

IFAST

Innovation Fostering in Accelerator Science and Technology

Horizon 2020 Research Infrastructures GA n° 101004730

STONE REPORT

Construction of the combined formers for CCT winding

STONE: MS34

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ABSTRACT

This milestone (MS34) confirms the successful construction of the combined formers for the Canted-Cosine-Theta (CCT) winding in IFAST WP8. The formers, produced within Task 8.4, ensure precise conductor placement and mechanical stability for the magnet demonstrator. The conformity certificate verifies compliance with specifications. This achievement marks a key step towards Deliverable D8.4 and the upcoming winding and assembly of the CCT demonstrator magnet.

IFAST Consortium, 2025

For more information on IFAST, its partners and contributors please see <https://ifast-project.eu/>

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Delivery Slip

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Executive summary

This report presents Milestone MS34 of I.FAST Work Package 8, dedicated to innovative superconducting magnet technologies.

Within Task 8.4, combined formers for the Canted-Cosine-Theta (CCT) winding have been successfully designed, manufactured, and inspected as a key step toward the realization of the CCT magnet demonstrator (Deliverable D8.4).

The formers ensure the precise definition of the conductor path and provide the necessary mechanical stability for winding and operation.

Dimensional checks and the related certificate of conformity, issued by Arquimea (Spain), confirm overall compliance with project specifications. Although a few deviations from nominal tolerances were identified, they are minor, non-critical, and manageable in the final magnet assembly.

The completion of this milestone provides validated components for the next phase of the project, enabling the winding and integration of the demonstrator magnet.

1. Introduction

Within the framework of I.FAST Work Package 8, dedicated to innovative superconducting magnet technologies, Task 8.4 focuses on the construction of a combined Canted-Cosine-Theta (CCT) magnet demonstrator based on Nb-Ti superconductor [1-3]. A critical step in this process is the fabrication of the combined formers, which define the precise geometry of the conductor path and provide the mechanical support necessary during winding and operation. Their accurate construction is essential to guarantee the field quality, structural integrity, and overall performance of the demonstrator magnet. This milestone (MS34) documents the completion of the formers, together with the conformity certificate attesting their compliance with the project specifications. The achievement represents a significant advance towards Deliverable D8.4, the realization of the CCT magnet demonstrator. A detailed dimensional report and the related certificate of conformity on the manufactured formers were issued by Arquimea (Spain) and presented in the following section.

2. Combined formers

The combined formers drawings and manufactured in Arquimea company are shown below.

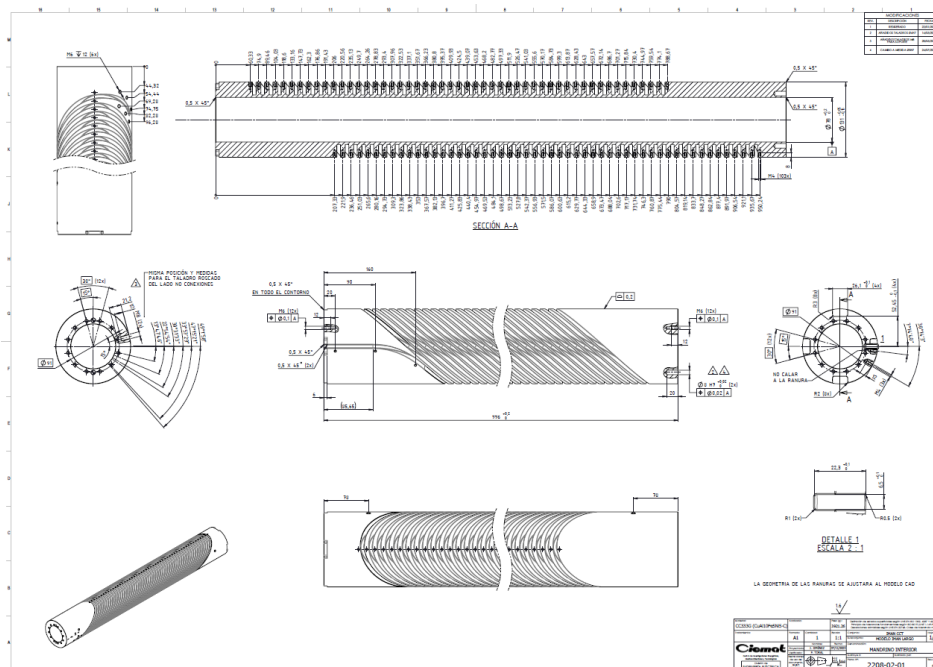


Figure 1. Manufacturing drawing for the inner former.

