International Conference on Research Reactors: Safe Management and Effective Utilization,
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PUSPATI TRIGA REACTOR UPGRADING: TOWARDS THE SAFE OPERATION & FEASIBILITY OF NEUTRONIC APPROACH

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Objectives

To develop capacity building in planning for a high power reactor and its application in the sense of:

- To develop expertises in Reactor Physics, Thermal Hydraulic, Instrumentation & Control

To share among the participant relevant activities prior to the PUSPATI TRIGA Reactor upgrading towards the safe operations manner and feasibility of neutronics approach

Contents

NUKLEAR MALAYSIA

MOSTI

Introduction

- PUSPATI TRIGA Reactor (RTP) is located at Malaysian Nuclear Agency complex.
- The one and only research reactor in Malaysia.
- First criticality on 28 June 1982.
- Used for various irradiation of samples for NAA, radioisotope production, beam experiments and education & trainings

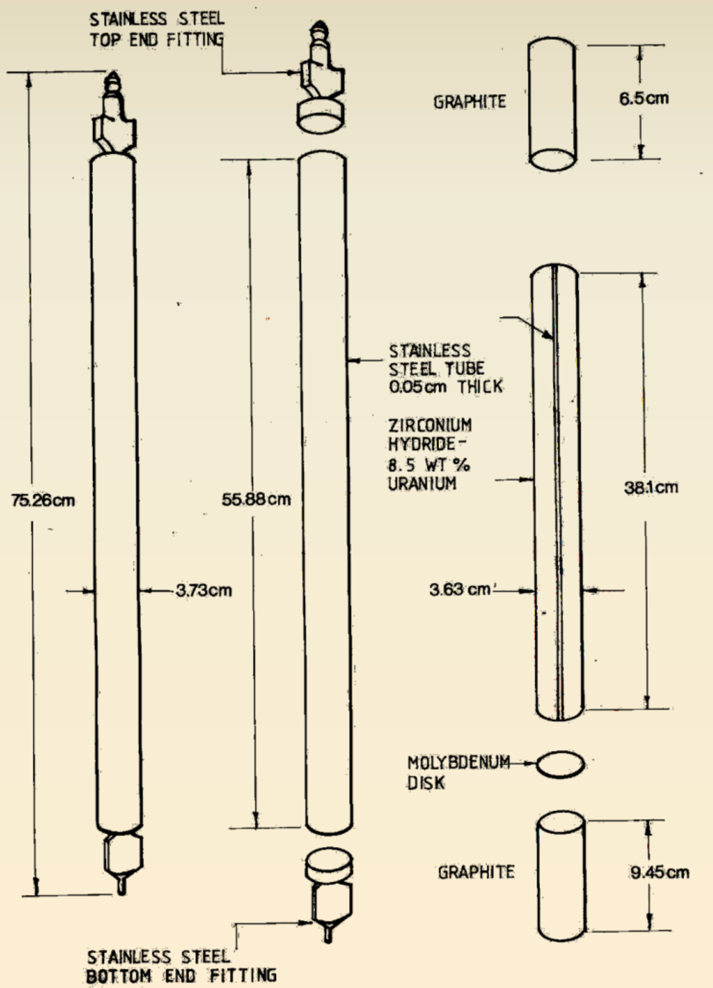
PUSPATI TRIGA Reactor (RTP)

- Collaboration with local universities & other research institute to enhance the utilization of RTP through Reactor Interest Group (RIG) platform

RTP Description

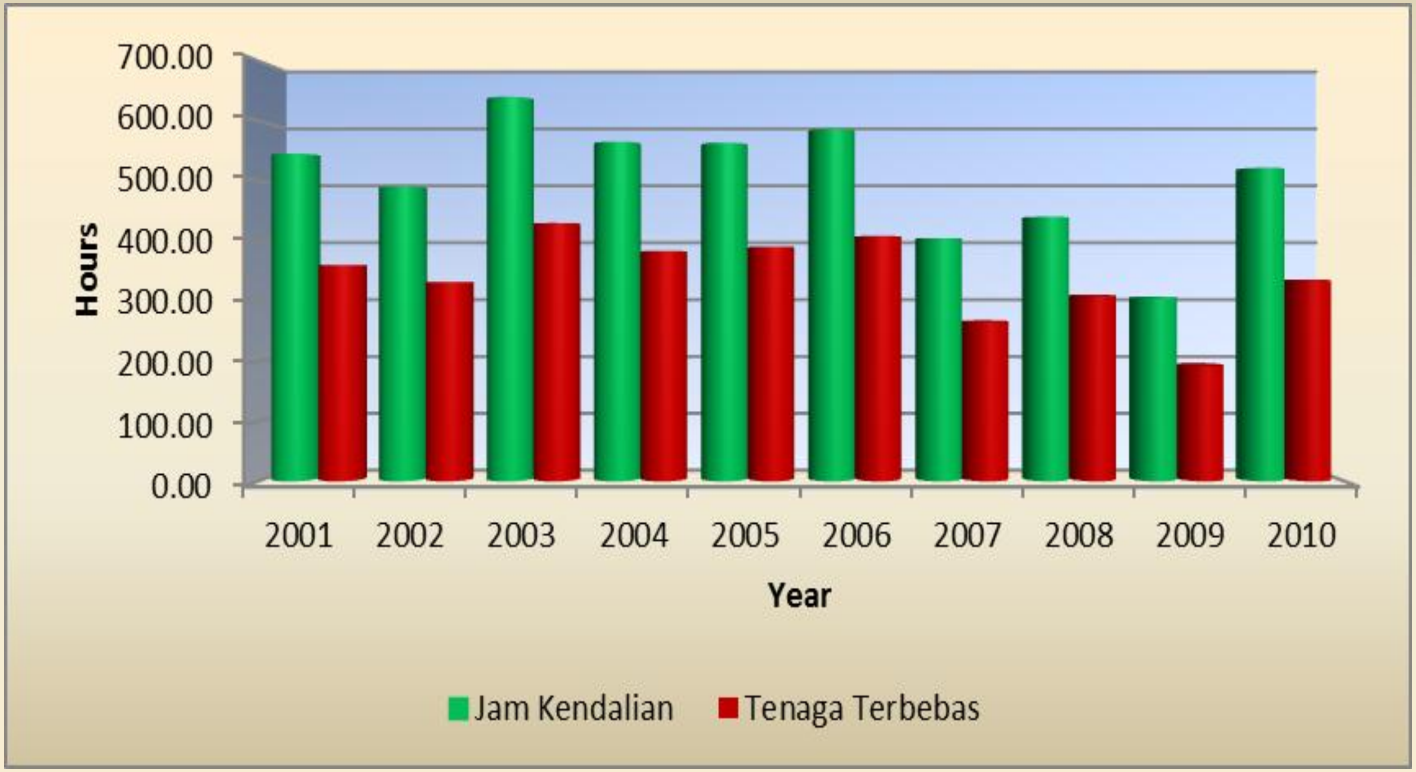
Items	Description
Name	PUSPATI TRIGA Reactor (RTP)
Purpose	NAA, Beam Experiment, Isotope Production, Education and Trainings
Type	Pool type
First Criticality	28 June 1982
Maximum Thermal Power	1MW
Pulsing Peak Power	1200MW (pulse width, 11ms)
Typical Neutron Flux	1×10^{12} n/cm^2/s
Maximum Thermal Neutron Flux	1×10^{13}n/cm^2/s
Coolant	Light water
Moderator	Light water
Number & Type of Control Rod	3FFCRs, 1AFCR & B_4C
Reflector	Graphite
Shape of fuel element	Rod type
Fuel material	$UZrH_{1.6}$ (standard TRIGA fuel)
Enrichment of U-235	19.9%

