Fiberglass Reinforced Polymer (FRP) As An Alternative to Stainless Steel

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- Leads development and publication of technical articles, white papers and educational materials.
- Editor-in-chief of the award-winning *AMCA inmotion* magazine.

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CORROSION RESISTANT EXHAUST SYSTEMS

MK PLASTICS

CORPORATION

Introductions & Guidelines

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  - Questions can be submitted anytime via the GoToWebinar platform and will be addressed at the end of the presentation.
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Doug Ross

Business Development Manager, AMCA Member Company

- Automation & Control Engineer from Auckland Technical Institute in New Zealand; moved to Canada in 2000
- Working in the Air Movement industry since 2005
- Focus on laboratory exhaust system design, especially in critical environment applications

FRP As An Alternative to Stainless Steel

Purpose and Learning Objectives

The purpose of this presentation is to inform industry professionals about Fiberglass Reinforced Polymer (FRP), comparing properties of corrosion resistance, typical applications Fiberglass Reinforced Polymer (FRP) is currently applied, the advantages of Fiberglass Reinforced Polymer (FRP) vs. Stainless Steel.

At the end of this presentation you will be able to:

1. Understand the different forms of Fiberglass Reinforced Polymer (FRP).
2. Determine the criteria to specify Fiberglass Reinforced Polymer (FRP).
3. Identify the relevant American Society of Testing and Materials (ASTM) standards applicable to Fiberglass Reinforced Polymer (FRP).
4. Practical examples of the advantages of Fiberglass Reinforced Polymer (FRP), compared to Stainless Steel.

Topics Covered

- FRP vs Stainless Steel
- History of FRP
- What is FRP?
- Typical applications for FRP equipment
- National Standards
- Advantages of FRP
- Conclusion

Introduction

- As Engineers, our goal:
  - Design systems
  - Efficient and cost effective
  - Life of the project

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- The Challenge:
    - Balance the budget
    - Life expectancy of equipment
    - Cost to project

Introduction

- As Engineers, our goal:
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- The Challenge:
  - Balance the budget
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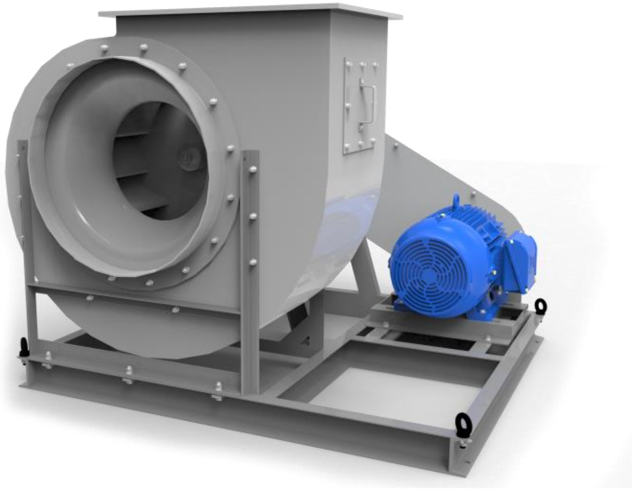
  - Cost to project
- This webinar:
  - Understand Fibreglass Reinforced Polymer (FRP)
  - Deliver cost effective equipment

FRP vs Stainless Steel

Both of these materials are used in corrosive environments

316 or 304 Stainless Steel Fan



Fibreglass Reinforced Polymer Fan

FRP vs Stainless Steel

Corrosive gases - industrial environment

•Ammonia
•Chlorine
•Hydrochloric Acid
•Hydrogen sulfide
•Iodine
•Mercaptans
•Ozone
•Sodium hypochlorite
•Sulphur dioxide

Some corrosive gases - laboratory environment

• **Ammonia**	• **Iodine**
• Bacteria	• Nitric Acid
• Bromine	• Ozone
• Chlorine	• Perchloric acid
• Fluorine	• Potassium Hydroxide
• Fungi	• Sodium Hydroxide
• Hydrochloric acid	• Sodium Hypochlorite
• Hydrogen sulfide	• Sulphur dioxide

For a full Chemical resistance chart view https://www.mkplastics.com/documents/technical/M.K._Plastics_Corrosion_Resistance_Guide_-_99-09-November_2014.pdf

FRP vs Stainless Steel

Common reasons for Stainless Steel – Corrosive environment

- Commonly chosen due to reputation for high corrosion resistance
- Contains 10.5% chromium
- Strength / low toughness
- Temperature depended on material and application – potentially in excess of 1,000°F

FRP vs Stainless Steel

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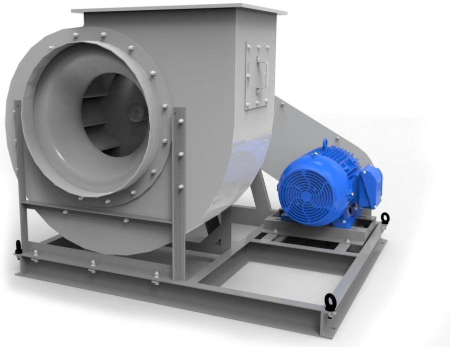
Common reasons for Fibreglass Reinforced Polymer (FRP) - Corrosive environment

- Excellent UV performance/ over 25 years of life expectancy
- High rigidity - Strength and Toughness
- Very good temperature range (-31 degrees F to 266 degrees F)
- Excellent chemical resistance
- Ease-of-processing complex shapes
- Repels water
- Self-extinguishing flammability

FRP vs Stainless Steel

- Both will provide protection in a variety of applications
  - Critical to evaluate the environmental factors of the application

316 or 304 Stainless Steel Fan

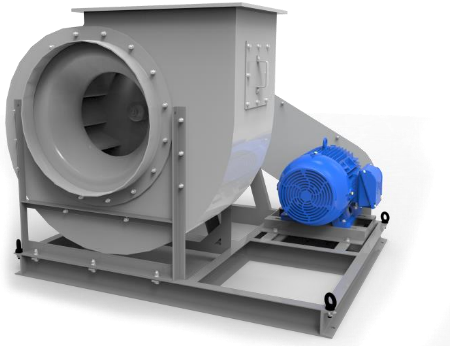


Fibreglass Reinforced Polymer Fan

FRP vs Stainless Steel

- Both will provide protection in a variety of applications
  - Critical to evaluate the environmental factors of the application
- Materials knowledge presented, thereby guaranteeing long-term reliability and reduced overall costs. **Performance of the material matters!**

316 or 304 Stainless Steel Fan



Fibreglass Reinforced Polymer Fan

History of Fibreglass Reinforced Polymer (FRP)

- First Known FRP product
- 1909
- Leo Baekeland, a Belgian chemist

Bakelite Lamp Holders

History of Fibreglass Reinforced Polymer (FRP)

- 1930
- United Kingdom researched Fibreglass Reinforced Polymer (FRP) for Commercial use.
- 1937
- Ray Greene
- Produced first Fibreglass-reinforced Polymer boat

What is Fibreglass Reinforced Polymer (FRP)?

What is Fibreglass Reinforced Polymer (FRP)?

