Oakridge Nuclear Reactor Manual

RBMK-1500

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Hi comrade, Your job will be operating The RBMK-1500.

The **RBMK-1500** (Russian: *Reaktor Bolshoy Moshchnosti Kanalnyy*, meaning "High Power Channel-type Reactor") is a Soviet-designed **nuclear reactor** used mainly in power plants for electricity generation. The number **1500** refers to its electrical output of **1,500 megawatts (MW)**, making it one of the most powerful variants in the RBMK series.

The RBMK-1500 is a **thermal neutron reactor**, meaning it uses slow (thermal) neutrons to sustain the nuclear chain reaction. It is **moderated by graphite**, which slows down neutrons, and **cooled by light (ordinary) water** circulating through pressure tubes. Unlike most reactors, the RBMK's core is made up of many individual vertical pressure tubes, each containing fuel rods, which allows the reactor to be **refueled while still in operation** — a significant operational advantage.

About RBMK-1500

1. Steam - Water - Hotwell - Deaerator - Core

   Steam from the reactor travels through the stream lines, then goes through the Bypass and Condensed into Water.

   That water then is getting stored in the Hotwell

   Then condensate pumps flow water from the hotwell into the deaerator, which gets transferred by the feedwater pumps back into the reactor

2. Reactor Core Rod Display

   Displays which control rods are inserted/withdrawn and at which percentages, 100% being fully inserted and 0% being fully withdrawn.

   The more withdrawn the control rods are the more power the reactor core creates at the cost of heat which is necessary to make power.

3. Reactor Core Power Index

   Xenon-135 and Iodine-135 Both reduce your overall reactor power and they also both decay/build up over time.

   Reactor Power MW and Reactor Power % are the same, 4800 MW at 100%.

   Neutron flux is used at low power and startup

4. Reactor Control

4.1 Reciriculation Drain 1-2

Used to drain water from the reactor core in case of too high pressure or water level

4.2 Auto Control Rods + Auto Set Point

Auto Control Rods system tries to stabilize the reactor power output at a stable output set by the operator.

It does this using the Automatic Control Rods that cannot be used otherwise, those control rods are predefined and there is no other use for them.

There are not that many automatic control rods so the core can still give too much of a power output when too many control rods are withdrawn.

4.3 Rod Selector

This is the rod selector panel, with this panel you can withdraw or insert control rods using the gray buttons.

The blue color coding for the Control Rods means those are the Shutdown Control Rods.

Red color coding for the Control Rods mean those are the Automatic Control Rods.

4.4 AZ-5 + Mode Selector

AZ-5 (A3-5) - Manual SCRAM button, used to almost instantly insert all control rods at a rapid pace to prevent reactor meltdown due to high temperatures.

Control Rods use graphite tips that are used to slow down neutrons that create reactor fission which generates power, therefore AZ-5 might temporarily spike the reactor power up.

Modes are used to indicate to the computers at what stage your reactor is at, this might disable/enable some functions.

MODE 0 - Shutdown/Pre-Startup.
MODE 1 - Startup.
MODE 2 - Operation.

4.5 Auto Scram

Automatic SCRAM system, can be disabled using the Bypass Key, more information about SCRAM in the 4.4 header (AZ-5).

4.6 Offline Core Cooling

Offline Core Cooling System is used to cool down the reactor whilst it is Offline/Shutdown.

4.6 Isolation Valves/MSIV

Allows steam to be transferred from the reactor to the steam lines.

4.7 Core Heat Distribution Display

Displays the heat distribution of the reactors core, the more spread out and even the reactor core the better it is and creates less issues.

Reactors Core should not Exceed 1600°F as being even close to this heat threshold might destroy/damage the core.

As well as uneven heat distribution might create problems such as:

Localized Overheating.

Hot Spots might damage fuel rods, deform fuel channels, rupture pressure tubes.

May lead to increase of radioactive material inside the reactor.

Power Excursion (Sudden Power Spike).