Fuel Description



Description	Nominal Value	
Fuel Moderator material		
H/Zr ratio	1.6	
Uranium content	8.5wt %, 12 wt %, 20wt%	
Enrichment (U-235)	20%	
Diameter	1.43 inch	
Length	15 inch	
Graphite end reflectors	Upper	Lower
Diameter	1.35 inch	1.35 inch
Length	2.6 inch	3.7 inch
Cladding		
Material	304 stainless steel	
Wall thickness	0.020 inch	
Length	22.10 inch	
End fixtures	304 stainless steel	
Overall element		
Outside diameter cladding	1.47 inch	
Length	29.6 inch	
Weight	~7 lb	

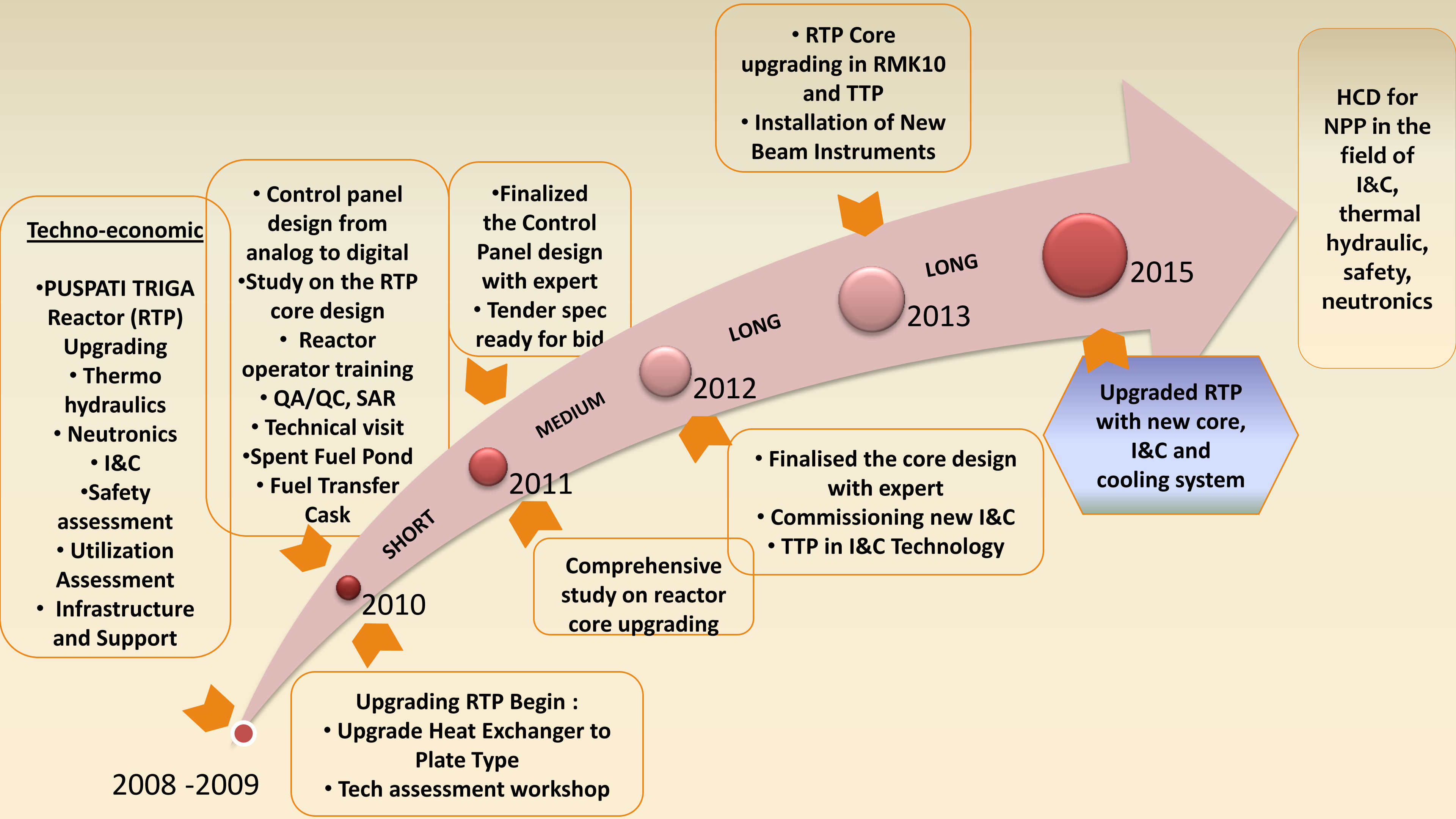
RTP Operation



- Accumulative operation time **24,042.03 hours**
- Accumulative energy release **16,044.00MWhrs**

