LM3 Advanced PHWR Features

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Learning Outcomes

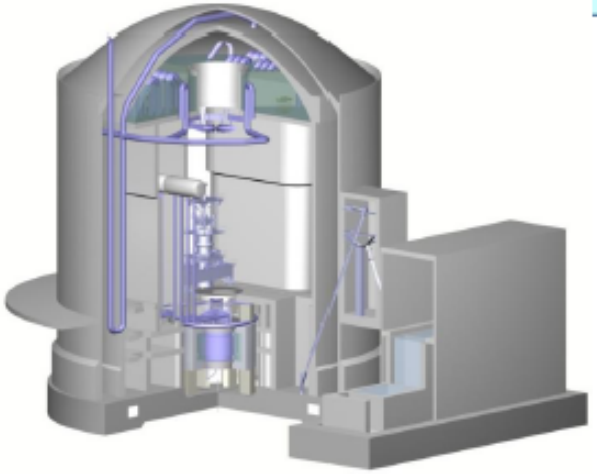
- Overview of Advanced PHWR Concepts
- Overview of Key Features of ACR-700

Advanced PHWR

- EC6 – Enhanced CANDU 6
  - Similar to Qinshan Design
  - Updated for latest Codes
- AFCR – Advanced Fuel CANDU Reactor
  - Improved EC6 for Thorium and DUPIC Fuels
- Indian APHWR
  - Higher power density
  - Thorium fuelled, Pu to FBR
- ACR-700 – Advanced CANDU Reactor
  - Significant cost reductions
  - Slightly higher thermal efficiency

Indian Advanced Heavy Water Reactor (AHR-Pu)

AHWR is a 300 MWe vertical pressure tube type, boiling light water cooled and heavy water moderated reactor using ^{233}U-Th MOX and Pu-Th MOX fuel.



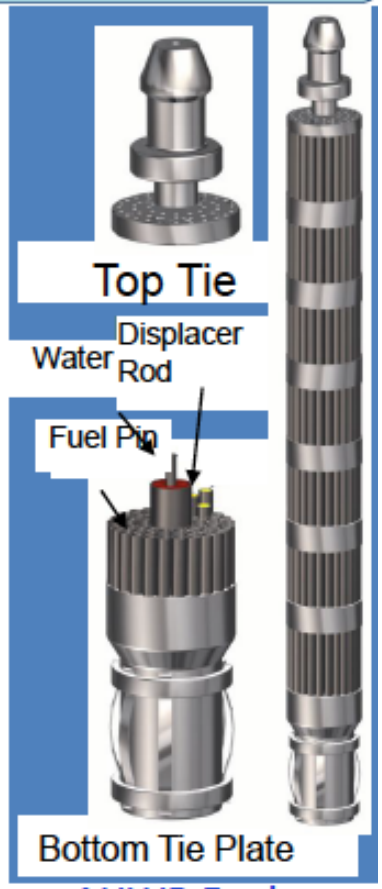
Design validation through extensive experimental programme.

Pre-licensing safety appraisal by AERB

Site selection in progress.

