Aluminium MICRO-CHANNEL

Climetal Heat Exchangers
The history

- Founded in 1988
- Family owned
- Initial technology was traditional tube & fin heat exchangers
- Adopted Nocolok brazing technology in 1997
The figures

- **5.800m² of manufacturing facilities**
- **US$ 10M sales**
- **US$ 1.5M capital**
- **US$ 3M investment in 2007 in new machinery and facilities**
- **Key machinery:**
  - 2 brazing furnaces
  - 3 helium leak testing machines
60 people = 15 indirect + 45 direct

General Manager
Agustín Maiz

Production
María O'Connor

Purchasing & Logistics
César Pérez

Quality
Ester Beneyto

Industrial Sales
E. Juanicorena
Francisco Gómez

Finance
David Álvaro

R&D
Alfonso Sanabria
Ángel Hernández

Maintenance
Enrique Vargas

Marketing
Mª José Blum

Automotive Sales
Jose A. Moreno
Quality

Heat Exchanger Inspection Tests
- Double Chamber Helium Leak Detection System
- Fin-Louver Degree
- Geometric control jigs

Heat Exchanger Durability Tests
- Vibration Tester
- Pressure cycle Tests
- Burst pressure
- Salt Spray
- SWAAT tests
- Metallographic analysis (scanning electron microscopy (SEM-EDX) – facilities at Department of Material Science and Metallurgical Engineering - Faculty of Chemistry Complutense University of Madrid

Heat Exchanger Performance Tests
- Testing facilities in the university of Vigo (Spain): Thermal Capacity Test (Calorie Bench), A/C System Simulation Test, Thermal Shock Test, etc.

Certification
UNE-EN ISO 9001:2008
Our customers

Automotive
- Denso
- Delphi
- Behr
- Hella

Industriall
- Nissens
- Valeo
- JDEUS
- Lennox
- Cubicoool
- FläktWoods
- Faiveley
- Ingersoll Rand
- GeoClima
- Thermo King
- Hyfra
- RhoSS
- Frimec
Automotive

- The biggest range of European after-market condensers (200 models)
- 3-4 new developments per month
- OEM standards
- Main supplier to the leading world manufacturers: Valeo, Behr-Hella, Denso, Delphi
Industrial Products

ADVANTAGES

Click to watch video

-65%
+45%
-25%

INTERNAL dp (kPa)
dP INTERNA (kPa)

PERFORMANCE (Kw)
RENDIMIENTO (Kw)

AIR DP (Pa)
dP Aire(Pa)
Industrial Products

Lower air dP

Perfect heat transfer

Copper

Mechanical expansion vs. brazed joint

Aluminum
**Geometries & Alloys**

**Alloys:**
- Fin ➔ AA3003 Modified + AA4343 Clad
- MP ➔ AA3102 + Zn coating
- Manifold ➔ AA3003 Modified (Long Life)
Geometries

MICROCHANNELS

MANIFOLD

FINS

CONNECTIONS
Leak Causes

- Corrosion
  - Pitting corrosion
  - Galvanic corrosion
- Bad fixing
  - Dilations
  - Vibrations
  - Weight
How to fix your microchannel coil

When designing your fixtures and brackets make sure you take into account the following concepts:

DILATIONS:
Your coil will expand and contract during its normal operation due to the extreme temperature changes it will go through. Make sure your fixing system allows the coil to expand and contract VERTICALLY and HORIZONTALLY. Otherwise, the aluminum will fatigue and leak after sometime. Make sure your fixing points are not rigid and allow the coil to expand freely, as dimensions will change according to the following formula:

\[ L_T = L_0 \cdot \lambda \cdot \Delta t^\circ \]

where
Aluminum \( \lambda = 24 \times 10^{-6} \)
\( L_0 \) = Initial length
\( L_T \) = final length
\( \Delta t^\circ \) = Temperature change

Example:
A 2 meter coil with \( \Delta t^\circ = 100^\circ \text{C} \) will expand and contract 4,8mm

VIBRATIONS:
Your coil will be most likely working under continuous vibrations either coming from the compressor or from the fans. You cannot eliminate the origin of your vibrations, but you can avoid them affecting your coil. Otherwise, the material will fatigue and, eventually, leak. Some best practices to avoid vibrations to affect your coil are:

• Use some flexible sections along your piping, specially the one going from the compressor to the coil inlet.
• Isolate the coil from the frame with elastic or flexible elements (rubber washers, shock absorbers, etc.).

Example of incorrect fixing:
weight is on the microchannel

WEIGHT:
• Avoid to have any extra weight (fans, metal shrouds, etc.) supported by the coil.
• Having the weight of the coil resting on the microchannel is a bad practice. The weight should be born by the manifold, which is the strongest part of the coil. If this is not possible, the coil should have an extra aluminum profile or a dummy microchannel tube.

