RasGas	RAS LAFFAN HELIUM 2 RECOVERY PROJECT (HeRu) **ALE Project :** **RHEA / 51-3458** **ALE N°:** **ALE NUMBER** **RG N°:** **RASGAS NUMBER** **DTA N°** **C1192 NT 703** **Rev :** **1**	AIR LIQUIDE

325Y003 - LIN - Heat Load

	Date:12/12/2011
Approved by:	**Diffusion :** **- DTA** **- ALE** **-** **RG**
Checked by: Project Manager : **M. LEICHER**	
Written by: Cryodiffusion Design Office Managerr : **V. KLEYMENOV**	

Revision	Date	Author	Modification
0	14/09/2011	V.KLEYMENOV	Issue for construction
1	12/02/2012	V.KLEYMENOV	As build

	Date:12/02/2012
Approved by:	**Diffusion :** **- DTA** **- ALE** **- RG**
Checked by: Project Manager : **M. LEICHER**	
Written by: Cryodiffusion Design Office Managerr : **V. KLEYMENOV**	

REV	DATE	Author	Modification
A	28/03/2011	V.KLEYMENOV	
B	14/09/2011	V.KLEYMENOV	Calculation for final design
C	12/02/2012	V.KLEYMENOV	As build

NDC11-04 Heat Load Calculation

0	DESIGN CONDITIONS

0.1 Calculation temperatures

Maximum air temperature	T h	300	°K

0.2 For piping and valves calculation

Steel		TP304L		SA-312
Conductivity Integral	λ int	*	W/m	* - See Table of λ int

0.3 For spacer

Fibreglass		G11		EPC203 and EPC308 (PERMALI)
Conductivity Integral	λ int	*	W/m	* - See Table of λ int

0.4 For Insulation

Multi Layer Insulation	MLI	Aluminium th. 6.35 mkm Paper: LYDAL 1303

Table of λ int

λ int - Conductivity Integral, W/m		
Temperature,°K	Stainless steel	Fibreglass
1	0	0
2	0	0
4.2	0	0
10	3	1
20	17	2
30	43	4
40	83	7
50	136	10
60	199	13
70	271	17
80	350	21
90	436	25
100	527	30
150	1050	58
200	1663	90
250	2340	127
273	2668	145
300	3065	167

Calculation of Upper Multilines - LHe Supply from Cold Box to Storage Line
Dwg. 3740706

1	CALCULATION

Global Heat Load Calculation according to:

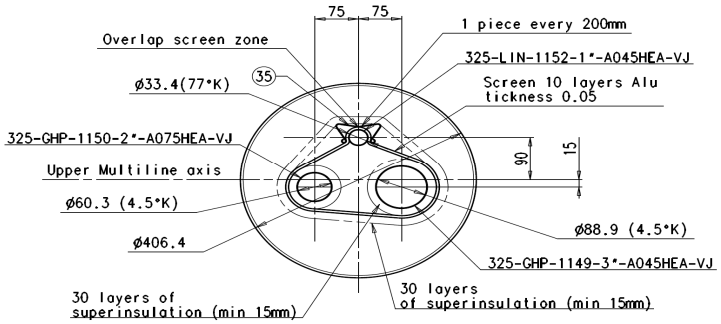
$$Q\,gl = h \times L\,tot + Q1xN1+(Q21+Q22)xN2+Q3xN3\ldots$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

1.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - Dwg.3740706
NOTE: There is an aluminium screen (10 layers of Aluminium sheets with total thickness about 0.5 mm), thermalised by LIN pipe, around of the He pipes.



Max temperature	TH	90	K	
Min temperature	Tc	4	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	Ñ	20	layer / cm	
Mean temperature	Tm	47	K	
Reference Constants:				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	εRT	0.03		equivalent to 200A aluminization thickness

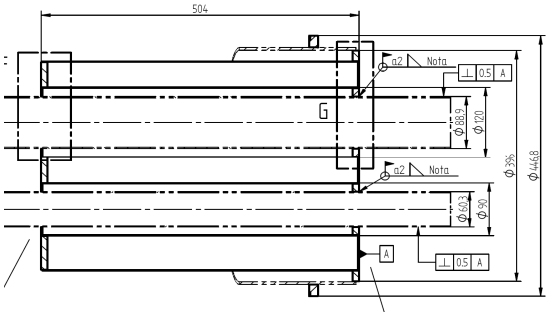
Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	5.14E-02	W/m2	q1 = q x mu
Screen outer diameter	Dt	60.30	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	75.30	mm	Dis=Dt+Th
Surface of insulation	S	0.24	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	1.22E-02	W	h = q1 x S

1.1 Q1 - Heat load through Fixed Point Support - stainless steel - Dwg.3741260

NOTE: There is a stainless steel plate, thermalised by LIN pipe, that used as a beginner for the Fixed Point Support for He line



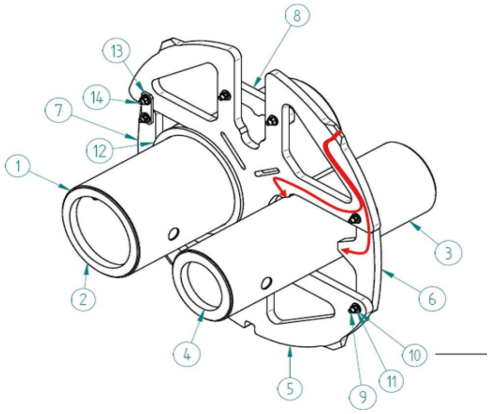
Max temperature	Th	90	K
Min temperature	Tc	4	K
Outer diameter	D	90	mm
Thickness	t	1	mm
Length	L	500	mm
Cross section	A	2.80E-04	m²
Thermal conductivity (integral)	λ int	435.15	W/m

Heat load Calculation according to: *Q1 = A/L x λ int*

Heat load	Q1	2.43E-01	W

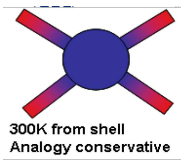
1.2 Q21 and Q22 - Heat load through Sliding Point support - G10 Fiberglass- Dwg.3741330

NOTE: Conservative calculation (pipe Ø 88.9x1.6 L=300, wellded with the process pipe, not taking into account)



- From 300 K to 4 K

Max temperature	Th	300	K
Min temperature	Tc	4	K
Thermal conductivity (integral)	λ int	167	W/m
Width	W	25	mm
Thickness	t	10	mm
Length	L	220	mm
Cross section	A	2.50E-04	m²
Quantity coefficient	N21	4	



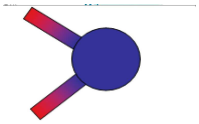
A = W x t

Heat load Calculation according to: *Q 21= A/L x λ int x N21*

Heat load	Q21	7.59E-01	W

- From 80 K to 4 K

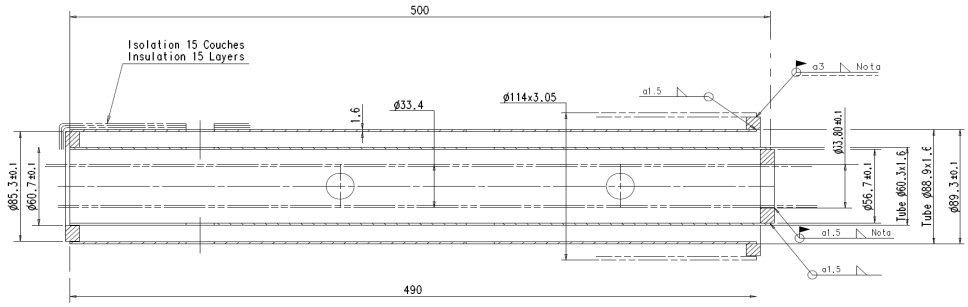
Max temperature	Th	80	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	21	W/m	
Width	W	25	mm	
Thickness	t	10	mm	
Length	L	80	mm	
Cross section	A	2.50E-04	m²	A = W x t
Quantity coefficient	N22	2		



Heat load Calculation according to: *Q22 = A/L x λ int x N22*

Heat load	Q22	1.31E-01	W	

1.3 Q3 - Heat load through Fixed Point support (storage) - Stainless Steel - Dwg.40963



Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D1	88.9	mm	
	D2	60.3	mm	
For calculation	D	74.6	mm	D = (D1+D2)/2
Thickness	t	1.6	mm	
Length	L	980	mm	
Cross section	A	3.67E-04	m²	
Thermal conductivity (integral)	λ int	3.06E+03	W/m	

Heat load Calculation according to: *Q 3= A/L x λ int*

Heat load	Q3	1.15E+00	W	

1 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740706	h	1.22E-02	35	0.43
Fixed Point support	3741260	Q1	2.43E-01	7	1.70
Sliding Point support	3741330	Q21+Q22	8.90E-01	13	11.57
Fixed Point support	3740963	Q3	1.15E+00	4	4.59
Q gl (Global Heat Load for Line), W					18.29

Q cal (Heat Load for 1 metre of Line), W/m	0.52

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m	
Verification	Q cal	≤	Q a	
	0.52	≤	1.00	Acceptable

Calculation of Upper Multilines - GHe Recovery Line
Dwg. 3740706

2	CALCULATION

Global Heat Load Calculation according to:

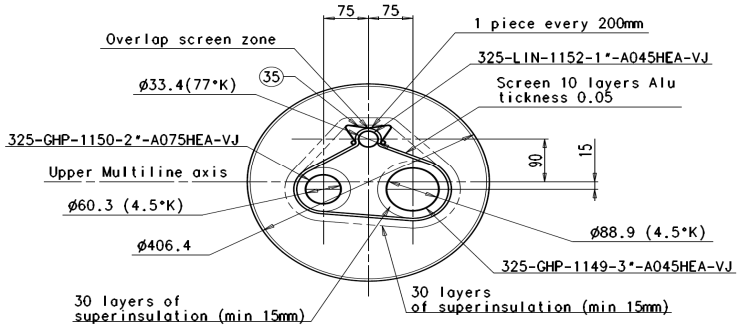
$$Q\,gl = h \times L\,tot + Q1xN1+(Q21+Q22)xN2+Q3xN3\ldots$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

2.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - Dwg.3740706
NOTE: There is an aluminium screen (10 layers of Aluminium sheets with total thickness about 0.5 mm), thermalised by LIN pipe, around of the He pipes.



