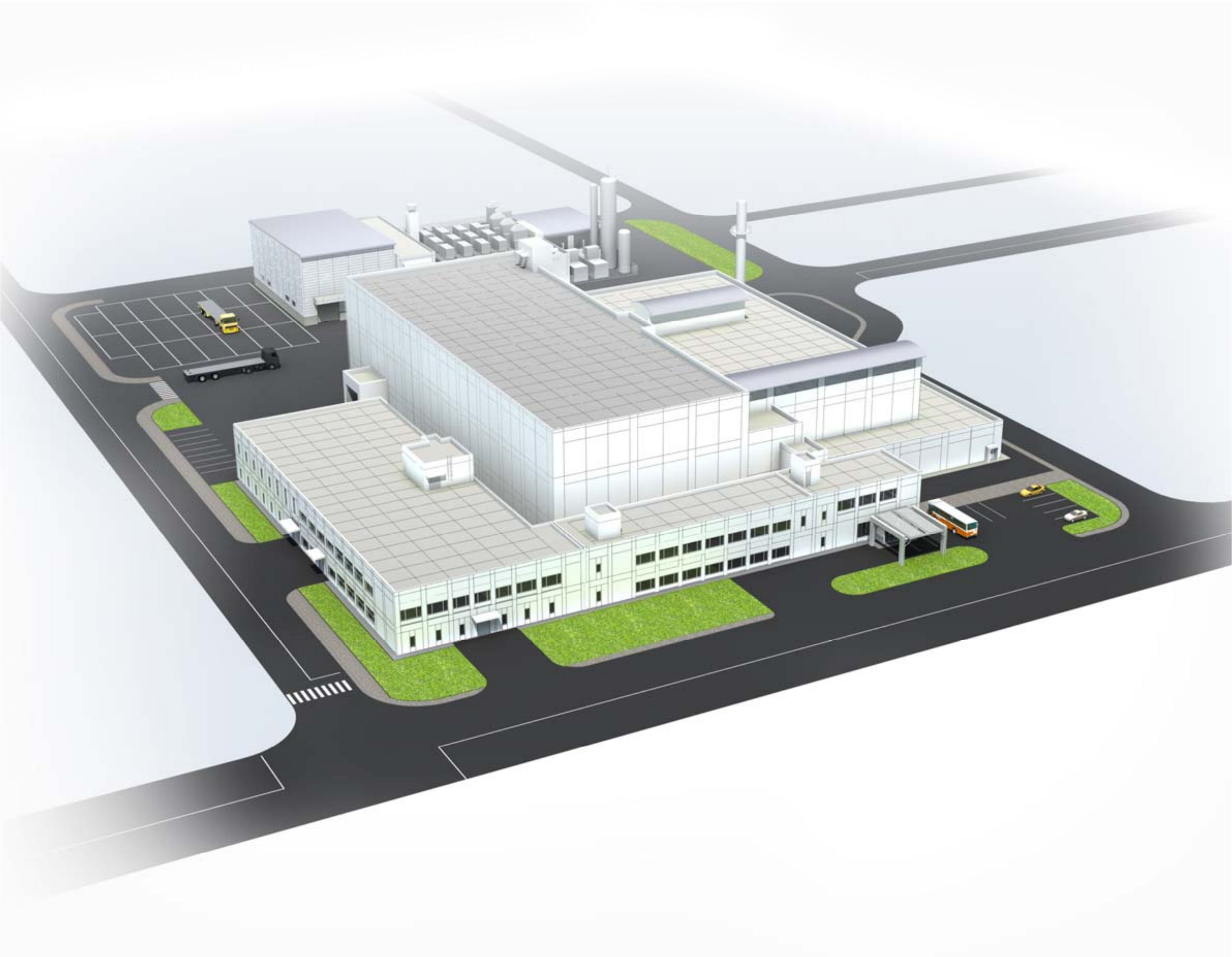
JNFL MOX Fuel Fabrication Plant (J-MOX)



JAPAN NUCLEAR FUEL LIMITED

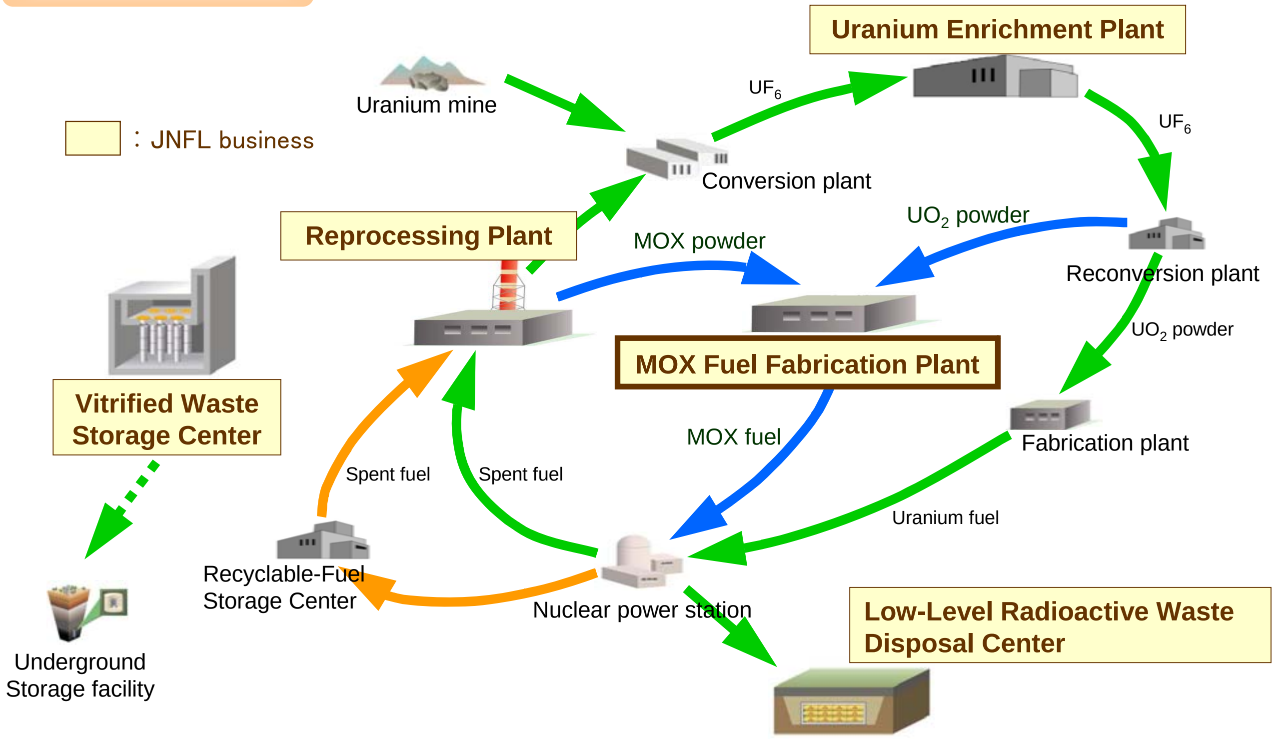
JNFL's MOX fuel fabrication plant (J-MOX) is the plant designed to fabricate MOX fuel assemblies for domestic Light Water Reactors (BWR and PWR) in Japan.

The J-MOX plant, together with the Rokkasho Reprocessing Plant (RRP), is the important facility in order to complete the nuclear fuel cycle in Japan.

Outline of the J-MOX	
Product	MOX fuel assembly for domestic light-water reactors (BWR and PWR)
Maximum fabrication capacity	130 tons HM*/year
Size of main building	Approx.85m x 85m, 2 above-ground levels and 3 underground levels
Completion	October, 2017

* "t-HM" stands for "tons of heavy metal" which indicates the weight of plutonium and uranium metallic content in MOX.

Nuclear fuel cycle



The details of the J-MOX project	
August 24, 2001	JNFL requested cooperation for the construction of MOX Fabrication Plant to Aomori prefecture and Rokkasho village.
April 19, 2005	"The Basic Cooperation Agreement for the construction of MOX Fuel Fabrication Plant" was concluded with Aomori prefecture and Rokkasho village.
April 20, 2005	JNFL applied the license for the approval to MOX fuel fabrication business.
May 13, 2010	The approval was granted on MOX fuel fabrication business.

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MOX fuel fabrication processes

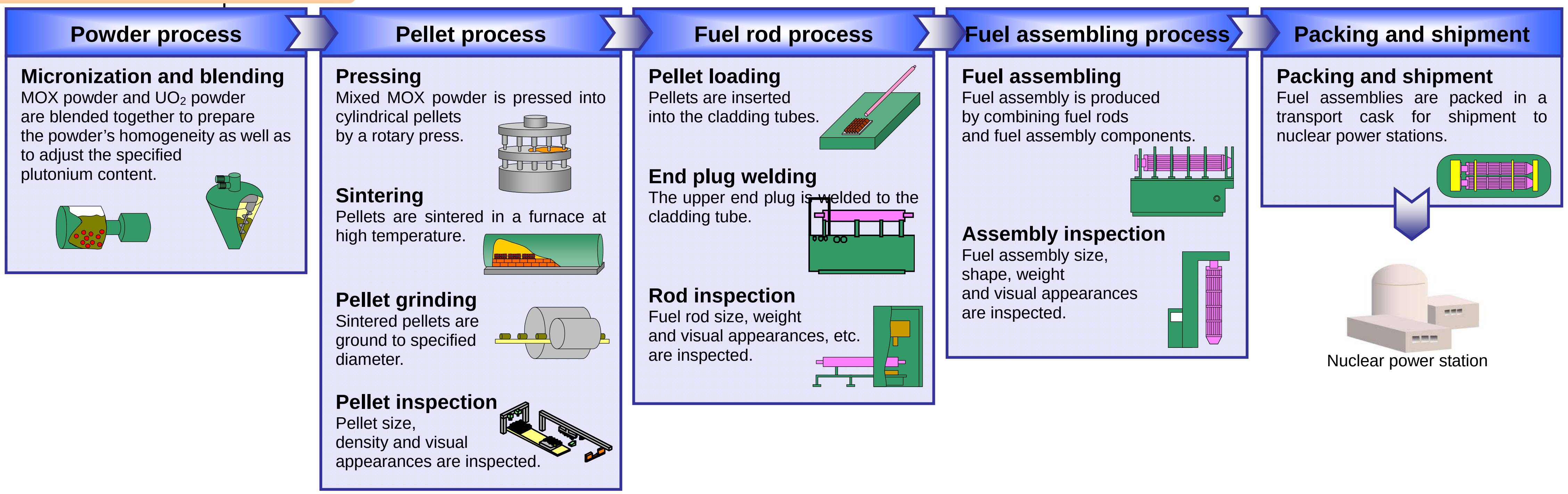
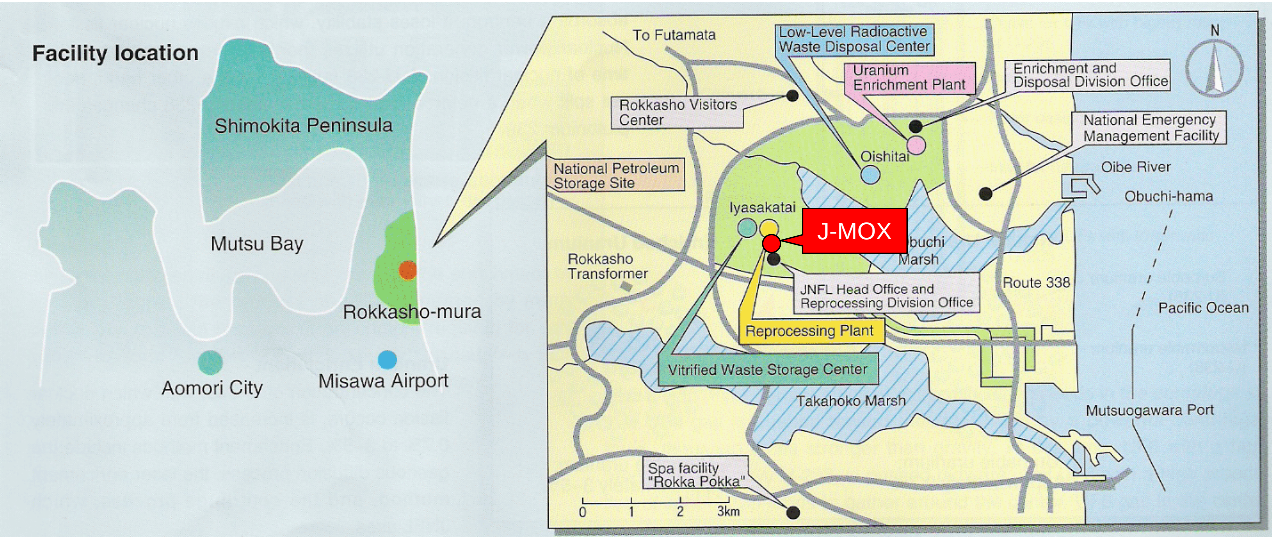


Image of MOX fuel

PWR fuel assembly
Length approx. 4m
Weight approx. 700kg

Pellets



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ROKKASHO REPROCESSING PLANT

JAPAN NUCLEAR FUEL LIMITED

Introduction

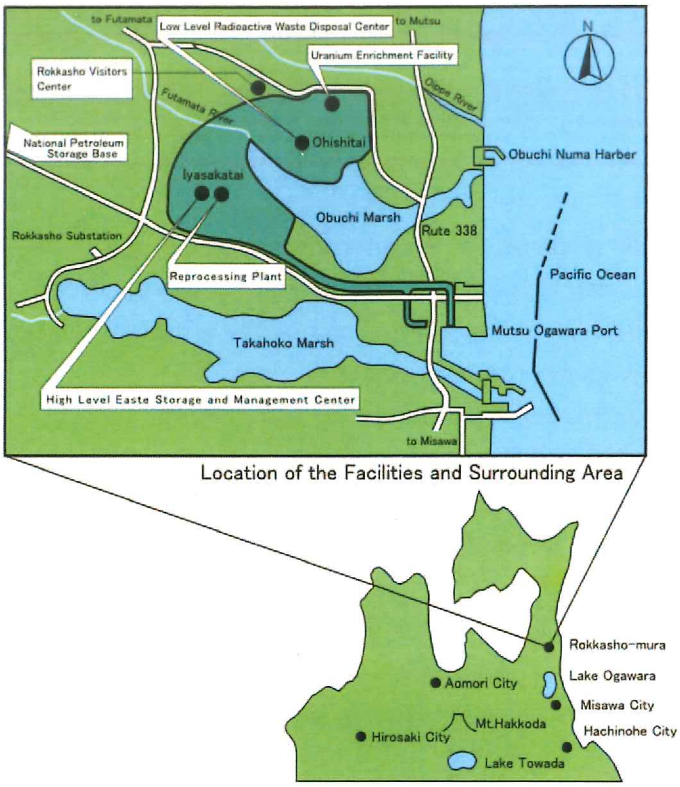
There exists a system by which Japan, country scarce in energy resources, can extract reusable uranium and plutonium from fuels spent in nuclear power plants that valuable uranium resources can be more effectively utilized. Such system is called ″reprocessing″. Because recycle of reprocessed uranium 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).

Contents

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 fy 2021: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.

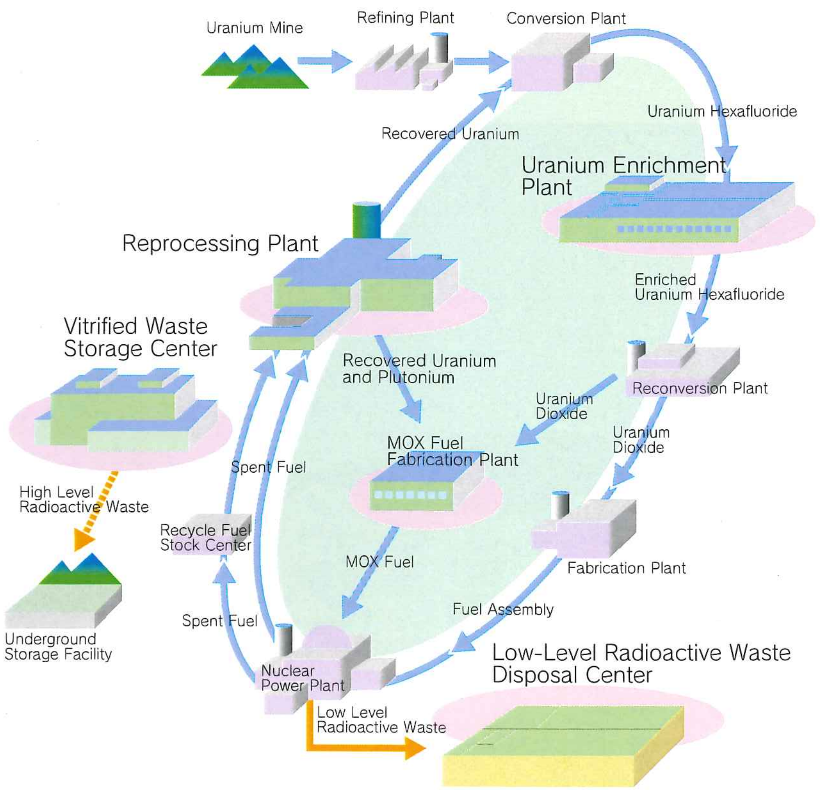
Then, the spent fuel is reprocessed to extract residual uranium as well as plutonium which has been produced during irradiation, in order to use them once more to feed nuclear power plants. This stream is called "nuclear fuel cycle".

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.

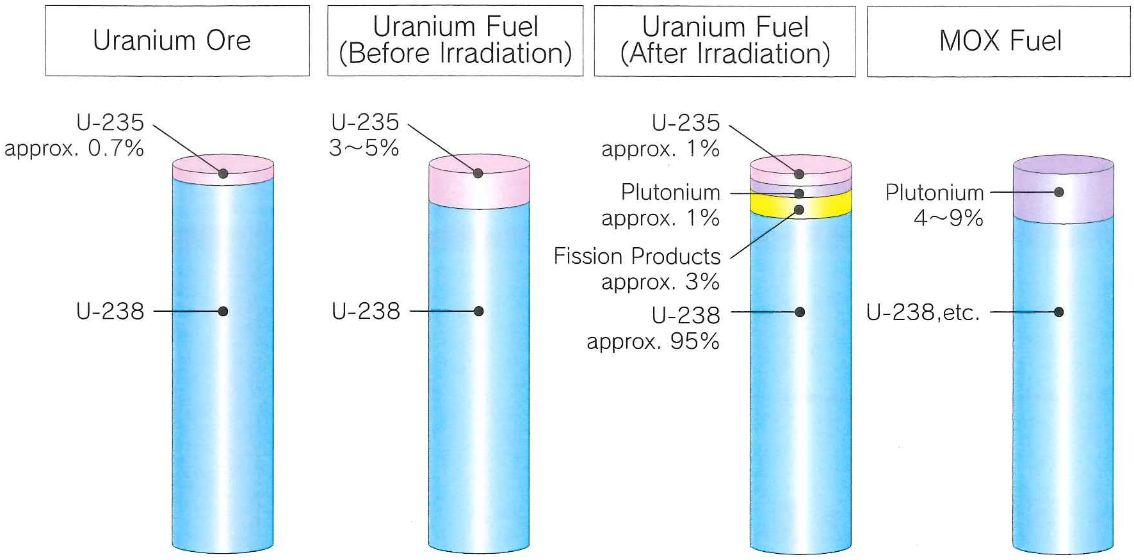
Uranium fuel for light water reactors contains 3 ～ 5 % of fissionable uranium, U-235. The rest is non-fissionable uranium, U-238. There remains still about 1 % of U-235 in spent fuel after 3 ～ 4 years of service in a reactor. 1 % represents substantial quantity, compared with the initial quantity which 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.

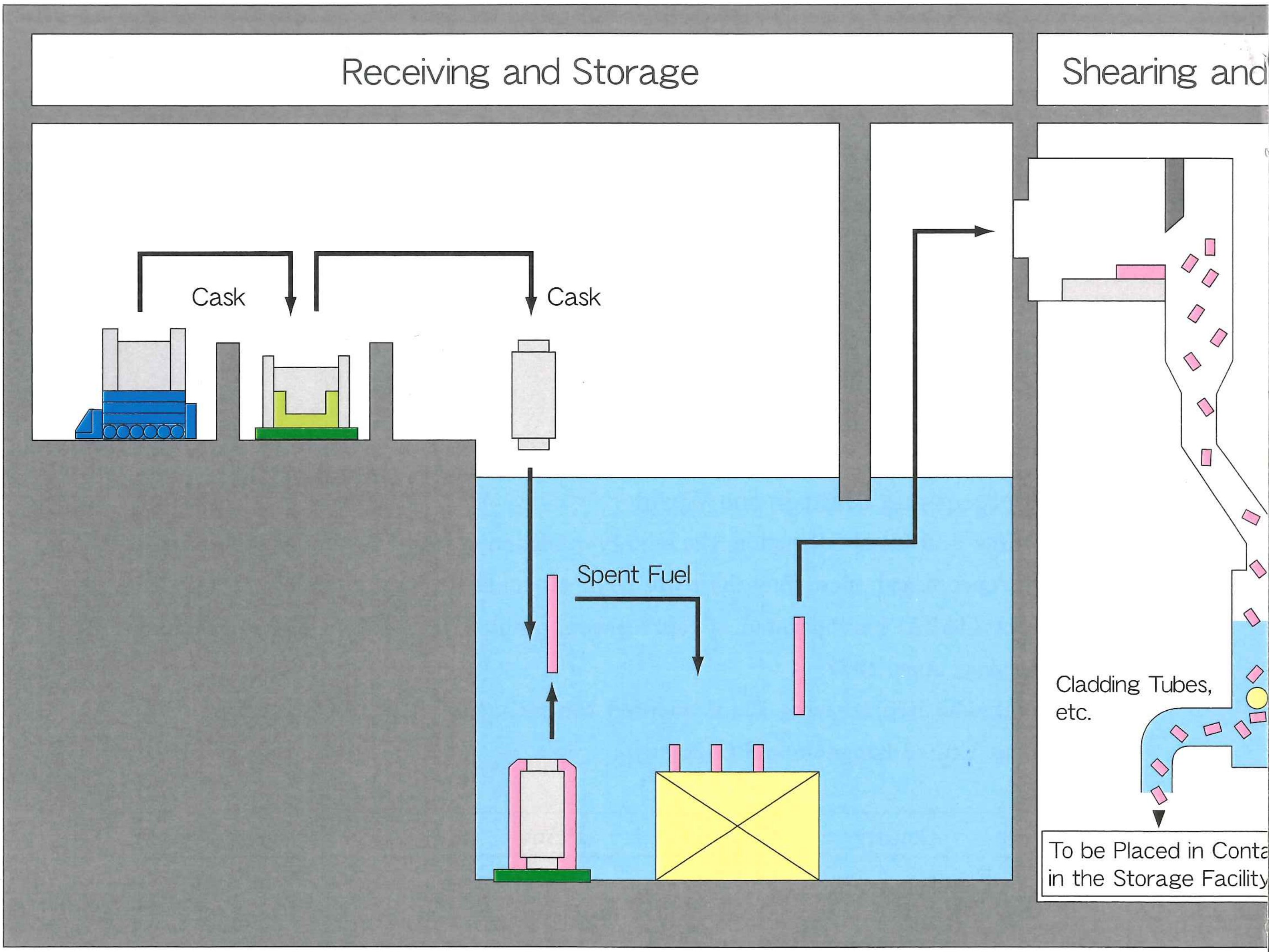
Rokkasho Reprocessing Plant adopted the technology and the experience of JAEA, France, United Kingdom and Germany.

