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日本の新規制基準に対する HTTR許認可の経験

概要 / 目的:

高温工学試験研究炉（HTTR）の固有の安全設計と安全性実証試験の結果を用いた新たな安全理論が日本の原子力規制委員会に承認された。この結果、HTTRの再稼働に向けて、原子力機構は2020年6月3日、新規制基準に基づく原子力規制委員会の許可を得た。HTTRは、高い固有の安全性を有しているため、追加の補強を行うことなく再稼働できる見込みである。HTTRの再稼働後には、様々な活動が予定されている。OECD/NEA **LOFCプロジェクトにおける安全性実証試験、熱利用システムの技術実証試験**、HTTRを活用した国際協力・人材育成等が予定されている。

講演者紹介:

石塚悦男博士は、日本原子力研究開発機構の高温工学試験研究炉部HTTR技術課の課長を務めている。1999年、東京大学で博士号を取得。現在は、炉心の管理・運転に関連する技術開発を担当している。この許認可対応において、HTTR技術課は、施設の耐震性評価と設計基準を超える事故を担当した。

1. HTTRに対する新規制要件

HTTRに対する新規性基準を、以前の基準と比較して説明した。

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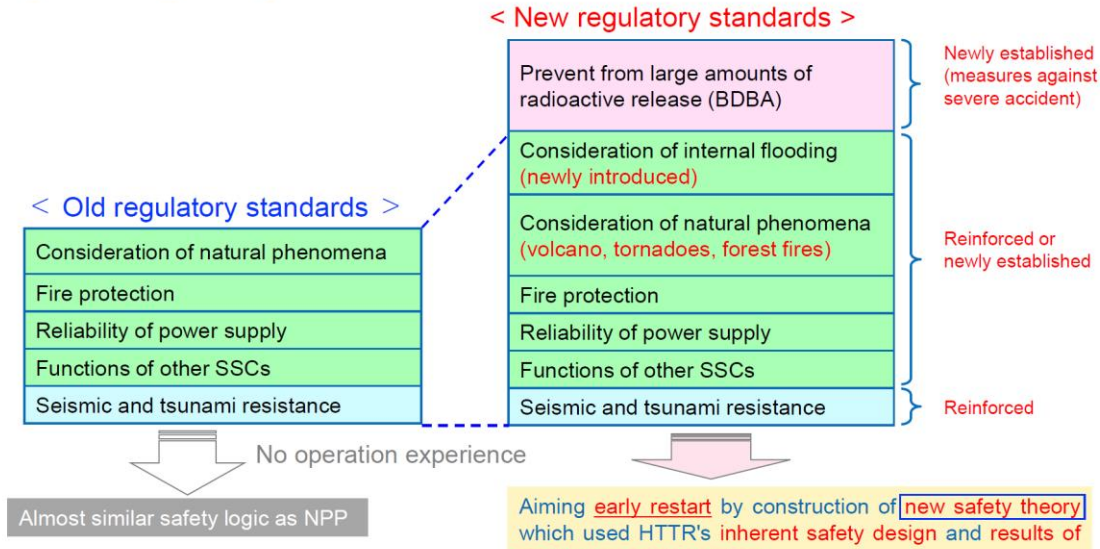
New regulatory requirements for HTTR



https://elaws.e-gov.go.jp/document?lawid=425M60080000021
https://www.nsr.go.jp/data/000172364.pdf

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2. HTTRの再稼働に向けて

HTTRの再稼働に向けた許認可に関する活動を整理した。

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Towards the restart of HTTR

- ✓ Following the nuclear accident at the Fukushima Daiichi nuclear power station on March 11, 2011, revised regulatory requirements were issued by the Nuclear Regulation Authority (NRA) in July 2013.
- ✓ JAEA had submitted the application including evaluation results satisfying the New Regulatory Requirements to the Nuclear Regulation Authority (NRA) on Nov. 26th, 2014.
- ✓ Through many discussions with the NRA, on June 3rd, 2020, JAEA obtained the permission by the NRA for changes to Reactor Installation of the HTTR.
- ✓ It is targeted to restart HTTR in July 2021.

