A basic guide to Gregtech 6 Nuclear Fission Reactors

This document will go through the mechanics of setting up and operating a GT6 Nuclear Fission Reactor successfully. This guide is by no means exhaustive and there is a lot to discover and learn about reactors, but is should be enough to teach the system and allow you to discover these tricks without explosions.

There are two types of reactor block available, the **1x1 and the 2x2 reactor block**. Reactors are multiblock structures that consist of at least one of these reactor blocks. Reactor blocks accept Coolant *liquids* into their internal tank, which is required for operation. The **Coolant** gets heated up by the nuclear fission reaction and **Heatant** builds up in the second internal tank.

Coolant liquid can be injected into any side of the reactor. Heatant comes out of the red side, which can be configured with a wrench. The blue side outputs Coolant when the internal coolant tank is more than half full, which is useful for pumping Coolant to many adjacent reactors. The blue side can be configured with a monkey wrench.

At the top of the reactor **Reactor Rods** can be manually inserted and removed with Pincers. The 1x1 reactor block has one slot for Reactor Rods and the 2x2 reactor block has four.

Reactor Rods are producing and interacting with **Neutrons**. These Neutrons are heating up the Coolant and producing Heatant, with **one Neutron heating up the Coolant by exactly one HU** (Heat Unit) of energy. These Neutrons are present on the Reactor Rod Slots, so a 2x2 reactor block can have four amounts of Neutrons. Neutrons are quite useful, but they also make nuclear reactors quite dangerous: They produce harmful radiation in an area around the reactor block proportional to the number of Neutrons in the reactor block. Personnel is therefore advised to wear **Radiation Hazard Suits**.

Neutrons can be measured with either the handheld **Geiger Counter** or the **Geiger Counter Sensor** block, which operates like any other GT6 sensor, meaning it has the capability to output a redstone signal based on the **Neutron Count**, the amount of Neutrons on a Reactor Rod. The sensor block will display the total number of Neutrons in a reactor block, so in the 2x2 reactor block, the Neutron values on the four slots get added up.

If there is no Coolant left, but neutrons are still produced in the reactor, the reactor will **violently disintegrate**. The same thing will also occur when the produced Heatant can’t go anywhere, because the Heatant tank is full. Luckily the Neutron production and interaction, therefore also the Heatant production, can be stopped by simply **shutting down** the reactor. This can be manually done by gently whacking the reactor with a Soft Hammer or by redstone with a Redstone Machine Switch. In the 2x2 reactor, each Reactor Rod can also be individually controlled to be turned off or on with a Selector Cover. A reactor rod inside a reactor that has been shut down in any of these ways is called **inactive** while one that didn’t is called **active**.

A reactor block can be **automated** by accessing the rod slots on the top and bottom side. However this can only be done if the reactor or the slot you want to access is shut down, so automation usually requires quite a bit of redstone and the use of extender blocks.

The Control Rods

Control rods don't produce Neutrons but interact with them. They are mainly used to control a nuclear reactor, reflect Neutrons and get extra efficiency (see *Efficiency*) out of the Fuel Rods. There are three types of control rods:

Neutrons that are emitted onto **Absorber Rods** will be converted to twice as much heat energy, meaning one Neutron on an Absorber Rod will yield two HU. This makes them useful for boosting the efficiency of reactors even when the Neutron Maximum (see *Efficiency*) is reached.

Reflector Rods simply bounce back, or in other words reflect, any Neutrons emitted onto them back to the rod that emitted them. This allows them to return emitted Neutrons onto Fuel Rods and boost their Neutron output that way.

Moderator Rods are much like Reflector Rods, but they reflect back multiple times the received emission, based on how many active Fuel Rods border them. If a Moderator Rod touches for example three active Fuel Rods, the **Reflection Multiplier** and therefore the reflected amounts will be three times the emissions of the Fuel Rods. Active Fuel Rods in the 1x1 reactor will count as two Fuel Rods for Moderator Rods in the 1x1 reactor. However, it's a very important detail about Moderator Rods, that they update their Reflection Multiplier **delayed by a second**, so you have to account for that in your redstone, because after turning one adjacent Fuel Rod inactive, the next time the Neutron Count updates, the Reflection Modifier will still include the now inactive Fuel Rod.

