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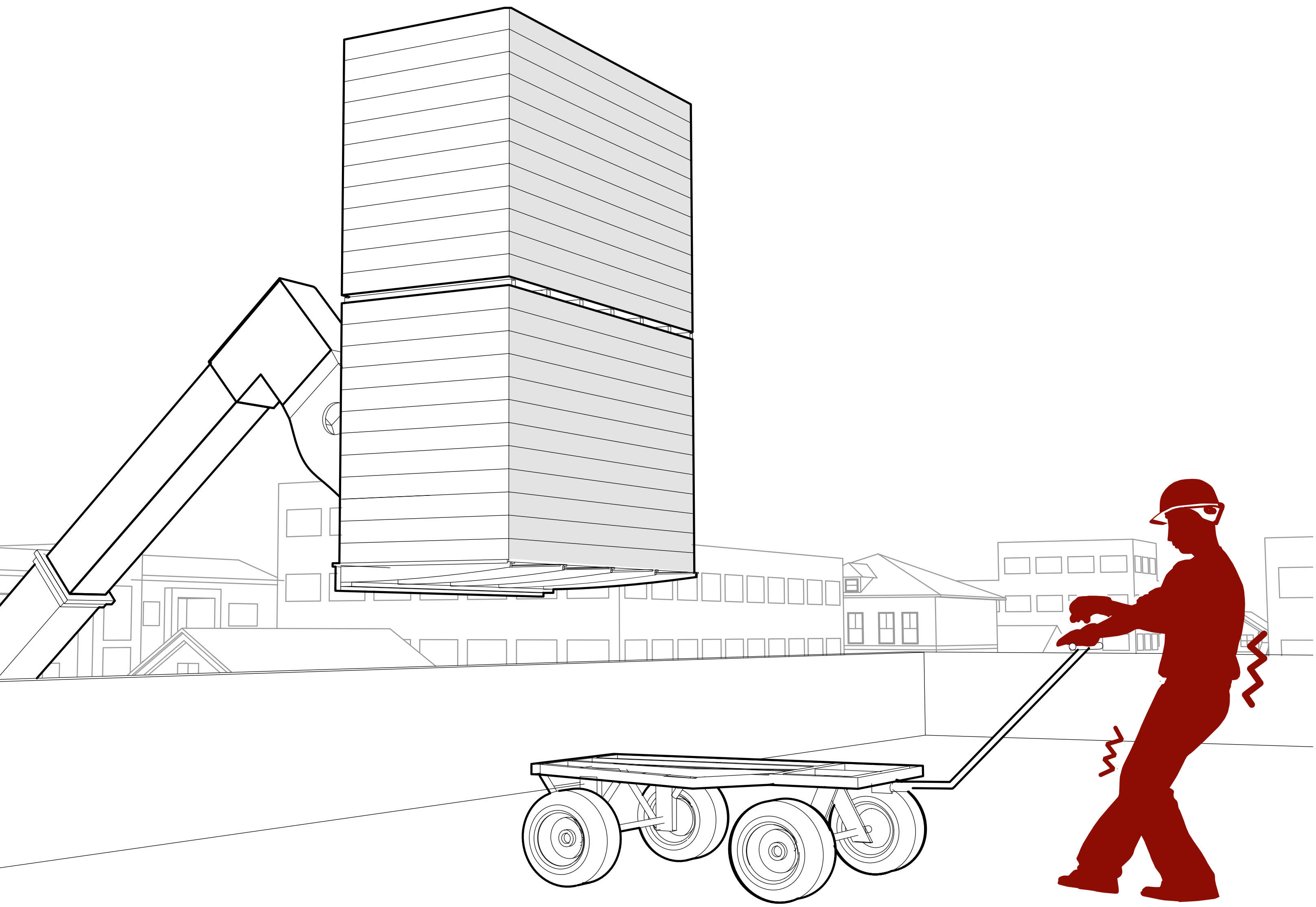
Ergonomic Guidelines

Using Four-Wheel Carts In The Roofing Trade



UNIVERSITY of WASHINGTON
SHARE Lab

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Ergonomic Guidelines

Using Four-Wheel Carts In The Roofing Trade

Safety & Health Investment Projects (SHIP) Grant Program
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SHARE Lab,
University of Washington

SHIP is a grant program under the Washington State Department of Labor & Industries. SHIP funds Safety & Health (S&H) ideas that prevent workplace injuries, illnesses, and fatalities, and projects for developing and implementing an effective and innovative Return-to-Work (RTW) program for injured workers.

Preface

About the SHARE Lab:

The Safety and Health Advancement through Research and Education (SHARE) Lab promotes construction safety and health through evidence-based innovation in research, education, and practices. The SHARE Lab creates new knowledge, learning resources, and practical solutions through industry partnerships and by using technology intervention such as wearable sensors, visualization, serious gaming and tablet computers.

We value the importance to convert research into practices. We embrace the interdisciplinary mindset and welcome collaboration. We have a strong passion for the safety, health and wellness of the construction workforce.

To learn more about what we do at the SHARE Lab, please visit:
https://share.be.uw.edu/

Disclaimers

The guidelines are developed by the SHARE Lab of the University of Washington under the supervision of Dr. Ken-Yu Lin, with funding from Safety and Health Investment Projects (SHIP) of the Washington State Department of Labor and Industries (Washington L&I). The sponsorship does not constitute Washington L&I's endorsement of the proposed guidelines. Washington L&I had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; or preparation, publication, and dissemination of the manuscripts. The opinions and recommendations in the guidelines are those of the SHARE Lab and do not necessarily reflect the official position and policy of Washington L&I.

While the SHARE Lab makes every effort to present accurate and reliable information, it makes no warranties, representations, or guarantees regarding the timeliness, quality, or reliability of information found in the guidelines. Neither the SHARE Lab nor its sponsor will be liable for any loss, damage, or claim with respect to any liabilities, including direct, special, indirect, or consequential damages, incurred in connection with the guidelines or reliance on the information presented. Safety and health information contained in the guidelines is not intended to provide specific medical advice, but rather to provide users with a general understanding of the health problems that can result from exposures to various workplace hazards and types of preventive measures.

These guidelines are not to be construed as standards. The guidelines are intended only as educational tools to provide information that may assist safety professionals in developing ergonomic solutions. Users are responsible for making their own assessments of workplace hazards and for adapting information found in the guidelines to their specific circumstances. Safety decisions in any particular case involve comprehensive analysis of the hazard. Therefore, practical safety measures may vary from the guidelines.

Acknowledgment

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- Josh Mullen, Chief Executive Officer, Snyder Roofing & Sheet Metal, Inc.
- John Nolan, President, Snyder Roofing of Washington
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The Share Lab would like to recognize the following University of Washington student researchers for their contribution to the guidelines:

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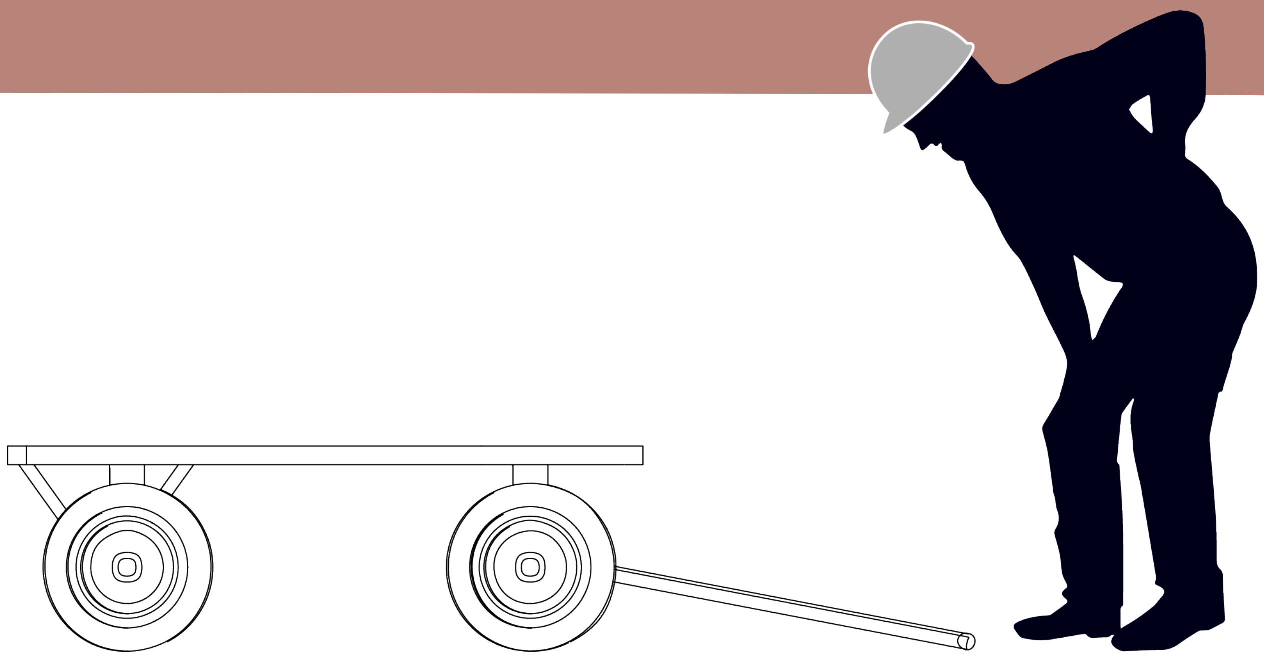
Overexertion in Cart Operation

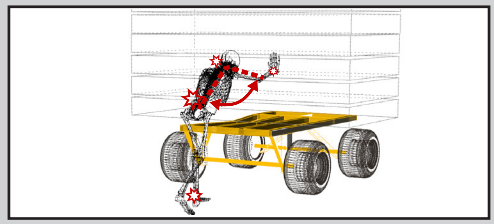


1 Overexertion in Cart Operation

Manual carts are being used every day in the roofing trade to transport materials.

However, cart handling is a physically demanding task and could cause overexertion when pulling and pushing, a leading cause of work-related musculoskeletal disorders (WMSDs).

In the U.S. construction industry, overexertion from pulling and pushing accounts for about 11.2% of the lost workdays caused by WMSDs.



1. How can overexertion caused by cart handling impact your company?

A review of injury logs from a commercial roofing contractor (with more than 120 employees) found that overexertion caused by cart handling created:

- **Substantial economic burden**
  Cart handling has directly caused 7 out of 40 total WMSDs over 4 years (2015-2018). These injuries imposed an economic burden of $65,405 medical and indemnity cost. The average lost time and average cost per claim are 21.2 days and $9,430, respectively.
- **High employee turnover**
  71% of overexertion in cart handling happened to new workers, where 57% of them left the company after the injury. This challenged the company's ability to build and retain a young workforce.
- **Low employee morale**
  Workers perceived cart operations as strenuous, and attributed low morale and reduced productivity to the malfunction of carts.

2. How can the guidelines help you prevent overexertion when handling carts?

The guidelines provide a series of recommendations to help you incorporate ergonomic principles into the process of cart handling:

- **When to replace aged carts**
- **Which tire to select to prevent injury and improve performance**
- **How to set up a good workspace for cart handling**
- **How to pre-plan cart handling tasks with proper team pulling/pushing and job rotation**

The guidelines also illustrate the benefits you can expect from adopting these recommendations. When you develop intervention programs to improve the practice of cart handling, the information on benefits will help you justify your suggestions and win support from senior managers and workers.

3. How did we develop the guidelines?

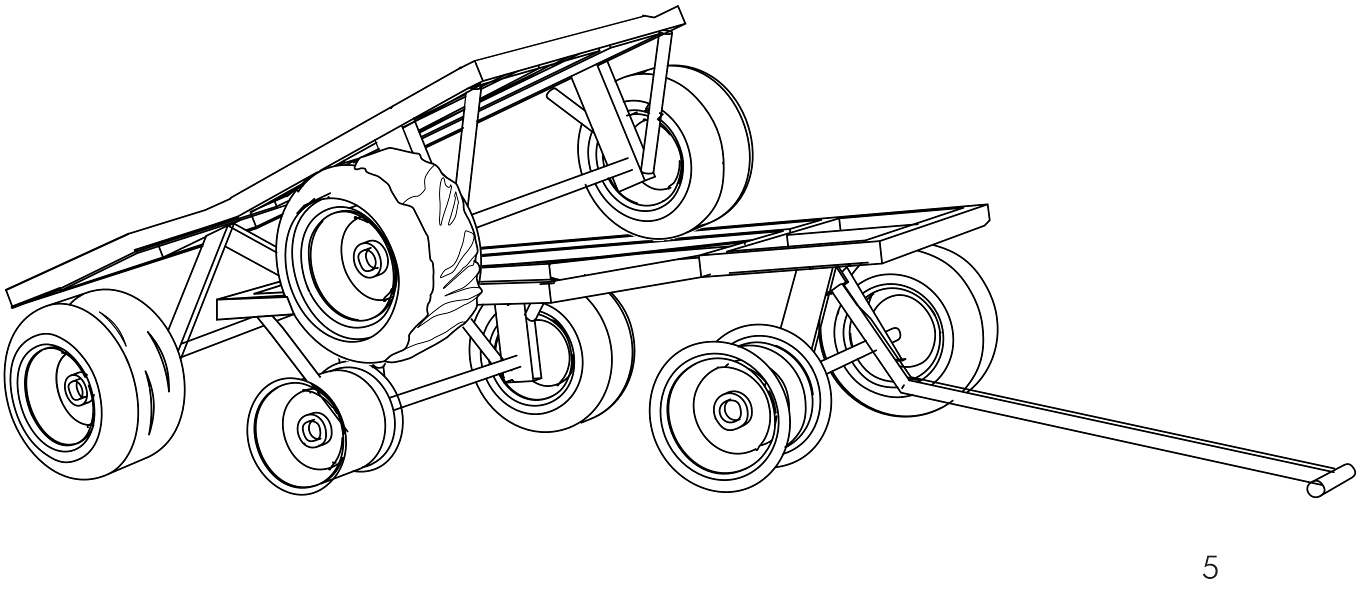
All data displayed in the guidelines are supported by laboratory research. The authors of the guidelines measured force and duration required to operate four-wheel carts under the various working conditions that are common on commercial roofing sites. Such setting allowed the authors to determine when a risk factor becomes harmful and to what extent it has to be addressed.