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)

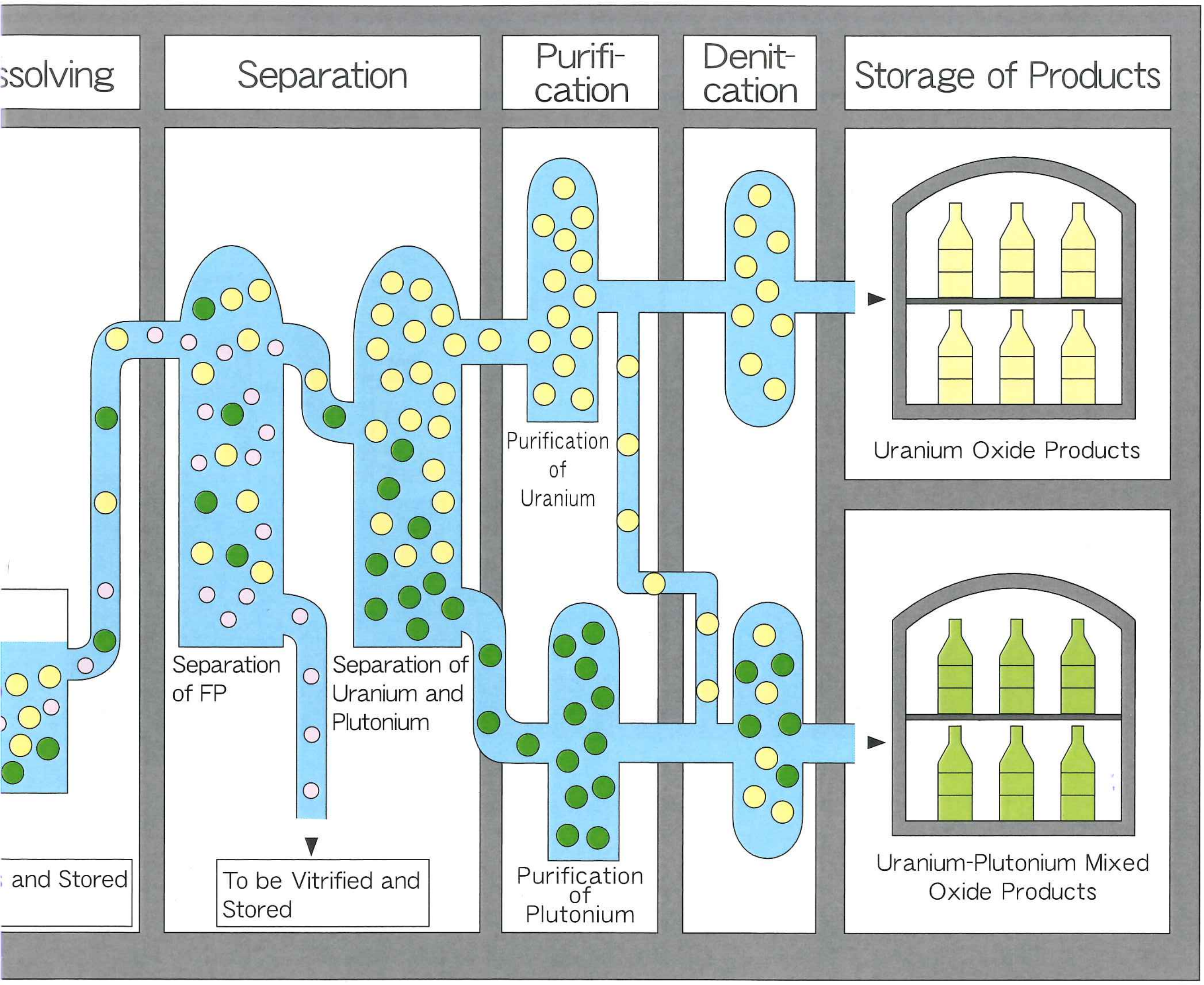
Ⅲ Reprocessing Plant

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.



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

Specifications of Spent Fuel to be Reprocessed

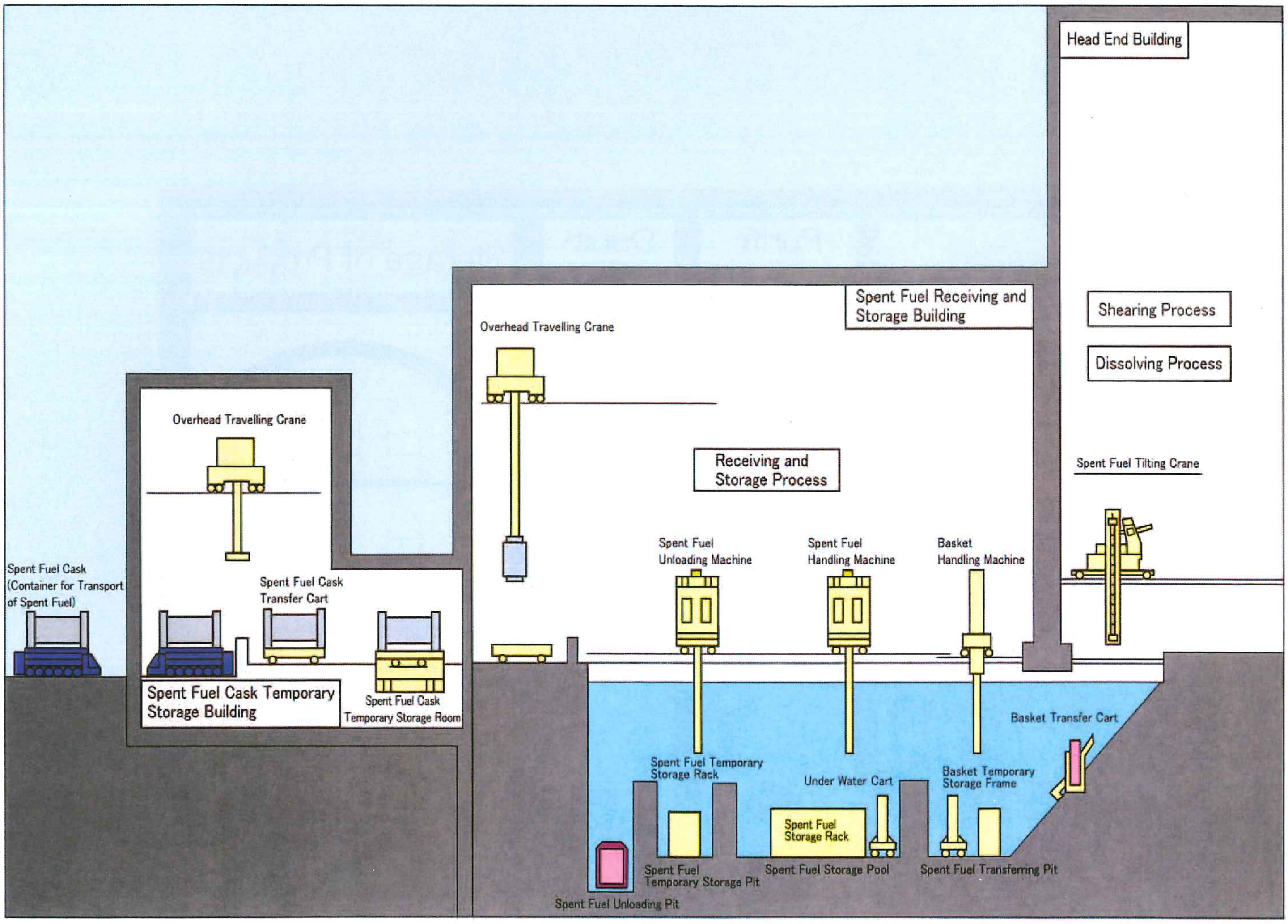
a. Enrichment of U-235
   Maximum Enrichment before Irradiation : 5 wt %
   Average Enrichment of Spent Fuel Assembly : less than 3.5wt %

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.

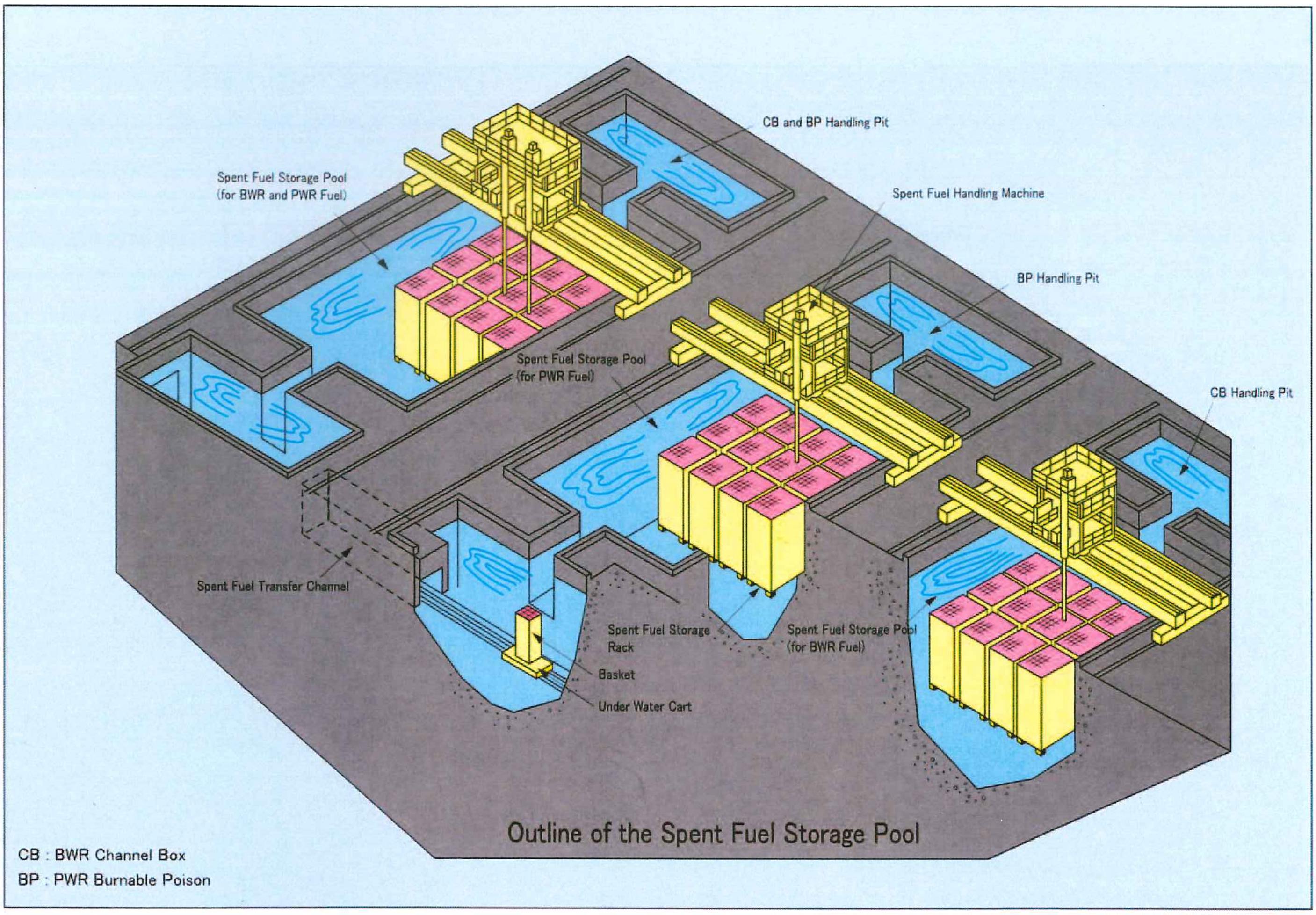
Receiving and Storage of Spent Fuel



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 lrradiation : 5 wt %

Average Enrichment of Spent Fuel Assembly : less than 3.5 wt %

(b) Cooling Time : more than 1 year

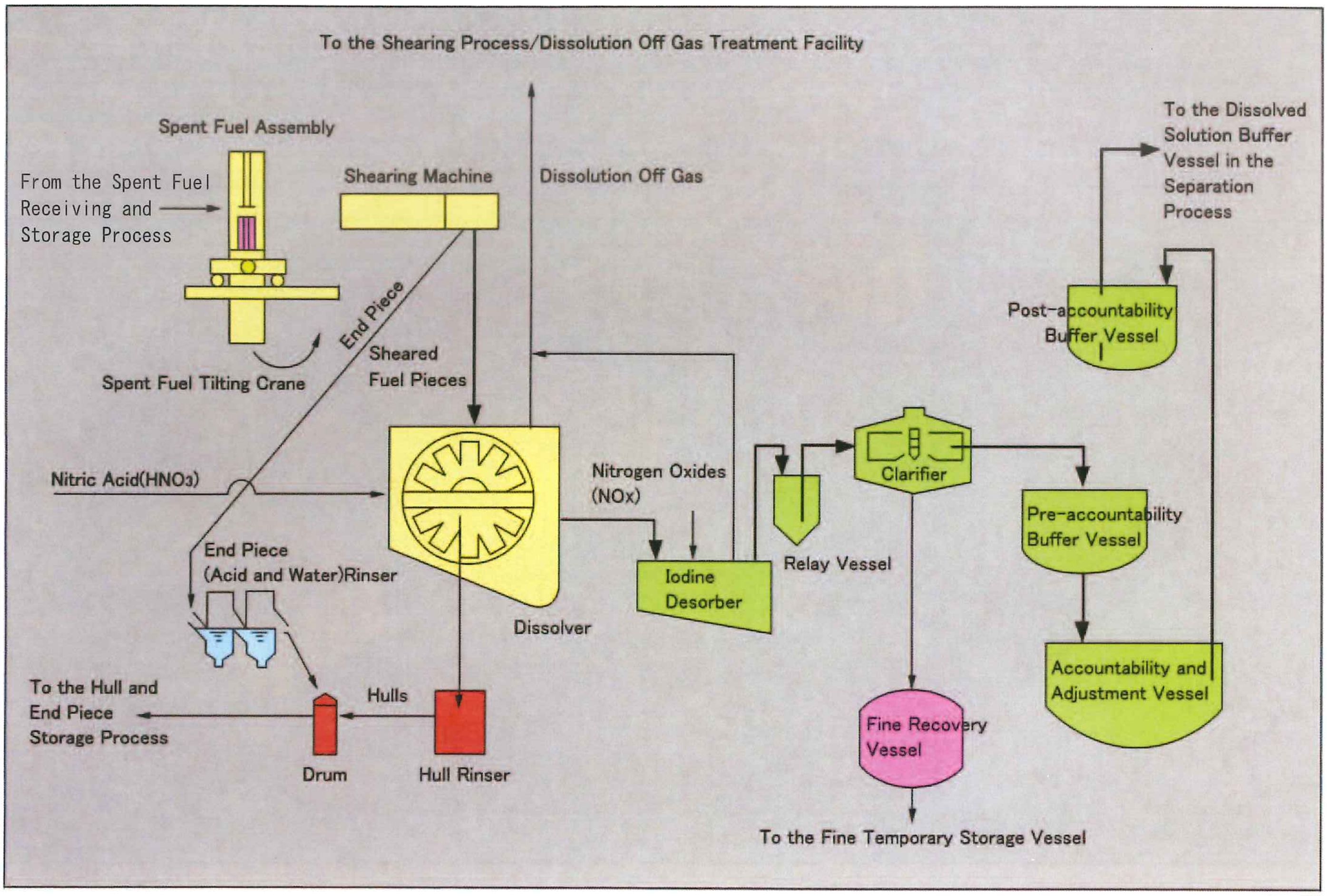
(c) Maximum Burnup of Spent Fuel Assembly : 55,000 MWd/t・U_{Pr}

＊ :

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.

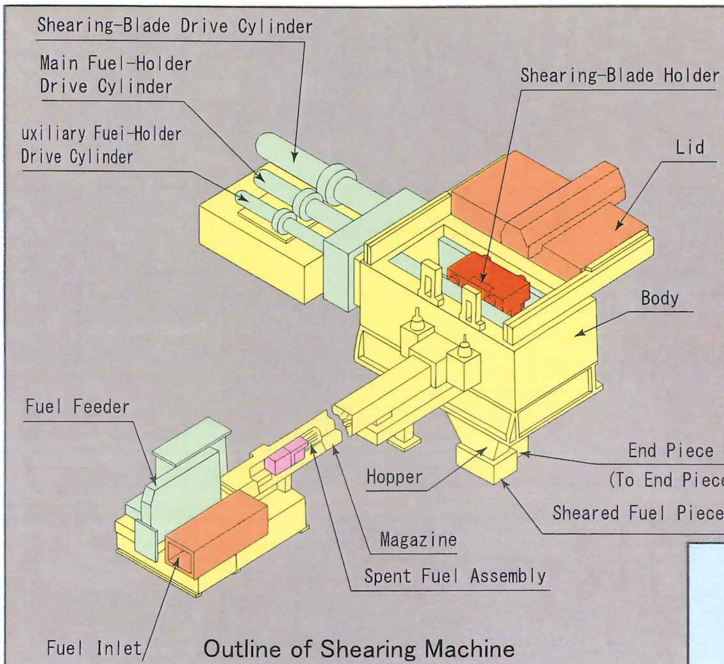
In the shearing process, the Spent Fuel Tilting Crane removes spent fuel assembly from the Basket Transfer Cart arriving from the receiving and storage process and transfers them to the Shearing Machine. Then, sheared fuel pieces are sent out to the Dissolver.

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

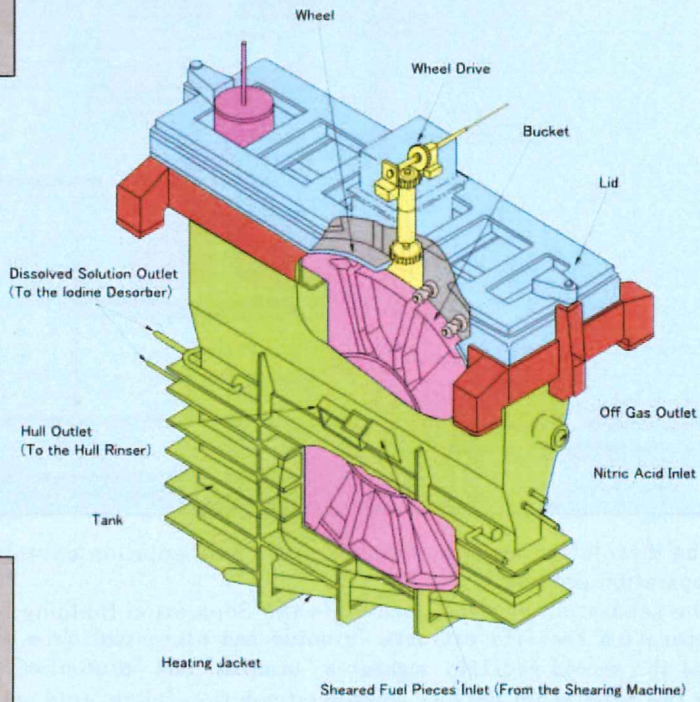
Shearing machine	: 2 sets (1 set/system)
Dissolver (continuous type)	: 2 sets (1 set/system)
Material	: Zirconium
Clarifier (centrifugal type)	: 2 sets (1 set/system)
Material	: Titanium



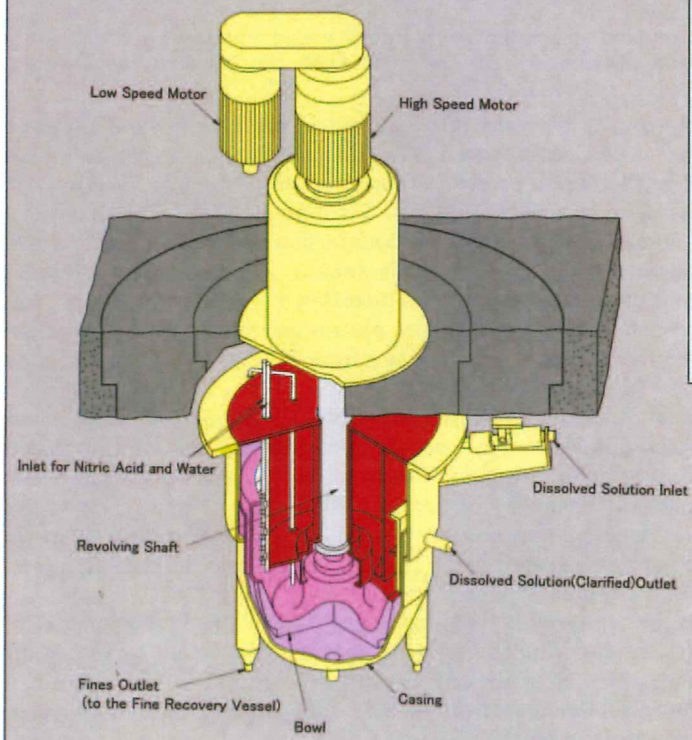
In the Shearing Machine, spent fuel assembly are changed into the Magazine and intermittently sent to the shearing part by the Fuel Feeder.The spent fuel assembly is sheared into small pieces, 3～4 cm in length.Sheared fuel pieces are transferred to the Dissolver and end pieces are transferred to the 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.