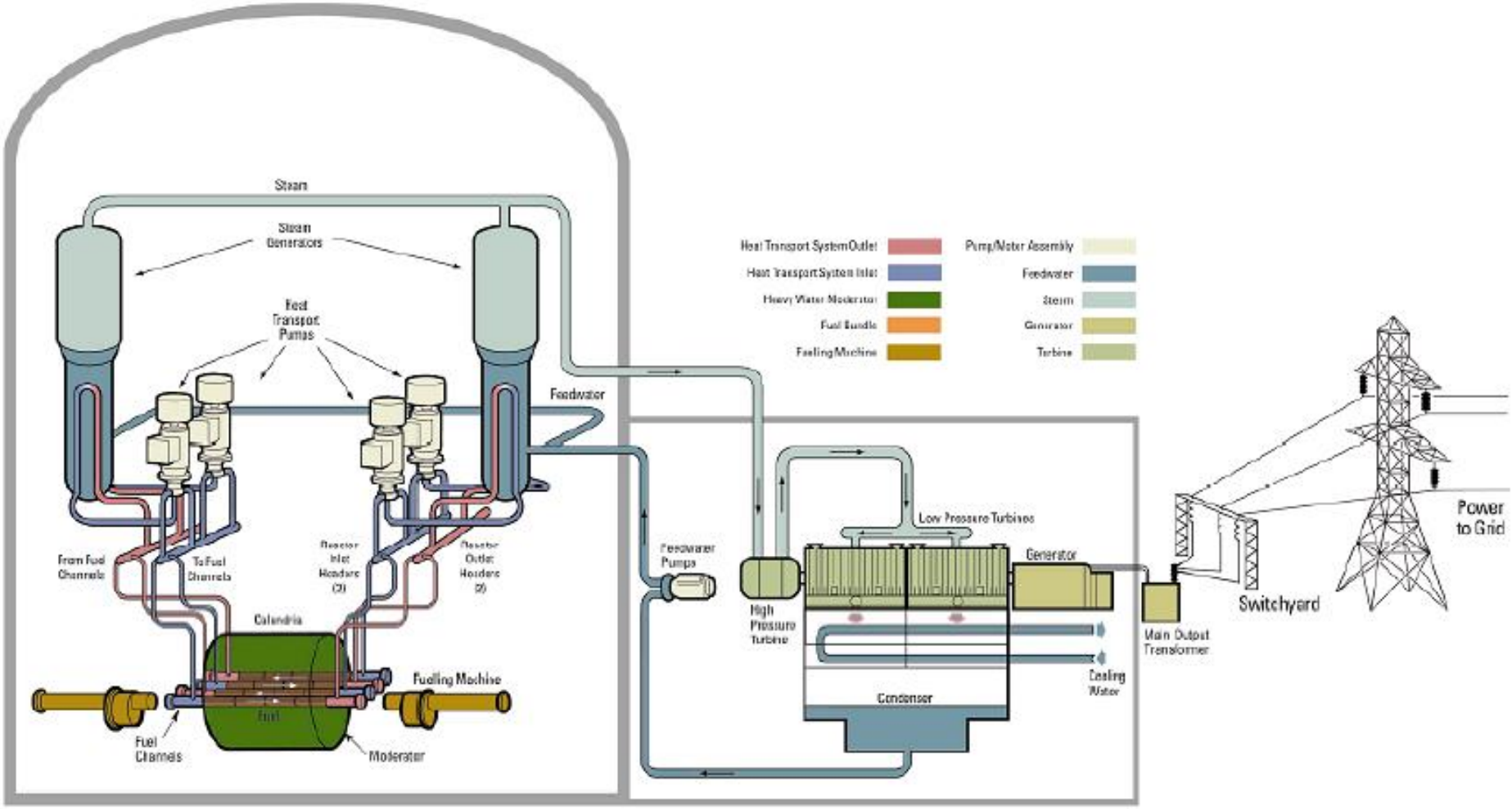
Major design objectives

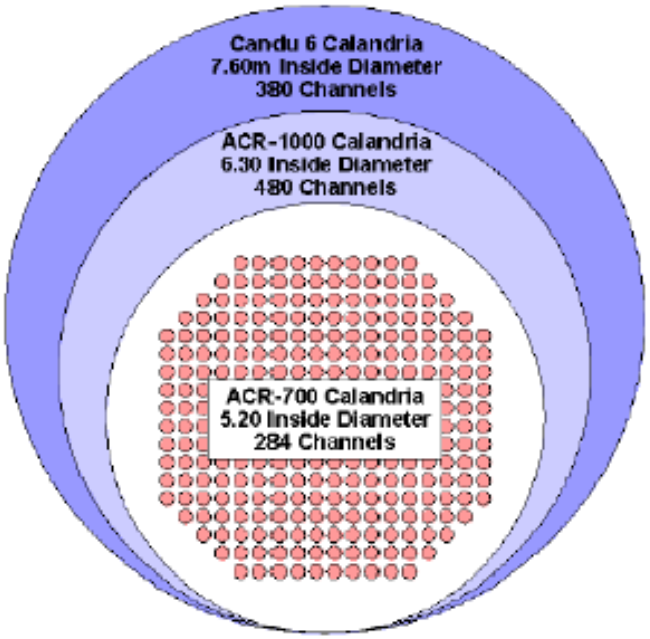
- 65% of power from Th
- Void Coefficient negative
- Several passive features
  - 10 days grace period
  - No radiological impact
  - Additional Passive shutdown system
- Design life of 100 years.
- Easily replaceable coolant channels.

