How does your Fin Shape Up?

Presented by Bob Carlo

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How does your Fin Shape Up?

Hi, I'm Bob Carlo from Voss Mfg in Sanborn NY. for those who don't know me, here's a quick summary

- ❑ I've been with Voss Mfg. for over 30 years now
- ❑ I'm a Tool Maker by trade specializing in Tooling and Equipment used in the Heat Transfer Industry
- ❑ I'm the Sales manager at Voss Mfg.. My group handles the sales and service of the Heat Exchanger Equipment and tooling along with general fabricating and machining services for local companies in the Western New York area

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How does your Fin Shape Up?

- We have a 100 man machine shop with machining, fabricating, grinding, electrical and controls programming capabilities, making us a full service shop. This aids in building our machinery and tooling used to manufacture heat exchanger fins
- I’m a Patent holder of two inventions, Special Pin Tooling for our RF-220 line of machines which manufacture the serpentine shape fins, and some LPD tooling to produce lance offset turbulators in the low flow direction

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How does your Fin Shape Up?

- I currently have machinery in over 40 different countries around the world, and have traveled to over 30 countries to see this equipment in action
- My hobbies are Sailing, Photography and Wood Working and always willing to talk about them.

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How does your Fin Shape Up?

- This is my first time speaking publicly about Heat Exchanger Fins and the Tooling related to manufacturing these fins. I’m hoping it will be informative and we all get something out of the information I share.
- It’s meant to be general information, but information you might not know or realize how it relates to heat exchangers. If you take one little tid bit out of this presentation, I’ll be happy.

How does your Fin Shape Up?

- I apologize in advance as I tend to talk fast. I'm very passionate about our field in heat exchanger fins and tend to talk fast about them because there is so much to know and learn about.

How’s Your Fin Shape Up?

- I’d like to talk about how the Shape of your Fins plays a critical role in the performance and endurance of the Heat Exchanger

- We’ll talk about 2 basic fins today, and to keep the terminology consistent, we’ll use these definitions

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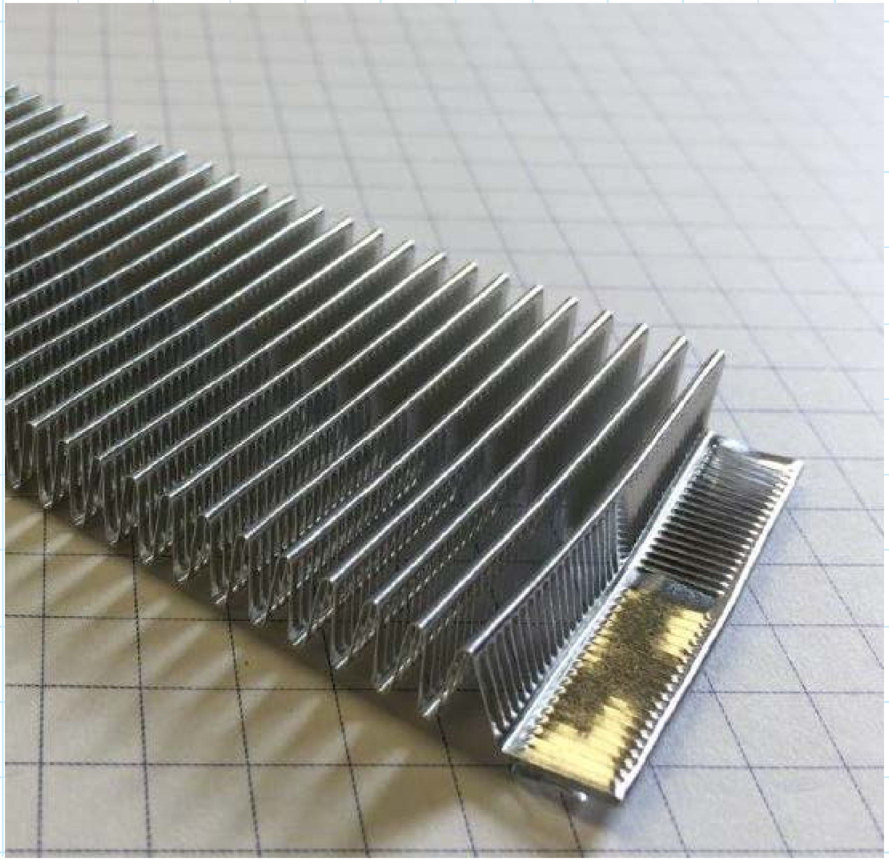
How’s Your Fin Shape Up?

- Serpentine Fins –



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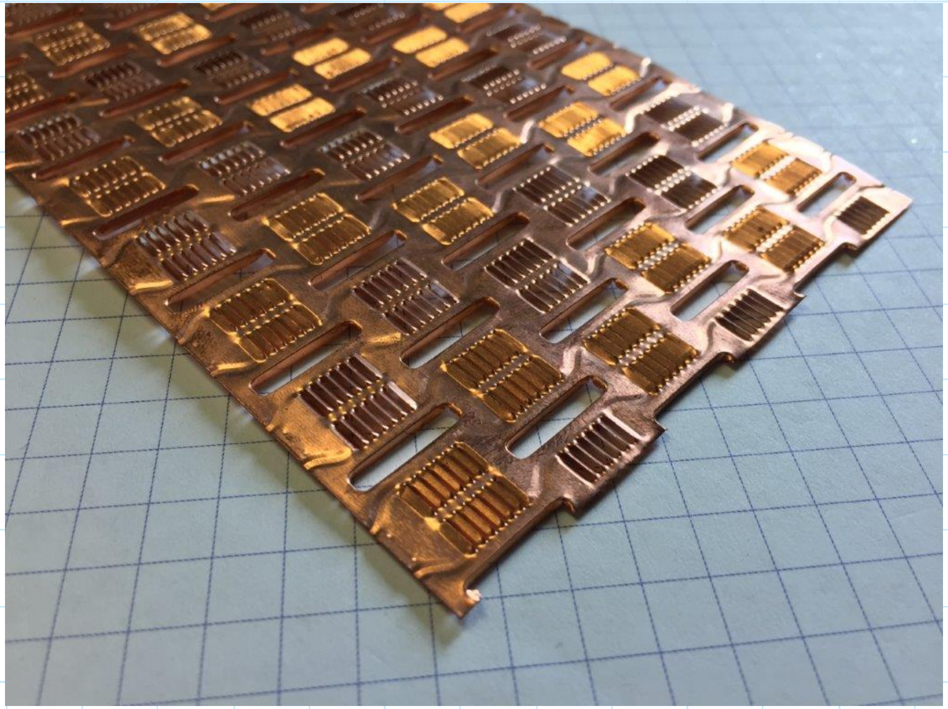
How’s Your Fin Shape Up?

- Flat Fins –



Features we'll be looking at:

- Tube to Fin Bond – important for performance. This is a critical area related to where the fin and tube are connected
- Fin Geometry - related to strength, structure and performance of the fin
- Assembly – how the geometry plays an important role in assembling your cores, What helps and what hurts? What helps in some areas and hurts in others

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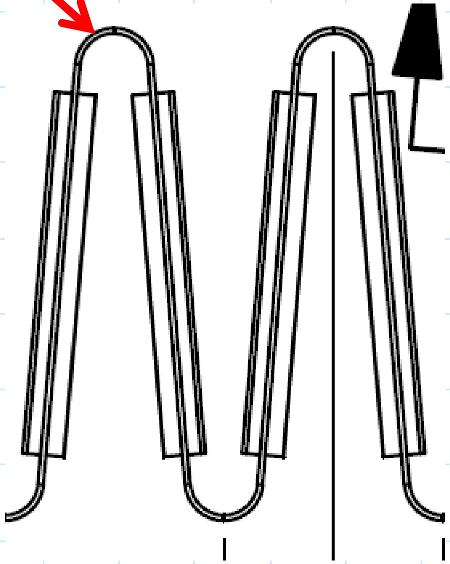
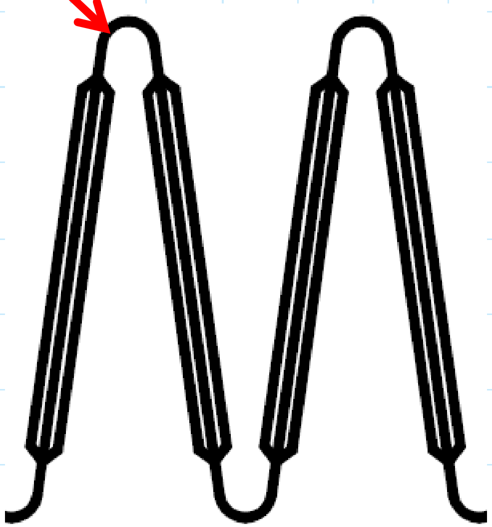
Serpentine Fins
Large vs Small Tip Radius

Large Tip Radius



Small Tip Radius



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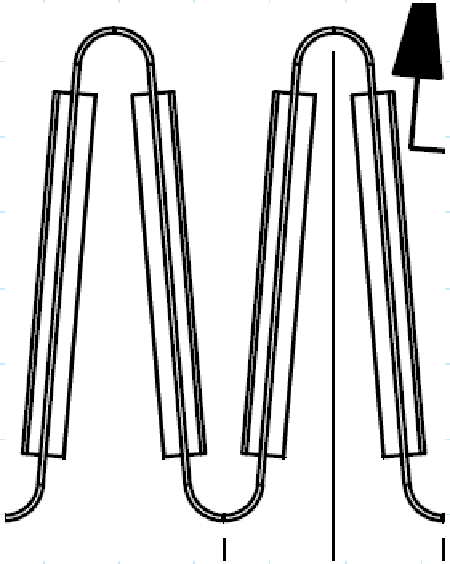
Large Tip Radius

- At first glance a Large Tip Radius seems to be very good for a couple reasons.
  - Large Tube to Fin Bonding area
  - Large Radius will compress slightly during assembly acting like a spring during core compression keeping everything tight
  - Larger opening at the tip for air to flow through
  - Straighter Legs to give more of a parallel opening



