

Dual Phase Field Cage Module Assembly Procedure

V 2.0 – June 13, 2017

1.0 Purpose and Scope

This procedure provides instructions for inspection, cleaning, assembly testing, and packaging of the Dual Phase Field Cage (DP_FC) submodules. UTA is responsible for the cleaning, assembly, and packaging of the field cage components which will be done in the warehouse area of the Chemistry and Physics Building. UTA will process, package, and send the final product to CERN.

2.0 References

- 2.1 ASTM D4385-13, "Standard practice for classifying visual defects in thermosetting reinforced plastic pultruded products"
- 2.2 ASTM D3917-15a, "Standard specification for dimensional tolerance of thermosetting glass-reinforced plastic pultruded shapes"
- 2.3 DP-FC-001, Field Cage Modules Overview
- 2.4 DP-FC-002, 1st Sub Module Main Beam, 6 Inch I-Beam
- 2.5 DP-FC-003, 2nd Sub Module Main Beam, 6 Inch I-Beam
- 2.6 DP-FC-004, 3rd Sub Module Main Beam, 6 Inch I-Beam
- 2.7 DP-FC-005, Fixing Plate Sub Modules 1
- 2.8 DP-FC-006, Fixing Plate Sub Modules 2
- 2.9 DP-FC-007, Cathode Fixing Plate
- 2.10 DP-FC-008, Horizontal Beam, 3 Inch I-Beam
- 2.11 DP-FC-009, Horizontal Beam L-Profile, 3x3x1/4 Inch L
- 2.12 DP-FC-010, Cathode Blocking Plate
- 2.13 DP-FC-011, Plate Between Modules
- 2.14 DP-FC-012, Insert for Modules Plate
- 2.15 DP-FC-013, Insert for Cathode Connection
- 2.16 DP-FC-014, Insert Sub Modules 1
- 2.17 DP-FC-015, Insert Sub Modules 2
- 2.18 DP-FC-016, Insert for L Short
- 2.19 DP-FC-017, Insert for L Long
- 2.20 DP-FC-018, Plate for FC Corner
- 2.21 DP-FC-019, L-Profile for FC Corner, 3x3x1/4 Inch L
- 2.22 DP-FC-020, Insert for FC Corner

3.0 Attachments

DP_FC_QC Inspection Checklist

4.0 Procedure

- 4.1 Receipt Inspection
 - 4.1.1 Aluminum Profiles

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Inspect Aluminum profiles for deformation and surface scratches.
Unsatisfactory profiles will be scrapped.

4.1.2 I-Beams and Fiber Reinforced Plastic (FRP) Plates

4.1.2.1 Perform Visual Inspection of material for the following defects:

- Category 1 defects (severe):
 - cracks affects structural integrity (not acceptable)
 - fractures not acceptable (affects integrity)
 - delamination (separation of two or more layers) not acceptable (affects structural integrity)
 - dry fiber (lack of resin fillout) not acceptable (affects structural integrity)
 - burn or thermal decomposition affects structural integrity

 - blisters (!) —> ok if small

what is acceptable from water absorption/LAr contamination point of view?
 - undercure (dull or bleached surface) not acceptable (affects structural integrity)
 - flatness of surface/wrinkle depression not acceptable
 - Critical dimension (the distance between the holes for the inter-submodule connecting plates and the profile slots on the 6" I-Beams) measurement in Fig. 1-1 outside of the tolerance, 0.5mm, compared to drawings DP-FC-002, DP-FC-003 and DP-FC-004.
- Category 2 defects (problematic only if large):
 - crater or shrink mark ok if part thickness is still within specs
 - craze ok (if on surface/ in resin)
 - chips small ok but must be < 10mm long/wide; chips past surface veil not acceptable
 - dullness determine size of affected area
 - * if large likely due to insufficient cure (e.g. cured from outside in) not acceptable (affects integrity) but could be repaired by postcure
 - * if abbreviated in size: ok, purely cosmetic

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- saw burn in principle ok, would be covered by resin or epoxy ?
- exposed reinforcement ok if < 11,1 mm from edge and < 25% of width of surface or <10% of circumference
- grooving ok if material thickness reduction <10% and groove width < 3.2mm
- die parting line ok on surface (e.g. within 0.5 mm) and if no loose fibers
- internal shrinkage cracks ok, if crack does not reach surface or penetrate through internal reinforcement layer
- porosity/internal voids does not affect structural integrity
 - if < 2 pinholes for every 1.6mm of thickness per 25.4 mm width

Is this acceptable from water absorption/LAr contamination point of view ?

