The new control system for the Vacuum of ISOLDE

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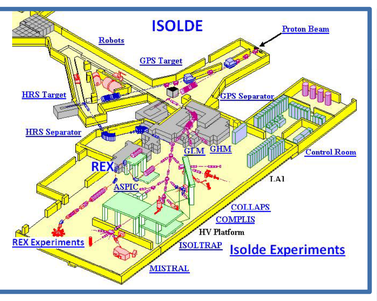
ABSTRACT

The On-Line Isotope Mass Separator (ISOLDE) is a facility dedicated to the production of radioactive ion beams for nuclear and atomic physics. From ISOLDE vacuum sectors to the pressurized exhaust gas storage tanks there are up to five stages of pumping for a total of more than one hundred pumps including turbo-molecular, cryogenic, dry, membrane and oil pumps. The ISOLDE vacuum control system is critical; the volatile radioactive elements present in the exhaust gases and the high and ultra high vacuum pressure specifications require a complex control and interlock system. This paper describes the reengineering of the control system developed using the CERN UNICOS-CPC framework. An additional challenge has been the usage of the UNICOS-CPC in a vacuum domain for the first time. The process automation provides multiple operating modes (rough pumping, bake-out, high vacuum pumping, regeneration for cryo-pumped sectors, venting, etc). The control system is composed of local controllers driven by PLC (logic, interlocks) and a SCADA application (operation, alarms monitoring and diagnostics).

PUMPING SYSTEM DESCRIPTION

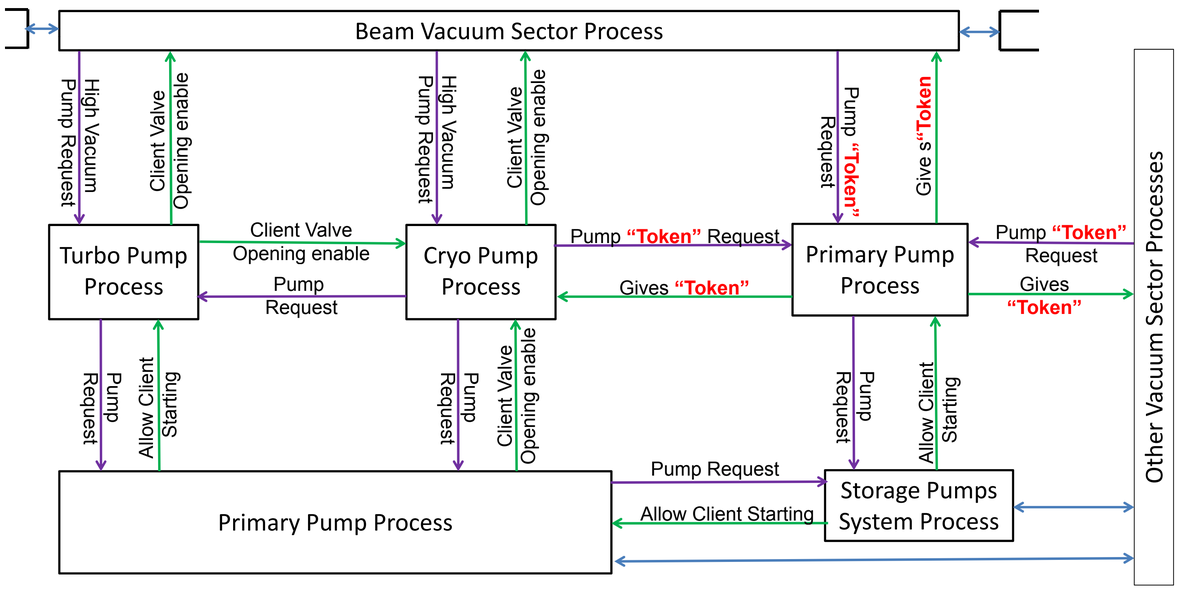
VACUUM SPECIFICATIONS:
- High Vacuum $< 1.10^{-6}$mbar and Ultra High Vacuum $< 1.10^{-10}$mbar
- High Vacuum pumps: turbo-molecular and cryogenic pumps
- Bake-out system (REX-EBIS Sector)
- Exhaust gas collected (volatile radioactive elements)
- Reduced number of primary pumps

A complex process has been developed to control this pumping system.

