



# Hot nitrogen for wave soldering

**A new innovation for increasing quality & productivity of wave soldering machines**

Laurent Coudurier\* - Fernand Heine\* - Didier Orlhac\*\*

\*Air Liquide technology center / Krefeld - Germany

\*\* Air Liquide IM-T&R markets / Paris - France



## Content

- ☐ Wave soldering - background situation
- ☐ Local Nitrogen inerting system
- ☐ Important operating parameters
- ☐ Why preheat N2 ?
- ☐ How to preheat N2 ?
- ☐ Impact on soldering quality - fields results
- ☐ Conclusions



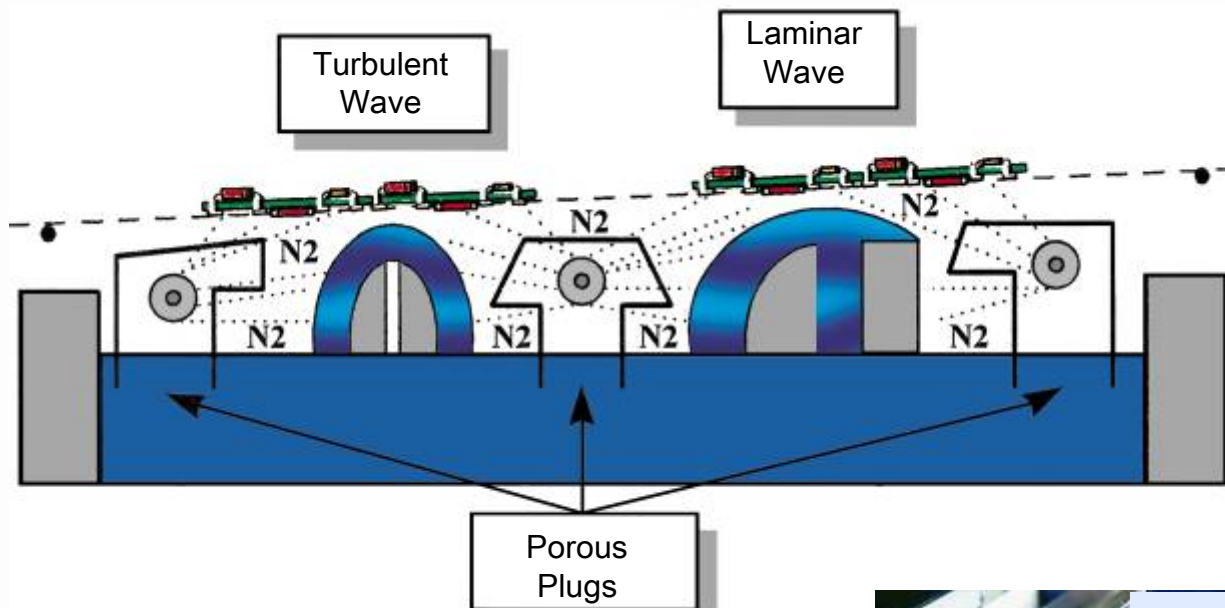
## Wave soldering - Background situation

- ❑ Main solder alloys for Tin Lead substitution
  - ✓ SAC 305, SAC 405, SN100C, SACX 0307, Sn99.3Cu0.7
- ❑ Solder pot temperature : 250 - 265° C
  - ✓ Solder melting temperature: 183 -217° C (SAC 305)
- ❑ Inert atmosphere now becomes very common, and is recommended by the main OEMs
  - ✓ Better wetting
  - ✓ Less dross
  - ✓ Use of less actives fluxes, and less flux consumption
  - ✓ Higher reliability and reproducibility
  - ✓ Less maintenance
- ❑ Inerting technologies for waves soldering machines:
  - ✓ Full tunnel
  - ✓ Local inerting system (original equipment or retrofit)



