

ITER TF Coils & Radial Plates advanced manufacturing

AIDA innova - Valencia

27th April 2022

SIMIC since 1975

a passion for challenges

Zanon RESEARCH & INNOVATION

SIMIC GROUP OVERVIEW

Since 1975, Simic is an Italian company with a solid experience in **engineering**,
high-quality manufacturing of critical process equipment, **assembly** and **maintenance**
of industrial plants.

Simic can reliably provide clients with a whole range of high-pressure products: from
heavy wall **Pressure Vessels**, **Reactors**, **Heat Exchangers**, **Vacuum Vessels,**
Cryogenic equipment to **mechanical components with very strict tolerances**.

Main sectors:
Oil & Gas – Chemical & Petrochemical – Fertilizers – Nuclear Energy & Decommissioning
Fusion Energy – Power Generation – Aerospace – Scientific Research – Renewable Energy

Business size of the Group (average):
170 M€ year turnover
24 M€ EBIT
830 manpower units

Industrial sites:
- **Camerana (**Cuneo) IT – Simic Workshop & Headquarter
- **Marghera** (Venice) IT – SIMIC High capacity workshop with direct dock access
- **Schio** (Vicenza) IT - Zanon workshops

Present in Germany, France, Belgium, Romania, Turkey, USA, Mexico, Chile & Brazil with Offices and Facilities.

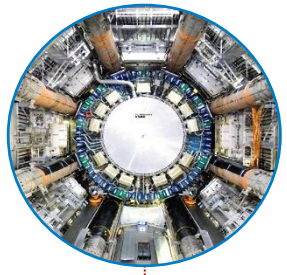
SIMIC HISTORY

1975

SIMIC was **founded** for mechanical prefabrication and on-site installations

1985

Opening of **Machining Department**

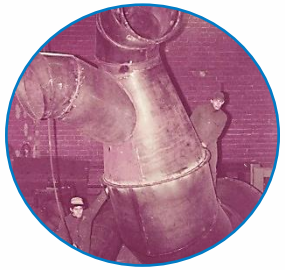


2000

CERN - LHC Project deep involvement

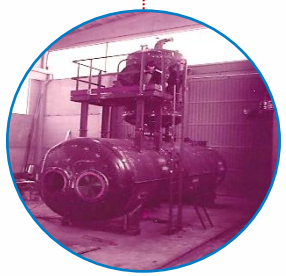
2009

Opening of Venice **High Capacity Workshop**



First **Pressure Equipment** are manufactured

1980



SIMIC enters in the **Research Field** and the first Cryostats and Vacuum Vessels are manufactured

1990

First **Turn-key** plant commissioned

2002

ITER Project deep involvement

2010-ongoing

SIMIC ASSETS

- **WELDING EQUIPMENT**

Simic is fully equipped with the **most adva**
systems.
Weld thickness from **0.2 mm up to 300 mm**.

- Submerged Arc Welding
- MIG-MAG semi-automatic / robotized welding
- TIG welding equipment
- TIG orbital welding machines
- Hot Wire Narrow Gap TIG welding machines/robots
- Cladding by Electro-slag welding machine

Fully equipped for:

- **3D MEASUREMENTS**
- **LEAK & PRESSURE TEST**
- **NON DESCTRUCTIVE EXAMINATION**
- **CLEAN AREAS FOR ASSEMBLY AND FINAL TESTS**

SIMIC ASSETS

MACHINING EQUIPMENT

Simic is fully equipped with the most advanced machining systems with 5 axis and CNC control

- PAMA milling & boring machine SPEEDRAM model

  X: 15,000 mm / Y: 14,000 mm / Z: 2,500 mm

- PAMA milling PORTAL machine VERTIRAM model

  X: 18,000 mm / Y: 10,100 mm / Z: 5,500 mm

  Temperature controlled environment (20±1°C)

  One of the largest machine in the world

- PAMA milling machine SPEEDRAM 1000 HP model

  X: 23,000 mm / Y: 4,000 mm / Z: 1,600 mm

- PAMA milling machine VERTIRAM 2000 GT model

  X: 8,000 mm / Y: 6,100 mm / Z: 1,600 mm

SIMIC GROUP BUSINESS UNITS

CRITICAL PROCESS EQUIPMENT

Design & Manufacturing of Process Equipment for:

- Oil & Gas
- Chemical & Petrochemical
- Fertilizer
- Power Generation
- Nuclear Energy

HIGH TECHNOLOGY COMPONENTS

Design & Manufacturing for:

- Fusion Energy
- Scientific Research
- Aerospace

Products:

- Cryostats
- High Vacuum Equipment
- Mechanical components

HIGH TECHNOLOGY PRODUCTS

For scientific research & industry:

- RF Cavities
- Cryomodules
- Ultra High Vacuum Vessels
- Special parts

SITE ERECTIONS & MAINTENANCE

Turn key projects for the following industrial sectors:

- Pharmaceutical
- Food
- Power Generation
- Tobacco
- Naval
- Renewable Energy
- Chemical & Petrochemical

CRITICAL PROCESS EQUIPMENT

Reactors & Pressure Vessels

Methanol, Ammonia & Urea equipment

SIMIC designs and manufactures critical process equipment for fertilizers, methanol and oil & gas sectors.

