Proceedings of the 18th International Symposium on the Packaging and Transportation of Radioactive Materials
PATRAM 2016
September 18-23, 2016, Kobe, Japan

5043

Design and Inspection Plan of Dual Purpose Dry Metal Casks for Interim Storage Facility in Japan

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【Abstract】

The purpose of this paper is to introduce operational plan of the first Interim Storage Facility (hereinafter referred to as ISF) built outside the property of nuclear power plant (hereinafter referred to as NPP) in Japan, located in Mutsu City, Aomori Prefecture. The paper will also introduce design and elaborate on inspection plans of the facility as well as the Dual Purpose Dry Metal Casks (hereinafter referred to as the Casks) which will be used in storage facility and for transporting and storing spent fuel.

The storage completed its first building, waiting to proceed on to its second one, and several casks are already manufactured. Preparation is currently under way for safety review of the Nuclear Regulatory Agency, NRA based on the new regulatory standard established by the wake of Fukushima Nuclear Power Plant accident triggered by the Great East Japan Earth Quake.

Several companies hold different roles in this duty. Tokyo Electric Power Company Holdings, Inc. (TEPCO) and the Japan Atomic Power Company (JAPC) are responsible for filling spent fuel into and packing casks, as well as transporting the Casks.

Recyclable–Fuel Storage Company (RFS), a subsidiary of TEPCO and JAPC is responsible for storing the Casks.

Metal Casks are designed so that basic safety requirements last for both 50 years of storing period and transportation, where casks travel from NPP to ISF and out to its next destination. The basic safety requirements of casks are maintaining subcriticality, removing heat, containing and shielding radiation.

【Introduction】

From the perspective of effective use of resources, reducing volume and lowering the level of toxicity of high level radioactive waste, Japan has a basic policy to promote nuclear fuel cycle to use uranium, plutonium and other materials effectively by reprocessing spent fuel arising from NPP.

Under this policy, interim storage is important measure to add flexibility to the management of nuclear fuel cycle. TEPCO and JAPC placing utmost focus on securing safety, dedicated themselves to build and operate ISF for the first time in Japan, located in Mutsu city, Aomori prefecture.

TEPCO, JAPC and RFS have different roles in this duty. TEPCO and JAPC are in charge of filling, packing and transporting the Casks while RFS is in charge of storing casks.

License for the Casks are divided by job responsibility, meaning TEPCO and JAPC awaits license approval on Package Design, and RFS requires Design and Construction Permit from the NRA.

The operation will be as follows: TEPCO or JAPC are responsible of filling spent fuel and packing into the Casks at their NPPs. After casks are fully filled, they will be transported to the ISF of RFS. Either TEPCO or JAPC will inspect casks before they leave their properties. Records taken during this inspection will be shared with RFS upon receipt of casks. RFS will review the documents while also conducting its own inspection. After soundness of casks is confirmed, they will be accepted by RFS, installed and stored in designated area of ISF. During storage period, casks will undergo several types of inspections and monitoring such as External Appearance, pressure between lids, surface temperature, and area radiation where casks are stored in the

building. At the end of the storage period, casks will be delivered out of storage facility by TEPCO or JAPC. Inspection records taken by RFS during storage will be handed over to TEPCO or JAPC responsible for transportation. Upon the handover of casks, TEPCO or JAPC will conduct their own inspections before transporting casks out of the storage facility.

RFS was licensed on establishing the ISF in May 2010, followed by design and constructing permit approval in August the same year. Planned start of the facility was initially in 2012, however, it is now preparing for safety review of the NRA based on the new regulatory standard established on the wake of Fukushima NPP accident, also being prepared for the operation.

The outline of the facility is planned as follows ;

- storage capacity：5000tU
- storage period： maximum 50 years
- structural dimension
  first building ：3000tU, 62m（width）×131m（length）×28m（height）
  second building：2000tU, structural dimension is yet to be decided
- storage cask type： Dry Metal Cask
- main facility and equipment： Dual Purpose Metal Cask, Storage Building and cask handling equipment

In this Interim Storage duty, the Casks hold dual roles, meaning usage for transport and storage. After casks are filled at the NPP, cask lids will never be opened throughout the whole process that starts from transporting casks out of NPP to the ISF, during storage period, and transporting casks out of ISF to the next destination.