These abilities of the Moderator Rods however comes at the big disadvantage of effected Fuel Rods being Moderated (see *Moderation*).

The Fuel Rods

Fuel rods are the most important type of rods for the nuclear reactor, because they produce Neutrons. Each second, after the **real Neutron Emission** has been calculated, the Neutron Count will again be set to 0. The Fuel Rods have several stats, which are displayed on their tooltip:

- The **Self stat** of the Fuel Rod describes how many Neutrons the Fuel Rod emits onto itself each second.
- The **Emission stat** describes how many Neutrons the Fuel Rod emits to any adjacent Reactor Rod each second, when there are no additional Neutrons on the Fuel Rod other than the amount set by Self.
- The **Factor stat** is used to calculate how many additional Neutrons get emitted when there are additional Neutrons on the Fuel Rod. This value combined with the Emission stat of the Fuel Rod adds up to the real Neutron Emission.
- The **Maximum stat** describes how many Neutrons the Fuel Rod can output each second without getting a durability loss penalty (see *Efficiency*). The total Neutron output of a Fuel Rod is the Self plus four times (because outputting to four sides) the real Neutron Emission.

These stats are often changed using different coolant types, which is also displayed in the tooltip.

Emission calculation

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

E_n	…	Real Neutron Emission
e	…	Emission stat of the Fuel Rod
s	…	Self stat of the Fuel Rod
f	…	Factor stat of the Fuel Rod
n	…	Neutron Count of Fuel Rod

This is the one calculation that really drives the Nuclear Fission Reactor. For those who don't want to bother with the maths, it means that the higher the Neutron Count the on a Fuel Rod, the higher the Neutron Output of that rod. Also the higher the Factor of a Fuel Rod, the more Neutrons it will gain this way.

This calculation makes reflecting Neutrons back at the Fuel Rod or placing Fuel Rods next to each other so they emit Neutrons onto each other very useful, as that will make the Neutron Count grow, thus increasing the growth even further. However, this will not continue infinitely unless the Factor times how many times the real Neutron Emission gets reflected back to the Fuel Rod is equal or greater than one. In practice this means that a Fuel Rod with a Factor of ¼ or lesser surrounded by 4 Reflector Rods will have an infinitely growing Neutron Count as

$$n_1 - s = e + ((n_0 - s) * \frac{1}{4}) * 4 = e + (n_0 - s)$$

n_0	…	Neutron Count of Fuel Rod this second
n_1	…	Neutron Count of Fuel Rod the next second

When this occurs in a Reactor, the Reactor is called **supercritical**, if it's not it's called **subcritical**. Supercritical reactors have the advantage that you can extract a lot of power from them with a very high efficiency, but they come with the downside of needing to be controlled as the Neutron Count would otherwise rise into infinity, producing more and more heat until the cooling system will be overwhelmed, either running out of Coolant of overfilling on Heatant, either way, the reactor will explode. So measuring the Neutron Counts and controlling the Reactor Rods with redstone is required.

Efficiency

The Fuel Rods in a reactor don't last infinitely, at one point they will turn into a **Depleted Fuel Rod**. The remaining time on the Fuel Rod is displayed on the tooltip in minutes. Most types of Fuel Rods will last for a few real life days. There are however several factors that will make the remaining time run out faster.

If the total Neutron Output of a Fuel Rod, which is the Self stat plus four times the real Neutron Emission, exceeds the **Maximum** stat of the Fuel Rod, the fuel will deplete four times faster scaling linearly with the Fuel Output.

If a Fuel Rod is **Moderated** (see *Moderation*) it will deplete four times as fast.

