The Accelerator Cryoplant at ESS

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Cryogenic cooling is vital for the ESS proton linac

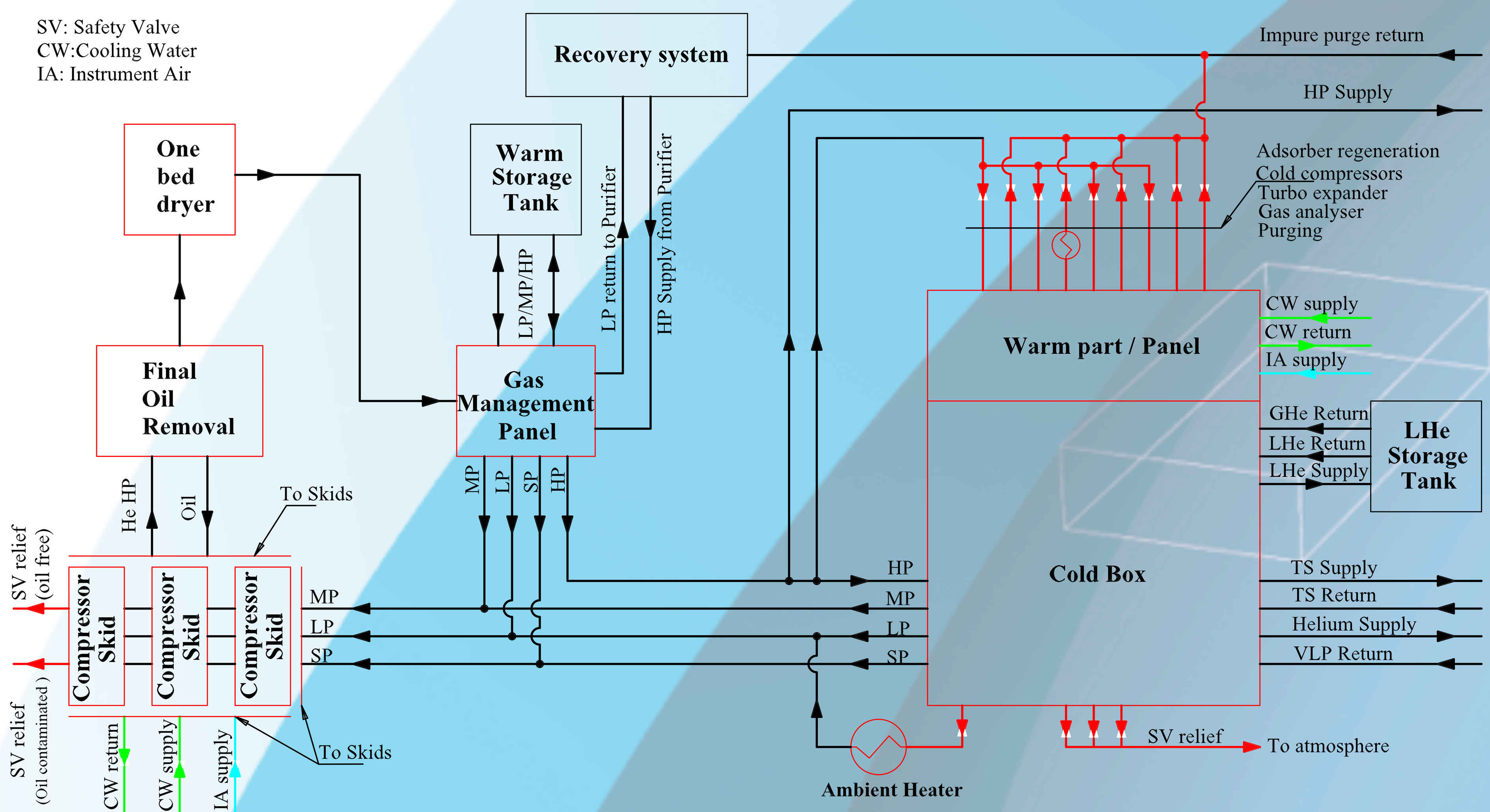
The accelerator cryoplant (ACCP) is the biggest piece of cryogenic equipment at ESS besides the target moderator cryoplant (TMCP), the test and instruments cryoplant (TICP), cryogenic helium and nitrogen distribution and storage facilities and auxiliary equipment. The ACCP shall

- Provide 2K cooling for the spoke and elliptical cavities in up to 57 cryomodules
- Provide liquid helium for cooling the RF main power couplers
- Provide thermal shield cooling for cryomodules and distribution system

The ACCP specification has been released in June 2014, contract award is expected in the beginning of 2015.

