

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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TECHNICAL SPECIFICATION OF THE TRANSFORMER AND RECTIFIER CUBICLES
FOR CORRECTION MAGNETS

(Power Circuitry)

C 11

The 300 GeV European Accelerator (SPS) will be equipped with two large Experimental Areas, where beams of particles (normally called secondary beams) and experiments will be installed.

This specification is concerned with small DC supplies (power circuitry) to feed the correction magnets installed along the beam lines.

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Drawings : Correction supplies Type C11 : EA 8083-4159-2D

1. GENERAL DESCRIPTION

1. DESCRIPTION OF THE EQUIPMENT AND WORKING CONDITIONS

In many cases small correction magnets will be used, (bending power less than 1/10 of the standard elements) to steer the beam correctly.

The required currents are normally centred around zero, to assure a symmetrical correction range (positive and negative). It can be assumed that for greater numbers of supplies the current utilisation factor will be lower than 50% on average.

This leads to a modular design as follows :

- a) Transformer cubicle. Its transformer is dimensioned to power 4 correction supplies at full current,
and
- b) Rectifier cubicle. It comprises 4 correction supply modules, which are connected to the common transformer cubicle.

Another rectifier cubicle may be attached to the basic assembly transformer + rectifier cubicle to form an extended assembly in which one transformer is commonly used by 8 correction supplies (provided that the average utilisation is $\leq 50\%$).

Drawing EA 8083-4159-2 shows the basic assembly with 4 power supplies of the type C11 and the possible extension to $8 \times C11$.

On the DC output terminals of a C11 unit

96 V at 250 A

can be obtained. The current will be stabilised to 10^{-3} , and the resolution of current adjustment will be 4×10^{-3} (which corresponds to steps of approximately 1 Amp.).

The lowest current to be stabilized will therefore be 1 A.

To assure stable operation of the thyristors at such a low current a bleeder circuit might be necessary if thyristors with a latching current ≥ 1 A are used (more detail under 3.2.2).

A contactor isolates the rectifier from the common AC-supply and makes the Cll units independent of the other units installed in the same cubicle.

The use of a DCCT as current sensing element permits a grounded transformer star-point which gives a ground-symmetrical output voltage of all rectifiers.

A negative magnet current will be obtained by means of a polarity reversal switch (commutation at zero current).

A load with a time constant of 0.5 s, supplied by a 3-phase thyristor bridge circuit with freewheeling diodes, will have a ripple current which is still somewhat lower than the required stability.

The supply electronics for two Cll units (furnished by CERN) share one crate, but will be electrically completely separated (each half will have its own power supply and therefore also a separated zero volt line).

The cubicles will be placed on a false floor (1100 mm depth). The space between the false floor and ground is used for cabling and will also be under slight air pressure. The temperature in the false floor varies between + 12°C in winter and + 32°C in summer.

The cubicles and cubicle assemblies (up to 1 transformer + 2 rectifier cubicles) should be able to be lifted by a fork truck (Clark), and should also be fitted with lugs for transport by crane.

In the power supply buildings the cubicles will rest on metal girders adequately arranged across the buildings. It is therefore necessary that all the cubicles have the same width namely 1500 mm.

Since units will be installed side by side, components and inter-connections from cubicle to cubicle should be arranged in such a way that easy access from front and rear is assured. The length of each cubicle should not exceed 750 mm.

To allow the installation of the cubicles in buildings with 1200 mm girder distance, the front feet should be removable to facilitate displacement.

The supplies will be connected to a three-phase 380 V cable (without neutral) led to the units through the interspace beneath the false floor.

The mains voltage may increase to 110% of nominal, this should be considered while designing the magnetic circuit of the transformers. The DC output cables leave the supplies at the bottom and go to the interspace below. All external connections are made by means of M12 bolts.

Both cubicles should be equipped with front and rear doors. The doors of the rectifier cubicle should be equipped with plexiglass windows over the entire height to facilitate inspection (position of the polarity reversal switch, failure indication in the electronic crate, etc.).

2. EQUIPMENT TO BE DELIVERED

Each power supply consists of a heavy current part and a regulation and control part. The latter, so far as it is located in the Electronic crate, does not belong to the equipment to be delivered; nevertheless the manufacturer must provide the space and the supporting rails for two electronic crates in each rectifier cubicle (one half-crate contains the electronics for one C11 unit).

The control circuits to be connected to the CERN electronics (Gate and polarity reversal control etc.) have to be brought to an AMP terminal strip near the electronic crate. CERN provides the cables from there to the crate.

The DC current transformer will be provided by CERN, but has to be installed by the manufacturer.

3. COMPONENTS AND EXECUTION

3.1. Transformer cubicle

3.1.1. AC-circuit breaker and common auxiliaries

The AC-circuit breaker is equipped with thermal overload and short circuit protection. The inrush current of the transformer has to

be taken into account when selecting the magnetic release for appropriate transformer secondary short circuit protection. A delayed tripping might be necessary to avoid switching off due to too high inrush current.