Max temperature	T_H	90	K	
Min temperature	Tc	4	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	$\tilde{N}$	20	layer / cm	
Mean temperature	Tm	47	K	
Reference Constants:				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

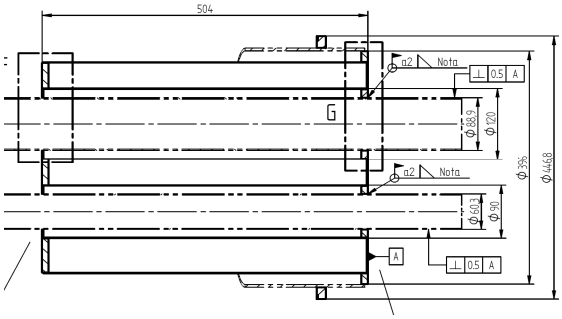
Heat load Calculation according to:

$$q = \frac{C_s(\tilde{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	5.14E-02	W/m2	q1 = q x mu
Screen outer diameter	Dt	88.90	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	103.90	mm	Dis=Dt+Th
Surface of insulation	S	0.33	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	1.68E-02	W	h = q1 x S

2.1 Q1 - Heat load through Fixed Point Support - stainless steel - Dwg.3741260

NOTE: There is a stainless steel plate, thermalised by LIN pipe, that used as a beginner for the Fixed Point Support for He line



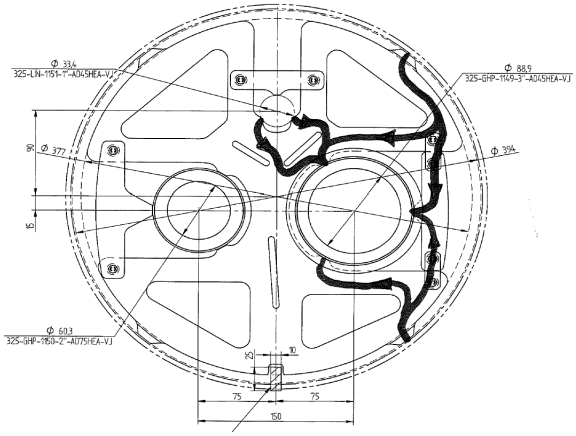
Max temperature	Th	90	K
Min temperature	Tc	4	K
Outer diameter	D	120	mm
Thickness	t	1	mm
Length	L	500	mm
Cross section	A	3.74E-04	m²
Thermal conductivity (integral)	λ int	435.15	W/m

Heat load Calculation according to: $Q1 = A/L \times \lambda\ int$

Heat load	Q1	3.25E-01	W

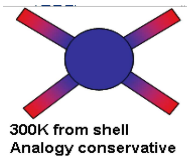
2.2 Q21 and Q22 - Heat load through Sliding Point support - G10 Fiberglass- Dwg.3741330

NOTE: Conservative calculation (pipe Ø 114.3x1.6 L=300, wellded with the process pipe, not taking into account)



- From 300 K to 4 K

Max temperature	Th	300	K
Min temperature	Tc	4	K
Thermal conductivity (integral)	λ int	167	W/m
Width	W	25	mm
Thickness	t	10	mm
Length	L	200	mm
Cross section	A	2.50E-04	m²
Quantity coefficient	N21	4	



A = W x t

Heat load Calculation according to: $Q\ 21 = A/L \times \lambda\ int \times N21$

Heat load	Q21	8.35E-01	W

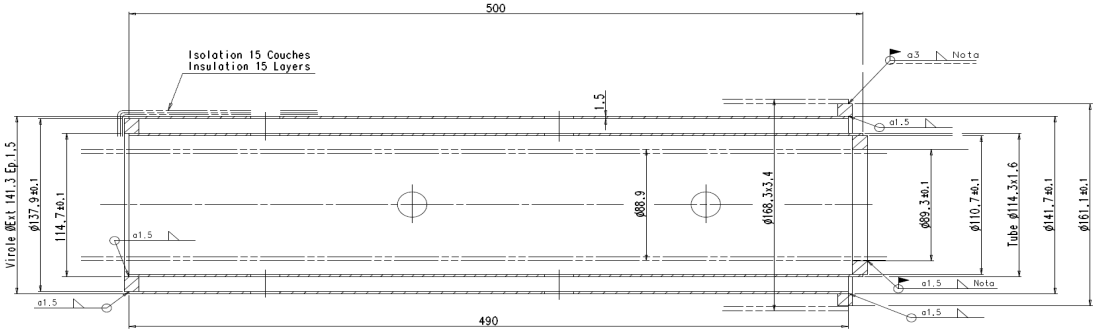
- From 80 K to 4 K

Max temperature	Th	80	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	21	W/m	
Width	W	25	mm	80K from LIN pipe Analogy conservative
Thickness	t	10	mm	
Length	L	80	mm	
Cross section	A	2.50E-04	m²	A = W x t
Quantity coefficient	N22	2		

Heat load Calculation according to: *Q22 = A/L x λ int x N22*

Heat load	Q22	1.31E-01	W

2.3 Q3 - Heat load through Fixed Point support (storage) - Stainless Steel - Dwg.40965



Max temperature	Th	300	K
Min temperature	Tc	4	K
Outer diameter	D1	141.3	mm
	D2	114.3	mm
For calculation	D	127.8	mm
Thickness	t	1.6	mm
Length	L	980	mm
Cross section	A	6.34E-04	m²
Thermal conductivity (integral)	λ int	3.06E+03	W/m

D = (D1+D2)/2

Heat load Calculation according to: *Q 3= A/L x λ int*

Heat load	Q3	1.98E+00	W

2 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740706	h	1.68E-02	35	0.59
Fixed Point support	3741260	Q1	3.25E-01	7	2.28
Sliding Point support	3741330	Q21+Q22	9.66E-01	13	12.56
Fixed Point support	3740965	Q3	1.98E+00	4	7.93
Q gl (Global Heat Load for Line), W					23.36

Q cal (Heat Load for 1 metre of Line), W/m	0.67

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m	
Verification	Q cal	≤	Q a	
	0.67	≤	1.00	Acceptable

Calculation of Upper Multilines - LIN Supply from Liquefier
Dwg. 3740706

3	CALCULATION

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3\ldots$$

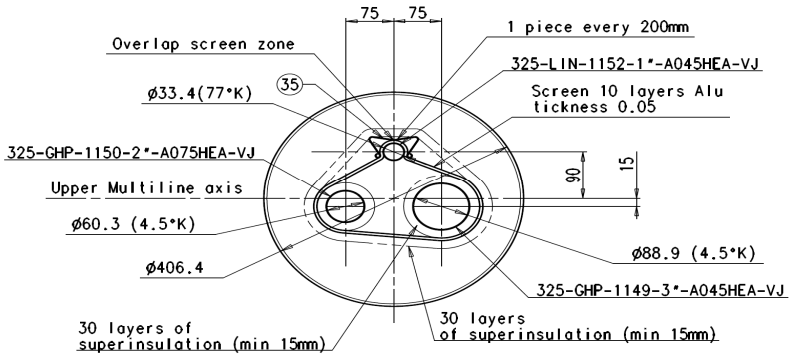
Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

3.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - Dwg.3740706

NOTE: There is an aluminium screen (10 layers of Aluminium sheets with total thickness about 0.5 mm), thermalised by LIN pipe, around of the He pipes.
Developed length (L dev) of MLI arround of alluminium screen taking into account for Heat load calculation



Max temperature	T_H	300	K	
Min temperature	Tc	90	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	Ň	20	layer / cm	
Mean temperature	Tm	195	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

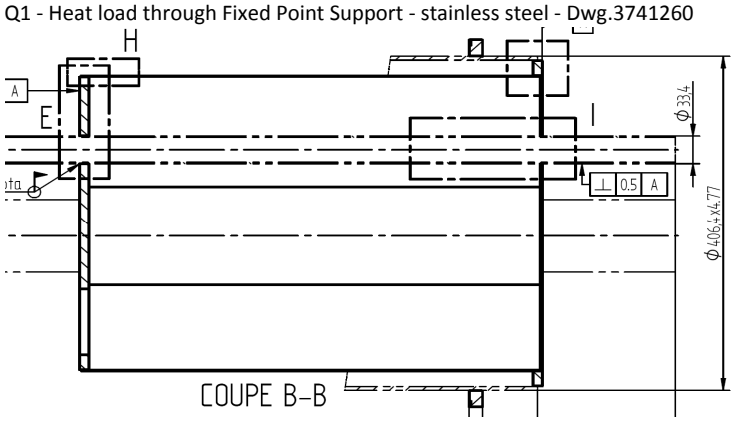
Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.04E-01	W/m2	q1 = q x mu
Insulation developed length	L dev	750.00	mm	
Insulation length	L	1000.00	mm	
Surface of insulation	S	0.75	m2	S=L x L dev

Heat load for 1 metre of length	h	6.78E-01	W	h = q1 x S

3.1 Q1 - Heat load through Fixed Point Support - stainless steel - Dwg.3741260

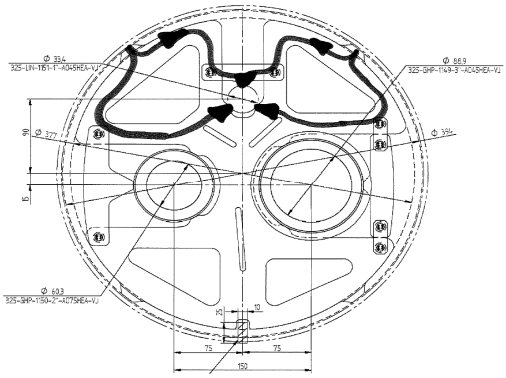


Max temperature	Th	300	K
Min temperature	Tc	90	K
Outer diameter	D	358	mm
Thickness	t	1	mm
Length	L	500	mm
Cross section	A	1.12E-03	m²
Thermal conductivity (integral)	λ int	2629.35	W/m

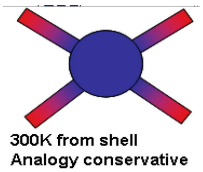
Heat load Calculation according to: *Q1 = A/L x λ int*

Heat load	Q1	5.90E+00	W

3.2 Q2 - Heat load through Sliding Point support - G10 Fiberglass- Dwg.3741330



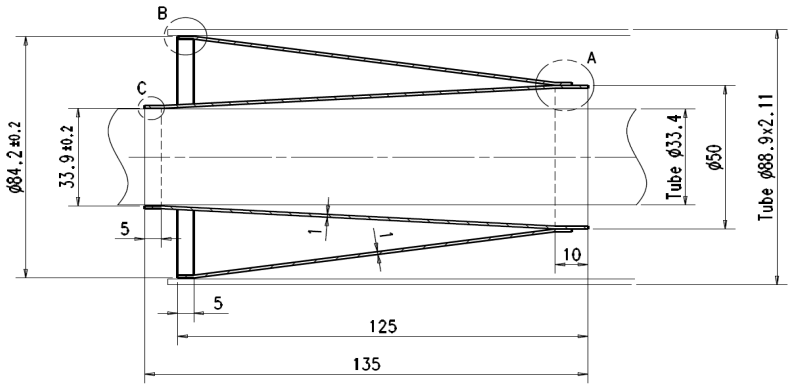
Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Thermal conductivity (integral)	λ int	146	W/m	
Width	W	25	mm	
Thickness	t	10	mm	
Length	L	220	mm	
Cross section	A	2.50E-04	m²	A = W x t
Quantity coefficient	N2	4		



Heat load Calculation according to: *Q 2= A/L x λ int x N2*

Heat load	Q2	6.64E-01	W

3.3 Q3 - Heat load through Fixed Point support (storage) - Stainless Steel - Dwg.40968



Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D1	88.9	mm	
	D2	33.4	mm	
For calculation	D	61.15	mm	D = (D1+D2)/2
Thickness	t	1	mm	
Length	L	250	mm	
Cross section	A	1.89E-04	m^2	
Thermal conductivity (integral)	λ int	2.72E+03	W/m	

Heat load Calculation according to: $Q\ 3 = A/L \times \lambda\ int$

Heat load	Q3	2.05E+00	W

3 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740706	h	6.78E-01	35	23.72
Fixed Point support	3741260	Q1	5.90E+00	7	41.29
Sliding Point support	3741330	Q2	6.64E-01	13	8.63
Fixed Point support	3740963	Q3	2.05E+00	1	2.05
Q gl (Global Heat Load for Line), W					75.69