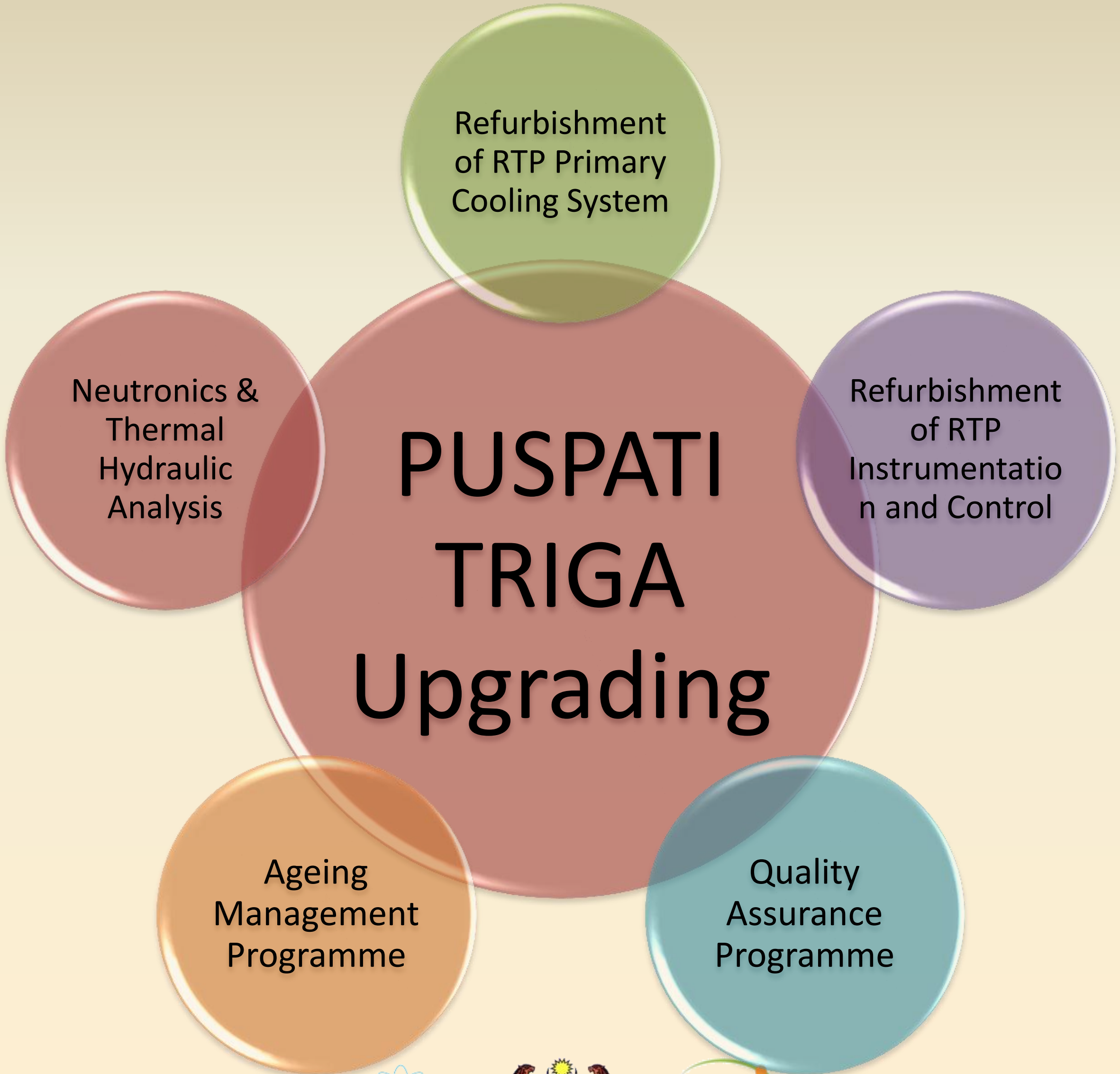
- The average operating hours and energy release for the past ten years is around **340.60MWhrs** and **506.59 hrs** respectively

RTP Upgrading Roadmap



NUKLEAR MALAYSIA MOSTI

Strategies To Enhance Safety

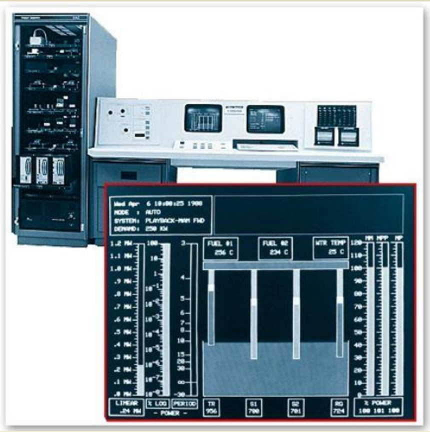


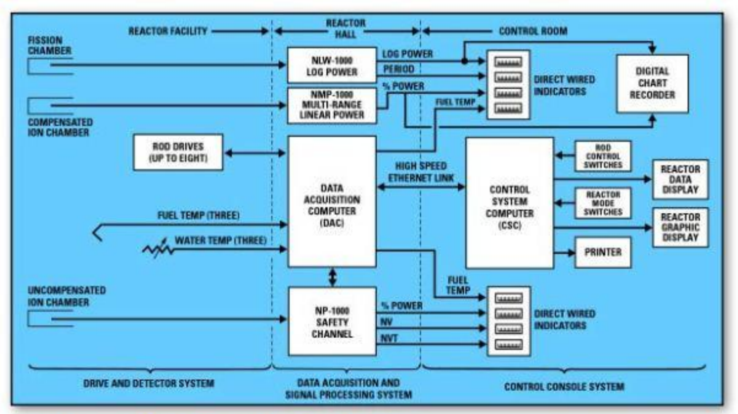
Refurbishment of RTP Primary Cooling System

- Replacement of the heat exchanger from shell & tube to plate-type
- To optimize the natural circulation for sufficient heat removal, as residual heat after reactor shutdown
- Higher capacity heat exchangers and pumps to cater higher thermal power
- Adopting SCADA control system → now the operator can automatically control the pumps and valves remotely from the control room

Refurbishment of RTP Instrumentation and Control

- There are an increased in system instability, errors on system's indicators , non-functional functions, intermittent signals which had led to the increment of downtime and maintenance time after 25 years of operation.
- Maintenance of the console faced a major difficulty due to ageing factors, spare parts procurements and lack of support by the manufacturer.
- The process of tender for the new console is still ongoing and expected to start by 2012.

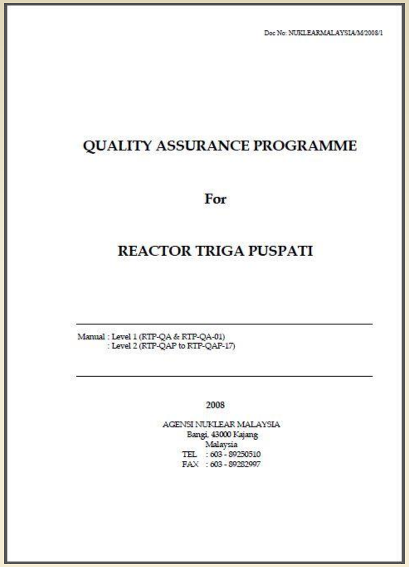




Simplified Research Reactor Control System Block Diagram

Quality Assurance Programme

- Adopted from the SS50C/SG-Q
- Covers :
  - the entire operations and maintenance of the reactor,
  - the management review,
  - the control of modifications of installations,
  - control of experimental and testing programmes and treatment,
  - storage and transport of fissile and radioactive material.



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QUALITY ASSURANCE PROGRAMME

For

REACTOR TRIGA PUSPATI

Manual : Level 1 (RTP-QA & RTP-QA-01)
: Level 2 (RTP-QAP to RTP-QAP-17)

2008

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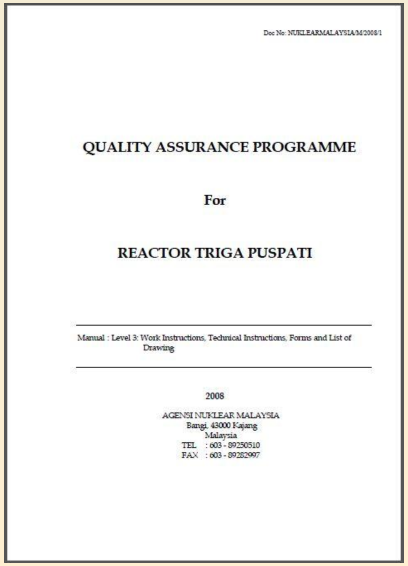

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QUALITY ASSURANCE PROGRAMME

For

REACTOR TRIGA PUSPATI

Manual : Level 3: Work Instructions, Technical Instructions, Forms and List of Drawing

