# SPACE EXPOSURE OF HST-SA1 TAGBOARDS

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ABSTRACT

The upper and lower outboards and the upper and lower inboards connected to the flexible harness are investigated. These small boards, also known as tagboards, contain several drilled non plated holes in which bifurcated terminals are swaged and soldered. Some of these terminals have conductor leads attached to it, soldered using a side route connection. The thermal cycle environment has a large impact on solderjoints. These solderjoints are investigated for thermal fatigue.

Keywords: tagboard, thermal fatigue, solder joint, solder fillet, cracking, orange peel

## 1. INTRODUCTION

The common cause of failure of solderjoints is thermal fatigue. Thermal cycling impose cyclic stresses on the solderjoints and the circuit board. The thermal expansion coefficient of the solderjoint and the board in which the solderjoints are made is not necessarily equal. The expansion coefficient of circuit boards is anisotropic in the sense that the CTE in the Z-direction is usually larger than those in the X-and Y-direction.. Solderjoints manufactured in the Z-direction experience large differences in CTE and therefor are prone to thermal fatigue.
Within the temperature limits of the HST thermal environment, the thermal expansion coefficients of the copper of the terminal and the solder are similar and around 17 $10^{-6}$ m/m/K while boards with layers of glass-fibre weave show an CTE of approx. 31 $10^{-6}$ m/m/K. For boards with a thickness of 1.6 mm the mismatch over a temperature range from +90$^{o}$C to -100$^{o}$C is 2.1 µm (assuming that both side of the solderjoint are free to move). The resulting stress can easily exceed the yield strength of the solder alloy. This stress and the high number of thermal cycles on the HST blanket (21000 thermal cycles between +90$^{o}$C and -100$^{o}$C) are responsible for the thermal fatigue.
Visually thermal fatigue on solderjoints shows itself as cicular cracks on the solder fillet and the so-called orange peel effect. Thermal fatigue does not necessarily results in a failed joint connection.
In the following paragraphs the visual inspection and the microsection results are given for some tagboards. Two of the four boards are only visual inspected to keep them for further investigations.

## 2. INTRUMENTATION

The main instruments used in this investigations are standard ESTEC laboratory equipment such as stereozoom microscopes (Wild M8 with camera attachment), Reichert MeF3a metallurgical microscope with camera attachments. Microsection samples were mounted in Caldofix mounting resin, ground and polished down to 1 µm using the Struers Abramin automatic polisher.

## 3. INVESTIGATION

The four tagboards are visually inspected. The outboard upper and the inboard lower tagboards are only connected to the flexible harness, but all through thickness holes have swaged bifurcated terminals soldered into it. No conductor wires are connected to these terminals. One of these boards is used for microsectioning (overall layout in figures 1a-b).
The outboard lower and the inboard upper tagboards are identical to the previous two boards but three bifurcated terminals per board have side routed connector wires soldered to it. One of these boards is used for microsection. These microsections are made through the terminals containing the soldered wires (overall layout in figures 1c-d).

## 4. RESULTS AND DISCUSSION

The visual inspection of the tagboards shows some common features on all boards. The delrin tagboard holders and the conductor leads show dark brown stains (figure 2a-d). These dark brown stains will not be further investigated in this report but will be addressed in further investigations.
The solder fillets at the outside of the tagboards are inspected. All these solder fillets exhibit thermal fatigue to a certain degree. In most cases only the orange peel effect is present on the surface. This is the case for those solderjoints which do not have a conductor wire connected to it.
The six bifurcated terminals containing a conductor lead more or less cracking of the solder fillet. An example of a $360^{o}$ crack in a solder fillet can be found in figure 3a. An example of the orange peel effect on a solder fillet is found in figure 3b.
Microsectioning reveals if the cracks found during visual inspection are real solderjoint failures. Microsections of a connected terminal pin and an unconnected one are shown in figures 4a-b. The swaged ends are clearly visible and the solder fillet connects the pad to the swaged end of the terminal. In the case of a connected terminal pin the complete bifurcated terminal is filled with solder alloy. Detailed view of the solder fillet area are given in figure 5a-b. These photographs are not from the terminal from figure 4 but from identical ones at another position.
The detailed view of the solder fillet of the connected terminal pin shows the locations of the $360^{o}$ cracks in the solder fillet (figure 5a). However, none of the connected joints failed after the 21000 thermal cycles. An adequate electrical path is still present between the conductor lead to the terminal to the solder pad. The cracks do not penetrated into the joint. None of these type of defects are seen on the non-connected terminals. The surface of the solder fillets are roughened (figure 5b), but no cracks are visible.

