

Looking
beyond



The MicroGroove Advantage Copper Alloys for ACR

Ed Rottmann – Luvata Tubes Americas

LUVATA
Partnerships beyond metals

Luvata has a global presence in metal solutions, manufacturing and engineering services

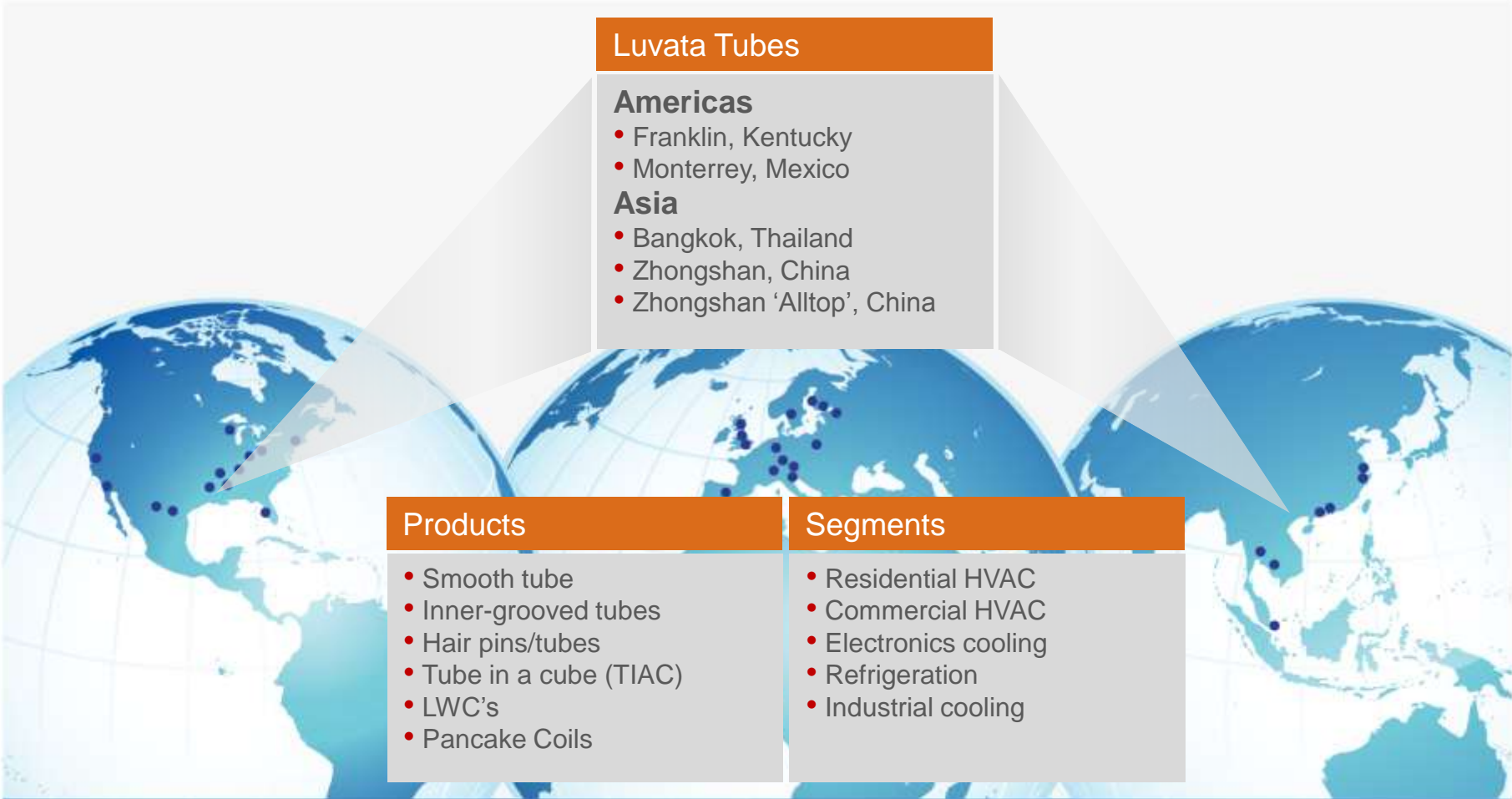
- **6,250 employees**
- **30 production facilities in 14 countries**
- **Total sales of EUR 2.1 billion***
- **Leading position in almost all operating markets**

