186th Meeting of the Machine Protection Panel

The meeting took place on **March 06th 2020** in 774/1-019.
Participants: Andy BUTTERWORTH (BE-RF), Verena KAIN (BE-OP), David NISBET (TE-EPC), Ivan ROMERA RAMIREZ (TE-MPE), Belen SALVACHUA FERRANDO (BE-BI), Jan UYTHOVEN (TE-MPE), Francesco VELOTTI (TE-ABT), Christoph WIESNER (TE-MPE), Daniel WOLLMANN (TE-MPE), Markus ZERLAUTH (TE-MPE)

The slides of all presentations can be found on the website of the Machine Protection Panel and on Indico.

1.1 Minutes and actions from the 184th MPP meeting

- No further comments have been received for the minutes of the last MPP meeting on injector topics (184th MPP). The open actions have been added to the MPP website.

1.2 Interlocking of the SPS MDSH injection bumper (Francesco Velotti, Ivan Romera)

- Ivan gave an overview of the **layout of the new SPS Injection Beam Interlock System (BIS)**. It will replace the current local link between the SPS Beam Dump System (SBDS) and the SPS injection kicker (MKP).
- The Injection BIS inhibits the injection into the SPS depending on the **status of the MKP, SBDS, Ring BIS and TT10 interlocks.** It acts on the **MKP** as well as on the power converters (PCs) of the **injection bumper (MDSH.11971)** and the switching magnets **BHZ.377/8.** In addition, it sends its status to the TT2-TT10 Master BIC, which removes the Injection Permit to the BHZ.377/8. Details can be found in EDMS 1934839.
- Before LS2, the MDSH powering was interlocked through the Ring WIC located in building BA1. The WIC switches off the PC in case of magnet overheating. However, the existing injection-inhibit functionality of the WIC was not activated due to the missing Injection BIS.
- After the installation of the new Injection BIC and WIC in TT10, the **full WIC functionality can now be used**. Therefore, the proposal is **to move the MDSH powering interlocks from the Ring WIC to the TT10 WIC** (both in BA1) to **inhibit TT2 extraction when the MDSH is OFF or in FAULT**. In addition, the MDSH PC control system will be connected to the SPS ring BIS and **remove the beam permit if the MDSH current is above 0 A**.
    - Markus asked if the MDSH PC will be FGC controlled. Ivan replied that this is not foreseen, instead it will remain controlled via MUGEF. Verena highlighted that for this case the MUGEF functionality to send the PC status to the WIC is fully sufficient. David added that indeed the state of the main circuit breaker will be sent to the WIC. If the state is OFF or FAULT, injection will be inhibited, while a current of 0 A will permit injection.

  - Jan remarked that the input to the ring BIS is not maskable. However, in case of a PC fault of the MDSH, no significant loss in availability is expected due to the existing efficient EPC piquet service.
- Ivan summarised the proposed modifications (Slide 5) that have been already endorsed by the LIU Commissioning Coordination Committee.
- Francesco presented the status of the MDSH interlock and operation after LS2. He recalled that the **function of the MDSH** is to centre the beam on the SPS injection dump (TBSJ) in case that the MKP does not fire. Without the MDSH, the beam would impact the TBSJ with a grazing angle. For LIU beams, this failure is acceptable for rare cases but not for consecutive shots. After LS2 a larger injection bump is required because of the missing dog-leg in LSS1.
- It was proposed to add a maskable **"MKP enabled" input to the TT2-TT10 slave BIC**. This way, if the MKP state is OK but the MKP is disabled, the beam will be stopped already at the BHZ, instead of being sent repetitively on the TBSJ. In addition, if the MKP is disabled, but the input is masked, it allows to test injection onto the TBSJ without the MDSH pulsing (see below).
  - The new input requires a new cable connection to the TT2-TT10 slave BIC. Action (I. Romera/TE-MPE-MI): Install new connection "MKP enabled" from the MKP to the TT2-TT10 slave BIC.
- A **new SBDS failure case**, which had existed already with the old beam dump system, was recently discovered: If the dump kickers MKDV/H experience an erratic pre-firing in a certain time window before injection, beam could be injected into the SPS without the SBDS being armed. This time window has now increased because the dump system has been moved from LSS1 to LSS5.
  - The **failure case is now mitigated by firing the MDSH on the circulating beam** in case the injection permit is FALSE 100 µs after injection. In this case, the beam will be lost at injection energy before being ramped.
  - Daniel asked where the beam would be lost. Verena answered that the beam will be lost around the aperture, which is not ideal but clearly preferable to ramping the beam without an armed SBDS. The next injection will then be blocked.
- In the new setup, the **MDSH will, thus, check the injection permit twice**: First, 270 ms before injection, and second, 100 µs after injection.
  - 1) If the injection permit is removed between 350 ms and 270 ms before injection, the beam is safely directed on the TBSJ with the MDSH ramped up to nominal current.
  - 2) If the injection permit is FALSE 100 µs after the injection, the MDSH will be ramped up with circulating beam to mitigate the newly discovered failure case discussed above.
  - David remarked that the delay of 270 ms can be likely reduced to 250 ms, and might even be reduced down to 188 ms. The final number has to be defined during commissioning.
  - Replying to a question from Jan, David explained that the PC ramp to 380 A (see green curve, Slide 14) is required for degaussing.

