Present Status of Taiyo Nippon Sanso Neon Turbo-Brayton Refrigerator

Shigeru Yoshida

TAIYO NIPPON SANSO
The Gas Professionals

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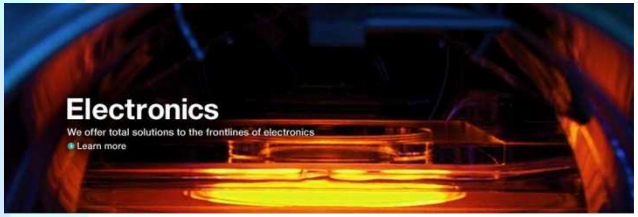
About Taiyo Nippon Sanso Corporation

Industrial gas

Plants & Engineering
（Air separation plant etc.）

Stable isotope (Medical)



Electronics

LP gas

Turbo-machinery

Cryogenic equipment

Refrigerator & Cooling System

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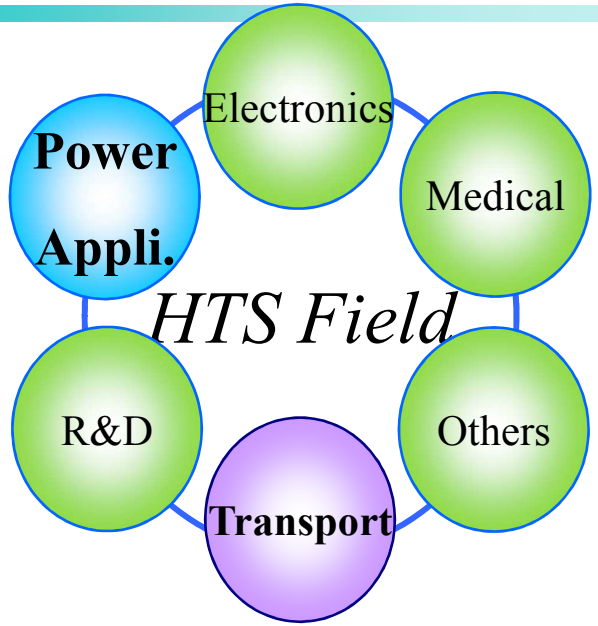
HTS applications

Power Cable



FCL

Railroad

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TNSC's Business Field in HTS Cable

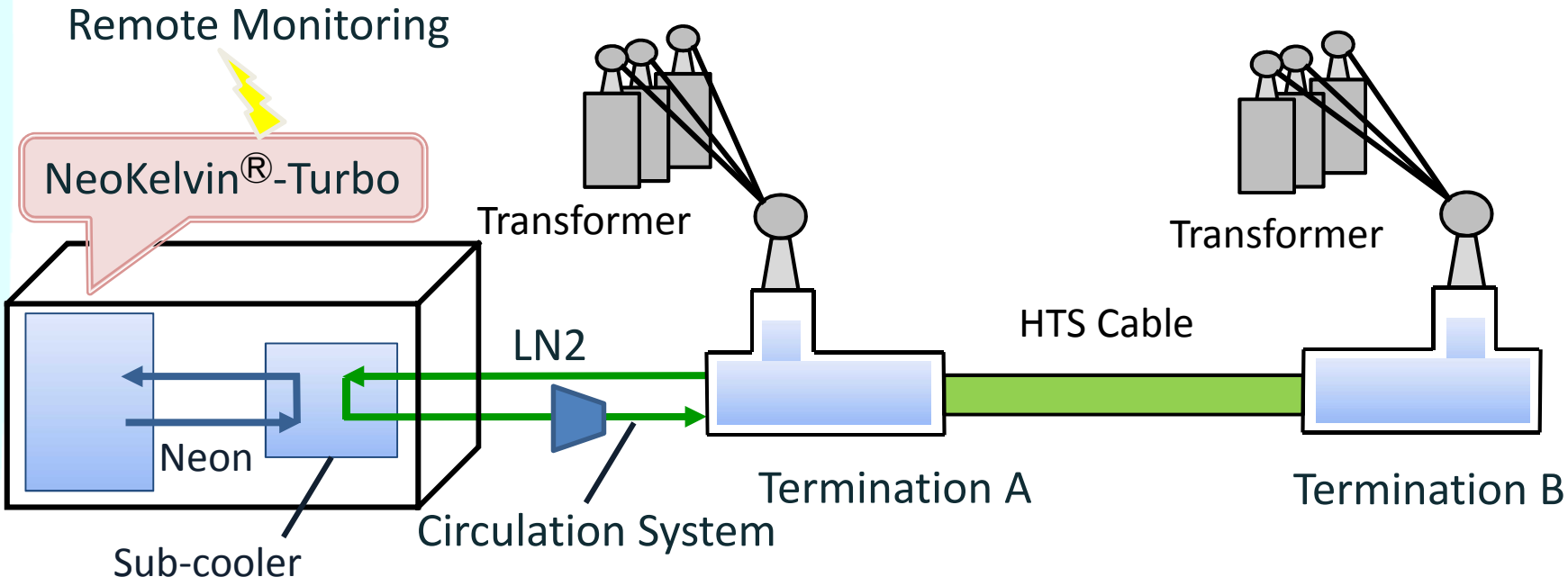
TNSC will provide HTS equipment cooling service to all over the world.

