E4ESS Magnets

D. Castronovo

Outline:

- ✓ Brief hystory
- ✓ Work In Progress
- ✓ Example: Q6



Brief hystory:

- 05/2014: The magnets IKC activity started with the development of the specifications.
 We were D.Castronovo (Elettra), E.Sargsyan (ESS) and C.Martins (ESS).
- 11/2015: **Pulsed** Quadrupole prototype definition. Scientific Collaboration with CERN.
- 05/2016: Q5, Q6, Q7, C5 and C7 CDR.
- 12/2016: Q5, Q6, Q7 CDR2, switching from *pulsed* to *DC*.
- 03/2017: Q6 prototype measurements.
- 04/2017: Q5, Q6, Q7, C5 and C7 tendering.
- 06/2017: D1, Q8 and C8 PDR.

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- 01/2018: D1, Q8 and C8 tendering.
- 02/2018: Contract with Danfysik (Q5, Q6, Q7, C5 and C7) and Kick off meeting.
- 11/2018: Contract with SigmaPhi (D1, Q8 and C8) and Kick off meeting.
- 02/2019: Danfysik Quadrupole and Corrector FOS, magnetic mesurements at Elettra.
- 02/2019: D1, Q8 and C8 FDR by SigmaPhi.
- 07/2019: End of the contract with Danfysik.
- 08/2019: End of Delivering to Daresbury.
- 10/2019: C8, D1 and Q8 FATs at SigmaPhi.

Hystory

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WIP:

SigmaPhi Quadrupole realisation.

• SigmaPhi Dipole and Quadrupole FOS magnetic measurements.

 Q5, Q6, Q7, C5 and C7 final report (performance calibrations, field quality, alignment references, magnetic measurements theory, etc.).



- 1. Based on ESS DOORS \rightarrow CDR and Prototype.
- 2. Proving of the feasibility by the prototype tests.
- 3. Based on the CDR (verified by the prototype) → Tendering technical specification, quality requirements.
- 4. After the contract signed with Danfysik, technical documentation with all the material and procedure certifications.
- 5. During the Danfysik realisation, FAT reports plus quality and conformity tests.
- 6. After the approval for the delivery to Elettra, magnetic measurements (mechanical alignment, hydraulic connection and verifications)
- 7. Approval for the delivering to Daresbury, draft report of the performance and the field quality.
- 8. Before the delivering to Daresbury, opening and closing procedure manual.
- Overviewing the first PC magnet test.
- Commissioning overviewing.



Lot B: CIG 7052141AD8 DANEscriptions for technical file

> Gregersensvej 8 DK-2630 Taastrup Denmark

Tel : +45 7220 2400 Fax: +45 7220 2410 VAT No.: DK31934826

sales@danfysik.dk www.danfysik.com Quadrupoles Q5, Q6 and Q7 for the ESS project



INFN – Laboratori Nazionali di Legnaro

Supply of Q5, Q6 and Q7 Quadrupole Magnets (Lot B: CIG 7052141AD8)

Danfysik ref. ITA 503367

List of Contents

Technical File Q5, Q6 and Q7 Quadrupoles

Written description:

• Technical description 503367 Quads

Time schedule:

• 503367 INFN Quads for ESS A-B schedule 180420

Drawings:

- 7103036652 (dx) 7103036710 (sx) Assembly drawing Q5 Quadrupole

 Incl. all manufacturing drawings in hierarchy below
- 7103036571 (dx) 7103036725 (sx) Assembly drawing Q6 Quadrupole
 - o Incl. all manufacturing drawings in hierarchy below
- 7103036655 (dx) 7103036726 (sx) Assembly drawing Q7 Quadrupole
 - o Incl. all manufacturing drawings in hierarchy below
- 7103036752: Winding tool for Q5
- 7103036732: Winding tool for Q6
- 7103036736: Winding tool for Q7
- 7103036700: Q5 Stacking tool
- 7103036621: Q6 & Q7 Stacking tool
- 7103036743: Molding tool assembly Q6
- 7103036717: Molding tool assembly Q7

QA process check sheets:

- 503367017-Q5_Coil test
- 503367020-Q5_Complete magnet test
- 503367023-Q6_Coil test
- 503367026-Q6_Complete magnet test
- 503367027-Q7_Coil test

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- 503367030-Q7_Complete magnet test
- 503367031 Q5 Lamination process check sheet
- 503367032 Q6 Lamination process check sheet
- 503367033 Q7 Lamination process check sheet

