

REFERENCES

The main sources used for this document are indicated below. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

3M, 2011. *Technical data sheet for the Growth Market car.*

[Online] Available at:

http://www.visteon.com/innovate/growthmarket/pdfs/3M_Paint_Protection_Film.pdf

[Accessed 10 November 2013].

AWR., n.d. *A.W.R. Smith Process Instrumentation cc.*

[Online] Available at:

<http://www.instruments.co.za/Catalog/Surface%20Roughness%20Tester.htm>

[Accessed 10 November 2013].

Aiken, D. & Aiken, Z. 2012. *Fibre glass repair polyester or epoxy*. 2nd ed. Atglen, PA: Schiffer Publishing, Ltd.

AMT Composites, 2013. *AMT composites.*

[Online] Available at: <http://www.amtcomposites.co.za/>

[Accessed 10 November 2013].

Argotec, 2008-2013. *The clear choice, why polyurethane.*

[Online] Available at: http://www.argotec.com/P_WhyPolyurethane.html

[Accessed 10 November 2013].

AVS, Opencart, 2013. *Auto vinyl solutions.*

[Online] Available at: http://autovinylsolutions.com/3M_1080/Gloss_White_Vinyl_Wrap

[Accessed 10 November 2013].

Babin, P. n.d. *Working with acrylic.*

[Online] Available at: <http://www.bcae1.com/plexi.htm>

[Accessed 10 November 2013].

Berg, P. 2013. *POPULAR MECHANICS, How to vinyl-wrap a car.*

[Online] Available at:

<http://www.popularmechanics.com/cars/how-to/repair/how-to-vinyl-wrap-a-car#slide-1>

[Accessed 10 November 2013].

Campbell, F. 2004. *Manufacturing processes for advanced composites*. Oxford: Elsevier Advanced Technology.

Canning, W. 1982. *The Canning handbook: surface finishing technology*. 23rd ed. New York: W. Canning plc. Birmingham.

Catia, 2012. *Catia Tutor, your best way to learn Catia V5.*

[Online] Available at: <http://catiatutor.com/Basic/CATIA-Handbook/class-a-surfacing.html>

[Accessed 10 November 2013].

Clubkit clearcote, n.d. *Clubkit clearcote*.

[Online] Available at:

<http://www.clubkitclearcote.com/instructions/Howtomake%20a%20fiberglass%20mold.pdf>

[Accessed 10 November 2013].

CNC cookbook, n.d. *CNC cookbook software and information for machinist*.

[Online] Available at:

<http://www.cnccookbook.com/CCCNCMillFeedsSpeeds.htm>

[Accessed 10 November 2013].

Coetzee, G. 2013. *Jonker Sailplanes 10day production cycle* [Interview] (4 October 2013). Notes in possession of the author of this dissertation.

Degarmo, E.P., Black, J.T. & Kohser, R.A., 2003. *Materials and processes in manufacturing* (9th ed.). In: s.l.:Wiley, p. 223.

Dirks, W. 2012. *DG Flugzeugbau GmbH*.

[Online] Available at: <http://dg-flugzeugbau.de/pur-lack-e.html>

[Accessed 10 November 2013].

DME. 2013. Plastic University, Mold Technology Series. [Online]

Available at: <http://www.dmeuniversity.net/english/c5.cfm?index=1>

[Accessed 10 November 2013].

Duffy, J. 2004. *Auto body repair technology*. 4th ed. New York: Thomson, Delmar Learning.

Farlex, Inc., 2012. *The free dictionary*.

[Online] Available at: <http://www.TheFreeDictionary.com/>

[Accessed 10 November 2013].

Fibreglass Warehouse, 2013. *Learning centre, gelcoat application and preparation*.

[Online] Available at: https://www.fiberglasswarehouse.com/gelcoat_application.php

[Accessed 10 November 2013].

Fibreglast, 2012. *Plug surface preparation and mold surface maintenance*.

[Online] Available at:

<http://www.fibreglast.com/product/plugin-surface-preparation-and-mold-surface-maintenance>

[Accessed 10 November 2013].

Gaunle, K. 2012. *ehow-Surface Finish Specifications*. [Online]

Available at: http://www.ehow.com/list_7684300_surface-finish-specifications.html

[Accessed 10 November 2013].

GlasCraft. 2012. *GlasCraft*. [Online]

Available at: <http://www.glascraft.co.uk/product.asp?catid=76&prodid=560>

[Accessed 10 November 2013].

Gliding Federation of Australia. 2001. *Chapter 3: Basic theory*. In: *Basic gliding knowledge*. Victoria, Australia: The Gliding Federation of Australia, p. 130.

Haddock, R. 2002. *Paint finishes for metal*. Metalmag. March/April 2002. [Online]
Available at: http://www.metalcoaters.com/pdf/AtoZPrt3_reprint.pdf
[Accessed 20 May 2014]

H&M. 2011. *H&M Houtbewerkingsmasjiene*. [Online]
Available at: <http://h-m.nl/index.php?lang=nl-NL>
[Accessed 10 November 2013].

Höchsmann GmbH, 2007-2013 . *Höchsmann, technology for wood*. [Online]
Available at:
<http://www.hoechsmann.com/index.php?module=16&category=1&fbID=11345&lang=en>
[Accessed 10 November 2013].

James Town Distributors, 2008. *MEKP Liquid hardener*. [Online]
Available at:
http://www.jamestowndistributors.com/userportal/show_product.do?pid=2084
[Accessed 10 November 2013].

Jones, R. 2006-2007. *One piece fibre glass mold construction*.
[Online] Available at: <http://www.fiberglassmoldmanual.com/>
[Accessed 10 November 2013].

Jonker, A. 2003. *Laminate analysis of composite materials*. Potchefstroom, SA: NWU,
Mechanical Engineering.

Julie, Z. Joseph, C. & Kirby, E., 2006. *Surface roughness optimisation in an end-milling operation using the taguchi design method*. Journal of Material Processing Technology.

Kirchoff, H, 2011. *ehow - SPI mold finish standards*. [Online]
Available at: http://www.ehow.com/info_12214752_spi-mold-finish-standards.html
[Accessed 10 November 2013].

Lion-Cachet, B., 2013. *AMT composites, Infusion tooling process for high temperature processing* [Interview] (March 2013). (Notes in possession of the author of the dissertation)

Lion-Cachet, B., 2013. *Zyvax - Mould release philosophy and application presentation*. Johannesburg: AMT Composites.

LLC. 2013. *Dictionary.com*. [Online]
Available at: <http://m.dictionary.com/>
[Accessed 10 November 2013].

MacKenzie, D. 2008. *Metrology centre, surface texture measurement fundamentals, technical seminar, metrology center open house*. [Online]
Available at:
<http://www.metrologycenter.com/Open%20House/Surface%20Texture%20Measurement%20Fundamentals%20For%20Metrology%20Center%20Open%20House.pdf>
[Accessed 10 November 2013].

Mike, S., Caleb, M. & Li, D. 1998-1999. *Surface Roughness prediction technique for CNC end-milling*. Journal of Industrial Technology, Volume 15(1):bladsynommers.

- Mjet, 2006. *Grafiwrap vehicle wrapping system*. [Online]
Available at: <http://www.sesoma.lv/sites/sesoma.lv/files/Grafiwrap-Spec.pdf>
[Accessed 10 November 2013].
- Morena, J. 1994. *Advanced composite mould making*. Malabar, Florida: Krieger Publishing Company.
- NGCC, 2013. *Network group for composites in construction, Glossary*. [Online]
Available at: <http://www.ngcc.org.uk/Information/Introduction/Glossary.aspx>
[Accessed 10 November 2013].
- Paint Shield, n.d. *Automotive protection specialists*. [Online]
Available at: <http://www.paintshield-china.com/en/paint-protection-film-101.php>
[Accessed 10 November 2013].
- Pandey, P., 2004. *Composite material, web based course*. [Online]
Available at: <http://ecourses.vtu.ac.in/nptel/courses/Webcourse-contents/IISc-BANG/Composite%20Materials/Learning%20material%20-%20composite%20material.pdf>
[Accessed 10 November 2013].
- Perspex SA, n.d. *Perspex South Africa, acrylic sheet information manual*. [Online]
Available at:
<http://www.perspex.co.za/Uploads/TechnicalManual/663ACRYLIC%20SHEET%20INFORMATION-COMPLETE.pdf>
[Accessed 10 November 2013].
- Pilkington, 2009. *Pilkington plateau*. [Online]
Available at:
http://www.pilkington.com/assetmanager_ws/fileservlet.aspx?cmd=get_file&file_id=1008&digest=Hr0z66OF19XN3gkbZu611w==&ct=pdf
[Accessed 10 November 2013].
- Raja, M., November, 2005. *Experimental optimization of process parameters to obtain class a surface finish in resin transfer moulding process*. Montreal: Doctorial Thesis, Department of Mechanical Engineering, McGill University.
- Rapp, P., 2002. *Surface roughness & conversion tables*. In: *Engineers black book*. 2nd Ed. Perth, Western Australia: Pat Rapp Enterprises, p. 150.
- Rashid, M. & Abdul Lani, M., 2010. *Surface roughness prediction for cnc milling process using artificial neural network*. World Congress on Engineering 2010, Vol III, WCE.
- SP systems, 2013. *AMTcomposites, guide to composites. the advantages of epoxy resin versus polyester in marine composite structures*. [Online]
Available at:
<http://www.amtcomposites.co.za/sites/default/files/media/howto/Advantages%20of%20Epoxy%20over%20Polyester.pdf>
[Accessed 10 November 2013].
- SPAREPARTS, 2012. *Pistonheads*. [Online]
Available at: <http://www.pistonheads.com/gassing/topic.asp?t=1125982>
[Accessed 10 November 2013].

Standex, 2008. *Standex*. [Online]
Available at: <http://www.standex.co.za/>
[Accessed 10 November 2013].

Sunbelt Materials, 1998. *Sunbelt materials*. [Online]
Available at: http://www.sunbeltmaterials.com/clcoat_intro.htm
[Accessed 10 November 2013].

Sutherland, J., 2009. *The John W. Sutherland research page*. [Online]
Available at: <http://www.mfg.mtu.edu/cyberman/quality/metrology/surface.html>
[Accessed 10 November 2013].

The Eastwood company, 2013. *Eastwood do the right job*. [Online]
Available at: <http://eastwood.com/1k-coating-vs-2k-coatings>
[Accessed 10 November 2013].

The mold polishing Co. Inc., 2012. *The mold polishing Co. Inc.*. [Online]
Available at: <http://www.moldpolishing.com/FinishingGuide.htm>
[Accessed 10 November 2013].

TIA 1, Technology Innovation Association, 2011-2012. *Standard workshop practise 13 composite repairs*. TIA. Available at Potchefstroom: Jonker Sailplanes

TIA 2, Technology innovation association, 2011-2012. *Standard workshop practise 28 spraying facilities*. TIA. Available at Potchefstroom: Jonker Sailplanes

TIA 3, Technology innovation association, 2011-2012. *Standard workshop practise 29 Spraying Facilities*. TIA. Available at Potchefstroom: Jonker Sailplanes

TIA 4, Technology innovation association, 2011-2012. *Standard workshop practise 36 release agents*. TIA. Available at Potchefstroom: Jonker Sailplanes

TIA 5, Technology innovation association, 2011-2012. *Standard workshop practise 41 composite tooling*. TIA. Available at Potchefstroom: Jonker Sailplanes

TIA 6, Technology innovation association, 2011-2012. *Standard workshop practise 50 glossary*. TIA. Available at Potchefstroom: Jonker Sailplanes

TIA 5, Technology innovation association, 2011-2012. *Standard workshop practise 10 composite repairs*. TIA. Available at Potchefstroom: Jonker Sailplanes

Trotec, n.d. *Laser, Marking, cutting, engraving*. [Online]
Available at: www.troteclaser.com
[Accessed 10 November 2013].

VISI, n.d. *VISI*. [Online]
Available at: <http://www.visicadcam.com/products>
[Accessed 10 November 2013].

VPS, 2012. *Vehicle protection shield*. [Online]
Available at: http://www.vpsprotection.co.za/Aviation_Home/aviation_home.html
[Accessed 10 November 2013].

Wanberg, 2009. *Composite materials fabrication handbook #1*. Stillwater: Wolfgang Publications Inc.

Wanberg, 2012. *Composite materials fabrication handbook #2*. Stillwater: Wolfgang Publications Inc.

APPENDIX A: FACTORY MOULD SURVEY DATA

This Appendix explains the mould evaluation survey conducted in the Jonker Sailplanes factory. The survey yielded valuable information on critical aspects of moulds. The survey was conducted on the moulds of the following parts of the JS1 Revelation, as illustrated below. The survey was conducted during the manufacturing of serial numbers 45 to 50.

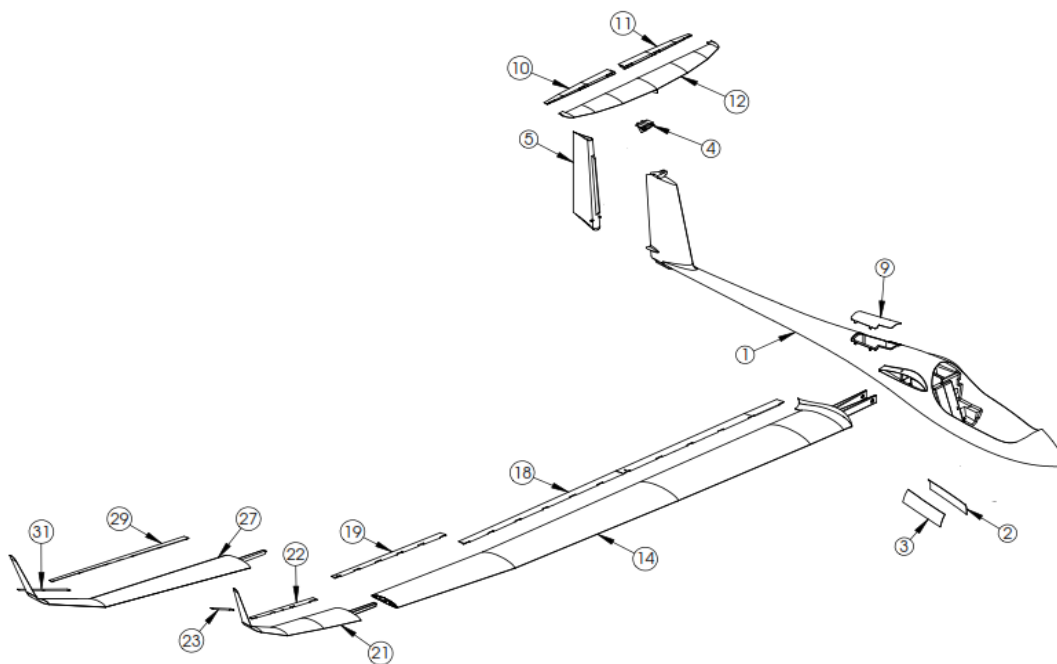
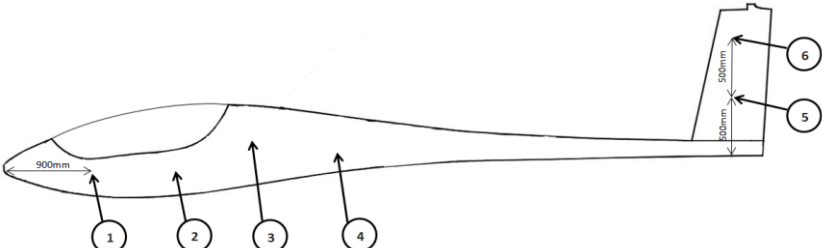


Figure A-0-1: Evaluated parts of the JS1. (Coetzee, 2013)

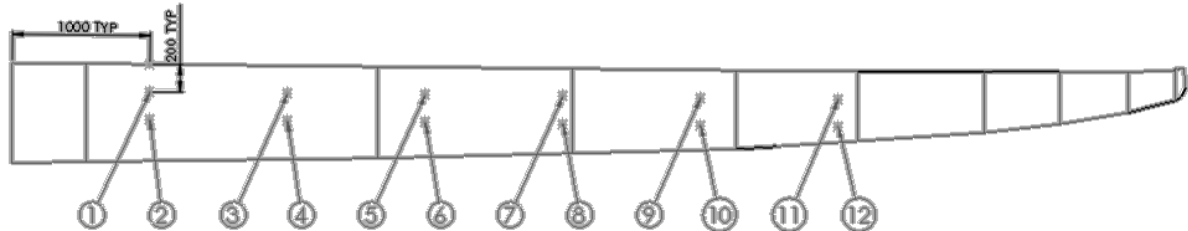
Table A-1: Parts & moulds evaluated in the survey

1	Fuselage	4	Elevator auto coupler
5	Rudder	10&11	Elevators
12	Tailplane	14	Wings
18	Flap 1	19	Flap 2
21	18 m Wing Tip	22	Flap 3 (18 m)
23	Flap 4 (18 m)	27	21 m Wing Tip
29	Flap 3 (21 m)	31	Flap 4 (21 m)

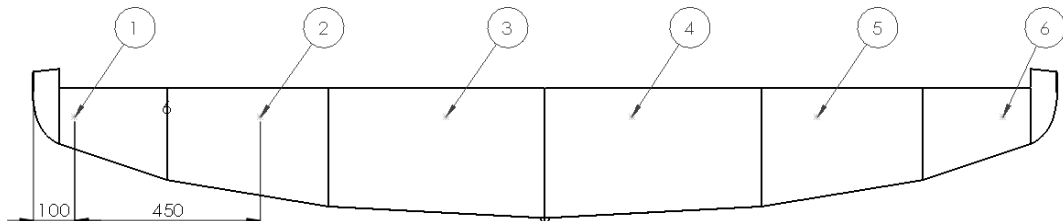
A.1. FUSELAGE & FUSELAGE MOULD

MOULD DIMENSIONAL DESCRIPTION						LENGTH:		10 m							
						WIDTH:		1.5 m							
						FLANGE WIDTH:		140 mm							
						THICKNESS:		8 mm							
						BACK SUPPORT HEIGHT:		900 mm							
															
MATERIAL				Glass fibre structure with tooling gelcoat surface				ALIGNMENT				Metal alignment pins and bushes. Bushes are open at the back. Pin diameter 20 mm, 15mm long, taper.			
INTERSECTION CORNER STRENGTHENING				Metal strip for trimming				DEMOULDING FEATURES				4mm gap formed by predesigned bonding line. None for section demoulding step			
															
1L	1R	2L	2R	3L	3R	4L	4R	5L	5R	6L	6R	AVE			
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):															
0.084	0.107	0.118	0.114	0.109	0.173	0.085	0.111	0.123	0.116	0.112	0.178	0.119			
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):															
0.118	0.156	0.167	0.163	0.162	0.244	0.117	0.158	0.165	0.167	0.160	0.247	0.169			
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):															
0.066	0.065	0.056	0.086	0.063	0.050	0.061	0.067	0.053	0.087	0.060	0.053	0.064			
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system									
BONDING LINE THICKNESS						4mm									
INTERSECTION CORNER QUALITY						Slightly damaged.									
TIME USED FOR FINISHING PART				87.4 HOURS		P600 GRIT SANDING		15.5 HOURS		CALCULATED PERCENTAGE		18%			
(Coetzee, 2013)															

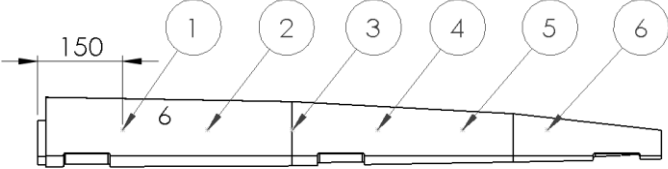
A.2. WING & WING MOULD

MOULD DIMENSIONAL DESCRIPTION				LENGTH:		10 m						
				WIDTH:		Between 700 mm and 900mm						
				FLANGE WIDTH:		80 mm to 200 mm						
				THICKNESS:		80 mm						
				BACK SUPPORT HEIGHT:		800 mm to 1200 mm						
												
MATERIAL		Nuceron651, Axson F16 surface layer		ALIGNMENT		Metal alignment pins and bushes. Bushes are close at the back. Pin diameter 20 mm, 15mm long, taper.						
INTERSECTION CORNER STRENGTHENING		Metal strips		DEMOULDING FEATURES		2mm gap formed by bonding line. None for section demoulding step						
												
1T	1B	2T	2B	3T	3B	4T	4B	5T	5B	6T	6B	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
0.402	0.352	0.280	0.354	0.523	0.631	0.399	0.357	0.278	0.358	0.803	0.799	0.461
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
1.579	1.916	1.748	1.187	0.822	0.928	1.573	1.916	1.748	1.187	1.726	1.776	1.509
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.051	0.060	0.052	0.045	0.056	0.057	0.050	0.060	0.046	0.045	0.056	0.057	0.053
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						8 mm						
INTERSECTION CORNER QUALITY						Severely damaged, bad condition						
TIME USED FOR FINISHING SET		154 HOURS		P600 GRIT SANDING		28 HOURS		CALCULATED PERCENTAGE		18%		
(Coetzee, 2013)												

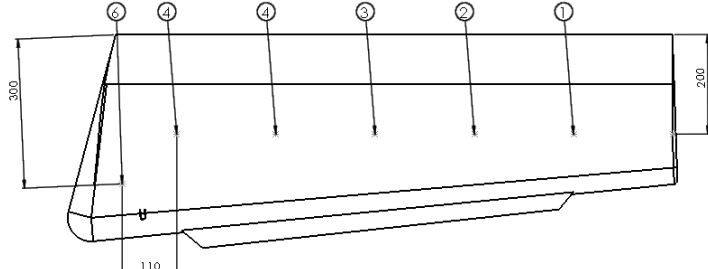
A.3. TAILPLANE & TAILPLANE MOULD

MOULD DIMENSIONAL DESCRIPTION				LENGTH: WIDTH: FLANGE WIDTH: BACK SUPPORT HEIGHT:		2700 mm average 560 mm 80 mm 900 mm						
												
MATERIAL		Glass fibre structure with tooling gelcoat surface		ALIGNMENT		Metal alignment pins and bushes. Bushes are open at the back. Pin diameter 20 mm, 15mm long, taper.						
INTERSECTION CORNER STRENGTHENING		Not strengthened		DEMOULDING FEATURES		None						
												
1T	1B	2T	2B	3T	3B	4T	4B	5T	5B	6T	6B	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
0.132	0.272	0.311	0.187	0.274	0.219	0.243	0.287	0.201	0.209	0.254	0.225	0.235
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
0.244	0.453	0.525	0.303	0.462	0.358	0.41	0.467	0.339	0.348	0.432	0.381	0.394
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.052	0.053	0.061	0.051	0.067	0.051	0.059	0.067	0.048	0.051	0.062	0.055	0.056
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						3 mm						
INTERSECTION CORNER QUALITY						Partly damaged						
TIME USED FOR FINISHING PART		25 HOURS		P600 GRIT SANDING		4 HOURS		CALCULATED PERCENTAGE		16%		
(Coetzee, 2013)												

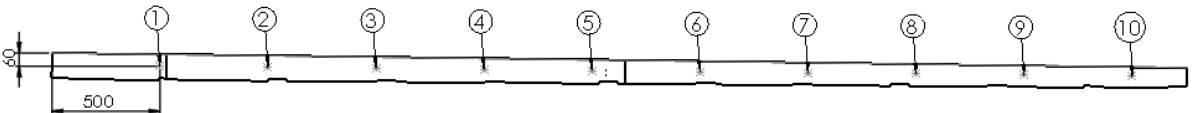
A.5. ELEVATOR & ELEVATOR MOULD

MOULD DIMENSIONAL DESCRIPTION				LENGTH:	1215 mm							
				WIDTH:	395 mm							
				FLANGE WIDTH:	50 mm							
				BACK SUPPORT HEIGHT:	200 mm							
												
MATERIAL		TOP: Nuceron651, Axson F16 surface layer BOTTOM: Glass fibre structure with tooling gelcoat surface		ALIGNMENT	Metal pins & bushes. Round pins, taper above, Ø20 mm.							
INTERSECTION CORNER STRENGTHENING		Not strengthened		DEMOULDING FEATURES	None							
												
1T	1B	2T	2B	3T	3B	4T	4B	5T	5B	6T	6B	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
0.419	0.236	0.119	0.138	0.409	0.237	0.103	0.129	0.417	0.291	0.139	0.128	0.230
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
1.673	0.953	0.402	0.488	1.673	0.953	0.402	0.488	1.673	0.953	0.402	0.488	0.879
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.058	0.055	0.046	0.045	0.056	0.053	0.049	0.051	0.052	0.061	0.047	0.052	0.052
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						1 mm						
INTERSECTION CORNER QUALITY						Severely damaged on top mould, partly damaged bottom mould						
TIME USED FOR FINISHING SET		8 HOURS		P600 GRIT SANDING		1.1 HOURS		CALCULATED PERCENTAGE		14%		
(Coetzee, 2013)												

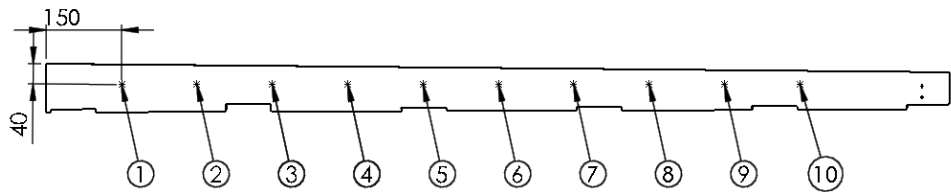
A.6. RUDDER & RUDDER MOULD

MOULD DIMENSIONAL DESCRIPTION				LENGTH: 1440 mm								
				WIDTH: 580 mm								
				FLANGE WIDTH: 50 mm								
				BACK SUPPORT HEIGHT: 900 mm								
												
MATERIAL		Glass fibre structure with tooling gelcoat surface		ALIGNMENT								
INTERSECTION CORNER STRENGTHENING		Not sure		DEMOULDING FEATURES								
				Metal pins & bushes. Tapered pins. Ø 15 mm, height 15 mm. Bushes open at back.								
				Wedge slot for top mould demould, but none for part demould.								
												
