

Development of a High-Capacity, High-Efficiency GM Cryocooler and Supercritical Helium Circulating Cooling System for HTS Applications

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01 Large-capacity, high-efficiency GM cryocooler

The HMR1020 is a single-stage GM cryocooler developed for liquid-hydrogen-temperature applications. At 1.9 MPa and 1.2 Hz, it delivers 112.2 W at 20 K with an rCOP of 11.80%.

112.2 W @ 20 K

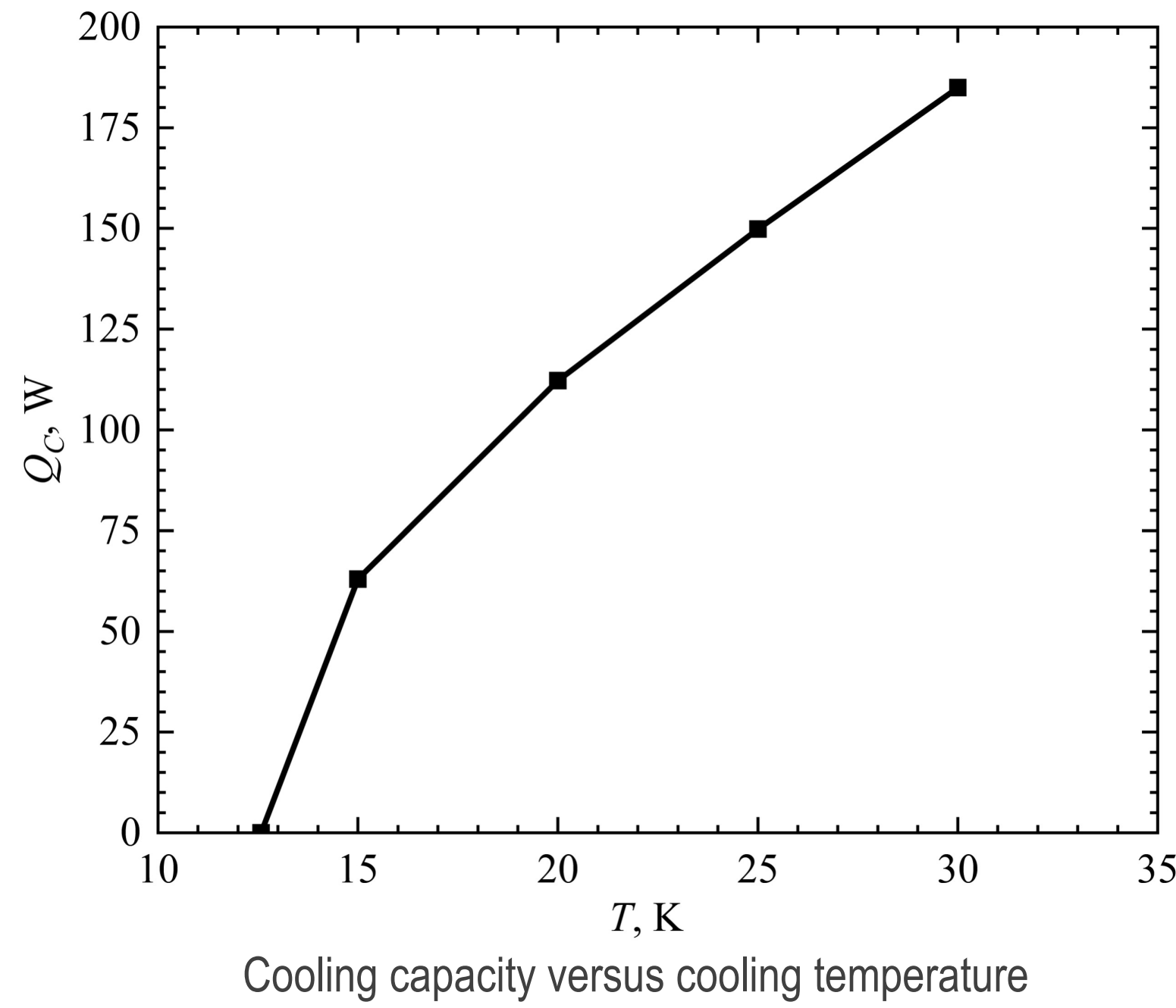
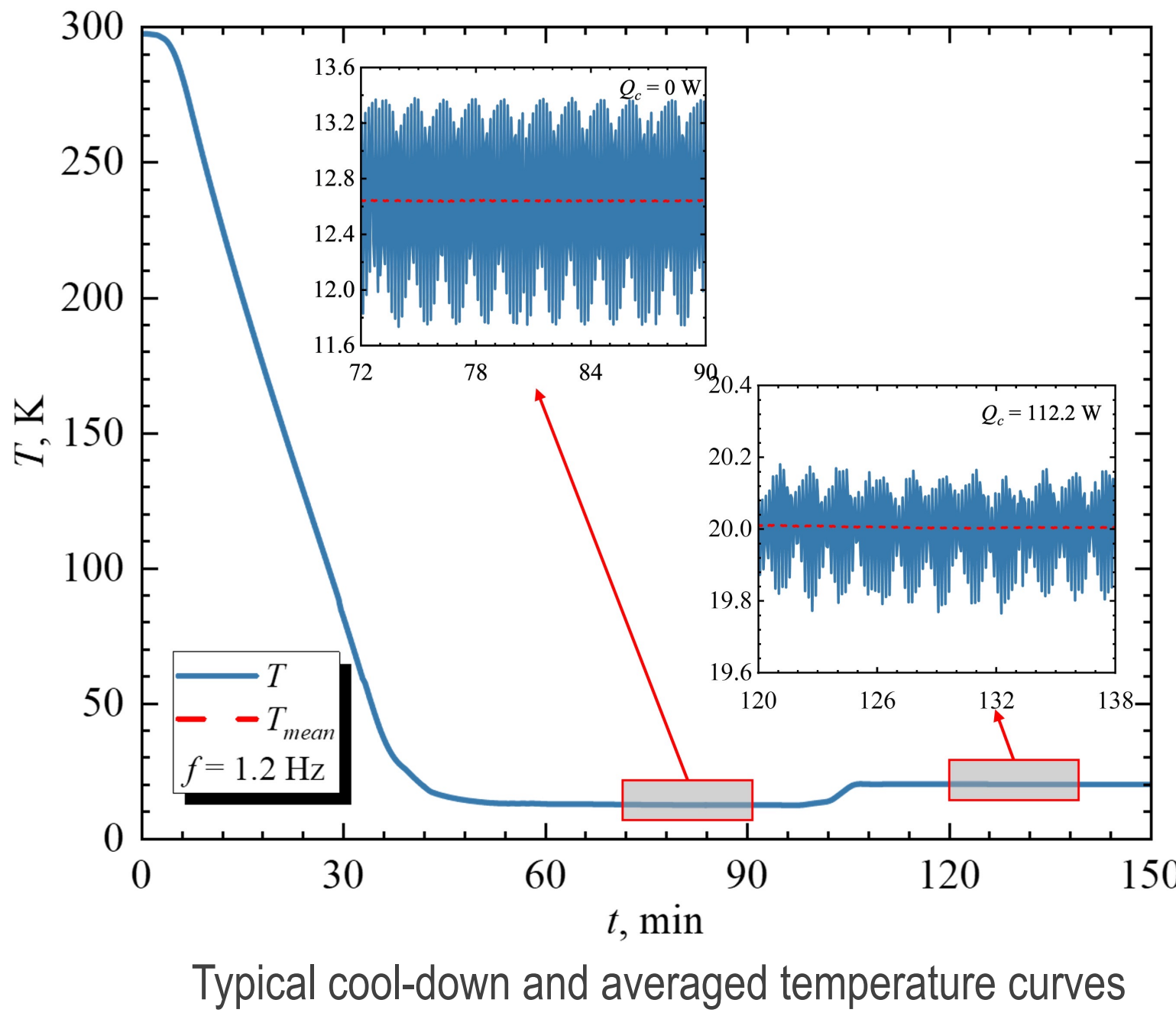
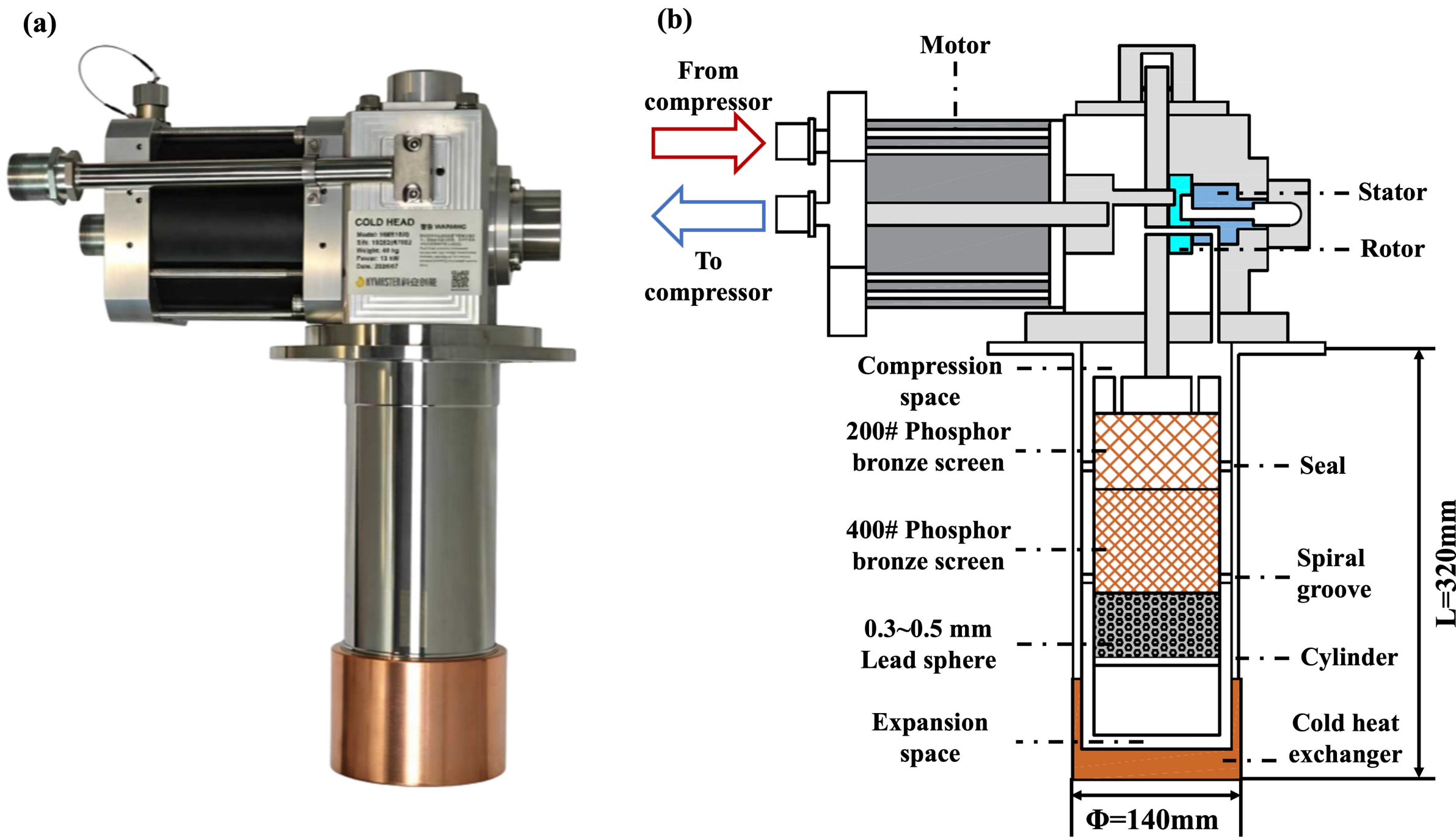
Cooling capacity