Main manufacturing skills

- **High technology welding**
- **High precision machining**
- **NDE techniques**
- **Heavy lifting**

Shell & Tube Heat Exchangers, Feed Water Heaters

Steam Surface Condensers

REFERENCES FOR OIL & GAS AND FERTILIZERS SECTORS

METHANOL REACTOR

MATERIAL	DESIGN CODE	SIZE
1 ¼ Cr. 0.5 Mo	ASME VIII Div. 2	thk/dia/length 218 x 6,500 x 38,000 mm weight 1,250 Tons

ATR – Auto Thermal Reformer

MATERIAL	DESIGN CODE	SIZE
1 ¼ Cr. 0.5 Mo	ASME VIII Div. 2	thk/dia/length 85 x 7,000 x 27,000 mm weight 400 Tons

WHB – Waste Heat Boiler

MATERIAL	DESIGN CODE	SIZE
1 ¼ Cr. 0.5 Mo 2 ¼ Cr. 1 Mo	ASME VIII Div. 2	height 19 meters weight 1,300 Tons in single unit

AMMONIA SYNTHESIS CONVERTER

MATERIAL	DESIGN CODE	SIZE
SA 336 Gr. F11	ASME VIII Div. 2	thk/dia/length 220 x 3,500 x 26,000 mm weight 750 Tons

HIGH TECHNOLOGY COMPONENTS

a passion for challenges

Cryostats

Vacuum Vessels

SIMIC designs
and manufactures complex products
for Fusion Energy & Scientific Research.

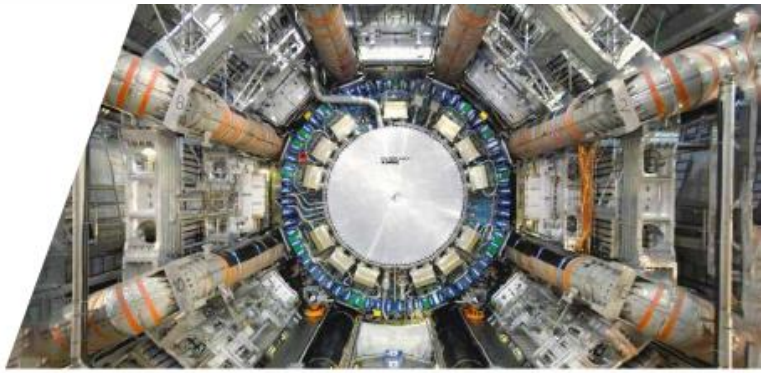
Main manufacturing skills
- **High technology welding**
- **High precision machining**
- **NDE techniques**
- **3D metrology**
- **Heavy lifting**

Cold Boxes

Complex mechanical parts

CERN LHC PROJECT

SIMIC has been working with **CERN** & many other Research Institutes for more than 20 years.
SIMIC is among the main contributors of **LHC Project** at **CERN**, Switzerland,
the European Council for Nuclear Research.



ENDCAP CRYOSTAT FOR ATLAS

Material: AL 5083
Diam: 5,500 mm
Thk: 160 mm
Weight: 40,000 kg
Cryogenic Tests at 90K
Super Insulation Leak Test < $1X10^{-8}$ mbar•l/s

250 CRYOMODULES FOR LHC

Material: AISI 304 L, Aluminium, Cu-Ni
Weigth: 2,000 Kg
Length: 6,650 mm
Pressure test up to 25 bar;
He Leak test < $1x10^{-8}$ mbar•l/s
3D Dimensional inspection, Instrumentation test

937 VACUUM VESSELS LHC Project - CERN

TESTS: He LEAK TEST < $1x10^{-8}$ mbar•l/s
On each vacuum vessel three-dimensional
computerized check of each vacuum vessel

ITER PROJECT

ITER Project for FUSION ENERGY - France

International Thermonuclear Experimental Reactor

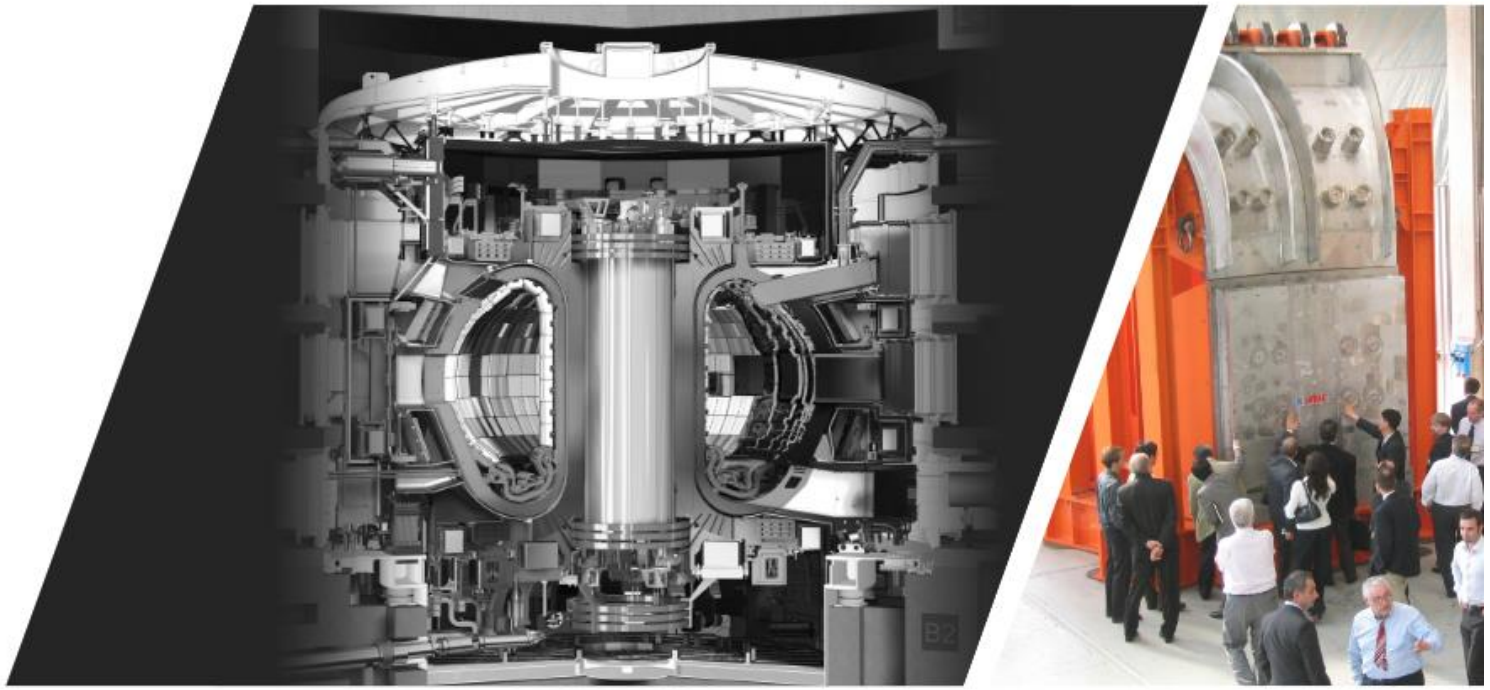
ITER objective is to demonstrate the scientific and technological feasibility of Fusion Energy for creating an alternative energy source.