## 5. CONCLUSION

All solder joints on the tagboards survived the thermal environment as experienced on HST. The 21000 thermal cycles between $+90^{o}C$ and $-100^{o}C$ roughened the solder fillets of the non-connected terminals pins (no solder alloy present inside the bifurcated terminal). These solder fillets show the so-called orange peel effect.
The connected terminal pins (solder alloy is present inside the bifurcated terminal) show to a large extend circular cracking on the solder fillet and to a lesser extend circular cracking inside the pin area.

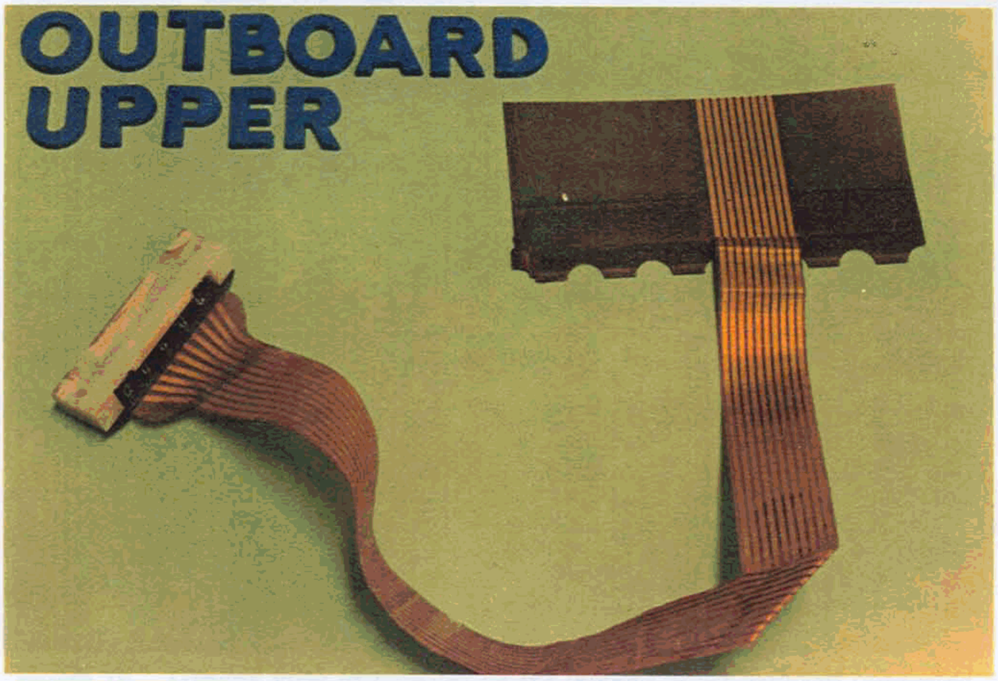


**Figure 1a.** *General view as received on the outboard upper tagboard connected to the flexible harness.*
*Magn. x0.5*


**Figure 1b.** *General view as received on the inboard lower tagboard connected to the flexible harness.*
*Magn. x0.5*

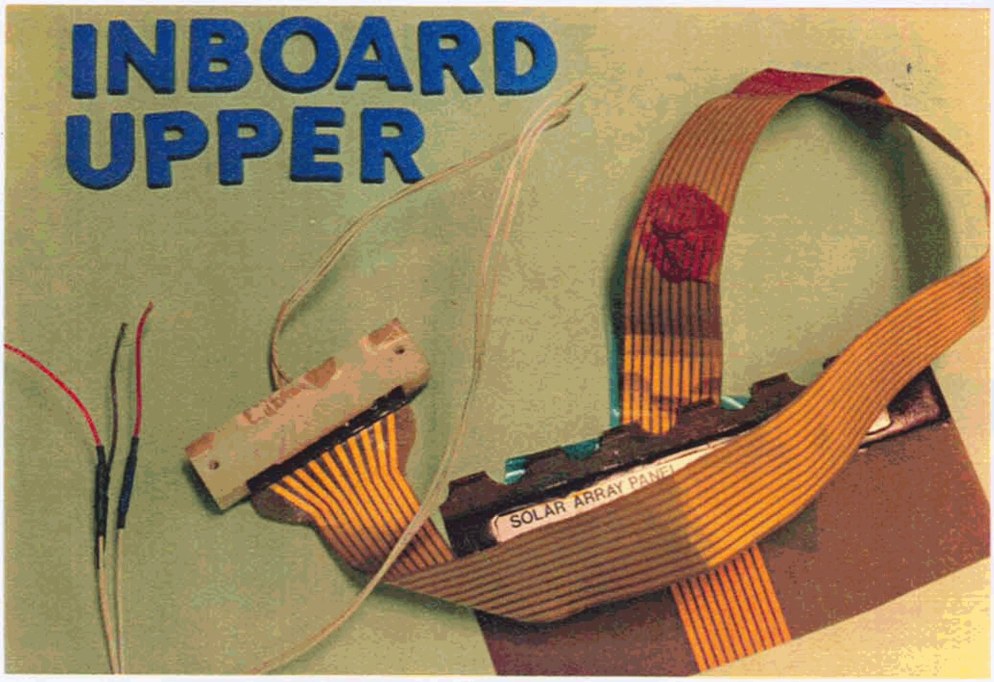


**Figure 1c.** *General view as received on the inboard upper tagboard connected to the flexible harness.*
*Magn. x0.5*

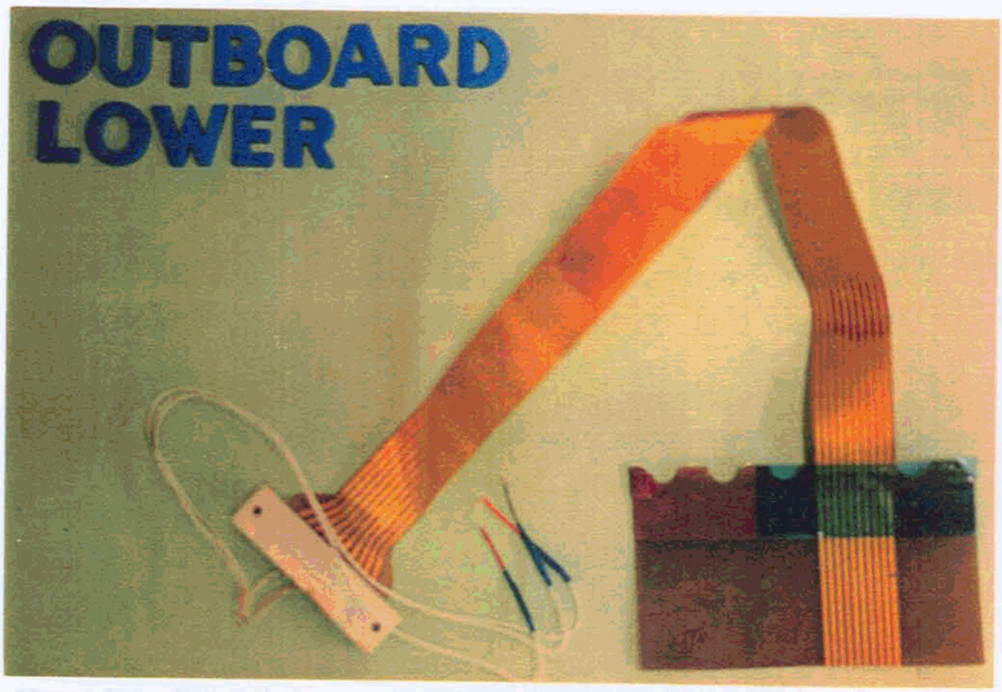


