WHITE PAPER

Code-compliant stair design for safety and ergonomics

LAPEYRE STAIR

www.lapeyrestair.com

SUMMARY

Providing code-compliant stairs is the first step to ensuring safe access in your facility. Additional measures of safety and improved ergonomic factors are achieved by limiting environmental, behavioral, and design factors that can contribute to the risk of using stairs.

This white paper will help you to:

- ✓ Determine which code applies to your stair application
- ✓ Identify design specifications for OSHA and IBC stairs
- ✓ Understand other factors that contribute to stair safety

> One of the best ways to prevent and control occupational injuries is to "design out" hazards and risks.
>
> *NIOSH's Prevention Through Design Program*

CONTENTS

INTRODUCTION

The team of stair experts at Lapeyre Stair has been manufacturing precision-built access solutions for virtually every industry and application since 1981. We operate two, state-of-the-art facilities with a total of 182,000 square feet fully dedicated to stair production.

Our 113 full-time employees have a combined 661 years of stair manufacturing experience and we execute every step of each project with an unwavering commitment to zero-defect manufacturing. All of our products undergo complete, structural analyses to ensure every stair we ship fully complies with all applicable codes and standards.

This white paper is culmination of the combined knowledge of our team of stair experts. Our goal in providing this information is to help you make informed decisions to confirm the stairs in your facility are code compliant and meet the highest standards of safety and ergonomics.

Lapeyre Stair is a division of Laitram, a forward-thinking company with an intense commitment to innovation, integrity, and continuous improvement. Laitram, headquartered in New Orleans, Louisiana, currently holds 1319 active patents.

⇦ Laitram founder, J.M. Lapeyre, established Lapeyre Stair upon the issue of the patent for the alternating tread stair in 1981.

PART ONE: CODE COMPLIANCE

OSHA stairs versus IBC stairs

OSHA (Occupational Safety and Health Administration) is part of the United States Department of Labor. OSHA sets and enforces standards related to working conditions. Its priority is to reduce the number of safety and health hazards at places of employment. OSHA-compliant, industrial stairs are intended for workplace areas that are not publicly accessible.

IBC (International Building Code) is a model building code developed by the International Code Council (ICC.) IBC standards address safety and health concerns for public buildings. Its priority is to protect public health and safety. IBC-compliant stairs are intended for areas accessible to the general public and their design is based on building type and occupancy.

OSHA and the ICC rely on referenced standards published by other organizations to ensure their standards comply with well-researched, best practices. These include: ANSI (American National Standards Institute), NFPA (National Fire Protection Agency), ASCE (American Society of Civil Engineers), and AISC (American Institute of Steel Construction.)

OSHA-compliant stairs

OSHA standards are federally regulated and apply to places of employment in the United States. OSHA-compliant stairs are intended for use in facilities designated as employee workspaces such as factories and manufacturing facilities. OSHA stairs can be used on both the interior and exterior of these locations to access equipment, platforms, mezzanines, pits, or other floors.

The information in this white paper that pertains to OSHA stairs is based on the standards for General Industry. OSHA has separate standards for Construction, Agriculture, and Maritime. There are other standards that may also apply; always double check to ensure your stairs comply with any and all applicable codes and standards.

IBC-compliant stairs

IBC standards apply to stairs accessible by the general public and focus on the safety of all people, including children and the elderly. IBC stairs are part of a building's means of egress. There are four IBC standards that apply to stairs: Industrial Egress, Commercial Egress, Accessible Commercial Egress, and Commercial Residential Egress. IBC stairs that are located in areas required to be handicap accessible must also comply with ADA (Americans with Disabilities Act) Accessibility Standards.

Most jurisdictions in the United States have adopted IBC standards as their base code. Always check with your local code enforcement to ensure your stairs comply with any and all applicable codes and standards.

Typical applications for OSHA stairs

- ✓ Equipment access stairs
- ✓ Crossover stairs and platforms
- ✓ Operator work platforms and stairs
- ✓ Maintenance access stairs

Quick check: Which code applies to your stair?

Is the stair accessible only to specific workers as part of their work operations?

YES ⇨ OSHA stair

Is the stair accessible to the general public?

YES ⇨ IBC stair

Is the stair part of the building structure?

YES ⇨ IBC stair

Typical applications for IBC stairs

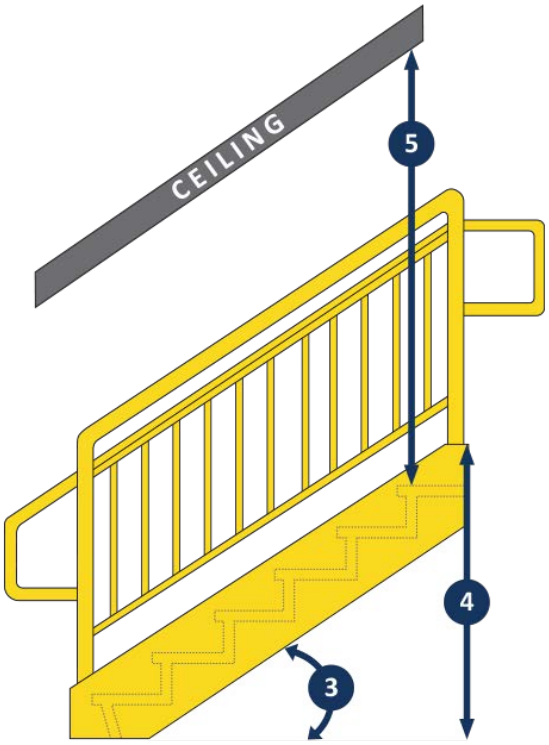
- ✓ Publicly-accessible egress stairs
- ✓ Mezzanine stairs
- ✓ In-plant office stairs

