Front Wing Inserts 2025-26

DCR

Requirement	Description	Design Implementation	Validation Method
1. Rule Compliance			
T.7.1.3	All aerodynamic devices must be rigidly mounted to ensure they remain stable and do not oscillate or flex excessively while the vehicle is in motion.	Rule	Pre-comp testing
T.7.1.4	All forward facing edges that could contact a pedestrian (wings, end plates, and undertrays) must have a minimum radius of 5 mm for all horizontal edges and 3 mm for vertical edges.	Rule	Mock Tech
IN.6.6.2	If any deflection is significant, then a force of approximately 200 N may be applied. In this situation, loaded deflection should be no more than 25 mm and permanent deflection should be less than 5 mm.	Rule	Mock Tech
2. Structural Requirements			
SR.1	The front wing inserts shall maintain a positive margin to yield and ultimate under all specified loading conditions (aero loads + cone strike + inertial loads).	FEA	Proof Load
SR.2	Should not alter CL and CD of the Front Wing	CFD	Wind Tunnel
SR.3	First Natural frequency of the front wing assembly shall be at least three times the dominant road input frequency (4-5Hz).	FEA	Pre-comp testing
SR.4	Deflection under static loads shall less than 0.125"	FEA/ Hand calc	Assembly
3. Serviceability			
SV.1	All fasteners should be accessible and serviceable using standard team-issued hand tools as well as reusable fasteners (that don't get threaded in one use).	CAD/use of standard hardware	Assembly
SV.2	The design shall incorporate a +/- 0.125" positional tolerance on all mounting points.	CAD	Assembly
SV.3	Front wing system shall be assembled and mounted by 2 people in 15 minutes	Thought out fastener placement	Test time
4. Manufacturability			
MF.1	Inserts should be manufactured within 2 weeks.	DFM and detailed production outline	Time

Analysis

Manufacturing - Materials

FDM Printing (Note Statasys uses ASTM (for Young's Modulus and Heat deflection) and IZOD (for Impact) while Polymaker uses a mix of ISO, DSC testing methods).

	Polymaker Polylite PETG	Stratasys Nylon 6	Stratasys Nylon 12	Stratasys PA11	Polymaker PPS-CF10	ABS CF 3D Tech	CarbonX Nylon 12
Young's Modulus (Upright - ZX)	2116.8 ± 68.1 MPa	1,817 MPa	3,000 MPa	1609 MPa	4646.9 ± 136.9 MPa	5120 MPa	8000 MPa
Heat Deflection (@1.8mpa)	75 °C	93 °C	93 °C	47 °C		76 °C	150 °C

Impact (ZX)	Charpy Impact strength (X-y) **2.6± 0.2 kJ/m2**	IZOD impact test Notched **106 J/m** Unnotched) **2,873 J/m (big number = good)**	Notched **106 J/m** Unnotched **346 J/m (not sure what happened here)**	Notched **4.5 Kj/m^2** (Used ASTM D256-10)	Notched **5.3 ± 0.2 kJ/m2** Unnotched **11.4 ± 0.7 kJ/m2** (Testing specimen were annealed prior, which can increase strength from 7-25%)	**Not listed**	**Not listed**
Ultimate Tensile Strength **XZ -** (printed sideways) **ZX -** (printed upright)	**Not listed**	**ZX -** 36.5 MPa **XZ** - 67.6 MPa	(Strength @Break) **ZX** - 32.7 MPa **XZ** - 83.5 (1.7) MPa	Ultimate Tensile Strength 45 °C **ZX** - (.74 * 47) = 34.78 MPa **XZ** - (.75 * 51) = 38.25 MPa	**Not listed**	Tensile Strength, Break 46 MPa	72 MPa
Notes	It's entirely possible Polymaker filament has yielded these results, just as Stratysys has. The Charpy Impact strength test is specifically designed for metals in mind, so using a method inherently not designed for plastics can yield this result. This also unfortunately doesn't make the results conveniently comparable since they are measured differently.						

Switch from FDM to SLS manufacturing for small element inserts.

Smaller element inserts will now be manufactured in-house via Simon Czuwal 's Bambu P1S as opposed to outsourcing them via SLS through a sponsor like Stratasys. This is done since:

- The inserts handle smaller loads, so our 3D prints will be able to sustain element aero loads.
- Simplifies the manufacturing process; rather than sending files back and forth to the sponsor, we can simply have a printed part ready for review / iteration.
- Speed. FDM in-house printing is simply much faster than outsourcing a prints.

The material that will be replacing Stratasys' own SLS offerings is listed below, as well as a comparison of its different properties.

All material strengths are assessed assuming printing is done in the XY orientation, which gives the highest strength for each material.

Legend:

Stratasys: (S)

Nylon11: N11

Nylon 12: N12

3DXTech: 3DX

Name	(S) N11FR	(S)N12AF	(S)N12CF	(S)N12FR	(S)N12GF	(S)N12HST	(S)N12PA	3DXN12PA
Density (g/cc)	1.04	1.36	1.07	1.02	1.25	1.2	.95	1.16
Tensile Strength (MPa)	46	32 MPa	60	48	44	48	46	72 (Assessed at Break)
Tensile Modulus (MPa)	1,586	2580	3654	1700	3585	5,500	1700	8000
Flexural Modulus (MPa)	1551	1990	6067	1500	2834	4412	1300	7900
Flexural Strength (MPa)	55	54	113	**Not Listed**	72	85	47	90

Condensed table

Name	Stratasys Nylon 12 CF	Stratasys Nylon 12 HST	3DXTech Nylon	Ultrafuse PAHT CF15	Aluminum 7075
Density (g/cc)	1.07	1.2	1.16	1.203	2.81
Tensile Strength (MPa)	60	48	72 (Assessed at Break)	103.2	503 (ultimate 572)
Tensile Modulus (MPa)	3654	5,500	8000	8386	
Flexural Modulus (MPa)	6067	4412	7900	8258	
Flexural Strength (MPa)	113	85	90	160.7	
Elastic Modulus **(GPa)**					71.7 MPa

Conclusion (for table above)

While 3DXTech's Nylon 12PA outperforms Stratasys' Nylon 12 materials in every assessment of Tensile and Flexural Modulus / Strength, it must be noted that while Stratasys uses ASTM tests, 3DXTech uses ISO tests to assess these properties.

Based on this comparison (although not all of Stratasys' Nylon 11 were assessed here), The 3DXTech Nylon 12 filament, which is compatible with our FDM-printing capabilities, is suitable for printing the smaller wing elements.

To-do: Cost/time benefit analysis of inserts fdm. Ultrafuse vs 3Dxtech vs sls Stratasys,

	SLS	SLS	FDM	FDM
	Stratasys NYLON CF12	Stratasys Nylon HST	3DXTech Nylon	Ultrafuse PAHT CF15
Weight (g)	115.23	129.23	124.92	129.55
Weight (lb)	0.254	0.285	0.275	0.286
Cost	Free	Free	21.98592	15.01916333
Time	24 Hours + Pickup time	24 Hours + Pickup time	4h41m	4h41m
Dollars per gram	Free	Free	0.176	0.1159333333
Density	1.07	1.2	1.16	1.203

Conclusion

Ultrafuse PAHT-CF15, given its tensile properties, is fit for printing smaller inserts and will be ordered. A cost analysis sheet can be found here and will be uploaded to sharepoint.

Testing

Deadlines

Timeline and Tasks

Deadline	Date	Deliverables