Criotec IMPIANTI S.p.A.

CRIOTEC IMPIANTI SpA

Via F. Parigi 32/a - 10034 Chivasso (TO) - ITALY

AIDA innova

Valencia

Cabling production of massive SC conductors and process control

Company Profile

- Founded in 1988 by group of specialists with more than 20 years of experience in the cryogenic field.
- Core business in cryogenics
- European market + worldwide supplies

- 50 employees
- 2018 Turnover: about 9 M€
- 2019 Turnover: about 11 M€
- 2020 Turnover: about 11 M€ (despite COVID-19)
- 2021 Turnover: about 11 M€

CRIOTEC expertise can be divided in the following technical areas:

➔ Cryogenics & High Vacuum

➔ Heat exchangers

➔ Gas distribution systems

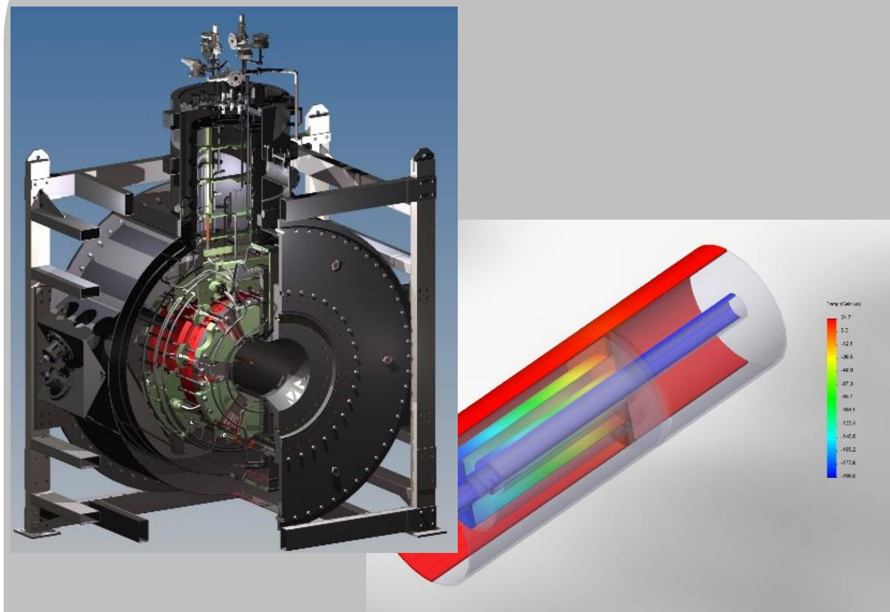
➔ Turn-key plants (engineering and manufacturing)

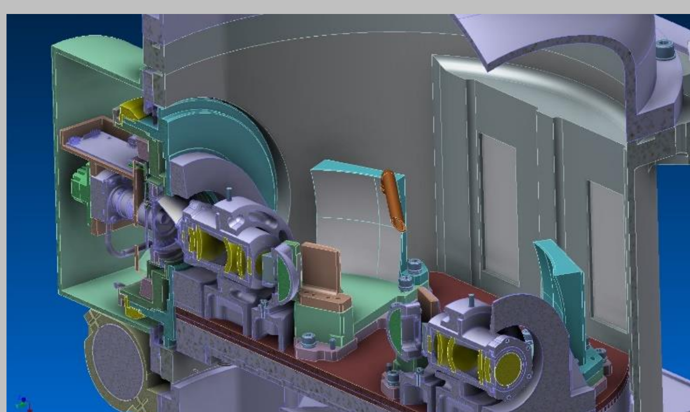
➔ Superconducting cables and magnets

➔ Aerospace components / test facilities

Company Profile

Engineering / Design





Production

Workshop area	3500 m²
Offices	600 m²
Clean room area ISO 8	64 m²

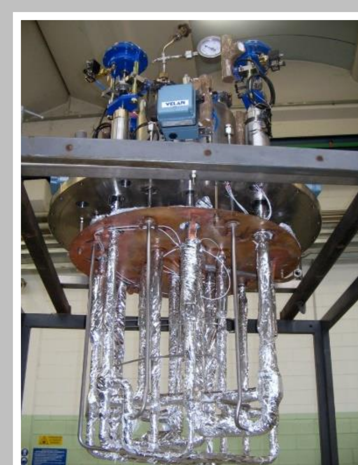
Cryogenics – Cryostats and transfer lines

Km of cryogenic transfer lines for LIN, LOX, LAr, LHe.

Liquid helium long vertical cryostat (7 mt long) for superconductivity tests – INFN

Fully flexible cryolines (60 m)

Liquid helium cryostats

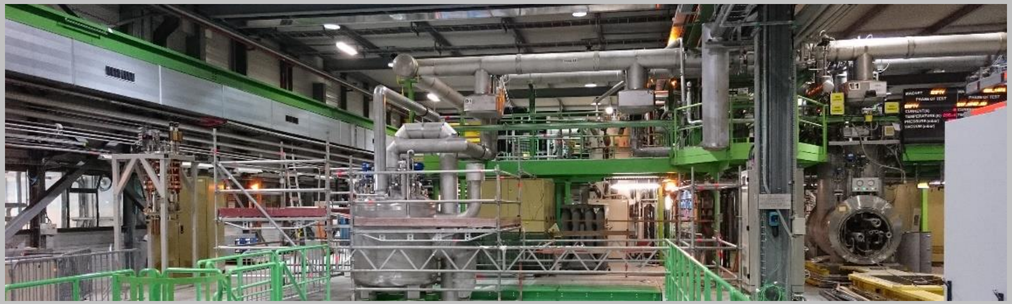


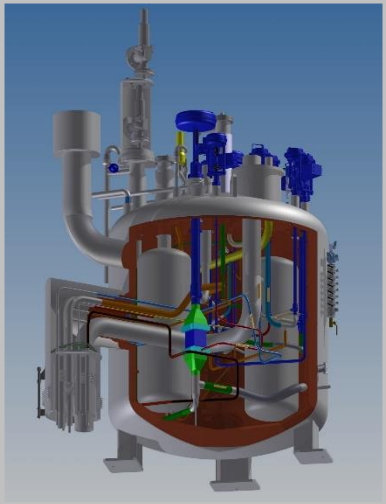
For LHe with active shield

Cryogenics: Liquid helium distribution systems

Cryogenic distribution system for liquid helium for ISOLDE project – CERN (Switzerland)

Cryogenic distribution system for Lhe for HFM e Cluster D (SM18) – CERN (Switzerland)





