Vacuum Pumping Group Controls Based on PLC

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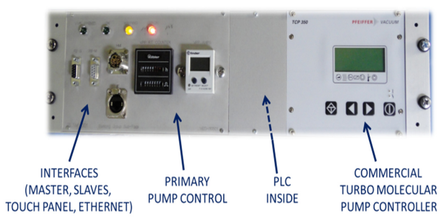
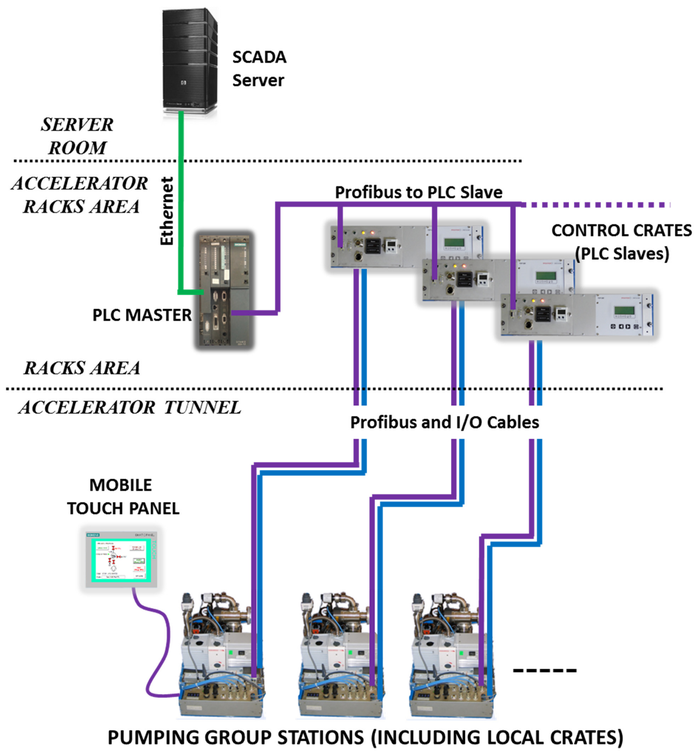
Abstract

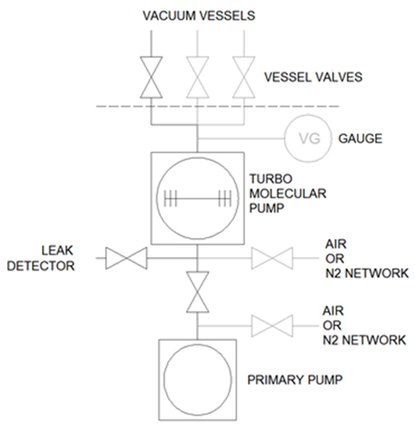
In CERN accelerators, high vacuum is needed in the beam pipes and for thermal isolation of cryogenic equipment. The first element in the chain of vacuum production is the pumping group. The control breaks down the pumping group into primary pump, turbo-molecular pump, valves, gauges, process and interlocks devices. At CERN accelerators, the pumping groups may be found in several hardware configurations, depending on the environment and on the vacuum system used; the control is always based on Programmable Logical Controllers (PLC) and communicates over a field bus; pumping groups are controlled by the same flexible and portable software. They are remotely accessed through a Supervisory Control and Data Acquisition (SCADA) application and can be locally controlled by a mobile touch panel. More than 250 pumping groups are permanently installed in the Large Hadron Collider, Linacs and North Area Experiments.

Hardware

The standard hardware architecture is composed of a local crate, a control crate, a touch panel (local Human Machine Interface), a vacuum gauges controller, a PLC master and a SCADA server.