The laboratory experiments

The guidelines use the metric "strength percentage" to measure and describe the risk of overexertion injury. Because cart operations are typically performed by male workers in the roofing trade, the strength percentage refers to the proportion of the male population that can be expected to do a specific task "without straining themselves or becoming unusually tired, weakened, overheated, or out of breath." For example, a 60% strength percentage means that a task will be acceptable to 6 out of 10 males. In other words, 4 out of 10 males are susceptible to getting hurt when performing this task.

2

Cart Condition and Maintenance

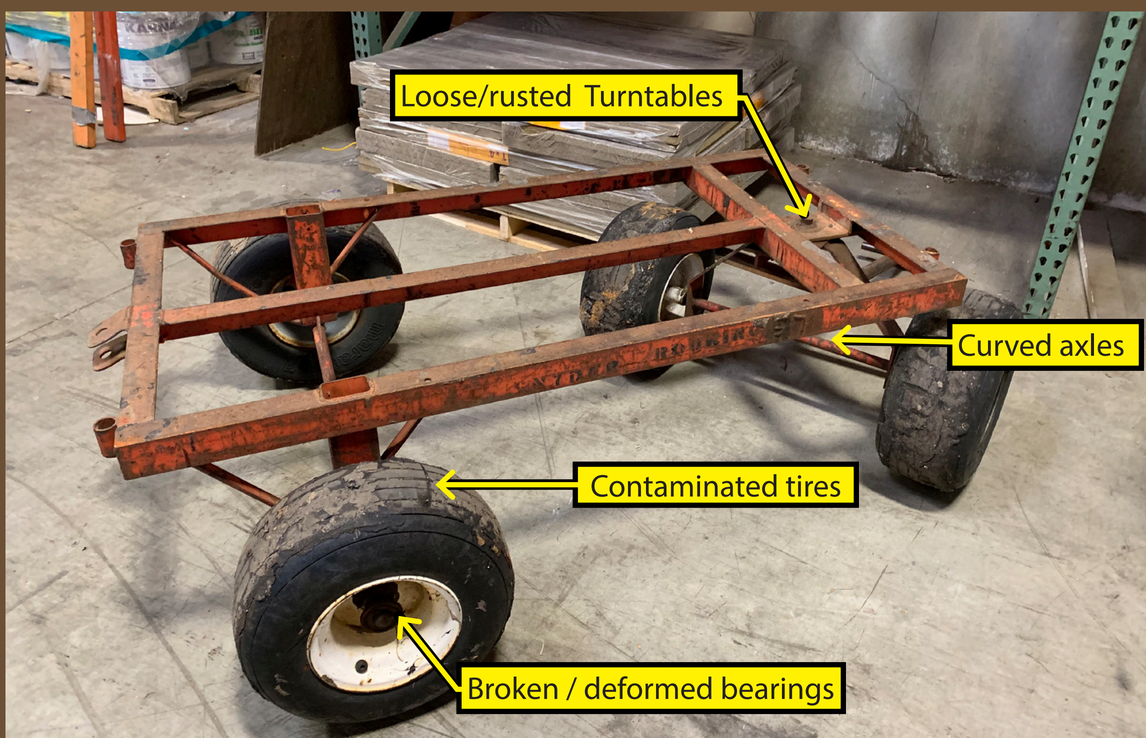


2.1 Cart Condition

Roofers rely on carts to handle heavy materials, but aged equipment will do more harm than good. The use of aged carts not only increases the risk of overexertion, but it also negatively impacts employee morale. Preventative replacement is necessary and can bring long-term benefits.

1. What could happen if you use carts that have outlived their life expectancy?

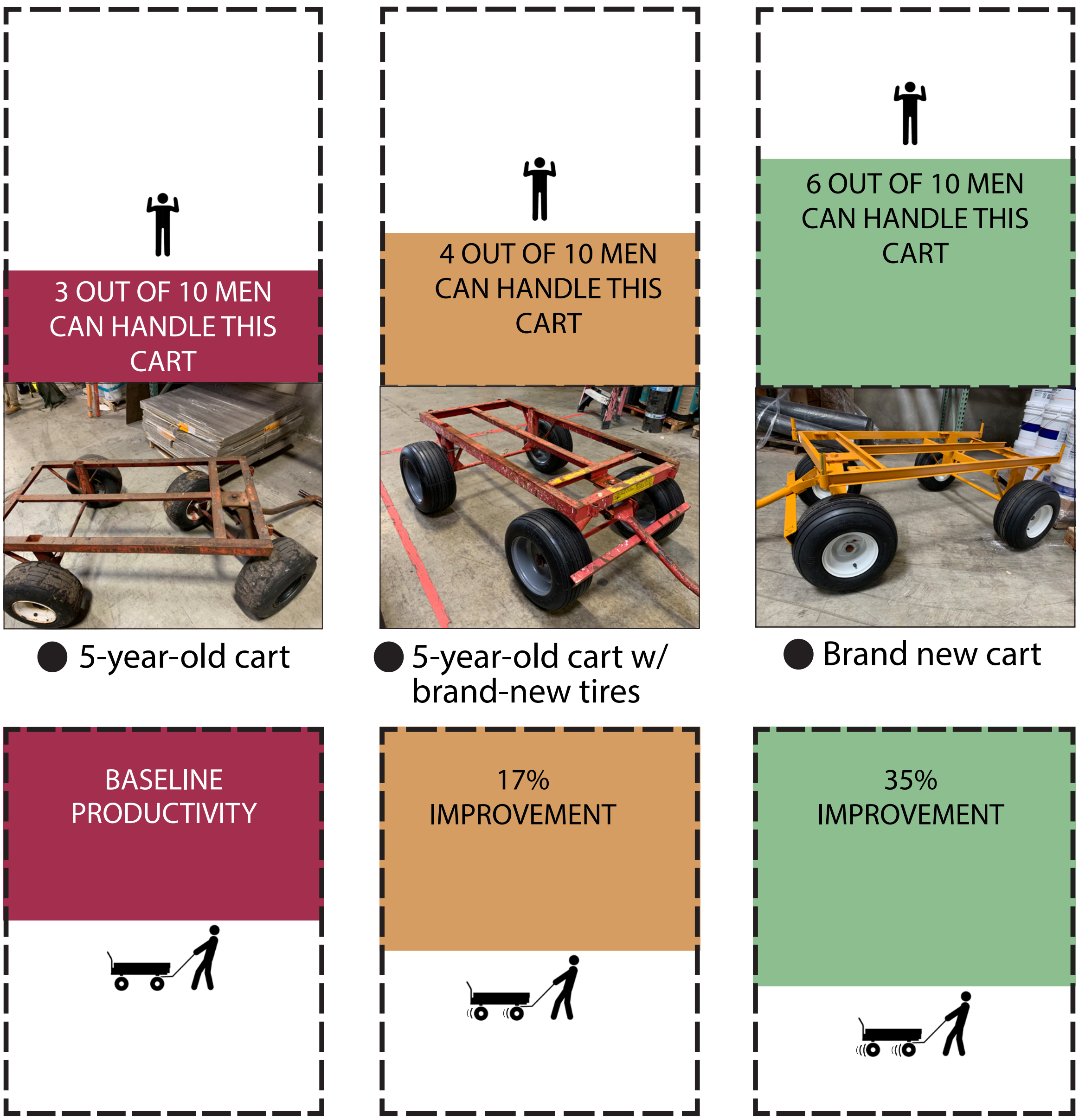
As a heavy-duty equipment, material carts can deteriorate fairly quickly and develop various structural problems.



Tip:

See the Appendix for a checklist that you can use for the cart condition inspection.

Loose rusted turntables, bent axles, contaminated tires, and broken/deformed bearings usually emerge after a cart is in service for 5 years and will adversely impact performance. The following diagram compares ergonomic and productivity performance of carts in three different conditions: 5-year-old carts with all problems mentioned above, 5-year-old carts with brand-new tires and brand new carts.



The results are based on experiments measuring mean hand forces when four-wheel carts loaded with 500, 750, and 1,000 lbs were operated by one person over 18 feet of a concrete flat floor. The strength percent capable was obtained through synchronizing postural data (pulling at thigh height), force data, and working circumstances(150 feet pulling distance and one pull every 5 minutes) in the SNOOK table. All differences shown here are statistically significant at the level of 0.05.

Warning:

Purchasing a brand new cart cannot fix all problems because of other ergonomic hazards which can cause overexertion during cart handling. For example, workers may ***overload*** a cart or use it for an ***extended period of time.*** There are also many physical hazards, such as ***space constraints***, ***ramps***, and ***obstacles***. Please refer to following chapters for ways to address these hazards and create an ergonomic workplace for cart handling.

2. When is it the right time to replace aged carts?

The general rule of thumb is to replace carts every 5 years. Alternatively, carts can be replaced whenever a number of structural problems arise, including:

- Contaminated tires
- Broken bearings
- Deformed bearings
- Curved axles
- Loose/Rusted turntables

Cart degradation does not manifest in the first year of service but will become a safety concern after 5 years. Operating aged carts is unacceptable to 7 in 10 of the male population and reduces productivity by as much as 35%. Replacing old tires for a 5-year-old cart can improve safety and productivity to a limited extent.

3. What is the return on investment you can expect from preventative replacement?

Are you wondering whether preventative replacement is worth the investment? We provide you with an example return on investment to answer your question. The following data is collected from a commercial roofing company who deploys 14 four-wheel carts in its routine production:

Cost Items	Continue using aged carts	Tire replacement (every 5 years)	Cart replacement (every 5 years)
Cost to purchase (annualized)	$0	$1,478	$3,284
Cost to maintain (annualized)	$2,100	$1,050	$350
Labor cost (annualized)	$21,714	$18,023	$14,114
Injury cost (annualized)	$16,351	$14,716	$11,446
Total estimated annual costs	$40,165	$35,267	$29,194
Estimated return on investment over 5 years	Baseline	$24,491	$54,854
Notes	• *$2,100 = 6 hours per cart x 14 carts x $25 hourly rate* • *$21,714 = 258.5 hours of cart use x 10% on pulling/pushing x 14 carts x 2 workers x $30 hourly wage* • *$16,351 = injury cost attributable to cart handling*	• *$1,478 = $132 EA x 56 tires / 5 years* • *$1,050 = 3 hours per cart x 14 carts x $25 hourly rate* • *$18,023 = $21,714 x (1 - 17%), save 17% labor time after tire replacement* • *$14,716 = $16,351 x (1 - 10%), reduce 10% injury rate after tire replacement*	• *$3,284 = $1,173 EA x 14 carts / 5 years* • *$350 = 1 hour per cart x 14 carts x $25 hourly rate* • *$15,851 = $21,714 x (1 - 35%), save 35% labor time after cart replacement* • *$11,446 = = $16,351 x (1 - 30%), reduce 30% injury rate after cart replacement*

The results show that cart replacement is the most cost effective option and can save $54,854 every 5 years than continuing to use aged carts. You can adjust some parameters (e.g. number of carts) to your particular situation and obtain your own return on investment.

Tip:

Keep in mind of the other benefits that are not easily measurable but no less important including:

- **Increased employee satisfaction:** Workers feel that their company cares about them and provide them with what they need to be safe and successful.
- **Higher employee retention:** Workers tend to stick around longer when they are satisfied with their company. This can save employers a lot of money on turnover.
- **Increased employee productivity:** When calculating savings in productivity, we only consider that which is related to the improvement of cart performance. You should also be aware that a worker's overall productivity will be improved as it is closely linked to their satisfaction with the company.

