

## FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1 – Tube Procedures

**Components:** Copper Tube [4.2.7.1.2.1]

**Material:**

**Tooling:**

**Location:**

**QC Form:** FCal1-QC-1.3.3.1.2-1 – Tube Traveler  
FCal1-QC-1.3.3.1.2-2 – Tube Rolling  
Inspection Report  
FCal1-QC-1.3.3.1.2-3 – Tube De-Burring  
Inspection Report  
FCal1-QC-1.3.3.1.2-4 – Tube Cleaning  
Inspection Report

**Process:**

1. ([1.3.3.1.1.1](#)) Tube Shipment Acceptance Inspection.
2. ([1.3.3.1.1.2](#)) Tube Processing.

**Remarks:**

**Global Process:** none

**Previous:** none

**Follow-Up:** [1.3.1.7](#) – Matrix Assembly

## FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1.1 – Tube Shipment Acceptance Inspection

**Components:** Copper Tube [4.2.7.1.2.1]

**Material:**

**Tooling:**

**Location:** UofA PAS 180

**QC Form:**

**Process:**

1. Record packaging (number of boxes/containers) and approximate total number of shipped tubes.
2. Inspect container(s) and boxes. Record damages and conditions.
3. ([1.3.3.1.1.2-1](#)) Visual tube inspection of 1 box of tubes.
4. ([1.3.3.1.1.1-1](#)) Tube dimension inspection for 200 randomly selected tubes from various boxes.
5. Reject shipment if number of unacceptable tubes is larger than 10% of total shipment.

**Remarks:**

- Rejection criteria are preliminary.

**Global Process:** [1.3.3.1.1](#) – Tube Procedures

**Previous:** none

**Follow-Up:** [1.3.3.1.1.2](#) – Tube Processing

## FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1.2 – Tube Processing

**Components:** Copper Tube [4.2.7.1.2.1]

**Material:**

**Tooling:**

**Location:** UofA PAS 180  
UofA PAS 346

**QC Form:** FCal1-QC-1.3.3.1.2-1 – Tube Traveler

**Process:**

1. ([1.3.3.1.1.2-1](#)) Visual tube inspection.
2. ([1.3.3.1.1.2-2](#)) Tube de-burring.
3. ([1.3.3.1.1.2-3](#)) Tube de-burring inspection.
4. ([1.3.3.1.1.2-4](#)) Tube cleaning.
5. ([1.3.3.1.1.2-5](#)) Tube cleaning inspection.
6. ([1.3.3.1.1.2-6](#)) Tube packaging and storage.

**Remarks:**

- Step 1 must be applied to each individual tube.
- Steps 2 to 6 are applied to each tube accepted in step1.
- Individual tubes can be taken out of the process at any step.

**Global Process:** [1.3.3.1.1](#) – Tube Procedures

**Previous:** [1.3.3.1.1.1](#) – Tube Acceptance Inspection

**Follow-Up:** [1.3.1.7](#) – Matrix Assembly

## FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1.1-1 – Tube Dimension Inspection

**Components:** Copper Tube [4.2.7.1.2.1]

**Material:** Nitril Gloves

**Tooling:** Digital Micrometer  
Starrett Custom Digital Bore Gauge  
24" Vernier Calipers

**Location:** UofA PAS 180A – Office

**QC Form:**

**Process:**

1. Wear nitril gloves for this entire process. Use 200 tubes passing the visual inspection process [1.3.3.1.1.2-1](#).
2. Measure tube outer diameter at two places (90° apart) at each end and in the center of the tube. Use the LabView application `micro` and `bg.vi` for this purpose. Save/store the data.
3. Measure tube inner diameter at two places (90° apart) at 1cm from tube end. Repeat for other end of tube. Save/store the data.
4. Measure tube length with caliper. Record.