**Figure 1d.** *General view as received on the outboard lower tagboard connected to the flexible harness.*
*Magn. x0.5*

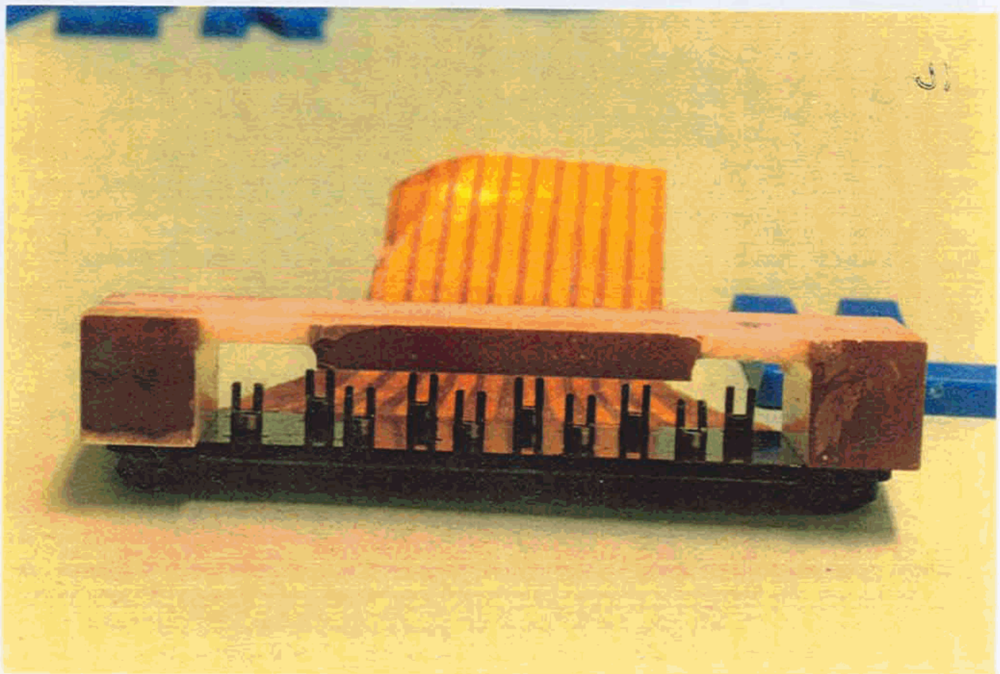

**Figure 2a.** *Detailed view from the front of the inboard lower tagboard, showing that no conductor wires are connected to the terminal pins. Notice the brown stain at the front. Magn. x1.75*

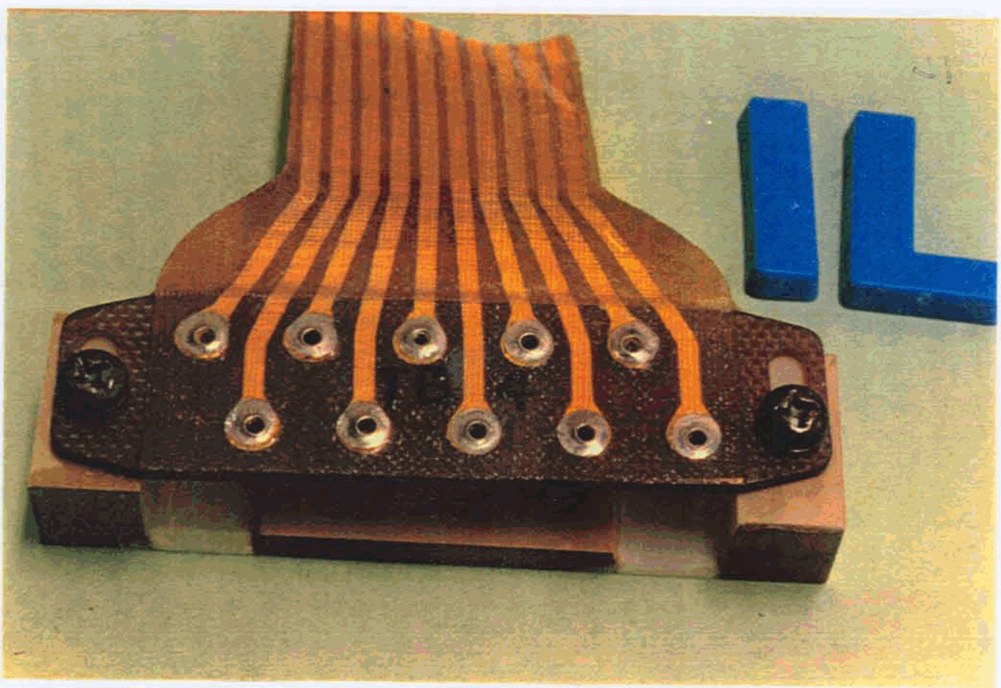

**Figure 2b.** *Detailed view on the tagboard of the inside lower connection. None of the terminal holes are filled with solder alloy. magn. x1.75*