Calendar year	2014	2015	2016	2017	2018	2019	2020	2021
Permission of changes to reactor installation							3, June ▼	
Operational Safety Programs								
Approval of the Design and Construction Method								
Inspection						Pre-service inspection		
Restart								Restart ▼

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3. 安全要件

モジュラー高温ガス炉と軽水炉の安全要件の比較が示された。

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Safety requirements

Safety requirements		Modular HTGRs	LWRs
Design extension condition (DEC)		DEC without significant fuel degradation	DEC without significant fuel degradation DEC with core melting
Reactor shutdown		At least two diverse and independent means (Inherent design features is regarded as one of means)	At least two diverse and independent systems
Heat removal from core		Passive cooling from the outside surface of reactor vessel (Passive cooling)	In shutdown states: Residual heat removal （Forced cooling） In accident condition：Emergency core cooling （Forced cooling）
Confinement of radioactive materials	Fuel integrity	In operational states and in accident conditions	In operational states (normal operation and AOO)
	Containment system	Confinement (i.e., vented low-pressure containment)	Containment Vessel
Additional specific considerations		Mitigation of air and water ingress into core during accidents	-

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4. 安全重要度分類

固有の安全設計と安全性実証試験の結果に基づき、既存の原子力発電所とは異なるHTTR独自の分類をNRAに提案した。

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Safety importance classification

HTTR safety characteristic

With lower power density than LWRs (~2.5MW/m^3 *vs* >50MW/m^3) and large heat capacity of graphite core, the HTTR can maintain in a stable state when the cooling function is lost completely, and further even the shutdown function and cooling function are lost simultaneously.

Safety importance classification

Reviewed with reference to "The guide* ".

Classification of importance in seismic design

Reviewed with reference to "The rule of seismic importance classification of research reactor".

Safety importance
PS1,2: Prevention System
MS1,2: Mitigation System

Seismic importance : (S, B, C)

Unique classification of the HTTR different from the NPP was proposed to the NRA by explaining the inherent safety design and results of safety demonstration test.

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* https://elaws.e-gov.go.jp/document?lawid=425M60080000021
https://www.nsr.go.jp/data/000172364.pdf

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5. NRAによるHTTR安全評価結果 (1/2)

地震、津波及び機器等の健全性に関するNRAによる安全評価結果を説明した。

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HTTR safety review results by Nuclear Regulation Authority (1/2)

Major discussion item		Regulatory review condition	Regulatory review results	Additional countermeasures
Earthquake	Design seismic ground motion	Raised from 350 gal to 973 gal	No large-scale reinforcement due to the degradation of the SSCs.	Not required
	Re-evaluation of seismic design classification	Some of structures, systems and components (SSCs) were downgraded taken into account the results of safety demonstration tests. ➢ Core heat removal: S class to B class ➢ Reactor internal structure: S class to B class.		
Tsunami evaluation		Assumption of tsunami height for evaluation : 17.8 m from sea level	Tsunami does not reach the site because siting location is 36.5 m high from the sea level.	Not required
Evaluation of integrity of SSCs against natural phenomena such as tornado, volcano, etc.		● Design basis tornado wind speed: 100 m/s ● Thickness of descent pyroclastic material by volcano: 50 cm	● All SSCs needed to be protected are installed inside the reactor building ● Fire proof belt necessary around reactor building.	Fire proof belt was required.

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6. NRAによるHTTR安全評価結果 (2/2)

火災、電源の信頼性及びBDBAに関するNRAによる安全評価結果を説明した。HTTRは固有の安全性を備えているため、大幅な追加補強無しに再稼働できる見込である。

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HTTR safety review results by Nuclear Regulation Authority (2/2)

Major discussion item	Regulatory review condition	Regulatory review results	Additional countermeasures
Fire	Burnable materials in and around the reactor building was additionally evaluated.	● Amount of burnable materials in the reactor building is limited. ● Cables necessary to be protected against fire	Cable protection against fire was required.
Reliability of power supply	Emergency power supply failure was evaluated.	Decay heat is removable from the core without electricity.	Only portable power generator for monitoring during accident is required.
Beyond design basis accident (BDBA)	Postulated BDBAs ➢ DBA + failure of reactor scram ➢ DBA + failure of heat removal from the core ➢ DBA + failure of containment vessel	● No core melt occurs in all BDBAs.	

(DBA : Design Basis Accident)

HTTR will restart without significant additional reinforcements due to its inherent safety features.

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