Cryogenics: special systems

CMS central superconducting solenoid thermal shield – CERN LHC (2005)

Dimensions
Height: 20 meters
Diameter: 12 meters

Awarded by CERN with the «CMS Gold Award» in 2005 for the results obtained

Liquid helium cryostat with 26 Tesla superconducting magnet – Helmholtz-Zentrum Berlin (Germany)

Roughly 370’000 times higher than the Earth’s magnetic field, equal to 0,00007 Tesla

Cryogenics: RF Cavities test facility in LHe

Cryogenic test facility (2x Cavities Support Inserts, 1 Cryostat, 1 horizontal valve box and related transfer lines) for STFC (UK)

Cryogenics

Satellite test facility (5 mt wide, 5 mt long, with cryogenic cooling system at 80 K)

Cryogenic heat exchangers / vaporizers

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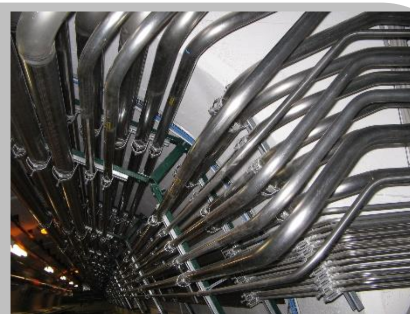
Cryogenic heat exchangers

Atmospheric vaporizers

Water vaporizers

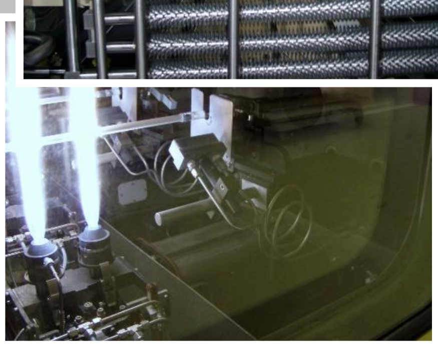
Special applications

Gas distribution system: gas panels



Installation of about 34 Km of austenitic stainless steel for LHC accelerator - CERN

Realization of gas distribution panels for VEGA launch PAD – Korou (French Guyana)

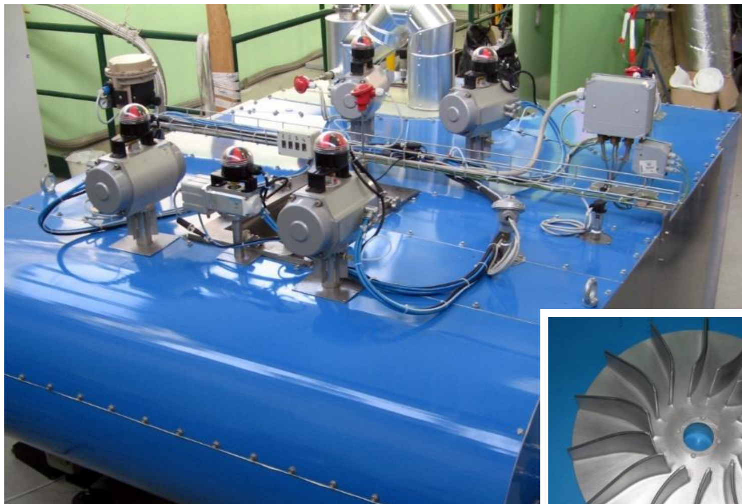


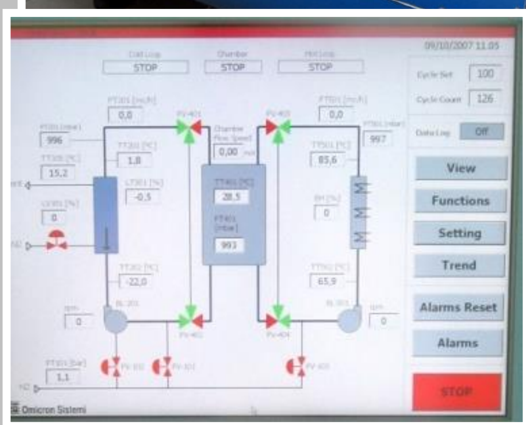
Optical fiber production gas cabinet – PIRELLI cavi (2003)

Panel gas trolley

Special systems

Accelerated climatic chamber to perform cycling test, installed at the European Space Agency (ESA)





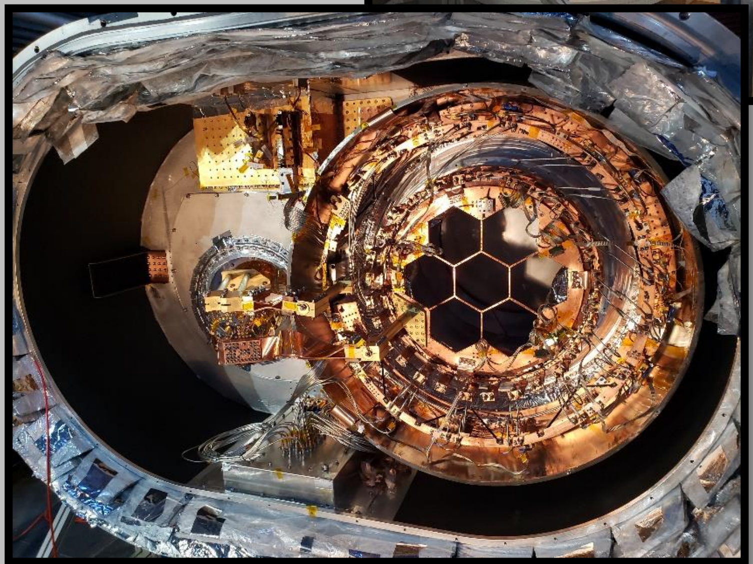
Cycles between -180 °C and +320 °C in 7 minutes

Cryostat for the cooling of an optical bench for the Telescope TNG in Canary Island (Spain)

Thermal stability of the bench at 77 K = ±10 mK

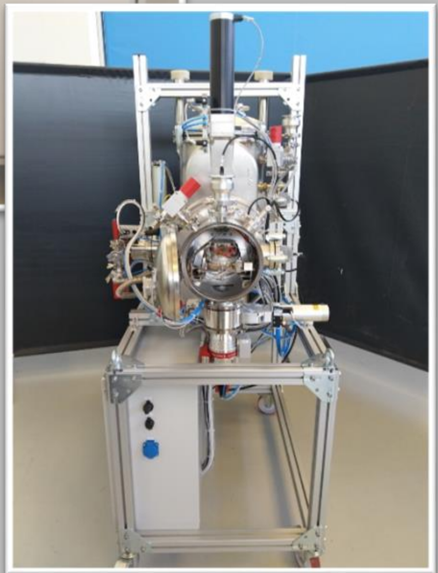
Special systems

Nr. 3 Cryostats for Simons Observatory telescope (San Diego University, CA)



Fully in aluminium alloy, 3 layers 4K, 40K, RT

Offgassing test chamber (Thales Alenia Space Italy)



Nuclear Fusion

HeFUS$_3$ (Helium for FUSion) – ENEA Brasimone

High temperature and high pressure test facility for helium cooling characterization for nuclear fusion application.

