Business Permit of JNFL Rokkasho Reprocessing Facility

November 2020
Nuclear Regulation Authority, Japan

Background

JNFL Rokkasho Reprocessing Facility obtained Permit of Business in 1992, and its spent fuel storage facility already started its operation in 1999. The reprocessing facility is in the stage of Pre-service Inspection. The Licensee submitted the application for Amendment of Business Permit in January 2014, following the enforcement of the new regulatory requirements for reprocessing facility in December 2013. After a series of review meetings and revisions of the application, the NRA permitted the amendment of Business Permit in July 2020.

Status of the facilities at JNFL Rokkasho Site

July 2020 Amendment of Business Permit for **Reprocessing Facility** permitted

August 2020 Amendment of Business Permit for **Waste Storage Facility** permitted
(Storage for vitrified high level radioactive waste returned from overseas)

October 2020 Amendment of Business Permit for **MOX Fuel Fabrication Facility** is under public comment process

Next Steps

- Approval of Design and Construction Plans
- NRA confirmation for Licensee's Pre-Service Inspection

The NRA showed the procedure of conformity review for Design and Construction Plans and confirmation of Licensee's Pre-Service Inspection in June 2020.

Consideration Points during Reprocessing Facility Conformity Review

(Refer to attached power point slides for more details)

Design Basis Facility

- Additional or strengthened requirements in the new Licensing Standards
  - Fire, ground displacement, earthquake, tsunami, external events (see below), unauthorized entry to site, flooding, leak of chemicals, operational error, facilities for DB, control room, monitoring system, electric power supply system, emergency response centre, communication equipment
- Prevention of damage caused by external events
  - Volcanic activity, tornado, external fire, airplane crash, lightning strike, other natural or

human induced events.

- External fire includes the one caused by airplane crash which is assumed to break out on outer wall of facility buildings.
- Prevention of damage caused by airplane crash: airplane crash probability is evaluated for each process area basis and confirmed not exceeding 10^{-7} times/year.

■ Change of spent fuel cooling period

- Prior to reprocessing: 4 years or more ⇒ 15 years or more

Severe Accident Facility

■ Measures against severe accident

Accidents that occur under severer conditions than the design conditions

1. Criticality accident
2. Evaporation to dryness due to loss of cooling function
3. Explosion due to hydrogen generated by radiolysis
4. Fire or explosion caused by organic solvent
5. Significant damage to spent fuel in the spent fuel storage facility
6. Leakage of radioactive material

Features of measures

- Criticality accident: Neutron absorber is automatically supplied immediately after criticality is detected. Radioactive materials are automatically transferred to waste gas storage tank.
- Evaporation to dryness: Direct water injection lines to internal loop, vessel, and cooling coil are equipped. Exhaust is concentrated and directed to another cell, and discharged through alternative filters.

During conformity review, the NRA confirmed that the amount of radioactive materials released for each accident and the amount released when severe accidents occur simultaneously are less than 100 TBq Cesium-137 equivalent, and as low as practicable.

■ Emergency response centre

■ Large-scale damage (response in the event of a large aircraft collision or other terrorisms)

NRA, Japan
Nuclear Regulation Authority

Conformity Review for Amendment of Business Permit of JNFL Rokkasho Reprocessing Facility

Nuclear Regulation Authority, Japan

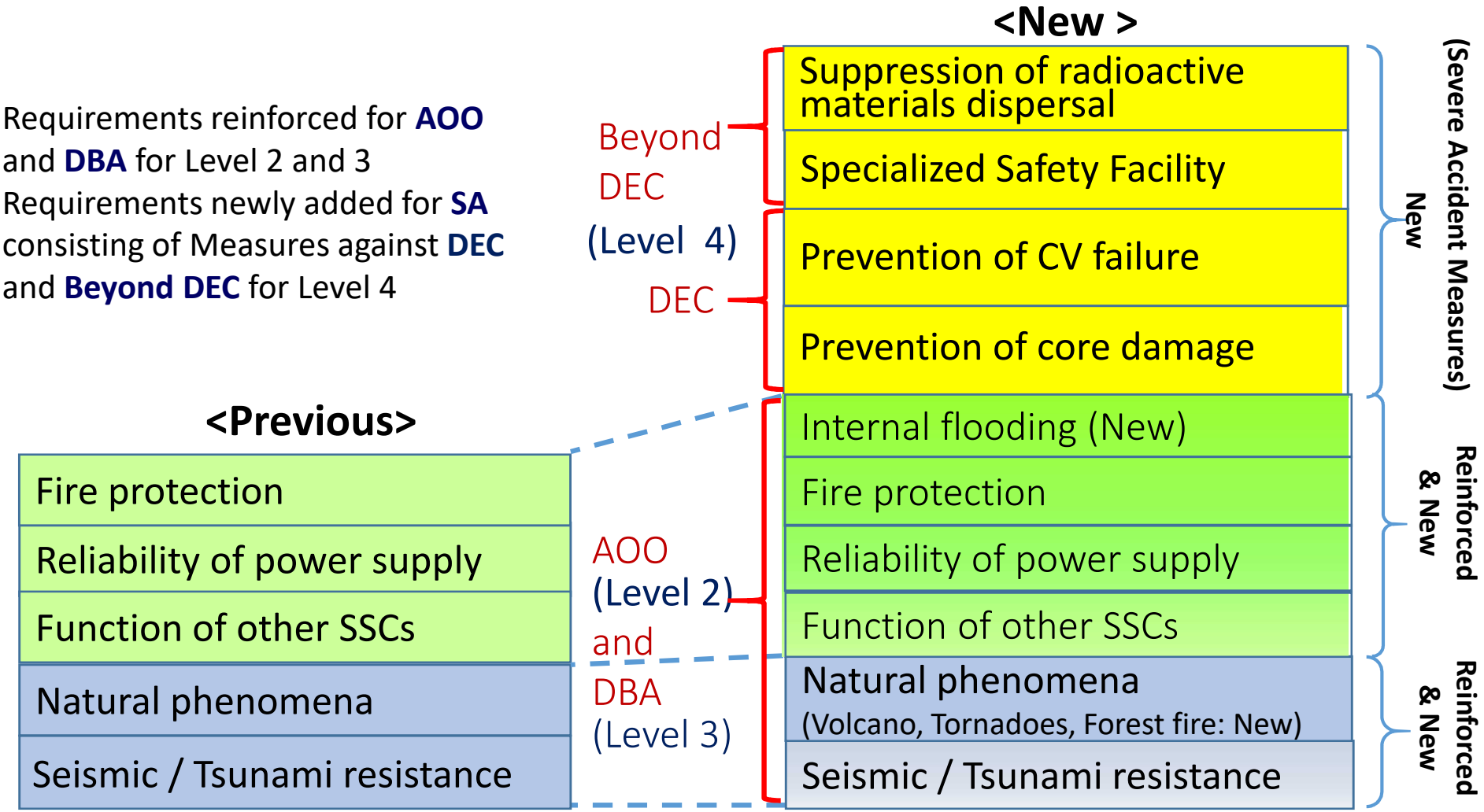
External Advisors Meeting, 25 November 2020