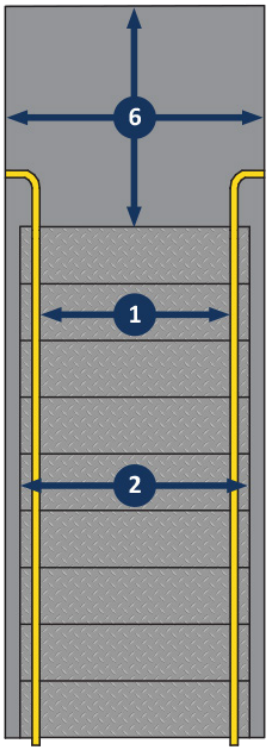
Stair components and definitions

OSHA Terminology & Definitions		**IBC** Terminology & Definitions	
Stairway (stairs) OSHA §1910.21(b)	Risers and treads that connect one level with another, and includes any landings and platforms in between those levels. Stairways include standard, spiral, alternating tread-type, and ship stairs	**Stair** IBC §202 **Stairway** IBC §202	A change in elevation, consisting of one or more risers One or more flights of stairs, either exterior or interior, with the necessary landings and platforms connecting them, to form a continuous and uninterrupted passage from one level to another
Standard stairs OSHA §1910.21(b)	A fixed or permanently installed stairway. Ship, spiral, and alternating tread-type stairs are not considered standard stairs	**N/A**	
Fall protection OSHA §1910.21(b)	Any equipment, device, or system that prevents an employee from falling from an elevation or mitigates the effect of such a fall (E.g. guardrail system, handrail)	**N/A**	
Guardrail system OSHA §1910.21(b) **Handrail** OSHA §1910.21(b) **Stair rail or stair rail system** OSHA §1910.21(b)	A barrier erected along an unprotected or exposed side, edge, or other area of a walking-working surface to prevent employees from falling to a lower level A rail used to provide employees with a handhold for support A barrier erected along the exposed or open side of stairways to prevent employees from falling to a lower level	**Guard** IBC §202 **Handrail** IBC §202	A building component or a system of building components located at or near the open sides of elevated walking surfaces that minimizes the possibility of a fall from the walking surface to a lower level A horizontal or sloping rail intended for grasping by the hand for guidance or support
Riser OSHA §1910.21(b) **Tread** OSHA §1910.21(b)	The upright (vertical) or inclined member of a stair that is located at the back of a stair tread or platform and connects close to the front edge of the next higher tread, platform, or landing A horizontal member of a stair or stairway, but does not include landings or platforms	**N/A** **N/A**	

Design criteria for standard stairs

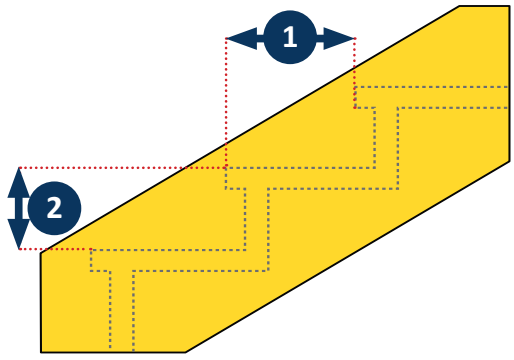
	OSHA COMPLIANT	IBC INDUSTRIAL / IBC COMMERCIAL
STAIR WIDTH OSHA §1910.25(c) IBC §1005.3; §1009.3; §1011.2	1 Minimum 22” between vertical barriers	1 Minimum 35” unobstructed width 2 Minimum 36” for < 50 occupants; minimum 44” for > 50 occupants
STAIR ANGLE OSHA §1910.25(c) IBC N/A	3 30 to 50 degrees from the horizontal	3 19.98 to 32.47 degrees (inferred from tread and riser requirements)
STAIR HEIGHT OSHA N/A IBC §1011.8	4 No maximum	4 Maximum 12’ height per single run
HEADROOM OSHA §1910.25(b) IBC §1011.3	5 Minimum 80” clearance	5 Minimum 80” clearance
LANDINGS OSHA §1910.25(b) IBC §1011.6	6 At least the width of the stair; minimum 30” deep in the direction of travel	6 At least the width of the stair; travel distance equal to or greater than the width of the stair

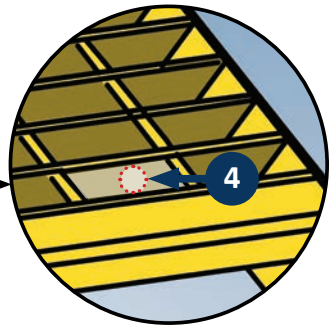


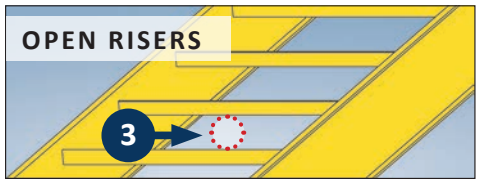


Tread and riser design criteria

	OSHA COMPLIANT	IBC INDUSTRIAL	IBC COMMERCIAL
PROJECTED TREAD DEPTH OSHA §1910.25(b) IBC §1011.5	❶ 9.5” minimum	❶ 11” minimum	
RISER HEIGHT OSHA §1910.25(c) IBC §1011.5	❷ 9.5” maximum	❷ 7” maximum	
TREAD/RISER TOLERANCE OSHA §1910.25(b) IBC § §1011.5; 1011.7	Must be uniform	0.1875” maximum between adjacent treads; 0.375” maximum for overall stair run	
RISER TYPE OSHA N/A IBC §1011.5	Both open and solid risers allowed	Both open and solid risers allowed	Solid risers only for accessible stairs; Both solid risers and open risers with 4” maximum opening for all others ❸
TREAD TYPE OSHA N/A IBC §1011.7	Both open and solid treads allowed	Both open and solid treads allowed; 1.125” maximum tread gap on open treads ❹	Both open and solid treads allowed; 0.5” maximum tread gap on open treads ❹

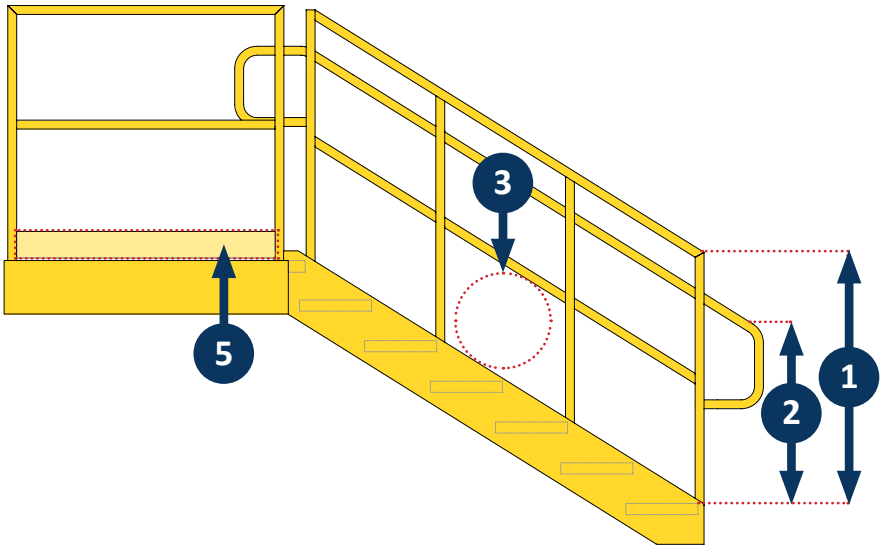






Guardrail and handrail requirements

	OSHA COMPLIANT	IBC INDUSTRIAL	IBC COMMERCIAL
GUARDRAIL/STAIR RAIL HEIGHT OSHA § 1910.29(b) IBC §1015.3	❶ 42” (± 3”)	❶ 42” minimum	❶ 36” minimum for residential; 42” minimum for all others
HANDRAIL HEIGHT OSHA § 1910.29(f) IBC §1014.2	❷ 36”	❷ 34” to 38”	
GUARDRAIL OPENING OSHA § 1910.29(f) IBC §1015.4	❸ Less than 19” sphere	❸ Less than 21” sphere	❹ Less than 4” sphere
NUMBER OF HANDRAILS OSHA § 1910.28(b) IBC §1011.11	One for stairs less than 44” wide; two for stairs more than 44” wide	Two	
TOE BOARD OSHA § 1910.29(k) IBC N/A	❺ 3.5” minimum height	Not required	



