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POWERING THE TRANSFER LINES TI2 AND TI8

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Abstract

Electrical power for the transfer tunnels will be distributed from the LHC side and the SPS side. For the injection tunnel TI2, buildings LHC SR2, SPS BA6 and BA7 will be used to house the power converters and MV/LV switchboards. Galleries and ducts will facilitate cabling between power transformers and converters. For TI8, buildings LHC SR8 and SPS BA4 will be used. MBI magnets will be powered by water-cooled cables whilst rest of the magnets will be powered by conventional copper and aluminium cables. A load of 16.15 MVA and 30 MVA was intended for the existing SPS 18 kV pulsed loop by TI2 and TI8 respectively. The main compensator associated with this loop will almost reach its capacity with the load of TI2 alone. Therefore a new 18 kV pulsed link from Prevessin to BA4 will be installed, compensated by the third compensator. This paper explains how the above tasks will be achieved.

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1 INTRODUCTION

This paper deals with the electrical power distribution for the transfer lines TI2 and TI8 and encompasses all known aspects, at the time of writing this paper, of the surface and underground electrical installations. Issues such as thermal conditions with respect to heat to air loss from power cables are comprehensively covered and the safety of the installation is consistent with the standards applied in the CERN power distribution network. Since the preliminary Project Note 153 "Powering the transfer Lines from SPS to LHC" was written there have been several important changes with respect to the location of power converters. These changes were mainly introduced to cut costs by keeping the QD/QF and MBI converters and their associated electrical installations on the LHC side. The MBI converters for TI8 will be moved to the SPS side as the same will also power the primary proton beam line for the CNGS via set of electronic switches. In view of these changes it was necessary to recommence with power balance as a starting point and continue in a logical manner.

2 BACKGROUND

The converters for the TI2 and TI8 transfer lines will be spread over a number of SPS and LHC Buildings i.e. BA4, SR8 for TI8 and BA6, BA7 & SR2 for TI2. The original philosophy was to pulse the load from the SPS side while on the LHC side, the converters would operate in a DC mode. This idea has been revised, mainly by SL/PO, and now all the converters on the SPS and LHC side will operate in the pulse mode. The decision to pulse these converters on the LHC side was taken on the basis that the current pulses resulting from the LHC injectors will not cause significant interference into LHC.

3 POWER BALANCE

The first step is to compare the reserve power capacity on the existing SPS pulsed power network, which passes through all the BA buildings, against the new load that will be added by the transfer lines TI2 and TI8 from the SPS side. The MBI circuits will be the major constituents of the load for the injection tunnels.

The minimum thermal MVA rating of the 18 kV pulsed loop in any BA buildings is **20 MVA.**

The total load connected at present to this SPS pulsed loop is	16 MVA evenly distributed
Leaving a reserve of:	24 MVA evenly distributed
The total load for TI2 fed from BA6 & BA7 will be:	16.15 MVA
The total load for TI8 fed from BA4 will be:	**30 MVA**

It can be deduced from the above that by adding the load of TI8 alone will exceed the capacity of the 18 kV SPS pulsed loop. But it will be acceptable to add the load of TI2 provided that the loop is closed. If the loop is operated in open mode then certain cables could be thermally overloaded. We also need to investigate the reserve capacity on the compensator associated with the 18 kV SPS pulsed loop to see if the reactive load of TI2 can be added.

The associated compensators for the above loop are the main compensator at Prevessin (BEF1) and an auxiliary compensator at BB3. The ratings of these compensators are as follows;

Maximum dynamic swing of the compensator (BEF1) is:	**95 Mvar**
Total compensation at present:	**85 Mvar**
Leaving a reserve of:	**10 Mvar**

The auxiliary compensator at BB3 can handle a swing of **18 Mvar**. The reactive power needed to be compensated for TI2 is **17 Mvar.** So the combination of BEF1 and the auxiliary compensator will suffice for TI2.

As mentioned earlier by adding the load of TI8 to the existing SPS pulsed loop would overload. Therefore for TI8 it is necessary to run an 18 kV pulsed link from the BE substation at Prevessin to BA4. The total length of this 18 kV link will be 1.67 km.

