Research Neutron Source
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Refurbishment of the Crane in the Reactor Hall at FRM II: Challenges and Lessons Learned

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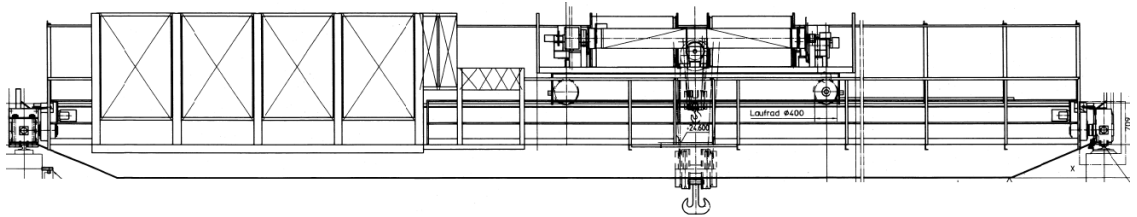
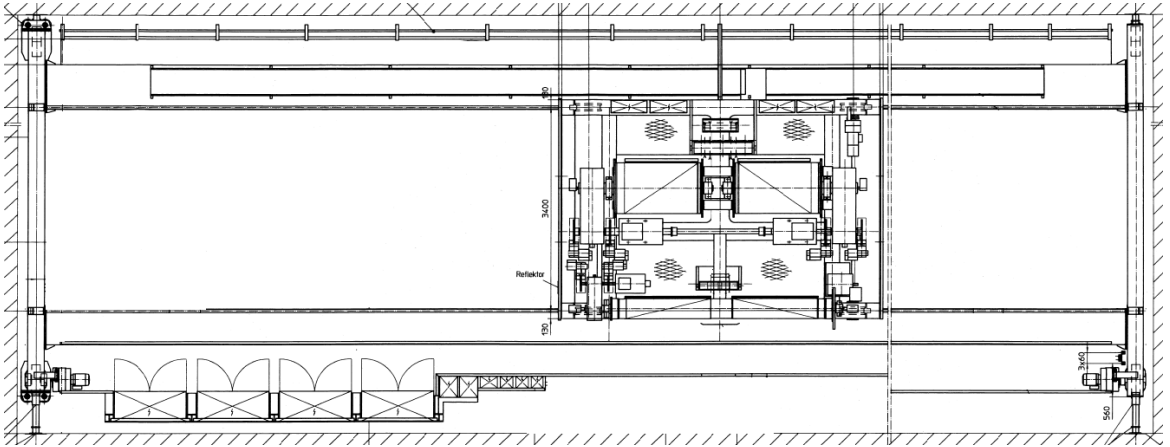
Introduction and Overview

- Research Neutron Source FRM II at Technical University of Munich in operation since 2004
- Most of the systems installed in late 1990s
- Crane in the reactor hall is one of the most vital systems

Introduction and Overview

- Double girder overhead crane with two hoists (3.2 t and 20 t)
- Used for transports within and into reactor hall and reactor pool
- Most important applications:
  - Main hoist 20 t: handling of storage containers for high-level nuclear waste
  - Auxiliary hoist 3.2 t: handling of fuel elements





Introduction and Overview

- Crane is in operation for more than 25 years:
  - Obsolete control system
  - Maintenance effort is increasing
  - More and more defective components → identical spare parts not available since most components have been discontinued and inventory stocks have been depleted → components need to be replaced with similar or successor components → extensive documentation, testing, and verification work

- Changes to the German nuclear safety standards (KTA) require extensive modifications to the crane's control system

➔ Estimation that replacement of whole electrical and control system is more time and cost effective than continuous repairs and application of necessary modifications

Project Schedule

- Internal planning started in 2017
- Official start mid-2019 following a Europe-wide tender
- First version of planning documents finished in August 2020 and transmitted to TSO
- Two revisions necessary before receiving approval by TSO in March 2022
- Factory acceptance test and EMC testing in January and February 2023
- On-site work completed in April 2023
- Acceptance and functional testing completed in May 2023