To ensure safe cask transport to and from storage facility, TEPCO and JAPC awaits license for transporting the Casks. This certification will be updated every once in 5 years so casks could be transported out of the facility any time during storage period according to necessity, and also to cover transportation of casks after storage period ends.

【Design for securing safety during transport】

The Casks need to be designed to comply with the transportation regulation to protect safety of the public, those engaged in cask transportation and radiation workers.

As basic requirements for safety, casks need to be designed with strong structural strength to enclose spent fuel, maintain subcriticality, remove heat, shield radiation.

As to assuring subcriticality, basket to collect spent fuel assembly should be designed in grid structure so that it can position and maintain fuel assembly in designated geometrical position. Boron will be added to the basket plate which is an efficient absorbent of neutron. Homogeneity will be confirmed through quality assurance during cask manufacturing.

In terms of removing decay heat, casks are designed to fill Helium gas in spent fuel containing area due to its high thermal conductivity. Inside neutron shields where thermal conductivity is low, heat transfer fins are placed to improve thermal conductivity.

In terms of shielding radiation from spent fuel, Casks are designed to shield both gamma ray and neutron. Gamma ray is shielded by carbon steel which is also the material structuring casks. Neutron is shielded by resin which contains considerable amount of hydrogen.

The Cask is designed to attach tertiary lid as sealant for transport safety. Rubber ring is applied for the sealant of the tertiary lid.

On structural strength, casks should be designed to avoid cracks and damages during regular transportation. To maintain basic safety requirements, important structural materials for the Casks are selected based on the environmental and loading conditions where casks will be used.

【Design to secure safety during storage】

The main equipment of the ISF would be the Casks, therefore, casks are responsible for many of the safety issues while storing spent fuel.

The Casks that complies with transportation regulation is designed to protect safety of the public, those engaged in cask transportation and radiation workers. To that end, casks are designed to contain spent fuel, maintain subcriticality, remove heat, and shield radiation to fulfill the basic safety requirements. .

By adding some safety elements on to casks designed as explained for transport use, many aspects of basic safety functions that RFS must manage would be sustained by the the Casks themselves.

Structures, systems and equipment deployed at RFS facility excluding the Casks will be designed to handle casks and secure functions necessary for storing numerous casks. To mention structures, systems and equipment other than the Casks would be: equipment to handle casks, manage operation, and storage building to add to further shielding.

The storage building is a facility to receive, store and prepare sending casks for next transport. Received casks will be stored vertically using storage skid. The capacity of the first building is 3000tU and can accommodate 288 casks at maximum.

Decay heat from spent fuel will be transferred to the surface of the Casks and will eventually be released out of the building by natural air circulating in the building.

Radioactivity released from the Casks will be shielded by sufficient thickness of concrete walls of the building.

Throughout the storage period, internal condition of the Casks will be maintained in negative pressure. For storage purpose, there are two lids (primary and secondary), and the third lid (tertiary lid) is applied for transport. Positive pressure is applied between primary and secondary lids to create pressure barrier. Considering the purpose of casks to contain spent fuels for a long period, metal gasket will be used for the sealant part of the lid because the material is highly resistant of heat, corrosion and is durable.

By monitoring the pressure between lids, leakage in any of the gaskets is detectable by design and indicates performance deterioration of containing spent fuel. Even in such event, casks are designed to fill Helium gas in spent fuel containing area maintaining negative pressure inside. So, gaseous body contained inside the cask will virtually not leak out directly to contact external environment.

The Casks will be anchored to the floor with the help of storage skid. Thus, casks will not topple down at times of earthquake and basic safety requirements will be met. Storage building must be located at places where damages to the facility will be minor

and not amplify. Basic safety requirements must be maintained during assumable seismic motion triggered by seismic force. Other than earthquake, weather condition such as typhoon and snowfall should not incur damages to the facility.

