

TABLE OF CONTENTS

FOREWORD	iii
FRP TASK FORCE	iv
CONSULTANTS	iv
NOTICE TO USERS OF THIS PUBLICATION	v
TABLE OF CONTENTS	vii
CHAPTER 1 INTRODUCTION	1.1
1.1 SCOPE	1.1
1.2 USES	1.1
1.3 WHAT IS FRP?	1.1
1.4 PURPOSE	1.1
1.5 CONTENTS	1.2
CHAPTER 2 MATERIALS	2.1
2.1 INTRODUCTION	2.1
2.2 THERMOSET RESINS	2.1
2.3 MIXING AND CURING THERMOSETS	2.2
2.4 CATALYSTS, PROMOTERS, INHIBITORS, AND OTHER ADDITIVES	2.2
2.5 MATERIALS HANDLING	2.4
2.6 FLAME RETARDANCE AND SMOKE GENERATION	2.4
2.7 ULTRAVIOLET STABILIZERS	2.5
2.8 TYPES OF REINFORCEMENT	2.5
CHAPTER 3 LAMINATE CONSTRUCTION	3.1
3.1 INTRODUCTION	3.1
3.2 CORROSION BARRIER RESIN	3.1
3.3 CORROSION BARRIER	3.1
3.4 STRUCTURAL LAYER	3.1
3.5 EXTERIOR SURFACE	3.1
3.6 POTENTIAL ADHESION PROBLEMS DURING LAMINATE CONSTRUCTION	3.3
3.7 WALL THICKNESS TOLERANCE	3.3
3.8 MECHANICAL PROPERTIES	3.3
3.9 SURFACE HARDNESS	3.3
3.10 APPEARANCE	3.3
CHAPTER 4 FIELD JOINING PROCEDURES	4.1
4.1 INTRODUCTION	4.1
4.2 PREPARATION FOR JOINING DUCT	4.1



4.3	PREPARATION OF STRAPPING	4.1
4.4	MIXING RESIN	4.4
4.5	JOINING DUCT	4.4
4.6	INTERNAL JOINT LAMINATING PROCEDURE	4.4
4.7	CLEAN-UP	4.4
CHAPTER 5	DESIGN OF ROUND FRP DUCT	5.1
5.1	DESIGN OF ROUND FRP DUCTS USING TYPES I AND II LAMINATES	5.1
5.2	DESIGN OF ROUND FRP DUCTS USING FILAMENT WOUND (TYPE X) LAMINATES	5.9
CHAPTER 6	DESIGN OF RECTANGULAR FRP DUCT	6.1
6.1	DESIGN OF RECTANGULAR FRP DUCTS USING TYPE I AND II LAMINATES	6.1
6.2	SELECTION OF STIFFENERS AND FLANGES FOR RECTANGULAR DUCT SYSTEMS	6.9
CHAPTER 7	REQUIREMENTS	7.1
7.1	TERMINOLOGY	7.1
7.2	CONTACT MOLDING	7.1
7.3	MATERIALS	7.1
7.4	STORAGE	7.1
7.5	STATIC ELECTRICITY	7.1
7.6	REINFORCEMENT	7.1
7.7	RAW EDGES	7.1
7.8	JOINTS (WELDS OR BONDS)	7.1
7.9	LAMINATE CONSTRUCTION	7.1
7.10	DESIGN REQUIREMENTS	7.2
7.11	OVERLAP	7.2
7.12	RECTANGULAR DUCT CORNERS	7.2
7.13	BOND CONSTRUCTION	7.2
7.14	FLANGE REQUIREMENTS	7.2
7.15	STANDARD ELBOWS AND MITERED JOINTS	7.3
7.16	FITTING CONFIGURATION	7.3
7.17	DUCT HANGERS AND SUPPORTS	7.3
7.18	FUME HOODS	7.6
7.19	DAMPERS	7.6
7.20	ACCESS OPENINGS AND END CAPS	7.7
7.21	DRAINS	7.7
7.22	VENTILATOR HEADS AND LOUVERS	7.7
7.23	FLEXIBLE CONNECTIONS	7.7



