

# SERIES PRODUCTION OF EXFEL 1.3 GHZ SRF CAVITIES AT E. ZANON: MANAGEMENT, INFRASTRUCTURES AND QUALITY CONTROL

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## Abstract

In this paper we report on the capability of Ettore Zanon S.p.A. (EZ) to implement a EXFEL 1.3 GHz SRF cavities production system. In order to assure the series efficient repeatability of the product, this system is based on *work team*, composed of people with different skills, *qualified infrastructures* and *technical procedures*.

A detailed study of the different work phases of the production cycle has been performed in advance, highlighting the technical difficulties and the production constraints.

Based on this result, infrastructures and processes have been optimized to guarantee the specified quality, time/cost requirements, procedures and operating instructions, where the most complex and delicate phases as well as the responsibilities and acceptance criteria are investigated, have been introduced [1].

Qualification operations and eight pre-series cavities have proven EZ capability of fulfilling the imposed requirements.

The above described manufacturing system allows nowadays a production rate of 4 cavities per week.

EZ future developments involve minimizing time and costs while keeping the highest quality standard.

## INTRODUCTION

The E. Zanon company was founded in 1919. It is located in the North-east of Italy 90 Km from Venezia.

The company works on two different fronts:

- the "standard" production for chemical industry (reactors, heat exchangers, etc),

- the "special" production of components for research institutes and laboratories (UHV, cryogenics, Fusion, Superconductivity).

E. Zanon S.p.A. has been working and manufacturing special components for superconducting applications since more than 20 years. Experience with niobium superconducting cavities started in the early 90's and has continued without interruption until nowadays.

E. Zanon company is currently involved in the European XFEL project to produce 2 Test Piece for weld qualification, 4+4 RCV-DCV cavities followed by 400 XFEL type series cavities (with manufacture of their Titanium Helium tanks) and 12 so-called HiGrade cavities, first used for quality assurance, later available for further investigations and treatments.

The cavities for the European XFEL have to be fabricated according to the Pressure Equipment Directive (PED 97/23/EC).

The European XFEL project is under construction at the Deutsches-Elektronen-Synchrotron (DESY).

The industrialization and commissioning of infrastructure will be presented.

## LAY-OUT AND INFRASTRUCTURES

To fulfil the contractual requirements, E. Zanon has employed strong effort to study and optimize the production lay-out.

The cavities production takes place into two buildings: building lot I and building lot IV. The first building is dedicated to manufacturing of half cells, dumb-bell, subassemblies, end groups EB welding, chemistry, while the second building is dedicated to final cavity welding, integration with Helium tank and surface treatments.

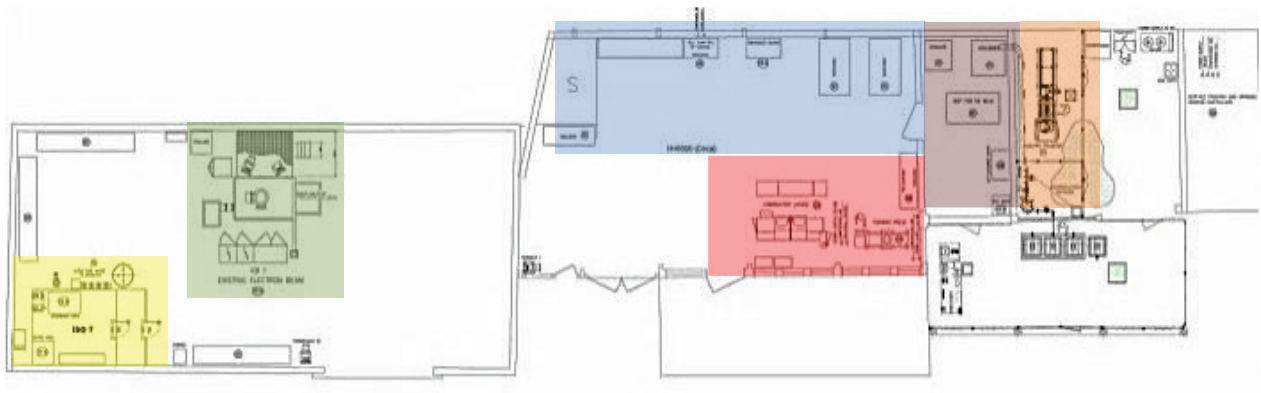


Figure 1: Building lot I.

