Commissioning of the Warm Compressor System for the ESS Accelerator Cryoplant

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CEC/ICMC 2019, Hartford, USA, 25th July 2019

Outline

1. ACCP Overview
2. Warm Compressor System Overview
3. Final Acceptance Tests
4. Selected Issues
5. Summary

1. ACCP Overview

Users and Performances

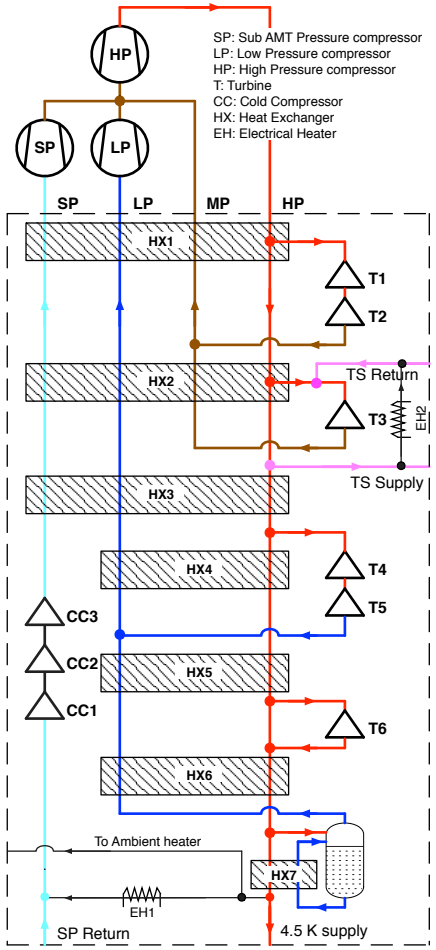
- **ESS superconducting LINAC**
  - 43 (+14) Cryomodules
  - Cryogenic Distribution System
- **Temperature levels**
  - Superconducting cavities @ 2 K
  - Thermal shield @ 40 -50 K
  - Couplers cooling @ 4.5 K – 300 K

- **Heat loads**
  - 3 kW @ 2 K
  - 9 g/s @ 4.5 K
  - 11380 W @ 40-50 K
- **Continuous Operation**
  - 24 h per day / 7 days per week
  - 2 years without scheduled shut-down
- **Availability**
  - > 99 % not count utilities & process control

1. ACCP Overview

System features

- **Three warm compressors, six turbines, three cold compressors and several bunches of plate fin heat exchangers**
- **Mixed compression cycle at 2 K plus helium guard system for SP compressor**
- **Capacity control**
  - Floating pressure cycle for HP compressor
  - VFD for SP, LP compressors and CCs
  - Exchange of CCs flow parts
- **All built-in acceptance test equipment**
- **Energy recovery**