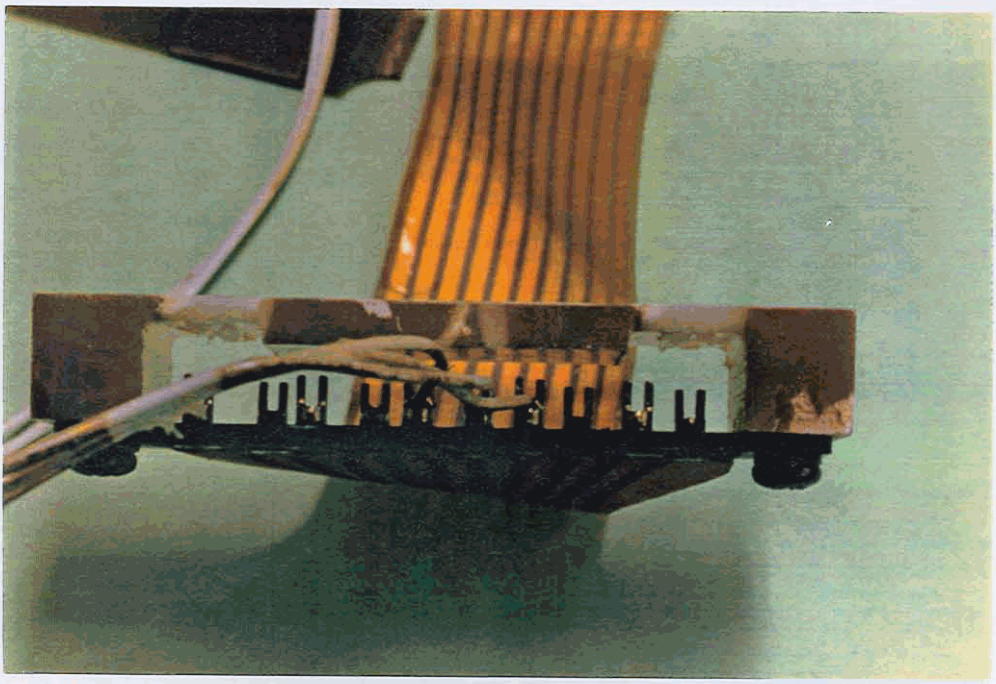

**Figure 2c.** *Detailed view from the front of the inboard upper tagboard, showing that three conductor wires are connected to the terminal pins. Notice the brown stain at the front. Magn. x1.75*

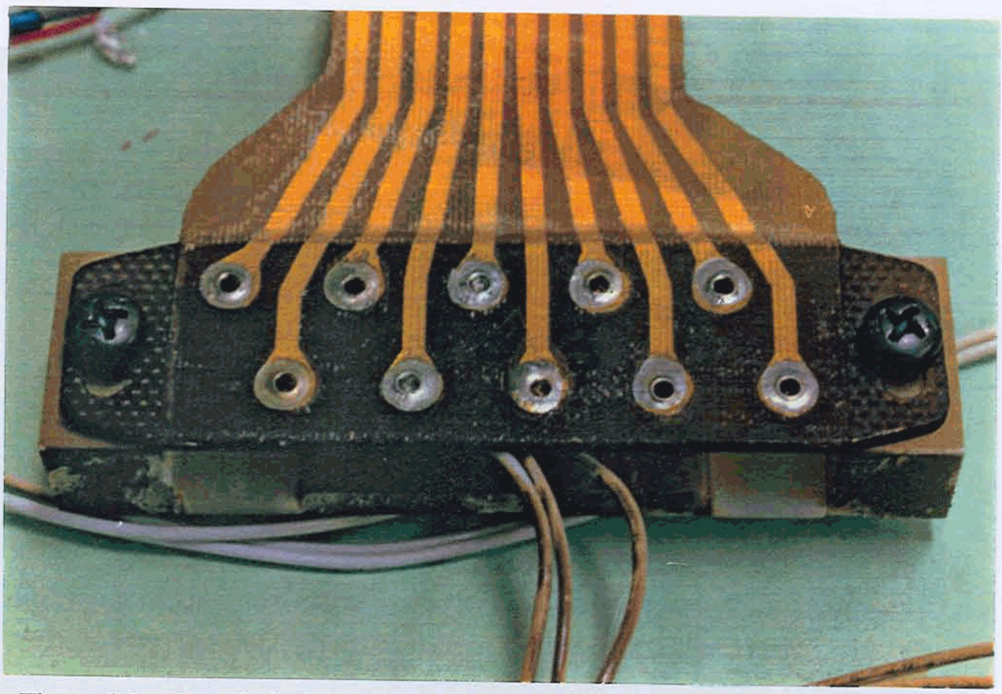

**Figure 2d.** *Detailed view on the tagboard of the outside lower connection. Three of the terminal holes are filled with solder alloy because of the conductor lead soldering. magn. x1.75*