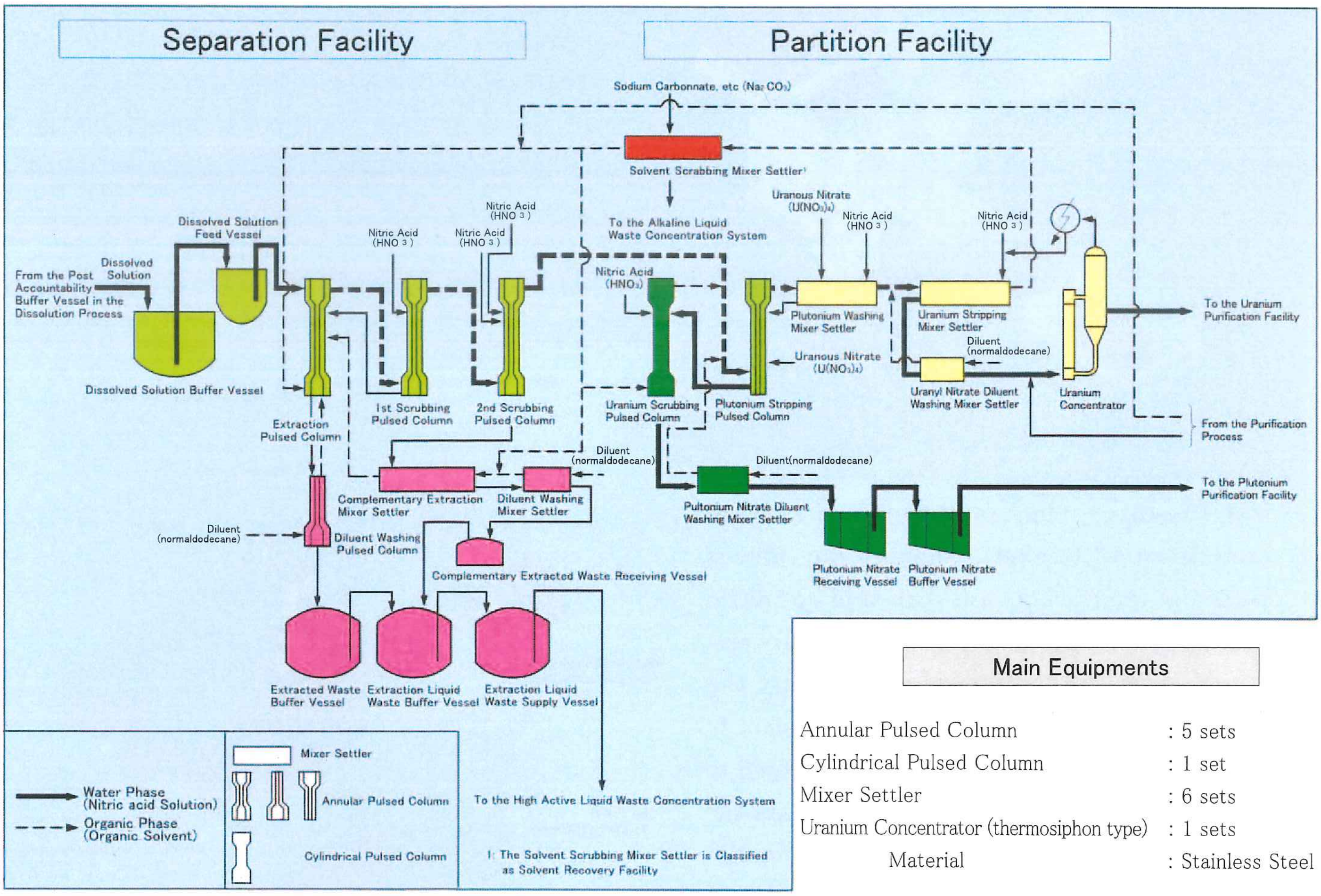
Outline of Dissolver



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".

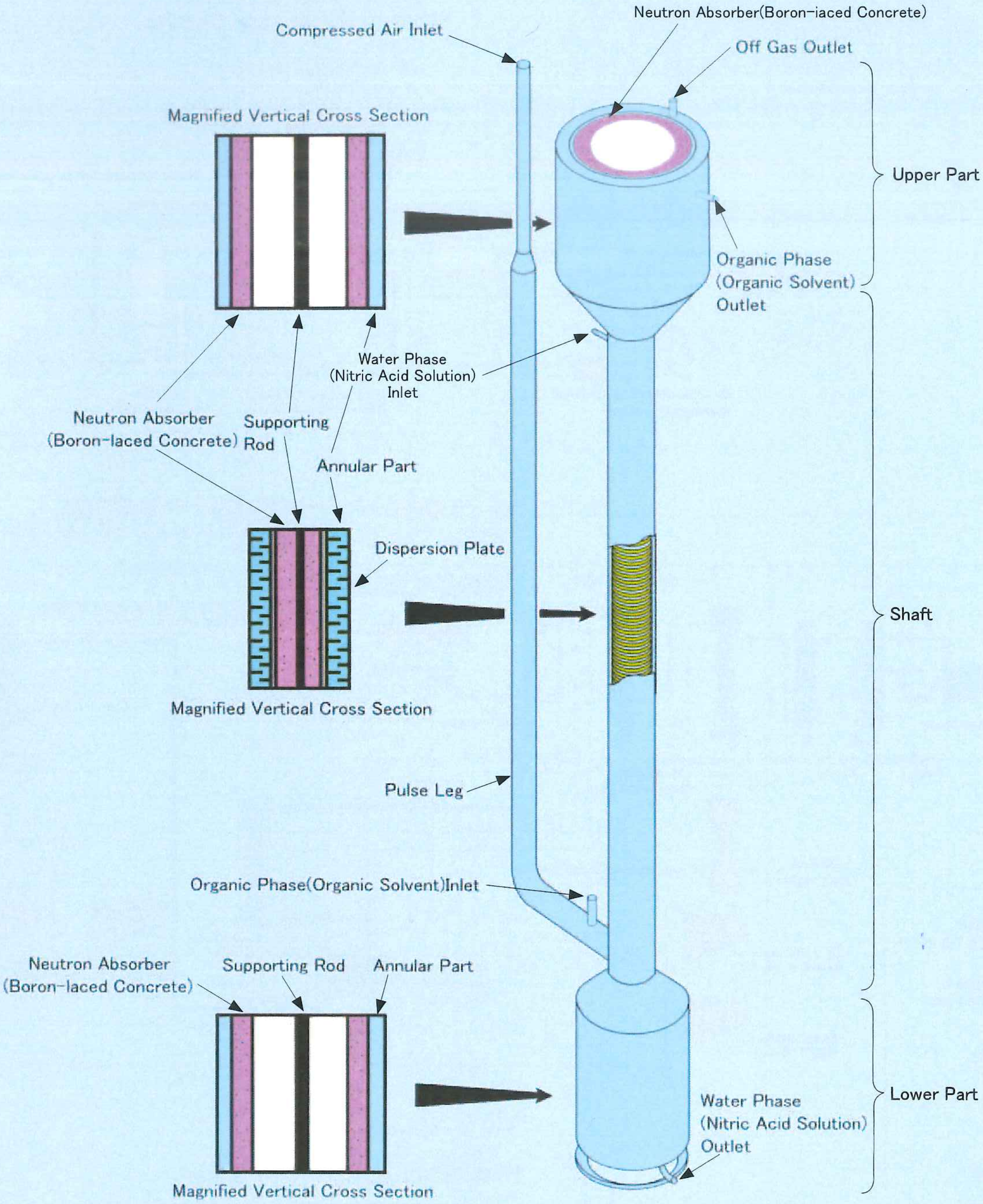
In the Separation Facility, dissolved solution (nitric acid solution) is brought into contact in counterflow with organic solvent (mixture of TBP used for solvent extraction and diluent) in the Extraction Pulsed Column (annular pulsed column) to extract uranium and plutonium into the organic solvent. 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 (normal-dodecane) to remove the very small amount of TBP still contained in the solution.

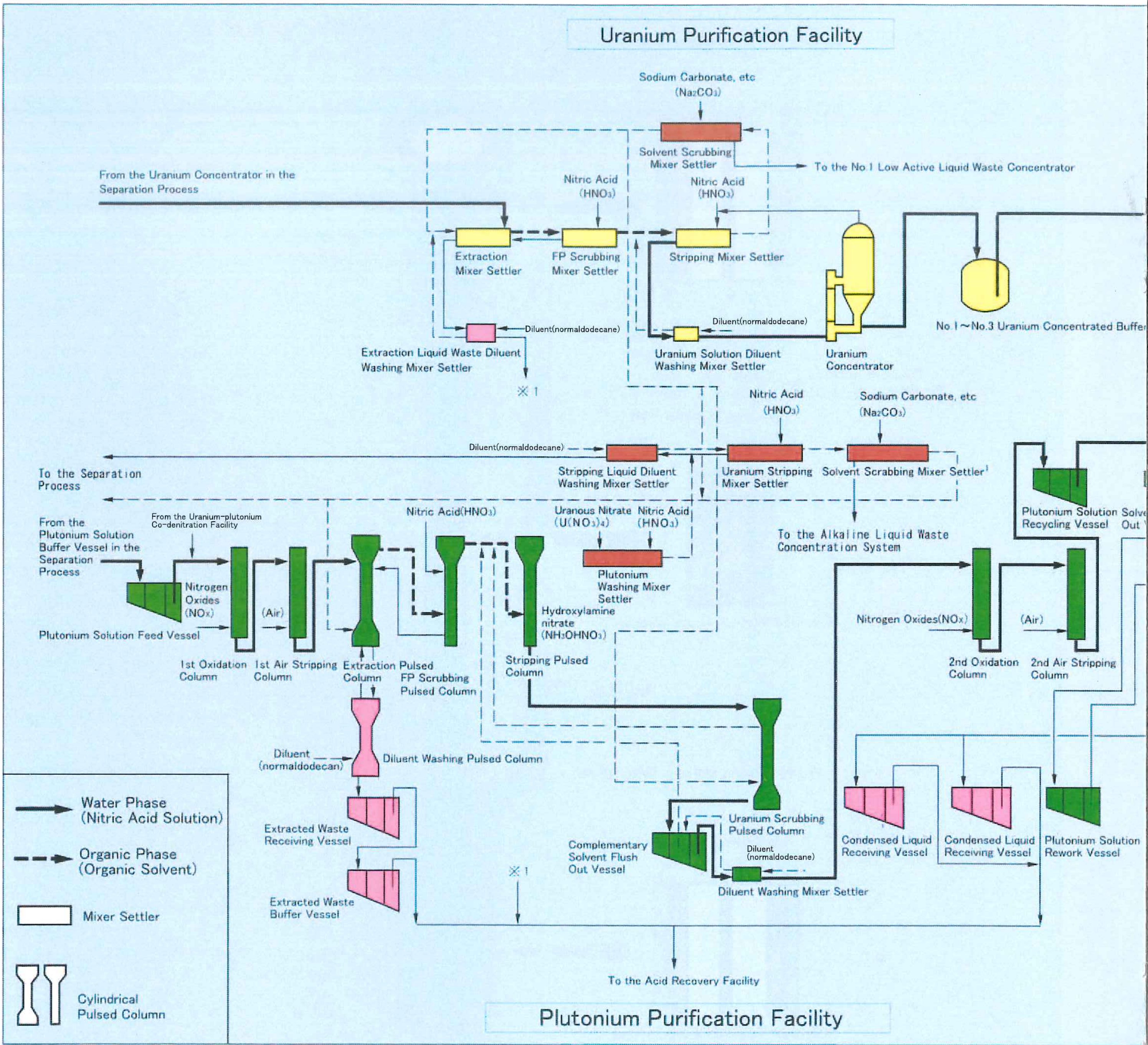
* TBP stands for TriButyl Phosphate. It is an extractant used to extract uranium and plutonium in solvent extraction method.



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.

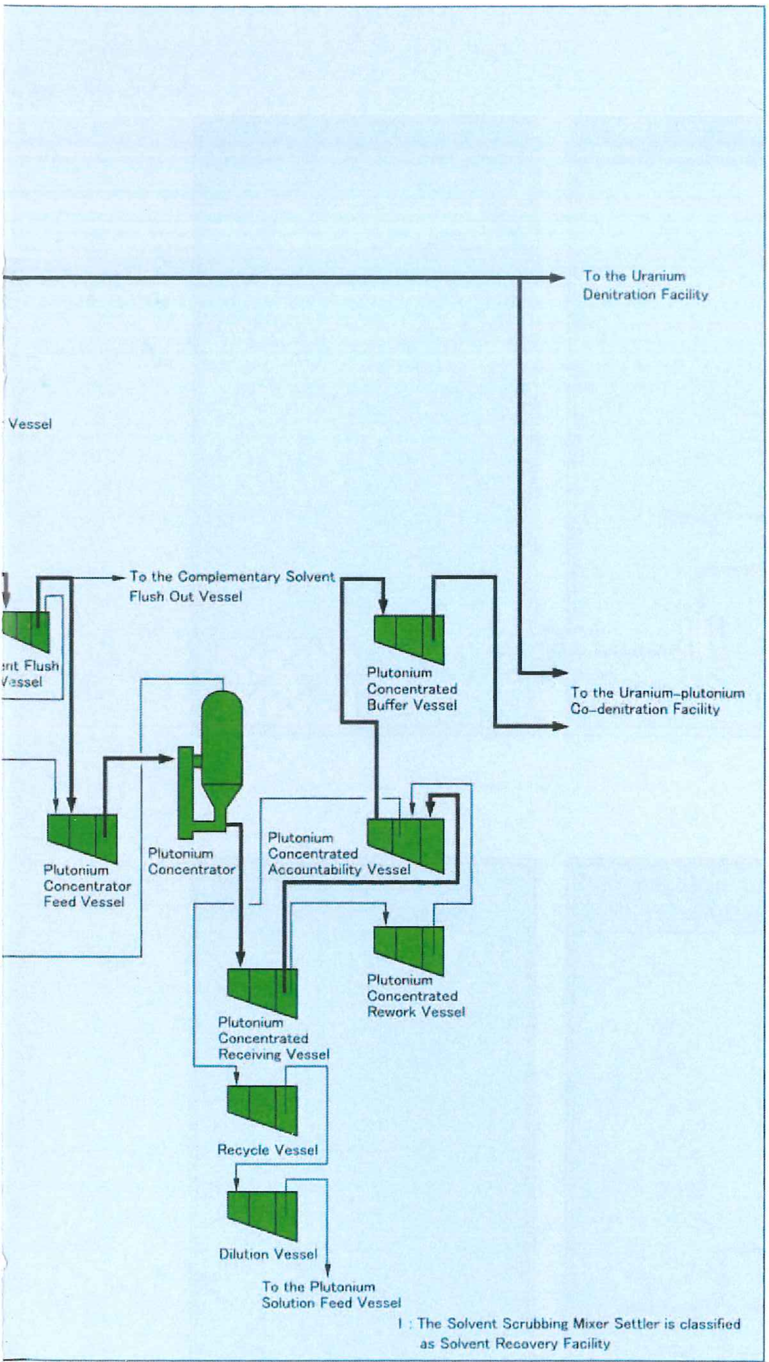
Purification



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

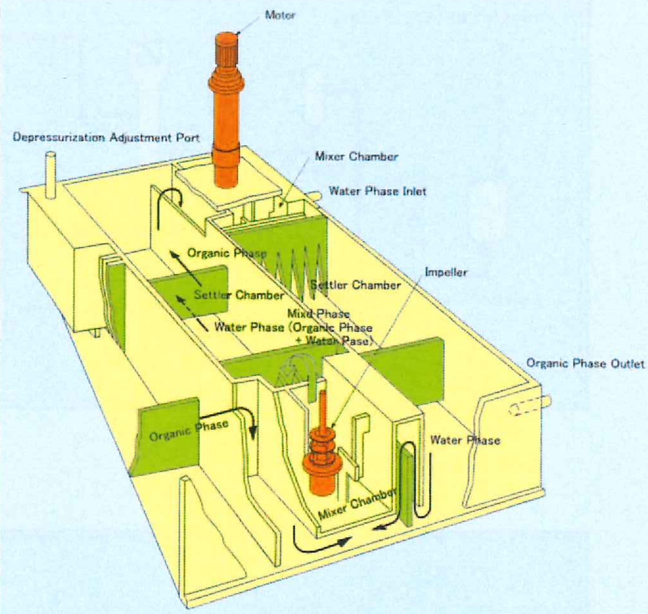
The uranyl nitrate solution (nitric acid solution containing uranium(Ⅳ)) is sent from the Uranium Concentrator of the separation process to the Uranium Purification Facility, where it goes through the series of operations consisting of extraction (via the Extraction Mixer Settler), washing for fission 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	



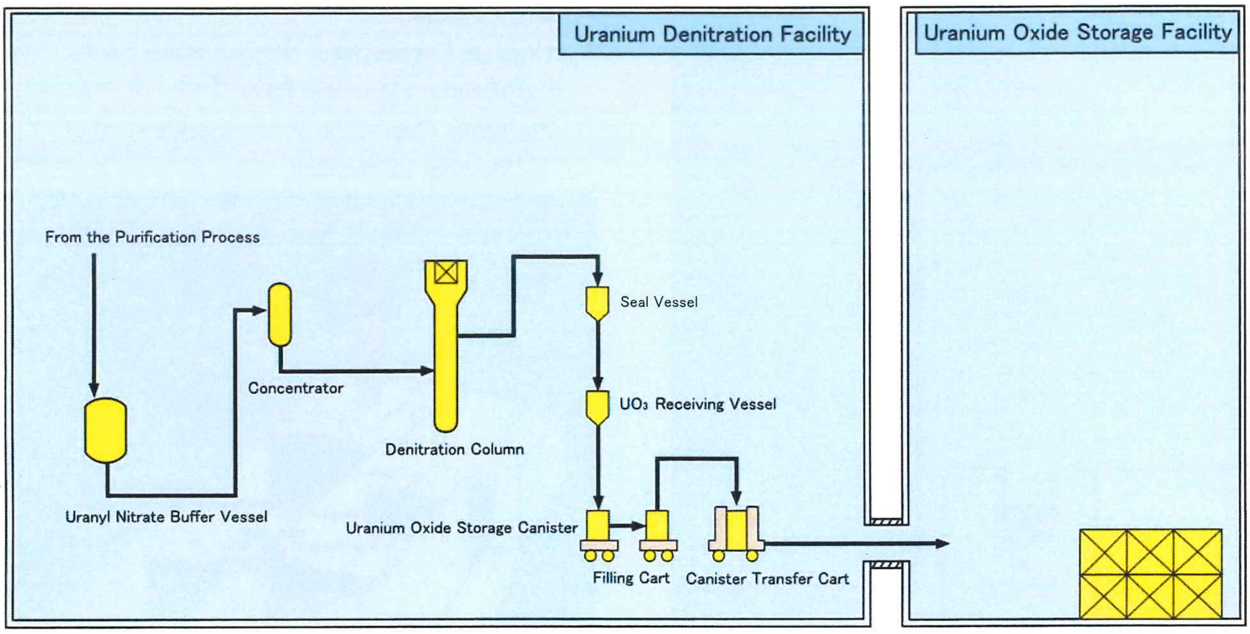
Outline of Mixer Settler

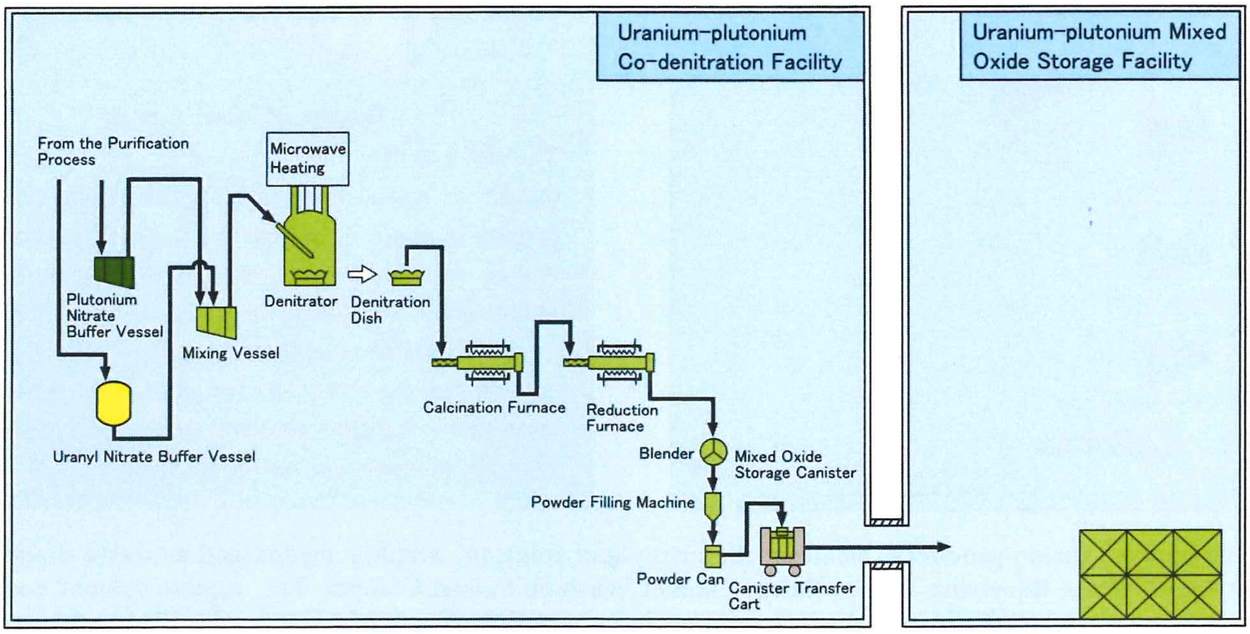
The Mixer Settler is an extractor to perform material movement between two liquid phases (aqueous and organic phases). In the mixer chamber the organic and aqueous phases are mixed by the impeller, and in the settler chamber the mixed phases are settled to create difference of density. As a result, the 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_3 $OHNO_3$), 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).