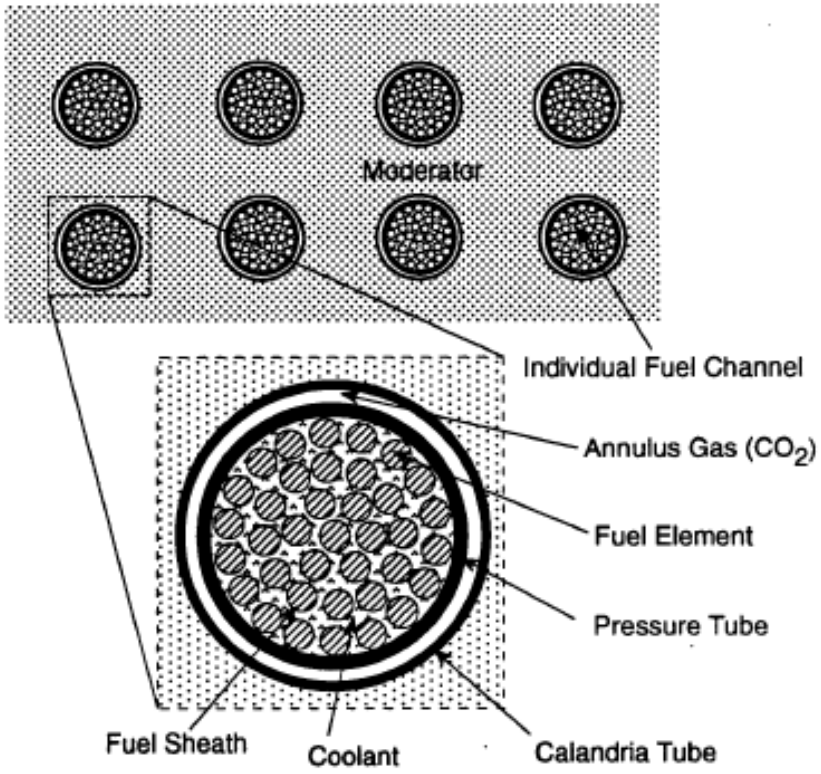


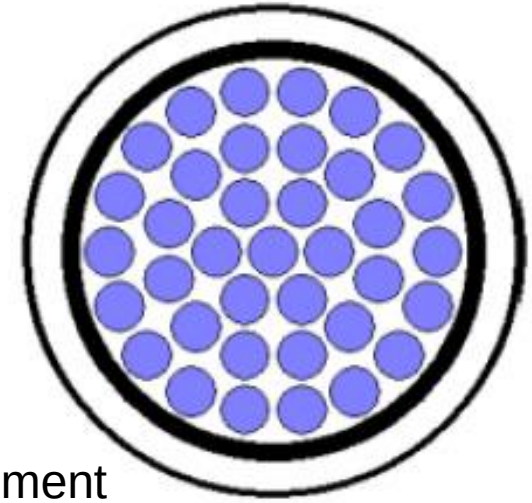
AHWR Fuel assembly

AHWR-Pu is a Technology demonstrator for the closed thorium fuel cycle

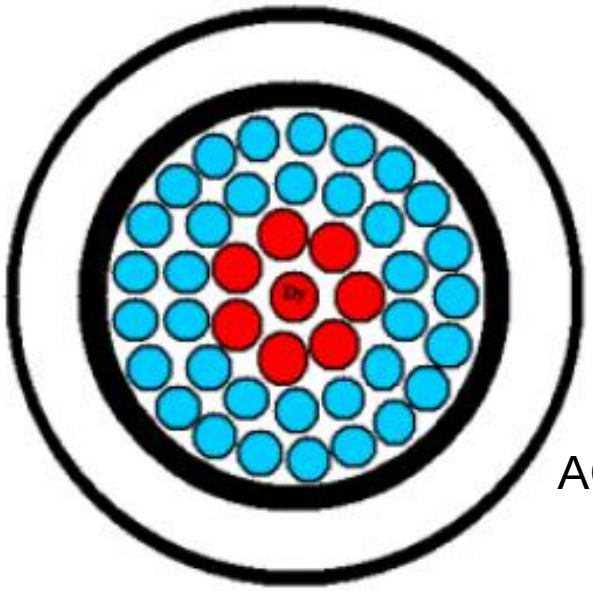

Steam
Steam Generators
Heat Transport Pumps
Feedwater
From Fuel Channels
To Fuel Channels
Reactor Inlet Headers (2)
Reactor Outlet Headers (2)
Calandria
Fuelling Machine
Fuel
Fuel Channels
Moderator
Heat Transport System Outlet
Heat Transport System Inlet
Heavy Water Moderator
Fuel Bundle
Fueling Machine
Pump/Motor Assembly
Feedwater
Steam
Generator
Turbine
Feedwater Pumps
Low Pressure Turbines
Generator
High Pressure Turbine
Condenser
Cooling Water
Main Output Transformer
Switchyard
Power to Grid


Candu 6 Calandria
7.60m Inside Diameter
380 Channels
ACR-1000 Calandria
6.30 Inside Diameter
480 Channels
ACR-700 Calandria
5.20 Inside Diameter
284 Channels


Moderator
Individual Fuel Channel
Annulus Gas (CO_2)
Fuel Element
Pressure Tube
Fuel Sheath
Coolant
Calandria Tube



