CALCULATION REPORT

Design of Suspension links

Comparison between several designs of suspension link

Several solutions are compared:

- Current design without changing the angle of inclination.
- Current design with an optimal angle of inclination (no increasing of tension during cooling) and with a minimal section to insure the mechanical integrity of the suspension link.
- The entire suspension link composed of Ti-6Al-4V with an optimal angle.
- The entire suspension link composed of Nitronic 50 with an optimal angle.

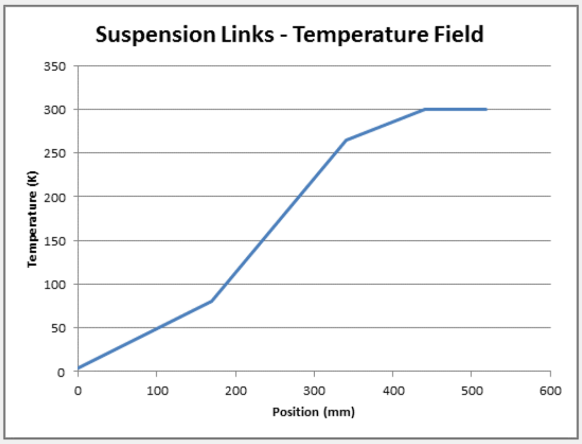
For all these solutions the total length of the suspension link is identical as well as the position of the thermal intercept.

	Current Design (Current angle)	Current Design (Optimal angle)	Ti-6Al-4V Only	Nitronic 50 Only
Angle (°)	22,5	25,35	25,78	29,59
Heat load on Helium Vessel (W)	0,76	0,55	0,59	1,67
Heat Load on Thermal Intercept (W)	3,27	2,36	1,9	5,68
Thermal Contraction (mm)	0,47	0,47	0,52	0,9
Maximum Force in suspension link (kN)	322	230	222	254
Section of Ti-6Al-4V (mm^2)	720 (29 x 25)	520 (26 x 20)	560 (28 x 20)	-
Section of Nitronic 50 (mm^2)	935 (D = 34,5)	675 (D = 29,3)	-	740 (D = 30,7)

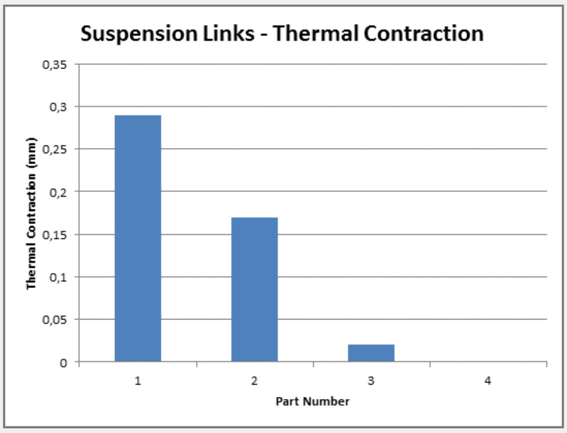
We observe that the best way to decrease the stress in the suspension link consists in changing the angle of inclination. The full Nitronic solution must be avoided because it increases significantly the section and consequently the heat load on helium vessel. The full Ti-6Al-4V solution doesn't decrease significantly the section of the suspension link.

Current Design (Current angle of inclination and current sections)

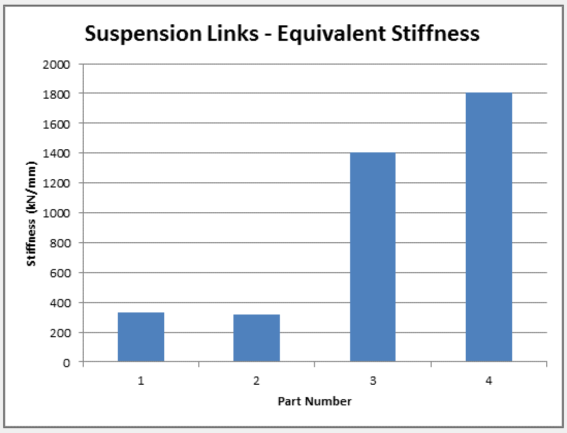
The following tables and graphs concern the current design of suspension link for an angle of inclination 22,5°. We observe that sections of the suspension link are inefficient.