Pressure = 80 bar

Temperature = 530 °C

He flow rate = 0,35 Kg/s

Injection line and main support frame of the HFPI project (High Frequency deuterium ice Pellet Injector EFDA – JET

Liquid litium cooling system LiFUS III, for corrosion tests and development of purification sensors working in litium – ENEA Brasimone

Design temperature: 500°C

High Speed Deuterium pellets injection system for the Ignitor Experiment – ENEA Frascati (ITALY) and Oak Ridge National Laboratories, TN USA

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Superconductivity

Jacketing line for the production of CICC conductors for ITER project

Winding line for the manufacturing of Superconducting magnets.

Design and manufacturing of 20 KA current leads, suitable to work with two cooling fluids (LHe and LN2) or at 10 KA with LHe only

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Space components

Gas trap

Refill valve

Buffer tank unit

Water tanks

Check valve

ON / OFF valve

Test Facilities

Testing Facilities in CLEAN ROOM ISO8

TVC1: D x l: 3’000 mm x 4’000 mm
Vacuum: < 1.0e-5 mbar
Temperature: -196 / +150 °C

TVC2: D x l: 800 mm x 2’000 mm
Vacuum: < 1.0e-5 mbar
Temperature: -196 / +80 °C

Other test facilities

Diameter: 4380 mm x 4040 mm (h)
Vacuum: < 1.0e-5 mbar

Diameter: 2760 mm x 2100 mm (h)
Vacuum: < 1.0e-5 mbar

Main customers

GAS INDUSTRIES

AIR LIQUIDE / AIR LIQUIDE Ad. Tec.
AIR PRODUCTS
LINDE
MESSER GROUP
NIPPON GASES (RIVOIRA)
PRAXAIR GROUP
SIAD GROUP
SOL

AEROSPACE SECTOR

D-ORBIT
DLR
ESA
LEONARDO FINMECCANICA
OHB-I
THALES ALENIA SPACE
NSPA (NATO Support and Procurement Agency)
DUTCH DEFENCE AIRFORCE
ITALIAN DEFENCE AIRFORCE

RESEARCH CENTERS BIG SCIENCE

CEA (France)
CERN (Switzerland & France)
CETIAT (France)
ESRF – SYNCROTRON in GRENOBLE (France)
ELETTRA - SYNCROTRON in TRIESTE (Italy)
ENEA (Italy)
HZB (Germany)
I.N.F.N. (Italy)
ITER ORGANIZATION, F4E, KODA, JADA
INRIM (Italy)
KIT (Germany)
L.N.G.S. Laboratori Nazionali Gran Sasso (Italy)
PSI (Switzerland)

