

Solution Product Specifications

(In order of decreasing priority)

1. . The solution, when implemented and used according to the written assembly and operating instructions, will prevent serious injury to people in or around the forklift by solving safety concerns outlined in the problem statement.

This is a disqualifying specification, meaning that any brainstormed solution which does not adhere to this requirement will not be considered when deciding on the most viable solution concept. All of the disqualifying specifications have the highest priority because if the prototype does not adhere to the disqualifying specifications, it is not a true solution to the core elements of the problem.

The solution must be able to make a forklift a safer piece of equipment to operate, otherwise it is not a solution to the problem statement.

Problem Statement: Forklifts have proven to be a significant source of accidents in warehouse working environments due to a combination of factors including lack of visibility and tip-overs.

Serious injury is defined as “a personal injury which results in death; dismemberment; significant disfigurement; a fracture; loss of a fetus; permanent loss of use of a body organ, member, function or system; permanent consequential limitation of use of a body organ or member; significant limitation of use of a body function or system; or a medically determined injury or impairment of a non-permanent nature which prevents the injured person from performing substantially all of the material acts which constitute such person's usual and customary daily activities for not less than ninety days during the one hundred eighty days immediately following the occurrence of the injury or impairment.”

- Hyacinthe v. United States, 2009 U.S. Dist. LEXIS 108192 (E.D.N.Y. Nov. 19, 2009)

<<http://definitions.uslegal.com/s/serious-injury/> (<http://definitions.uslegal.com/s/serious-injury/>) >

2. The solution, when correctly implemented, will not have the reasonable potential to directly cause serious injury to people in or around the forklift by creating additional safety concerns not outlined in the problem statement.

This is a disqualifying specification.

In the team's attempt to improve the prevention of fatal and major injuries, we cannot engineer a solution which creates new and additional safety concerns.

The definition for serious injury is identical to the one in specification 1.

"Reasonal Potential" refers to any scenario in which the user of the device does not knowledgably use the device in a manner in which it is not meant to be used and is not outlined in the operating instruction manual.

3. The technology necessary to implement all aspects of the solution does exist.

This is a disqualifying specification.

If the technology needed to implement the chosen solution does not exist, then all efforts to design and construct a prototype will be in vain. The team does not possess the time needed to design any technology that does not currently exist for any component of the solutions in the given time frame.

4. The solution will adhere to both OSHA and ANSI forklift regulations.

This is a disqualifying specification.

If the solution conflicts with any restrictions from the Occupational Safety and Health Administration or the American National Standards Institute, the two American governing entities for forklift regulations, then forklift owners would not be able to purchase or use the solution because of liability concerns. Companies found to be using forklift attachments or devices which do not adhere to such regulations are subject to possible fines.

- Chip Gorham, Executive Vice President of Thompson and Johnson Equipment Co., Inc. which provides material handling equipment solutions such as forklifts to customers in Upstate New York

5. The solution concept will not overwhelmingly resemble concepts of existing designs or solutions for similar problems.

The reason for this specification is that it would be far preferable if the solution is not similar to a solution for a similar problem in a different application. For example, many concepts of safety solutions which are currently implemented in automobiles could be applied as a potential solution to forklift safety. However, it is more likely that the most viable solution concept will be original, because solutions similar to existing technologies have had the opportunity to be implemented on forklifts.

Although this is not a disqualifying specification, this spec is highly important because it is the opinion of the team that in order to optimize the engineering learning experience, the solution concepts should be original.

6. The solution will function, when correctly implemented, on the Toyota 8 Series Model 8FGCU20, a counterbalance forklift truck and will have the potential to be easily and quickly implemented on different forklift models as well.

A counterbalance forklift truck was chosen because "Counterbalance forklift trucks are the most common type of forklift truck."

"What Are the Different 'types' of Forklift Truck?" Bendigo Mitchell: Forklift Truck Hire, Sales & Service. Web. 28 Nov. 2012.

<<http://www.bendigomitchell.com/kb/forklift-truck-types> (<http://www.bendigomitchell.com/kb/forklift-truck-types>) >

Picture Source: "Forklift Classes." Lift Boss Material Handling Group. Lift Boss Material Handling Group. Web 28 Nov. 2012

<http://www.liftboss.ca/media/uploads/user-files/Forklift_classes.jpg (http://www.liftboss.ca/media/uploads/user-files/Forklift_classes.jpg) >

The solution will be designed using the specifications of the Toyota Model 8FGCU20 forklift. This model was chosen because it is a good representation of the dimensions and load capacity of the majority of forklifts used in small warehouses. The image above showcases a list of the forklift classes that exist. Class I, IV and V are the most commonly used forklifts in a warehouse, they are designed to for indoor environments. The Toyota forklift that the team will be working with is a Class IV.

- Chip Gorham, Executive Vice President of Thompson and Johnson Equipment Co., Inc.

In addition to being a good representation of other forklift models, the 8FGCU20 is the model of forklift that has been provided for the use of the team by Thompson & Johnson Equipment Co., Inc.

The reason why this specification was determined to be so important is that the solutions will be designed for implementation by businesses which already use forklifts in a warehouse environment. Different businesses use different models of forklifts, even within individual businesses. Therefore, it is necessary for the solution to be as versatile as reasonably possible to maximize the availability of the solution.

- Mike Ascoli, Albany Branch Manager of Thompson and Johnson Equipment Co., Inc.

7. The solution will be designed for implementation on pre-existing forklifts, or after the forklift has been manufactured.