2.2 Tire Selection

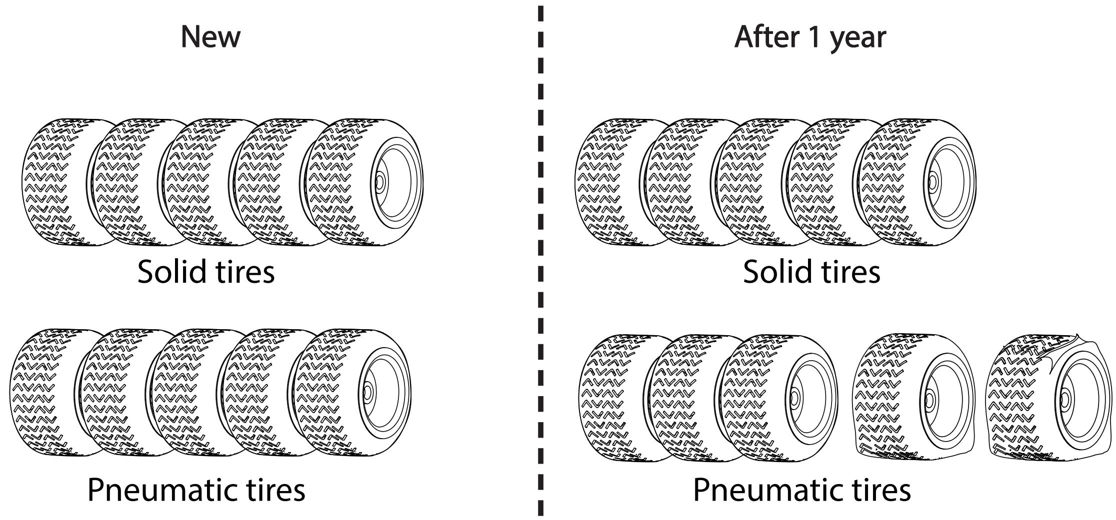
Solid (polyurethane foam-filled rubber) tires are recommended as the replacement for pneumatic (air-filled rubber) tires. Solid tires are more cost effective because of their never-getting-flat and maintenance-free nature.

1. What differences exist between the two tire types?

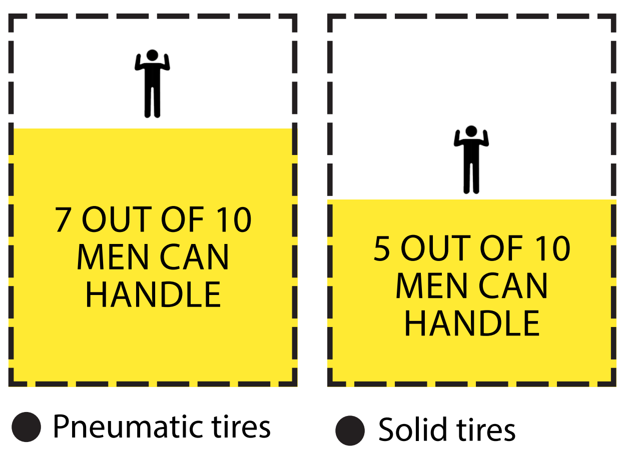
Solid tires have recently been introduced in the construction industry. Unlike pneumatic tires that are filled by air, solid tires are made of solid, micro-cellular polyurethane foam. Solid tires have the benefits of never-getting-flat and maintenance-free. However, solid tires have the drawbacks of being heavier (about 5.25 kg) and more expensive (about $132 each vs. $66 for a pneumatic tire).

OR?

Based on a trial tracking on the routine use of 20 pneumatic tires, 8 (40%) deflated in 12 months with 4 (20%) being irreparable.



The following diagram compares the ergonomic performance of two tire types. The additional weight of solid tires may not sound like much, but they do make a difference. Solid tires make the task of cart handling unacceptable to 5 in 10 of the male population, compared to 3 in 10 for pneumatic tires.



The results are based on an experiment measuring mean hand force when a brand-new four-wheel roofing cart equipped with each type of tires and loaded with 500, 750, and 1,000 lbs was operated by one person over 18 feet of a concrete flat floor. The strength percent capable was obtained through synchronizing postural data (pulling at thigh height), force data, and working circumstances (150 feet pulling distance and one pull every 5 minutes) in the SNOOK table. All differences shown here are statistically significant at the level of 0.05.

2. What is the return on investment you can expect from purchasing solid tires?

Are you wondering whether the benefits behind a solid tire can outweigh its weakness in ergonomic performance? We provide you with an example return on investment. It turns out that solid tires are more cost effective and can save $31,117 every 5 years when compared to pneumatic tires. You can adjust some parameters to your particular situation and obtain your own return on investment.

Options	pneumatic (air-filled rubber) tires	Solid (polyurethane foam-filled rubber) tires
Cost to purchase (annualized)	$887	$1,478
Cost to maintain (annualized)	$2,240	$0
Downtime cost (annualized)	$8,064 (Down time cost $8,064)	$0
Injury cost (annualized)	$16,351	$19,622
Total estimated annual costs	$27,542	$21,100
Estimated return on investment over 5 years	Baseline	$32,212
Notes	• *$887 = $66 EA x 56 tires x (1 + 20%) / 5 years, 20% tires occur irreparable damage* • *$2,240 = 40% flat-tire x 56 tires x 4 hours per tire including transportation and repair time x $25 hour rate* • *$8,064 = 40% flat-tire x 56 tires x 3 days downtime x 2 hours/day extra time for material handling x 2 workers x $30 hour rate* • *$16,351 = injury cost attributable to cart handling*	• *$1,478 = $132 EA x 56 tires / 5 years* • *$19,622 = $16,351 x (1 + 20%), injury rate increases 20% by using solid tires*

Warning:

Injury rates increased by solid tires can be largely reduced by performing team pulling/pushing. Please refer to Chapter 4 for details.

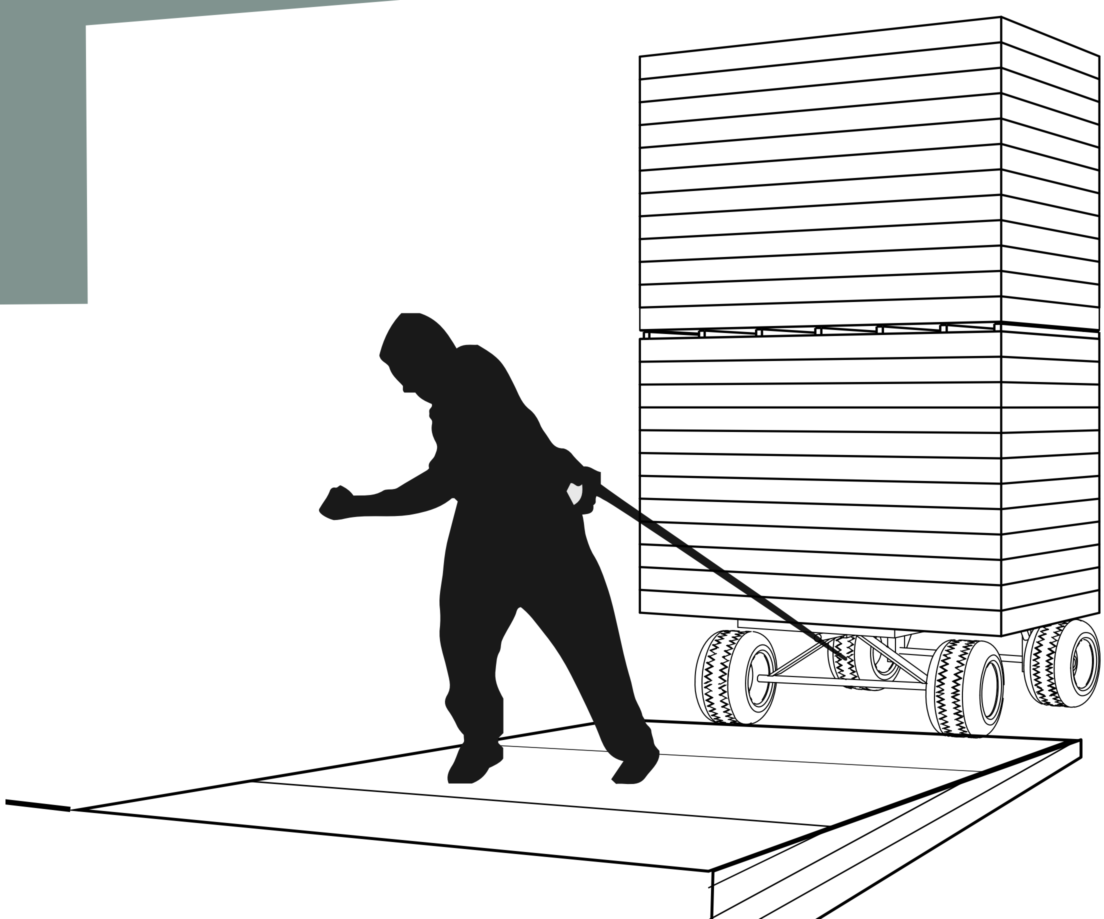
3. Which type of tire should you use?

In general, we recommend that you purchase solid tires and then use other measures illustrated in the following chapters to make up for their shortcomings in injury prevention.

Flat tires often occur during tear-off (caused by nails in old roofs). If your company works more often on new construction and always maintains good housekeeping, you might prefer to use pneumatic tires. Still you must make certain that the pneumatic tires are inflated to the recommended pressure, or their advantage of allowing for ease of pulling could easily fall short.

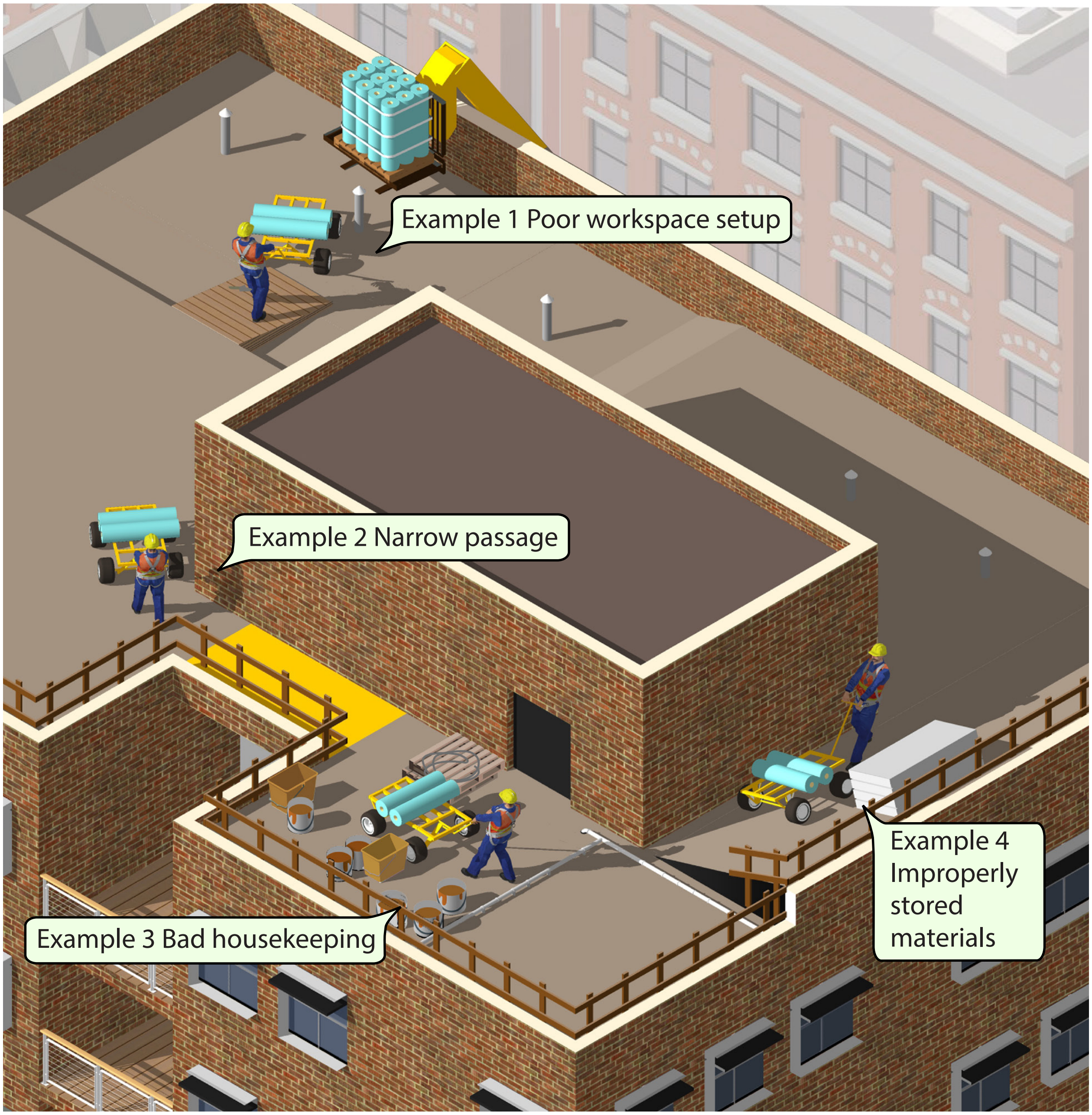
3

Workspace Setup



3.1. Space Constraint

Space constraints, or tight spaces, are common on a commercial roofing site. They come from physical restrictions of the site or are a by-product of bad workspace setups. Be cautious when pulling a cart in tight spaces as they require a higher degree of cart control precision and will increase the risk of overexertion. Here are some examples of space constraints.