Contents

New Regulatory Requirements

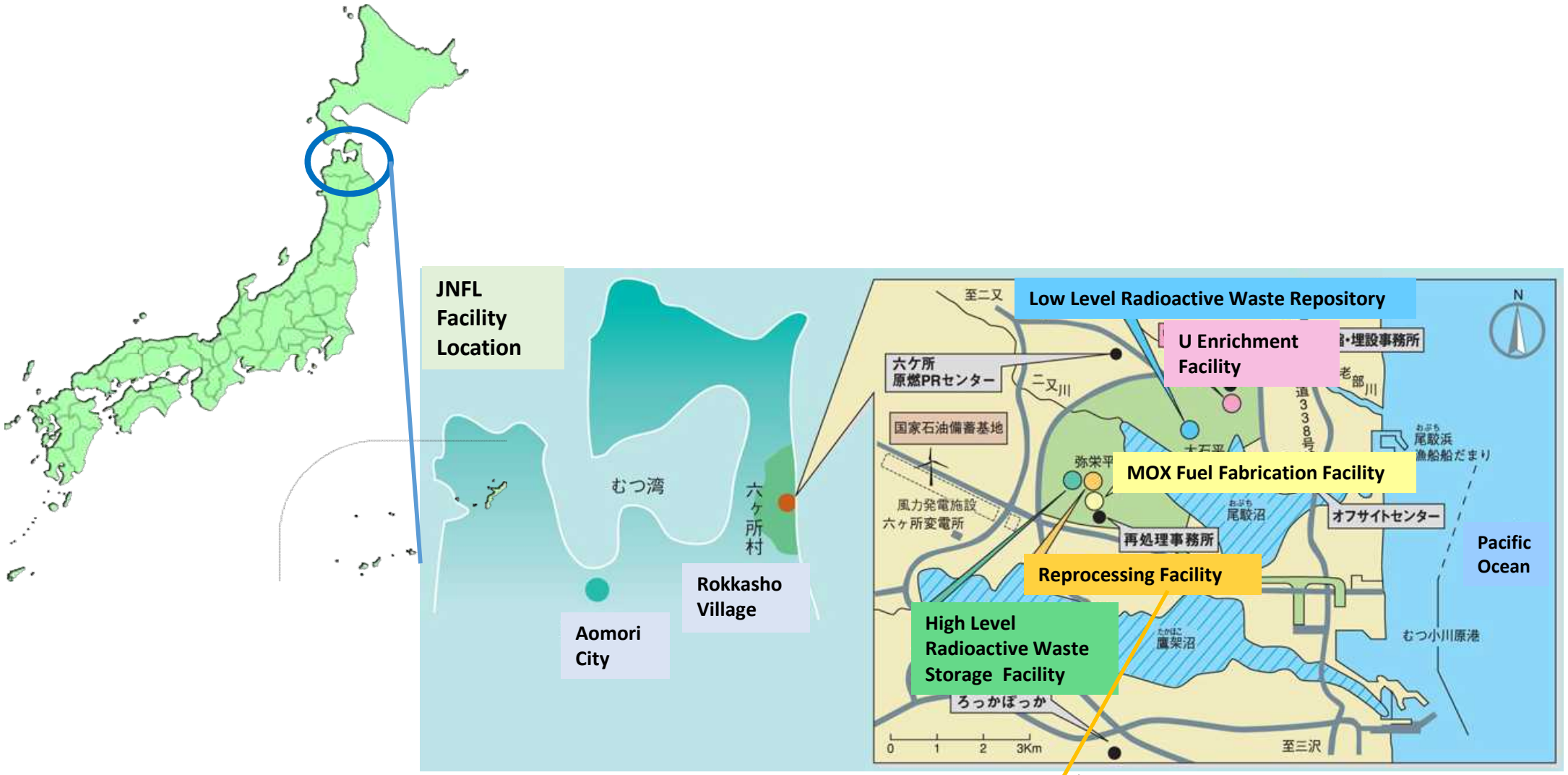
- The figure below explains the new regulatory requirements for commercial power reactors, and the new requirements for reprocessing was established in line with this concept.

- ✓ Requirements reinforced for **AOO** and **DBA** for Level 2 and 3
- ✓ Requirements newly added for **SA** consisting of Measures against **DEC** and **Beyond DEC** for Level 4



AOO : Anticipated Operational Occurrences
SA : Severe Accident
DBA : Design Basis Accident
DEC : Design Extension Condition

Overview of JNFL Rokkasho Reprocessing Facility



(Extracted and modified from JNFL HP < https://www.jnfl.co.jp/ja/company/facility/>)

JNFL Rokkasho Reprocessing Facility

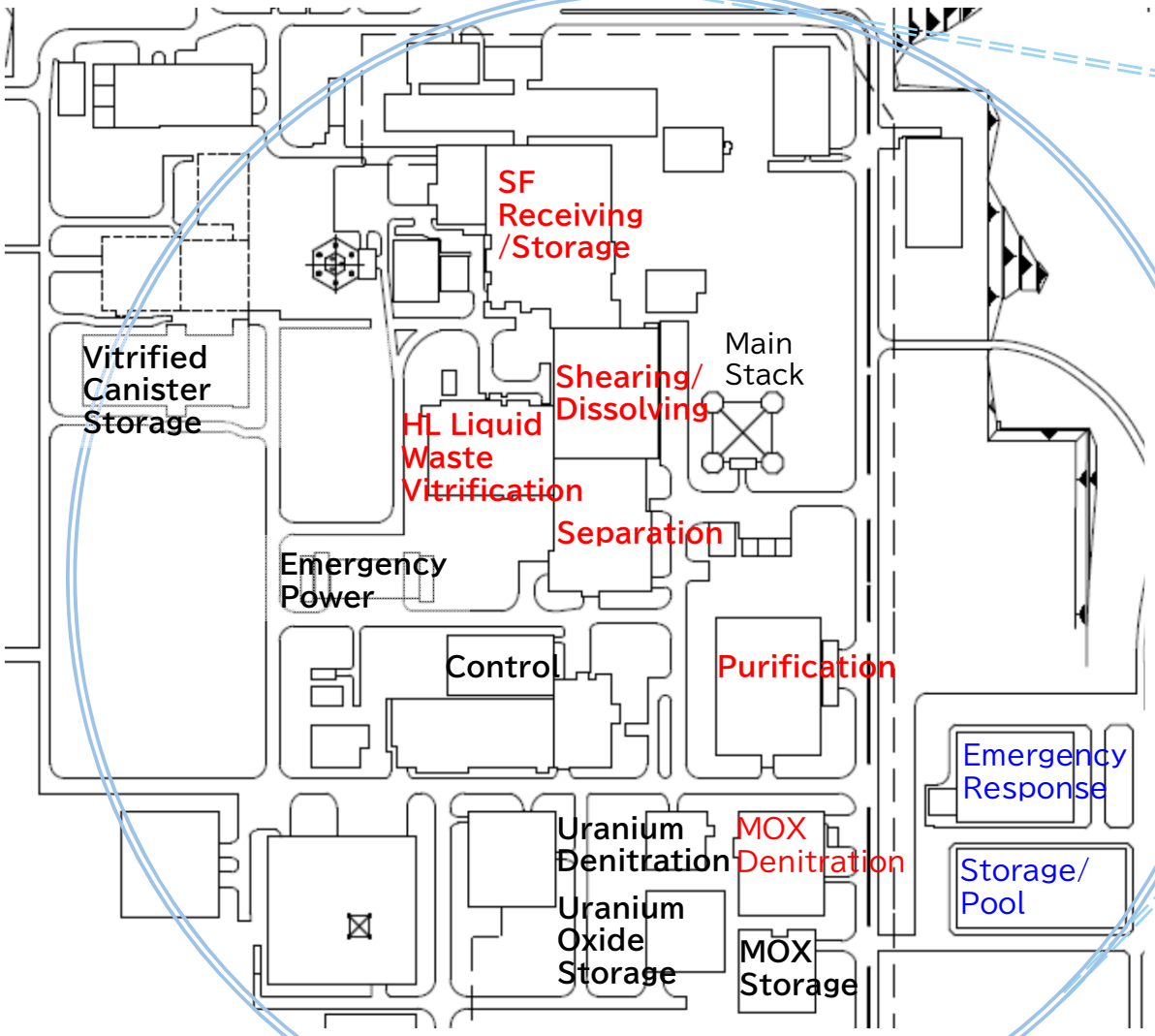
The maximum capacity of the plant: **800 ton-U/year**

