MANUFACTURING OF NEUTRON REFLECTOR FRAME FOR JMTR

Yoshio Hanawa[1], Kazuaki Tsuboi[1],
Munenori Uchida[2], Ken Suzuki[2], Kunihiro Takahashi[1]

[1]Japan Atomic Energy Agency

[2]NGK INSULATORS, LTD.

Backgrounds and Objective

Japan Materials Testing Reactor

- First criticality in 1968
- Utilization for materials testing (Fuels/materials lifetime study, etc.) and RI production
- Refurbishment from 2007 to 2010

Beryllium (Be) neutron reflector

- 7th generation is now manufactured.
- Swelling camber ⇨ lifetime

Contents of this presentation

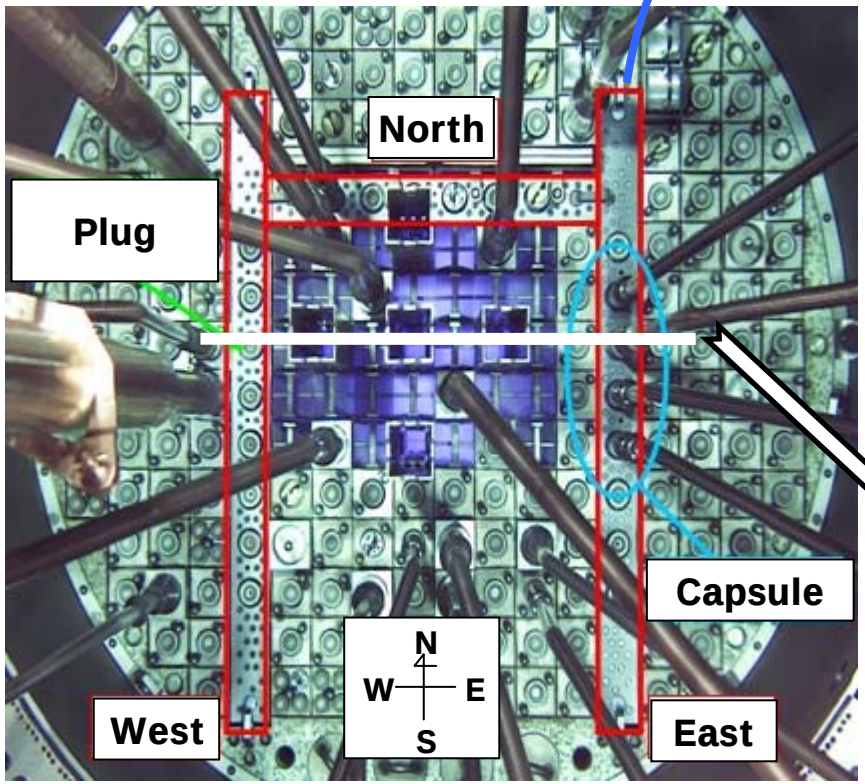
-To review the technical issue of Be reflector

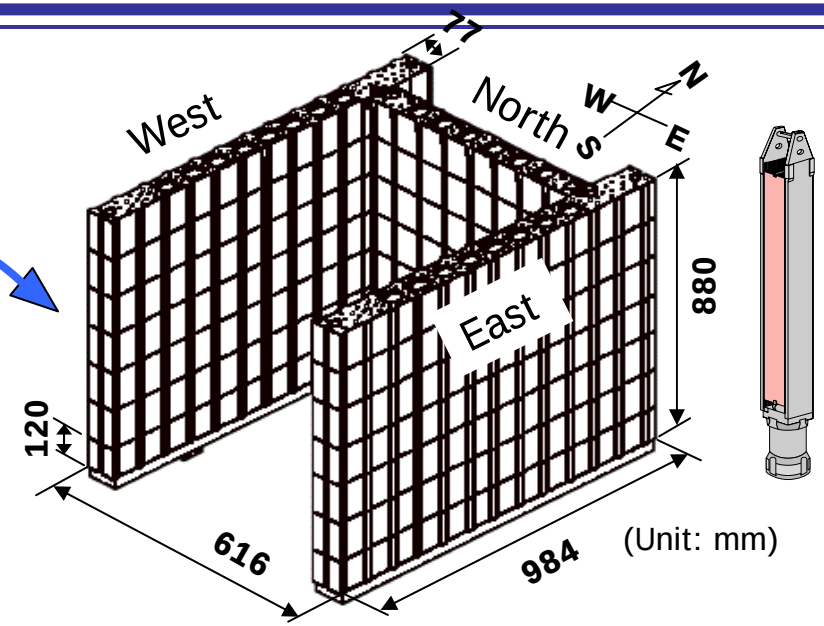
-To introduce the status of 7th gen. replacement

