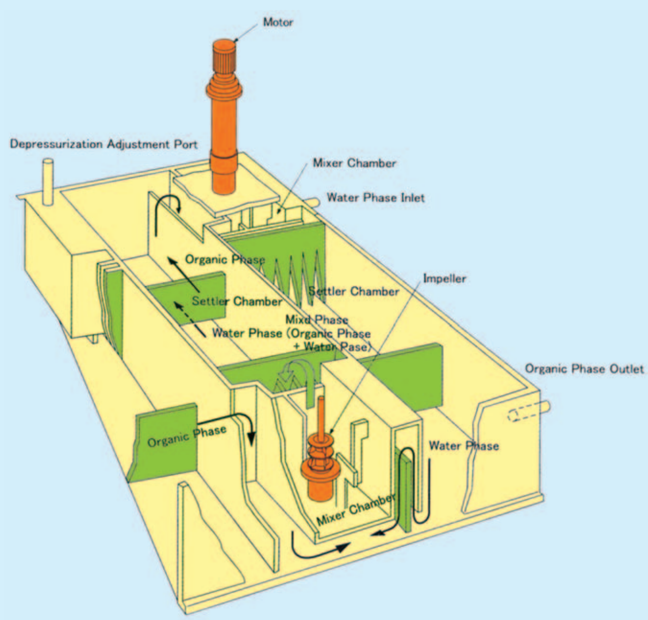
The uranyl nitrate solution (nitric acid solution containing uranium(Ⅳ)) is sent from the Uranium Concentrator of the separation process to the Uranium Purification Facility, where it goes through the series of operations consisting of extraction (via the Extraction Mixer Settler), washing for fission products (via the FP Scrubbing Mixer Settler), stripping (via the Stripping Mixer Settler), washing for TBP (via the Uranium Solution Diluent Washing Mixer Settler), and concentration (via the Uranium Concentrator), in order to remove any remaining FP and TBP.

The plutonium nitrate solution (nitric acid solution containing plutonium) is sent from the Plutonium Solution Buffer Vessel of the separation process to the Plutonium Purification Facility. In the Oxidation Column, nitrogen oxides (NOx) is blown into the solution to oxidize plutonium so that the valence of plutonium is converted from Pu^{3+} to Pu^{4+}. Then, the nitric acid solution is brought into contact in counter-flow with organic solvent in the Extraction Pulsed Column. Most of the Pu^{4+} shifts into the organic solvent,



Main Equipments

Cylindrical Pulsed Column	: 5 sets
Mixer Settler	: 9 sets
Uranium Concentrator (thermosiphon type)	: 1 sets
Material : Stainless Steel	
Plutonium Concentrator (thermosiphon type)	: 1 sets
Material : Zirconium	



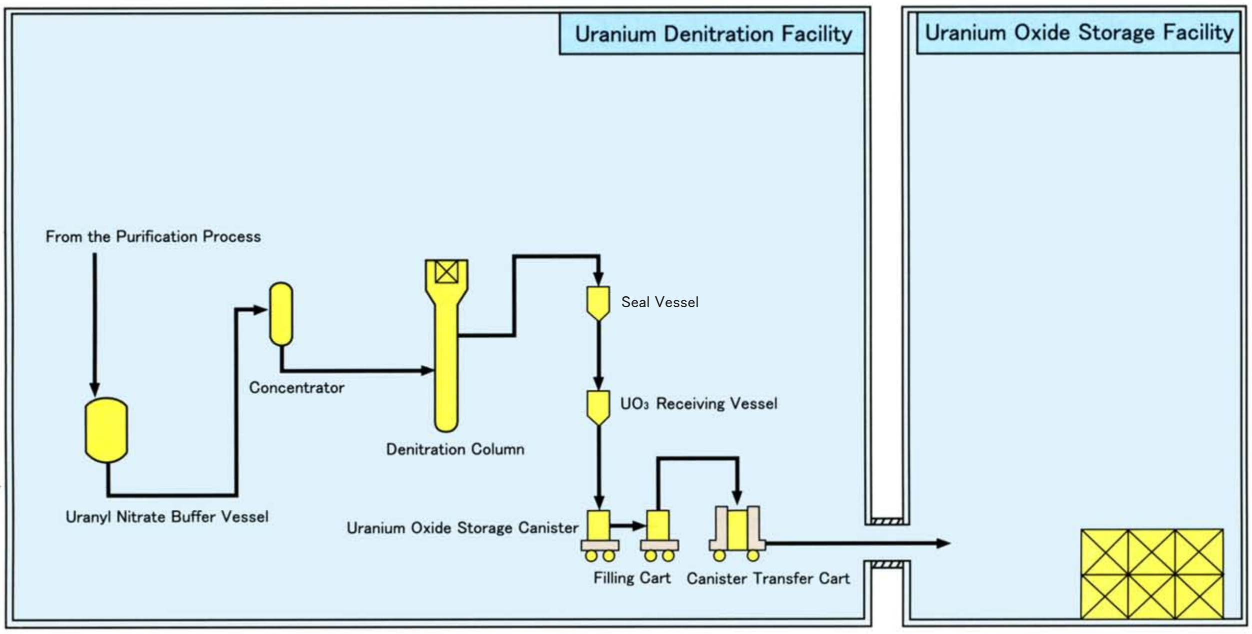
Outline of Mixer Settler

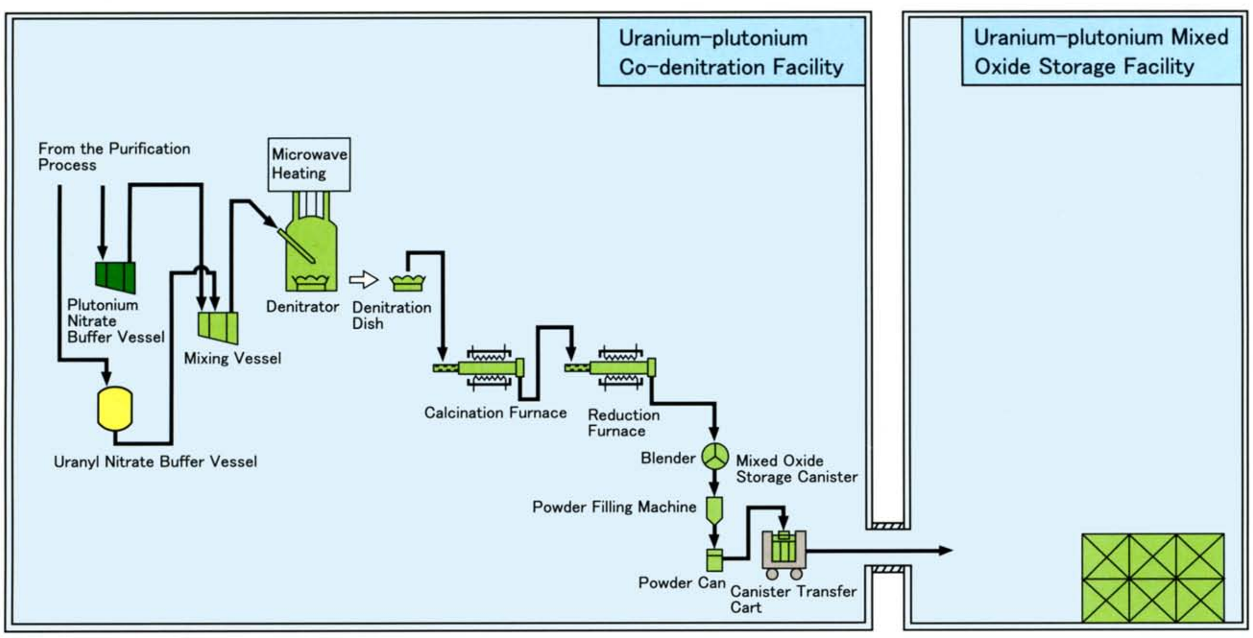
The Mixer Settler is an extractor to perform material movement between two liquid phases (aqueous and organic phases). In the mixer chamber the organic and aqueous phases are mixed by the impeller, and in the settler chamber the mixed phases are settled to create difference of density. As a result, the desired substances are extracted and separated. A single mixer settler consists of several stages, each containing a set of mixer and settler chambers.