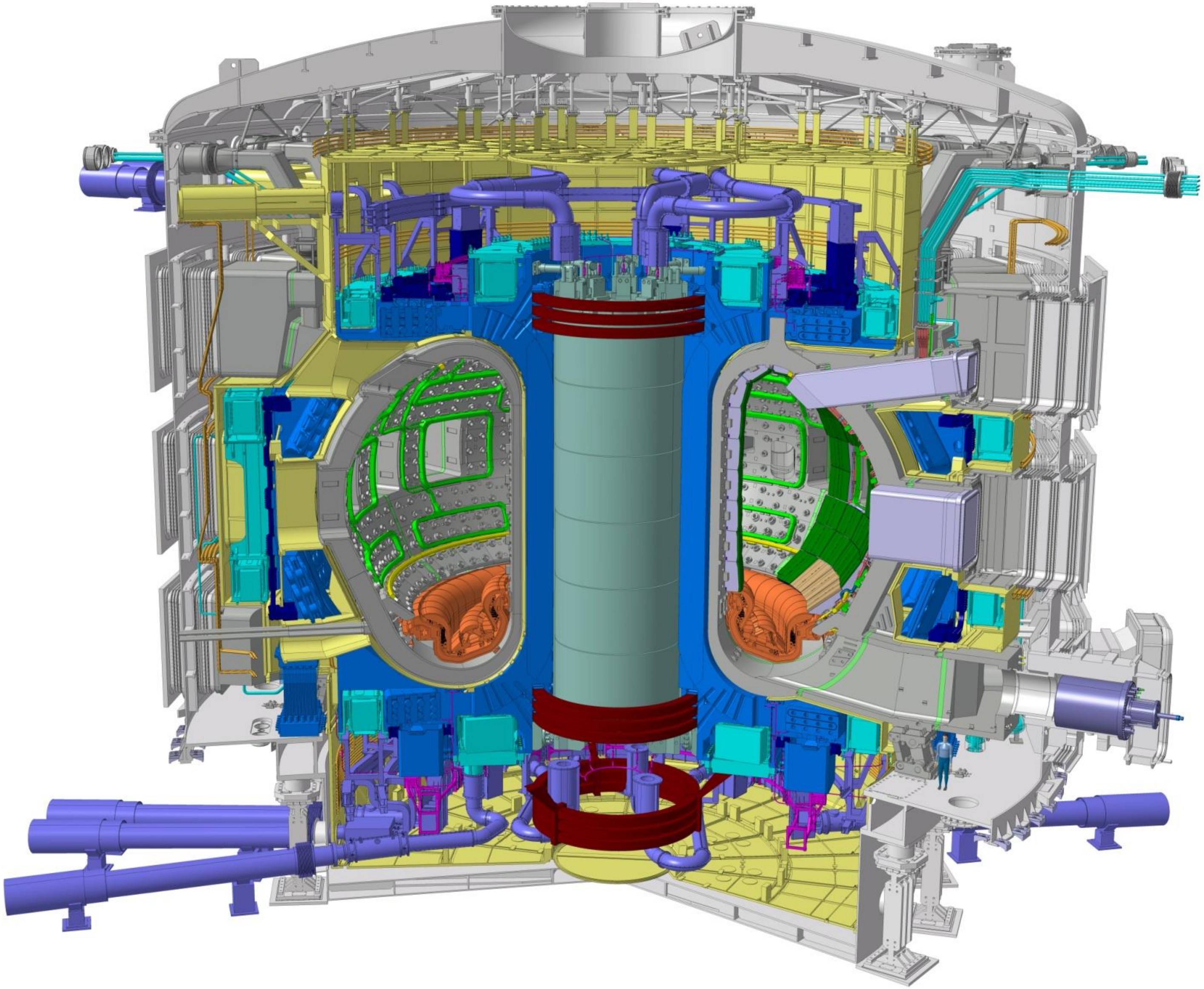
UNIVERSITIES

NHMFL, Florida State University (U.S.A.)
COLUMBIA University (U.S.A.)
PRINCETON University (U.S.A.)
POLITECHNIC SCHOOL OF TORINO, MILANO (Italy)
UNIVERSITIES OF TORINO, MILANO, GENOVA, NAPOLI (Italy)
SAN DIEGO University (U.S.A)

PRIVATE COMPANIES

ASG SUPERCONDUCTORS
ANSALDO ENERGIA / NUCLEARE
BIDACHEM (Boehringer Ingelheim)
PRYSMIAN GROUP

CRIOTEC & ITER PROJECT



Superconducting Cables Jacketing line

Criotec IMPIANTI S.p.A.
CRYOGENIC AND HIGH VACUUM TECHNOLOGIES

ENEA

TRATOS

ICAS
ITALIAN CONSORTIUM FOR APPLIED SUPERCONDUCTIVITY

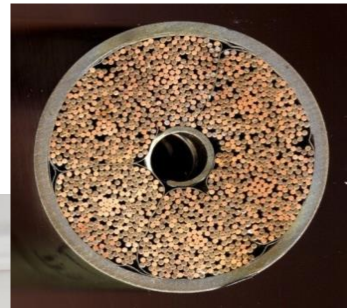
ITER SC Contracts (2010-2023)

Customer	Description
FUSION FOR ENERGY	All the European portion of ITER TF and PF conductors. Supply of about 20 km of ITER TF conductors, 22 km of ITER PF1/6 conductors (jacketing only) and of all the JT-60SA TF conductors (about 30km).
NFRI 국가핵융합연구소 National Fusion Research Institute	All the Korean portion of the ITER TF conductor supply (about 20 km, jacketing only).
VNIIKP	Manufacturing of 3 ITER PF samples for test in the SULTAN facility
Kiswire	Manufacturing of one additional ITER TF unit length (jacketing only)
NFRI 국가핵융합연구소 National Fusion Research Institute	Manufacturing of a portion of the ITER TF conductors supplied by USA (about 4.5km, jacketing only)
iter	Manufacturing of In-Vessel Coils Conductors (IVC)

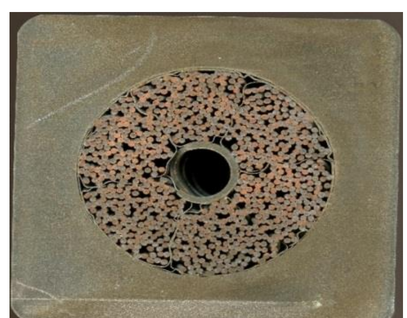
850 mt Jacketing Line

Superconducting Cables Jacketing line

Toroidal Fields (TF)



TF Japan Torus (JT60)



Poloidal Field (PF)

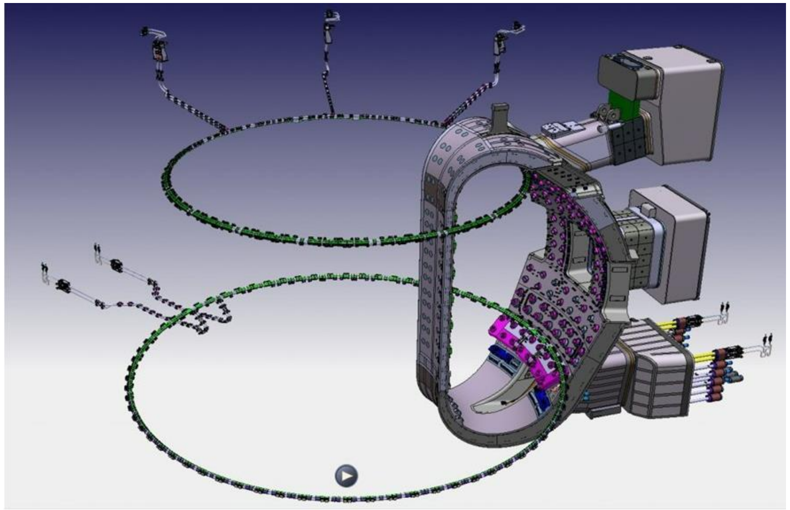
Conduttori per ITER IVC (In-Vessel Coils)

Production of several spools, each 120 mt long, of conductors consisting of:

- 59-mm outer diameter **stainless steel jacket**,
- an insulating layer of **magnesium oxide,**
- an inner **copper** conductor.

Magnesium oxide is chosen for its ability to withstand the harsh radiation environment within the Tokamak.

In total, the in-vessel coils require more than 4 km of mineral-insulated conductors.



ITER NEWSLINE -

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In-vessel coils

FIRST COMPONENTS ARRIVE ON SITE

Anna Encheva, ITER Magnet Division

ITER has received the first shipments of mineral-insulated conductor for ITER's in-vessel coils. The first lengths are destined for winding and bending trials as well as for the production of the first vertical stability coils on site.

Produced by the Italian consortium ICAS S.r.l., the first four conductor lengths—each 105 metres long, on spools—have been transferred to a special temperature and humidity-controlled storage area on site.

Another two sets of straight conductor lengths (20 units, each 12 metres long) have been delivered to ITER contractor Vitzrotech, in South Korea, for the qualification and manufacturing of an auxiliary component called in-vessel coil feedthroughs.

Coming after nearly a decade of development and a detailed qualification phase to confirm the manufacturability of the final design, these deliveries represent a major milestone in the ITER in-vessel coil program.

The mineral-insulated conductor has been specially developed for the in-vessel coils to withstand large transient electromagnetic fields, high radiation flux, and high temperature. The

The first spools of mineral-insulated conductor for ITER's in-vessel coils have arrived. All conductor lengths for the vertical stability coils will be delivered to ITER, while those destined for the manufacture of ELM coils and feedthroughs will be delivered directly to the supplier.

