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Tube Kit Assembly Guidelines:

This document is to assist the builder in constructing tube structures using profiled tube kits manufactured by VR3 Engineering with the Cartesian Tube Profiling Process by offering suggestions and ideas.

Tube kits are generally per plans by the original designer. Variations may exist due to interpretation or inconsistencies in the original design plans or accepted modifications. The builder must own the rights to the designer's set of plans and use it as the design basis for manufacturing the structure. The drawings by VR3 / Cartesian are intended to assist with the organization and assembly of the profiled tube kit.

Checklist:
The following items are provided with each tube kit:

a) Packing List and itemized component material listing
b) Isometric drawing with balloons, part numbers, tube location and basic tube size
c) Set of profiled tubes: profiled, sawcut and formed tubes
d) Dimension drawings which should correspond to original plans as accurately as possible. Additional reference dimensions are provided to check positioning and squareness of the structure

Each profiled tube is labeled with a unique part number and goes in one location only. Left side and right side tubes are generally **'not'** interchangeable.

Check tube kit components versus material list. Make sure that all parts are accounted for. If space permits, sort the tubes in numerical order on a table. This will simplify searching for individual tube numbers as you proceed with assembly

Additional shorts/drops are often provided for practice welding. These are typically 'unmarked' tubes. We also have a practice welding kit available with a range of profiled tubes of different sizes, various cluster configurations and weld seams to practice and improve your tack welding and finish welding skills.

General Suggestions:

1. Build tube weldment assembly as a three dimensional(3D) structure:
   - All tubes are manufactured to suit the 3D geometry and final positioning
   - In order to achieve accurate station positions and the firewall to tail post dimension, the tubes must be assembled in 3D space
   - Do not build the sides as flat sub-assemblies because the tube kits have the profiles, pre-formed longerons and other tubes based on the final 3D geometry

2. Build the kit "vertical up" in it's normal flying position:
   - Helps avoid confusion about left hand/ right hand orientations
   - It may be tempting to build the structure relative to an alternate 'flat' surface or upside down. Do not be fooled as this will lead to confusion as the assembly progresses

3. If gaps are visible at a tube end when it is in position, the tube is likely incorrectly positioned. Try:
   - Flipping the tube end for end
   - Rotate tube 90°,180°,270° or as required
   - Verify that all mating tubes to the cluster are also positioned

- Confirm the tube number and position with the drawing

4. Select the horizontal cross tubes for the tube structure. These are usually symmetrical tubes with perhaps small variations in the end profiles. Mark a centerline ring around the perimeter of the tube. This will be used later as reference points to confirm centerline symmetry using a large square or plumb bob to the table surface and ensure the tube structure is not twisting

Jigs / Fixtures:

One of the primary advantages of our profiled tubing kits is that the profiled tubes become a significant part of the 'jig and fixture'. Secondly, because the tubes fit tight to each other at the clusters, shrinkage and distortion are almost eliminated. This simplifies or eliminates the requirements for rigid, heavy, complicated and expensive fixtures.

A flat, solid table surface is the best place to start. For the homebuilder, this can be made of plywood or mdf. Ideally, this surface would be as long as the fuselage from firewall to tail post. It is certainly possible to do this in half this length also. The width of the table top should exceed the width of the structure by 3 to 4 inches on each side. The base frame (wood or metal tubing should be anchored to the floor and the top surface leveled in all directions. A good height would be 24 to 30 inches above the floor and depend somewhat on the ceiling height available in your work shop.

Mark a centerline down the length of the table and mark the primary station centerlines of the lower fuselage starting with the firewall. The tube structure will now be assembled above this reference surface.

Note that the primary design dimensions on the drawing are typically to the tube centerlines. When measuring from surfaces such as tube outside diameters, ensure to calculate the correct offset to suit the tube radius.

The best place to start on a fuselage structure is usually the firewall sub assembly. This is typically a two dimensional sub assembly that can be tacked together on the flat table surface. Simply clamp or screw aluminum or wooden blocks to the table to form an outside frame. Be sure to nest all the diagonal tubes into position before tack welding. These tubes will be difficult to nest into place otherwise and will also assist in maintaining the frame dimensionally correct, square and symmetrical. This subassembly should give the builder a 'feel' and understanding of fitting the profiled tube components.

Position the horizontal tubes of the fuselage bottom into blocks above the table at the corresponding station positions and secure at the proper elevation. Also position the firewall frame and tail post tube (if length permits) to establish vertical reference surfaces.
Place the lower longerons into position and confirm relationship to the firewall. Once these are properly positioned, there are may choices as to which tubes to place into position first. Remember that there should be no visible gaps at any of the profiled ends of the tubes.

