ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Group Code.: SL-PO/RG/cb
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The Large Hadron Collider Project *IT-2920/SL/EXP*

Technical Specification

For

Cast-resin Rectifier Power Transformers

rated 4.8 MVA

Abstract

This Technical Specification concerns the design, manufacture, conformity tests, delivery to CERN and documentation of five cast-resin rectifier power transformers, rated 18 kV/900 V, 4.8 MVA and three pre-magnetising transformers. The power transformers will feed 6-pulse rectifier thyristor bridges in DC power converters. The power converters will be used in the ALICE and LHCb experiments.

Complete delivery is foreseen for the end of December 2002.

June 2001

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Terms and Definitions

Term	Definition
CDD	CERN Drawing Directory
EDMS	Engineering Data Management System
QAP	Quality Assurance Plan

1. INTRODUCTION

1.1 Introduction to CERN

The European Organization for Nuclear Research (CERN) is an intergovernmental organization with 20 Member States*. It has its seat in Geneva but straddles the Swiss-French border. Its objective is to provide for collaboration among European States in the field of high energy particle physics research and to this end it designs, constructs and runs the necessary particle accelerators and the associated experimental areas.

At present more than 5000 physicists from research institutes world-wide use the CERN installations for their experiments.

1.2 Introduction to the LHC Accelerator and the Experiments

The Large Hadron Collider (LHC) is the next accelerator being constructed on the CERN site. The LHC collider will mainly accelerate protons to energies reaching 7 TeV and also heavy ions such as Pb. It will be installed in the existing ring tunnel of 27 km circumference, about 100 m underground, previously housing the Large Electron Positron Collider (LEP). The LHC machine will accelerate two beams of protons or heavy ions circulating in opposite direction to each other and collide them head-on in 4 large underground experimental areas. The LHC machine magnets, which guide the beams around the 27 km ring, are super-conducting twin-aperture magnets which operate in a super-fluid helium bath at 1.9 K.

Large experiments will be installed in the underground experimental halls at the 4 interaction points to identify and measure the trajectories and properties of all secondary particles created in the head-on collisions of the two beams. For this purpose very large powerful magnets are required to deviate the produced particles in strong magnetic fields. Two of these experiments, named ATLAS and CMS, will use big super-conducting toroids or solenoids for the particle analysis. The other two experiments, ALICE and LHCb, will employ resistive dipole magnets for the same purpose. In all cases, the magnets will be powered by DC power converters.

1.3 Subject of this technical specification

The transformers covered by this specification will be an integral part of DC power converters (see Fig. 1) used to feed the dipole spectrometer magnets for the LHCb and ALICE experiments.

* CERN Member States are: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, The Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom.

2. SCOPE OF THE TENDER

2.1 Scope of the supply

The following products and services shall be part of the supply :

- The design, manufacture and factory tests of five cast-resin rectifier power transformers (two per power converter and one spare)
- The design, manufacture and factory tests of three pre-magnetising transformers for the above transformers (one per power converter and one spare)
- The design and manufacture of two enclosures (one enclosure housing two power transformers for each power converter) see Fig. 2.
- Documentation and test results
- Delivery to CERN as defined in the Tender Form
- Short-circuit test for the first power transformer.

2.2 Not included in the supply

The following products and services are not included in the supply, but will be provided by CERN at the time of installation on site.

- Transformer external cabling
- Commissioning on CERN site.

2.3 Pre-series construction

The series production shall be preceded by the production of pre-series units (one power transformer and one pre-magnetising transformer). The pre-series units shall be re-worked to become identical and part of the series units, at no additional cost to CERN.

3. GENERAL CONDITIONS FOR TENDERING AND CONTRACTING

Please refer to the commercial bidding documents for complementary information.

Tenders will only be considered from firms having been selected as qualified Bidders by CERN, as a result of the Market Survey ref. MS-2920/SL/LHC. CERN reserves the right to disqualify any Bidder whose reply to this Market Survey is found to have been incorrect.

3.1 Test equipment

The Contractor shall have the necessary test equipment to fully confirm the performance as laid down in this specification.

3.2 Tender procedure

3.2.1 Pre-tender discussions

The Bidder is strongly encouraged to contact CERN and discuss details of this Technical Specification before making an offer. In particular, CERN wishes to ensure that no doubt exists as to the interpretation of this Technical Specification.

3.2.2 Alternative solutions

If the Bidder finds that any part of this Technical Specification is difficult, or costly to meet, he is free to propose an alternative solution, provided that the deviations from this Technical Specification, together with the reasons and advantages, are clearly indicated in the tender. Such alternative solutions shall always be made in addition to the basic offer, which must comply fully with this Technical Specification.

CERN reserves the right to accept or reject the proposed alternative solutions without justification.

3.2.3 Preliminary programme

The Bidder shall propose a preliminary design and manufacturing schedule with the tender, based on the specified CERN provisional delivery schedule.

3.2.4 Subcontractors

The Bidder shall declare in the tender documents any subcontractors whose services he intends to use in the event of a contract. Refer to the commercial bidding documents for more details. If awarded the contract, the Bidder shall restrict himself both to the subcontractors and the amount mentioned in the tender document. If, for some reason, he wants to change any subcontractor, or the scope of subcontracted work, or the amount subcontracted, he must obtain CERN’s prior agreement in writing.

3.2.5 Technical questionnaire

The Technical Questionnaire attached to this Technical Specification shall be completely filled in and returned with the Tender Form, otherwise the tender will not be considered as complete and will be discarded.

3.2.6 Presentation of tender

The Bidder may be required to make a formal presentation of his tender at CERN at his own expense. He shall be ready to do so within a week of notification.

