

Form Annex 1 Design specification

1.1 Design specifications

The specifications are not final yet and can change. Gasunie retains the right to change the specifications.

1 Airfin-cooler for the TEG (Triethylene glycol) unit

Design Pressure	Pd	90	Bar(a)	
Design Temperature	Td	80	deg. C	
Maximum flow	Qmax	40	Ton/hr	Pure hydrogen (note 1)

2 An airfin-cooler for the interstage of the hydrogen compressors.

Design Pressure	Pd	140	Bar(a)	
Design Temperature	Td	160	deg. C	
Maximum flow	Qmax	20	Ton/hr	Pure hydrogen (note 1)

3 An airfin-cooler for the discharge of the hydrogen compressors.

Design Pressure	Pd	220	Bar(a)	
Design Temperature	Td	160	deg. C	
Maximum flow	Qmax	20	Ton/hr	Pure hydrogen (note 1)

Note1: 40 ton/hr or 20 ton/hr is based on pure hydrogen and does not incorporate impurities. The hydrogen concentration can be between 98 and 100 mol%. When 98mol% the overall mass flow will be more than 40 of 20 Ton/hr due to the impurities present in the gas.

1.2 Process conditions

Per Airfin-cooler 2 cases are given:

1. Design case at maximum capacity and high ambient conditions.
The airfin-cooler should be large enough to provide sufficient cooling capacity.
2. Worst case at minimum capacity and low ambient conditions.
At low ambient conditions the water that condenses due to the arfin-cooler should not freeze causing a plug and potential damage to the cooler and downstream equipment. The minimum temperature of the gas and tube wall shall be above 3°C.

Due to the condensation of water in the airfin-cooler during standstill and low ambient conditions the air-fin cooler design should make sure that all free water can drain towards the TEG contactor or compressor separators.

Note: The data indicated in the below tables is preliminary and needs to be verified with the TEG and Compressor vendor during detailed design once these vendors have been selected.

TEG coolers:

Design case Airfin-cooler for 1 TEG (Triethylene glycol) unit (maximum capacity)			
Maximum gas Capacity:	40.000	[kg/h]	Pure hydrogen (note 1,4)
Water content gas:	Saturated at operational pressure and temperature		
Maximum gas operational pressure in:	90	[bar(a)]	
Normal gas Operational pressure in:	71	[bar(a)]	
Minimum gas Operational pressure in:	30	[bar(a)]	Note 1
Maximum gas Operational temperature in:	70	[deg. C]	
Maximum gas Operational temperature out:	40	[deg. C]	
Minimum gas Operational temperature out:	3	[deg. C]	Note 3
Inlet air temperature	30	[deg. C]	
Worst case Airfin-cooler for 1 TEG (Triethylene glycol) unit (minimum capacity)			
Minimum gas Capacity:	4000	[kg/h]	Pure hydrogen (note 1, 4)
Water content gas:	Saturated at operational pressure and temperature		
Maximum gas operational pressure in:	90	[bar(a)]	
Normal gas Operational pressure in:	71	[bar(a)]	
Minimum gas Operational pressure in:	30	[bar(a)]	Note 1
Minimum gas Operational temperature in:	25	[deg. C]	Note 2
Maximum gas Operational temperature out:	40	[deg. C]	
Minimum gas Operational temperature out:	3	[deg. C]	Note 3
Inlet air temperature	-20	[deg. C]	

Note 1: During normal operation the pressure in the airfin-cooler will be 71 bar(a). If the pressure control valve fails in the discharge of the TEG unit the pressure could drop to 30 bar(a). This is not a

normal operational scenario but the airfin-cooler should mechanically not be damaged due to high velocity of the gas.

Note 2: The minimum cavern temperature is 50°C at 80 barg. At low ambient conditions (ground temperature of 5°C and air temperature of -20°C) and a low gas flow rate (4000kg/hr) the gas can cool to approximately 25°C.

Note 3: At minimum flow conditions the minimum gas temperature and tube wall temperature of the airfin-cooler must be above 3°C to prevent freezing of free water.

Note 4: During normal operation the maximum flow is 40 000kg/h. There are fail scenarios of the control system where the hydrogen flow can briefly go up to 80 000kg/h at 71barg. This is not a normal operational scenario but the airfin-cooler should mechanically not be damaged due to high velocity of the gas.