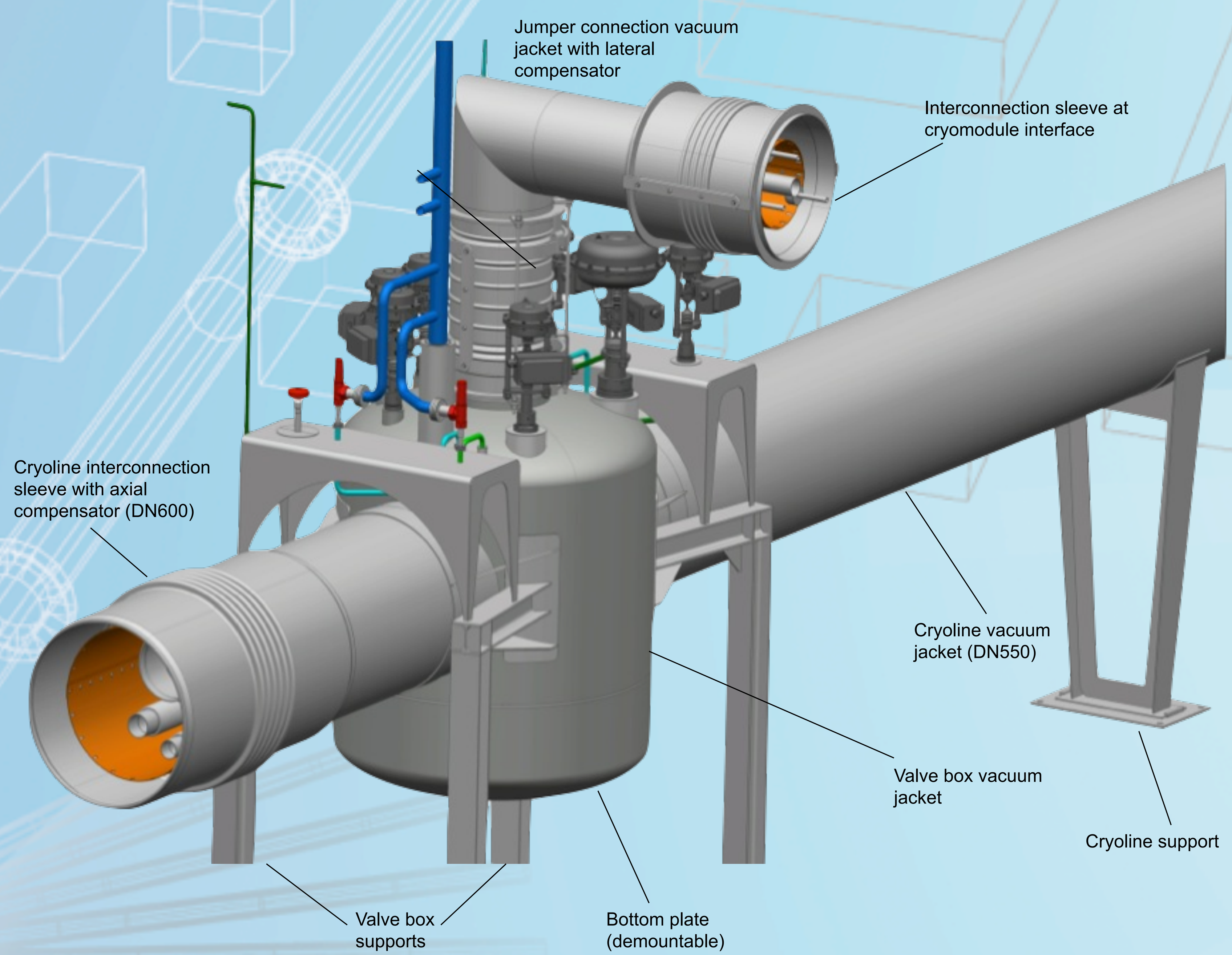
Main Components of ACCP

- The warm compressor station circulating helium at the flows and pressures required by the ACCP cold section
- Helium gas treatment comprising bulk and final oil removal and a gas dryer
- Gas management panel for process control
- One coldbox containing all required equipment to provide the specified cooling,
- An ambient heater to assist warm-up of the system or the cool-down of single cryomodules
- Warm helium storage, liquid helium storage tank with 2nd fill, recovery system, distribution system etc. are separate procurements or in-kind contributions