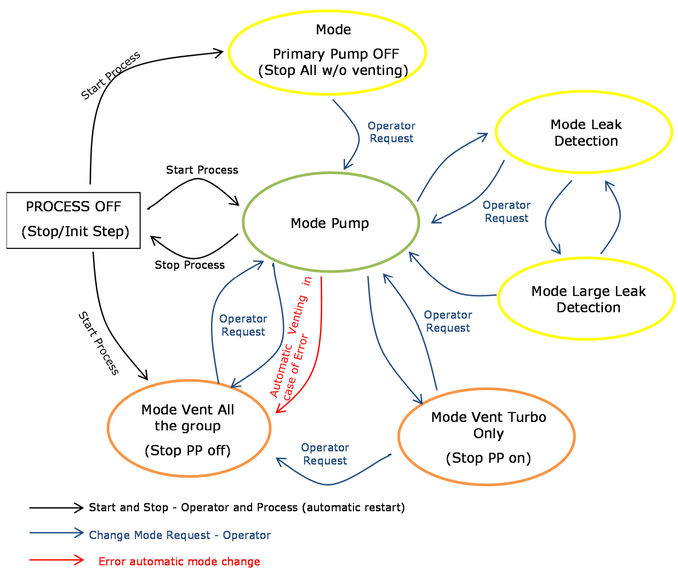


The new control system is compatible with any hardware control crates based on Siemens® PLC S7-300 or S7-400 series with a minimum of 64Kb working memory. The control system is compatible with the recent CERN designed crate shown in Figure 2 but also with the 15 years old crates.
Pumping group devices are controlled using direct PLC Input/Output or Profibus® fieldbus.

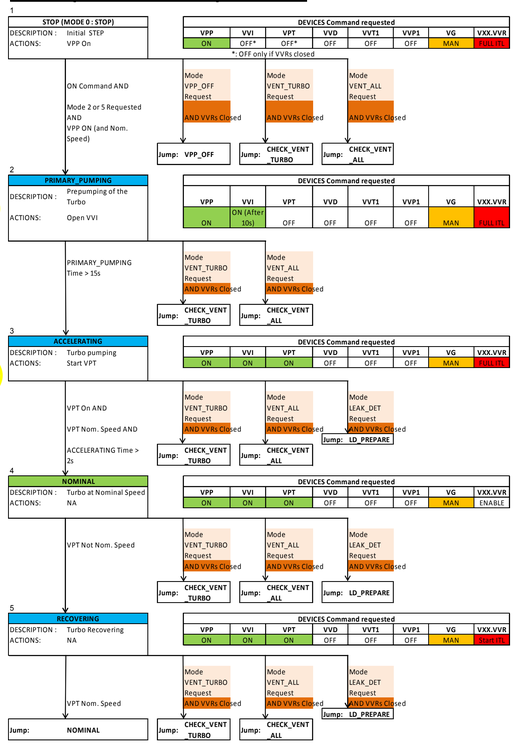
Process and PLC Software

Transitions between modes are requested either by the operator or by the process itself.
Phase sequencer, including series of steps with transition conditions and time dependencies, sends "AUTOMATIC" orders to devices of pumping group in order to reach final state of group, depending on mode.

Operational modes and available transitions:



"Pump" mode Sequencer:



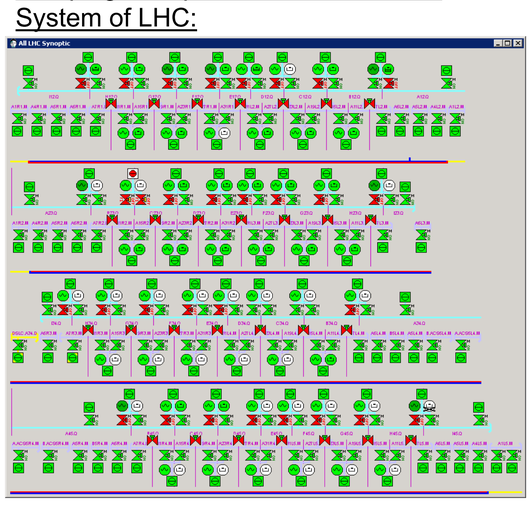
The PLC software has the following specifications:

- SIEMENS-SCL Language: textual high-level language ST (Structured Text) defined in the standard IEC 61131-3. This language allows to program complex functions.
- Function Block (FB): Programs routine working with instance memories; one routine (FB) per device type and one instance memory block (DB) per device. Devices represent hardware equipment (pumps, valves…) or virtual devices (processes, interlocks…).
- Phase Sequencer: the phase sequencer is developed with the language SIEMENS-GRAPH.