As already mentioned at the introduction phase, pressure between lids and surface temperature of casks will be monitored during storage period.

【Inspection and monitoring】

Inspection at manufacturing site (transportation and storage)

Casks must undergo inspection at manufactured plants, whether they meet basic safety requirements, have sufficient structural strength, and are able to show performance as designed. To confirm the mountability of shock absorber and the tertiary lid on the Cask body, inspectors do not have to inspect every one of them, but select one randomly for verification if they are designed in the same way.

Inspection prior to casks leaving nuclear power plant (transportation)

When casks are leaving NPP, safety issues for transportation and some storage condition issues must be confirmed whether they were met or not.

Receiving casks/ Inspection before storage (storage)

When casks are received at the ISF and prior to starting their storage period, casks must undergo confirmation that they fulfill general safety requirements and have sufficient structural strength.

Inspection and monitoring during storage period (transportation and storage)

Basic requirements on safety and structural strength must be checked regularly during storage period to confirm casks are in good condition and are capable for transportation and storage.

Pressure between lids, surface temperature of the Casks, and area radiation where casks are stored in the building will be monitored etc. during storage period.

Inspection before casks leave storage facility (transportation)

When storage period ends, cask soundness is confirmed for safe transport when they are leaving the IS F.

The ISF do not possess facility/equipment to open cask primary lid. The scheme is to enclose spent fuels in one Cask for 50 years at maximum without refilling spent fuels into another cask.

When transporting casks out of NPP, inspections such as Appearance Inspection on spent fuel, measuring internal condition of casks will be conducted. However, since RFS do not possess facility to open cask primary lid, RFS will not be able to conduct the same inspection when preparing casks for the next destination.
Indicated below are the three inspections where RFS will not be able to conduct similar inspections as done when casks left NPP.

① Subcriticality inspection
Subcriticality inspection is to verify whether there is no distortion to the basket that could negatively impact function to maintain subcriticality. When delivering casks out from NPP, External Appearance Inspection will be conducted on the basket structure before filling spent fuel in.

② Content inspection
This inspection is to verify the soundness of spent fuel assembly and whether design condition such as specification, number of spent fuel, and content arrangements are met. When delivering casks out from NPP, exposure of spent fuel assembly would be calculated based on the operational record of the nuclear reactor.
When loading spent fuel to casks, number of spent fuel and its arrangement will be examined by External Appearance Inspection.

③ Pressure retaining inspection
This inspection is to verify dryness inside the Metal Casks and between lids, as well as checking whether gas composition and pressure are all following the design criteria. When delivering casks out from NPP, vacuum level after vacuum drying, or residual moist after gas is filled into casks will be checked after filling spent fuel into casks. Gas component, filling quantity, and pressure will also be measured.

