Risposte alle richieste di chiarimenti relative alla gara pubblica per la 'Fornitura di magneti correttori e quadrupoli, suddivisa in due lotti e relative opzioni per il progetto ESS ERIC', atto GE n. 11332/2017, lotto 1 CIG: 7052110146, lotto 2 CIG: 7052141AD8.

Replies to the questions related the public tender for the 'Supply of the corrector and quadrupole magnets, divided in lots e related options for the ESS ERIC project', atto GE n. 11332/2017, lotto 1 CIG: 7052110146, lotto 2 CIG: 7052141AD8.

General questions/requests:

1. **Would it be possible to provide the tender documents in English format. If this is not available, can you please provide electronic (pdf) version of these documents so we can easily cut and paste the text to translate.**
   REPLY: The official language to be referenced to the tender is the Italian language and as a courtesy, only the technical specifications of the devices subject of the tender have been provided in English format. No additional translation will be done.
   To facilitate the translation of the documents, we make available on line the electronic version (pdf) of the following documents for both lots:
   - Allegato2-Disciplinare di gara
   - Allegato4-Condizioni Contrattuali

2. **In order to establish the bank guarantee for this tender, could you tell us the opening date of the offers?**
   REPLY: The date of the public sessions for opening the administrative, technical and economic offers shall be set once the terms for applying the tender will be expired on June 20th, 2017. Presumably, the first public session will be held on mid-July.

3. **It is possible to also provide 3D model files of the magnet? Do you have step files of those magnets that you could send us?**
   REPLY: A set of technical drawings of the magnets have been already provided by Elettra in accordance with INFN. Such a documentation is fairly exhaustive for allowing the supplier to make a detailed technical offer and economic as well. Since the 3D drawings include sensitive information that might result in loss of know-how, his disclosure will be done once the contract will be signed.

Technical questions/requests (see references at the end of document):

- **Correttors C5 - C6:**

1. **Manca il disegno del lamierino e le dimensioni del pacco magnetico. E' possibile avere il disegno del lamierino di entrambi i correttori C5 e C6?**
   The drawings of the lamination and the dimensions of the magnetic core are missing. Is it possible to have the sheet design of both C5 and C6 correctors?
   REPLY: The drawings (C5C001 sheet 3 and C6C001 sheet 3) are attached to this document.

2. **Manca il disegno dell'avvolgimento e dalle misure della bobina finita presenti nel disegno C5C001 fa intendere che: l'avvolgimento viene eseguito sul lato stretto del conduttore (3.55 x 18 = 63.9 senza tener conto che manca ancora lo spessore dell'isolamento stesso; sulla superficie interna ed esterna, della parte larga della bobina, oltre alla nastratura del conduttore e del contromassa, fa intendere che c'è un ulteriore rivestimento, dove poi viene fissato il thermal switch. Se è così, di che materiale è composto il rivestimento?**
   The drawing of the winding is missing and according to the dimensions of the coil, reported in drawing C5001, the following is assumed:
   - ***the winding is realized on the narrow side of the conductor (3.55 x 18 =63.9) not taking into account that the thickness of the insulation is missing;***
   - ***on the inner and outer surfaces of the large side of the coil, in addition to the conductor taping and to the ground insulation there is a further coating on which the thermal switch is being fixed. If so, which material this further coating is made of?***

   REPLY: According to [1] section 5.3.3 "The inter-turn insulation will be realized by means of fiber-glass taping around the conductor, or, in alternative, adopting a suitable pre-insulated conductor; in both cases the chosen method shall be submitted and approved by INFN, in agreement with Elettra. The insulated conductor shall then be formed into the final coil shape. After the coil forming, an additional insulation to ground shall be realized by means of a further fiber-glass layer". Thus there are 2 insulation layers, the first is the conductor insulation and the second is the insulation to ground. After the resin impregnation the thermal switches will be fixed on the outer surface of the coil.

   According to [1] tab. 3, the H length of the coil is 18 x 3.55 = 63.9, but in drawing C5001 the same length is 63. However the drawings are not meant as construction drawings. The detailed and updated construction drawings as well as the 3d models (step files) will be available after the signing of the contract.