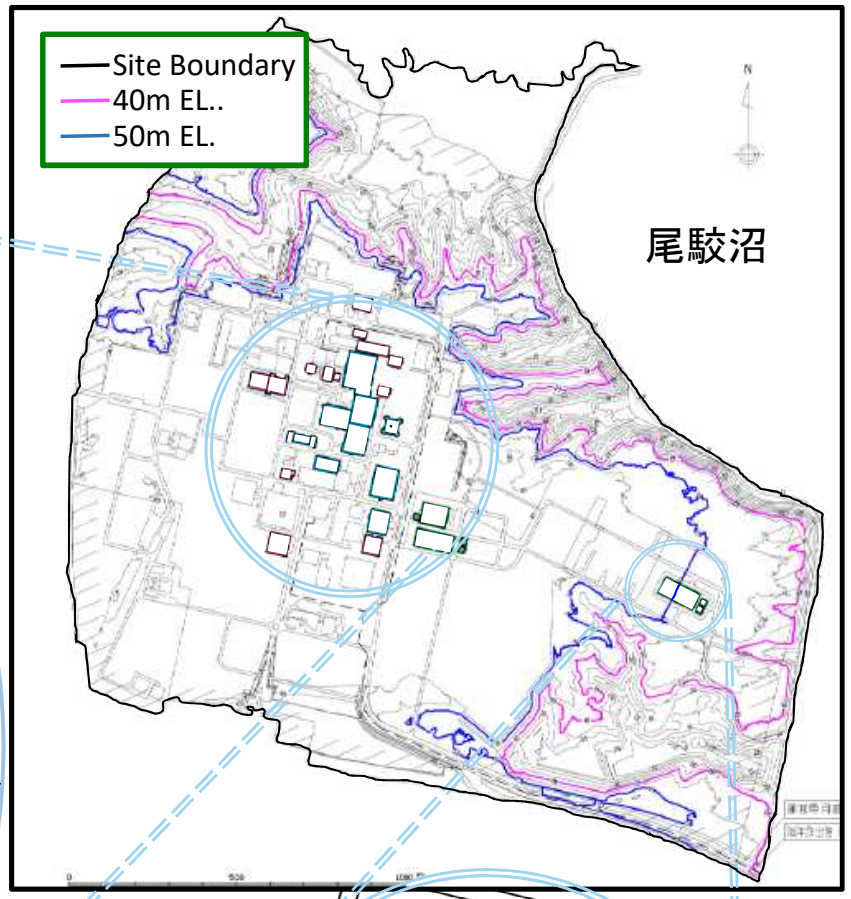
The maximum capacity of spent fuel pool: **3,000 ton-U**

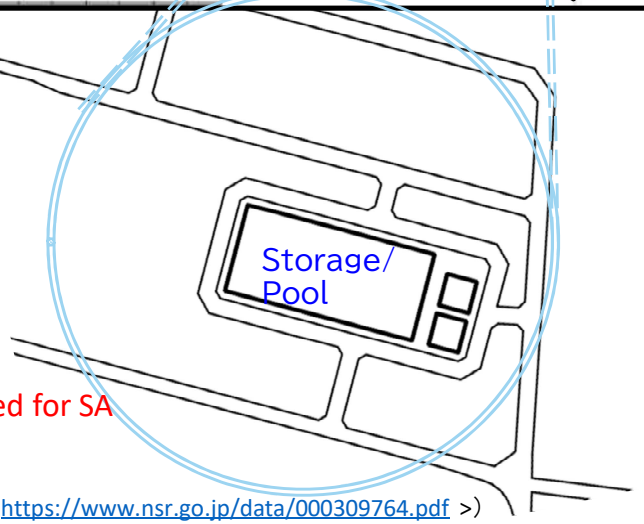
Rokkasho Reprocessing Facility Site Map

- Site Area : Approx. 3.9 km^2
- Site Elevation : Approx. 55 m

Site Map



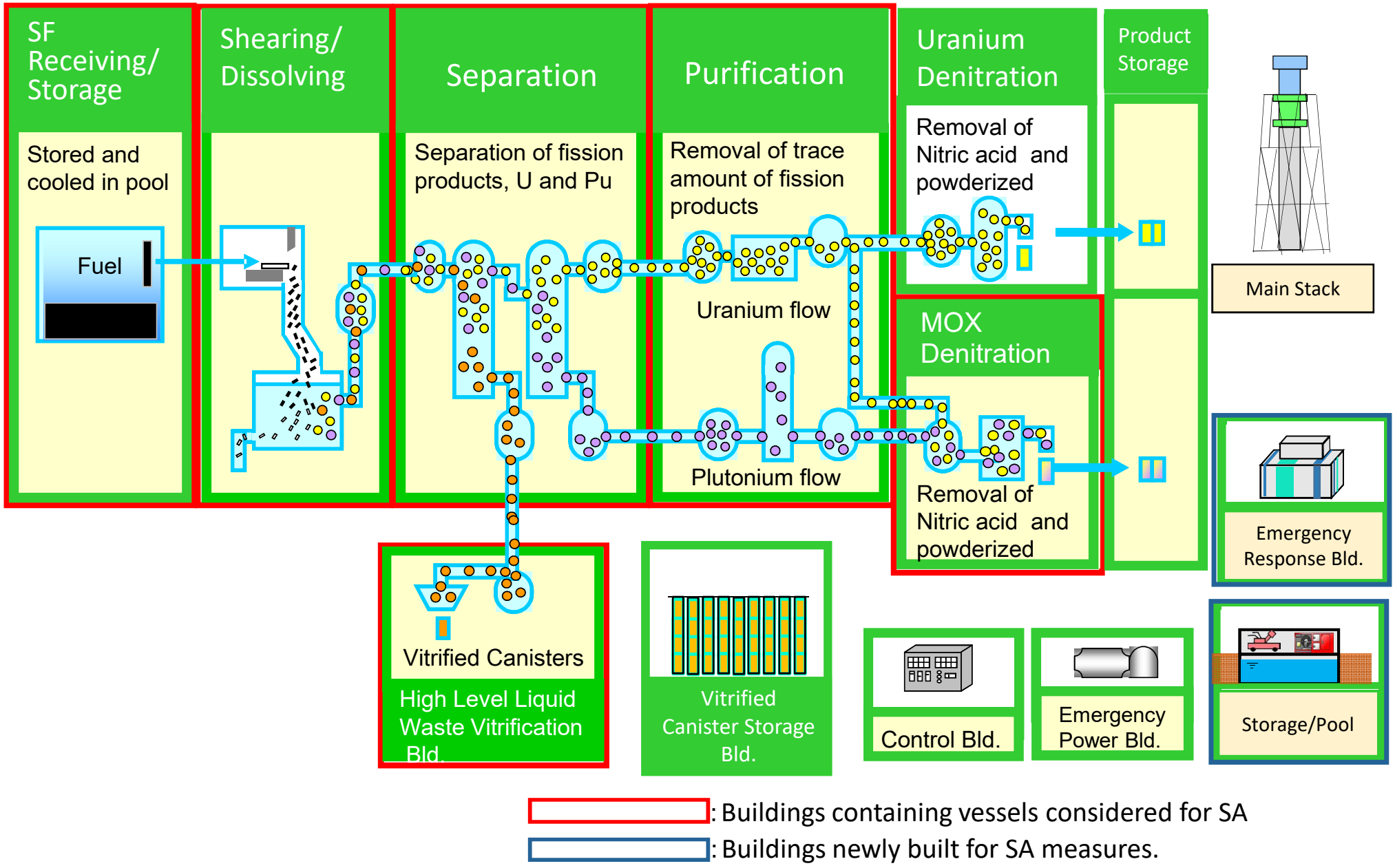




NOTE : Buildings containing vessels considered for SA
Buildings newly built for SA measures

(Extracted and modified from the document of the application amendment（April 28, 2020） < https://www.nsr.go.jp/data/000309754.pdf, https://www.nsr.go.jp/data/000309764.pdf >)

Process Flow of Rokkasho Reprocessing Facility



(Extracted and modified from the document of the 271th Conformity Review Meeting for Nuclear Fuel Facilities（April 23, 2019） < https://www.nsr.go.jp/data/000268488.pdf >)

Points of Conformity Review for DB Facility

Change of Spent Fuel Cooling Period

Outline of Application

- Safety design based on cooling period in Past Permit is maintained for safety conservativeness, although the amount of radioactivity is reduced due to cooling period change. Discharge control target is set lower than Past Permit based on revised cooling period.