3.3 Contract execution

3.3.1 Responsibility for design, components and performance

The Contractor shall be responsible for the correct performance of all items supplied, irrespective of whether they have been chosen by the Contractor or suggested by CERN. CERN's approval of the design and component choice does not release the Contractor from his responsibilities in this respect.

CERN assumes responsibility for the performance of items and sub-systems supplied by CERN.

CERN reserves the right to make minor modifications to this Technical Specification before placing the contract. These minor changes shall not affect the contractual price that shall remain fixed.

3.3.2 Contract follow-up

3.3.2.1 Contract engineer

The Contractor shall assign an engineer to be responsible for the technical execution of the contract and its follow-up throughout the duration of the contract.

3.3.2.2 Progress report

The Contractor shall supply, within one month of notification of the contract, a written programme detailing the manufacturing and testing schedules. The programme shall include preliminary dates for inspections and tests.

A written progress report shall be sent to CERN every two months until completion of the contract.

3.3.2.3 Design approval and production

The detailed design shall be submitted to CERN for approval. CERN will give its approval or refusal, in writing, within one month. Component ordering and equipment manufacture shall not start without CERN's written prior agreement.

3.3.3 Deviations from this Technical Specification

If, after the contract is placed, the Contractor discovers that he has misinterpreted this Technical Specification, this will not be accepted as an excuse for deviation from it and the Contractor shall deliver equipment in conformity with this Technical Specification at no extra cost.

During execution of the contract, all deviations from this Technical Specification, the tender, or any other subsequent contractual agreement, proposed by the Contractor, shall be submitted to CERN in writing for approval.

CERN reserves the right to modify this Technical Specification during execution of the contract. The consequences of such modifications shall be mutually agreed between CERN and the Contractor.

3.4 Factory access

CERN and its representatives shall have free access during normal working hours to the manufacturing or assembly sites, including any subcontractor's premises, during the contract period. The place of manufacture, as stated in the Technical Questionnaire, may only be changed after written approval by CERN.

4. TECHNICAL REQUIREMENTS

4.1 General description

The power converter (6.5 kA, 950 V) consists of two 6-pulse rectifier/filter modules with passive filters, connected in parallel. The bridges are fed from the 18 kV network through two power transformers phase-shifted 30° (see Fig. 1).

Two transformers will be housed in each common cubicle according to Fig. 2. The fifth transformer is a spare.

The transformers for each 6-pulse module shall be identical, extended delta/star, transformers. With reference to the incoming mains phases, the secondary voltages of the power transformers are shifted +15° in the module A and –15° in the modules B; an overall 12-pulse behaviour is therefore achieved. The negative shift is obtained by swapping the S and T phases.

The transformers shall be naturally air-cooled and for indoor operation.

The transformers shall be adequately rated for continuous operation under the worst case of incoming mains and environmental conditions.

4.1.1 Transformer ratings and parameters

Type	3-phase, separate windings, dry-type, indoor
Cooling	AN
Rated equivalent sinusoidal power	4800 kVA
Frequency	50 Hz
System short-circuit level	600 MVA, 1s
Maximum peak inrush current at 18 kV	1540 A (10 In) without pre-magnetising transformer
Maximum peak inrush current at 18 kV	154 A (1 In) with pre-magnetising transformer
Decay time	2 s maximum
Nominal primary voltage	18 kV
System highest voltage	24 kV
Primary winding connection	Extended Delta
Primary insulation level	50 kV, 1 min/125 kV (1.2/50 μs)
Method of earthing	Non-effectively earthed neutral
Nominal secondary no-load line voltage	900 V
Secondary winding connection	Star
Secondary withstand voltage	10 kV, 50 Hz, 1 min
Tolerance on secondary voltage	- 0% / +3%
Amplitude balance of secondary voltages	± 0.3%
Secondary nominal square-wave line current	2652 A r.m.s.
Secondary equivalent sinusoidal current	3080 A r.m.s.
Impedance voltage at 3080 A	7% to 8%
Matching of short-circuit currents	± 1%
Vector group	Dy 11.5
Phase-shift primary to secondary	+ 15°
Accuracy of 15° phase-shift	± 0.05°
Maximum total losses in converter operation	50 kW
Maximum acoustic noise at 1 meter at In	65 dBA
Primary insulation	Cast-resin
Secondary insulation	Cast-resin or vacuum impregnation
Insulation class	At least B for cast-resin
Insulation class	At least F for vacuum impregnation

Maximum winding temperature rise with 40°C ambient	< 80 K
Maximum hotspot temperature with 40°C ambient	According to insulation class
Fire classification...	F1 (CENELEC HD637)

The thermal design shall include the cubicle.

The transformer cubicles will be placed on a false floor.

The transformer shall be capable of withstanding asymmetric and symmetric short-circuits of 500 ms duration at the secondary terminals without damage. No maintenance shall be required as a result of the first 10 such short-circuits.

4.1.2 Windings

The winding material shall be copper or aluminium and the secondary terminals shall be copper.

The primary terminals shall be on one side and the secondary terminals shall be on the opposite side.

The primary windings shall be strip type.

The secondary windings shall be executed as full-width band winding.

The neutral connection shall be adjacent to the secondary terminals to provide symmetrical commutating impedances.

4.1.3 Electrostatic Screens

Individual insulated copper screens shall be placed between the primary and secondary windings on each phase; their connections shall be individually brought out to a transformer earthing stud. The screen and its connections to earth shall withstand an insulation fault for 1 kA, 1 second.

The large dV/dt values, occurring during the thyristor commutation, will cause leakage currents through the insulation between screen and winding. The total capacitance between the screens and the three H.V. and L.V. windings respectively, shall be less than 15 nF.