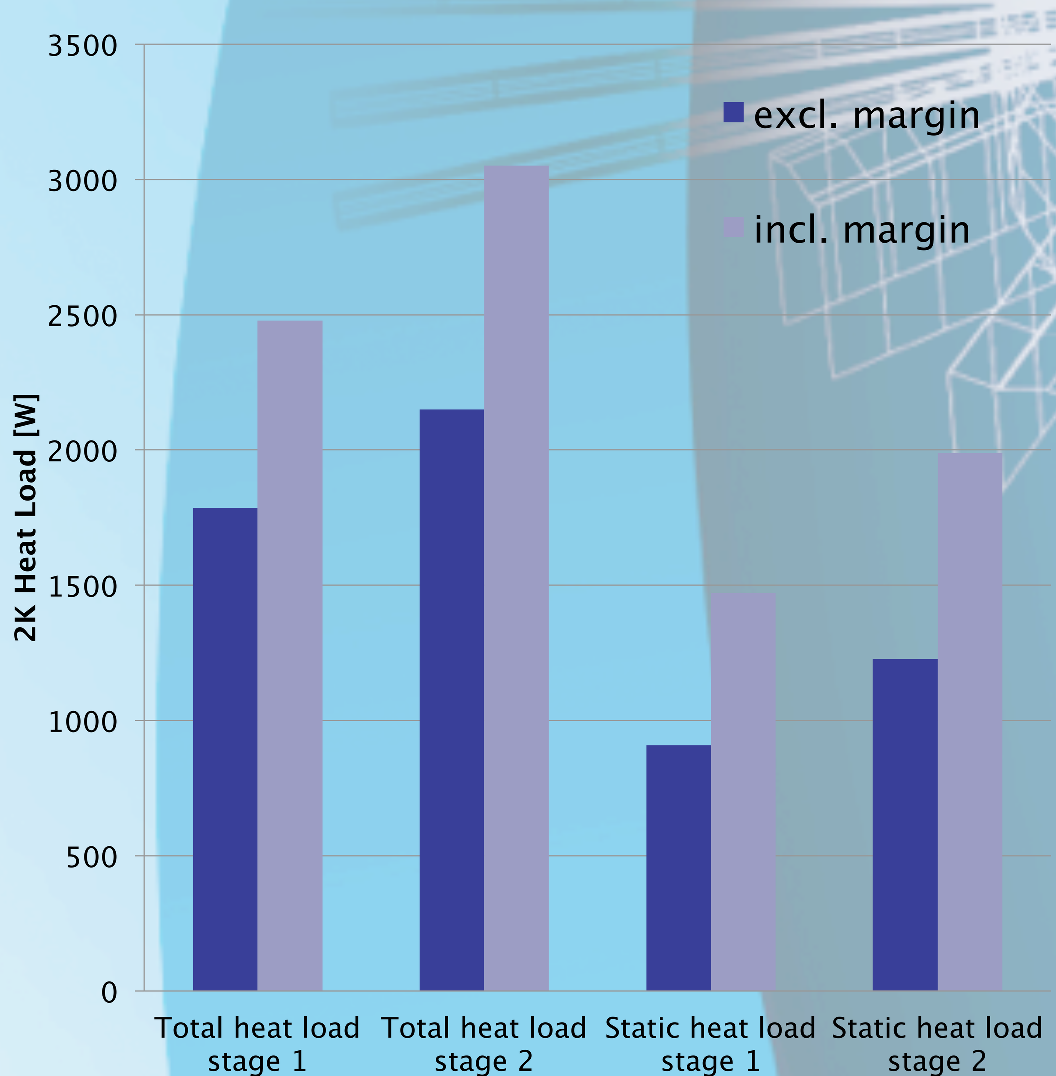
Evaluation Criteria

- ESS will award the contract to the bidder presenting the economically most advantageous tender, which includes considerations of capital cost (30 scores), operational cost (30 scores) and qualitative aspects (40 scores)
- Operational cost is calculated using the indicated electrical power consumption of the warm compression system in a pre-defined operational regime, comprising a mix of full and part load cases. The indicated consumption will be subject to a bonus and penalty regulation in the future site acceptance tests to prevent over-optimistic energy consumption estimates in the bidding phase
- In the qualitative evaluation scores are distributed to a number of criteria as e.g. compliance to the technical specification, simplicity of design and plant layout, control strategy, liquefaction capacity and offered additional features
- By assessing the plant concept, layout and equipment and the number of cold and hot spares ESS engineers estimate the plants availability of the different offers
- Assessing recovery times from trips of rotating machinery by requested preliminary descriptions of failure scenarios and mitigation strategies along with assumptions on how long it takes to resume normal operation without equipment damage



Design Choices

- Production of 2 K helium in the tunnel by means of a 2 K heat exchanger and a subsequent Joule-Thomson valve in each of the cryomodule–valve box assemblies, permitting independent warm-up / maintenance / cool-down of single cryomodules while the rest of the system is maintained in cold condition
- Combination of cold and warm compression stages ensuring high flexibility regarding load adaption at optimal efficiency
- One integrated coldbox for all cold ACCP components providing highest space and investment cost saving
- No LN2 pre-cooling as the load is dominated by 2K refrigeration (~80%) and low cold mass (~20 tons) does not impose tough cool down requirements. Only expansion turbines will provide the cryogenic refrigeration in the ACCP, increasing reliability, capital cost saving and traffic reduction.