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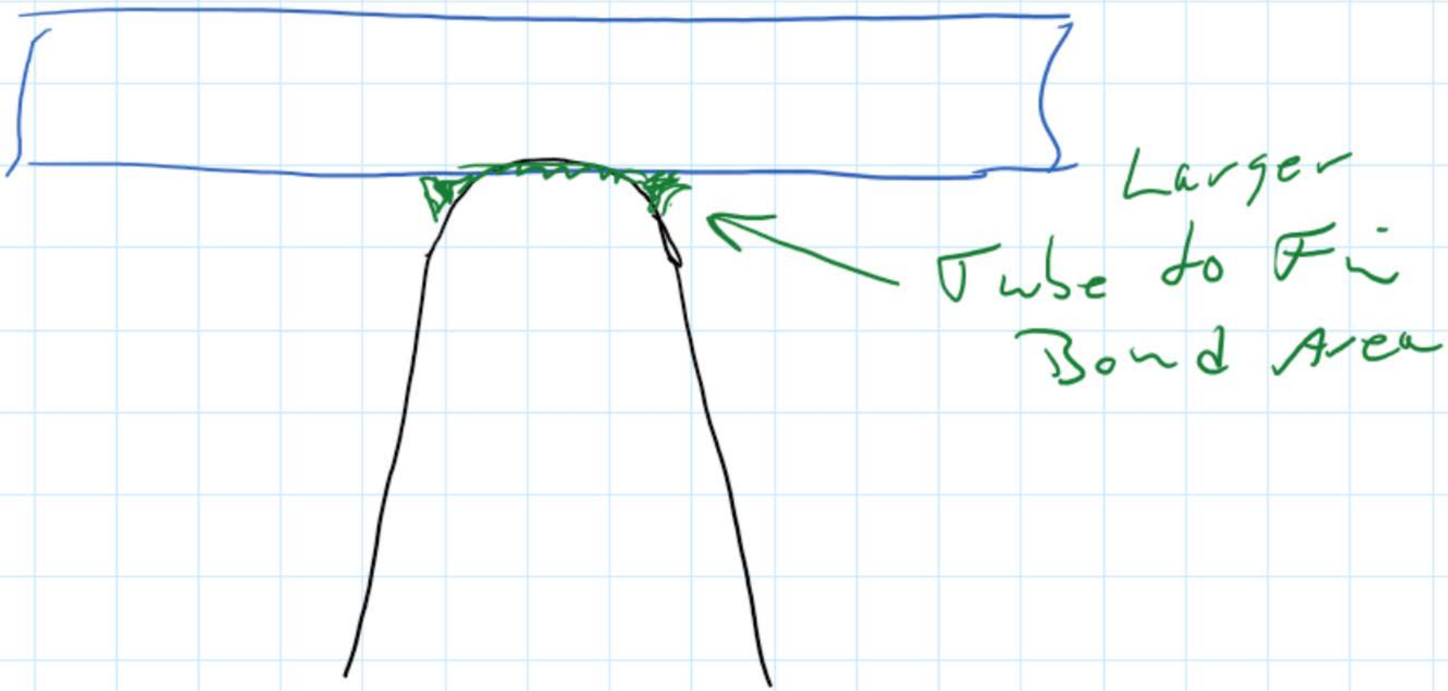
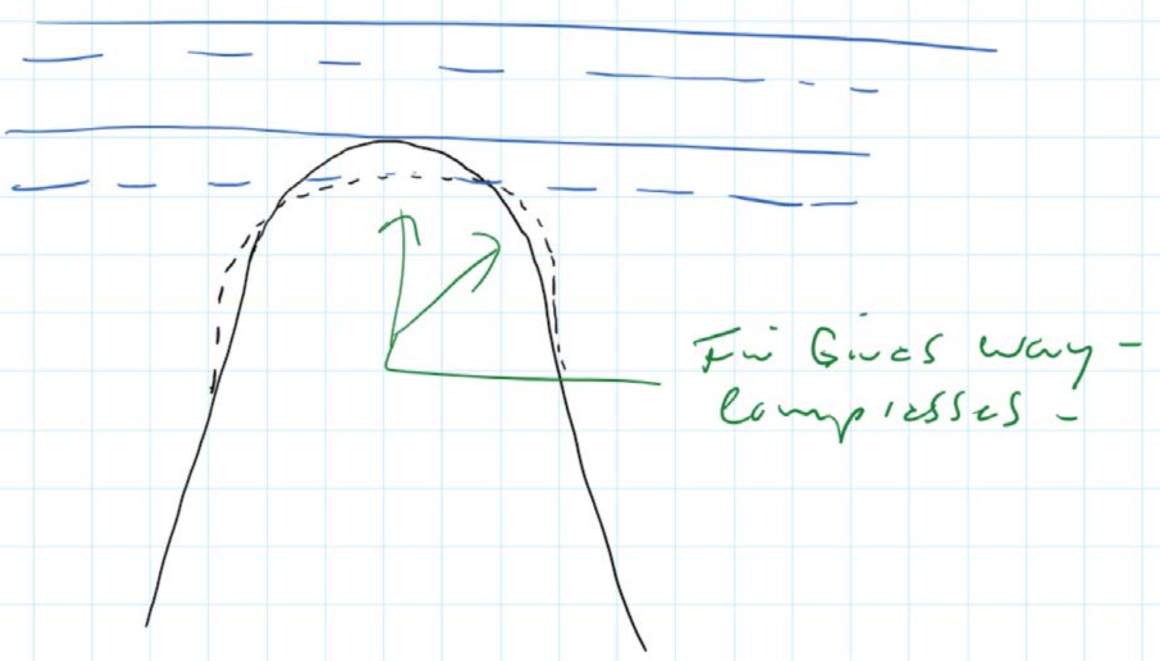
Large Tip Radius

- ❑ Large Tube to Fin Bonding area



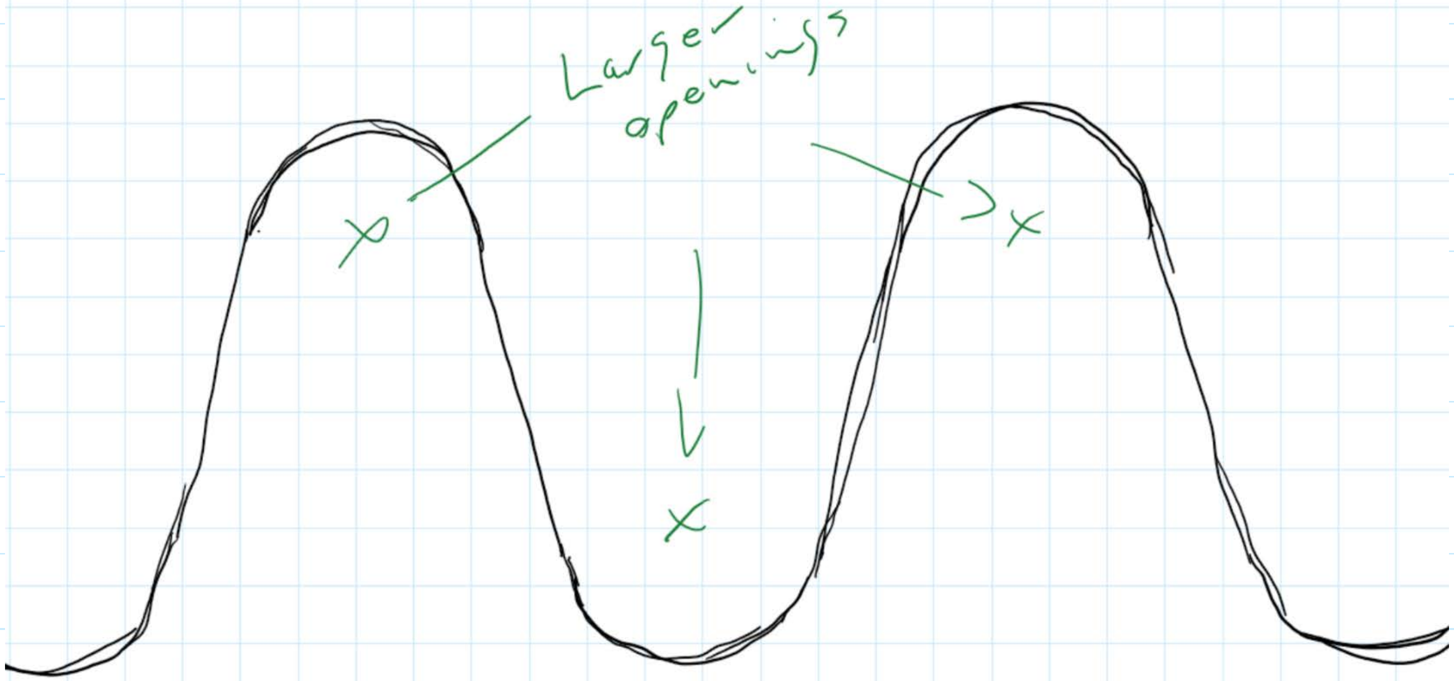
Large Tip Radius

- Large Radius will compress slightly during assembly acting like a spring during core compression keeping everything tight



Large Tip Radius

- ❑ Larger opening at the tip for air to flow through



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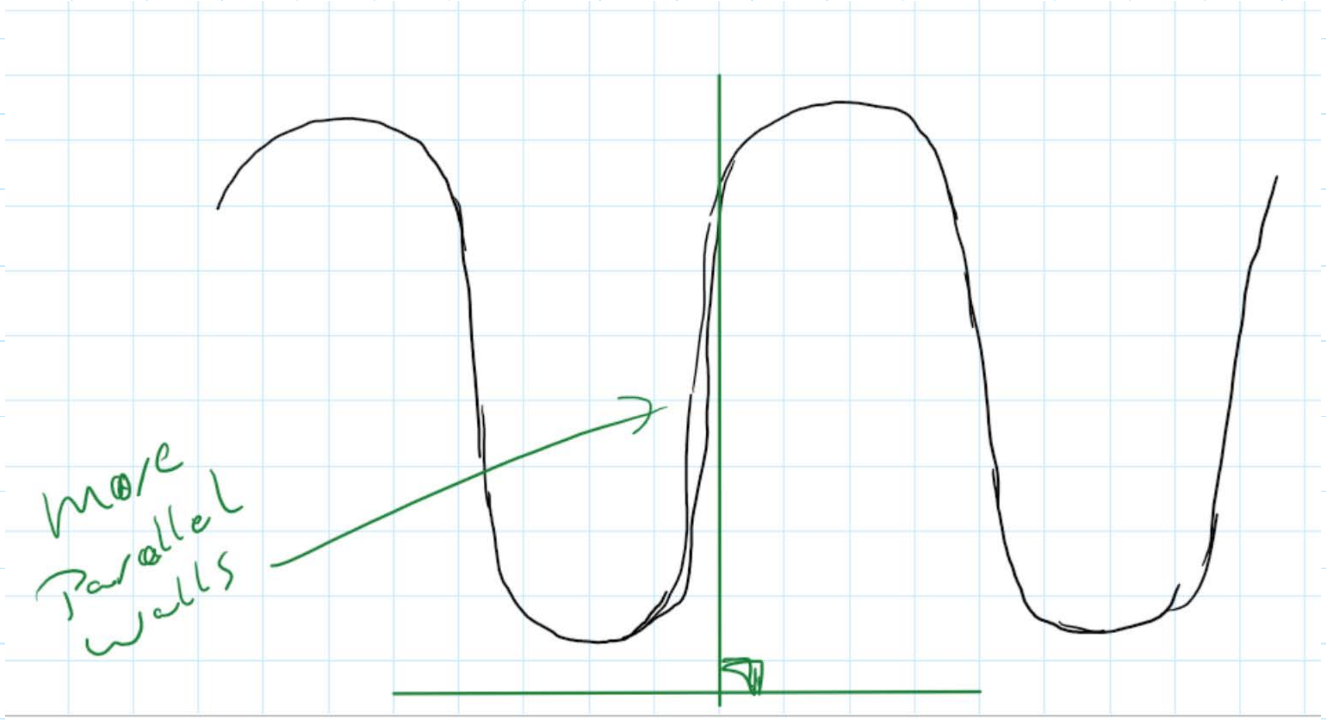
Large Tip Radius

- Straighter Legs to give more of a parallel opening



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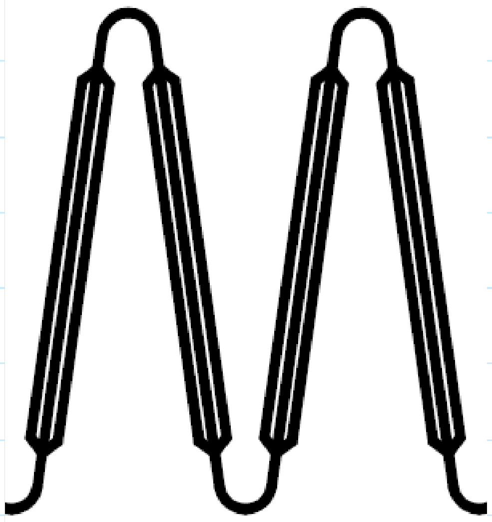
Small Tip Radius

- Appears to have all the disadvantages compared to a Large Tip Radius, But does it?