EXAMPLE 1 Poor workspace setup

A temporary ramp is placed in front of a penetration, which creates a limited landing area for moving a cart onto the ramp. The landing is uneven and poorly set up. The worker has to overcome the uneven surface from the limited space and then to pull along the ramp. This significantly increases the risk of overexertion.

EXAMPLE 2 Narrow passage

Workers have to apply a greater force to position a cart into the narrow passage. The extra force could be adding 12% more pressure on the worker's lower back and shoulder.

Additionally, when moving a cart across the narrow passage, extra force is needed to minimize lane deviation.

EXAMPLE 3 Bad housekeeping

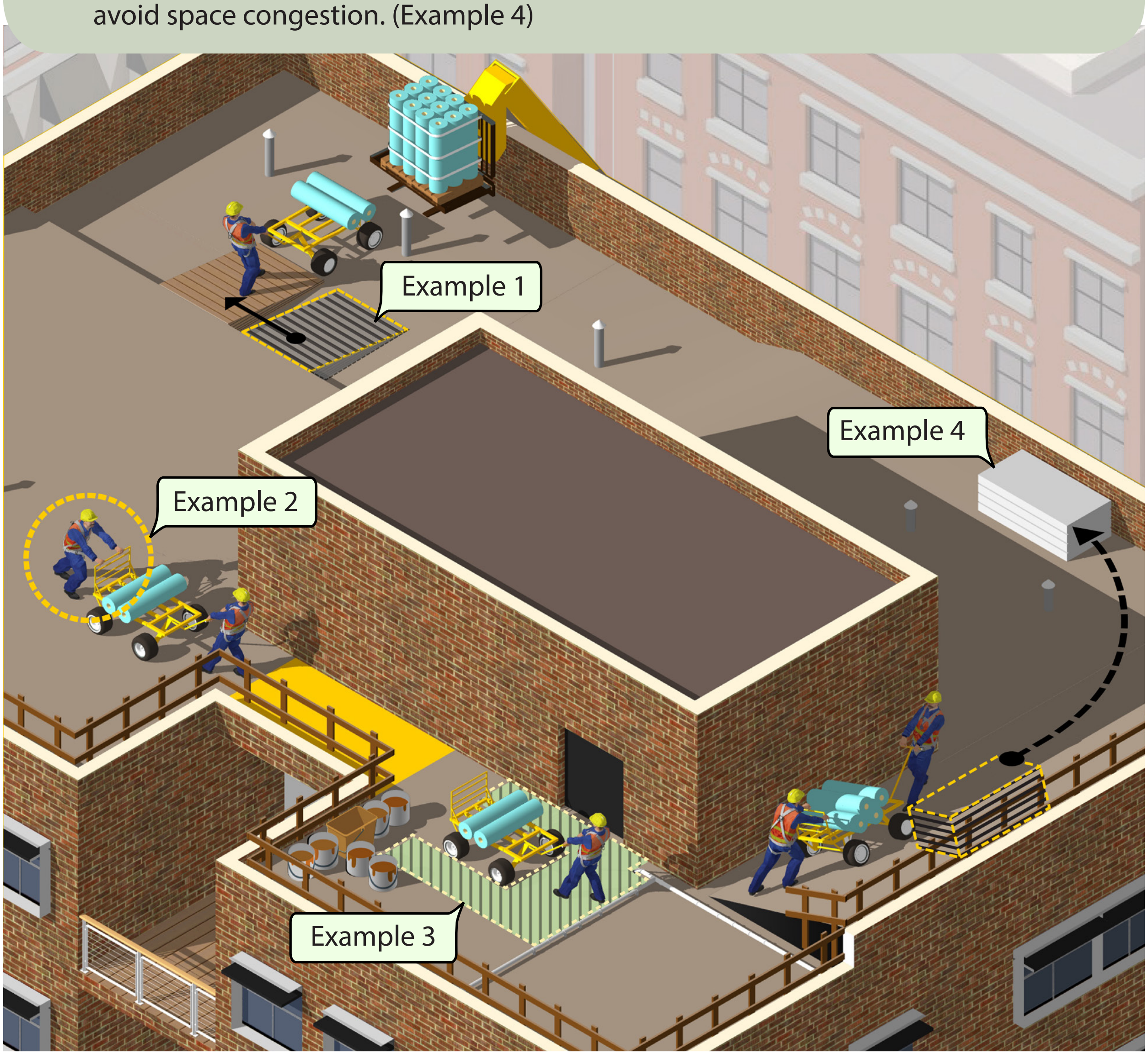
Construction debris sits along the path, forcing workers to pull the cart through a tight space. Overcoming and pulling over an obstacle in an open area is relatively easy. An open space allows operators to build enough cart momentum and sustain relatively constant velocity before contacting the obstacle. In contrast, cart speed is relatively lower in a tight space like the example shown here. Operators cannot depend on cart momentum and thus need to apply a much larger force to not only get over the obstacle but also initiate the cart movement. In this case, even a small obstacle will make a big impact.

EXAMPLE 4 Improperly stored materials

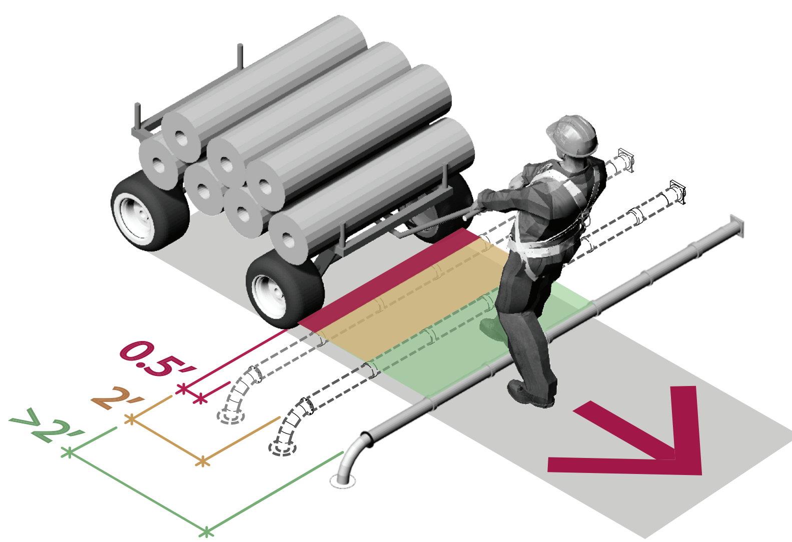
Bundled materials are improperly placed in the path of cart movement which creates a very narrow passage for cart operation.

1. How to reduce space constraints?

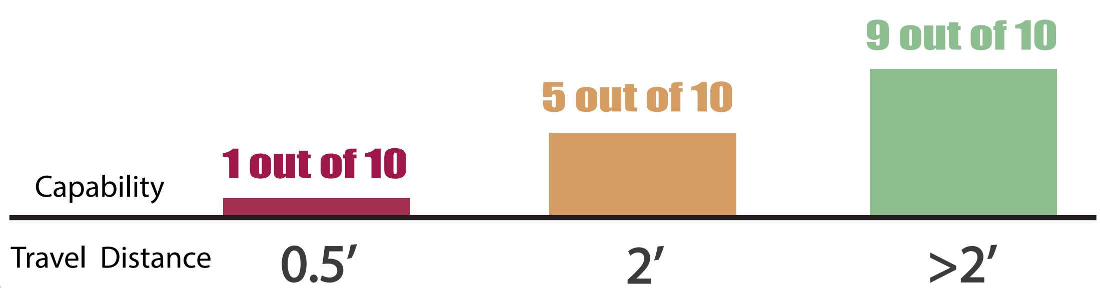
- Position the ramp at a better place to eliminate space constraints. Build a smooth landing for the ramp to ensure the path of travel is free of obstacles. (Example 1)
- Team pulling/pushing is needed when the space constraint is inevitable. Also ensure good housekeeping so the path of travel is free of obstacles. (Example 2)
- When an obstacle cannot be removed, keep an open and clean workstation so that workers can start by moving the cart at least 2 feet away from the obstacle. Always consider setting up a ramp to bridge an obstacle. (Example 3)
- A two feet clearance is needed on both sides of hallways or passages through which carts will be operated. Do not store materials in hallways or passages to avoid space congestion. (Example 4)



It takes more than two feet to get a cart moving, and significant pulling force is required during this time. This initial force is three times more than the forces required to sustain the cart movement. A tight space won't allow a cart to move fully, so operators must continually apply the initial force which increases the risk of overexertion.
Keeping an open space is extremely important when operators need to pull over obstacles. As shown in the diagram below, starting by moving the cart at least two feet away can reduce injury rate by five to nine times. This is because the open space allows operators to move the cart fully and build momentum to overcome the obstacle.



How many males can safely handle this task provided the different open space?

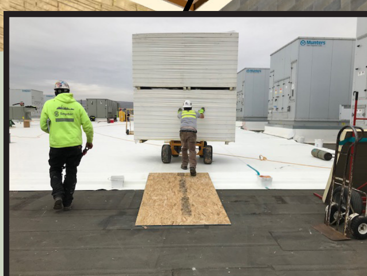


The results are based on an experiment in which peak/mean hand forces were measured when a brand-new four-wheel roofing cart loaded with 500 lbs was pulled by one operator to overcome a 1.5" plywood obstacle from travel distances of 0.5', 2' and 11'. All differences shown here are statistically significant at the level of 0.05. The strength percent capable was obtained through synchronizing postural and force data in the software 3DSSPP. Further analysis indicates that operators are exposed to a similar level of injury risk when travel distances are more than 2' (including 11').

3.2. Ramps

Ramps provide an aid for raising or lowering material carts, but they will cause safety problems when not set up properly. Building a stable ramp with a gentle slope is the key to keep cart handling safe and productive.

Protecting conduits



Bridging gaps between two levels of roof

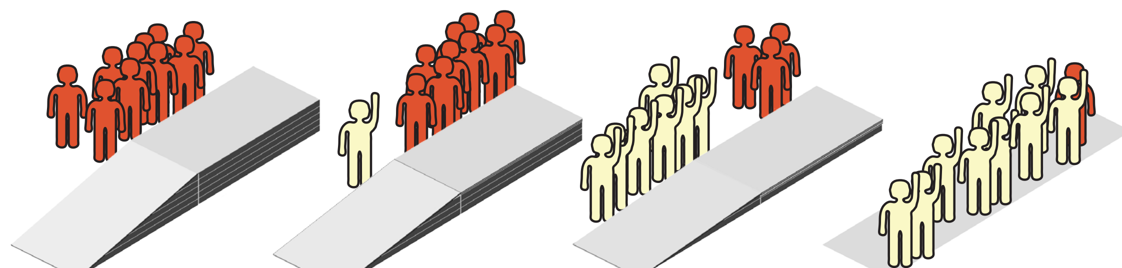
Making a transition between two flooring surfaces

1. How can I tell if a ramp is harmful?

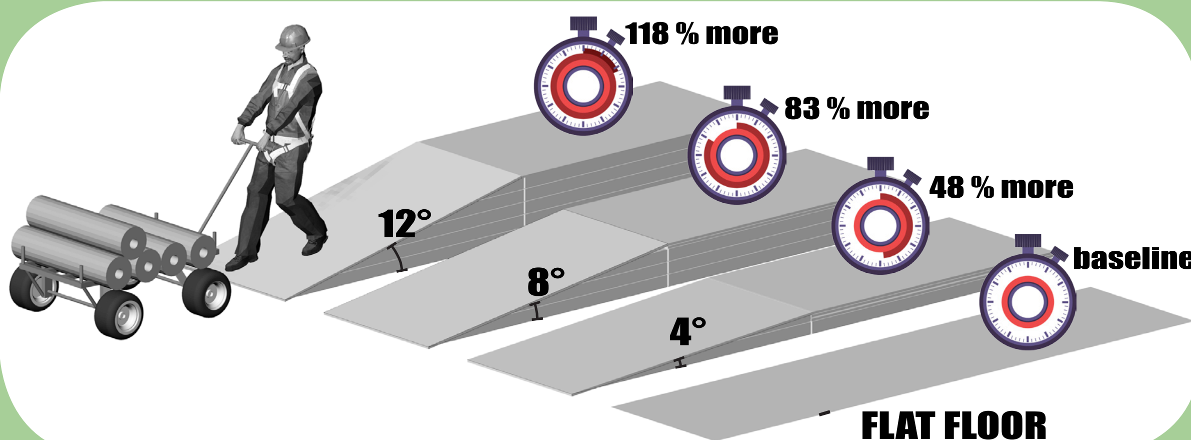
The recommended slope is 4 degrees.