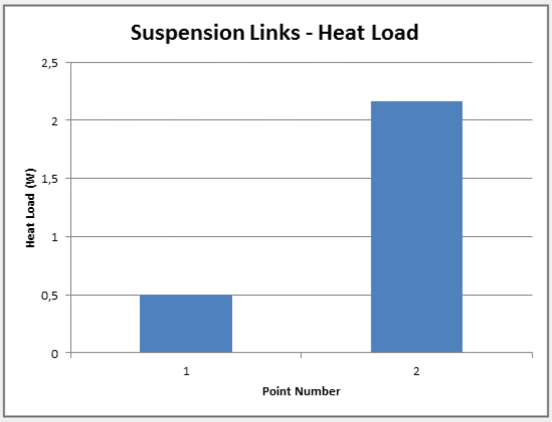
Caracteristic Point	Position (mm)	Temperature (K)
Fixation on Helium Vessel	0	4
Thermal intercept	170	80
Junction between the two parts	340	265
Suspension Bellow	440	300
Fixation on Outer Vessel	518	300



Designation	Number of the part	Thermal Contraction (mm)
Between Fixation on Helium Vessel and Thermal intercept	1	0,29
Between Thermal intercept and Junction between the two parts	2	0,17
Between Junction between the two parts and Suspension Bellow	3	0,02
Between Suspension Bellow and Fixation on Outer Vessel	4	0
TOTAL		**0,47**



Part of the suspension link	Part Number	Stiffness (kN/mm)
Between Fixation on Helium Vessel And Thermal intercept	1	335
Between Thermal intercept And Junction between the two parts	2	318
Between Junction between the two parts And Suspension Bellow	3	1407
Between Suspension Bellow And Fixation on Outer Vessel	4	1804
Equivalent Stiffness		**135**



Caracteristic point	Point Number	Heat Load (W)
Fixation on Helium Vessel	1	0,5
Thermal intercept	2	2,16

Tension in suspension links before cooling

N° suspension link	Tx (kN)	Ty (kN)	Tz (kN)	T (kN)
1	30	30	17	**45**
2	-30	30	17	**45**
3	0	0	0	**0**
4	0	0	0	**0**
5	51	51	-30	**79**
6	-51	51	-30	**79**
7	-22	-22	-13	**33**
8	22	-22	-13	**33**

Tension in suspension links after cooling

N° suspension link	Tx (kN)	Ty (kN)	Tz (kN)	T (kN)
1	55	55	32	**84**
2	-55	55	32	**84**
3	-25	-25	15	**39**
4	25	-25	15	**39**
5	77	77	-45	**117**
6	-77	77	-45	**117**
7	-47	-47	-28	**72**
8	47	-47	-28	**72**

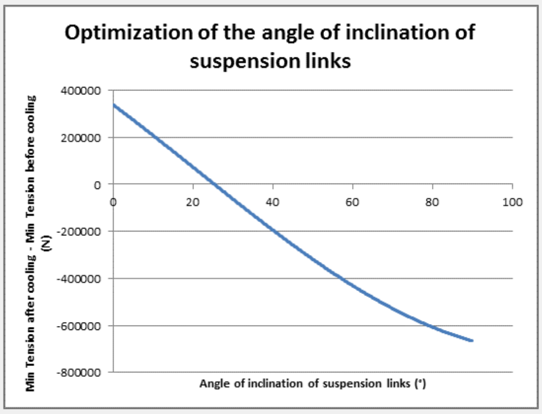
Tension in suspension links in Worst Case scenario