1) NeoKelvin® -Turbo (Neon Refrigerator)

2) Termination & Circulation System (Design and Manufacture)

3) Liquid Nitrogen

4) Remote Monitoring



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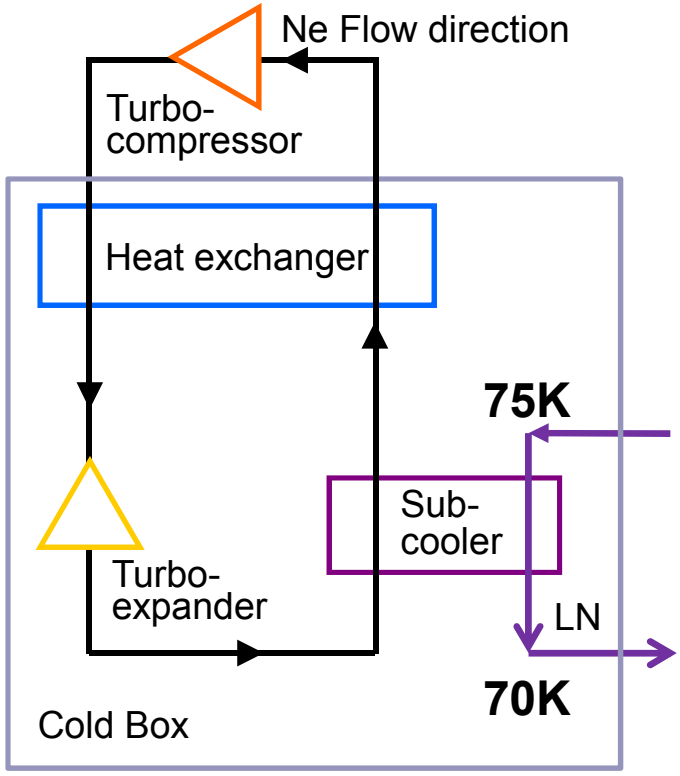
"NeoKelvin ® -Turbo" concept

- Neon gas is used as a working fluid
- Magnetic bearings are adopted in rotational machines
- Plate-fin heat exchanger is used as a sub-cooler



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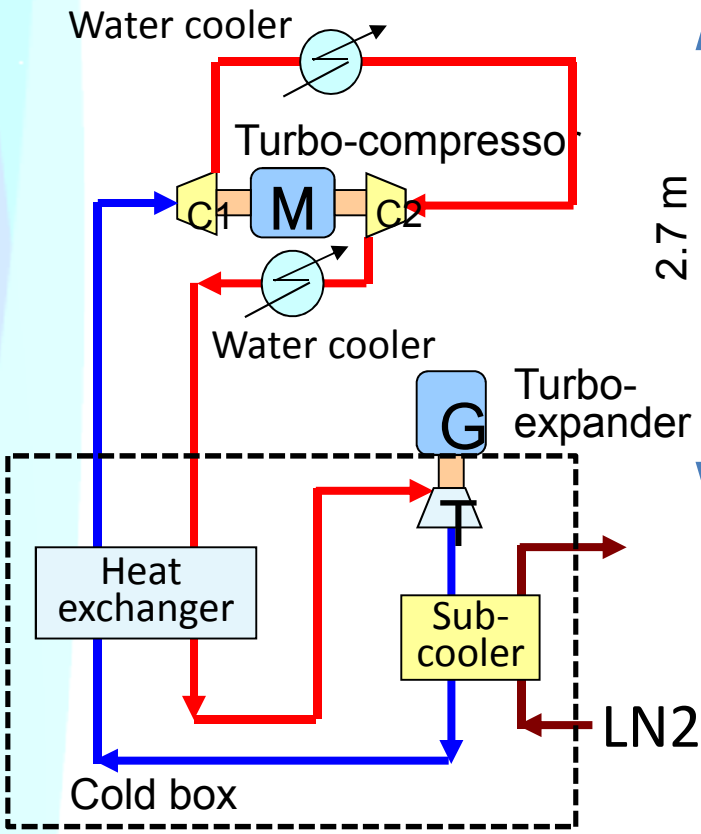
NeoKelvin®-Turbo 2kW