Moving a cart over a 4-degree ramp is unacceptable for 3 in 10 of the male population and presents little additional risk compared to a flat surface. However, a ramp soon becomes a hazard when it reaches 8 degrees or higher.

How many can safely pull a 500 lbs cart up different inclines?



The time required to overcome the ramp also surges by 23% - 47% as the slope increases. This means that workers need to apply a greater hand force for a longer time when overcoming a steeper ramp. This will greatly increase the workers' chance of getting injured.



The results are based on an experiment measuring hand forces when a brand-new four-wheel roofing cart loaded with 500 lbs was operated over 4, 8 and 12 degree plywood ramps. All differences shown here are statistically significant at the level of 0.05. The strength percent capable was obtained using the SNOOK Table, and the results indicate the percentage of the male population who can safely handle the load weight when pulling at thigh height over 7' every 5 minutes.

Ramps should be stable with a smooth running slope and landings.

Poorly set up ramps often come with gaps, obstacles, and ridges that are harmful. This is because workers cannot depend on the cart momentum to overcome these hazards while moving a cart over the ramp. In the following examples, a worker's chance of injury increases from 10% to 90% because of these "small" problems.

This ramp was built with loose insulation boards. When a worker stood on the ramp, gaps were created between the two boards and between the running slope and the top landing.

Uneven running slope

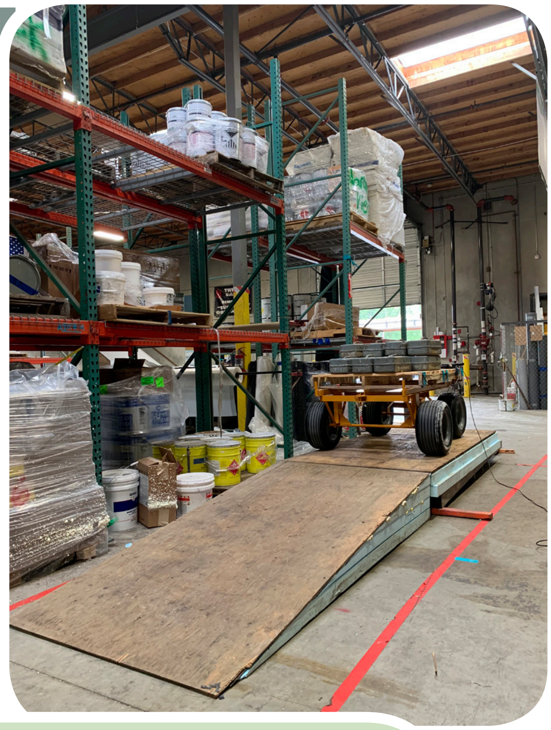
Uneven bottom landing

2. How can I build a ramp?

Here are some solutions you should consider:

- **Plan ahead** before building a ramp.
- **Secure boards** the day before to stabilize the ramp.
- **Use heavy sheets** to bridge gaps and make a smooth surface.

These small changes will bring big results.



Don’t build steep ramps

Extend ramp lengths or lower ramp rises to make certain the slopes are less than **4 degrees**.

3. What if a ramp is steeper than 4 degrees?

Some construction sites might not allow for a gentle slope, because there is no room for extended ramp lengths, or ramp rises are a part of the building structure and non-removable.. In these cases, team pulling/pushing or a lower cartload is recommended. See Chapter 4 for detailed recommendations.

3.3. Obstacles

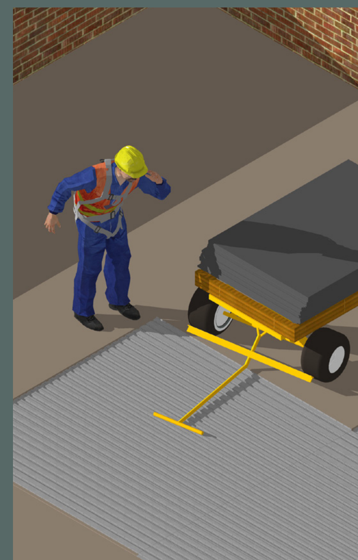
Obstacles are common on a construction site. Moving a cart over an obstacle will increase the risk of overexertion. It is important to make certain that the path of cart movement is free of obstacles.

Old roofs become obstacles during tear-off

Parapet wall

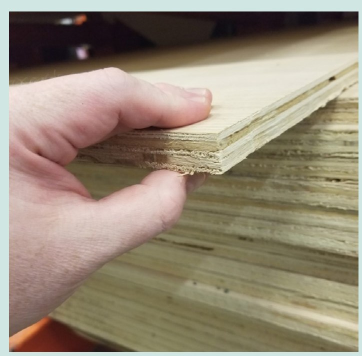
Gas hose (Other conduits, electrical cords, or pipelines can also become obstacles.)

Gaps between different floor surfaces when installing roofing sheets



1. How to tell if an obstacle is dangerous?

Reduce any obstacle higher than 0.75 inches (the thickness of one piece of plywood shown in the image on the right).



The larger an obstacle is, the riskier it becomes. In an open space, an obstacle under 0.75″ will barely increase the chance of a worker getting an overexertion injury compared to pulling over a flat surface.

2. How to reduce obstacles?

Eliminate obstacles whenever possible:

- Use tapes/strips to secure the boards and avoid board movement

- Cut parapet walls

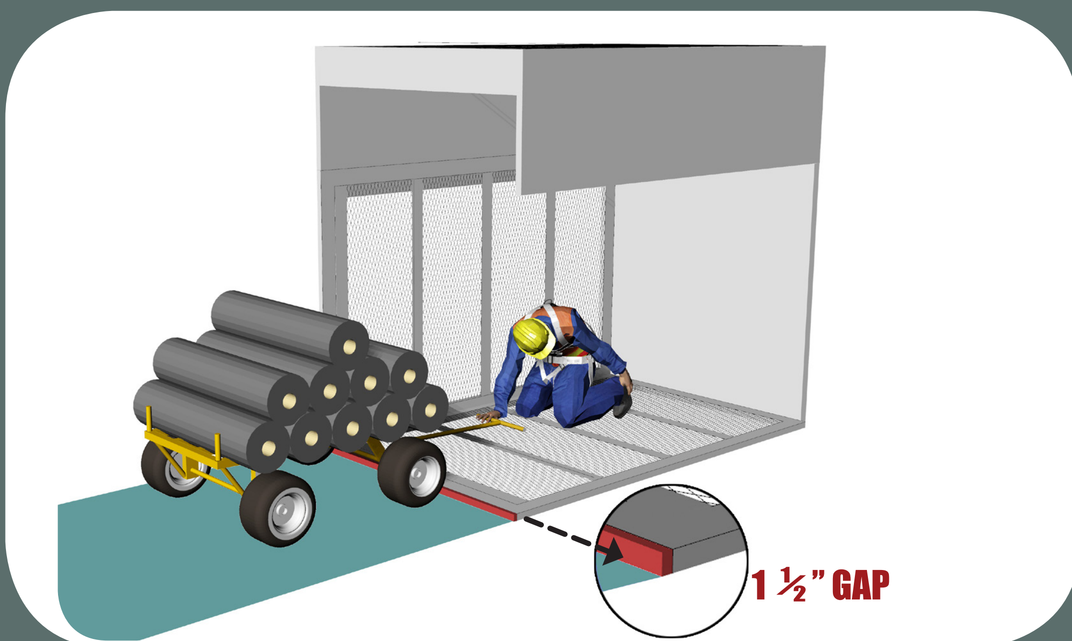
3. What if obstacles are immovable or unavoidable?

Here are some options for dealing with immovable obstacles:

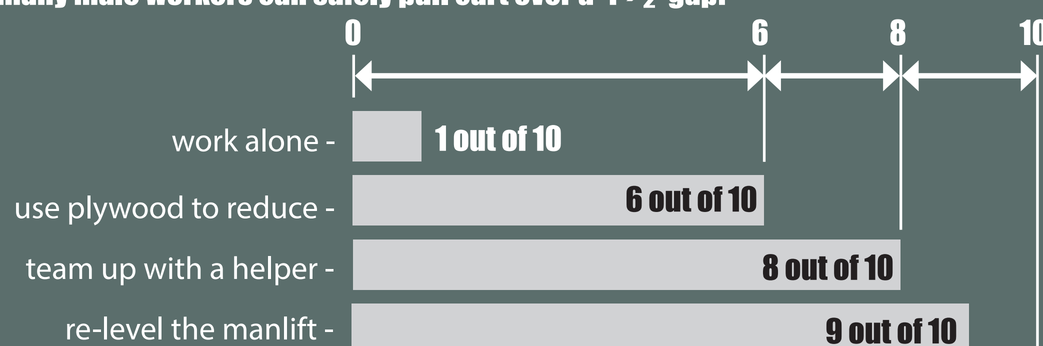
- Plan ahead and select the best possible path of movement to avoid obstacles
- Perform team pulling/pushing (see recommendations in Chapter 4).
- Reduce cartloads.
- Use materials (e.g. plywood) to bridge the gaps created by obstacles.

Case example: Why these solutions are important?

A roofer tried to push a 1,000 lbs. cart onto a man-lift which was not level with the platform. The ridge was about 1 1/2" and stopped the cart at the gate. The workspace was tight, leaving little room for the roofer to build cart momentum. The roofer decided to save time and muscle the cart forward. As he gave the final push, he felt a snap on the back of his calf and dropped to his knees. His Achilles Tendon had ruptured, resulting in days away, surgery and extended light duty.



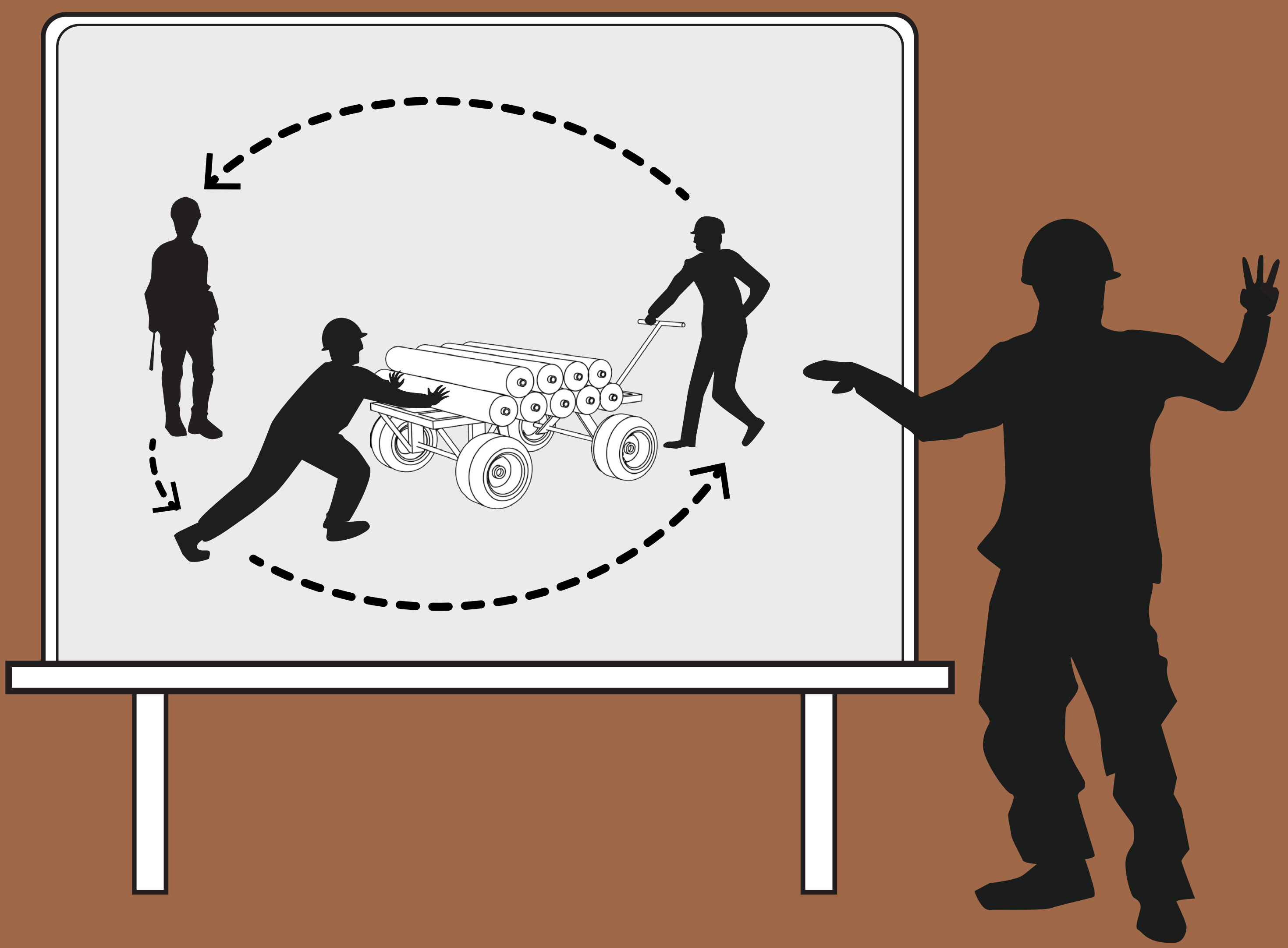
How many male workers can safely pull cart over a 1 ½" gap?



