WPMAG – CEA IRFM
Design

14/01/2025

A. Torre

2025 CEA TS
Design / Ind Study / Procurement

TS Title:	CEA Design studies on Magnet Systems		
TS Ref. Nr.:	MAG-S.01.01-T024	Task coordinator:	Alexandre Torre

ID	Title
MAG-S.01.01-T024 - D001	Deliverable on 2025 CEA TF-WP4 design
MAG-S.01.01-T024 - D002	Deliverable on 2025 CEA CS designs
MAG-S.01.01-T024 - D003	Deliverable on 2025 CEA Industrial study
MAG-S.01.01-T024 - D004	Deliverable on 2025 CEA conductor procurement

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MAG-S.01.01-T024-D001

Deliverable on 2025 CEA TF-WP4 design

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MAG-S.01.01-T024-D001 Deliverable on 2025 CEA TF-WP4 design

Since no major changes were foreseen in 2025 on the TF design, this task was used to make a **sorting/regroupoing work in view of the 2025 Gate Review**, trying to provide the Work Package Leader and DCT a clear view of the latest design, along with what had been done in terms of analysis. **Summary sheets** were also provided.

2 Summary of the TF-WP4 design

EUROFusion

Magnet Summary Sheet	
Coil	MAG.TF.WP4.NOM
IDM ref.	
Version	0
Date of Issue	2025-08-05
Author	A. Torre
Reviewer	
Approver	V. Corato

Conductor	TF value	Type	Tolerance+Margin
Maximum operating current, I_{op}, kA	82.00		
Peak field, Bp, T (excluding contribution of other coil	11		±0.1 T
Maximum field along the conductor axis, Bc, T (excluding contribution of other coil subsystems)	*not available*		*not available*
Max. effective field, Beff, T (excluding contribution of other coil subsystems)			
Peak field, Bp, T (including contribution of other coil	*11.300*		
Maximum field along the conductor axis, Bc, T (including contribution of other coil subsystems)	*not available*		*not available*
Max. effective field, Beff, T (including contribution of other coil subsystems)	*not available*		*not available*
Type of s.c. strand	Nb3Sn		n/a
S.c. strand diameter (incl. coating), mm	1		AR: 0.7-2
Cu-to-nonCu ratio	1		AR: 0.9-1.3
S.c. strand RRR	100		AR: 50-300
Cable pattern	*1Cu)x3+1Cu)x3+(3x3 Cu))x4+(3x4x4 Cu))x5*		*not available*
Number of s.c. strands	360		AR: 300-2000
Segregated Cu wire diameter, mm	1		AR: 0.7-4
Segregated Cu wire RRR	300		AR: 100-400
Number of segregated Cu wires	660		AR: 300-2000
void fraction, %	31		AR : 20-36
Cooling channel dimensions (if present), mm	8 / 10		AR : 5-20
Cable (=bundle) dimensions: radial x toroidal, mm^2 , or cable diameter, mm.	42 (diameter)		AR : 30-60
Conductor transverse dimensions: radial x toroidal, mm^2 , or cable diameter, excluding insulation, mm	46.00		AR : 50-90
Conductor manufacturing length			< 1400