OSHA’s fall protection requirement

OSHA 1910.28 Employers duty to provide fall protection

1910.28(b)(1)(i) Except as provided elsewhere in this section, the employer must ensure that each employee on a walking-working surface with an unprotected side or edge that is 4 feet (1.2 m) or more above a lower level is protected from falling by one or more of the following:

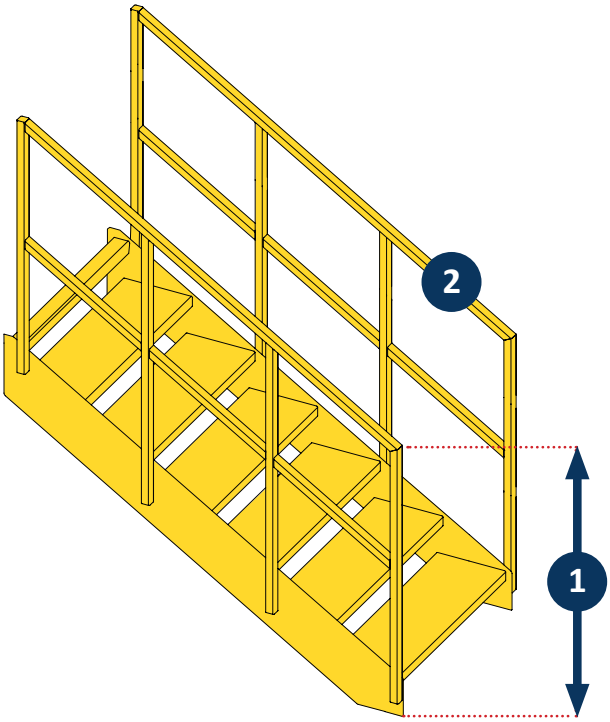
- ✓ 1910.28(b)(1)(i)(A) Guardrail systems;
- ✓ 1910.28(b)(1)(i)(B) Safety net systems; or
- ✓ 1910.28(b)(1)(i)(C) Personal fall protection systems, such as personal fall arrest, travel restraint, or positioning systems.

OSHA-compliant guardrail systems satisfy the requirement for employers to provide fall protection on both standard and non-standard stairs.

Current OSHA handrail requirements

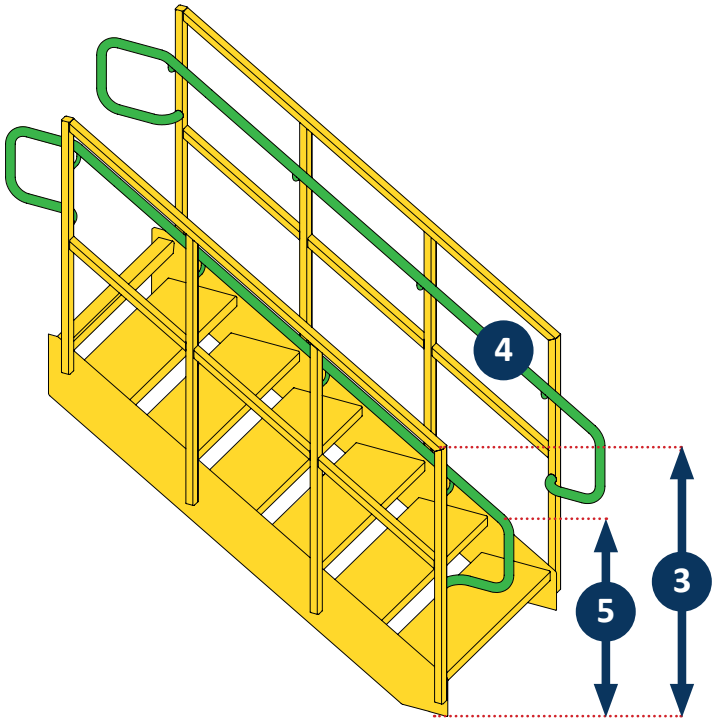
Stairs installed prior to January 17, 2017

❶ Guardrail height of 36” to 38”
❷ Separate handrails are not required; the guardrail also serves as the handrail



Stairs installed after January 17, 2017

❸ Guardrail height of 42” (± 3”)
❹ Separate handrails are required
❺ Handrail height of 36”



PART TWO: NON-STANDARD STAIRS

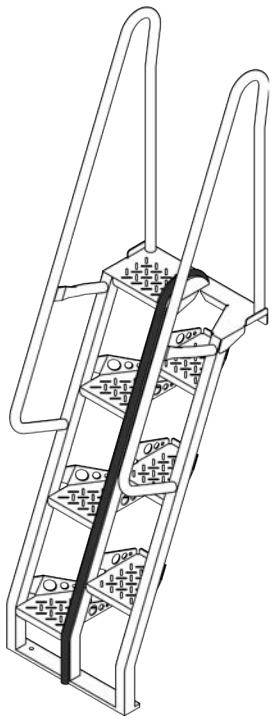
OSHA Terminology & Definitions

Alternating tread-type stair OSHA §1910.21(b)	A type of stair consisting of a series of treads that usually are attached to a center support in an alternating manner such that users typically do not have both feet on the same level while using the stair
Ship stair OSHA §1910.21(b)	A stair that is equipped with treads, stair rails, and open risers, and has a slope that is between 50 and 70 degrees from the horizontal
Spiral stair OSHA §1910.21(b)	A series of treads attached to a vertical pole in a winding fashion, usually within a cylindrical space

