Why Steel?

Performance Study of Steel Doors Compared to Other Door Materials

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FINDINGS

"*Why Steel?"* presents the performance characteristics of steel doors compared to alternate materials such as wood, aluminum and fiberglass. This data can be used to help determine the best door material for a specific project based on the required performance attributes.

The quantitative and qualitative data in this report is based on extensive research including the use of independent testing agencies, standards organizations, and online information, plus interviews with over 20 door and frame industry professionals.

The performance characteristics that were evaluated using quantitative tests (e.g. measurements by a testing organization and/or to defined standards) were:

- Fire rating
- Sound transmission
- Thermal performance
- Tornado resistance
- Blast resistance
- Forced entry resistance

The performance characteristics that were determined by qualitative evaluation, primarily through examination of material attributes and interviews with door and frame experts, were:

- Anti-microbial properties (sanitation)
- Corrosion and water resistance
- Maintenance and repair

Steel doors are shown to have superior performance for strength and durability compared to other door materials**. Steel or stainless steel doors performed at a high level in every one of the performance characteristics evaluated in this study.**

This superior performance is partly due to the natural strength of steel. In its unaltered state, steel can withstand more environmental and physical abuse and is easier to maintain than wood, aluminum, or fiberglass.

When properly installed and maintained, steel doors often last 30 years or longer. When repairs are necessary, they typically occur in the field at a relatively low cost. A result of the strength and durability of steel is that **steel doors have the lowest lifecycle cost of any of the materials in this performance comparison and are fully recyclable at the end of their service life.**

RESEARCH CITATIONS

Technical data was obtained from a variety of sources. The most commonly referenced documents were:

- HMMA 805:12 - Recommended Selection and Usage for Hollow Metal Doors and Frames
- ANSI/SDI A250.8-2017- Specifications for Standard Steel Doors and Frames
- ANSI/SDI A250.4-2018 - Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors, Frames and Frame Anchors

PERFORMANCE TABLES

Purpose

The purpose of these tables is to illustrate the different performance characteristics of various door materials. These tables convey the natural and enhanced strength of steel. Relevant standards are included where possible.

Methodology

The first section of tables in this report are quantitative, with measurable performance characteristics (e.g., fire or sound transmission). These test results are generally provided by independent testing organizations such as Intertek or UL. Test results were generally obtained from manufacturer websites.

The remaining tables include performance characteristics without a definable metric (e.g., anti-microbial properties and corrosion resistance). Because these qualitative characteristics can be very important in material selection, the authors developed performance tables for the qualitative characteristics. The content in these tables was also obtained from manufacturer websites.

In all cases, the performance tables were reviewed by industry professionals. More than 20 individuals from 15 manufacturers or trade associations were interviewed and/or reviewed the performance tables prior to publication.

Limitations

It became very clear during our research that comparative performance testing of alternate door materials is rarely performed. While every effort was made by the authors to provide a fair and accurate assessment of all materials, some performance tables could not be completed for all materials due to a lack of publicly available test data or information.

Exclusions

In the specialty door market, doors made by materials other than steel can be enhanced to perform at a higher level than their mass market products generally perform. An example is wood, which has minimal natural sound reduction or fire protection qualities. Wood doors can be manufactured to have a 51 STC rating or a 90 minute fire rating, however these enhancements are often quite expensive. Therefore the performance tables do not reflect performance characteristics that can only be obtained by very costly manufacturing, rather, they convey the performance that can generally be expected.

Performance Tables

Fire Rating				
Material	Maximum (Best Case) Metrics	Performance Best ● Medium Θ Worst o	Comparative Cost ($, $$, or $$$)	Comments
Steel	3 hours	●	$	Only door material that offers a three hour fire rating. Twenty minute steel doors generally perform to a three hour standard.
Wood	90 minutes	Θ	$$$	Depending on the fire rating, wood may require the use of intumescent seals, which expand when hot. Depending on the fire rating and the door manufacturer, a pair of fire-rated wood doors may require a 5 inch metal edge at the meeting style.
Aluminum	90 minutes	o	$$$	
Fiberglass	90 minutes	Θ	$$$	Fiberglass requires an intumescent seal.

Because fire ratings are so frequently specified, comparative fire rating information is available for all four materials.

- Steel is the only door material that offers a three hour fire rating.
- Wood is inherently flammable. Therefore wood doors cannot readily achieve a high fire rating; 90 minutes tends to be the high end. As the fire rating increases, the cost generally does too.
- Aluminum and fiberglass doors are not as well-suited to fire resistance as steel due to the natural properties of the materials.

CONCLUSION - Steel doors have the best fire rating capabilities and are the sole door material to deliver a 3 hour fire rating. They are also generally priced lower than other fire rated doors.