EC6 37 Element



ACR 43 Element

DATA	CANDU 6	ACR-700
Reactor		
Type	PTR	PTR
Thermal Output to Steam Generators [MWth]	2064	2034
Coolant	Pressurized Heavy Water	Pressurized Light water
Moderator	Heavy Water	Heavy water
Calandria diameter [m]	7.6	5.2
Fuel channel	Horizontal Zr 2.5wt% Nb alloy with modified 403 SS end fittings	Horizontal Zr 2.5wt% Nb alloy with modified 403 SS end fittings
Number of fuel channels	380	292
Lattice pitch [mm]	286	220
Reflector thickness [mm]	655	480
Fuel		
Fuel	Sintered pellets of Natural UO_2	Sintered pellets of slightly enriched UO_2 & Natural UO_2 in central element
Enrichment level	0.71 wt% ^{235}U	Average 2.1 wt% U-235 in 42 elements, central element NU with Dysprosium
Fuel burn-up [MWd/te U]	7,500	20,500
Fuel bundle assembly	37 element	43 element CANFLEX
Length of bundle [mm]	495.3	495.3
Outside diameter (maximum) [mm]	102.7	103
Bundle weight [kg]	24.1 (includes 19.2 kg U)	22.7 (includes 18 kg U)
Bundles per fuel channel	12	12
Heavy Water		
Moderator Systems [Mg D_2O]	265	126
Heat Transport Systems [Mg D_2O]	192	0
Reserve [Mg D_2O]	9	4
Total [Mg D_2O]	466	130

