A close-up, black and white photograph of aluminum heat exchanger coils. The image shows several parallel rows of tightly packed, wavy metal fins, creating a complex, textured pattern. The lighting highlights the metallic sheen and the repetitive geometric shapes of the coils.

May 7, 2019

# ALUMINIUM HEAT EXCHANGER TECHNOLOGIES FOR HVAC&R

6<sup>th</sup> International Congress

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R&D MANAGER

**Honeywell**

# AGENDA

## Alternatives to traditional PaintFlux solutions – Aluminium brazing PaintFlux toolbox

1. Toolbox Concept
2. Paint Formulation Basics
3. Brazing Performance
4. Anticorrosive Properties

# PROBLEMS RELATED TO PAINTFLUX

- Customer is not satisfied with short shelf-life of PaintFlux
  - In-house PaintFlux mixing do not achieve consistent quality
  - In-house powder handling creates safety issues
  - Flux residues interact with cooling fluid
- 
- Targets for a new PaintFlux application technology
    - Long shelf-life
    - Easy handling
    - Cost-effective
    - No fluoride leaching into cooling fluids

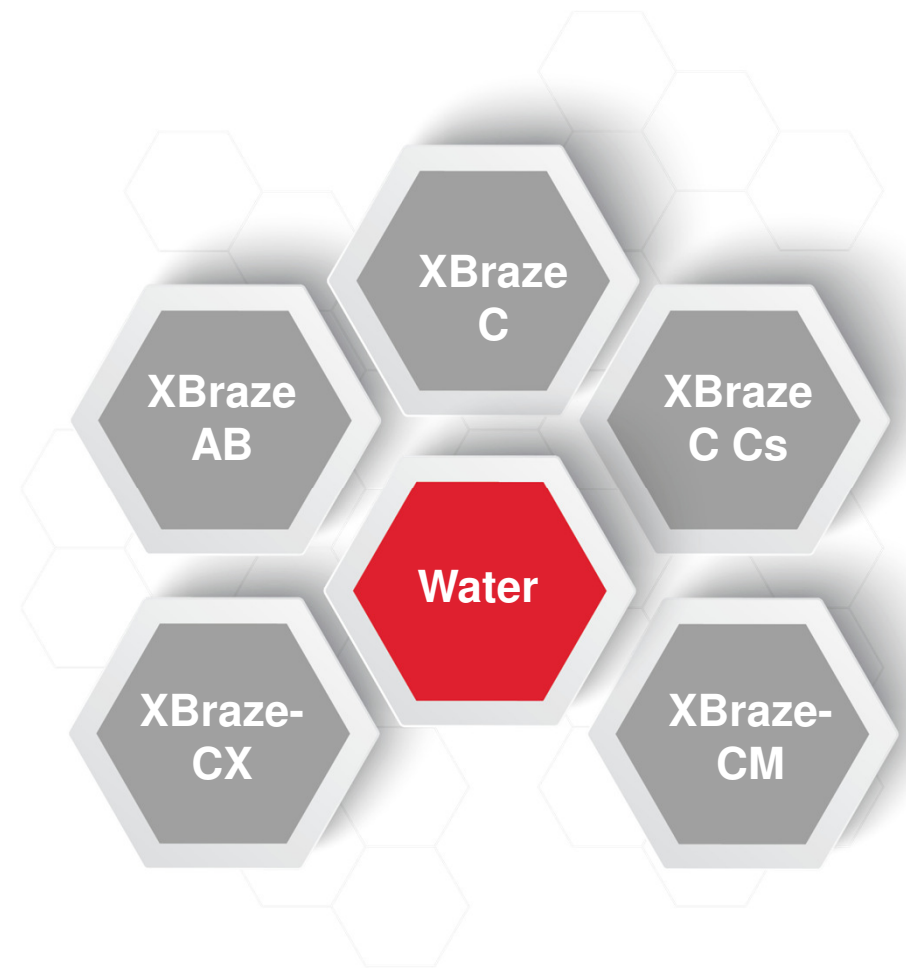


# WHAT IS THE SOLUTION?

**Separate flux and binder concentrates are mixed to achieve a PaintFlux**

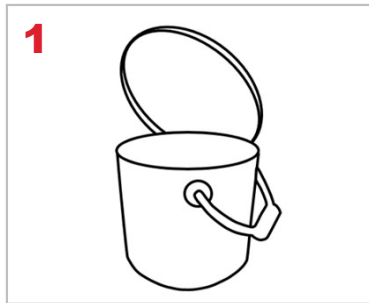
## Features and Benefits

2-components	long shelf-life
Wet-in-wet process	working and safety conditions improved
Predispersed flux	fine nozzle - good atomization
Accurate spray	lower flux loading - cost savings
Highly reactive flux	lower flux loading - cost savings