while most of fission products remain in the nitric acid solution, which is discharged as waste liquid to the Extracted Waste Receiving Vessel via the Diluent Washing Pulsed Column. The organic solvent containing the extracted plutonium is brought into contact in counterflow with nitric acid in the FP Scrubbing Pulsed Column so that the fission products still contained in the organic solvent shift into the nitric acid solution. As a result, impurities in the organic solvent containing plutonium will be rebuced.

When the organic solvent containing the purified plutonium is sent to the Stripping Pulsed Column and brought into contact in counterflow with nitric acid solution containing hydroxylamine nitrate (NH_3OHNO_3), the plutonium is reduced to Pu^{3+} and shifts again to a nitric acid solution as it has happened in the separation process. Then, the plutonium nitrate solution (nitric acid containing plutonium) is sent to the Diluent Washing Mixer Settler and brought into contact with normaldodecane to remove TBP still remaining in the solution, Through the series of operations, a nitric acid solution containing purified plutonium can be obtained. The purified plutonium nitrate solution (nitric acid containing plutonium) is further concentrated in the Plutonium Concentrator.

Denitration and Product Storage





Specifications

Uranium Oxide Storage Facility

Maximum storage capacity: 4,000 t・U

Uranium-Plutonium Mixed Oxide Storage Facility

Maximum storage capacity : 60 t ・(U+Pu)

After fission products have been removed through the separation and purification processes, the uranyl nitrate solution (nitric acid containing uranium) and plutonium nitrate solution (nitric acid containing plutonium) are sent to the denitration process to produce uranium oxide (UO_3) powder and uranium-plutonium mixed oxide (UO_2-PuO_2) powder (referred as MOX powder below).

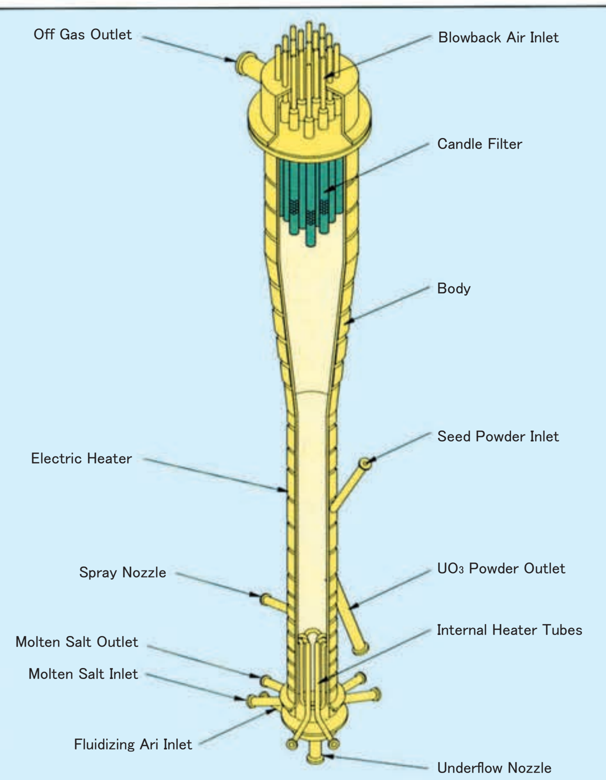
●Uranium Denitration Facility

The uranyl nitrate solution (nitric acid containing uranium) received from the purification process is temporarily stored in the Uranyl Nitrate Buffer Vessel, before it is concentrated in the Concentrator and supplied to the Denitration Column. The Denitration Column is a fluidized-bed reaction tower which thermally decomposes uranyl nitrate solution (nitric acid containing uranium) and produces UO_3 powder. The generated UO_3 powder is sent to the Seal Vessel, then to the UO_3 Receiving Vessel, before it is placed and sealed into Uranium Oxide Storage Canister and transferred to the Uranium Oxide Storage Facility.

●Uranium-plutonium Co-denitration Facility

The plutonium nitrate solution (nitric acid containing plutonium) and uranyl nitrate solution (nitric acid containing uranium) that are respectively received in the Plutonium Nitrate Buffer Vessel and the Uranyl Nitrate Buffer Vessel from the purification process, are blended in the Mixing Vessel in such a member that the concentration of uranium becomes equal to that of the plutonium. Then, some specific amount of the mixed solution is supplied at intervals to the Denitration Dish in the Denitrator, then vaporized, concentrated and denitrated by microwave heating to produce mixed uranium-plutonium denitrated powder.
The mixed uranium-plutonium denitrated powder is heated to approximately 800℃ in the air atmosphere in the Calcination Furnace (calcination), and then heated to approximately 800℃ in the nitrogen-hydrogen mixed atmosphere in the Reduction Furnace (reduction) to produce MOX powder, which is blended by the Blender and loaded into Powder Cans. Then, the Powder Cans are placed and sealed in the MOX Storage Canister and transferred to the Uranium-plutonium Mixed Oxide Storage Facility.