- porosity/surface voids does not affect structural integrity

Is this acceptable from water absorption/LAr contamination point of view ?

- reinforcement distortion ok if fits within 76.2 mm (3") circle
- resin rich area ok
- roving knot ok
- scale ok, if no sharp exposed edges
- scuffing ok (if <30 cm long, <19mm wide)
- discolorations mostly harmless

4.1.2.2 Perform a dimensional inspection of the I-beam and FRP Plates for the following dimensions:

- cross sectional dimensions for rods, plates and bars
- length
- straightness
- flatness
- camber
- Critical dimension within the tolerance 0.5mm (see Fig. 1-1) of the dimensions specified in drawing DP-FC-002, 003 and 004.

The items shall meet the following acceptance criteria taken from Reference 2:

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The inspections will be documented on the attached forms.

TABLE 1 Cross-Sectional Dimensions—Standard Rods, Bars, and Shapes

The diagram illustrates a pultruded section with three key dimensions labeled A, B, and C. Dimension A represents the 'Die Struck Dimension' and is shown as the overall width of the section. Dimension B represents the 'Wall Thickness' for open shapes and is shown as the thickness of the flange. Dimension C represents the 'Wall Thickness' for closed shapes and is shown as the thickness of the web.

Solid Dimensions, ±in. (mm)					
A Die Struck Dimension ^{A, B}	B Wall Thickness ^B (Open Shape)	B Thickness (Flat Sheets)		C Wall Thickness ^B (Closed Shape)	
		Thickness			
		0.125 (3.175) and under	over 0.125 (3.175)		
±4 %	±10 %	±15 %	±10 %	±20 %	
0.094 (2.39) max	±0.010 (0.25) min	±0.010 (0.25) min	±0.050 (1.27) max	±0.010 (0.25) min	

^AThe outside dimension of a part.

^BStandard pultruded section with dimension up to 36-in. (914-mm) diameter.

TABLE 2 Length—Standard Rods, Bars, Shapes, and Flat Sheet

	Allowable Deviation from Specified Length, +, - in. (+, - mm), except as noted		
	Length up to 8 ft (2.44 m) inclusive	Length over 8 to 24 ft (2.44 to 7.32 m) inclusive	Length over 24 ft (7.32 m)
	All Rods, Bars, and Shapes +0.25, -0 (+6.35, -0)	+0.5, -0 (+12.7, -0)	+3, -0 (+76.2, -0)

TABLE 3 Straightness^A—Standard Bars, Rods, Shapes, and Flat Sheet

Product	Specified Diameter (Rods) Specified Width (Bars) Max Dimension (Shapes)	Specified Thickness (Rectangles) Minimum Thickness (Shapes)	Allowable Deviation (D) from Straight, in. (mm)	
	in. (mm)	in. (mm)	In Total Length of Piece 0.030 (2.5) × length, ft (m)	
Rods and square, hexagonal, and octagonal bars	all	...		
Rectangular bars	Up to 1.499 (38.07), incl	Up to 0.094 (2.4), incl	0.050 (4.17) × measured length, ft (m)	
		0.095 (2.4) and over	0.040 (3.33) × measured length, ft (m)	
Shapes—Open	1.500 (38.10) and over	all	0.040 (3.33) × measured length, ft (m)	
Shapes—Closed	all	all	0.050 (4.17) × measured length, ft (m)	
Flat Sheet	all	all	0.030 (2.5) × measured length, ft (m)	
	all	all	0.030 (2.5) × measured length, ft (m)	

^AMeasured when weight of pultrusion minimizes the deviation by contact with flat surface.

Figure 1: Dimensional Tolerances

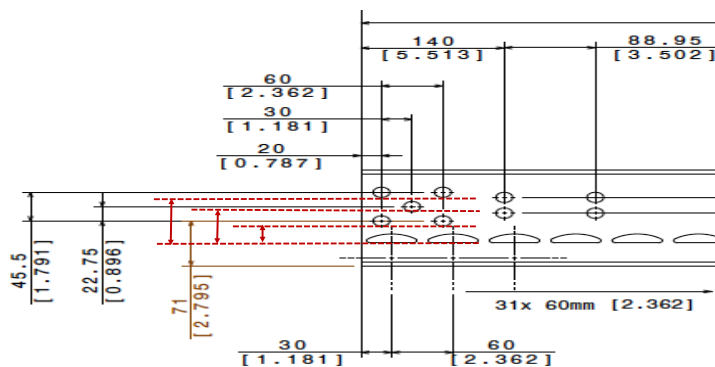


Figure 1-1: Critical Dimensional Measurement, the red arrows specify the places to measure

