HOW DO WE KEEP TRACK OF UPGRADES / CHANGES

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Abstract

Layout and electrical circuits of the LHC machine are well documented in the databases and the data has been used throughout hardware and beam commissioning. During the shutdown a number of changes will be made all around the accelerator to many different systems. The presentation will address in what areas changes are expected and how the changes are (or are not) documented. Proposals are made how to record and track the changes in order to avoid using data that does not correspond to the as-built status when restarting the machine.

INTRODUCTION

Tracking changes is very important for LHC since it is an extremely complex and unique accelerator with a large amount of energy stored in magnets and beams and therefore has many critical systems. Commissioning and operation relies on the correct understanding of the installation and is very much data driven, therefore depends on information stored in databases.

In this presentation I try to identify relevant changes. This not a complete list of all modifications, the objective is rather to give an idea of the changes that are being done. Details of the changes to several systems are discussed in other presentations.

WHAT TYPES OF CHANGES?

Most activities in the LHC during the shutdown need to be recorded:

- Changes to the hardware of the LHC main ring and transfer lines including repair, even if the system after repair is considered to be as before.
- Warming up cryostats to a temperature above ~100 K
- Disconnection of high current DC cables and reconnection.
- Changing parameters (maximum current in a circuit, etc….).

In general, changes require an ECR (in particular for installation of new equipment). Other activities that do not require an ECR (e.g. disconnection and reconnection of a high current DC cable) should still be recorded.

Most of the LHC systems are concerned by the changes: superconducting magnets and bus bars, cryostats, cryogenics, vacuum system, DFBs, power converters, QPS, DC cables, normal conducting magnets, interlocks, controls and networks, UPS, safety systems (AUG, access, ODH, fire detection,…), RF system, BI, collimators, injection and extraction, beam dumping system, cooling and ventilation, civil engineering, survey, shielding, AC distribution, experiments, anti blast doors, etc.

WHY TO KEEP TRACK?

Changes can have an impact on:

- **EL**ectrical **Q**uality **A**ssurance (ELQA), for example an ELQA campaign is required after warming up a magnet.
- Commissioning and operation of the cryogenic system.
- Commissioning and operation of the powering system.
- IST of QPS, Energy Extraction, PIC, Power converters.
- Commissioning procedures for electrical circuits.
- (Re-) commissioning of circuits.
- Verification of alignment.
- Commissioning and operation of other systems (BI, RF, injection and extraction, collimators, …).
- PiM testing (and repair) when a sector was warmed up to a temperature above 100K.
- Beam operation.
- Safety.

HOW TO FIND OUT ABOUT CHANGES

Today only very few changes are documented in ECRs and non-conformity reports. The information in this presentation comes from:

- Shutdown coordination and planning.
- Other meetings (such as MARIC minutes, …).
- Discussions with many people.
- ….this Chamonix meeting.

To find ECRs relevant for this shutdown is not straightforward. This will be improved by a link to a list of ECRs for this shutdown 2009 [1].

CHANGES WITH AN IMPACT ON POWERING SC MAGNETS

For the powering system, all changes of equipment in the circuit have an impact on re-powering:

- Change of magnet.
- Change of interconnect.
- Change or repair of bus-bar.
- Change of temperature of cold circuit components to a value above about 80 K.
- Change of power converter.
- Change of warm DC cable.
- Disconnection and reconnection of DC cable on power converter or DFB side.

- Change of the name or a parameter of a circuit component.

Example: The replacement of a main dipole requires opening all interconnects of bus-bars running through the magnet. This requires full re-commissioning of all circuits that are powered via one of the bus-bars running through the magnet.

CATALOGUE OF CHANGES

Major activities requiring warm up

- Repair work in sector 34. This has a significant impact on the Reference DB. The baseline layout changes and new types of assemblies will be defined [2].
- Exchange of main dipole magnets in sector 12 and 67.
- Activities on stand-alone cryostats.
- For MQY and MQM cryostats some flexible tubes will be replaced to improve the control of the helium level (not yet possible for all assemblies of this type).
- Repair of bus bars in connection cryostat in sector 56.
- Modification of the cryogenic link for 600A circuits powered from UJ33.
- Repair of Y Line, in sectors 12 and 34, and in sectors 78 and 81 (if warm).
- Installation of copper strips and thermometers outside of the cold mass in the insulation vacuum, in inner triplet in L5 and R1.
- Installation of pressure relief valves for dipole cryostats (warm sectors) and SSS cryostats (cold sectors).
- Finish installation of helium guards for QRL in sector 56 (has already been done in other sectors).
- Replace undulator magnet L4 (to be decided).

