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.
- 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.

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.).

- …

Example: Q6

1. Based on ESS DOORS ➔ 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.*

INFN – Laboratori Nazionali di Legnaro

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

Danfysik ref. ITA 503367

Gregersensvej 8
DK-2630 Taastrup
Denmark
Tel : +45 7220 2400
Fax: +45 7220 2410
VAT No.: DK31934826
sales@danfysik.dk
www.danfysik.com

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
  - Incl. all manufacturing drawings in hierarchy below
- 7103036655 (dx) 7103036726 (sx) Assembly drawing Q7 Quadrupole
  - 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
- 503367030-Q7_Complete magnet test
- 503367031 Q5 Lamination process check sheet
- 503367032 Q6 Lamination process check sheet
- 503367033 Q7 Lamination process check sheet

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)

ThyssenKrupp Steel AG
Electrical Steel Bochum -Division Industry-

Bonding lacquer coating Stabolit 70

Stabolit 70 is a bonding lacquer based on a heat adherent synthetic resin which can be used for bonding electrical steel stampings into stacks as an alternativ to riveting or welding.Under the name `Stabolit 70´, a surface coating has been developed which acts as an adhesive and therefor as a bonding element between the lamitions in the stack. Besides optimal bonding properties, improvement of punchability has also been considered.Stabolit 70 is a colourless lacquer coating which is applied to one or both sides of the strip in a thickness of approximately 7 µm. In the delivered state, the lacquer coating is completely dry and non-adherent which allows the sheets to be stored and the coils to be tightly wound, even when significant pressure involved.

No bonding will occur at normal storage temperatures, even after an extended period. In this state the bonding lacquer is not resistant to solvents. From strip coated with Stabolit 70, laminations can be produced in the usal manner to be bonded together by applying pressure an temperature to the stack. During this procedure the previously dry lacquer coating softens, bonds the laminations and then hardens again. Experiences in the field of electrical engineerig have shown that the application of the bonding lacquer coating is not restricted to the production of small motors. The use of Stabolit 70 has enabled a considerable saving in time and costs in many applications.

Treatment conditions

1. Bonding
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 well-proven 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*
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 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 solvents.

5. *Degreasing*
Before bonding oil or grease must be removed with alkaline degreasers.

6. Insulation resistance
Depending on the pressure some direct contact between the laminations may occur after bonding.

7. Protection of labour
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 coeer-sponds to approx. 0,7 g/m² of bonded electrical steel with a7 µm 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 yellowed or cloudy.

Issue January 2005

DANFYSIK

February 2013

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

DANFYSIK

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.

2. Impregnation Procedure
Components are mixed under vacuum. Vacuum impregnation is performed at 60ºC and < 4mBar.

3. Curing
Gelling at 80ºC for 5 hours
Curing at 125ºC 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}/ºC
Deflection temperature (ASTM. D 648)	65ºC
Electric strength (IEC 243)	17 kV/mm
Radiation resistance	0.75 x 10^{9} Rad

(Samples irradiated and tested according to CERN-standard and ASTM-D790)

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

LUVATA SPECIAL PRODUCTS

Data Sheet

GENERAL DESCRIPTION
– SUBJECT TO CHANGES OR DEVIATIONS

Oxygen-free Copper Cu-OF – Luvata Special Products Alloy OF-OK®

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:

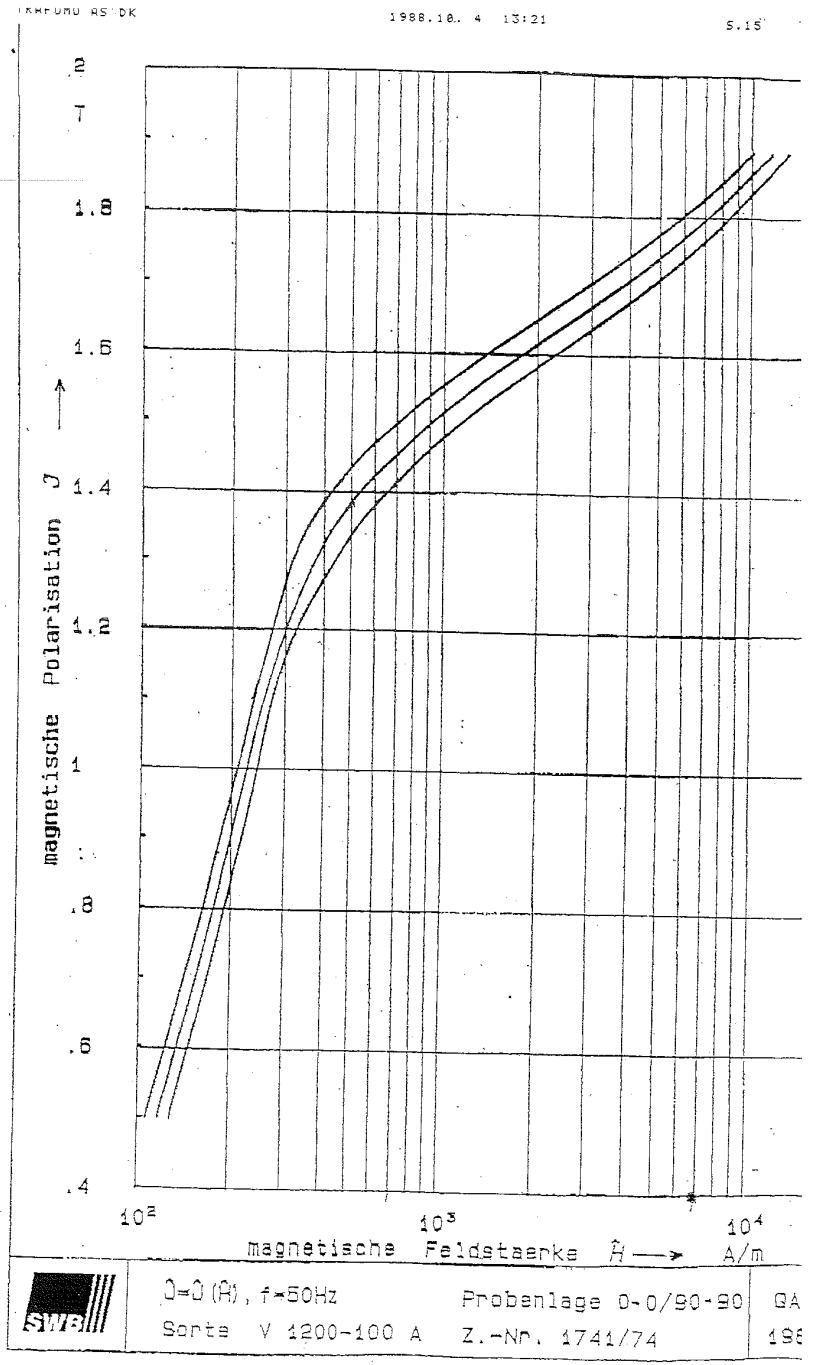
- EN 13600 – Copper and copper alloys.
  Seamless copper tubes for electrical purposes.
- EN 13601 – Copper and copper alloys.
  Copper rod, bar and wire for general electrical purposes.
- EN 13605 – Copper and copper alloys.
  Copper profiles and profiled wire for electrical purposes.

