



How do we keep track of upgrades / changes?

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 different systems.
- The presentation will address in what areas changes are expected and how the changes are (or are not) documented.
- Proposals will be made how to record and track the changes in order to avoid to use data that does not correspond to the as-built status when restarting the machine ~~in Spring~~.

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Table of content

- Why keeping track of...
-what ?

- Catalogue of main changes
- Changes with repercussions to commissioning and operation
- Changes in the powering system

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- Suggestions and Conclusion



Tracking changes: very relevant for LHC

- LHC is an extremely complex accelerator
- Many activities are performed during this shutdown, as complex as building a new (small....) accelerator
- LHC is unique with a large amount of energy stored in magnets and beams
- Many critical systems
- Commissioning and operation relies on correct understanding of the installations and is very much data driven – depends on information stored in databases



What type 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 system after repair is as before
- Warming up cryostats to a temperature above ~100 K
- Disconnection of high current DC cables and reconnection
- Changing parameters (maximum current,)

Some activities require an ECR, some others not (e.g. disconnection and reconnection of a high current DC cable)

Change / maintenance / upgrade / activities to many systems

- sc magnets and bus bars, cryostats, cryogenics, vacuum system, DFBs, power converters, QPS, DC cables, nc 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,



Motivation for keeping track

Changes can have an impact on....

- **ELectrical Quality Assurance (ELQA)**
- Commissioning and operation of the cryogenics 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 sector was brought to above 100K
- Beam operation
- Impact on safety **!!!**



How to find out about changes

Some changes are documented in ECRs and non-conformity reports.....

Doc. page	LHC-BPMSW-EC-0002 v.1.0	THE ADDITION OF A BUTTON ELECTRODE PICK-UP IN FRONT OF Q1 IN IR1 AND IR5	Accepted
		LHC-BPMSW-EC-0002-10-00 doc (256 Kb) pdf (445 Kb)	
Doc. page	LHC-CI-EC-0004 v.1.0	Improvement of transmission dependability for the Power Permit of 60A DOC	Accepted
		LHC-CI-EC-0004-10-00 doc (140 Kb) pdf (86 Kb)	
Doc. page	LHC-DFBA-EC-0005 v.1.0	Change of Current Lead Assignments on DFBA and DFBA for circuits RQD and RQF	Accepted
		LHC-DFBA-EC-0005-10-00 doc (849 Kb) pdf (296 Kb)	
Doc. page	LHC-DFBL-FC-0001 v.1.0	Change of Current Lead Assignments on DFBLA, DFBLB, DFBLD and DFBLE	Accepted
		LHC-DFBL-EC-0001-10-00 doc (893 Kb) pdf (286 Kb)	
Doc. page	LHC-DWACF-EC-0001 v.1.0	Modification du câblage DC des circuits RQT4.R3 et RQT5.R3	Accepted
		LHC-DWACF-EC-0001-10-00 doc (1 Mb) pdf (66 Kb)	
Doc. page	LHC-LJ-EC-0019 v.1.0	Protection of equipment located in UJ76	Accepted
		LHC-LJ-EC-0019-10-00 doc (856 Kb) pdf (252 Kb)	
Doc. page	LHC-LJ-EC-0019 v.0.1	Protection of equipment located in UJ76	Approval Closed
		LHC-LJ-EC-0019-00-10 doc (848 Kb) pdf (248 Kb)	
Doc. page	LHC-MQXA-EC-0001 v.1.0	Change of protection and interlock scheme for the main quadrupole circuits of the LHC inner triplets	Accepted
		LHC-MQXA-EC-0001-10-00 doc (118 Kb) pdf (67 Kb)	
Doc. page	LHC-P-EC-0001 v.0.1	Point 1 (ATLAS) and Point 5 (CMS) Shelter Areas	Under Approval
		LHC-P-EC-0001-00-10 doc (2 Mb) pdf (346 Kb)	
Doc. page	LHC-QIT-EC-0001 v.1.0	Consolidation of the voltage withstand level for the measuring chain of the current leads thermometers	Accepted
		LHC-QIT-EC-0001-10-00 docx (71 Kb) pdf (91 Kb)	
Doc. page	LHC-RPMB-EC-0001 v.1.0	The RPMB type LHC power converters	Accepted
		LHC-RPMB-EC-0001-10-00 doc (145 Kb) pdf (127 Kb)	

