RAS Working Group meeting

Participants: A. Apollonio, R. Bianchi , M. Blumenschein, D. Calcoen, S. Eitelbuss, L. Felsberger, C. Martin, A. Niemi, T. Podzorny, O. Rey Orozco , I. Romera, R. Secondo, V. Schramm, J. Schwenk, D. Sollich, Y. Thurel, B. Todd, J. Uythoven and E. Vergara

The slides of the presentation can be found on the Indico page: https://indico.cern.ch/event/743988/

CIBD Power Supply Overview (C. Martin - slides)

In order to introduce the Reliability studies performed by Y. Thurel, C. Martin gave an overview of the Controls Interlocks Beam DC supply (CIBD).

The Beam Interlock system (BIS) collects around 450 “User Permit” signals from the different users CERN wide. Each “User Permit” is connected to a Beam Interlock Controller (BIC). These connections are realized thanks to a standard User Connection Interface (CIBU). Depending on the connection type and length, which can be up to 12 km long in the LHC, different CIBU types can be used: CIBUS (400mA power consumption), CIBUD (900mA power consumption) and CIBFx (2.4A power consumption). Two independent and redundant power supplies power all CIBUS: the CIBD. A schematic of the CIBD is given is Slide 12. All components are “passive” components with the exception of the shelves AC/DC converter.

Since the beginning of the BIS operation in 2007, 51 failed CIBD units have been found among the 845 CIBD in operation. Since the beginning of 2018 4 CIBD failures occurred on CIBF modules and during the TS1 in 2018 the 138 CIBDs mounted on CIBFx have been exchanged. For this reason, a dedicated reliability study has been done to investigate on the CIBD module and in particular, on the AC/DC Traco power converter affecting the different CIBD families running at different currents.

HCCIBD Reliability Analyse (Y. Thurel - slides)

Y. Thurel reported on the Reliability study performed for the CIBD. The goal of the study was to understand why the failures were occurring, estimate the level of failures in the next coming months and understand why only some families of the CIBD where affected. The starting point of the study was an excel file containing a record of all the failures occurred and their description. Four different failure modes were identified.

The Reliability analysis of each failure mode was done following Weibull Curves. For this, Y. Thurel included a short description of the method and possible outputs.

Regarding the first failure mode analysis, J. Uythoven asked if a Beta of 1.78 could still be considered close to one. Y. Thurel explained that the case could be neglected because of the fact that even if the Beta value is not close enough to one, the Eta value is still very high to compromise the system in the following years. V. Schramm commented that it seems to be a stop between points and a steeper slope after the first set of points in Slide 17. Y. Thurel explained that it has been observed an additional stress in the units after switching then on after shut down, causing an increase in the failure frequency.

About Failure Mode 2, the Eta and Beta values obtained from the Weibull analysis are not alarming and therefore, the failure mode is not significant.

For Failure Mode 3, the failure only encountered in the CIBDs with higher output current, the beta value observed is very high and therefore, dedicated studies have been performed to understand the root cause of this failure. It was found that the fault occurs due to the degradation of the C8 electrolyte capacitor due to temperature elevation. By extrapolating the lifetime of the AC/DC Traco power converter, i.e. Failure Mode 3, the level of failures in the worst case scenario are shown in Slide 36. Note that the calculations do not take into account the fact that all CIBD units will be off during Technical Stop 2.

Y. Thurel concluded that the Failure Mode 3 is quite severe and should be taken into consideration for future decisions. The other failure modes instead, are not significant.

C. Martin concluded showing the cost of exchanging the 700 CIB, if necessary, and noted that the CIBD, despite the present severe Failure Mode 3, would only stop operation, if both CIBUx units were defective at the same time, due to the implemented redundancy.

C. Martin also took the opportunity to thank Y. Thurel and his team for the reliability study and the support given.

J. Uythoven considered then two possible solutions; either change during LS2 all the CIBD units to avoid 50 failed units up to 2024 (worst case scenario) or have 50 spares available. The decision should be taken under the consideration that no failures have been observed until now in 600 units. He also mentioned that as the worst-case scenario is considered, one could expect that if there is no failure until 2019 then the curve will be shifted. To the comment of J. Uythoven, Y. Thurel added that it is important to know also where we are in the curve, i.e. failures observed until now, to understand the failure tendency in the future. It needs to be taken into consideration that after switching off the devices, the added additional stress could cause an increase in the observed failures. As commented by I. Romera, after LS1 many fuse failures were observed due to switching on off the devices, but this was never a problem for the capacitor.

T. Podzorny asked if erratic failures are always tracked. C. Martin explained that the case is not always clear, if one unit failed, you can know it by remote control, but erratic failures are difficult to detect unless you go into the tunnel and perform measurements. For the next generation of CIBS devices, B. Todd suggested to remotely record the output current of the CIBD units to detect failed units.