Blast Resistance				
Material	Relevant Standards	Maximum (Best Case) Metrics	Performance Best ● Medium ϴ Worst **o**	Comments
Steel	ASTM F2247, ASTM F2927, UFC 4-010-01	Pass	●	Steel can pass each of these blast resistant standards.
Wood		Fail	**o**	Wood doors are not capable of being blast resistant.
Aluminum		Pass	●	Aluminum can pass each of these blast resistant standards.
Fiberglass		Fail	**o**	Fiberglass doors are generally not blast resistant.

Blast resistant steel and aluminum door assemblies are capable of passing the common standards for blast resistant openings. Wood and fiberglass are not specified for blast resistant openings.

Sound Transmission					
Material	Relevant Standards	Typical Range	Performance Best ● Medium ϴ Worst **o**	Comparative Cost ($, $$, or $$$)	Comments
Steel	ASTM E90 ASTM E413 ASTM E336	STC 32 – STC 55	●	$	Tested as complete operable assembly. Steel products for pairs normally range from STC 40 – STC 48. Steel sound doors can achieve a three hour fire rating. Vision lights and embossments are available too.
Wood		STC 32 – STC 52	ϴ	$$	Paired doors generally only rated to STC 44.
Aluminum		Generally not available	**o**	N/A	Aluminum doors are not suitable for sound reduction.
Fiberglass		STC 29 – STC 39	**o**	$$$	Rarely used for STC doors.

Doors with sound reducing properties, measured by the STC (Sound Transmission Coefficient) rating, are increasingly specified for offices, schools, and other facilities where sound reduction is important. This is because of a growing awareness of the health and productivity benefits of lower noise levels.

- Steel offers the highest STC rating of any door material. Single steel STC doors generally range from STC 32 to STC 55 (and up to 66 with highly specialized doors), with pairs generally rated up to STC 48. Steel sound resistant doors can also achieve a three hour fire rating. Vision lights are available.
- Wood doors have lower STC ratings and higher lifecycle costs.
- Aluminum doors are not suitable for sound reduction due to the nature of the material.
- Fiberglass is rarely used in sound reduction environments due to the low STC ratings.

CONCLUSION - Steel doors have the best STC performance characteristics. They are well suited to sound reduction specifications and offer lower lifecycle costs in those environments.

Forced Entry Resistance			
Material	Relevant Standards	Performance Best ● Medium **Ɵ** Worst **o**	Comments
Steel	ASTM F1233 ASTM F3038 SD-STD-01.01	●	Steel door assemblies can pass the three commonly specified test criteria for forced entry resistance in government and non-government buildings.
Wood		**o**	Wood doors are not suited for forced entry resistance. The material is soft and susceptible to cracking.
Aluminum		**o**	Aluminum is a softer material than steel.
Fiberglass		●	Strong, but prohibitively expensive for many projects.

Due to its inherent strength and lower lifecycle costs, steel is the optimal and most commonly specified door material for forced entry resistant openings.

Tornado Resistance				
Material	Relevant Standards	Maximum (Best Case) Metrics	Performance Best ● Medium ϴ Worst **o**	Comments
Steel	FEMA 361 International Code Council ICC 500	Pass	●	Steel passes the FEMA 361 and ICC 500 tornado test (250 mph wind speeds).
Wood		Fail	**o**	Not listed for tornado resistance
Aluminum		Fail	**o**	Not listed for tornado resistance.
Fiberglass		Fail	**o**	Not listed for tornado resistance.

Steel doors pass the tornado resistance tests of the two primary standards developers. None of the alternate materials pass the tornado resistance tests. Therefore steel doors are the only door material that are viable for tornado resistant applications.

Thermal Performance					
Material (core)	Relevant Standards	Typical U-Factor	Typical R-Value	Performance Best ● Medium ϴ Worst **o**	Comments
Steel (Polyurethane)	ASTM C1199-09 ASTM C1363-05 ASTM E1423-06	0.38	2.65	ϴ	Steel doors with a polyurethane core transmit little heat compared to other materials. It's U-Factor is just above fiberglass.
Steel (Polystyrene)		0.41	2.44	ϴ	
Steel (Honeycomb)		0.56	1.79	ϴ	
Hollow Metal (Steel Stiffened)		0.61	1.63	**o**	Hollow metal doors with a steel stiffened core transfer the most heat of the steel core materials.
Wood		0.40	2.50	ϴ	Wood doors transfer more heat than fiberglass and some steel doors, however their thermal transmittance is relatively low.
Aluminum		0.83	1.20	**o**	Aluminum doors allow the most heat flow of all the materials.
Fiberglass		0.35	2.85	●	Fiberglass doors have the best natural thermal performance of the materials.