VACUUM VESSEL prototype (PSM)

The large stainless steel vacuum vessel provides an enclosed, vacuum environment for the fusion reaction.
The Prototype consists of a Vacuum Vessel Sector of the ITER reactor.

Material: AISI 316 LN IG (ITER Grade)
PSM weight: 23 Tons
Structure Weight: 70 Tons

Narrow Gap Tig Welding Process
Thickness 60 mm



ITER PROJECT

DIVERTOR COMPONENTS

SIMIC has manufactured the **prototypes** for the ITER Divertor Project, such as:

- Cassette Body
- Dome Liner
- Inner Vertical Target
- Outer Vertical Target

ITER PROJECT

RADIAL PLATE SERIES PRODUCTION

Fusion for Energy (F4E) awarded to the consortium SIMIC - CNIM the contract to manufacture **70 radial plates** for ITER. The contract lasted 4.5 years and is among the biggest industrial contributions of Europe's share to the ITER toroidal field magnet system.

In May 2017 the last Radial Plate has been successfully delivered to ITER.

The radial plates are «D» shaped mechanical structures measuring **13.8 m x 8.7 m x 112 mm**.

They are made from **316LN stainless steel** and they will form the 'backbone' of the 18 field magnets needed to keep the plasma confined within the ITER vacuum chamber.

The radial plates have on each side spiral round-shaped grooves which are closed by cover plates.

ITER PROJECT

WP COLD TEST & INSERTION INTO TF COIL CASES (10 TF COILS)

SIMIC has been selected to perform the Cold Test of 10 TF Winding Packs
and to supply the **10 European Toroidal Field Coils of ITER**.

The most critical aspects:

- Impressive **size & weight** 14 m (L) x 9 m (W); over **300 Tons** each TF
- **variable welding thicknesses** ranging from 40 mm up to 130 mm
- weld **difficult to inspect** due to combination of large thickness and
  limited accessibility
- **tight machining tolerances**
- control of **deformations** during welding of the case

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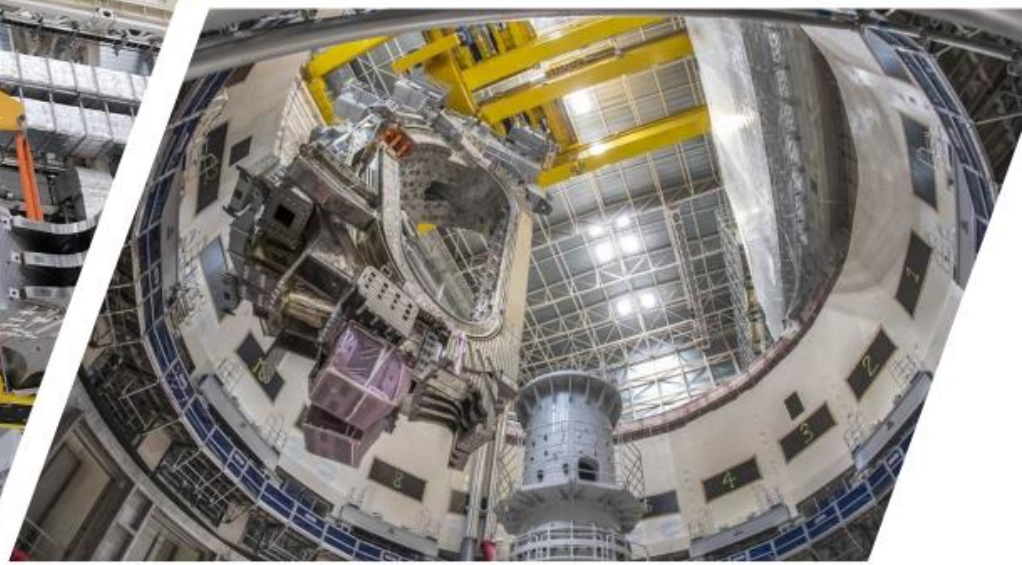
ITER PROJECT

TOKAMAK ASSEMBLY MACHINE (TAC-2)

As part of DYNAMIC consortium, composed by ANSALDO NUCLEARE, ANSALDO ENERGIA, SIMIC, ENDEL, ORYS and LEADING METAL SOLUTIONS, Simic is working for the Assembly of the Tokamak machine at ITER site, Cadarache (France).