The design of the insulation between screen and windings shall take into account the higher dielectric losses due to the non-sinusoidal voltages.

4.1.4 Core Material, Magnetising Current, No-load Losses

High quality, low-loss, grain-oriented, insulated silicon steel laminations shall be used for the cores. The same core material shall be used for all the transformers. Neither the induction, Bm, nor the iron losses are specified by CERN. However :

– At 1.1 x Un, , the r.m.s. value of the magnetising current shall not exceed 1.7 times its nominal value
– Particular attention shall be paid to the required maximum peak inrush current, imposing limits on both the maximum induction (Bm) and the remanence (Br) of the finished cores.

4.1.5 Thermal overload protection and monitoring :

The following monitoring signals shall be provided via a terminal box fixed on the transformer :

- A two-level thermal protection system giving two independent normally closed contacts. The fault contact trip temperature shall be set according to the insulation class employed. The warning temperature shall be 10 K lower. If an auxiliary voltage is needed, it shall be 24 or 48 V DC.
- The contacts shall open on fault or when the auxiliary supply is absent.
- A 4-wire Pt-100 probe shall be installed in the hottest part of the S-phase winding. This will be connected to a remote temperature monitoring system.

4.2 Connection to the 18 kV network

The two transformers will be fed together from one CERN 18 kV circuit-breaker, which will be controlled directly by the CERN converter electronics.

For the primary terminals, moulded bushings of the Elastimold type (12/20 kV, 400 A, K400 series), or identical, shall be used. All 18 kV busbar interconnections shall be moulded and it shall not be possible to access directly any part under H.V.

The 18 kV cables will enter the cubicle through the false floor. Appropriate supporting facilities shall be provided.

4.3 Secondary terminals

The secondary copper terminals will receive 6 copper cables, 240 mm^2, per phase. Appropriate supporting facilities shall be provided. The cables shall leave through the false floor.

4.4 Pre-magnetising system

A pre-magnetising system shall be installed to avoid the inrush current of the power transformers. It shall comprise special transformers to pre-magnetise the two high power transformers (2 x 4.8 MVA) of the power converter.

The wiring of the pre-magnetising system is shown in Fig. 3.

The time sequence is as follow:

- Switch-on C1 contactor. The secondary (900 V) of the pre-magnetising transformer is virtually in short-circuit during the pre-magnetisation time of TRA/B and will at the end supply the pre-magnetising current of TRA/B.
- After 3 s , the 18 kV circuit breaker is switched on and the current in the pre-magnetising transformer will then depend on the 400 V and 18 kV values.
- Half a second later, the C1 contactor is switched-off and the transformer is fed by the 900 V side at no load permanently 24h/24h. The 900 V voltage is strongly perturbed due to thyristor commutations. High dV/dt spikes are superimposed on the sinusoid.

As the CERN 18/0.4 kV transformers have a vector group Dyn11, the pre-magnetising transformers shall have a vector group Dy 0.5.

4.4.1 Pre-magnetising transformer ratings

Type	3-phase, separate windings, dry-type, indoor
Cooling..	AN
Nominal mains input.......................................	400 V r.m.s., 50 Hz
Secondary voltage...	According to main transformer (defined by Contractor
Input short-circuit power.................................	20 MVA
Peak inrush current at 440 V r.m.s., 50 Hz	<10 In
Decay time	2 s maximum
Impedance voltage	5.5% to 6.5%
Phase-shift primary to secondary	- 15°
Vector group	Dy 0.5
Matching of short-circuit currents	± 1%
Amplitude balance of secondary phase voltages	± 0.3%
Withstand voltage 900 V windings	10 kV r.m.s., 50 Hz, 1 min
Withstand voltage 400 V windings	3 kV r.m.s., 50 Hz, 1 min
Insulation class	B or better
Insulation	cast-resin or vacuum impregnation
Maximum winding temperature rise with 40°C ambient	According to insulation class
Maximum hotspot temperature with 40°C ambient	According to insulation class
Fire classification	F1 (CENELEC HD637)

The transformers shall be wound from insulated copper wire (minimum grade 2 : two-ply varnish) with re-inforced insulation between turns.

Insulated copper screens shall be placed between the primary and the secondary windings and their connections brought out to a transformer earthing stud. The total capacitance between screens and windings (primary or secondary) shall be less than 3 nF.

At 1.1 x Un, the r.m.s. value of the magnetising current shall not exceed 1.5 times its nominal value.

The transformer shall be capable of withstanding asymmetric and symmetric short-circuits at the secondary terminals without damage. The short-circuit duration shall be at least twice the time constant of the inrush current decay time in the main transformers. No maintenance shall be required as a result of the first 10 such short-circuits.

The other pre-magnetising transformer ratings shall be defined by the Contractor according to the main transformer ratings.

The pre-magnetising transformers shall be tested according to IEC recommendations for the type and routine tests.

Thermostats, normally closed contacts, opening according to the insulation class shall be mounted at the measured hottest point of each limb and wired to a connector block. They shall be in good thermal contact, but electrically insulated (3 kV r.m.s., 1 min. to earth).

4.5 Mechanical construction and layout

The power transformers shall be housed in indoor cubicles. The exact layout will be discussed with the Contractor.

The transformers and the cubicles will be placed on a false floor constructed of 10 cm width I-profile beams with a grid interval of 90 cm.

Each transformer shall be equipped with lifting eyes.

Based on the suggested building layout of Fig. 2 and on the crane capacity (only 5 t), the transformers shall be equipped with wheels to facilitate positioning. The wheels shall have a track width of 90 cm (see Fig. 4).

