

# Why Steel?

## Performance Study of Steel Doors and Frames Compared to Other Materials

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## FINDINGS

“*Why Steel?*” presents and analyzes the performance characteristics of steel doors and frames compared to alternate materials wood, aluminum and fiberglass. This data can be used to help determine the best material for a project.

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:

- Swing test (cycle test)
- Fire rating
- Acoustical performance (sound transmission coefficient)
- Thermal performance
- Hurricane resistance
- Tornado resistance

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

- Resistance to physical abuse
- Anti-microbial properties (sanitation)
- Corrosion- and water-resistance
- Maintenance and repair
- Longevity (life of door)

Steel doors and frames are shown to have superior performance for strength and durability compared to the alternate materials. **Steel or stainless steel doors earned the highest ranking of any of the four door materials for every one of the ten 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 natural and man-made abuse, is more sanitary, and easier to maintain than any of the other materials evaluated—wood, aluminum, and 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 relatively low cost. A result of the strength and durability of steel is that **steel doors have the lowest total cost of ownership of any of the materials in this performance comparison.**

## RESEARCH CITATIONS

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

- HMMA 805:2010 - Recommended Selection And Usage For Hollow Metal Doors And Frames
- ANSI/SDI A250.8-2003 (R2008) - Recommended Specifications for Standard Steel Doors and Frames
- ANSI/SDI A250.4-2011 - 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 accurately and effectively display the natural, and enhanced, strength of steel. Relevant standards are also included where possible.

### **Methodology**

The first six tables are quantitative, with measurable performance characteristics such as a sound transmission coefficient (STC) or fire rating. These test results are generally provided by independent testing organizations, such as Intertek or UL. Test results were generally obtained from manufacturer and association websites.

The remaining five performance characteristics, which include vandal resistance and anti-microbial properties, lack a definable metric. However, because these more qualitative characteristics can be very important in material selection the authors developed performance tables for the qualitative characteristics as well. The content of these tables was also obtained from manufacturer and association websites.

In all cases the performance tables, both quantitative and qualitative, were reviewed with 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 materials is rarely performed. Therefore, some performance tables could not be completed for all materials. However, every effort was made by the study authors to provide a fair and accurate assessment of all materials, including review by industry veterans with experience in all four materials.

### **Exclusions**

In the specialty door market, doors made by materials other than steel can enhance their products to perform at a higher level than the product performances with mass market products. An example is wood, which has minimal sound reduction or fireproof qualities naturally. Wooden doors can be customized to have a 51 STC rating or a 90 minute fire rating, however these specialty door enhancements are often extremely expensive. Therefore the performance tables do not reflect performance characteristics that can only be obtained by very costly specialty manufacturing.

**Performance Tables and Narration**

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Swing Test (Cycle Test)				
Material	Relevant Standards	Standard Metrics	Performance Best ● Medium ⊖ Worst ○	Comments
<b>Steel</b>	ANSI 250.4	2- 4 million cycles is common	●	Standard maximum requirement is 1 million cycles; hinges replaced multiple times during test. Steel doors have been successfully tested to 10M cycles.
<b>Wood</b>	ANSI 250.4		○	Wood doors are not recommended for high cycle environments. In a test by Intertek in 2012, wood failed the one million cycle test in accordance with ANSI A250.4. Wood doors are generally tested to WDMA standard T.M. 7, which is not as stringent.
<b>Aluminum</b>	ANSI 250.4		⊖	Aluminum failed the one million cycle test performed by Intertek on 2/27/2012.
<b>Fiberglass</b>	ANSI 250.4	25,000 – 500,000	⊖	Fiberglass failed the one million cycle test performed by Intertek on 2/27/2012.

A cycle test (also known as a swing test) replicates opening and closing a door within a door, frame and hinge assembly. The test “swings” the door open and shut many times in a standard fashion. The ability of a material to withstand a high number of swings is strong evidence of likely longevity during field usage. The standard maximum requirement for steel doors is often in the range of 1 million cycles. Some steel doors have been successfully tested to 10 million cycles.

- Steel excels at the cycle test. The test demonstrates that steel doors should be able to last for many decades in the field with respect to the wear and tear of being opened and shut.
- Wood was the worst-performing door material in the one million cycle test conducted by Intertek on 2/27/2012. For this reason, wood is rarely used in high cycle environments.
- Aluminum failed the one million cycle test performed by Intertek on 2/27/2012. Aluminum is a relatively soft material unlikely to perform well, and is generally not used in high cycle environments.



- Fiberglass did not pass the one million cycle test performed by Intertek. In the June 2011 revision of AAMA 920-11, it specifies meeting cycle performance of 25,000 to 500,000 swings. This is significantly less than the independently tested swing results of steel doors.

CONCLUSION - Steel doors have the best cycle test performance. They have proved to withstand the constant opening and closing of the door in high traffic environments significantly better than other materials.

