

Project	Nikhef Virgo Cryostat
Project Nr.	P100331
Subject	Process calculation
By	ML
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#### Calculated Total LN2 usage with varying emissivity

Note: This is a verifying calculation, emissivity for vessel and shields considered equal

Emissivity	LN2 usage		Outlet flow regime Exhaust line ( ID 100 mm)
	g/s	l/h	
0,1	0,62	2,81	Laminar
0,14	0,9	4	Laminar
0,157	0,99	4,46	Laminar
0,158	1	4,5	Critical
0,2	1,28	5,78	Critical
0,207	1,35	6	Critical

#### Calculation Heat Losses Normal Operation

Radial heat losses by radiation on AL vessel with two radiation shields

Note: Emissivity level 0,2      P      127 W

Axial heat losses by radiation on AL vessel with two radiation shields

P      9,4 W

Axial heat losses by radiation through shield holes

P      72,4 W

Conduction by supporting structure

P      5,15 W

Total heat loss

Note: Emissivity level 0,2

P      214 W

Calculation safety factor

20 %

LN2 supply based on evaporating

1,28 g/s

5,78 l/h

#### Calculation cool down LN2 useage

	Vessel		527 kg
	Shields		26,7 kg
Details (supports, hoses)	10%		55,4 kg
LN2 useage for cool down			609 kg

#### Calculation Drain to empty, drain line and LN2 vessel pressure

Note: Drain time 5 hours

Liquid contents vessel      300 l

Flow      13,33 g/s

Pressure versus drain line size

Drain line	Pressure mbar
DN 6	180
DN 8	165
DN 10	160

#### Calculation of Heating power (normal operation)

Note: outlet gas to 20C

Note: Based on emissivity 0,2

LN2 useage	1,28 g/s
Total heating power (EH1)	301 W

#### Calculation of Heating power (Liquid drain mode)

Note: outlet gas to 20C

Note: draining in 5 hours

LN2 useage	13,33 g/s
Evaporation power	2658 W
gas heating power	3122 W
Total heating power (EH2)	5780 W

#### Calculation of Phase separator supply pressure

Note: Based on 6 l/h LN2 supply in vessel

Pressure loss	0,04 bar
Height difference Phase separator/cryostat	0,5 m

#### Calculation Safety valve discharge capacity

Heat inleak	3,8 W/cm <sup>2</sup>
Surface	13,9 m <sup>2</sup>
Evaporating power	390 kW
Evaporated liquid	1,97 kg/s
Gas medium through safety valve	1222 m <sup>3</sup> /h
Minimum flow diameter	90,47 mm
Supply line inner diameter	100 mm
Max. Length of pipe after safety valve	833 mm

Note: based on AD2000-A2