Maximum dimensions for transformer (see Fig. 4):

Length:	3000 mm
Width:	1000 mm
Height:	2500 mm

Maximum dimensions for cubicle (see Fig. 2 and 4):

Length:	3500 mm
Width:	3300 mm
Height:	2900 mm

A minimum 60 cm corridor shall be kept in the middle of the cubicle to improve component accessibility.

Each cubicle shall have rigid metal frames that support the roof, the removable panels and the door. The cubicle shall be easily dismantled.

The cubicles shall be equipped with a door. The door shall cover the full height of the cubicle. The width of the door shall not exceed 800 mm.

The cubicles shall be equipped with removable panels on the entire perimeter.

The door shall be equipped with adequate earth straps and have one lockable handle.

The cubicle shall be equipped with an integral mesh top IP20, which shall be capable of supporting 150 kg/m^2.

The door and the side panels shall be at least IP40. The protection under the false floor is part of the CERN building infrastructure.

4.6 Door interlock switch

A switch shall be mounted on the door of the cubicle. The contact shall open whenever the door is opened. These will be used to switch off the main circuit breaker. However, the switch shall have an override facility making it possible to disable this function. The override shall be reset by the closure of the door. CERN suggests BURGESS switch type DS3.

5. SERVICE CONDITIONS

5.1 General

The power transformers shall be rated for continuous operation.

5.2 Ambient conditions

Altitude above sea-level .... 300 m to 600 m

Temperature variation (operation indoor) .... +10°C to +40°C

Temperature variation (storage) .... -25°C to +50°C

Relative humidity... 30% to 90%.

5.3 Mains supply 400V

Nominal value (3-phase with neutral) .... 400 V /230 V r.m.s. 50 Hz

Operating variations.. ± 10%

Mains transients .... step changes within the mains tolerance

Phase imbalance.. ± 1.5%

Maximum total harmonic voltage-distortion......... 5% r.m.s.

Frequency variation .... ± 0.5%

Short-circuit power .... 1 - 20 MVA

Peak mains surges... 1200 V for 0.2 ms

Mains over-voltage .... 1.5 x nominal value for 10 ms

Dips in the mains supply of up to 100 ms duration and varying amplitudes, in one or more of the 3 phases, occur frequently during thunderstorms.

5.4 Mains supply 18 kV

Nominal value (3-phase, no neutral) .... 18 kV rms 50 Hz

Operating variations .... ± 5%

Mains transients ....step changes within the mains tolerance
Phase imbalance ....± 1.5%
Maximum total harmonic voltage-distortion ....3% rms
Frequency variation..± 0.5%
Short-circuit power...100 - 600 MVA
Peak mains surges ....50 kV for 0.2ms
Maximum mains over-voltage ....1.5 x nominal value for 10 ms

Dips in the mains supply of up to 100 ms duration and varying amplitudes, in one or more of the 3 phases, occur frequently during thunderstorms.

6. ENGINEERING STANDARDS

6.1 Workmanship and materials

6.1.1 Materials

Materials used in the manufacture of the specified equipment shall be of the kind, composition and physical properties best suited to their various purposes and in accordance with the best engineering practices. In particular, insulating materials shall be self-extinguishing and not release any toxic or corrosive products when subjected to fire.

6.1.2 Workmanship standard

Workmanship shall be of the highest quality and conform to the best modern practice for the manufacture of high-grade machinery and electrical equipment. CERN will upon request give examples of the minimum acceptable level.

All work shall be performed by mechanics and electricians skilled in their various trades and holding relevant recognised national qualifications.

6.1.3 Metric system

The design, systems, parts and components shall be in accordance with the metric system.

6.1.4 Paint and anticorrosion treatment

All metal parts shall, unless non-corrosive, be surface treated against corrosion and painted with a primer before final colour.

Cubicle exterior	Finish	:	Spatter (leather)
	Colour	:	German standard RAL 5014 Pigeon blue
Cubicle interior	Finish	:	Smooth
	Colour	:	White

6.1.5 Wiring and Colour codes

The following international and CERN colour codes shall be used for all cabling, busbars and terminals :

R-phase	:	Orange	Neutral	:	Light blue

S-phase	:	Green	Earth	:	Yellow / Green
T-phase	:	Violet	Positive	:	Red
Non specified phase	:	Brown	Negative	:	Dark blue

The minimum cross-section for all auxiliary wiring shall be 1 mm^2. Flexible multi-stranded wire, of at least 25 strands, shall be used. The ends shall be terminated by a crimped connection and clearly identified with the same code at both ends according to the circuit diagrams. Not more than 2 wires can terminate together on a screw-terminal.

All wiring shall be adequately supported and collected in harnesses, wherever appropriate. Main cable runs shall be housed in plastic cable channels.

All wiring and cables shall have halogen- and sulphur-free insulation and sheath. CERN can name possible suppliers on request.

Earth wire cross-sections shall be calculated considering prospective fault currents and respecting applicable norms.

6.2 Design principles

6.2.1 General

Unless stated otherwise in this specification, the following design principles shall be used.

CERN attaches great importance to a design, which is extremely reliable, requires a minimum of maintenance and enables easy replacement of faulty components.

All components shall be rated according to the worst-case design principle. All components shall have sufficiently high individual Mean Time Between Failure (MTBF) figures under the worst-case operating conditions in this specification, in order to reach an overall MTBF > 100’000 hours. Any supporting calculation shall be made according to MIL-HDBK217.

6.2.2 Mechanical layout

The layout shall be executed so as to minimise thermal stresses on all components, facilitate access to components for replacement and simplify inspection and maintenance. All power components shall be directly accessible and easily dismounted for repair.

6.2.3 Rating plates

An easily visible rating plate shall be attached to the front of the equipment giving, in English or French, input and output electrical parameters, total mass, Contractor's serial number, year of manufacture, etc. Each magnetic component shall have a rating plate according to IEC.