3. **A seguito di quanto sopra descritto mancherebbero le quote per la forma di avvolgimento e le posizione delle uscite delle bobine in modo da capire come sviluppare l'avvolgimento stesso.**

According to what above mentioned the dimensions of the winding are missing as well as the position of the terminals of the coils, in order to understand how the winding itself is to be realized.
REPLY: See previous answer concerning the drawings. Concerning the position of the terminals of the coil, this is somehow left to the discretion of the constructor; see [1] section 3.1.11.

4. **Nei punti di unione dei 4 semigioghi ci sono 8 particolari (2 per ogni angolo), mentre tra la superficie più esterna dei 4 semigioghi e la bobina, ci sono 4 piastrine. Di quale materiale devono essere costruiti?**
There are 8 particulars (2 for each corner) in the junction regions of the 4 yokes; similarly there are 4 small plates between the 4 yokes and the coils. What material are they made of?
REPLY: According to [1] paragraph 5.1 "The design, the engineering and the selection of raw materials and semi-finished products to be used for the construction, shall ensure a correct operation of the magnets for a life time cycle equal to at least 20 (twenty) years and shall take into account the operating environment where the magnets will be installed, which is, a tunnel where a linear proton accelerator (of which the magnets will be part) will be assembled. The accelerator will operate at a maximum energy of 2 GeV and ionizing radiations will be present in the tunnel itself. The temperature in the tunnel will be about 20 °C and the expected total integrated radiation dose, during 40 years of operation, is equal to 10 MGy". This is mandatory.

   Concerning the mentioned component, suggested material is fiber-glass, but the final choice is left to the constructor (subject to approval by Elettra, but under responsibility of the constructor).

5. **Al paragrafo 3.1.2 della specifica è riportato che, soltanto dopo la firma del contratto verranno forniti il modello 3D e la lista dettagliata dei test da eseguire sui magneti. Entrambi sarebbero necessari in fase di preparazione dell'offerta; è possibile riceverli in fase di offerta almeno in forma preliminare?**
According to [1] section 3.1.2, the 3D models and the detailed list of the tests to be performed on the magnets will be provided at the signing of the contract. Both would be necessary for preparing the quotation; is it possible to have them at least in a preliminary stage?
REPLY: The detail concerning the tests is related mainly to the procedure of the tests themselves. The envisage tests are listed in [1] chap. 5 and 6. The 3D models (step files) contain information protected by the intellectual property and are not available at this stage.

6. **Relativamente ai dati di progetto sono necessarie, per entrambi i correttori C5 e C6, le seguenti informazioni:**
   - **Corrente nominale**
   - **Massimo ΔT di progetto sulle bobine in condizioni nominali**
   - **Qualità di campo richiesta**

   Concerning the design parameters, for both C5 and C6 the following information are needed
   - ***Nominal current***

- ***Maximum nominal design ΔT of the coils***
- ***Requested field quality***

REPLY: See [3] Tab. 1 – Tab. 5 for the requested information.

7. **Con quale materiale devono essere realizzati i blocchetti sagomati tra le bobine (all'interno della finestra del giogo), e le piastre tra bobine e giogo?**
   What material are the blocks between the coils (inner window of the yoke) made of? And what about the small plates between the coils and the yoke?
   REPLY: According to [1] paragraph 5.1 "The design, the engineering and the selection of raw materials and semi-finished products to be used for the construction, shall ensure a correct operation of the magnets for a life time cycle equal to at least 20 (twenty) years and shall take into account the operating environment where the magnets will be installed, which is, a tunnel where a linear proton accelerator (of which the magnets will be part) will be assembled. The accelerator will operate at a maximum energy of 2 GeV and ionizing radiations will be present in the tunnel itself. The temperature in the tunnel will be about 20 °C and the expected total integrated radiation dose, during 40 years of operation, is equal to 10 MGy". This is mandatory.
   Concerning the mentioned component, suggested material is fiber-glass, but the final choice is left to the constructor (subject to approval by Elettra, but under responsibility of the constructor).