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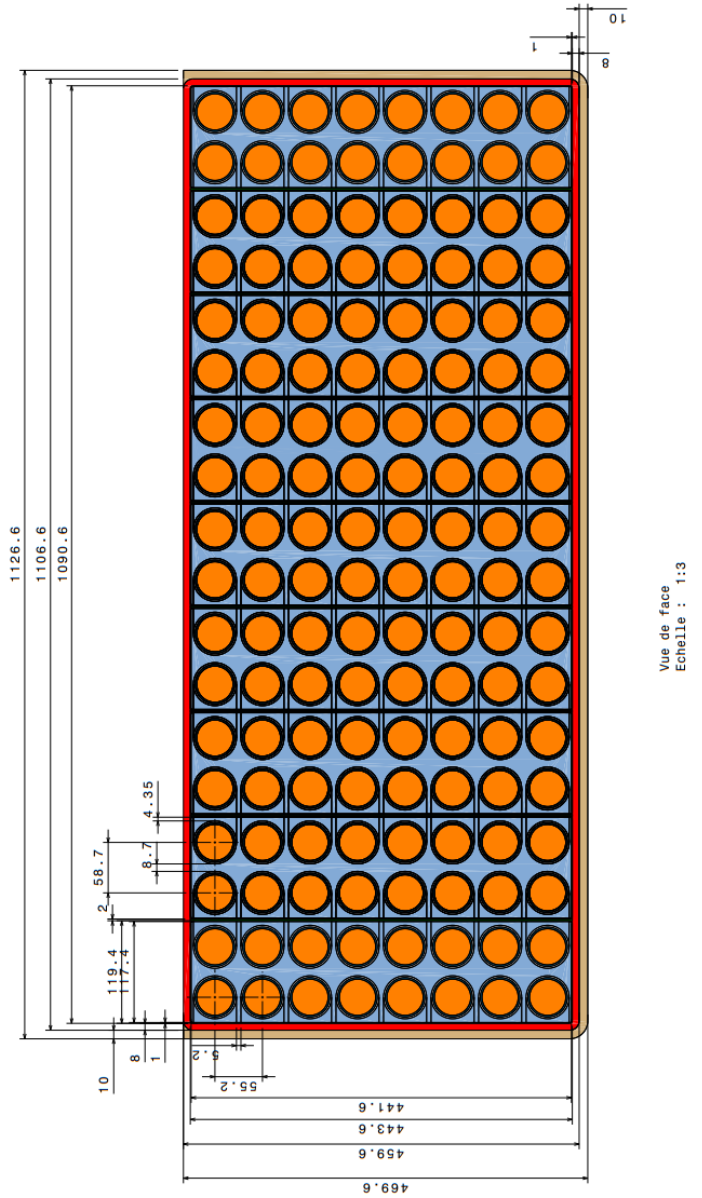
A detailed 2D drawing was also added to the preparatory documents for Gate Review.



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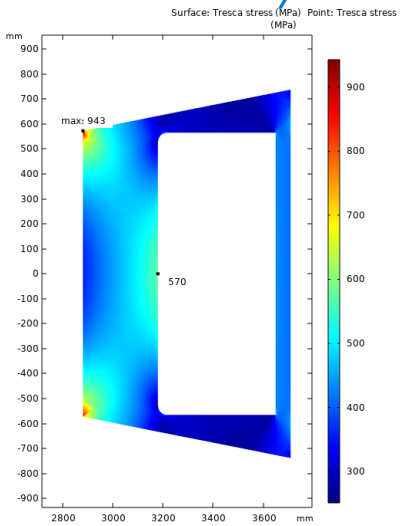
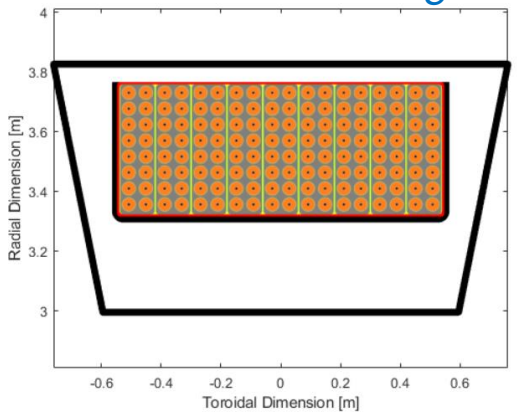
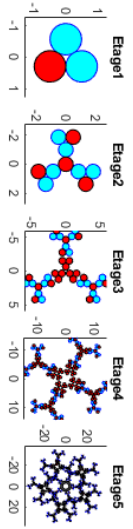
Finally, after some discussion with WP-Leader and DCT, the report itself grouped and referenced the analyses that had been made to constitute a reference document for TF-WP4 design.

