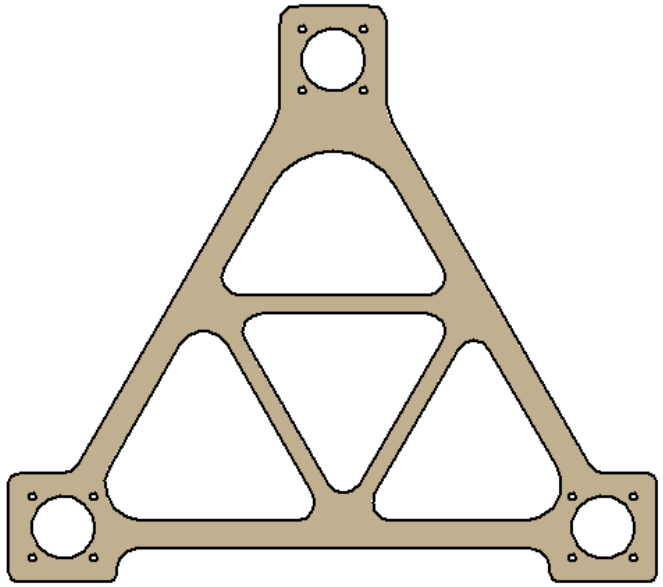
Thermal calculations of the cold mass and the thermo-siphon method of cooling the SPD solenoid