Q cal (Heat Load for 1 metre of Line), W/m	2.16

Calculation of Lower Multilines Section - LHe Valve Box
Dwg.3740723; 3740724; 3740725; 3740746

4	CALCULATION

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3\ldots$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

4.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - part without Aluminium screen thermalised by LIN pipe

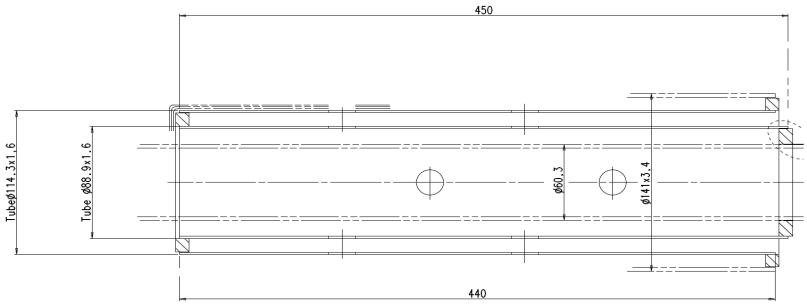
Max temperature	T_H	300	K	
Min temperature	Tc	4	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	Ñ	20	layer / cm	
Mean temperature	Tm	152	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08		
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.55E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	60.30	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	75.30	mm	Dis=Dt+Th
Surface of insulation	S	0.24	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	2.26E-01	W	h = q1 x S

4.1 Q1 - Heat load through Fixed Point support - Stainless Steel - Dwg.40964

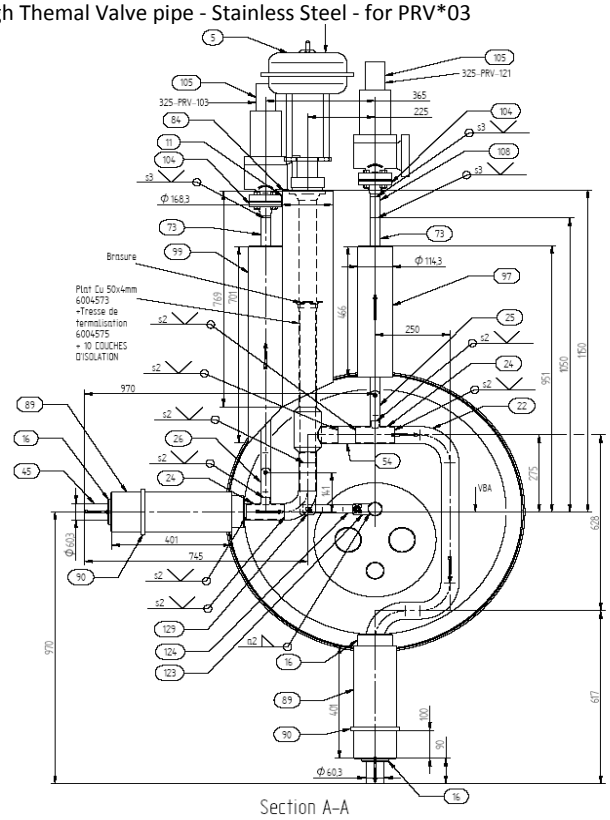


Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D1	114.3	mm	
	D2	88.9	mm	
For calculation	D	101.6	mm	D = (D1+D2)/2
Thickness	t	1.6	mm	
Length	L	890	mm	
Cross section	A	5.03E-04	m²	
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: *Q 1= A/L x λ int*

Heat load	Q1	1.73E+00	W

4.2 Q2 - Heat load through Themal Valve pipe - Stainless Steel - for PRV*03



Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D	33.4	mm	
Thickness	t	1.65	mm	
Length	L	1250	mm	
Cross section	A	1.65E-04	m^2	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: *Q 2= A/L x λ int*

Heat load	Q2	4.03E-01	W

4.3 Q3 - Heat load through Themal Valve pipe - Stainless Steel - for PRV*21

Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D	33.4	mm	
Thickness	t	1.65	mm	
Length	L	780	mm	
Cross section	A	1.65E-04	m^2	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: *Q 3= A/L x λ int*

Heat load	Q3	6.47E-01	W

4 results — CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740723 etc	h	2.26E-01	2.79	0.63
Fixed Point support	3740964	Q1	1.73E+00	2	3.46
Thermal Valve pipe	For PRV*03	Q2	4.03E-01	1	0.40
Thermal Valve pipe	For PRV*21	Q3	6.47E-01	1	0.65
Valves	HV*21	Q4	2.6	1	2.60
Global Heat Load for one Line, W					7.74
Global Heat Load for 4 Lines, W					30.97

Q cal (Heat Load for 1 metre of Line), W/m	2.77

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m	
Verification	Q cal	≤	Q a	
	2.77	≤	1.00	

Acceptable - see SYNTHESIS NOTE

Calculation of Lower Multilines - GHe from Valve Box to Cold Box / Cold Track
Dwg.3741271; 3740723; 3740724; 3740725; 3740746

5	CALCULATION

Global Heat Load Calculation according to:

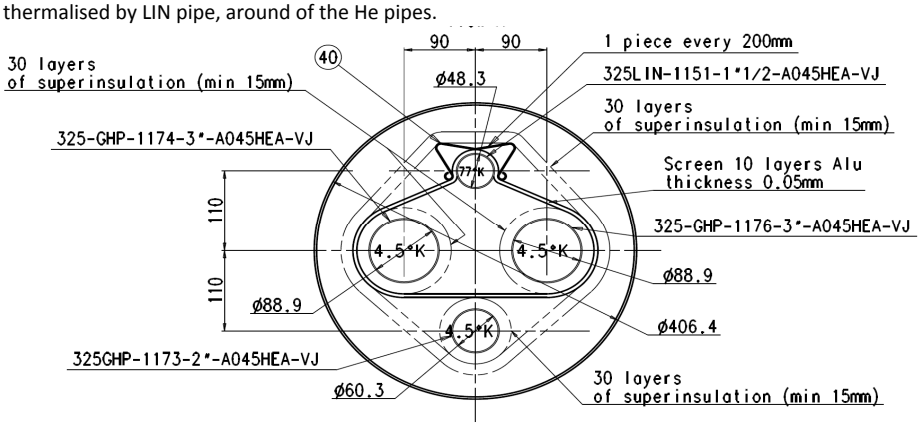
$$Q\,gl = h \times L\,tot + Q1xN1+(Q21+Q22)xN2\ldots$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

5.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - Dwg.3741271
NOTE: There is an aluminium screen (10 layers of Aluminium sheets with total thickness about 0.5 mm), thermalised by LIN pipe, around of the He pipes.



Max temperature	T_H	90	K	
Min temperature	Tc	4	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	Ň	20	layer / cm	
Mean temperature	Tm	47	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	5.14E-02	W/m2	q1 = q x mu
Screen outer diameter	Dt	88.90	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	103.90	mm	Dis=Dt+Th
Surface of insulation	S	0.33	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	1.68E-02	W	h = q1 x S

5.01 h1 - Heat load through 1 metre of MLI (Multi Layer Insulation) - part without Aluminium screen thermalised by LIN pipe
dwg. 3740723; 3740724; 3740725; 3740746

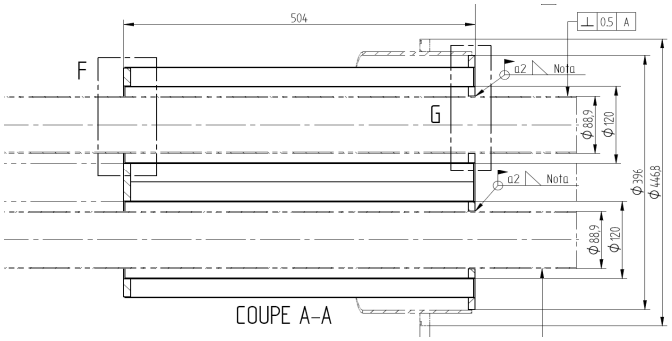
Max temperature	T_H	300	K	
Min temperature	Tc	4	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	Ň	20	layer / cm	
Mean temperature	Tm	152	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56} T_m}{N_s + 1}(T_H - T_C) + \frac{C_r \varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.55E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	60.30	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	75.30	mm	Dis=Dt+Th
Surface of insulation	S	0.24	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h1	2.26E-01	W	h = q1 x S

5.1 Q1 - Heat load through Fixed Point Support - stainless steel - Dwg.3740634
NOTE: There is a stainless steel plate, thermalised by LIN pipe, that used as a beginner for the Fixed Point Support for He line



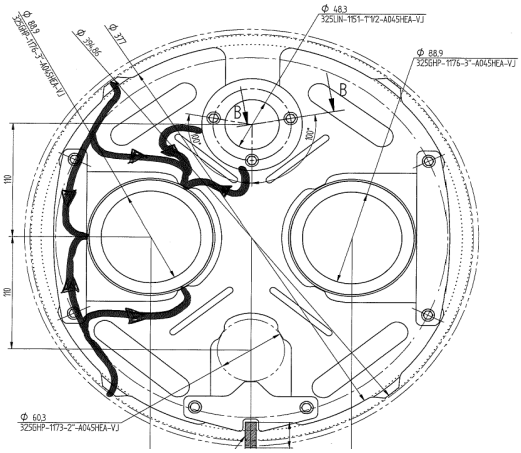
Max temperature	Th	90	K	
Min temperature	Tc	4	K	
Outer diameter	D	120	mm	
Thickness	t	1	mm	
Length	L	500	mm	
Cross section	A	3.74E-04	m²	
Thermal conductivity (integral)	λ int	435.15	W/m	

Heat load Calculation according to: *Q1 = A/L x λ int*

	Heat load	Q1	3.25E-01	W

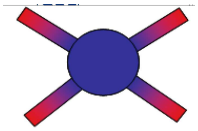
5.2 Q21 and Q22 - Heat load through Sliding Point support - G10 Fiberglass- Dwg.3740727

NOTE: Conservative calculation (pipe Ø 114.3x1.6 L=300, wellded with the process pipe, not taking into account)



- From 300 K to 4 K

Max temperature	Th	300	K
Min temperature	Tc	4	K
Thermal conductivity (integral)	λ int	167	W/m
Width	W	25	mm
Thickness	t	10	mm
Length	L	170	mm
Cross section	A	2.50E-04	m²
Quantity coefficient	N21	4	



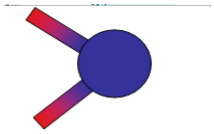
A = W x t

Heat load Calculation according to: *Q 21= A/L x λ int x N21*

Heat load	Q21	9.82E-01	W

- From 80 K to 4 K

Max temperature	Th	80	K
Min temperature	Tc	4	K
Thermal conductivity (integral)	λ int	21	W/m
Width	W	25	mm
Thickness	t	10	mm
Length	L	100	mm
Cross section	A	2.50E-04	m²
Quantity coefficient	N22	2	