The results are based on an experiment measuring hand forces when a brand-new four-wheel roofing cart loaded with 500 lbs was operated over 4, 8 and 12 degree plywood ramps. All differences shown here are statistically significant at the level of 0.05. The strength percent capable was obtained using the SNOOK Table, and the results indicate the percentage of the male population who can safely handle the load weight when pulling at thigh height over 7 feet every 5 minutes.

4

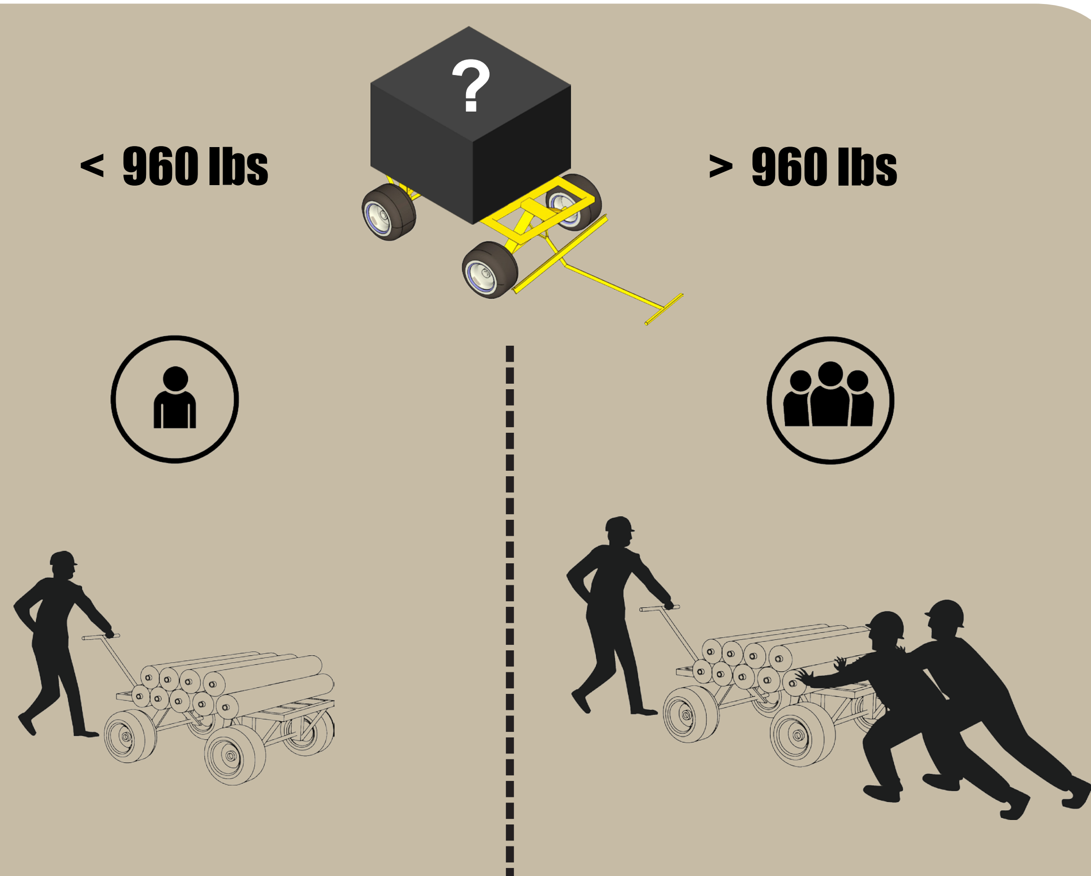
Pre-Task Planning



4.1 Team Pulling/Pushing

Load weight directly determines the amount of force that workers must exert when handling a cart. By applying team pulling/pushing, workers can share cartloads and minimize the risk of overexertion. This ergonomic recommendation is particularly useful when physical hazards cannot be eliminated.

1. When Team pulling/pushing is needed?



Roofers often need to handle heavy materials. Even with the aid of wheeled equipment, roofing materials are still too heavy for a single worker. We recommend 960 lbs as the maximum load weight when one worker pulls a cart over a flat roof (maximum 2-hour per day). Given that most of the materials exceed a cart's ergonomic load capacity, there is a high chance a worker can get hurt if teamwork is not adopted.

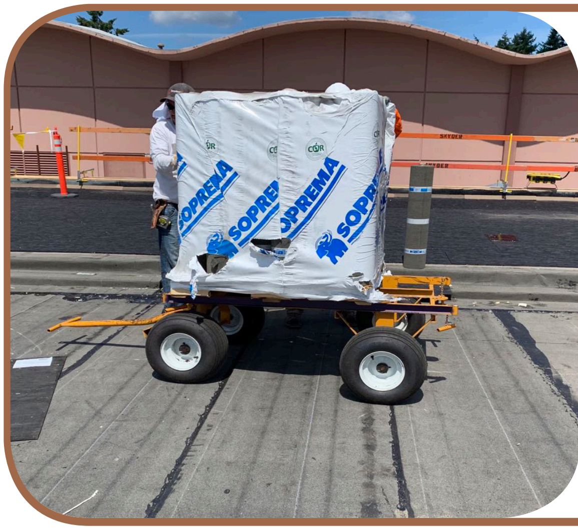
2 bundles of insulation = 700 lbs.

10 rolls of base sheets = 820 lbs.

10 rolls of cap/sanded sheets = 960 lbs.

1 bundle of 1/4" Densdeck 4' × 8' sheet = 1,600 lbs.

1 bundle of 1/2" Densdeck 4' × 8' sheet = 1,600 lbs.



1 bundle of base sheet = 2,500 lbs.

1 bundle of cap/sanded sheet = 2,900 lbs.

1 bundle of PermaBase protection board = 2,800 lbs.

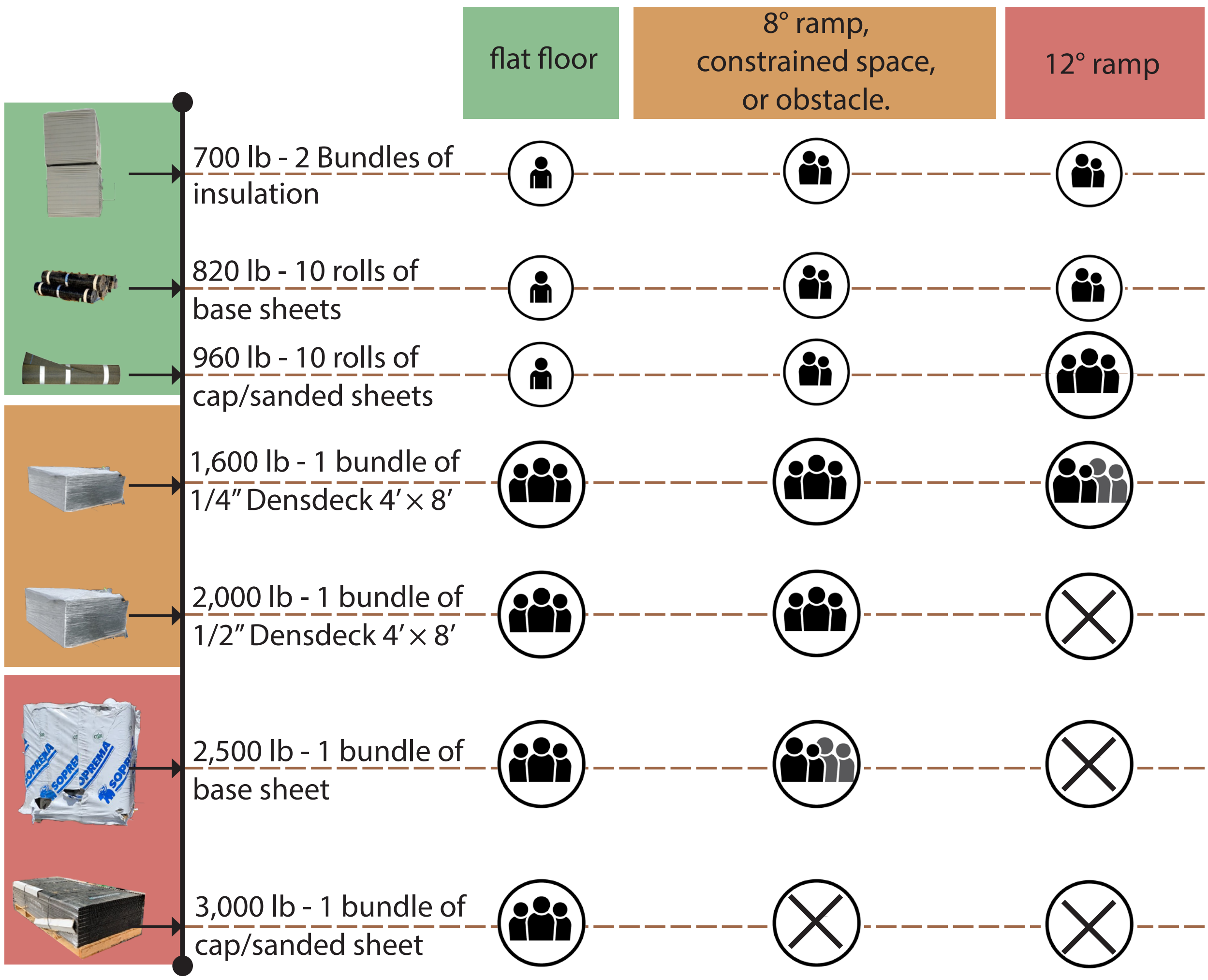
2. What are other benefits of team pulling/pushing?

In addition to preventing overexertion injuries, team pulling/pushing can help shape safety culture in your workplace:

- Encourages workers to watch out for each other and offer a helping hand when needed.
- Empowers workers to build a habit of asking for help.
- Develops a sense of unity as workers go towards the same goal.

3. How should I perform team pulling/pushing?

The chart below provides comprehensive guidance on team pulling/pushing. This chart shows the recommended team sizes for various types of roofing materials (shown in horizontal rows) under different working circumstances (shown in vertical columns).



The recommendations are targeted for acceptance of 6 in 10 of the male population as a minimal threshold. A careful balance is made between safety precaution, productivity requirement, and feasibility. Nevertheless, you are encouraged to set higher standards.

A job rotation of 2 hours per day or one pull every 30 minutes *is recommend as a complementary measure to team pulling/pushing. See next section for details.*

4. What should you be aware of when applying team pulling/pushing?

- Assign a leader to the team.
- Determine a set of commands and make sure that everyone knows what to do when they hear the command.
- The Team leader should survey the field and pre-determine the path of cart movement (enough space for movement, obstacle free).

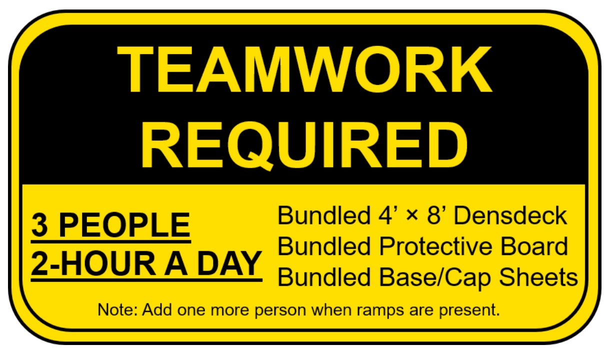
Useful tips

Tip 1:

Do you feel it is hard for workers to remember all the information regarding team pulling/pushing? Warning signage will help.

Signage to assemble teamwork

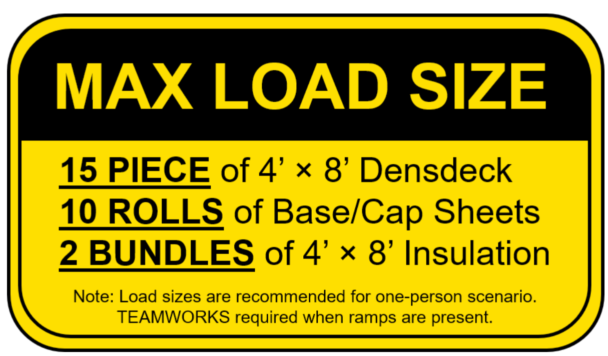
When loading materials, a crane unloads bundled materials onto a cart which is then moved by roofers to storage locations. By attaching this signage to the bundled materials, the roofers will be offered an explicit point-of-choice prompt for team pulling.



Example Signage

Signage to articulate capacity

During installation, roofers need to split bundled materials and transport them across a site. This warning signage can remind a roofer of the maximum load sizes he can handle by himself.