A. Orlova, E. Pyata, T. Bedareva, S. Pivovarov

SPD collaboration meeting
24-27 April 2023

Cold mass support



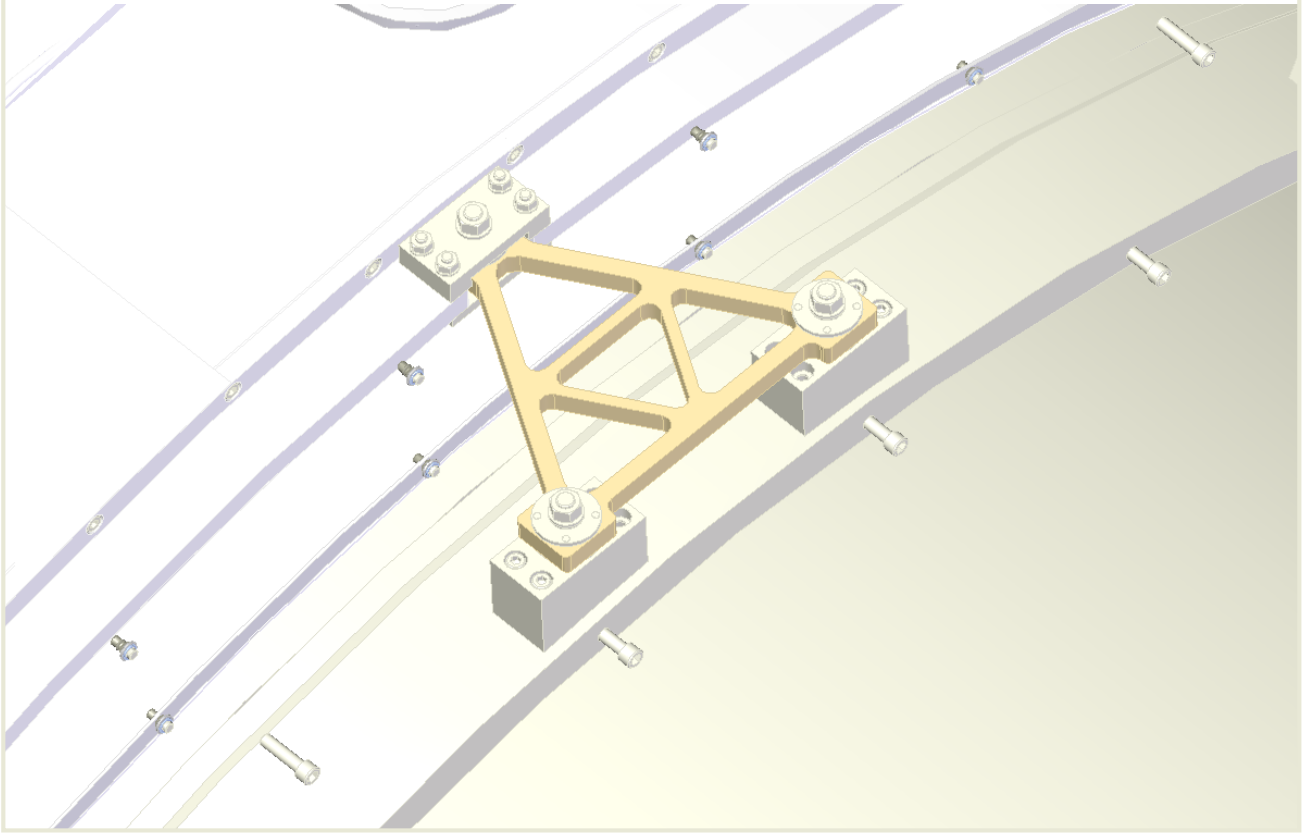
Material: STEF

Minimum temperature 4.5 K

Maximum temperature 300 K

Quantity: 24 supports