11.80% rCOP @ 20 K

Relative Carnot efficiency

12.62 K

Minimum no-load temperature

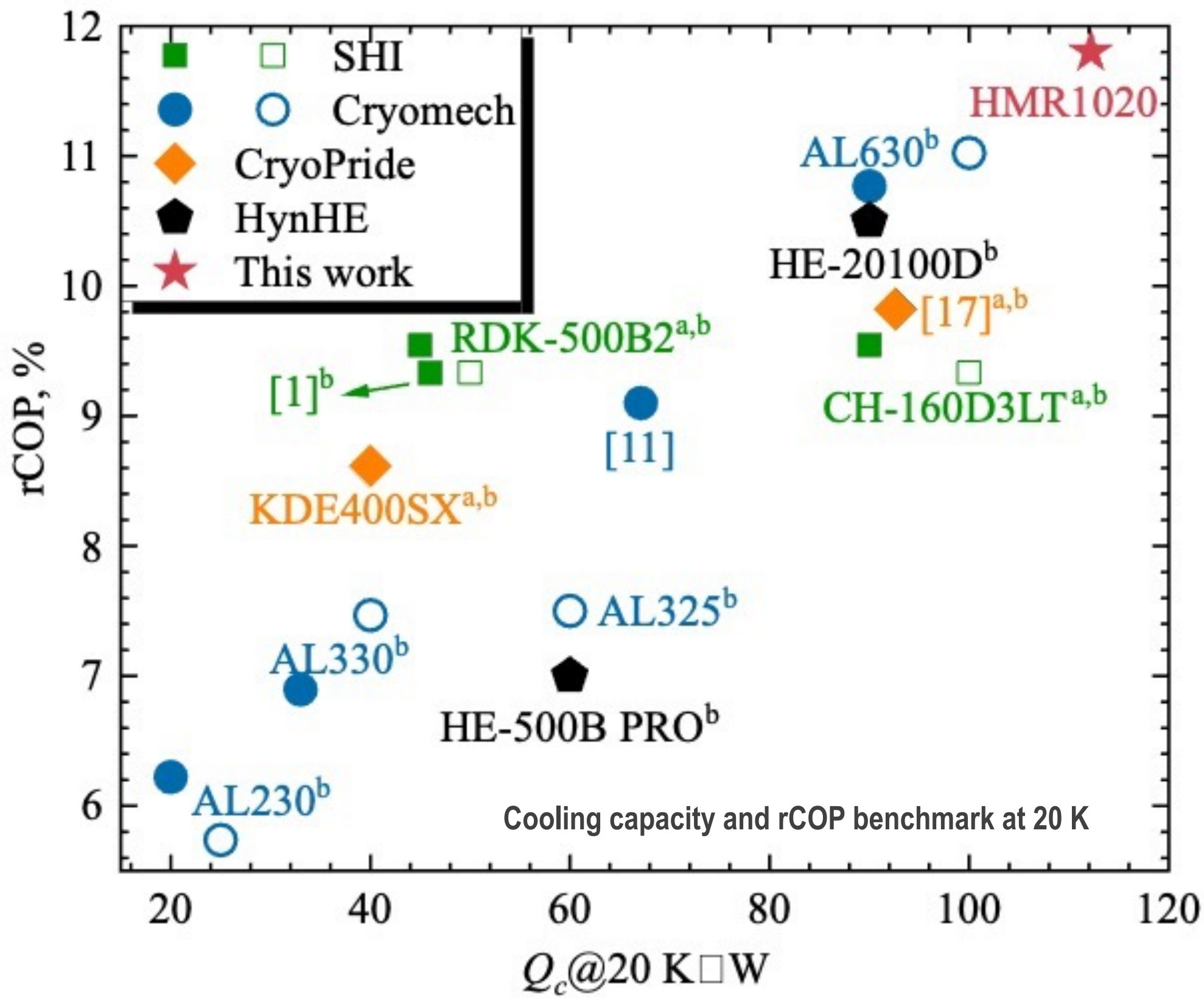
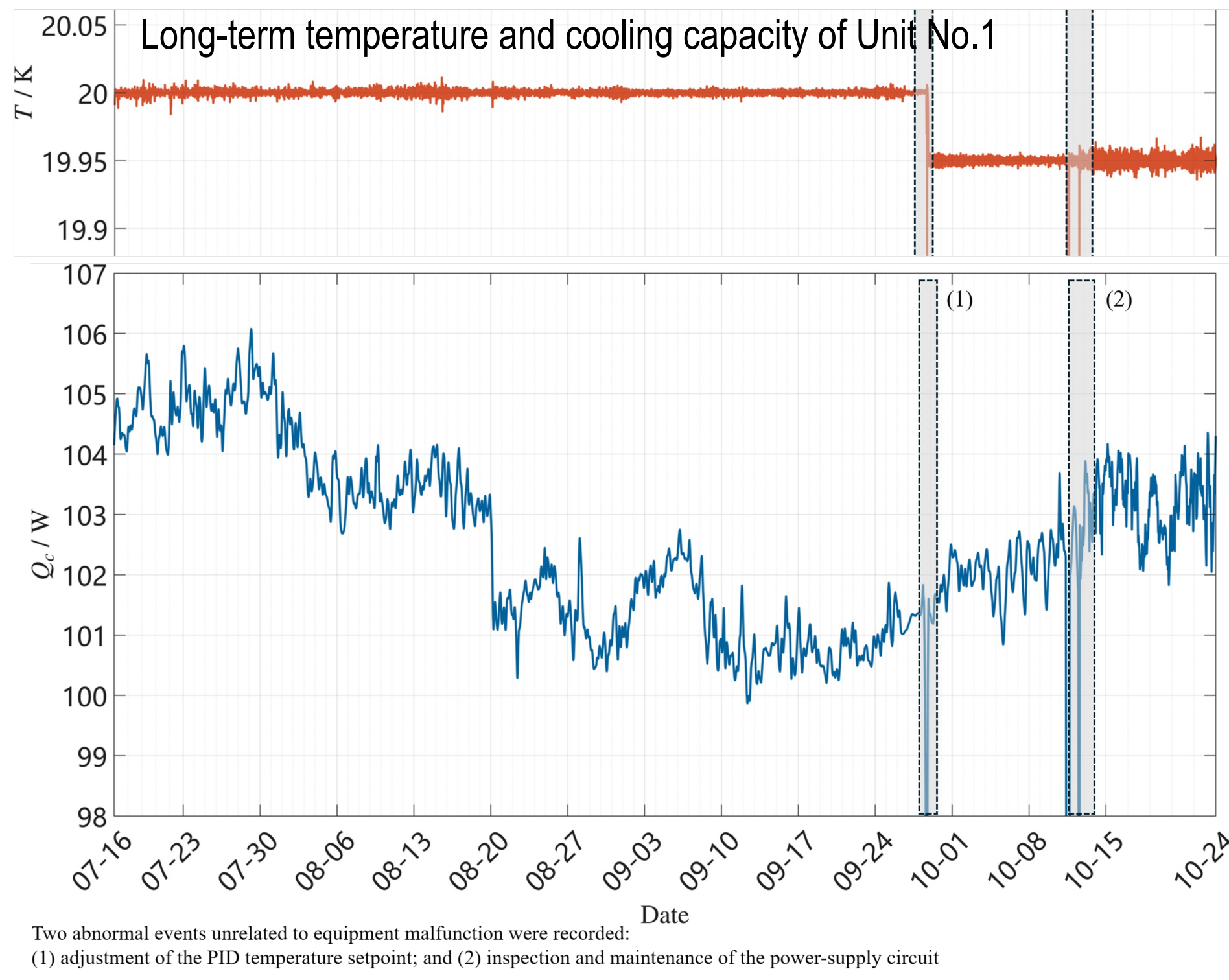