ECRs status 26 January 2009 (not trivial to get the list and outcome not complete)

Information comes from

- shutdown coordination and planning
- other meetings (such as MARIC minutes, ...)
- discussions with many people (thanks to all of them)
-this Chamonix meeting



LHC Hardware Baseline: link to EDMS documents for shutdown

LHC Hardware Baseline

Reset
 Set as Top
 Search
 Re-login
RUDI

EDMS Shutdown 2009 changes

[EDMS Portal](#) | [Navigator](#) | [Search](#) | [Help](#) | [Caddie](#) | [Logout](#)

User: *RUDI*

Description:

Eq. Code:

EDMS Id: **LHCPM054 v.0**

Responsible:

Displayed

[Compact listing](#)

[Extended listing](#)

[Hide obsolete](#)

[Show obsolete](#)

Sorted by

[Default](#)

[Number](#)

[Creation Date](#)

[Status](#)

Documents in this node: 2 Advanced

LHC-LJ-EC-0019 v.1.0 Protection of equipment located in UJ76
Accepted

EDMS Id 977085

The level of radiation expected from the collimation system at point 7, and more precisely the flux of hadrons with energy in the multi MeV range, will induce Single Event Errors of the standard electronics present in many of the control equipment located in UJ76. Such event would perturb the LHC, possibly leading to dangerous situations for the machine elements. It is furthermore proposed to relocate part of the equipment installed in UJ76 into the TZ76 gallery, where the amount of radiation is reduced, and to install additional shielding to protect the equipment that cannot be moved. We foresee this process in steps, as the beam current and luminosity rises and as we get more information on the radiation level and sensitivity of the equipment: the TZ76 area will be prepared during the upcoming shut-down and the data collected in 2009 will be analysed by the RADWG to decide which equipment has to move. We however need to insure that the machine elements are always protected and hence propose to relocate without delay the Uninterruptible Power System.

[Doc. page](#)
LHC-LJ-EC-0019-10-00 doc (856 kb)
0 sub-doc 3 versions

[pdf](#) (252 kb)
[Sylvain Weisz](#)
2008-12-16

Engineering Change Request

LHC-RPMB-EC-0001 v.1.0 The RPMBB type LHC power converters
Accepted

EDMS Id 977059

The RPMBB type LHC power converters are not provided with a DC contactor between the power module and the crowbar system. Sixteen circuits in the machine arcs are powered by RPMBB converters without external energy extraction systems. If a quench occurs in one of these circuits and the converter fails with a short-circuit at the level of the output module the discharge time constant will not be determined by the crowbar resistance but by the low resistance of the DC cable, which could be too long for the part being quenched resulting in a damage of the superconductor. The DC contactor has to be implemented on the sixteen power converters before the end of the 2008-2009 LHC shutdown.

- ▣ LHC Hardware Baseline
- ▣ Layouts & Integration
- ▣ Shutdown 2009 changes
- ▣ Cryo Magnets in Common Arc Cryostats
- ▣ Long Straight Sections
- ▣ Cryogenics
- ▣ Vacuum System
- ▣ DC Powering and Quench Protection
- ▣ Radiofrequency System
- ▣ Transfer Lines, Injections and Beam Dumping
- ▣ Other Machine Systems
- ▣ Civil Engineering Works and Infrastructure
- ▣ General Services
- ▣ Installation
- ▣ LHC Specific Facilities

Link to list of ECRs for this shutdown 2009 (thanks to S.Chemli), to be populated



Impact of change for circuit with sc magnets

Powering system: all changes of elements 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 100K
- 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 (opening all interconnects of bus-bars running through the magnet) requires full re-commissioning of all circuits that are powered via one of the bus-bars running through)



What happens to LHC during the shutdown?