2D Mech Analysis

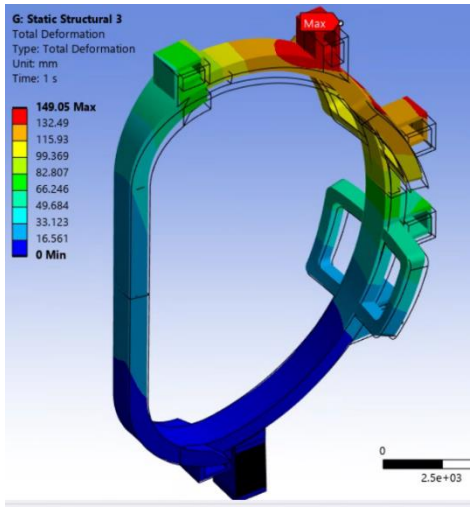


Design and conductor cabling



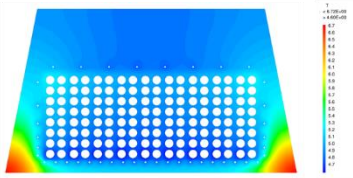


3D Mech Analysis (preliminary)

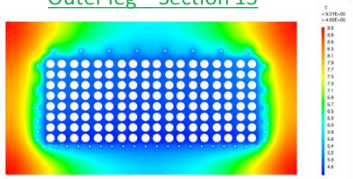


FSD thermal analysis

Inner leg – Section 17



Outer leg – Section 13



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MAG-S.01.01-T024-D001 Deliverable on 2025 CEA TF-WP4 design

What could be added in the report is a parametric mechanical study of structural supports using the CIRCE toolbox.

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MAG-S.01.01-T024-D002

Deliverable on 2025 CEA CS designs

2025 CEA TS
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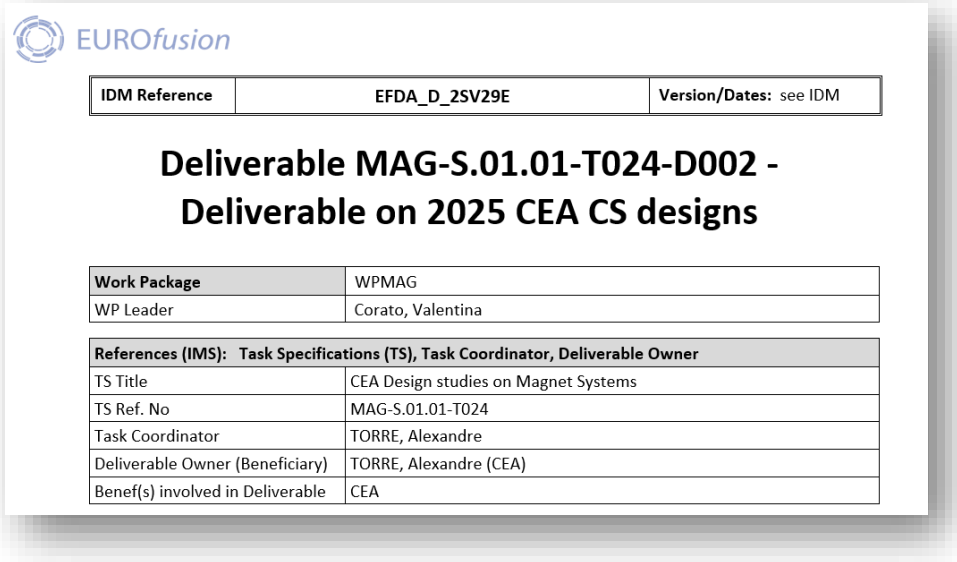
MAG-S.01.01-T024-D002 Deliverable on 2025 CEA CS designs

Here again, we proposed an initial version of the reportwith a **CS Design Overview for the 2025 Gate Review**, trying to provide the Work Package Leader and DCT a clear view of the latest design, along with what had been done in terms of analysis.



EUROfusion

IDM Reference	EFDA_D_2SV29E	Version/Dates: see IDM

Deliverable MAG-S.01.01-T024-D002 - Deliverable on 2025 CEA CS designs

Work Package	WPMAG
WP Leader	Corato, Valentina

References (IMS): Task Specifications (TS), Task Coordinator, Deliverable Owner	
TS Title	CEA Design studies on Magnet Systems
TS Ref. No	MAG-S.01.01-T024
Task Coordinator	TORRE, Alexandre
Deliverable Owner (Beneficiary)	TORRE, Alexandre (CEA)
Benef(s) involved in Deliverable	CEA