**Remarks:**

**Global Process:** [1.3.3.1.1.1](#) – Tube Acceptance Inspection

**Previous:** [1.3.3.1.1.2-1](#) – Visual Tube Inspection  
*[some or all selected tubes]*

**Follow-Up:** none

# FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1.2-1 – Visual Tube Inspection

**Components:** Copper Tube [4.2.7.1.2.1]

**Material:** Nitril Gloves

**Tooling:**

**Location:** UofA PAS 180 – Garage/Granite Table

**QC Form:** FCal1-QC-1.3.3.1.2-1 – Tube Traveler  
FCal1-QC-1.3.3.1.2-2 – Rolling Inspection

**Process:**

1. Put on Nitril gloves before handling tubes.
2. Unpack tubes from vendor.
3. Visually inspect tube ends held in bunches.
4. Set aside tubes with visually out-of-round ends in well-marked Reject bin.
5. Move tube bunch to granite surface plate for inspection by rolling.
6. Roll each tube (about 10 turns) on granite surface plate, inspecting for dents dings, cracked tubes, bent tubes, curved tubes, and out-of-roundness.
7. Dented tubes, dinged tubes, cracked tubes and bent tubes to be set aside in well-marked Reject bin.
8. Out-of-straight tubes to be accepted or rejected according to tolerance given in tube drawing.
9. Record date and name of inspector on traveler form for batches of approximately 1,000 tubes.

## Remarks:

- Process applies to acceptance inspection (1 box selected from batch) and systematic inspection of all tubes, except for item 9 (only for systematic tube inspection).

**Global Process:** [1.3.3.1.1.1](#) – Tube Acceptance Inspection  
[1.3.3.1.1.2](#) – Tube Processing

**Previous:** none

**Follow-Up:** [1.3.3.1.1.1-1](#) – Tube Dimension Inspection  
[200 extracted tubes]  
[1.3.3.1.1.2-2](#) – Tube De-Burring  
[all accepted tubes]

## FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1.2-2 – Tube De-Burring

**Components:** Copper Tube [4.2.7.1.2.1]

**Material:** Nitril Gloves  
Compressed Air/Nitrogen

**Tooling:** Drill Press  
Grinder  
60° Angle De-burring Tool  
Compressed Air/Nitrogen Gun

**Location:** UofA PAS 346 – Laboratory

**QC Form:** FCal1-QC-1.3.3.1.2-3 – De-Burring Inspection

### Process:

1. Gloves should be worn whenever tubes are handled.
2. Place de-burring cutter into drill press.
3. Set drill press to lowest speed.
4. De-burr both ends of selected tubes. De-burring diameter should be less than half of the tube's wall thickness.
5. Wire-brush each de-burred end with .10 wire wheel in grinder.
6. Remove de-burring debris with a blast of compressed air.
7. Place de-burred tubes in plastic bin for inspection (see process sheet [1.3.3.1.1.2-3](#)).
8. Note date and name of person completing de-burring on tube traveler form assigned to each batch.

### Remarks:

**Global Process:** [1.3.3.1.1.2](#) – Tube Processing

**Previous:** [1.3.3.1.1.2-1](#) – Visual Tube Inspection

**Follow-Up:** [1.3.3.1.1.2-3](#) – Tube De-Burring Inspection

# FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1.2-3 – Tube De-Burring Inspection

**Components:** Copper Tube [4.2.7.1.2.1]

**Material:** Nitril Gloves

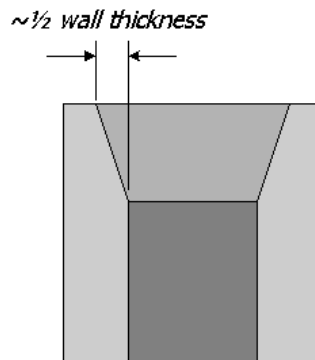
**Tooling:** Magnifying Loupe

**Location:** UofA PAS 346 – Laboratory

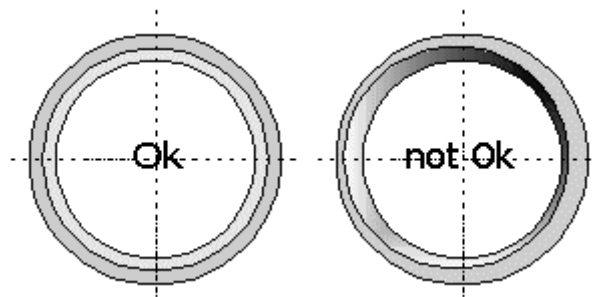
**QC Form:** FCal1-QC-1.3.3.1.2-3 – De-Burring Inspection