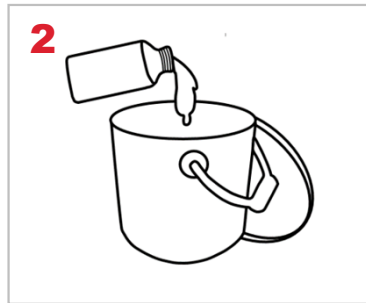


# APPLICATION – XBRAZE PAINTFLUX

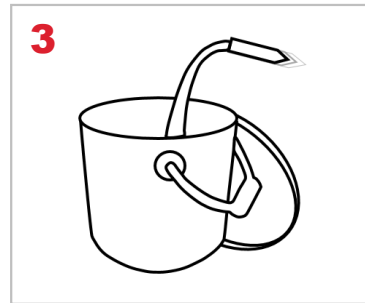
Formulating is simple!



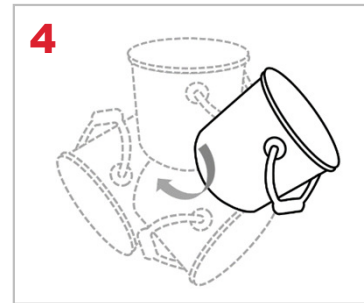
Open pail with  
flux concentrate  
– **XBraze-C**



Add precise  
amount of binder  
concentrate –  
**XBraze-AB**



Add deionized  
water to dilute  
flux concentration

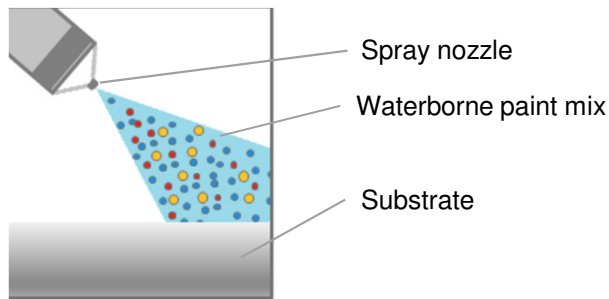


Mix for 5 minutes  
using a gyroscopic  
mixer or a motor  
stirrer with  
propeller



Formulated paint  
– ready for use!

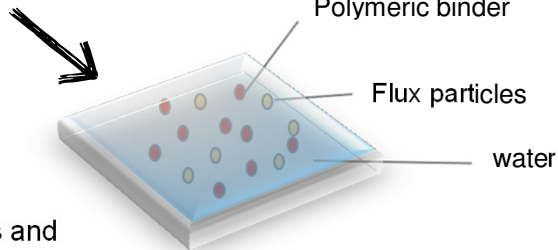
# PAINTFLUX SPRAYING PROCESS



Spray nozzle

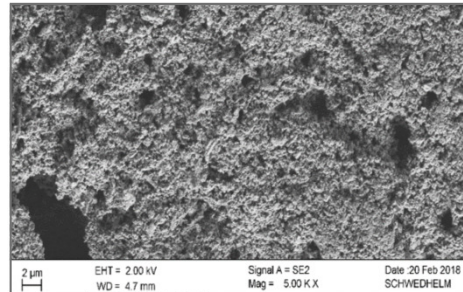
Waterborne paint mix

Substrate

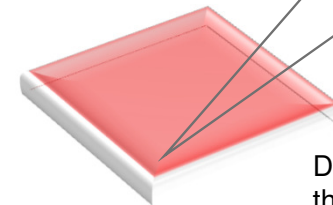
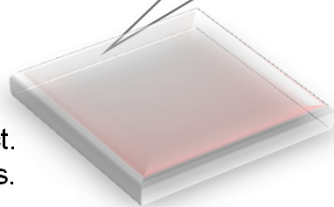


The flux wets and adheres to the substrate. Drying and cross-linking begins.