ITER PROJECT

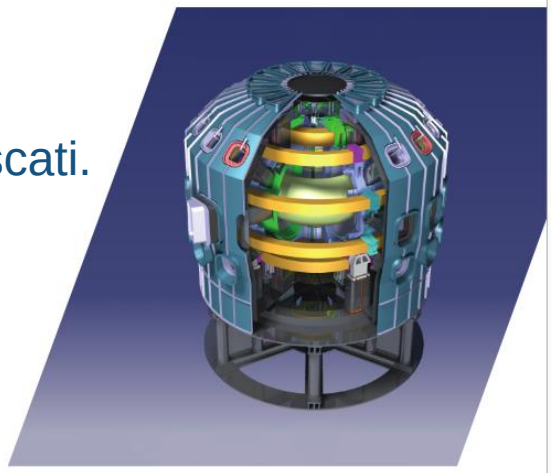
CRYOGENIC PLANTS AND DISTRIBUTION BOXES

SIMIC takes part, with Linde Kryotechnik, to the manufacturing of **5 large Distribution Boxes** for the **ITER Cryodistribution plant**.

The units are complete of internal piping and super-insulation suitable to achieve cryogenic temperatures.

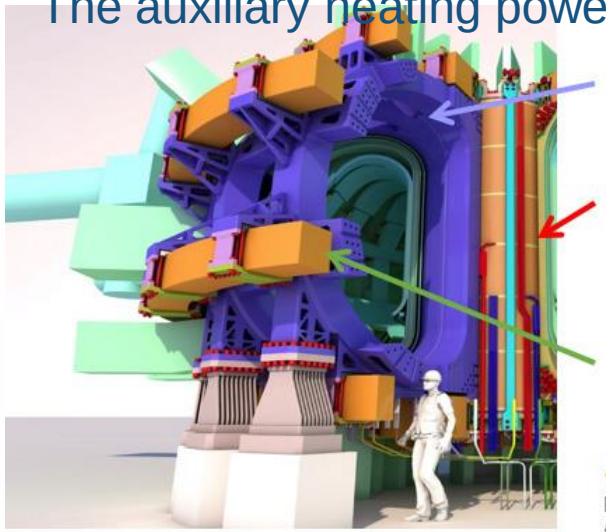
The Vacuum Vessel will be leak tested, while the piping will be pressure tested.

DTT PROJECT



Simic has been awarded the contract for the production of **18 TF Coil cases for the DTT Project**.

The Divertor Tokamak Test Facility (DTT), has been recently started at **ENEA** site in Frascati. **DTT** will be a high field superconducting toroidal device (6 T) carrying plasma current up to 5.5 MA in pulses with length up to about 100s, with a D-shape cross section defined by major radius R=2.19 m, minor radius a=0.70m and average triangularity 0.4. The auxiliary heating power will be 45 MW.

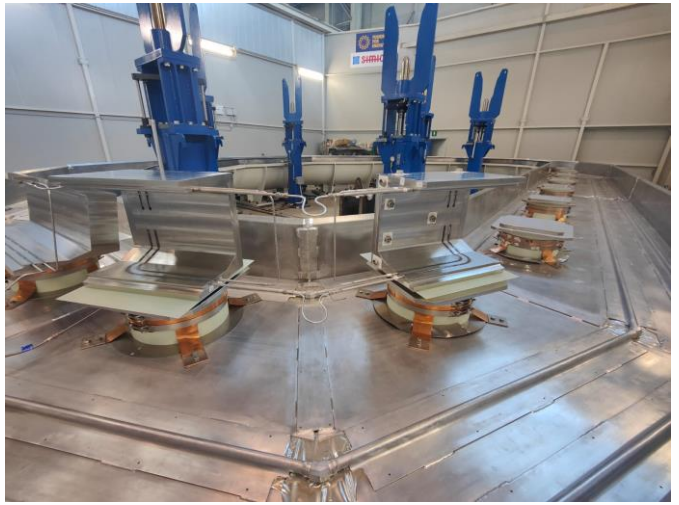


Design based on proven and reliable technologies

6 Poloidal Field coils
4 NbTi Cable-In-Conduit Conductors
2 Nb_3Sn Cable-In-Conduit Conductors
6 *independent modules*

6 Central Solenoid module coils
Nb_3Sn Cable-In-Conduit Conductors
6 *independent modules*

18 Toroidal Field coils
Nb_3Sn Cable-In-Conduit Conductors
5 *Double-Pancakes* (3 regular + 2 side)



SIMIC since 1975
a passion for challenges

SITE ERECTIONS AND MAINTENANCE

a passion for challenges

Mechanical

Electrical

SIMIC offers
a complete Installation
and Maintenance service

Instrumental

Pneumatic

**Turn key projects
for the following industrial sectors:**

- **Pharmaceutical**
- **Food**
- **Power Generation**
- **Tobacco**
- **Naval**
- **Renewable Energy**
- **Chemical & Petrochemical**

INSTALLATION & MAINTENANCE OF INDUSTRIAL

FERRERO

FOOD INDUSTRY - FERRERO do Brasil

Project Name: FERRERO BRAZIL PRODUCTION PLANT - POCOS DE CALDAS - MG - BRAZIL
Customer: Ferrero do Brasil LTDA
Description: Complete utilities, HAVAC and Sprinkler system for new Product Warehouse - G3
Utilities for production buildings G1 - G2
Product piping and Mixing units manufacturing and installation

FERRERO

FOOD INDUSTRY - FERRERO de MEXICO

Project Name: FERRERO NEW MEXICO FACTORY - San Josè Iturbide - MEXICO
Client: Ferrero S.p.a.
Description: Turn Key Material Storage and Product Preparation Lines
Mechanic and Electric

INSTALLATION & MAINTENANCE OF INDUSTRIAL PLANTS

Gnosis by Lesaffre

PHARMACEUTICAL PLANT - GNOSIS BIORESERCH S.r.l.

