

Why Steel?

Performance Study of Steel Doors and Frames Compared to Other Materials

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TABLE OF CONTENTS

FINDINGS	4
RESEARCH CITATIONS	5
PERFORMANCE TABLES	6
Swing Test (Cycle Test).....	8
Fire Rating	10
Acoustical Performance (Sound Transmission Coefficient) - Single Door	11
Thermal Performance	13
Hurricane Resistance	15
Tornado Resistance.....	16
Relative Performance - Abuse.....	17
Relative Performance - Sanitation (Anti-microbial Properties)	18
Relative Performance - Corrosion and Water Resistance.....	19
Relative Performance - Maintenance and Repair.....	20
Relative Performance - Longevity.....	21

FINDINGS

“*Why Steel?*” presents and analyzes the performance characteristics of hollow metal 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 (the terms “steel” and “hollow metal” are used interchangeably in this document) are shown to have superior performance for strength and durability compared to the alternate materials. **Hollow metal 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, hollow metal 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, hollow metal 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 **hollow metal 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 hollow metal. 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 hollow metal 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

Swing Test (Cycle Test)..... 8

Fire Rating..... 10

Acoustical Performance (Sound Transmission Coefficient) 11

Thermal Performance 153

Hurricane Resistance..... 155

Tornado Resistance 16

Relative Performance - Abuse 17

Relative Performance - Sanitation (Anti-microbial Properties)..... 18

Relative Performance - Corrosion and Water Resistance..... 19

Relative Performance - Maintenance and Repair 20

Relative Performance - Longevity..... 21

Swing Test (Cycle Test)				
Material	Relevant Standards	Standard Metrics	Performance Best ● Medium ⊖ Worst ○	Comments
Hollow Metal	ANSI 250.4	2- 4 million cycles is common	●	Standard maximum requirement is 1 million cycles; hinges replaced multiple times during test. Hollow metal doors have been successfully tested to 10M cycles.
Wood	ANSI 250.4		○	Wood failed the one million cycle test performed by Intertek on 2/27/2012. Wood is rarely used in high cycle environments as it tends to be in interior office and hotel room environments.
Aluminum	ANSI 250.4		⊖	Aluminum failed the one million cycle test performed by Intertek on 2/27/2012.
Fiberglass	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 hollow metal doors is often in the range of 1 million cycles. Hollow metal doors have been successfully tested to 10 million cycles.

- Hollow metal 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 hollow metal doors.

CONCLUSION - Hollow metal 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
Hollow metal	3 hours	●	\$	Only door material that offers a three hour fire rating. Twenty minute hollow metal doors generally perform to a three hour standard.
Wood	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.
Aluminum	60 minutes	○	\$\$	
Fiberglass	90 minutes	⊖	\$\$\$	Fiberglass requires an intumescent seal.

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

- Hollow metal 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 - Hollow metal 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
Hollow Metal	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 53. Hollow metal sound doors can achieve a three hour fire rating. Vision lites are available.
Wood		STC 32 – STC 51	◐	\$\$	Wood doors are tested as components only. Highest fire rating of a wood acoustic door is typically only 20 minutes. STC paired doors are not available. Vision lites are not available.
Aluminum		No data	○	N/A	Aluminum doors are not suitable for sound reduction.
Fiberglass		STC 29 – STC 36	○	\$\$\$	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.

- Hollow metal offers the highest STC rating of any door material. Single hollow metal STC doors generally range from STC 32 to STC 55, with pairs generally ranging from STC 40 to STC 53. Hollow metal sound doors can achieve a three hour fire rating. Vision lites 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. The highest fire rating of a wood acoustic door is typically only 20 minutes. STC paired doors are not available. Vision lites are not available.

- 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 - Hollow metal 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
Hollow Metal (Polyurethane)	ASTM C1199-09 ASTM C1363-05 ASTM E1423-06	0.38	2.65	⊖	Hollow metal doors with a polyurethane core transmit little heat compared to other materials. It's U-Factor is just above fiberglass.
Hollow Metal (Polystyrene)		0.41	2.41	⊖	
Hollow Metal (Honeycomb)		0.56	1.80	⊖	
Hollow Metal (Steel Stiffened)		0.61	1.63	○	Hollow metal doors with a steel stiffened core transfer the most heat of the hollow metal core materials.
Wood		0.40	2.48	⊖	Wood doors transfer more heat than fiberglass and hollow metal doors with a polyurethane core, 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 thermal performance of the materials.

Each of the door materials, along with the various hollow metal cores, was tested by Intertek from September 20 – October 4, 2011.

- Hollow metal's thermal performance is directly related to its core. The polyurethane core transferred the least heat of the hollow metal doors. It outperformed the wood door, but transferred more heat than the fiberglass door.
- The wood door transferred more heat than the fiberglass door and hollow metal door with a polyurethane core.

- The aluminum door transferred by far the most heat of the door materials tested.
- Fiberglass had the best performance in Intertek's thermal performance test.

Hurricane Resistance					
Material	Relevant Standards	Size	Maximum Tested PSF	Comparative Cost (\$, \$\$, or \$\$\$)	Comments
Hollow Metal	Miami Dade County	4'0" x 8'0"	100 PSF	\$\$	Highest PSF resistance. Most vendor choices (i.e. size).
		8'0" x 8'0"	90 PSF		
Wood	Florida Building Code	4'0" x 8'0"	80 PSF	\$\$\$	Typically residential.
		8'0" x 8'0"	Not available	N/A	
Aluminum	Florida Building Code	4'0" x 8'0"	70 PSF	\$\$\$	
		8'0" x 8'0"	Not available		
Fiberglass		4'0" x 8'0"	80 PSF	\$\$\$	
Hollow Metal - NOA 10.0209.07 Aluminum – NOA 11-0228.04 Fiberglass – FL 7026					

Hurricane resistance is important in certain geographies in the United States, and hurricane resistant doors are specified with PSF (pounds per square foot) test ratings.