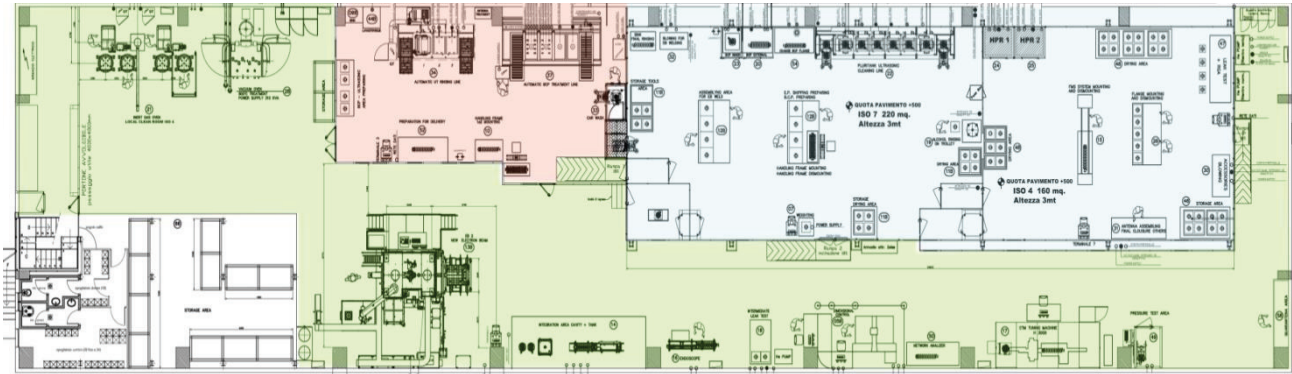


Figure 2: Building lot IV.

In detail, as shown in figure 1, the building lot I is divided as follows:

- in the *yellow area* is located Clean room ISO7 and UPW production unit (18MΩcm),
- in the *green area* is positioned Electron beam plant 150KV-30KW with cryogenic pump,
- the *blue area* is used for storage and for the incoming controls of the raw material (niobium),
- the *red area* is dedicated to stamping and reshaping of the half cells,
- in the *orange area* is positioned Electropolishing with UPW plant(18MΩcm),
- in the *brown area* UT and BCP treatment of sub-components before welding process.

The building IV is organized in three main areas (see figure 2):

- chemical treatment area (*pink area*),
- clean room ISO7/ISO4 (*blue area*),
- electron beam plant, Integration in Helium Tank, 800°C -120°C treatments and testing area (*green area*).

A "technical area" has been built outside the building IV, in which all the equipment and services, necessary for the production line, have been concentrated (see figure 3). The technical area consists in maintenance area, chemistry service area (the storage of BCP acid, tanks-cooling systems for BCP stations, Scrubber for acid gasses vent), plants for Ultra Pure Water (UPW) production, pumps for High Pressure Rinsing and Pure Nitrogen storage tank for venting of EBW machine and of leak check groups, etc.

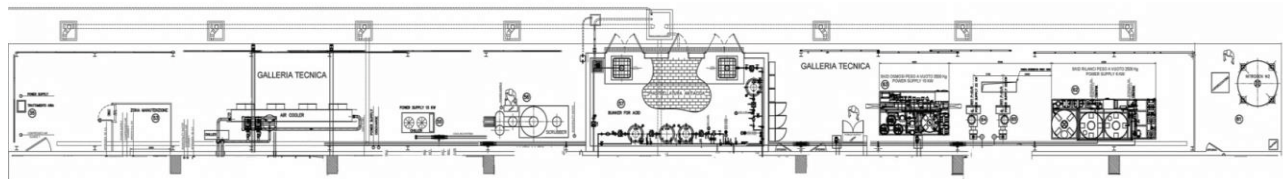


Figure 3: Technical area.

The infrastructures described, the organization by Manufacturing and Testing Station (MTS) were positioned to suit the production flow. In fact, the infrastructures have been designed and organized in order to simultaneously handle about 10.000 pieces within the production line.

In order to qualify infrastructures and establish the production cycle, four pre-series cavities have been used.

### MANAGEMENT AND QUALITY CONTROL

All semi-finished products for pressure bearing components of cavities have to be fabricated according to PED requirements and their traceability has to be guaranteed (see figure 4). Under EXFEL project, together with a Notified Body (in this case TUEV Nord), the so-called modules B and F of PED are applied. Module B has included vendors, procedures and the manufacturing of the Test Piece for weld qualification. Module F, currently in progress for series production, is based on Module B and requires the pressure test of each individual cavity [2].