6.3 Information and documentation management

6.3.1 General

All documentation, information, circuit diagrams and drawings shall be produced in MS Word and AutoCAD format. One complete set of printed documents and 3½” diskettes with all files shall be supplied to CERN with the equipment delivery.

6.3.2 Manufacturing drawings

The Contractor shall supply a complete set of drawings to CERN at the delivery. The drawings shall be neat and to a good professional standard. A complete set includes :

- mechanical construction drawings
- electrical power circuit diagrams
- auxiliary circuit diagrams
- wiring diagrams
- parts list including details of all components, manufacturer, type number, second source manufacturer, etc.

If modifications are performed subsequently by the Contractor, new drawings shall be supplied free of charge.

6.3.3 Marking

Marking of components on the drawings shall correspond with those in the equipment. All wiring coding shall appear on the diagrams such that it is easy to follow the circuit on the drawings as well as in the equipment.

The mechanical drawings shall be executed with all dimensions marked according to the metric system.

7. APPLICABLE DOCUMENTS

Please refer to the Covering Letter for the complete list of documents attached to this Invitation to Tender.

7.1 Standards

The following standards, in order of priority, are applicable for the execution of the contract.

7.1.1 CERN standards

The equipment shall comply with the CERN Electrical Safety Code C1 issue 1990. Insulating materials and cables shall comply with CERN Safety Instruction N°23, Rev. 2 (included on the CERN CD-ROM).

7.1.2 International standards

Unless noted otherwise in this specification, all equipment and drawings shall comply with the relevant I.E.C. standards, recommendations and reports including the latest revision.

7.1.3 On site work regulations

If work is to be carried out on the CERN site, attention is drawn to the fact that CERN has specific rules concerning safety regulations applicable to works of Contractors at CERN, access to and activities on the CERN site, occupational health and safety on the Organization's site and special health and safety matters.

8. QUALITY ASSURANCE PROVISIONS

The Contractor shall plan, establish, implement and adhere to a documented quality assurance program that fulfils all the requirements described in this Technical Specification and drawn up according to the Quality Assurance Plan for the LHC Project.

The list of relevant topics covered by the LHC Quality Assurance Plan, together with the corresponding documents, is given in Table 1 below and available on the provided CD-ROM (Version 2.0).

Table 1 - LHC QAP topics and documents

Topic	Document Title	Doc. Number
Policy and Organisation	Quality Assurance Policy and Organisation	LHC-PM-QA-100.00
	Glossary, Acronyms, Abbreviations	LHC-PM-QA-203.00
Design	Quality Assurance Categories	LHC-PM-QA-201.00
	Drawing Management and Control	LHC-PM-QA-305.00
	Drawing Process-External Drawings	LHC-PM-QA-306.00
Manufacturing and Inspection	Manufacturing and Inspection of Equipment	LHC-PM-QA-309.00
	Handling of Non-conforming Equipment	LHC-PM-QA-310.00
	LHC Part Identification	LHC-PM-QA-206.00

9. TESTS

9.1 Tests to be carried out at the Contractor's premises

9.1.1 Quality control

The Contractor's quality system shall be equivalent to the requirements of ISO 9001.

9.1.2 Factory tests

The factory tests shall establish that the equipment completely fulfils the CERN specification. If the tests show that any part of the specification is not met, then the Contractor shall correct the fault and the tests shall be repeated at the Contractor's cost. The Contractor shall fully test the equipment in the factory, but CERN reserves the right to repeat any of the tests on the CERN site.

9.1.3 Type tests for the pre-series units

The transformers shall be tested according to IEC recommendations for the type tests.

In addition to the routine tests, the first transformer shall be subjected to a short-circuit capability test. This test shall be carried out according to IEC 76-5 and following the type tests. An 18 kV mains network rated 600 MVA shall be used. Both symmetric and asymmetric short-circuits shall be applied. At the end of these tests, the type tests and capacitance measurements shall be repeated.

The short-circuit current shall be measured on the secondary side because the current measurement on the primary is distorted by the inrush current.

A heat run shall be carried out on the pre-series units. The equivalent sinusoidal current shall be used for the heat run.

The transformer inrush current shall also be measured on the pre-series units (thirty measurements).

9.1.4 Routine tests

All the transformers shall be tested according to IEC recommendations for the routine tests, including :

- Lightning impulse voltage withstand test of the H.V. windings.
- Power-frequency voltage withstand tests of H.V. and L.V. windings.
- Induced overvoltage withstand test
- Determination of load losses and no-load losses
- Resistance, impedance voltage and turns ratio measurements.
- Insulation resistance measurement (at least 50 MΩ at 2 kV DC to earth or between circuits).
- Functional checks and power-frequency voltage withstand tests of auxiliary circuits (2 kV r.m.s. 50 Hz 1 min).
- Partial discharge test.
- Acoustic noise level.

9.1.5 Witness tests

CERN reserves the right to have a representative present to witness the factory tests. The Contractor shall give at least 2 weeks notice to CERN of the proposed date for each test.

9.1.6 Test record

A test record with the individual test results shall be established for each transformer. Two copies of this record shall be delivered with the equipment.

9.2 Tests to be carried out at CERN

9.2.1 Provisional acceptance

Provisional acceptance tests will be carried out at CERN to establish that the equipment meets the specification and that no damage or changes have occurred during transport. A representative of the Contractor is not required for these tests but may be present.

In the event of any errors found during the provisional acceptance test, the Contractor shall correct them immediately at his cost at CERN.

Provisional acceptance will only be granted after successful tests and approval of the documentation.