N° suspension link	Tx (kN)	Ty (kN)	Tz (kN)	T (kN)
1	111	111	65	**170**
2	-160	160	94	**245**
3	-112	-112	66	**172**
4	63	-63	37	**97**
5	133	133	-78	**204**
6	-182	182	-107	**279**
7	-134	-134	-78	**205**
8	85	-85	-50	**130**

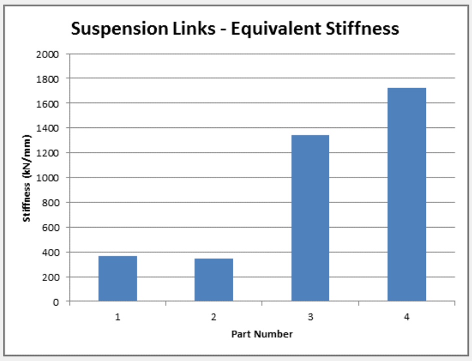
Stress in suspension links in worst case scenario

Part of the suspension link	Stress in this part (MPa)	Maximum Allowable Strength (MPa)
Between Fixation on Helium Vessel And Thermal intercept	587	448
Between Thermal intercept And Junction between the two parts	587	448
Between Junction between the two parts And Suspension Bellow	394	345
Between Suspension Bellow And Fixation on Outer Vessel	394	345

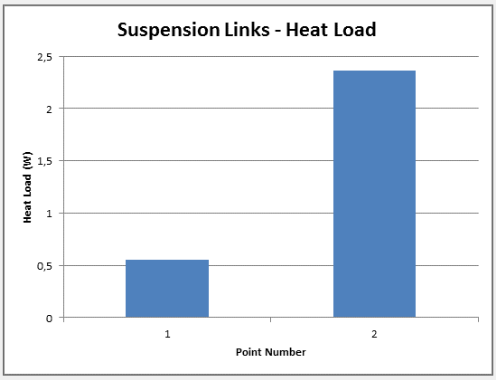
Current Design with optimal angle of inclination and optimal sections



The optimized angle of inclination is 25,35°.



Part of the suspension link	Part Number	Stiffness (kN/mm)
Between Fixation on Helium Vessel And Thermal intercept	1	366
Between Thermal intercept And Junction between the two parts	2	348
Between Junction between the two parts And Suspension Bellow	3	1343
Between Suspension Bellow And Fixation on Outer Vessel	4	1722
Equivalent Stiffness		**144**



Caracteristic point	Point Number	Heat Load (W)
Fixation on Helium Vessel	1	0,55
Thermal intercept	2	2,36

Tension in suspension links before cooling

N° suspension link	Tx (kN)	Ty (kN)	Tz (kN)	T (kN)
1	30	30	20	**46**
2	-30	30	20	**46**
3	0	0	0	**0**
4	0	0	0	**0**
5	49	49	-33	**76**
6	-49	49	-33	**76**
7	-19	-19	-13	**30**
8	19	-19	-13	**30**

Tension in suspension links after cooling

N° suspension link	Tx (kN)	Ty (kN)	Tz (kN)	T (kN)
1	30	30	20	**46**
2	-30	30	20	**46**
3	0	0	0	**0**
4	0	0	0	**0**
5	49	49	-33	**76**
6	-49	49	-33	**76**
7	-19	-19	-13	**30**
8	19	-19	-13	**30**

Tension in suspension links in Worst Case scenario

N° suspension link	Tx (kN)	Ty (kN)	Tz (kN)	T (kN)
1	79	79	53	**124**
2	-128	128	86	**200**
3	-80	-80	54	**125**
4	31	-31	21	**48**
5	98	98	-66	**154**
6	-147	147	-99	**230**
7	-99	-99	-66	**155**
8	50	-50	-33	**78**

Stress in suspension links in worst case scenario

Part of the suspension link	Stress in this part (MPa)	Maximum Allowable Strength (MPa)
Between Fixation on Helium Vessel And Thermal intercept	443	448
Between Thermal intercept And Junction between the two parts	443	448
Between Junction between the two parts And Suspension Bellow	341	345
Between Suspension Bellow And Fixation on Outer Vessel	341	345