Compressor interstage coolers:

Design case Airfin-cooler for 1 interstage compressor (maximum capacity)			
Maximum gas Capacity	20.000	[kg/h]	Pure hydrogen (note 1)
Water content gas:	See dewpoint curve		
Gas Operational pressure in:	88	[bar(a)]	
Gas Operational temperature in:	133	[deg. C]	
Maximum gas Operational temperature out:	40	[deg. C]	
Air temperature at inlet of the Cooler	30	[deg. C]	
Worst case Airfin-cooler for 1 interstage compressor (minimum capacity)			
Minimum gas Capacity	13 000	[kg/h]	Pure hydrogen (note 1)
Water content gas:	See dewpoint curve		
Gas Operational pressure in:	75	[bar(a)]	
Gas Operational temperature in:	15	[deg. C]	
Maximum gas Operational temperature out:	40	[deg. C]	
Minimum gas Operational temperature out:	3	[deg. C]	Note 3
Air temperature at inlet of the Cooler	-20	[deg. C]	

Compressor Discharge coolers:

Design case Airfin-cooler for discharge compressor (maximum capacity)			
Maximum gas Capacity	20.000	[kg/h]	Pure hydrogen (note 1)
Water content gas:	See dewpoint curve		
Gas Operational pressure in:	201	[bar(a)]	
Gas Operational temperature in:	133	[deg. C]	
Maximum gas Operational temperature out:	40	[deg. C]	
Air temperature at inlet of the Cooler	30	[deg. C]	
Worst case Airfin-cooler for discharge compressor (minimum capacity)			
Minimum gas Capacity	6000	[kg/h]	Pure hydrogen (note 1)
Water content gas:	See dewpoint curve		
Gas Operational pressure in:	81	[bar(a)]	
Gas Operational temperature in:	15	[deg. C]	
Maximum gas Operational temperature out:	40	[deg. C]	
Minimum gas Operational temperature out:	3	[deg. C]	Note 3
Air temperature at inlet of the Cooler	-20	[deg. C]	

1.3 Hydrogen composition;

Gas quality specification		
Components	Unit	Requirement
Hydrogyn (H ₂)	mol%	≥ 98
Inert (N ₂ , Ar, He)	mol%	≥ 2
Total hydrocarbon content (including CH ₄)	mol%	≤ 1,5
Hydrocarbon dew point	°C	≤ -2 at 1-70 bar(a)
Water dew point (H ₂ O) ¹	°C	≤ -8 at 1-70 bar(a)
Oxygen (O ₂)	μmol/mol (ppm)	≤ 10
Carbon dioxide (CO ₂)	μmol/mol (ppm)	≤ 20
Total sulfur (S) content (including H ₂ S)	μmol/mol (ppm)	≤ 3
Halogens	nmol/mol (ppb)	≤ 50
Carbon monoxide (CO)	μmol/mol (ppm)	≤ 20
Formic acid (CH ₃ OOH)	μmol/mol (ppm)	≤ 10
Ammonia (NH ₃)	μmol/mol (ppm)	≤ 10
Formaldehyde (CH ₂ O)	μmol/mol (ppm)	≤ 10
Dust particles		Disclaimer ²
Wobbe-index	MJ/m ³ (n)	44,85 – 48,35 ⁴

Pressure	Water Dewpoint
[barg]	[oC]
1	-48,5
5	-33,6
10	-26,7
20	-19,7
30	-15,7
40	-12,9
50	-10,9
60	-9,3
66,2	-8,5
70	-8
80	-7
90	-6,1
100	-5,4
150	-3,1
200	-2,1

1.4 Mechanical requirements

- EU Directives
- NEN EN 13445
- API661, NEN EN ISO 13706
- Eurocode (NEN EN 1990, 1991 etc)
- HTRI
- Own frequency and vibration analysis
- Structural calculations
- PostWeldHeatTreatment

VENDOR shall perform all necessary static and dynamic calculations to properly design the equipment, in order to comply with the appropriate Codes and Standards, Project Specifications and site conditions, in order to allow compliant installation and safe operation.

Threaded connections are **not** allowed.

1.4.1 Cycle loads, fatigue and failure mode assessment

The equipment shall be designed for 12 full cycles a day for a lifetime of 30 years.

A detailed fatigue assessment acc. NEN en 13445-3 clause 18 is required. The manufacturing tolerance shall be in accordance with the fatigue class but shall not exceed the values as per EN 13445.

Vendor shall perform a failure mode analyses according API579-1 or BS7910 as specified in project specification.

1.4.2 Lay-out compressor coolers