Example: Q6

CIG 7052141AD8 Quads INFN/Elettra Quadrupoles type Q5, Q6 and Q7 for ESS Specification E-ST ESS MGN TSD 001

Danfysik ref. ITA 503367

Technical Description

For Technical File Quad Q5 part no. 7103036652 (dx) 7103036710 (sx) Quad Q6 part no. 7103036571 (dx) 7103036725 (sx) Quad Q7 part no. 7103036655 (dx) 7103036726 (sx)

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Bonding lacquer coating Stabolit 70

Stabolit 70 is a bonding lacquer based on a heat ad- No bonding will occur at normal storage temperatures, even livered state, the lacquer coating is completely dry costs in many applications. and non-adherent which allows the sheets to be stored and the coils to be tightly wound, even when significant pressure involved.

herent synthetic resin which can be used for bonding after an extended period. In this state the bonding lacquer is electrical steel stampings into stacks as an alternativ not resistant to solvents. From strip coated with Stabolit 70. to riveting or welding. Under the name Stabolit 70', a laminations can be produced in the usal manner to be bonsurface coating has been developed which acts as an ded together by applying pressure an temperature to the adhesive and therefor as a bonding element between stack. During this procedure the previously dry lacquer coatthe lamitions in the stack. Besides optimal bonding ing softens, bonds the laminations and then hardens again. properties, improvement of punchability has also Experiences in the field of electrical engineerig have shown been considered. Stabolit 70 is a colourless lacquer that the application of the bonding lacquer coating is not coating which is applied to one or both sides of the restricted to the production of small motors. The use of Stastrip in a thickness of approximately 7 µm. In the de- bolit 70 has enabled a considerable saving in time and

Treatment conditions

1. Bondina

a)Temperature

Both induction heating and radiant heating are suitable for heating the stacks. A temperature of210°C must not be exceeded for a period of several minutes anywhere in the stack. Therefor small segments, which can be rapidly heated troughout the core, can be bonded with a short soaking time at higher temperatures (e.g. 2 min, soaking time at 210°C) whereas larger pieces must be heated more slowly and are bonded over a longer period at lower temperatures (e.g. at 190°C and with a soaking time of 15 min.). The method of heating and has to be individually approved.

b.)Pressure

A pressure of 150 to 300 N/cm² has been tried and wellproven in a wide range of applications. Hydraulic pressing devices as well as clamping devices with spring washers are suitable. The pressure should be maintained for as long as possible during the cooling process.

2. Temperature resistance

Issue January 2005

The bonded cores can withstand temperatures up to 150°C during continuous operation. Temperatures up to 200°C over a short period of time will not cause any damage.

3. Adhesive strenght of the bonding

The results of shear tests demonstrates that, when perfectly bonded, fracture is generally caused by material failure. Therefore the bonding strenght depends on the electrical steel grade and it thickness. For the grade M 400-50 A the shear strenght according to DIN 52283 (typical value

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14 N/mm²) and the peeling resistance measured according to DIN EN 1464 during the floating roller peel tests exceeds (typical value 6 N/mm²).

4. Resistance against corrosive liquids

Stabolit 70 is resistant against normal grades of oil. The unbonded coating is not solvent-resistant. Under bonded conditions, a slight softening should be allowed for with some so Ivents.

5 Degreasing

Before bonding oil or grease must be removed with alkaline deare asers

6. Insulation resistance

Depending on the pressure some direct contact between the laminations may occur after bonding

7 Protection of Jabour

About 5 % of the bonding lacquer volume is continually given off as voltile material over a heating period of 50 minutes from 140°C to 205°C during the bonding procedure. The coeersponds to approx. 0.7 g/m² of bonded electrical steel with a7 um coating on both sides. Terefor good ventilation must be provided at high flow rates.

8. Storage life of the insulation material

At temperatures lower than 27°C the storage life is more than 1 year. The material must be protected from exposure to sunlight or ultraviolet irradiation. The processing of the material is guaranteed as long as the insulation is clear and not vellowed or cloudv

Coil test - Procedures and equipment

Danfysik sheet no. D-207

- 1. Mechanical dimensions control Important mechanical dimensions are checked by means of traditional measuring tools, in some cases by means of a control template.
- 2. Measurement of water flow

Water flow at a specified pressure drop is measured. Equipment available with centrifugal pump, Fischer & Porter flow-meter and reliable manometers.