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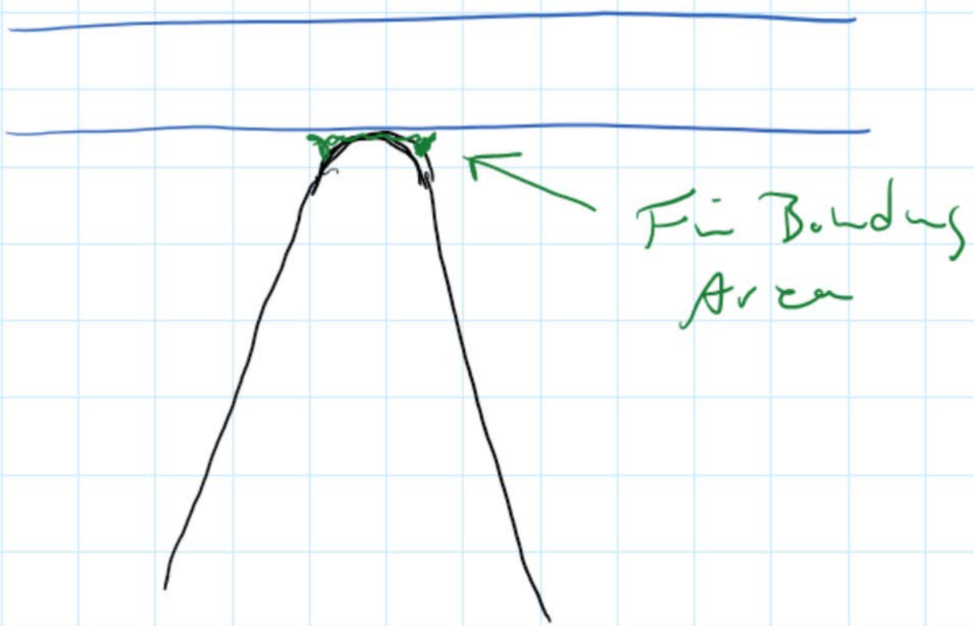
Small Tip Radius

- Fin to Tube Bond / Fillet Area
  - Smaller Tube to Fin Bonding area
    - Although true, what is really needed to transfer the energy from the tube to the fin?
      - It’s the leg of the fin that is the determining factor, the thicker the better for more conductivity/heat transfer.
      - There is no benefit to have a thick cross section at the tube to fin joint. The heat has to be transferred into the fin for the fin cooling to work properly



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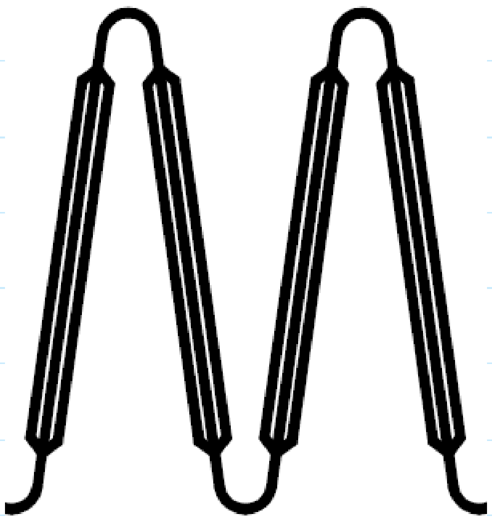
Small Tip Radius

- Fin to Tube Bond / Fillet Area
  - Larger radius fins tend to have a larger fillet area. Normally 2x material thickness is required for a proper fillet size, anything larger doesn't benefit but can hurt by making the fin leg shorter.



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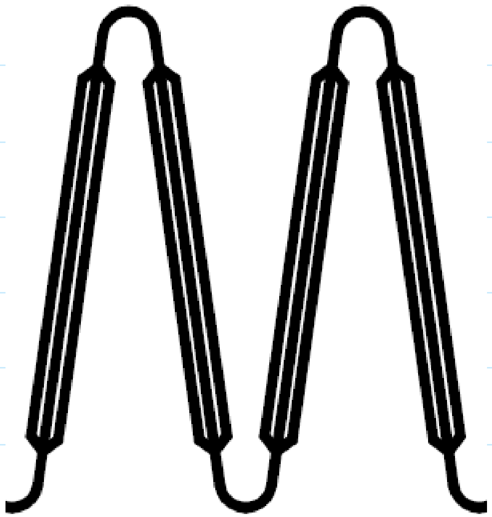
Small Tip Radius

- Spring Like Feature
  - A Small Tip Radius will have less Spring-like features, also True. How can this be better?



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Small Tip Radius

❑ Spring Like Feature

- What happens to Spring-Like joints over time?

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Small Tip Radius

- Spring Like Feature
  - What happens to Spring-Like joints over time? Fatigue!

Small Tip Radius

❑ Spring Like Feature

- What happens to Spring-Like joints over time? Fatigue! The very feature that allows the fin to compress slightly during assembly also allows the core to compress / expand slightly during Thermal and Pressure cycling Causes the Tangent point of the radius and fin leg bend back and forth until eventual failure.

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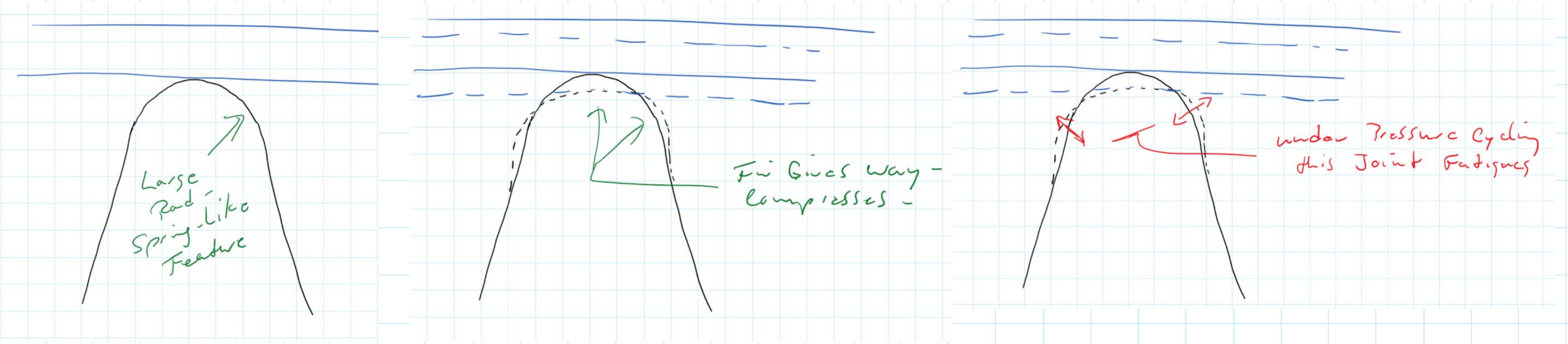
Small Tip Radius

❑ Spring Like Feature

- You can see in this diagram where the fin can flex and eventually fatigue in this corner or tangent point



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Small Tip Radius

❑ Spring Like Feature

- Voss has had on 4 occasions where test results have come in that the small tip radius fins outperformed the larger tip radius fins on pressure cycling. One to the extent they stopped the test thinking something else was wrong, only to find it was the new fin that was holding up better.

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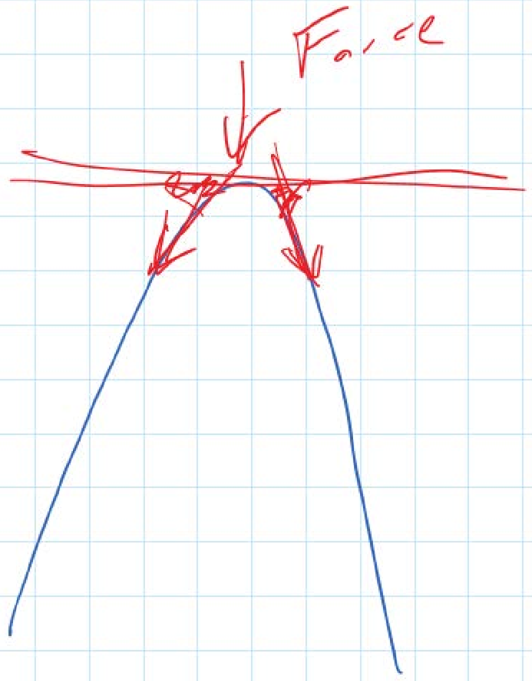
Small Tip Radius

- Spring Like Feature
  - On the Small Tip Fin, you can see how the force is directed more down along the leg axis, instead of bowing or bending the tip rad, the force is transmitted to the legs of the fin



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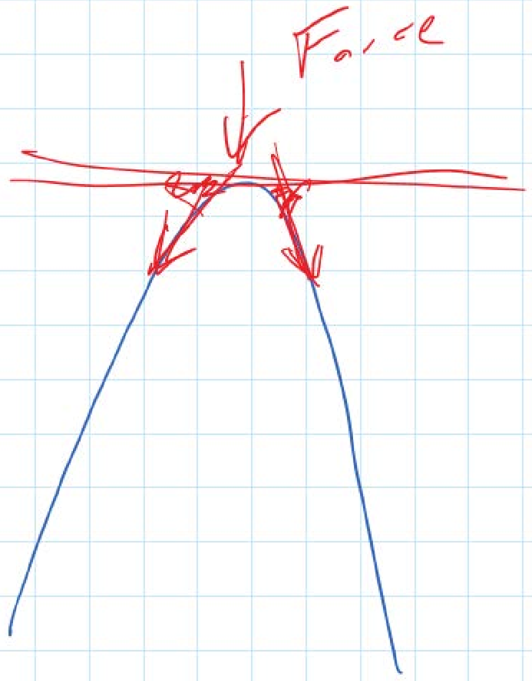
Small Tip Radius

❑ Non-Spring Like Feature

- Another area where this type of fin can be used is where the fin aids in compressing the tube against an internal fin or turbulator.
- This strong fin allows for added compression strength during this compression in assembly
- Also would lead to higher burst pressures due to the added support of the fin in the core assembly



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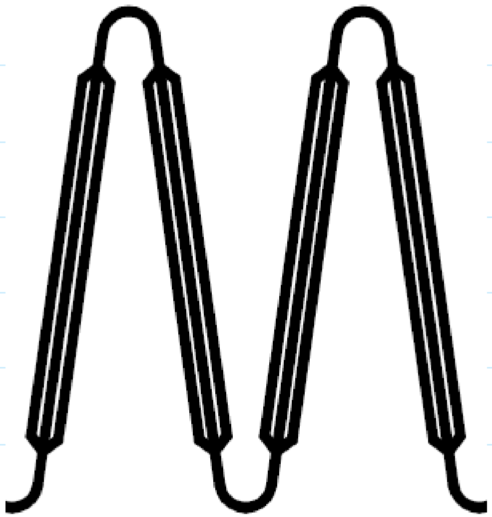
Small Tip Radius

- ❑ Larger opening in the tips of the fin on the Large Tip Radius
  - ❑ Depending on the fin density this can be a disadvantage due to some clogging of the fin in these tight corners



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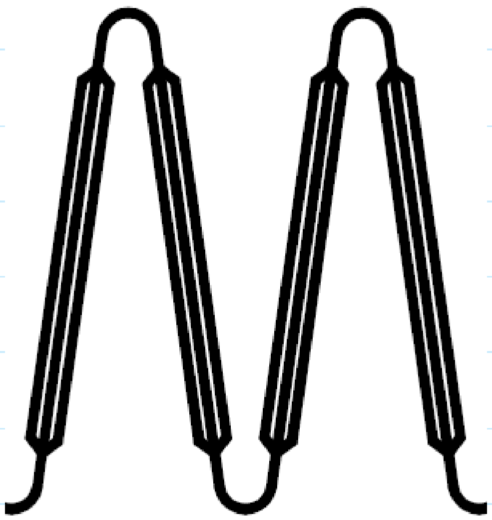
Small Tip Radius

❑ Parallel Fin Walls

- ❑ From a geometry point of view, a trapezoid shape is stronger than a square shape. A fin with parallel walls will act more as a square than a trapezoid, therefore be a little weaker structurally in the overall core assembly. “degrees of freedom” is what engineers call it. On a square shape think of it as how a square becomes a parallelogram, it can rotate about its corners to form a parallelogram. This is not possible in a trapezoid or triangle shape, as there are no degrees of freedom in these shapes.



