Pilot Cooling Supply for the CBM Silicon Tracking System Detector Electronics

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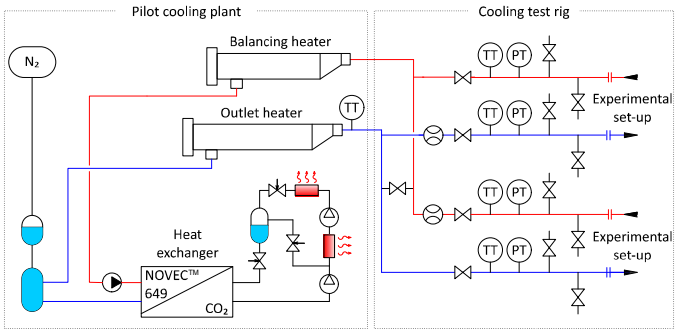
Motivation

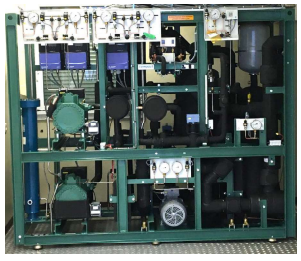
- Due to the considerable power dissipation (50 kW), the CBM Silicon Tracking System (STS) detector requires extensive cooling.
- From 2022, the last EU legislation imposes global warming potential (GWP) limit of 150 on multipack refrigeration with a capacity of 40 kW, except for cascade systems.
- The refrigeration industry is shifting towards usage of low GWP refrigerants, one of which is CO_2 itself.
- CO_2 has disadvantage of high expansion coefficient, high operation pressure, toxicity, and requires qualified personell for the maintenance.
- 3M™ NOVEC™ 649 or perfluoro(2-methyl-3-pentanone) has advantage of low operating pressure, non-toxicity, low GWP, and being easy to use.
- The STS cooling supply makes use of CO_2 and NOVEC™ 649 simultaneously to take advantage of the both.

Pilot Cooling Supply

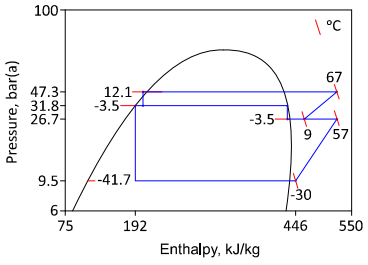


- The pilot cooling is a booster-type CO_2 refrigeration system that extracts heat from the secondary side coolant through a heat exchanger (evaporator).
- Outlet heater extends temperature range of the pilot cooling plant.
- Balancing heater covers the mismatch between the minimum cooling demand of the plant and experimental set-ups.
- With the cooling test rig, various experimental set-ups and the drainage system can be connected to the cooling supply.

Pilot Cooling Plant: Specs



The pilot cooling plant



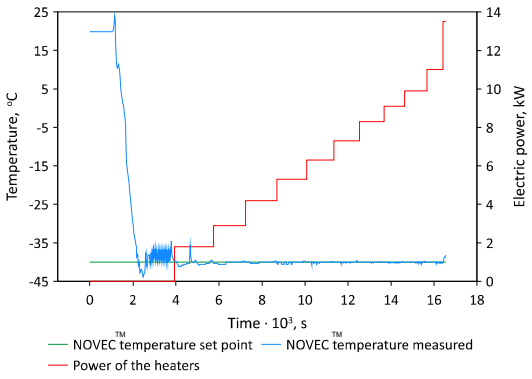
P - H diagram of the refrigeration cycle

Nominal cooling capacity, kW	15
Minimal cooling demand (partial load), kW	6.4
Primary side refrigerant	CO_2
Secondary side coolant	3M™ NOVEC™ 649
Secondary side outlet temperature[1], °C	-40 ... 10
Refrigeration cycle coefficient of performance (COP)	2.05
Secondary side flow rate[2], kg/s	0.6 ... 1.4
Secondary side pressure difference[2], bar	0.5 ... 2.5
Balancing heater power, kW	0 ... 11
Outlet heater power, kW	0 ... 24

1) Temperature range from the refrigeration cycle -40 ... -30 °C. With the outlet heater -30 ... 10 °C.
2) Tested with a bypass line.

Pilot Cooling Plant: Trial-run

A trial-run was performed to test the performance of the pilot cooling plant: electric power of the heaters was increased in steps to check if the plant can keep up the temperature set-point -40 °C.



- Steady-state operation is only possible with delivering minimum 1.8 kW of electric power from the balancing heater.
- The set-point cannot be maintained after 13.5 kW of electric power was reached - nominal capacity was achieved in the previous step.

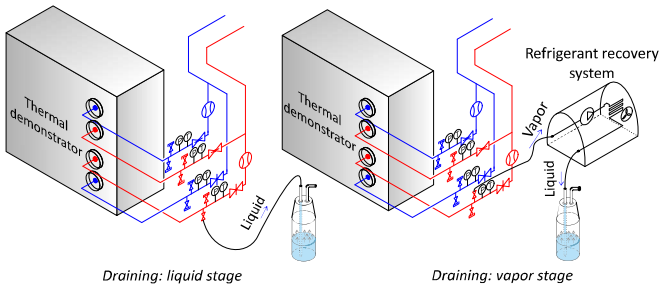
Cooling Test Rig

- Supports connecting the liquid cooling system of various experimental set-ups through a standard flange connection DN25.
- Supports connecting the thermal demonstrator.
- Supports connecting the STS detector for testing without a beam.
- Monitors flow parameters:
  - flow rate;
  - inlet and outlet temperature;
  - inlet and outlet pressure.
- Supports connecting the drainage system.

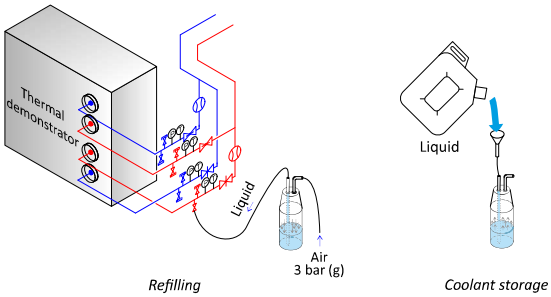
The cooling test rig

Drainage System

The drainage system allows for draining and refilling experimental set-ups with NOVEC™ 649 without losing the liquid.



Draining: liquid stage *Draining: vapor stage*



Refilling *Coolant storage*