

THE DO'S AND DON'T'S IN PROCESS CONTROLS

LESSONS LEARNED OVER 35 YEARS

M. Clausen, T. Boeckmann, J. Hatje, O. Korth, M. Moeller, J. Penning, H. Rickens, B. Schoeneburg
Deutsches Elektronen Synchrotron DESY
Hsinchu, Taiwan, 17. October 2018

THE DO'S AND DON'T'S IN PROCESS CONTROLS

Lessons learned over 35 years

M. Clausen, T. Boeckmann, J. Hatje, O. Korth, M. Moeller, J. Penning, H. Rickens, B. Schoeneburg
Deutsches Elektronen Synchrotron DESY
Hsinchu, Taiwan, 17. October 2018

Summarizing 35 Years

... is not possible

01 Process Controls for Cryogenics

- How we started
- Some History

02 To use or not to use PLCs

- PLCs for machine interlocks
- PLCs as data concentrator
- Communication with the process controller
- Where does the intelligence reside?
- Reliability/ Flexibility
- Control software on the PLC/ IOC
- Process engineer/ controls engineer
- The DESY approach

03 Testing controls applications

- The test environment: Simulation of signals
- Save/ restore
- Graphical user interface
- Full integration test end to end
- Logging in state notation programs

04 Project Organization

- Just in time
- One step ahead
- Commissioning hardware
- Quality of cable works
- Sliding project plans
- Working with industry

05 Conclusions

Process Controls for Cryogenics

The Beginning

Process Controls 'Hand made'

Analog Controllers

- Control loops implemented in analog controllers.

Machine Protection

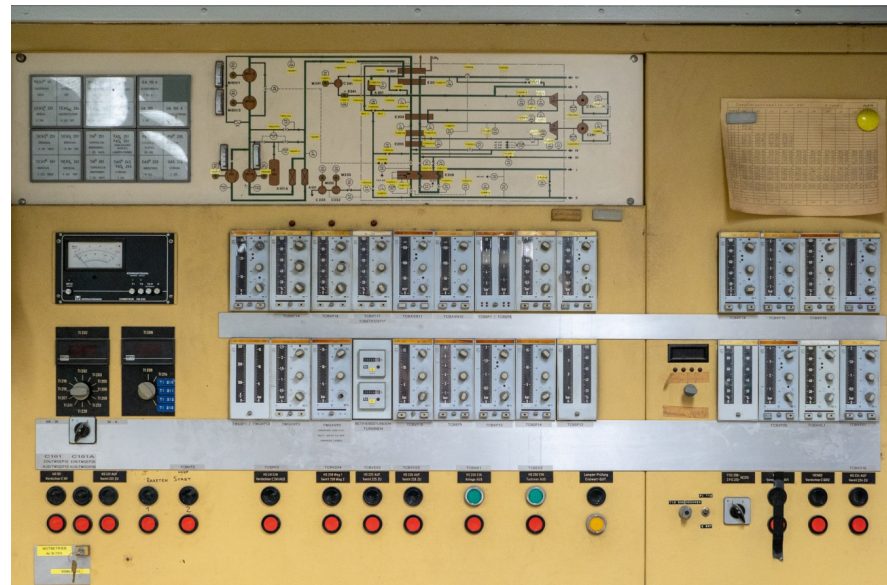
- A hardware interlock to protect the sensitive cryogenic turbines was implemented in a PLC

24/7 Operations

- An archiving system based on a PC was implemented later for post mortem analysis

Computer Based Process Controls followed later

- After gaining experience with two cryogenic plants this way DESY installed the first Distributed Control System (DCS) using PDP computers and Intel microcomputers for HERA in 1987.



