Science and Technology Facilities Council

Central Laser Facility

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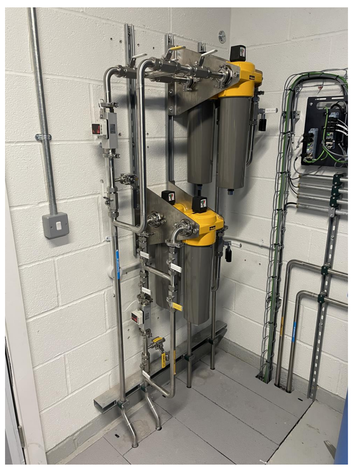
Design and Installation of a Compressed Air and Nitrogen Generation System for EPAC

Overview

This system supplies compressed air (CA) at 8bar for the operation of pneumatic valves and the letting up of vacuum chambers to atmospheric pressure, and nitrogen (N2) at 7bar for the purging of vacuum pumps and lasers. It consists of three oil-free air compressors, two desiccant dryers, two PSA nitrogen generators, six large storage receivers, and a high purity filtration and gas quality monitoring station, as well as a sophisticated control and safety system, detailed below.

It has been designed to maximise up-time and reliability by utilising double redundancy, such that individual components can be isolated for maintenance and repair whilst the system remains online.
The air for vacuum chamber let-up is separately controlled so that the CA and N2 will not see a drop in pressure during use. The system is a collaboration with Activ-Air Automation Ltd., an industry specialist.

