TAMPERE UNIVERSITY OF TECHNOLOGY

Status and update from TUT: Quench protection

What is done, what is ongoing, and the plans for the future

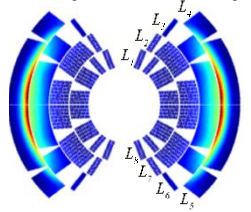
Tiina Salmi, Antti Stenvall

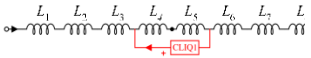
US-EuroCirCol/European meeting 3.12.2018

TUT QP work in EuroCirCol

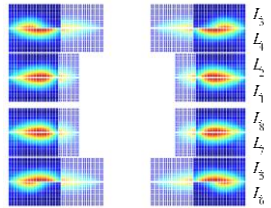
- **Main dipole quench protection (QP)** (Cosθ, Block, Common-coil)
  - Support magnet designs from QP point of view
  - Protection schemes with CLIQ (baseline) and heaters (back-up)
    - Collaboration with CERN (esp. Marco Prioli, now with INFN)
- **Main quadrupole protection**
  - Protection scheme with CLIQ

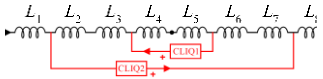
Cosθ by INFN, Italy



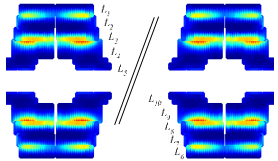


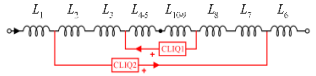
Block by CEA, France





Common-coil by CIEMAT, Spain

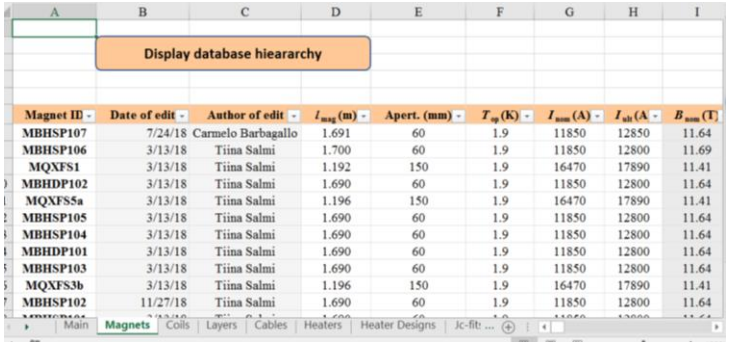




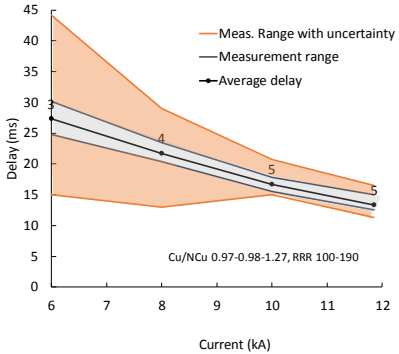
CLIQ connection schemes, simulations using LEDET and Co-sim

Ongoing

- **Quench Protection Database (QPDB) project with CERN 2017-2018** (contact person Susana Izquierdo-Bermudez)
- Goals:
  - Development of DB for storage of experimental results
  - Analysis of heater delays and current decays and comparison with simulations
- Status: DB developed together with Timo Tarhasaari (was with TUT), and filled with results from several MQXFS and 11 T models
- Ongoing: Analysis of heater delays: Summaries, general trends, uncertainties



Relational DB built with MS EXCEL, allowing storage of magnet parameters, test set-ups, and test results such as heater delays and current decays. Internal computation of coil Jc, MIITs, and several other parameters.



Example of heater delays in 11 T MBHSP105 and MBHSP106 with experimental uncertainty ranges.

Plans for future

- January 2019: Quench protection sections for each magnet for FCC CDR
- Tiina: applied 5-year national fellow funding for continuing quench studies of future high field magnets. Willing to collaborate regarding the FCC demo magnets! (Result of the application in May, Let’s discuss more)
- Antti: preparing proposal for cloud based database of materials used in superconductor applications (national and EU-level)

TAMPERE UNIVERSITY OF TECHNOLOGY

Manufacturing cost modeling approach for 16T dipole arc magnets

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Cost Modeling and Production monitoring Methodology

1. Research is being conducted at Tampere University of Technology to define **performance indicators** for Nb3Sn magnet manufacturing and select **key performance indicators** (KPIs) for manufacturing cost and quality