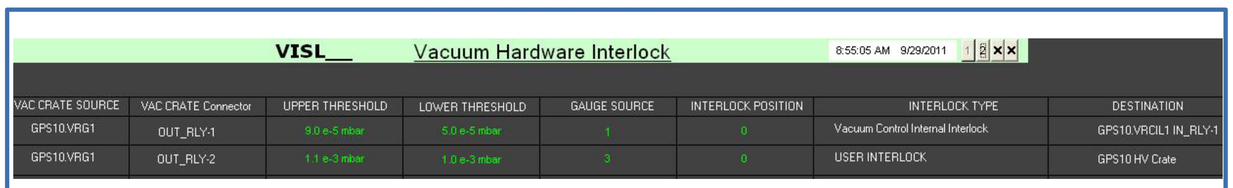


CONTROL PROCESSES

- Pumping groups are linked together.
- 127 processes of 10 types (beam sector, turbo pump, cryo pump, primary pump, venting, storage,…)
- Pump process interlocks the client process.
- Some processes are multi-client, a « token » system avoids that two clients are pumped in the same time.



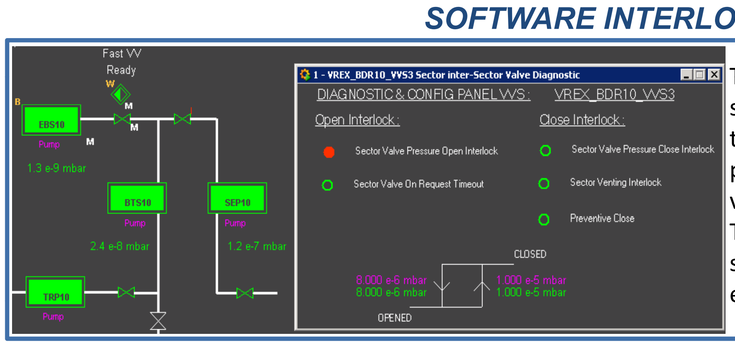
HARDWARE INTERLOCKS



VAC CRATE SOURCE	VAC CRATE Connector	UPPER THRESHOLD	LOWER THRESHOLD	GAUGE SOURCE	INTERLOCK POSITION	INTERLOCK TYPE	DESTINATION
GPS10.VRG1	OUT_RLY-1	9.0 e-5 mbar	5.0 e-5 mbar	1	0	Vacuum Control Internal Interlock	GPS10.VRCIL1 IN_RLY-1
GPS10.VRG1	OUT_RLY-2	1.1 e-3 mbar	1.0 e-3 mbar	3	0	USER INTERLOCK	GPS10 HV Crate

The hardware interlocks are potential free relay contacts. The 2 PLC generate interlocks depending on the states of different processes. The PLC provides hardware interlocks to other equipments like transformers, water cooling, target heaters, etc.
Gauge controllers provide fast pressure hardware interlocks to high-voltage power supplies.
PLC ⟺ Gauge Controllers asynchronous communication via the Profibus-DP.
SCADA Panel : to set, monitor and diagnose a large number of hardware interlocks.

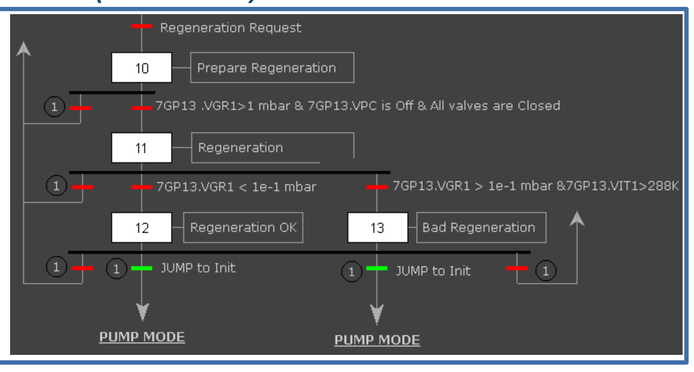
SOFTWARE INTERLOCKS



The PLC provides software interlocks for the sector valves, a low pressure threshold is set to disable the opening of the valve and a high pressure threshold is set for a fully interlocked valve.
The SCADA panel displays the detail and the source of the interlock providing a rapid and easy diagnostic.

