	La Sarthe sustaining engineering	LEAD FREE PROJECT
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Le Mans, May 18<sup>th</sup>, 2004

**SUBJECT** : QUALIFICATION PROCEDURE FOR CONNECTOR HEAT RESISTANCE TO LEAD FREE WAVE SOLDERING

## **1- PURPOSE**

The purpose of this document is to propose plastic heat resistance tests methods for connectors which are soldered with lead-free wave soldering method.

Only plastics aspect will be studied.

This specification proposes adaptation of the test procedure and criteria for assessing acceptability of polymers for use in lead-free wave soldering processes.

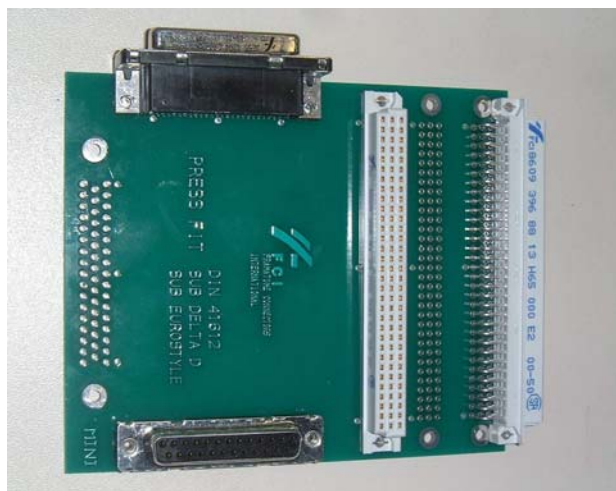
## **2- PROCEDURE**


Chosen procedure: real test in wave soldering equipment with adaptable temperature profile and whole PCB.

### **2-1 Samples and configuration**

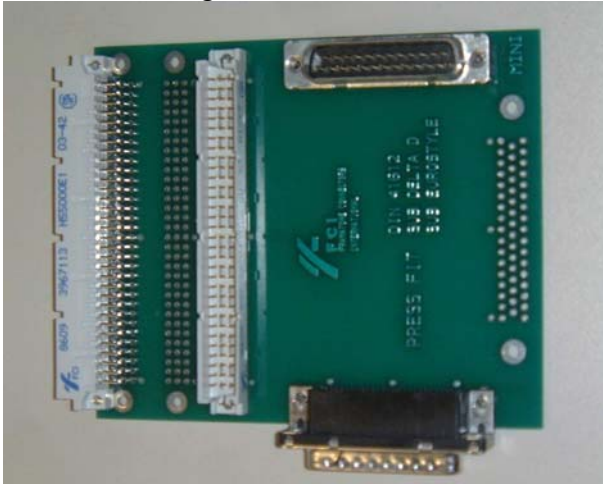
We worked with different types of configurations and 10 samples of each configuration :

- 10 PCB with:
  - 1 female right angle SUB Delta D in PBT Valox
  - 1 female straight SUB Delta D in PBT Valox
  - 1 female right angle DIN in PBT Valox
  - 1 female straight DIN in PBT Valox



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- 10 PCB with
  - 1 male right angle SUB Delta D in PBT Valox
  - 1 male straight SUB Delta D in PBT Valox
  - 1 male right angle DIN in PBT Valox
  - 1 male straight DIN in PBT Valox



- 10 PCB with
  - 1 female right angle DIN in PBT Pocan



## **2-2 Test conditions :**

The Wave soldering machine is :

- an “Europak with  $\Omega$ mega Wave by Electrovert” (picture 1 and 2)
- one wave system
- divided into three main areas :
  - ◆ flux (picture 3)
  - ◆ pre-heating
  - ◆ wave soldering (picture 4 and 5)

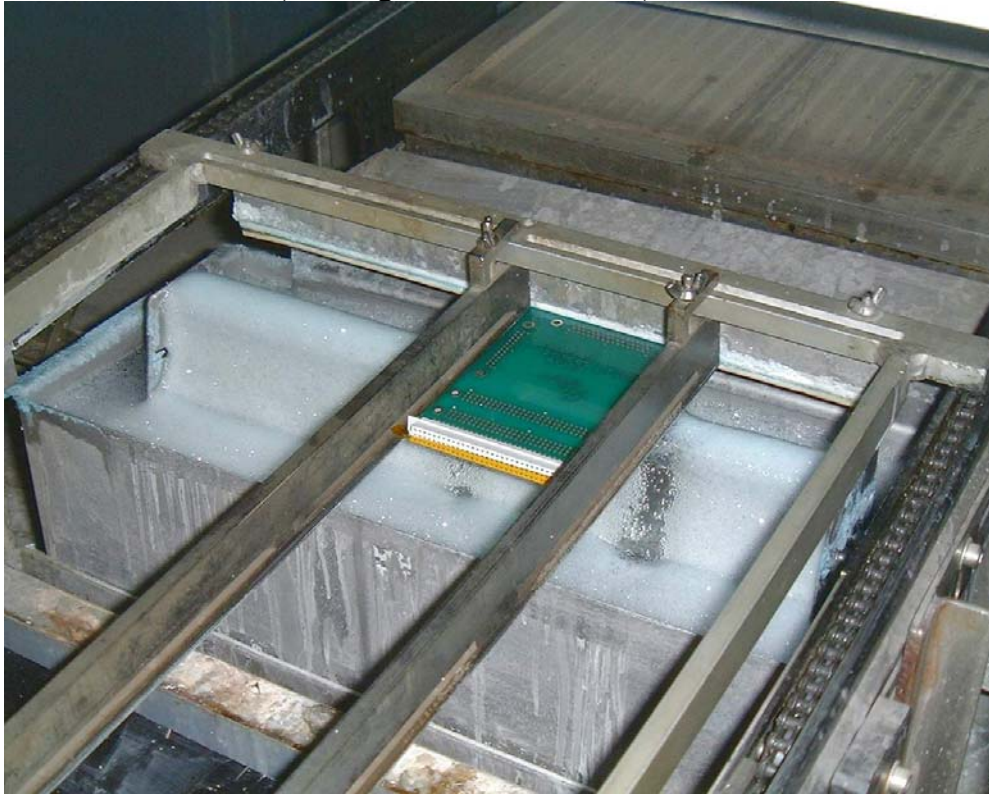
*Picture 1* : general view of wave soldering machine



*Picture 2* : general view of wave soldering machine



*Picture 3* : Flux area (foaming of alcohol solution)



*Picture 4* : wave (alloy Sn65Pb35)



*Picture 5* : PCB on the wave



In order to respect the recommendations of customers (Philips, ...) we use the same system of flux and wave soldering as before lead-free legislation without any change of our subcontractors or customers systems than before.

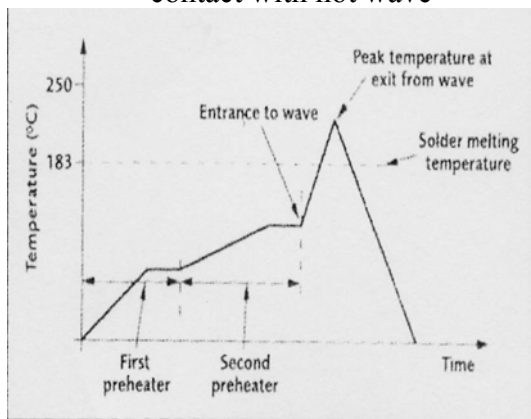
The current use of wave soldering user in connectics is to protect the active face of the connector (for right angle version) in contact with wave alloy with :

- Kapton adhesive
- Or Protective metallic device

As a consequence we have decided to make tests with and without protection at range of 235-250°C and 260-265°C in order to make comparison and to verify that more serious situation (temperature at 265 °C) is acceptable with such protection.