4:

EBG
THYSSEN STAHL AG
BOCHUM
GERMANY

PRODUCT INFORMATION

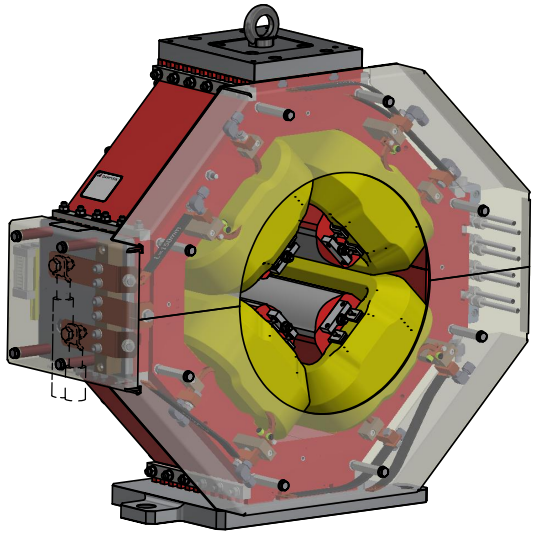
ELECTRICAL STEEL QUALITY 1200-100-A

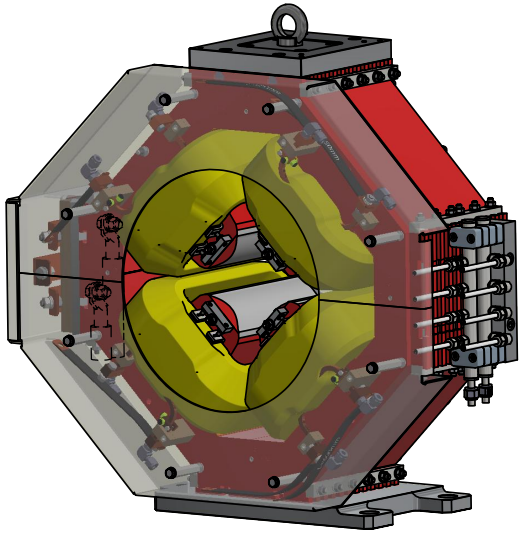


4:

POS.	QTY.	DESCRIPTION	PRODUCT NO.	MATERIAL
73	2	Pan head screw with type Z cross recess - product grade A	ISO 7045 - M6 x 12 - 4.8 - Z	Steel
72	4	Glass fiber sleeve, silicone impregnated	9000012665	Glass fiber
71	2	Male Connector 3/8" Ø10 ISO Parallel Thread	9000015856	AISI 316.
70	12	Distance bolt M8 x 60	9000015853	1.4305.
69	18	T-nut DIN 508 long - Halder 23020.0120 - Norelem 07061-10	9000015851	Steel, Hardened
68	8	Positionable male elbow SS-8M0-2-2PR	9000014002	AISI 316.
67	8	Vukolan with adhesive side - 4x50x2000 mm	9000013939	Vulkolan D15M.
66	8	Vukolan with adhesive side - 1x50x2000 mm	9000013935	Vulkolan D15M.
65	1	Glass/silicone sleeve SCS 4kV Ø12 red	9000012665	Generic
64	8	Hose PA 12 HA Ø8/Ø5	9000012031	-
63	4	Swagelok Union SS-8M0-6	9000000177	AISI 316.
62	4	Swagelok Elbow SS-8M0-9	7900070065	AISI 316.
61	4	Thermoswitch clamp	7103036671	Copper
60	8	Q6/Q7 Coil fixation bracket 1	7103036670	EN AW-6082-T6
59	8	Q6/Q7 Coil fixation bracket 2	7103036669	1.4301.
58	4	Coil tail fixation - part 3	7103036654	G-Etronax EP11
57	8	Coil tail fixation - part 2	7103036653	G-Etronax EP11
56	4	Coil tail fixation - part1	7103036643	G-Etronax EP11
55	16	Vulkolan pad	7103036614-01	Vulkolan D15M.
54	4	Q6_M8 Threaded Rod 3	7103036612	
53	4	Coil assembly Q6	7103036593	
52	1	Terminal - Eneg	7103036591	OF Copper
51	1	Terminal - E0	7103036590	OF Copper
50	1	Terminal - Epos	7103036589	OF Copper
49	1	plate for electrical terminals	7103036587	EN AW-6082-T6
48	1	Terminal rest	7103036585	
47	1	Q5/Q6/Q7 Base plate	7103036584	EN AW-6082-T6
46	1	Q6/Q7 Clear Cover teminals	7103036573	Polycarbonate, Clear
45	2	Q6/Q7 Clear Cover	7103036572	Polycarbonate, Clear
44	1	Q6/Q7 Top Hoisting plate	7103036570	EN AW-6082-T6
43	1	Top alignment plate Q6	7103036569	EN AW-6082-T6
42	1	Yoke assembly Q6	7103036558	
41	9	Q6_M8 Threaded Rod 1	7103036545	
40	1	Q6/Q7 Manifold connection plate	7103036544	EN AW-5083.
39	2	Water Manifold 4xØ6mm/1xØ10mm	7103036543	
38	1	Label	7103034078-01	-
37	10	Terminal 2.5mm^2/24A-Beige	6700109002	PA 66
36	1	WAP 2.5-10 - End plate	6700106102	Generic
35	2	Rail-end Stop for DIN 35 (Alu)	6700101020	Aluminum (Cast).
34	1	TS 35x7.5 DIN RAIL	6700100000	S235 JRG2
33	2	BUSSBAR, Ultraflex, L: 650 mm/50mm^2	6402050651	Copper
32	1	BUSSBAR, Ultraflex, L: 600 mm/50mm^2	6402050601	Copper
31	1	BUSSBAR, Ultraflex, L: 450 mm/50mm^2	6402050451	Copper
30	1	BUSSBAR, Ultraflex, L: 300 mm/50mm^2	6402050301	Copper
29	1	BUSSBAR, Ultraflex, L: 150 mm/50mm^2	6402050151	Copper
28	16	Stiffener Sleeve 8x5 Nº0560030136	5400820015	AISI 316.
27	3	DIN 127B - 10	5400800115	A4-70
26	8	DIN 127B - 8	5400800114	A4-70
25	4	DIN 127B - 4	5400800111	A4-70
24	6	ISO 7089 - 10	5400800036	A4-70
23	56	ISO 7089 - 8	5400800035	A4-70
22	12	DIN 1587 - M8 - Hexagon Domed Cap Nuts	5300800201	A4-70
21	16	ISO 4035 - M6	5300800150	A4-70
20	3	ISO 4032 - M10	5300800067	A4-70
19	25	ISO 4032 - M8	5300800066	A4-70
18	16	ISO 4027 - M6 x 25	5200804312	A4-70
17	4	ISO 4026 - M8 x 25 Socket set screws	5200804164	A4-70
16	1	DIN 580 - M16 x 27	5200803997	C15, Zink Plated.
15	4	DIN 7991 - M10 x 25	5200803959	A4-70
14	2	ISO 8735 A - Ø6 x 70 - m6	5200803652	Steel, Hardened
13	3	ISO 4017 - M10 x 25	5200803121	A4-70
12	8	ISO 4017 - M8 x 30	5200803100	A4-70
11	12	ISO 4017 - M8 x 16	5200803095	A4-70
10	4	ISO 4017 - M4 x 20	5200803043	A4-70
9	2	ISO 4762 - M8 x 30	5200800670	A4-70
8	6	ISO 4762 - M8 x 20	5200800668	A4-70
7	4	ISO 4762 - M6 x 65	5200800661	A4-70
6	4	ISO 4762 - M6 x 25	5200800653	A4-70
5	2	ISO 4762 - M10 x 60	5200800394	Class 8.8 Zink Plated
4	12	ISO 4762 - M10 x 25	5200800387	Class 8.8 Zink Plated
3	4	ISO 4762 - M6 x 80	5200800368	Class 8.8 Zink Plated
2	8	Pipe holder for Ø21,3mm (C4)	5100110001	-
1	8	Thermal Switch 60degC NC 1,6A	1400601300	-

REVISION HISTORY			
REV	REVISION COMMENT	DATE	APPROVED
A	Released		





"Q6 - SX" is identical to the DX version 7103036571 - but **mirrored**.
Please use 7103036571 and 3D model as assembly guides.

