CLRC

8th May 2003

To: Chris Jewell
From: John Delderfield

SPIRE-RAL-NOT-001637

cc: Matt Griffin, Lionel Duband, Horst Faas, Jérôme Guichard, Bruce Swinyard, Anne-Sophie Goizel, Michael Langfermann, Ruediger Hohn, Juergen Kroeker, Vincent Lebreton, Nicolas Balcet, Bernhard Kettner, Mathias Alberti, Bernard Collaudin, Juergen Hinger, Armin Hauser, Carlos Pascual Juarros, Chris Brockley-Blatt.

SPIRE L0 THERMAL STRAPS.

Anneso and I attended a meeting about L0 interfaces at Freidrichshafen on 3rd and 4th March together with most of this copy list.

Spire presented a case for a 100mW/K L0 cooler evaporator/shunt strap and two other 50mW/K L0 straps, one for the cooler pump and one for the detector boxes. These cooler strap conductivities are as specified by Lionel and backed-up by calculation. The detector boxes' value is derived using instrument thermal model sensitivity analysis. It was noted that the sorption cooler had been developed under ESA contract with its L0 interfaces at 1.7K, the boundary condition at which its performance is specified. We saw how this was achieved during development by locating the cooler close to a 1.65K helium vessel and using substantial fully annealed high purity copper straps. Bernard Collaudin was the ESA monitor for this TRP contract and so expertise has luckily been transferred into the Herschel industrial team. I have since looked at RAL's instrument thermal control document and see that Bruce Swinyard clarified these conductance requirements for Spire in July 2000.

At the meeting Spire did not take a parochial perspective, but considered values overall from the HeII surface to the sub-system requiring cooling. These values are to allow Spire to work to specification in flight; we can accept somewhat poorer conductivities during ground test when the full cooler hold-time is not needed and sky background is only simulated.

It was very clear how much easier the PACS accommodation is than Spire's. This was not new but some had suggested the two might be of the same difficulty. Primarily the PACS cooler is much nearer to the HeII and seems to have a lower 300mK load. In addition, the flexible braid needing to de-stress the PACS cooler I/F can be supported straight on the Hershel thermal link.

This soon brought us to the question of how to budget the above conductances into its various contributions, primarily between Spire and Herschel. I restated my proposal from 19th November 2002 that for each strap it should be split 3 equal ways: the mechanical transfer from HeII to the Spire/Herschel interface; the Spire internal section that includes the electrical isolation; the Spire internal flexible{each with an associated I/F impedance}. Rather surprisingly some present seemed not to have heard of this being proposed!

At the end of the day we reached a conclusion, but it was to some extent interim and as necessary to get the critical path HeII tank final machining initiated. A major problem is that Spire is well into instrument hardware build to meet delivery dates required by ESA. Our resources are sized to achieve this. Many flight model items already exist. The urgent need for the Herschel industrial team to catch up has been well emphasised. So the Spire team hoped the Freidrichshafen meeting would fully close out the L0 interfaces.

Before the meeting it was clear that this could not happen. How far we could progress was limited because Astrium did not table its substantial presentation ahead of time, as strongly requested, so it could be properly considered in detail by the instruments. This presentation contained new information not previously seen by us within documents. In addition, ESA and Astrium soon made it clear that they had a pre-agreement that this meeting's remit was just part of a sequence. Spleen venting communication has since gushed forth from those responsible for achieving the overall Spire programme, complaining that L0 requirements were not closed out. If I might say so, Chris, this continued tension has also caused some ill-judged comments from yourself. Let's hope we shall be amused about such things when Spire is working well in orbit and we can all take a more detached view!

It's vital we keep this process moving forward very constructively. For instance, at our recent Spire to industry meeting, we discussed getting the IID-B signed off, now that at last we have reasonable agreement about much of ECR9, etc. Bruce usefully distinguished between an overall understanding of requirements and the specific parameters. So it was agreed that RAL would redraft ECRs 8 and 9 {8 being a number originally used for a thermal ECR that never made much progress} so ECR8 would contain the overall understanding of requirements and can probably be signed of as quickly as process allows, whereas ECR9 contains all the in-flight case specific numerical parameters and will probably need an overall L0 draft design and Astrium's next reduced spacecraft thermal interface model before both sides can sign.