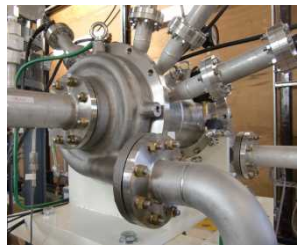
<Specification>

Cooling capacity 2kW at 70K

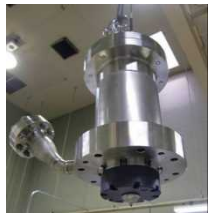
Input Power 55kW

Sub-cooler inside Cold box





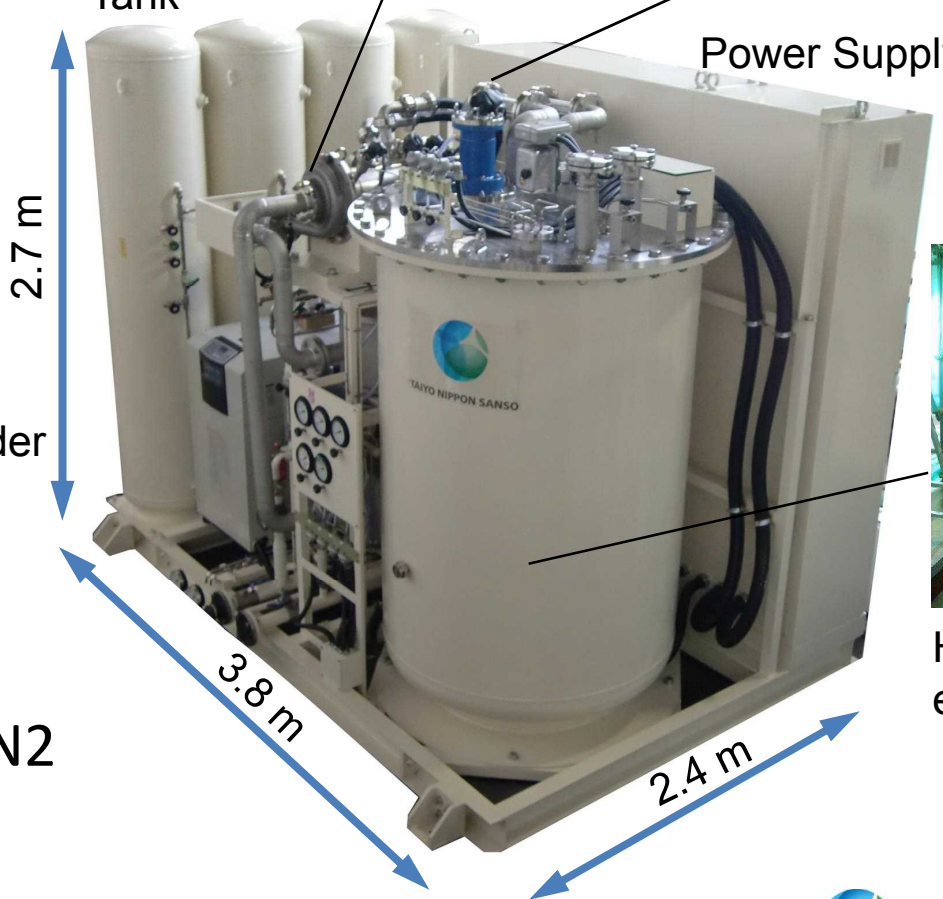
Turbo-Compressor



Turbine

Storage Tank

Power Supply Unit



Heat-exchanger

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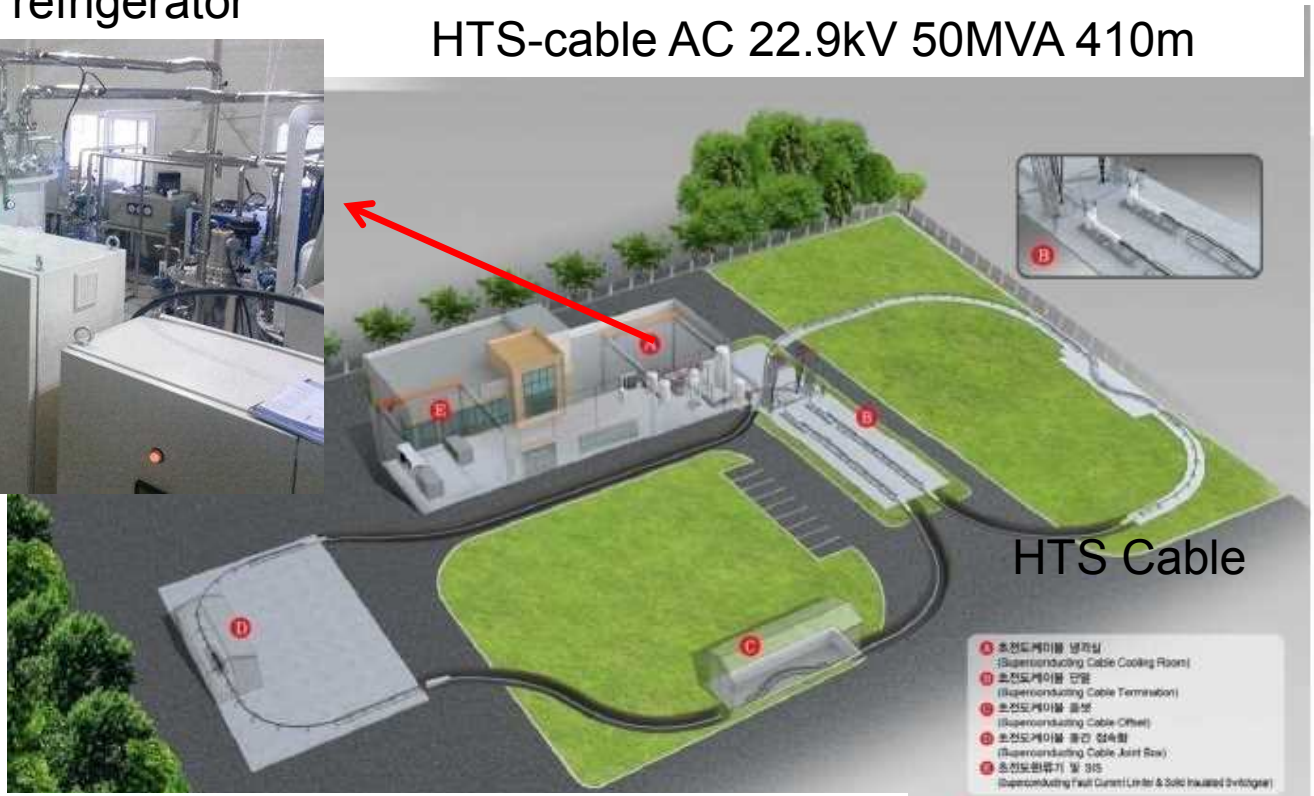
Icheon Substation Field Test