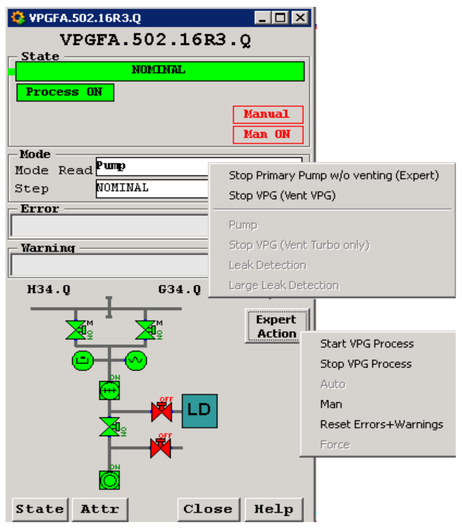
Supervisory Control and Data Acquisition

The pumping group control is included in the Vacuum SCADA vacuum application.
The overview panel and the details panel provide a state monitoring and a remote control to operators.
Operators may configure in SCADA e-mail/SMS notifications to be notified in case of pumping group error, stop or unexpected pressure increase.

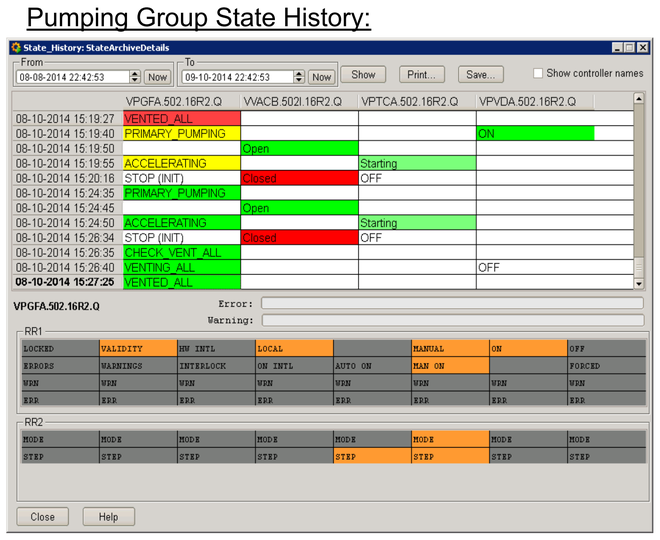
Pumping Groups in Isolation Vacuum System of LHC:



Pumping Group Details Panel:

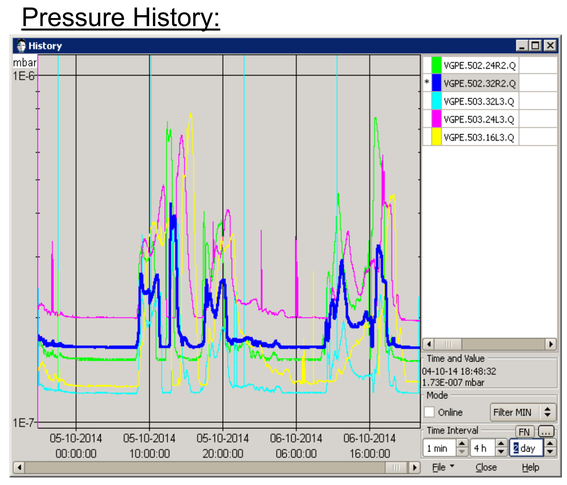


Pumping Group State History:



The state history panel allows comparing archived values of status, operational mode and sequencer step of pumping group; it is very useful for a post-mortem diagnostic.

Pressure History:



The pumping group pressure gauges history is an additional tool to check pumps efficiency, analyse pumping speed and detect leaks.

Conclusion

The vacuum pumping group control offers a robust solution to drive a large variety of different turbo molecular pumping groups. It has been successfully deployed to more than 250 pumping groups and is foreseen to be installed in future CERN vacuum systems as a standard solution. The identical software for all turbo molecular pumping groups has reduced the maintenance and facilitated intervention. It has improved flexibility, remote control, diagnostics and data logging.

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