- During **commissioning**, the **injection behaviour** onto the TBSJ with and without the MDSH pulsing has to be tested.
  - To inject beam onto the TBSJ without the MDSH pulsing, the MKP will be disabled while the "MKP enabled" input to the TT2-TT10 slave BIC is masked.
  - To inject beam onto the TBSJ with the MDSH pulsing, a cycle with two injections of single bunches will be used and an early dump programmed 280 ms before the second injection. This way, the MKP firing for the second injection will be blocked while the MDSH has already ramped up. Also for this case, the "MKP enabled" input has to be masked.
  - David remarked that the PC functionality is tested already by firing the MDSH, and it doesn't have to be tested separately.
  - Jan asked how the SPS commissioning is organised. Verena replied that the dedicated checklist tool is used. Action (V. Kain/BE-OP): Update commissioning procedure and checklists for injection tests with new MDSH functionality.
- Jan reminded that the corresponding documentations have to be updated.
  - Action (I. Romera/TE-MPE): Update the specifications for the SPS Injection BIS with the new "MKP enabled" input to the TT2-TT10 slave BIC.
  - Action (R. Mompo/TE-MPE): Update specifications for the SPS and TT10 WIC with the modified MDSH connections.
  - Action (D. Nisbet/TE-EPC): Update specifications of the MDSH PC.
- The **proposed changes to the MDSH interlocking were endorsed by the MPP**.

1.3 Proposal of rMPP on Injectors (Jan Uythoven)

- Jan recalled that the discussion was triggered by a presentation from Bettina concerning the injection into less than 4 PSB rings (182nd MPP, 11.10.2019), which would require **masking of critical BIS channels**. The proposal was that the core members of the MPP (injectors) should be responsible to take this decision and would, thus, play a similar role as the rMPP members for the LHC.
- The **current rMPP mandate** is limited to the LHC, but already includes, among other topics, the discussion of machine protection related issues that arise during operation and require timely reaction, as e.g. the masking of critical interlocks, as well as the definition of boundary conditions for MDs related to machine protection.
- Therefore, Jan proposed to extend this approach to the injectors and establish **a dedicated rMPP for injectors**. Consequently, the current rMPP mandate would need to be extended from the LHC to the injectors.
  - Action (J. Uythoven/TE-MPE): Present the extension of the rMPP mandate to the injectors to the IEFC.
- The **proposed members are the core members for MPP injector topics**, i.e. one representative for each machine plus key MPP representatives (see Slide 5).
  - Action (J. Uythoven/TE-MPE): Verify the acceptance of the proposed members to be part of the rMPP for injectors, for those not present at the meeting.

  - Jan remarked that the members don't have to be necessarily experts on all the treated topics, but should provide an external check for critical machine-protection questions ("stop – think – decide – communicate - record"). The decision has to be recorded in the existing rMPP EDMS structure.
  - Belen asked if a member from BI should be included. Jan explained that this would be very much appreciated, especially because many of the BI systems play an important role in the interlocking chain of the injectors. However, it is not considered mandatory because, in difference to LHC rMPP, the Injector rMPP is not system-based, but machine-based.
  - Jan stressed that one of the challenges will be that several rMPP members are also OP responsibles for certain machines. Therefore, they should be conscious about their different roles and involve other members as required.
  - Verena agreed and explained that during operation one can end up in the situation where a decision has to be taken on whether or how to continue operation even though a certain protection functionality has been lost. Therefore, she considered it very important to have a body like the rMPP, which can be involved in these situations.
- David asked if the Injector rMPP should also be involved in defining the **boundary conditions for injector MDs** related to machine protection. Verena replied that one should agree on general machine protection rules for all MDs and only discuss the cases that don't comply with these rules. Daniel commented that indeed one should discuss only the procedures of machine protection critical MDs in the rMPP, as already done for the SPS in 2018, e.g. for slow extraction or crab cavities.
  - Action (J. Uythoven/TE-MPE): Discuss with the MD coordinators for all the injector chain the role of rMPP in the preparation of machine protection critical MDs.
- Markus, as chairmen of the LHC rMPP, commented that the proposal sounded very good and should be implemented.