Past Permit		Amendment Application
More than 1 year before receiving	changed	Less than 600t is 4 years or more, and the other is 12 years or more in the entire pool storage (3,000t).
More than 4 years before shearing		More than 15years before shearing

*Year-count starts when reactor shut-down for fuel removal.

Summary of Conformity Review Results

The NRA judged that the new discharge control target conforms to the Licensing Standards and maintaining the design based on the Past Permit does not deteriorate safety margin.

(Reference)

① Typical Decay Heat Densities of Various Solutions (W/m³)

Liquid Type	4 years Cooling Period	15 years Cooling Period
Dissolution	1,500W/m³	600W/m³
Plutonium Concentrated	8,800W/m³	8,600W/m³
High Level Concentrated	10,000W/m³	3,600W/m³

② Radioactivity of Typical Nuclides (Bq/tU)

Nuclide	4 years Cooling Period	15 years Cooling Period
Ru-106	1.5×10^{15}	7.9×10^{11}
Cs-137	4.7×10^{15}	3.7×10^{15}

③ Major Control Target for Gaseous Waste (Bq/y)

Nuclide	4 years Cooling Period	15 years Cooling Period
Kr-85	3.3×10^{17}	1.6×10^{17}
C-14	5.2×10^{13}	5.1×10^{13}
I-129	1.1×10^{10}	1.1×10^{10}

④ Major Control Target for Liquid Waste (Bq/y)

Nuclide	4 years Cooling Period	15 years Cooling Period
H-3	1.8×10^{16}	9.7×10^{15}
I-129	4.3×10^{10}	4.3×10^{10}

⑤Effective Dose Calculated from Control Target Values for Gaseous and Liquid Waste (mSv/y)

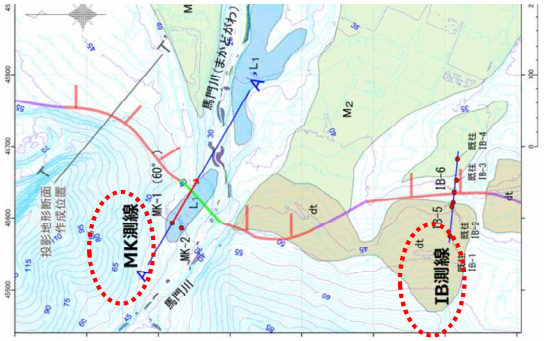
Nuclide	4 years Cooling Period	15 years Cooling Period
Gas	Approx. 1.9×10^{-2}	Approx. 1.2×10^{-2}
Liquid	Approx. 3.1×10^{-3}	Approx. 1.9×10^{-3}

Design Basis Ground Motion – Capable Faults –

Requirements

- To evaluate capable faults as seismic sources, it is required to evaluate the results of bibliographic survey, tectonic geomorphologic survey and geological survey comprehensively and identify locations, attitudes and activities of capable faults.

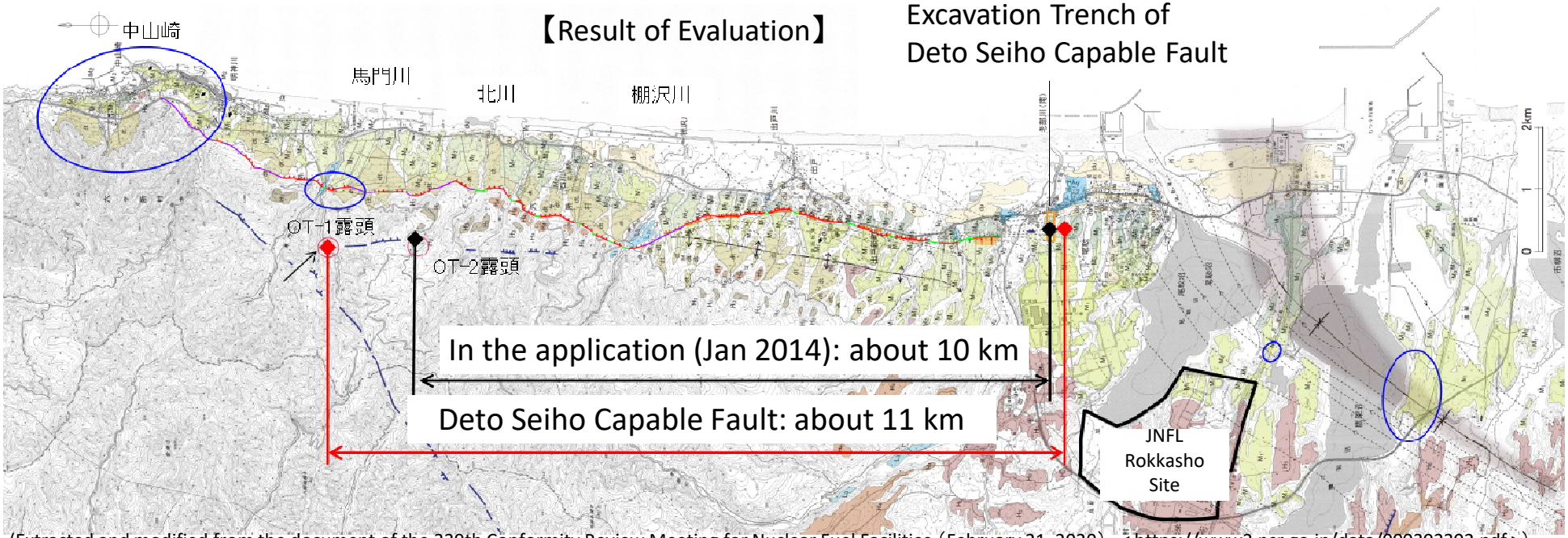
Deto Seiho Capable Fault



- In the initial amendment application (Jan 2014), Deto Seiho capable fault was evaluated as about 10 km long. As a result of additional survey in response to the NRA's indication, the north and south ends of the fault were reconsidered and the length was reevaluated as about 11 km. In addition, further survey was conducted in response to the NRA's comment and the licensee reconfirmed the evaluation of the length and location.

【Result of Evaluation】

Excavation Trench of
Deto Seiho Capable Fault



(Extracted and modified from the document of the 339th Conformity Review Meeting for Nuclear Fuel Facilities（February 21, 2020） < https://www2.nsr.go.jp/data/000302302.pdf >)

Design Basis Ground Motion – Establishment of DBGM –

Requirements

- DBGM shall be established in light of the latest scientific and technical knowledge from a seismological and earthquake engineering point of view such as geology, geological structure, seismic structure, seismic activities, etc. in the site and site vicinity.
- "Seismic ground motion to be formulated without identifying seismic sources (diffuse seismicity)" shall be established by collecting the observation records from the past earthquakes that occurred in the continental crust with seismic sources difficult to be related to capable faults, and based on that, by developing seismic response spectra in response to the ground characteristics of the site with various uncertainties taken into accounts.