- The 2kW prototype was installed at Gochang test site in Dec. 2013, and moved to Icheon substation in 2015.
- The total operation time in Korea is more than 8500 hours

2kW prototype refrigerator

HTS-cable AC 22.9kV 50MVA 410m



Icheon substation bird's-eye view

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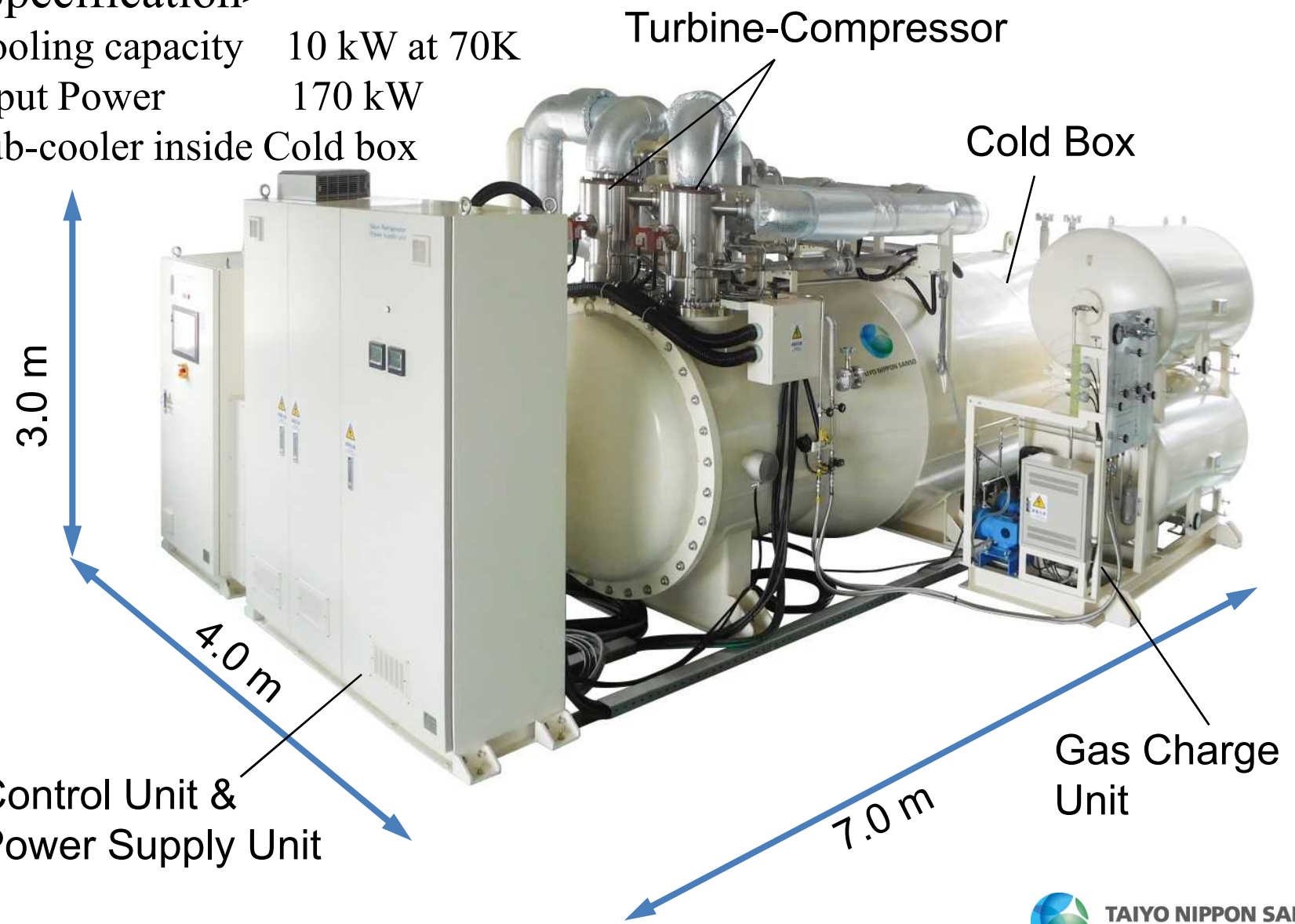
NeoKelvin®-Turbo 10kW