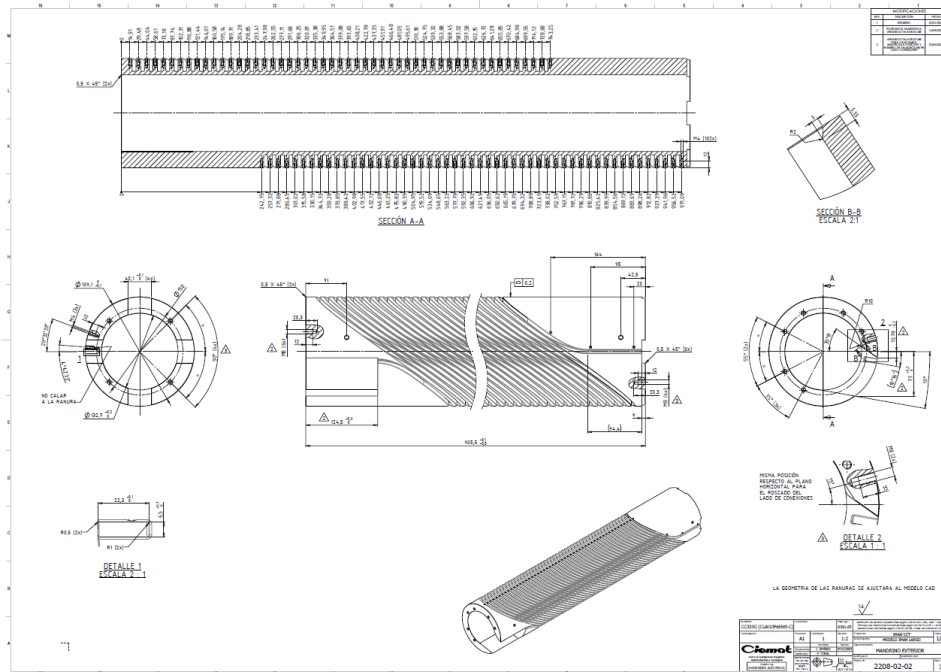


Figure 2. Manufacturing drawing for the inner former.

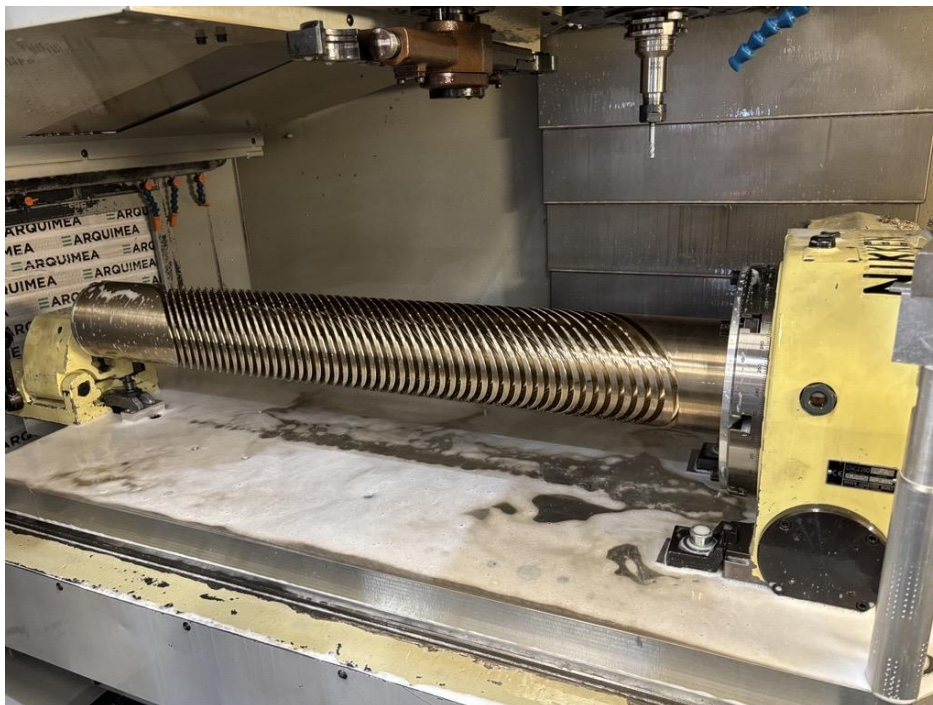


Figure 3. Machining of the inner former.



Figure 4. Manufacturing of the outer former.

