

# Gregtech 6.15.00 Fission Reactor Guide

## Reactor Operation Basics

The Nuclear Reactor Core (2x2) has slots for four reactor rods. Rods inserted into the reactor will only directly interact with directly adjacent reactor rods, also including adjacent slots on different, but adjacent, reactor core blocks. Rods can be manually inserted into a slot by right clicking it with the rod. Right clicking a slot with Pincers will pull out the reactor rod inside the slot. The reactor rods can also be automatically inserted on the top side when the reactor block is off. It is also possible to automatically extract them from the bottom side when the block is off.

The reactor can be manually toggled on or off with a soft hammer. A redstone machine switch will allow controlling this with redstone. While the reactor is off, the reactor will behave as if it doesn't contain any rods. Individual rods can also be toggled on or off to behave as if the slot were empty. This can be done with either the redstone or manual selector. The reactor core has two internal tanks to store 64\_000 liters of cold and hot coolant. Different coolant can have different effects on the inserted reactor rods. Cold coolant can be inserted from any side. Hot coolant will be automatically output on the red facing. If the cold coolant tank is more than half full, cold coolant will be automatically output on the blue facing. The red facing can be moved with a wrench and the blue one with a monkey wrench.

While the reactor is on, Neutrons can be present on active reactor rods. The neutrons might interact with the reactor rods in different ways.

Generally, the number of neutrons is directly output as HU into the reactor each tick. Neutrons only last for one second and will therefore be updated only every second.

Neutron counts can be manually measured by right-clicking the reactor core with a Geiger Counter. The Geiger Counter Sensor can also be attached to the reactor core to measure the sum of all neutrons on the reactor rods. 100% of the percentage modes of the sensor refers to the sum of neutron maximums of all fuel rods inside the reactor core. A reactor will also emit radiation with a ranged based on the highest number of neutrons on any reactor rod. Building the reactor far away from any settlements and wearing a radiation hazard suit is strongly advised. Any reactor core will explode when heat gets added without coolant being present.

Should new heat energy from neutrons be added when the reactor is out of coolant, the reactor will violently disintegrate. Should there be no space for the produced hot coolant remaining in the reactor, the reactor will be undergo rapid unplanned disassembly.

# Guide to Reactor Rods

## Empty Reactor Rod

Does nothing when inside a reactor. Doesn't accept neutrons.

## Fuel Rod

Fuel rods emit Neutrons onto themselves and adjacent reactor rods. They have several stats that vary based on the material of the rod and the coolant that is used in the reactor:

- The *Self* stat describes how many Neutrons the rod outputs onto its own slot.
- The *Emission* stat describes how many Neutrons it outputs onto each adjacent reactor rod.
- The *Factor* stat describes how many additional neutrons it will output onto adjacent reactor rods based on how many neutrons are on itself. A bigger Factor ( $1/3 > 1/32$ ) means more additional neutrons are output per neutron on the fuel rod.
- The *Maximum* stat describes how many neutrons can be on this fuel rod before it will be losing duration faster. When over the maximum, the fuel rod will be losing duration at minimum four times faster, scaling linearly with the amount of neutrons over the maximum.

Moderated fuel rods will make adjacent active fuel rods also moderated. Moderated fuel rods will deplete four times faster and can't put neutrons onto breeder rods. When the remaining duration of the fuel rod runs out, it will convert to a Depleted Fuel Rod.

## Depleted Fuel Rod

Does nothing when inside a reactor. Doesn't accept neutrons. Can be centrifuged to obtain some fuel and some higher tier fission fuel back.

## Absorber Rod

Absorber rods accept neutrons from adjacent fuel rods. Each neutron on an absorber rod gets converted to two HU instead of just one.

## Reflector Rod

Return any neutrons put onto them directly to their source. They therefore will never have any neutron on them.

## Moderator Rod

Like reflector rods they return neutrons directly back to their source, but the number of neutrons they return gets multiplied by the number of fuel rods that emit neutrons onto them. They therefore can reflect up to four times as many neutrons back and will never have any neutron on them. Moderator rods also moderate adjacent fuel rods, making them deplete four times faster and unable to put neutrons onto breeder rods. Moderated fuel rods will also make adjacent active fuel rods moderated.