CANDU Type Reactor

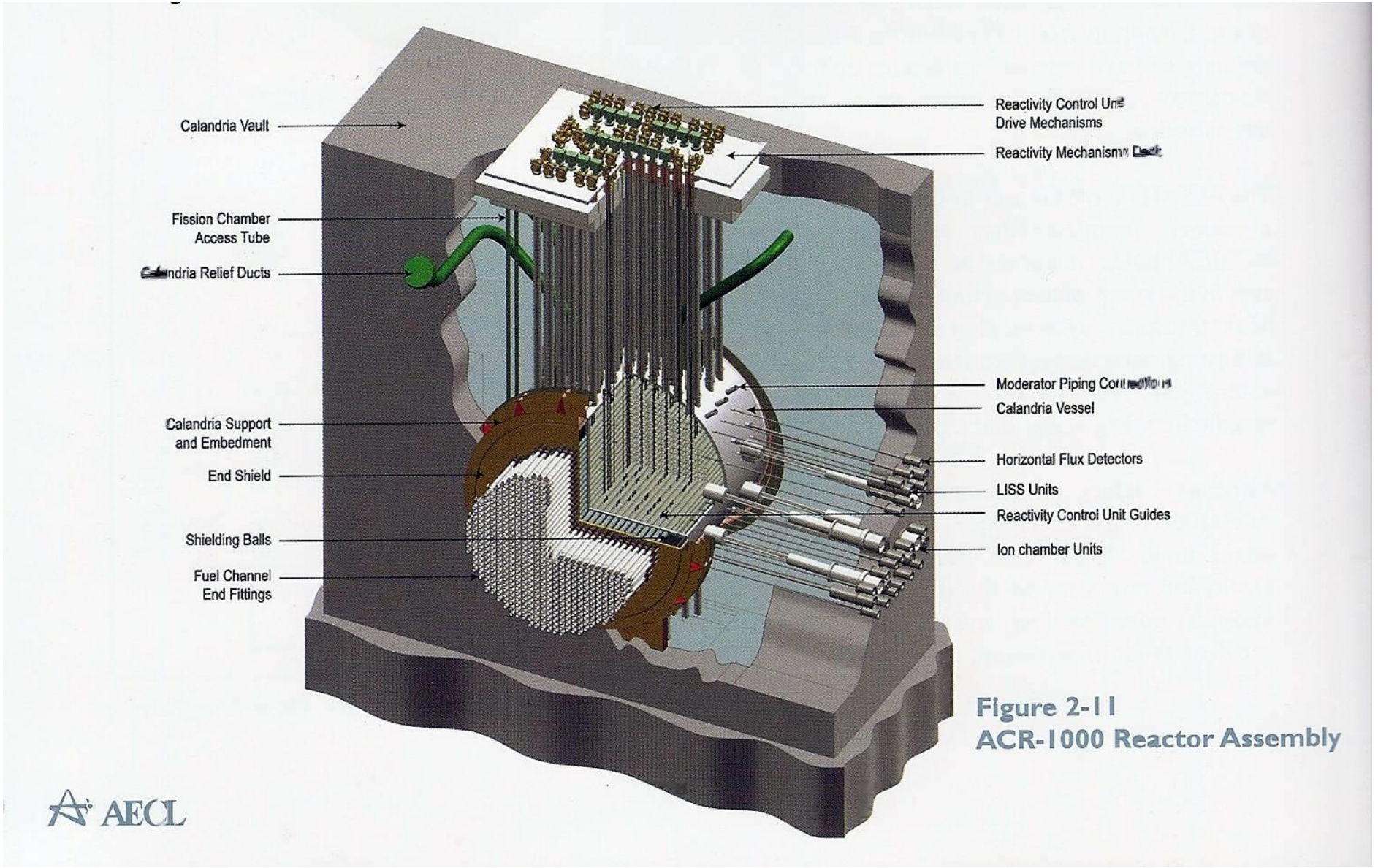
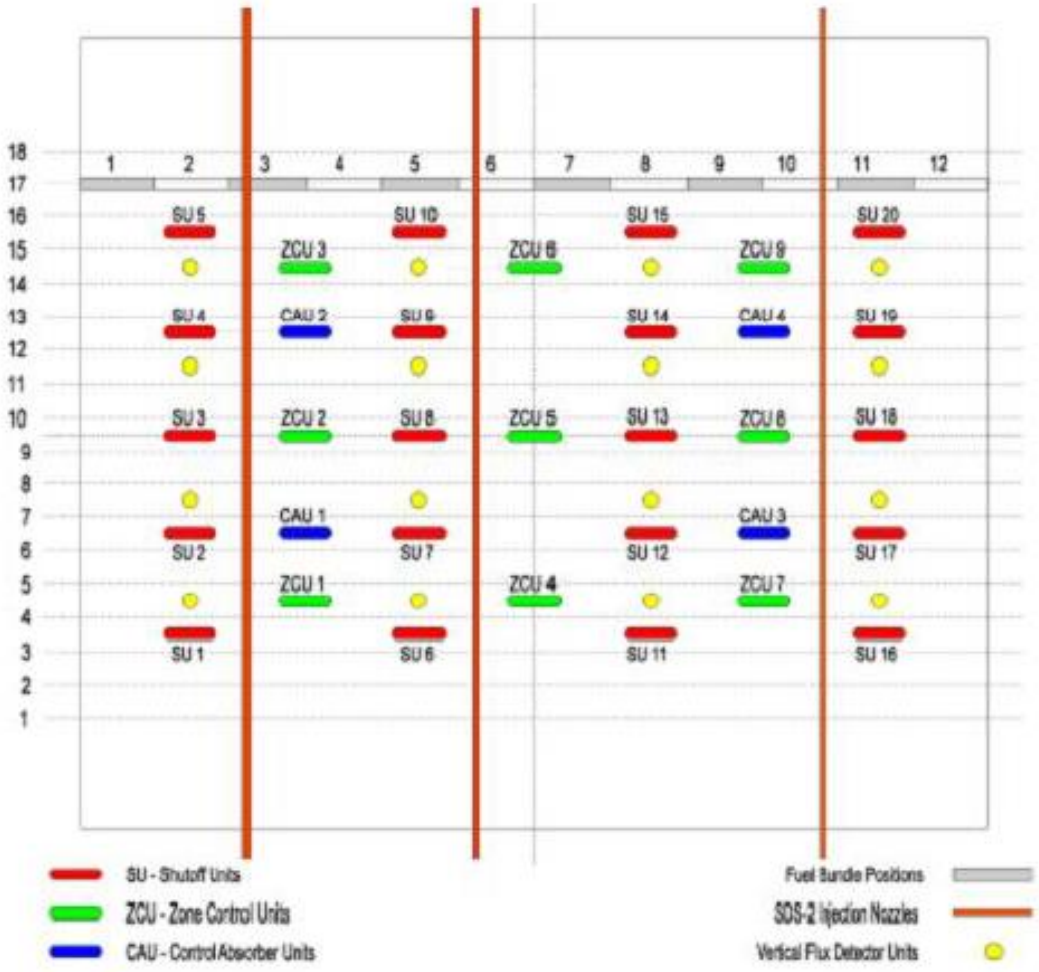
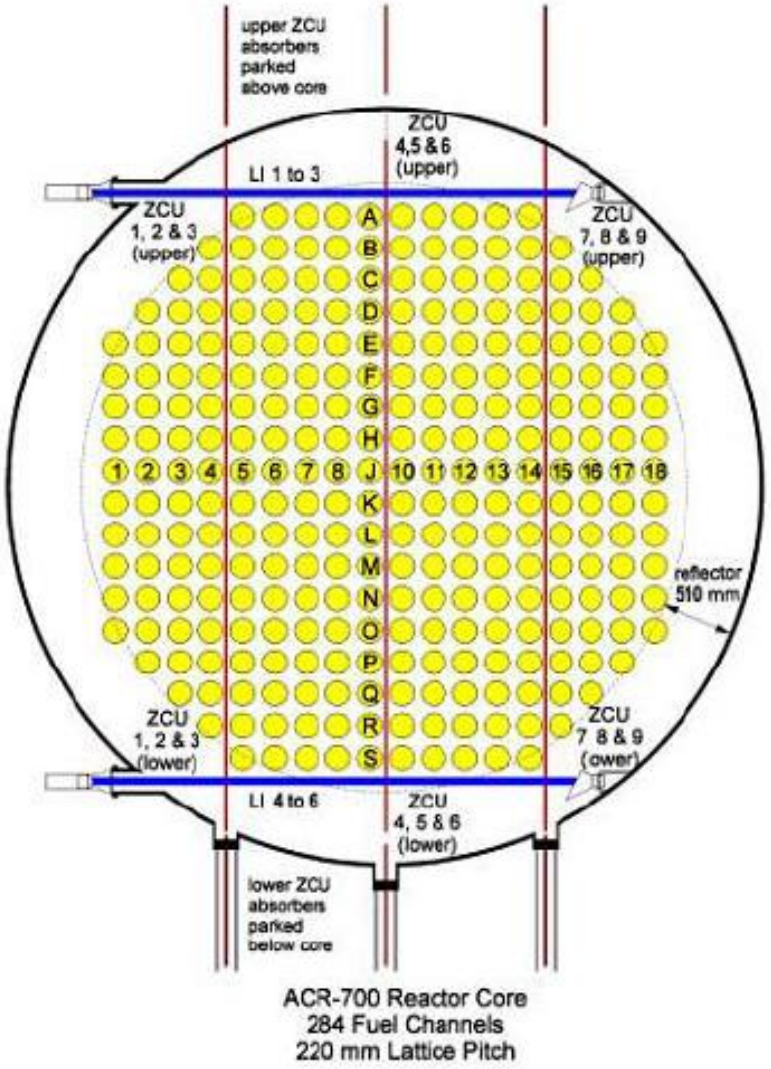