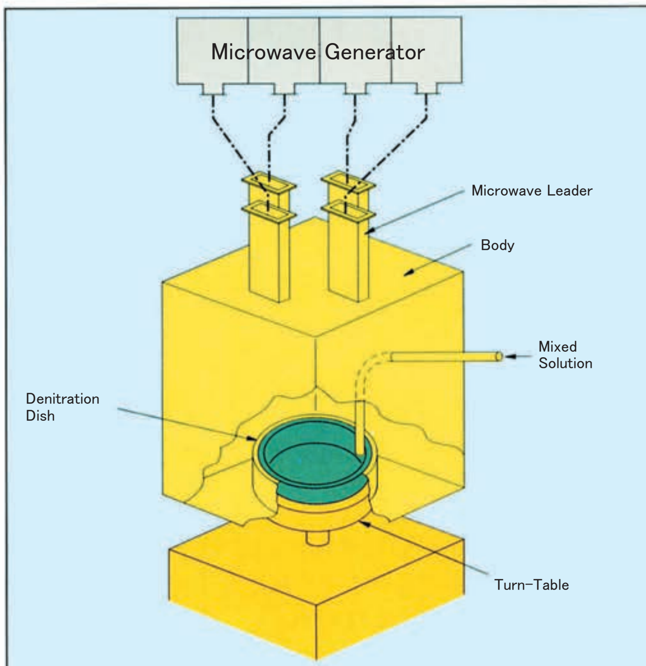
In the product storage process, the UO_3 powder and MOX powder produced in the denitration process are stored until these products are delivered to the fabrication and related facilities.



Outline of the Denitration Column

In the Denitration Column that is installed in the Uranium Denitration Facility, air is supplied from the lower part of the column to form the fluidized bed of the UO_3 powder. The uranyl nitrate solution is sprayed into this fluidized bed from spray nozzles with air, and electric heaters thermally decompose the solution at approximately 300℃.

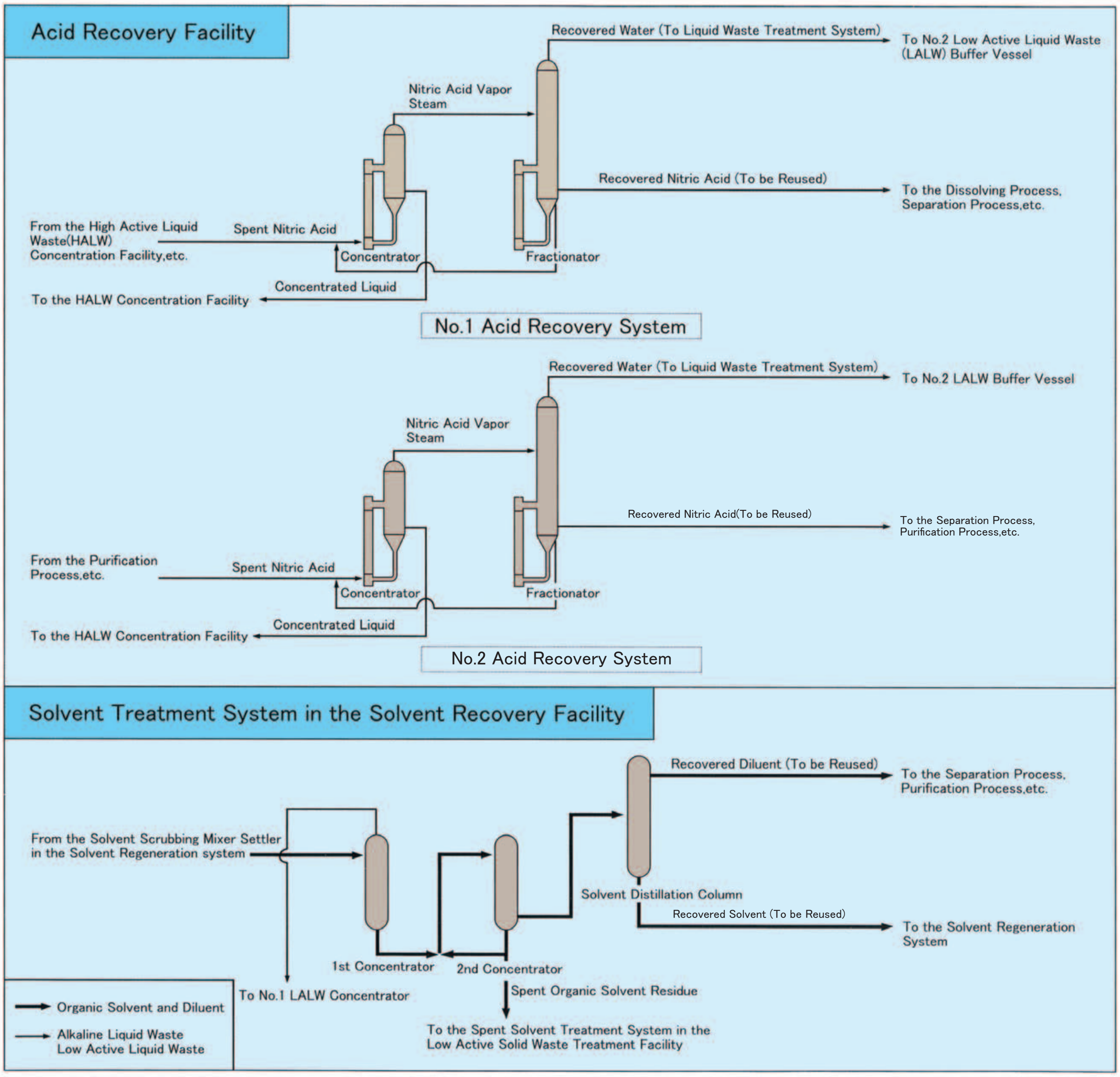
＊ :Fluidized-bed is a state in which particles behave as liquid, when small particles filled in a container are blown with gas from the bottom (UO_3 particles in the case of Uranium Denitration Facility).
For microwave heating, the same frequency is used as microwave oven for home use.



Outline of the Denitrator

In the Denitrator that is installed in the Uranium-plutonium Co-denitration Facility, the mixed solution of the plutonium nitrate solution and the uranyl nitrate solution is surprised into the Denitration Dish, then concentrated and denitrated by microwave.

Recovery of Acid and Solvent



In the reprocessing process, a large amount of nitric acid and organic solvent are used as reagents for chemical processing. The Acid and Solvent Recovery Process is for recycling these reagents as much as possible to minimize the amount of waste produced. The Acid Recovery Facility consists of No. 1 and No. 2 Acid Recovery Systems. The No. 1 Acid Recovery System recovers spent nitric acid produced in the High Active Liquid Waste (HALW) Concentration Facility, etc. The No. 2 Acid Recovery System recovers spent nitric acid produced in the Purification process, etc. In both systems, concentrators and fractionators are the main equipments. The Concentrator evaporates spent nitric acid under reduced pressure so that impurities are concentrated and removed, before acid is separated from water in the Fractionator. The concentrated liquid produced in the Concentrator is returned to the HALW Concentration Facility for treatment.
Solvent Recovery Facility consists of Solvent Regeneration System and Solvent Treatment System.
In the Solvent Regeneration System organic solvent used in the separation and purification process is washed by the mixer settler using sodium carbonate (Na_2CO_3), nitric acid (HNO_3)and sodium hydroxide (NaOH) to remove degraded components from organic solvent. The regenerated organic solvent is reused. In the Solvent Treatment System, part of the washed organic solvent is received by the Solvent Regeneration System, where concentrator removes water and spent organic solvent residue, before the Solvent Distillation Column recovers the diluent (normaldodecane) and solvent (more than approx. 60 % of TBP). The recovered diluent and solvent are reused in the reprocessing process.