Key performance	
Cool-down time	~ 50 min
Fluctuation at 20 K	0.2 K
Charging pressure	1.9 MPa
Cold-head frequency	1.2 Hz

02 Reliability verification

Reliability is being verified through a time-censored test in accordance with GJB 899A-2009. Three units operate in parallel toward 11,000 cumulative unit-hours, with zero attributable failures required to demonstrate an MTBF above 10,000 h.

Reliability criteria	
Test fleet	3 units
Cumulative duration	11,000 unit-hours
Acceptance	0 attributable failures
MTBF target	>10,000 h
Cooling capacity after 10,000 h	> 95 W at 20 K



03 Supercritical helium circulation system

The 20 K supercritical helium circulation system demonstrator integrates four HMR1020 GM cryocoolers and a cryogenic turbine fan. Two parallel helium branches pass through two cold-end heat exchangers in series to provide rapid precooling and stable cryogenic operation for HTS systems. Furthermore, pressurized helium vessel associated a LIN-cooled cold trap is used for helium supply to maintain the system pressure during the cool-down process.

Cryogenic turbine fan	
Inlet temperature	20 K
Mass flow	60 g/s
Inlet pressure	20 bara
Pressure rise	50 kPa
Rated speed	28,300 rpm
Input power	<120 W
Expected efficiency	>70%
Impeller diameter	35 mm

Two-stage cold-end heat exchangers	
Mass flow	25 g/s
Helium inlet / outlet	21 K / 19.94 K
CH1 cold-head temperature	19.94 K
CH2 cold-head temperature	19.44 K
Total heat transfer	155.99 W
Total pressure drop	~ 1.8 kPa