## Breeder Rod

Each tick, the number of neutrons on this rod get subtracted from the neutrons needed. If the needed neutrons reach zero, the rod will turn into an enriched rod. Breeder rods will not accept neutrons from moderated fuel rods. The loss stat gets subtracted from each number of neutrons emitted onto this rod, meaning the loss applies to the neutrons coming from any fuel rod emitting onto it and not just once for the breeder rod.

# Guide to Reactor Coolants

## Distilled Water

Converts directly into steam, doesn't need a heat exchanger. 80 HU turns 1L of Distilled Water into 160L of Steam. Moderates any fuel rods inside. No fuel rod stat changes.

## Semi-heavy Water

40 HU turns 1L of Semi-heavy Water into 1L of Hot Semi-heavy Water. Moderates any fuel rods inside. No fuel rod stat changes.

## Heavy Water

50 HU turns 1L of Heavy Water into 1L of Hot Heavy Water. Moderates any fuel rods inside. Divides maximum stat of fuel rods by 8.

## Tritiated Water

60 HU turns 1L of Tritiated Water into 1L of Hot Tritiated Water. Moderates any fuel rods inside. Divides maximum stat of fuel rods by 16.

## Industrial Coolant

20 HU turns 1L of Industrial Coolant into 1L of Industrial Heatant. Multiplies self stat of fuel rods by 4. Multiplies emission stat of fuel rods by 4. factor stat of fuel rods by 2. Decreases divisor of factor stat of fuel rods by 1.

## Carbon Dioxide

20 HU turns 1L of Carbon Dioxide into 1L of Hot Carbon Dioxide. Multiplies self stat of fuel rods by 3.

## Helium

30 HU turns 1L of Helium into 1L of Hot Helium. Divides emission stat of fuel rods by 2.

## Molten Lithium Chloride

15 HU turns 1L of Molten Lithium Chloride into 1L of Hot Molten Lithium Chloride. Multiplies self stat of fuel rods by 5. Divides emission stat of fuel rods by 2. Increases maximum stat of fuel rods by 25%.

## Molten Tin

40 HU turns 1L of Molten Tin into 1L of Hot Molten Tin. Neutrons only convert only to a third of the HU. Decreases divisor of factor stat of fuel rods by 1.

## Molten Sodium

30 HU turns 1L of Molten Sodium into 1L of Hot Molten Sodium. Neutrons only convert only to a sixth of the HU. Decreases divisor of factor stat of fuel rods by 1.

## Molten Thorium Salt

2\_560\_000 HU turns 1L of Molten Thorium Salt into 1L of Molten Lithium Chloride. Sets self stat of fuel rods to 0. Divides emission stat of fuel rods by 2. Multiplies maximum stat of fuel rods by 4.

# Stable Reactor Design Guidelines

Stable nuclear fission reactors, also commonly called subcritical reactors, are a design of fission reactor that have no critical fuel rods. This means that the neutron count and thus heat output doesn't constantly increase while the reactor is running.

The advantages of stable reactors are:

- No external control required
- Stable neutron/HU output
- Increased Safety
- Easy to design
- Function with any nuclear fuel

Disadvantages of stable reactors are:

- Not very fuel efficient
- Only really usable as power generating reactors
- Generally bigger than comparable critical reactors

A reactor rod can be considered critical when the number of neutrons reflected back onto the rod times the factor of the rod is greater or equal to the emission of the fuel rod. This means that a rod is critical if the number of reflectors around it times the factor is greater or equal to 1. So a fuel rod with a factor of  $1/3$  needs at least 3 adjacent reflector rods to be critical.

Therefore it is advised to use Industrial Coolant as a reactor coolant for stable reactors. Industrial Coolant decreases the factor of fuel rods, making it impossible for any fuel rod to go critical without moderator rods. It also increases the self and emission stat which is really advantageous in stable reactors, as it means more Neutrons and therefore more efficiency.

You can generally adhere to these four rules to get your stable reactor to the best efficiency:

- If the fuel used has a factor lesser than  $1/8$ , surrounding fuel rods with absorber rods yields the greatest HU output.
- If the fuel used has a factor of  $1/8$ , surrounding your fuel rods with absorber, reflector or other fuel rods yields to the exact same HU output.
- If the fuel used has a factor greater than  $1/8$ , surrounding your fuel rods with reflectors or other fuel rods yields the greatest HU output.
- Don't use water based coolant or moderator rods in stable reactors, as they massively decrease the duration and therefore efficiency of fuel rods by moderating them without any real benefit in stable reactor designs.