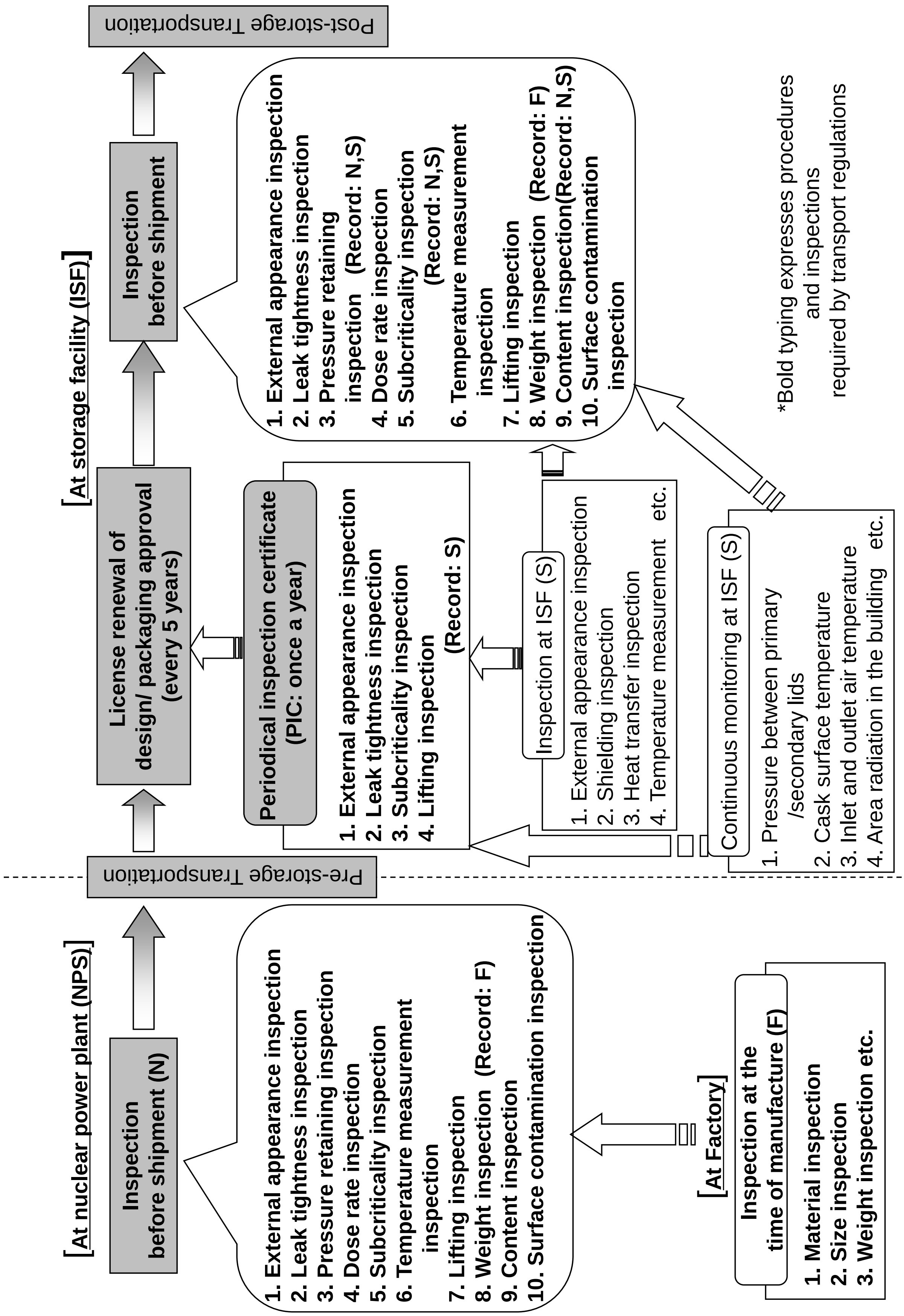
Alternate Inspections for storage- ended casks and pre-transport

Subcriticality inspection could be replaced by combining several inspection results

starting with cask inspection done at NPP prior to transporting casks. In addition, records of External Appearance Inspection, lid pressure inspection, surface temperature monitoring taken during storage and External Appearance Inspection will be conducted prior to transporting casks out from ISF to confirm casks had no subcriticality issue during storage.

Content inspection could be replaced by combining several inspection results which are: content inspection done at NPP before casks depart for transport. In addition, records of External Appearance Inspection, lid pressure inspection, surface temperature monitoring taken during storage will be used to confirm casks had no Content related issue during storage, and External Appearance Inspection will be conducted prior to transporting casks out from ISF.

Pressure Retaining Inspection could be replaced by checking records of pressure measurement inspection done at NPP prior to transporting casks, as well as confirming record of lid pressure inspection to confirm casks had no internal space issue or lid concerns during storage.