Flux film under the electron microscope.



Flux particles and binder droplets coalesce and react. Interstitial water evaporates.



Brazed angle coupon



During the CAB brazing cycle the organic components debind and the flux melts.

# **XBRAZE – MULTIPLE CONCENTRATES FOR ADDED FLEXIBILITY**

## **XBraze-AB**

- Long shelf-life
- Excellent thermal stability, up to 60 °C
- High solid content
- Provides thixotropic FluxPaint flow.

## **XBraze-C**

- High concentration of  $\text{KAIF}_4$  ~55-60 %
- Predispersed flux prevents nozzle blockage and fine atomization
- Provides accurate spray
- Contains highly reactive flux

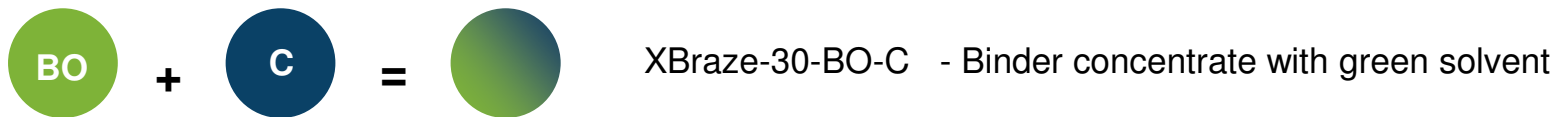
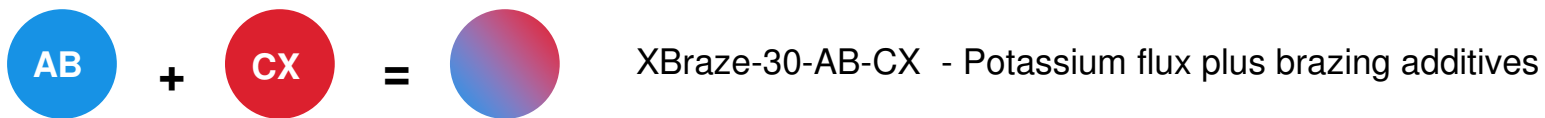
## **XBraze-CM**

- Long shelf-life
- Micronized  $\text{KAIF}_4$  flux
- D100 typically found at < 30  $\mu\text{m}$
- Discretely dispersed flux particles
- Low flux coverage possible, less fluoride leaching.

## **XBraze-CX**

- Next generation flux concentrate
- Stops fluoride leaching into cooling fluids
- Passivates the brazed surfaces
- Improved flux spreading behavior

# **XBRAZE TOOL COMBINATIONS**





# THE BENEFIT OF PREDISPERSED POWDERS

## Check for wetting

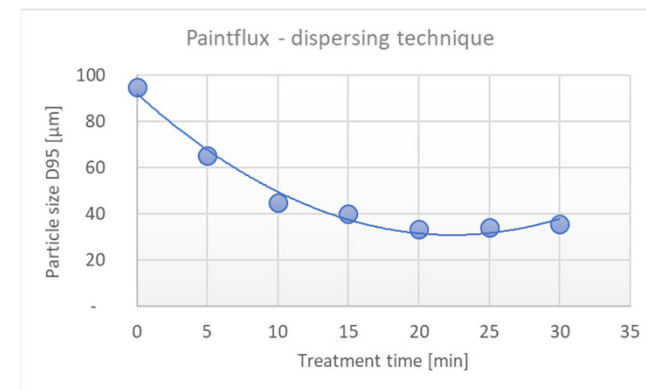
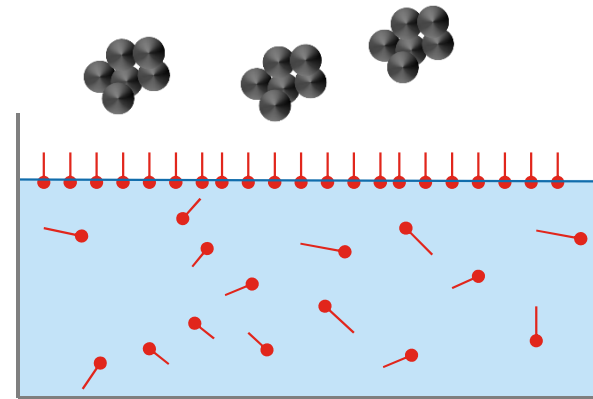
- Use surfactants to wet the powder surface
- Surfactants lower surface tension from 70 to 30 mN/m.
- Keep concentration below the CMC

## Choose dispersants

- When particles approach close enough to cross potential barrier they agglomerate.
- Find strong dispersants to keep particles apart!