*2012



Luvata Tubes - American and Asian footprint

A broad product offering



Alloys – Background and Applications

- Standard DHP has been used for decades
 - Processes well in supplier and customer manufacturing (forming, brazing)
 - Reparable, high conductivity, very good corrosion resistance in wide range of outdoor environments
 - Conducive to installation processes
 - Compatible with wide range of refrigerants – from water to CO2
- Alloys can be used to reduce overall unit cost and extend life, while maintaining basic advantages of DHP.
- Alloys, along with coatings, can extend life, reduce warranty cost and combat formicary corrosion.
- Higher strength alloys can reduce material cost and enable standard-type coil designs to perform at higher pressures like what are found with CO2 systems.

Alloy Chemical Compositions

Two examples of alloy solutions are shown here – others are available

UNIGUARD™ C42210

Chemical Composition

(%Max., unless shown as range)

| | Cu | Fe | Pb | Ni | P | Se | Te | Sn | Zn |
|-----------|-----------|-------|------|-----|-----------|-------|-------|---------|------|
| Min./Max. | 86.0-89.0 | 0.035 | 0.01 | 0.5 | .001-.010 | 0.005 | 0.005 | 1.1-1.6 | Rem. |
| Nominal | 87.5 | - | - | - | 0.005 | - | - | 1.3 | 11.2 |

UNILLOY™ C19022

Chemical Composition

(%Max., unless shown as range)

| | Cu | Fe | Pb | Ni | P | Sn | Zn |
|-----------|------|------|-------|--------|---------|--------|-----|
| Min./Max. | Rem. | 0.04 | 0.009 | .3-1.0 | .01-.07 | .3-1.0 | 0.2 |
| Nominal | 98.6 | - | - | 0.6 | 0.03 | 0.6 | - |

UNIGUARD Alloy Solution for Formicary Corrosion

- UNIGUARD 42210 Alloy has performed 50+ times better than DHP in standardized formicary corrosion tests done by a 3rd party lab.
- UNIGUARD coils have not had a field failure to date with thousands of coils placed in known problem environments over the past six years
- Combination of zinc and tin have resulted in a departure from the ants nest morphology; pits are broad and shallow – see next slide.
- Chemistry has been refined and product is patent pending.

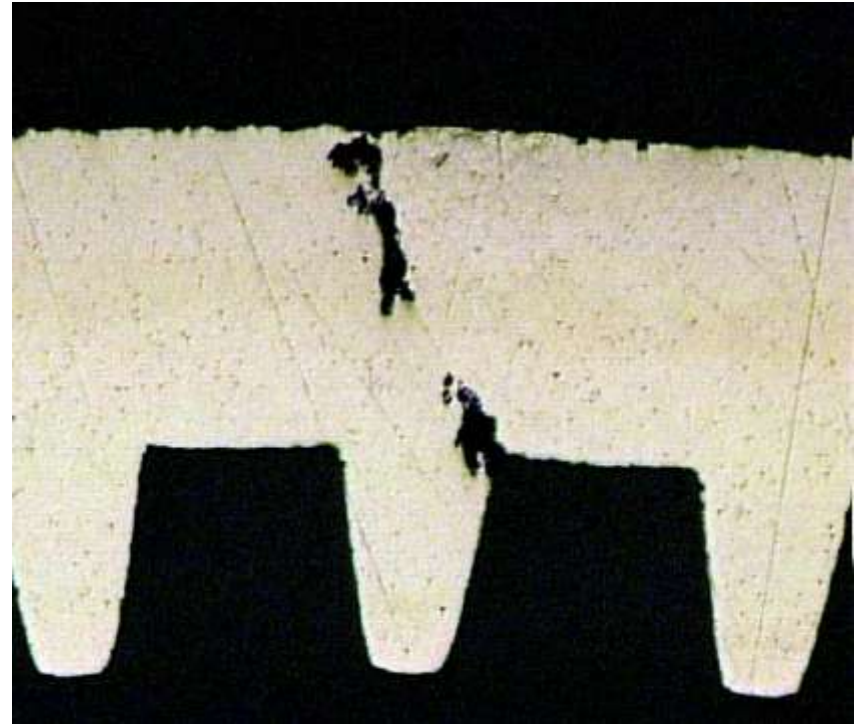
Luvata has worked in cooperation with a leading 3rd party lab since 2001 to develop test methods and identify cause factors for formicary corrosion.