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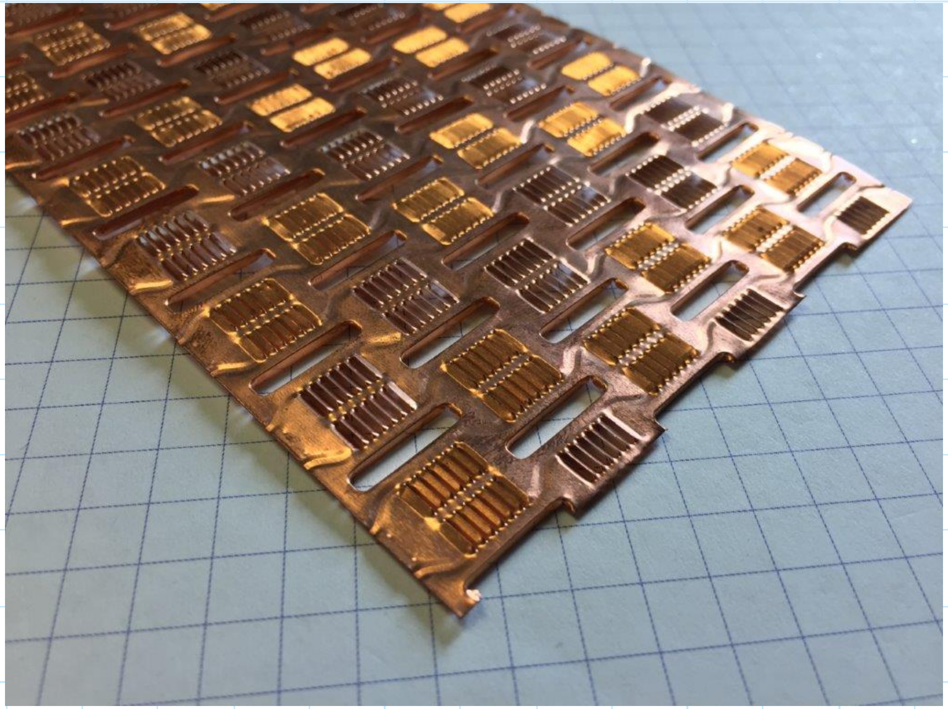
How's Your Fin Shape Up?

- ❑ Flat Fins –



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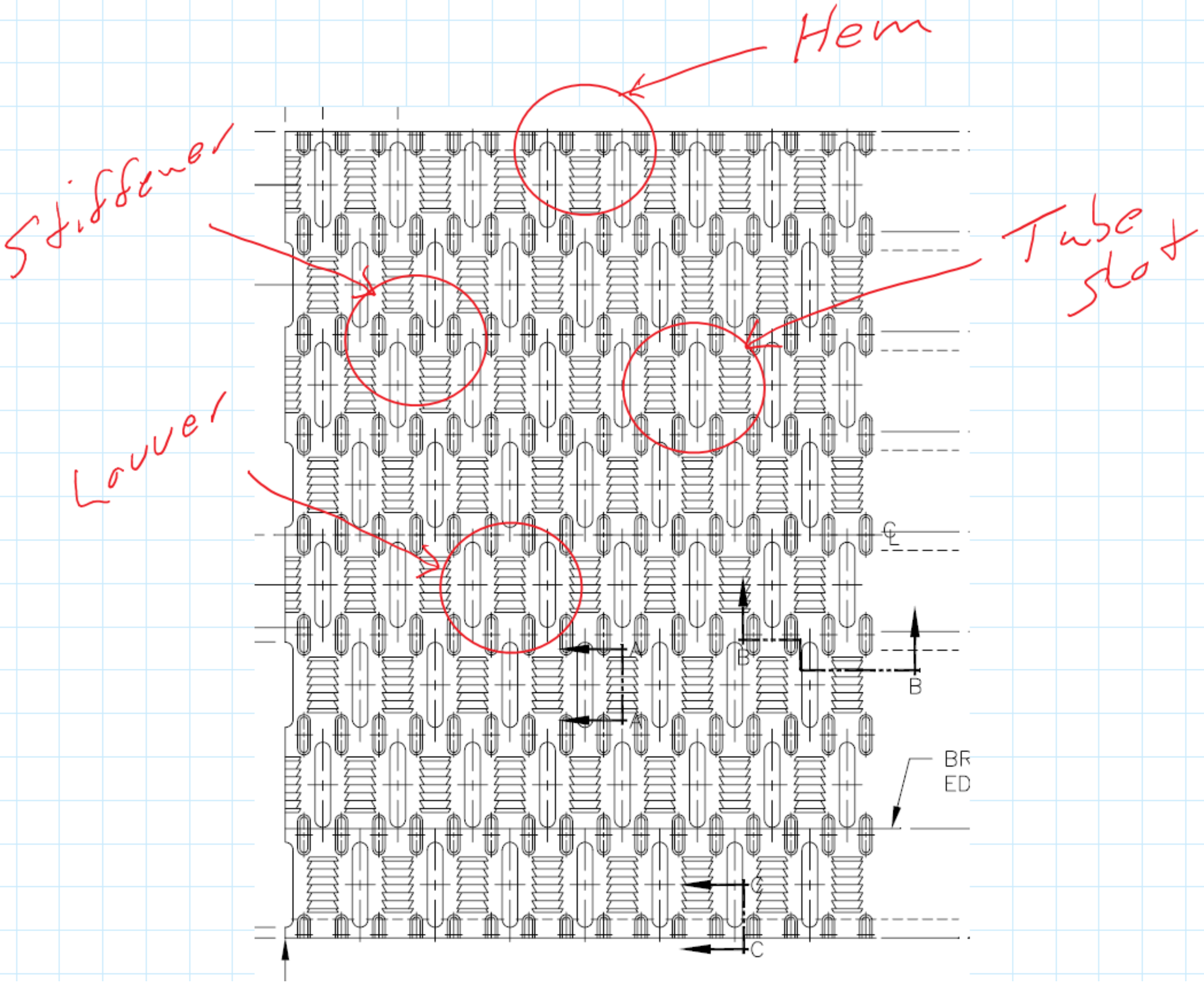
Flat Fins

- ❑ Four areas of interest in the Flat Fin
  - ❑ Tube Slot Geometry, shapes
  - ❑ Hemmed Edge, Size
  - ❑ Louvers / Dimples, shapes and sizes
  - ❑ Stiffeners, their shapes and locations



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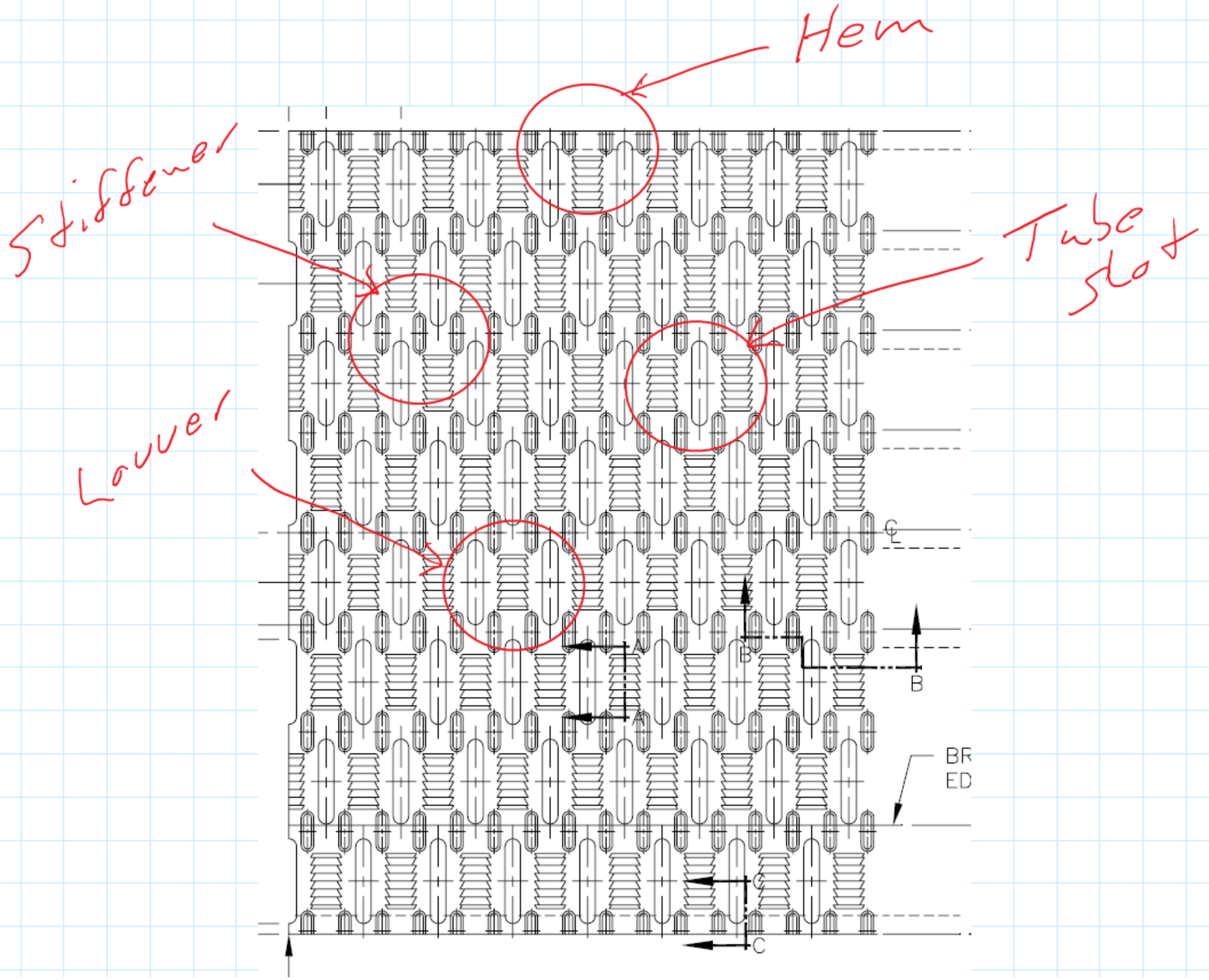

Flat Fins

❑ Tube Slot Geometry, shapes

- ❑ Flat fins are a different from Serpentine Fins whereas the tube penetrates the Fin forming a more structural assembly.
- ❑ What we'll look at is this connection between the tube and fin

- ❑ It's all about the Tube Slot and how it interacts / fits with the Tube. Both are equally as important
- ❑ The shape of the tube is important, parallel walls with a very slight belly are idea to fit into the collar. When forming the collar, think of it like a press-brake, the fin material is being bent over the die block to form the flange. This flange when straight will act like a spring to hold some pressure onto the tube as it's inserted

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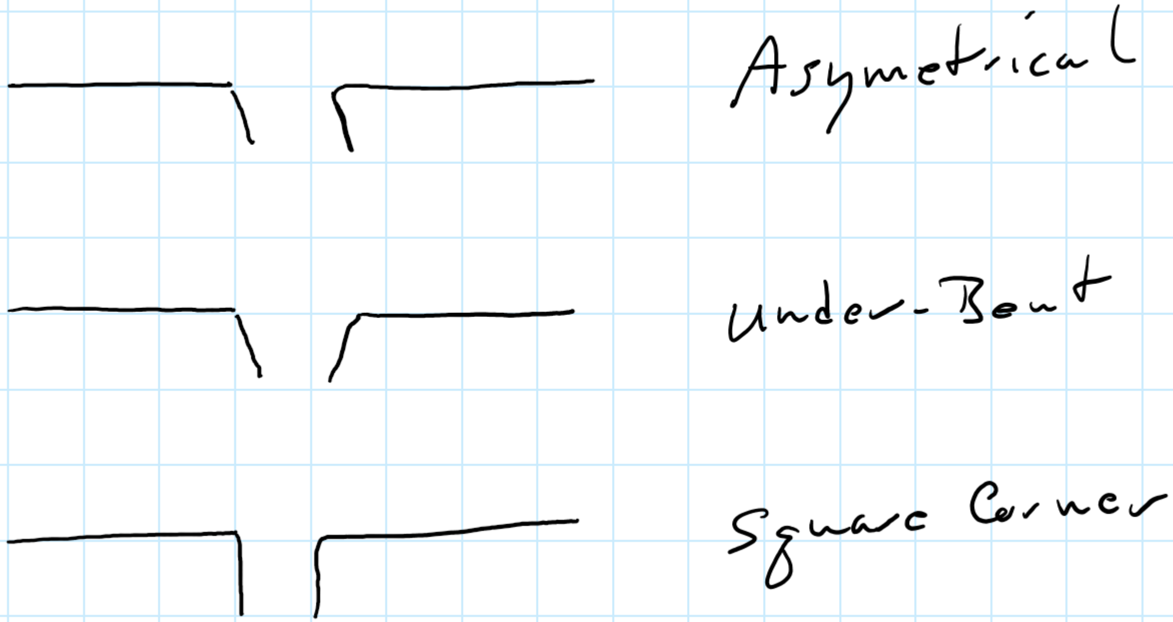
Tube Slot Geometry