- **Fiberglass Reinforced Polymer (FRP):**

A complex non-isotropic material, in which two or more distinct, structurally complementary substances, glass fiber and thermoset polymer resin, combine to produce structural or functional properties not present in the individual component.

What is Fibreglass Reinforced Polymer (FRP)?

- General Composition

- Fiber { Glass, Carbon, Etc. }

+

- Resin [Thermoset Polymer}

Fiber Reinforced Polymer

What is Fibreglass Reinforced Polymer (FRP)?

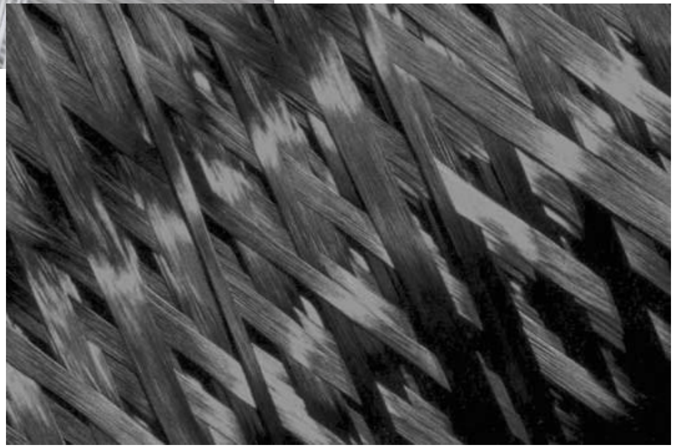
- Used in many different forms

Short Fibers

Long Fibers

Chopped Fibers

Woven Fibers



What is Fibreglass Reinforced Polymer (FRP)?

- Common Fiber Types:
  - ✓ **Aramid fibers**
    - ✓ Heat-resistant and strong synthetic fibers.
    - ✓ Used in aerospace and military applications.
  - ✓ **Glass** (Most Widely Used)
    - ✓ In a variety of building materials from Insulation to structure components and mechanical equipment as FRP products.
  - ✓ **Carbon** (Premium Cost)
    - ✓ aerospace, motorsports, boat building industries.
  - ✓ **Basalt** (Less expensive than Carbon Fibre)
    - ✓ Basalt rock fibers mainly used in the concrete industry.

What is Fibreglass Reinforced Polymer (FRP)?

Resins

- **Two Categories:**
  - Thermoset Resins (most common for structural uses)
  - Thermoplastic Resins (recycled plastic pellets)

What is Fibreglass Reinforced Polymer (FRP)?

Resins

- **Thermoset Resins** (most common for structural uses)
  - Liquid state at room temperature prior to curing
  - Impregnated into reinforcing fibers prior to heating
  - Chemical reaction occurs during heating/curing
  - Solid after heating/curing
  - **Can't** be reversed/reformed

What is Fibreglass Reinforced Polymer (FRP)?

Resins

- **Thermoplastic Resins**
  - Solid state at room temperature (recycled plastic pellets)
  - Heated to a liquid state and pressurized to impregnate reinforcing fibers
  - Cool under pressure; **can** be reversed/reformed

What is Fibreglass Reinforced Polymer (FRP)?

Resins

- Common **Thermoset Resin** Types:
  - ✓ Polyester
    - Lowest cost
  - ✓ Vinyl ester
    - Industry Standard
  - ✓ Polyurethane
    - Premium Cost
  - ✓ Epoxy
    - Highest Cost
    - Commonly used in aerospace applications

What is Fibreglass Reinforced Polymer (FRP)?

Resins

- **Polyesters**
  - ✓ Advantages:
    - Easy to use
    - Lowest Cost of resins available
  - ✓ Disadvantages:
    - Sensitive to UV degradation
    - Only moderate mechanical properties

What is Fibreglass Reinforced Polymer (FRP)?

Resins

- **Vinyl esters**
  - ✓ Advantages:
    - Very high chemical/environmental resistance
    - Higher mechanical properties than polyesters
  - ✓ Disadvantages:
    - Sensitive to heat
    - Higher cost than polyesters

What is Fibreglass Reinforced Polymer (FRP)?

Resins

- **Polyurethanes**
  - ✓ Advantages:
    - Higher strength and flexibility than vinyl esters
    - Very high chemical/environmental resistance
    - Higher mechanical properties than vinyl esters
  - ✓ Disadvantages:
    - Higher cost than vinyl esters (about 1.5x)

What is Fibreglass Reinforced Polymer (FRP)?

Resins

- **Epoxies**
  - ✓ Advantages:
    - Higher mechanical and thermal properties
    - High moisture resistance
    - Long working times available
    - High temperature resistance
  - ✓ Disadvantages:
    - More expensive than polyurethanes
    - Critical mixing/consistency
    - Corrosive handling

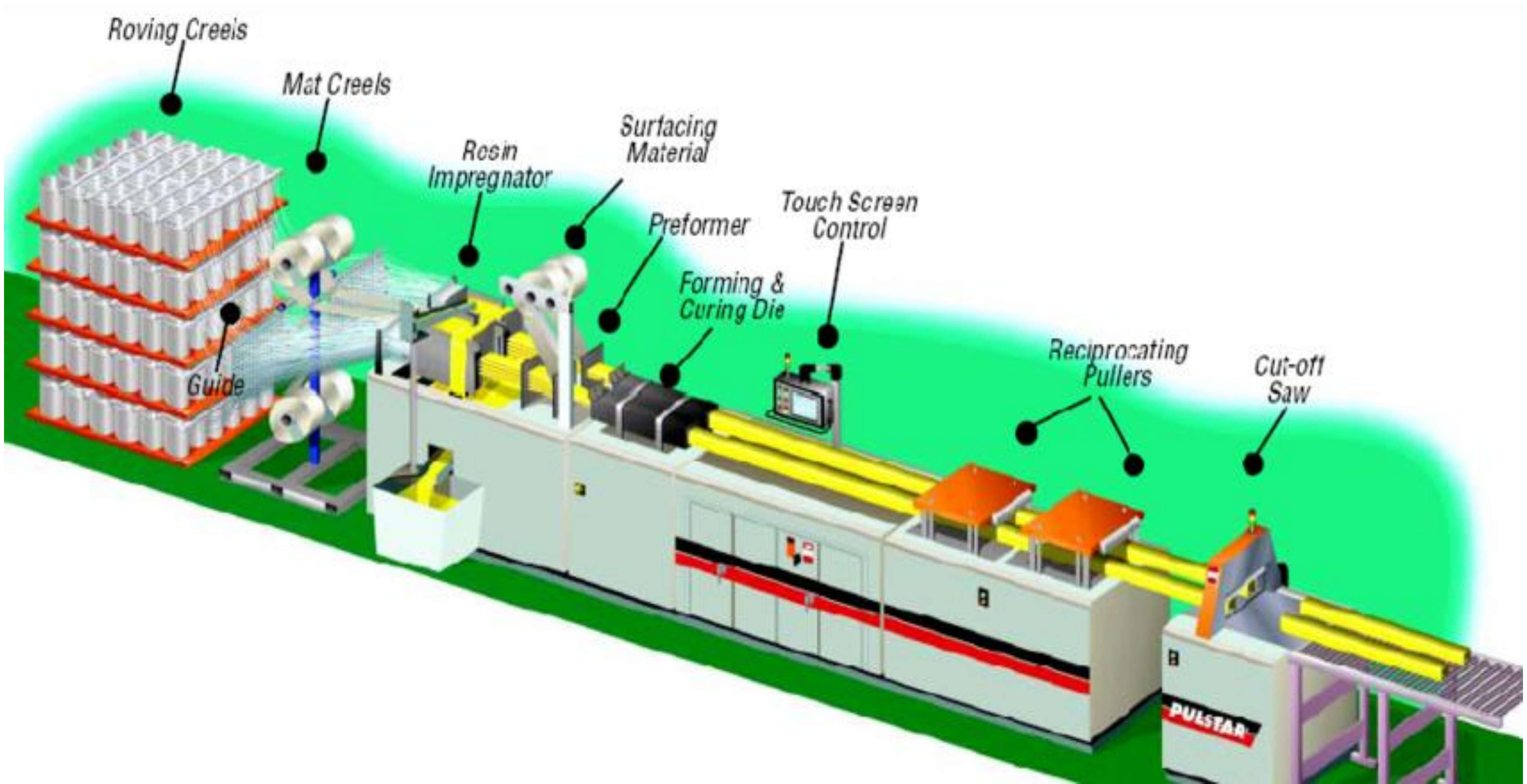
What is Fibreglass Reinforced Polymer (FRP)?