<Specification>

Cooling capacity 10 kW at 70K

Input Power 170 kW

Sub-cooler inside Cold box



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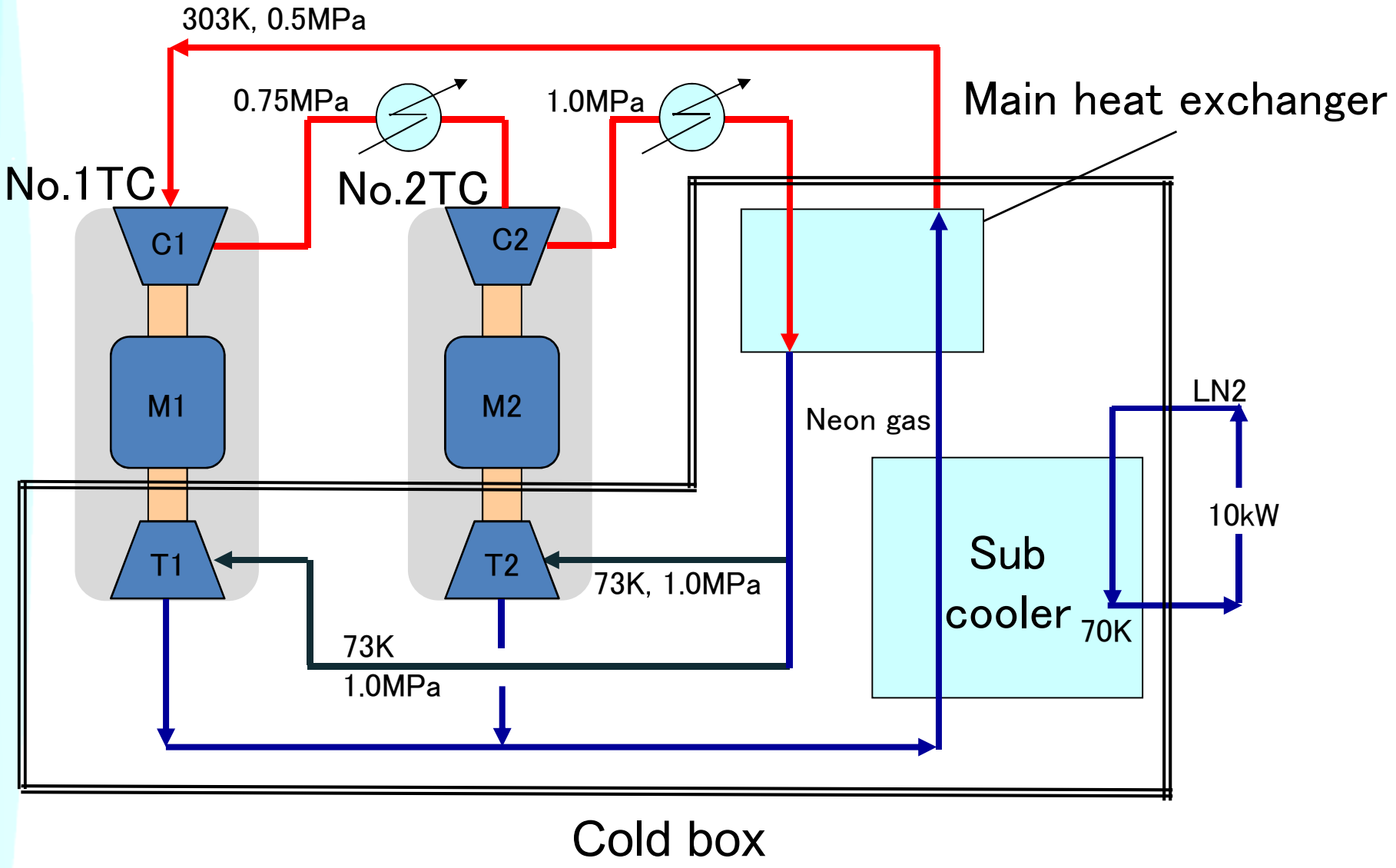
NeoKelvin®-Turbo 10kW Flow diagram