## Process:

1. Gloves should be worn whenever tubes are handled.
2. Check both de-burred tube ends for width of the cut (optical inspection using the loupe). The width of the cut should not exceed  $\frac{1}{2}$  of the tube wall thickness:



3. Check both de-burred tube ends for planarity of cut surface (chatter). Use the loupe to find uneven spots.
4. Check both tube ends for completeness and center of cut



5. Check both tube ends for burr/copper flakes.

**Process Spec:** 1.3.3.1.1.2-3 – Tube De-Burring  
Inspection<sup>cont'd</sup>

**Process (continued):**

6. Record all observations on Tube De-Burring Inspection Report. Tubes not passing must be placed into Reject bin if not correctable, or returned to [1.3.3.1.1.2-2](#) (Tube De-Burring) for redo.

**Remarks:**

**Global Process:** [1.3.3.1.1.2](#) – Tube Processing

**Previous:** [1.3.3.1.1.2-2](#) – Tube De-Burring

**Follow-Up:** [1.3.3.1.1.2-4](#) – Tube Cleaning  
*[all accepted tubes]*



## FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

<b>Process Spec:</b>	1.3.3.1.1.2-4 – Tube Cleaning
<b>Components:</b>	Copper Tube [4.2.7.1.2.1]
<b>Material:</b>	Nitril Gloves Heavy Chemical Gloves Citranox Cleaner LPS Cleaner Isopropyl Alcohol Mineral Spirits Clean Room Wipes Filtered, De-ionized (FD) Water Compressed Nitrogen Gas
<b>Tooling:</b>	Ultrasonic Transducers w. Power Supplies (2) Cleaning Matrix/Tube Carrier (4) Tanks for Cleaning/Rinsing Solutions (5) Belt Heaters (2) Compressed Nitrogen Nozzle Large Cart Ph/Temperature Meter Conductivity Meter
<b>Location:</b>	UofA PAS 180 – Cleaning Station UofA PAS 180 – Clean Room
<b>QC Form:</b>	FCal1-QC-1.3.3.1.2-4 – Cleaning Inspection

### Process:

1. Wear gloves whenever tubes are being handled. Heavy chemical gloves can be worn when handling hot objects. Otherwise, latex/nitril gloves should be worn.
2. Pre-soak selected tubes in mineral spirits (tub) for at least 24 hours.
3. Load cleaning matrix with 132 de-burred tubes (fill all holes in matrix except the row under the handle).
4. Use electric hoist to move cleaning matrices into, out of, and between tanks. Slide matrix handle over the hook on the hoist taking care to center the handle on the hook before lifting.

## FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1.2-4 – Tube Cleaning<sup>cont'd</sup>

### Process (continued):

5. Place the matrix with tubes in tank 1, which is filled with warm (66°C) 5% LPS solution, and activate ultrasonic transducer timer for 40 minutes. *Check solution with Ph meter to assure reading is above 11.6 before each load.*
6. Remove cleaning matrix with tubes from LPS bath and place in tank 2, a rinse vat filled with clear water. Agitate the cleaning matrix (up and down motion) 6 times to completely flush water through tubes.
7. Place matrix with tubes in tank 3, which is filled with warm (66°C) 2% Citranox solution, and activate ultrasonic timer for 40 minutes. *Check solution with Ph meter to assure reading is below 2.5 before each load.*
8. Remove cleaning matrix with tubes from Citranox bath and place in tank 4, a rinse vat filled with FD water. Agitate the cleaning matrix (up and down motion) 6 times to completely flush FD water through tubes. *Check FD water with conductivity meter to assure conductivity of 1 µS or less.*
9. Remove cleaning matrix with tubes from tank 4 and place in tank 5, a pre-drying vat filled with isopropyl alcohol. Agitate the cleaning matrix (up and down motion) 6 times as before. Remove matrix with tubes from tank 5 to the lab bench behind tank farm.
10. Give a blast of nitrogen down each tube (while still in matrix) and blow liquid from outside of the tubes and cleaning matrix.
11. Perform QC check as outlined in Quality Control of Copper Tube Cleaning Process Specification [1.3.3.1.1.2-5](#).
12. Place the cleaning matrix with tubes on drying bench (large cart) in the clean room.