1L	1R	2L	2R	3L	3R	4L	4R	5L	5R	6L	6R	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
0.189	0.283	0.218	0.241	0.132	0.272	0.311	0.189	0.274	0.219	0.287	0.213	0.236
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
0.303	0.462	0.358	0.41	0.467	0.348	0.432	0.383	0.453	0.525	0.308	0.469	0.410
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.044	0.056	0.052	0.075	0.052	0.061	0.047	0.052	0.053	0.049	0.051	0.049	0.053
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						Leading edge: 10 mm, Trailing edge: 2 – 3 mm						
INTERSECTION CORNER QUALITY						Partly damaged						
TIME USED FOR FINISHING PART		31.4 HOURS		P600 GRIT SANDING		4 HOURS		CALCULATED PERCENTAGE		13 %		
(Coetzee, 2013)												

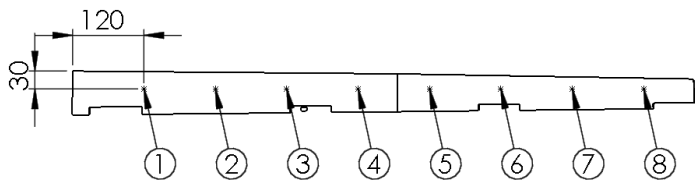
A.7. FLAP 1 & FLAP 1 MOULD

MOULD DIMENSIONAL DESCRIPTION						LENGTH:		2970 mm																	
						WIDTH:		670 mm																	
						FLANGE WIDTH:		150 mm																	
						BACK SUPPORT HEIGHT:		1 m																	
																									
MATERIAL			Nuceron651, Axson F16 surface layer			ALIGNMENT			Round, untapered metal pins & bushes; Ø 15 mm, 10 mm high.																
INTERSECTION CORNER STRENGTHENING			none			DEMOULDING FEATURES			Epoxy squeeze-out slots																
																									
1T -		1T		2T -		2T		3T -		3T		1B		1B -		2B		2B -		3B		3B -		AVE	
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):																									
0.790		0.930		0.962		1.243		0.399		0.357		0.278		0.358		0.803		0.352		0.280		0.354		0.592	
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):																									
1.761		1.665		2.711		2.449		1.916		1.748		1.187		0.822		1.187		1.726		1.762		2.231		1.764	
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):																									
0.068		0.069		0.056		0.060		0.058		0.055		0.092		0.086		0.056		0.060		0.058		0.049		0.064	
RELEASE AGENT USED ON MOULD												Loctite Frekote 770-NC release system													
BONDING LINE THICKNESS												1 – 2 mm													
INTERSECTION CORNER QUALITY												Severely damaged													
TIME USED FOR FINISHING SET				11.75				P600 GRIT SANDING				2.5				CALCULATED PERCENTAGE				21%					
(Coetzee, 2013)																									

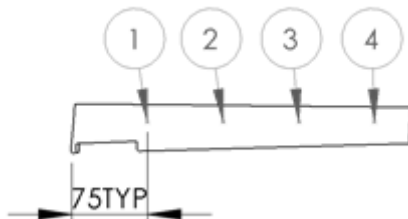
A.8. FLAP 2 & FLAP 2 MOULD

MOULD DIMENSIONAL DESCRIPTION						LENGTH:		5400 mm					
						WIDTH:		360 mm					
						FLANGE WIDTH:		40 mm					
						BACK SUPPORT HEIGHT:		200 mm					
													
MATERIAL		TOP: Nucoron651, Axson F16 surface layer BOTTOM: Glass fibre structure with tooling gelcoat surface				ALIGNMENT		Round, untapered metal pins & bushes; Ø 15 mm, 10 mm high.					
INTERSECTION CORNER STRENGTHENING		TOP: none, BOTTOM: Metal inserts				DEMOULDING FEATURES		Epoxy squeeze-out slots					
													
1T -	2T	3T -	4T	5T -	6T	AVE _T	1B -	2B	3B -	4B	5B -	6B	AVE _B
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (µm):													
1.458	1.701	1.402	1.713	1.451	1.755	1.580	0.875	1.021	0.841	1.028	0.871	1.053	0.948
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (µm):													
2.591	2.213	1.023	2.112	2.445	2.103	2.081	1.137	1.531	1.262	1.542	1.306	1.580	1.393
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (µm):													
0.061	0.065	0.095	0.084	0.087	0.052	0.074	0.058	0.051	0.057	0.054	0.052	0.071	0.057
RELEASE AGENT USED ON MOULD						Loctite Frekote 770-NC release system							
BONDING LINE THICKNESS						1 – 2 mm							
INTERSECTION CORNER QUALITY						Partly damaged on both top and bottom							
TIME USED FOR FINISHING SET		9 HOURS		P600 GRIT SANDING		1.5 HOURS		CALCULATED PERCENTAGE		17 %			
(Coetzee, 2013)													

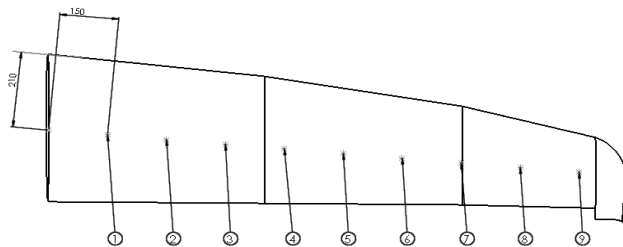
A.9. FLAP 3 (18M) & FLAP 3 (18M) MOULD

MOULD DIMENSIONAL DESCRIPTION				LENGTH: WIDTH: FLANGE WIDTH: BACK SUPPORT HEIGHT:		1160 mm 200 mm 35 mm 150 mm						
												
MATERIAL		Nuceron651, Axson F16 surface layer		ALIGNMENT		Metal pins, no bushes.						
INTERSECTION CORNER STRENGTHENING		None		DEMOULDING FEATURES		None						
												
1T	1B	2T	2B	3T	3B	4T	4B	5T	5B	6T	6B	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
1.458	1.701	1.402	1.713	0.358	0.803	1.755	0.354	0.803	0.841	1.028	0.215	1.036
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
2.406	2.807	2.313	2.354	0.591	1.325	2.896	0.985	1.325	1.388	1.753	0.354	1.708
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.068	0.069	0.056	0.060	0.095	0.084	0.087	0.057	0.054	0.052	0.058	0.049	0.066
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						1 mm						
INTERSECTION CORNER QUALITY						Severely damaged						
TIME USED FOR FINISHING SET		4 HOURS		P600 GRIT SANDING		0.7 HOURS		CALCULATED PERCENTAGE		18 %		
(Coetzee, 2013)												

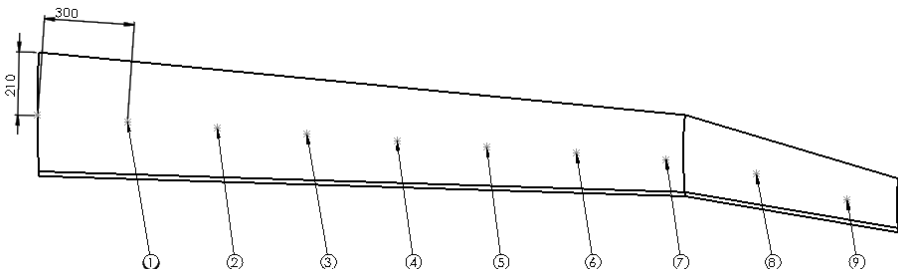
A.10. FLAP 4 (18M) & FLAP 4 (18M) MOULD

MOULD DIMENSIONAL DESCRIPTION						LENGTH:		400 mm				
						WIDTH:		140 mm				
						FLANGE WIDTH:		20mm and 50 mm				
						BACK SUPPORT HEIGHT:		150 mm				
												
MATERIAL			Nuceron651, Axson F16 surface layer			ALIGNMENT			Metal pins, Ø 15 mm			
INTERSECTION CORNER STRENGTHENING			None			DEMOULDING FEATURES			None			
												
1T	1B	2T	2B	3T	3B	4T	4B	5T	5B	6T	6B	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
0.357	0.278	0.962	1.745	1.402	1.985	2.415	0.962	0.803	0.352	0.280	0.803	1.029
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
1.761	1.665	2.711	2.449	1.916	1.748	1.187	0.822	1.187	1.726	1.762	2.231	1.764
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.068	0.069	0.056	0.060	0.058	0.055	0.092	0.086	0.056	0.060	0.058	0.049	0.064
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						1 mm						
INTERSECTION CORNER QUALITY						Severely damaged						
TIME USED FOR FINISHING SET		3.1 HOURS		P600 GRIT SANDING		0.5 HOURS		CALCULATED PERCENTAGE		16 %		
(Coetzee, 2013)												

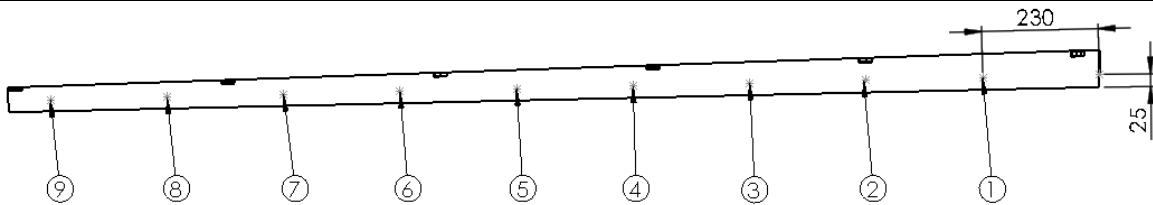
A.11. 18M TIP & 18M TIP MOULD

MOULD DIMENSIONAL DESCRIPTION				LENGTH: WIDTH: FLANGE WIDTH: BACK SUPPORT HEIGHT:		(PART OF WING MOULD)						
												
MATERIAL		Nuceron651, Axson F16 surface layer		ALIGNMENT				(PART OF WING MOULD)				
INTERSECTION CORNER STRENGTHENING		(PART OF WING MOULD)		DEMOULDING FEATURES				(PART OF WING MOULD)				
												
1T	1B	2T	2B	3T	3B	4T	4B	5T	5B	6T	6B	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
0.649	0.626	0.329	0.593	0.329	0.635	0.628	0.695	0.596	0.560	0.612	0.615	0.572
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
0.876	0.845	0.444	0.801	0.451	0.857	0.872	0.938	0.805	0.654	0.826	0.824	0.766
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.060	0.071	0.084	0.087	0.057	0.069	0.056	0.055	0.084	0.078	0.071	0.062	0.070
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						3 – 4 mm						
INTERSECTION CORNER QUALITY						Severely damaged						
TIME USED FOR FINISHING SET		67.5 HOURS		P600 GRIT SANDING		5.9 HOURS		CALCULATED PERCENTAGE		9 %		
(Coetzee, 2013)												

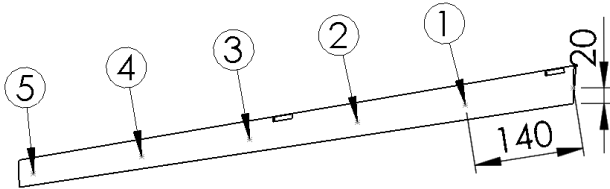
A.12. 21M & 21M TIP MOULD

MOULD DIMENSIONAL DESCRIPTION				LENGTH: 4 m								
				WIDTH: 1m								
				FLANGE WIDTH: 150 mm								
				BACK SUPPORT HEIGHT: 900 mm								
												
MATERIAL		Nucoron651, Axson F16 surface layer		ALIGNMENT								
INTERSECTION CORNER STRENGTHENING		Not strengthened		Metal pins and bushes; Ø 10 mm x 20 mm high.								
				DEMOULDING FEATURES								
				None								
												
1T	1B	2T	2B	3T	3B	4T	4B	5T	5B	6T	6B	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
0.634	0.529	0.314	0.578	0.547	0.574	0.613	0.485	0.581	0.545	0.548	0.596	0.545
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
0.951	0.655	0.471	0.613	0.8205	0.665	0.615	0.744	0.874	0.412	0.813	0.634	0.689
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.056	0.060	0.058	0.055	0.055	0.084	0.078	0.071	0.057	0.054	0.052	0.081	0.063
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						3 – 4 mm						
INTERSECTION CORNER QUALITY						Slightly damaged						
TIME USED FOR FINISHING SET		77.1 HOURS		P600 GRIT SANDING		7.3 HOURS		CALCULATED PERCENTAGE		21		
(Coetzee, 2013)												

A.13. FLAP 3 (21M) & FLAP 3 (21M) MOULD

MOULD DIMENSIONAL DESCRIPTION				LENGTH:	2.2 m							
				WIDTH:	180 mm							
				FLANGE WIDTH:	40 mm							
				BACK SUPPORT HEIGHT:	200 mm							
												
MATERIAL		Glass fibre structure with tooling gelcoat surface		ALIGNMENT	Metal pins and bushes. Ø 10 mm x 20 mm high.							
INTERSECTION CORNER STRENGTHENING		Not strengthened		DEMOULDING FEATURES	Epoxy squeeze out slots							
												
1T -	1T	2T -	2T	3T -	3T	1B	1B -	2B	2B -	3B	3B -	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
0.177	0.101	0.148	0.154	0.161	0.157	0.243	0.158	0.272	0.178	0.222	0.203	0.181
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
0.366	0.336	3.571	0.818	0.511	1.243	3.309	3.066	0.712	0.617	0.332	0.371	1.271
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.061	0.111	0.057	0.102	0.057	0.102	0.102	0.054	0.081	0.056	0.071	0.061	0.076
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						1 – 2 mm						
INTERSECTION CORNER QUALITY						good						
TIME USED FOR FINISHING SET		5 HOURS		P600 GRIT SANDING		0.6 HOURS		%		12 %		
(Coetzee, 2013)												

A.14. FLAP 4 (21M) & FLAP 4 (21M) MOULD

MOULD DIMENSIONAL DESCRIPTION						LENGTH:		750 mm				
						WIDTH:		170 mm				
						FLANGE WIDTH:		40 mm				
						BACK SUPPORT HEIGHT:		180 mm				
												
MATERIAL			Glass fibre structure with tooling gelcoat surface			ALIGNMENT			Metal pins and bushes; Ø 10 mm x 20 mm high.			
INTERSECTION CORNER STRENGTHENING			Not strengthened			DEMOULDING FEATURES			Epoxy squeeze-out slots			
												
1T -	1T	2T -	2T	3T -	3T	1B	1B -	2B	2B -	3B	3B -	AVE
AVERAGE SURFACE ROUGHNESS MOULD [Ra] (um):												
0.191	0.187	0.272	0.178	0.222	0.101	0.148	0.154	0.161	0.177	0.101	0.108	0.167
AVERAGE SURFACE ROUGHNESS OF PART AFTER DEMOULD [Ra] (um):												
0.347	0.418	0.439	0.415	0.312	0.308	0.996	0.307	0.352	0.419	0.423	0.407	0.429
AVERAGE SURFACE ROUGHNESS OF PART AFTER PAINT [Ra] (um):												
0.062	0.101	0.054	0.112	0.061	0.086	0.053	0.088	0.057	0.087	0.042	0.078	0.073
RELEASE AGENT USED ON MOULD						770NC Loctite Frekote 770-NC release system						
BONDING LINE THICKNESS						1 mm						
INTERSECTION CORNER QUALITY						slightly damaged						
TIME USED FOR FINISHING SET		3.2 HOURS		P600 GRIT SANDING		0.3 HOURS		%		9		%
(Coetzee, 2013)												

APPENDIX B: EXTRA DETAIL ON TESTS

B.1. SURFACE ROUGHNESS MEASURING

The purpose of the surface roughness testing is to provide a measurable value for each sample and to determine whether one particular sample is in fact a better quality than the other. Samples are compared in terms of their surface roughness (R_z) and the arithmetical average height (R_a).

Measuring of the surface roughness is fairly easy and it is done by a hand-held Roughness gauge, the AR-132C Surface Roughness Tester (AWR, n.d).

The following process and guidelines should be followed to ensure that the results measured are reliable (AWR, n.d.):

1. Locate the areas which will require measuring
2. On each location, about 10mm in front of where the needle will require measuring, mark a 12.5mm position as illustrated in Figure B-1.
3. Turn on the AR-132C Tester and ensure that it is set to metric and that the cut-off set to 2.5mm.
4. Position the tester with the measuring position in line with marked position on the sample, as illustrated in Figure B-2. Ensure that the needle is on the measuring position and not on the marked position.
5. Carefully press either of the start buttons and ensure not to distort the tester before the reading is shown.
6. Write down the R_a and R_z values.

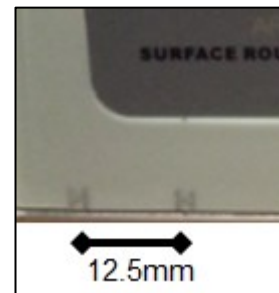


**Figure B-0-1: AR-132C
Required Measuring
Area.**

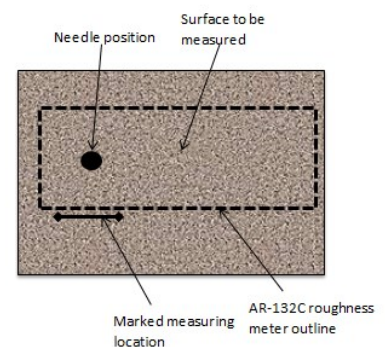


**Figure B-0-2: Top view of measuring
with AR-132 C roughness meter**

This test will be performed as one of the quality indicators for the tests described hereafter. Whenever a test refers to the surface roughness measuring, this test will be applicable.

BEST PRACTISES FOR PROFILOMETER MEASURING

According to (MacKenzie, 2008), the following can be considered as best practises to obtain the best results when measuring with a Profilometer:

- ◆ The skid should be flush and parallel with surface being measured. As illustrated in Figure B-3.
- ◆ Ensure that the skidless drive datum level is flush to surface being measured.
- ◆ Ensure that the drive X axis is parallel to the part axis.
- ◆ Measurements should be on the outer top dead centre or bottom of the bore.
- ◆ The racing arm must be assembled properly (use the set screw or another method).
- ◆ The part held should be affixed in a rigid mount.
- ◆ The set up should be free from ambient vibration.
- ◆ Surface to be measured must be clean.
- ◆ Measurements should be taken 90 degrees to “lay” unless otherwise specified.

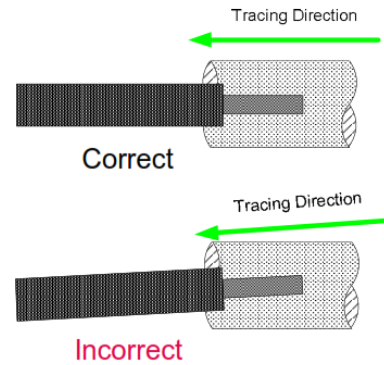


Figure B-0-3: Correct tracing direction of a profilometer.

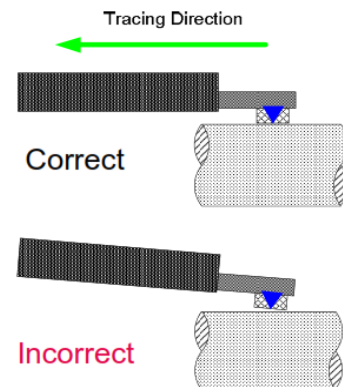


**Figure B-0-4: Correct Profilometer skid position.
(MacKenzie, 2008)**

With the Class A surface finishing defined and with information available on how to measure the surface quality, this study will proceed to define the type of parts which these qualities will be based on.

B.2. TEST 6: APPLICATION OF TOOLING GELCOAT VERSUS THE USAGE OF EPOXY FILLER SURFACES

The following test procedure should be followed:

- 1 Prepare 2 pieces of Plexiglass TM 100mm x 100mm
- 2 Prepare the acrylic surfaces with at least 5 layers of Mequiars Mirror Glaze 87 Wax.
- 3 Prepare the brushes for application by trimming the hair of the brush to about half of the original brush hair length.
- 4 Plug in the heat gun and have it ready on the lowest setting.
- 5 Follow the processes set out in Table B-1:

Table B-1: Application of surface layers

APPLICATION OF GC1150	APPLICATION OF EPOXY & CAB-O-SIL
1 Mix 30 g of GC1050 with 6 g of G15.	1 Sieve about 30grams of Cab-o-sil
2 After the tooling gelcoat is mixed, it should be scraped out of the cup and put into another cup before applying it. This helps to prevent any unmixed areas from being applied to the tool.	2 Mix a total of 50 grams of epoxy.
3 Whilst carefully heating the application area with the heat gun, apply the gelcoat in long full strokes. (It should not be heated too much)	3 Start mixing in the Cab-o-sil, noting how much is added every time, into the epoxy mix until the epoxy has the same thixotropy as the tooling gelcoat.
4 Apply the gelcoat to the entire area.	4 With the other brush apply this mixture in the same way as described for the tooling gelcoat.
5 Let the gelcoat cure for at least two hours before apply the bonding layers. Then the other sample can be applied.	5 After the entire area has been applied, lightly heat the entire area to decrease the viscosity and thus assisting with the release of any air bubbles trapped on the bottom.
	6 Let the epoxy cure for at least two hours before applying the bonding layers.

Application of layers

After the surface layers have cured for about 1h30min, the following bonding/structural layers can be cut in blocks (balanced & symmetric layout):

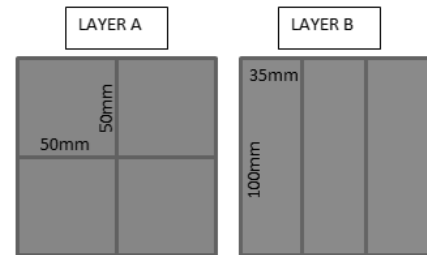


Figure B-0-5: Layer style of Fibre blocks

Table B-2: Orientation and layer style of samples

Layer number	Material	Orientation	layer style
1	Glass veil	NA	Layer A style
2	Glass veil	NA	Layer B style
3	90070	45	Layer A style
4	90070	90	Layer B style
5	92110	45	Layer A style
6	92110	90	Layer B style
7	92125	45	Layer A style
8	92125	90	Layer B style
9	92125	90	Layer A style
10	92125	45	Layer B style
11	92110	90	Layer A style
12	92110	45	Layer B style
13	90070	90	Layer A style
14	90070	45	Layer B style

APPENDIX C: TEST 2 CNC TESTING EXTRA INFORMATION

In this section the entire process of how the CNC samples were designed and manufactured is explained. The section will first look at the design and will then explain the steps followed for each of the individual features of the CNC test samples.

C.1. CNC SAMPLE DESIGN

The CNC sample design needed to test certain features which influence CNC machining. The “S”-shaped samples were designed to capture those features, whereas the block design formed part of the conventional material tests.

The “S”-shaped samples were all dimensionally the same and had the following features, as illustrated in the Figure C-1:

- As only one size ball nose cutter would be used, the radiuses needed to be larger than the radius of the cutter. The cutter size was 12mm, thus the radii were made 22mm.
- The samples needed to have a draft angle as to let the cutter avoid roughening a 90 degree vertical surface when it is cutting close to the bottom
- The samples needed to form curves, as flat block samples (like the block in the sample board) only need the roughing tools to obtain a perfectly good surface finish, whereas curves need the use of ball nose cutters.
- The sample needed to change direction, as any change in direction of the sample can cause defect points in the cutting process, which will reflect on resulted sample.
- Because the surface roughness actually needed testing, the top surface needed to be flat, to allow for a more accurate testing surface.

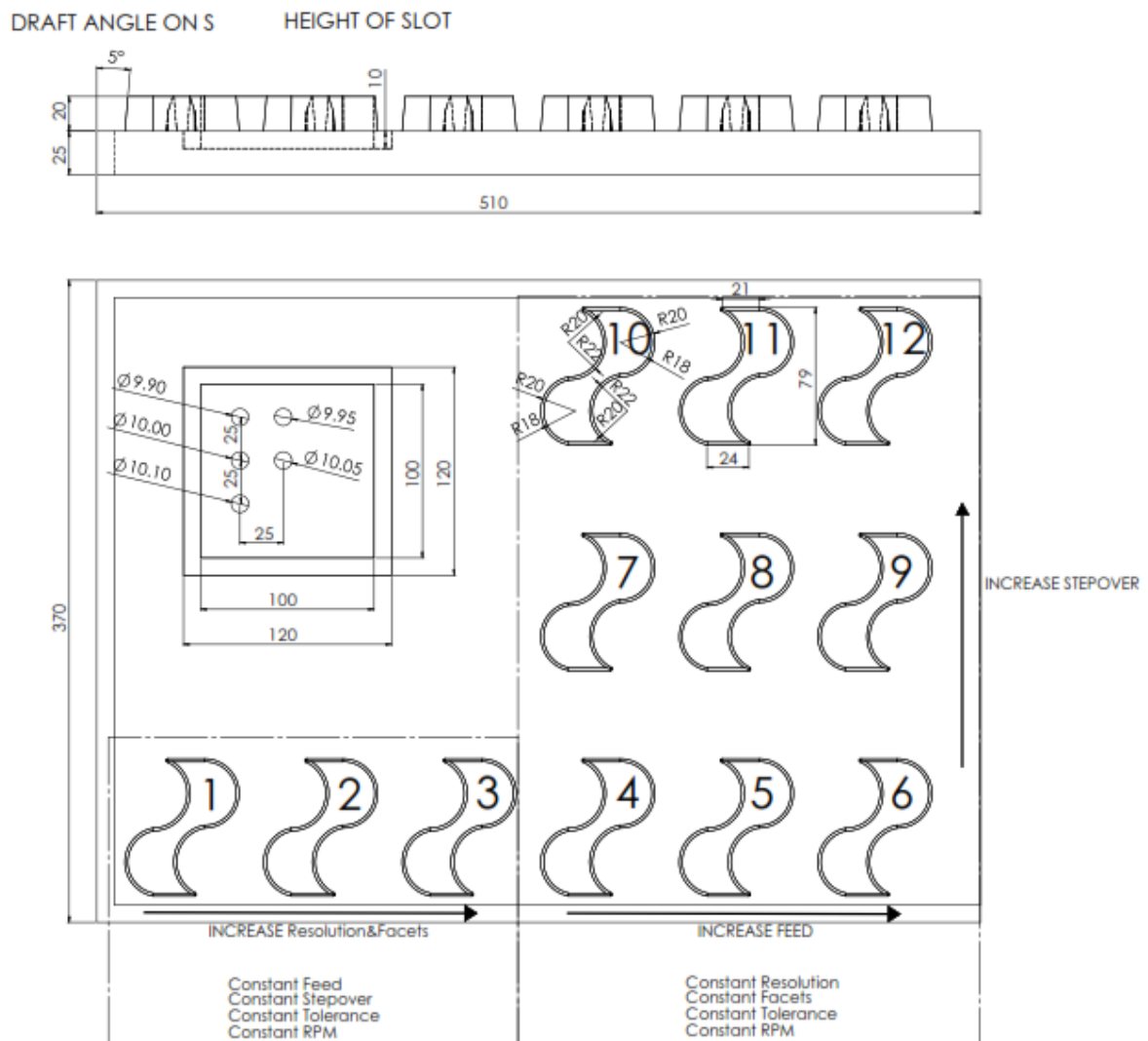


Figure C-1: CNC sample design layout

The block shaped sample did not need a great many variables as the only testing was aimed at creating a perfectly good corner. In order to ensure that the corner is sharp, the sample was cut past the split surface, creating a slot around the plug area. The slot then prevented the split surface from being affected by the spraying of the plug area, as it would then be covered by Plexiglass TM as explained later.

Each one of the features of the sample board will now be explained in the order of machine operations of the CNC.

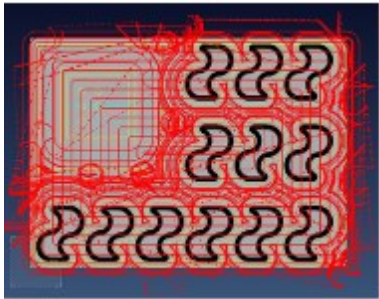
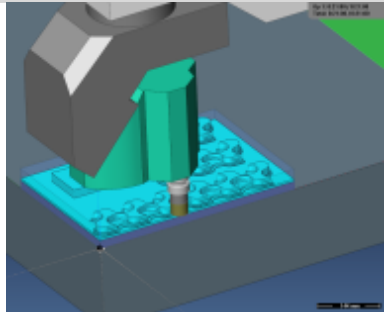
C.2. CNC TOTAL CUTTING TIME AND MACHINE LAYOUT ILLUSTRATION

CNC machining consists of a few steps that are necessary in order to optimise tool capabilities. The part is first broadly roughened to a near shape, and then roughened more to a close near shape with a roughening tool. After the roughening is completed, the actually testing starts by applying different settings to a ball nose cutter.