Main Equipments

Acid Recovery Facility

- Concentrator
  - (thermosiphon type evaporator under reduced pressure) : 2 sets
    - Material : Stainless Steel
- Fractionator
  - (rack type fractionator under reduced pressure) : 2 sets
    - Material : Stainless Steel

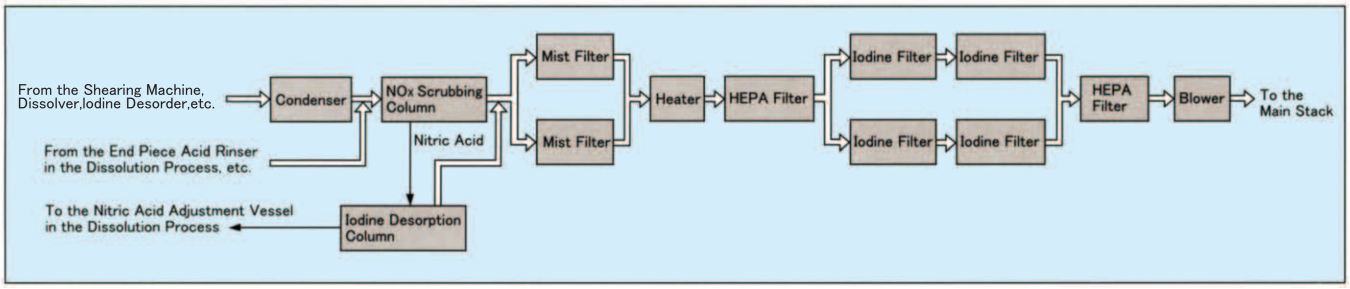
Solvent Recovery Facility

- Mixer settler
  - (Solvent Scrubbing Mixer Settler in the Solvent Regeneration System) : 9 sets
- Concentrator (thin film type Concentrator under reduced pressure) : 2 sets
  - Material : Stainless Steel
- Solvent Distillation Column (filling type distiller under reduced pressure) : 1 set
  - Material : Stainless Steel

Gaseous Waste

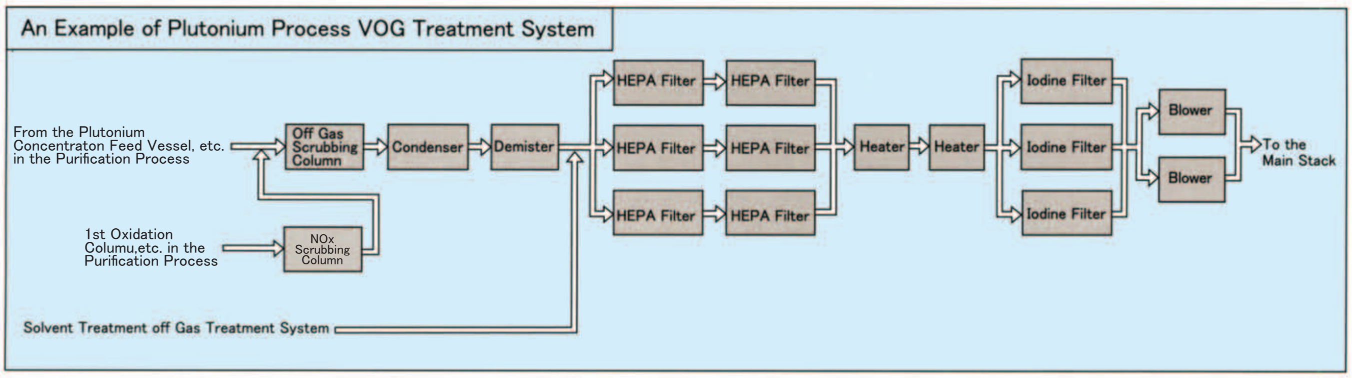
Gaseous waste is mainly treated in the following three facilities, according to the condition of the off gases to be treated.

(1) Shearing Off Gas and Dissolution Off Gas Treatment Facility



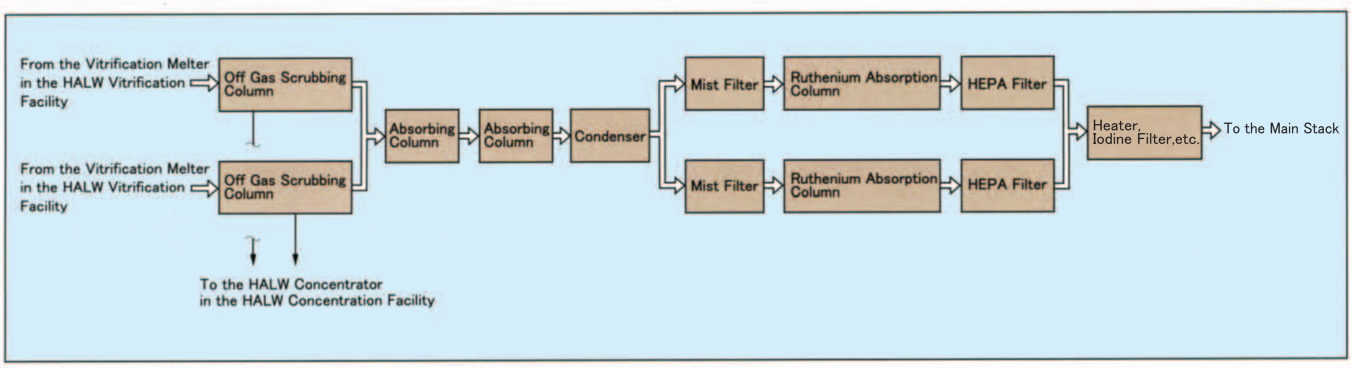
The off gases originated from the Shearing Machine in the shearing process as well as from the Dissolver and Iodine Desorber in the dissolution process are cooled by the Condenser. Then, Nitrogen Oxides (NOx) and radioactive substances are removed from the off gases by the NOx Scrubbing Column, before the gases are treated combining such treatments as filtration by Mist Filter, heating by Heater, filtration by HEPA Filter and removal of Iodine by Iodine Filter.

(2) Vessel Off GasTreatment Facility



VOG in each buildings is treated with the combination of HEPA Filters, Off Gas Scrubbing Column, Condenser, Demister, Heaters and Iodine Filter, according to the condition of the gases.

(3) HALW Vitrification Off Gas Treatment Facility



Off gases originated in the Vitrification Melter in the HALW Vitrification Facility are treated with the combination of washing and cooling by the Off Gas Scrubbing Column, scrubbing by the Absorbing Column, cooling by the Condenser, removing of volatile ruthenium by the Ruthenium Absorption Column, filtrating by HEPA Filter, heating by the Heater and removing iodine by the Iodine Filter.
Liquid Waste originated in the Off Gas Scrubbing Column is returned to the HALW Concentrator in the HALW Concentration Facility for treatment.