2008

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Ageing Management Programme

- Ageing problems arise on the system, structure and components (SSCs)
- Several reactor components was out dated
- Periodic inspection and maintenance itself is not enough to ensure the integrity of SSCs in the reactor at all time

Phase 1	• Identify the ageing factor that occurs in SSCs • Identify the party responsible for each SSCs • Further explanation and study on problems related to ageing of safety related SSCs
Phase 2	• Reviewing the ageing mechanisms to understand their behaviour and influence to the reactor system • Provides guidelines to assists the operator in the detection and assessment of ageing effects • Implementation of transformation plans to overcome the ageing effects
Phase 3	• To provide information that can be used to assess the safety on operation of reactor • To propose preventive and corrective measures to mitigate the effects of ageing • To provide guidance for the manager in decision making on replacement or upgrading the SSCs
Phase 4	• Training, courses or information sharing to capture new ideas or method to handle ageing of SSCs in reactor facility • Providing guidance and consultancy for the ageing management of other facility in the organization

Neutronics & Thermal Hydraulic Analysis

Neutronics

- Using MCNP
- MCNP to calculate keff, power distribution, peaking factor, shutdown margin

Thermal Hydraulic

- Using PARET and RELAP
- PARET to calculate coolant and fuel temperature
- RELAP to deliver flowrate in PARET calculation

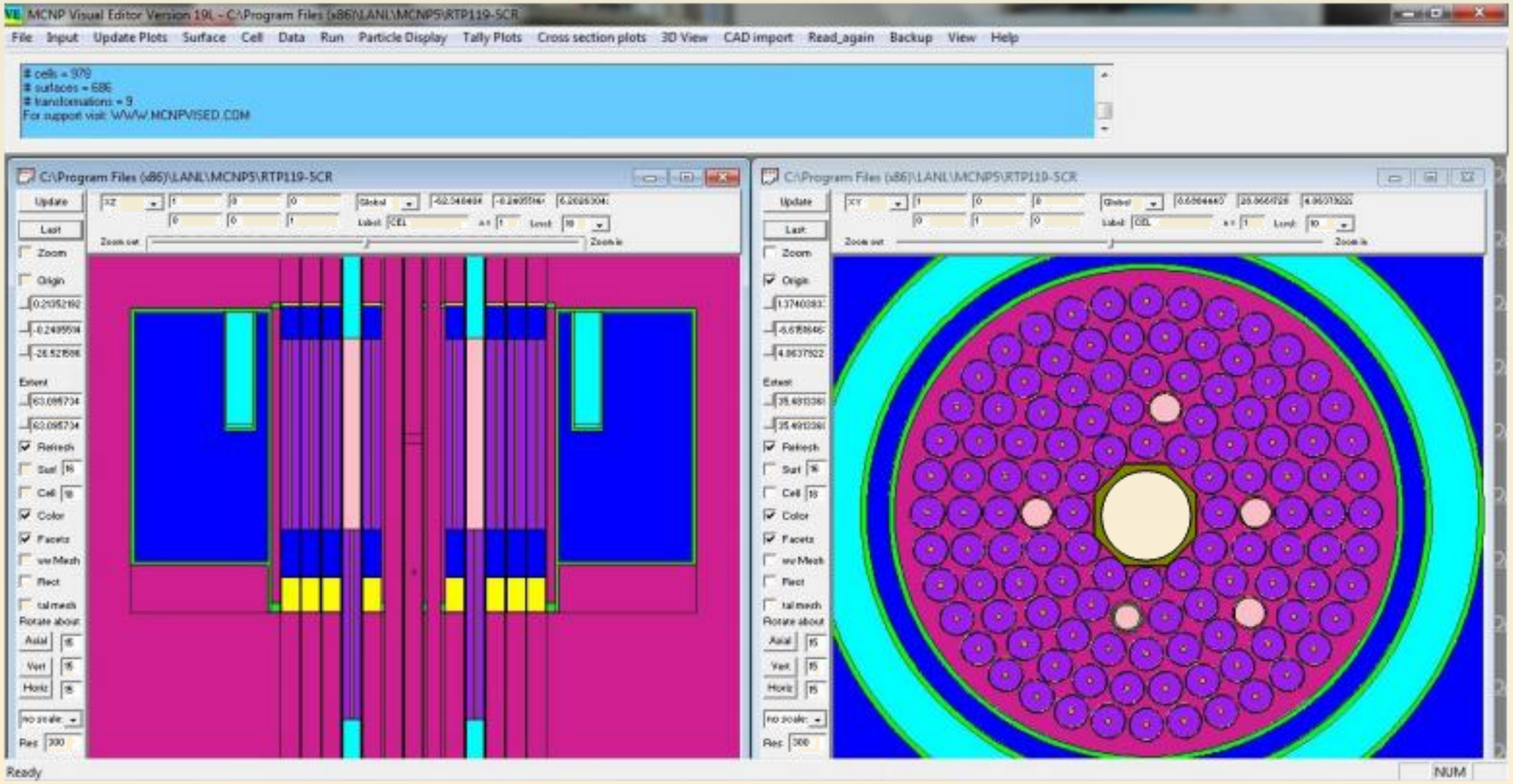
ANALYSIS

- 2MW- RING-119FE- Central flux trap- Natural convection flow (upward)
- 3MW- RING-119FE- Central flux trap- Natural convection flow (upward)
- 3MW- RING-119FE- Central flux trap- Forced flow (Downward)

Neutronic Analysis

MCNP core configuration with 119 FE and central flux trap
119 fuel element, 8.5% standard TRIGA kcode: 1000000 nps & 1000 histories of neutron error <0.01 neutron flux & power normalization constants for 2MW:

F = 1.53E+17 (1/k_eff) , P = 2.45E+4 (1/k_eff)



Neutronic Analysis

Reactivity results:

i. Keff : 1.06584

ii. Shutdown margin: (CR worth – core reactivity excess must be positive)

	Keff				CR	
CR	up 100%	core $	down 100%	core $	worth $	Shutdown margin
4Cr in	1.06584	8.82	0.98784	-1.76	10.58	1.76
5Cr in	1.06584	8.82	0.97326	-3.92	12.75	3.92
3Cr in	1.06584	8.82	1.01671	2.35	6.48	-2.35

iii. Neutron flux: (2MW)

	ROTARY RACK	CENTRAL TIMBLE
THERMAL	1.02E+13	6.99E+13
EPI	7.73E+12	2.02E+13
FAST	1.73E+12	6.28E+12

Axial Power Distribution

Rotary Rack

3.50E-05	**RotaryR**		core-01
2.89E-05			***RR bottom***
6.99E-06	nf	1/keff	***th flux***
7.09E-05	1.53E+17	0.938227126	**1.02E+13**
2.79E-06			core-01
2.58E-05			***RR bottom***
2.52E-05	nf	1/keff	***epi flux***
5.38E-05	1.53E+17	0.938227126	**7.73E+12**
			core-01
			RR bottom
1.20E-05	nf	1/keff	***fast flux***
1.20E-05	1.53E+17	0.938227126	**1.73E+12**

