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Present Status of Kyoto University Research Reactor, KUR

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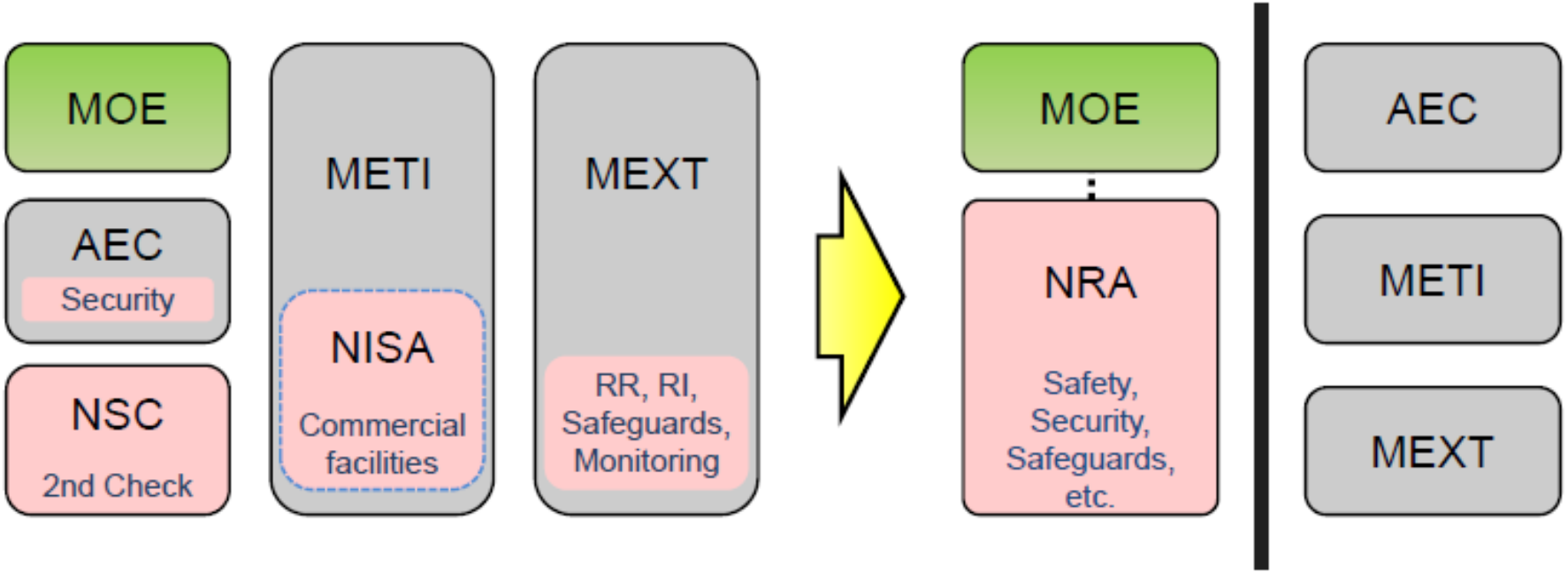
Accident of Fukushima Daiichi NPP on March 11, 2011

SBO & Loss of UHS → Loss of Cooling function → Hydrogen explosion → Release of Radioactive nuclides

Shutdown: OK, Cooling & Confinement: NG

Nuclear Regulation Authority (NRA)
(established in September 2012)



AEC : Atomic Energy Commission
METI : Ministry of Economy, Trade and Industry
MEXT : Ministry of Education, Culture, Sports, Science and Technology
MOE : Ministry of the Environment
NISA : Nuclear and Industrial Safety Agency (abolished)
NSC : Nuclear Safety Commission (abolished)

New Nuclear Regulations in Japan

- Reform of Regulation system (organization)
  - All the nuclear regulations (NPPs, RRs, Fuel fabr. etc.) are conducted by the independent body, Nuclear Regulation Authority (NRA).
    NRA has been established in Sept. 2012.
- Revision of laws, codes, guides, etc.
  - Those relating to Nuclear Regulation and Emergency Preparedness have been revised.
    New safety requirements for RRs have been executed in Dec. 2013.
    → All the RRs must comply with the requirements.