The difference in structure and shape of pits for UNIGUARD compared to DHP are evident.

UNIGUARD sample 125x magnification - after 180 days of accelerated formicary corrosion testing, with no through-wall failure.



DHP (C122) alloy sample 125x magnification - after 7 days with failure, of accelerated formicary corrosion testing.



Challenges with Developing High Strength Alloys for ACR

- Key issue is to capitalize on advantages of DHP copper while adding strength and reducing material weight
 - Numerous alloys are available
- Characteristics must include:
 - Formability, coil processes are demanding
 - Braze-ability, in field with difficult joint locations
 - High conductivity
 - Corrosion resistance
 - Cycle fatigue
 - Compatibility with refrigerants
- Time period and ability to pass rigorous testing
 - UL
 - OEM corrosion tests
 - Field testing

UNILLOY

- UNILLOY

- Nickel and tin additions result in higher strength than DHP and 10-20% material savings
- Applications are ACR heat exchangers
- Provides basis for next generation CO2 heat exchangers
- Concept is to reduce base wall thickness and provide same heat transfer surfaces available with DHP
- Same brazing properties as DHP

- UNILLOY data and qualifications:

- Meets 40% elongation with a grain size between 15 and 40 μm
- Exceeds 50% IACS for conductivity
- UNILLOY coils meet UL burst and cycle fatigue test
- Equivalent heat transfer & pressure drop to the current tube
- Passed salt spray test per ASTM B117 for 1000 hours
- As good or better in formicary corrosion testing

Alloys can be combined with other methods to reduce total cost

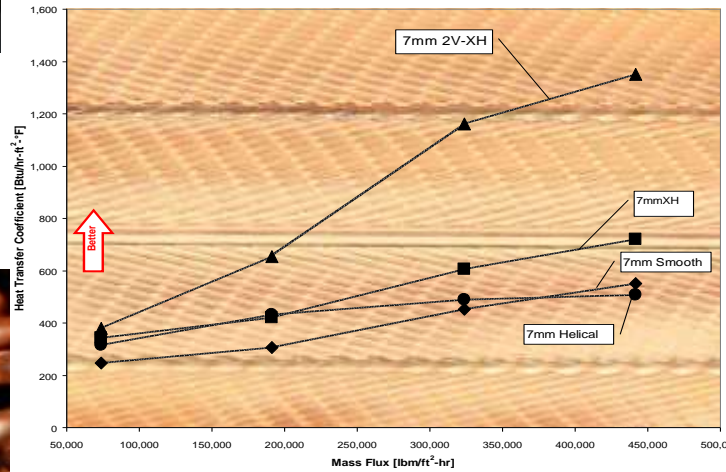


UNIGUARD™ and UNILLOY™
IG Tubes



PINS-IN-A-BIN™
IG Tubes

High Performance
2V-XH™ IG Tube



T-Proof™ Coating Technology
IG Tubes



TIAC™ Packages