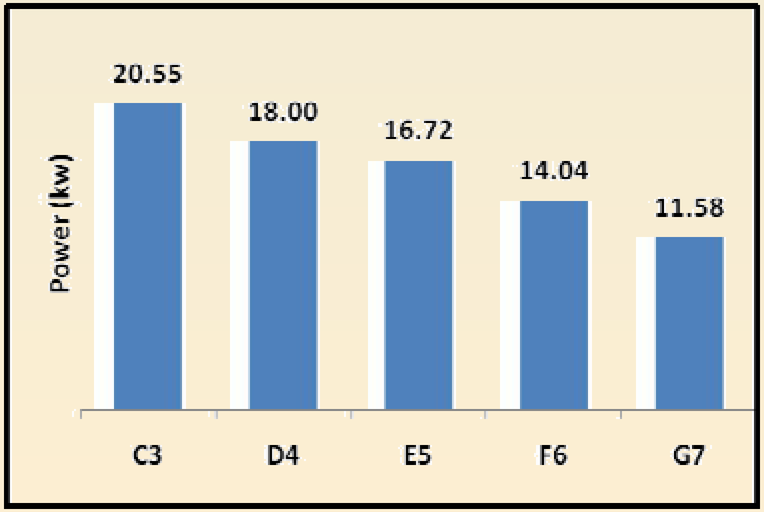
Central Thimble

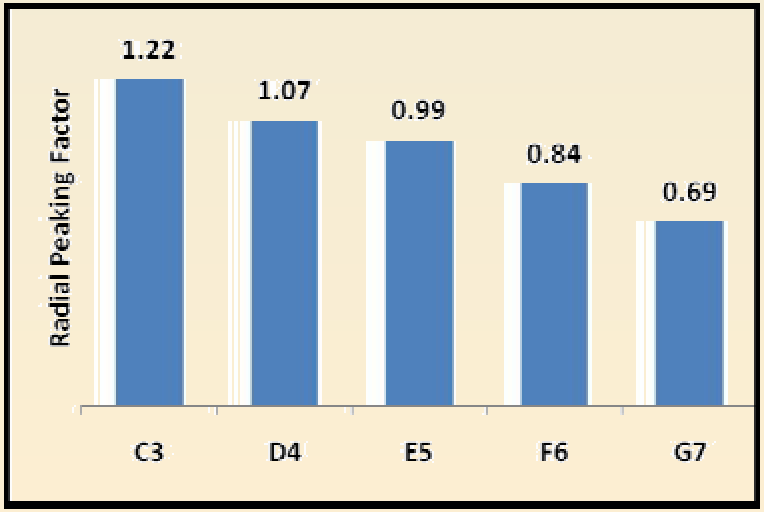
	CT water		
2.68E-04	**inside**		core-01
1.90E-04			***CT***
2.81E-05	nf	1/keff	***th flux***
4.86E-04	1.53E+17	0.938227126	**6.99E+13**
9.38E-06			core-01
7.17E-05			***CT***
5.98E-05	nf	1/keff	***epi flux***
1.41E-04	1.53E+17	0.938227126	**2.02E+13**
			core-01
			CT
4.37E-05	nf	1/keff	***fast flux***
4.37E-05	1.53E+17	0.938227126	**6.28E+12**

Power and PPF Distribution in Fuel Rings- Radial

RADIAL POWER (kw)		ave power	Peaking Factor
C3	20.55	16.8067227	1.22
D4	18.00	16.8067227	1.07
E5	16.72	16.8067227	0.99
F6	14.04	16.8067227	0.84
G7	11.58	16.8067227	0.69

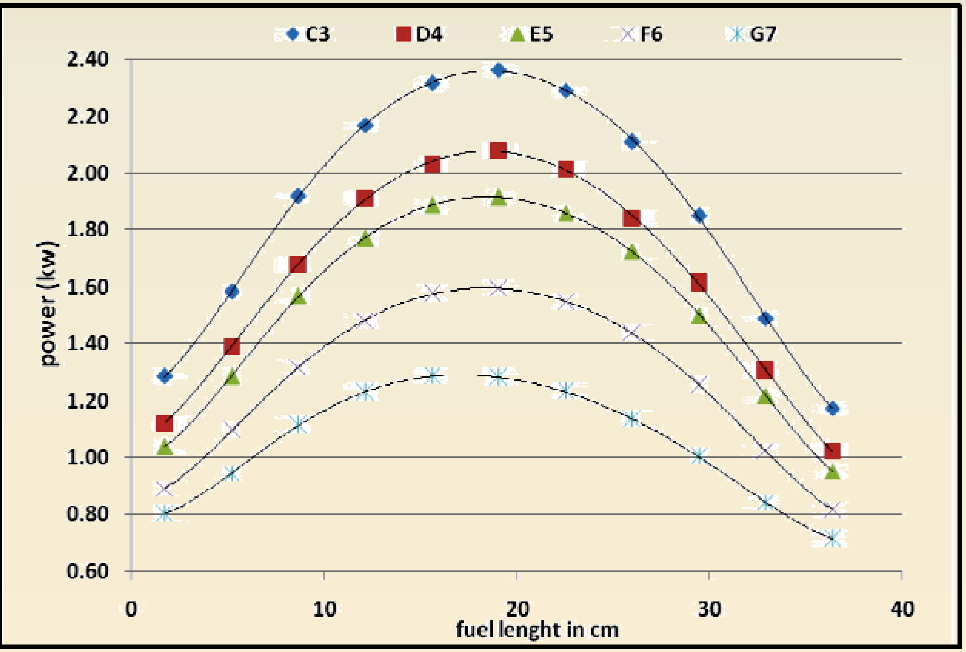
<u>Histogram correspond to power and peaking factor</u>