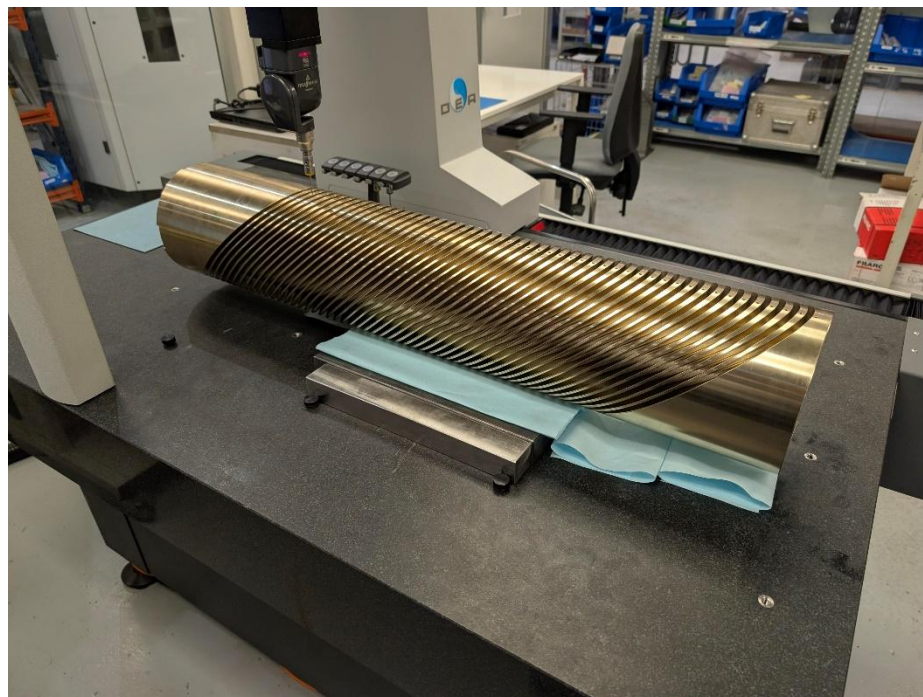


Figure 5. Dimensional control of the inner former.

3. Dimensional report with conformity certificate

ARQUIMEA Arquimea Advanced Systems	NOTA DE ENTREGA <i>DELIVERY NOTE</i> CIEMAT Avda. Complutense 40 MADRID 28040 España								
NOTA Nº <i>DELIVERY NOTE</i> 0061/25	FECHA <i>DATE</i> 08/09/2025								
S/PEDIDO <i>YOUR ORDER</i> 298488									
<table><thead><tr><th>CONCEPTO <i>DESCRIPTION</i></th><th>UNIDADES/<i>QTY</i></th></tr></thead><tbody><tr><td>MANDRINO INTERIOR 2208-02-01</td><td>1</td></tr><tr><td>MANDRINO EXTERIOR 2208-02-02</td><td>1</td></tr><tr><td>TUBO EXTERIOR 2208-02-03</td><td>1</td></tr></tbody></table>	CONCEPTO <i>DESCRIPTION</i>	UNIDADES/ <i>QTY</i>	MANDRINO INTERIOR 2208-02-01	1	MANDRINO EXTERIOR 2208-02-02	1	TUBO EXTERIOR 2208-02-03	1	
CONCEPTO <i>DESCRIPTION</i>	UNIDADES/ <i>QTY</i>								
MANDRINO INTERIOR 2208-02-01	1								
MANDRINO EXTERIOR 2208-02-02	1								
TUBO EXTERIOR 2208-02-03	1								
COMENTARIOS <i>COMMENTS</i>									
<div>Recibi <i>Received</i></div> <div>Verano 9 · Pol. Ind. Las Monjas · 28850 Torrejón de Ardoz · Madrid adminfinaas@arquimea.com www.arquimea.com</div>									

ARQUIMEA
Arquimea Advanced Systems



CERTIFICADO DE CONFORMIDAD

CERTIFICATE OF CONFORMANCE

Nº CoC 061/25-1

Nº REF CLIENTE CUSTOMER REF. 298488

DESTINATARIO TO CIEMAT

DENOMINACION /Nº PLANO /REV DESIGNATION /DRAWING Nº /ISSUE	CANT QTY
MANDRINO INTERIOR 2208-02-01	1
MANDRINO EXTERIOR 2208-02-02	1
TUBO EXTERIOR 2208-02-03	1