2025 CEA TS
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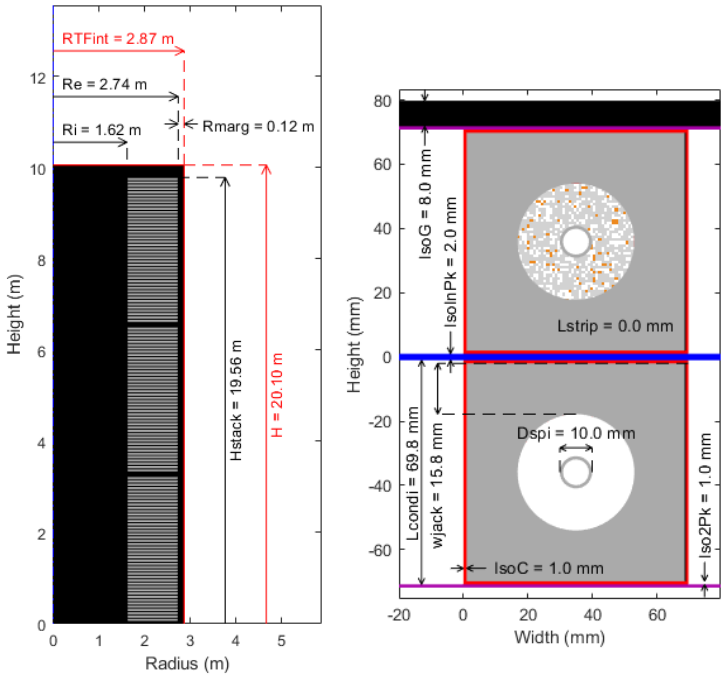
MAG-S.01.01-T024-D002 Deliverable on 2025 CEA CS designs

We summarized the basline CS proposed (LTS/JK2LB/218Wb), and discussed briefly the potential impact of alternative configurations (CHSN01 or hybrid)

Baseline: ITER-like
LTS / JK2LB – 218Wb

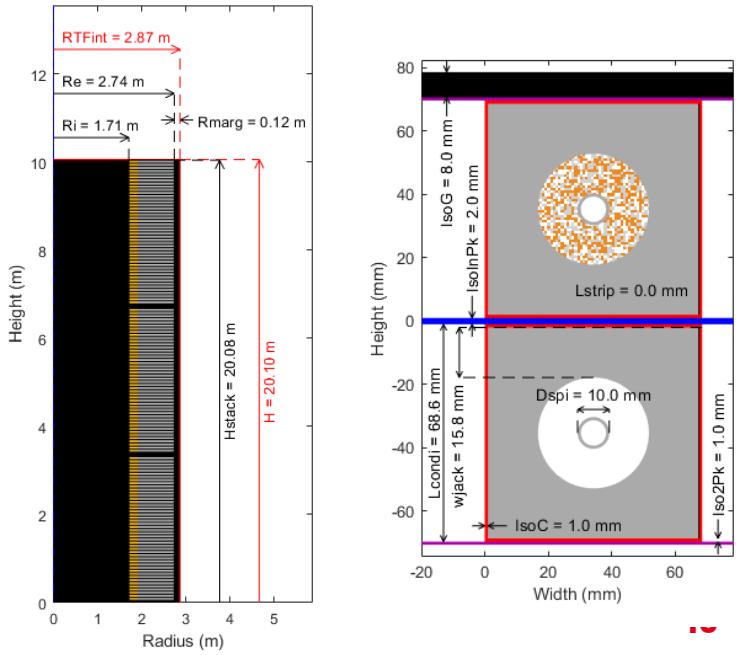


Using CHSN01 (ex N50H) on Baseline design – 228Wb

Optimum LTS-CHSN01 design – 232Wb

"Constant Tension" using a co-wound steel strip – 228Wb

Hybrid design: Using CHSN01 (ex N50H) and HTS inner turns – 239Wb



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MAG-S.01.01-T024-D002 Deliverable on 2025 CEA CS designs

Our goal before submitting final report is to provide additional analyses for CS, in particular a mechanical analysis that should be done by CEA IRFU (F. Nunio / R. Cubizolles).

Their feedback is that they are on track to do it in the next month or so.