Figure 2-11
ACR-1000 Reactor Assembly





ACR-700 Reactor Core
284 Fuel Channels
220 mm Lattice Pitch

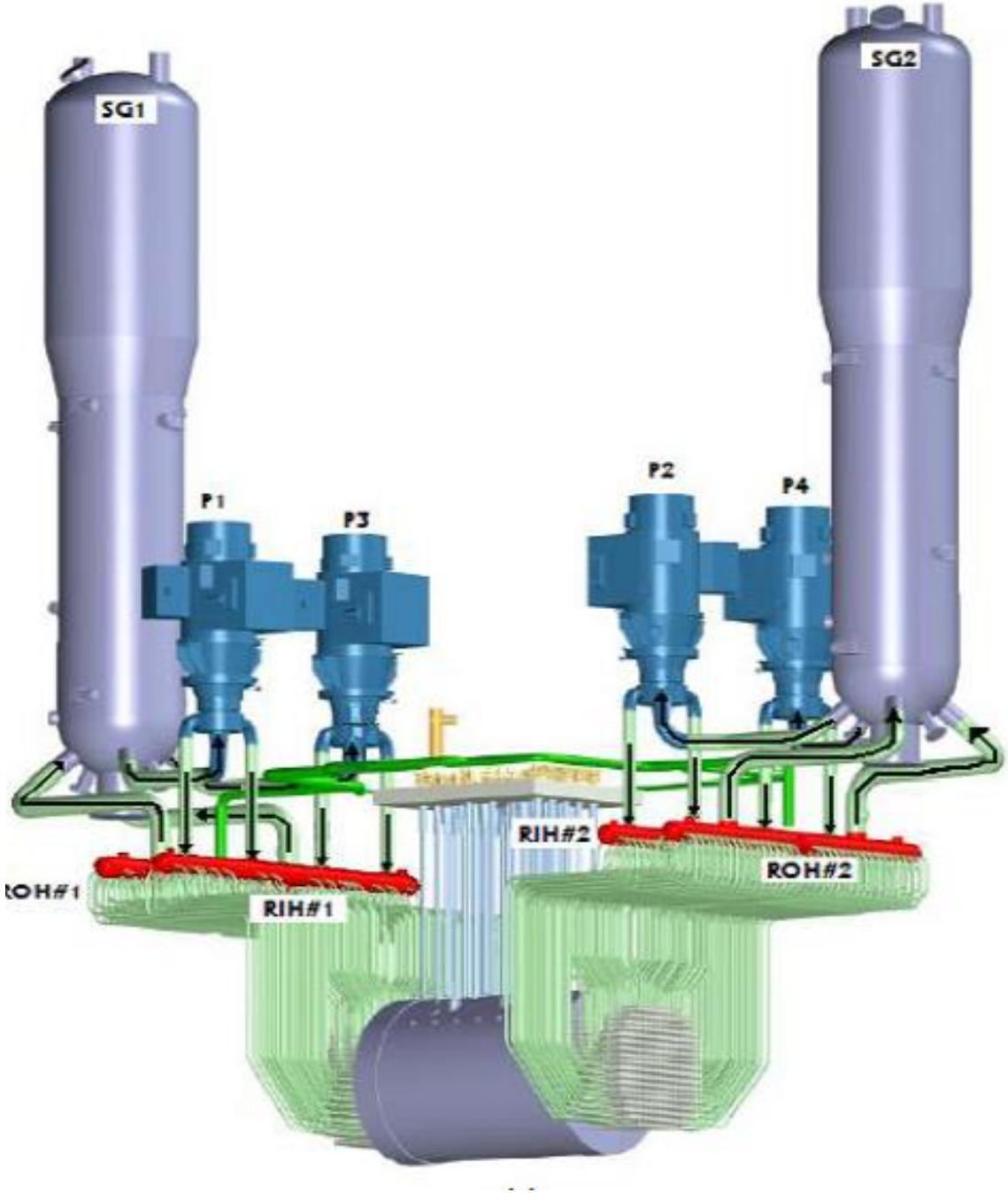
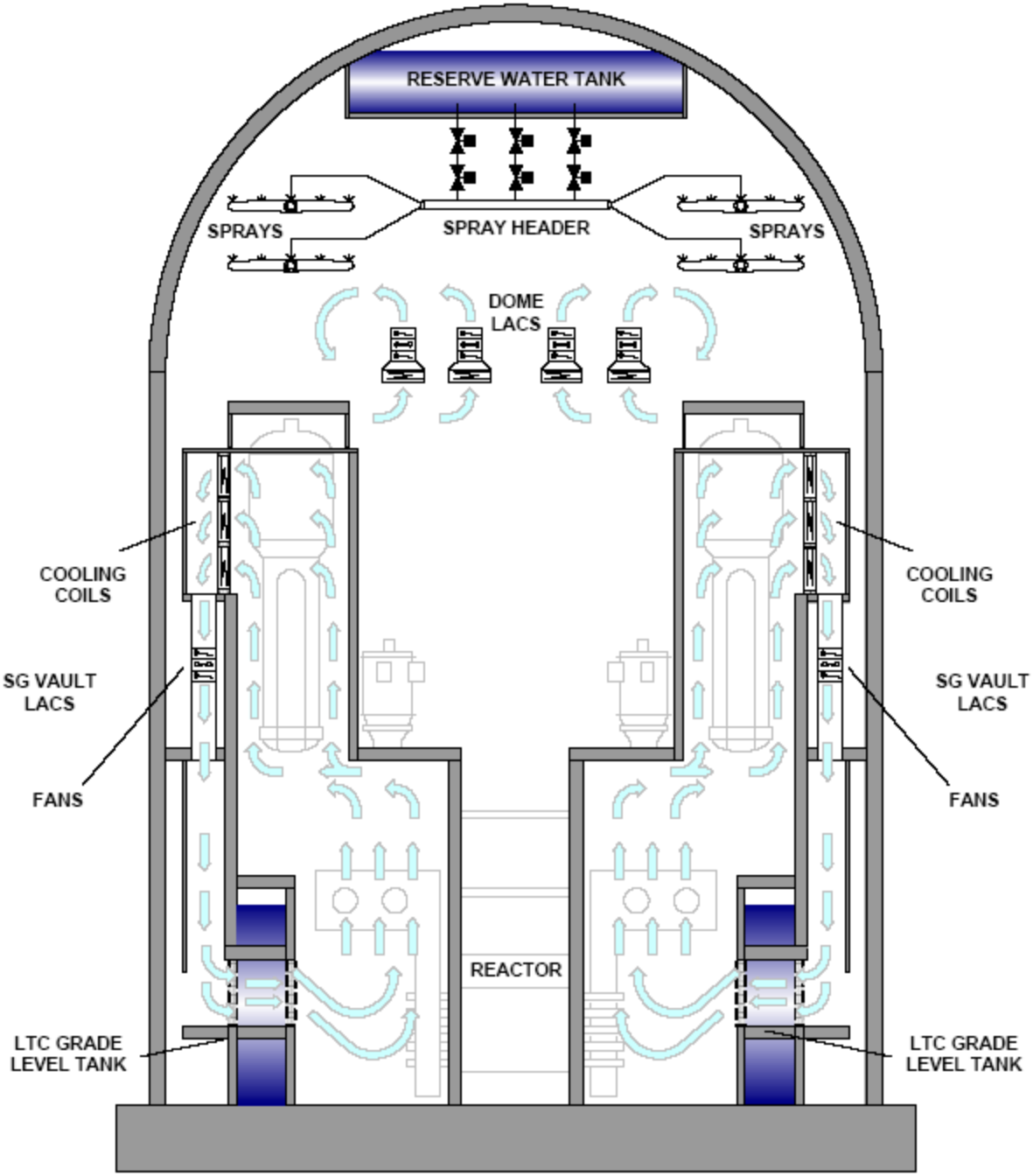
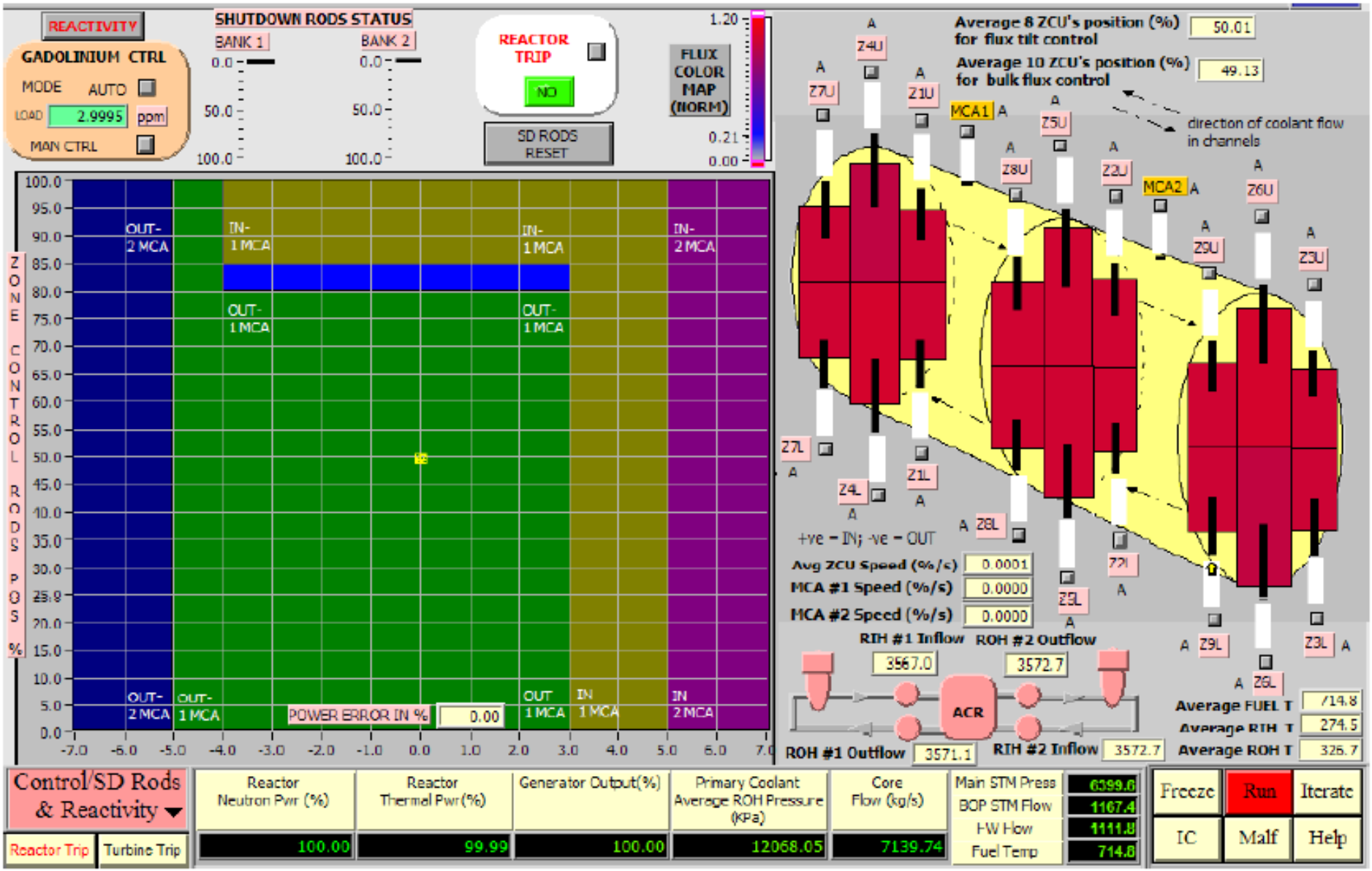