Rubber washer

Flexible hose

Example of incorrect fixing:
weight is on the microchannel

Rubber support
Some examples of good fixing
Vertical floating brackets

Example 1

Rubber support
Horizontal floating brackets
Top and bottom pins

Example 3

NOT RECOMMENDED FOR COILS BIGGER THAN: 1000x1000mm
Side brackets with rubber washers

NOT RECOMMENDED FOR COILS BIGGER THAN: 1000x1000mm
Aluminium corrosion principles

- Galvanic corrosion
- pH 4.5-8.5
- Aluminum oxide
- Salt water
How to avoid galvanic corrosion

- Avoid contact between aluminum and other metals. Attention to plywood and concrete.
- Avoid extreme pH environments.
- If contact cannot be avoided try to isolate them from the electrolyte (sleeves, paint...).
- Avoid errand electrical currents. Good grounding.
CLIMETAL BRAZED CONDENSERS SWAAT TESTS
Tested at National Institute of Aerospace Technique (Ministry of Defense), INTA
Material:
- 4 heat exchangers with current standard Climetal material combination
  MPE Long life alloy (25mm)
  FIN with clad in both sides (25mm)
  HEADER with clad (32mm)
  2 heat exchangers without coating and without protection in the joint
  2 heat exchangers protected with epoxi and adhesive sleeve in the joint
**Conditions in Salt Spray Chamber:**
The conditions in salt spray chamber are according to ASTM G85 Annex 2 “Cyclic acidified salt spray test”.

Definition of 1 cycle:
- 45 minutes of saltwater spray at 49 ± 2°C
- 120 minutes of drying at 49 ± 2°C
- 195 minutes (soak period) at 49 ± 2°C and 98%± 2% relative humidity.

**Test dates:** From 20th June to 4th November 2013 (2200 hours).

**Note:** Two chamber stops

**Total test duration:** 2200 hours.

**Test Equipments:**
- Salt Spray Chamber CCI
- Pressure measuring made at Climetal installations (Leak test machine)

**Note:** During the salt spraying test, the inlet tubes of the samples are covered with a plastic tap in order to protect them from the spray.

**Samples Evaluation: Visual inspection**
Visual inspection of the samples with photographs has been performed:
1. The first visual inspection has been performed before the beginning of the test.
2. The following visual inspection takes place after every 300 hours.
Leak of samples is evaluated at the beginning of the test and during the test every 150 hours. In this evaluation, each sample has been tested by compressed air (35 bar) in CLIMETAL’s leak testing machine.

**TEST RESULTS:**

<table>
<thead>
<tr>
<th>IDENTIFICATION</th>
<th>AIR PRESSURE VALUE (BAR)</th>
<th>Salt spray test duration (hours) until pressure leak is detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONDENSER 1</td>
<td></td>
<td>no leaks after 2200 hours</td>
</tr>
<tr>
<td>CONDENSER 2</td>
<td></td>
<td>no leaks after 2200 hours</td>
</tr>
<tr>
<td>PAINTED CONDENSER 1</td>
<td>35 BAR</td>
<td>no leaks after 2200 hours</td>
</tr>
<tr>
<td>PAINTED CONDENSER 2</td>
<td></td>
<td>no leaks after 2200 hours</td>
</tr>
</tbody>
</table>
After 1200hrs
non-painted
After 2200hrs non-painted

Presence of corrosion. The upper and lower elements (plates and fin) are detached from the coil. The Copper/Aluminum joint shows presence of corrosion. Nevertheless, no leaks after 2200 hours of exposure. End of the test.
After 1200hrs painted
After 2200hrs painted

The coating has fallen off in several areas. However the general aspect of the fins, multiport tubes, manifolds and Cu/Al joints has been preserved almost intact. After 2200 hours of exposure, leakage is not detected. End of test. Although none of the 4 samples had leaks, we observe a logical significant difference between unpainted & painted samples
CLIMETAL CU/AL BRAZED JOINTS SWAAT TEST
Tested at National Institute of Aerospace Technique (Ministry of Defense), INTA
Conditions in Salt Spray Chamber:
The conditions in salt spray chamber are according to ASTM G85 Annex 2 “Cyclic acidified salt spray test”.
Definition of 1 cycle:
• 45 minutes of saltwater spray at 49 ± 2°C
• 120 minutes of drying at 49 ± 2°C
• 195 minutes (soak period) at 49 ± 2°C and 98%± 2% relative humidity.

Test dates: From 20th June to 04th November, 2013 (2200 hours).
Note: Two stops of chamber
Total test duration: 2200 hours.

Test Equipments:
• Salt Spray Chamber CCI
• Pressure measuring made in Climalt installations (Leak test machine)

Note: During the salt spraying test, the inlet tubes of the samples are covered with a plastic tap in order to protect the interior from the spray.