Processes

- Manufacturing Processes
  - ✓ Predominate Processes
    - Pultrusion
    - Vacuum Infusion
  - ✓ Other processes

What is Fibreglass Reinforced Polymer (FRP)?

Processes



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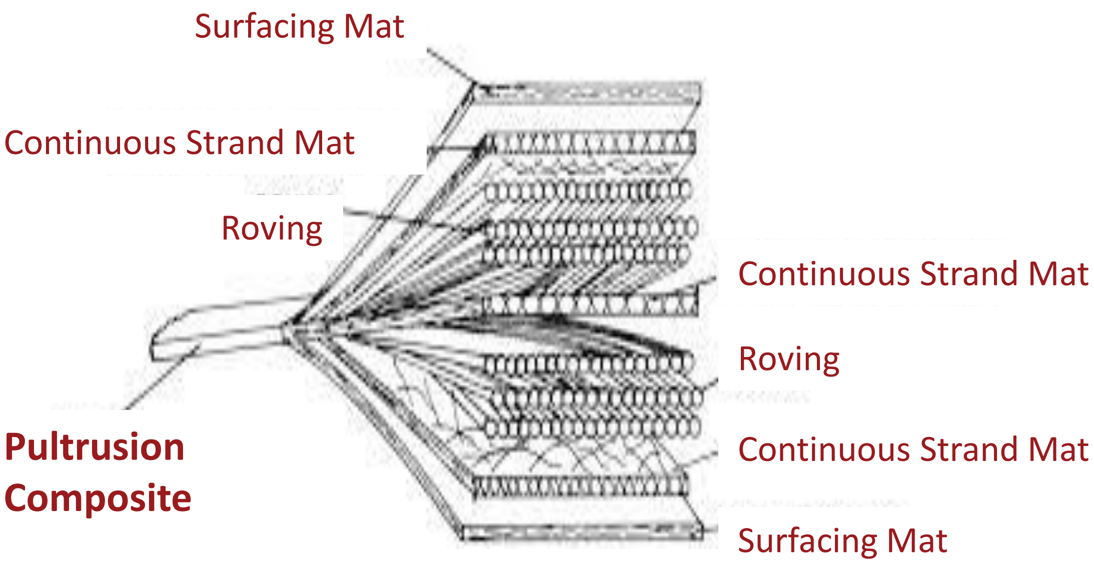
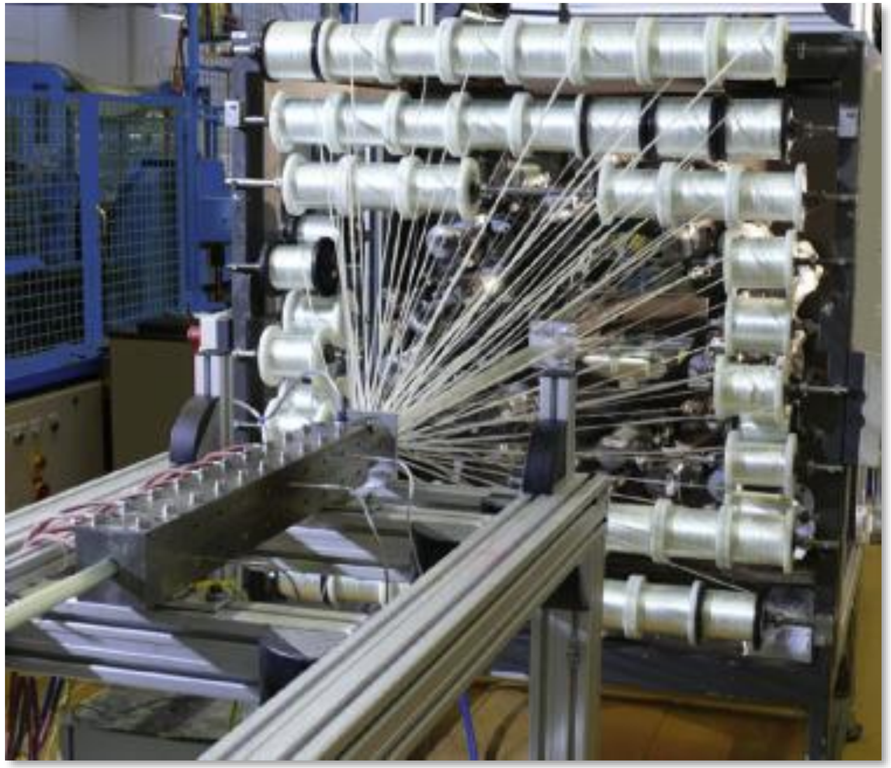


