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Telefax/Telecopy

Herschel

Datum/Date: 15/11/02

An/To:
+44 1235 44 6667
RAL, Oxfordshire, UK
J. Delderfield, E. Sawyer

+44 1483 278312
Mullard Space Science Lab.
Berend Winter

Kopie an/ Copy to:
+33 4 92 92 30 10
Alcatel Space, Cannes, F
G. Lund

+31 71 565 32 44
ESTEC, Noordwijk, NL
A. Heske

Abs./Sender: Dieter Tenhaeff
Abt./Dep.: ED65/Herschel
Tel./Phone: +49 75 45 8-9095
Fax/Fax: +49 75 45 8-42 43
E-Mail: Dieter.Tenhaeff@astrium-space.com
Ref.: HP-ASED-FX-0751-02

Seite/Page: 1 von/of 1 Seiten/Pages

Betreff/Subj.:

Displacements of SPIRE level 0 I/F

Dear Sir,

in the annex you find the displacement of the SPIRE level 0 I/F

Kind regards

Astrium GmbH

W. Rühe   J. Kroeker

i. V. W. Rühe   i. A. J. Kroeker

Astrium GmbH - Earth Observation & Science Division - 88039 Friedrichshafen - Deutschland/Germany
Telefon +49 (0)7545 8-01 - Telefax +49 (0)7545 8-4411
Amtsgericht München, HRB-Nr. 107 647 - Ust. Ident. Nr. / VAT reg. no DE 187015356
Bayerische Hypo- und Vereinsbank AG Lindau - BLZ 600 202 90 - Konto-Nr. 1 285 599

Abs./Sender: Dieter Tenhaeff
Datum/Date: 15.11.02

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Displacements of the SPIRE Level 0 Thermal Link I/F

Scope

The paper shows the analysis results of the Spire Level 0 I/F at Herschel PLM I/F.

The movement is due to

- pressure in the tank
- deformation due to cooling down
- vibration

The He II Tank design is still not finalised. Therefore these numbers are a best guess and include some margins for design development. . Following the delivery of the finite elements of the HTT by Air Liquide the calculations should be repeated.

Summary

It is proposed to take the following enveloping load case for the design.

x → +- 2 mm
y → -4 mm to 2 mm
z → -3.5 mm to 2 mm

In detail this load case is derived from the following considered load cases. Some margins are added to cover potential changes due to tank design changes.

Analysis

The following load cases has been investigated:

Load Case #1 (Vibration test:)
The internal pressure of the HTT is 1.76 bar. This results in a tangential movement of 1.76 mm in –z direction and an axial movement of 1.1 mm. This has to be superposed with the values due to cooling down. The dynamic amplitude is as defined for the vibration test.

Load Case #2 (tank load up to latest opening of the rupture disk)
The maximum displacement from pressurising the tank of 3.1 mm has to be superposed to the displacements of cooling down. Vibration at the same time has not to be taken into account

Load Case #3 (Failure case, 1 bar in CVV, He II Tank has vacuum)
The maximum displacement resulting from outer pressure on the tank of 1 mm. This load has not to be superposed with thermal distortion and vibration

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Load Case	Pressure	Cooling down	Vibration	Superposition
#1	x = 0 to + 1.03 mm y = 0 mm z = 0 to - 1.76 mm	x = -0.7 mm y = -1.75 mm z = 0 mm	x = +- 1 mm y = +- 1.7 mm z = +- 1.7 mm	x = -1.7 mm to 1.3 mm y = -3.5 mm to 0 z = -3.5 to 1.7 mm
#2	x = 1.8 mm y = 0 mm z = -3.1 mm	x = -0.7 mm y = -1.75 mm z = 0 mm	-	x = 1.1 mm y = - 1.75 mm z = -3.1 mm
#3	x = -0.6 mm y = 0 mm z = 1 mm	-	-	x = -0.6 mm y = 0 mm z = 1 mm

Table 1: Displacements of the Spire Level 0 I/F.

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ANNEX (Detailed Results)

The annex contains figures indicating the value and direction of the individual dispalcements.