Steam bubbles (Positive Void Coefficency) forming in the coolant increase reactivity.

More Steam Forms → Reactivity Increases → Even More Heat → Runaway Reaction Risk

Loss Of Control.

Steam Explosion or Core Rupture.

Radiation Release.

5. Pressure Relief Valves

Reactor Vessel - Relieves pressure from the reactor core.

Steam Line A-B - Relieves pressure from the steam lines.

Hotwell Drain - Drains water from the Hotwell area.

6. Emergency Core Cooling System (ECCS)

Enabling "nitrogen value" begins filling the ECCS pressurized tank with Nitrogen, Nitrogen is a great neutron absorber.

Relief Valve empties the ECCS pressurized tank.

Enabling "injection valve" releases both the pressurized tank and the ECCS water tank into the reactor core.

7. Condensate pumps

Condensate pumps move water from the Hotwell into the deaerator where they can go back into the feedwater and into the reactor core.

8. Service/Makeup water

8.1 Makeup Pump

Makeup Pump (Next to "Service Pump") allows normal water to be used in the reactor core from storage tanks.

8.2 Service Pump

Service Pump pumps normal water from the river to the storage water tanks.

8.3 CND Feed Valve

CND Feed Valve A/B allow to refill the Hotwell A/B (Depends on the CND feed valve used), This requires Makeup Pump!

8.4 ECCS Feed Valve

ECCS Feed Valve allows to refill the ECCS Water Tank, Also requires Makeup Pump.

8.5 Emergency Pure CND

Left Switch switches from normal water tanks to Emergency Water Tanks in case of a problem/issue.

8.6 Emergency CND - Service

Allows water to be used from the Emergency Water Tanks.

9. Recirculation Pumps

Recirculation Pumps/System recirculate water around the reactor to cool it down, the more recirculation pumps online and at a higher speed the more Feedwater is required.

10. Feedwater

Feeds pumps water into the tank.

Feed Auto limiter valve controls how much water gets into the reactor or keeps valve open at a desired percentage. 000% for fully automatic control.

11. Deaerators

Deaerators remove dissolved gasses before entering the reactor.

Steam Inlet Valve decreases/increases deaerator temperature.

Relief Valve decreases/increases deaerator pressure.

A-B Bleed Valve equalizes the water level between both deaerators.

Overflow Valve Drains the water if the water level gets too high.

12. Condenser Cooling

Each side is for each turbine, Steam flows through bypass/turbine then gets condensed into water.

Steam Heats up the condensers therefore it is needed to enable pumps to cool it.

If the steam heats up too much you will get High Outlet Pressure Error Code, this will gradually increase turbine vibration which may make it trip.

Error Codes

1. Mode Conflict

   Generally indicates whenever you have things that do not fit the current mode, this in most occurrences can be ignored safely.

2. Recirc Loop Dry/Insufficient Recirc

   This indicates that you have no or not high enough number of Recirculating pumps running.

3. Feed Loop Dry/Insufficient Feed

   This indicates that you have no or not high enough number of Feedwater pumps running.

   This does not matter if the reactor is at low power or shut down whenever you're not boiling water.

4. Coolant Loop Dry A/B

   Error triggers when you do not have any coolant pumps running/enabled.

5. Turning Gear Engaged

   Error triggers when you open Steam inlet while turning gear is engaged.

   When you want to open Steam Inlet valve call our engineering team at 106 to tell them you are ready to disengage turning gear A/B (This depends on which turbine Panel you want to open steam inlet valve at).

6. Core Heat Imbalance

Generally indicates that one or more of your control rods are heating way more than the rest, this is also indicated by the flashing light at the Core Heat Distribution Display.

To Fix this enable more recirculating pumps and feedwater, this will cool down the reactor.

7. Core Water Low

This error indicates that the water level is too low for the reactor core.

Increase feedwater and condensate pumps to increase water lever.

8. Circuit Over-pressure

Indicates High Pressure in the steam lines.

Increase bypass on Turbine A or both if A-B bleed is enabled.