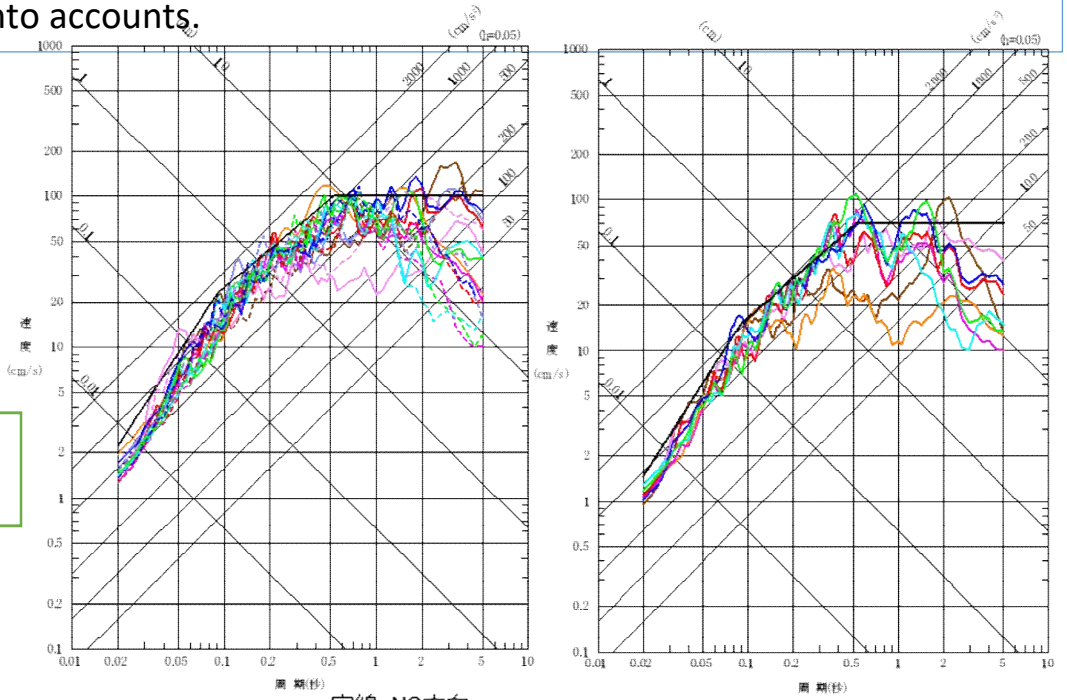
Response Spectra of DBGM

- DBGM based on response spectrum
- Earthquake by Deto Seiho capable fault
- Earthquake by Deto Seiho capable fault
- Earthquake by Deto Seiho capable fault
- Earthquake by Deto Seiho capable fault
- Earthquake by Deto Seiho capable fault
- 2004 Hokkaido Rumoe South earthquake
- 2008 Iwate-Miyagi Continental earthquake
- 2008 Iwate-Miyagi Continental earthquake
- 2008 Iwate-Miyagi Continental earthquake

With identifying seismic sources

Added in the process of conformity review

Without identifying seismic sources



実線：NS方向
ダム軸方向（Ss-C2のみ）
破線：EW方向
上下流方向（Ss-C2のみ）

水平方向 **Horizontal**

鉛直方向 **Vertical**

(Extracted and modified from the document of the 339th Conformity Review Meeting for Nuclear Fuel Facilities（February 21, 2020） < https://www2.nsr.go.jp/data/000302308.pdf >)

Summary of Conformity Review Results

The NRA confirmed that DBGMs are adequately established with various uncertainties taken into accounts enough. Thus the NRA judged that the application meets the Licensing Standards in terms of DBGM.

Prevention of Damage Caused by External Events -Volcanic Activity-

Requirement DB Facility is required that the safety function shall not be impaired against volcanic activity.

Identification of volcanos that may affect Reprocessing Facility

Evaluations of volcanic activities beyond DB:
Towada Volcano and Hakkoda Volcano

Evaluations of volcanic activities beyond DB:
Other than Towada Volcano and Hakkoda Volcano

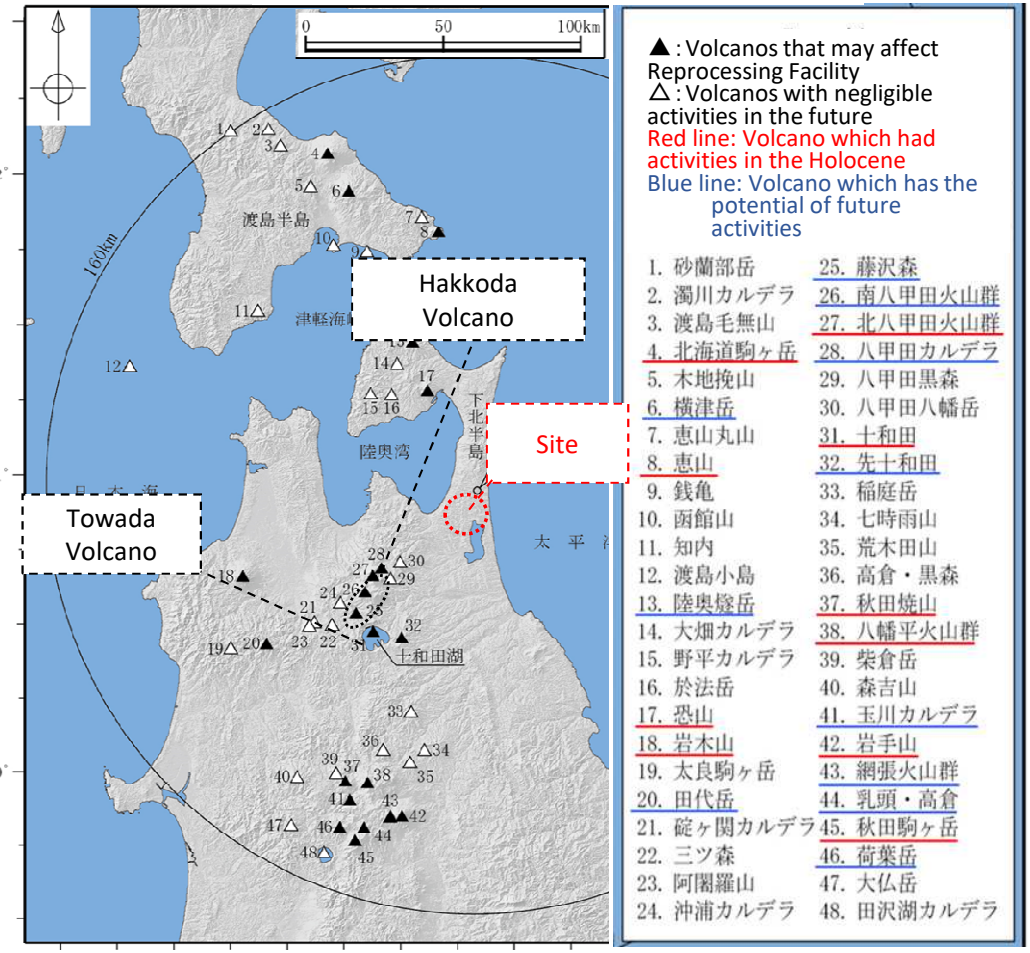
Summary of Conformity Review Results

The NRA judged that the individual evaluation of volcanic activities presented by the licensee was conducted according to the evaluation guide issued by the NRA and thus appropriate.

Evaluation of extremely large volcanic eruption of both Towada Volcano and Hakkoda Volcano showed that possibilities of such eruptions during operation lifetime of reprocessing facility were small enough based on the facts that the current volcanic activities does not appear imminent and that no scientifically reasonable basis was found for possible extremely large volcanic activities during operation lifetime.

Evaluation of volcanic activities after the last extremely large activities of both Towada Volcano and Hakkoda Volcano, and of volcanic activities of the others beyond DB, showed that possibilities of such eruptions causing damages to DB facilities were small enough based on the facts that physical distances between volcanic origins and facilities are sufficiently away from each other.

【Location of Volcanos in the Geographical Area】



(Extracted and modified from the 339th Conformity Review Meeting Material for Nuclear Fuel Facilities (February 21, 2020) <https://www2.nsr.go.jp/data/000302318.pdf>)

However, in view of the evidences of ancient pyroclastic flows that were found in the Rokkasho site, the licensee should annually conduct seismic, geophysical and geodetic monitoring of Towada Volcano and Hakkoda Volcano to confirm stability of the volcanic activities since the time of licensing.

Prevention of Damage Caused by External Events -Volcanic Activity-

Outline of application

- Direct effects of volcanic ash
  - ・Design buildings and outdoor equipment to endure 0.55m of accumulated volcanic ash.
  - ・Install filters to prevent volcanic ash from entering the facility, e.g. at an intake port of emergency diesel generator.
  - ・Paint exteriors of buildings so that the safety function is not impaired by corrosion caused by volcanic ash.
- Indirect effects of volcanic ash
  - ・Design to supply power by operating emergency diesel generators continuously for 7days for maintaining the safety function in case of loss of offsite power and traffic disruption due to volcano ash fall.

