ELectrical Quality Assurance (ELQA) scope of work for SC links

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ELQA related presentations:

- ELQA scope of work and electrical design criteria *(Tuesday PM - WP3/WP7)*
- ELQA tests for the HL-LHC IT String *(Thursday AM - IT String - WP16/WP1/WP3/WP6A/WP7/WP9)*
- ELQA scope of work for SC links *(Thursday PM - WP6A/WP7)*

Outline

- Introduction
- SC link qualification challenges
- Test voltage levels
- First tests
- Summary

ELQA tests on SC links

- The main ELQA procedure for IT string **EDMS 2746933** foresees a dedicated qualification set named Superconducting Link Check (SLC) with the following tests to be executed:
  - HVQ – High Voltage Qualification
  - TFM – Transfer Function Measurement
  - IRC – Instrumentation Resistance Check
  - ICC – Instrumentation Configuration Check
  - TDR – Time Domain Reflectometry
  - COC – Continuity of Conductor check
  - TSQ – Temperature Sensor Qualification

SC link qualification challenges

- Large number of V-taps
- Connection of some V-taps is done in the tunnel
  - ELQA checks need to accompany the installation
- Significant length of V-taps and main busbars
- Distance between the two ends of the link, including the height difference
  - Dedicated cable will be permanently installed between UL and UR to allow efficient testing
  - Sensitive equipment that might be connected to the SC link conductors (for example magnets!)
  - Safety during tests needs to be taken with care

SC link qualification challenges – HV test

- Insulation test voltage
  - Nominal Operating Conditions (NOC) for SC links is 20 K gaseous helium
  - During operation the highest possible voltage to ground or to other conductors is estimated to be at the level of 900 V
  - The test level at NOC in the tunnel depends on connected magnets: 300 V - 940 V
  - Given the fact that air at warm has a higher dielectric strength than gHe at 20 K, the test in air at warm should be performed at a higher voltage
  - The magnets on the other hand are sensitive (risk of helium pockets) and require the test voltage to be significantly lower at warm than at NOC
    - After the connection of magnets, the SC link cannot be fully qualified at warm
  - The most meaningful test to be executed is during the cold tests on F2 bench in SM18
  - These tests will be accompanied by tests at warm
  - The test levels for ELQA were proposed and need to be approved

Definition of HV test levels for ELQA

Location	Description	Configuration	Conditions	SC link (incl. cold instrumentation)	MQXF magnets
Tunnel	**Max voltage expected during operation**	Complete circuits	**NOC**	**~900 V**	**670 V**
	ELQA at cold		NOC	**804 V**	
	ELQA at warm		Warm (air, possible gHe traces)	**368 V**	
	After installation, before connecting the magnets	Cold powering system not connected to magnets	Warm (air, possible gHe traces)	2300 V	**368 V**
Test station	Before transport to the final location		Warm (gHe)	2300 V	**368 V**
	Cold tests		NOC	2300 V	**1840 V**
	Before cooling down, after flushing		Warm (gHe)	3000 V	**368 V**
	Warm tests after manufacturing		Warm (air)	3000 V	**368 V**
	Tests after cryostating	cryostat + DSCA1 cable, not connected to magnets	Warm (air)	**5000 V**	**3680 V**
CERN	Reception tests	DSCA1 (MgB_2 cable)	Warm (air)	**10 000 V**	**-**
Supplier	Acceptance tests		Warm (air)	**10 000 V - 15 000 V**	**-**

- **Magnet test levels are approved (EDC)**
- Proposed SC link components test levels

ELQA HVQ of the SC link conductors

- First reference HVQ of DSHM and DSHX cables performed at 3 kV
- 183 conductors tested
- Test reports:

  HCDSCA2003-I4SE6_11:
  https://edms.cern.ch/document/2747266
  HCDSCA1002-I4SE2_11:
  https://edms.cern.ch/document/2747263

- Reference for future ELQA tests
  - Leakage current
  - Capacitance
  - Charging current