- Hollow metal offers the highest hurricane resistance. There are many vendors supplying hollow metal hurricane resistant doors, which can provide a price advantage to the buyer. They can support up to 100 PSF (see table above).
- 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 has similar limitations to wood, but with even lower maximum hurricane resistance.
- Fiberglass offers an equivalent rating to wood.

CONCLUSION - Hollow metal 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	○	No wood door, with or without metal sheathing, has successfully passed FEMA 361.
Aluminum		Fail	○	Not listed for tornado resistance.
Fiberglass		Fail	○	Not listed for tornado resistance.

- Hollow metal doors pass the tornado resistance tests of the two primary standards developers.
- None of the alternate materials pass the tornado resistance tests, not even wood doors with metal sheathing.

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

Relative Performance - Abuse			
Material	Relevant Standards	Performance Best ● Medium ⊖ Worst ○	Comments
Hollow Metal	HMMA 805-10	●	Hollow metal is the most vandal resistant material. It is a sturdy material; ideal for high usage or high abuse situations. Hardware can be concealed inside the door for protection and appearance.
Wood		○	Material is soft and easily penetrated. Less 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.
Aluminum		⊖	Material can be damaged.
Fiberglass		●	Material is strong, but very expensive.

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, the following comments can be made:

- Hollow metal is the most vandal resistant material. It is a sturdy material, ideal for high abuse situations. Hardware can be concealed inside the door for protection and appearance.
- Wood is soft and not well suited to high abuse situations. Concealed hardware in a wood door usually voids the warranty, but exposed hardware gets damaged and requires more replacement, increasing the cost of ownership.
- Aluminum does not withstand abuse as well as other materials, especially hollow metal.
- Fiberglass doors are strong, but prohibitively expensive for many projects.

CONCLUSION - Hollow metal doors are exceptional at withstanding abuse. Coupled with the superior performance in the cycle test, hollow metal 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
Stainless Steel	●	Custom stainless steel has excellent anti-microbial properties with a custom seamless edge. Washes easily and sanitizes.
Hollow Metal	⊖	Great use for hollow metal. Washes easily with appropriate finish and a custom seamless edge. Antimicrobial resin is available for additional protection.
Wood	○	Porous material. Antimicrobial resin is available.
Aluminum	○	Very porous; hard to sanitize. Very few aluminum doors have anti-microbial protection.
Fiberglass	○	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.
- Hollow metal is well suited to environments requiring high levels of sanitation. Hollow metal 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 hollow metal doors have the best anti-microbial properties.

Relative Performance - Corrosion and Water Resistance		
Material	Performance Best ● Medium ⊖ Worst ○	Comments
Stainless Steel	●	A marine grade 316 is required for high salt or high chemical environments.
Steel	⊖	Galvannealing and finishes prevent corrosion in most circumstances.
Wood	○	Material does not corrode; but water will degrade wood.
Aluminum	○	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. A marine grade 316 is required for high salt or high chemical environments, such as coastal applications (salt) and indoor swimming pools.
- 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 corrosion-resistant, so fiberglass doors are well suited to this application.

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

Relative Performance - Maintenance and Repair		
Material	Performance Best ● Medium ⊖ Worst ○	Comments
Hollow Metal	●	Does not crack and does not dent easily. Often repaired in field with body filler or re-welding for a relatively low cost.
Wood	○	Gouges easily. Expensive to repair, but may be repaired in some circumstances.
Aluminum	⊖	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 hollow metal.

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

- Hollow metal doors provide superior performance because hollow metal does not crack and does not 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 gouges easily and can be expensive to repair; damaged wood doors are frequently replaced rather than repaired.
- The nature of the aluminum material is that it dents fairly easily. A dented aluminum door cannot be repaired; it must be replaced as it cannot be reannodized.
- Fiberglass doors, like hollow metal doors, also offer superior performance for maintenance and repair. However the purchase price of a fiberglass door can be three to six that of hollow metal.

CONCLUSION – Hollow metal 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
Hollow Metal	30-40 years	●	Hollow metal is sturdy, and field repair is possible and relatively inexpensive.
Wood	Up to 15 years; much lower in high abuse environments	○	Worst. Wood is soft and dents and gouges easily.
Aluminum	About 15 – 20 years	⊖	It is a hard material but longevity is problematic as it cannot be repaired.
Fiberglass	About 20 years	⊖	Fiberglass is a newer material so 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:

- Hollow metal has the longest life of any of the materials studied. Hollow metal doors can last 30 to 40 years. Hollow metal is sturdy, and field repair of the doors is relatively inexpensive.
- The life of wood is much shorter, because the material is soft and dents and gouges easily. While wood doors can last up to 15 years (or more) in low impact environments, their longevity drops rapidly in high abuse environments.
- Aluminum doors are hard, and in theory can last about 15 to 20 years. However, longevity is problematic as they cannot be reanodized, limiting the ability to be repaired.
- Fiberglass is a newer material so historical data on longevity does not exist. They are estimated to have a shorter life than hollow metal, and a longer life than wood doors.

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