Project Name: NEW PHARMACEUTICAL PLANT - PISTICCI SCALO (MT) - ITALY
Client: Gnosis Bioresearch S.r.l.
Description: Complete installation of the new plant: Mechanical, Electrical and Instrumental part
SIMIC is carrying out the ordinary Maintenance of the plant in Global Service.

SOLVAY

CHEMICAL PLANT - SOLVAY Specialty Polymers

Complete Mechanical Installation of a new HF Plant (Hydrofluoric Acid recovery & production)
Complete Mechanical Installation of a new PFP Plant

RENEWABLE ENERGY

Simic in engaged in **renewable power generation**, with solar and wind plants fully owned, developed and built.

MISSION

Making a contribution to green energy transition for a secure and sustainable future

VISION & ROADMAP

To increase the portfolio of renewables plants within the **next 5 years**.

- **30 MW** installed capacity
- **100 MW** in construction
- **250 MW** in development

CURRENT FIGURE

- **25 MW** solar plants + **35 MW** wind plants
- **40,000 MWh** of energy produced per year (7 times the internal energy intake
- ~**13,000 tons** of avoided **CO2** emissions per year
- Equivalent to the CO2 absorption of ~**500,000 trees**

ON-GOING PROJECTS

- **100 MW** wind plants under construction
- **250,000 MWh** of energy produced per year
- Enough to power more than **100,000 houses**
- ~**90,000 tons** of avoided **CO2** emissions per year
- Equivalent to the CO2 absorption of ~**3,500,000 trees**

RENEWABLE ENERGY

In 2022, with the 30 MW “Fiume Santo” wind plant in Sardinia (Italy), SIMIC took a leading role in energy transition and evolution of wind turbines by installing the **first 6 MW wind turbine in Italy**.

Wind turbine model: V162-6.0 MW
Number of turbines: 5
Rotor diameter: **162 m**
Hub height: **119 m**
Tip height: **200 m**

The project featured **the largest and most powerful wind turbine ever installed in Italy** until then.

ZANON RESEARCH & INNOVATION (SIMIC SYSTER COMPANY)

ZANON RESEARCH & INNOVATION (SIMIC SYSTER

Working closely for more than 30 years with the most important Physics Research Institutes in the world, from prototyping to series production.

Superconducting RF cavities

Ultra high vacuum chambers

Cryomodules and cryostats

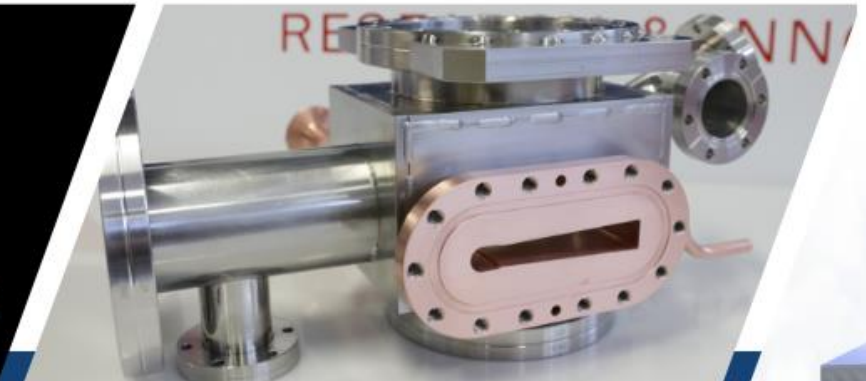
Special mechanical parts

Skills

- Metal forming
- Electron Beam & Tig Welding
- Brazing
- High precision machining
- Cleanrooms and special cleaning
- Special surface treatments
- Thermal treatments
- 3D Metrology

MAIN MATERIALS

- High Alloy Steel
- Niobium
- Titanium
- Copper & Copper alloys
- Nickel and Nikel Alloys



ZANON ASSETS

Nr.2 EBW Electron Beam Welding Stations
+30 years experience in EBW welding

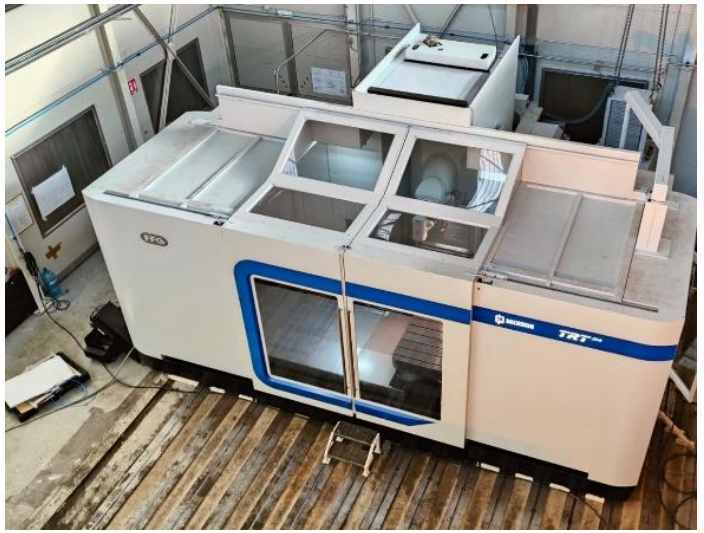
3D METROLOGY
Equipped with the state of the art 3D measuring devices
Large know-how on reverse engineering

RADIOFREQUENCY TEST & TUNING
Dedicated RF tests equipment including DESY machine for cavities final tuning

ZANON ASSETS

SPECIAL MILLING & TURNING MACHINES

3 and 5 axis milling and turning machines
EDM and super finishing machines
Dedicated machines for Niobium machining