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MAG-S.01.01-T024-D003

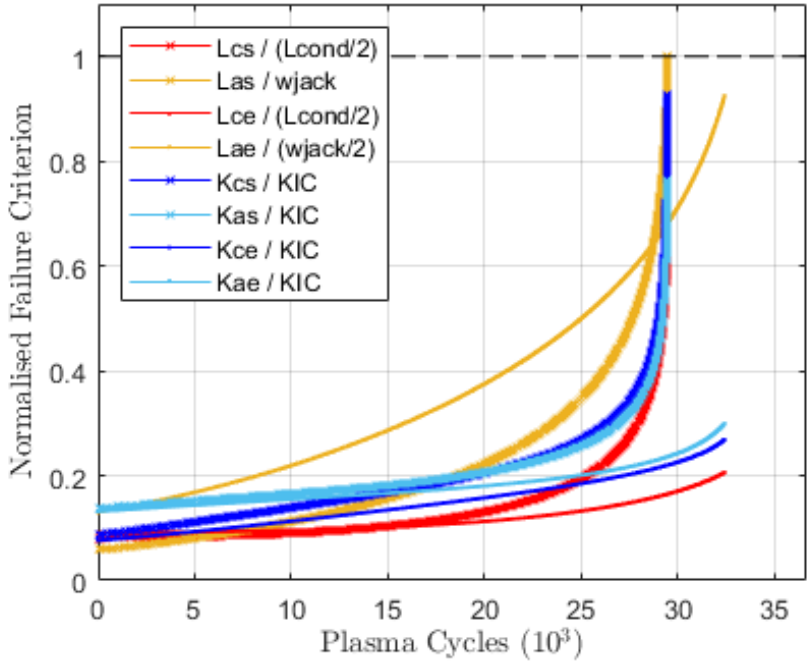
Deliverable on 2025 CEA Industrial study

2025 CEA TS
Design / Ind Study / Procurement

MAG-S.01.01-T024-D003 Deliverable on 2025 CEA Industrial study

We had planned to make an industrial study to get a feedback on the **fatigue methodology** used in CS conductor jacket design and on **cryogenic tests of N50H/CHSN01**

This was also linked, but in parallel, to the DCT fatigue workgroup.



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MAG-S.01.01-T024-D003 Deliverable on 2025 CEA Industrial study

We wrote 2 Tech Specs and sent it out to :

- **BeBlue Cryotech [Belgium]**
- **CETIM [France]**

Review & Methodology

Nature	TECHNICAL NOTE
Titre *Title*	Specifications: Support and critical review of fatigue analysis for steel jackets of superconducting cables
Résumé *Abstract*	This note describes the specifications for support and critical review of fatigue analyses performed on steel jackets of superconducting cables. An underlying activity involves support and critical evaluation of non-destructive testing (NDE) methods for detecting initial defects (input data for fatigue analyses).
Référence(s) / Version	
Date de la version *Version* date	23/09/2025

Tests and characterization

Nature	TECHNICAL NOTE
Titre *Title*	Specifications: Experimental campaign dedicated to the study of CHSN01 steel jacket properties
Résumé *Abstract*	This note presents the specifications for an experimental campaign aimed at characterizing CHSN01 steel jackets. It includes residual stress measurements, standardized tests to determine Paris law parameters, and full-scale jacket fatigue testing for design purposes.
Référence(s) / Version	
Date de la version *Version* date	V1.0 - 23/09/2025

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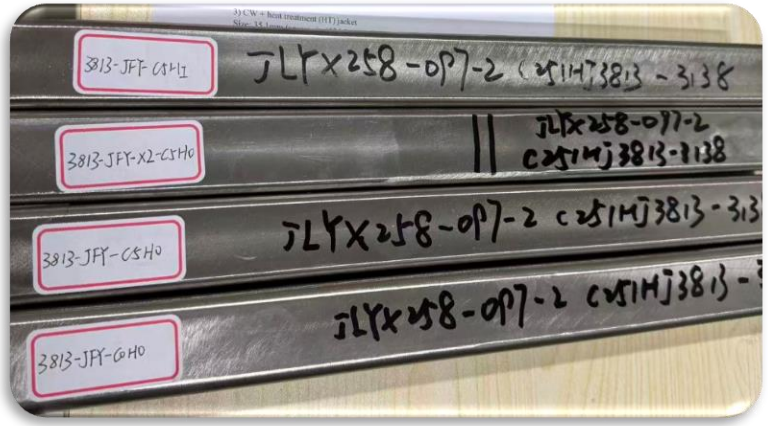
MAG-S.01.01-T024-D003 Deliverable on 2025 CEA Industrial study