The associated compensator for the new 18 kV Prevessin link is the north compensator (BEF3) installed at Prevessin with the ratings as follows:

Dynamic rating of the North compensator for the above is	**95 Mvar**
Total compensation at present is:	**72 Mvar**
Leaving a reserve of	**23 Mvar**

Reactive power needed to be compensated for TI8 is **29 Mvar.** CERN is in the process of purchasing the 3rd compensator with a maximum dynamic swing of 150 Mvar and this new compensator will be put in service before the transfer lines are commissioned. A detailed study has been made within the ST/EL group concerning the compensation for reactive power as a whole and reactive power resulting from the transfer lines has been accounted for. Redistribution of the pulsed load for the SPS pulsed loop has been carefully studied and will be realised.

On the LHC side the power situation is much simpler in that there is ample power available on the network to accept a maximum thermal load of 7.4 MVA for TI2 and 5.8 MVA for TI8. At point 2 there are two 38 MVA transformers connected in parallel and at point 8 there is a single transformer with a rating of 38 MVA. There is a compensator available at point 2 with a maximum swing of 50 Mvar and at point 8 the available compensator has a maximum swing of 25 Mvar.

4 COOLING & VENTILATION / HEAT TO AIR LOSSES FOR TI2

The approach for determining the heat dissipation to air is by considering the heat to air loss per meter of tunnel. This method gives a very clear understanding of the tunnel conditions with respect to heat rise. Calculations below are for total heat loss emanating from all the heat generating sources in the tunnels only.

Total dissipated heat to air by magnets with water cooling present is:	**182 kW**
Total dissipated heat to air by cables:	**170 kW**
Total dissipated heat to air loss by remaining sources:	**25 kW**
Total dissipated heat to air for tunnel only:	**377 kW**
Possible heat removal by ventilation:	**-175 kW**
Total dissipated heat to air with cooling and ventilation present:	**202 kW**

Net dissipated heat to air per meter of tunnel = 202 kW / 2.65 km (tunnel length) = 76 W

One meter of tunnel = 6.06 m^3 of space.

This is less than heat dissipated by a 100 W light bulb in a room measuring 1.82 m cubed. Using the same approach for TI8 we arrive at 136 W dissipated heat to air per meter.

5 CABLE DIMENSIONING, VOLTAGE DROP AND HEAT DISSIPATION

For each magnet circuit the voltage drop has been calculated for TI2 and TI8 and a cable size chosen as not to exceed the permitted voltage drop. During the process of determining cable sizes, consideration was given to space on cable trays, heat dissipated to air by power cables for each circuit and cost. Corrector cables will be carefully selected to keep the voltage drop to an acceptable level and may not necessarily be a uniform cross section area for each corrector circuit. Furthermore, the correctors will be wired from both ends to keep the costs to a minimum. This will also allow us to recuperate all the existing corrector cabling at P2 and P8.

6 RECUPERATION

It is absolutely vital to consider the process of recuperation from the LEP dismantling where it is financially justifiable and also if the installation meets the present CERN safety and technical standards. With recuperation on top of the priority list, below is a list of very strong possibles that will be recuperated.

6.1 HV switchgear and cabling

Most cables that will become redundant and are of interest to us in BA4 and BA7 are PVC sheathed and therefore will not be recuperated. However, water cooled cables that are longer than 100 m will be recuperated as these cables do comply with present CERN safety standards. Transformers for the small LV converters will be recuperated in BA4 and BA7. HV switchgear in BA4 for the pulsed load will be new and recuperated for stable load. HV switchgear in BA7 will all be recuperated. For BA4 we require one 18 kV incomer and five 18 kV feeders and for BA7 one 18 kV incomer and three 18 kV feeders. A total of twelve power transformers will be recuperated from SR2, SR4, SR6 and SR8 for the HV converters.

For the existing LEP installation there are six type QTL magnets wired from BA6, these magnets are also needed for the LHC, therefore recuperating switchgear and cables for these magnets should be straightforward. Although, slight rerouting of cabling will be required as the location of these magnets for the LHC is slightly different than that of the LEP.

All converters fed from SR2 and SR8 can be wired by recuperating redundant cables, even though all cables are aluminium. Recuperated cables from SR2 and SR8 can also wire general services to the bottom of the pits at SR2 and SR8. Cabling for general services from BA4 and BA7 will all be new.

All correctors fed from SR2 and SR8 will be wired, from surface to the bottom of the pits, by recuperated corrector cables. All cables are copper.