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TABLE 5 Flatness (Flat Surfaces)—Standard Bars, Solid Shapes, Semihollow Shapes, and Flat Sheet

Surface Width, in. (mm)	Maximum Allowable Deviation (<i>D</i>), in. (mm)
	
Up to 1 (25.4), incl	0.008 (0.20)
Over 1 (25.4)	$0.008 (0.008) \times W$, in. (mm)
In any 1 in. (25.4 mm) of width	0.008 (0.20)
Flat Sheet	$0.008 (0.008) \times W$, in. (mm)
	0.25 (6.35) Max

TABLE 6 Flatness (Flat Surfaces)—Standard Hollow Shapes

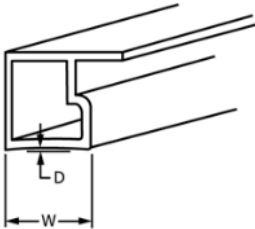
Minimum Thickness of Composite Forming the Surface, in. (mm)	Maximum Allowable Deviation (<i>D</i>), in. (mm)
	
	Widths up to 1 in. (25.4 mm), incl, or any 1-in. (25.4-mm) Increment of Wider Surfaces
	Widths over 1 in. (25.4 mm)
Up to 0.187 (4.7), incl	0.012 (0.30)
0.188 (4.8) and over	0.008 (0.20)
	$0.012 (0.012) \times W$, in. (mm)
	$0.008 (0.008) \times W$, in. (mm)

Figure 2: Flatness Tolerances

TABLE 8 Camber—Standard Shapes (See 3.8)

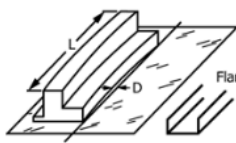
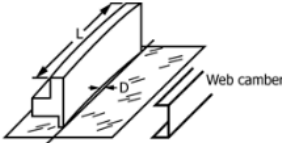
			
	Flange camber	Web camber	
Product	Envelope Diameter (Shapes) in. (mm)	Minimum Thickness (Shapes) in. (mm)	Allowable Deviation (<i>D</i>) from Straight, in. (mm) In total length of piece
Shapes	All	Up to 0.094 (2.4), incl	0.050 (4.17) x measured length, ft (m)

TABLE 9 Squareness of End Cut—Standard Rods, Bars, Shapes, and Flat Sheet

Profiles over 2 in. (50.8 mm) in diameter or width	$\pm 1^\circ$
Profiles 2 in. (50.8 mm) inclusive and under in diameter or width	$\pm 2^\circ$

Figure 3: Camber and Squareness Tolerances

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4.1.3 HV Divider Boards

- 4.1.3.1 Bare board visual inspection: Inspect the bare boards visually for disconnected traces and the locations of the parts soldering
- 4.1.3.2 Bare board electrical continuity test: Test continuity for each traces in warm. Test the continuity again after a thermal shock of the board.
- 4.1.3.3 Stuffed board visual inspection: Inspect the stuffed boards visually for all electrical component mounting, disconnected traces, solder quality and the locations of the parts
- 4.1.3.4 Stuffed board electrical continuity test: Test continuity for the soldering of each component in warm. Test the continuity again after a thermal shock of the board.

4.2 Deburring, defibering, sanding, polyurethane coating and cleaning of FRP Parts

- 4.2.1 Debur machined holes and slots with the deburring tool to remove large remaining pieces of the FRP from all parts
- 4.2.2 Defiber using 600 grit sandpaper followed by a wet 1500 grit sandpaper. Be sure to wear disposable long sleeve lab coats, goggles, N95 masks and nitrile gloves to protect the body. Be sure to use the shop-vac to minimize airborne fibers and dust.
- 4.2.3 Clean the I-beams and support beams with de-ionized water and “simple green” and a Kimwipe on the cleaning table.
- 4.2.4 Dry components with an air gun to remove all moisture.
- 4.2.5 Apply polyurethane coat using gloved finger as uniformly as possible in the profile slots and cut edges but not the screw holes. Wipe excess polyurethane off of I-beams using Kimwipe as much as possible. Inspect the coating quality to ensure uniform application of the coat and any remaining pieces of fiber or Kimwipe on the I-beam.
- 4.2.6 Let the polyurethane coating to dry and cure for at least 30 hours in the semi-clean room area.
- 4.2.7 After 30 hours of curing, I-beams and support beams with de-ionized water and “simple green” and a Kimwipe on the cleaning table in the semi-clean storage area.
- 4.2.8 Small parts, such as threaded rods, nuts, screws, slip-nuts and inserts will be cleaned in ethanol in an ultrasonic cleaner.
- 4.2.9 Inspect parts for cleanliness after drying.
- 4.2.10 Store the cleaned parts on the semi-clean room small parts shelves.