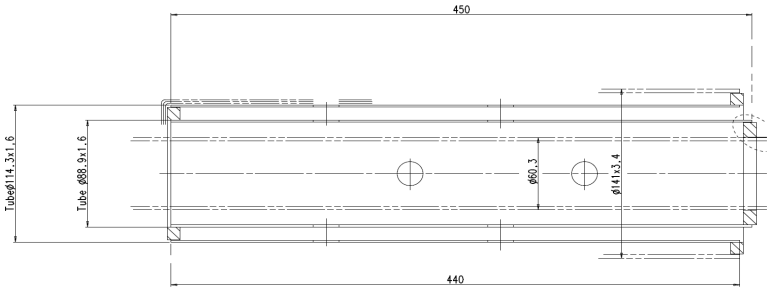


A = W x t

Heat load Calculation according to: *Q22 = A/L x λ int x N22*

Heat load	Q22	1.05E-01	W

5.3 Q3 - Heat load through Fixed Point support - Stainless Steel - Dwg.40964



Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D1	114.3	mm	
	D2	88.9	mm	
For calculation	D	101.6	mm	D = (D1+D2)/2
Thickness	t	1.6	mm	
Length	L	890	mm	
Cross section	A	5.03E-04	m²	
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: *Q 3= A/L x λ int*

Heat load	Q3	1.73E+00	W

5 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3741271	h	1.68E-02	61.06	1.02
MLI	3740723...	h1	2.26E-01	14	3.16
Fixed Point support	3740634	Q1	3.25E-01	10	3.25
Sliding Point support	3740727	Q21+Q22	1.09E+00	22	23.92
Fixed Point support	3740964	Q3	1.73E+00	4	6.92
Valve	HV*27/HV*28	Q4	2.60E+00	8	20.80
Q gl (Global Heat Load for 2 Lines), W					59.09

Q cal (Heat Load for 1 metre of Line), W/m	0.97

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m	
Verification	Q cal	≤	Q a	
	0.97	≤	1.00	Acceptable

Calculation of Lower Multilines - GHe from Valve Box to Gaz Bag
Dwg.3741271; 3740723; 3740724; 3740725; 3740746

6	CALCULATION

Global Heat Load Calculation according to:

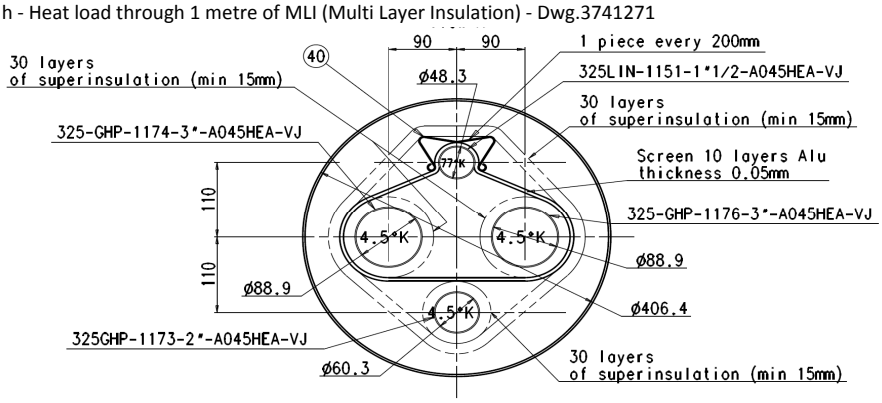
$$Q\,gl = h \times L\,tot + Q1xN1+(Q21+Q22)xN2...$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

6.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - Dwg.3741271



Max temperature	TH	300	K	
Min temperature	Tc	4	K	
Number of lyers	Ns	60		
Insulation thickness	Th	30	mm	
Assembly efficency	mu	2		
Layer Density	Ñ	20	layer / cm	
Mean temperature	Tm	152	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ƐRT	0.03		equivalent to 200A aluminization thickness

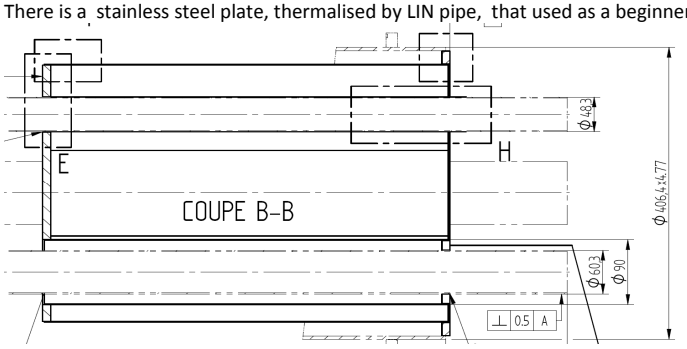
Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	4.82E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	60.30	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	90.30	mm	Dis=Dt+Th
Surface of insulation	S	0.28	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	1.37E-01	W	h = q1 x S

6.1 Q1 - Heat load through Fixed Point Support - stainless steel - Dwg.3740634

NOTE: There is a stainless steel plate, thermalised by LIN pipe, that used as a beginner for the Fixed Point Support for He line

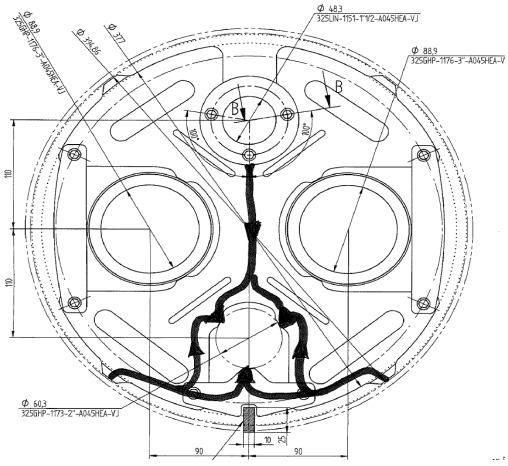


Max temperature	Th	90	K
Min temperature	Tc	4	K
Outer diameter	D	90	mm
Thickness	t	1	mm
Length	L	500	mm
Cross section	A	2.80E-04	m²
Thermal conductivity (integral)	λ int	435.15	W/m

Heat load Calculation according to: *Q1 = A/L x λ int*

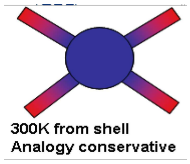
Heat load	Q1	2.43E-01	W

6.2 Q21 and Q22 - Heat load through Sliding Point support - G10 Fiberglass- Dwg.3740727



6.21 From 300 K to 4 K

Max temperature	Th	300	K
Min temperature	Tc	4	K
Thermal conductivity (integral)	λ int	167	W/m
Width	W	25	mm
Thickness	t	10	mm
Length	L	170	mm
Cross section	A	2.50E-04	m²
Quantity coefficient	N21	4	



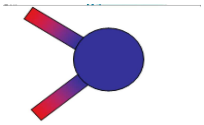
A = W x t

Heat load Calculation according to: *Q 21= A/L x λ int x N21*

Heat load	Q21	9.82E-01	W

6.22 From 80 K to 4 K

Max temperature	Th	80	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	21	W/m	
Width	W	25	mm	
Thickness	t	10	mm	
Length	L	130	mm	
Cross section	A	2.50E-04	m²	A = W x t
Quantity coefficient	N22	1		



Heat load Calculation according to: *Q22 = A/L x λ int x N22*

Heat load	Q22	4.04E-02	W

6.3 Q3 - Heat load through Themal Valve pipe - Stainless Steel - for PRV*29

Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D	33.4	mm	
Thickness	t	1.65	mm	
Length	L	1150	mm	
Cross section	A	1.65E-04	m²	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: *Q 3= A/L x λ int*

Heat load	Q3	4.39E-01	W

6 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3741271	h	1.37E-01	30.53	4.18
Fixed Point support	3740634	Q1	2.43E-01	5	1.22
Sliding Point support	3740727	Q21+Q22	1.02E+00	11	11.25
Thermal Valve pipe	For PRV*29	Q3	4.39E-01	4	1.75
Valves	HV*29	Q4	1.25	4	5.00
Q gl (Global Heat Load for Line), W					23.40

Q cal (Heat Load for 1 metre of Line), W/m	0.77

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m	
Verification	Q cal	≤	Q a	
	0.77	≤	1.00	Acceptable

Calculation of Lower Multilines - LIN Supply from Liquefier
Dwg.3741271; 3740723; 3740724; 3740725; 3740746

7	CALCULATION

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3\ldots$$

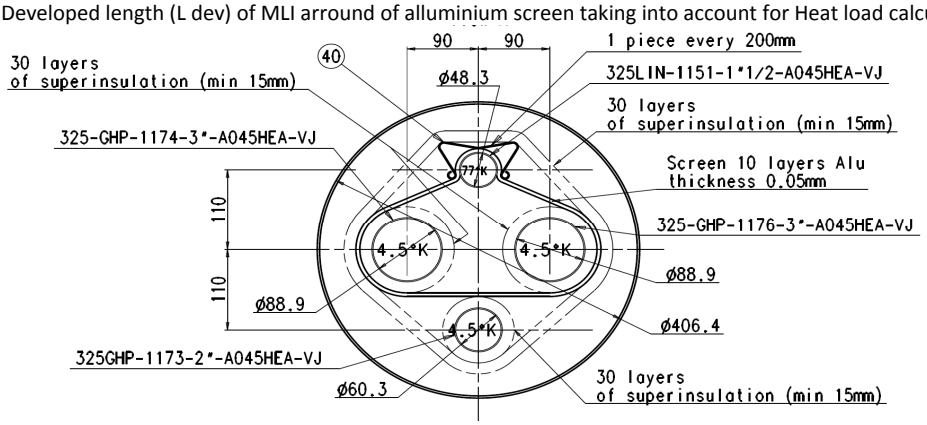
Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

7.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - Dwg.3741271

NOTE: There is an aluminium screen (10 layers of Aluminium sheets with total thickness about 0.5 mm), thermalised by LIN pipe, around of the He pipes.
Developed length (L dev) of MLI arround of alluminium screen taking into account for Heat load calculation



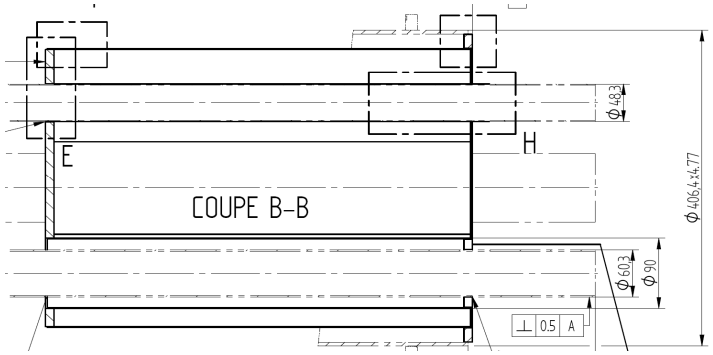
Max temperature	T_H	300	K	
Min temperature	Tc	90	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	Ň	20	layer / cm	
Mean temperature	Tm	195	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.04E-01	W/m2	q1 = q x mu
Insulation developed length	L dev	890.00	mm	
Insulation length	L	1000.00	mm	
Surface of insulation	S	0.89	m2	S=L x L dev
Heat load for 1 metre of length	h	8.04E-01	W	h = q1 x S