7.24	FLEXIBLE MATERIALS	7.7
7.25	LINEAR COEFFICIENT OF THERMAL EXPANSION	7.7
7.26	TOLERANCES	7.8
7.27	DRAINAGE	7.8
7.28	SPRINKLERS	7.8
7.29	BURIED DUCT	7.8
7.30	MANUFACTURER'S SHOP REVIEW	7.8
7.31	INSPECTION	7.9
7.32	HANDLING, SHIPPING, AND INSTALLATION	7.9
CHAPTER 8	QUALITY CONTROL AND SAFETY	8.1
8.1	QUALITY CONTROL	8.1
8.2	SAFETY	8.2
8.3	HEALTH CONCERNS	8.2
CHAPTER 9	FRP GUIDE SPECIFICATIONS	9.1
9.1	GENERAL	9.1
9.2	DRAWINGS	9.1
9.3	SEISMIC RESTRAINT PROVISIONS	9.1
9.4	GUIDE SPECIFICATIONS	9.1
APPENDIX A	DEVELOPMENT OF THE TABLES	A.1
APPENDIX B	CHEMICAL RESISTANCE OF FRP DUCT	B.1
APPENDIX C	ALTERNATE ROUND DUCT DESIGN TABLES	C.1
APPENDIX D	GLOSSARY	D.1
APPENDIX E	REFERENCED DOCUMENTS	E.1
	INDEX	I.1



TABLES

Table 5-1 Standard Composition of Type I Laminates 5.3

Table 5-2 Standard Composition of Type II Laminates 5.4

Table 5-3 Minimum Mechanical Properties of Types I and II Laminates 5.5

Table 5-4 Negative Pressure Ratings of Types I & II Laminates in in. wg 5.6

Table 5-4M Negative Pressure Ratings of Types I & II Laminates in Pa 5.7

Table 5-5 Minimum Flange Dimensions for Round Duct 5.8

Table 5-6 Filament Wound (Type X) Composite Laminates 5.10

Table 5-7 Minimum Mechanical Properties of Filament Wound (Type X) Laminates 5.11

Table 5-8 Minimum Bond Construction for Filament Wound (Type X) Laminates 5.11

Table 5-9 Negative Pressure Ratings of Filament Wound (Type X) Laminates in in. wg 5.12

Table 5-9M Negative Pressure Ratings of Filament Wound (Type X) Laminates in Pa 5.13

Table 6-1 Positive Design Pressure of 10 in. wg 6.3

Table 6-1M Positive Design Pressure of 2500 Pa 6.3

Table 6-2 Positive Design Pressure of 20 in. wg 6.4

Table 6-2M Positive Design Pressure of 5000 Pa 6.4

Table 6-3 Positive Design Pressure of 30 in. wg 6.5

Table 6-3M Positive Design Pressure of 5000 Pa 6.5

Table 6-4 Negative Design Pressure of 10 in. wg 6.6

Table 6-4M Negative Design Pressure of 2500 Pa 6.6

Table 6-5 Negative Design Pressure of 20 in. wg 6.7

Table 6-5M Negative Design Pressure of 5000 Pa 6.7

Table 6-6 Negative Design Pressure of 30 in. wg 6.8

Table 6-6M Negative Design Pressure of 7500 Pa 6.8

Table 6-7 Minimum Flange Dimensions for Rectangular Duct 6.14

Table 6-8 Maximum Allowable Stiffener Span in in. for Positive or Negative Pressure
of 10 in. wg 6.16

Table 6-8M Maximum Allowable Stiffener Span in mm for Positive or Negative Pressure
of 2500 Pa 6.17

Table 6-9 Maximum Allowable Stiffener Span in in. for Positive or Negative Pressure
of 20 in. wg 6.20

Table 6-9M Maximum Allowable Stiffener Span in mm for Positive or Negative Pressure
of 5000 Pa 6.21

Table 6-10 Maximum Allowable Stiffener Span in in. for Positive or Negative Pressure
of 30 in. wg 6.24

Table 6-10M Maximum Allowable Stiffener Span in mm for Positive or Negative Pressure
of 7500 Pa 6.25