F4E-OPE-018 - Contractual requirements

Table 11: Technical requirements for the TF steel jacket

Item	Requirements
Base material	modified 316LN as specified in section 4.5.4
Minimum length	7 m
Outer diameter, A_0	46 – 48 mm to be finalised during Process Qualification (see section 6) target tolerance ± 0.2 mm
Wall thickness, T_0	2 mm ± 0.1 mm
Straightness	1 mm/m

Table 14: Technical requirements for the PF stainless steel jacket sections

Item	Requirements
Base material	316L as specified in section 4.6.4
Minimum length	6 m
Outer dimension, $A_0 \pm a_0$	To be finalized during Process Qualification (see section 6); the tolerance value is: ±0.2 mm
Difference between vertical and horizontal outer dimensions	< 0.2 mm
Inner diameter, $D_0 \pm d_0$	To be finalized during Process Qualification (see section 6); the tolerance value is: ±0.2 mm
Corner radius, R	To be finalized during Process Qualification (see section 6); the tolerance value is: ±1 mm
Tolerance on cross section, $A_0^2 - \pi D_0^2/4$	± 20 mm^2
Bore eccentricity, Ecc	< 10%
Target roughness, Ra	< 1.6 μm (or equivalent to N7)
Straightness	< 1 mm/m
Twist about the longitudinal axis	< 1 mm/m

F4E-OPE-018 - Contractual requirements

Item	Requirements for TF Conductor	Requirements for PF Conductor	Requirements for JT-60SA TF Conductor
Components	– final stage cable as specified in section 4.4 – stainless steel jacket assembly as specified in section 4.9	– final stage cable as specified in section 4.4 – stainless steel jacket assembly as specified in section 4.9	– final stage cable as specified in section 4.4 – stainless steel jacket assembly as specified in section 4.9
Lengths	as specified in section 4.10.6		
Conductor outside dimensions (after compaction)	Diameter 43.7 ± 0.2 mm (see section 14.1)	$A_1 \pm a_1$: 53.8 ± 0.2 mm (see section 14.2)	22 ± 0.1 mm x 26 ± 0.1 mm
Jacket thickness (after compaction)	2.0 ± 0.1 mm	n.a.	2.0 -0.1 +0.2 mm
Difference between vertical and horizontal dimensions	n.a.	< 0.2 mm	n.a.
Target conductor inner diameter (after compaction)	39.7 mm	37.7 mm	n.a.
Corner radius	n.a.	3 ± 1 mm	4 ± 1 mm
Target central spiral inside diameter (after compaction)	7.9 – 8.1 mm	9.8 – 10.2 mm	n.a.
Packaging	As specified in section 4.10.13		

Main conductors size

ITER TF conductors (round to round)

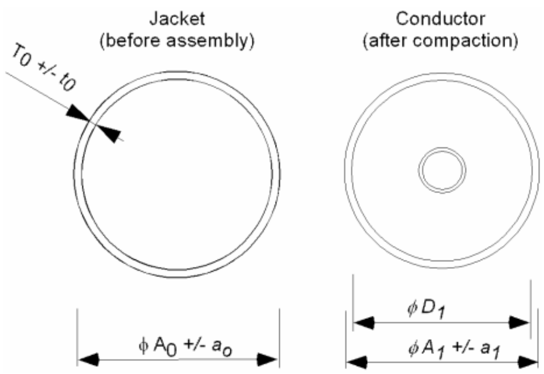


Figure 5: Optimisation of jacket section geometry.

JT-60 TF conductors (round to rect.)

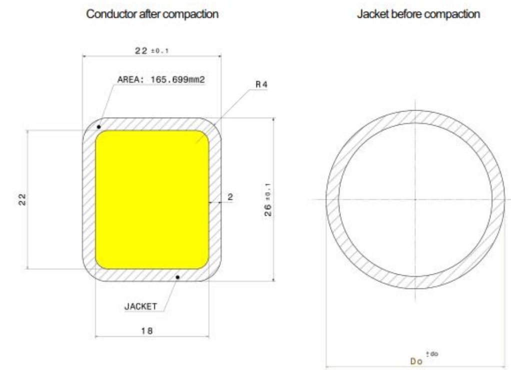
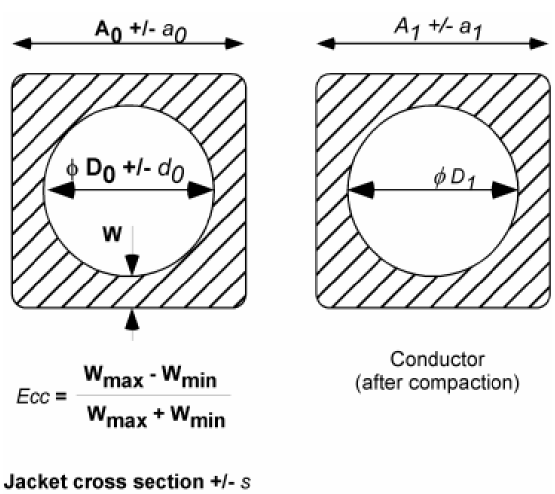


Figure 8: Optimisation of jacket section geometry.

ITER PF conductors (square to square)



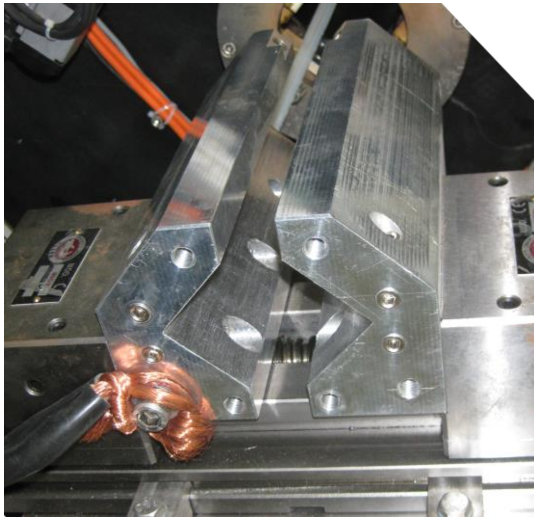
Superconducting Cables Jacketing line

Welding is one of the main key activity of the production process

ITER TF conductors (round to round)

JT-60 TF conductors (round to rect.)