9. Deaerator A/B Water level low

Indicates low water levels in the Deaerators, this can be a significant issue for the reactor possibly exploding it.

Increase condensate pumps or enable more of them.

10. Deaerator A/B Water temp low

    Indicates low water temperatures in the Deaerators.

    Increase Steam Inlet Valve.

11. Deaerator A/B Water pressure low

    Indicates low water pressure in the Deaerators.

    Decrease Relief Valves.

12. Pump Cavitation

    Indicates deaerator water levels are too low for the feedwater to use, this causes feedwater pumps to trip.

    Increase Deaerator Water levels.

13. Low Hotwell Level

    Indicates low water levels in a Hotwell.

    Turn on makeup pumps and one of the CND Feed Valves A/B (Depends which Hotwell level is insufficient).

14. High outlet pressure

    Indicates that either Condenser A/B temperatures are too high, this can increase turbine vibration which can cause the turbine to trip.

    Increase condenser coolant pumps.

15. Transformer Load

Indicates that the transformer load goes over 95% or 36 MW.

To fix this disable any unnecessary pumps and reduce power usage.

16. Heat Exchanger Loop Dry

Indicates OCC Circ Pumps are disabled while OCC is enabled.

Enable OCC Circ Pumps when reactor is shut down or at pre-startup stage.

Disable OCC when reactor is in operation.

Pre-Startup Procedure

When you first enter the Reactor Core's Building Control Room, Do NOT forget to take your "Bypass Key". It is located on the right side of the opening door, hidden inside the Orange box.

Nuclear Generator Pre-Startup Procedure

Now do all of these things in absolute order and precision to *NOT* stall or destroy the reactor core:

- Turn on Condenser Coolant A1 + A2 on Speed 2 (Yellow)
- On "Steam Turbine Generator A" panel turn on A-B bleed and open bypass to 100%

  To do that you will need to:
  - Turn on Turbine A-B Bleed. (Under Bypass Valve)
  - Turn on the Bypass Valve.
  - Turn on the Increase Flow "Loose" switch.
  - Wait till the "Turbine Bypass" On the right side will show 100 (%).

- Turn off deaerator A-B bleed (Switch on the wall).
- On the deaerator A open "Steam inlet valve" to 25%.
- On the deaerator A open "Relief valve" to 50%.
- Activate feed limiter valve (Separator Feedwater pumps).
- Recirc Pump A1 to Speed 2 (Yellow).
- Recirc Pump A2 to Speed 2 (Yellow).
- Activate *ALL* isolation valves.
- Activate nitrogen valve to reach 1500 PSI (ECCS) DO NOT EXCEED 1500 PSI.
- Set Hotwell Level to 35.
- Enable Hotwell auto valve control.
- Enable Breaker 18M-G1.

- Activate G1<64A primer. (DO NOT CLICK THE BUTTON)
- Turn off Auto G1 offload.
- Activate Breaker 64B-M (Switch on the wall)

This is the end of the Pre-Startup generator core set procedure, At this point you should be ready to start the startup procedure which we will document shortly.

Startup Procedure

Firstly go up to the main control Panel and enter Mode 1.

- Turn off Heat Exchange Valve A.
- Turn off Heat Exchange Valve B.
- Turn off OCC Circuit Pump 1.
- Turn off OCC Circuit Pump 2.
- Activate Shutdown Control Rods.
- Activate Auto Control Rods.
- Set Auto Control to 1500 MW.
- Wait for the Shutdown Control Rods to Reach 0%.
- Wait for the Auto Control Rods to Reach 0%.

To start generating Power go up to the Control Rods Panel, You should see high amount of GREY buttons, those are the Control Rods you can Remove or/and Insert.

Firstly Select the Outer Control Rods.

Remove the First section of rods down to 0%.

Now Select the Second section of Control Rods.

Start removing the Second section of rods.

Remember to not exceed 2100 MW!