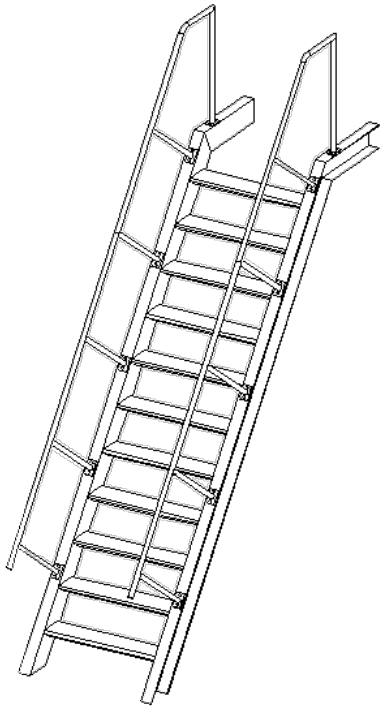
IBC Terminology & Definitions

Alternating tread device IBC §202	A device that has a series of steps between 50 and 70 degrees from horizontal, usually attached to a center support rail in an alternating manner so that the user does not have both fee on the same level at the same time
Ships ladder IBC N/A	Permitted applications for ships ladders are addressed in the code but otherwise not explicitly defined
Stairway, spiral IBC §202	A stairway having a closed circular form in its plan view with uniform section-shaped treads attached to and radiating from a minimum-diameter supporting column

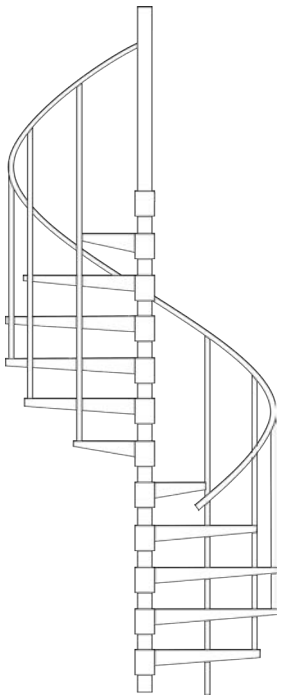
Alternating tread stair



Ship stair



Spiral stair



Applications with space restrictions

Alternating tread stairs and ship stairs are often used in applications where space restrictions prohibit the use of standard stairs; the steep-angle design of these devices requires less floor space to install than a standard stair. The chart* below illustrates the amount of space required to install non-standard stairs with angles of 68° and 56° versus a standard OSHA stair with a 45° angle.

STAIR RISE (VERTICAL HEIGHT)	STEEP-ANGLE STAIRS		STANDARD 45° OSHA STAIR
	68°	56°	
	STAIR RUN (HORIZONTAL PROJECTION)		
4’	2’2”	3’1”	4’3”
6’	2’11”	4’5”	5’10”
8’	3’9”	5’9”	8’2”
10’	4’7”	7’1”	9’9”
12’	5’4”	8’6”	12’2”
14’	6’2”	9’10”	13’9”
16’	7’	11’2”	16’1”
18’	7’10”	12’6”	17’8”
20’	8’7”	13’10”	20’1”

68° ALTERNATING TREAD STAIR VERSUS 45° STANDARD STAIR

OSHA COMPLIANT

OSHA-compliant use of non-standard stairs §1910.25(b)(8)

✓ Applications where a standard stair is not feasible

IBC COMPLIANT

IBC-compliant use of non-standards stairs §1011.14

✓ Access to unoccupied roofs
✓ Egress from mezzanines under 250 square feet with five or less occupants
✓ Egress from guard towers, observation towers, and control rooms under 250 square feet

*Chart is intended for illustrative purposes only; measurements are rounded up to the nearest inch.

Use-case for non-standard stairs

- ✓ Standard stairs are used to provide access from one walking-working surface to another when operations necessitate regular and routine travel between levels, including access to operating platforms for equipment OSHA §1910.25(b)(7)
- ✓ Spiral, ship, or alternating tread-type stairs are used only when the employer can demonstrate that it is not feasible to provide standard stairs OSHA §1910.25(b)(8)

* **Typically, the use-case is space limitations.** But, it could be any theoretical reason as long as the employer can demonstrate that it is not possible to use a standard stair.

> OSHA believes that the language in the final rule gives employers greater flexibility (than the previous language.) The final rule limits the use of non-standard stairs to those circumstances where, based on specific case-by-case evaluations and demonstrations, it is not possible to use standard stairs.
>
> *Federal Register / Vol. 81, No. 223*

Ladders versus non-standard stairs

Fixed, vertical ladders are classified separately from stairs; they are not considered to be non-standard stairs.

Unlike stairs, OSHA does not specify the use of ladders for regular and routine travel between levels

Part Four of this guide includes information about the safety and ergonomics of ladders.

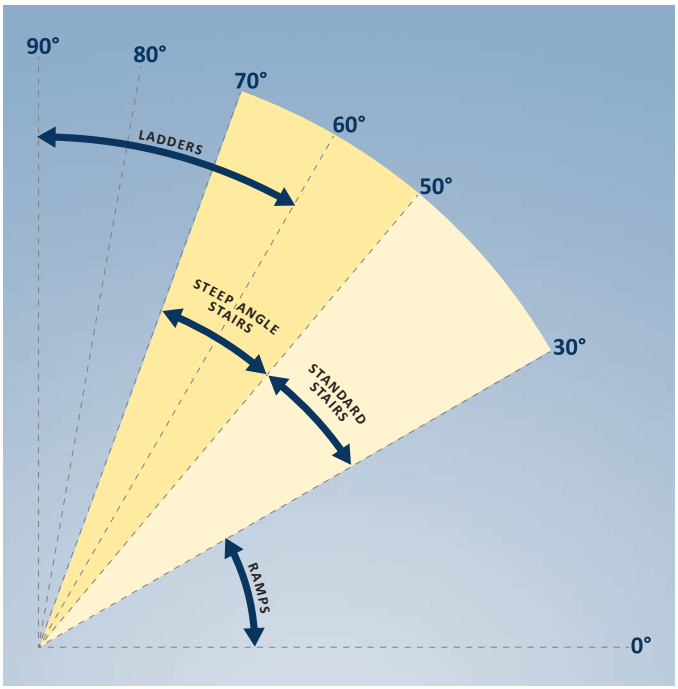
68° ALTERNATING TREAD STAIR

70° SHIP STAIR

PART THREE: STAIR DESIGN SAFETY FACTORS

Minimum/maximum stair angles

		OSHA COMPLIANT	IBC COMPLIANT
	STANDARD STAIRS OSHA §1910.25(c)(1) IBC *Inferred*	30° to 50°	20° to 32°
NON-STANDARD STAIRS	**ALTERNATING TREAD STAIRS** OSHA §1910.25(f)(1) IBC §1011.14.2	50° to 70°	50° to 70°
NON-STANDARD STAIRS	**SHIP STAIRS** OSHA §1910.25(e)(1) IBC *Inferred*	50° to 70°	63°