9.2.2 Final acceptance

Final acceptance shall take place at the end of the two-year guarantee period (Art. 16, General Conditions of CERN Contracts, FC/1814-II), during which time the equipment shall fully meet the CERN specification. In the event of doubt CERN reserves the right to repeat the provisional acceptance tests. Any deviations from the specification shall be corrected immediately at CERN at the Contractor's cost.

10. DELIVERY AND COMMISSIONING

10.1 Delivery schedule

CERN shall be informed in writing of the date of delivery at least two weeks in advance.

The equipment shall be delivered to the CERN, Meyrin Site (Switzerland).

The following stages apply :	**Maximum allowed time**
Design report (mechanical, electrical, etc.)	1 month
CERN approval	2 weeks
Pre-series production	7 months
Series production	7 months

10.2 Packing and transport to CERN

The Contractor is responsible for the packing and the transport to CERN. He shall ensure that the equipment is delivered to CERN without damage and any possible deterioration in performance due to transport conditions.

10.3 Commissioning

The equipment will be commissioned by CERN.

10.4 Purchase options

CERN reserves the right to purchase additional transformers according to this specification after the initial order. See tender form.

11. PERSONS TECHNICALLY RESPONSIBLE AT CERN

Name	**Tel & Fax**	**Email**
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Annex A: List of Drawings