The supports are fixed between vacuum shell and cold mass

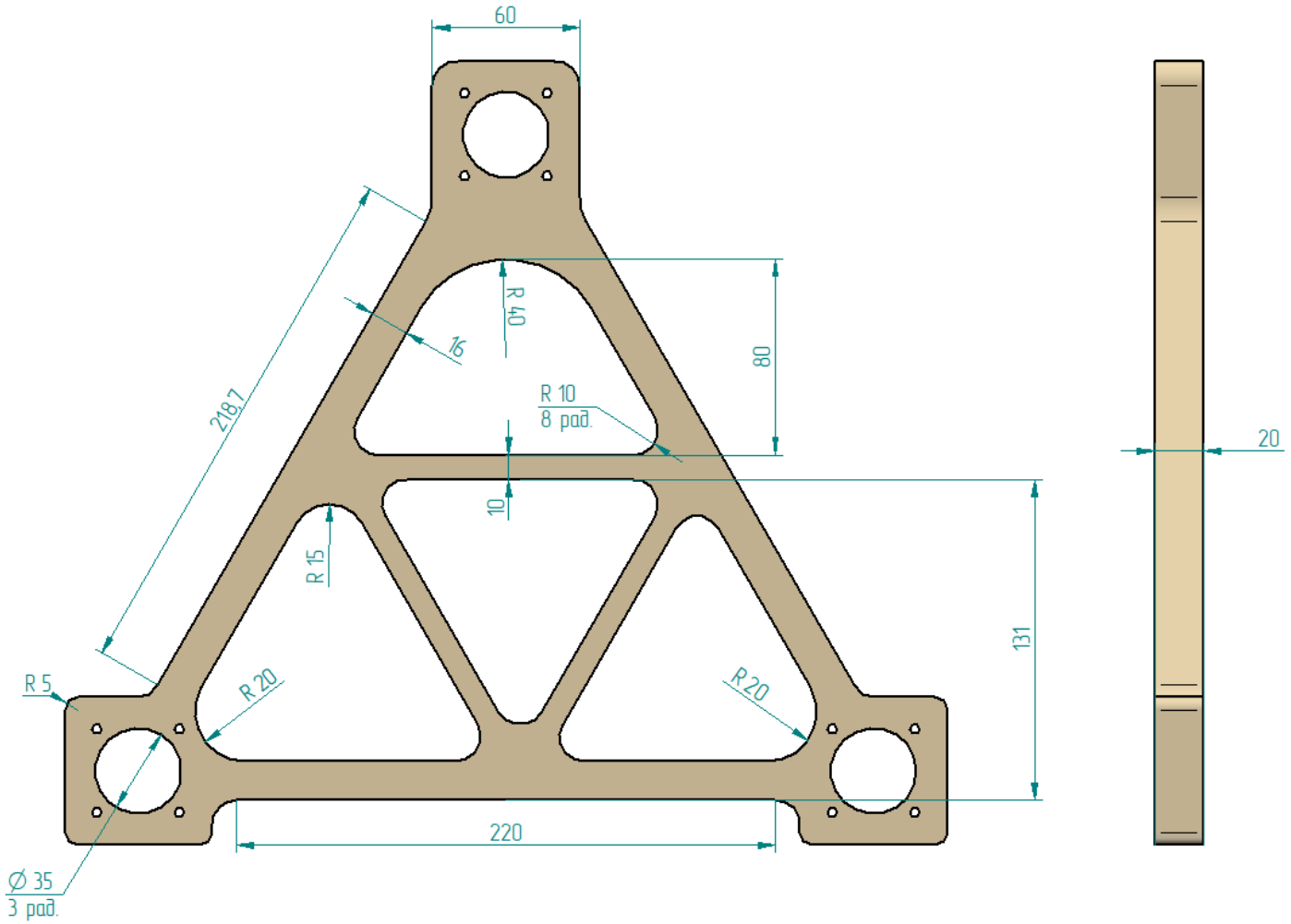


Cold mass support

- ***Material: STEF***
- ***Minimum temperature 4.5 K***
- ***Maximum temperature 300 K***
- ***Quantity: 24 supports***