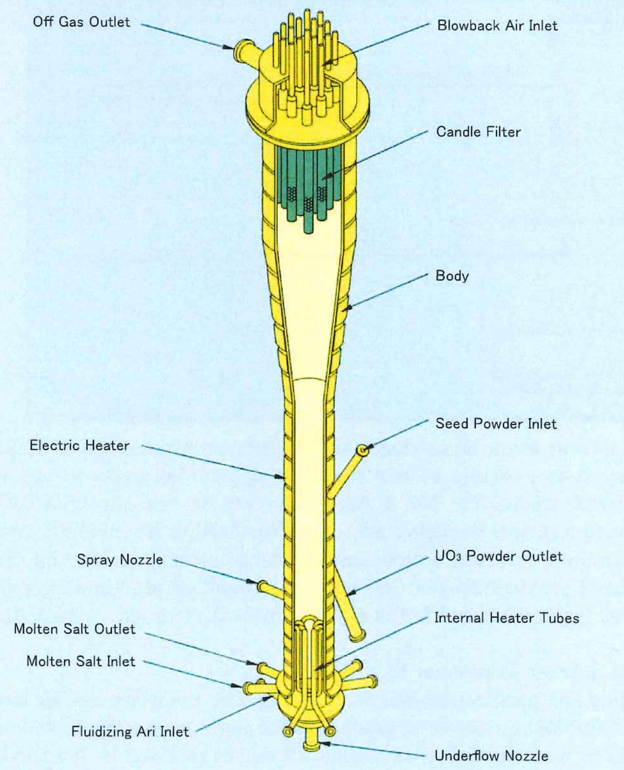
●Uranium Denitration Facility

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.

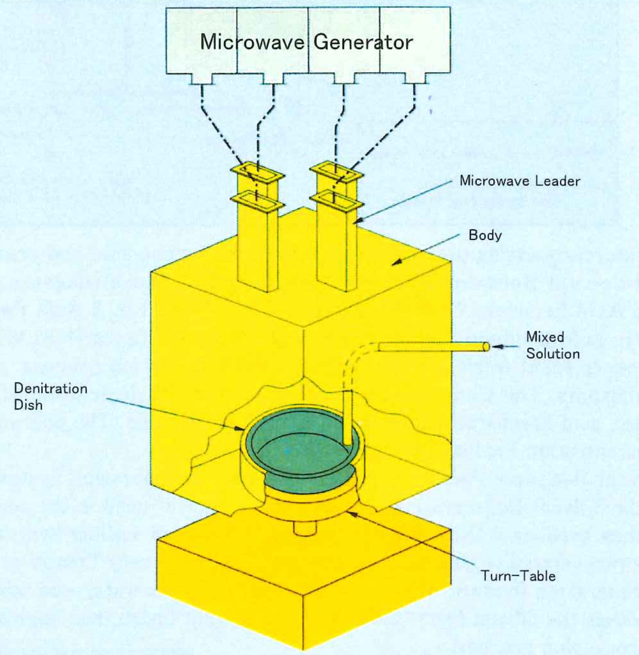
In the product storage process, the UO_3 powder and MOX powder produced in the denitration process are stored until these products are delivered to the fabrication and related facilities.



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℃.

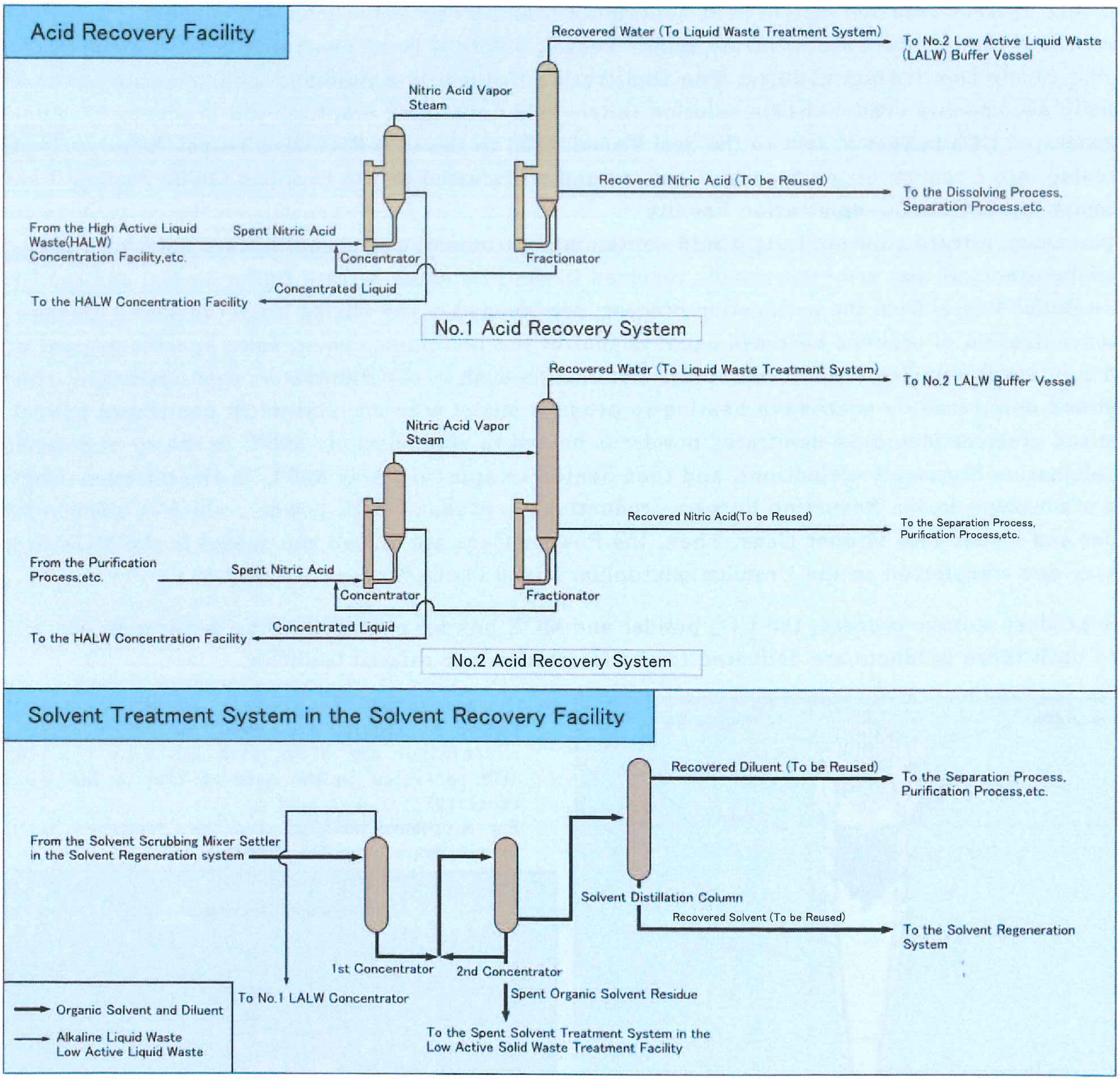
* :Fluidized-bed is a state in which particles behave as liquid, when small particles filled in a container are blown with gas from the bottom (UO_3 particles in the case of Uranium Denitration Facility).
For microwave heating, the same frequency is used as microwave oven for home use.



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

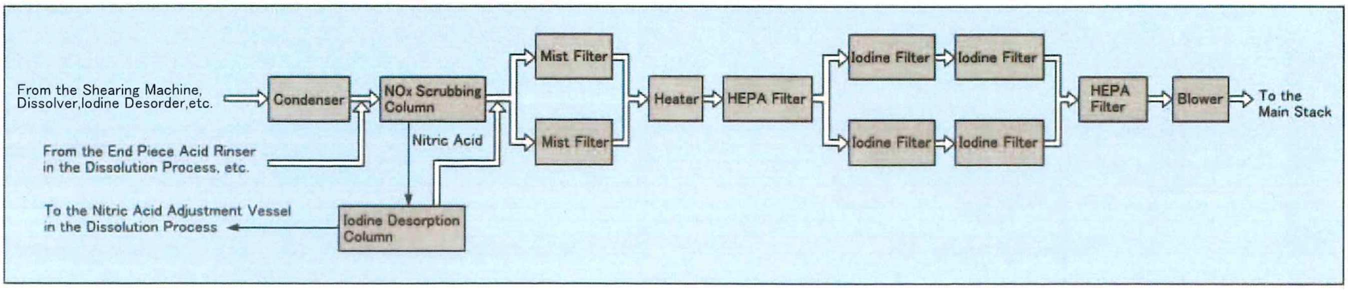
Solvent Recovery Facility

- 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

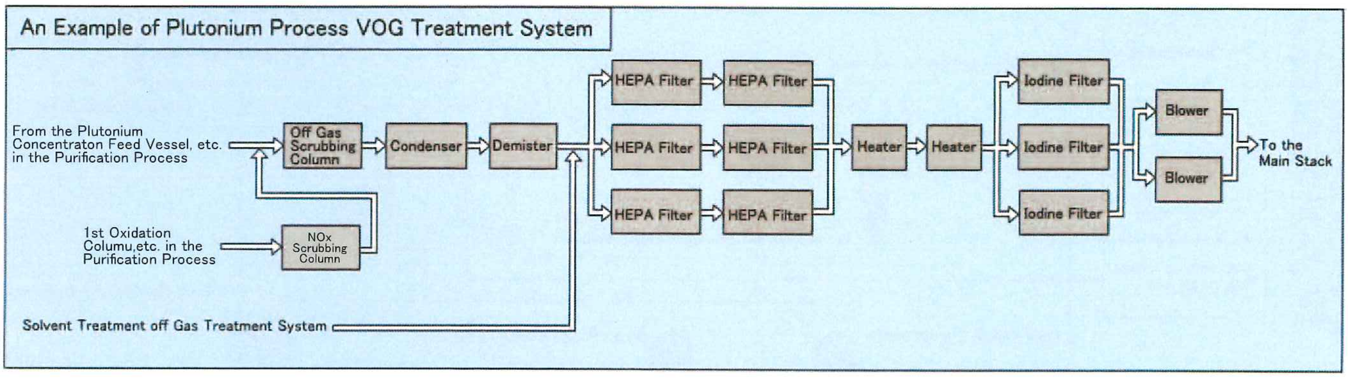
Gaseous waste is mainly treated in the following three facilities, according to the condition of the off gases to be treated.

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



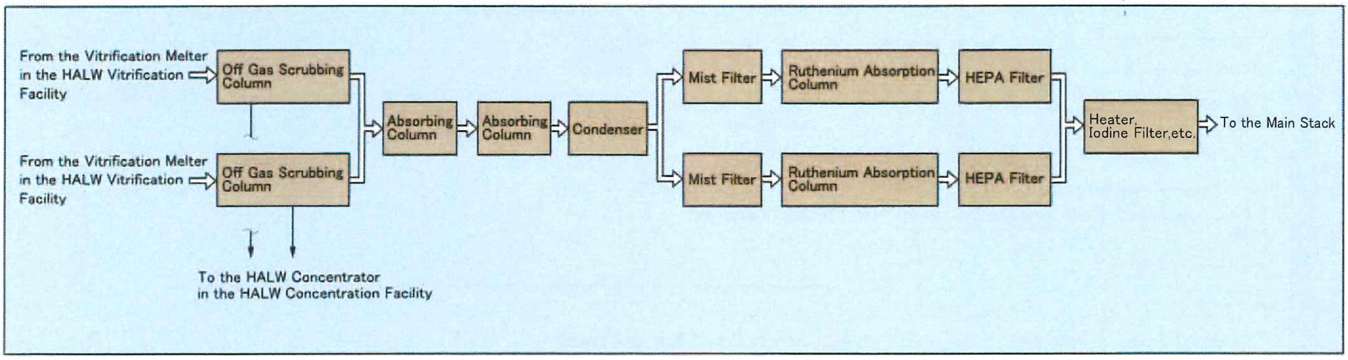
The off gases originated from the Shearing Machine in the shearing process as well as from the Dissolver and Iodine Desorber in the dissolution process are cooled by the Condenser. Then, Nitrogen Oxides (NOx) and radioactive substances are removed from the off gases by the NOx Scrubbing Column, before 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.

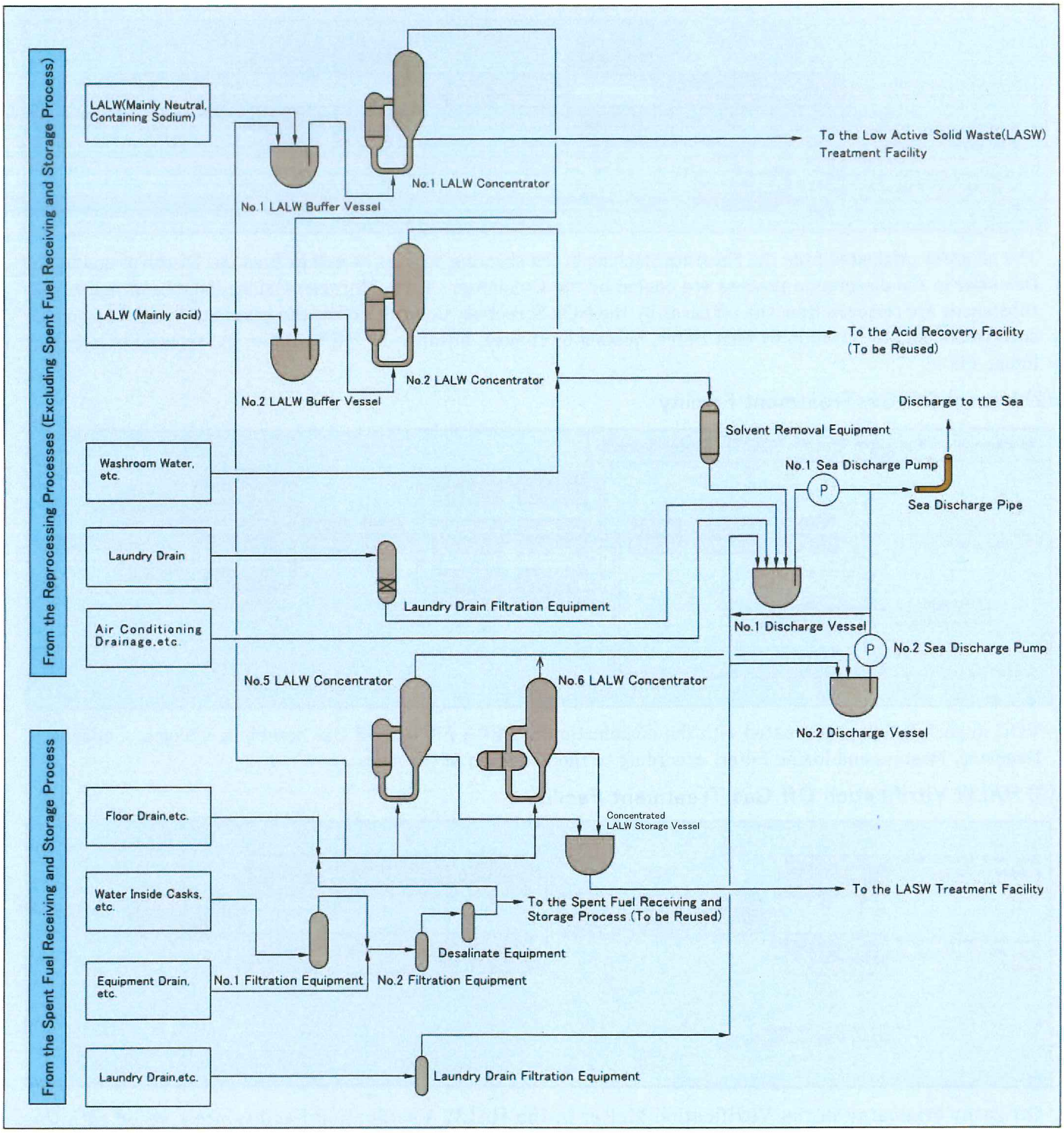
Main Equipments

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))

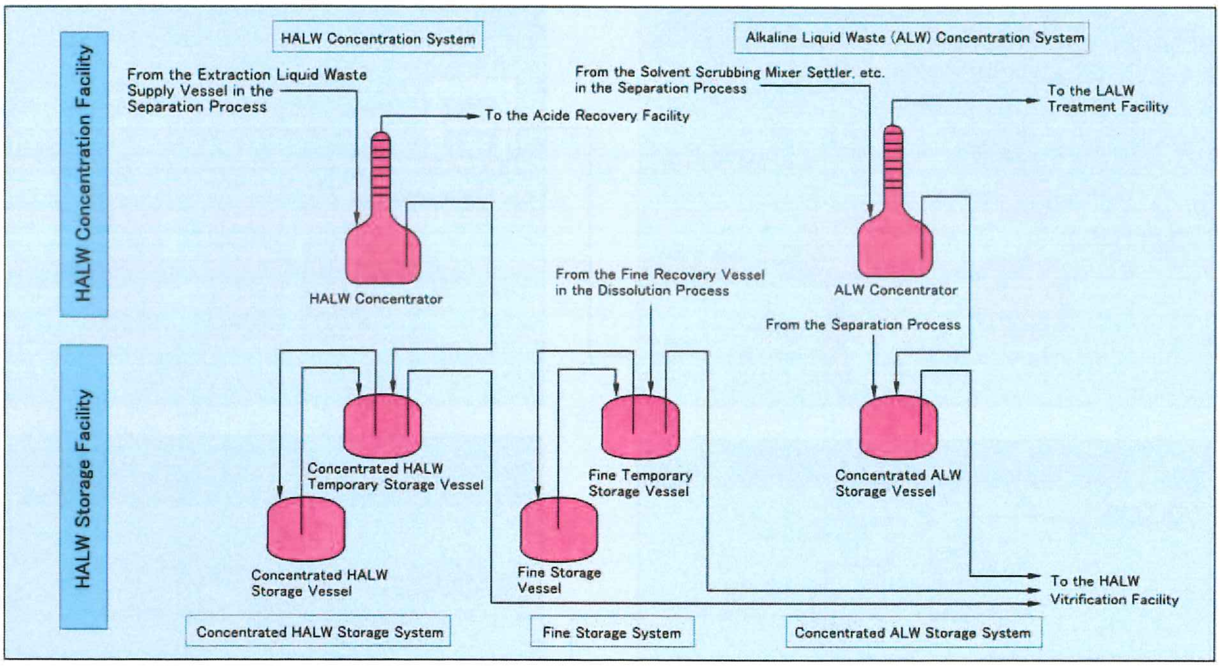


Low Active Liquid Waste (LALW) is classified according to its conditions (acid or neutral, containing Salt (Na) or not, etc.) and treated by the LALW concentrator, filters and other equipment. After treatment, liquid waste is measured for concentration of radioactive substances, hydrogen ion concentration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

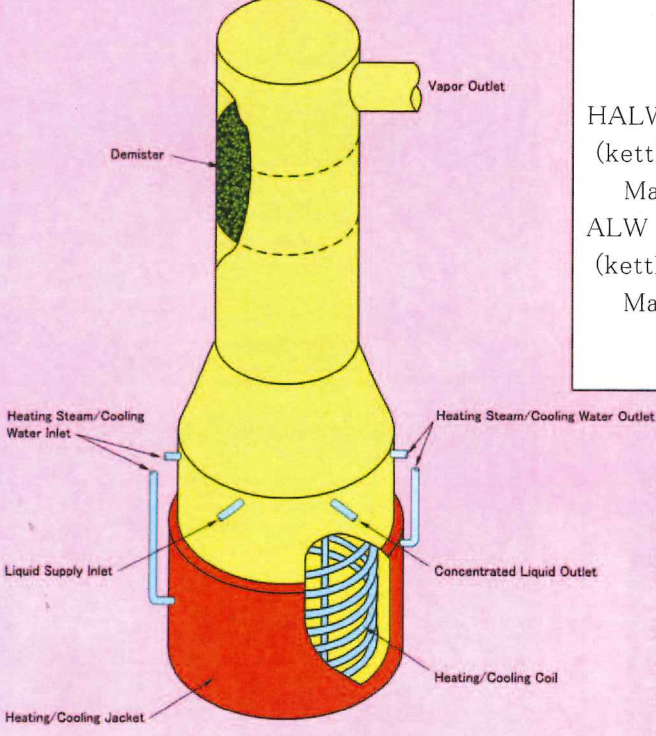
Main Equipments

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.