Overview of New Control System

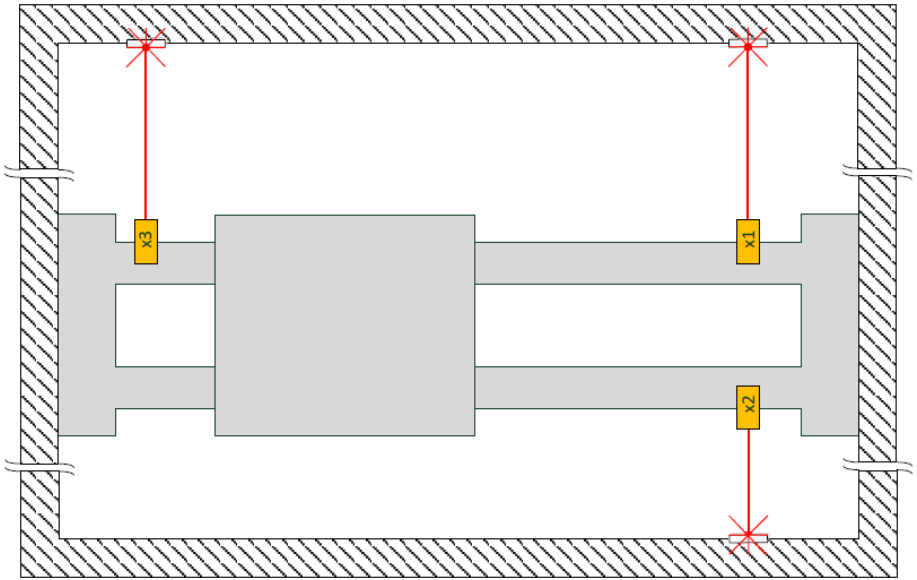
- Core components: two independent PLCs, an operational PLC and a safety-related PLC

- Operational PLC: responsible for all standard control functions of the crane

- Safety PLC:
  - Monitoring the operational PLC and all other components and parameters
  - Ensure transition to a safe state in case of inadmissible operating conditions, excess of limitations, malfunction, or failure → sensors and transmissions have to fulfill highest requirements (usually Performance Level d or e according to ISO 13849-1) and high levels of redundancy and diversity

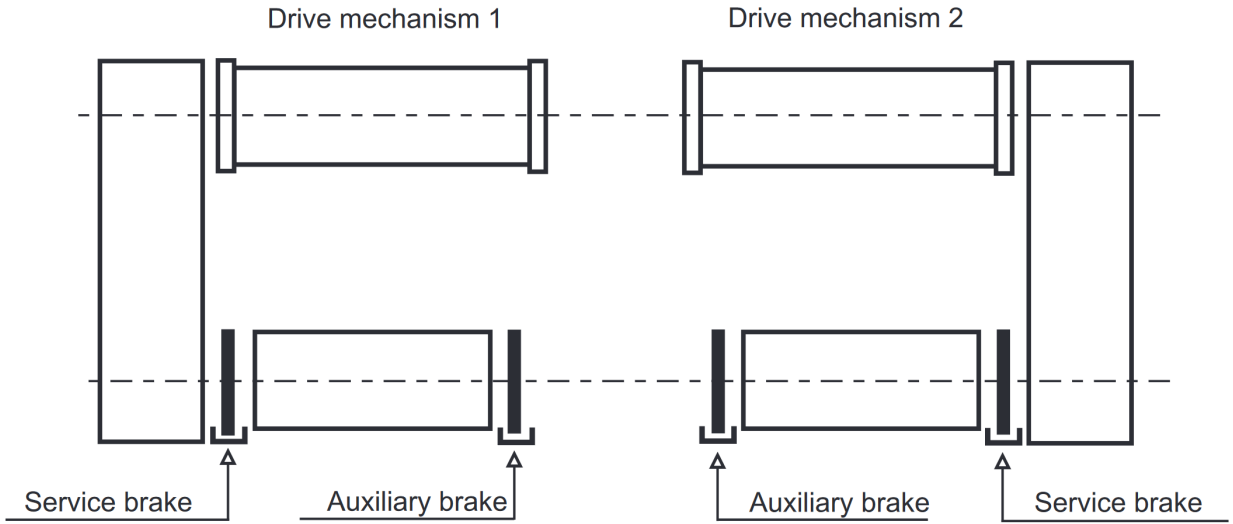
Example for High Level of Redundancy and Diversity

