Construction of Small Diameter Copper Tube Fin Heat Exchangers

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Who are we?

Optimized Thermal SYSTEMS

Optimized Thermal SYSTEMS

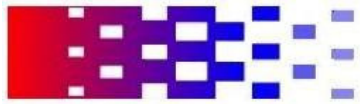
Serving the HVAC&R industry through cutting edge research, state-of-the-art software, and performance measurement and verification of new technologies that can reduce energy consumption and address growing environmental concerns.

Cu Copper Alliance™

Defend and grow markets for copper based on its superior technical performance and its contribution to a higher quality of life worldwide. Members include copper mining and fabricating companies.

Burr OAK Tool

For over 70 years, providing machines, tools, and expertise to the heat transfer and tube processing industries.



Heat Transfer Technologies LLC

Providing heat exchanger design, prototyping and manufacturing assistance for the HVAC&R industry with a focus on materials, joining methods, and novel designs.

Speakers

Daniel Bacellar, Moderator

- Ph.D., Mechanical Engineering
- Engineering Manager, Optimized Thermal Systems, Inc.

Rocky Smith, Subject Matter Expert

- Product Manager – Coil Production, Burr Oak Tool, Inc.

Yoram Shabtay, Subject Matter Expert

- President, Heat Transfer Technologies, LLC

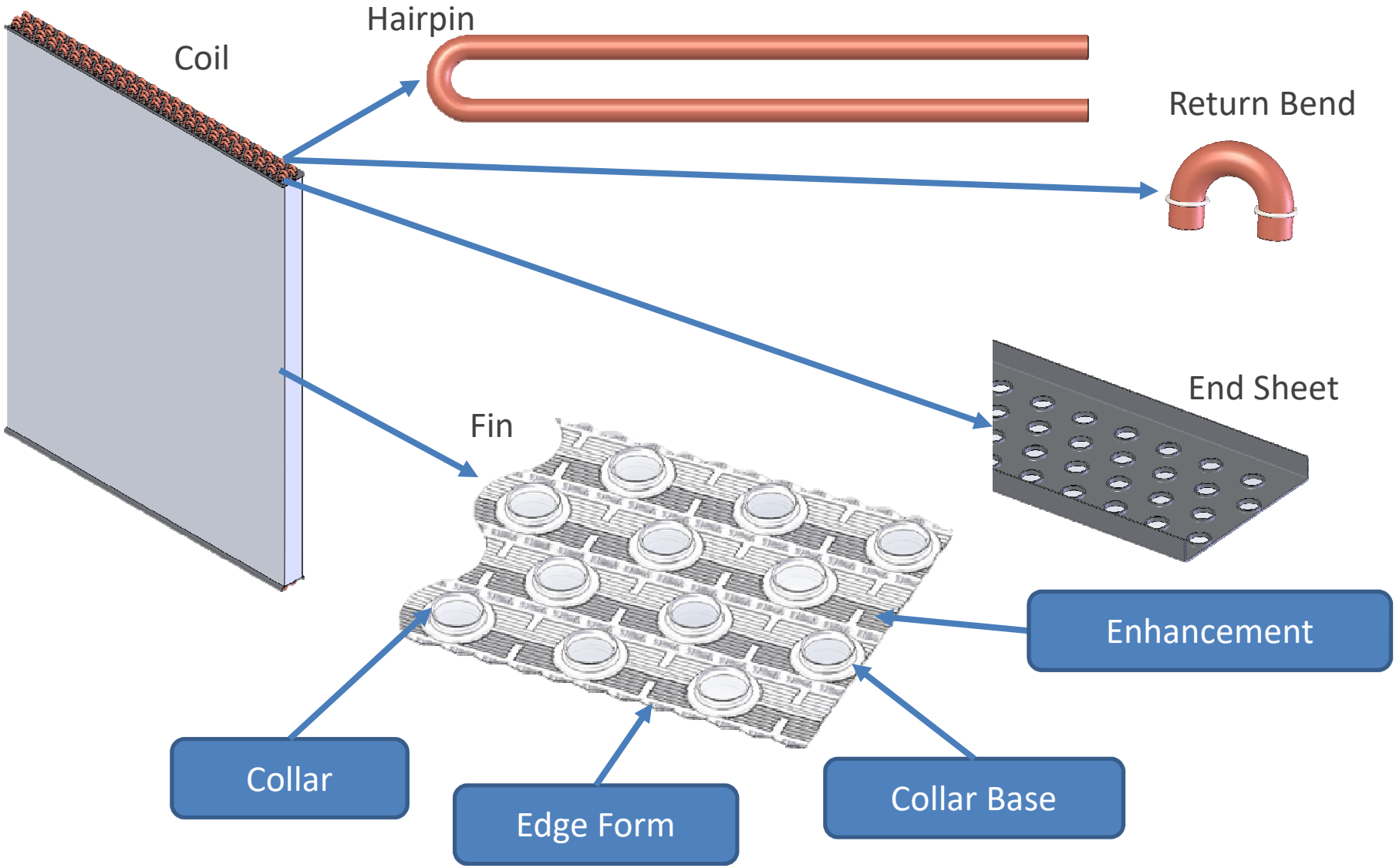
Contents

Introduction

Round Tube Plate Fin (RTPF) Coils

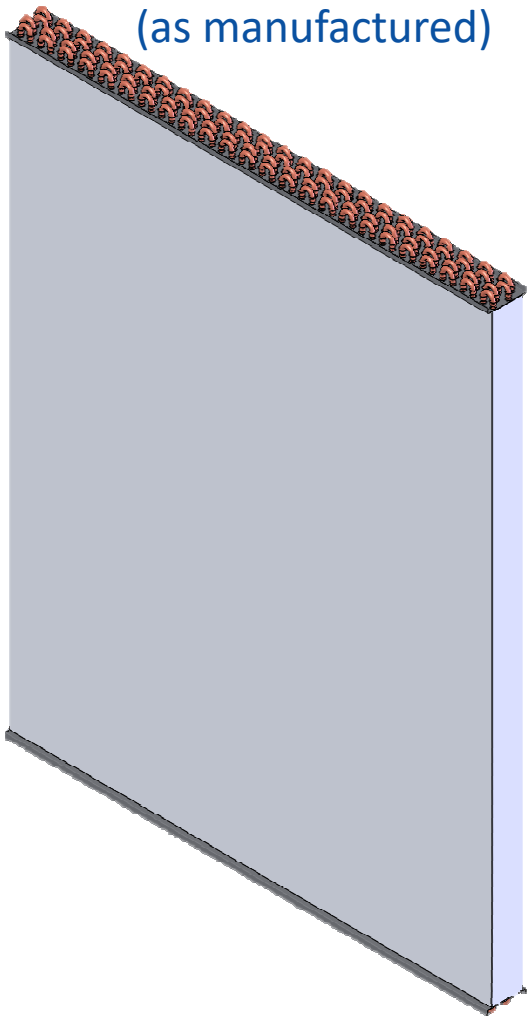
- **Why do we use RTPF for HVAC applications?**
  - **Established technology**
  - **Good water shedding properties**
  - **Customizable fin, tube, and coil geometry**

RTPF Anatomy

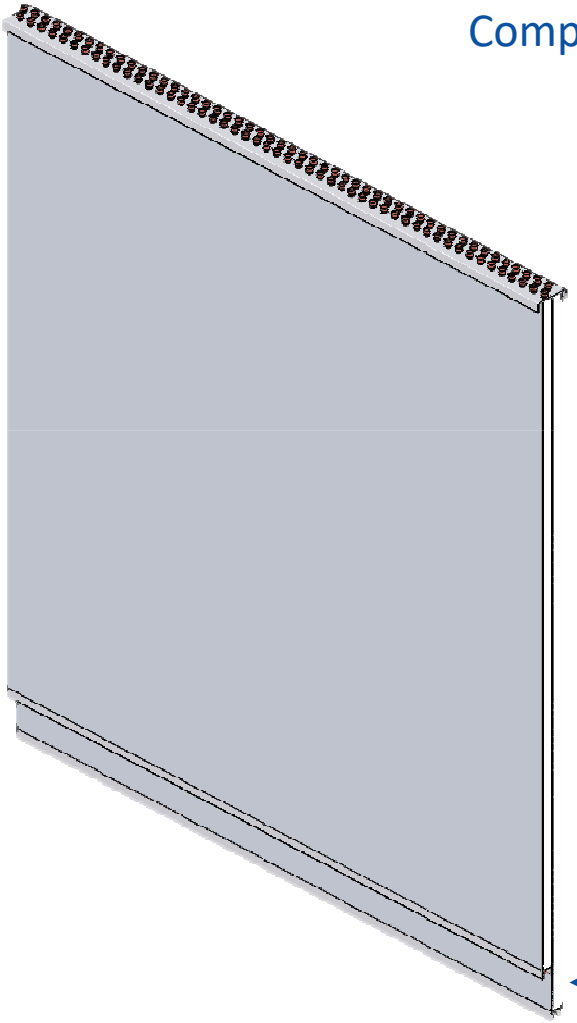


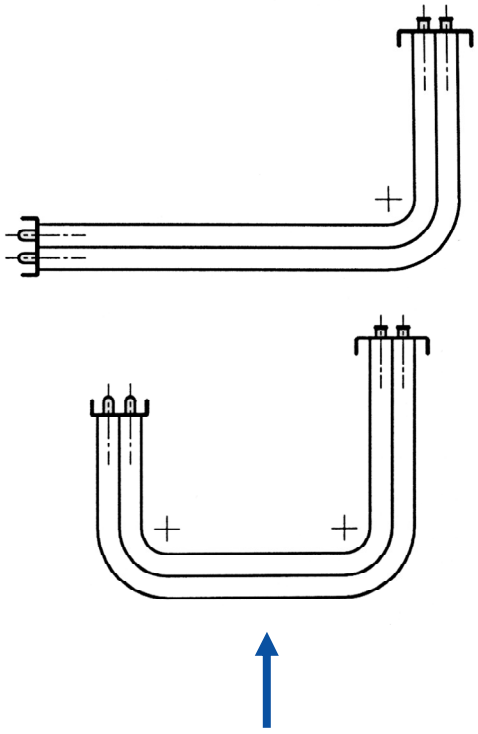
RTPF Flexibility

Flat Coil
(as manufactured)



Composite Or “1+1”

