3D printable ITER package user guide

1. Introduction

This document aims to describe all parts of the 3D printable ITER package. It also contains suggestions, tips, and example projects for FDM(Fused Deposit Modeling) 3D printing technology. The models are made ready for printers that have 300mmx300mmx300mm or larger build volume but can be further processed by users to make them ready for smaller printers as well.

The models are 1:100 scale to the original device size.
More info on the ITER project can be found here: https://www.iter.org/

2. Package contents

a. Models
b. Examples
c. Tips for filament type and colors
d. User Guide

3. Basic information

We used Cura slicer to create GCode from the design (.stl files) and PLA material for printing the parts. The prototyping as test prints were done on Creality CR-10 V2, Wanhao Duplicator i3, and a Tronxy printer. The largest printed part was 29.8 cm in diameter so we recommend trying this project on a printer with 30x30x30 cm or larger build volume. In the project directory, you can find the models for printing, Cura projects with the settings we used for printing and a sheet with filaments and types we used. The approximate weight of the used material is about 4kg, the final product will be about 3kg. The printing time is about 4 weeks altogether. The parts can be printed in any order.

4. Parts description

The fully printed model contains 56 parts altogether.

- 4 Cryostat part
- 1 Central solenoid
- 6 Poloidal field coils
- 9 Vacuum vessel part
- 18 Toroidal field coils
- 18 Divertor parts

a. **Cryostat**
   The cryostat has the largest components, with about 30 cm in diameter. There are 4 cryostat parts.

b. **Central solenoid**
   This part will be installed almost lastly

c. **Poloidal field (PF) coils**
   The 6 poloidal field coils are numbered from 1 to 6, number 1 will be on the top and number 6 will be on the bottom

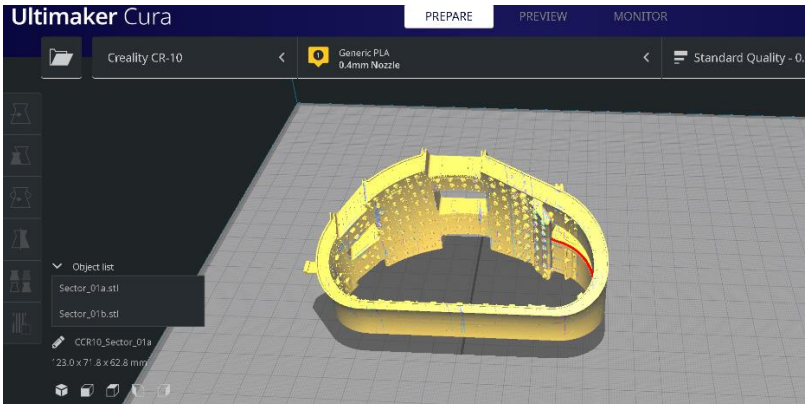
d. **Vacuum vessel parts**
   There are 9 parts each identified with a number from 1 to 9

e. **Toroidal field (TF) coils**
   There are 7 types of TF coils, each vacuum vessel(VV) sector has 2 TF coils, their order in counterclockwise direction starting from VV sector 1: BC-DE-FG-BC-DE-FA-BC-DE-FA

f. **Divertor**
   The divertor parts are all the same so there is no order how to install them

5. Printing the parts

Nearly all parts are in one piece to print. They are quite easy to print with the provided cura project examples. However in this current version the vacuum vessels are in two pieces. They have also example files but in the case you are using other slicers we descibe how to place them in the printing area to match each other. You have to place the two VV models in Cura, for example Sector_01a.stl and Sector_01b.stl from the Models directory. Now you have to rotate them 90 degree, make them lay flat, center them tot he origo and then move one piece with -61 mm on the X direction. You should get it like on the picture below.