Requirements of PED include examination of cavity design, testing of material, creation of the particular material appraisal (PMA), examination of material suppliers, examination of purchased semi products, examination of the fabrication procedure, analysis of welding, examination of the welding procedure and welder qualification, destructive and nondestructive tests of welding connections, pressure test on each cavity with a helium tank etc [2].

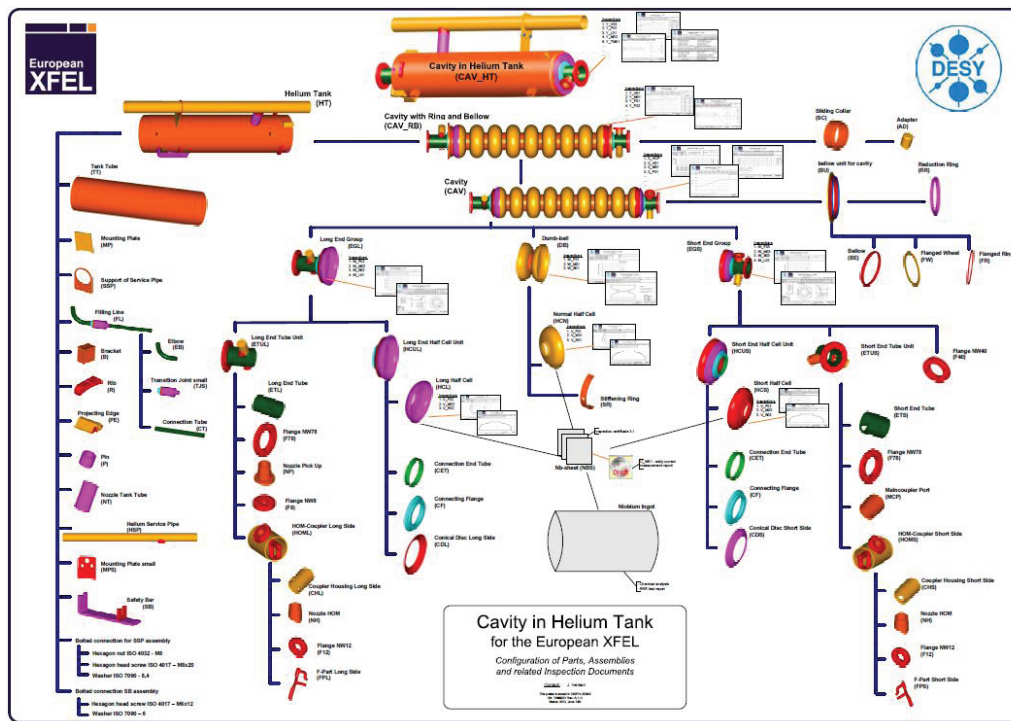


Figure 4: Manufacturing view of cavity with Helium Tank, showing the subassembly breakdown structure [2].

To ensure the traceability for pressure bearing parts, a data management system (*Galileo* software) has been implemented. The system is used in EXFEL project as a central archive of all technical documentation, including the documentation of the manufacturing process from niobium sheets to the completed cavity and the non-conformity reports [3].

To ensure product quality, high-precision measurement systems have been defined, along with monitoring and analysis of data during the various step of production.

Technical procedures have been issued in order to provide detailed guidance on operating modes, with particular attention to the phases of production previously considered critical.

A parallel technical effort was done to reach good efficiency of the production toolings in order to optimize the quality of the product. For this purpose, special jigs to handle multiple subassemblies are employed for machining, welding and dimensional controls. A total of about 100 new tools have been designed and manufactured.

Quality management has taken into account the planning and development of production processes [4].

Analysis of simulations were necessary for the planning of the production process and in respect to each phase of it, all possible bottlenecks were analyzed, optimizing the time and cost of production, maintaining high product quality.

## CONCLUSION

Ettore Zanon s.p.a. has realized with great effort a dedicated lay-out for the production of 420 series cavities, under the European XFEL project.

Qualification's cavities and pre-series cavities are finished and they had very satisfactory results.

Serial production has started in January 2013. The tested cavities demonstrated adequacy for EXFEL performance.

With new production techniques and optimization of infrastructure, 4/5 cavities per week could be manufactured at this company.

## ACKNOWLEDGEMENTS

We would like to thank all participating colleagues. About 100 people are actually fully involved for the EXFEL task, whose enthusiastic effort and whose professionalism allows us to push forward the work with excellent results on cavities for EXFEL project.

## REFERENCES

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