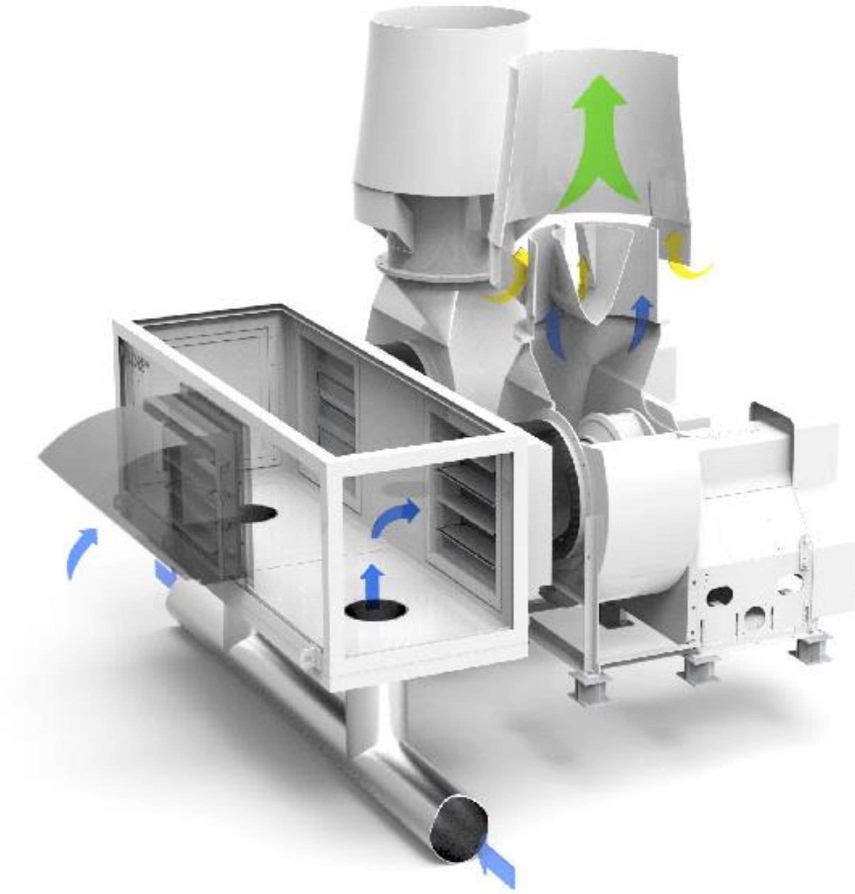


Continuous Strand Mats: Reinforcements in any direction; consistent along the length of the member

What is Fibreglass Reinforced Polymer (FRP)?

Processes

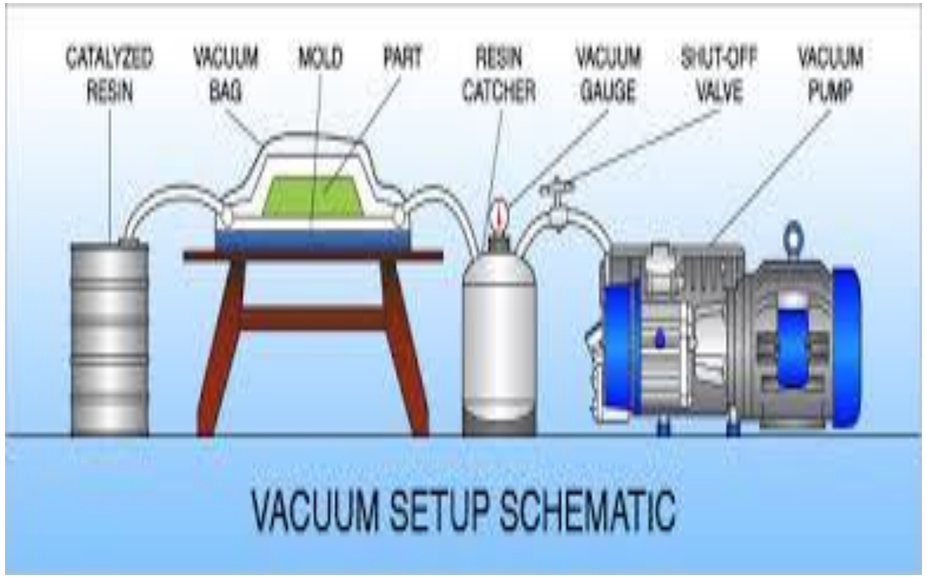
- Manufacturing Processes
  - ✓ Predominate Processes
    - Pultrusion
    - Vacuum Infusion
  - ✓ Other processes



What is Fibreglass Reinforced Polymer (FRP)?

Processes

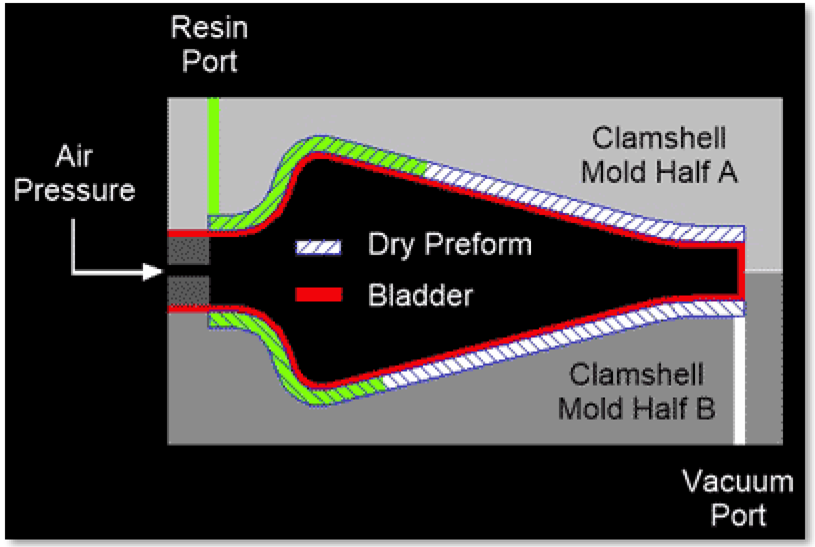
- Vacuum Infusion (VIP):

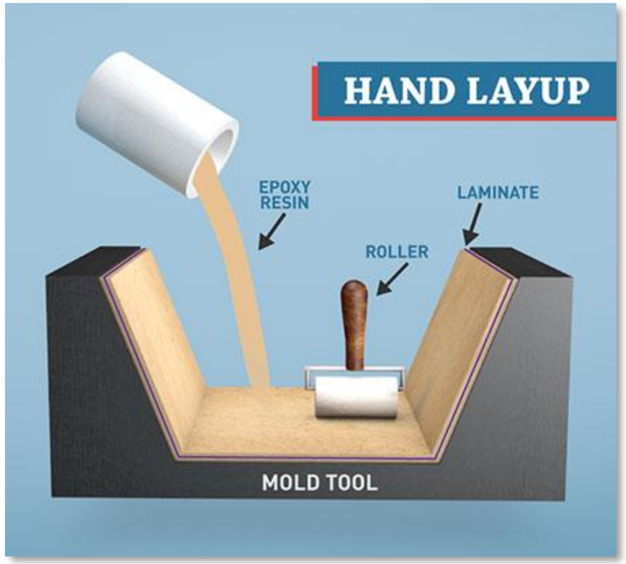


Benefit of VIP:
- Reinforcing fibers oriented in any direction at specific and targeted locations.