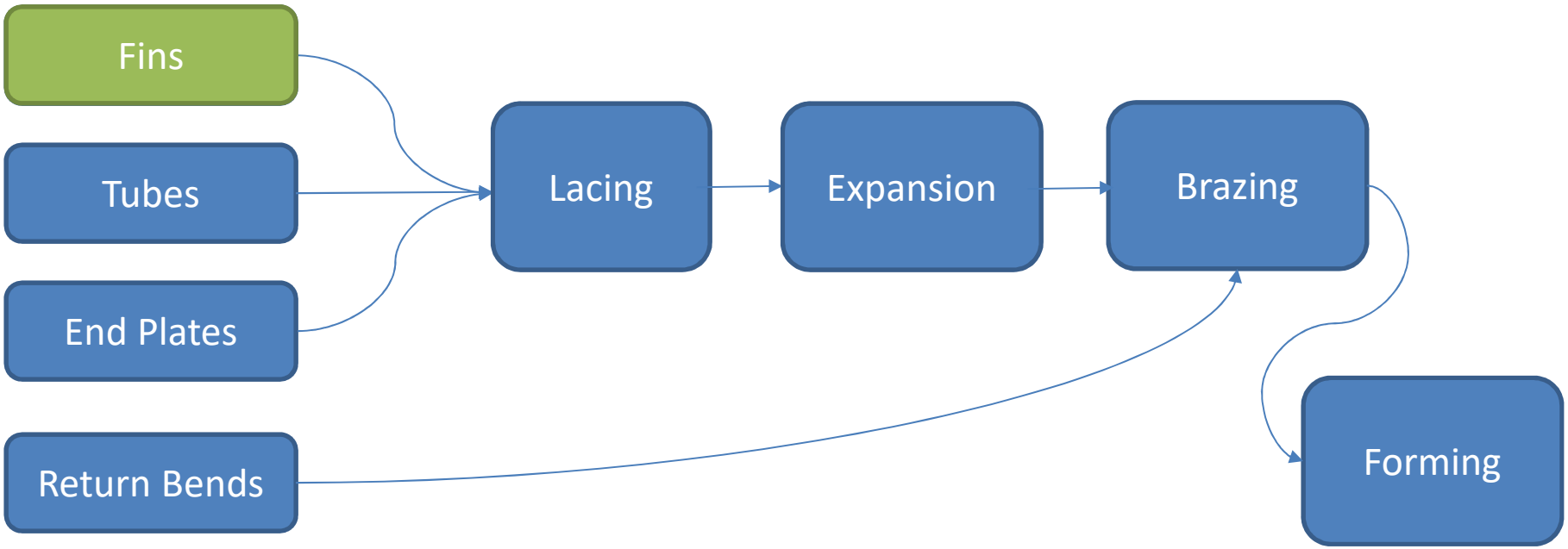




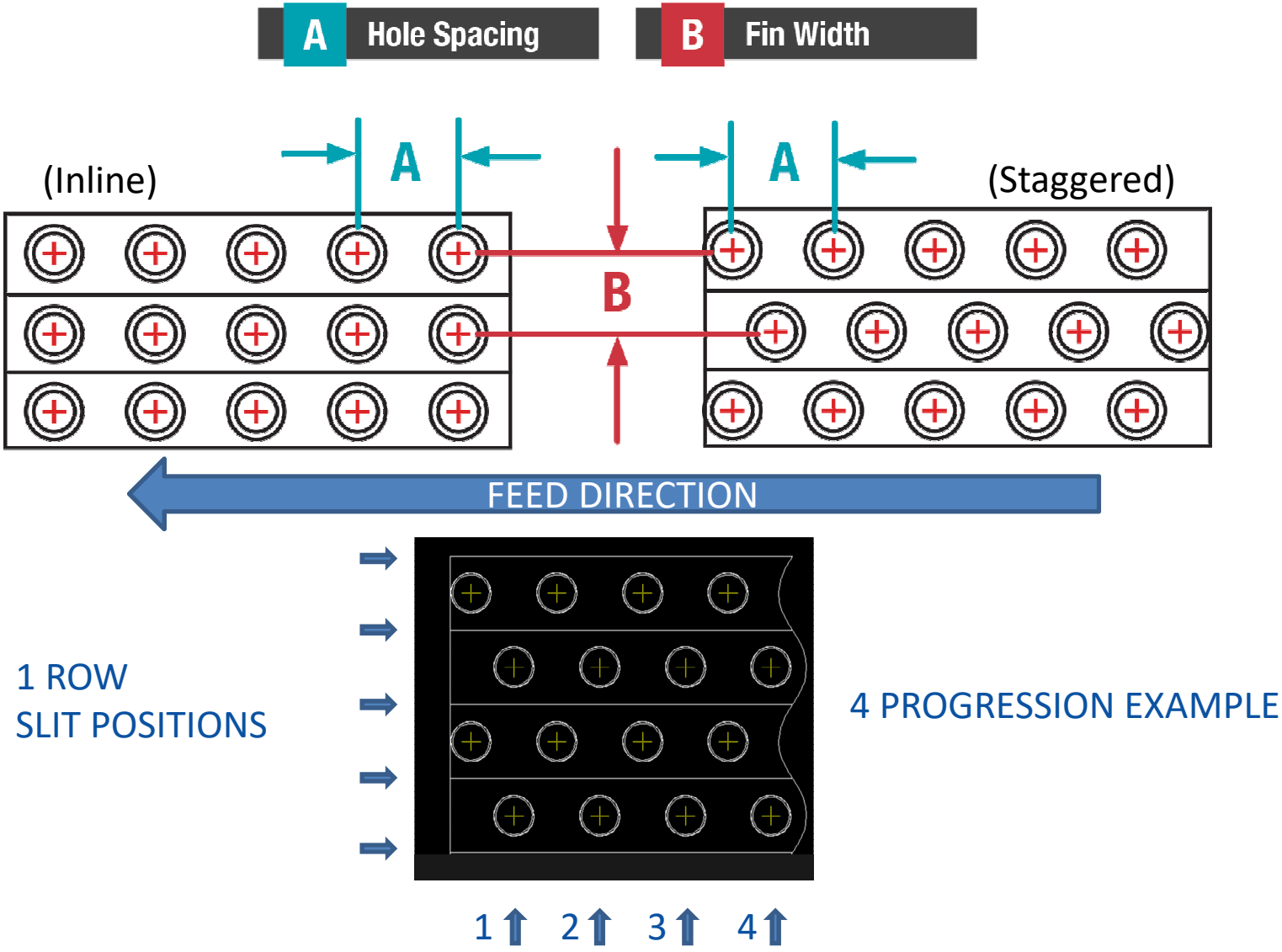
Ability to bend
multi-row coils

Coil Manufacturing

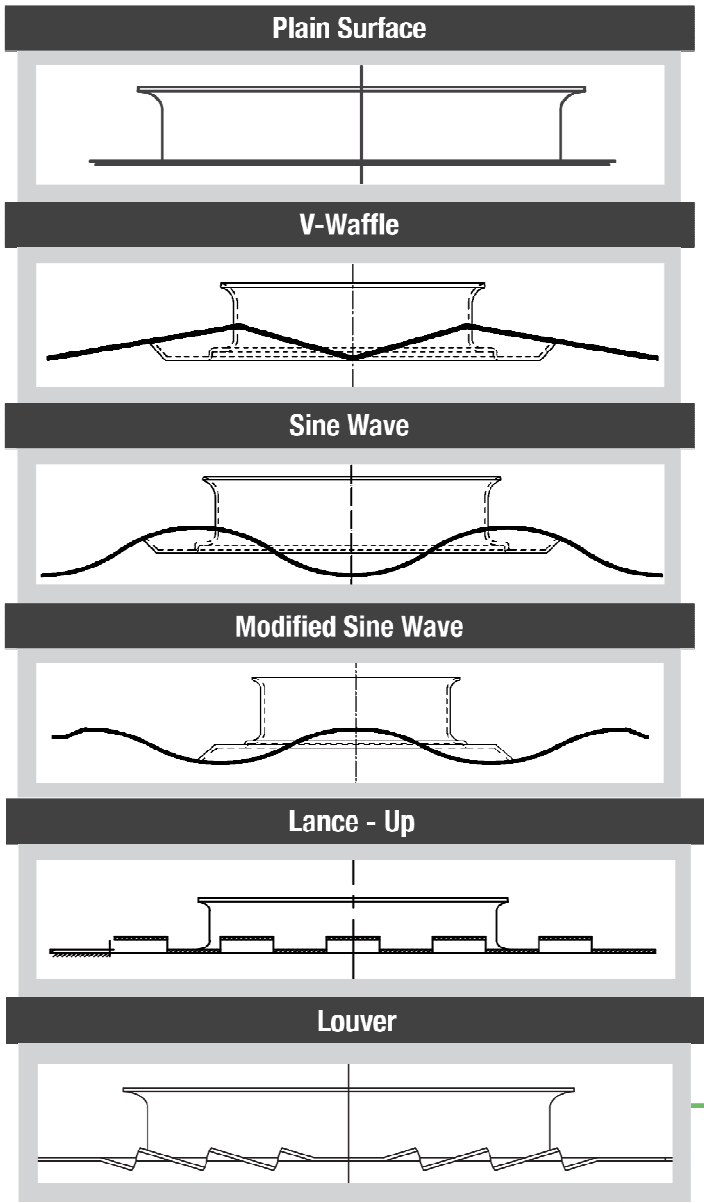
Coil Manufacturing

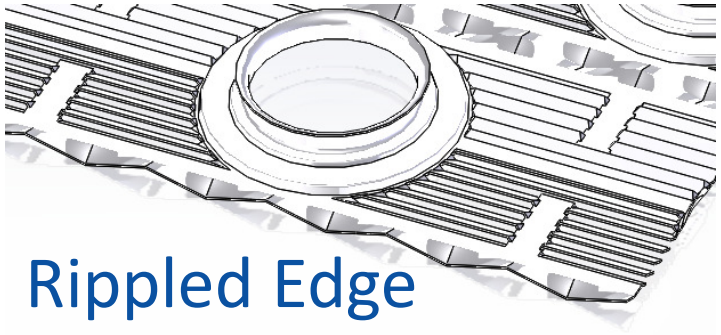


Fin Geometry

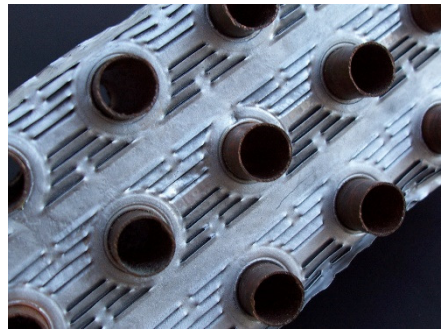


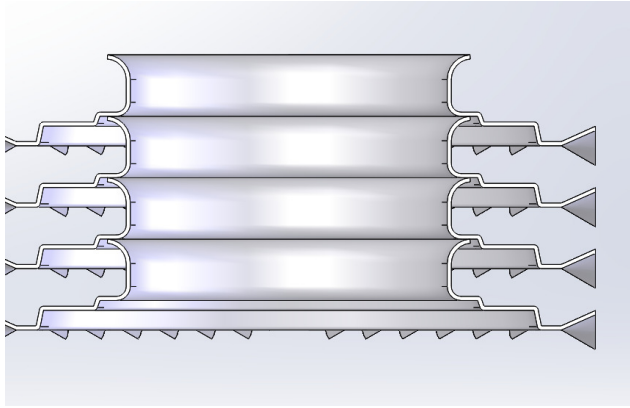
Fin Features



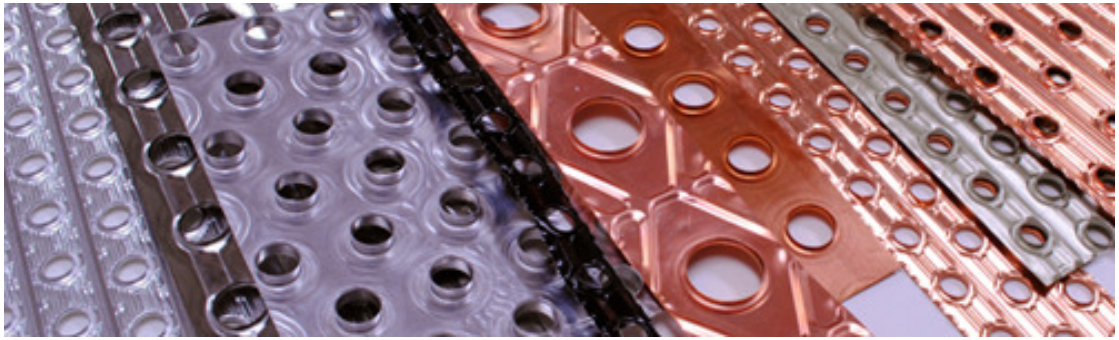


Rippled Edge





Raised
Collar Base

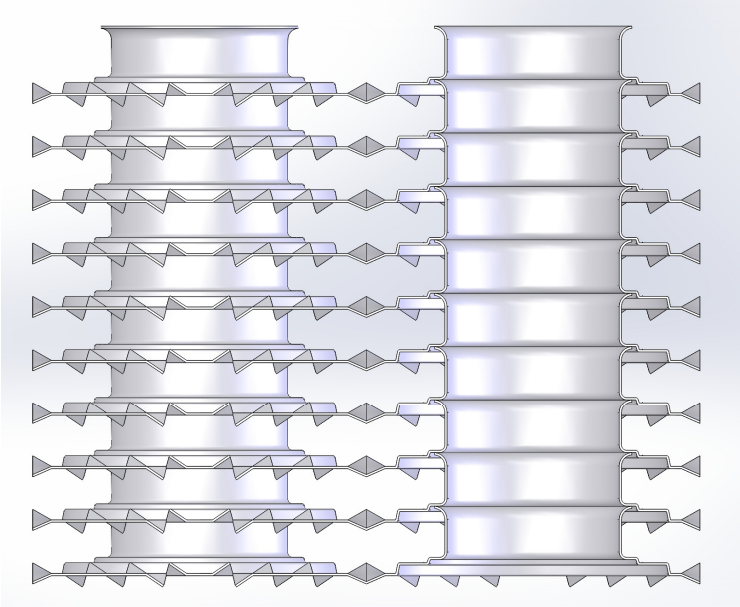


Fin Geometry

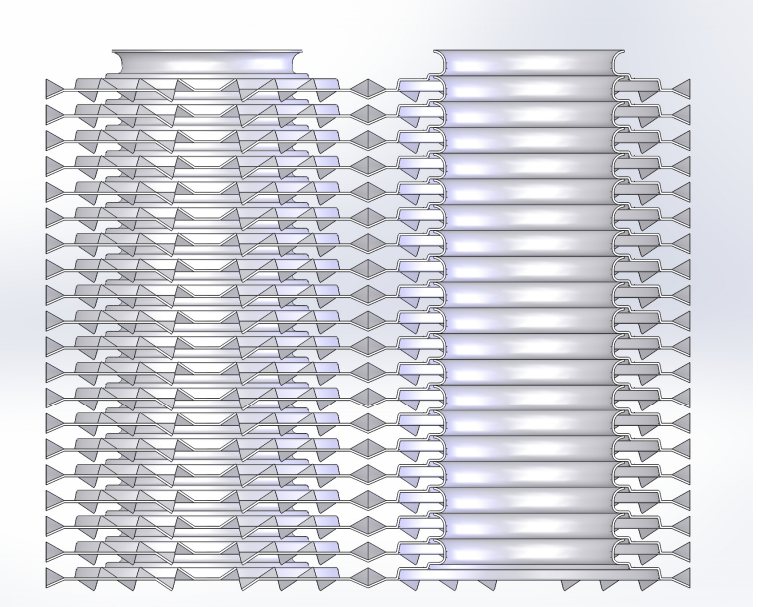
Fin Density Examples

FPI = Fins Per Inch

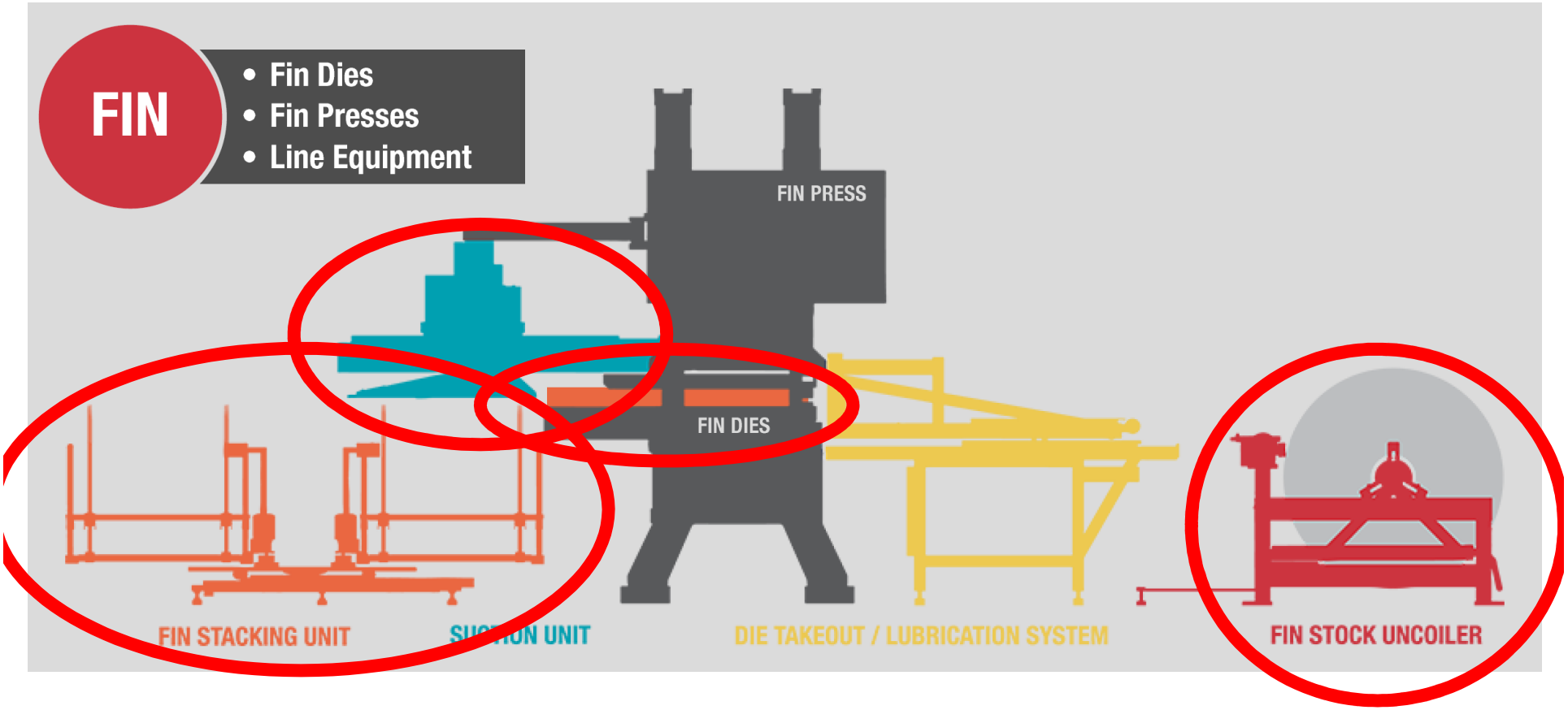