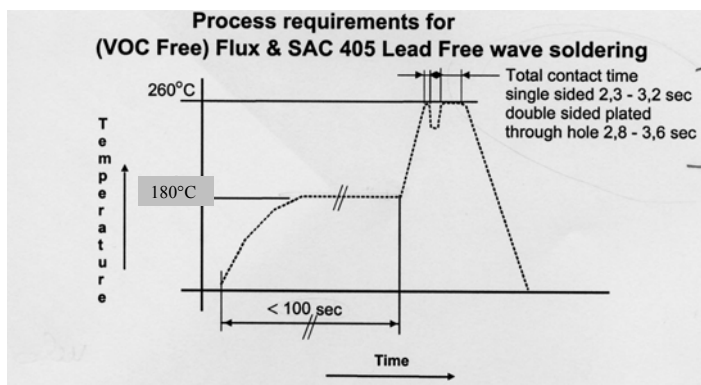
We might mention, for the record , that the current values are :

- peak at 235-250°C during 3 s
- preheating from 20°C to 170°C during around 1 minute
- two or one wave peak with alloy Sn65Pb35
- protection with Kapton adhesive or protective cache of the connector face in contact with hot wave



The chosen parameters for lead free test are :

- peak at 260-265 °C during 2.8 to 3,6 s
- preheating during 73 s from 20°C to 170-190°C (function of the speed of the conveyor)
- only one wave peak instead of two with alloy Sn65Pb35



**2-3 Tests**

### 2-3-1 Sample requirements

Each sample have been completed all manufacturing processes required prior to shipment. They have been performed in the “as received condition”.

Each plastic housing have been inspected with microscope for any defects such as deformation, cracks ...

We have decided to verify the impact of a protection (Kapton adhesive) on the polymer behavior (see picture 6).

### 2-3-2 Description of the different tests

- A1 : male right angle DIN in PBT Valox 420SEO
- A2 : female right angle DIN in PBT Valox 420SEO
- A3 : female right angle DIN in PBT Pocan
- A4 : male right angle SUB Delta D in PBT Valox 451E
- A5 : female right angle SUB Delta D in PBT Valox 451E
- B1 : male straight DIN in PBT Valox 420SEO
- B2 : female straight DIN in PBT Valox 420SEO
- B3 : male straight SUB Delta D in PBT Valox 451E
- B4 : female straight SUB Delta D in PBT Valox 451E

Nbr of samples	A1	A2	A3	A4	A5	B1	B2	B3	B4
265 °C no protection	10	10	10	10	10	10	10	10	10
265 °C protection	4	4	4	0	0	0	0	0	0
245 °C no protection	4	4	0	0	0	0	0	0	0
245 °C protection	4	0	0	0	0	0	0	0	0

The flux and pre-heating stages are the same for the 4 tests.

*Picture 6* : the protection is a Kapton adhesive stuck on the surface of the connector on contact with the hot alloy.



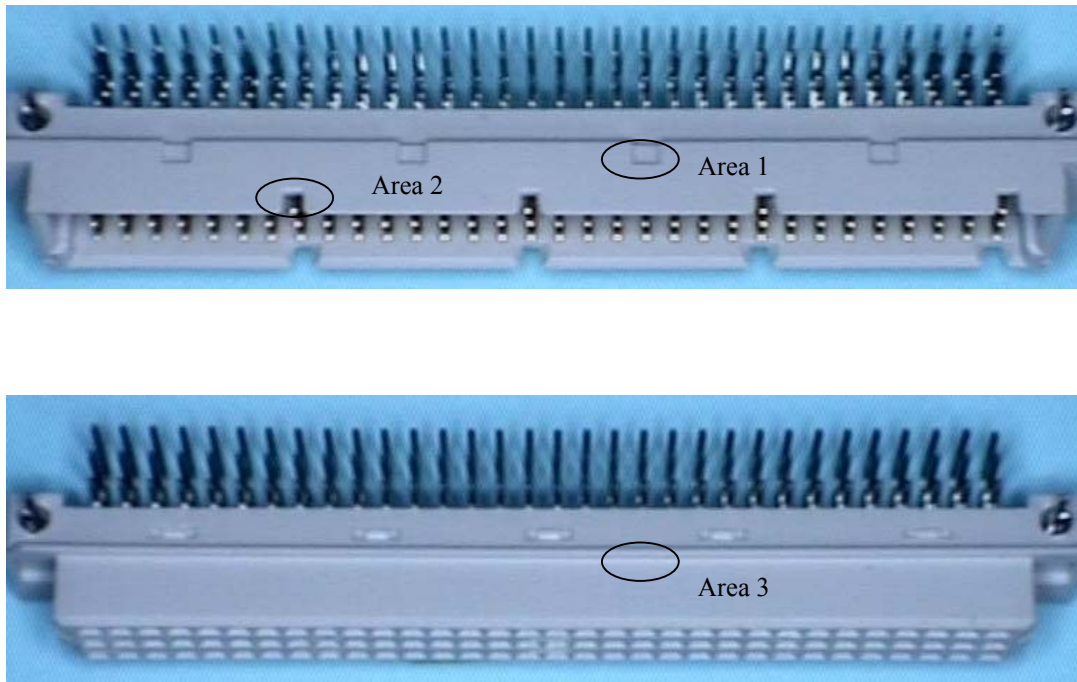
### 2-3-3 Final inspection

All sample have been observed with microscope for the surface aspect, presence or not of external cracks, blistering , no deterioration contact... with comparison with witness.

Test of “plug-unplug” have been made in each case.

In order to have references, the observations have been made on different area of the part, described picture 7.

*Picture 7* : areas where observations have been made (male and female).