## Typical layout of a local Nitrogen inerting system

System showed:  
ALIX Inertwave  
equipment -  
Air Liquide



Titanium Frame



N2 flow control  
Panel

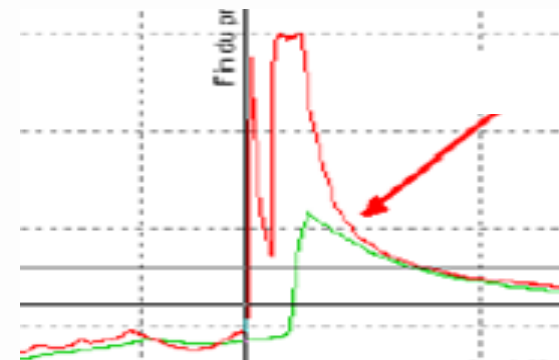


In Process



## Important parameters for wave soldering

- ❑ Heat transfer and contact time between solder alloy and PCB
  - ✓ 2 most important criteria for quality of soldering joints
- ❑ All other operating parameters have to be set accordingly:
  - ✓ Preheating and solder bath temperatures, wave nozzles geometry, rotating speed of the pumps, conveyor speed
- ❑ Need to increase heat-transfer and contact time on PCBs
  - ✓ Why? Lead free solder and massive PTH components
  - ✓ Possible solutions:
    - ✓ Reduce conveyor speed 🙄
    - ✓ Increase overall length of solder nozzles geometry (laminar wave) : limited effect !
  - ✓ Temperature drop between the 2 waves is critical
    - Intermediate solidification of the solder joints
    - Possible increase of intermetallics layer







## Why preheat nitrogen ?

### 1st reason

#### ❑ Increase heat transfer and contact times

✓ Thanks to the convection effect given by hot nitrogen, **the temperature drop between the 2 waves is reduced**

- solder joints remain at higher temperature between the two waves.



✓ **And the equivalent contact time\* is longer**

- The conveyor speed can be increased (higher production capacity)
- Defects rate is reduced significantly
- The solder joints quality is increased

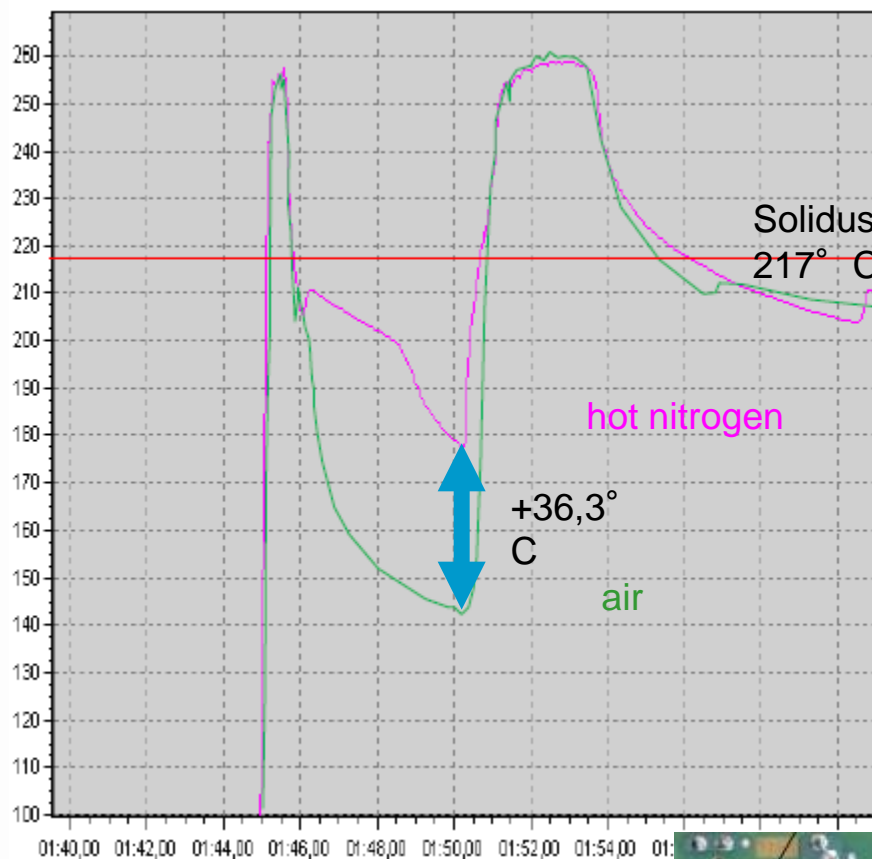


(\* Time above liquidus temperature)

