Instrumentation Status of the Low-beta Magnet Systems at the LHC

Christine Darve, Christoph Balle, Juan Casas-Cubillos, Antonio Perin, Nicolas Vauthier

July 22nd, 2010

Headlines:

System Description Instrumentation Identification Reliability Availability Traceability

The Low-beta Magnet Systems at the LHC



Type of instrumentation



Type of instrumentation







*HTS leads *VCL leads *Inner triplet feedthrough



CV8xx: control valve





Christine Darve

ICEC23- July 22nd, 2010

Reliability – Instrumentation (quality + quantity)

Example for the Temperature sensors :

→ Goal: precision must remain better than 0.25% (5 mK at 2 K)

By principle, use redundant system

Test benches:

- □ Thermo cycle
- Irradiation test : fluence values close to 10¹⁵ neutrons/cm², corresponding to 2.10⁴ Gy

Thermometer (+number tested)	R @ 1.8K	dR/dT @ 1.8K	σ _т @ 1.8K	beam heating mK/(n.cm ⁻² .s ⁻¹)	ΔT Irradiation for 4 10 ¹⁴ n.cm ⁻²	Expected ΔT in LHC
AB (44)	6600 Ω	-10600 Ω.K ⁻¹	8.10-5	9 10 ⁻¹⁰	+2 mK	< 2 mK
TVO (44)	5700 Ω	-3300 Ω.K ⁻¹	3.3 10-5	3 10 ⁻¹⁰	+0.3 mK	< 0.5 mK
CX (66)	12600Ω	-12000 Ω.K ⁻¹	2.5 10-5	10-10	+1 mK	< 2 mK
Ge (5)	9000 Ω	-8000 Ω.K ⁻¹	1.2 104	0	+300 mK	+300 mK
RhFe thin-film (46)	15 Ω	$+0.7 \Omega.K^{-1}$	3.10 ⁻⁵	0	+12 mK	+3 mK/year
RhFe wire (36)	5.4 Ω	$+0.6 \Omega.K^{-1}$	$2.6 10^{-5}$	0	+5 mK	+1.5 mK/year
Pt (22)	$1.7 \ \Omega$	$+3.5 \ 10^4 \ \Omega.K^{-1}$	-	-	+1.5 K	-

Table 1 Results of irradiation at 1.8 K (average values)

References:

Amand,, et. al., Neutron irradiation tests in superfluid helium of LHC cryogenic thermometers, International Cryogenic Engineering Conference - 17, Bournemouth, UK (1998), 727-730

Amand,, et. al., Neutron Irradiation Tests of PressureTransducers in Liquid Helium, Advances In Cryogenic Engineering (2000), 45B, 1865-1872

Reliability – Performance measurement



Christine Darve

ICEC23- July 22nd, 2010

Availability: Data flow & LHC Logging Cryogenics Data



ICEC23- July 22nd, 2010

Availability : Process Control Object



Availability : Option modes / steppers



Christine Darve

Availability - Radiological risk mitigation - 21-OR-2-05

LHC operation annual radiation dose for the arc magnet and for the CMS/ATLAS low-k regions are 1 and 1000 Gy, respectively

- \rightarrow No easy repair when inherent radiation !
- → The chosen instrumentation and equipment are radHard and halogen free
- → Use of redundancy
- → Specific hazard analysis is requested before personnel intervention

→ Radiological survey is systematical performed prior intervention (< 1mSv/hr)</p>

→ Limit the personnel exposition time (individual and collective radiation doses)

→ Radio-Protection Procedures to be written based on lessons learned and other institutes experiences



Christine Darve

Traceability - MTF



Conclusion

- The low-β system is among the most critical for the operation and performance of the LHC. For the planned upgrades, maintenance and removal will yield an inherent radiological risk
- During the LHC hardware commissioning, the original equipment and instrumentation were tested → leading to the need of further implementation
- Every intervention must be carefully planned with RP
- Continuous improvement of reliability, availability, traceability is on-going.

Acknowledgement: the TE/CRG personnel, the hardware commissioning team for their technical support, the integration group (ILC) and the safety group (TGS).