- Position measurement must be precise and failsafe, since the crane is used to transport fuel elements
- Redundancy: parallel and opposite laser sensors
- Diversity: additional encoders on motor shafts are used to determine position
- Deviation between determined position by two lasers or by a laser and an encoder result in immediate safety shutdown



Hoist Brake System and Encountered Issues

- 4 brakes on 20 t hoist:
  2 service brakes, 2 auxiliary brakes
- During regular operation, braking is performed by frequency converters and brakes engage only when the crane is almost at a standstill
- Static and dynamic brake test had to be performed during acceptance test



Static Brake Test

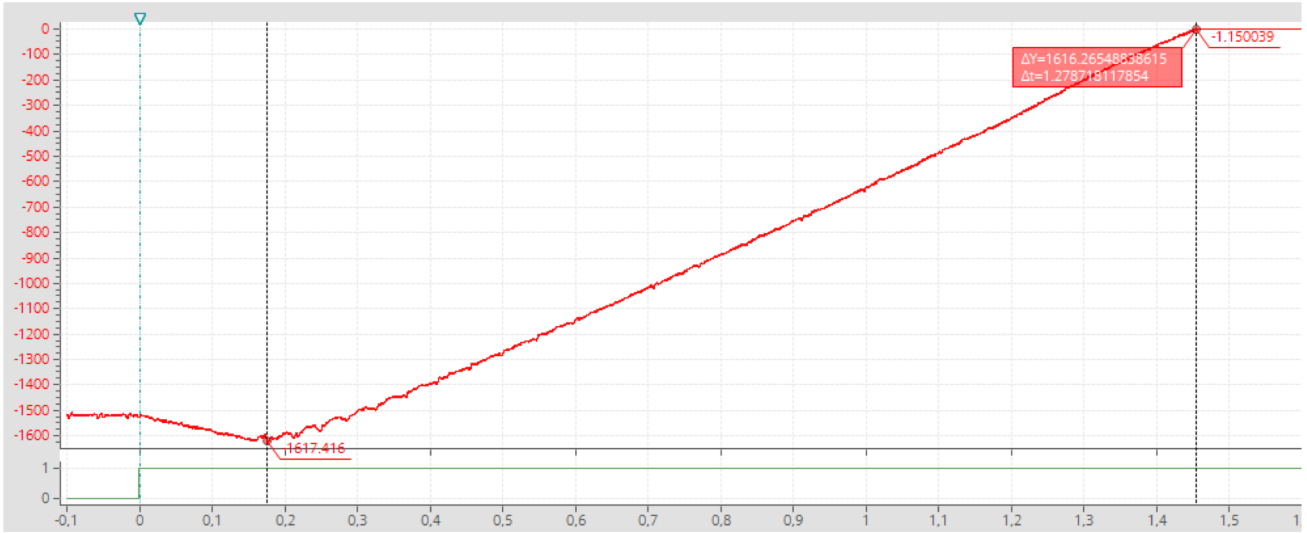
- Static holding force of each individual brake had to be tested
- Test load of 20 t is lifted, and then all brakes except the one being tested are released
- Test conducted for each brake individually
- Each brake was able to hold the load without any noticeable drop → all brakes passed the test

Dynamic Brake Test

- Load of 20 t is lowered at maximum speed
- Test command issued: frequency converters are abruptly switched off (→ cannot contribute to braking effect) and brakes are activated
- Test done for all brakes together, every possible combination of two brakes, and each brake individually

Dynamic Brake Test

- t < 0 s: moves at maximum, constant speed (≈ 1500 rpm)
- t = 0 s: test command issued → frequency converter shuts down almost immediately, brakes require a certain time (≈ 0.2 s) to engage → acceleration
- t > 0.2 s: braking effect
- Standstill ≈ 1.3 s after brakes engaged



Dynamic Brake Test

- Results were compared with specifications from initial installation
- Not all such data were available, documentation was incomplete, only values for individual brakes but not for combinations
- One brake was found to be not properly function and need to be repaired
- Braking times did not always meet specifications: partially too short (→ increased mechanical stress), partially too long (→ greater coasting distance)
- Calculation of missing values and repairing defective brake currently ongoing

Summary

- Refurbishment of the crane went as smooth as reasonably possible
- Remarkable results from brake test
- Similar renovation will be carried out for three additional cranes at FRM II in the near future
  → experiences and insights gained will contribute to an even better and faster outcome

Thank you for your attention!