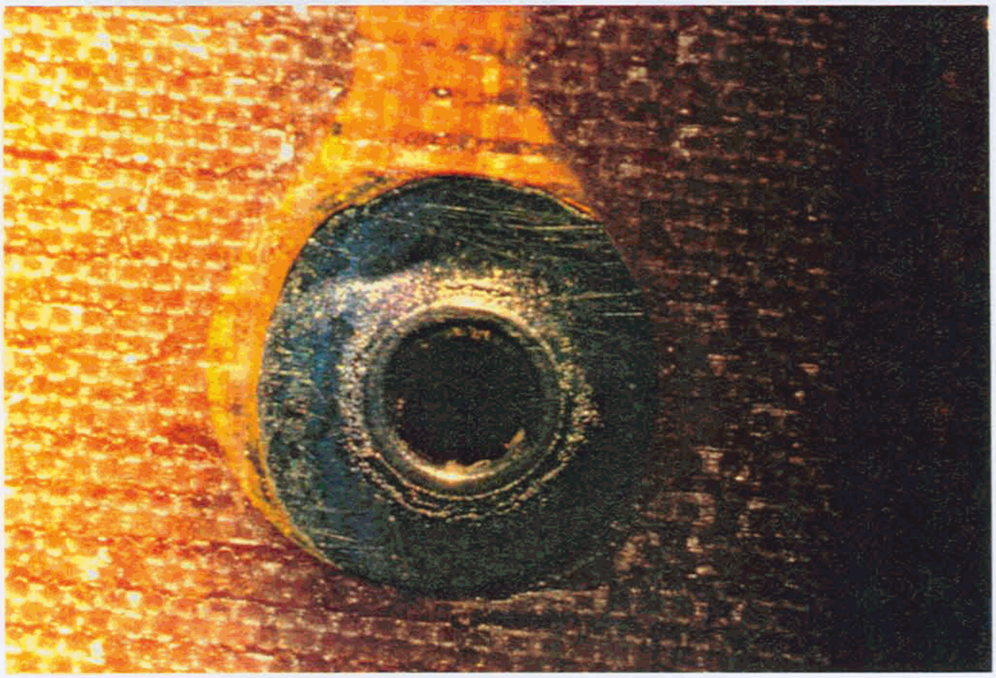

**Figure 3a.** *Detailed view on a solder fillet from a connected terminal pin from on the outside lower tagboard, showing the circular cracking in the solder fillet.*
*Magn. x12*

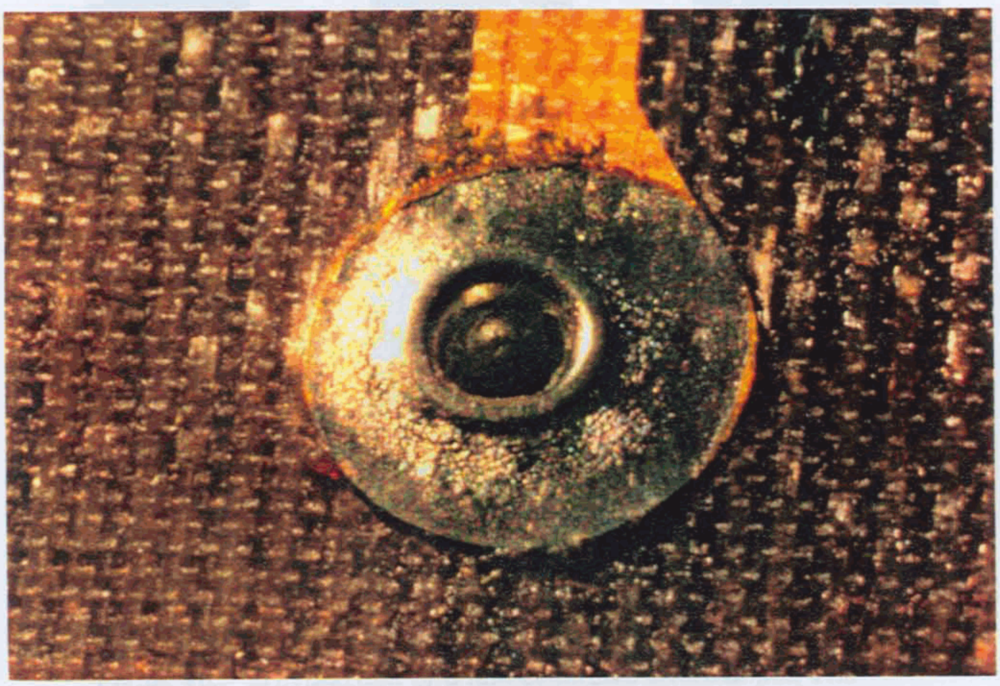

**Figure 3b.** *Detailed view on a solder fillet from a un-connected terminal pin from on the inside lower tagboard, showing the orange peel effect on the solder fillet.*
*Magn. x12*