## Add energy

- Apply mechanical shearing action, intensive stirring
- Treat the powder with ultrasonic waves



**Powder dispersing: KAIF4 powder under shearing action**

# RHEOLOGY OF FLUX PAINTS

## How to prevent particle settling

- The suspension of dispersed flux particles need to be a shear thinning system.
- Pseudoplastic recovery is favorable

## Formulation criteria

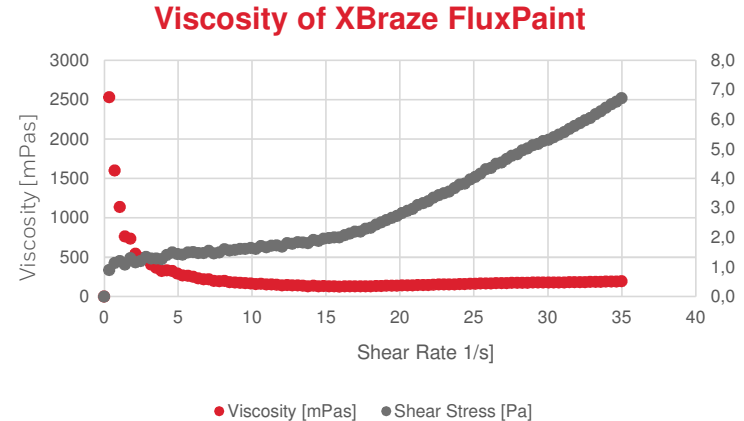
- Find the right thickener which is compatible with solvent, binder and flux
- Choose the right binder to flux ratio
- Choose the right thickener/binder ratio

## Measuring viscosity

- Only rotational viscosimeters are able to measure the shear forces in flux suspensions correctly.



**Example:** From ideally viscous liquids to elastic solids. Viscoelastic materials in everyday life



**Viscosity measurement:** Waterborne FluxPaint with thixotropic viscosity

# XBRAZE – HOW TO ACHIEVE THE RIGHT PERFORMANCE

Understanding and reducing the variations in PaintFlux formulations via DoE.