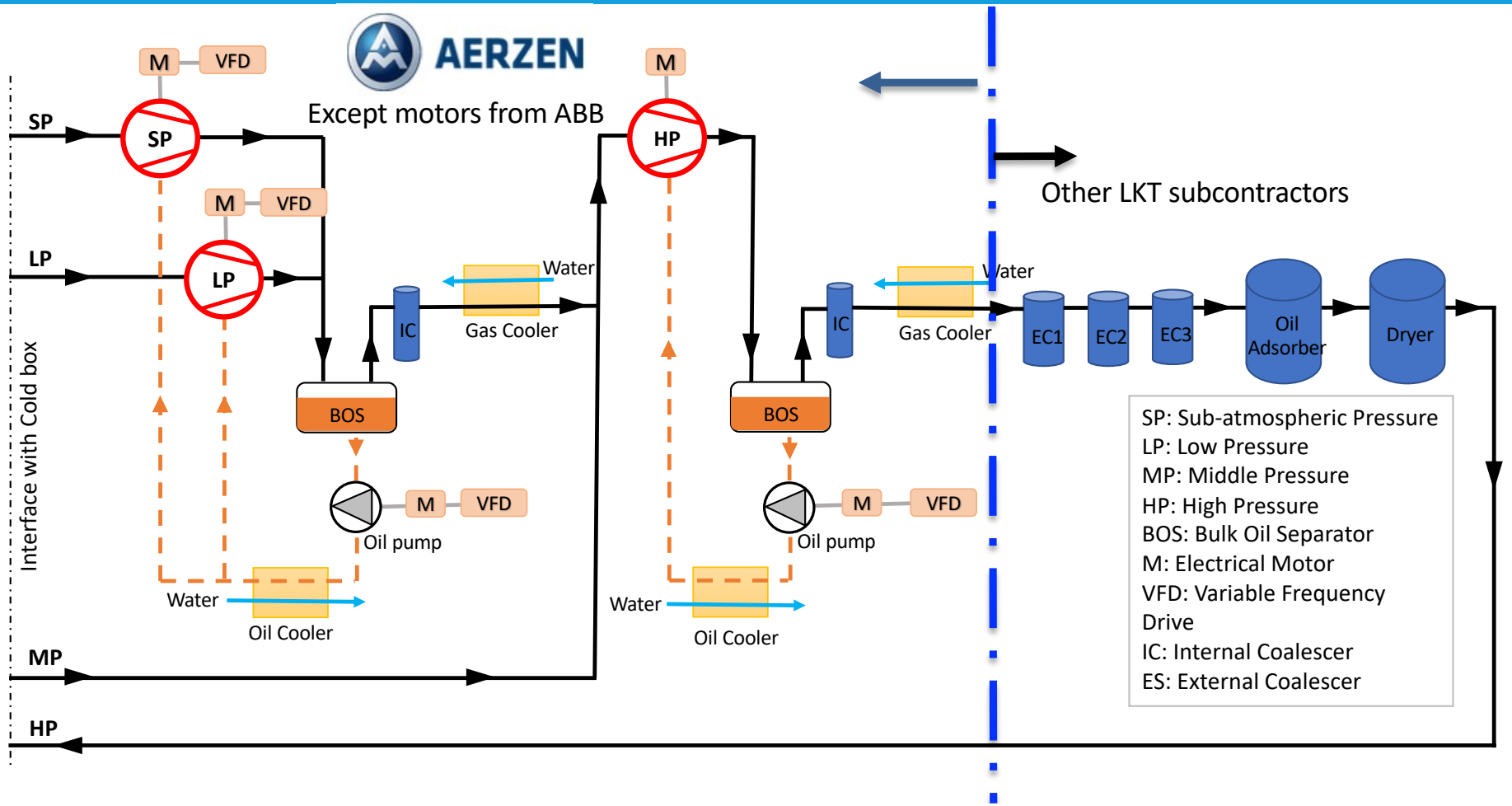
1. ACCP Overview

System parameters

Main electrical power	2.37 MW					
Power at 4.5 K equivalent	~9 kW with exergy efficiency 25.9%					
	Vi	Psuc, bara	Pdis, bara	$\dot{m}$, g/s	Ps, kW	VFD
SP compressor (33K/71K)	4.0	0.607	4.25	117	303	Yes
LP compressor (33K/83K)	2.6	1.05	4.25	285	516	Yes
HP compressor (40K/83K)	2.6	4.05	20.5	735	1383	NO
Impurity removal (ORS/dryer/cryogenic adsorbers)	Oil	BOR (1000 ppm) - Coalscer in skid (10 ppm) - FOR (0.5 ppm Aerosols and 10 ppb Vapour)				
	Water	One bed on line dryer (0.1 ppmv)				
	Air	Two 80 K Adsorbers (73 K, 20 bar) and one 20 K adsorber (24 K, 20 bar)				
Liquid He storage	20'000 Dewar (2.2 tons) + Subcooler in cold box (1500 liter)					
Warm He storage tank	14 X 70 m^3 at 20 bar (2.7 tons) (CMs + CDS + ACCP in total)					