- Staged design by by means of two sets of flow parts for cold rotating equipment, turbine expanders and cold turbo compressors, and variable frequency drives in the warm LP compressor system for high flexibility at required long term load adaption
- ACCP control system based on local PLCs for internal, time critical and deterministic control loops and safety functions while supervisory controls and high level batch operations run in the EPICS process controller. HMI, alarm handling and data archiving are based on EPICS. This functional split between local PLCs and EPICS IOC provides safe operation even in case the EPICS IOC shuts down, while the ACCP control system is compatible with the other linac control, providing all advantages of an open control system.
- Compressors coolers designed to minimize the temperature differences between cooling and warming flows to achieve high temperature spread between inlet and outlet of the cooling water. Besides reducing the required cooling water flow the water returns at elevated temperatures, enabling efficient heat recovery to serve Lunds district heating system and other potential greenhouse applications



Operation modes		2 K Load, W			4.5 K Load		40–50 K, W
		Isothermal	Non-isothermal	Total	4.5 K, W Total	Liquefaction, g/s	Total
Stage 1: 2019–2023	Nominal	1860	627	2478		6.8	8551
	Turndown	845	627	1472		6.8	8551
	Standby				1472	6.8	8551
	TS Standby	–	–	–		–	8551
	Maximal Liquefaction	Loads in standby mode plus maximum liquefaction rate at rising level into the storage tank					
Stage 2: 2023–…	Nominal	2226	824	3050		9.0	11380
	Turndown	1166	824	1990		9.0	11380
	Standby				1990	9.0	11380
	TS Standby	–	–	–	–		11380
	Maximal Liquefaction	Loads in standby mode plus maximum liquefaction rate at rising level into the storage tank					

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