The neutral of the 3-phase 380 V system will not be distributed. Single phase 220 V auxiliaries (contactor coil, DCCT-supply, etc.) will therefore be connected to a single phase 380/220 V transformer.

The mimic diagram uses 10:1 dividers to measure mains and transformer secondary voltages without danger ($2 \times 270 \text{ k}\Omega$ - 1 W parallel connected resistors followed by a 15 k Ω resistor).

Earth protection is common for all C11 units connected to one transformer. The rectifiers will not be blocked, only fault indication sent to the control room.

3.1.2. Transformer

The common supply transformer, dimensioned for 4 supplies operating at full current is an ordinary delta/star transformer whose secondary neutral will be connected to the common anode/cathode of the freewheeling diodes. The transformer has to be designed for convection cooling.

3.1.3. Mechanical arrangement

The AC-circuit breaker and the mimic diagram should be accessible from the front (definition of "front" see drawing EA 8083-4159-2). The transformer cubicle does not require a right side cover (where the rectifier cubicle will be attached). Provisions should be made, that a transformer cubicle with a rectifier cubicle can be bolted together.

3.2. Rectifier cubicle

3.2.1. AC-contactors and fuses

The AC-contactor in front of the fuses permits isolation of one C11 supply from the others; its incoming cable connections should be protected by a cover.

The line fuses should protect the thyristors in case of inverse blocking failures : the I^2t of the fuses must be lower than that of the thyristors; and the fuses have to be equipped with normally closed auxiliary contacts. A circuit breaker connected in parallel with the fuses instead of auxiliary contacts will not be accepted (uncertain release when thyristors operate in the lower voltage range). The access to the fuses should be easy.

3.2.2. Thyristors, freewheeling diodes and bleeder circuit

CERN prefers convection cooled thyristors and diodes, but would accept proposals using small blowers to improve somewhat the cooling of an assembly without cooling duct. Such a solution might be of particular interest, if a thyristor type with a latching current < 1 A could be used and therefore the bleeder circuit be omitted (or simply replaced by a basic load resistor). Nevertheless, the rectifier should be offered in any case with bleeder circuit. Its omission should be quoted separately as a price reduction.

The design should provide at least the space for the bleeder circuit components to facilitate later introduction if necessary. (Installation preferably at the centre of the cubicle to avoid heating up of the electronic crate).

A thyristor/diode assembly which could be replaced as a whole (after simple disconnection of AC, DC and control cables), would be of an advantage.

Thyristors just not sufficient in output current can be offered as a variant, with the indication at which ambient temperature the 250 A output current could be delivered, and to which level the output current must be reduced in order to operate at 32°C ambient temperature.

3.2.3. Polarity reversal

The polarity reversal switch opens and changes position only after current-zero check (part of the CERN electronics). The proposed switch is used in other power supplies and the developed logic circuit could be used in this case as well. The auxiliary contacts (position indication) should be easily accessible.

3.2.4. Interconnection with CERN electronics

The CERN electronic crate has a socket panel accessible from the front. All internal control wiring of the cubicle should end up at a AMP-terminal strip to be installed close to the socket panel. The interconnection between socket panel and terminal strip is provided by CERN.

3.2.5. Auxiliary equipment and control cabling

Circuit breakers, auxiliary mains switch etc. (3-phase and single phase interruption) should have protection covers for the incoming cables, so that maintenance work can be executed on one module whilst others are still under voltage. Control wires and cables start and end on AMP-terminal strips or spade connectors (i.e. gate pulse transformers). All wires, terminal strips and components should be clearly marked and the wires preferably protected by cable ducts.

The direct interconnection socket panel/DCCT will be provided by CERN.

3.2.6. Mechanical arrangement

The thyristors and diodes should be installed in the upper part of the cubicle.

The electronic crate for two CII supplies including its socket panel has an overall height of 10 units (445 mm) and width corresponding to a 19 inch chassis.

The electronic crate should rest on two horizontal rails positioned at 1000 mm above floor level and fixed on horizontal rails.

The polarity reversal switch should be mounted under the electronic crate somewhat recessed to facilitate the installation of the control cables leading to the socket panel.

At the lower centre of the rectifier cubicle the AC cables including the neutral of the 4 modules should be connected together and a set of cables provided leading to the left which permits the connection

- a) of the first rectifier cubicle to the transformer cubicle,
- b) of the second rectifier cubicle to the first one.

To facilitate b), the interconnection point should be equipped with two M16 bolts per pole. The interconnection point should be protected by a removable cover.

The rectifier cubicle does not require a left side cover (normally connected either to a transformer or another rectifier cubicle).

The right side cover should be easily removable (no doors).

Provisions should be made to attach a transformer cubicle to the left and another rectifier cubicle to the right (mounted together with bolts).