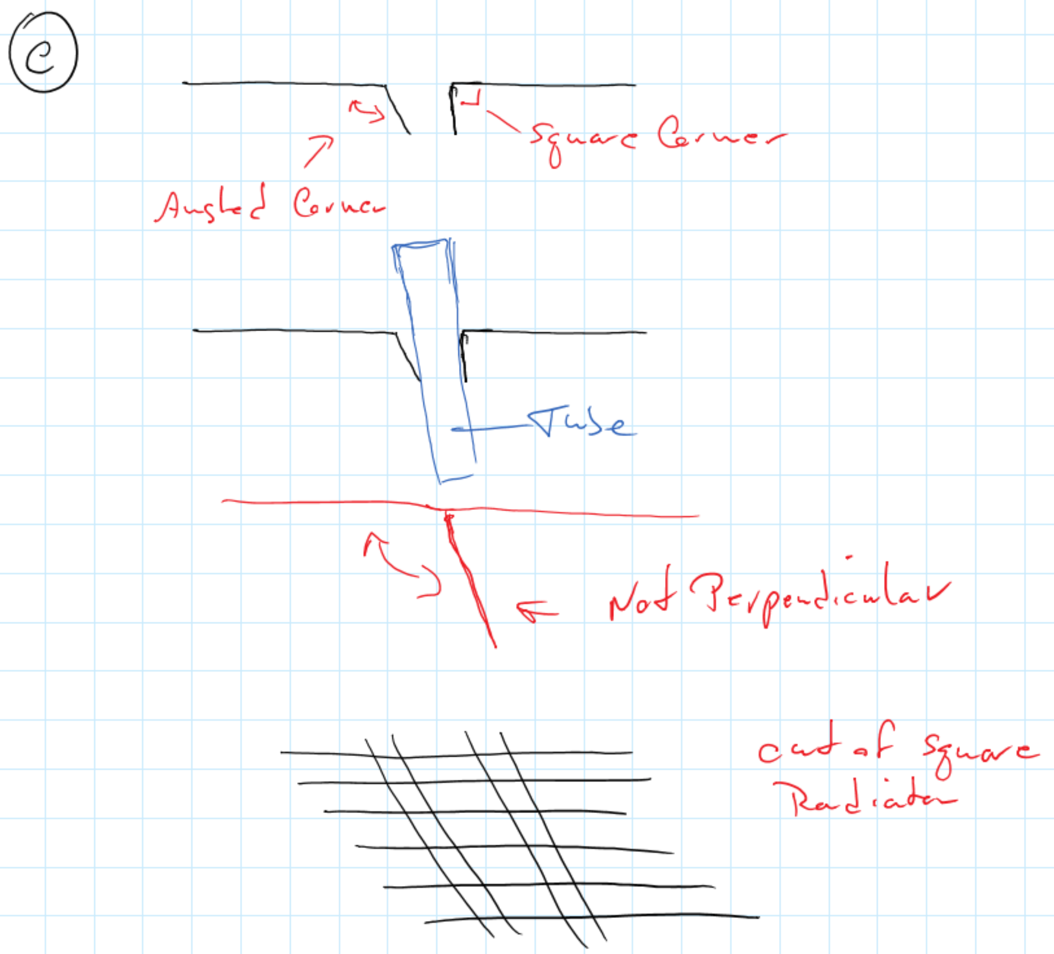
- Looking at the cross section of the tube slot in the fin
- We have 3 basic shapes, or combinations of these shapes



Tube Slot Geometry

- Shape three is an asymmetrical collar, with the collars pointing the same direction towards one side. This prevents the tube from being perpendicular with the fin. Actually can show up in the core block as not being square

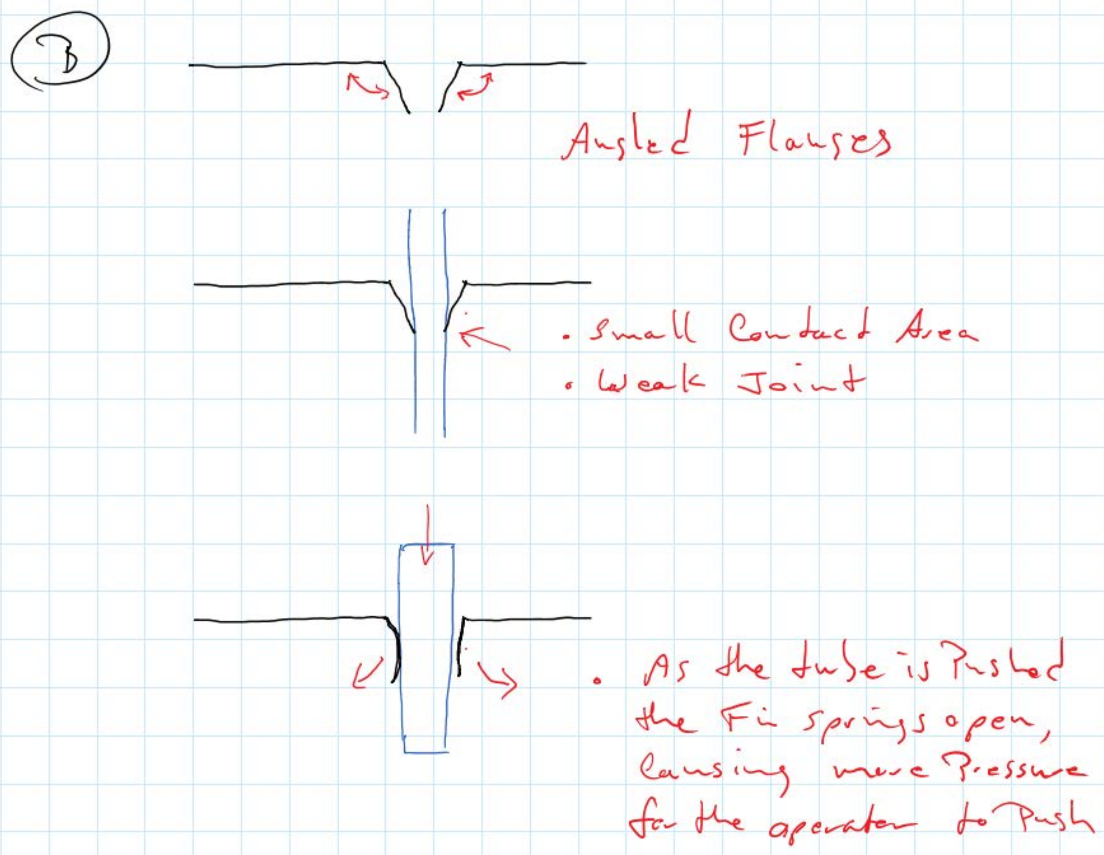
Asymmetrical



Tube Slot Geometry

- Shape two is an under-bent collar, with the top a little larger than the tube, and the bottom smaller than the tube.
- Some problems associated with this shape are:
  - Hard to push the tubes into the core, as the collars build up pressure as the tube is pushed through the fins
  - Or if the tubes can be pushed, the small contact between the tube and fin create a week joint
  - Large solder fillet on top doesn't facilitate heat transfer as well

Under Bent



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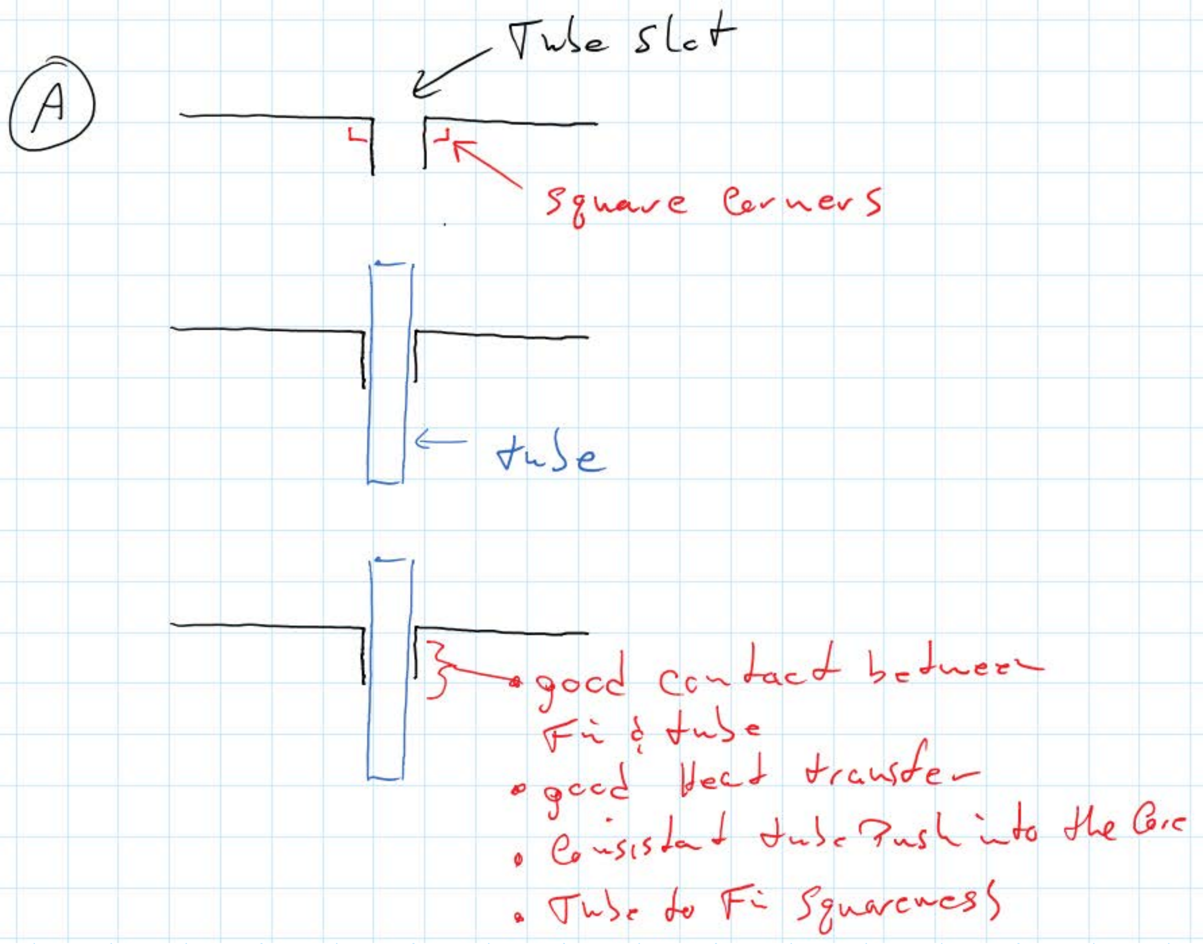
Tube Slot Geometry

- Shape three is a square corner
- This is preferred for Flat Fins. Giving Ultimate Tube to Fin Bond
- The corners of the flange are nice and square, matching the tube size from top to bottom
- The legs are angled in just a little to ensure they touch the tube for the soldering process
- No accumulation, or less accumulation of force needed to push your tubes into the core assembly

