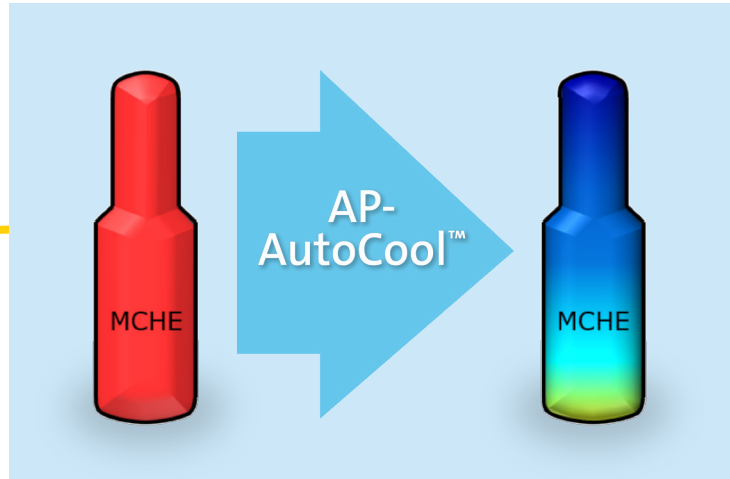


Automated LNG MCHE cooldown AP-AutoCool™ program



Scope of services

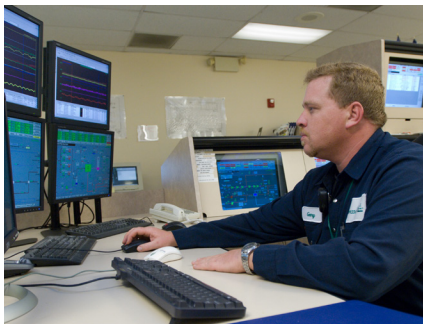
Develop automatic cooldown control scheme based on the specific plant

Review instrumentation readiness

Determine key controller parameters using dynamic simulation

Provide operator training

Tune controllers and provide on-site advisory services



The AP-AutoCool program is proprietary cooldown technology that automatically cools the Main Cryogenic Heat Exchanger (MCH E).

Benefits of the AP-AutoCool program include:

- Faster and smoother cooldown for start-up
- Reduced flaring during cooldown
- Maximum cooldown rate within design limits
- Increased plant availability
- Consistent cooldown method
- Customized for new or existing plants

During a start-up or re-start of a liquefaction system, the MCHE is cooled to establish the required temperature profile, with the cold end of the MCHE reaching approximately -160°C (-256°F). Important design limits during the cooldown are:

- The cooldown rate (temperature change per hour)
- The temperature differences between process streams

Traditionally, the cooldown method has been manual and involved the adjustment of several process variables, such as JT valve positions and component make-up rates, using operator judgement. Using an automatic method frees up operator time to focus on other areas of the plant, and potentially reduces the operator skill level required.

The AP-AutoCool Program is easily configured into an existing control system. This technology has been evaluated in depth for various MCHE cooldown scenarios using Air Products' advanced dynamic simulation models and tools. It can be customized to fit various liquefaction cycles, such as the AP-SMR™, AP-C3MR™, AP-DMR™ and AP-N™ processes.

About Air Products

Air Products is a world-leading Industrial Gases company celebrating 75 years of operation. The company's core Industrial Gases business provides atmospheric and process gases and related equipment to manufacturing markets, including refining and petrochemical, metals, electronics, and food and beverage. Air Products is also the world's leading supplier of liquefied natural gas process technology and equipment.

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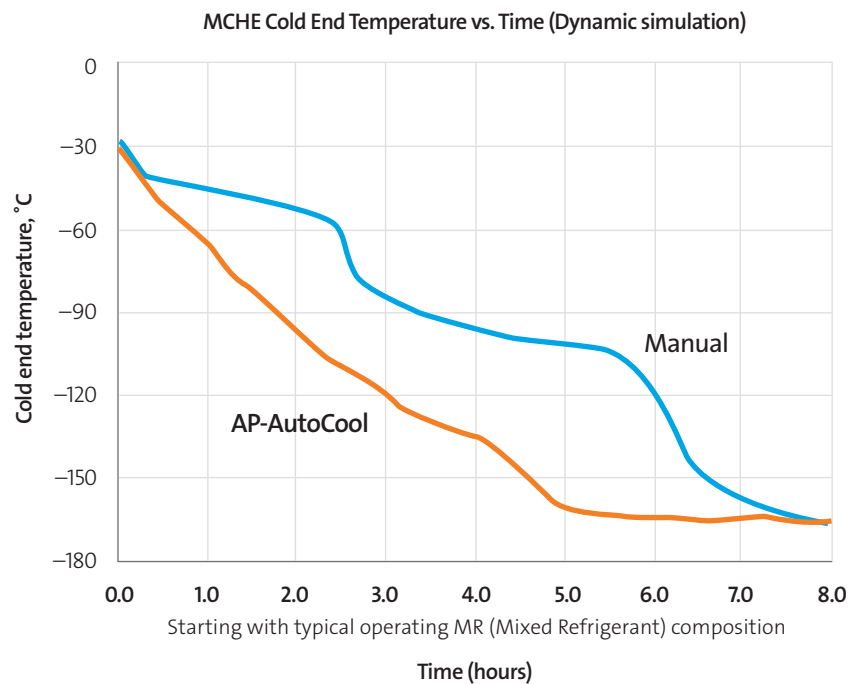
Cooldown method comparison

Cooldown method	AP-AutoCool	Manual
Cooldown time (hours)*	5–7	7.5–10
Average cooldown rate (°C/hour)	25	17
Cooldown rate standard deviation (°C/hour)	9	17
Off-spec LNG (tonnes)	52–73	105–140
Extra LNG production (tonnes)**	1500–1800	0

*Cooldown time depends on the starting MR (Mixed Refrigerant) composition

**Assuming 5 MTPA (600 MT/hr) LNG production

Example: AP-C3MR™ MCHE cooldown potential improvement



For AP-SMR™ processes, the pre-cooldown can also be included, starting from ambient temperatures, e.g. +30°C.



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