# Critical Reactor Design Guidelines

Critical nuclear fission reactors, also commonly called supercritical reactors, are a design of fission reactor that have critical fuel rods. This means that the neutron count and thus heat output constantly increases while the reactor is running.

The advantages of critical reactors are:

- Greater efficiency
- Completely configurable neutron output
- Generally smaller than comparable stable reactors
- Able to work as burner or breeder reactors

Disadvantages of critical reactors are:

- Need external control
- Constantly fluctuation HU output
- Harder to design
- Decreased safety
- Need fuel with higher factors

A reactor rod can be considered critical when the number of neutrons reflected back onto the rod times the factor of the rod is greater or equal to the emission of the fuel rod. This means that a rod is critical if the number of reflectors around it times the factor is greater or equal to 1. So a fuel rod with a factor of  $1/3$  needs at least 3 adjacent reflector rods to be critical.

Since the neutron count on the fuel rod will be indefinitely increasing, you need to control the reaction so you won't output more power than you can handle. Geiger counter sensors allow such control in an automatic fashion when combined with redstone machine switches or selectors. So when the neutron count gets too high you want to turn a reactor rod off to make the fuel rod subcritical again, making the neutron count shrink.

For the greatest efficiency you want your neutron count on the fuel rod stay beneath the maximum stat of that fuel rod at all times, while coming as close to it as you can. You'd also want the neutron count to shrink as little as possible when controlling the reactor, so your average HU output stays as high as possible.

Therefore you need a fuel with a factor of at least  $1/4$  to be able to build a critical reactor without the use of moderator rods. The easiest to acquire fuel that fulfils this condition is Uranium 235. You can get it by processing Uraninite. When using moderator rods the fuel can have a factor down to  $1/16$ , so using Uranium 238 is possible.

# Burner Reactor Design Guidelines

Burner Reactors are a type of nuclear fission design, with the purpose of burning through fuel rods as quickly as possible, allowing the depleted fuel rods to be processed for better nuclear fuel materials.

There are two ways to make fuel rod depletion significantly quicker:

- Moderating the fuel rod
- Running above the neutron maximum

A fuel rod can be moderated by either by having it placed in reactor cooled with Distilled/Semi-Heavy/Heavy/Tritiated Water or placing it next to a moderator rod or moderated fuel rod. When moderated, the fuel rod will deplete four times faster. When having a neutron count greater than the maximum stat of the fuel rod on the fuel rod, it will also deplete four times faster, stacking with moderation to 16 times faster.

The more you go over the maximum, the quicker the fuel rod will deplete, having a neutron count twice as high as the maximum on the rod will make it deplete twice as fast yet again, which would be stacking with moderation to 32 times faster depletion. Neutron counts 17 times the maximum would therefore make the fuel rod deplete 17 times faster times, times 4 because of going over the maximum, so 68 times faster, times 4 if the rod is moderated, so 272 times faster than an unmoderated rod with neutron counts below the neutron maximum.

Instead of significantly increasing the neutron count on the fuel rod, it is also possible to lower the neutron maximum to take advantage of this effect. This can be easily done by using either Heavy or Tritiated Water, which lower the maximum stat by 8 and 16 times respectively and additionally also moderate all fuel rods because they are water based.

To archive really high neutron counts, it is advisable to utilize a critical reactor design, though it is also feasible to run a burner reactor as a stable design. Cobalt 60, while being almost useless as a reactor fuel itself, is really easy to burn into Thorium, which is much more useful.

# Breeder Reactor Design Guidelines

Breeder reactors have the goal of turning breeder rods into enriched rods. They allow getting really good nuclear fuel from lesser, more abundant fuels, like Thorium and Uranium 238. However while similar to burner reactors, they are much harder to build, requiring a non-moderated, critical reactor design. Breeder rods have a stat called loss. It describes how many neutrons are subtracted from any amount of neutrons put onto it.

So when you have a breeder rod with a loss of 500 neutrons and try to emit 300 neutrons onto it from a single adjacent fuel rod, the breeder rod receive no neutrons, which means that the breeding process won't be advanced. When emitting 300 neutrons from another adjacent fuel rod onto the same breeder rod, now essentially emitting 300 neutrons twice onto it, there will still be no neutrons on the breeder rod, as the loss is applied to each amount of neutrons.

This means that high neutron outputs from a single fuel rod are required, which make it infeasible to run a non-critical reactor design as a breeder.