The efficiency of a fuel, the Neutrons per Durability, is therefore halved by using Moderated Fuel Rods and maxes out at a Neutron Output equalling the Maximum, being constant and four times lower when exceeding the Maximum.

So to make a Fuel Rod as efficient as possible, you'll therefore need to archive a Neutron Output as close to the Maximum as possible, but never exceeding it. However, a higher Stability (see *Stability*) will also raise the average output and thus efficiency as well as using **Absorber Rods** to convert the Neutrons into HU more efficiently.

Stability

The stability describes the difference between the **true average Neutron Output** of a Fuel Rod and the Maximum of that Fuel Rod in a **supercritical reactor**. Because a supercritical reactor will have ever increasing Neutron Counts on the Fuel Rods, these will at some time exceed the Neutron Maximum if not controlled. Controlling however means disabling some Reactor Rod, usually a Reflector Rod. This will however cause the Reflector Rod not to reflect the Neutrons emitted back, thus drastically lowering the Neutron Count on the Fuel Rod and lowering thus lowering the next calculated real Neutron Emission quite drastically and also making the reaction not supercritical.

So when the Reflector Rod gets enabled again the next second, the Neutron Output will be lower and will need to rise back again towards the Maximum for a time. Because of this, the average Neutron Output will not be the Fuel Rod's Maximum, but the value roughly in the middle of the Maximum and the lowest Neutron Output after the reactor has been controlled.

So the stability of a Factor ¼ Fuel Rod surrounded by 4 Reflectors will be roughly 1/8 of the Maximum, as disabling one Reflector Rod roughly means losing ¼ the Neutron Output.

Moderator Rods can therefore also lead to more stable reactors, as a Factor 1/16 Fuel Rod surrounded by four Moderator Rods, which are surrounded by Fuel Rods on all sides, reflecting 16 times, can just disable one of those Fuel Rods to make the reaction subcritical while just losing roughly 1/16 of the Neutron Output, resulting in a stability of roughly 1/32 of the Maximum of the Fuel Rod.

Moderation

A Fuel Rod can become **Moderated** by either being in a **water based Coolant** (Distilled Water, Semi-heavy Water. Heavy Water, Tritiated Water) and/or touching an **active Moderator Rod** or **active Moderated Fuel Rod**. Moderated Fuel Rods will have four times the durability consumption and can't be used for Breeding (see *Breeder Rods*). Deactivating a Moderated Fuel Rod for a second or not having it sit next to an active Moderator Rod or active Moderated Fuel Rod will cause it being not Moderated again.

The Breeder Rods

Breeder Rods are absorbing the Neutrons emitted onto them every tick to slowly convert into a **product**, usually a better Fuel Rod. While doing so, the Neutrons on the Breeder Rod will only yield half the HU.

The more Neutrons are emitted at the Breeder Rod at once, the more extra progress it will gain for converting into the product. In fact, the progress gained from bigger Neutron Counts raises exponentially:

$$n_p = n * 1{,}5^{(n / 500)}$$

n_p	...	Neutrons gained towards the Breeding progress
n	...	Neutron Count of the Breeder Rod

So for every additional 500 Neutrons on the Breeder Rod, the Neutrons that are added to the progress will be multiplied by 1.5. So for the best **breeder reactor efficiency**, even going over the Neutron Maximum will be worth it, as breeding efficiency scales into infinity.

But be aware that Breeder Rods that turn into Fuel Rods will start to act as such and thus output Neutrons. This also allows detecting that the breeding process has been finished.

Reactor Coolants

There are a lot of reactor Coolants available, each with their unique advantages and disadvantages. This will describe several reactor types and the coolants that are used in GT6 to create them.

Industrial Coolant Reactors

Unlike the other reactor types, this one isn't based on the real world and is entirely fictional. It uses **Industrial Coolant** as the Reactor Coolant and produces Industrial Heatant, which has a medium **Heat Capacity**, the HU transferred by each mB/L of the Heatant.