The final steps are each completed on its own. This section will explain these steps in order of the machining processes, with illustrations taken from the VISICAM software used to program the SCM RECORD 110 AL PRISMA, CNC machine, which makes use of the Xilog Plus operating software for cutting. Each one of the different tools has been programmed into the Visicadcam software. The Tables below provide information for each individual step in the process:

C.3 ROUGHING: 40MM

Tool used: T3 - END MILL Ø40mm
Cutting illustration



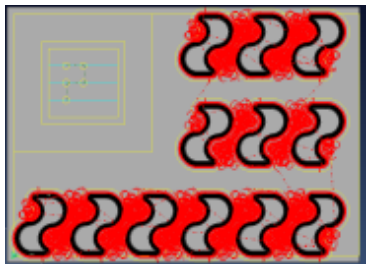
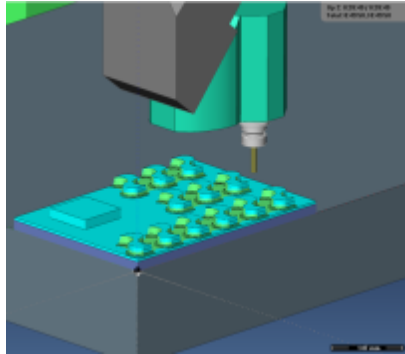
ROUGHNING SPIRAL IN
SETTINGS

Passes	Side allowance	0.5
	Bottom allowance	0.5
	Step-over method	Spiral in
	Step-over setting	20
	Step down method	Automatic
	Step down setting	4
Limit	Min	20
	Max	50
Leads	Boundary	Past
	Plunging method	Helical
	Rapid style	Clearance plane
	Lead in	Horizontal
	Lead out	Horizontal
	Cut mode	Rough
Cutting parameters	Spindle speed (rev/min)	17109
	Feed (mm/min)	7186
time	Reduction feed (mm/min)	3596
	RESOLUTION	20
	FACETS	2.5
	Time taken to cut	21min

C.4 ROUGHING: 11.5MM

Tool used: T1 - END MILL Ø11.5mm

Cutting illustration



ROUGHNING SPIRAL OUT

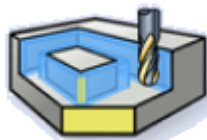
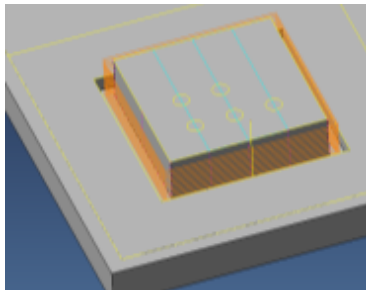
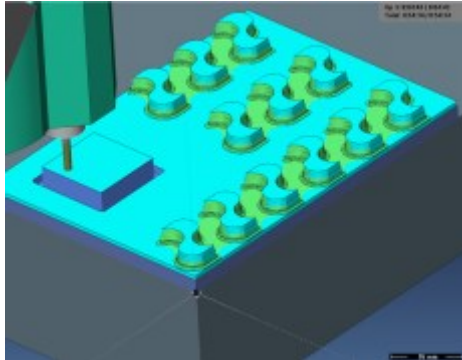
SETTINGS

Passes	Side allowance	0.5
	Bottom allowance	0.5
	Step-over method	Spiral out
	Step-over setting	5.75
	Step down method	Automatic
	Step down setting	2
Limit	Min	25
	Max	50
	Boundary	Past
	Plunging method	Helical
Leads	Rapid style	Clearance plane
	Lead in	Horizontal
	Lead out	Horizontal
	Cut mode	Finish
Cutting parameters	Spindle speed (rev/min)	16955
	Feed (mm/min)	3000
	Reduction feed (mm/min)	3569
	RESOLUTION	20
time	FACETS	2.5
	Time taken to cut	28min49sec

C.5. SLOT MILL: 10MM

Tool used: T5 – SLOTMILL Ø10mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

time

MILL

SETTINGS

Side allowance 0

Bottom allowance 0

Step-over method N/A

Step-over setting 5

Step down method N/A

Step down setting 2

Min 0

Max 0

Boundary N/A

Plunging method N/A

Rapid style N/A

Lead in N/A

Lead out N/A

Cut mode Finish

Spindle speed (rev/min) 17000

Feed (mm/min) 1500

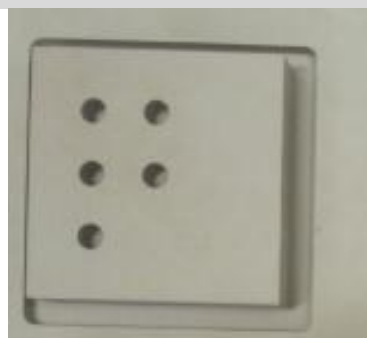
Reduction feed (mm/min) 750

RESOLUTION 20

FACETS 2.5

Time taken to cut 4min43sec

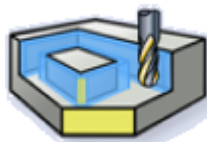
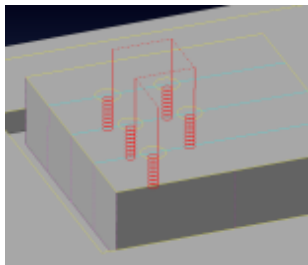
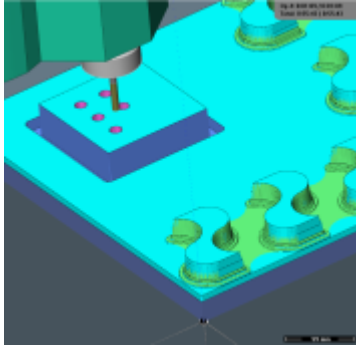
RESULTS



C.6. SLOT MILL: 6MM

Tool used: T9 – SLOTMILL Ø6.05mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

time

MILL

SETTINGS

Side allowance 0

Bottom allowance 0

Step-over method N/A

Step-over setting 3.025

Step down method N/A

Step down setting 2

Min 0

Max 0

Boundary N/A

Plunging method N/A

Rapid style N/A

Lead in N/A

Lead out N/A

Cut mode Finish

Spindle speed (rev/min) 17000

Feed (mm/min) 1000

Reduction feed (mm/min) 1000

RESOLUTION

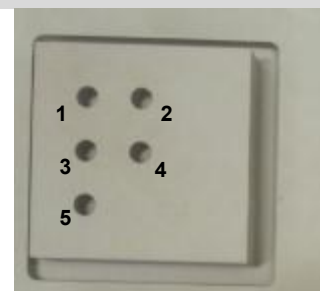
FACETS

Time taken to cut 1min9sec

HOLE DIAMETERS

RESULTS

HOLE	PROGRAMMED DIAMETER	FITMENT WITH G6 TOLERANCE SHAFTS
1	9.9	TO SMALL
2	9.95	FIT
3	10	FIT
4	10.05	TO LOOSE
5	10.1	TO LOOSE

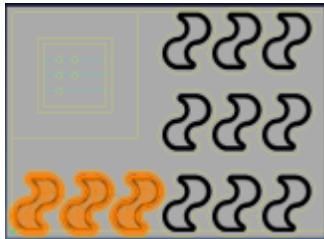
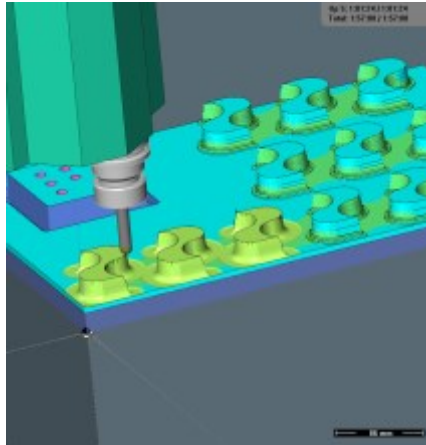


For a 10mm g6 shaft, the best setting for the
CNC machine is 9.95 and 10 mm

C.7. CONSTANT STEP OVER (1, 2, 3):

Tool used: T12 – BALLNOSE Ø12 mm

Cutting illustration



CONSTANT STEPOVER

SETTINGS

Passes

Limit

Leads

Cutting
parameters

time

Side allowance 0
Bottom allowance 0
Step-over method N/A
Step-over setting 0.7
Step down method N/A
Step down setting 0.7

Min 0
Max 45

Boundary ON

Plunging method Plunging

Rapid style Clearance plane

Lead in Horizontal

Lead out Horizontal

Cut mode 17000

Spindle speed (rev/min) 800

Feed (mm/min) 400

Reduction feed (mm/min)

Time taken to cut 1h1min24sec

FACETS: 20

RESOLUTION 2.5

40

1

60

0.5

RESULTS

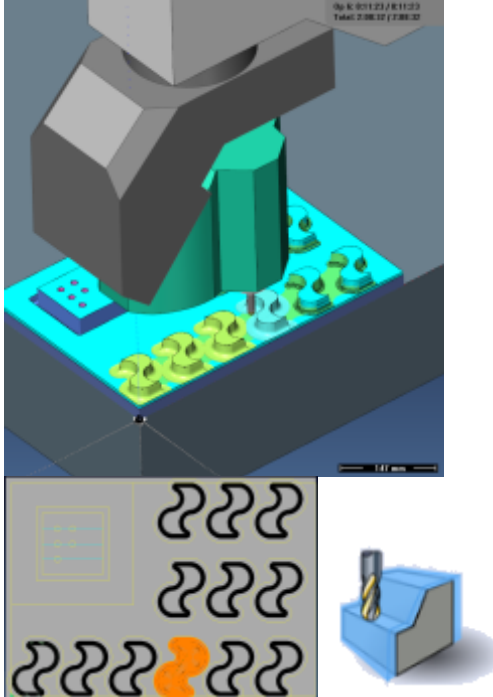


POSITION	Ra(um)
1	9.77
2	13.26
3	11.78
4	3.472

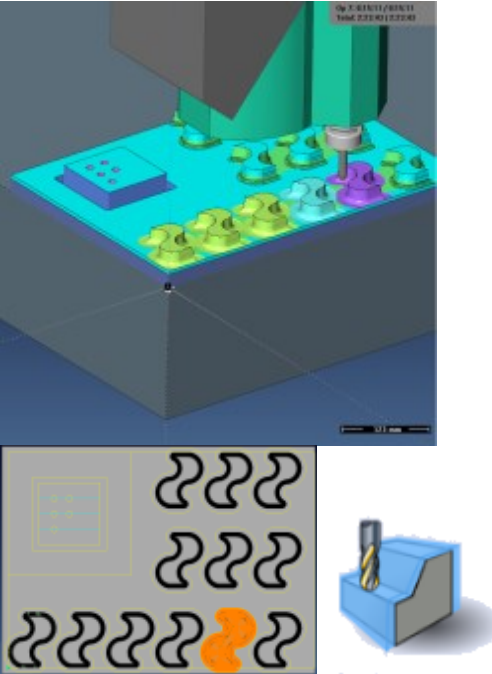
Ra(um)
9.768
7.695
11.95
10.58

Ra(um)
10.58
8.404
11.84
3.723

C.8. CONSTANT STEP OVER (4):

Tool used: T12 – BALLNOSE Ø12 mm		CONSTANT STEPOVER	
Cutting illustration		SETTINGS	
	Passes	Side allowance	0
		Bottom allowance	0
		Step-over method	N/A
	Limit	Step-over setting	0.5
		Step down method	N/A
		Step down setting	0.5
	Leads	Min	0
		Max	45
		Boundary	ON
	Cutting parameters	Plunging method	Plunging
Rapid style		Clearance plane	
Lead in		Horizontal	
Lead out		Horizontal	
Cut mode		Finish	
Spindle speed (rev/min)		17000	
time	Feed (mm/min)	2000	
	Reduction feed (mm/min)	1000	
FACETS	120	Time taken to cut	11min23sec
RESOLUTION	0.1		
RESULTS		SURFACE ROUGHNESS	
		Ra(um)	
		Position 1	9.659
		Position 2	11.18
		Position 3	10.2
		Position 4	11.45

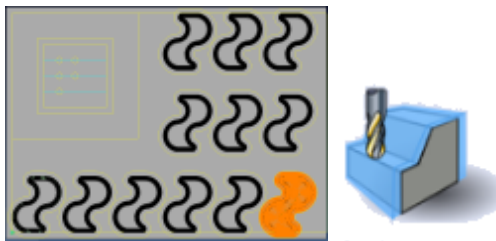
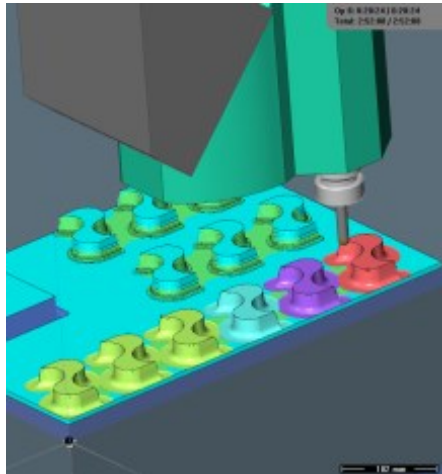
C.9. CONSTANT STEP OVER (5):

Tool used: T12 – BALLNOSE Ø12 mm		CONSTANT STEPOVER	
Cutting illustration		SETTINGS	
	Passes	Side allowance	0
		Bottom allowance	0
		Step-over method	N/A
		Step-over setting	0.5
		Step down method	N/A
		Step down setting	0.5
	Limit	Min	0
		Max	45
		Boundary	ON
	Leads	Plunging method	Plunging
Cutting parameters		Rapid style	Clearance plane
		Lead in	Horizontal
		Lead out	Horizontal
time		Cut mode	Finish
		Spindle speed (rev/min)	17000
		Feed (mm/min)	1500
		Reduction feed (mm/min)	750
		Time taken to cut	15min11sec
FACETS		RESULTS	
RESOLUTION		SURFACE ROUGHNESS	
		Ra(um)	
		Position 1	10.36
		Position 2	8.349
		Position 3	9.822
		Position 4	14.19

C.10. CONSTANT STEP OVER (6):

Tool used: T12 – BALLNOSE Ø12 mm

Cutting illustration



FACETS 120
RESOLUTION 0.1

RESULTS



CONSTANT STEPOVER

SETTINGS

Passes	Side allowance	0
	Bottom allowance	0
	Step-over method	N/A
	Step-over setting	0.5
	Step down method	N/A
	Step down setting	0.5
Limit	Min	0
	Max	45
Leads	Boundary	ON
	Plunging method	Plunging
	Rapid style	Clearance plane
	Lead in	Horizontal
Cutting parameters	Lead out	Horizontal
	Cut mode	Finish
	Spindle speed (rev/min)	17000
	Feed (mm/min)	800
time	Reduction feed (mm/min)	400
	Time taken to cut	28min24sec

SURFACE ROUGHNESS

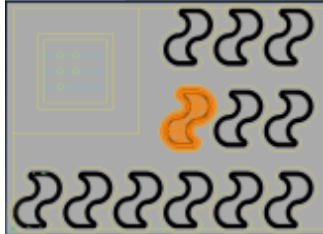
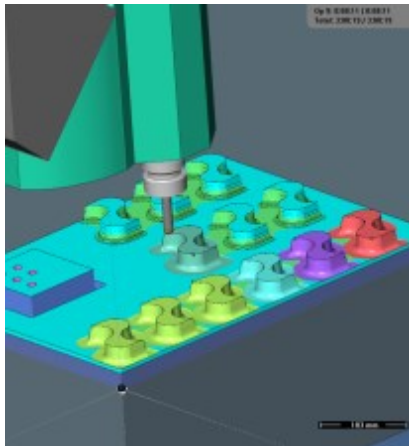
Ra(um)

Position 1	9.659
Position 2	10.09
Position 3	8.622
Position 4	3.356

C.11. CONSTANT STEP OVER (7):

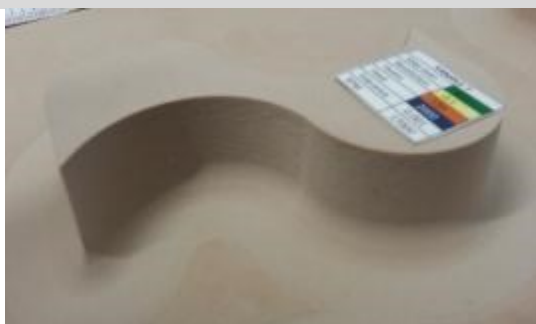
Tool used: T12 – BALLNOSE Ø12 mm

Cutting illustration



FACETS 120
RESOLUTION 0.1

RESULTS



CONSTANT STEPOVER SETTINGS

Passes	Side allowance	0
	Bottom allowance	0
	Step-over method	N/A
	Step-over setting	0.7
	Step down method	N/A
	Step down setting	0.7
Limit	Min	0
	Max	45
Leads	Boundary	ON
	Plunging method	Plunging
	Rapid style	Clearance plane
	Lead in	Horizontal
	Lead out	Horizontal
Cutting parameters	Cut mode	Finish
	Spindle speed (rev/min)	17000
	Feed (mm/min)	2000
	Reduction feed (mm/min)	1000
time	Time taken to cut	8min11sec

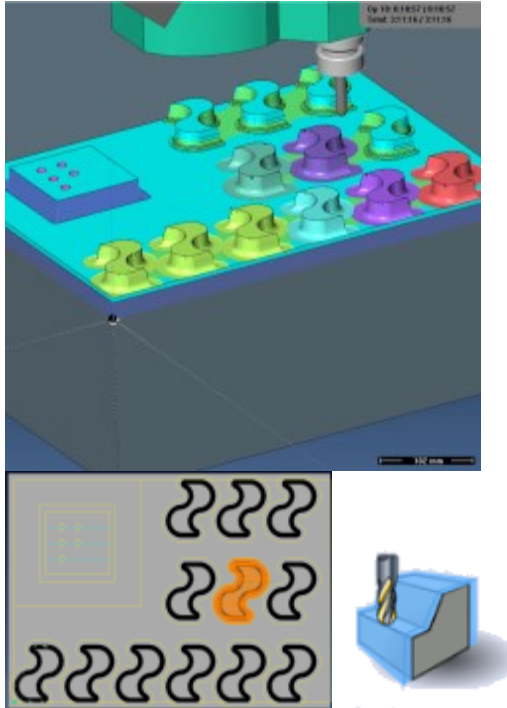
SURFACE ROUGHNESS

Ra(um)

Position 1	9.331
Position 2	8.895
Position 3	12.11
Position 4	9.822

C.12. CONSTANT STEP OVER (8):

Tool used: T12 – BALLNOSE Ø12 mm
Cutting illustration



CONSTANT STEPOVER SETTINGS

Passes

Limit

Leads

Cutting
parameters

time

Side allowance	0
Bottom allowance	0
Step-over method	N/A
Step-over setting	0.7
Step down method	N/A
Step down setting	0.7
Min	0
Max	45
Boundary	ON
Plunging method	Plunging
Rapid style	Clearance plane
Lead in	Horizontal
Lead out	Horizontal
Cut mode	Finish
Spindle speed (rev/min)	17000
Feed (mm/min)	1500
Reduction feed (mm/min)	750

FACETS 120
RESOLUTION 0.1

Time taken to cut 10min57sec

RESULTS

SURFACE ROUGHNESS

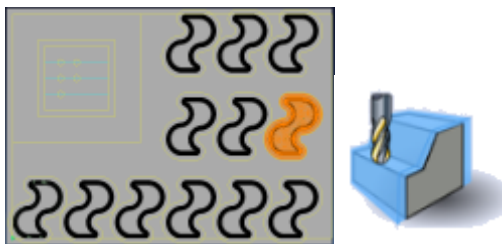
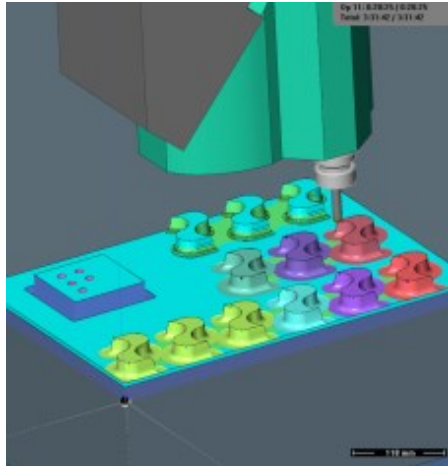


Ra(um)

Position 1	10.96
Position 2	10.25
Position 3	11.62
Position 4	11.35

C.13. CONSTANT STEP OVER (9):

Tool used: T12 – BALLNOSE Ø12 mm
Cutting illustration



CONSTANT STEPOVER SETTINGS

Passes

Limit

Leads

Cutting
parameters

time

Side allowance 0

Bottom allowance 0

Step-over method N/A

Step-over setting 0.7

Step down method N/A

Step down setting 0.7

Min 0

Max 45

Boundary ON

Plunging method Plunging

Rapid style Clearance plane

Lead in Horizontal

Lead out Horizontal

Cut mode Finish

Spindle speed (rev/min) 17000

Feed (mm/min) 800

Reduction feed (mm/min) 400

FACETS 120

RESOLUTION 0.1

Time taken to cut 20min25sec

RESULTS

SURFACE ROUGHNESS



Ra(um)

Position 1 10.15

Position 2 10.96

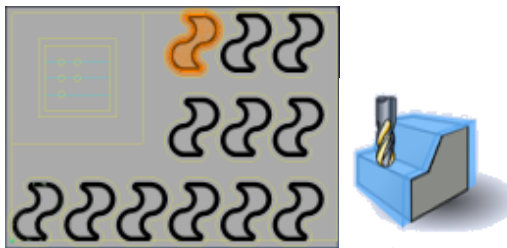
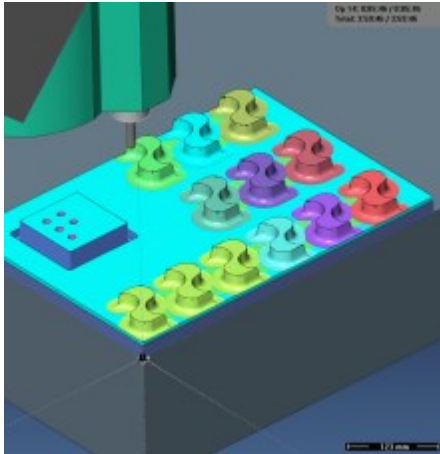
Position 3 9.877

Position 4 3.800

C.14. CONSTANT STEP OVER (10):

Tool used: T12 – BALLNOSE Ø12 mm

Cutting illustration



CONSTANT STEPOVER SETTINGS

Passes

Limit

Leads

Cutting
parameters

time

Side allowance	0
Bottom allowance	0
Step-over method	N/A
Step-over setting	1
Step down method	N/A
Step down setting	1

Min	0
Max	45

Boundary ON

Plunging method Plunging

Rapid style Clearance plane

Lead in Horizontal

Lead out Horizontal

Cut mode Finish

Spindle speed (rev/min) 17000

Feed (mm/min) 800

Reduction feed (mm/min) 400

FACETS 120

RESOLUTION 0.1

Time taken to cut 7min51sec

RESULTS

SURFACE ROUGHNESS



Ra(um)

Position 1 10.69

Position 2 10.58

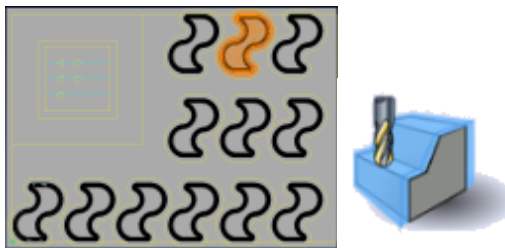
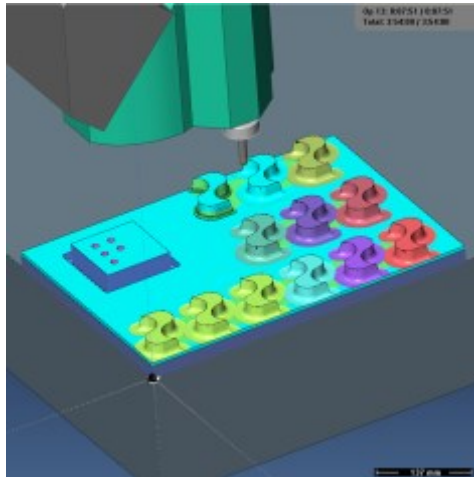
Position 3 9.986

Position 4 8.676

C.15. CONSTANT STEP OVER (11):

Tool used: T12 – BALLNOSE Ø12 mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

time

CONSTANT STEPOVER SETTINGS

Side allowance	0
Bottom allowance	0
Step-over method	N/A
Step-over setting	1
Step down method	N/A
Step down setting	1
Min	0
Max	45
Boundary	ON
Plunging method	Plunging
Rapid style	Clearance plane
Lead in	Horizontal
Lead out	Horizontal
Cut mode	Finish
Spindle speed (rev/min)	17000
Feed (mm/min)	1500
Reduction feed (mm/min)	400

FACETS 120
RESOLUTION 0.1

Time taken to cut 7min51sec

RESULTS



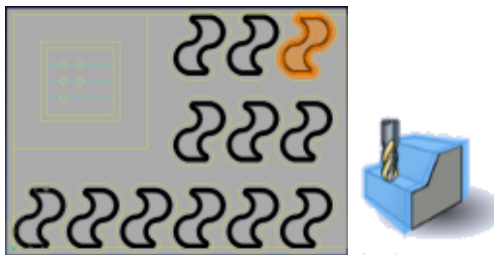
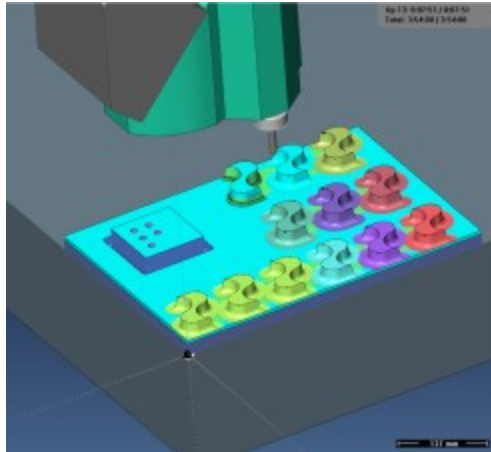
SURFACE ROUGHNESS

	Ra(um)
Position 1	9.932
Position 2	10.85
Position 3	10.25
Position 4	7.203

C.16. CONSTANT STEP OVER (12):

Tool used: T12 – BALLNOSE Ø12 mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

time

CONSTANT STEPOVER SETTINGS

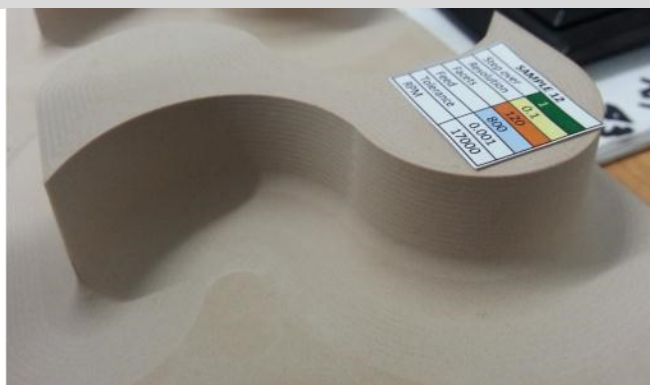
Side allowance	0
Bottom allowance	0
Step-over method	N/A
Step-over setting	1
Step down method	N/A
Step down setting	1
Min	0
Max	45
Boundary	ON
Plunging method	Plunging
Rapid style	Clearance plane
Lead in	Horizontal
Lead out	Horizontal
Cut mode	Finish
Spindle speed (rev/min)	17000
Feed (mm/min)	2000
Reduction feed (mm/min)	1000

FACETS 120

RESOLUTION 0.1

Time taken to cut 5min46sec

RESULTS



SURFACE ROUGHNESS

Ra(um)

Position 1	9.877
Position 2	11.62
Position 3	11.89
Position 4	4.61

C.17. FINISHING OF THE BLOCK SAMPLE

The finishing of the block sample commenced in the normal process of plug finishing:

STEP 1: The surrounding area was wrapped with plastic to prevent contamination during spraying.



