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 tricky 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 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 block can be **automated** by accessing the inventory 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 use of extender blocks.

The Control Rods

Control rods don't produce Neutrons but interact with them. They are used mainly to control a nuclear reactor, reflect neutrons and get extra 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 it 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 Fuel Rods border them. If a Moderator Rod touches for example three fuel rods, the reflected amounts will be three times the emissions of the fuel rods. Fuel Rods in the 1x1 reactor will count as two fuel rods for Moderator Rods in the 1x1 reactor. This ability however comes at a big disadvantage of effected Fuel Rods being Moderated (see *Moderation*).

The Fuel Rod

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 amount 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 … Amount of Neutrons on the 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 amount of Neutrons 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

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

n_0 … Amount of Neutrons on the Fuel Rod this second
n_1 … Amount of Neutrons on the 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 long, 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 twice as fast.

The efficiency of a fuel, the Neutrons per Durability, is therefore halved by using Moderated Fuels 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 **enabled Moderator Rod** or **enabled Moderated Fuel Rod**. Moderated Fuel Rods will have twice the durability consumption and can't be used for Breeding (see *Breeder Rods*). Disabling a Moderated Fuel Rod for a second or not having it sit 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 amounts of Neutrons raises exponentially:

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

n_p	...	Neutrons gained towards the Breeding progress
n	...	Neutrons on 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. Water based reactors are have the big disadvantage of moderating any fuel rods inside, but otherwise they are quite balanced and cheap. The **Distilled water** variant has the added advantage of outputting steam directly, but that is obviously also a disadvantage, as the loop is unsustainable by itself and steam can quickly overflow any pipe.

Semi-heavy, **Heavy** and **Tritriated water** however need a heat exchanger and have an increasingly greater heat capacity.

Sodium and **Tin** are awful for creating power producing reactors as they have a lower Neutron to HU conversion rate, but this is also their big advantage if they are used as Breeder Reactors.

Carbon Dioxide is great for unmoderated supercritical reactors and breeders, as it raises the Factor and isn't moderated like the water reactors.

Helium is good for making very powerful high factor fuels more stable, as it lowers the Factor a bit.

Molten Lithium Chloride provides a higher Maximum and therefore allows for very stable reactors.

Thorium Salt drastically raises the Maximum, but doesn't produce heatant, so you'll need to build a **mixed coolant reactor** to actually get energy out of it or use it as a breeder.