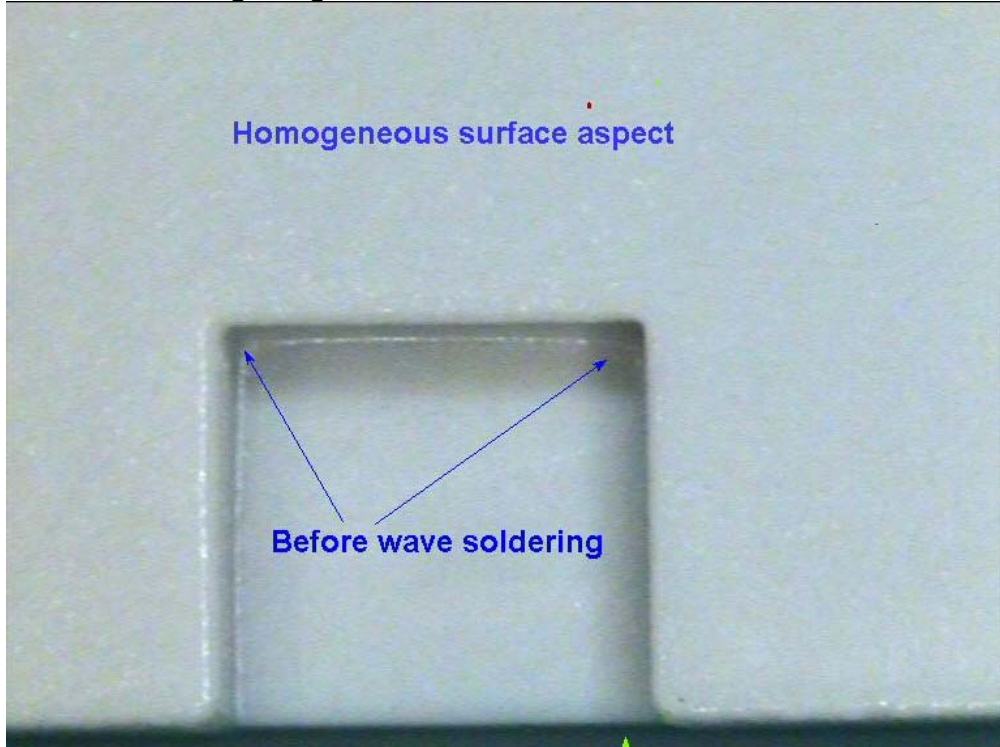
### **3- RESULTS**

#### 3-1 Tests at 260-265 °C

##### 3-1-1 Without Kapton adhesive protection

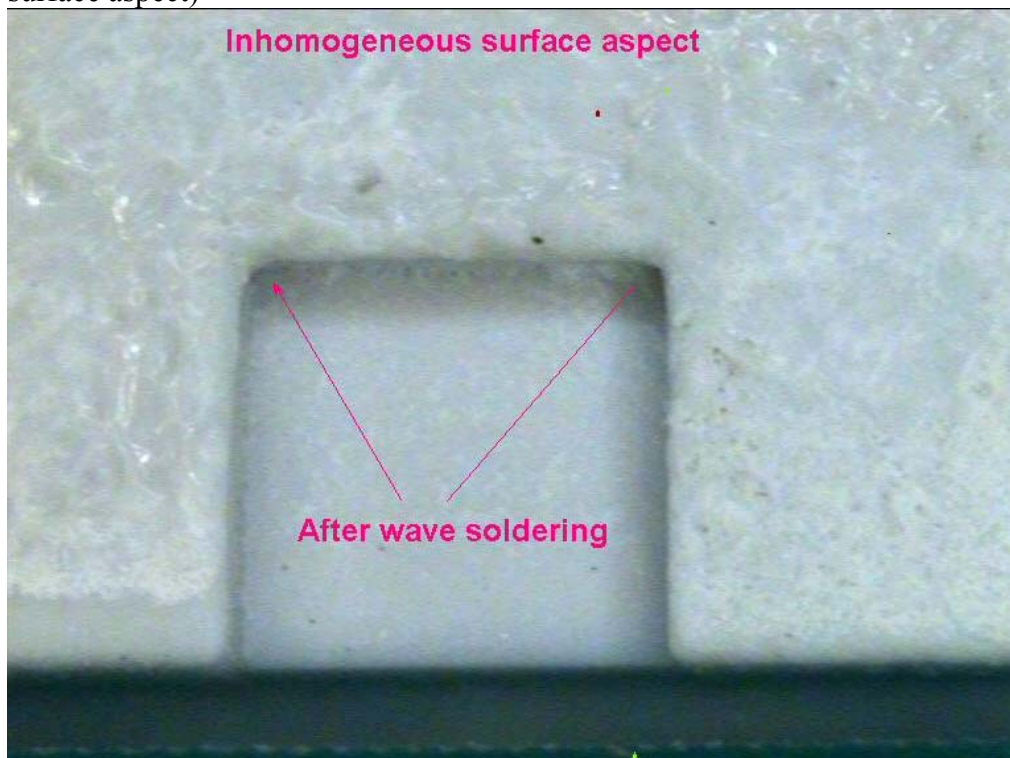
- For all connectors tested (right angle and straight, male and female) all the tests “plug-unplug” are accurate.
- **No problems for straight connector because the PCB is a heat shield and as a consequence minimize the impact of the hot temperature on the plastic housing.**
- All the right angle male and female connectors have surface aspect problems. The result is more important for DIN male because the surface of the polymer is nearer the hot alloy of the wave. So all the following pictures are for right angle connectors.

*Picture 8* : male right angle DIN in PBT Valox 420SEO before wave soldering (Witness)



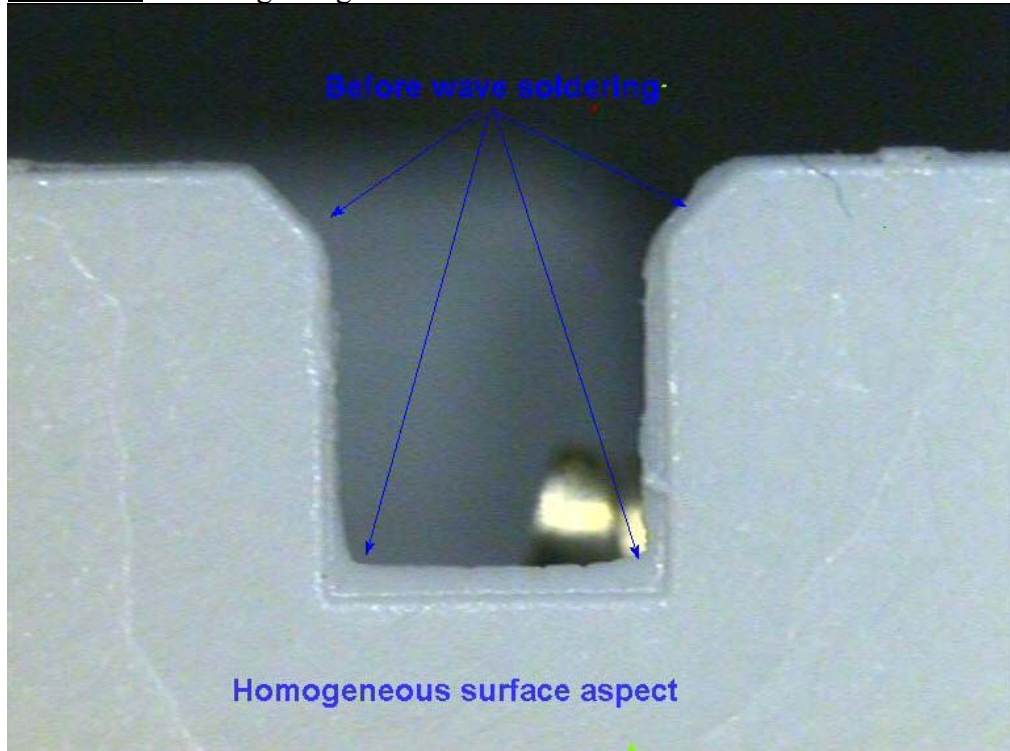
magnification x20

*Picture 9* : male right angle DIN in PBT Valox 420SEO at 265 °C without protection (molten surface aspect)



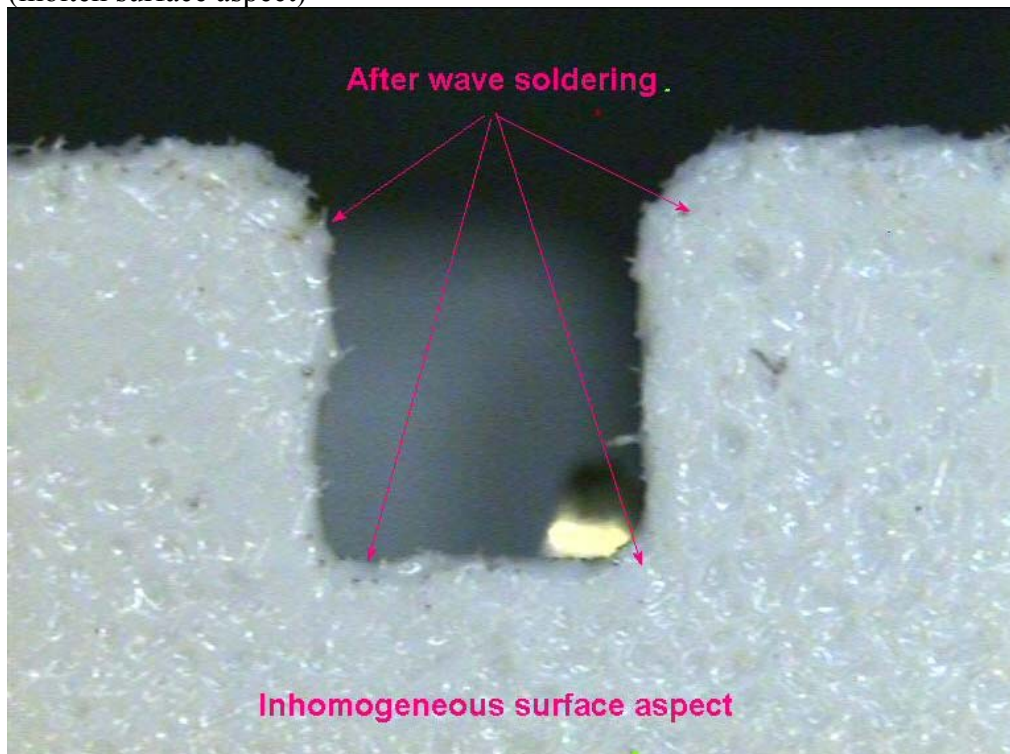
magnification x20

Picture 10 : male right angle DIN in PBT Valox 420SEO before wave soldering (Witness)