Pressure Loads

The Helium II Tank can see following pressure cases:

external pressure of 1 bar: → failure case, He Tank at room temperature only)
internal pressure between 0 bar and 1.76 bar → operating pressure (ground and orbit)
internal pressure of 3.06 bar → failure case (opening of rupture disc)

The internal pressure causes a movement of the level 0 I/F in –z direction .

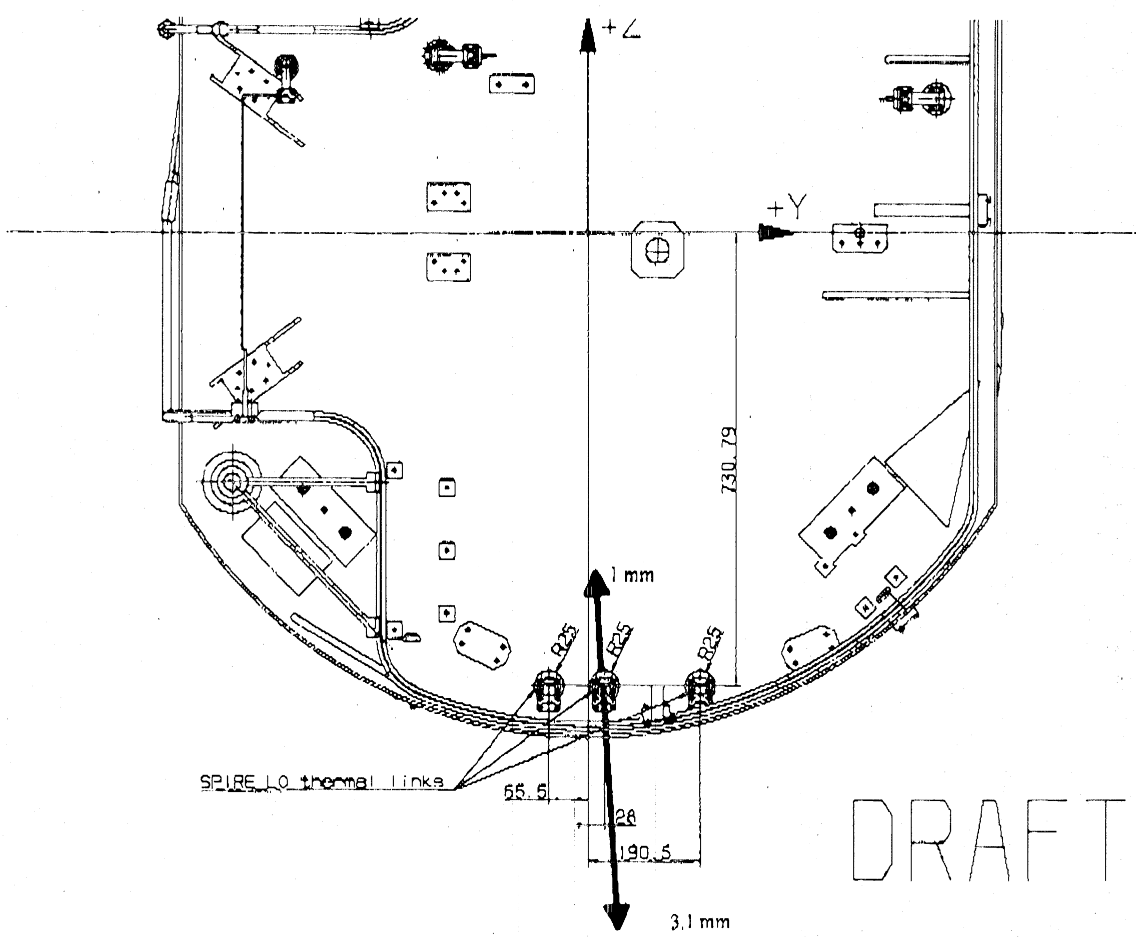

Figure 1: Lateral displacement of the Spire level 0 I/F in dependence of the pressure (3.1 mm is related to 3.06 bar internal pressure, 1 mm is related to 1 bar external pressure).

