Nuclear Fusion Reactors – Part Two

In the second part of our investigation of Nuclear Fusion Reactors we studied the reconstruction of the Japanese JT-60U reactor as a result of the "Broader Approach" agreement between the EU and Japan. This agreement was reached after a two-year standoff while the argument proceeded as to whether ITER should be built in Japan or France. France won and the agreement was the payoff to Japan and has already been extended. Physical construction was completed in March 2020 and commissioning has been ongoing since then but was interrupted in March 2021 by the failure of insulation in the connections to the Equilibrium Coil EF1 at 25% full power. Commissioning was expected to recommence in February 2022 but has not done so yet. This major setback was said to be a failure of quality control of the design and specification of critical components. Finding and correcting these things are what such comprehensive commissioning tests are for.

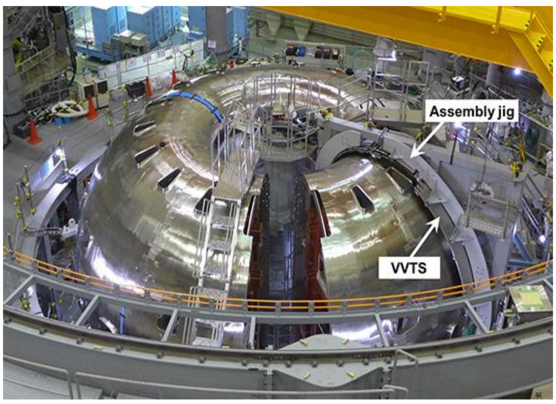
The EU and Japan formalised their 'Broader Approach' to fusion technology on 22 November 2006 when representatives from both initialled an agreement on three large research projects to be carried out in Japan.

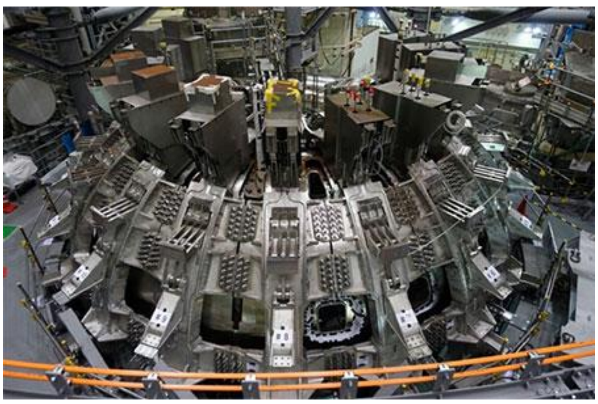
The agreement creates a privileged partnership between the EU and Japan and is intended to complement ITER. It will have a duration of 10 years and will receive €340 million in EU investment.

One major project is the Japan-EU 'Satellite' Tokamak Programme. During the construction of ITER, major experimental facilities will be required to test operating scenarios and address key plasma issues. The JT-60U tokamak in Japan has been identified as being able to fulfil these objectives but will need to be first upgraded to an advanced superconducting tokamak. It will then be used as a satellite facility to ITER.

JT-60SA, unlike ITER, will not operate by fusing deuterium and tritium, but instead use initially hydrogen and later deuterium to explore plasma behaviour, in which Japan has great expertise. This allows the machine to become only minimally radioactive over its lifetime, allowing much more flexibility in the ways it can be reconfigured as experimental knowledge is gained. This short video shows the construction.