## Response functions

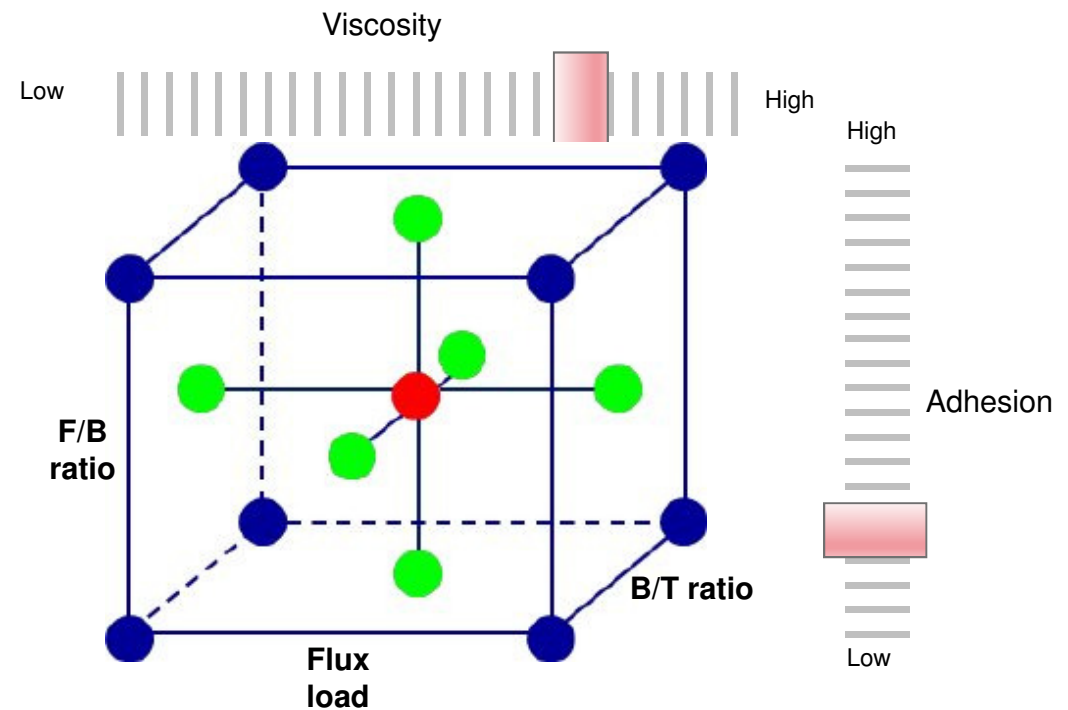
- Adhesion
- Viscosity
- Joint strength

## Influencing parameters

- Flux/Binder ratio

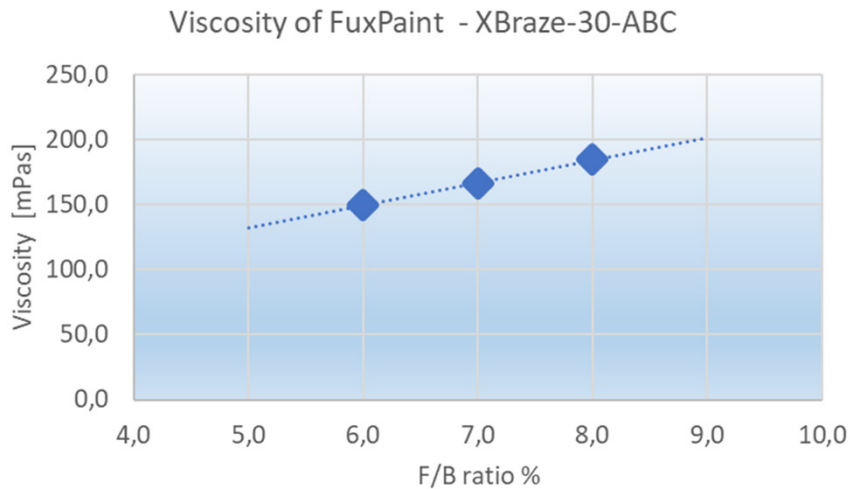
$$\frac{F}{B} = \left( \frac{\text{flux} + \text{binder} + \text{thickener}}{\text{binder} + \text{thickener}} \right) \times 100$$

- Binder/Thickener ratio
- Flux load



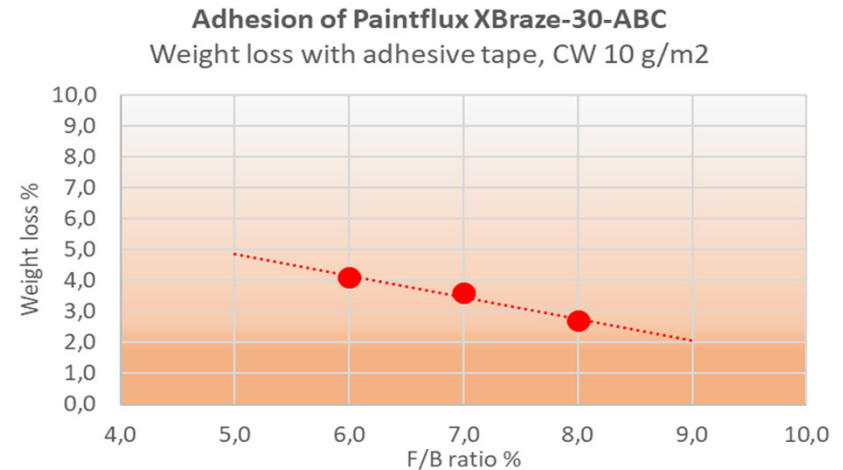
# DOE DATA ALLOW CONTROL OF PERFORMANCE

Higher viscosity – leads to reduced settling.