Square Corner



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Flat Fins

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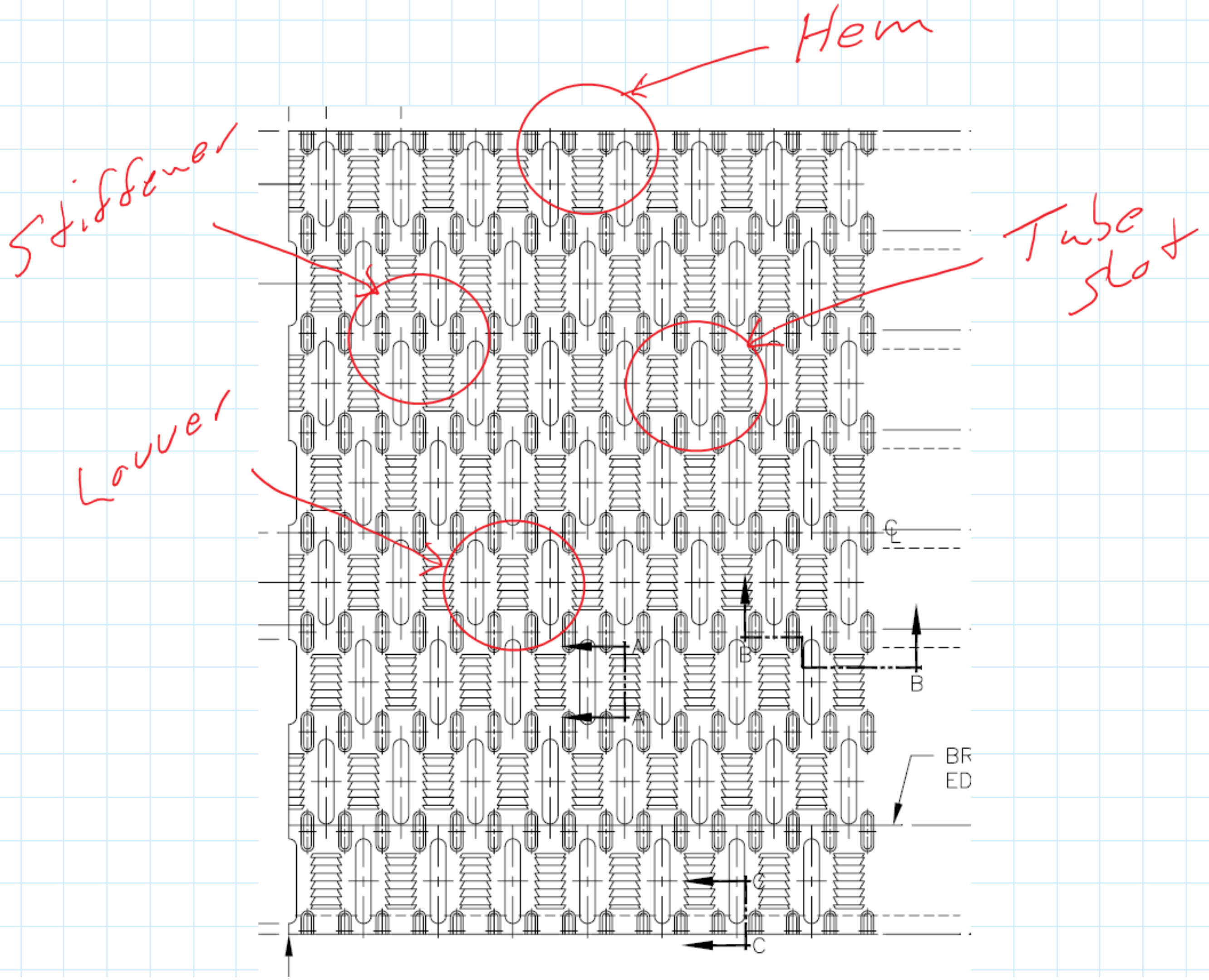
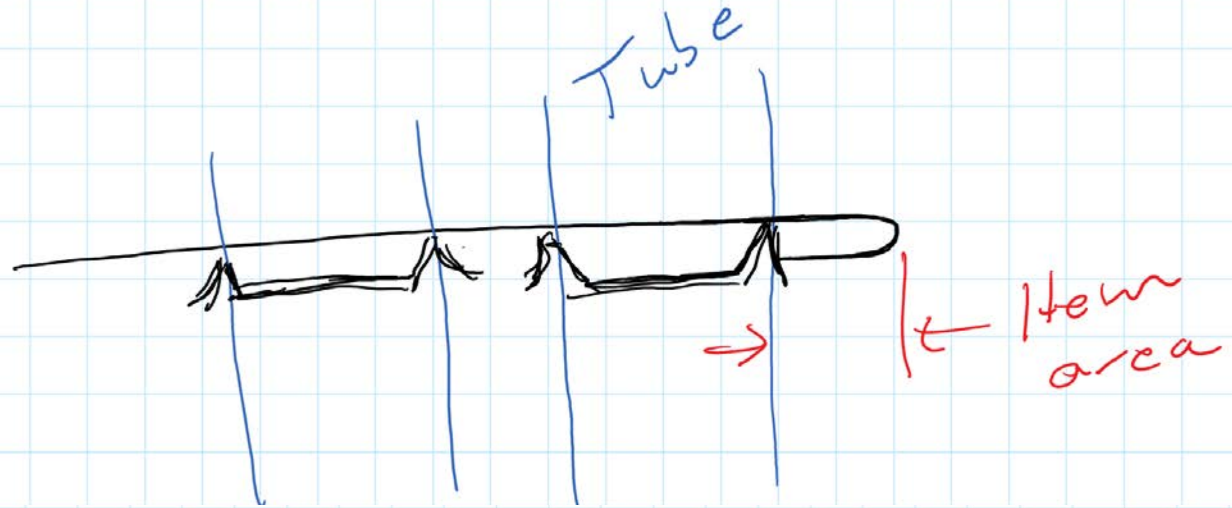
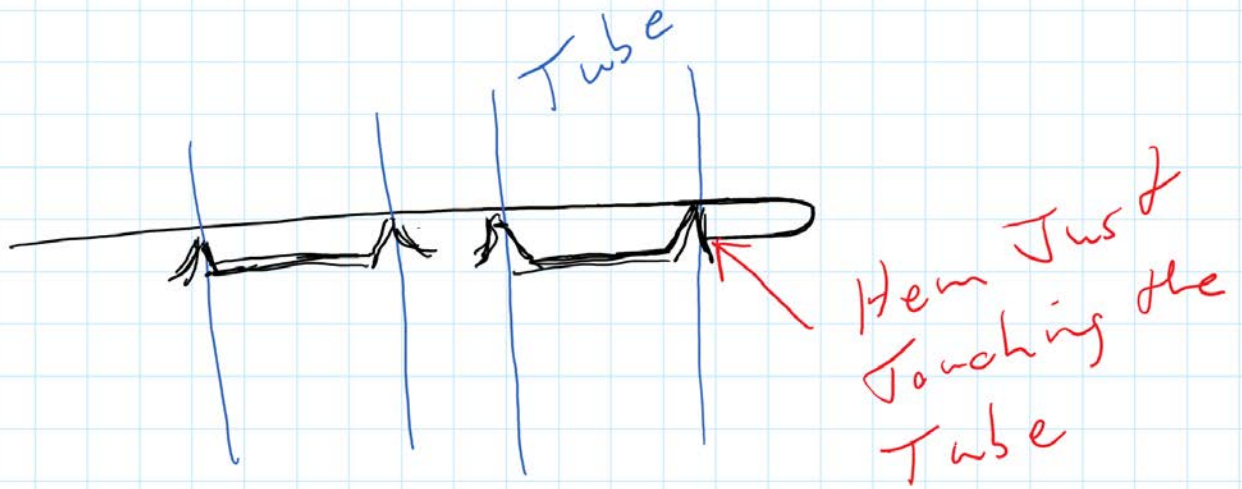
  - Tube Slot Geometry, shapes
  - Hemmed Edge, Size
  - Stiffeners, their shapes and locations
  - Louvers / Dimples, shapes and sizes



Hemmed Edge, Size

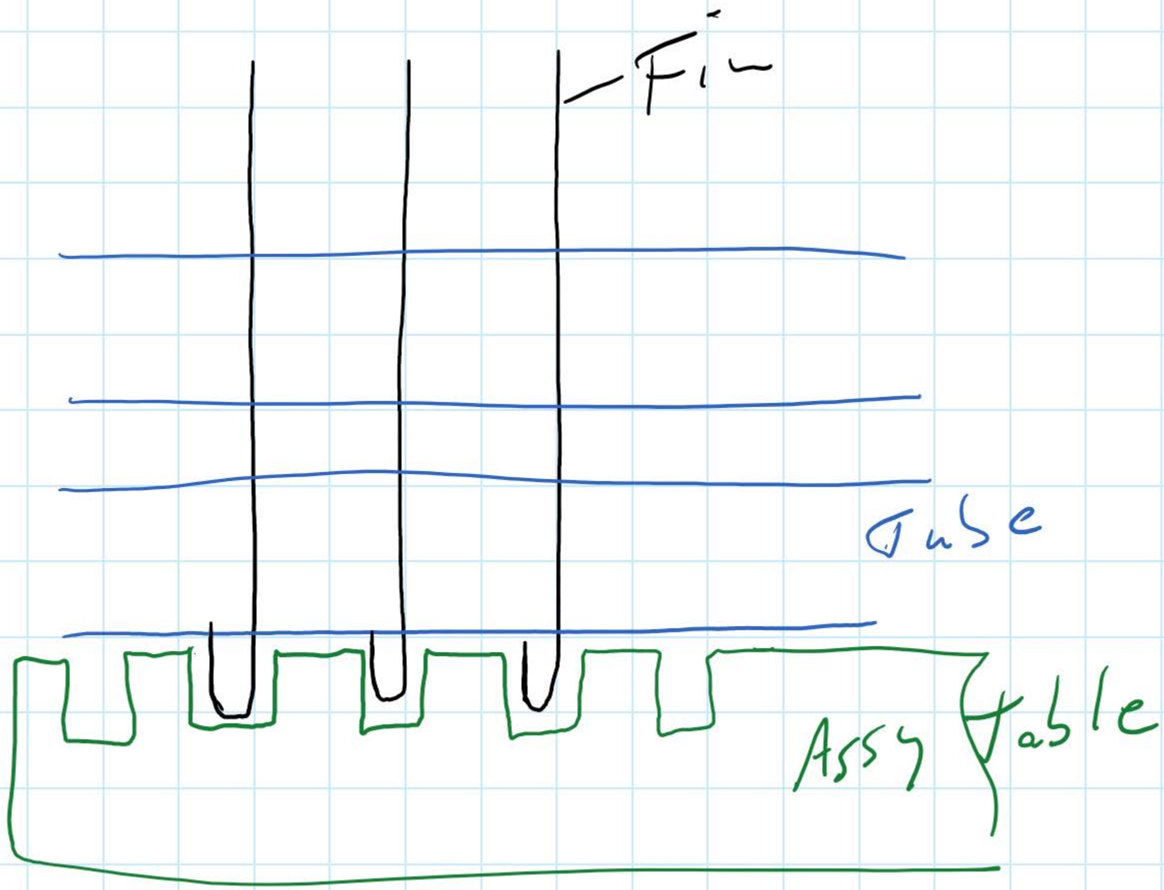
- The Size and Overhang of the Hem is what's important
- The Size of the Hem should extend to just touching the tube for optimal strength. Double thickness of material for the entire hemmed edge
- Just touching the tube has been known to wick just a little solder from the tube and help secure the hem





Hemmed Edge, Size

- ❑ Overhang is how far it extends past the tube. This is related to how strong the face of the core is
- ❑ Overhang also relates to how it fits into the Assembly Fixture, being sure you still have the support you need to push the tubes into the core