Research Reactors in Japan (3 in operation)

Name	Type	Power (kW)	Start Year	Utilization	Present status	Owner
JRR-3*	Pool	20,000	1990	Multi-purpose	Temp. Shutdown	JAEA/Tokai
JRR-4**	Pool	3,500	1965	Multi-purpose		
NSRR*	TRIGA (Pulsing)	300 (23,000,000)	1975	Fuel behavior experiments		
TCA**	Critical Assembly (C.A.)	0.2	1962	Reactor physics experiments		
FCA**	C.A. Fast	2	1967	ibid.		
STACY*	C.A. Homog.	0.2	1995	ibid.		
TRACY**	Homog. (Pulsing)	10 (5,000,000)	1995	Criticality accident experiment		
JMTR**	Tank	50,000	1968	Multi-purpose	ibid.	JAEA/Oarai
HTTR*	High Temp Gas	30,000	1998	HTGR plant test		
JOYO*	Fast, Na Cooled	140,000	1977	FBR fuel & material irradiation		
NCA	C.A.	0.2	1963	Reactor physics experiments	ibid.	Toshiba
UTR-KINKI	ARGONAUT	0.001	1961	ibid.	Operation	Kinki Univ.
KUR	Tank	5,000	1964	Multi-purpose	Operation	Kyoto Univ.
KUCA	C.A.	0.1	1974	Reactor physics experiments		

* Under safety review by NRA (5 RRs).

** To be decommissioned (5 RRs).

Revised from IAEA Research Reactors Database
http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx?rf=1

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Present status

- There are14 RRs in Japan at present.
- All RRs have to clear the safety review by the NRA to re-start under the new regulation requirements.
- Eight RRs have submitted the application for the safety review, and three of them (UTR-KINKI, KUCA and KUR) have cleared the review and re-started in 2017.
- Five RRs are determined to be decommissioned in the near future.

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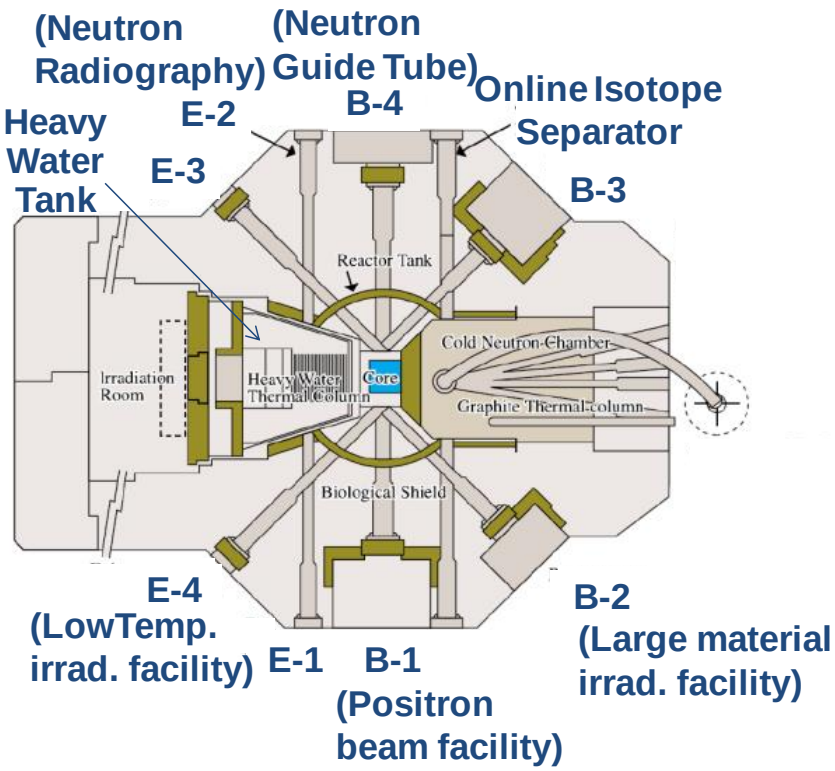
Kyoto Univ. Research Reactor Institute (KURRI)

- Established in 1963
- Joint research institute opened to all Japanese universities
- Main Facility
  - KUR (Kyoto University Research Reactor) & Hot Lab.
  - KUCA (Kyoto University Critical Assembly)
  - Electron LINAC (Linear Accelerator)
  - Proton Accelerators (Cyclotron, FFAG)
  - Co-60 Irradiation Facility
- Various experimental training courses have been offered for students using those facilities.

Kyoto University Research Reactor (KUR)

- Light water moderated thermal reactor with EU
- First criticality was attained in 1964.
- Max. Power is 5 MW

Change of fuel to low-enriched uranium finished in 2010.



- Neutron irradiation and beam experiments
  - Pneumatic tubes
  - Neutron radiography facility
  - Controlled irradiation facility
  - Boron neutron capture therapy (BNCT) facility for cancer treatment
  - Positron beam facility (Newly installed) etc.