**Viscosity:** Adjusting the F/B ratio to control the viscosity

Fewer weight loss – means good adhesion!



**Adhesion:** Adjusting the F/B ratio to control the adhesion

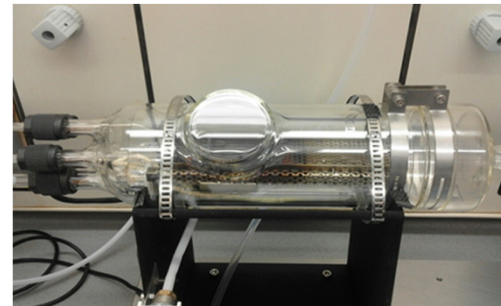
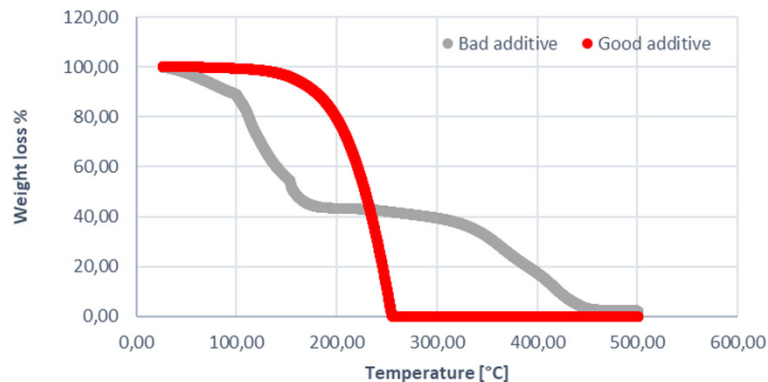
**Performance properties correlate with flux/binder ratio**

# DOE ALLOWS SELECTION OF GOOD ADDITIVES

## Brazing

- The brazing requirements limits the total amount of organic in the formula.
- Not all paint additives which can be found on the market are good.

TGA - Verification of debinding properties



**Brazing:** Glass furnace with nitrogen purge and temperature controller



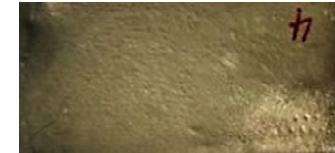
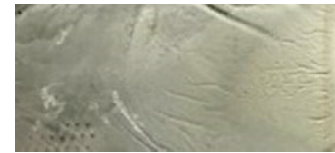
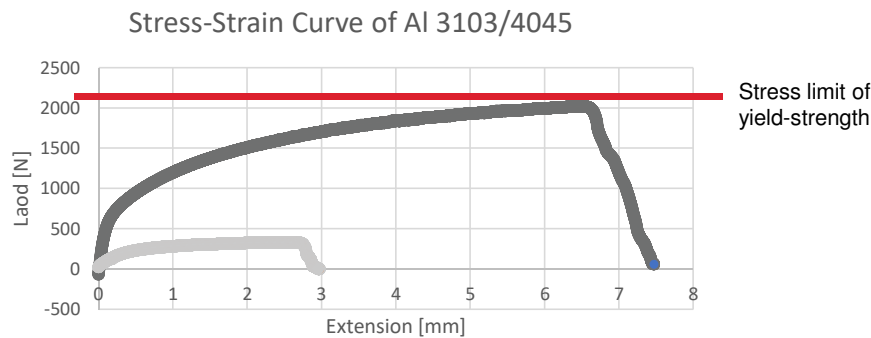
**Brazing performance:** left, conventional paint with high amount of organics. Right, paint formulated with XBraze concentrate

**XBraze flux concentrates braze w/o residue**

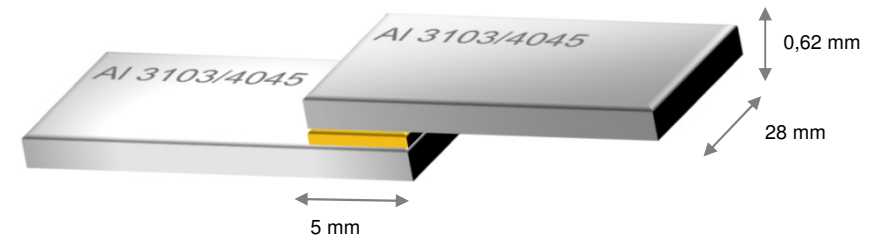
# DOE ALLOWS TO MAXIMIZE BRAZE JOINT STRENGTH