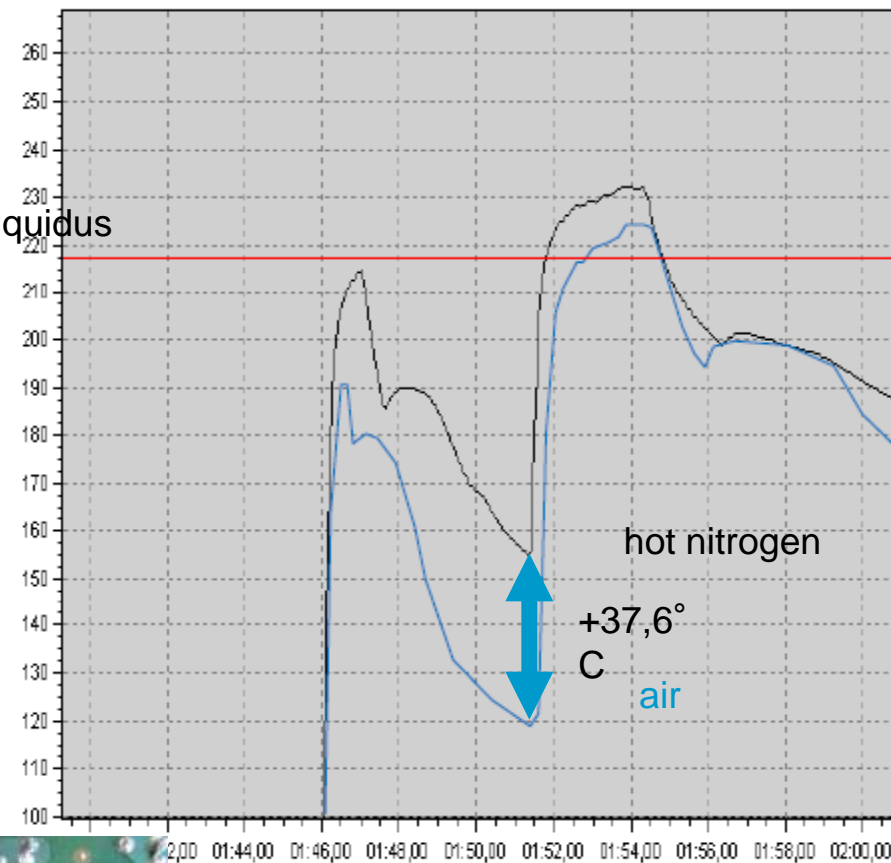
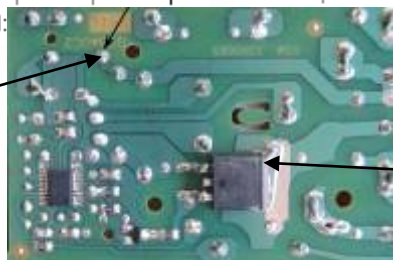