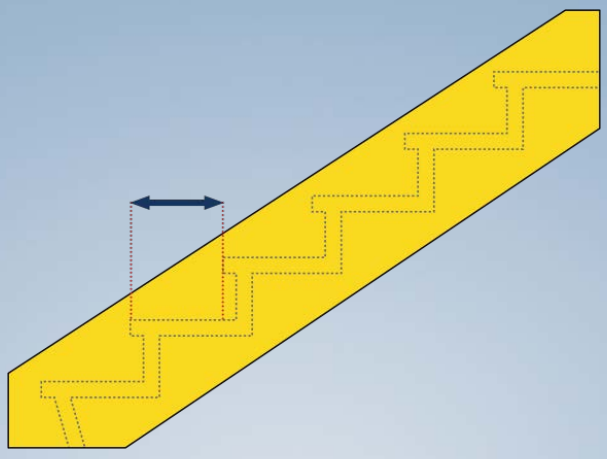


Minimum projected tread depths

		OSHA COMPLIANT	IBC COMPLIANT
	STANDARD STAIRS OSHA §1910.25(c)(3) IBC §10.11.15.2	9.5”	11”
NON-STANDARD STAIRS	**ALTERNATING TREAD STAIRS** OSHA §1910.25(f)(3) IBC §1011.14.2	8.5”	8.5”
NON-STANDARD STAIRS	**SHIP STAIRS** OSHA §1910.25(e)(3) IBC §1011.15.2	4”	5”

OSHA’s definition of tread depth

Tread depth is measured horizontally between the vertical planes of the foremost projection of adjacent treads and at a right angle to the treads leading edge



KEY TAKEAWAY

Steep-angle stairs ***require less floor space*** to install but also ***provide less usable tread depth*** to users

Design-induced risk factors of stairs

Risk factors related to tread depth

- ☒ Missteps become increasingly more frequent as tread depth decreases below 12”
- ☒ Inadequate tread depth provides insufficient foot support and causes postural instabilities

Risk factors related to tread design

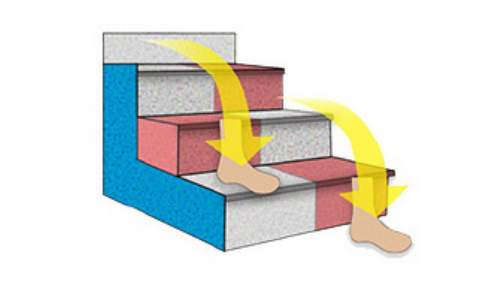
- ☒ Inconsistent dimensions of tread or rise cause missteps
- ☒ Inappropriate combinations of tread depth and riser height cause awkward walking mode and missteps
- ☒ Slippery and rough treads cause missteps
- ☒ Confusing color patterns on the tread
- ☒ Poor visibility of tread nosing
- ☒ Nosing strips that project above the tread

Additional design-induced risk factors

- ☒ One or two isolated steps without cues to their presence
- ☒ Lack of a graspable, reachable handrail
- ☒ Presence of a discontinuous handrail

SOURCE: Fall Prevention and Protection (Human Factors and Ergonomics)

STANDARD STAIRS VERSUS STEEP-ANGLE STAIRS



⇧ STANDARD STAIRS
Each foot uses about half of each tread, stepping out and over the unused section

⇧ SHIP STAIRS
The unused half tread becomes an obstacle by reducing the usable depth of the tread below

⇧ ALTERNATING TREAD STAIRS
The unused half tread is removed to provide more usable tread depth at steep angles

Risk factors of decreased tread depth

Missteps increase as tread depth decreases

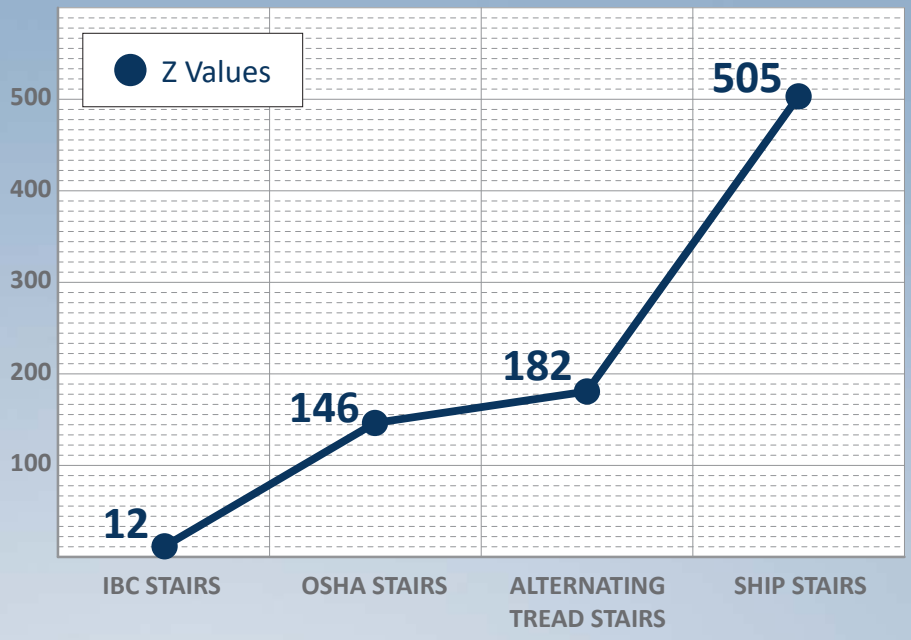
Ergonomic studies show that missteps and the likelihood of falls increase on stairs that have less usable tread depth:

- ✓ Missteps increase as tread depth decreases *Templer, 1975*
- ✓ Treads that are too short force the stair user to either rest only part of the foot on each tread or to twist the foot unnaturally; both of these cases increase the risk of a misstep *Jackson and Cohen, 1995*

Z-INDEX VALUE: PERCEIVED DIFFICULTY IN DESCENT BY STAIR TYPE

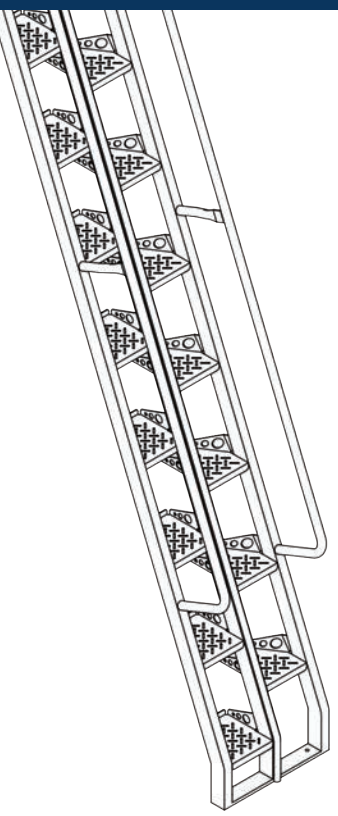
- ✓ The Z-Index Value was developed by Hisao Nagato of the Ohara Memorial Institute for Science of Labor in Japan to measure the "Perceived Difficulty in Descent" of a stairway
- ✓ **Stairs with a higher Z-Index value are more difficult for users to descend**