## Tensile strength

- Ultimate tensile strength UTS is measured by the maximum stress that a material can withstand while being stretched or pulled before breaking.
- The highest point of the stress–strain curve is the UTS



**Tensile test:** tensile force measurements



**Tensile test:** Lap joint configuration

**Braze joints strength reaches stress limit of base alloy**

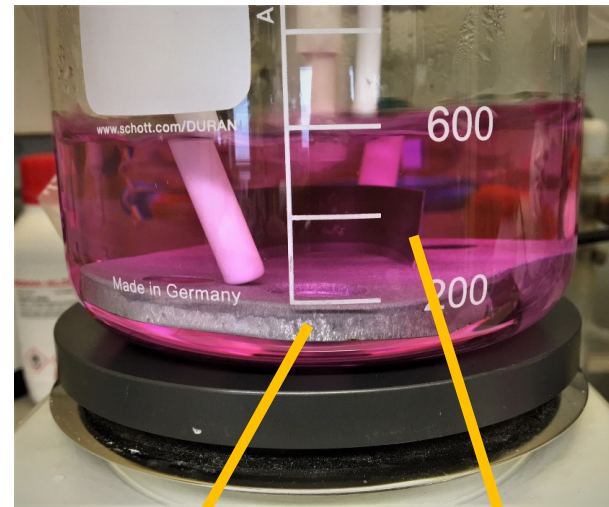
# ANTI-CORROSION PROPERTIES

## Fluoride leaching

- Immersion test of brazed aluminium panels were conducted in laboratory.
- Brazing residues can be dissolved by the cooling fluid.

## Corrosion products in cooling fluids

- Post braze flux residue is not inert on aluminium surfaces in the presence of various types of coolants.
- Many corrosion mechanisms are likely to interact with the aluminium tubes.
- Aluminium oxide and fluorides can be leached from the brazed surface.



**Corrosion test:**  
Immersion of brazed aluminium angles in cooling fluid.



**Brazing residues react with cooling fluid**

# SOLUTION FOR HIGH-ANTICORROSION PROPERTIES

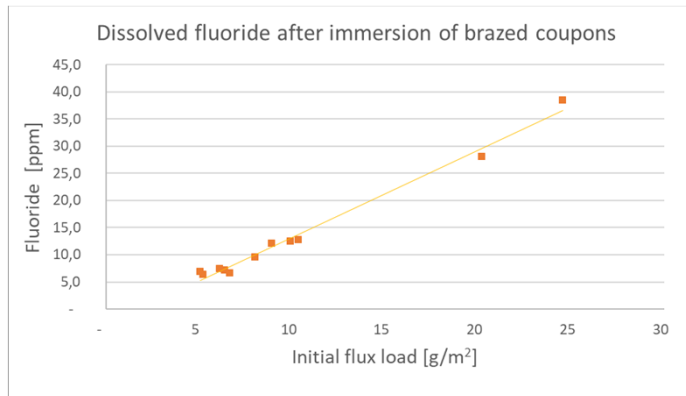
**F-leaching decreases by reducing the flux load on the aluminium part.**

## Methods to lower the fluoride release

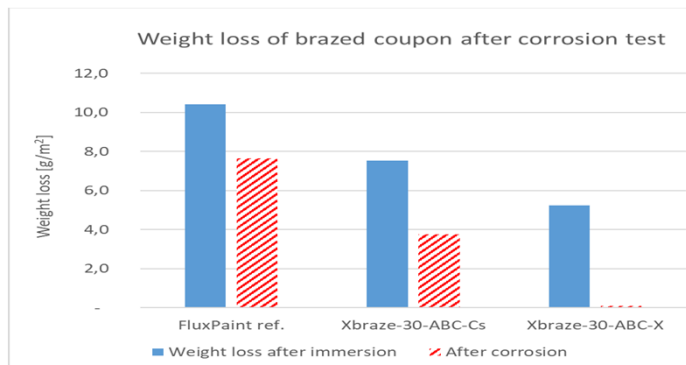
- Flux concentrates with **micronized flux** reduce the necessary coating weight below 10 g/m<sup>2</sup>.
- **Fluoride scavengers** bind the fluoride ions in the aluminium surface.