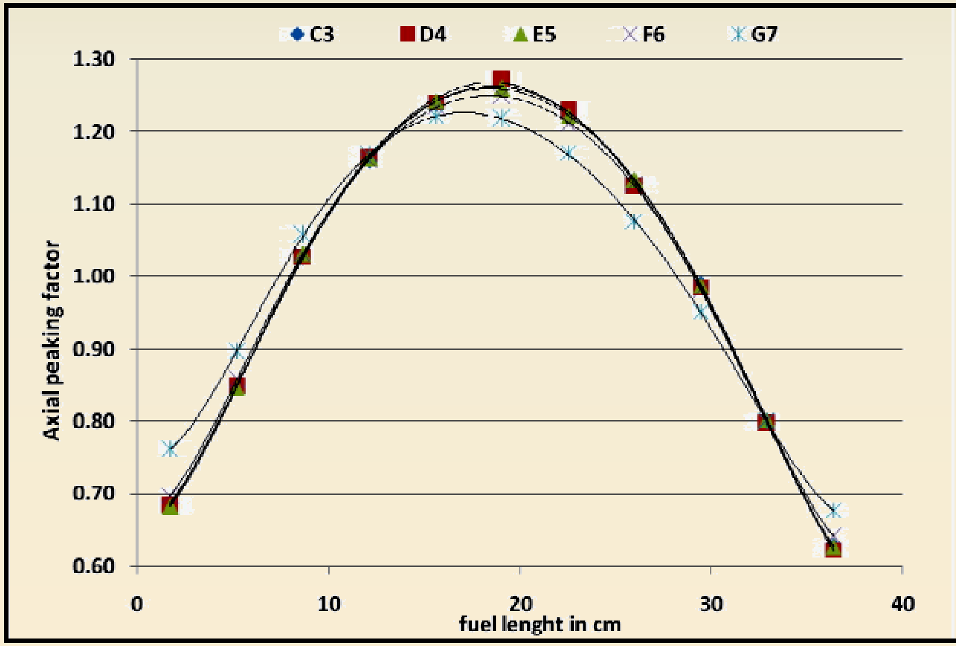


Power and PPF Distribution in Fuel Rings- Axial

Power Distribution vs Fuel length



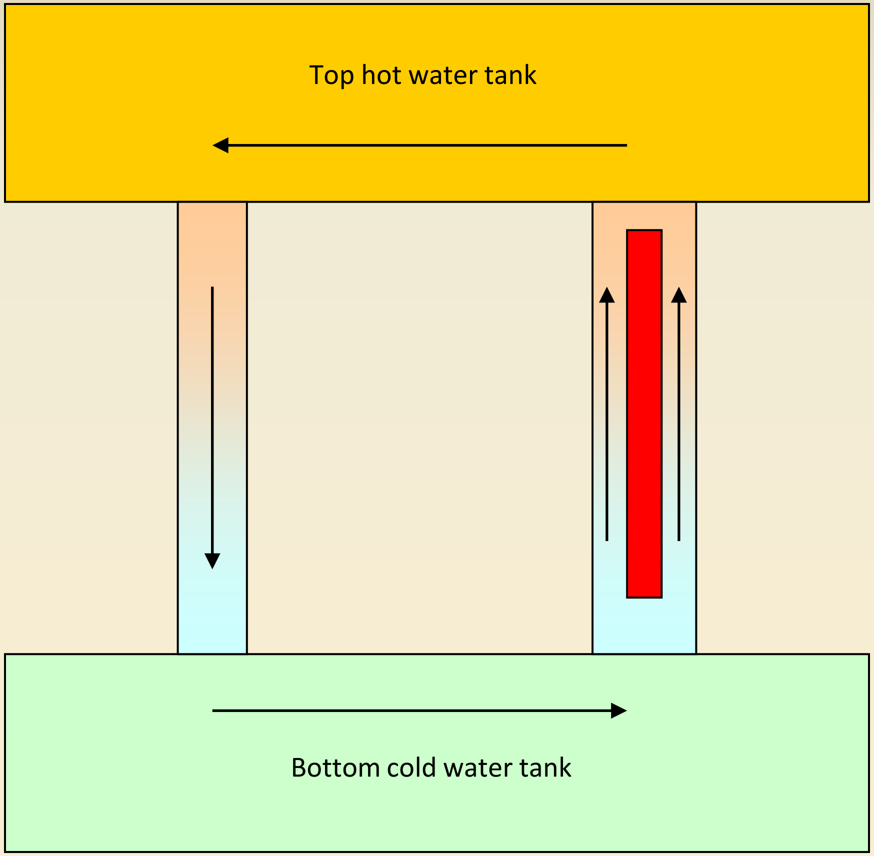
Axial Peaking Factor vs Fuel length



The main hydraulic parameters for those two type of fuel is presented in the next table:

Thermal Hydraulic Analysis

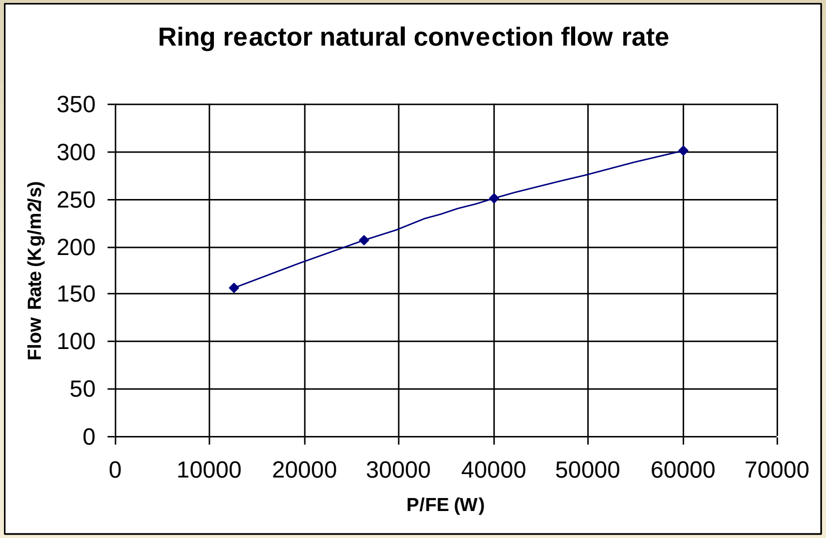
- Set up a RELAP model which will estimate the flow rate in natural convection loop
- RELAP calculations cover for the first case the power interval between **10KW-60KW** per ring fuel element and for the second case cover the interval between **1.8KW-17KW** per bundle fuel element.

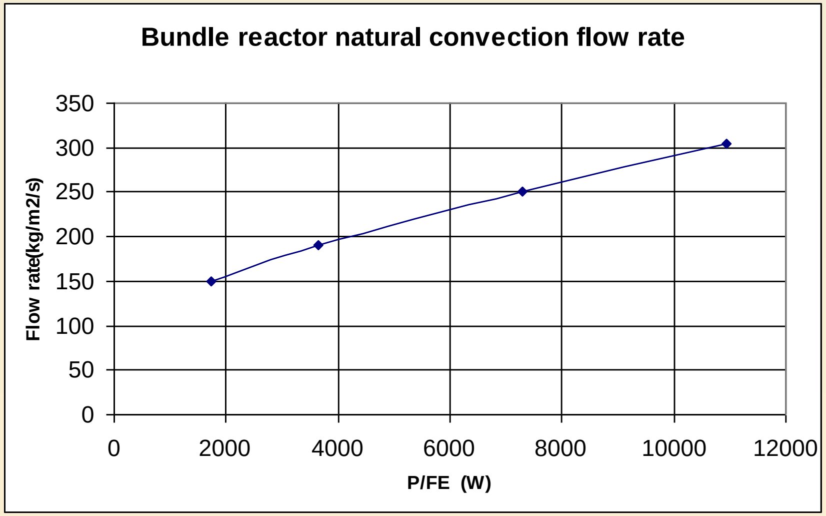


Hydraulic Parameters

The main hydraulic parameters for two types of fuel

Dim. (cm; cm2; cm3)	Ring fuel element	Bundle fuel element
Fuel radius	1.8224	0.6467
Gap radius	1.8262	0.6473
Clad radius	1.8770	0.6883
Water channel radius	2.3000	0.9201
Lateral clad area	449.33	164.77
Fuel volume/FE	397.52	50.058
Flow area/FE	5.6250	1.1458
Fuel height	38.100	38.100
Clad xsection area	11.068	1.4883