Each of the door materials, along with the various steel cores, was tested by Intertek from September 20 – October 4, 2011. Some manufacturers only test the central portion of their door panels when analyzing their products' U-values. This does not reflect operable conditions as it does not include the entire door, frame or hardware, which affects the transfer of heat. These Intertek tests were according to ASTM E1423-06 and included the entire operable assembly. It may be appear these materials have a higher thermal conductivity than previously, although that is not the case. This is simply a more accurate test method.

- Steel's thermal performance is directly related to its core.
- The wood door transferred more heat than the fiberglass door and steel door with polyurethane and steel stiffened cores.

- The aluminum door transferred by far the most heat of the door materials tested.

Relative Performance - Sanitation (Anti-microbial Properties)		
Material	Performance Best ● Medium ϴ Worst **o**	Comments
Stainless Steel	●	Stainless steel doors with a seamless edge have excellent anti-microbial properties. Washes/sanitizes easily.
Steel	ϴ	Great use for steel. Washes easily with appropriate finish and a custom seamless edge. Antimicrobial resin is available for additional protection.
Wood	**o**	Porous material. Antimicrobial resin is available.
Aluminum	**o**	Porous and not easily sanitized. Very few aluminum doors have anti-microbial protection.
Fiberglass	ϴ	Sometimes selected for its anti-microbial properties.

There is not a standard measurement in the door industry for sanitation properties. However, based on the characteristics of the materials in this study, the following comments can be made:

- Stainless steel doors with a custom seamless edge have superior anti-microbial properties. They wash easily and sanitize thoroughly, making them a good choice for sanitary environments, such as food handling and medical.
- Steel is well suited to environments requiring high levels of sanitation. It washes easily when specified with the appropriate finish and a custom seamless edge. Antimicrobial resin is available for additional protection.
- Wood is naturally porous and difficult to sanitize. Antimicrobial resins are sometimes applied to wood specialty doors to improve the sanitation performance.
- Aluminum is naturally porous, making it hard to sanitize.
- Fiberglass doors are sometimes used in environments requiring high sanitation.

CONCLUSION – Other than all glass doors, stainless steel and steel doors have the best anti-microbial properties.

Relative Performance - Corrosion and Water Resistance		
Material	Performance Best ● Medium ϴ Worst **o**	Comments
Stainless Steel	●	Type 316 is required for high salt or high chemical environments.
Steel	ϴ	Galvannealing and finishes prevent corrosion in most circumstances.
Wood	**o**	Material does not corrode, however water can degrade wood and cause mold. Most wood door warranties are void if they are used on exterior openings.
Aluminum	**o**	Finish may be applied to reduce corrosion.
Fiberglass	●	Material does not corrode.

There is no quantitative measurement that is used in the door industry to measure corrosion and water resistance. However, based on the characteristics of the materials in this study, the following comments can be made:

- Stainless steel doors are commonly specified for environments requiring corrosion or water resistance. Type 316 is required for high salt or high chemical environments, such as coastal applications (salt) and indoor swimming pools.
- Steel earned a medium performance rating for corrosion and water resistance. While naturally susceptible to rust, steel is a versatile material and cost effective galvanized coatings and applied finishes are readily available.
- Wood does not corrode, but water will degrade wood. Because corrosive materials frequently are encountered in a moist environment, wood doors are not well suited to many corrosive environments.
- Aluminum is susceptible to corrosion. Although a corrosion-reducing finish may be applied to aluminum doors, aluminum is rarely chosen for corrosive environments.
- Fiberglass is naturally resistant to corrosion.

CONCLUSION – Stainless steel and fiberglass doors have the best performance for corrosion resistance.

Relative Performance - Maintenance and Repair		
Material	Performance Best ● Medium ϴ Worst **o**	Comments
Steel	●	Does not crack or dent easily. Often repaired in field with body filler or re-welding for a relatively low cost.
Wood	**o**	Susceptible to cracking. Expensive to repair, but may be repaired in some circumstances.
Aluminum	ϴ	Susceptible to scratches and dents. Must be replaced when dented as it cannot be reannodized.
Fiberglass	●	Requires minimal maintenance. However the purchase price can be 3-6 times that of steel.

There is no quantitative measurement that is used in the door industry to measure the typical cost of maintenance and repair. However, based on the characteristics of the materials in this study, the following comments can be made:

- Steel doors provide superior performance because steel does not crack or dent easily. They can often be repaired in the field, which provides an economic advantage over wood and aluminum doors.
- Wood has the lowest relative performance in terms of maintenance and repair. Wood is susceptible to cracking and can be expensive to repair. Damaged wood doors are frequently replaced rather than repaired.
- Aluminum doors often get dented or scratched. A dented aluminum door cannot be repaired; it must be replaced as it cannot be reannodized.
- Fiberglass doors, like steel doors, also offer superior performance for maintenance and repair. However the purchase price of a fiberglass door is cost prohibitive for many projects.

CONCLUSION – Steel doors have the best price/performance advantage for maintenance and repair.