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Jeju Island Field Test (Energized at April 2016)

KEPCO, LSC
Superconducting Power System Center
HTS-cable AC 154kV 600MVA 1km

10kW Prototype Refrigerator

HTS Cable Terminals

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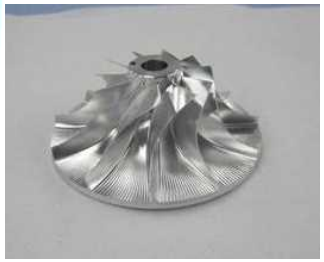
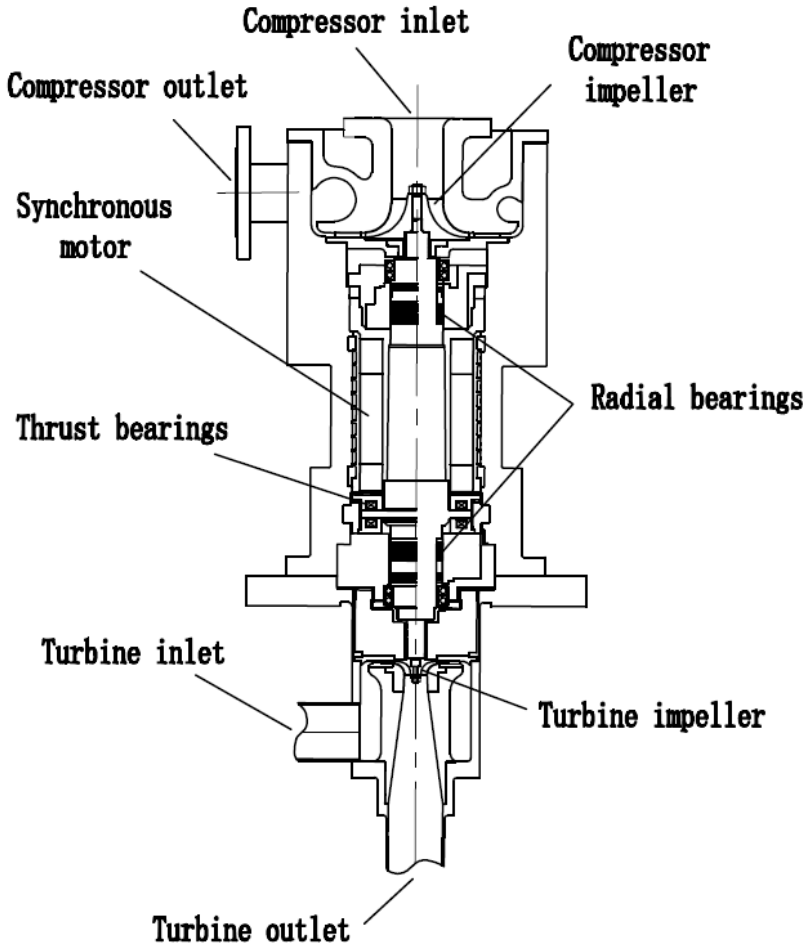
Turbine-Compressor

- Increased pressure ratio of compressor impeller
- Improved Motor performance
- Improved insulation structure for reducing heat-in leak