Reactor Core and Be Reflector Frame

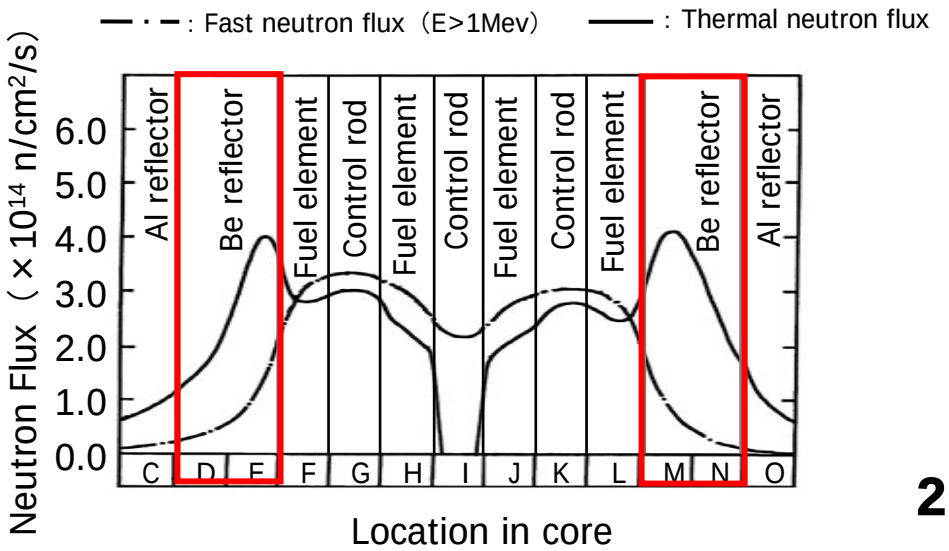
Be Reflector Frame

To moderate and reflect neutron generated in fuel region for irradiating the sample efficiently





Neutron flux distribution



Operation Condition of JMTR

Parameter	Condition
Reactor thermal power	50 [MW]
Maximum fast neutron flux(E>1MeV)	$4x10^{18}$ [n/(m^2s)]
Maximum thermal neutron flux(E<0.683eV)	$4x10^{18}$ [n/(m^2s)]
Maximum gamma heating rate	$1.24x10^{7}$ [W/m^3]
Maximum surface temperature	100 [ºC]
Primary Coolant water	Light water pH 5.5-7.0 Minimum resistivity $5x10^{5}$ [Wcm] Maximum coolant velocity 11 [m/s]
Inlet pressure	1.47 [MPa]
Pressure difference	294-314 [kPa]
Maximum heat generation per a capsule	100 [kW]

History of JMTR Be Reflector

Generation	Term	Accumulated power (MWD)	Neutron Fluence ($x10^{26}m^{-2}$)	Camber (mm)
1st	**1966-1974**	**~24,000**	**0.96**	**0.71**
2nd	**1975-1983**	**~28,000**	**1.12**	**0.84**
3rd	**1984-1987**	**~25,000**	**1.00**	**0.75**
4th	**1988-1995**	**~36,000**	**1.44**	**1.24**
5th	**1996-2002**	**~29,000**	**1.15**	**1.09**
6th	**2003-2007**	**~25,000**	**1.00**	**-**