FRP Overview: Processes

- Other Processes
  - ✓ Bladder molding
  - ✓ Compression molding
  - ✓ Thermoplastic Extrusion
  - ✓ Filament winding
  - ✓ Wet Lay-up
  - ✓ Others



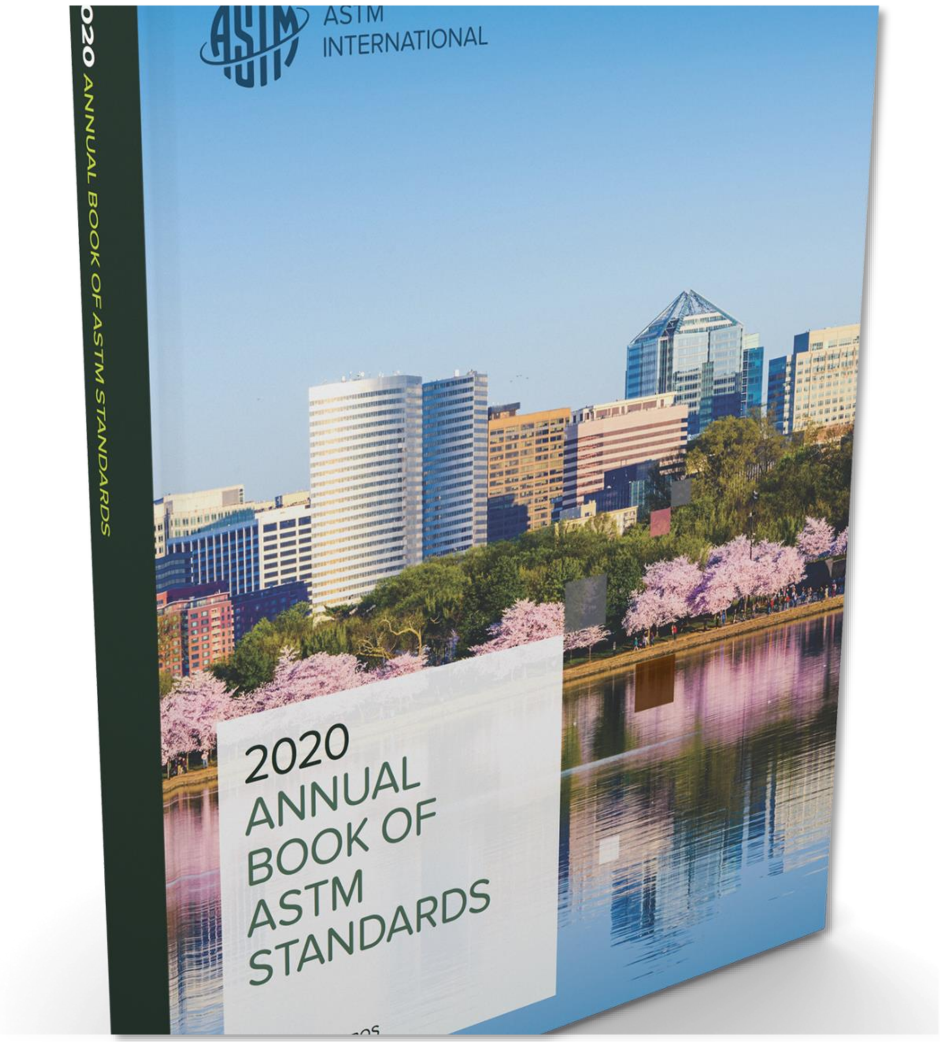


Typical applications for
Fibreglass Reinforced Polymer (FRP) equipment

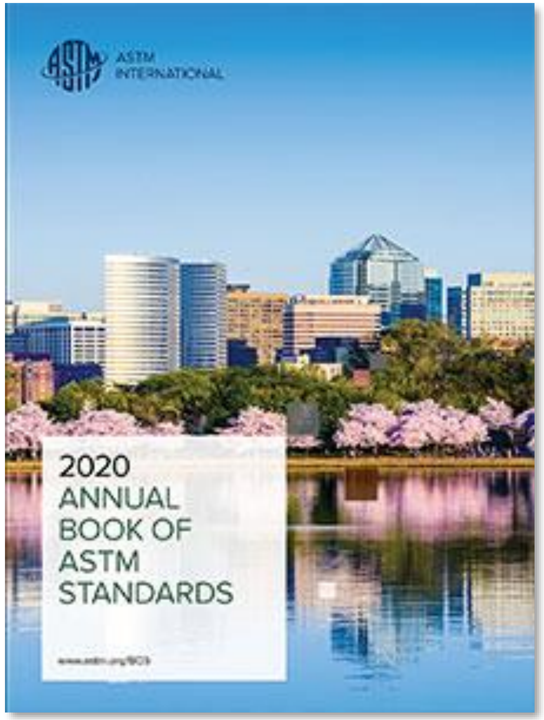
- HVAC industry in Critical Environments
  - Acid fume hood laboratory exhaust
  - Waste Water Treatment Plants
  - Chemical laden processes

National Specifications Applicable to FRP Product

- Piping and Ducting
- Tanks
- Fans and Blowers



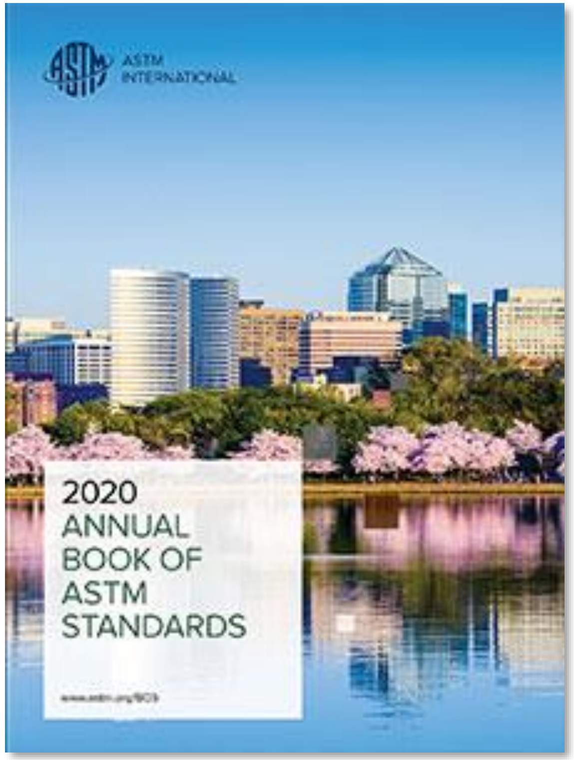
National Specifications For Piping and Ducting



- ASTM C581 – 20 Standard Practice for determining Chemical resistance of Thermosetting resins used in Glass-Fibre Reinforced Structures intended for Liquid Service
- ASTM D2310 – Standard Classification for machine-made “Fibreglass” Pipe
- ASTM D2412 – Standard Test method for determination of external loading Characteristics of Plastic Pipe by Parallel-Plate loading
- ASTM D2996 – Standard specification for filament Wound “Fiberglass” (Glass Reinforced Thermosetting-Resin) Pipe
- ASTM D3567 – Standard practice for determining dimensions of Fiberglass (Glass-Fiber Reinforced – Thermosetting- Resin) Pipe
- ASTM D3982 – 08 (2014) – Standard Specification for Contact Molded “Fiberglass” (Glass Fiber Reinforced Thermosetting Resin) Ducts
- ASTM D5421 – 15 Standard Specification for Contact Molded “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Flanges
- ASTM D6041 – 18 Standard Specification for Contact-Molded “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Corrosion Resistant Pipe and Fittings
- ASTM E84 – Standard Test Method for Surface burning Characteristics of Building materials.
- ANSI RTP-1 – Reinforced Thermoset Plastic Corrosion Resistant Equipment