Emitting 900 neutrons onto the same breeder rod with a loss of 500 neutrons would mean that 400 neutrons would end up on the breeder rod, meaning that they would be added to the process of turning into an enriched rod each tick. Another fuel rod emitting 900 neutrons onto the same breeder rod, so essentially 900 neutrons twice, would therefore mean 800 neutrons on the breeder rod.

Since the breeder rod essentially needs to be adjacent to a critical fuel rod, the fuel rod only has three sides remaining for reflectors, which means it can only go critical if its factor is  $\frac{1}{3}$  or greater. Moderator rods are obviously not usable here, since breeder rods can't accept neutrons from moderated fuel rods. This means either fuels with a higher factor like Plutonium are required or a coolant that raises the factor needs to be used.

Molten metal coolants like Molten Tin or Molten Sodium are therefore best for breeder reactors, since they raise the factor of fuel rods inside, making breeding possible with more common fuel materials like Uranium 235 or allowing better fuel materials to breed more breeder rods at once. They also have the advantage of lowering the HU output of the neutrons, which means higher neutron counts are possible with less cooling.

Emitting higher neutrons counts onto the breeder rods amounts to a quicker and also more efficient breeding process, as the neutron loss would be applied over a shorter time, resulting in fewer neutrons lost in total.

# Thorium Salt Reactor Design Guidelines

Thorium Salt is a really special kind of coolant. In fact, it can't even be considered a coolant, as it doesn't get converted into an energy carrying liquid. Instead it can be seen more of as a fuel itself, since it turns into Molten Lithium Chloride, meaning that essentially the thorium inside the thorium salt gets used up as a fuel. Thorium salt also depletes really slowly into Molten Lithium Chloride, only for every 2\_560\_000 neutrons one liter of Thorium Salt gets turned into Molten Lithium Chloride.

The main advantage of using Thorium Salt is how it effects the stats of any fuel rod inside, massively boosting them. However, since power can't be extracted from the Thorium Salt, since it doesn't turn into an energy carrying liquid, you can't simply use Thorium Salt alone in any reactor design.

A reactor design utilizing Thorium Salt needs to be using at least one other, additional coolants instead. The reactor core filled with Thorium Salt would house the fuel rods, while adjacent reactor cores filled with another coolant would capture the neutrons emitted from that reactor with neutron absorber rods. Since the Thorium Salt main advantage is how it massively raises the maximum stat of fuel rods inside, it generally only really makes sense as a critical reactor design.

Critical Thorium Salt reactors are the most efficient power generating reactors possible, but also among the hardest to build.

## Advanced Fission Reactors

This chapter will give you some tips and the mathematical formulas to build the most advanced and efficient reactors possible.

### Calculating the neutron emission

A fuel rod will emit more neutrons onto its neighbors when it has a higher neutron count on it. The exact amount of neutrons any fuel rod would emit onto one adjacent neighbor can be calculated like this:

$$e_n = e + (n - s) * f$$

- $e_n$ : Neutrons emitted onto neighbor
- $e$ : Emission stat of the fuel rod
- $n$ : Neutron count on the fuel rod
- $s$ : Self stat of the fuel rod
- $f$ : Factor of the fuel rod

### Calculating the depletion rate of a fuel rod

A fuel rod usually has a depletion rate of one and will therefore last as long as the time on the tooltip suggests. However, when having a greater amount neutrons on the fuel rod than the neutron maximum, the depletion rates gets multiplied by this factor:

$$f = 4 * n / m$$

- $f$ : Depletion rate multiplier
- $n$ : Neutron count on the fuel rod
- $m$ : Maximum stat of the fuel rod

Furthermore, having the fuel rod moderated will additionally multiply its depletion rate by a factor of 4. Divide the time remaining stat of the fuel rod by the calculated depletion rate to get the real time until depletion.

## Tips and Tricks

- You can build reactor designs using multiple coolants.
- For critical reactors using moderator rods it is smarter to control one adjacent fuel rod, rather than the moderator rod itself to control the neutron counts.
- Robot arms allow for precise automation of reactor cores.
- Filters can be used for easier automation of burner and breeder reactors.
- A higher self stat is bad in critical reactor designs, as contributes to the maximum without effecting the neutron emission.
- The emission stat is mostly irrelevant for efficiency in critical reactor designs.
- Setting the geiger counter sensor to hexadecimal mode is useful when trying to control neutron counts greater than 9\_999. In hexadecimal mode you can compare up to 65\_535 neutrons.

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