7.1 Q1 - Heat load through Fixed Point Support - stainless steel - Dwg.3740634

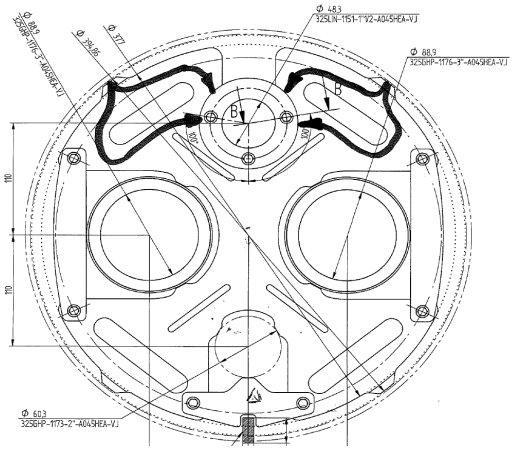


Max temperature	Th	300	K
Min temperature	Tc	80	K
Outer diameter	D	358	mm
Thickness	t	1	mm
Length	L	500	mm
Cross section	A	1.12E-03	m²
Thermal conductivity (integral)	λ int	2715	W/m

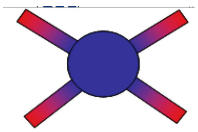
Heat load Calculation according to: *Q1 = A/L x λ int*

Heat load	Q1	6.09E+00	W

7.2 Q2 - Heat load through Sliding Point support - G10 Fiberglass- Dwg.3740727



Max temperature	Th	300	K
Min temperature	Tc	80	K
Thermal conductivity (integral)	λ int	146	W/m
Width	W	25	mm
Thickness	t	10	mm
Length	L	220	mm
Cross section	A	2.50E-04	m²
Quantity coefficient	N2	4	

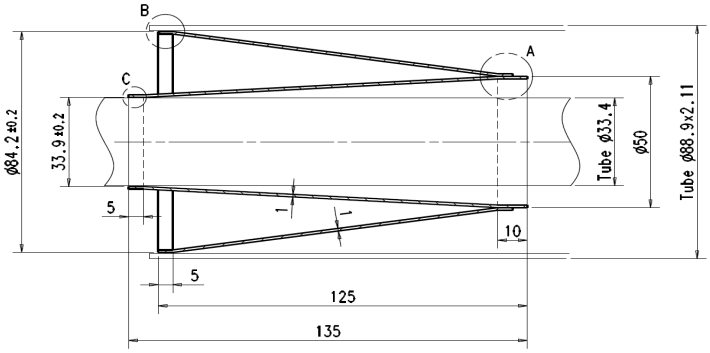


A = W x t

Heat load Calculation according to: *Q 2= A/L x λ int x N2*

Heat load	Q2	6.64E-01	W

7.3 Q3 - Heat load through Fixed Point support - Stainless Steel - Dwg.40968

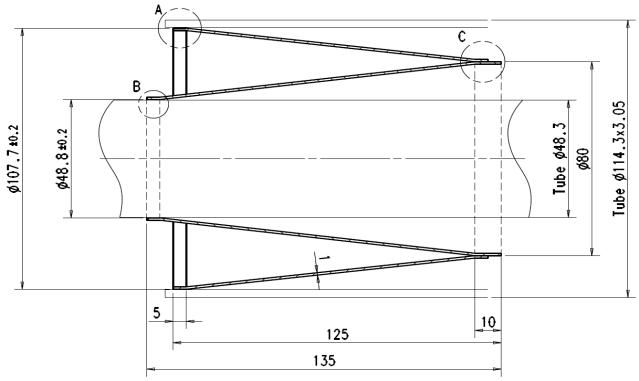


Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D1	88.9	mm	
	D2	33.4	mm	
For calculation	D	61.15	mm	D = (D1+D2)/2
Thickness	t	1	mm	
Length	L	250	mm	
Cross section	A	1.89E-04	m²	
Thermal conductivity (integral)	λ int	2715	W/m	

Heat load Calculation according to: *Q 3= A/L x λ int*

Heat load	Q3	2.05E+00	W

7.4 Q4 - Heat load through Fixed Point support - Stainless Steel - Dwg.40749

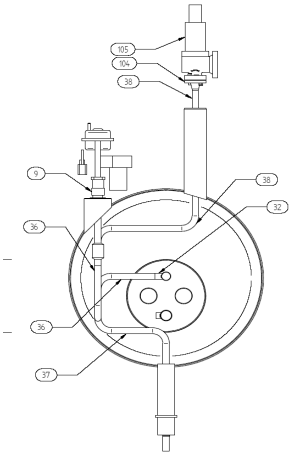


Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D1	107.7	mm	
	D2	48.8	mm	
For calculation	D	78.25	mm	D = (D1+D2)/2
Thickness	t	1	mm	
Length	L	250	mm	
Cross section	A	2.43E-04	m²	
Thermal conductivity (integral)	λ int	2715	W/m	

Heat load Calculation according to: *Q 4= A/L x λ int*

Heat load	Q4	2.64E+00	W

7.5 Q5 - Heat load through Themal Valve pipe - Stainless Steel - for PRV*70



Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D	33.4	mm	
Thickness	t	2.77	mm	
Length	L	1200	mm	
Cross section	A	2.67E-04	m^2	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	2715	W/m	

Heat load Calculation according to: $Q\ 5 = A/L \times \lambda\ int$

Heat load	Q5	6.03E-01	W

7 results — CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3741271	h	0.8	30.53	24.55
Fixed Point support	3740634	Q1	6.1	5	30.45
Sliding Point support	3740727	Q2	0.7	11	7.30
Fixed point support	40968	Q3	2.1	4	8.21
Fixed point support	40749	Q4	2.6	1	2.64
Thermal Valve pipe	for PRF*70	Q5	0.6	4	2.41
Valve	HV*70	Q6	2.5	4	10.00
Q gl (Global Heat Load for Line), W					85.56

Q cal (Heat Load for 1 metre of Line), W/m	2.80

Calculation of Single Line - LHe Filling of Storage
Dwg.3740722

8	CALCULATION

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3+Q4xN4$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

8.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - Dwg.3740722

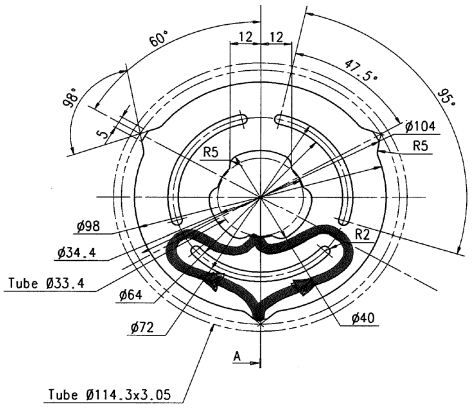
Max temperature	T_H	300	K	
Min temperature	Tc	4	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	$\check{N}$	20	layer / cm	
Mean temperature	Tm	152	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.55E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	33.40	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	48.40	mm	Dis=Dt+Th
Surface of insulation	S	0.15	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	1.45E-01	W	h = q1 x S

8.1 Q1 - Heat load through Spacer - G10 Fiberglass- Dwg.3740938

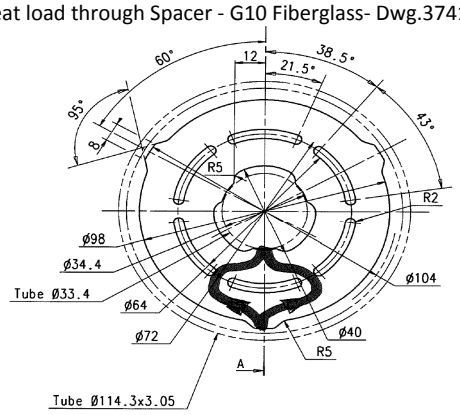


Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	167	W/m	
Width	W	12	mm	
Thickness	t	6	mm	
Length	L	90	mm	
Cross section	A	7.20E-05	m²	A = W x t
Quantity coefficient	N1	2		

Heat load Calculation according to: *Q 1= A/L x λ int x N1*

Heat load	Q1	2.67E-01	W

8.2 Q2 - Heat load through Spacer - G10 Fiberglass- Dwg.3741561

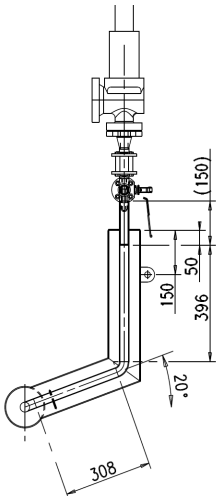


Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	167	W/m	
Width	W	9	mm	
Thickness	t	6	mm	
Length	L	45	mm	
Cross section	A	5.40E-05	m²	A = W x t
Quantity coefficient	N2	2		

Heat load Calculation according to: *Q 2= A/L x λ int x N2*

Heat load	Q2	4.01E-01	W

8.3 Q3 - Heat load through Themal Valve pipe - Stainless Steel - Dwg.40722



Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D	33.4	mm	
Thickness	t	1.65	mm	
Length	L	950	mm	
Cross section	A	1.65E-04	m²	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	3.06E+03	W/m	

Heat load Calculation according to: *Q 3= A/L x λ int*

Heat load	Q3	5.31E-01	W

8 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740722	h	1.45E-01	3.8	0.55
Spacer	3740938	Q1	2.67E-01	4	1.07
Spacer	3741561	Q2	4.01E-01	2	0.80
Thermal Valve pipe	3740963	Q3	5.31E-01	1	0.53
Valves	PV101/MV102	Q4	1.25	2	2.50
Global Heat Load for one Line, W					5.45
Global Heat Load for 4 Lines, W					21.81

Q cal (Heat Load for 1 metre of Line), W/m	1.44

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m
Verification	Q cal	≤	Q a
	1.44	≤	1.00

Acceptable - see SYNTHESIS NOTE

Calculation of Single Line - LHe Storage - Valve Box
Dwg.3740718

9	CALCULATION

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3\ldots$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

9.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - Dwg.3740718

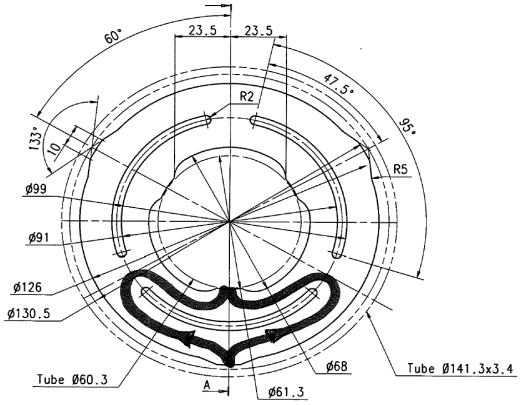
Max temperature	TH	300	K	
Min temperature	Tc	4	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	Ň	20	layer / cm	
Mean temperature	Tm	152	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08		
Emissivity of the Radiation Shields	ƐRT	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.55E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	60.30	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	75.30	mm	Dis=Dt+Th
Surface of insulation	S	0.24	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	2.26E-01	W	h = q1 x S

9.1 Q1 - Heat load through Spacer - G10 Fiberglass- Dwg.3740945

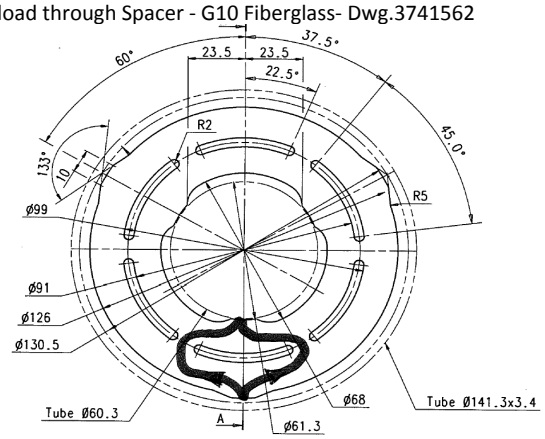


Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	167	W/m	
Width	W	13.5	mm	
Thickness	t	6	mm	
Length	L	90	mm	
Cross section	A	8.10E-05	m²	A = W x t
Quantity coefficient	N1	2		