National Specifications For Tanks

- ASTM C582 – 09 (2016) – Standard specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment
- ASTM D3299 – 18 Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
- ASTM D4097 – 19 Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
- ASTM E84 – Standard Test Method for Surface burning Characteristics of Building materials.
- ANSI RTP-1 – Reinforced Thermoset Plastic Corrosion Resistant Equipment



National Specifications for Fans and Blowers

- ASTM C582 – 09 (2016) – Standard specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment
- ASTM D4167 - 15 – Standard Specification for Fiber-Reinforced Plastic Fans and Blowers
- ASTM D5421 – 15 Standard Specification for Contact Molded “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Flanges
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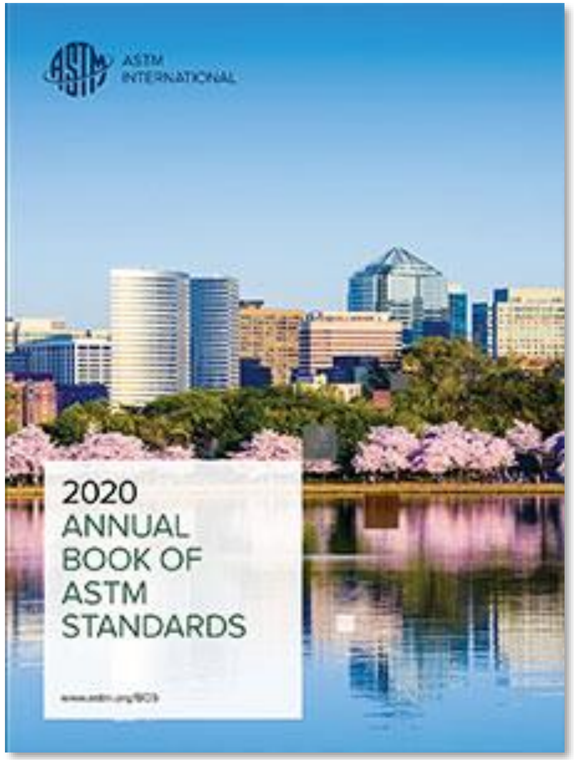

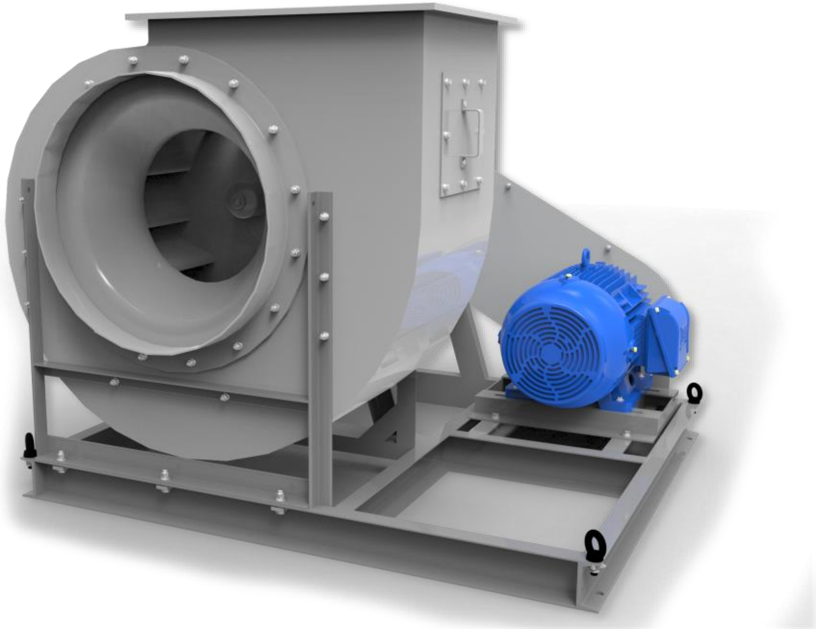

Advantages of FRP Air Movement & Control Equipment

1. Corrosion Resistance
   Chemical Resistance
2. Good Dielectric properties
   Spark and Static Resistant meeting AMCA Standard 99-0401-86
3. Excellent processability
   ability to be formed into complex shapes
4. High Strength to Weight ratio
   comparison to metals
5. ROI and Useable Life
   Initial Cost & Return on Investment vs Alloys

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Advantages of FRP Air Movement & Control Equipment

Chemical Resistance

Corrosion resistance of FRP is a function both of resin content and the specific resin used in the laminate.

FRP CORROSION RESISTANCE FOR INDUSTRIAL SOLUTIONS	FRP CORROSION RESISTANCE APPLICATIONS FOR WASTE WATER PROCESSES
Hydrochloric acid	Odour Control
Acetic Acid	Pollution Control
Wet Chlorine Gas	Scrubbers
Ferric Chloride	Process Ventilation
Hydrogen Sulfide	General Ventilation
Sulfur dioxide fumes	Air Control Products
Sodium hypochlorite	

For a full Chemical resistance chart view
https://www.mkplastics.com/documents/technical/M.K._Plastics_Corrosion_Resistance_Guide_-_99-09-November_2014.pdf

Advantages of FRP Air Movement & Control Equipment

- **Chemical Resistance**
- **Coated steel fans** vary greatly in the degree of protection
- Have an inherent failure: pin-holes

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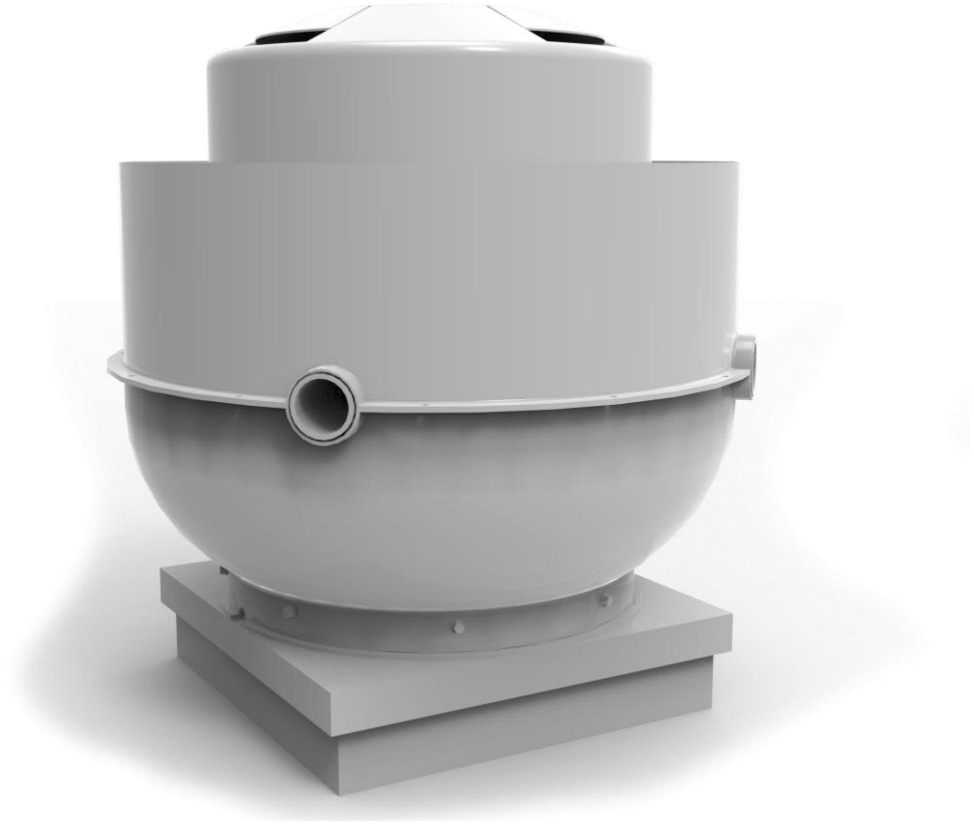
Advantages of FRP Air Movement & Control Equipment