New Regulation Requirements

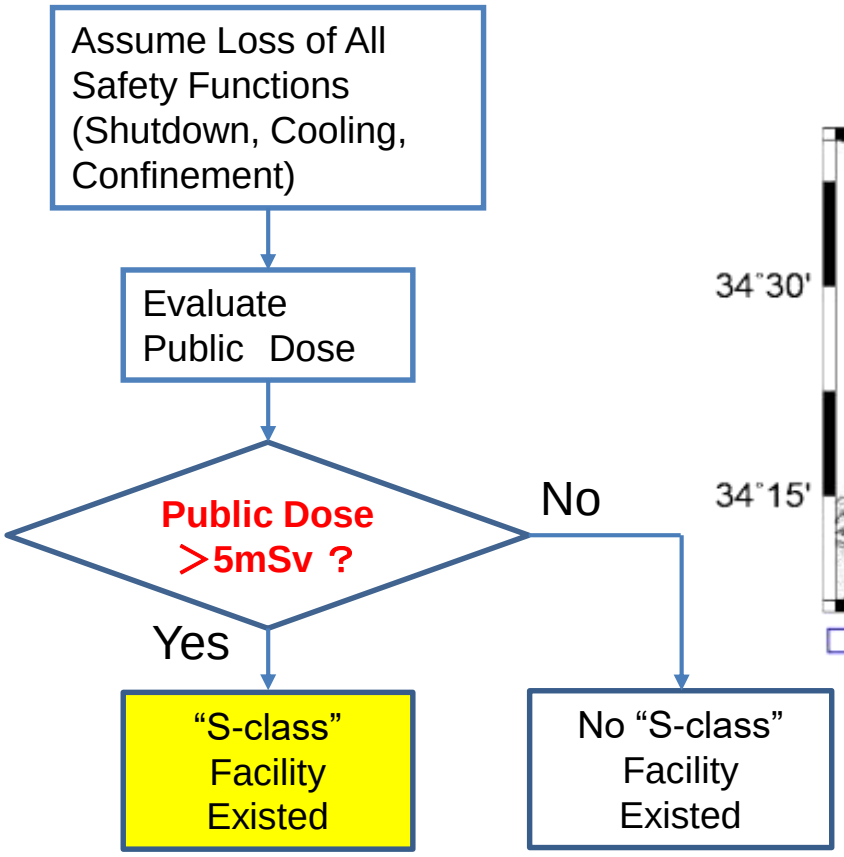
- Emphasis on defense-in-depth concept.
  - Prepare multi-layered protective measures and, for each layer, achieve the objective only in that layer regardless of the measures in the other layers
- Assessment and enhanced measures against extreme natural hazards.
  - Introduce accurate approaches in assessment of earthquake and tsunami and measures against tsunami inundation.
  - Introduce assessment of volcano, tornado, & forest fire.
- Prevention of common cause failures.
  - Enhance measures against fire, internal flooding, & loss of power.
  - Make much account of “diversity” and “independence”.
- Protective measures against severe accidents and terrorism.
  - For research reactors, those measures are not legally required; however, the NRA requests some measures even for research reactors.
- Back-fitting to the existing plants.

KUR Safety Re-evaluation/Measures

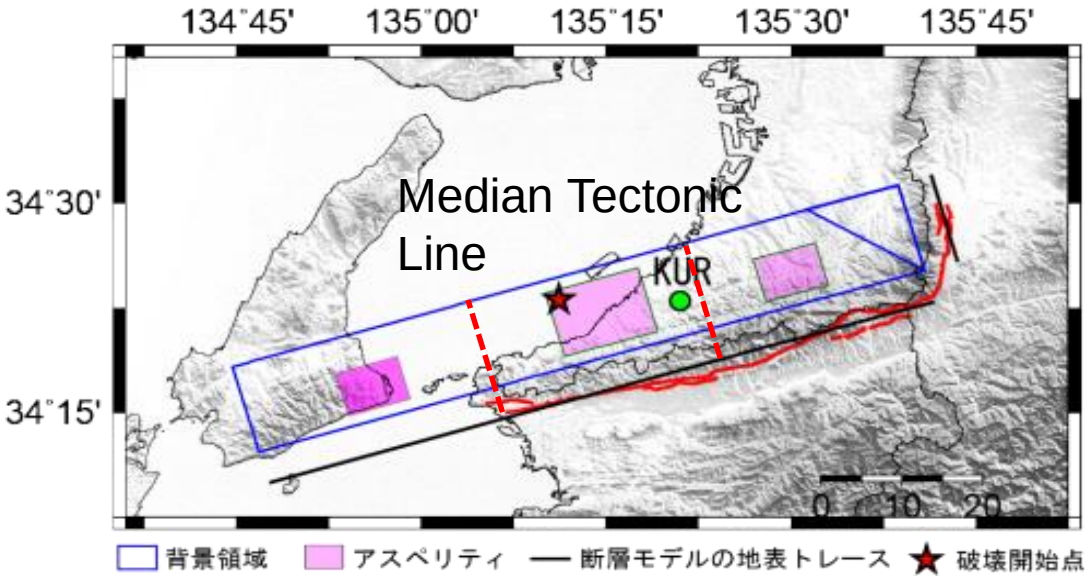
- External Natural Hazards
  - Earthquake, Tornado, Volcano, Forest fire
    (No Tsunami hazard for KUR)
- Internal Hazards
  - Internal fire, Internal flooding, Loss of power
    Against those internal hazards, the multiplicity and diversity of the safety systems have been enhanced.
- Severe Accidents
  - LOCA as BDBA
    ex) LOCA + All Rods Stuck + SBO