STEP 2: The block was sprayed with Standox 1K primer.



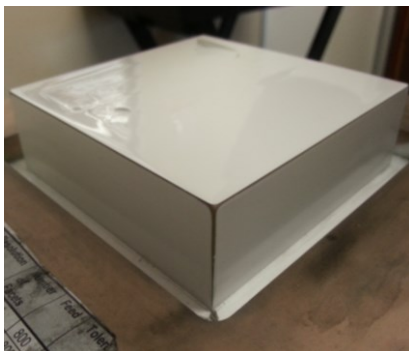
STEP 3: The block was left to dry and wet sanded to a P800 grit.



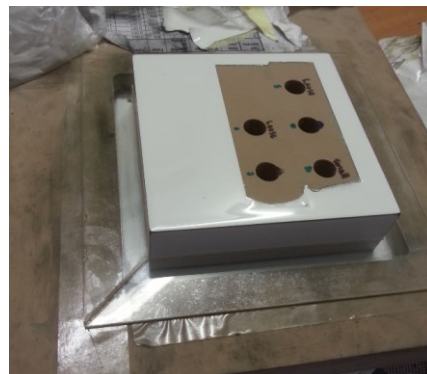
STEP 4: The block was sprayed with Standox 2K paint and left to dry.



STEP 4: The block was sanded with a P800 to a P2000 grit and polished.



STEP 5: The Plexiglass TM was applied with double-sided tape.



APPENDIX D: MANUFACTURING OF JS1 INSTRUMENT PANEL

The manufacturing of the instrument panel that has been used to verify the process described in Chapter 6 is described in this Appendix. The process started with the CAD design and the plug manufacturing, it then proceeds to the mould design and manufacturing and ends with the part manufacturing

D.1. CAD DESIGN

The general shape of the part was predetermined by the original design of the JS 1 and the old mould was used to obtain an outline of the top face. The outline was drawn on Solidworks, enlarged by 3mm to account for the radius in the old mould and extruded for 20 mm, with a 3 mm draft (Figure D-1a). A split surface was added to obtain the top plug. (Figure D-1b)

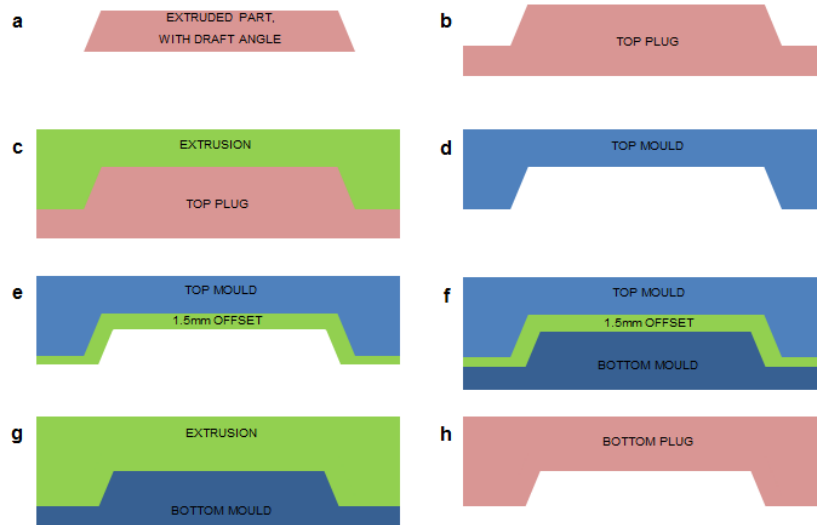


Figure D-0-1: CAD Design process followed to create JS1 instrument panel plugs.

The top plug was then used to create a top mould by extruding a block and subtracting the plug. (Figure D-1c, d). The top mould surface was then offset by 1.5mm to create the bottom mould surface (Figure D-1e, f). By extruding a block and subtracting the bottom mould, the bottom plug was created (Figure D-1g, h).

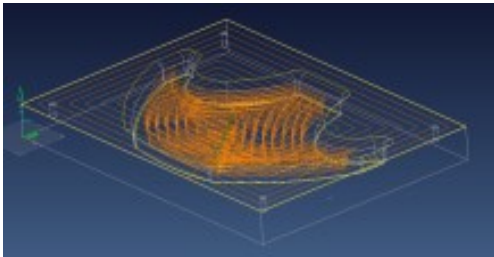
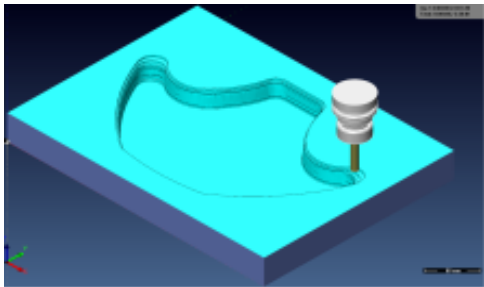
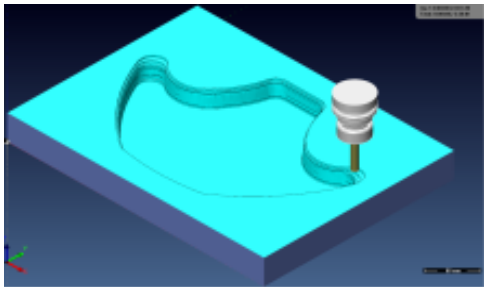
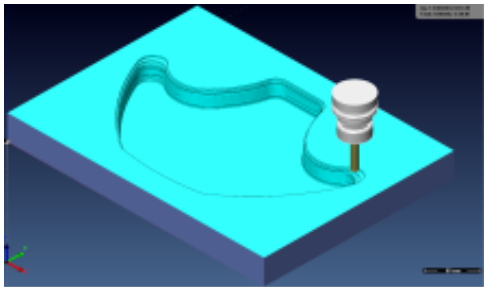
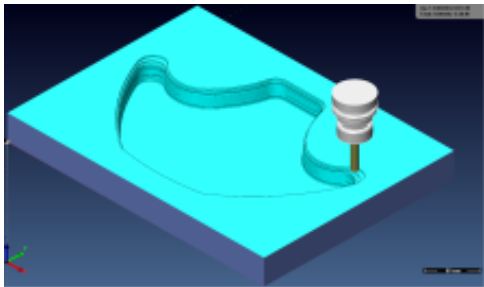
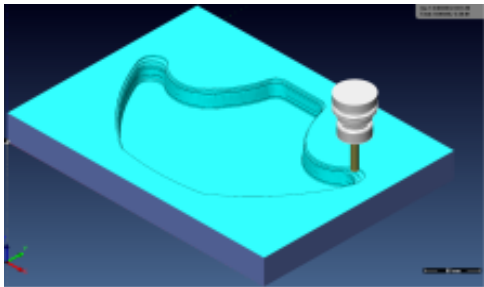
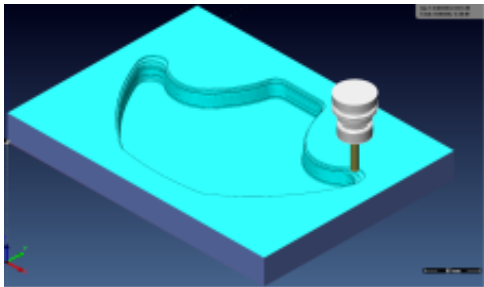
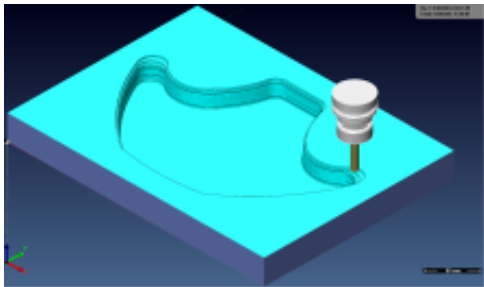
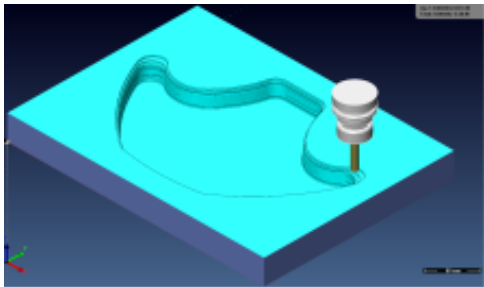
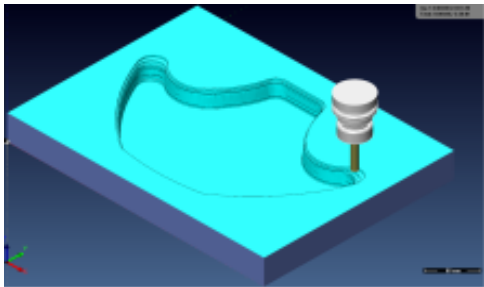
D.2. PLUG

The plugs were created by importing the parasolid file, created by the CAD modelling, into VISCAM and creating the tool paths with settings set out in Chapter 6. The plugs were then cut on the CNC machine out of Nuceron651 tooling board. After cutting, the plugs were finished.

D.2.1. CNC PROGRAMMING AND CUTTING

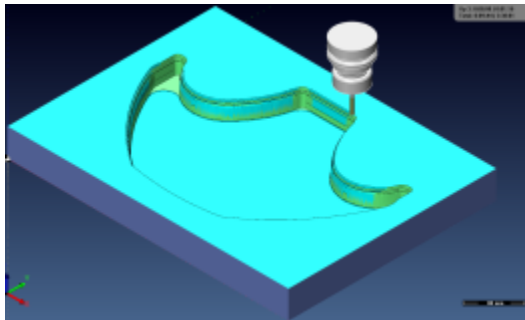
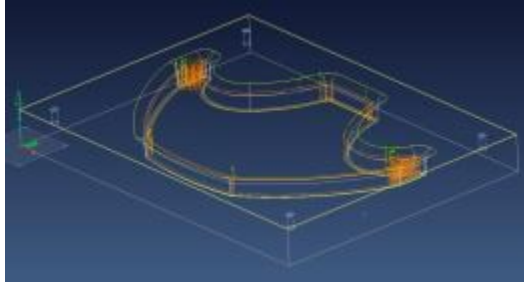
The Tables in D2.2. and D2.3 provide the tool path settings created with VISICAM for both the bottom and the top plug. The tables start with the roughing operations and goes into the finishing operations. The total cutting time for each operation is provided, and an estimated cutting time for 1sqm by 50 mm high is calculated. These values can be used to determine cutting times for future projects.

D.2.2. BOTTOM PLUG CNC TOOLPATH SETTINGS

Tool used: T3 - END MILL Ø40mm		ROUGHNING SPIRAL OUT	
Cutting illustration		SETTINGS	
	Passes	Side allowance	0.5
		Bottom allowance	0.5
	Limit	Step-over method	Spiral out
		Step-over setting	20
	Leads	Step down method	Automatic
		Step down setting	3
	Cutting parameters	Min	0
		Max	50
		Boundary	On
		Plunging method	Plunging
		Rapid style	Clearance plane
		Lead in	Axial
		Lead out	Axial
		Cut mode	ROUGH
		Spindle speed (rev/min)	17109
		Feed (mm/min)	7186
		Reduction feed (mm/min)	3593
		RESOLUTION	0.1
		FACETS	120
	Time	Time taken to cut	8min

Tool used: T1 - END MILL Ø12mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

Time

ROUGHNING SPIRAL OUT

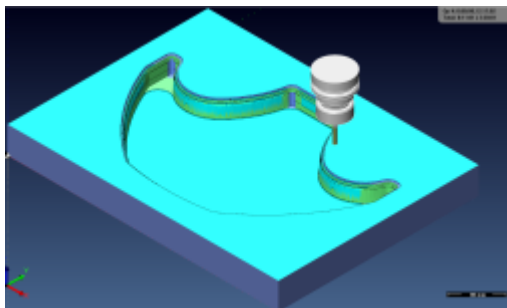
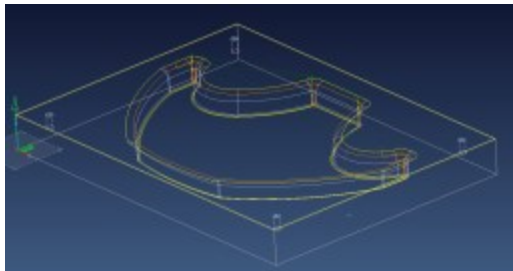
SETTINGS

Side allowance	0.5
Bottom allowance	0.5
Step-over method	Spiral out
Step-over setting	6
Step down method	Constant
Step down setting	3
Min	0
Max	50
Boundary	On
Plunging method	Plunging
Rapid style	Clearance plane
Lead in	Axial
Lead out	Axial
Cut mode	ROUGH
Spindle speed (rev/min)	16995
Feed (mm/min)	7138
Reduction feed (mm/min)	3569
RESOLUTION	0.1
FACETS	120

Time taken to cut 1min44sec

Tool used: T9 – SLOT MILL Ø6.05mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

Time

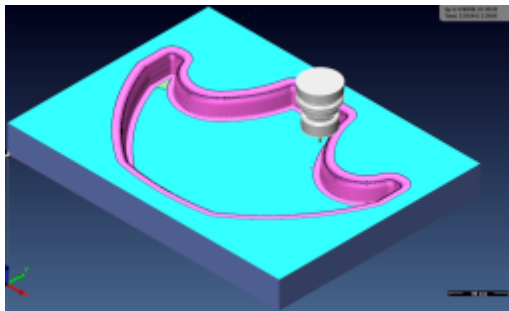
ROUGHNING SPIRAL OUT

SETTINGS

Side allowance	0.5
Bottom allowance	0.5
Step-over method	Spiral out
Step-over setting	3.025
Step down method	Constant
Step down setting	3.025
Min	0
Max	50
Boundary	On
Plunging method	Plunging
Rapid style	Clearance plane
Lead in	Axial
Lead out	Axial
Cut mode	Rough
Spindle speed (rev/min)	17000
Feed (mm/min)	2000
Reduction feed (mm/min)	1000
RESOLUTION	0.1
FACETS	120

Time taken to cut 1min16sec

Tool used: T7 – BALLNOSE Ø6 mm
Cutting illustration



Passes

Limit

Leads

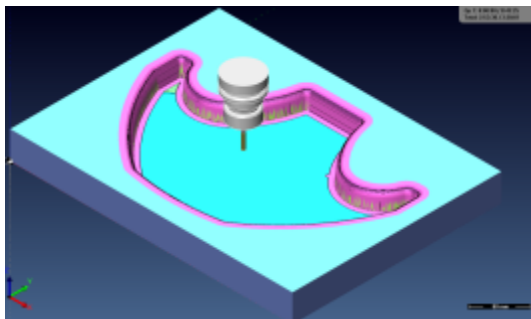
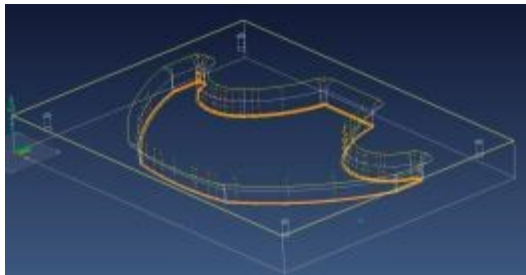
Cutting
parameters

Time

STEEP / SHALLOW
SETTINGS

Side allowance	0
Bottom allowance	0
Step-over method	Upper
Step-over setting	0.5
Step down method	Adaptive
Step down setting	0.5
Min	19
Max	49
Boundary	Past
Plunging method	(x-250) (y-185)
Rapid style	Clearance plane
Lead in	Horizontal
Lead out	Horizontal
Cut mode	Finish
Spindle speed (rev/min)	17000
Feed (mm/min)	800
Reduction feed (mm/min)	400
RESOLUTION	0.1
FACETS	120
Time taken to cut	2h17min2sec

Tool used: T10 – BALLNOSE Ø3mm
Cutting illustration



Passes

Limit

Leads

Cutting
parameters

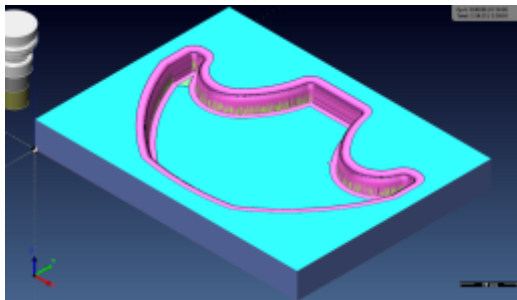
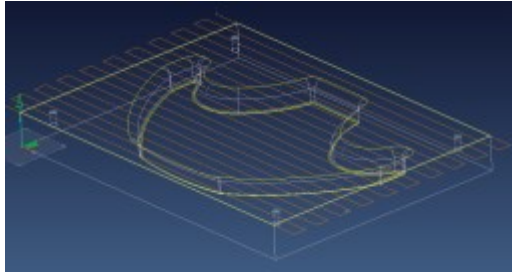
Time

REST AREA
SETTINGS

Side allowance	0
Bottom allowance	0
Step-over method	By rest area
Step-over setting	0.5 (previous 6)
Step down method	By rest area
Step down setting	0.5
Min	19
Max	49
Boundary	On
Plunging method	(x-250)(y-185)
Rapid style	Clearance plane
Lead in	Vertical
Lead out	Vertical
Cut mode	Finish
Spindle speed (rev/min)	17000
Feed (mm/min)	800
Reduction feed (mm/min)	400
RESOLUTION	0.1
FACETS	120
Time taken to cut	10min28sec

Tool used: T3 – ENDMILL Ø40mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

Time

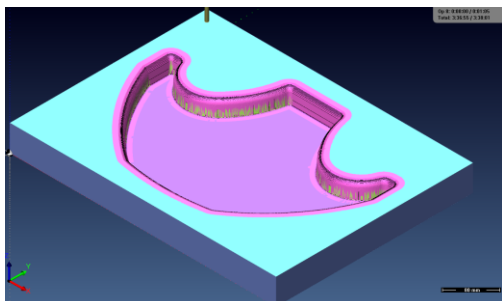
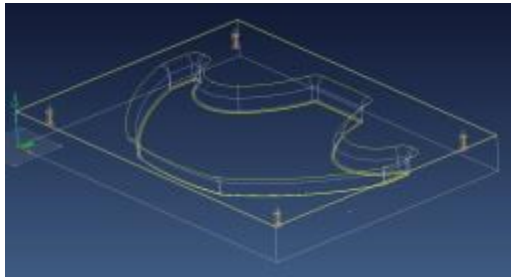
FACEMILL ZIGZAG

SETTINGS

External extension value	20
Bottom allowance	0
Step-over method	ZigZag
Step-over setting	20
Step down method	ZigZag
Step down setting	20
Min	0
Max	0
Shape methods	Silhouette
Plunging method	N/A
Rapid style	N/A
Lead in	N/A
Lead out	N/A
Cut mode	Finish
Spindle speed (rev/min)	17000
Feed (mm/min)	800
Reduction feed (mm/min)	400
RESOLUTION	0.1
FACETS	120
Time taken to cut	14min58sec

Tool used: T9 – SLOTMILL Ø6.05 mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

Time

PLANAR FACES

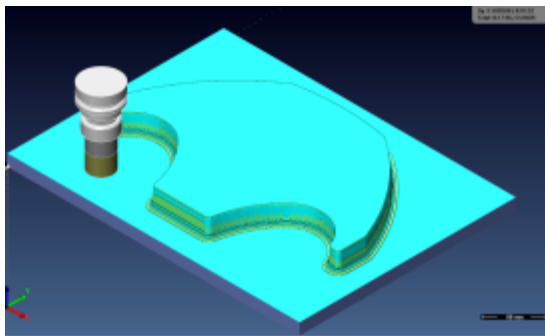
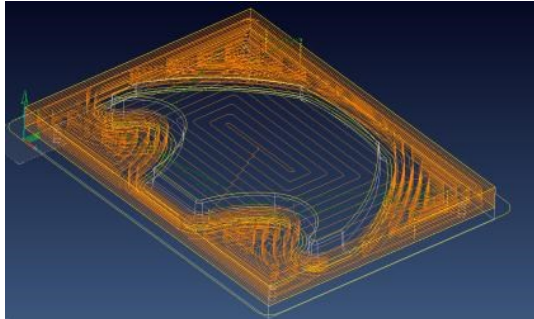
SETTINGS

Side allowance	0
Bottom allowance	0
Step-over method	N/A
Step-over setting	3
Step down method	N/A
Step down setting	N/A
Min	19
Max	19
Boundary	On
Plunging method	Ramping
Rapid style	Clearance plane
Lead in	Vertical
Lead out	Vertical
Cut mode	Finish
Spindle speed (rev/min)	17000
Feed (mm/min)	800
Reduction feed (mm/min)	400
RESOLUTION	0.1
FACETS	120
Time taken to cut	1min5sec

D.2.3. TOP PLUG CNC TOOLPATH SETTINGS

Tool used: T3 - END MILL Ø40mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

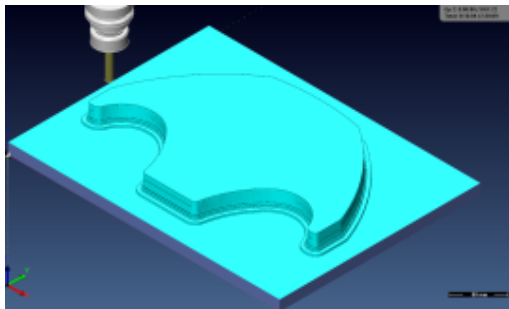
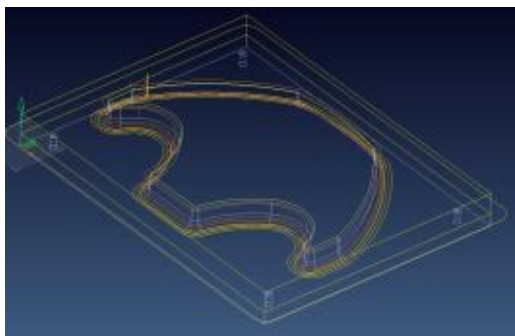
Time

ROUGHNING SPIRAL OUT SETTINGS

Side allowance	0.5
Bottom allowance	0.5
Step-over method	Spiral out
Step-over setting	20
Step down method	Automatic
Step down setting	3
Min	0
Max	50
Boundary	On, Default
Plunging method	Plunging
Rapid style	Clearance plane
Lead in	Axial
Lead out	Axial
Cut mode	Rough
Spindle speed (rev/min)	17109
Feed (mm/min)	7186
Reduction feed (mm/min)	3593
RESOLUTION	0.1
FACETS	120
Time taken to cut	16min4sec

Tool used: T1 - END MILL Ø12mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

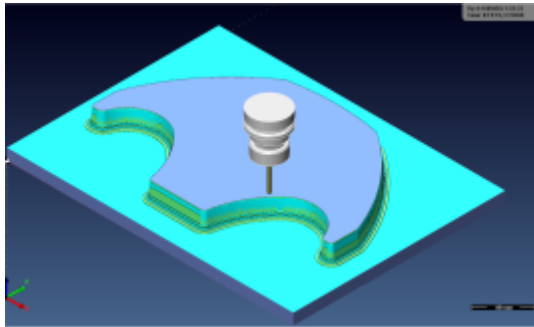
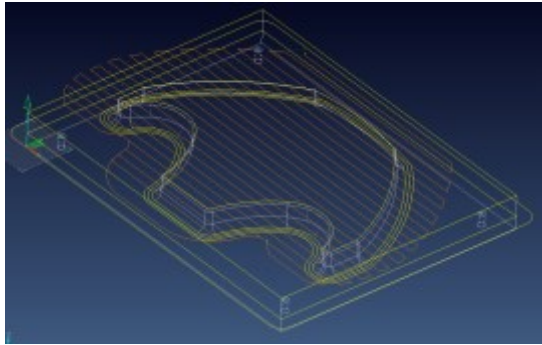
Time

ROUGHNING SPIRAL OUT SETTINGS

Side allowance	0.5
Bottom allowance	0.5
Step-over method	Spiral out
Step-over setting	5.75
Step down method	Automatic
Step down setting	2
Min	29
Max	50
Boundary	On
Plunging method	Plunging
Rapid style	Clearance plane
Lead in	Axial
Lead out	Axial
Cut mode	Rough
Spindle speed (rev/min)	16995
Feed (mm/min)	5000
Reduction feed (mm/min)	2500
RESOLUTION	0.1
FACETS	120
Time taken to cut	1min22sec

Tool used: T3 – ENDMILL Ø40mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

Time

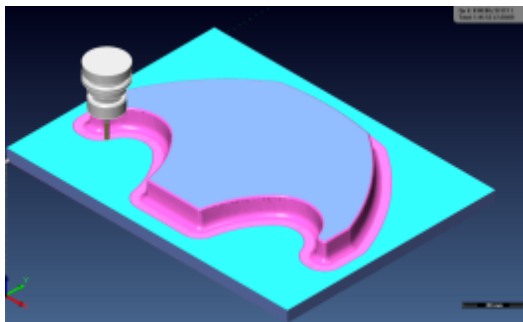
FACEMILL ZIGZAG

SETTINGS

External extension value	50
Bottom allowance	0
Step-over method	ZigZag
Step-over setting	15
Step down method	ZigZag
Step down setting	20
Min	0
Max	0
Shape method	Silhouette
Plunging method	N/A
Rapid style	N/A
Lead in	N/A
Lead out	N/A
Cut mode	Finish
Spindle speed (rev/min)	15120
Feed (mm/min)	6350
Reduction feed (mm/min)	3593
RESOLUTION	0.1
FACETS	120
Time taken to cut	1min52sec

Tool used: T7 – BALLNOSE Ø6 mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

Time

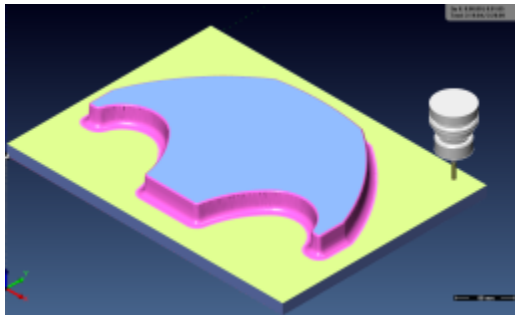
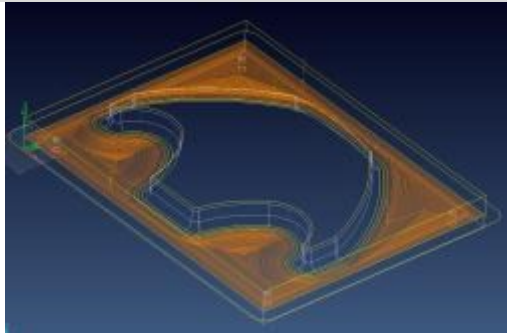
CONSTANT STEPOVER

SETTINGS

Side allowance	0
Bottom allowance	0
Step-over method	N/A
Step-over setting	0.5
Step down method	N/A
Step down setting	0.5
Min	19
Max	49
Boundary	On
Plunging method	Plunging
Rapid style	Clearance plane
Lead in	Horizontal
Lead out	Horizontal
Cut mode	Finish
Spindle speed (rev/min)	17000
Feed (mm/min)	1500
Reduction feed (mm/min)	750
RESOLUTION	0.1
FACETS	120
Time taken to cut	1h22min33sec

Tool used: T9 – SLOTMILL Ø 6.05 mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

Time

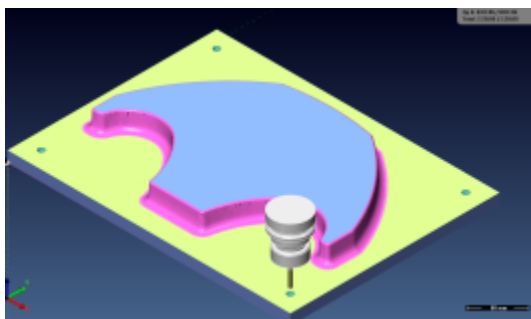
PLANAR FACES

SETTINGS

Side allowance	0
Bottom allowance	0
Step-over method	N/A
Step-over setting	2.8
Step down method	N/A
Step down setting	N/A
Min	19
Max	19
Boundary	On
Plunging method	Ramping
Rapid style	Clearance plane
Lead in	Vertical
Lead out	Vertical
Cut mode	Finish
Spindle speed(rev/min)	17000
Feed(mm/min)	1500
Reduction feed (mm/min)	750
RESOLUTION	0.1
FACETS	120
Time taken to cut	37min11sec

Tool used: T9 – SLOTMILL Ø 6.05 mm

Cutting illustration



Passes

Limit

Leads

Cutting
parameters

Time

MILL

SETTINGS

Side allowance	0
Bottom allowance	0
Step-over method	N/A
Step-over setting	3.025
Step down method	N/A
Step down setting	3.025
Min	0
Max	0
Boundary	N/A
Plunging method	N/A
Rapid style	N/A
Lead in	N/A
Lead out	N/A
Cut mode	Finish
Spindle speed(rev/min)	17000
Feed(mm/min)	800
Reduction feed (mm/min)	400
RESOLUTION	0.1
FACETS	120
Time taken to cut	1min5sec

D.2.4. PLUG AFTER CNC CUTTING

Figure D-2 and D-3 illustrate the cutting surfaces of both the top and bottom plugs. The Figures show that even though the CNC tool paths have been optimised, various surface discrepancies are caused by the cutting itself, which was not predicted on the CAM modelling.