❑ Good Dielectric properties

- ✓ Spark and Static Resistant meeting AMCA Standard 99-0401-86 SPARK A
- Only FRP components in the airstream
- Static electric charges can develop



Advantages of FRP Air Movement & Control Equipment

❑ Low Thermal Conductivity

✓ FRP panel requires no thermal breaks eliminating sweating

Property	FRP Composites Pultruded GRFP	Steel A 709 Grade 50	Aluminium 6061 –T651 & 6061-T6
Thermal Conductivity {BTU in / (hrft^2 °F)}	4	320	1,160

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Advantages of FRP Air Movement & Control Equipment

- ❑ **Excellent processability**

✓ Bifurcated exhaust nozzle for High Plume Dilution Exhaust fans

✓ The vast number of product that is now manufactured in FRP attests to the excellent processability

Advantages of FRP Air Movement & Control Equipment

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   Chemical Resistance
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Advantages of FRP Air Movement & Control Equipment

High Strength to Weight Ratio

Airbus A350 XWB consists of 52% Carbon Fiber Reinforced Polymer

Property	FRP Composites Pultruded GRFP	Steel A 709 Grade 50	Aluminium 6061 – T651 & 6061-T6
Density (lb/ft³)	107 - 120	490	169
Tensile Strength (psi)	30,000 (LW) 7,000(CW)	65,000	45,000
Tensile Modulus (x10$_6$ PSI)	1.8 (LW) 0.8(CW)	30	10
Thermal Expansion (x10-6 in/in/°F)	7 to 8	6 to 8	13

LW = Lengthwise / CW = Crosswise
References: Datasheets from www.matweb.com

Advantages of FRP Air Movement & Control Equipment

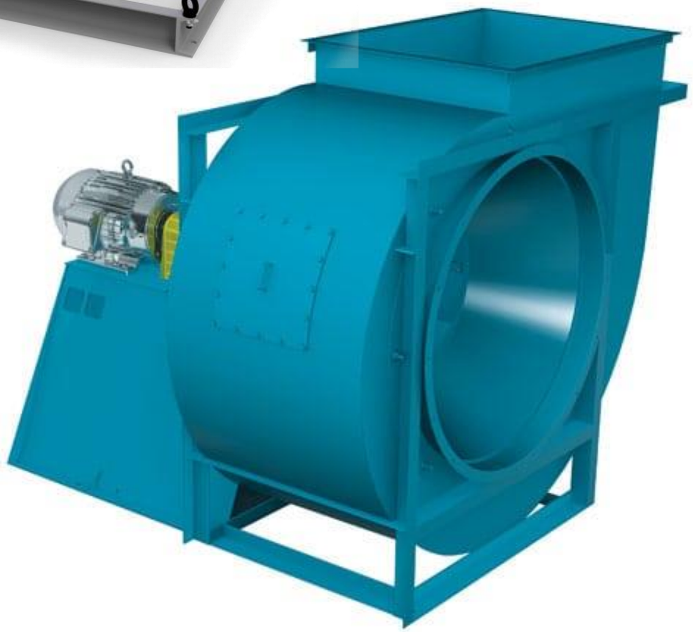
❑ High Strength to Weight Ratio

Weight benefits of an FRP fan can range from 10% through to 30% weight advantage; the big range is due to the variance in fan size and comparable motor size.

See chart below:

Propeller Fan Direct Drive Horizontal Mounted Fan			
	Model AXPR 36" FRP Fan and Impellor	SS-2-36 Model 36" Steel fan 17,116CFM	Percentage Weight Saving
18,094 CFM @ 0.3" W.G	135lbs Base Fan	159lbs Base Fan	15%
Airfoil Centrifugal SWSI Class III Utility Fan			
	Model DHK 3650 Class III FRP Fan and Impellor	BAE-SW 365 Model Steel Fan Class III	Percentage Weight Saving
20,000 CFM @ 12" W.G	1265 lbs Base Fan	1778 lbs Base Fan	28%


DHK 3650


BAE-SW 365

Advantages of FRP Air Movement & Control Equipment

High Strength to Weight Ratio

Weight benefits of an FRP double wall plenum material can be a weight saving of over 50% compared to double wall 18Ga Galv outer wall and 22 Ga 304 Stainless Steel inner wall.

FRP Plenum base measuring 144" x 144"

Advantages of FRP Air Movement & Control Equipment

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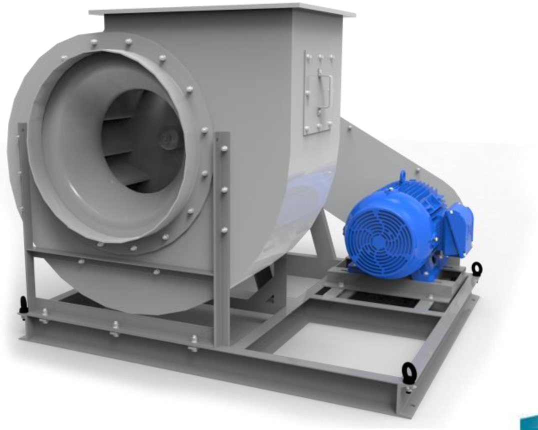
Advantages of FRP Air Movement & Control Equipment

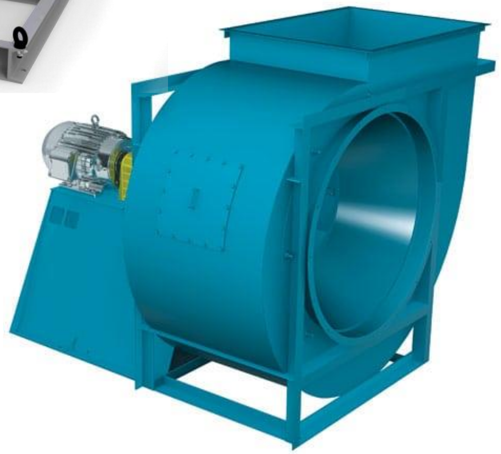
- ROI and Useable Life

✓ FRP is an economical alternative to 304 Stainless Steel and significantly less expensive than 316 Stainless Steel.

Stainless Steel Fan – Purchase Price $4

FRP Fan – Purchase Price $2





Steel Fan – Purchase Price $1

Advantages of FRP Air Movement & Control Equipment

- ROI and Useable Life

✓ FRP is an economical alternative to 304 Stainless Steel and significantly less expensive than 316 Stainless Steel.