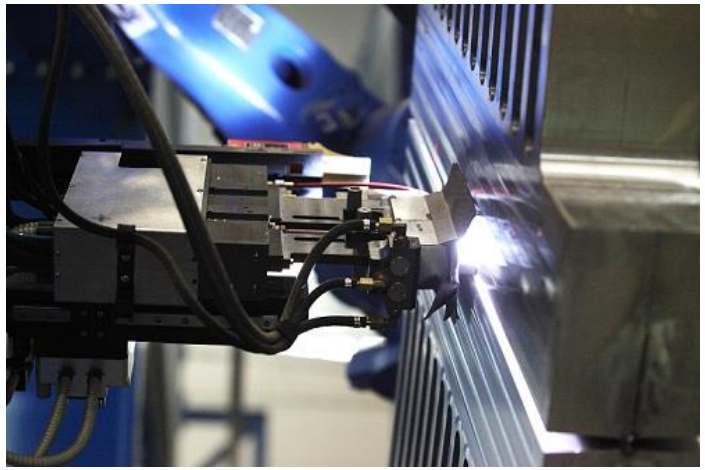


FORMING MACHINES

Deep drawing, spinning, bending, rolling

ROBOTIZED TIG WELDING MACHINES

Hot Wire Narrow Gap robotized Tig welding
Orbital welding machines

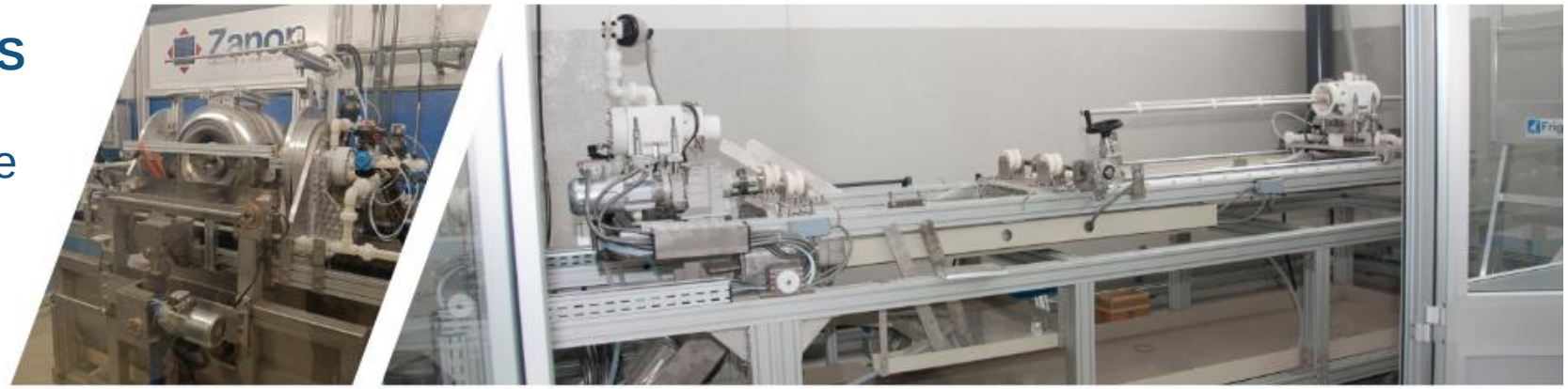


ZANON ASSETS

ISO 7 and ISO 4 Clean Rooms 450 m²
For clean assembly, final surface treatments, assembly
For RF cold test. High Pressure Rinsing
with Ultra Pure Water.
ISO7 area 220 m²
ISO4 area 200 m²

THERMAL TREATMENTS IN VACUUM
Vacuum Oven up to 1200°C, cryopumps,
RGA, Molibdenum Hot Chamber
RF cavities Nitrogen doping

CHEMICAL SURFACE TREATMENTS
Electropolishing plant
New Horizontal Rotating BCP machine



ITER TF RADIAL PLATES SERIES MANUFACTURING

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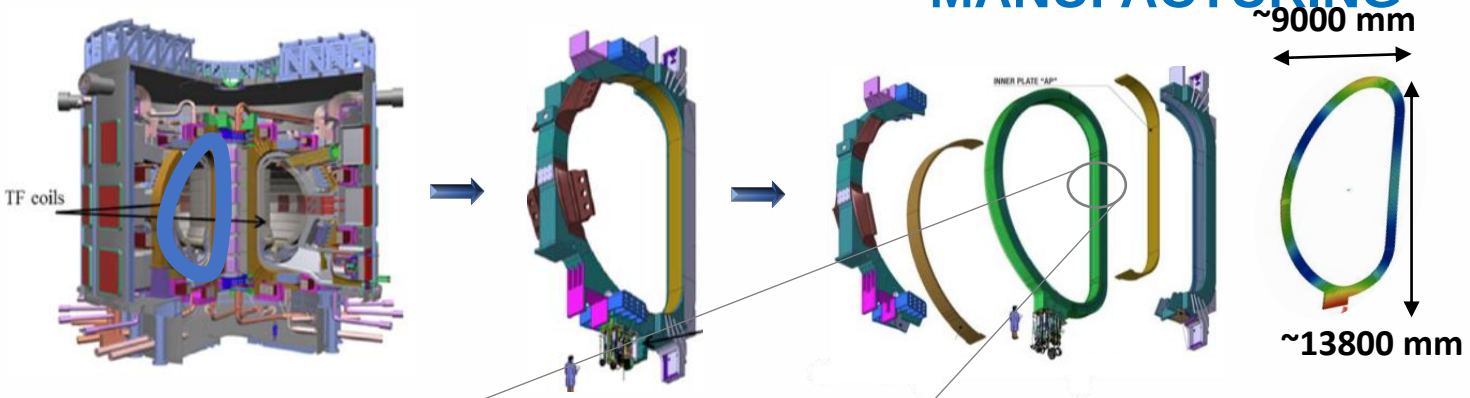
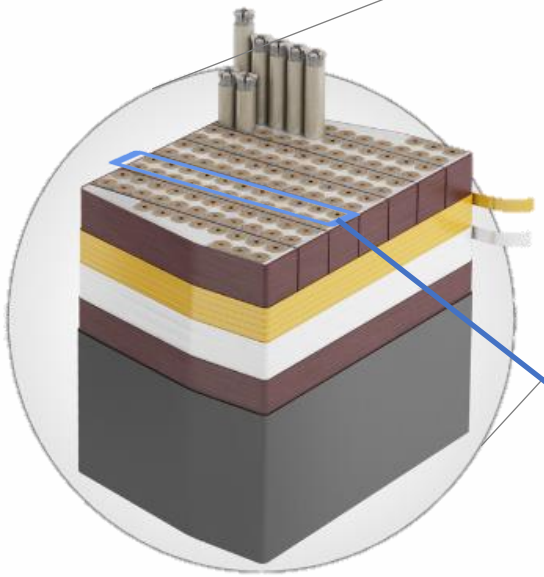
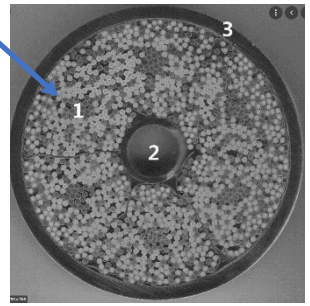