Prior to positioning or tack welding tubes, refer to recommendations regarding cleaning and preparation of the tubes.

The following items will assist with the assembly of a profiled tube kit:

* clamps; variety of styles and sizes
* electrical tape
* bungy cords
* ratchet straps
* an assistant for an extra pair of hands
* plumb bob(s) and string line
* straight edges, carpenter squares
* measuring tapes

Always check tube positions for symmetry to the fuselage centerline and diagonally to maintain squareness. Hang plumb bobs from the centerline of the top horizontal tubes down to the table centerline reference to ensure the structure is straight and true.

Tube Cleaning and Preparation:

Before placing the tubes into position, it is important to prepare and maintain a clean surface for optimum weld quality. Wipe off any excess oil or protective coating from the outside and inside diameter surfaces of the tube. Also clean the ends of the tubes as well as the intermediate weld areas of tube clusters with a 'Scotch-Brite' pad to remove the oxide layer and expose 'bare' metal on the tube outside surface. This will provide an ideal surface for tack welding and finish welding.

Welding:

There are many choices of welding processes and equipment suitable for welding 4130 tubing structures. Doing a good job with any process is better than doing a poor job with any another process.

Profiled tube kits are ideal for the TIG welding process because the tubes fit with metal to metal contact around the contact perimeter. This process allows for minimum use of filler material, and a reduced overall heat input while producing optimum weld sizes and strength. Modern technology and equipment have made the TIG welding process economical, convenient and easier to learn.

When you are certain about tube placement and positioning, place a small tack on the joint to hold the tube in position. We recommend assembling the structure as much as possible by just tacking it enough that it will hold the tubes in position.

Locate tack welds in spots that will be easier to break or remove if required. This usually implies that it will also be easier to blend the tack welds while welding the final pass. Maintain the tack welds as small as practical. When finish welding, these tacks will need to be remelted and blended with the finish weld to eliminate the potential of defects or stress concentrations.

Once again, ensure that all the diagonal tubes are placed into position as you progress down the length and around the perimeter of the structure. Many diagonal tubes may not fit easily into place without removing a portion of the tube or breaking some tack welds.

There are often 5,6 or 7 tubes meeting at the main station clusters. An extra pair of hands will be a great asset at those times. Another advantage of the tube kit is that all the tubes are cut before you start the assembly process. You can organize these tubes in groups and prepare an assembly process on your own time to optimize the use of an assistant when required. Alternatively, one could cut fixture blocks and work entirely on your own.

A 3D tube kit is manufactured to numbers. Trust the numbers and dimensions. It will be difficult to correct errors down stream. Also trust your intuition, if it does not look right, it probably is not right.

The entire tube kit should be assembled with a minimal amount of tack welds so that the overall dimensions, symmetry and squareness are confirmed before it is too difficult to adjust.

When all of the tubes are placed into position, confirm overall measurements and ensure that the structure is properly orientated (straight and symmetrical). Visually inspect each cluster for visual gaps.

Once all tubes have been positioned and held into place, additional tack welds should be added at all the tube clusters throughout the structure. You will likely be surprised how rigid the structure becomes with

each small tack weld. If you are not comfortable and confident to do the final welding, en experienced welder would appreciate the opportunity to complete the welding on this structure without the need to cut fit and grind tubes one at a time. They will also be very efficient with their time.

By design, tubular fuselage structures are very stable in all directions once they are welded or in the case of our profiled tube kits, adequately tacked together. Begin welding portions of clusters at various positions throughout the structure generally in a symmetrical fashion to balance the effects of heating and cooling. Weld tops and bottoms, insides and outsides of various clusters, side to side, front and back to stabilize the structure.

The structure can then be released from the table and fixture supports. Welding can then be completed by rotating the fuselage in free space or set on the table in various positions to gain easier and more comfortable access to all clusters.

Rolled/ Formed Tubes:

In many tube kits, there are a few tubes with rolled, contoured or formed bends and shapes. It is not always possible or practical to profile the tube ends before bending or rolling. In these cases some minor fitting may be required to nest the tubes accurately into position.

In the case of longerons with formed 'dogleg' bends, small variations in the bend angle result in significant movement at the ends of the tubes. Use the mating tubes as fixture tubes to push or pull the nodes into position. During the final welding process, these tubes will adjust to their 'held' position.

The same applies to the longeron tubes with large sweeping curvatures. 'Flex' the tube into position using the horizontal, vertical and diagonal tubes as locating points at each station cluster.