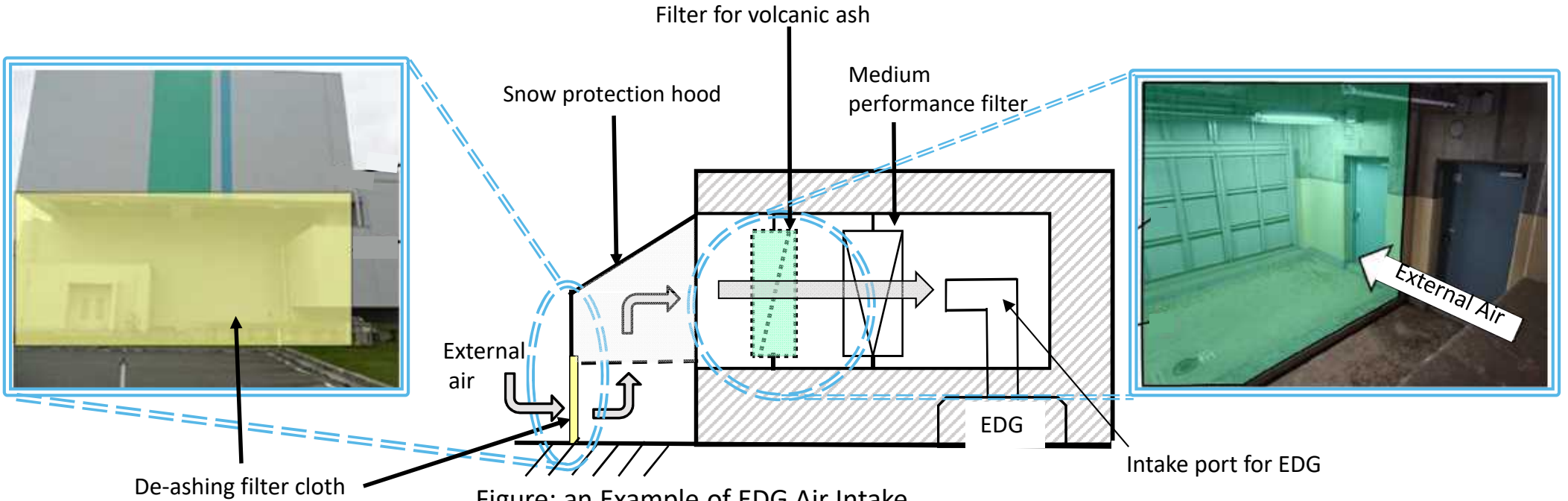


Figure: an Example of EDG Air Intake

(Extracted and modified from the document of the 316th Conformity Review Meeting for Nuclear Fuel Facilities（November 25, 2019）<http://www2.nsr.go.jp/data/000291574.pdf>)

Summary of Conformity Review Results

The NRA judged that the safety function of DB Facility is not impaired against volcanic activity, thus conforms to regulatory requirement.

Evaluation of External Fire Caused by Airplane Crash -External Fire-

Outline of Application

- Evaluate effects based on the NRA's direction how to apply reactor's external fire guide to reprocessing facility;
  - Assuming fire breaks out on exterior wall of the buildings since the buildings locate close to each other, not applying the concept for reactor in which crash point is postulated.
- By implementing protective measures as necessary, safety function of facilities are not impaired due to fire caused by airplane crash.

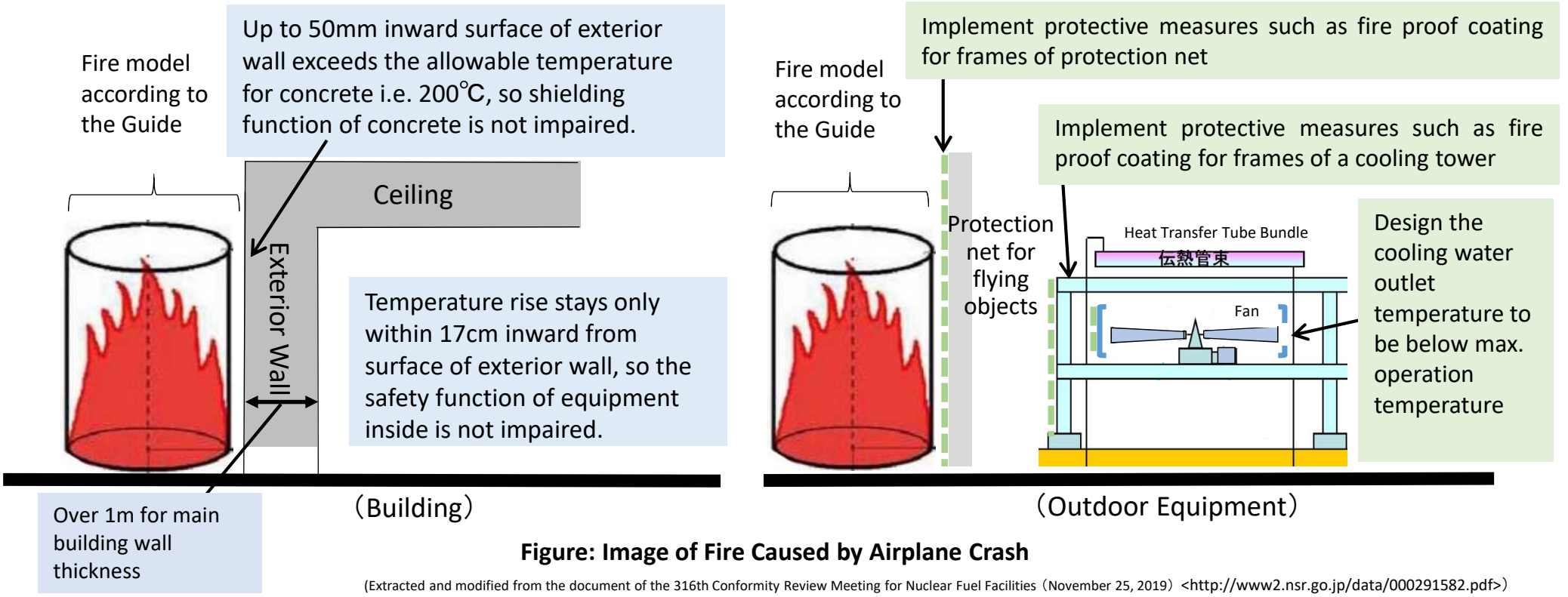


Figure: Image of Fire Caused by Airplane Crash

(Extracted and modified from the document of the 316th Conformity Review Meeting for Nuclear Fuel Facilities（November 25, 2019）<http://www2.nsr.go.jp/data/000291582.pdf>)

Summary of Conformity Review Results

The NRA judged that the evaluation of exterior wall temperature are conducted properly according to the NRA's direction, and the design is made for the safety function of buildings and necessary equipment not to be impaired by the fire.