Fire Rating				
Material	Maximum (Best Case) Metrics	Performance Best ● Medium ◊ Worst ○	Comparative Cost (\$, \$\$, or \$\$\$)	Comments
<b>Steel</b>	3 hours	●	\$	Only door material that offers a three hour fire rating. Twenty minute steel doors generally perform to a three hour standard.
<b>Wood</b>	90 minutes	◊	\$\$\$	Wood must use an intumescent seal, which expands when hot. Wood doors are not approved for all hardware, therefore there are fewer options. A pair of fire-rated wood doors requires a 5 inch metal cap, which diminishes the aesthetic appeal of the door. Additionally, as the fire rating increases, so does the cost.
<b>Aluminum</b>	90 minutes	○	\$\$	
<b>Fiberglass</b>	90 minutes	◊	\$\$\$	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 (with the possible exception of highly specialized and very expensive doors of the alternate materials).
- 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, so does the cost.
- Aluminum doors are not well suited to fire resistance because of the natural properties of the metal. They are rarely used where fire ratings are required.
- Fiberglass is also not well suited to high fire rating specifications.

**CONCLUSION** - Steel doors have the best performance characteristics for fire ratings, and are the sole door material to deliver a 3 hour fire rating. They are also generally priced lower than the alternate materials for a similar (lower) fire rating.

Acoustical Performance (Sound Transmission Coefficient) - Single Door					
Material	Relevant Standards	Typical Range	Performance Best ● Medium ◐ Worst ○	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	◐	\$\$	Wood doors are tested as components only. Paired doors only rated to STC 40, when available.
Aluminum		Generally not available	○	N/A	Aluminum doors are not suitable for sound reduction.
Fiberglass		STC 29 – STC 39	○	\$\$\$	Rarely used for STC doors.

Doors with sound reducing properties, measured by the STC (Sound Transmission Coefficient) rating, are increasingly specified for applications where they were not previously specified. 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, with pairs generally rated up to STC 48. Steel sound doors can achieve a three hour fire rating. Vision lights are available. They also usually cost less than STC doors of alternate materials.
- Wood doors have lower STC ratings and are more costly for the STC capability.
- 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 a cost advantage in those environments.



Thermal Performance					
Material (core)	Relevant Standards	Typical U-Factor Range	Typical Measured Overall R-Value	Performance Best ● Medium ⊖ Worst ○	Comments
Steel (Polyurethane)	ASTM C1199-09	0.38	2.65	⊖	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	⊖	
Steel (Honeycomb)		0.56	1.79	⊖	
Hollow Metal (Steel Stiffened)	ASTM C1363-05	0.61	1.63	○	Hollow metal doors with a steel stiffened core transfer the most heat of the steel core materials.
Wood	ASTM E1423-06	0.40	2.50	⊖	Wood doors transfer more heat than fiberglass and some steel doors, however their thermal transmittance is relatively low.
Aluminum		0.83	1.20	○	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 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 a polyurethane and steel stiffened cores.
- The aluminum door transferred by far the most heat of the door materials tested.

Hurricane Resistance					
Material	Relevant Standards	Size	Maximum Tested PSF	Comparative Cost (\$, \$\$, or \$\$\$)	Comments
<b>Steel</b>	Miami Dade County Florida Building Code	4'0" x 8'0"	100 PSF	\$\$	Highest PSF resistance. Most vendor choices (i.e. size).
		8'0" x 8'0"	90 PSF		
<b>Wood</b>		4'0" x 8'0"	80 PSF	\$\$\$	Typically residential.
		8'0" x 8'0"	Not available	N/A	
<b>Aluminum</b>		4'0" x 8'0"	90 PSF	\$\$\$	Available up to 90 PSF in single and paired doors. Pairs of hurricane resistant doors are less readily available.
		8'0" x 8'0"	90 PSF		
<b>Fiberglass</b>		4'0" x 8'0"	80 PSF	\$\$\$	
		8'0" x 8'0"	Not available		
<b>Steel - NOA 10.0209.07</b> <b>Aluminum – NOA 11-0228.04</b> <b>Fiberglass – FL 7026</b>					

Hurricane resistant doors are specified with PSF (pounds per square foot) test ratings.

- Steel offers the highest hurricane resistance (100 PSF). There are many vendors supplying steel hurricane resistant doors, which can provide a price advantage to the buyer.
- Wood hurricane doors provide a lower (less resistant) PSF and are generally not available in large door sizes (8'0" x 8'0"). This tends to limit the use of wooden hurricane resistant doors to residential applications.
- Aluminum doors are available up to 90 PSF. Hurricane resistant aluminum doors are occasionally available in large sizes (8'0" x 8'0").
- Fiberglass offers an equivalent rating to wood.

**CONCLUSION** - Steel doors have the best hurricane resistance performance characteristics. They can also obtain a higher rating than the alternate materials in large doors, which are frequently used for commercial applications.