Samples Evaluation: Visual inspection
Visual inspection of the samples with photographs has been performed:
1. The first visual inspection has been performed prior to the beginning of the test.
2. The following visual inspection after every 300 hours or when any leak has been detected.
## Cyclic acidified salt spray test

<table>
<thead>
<tr>
<th>TYPE SAMPLE</th>
<th>Nº</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without sleeve (using current filler material 2%Aluminum &amp; 98%Zn)</td>
<td>6</td>
<td><img src="image1" alt="Picture" /></td>
</tr>
<tr>
<td>Without sleeve (using filler material 22%Aluminum &amp; 88%Zn)</td>
<td>6</td>
<td><img src="image2" alt="Picture" /></td>
</tr>
</tbody>
</table>
Cyclic acidified salt spray test

<table>
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<tr>
<th>TYPE SAMPLE</th>
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<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>With non adhesive sleeve</td>
<td>8</td>
<td><img src="image1" alt="Image" /></td>
</tr>
<tr>
<td>With adhesive sleeve</td>
<td>9</td>
<td><img src="image2" alt="Image" /></td>
</tr>
</tbody>
</table>
### Cyclic acidified salt spray test

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<th>TYPE SAMPLE</th>
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<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>With adhesive sleeve and SIKAFLEX</td>
<td>9</td>
<td><img src="image1.jpg" alt="Picture of samples" /></td>
</tr>
<tr>
<td>Epoxi coated</td>
<td>9</td>
<td><img src="image2.jpg" alt="Picture of samples" /></td>
</tr>
</tbody>
</table>
Cyclic acidified salt spray test

**Samples Evaluation: Pressure leak checking test**
Leak of samples is evaluated at the beginning of the test and during the test every 150 hours. In this evaluation, each sample has been tested by compressed air (35 bar) in CLIMETAL’s leak testing machines.

**TEST RESULTS:**

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<tr>
<td>JOINT 2%</td>
<td>35 bar</td>
<td>no leaks after 2200 hours</td>
</tr>
<tr>
<td>JOINT 22%</td>
<td>35 bar</td>
<td>no leaks after 2200 hours</td>
</tr>
<tr>
<td>JOINT WITH NON ADHESIVE SLEEVE</td>
<td>35 bar</td>
<td>no leaks after 2200 hours</td>
</tr>
<tr>
<td>JOINT WITH ADHESIVE SLEEVE</td>
<td>35 bar</td>
<td>no leaks after 2200 hours</td>
</tr>
<tr>
<td>JOINT WITH ADH. SLEEVE AND SIKAFLEX</td>
<td>35 bar</td>
<td>no leaks after 2200 hours</td>
</tr>
<tr>
<td>PAINTED JOINT</td>
<td>35 bar</td>
<td>no leaks after 2200 hours</td>
</tr>
</tbody>
</table>

Next Step: Visual and Metallurgical inspection of joints in external Laboratory
After 2200hrs non-protected

Metallographic analysis:
Cross section. The samples show evidence of severe corrosion

Presence of corrosión is observed all over the sample. Nevertheless no leaks after 2200 hours of exposure. End of test.
After 2200hrs epoxy

Presence of corrosión is observed all over the Cu/Al joint. No leaks after 2200 hours of exposure.

Metallographic analysis:

Cross – section. The sample shows almost no evidence of corrosión.
After 2200hrs non-adhesive sleeve

Presence of corrosión is observed all over the sample. After removing the sleeve, there is almost no evidence of corrosión on the joint.

Metallographic analysis:

Cross – section. The sample shows minor corrosion.
After 2200hrs adhesive sleeve

Presence of corrosión is observed all over the sample. After removing the sleeve, there is almost no evidence of corrosión on the joint. No leaks after 2200 hours of exposure.

Metallographic analysis:

Cross – section. The samples shows some minor corrosión.
After 2200hrs adhesive sleeve + sikaflex

Presence of corrosión is observed all over the sample. After removing the sleeve, there is almost no evidence of corrosión on the joint. No leaks after 2200 hours of exposure.

Metallographic analysis:

Cross – section. The sample shows NO CORROSION at all. This is the best among the three cross-sections samples.
The objectives of Climetal's packing are to avoid:

- Dents by hits in falls during any time of handling or during the physical distribution.
- Damages by compression due to the same products stacked one on top of others, or other goods placed on top of the pallets.
- Damage caused by continuous vibration during the transportation.
- Breaks in storage.

The coils could be delivered in wooden box or in cardboard boxes, (depending of the coil size and quantity) plus a wooden pallet.
Depending of the coil’s configuration, and the quantity to be packed, the heat exchangers must be separated by foam combs, foam bags, corrugated cardboard separators or simple cardboard separators, in order to protect the connections and the coil.

The coils must be fixed with plastic straps and carton corners (if needed). In this way when the goods are being handling the content don’t move.