Safety Re-evaluation/Measures: Earthquake

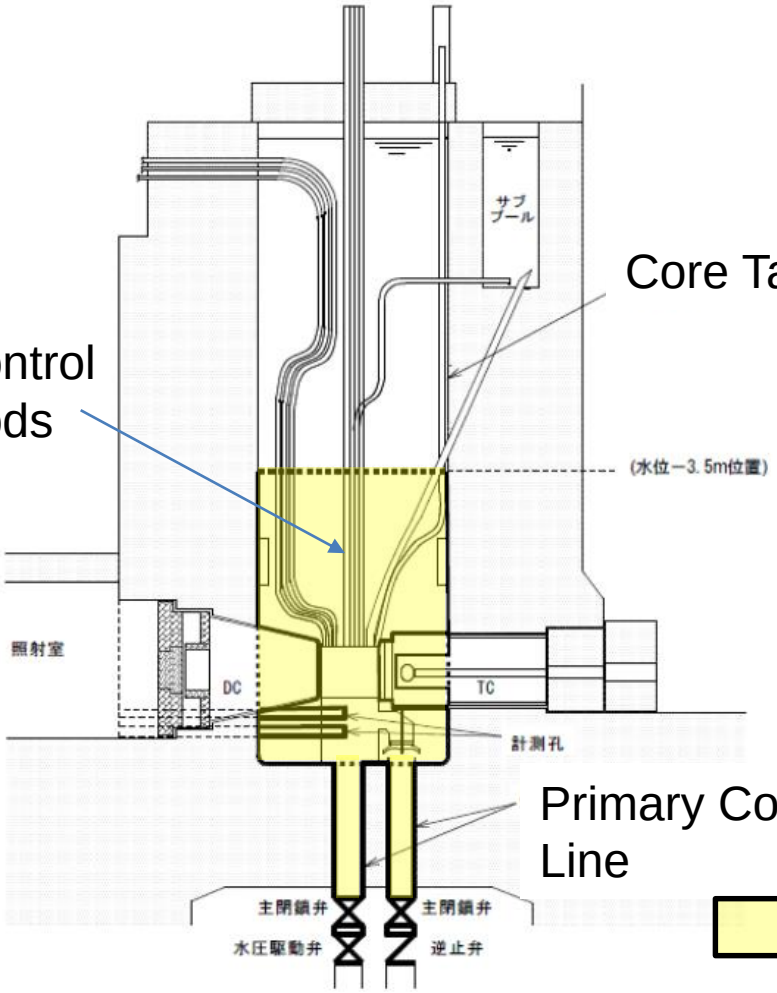
Flow chart to select “S-class” facility



Evaluation of basis ground motions

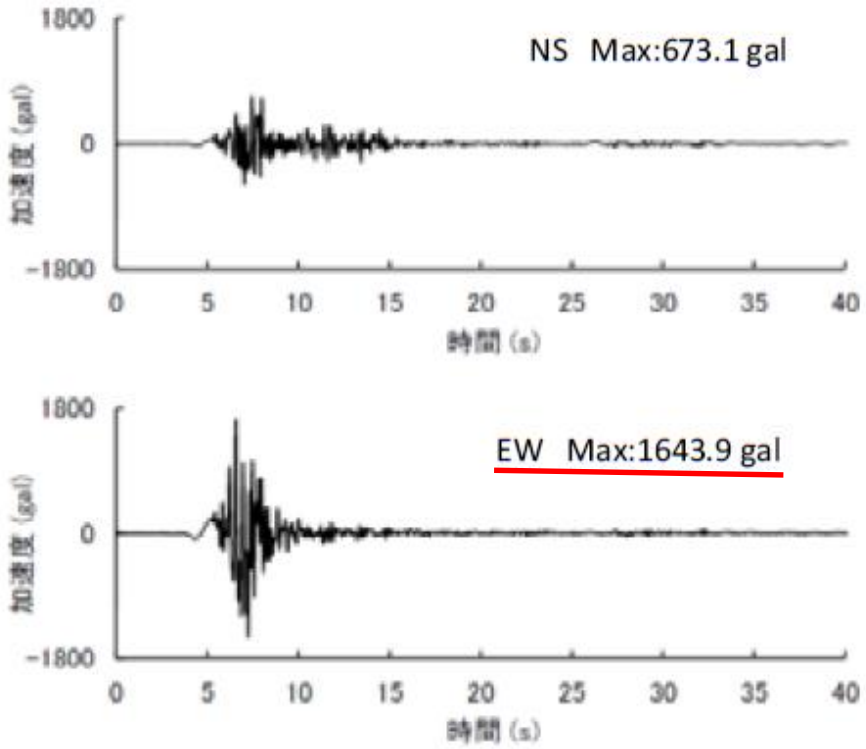


Safety Re-evaluation/Measures: Earthquake



Primary Coolant Line