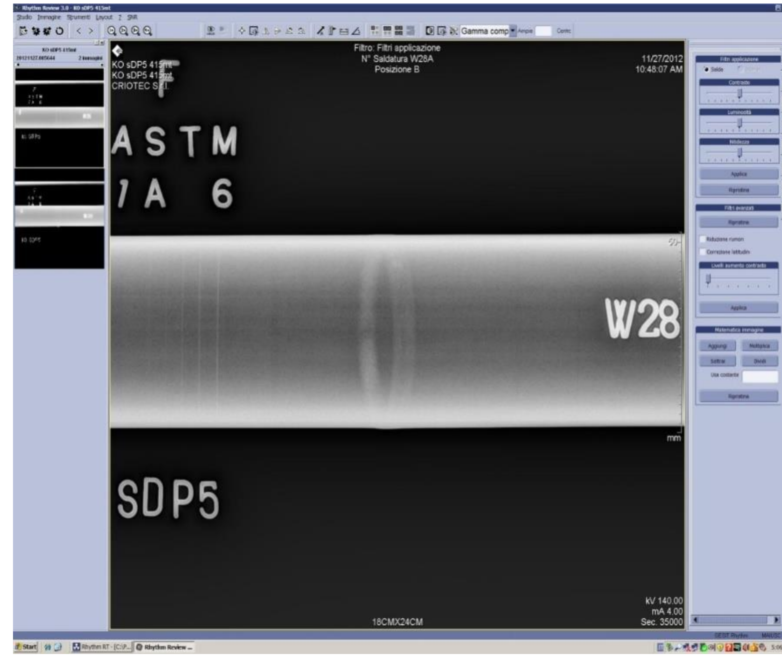
ITER PF conductors (square to square)



Superconducting Cables Jacketing line

ITER contractual requirements on welding:

- 100% Visual Inspection
- 100% Local Helium Leak Test
- 100% go / no-go gauge
- 100% Radiographic Examination
- 100% Dye Penetrant Test



Performed on over 8’000 welds during the 7 years contract

Cable Insertion

Figure 4.a) The connection between the pulling rope and the cable

Figure 4.b)the cable entering the jacket

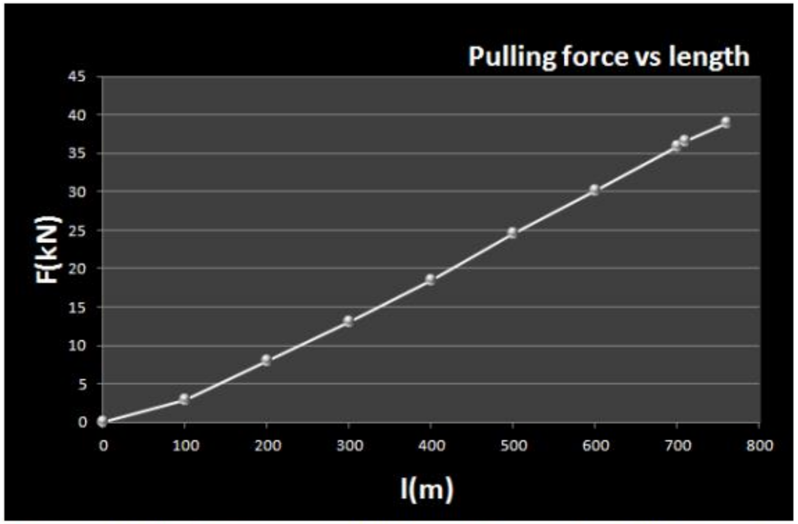


Figure 5. Pulling force vs cable length checked during some trials

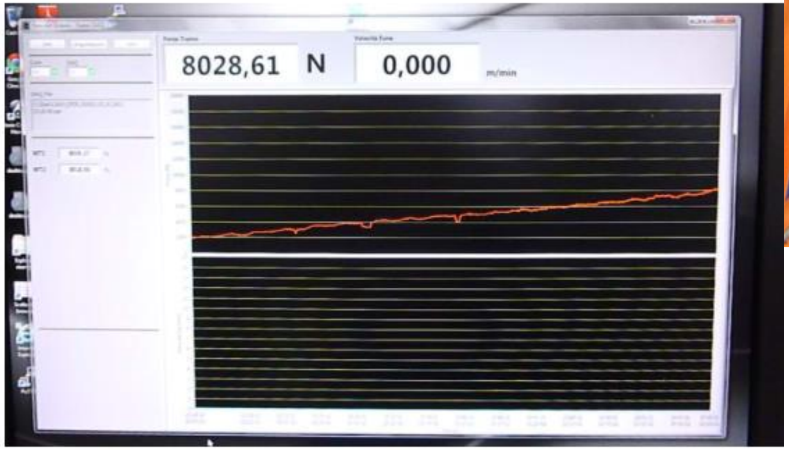


Figure 6. Interface of the data acquisition for pulling force

Compaction

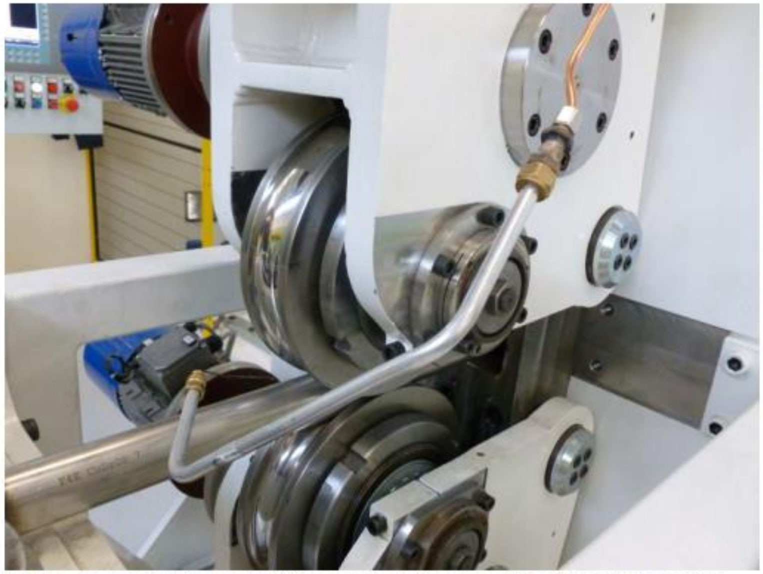


Fig.2 a. Second roller pair of the compaction machine (it is visible on the tube the laser marking of the 7th weld "F4E CuDrDP 7")