Major activities, no warm up required

- Modification to DFBs [3].
- Install electrical protections in front of current leads.
- Install mechanical protection for DFBM & DFBA links.
- Install additional pressure switches for the dry air system.
- Improve LHe level regulation for DFBAC LCM.
- Improve the configuration of the safety valves discharge outlet.
- Add heaters on top plates of DFBXs to avoid heavy condensation.
- Works in UJ76 due to risks of single-event upsets (impact on many systems) - Protection of equipment located in UJ76, EDMS Doc. 977085.
- Reinforcements of the jacks for the SSS equipped with a vacuum barrier. The type of jack changes, this has an impact on databases.
- Installation or modifications of collimators and their support systems.
- Installation of Roman Pots for TOTEM around point 5 and Roman Pots around point 1.
- De-installation and re-installation of the ALICE corrector magnet.
- RF system: improvement of the tuning system [4].

Power converters

- Exchange of three 60 A power converters with issues, Sector 1-2: RPLA.20L2.RCBV20.L2B1, Sector 8-1: RPLA.12R8.RCBV11.R8B1, Sector 4-5: RPLA.30R4.RCBV30.R4B2.
- Installation of DC contactors for eight RQS circuits and for eight RTQX1 power converters to improve the protection.
- Type name changes for RQS power converters from RPMBB to RPMBA.
- Type name change of RTQX1 power converter (600A trim for inner triplets) – crowbar resistance 1 mOhm, name change from RPMBB to RPMBC.
- DCCT upgrade for D2, D4 and inner triplet power converters, not for this shutdown (currently limiting energy slightly below 7 TeV).

Beam dump, injection and transfer lines

- Additional 2H and 2V dilution kickers per dump line.
- New TCDQ energy interlocking (via SW).
- New BLMs on the MKI kickers to try to avoid flashover after beam loss at kickers.
- Exchange of MKI kicker magnet in point 2.
- Four new BPMs in TI8 to improve optics matching.

Closing of the transfer line tunnel is planned for end March, to be ready by May with beam tests. Modifications to transfer line collimators are planned for later, if the tunnel is closed end March. If this happens later, the modification could be done during this shutdown.

QPS, BLMs and interlocks

- Installation of a new quench detection system (incl. 230 km of cabling). This is presented elsewhere and has major impact on the data stored in the LHC Reference DB [5].
- QPS: Installation of a reset option for the FPGA on front end electronics (modification of many cards).
- Possible installation of thermo switches on current leads (0.6, 6 and 13kA leads, to be decided) for protection from overheating. This requires cabling, and has a possible impact on other systems.
- Modifications of the Powering Interlock Controllers (PIC), limited to changes in functionality (type tests required). Some cables are disconnected, and interlock tests during re-commissioning are required.
- Modifications of the Warm magnet Interlock Controllers (WIC), including the activation of fast interlock module for beam abort.
- Upgrade of the system for distributing critical parameters (SMP).

- New BLM HV cables in straight sections to improve EMC.

Other activities

- Exchange of DC cables for magnet circuits powered from UJ33.
- Exchange of warm DC cables left of point 6 by FLOHE due to non-conformities of cables. This includes de-installation of cables, repair of cable ducts at FLOHE, and re-installation.
- Sector 56: water connection on the end of the cables to be redone on DFB side (done in all other sectors).
- The addition of a button electrode pick-up in front of Q1 in IR1 and IR5, EDMS 976179.
- Additional shielding: chicane at point 7, and shielding in the "fourreaux" at point 6, ECR being prepared.
- Possible exchange of the BSRT system (synchrotron light telescope).
- Cooling and ventilation, this is a system that is not described in LHC Reference Databases.
- Changes of filters for the water cooling system around the entire machine.
- Installation of additional flow meters in point 3, 6 and 7.