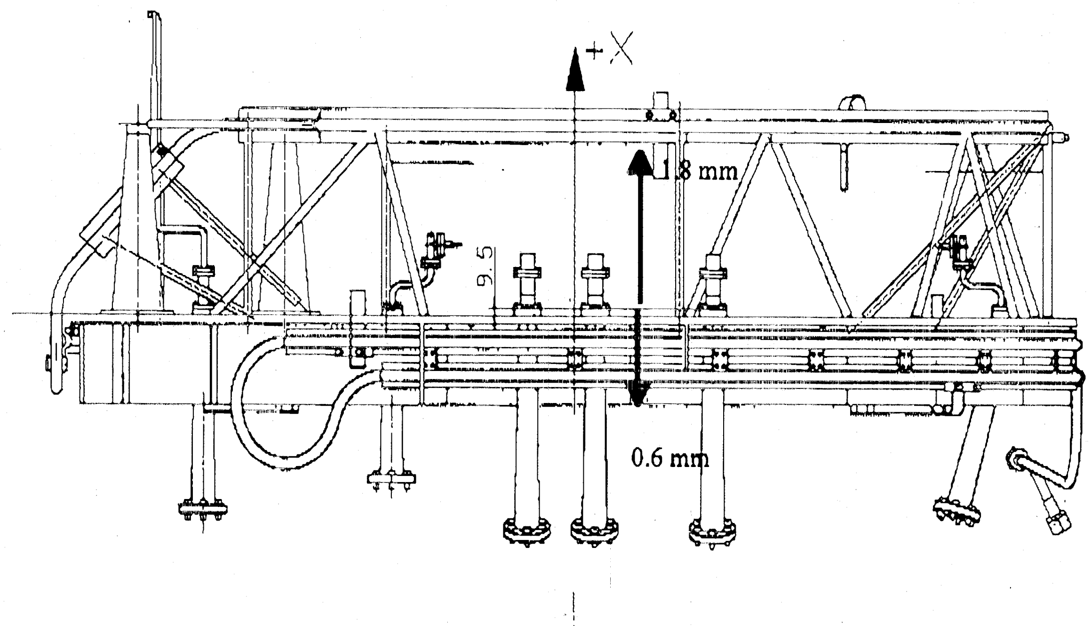

Figure 2: Axial displacement due to the pressure in the tank, (1.8 mm is related to 3.06 bar internal pressure, 0.6 mm is related to 1 bar external pressure)

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Thermal Distortion Load Case (Cooling down)

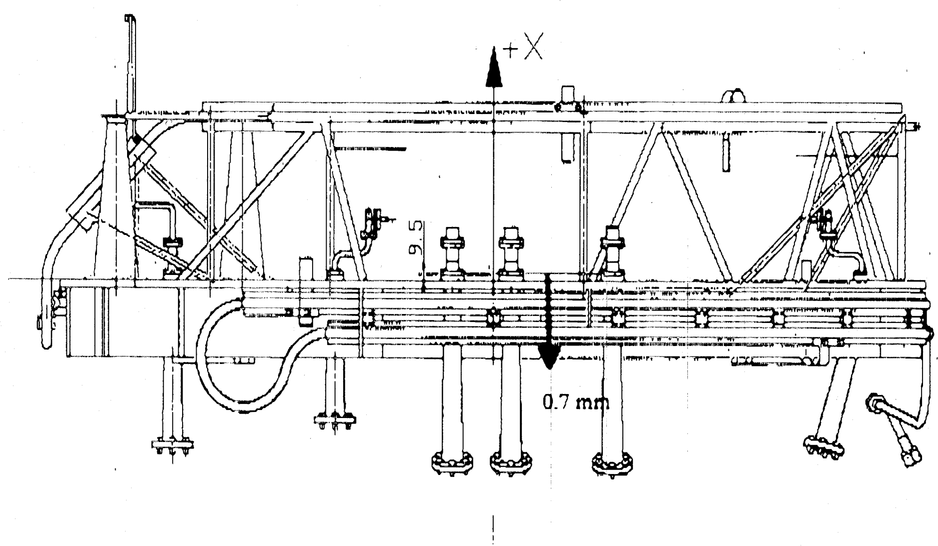

Figure 3: Axial displacement of the top of the level 0 I/F due to thermal distortion