Compressor impeller



Turbine impeller



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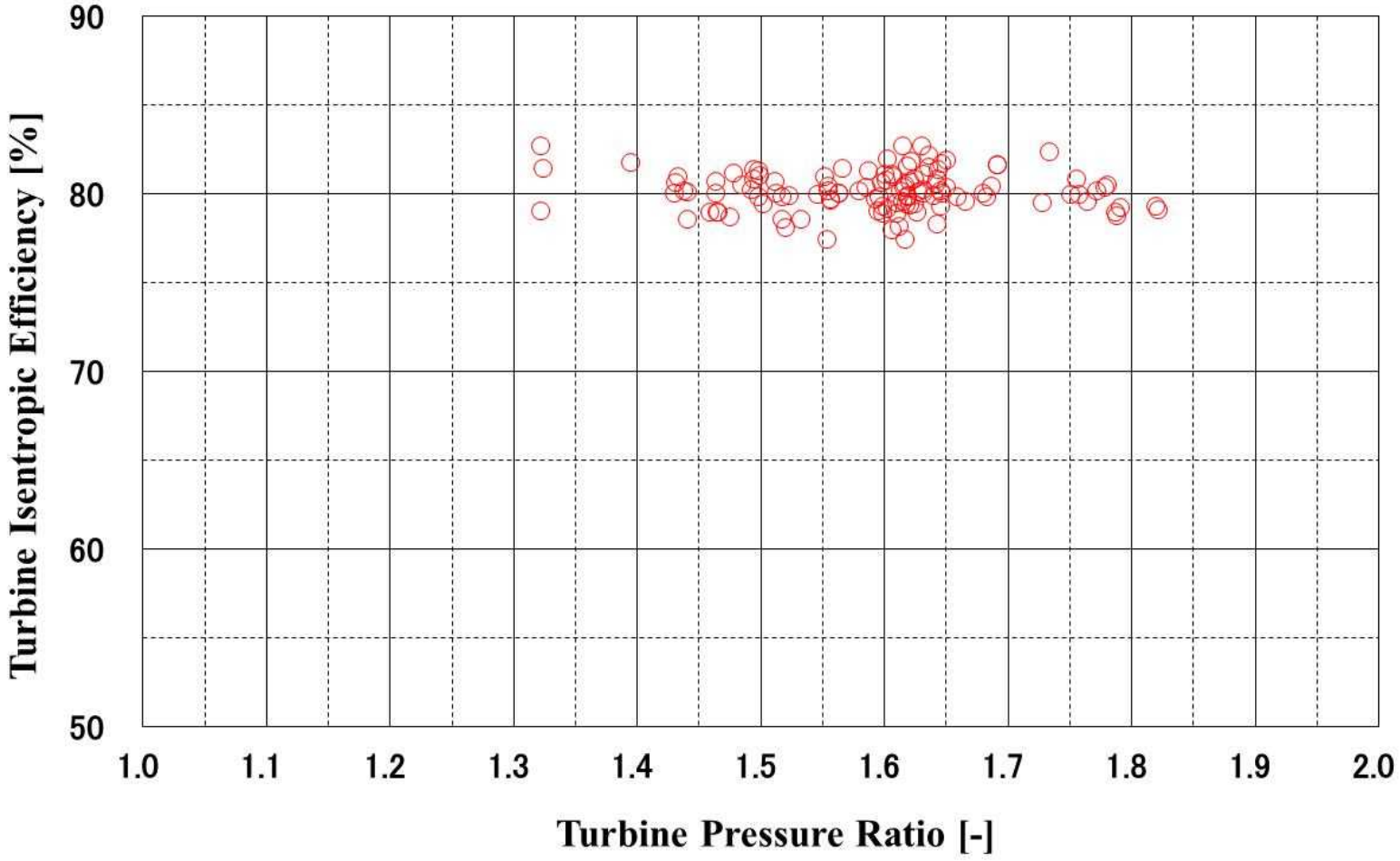
Performance of turbine of Improved TC

- Turbine efficiency was improved to 80 %
- Over 5kW cooling power was obtained by using one Improved TC



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Test Facility for NeoKelvin®-Turbo

- The new Testing House has been built in 2015
- Turbine-compressor can be tested under cryogenic condition using test facility
- Refrigerator can be tested in Testing house with Liquid Nitrogen Circulation