Try to identify all relevant changes

- The list of activities is certainly not complete!
- The objective is not to present a completed list, but to give a idea of the changes being done (many topics are discussed in other talks)
- Other presentation will detail many of the changes being done

This has been a rather time consuming task



Major activities requiring warm up

- Repair work in sector 34 (discussed yesterday)
 - impact on Reference DB, new types of assemblies, ...
- Exchange of main dipole magnets in sector 12 and 67
- Activities on stand-alone cryostats
 - for MQY and MQM cryostats the flexibles will be replaced to improve the control of the Helium level (not yet possible for all)
- Repair of bus bars in interconnecting 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 5L and 1R
- 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 (presented already)
 - Install electrical protections in front of current leads
 - Install mechanical protection for DFBA & DFBA links
 - Install additional pressure switches for the dry air system
 - Improve LHe level regulation for DFBA LCM
 - Improve the configuration of the safety valves discharge outlet
 - Add heaters on top plates of DFBA 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
 - type of jack changes, impact on databases
- Installation or modifications of collimators and their support systems
- Installation of Roman Pots for TOTEM around point 5
- De-installation and re-installation of the ALICE corrector magnet
- RF system: improvement of the tuning system (see E.Ciapala)



Power converters

- Exchange of three 60 A power converters with issues
 - Secteur 1-2 : RPLA.20L2.RCBV20.L2B1
 - Secteur 8-1 : RPLA.12R8.RCBV11.R8B1
 - Secteur 4-5: RPLA.30R4.RCBV30.R4B2
- Installation of DC contactors for eight RQS circuits and for eight RTQX1 power converter to improve the protection
 - Type name changes from 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 (limiting energy slightly below 7 TeV)



Beam dump, injection and transfer lines

- Beam dumping system
 - Extra 2H and 2V dilution kickers per dump line
 - New TCDQ energy interlocking (via SW)
- Injection systems and transfer lines
 - New BLMs on the MKI kickers to try to avoid flashover after beam loss at kickers
 - Exchange of MKI kicker magnet in point 2
- Transfer lines
 - Four new BPMs in TI8 to improve optics matching
 - Closing of tunnel planned for end March, to be ready by May with beam tests
 - modifications to transfer lines collimator for later, if tunnel closes end March. If tunnel closes 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)
 - presented elsewhere, major impact on content of reference DB
- QPS: Installation of reset option for 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)
 - protection from overheating
 - requires cabling, possible impact on other systems
- Modifications of the **P**owering **I**nterlock **C**ontrollers (PIC)
 - limited to changes in functionality (type tests required)
 - some cables disconnected
- Modifications of the **W**arm magnet **I**nterlock **C**ontrollers (WIC)
 - 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 6L (FLOHE due to non-conformities of cables)
 - de-installation of cables, change of Ducts at FLOHE, 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 written
- Possible exchange of the BSRT system (synchrotron light telescope)

Cooling and ventilation, not captured 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?

LHC Reference Database

- Layout Database, Equipment catalogue and MTF

Drawings derived from LHC Reference Database

- Layout mechanical drawings and Layout electrical drawings

Operational Databases that receive data from LHC Reference Database

- LSA, Measuring and Logging DB, Post Mortem DB

Other databases

- Cablothèque, Survey Database, Vacuum Database, Cryogenics Database, Controls configuration Database, ELQA Database, FIDEL

All those DBs should be consistent

- ECRs, information to P.Le Roux, S.Chemli and M.Zerlauth to ensure correct updating of data in database



Design versus As Build Database

LHC Reference database must be up-to-date

- The LHC **Reference DB** changed throughout the years
- The LHC **As Build** data is different from the “design configuration” and will further evolve
- There will be no specific **As Build DB**
- The changes are captured in different versions of LHC Reference Database (version 2008, 2009, 2010, ...)
- There is a “Study” and a “Production” version of the DB