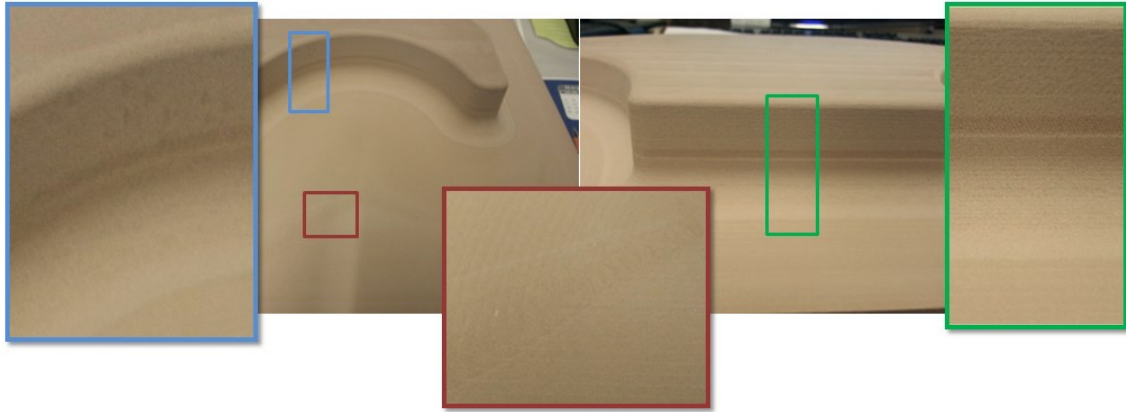


Figure D-2: Top plug discrepancies

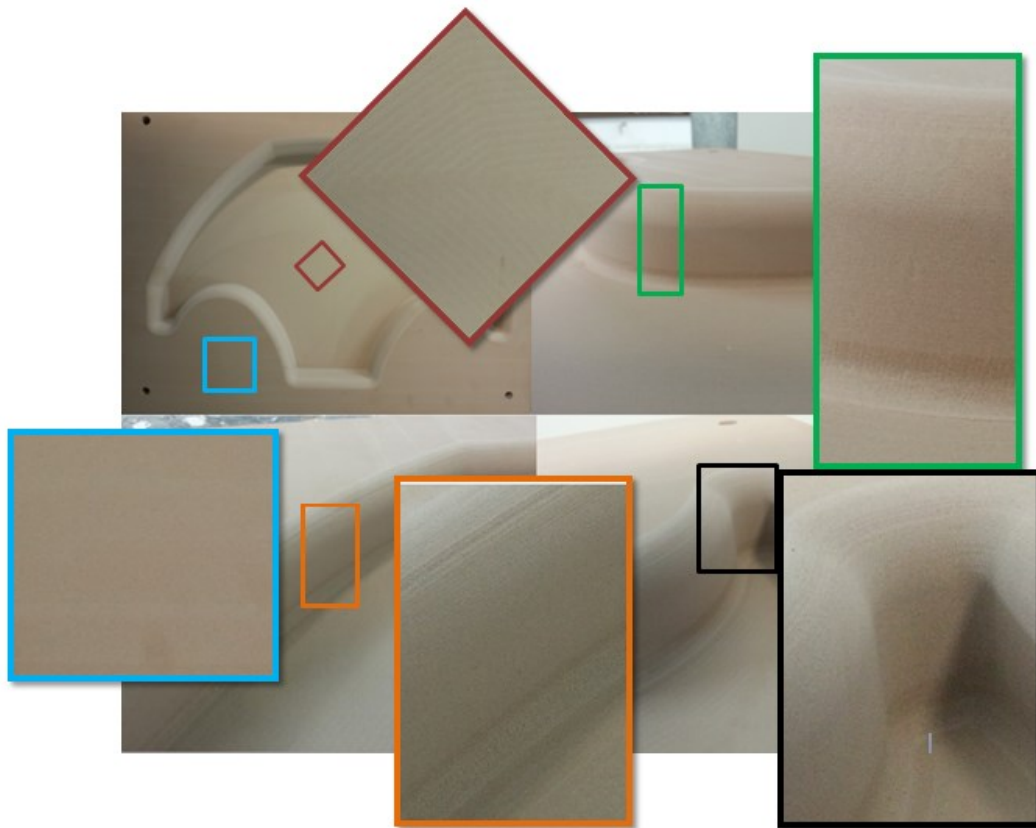


Figure D-3: Bottom plug discrepancies

D.2.5. PLUG FINISHING

The plugs were finished with the process described in Chapter 6. Figure D-4 illustrates a number of areas in the plug which were repaired during finishing as well as the enlarged images of critical areas after finishing:

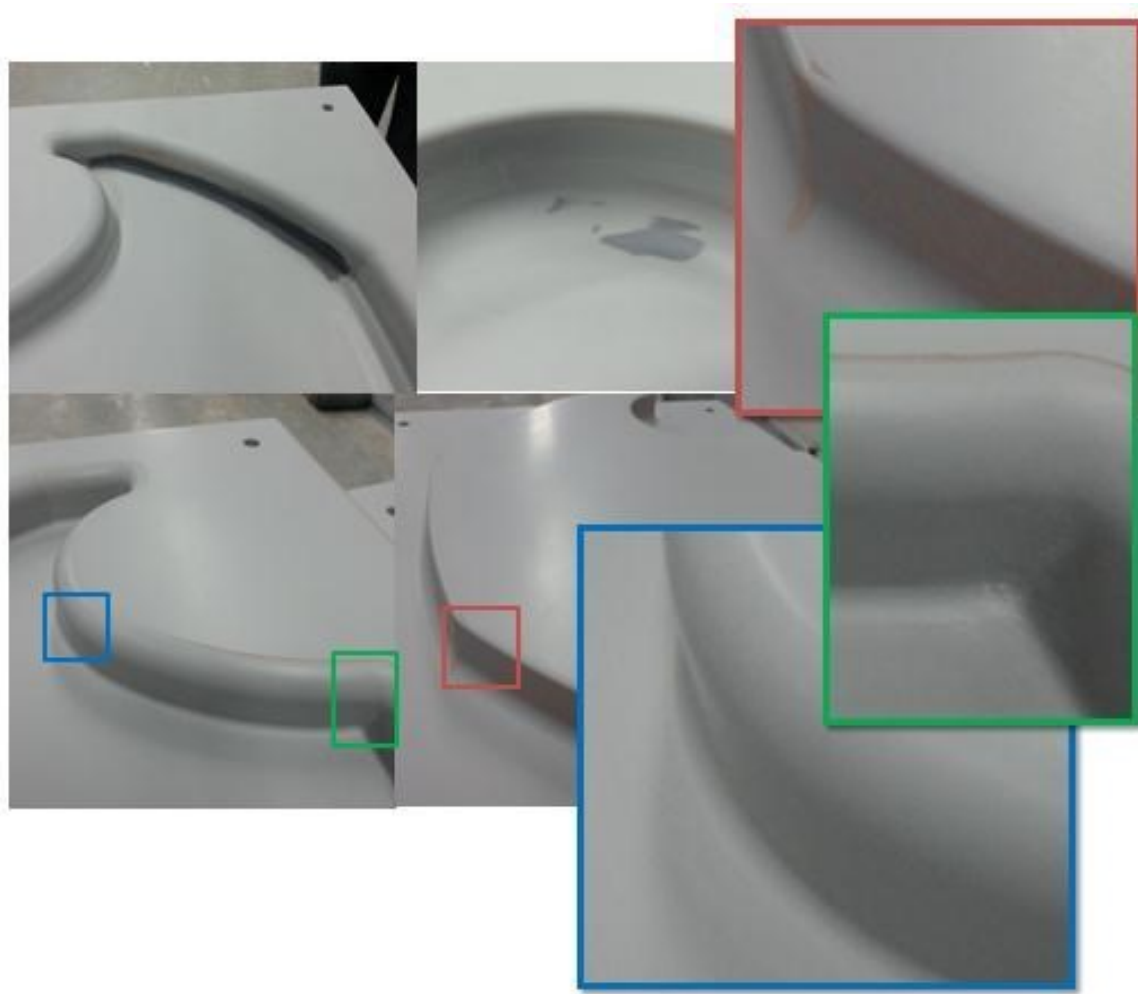


Figure D-4: Plug surfaces after finishing

After the plugs have been finished and prepared with a Mequiars Mirror Glaze 87 Wax, it was time to manufacture the moulds

D.3. MOULD OF INSTRUMENT PANEL

Creating composite moulds requires one to follow a few steps involving both design and manufacturing. The mould composition and mould inserts required designing after which the inserts required manufacturing before the mould manufacturing commenced. This section describes these processes in more detail, starting with the design of the mould layup. It should be noted that the design part and insert manufacturing commenced parallel to the plug manufacturing, as these processes were not influenced by each other. This ensured that the moulds could be manufactured as soon as the plugs were finished. The first step in the mould process was to design the mould layup.

D.3.1. MOULD LAYUP DESIGN

Table D-1 indicates the balanced, symmetrical layup schedule prepared for the manufacturing of composite moulds. The materials used were all bidirectional, thus eliminating the need for a counter angled layer of each material. The brick layer styles are indicated in Figure D-5.

To determine how much material was required, the total area of the mould was calculated. The calculated areas were used to determine how much material will be required in the 45° and 90° direction. The quantities of gelcoat and epoxy were also calculated, illustrated in Table D-2.

Table D-1: Layup schedule of mould

Layer	Material used	Orientation (Degrees)	Thickness (mm)	Brick layer style
1	Tooling Gelcoat	inside to outside		a
2	Glass veil x 4	n/a	0.04	Cut to fit
3	90070	45	0.12	a
4	90070	90	0.12	b
5	92110	45	0.16	a
6	92110	90	0.16	b
7	92125	45	0.25	a
8	92125	90	0.25	b
9	400gsm	45	1.2	a
10	400gsm	90	1.2	b
11	Supawood	0	16	a
12	400gsm	90	1.2	b
13	400gsm	45	1.2	a
14	92125	90	0.25	b
15	92125	45	0.25	a
16	92110	0	0.16	b
17	92110	45	0.16	a
18	Peel ply	90	removed	b
			22.72	

Table D-2: Area and material required calculations

AREA OF MOULD		TOTAL MATERIAL NEEDED FOR 1 MOULD	
LENGTH+ 60 mm for trimming	0.560 m	Gelcoat = $A_T \cdot G \cdot 10^6$	= 120 g
WIDTH+ 60 mm for trimming	0.430 m	PB = $((L \cdot W) \cdot A_R) \cdot 4$	= 0.9 m ²
HEIGHT	0.030 m	90070 = $A_T \cdot 1$	= 0.3 * m ²
TOTAL AREA (A_T)	0.241 m ²	92110 = $A_T \cdot 2$	= 0.5 * m ²
PERIMETER of shape	1.25 m	92125 = $A_T \cdot 2$	= 0.5 * m ²
Area required for ribbon (A_R)	0.04 m ²	92146 = $A_T \cdot 2$	= 0.5 * m ²
Gelcoat thickness (G)	0.0005 m	Epoxy = E	= 500 g
* Required for only 90° or 45°.			
$E = (0.3 \text{ m}^2 \cdot 86\text{gsm}) + (0.5 \text{ m}^2 \cdot 163\text{gsm}) + (0.5 \text{ m}^2 \cdot 280\text{gsm}) + (0.5 \text{ m}^2 \cdot 450\text{gsm}) + (0.9 \cdot 30\text{gsm})$			

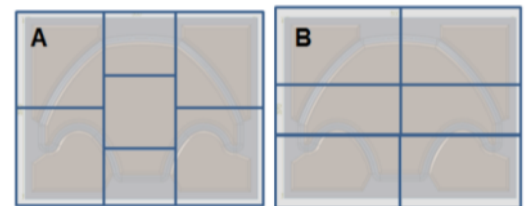


Figure D-5: Brick layers styles

D.3.2. MOULD INSERT DESIGN

The moulds required inserts for the core of the layup as well as alignment inserts. The core inserts were manufactured with the CNC machine from 12mm Supawood, as illustrated in Figure D-6.

The metal inserts were manufactured out of 316 stainless steel with a g6/H7 tolerance. Extra pins, which were used for locating the bushes during manufacturing, were manufactured. The metal pins as well as the manufacturing drawing are illustrated in Figure D-7.

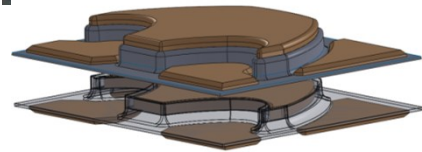
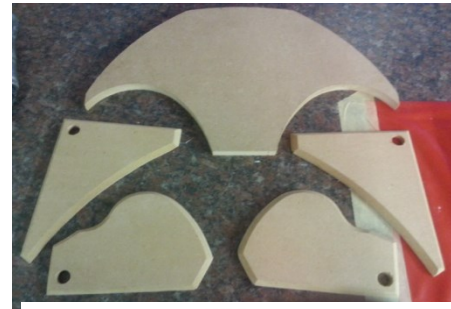


Figure D-6: Supawood inserts cut on the CNC machine, with illustration to show how they fit onto the moulds.

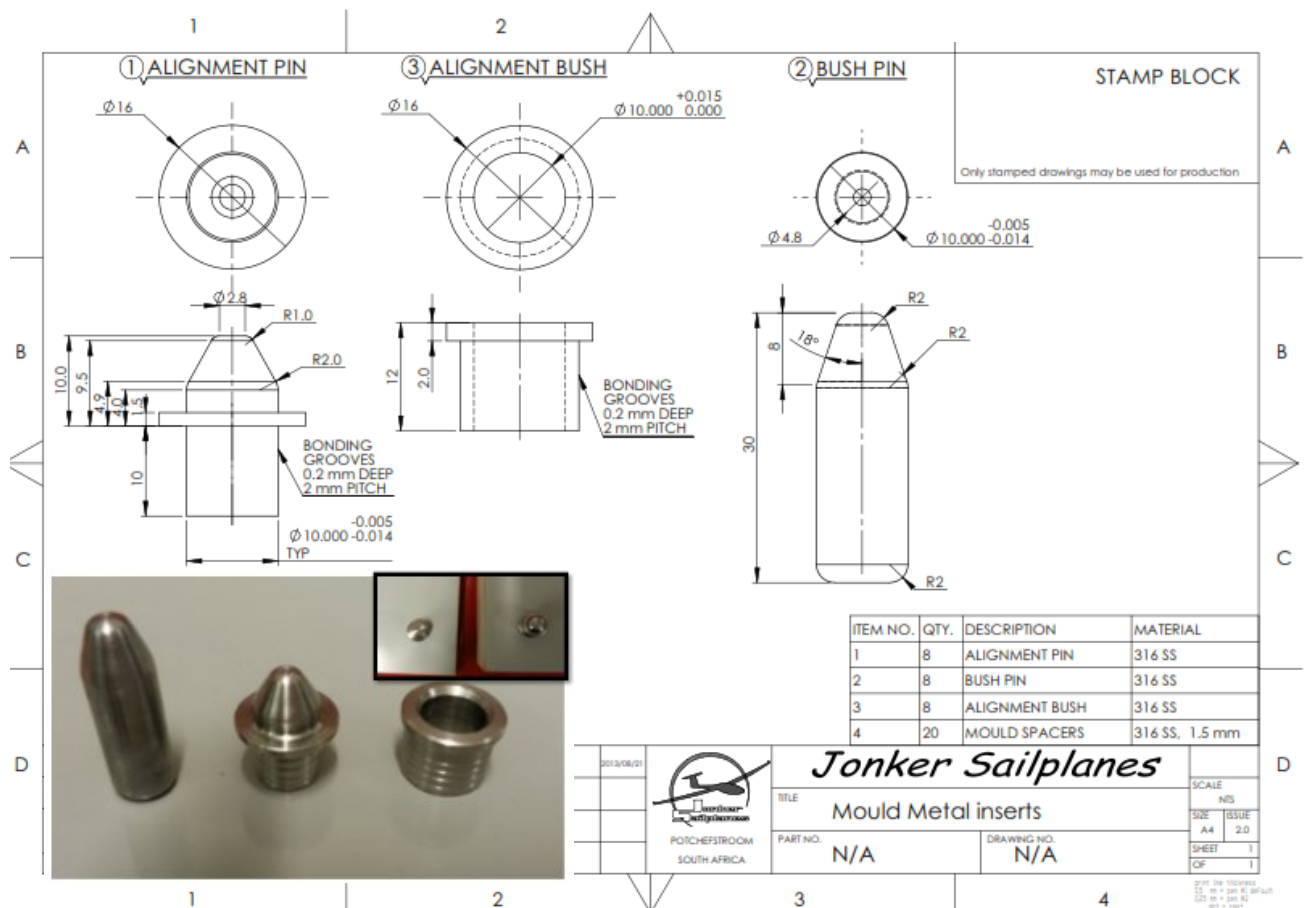


Figure D-7: Metal inserts and metal insert manufacturing drawings

D.3.3. MOULD MANUFACTURING

Figure D-8 briefly illustrate the steps of the mould manufacturing as described in Chapter 6. Figures D-8-1 and D-8-2 illustrate the application of the tooling gelcoat with a heat gun. In Figures D-8-3 and D-8-4, the print barrier is applied, followed by the structural layers shown in Figure D-8-5. The Supawood inserts are prepared with the epoxy bonding mix and applied, as shown in Figure D-8-6. In Figures D-8-7 and D-8-8 the symmetry layers are applied, followed by the layer of peelply. The moulds were then cured for 36 hours at an average of 23°C, after which it was demoulded, as shown in Figure D-8-9.

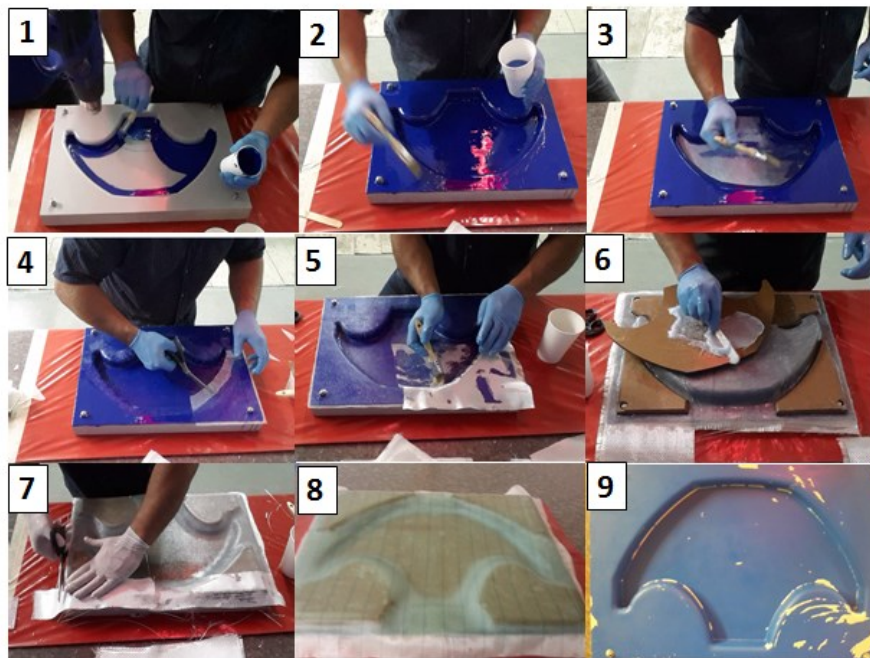


Figure D-8: Mould Manufacturing process

After the moulds have been demoulded, they were cleaned, all defaults, Figure D-9, were repaired, and they were sanded with a P1000 – P2000 grit and polished, illustrated in Figure D-8.



Figure D-8: Moulds being sanded

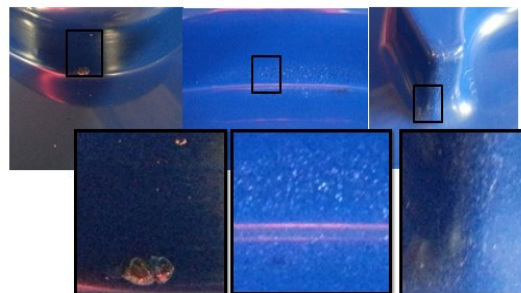


Figure D-9: Mould defects after demoulding

D.4. PART OF INSTRUMENT PANEL

The part manufacturing commenced as described in Chapter 6. After demoulding, the part was revealed to have a few marks, as illustrated in Figure D-10 possibly due to the release agent which was not properly wiped off before spraying. These marks can be prevented if the release agent is properly wiped off before spraying the 2K paint. However, these marks disappeared easily after polishing the part.

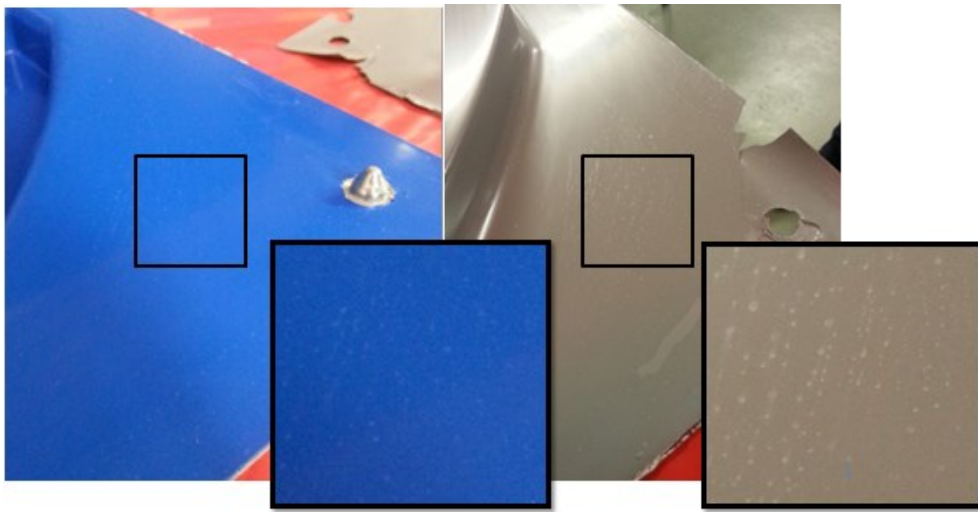


Figure D-10: Marks created by release agent

APPENDIX E: FINISHING OF SURFACES

The composite parts produced in this study are parts that have surface layers consisting of gelcoats and paints. These types of surface finishes have certain properties and require particular approaches to finishing. This section provides more insight on this subject.

E.1. OUTER SKIN OF THE PART – SURFACE LAYERS

The method of painting gliders over the years has changed little. Polyester paint, or better known as, gelcoats, ("Schwabbellack" or "Vorgelat") are sprayed into the open mould and the part (fuselage or wing) is laid up on the wet layer. (Dirks, 2012)

After the wing or fuselage halves are put together, the joints are cleaned, painted, and sanded with an increasingly fine paper and, finally, it is polished. Regardless of the paint being used, it is a difficult task which requires skill that may take years to perfect. The result is a very evenly painted gelcoat surface. This layer has a certain thickness and the shrinkage of the underlying structure evens it out. Even when the gelcoat is of the highest quality, however, it may turn yellow over the course of time. This yellowing is especially noticeable after re-finishing or repairing of a glider structure.

Gelcoat finishes may also split because of large temperature changes. This is caused by the different coefficients of expansion of the polyester gelcoat and underlying reinforced epoxy plastic. These cracks and flaking happen mostly because of high altitude flights and can ruin the entire glider surface. This situation can be compared to automobiles that stand in the sun, summer and winter, with little change to their surfaces. Polyurethane paints offer the very highest quality, and is so elastic that it will not crack even if the filler underneath it gets hair thin cracks. This is the reason why modern glider manufactures make use of Polyurethane surface layer systems on top of the in mould gelcoat finish. (Dirks, 2012)

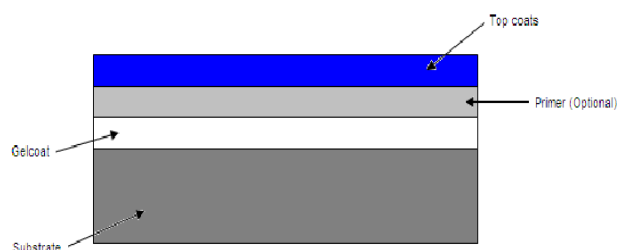


Figure E-1: Surface layers of Composite structures.
(TIA SWP 29, 2012)

Finishing the glider with Polyurethane in the mould is, however, not conventional at the moment, and the current study will investigate possibilities of applying Polyurethane paints as topcoats with in-mould coatings to produce Class A finished composite structures directly out of the mould. Because the mould finishing for these types of parts plays a significant role in the part's finishing, an entire section will now be devoted to the manufacturing of moulds for these types of parts. (Dirks, 2012)

E.2. PREPARATION OF THE SURFACE FOR FINISHING

Several preparations are required for the spray painter to achieve an evenly applied gloss shiny surface, which is free from dust flaws, pinholes, orange peel, and so on (TIA, 2012). These include:

- ◆ The surface to be sprayed on must be flawless, clean of dust or any other contamination.
- ◆ The paint must be selected and mixed correctly.
- ◆ To obtain the correct viscosity of the paint, the correct amount of thinners must be applied.
- ◆ The spraying plays a crucial part and the spray area should be kept clean and properly maintained.
- ◆ It is essential to spray in a dust free environment like a spray booth.
- ◆ The spray environment and surface to be coated must be kept at the prescribed standards of the paint system to be used.
- ◆ The spray gun jet must be selected correctly and be adjusted according to the surface to be sprayed on.
- ◆ Always let the paint layers flash before applying the next layer, as this will result in better bonding between layers.
- ◆ Any disturbance of the painter whilst spraying may result in thicker application or may cause the formation to run. It is thus crucial that the area around the paint job is obstacle free and that the spray gun airline must have sufficient reach.