DANFYSIK
www.danfysik.com
danfysik@danfysik.dk
Phone: +45 7220 2400

Important:
This document contains informations which are the property of DANFYSIK A/S Denmark. It is submitted to you in confidence that it will not be disclosed or transmitted to others or used for manufacturing without DANFYSIK's authorization in writing.

Size: A2	Customer:	Surface machining:	Note:
Scale: 1 : 5	Order No.:	Surface treatment:	
Projection:	Dimensions without tolerance indication:	Material:	Mass: 524,8 kg
		Description: Q6 - C100-sx - main assembly	
		Product No.: 7103036725	Rev.: A
	Date: / Name:	Doc. No.:	
App. by	20-04-2018 KAME		
Check by	20-04-2018 UHJN	CAD Program: Inventor AIS 2018	Plot date:
Drawn by	20-04-2018 UHJN	File name: 7103036725.idw	Sheet: 1 of 1

5:

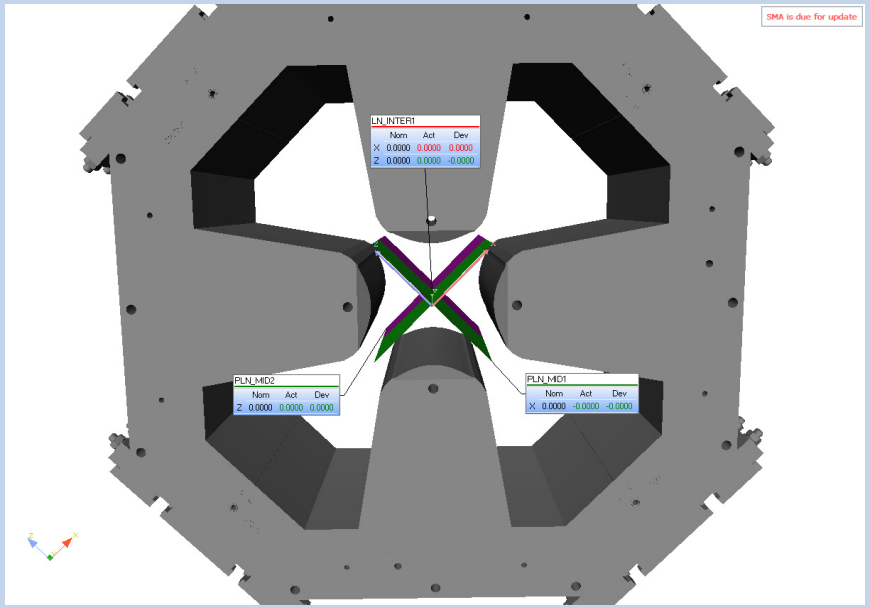
INSPECTION REPORT

Part No: 7103036558
Operator: CL.AM værktøj A/S
Date: Friday, January 11, 2019
Time: 7:36:43 AM
Seriel Nr.: 7103036558-18134-002
Rev: D
Part Temperature 20.0C
Temperatur:
Workpiece: 20,0
X axis: 20.2
Y axis: 20.4
AMV Seriel Nr.: 7103036558-002

Nom	Act	Dev	LwTol	UpTol	Trend

Alignment

Datum A(LN_INTER1)