Double Pancake Insulation

Radial Plate

The radial plates are «D» shaped mechanical structures of measure **13.8 m x 8.7 m x 112 mm.** They are made from **316LN** stainless steel and they will form the '**backbone**' **of** the 18 **Toroidal Field Coils** needed to keep the plasma confined within the **ITER** vacuum chamber.

The radial plates have on each side spiral round-shaped grooves which are closed by cover plates.

Conductor: Nb3Sn and Cu strands

ITER TF RADIAL PLATES SERIES MANUFACTURING

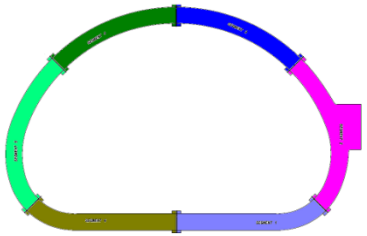
In **2012**, F4E trusted SIMIC for the **series manufacturing of 70 ITER TF Radial Plates**

For this Contract, **SIMIC and CNIM joined their forces** to guarantee the challenging delivery rate requested by F4E: **4 RPs every month** (2 by SIMIC and 2 by CNIM).

ITER TF RADIAL PLATES SERIES MANUFACTURING

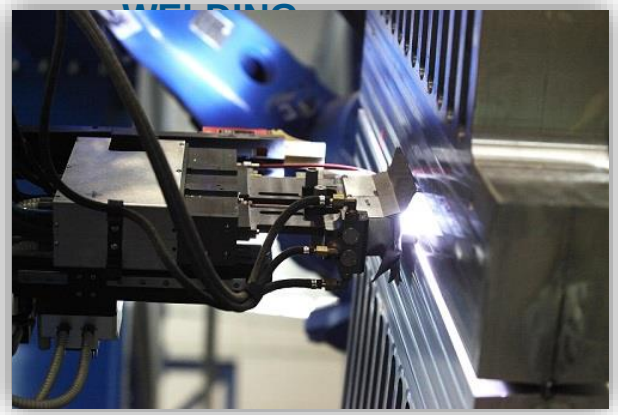
The processes developed for the Prototype have been optimized for the **massive production of the Series**

1. FORGED



- Nr. 6 AISI 316 LN forgings each RP
- Material tested @4K

2. RP SECTORS



- Hot Wire Narrow Gap Tig
- Welding qualified @4K
- 100% UT Phased Array
- Welding deformation monitored by 3D metrology
- Stress relieving by Vibration treatment

3. RP SECTORS

- High speed machining
- Special cutting tools developed for AISI 316LN
- Dedicated machining sequence to compensate deformations

4. RP ASSEMBLY &

- 3 welds performed simultaneously by a special assembly tools designed by

- 100% UT Phased A

ITER TF RADIAL PLATES SERIES MANUFACTURING

5. NDE INSPECTIONS

- 3D metrology
- 100% UT Phased Array
- 100% PT

6. FINAL MACHINING

- Special cutting tools
- Very tight tolerances
- 2 flipping
- Constant 3D metrology
- Controlled temperature at 20°C

7. SURFACE TREATMENT & COVER PLATE ASSEMBLY

- Sanblasting & cleaning
- CP assembly with tight tolerances
- Special inspection tool developed on purpose

8. FINAL INSPECTION & SHIPPING

- Final DI including CP-RP gap
- Cleaning check

SECOND CHAPTER – ITER TF RADIAL PLATES SERIES MANUFACTURING

The Radial Plate Contract was completed successfully in about **4 years** and the last RP was delivered in **July 2017**.

A few numbers of the Project:

- Raw material purchased for 1 RP= 25 tons > for 70 RP= 1.750 tons
- Weight of delivered RP= 5.3 tons > for 70 RP= 457 tons
- **Chips** produced on all project= 1750-371= **1293 tons of AISI 316LN scrapped**

- Nr. **2672 document** shared with F4E

- Nr. **210 welding joints** thk. 126 mm performed by **Tig** Narrow Gap process
- Very low percentage of repair **2.3%**

- Over **50 SIMIC workers** engaged for 4.5 years on 3 shifts 24h 7days/week
- Total number of **working hours** in SIMIC **> 300.000h**