WHERE DO WE CAPTURE DATA?

The main source of information is the LHC Reference Database, including the Layout Database, the Equipment Catalogue and MTF.

Drawings are derived from the LHC Reference Database, both for the mechanical and the electrical layout.

Operational Databases such as LSA, Measurement and Logging DB, Post Mortem DB receive and are synchronized with data from the LHC Reference Database.

Other databases in use are the Cablothèque, Survey Database, Vacuum Database, Cryogenics Database, Controls Configuration Database, ELQA Database, and FIDEL.

The data in all DBs should be consistent. All relevant changes must be documented in an ECR, and the information should be transmitted to P.Le Roux, S.Chemli and M.Zerlauth to ensure correct updating of data.

The LHC Reference DB changed throughout the years. The LHC "As Build" database is different from the "Design Configuration" and will further evolve. There is a "Study" and a "Production" version of the DB to distinguish between the last approved version and the version in work. Some time ago it was planned to develop a specific "As Build" DB. This is not necessarily required, since changes are from now on captured in different versions of LHC Reference Database (version 2008, 2009, 2010, etc…). A large number of non-conformities from installation and commissioning of the LHC machine remain however to be integrated into the LHC Reference DB to generate the fully accurate picture of the "As Built" machine.

Information on electrical circuits must be correct. For the powering system, the changes will be implemented in…

- The layout database and the equipment catalogue.
- The electrical drawings (Ph.Orlandi)

Information on mechanical drawings should be up-to-date:

- Mechanical installation non-conformities (J.P.Corso)
- Layout drawings are generated from the DB by H.Prin and are obtained from CDD: LHCLSX__0%, LHCLSXG__0%.
- Detailed drawings are generated by S.Chemli and are obtained from CDD: LHCLJ___0%. About 90% of the LHC is described. To completed this work, further equipment models are required and some time for implementation.

ROLES

The shutdown activities are co-ordinated by the team of S.Baird and K.Foraz, following up all the works during the shutdown.

The Team working on the Reference Database and drawings documents all changes.

The point owners should be informed – one point owner per two sectors. They are working in collaboration with the Shutdown co-ordination team.

- Antonio Vergara sectors 78 and 81
- Boris Bellesia sectors 34 and 45
- Matteo Solfaroli sectors 12 and 23
- Mirko Pojer sectors 56 and 67

A table is suggested, listing the changes and their impact on commissioning (see below).

Impact of changes to commissioning and operation will be documented in a table (example for a few modifications)

	ELQA	Cryo	QPS IST	PC IST	PIC IST	Systems
Exchange of DC cables for magnet circuits powered from UJ33 for RQT circuits	Y	N	N	Y	N	Circuit names
Support posts for SSS with vacuum barrier	N	N	N	N	N	
Modifications of the Powering Interlock Controllers	N	N	N	N	Y	PICs concerned
Modification of the cryogenic link for 600A circuits powered from UJ33	Y	Y	Y	Y	Y	Circuits names

CONCLUSIONS

Appropriate tools to describe the LHC Layout and Parameters are operational.

ECRs or NCs are required for many changes and are used to update the information in the databases and drawings in a coherent manner. ECRs are required if a change has an impact:

- on the LHC optics, aperture and powering.
- on other equipment / teams.
- on cost and schedule.
- on commissioning and operation.

Although ECRs were developed for the LHC, it seems that the system is currently better used in the SPS than for LHC.

Other activities that could have an impact on commissioning and operation should be captured and recorded.

For minor changes, the point owner should be informed to collect the information.

Identifying all changes is a rather time consuming task. This needs to be improved, for the future (next shutdown?) another type of "light" document could be envisaged to document a change (such as disconnection and connection of a cable to a current lead, replacement of a power converter, etc…)

Before starting (re-)commissioning the powering system, summary documents describing the changes related to the powering system will be made available by the point owners.

There are some open issues:

- This shutdown is rather special, due to the large number of changes within a short time.
- For the future, some effort is required to develop a system for tracking changes.
- Following up all changes is a task for the "Technical Coordination".
- Approval of (all) changes – where and how? LMC (LHC Machine Committee)?

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