✓ Life expectancy of an FRP unit when UV inhibitors are included in the Resin is between 25 to 50 years.

FRP fan installed in 1996 at Minatco (currently Orano) for their uranium processing McClean Lake Mill

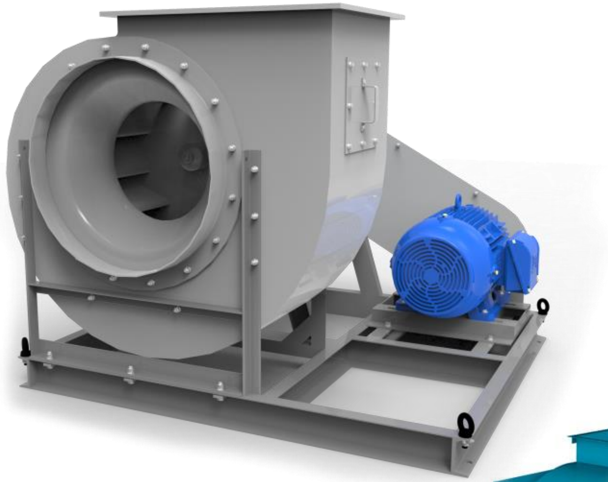
Advantages of FRP Air Movement & Control Equipment

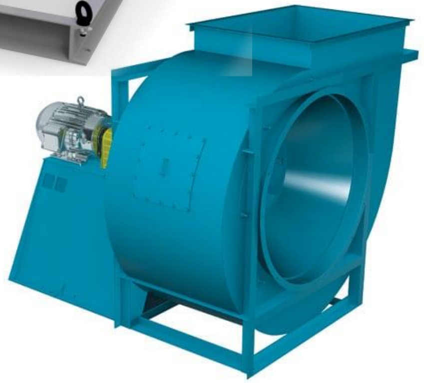
- ROI and Useable Life

Typical Building Installation	Initial Purchase Price	Cost to Replace after 15 years assuming 2% inflation/Yr.	Cost of equipment for the building life of 30 years
Galvanized Metal Fan	$1000	$1,320	$2,320
FRP Fan	$2000	$0	$2,000

Stainless Steel Fan – Purchase Price $4

FRP Fan – Purchase Price $2





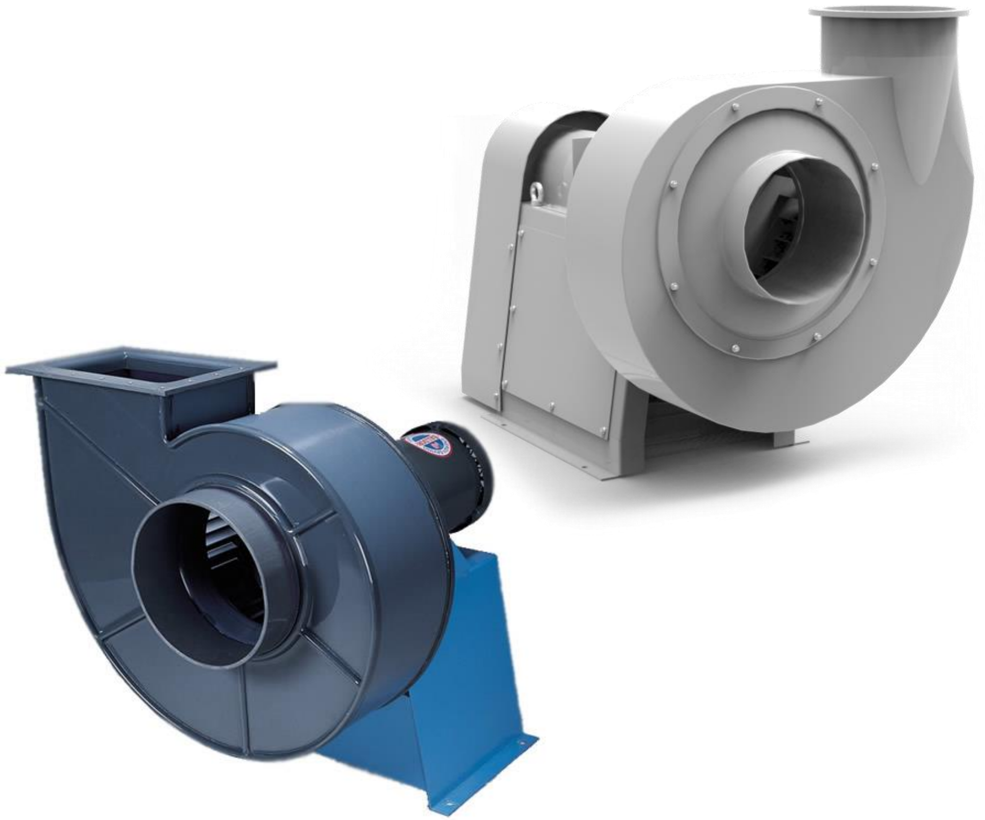
Steel Fan – Purchase Price $1

FRP is not Rigid Polyvinyl Chloride (PVC)

While rigid polyvinyl chloride (PVC) have an all-round corrosion resistance they have two limiting factors:

1. PVC becomes brittle at temperatures below freezing.
2. PVC loses strength characteristics with increasing temperatures, causing wheels to sag affecting performance.

FRP fan casing - ample strength additional ribbing is not required



PVC Fan notice ribbing for strength on casing

WHY IS FIBERGLASS REINFORCED POLYMER AN ALTERNATIVE TO STAINLESS STEEL?

Summary

Fiberglass Reinforced Polymer provides:

1. Ability to manufacture complex shapes
2. Corrosion resistance capabilities similar to 304 and 316 Stainless Steel
3. Strong while being less weight than comparable materials
4. Spark and Static resistant meet AMCA 99 – 041 – 86 Spark A
5. Low thermal conductivity greatly reducing sweating.
6. Cost competitive to 316 and 304 Stainless Steel
7. Life expectancy of over 25 years providing excellent return on investment

Resources

- **AMCA International**: *www.amca.org*
- **AMCA Certified Products:** *www.amca.org/certify*
  > Certified and listed fiberglass products by company name
- **ASTM International – Standards and Publications:** *www.astm.org/standards/standards-and-publications.html*

Thank you for your time!

To receive PDH credit for today's program, you must complete the online evaluation, which will be sent via email following this webinar.

If you viewed the webinar as a group and only one person registered for the webinar link, please email Lisa Cherney** (lcherney@amca.org) **for a group sign-in sheet today. Completed sheets must be returned to Lisa by tomorrow, May 28.

PDH credits and participation certificates will be issued electronically within 30 days, once all attendance records are checked and online evaluations are received.

Attendees will receive an email at the address provided on your registration, listing the credit hours awarded and a link to a printable certificate of completion.

Questions?

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NEXT PROGRAM

Join us for our next AMCA *insite* Pop-Up Webinar:

- Wednesday, June 3
- 12:00-1:00pm CDT
- ***TOPIC: Balance and Vibration***
- Presenter: Rad Ganesh, Director- Product Applications, AMCA Member Company

>> For additional webinar dates go to: *www.amca.org/webinar*

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