8. **Con quale materiale devono essere realizzati i blocchetti per il bloccaggio dei "quarti" di giogo?**
   What material are the fixing blocks of the yoke quadrants made of?
   REPLY: According to [1] paragraph 5.1 "The design, the engineering and the selection of raw materials and semi-finished products to be used for the construction, shall ensure a correct operation of the magnets for a life time cycle equal to at least 20 (twenty) years and shall take into account the operating environment where the magnets will be installed, which is, a tunnel where a linear proton accelerator (of which the magnets will be part) will be assembled. The accelerator will operate at a maximum energy of 2 GeV and ionizing radiations will be present in the tunnel itself. The temperature in the tunnel will be about 20 °C and the expected total integrated radiation dose, during 40 years of operation, is equal to 10 MGy". This is mandatory.
   Concerning the mentioned particular, suggested materials are stainless steel, aluminum ..., but the final choice is left to the constructor (subject to approval by Elettra, but under responsibility of the constructor).

9. **Time schedule: nella time schedule fornita si considerano 240 gg per la costruzione dei 13 correttori C5 e 200 gg per la costruzione dei 55 correttori C6; è corretto ? Sarebbe eventualmente possibile proporre una schedula alternativa in modo tale da mantenere la durata complessiva del lotto, ma distribuendo in maniera differente le consegne intermedie?**
   Time schedule: according to the attached time schedule 240 d are assumed for the construction of 13 corrector C5 and 200 d for the construction of 55 correctors C6; is this correct? Could it be possible to

propose an alternative schedule that keeps fixed the delivery of the whole lot, but changing the distribution of the intermediate deliveries?

REPLY: The time schedule provided with the tender documents is bonded to the milestones of the whole project; this includes also activities to be performed at Elettra. It is recommended not to change the time schedule.

- **Quadrupoles Q5-Q6-Q7:**

1. **Q5 e Q7 - Dal disegno Q5C100 e Q7C100 (Fogli n° 2) fa intendere che ogni semigiogo è composto da due pacchi di lamierini. Chiedo conferma.**
   Q5 and Q7 – According to drawing Q5C100 and Q7C100 (sheet n.2) each quadrant is realized by 2 laminations pack. We ask for a confirmation.
   REPLY: According to [2] section 5.2.1, "The magnetic yokes shall be realized assembling four quadrants; each quadrant will be built gluing a suitable pack of steel laminations, which are realized by a stamping process". The four quadrants are assembled in such a way to realize an upper and a lower half-yoke. Each quadrant is made by a single lamination pack.

2. **Sulle due estremità di ogni semigiogo, nella zona dell'espansione polare, c'è una smussatura. Viene creata inserendo un inserto su una parte di lamierini a cui viene tranciata la stondatura sull'espansione polare?**
   At the 2 ends of each quadrant, in the pole profile region, a chamfer is visible. Is that chamfer realized inserting a machined component on the lamination pack, cutting a portion of the lamination?
   REPLY: The chamfer is realized machining the glued lamination pack of each quadrant.

3. **Per il collegamento elettrico tra le bobine e la morsettiera, dato che a disegno dalle uscite delle bobine ci sono piastrine corredate di foro, si può utilizzare spezzoni dello stesso conduttore delle bobine opportunamente sagomati (anche se la foratura non verrebbe utilizzata), con le estremità corredate di terminale a occhiello sempre in rame OFHC?**
   Since in the drawings, at the coil terminals, connection plates with suitable holes are visible, is it possible to adopt suitably shaped pieces of the same conductor used for the coil construction and provided with suitable OFHC copper eyelet terminals, to connect the coils and the connection block (even if the holes would not be used)?
   REPLY: The conductor adopted for the construction of the coils is dimensioned to work with a suitable coolant flow. Any connection between the coils and to the magnet connection block will not be cooled by any coolant medium (i.e. will be air-cooled) and thus it must be realized either with solid bars or flexible cables (the final choice is left to the constructor, subject to approval by Elettra, but under responsibility of the constructor) with a cross section able to sustain a DC maximum current of 200 A. See also [4] Tab. 6 – Tab. 11 for the magnets operating parameters.