10 FPI



20 FPI

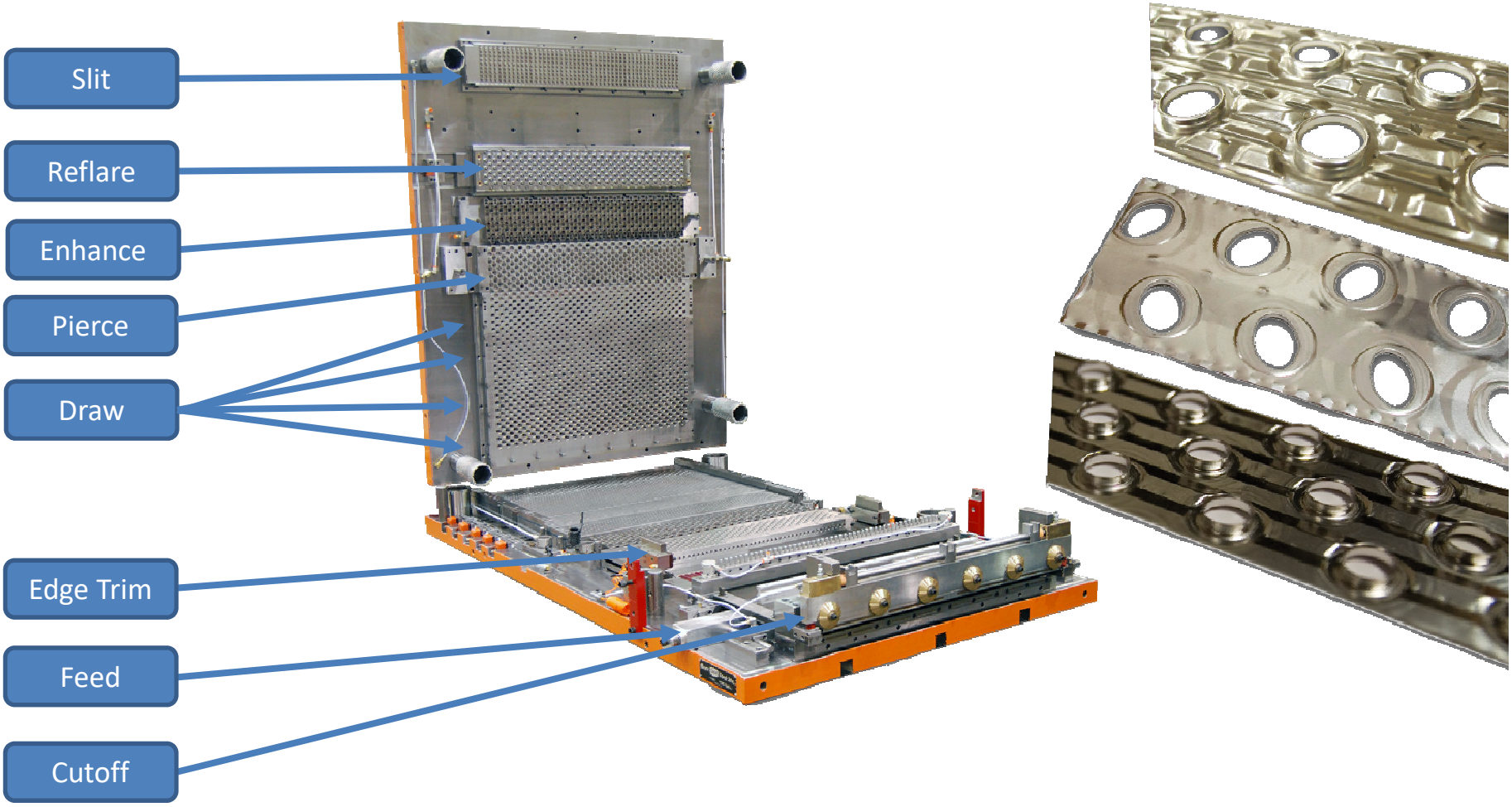


Fin Stamping



FEED DIRECTION

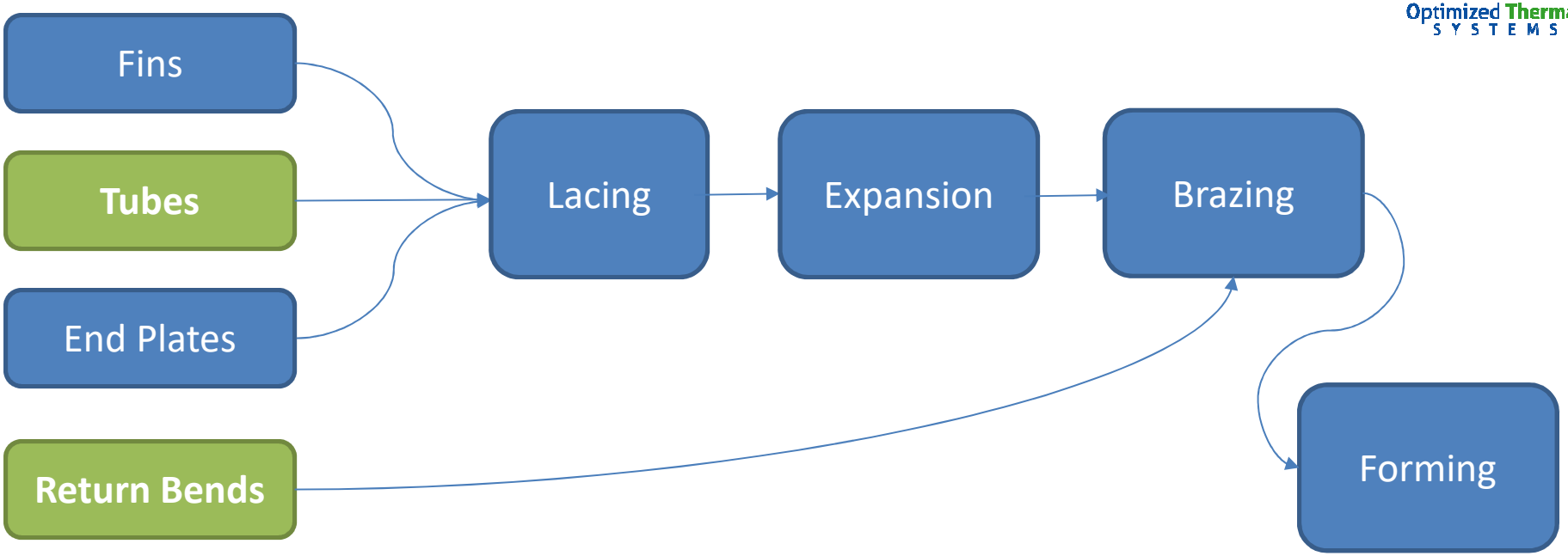
Fin Stamping



Fin Stamping & Stacking

Fin Stamping & Stacking

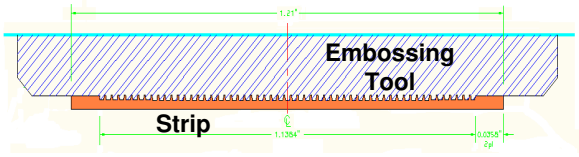
Fin Stamping & Stacking

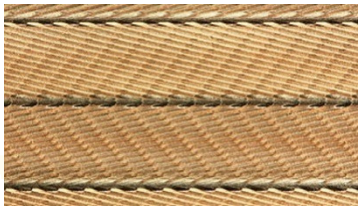


Coil Manufacturing

Tubes & Return Bends

Roll & Weld



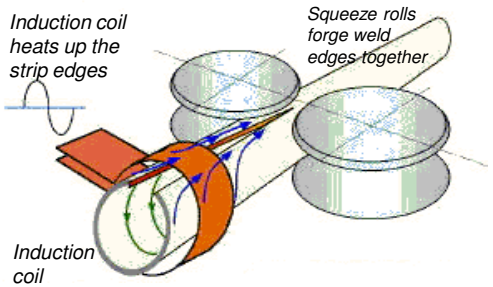


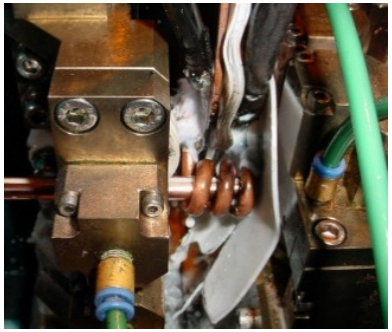
Embossing Process

- Eliminates constraints on surfaces
- Mature technology (wet and dry)
- Speed independent
- Closed loop control of Key Variables