Cables connecting converters to transformers (AC cabling) will all be recuperated from SR2 and SR8 and used in BA4, BA7, SR2 and SR8. However the secondary AC cabling at BA4 and BA7 will all be new, as the present cable lengths at SR8 are only 11 meters long.

The magnet installations MBI22134 and MBIAV26852 at SR2 will be recuperated in their entirety. No modifications will be needed. This also applies to magnet installations MQIF 87000 & MQID 87100 at SR8.

6.2 LV Switchgear requirements

At BA4 we require11 feeders, a switchboard of 3 columns equipped with an incomer and 11 fused switch feeders. Switchgear for this will be recuperated from BA4 and at present it is known as ERD1/A4, since we have an ongoing contract with Hazemeyer for this LV switchgear we can simply extend this to cover our needs at BA4. Switchgear and transformer for general services will be recuperated from BA4 and used at BA4. This also applies to LV converter transformers at BA4.

At BA7 we require 6 feeders, a switchboard of two columns equipped with an incomer and 6 fused switch feeders. Switchgear for this will be recuperated from BA7 and at present it is known as ERD3/A7, at present there are 9 spare feeders on this switchboard, 4 x 800 Amps and 5 x 630 Amps. Switchgear and transformers for general services will be recuperated from BA7 and used at BA7. This also applies to LV converter transformers at BA7.

All of the LV switchgear and transformers for small converters will be recuperated at BA6, SR2 and SR8. This also applies for general services.

7 CIVIL WORKS AND SPACE CONSIDERATION

Civil works will be required for transformer pits and galleries outside BA4 and BA7. The projected date for commencing civil works at present is Summer 2001.

7.1 Space Considerations

Buildings BA6, BA7, SR2 and SR8 have ample space for HV/LV switchgear. Also free space in the floor voids is sufficient for AC/DC cabling.

BA4 is congested above and below the floor, therefore AC/DC cables will have to be laid on the floor without cable trays. Space for HV/LV switchgear has strategically been chosen as to keep free space for all the new converters.

In the transformer cable galleries at BA4, there will be 8 cable trays to accept the primary and secondary cabling. There will be approximately 24 cables per tray.

There will be 4 cable trays each in TI2 and TI8 tunnels. Two cable trays for magnet cabling, one for control and one for general services and alarms. The middle part of the injection tunnels will only have three cable trays. For the power cables, approximately 14 cables per tray are foreseen.

Space in shafts PP4 and PA7 should not present a problem as many cables will be removed along with the equipment that is no longer in service. But to install cables down the BB4 (PAP4) shaft will cause a slight problem, especially at the bottom of the shaft. This part of the shaft and area around it has to be opened or modified slightly to facilitate the electrical installations.

8 GENERAL SERVICES

Normal lighting, emergency lighting, exit lighting, power sockets, red telephone points, normal telephone points and sirens will all be consistent with the LEP design.

9 SAFETY ASPECTS

The emergency stop system will comply with the CERN safety instruction N° 5. All incoming sources will be cut in the locality of the emergency. Care has to be taken in that the tunnels are fed both from SPS and LEP so the design has to allow for this. To maintain consistency all materials and cables will comply with CERN safety instruction SI 23. All cables and materials will be halogen free plastics and low smoke fumes (LSF) as described in instruction SI 23. Any recuperated materials and cables from underground will be tested for radioactive contamination before reusing.

10 PLANNING

For the injection tunnels the critical path is the time allowed for the ST/EL/CV groups in the tunnels for the installation of general services and power cabling. From the LHC planning chart it can be seen that EL/CV have been allocated a total of six months for the installation of general services. So it is best to begin by looking at the amount of cabling and cable trays that will be installed in the tunnels only. By using the experience of CERN's previous tunnel installations, it can be shown how the figures below are derived.

Cable trays and tray supports:	7	weeks
Cabling:	12.75	weeks
Fixture of General Services:	2	weeks
Transportation and movement of equipment:	1	week
Preparing and making connections	2	weeks
Total for each tunnel:	**24.75**	**weeks**

11 CONCLUSIONS

The execution of this installation should cause no technical problems as conventional and proven technologies are being reemployed. There are enough reserves on our power network to allow for the additional load from TI2 and TI8. The two existing compensators together with the new 3rd compensator will have sufficient reserve capacity to absorb the resultant reactive power from the additional loads. There is a fair amount of recuperation on surface at SR2, SR8, BA4 and BA7. Also all the transformers required will be recuperated.