WARNING: Near the start of the Second Section rods removing or the end of removing first section you will hear an alarm, this means that the Reactor is making power, you can safely ignore/acknowledge the error alarm.

READ NEXT PAGE IMMEDIATELY.

But from this moment you have to pay attention to the water temperature gauge, when it reaches 200-256 Enable Mode 2.

Proceed to remove the Second Section of Control rods whilst still being cautious about the Water Temperature Gauge.

When Mode 2 is Enabled:

- Activate condenser pump 1.
- Activate feedwater pump 1 to speed 2 (Yellow).

Set Auto Control Rods to 2100 MW

if the Second Section or Control Rods are still not fully removed you can fully remove them from the reactor core to raise the power to 2100 MW.

If the power exceeds 2100MW You shall not worry, the Auto Control Rods will bring it down.

When the power is at 2100 Call (Plant Operations)
Our Engineering team (106) to tell them they have a green light to disengage turning gear A.

When you called the Our Engineering team and already disengaged turning gear A Proceed with the following:

- Close Bypass Valve to 20%.
- Open Main Valve to 30-40 (%).

Gauges should be visible on the right side of
"Steam Turbine Generator A" under "Turbine Bypass".

When Turbine A's Revolutions Per Second (RPMs) reach 1600-1700 (RPMs), Stabilize the flow at around 0.

Read Next Page Immediately

to do so do the following:

- Decrease the flow in Turbine Valve using the Loose and Precise Switches.
- You will see the Synchroscope spinning, using the flow make it spin slower.
- Make sure the flow is at around 0 at All times.
- At around 1780-1810 RPMs you should hear a beep from the Synchroscope click the green "SYNC" button on the left, the Synchroscope should also be in the Red zone.

If not Successfully Synced:

- wait for turbine RPM to be less than 600 (RPMs < 600)
- Return to runup section and repeat trying to sync the turbine again.

If Successfully Synced:

When Turbine is in Sync, Open Main Valve to 100% and close the bypass down to 0%.

After Opening Main Valve proceed with the following:

Enable Breaker 64A-M

After Enabling Breaker 64A-M call our Engineer team to Reset the breakers.

Under the "Separator Feedwater Pumps" you should see the Green Light above "Breaker 2"

Now proceed with the following on both deaerators sets:

- Set the Inlet Valve to 45%.
- Set the Valve Relief to 25%.
- Activate A-B Bleed (Switch on the wall).
- Activate Condenser Pump 2.
- Activate Feedwater Pump 2 to Speed 1 (Red).

Now you can safely go up to the main control rods panel and set the Automatic Control Rods to "3000" MW.

After doing so proceed with this procedure:

- Set Recirc Pump A1 to Speed 3 (Green).
- Set Recirc Pump A2 to Speed 3 (Green).
- Activate Recirc B1 to Speed 1 (Red).
- Activate Recirc B2 to Speed 1 (Red).
- Set Condenser Coolant A1 to Speed 3 (Green).
- Set Condenser Coolant A2 to Speed 3 (Green).

If Automatic Control Rod System cannot up the Reactor Power to 3000 MW, You should be safe to Raise the rods manually. Remember to raise them symmetrically and in the same time to reduce uneven heat distribution A.K.A: (heat imbalance).

If you trigger Heat Imbalance alarm, *MAKE SURE* that control rods *DO NOT* exceed 1600°F, If needed you are allowed to enable more reciric pumps.

When the power reaches 3000 MW, Call our Engineering team again to give them a green light about disengaging Turning gear B.

When the call is done:

- Enable Condenser Coolant B1 to Speed 3 (Green).
- Enable Condenser Coolant B2 to Speed 3 (Green).

Now Start Running our Turbine B, this is the same procedure as the Turbine A after enabling Mode 2 (See page 3).

When Turbine B is in sync:

- Enable Condenser 2 to Speed 3 (Green).
- Enable Feedwater 2 to Speed 3 (Green).
- Set Recirc Pump B1 to Speed 3 (Green).
- Set Recirc Pump B2 to Speed 3 (Green).
- Activate Condenser Coolant A3 to Speed 1 (Red).
- Activate Condenser Coolant B3 to Speed 1 (Red).