How to place VV sectors in Cura

6. Parts assembly

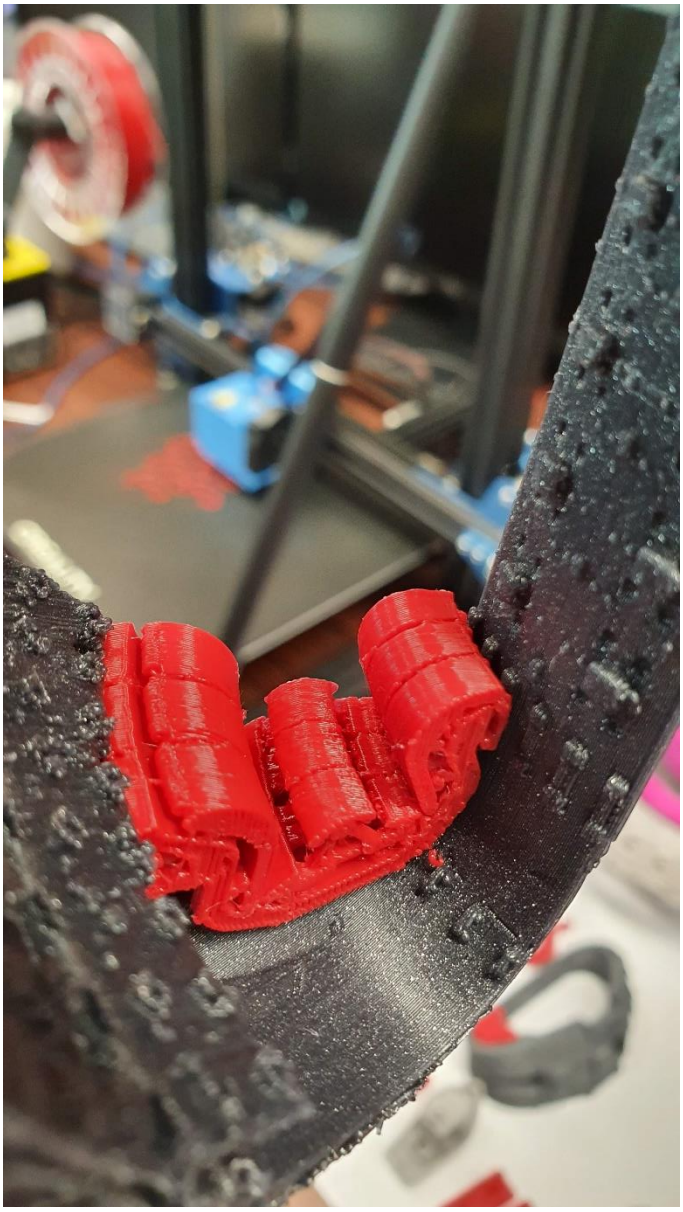
Real ITER will be assembled in a predefined order. You can see the steps in this video which also helps how the 3D printed version should be assembled, although with some modifications for the current model. The assembly, in general, is quite straightforward but to match the correct TF coils to the VV sector is not that clear. The table below will help you identify what goes where.

VV sector with 2 TF coils

However putting the wrong TF coil to a VV sector won't crash your model, you can assemble them anyhow but on the real machine, it will be crucial.

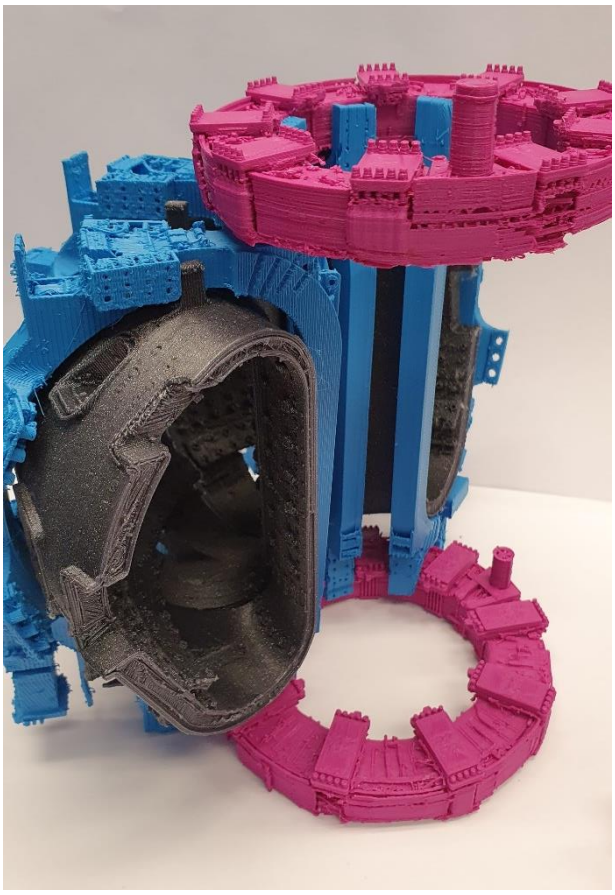
VV	1		2		3		4		5		6		7		8		9	
TF	b	c	d	e	f	g	b	c	d	e	f	a	b	c	d	e	f	a

Assembling the diverter is very easy you just have to use 2 pieces for each VV sector.