4. **Mentre per la parte idraulica, secondo quanto fanno intendere i disegni, i raccordi sono ad attacco rapido per tubo plastico? Tipo quelli per aria compressa? Nella specifica non sono contemplate prove idrauliche dopo l'assemblaggio del quadrupolo, ma solo la prova del passaggio di una sfera calibrata dopo la costruzione della singola bobina. E' possibile sapere qual'è la pressione nominale di funzionamento del circuito idraulico ed a quale pressione massima deve essere provato?**
Concerning the hydraulic circuit, according to the drawings, are the joints provided with fast connection terminals? Suitable for plastic pipes? No hydraulic tests are specified on the assembled magnet, but only a test based on the passage of a calibrated sphere after the realization of each single coil. Is it possible to know the nominal working pressure of the hydraulic circuit and the maximum test pressure?
REPLY: Refer to drawings Q5C100 sheet 3, Q6C100 sheet 3 and Q7C100 sheet 3.
Suggested hydraulic connections are of the swagelock type:
Coil to coil connection: SS_8M0_1_2RS_20012 SS_8M0_2_2PR_20024
Coil to distribution connection (IN1, 2, 3, 4 and OUT1, 2, 3, 4): SS_8M0_9_20299
but the final choice is left to the constructor (subject to approval by Elettra, but under responsibility of the constructor).
According to [2] section 6.5.2, "Each assembled magnet shall undergo a pressure test of the cooling circuit. The test procedure shall be proposed by the Contractor in the Technical File and shall be approved by INFN, in agreement with Elettra". The nominal pressure of the water distribution for cooling is 10 bar; suggested maximum pressure test is 30 bar.

5. **I carter di protezione della parte frontale e della morsettiera con quale materiale devono essere costruiti?**
What material are the front and connection block protection covers made of?
REPLY: According to [2] paragraph 5.1 "The design, the engineering and the selection of raw materials and semi-finished products to be used for the construction, shall ensure a correct operation of the magnets for a life time cycle equal to at least 20 (twenty) years and shall take into account the operating environment where the magnets will be installed, which is, a tunnel where a linear proton accelerator (of which the magnets will be part) will be assembled. The accelerator will operate at a maximum energy of 2 GeV and ionizing radiations will be present in the tunnel itself. The temperature in the tunnel will be about 20 °C and the expected total integrated radiation dose, during 40 years of operation, is equal to 10 MGy". This is mandatory.
Suggested material is Lexan, but the final choice is left to the constructor (subject to approval by Elettra, but under responsibility of the constructor).

6. **Solo per il Q5 - Si può avere il peso approssimativo che deve sostenere la base del magnete, dato che la parte che unisce il Magnete con la Piastra inferiore, a disegno fa intendere che sia uno scatolato?**

Only for Q5 – According to the drawings it seems that the component that connects the magnet to the base plate is made in a box-fashion. Is it possible to know the approximate weight that will support the base of the magnet?

REPLY: The component that connects the magnet to the base plate is machined from a solid block of metal. Information concerning the weight of the magnets is included in [4] Tab. 6 – Tab. 11.

7. **Relativamente ai dati di progetto sono necessarie, per entrambi i quadrupoli Q5, Q6 e Q7, le seguenti informazioni:**
   - **Corrente nominale**
   - **Massimo ΔT di progetto sulle bobine in condizioni nominali**
   - **Qualità di campo richiesta**

   Concerning the design parameters, for quadrupoles Q5, Q6 and Q7 the following information are needed
   - **Nominal current**
   - **Maximum nominal design ΔT of the coils**
   - **Requested field quality**

   REPLY: See [4] Tab. 6 – Tab. 11 for the requested information.

8. **Ci sono prescrizioni sul tipo di raccordi idraulici da utilizzare?**
   Are there any prescriptions about the hydraulic joints?
   REPLY: According to [1] paragraph 5.1 "The design, the engineering and the selection of raw materials and semi-finished products to be used for the construction, shall ensure a correct operation of the magnets for a life time cycle equal to at least 20 (twenty) years and shall take into account the operating environment where the magnets will be installed, which is, a tunnel where a linear proton accelerator (of which the magnets will be part) will be assembled. The accelerator will operate at a maximum energy of 2 GeV and ionizing radiations will be present in the tunnel itself. The temperature in the tunnel will be about 20 °C and the expected total integrated radiation dose, during 40 years of operation, is equal to 10 MGy". This is mandatory.
   Suggested hydraulic connections are of the swagelock type:
   Coil to coil connection: SS_8M0_1_2RS_20012 SS_8M0_2_2PR_20024
   Coil to distribution connection (IN1, 2, 3, 4 and OUT1, 2, 3, 4): SS_8M0_9_20299
   but the final choice is left to the constructor (subject to approval by Elettra, but under responsibility of the constructor).