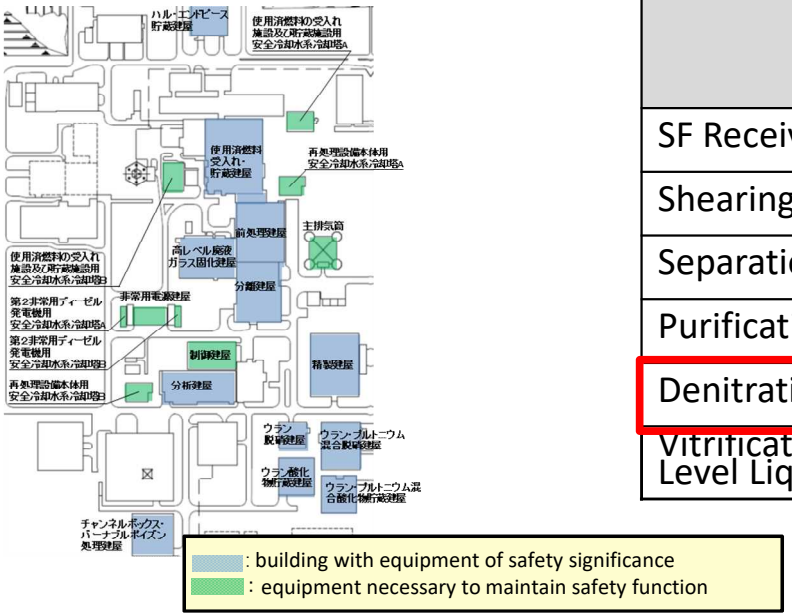
Prevention of Damage Caused by External Events -Airplane Crash-

Outline of Application

Evaluation based on the NRA's direction for airplane crash probabilistic analysis is conducted as follows;

・As each process consists of plural buildings with independent safety functions, each process is evaluated separately, and the target area is the total area of buildings with equipment of safety significance and equipment necessary to maintain safety function for each process.

・Reprocessing facility has already implemented safety measures against F-16 type airplane. Therefore the same rule as for small civil airplane that is to multiply its crash probability by 1/10 is applied for Self-Defense Force or US military airplanes with effects equal or bellow to that of F-16.



Process	Area of Target※1(km²)	Airplane Crash Probability※2 (times／year)
SF Receiving/ Storage	0.016	1.9×10^{-8}
Shearing/Dissolving	0.039	4.3×10^{-8}
Separation	0.039	4.3×10^{-8}
Purification	0.039	4.3×10^{-8}
Denitration of U/MOX	0.043	4.6×10^{-8}
Vitrification of High Level Liquid Waste	0.039	4.3×10^{-8}

Max. Crash Probability

※1 Including area of equipment to maintain important safety function such as cooling and confinement (emergency auxiliary power system, emergency air system, cooling water system and instrumentation and control system).

※2 Sum of the results for civil, Self-Defense Force and US Military airplanes.

(Extracted and modified from application amendment（April 28,2020）<https://www.nsr.go.jp/data/000309754.pdf>)

Summary of Conformity Review Results

The NRA confirmed that no additional protective measures are required, because the total crash probability calculated based on the NRA's direction does not exceed the criteria of 10^{-7} times/year for each process unit.

Points of Conformity Review for SA Facility

< Postulated Severe Accidents in Reprocessing Facility >

- Severe accidents in reprocessing facility are the ones that occur under conditions beyond design basis, stipulated in the Licensing Standards as follows;

1. Criticality accident
2. Evaporation to dryness due to loss of cooling function*
3. Explosion due to hydrogen generated by radiolysis
4. Fire or explosion caused by solvent (excluding 3.)
5. Significant damage to spent fuel in the spent fuel storage facility
6. Leakage of radioactive material (excluding 1. to 5.)

* Sequential phenomena in the event of loss of cooling function to high-level liquid waste. (i.e. evaporation of water in solution due to boiling of high-level liquid waste, followed by drying up, and eventual solidification of solute.)

Amount of Radioactive Material Released in the Event of Severe Accident

Outline of Application

Amount of radioactive material released in the event of severe accident (Cesium-137 equivalent)*1

Severe Accident	Amount released	
	Single or Simultaneous Occurrence of Same Type of Accident	Simultaneous Occurrence of Different Type of Accident*2
Criticality accident	8×10^{-7} TBq	Not postulated
Evaporation to dryness due to loss of cooling function	1×10^{-5} TBq	2×10^{-3} TBq
Hydrogen explosion	2×10^{-3} TBq	
Damage to spent fuel in spent fuel storage pool	No release	
Rapid decomposition reaction due to mixing of TBP	3×10^{-5} TBq	Not postulated

*1 The amount represents in the safety effectiveness assessment the total of radioactive materials released until the event is settled assuming escalation prevention measures function, or the summation of each amount in case of simultaneous occurrence of the same type of severe accident.
*2 Three SAs (evaporation to dryness due to loss of cooling function, hydrogen explosion and damage to spent fuel in the spent fuel storage pool) are postulated to occur simultaneously. Criticality accident and rapid decomposition reaction due to TBP are not postulated to occur simultaneously.

Summary of Conformity Review Results

The amount of radioactive material released to outside of nuclear site is evaluated far below 100 TBq and remains as low as practicable even in case of simultaneous occurrence of severe accidents.

(Reference) Amount of radioactive material released (Cesium-137 equivalent) when escalation prevention measures do not function are as follows;

Severe Accident	Amount Released (Cesium-137 equivalent)
Criticality accident	2×10^{-1} TBq
Evaporation to dryness due to loss of cooling function (in case volatile ruthenium is released)	5 TBq
Rapid decomposition reaction due to mixing of TBP	8×10^{-3} TBq

(Source: 16th NRA Commission Meeting (July 3, 2019) <http://www.nsr.go.jp/data/000275653.pdf>)

Measures against Criticality Accident

Characteristics of Accident

- When criticality accident occurs, the amount of radioactive materials released into air increases, as fission reaction produces rare gas, radioactive gas such as iodine and radioactive aerosols.
- Hydrogen concentration in vessels becomes higher than during normal operation due to radiolysis by fission reaction.

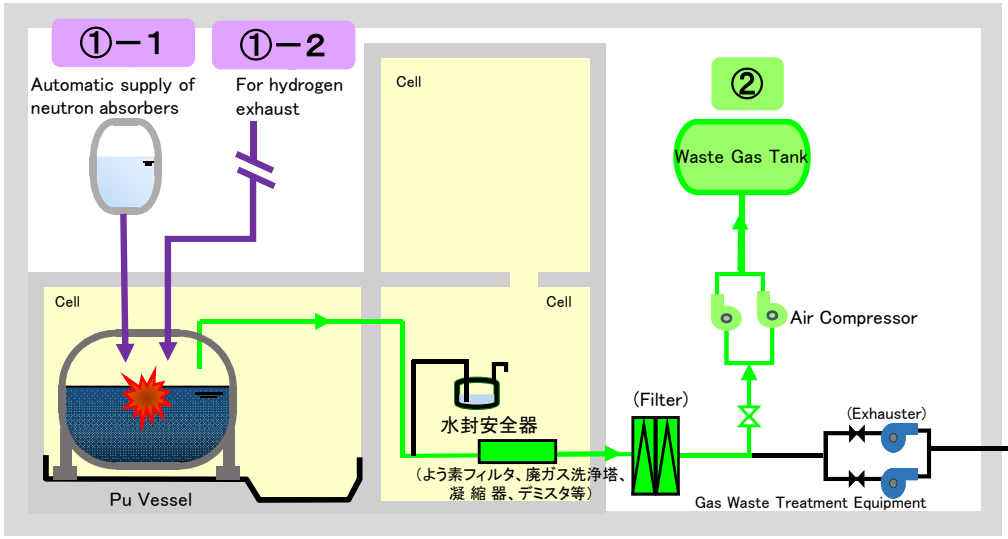
Requirements

- Immediately after detection of criticality, shifts to subcriticality and maintains the condition (Escalation Prevention Measures)
- Mitigate the effects of radioactive substance release (Mitigation measures)

Measures to prevent criticality accident are required in design basis facility, and further escalation prevention measures are required assuming criticality accident does occurs .