Main Equipments

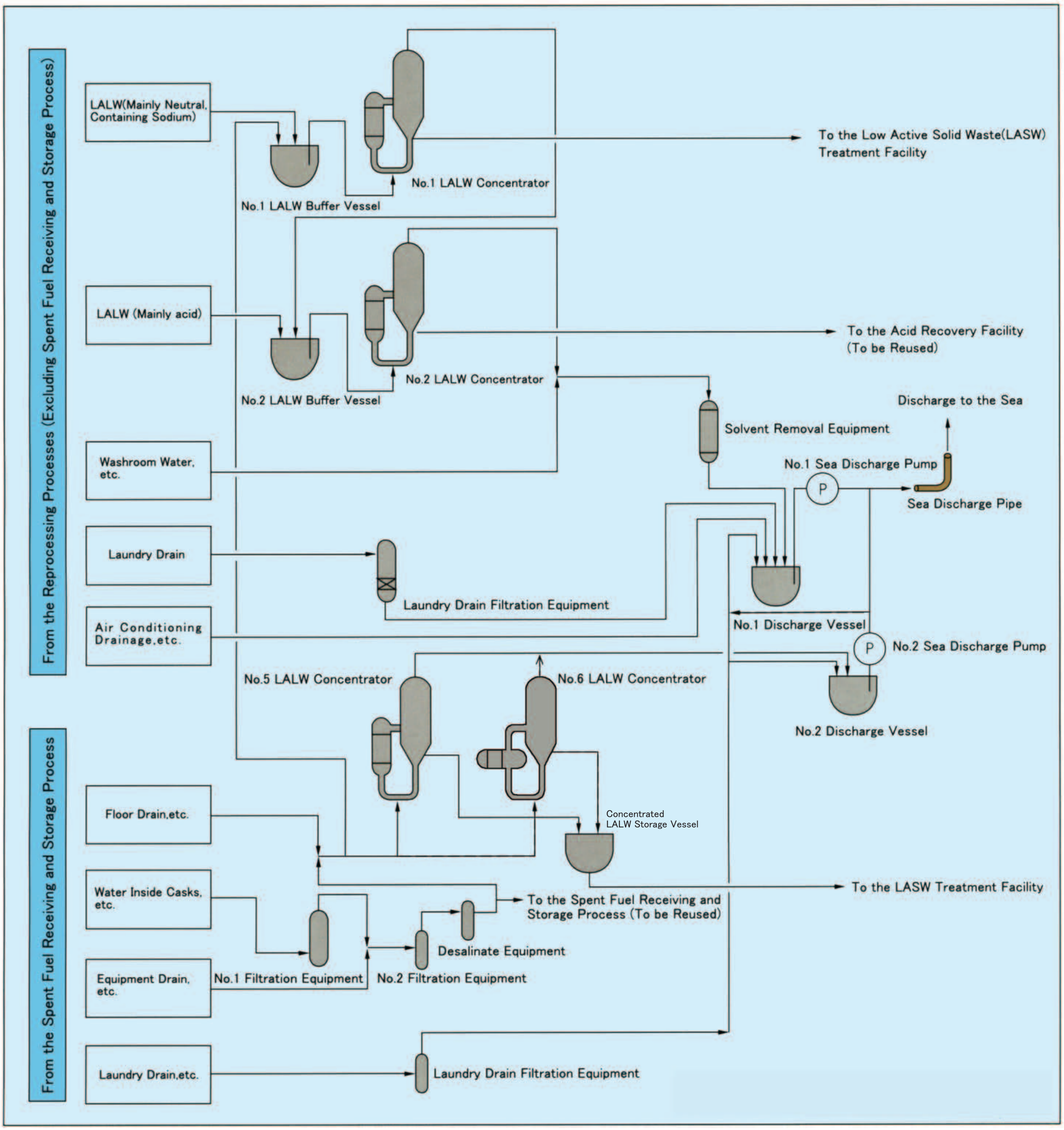
Shearing Off Gas and Dissolution Off Gas Treatment Facility
HEPA Filter : 6 sets(composed of 2 stages)
Particle elimination efficiency : more than 99.9%(0.3μmDOP particle)/stage
Iodine Filter : 12 sets(composed of 2 stages)
Iodine elimination efficiency : more than 99.6%

Vessel Off Gas Treatment Facility HEPA Filter
Particle elimination efficiency : more than 99.9%(0.3μmDOP particle)/stage
Iodine Filter
Iodine elimination efficiency : more than 90%

HALW Vitrification Off Gas Treatment Facility
HEPA Filter
Column type : 4 sets(composed of 2 stages)
Box type : 2 sets
Particle elimination efficiency : more than 99.9%(0.3μmDOP particle)/stage
Iodine Filter : 2 sets
Iodine elimination efficiency : more than 90%

Liquid Waste

(Low Active Liquid Waste (LALW))

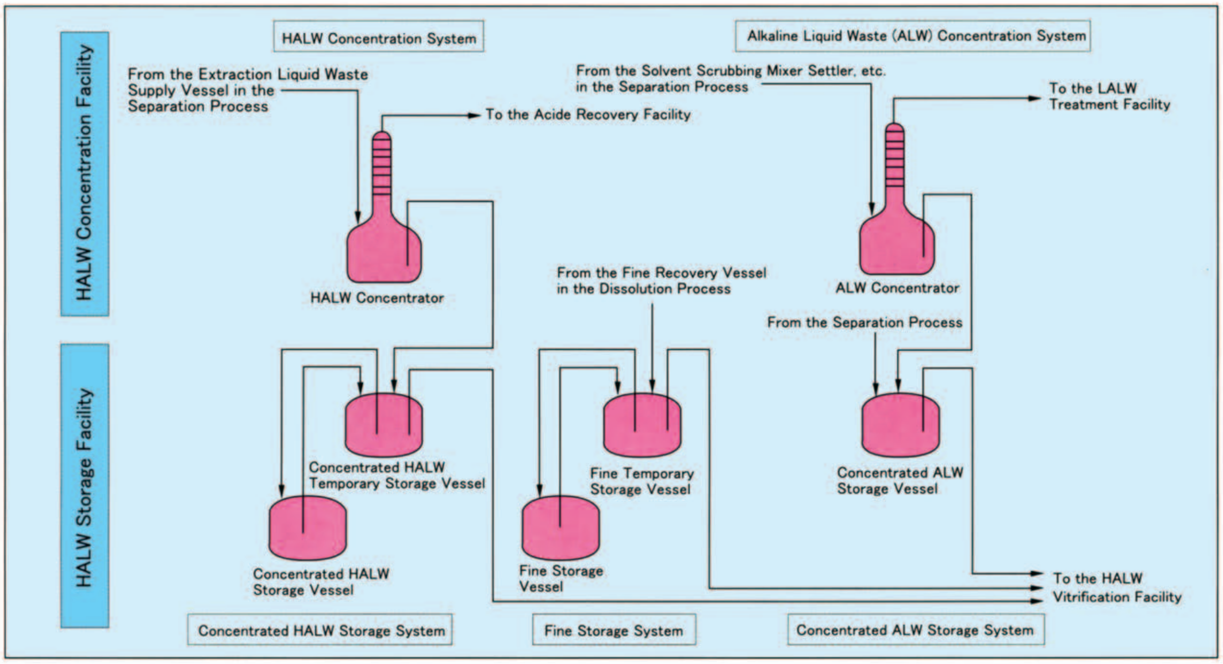


Low Active Liquid Waste (LALW) is classified according to its conditions (acid or neutral, containing Salt (Na) or not, etc.) and treated by the LALW concentrator, filters and other equipment. After treatment, liquid waste is measured for concentration of radioactive substances, hydrogen ion concentration (pH) and other elements to confirm that they are below the specified values. Finally, the liquid waste is discharged into the ocean.