# Temperature profiles



Temperature measurement  
on small diode pin

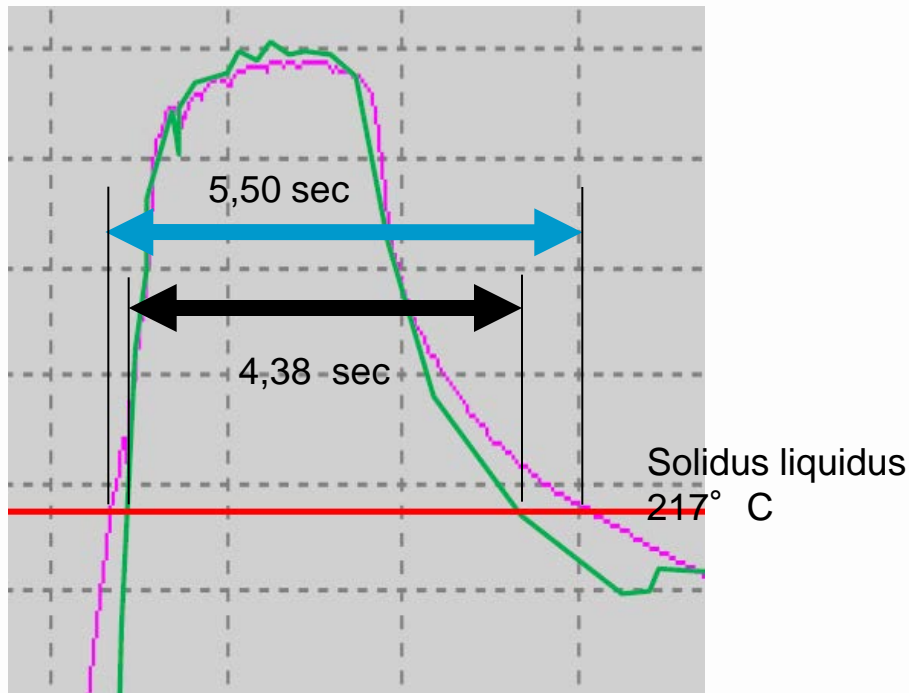


Temperature measurement  
on triac SMD

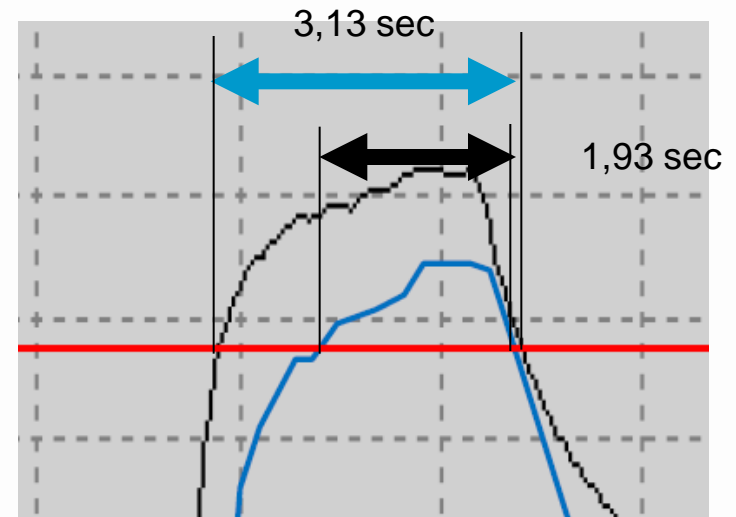




## Equivalent contact times



Temperature measurement on small diode pin  
(+ 25% equivalent contact time)



Temperature measurement on triac SMD  
(+ 60% equivalent contact time)

(conveyor speed: 1,30 m/min)







## Why preheat nitrogen ?

### 2nd reason

#### ❑ Reduce maintenance

- ✓ avoid clogging of the N2 diffusers
  - High speed of the pumps for powerful solder flow due to the mask technology ( selective soldering).  
Solder is often over flowing and can easily hit the surroundings and solidify on the N2 diffusers
  - With hot Nitrogen, the solidification can not occur
- ✓ avoid condensation of flux vapors on the N2 diffusers





## How to preheat nitrogen ?

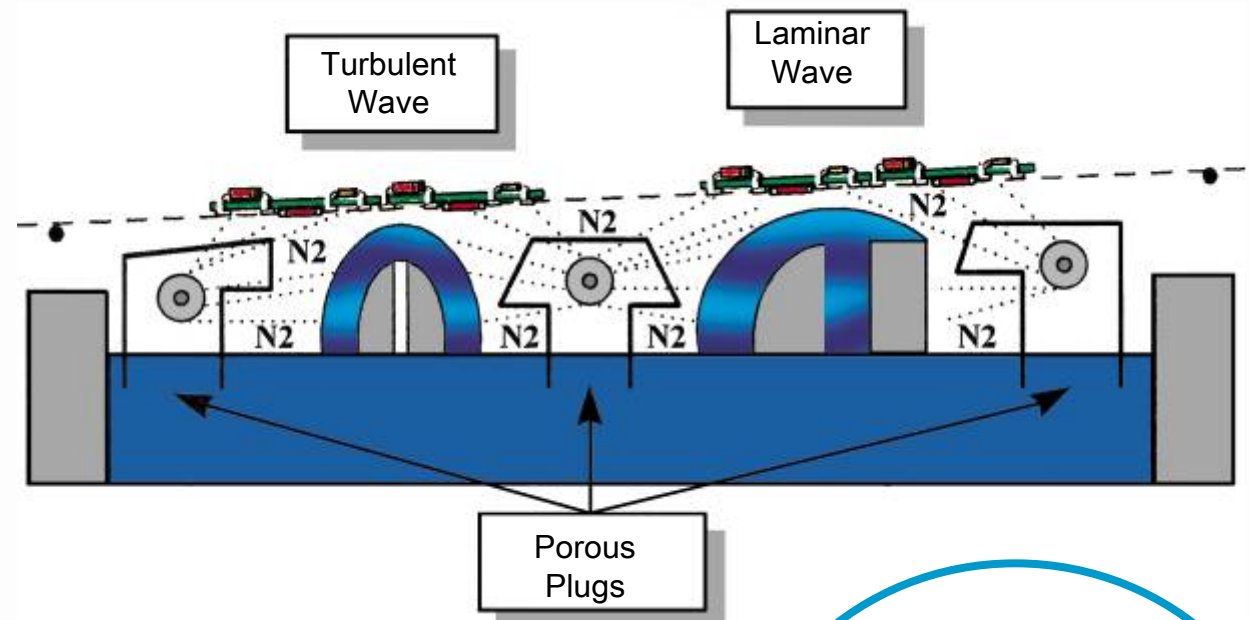
- ❑ A heat exchanger is necessary:
  - ✓ Use the enthalpy of the solder pot is easier and less expensive than an external heating
  - ✓ N2 temperature must reach at least the solidification temperature of the solder alloy  
(217° C for SAC305 – 227° C for Sn100C)
  - ✓ Possible to reach nitrogen temperature of 230° C.
  - ✓ Design is adapted to the machine geometry and available space