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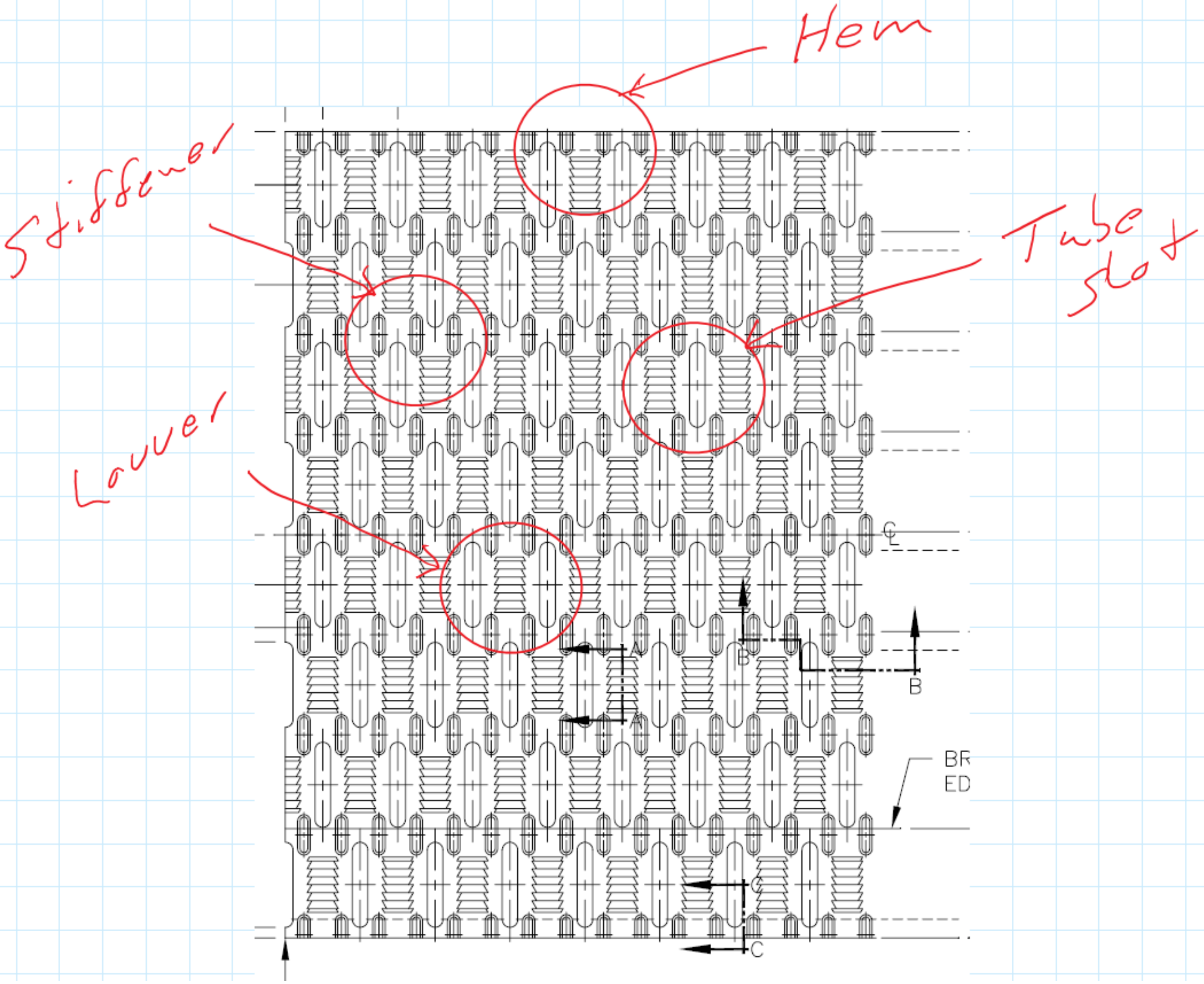
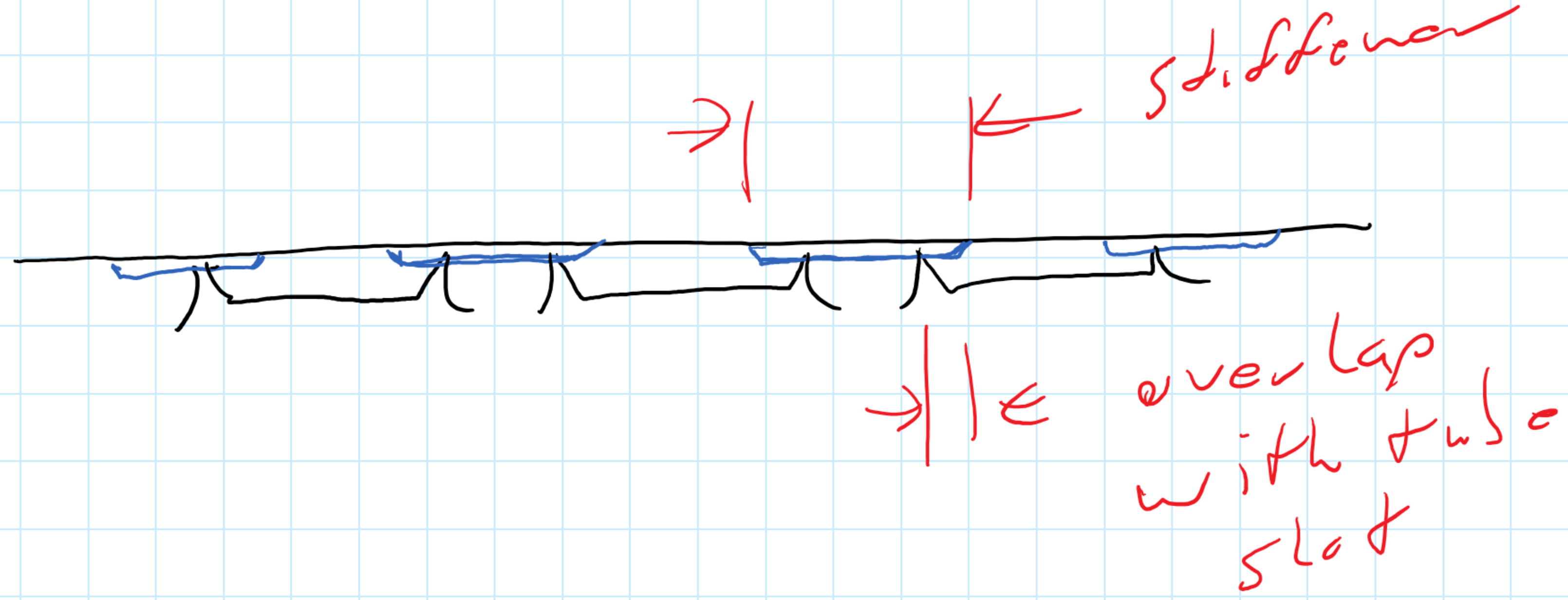


Stiffeners, their shapes and locations

- The Size and Position of the Stiffener is what's important
- The purpose of a stiffener it to do just that, stiffen the fin.
- This is used primarily when assembling the core. The stiffener bridges the gap between the tube rows giving the base fin material more strength to support the pushing force



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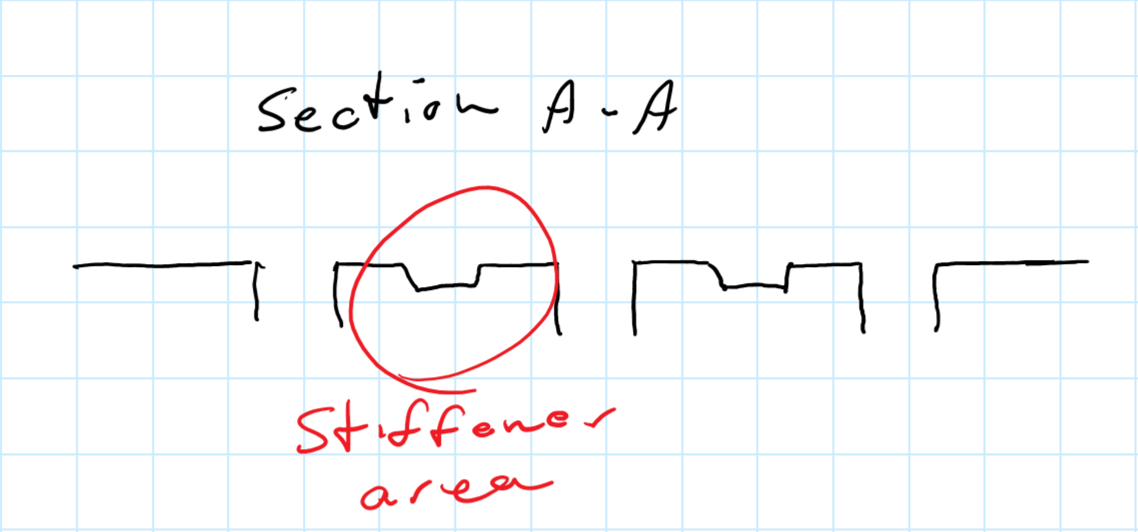
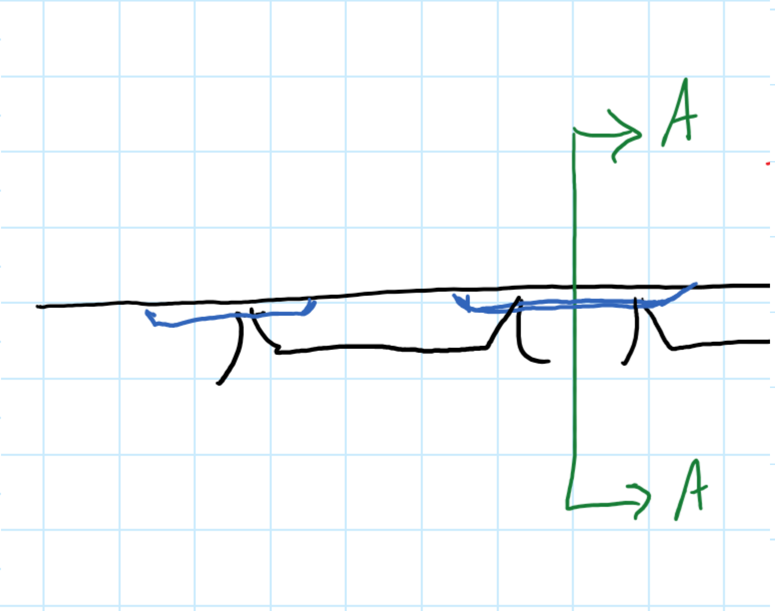
Stiffeners, their shapes and locations

- The key is to bridge the gap between the tube slot collars. The collars themselves cannot bend as they are perpendicular to base fin material
- The stiffener forms a secondary shape that acts like a c-channel in these neutral areas making it more ridged





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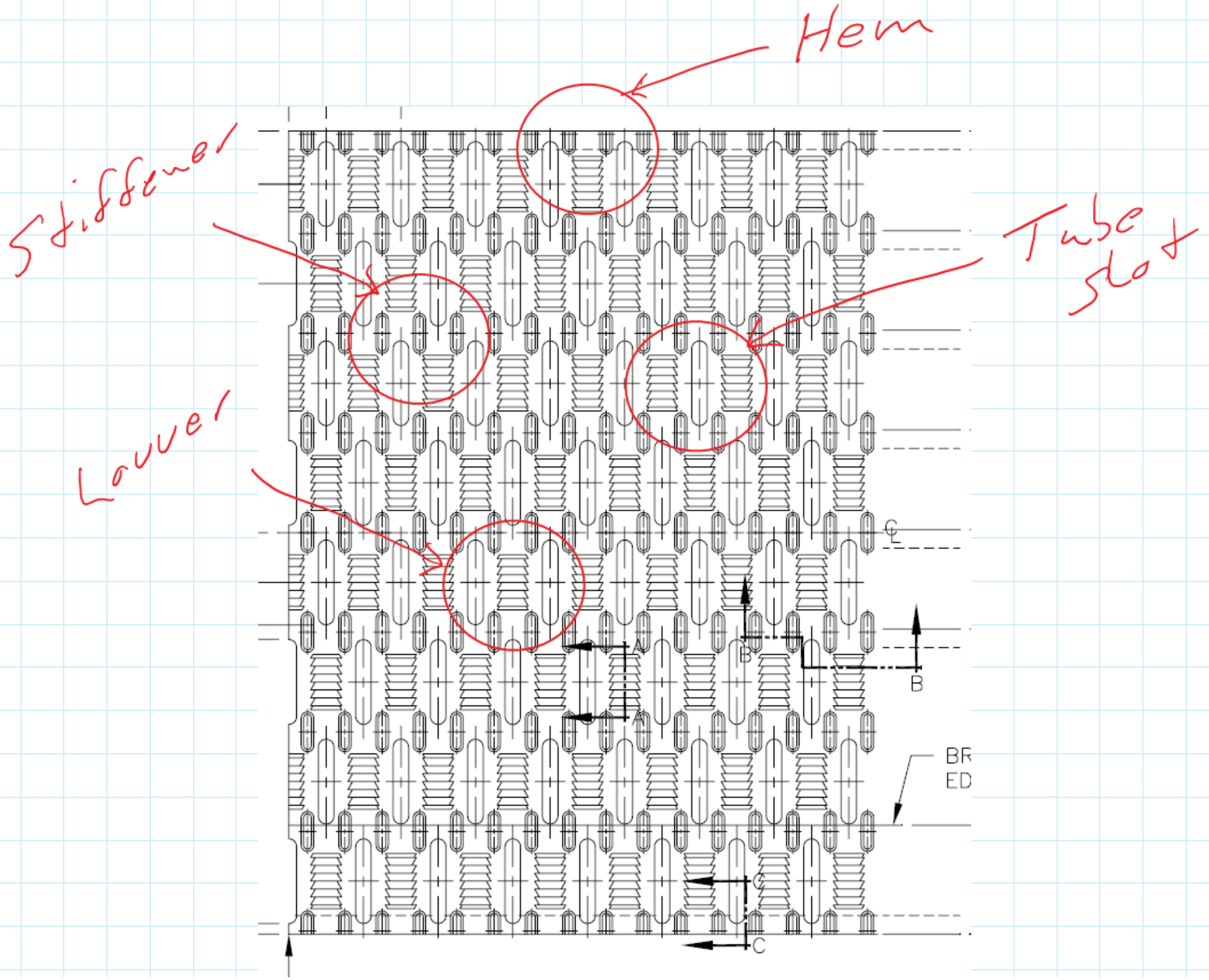