‘To use or not to use’

PLCs in Process Controls

PLCs

Serving different basic purposes

Machine Protection

- Hardware interlocks implemented in PLCs
- Programmed once – running for ever.
- Well tested and documented

Data Concentrator/ Collector

- Controller communicates with local I/O modules
- No programming on the controller side
- Data exchange with front-end controller via field-bus

Running Controls Logic

- This option is used in many places
- See next slides

Comparison: Controls Logic in PLC vs. Process Controller

(Process Controller running EPICS)

PLC Implementation

- Many engineers are familiar with the PLC configuration tools
- Access from the console level to each and every property of the process blocks in PLCs must be configured in the communication protocol PLC <-> (EPICS) IOC
- Integrating signals from other systems requires configuration on both sides
- Changing block structures and/ or signal flow requires deep PLC programming skills and can only be implemented from the programming interface

Process Controller (Compact PCI CPU)

- DESY created a configuration tool similar to those for PLCs
- Transparent access from the console level to each field in the EPICS records is possible by default. No additional configuration is necessary.
- Integration of remote signals can be implemented during runtime. Signals are connected 'on the fly'.
- Changes in the signal processing between records can be modified from the operator console. No special programming skills are required.

Reliability

What makes a PLC reliable?

PLC Implementation

- Reliable operating system with deterministic scheduler
- Processing blocks running in thousand of installations
- Robust hardware – no active cooling
- Redundant power supplies
- Redundant PLCs for high availability

Front End Controller (CompactPCI CPU)

- (Hard) Real-time operating system with deterministic scheduler
- Basic EPICS records running in several hundred installations. Custom records may be risky.
- Industrial cPCI CPU – no active cooling
- Redundant power supplies
- Redundant IOCs for high availability

Reliable control systems can be implemented based on both approaches

Testing Process Control Hardware

Test of the I/O Hardware

Best Praxis (here the deliverable is a control rack full of I/O components)

1) Factory Acceptance Test

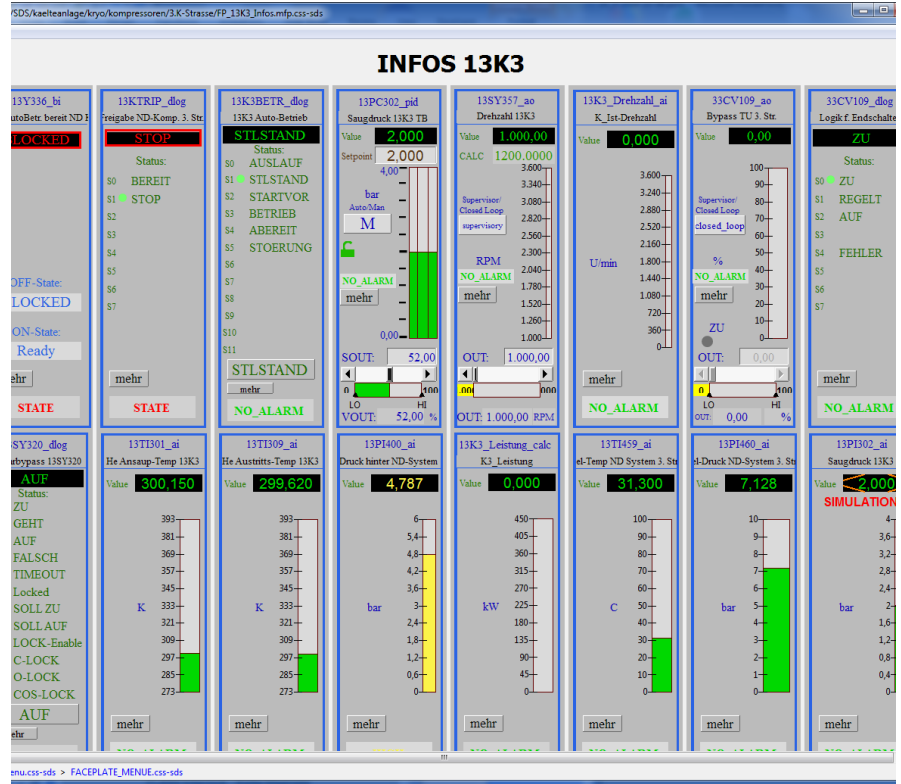
- Test basic mechanical installation.
- Test ~30% of the cabling in the first rack
- Ideally the first rack will be tested with a real process controller (including field bus connection)

2) Test on Site

- Prepare for an 'end to end' test
 - Fully configure the process logic (for I/O signals)
 - Configure basic graphics (synoptic displays)
 - Configure final synoptoc displays for the operators
- Run a 100% test for _all_ delivered components prior to installation in the field

Faceplates

Old and new style. In any case an ideal approach for deep testing all of the signals.