GTAW Process

- Gas tungsten arc welding
- In-line induction annealer
- Eddy Current Testing
- In line finish packaging





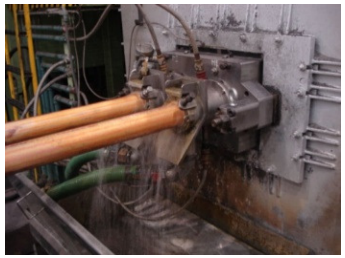
High Frequency Process

- Precision control of weld parameters
- Forged / resistance weld
- Reduction to small diameters
- High Speed Production
- Close tolerances held

Information Provided by LUVATA

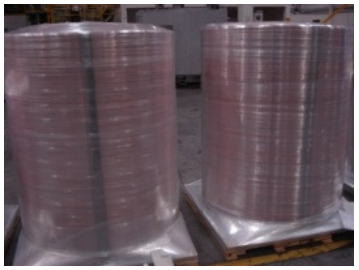
Cast & Roll

Utilizes high rotary forces and dynamic recrystallization to generate large reductions and a fine grain structure



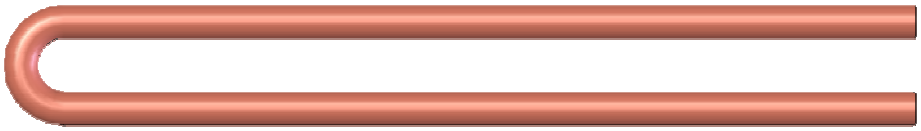
Traditional drawing to small diameters and light wall thickness

Rotary swaging process forms helical enhancements

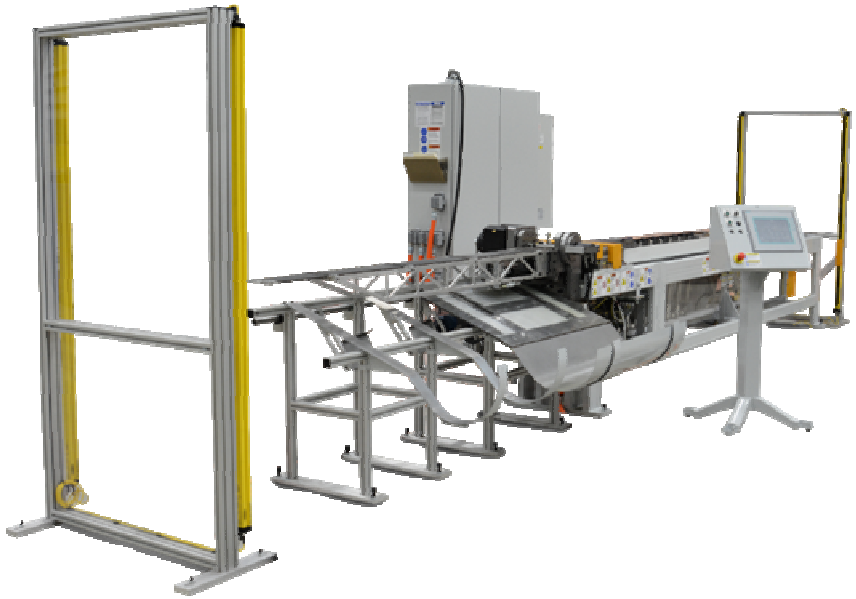


Information Provided by Wieland

Tube Processing



Vertical Bend Hairpin Bender



Straight Tube Cut Off Machine

Return Bend Process

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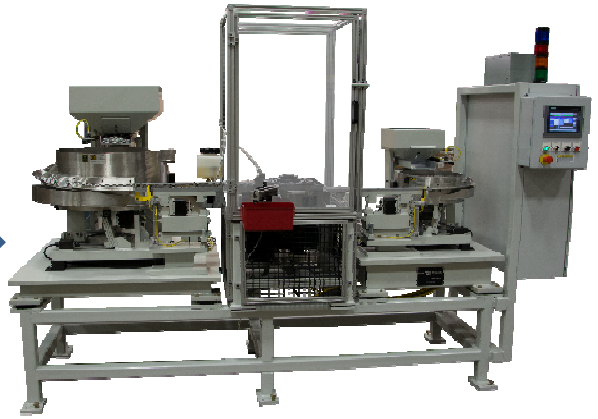
Bender