Horizontal Accelerations



Boundary to be protected against Earthquake (S-class)

Safety Re-evaluation/Measures: Tornado

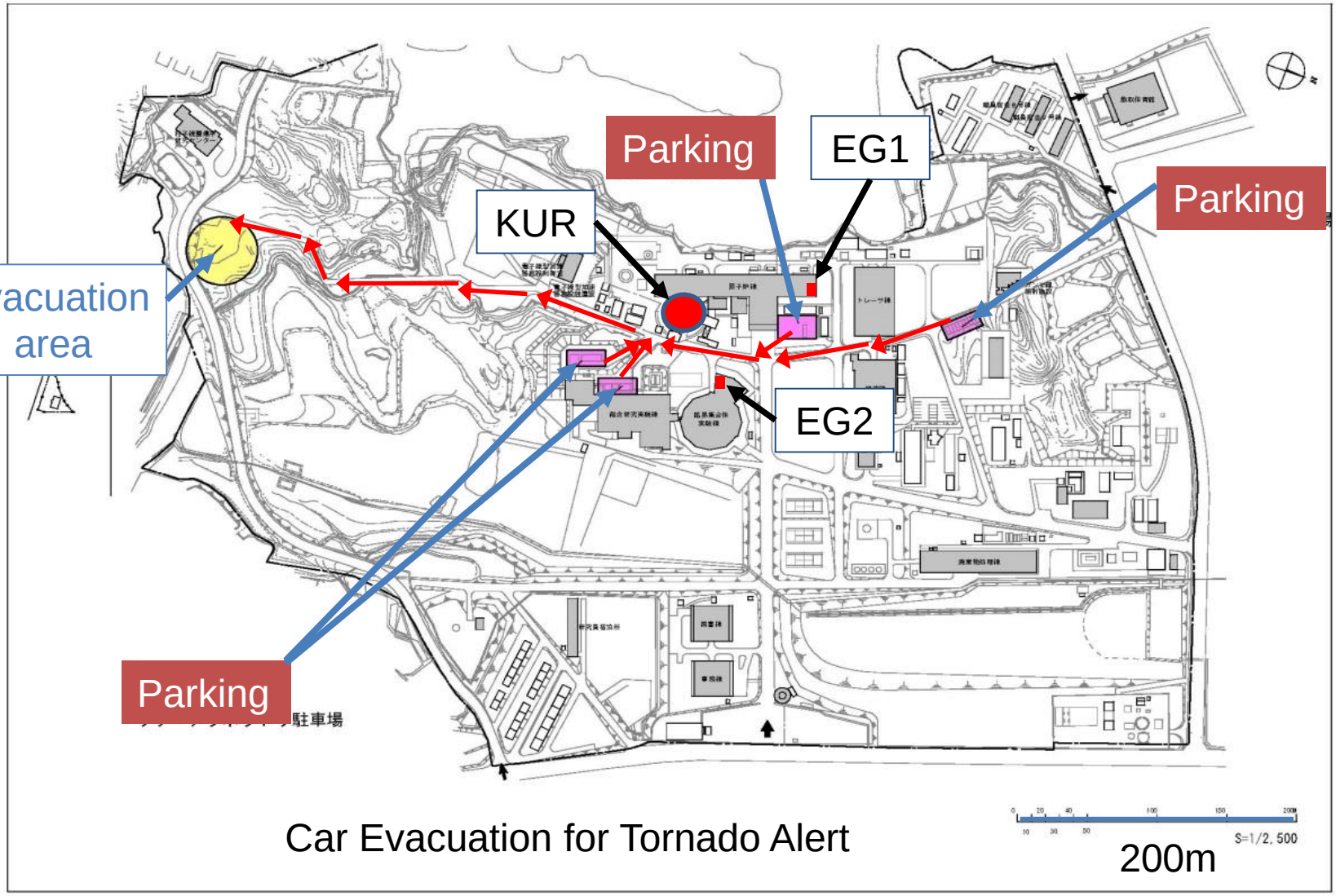
Maximum wind speed of Tornado :92m/s
according to the Guide of Tornado evaluation for NPPs