Tornado Resistance				
Material	Relevant Standards	Maximum (Best Case) Metrics	Performance Best ● Medium ⊖ Worst ○	Comments
Steel	FEMA 361	Pass	●	Steel passes the FEMA 361 and ICC 500 tornado test (250 mph wind speeds).
Wood	International Code Council 500	Fail	○	Wood doors, with or without metal sheathing, cannot pass FEMA 361.
Aluminum		Fail	○	Not listed for tornado resistance.
Fiberglass		Fail	○	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.

CONCLUSION - Steel doors are the only door material that are viable for tornado protection applications.



Relative Performance - Abuse			
Material	Relevant Standards	Performance Best ● Medium ⊖ Worst ○	Comments
<b>Steel</b>	HMMA 805-10	●	Steel is vandal resistant when paired with appropriate hardware. Its sturdiness is ideal for high usage or high abuse situations. Hardware can be concealed inside the door for protection and appearance.
<b>Wood</b>		○	Material is soft and susceptible to cracking. Fewer options and flexibility than steel. Concealed hardware usually voids the warranty, but exposed hardware gets damaged and requires more replacement, increasing the cost of ownership.
<b>Aluminum</b>		⊖	Material can be damaged and is generally not repairable.
<b>Fiberglass</b>		●	Strong, but prohibitively expensive for many projects.

There is no quantitative measurement at this time for measuring performance in an abusive situation. However, based on the characteristics of the four materials in this study, we can conclude that steel doors are exceptional at withstanding abuse. Coupled with the superior performance in the cycle test, steel doors provide a superior lifetime value when longevity, maintenance, and repair are all considered.

Relative Performance - Sanitation (Anti-microbial Properties)		
Material	Performance Best ● Medium ⊖ Worst ○	Comments
<b>Stainless Steel</b>	●	Custom stainless steel has excellent anti-microbial properties with a custom seamless edge. Washes easily and sanitizes.
<b>Steel</b>	⊖	Great use for steel. Washes easily with appropriate finish and a custom seamless edge. Antimicrobial resin is available for additional protection.
<b>Wood</b>	○	Porous material. Antimicrobial resin is available.
<b>Aluminum</b>	○	Very porous; hard to sanitize. Very few aluminum doors have anti-microbial protection.
<b>Fiberglass</b>	○	More porous than metal; not common in medical or food handling.

There is no quantitative measurement that is used in the door industry to measure 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 the superior choice for sanitation environments, such as food handling and medical environments.
- Steel is well suited to environments requiring high levels of sanitation. Steel 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.
- The nature of the aluminum material is porous, making it hard to sanitize.
- Fiberglass doors are more porous than metal doors, and are rarely used in environments requiring high sanitation.

**CONCLUSION** – Stainless steel and steel doors have the best anti-microbial properties.

Relative Performance - Corrosion and Water Resistance		
Material	Performance Best ● Medium ⊖ Worst ○	Comments
<b>Stainless Steel</b>	●	A marine grade 316 is required for high salt or high chemical environments.
<b>Steel</b>	⊖	Galvannealing and finishes prevent corrosion in most circumstances.
<b>Wood</b>	○	Material does not corrode; but water will degrade wood and cause mold.
<b>Aluminum</b>	○	Finish may be applied to reduce corrosion.
<b>Fiberglass</b>	●	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. A marine grade 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 ⊖ Worst ○	Comments
<b>Steel</b>	●	Does not crack or dent easily. Often repaired in field with body filler or re-welding for a relatively low cost.
<b>Wood</b>	○	Susceptible to cracking. Expensive to repair, but may be repaired in some circumstances.
<b>Aluminum</b>	⊖	Dents. Must be replaced when dented as it cannot be reannodized.
<b>Fiberglass</b>	●	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. 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.

Relative Performance - Longevity			
Material	Common Lifecycle (If installed and maintained properly, excluding hardware)	Performance Best ● Medium ⊖ Worst ○	Comments
<b>Steel</b>	20-40 years	●	Steel is sturdy and field repair is possible and relatively inexpensive.
<b>Wood</b>	Up to 15 years; much lower in high abuse environments	○	Worst. Wood is soft and is susceptible to cracking.
<b>Aluminum</b>	About 15 – 20 years	⊖	It is a hard material but longevity is problematic as it cannot be repaired.
<b>Fiberglass</b>	About 20 years	⊖	Fiberglass is a newer door material, therefore historical data does not exist.

There is no quantitative measurement that is used in the door industry to measure longevity. Longevity itself is a subjective combination of physical longevity, maintenance and repair during the period of usage, and aesthetic considerations as a door ages. Based on the characteristics of the materials in this study, the following comments can be made:

- Steel has the longest life of any of the materials studied. Steel doors can last decades in low abuse environments. Steel is sturdy, and field repair is inexpensive.
- The life of wood is much shorter, because the material is soft and can crack. While wood doors can last up to 15 years (or more) in low impact environments, their longevity drops rapidly in other environments.
- Aluminum doors are hard, and in theory can last about 15 to 20 years. However, longevity is problematic as they can rarely be repaired.
- Fiberglass is a newer material so historical data on longevity does not exist.

**CONCLUSION** – Steel doors provide the greatest longevity. This provides superior economic value over the life of the door.