Bend & Cut

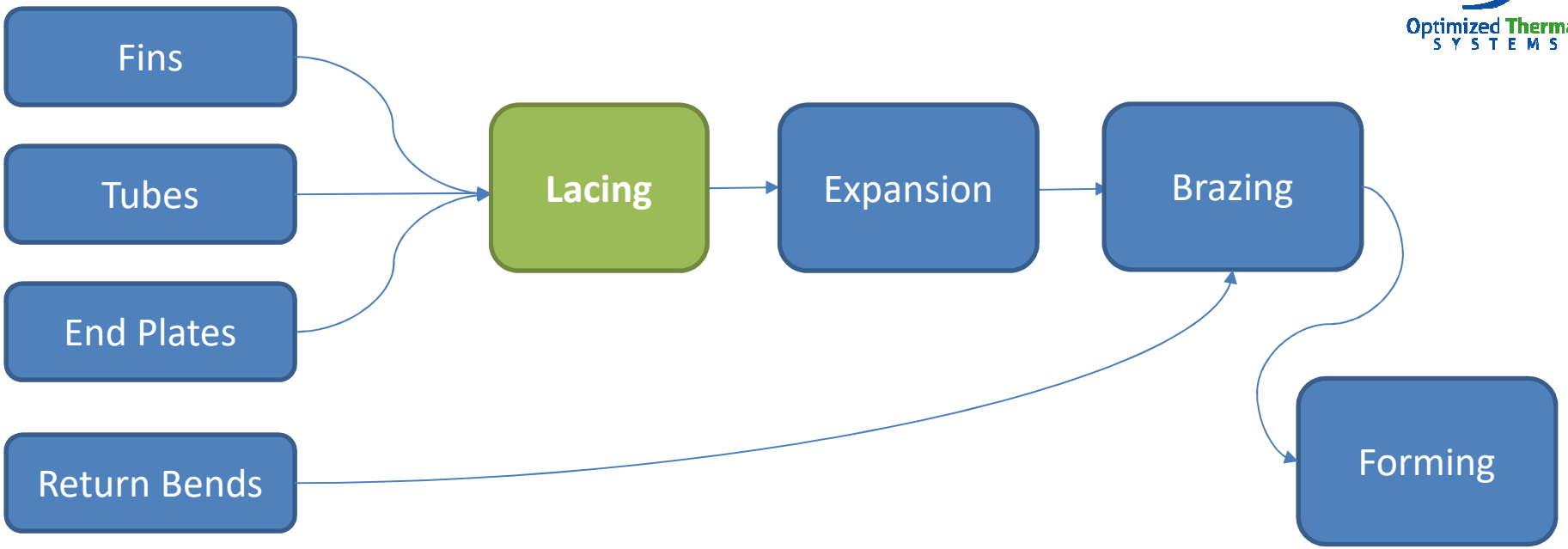
Cleaning Unit

Clean

Size and Ring Machine



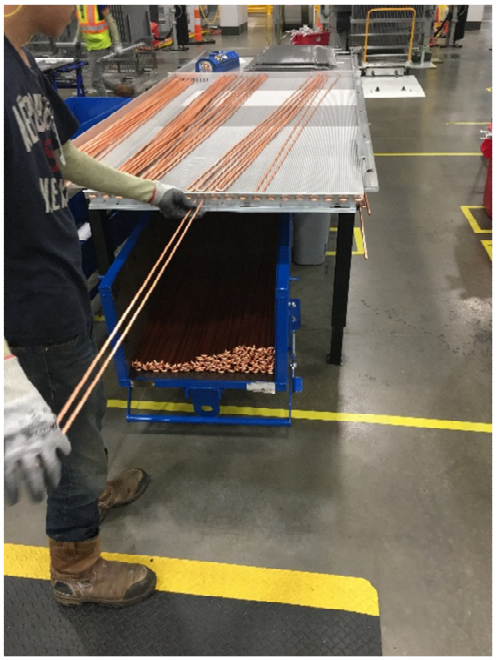
Size & Ring

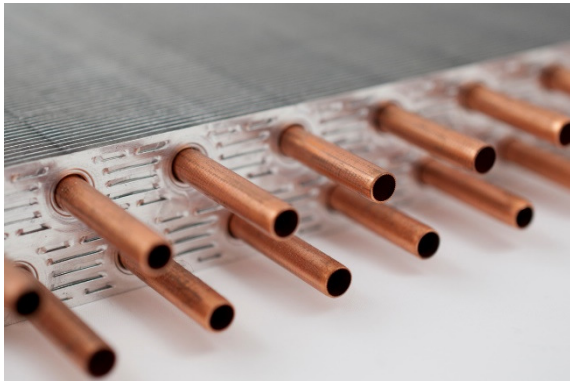


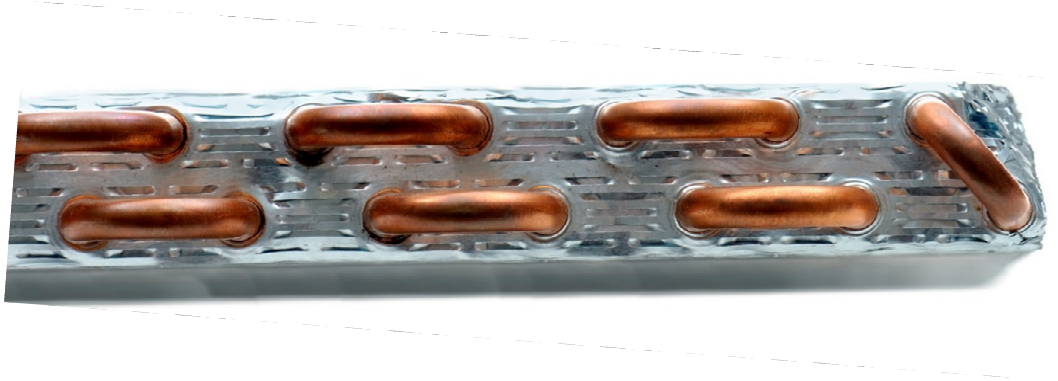
Coil Manufacturing

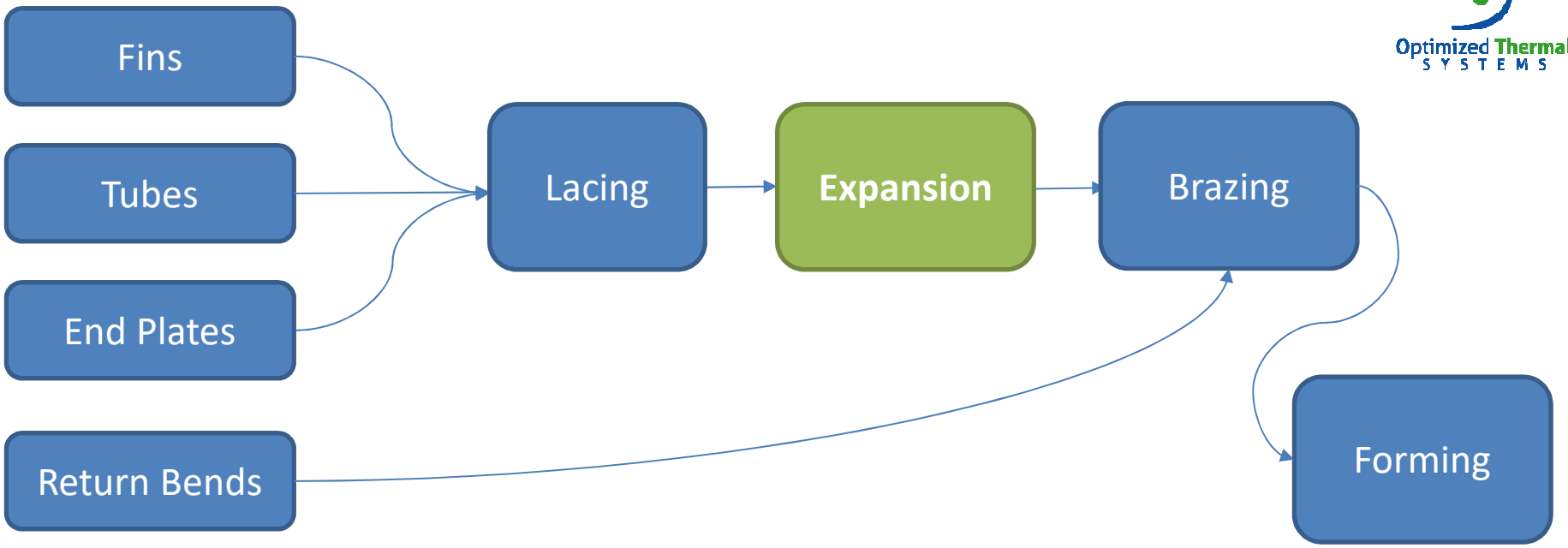
Lacing

Lacing









Coil Manufacturing

Expansion

Expansion

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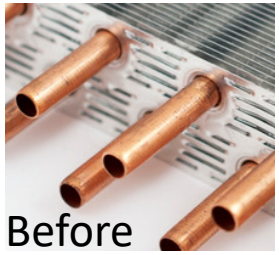
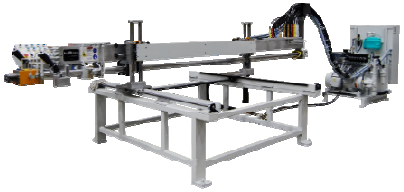
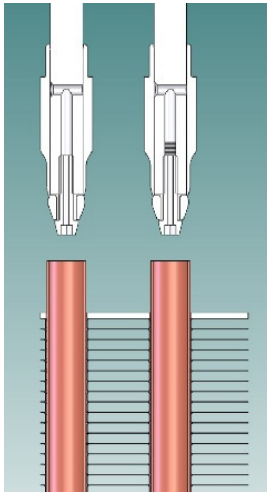
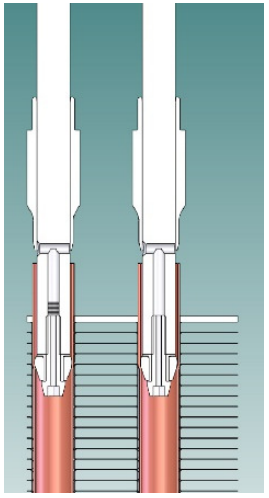
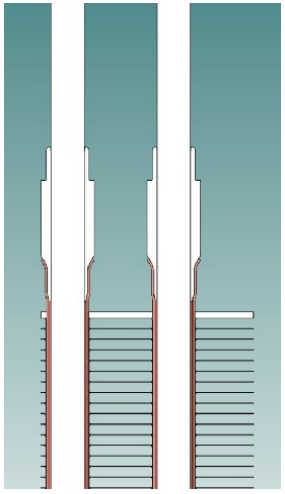
Create a rigid coil from loose raw material

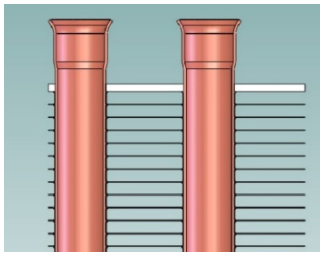


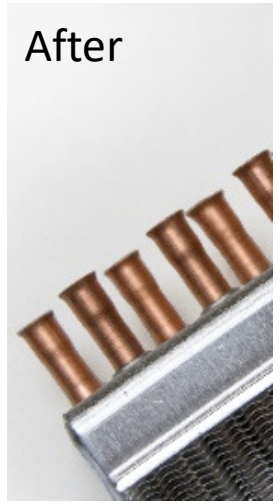






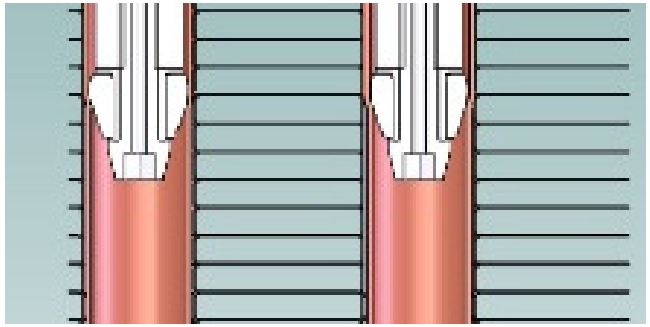


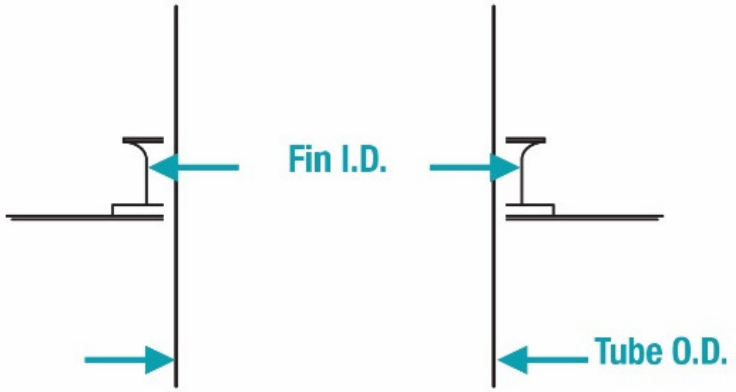


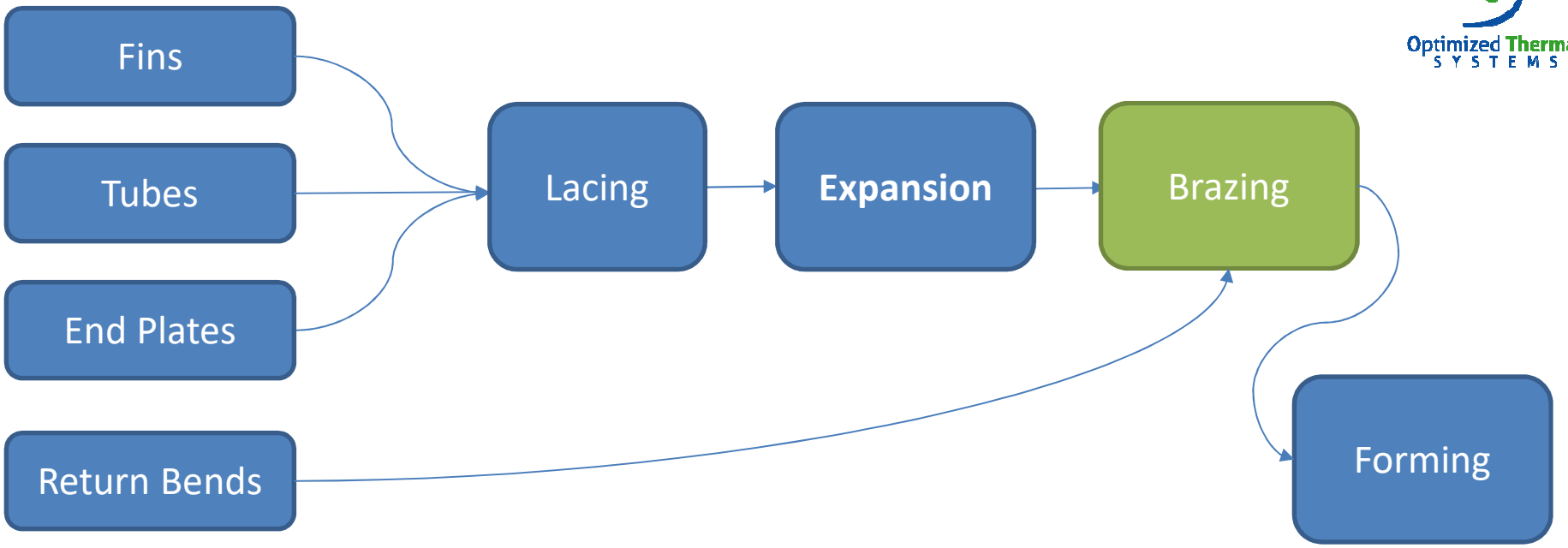


Expansion

- Establishes the contact between tube and fin to conduct heat
- Interference =
  Expanded Tube OD – Fin Collar ID
- Min interference must be maintained to account for thermal expansion of dissimilar materials
- Industry standard - .004”
- Material & Tooling Tolerance Factors *(Mechanical Expansion Only)*
  - Min Developed Interference - .0005”
  - Max Developed Interference - .0075”