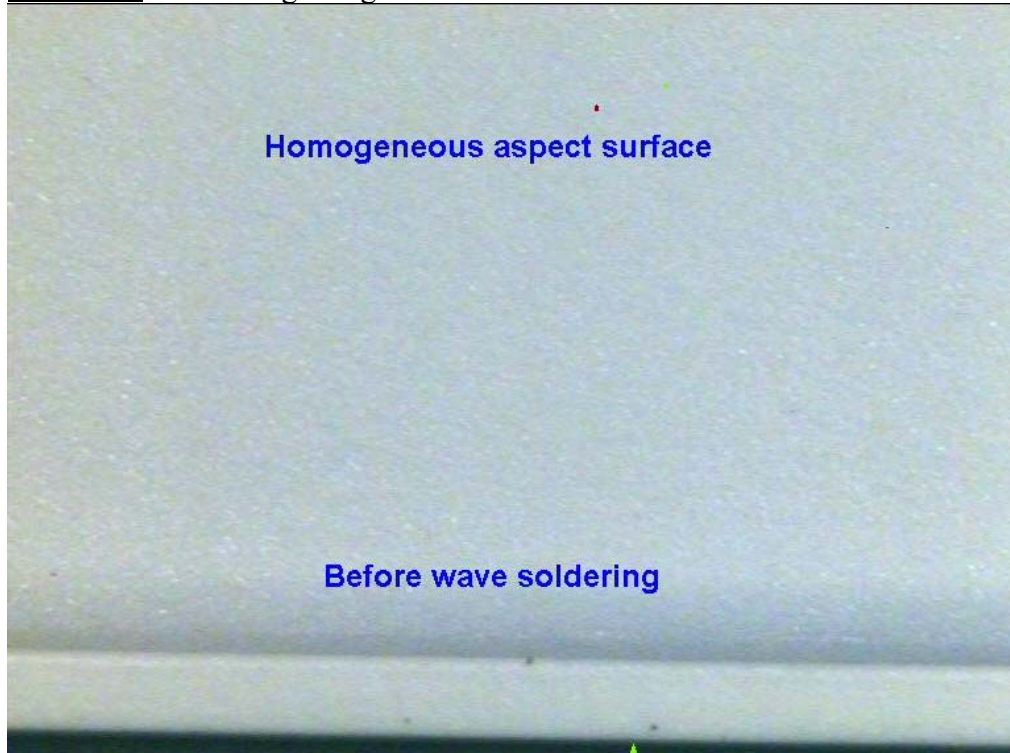
magnification x20

Picture 11 : male right angle DIN in PBT Valox 420SEO at 265 °C without protection (molten surface aspect)



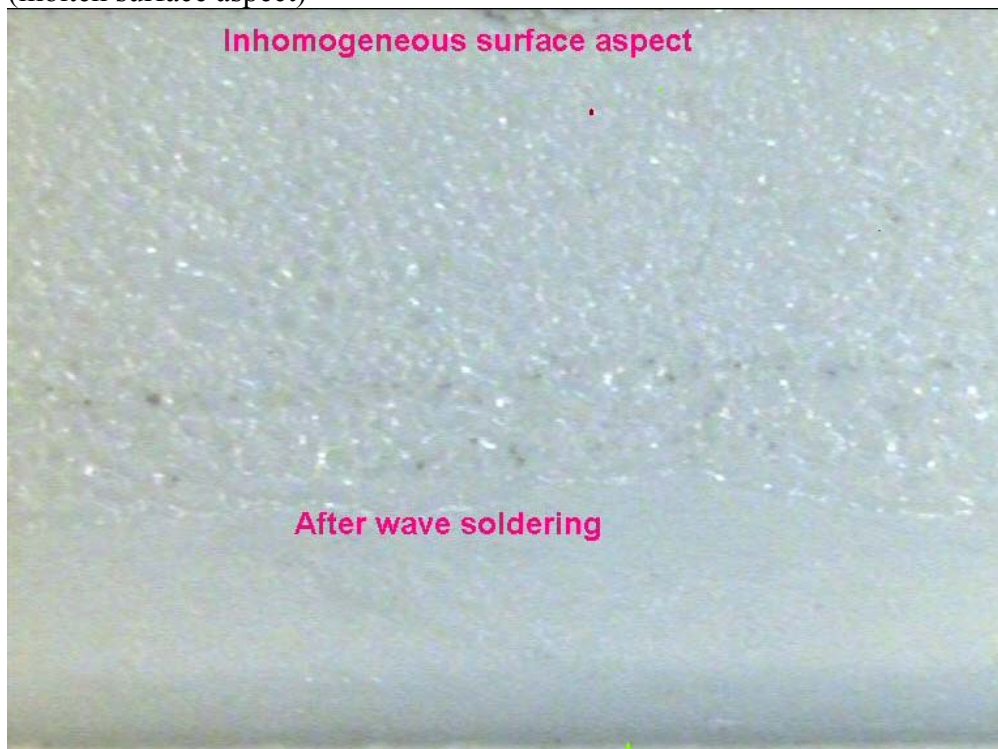
magnification x20

*Picture 12* : female right angle DIN in PBT Valox 420SEO before wave soldering ([Witness](#))



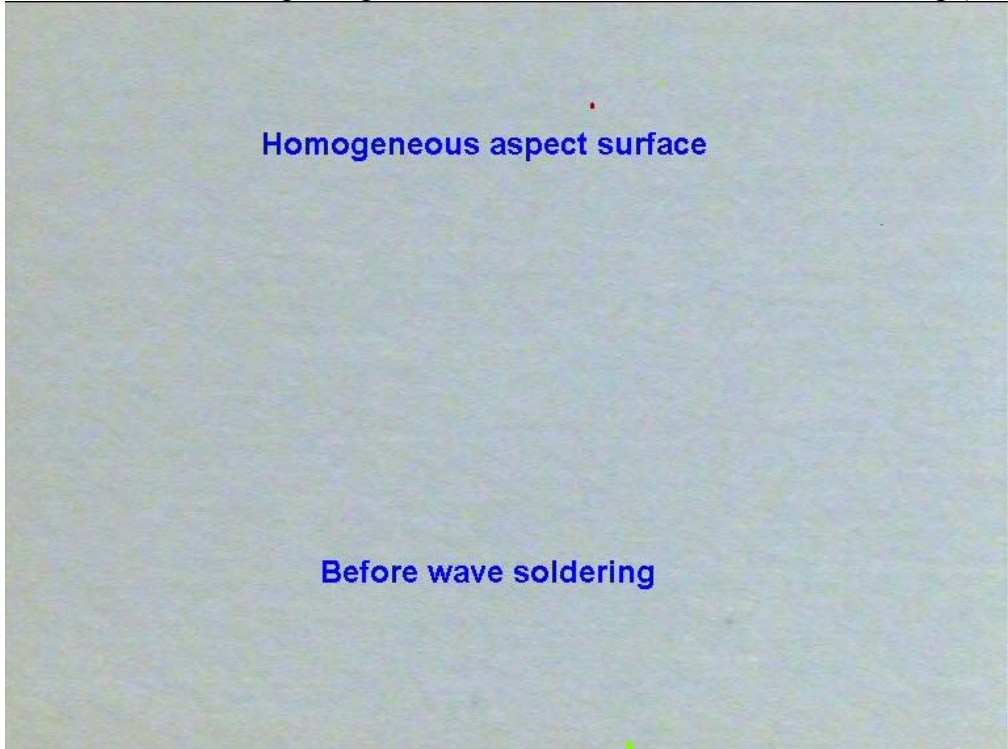
magnification x20

*Picture 13* : female right angle DIN in PBT Valox 420SEO at 265 °C without protection (molten surface aspect)