4.3 Assembly of DP-FC Sub Modules

Drawing “ProtoDune_DP_Field Cage 09_03_2017.pdf” shows the details of Dual Phase Field Cage modules. Assembly will be done inside the clean room at the assembly table. All the components are cleaned before delivery to this area.

- 4.3.1 A 2mx2m support based on two A-frames will be used for assembly of the sub-module

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- 4.3.2 Place the main I-beams on the A-frame tables as shown, and connect them to the horizontal I-beams using the 4 L-plates each as shown in figure 4. Make sure that the flat part of the aluminum profile slot faces up so that the assembly of the profiles can be done without further manipulation of the FRP frames.

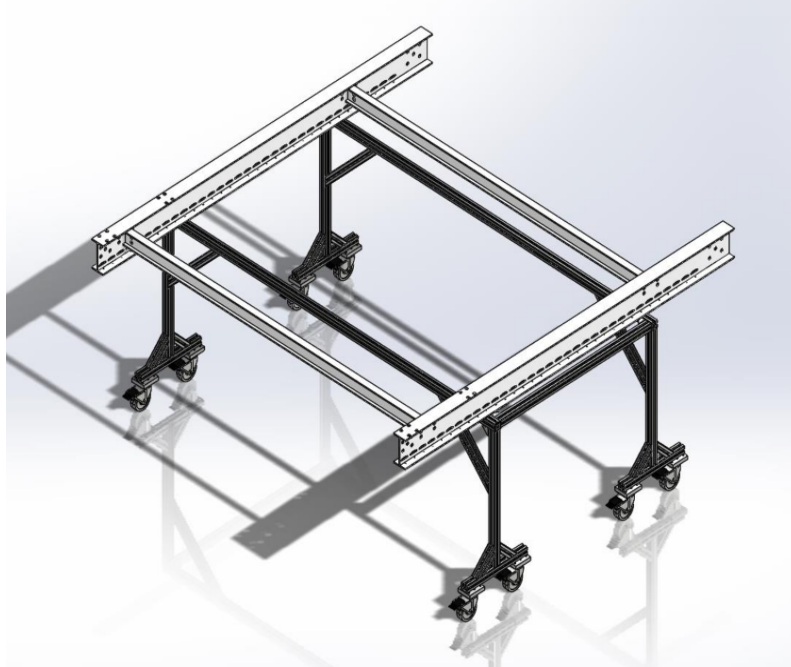


Figure 4 – 2mx2m A-Frame based support schematic diagram

- 4.3.3 The field-shaping profiles, as shown in figure 5, should slide through the cutouts on both main I-beams and connect using a slip nut and screw arrangement on one of the two primary I-beams close to the bent profile.



Figure 5 DP FC Field-shaping Profile with a 45 degree bend on one end.

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- 4.3.4 Check the alignment of the I-beams and profiles to be sure they're straight.

4.4 Disassembly and Packaging

- 4.4.1 Once the fitness of all parts is ensured, disassemble and collect the parts - screws, nuts and threaded rods, visually inspect the integrity and the cleanliness of the parts, and put them in a zip-lock bag for safe keeping.
- 4.4.2 Slide all aluminum profiles out of the slots carefully and store them onto the storage shelf one at a time.
- 4.4.3 Disassemble the I-beams. Tag all I-beams by the drawing number and sequence number, e.g. DP-FC-002-1, DP-FC-002-2, etc. Collect all nuts, threaded rods, and inserts as they are taken off, visually inspect the integrity and cleanliness of the parts, and bag them in a smaller bag. This bag should then be inserted into the bag on step 1 above.
- 4.4.4 Collect all I-beams and wrap them in a shrinkable plastic sheet sufficiently large to completely seal all of them in one package.
- 4.4.5 Tape securely the small parts bag onto the I-beam.
- 4.4.6 Seal the package with large cling wrap separately twice to ensure a good seal.
- 4.4.7 Wrap the cling wrapped package with a large bubble wrap and tie it strong with a plastic package strap, properly protecting the edges of the I-beams.
- 4.4.8 Move them into the storage area and stack them for shipping for reassembly at CERN.