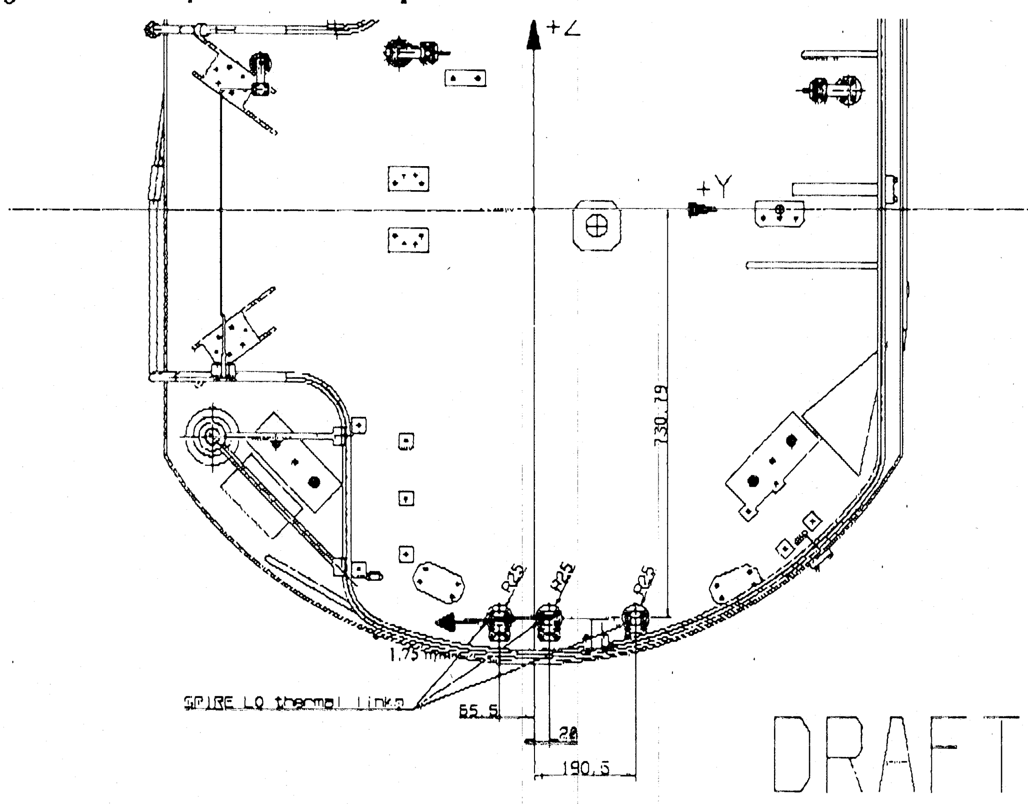

Figure 4: Lateral displacement of the top of the level 0 I/F due to thermal distortion