OBSERVACIONES REMARKS

Ver observaciones en Informe de Verificación

ARQUIMEA ADVANCED SYSTEMS CERTIFICA QUE LOS SUMINISTROS O SERVICIOS ARRIBA DETALLADOS ESTAN CONFORMES RESPECTO A LAS ESPECIFICACIONES, PLANOS Y CONTRATO (A EXCEPCIÓN DE LAS DESVIACIONES NOTIFICADAS EN LA CASILLA DE OBSERVACIONES). ADEMÁS, TODOS LOS SUMINISTROS HAN SIDO INSPECCIONADOS Y PROBADOS DE ACUERDO CON LAS CONDICIONES Y REQUISITOS DEL CONTRATO.
ARQUIMEA ADVANCED SYSTEMS CERTIFIES THAT THE SUPPLIES OR SERVICES ABOVE DETAILED CONFORM RESPECTS TO THE SPECIFICATION(S), DRAWING(S) AND CONTRACT (APART FROM THE DEVIATIONS NOTED IN BOX OF REMARKS). ALSO ALL THE SUPPLIES HAVE BEEN INSPECTED AND TESTED IN ACCORDANCE WITH THE CONDITIONS AND REQUIREMENTS OF THE CONTRACT

NOMBRE NAME M. Mar López

FECHA DATE 08/09/2025





FUNCIÓN FUNCTION Dir.ª de Calidad


FIRMA SIGNATURE


Arquimea Advanced Systems

Verano 9 - Pol. Ind. Las Monjas - 28850 Torrejón de Ardoz - Madrid - www.arquimea.com

RP00910-C



ARQUIMEA		INFORME DE VERIFICACIÓN		CONTROL CERTIFICATE		 	
Arquimea Advanced Systems							
CLIENTE: CIEMAT <i>Customer</i>		Nº Serie/Ref: <i>Serial N°</i>		INFORME Nº: 23294-04 <i>Certificate N°</i>			
Nº de Plano: 2208-02-01 <i>Drawing N°</i>		Edición: 4 <i>Issue</i>		Cantidad: 1 <i>Quantity</i>			
¿ESTA EL PRODUCTO EN SU CONFIGURACIÓN CORRECTA? <input checked="" type="checkbox"/> SI <input type="checkbox"/> NO IS THE PRODUCT IN ITS CORRECT CONFIGURATION?							
ITEM	TIPO	MEDIDA NOMINAL Specified Size	Tol. -	Tol. +	MEDIDA REAL Measured Size		OBSERVACIONES Remarks
					Min	Máx	
2.1	∅	131	0,15	0,05	130,890		
	∅	78	0	0,2	78,140		
	↔	996	0	0,2	996,04		
	⌒	0,2	0,2	0	0,082		
	↔	26,1 (4x)	0	0,1	26,122	26,133	
	↔	52,45	0,1	0	52,429	52,450	
	RM	M6 (30x)			OK		
	⊕	∅ 0,1 A (24x)	0,1	0	0,015	0,082	Posición M6
	▽	12 (30x)	0	8	13,20		
	↔	6,5	0	0,1	6,553	6,661	
	↔	22,3	0	0,1	22,336	22,449	
	↔	Posición ranura			0,001	0,044	Desviación distancia lineal medida en 101 posiciones
	∅	8 H7 (2x)	0	0,015	8,009	8,010	
	⊕	∅ 0,02 A	0,02	0	0,02		
	RM	M4 x 12 (106x)			OK		
	↔	Posición M4 (103x)			0,005	0,111	Desviación distancia lineal en totalidad de las 103 roscas M4
OBSERVACIONES: Cuando no se especifique tolerancia, aplicará la general de plano ISO 2768-mK <i>Remarks:</i> Desviaciones notificadas a cliente y autorizadas para entrega							
EQUIPOS DE MEDIDA UTILIZADOS: PR-117 3D-03 PR-120 MI-15-2 CLR-63 CLR-01-4 <i>Measuring Equipment Used</i>							
TEMPERATURA DE REFERENCIA: 20° C ± 2°C COMPROBADO: <input checked="" type="checkbox"/> <i>Reference Temperature</i> <i>Checked</i>							
TRAZABILIDAD: Los patrones e instrumentos indicados en este informe tienen garantizada su trazabilidad a través de los certificados de calibración vinculados o emitidos por laboratorios reconocidos por ENAC (Entidad Nacional de Acreditación) u otra entidad perteneciente a EA (European Co-Operation for Accreditation).							
RESULTADOS: Los resultados que aparecen en el certificado de Control se refieren al momento y condiciones en que se realizaron las mediciones.							
NORMA O PROCEDIMIENTO UTILIZADO: PT-011 "PAUTA DE VERIFICACIÓN"							
NORM:							
REALIZADO POR: Juan Carlos Prados <i>Elaborated by</i>				REVISADO POR: Ignacio Zamora <i>Reviewed by</i>			
FECHA: 08/09/2025 				FECHA: 08/09/2025 			