Heat load Calculation according to: *Q 1= A/L x λ int x N1*

Heat load	Q1	3.01E-01	W

9.2 Q2 - Heat load through Spacer - G10 Fiberglass- Dwg.3741562



Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	167	W/m	
Width	W	9	mm	
Thickness	t	6	mm	
Length	L	55	mm	
Cross section	A	5.40E-05	m²	A = W x t
Quantity coefficient	N2	2		

Heat load Calculation according to: *Q 2= A/L x λ int x N2*

Heat load	Q2	3.28E-01	W

9 results | CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740718	h	2.26E-01	7.2	1.63
Spacer	3740945	Q1	3.01E-01	5	1.50
Spacer	3741562	Q2	3.28E-01	1	0.33
Valves	MV103	Q3	2.6	1	2.60
Global Heat Load for one Line, W					6.06
Global Heat Load for 4 Lines, W					24.23

Q cal (Heat Load for 1 metre of Line), W/m	0.84

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m	
Verification	Q cal	≤	Q a	
	0.84	≤	1.00	
				Acceptable

Calculation of Single Line - GHe Recovery of Storage
Dwg.3740721

10	CALCULATION

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3\ldots$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

10.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation) - Dwg.3740721

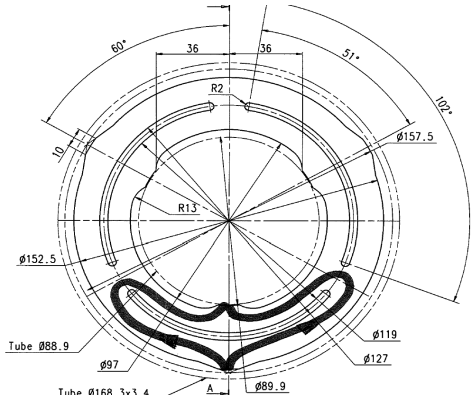
Max temperature	T_H	300	K	
Min temperature	Tc	4	K	
Number of lyers	Ns	30		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	$\check{N}$	20	layer / cm	
Mean temperature	Tm	152	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08		
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.55E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	88.90	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	103.90	mm	Dis=Dt+Th
Surface of insulation	S	0.33	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	3.12E-01	W	h = q1 x S

10.1 Q1 - Heat load through Spacer - G10 Fiberglass- Dwg.3740951

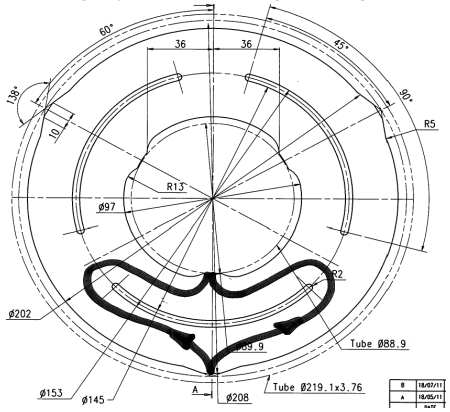


Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	167	W/m	
Width	W	12.5	mm	
Thickness	t	6	mm	
Length	L	115	mm	
Cross section	A	7.50E-05	m²	A = W x t
Quantity coefficient	N1	2		

Heat load Calculation according to: *Q 1= A/L x λ int x N1*

Heat load	Q1	2.18E-01	W	

10.2 Q2 - Heat load through Spacer - G10 Fiberglass- Dwg.3740952



Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	167	W/m	
Width	W	24	mm	
Thickness	t	6	mm	
Length	L	140	mm	
Cross section	A	1.44E-04	m²	A = W x t
Quantity coefficient	N2	2		

Heat load Calculation according to: *Q 2= A/L x λ int x N2*

Heat load	Q2	3.44E-01	W	

10 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740721	h	3.12E-01	4.4	1.37
Spacer	3740951	Q1	2.18E-01	1	0.22
Spacer	3740952	Q2	3.44E-01	2	0.69
Valves	MV109	Q3	4.8	1	4.80
Global Heat Load for one Line, W					7.08
Global Heat Load for 4 Lines, W					28.31

Q cal (Heat Load for 1 metre of Line), W/m	1.61

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m
Verification	Q cal	≤	Q a
	1.61	≤	1.00
			Acceptable - see SYNTHESIS NOTE

Calculation of Single Line - LHe Filling of Container (Line + Flexible)
Dwg.3740715, 3741359, 3741477

11	CALCULATION

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3+Q4xN4...$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

11.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation)

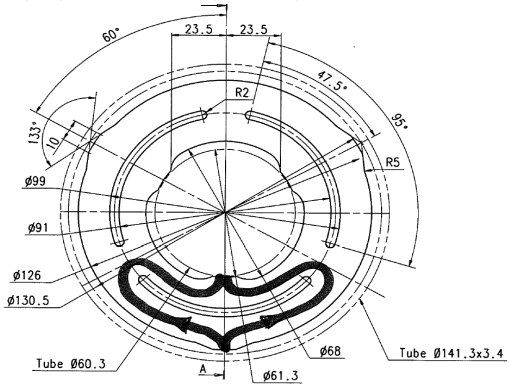
	Max temperature	T_H	300	K	
	Min temperature	Tc	4	K	
	Number of lyers	Ns	30		
	Insulation thickness	Th	15	mm	
	Assembly efficency	mu	2		
	Layer Density	Ň	20	layer / cm	
	Mean temperature	Tm	152	K	
	Reference Constants				
	Radiation Heat Transfer	Cr	5.39E-10		
	Solid Conduction	Cs	8.95E-08	W/(m²K²)	
	Emissivity of the Radiation Shields	εRT	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

	MLI Hflow result	q1	9.55E-01	W/m2	q1 = q x mu
For line part	Screen outer diameter	Dt	60.30	mm	
	Screen length	L	1000.00	mm	
	Insulation mean diameter	Dis	75.30	mm	Dis=Dt+Th
	Surface of insulation	S	0.24	m2	S=pi() x Dis x 1
	Heat load for 1 metre of length	h	2.26E-01	W	h = q1 x S
For flexible part	Screen outer diameter	Dt	73.00	mm	
	Screen length	L	1000.00	mm	
	Insulation mean diameter	Dis	88.00	mm	Dis=Dt+Th
	Surface of insulation	S	0.28	m2	S=pi() x Dis x 1
	Heat load for 1 metre of length	h	2.64E-01	W	h = q1 x S

11.1 Q1 - Heat load through Spacer - G10 Fiberglass- Dwg.3740945



Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	167	W/m	
Width	W	13.5	mm	
Thickness	t	6	mm	
Length	L	90	mm	
Cross section	A	8.10E-05	m²	A = W x t
Quantity coefficient	N1	2		

Heat load Calculation according to: *Q 1= A/L x λ int x N1*

Heat load	Q1	3.01E-01	W	

11.2 Q2 - Heat load through Cryenco 2'' male connexion

Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D	50.8	mm	
Thickness	t	1.65	mm	
Length	L	370	mm	
Cross section	A	2.55E-04	m²	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: *Q 2= A/L x λ int*

Heat load	Q2	2.11E+00	W	

11.3 Q3 - Heat load through Cryenco 2'' female connexion

Max temperature	Th	315	K	
Min temperature	Tc	4	K	
Outer diameter	D	54	mm	
Thickness	t	1.65	mm	
Length	L	370	mm	
Cross section	A	2.71E-04	m²	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: *Q 3= A/L x λ int*

Heat load	Q3	2.25E+00	W	

11 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI (Line part)	3740715	h	2.26E-01	5.34	1.21
MLI (flexible part)	3741477	h	2.64E-01	6.11	1.61
Spacer	3740945	Q1	3.01E-01	7	2.10
Cryenco 2'' male connexion		Q2	2.11E+00	2	4.22
Cryenco 2'' female connexion		Q3	2.25E+00	1	2.25
Global Heat Load for one Line, W					11.39
Global Heat Load for 4 Lines, W					45.57

Q cal (Heat Load for 1 metre of Line), W/m	0.92

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m
Verification	Q cal	≤	Q a
	0.92	≤	1.00
			Acceptable

Calculation of Single Line - GHe Recovery of Container (Line + Flexible)
Dwg.3740716, 41360, 3741490

12	CALCULATION

Global Heat Load Calculation according to:

$$Q\ gl = h \times L\ tot + Q1xN1+Q2xN2+Q3xN3+Q4xN4...$$

Heat Load Calculation for 1 metre of length according to:

$$Q\ cal = Q\ gl / L\ tot$$

where:

12.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation)

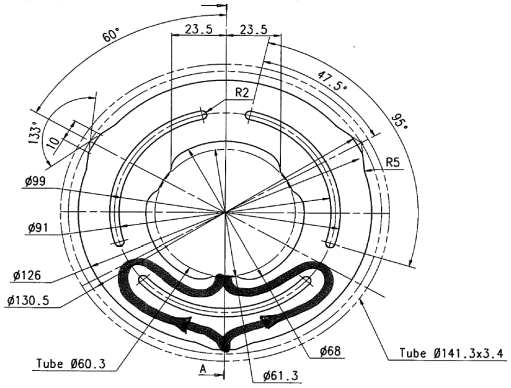
	Max temperature	T_H	300	K	
	Min temperature	Tc	4	K	
	Number of lyers	Ns	30		
	Insulation thickness	Th	15	mm	
	Assembly efficency	mu	2		
	Layer Density	Ň	20	layer / cm	
	Mean temperature	Tm	152	K	
	Reference Constants				
	Radiation Heat Transfer	Cr	5.39E-10		
	Solid Conduction	Cs	8.95E-08	W/(m²K²)	
	Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

	MLI Hflow result	q1	9.55E-01	W/m2	q1 = q x mu
For line part	Screen outer diameter	Dt	60.30	mm	
	Screen length	L	1000.00	mm	
	Insulation mean diameter	Dis	75.30	mm	Dis=Dt+Th
	Surface of insulation	S	0.24	m2	S=pi() x Dis x 1
	Heat load for 1 metre of length	h	2.26E-01	W	h = q1 x S
For flexible part	Screen outer diameter	Dt	73.00	mm	
	Screen length	L	1000.00	mm	
	Insulation mean diameter	Dis	88.00	mm	Dis=Dt+Th
	Surface of insulation	S	0.28	m2	S=pi() x Dis x 1
	Heat load for 1 metre of length	h	2.64E-01	W	h = q1 x S

12.1 Q1 - Heat load through Spacer - G10 Fiberglass- Dwg.3740945



Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Thermal conductivity (integral)	λ int	167	W/m	
Width	W	13.5	mm	
Thickness	t	6	mm	
Length	L	90	mm	
Cross section	A	8.10E-05	m²	A = W x t
Quantity coefficient	N1	2		