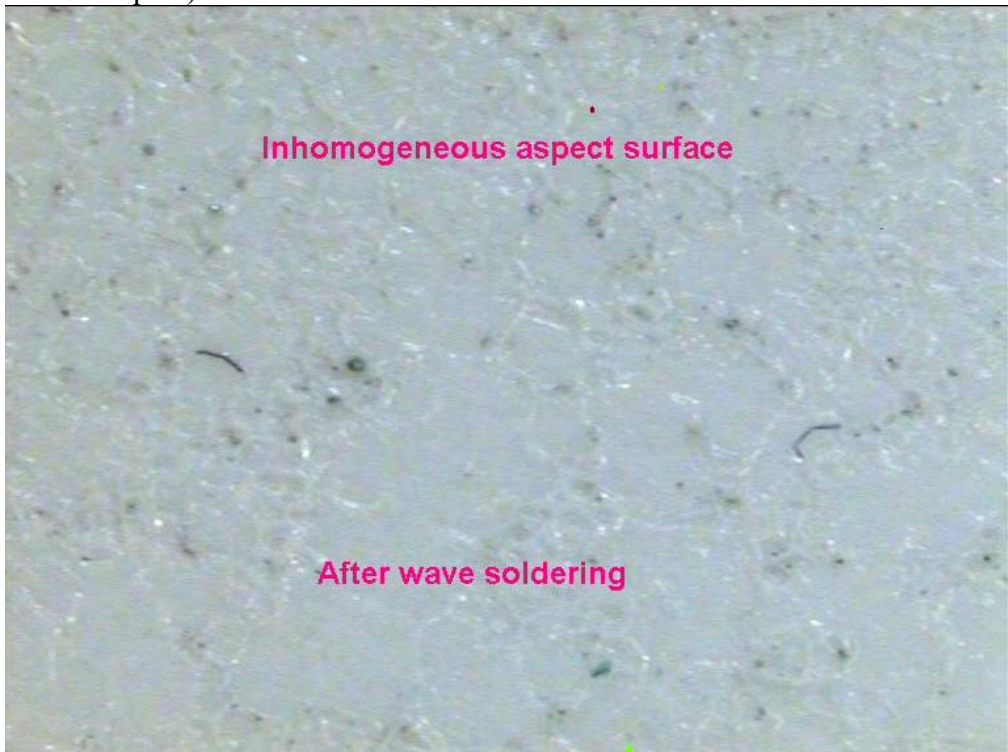
magnification x20

Picture 14 : female right angle DIN in PBT Pocan before wave soldering (Witness)



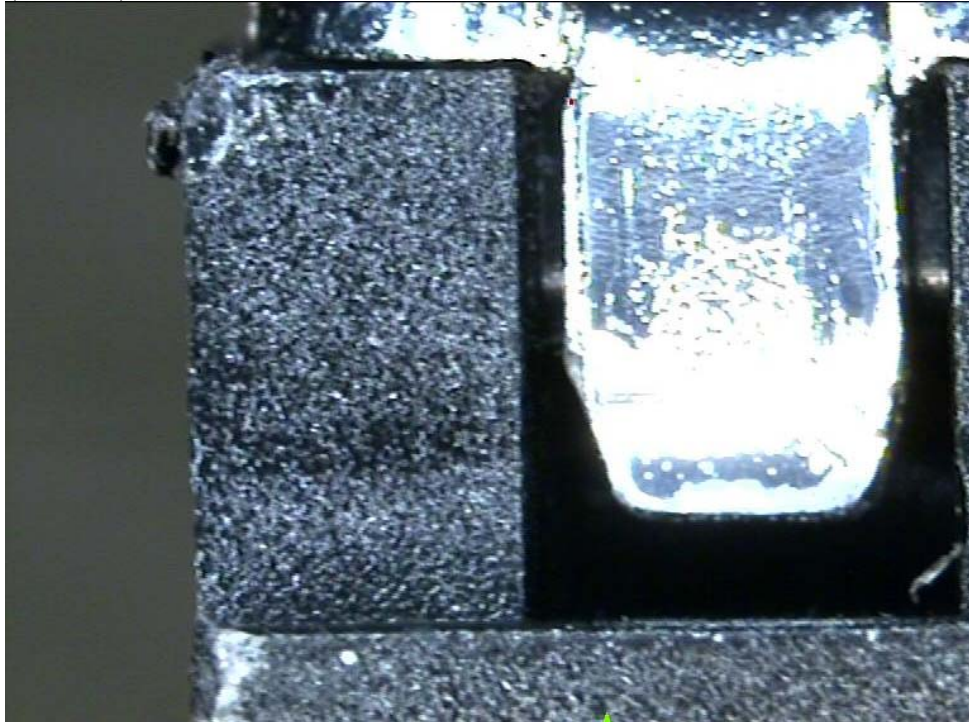
magnification x20

Picture 15 : female right angle DIN in PBT Pocan at 265 °C without protection (molten surface aspect)



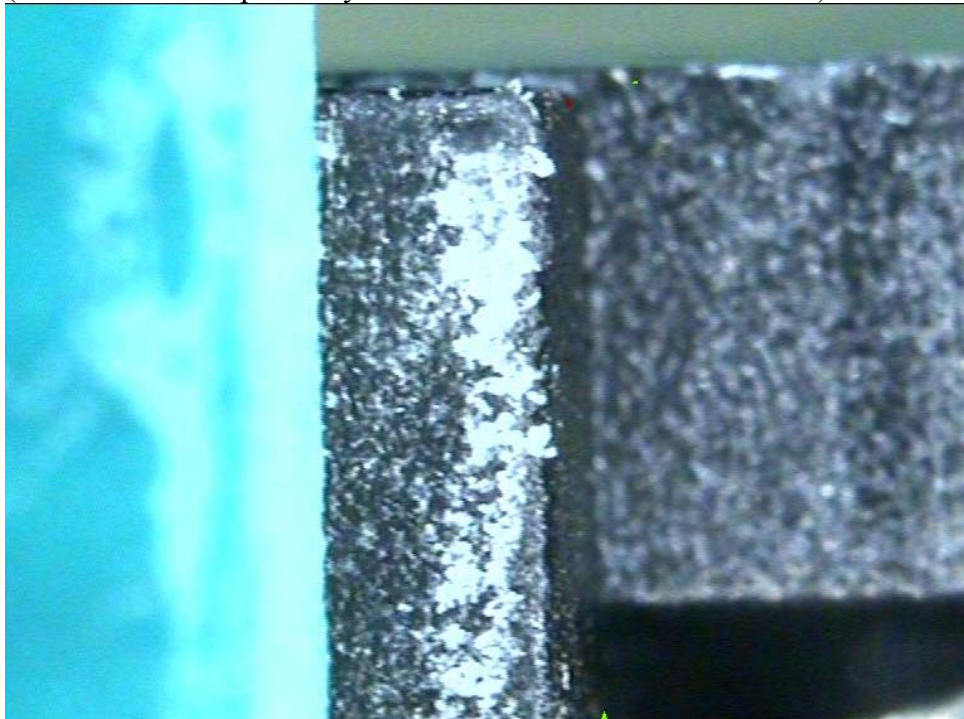
magnification x20

*Picture 16* : male right angle SUB Delta D in PBT Valox 451E before wave soldering  
(Witness)



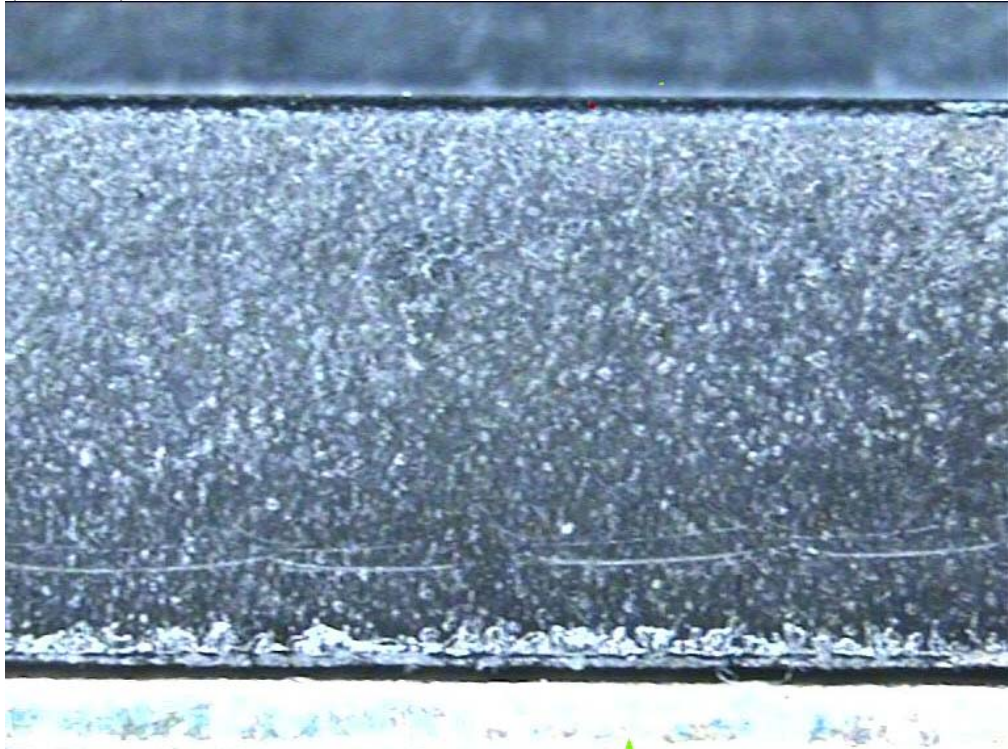
magnification x30

*Picture 17* : male right angle SUB Delta D in PBT Valox 451E at 265 °C without protection  
(molten surface aspect only in small area near the wave contact)