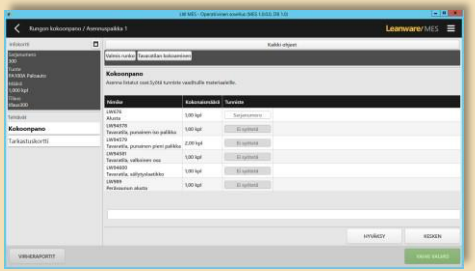
2. Machine learning based techniques are under investigation for selection of KPIs

3. In the following months,

    1. Monitoring of 11T Nb3Sn dipole magnet production is planned at Large Magnet Facility in CERN
    2. Production monitoring software known as **Manufacturing Execution System** (MES) will be used for this purpose
    3. MES will provide high degree of visibility of the manufacturing in terms of **tracking and tracing of magnet parts**, **production scheduling**, **tracking major tooling and quality management**

4. Tampere University of Technology is working with their industrial partners to prepare a prototype for production monitoring software for 11T Nb3Sn dipole magnet production (more dialogue between all parties are needed)

MES concept for 11T production



LeanwareMES

Production Monitoring and Quality

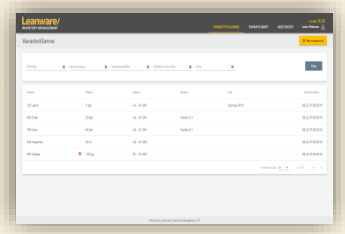
- ✓ Production Order Creation
  - ✓ Simple routings, sub orders for components
- ✓ Job Lists
- ✓ Work Phase Execution
  - ✓ Progress reporting, actual hours
- ✓ Traceability
  - ✓ Time stamps, batch/serial numbers
- ✓ Quality In-Process Control
- ✓ Work Instructions