Fig2. B. Third roller pair at the compaction machine exit

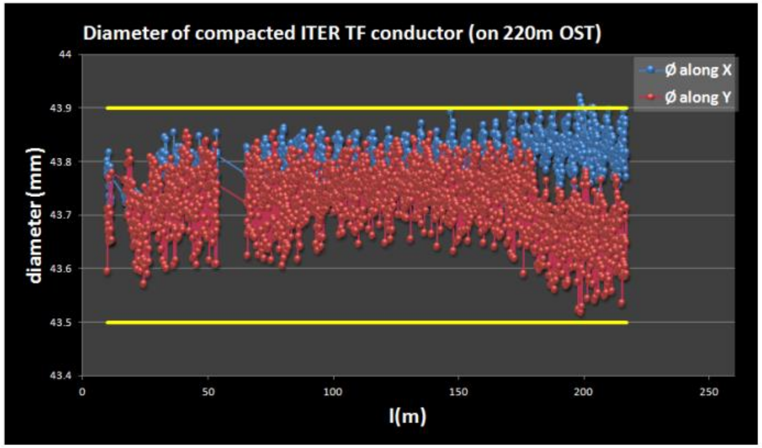


Fig.3. measured diameter of compacted 220m IETR TF conductor length; in yellow the tolerances requested by PA.

The conductor compacted length is measured by 3 different systems:
a mechanical wheel, a laser and an electro-mechanical encoder. The first two systems are placed just after the compaction machine, whereas the third one is integrated in the bending machine.

Spooling

Exiting the compaction machine, the conductor enters the bending machine in order to be properly curved for the spool which has an internal diameter of 4.00±0.03m

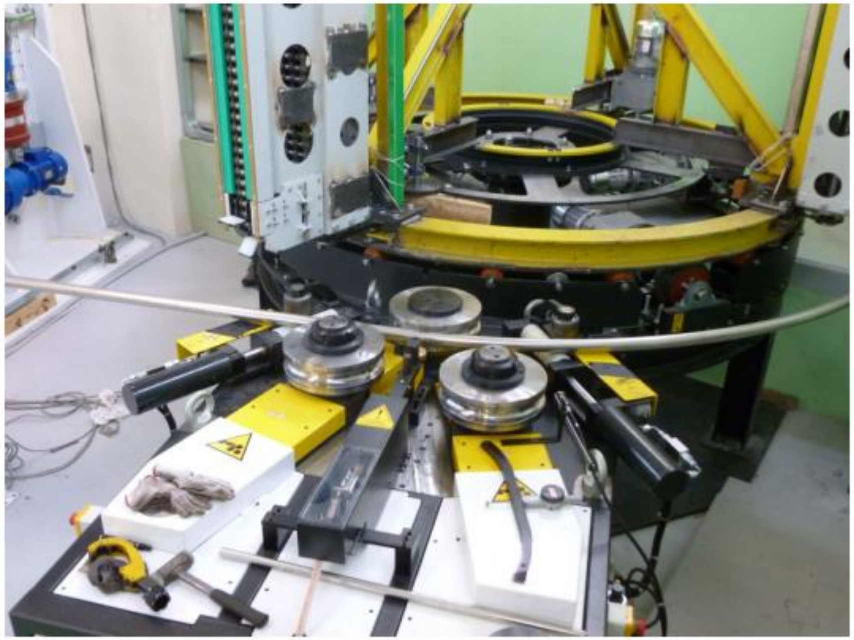


Fig.4. Tauring bending machine

Fig.7 a. spooled ITER TF Cu dummy conductor

Superconducting Cables Jacketing line

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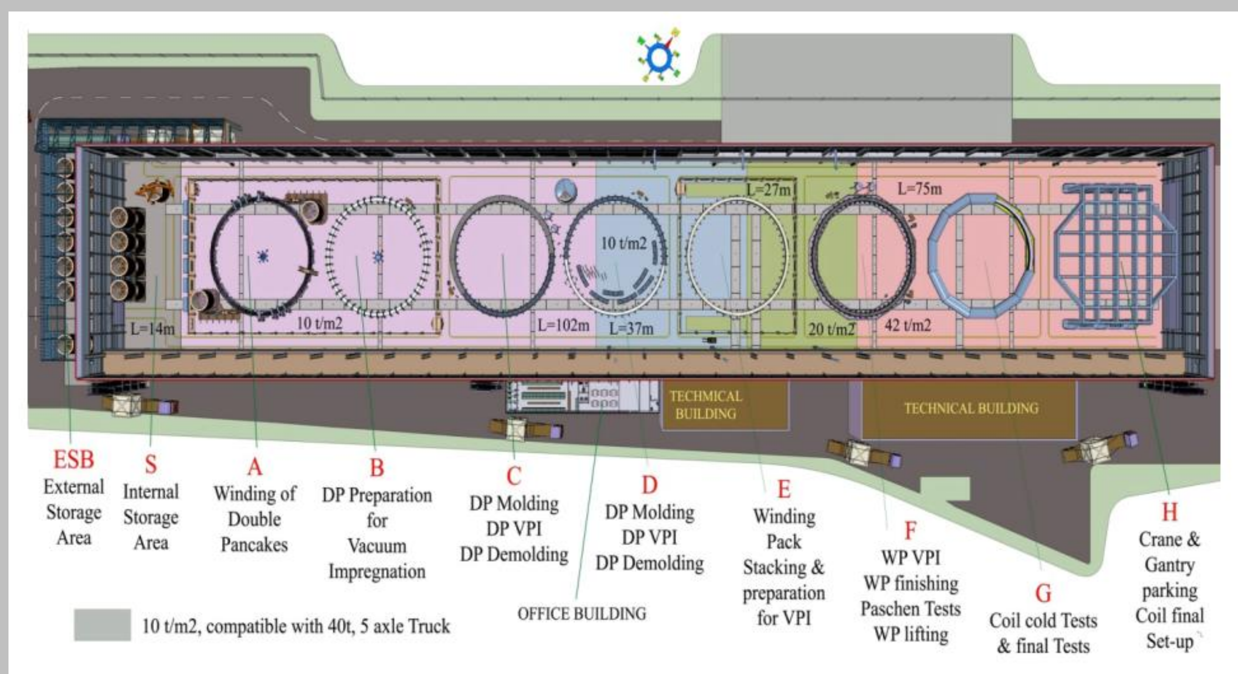
ITER PF Building (257 mt long, 49 mt wide, 18 tall)



ITER PF Cold Test Facility

Design and manufacturing of the Cold Test Facility to perform Helium Leak Test at liquid nitrogen temperature of ITER PF coils at Cadarache Site (France).