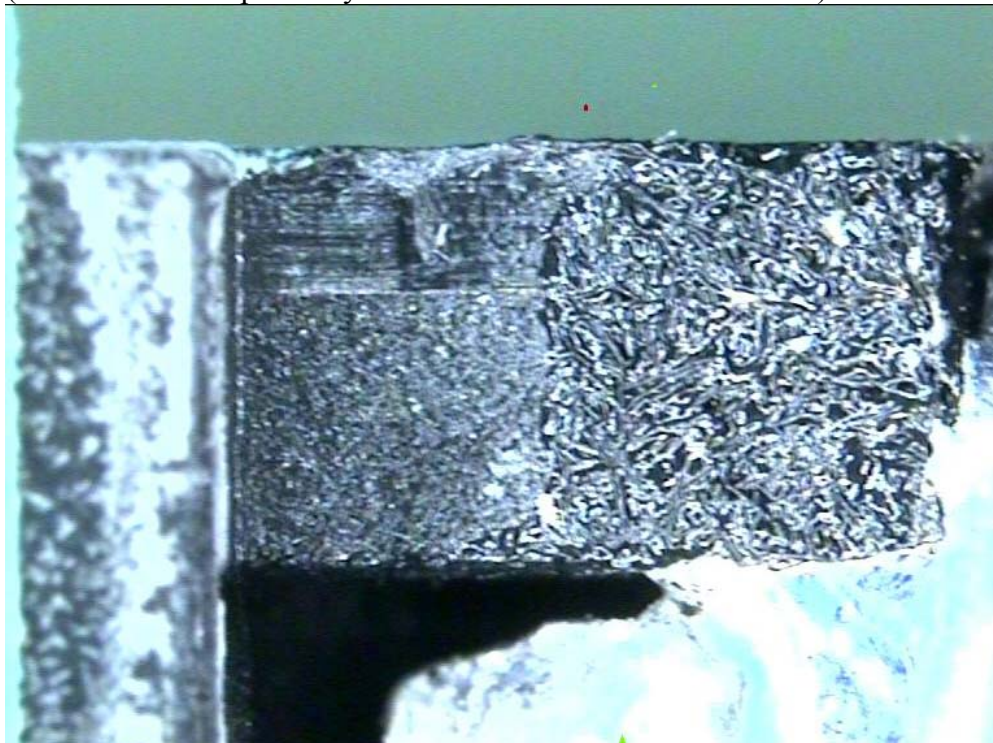
magnification x40

*Picture 18* : female right angle SUB Delta D in PBT Valox 451E before wave soldering  
(Witness)



magnification x30

*Picture 19* : female right angle SUB Delta D in PBT Valox 451E at 265 °C without protection  
(molten surface aspect only in small area near the wave contact)

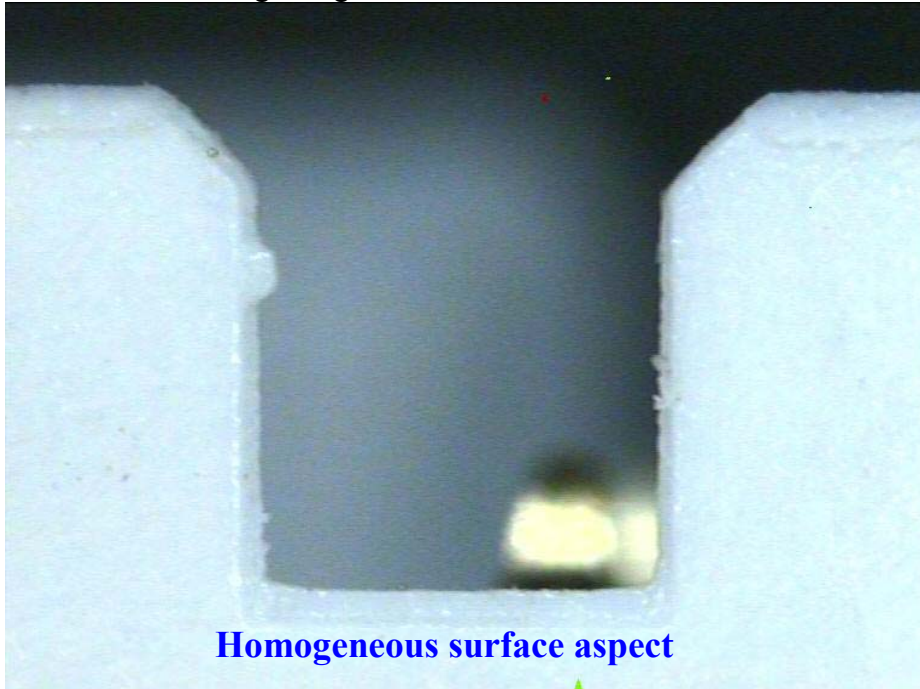


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3-1-2 With Kapton adhesive protection

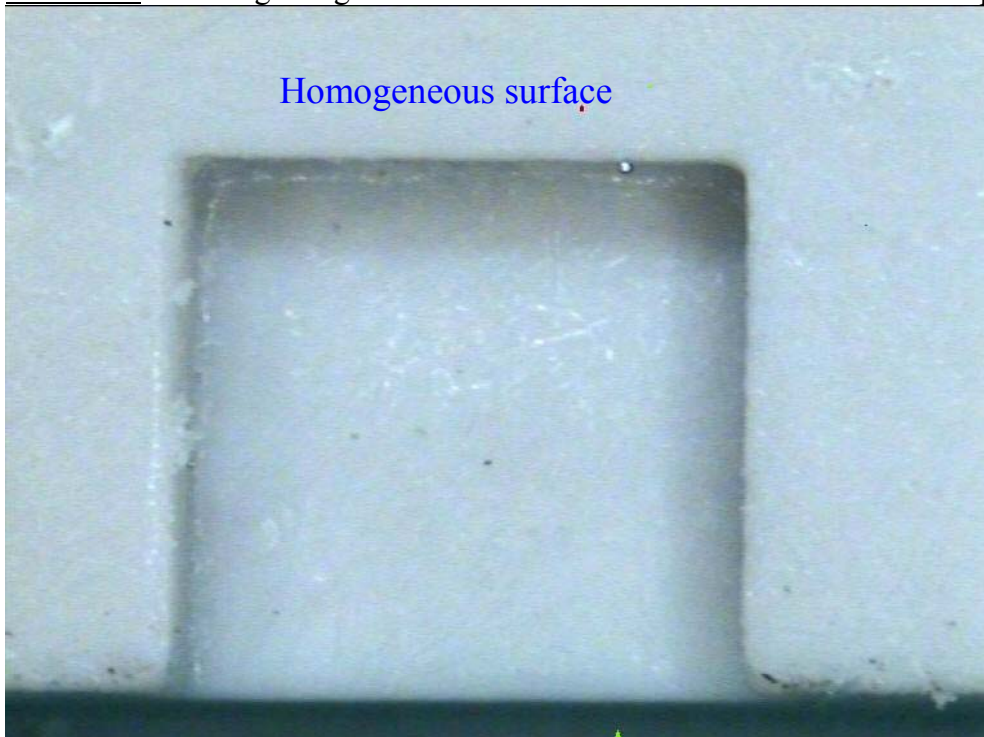
To protect the surface during the wave soldering we have decided to use a “Kapton” adhesive, glued on the connector surface in contact with hot wave.