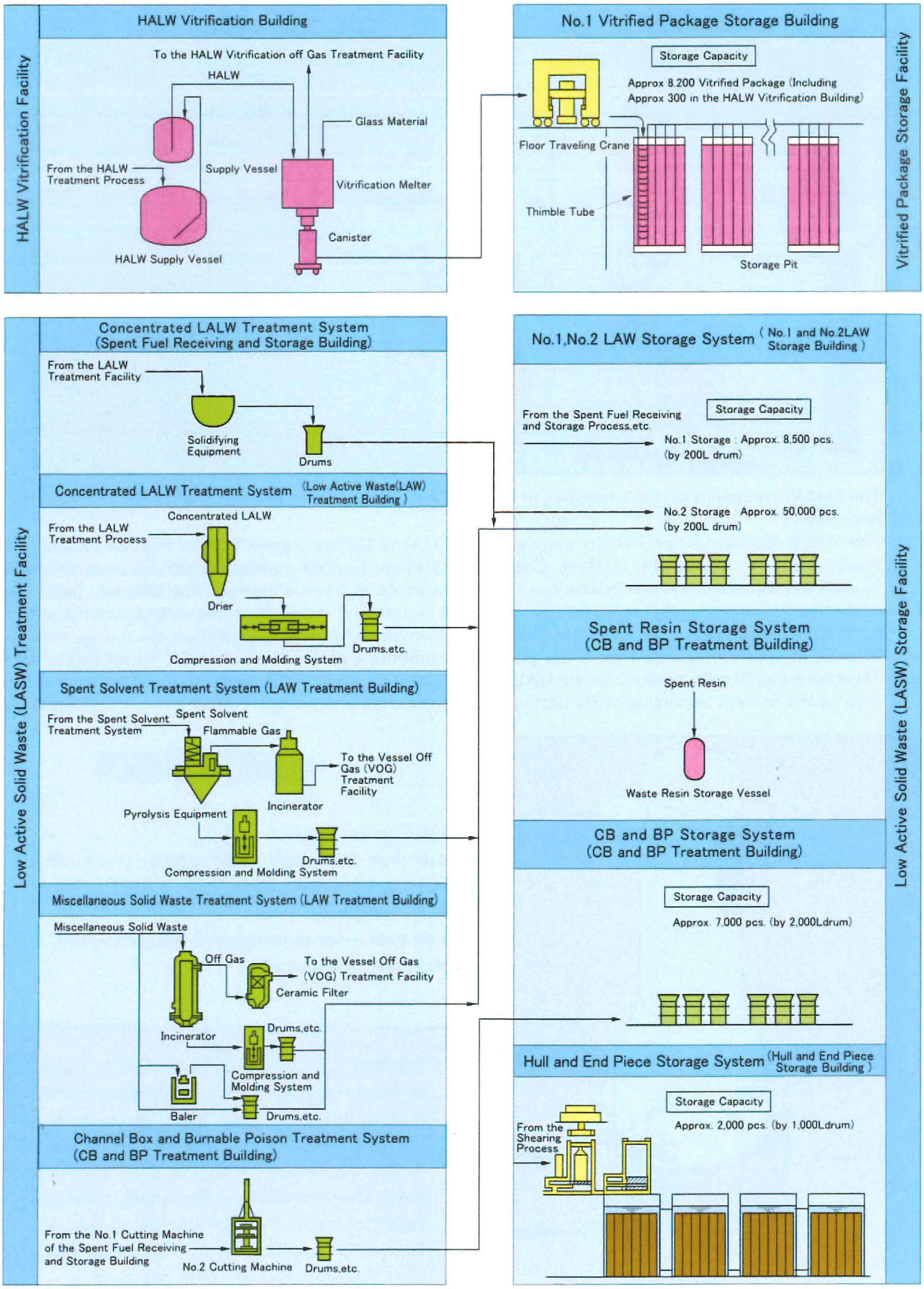
Outline of HALW Concentrator

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
Vitrified Package Storage Facility
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
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
Drums.etc.
Compression and Molding System
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.
Low Active Solid Waste (LASW) Storage Facility
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

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

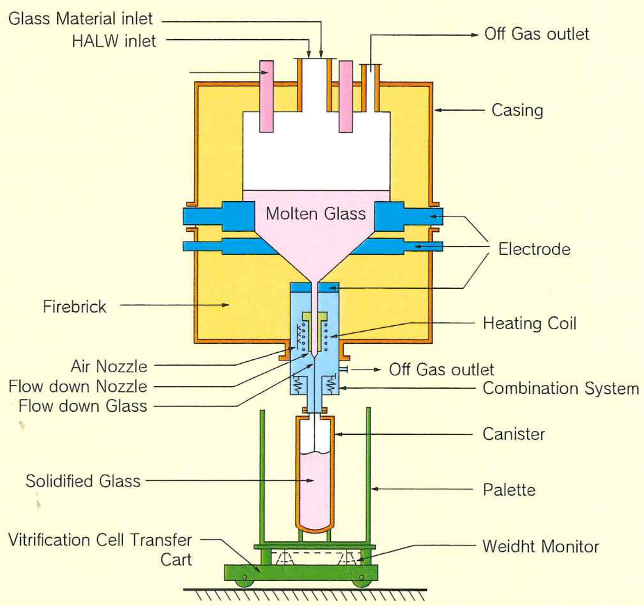
Paper, filters, pumps and other miscellaneous solid waste from the facilities are incinerated or compressed to reduce volume, then loaded into drums.

(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.

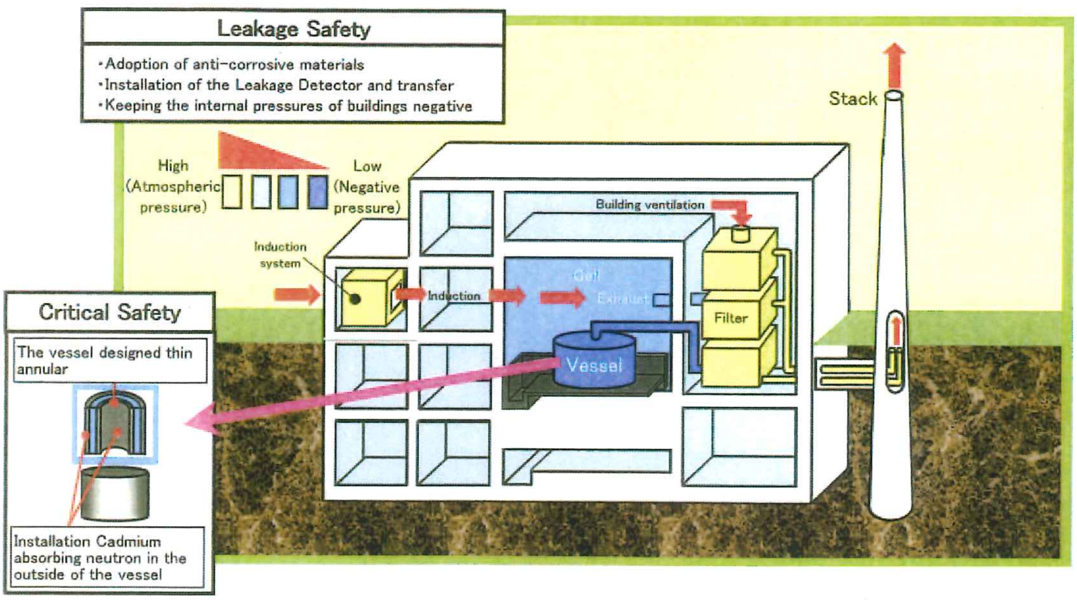
② Prevention of expansion of incidents

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.

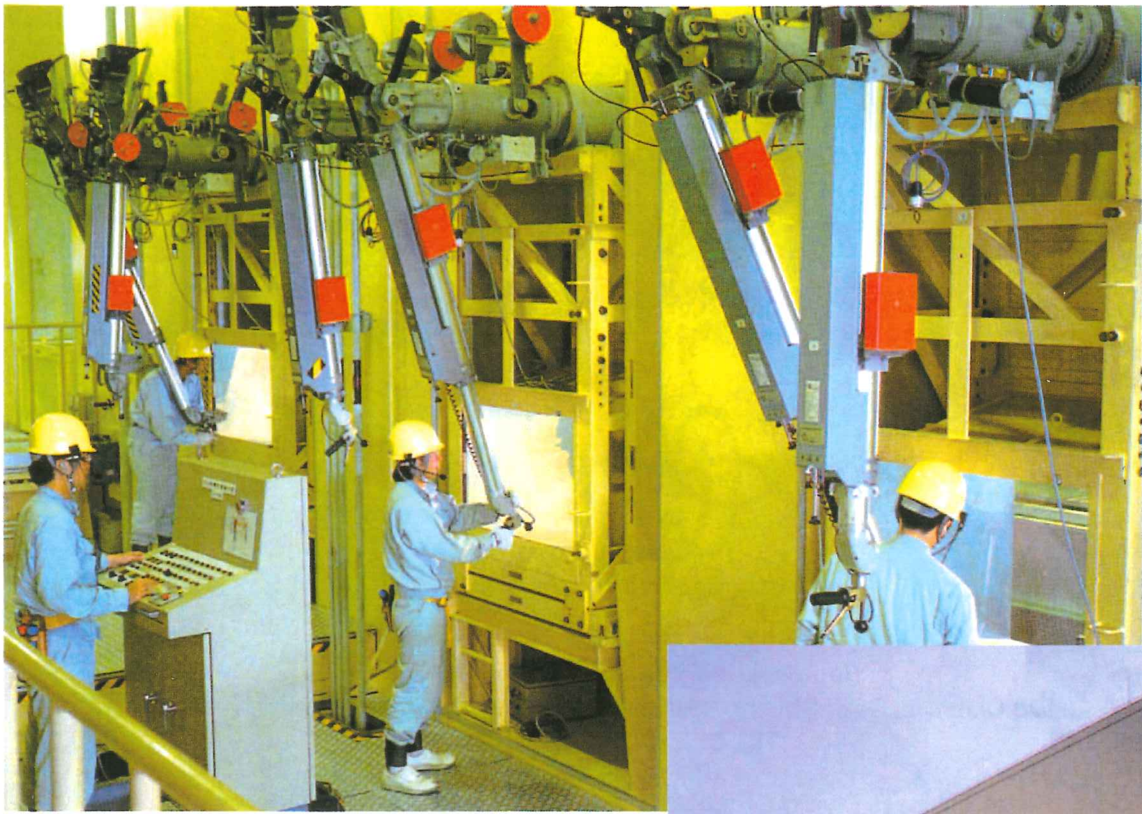
③ Mitigation of consequences to environment

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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URL http://www.jnfl.co.jp/

2018.3

Rokkasho Uranium Enrichment Plant

JAPAN NUCLEAR FUEL LIMITED

Uranium Enrichment Process

▲Central Control Room

▲Cascade Room

Feed cylinder is transferred from storage to feed cylinder vessel.

Feed Cylinder (approx. 12t UF_6)
(48Y Cylinder)

Heating

Feed Cylinder Vessel

1 Feed cylinder is inserted in feed cylinder vessel and heated to vaporize the natural UF_6, which is then fed to the cascade.

[Natural UF_6]

Cascade

[Enriched UF_6]
(less than 5% enrichment)

[Depleted UF_6]

2 Enrichment performed repeatedly by cascade of centrifuges, gradually increasing the enrichment level.

Cooling/Heating

Cold Trap for Product

3 Enriched UF_6 is collected in solid form by the cold trap.

Cooling

Product Cylinder Vessel

4 The cold trap is heated to vaporize the enriched UF_6, and its gas is piped to the cooled product cylinder and collected in solid form.

▲30B Cylinder ▲Intermediate Product Cylinder ▲48Y Cylinder

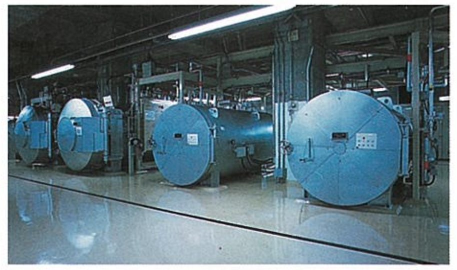
Intermediate Product Cylinder (IPC) (approx. 4t UF_6)

The IPC is transferred from the product cylinder vessel to the homogenization vessel.

Heating

Homogenization Vessel

5 The IPC inside the homogenization vessel is heated to liquefy and homogenize the enriched UF_6. Samples are taken to measure the enrichment, and the enrichment level is adjusted if necessary by blending.



▲Homogenization Room

Cooling

Product Cylinder Vessel

6 The IPC is heated in the homogenization vessel. The enriched UF_6 is vaporized and piped to the cooled product cylinder vessel, and collected in solid form.

Product Cylinder (approx. 2t UF_6)
(30B Cylinder)

The product cylinder is transferred to the storage and stored until shipment.

Cooling/Heating

Cold Trap for Tails

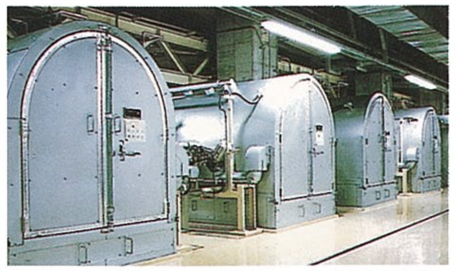
7 Depleted UF_6 is piped to the cooled tails cylinder through the cold trap to be collected in solid form.

Cooling

Tails Cylinder Vessel

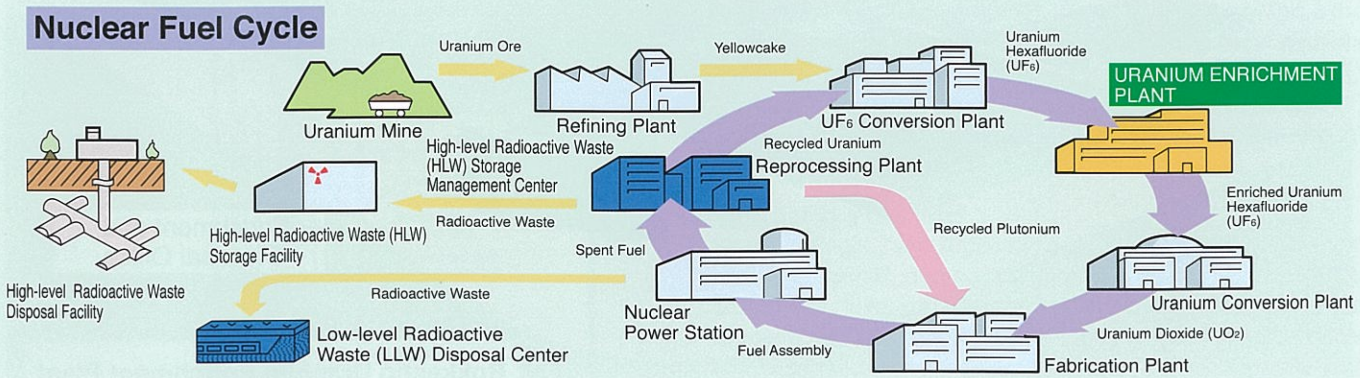
Tails Cylinder (approx. 12t UF_6)
(48Y Cylinder)

Tails cylinder is transferred to storage and stored.



▲Feed and Withdrawal Room

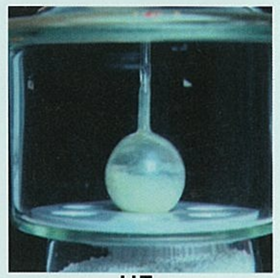
Nuclear Fuel Cycle



Characteristics of Uranium Hexafluoride(UF_6)

Uranium hexafluoride (UF_6) is a molecule made up of one uranium (U) atom and six fluorine (F) atoms. While fluorine has no isotopes, uranium is composed of U-235 and U-238. For this reason the molecular weight of UF_6 depends on the uranium isotope composition.

The physical form of UF_6 can be changed easily by controlling the temperature and pressure around it. At room temperature or in a slightly heated state, UF_6 is in a mixed low-pressure gaseous and solid form. When heated in a sealed container, UF_6 becomes a mixture of liquid and high-pressure gas. When cooled, UF_6 changes to a solid and its pressure reduces. Because of these characteristics, UF_6 can be piped from one vessel to another.



UF_6

Rokkasho Uranium Enrichment Plant

For a Stable Supply of Nuclear Energy

Nuclear power generation currently has accounted for about 30 percent of Japan's entire electrical energy consumption, including domestic and industrial usage. Most of the fuel used in Japanese nuclear power plants – enriched uranium – used to be acquired from commissioned uranium enrichment services in the U.S.A. and France.

To meet the domestic goal of greater self-sufficiency and ensure a more stable supply of energy, Japan Nuclear Fuel Limited (JNFL) has been operating Japan's first commercial uranium enrichment plant since 1992. Situated in Rokkasho-mura, a village some 700 km north of Tokyo in Aomori Prefecture, the plant will enable Japan to complete the nuclear fuel cycle. All equipment at the plant is based on domestic technologies.

•Location

Nozuki Aza,Obuchi Oaza, Rokkasho-mura, Kamikita-gun, Aomori Prefecture, Japan

•Summary of Plant

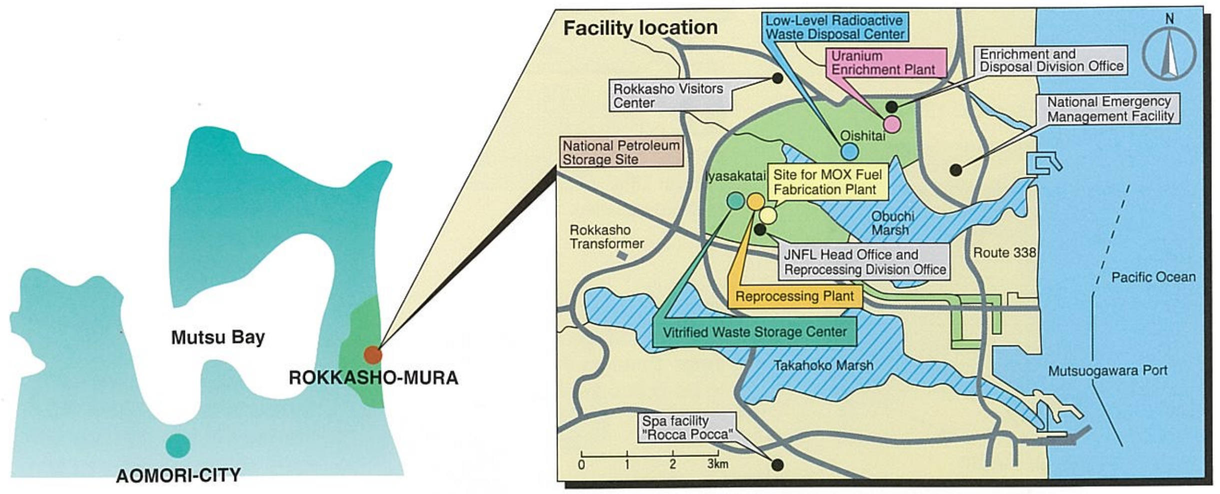
The uranium enrichment plant started operations at 150tSWU / y in 1992, and then expanded at every 150tSWU / y

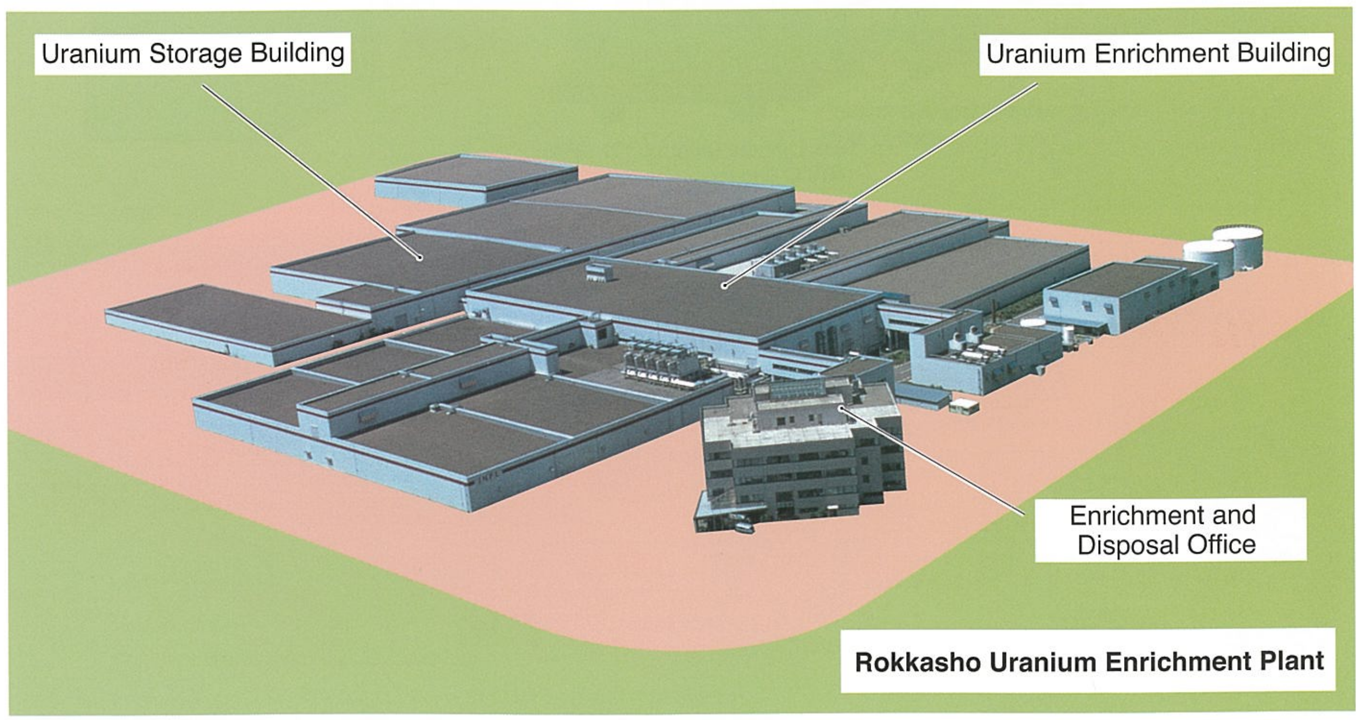
We started construction to upgrade to the advanced centrifuge in 2010, and in 2012 we started production using the advanced centrifuge.

In the future, we will gradually update to advanced centrifuge and eventually aim for 1500t SWU / y.

•Site Dimensions

3.4 million m²(approx.), including LLW disposal center





Rokkasho Uranium Enrichment Plant

Safety is Our Highest Priority

Low-enriched uranium emits very little radioactivity.