Information on electrical circuits must be correct

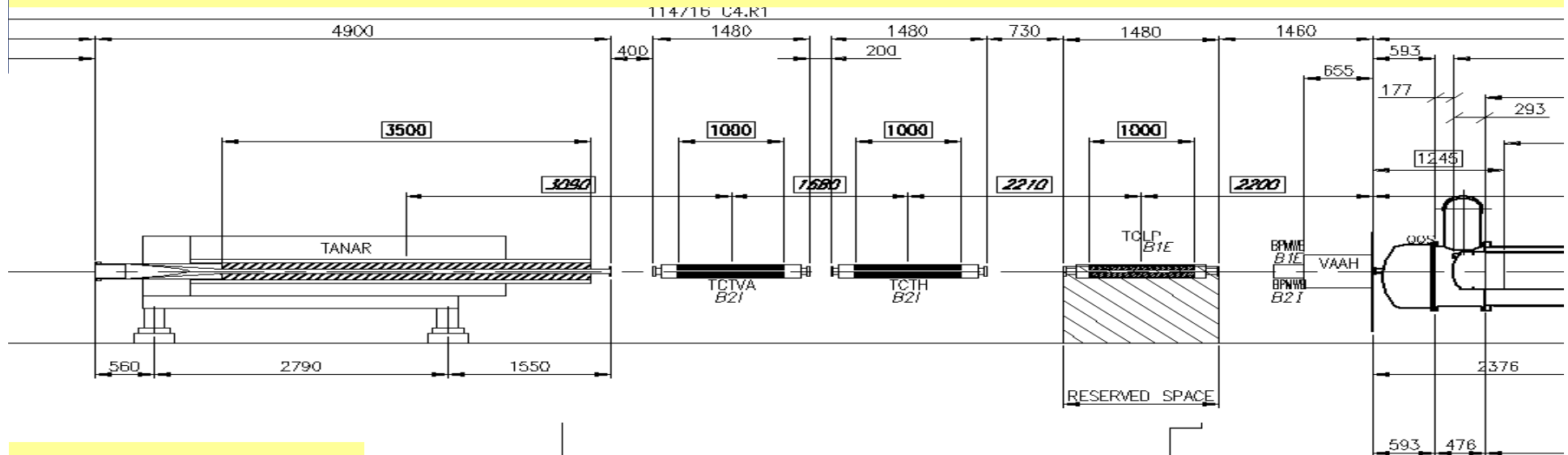
For the **powering system**, the changes will be implemented in...

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

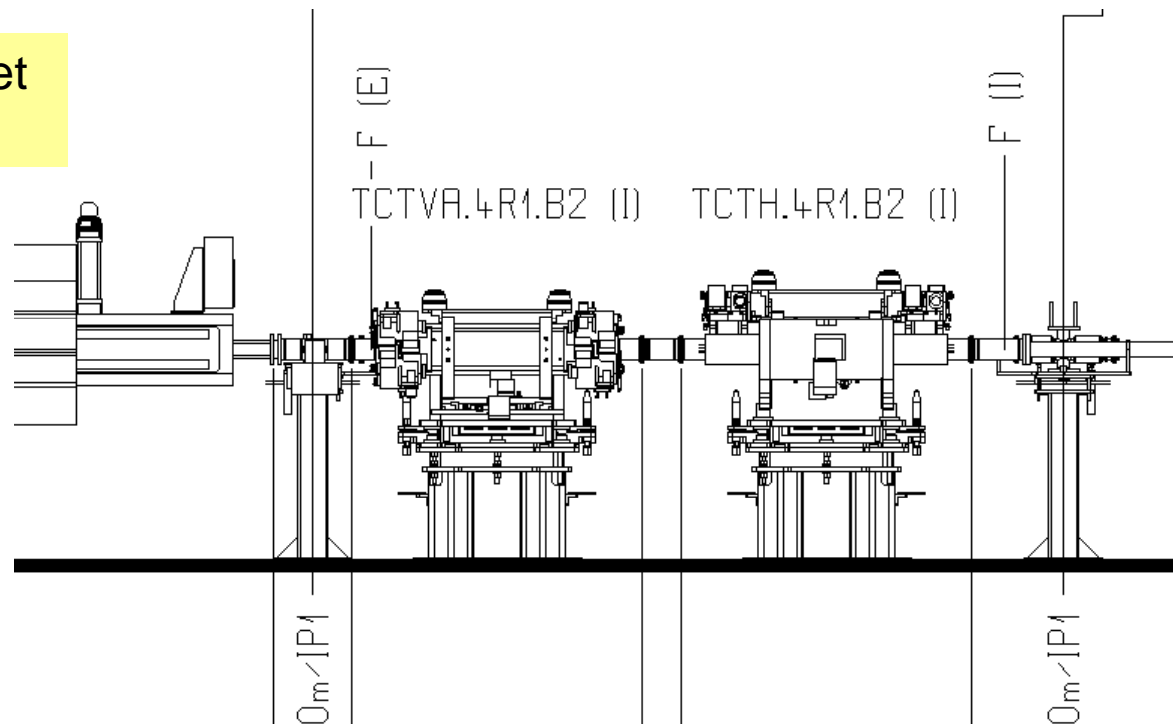
Information on mechanical drawings should be up-to-date