Let me restate the interim conclusions from Freidrichshafen, putting in more detail than is minuted in HP-2-ASED-MN-0343.pdf, with its roadmap forward.

1. ***ESA agreed that their contractor's spacecraft would provide Spire with three L0 interfaces at our agreed mechanical interface plane that achieved a conductance of >100mW/K to <1.7K HeII in flight, including the interface impedance at the Spire/Herschel interface.***
2. ***They also agreed that an extra open He flange would be provided in a triangle with the two existing Spire cooler flanges so that, if final overall L0 performance analysis required it, this could be brought into play to provide a higher performance evaporator strap.***
3. ***It was further noted that there were real technical limitations on how massive the HeII tank extensions could be, set by the stress they exert on the thin walled tank, not least at launch. After discussion we agreed that imposing a particular geometry rather than a requirement was not the way to go. Within these limitations, and that of achieving the required gas tightness, Air Liquide were to accept an instruction from Astrium to strive to do as well as possible, not merely to achieve <100mW/K.***
4. ***The meeting noted that Spire's expectation was this specification would be well exceeded because Astrium had stated that predicted performance was on the basis of conservative performance figures to which they were prepared to sign up contractually.***
5. ***Measurements were planned on the 6 litre cooler, to check modelled extrapolations from the 4 litre version and to explore performance variations as operating conditions altered away from the ideal ones referenced in the specification.***
6. ***In order that there should be a high level of openness, and an understanding that every reasonable measure was being taken as the overall L0 design was finalised, ESA assured Spire there would be both a PDR and a CDR on the L0 system and that Spire would be invited to attend at least the first as an observer. It was planned for May, with a data pack a fortnight before the meeting.***

To clarify point 3, on my return to RAL I generated SPIRE-RAL-NOT-1594 which calculated a mass of 626 grams and an unbalanced moment of 0.086Kg-m to be properties of the Astrium L0 cone design. I take this to be a reasonable guide for what can be attached to tank ports. (My note also contained a first order estimate of conductance, but you quickly pointed out that the Astrium cones had already been superseded by design iteration, and cautioned I should wait for more definitive design suggestions).

Well this review process has now started and I am in receipt of three documents:

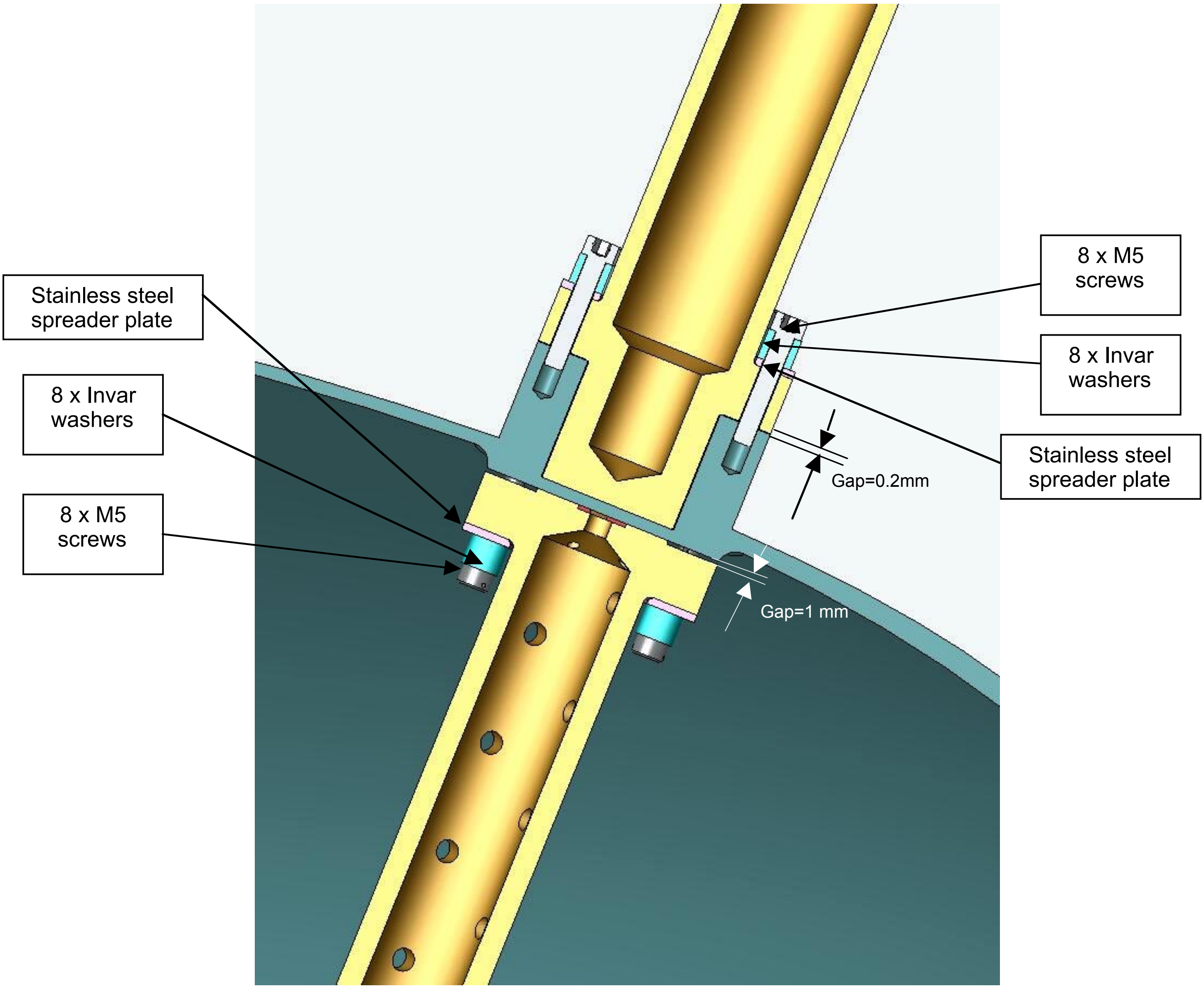
- RD-1 HP-2-AIRL-AN-0004 (1).doc
- RD-2 HP-2-AIRL-DD-0002 (1).doc
- RD-3 HP-2-AIRL-IC-0001 (1.1).doc

I hope you can arrange for these be revised before PDR, to take into account the following comments, which I will split out on to RID forms if you would like (and if you send me a proforma!).

On 27th September 2002 at Freidrichshafen Spire agreed its L0 mechanical I/F location, and Herschel ceased to provide Spire LO straps with flexibles. The interface is correctly represented in 2547-121140-000-007-0A. Horst Faas apologised for such a major shortcoming with the L0 study to date. Nor is it just a matter of ignoring the flexibles in the present study because they are right at the of the link as supported by the HeII tank and contribute maximum moment to the flange, so mechanically-allowed material cross-sections would not scale. "Progress" seems to have been permitted to consider an out-dated direction for 8 months.

The function of the flexibles, whoever provides them, may need clarifying. There are some significant low frequency (almost d.c.) flexings due to CVV pressure changes + they need to permit the relative instrument to HeII tank movements during launch vibration. I recall that at the 27/9/02 meeting their flexing due to thermal expansiosn, even during cooldown, was said to be small compared to these two effects.

I see from the documents that the basic Spire strap has an interface to the HeII tank that looks like:



The thinned 5083 tank wall in the centre disc is computed on page 19 of RD-1 to have a conductance of 400mW/K. This uses a conductivity of 1.7W/m-K at 1.7K. for 5083. Were the value I use of 1.23W/m-K to be correct for this material as machined, its conductance would be only 289 mW/K. This miniscule element alone would then have less conductance that Spire proposed for the whole HeII to instrument I/F section.

