



Engineering Specification

THE EARTHING SYSTEM IN THE LHC.

Abstract

The earthing system in the surface access zones, the machine tunnel and in the underground structures of the LHC and the experimental areas is described. There is one earthing system only; and all equipment is connected to the same earthing system. The main purpose of the earthing system is to assure equi-potentiality and avoid hazardous voltage differences between accessible parts.

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1. INTRODUCTION

The term *earthing* means the connection to a reference potential of all electrical equipment and all metallic structures. This reference potential is commonly referred to as *earth or ground*. Ideally, no current will flow in these earth connections. However in the case of asymmetric faults or isolation breakdown, the fault current will flow back through the earthing system. To avoid dangerous potential differences (step voltages and touch voltages), all installations susceptible of conducting a possible fault current must be connected together and to the reference.

There is only one single earthing system at CERN; for LV and HV installations, surface buildings, underground structures, LHC machine and LHC experiments. All equipment is connected to the same earthing system; metallic structures with floating potential are not permitted.

The earthing system is systematically meshed and interconnected to decrease impedance and to increase reliability.

2. GENERAL IMPLEMENTATION OF THE EARTHING

At CERN the reference potential is given by an earthing system at the surface. The reference potential is that of a number of earth-spikes inserted in the ground around the surface buildings; the dimensions, relative positions and insertion of these spikes is specified in standards. The quality of the ground (humidity, granularity etc.) is also considered in the design.

Each building is equipped with a copper loop buried in the foundations, that – together with the - spikes form the basic earthing network. The buildings are generally interconnected, thus forming a grid, which is able to conduct important fault currents without hazardous potential differences.

The underground structures are connected to the surface reference grid via copper cable links in the pits. The earthing network is continued into the machine tunnel, the galleries, the caverns etc.

In general the earthing system is always built up of loops or double connections, such that an accidental rupture of a earthing link will not cause a hazard.

In certain areas with high power densities special measures have been taken to reinforce the earth system.

3. EARTHING INSTALLATIONS

3.1 EARTHING INSTALLATIONS PROVIDED BY TS-EL

As part of its mandate TS-EL provides:

- The earthing loop buried in the foundations of the buildings.
- Earthing collectors in the buildings, i.e. copper bars bolted to the foundation loops. The loops are drawn into the buildings approximately every 10 to 15 linear meters along the perimeter of a building.
- Earthing of all cable ways. The earthing is done by running a cable along one cable way and connecting straps to the neighbouring ones at short intervals.
- Earthing of all existing electrically conducting building structures: metallic supports, stairs, passage ways, metal doors and equipment platforms.
- Earthing of all electrical equipment installed by the TS-EL group.

3.2 EARTHING INSTALLATIONS PROVIDED BY TS-EL ON REQUEST

TS-EL will, on request, install the earthing connections of all metal parts or particular systems, identified by their installer and for which the earthing is requested (for example pipe work, magnets, cryostats, power converters, racks etc.)

3.3 LABELLING

Equipment groups are requested to mark the earthing stud of their equipment with the earthing symbol.

4. DETAILS ON EARTHING

4.1 SURFACE BUILDINGS

Each building is equipped with a copper loop buried in the foundations. In regular intervals the copper loop is brought to the floor level of the building and a copper bar, earth collector, is installed. These collectors permit all equipment in the building to be connected to the earth grid.

4.2 UNDERGROUND STRUCTURES

The underground structures are connected to the surface reference grid via copper cable links in the pits. The earthing network is continued into the machine tunnel, the galleries, the caverns etc.

4.2.1 MACHINE TUNNEL, INJECTION TUNNELS AND BEAM DUMP TUNNELS

The backbone of the tunnel earthing system is a 120 mm² bare copper cable fixed to one of the main cable ways, normally the general service cable ladder. All other metal structures will be connected by appropriate cables and strips.

4.2.2 MINOR CAVERNS

Minor caverns, that can be considered enlargements of a tunnel, will receive an earth installation very much like the tunnel. Most of the installations will be a continuation of the tunnel installations.

4.2.3 MAJOR CAVERNS

The major caverns require a more elaborate study, in particular earthing of moving parts. This is being done in collaboration with the experiments.

4.3 MACHINE CRYOSTAT

The cryostat will be connected to the earthing system every half cell, i.e. every 53 m at the SSS. The cryostat of DFBA's at the end of the continuous magnet cryostat will also be earthed.

The machine cryostat outer tube is a continuous metal structure that will be in parallel to the earthing system. It will contribute to the lowering of the impedance of the overall reference.

Every stand-alone cryostat in the long straight sections shall be earthed individually. The cryostats shall be equipped with an earthing stud. The earthing of the cryogenic feed box shall be assured by this earthing.

4.4 INDIVIDUAL WARM MAGNETS

Each warm magnet in the long straight sections shall be earthed individually. The magnets shall be equipped with an earthing stud.

5. CRYOGENIC SUPPLY LINE QRL

The QRL will be connected to the earthing system every cell, i.e. every 106 m. The QRL tube is a continuous metal structure that will be in parallel to the earthing system. It will contribute to the lowering of the impedance of the overall reference.

6. KICKERS

The kicker magnets will be equipped with a reinforced shielding by the responsible group. The earthing system will be equipped with a adequate number of connection points to the kicker system shielding. *These connections have to be defined.*

7. RADIO FREQUENCY SYSTEM

The need of the R.F. installations for interconnections to the earthing system will be covered by a set of copper bars brought to the bunkers and klystrons in UX 45. Further it is foreseen to reinforce the earthing with a copper rail in the UA 43 and UA 47 as it was done in the klystron galleries of the LEP.

8. QUENCH PROTECTION SYSTEM

No special earthing needs have been identified. The earthing foreseen by TS-EL is limited to the earthing of the metallic structures occupied by the quench protection system

9. POWER CONVERTER SYSTEM

The DC circuits, fed by the power converters, are equipped with a reference earth. This earthing serves several purposes, see LHC-D-ES-0001 rev. 2.0. [1] One of them is the connection of the circuit to the general earthing.

The earthing foreseen by TS-EL is thus limited to the earthing of the metallic structures occupied by the power converter system

10. EARTHING OF ELECTRONICS, EMC PROBLEMS

TS-EL has prepared a document, proposing a number of simple ways of improving the EMC performance: LHC-E-EN-0001, "Liaisons equipotentielles et protection electromagnetic" [2]

REFERENCES

- [1] EARTHING OF THE LHC DC ELECTRICAL CIRCUITS, F. Bordry, V. Montabonnet, Y. Thurel, A. Dupaquier AB-PO, EDMS-No 309372,
- [2] 'LIAISONS EQUIPOTENTIELLES ET PROTECTIONS ELECTROMAGNETIQUES' (2002), P. Guenat, TS-EL, EDMS-No. 358369