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Vibration

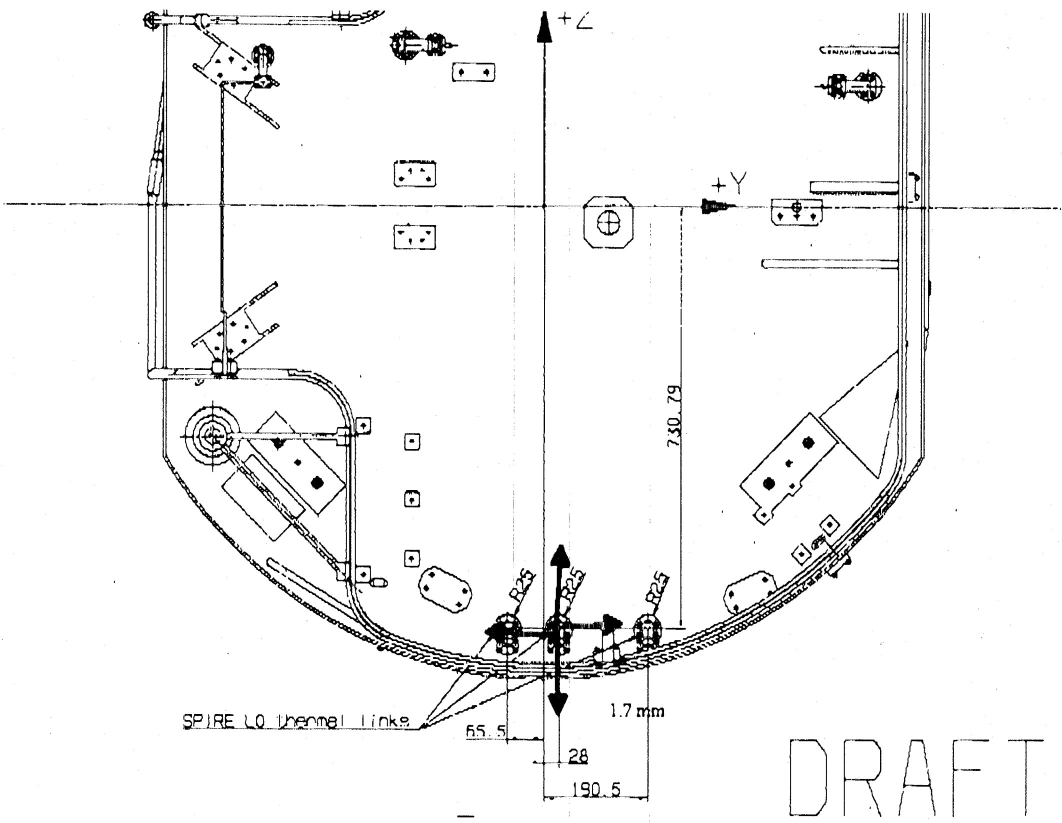

Figure 5: Lateral displacement of level 0 I/F due to vibration

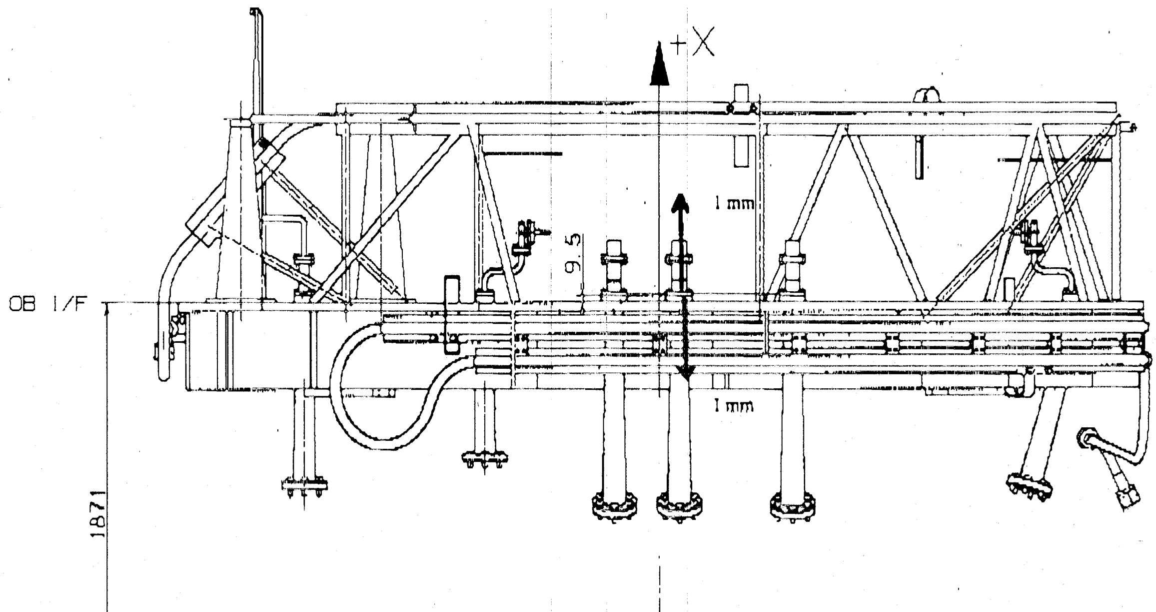

Figure 6: Axial displacement of level 0 I/F due to vibration