There's a more major problem with this tank closure however. The geometry shown above, if not prejudged as to function, might otherwise be taken to be a punch aimed at removing this central disc! At the very least I would expect stress corrosion and He leaks at the rim around its periphery. The inclusion of the two “special gaps” increases the tendency of this disc’s periphery to flex/shear with any rocking motion transmitted via the tensioned bolts’ elasticity.

I like the internal cone for ground use, the way it keeps a circulating HeII film close to the cone’s outer end, and the use of invar to maintain bolt tension. I would actually throw away the stainless steel spreader plate and make a drilled Invar annulus instead, one piece instead of 9, although heavier, as it would a better load spreader for He sealing (see later, but it only includes one set of bolts and one spreader).

I don’t like un-inspectable fasteners inside the HeII tank, or the number of clamped interfaces in the thermal path.

Point 2 above of the agreement has not been implemented. It looks as though the evaporator port has been opened instead. I don’t have any problem technically with this, but agreements involve both parties and if I am right about this being changed it should NOT have happened without everyone’s prior agreement.

When I submitted SPIRE-RAL-NOT-1594 you said to me that design iterations were taking place daily. However, I note that most of the above comments already exist in what I sent you on 24/3/03 (this is attached as last page) which was based on digesting the Freidrichshafen presentation. Also everything in the documents seems to fit with the subset we saw at Freidrichshafen a month ago. So am I right and are these documents from Air Liquide actually up to date?

I’ve passed the documents to Anne-Sophie and she may well respond with detailed thermal engineering comments.

One out of order comment, if Air Liquide took the idea as per this last page and implemented it for all three Spire L0 straps, SPIRE-RAL-NOT-1594 suggests its conductance in flight would be 2170 mw/K in series with 600mW/K I/F conductance, combining to 470mW/K.. It also has:

- No He swilling about in cones
- Higher mass than the early Astrium solution but lower unbalanced moment
- No need for He to fill up into the outer cones on ground
- Welds configured on strap units ,which can be replaced from the outside the HeII vessel if needed, and which can be tested as subsystems (at 100Bar He?).

470mW/K is significantly above Spire’s most awkward 300mW/K request, we could all save our travel money and time, job done