You should now be safe to raise the Automatic Control Rods Power to 4000 MW, and raise any other control rods that aren't fully raised.

If you still aren't at 4000 MW, Raise more Control Rods till you reach 4000 MW.

Again make sure the Control Rods do *NOT* exceed 1600°F Or Remotely close to that, If needed Activate more Recirc Pumps.

Once the power reaches 4000 MW, Call Our Grid Team (7782) to tell them you can go Online.

Shortly after that call you made, you should get another call about the Demand if it rises or lowers, this depends on the Time of day.

Do NOT Forget to Enable Auto Bypass on Both Generators.

In the Information center on the right side of the desk you should see "Automatic Bypass Setpoint [...]", There you should enter Half of your Grid Demand into both of they keypads.

Reactor Variability

Low Power Range [4000 MW – 4200 MW]
- Recirculation Pumps C1.C2 to Speed 1 (Red).

Medium Power Range [4200MW – 4500 MW]
- Recirculation Pumps C1.C2 to Speed 2 (Yellow).
- Condenser Coolant Pump A3.B3 to Speed 2 (Yellow).
- Condensate / Feedwater 1 to Speed 3 (Green).

High Power Range [4500 MW – 4800 MW]
- Recirculation Pumps C1.C2 to Speed 3 (Green).
- Condenser Coolant Pump A3.B3 to Speed 3 (Green).

- The deaerator significantly contributes to the amount of steam the generator can produce: adjust the inlet and outlet valves accordingly.

Emergency Procedures

1. **High RPV Pressure**
   - Open relief valves to release pressure.
   - Insert control rods to reduce reactor power.
   - Increase turbine/bypass steam flow to lower pressure.
   - Monitor RPV pressure instruments.
   - Press AZ-5 if pressure remains high or rises.

2. High RPV Temperature
   - Verify recirculation pumps are running.
   - Increase recirculation flow
   - Insert control rods to lower thermal power if the recirc pumps cannot provide sufficient core flow.
   - Monitor temperature gauges constantly and ensure there's no fuel damage.
   - Press AZ-5 if a critical temperature is reached.

3. High Water Level
   - Reduce feedwater flow.
   - Close the ECCS injection valve if open
   - Open recirculation drain valves to lower water level if necessary.
   - Monitor water level indicators.

4. Low Water Level
   - Do NOT increase reactor power.
   - Increase feedwater injection.
   - Monitor water levels closely.
   - Be ready to activate ECCS.
   - Activate ECCS if feedwater pumps are ineffective.
   - Decrease power if necessary.
   - Press AZ-5 if levels continue to drop.

5. Very Low Water Level
   - Press AZ-5 if necessary. (recommended)
   - Activate ECCS to raise water level.
   - Ensure feedwater pumps are running.
   - Monitor RPV temperature and pressure.

6. Fuel Channel Leak
   - SCRAM
   - Start every recirculation pump at maximum speed.
   - Open any necessary relief valves if required.
   - Start OCC pumps and open heat exchanger valves.
   - Monitor core parameters.
   - If you successfully shutdown the reactor, call engineering to fix core damage.

     PS: Don't panic or you will definitely blow up your reactor.

7. Loss Of Offsite Power (LOOP)
   - Start EDG 1 or 2 (Emergency Diesel Generator).
   - Ensure core cooling systems, relief valves and ECCS are ready and functional.
   - Monitor temperature, pressure, and water level.
   - Initiate ECCS if there is a low water level.
   - Press AZ-5, *if not already tripped.*
   - Act and adjust accordingly.
   - Await return of offsite power.

Credits

- **Koyot Digitals** (Game Creators)
- **Onoxic** (Tutorial Creator)
- **Noodle Poodle** (Tutorial Creator)
- **Oakridge NPS Fandom Wiki Maintainers**