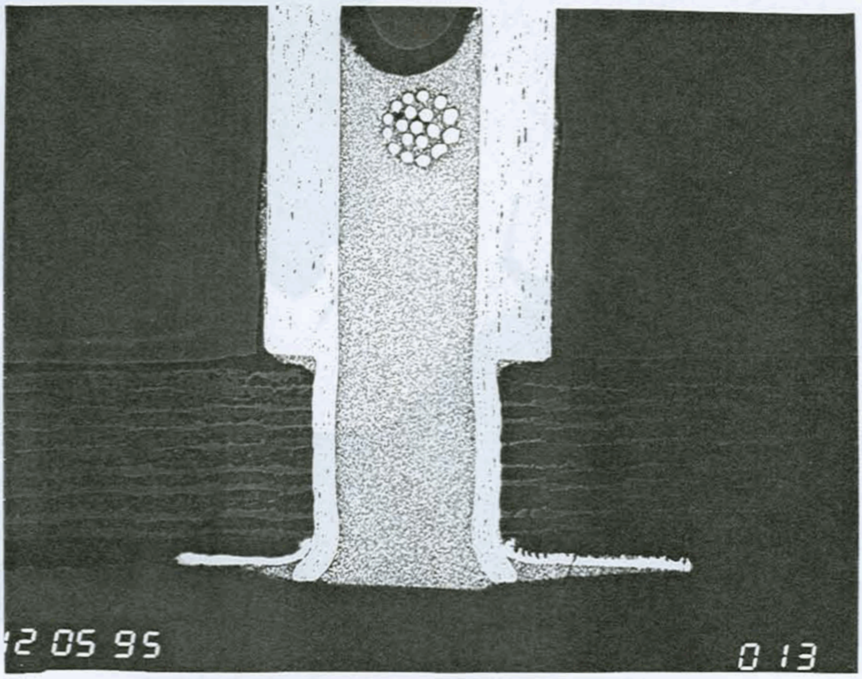


**Figure 4a.** *Microsection of a connected terminal pin. The inside of the terminal pin is filled with solder alloy. The swaged end of the terminal pin is soldered to the ad on the board. Magn. x16*

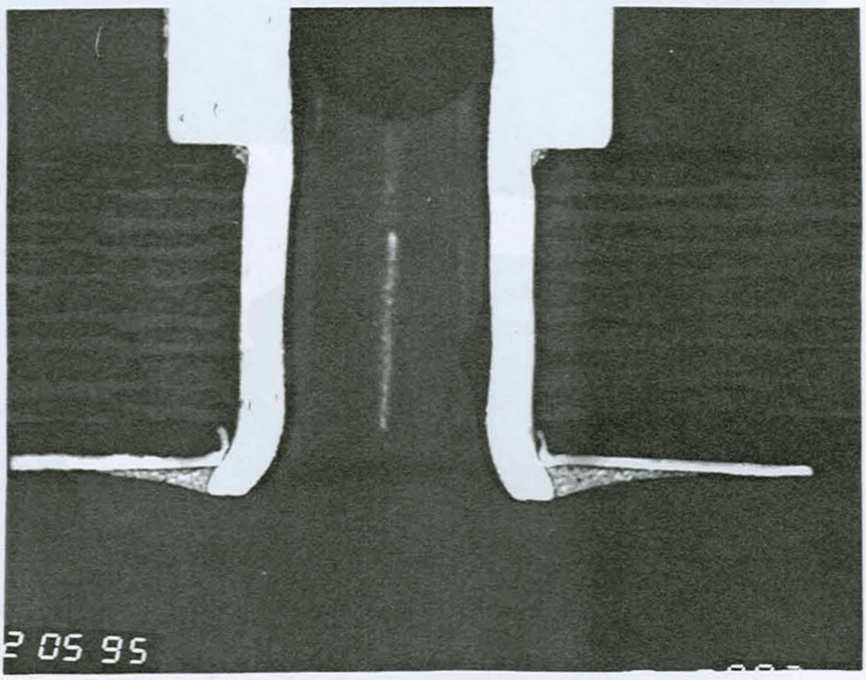


**Figure 4b.** *Microsection of a non-connected terminal pin. The inside of the terminal pin is not filled with solder alloy. The swaged end of the terminal pin is soldered to the pad on the board. Magn. x32*