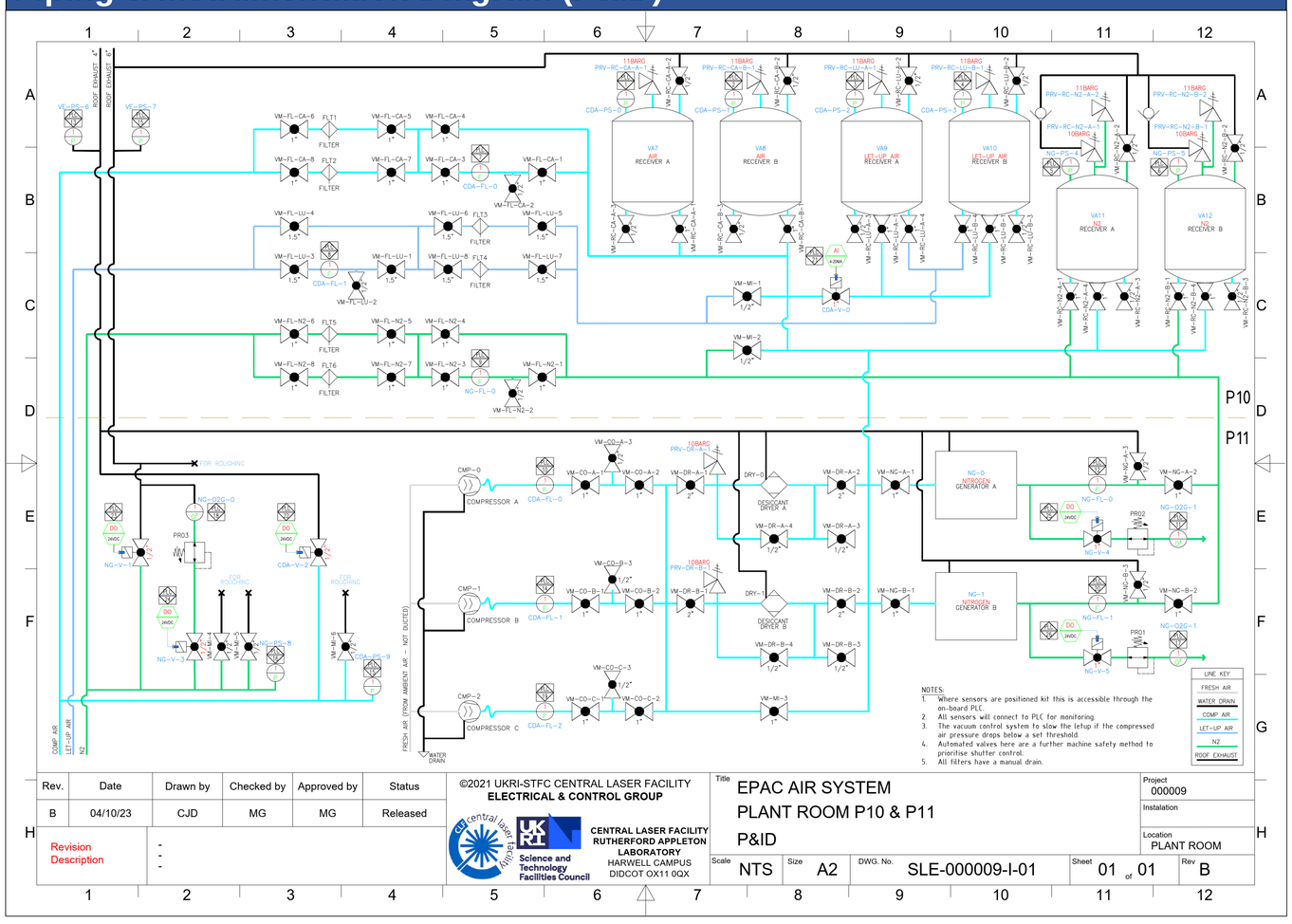


Use of Pressure Swing Adsorption (PSA) Technology

Historically, the CLF has used liquid nitrogen (LN2) boil-off to produce N2 gas for all CA and N2 requirements, which is very pure, very clean and very dry. However, using boil-off gas is costly, has a large environmental impact, and increases the asphyxiation hazard due to the increase in N2 provision across the facility. [1]

The EPAC system utilises PSA technology, with carbon molecular sieves to adsorb the oxygen (O2) molecules, alternating across pairs of cylinders to give a continuous flow of high-pressure N2 gas, venting the O2 into an exhaust during the regeneration step. [2] This provides a robust, cost-effective source of N2, without relying on regular deliveries of LN2 to site.

Piping & Instrumentation Diagram (P&ID)



Rev.	Date	Drawn by	Checked by	Approved by	Status
B	04/10/23	CJD	MG	MG	Released

Revision Description: - - -

CENTRAL LASER FACILITY
RUTHERFORD APPLETON LABORATORY
HARWELL CAMPUS
DIDCOT OX11 0QX

Title	Project	Location
EPAC AIR SYSTEM PLANT ROOM P10 & P11 P&ID	000009	PLANT ROOM

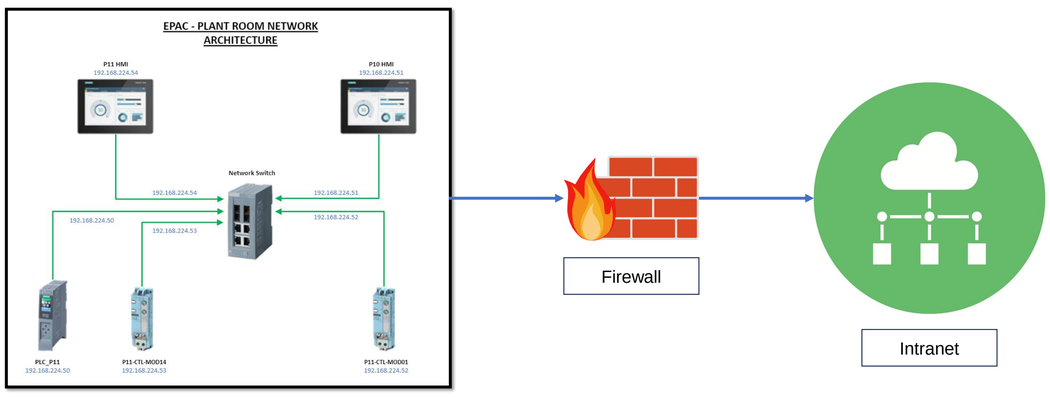
Installation:

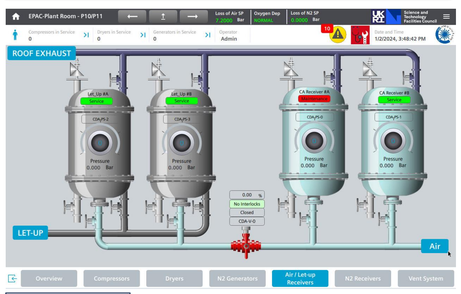
Scale	Size	DWG. No.	Sheet	Rev
NTS	A2	SLE-000009-I-01	01 of 01	B

Control System Architecture

- The EPAC CA/N2 control system consists of a standard PLC control panel with several ET200 AL IO modules. Additionally, there are two RS232 modules for communicating with the vacuum pumps and compressors. To facilitate seamless control and monitoring of these systems, The PL+C control panel is equipped with multiple ET200 AL IO modules, enhancing the system's flexibility and adaptability.

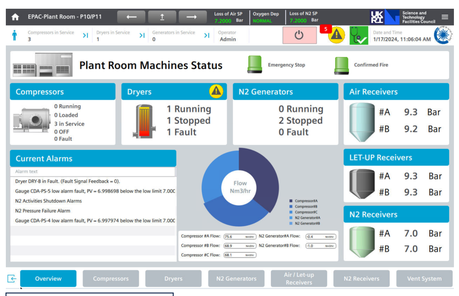
- The control system of the plant room will be securely connected to a higher-level system to enable remote access, comprehensive reporting, and early alarming capabilities. Additionally, it will facilitate data archiving for advanced diagnostics.