Heat load Calculation according to: *Q 1= A/L x λ int x N1*

Heat load	Q1	3.01E-01	W	

12.2 Q2 - Heat load through Cryenco 2'' male connexion

Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D	50.8	mm	
Thickness	t	1.65	mm	
Length	L	370	mm	
Cross section	A	2.55E-04	m²	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: *Q 2= A/L x λ int*

Heat load	Q2	2.11E+00	W	

12.3 Q3 - Heat load through Cryenco 2'' female connexion

Max temperature	Th	300	K	
Min temperature	Tc	4	K	
Outer diameter	D	54	mm	
Thickness	t	1.65	mm	
Length	L	370	mm	
Cross section	A	2.71E-04	m²	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: *Q 3= A/L x λ int*

Heat load	Q3	2.25E+00	W	

12 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI (Line part)	3740716	h	2.26E-01	4.26	0.96
MLI (flexible part)	3741490	h	2.64E-01	6.1	1.61
Spacer	3740945	Q1	3.01E-01	7	2.10
Cryenco 2'' male connexion		Q2	2.11E+00	2	4.22
Cryenco 2'' female connexion		Q3	2.25E+00	1	2.25
Global Heat Load for one Line, W					11.15
Global Heat Load for 4 Lines, W					44.58

Q cal (Heat Load for 1 metre of Line), W/m	0.98

Acceptable Heat Load according to AL C1192-SP-120	Q a	1.00	W/m
Verification	Q cal	≤	Q a
	0.98	≤	1.00
			Acceptable

Calculation of Single Line - LIN Filling of Storage Chamber
Dwg.3740713, 3741361, 3741362, 3741363

13	CALCULATION

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3+Q4xN4$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

13.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation)

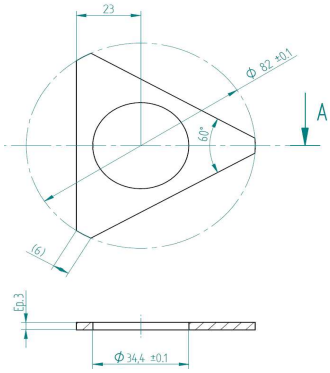
Max temperature	T_H	300	K	
Min temperature	Tc	80	K	
Number of lyers	Ns	32		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	$\check{N}$	21.33333333	layer / cm	
Mean temperature	Tm	190	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.46E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	33.40	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	48.40	mm	Dis=Dt+Th
Surface of insulation	S	0.15	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	1.44E-01	W	h = q1 x S

13.1 Q1 - Heat load through Spacer - G10 Fiberglass- Dwg.3741295

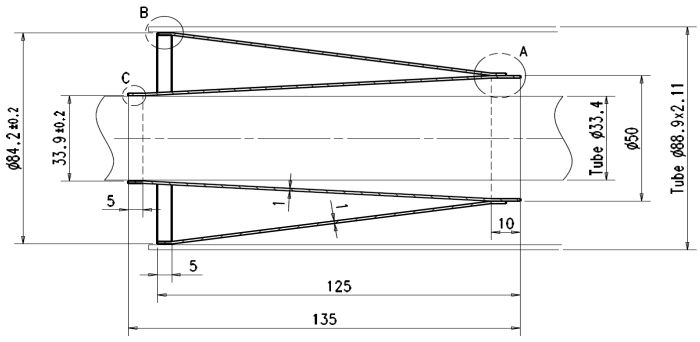


Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Thermal conductivity (integral)	λ int	146	W/m	
Width	W	6	mm	
Thickness	t	3	mm	
Length	L	23.8	mm	
Cross section	A	1.80E-05	m²	A = W x t
Quantity coefficient	N1	1		

Heat load Calculation according to: *Q 1= A/L x λ int x N1*

Heat load	Q1	1.10E-01	W	

13.2 Q3 - Heat load through Fixed Point support - Stainless Steel - Dwg.40968



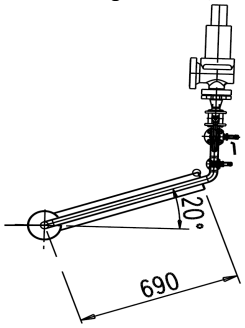
Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D1	88.9	mm	
	D2	33.4	mm	
For calculation	D	61.15	mm	D = (D1+D2)/2
Thickness	t	1	mm	
Length	L	250	mm	
Cross section	A	1.89E-04	m²	
Thermal conductivity (integral)	λ int	2715	W/m	

Heat load Calculation according to: *Q 3= A/L x λ int*

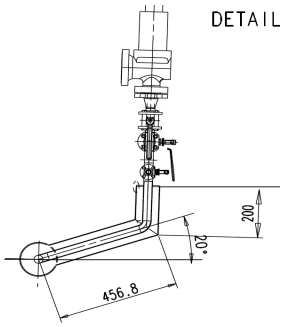
Heat load	Q3	2.05E+00	W	

13.3 Q3 - Heat load through Themal Valve pipe - Stainless Steel

For dwg. 3740713, 3741363



For dwg. 3741361, 3741362



Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D	33.4	mm	
Thickness	t	2.77	mm	
Length	L	650	mm	
Cross section	A	2.67E-04	m²	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	2715	W/m	

Heat load Calculation according to: $Q\ 3 = A/L \times \lambda\ int$

Heat load	Q3	1.11E+00	W

13 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740713	h	1.44E-01	14.7	2.11
Spacer	3741295	Q1	1.10E-01	11	1.21
Fixed point support	3740968	Q2	2.05E+00	6	12.31
Thermal Valve pipe	-	Q3	1.11E+00	1	1.11
Valves	MV111	Q4	2.5	1	2.50
MLI	3741361	h	1.44E-01	9.43	1.36
Spacer	3741295	Q1	1.10E-01	7	0.77
Fixed point support	3740968	Q2	2.05E+00	4	8.21
Thermal Valve pipe	-	Q3	1.11E+00	1	1.11
Valves	MV211	Q4	2.5	1	2.50
MLI	3741362	h	1.44E-01	6.57	0.94
Spacer	3741295	Q1	1.10E-01	5	0.55
Fixed point support	3740968	Q2	2.05E+00	2	4.10
Thermal Valve pipe	-	Q3	1.11E+00	1	1.11
Valves	MV311	Q4	2.5	1	2.50
MLI	3741363	h	1.44E-01	11.62	1.67
Spacer	3741295	Q1	1.10E-01	9	0.99
Fixed point support	3740968	Q2	2.05E+00	4	8.21
Thermal Valve pipe	-	Q3	1.11E+00	1	1.11
Valves	MV411	Q4	2.5	1	2.50
Global Heat Load for 4 Lines, W					56.91

Q cal (Heat Load for 1 metre of Line), W/m	1.34

Calculation of Single Line - LIN Filling of Vessel Separator
Dwg.3740712

14	CALCULATION

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3+Q4xN4\ldots$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

14.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation)

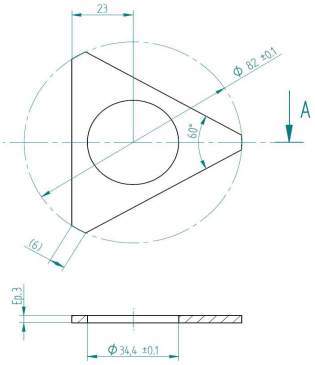
Max temperature	T_H	300	K	
Min temperature	Tc	80	K	
Number of lyers	Ns	32		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	$\check{N}$	21.33333333	layer / cm	
Mean temperature	Tm	190	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.46E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	33.40	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	48.40	mm	Dis=Dt+Th
Surface of insulation	S	0.15	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	1.44E-01	W	h = q1 x S

14.1 Q1 - Heat load through Spacer - G10 Fiberglass- Dwg.3741295

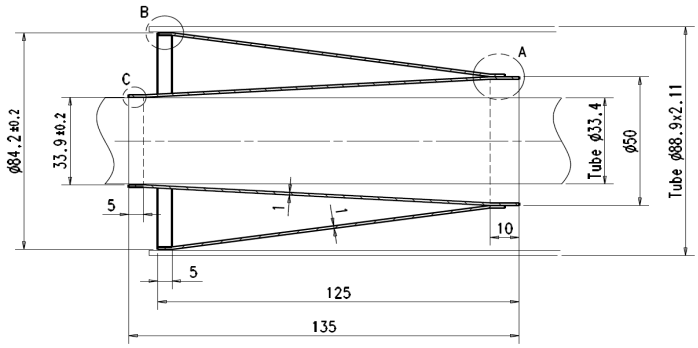


Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Thermal conductivity (integral)	λ int	146	W/m	
Width	W	6	mm	
Thickness	t	3	mm	
Length	L	23.8	mm	
Cross section	A	1.80E-05	m²	A = W x t
Quantity coefficient	N1	1		

Heat load Calculation according to: *Q 1= A/L x λ int x N1*

Heat load	Q1	1.10E-01	W

14.2 Q2 - Heat load through Fixed Point support - Stainless Steel - Dwg.40968

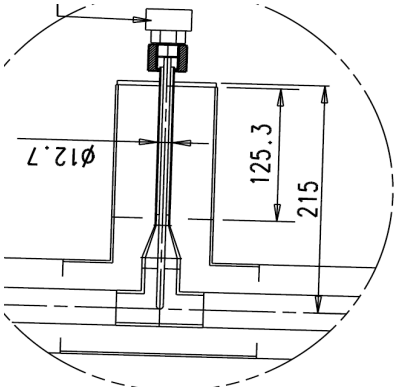


Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D1	88.9	mm	
	D2	33.4	mm	
For calculation	D	61.15	mm	D = (D1+D2)/2
Thickness	t	1	mm	
Length	L	250	mm	
Cross section	A	1.89E-04	m²	
Thermal conductivity (integral)	λ int	2715	W/m	

Heat load Calculation according to: *Q 2= A/L x λ int*

Heat load	Q3	2.05E+00	W

14.3 Q3 - Heat load through PT100 - Stainless Steel



Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D	12.7	mm	
Thickness	t	0.9	mm	
Length	L	125	mm	
Cross section	A	3.34E-05	m²	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	2715	W/m	

Heat load Calculation according to: $Q\ 3 = A/L \times \lambda\ int$

Heat load	Q3	7.25E-01	W

14 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740712	h	1.44E-01	13.79	1.98
Spacer	3741295	Q1	1.10E-01	8	0.88
Fixed point support	3740968	Q2	2.05E+00	6	12.31
PT100	-	Q3	7.25E-01	1	0.72
Valves	LV600	Q4	2.5	1	2.50
Global Heat Load for one Line, W					18.40

Q cal (Heat Load for 1 metre of Line), W/m	1.33

Calculation of Single Line - LIN Filling of Container (Line + Flexible)
Dwg.3740714, 3741364

15	CALCULATION

NOTE: Only vacuum insulated part is taken into account for calculation

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3+Q4xN4...$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

15.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation)

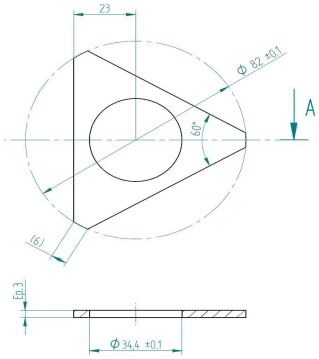
Max temperature	T_H	300	K	
Min temperature	Tc	80	K	
Number of lyers	Ns	32		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	$\tilde{N}$	21.33333333	layer / cm	
Mean temperature	Tm	190	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.46E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	33.40	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	48.40	mm	Dis=Dt+Th
Surface of insulation	S	0.15	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	1.44E-01	W	h = q1 x S