SOURCE:
Fall Prevention and Protection (Human Factors and Ergonomics)



✱ **KEY TAKEAWAY** Adequate tread depth = more stability and comfort

Virginia Tech conducted a study comparing alternating tread stairs to ship stairs and concluded that **alternating tread stairs have a clear comfort and safety advantage over ship stairs**



TEST SUBJECTS STRONGLY PREFERRED ALTERNATING TREAD STAIRS OVER SHIP STAIRS FOR SAFETY AND COMFORT:

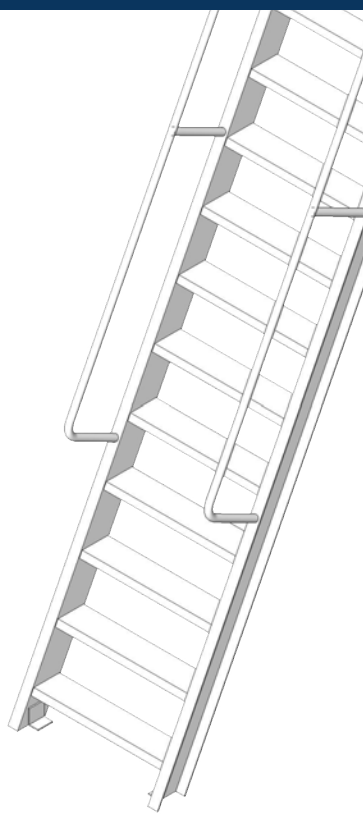
- **89%** PREFERRED FOR SAFER TREAD DEPTH
- **85%** PREFERRED FOR MORE COMFORTABLE TREAD DEPTH
- **72%** PREFERRED FOR SAFER ASCENT
- **89%** PREFERRED FOR MORE COMFORTABLE ASCENT
- **82%** PREFERRED FOR SAFER DESCENT
- **85%** PREFERRED FOR MORE COMFORTABLE DESCENT

MORE MISSTEPS WERE RECORDED ON SHIP STAIRS THAN ALTERNATING TREAD STAIRS

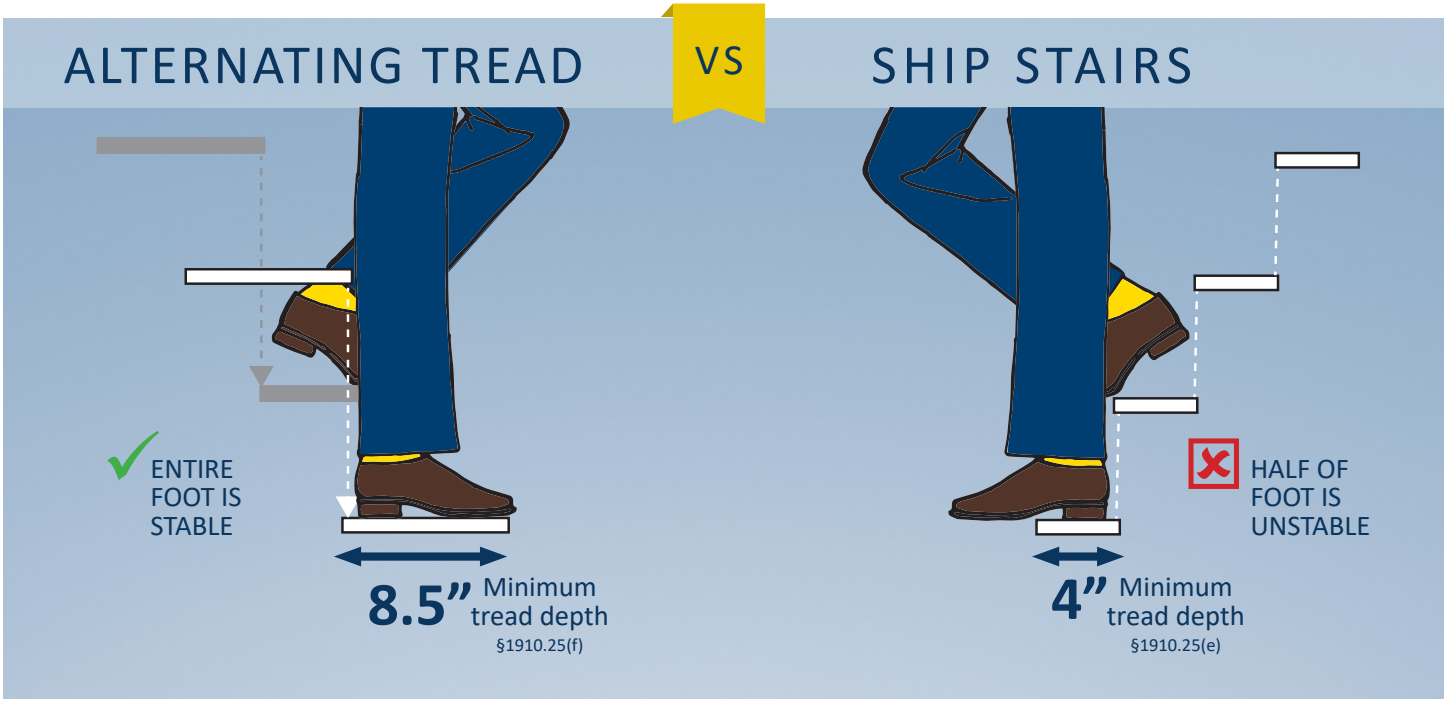
- **73%** MORE OVERALL MISSTEPS
- **129%** MORE MISSTEPS WHEN DESCENDING WITH A LOAD