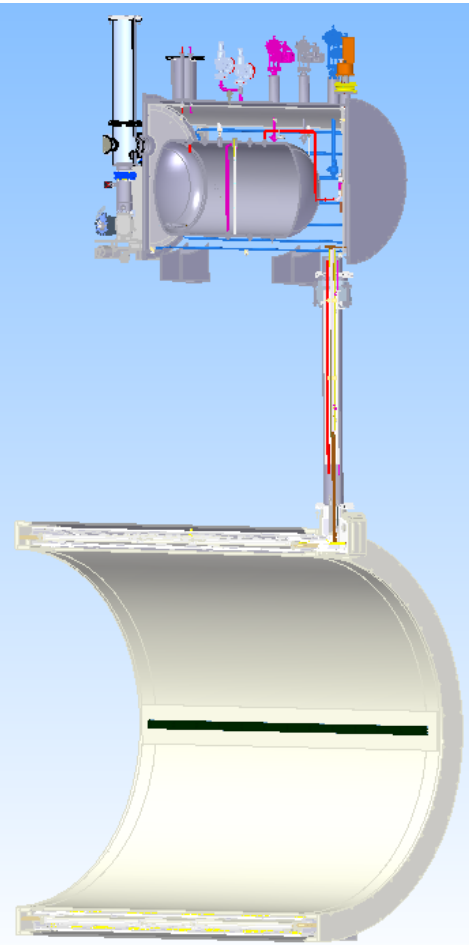
$$q = 0.15\ W$$

$$q_{\Sigma} = 3,6\ W$$



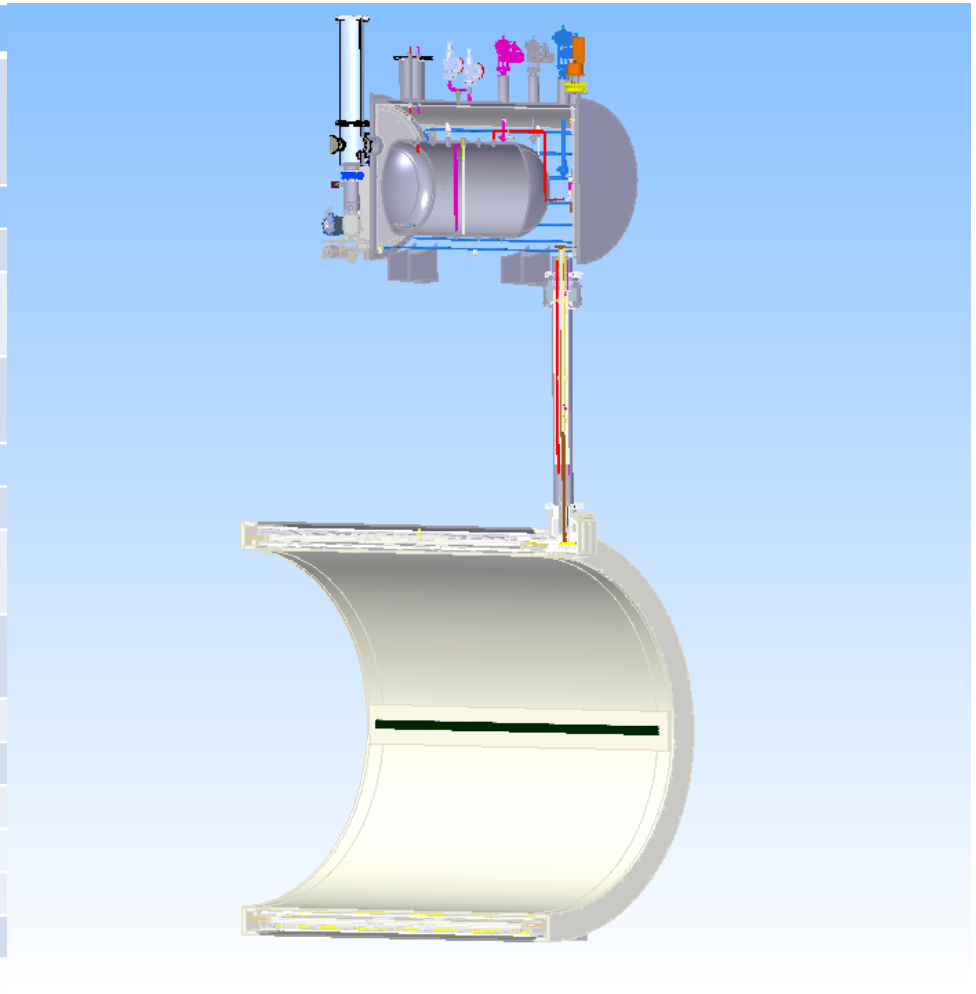
Heat loads

T=4.5K	Heat loads, W		
	Normal condition	Without magnetic field	Current ramping
Cryostat			
radiation	7,80	7,80	7,80
supports	3,60	3,60	3,60
eddy current loss in cold mass	-	-	11,50
eddy current loss in conductor	-	-	0,09
current leads, 6.5kA B=1.25T	10,00	8,00	8,00
Control Dewar			
radiation	0,50	0,50	0,50
supports	0,26	0,26	0,26
cold valves	0,93	0,93	0,93
safety relief valves	4,30	4,30	4,30
vacuum barrier	0,35	0,35	0,35
Transfer line			
radiation	0,12	0,12	0,12
supports	0,32	0,32	0,32
Total	28,18	26,18	37,77