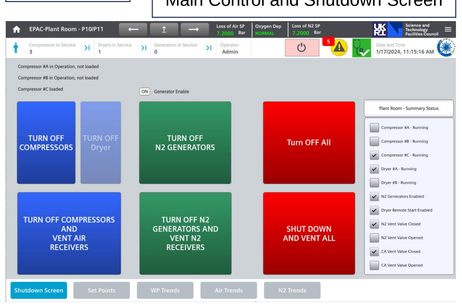
Air Receivers

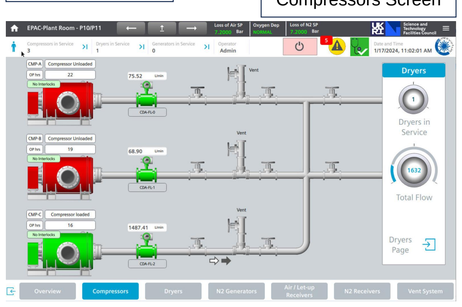
Main Control and Shutdown Screen



System Overview

Compressors Screen





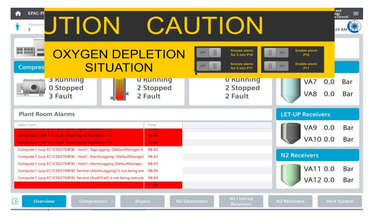
Safety System

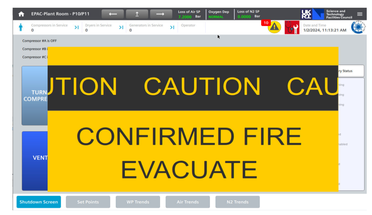
- **Oxygen Depletion System**
  - The implementation includes a connection from the oxygen depletion controller to the PLC and ensures a connection for each zone. The system can promptly detect any potential oxygen depletion issues and trigger appropriate safety protocols.

- **Emergency shutdown system**
  - An emergency stop (E-Stop) system was installed, featuring E-Stop buttons placed at multiple locations. A safety relay was utilised to manage the system. In the event of a safety function being triggered, safe shutdown is initiated for compressors, dryers, nitrogen generators, and pumps, with the stored gas vented to atmosphere.

- **Fire Alarm System**
  - Connection from the fire alarm control panel to the PLC can indicate a confirmed fire and the system automatically initiates an emergency shutdown as described above.

- **Operation optimisation protection**
  - The system features real-time monitoring of all parameters to optimise operations, conserve energy, and ensure environmental friendliness. It detects anomalies like compressor issues during system venting, promoting efficient and safe functioning.





Diagnostics, Alarming and Control Features

- The system is equipped with a comprehensive alarm system for each piece of equipment on-site, enabling real-time diagnostics and minimising troubleshooting time.

- This ensures high reliability in supplying compressed air and nitrogen to EPAC, enhancing operational efficiency and reliability.

- The system boasts an advanced trending and logging system featuring a 1-second interval for all analogue signals. This capability enables thorough tracking and recording of data, facilitating detailed analysis and enhancing operational insight. The system provides invaluable support for monitoring, troubleshooting, and optimising performance across the board.

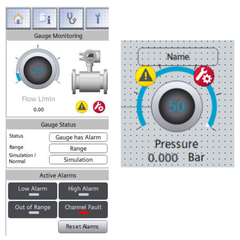
- An audit trail feature is enabled to record every user action. This ensures accountability and transparency by documenting all interactions within the system.

Standardisation and Modernisation of Graphics Interface

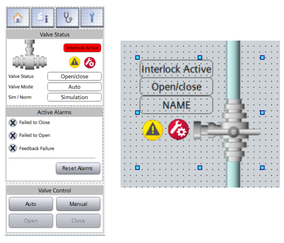
- The modernisation and standardisation effort aims to make user graphics interfaces across all CLF systems more user-friendly. By implementing a library of faceplates designed for universal use across EPAC projects, the goal is to achieve uniformity and ease of use throughout the facility.

- This initiative streamlines operations, enhances efficiency, and promotes seamless integration of systems, ultimately improving overall user experience and productivity.

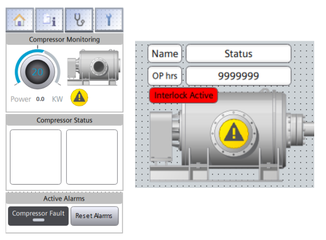
Example for Pressure Symbols



Example for Valve Symbols



Example for Compressor Symbol



References

[1] S. Blake, *et al.*, “Nitrogen Usage and Nitrogen Generation”, *CLF Annual Report 2011-12.*
[2] Sysadvance (2024) *Nitrogen Generators.* Available at: https://sysadvance.com/industrial/nitrogen-generators/ (Accessed: 05 April 2024)