Following these guidelines entails good practice and will help to ensure that the greatest number of paint flaws is prevented, but it still does not ensure a good quality surface by

itself. Spraying a good surface is an artful skill; however, there are further steps to following for applying the paint.

E.3. APPLICATION PROCESS OF PAINT OR GELCOATS

One can ensure that the entire surface is painted and that paint would not create pin holes or flake after demoulding or application by following the following spray coats (Duffy, 2004):

1. Application of mist coats

A mist coat (drop coat, dustcoat or tack coat) is a very lightly applied, thin coat which looks like small, dense drops after application. It is obtained by reducing the spray gun pressure and holding the gun a little further away from the surface. The spray gun is also moved at a faster pace. Mist coats cures relatively fast to create a slightly textured film of paint. The purpose of the mist coat is to improve bonding.

2. Application of light coats

Light coats are usually used when applying the first colour coat (or so-called priming coat). This coat is obtained by moving the spray gun quickly across the surface. Applying a larger number of thin light coats yields a more durable coat that is less prone to problems than thick coatings, which crack and chip more easily.

3. Application of medium wet coats

Medium wet coats are obtained by moving the spray gun across the area at a normal rate. This layer's advantage is that it provides a normal glossy surface, provides sufficient coverage, and helps to prevent sagging and running of the paint.

4. Application of full wet coats

A full wet coat is obtained by moving the spray gun at a slower than average pace across the surface. This will result in more paint being deposited onto the surface. Full wet coats are usually used when applying clear coats, which result in a thick glossy finish. Full wet coats can easily result in running and sagging if not applied properly. The following guidelines can help to ensure a good quality full wet coat (TIA, 2012):

- ◆ Objects painted should, if possible, be positioned horizontally, as vertical surfaces are much more prone to running and sagging.
- ◆ Maintaining the correct distance between the spray gun and object is very important. Each spray job is different and the distances may vary depending on the material of the surface, the spraying pressure and the size of the spray gun jet. The following should be noted:

- Holding the spray gun too close to the object results in the spray angle to decrease. This results in over-depositing of paint to the surface and usually results in running of the paint.
- Holding the spray gun too far from the object causes the material to almost dry before it reaches the surface. The painted surface will be rough which results in orange peel and a loss of glossiness.
- ◆ The spray gun should be held exactly parallel to the object and not arched. While spraying, the gun needs to be moved in smooth and slow wave-like movements, so that the colour jet of the next spray route overlaps the preceding half of the sprayed route.
- ◆ By spraying crosswise, an equally coloured surface is obtained. This is achieved by leading the gun from left to right (a horizontal process). This is followed by transposing the jet head and leading the gun from top to bottom (vertical process). The spray stripes should overlap wet in wet. This spraying process is right-angled and therefore this method of gun leading is known as the “cross process”. The process further requires that the edges of an object must be sprayed before the areas that are more difficult to reach.
- ◆ Care should be taken when filling and closing the cover of the cup of the gun, as any paint drops which fall onto the object will cause running.

If these steps are followed by a trained painter, the resulted paint layers of the surface will be of good quality; however, there are still a large number of causes that can result in poor paint jobs.

E.4. POLISHING OF PAINTED SURFACES

The polishing of a painted surface can involve various abrasive pastes and liquids, which can be applied by either hand or machine. Machine compounds reduce the polishing time, but intricate corners and dwells or smaller parts are difficult to polish. In these cases hand compounding may be used to obtain the sufficient surface quality.

Because sanding to a P2000 quality already produces a high surface quality, one might feel that polishing is not required. The following reasons for polishing are provided (Canning, 1982):

- ◆ To achieve a bright, semi-bright and textured surface finish for decorative and aesthetic purposes.
- ◆ To create a suitable basis for further coating.
- ◆ To remove surface imperfections and contaminants.
- ◆ To improve and refine the surface.

One must always use the appropriate machine compound and only apply correct sufficient amount to polish a small area. The compound should be worked around the face of the pad and over the surface before the machine is switched on. This will prevent the compound from flying from the surface when the machine is switched on.

Compounds have the tendency to dry out and thus buffing of large areas should be avoided. Even when small areas are buffed, the machine should be moved around the surface constantly. If it is kept at one place, it may burn through the topcoat.

A higher machine speed will result in a deeper shine. The following procedures should be followed along with the guidelines above:

- ◆ The machine should be kept at a 5 degree angle to the surface and only tilted to reach into corners or match curve lines.
- ◆ The machine should not be pushed down into the surface, as it can cut through the topcoat. Rather let the machine do the work.
- ◆ Care should be taken around panel edges to avoid burn-out.

- ◆ The area should often be inspected and more compounding applied if necessary. The area should be buffed until the compounds dry out, but then buffing should not continue.
- ◆ The face of the buff pad should never be placed on an area which might contaminate it with dirt or debris, as even one grain of sand could severely scratch a surface.
- ◆ A powered buffer should never be used with hand-rubbing compounds as it can cause scratches and swirl marks due to the compound being used at a faster rate than it was designed for.
- ◆ A lightly foam pad and fine glazing compound should be applied after the initial compounding with the wool pad. This final step removes any swirl marks left by the initial polishing and brings out the paint gloss.

After the surface has been polished, the surface could be said to be a Class A product. The processes described above should be applied to the plug, the mould or the part surface finish. This is because each surface drawn from the previous step will have small imperfections which were left on that surface. The surface of the part will thus reflect the surface of the mould.

Mould surfaces are subjected to a large number of stresses and strains in a production cycle. Maintaining a good mould surface starts by manufacturing a mould that is durable and that can withstand the everyday processes of production. The next section provides guidelines on this.

E.5 SANDING OF PAINTED SURFACES TO A CLASS A FINISH

The surface may be sanded and polished to create a flat, glossy surface, after the paint has fully cured. Sanding may not always be needed if the sprayed surface is sufficiently smooth, but in most cases sanding is required. The sufficient methods of sanding to follow when the final layers of paint have cured are provided (TIA, 2012):

1. The part should be cleaned of any dust or sand to prevent any deep scratches in the paint during the sanding process.
2. The surface dye should be applied to the entire surface.
3. Choose the initial grade of the wet sanding paper. This may depend on the depth of the impurities:

- a. To sand out orange peel on a gelcoat surface may require an initial grade of P320 using a hard aluminium block.
 - b. To sand out orange peel on a 2K-paint surface may require an initial grade of P600 using a hard aluminium block.
 - c. For sanding out very fine dust imperfections, a grade of P2000 may be used.
4. Sand the surface until all the impurities shown by the surface dye are removed, always ensuring that the surface is wet.
 5. After all impurities of one grade have been removed, surface dye should be applied again and the sanding of the next grade should commence until a grade of P2000 is reached. Each grade should be sanded at a different angle opposed to the previous grade, as illustrated in the Figure E-2.

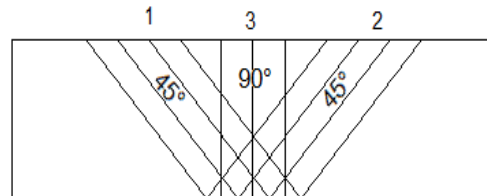


Figure E-2: Directions of sanding to remove marks of previous steps.(TIA, 2012)

After the surface has been sanded to a P2000 finish, it should be polished to obtain the gloss recognised by Class A finishes.

E.6. TYPICAL SURFACE COAT PROBLEMS

Surface coat problems include a wide range of defects that can be found before or after painting. To maintain repair quality and satisfy customers, one must be able to analyse and correct finish problems efficiently (Duffy, 2004).

Surface coat defects usually originate as a result of problems in the preparation of the body surface, painting procedure, environment, paint ingredients, and other sources;

◆ Removal of foreign matter in wet paint

Paint foreign matter includes anything one can see in the paint that will adversely affect the finish (dust, lint, hair, etc.). Upon noticing, try to remove immediately with the aid of sharp tweezers, fine wire, tooth pick etc. After removal of debris, blend-spray a coat of paint over the area right away.



Figure E-3: Foreign matter in paint. (Duffy, 2004)

◆ **Wet sanding between coats**

- ◆ Upon noticing small particles or imperfections in the colour coat, repair them before spraying the clear coats. It can be done by carefully wet sanding over the top of the flawed paint with ultrafine, #1000 to #1200, grit sandpaper. Wipe the area dry. Lightly mist and blend the basecoat over the surface flaw to cover any visible problem in the colour.

◆ **Orange peel**

Orange peel can be described as any uneven surface formation, much like that on the skin of an orange. When viewed under a magnifying glass, the paint surface looks rough, bumpy or textured.

Correcting: Two full coats of clear coat, properly applied, with the correct flash times between each coat will normally correct an orange peel problem. Minor orange peel can be corrected by machine buffing.

◆ **Bull's eye featheredge**

This refers to an indented area that results from shrinkage of spot putty or filler, producing an area that is lower over the top of the putty or filler.

Correcting: Sand and refinish the affected area.

◆ **Runs and sags**

Paint runs: This occurs when gravity produces a mass slippage of an over wet and thick paint film.



Figure E-4: Paint running. (Duffy, 2004)

Paint sag: Is a partially slipping down of the paint created by a film that is too heavy to support itself.



Figure E-5: Paint sagging. (Duffy, 2004)

Correcting: On small areas of wet paint: Use solvent to wash off the run or sag before repainting. Larger panels: Allow paint to dry enough for wet sanding. Use coarse #600 grit wet sandpaper and a stiff sanding rubber block to level off the run or sag. Block sand the area with a finer, #1000 grit, wet sandpaper to avoid sand scratches.

◆ **Paint fish eyes**

These are “BB-sized” dimples or craters that form in the liquid paint film right after spraying.

Correcting: Mix a small amount of fish-eye eliminator additive with the paint. Spray another coat over the affected area ASAP to see if the paint film will flow out smoothly over the fish-eye dimples. If the area cures too much or if the problem is too severe, allow the paint to cure or dry. Then, wet sand or power dry sand the area to level the dimples in the paint surface. Repaint the spot as needed.

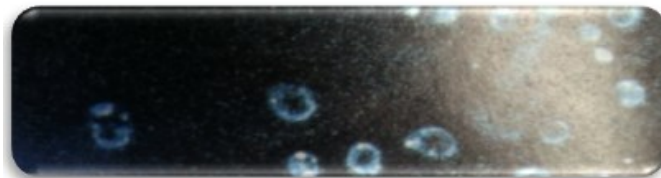


Figure E-6: Fish eyes formed by painting on a contaminated surface. (Duffy, 2004)

◆ **Pin holing**

Tiny holes in the finish which are usually the result of trapped solvents, air, or moisture. Correcting: Sand the affected area down as deeply as necessary and refinish the area.



Figure E-7: Pinholes looks like small chips in the paint. (Duffy, 2004)

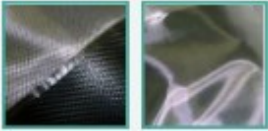
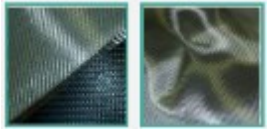
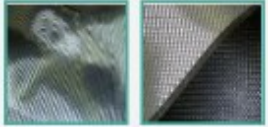
E.7. SANDPAPER GRIT SIZES

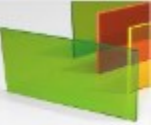
Table E-1: Sandpaper grit size comparison

	ISO/FEPA Grit designation	CAMI Grit designation	Average particle diameter (µm)
MICROGRITS			
Very Fine (sanding finishes between coats)	P240		58.5
		240	53.0
	P280		52.2
	P320		46.2
	P360		40.5
Extra fine, start polishing of wood		320	36.0
	P400		35.0
	P500		30.2
		360	28.0
	P600		25.8
Super fine (final sanding of finishes, final sanding of wood)		400	23.0
	P800		21.8
		500	20.0
	P1000		18.3
		600	16.0
	P1200		15.3
Ultrafine (final sanding and polishing of thick finishes)	P1500	800	12.6
	P2000	1000	10.3
	P2500		8.4

APPENDIX F: MATERIALS, EQUIPMENT, SOFTWARE USED

F.1. MATERIALS

MATERIAL NAME & ILLUSTRATION	CLASS	DESCRIPTION
3M™ Ventureshield 	Surface layer (Non-conventional)	PPF (paint protection film). A high grade, resistant, colourless urethane film, which can be applied to areas of a vehicle which is subjected to high impacts due to the effect of detrimental road debris (3M, n.d.).
3M™ Scotchprint 1080 Vinyl Wrap - Gloss White 	Surface layer (Non-conventional)	Specifically designed dual cast vinyl film that provides dimensional stability and durability, without the need for an over laminate. The wrap's adhesive is pressure activated, which allows you to reposition the film during application. The material is flexible, allowing it to conform and bend easily. Specially designed air releases channels in the film assure a fast, easy, and virtually bubble-free insulation (AVS, Opencart, 2013).
90070 	Print Barrier	Glass fibre, plain weave, 86 GSM, 0.09 mm thickness, 4.5mm overlap (TIA, 2012; AMT Composites, 2013).
92110 	Reinforcement	Glass fibre, twill weave, 163GSM, 0.16 mm thickness, 8mm overlap (TIA, 2012; AMT Composites, 2013).
92125 	Reinforcement	Glass fibre, twill weave, 280GSM, 0.28 mm thickness, 14mm overlap (TIA, 2012; AMT Composites, 2013).
Axson F16 Fast cast Polyurethane 	Tooling board adhesive	F16 fast cast Polyurethane has a low viscosity and is heat resistant. It has a two minute pot life, shore 72D hardness. It has a 100 to 100 mixing ratio and viscosity of 90 Mpa.s at 25°C. It is mostly used for the casting of negatives, moulds and mock-ups.
Cab-O-Sil 	Filler	Fumed silica (e.g. Cab-o-Sil™) is a non-crystalline form of silicon dioxide, also called silica. (TIA, 2012).
3M™ ClearPlex® 	Surface layer (Non-conventional)	ClearPlex® is the first and only optically-clear protection film for auto windshields. This patent-pending product absorbs the impact of standard road hazards. The film is thermally fitted to every curve of the windshield, forming a bond with the glass (AVS, Opencart, 2013).

MATERIAL NAME & ILLUSTRATION	CLASS	DESCRIPTION
GC 1150 Tooling Gelcoat 	Surface layer	This dark blue tooling gelcoat is easily polished and it offers high chemical resistance. It is suitable for polyester and epoxy resin transfer moulds, polyurethane foam moulds and RIM (AMT Composites, 2013).
Glass veil 	Print Barrier	Glass Fibre veil, random orientations weave. 15-20 mm overlap. 30 GSM (Wanberg, 2009).
Loctite Frekote 770- NC, FMS, PMC 	Release system	Frekote PMC is a blend of solvents mould cleaner. Frekote FMS mould sealer is fast curing mould porosity sealer for glass fibre reinforced polyester, epoxy and other resin-type moulds. Use to seal new and older moulds. Frekote 770-NC is a low odour, fast evaporating, various moulding applications, Max temp 400°C. (AMT Composites, 2013)
Mequiars Mirror Glaze 87 Wax 	Release agent	Mirror Glaze 87 high temp mould release wax is a unique blend of exceptionally hard waxes & thermoset resins. It provides excellent mould release capabilities when conventional mould releases fail to deliver. Max temperature 105 °C (AMT Composites, 2013).
Nucron65 1 	Tooling Board	Application for master models, very fine structure, smooth surface, easy to varnish, excellent processing properties. Shore D = 68, temperature resistance 70°C, Density 0.70 g/cm ³ (AMT Composites, 2013).
Plexiglass TM 	Surface layer (Non- conventional)	Acrylic is a widely used material, which is a cell cast high molecular mass. These sheets are available in a wide range of sheets, with various thicknesses, colours and even surface patterns. The surface finish of these sheets can vary, depending on the manufacturer and type, but are generally a high gloss, hard finish or can be compared to clear glass, as it is defined by (Pilkington, 2009)
Scottbader Crystic Gelcoat 253PA 	Surface layer	Crystic Gelcoat 253PA is a thixotropic, pre-accelerated, isophthalic gelcoat designed as an in-mould gelcoat with excellent adhesion to epoxy resins and pre-pregs without the need for a tie-coat. Formulated for spray application, Crystic Gelcoat 253PA is available in a wide range of colours and the information contained in this technical data sheet also applies to these pigmented versions.
Standocryl 2K white HPMix 015 	Surface layer	MIX 015 WHITE HP, 02083400, Non-hazardous substance, mixture of synthetic resins, pigments, and solvents (Standox, 2008).
Zyvax Enviroshield 	Release agent	Glass fibre, plain weave, 400 GSM, 0.5 mm thickness, 4.5mm overlap (AMT Composites, 2013).

MATERIAL NAME & ILLUSTRATION	CLASS	DESCRIPTION
Zyvax Sealer GP 	Release system sealer	Universal solvent-free release agent designed specifically to meet the “green chemistry” requirements, Thermal stability: 260 °C, High gloss, high slip / lubricity, No build-up on mould. No transfer to mould (AMT Composites, 2013).
Zyvax Flex- Z1, Z3 	Release agent	High modulus, clear, flexible film with superior substrate adhesion that forms a protective shield on the mould or tool surface. As a conditioner, designed to treat both the chemical and physical bonding sites (AMT Composites, 2013).
Zyvax Nano 	Release agent	A variable release system that gives total control to the moulder. Thermal stability: 480 °C. Z1: minimum slip; linhibits pre-release and promotes tape adhesion. Prevents styrene build up. Z3: medium slip, standard choice for large hulls and flat areas (AMT Composites, 2013).
Zyvax Waterclean 	Release system cleaner	Nano release high performance coating is a breakthrough in green chemistry based on non-polluting, odour-free Nano E.G.O. polymer technology. Hazard-free and user safe (AMT Composites, 2013).

F.2. EQUIPMENT & CONSUMABLES USED

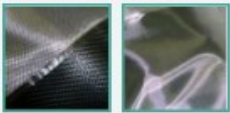
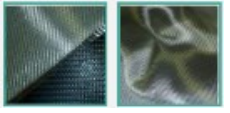
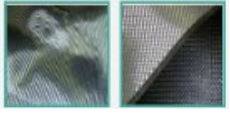
EQUIPMENT NAME & ILLUSTRATION	CLASS	DESCRIPTION
3M wetordry™ 	Sanding Paper	3M wet or dry TM sanding paper GRIT P400 to P3000. COLAD foam sanding pads - medium, fine.
BALL NOSE Ø6mm 	Equipment	CNC ball nose finishing tool. CARBIDE, JS internal code none, d=6mm, r=3mm, L=131.15mm, l=10mm, Le=17.5mm, P=0mm
END MILL Ø12mm 		CNC End mill roughing tool. CARBIDE, JS internal code M30120CN, d=12mm, r=0mm, L=101mm, l=55mm, Le=59mm, P=0mm
END MILL Ø40mm 	Equipment	CNC End mill roughing tool. CARBIDE, JS internal code M00450AR, d=40mm, r=0mm, L=128.42mm, l=29mm, Le=54mm, P=0mm

EQUIPMENT NAME & ILLUSTRATION		CLASS	DESCRIPTION
General Electronic desktop scale		Equipment	Electronic scale, maximum weight 30kg x 0.5g increments. Large LCD display with backlight, Weight accumulation, kg/lb weight selection.
General Paint Brushes		Consumable	Normal 38 mm width paint brushes, wooden handles.
General Paint Roller		Consumable	Paint brushes, 80mm diameters, 50mm widths.
Latex Gloves		Consumable	For hand protection against chemicals
Paper Cups		Consumable	Used as mixing containers
SCM RECORD 110 AL PRISMA		Equipment	Wood, 5 axis-CNC machining, Industrial machine with heavy-duty structure . Rear tool changer magazine with nr. 16 positions. Control and program system XYLOG PLUS (H&M , 2011)& (EXA Pro, 2004-2013).
SLOT MILL Ø6.05mm			CNC Slot mill finishing tool. CARBIDE, JS internal code none, d=6.05mm, r=0mm, L=64mm, l=27mm, Le=45mm, P=0mm
Spray booth		Equipment	A spray booth is a dedicated facility to provide a clean, safe, well-lit, and well ventilated enclosure for the purpose of spray painting. The booth isolates the painting operation from dirt- and dust producing activities and at the same time confines and exhausts the volatile fumes created by spray painting. The air movement in the booth moves vapours out of the booth, reducing worker exposure to vapours (TIA, 2012).
Spray gun		Equipment	A spray gun breaks the liquid paint substance into a fine mist and forces it into a refinishing system. It consists of a cup, lid, air cap, fan/pattern adjustment, flow adjustment, handle and air inlet. It is operated with air pressure (Duffy, 2004).
Wooden spatulas		Consumable	For mixing of chemicals

F.3. SOFTWARE USED

MATERIAL / EQUIPMENT	CLASS	DESCRIPTION
Visicadcam 3D / 5 Axis v19.0 	Software	VISI Machining 3D creates intelligent toolpaths for CNC machining on the most complex 3D parts. Extensive range of CAD interfaces and powerful modelling. VISI can work directly with Parasolid, IGES & Solid Works (VISI, n.d.).
Solidworks Standard 	Software	SolidWorks is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows. SolidWorks is a Parasolid-based solid modeller, and utilizes a parametric feature-based approach to create models and assemblies. Building a model in SolidWorks usually starts with a 2D sketch (although 3D sketches are available for power users)., Supported files include: SolidWorks Files (*.sldprt, *.sldasm, *.slddrw), Part Files (*.prt, *.sldprt), Parasolid (*.x_t, *.x_b, *.smt_txt, *.xmt_bin). (Solidworks, 2013)
Xilog plus 	Software	The software Xilog Plus from the SCM Group is used to manage the CNC-machining centres with numerical control. It consists of two pieces of software, which can be installed separately or together: the program editor and the machine control panel (Höchstmann GmbH, 2007-2013).

APPENDIX G: DATASHEETS

MATERIAL NAME	ILLUSTRATION	PAGE NUMBER	MATERIAL NAME	ILLUSTRATION	PAGE NUMBER
90070		G2	Nuceron651		G16
92110		G3	Scottbader Crystic Gelcoat 253PA		G18
92125		G4	Standocryl 2K white HPMix 015		G19
Axson F16 Fast cast Polyurethane		G5	Zyvax Enviroshield		G22
MGS Laminating Resin 285 & hardener 205, 286, 287		G6	Zyvax Flex-Z1, Z3		G23
GC 1150 Tooling Gelcoat		G11	Zyvax Waterclean		G24
Loctite Frekote 770-NC, FMS, PMC		G13			

G.1. 90070 DATASHEET



00235 1050

TISSU VERRE E / E GLASS FABRIC

Fiche Technique / Product Data

Renfort Textile pour Composites Hautes Performances

Textile Reinforcement for High Performance Composites

DEFINITION / DESCRIPTION

Edition 09/2006 / Issue 09/2006

Type de fils Type of yarns	Chaîne / Warp : EC9 34 Trame / Weft : EC9 34
Masse nominale/ Nominal weight	86 g/m ² 2,54 oz/sqy ²
Armure Weave style	TAFFETAS PLAIN
Poudrage Powdering	
Traitement Finish	
Largeur standard Standard width	1050 mm 41 in

CARACTERISTIQUES / CHARACTERISTICS

Contexture nominale Nominal construction	Chaîne / Warp : 12,0 fils-yarns/cm Trame / Weft : 12,5 coups-picks/cm
Répartition en masse Weight distribution	Chaîne / Warp : 49 % Trame / Weft : 51 %
Epaisseur / Thickness (*)	0,06 mm

PROPRIETE MECANIQUE SUR STRATIFIE* / MECHANICAL PROPERTIES ON LAMINATE*

Mise en oeuvre (60 min à 120°C, vide 0,85 bar, pression 3 bars) / Cure cycle (60 min at 120°C, vacuum 0,85 bar, pressure 3 bars)

	Traction chaîne Warp tensile	Flexion chaîne Warp flexural	C.I.L. chaîne Warp I.L.S.S.
Contrainte / Strenght (Mpa)			
Module / Modulus (Gpa)			
Normes / Standards			

*Nota: Les valeurs moyennes ci-dessus sont obtenues sur la base d'un stratifié epoxy de mm avec % de fibres en volume.

*NB : The above average values are obtained with epoxy laminate of mm at % of fibres in volume.

IMPORTANT

Les renseignements contenus dans la présente fiche produit sont fondés sur nos connaissances actuelles et sur les résultats d'essais effectués avec un constant souci d'objectivité. Ils doivent être adaptés à chaque cas particulier. Les performances du produit après utilisation étant liées aux conditions particulières de mise en œuvre, elles ne sauraient engager notre responsabilité.

All information is believed to be accurate but is given without acceptance of liability. Users should make their own assessment of the suitability of any product for the purpose required. All sales are made subject to our standard terms of sales which include limitations on liability and other important terms.



HEXCEL Reinforcements
Composite & Industrial Reinforcements
3, av. Condorcet B.P. 1208 • 69608 Villeurbanne Cedex • France
Tél. +33 (0)4 72 44 40 00 • Fax +33 (0)4 72 44 45 77
www.hexcel.com

© Copyright Hexcel

G.2. 92110 DATASHEET



Glasfasergewebe / Glass Fibre Fabric / Tissu de Verre Style 92110

US-Style:

WLB Nr.: 8.4548.60

Flächengewicht / Areal Weight / Poids à mètre carré: 163 g/m²

: Körper 2/2; 2x2 Twill; Sergé 2/2

Finish: FK144

Garn / Yarn / Fil:

Kette / Warp / Chaîne EC9-68

Fadendichte / Fibre Count / Densité de Fils:

Kette / Warp / Chaîne 12,0 Fd/cm (1/cm; Fils/cm)

Dicke (Richtwert trocken) / Thickness (approx. dry)

Epaisseur (valeur nominale à sec) 0,18 mm

Traction:

Kette / Warp / Chaîne 335 MPa

Schuss / Weft / Trame 320 MPa

Zug-E-Modul / Young's-Modulus / Module d'Elasticité :

Kette / Warp / Chaîne 19 GPa

Schuss / Weft / Trame 18 GPa

G.3. 92125 DATASHEET



PRODUCT SPECIFICATION

		Specification	
Style Number	92125	MIL-Y-1140H	
US Style			
WLB No.	8,4551,60	DIN 65066	
British Standard		BS 3396	
Finish/Designation	FK144		
	Unit	Tolerance Specification	
Weave pattern	2 x 2 twill	DIN ISO 9354	
Area weight	g / m ² 280.0	± 5%	DIN EN 12127
Yarn	tex	DIN EN 12654	
warp yarn	EC9-68x3 10		
weft yarn	EC9-204		
Fibre count	1 / cm	DIN EN 1049	
warp ends	7.0	± 5%	
weft picks	6.5	± 5%	
Temperature resistance 1)			
Continuous load	°C 260		
Short time resistance	°C 600		
Moisture content	% < 0.2	± 1%	DIN EN 3616
Finish content	% 0.08 - 0.28	± 5%	DIN ISO 1887
			DIN EN 60
Thickness (approx. dry)	mm 0.35	± 5%	DIN ISO 4603/E
in laminate (43% Vol.)	mm 0.25	± 5%	

All statements herein are expressions of opinion which we believe to be accurate and reliable, but are our part. Statements concerning possible use of our products are not intended as recommendations for their use in the infringement of any patent. No patent warranty of any kind, express or implied, is
INTERGLAS Technologies AG, Benzstraße 14, D-89155 Erbach, Telefon +49 (0)7305 / 955-416, Fax +49 (0)7305 / 955-512
TS / 16/05/2008

Page 1 of 2

G.4. AXSON F16 FAST CAST POLYURETHANE DATASHEET



F 16 FASTCAST POLYURETHANE CAN BE FILLED POT LIFE 2'30 - T_g 100°C

DESCRIPTION

Negatives, moulds, masters and mock-ups using the unfilled product or filled with RZ 30150 mineral filler in order to limit exotherm and to get easy machining.