4th Generation-
Design improvement for extending lifetime

Improvement of Swelling Camber

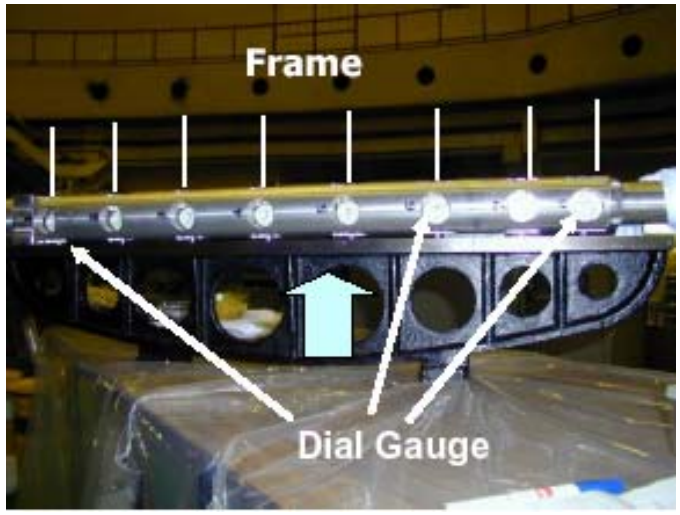
Improvement after 4th generation frame

Design improvement

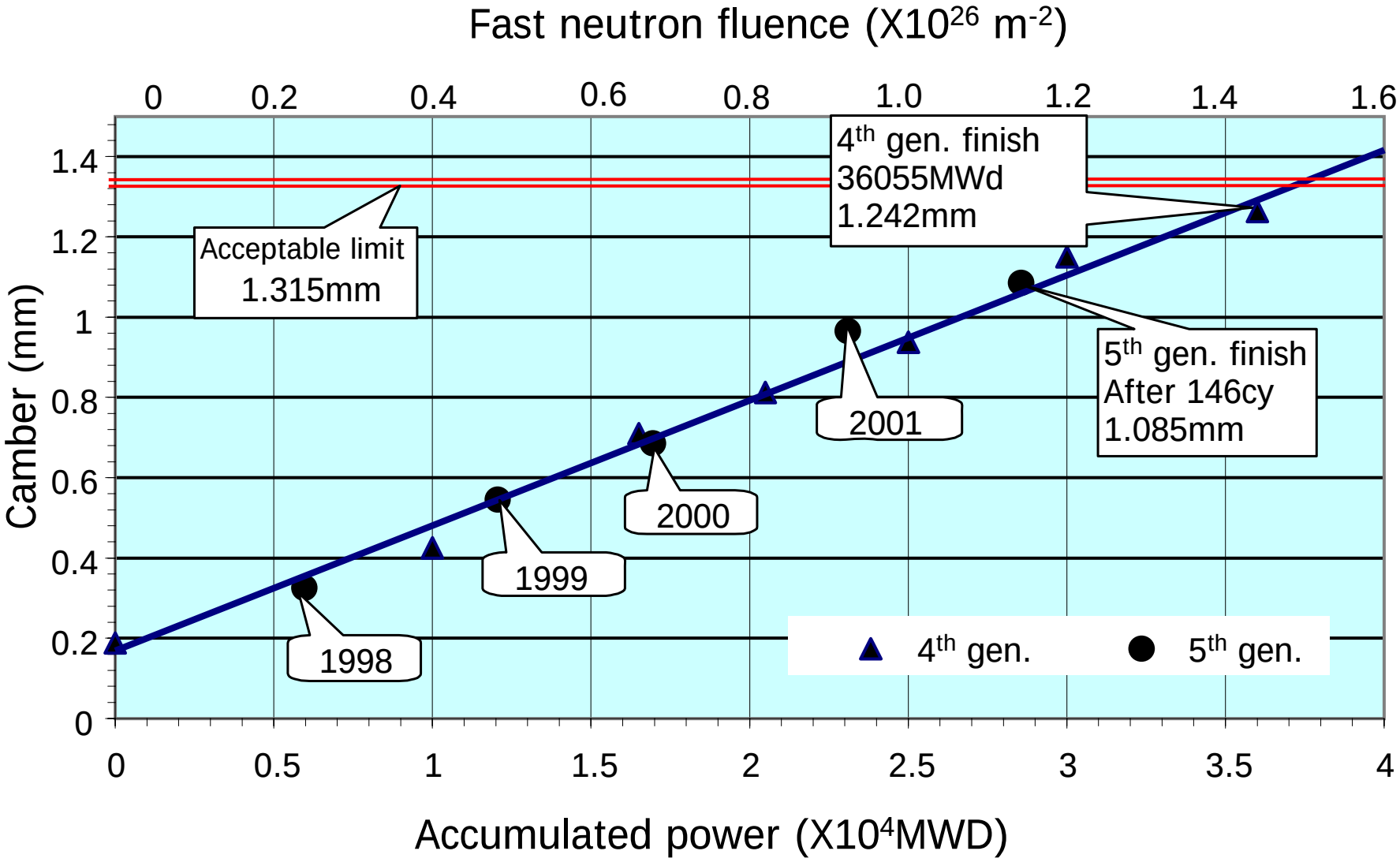
1. Enlargement of the gap between Be frame and fuel element
2. Shape change of bottom block
3. Joint design change