### Remarks:

- If Ph readings are not within required range more solution must be added until desired Ph reading is obtained.
- The FD water in the second rinse vat must be replaced if its conductivity is higher than 1 µS (micro-Siemens).

**Global Process:** [1.3.3.1.1.2](#) – Tube Processing

**Previous:** [1.3.3.1.1.2-3](#) – Tube De-burring Inspection

**Follow-Up:** [1.3.3.1.1.2-5](#) – Tube Cleaning Inspection

## FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1.2-5 – Tube Cleaning Inspection

**Components:** Copper Tube [4.2.7.1.2.1]

**Material:** Latex Gloves  
Isopropyl Alcohol  
Clean Room Foam Swab

**Tooling:** Magnifying Loupe

**Location:** UofA PAS 180 – Laboratory

**QC Form:** FCal1-QC-1.3.3.1.2-4 – Cleaning Inspection

### Process:

1. Take a random sample of 14 tubes from every batch of 132 tubes cleaned.
2. Wipe down the inner tube length with a foam swab dipped in isopropyl alcohol.
3. With the loupe examine the swab for traces of grease, dirt or metal flakes.
4. If the sample shows contamination for 1 or more the entire batch shall be re-cleaned as described in process sheet [1.3.3.1.1.2-4](#) and cleaning methods/solutions may possibly be re-evaluated.
5. If all the samples pass the swab test, within requirements, the batch of tubes will proceed to storage (process sheet [1.3.3.1.1.2-6](#)).

### Remarks:

- For the first few batches, a sample of 14 tubes from various locations in the tube holder will be examined. As confidence in the cleaning processes increase, the number of tubes swabbed may decrease.
- The efficiency of the actual cleaning process should be evaluated by recording the number of rejected/accepted tube batches. The reason for rejection should also be recorded.

**Global Process:** [1.3.3.1.1.2](#) – Tube Processing

**Previous:** [1.3.3.1.1.2-4](#) – Tube Cleaning

**Follow-Up:** [1.3.3.1.1.2-6](#) – Tube Packaging and Storage

## FCAL1 Process Sheet

T.Embry/P.Loch/L.Shaver

**Process Spec:** 1.3.3.1.1.2-6 – Tube Packaging and Storage

**Components:** Copper Tube [4.2.7.1.2.1]

**Material:**  
Nitril Gloves  
Compressed Nitrogen Gas  
Plastic Bags  
Clean Room Wipes

**Tooling:**  
Large Steel Cart  
Storage Rack  
Compressed Nitrogen Nozzle  
Thermal Bag Sealer

**Location:** UofA PAS 180 – Clean Room

**QC Form:** FCal1-QC-1.3.3.1.2-1 Tube Traveler

### Process:

1. Wear nitril gloves when handling tubes.
2. Cleaned batches of (typically) 132 tubes passing the QC check described in [1.3.3.1.1.2-5](#) are to be packed into clean plastic bags. Fill bags with compressed nitrogen gas, one clean room wipe, and completely dried tubes, then thermally seal with bag sealer.
3. Bags have to be numbered. Also note date of packing, name of packing person, and exact number of tubes on bag. Record the same information in logbook.
4. Store packaged tubes in clean room on wire shelves under plastic tenting which provides a low-flow nitrogen atmosphere.

### Remarks:

- Update total number of stored bags and tubes in logbook regularly.

**Global Process:** [1.3.3.1.1.2](#) – Tube Processing

**Previous:** [1.3.3.1.1.2-5](#) – Tube Cleaning Inspection

**Follow-Up:** [1.3.1.7](#) – Matrix Assembly  
*[all stored tubes]*