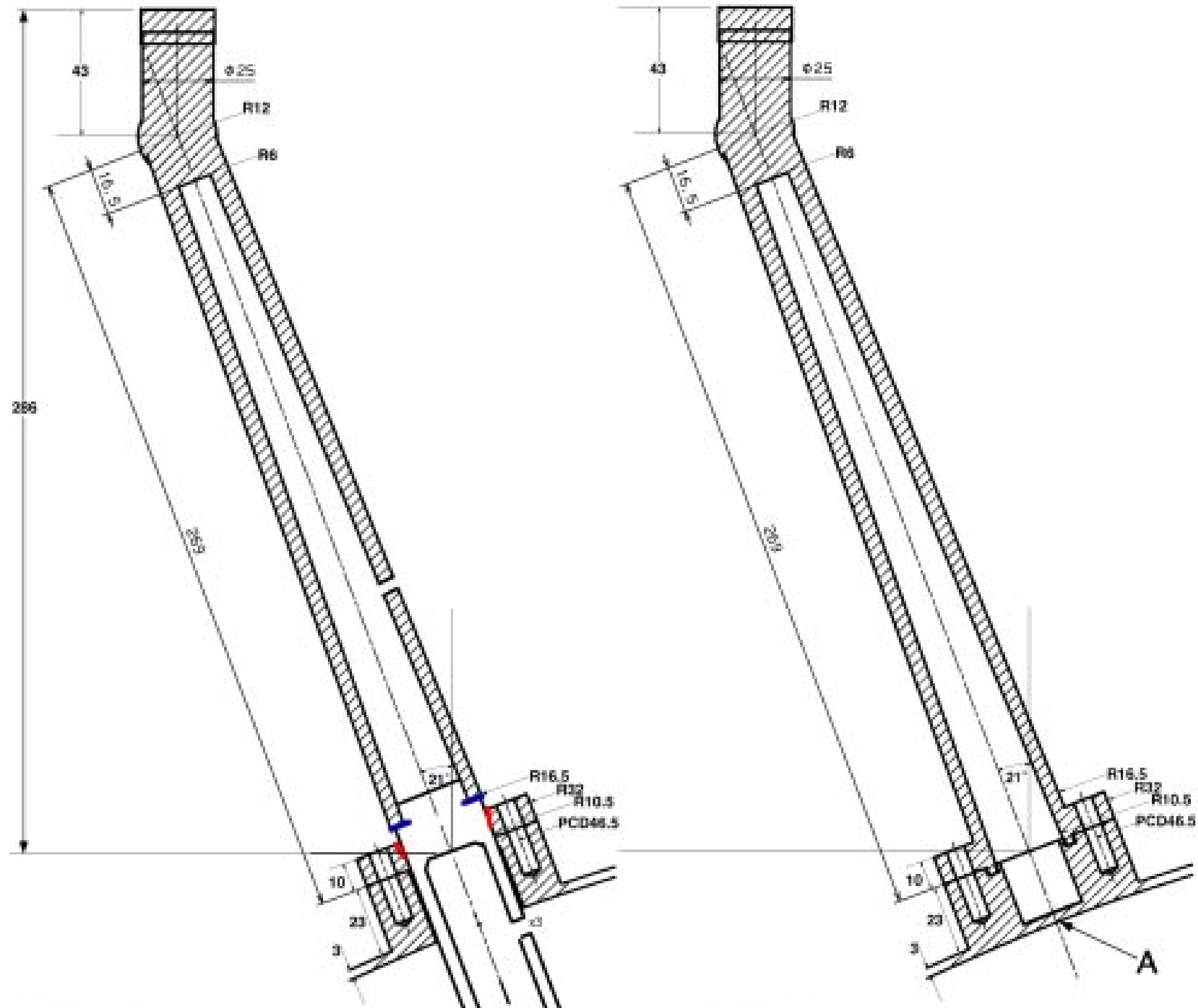
Anyway, this was out of order. Let’s continue the iterative process.

In order to fit in with pressing instrument timescales please would you now confirm early dates for point 6 of our agreement. Given the need to keep everything together, and particularly given your stated perception of how the Spire consortium works, I request that the Spire PI also be invited to attend.

Best regards

PS It’s encouraging to see that 6082 to pure aluminium welding technology is being sorted anyway for the EM cryostat. Hopefully it will be applicable to the easier-to-weld 5083.

Generated 24/4/03:



DESCRIPTION

Three parts to ease manufacture.

Inside tube with 5083 flange ring welded on as in red.

Outer empty thermal cone pushed on and welded as in blue.

Inside tube and thermal cone both 5 nines Al, annealed before fabrication.

ADVANTAGES

Reaches into cryogen on ground better and needs no fountain spray to be fitted.

Has no thinwall parts in other than 5083 and no He going up extended external tubes.

Has hard 5083 standard flanges.

HAS NO 5083 SECTION OR CLAMPED JOINT IN THE CONDUCTION PATH TO COOLER.

Gives mechanical balance about flange for moment of outer thermal cone...less launch leakage.

Provided tank flange has been machined to suite metal

ADVANTAGES contd.

seal, can be implemented as a rework of a closed tank as per r.h.s. picture.

No fasteners (uninspectable) inside tank.

No need, as in some schemes, to obtain high finish inside and outside at "A", to then maintain high pressures on it and avoid stress build-up around its edge (cycling+section change).

DISADVANTAGES

5083 flange probably needs final machining to ensure welding has not distorted it.

Use of vacuum deep E-beam welding to minimise contamination of 5 nines Al.

"Not invented here!"