Emergency actions will be taken when the tornado alert was activated ;

- Reactor shutdown
- Evacuation of cars parked at the designated areas close to the KUR facilities.

Protection Cage for Cooling Tower of Emergency Generator (EG1)

Safety Re-evaluation/Measures: Tornado



Car Evacuation for Tornado Alert

Safety Re-evaluation/Measures:
Volcano & Forest Fire

Volcano

It was no hazard due to the volcanos located within the area of 160km from KUR. However, there is a possibility of volcanic ash falling from the volcanos out of the area. It was evaluated that the maximum deposit thickness of the ash was 2cm, and it did not affect the safety of KUR.

Forest Fire

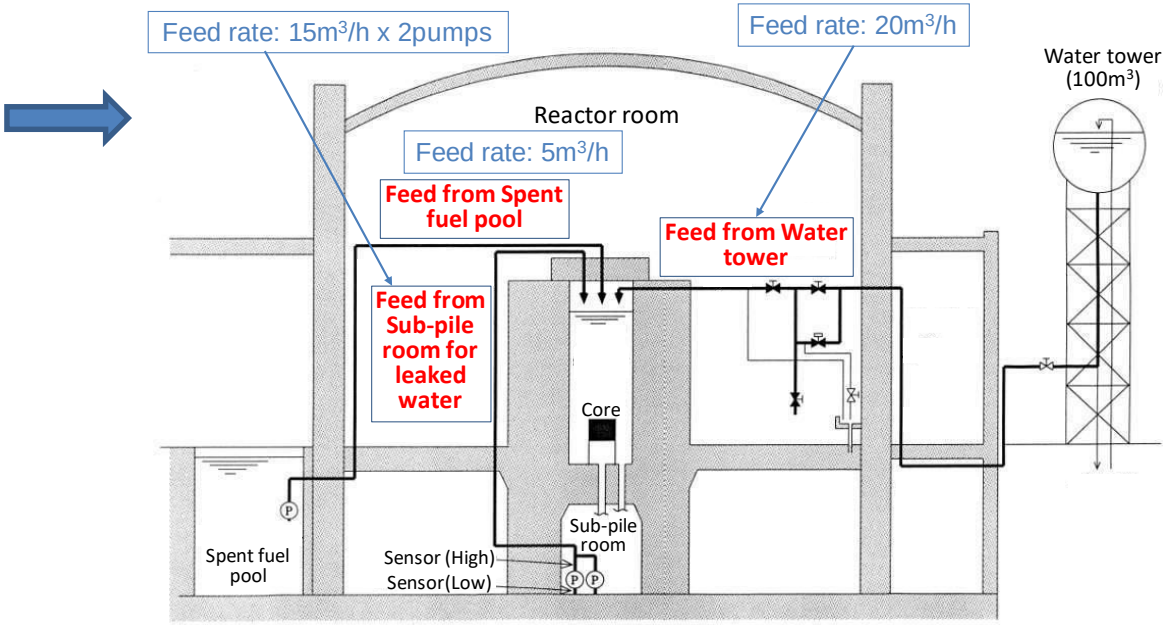
Inside the site, there is a small forest on the south of KUR. To protect the KUR facilities from the forest fire, we have constructed a fire-protection area between the forest and the facilities, in which water is sprinkled for the prevention of fire spreading by the persons on duty when the fire is detected.

Construction of
Fire-Protection Area

Safety Measures of KUR
(existing before the Fukushima Accident)

- For the Loss of External Power
  - No power used for Shut-down and Core-flooding
  - Emergency Diesel Generator(s) and Uninterrupted Power Supply are available.