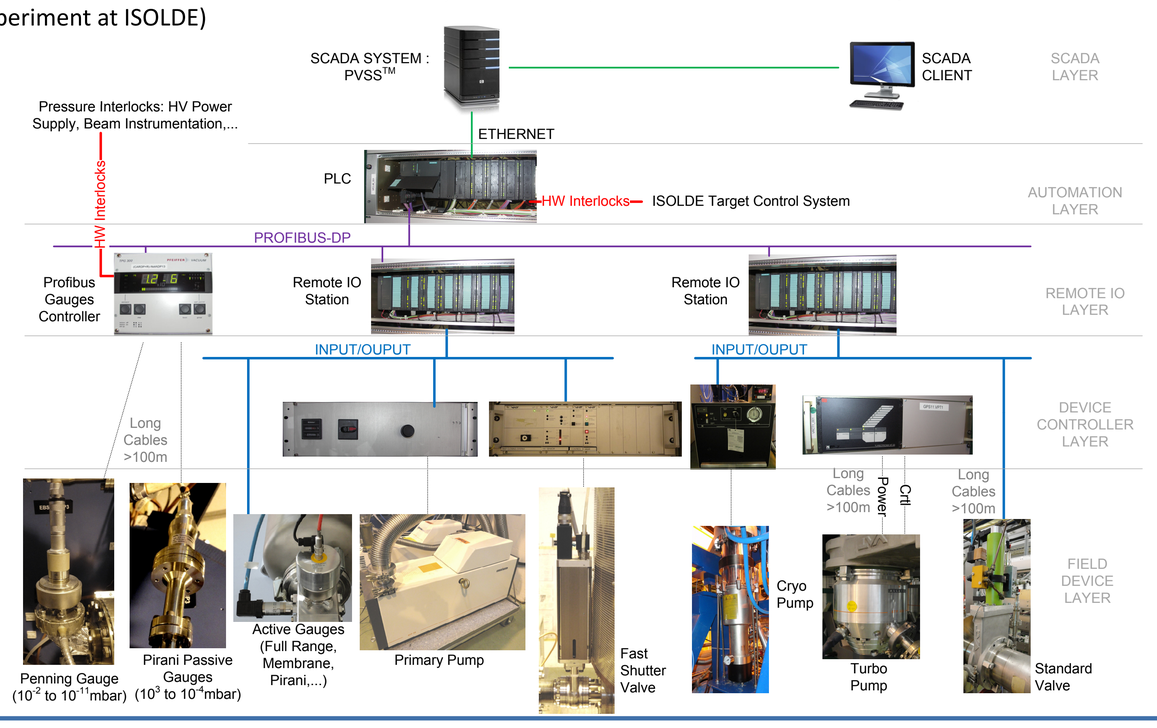
SEQUENCER (GRAFCET)

13 different Grafcets provide a fully automatic system with a large choice of operating modes: pump, leak detection, vent, bake-out, regeneration, etc.
The Grafcets are directly monitoring a SCADA panel. The operator can follow the process and see the active steps and transitions.