[At nuclear power plant (NPS)]
Inspection before shipment (N)
1. External appearance inspection
2. Leak tightness inspection
3. Pressure retaining inspection
4. Dose rate inspection
5. Subcriticality inspection
6. Temperature measurement inspection
7. Lifting inspection
8. Weight inspection (Record: F)
9. Content inspection
10. Surface contamination inspection
Pre-storage Transportation
[At storage facility (ISF)]
License renewal of design/ packaging approval (every 5 years)
Periodical inspection certificate (PIC: once a year)
1. External appearance inspection
2. Leak tightness inspection
3. Subcriticality inspection
4. Lifting inspection
(Record: S)
Inspection at ISF (S)
1. External appearance inspection
2. Shielding inspection
3. Heat transfer inspection
4. Temperature measurement etc.
Continuous monitoring at ISF (S)
1. Pressure between primary /secondary lids
2. Cask surface temperature
3. Inlet and outlet air temperature
4. Area radiation in the building etc.
Inspection before shipment
1. External appearance inspection
2. Leak tightness inspection
3. Pressure retaining inspection (Record: N,S)
4. Dose rate inspection
5. Subcriticality inspection (Record: N,S)
6. Temperature measurement inspection
7. Lifting inspection
8. Weight inspection (Record: F)
9. Content inspection(Record: N,S)
10. Surface contamination inspection
Post-storage Transportation
[At Factory]
Inspection at the time of manufacture (F)
1. Material inspection
2. Size inspection
3. Weight inspection etc.
*Bold typing expresses procedures and inspections required by transport regulations

Conducting series of inspection and monitoring are considered to secure the safety of transporting casks after storage period ends.

However, Interim Storage is a long span duty with casks stored for 50 years maximum. Judging from the fact that proven results for long term storage is yet to be accumulated especially on the Casks, it is desirable to acquire further related knowledge going forward.

TEPCO and JAPC stores some spent fuel using the Casks exclusively used for storage at their NPP, therefore, they are dedicated to continue with regular investigations on soundness of the Casks and its Content spent fuel during long storage period to accumulate knowledge.

Accumulating know-hows and knowledge for long period storage

So far, TEPCO conducted investigations for casks stored for 5 years and 10 years which took place in 2000 and 2011. Investigation after the 2011 Fukushima accident took place in 2013 on casks stored for 17years. Investigation items were mainly focused on the leaktightness of the Casks and soundness of the cladding tube of spent fuel.

JAPC conducted same investigation on casks and spent fuel stored for 7 years in 2009.

To confirm the leaktightness of the Casks, External Appearance Inspection was conducted on metal gasket for primary lid, and also on flange seal respectively to confirm gas was not leaking. To confirm the soundness of the cladding tube of spent fuel, sampling and measuring gas from the cask was conducted along with Appearance Inspection on fuel assembly of spent fuel.

Through investigations, TEPCO and JAPC have come so far as to prove the soundness of leaktightness of the Casks and cladding tube of spent fuel stored for around 17 years as the evidence.

To strengthen safety of long-period storing of spent fuel using the Casks and securing safety during transportation that happens before and after storage, it is essential to continue on with relevant investigations.

Table 1. Feature of Spent Fuels subject for investigation

	Fukushima Daiichi NPP			Tokai Daini NPP
Type of fuel stored	8×8 fuel		new form 8×8 fuel	new form 8×8 zirconium liner fuel
storing period	approximately 10 years	approximately 17years	approximately 5years	approximately 7years
exposure	approximately 28,000MWd/t	approximately 24,000MWd/t	approximately 32,000MWd/t	approximately 33,500MWd/t

【Conclusions】

Metal Casks handled by RFS requires robust design that assures safety during maximum 50 years of storage period and transports. Cask is designed to meet basic safety requirements and structural strength. To confirm whether casks are performing as designed during usage i.e. during storage and transport could be confirmed through regular inspections and monitoring of the Casks etc.

RFS do not possess facility/equipment to open cask primary lid. Therefore, some inspections to be conducted at the end of the storage term could be replaced by confirming record of other inspections.

To further improve credibility of Interim Storage duty, TEPCO and JAPC are dedicated to continue regular investigations on soundness of the Casks and its Content spent fuel during long-storage-period to accumulate knowledge.

References

[1] T.Takahashi.et al., “CONFIRMATION OF MAINTENANCE OF FUNCTION FOR TRANSPORT AFTER LONG-TERM STORAGE USING DRY METAL DUAL PURPOSE CASKS” Proceedings of the 16th International Symposium on the Packaging and Transportation of Radioactive Materials,PATRAM2010,October 3-8,London, UK,(2010)

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