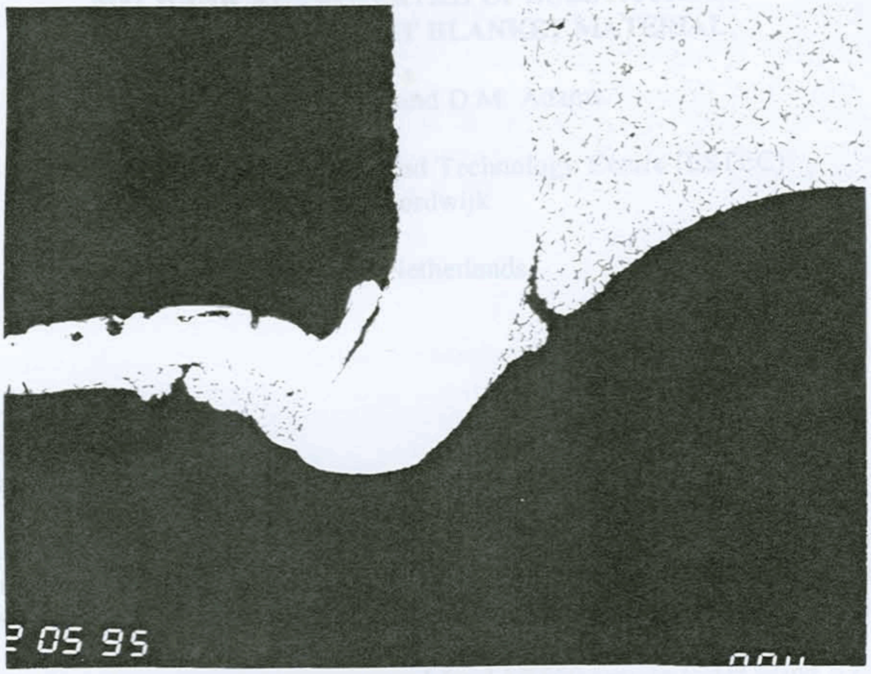


**Figure 5a.** *Detailed view on solder fillet of a connected terminal pin showing cracking of the solder fillet and cracking in the solder inside the terminal pin area. Magn. x100*

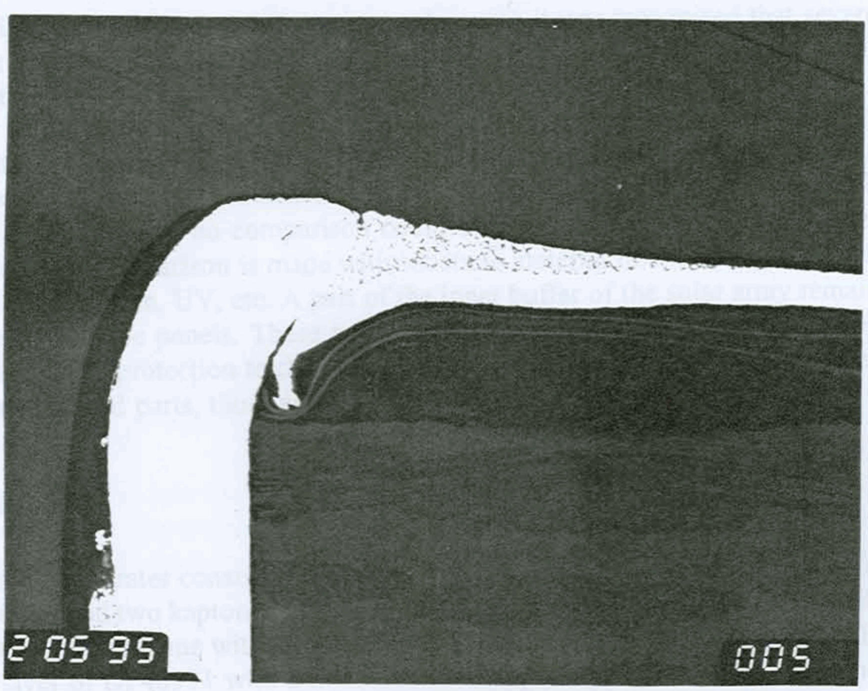


**Figure 5b.** *Detailed view on solder fillet of a non-connected terminal pin showing no cracking in the solder fillet. Magn. x100*