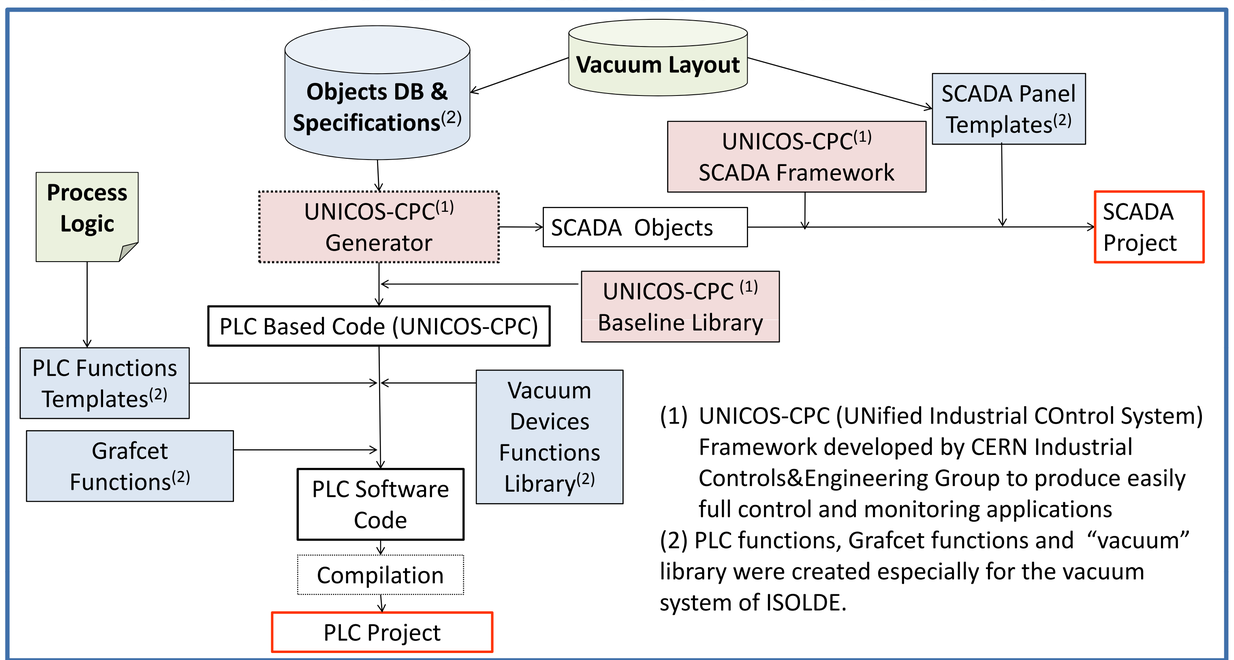


HARDWARE ARCHITECTURE

- Based on Programmable Logic Controller (PLC) - Two independent control systems:
- In 2010, installation of the vacuum control system for ISOLDE front-ends, separators and experiments
- In 2011, installation of the vacuum control system for the post-accelerator REX-ISOLDE (Radioactive beam EXperiment at ISOLDE)



UNICOS-CPC FRAMEWORK AND SOFTWARE GENERATION



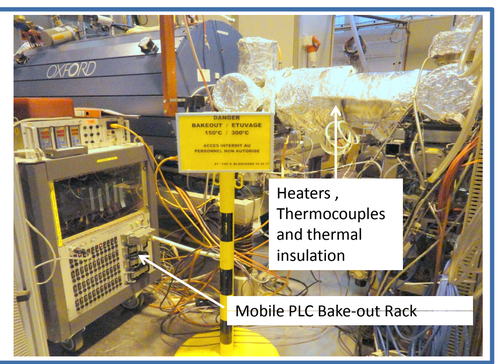
(1) UNICOS-CPC (UNified Industrial COntrol System) Framework developed by CERN Industrial Controls&Engineering Group to produce easily full control and monitoring applications
(2) PLC functions, Grafcet functions and "vacuum" library were created especially for the vacuum system of ISOLDE.

ULTRA HIGH VACUUM: BAKE-OUT CONTROL

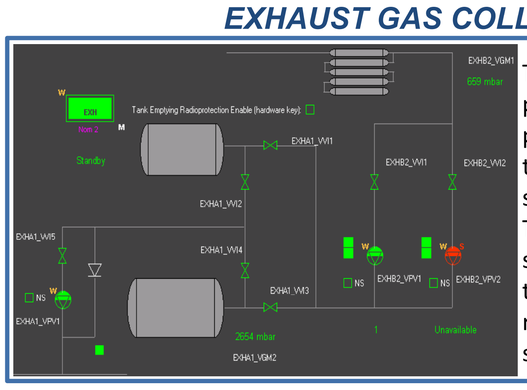
BAKE-OUT : reduces the chamber's gas desorption and activates the in-house guetter pumps ⟹ Vacuum Improvement

- The bake-out control system is compact and mobile with :
  - PID (Proportional/Integral/Derivative) regulation
  - complex temperature cycles
  - interlocks, error management
  - alert and diagnostic tools

This bake-out controller was developed previously by the vacuum control section for all the CERN accelerators and laboratories.



EXHAUST GAS COLLECTING AND STORAGE SYSTEM



The exhaust gas collection and storage process is one of the most important processes as its failure would result in the complete shutdown of the vacuum system.
The control has been designed to avoid stops . If the pressures in the storage tanks increase abnormally, the responsible client process is preventively stopped (storage system is still available).

CONCLUSION

The vacuum control system of ISOLDE including REX-ISOLDE is the result of a successful CERN internal collaboration between the Control Section of the Vacuum, Surfaces and Coating Group and the Industrial Controls&Engineering Group. This system provides all the features to fully operate and monitor the vacuum system of ISOLDE. The diagnostic tools and the ability to access them remotely have considerably reduced the vacuum intervention time.

ISOLDE CERN

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Technology Department TE Vacuum Surfaces.. Coatings

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