Overview of Measures

Amount of radioactive materials released into air : 8×10^{-7}TBq（Cs-137 conversion）
（In case of SA at 7th Temporary Storage Treatment Vessel in Purification Bld.）



①－1 Escalation Prevention Measures

Supply neutron absorbers automatically promptly after criticality detection, and shift to subcritical state

①－2 Escalation Prevention Measures

Increase hydrogen exhaust temporarily to lower the concentration of hydrogen in addition to normal hydrogen exhaust against hydrogen increase during criticality accident

② Mitigation Measures

Guide radioactive materials toward waste gas tank in order to suppress the release of radioactive materials

Summary of Conformity Review Results The NRA confirmed:

- Effectiveness evaluations were conducted assuming criticality accidents occur in 8 storage vessels.
- Each measure captures the characteristics of criticality accident progression such as supply of soluble neutron absorbers, additional hydrogen exhaust capability for hydrogen explosion prevention, and guiding radioactive gaseous toward waste gas tank to suppress the release of radioactive materials.
- Amount of radioactive materials released to outside of the site is evaluated lower than 100TBq and as low as practicable.
- Equipment and procedures necessary to take measures against criticality accident are set up.

Measures against Evaporation to Dryness

Characteristics of Accident

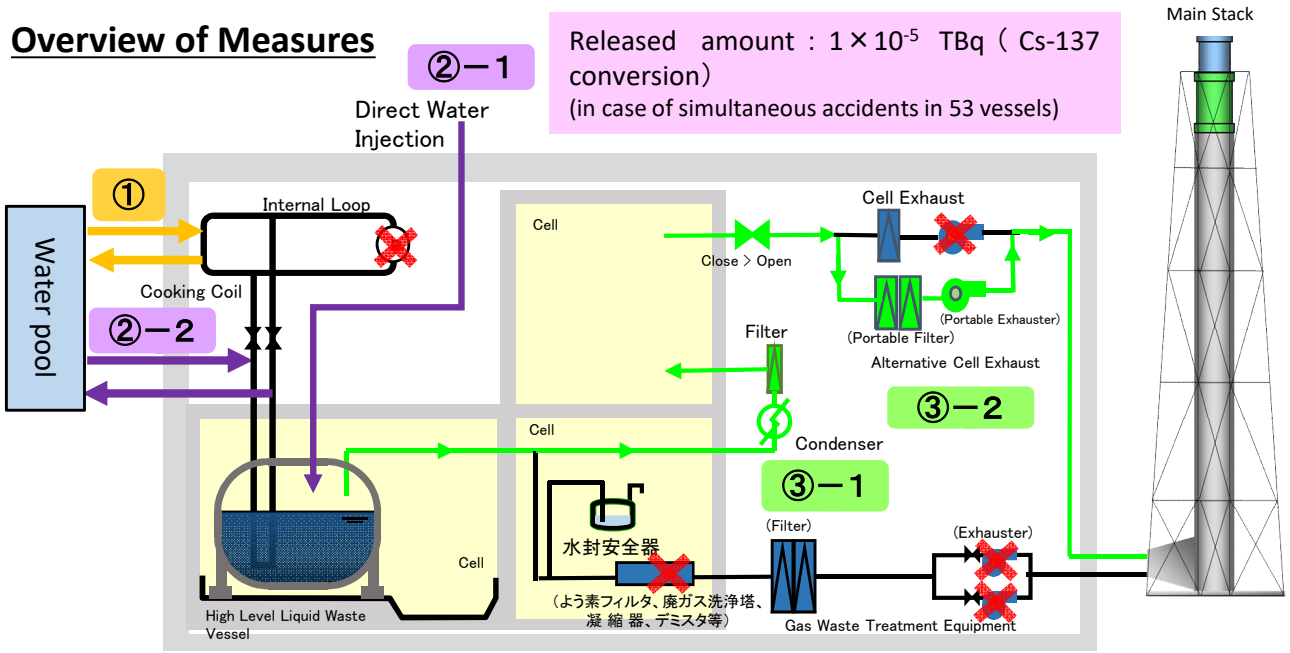
- When boiling of solution occurs by loss of cooling function, discharge increases by produced radioactive aerosols.
- When boiling of high level liquid waste containing Ru continues up to 120 ℃ and nitric acid concentration reaches more than 6N, discharge increases even more by a large amount of produced volatile Ru.
- In case boiling of high level liquid waste continues until dryness and solidification, it results in damage of vessels by increased temperature.

Requirement

- Cool high level liquid waste before it starts boiling in order to prevent accident (Prevention Measure)
- Implement direct water injection to vessels, maintain water level and mitigate concentration. Afterwards, remove heat from vessels by water flow to cooling coils (Escalation Prevention Measure)
- Mitigate effects of radioactive material release (Mitigation Measure)

Overview of Measures

Released amount : 1×10^{-5} TBq（Cs-137 conversion）
(in case of simultaneous accidents in 53 vessels)



① Prevention Measure

Inject water to the internal loop by alternative cooling system to cool the vessels

②－1 Escalation Prevention Measure

Inject water directly to the vessels by alternative cooling system and avoid further decline of water level

②－2 Escalation Prevention Measure

Inject water to cooling coils by alternative cooling system to cool vessels

③－1 Mitigation Measure

Guide radioactive materials to another cell

③－2 Mitigation Measure

Decrease discharge by alternative cell exhaust system

Summary of Conformity Review Results The NRA confirmed:

- Effectiveness evaluations assuming the accident occur in 53 vessels simultaneously were conducted.
- Each measure captures the characteristics of accident progression.
- These measures enable to maintain the liquid level constant and maintain temperature of high level liquid waste including Ru under 120 ℃, subsequently, to converge situation by cooling vessels.
- Amount of radioactive materials released to outside of the site is evaluated lower than 100TBq and as low as practicable.
- Equipment and procedures necessary to take measures against criticality accident are set up.

Additional Information

JNFL Rokkasho Reprocessing Facility
– History –

1992 JNFL obtained the Permit of Business for Rokkasho reprocessing facility.

1993 Construction work started.

1999 Spent fuel storage facility started operation.

- Spent fuel assemblies stored in the SF pool (as of 2020)
  12,069 assemblies (approx. 99 % of the maximum capacity 12,228)

2004 JNFL started commissioning test using Uranium.

2006 JNFL started commissioning test using spent fuel (so-called Active Test)

- Amounts reprocessed during Active Test (2006-2008)
  Approx. 430 tU

2007 JNFL implemented Vitrification test until 2013.

- Canisters vitrified during the test
  346 canisters
- High level liquid waste currently stored in the vessel (as of 2020)
  Approx. 211m^3

*Reprocessing facility is still in the stage of Pre-service Inspection

2013 New regulatory requirements for reprocessing facility enforced.

2014.01 JNFL submitted the application of Amendment of Business, and the conformity review started

~2020.07 Conformity review meetings and revisions of the application

2020.07 NRA permitted Amendment of Business.

Additional Information

JNFL Rokkasho Reprocessing Facility
Prevention of Damage Caused by External Events
-Probability Analysis of Airplane Crash-

- **The review standards for airplane crash probability analysis** was established for commercial power reactors in 2009 by the former regulatory body, which showed that, if the airplane clash probability is not more than 10^{-7} times/reactor・year, it is not necessary to consider it as the external event for design.
- During the conformity review of reprocessing facility, the NRA decided to apply this guide to reprocessing facility by **adapting the following two points**:

  1. **Area of Target:** in the case of commercial power reactor, the area of target is the total of all the buildings and equipment necessary for operating the reactor. For reprocessing facility, as each process, e.g. shearing/dissolving, separation, purification and denitration, consists of plural buildings with independent safety function, the NRA decided that the analysis is to be conducted for each process separately and the target area of each process is the total area of buildings which contain facilities important for safety and equipment necessary to maintain safety function in each process.
  2. **Small airplane:** according to the standards, the coefficient of 1/10 can be applied for the evaluation for small civil airplane because of its weight, speed and expected impact. As the Rokkasho reprocessing plant has already implemented safety measures against F-16 type airplane, the NRA decided that the same coefficient of 1/10 can also be applied to Self-Defense Force or US military airplanes which effects are equal or below to that of F-16.

- As the result of the licensee's analysis, the maximum probability was 4.6×10^{-8} times/year for the denitration process, which does not exceed the criteria of 10^{-7} times/year.
- For reference, the licensee also made analysis against the total area summing all the area of buildings and equipment important for safety of the Rokkasho reprocessing facility, which result was 8.8×10^{-8} times/year.