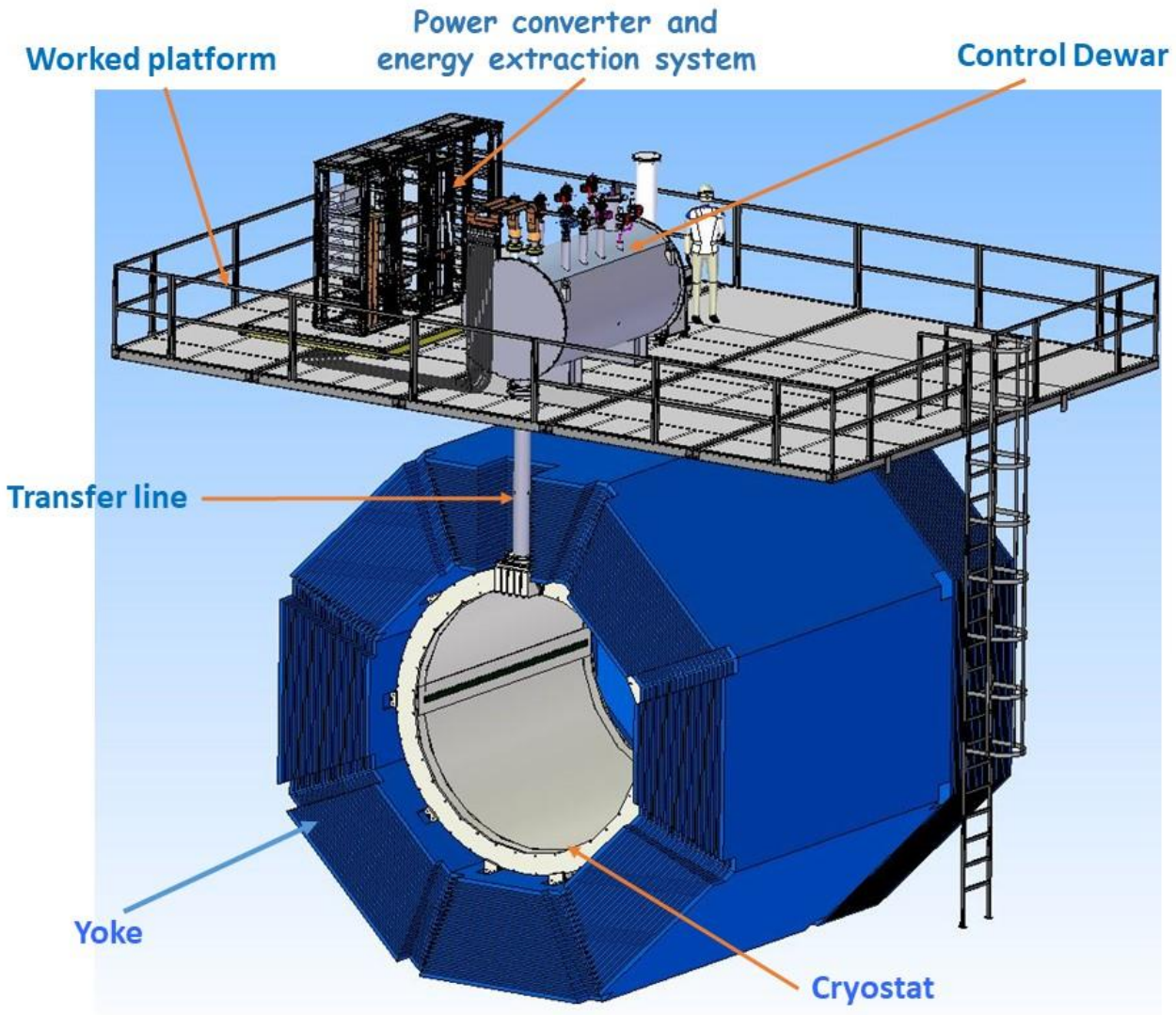


Heat loads

T=60K	Heat loads, W		
	Normal condition	Without magnetic field	Current ramping
Cryostat			
radiation	160,00	160,00	160,00
supports thermal shields	12,00	12,00	12,00
eddy current loss in thermal shields	-	-	47,00
Control Dewar			
radiation	11,60	11,60	11,60
supports thermal shields	6,50	6,50	6,50
supports Helium vessel	9,12	9,12	9,12
cold valves	9,50	9,50	9,50
safety relief valves	1,10	1,10	1,10
vacuum barrier	1,18	1,18	1,18
Transfer line			
radiation	1,05	1,05	1,05
supports	2,35	2,35	2,35
Total	214,40	214,40	261,40



Cold mass cooling



The cold mass of the SPD solenoid is indirectly cooled by circulating two-phase helium by natural convection.