ARQUIMEA
Arquimea Advanced Systems

INFORME DE VERIFICACIÓN

CONTROL CERTIFICATE

CLIENTE: CIEMAT
Customer

Nº de Plano: 2208-02-02
Drawing Nº

Nº Serie/Ref:
Serial Nº

Edición: 3
Issue

INFORME Nº: 23294-05
Certificate Nº

Cantidad: 1
Quantity

¿ESTA EL PRODUCTO EN SU CONFIGURACIÓN CORRECTA? ☒ SI ☐ NO
IS THE PRODUCT IN ITS CORRECT CONFIGURATION?

ITEM	TIPO	MEDIDA NOMINAL <i>Specified Size</i>	Tol. -	Tol. +	MEDIDA REAL <i>Measured Size</i>		OBSERVACIONES <i>Remarks</i>
					Min	Máx	
2.2	∅	189,1	0,1	0	189,080		
	∅	132,7	0	0,2	132,750		
	↔	985,5	0,1	0,3	985,59		
	⌒	0,2	0,2	0	0,169		
	↔	40,1 (4x)	0	0,1	40,15		
	▽	124,5	0	0,2	124,19		
	°	10°	0,5	0,5	9,939°		
	°	35,13°	0,5	0,5	35,317°		
	RM	M8 x 12 (10x)			OK		
	RM	M8 x 15 (2x)			OK		
	RM	M4 x 12 (105x)			OK		
	↔	Posición M4 (102x)			0,066	0,216	Desviación distancia lineal en totalidad de las 102 roscas M4
	↔	6,5	0	0,1	6,654	6,728	
	▽	22,3	0	0,1	22,225	22,473	
	↔	Posición ranura			0,116	0,198	Desviación distancia lineal medida en 100 posiciones

OBSERVACIONES: Cuando no se especifique tolerancia, aplicará la general de plano ISO 2768-mK
Remarks: Desviaciones notificadas a cliente y autorizadas para entrega

EQUIPOS DE MEDIDA UTILIZADOS: PR-117 3D-03 PR-120 MI-15-2 CLR-63 CLR-01-5
Measuring Equipment Used

TEMPERATURA DE REFERENCIA: 20° C ± 2°C **COMPROBADO:** ☒
Reference Temperature *Checked*

TRAZABILIDAD: Los patrones e instrumentos indicados en este informe tienen garantizada su trazabilidad a través de los certificados de calibración vinculados o emitidos por laboratorios reconocidos por ENAC (Entidad Nacional de Acreditación) u otra entidad perteneciente a EA (European Co-Operation for Accreditation).

RESULTADOS: Los resultados que aparecen en el certificado de Control se refieren al momento y condiciones en que se realizaron las mediciones.

NORMA O PROCEDIMIENTO UTILIZADO: PT-011 "PAUTA DE VERIFICACIÓN"


NORM:


REALIZADO POR: Juan Carlos Prados
Elaborated by

FECHA: 05/08/2025

REVISADO POR: Ignacio Zamora
Reviewed by

FECHA: 04/09/2025





Página 2 de 3

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4. Conclusions

The construction of the combined formers for the CCT winding has been successfully completed and verified through dimensional inspection and the conformity certificate provided by Arquimea (Spain). The measurements confirm overall compliance with the design specifications, ensuring suitability for the magnet demonstrator. A few minor deviations from the nominal tolerances were identified; however, these are not critical and can be managed without impact on the winding process or the final magnet assembly. The manufactured formers are therefore validated for integration into the next phase of Task 8.4, representing a key step toward the realization of Deliverable D8.4.

5. References

- [1] E. De Matteis, G. Ceruti, S. Mariotto, M. Priol, S. Sorti, «Conceptual Design of combined CCT in LTS», Zenodo, feb. 2022. doi: 10.5281/zenodo.6389851.
- [2] E. De Matteis et al., "Straight and Curved Canted Cosine Theta Superconducting Dipoles for Ion Therapy: Comparison Between Various Design Options and Technologies for Ramping Operation," in IEEE Transactions on Applied Superconductivity, vol. 33, no. 5, pp. 1-5, Aug. 2023, Art no. 4401205, doi: 10.1109/TASC.2023.3259330.
- [3] F. Toral et al., "Status of Nb-Ti CCT Magnet EU Programs for Hadron Therapy," in IEEE Transactions on Applied Superconductivity, vol. 34, no. 5, pp. 1-5, Aug. 2024, Art no. 4401705, doi: 10.1109/TASC.2023.3349252.