1.4 Action follow-up: Latency in consolidated PM system (Markus Zerlauth)

- Markus reported on a **follow-up action from the MPP workshop**: "Define data volume and latency requirements for XPOC, IQC, and SPSQC use-cases within PM so that it can be used for operation and interlocking."
- He recalled that towards the end of Run2 the Post Mortem (PM) file storage started reaching its performance limitations due to the continuously increasing demands (data rate and volume), new use cases and the static load balancing implemented for the legacy system. Therefore, the **new system was designed based on NXCALS**, preceded by a dynamic load balancing for the PM data ingestion and a Kafka cluster to push the data to the storage.
- The new PM storage implementation using the NXCALS pipeline is ready but does not meet the requirements for the low-latency uses-cases such as IPOC/XPOC/SPSQC. To mitigate the issue, awaiting improvements of the NXCALS

performance, a **parallel storage based on Oracle database** was implemented for the low-latency cases. This service will be used for LHC XPOC and LHC IQC, and a separate database instance will be provided for the SPSQC based on the final requirements agreed with SPS OP. For the user, it will be transparent which data source (Oracle, NXCALS) is used.

- For the SPSQC, **benchmarking tests** were performed for different numbers of data dumps and data sizes. The **overall latency for a typical event is 1.5 seconds**, not including the time for PM dump generation on the client side, event building and the analysis of the data.
    - The database reading and writing speed depends strongly on the number and size of the data dumps. Therefore, it is recommended not to exceed 1-2 MB per dump file.
- Replying to a remark of Jan during the MPP workshop, Markus underlined that the system can be used to verify that a data file was received for a given event, but **ultimately the client is responsible for the provision and correctness of the data** sent.
- Jan asked what kind of checks are required for the new SBDS. Verena explained that the dump system has its **internal IPOC check** that interlocks internally in case of faulty behaviour and then removes the injection permit via the BIS.
- Jan recalled that presently **no automatic checks of the BIS internal behaviour** are performed.
    - Action (J. Uythoven/TE-MPE): Evaluate if automatic checks of the internal performance of the SPS BIS systems are required.
- Verena added that the low latency is also essential for **tuning machine parameters** during operation. Otherwise, one would need to wait several cycles until the information about e.g. the beam transmission becomes available during a trim. Markus commented that it should be studied if the PM processing chain (where for protection reasons emphasis is put on reliable persistence of all data dumps) is actually the most adequate long-term strategy for use cases such as machine tuning or if the performance analysis should be separated from the PM functionality, which would allow exploiting streaming solutions.
- Verena summarized that the solution found looked very good.

1.5 Open Actions

The actions from the meeting are:

- Action (I. Romera/TE-MPE-MI): Install new connection “MKP enabled” from the MKP to the TT2-TT10 slave BIC.
- Action (V. Kain/BE-OP): Update commissioning procedure and checklists for injection tests with new MDSH functionality.
- Action (I. Romera/TE-MPE): Update the specifications for the SPS Injection BIS with the new “MKP enabled” input to the TT2-TT10 slave BIC.
- Action (R. Mompo/TE-MPE): Update specifications for the SPS and TT10 WIC with the modified MDSH connections.
- Action (D. Nisbet/TE-EPC): Update specifications of the MDSH PC.
- Action (J. Uythoven/TE-MPE): Present the extension of the rMPP mandate to the injectors to the IEFC.

- Action (J. Uythoven/TE-MPE): Verify the acceptance of the proposed members to be part of the rMPP for injectors, for those not present at the meeting.
- Action (J. Uythoven/TE-MPE): Discuss with the MD coordinators for all the injector chain the role of rMPP in the preparation of machine protection critical MDs.
- Action (J. Uythoven/TE-MPE): Evaluate if automatic checks of the internal performance of the SPS BIS systems are required.