TEST SUBJECTS FELT LESS SAFE AND LESS COMFORTABLE ON SHIP STAIRS THAN ALTERNATING TREAD STAIRS

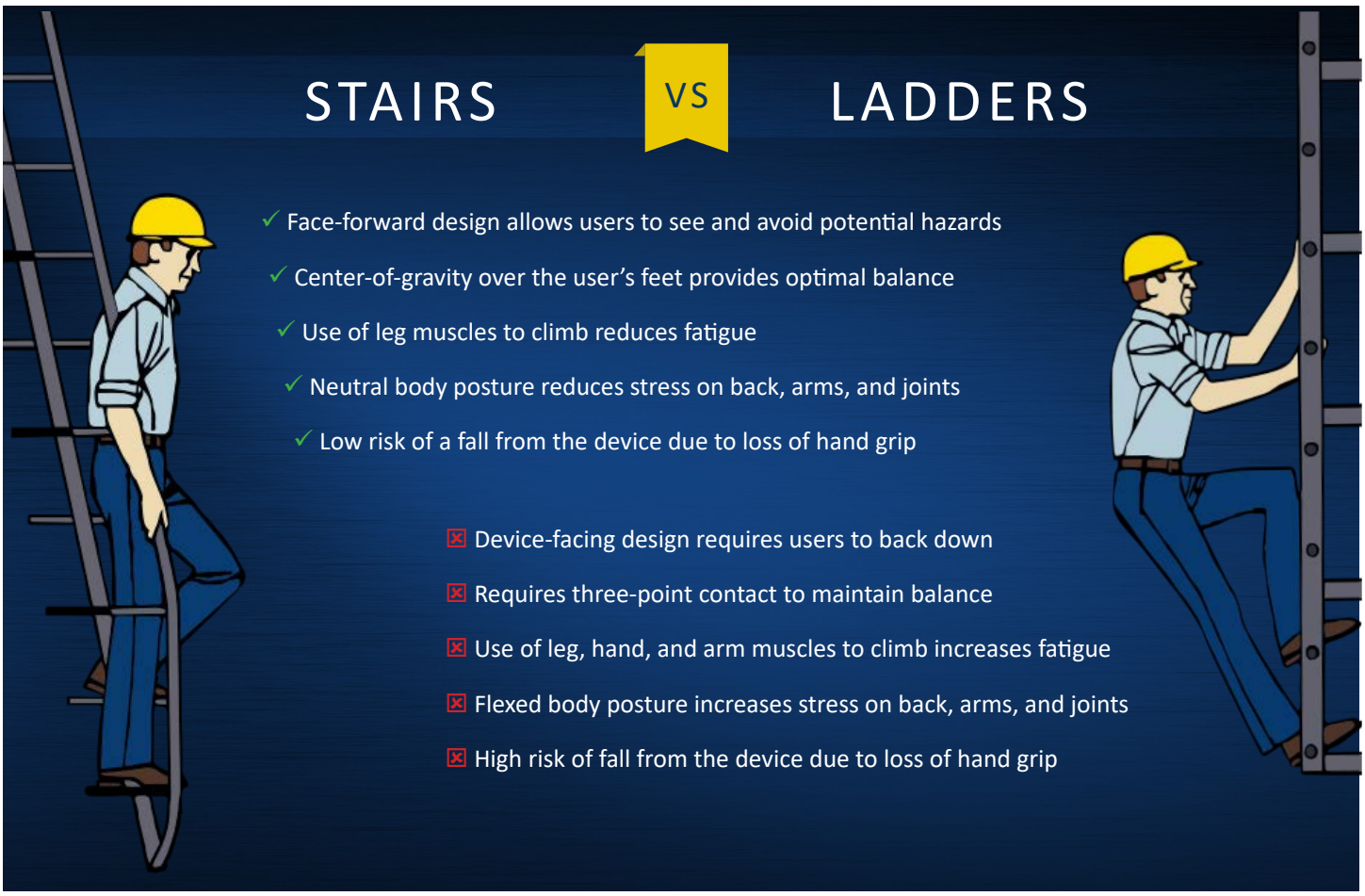
- **64%** FELT MORE LIKELY TO SLIP/TRIP ON ASCENT
- **85%** FELT MORE LIKELY TO SLIP/TRIP ON DESCENT



Findings from the conducted by the Department of Industrial Engineering at Virginia Polytechnic Institute and published in the proceedings of the Human Factors Society's 32nd Annual Meeting



PART THREE: ADDITIONAL SAFETY FACTORS



> **Lack of user-stability accounts for 55.2% of all cases of ladder-related falls** from self-supported ladders that are associated with the main ladder-use interactions and fall mechanisms (slip, trip, loss of balance, stuck by object, lost hand grip.) Fall Prevention and Protection (Human Factors and Ergonomics)

KEY TAKEAWAY

When adequate tread depth is present, face-forward descent on stairs provides safety and ergonomic benefits over backing down ladders

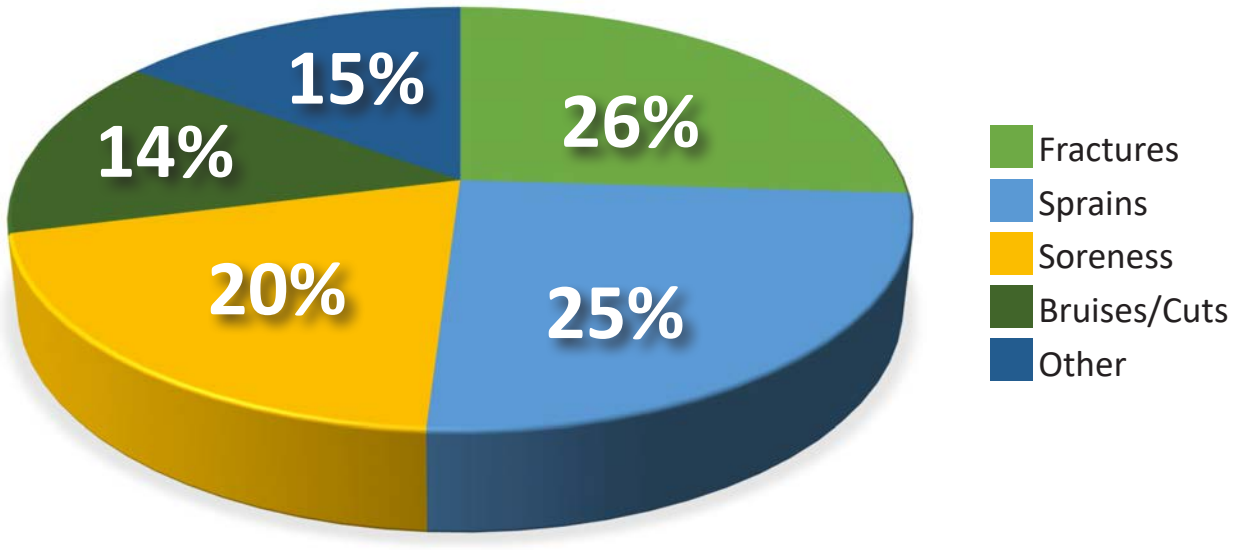
Falls from ladders

> Falls from ladders account for 20% of all fatal and lost work-day injuries in general industry
>
> *Bureau of Labor Statistics*

