SWEP Lead Business Engineer Stefan Brohm by the new CO_2-cooling systems for CERN detectors CMS and ATLAS.

SWEP heat exchangers integrated into CERN's new CO_2 cooling system

Extreme cooling requires specialized SWEP components and expertise.

CERN, the largest laboratory for particle physics in the world, provides a unique range of particle accelerator facilities to scientists performing ground-breaking research in fundamental physics. The ATLAS and CMS detectors at CERN are currently being upgraded to make them ready for the new High-Luminosity LHC program. This upgrade will result in increased levels of radiation.

To withstand the higher levels of radiation, the detectors must be maintained below -25°C, which requires a cooling system capable of reaching temperatures as low as -40°C. To achieve this level of cooling, the existing CO_2 system, which was installed in the LHCb and AMS detectors in the early 2000s, had to be upscaled by 2 orders of magnitude. An increase of this size demanded an extremely effective, large heat exchanger, positioned as a CO_2 evaporator. To meet this demand, SWEP developed the Q185H brazed plate heat exchanger (BPHE), by updating their existing B185 BPHE with the inclusion of a Q-pipe, creating the SWEP Q185H.

Next, working in close collaboration with CERN engineers, SWEP Engineers adapted the Q185H to meet the specific technical requirements of CERN's new CO_2-cooling project. The entire installation, which has been optimized to cool CO_2 to -53 °C, close to the temperature where it solidifies, was dimensioned and built specifically to incorporate these robust units.

Ultimately, both the SWEP B185 and SWEP Q185H brazed plate heat exchangers play critical roles as CO_2 superheaters and CO_2 cascades in the cooling system.

The new installations for both ATLAS and CMS rely exclusively on natural CO_2, eliminating synthetic refrigerants entirely. The unique properties of CO_2 enable the use of small pipes – a significant advantage where space is limited. The space available underground at CERN is insufficient to house both a primary refrigeration system and an oil-free CO_2 compression system. Utilizing CO_2 for primary refrigeration, however, has made it possible to install the systems above ground, far from both the detectors and the tight underground space.

Collaborations
CERN has a long-standing collaboration with SWEP for the development of high-pressure heat exchangers. SWEP's first high-pressure heat exchanger was developed for LHCb CO_2 cooling, in 2005. This led to the development of the B16DW, reinforced heat exchanger, the first high-pressure model SWEP placed on the market. SWEP has continued its close collaboration with CERN ever since, successfully installing a wide range of high-pressure models.

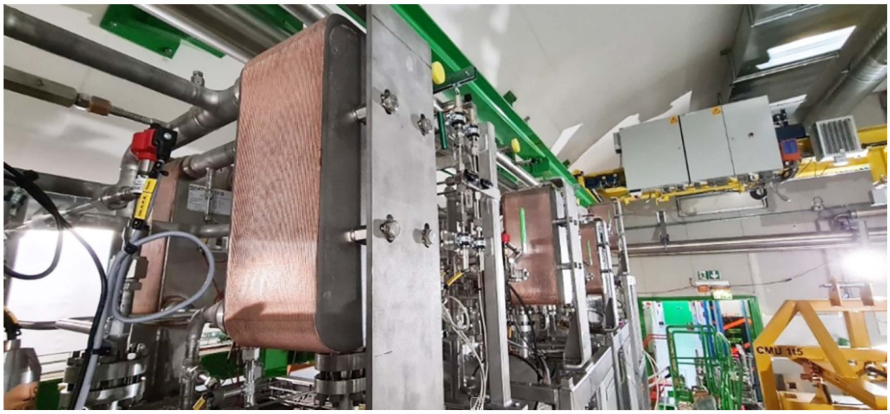
Sustainability focus
Earlier cooling systems for ATLAS and CMS utilized high-GWP synthetic refrigerants (including fluorinated gases). While effective, these refrigerants were also responsible for a significant portion of CERN's direct greenhouse-gas emissions. The introduction of CO_2 (R744) refrigeration as primary cooling has prompted CERN to rethink its use of other fluorinated refrigerants and has led to the development of a sustainability roadmap aimed at cutting greenhouse gas emissions throughout its facilities. The installation of low-GWP CO_2 systems is a major step toward achieving their environmental goals. The introduction of CO_2 for detectors and other refrigeration has led to a significant reduction in greenhouse gases. Multiple systems are also under construction that will replace the present generation of gaseous detectors, which have a limited rate capability, with GEM-based detectors that use CO_2.

Next-generation cooling
The new CMS and ATLAS detector cooling systems are planned to be in operation from 2030 until 2045. As of 2025, the nine next-generation carbon dioxide (CO_2) cooling plants have been installed in the underground Service Cavern of the CMS experiment in Cessy, France. Yann Herpin, Cooling Engineer at CERN EP-DT-FS explains: "With the CO_2 refrigeration system and performance of up to 1 MW of cooling down to a temperature of -53°C, we have been able to push the boundaries of what can be achieved with this natural refrigerant. We are proud to say that this new system, developed by CERN's Engineering and Experimental Physics departments, in collaboration with SWEP's experts, is paving the way for further development in CO_2 refrigeration technology, which will lead reduced emissions in many other industrial applications."

Adapting to future climate practices
While CERN is famous for its cutting-edge research, its adoption of new low-GWP refrigerants to replace hydrofluorocarbon gases is not unique. Climate concerns have led many industries to reconsider common practices that generate greenhouse gas emissions. With new legislation in place in the EU and elsewhere, the phase-out of hydrofluorocarbon gases (HFCs) is well underway.

The installations for detector cooling systems to run from 2030-2045 with SWEP brazed plate heat exchangers partially in place

SWEP heat exchangers in next-generation CO_2 cooling
As the use of CO_2 and other natural refrigerants continues to grow across a wide range of industries, so will the demand for new technologies designed to operate optimally with these solutions. Currently, SWEP offers a complete range of reliable, compact brazed plate heat exchangers that are designed to perform optimally under the extreme pressure required by CO_2, including units that can operate up to 140bar at 135°C. As the market progresses, SWEP will continue to lead the way – working closely with OEMs and component suppliers as they to adapt their systems and make the transition to a more sustainable future.



SWEP Large Ultra High-Pressure heat exchangers installed at CMS detector location in Cessy, France.

Facts about CERN:
- The European Laboratory for Particle Physics, known as CERN, operates the largest particle physics laboratory in the world.
- The 27-km Large Hadron Collider (LHC) at CERN is the largest and most powerful particle accelerator ever built.
- The CO_2 refrigeration system shows that performance up to 1 MW of cooling down to a temperature of -53°C can be achieved with this natural refrigerant.

Article sources:
CERN website: https://home.cern/
CERN movie: Using carbon dioxide to reduce carbon dioxide emissions | CERN

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