RationalDMIS(TM) External-Array Software, Inc Page 1 Leader-nc

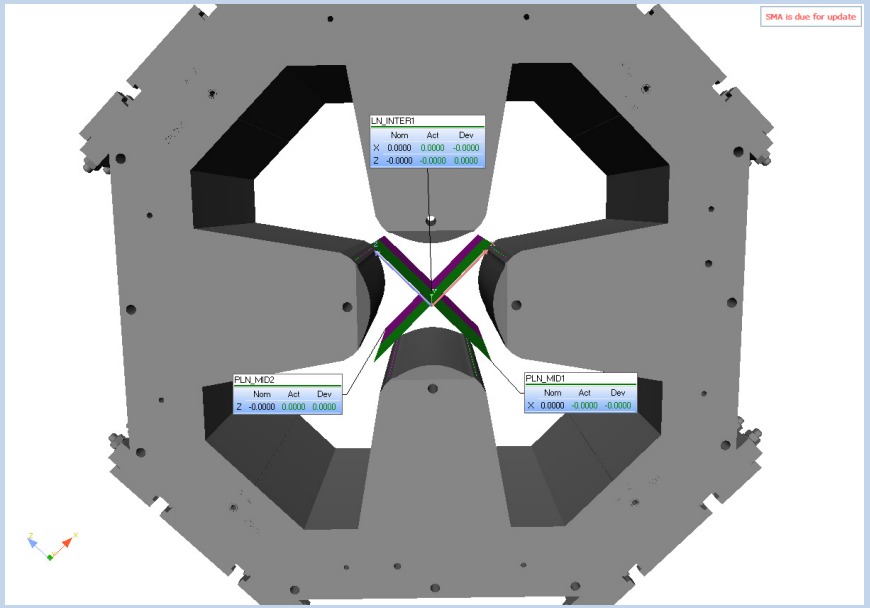
INSPECTION REPORT

Part No: 7103036558
Operator: CL.AM værktøj A/S
Date: Friday, January 11, 2019
Time: 8:59:00 AM
Seriel Nr.: 7103036558-18134-002-ADSKILT
Rev: D
Part Temperature 20.0C
Temperatur:
Workpiece: 20,0
X axis: 20.2
Y axis: 20.4
AMV Seriel Nr.: 7103036558-002-ADSKILT

Nom	Act	Dev	LwTol	UpTol	Trend

Alignment

Datum A(LN_INTER1)



RationalDMIS(TM) External-Array Software, Inc Page 1 Leader-nc

5:

DANFYSIK

Doc. No.:	Rev.No:	Description:	Product description:
503367026	C	COMPLETE MAGNET TEST	Q6_Quad Magnet
Order No.:	Customer:	Part/drawing No.:	Magnet No.:
503367	INFN (ESS)	7103036571 / 7103036725	18 134

To be carried out after assembling

No.	Description	Test equipment (DF Reg. Nr.)	Result measured	Criteria and tolerance	Accepted	Sign./Date
1	**Visual inspection according to main drawing** Check paint, brazing, screws, BOM etc.	N/A	N/A	N/A	Ok	8/2-19 mmel
2	Check shoulder gaps of 40±0.02 at both ends of magnet with dedicated gauge before disassembly. See drawing no 7103036558	N/A	X OK / Not OK	Ok	Ok	8/2-19 mmel
3	**Coil numbers** Record the last three digits in coil serial number. When looking from the coil connection end. 7103036593-**XXX**	NA	Top right coil 398 Bottom right coil 353 Bottom left coil 372 Top left coil 401	Visible coil no. Visible coil no. Visible coil no. Visible coil no.	Ok	11-2-19 MS
4	Check shoulder gaps of 40±0.02 at both ends of magnet with dedicated gauge after assembly. See drawing no 7103036558	N/A	X OK / Not OK	Ok	Ok	8/2-19 mmel

503367026-Q6_Complete magnet test C.docx
Danfysik A/S • Gregersensvej 8 • DK-2630 Taastrup • Denmark • Tel. +45 7220 2400 • Fax +45 7220 2410 • sales@danfysik.dk • www.danfysik.com • VAT reg. No. DK 31 93 48 26 • Bankers: Jyske Bank, Denmark