Critical spares

LHC Performance Workshop

Components of the machine for which

- there are little or no spares
- the provisioning would take longer than the warm up time of the collider & the removal of the failed component

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with contributions from A.Ballarino, Ch.Darve, G.Fernqvist, J.Íñigo-Golfín, K-H.Meß, V.Mertens, M.Modena, A.Perin, L.Rossi, L.Tavian

approach

1 Based on the ATC/ABOC days, Chamonix Workshops, LTC, MARIC, systematically review all

- the accelerator components
  - LHC Injectors
  - LHC
- the infrastructure systems
  - Cooling and ventilation
  - Electrical distribution
  - Access control
  - Safety systems

} Only Δ and !

2 With the knowledge of the LHC and the experience we have today, list the spares which are perceived as critical.

the critical spares

LHC superconducting magnets

- Arc magnets following the September 19th incident
- DS & LSS magnets dispersion suppressor and matching section quadrupoles, triplet quadrupoles, separation and recombination dipoles

DFBs arc, LSS including IT

Infrastructure systems new installations but a lot was inherited from LEP

- Cooling and ventilation
- Electricity distribution

The injector chain was reviewed regularly and actions taken to consolidate or mitigate the effects in case of failure.

arc magnets

dipoles

Two cold mass types

- Two types of spool piece corrector sets: sextupole only and sextupole and combined octupole decapole as well as the bus bar internal routing
- Diode polarity, which can be easily reversed

Assembly types depend on the cold mass + the mechanical interfaces at the extremities + the beam screens (B1 internal or external). This also is easily reconfigured.

All this gives 12 different types in the arc and 22 in the DS region, **but** the hard ones are only 2: the two types of cold masses.

Courtesy S.Chemli, M.Modena, L.Rossi

arc magnets

dipoles

After

1. the repair of sector 34
2. the replacement of the 100 & 47 nOhm in Sectors 12 & 67

type	cold mass	tested	Total
A	3		3
B	0		0

Not yet tested!

Courtesy M.Modena, L.Rossi

arc magnets

dipoles

Sector 34 30 dipoles were recovered of which a few are damaged beyond “immediate” repair

Sector 12 1 dipole (100 nOhm) was recovered, may be repaired

Sector 67 1 dipole (47 nOhm) will be recovered

non-conform spares

type	
A	1
B	3

measured on the test bench by Marta

Courtesy M.Modena, L.Rossi

arc magnets

quadrupoles

40 cold mass types

- Made by combining different types of corrector families, BPM types and quadrupole powering

61 assembly types

- Again, the cold mass is the hard part. The envelope can be adapted to the position/function in the tunnel.

Spares after the repair of sector 34:

- 6 cold masses, which have not yet been tested. One has a suspected leak which is being investigated.
- 2 SSS have been tested and qualified

Sector 34 6 SSS were recovered of which a few are damaged beyond "immediate" repair

Courtesy S.Chemli, M.Modena, L.Rossi

DS & MS quadrupoles

Dispersion Suppressor including Q7

* 29 types of cold masses,
* made by combining 7 different types of magnets plus the corrector families,
* 78 sets installed
* One Q9 type and one Q11 type spare available

Matching Section

* 19 types,
* made by combining 7 different types of magnets plus the corrector families,
* 36 sets installed

No complete spares available due to the big number of different combinations. At least two months for building a new assembly, and another month for test, installation, ELQA, cool down, ELQA in-situ.