Thermoforming masters using the product filled with RZ 209/6 aluminium powder in order to increase thermal conductivity.

PROPERTIES

- Fast demoulding
- Low viscosity
- Good temperature resistance after heat curing
- Easy-to-use mix ratio (1:1 by weight)
- Adjustable filler content

PHYSICAL PROPERTIES					
Composition		PART A POLYOL	PART B ISOCYANATE	UNFILLED MIXING	MIXING FILLED WITH RZ 30150
Mix ratio by weight		100	100	-	300
Aspect		liquid	liquid	liquid	liquid
Colour		off-white	light amber	beige	beige
Viscosity at 25°C (mPa.s)	BROOKFIELD LVT	90	55	80	1,500
Specific gravity at 25°C (g/cm ³)	ISO 1675 : 1985	1.00	1.10	-	-
Specific gravity of cured product at 23°C	ISO 2781 : 1996	-	-	1.05	1.61
Pot life at 25°C on 200 g (min)	Gel Timer TECAM			2'10 – 2'30	-

MECHANICAL PROPERTIES at 23°C (1)				
			UNFILLED MIXING	MIXING FILLED WITH 360 phr RZ 30150
Hardness	ISO 868 : 2003	Shore D1	72	82
Flexural modulus	ISO 178 : 2001	MPa	1,000	3,600
Flexural strength	ISO 178 : 2001	MPa	37	39
Compressive strength at yield	ISO 604 : 2002	MPa	33	60
Impact strength (CHARPY) Unnotched specimens	ISO 179/1eU : 1994	kJ/m ²	13	-

(1) : Average values obtained on standard specimens / Hardening 14 hr at 60°C

HANDLING PRECAUTIONS

Normal health and safety precautions should be observed when handling these products :

- Ensure good ventilation
 - Wear gloves, safety glasses and waterproof clothes.
- For further information, please consult the product safety data sheet.

Page 1/2- 17 octobre 2005-a

AXSON France BP 40444 95025 Cergy Cedex FRANCE Tel. (+33) 1 34 40 34 60 Fax (+33) 1 34 21 97 87 Email : axson@axson.fr	AXSON GmbH Ditzingenbach Tel. (+49) 60 74 407 110 AXSON ITALIA Saronno Tel. (+39) 02 96 70 23 36	AXSON ISERICA Barcelona Tel. (+34) 93 225 16 20 AXSON UK Neumarket Tel. (+44) 1636 660 062	AXSON Central Europe Zlate Moravce Tel. (+421) 3764 22526 AXSON MEXICO Mexico DF Tel. (+52) 555 2644 922	AXSON SHANGHAI Shanghai Tel. (+86-21) 58683037 AXSON NA USA Eaton Rapids Tel. (+1) 517 6638191	AXSON JAPAN Okazaki city Tel. (+81) 564 262591 AXSON MIDDLE EAST info.middleeast@axson.com	AXSON INDIA Pune info.india@axson.com AXSON KOREA Seoul info.korea@axson.com
---	---	---	---	---	--	---

G.5. MGS LAMINATING RESIN AND HARDENER DATASHEET



Laminating resin L 285
Hardeners 285, 286, 287

Résine L 285
Durcisseurs 285, 286, 287

Characteristics

Caractéristiques

Approval:	GERMAN FEDERAL AVIATION AUTHORITY
Application:	Production of gliders, motor gliders and motor planes Boat and shipbuilding Sports equipment Model airplanes Moulds and tools
Operational temperature:	-60°C → +50-60°C (-75°F → +120-140°F) without -60°C → +80 - +100°C (-75°F → +175-210°F) after heat treatment
Processing:	At temperatures between 10°C and 50°C (50-120°F) All usual processing methods
Special properties:	Extremely good physiological compatibility Good mechanic and thermic properties Pot life from approx. 45 min. to approx. 5 hours
Special modifications:	L 285 T: Thixotropic L 285 W: White

Homologation:	SERVICES FÉDÉRAUX DE L'AÉRONAUTIQUE CIVILE
Domaines d'application:	Constructions de planeurs, de planeurs à moteur et d'avions à moteur Construction de bateaux, équipe- ments sportifs, aéromodélisme Construction de moules, de gabarits et de montures
Température d'application:	-60°C à +50-60°C sans - -60°C à +80 - +100°C avec traitement thermique
Mise en oeuvre:	A des températures entre 10°C et 50°C Tous les procédés de traitement d'usage
Particularités:	Excellent caractère physiologique Bonnes propriétés mécaniques et thermiques Temps d'utilisation env. 45 minutes à 5 heures
Adaptations spéciales:	L 285 T: thixotrope L 285 W: teinture blanche



Laminating resin L 285 Hardeners 285, 286, 287

Résine L 285 Durcisseurs 285, 286, 287

Application

Laminating resin system approved by the **GERMAN FEDERAL AVIATION AUTHORITY** with different pot lives for processing of glass, carbon and aramide fibres, featuring high static and dynamic loadability.

After heat treatment at 50 - 55 °C (120-130 °F), the system meets the standards for gliders and motor gliders (operational temperatures -60 °C (-75 °F) to +54 °C (130 °F)). In order to meet the standards for motor planes (operational temperatures -60 °C (-75 °F) to +72 °C (160 °F)), heat treatment at 80 °C (175 °F) is necessary.

The range of pot lives is between approx. 45 min and 5 h. The hardeners have the same mixing ratio and can be mixed among themselves in any ratio. This permits a selection of the optimum system for all processing methods. After initial curing at room temperature, the components manufactured are workable and demouldable. You will receive high-gloss and non-tacky surfaces, even with unfavourable precuring conditions, e. g. lower temperatures or high humidities.

The mixing viscosity guarantees fast and complete impregnation of the reinforcement fibres; however, the resin will not spill out of the fabrics on vertical surfaces. In order to obtain special properties, it is also possible to add fillers to the mixture of resin/hardener, such as Aerosil, microballoons, cotton flakes, metal powder, etc.

If high heat resistance or aircraft approval are not necessary, hardener 285 can also be used without heat treatment afterwards. However, the indicated properties will only be obtained after heat treatment at temperatures over 50 °C (120 °F).

—

Application

*Système de résine pour stratifiés homologué par les **SERVICES FÉDÉRAUX DE L'AÉRONAUTIQUE CIVILE** avec différents temps d'utilisation pour la mise en oeuvre de fibres de verre, de carbone et d'aramide. Les bonnes propriétés mécaniques de ces systèmes permettent de produire des composants à charge statique et dynamique élevée.*

Après avoir subi un traitement thermique entre 50 - 55 °C, les systèmes remplissent les exigences requises pour les planeurs et planeurs à moteur (température d'application - 60 °C à + 54 °C). Un traitement thermique à 80 °C est nécessaire pour satisfaire aux exigences relatives aux avions à moteur (températures d'application - 60 °C à + 72 °C).

Les temps d'utilisation se situent env. entre 45 min et 5 heures. Les durcisseurs ont le même rapport de mélange et sont miscibles entre eux dans chaque rapport, ce qui permet d'obtenir le système optimal pour chaque cas d'application. Après le durcissement initial à température ambiante, les pièces peuvent être traitées et démoulées. Même dans des conditions de durcissement désavantageuses (basses températures ou humidité de l'air élevée) on obtient des surfaces polies et non adhérentes.

La viscosité de mélange est définie de façon à assurer, d'une part, une imprégnation rapide et optimale des fibres de renforcement et, d'autre part, d'empêcher des fuites de résine au niveau des tissus posés sur des surfaces verticales. Pour obtenir des propriétés spéciales, il est également possible d'ajouter au mélange résine/durcisseur des additifs tels que Aerosil, microballons, flocons de coton, poudre métallique, etc.

Pour de nombreuses applications où une résistance thermique élevée ou l'homologation aéronautique n'est pas requise, le durcisseur 285 peut être utilisé sans traitement thermique consécutif. Cependant, les propriétés finales indiquées ne seront atteintes qu'après un post-durcissement à des températures supérieures à 50 °C.

—



Laminating resin L 285
Hardeners 285, 286, 287

Résine L 285
Durcisseurs 285, 286, 287

Application

The laminating resin system has a hydrophilic character (higher humidity absorption, lower resistance to diffusion of steam). Therefore, we do not expect any problems concerning compatibility in case of combination with polyester gelcoats, diverse paints (e. g. on the basis of PUR), etc. However, comprehensive tests are indispensable.

Since the approval of laminating resin L 285 in 1985, it has been used by nearly all manufacturers of planes and gliders and - especially because of the extremely good physiological compatibility - it is the most commonly used system in the aircraft industry today. It often happens that workers who have experienced problems with some epoxy resins concerning allergies or skin irritation are able to process laminating resin L 285.

The relevant industrial safety regulations for the handling of epoxy resins and hardeners and our instructions for safe processing are to be observed.

Le système de résine pour stratifiés a des propriétés hydrophiles (absorption d'humidité élevée, faible résistance à la diffusion de vapeur d'eau). Il est donc peu probable de rencontrer des problèmes de compatibilité lors de l'utilisation combinée de gelcoats UP, de vernis divers (p. ex. à base de PUR) et autres. Cependant, il est absolument nécessaire d'effectuer des essais préalables.

Depuis son homologation en 1985, la résine pour stratifiés L 285 est appliquée par tous les constructeurs d'avions de renommée et représente, grâce à son excellent caractère physiologique, la résine la plus utilisée dans la construction aéronautique. Il a été constaté que des utilisateurs ne supportant pas certains types de résines (irritation de la peau et allergies) peuvent par contre travailler avec la résine pour stratifiés L 285.

Il est impératif d'observer les consignes de sécurité concernant la manipulation de résines époxy et de durcisseurs ainsi que nos recommandations pour une mise en œuvre en toute sécurité.



Laminating resin L 285
Hardeners 285, 286, 287

Résine L 285
Durcisseurs 285, 286, 287

Specifications

Spécifications

		Laminating resin L 285 <i>Résine L 285</i>
Density	lbs/gal / 77°F	9.85 - 10.26
<i>Densité</i>	<i>g/cm³ / 25°C</i>	1,18 - 1,23
Viscosity	cps / 77°F	600 - 900
<i>Viscosité</i>	<i>mPas / 25°C</i>	
Epoxide equivalent	—	165 - 170
<i>Equivalent époxy</i>		
Epoxide value	—	0,59 - 0,65
<i>Valeur EP</i>		
Colour	Gardner	max 3
<i>Coloration selon</i>		

		Hardener 285 <i>Durcisseur 285</i>	Hardener 286 <i>Durcisseur 286</i>	Hardener 287 <i>Durcisseur 287</i>
Density	lbs/gal / 77°F	7.84 - 8.10	7.84 - 8.10	7.76 - 8.00
<i>Densité</i>	<i>g/cm³ / 25°C</i>	0,94 - 0,97	0,94 - 0,97	0,93 - 0,96
Viscosity	cps / 77°F	50 - 100	60 - 100	80 - 100
<i>Viscosité</i>	<i>mPas / 25°C</i>			
Amine value	mg KOH / g	480 - 550	450 - 500	450 - 500
<i>Indice d'amine</i>				
Colour	Gardner	max 3(*)	max 3(*)	max 3(*)
<i>Coloration selon</i>				

(*) Applies to transparent hardener only -
hardeners are coloured transparent blue

(*) Valable pour réglage incolore; les durcis-
seurs sont colorés bleu transparent



Laminating resin L 285
Hardeners 285, 286, 287

Résine L 285
Durcisseurs 285, 286, 287

Processing details

Caractéristiques de mise en oeuvre

	Resin L 285 <i>Résine L 285</i>	Hardener 285 <i>Durcisseur 285</i>	Hardener 286 <i>Durcisseur 286</i>	Hardener 287 <i>Durcisseur 287</i>
Average EP - Value <i>Valeur moyenne EP</i>	0,62	—	—	—
Average amine equivalent <i>Equivalent moyen d'amine</i>	—	64	64	64

Mixing ratios

Rapports de mélange

	Resin L 285 : Hardener 285, 286, 287 <i>Résine L 285 : Durcisseur 285, 286, 287</i>
Parts by weight <i>Parts de poids</i>	100 : 40 (+/-2)
Parts by volume <i>Parts de volume</i>	100 : 50 (+/-2)

G.6. GC 1150 TOOLING GELCOAT DATASHEET

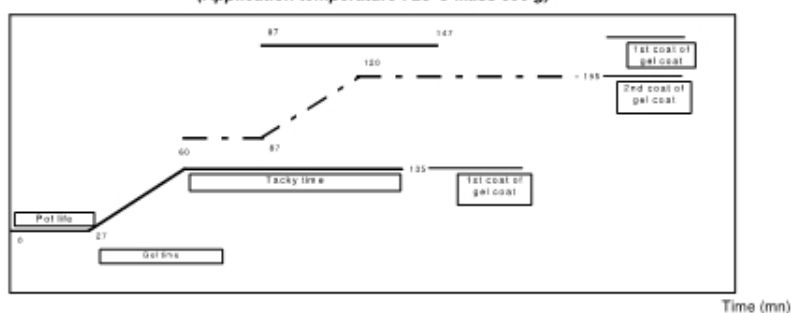


TECHNICAL DATA SHEET

GC1 150 / GC 15

PHYSICAL PROPERTIES				
		RESIN GC1 150	HARDENER GC 15	MIXING
Mixing ratio by weight		100	20	
Aspect		paste	liquid	thick liquid
Color		dark blue	light amber	dark blue
Brookfield LVT viscosity at 25 °C (mPa.s)	-	thixotrope	850	thixotrope
Density at 25 °C	ISO 1675-85	1.25 – 1.35	1.05 – 1.09	-
Density of the cured product	ISO 2781-88	-	-	1.25 – 1.26

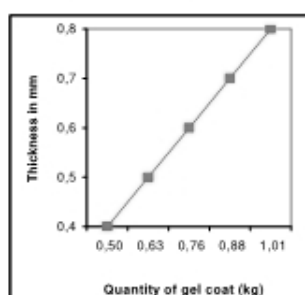
Application diagram of GC1 150/GC 15
(Application temperature : 23 °C Mass 390 g)



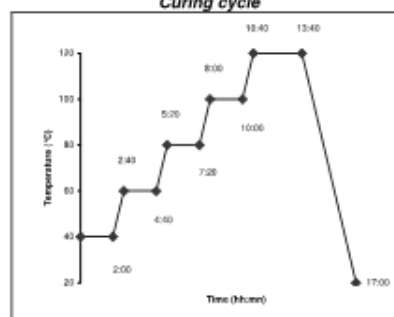
PROCESSING CONDITIONS

Apply DEMOLDING AGENT 841 or WAX 827 on a non porous pattern.
Back-up : EPOLAM 2050 and reinforcements
EPO 4030

Quantity of gel coat for production of 1 m² surface
(for information only)



Curing cycle



Initial stabilization 16 hrs at room temperature

GC1 150 / GC 15

TECHNICAL DATA SHEET

EPOXY GEL COAT
CAN BE SANDED – GLOSS RECOVERY
GOOD TEMPERATURE RESISTANCE
GOOD CHEMICAL RESISTANCE

USE

olds : Polyester RTM, polyurethane foaming.

MECHANICAL AND THERMAL PROPERTIES AT 23°C ⁽¹⁾			
Hardness	ISO 868-85	Shore D1 / D15	87 / 86
Compressive modulus	ISO 604-97	MPa	6000
Compressive yield strength	ISO 604-97	MPa	120
Flexural modulus	ISO 178-93	MPa	4800
Flexural strength	ISO 178-93	MPa	103
Glass transition temperature after curing	T.M.A.-Mettler	°C	130
Glass transition temperature without curing (24hrs at room temperature)	T.M.A.-Mettler	°C	100

(1) : Average values obtained on standardized specimens / Hardening 16 hrs at 25°C + curing described in processing conditions

STORAGE CONDITIONS

se before 24 months according to the manufacturing date. Expiration date indicated on the packaging.

HANDLING PRECAUTIONS

ormal health and safety precautions should be observed when handling these products :

ensure good ventilation
wear gloves, safety glasses and clothes.

or further information, please consult the product safety data sheet.

PACKAGING

<i>esin</i>	<i>Hardener</i>
<i>1 x 8.69 kg</i>	<i>1 x 1.740 kg</i>
<i>12 x 0.326 kg</i>	<i>Carton de 12 x 0.065 kg</i>

GUARANTEE

he information of our technical data sheet are based on our present knowledge and the result of tests conducted under precise conditions. It is the responsibility of the user to determine the suitability of AXSON products, under their own conditions before commencing with the proposed application. AXSON refuse any guarantee about the compatibility of a product with any particular application. AXSON disclaim all responsibility for damage from any incident which results from the use of these products. The guarantee conditions are regulated by our general sale conditions.

The technical data sheet and the safety data sheet are also available on our website : www.axson.com

Page 1/2 01082

G.7. LOCTITE FREKOTE 770-NC, FMS, PMC DATASHEET

LOCTITE 1001 Trout Brook Crossing Rocky Hill, CT 06067-3910 Telephone: (860) 571-5100 FAX: (860) 571-5465		Product Description Sheet FREKOTE® 700-NC Mold Release Agent Industrial Products, September 2001	
Description Loctite® Frekote® 700-NC offers excellent release properties for the most demanding applications. Frekote 700-NC releases epoxies (thermosets and prepreps), polyester resins, and thermoplastic compounds.		1. Only a thin wet film is required. Wipe or spray on a smooth, thin, continuous, wet film. Avoid wiping or spraying over the same area that was just coated until the solvent has evaporated. If spraying, hold nozzle 8-10 inches (20-30 cm.) from mold surface. It is suggested that small areas be coated working progressively from one side of the mold to the other.	
Features No chlorinated solvents High gloss and high slip No contaminating transfer Versatile - releases most polymers No mold build-up Room temperature cure		2. Initially, apply two or more base coats, allowing up to 5 - 10 minutes after each application for complete solvent evaporation. The film should be dry and not feel tacky.	
Properties Appearance Clear liquid Odor Hydrocarbon Solvents Aliphatic Hydrocarbon, Dibutyl Ether Specific Gravity 0.760 +/- .010 Flash Point 31°C (88°F) Tag Closed Cup Special Cautions Moisture sensitive, keep container tightly closed when not in use. Shelf Life 1 year from date of manufacture Application Temp 13°C - 135°C (55°F - 275°F) Thermal stability when cured 400°C (750°F)		3. Aerosols may sometimes leave a matte surface finish. To enhance gloss, use a cotton cloth to gently buff up dry film, if required.	
Mold Preparation The mold surface must be clean and free of any release agent or other contaminants for Frekote 700-NC to be completely effective. Remove any contaminants with Frekote PMC, PMC Plus or suitable cleaning solvent. Light industrial abrasives can be used to remove heavy resin build up.		4. Performance is enhanced by recoating once, after the first few initial pulls. Maximum releases will be obtained as the mold surface becomes conditioned to Frekote 700-NC.	
New Molds: Full curing of new molds is advisable to ensure the best bonding of the Frekote to the mold surface. New fiberglass and epoxy molds should be cured per manufacturer's instructions before starting full scale production.		5. When any release difficulty is experienced, the area in question can be "touched-up" by recoating the entire mold surface or just those areas where release difficulty is occurring. For temperatures up to 135°C (275°F), use Frekote 700-NC allowing the film to thoroughly dry before continuing molding operation. If application temperatures exceed 135°C (275°F), Frekote 800-NC is recommended.	
Note: For porous, green or repaired molds, a Frekote Sealer should be used - technical data is available. Consult with your Frekote Representative for assistance.		Note: Touch-up coats applied at regular intervals before the base film breaks down will extend the number of releases obtainable and reduce possible resin attack/build-up.	
Application *Consult MSDS prior to use.*		Precaution: Users of closed mold systems (i.e. rotomolding) must be certain that solvent evaporation is complete and that all solvent vapors have been ventilated from the mold cavity prior to closing the mold. An oil-free compressed air source can be used to assist in evaporation of solvents and ventilation of the mold cavity.	
Frekote 700-NC can be applied to mold surfaces at room temperature up to 135°C (275°F) by spraying, brushing or wiping with a clean lint-free, cloth. When spraying, ensure a dry air source is used or use an airless spray system. When gel coats are used, a wipe-on-wipe-off method of application is recommended. If possible, warm the mold prior to applying Frekote 700-NC to approximately 50°C (120°F) to drive off any moisture entrapped on the mold surface.		Flammability/ Storage Frekote 700-NC contains flammable solvents. The product should always be used in well ventilated areas. Store in a cool, dry place. Keep container tightly closed when not in use.	
NOT FOR PRODUCT SPECIFICATIONS THE TECHNICAL DATA CONTAINED HEREIN ARE INTENDED AS REFERENCE ONLY. PLEASE CONTACT LOCTITE CORPORATION QUALITY DEPARTMENT FOR ASSISTANCE AND RECOMMENDATIONS ON SPECIFICATIONS FOR THIS PRODUCT. ROCKY HILL, CT FAX: (860)-571-5473 DUBLIN, IRELAND FAX: (353)-(1)-451-9958			

LOCTITE

1001 Trout Brook Crossing
Rocky Hill, CT 06067-3910
Telephone: (860) 571-5100
FAX: (860) 571-5465

Product Description Sheet

FREKOTE® Mold Sealer (FMS)

Industrial Products, October 2003

Description

Loctite® Frekote® Mold Sealer (FMS) is formulated specifically as a sealer for fiberglass reinforced polyester, epoxy and other composite molds commonly used in the fiberglass molding industry. This sealer must be used when using green or new molds as well as when sealing older molds with micro-porosity and other slight surface imperfections.

Features

Fast Curing
Seals "green" molds and repaired areas
Eliminates porosity/micro-porosity
High gloss finish
Easy application

Properties

Odor	Hydrocarbon
Solvents	Dibutyl Ether/Aliphatic Naphtha
Specific Gravity	0.762 +/- 0.015
Special Cautions	Moisture sensitive, keep container tightly closed when not in use.
Application Temp	13°C - 35°C (55°F - 90°F)
Shelf Life	One year from date of manufacture

Mold Preparation

The mold surface must be dry, clean and free of any release agent or other contaminants for the sealer to be completely effective. Remove any contaminants with Frekote PMC or other suitable cleaning solvents. Full curing of green/new molds is highly recommended to ensure optimal performance of the sealer. Always follow your tooling supplier's guidelines for proper curing of new molds.

Application *Consult MSDS prior to use*

FMS should be applied at room temperature (less than 35°C or 95°F) by wiping on with a clean, lint-free, cotton cloth.

1. Soak cloth with FMS until it is wet, but not dripping. Wipe on a smooth, wet film over a 2' x 2' to 2' x 3' area of the mold surface. Do not over apply.
2. Wait 15-20 seconds at 21°C (70°F) after application. Gently wipe dry starting from the out working inward with a second clean and dry, cotton cloth.

Note: Changes in temperature will affect solvent dry time. At temperatures below 18°C (65°F), waiting time between wiping on and drying off can be slightly longer than 20 seconds. At higher than normal temperatures (greater than 35°C or 95°F) the wait time is significantly reduced and can be as quick as 1-2 seconds. In these conditions it is also advisable to reduce your wipe area to 1' x 1' in order to eliminate streaking due to the increased solvent evaporation and polymer cure times. A general guideline is to wait until the edges of the wiped area begins to creep inwards indicating that evaporation has just begun. Wipe from the outside and slowly work your way towards the center. Light hand pressure is all that is needed. No

hard rubbing is required. Change cloth frequently to ensure proper drying of the mold. On small molds, allow up to 15 minutes between coats. If one coat takes more than 15 minutes, simply go back to starting point and begin to apply next coat.

3. Coat the entire mold surface overlapping the last area coated. Green molds will need a minimum of three coats and fully cured molds (not green) require 1-2 coats for proper sealing.
4. Once the final coat is applied, the coating should be cured at room temperature for 15-20 minutes.
5. The mold must now be coated with the designated Frekote release agent.
For example:
For a gloss finish use Frekote SOLO, WOLO or FRP-NC.
For a matte finish use Frekote 44-NC.
For a lay-up without gel coat, use Frekote 770-NC.

Refer to the appropriate technical data sheet for further instructions.

Flammability/Storage

Frekote FMS contains flammable solvents. The product should always be used in well-ventilated areas. Store in a cool, dry place. Consult MSDS for complete details.

Note

The data contained herein are furnished for information only and are believed to be reliable. We cannot assume responsibility for the results obtained by others over whose methods we have no control. It is the user's responsibility to determine suitability for the user's purpose of any production methods mentioned herein

protection of property and of persons against any hazards that may be involved in the handling and use thereof. In light of the foregoing, **Loctite Corporation specifically disclaims all warranties expressed or implied, including warranties of merchantability or fitness for a particular purpose, arising from sale or use of Loctite Corporation's products. Loctite Corporation specifically disclaims any liability for consequential or incidental damages of any kind, including lost profits.** The discussion herein of various processes or compositions is not to be interpreted as representation that they are free from domination of patents owned by others or as a license under any Loctite Corporation patents that may cover such processes or compositions. We recommend that each prospective user test his proposed application before repetitive use, using this data as a guide. This product may be covered by one or more, United States, or foreign patents or patent applications.

NOT FOR PRODUCT SPECIFICATIONS

PLEASE CONTACT LOCTITE CORPORATION QUALITY DEPARTMENT FOR ASSISTANCE AND RECOMMENDATIONS ON SPECIFICATIONS FOR THIS PRODUCT.
ROCKY HILL, CT FAX: +1 (860)-571-5473 DUBLIN, IRELAND FAX: +353 (1)-451-9959

Loctite and Frekote are Registered Trademarks of Loctite Corporation U.S.A.

LOCTITE

1001 Trout Brook Crossing
Rocky Hill, CT 06067-3910
Telephone: (860) 571-5100
FAX: (860) 571-5465

Product Description Sheet

FREKOTE® PMC Mold Cleaner

Industrial Products, October 2003

Description

Loctite® Frekote® PMC is a special blend of solvents designed to dissolve and remove wax from polyester molds without dulling the surface. PMC can also be used to clean epoxy and metal mold surfaces as well as for cleaning brushes and equipment. PMC is highly recommended for preparing polyester mold surfaces prior to application of Frekote Mold Sealers and Mold Release Agents.

Properties

Specific Gravity	0.830 +/-0.015
Special Cautions	Keep away from heat, sparks and open flame.
Shelf Life	Two years from date of manufacture.