9. **Non sono presenti indicazioni sui tubi flessibili:**
   - **Sono inclusi nella fornitura o verranno forniti da INFN-Elettra?**
   - **Nel caso siano inclusi nella fornitura sono necessarie informazioni di dettaglio sul tipo di tubo da utilizzare.**

No indications are reported concerning the flexible pipes

- ***Are they included in the supply or they will be supplied by INFN - Elettra?***
- ***If they are included in the supply detailed information about the pipe to be adopted are necessary.***

REPLY: According to [1] paragraph 5.1 "The design, the engineering and the selection of raw materials and semi-finished products to be used for the construction, shall ensure a correct operation of the magnets for a life time cycle equal to at least 20 (twenty) years and shall take into account the operating environment where the magnets will be installed, which is, a tunnel where a linear proton accelerator (of which the magnets will be part) will be assembled. The accelerator will operate at a maximum energy of 2 GeV and ionizing radiations will be present in the tunnel itself. The temperature in the tunnel will be about 20 °C and the expected total integrated radiation dose, during 40 years of operation, is equal to 10 MGy". This is mandatory.

Flexible pipes are included in the supply. The final choice is left to the constructor (subject to approval by Elettra, but under responsibility of the constructor).

10. **Non sono presenti indicazioni sui collegamenti elettrici tra le bobine e le bobine terminali.**
No indications are reported concerning the electrical connections between the coils and the coil terminals.
REPLY: Point to point connections are listed in the drawings (Q5C100 sheet 3, Q6C100 sheet 3 and Q7C100 sheet 3). However the conductor adopted for the construction of the coils is dimensioned to work with a suitable coolant flow. Any connection between the coils and to the magnet connection block will not be cooled by any coolant medium (i.e. will be air-cooled) and thus it must be realized either with solid bars or flexible cables (the final choice is left to the constructor, subject to approval by Elettra, but under responsibility of the constructor) with a cross section able to sustain a DC maximum current of 200 A. See also [4] Tab. 6 – Tab. 11 for the magnets working parameters.

11. **Quadrupolo Q5, Q6 e Q7: quali sono i materiali da considerare per basamento e piastre superiori?**
Quadrupoles Q5, Q6 and Q7: what material are the base plates and the upper plates made of?
REPLY: According to [1] paragraph 5.1 "The design, the engineering and the selection of raw materials and semi-finished products to be used for the construction, shall ensure a correct operation of the magnets for a life time cycle equal to at least 20 (twenty) years and shall take into account the operating environment where the magnets will be installed, which is, a tunnel where a linear proton accelerator (of which the magnets will be part) will be assembled. The accelerator will operate at a maximum energy of 2 GeV and ionizing radiations will be present in the tunnel itself. The temperature in the tunnel will be about 20 °C and the expected total integrated radiation dose, during 40 years of operation, is equal to 10 MGy". This is mandatory.

Information concerning the weight of the magnets is included in [4] Tab. 6 – Tab. 11. Suggested materials are stainless steel, aluminum ..., the final choice is left to the constructor (subject to approval by Elettra, but under responsibility of the constructor).

12. **Quadrupolo Q5, Q6 e Q7: quanti sono i quadrupoli in configurazione SX e DX?**
    Quadrupoles Q5, Q6 and Q7: how many are right-side and how many are left-side?
    REPLY: Approximately 50% of the magnets are right-side and 50% are left-side, but the exact numbers will be communicated after the signing of the contract.