The uranium handled in the Rokkasho Uranium Enrichment Plant is in the chemical form of UF_6 (uranium hexafluoride), which is at very low levels of 3 to 5 percent enrichment. The radioactivity of the enriched uranium thus resembles that of natural uranium. Furthermore, UF_6 is neither combustible nor explosive.

Critical safety design.

The Rokkasho Uranium Enrichment Plant is designed not to become critical state in any kind of case by aspect ratio management of equipments and vessels in the process.

And UF_6 is handled in a vacuum airtight process to avoid atmospheric humidity and handled not to exceed 5% of uranium enrichment ratio (less than 5%),

Earthquake-proof plant design.

The degree of earthquake-proof plant design have been applied to the design of the various buildings in the plant, each of which has been given the earthquake resistance required to protect the public from any hazard caused by uranium leakage.

And, the building is designed to be supported by a "Taka-hoko formation" that has sufficient ground capacity.

Furthermore, it is designed not to damage equipment and buildings in the earthquake that exceeds design expecta-tions.

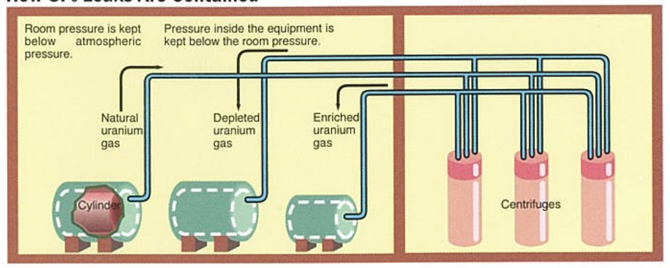
Strict measures to prevent fire and explosions.

The buildings at the Rokkasho plant are constructed to be as nearly fireproof as possible. Nonflammable and difficult-to-burn material is used in the equipment and instruments, and no flammable or explosive substances are used in the main process.

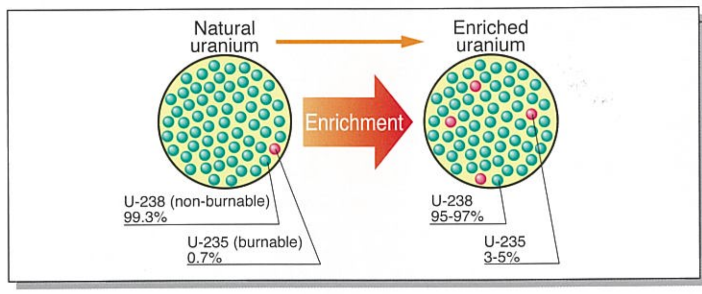
Strict measures to prevent UF_6 leakage.

The equipment in the Rokkasho plant that handles UF_6 is designed to prevent any leakage of the gas. In the unlikely event of UF_6 leakage, the equipment is designed to minimize the extent of the leakage, preventing any spread of the material outside the facility. Also, areas with the highest likelihood of contamination (classified as 1st Class Management Zones) are kept sealed, with the air processed by exhaust equipment before being emitted to the external environment.

How UF_6 Leaks Are Contained



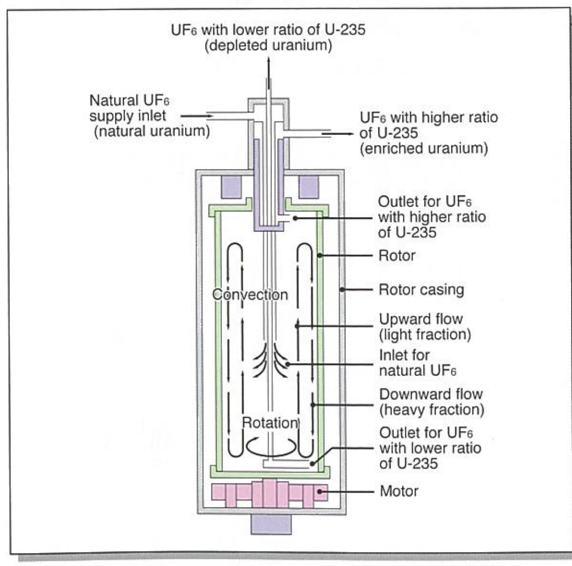
Uranium Enrichment



●What is uranium enrichment?

Natural uranium contains two isotopes – U-235 and U-238 – in a ratio of 0.7 percent to 99.3 percent. Only U-235 can be burned as fuel in nuclear reactors. Since natural uranium cannot be used "as is" in light water reactors, the U-235 isotope is enriched to approximately 3 to 5 percent at the Rokkasho Enrichment Plant.

Illustration of centrifuge operation



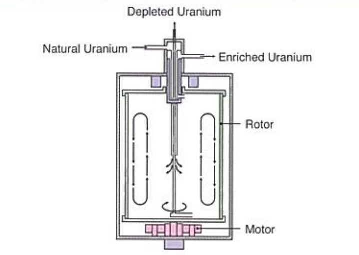
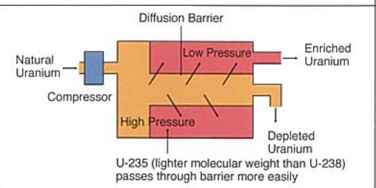
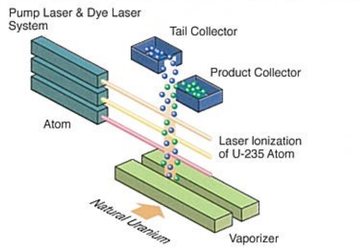
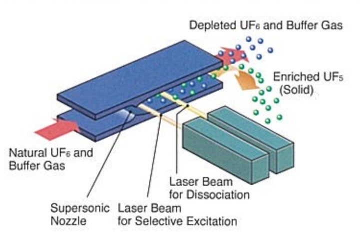
●Centrifuge

The centrifuge uses the same principle as the spin-drier in a household washing machine, but the rotor inside spins at super-high speed. UF_6 gas fed into the rotor is pushed against the wall surface of the rotor by a centrifugal force that is many thousands of times stronger than gravity. And the heavier U-238 rich UF_6 is pushed outward and the lighter U-235 rich UF_6 gathered inward of the rotor. The U-238 rich UF_6 gas and the U-235 rich UF_6 gas are then extracted through separate tube.

●What is a cascade?

Since a single centrifuge can only increase the enrichment level by a small degree, the process must be repeated to attain the level of enrichment required for light water reactors. To accomplish this, a series of centrifuges – called a "cascade" – is thus linked to produce the necessary level of enrichment.

Overview of Various Uranium Enrichment Processes

Name off Process	Enrichment Principle	Major Characteristics	Amount of Electricity Consumed	Diagram	Current Status
Centrifuge Process	Centrifugal force is applied to UF_6 gas by a centrifuge, and gas is enriched and collected.	① Consumes little electricity. ② Has many moving parts.	Little		In Use
Gaseous Diffusion Process	Utilizes the difference in the kinetic speeds between UF_6 gas containing U-235 and UF_6 gas containing U-238.	① Consumes much electricity. ② Requires large equipment.	Much		In Use
Laser Process (Atomic)	After metallic uranium is vaporized, a laser is used to ionize only the U-235, which is then collected separately.	① Has few movable parts. ② Required equipment is compact.	Little		–
Laser Process (Molecular)	UF_6 gas is cooled by an ultrasonic nozzle. A laser converts only the U-235 to UF_5 powder, which is then collected	① Conforms well with existing nuclear fuel cycles. ② Facility costs can be decreased significantly.	Little		–

World capacity of Uranium Enrichment

Country	Organization	Site Location	Enrichment Process	Plant Capacity (approx.)	Business operation start
U.S.A	Louisiana Energy Service LLC	New Mexico	Centrifuge	3,200tSWU/y	2010
France	—	Tricastin	Centrifuge	7,500tSWU/y	2011
Netherlands	URENCO Netherland B.V.	Almelo	Centrifuge	5,400tSWU/y	1972
Germany	URENCO Deutschland GmbH	Gronau	Centrifuge	4,100tSWU/y	1985
Russia	Fuel Company of Rosatom TVEL	Tomsk	Centrifuge	—	1953
		Angarsk	Centrifuge	—	1954
U.K	URENCO UK Ltd.	Capenhurst	Centrifuge	4,900tSWU/y	1972
Japan	JNFL	Rokkasho-mura (Aomori Prefecture)	Centrifuge	1,050tSWU/y	1992
Brazil	Indústrias Nucleares do Brasil	Rio de Janeiro	Centrifuge	125tSWU/y	2009

Source:Graphical Flip-chart of Nuclear & Energy Related Topics(Japan Atomic Energy Relations Organization)

Profile of JNFL

Official Name Japan Nuclear Fuel Limited (Abbreviation: JNFL)
Capitalization ¥400 billion
Number of Staff 2,744 (as of Apr. 2018)

Scope of Business
1)Uranium enrichment
2)Reprocessing of spent nuclear fuel
3)Temporary storage of nuclear fuel materials and wastes returned from overseas reprocessing plant
4)Disposal of low-level radioactive wastes
5)Mox fuel fabrication
6)Transportation of uranium, low-level radioactive wastes, and spent fuel, etc.
7)Other businesses related to above-listed activities

History of Rokkasho Uranium Enrichment Plant

First period：RE-1

Date	Main items
March 1, 1985	Japan Nuclear Fuel Industry Limited was established.
May 26, 1987	Applied licence for the approval to uranium enrichment business (First period：600tSWU/y)
August 10, 1988	Approval of uranium enrichment business
October 14, 1988	Construction of the Uranium Enrichment Plant started.
March 27, 1992	The Uranium Enrichment Plant of RE-1A (150tSWU/y) started operation. (Apr 3, 2000 closed.)
July 1,1992	Japan Nuclear Fuel Service Limited and Japan Nuclear Fuel Industry Limited merged to create Japan Nuclear Fuel Limited.
December 18,1992	The Uranium Enrichment Plant of RE-1B (150tSWU/y) started operation. (Dec 19, 2002 closed.)
May 27, 1993	The Uranium Enrichment Plant of RE-1D (150tSWU/y) started operation. (Nov 30, 2005 closed.)
September 21, 1994	The Uranium Enrichment Plant of RE-1C (150tSWU/y) started operation. (Jun 30, 2003 closed.)
May 14, 2013	Applied for the change approval to uranium enrichment business in relation to abolition of equipment for the first period. (Change capacity from 1,050tSWU/y to 450tSWU/y)
May 17, 2017	Approval of applied for the change approval to uranium enrichment business in relation to abolition of equipment for the first period. (Change capacity from 1,050tSWU/y to 450tSWU/y)

Second period：RE-2

Date	Main items
July 3, 1992	Applied for the change approval to uranium enrichment business in relation to second period expansion (450tSWU/y).
July 12, 1993	Approval of applied for the change approval to uranium enrichment business.
September 9, 1993	Construction of the Uranium Enrichment Plant of Second period started.
October 17, 1997	The Uranium Enrichment Plant of RE-2A (150tSWU/y) started operation. (Nov 30, 2006 closed.)
April 1, 1998	The Uranium Enrichment Plant of RE-2B (150tSWU/y) started operation. (Dec 15, 2010 closed.)
October 6, 1998	The Uranium Enrichment Plant of RE-2C (150tSWU/y) started operation. (Feb 12, 2008 closed.)
December 16, 2008	Applied for the change approval to uranium enrichment business in relation to upgrade to the advanced centrifuge in a part of second period of uranium enrichment plant (75tSWU/y within RE-2A(150tSWU/y))
January 21, 2010	Approval of applied for the change approval to uranium enrichment business. (75tSWU/y)
March 1, 2010	Construction of the Uranium Enrichment Plant for upgrade to the advanced centrifuge started.(75tSWU/y)
March 9, 2012	The Uranium Enrichment Plant of RE-2A (37.5tSWU/y) started operation. (Upgrade to the advanced centrifuge) (Production operation suspension ,Sep 12, 2017)
May 14, 2013	Applied for the change approval to uranium enrichment business in relation to upgrade to the advanced centrifuge in a part of second period of uranium enrichment plant (375tSWU/y within 450tSWU/y))
May 21, 2013	The Uranium Enrichment Plant of RE-2A (37.5tSWU/y) started operation. (Upgrade to the advanced centrifuge) (Production operation suspension ,Sep 12, 2017)
May 17, 2017	Approval of applied for the change approval to uranium enrichment business. (375tSWU/y)

Pond smelt fishing at Uchi Marsh

Swan in Obuchi Marsh

Sunset at Takahoko Marsh

JNFL
JAPAN NUCLEAR FUEL LIMITED

●**Head office** 4-108 Okitsuke Aza, Obuchi Oaza, Rokkasho-mura, Kamikita-gun, Aomori Prefecture, Japan TEL +81-175-71-2000

Enrichment & Disposal Office 504-22, Nozuki Aza, Obuchi Oaza, Rokkasho-mura, Kamikita-gun, Aomori Prefecture, Japan TEL +81-175-72-3311

Reprocessing Office 4-108, Okitsuke Aza, Obuchi Oaza, Rokkasho-mura, Kamikita-gun, Aomori Prefecture, Japan TEL +81-175-71-2000

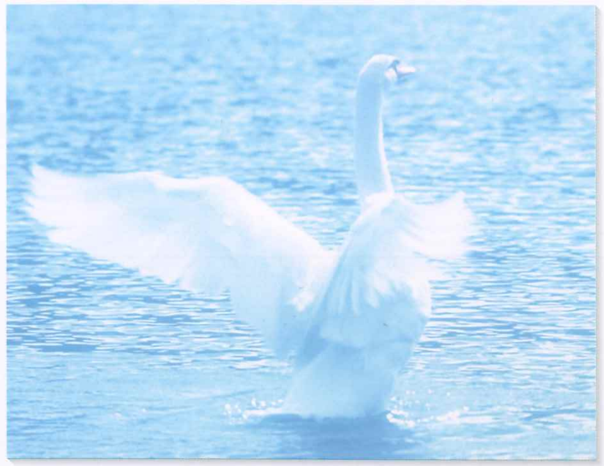
●**Aomori Office** Daiichi Seimei Bldg., 1-2-15 Honcho, Aomori City, Aomori Prefecture, Japan TEL + 81-17-773-7171

●**Tokyo Office** Bussan Bldg. Annex (7F) 1-1-15 Nishi-Shimbashi, Minato-ku, Tokyo, Japan TEL + 81-3-6371-5800

2021.12

Rokkasho Low-level Radioactive Waste (LLW) Disposal Center

Overview of the Center, and Discussion of Its Safety



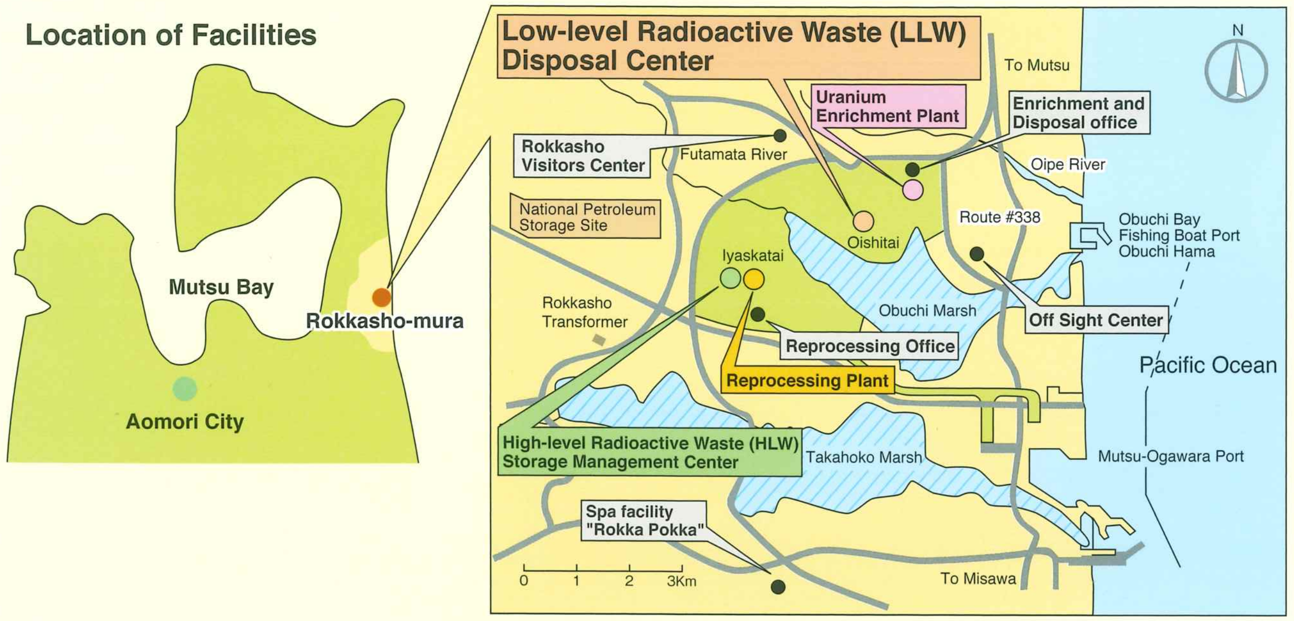
Rokkasho Low-level Radioactive Waste (LLW) Disposal Center

Overview of the Center, and Discussion of Its Safety

CONTENTS

Location of LLW Disposal Center

The Low-level Radioactive Waste (LLW) Disposal Center is located in Oishitai, Rokkasho-mura, Kamikita-gun, of Aomori Prefecture. This district is situated in the southern part of the Shimokita Peninsula in the northeastern corner of the prefecture, which lies at the northern tip of Honshu, Japan's main island.



Site Covers 360 Hectares (Including Uranium Enrichment Plant and Roads)

The site lies on the Pacific Ocean side of the Shimokita Peninsula. To the north is the Oipe River, and to the south, the Futamata River and the Obuchi Marsh. The site rests upon a plateau some 30 to 60 meters above sea level.

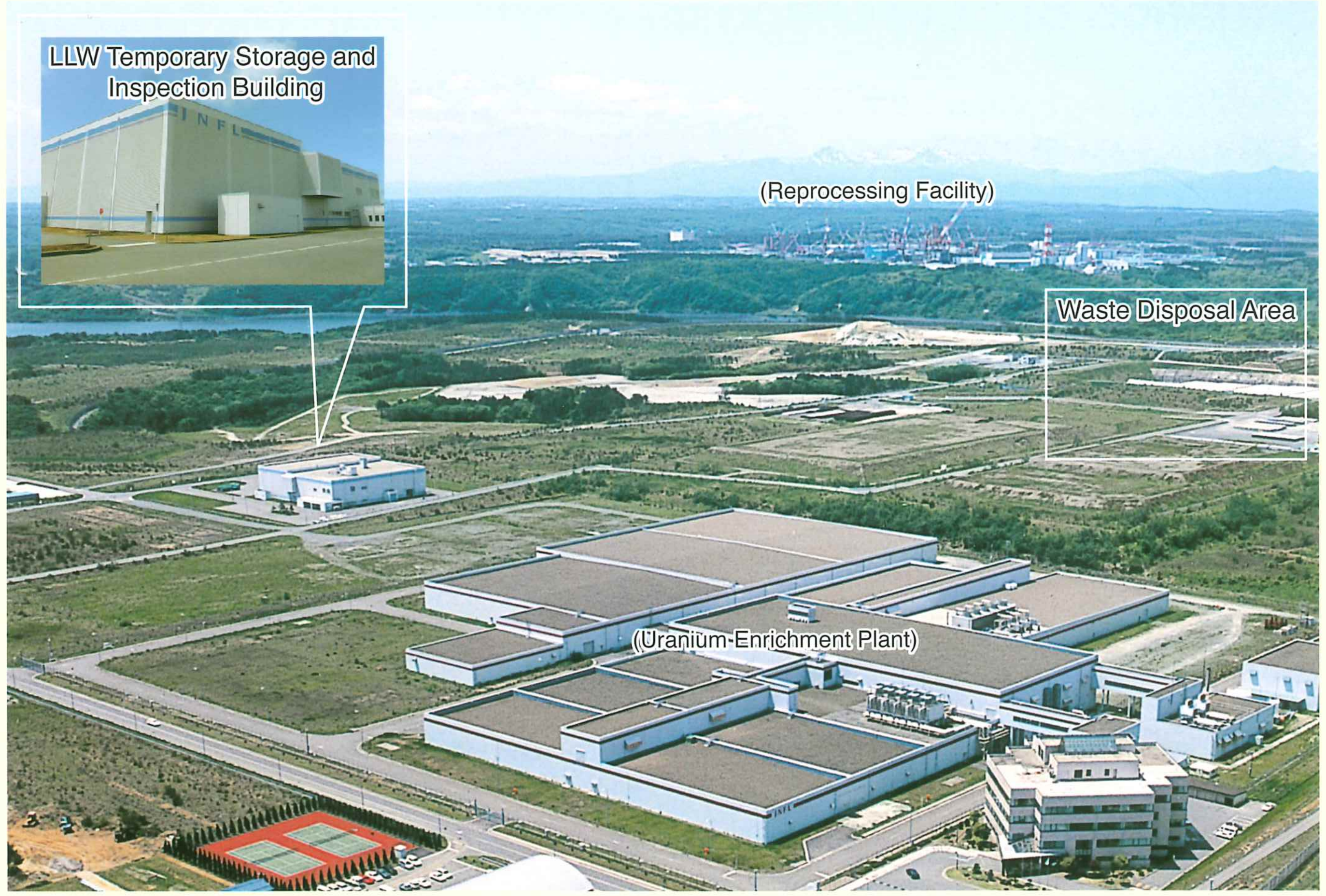
The Center contains a management building for the temporary storage and inspection of LLW as well as disposal areas for burying the waste.