Test facility for
Turbine-compressor(TC) inspection

Cryogenic Testing House

Refrigerator Test Area

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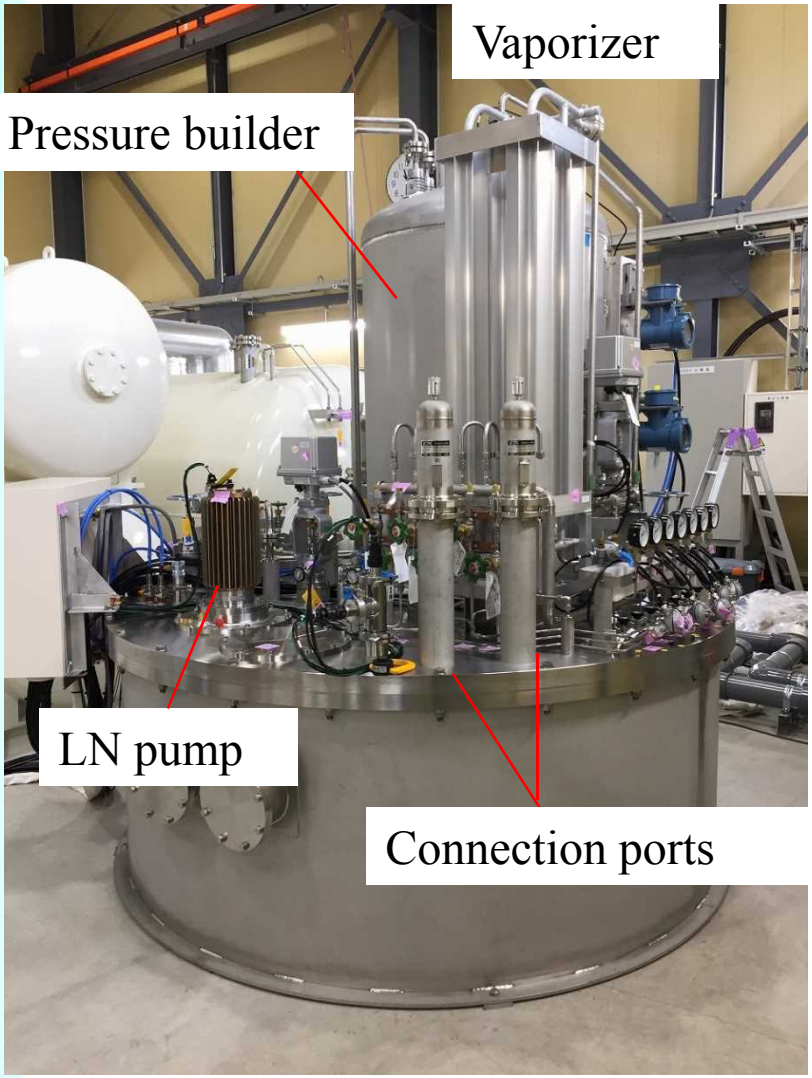
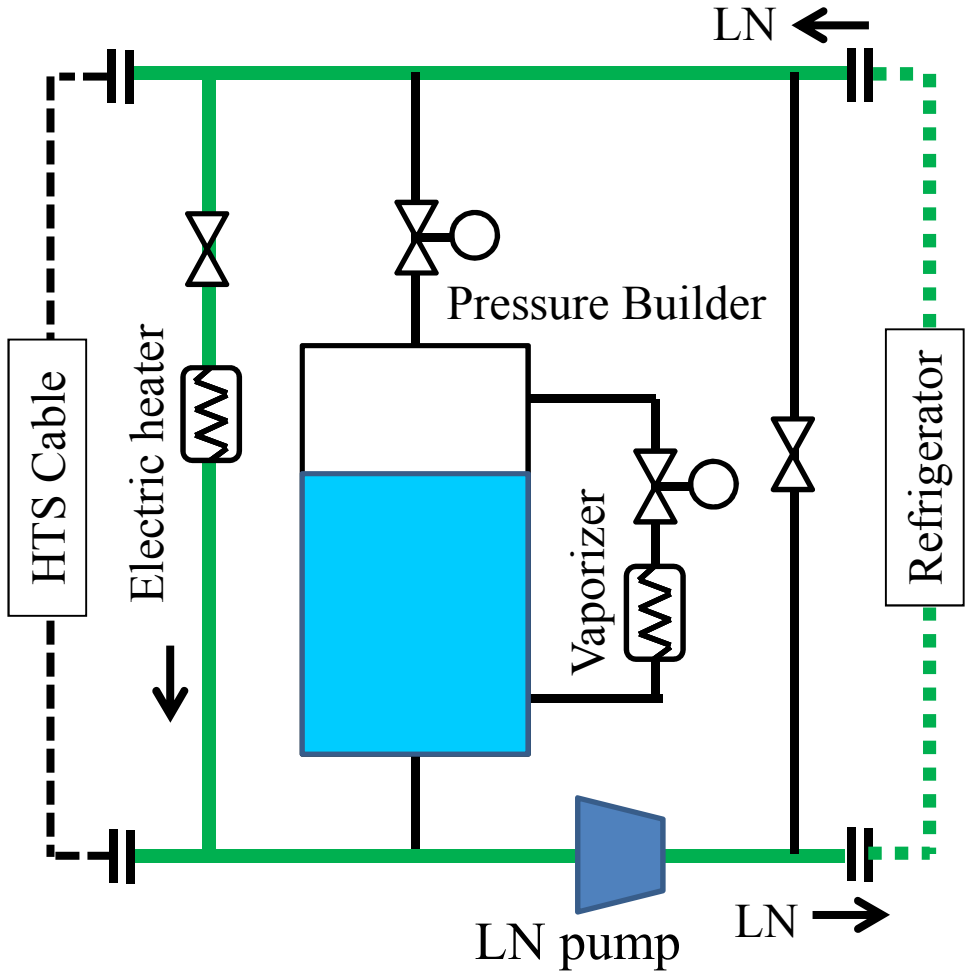
LN Circulation Unit



Refrigerator performance test flow diagram



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NeoKelvin®-Turbo User List

Year	User	Type	# of sets
2013	LSC/KEPCO	2kW Prototype	1
2014	Ishikari Project	2kW Commercial type	3
2015	LSC/KEPCO	10kW Prototype	1
2015	RTRI	2kW Commercial type	1
2016	SWCC	2kW Commercial type	1
2017	KEPCO	10kW Commercial type (7.5kW spec.)	1
2018	SOX	2kW Commercial type	3

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Summary

- Total operation time of 2kW prototype refrigerator is more than 8,500 hours in KOREA.
- 10kW prototype refrigerator has been operated suitably for cooling HTS cable for ten months in Jeju.
- Turbine-Compressor (TC) performance was improved to get cooling power of 10kW.
- Improved TC has been operated continuously for seven months in the test facility. Operation will be extended to 12 months.

Thank you

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