- 3. Water pressure leak test The coils are tested for leaks by means of pressurized water. Air hydro-pumps fo 70 Bar are available, make Madan cub.
- 4. Interturn insulation test

Capacitive discharge method. A suitable capacitor will be charged to its nominal voltage and discharged across the coil. The resulting sinusoidal damped signal must exhibit no variation in frequency and no voltage spikes. Instrumentation: Wayne Kerr Impulse/Surge tester model 7720 - 5kV max.

- 5. Electrical resistance measurement Equipment for measurement of electrical resistance is currently in use. The resistance is measured at a current of 1 amp.
- 6. Ground insulation test The electrical strength of the ground insulation is tested after impregnation as a water immersion test.

Following equipment is used:

- a) DC measurement of Insulation resistance Danbridge instrument, Type JP12A. 0 - 12 kV - DC with measurement of leak current.
- b) AC High Voltage test Special designed equipment. 0 – 10 kV – AC/250 m Amp/50 Hz eff.
- 7. Thermal cycling test

Automatic test equipment for thermal cycling test is available in the factory. The coils are heated by electric heating and temperature is continuously recorded.

Depending on customers' requirements a number of or all of the above described tests will be performed.

A typical test program would be:

- Before impregnation
 - Mechanical dimension control Measurement of water flow Water pressure leak test Interturn insulation test Electrical resistance measurement
- After impregnation Mechanical dimension control Interturn insulation test Ground insulation test

Example: Q6 Sincrotrone

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Epoxy system type C for impregnation of coils

Danfysik Sheet no. E-208

1.

- Mix (Huntsman Products) Araldite F 100 p.b.w. HardenerHY905 100 p.b.w. Accelerator DY073 0.4 p.b.w. Flexibilizer DT040 20 p.b.w.
- Impregnation Procedure Components are mixed under vacuum. Vacuum impregnation is performed at 60°C and < 4mBar.
- 3. Curing Gelling at 80°C for 5 hours Curing at 125°C for 14 hours
- 4. Typical Properties for Cured Resin Tensile strength (ASTM. D 638-64T) 70 N/mm² Elongation at break (ASTM. D 638-64T) 3-4% Modules of elasticity (Tension ASTM. D 638-64T) 3500 N/mm² Coefficient of expansion (ASTM D 696-44) 80 x 10 -6/°C Deflection temperature (ASTM, D 648) 65°C Electric strength (IEC 243) 17 kV/mm Radiation resistance 0.75 x 10⁹ Rad (Samples irradiated and tested according to CERN-standard and ASTM-D790)

Data Sheet

DANEYSIK

Oxygen-free Copper Cu-OF – Luvata Special Products Alloy OF-OK® GENERAL DESCRIPTION – SUBJECT TO CHANGES OR DEVIATIONS

Alloy description

Luvata Special Products OF-OK® oxygen-free copper is high purity copper that is immune against hydrogen embrittlement. It is used in applications where high electrical and thermal conductivity are the essential requirements. It can be joined with all welding and brazing methods and it is suitable for manufacturing processes requiring extreme deformability.

Typical applications:

- Magnet windings
- Semiconductor components
- Electric motors
- Wave guide tubes
- Induction furnaces
- Electrical components
- Switchgear applications
- · Generator material in rotor and stator windings
- Other applications where high electrical and thermal conductivity is needed

Products / shapes:

Profile tubes, round tubes, round rods, wire and strip coils, rectangular bars and solid profiles. Corresponding EN-norms for different products are as follows:

- EN 13600 Copper and copper alloys. Seamless copper tubes for electrical purposes.
- EN 13601 Copper and copper alloys. Copper rod, bar and wire for general electrical purposes.
- EN 13605 Copper and copper alloys. Copper profiles and profiled wire for electrical purposes.

2018-04-06 - E 208 Epoxy system C for impregnation of coils.docx





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				To be carri	ied out after asse	mbling			
		Descri	iption	Test equipment (DF Reg. Nr.)	Result measu	Ired	Criteria and tolerance	Accepted	Sign./Date
107. 1	Visual inspec	ction accol	rding to main drawing ews, BOM etc.	N/A	N/A		NIA	40	8/2-19 brud
	Check should magnet with d disassembly. §	er gaps of ⁴ edicated ga See drawin	40±0.02 at both ends of auge before g no 7103036558	W/A	JAC OK / Not OK		ok	ok	8/2-19 mucel
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