PARET Analysis

- The three main parameters in SAR are:
  - **Total flow rate of the core 6.7 kg/s**
  - **Maximum fuel temperature 415C**
  - Another derived parameter from above two is the water temperature evolution for the average channel. (32C-67C SAR prediction)
- The flow rate for the average channel (P=12500W : Flow area 450cm2) was determined in above calculations using RELAP5 (**7.1kg/s)**,
- This is in very good agreement with original SAR .
- In order to calculate all these parameters, two PARET inputs has been made:
  - Average cannel
  - Maximum channel

Restrictions:

Maximum fuel temperature   - 900C (SAR)

Maximum DNB Heat Flux – 127W/cm2 (SAR, natural convection)

Maximum Clad temperature – 400C (SAR, However temperature of the clad is situated under DNB Heat flux due to corrosion problems <150 C)

Exit coolant temperature < 90C (avoiding boiling and flow instabilities)

PARET for SAR using 80FE-average

Paret main output parameters for SAR 80FE Ring reactor
Average channel Natural Convection (SAR water exit 67C)
Power =1MW
Subchannel power 12500w PPF=1. APF=1. CPF=1. Qmax.=27.01W/cm2
Results: Exit temperature 66C very good agreement with SAR

AXIAL NODE	LIQUID(VAPOR) TEMPERATURE (DEG. C)	CLAD SURFACE TEMPERATURE (DEG. C)	FUEL SURFACE TEMPERATURE (DEG. C)	FUEL CENTER TEMPERATURE (DEG. C)	MASS FLOW RATE KG/S*M**2)	MODERATOR REGIME
1	32.0000	118.0678	160.6136	269.5145	155.00	LIQUID
2	34.4281	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
3	36.0468	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
4	37.6641	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
5	39.2814	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
6	40.8987	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
7	42.5151	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
8	44.1309	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
9	45.7468	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
10	47.3623	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
11	48.9766	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
12	50.5909	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
13	52.2052	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
14	53.8182	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
15	55.4309	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
16	57.0435	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
17	58.6556	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
18	60.2666	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
19	61.8775	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
20	63.4885	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.
21	65.9024	118.9735	160.5193	269.4202	155.00	NUCLEATE BOIL.

PARET for SAR using 80FE-maximum

Paret main output parameters for SAR 80FE Ring reactor
Maximum channel Natural Convection(SAR max fuel temperature 415C)
Power =1MW
Subchannel power 26500W PPF=1.7 APF=1.25
CPF=2.12 Qmax.=56.7

Results:
Maximum exit temperature=81.2C
Maximum clad temperature=121.3C
Maximum fuel center temperature=439C
Nucleate boil

AXIAL NODE	LIQUID (VAPOR) TEMPERATURE (DEG. C)	CLAD SURFACE TEMPERATURE (DEG. C)	FUEL SURFACE TEMPERATURE (DEG. C)	FUEL CENTER TEMPERATURE (DEG. C)	MASS FLOW RATE (KG/S*M**2)	MODERATOR REGIME
1	32.0000	119.2542	173.9933	316.5068	185.00	LIQUID
2	34.4840	119.7516	174.4675	317.8899	185.00	NUCLEATE BOIL.
3	36.3857	120.1299	181.9502	343.9947	185.00	NUCLEATE BOIL.
4	38.5043	120.4452	188.5389	367.0274	185.00	NUCLEATE BOIL.
5	40.8133	120.7045	194.1991	386.8447	185.00	NUCLEATE BOIL.
6	43.2826	120.9142	198.9373	403.4532	185.00	NUCLEATE BOIL.
7	45.8853	121.0806	202.8013	417.0093	185.00	NUCLEATE BOIL.
8	48.5921	121.2033	205.7076	427.2119	185.00	NUCLEATE BOIL.
9	51.3749	121.2880	207.7450	434.3677	185.00	NUCLEATE BOIL.
10	54.2054	121.3345	208.8716	438.3258	185.00	NUCLEATE BOIL.
11	57.0563	121.3452	209.1316	439.2391	185.00	NUCLEATE BOIL.
12	59.8993	121.3184	208.4817	436.9557	185.00	NUCLEATE BOIL.
13	62.7060	121.2521	206.8781	431.3228	185.00	NUCLEATE BOIL.
14	65.4480	121.1504	204.4499	422.7962	185.00	NUCLEATE BOIL.
15	68.0986	121.0063	201.0652	410.9171	185.00	NUCLEATE BOIL.
16	70.6290	120.8207	196.8081	395.9878	185.00	NUCLEATE BOIL.
17	73.0112	120.5861	191.5880	377.6996	185.00	NUCLEATE BOIL.
18	75.2185	120.3032	185.5302	356.5045	185.00	NUCLEATE BOIL.
19	77.2219	119.9582	178.4963	331.9376	185.00	NUCLEATE BOIL.
20	78.9952	119.5442	170.5626	304.2928	185.00	NUCLEATE BOIL.
21	81.2667	119.0392	161.6237	273.2471	185.00	NUCLEATE BOIL.

PARET for 2MW using 119FE-maximum

Paret main output parameters for 119FE, flux trap, Ring reactor
Maximum channel Natural Convection
Power =2MW
Subchannel power 35294W PPF=1.7 APF=1.25
CPF=2.12 Qmax.=75.3W/cm2

Results:
Maximum exit temperature=87.6C;
Maximum clad temperature=122.6C
Maximum fuel center temperature=550C;
Nucleate boil

AXIAL NODE	LIQUID (VAPOR) TEMPERATURE (DEG. C)	CLAD SURFACE TEMPERATURE (DEG. C)	FUEL SURFACE TEMPERATURE (DEG. C)	FUEL CENTER TEMPERATURE (DEG. C)	MASS FLOW RATE (KG/S*M**2)	MODERATOR REGIME
1	32.0000	119.6941	193.5664	386.3688	220.00	LIQUID
2	34.8098	120.7096	194.3122	387.2408	220.00	NUCLEATE BOIL.
3	36.9605	121.1443	204.3035	422.2821	220.00	NUCLEATE BOIL.
4	39.3571	121.5065	213.1046	453.2033	220.00	NUCLEATE BOIL.
5	41.9685	121.8043	220.6677	479.8103	220.00	NUCLEATE BOIL.
6	44.7610	122.0452	227.0002	502.1104	220.00	NUCLEATE BOIL.
7	47.7045	122.2364	232.1653	520.3131	220.00	NUCLEATE BOIL.
8	50.7651	122.3773	236.0506	534.0134	220.00	NUCLEATE BOIL.
9	53.9115	122.4747	238.7747	543.6226	220.00	NUCLEATE BOIL.
10	57.1119	122.5281	240.2811	548.9377	220.00	NUCLEATE BOIL.
11	60.3345	122.5404	240.6287	550.1642	220.00	NUCLEATE BOIL.
12	63.5491	122.5097	239.7597	547.0979	220.00	NUCLEATE BOIL.
13	66.7206	122.4334	237.6157	539.5337	220.00	NUCLEATE BOIL.
14	69.8204	122.3167	234.3692	528.0838	220.00	NUCLEATE BOIL.
15	72.8152	122.1511	229.8445	512.1328	220.00	NUCLEATE BOIL.
16	75.6748	121.9379	224.1544	492.0865	220.00	NUCLEATE BOIL.
17	78.3662	121.6684	217.1785	467.5316	220.00	NUCLEATE BOIL.
18	80.8599	121.3433	209.0852	439.0761	220.00	NUCLEATE BOIL.
19	83.1232	120.9469	199.6911	406.0970	220.00	NUCLEATE BOIL.
20	85.1266	120.4714	189.1001	368.9911	220.00	NUCLEATE BOIL.
21	87.6916	119.8912	177.1749	327.3282	220.00	NUCLEATE BOIL.