- mechanical installation non-conformities (J.P.Corso)

layout drawings generated from DB (H.Prin) in CDD: LHCLSX__0%, LHCLSXG__0%



TCT and magnet right of ATLAS



detailed drawings generated by S.Chemli in baseline (links) in CDD: LHCLJ__0% now to 90%, to be completed, equipment models required and time to implement



Roles

- Shutdown co-ordination by Simon Baird, Katy Foraz et al. following up all the works during the shutdown
- Database Team and colleagues working on drawings: many of the changes need to be documented in the databases
- Changes should be known to the point owners – one point owner per two sectors – working together 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



Impact of changes to commissioning and operation (example for a few modifications)

Commissioning activities

	ELQA	Cryo	QPS IST	PC IST	PIC IST	Systems
Modifications						
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 1/2

- We have appropriate tools to describe the LHC Layout and Parameters
- **ECRs or NCs are required** for many of the changes and are used to update the information in (different) databases, they are required in particular if there is an impact
 - on the LHC optics, aperture and powering
 - on other equipment / teams
 - on cost and schedule
 - on commissioning and operation.....seems that ECRs in the SPS are working better than for LHC
- All changes that have could have an impact on commissioning and operation should be captured and recorded
 - For minor changes, please inform the point owner that will collect the changes

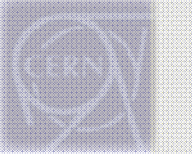


Conclusions 2/2

- 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,)
- Before starting (re-)commissioning the powering system, summary documents describing the changes will be made available by the point owners (suggestion for a WEB tool that lists all changes that are known)

Open issues

- This shutdown is a little difficult – many many many 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**)?



Commissioning procedures for electrical circuits

Depend on the history of a sector

sector kept cold below, say, below 100 K

- re-commissioning type: RESTART AFTER SHUTDOWN

sector warmed up, no interventions on the sc magnet system (sector 56)

- re-commissioning type: AS SECTOR 45

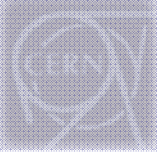
sector was warmed up, exchange of magnet (such a dipole in sector 12)

- re-commissioning type: AS NEW SECTOR

sector was damaged and repaired (risk of non-conformities) – sector 34

- re-commissioning type: SPECIAL PROCEDURES FOR QUALIFICATION

The procedures will be developed by MPP (all relevant groups are involved)
in close collaboration with HC



Comment on repair in sector 34

- Changes of SSS types in sector 34
 - interconnects
 - electrical circuits
 - cryogenics
 - ELQA
 - HC
- New LB layout LB(A,B)(L,R)(A,B,D)
 - beam screen orientation with respect to diodes: some new assemblies will be defined
 - New arc dipole variants require new names for such assemblies