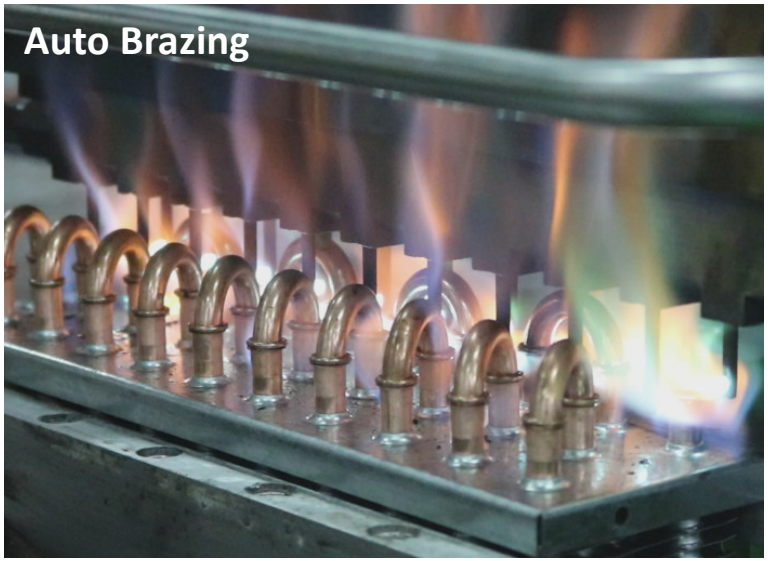


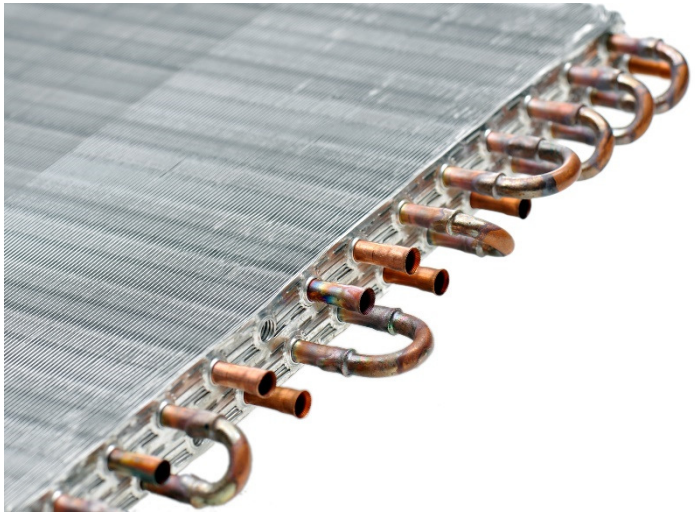


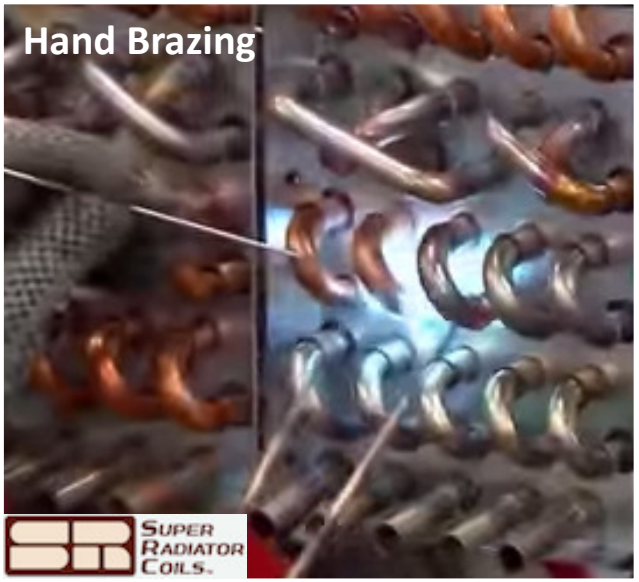
Coil Manufacturing

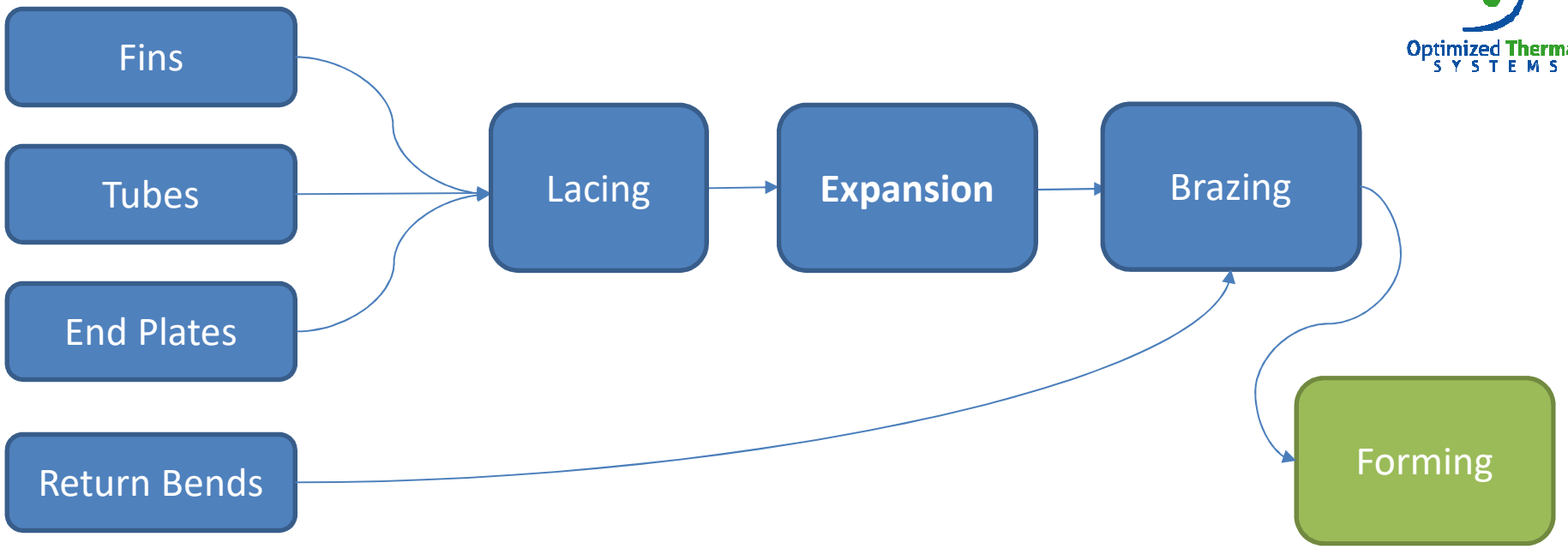
Brazing

Brazing







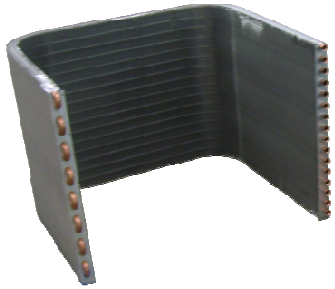


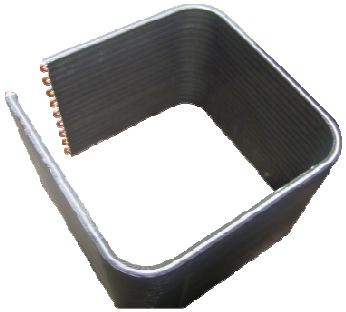
Coil Manufacturing

Forming

Forming

- Forms expanded coil into shapes for installation into unit (i.e. “L”, “U”, “D”)
- Single or multi-row composite capability
- Forming parallel or perpendicular to tubes



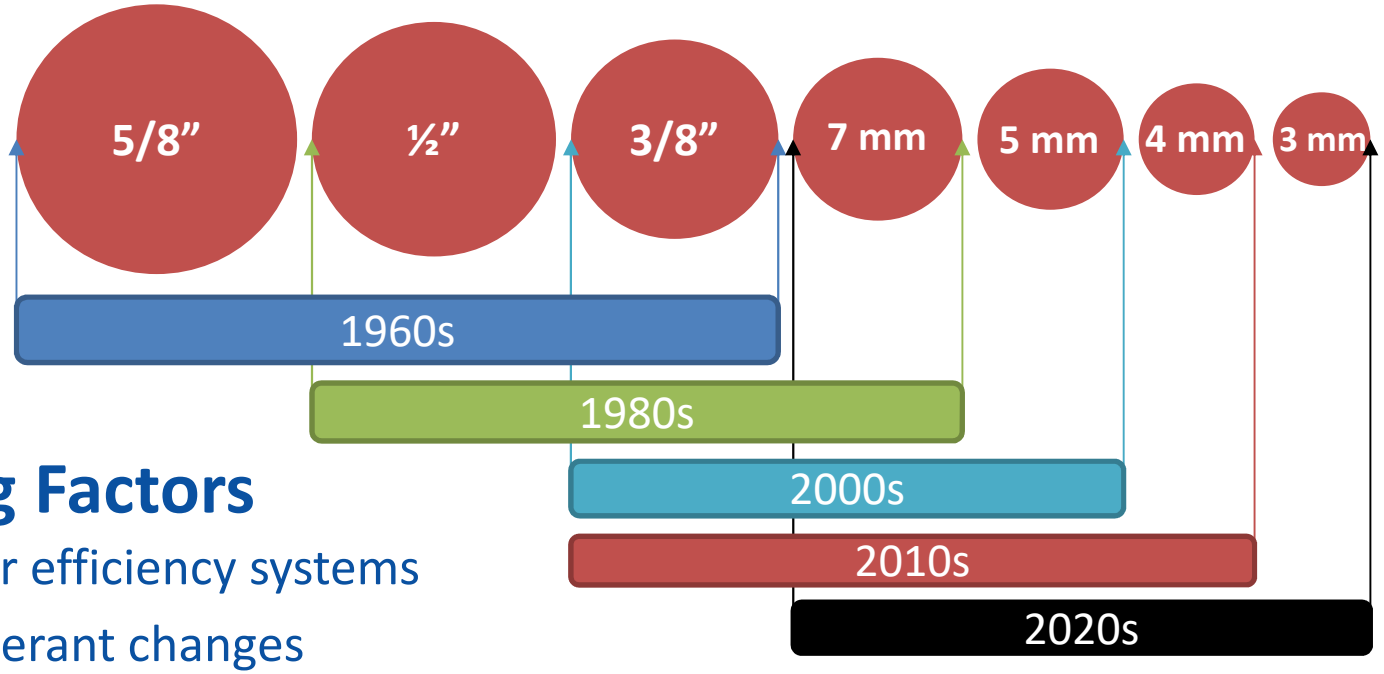


Historical Trends

Historical Trends

Areas of Change

- Pattern & Tube Geometry
  - Smaller Tube Diameter → Denser Tube Patterns
  - Reduction in Tube Wall Thickness
- Fin Design & Material
  - Reduction in Fin Thickness
  - Alternate Fin Alloys



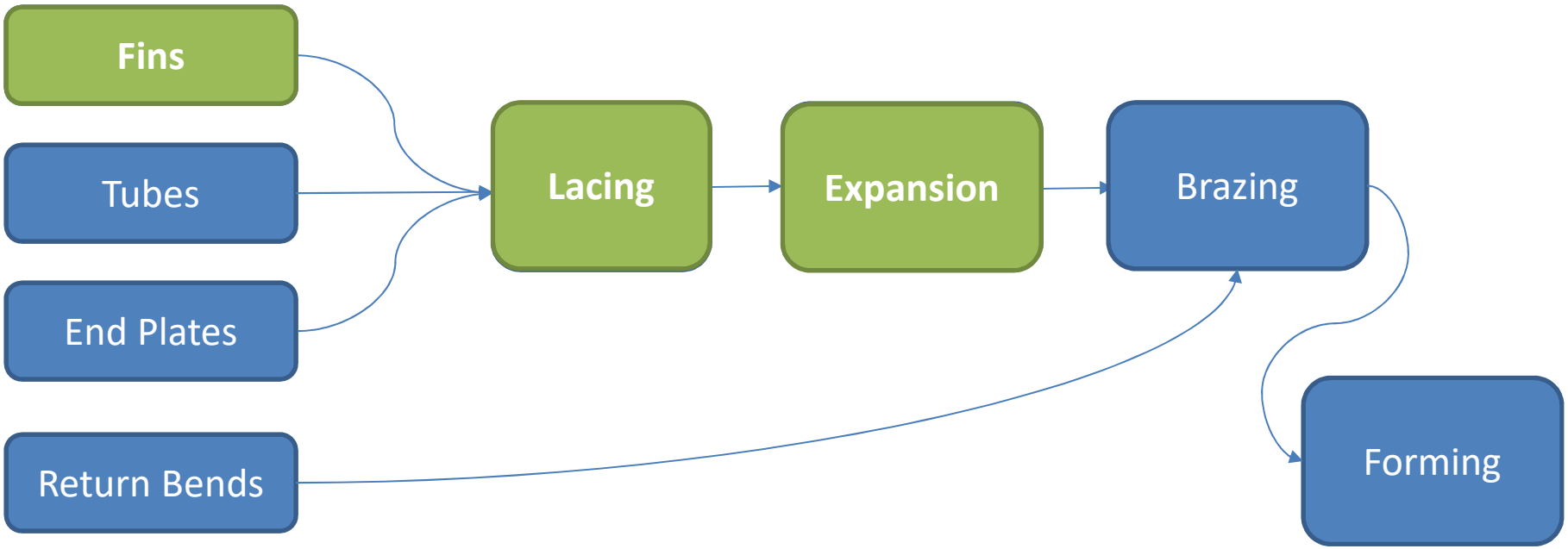
Driving Factors

- Higher efficiency systems
- Refrigerant changes
- Material & Labor Costs

Manufacturing Considerations

For Small Diameter Coils

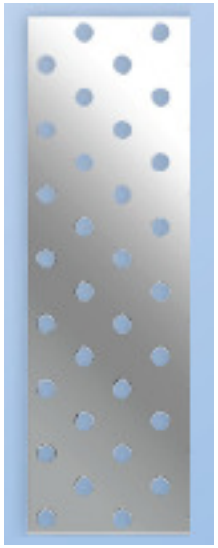
Considerations With Small Diameter Coils



Fin Production Considerations

- Smaller, denser fin patterns
- Fin stacking

3/8”



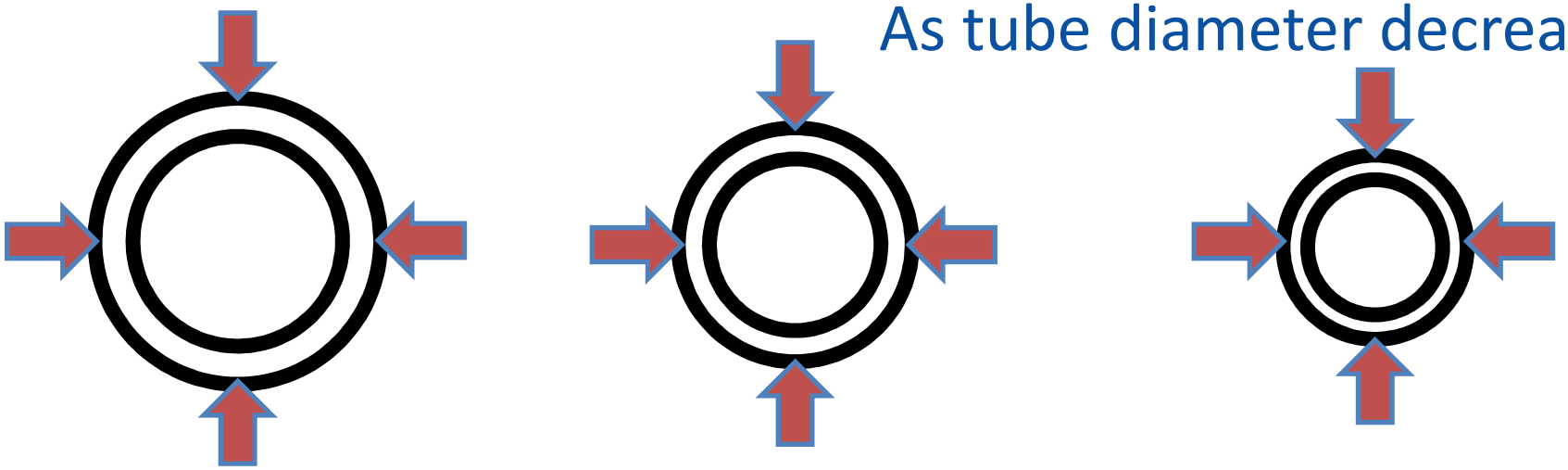
5mm

Lacing Considerations

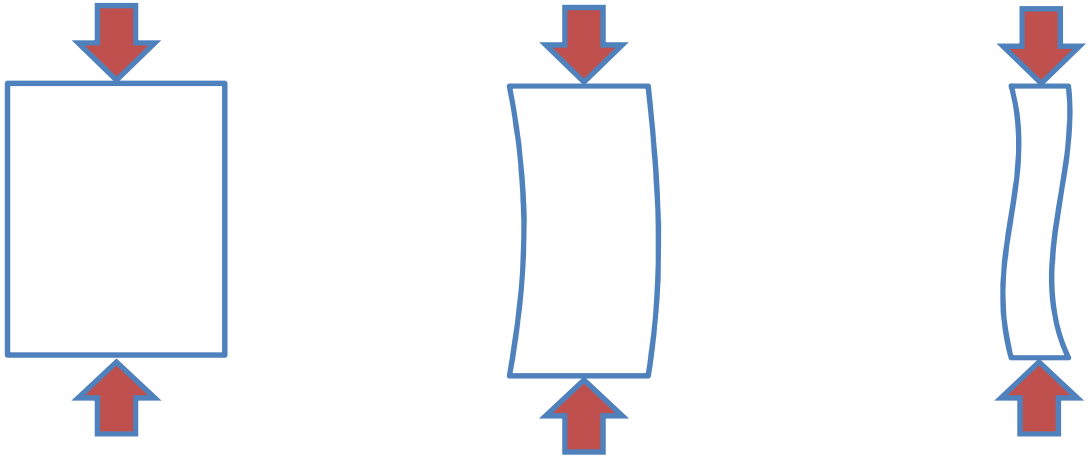
- More tubes, more time for manual labor
  - Raw material saving easily outweigh labor costs
- Challenges in inserting tubes – potential buckling/sagging