Picture 20 : male right angle DIN in PBT Valox 420SEO at 265°C with Kapton protection



magnification x20

Picture 21 : male right angle DIN in PBT Valox 420SEO at 265°C with Kapton protection



magnification x30

Picture 22 : female right angle DIN in PBT Valox 420SEO at 265°C with Kapton protection (correct aspect surface)



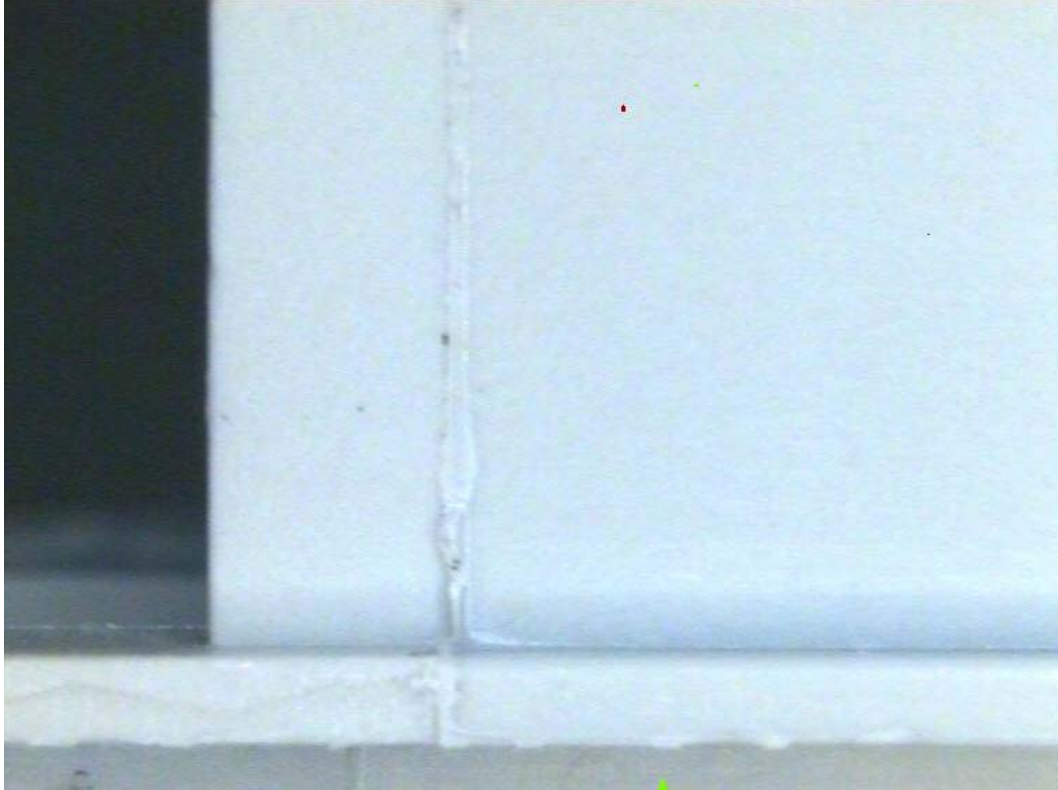
magnification x20

Picture 23 : female right angle DIN in PBT Pocan at 265°C with Kapton protection



magnification x20

*Picture 24* : female right angle DIN in PBT Pocan before wave soldering (Witness)



**magnification x20**

### 3-2 Tests at 235-250 °C

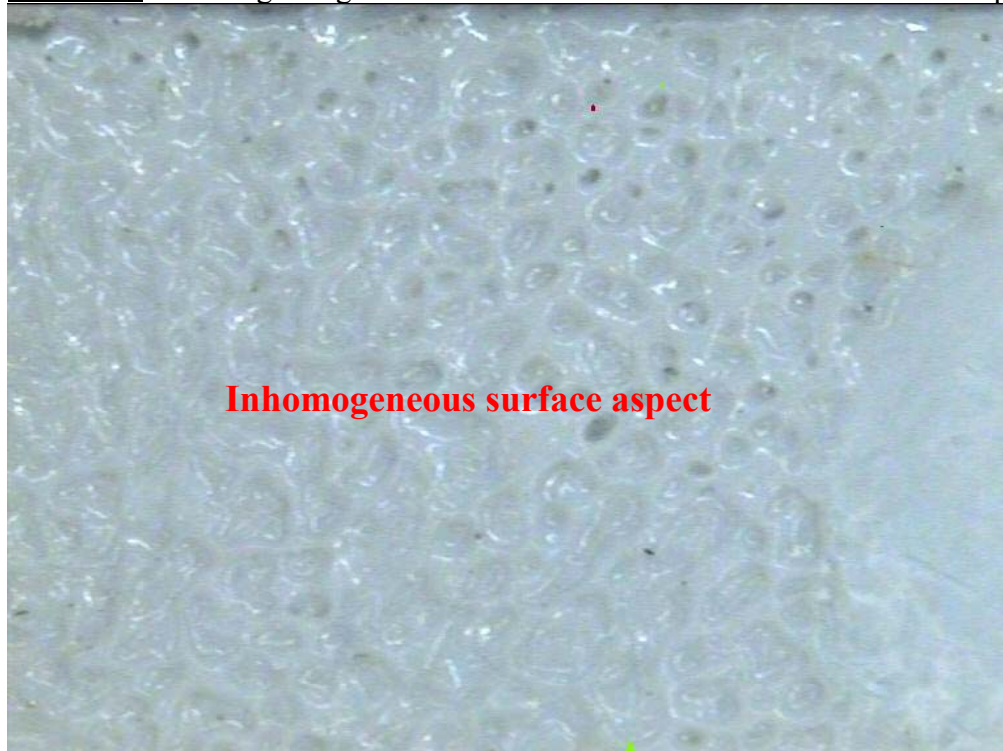
Connectors and electrical industries use commonly wave soldering at 235°C-250°C with Kapton adhesive or protective cache on the critical face near the hot wave.

To make comparisons with samples at 265°C, we have decided to make test on the best critical parts ( right angle connectors ) at 235°C-250°C.

#### 3-2-1 Without Kapton adhesive protection protection

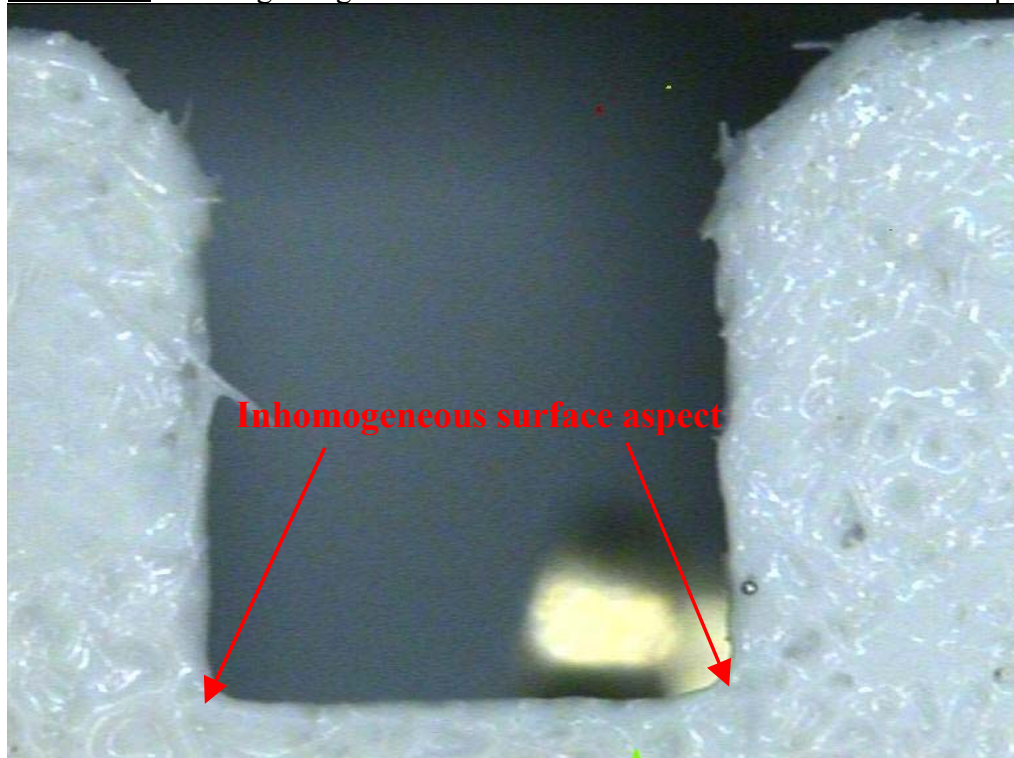
- For all connectors tested (right angle male and female DIN) all the tests “plug-unplug” are accurate..
- All the right angle male and female connectors have surface aspect problems. The result is more important for DIN male because the surface of the polymer is nearer the hot alloy of the wave.