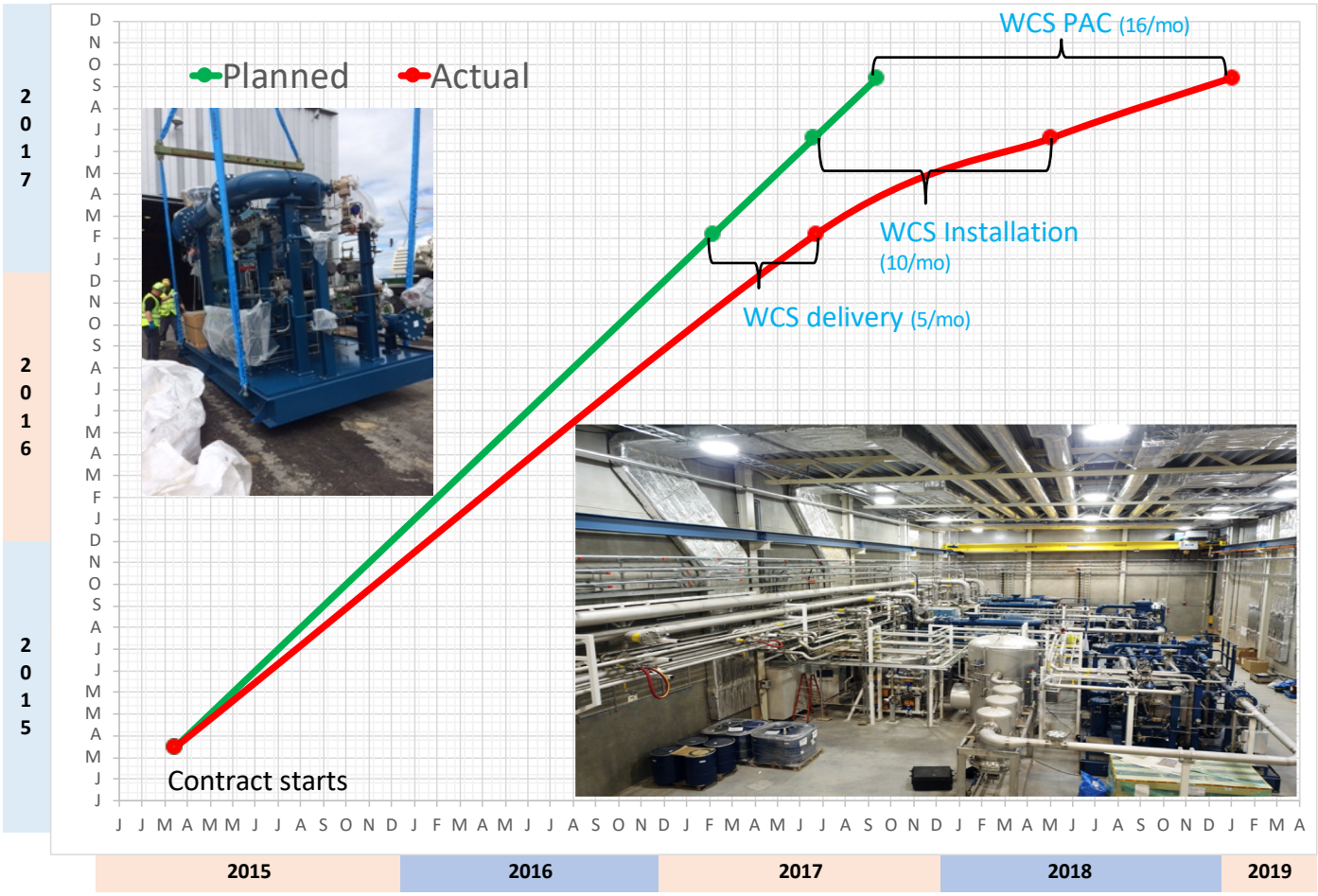
2. Warm Compressor System Overview

Layout



2. Warm Compressor System Overview

Schedule



3. Final Acceptance Tests and Results

General test procedures

Aerzen workshop

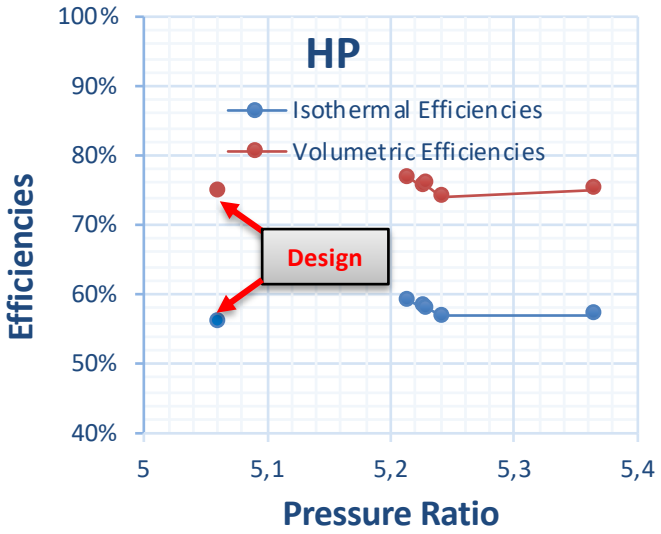
- Pressure and leak tests
- Functional tests with ambient air
  - Minimum of two hours
  - Restrictions: test motor capacities

ESS site

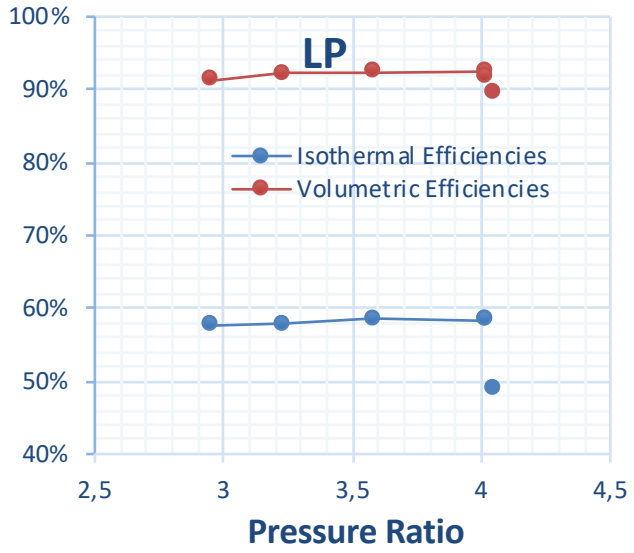
- Mechanical completion inspection
- Electrical installation inspection
- Control loop check
- Documentation completion check
- Functional tests
- 100 hours full load, steady-state run
- 2 hours partial loads, steady-state run