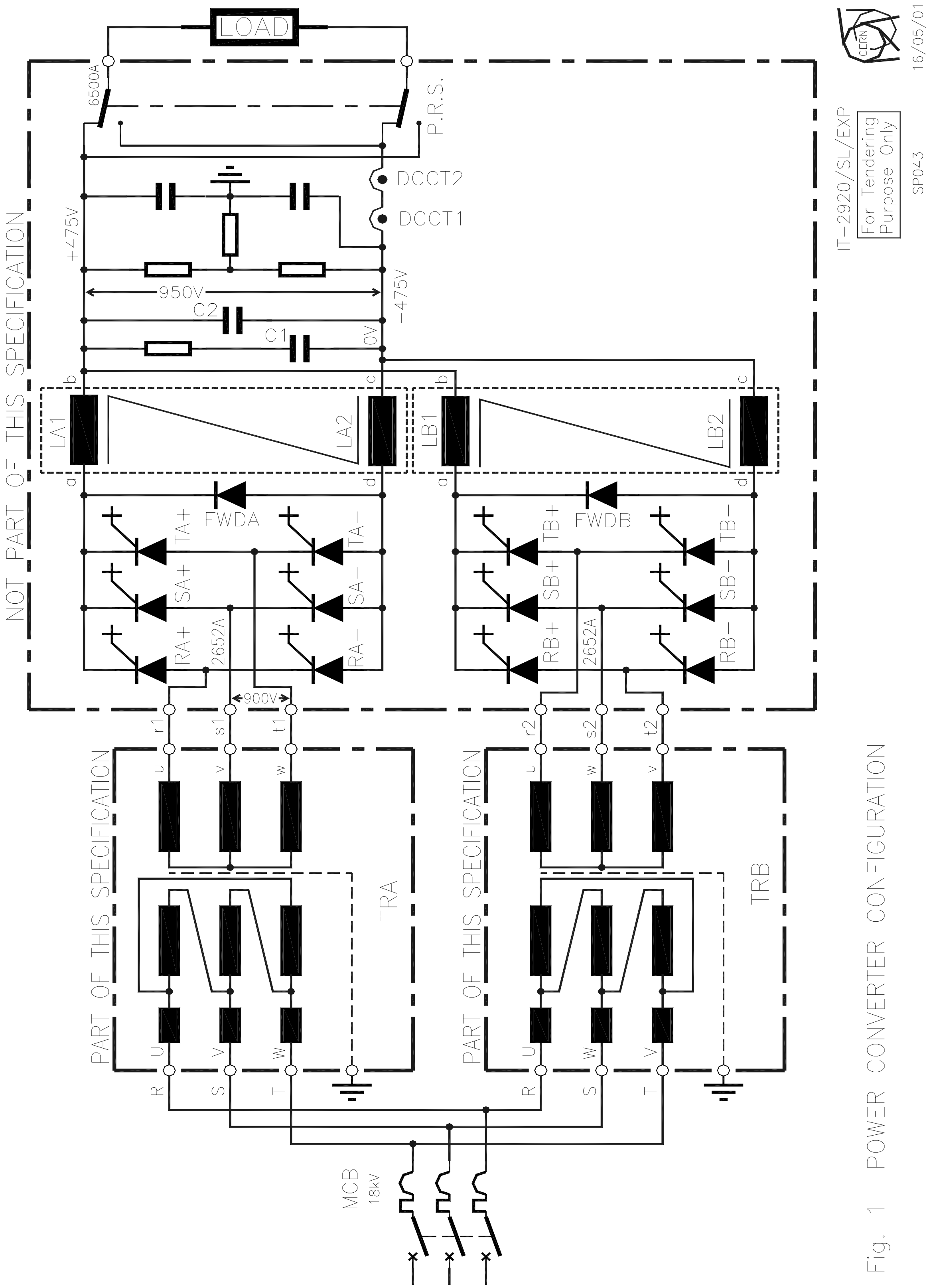

Fig. 1 POWER CONVERTER CONFIGURATION

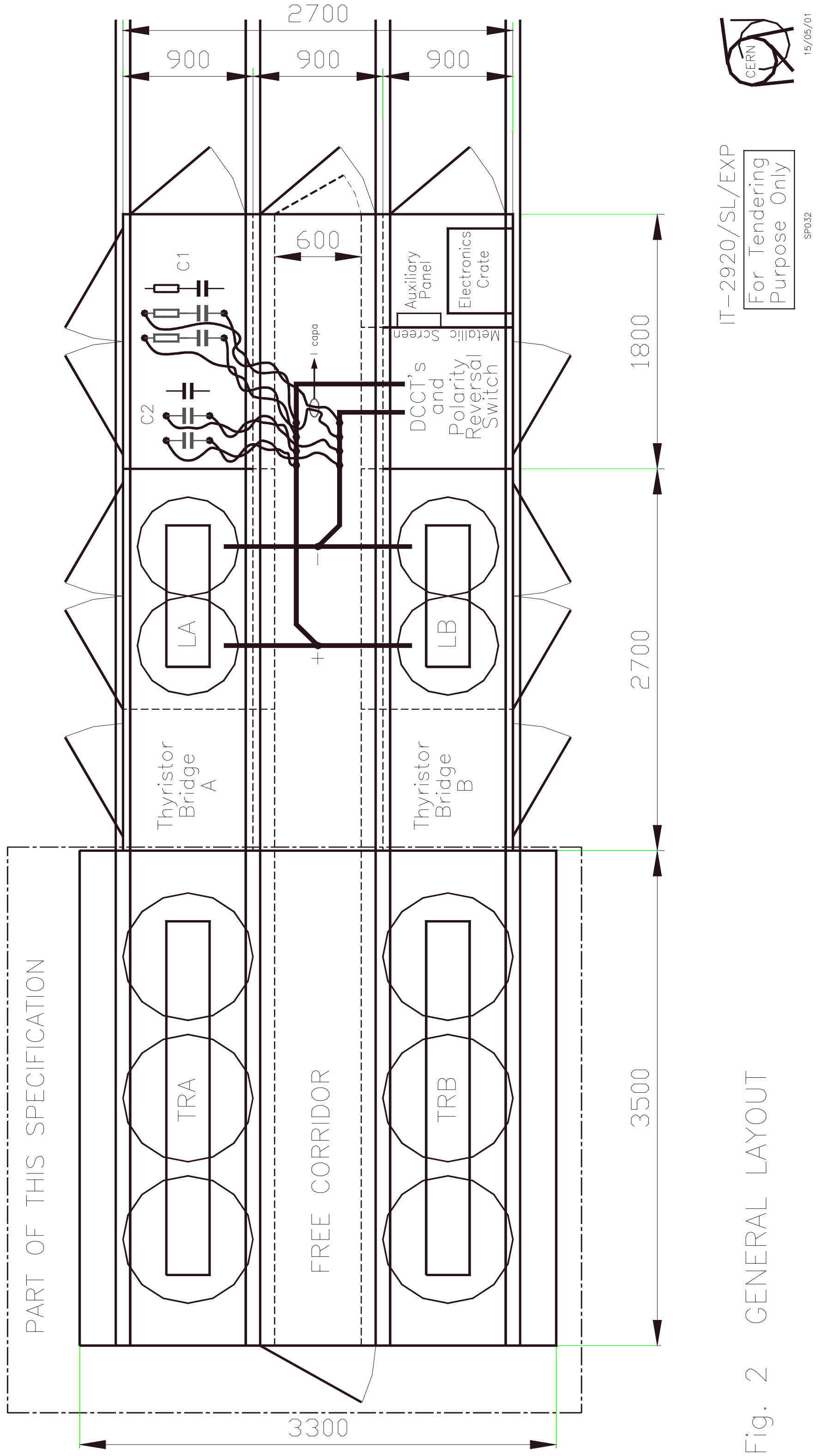

Fig. 2 GENERAL LAYOUT

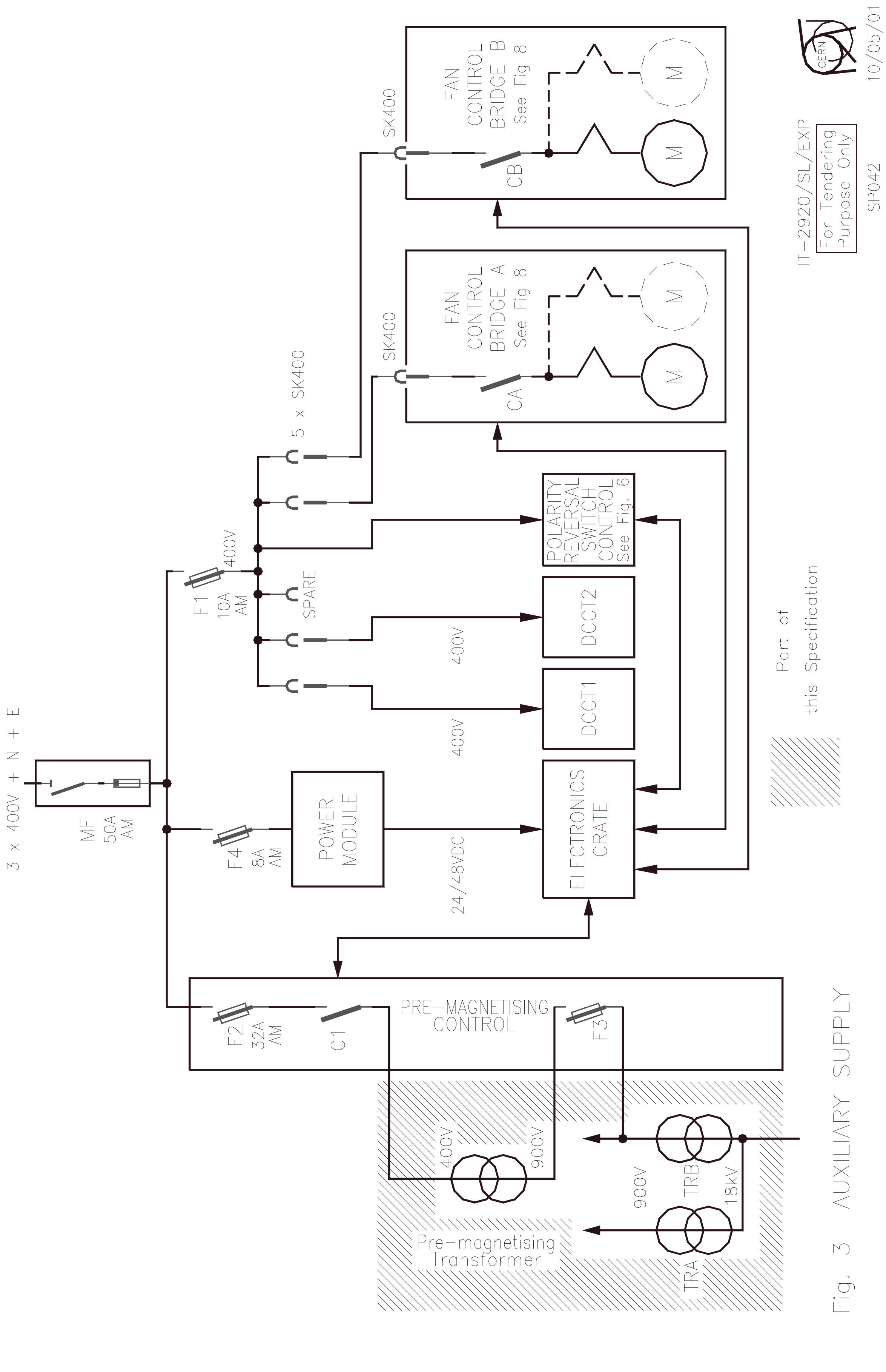