- For the Loss of Cooling Function (Core-Flooding)
  - Emergency Core Cooling Systems
  - Water injection with Fire-hydrant

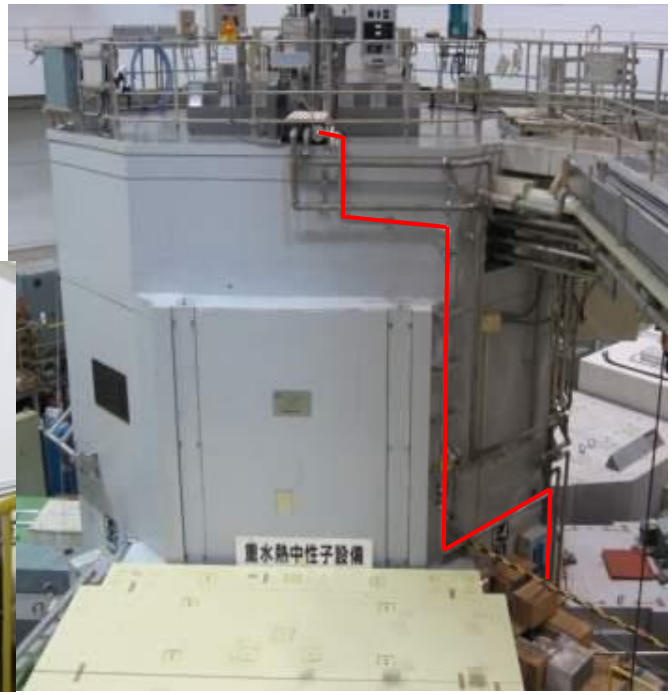


Additional Safety Measures (post Fukushima)

For additional safety measures;

a 40ton water storage tank was settled near the reactor room,
a portable fire pump, a portable power generator,
an additional water injection line and
an additional power supply line were prepared.