3. Final Acceptance Tests and Results

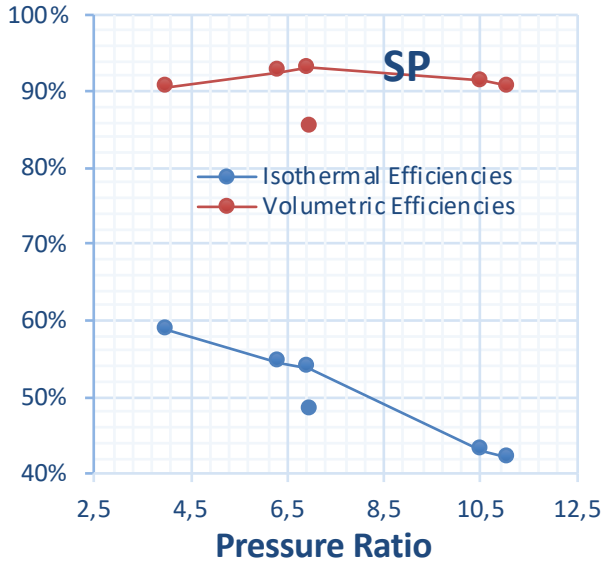
Results and Conclusions



$\eta_{iso} = 59.1$ $\eta_v = 76.9$



$\eta_{iso} = 58.4$ $\eta_v = 92.5$

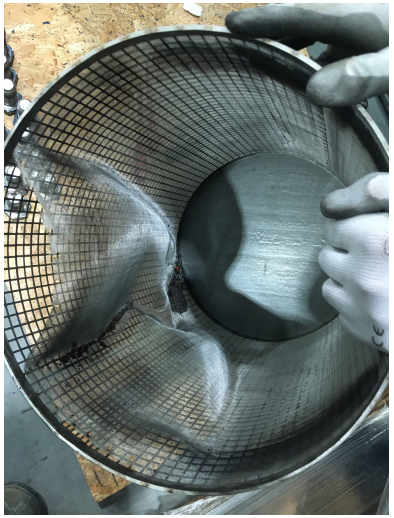


$\eta_{iso} = 53.9$ $\eta_v = 93.1$

- **The state of art isothermal and volumetric efficiencies**
- **Mass flow and power consumption is fulfilled**
- **Impurities keep constant during tests (N_2: 15 vpm, H_2O: 5 vpm)**
- **Vibration less than 3 mm/s (Design: 10 mm/s)**
- **The WCS had been handed over to LKT**

4. Selected Issues

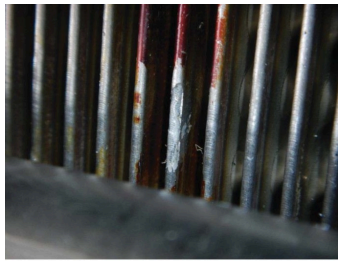
HP compressor damage



- **Incident**
  - LKT and Aerzen PLC communication lost
  - Suction and discharge valves closed
  - HP compressor kept run
  - Suction pressure dropped <0.05 bar
  - Pressurized oil pushed the radial bearing
  - Movement of bearing sheared off the T sensor
  - Trip the HP compressor
- **Root cause**
  - Lack of suction low pressure and vibration trip signal
  - Huge reverse oil flow broke the suction strainer
  - Dust and particles dropped into the compressor
- **Implementations**
  - Add low suction pressure, both vibration sensors over-range and PLC communication loss trip signals
  - Re-use or repair is under discussion

4. Selected Issues

Two oil coolers leaky by corrosions (Six months delay)



- **Key components failure or damage**
  - Take time for trouble shooting, decision making and replacement
  - Sub-contractor's quality control and reliability

4. Selected Issues

Under estimation of ESS CF work and ESS site work coordination and conflicting schedule (Four months delay)

Concrete foundation of compressor skids

Site work coordination and conflicting

5. Summary

- **The ESS ACCP warm compressor system had been commissioned and successful passed the final 100 hours acceptance tests**
- **The compressor performances are beyond the guaranteed ones**
- **They have proved to be efficient, reliable and possibly maintained**
- **The compressor system has been handed over to LKT**
- **The ACCP is planned to be finished at the end of this year**

Acknowledgements

Team works by Aerzen/LKT/ESS

Aerzen Roland Wischhoefer, Mattias Staedler, Ali Jaber

LKT Jens Rother, Paolo Selva

ESS Per Nilsson, Johnny Råström, Romain Goncalves, Mattias Olsson

Many others involved