Main Equipments

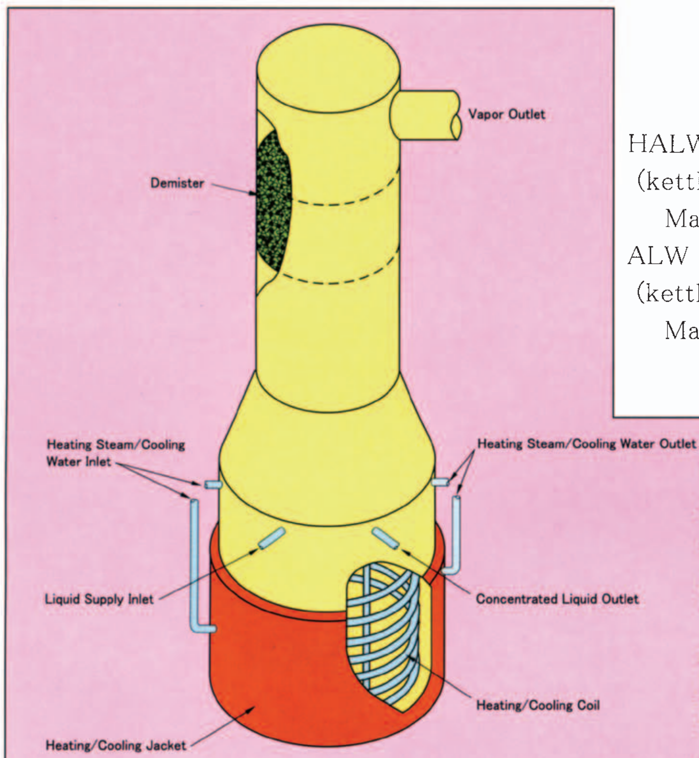
LALW Concentrator (thermosiphontype) : 3 sets
Material : Stainless Stterl
LALW Concentrator (forced circuration type) : 1set
Material : Nickel Alloy

Liquid Waste
(High Active Liquid Waste (HALW))



The HALW treatment process consists of HALW Concentration Facility and the HALW Storage Facility Reservoirs.

The HALW Concentration Facility consists of the HALW Concentration System and the Alkaline Liquid Waste (ALW) Concentration System. The HALW Storage Facility consists of the Concentrated HALW Storage System, Fine Storage System and Concentrated ALW Storage System. The different types of liquid waste are evaporated and concentrated in adequate system and stored in proper vessel, according to their conditions. For example, the extraction liquid waste originated from the separation process and the scrubbing liquid waste originated from the Off Gas Scrubbing Column in the HALW Vitrification Off Gas Treatment Facility are treated by the HALW Concentrator, while liquid waste originated from equipments such as the Solvent Scrubbing Mixer Settler in the separation process is treated by the ALW Concentrator.



Outline of HALW Concentrator

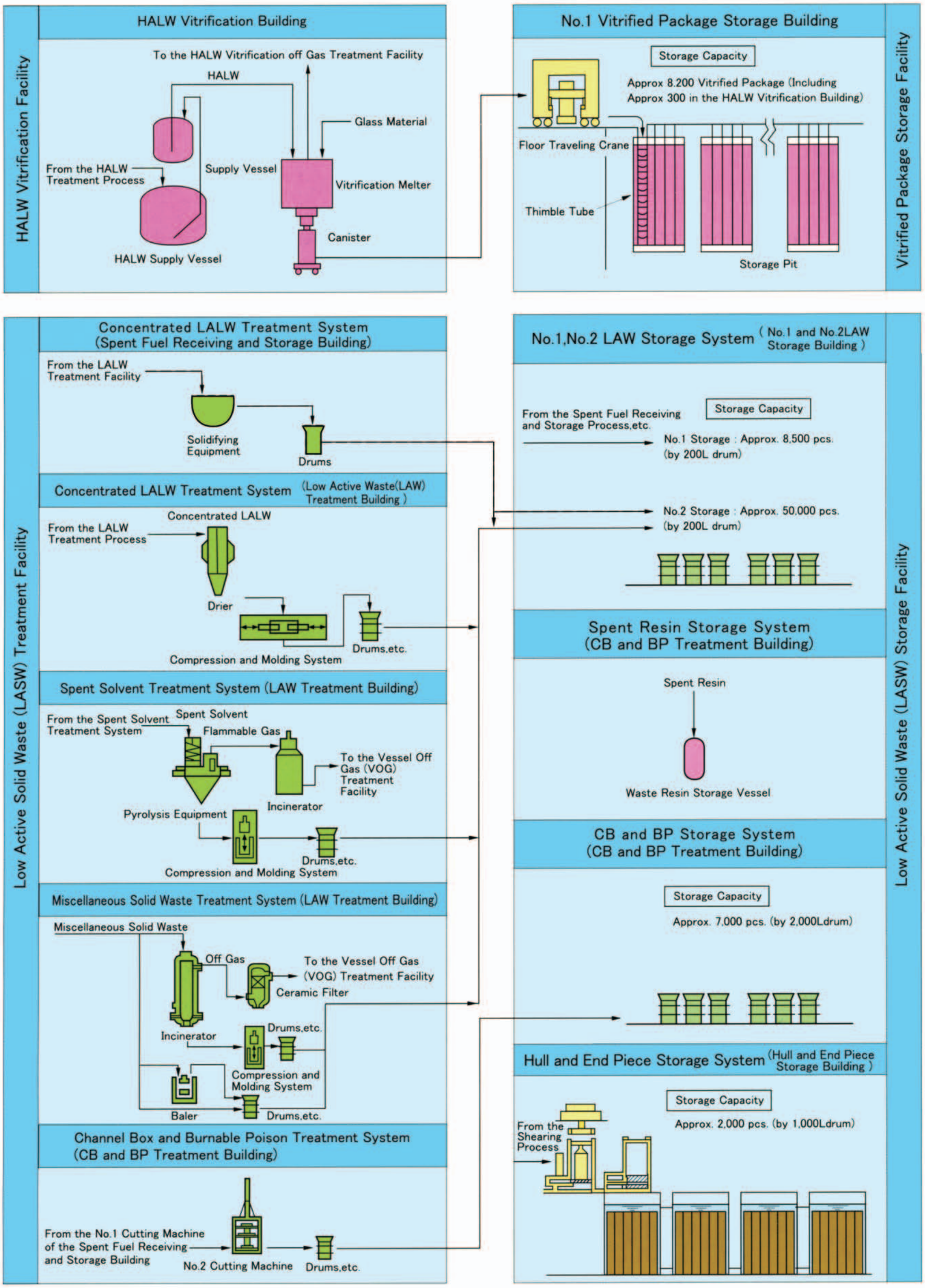
Main Equipments

HALW Concentrator
(kettle type evaporator under reduced pressure) : 2 sets
Material : Stainless Steel