Emergency power supply line



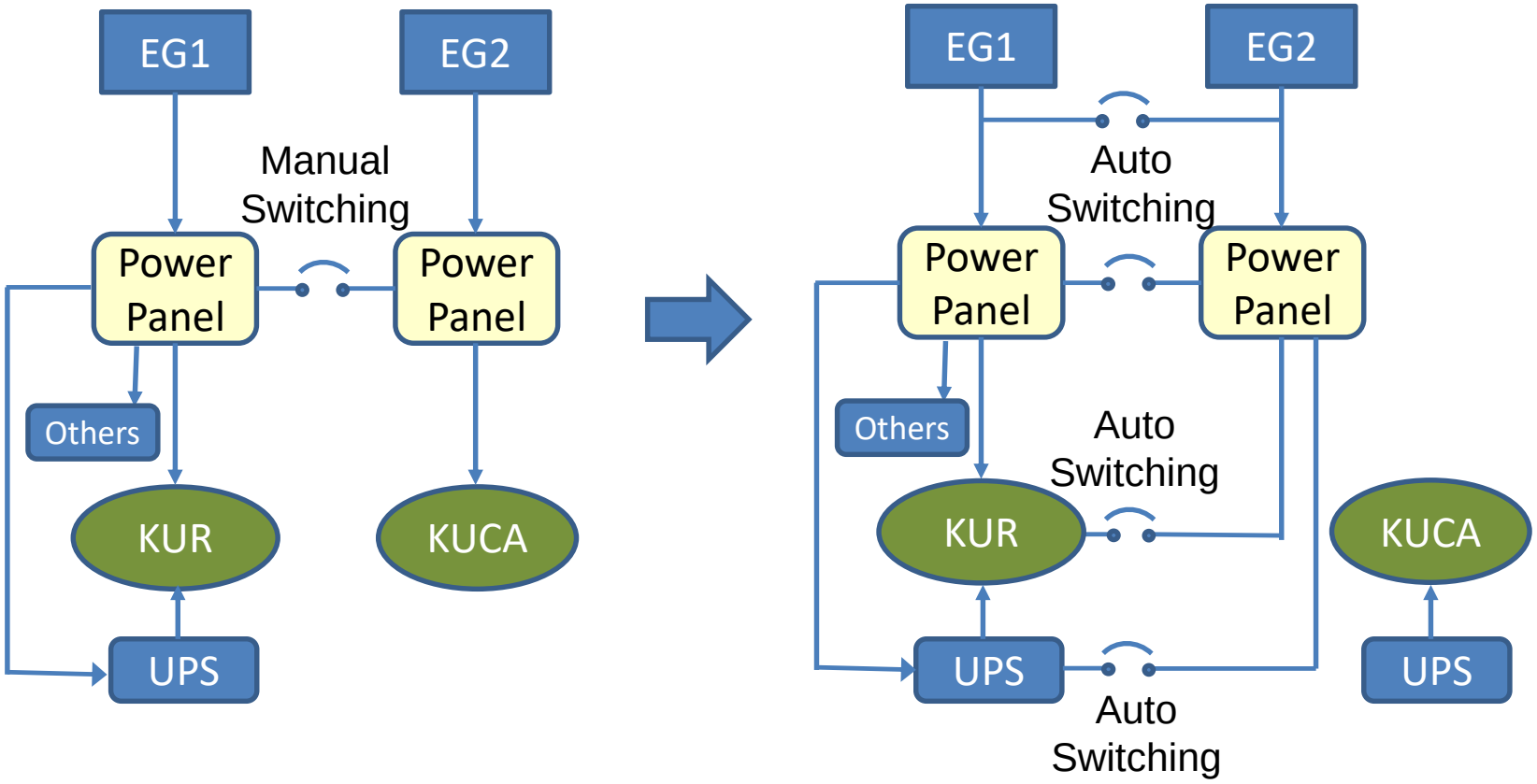
Additional water injection line

Modification of Emergency Power Supply for KUR

- For the Loss of External Power
  - No power used for Shut-down and Core-flooding
  - Emergency Diesel Generator(s) and Uninterrupted Power Supply are available.

- For the loss of external power, an emergency diesel generator (EG) was installed for KUR. In addition, there was another EG for KUCA, a critical assembly with the maximum power of 100W. In the safety review for KUCA, it was concluded that it was not necessary to facilitate the EG for KUCA because KUCA required no cooling system due to its low power. Then, we have modified the power distribution system from the EGs so that the both EGs can supply the power to KUR in emergency cases. Moreover, the battery power supply system, which would be used for the instrumentation, has been change to the larger capacity one.

Modification of Emergency Supply for KUR



Multiplicity & Diversity

Additional Safety Measures to enhance general safety

- Redundancy of Power Supply
  - External power supply: 1 line → 2 lines
  - Additional Emergency Diesel Generator for Non-reactor facilities including the telephone and network systems
  - Additional lines (cables) connecting each facility for the back-up of power supply
- Redundancy of Water Supply
  - In addition to the groundwater, public water supply with a 500ton storage tank will be introduced.

Those measures were completed in FY2013.

Safety Re-evaluation for BDBA: Conditions

For the BDBA evaluation, the following conditions are added to the DBA evaluation.

- Loss of Shutdown function
  - KUR has four shim rods for shutdown, and one rod stuck condition has been employed for the DBA evaluation.
  - For the BDBA evaluation, all rods stuck condition is employed.
- Loss of Cooling function (Core Flooding function)
  - LOCA occurs due to the break of the primary coolant line (one of the inlet or outlet lines) between the core and the main shutoff valve.
  - For BDBA evaluation, no water feed pumps are available, and the water tower is not available, too. (Because they are not seismic S-class facilities.)

Safety Re-evaluation for BDBA: Results

- Loss of Shutdown function
  - Even for the all rods stuck case, the power decreases securely due to the negative reactivity caused by temperature rise.
  - For the backup of shutdown function, the boronic acid powder is prepared that will be thrown into the core water.
- Loss of Cooling function (Core Flooding function)
  - The core flooding can be kept by using the portable fire pump, and the 40ton tank + SF pool as the water resource.
  - Under the present operation pattern* of KUR, the cooling (flooding) time over than 48hours is enough for fuel safety.

    * (1MWx48hrs + 5MWx8hrs) / Week + (5MWx56hrs / Week) x 2 times
- In preparation for the release of radioactive materials, full-face masks with charcoal filter, Tyvek suits etc. are equipped in the control room.

Summary

- There are 14 RRs in Japan, including 6 critical assemblies, and they have been playing important roles in the various fields.
- New regulatory body, NRA, has devised new safety requirements for RRs (executed in Dec. 2013), and all the RRs must comply with the requirements.
- At present, only three research reactors, KINKI-UTR, KUR and KUCA are operating.

- KUR is an only operating RR as a non-zero power reactor in Japan after the Fukushima-accident.
- In addition to the pre-existing safety measures, new measures (a 40ton water tank, a portable fire pump, a portable power supply) were prepared.
- The safety re-evaluation for BDBA showed the effectiveness of those additional safety measures.


Thank you for your attention.