Thermo-syphon circuit

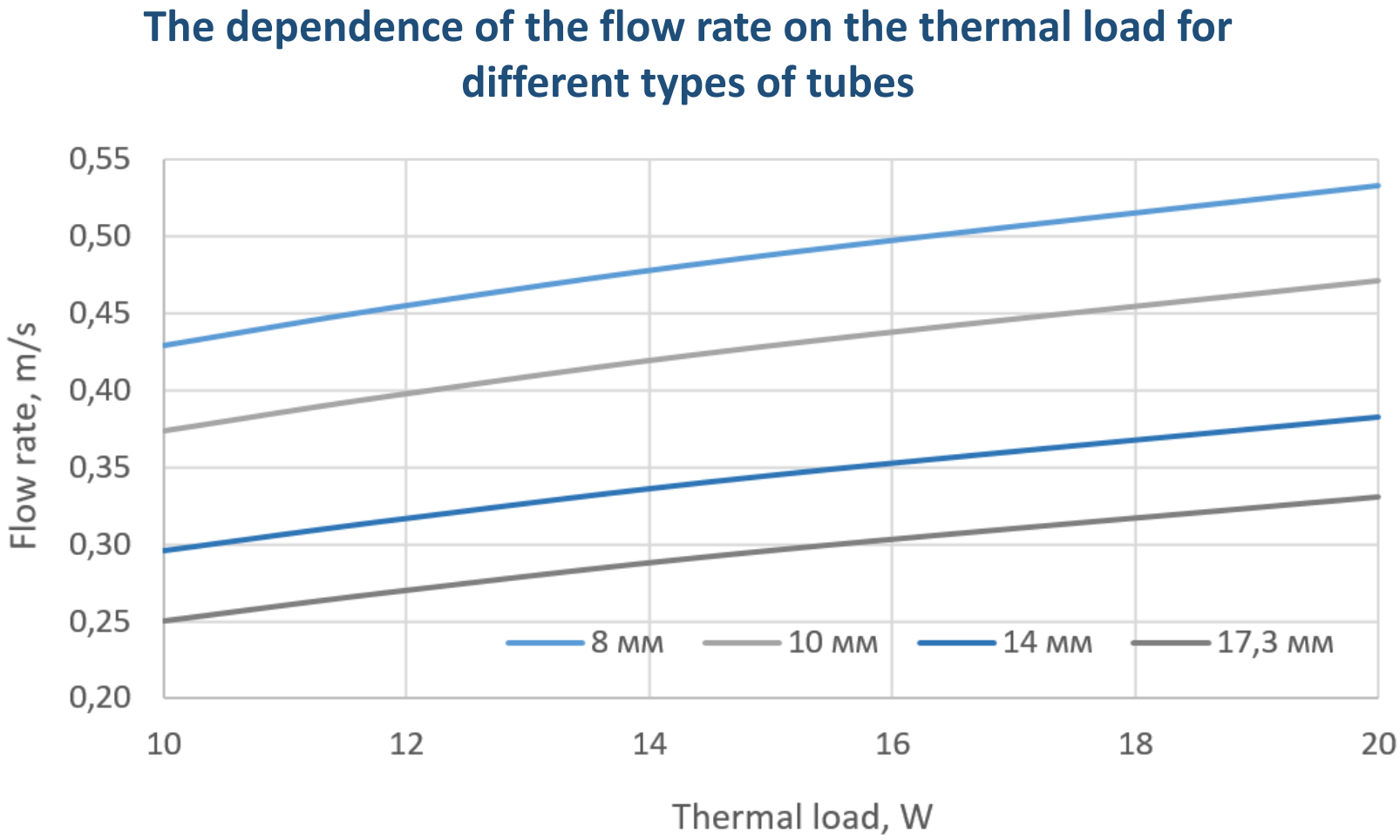
Cold mass cooling

The cryogenic scheme relies on indirect cooling of the cold mass by circulating saturated helium at 4.5 K by natural convection.