*Picture 25* : male right angle DIN in PBT Valox 420SEO at 245 °C without protection



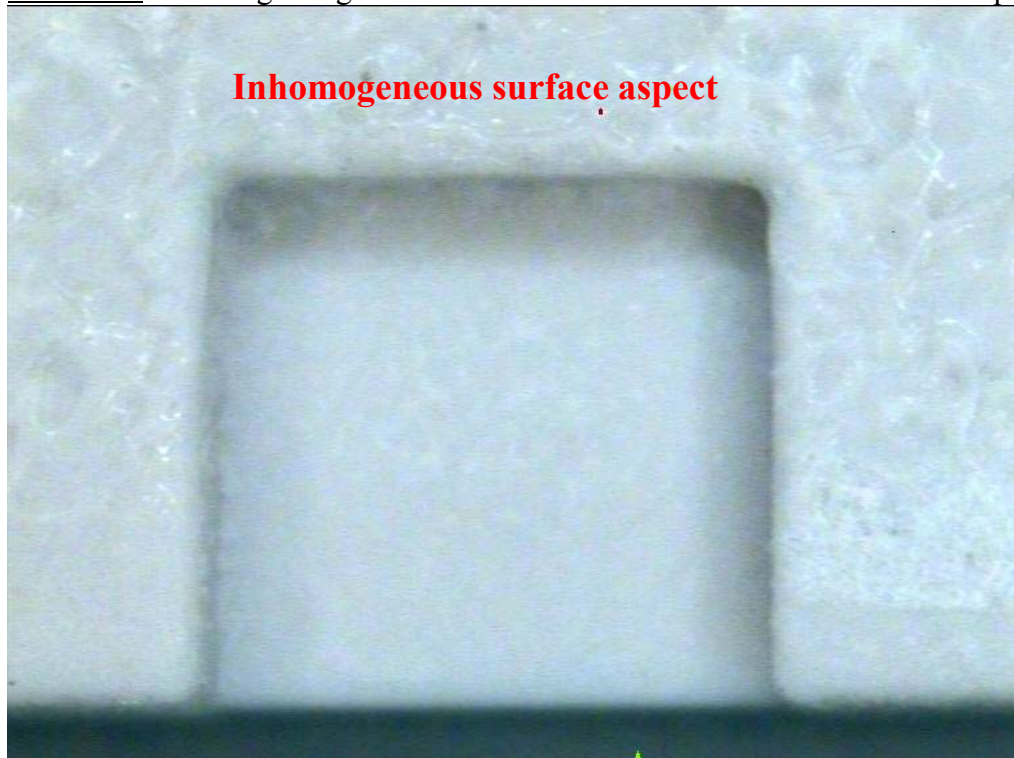
magnification x30

*Picture 26* : male right angle DIN in PBT Valox 420SEO at 245 °C without protection



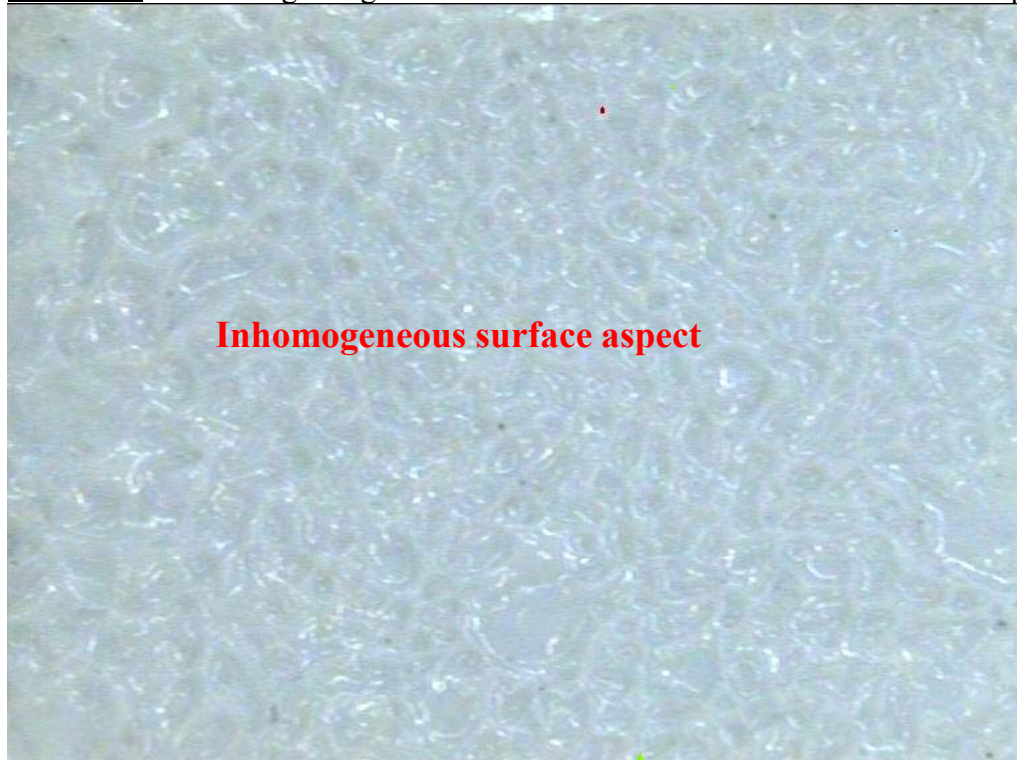
magnification x30

*Picture 27* : male right angle DIN in PBT Valox 420SEO at 245 °C without protection



magnification x30


*Picture 28* : female right angle DIN in PBT Valox 420SEO at 245 °C without protection



magnification x30

3-2-2 With Kapton adhesive protection

- For all connectors tested (right angle male and female DIN) all the tests “plug-unplug” are accurate..
- **All the right angle male and female connectors have correct surface aspect.**

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#### 4- CONCLUSION

Summary of the results :

- All the plug/unplug tests are accurate, whatever the temperature and the type of connectors
- **No problem appears with straight connectors, whatever the PBT, whatever the temperature and whatever the type male or female. The PCB is a heat shield and as a consequence minimize the impact of the hot temperature on the plastic housing,**
- Aspect problems appear for right angle for male and female connectors at 265°C and 235°C, whatever the PBT
  - Surface aspect problems are more important for male than for female because of the proximity with the hot wave
- **If we use protective adhesive or metallic device, no problem appears with right angle connectors, whatever the PBT, whatever the temperature and whatever the type male or female. The protection is a heat shield and as a consequence minimize the impact of the hot temperature on the plastic housing**
  - The use of a protective adhesive at hot temperature is accurate. The surface is protected and not deteriorated. But it is necessary to use an adhesive with glue which accept temperature higher than 280°C (type Kapton or Teflon) and correctly stuck.

As a consequence :

**It is possible to use PBT (Valox 420SEO, Valox 451E and Pocan) for wave soldering in lead-free applications if we use protective adhesive or protective metallic device for right angle connectors at 260-265°C as it is used now in classical lead wave soldering at 235-250°C.**

**It is also possible to use PBT (Valox 420SEO, Valox 451E and Pocan) for wave soldering in lead-free applications for straight connectors at 260-265°C as it is used now in classical lead wave soldering at 235-250°**