Test of the I/O Hardware

Best Praxis (here the deliverable is a control rack full of I/O components)

3) Test in the field

- Install racks in the final position in the field
- Connect _all_ cables in the field
- Run a 100% test – ‘end to end’ of _all_ (important*) signals
- This will be the second full test. The error rate should be below one per mill.
- Keep track of all tests in Excel sheets – or similar

* Thousands of diagnostic channels might be tested sporadically

Project Management

Project Management: Just in Time vs. Look Ahead

Stay healthy: Personally and project wise

Just in Time

- Wait until last specification is available
- Wait with implementing (hardware and software) until the final milestone can 'just' be fulfilled
Arguments: **Avoid double work**. Specs could change...
- Built hardware in house (writing the specs just takes as long as just doing it yourself)
=> Documentation will be limited.
- Test might only be carried out in the field.
This is a nasty job and a 100% 'end to end' test will take really longer – while the project manager is sitting in you back...

Look Ahead

- Define milestones when specs must be available
- Start implementing hardware and software as soon as the specification is available.
- Let industry build the I/O racks. Let industry prepare the eCAD drawings and you will get the documentation 'for free'.
- Run your tests whenever racks arrive on site or the racks can be installed in the field.
Whenever you get time for installation – you are ready and finish the job in a short time.

The Sliding Project Plan

How to avoid unrealistic mile stones

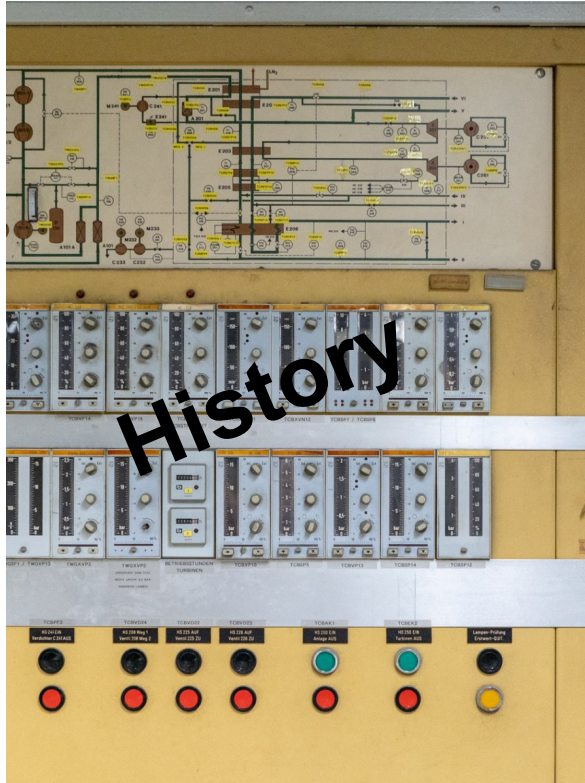
The 'Controls Ready' Milestone

- Controls are always the last ones getting the time to install equipment and to run the 'end to end' tests.
- The controls task depends on nearly all of the other tasks in a project.
- 'Hard' mile stones cannot be fulfilled and cause frustration

The Sliding Project Plan

- Calculate realistically how much time is necessary to finish the controls tasks – after certain conditions are fulfilled:
 - Controls will need 3 weeks to run commissioning the hardware after controls hardware can be installed in the field (requires 'hardware ready' before that time)
 - Controls logic will be ready 6 weeks after the specification is available
 - After that the software commissioning will take 1 week
 - If you have an industrial partner: Process engineers must be available for commissioning ... weeks after the software specs are available.

Cryogenic Controls Today



Thank you

Contact

DESY. Deutsches
Elektronen-Synchrotron

www.desy.de

Matthias Clausen
Cryogenic Controls
Matthias.Clausen@desy.de
+49-40-8998-3256
(until 31.12.2018)