Monitoring of swelling camber

1. Camber monitoring apparatus
2. Yearly monitoring
3. Setting the controlling criteria



Results of Recent Operation



Material Specification of JMTR

Specification for chemical composition

Elements	Acceptable limits (%)
Be	98.5 min.
BeO	1.3 max.
Al	0.06 max.
B	0.0003 max.
Cd	0.0002 max.
Ca	0.02 max.
C	0.15 max.
Cr	0.02 max.
Co	0.001 max.
Cu	0.015 max.
Fe	0.13 max.
Pb	0.002 max.
Li	0.0003 max.
Mg	0.03 max.
Mn	0.015 max.
Ni	0.03 max.
Mo	0.002 max.
Si	0.05 max.
Ag	0.001 max.
Cl	0.04 max.
N	0.05 max.
U	—

Elements	Acceptable limits (ppm)
Gd	10 max. (Total content of 4 elements)
Sm	
Dy	
Eu	
Boron equivalent value	10 max. (Total content of elements excluding Be,Gd,Sm,Dy and Eu)

Requirements for material of JMTR

(1) Low swelling

(2) Low radio-activation

Requirements for Beryllium

(1) High Beryllium purity

(2) Low impurity (Fe, Al, Si, Mg, Co, U)

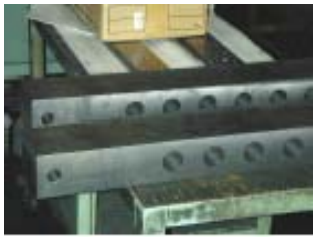
(3) Low boron equivalent value

Manufacturing Flow

Procurement

Rough machining

Drilling

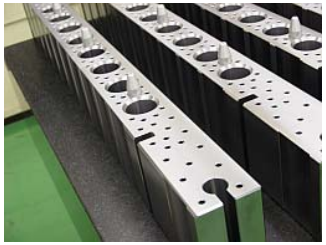


Finish machining

Finish polishing

Inspection

Joint parts setting



Assembling

Machining Process

Requirements for Beryllium machined frame

(1) Dimension accuracy for assembly
(2) No damage on surface
(3) No corrosion on surface

Key points

(1) Tooling and machining condition to avoid damage
(2) Be health & safety management

Beryllium Health & Safety

1. Japanese Law

- Ordinance on the prevention of the hazard due to specified chemical substances
- To prevent disturbance of respiratory function among employee.

2. Duty of Employer

- Beryllium is classified as specified chemical substances by the law.
- Beryllium processors are required to minimize exposure to employee.

3. Beryllium Health & Safety Management

3.1 Control of the work environment

- Reduction of beryllium concentration with local ventilation equipments (Exposure Limit : 2ug/m^3)

3.2 Control of beryllium workers

- Health & Safety Education
- Wearing mask
- Washing body after working
- Periodical health checkup

Schedule of 7th Gen. Frame

Task	2008	2009	2010
Procurement			
Machining			
Assembling			
Inspection			
Replacement			

Conclusion

- Be reflector frame has been used in JMTR since 1966.
- Swelling camber is key issue to control lifetime and the lifetime management has been established.
- Manufacturing is required some key points from the viewpoints of swelling, ductility, health & safety, etc.
- 7th generation Be frame is now well manufactured and will be replaced in early 2010.