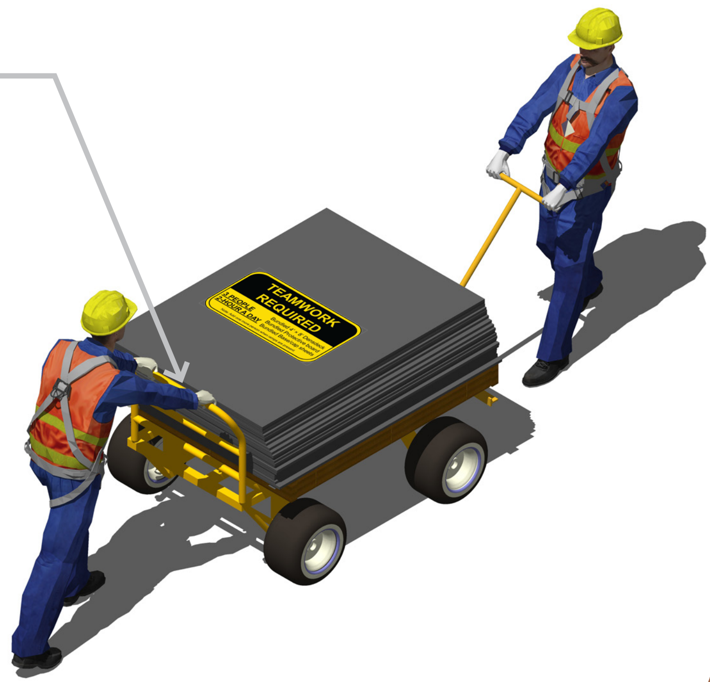
Example Signage

Useful tips:

Tip 2

Carts can be remodeled to allow teammates to more easily push by installing a rear handle.

Similar to the warning signage, this additional handle can offer a clear reminder and a mental hint to consider team pulling.



Useful tips:

Tip 3

You may also consider engineering controls. Although the control might come at a cost, they can bring considerable long-term benefits.

- Mechanical devices, such as motorized push-pullers, can help workers pull carts that exceed the load weight limit. Note that motorized push-pullers are not suitable for all facilities, as they require extra hallway space and steering room.
- When working on a large roof, a motorized car is also an option which can be used to tow a cart or several carts together without the need for manual effort.

4.2 Job Rotation

Job rotation requires workers to rotate between different tasks. This control measure can prevent workers from being exposed to some particular ergonomic stressors for extended periods of time. By being involved in different tasks, workers can also increase their skill base, find more fun in the work, and become more productive. Job rotation is recommended to prevent overexertion in cart handling.

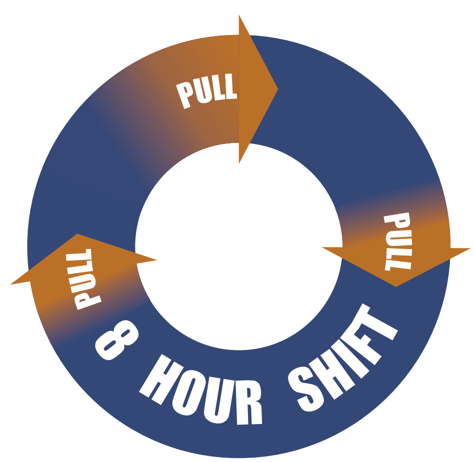
1. Should job rotation be performed?

Job rotation is recommended for all workers who handle carts as a complement to team pulling/pushing.

2. What is the frequency of rotation?

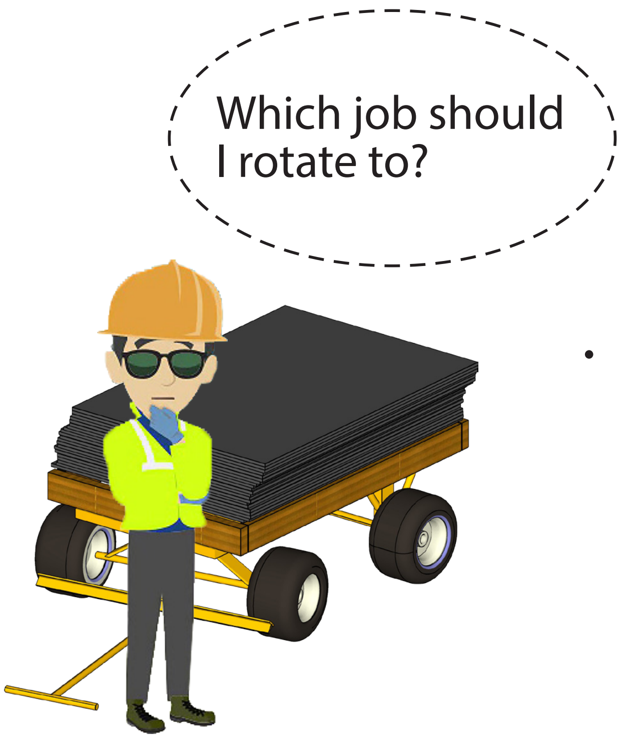
A 2-hour rotation schedule is recommended. This means that each worker should be assigned to handle carts up to 2 hours within an 8-hour work shift.

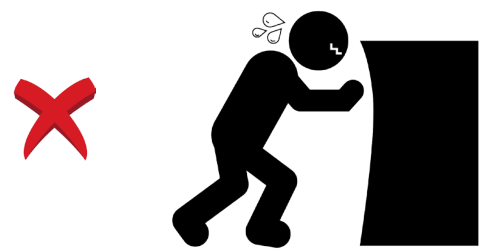
Alternatively, an 8-hour work shift is allowed but workers must operate carts at a lower frequency: no more than one pull every 30 minutes. No other heavy physical activities should be performed in between pulls.



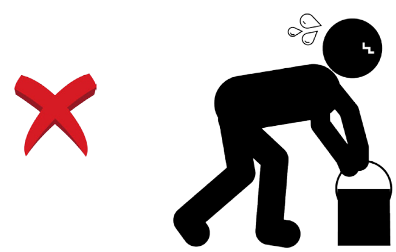
3. What job tasks can be rotated?

From a biomechanical perspective, cart handling involves forceful, sustained shoulder elevation and a forward bending posture. Workers should be rotated through the tasks that do not involve these ergonomic risk factors. Here are some generic principles you can follow:

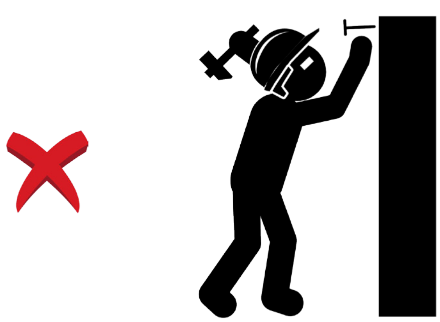




- No forceful pushing or pulling of equipment or materials



- No forceful lifting and carrying (50 lbs)



- No objects handled above the shoulder.

- No awkward back angles involved (>30°)

Here are some roofing tasks you could consider when performing a job rotation for cart operators:

- Assemble equipment or structures.
- Inspect equipment, structures, or material
- Cut or install materials
- Apply sealants or other protective coatings
- Smooth surfaces with abrasive materials or tools

Warning:

Before implementing job rotation, a qualified person should conduct a jobsite analysis to ensure that the same ergonomic risk factors are not involved.

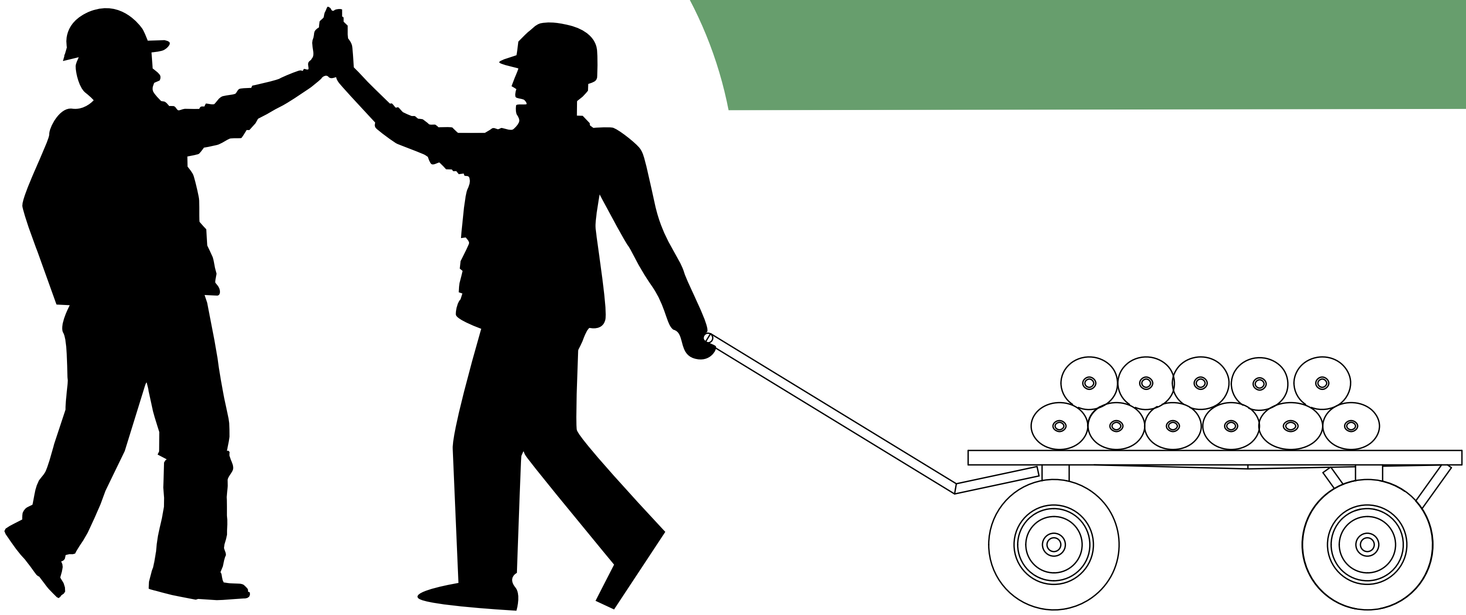
A "qualified person" is one who has thorough training and experience sufficient to identify ergonomic hazards in the workplace and recommend an effective means of correction.

Useful resources:

Formal job rotation demands a consistent and systematic method. For more detailed instructions, a good source is ErgoPlus - "A Step-by-Step Guide to Job Rotation" (ergo-plus.com/learn-job-rotation/).

5

Developing Your Ergonomic Intervention



5.1 Developing Your Ergonomic Intervention

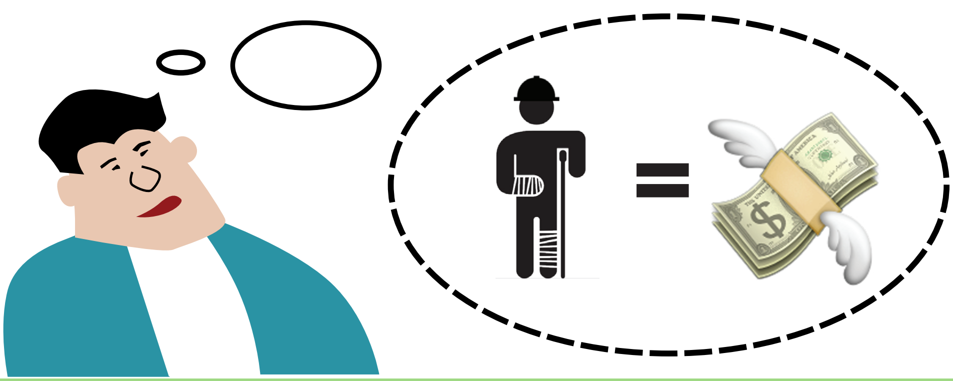
Ergonomic changes do not happen overnight. It happens little by little. Implementing an intervention program can help you incorporate the solutions recommended in the guidelines into your company's daily practice. Here are six steps you want to follow:

1. Have you obtained support from senior management?

Implementing an intervention program requires resources and investment. This is particularly true for solutions like preventative replacement and tire selection. You need to make senior managers be aware of the important safety and financial benefits. Previous chapters have provided you with reference information to communicate and convince your senior managers. You can also use this information to develop a clear return on investment based on your own company's situation. The tailored information will be more persuasive.

Tip:

You can use the ROI calculator offered by CPWR: https://www.safecalc.org/. By adjusting some parameters such as the number of carts deployed, you can easily obtain your own return on investment data.



2. Are you ready to elevate workers' motivation?

Worker engagement is the key to a successful ergonomic program because the workers will be the ones making necessary changes (e.g. workplace layout, team pulling/pushing). You should make employees be aware of the prevalence of overexertion hazards caused by cart handling and the health consequences if no changes are made. For this purpose, awareness trainings are needed, and previous chapters have provided you basic information to prepare that training.

Educational Video Clip

The authors of the guidelines developed two animation videos which can be shown during your safety training to raise an audience's ergonomics awareness for cart handling.