Fig. 3 AUXILIARY SUPPLY

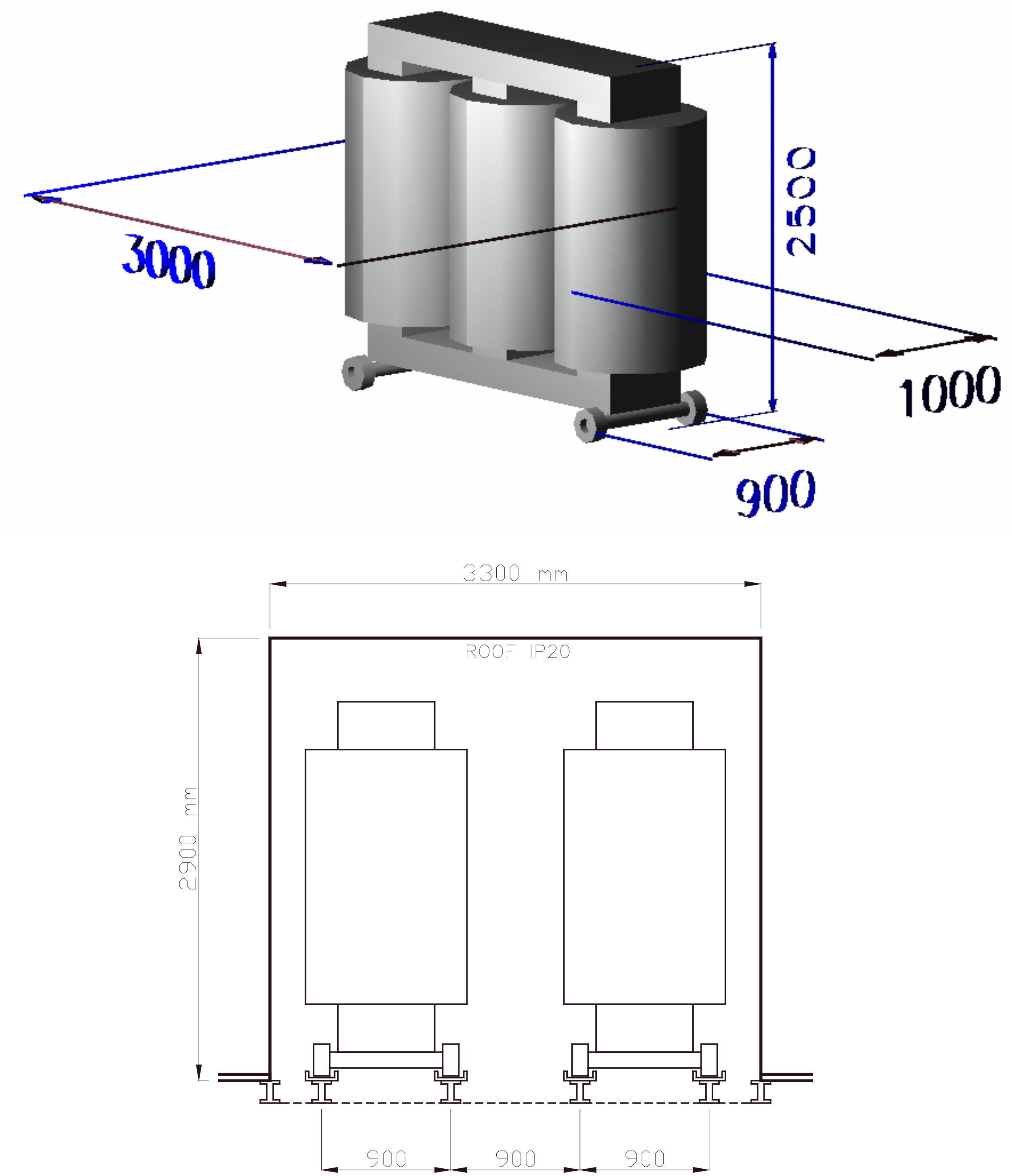

Fig. 4 MECHANICAL LAYOUT

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