2. SPECIFICATIONS

1. PART LIST AND COMPONENT SPECIFICATION FOR THE TRANSFORMER CUBICLE

Part No.	Qty.	Description	Remarks
1	1	3-phase circuit breaker with overload and short circuit release 250 A, 380 V normal operated with auxiliary contacts.	Observe remarks under 3.1.1.
2	1	3-phase transformer 105 kVA Primary : delta, 380 V, 160 A Secondary : star, 45 V idle phase to neutral, 784 A Short circuit voltage : 6% Convection cooled	The transformer is dimensioned for 4 C11 supplies operated at nominal current. Copper windings
3	1	Circuit breaker for earth protection 0.1 ÷ 0.14 A with auxiliary contacts	
4	3	Fuses 25 A	
5	1	Fuse 10 A	
6	1	380 V auxiliary mains switch 25 A	

Part No.	Qty.	Description	Remarks
7	1	Single-phase transformer 380 V/220 V ; 1 kVA	
8	1	AMP terminal strip	Auxiliary voltage distribution
9	1	Mimic diagram All potentials over 10 : 1 divider (2 × 270 kΩ - 1 W in parallel + 15 kΩ basic resistor)	
10	1	Auxiliary source Input : 380 V 3-phase via fuses 1.5 A Outputs : 48 V d.c. 7 A 30 V d.c. 2 A (3-phase bridge circuits) Both outputs equipped with fuses	Output filter not necessary

2. PART LIST AND COMPONENT SPECIFICATION FOR RECTIFIER CUBICLE

Quantities given for one C11 module, unless otherwise noted

Part No.	Qty.	Description	Remarks
1	1	Contactor 200 A coil 220 V AC	
2	3	Thyristor fuses adapted to the I^2t of the thyristor with normally closed indicator contact	

Part No.	Qty.	Description	Remarks
3	1	3-phase thyristor bridge for 250 A continuous output current, preferably convection cooled. Repetitive blocking voltage : 275 V including RC networks and gate pulse transformers(3 : 1 ratio, sec. volt. time area 1,5 mVs suitable for unidirectional drive circuit).	See remark under 3.2.2. CERN could indicate suitable manufacturers on request.
4	2	Freewheeling diodes 80 A - 180° convection angle sinusoidal preferably convection cooled, repetitive blocking voltage 300 V, including RC-network	Should form an assembly together with the thyristor bridge
5	1	Polarity reversal switch 2 pole 250 A Motor driven 3 phase 380 V with auxiliary contacts showing the positions : normal, inverted, zero (open) and between zero and normal.	Suggested manufacturer : W. Berg Käfertaler Str. <u>MANNHEIM</u> (Germany)
6	1	AMP terminal strip installed near the socket panel.	Details see 3.2.4.
7	1	Auxiliary mains switch 10 A - 8 pole	
8	2	M12 bolts	DC output terminals
9	1	Interconnection point including cable connection to either transformer or another rectifier cubicle	Common for all 4 supply modules, details see 3.2.6.
10	1	Circuit breaker for thyristor fan	Only in case of forced air cooled thyristors

Part No.	Qty.	Description	Remarks
11	3	Fuses 2 A	
12	1	3 phase diode bridge 2 A output current blocking voltage 400 V	
13	2	Resistors 47 Ω , 500 W	
14	2	Fuses 2 A	Rectifier voltage measurement

3. TESTS

(Values for the various tests to be found in the component specification)

1. TESTS TO BE CARRIED OUT IN THE FACTORY

a) Transformer test

- Isolation test 2.5 kV, 50 Hz, 1 min. between all windings and all windings and the core.
- Idle secondary voltage to be measured.
- Short circuit voltage to be measured.
- Iron and copper losses to be measured.
- Copper temperature (hot spot after 3 hours) to be measured.

b) Cubicle test

CERN will provide one electronic crate (for 2 \times C11) and the necessary interconnection cables to the terminal strip. A representative of CERN will supervise the following tests :

- Cable check.
- System test at low current.
- Test of the power circuitry at full load current including a "temperature run" of several hours for the first unit and 1 hour for the following units.

The manufacturer should undertake to supply the following for the above testing :

- Differential oscilloscope
- Voltmeters and Ammeters
- A load (approx. 50 V, 250 A with a time constant of approximately 20 ms). If this cannot be supplied by the manufacturer then CERN will supply it; the cost of transport being taken into consideration when assessing the tenders (1 mH, 1000 A filter choke).
- A 3-phase roller transformer in order to perform initial tests at low voltage and current.

The manufacturer should also during these tests delegate to the CERN representative a competent person to effect any changes due to defects and generally to assist with the testing.

2. PROVISIONAL ACCEPTANCE TESTS

After completion of successful factory tests, units shall be delivered to CERN site where provisional acceptance tests will be carried out by CERN personnel. These tests will include :

- Mechanical inspection,
- A 24-hour run at nominal ratings using the supply electronics.

These tests will be carried out within six months of delivery.