- Over **50 sub-suppliers** involved only by SIMIC

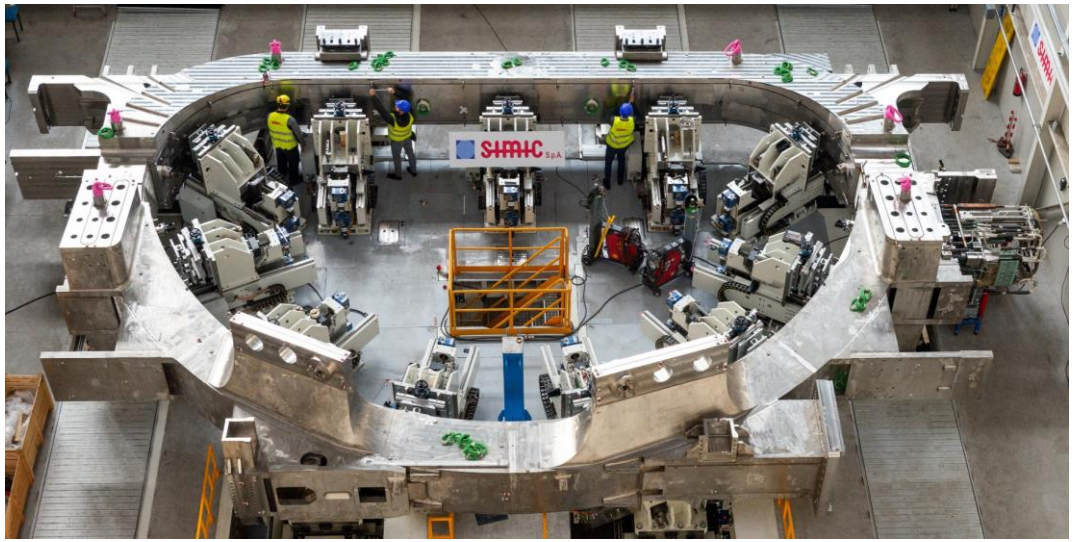
ITER EU TF COILS MANUFACTURING

ITER EU TF COILS MANUFACTURING

In **2014**, SIMIC as Main Contractor, in collaboration with BNG as subcontractor, signed the contract with F4E to supply the **10 European TF Coils**, the **largest ITER**

SIMIC scope of the Contract:

- **Development & qualification** of each process involved
- **Winding Packs testing** (DI, High voltage, Leak & Vacuu
- **Coil Cases sub assembly testing** (DI, Pressure test, Le
- **Cold test @80K** of the 10 Winding Packs
- **WPs insertion** into the 10 Coil Cases
- Closure **welding** of the Coil Cases
- **Filling by special resin** the gap between WP and CC
- **Final machining** of TF coils
- **Final testing** (DI, HV, pressure test…)
- **Packing and shipment** of 10 TFC to ITER site



ITER EU TF COILS MANUFACTURING

TF COIL TECHNICAL CHALLENGES:

- Impressive size **14m x 9m x 320 tons** each TFC
- **High technology**, critical welds & process
- AISI **316 LN** material
- ~**100 m of critical Tig** welding each TFC
- Robotized HW Narrow Gap Tig welding
- High thicknesses **40-125 mm** from 1 side only
- **Difficult to inspect** due to the large thickness & limited accessibility, by UT Phased Array tecnique
- **Risk to damage the WP** placed at a distance of only 4 mm
- **Tight tolerances** on finished component
- Long and **complex tests** to be performed (HV, Cold test, Leak & Vacuum, DI…)

ITER EU TF COILS MANUFACTURING

1. WP TESTING

- Dimensional inspection
- Pressure & leak test
- HV Electrical test
- Paschentest
- Sensors check

2. COIL CASES TESTING

- Dimensional inspection
- Pressure & leak test

3. WP COLD TEST @80K

- 2 very large cryostats
- Hybrid cold test unit LIN-He by BNG
- Fully automatic control
- 40 days of cool down & warm up 24h 7 days/week
- Electrical test @RT and @80K

4.WP INSERTION INTO CC

- Special Tools developed by SIMIC
- 2 very large & complex machines
- 76 electrical motors managed by automatic control
- Accuracy of movement <0.1 mm
- Minimun gap WP-CC 4 mm

a passion for challenges

ITER EU TF COILS MANUFACTURING

5. CLOSURE WELDING

- Manual Tig + Robotized Hot Wire Narrow Gap Tig
- All welding positions
- Thicknesses 35-125 mm only from one side
- Mechanical tests at 4K
- UT Phased Array at the limit of the feasibility

6. GAP FILLING BY RESIN

- Special resin implemented
- Qualification program lasted 2.5 years
- Special curing process
- Process must not be stopped

7. FINAL MACHINING

- Very large Portal machine
- Machining on both sides
- Temperature controlled area 20°C±2°C
- Very tight tolerances

8. FINAL TEST & SHIPPING

- Dimensional Inspection
- Pressure & leak tests
- HV Electrical tests
- Very large cargo 9x9x18 m
- Total weight 600 tons
- Shipping time 40 days

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Status of production:

- **1st , 2nd, 3rd, 4th, 5th, 6th, 7th , 8th , 9th** TF coils **delivered to IO site**

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10th TF coils **under final machining phase.**
Expected Project completion – Q2 **2023**

A few numbers of the Project:

- > 26.500 hours of **Tig welding performed**
- > 5.000 kg of **filler metal melted**
- > 26.000 hours of **machining**
- > 25.000 tons **lifted** by workshop cranes
- > 20.000 hours of **Laser Tracker** switched on
- > 8.000 hours of **UT Phased Array** probes passed on the welds
- > 18.000 liters of **resin injected** into the Coils
- > 2.500 m^3 of **Liquid Nitrogen liquefied** to cool down the magnets
- > 2.000 **meetings held**
- > 6.000 **document shared** with F4E

FUSION FOR ENERGY

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Questions???

Thank you for your attention

www.simic.it

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