SG1
SG2
P1
P3
P2
P4
ROH#1
RIH#1
RIH#2
ROH#2

Figure 3 Containment Cooling System




REACTIVITY
GADOLINIUM CTRL
MODE AUTO
LOAD 2.9995 ppm
MAN CTRL
SHUTDOWN RODS STATUS
BANK 1
BANK 2
0.0
50.0
100.0
REACTOR TRIP
NO
SD RODS RESET
FLUX COLOR MAP (NORM)
1.20
0.21
0.00
ZONE CONTROL RODS POS %
OUT- 2 MCA
IN- 1 MCA
OUT- 1 MCA
IN- 2 MCA
POWER ERROR IN % 0.00
Average 8 ZCU's position (%) for flux tilt control 50.01
Average 10 ZCU's position (%) for bulk flux control 49.13
direction of coolant flow in channels
MCA1
MCA2
+ve = IN; -ve = OUT
Avg ZCU Speed (%/s) 0.0001
MCA #1 Speed (%/s) 0.0000
MCA #2 Speed (%/s) 0.0000
RIH #1 Inflow 3567.0
ROH #2 Outflow 3572.7
ACR
ROH #1 Outflow 3571.1
RIH #2 Inflow 3572.7
Average FUEL T 714.8
Average RIH T 274.5
Average ROH T 326.7
Control/SD Rods & Reactivity
Reactor Trip
Turbine Trip
Reactor Neutron Pwr (%) 100.00
Reactor Thermal Pwr(%) 99.99
Generator Output(%) 100.00
Primary Coolant Average ROH Pressure (kPa) 12068.05
Core Flow (kg/s) 7139.74
Main STM Press 6399.6
BOP STM Flow 1167.4
FW Flow 1111.8
Fuel Temp 714.8
Freeze
Run
Iterate
IC
Malf
Help

Next Steps

ACR-700 Simulator

– Practise power maneuvers for Normal Operation Conditions