	STAIRS	VS	LADDERS
Average number of annual injuries	11,361		22,594
Average number of annual fatalities	25		149
Average annual cost of worker's comp claims	$490M		$1.1B
Total musculoskeletal injuries (2011-2016)	740		12,700
Median lost workdays for musculoskeletal injury	8		12
% of body weight placed on hand grip alone	5-10%		30-36%

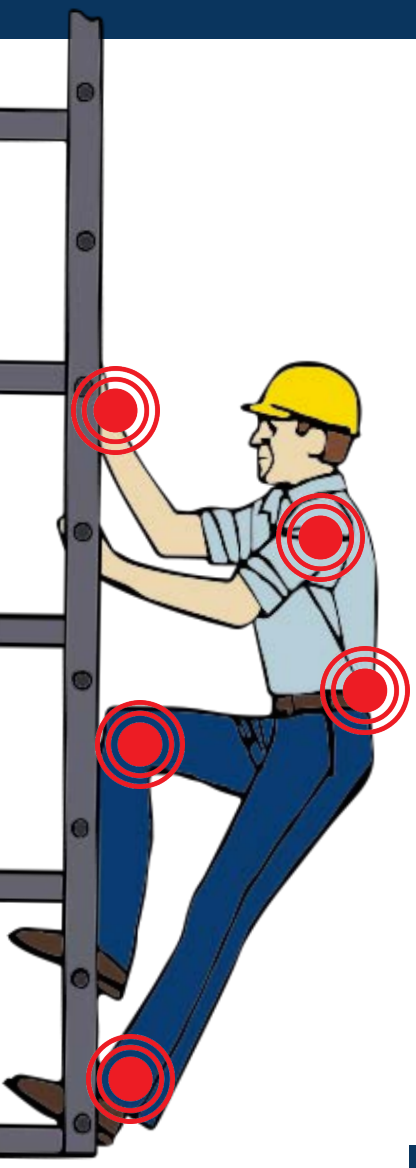
SOURCE: Bureau of Labor Statistics

Types of injuries due to falls from ladders



SOURCE: Bureau of Labor Statistics

MSDs and ladders



> The National Institute for Occupational Safety and Health (NIOSH) defines a **musculoskeletal disorder (MSD)** as a soft-tissue injury caused by **sudden** or **sustained exposure** to repetitive motion, force, vibration, and awkward positions.

1,680
Diagnosed MSDs due to ladders that resulted in lost workdays

38 Median days away from work

2,500
Lost work-day injuries caused by overexertion due to ladders

45 Median days away from work

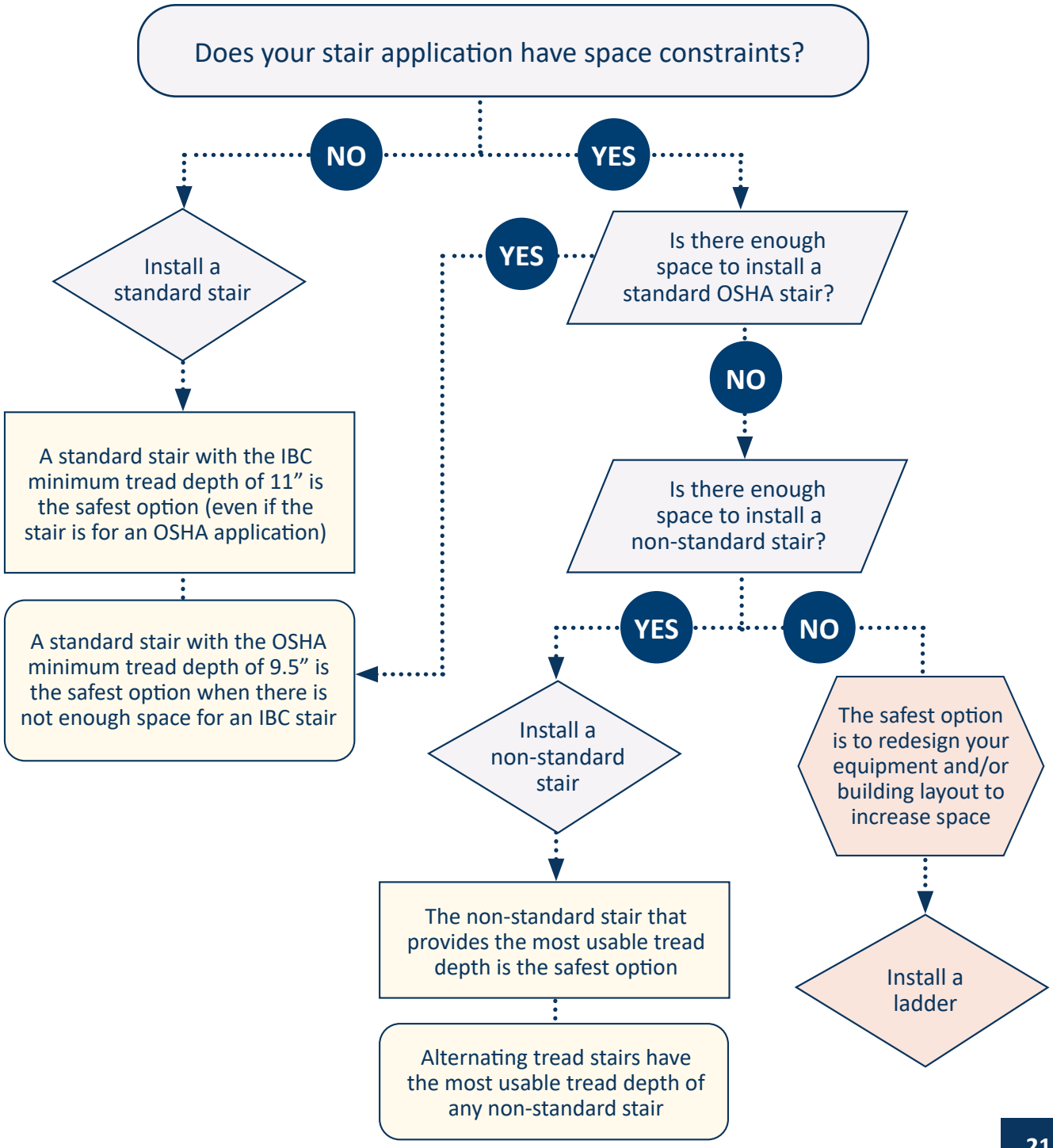
$90,000
Average cost of a MSD-related worker's compensation claim

100%
Percent of MSDs that could be prevented

SOURCE: Bureau of Labor Statistics, 2018 Workplace Injuries & Illnesses Database; Central for Disease Control

Stair design for safety and ergonomics

This flowchart was developed to help you make decisions about the stairs in your facility. Following these guidelines will ensure your stairs are designed to provide users with maximum safety and ergonomics.



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