## Honeywell solutions

- XBraze-CM with micronized flux
- XBraze-CX with F-scavengers



**F-leaching:**  
Immersion test  
weight loss of  
brazed panels DE  
water



**Immersion test:**  
weight loss of  
brazed aluminium  
panel after  
immersion test

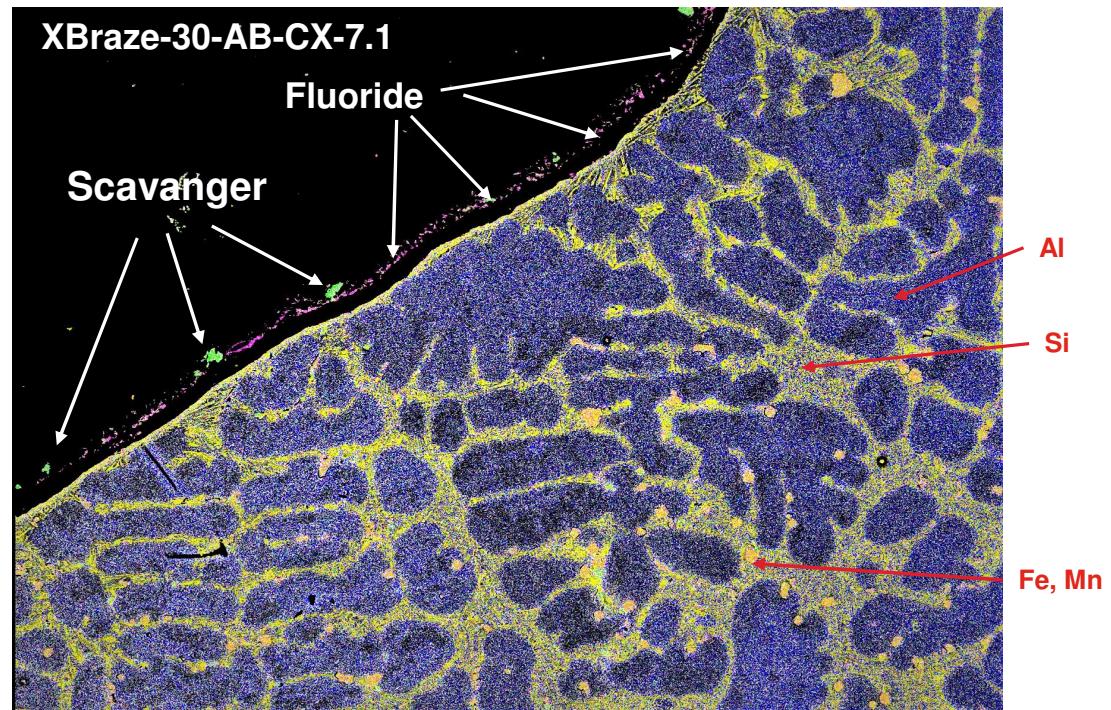
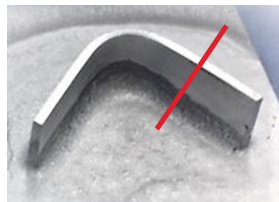
**Solutions to reduce corrosion phenomena exist**



# MICROGRAPHS OF BRAZED T-JOINT - REM-EDX INVESTIGATION

## F-Scavengers

- Fluoride scavengers were being used to minimize the fluoride leaching from brazed aluminium alloy into the cooling fluids.



EDX gives evidence that f-scavengers perform on the surface

# **SIMPLE. CLEAN. EFFICIENT. BRAZE JOINT QUALITY YOUR WAY.**

## **High quality braze joints with the following benefits**

- Elimination of dry powder handling
- Reduced manufacturing costs
- Increased storage life times

## **The Honeywell XBraze Toolbox makes paint formulating easy**

The XBraze product portfolio was developed to include compatible brazing ingredients that can simply and easily be blended to formulate your paint formulation.

## **XBraze formulations can prevent the fluoride leaching into cooling fluids**

# THANK YOU