Courtesy S.Chemli, KH Meß – Chamonix 2005

triplet magnets & separation dipoles

Cold Separation Dipoles

- 4 types,
- 20 installed (4 spares)

Inner Triplet Magnets

- 3 types,
- made using 12 different magnets,
- 8 sets of three magnets installed (1 spare of each type)

Replacement with the existing one spare would require the warming-up of the sector and the repair of the magnet will take six months at least

Courtesy KH Meß – Chamonix 2005

DFBs

arc LSS

Four main types of DFBs: DFBA, DFBM, DFBL, DFBX

- For the first three:
  - 31 different types
  - 56 installed
- For the DFBXs: **no spares**
  - 6 different types
  - 8 installed

No spare DFBs nor modules but spare chimneys (10%) and current leads

type			number
13	kA	hts	8
6	kA	hts	25
600	A	hts	6 x 4
60 -120	A	conduction cooled	0

The production of additional hts leads require one year, but the know how exists in house

Courtesy A.Ballarino, Ch.Darve, A.Perin

electrical distribution

24 V_{dc} power supplies

Rack design induced too high temperatures; is being fixed during this shutdown

SPS 18 kV cables

Water treeing in old XLPE cables; a long term replacement program has started. In the meantime, when a fault occurs it takes one to two weeks to repair BUT it does not interfere with machine operation : loop or spare dipole rectifiers

cast-resin transformers

A recent spare restoration program resolved this issue

Courtesy G.Fernqvist

electrical distribution

UPS

- Spares purchased and delivered; the fast intervention maintenance contract is in place

water cooled DC cables in the tunnel

- The hoses are not halogen free as specified and show signs of premature ageing. A negotiation with the company which supplied the hoses around the conductor is ongoing but a clear consolidation program is far from being ready

Courtesy G.Fernqvist

cooling & ventilation

Production of chilled water,
Cooling and circulation of demineralized water,
Circulation and drying of air in the underground works
Production of compressed air

Rely on

- Industrial machinery
- Process control equipment
- Electrical distribution cubicles

some of it dates back from the LEP days

We have a flying spare 2-3 days

missing spares:

- Demineralized water pump hot spares for the UWs
- York compressors
- Compressed air dryers
- PLC components
- Electrical drawers
- Control valves

5 MCHF

300 kCHF

Courtesy J.Inigo-Golfin

cryogenic system

Spare turbines for the cryoplants

∗ 64 turbines installed on 4 different types of cryoplants
∗ 36 turbines identified as critical (important loss of refrigeration capacity)
∗ 18 turbine spares identified to cover the critical needs. One already available.

Call for tender issued with an adjudication at the Nov'08 Finance Committee but the budget remains to be found within the LHC operation budget. Is it a priority for 2009?

Impact on accelerator operation: few weeks to a month at worst or operation at reduced capacity when possible

Courtesy L.Tavian

what did I forget?

* RF system
* Injection and dump systems

Injection kickers MKI

Wave of debris through beam pipe of LSS2L or LSS8R could render the full set of 4 MKI in one injection inoperable at once.

Scenario at design time not considered likely enough to justify a complete set of spares. Presently 1 spare magnet for 8 installed. Spare situation was reviewed in LTC in Sept 2007. Proposed to start building a 2nd spare, largely from remaining spare pieces. This will get ready for beam in QIII/2009.

Refurbishing 4 magnets (disassembly, cleaning, re-assembly, oven bake-out, HV conditioning/pulse testing, installation, interconnect bake-out, 2nd HV test) would take about 20 – 24 weeks (provided no problem occurs; a simple air leak would already mean 4 – 6 weeks downtime). A single production line (large oven, test stand).

Likelihood that repair time is in shadow of "root damage" repair ?
Additional fast valves might help in certain (but not all) cases.
Complete one full suite MKI spares (i.e. build 2 more) ?

Long lead time (> 1 yr) for special components. Cost ~ 1 MCHF.

Courtesy V.Mertens

conclusion

there is an acute critical spare issue for some **LHC components**

a less critical spare but a consolidation issue for some **infrastructure systems**

1. we need the detailed inventory of
   a) the existing spares and spare components of the LHC elements
   b) the existing spare components of the LHC infrastructure systems
   c) their present weakness
2. we have to assess the quantity of missing spares and the required consolidation
3. we must define the repair strategies

we must secure the budget and start a program to restore the spare inventory and to consolidate the vulnerable infrastructure systems