Industrial Coolant quadruples the Self and Emission stats while halving the Factor of Fuel Rods inside compared to running the Fuel Rod in any water based reactor. This makes building supercritical reactors impossible without Moderator Rods, but makes a stable and easy to operate subcritical reactors all the more profitable, because of the high boost to the base output.

Boiling Water Reactors

A BWR uses regular **Distilled Water** as the Coolant. Its most prominent and obvious attribute is it directly **outputting Steam**, instead of a Heatant that has to be processed in a heat exchanger. While it directly outputting Steam is very convenient, Steam also has a terrible Heat Capacity and not all the Steam is turned back into Distilled Water by the Turbine, making the reactors coolant loop unsustainable.

While the stats of any water based reactors are quite good, serving as the baseline compared to all other coolants, they also have the big disadvantage of **moderating** (see *Moderation*) any Fuel Rods inside, causing them to only a quarter as long. This however makes using Moderator Rods quite useful, as the main disadvantage of using them is still present in water based reactors anyway.

Presurrized Water Reactors

PBRs use **Semi-heavy**, **Heavy** and **Tritriated Water** as their Coolant and, unlike Distilled Water, produce hot versions of themselves as Heatant. Otherwise they are stat wise identical to BWRs and also moderate any Fuel Rods inside. Their big advantage over other Coolants is the huge Heat Capacity they possess. The heavier the water, the bigger the Heat Capacity.

Liquid Metal Cooled Reactors

Molten Sodium and **Molten Tin** are used as Coolant a LMR and turn into hot versions of them as a Heatant, having a quite good Heat Capacity. They have the same stats as water based reactors without moderating the Fuel Rods inside, but are terrible as power producing reactors, as they output less HU per Neutron, Molten Tin outputting a third and Molten Sodium only a sixth.

This however makes them perfect for building Breeder (see *Breeder Rods*) reactors, as it allows for much higher Neutron Counts to archive more breeding reactor efficiency while still having a manageable heat production.

Gas Cooled Reactors

GCRs use either **Carbon Dioxide** or **Helium** as their Coolant which turns into hot versions as the Heatant, with slightly better than average Heat Capacity. As they also don't moderate the Fuel Rods, they are quite good for building very efficient high factor fuel supercritical power producing reactors.

Carbon Dioxide slightly raises the Factor of contained Fuel Rods while **Helium** slightly lowers it. This makes CO_2 better for serving either as a breeder (see *Breeder Rods*) or being a bit more efficient by allowing to use an additional Absorber Rod, while still keeping the reactor supercritical. Helium however allows for more stable (see *Stability*) reactors when using high factor fuels by lowering the Factor of these and also halves the Emission stat of Fuel Rods, making it possible to get that bit closer to the Maximum while also having a slightly higher Heat Capacity than CO_2.

Molten Salt Reactors

Molten Lithium Chloride is used in MSRs and produces a hot version of itself as the Heatant, which has the lowest Heat Capacity of any Heatant. Like Helium, it halves the Emission stat of contained Fuel Rods.

It's most notable feature is providing a 25% higher Maximum stat on contained Fuel Rods, which allows for building even more efficient (see *Efficiency*) reactors.

Molten Thorium Salt Reactors

MTSRs are special, as the **Molten Thorium Salt** they use as a Coolant doesn't turn into a Heatant, but the Molten Salt used to create it (Molten Lithium Chloride), so only Thorium Dust is consumed. They turn **1mB/L per 10000HU of Molten Thorium Salt into Molten Lithium Chloride**.

They however provide huge advantages, providing a **four times higher Maximum** on Fuel Rods contained. Extracting power from this type of reactor requires using a different Coolant in adjacent reactor blocks, resulting in the necessity of so called **Poly-Coolant Reactors**. To make extracting power from them easier, they also halve the Emission stat and increase the Factor stat of contained Fuel Rods.