We also discussed with ASIPP to procure some test specimens (~400mm long)

1) Initial jacket
2) Cold working (CW) jacket
3) CW + heat treatment (HT) jacket
4) Weld joint



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MAG-S.01.01-T024-D003 Deliverable on 2025 CEA Industrial study

Clarification meetings have been done with the companies, with some of them that could do only part of the expected work.

The CHSN01 conductor jackets are only now arriving in France…

We've had mail answers regarding potential prices and planning for these tests.

Unfortunately, the delay for obtaining these offers means we only could have the tests in June-July. Thus we could either propose to:

- ***Launch this 2025activity in 2026 (if still possible)***
- ***Wait for 2026 activities to see if we could fit it in.***
- ***Cancel this activity***

2025 CEA TS
Design / Ind Study / Procurement

MAG-S.01.01-T024-D004

Deliverable on 2025 CEA conductor procurement

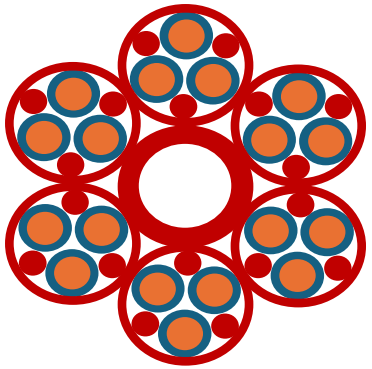
2025 CEA TS
Design / Ind Study / Procurement

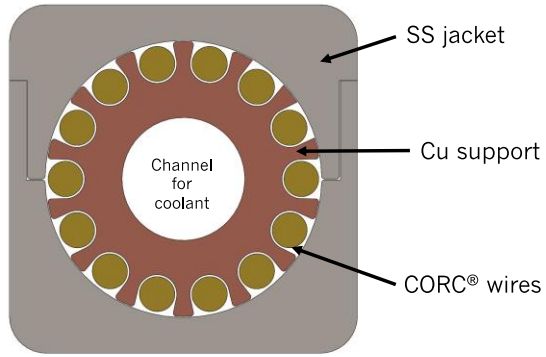
MAG-S.01.01-T024-D004 Deliverable on 2025 CEA conductor procurement

In 2025, we proposed the procurement of small diameter HWRC (Helically Wound Rebco Cables), like CORC@ wires or STAR@ wires, in view of a multi-wire cable in SULTAN.

For this we wrote a Tech Spec with the following points:

- ~3kA@(18T,4,2K) HWRC wires
- ~48mm-width of HTS Rebco tapes
- Total length 100m





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MAG-S.01.01-T024-D004 Deliverable on 2025 CEA conductor procurement

Offers were received in September.

ACT (CORC-wires) was the best offer.
- 8 layer wire
- 2 tapes of 3mm per layer
- OD 4mm

Order is being processed
(to be finalized feb 2026)

Advanced Conductor Technologies
www.advancedconductor.com

Expected cable layout

	# tapes	type	thickness [mm]	Width [mm]	ID [mm]	gap [mm]	pitch [mm/rev]	alpha [°]
1	2	SC	0.048	3	3.05	0.4	9.65	45.21
2	2	SC	0.048	3	3.146	0.4	9.37	43.47
3	2	SC	0.048	3	3.242	0.4	9.13	41.89
4	2	SC	0.048	3	3.338	0.4	8.93	40.42
5	2	SC	0.048	3	3.434	0.4	8.76	39.07
6	2	SC	0.048	3	3.53	0.4	8.61	37.82
7	2	SC	0.048	3	3.626	0.4	8.48	36.65
8	2	SC	0.048	3	3.722	0.4	8.36	35.56
9	2	Cu	0.05	4	3.818	0.4	12.95	47.19
10	2	Cu	0.05	4	3.918	0.4	12.59	45.64
				Final OD	4.018	mm		