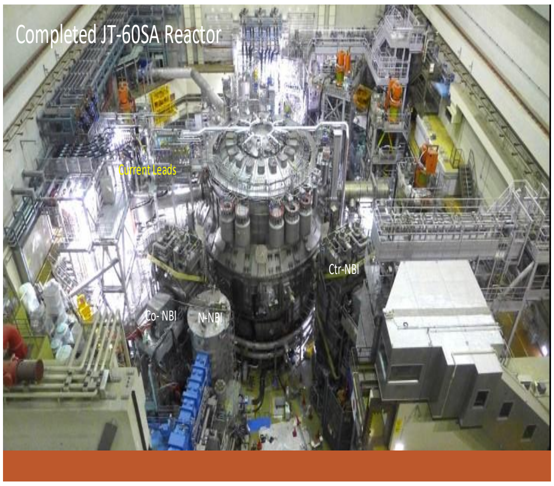
https://www.youtube.com/watch?v=NdCTONVDS3s&t=2s

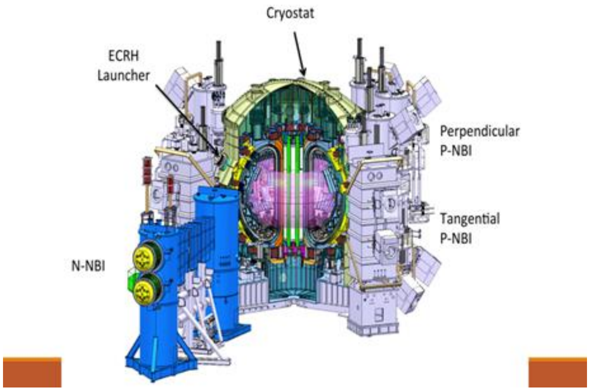




Non-magnetic stainless steel Vacuum Vessel

Toroidal Field Coils in position

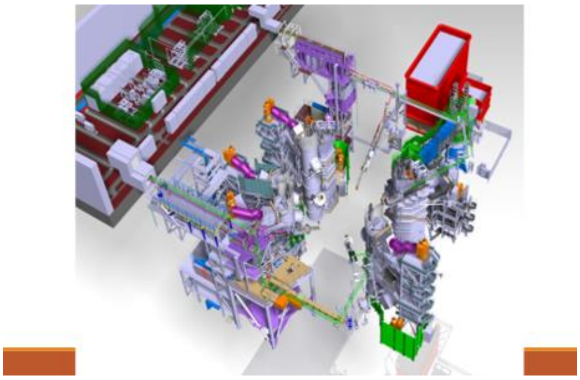


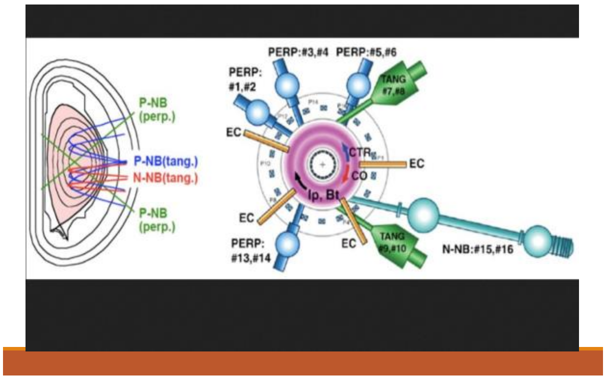


Completed Reactor

Cross section showing heaters

JT-60SA will have up to 41 MW of heating power. This heating power will be provided by two different types of heating sources, Electron Cyclotron Resonance Heating and Neutral Beam (NBI) heating. The blue N-NBI with its red power supply produces 30 MW of heating for 100 seconds.





Plan view of heaters

NB Is also control shape and position of plasma

(Note colours have been reversed in the Plasma)

A complete description of the construction is available at this website:
https://www.qst.go.jp/site/jt60-english/6599.html

The requirement for superconductor material and cryogenic cooling at 4 degrees K for all 28 magnet coils has led to an enormous increase in cost and complexity of construction and operation of tokomaks. This the only way to increase the fusion efficiency and maximise the power output to make the tokomak viable for electricity generation.

In addition to studying how best to get to and beyond breakeven conditions, JT-60SA is designed to explore the steady-state operation of tokomaks which is essential to the generation of electricity for grid applications. To date, the record is 5 seconds at the JET reactor. JT-60SA targets 100 seconds initially, while ITER aims at 400 seconds initially.