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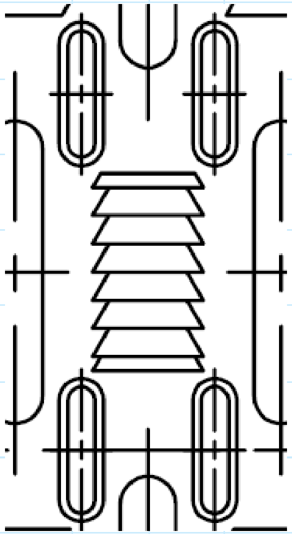
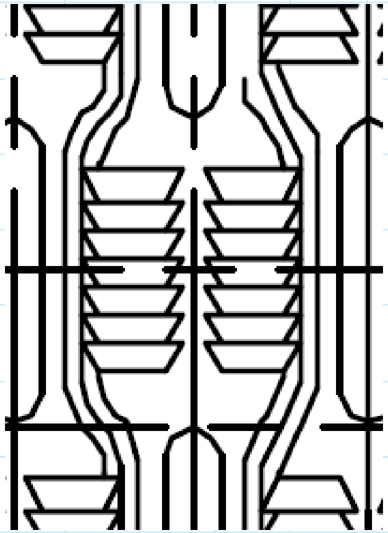
Louvers / Dimples, shapes and sizes

- Louvers are an important part of any fin when used in environments where the cooling air is relatively clean
- I just want to point out two features of the Louver,
  - Full Louvers
  - Split Louvers





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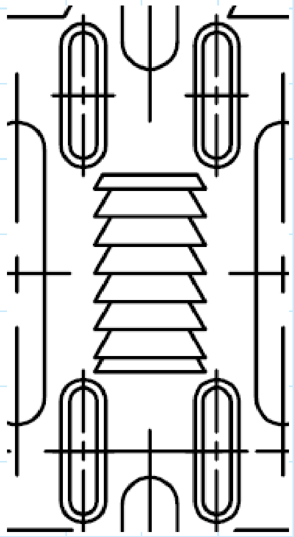
Louvers / Dimples, shapes and sizes

- I just want to point out two features of the Louver,
  - Full Louvers
  - Split Louvers

- Normally used when the louver length is very small, on tight pitch Fins
- When using a Full Louver on longer length Louvers, they can tend to close up over time, or become damaged as the Louver itself is weak



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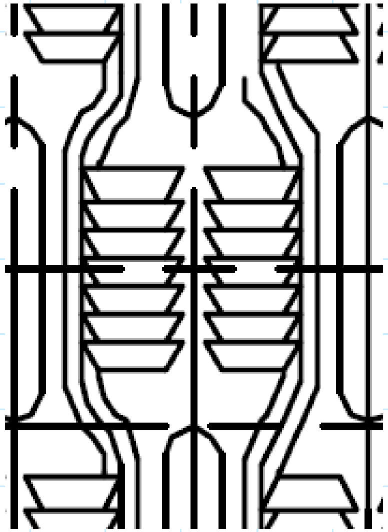

- Split Louvers on the other hand are much Stronger when the louver length is longer.
- By splitting them in the middle, the louver area becomes very strong, supporting the louver shape, angle and openings much better over time

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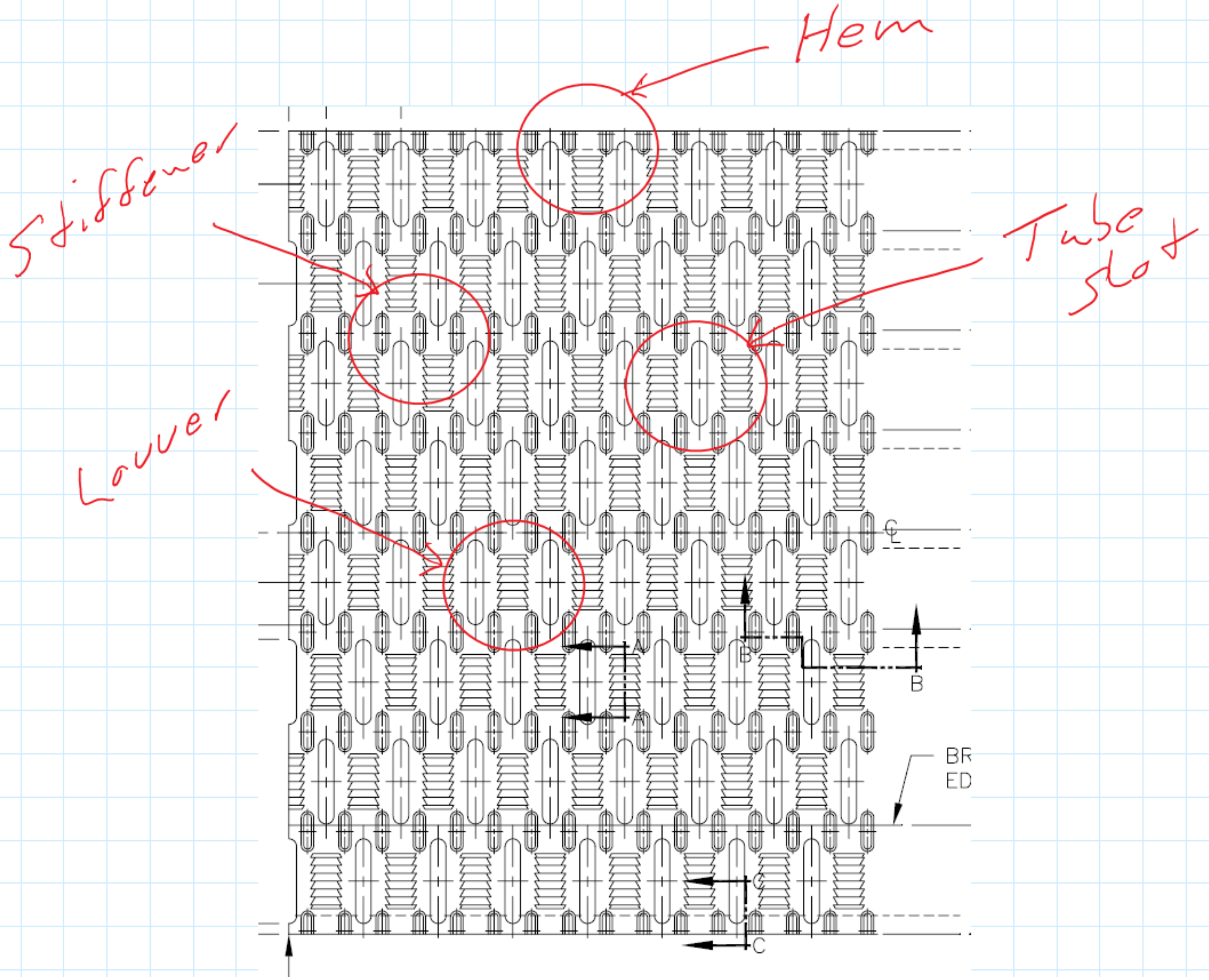

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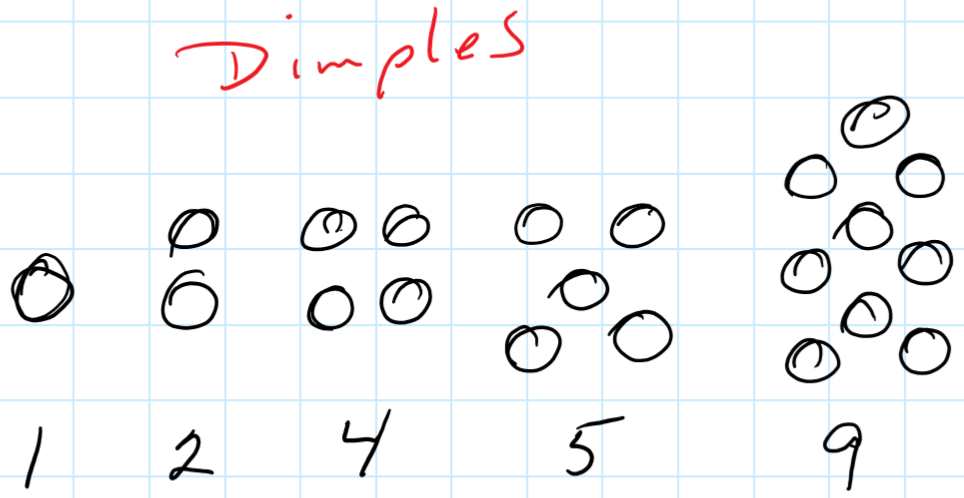
Louvers / Dimples, shapes and sizes

- Dimples, Dimples and more Dimples, there are plenty of variations of them
  - Single, Double, up/down Double, Quad, Five, all the way up to 9 Dimples in one pattern.



  - Why so many variations?

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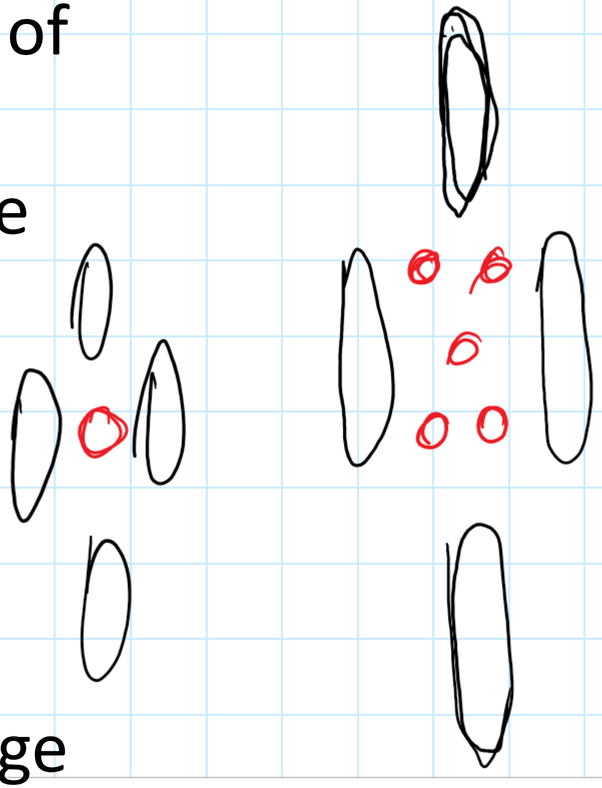
Louvers / Dimples, shapes and sizes

- Dimples, Dimples and more Dimples, there are plenty of variations of them
  - Single, Double, up/down Double, Quad, Five, all the way up to 9 Dimples in one pattern.
  - Why so many variations?
    - Mostly Uniqueness
    - Or Space availability
    - Or Copying the other guy
  - From a heat transfer point of view, not much change
  - From a structural point of view, some help strengthen the fin pending their size and placement



Summary

- In closing, I hope this was informative for you and you go away knowing a little more about Fin and their geometries and how they relate to areas of the heat exchanger that you may not have been aware of
- Understanding the shapes, and the methods that produce them is the key to a solid manufacturing process ensuring you are building / purchasing the best you can and took that extra step to understand the details that go into each and every fin

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Closing

I’ll leave you with a quote from Gandhi

“Live as if you were to die tomorrow.
Learn as if you were to live forever.”

Learn every day, these seminars are for you, use them,
learn from them, teach your colleagues.
We are never to old to learn, nor should we ever stop.

Thank you Narsa for having me,
Thank you all for listening to me
I hope we all learned something today

Bob Carlo

How does your Fin Shape Up?

Presented by Bob Carlo
2017

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