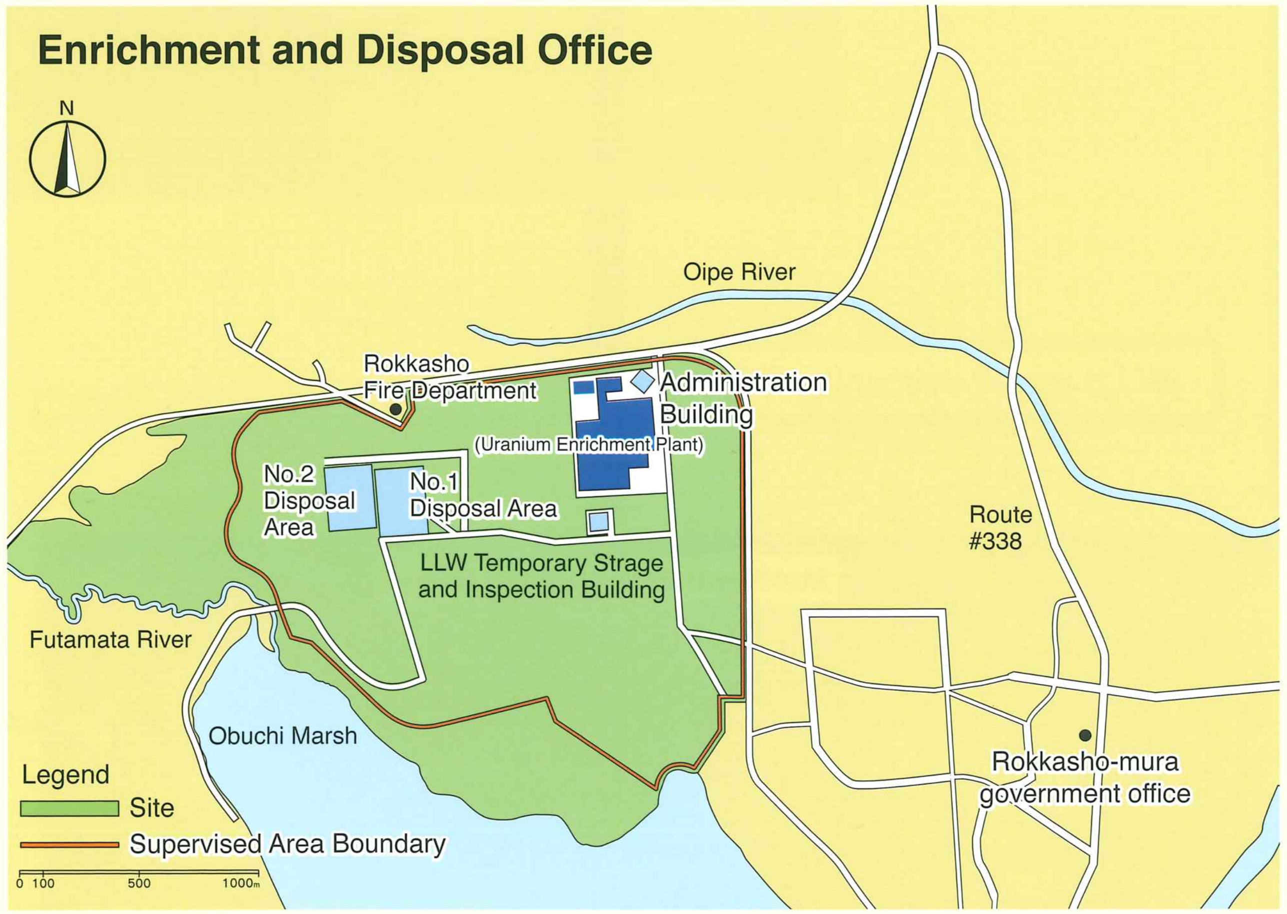
LLW Disposal Capacity is 80,000 Cubic Meters

The No.1 disposal facility was certified on November 15,1990, to dispose of 40,000m³ (equivalent to 200,000 drums) of LLW. Thereafter, on October 8, 1998, the No.2 disposal facility was certified to hold an additional 40,000m³ of disposal capacity, giving the facility a total LLW disposal capacity of 80,000m³.

In the future, some 600,000m³ of LLW are expected to be disposed of at the site.

Bird's-view of Enrichment and Disposal Office





Situation of LLW Disposal Business

Electricity is used in our daily lives and industries as a safe, clean form of energy. At present, the amount of electric power generated in Japan yearly is 900 billion kWh, around 30% of which comes from nuclear power.The completion of the nuclear fuel cycle—consisting of uranium enrichment, reprocessing, and waste disposal—is indispensable if nuclear power is to be utilized even more effectively in the future.

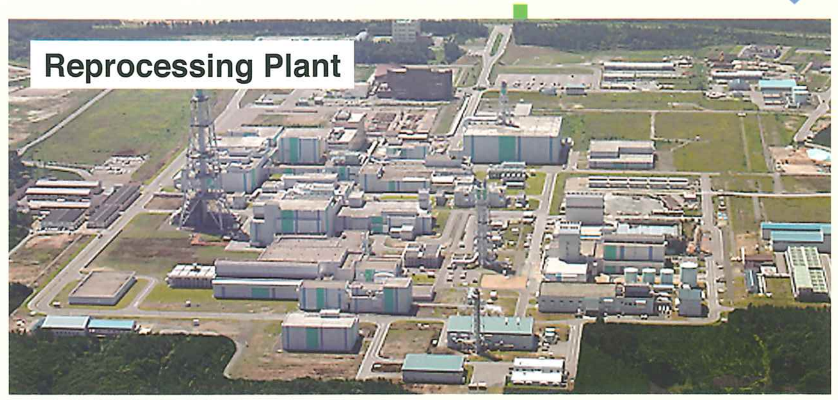
JNFL's LLW Disposal Center takes LLW from nuclear power plants and other places, and disposes of them safely while protecting human beings and the environment.

Reconversion and Fabrication

Spent Fuel

Low-level Radioactive Waste (LLW)

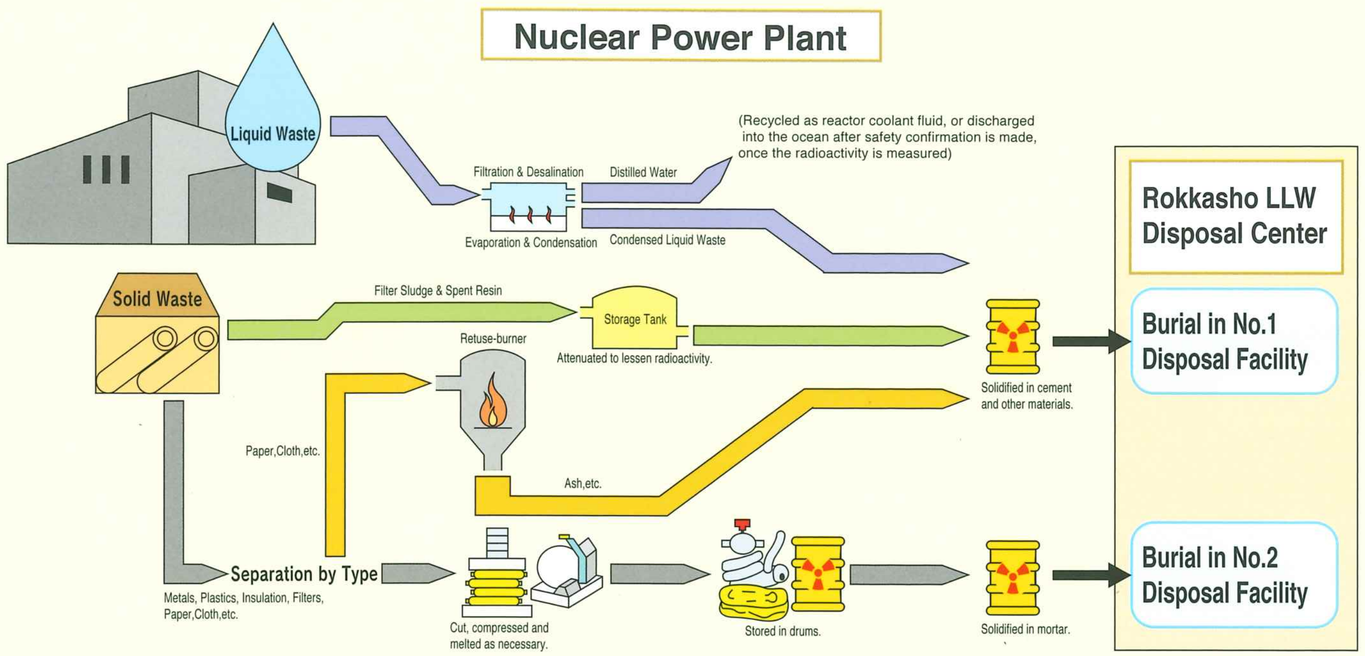
Low-level Radioactive Waste (LLW)



Conversion

Treatment and Conditioning of Waste

Waste Treatment

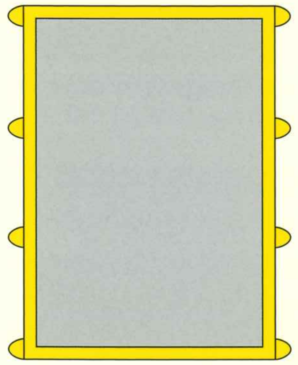


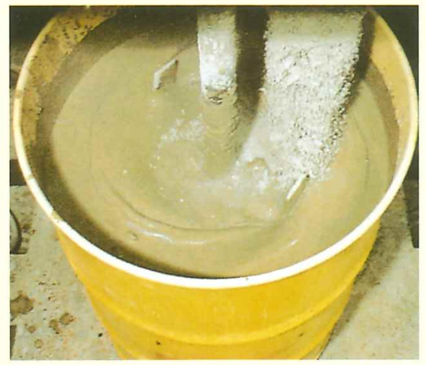
- Liquid waste, such as water from nuclear power plants (NPPs), is evaporated and condensed, then solidified with cement.
- The filter sludge and ion-exchange resin used to purify the water utilized in NPPs are stored in the storage tank, and then solidified with cement or other materials after the radioactivity decays.
- Combustible wastes from NPPs, such as paper and cloth, are incinerated, and the ashes are then solidified with mortar.
- Solid wastes, such as metal produced during periodical maintenance and inspections, are classified, and then cut or compressed as necessary, after which they are solidified with mortar.

Waste Form Buried in No.1 Disposal Facility

●Solidification of Liquid LLW

Liquid LLWs are produced during the operation of NPPs. They include condensed liquid waste and spent resin, which are mixed with cement, asphalt or plastic. And then, they are made homogeneous and uniform. They are then poured into 200L steel drums for solidification.



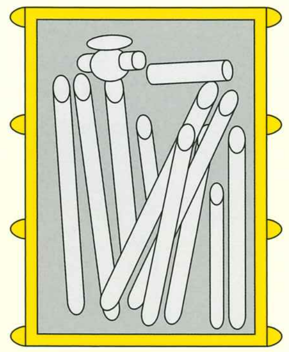


Concentrated waste solidified with cement

Waste Form Buried in No.2 Disposal Facility

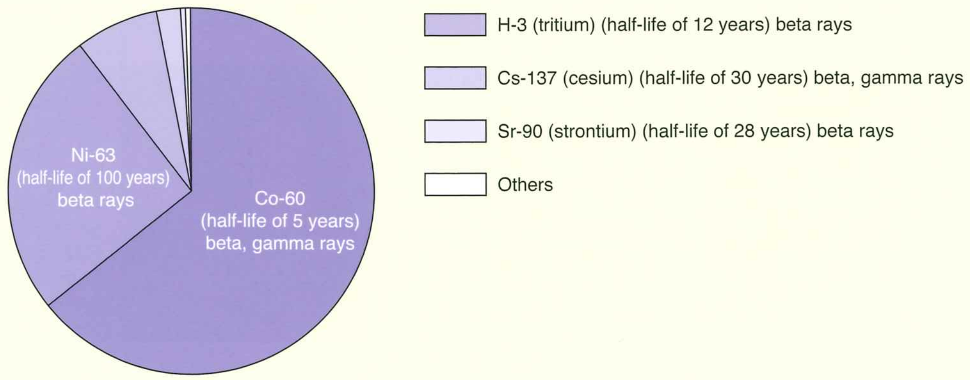
● Solidification of Solid LLW

Solid LLWs are produced during the operation of NPPs. They include metal, plastics, insulation, and filters. They are classified, and cut or condensed as necessary, after which they are stored in 200L drums and solidified with mortar.



Metal stored and solidified with mortar

Composition Ratios of Radioactive Nuclides in Buried LLW



Process of Inspecting Waste Packages in Nuclear Power Plants

1 Inspection in Nuclear Power Plant

The waste packages are removed from storage for inspection.

Waste packages are removed from the storage facility.

They are then transferred to the inspection room.

●Measurement of Surface Contamination Density

Using the smear method, the top, sides and bottom of the waste package are inspected for surface contamination. Afterwards, charcoal filter paper is placed on the measuring device.

●Measurement of Axial Compressive Strength of Hardened Cement (Waste for No.1 Disposal Facility)

Ultrasonic waves are passed through the waste package from the outside, and their speed is measured. That measures the axial compressive strength of the waste solidified in the cement.

●Measurement of Radioactive Nuclides Content and Weight

This device measures the density of the radioactive nuclides by a Ge-NaI detector as well as the weight of the waste package. The radioactive nuclides content can be calculated after those two measurements are obtained.

●Inspection of Outer Shell, Measurement of Dose Rate

A GM detector measures the dose rate of the outer surface of the waste packages, verifying that it does not exceed the stipulated standards. Also, cameras affixed to the top, sides, and surface of the drum check for any damage to the drum.

●Attachment of Identification Number and Colored Band to Drum

After the waste package has cleared all the necessary inspections, a identification number label is automatically printed out on the basis of computer data, and attached to the drum. Also, a colored band is also affixed to a prescribed spot on the drum, indicating the surface dose rate level.

Waste packages are stored in transport containers.

2 Transportation

Waste packages that have passed inspection are then transported to the LLW Disposal Center by ship and truck.

Surface inspections are made of the radioactivity dose rate before the waste is transported.

Transport containers are loaded onto the transport ship.

Waste is transported by sea (pictured is the special transport ship, the Seiei-maru).

Transport containers are unloaded from the transport ship in the dock.

Radioactivity measurement is made by the gate monitor.

Transport containers are transported to the LLW Temporary Storage and Inspection Building in the LLW Disposal Center.

Process of Inspecting Waste Packages in LLW Disposal Center

3 Rokkasho LLW Disposal Center

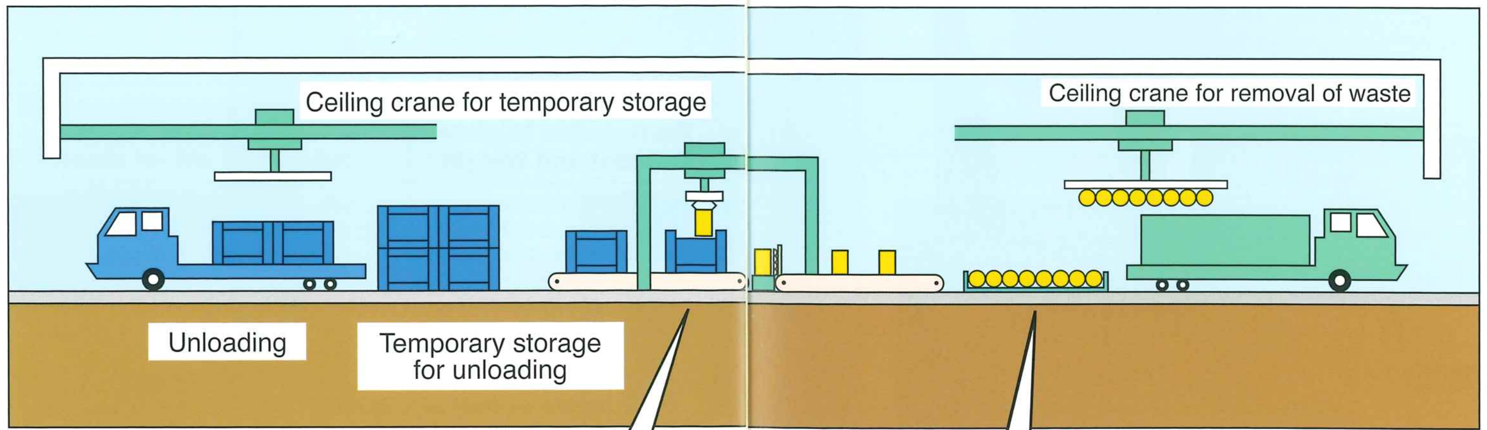
Inspection

Final inspection is made of the waste packages brought into the LLW Disposal Center.

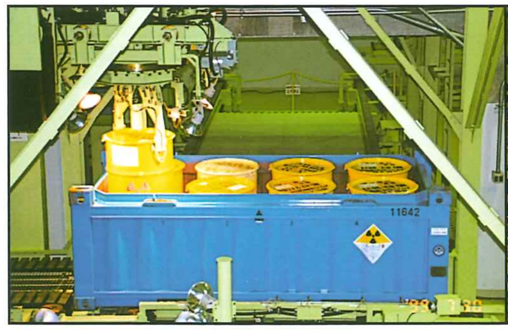
- Drum surface inspection
  (checking for damage in transit)
- Confirmation of identification number
  (checking whether the received drums are the same as those sent by the NPP)
- Confirmation of RI Mark


View of control room


Transport containers are brought into the LLW Temporary Storage and Inspection Building




Waste Moved to LLW Disposal Area


Waste packages raised to inspection device


Inspection


Waste packages removed

4 LLW Disposal Area

Process of Disposing of Waste Packages

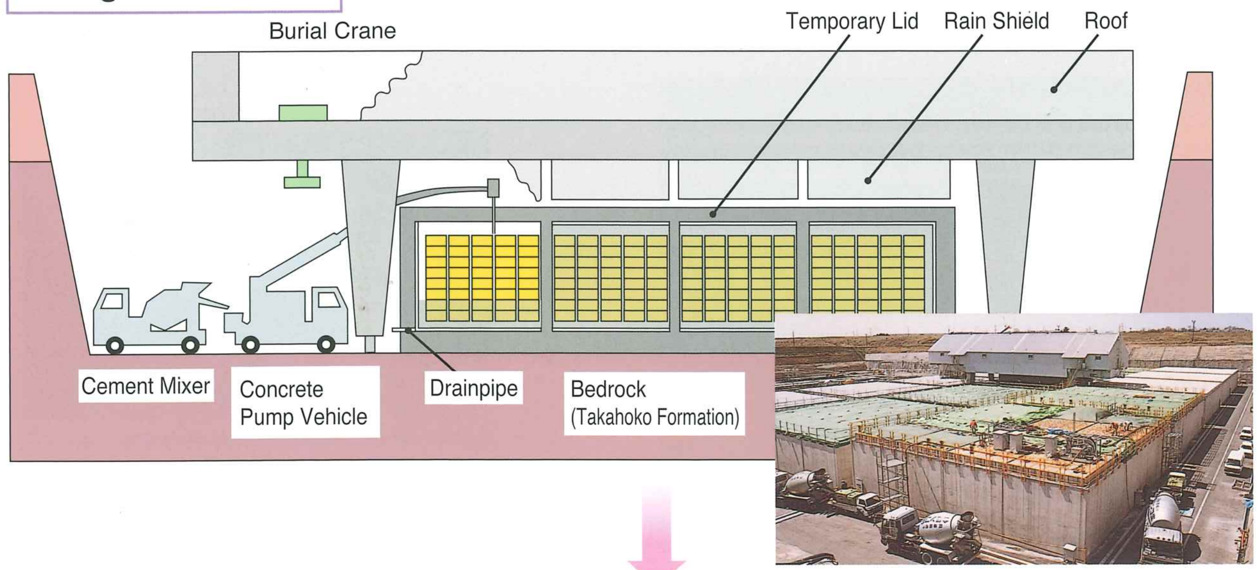
4 LLW Disposal Area

Stacking Drums

Waste packages are stacked inside the disposal facility.

Filling with Mortar

Mortar is poured in the spaces between the waste packages.



Covering with Concrete

A reinforced-concrete lid is placed atop the disposal facility, resembling a monolithic rock.

Covering with Soil

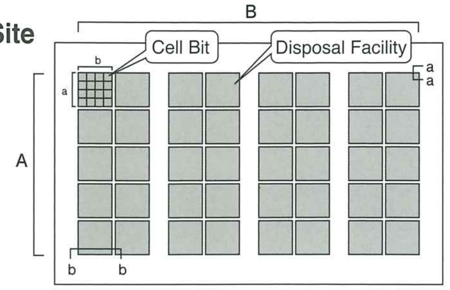
Inspection tunnels are attached to the disposal facility. The top and sides of the facilitiy are covered with a mixture of water-impervious soil and bentonite (a kind of clay). The top of it is covered with a layer of soil, above which sod (grass) planted.

Structure of Disposal Facilities and Cover Soil

Structure of No.1 Disposal Facility

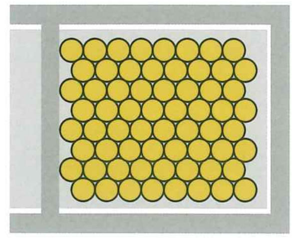
●Plan of Entire Site

A: 132m
B: 231m
a: 24m
b: 24m

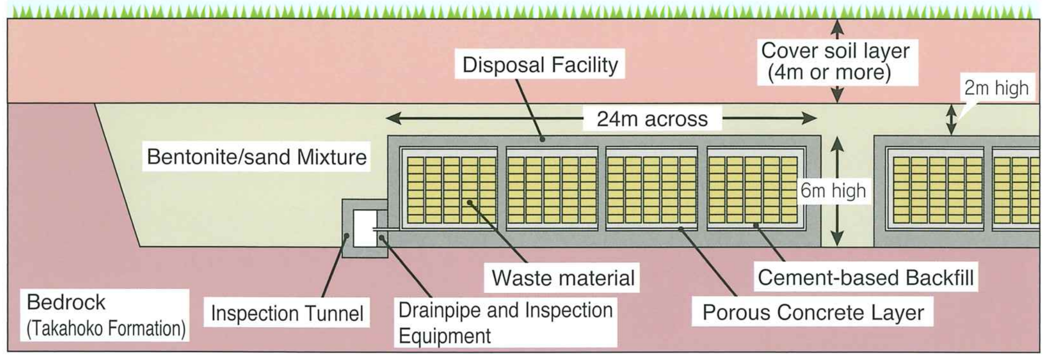


●Cross-section View of Cell (Viewed along a-a Axis)

The waste is arranged in 8 layers measuring 8 drums across and 5 drums deep. The waste packages are placed in 8 rows by 5 columns on 8 tiers.