ALW Concentrator
(kettle type evaporator under normal pressure) : 1 set
Material : Stainless Steel

The HALW Concentrator is exposed to a corrosive environment. Therefore, the operating temperature is reduced to approximately 50℃ through evaporation under reduced pressure of approximately 50 mmHg. To remove decay heat originated from waste liquid inside the Concentrator, the system is designed to supply cooling water appropriately to the Heating/Cooling Coil and the Heating/Cooling Jacket when the Concentrator is not operation.

Solid Waste



HALW Vitrification Facility
HALW Vitrification Building
To the HALW Vitrification off Gas Treatment Facility
HALW
Glass Material
From the HALW Treatment Process
Supply Vessel
Vitrification Melter
Canister
HALW Supply Vessel
No.1 Vitrified Package Storage Building
Storage Capacity
Approx 8,200 Vitrified Package (Including Approx 300 in the HALW Vitrification Building)
Floor Traveling Crane
Thimble Tube
Storage Pit
Vitrified Package Storage Facility
Low Active Solid Waste (LASW) Treatment Facility
Concentrated LALW Treatment System (Spent Fuel Receiving and Storage Building)
From the LALW Treatment Facility
Solidifying Equipment
Drums
Concentrated LALW Treatment System (Low Active Waste(LAW) Treatment Building)
Concentrated LALW
From the LALW Treatment Process
Drier
Compression and Molding System
Drums,etc.
Spent Solvent Treatment System (LAW Treatment Building)
From the Spent Solvent Treatment System
Spent Solvent
Flammable Gas
To the Vessel Off Gas (VOG) Treatment Facility
Incinerator
Pyrolysis Equipment
Drums,etc.
Compression and Molding System
Miscellaneous Solid Waste Treatment System (LAW Treatment Building)
Miscellaneous Solid Waste
Off Gas
To the Vessel Off Gas (VOG) Treatment Facility
Ceramic Filter
Incinerator
Drums,etc.
Compression and Molding System
Baler
Drums,etc.
Channel Box and Burnable Poison Treatment System (CB and BP Treatment Building)
From the No.1 Cutting Machine of the Spent Fuel Receiving and Storage Building
No.2 Cutting Machine
Drums,etc.
No.1,No.2 LAW Storage System (No.1 and No.2LAW Storage Building)
From the Spent Fuel Receiving and Storage Process,etc.
Storage Capacity
No.1 Storage : Approx. 8,500 pcs. (by 200L drum)
No.2 Storage : Approx. 50,000 pcs. (by 200L drum)
Spent Resin Storage System (CB and BP Treatment Building)
Spent Resin
Waste Resin Storage Vessel
CB and BP Storage System (CB and BP Treatment Building)
Storage Capacity
Approx. 7,000 pcs. (by 2,000Ldrum)
Hull and End Piece Storage System (Hull and End Piece Storage Building)
Storage Capacity
Approx. 2,000 pcs. (by 1,000Ldrum)
From the Shearing Process
Low Active Solid Waste (LASW) Storage Facility

High Active Liquid Waste (HALW), Concentrated Low Active Liquid Waste (LALW), Spent Solvent and Miscellaneous Solid Waste originated in the reprocessing plant are processed according to their condition, placed in canisters or drums and temporarily stored.

●HALW Vitrification Facility

In this facility, the composition of the HALW received from the HALW treatment process is adjusted as required, before the liquid waste is sent to the Supply Vessel, then transferred to the Vitrification Melter where the liquid waste is melted together with glass material at 1,100～1,200℃. The melted glass is injected into the canister, and after the lid is welded shut, the canister is transferred to the Vitrified Package Storage Facility.

●Vitrified Package Storage Facility

This facility receives vitrified waste from the HALW Vitrification Facility and stores it temporarily. The facility has the storage capacity of approximately 8,200 vitrified packages.

●Low Active Solid Waste (LASW) Treatment Facility

(1) Concentrated Low Active Liquid Waste (LALW) Treatment System

Concentrated LALW received from the LALW treatment process is dried by the Drier, compressed and molded or solidified, then loaded into drums.

(2) Spent Solvent Treatment System

Spent solvent originated from the Solvent Treatment System is mixed with calcium hydroxide, then pyrolyzed by the Pyrolysis Equipment and separated into phosphate and flammable gas. The phosphate is removed from the Pyrolysis Equipment, compressed and molded, then loaded into drums. The flammable gas is sent to the incinerator and burned.

(3) Miscellaneous Solid Waste Treatment System

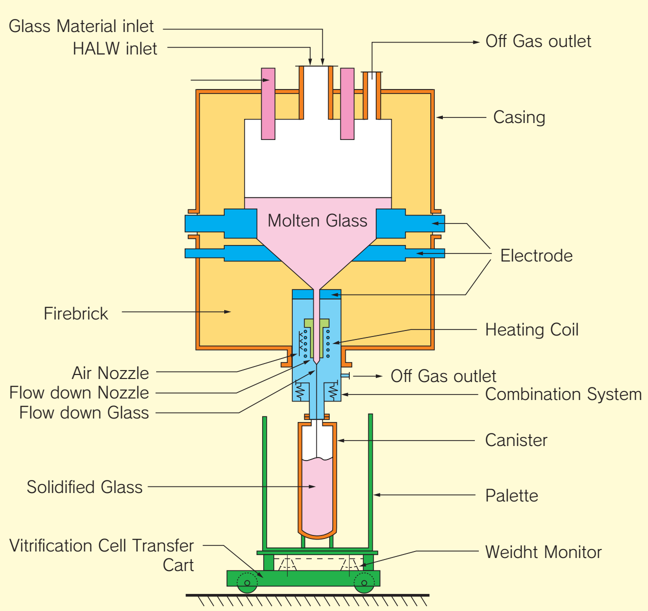
Paper, filters, pumps and other miscellaneous solid waste from the facilities are incinerated or compressed to reduce volume, then loaded into drums.

(4) Channel Box and Burnable Poison (CB and BP) Treatment System

The channel box and burnable poison are removed from the spent fuel assembly in the CB and BP Handling Pit in the Spent Fuel Receiving and Storage Building, prior to be cut by the No. 1 Cutting Machine located in the CB and BP Handling Pit. Then they are cut by the No. 2 Cutting Machine located in the CB and BP Treatment Building and finally loaded into drums.