13. **Time schedule: nella time schedule fornita si considerano 310 gg per la costruzione dei 25 quadrupoli Q5, 265 gg per la costruzione dei 95 quadrupoli Q6 e 85 gg per la costruzione dei 12 quadrupoli Q7; è corretto ? Sarebbe eventualmente possibile proporre una schedula alternativa in modo tale da mantenere la durata complessiva del lotto, ma distribuendo in maniera differente le consegne intermedie?**
    Time schedule: according to the provided time schedule 310 d are assumed for the construction of 25 quadrupole Q5, 265 d for the construction of 95 quadrupole Q6 and 85 d for the construction of 12 quadrupole Q7; is this correct? Could it be possible to propose an alternative schedule that keeps fixed the delivery of the whole lot, but changing the distribution of the intermediate deliveries?
    REPLY: The time schedule provided with the tender documents is bonded to the milestones of the whole project; this includes also activities to be performed at Elettra. It is recommended not to change the time schedule.

References

[1] E-ST ESS MGN TSD 002, Technical specification for the construction of the corrector magnets C5 and C6, rev. 2, 16-03-2017.

[2] E-ST ESS MGN TSD 001, Technical specification for the construction of the quadrupole magnets Q5, Q6 and Q7, rev. 2, 16-03-2017.

[3] Correctors parameters

Requirements for magnet type **C5**				
ID	**Parameter**		**value**	**unit**
SPK.BMD-17	Full aperture	≥	67	mm
SPK.BMD-16	Overall length	≤	70	mm
SPK.BMD-21	Nominal magnetic field integral	=	12	Gm
SPK.BMD-22	Operating range	=	± 12	Gm
SPK.BMD-23	Maximum magnetic field integral	=	13	Gm
SPK.BMD-26	Good field region radius	≥	22	mm
SPK.BMD-24	Integrated field quality (∆∫B/∫B0)	<	± 4	%
SPK.BMD-25	Multiple content B_n / B_2 (n = 3 ÷ 10)	<	± 4	%

Tab. 1 - C5 ESS requirements

Requirements for magnet type **C6**				
ID	**Parameter**		**value**	**unit**
MBL.BMD-17	Full aperture	≥	112	mm
MBL.BMD-16	Overall length	≤	100	mm
MBL.BMD-21	Nominal magnetic field integral	=	24	Gm
MBL.BMD-22	Operating range	=	± 24	Gm
MBL.BMD-23	Maximum magnetic field integral	=	26	Gm
MBL.BMD-26	Good field region radius	≥	35	mm
MBL.BMD-24	Integrated field quality (∆∫B/∫B0)	<	± 4	%
MBL.BMD-25	Multiple content B_n / B_2 (n = 3 ÷ 10)	<	± 4	%

Tab. 2 – C6 ESS requirements

Parameters	**C5**	**C6**	**unit**
Full aperture	68	112	mm
Yoke overall width and height	138	206	mm
Good field region radius r_0	22	35	mm
Yoke length	35	65	mm
Coils overall length	68	98	mm
Magnetic length L_{eff} at nominal I_c	146	221	mm
Maximum integrated gradient	16.7	31.5	Gm
Integrated field quality (∆∫B/∫B0)	4.2	2.7	%
Harmonic contents at r_0	< 3.4	< 1.8	%
Inductance	2.4	9.4	mH

Tab. 3 - Correctors parameters and performances

Parameters	C5	C6	unit
Type	Laminated		mm
Material	Low carbon steel		mm
Packing factor	≥ 97		mm
Yoke width / height	138	206	mm
Yoke length	35	65	mm
Yoke mass	1.6	7.6	kg

Tab. 4 – Correctors yoke parameters

Parameters	C5	C6	unit
Type	Racetrack		
Cooling	Air-cooled		
Conductor cross section	3.15 x 3.55		mm
Space between coils and yoke	3		mm
Maximum current density j	1.5		A/mm^2
Conductor length for one coil	10.2	25.7	m
Resistance for one coil	16.1	40.4	mΩ
Coil overall length	68	98	mm
Coil mass	1.4	3.6	kg
Power Converter Maximum current I_{MAX}	16		A
Maximum voltage	0.5	1.3	V
Maximum power dissipation	8	22	W