Table 7-1 Minimum Strap Sizes for Round Duct 7.4

Table 7-2 Weight of FRP Laminates 7.4

Table 7-3 Trapeze Angle Support Capacity 7.5



Table 7-4	Hanger Rod (ATR) Capacity	7.5
Table 7-5	Minimum Bond Widths	7.10
Table A-1	Nominal Laminate Thickness (in.) Given Duct Diameter and Vacuum	A.11
Table A-1M	Nominal Laminate Thickness (mm) Given Duct Diameter and Vacuum	A.12
Table A-2	Safety Factors Given Filament Wound Laminate Combination and Vacuum	A.13
Table A-2M	Safety Factors Given Filament Wound Laminate Combination and Vacuum	A.14
Table A-3	Material Properties For Filament Wound Laminates Model In L-t Coordinates, Combination S-5 (for Round Duct)	A.23
Table A-4	Data for Each Lamina (Theta (Θ) Measured Clockwise from +Y Axis)	A.23
Table A-5	Material Properties for Filament Wound Laminates Model In L-t Coordinates, Combination S-7 (for Round Duct)	A.23
Table A-6	Data for Each Lamina (Theta (Θ) Measured Clockwise from +Y Axis)	A.24
Table A-7	Average Material Properties for All Rectangular Ducts	A.24
Table B-1	Typical Chemical Resistance of Various Resins Used in FRP Duct	B.11
Table C-1	Negative Pressure Ratings of Types I & II Laminates in in. wg	C.2
Table C-1M	Negative Pressure Ratings of Types I & II Laminates in Pa	C.3
Table C-2	Negative Pressure Ratings of Filament Wound (Type X) Laminates in in. wg	C.6
Table C-2M	Negative Pressure Ratings of Filament Wound (Type X) Laminates in Pa	C.7



FIGURES

Figure 2-1	Gel Time vs. Catalyst Concentration at Various Temperatures	2.3
Figure 3-1	Lay-up Sequence for FRP Duct – Types I, II, and X Laminates	3.2
Figure 4-1	Preparation of Strapping	4.2
Figure 4-2	Application of Strapping	4.2
Figure 4-3	Butt-and-Strap End-to-End Joint	4.3
Figure 4-4	Bell-and-Spigot Joining Method	4.3
Figure 4-5	Gel Time vs. Catalyst Concentration at Various Temperatures	4.4
Figure 5-1	FRP Flange Details	5.5
Figure 6-1	Corner Reinforcement Detail	6.10
Figure 6-2	Wood Stiffeners with FRP Bond	6.11
Figure 6-3	Construction of Transverse Stiffeners	6.12
Figure 6-4	Semi-Circular Foam Stiffeners with FRP Bond	6.13
Figure 6-5	FRP Flange Details	6.14
Figure 7-1	Trapeze Angle with Hanger Rods	7.6
Figure 7-2	Flange Cant	7.11
Figure 7-3	Flange Tolerance Description	7.11
Figure 7-4	Flange Offset	7.12
Figure 7-5	Flange Attachment	7.12
Figure 7-6	Weld Width and Thickness	7.13
Figure 7-7	Bolt Tightening Sequence	7.13
Figure 7-8	Square Throat Elbows	7.14
Figure 7-9	Round or Rectangular Standard Elbow	7.14
Figure 7-10	Round or Rectangular Angles	7.15
Figure 7-11	Rectangular Tees	7.15
Figure 7-12	Round or Rectangular Offsets	7.16
Figure 7-13	Transition Elbows	7.16
Figure 7-14	Five Segment Elbow	7.17
Figure 7-15	Round / Square Reducers	7.17
Figure 7-16	Round or Rectangular Eccentric Reducers	7.18
Figure 7-17	Round Tees	7.18
Figure 7-18	Conical Tees	7.19
Figure 7-19	Conical Reducing Tees / Lateral	7.19
Figure 7-20	Reducing Tees / Lateral	7.20
Figure 7-21	Conical Laterals	7.20
Figure 7-22	Tee / Lateral Crosses	7.21
Figure 7-23	Round or Rectangular Wyes	7.21

Figure 7–24	Round or Rectangular Reducing Wyes	7.22
Figure 7–25	Round or Rectangular Offsets	7.22
Figure 7–26	Conical Tee Crosses	7.23
Figure 7–27	Typical Louver Construction	7.23
Figure 7–28	Duct Hangers – Horizontal	7.24
Figure 7–29	Support for Vertical Duct	7.25
Figure 7–30	Turning Vane Construction	7.26
Figure 7–31	Typical Blast Gate	7.27
Figure 7–32	Typical Butterfly Damper with Locking Device	7.28
Figure 7–33	Gravity Back–Draft Damper for Vertical Duct	7.29
Figure 7–34	Duct Openings	7.30
Figure 7–35	Typical Stackheads	7.31
Figure A–1	Cross Section of a 20" x 20" Duct	A.15
Figure A–2	Cross Section of a 36" x 18" Duct	A.15
Figure A–3	Vacuum / Pressure Test of FRP Duct	A.17