- No issues were identified

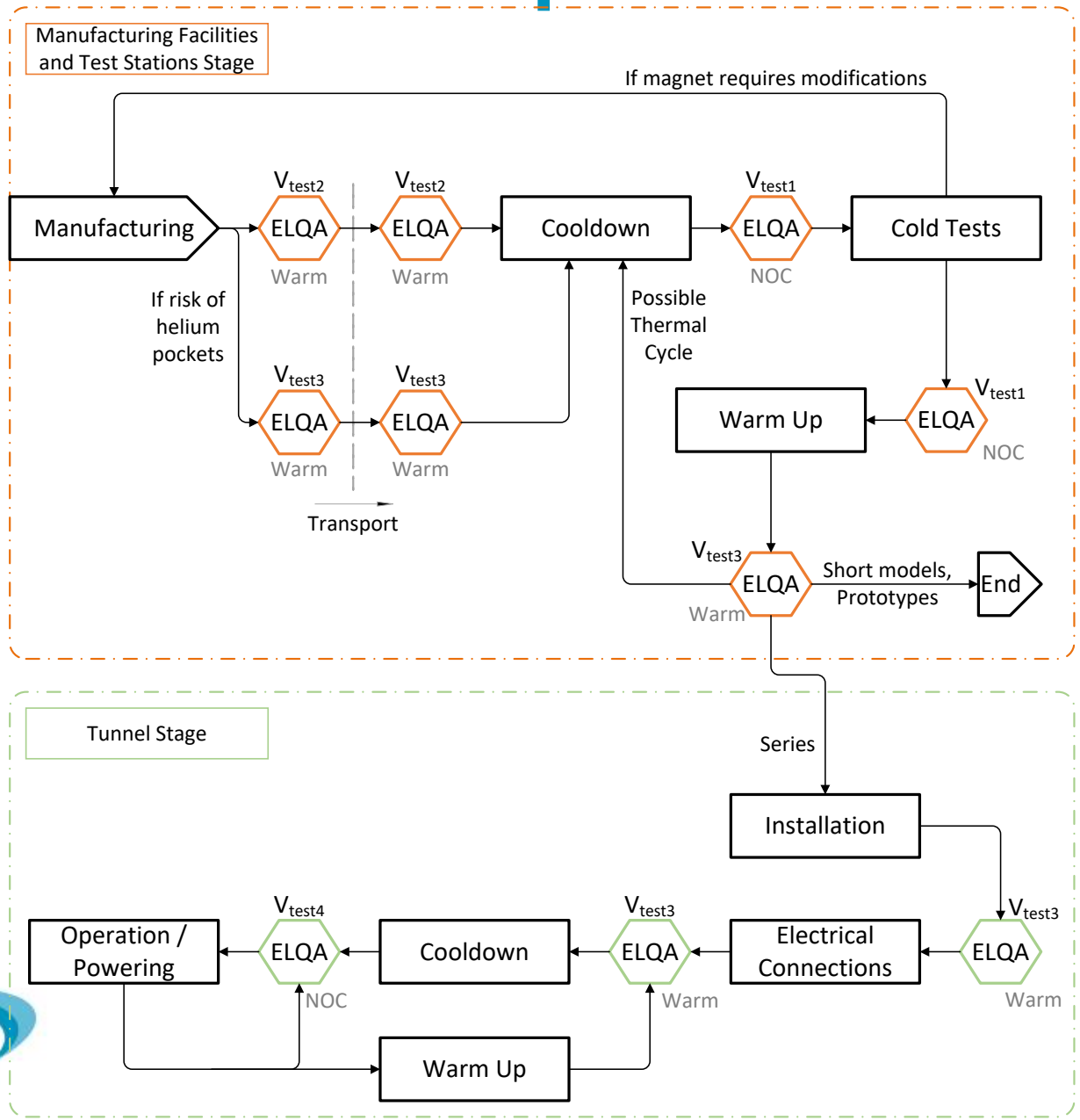
Summary

- ELQA will systematically test all final SC link assemblies
- First samples of SC link cables were tested
  - All tests passed
- Qualification of SC links represents a real challenge and needs to be well planned
- The main frame of the program of ELQA tests is prepared, this includes a full qualification set, not only HV insulation tests
- HV test levels for ELQA tests were proposed and need to be approved


Thank you for
your attention!

Annex slides

Components' lifecycle



Following the Electrical Design Criteria documents the ELQA tests at an adapted level of voltage need to be performed at multiple stages of a component lifecycle

NOC – Nominal Operating Conditions