15.1 Q1 - Heat load through Spacer - G10 Fiberglass- Dwg.3741295

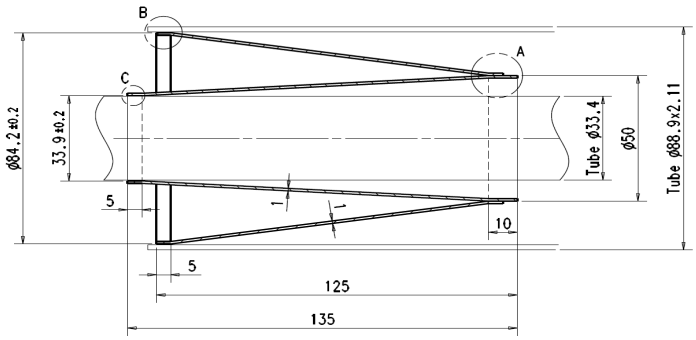


Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Thermal conductivity (integral)	λ int	146	W/m	
Width	W	6	mm	
Thickness	t	3	mm	
Length	L	23.8	mm	
Cross section	A	1.80E-05	m²	A = W x t
Quantity coefficient	N1	1		

Heat load Calculation according to: *Q 1= A/L x λ int x N1*

Heat load	Q1	1.10E-01	W	

15.2 Q2 - Heat load through Fixed Point support - Stainless Steel - Dwg.40968



Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D1	88.9	mm	
	D2	33.4	mm	
For calculation	D	61.15	mm	D = (D1+D2)/2
Thickness	t	1	mm	
Length	L	250	mm	
Cross section	A	1.89E-04	m²	
Thermal conductivity (integral)	λ int	2715	W/m	

Heat load Calculation according to: *Q 2= A/L x λ int*

Heat load	Q2	2.05E+00	W	

15 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740714	h	1.44E-01	11.17	1.61
Spacer	3741295	Q1	1.10E-01	5	0.55
Fixed point support	3740968	Q2	2.05E+00	3	6.16
MLI	3741364	h	1.44E-01	11.42	1.64
Spacer	3741295	Q1	1.10E-01	5	0.55
Fixed point support	3740968	Q2	2.05E+00	3	6.16
Global Heat Load for 4 Lines, W					33.30

Q cal (Heat Load for 1 metre of Line), W/m	0.74

Calculation of Single Line - LIN Output to 5th bay (Line + Flexible)
Dwg.3740720, 3742602

16	CALCULATION

NOTE: Only vacuum insulated part is taken into account for calculation

Global Heat Load Calculation according to:

$$Q\,gl = h \times L\,tot + Q1xN1+Q2xN2+Q3xN3+Q4xN4\ldots$$

Heat Load Calculation for 1 metre of length according to:

$$Q\,cal = Q\,gl / L\,tot$$

where:

16.0 h - Heat load through 1 metre of MLI (Multi Layer Insulation)

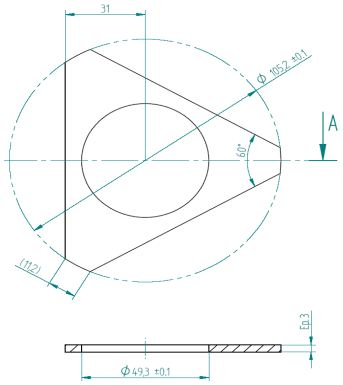
Max temperature	T_H	300	K	
Min temperature	Tc	80	K	
Number of lyers	Ns	32		
Insulation thickness	Th	15	mm	
Assembly efficency	mu	2		
Layer Density	$\check{N}$	21.33333333	layer / cm	
Mean temperature	Tm	190	K	
Reference Constants				
Radiation Heat Transfer	Cr	5.39E-10		
Solid Conduction	Cs	8.95E-08	W/(m²K²)	
Emissivity of the Radiation Shields	ε_{RT}	0.03		equivalent to 200A aluminization thickness

Heat load Calculation according to:

$$q = \frac{C_s(\bar{N})^{2.56}T_m}{N_s+1}(T_H - T_C) + \frac{C_r\varepsilon_{RT}}{N_s}(T_H^{4.67} - T_C^{4.67})$$

MLI Hflow result	q1	9.46E-01	W/m2	q1 = q x mu
Screen outer diameter	Dt	48.30	mm	
Screen length	L	1000.00	mm	
Insulation mean diameter	Dis	63.30	mm	Dis=Dt+Th
Surface of insulation	S	0.20	m2	S=pi() x Dis x 1
Heat load for 1 metre of length	h	1.88E-01	W	h = q1 x S

16.1 Q1 - Heat load through Spacer - G10 Fiberglass- Dwg.3741024

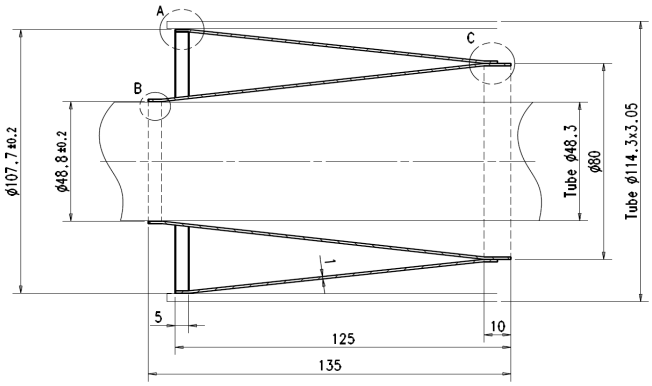


Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Thermal conductivity (integral)	λ int	146	W/m	
Width	W	6	mm	
Thickness	t	3	mm	
Length	L	27.95	mm	
Cross section	A	1.80E-05	m²	A = W x t
Quantity coefficient	N1	1		

Heat load Calculation according to: *Q 1= A/L x λ int x N1*

Heat load	Q1	9.40E-02	W	

16.2 Q2 - Heat load through Fixed Point support - Stainless Steel - Dwg.40749

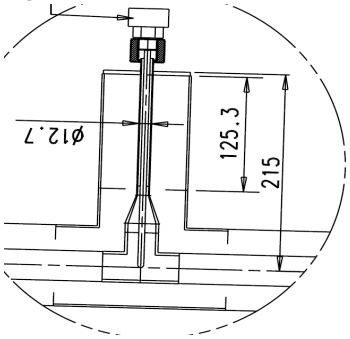


Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D1	107.7	mm	
	D2	48.8	mm	
For calculation	D	78.25	mm	D = (D1+D2)/2
Thickness	t	1	mm	
Length	L	250	mm	
Cross section	A	2.43E-04	m²	
Thermal conductivity (integral)	λ int	2715	W/m	

Heat load Calculation according to: *Q 2= A/L x λ int*

Heat load	Q2	2.64E+00	W	

16.3 Q3 - Heat load through PT100 - Stainless Steel



Max temperature	Th	300	K	
Min temperature	Tc	80	K	
Outer diameter	D	12.7	mm	
Thickness	t	0.9	mm	
Length	L	125	mm	
Cross section	A	3.34E-05	m²	A= pi() x (D-t) x t
Thermal conductivity (integral)	λ int	3064.5	W/m	

Heat load Calculation according to: $Q\ 3 = A/L \times \lambda\ int$

Heat load	Q3	8.18E-01	W

16 results

CALCULATION RESULTS

Element	Dwg. N°	Symbol	Heat Load , W (by 1 Element or by 1 metre)	Quantity (pieces or metre)	Heat Load , W
MLI	3740720	h	1.88E-01	8.98	1.69
Spacer	3741295	Q1	9.40E-02	2	0.19
Fixed point support	3740968	Q2	2.64E+00	2	5.27
PT100	-	Q3	8.18E-01	1	0.82
Valve	TV579	Q4	2.5	1	2.50
Valve	HV570	Q5	2.5	1	2.50
MLI	3742602	h	1.88E-01	5	0.94
Spacer	3741295	Q1	9.40E-02	2	0.19
Fixed point support	3740968	Q2	2.64E+00	2	5.27
Global Heat Load for 2 Lines, W					19.37

Q cal (Heat Load for 1 metre of Line), W/m	1.39

SYNTHESIS TABLE OF HEAT LOAD FOR ALL LINES (including valves heat loads)

(Conservative calculation)

1 LHe Thermal losses = 382.51 W

Type	Lines	Chapter	Line Heat Load,W	Quantity	Total Heat Load for Lines, W	Total Length, m	Q cal (Heat Load for 1 metre of Line), W/m
Upper Multiline	LHe Supply from Cold Box to Storage Line	1	18.29	1	18.29	35	0.52
Single Line	LHe Filling of Storage	8	5.45	4	21.81	15.20	1.44
Single Line	LHe Storage - Valve Box	9	6.06	4	24.23	24.23	1.00
Lower Multiline	Lhe Valve Box	4	7.74	4	30.97	11.16	2.77
Single Line	Lhe Filling of Container (Line+Flexible)	11	11.39	4	45.57	49.80	0.92
		Total			140.87	135.39	1.04
Storage	Storage	-	38.00	4	241.64		

2 GHe Thermal losses - Return from Storage = 51.67 W

Type	Lines	Chapter	Line Heat Load,W	Quantity	Total Heat Load for Lines, W	Total Length, m	Q cal (Heat Load for 1 metre of Line), W/m
Single Line	GHe Recovery of Storage	10	7.08	4	28.31	17.6	1.61
Upper Multiline	GHe Recovery Line	2	23.36	1	23.36	35	0.67
		Total			51.67	52.60	0.98

3 GHe Thermal losses - Return from Truck = 127.06 W

Type	Lines	Chapter	Line Heat Load,W	Quantity	Total Heat Load for Lines, W	Total Length, m	Q cal (Heat Load for 1 metre of Line), W/m
Single Line	GHe Recovery of Container (Line+Flexible)	12	11.15	4	44.58	45.44	0.98
Lower Multiline	GHe from Valve Box to Cold Box/Cold Track	5	59.09	1	59.09	61.06	0.97
Lower Multiline	GHe from Valve Box to Gaz Bag	6	23.40	1	23.40	30.53	0.77
		Total			127.06	137.03	0.93

4 LIN Thermal losses = 218.15 W

Type	Lines	Chapter	Line Heat Load,W	Quantity	Total Heat Load for Lines, W	Total Length, m	Q cal (Heat Load for 1 metre of Line), W/m
Upper Multiline	LIN Supply from Liquefier	3	75.69	1	75.69	35	2.16
Lower Multiline	LIN Supply from Liquefier	7	85.56	1	85.56	30.53	2.80
Single Line	LIN Filling of Storage Chamber	13	-	4	56.91	42.32	1.34
Single Line	LIN Filling of Vessel Separator	14	18.40	1	18.40	13.79	1.33
Single Line	LIN Filling of Container (Line+Flexible)	15	-	4	33.30	44.93	0.74
Single Line	LIN Output to 5th bay (Line+Flexible)	16	-	2	19.37	13.98	1.39
		Total			218.15	107.85	2.02

SYNTHESIS NOTE: Global heat load by 1 metre for all He lines is acceptable according to AL C1192-SP-120