PARET for 3MW using 119FE-maximum, natural convection

Paret main output parameters for 119FE, flux trap, Ring reactor, Maximum channel Natural Convection Power =3MW, Subchannel power 53941W PPF=1.7 APF=1.25 CPF=2.12 Qmax.=113.42W/cm2

<u>Results</u>

Maximum exit temperature=102.6C;
Maximum clad temperature=124.4C
Maximum fuel center temperature=765C; Nucleate boil
This core configuration cannot work at 3MW due high water exit temp.

AXIAL NODE	LIQUID(VAPOR) TEMPERATURE (DEG. C)	CLAD SURFACE TEMPERATURE (DEG. C)	FUEL SURFACE TEMPERATURE (DEG. C)	FUEL CENTER TEMPERATURE (DEG. C)	MASS FLOW RATE (KG/S*M**2)	MODERATOR REGIME
1	32.0000	121.3068	231.6154	520.8190	260.00	NUCLEATE BOIL.
2	35.5663	122.2544	232.6584	522.0514	260.00	NUCLEATE BOIL.
3	38.2951	122.7800	247.5188	574.4868	260.00	NUCLEATE BOIL.
4	41.3369	123.2179	260.6150	620.7632	260.00	NUCLEATE BOIL.
5	44.6491	123.5780	271.8730	660.5869	260.00	NUCLEATE BOIL.
6	48.1923	123.8692	281.3017	693.9669	260.00	NUCLEATE BOIL.
7	51.9254	124.1003	288.9937	721.2155	260.00	NUCLEATE BOIL.
8	55.8068	124.2707	294.7806	741.7247	260.00	NUCLEATE BOIL.
9	59.7963	124.3885	298.8384	756.1101	260.00	NUCLEATE BOIL.
10	63.8539	124.4530	301.0825	764.0674	260.00	NUCLEATE BOIL.
11	67.9381	124.4678	301.6003	765.9036	260.00	NUCLEATE BOIL.
12	72.0104	124.4307	300.3057	761.3130	260.00	NUCLEATE BOIL.
13	76.0294	124.3385	297.1119	749.9888	260.00	NUCLEATE BOIL.
14	79.9552	124.1973	292.2762	732.8480	260.00	NUCLEATE BOIL.
15	83.7472	123.9971	285.5373	708.9696	260.00	NUCLEATE BOIL.
16	87.3670	123.7394	277.0642	678.9623	260.00	NUCLEATE BOIL.
17	90.7740	123.4136	266.6788	642.2086	260.00	NUCLEATE BOIL.
18	93.9279	123.0206	254.6334	599.6198	260.00	NUCLEATE BOIL.
19	96.7926	122.5414	240.6577	550.2665	260.00	NUCLEATE BOIL.
20	99.3246	121.9665	224.9096	494.7461	260.00	NUCLEATE BOIL.
21	102.5691	121.2651	207.1906	432.4206	260.00	NUCLEATE BOIL.

PARET for 3MW using 119FE-maximum, forced flow

Paret main output parameters for 119FE, flux trap, Ring reactor
Maximum channel Forced Flow
Power =3MW, Flow rate= 200 l/s
Subchannel power 53941W PPF=1.7 APF=1.25 CPF=2.12
Qmax.=113.42W/cm2

Results
Maximum exit temperature=36.6C;
Maximum clad temperature=111.0C
Maximum fuel center temperature=747C; Liquid

AXIAL NODE	LIQUID (VAPOR) TEMPERATURE (DEG. C)	CLAD SURFACE TEMPERATURE (DEG. C)	FUEL SURFACE TEMPERATURE (DEG. C)	FUEL CENTER TEMPERATURE (DEG. C)	MASS FLOW RATE (KG/S*M**2)	MODERATOR REGIME
1	36.6163	76.5765	170.8851	418.0887	-4000.00	LIQUID
2	36.3847	83.2674	193.6713	483.0644	-4000.00	LIQUID
3	36.2073	89.2665	214.0053	540.9733	-4000.00	LIQUID
4	36.0096	94.5630	231.9602	592.1085	-4000.00	LIQUID
5	35.7940	99.1223	247.4174	636.1313	-4000.00	LIQUID
6	35.5632	102.9438	260.3763	673.0415	-4000.00	LIQUID
7	35.3199	106.0603	270.9536	703.1754	-4000.00	LIQUID
8	35.0667	108.3967	278.9067	725.8508	-4000.00	LIQUID
9	34.8063	110.0212	284.4712	741.7429	-4000.00	LIQUID
10	34.5413	110.8932	287.5227	750.5076	-4000.00	LIQUID
11	34.2742	111.0440	288.1765	752.4798	-4000.00	LIQUID
12	34.0077	110.4321	286.3071	747.3144	-4000.00	LIQUID
13	33.7445	109.0157	281.7891	734.6660	-4000.00	LIQUID
14	33.4872	106.8993	274.9782	715.5500	-4000.00	LIQUID
15	33.2384	103.9683	265.5085	688.9408	-4000.00	LIQUID
16	33.0007	100.2919	253.6167	655.5148	-4000.00	LIQUID
17	32.7768	95.7931	239.0583	614.5880	-4000.00	LIQUID
18	32.5693	90.5799	222.1928	567.1792	-4000.00	LIQUID
19	32.3807	84.5406	202.6568	512.2656	-4000.00	LIQUID
20	32.2139	77.7491	180.6922	450.5287	-4000.00	LIQUID
21	32.0000	70.0893	156.0149	381.2449	-4000.00	LIQUID

Conclusion

- The safety approaches that were implemented for RTP has ensured the prolong operations and safety of the reactor.
- The introduction of Ageing Management Programme has contributed very significantly towards to enhance the safe operation of the reactor and increase the efficiency of every system in RTP.
- The reactor instrumentation and control upgrading project that is expected to begin in 2012 will become the stepping stone for RTP to provide a continuous utilization in various field.
- The RTP upgrading work continues by taking into accounts on the expert recommendation and safety assessment of the reactor.
- The objective of increasing the human capability and capacity building in the sense of to develop expertises in Reactor Physics, Thermal Hydraulic, Instrumentation & Cont was achieved through the upgrading exercises

Last but not least..

- Highly appreciation to the person that contribute into this presentation material and work

THANK YOU

NUKLEAR MALAYSIA

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