Expansion Considerations

As tube diameter decreases

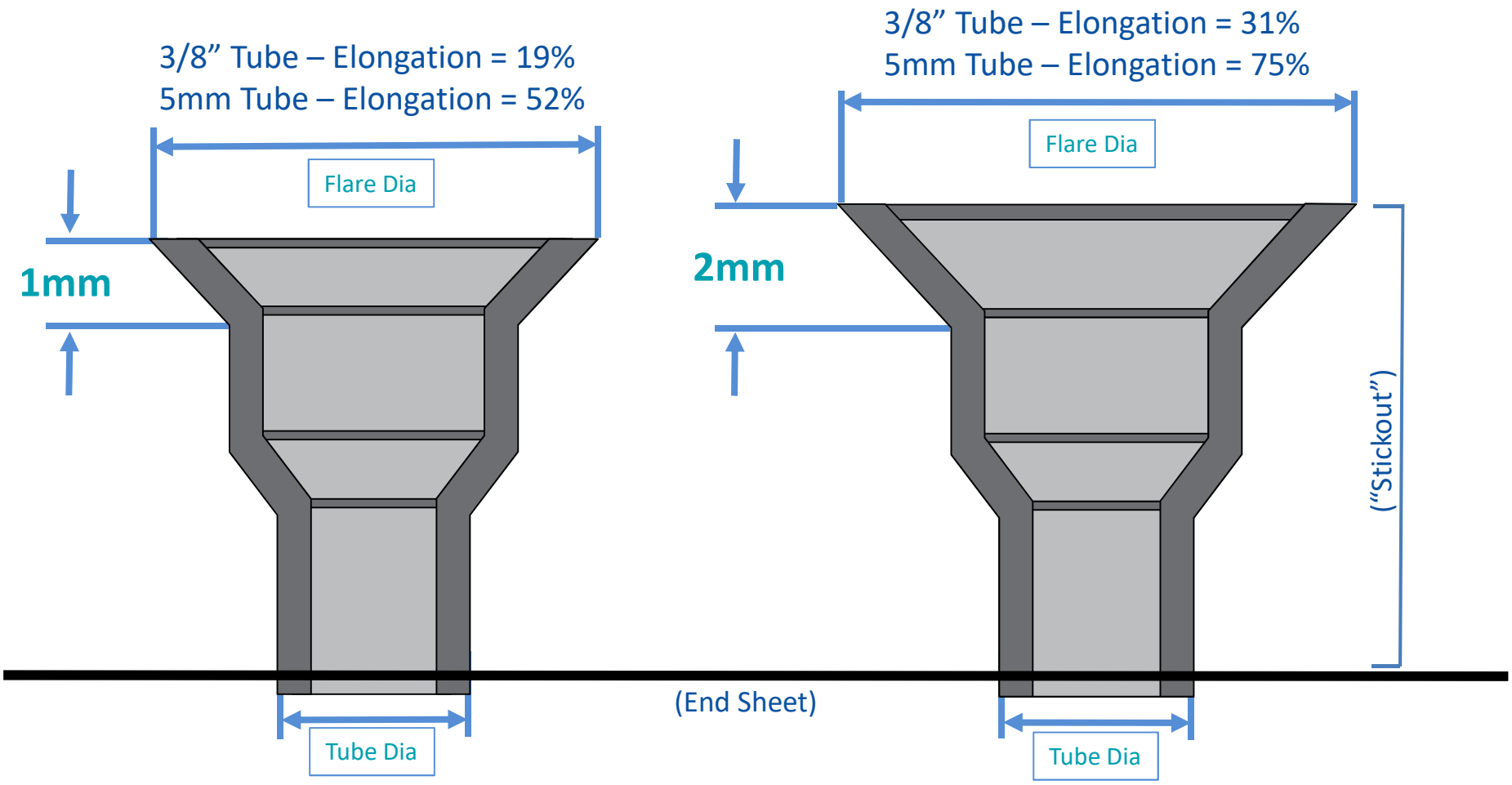


the tube's **hoop strength** increases to resist the expansion force of the bullet



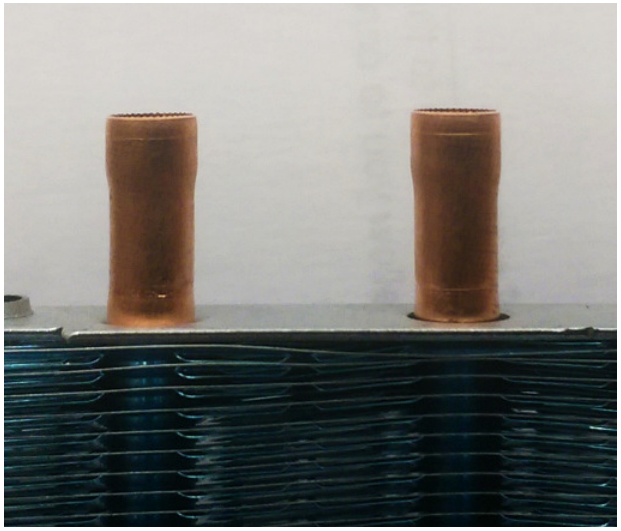
And the tube's **column strength** decreases to resist buckling of the tube

Bell and Flare Considerations

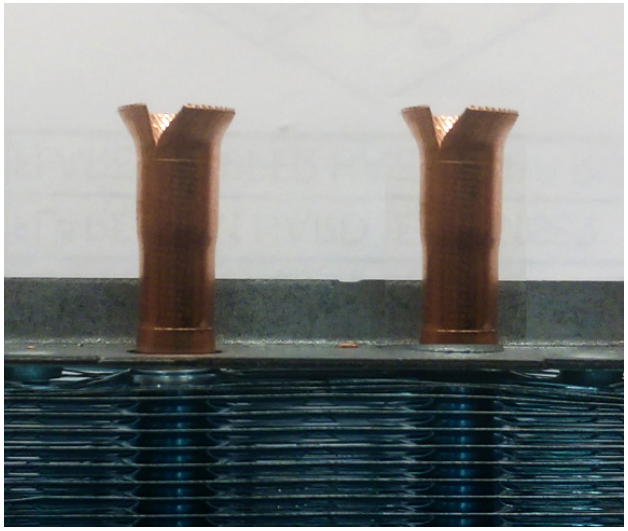


Bell and Flare Considerations, Cont'd.

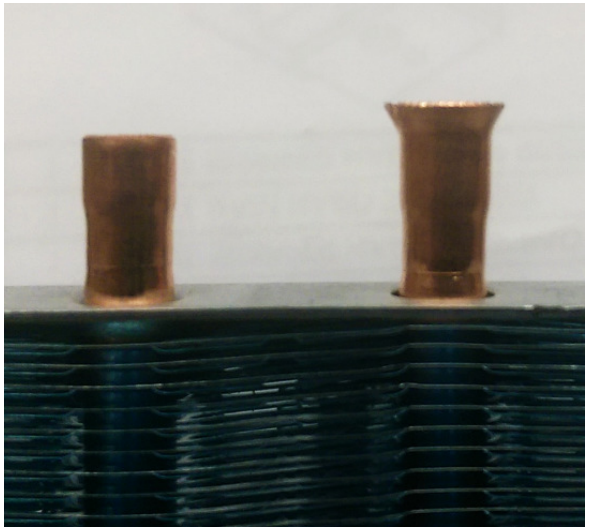
Too Short = No Flare



Too Long = Splits



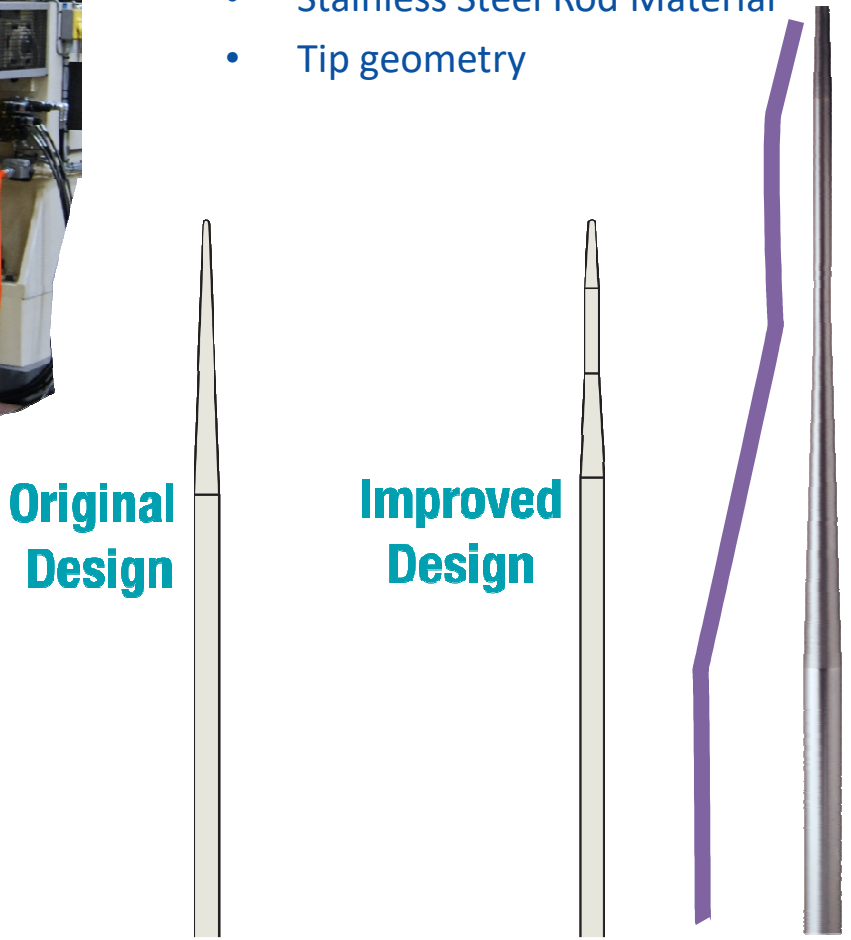
Peg Leg = Splits & No Flare



Manufacturing Solutions

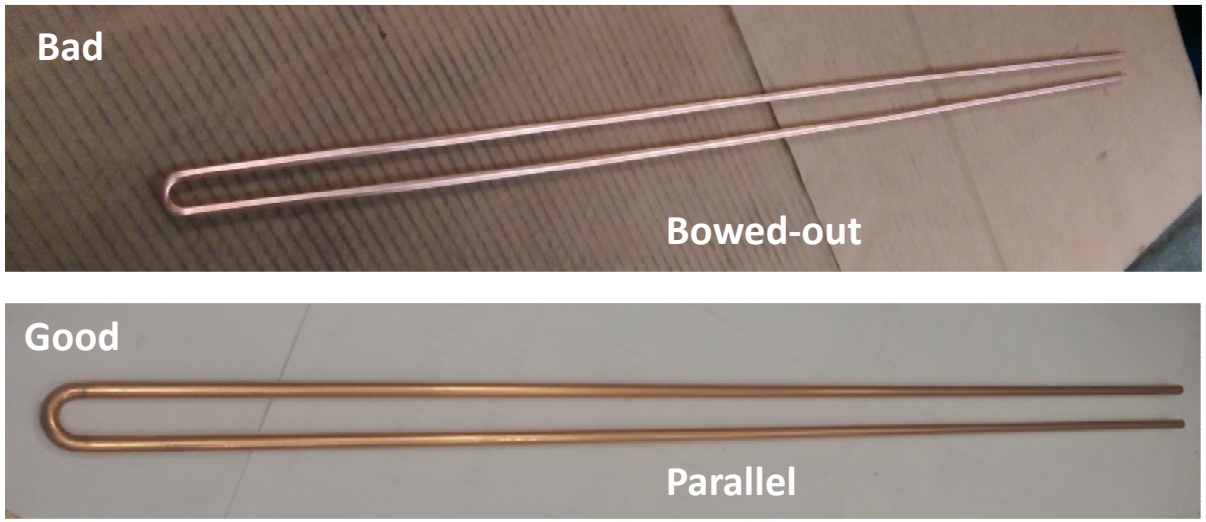
Fin Handling – Stacking Improvements

- Heavy-Duty Stacking Unit
- Improved Stacker Rods
  - Stainless Steel Rod Material
  - Tip geometry