Manufacturing Parameters / Measurement Data

Material Usage

SOLUTION OPTIONS

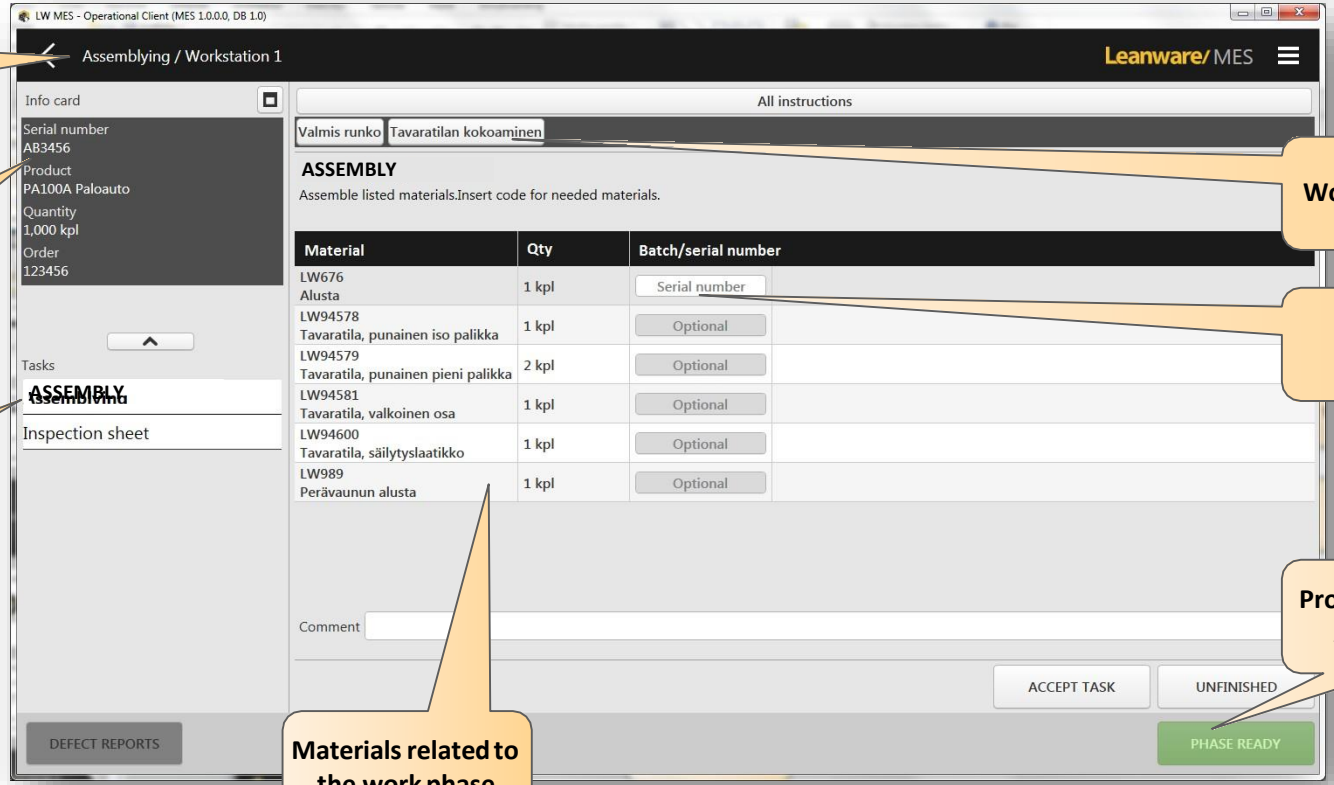
CERN Production/Measurement Equipment



LeanwareINVENTORY

- ✓ Materials' Stock Balances

EXAMPLE 1: WORK PHASE EXECUTIO



Work phase

Product and order information

Sub tasks

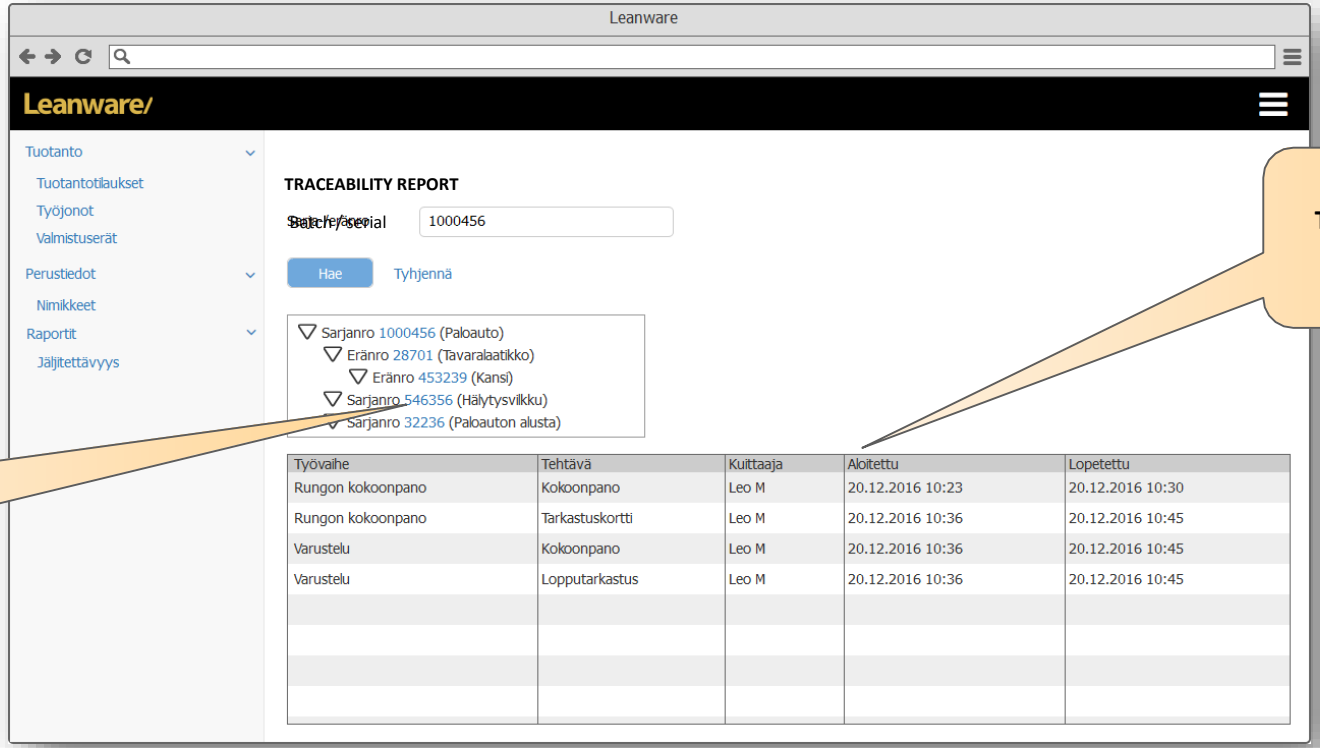
Work instructions

Batch/serial numbers

Progress reporting
Actual hours

Materials related to the work phase

EXAMPLE 2: TRACEABILITY REPORT



Time stamps for execution

Link to batch/serial no. data in trace batch hierarchy (e.g. 546356)