The supply includes:

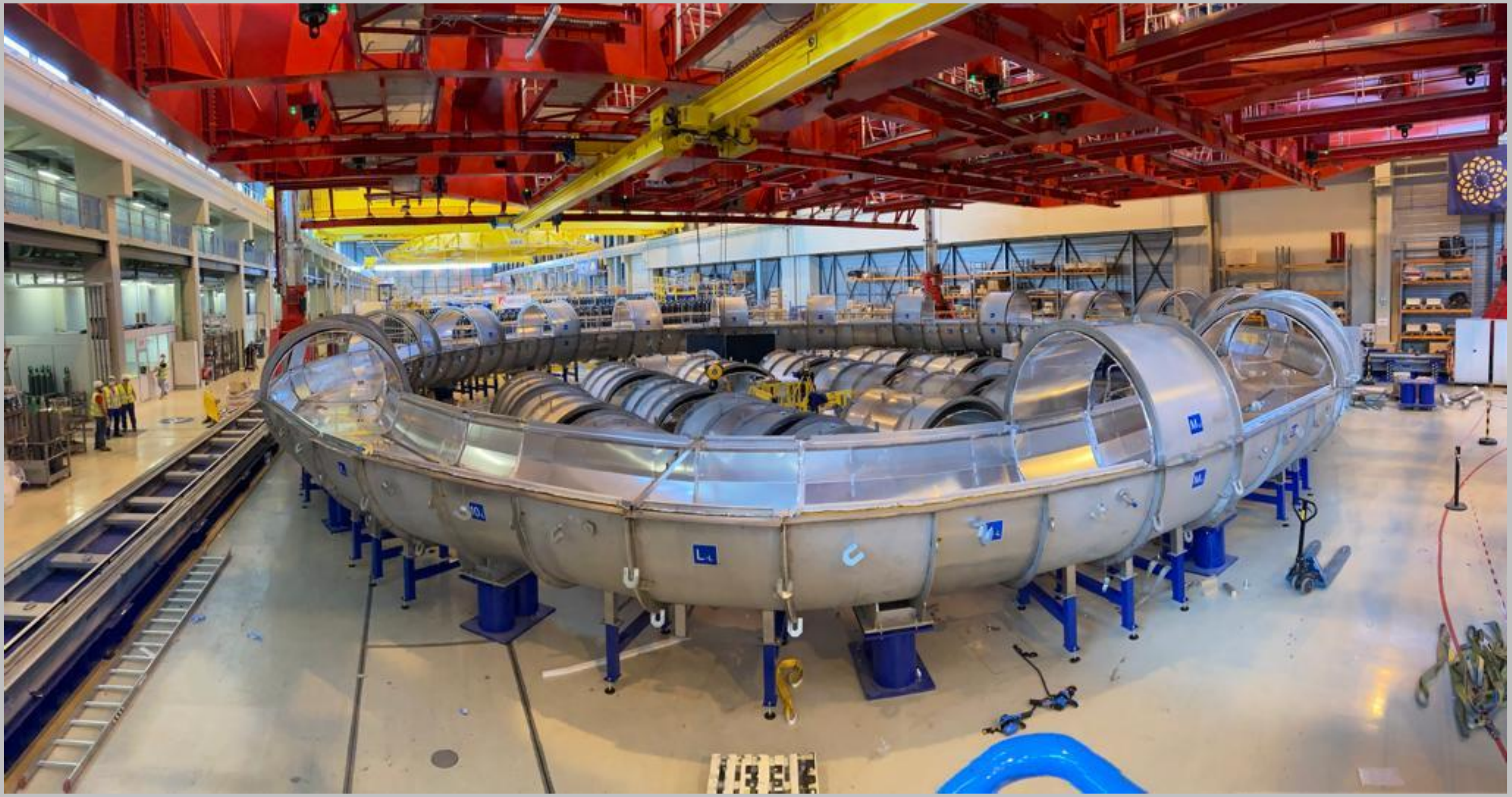
- Toroidal vacuum vessels, 10, 20 and 30 mt wide.
- Cryoplant (liquid nitrogen / gas helium)
- Helium recovery system
- PLC Control system and electrical cabinets
- Transport, installation, FAT, SAT, FiAT

ITER PF Building (257 mt long, 49 mt wide, 18 tall)

ITER PF Building (257 mt long, 49 mt wide, 18 tall)

IMPIANTI S.p.A.

ITER PF Building (257 mt long, 49 mt wide, 18 tall)



DTT - DIVERTOR TOKAMAK TEST Facility

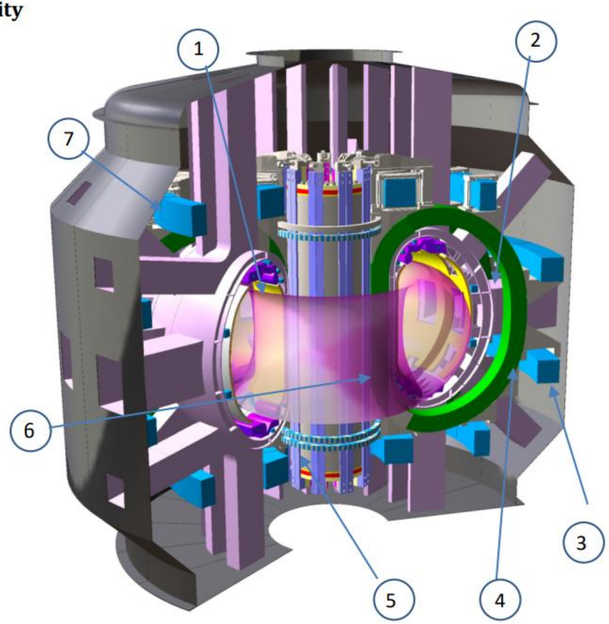
Facility DTT is a key facility in the framework of mission ("Heat-exhaust system") from EUROfusion roadmap. It is aimed at carrying out alternative solutions to the problem of disposing the heat load.

DTT is addressed to:

- Explore and qualify alternative power exhaust solutions for DEMO.
- Test the physics and technology of various alternative divertor concepts under plasma conditions that can be extrapolated to DEMO.
- Ultimately show whether alternative configuration or liquid metal plasma facing components are technologically viable, technically maintainable and economically attractive.
- Train new generations of engineers and scientists for science and technological transfer.

Fig. 1 DTT Divertor Tokamak Test facility

1	**Camera del Plasma**
2	Prima parete
3	Magneti Poloidali
4	Magnete Toroidale
5	Divertore
6	Plasma
7	Criostato



Domande?