Lacing Solutions

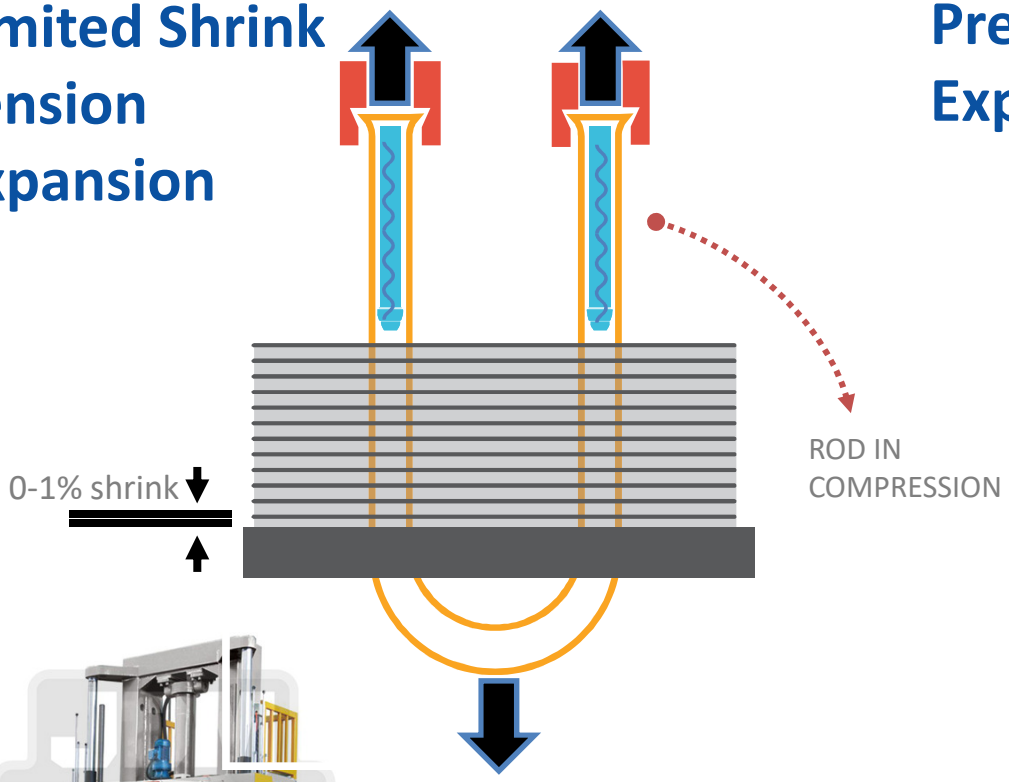
- Operator Training
- Better Hairpins



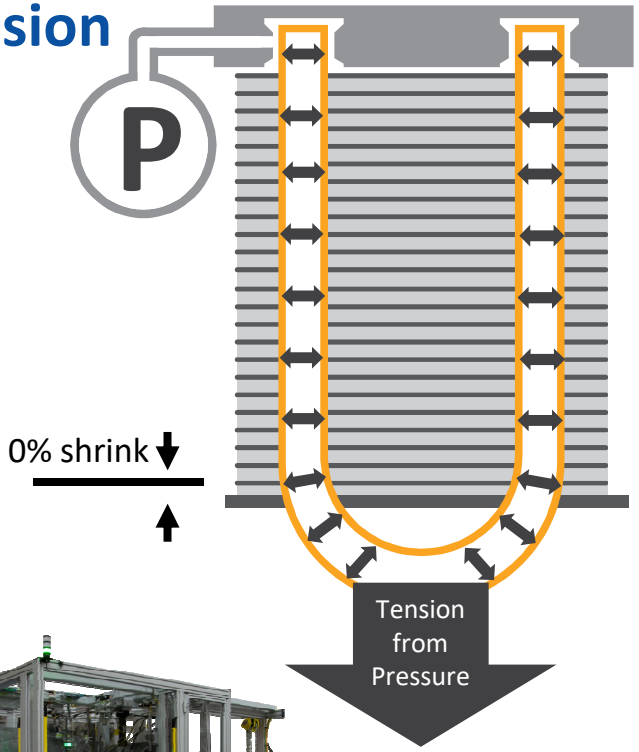
- Automation
  - Tube insertion
  - Laced coil transfer to expander

Expansion Solutions

Limited Shrink Tension Expansion

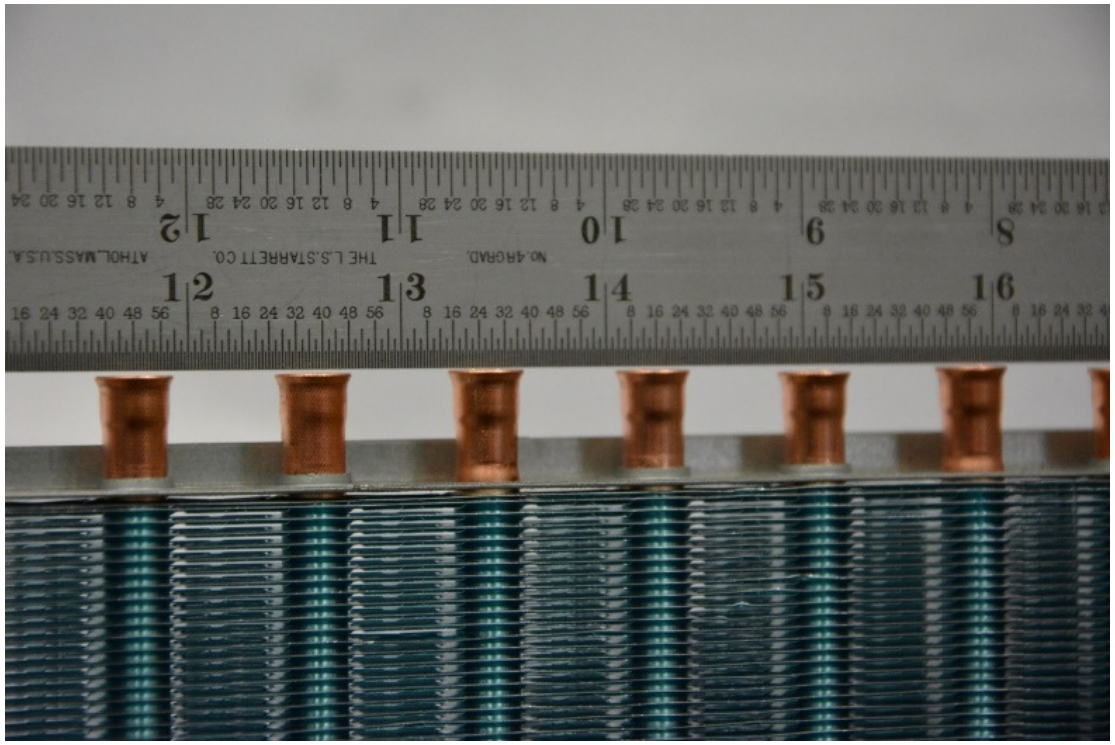


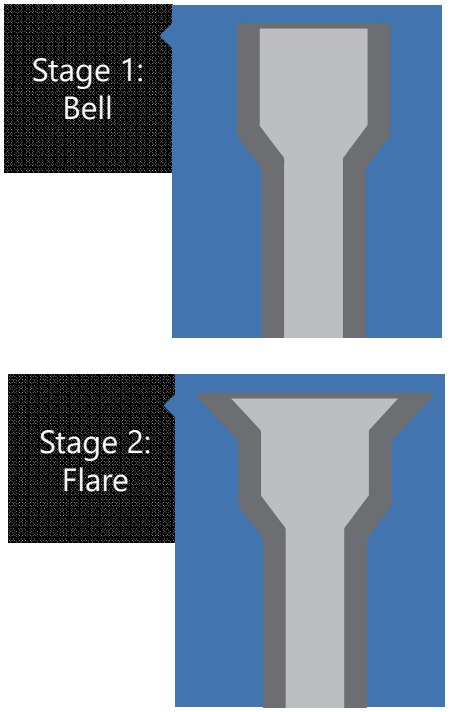
Pressure Expansion



Bell and Flare Solutions

- 2-Stage Bell and Flare
  - Peg Leg Control
  - Precise Bell & Flare dimension
  - No Splits in Bell & Flare

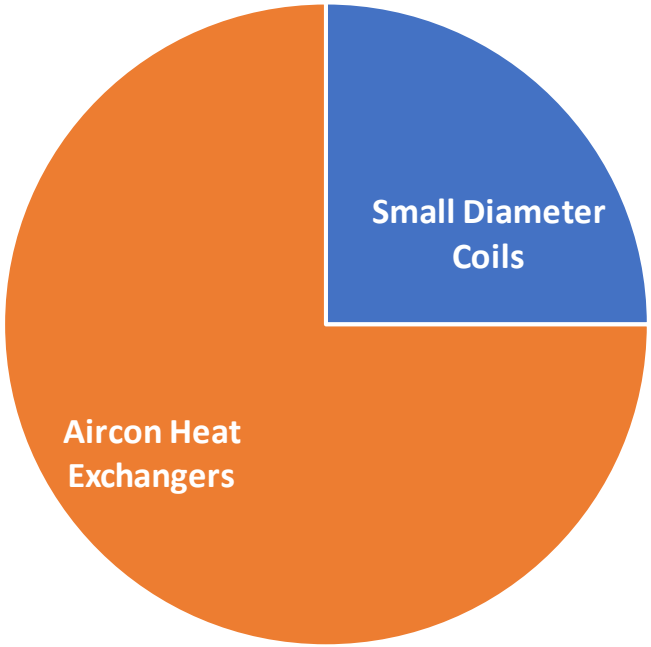




The Effects of Using Small Diameter Tubes

- Higher hoop strength
  - Withstand higher operating pressures
  - Need for alternate expansion method
- Reduced wall thickness
  - Reduce material consumption – cost savings!
  - Reduced column strength – need for controlled lacing and expansion
- Greater fin complexity
  - Both design and density
  - Improved stacking processes

Market Potential



- 134 million Aircon units made in 2011
- 268 million RTPF HXs ➔ 8 HXs / second!
- 25% use small diameter copper tube HXs ➔ 2 HXs / second!

Millions of small diameter coils are produced each year across the world.

It's EASY – with the RIGHT tools and procedures!

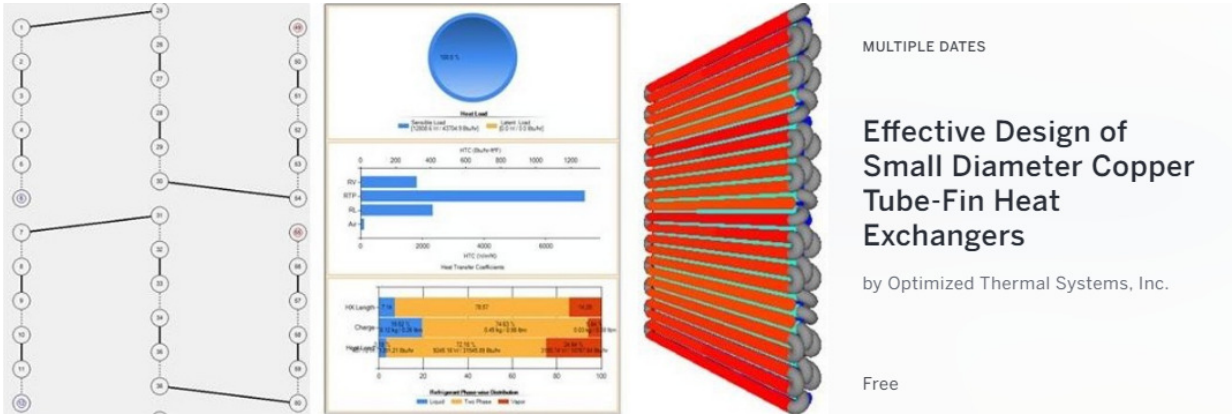
BSRIA "55586 Report – Interrelation/future trends in use of copper for air conditioning," May 2012

Coming Next

Webinar #03

When:

Wednesday, May 24, 2017
Morning Session: 8:00AM EST
Afternoon Session: 4:00PM EST



Registration: http://www.microgroove.net/ots-ica-educational-outreach

THANK YOU!

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