For FRP Molds and Wax Removal

PMC should be applied to the mold surface with a clean cotton cloth. Wax will immediately begin to dissolve and should be removed from the surface with a second clean cloth while it is still dissolved in the PMC. As the cloth becomes saturated with wax, dispose of it and use a new cloth. Repeat process until wax residue is removed. Wipe dry. The mold is then ready for application of Frekote Mold Sealer or Release.

A simple test to assess mold cleanliness is the use of masking tape. A waxed surface will allow easy release of masking tape, whereas a wax free surface will allow good adhesion of masking tape. This test can also be used to determine the effectiveness of a Frekote interface. A good interface will prevent any significant degree of tape adhesion.

Note

release, be sure to wipe clean with PMC after doing so, as many buffing compounds contain wax.

Flammability/Storage

Frekote PMC contains flammable solvents. The product should always be used in well-ventilated areas. Store in a cool, dry place. Consult MSDS for complete details.

Note

The data contained herein are furnished for information only and are believed to be reliable. We cannot assume responsibility for the results obtained by others over whose methods we have no control. It is the user's responsibility to determine suitability for the user's purpose of any production methods mentioned herein and to adopt such precautions as may be advisable for the protection of property and of persons against any hazards that may be involved in the handling and use thereof. In light of the foregoing, **Loctite Corporation specifically disclaims all warranties expressed or implied, including warranties of merchantability or fitness for a particular purpose, arising from sale or use of Loctite Corporation's products. Loctite Corporation specifically disclaims any liability for consequential or incidental damages of any kind, including lost profits.** The discussion herein of various processes or compositions is not to be interpreted as representation that they are free from domination of patents owned by others or as a license under any Loctite Corporation patents that may cover such processes or compositions. We recommend that each prospective user test his proposed application before repetitive use, using this data as a guide. This product may be covered by one or more, United States, or foreign patents or patent applications.

NOT FOR PRODUCT SPECIFICATIONS
THE TECHNICAL DATA CONTAINED HEREIN ARE INTENDED AS REFERENCE ONLY.
PLEASE CONTACT LOCTITE CORPORATION, QUALITY DEPARTMENT FOR ASSISTANCE AND RECOMMENDATIONS ON SPECIFICATIONS FOR THIS PRODUCT.

Loctite and Frekote are Registered Trademarks of Loctite Corporation U.S.A.

G.8. NUCERON651 DATASHEET



NECURON® 651

Data Sheet

1/2

Characteristics:

- very fine structure
- smooth surface
- easy to varnish
- excellent processing properties

Applications:

- master models and copy models
- cubing models
- work models
- general modelling

Technical data:

Colour	brown
Coefficient of thermal expansion	approx. $52 \times 10^{-6} \text{ K}^{-1}$
Temperature resistance	approx. 70°C
Shore D	approx. 68
Compressive strength	approx. 26 N/mm ²
Flexural strength	approx. 30 N/mm ²
Density	approx. 0.70 g/cm ³
Abrasion resistance (at defined parameters)	approx. - mm ³
Fire protection classification	B2
Electrical current resistance	approx. - $\Omega \times \text{cm}$
Notched impact strength	approx. - kJ/m ²
Thermal conductivity	approx. 0.11 W/mk

- contains no halogens, plasticizer or solvent
- manufactured fluorocarbohydrate-free
- physiologically harmless

Measurements:

1200	500	130	mm
1200	500	150	mm
1500	500	40	mm
1500	500	50	mm
1500	500	60	mm
1500	500	75	mm
1500	500	100	mm
1500	500	130	mm
1500	500	150	mm

surfaces machined parallel, other dimensions on request

Storage/Transport:
NECURON®-boards should be stored on a flat underground and in a dry space at a temperature between 18°C and 25°C.
Variations in temperature should be avoided during the transport and storage.

© Necumer-Product GmbH- Bruchheide 16 - D-49163 Bohrte Tel (+49)5471/95020 - Fax (+49)5471/950299
E-Mail: info@necumer.de - Internet www.necumer.de Stand: 19. November 2008

NECURON® 651

Data Sheet

2/2

Processing:

Adhesive / Putty	Colour	Mixture ratio A to B	Pot life in minutes at 20°C	Curing time at 20°C in hours
NECURON® K6	brown	1:1	2-3	0.5
NECURON® K8	transparent	1:1	10	4-6
NECURON® S6	brown	1:1	10-12	6-8

or usual and compatible patternmaking adhesives/resins

We recommend that boards are plane-parallel to ensure good glue joints.

Machining:

Machining temperature:

20°C - 25°C

Tools:

metal-working tools

Milling parameters:

	Roughing	Finishing
Type of tool	finishing tools d=80mm	finishing tools d=80mm
Tool diameter [d] (mm)	80	80
Cutting speed [Vc] (m/sec)	50	50
Speed [n] (1/min)	12000	8000
Feed speed (m/min)	10	7.5
Tooth speed [fz] (mm)	0.21	0.21
Number of teeth [z]	4	4
Cutting depth [a _p] (mm)	4	0.5
Cutter mark length [f _{zett}] (mm)	38	5

NECURON® 651

This material does not contain any fillers that release harmful dust during machining. Nevertheless the dust content in the air should not rise above 6 mg/m³. Safety procedures recommended by the vocational co-operative of the chemical industry should be complied with. The article is not a regulatory product according to ICC regulations. In accordance with general local and national regulations waste is to be disposed by incineration in authorised places or conveyed to authorised tips (EAK 120105).

Technical statements and recommendations refer to current standard of technique and are based on our own experience. Further developments and improvements are reserved. Due to the variety of processing possibilities own experiments are recommended to optimise results.

G.9. SCOTTBADER CRYSTIC GELCOAT 253PA DATASHEET



CRYSTIC GELCOAT 253PA

Spray Gelcoat for Use with Hand-lay and Infusion Epoxy Laminating Systems

Introduction

Crystic Gelcoat 253PA is a thixotropic, pre-accelerated, isophthalic gelcoat designed as an in-mould gelcoat with excellent adhesion to epoxy resins and pre-pregs without the need for a tie-coat. Formulated for spray application, Crystic Gelcoat 253PA is available in a wide range of colours and the information contained in this technical data sheet also applies to these pigmented versions.

Applications

Crystic Gelcoat 253PA is designed for use with wet lay and vacuum injected epoxy systems.

It is not recommended for use in any application which is subject to continuous immersion in water.

Features and Benefits

Crystic Gelcoat 253PA has good epoxy bonding characteristics and excellent weather resistance. It has been shown to give a robust, reliable bond with a number of wet lay, and vacuum injection, epoxy resin systems, but users should check with their specific epoxy system supplier or perform a test themselves before proceeding with use.

Application

Crystic Gelcoat 253PA should be allowed to attain workshop temperature (18°C- 20°C) and mixed before use. Crystic Gelcoat 253PA requires the addition of an initiator to start the curing reaction. Use Butanox M-50 (or other equivalent catalyst) and incorporate this into the gelcoat at 1 – 2% v/w. Unsaturated polyester products release heat when they cure in bulk. If manually adding catalyst to the product prior to spraying, do not prepare more material than is required to complete the job and spray within 3 minutes. Ensure that all equipment is thoroughly cleaned after use. Prepregs that can be used with Crystic Gelcoat 253 PA should have a cure temperature of at least 80-85°C to ensure adequate adhesion.

DO

- Gently stir the gelcoat before use, by hand or with a low shear mixer.
- Ensure that the workshop temperature is between 18 and 25 °C.
- Spray at the minimum pressure to achieve an acceptable spray pattern.
- Apply the gelcoat in thin even passes, building up the film thickness to 0.5 – 0.6 mm wet.
- Ensure adequate mould ventilation.

DON'T

- Exceed a wet film thickness of 0.8 mm or drainage may occur.
- Allow vapour to be retained in deep mould sections as this will slow the cure.
- Apply excessive gelcoat in corners of moulds as this can cause pre-release.

Pot Life

Temperature	Pot Life in Minutes
15°C	25
20°C	15
25°C	10

Additives

Crystic Gelcoat 253PA is supplied in a wide range of colours. This eliminates the potential for mixing errors with small quantities of pigment paste. The addition of fillers or other additives can adversely affect the properties of the gelcoat and are not recommended.

G.10. STANDOCRYL 2K WHITE HPMIX 015 DATASHEET



SAFETY DATA SHEET

02083400 v1.1
Revision Date: 2008-07-28
Print Date: 2008-08-13
en/AU Page 1 - 9

1. Identification of the substance/preparation and of the company/undertaking

Product name MIX 015 WHITE HP
Product code 02083400
Intended use of the substance/preparation
Coating for professional use
Company/Undertaking Identification
Producer/Supplier DuPont Australia Ltd
Street/Box 7 Eden Park Drive
Nat.-Code/Postal code/City Macquarie Park NSW 2113, Australia
Telephone (02) 9923 6111
Telefax (02) 9923 6011
Product Information
Telephone (02) 9923 6111
Emergency Information
Medical Emergency Phone 1800 674 415
Transportation Emergency Phone (02) 9923 6275
For further information, please also consult our Internet site
<http://www.standex.com>

2. Hazards identification

Dangerous Goods. Non-Hazardous Substance.

Human health hazards

Classification : dangerous for the environment; Flammable;

Flammable. Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment. Repeated exposure may cause skin dryness or cracking. Vapours may cause drowsiness and dizziness.

Special hazard instructions for humans and environment

Do not breathe vapour/spray.

In case of insufficient ventilation, wear suitable respiratory equipment.

3. Composition/information on ingredients

Chemical characterization

Mixture of synthetic resins, pigments, and solvents

Hazardous components

CAS-No.	Chemical Name	Concentration	Classification
123-86-4	n-butyl acetate	15.00 - < 20.00 %	R10 R66 R67
1330-20-7	xylene	7.00 - < 10.00 %	R10 Xn; R20/21 Xi; R36
64742-95-6	solvent naphtha (petroleum), light arom. (<0,1% benzene)	5.00 - < 7.00 %	R10 Xi; R37 N; R51/53 Xn; R65 R66 R67 NotatH NotatP



SAFETY DATA SHEET

02083400 v1.1
Revision Date: 2008-07-28
Print Date: 2008-08-13
en/AJ Page 2 - 9

CAS-No.	Chemical Name	Concentration	Classification
95-63-6	1,2,4-trimethylbenzene	3.00 - < 5.00 %	R10 Xn; R20 Xi; R36/37/38 N; R51/53
100-41-4	ethylbenzene	2.00 - < 2.50 %	F; R11 Xn; R20
108-67-8	mesitylene	0.50 - < 1.00 %	R10 Xi; R37 N; R51/53
26761-45-5	neodecanoic acid, 2,3-epoxypropyl ester	0.50 - < 1.00 %	N; R51/53 R43
103-65-1	n-propylbenzene	0.25 - < 0.50 %	R10 Xn; R65 Xi; R37 N; R51/53
98-82-8	cumene	0.10 - < 0.20 %	R10 Xn; R65 Xi; R37 N; R51/53
8052-41-3	Stoddard solvent	0.10 - < 0.20 %	N; R51/53 Xn; R65 R66 R10 R67

Additional advice
See full text of R-phrases in chapter 16.

4. First aid measures

General advice
When symptoms persist or in all cases of doubt seek medical advice. Never give anything by mouth to an unconscious person.

Inhalation
Avoid inhalation of vapour or mist. Move to fresh air in case of accidental inhalation of vapours. If breathing is irregular or stopped, administer artificial respiration. If unconscious place in recovery position and seek medical advice. If symptoms persist, call a physician.

Skin contact
Do NOT use solvents or thinners. Take off all contaminated clothing immediately.

Eye contact
Remove contact lenses. Irrigate copiously with clean, fresh water for at least 15 minutes, holding the eyelids apart. Seek medical advice.

Ingestion
If swallowed, seek medical advice immediately and show this container or label. Do NOT induce vomiting. Keep at rest.

5. Fire-fighting measures

Hazardous combustion products
Fire will produce dense black smoke containing hazardous combustion products (see heading 10). Exposure to decomposition products may be a hazard to health.



SAFETY DATA SHEET

02083400 v1.1
Revision Date: 2008-07-28
Print Date: 2008-08-13
en/AJ Page 5 - 9

these can easily damage the gloves and make them ineffective. The instructions and information provided by the glove supplier on use, storage, maintenance and replacement must be followed. Damaged gloves or those showing signs of wear should be replaced immediately.

Eye protection
Wear protective eyewear for protection against solvent spatter.

Skin and body protection
Wear suitable protective clothing. Personnel should wear antistatic clothings made of natural fiber or of high temperature resistant synthetic fiber.

Hygiene measures
Wash skin thoroughly with soap and water or use recognized skin cleanser. Do not use organic solvents!

Environmental exposure controls
Do not let product enter drains. For ecological information refer to section 12.

9. Physical and chemical properties

Appearance

Form: liquid Colour: white

Important physical and chemical information

	Value	Method
Flash point	28 °C	
Autoignition temperature	407 – 463 °C	DIN 51794
Boiling point/boiling range	125 – 170 °C	
Lower explosion limit	0.9 %	
Upper explosion limit	12.3 %	
Vapour pressure	3.6 hPa	
Relative density	1.27 g/cm ³	DIN 53217/ISO 2811
Water solubility	partly miscible	
Viscosity (23 °C)	50 s	ISO 2431-1993 6 mm
Solvent separation test	< 3%	ADR/RID
Content of volatile components (including water)	37.9%	Basis Vapour pressure >= 0.01 kPa
pH	Not applicable.	

10. Stability and reactivity

Stability
Stable

Conditions to avoid
Stable under recommended storage and handling conditions (see section 7).

Materials to avoid
Keep away from oxidising agents, strongly alkaline and strongly acid materials in order to avoid exothermic reactions.

Hazardous decomposition products
When exposed to high temperatures may produce hazardous decomposition products such as carbon monoxide and dioxide, smoke, oxides of nitrogen.

11. Toxicological information

General observations
There is no data available on the product. See sections 3 and 15 for details.

Practical experience
Exposure to component solvents vapours concentration in excess of the stated occupational exposure limit may result in adverse health effect such as mucous membrane and respiratory system irritation and adverse effect on kidney, liver and central nervous system. Symptoms and signs include headache, dizziness, fatigue, muscular weakness, drowsiness and in extreme cases, loss of consciousness. Through skin resorption, solvents can cause some of the effects described here. Repeated or prolonged contact with the preparation may cause removal of natural fat from the skin resulting in non-allergic contact dermatitis and

G.11. ZYVAX ENVIROSHIELD DATASHEET



ZYVAX, INC
Zyvax.com

P.O. 1825
Ellijay, GA 30540 USA
+1 706 698 4405

ENVIROSHIELD

DESCRIPTION

ENVIROSHIELD is a universal solvent-free release agent designed specifically to meet the "Green Chemistry" requirements around the world. ZYVAX ENVIROSHIELD chemically bonds to the mold conditioner, without transfer to the molded part, or other processing equipment. Micro-polymer resin prevents build-up on mold and high lubricity allows quick effortless demolding. For the 100% SOLVENT-FREE mold release system best suited to your needs, see our website: www.zyvax.com.

ENVIROSHIELD BENEFITS

- * Environmentally safe
- * No CFCs, VOCs, or ODCs
- * No odor - solvent and alcohol free
- * Exempt from REACH requirements
- * Thermal stability: 260 °C (500 °F)
- * Fast, room temperature application
- * Non-flammable and safe to use
- * No resp
- * High gloss
- * High slip / lubricity
- * No build-up on mold

USES

ENVIROSHIELD is recommended for applications requiring multiple releases, superior surface finish with high gloss and easy touch-up for seamless production cycles. ENVIROSHIELD can be used for releasing epoxies, phenolics, polyester resins, polyamides, polybismaleimides, various rubbers and elastomers.

HOW TO USE

Before applying ENVIROSHIELD:

- ✓ All previous surface treatments, residues, waxes or oils should be removed using a ZYVAX mold and part cleaner.
 - ✓ The mold should be properly sealed with a ZYVAX mold sealer according to the technical data sheet.
1. Apply one light coat of ENVIROSHIELD to a small area of the mold (1-2 ft²; 0.2 m²) using a clean, lint-free cloth or hand sprayer.
 2. Wait approximately 60 seconds, and then wipe the mold surface dry using a separate clean cloth.
Make sure the entire mold surface is coated in this manner, slightly over-lapping the last coated area if you are applying in sections. Be certain that all contours are adequately coated.
 3. Wait for a minimum of 15 minutes.
 4. Apply a second coat of ENVIROSHIELD in the same way, and wait for a minimum of 30 minutes before using mold.
For mold temperatures above 80 °C (180 °F), apply one very light coat of ENVIROSHIELD and do not wipe off. Wait for a minimum of 15 minutes before using mold.
For touch-up, apply one coat of ENVIROSHIELD as above.

SAFETY DATA

Material safety data sheets for all ZYVAX products are available at www.zyvax.com and should be consulted prior to use of product.

STORAGE & SHELF LIFE

Store product between 5 °C and 30 °C (41 °F and 86 °F). Shelf life is 18 months from the date of manufacture, in the original unopened container.

USE LIFE

Use life of product is 60 days from opening of container. Product must be kept in the original container and the lid replaced immediately after dispensing. After opening, product should continue to be stored properly. **WARNING:** Never puncture any ZYVAX product container.

LIMITATIONS OF LIABILITY

To the best of our knowledge, the technical data contained herein are true and accurate at the date of issuance, and are subject to change without prior notice. User must contact ZYVAX to verify correctness before specifying or ordering. No guarantee of accuracy is given or implied. We guarantee our products to conform to ZYVAX quality control. We assume no responsibility for coverage, performance, or its use. Liability, if any, is limited to replacement of products. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY ZYVAX, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING FITNESS FOR A PARTICULAR PURPOSE.

ENVIROSHIELD

ENGLISH

REVISION 7

G.12. ZYVAX FLEX-Z1, Z3 DATASHEET

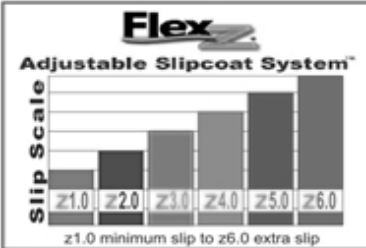


Adjustable Slipcoat System

HOW TO SELECT YOUR SLIPCOAT

FLEX-Z	SLIP	Description
FLEX-Z 1.0	MINIMUM SLIP	Inhibits pre-release and promotes tape adhesion
FLEX-Z 2.0	LOW / MEDIUM SLIP	Ideal for the occasional pre-release problem
FLEX-Z 3.0	MEDIUM SLIP	Standard choice for large hulls and flat areas
FLEX-Z 4.0	MEDIUM / HIGH SLIP	If you don't know where to start, start here
FLEX-Z 5.0	HIGH SLIP	Excellent choice for small parts and high wear areas
FLEX-Z 6.0	EXTRA SLIP	Use on difficult-to-release male molds or as a flange release

FLEX-Z can be applied directly onto molds previously treated with Zyvac solvent-based release coatings. It can be sprayed on or wiped on. On new molds or when converting old molds, follow the instructions outlined below.



z1.0 minimum slip to z6.0 extra slip

CLEANING

WATERCLEAN - for mold stripping

1. Apply a small amount of WATERCLEAN directly to the mold surface.
2. Dampen a clean cloth with water and scrub the surface. A plastic brush can be used on non-skid areas to clean more effectively.
3. Rinse the mold surface with clean water until no residue remains.
4. Repeat as necessary to achieve a waterbreak-free surface.
5. The mold is now ready for sealing.

SURFACE CLEANER - for in-process cleaning

1. Apply SURFACE CLEANER to a clean cloth.
2. Working in small areas, wipe the cleaner onto the surface. Use as much scrubbing action as required to remove contaminants.
3. Before it flashes off, wipe the surface dry with a clean cloth.
4. Repeat as necessary to achieve a clean surface.
5. Apply two coats of the appropriate slipcoat before continuing processing.

SEALING (AS REQUIRED)

Use SEALER GP on

- ☐ New molds
- ☐ Old molds that are always difficult to release
- ☐ Molds in closed molding processes
- ☐ Molds (or areas of molds) that have been patched or repaired
- ☐ Areas of a mold with exposed porosity

Applying SEALER GP

1. Lightly apply SEALER GP to a clean cloth.
2. Wipe onto the mold surface. Wipe off while it is still wet.
3. Work in small sections (1-2 sq. ft.), overlapping as necessary.
4. Continue in this manner until the entire mold (or section of the mold) has been coated.
5. Allow 15 minutes to cure before applying the second coat.
6. Apply a second coat of SEALER GP in the same manner and allow 15 minutes to cure before applying the selected FLEX-Z slipcoat.

☐ Some tools may require additional coats of SEALER GP. If necessary, apply additional coats of sealer in the same manner.

SLIPCOAT

Application Instructions - Wiping

1. Apply FLEX-Z to a small area of the mold section using a 100% cotton cloth wipe or Bounty® paper towel.
2. Wipe on a light coat and DO NOT WIPE OFF.
3. Carefully and thoroughly coat the entire mold surface.
4. Allow 15 minutes to cure before applying the next coat.
5. Apply three additional coats of FLEX-Z in the same way, and wait for a minimum 15 minutes before using the mold.

- ☐ For touch ups, apply a single coat of FLEX-Z, wait 15 minutes, and continue processing.
- ☐ If more or less slip is needed, simply move up or down the FLEX-Z slipcoat scale. A single coat can be applied when doing so.
- ☐ Individual sections of a mold can be treated with different slipcoats to achieve optimum results.

Application Instructions - Spraying

1. Using an HVLP type sprayer, FLEX-Z should go on as a dry spray with no wet areas left behind the spray.
2. Keeping the spray head 6-12 inches (if possible) from the surface, carefully and thoroughly spray the entire mold surface.
3. If an area is over saturated, simply wipe the wet area with a clean, dry cloth to ensure even coverage.
4. Allow 15 minutes to cure before applying the next coat.
5. Apply three additional coats of FLEX-Z in the same way, and wait for a minimum 15 minutes before using the mold.

- ☐ For touch ups, apply a single coat of FLEX-Z, wait 15 minutes, and continue processing.
- ☐ If more or less slip is needed, simply move up or down the FLEX-Z slipcoat scale. A single coat can be applied when doing so.
- ☐ Individual sections of a mold can be treated with different slipcoats to achieve optimum results.

G.13. ZYVAX WATERCLEAN DATASHEET



ZYVAX, INC
Zyvax.com

P.O. Box 1825
Ellijay, GA 30540 USA
+1 706 698 4405

WATERCLEAN

DESCRIPTION

WATERCLEAN has been developed to provide an environmentally safe and effective solvent-free alternative to solvent washing for the removal of surface contaminants from molds and molded parts. WATERCLEAN is non-hazardous, non-flammable and will not harm the surface. WATERCLEAN eliminates solvent washing when preparing parts for painting, bonding or other processes that require a completely clean surface. For the 100% SOLVENT-FREE mold release system best suited to your needs, see our website: www.zyvax.com.

WATERCLEAN BENEFITS

- * Easy to apply
- * Cost effective
- * Environmentally safe
- * Exempt from REACH requirements
- * No odor
- * Non-flammable
- * No solvents or alcohol
- * No CFCs, VOCs or ODCs

USES

WATERCLEAN is suitable for all surfaces including gelcoat. WATERCLEAN cleaning of molds, molds, equipment and finished parts.

HOW TO USE

- ✓ WATERCLEAN should appear uniform in container. If not, then shake or stir.
- 1. Apply a SMALL amount directly to the dry mold surface.
- 2. Using a damp paper towel, scrub the surface. Work with small sections until the entire surface is scrubbed.
DO NOT allow WATERCLEAN to dry on the surface.
- 3. Remove using only clean WATER. This can be done by rinsing with a wet cloth or water sprayer.
Rinse until no residue remains; the surface should feel clean. Rinsing will highlight areas that require more cleaning.
- 4. Repeat until a waterbreak-free surface is achieved.
You are now ready to apply a sealer and release agent.

SAFETY DATA

Material safety data sheets for all ZYVAX products are available at www.zyvax.com and should be consulted prior to use of product.

STORAGE & SHELF LIFE

Store product between 5 °C and 30 °C (41°F and 86 °F). Shelf life is 18 months from the date of manufacture, in the original unopened container. NOTE: WATERCLEAN needs to be carefully sealed when not in use in order to avoid water evaporation.

USE LIFE

Use life of product is 60 days from opening the container. Product must be kept in the original container and the lid replaced immediately after dispensing. After opening, the product should be stored properly. WARNING: Never puncture any ZYVAX product container.

LIMITATIONS OF LIABILITY

To the best of our knowledge, the technical data contained herein are true and accurate at the date of issuance, and are subject to change without prior notice. User must contact ZYVAX to verify correctness before specifying or ordering. No guarantee of accuracy is given or implied. We guarantee our products to conform to ZYVAX quality control. We assume no responsibility for coverage, performance, or injuries resulting from its use. Liability, if any, is limited to replacement of products. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY ZYVAX, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING FITNESS FOR A PARTICULAR PURPOSE.

WATERCLEAN

ENGLISH

REVISION 7



P.O. Box Ellijay, GA • () - • { • Fax: { www.zyvax.com

SURFACE CLEANER

DESCRIPTION

SURFACE CLEANER is a combination of solvents specially blended to aid in the preparation of new and used molds and plugs prior to treatment with ZYVAX MOLD CONDITIONERS AND RELEASE AGENTS. It readily removes waxes and other surface contaminants without harming or dulling the working surfaces of the mold. For the 100% SOLVENT-FREE mold release system best suited to your needs, see our website: www.zyvax.com.

SURFACE CLEANER BENEFITS

- * Can be used to remove all release agents
- * Ease of application and use
- * No residue
- * Fast drying

USES

SURFACE CLEANER is safe and effective cleaning for molds, molds, equipment and finished parts and will remove uncured resin or gelcoat. **SURFACE CLEANER** will also clean brushes and spray equipment used to apply various release products and elastomeric materials.

HOW TO USE

1. Apply **SURFACE CLEANER** liberally to the surface of the mold with a clean cloth.
2. As the waxes and other contaminants begin to dissolve and loosen, remove them from the surface while still wet using a separate clean cloth or abrasive pad.
Make sure entire mold surface is cleaned in this manner, slightly over-lapping the last area if you are working in sections. Be certain that all contours are adequately cleaned.
3. Repeat this process until the entire mold is clean.
The cleaning cloths should be regularly replaced as they become saturated with wax, etc.
4. When all the contaminants have been removed, wipe the entire surface with a clean cloth soaked with **SURFACE CLEANER**, and buff until dry.

SAFETY DATA

Material safety data sheets for all ZYVAX products are available at www.zyvax.com and should be consulted prior to use of product.

STORAGE & SHELF LIFE

Store product between 5 °C and 30 °C (41 °F and 86 °F). Shelf life is 18 months from the date of manufacture, in the original unopened container.

USE LIFE

Use life of product is 60 days from opening of container. Product must be kept in the original container and the lid replaced immediately after dispensing. After opening, product should continue to be stored properly. **WARNING** Never puncture any ZYVAX product container.

LIMITATIONS OF LIABILITY

To the best of our knowledge, the technical data contained herein are true and accurate at the date of issuance, and are subject to change without prior notice. User must contact ZYVAX to verify correctness before specifying or ordering. No guarantee of accuracy is given or implied. We guarantee our products to conform to ZYVAX quality control. We assume no responsibility for coverage, performance, or injuries resulting from its use. Liability, if any, is limited to replacement of products. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY ZYVAX, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING FITNESS FOR A PARTICULAR PURPOSE.

SURFACE CLEANER

ENGLISH

REVISION 8