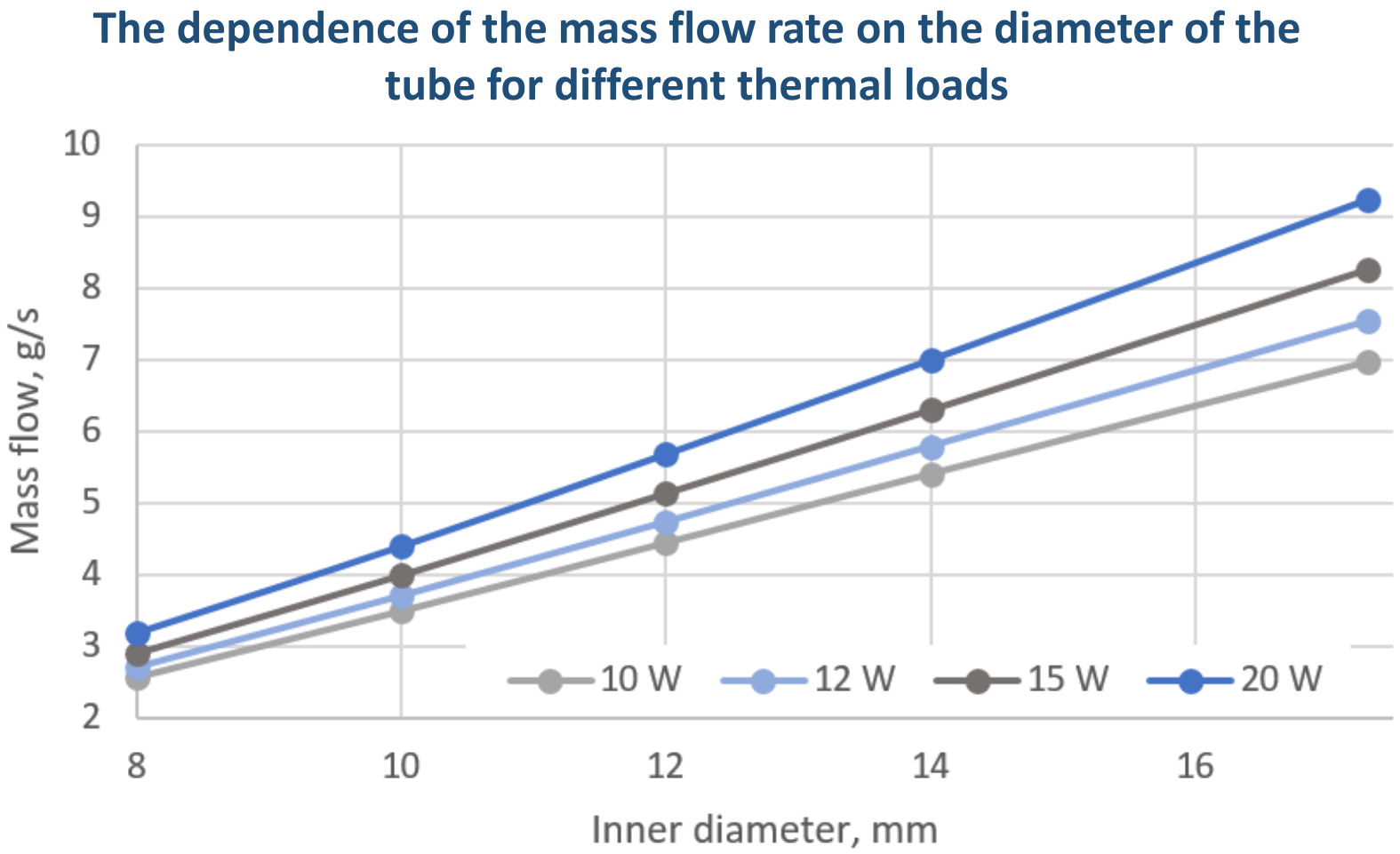
The thermosyphon circuit consists of a bottom and top manifolds connected by 12 parallel syphon tubes.

Natural circulation loop works on the principle that a heat load on the channels of the heat exchanger produces a two-phase flow that is on average less dense than the liquid phase.

Cold mass cooling



Cold mass cooling



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