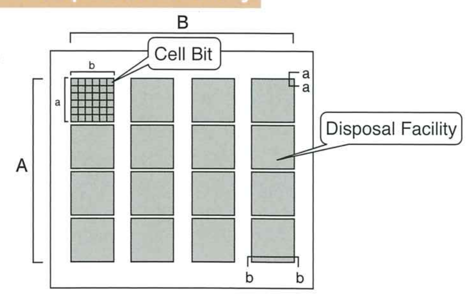
●Cross-section View of Disposal Facility (Viewed along b-b Axis)



Structure of No.2 Disposal Facility

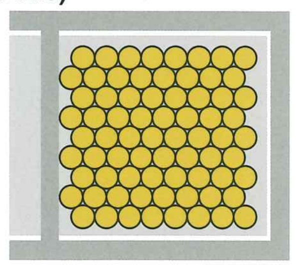
●Plan of Entire Site

A: 152m
B: 191m
a: 36m
b: 37m

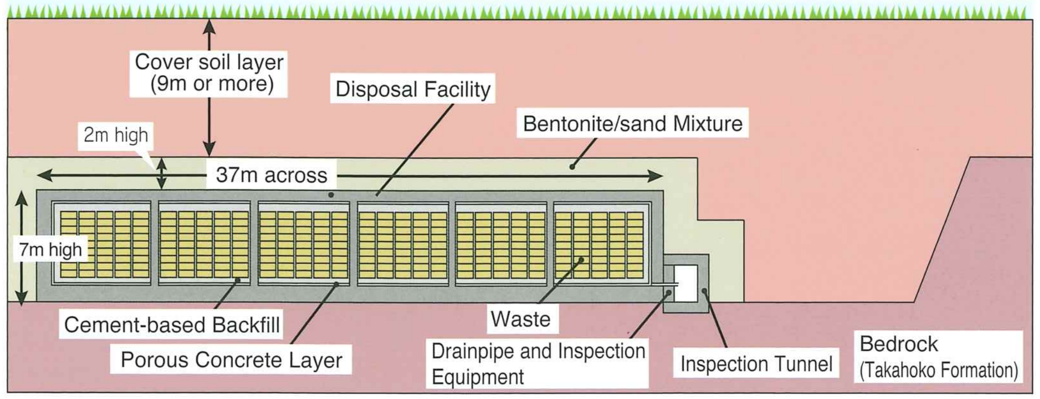


●Cross-section View of Cell (Viewed along a-a Axis)

The waste packages are placed in 8 rows by 5 columns on 9 tiers.



●Cross-section View of Disposal Facility (Viewed along b-b Axis)



Efforts to Maintain Safety at Disposal Facility

Phased Management after Waste Burial

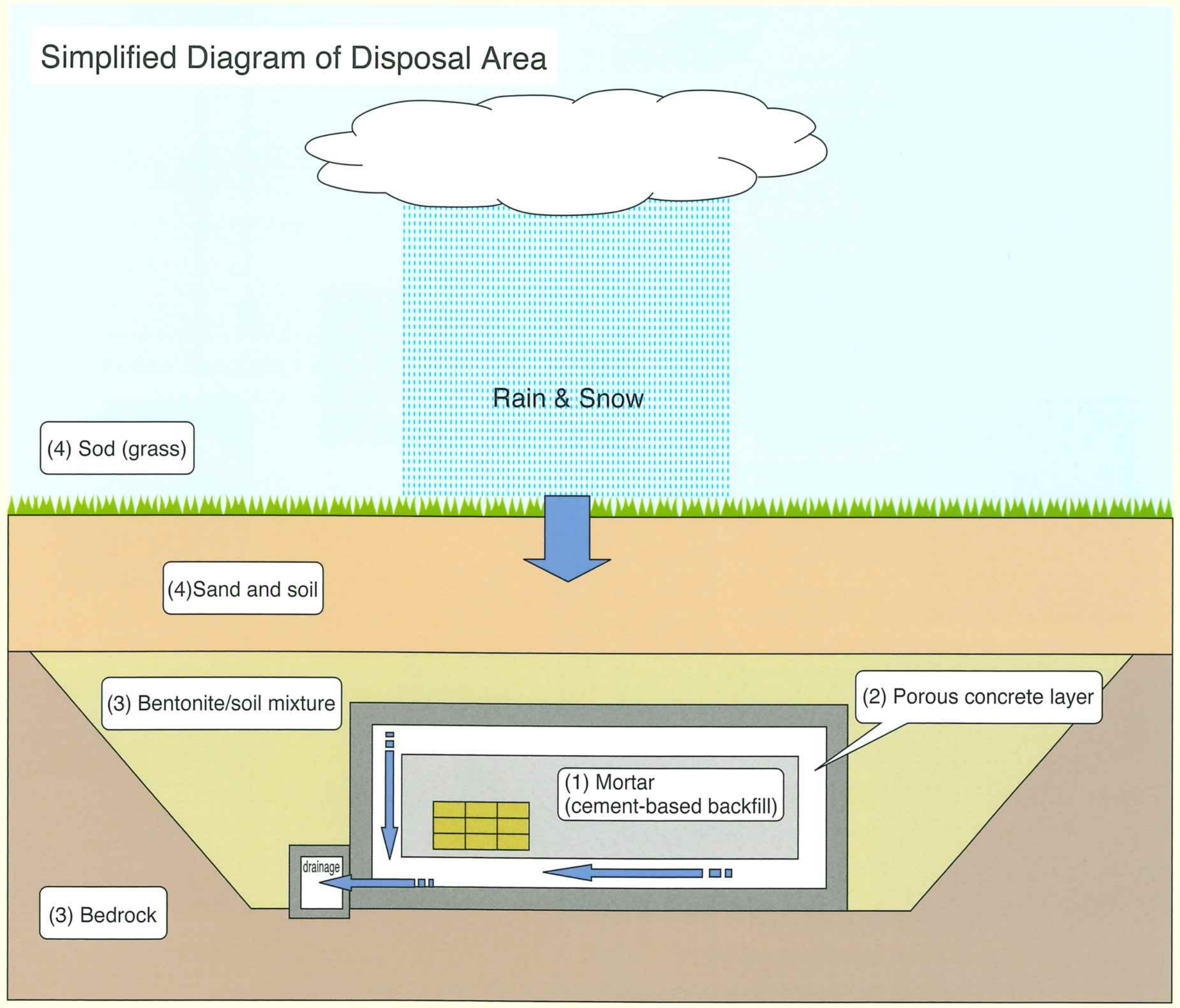
In the management of the waste disposal facility, three phases have been instituted in accordance with the "Fundamental Guidelines of Licensing Review of the Burial Disposal Facility of Low-level Radioactive Waste," as determined by the Nuclear Safety Commission.

The phased management of LLW disposal at the Center will be carried out over a period of some 300 years. The radioactivity of buried waste will decline to safe levels over that time.

	1st Phase	2nd Phase	3rd Phase
Scheduled Period	Time elapsed after initial disposal No.1:30-35 years No.2:25-30 years	Time elapsed after 1st Phase: 30 years	Time elapsed after 1st Phase: 300 years
Purpose	Containment within disposal facilities	Prevention of transfer using disposal facilities and cover soil	Prevention of transfer, primarily through cover soil
Control Management	·Establishment of disposal maintenance area, monitoring of waste burial, restoration of cover soil ·Environmental monitoring		
	·Establishment of supervised area ·Monitoring of density of radioactive substances in groundwater ·Drainage of water, supervisory facilities water drainage		·Restrictions on excavation, etc.
	·Monitoring for any leakage ·Repairs of disposal facilities, etc.	·Monitoring of leakage conditions	

Steps Taken to Prevent Radioactivity Leakage

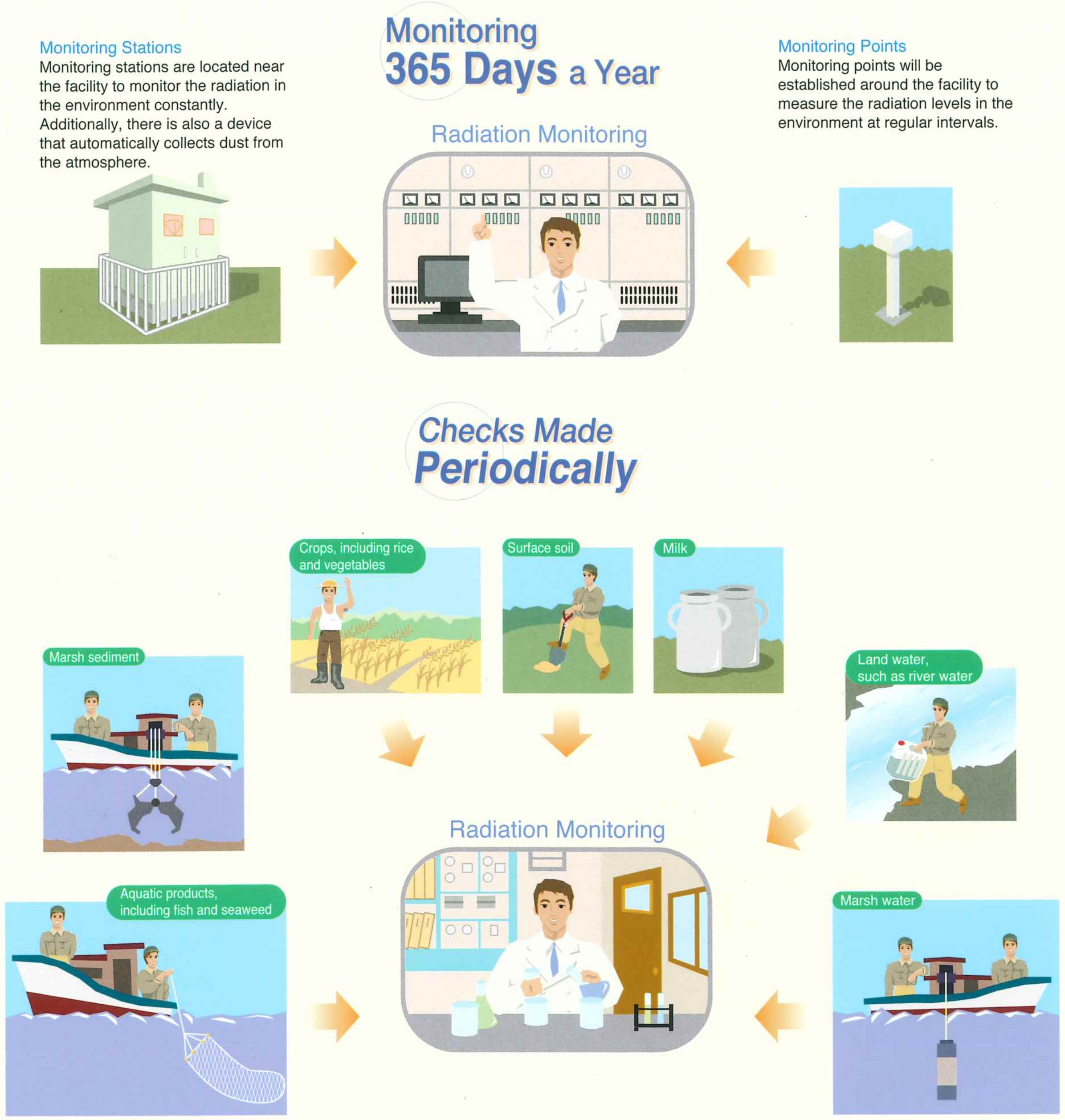
(1) Waste packages received at the LLW Disposal Center are set into place in the reinforced-concrete disposal facility. Radioactivity in the waste is sealed in through mortar (cement-based backfill) that is poured between the waste packages so as to leave no holes or cracks.
(2) Porous concrete (consisting of tiny pores to allow water to pass freely) is used to line the inside of the disposal facility. That allows for drainage of any water that has seeped in before it reaches the waste packages.
(3) The disposal facility is built within a bedrock layer that is not permeable to water. Moreover, the sides and top are covered with a layer containing a mixture of soil and bentonite (a kind of clay), which is even less permeable than bedrock, further preventing any water from seeping in.
(4) Sand and soil are placed over the whole facility, and sod (grass) planted on top.



Radioactivity attenuates over time. Also, even if the disposal facitilites deteriorate in the future, safety is guaranteed because the surrounding bedrock and soil (as illustrated) prevent the seepage of radioactivty into the environment.

Monitoring of Environmental Impact

Before operation begins, measurements are taken of the natural radiation occurring in the vicinity of the nuclear fuel cycle facilities. After the commencement of operation, then, exhaust gases and effluents are discharged only after their safety is thoroughly checked. Simultaneously, the surrounding environment is continuously monitored. Those data are then compared with the data collected before operations began, so as to verify that no environmental impact is being made.



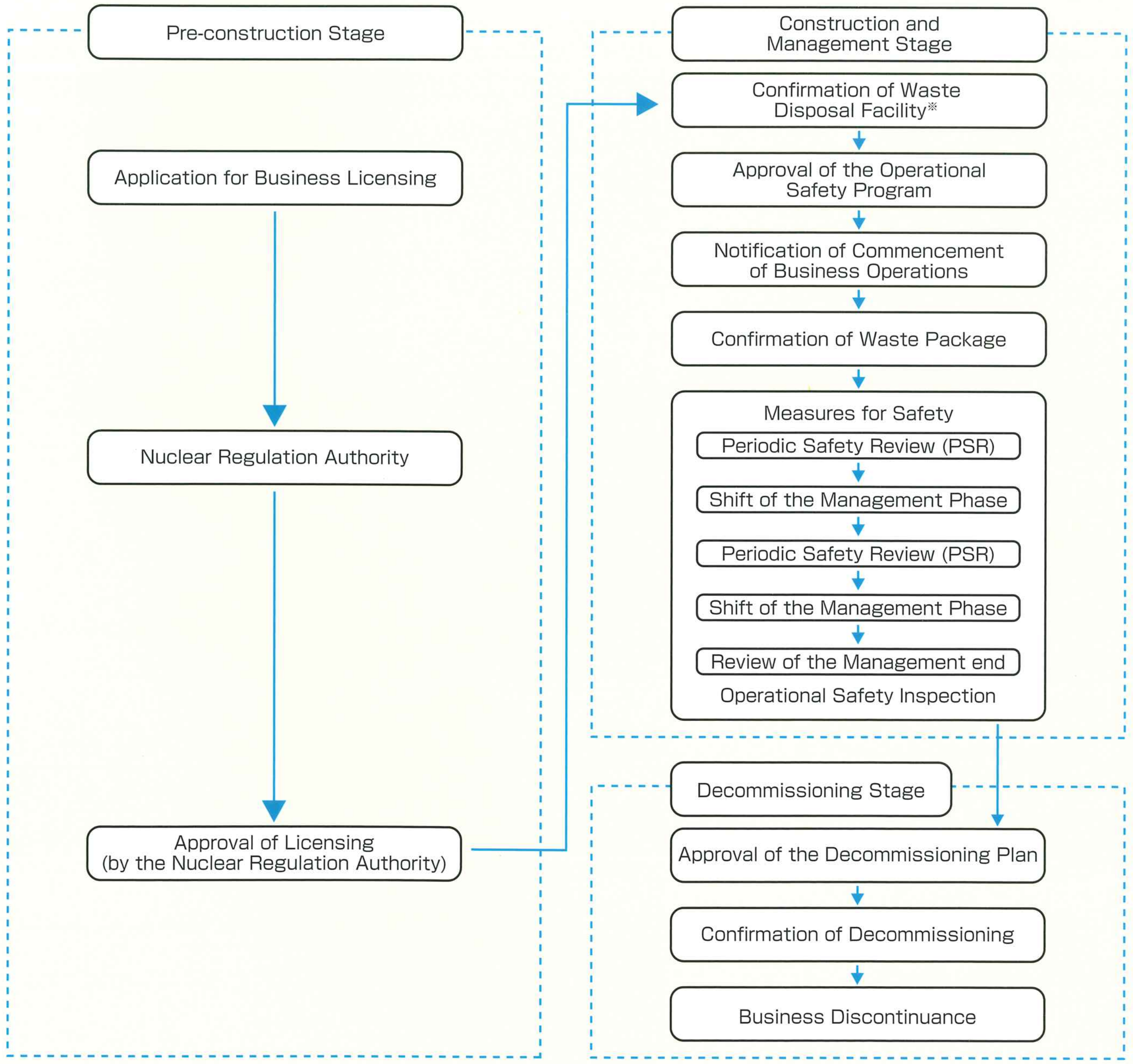
Measurement Data is Given to Aomori Prefecture Residents

Environmental monitoring is carried out by both JNFL and Aomori Prefecture. Both sets of data are periodically released by the Prefecture to local residents, after being discussed and evaluated by the council set up by the Prefecture to monitor and evaluate the environmental radioactivity emitted by the nuclear facilities.

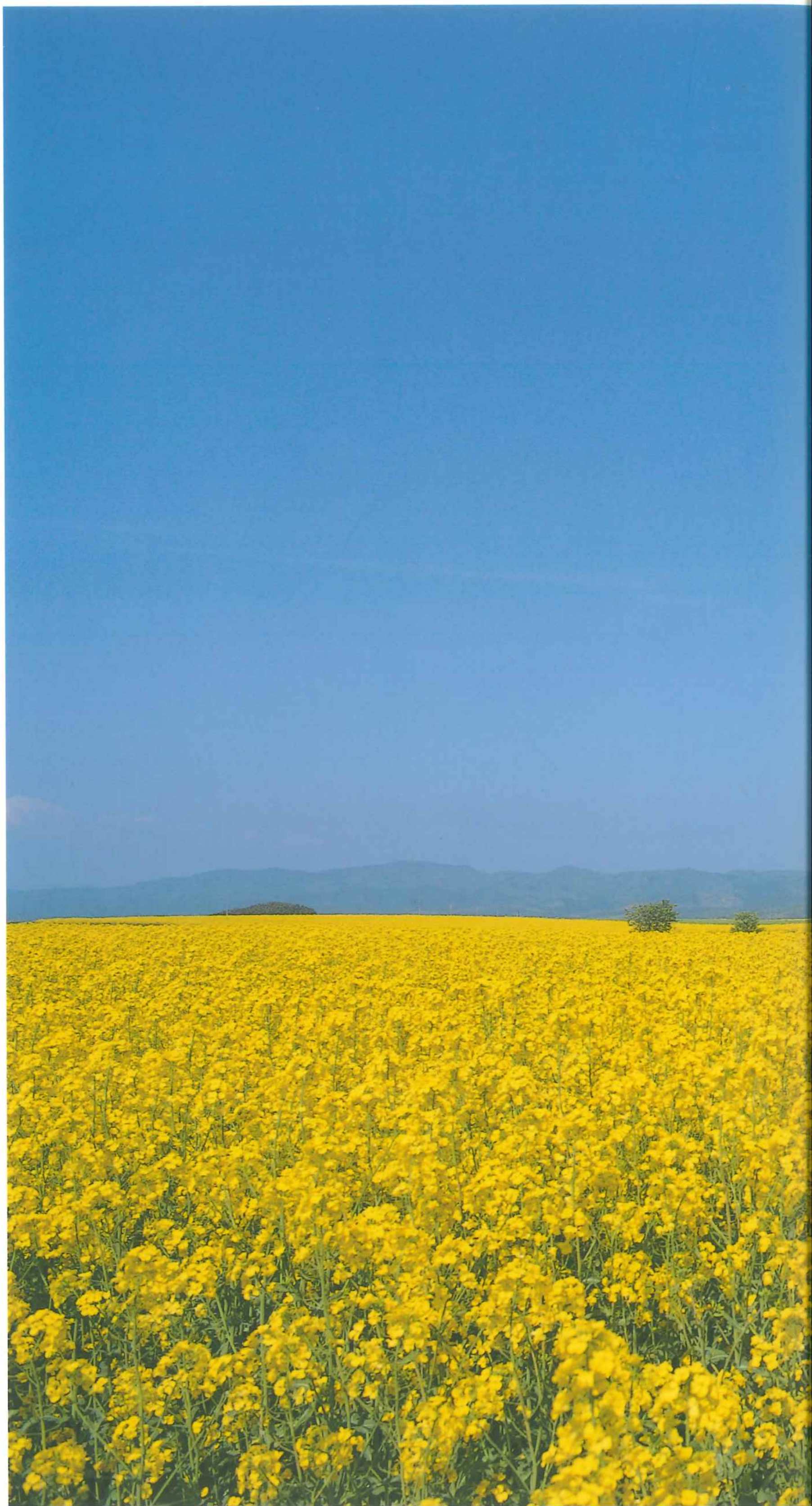
Regulations on Waste Disposal Business

In order to start a waste disposal business in Japan, the applicant has to submit the application for business licensing to the Nuclear Regulatory Authority (NRA) and gain a business licensing on the basis of the "Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors". The NRA grants permission to the applicant after confirming that safety described in the application meets regulatory requirements based on the above Act through a safety examination.

After gaining the business licensing, the applicant (the license holder) has to apply to the NRA for approval of the Operational Safety Program on the waste disposal facility prior to the start of the business. After that, the Nuclear Safety Inspectors (on-site NRA staff members) check the safety measures on the waste disposal facility through the regulatory process of the Operational Safety Inspection once a quarter. Also, the license holder has to perform "Periodic Safety Reviews (PSR)" on the waste disposal facility about once a decade . The NRA checks the results of PSR and additional safety measures for the license holder.



※The confirmation of Waste Disposal Facility is performed continuously.



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