Tab. 5 – Correctors coil parameters

[4] Quadrupole parameters

ID	Parameter			value	unit
5044	Bore diameter		≥	67	mm
5032	Overall length		≤	250	mm
5034	Nominal magnetic length		≥	150	mm
5035	Nominal integrated field gradient		=	1.8	T
5036	Operation range		=	1.05 ÷ 1.8	T
5037	Maximum integrated gradient		>	1.9	T
5038	Good field region radius		≥	22	mm
5041	Multiple content B_n / B_2 (n = 3 ÷ 10)		<	± 0.1	%
2485	Maximum fringe field magnitude at: (from the longitudinal center of the magnet and within transverse radius of 290 mm)	285 mm	<	8.5e-4	T
2484		688 mm	<	1.0e-4	T

Tab. 6 - Q5 DOORS requirements

ID	Parameter			value	unit
4906	Bore diameter		≥	112	mm
4894	Overall length		≤	350	mm
4896	Nominal magnetic length		≥	250	mm
4897	Nominal integrated field gradient		=	2.2	T
4898	Operation range		=	1.2 ÷ 2.2	T
4899	Maximum integrated gradient		>	2.3	T
4900	Good field region radius		≥	35	mm
4903	Multiple content B_n / B_2 (n = 3 ÷ 10)		<	± 0.1	%
2488	Maximum fringe field magnitude at: (from the longitudinal center of the magnet and within transverse radius of 244 mm)	430 mm	<	8.5e-4	T
2489		841 mm	<	2.0e-4	T

Tab. 7 - Q6 DOORS requirements

ID	Parameter		value	unit
4732	Bore diameter	≥	112	mm
4722	Overall length	≤	400	mm
4724	Nominal magnetic length	≥	250	mm
4725	Nominal integrated field gradient	=	2.7	T
4726	Operation range	=	0.85 ÷ 2.7	T
4727	Maximum integrated gradient	>	2.9	T
4732	Good field region radius	≥	35	mm
4731	Multiple content B_n / B_2 (n = 3 ÷ 10)	<	± 0.1	%

Tab. 8 - Q7 DOORS requirements

Parameters	Q5	Q6	Q7	unit
Aperture radius	34	56		mm
Yoke overall width and height	440	650		mm
Good field region radius r_0	22	35		mm
Yoke length	170	230	290	mm
Coils overall length	250	340	400	mm
Magnetic length L_{eff} at nominal I_c	201	278	338	mm
Maximum integrated gradient	2.21	2.47	3.01	T
Content B_n / B_2 (n = 3 ÷ 10) at r_0	< 0.04	< 0.02	< 0.01	%
Inductance	8.2	36.5	45.0	mH

Tab. 9 - Quadrupole parameters and performances

Parameters	Q5	Q6	Q7	unit
Type	Laminated			
Simulated material	M270-50A			
Packing factor	≥ 97			%
Yoke width / height	420	650		mm
Yoke length	170	230	290	mm
Yoke mass	~ 85	~ 330	~ 415	kg

Tab. 10 – Quadrupoles yoke parameters

Parameters	Q5	Q6	Q7	unit
Type	Racetrack			
Cooling	demineralized water			
Conductor cross section	8.2 x 7.2 mm - hole Ø 3.8 mm = 46.8			mm^2
Number of turns	30	61		#
Space between coils and yoke	6			mm
Maximum current density *j*	4.27			A/mm^2
Conductor length for one coil	17.6	55.6	61.4	m
Resistance for one coil at 35°C	7.00	21.8	24.4	mΩ
Coil overall length	250	340	390	mm
Coil mass	~ 8.5	~ 30	~ 34	kg
Power Converter maximum required current I_{RMax}	148	173	179	A
Coolant total flow (minimum required)	0.7 (0.4)	2.7 (1.6)	3.2 (1.9)	l/min
Power dissipation at I_{RMax}	0.6 (0.6)	2.6 (2.7)	3.1 (3.2)	kW
Cooling branches number	1	4	4	#
Coolant temperature rise at I_{RMax}	14.0 (25.0)			ºC
Coolant velocity on each coil	0.9 (0.5)	1.0 (0.6)	1.2 (0.7)	m/s
Coolant pressure drop	3.0 (1.1)	2.7 (1.0)	4.0 (1.5)	bar

Tab. 11 – Quadrupoles coil parameters; in parenthesis the values at the minimum required coolant flow

Il Responsabile Unico del Procedimento

Mario Maggiore