●Low Active Solid Waste (LASW) Storage Facility

The LASW Storage Facility stores the solid waste treated by the facilities (1)～(4) mentioned above. The Facility consists of the No. 1 LAW Storage System, No. 2 LAW Storage System, Spent Resin Storage System, CB and BP Storage System and Hull and End Piece Storage System.



Outline of Vitrification Melter

In the Virtification Melter, electric current passes directly through the glass by using electrode installed in the furnace, and it melts by the generating heat of Joule. The molten glass in a Vitrification Melter is poured into the canister by heating the flow-down nozzle located at the lower part of casing.

Central Control Room

The Processes progressing in different locations dispersed in the reprocessing plant site are operated and monitored intensively from the Central Control Room.

The Central Control Room consists of monitoring control panels located on six islands and a process computer. Its remarkable features are digital control system capable of rational processing of a huge amount of data and the man-machine system based on the sophisticated CRT operation.

Based on the highly reliable and safe instrumentation and control system, the central control room is an large facility for its kind.

To support smooth operation of the reprocessing plant, the Total Data Management System (TDMS) is provided for processing and intensive management of information that must be controlled for the plant as a whole.

Analysis Facility

The Analysis Facility gathers, transfers and analyzes samples for process control and safety ensuring of the reprocessing plant, and treats post-analyzed solutions and other chemicals.

The analysis samples are transferred mainly by the air transfer pipings to the specified glove boxes etc. located in the Analytical Laboratory and other buildings. According to the condition and radiation dose of the samples, analysis is performed in the analysis cells, glove boxes or hoods.

- Analysis cell: To analyse samples with high dose gamma radiation (dissolved solution, etc.)
- Glove box: To analyse samples with low dose gamma radiation (low active liquid waste, etc.)
- Hood: To analyse samples with very low dose gamma radiation (treated liquid waste, etc.)

IV Safety Measures

The safety of the Reprocessing Plant is ensured by adopting the latest and the best technology developed through the long experiences accumulated both in Japan and overseas. Staying in conformity with the authorities safety regulations, all measures will be considered to ensure the safety of the reprocessing plant. The main safety measures of the facility are as follows.

(1) Safety Design

The Reprocessing Plant adopts every possible safety measure against postulated incidents such as fire, explosion, criticality accident, leakage, etc. The principle of these measures is to secure the safety of people in the vicinity of the plant. With this aim in view, the plant is designed on the basis of "Multiple Protection" Policy which consists of the following 3 concepts;

1. Prevent occurrence of incidents,
2. Prevent expansion of incidents when they occur, and
3. Mitigate the consequences to the surrounding area in accidental situation.

(2) Critical Safety

① Prevention of occurrence

The Reprocessing Plant is designed to prevent criticality by means of controlling dimensions of equipments, concentration, mass and isotope composition of Uranium and Plutonium, and combinations of these means.

② Prevention of expansion of incidents

The allowable limits related to concentration,etc, and the Reprocessing Plant is designed to stop its operation automatically before values such as concentration reach the allowable limits.

③ Mitigation of consequences to environment

Thick concrete wall (approx. 1m) shields radiation generated by criticality.

(3) Leakage Safety

① Prevention of occurrence

Systems and equipments containing radioactive materials are designed to prevent leakage by means of adoption of anti-corrosive materials and anti-leak structure such as welding.

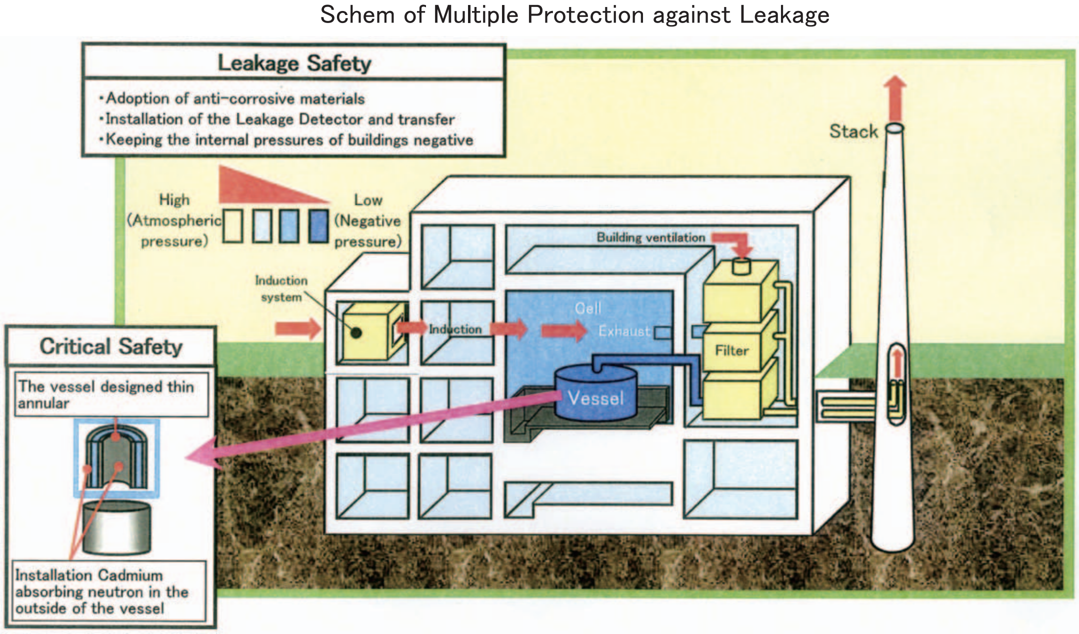
② Prevention of expansion of incidents

Cells in which systems and equipments containing radioactive solutions are installed have drip trays.

③ Mitigation of consequences to environment

Should radioactive materials leak out on drip tray, the leakage is found by the Leakage Detector, transferred and treated safely. The internal pressures of cells and buildings are usually kept negative to prevent leakage of gas containing radioactive materials to environment.

Schem of Multiple Protection against Leakage



(4) Fire and Explosion Safety

① Prevention of occurrence

The Reprocessing Plant is kept lower temperature than flash point of organic solvent. And any source of fire is eliminated by earth etc.

② Prevention of expansion of incidents

Should the temperature approach the flash point, the heating is automatically stopped.

③ Mitigation of consequences to environment

Fire Detectors and Fire Extinguish Facilities are installed in consideration of materials used in the area. The refractory walls are prepared to prevent spread of fire.

V Center For Research & Development

With the aim of improving the safety, reliability and economical efficiency of the Reprocessing Plant, the following items are listed as research and development subjects, without implicating either uranium or plutonium;

1) Improvement and development concerning maneuverability of the important pre-treatment devices in the Reprocessing Plant.
2) Improvement and development concerning the remote maintenance and repair technology to improve the availability factor and reliability.
3) Improvement and development of the operating techniques to support the operation of the Reprocessing Plant.

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