Video 1: Slow and Steady Wins the Safety Race
Link: https://youtu.be/OyPGBUggwyw

This animation recreates the real-life story of a roofer who ruptured his Achilles tendon while maneuvering a heavily loaded cart. Three solutions are recommended with embedded scientific evidence showing that even a simple solution like team pulling could have prevented this injury. The moral of the Tortoise and the Hare is embedded in the animation to remind audiences to pay attention to the danger of ergonomic hazards.

Educational Video Clip

Video 2: Be your Co-worker's Keeper and Win the Safety Race Together
Link: https://youtu.be/2v6p52GRJlE

This animation is based on the real-life story of a roofing apprentice who left the industry after getting injured while overcoming a poorly-setup ramp with a material cart. Three scientific, evidence-based solutions are provided to inform supervisors how a similar incident can be prevented through ergonomic workplace layout and task pre-planning. The moral of the Tortoise and the Hare is embedded in the animation to encourage supervisors to become thoughtful leaders, creating a safer and caring environment for others.

Here are some good points you can discuss with audiences after watching the videos:

Have you personally been injured or do you know someone who has been injured during cart operation?

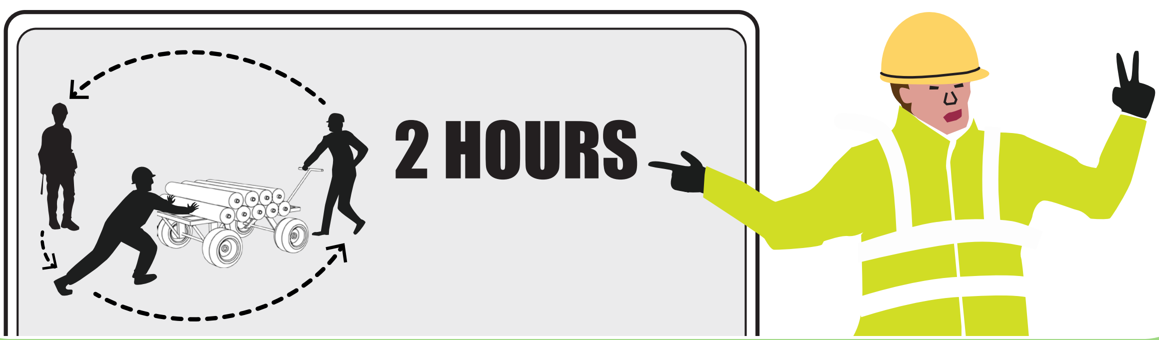
What common shortcuts do you see?

Besides injury, what other negative things can be caused by shortcuts?

What can you do today to make your assigned tasks safer?

3. Have you provided skill trainings to workers and site supervisors?

Workers and site supervisors must be able to recognize the risk factors associated with cart handling. They must understand general control measures for reducing these risk factors before they can practically participate in the program. You can turn Chapter 3 and 4 into training materials for the foreman's meeting and toolbox talks.

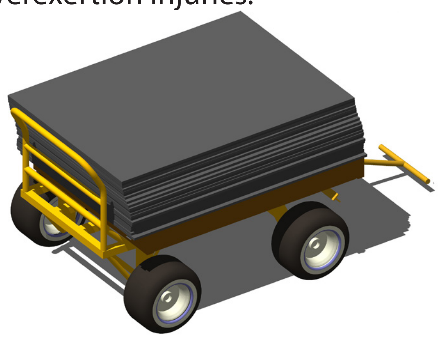


4. Have you provided site-specific instructions?

Training your workers and site supervisors on the general risk control measures is not enough. As safety professionals, you should also offer them site-specific instructions. Consider revising your company's template for job hazard analysis, safety planning, and inspection checklist to incorporate our guidelines. For example, you can add ergonomic hazards specified in the previous chapters to your safety inspection checklist. This help you identify and correct safety issues timely.

5. Have you redesigned the working environment to provide cues for actions?

Work with your warehouse manager/workers to remodel carts by installing a handle to enable easy team pushing from behind. You can also print warning signage (shared in Chapter 4) and ask warehouse workers to attach to both carts and bundled materials before they are sent to jobsites. These measures will remind workers and site supervisors to take action against overexertion injuries.



6. How can you determine if the program is a success?

Evaluation is the key step to prove your efforts have paid off. Here are three signals you can watch out for during your program:

Reduced overexertion injuries. Review your company's injury log before and after the program. Specifically, track claim numbers, total lost days, and economic cost that are associated with cart handling.

Improved health status of workers. Deliver a health questionnaire to those workers who handle material carts and track the changes of their health status.

Changed practices by workers and site supervisors. When visiting jobsites, you can observe field workers' practices of cart handling. Documenting the results will help you track if ergonomic hazards associated with cart handling are being increasingly addressed.

Tip:

The following resources may be helpful if you are interesting in getting general guidelines on how to develop and evaluate an ergonomics program.

Elements of Ergonomics Programs provided by NIOSH:
https://www.cdc.gov/niosh/topics/ergonomics/ergoprimer/default.html

Reducing Sprains and Strains in Construction through Worker Participation provided by The Center for Construction Research and Training:
http://www.elcosh.org/document/980/d000011/

Construction Industry Ergonomics Best Practices offered by the Ohio Bureau of Worker's Compensation
https://www.bwc.ohio.gov/downloads/brochureware/publications/ConstSafeGrant.pdf

APPENDIX

Four-wheel Cart Inspection Checklist

Inspection date: _________ *Cart Number:*_____ *Inspector:*_________________

1. General state of repair:

☐ Good state of repair. ☐ Reasonable state ☐ Poor state

Left Front Tire

2. Contaminated tire. The percentage of contaminated area:

☐ 0% ☐ 16% – 30% ☐ Check if replace is needed
☐ Less than 15% ☐ More than 31%

3. Tire pressure. The percentage of the recommended tire pressure:

☐ 100% ☐ 80% - 89% ☐ Check if refill is needed
☐ 90% - 99% ☐ Less than 79%

4. Wheel deformation:

☐ Not noticeable ☐ Noticeable ☐ Check if replace is needed
☐ Rarely Noticeable ☐ Very noticeable

5. Contaminated bearing:

☐ Clean ☐ Severely contaminated ☐ Check if replace is needed
☐ Contaminated ☐ Stuck rollers

Right Front Tire

6. Contaminated tire. The percentage of contaminated area:

☐ 0% ☐ 16% – 30% ☐ Check if replace is needed
☐ Less than 15% ☐ More than 31%

7. Tire pressure. The percentage of the recommended tire pressure:

☐ 100% ☐ 80% - 89% ☐ Check if refill is needed
☐ 90% - 99% ☐ Less than 79%

8. Wheel deformation:

☐ Not noticeable ☐ Noticeable ☐ Check if replace is needed
☐ Rarely Noticeable ☐ Very noticeable

9. Contaminated bearing:

☐ Clean ☐ Severely contaminated ☐ Check if replace is needed
☐ Contaminated ☐ Stuck rollers

Left Back Tire

10. Contaminated tire. The percentage of contaminated area:

☐ 0% ☐ 16% – 30% ☐ Check if replace is needed
☐ Less than 15% ☐ More than 31%

11. Tire pressure. The percentage of the recommended tire pressure:

- ☐ 100%
- ☐ 90% - 99%
- ☐ 80% - 89%
- ☐ Less than 79%
- ☐ Check if refill is needed

12. Wheel deformation:

- ☐ Not noticeable
- ☐ Rarely Noticeable
- ☐ Noticeable
- ☐ Very noticeable
- ☐ Check if replace is needed

13. Contaminated bearing:

- ☐ Clean
- ☐ Contaminated
- ☐ Severely contaminated
- ☐ Stuck rollers
- ☐ Check if replace is needed

Right Back Tire

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14. Contaminated tire. The percentage of contaminated area:

- ☐ 0%
- ☐ Less than 15%
- ☐ 16% – 30%
- ☐ More than 31%
- ☐ Check if replace is needed

15. Tire pressure. The percentage of the recommended tire pressure:

- ☐ 100%
- ☐ 90% - 99%
- ☐ 80% - 89%
- ☐ Less than 79%
- ☐ Check if refill is needed

16. Wheel deformation:

- ☐ Not noticeable
- ☐ Rarely Noticeable
- ☐ Noticeable
- ☐ Very noticeable
- ☐ Check if replace is needed

17. Contaminated bearing:

- ☐ Clean
- ☐ Contaminated
- ☐ Severely contaminated
- ☐ Stuck rollers
- ☐ Check if replace is needed

---

18. Curved axle. Shortest horizontal distance from the tire to cart frame:

- ☐ 7’’
- ☐ 4 - 6’’
- ☐ 1 - 3’’
- ☐ 0’’
- ☐ Check if maintenance is needed

19. Rusted turntable:

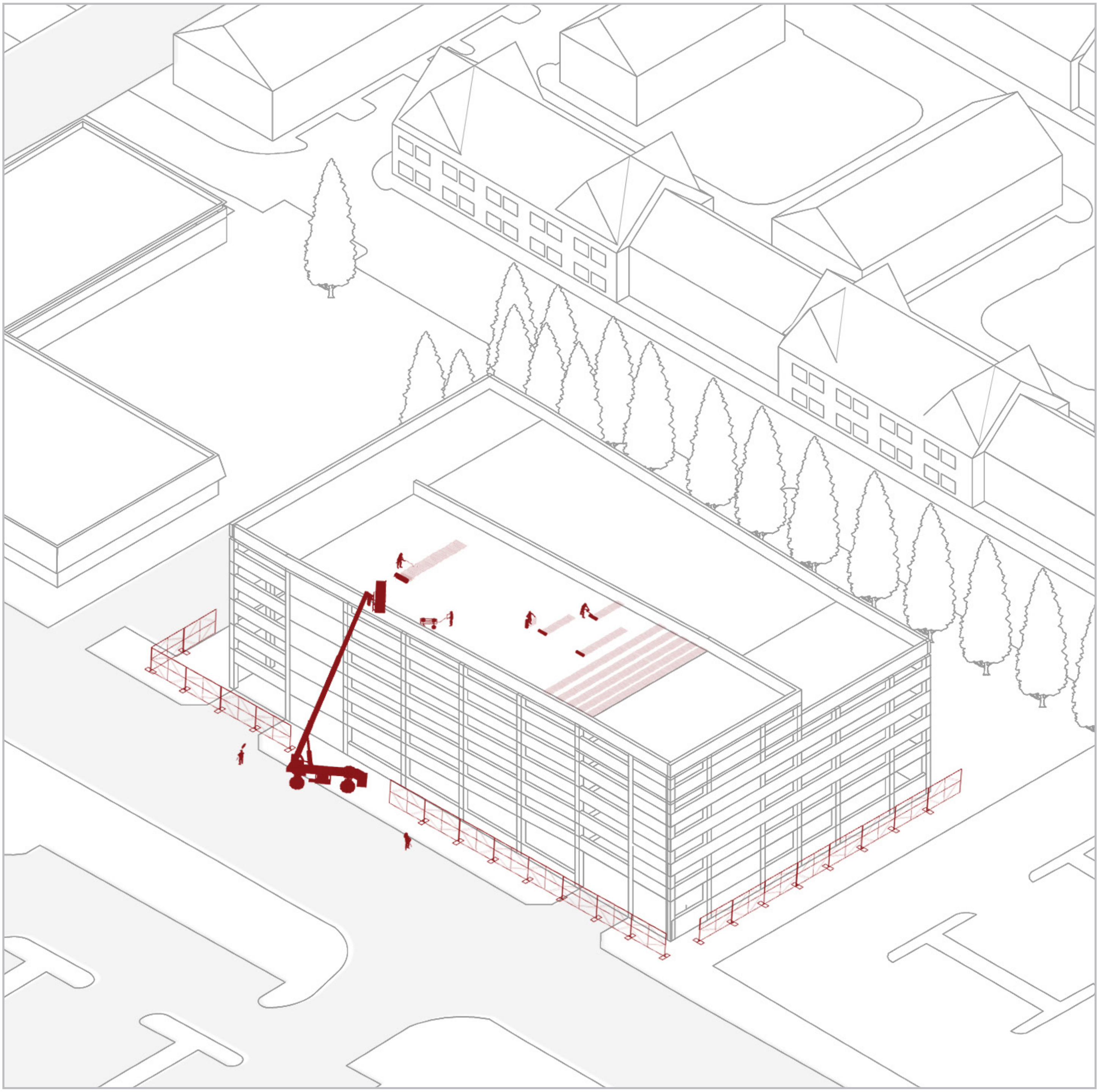
- ☐ Clean
- ☐ Contaminated
- ☐ Severely contaminated
- ☐ Stuck rollers
- ☐ Check if replace is needed

20. Loose Turntable. Maximum horizontal displacement of the handle when cart stays stationary:

- ☐ 0’’ (tightly fastened)
- ☐ Less than 1/2’’
- ☐ ½’’ - 1’’
- ☐ More than 1’’
- ☐ Check if maintenance is needed

Note

Note



Ergonomic Guidelines

Using Four-Wheel Carts In The Roofing Trade

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