## Hot nitrogen for local N2 inerting system - principle

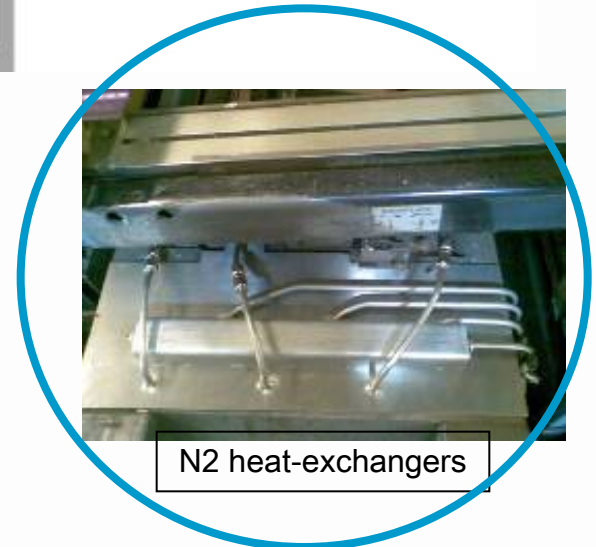
System showed:  
ALIX Inertwave  
equipment -  
Air Liquide



Titanium Frame



N2 flow control  
Panel



N2 heat-exchangers





## Example of implementation





## Impact of hot Nitrogen on soldering quality

❑ Case 1 : power supplies - Lead free

	Cold nitrogen local inerting	Hot nitrogen local inerting	Delta
Defects total	793 dppm	522 dppm	- 34%
missing solder	364 dppm	183 dppm	- 50%
bridges	277 dppm	183 dppm	- 34%
icicles	41 dppm	43 dppm	+ 5%
others	111 dppm	113 dppm	+ 2%
Dross			- 10%
N2	18 Nm3/h	18 Nm3/h	0 %







## Impact of hot Nitrogen on soldering quality

❑ Case 2 : power supplies for computer - Lead free

	Reference	Hot nitrogen local inerting	Delta
PCB A - Defects total	1765 dppm	1247 dppm	- 30%
missing solder	665 dppm	477 dppm	- 28%
shorts-bridges	950 dppm	640 dppm	- 33%
Total PCB joints	147420	68880	
PCB X - Defects total	6313 dppm	3297 dppm	- 48%
missing solder	2512 dppm	386 dppm	- 85%
shorts-bridges	3756 dppm	1949 dppm	- 48%
Total PCB joints	86800	157 850	
Dross	0,4 kg/h	0,03 kg/h	- 93%
N2	-	19 Nm3/h	





## Impact of hot Nitrogen on soldering quality

□ Case 3 : EMS - data center I/O connectivity products - Lead free

	Reference	Hot nitrogen local inerting	Delta
Defects	8900 dppm	2600 dppm	- 67%
Dross	1.5kg/hr	0.06kg/hr	- 96%
Flux	1.16kg/hr	0.78kg/hr	- 33%
N2	-	17.2Nm3/hr	



## Conclusions

- ❑ Hot nitrogen technology for local inerting system of wave soldering machines has proved to give significant advantages with Tin Lead or Lead free solders:
  - ✓ Better heat transfer on the PCBs, especially between the 2 waves (very important for lead free)
  - ✓ Longer equivalent contact time (up to +60% for massive components), allowing a higher conveyor speed
  - ✓ Better soldering quality, less joints defects: average -40% (up to -80% in some cases)
  - ✓ Almost maintenance-free system: no solder clogging and no flux vapors residues on the N2 diffusers (cleaning effect)
- ❑ Already more than 100 field references with ALIX Inertwave HT system of Air Liquide (patent apply for design)