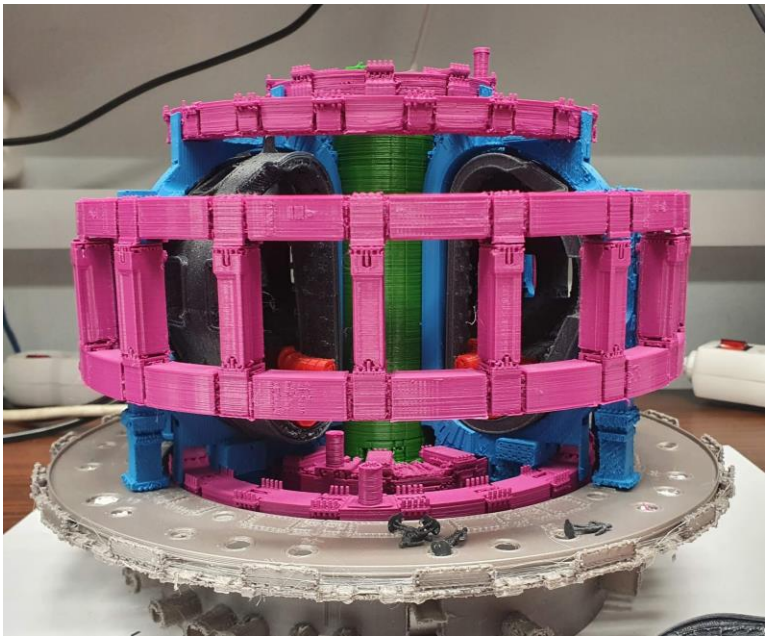


Divertor piece attached to a VV sector

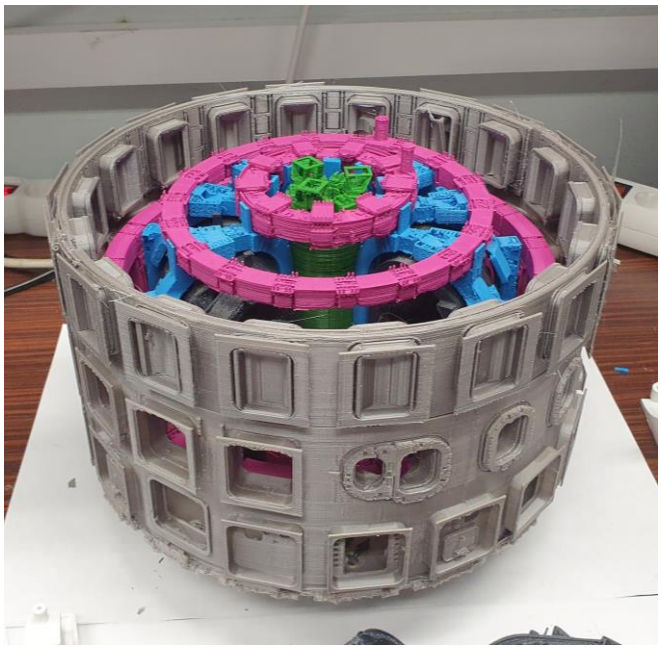
We recommend now to attach the PF coils to the assembled sectors. PF coil number 6 is the lowest one and it'll attach to the TF coils like on this photo below. You can also attach PF number 1 to the top.



PF coil no 2 and 5 will follow, they’re place is pretty straight forward after the sectors are assembled. They might tightly fit but this is due to 3D printing. The largest PF coils, 3 and 4 can be placed like on the photo below: PF 4 will be the first.



After the VV sectors, TF coils, PF coils and the divertor assembled we recommend to continue with the cryostat. The cryostat has 4 parts, the base which is the very first component installed in the real device. On the base we can place the lower cryostat part then the sectors we assembled earlier together with the VV, TF, PF and Divertor can be placed on the top of the base. After that you can put the power and upper cryostat part.



Finally, you can insert the central solenoid which might be also a bit tight but should fit in the center and on the top cryostat top part will go. This is how the ITER 3D printed model should be assembled.

7. Further improvements

We'll continue working on improving the models so the assembly and disassembly of the 3D printed ITER will be easier especially for children and for exhibitions and presentations to communicate about fusion energy research.

8. Support

If you have questions about this project or you have an idea to improve this package please feel free to contact the project members.

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