The least safe forklifts tend to be the older models which businesses operating in smaller warehouses often cannot afford to replace. Therefore a safety solution would be most effective if it could be implemented on a wider range of working forklifts, not just on new models.

A brand new forklift, like the kind which the solution will be optimized for use on, has an average cost of \$23,000.

A used forklift has an average cost of between \$10,000 and \$15,000, depending on its hours of total use.

- Mike Ascoli, Albany Branch Manager of Thompson and Johnson Equipment Co., Inc.

Because used forklifts are significantly less expensive than brand new models, a business seeking to buy and/or replace a forklift may buy an older model anyway.

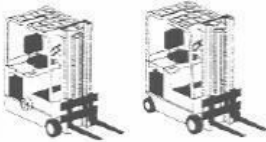






8. Each solution, for visibility and for stability, will not individually cost more than \$750.

If the solution costs too much, businesses may not be able to afford to implement it.

To determine the cost mentioned above, the team conducted an oral survey through an industry professional. For details, see [Element F: Consideration of design viability](#).

9. The solution will not increase the width of the forklift under normal operating conditions.

Warehouses are set up so that the width of the aisles and the size of the intersections will accommodate the turn radii of forklifts. Therefore, if either solution increases the width of a forklift, thereby increasing the turn radius, the forklift will need more space to negotiate a turn. This may result in forklift operators having to exercise more caution while turning or the solution not being able to be implemented because of pre-existing warehouse conditions.

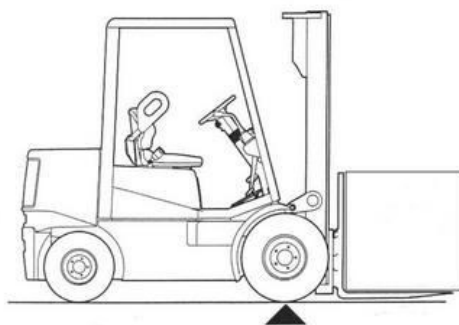
FORKLIFT CLASSES AND LIFT CODES				
CLASS #	TYPE OF PRODUCT AND OPERATION	LIFT CODES	DESCRIPTIONS	PICTURES
I	Electric Motor Rider	4	Counterbalanced, sit-down, 3-wheel	
		5	Counterbalanced, sit-down, cushion (solid) tire	
		6	Counterbalanced, sit-down, pneumatic tire	
III	Electric Motor Walkie	2	Low-lift pallet	
		5	High lift reach type	
		7	High lift counterbalanced	
IV	Internal Combustion Engine Rider	3	Counterbalanced, sit-down, cushion (solid) tire	
V	Internal Combustion Engine Rider	4	Counterbalanced, sit-down, pneumatic tire	
VI	Rough Terrain	1	All types	

The width of warehouse forklifts are typically no greater than 48 inches⁽¹⁾ because this is the width of a standard load pallet. An increase to the width of a warehouse forklift will result in the forklift no longer being able to maneuver between stacks of pallets, thereby potentially decreasing its productivity⁽²⁾.

- (1) Toyota Industrial Equipment 8 Series Specifications. Toyota Material Handling, U.S.A., Inc., 2008. PDF.

- (2) Chip Gorham, Executive Vice President of Thompson and Johnson Equipment Co., Inc.

10. No part of the solution will be located forward of the front wheel centerline of the forklift.



The Front Wheel Centerline is an imaginary line stretching from the bottom of the front wheels (denoted by the arrow in the picture) vertically upward. The area where the front wheels touch the floor acts as a fulcrum between the weight in front of and behind the front wheel centerline.

Picture Source: "Determining Truck Capacity Requirement." Neon Material Handling. Neon Material Handling. Web 05 Nov. 2012

<http://www.neonmaterialhandling.com/shop/material_handling/forklift_truck_selection_guide/determining_truck_capacity_requirement (http://www.neonmaterialhandling.com/shop/material_handling/forklift_truck_selection_guide/determining_truck_capacity_requirement) >

As proven through calculations performed by the team, even relatively low weight attachments can have a significant negative impact on the safe load capacity if the attachment is located forward of the forklift's front wheel centerline. (See the Forklift Attachment Calculations section of **Element E: Application of STEM principles and practices**)

If the solution had any part located forward of the front wheel centerline, then the weight of the part would cause the forklift to have to be down rated for businesses to avoid liability issues, as per OSHA regulations:

1910.178(a)(4) "Modifications and additions which affect capacity and safe operation shall not be performed by the customer or user without manufacturers prior written approval. Capacity, operation, and maintenance instruction plates, tags, or decals shall be changed accordingly."

1910.178(a)(5) "If the truck is equipped with front-end attachments other than factory installed attachments, the user shall request that the truck be marked to identify the attachments and show the approximate weight of the truck and attachment combination at maximum elevation with load laterally centered."

Down rating a forklift after it has been manufactured and in use by a business could potentially have serious consequences for the business in question because the forklift will not be able to safely lift loads with as much weight as it previously could. This may preclude businesses from implementing the solution.

The hassle of complying with all of these regulations for the addition of a safety feature may also persuade businesses not to implement the solution.

11. No part of either solution will be located to the left or right of the center of gravity when viewing the forklift from behind unless such part(s) is/are balanced on the other side or the tipping of a forklift necessitates the movement of the lateral center of gravity to prevent a full tip over.

This ensures that the solution will not change the location of the lateral center of gravity unless it is reacting to a tipping force. If the forklift's lateral center of gravity is shifted when the forklift is stable, then the forklift would be more susceptible to side tip overs.

12. The solution will operate under its own power source, if a source of power is deemed necessary or optimal.

The solution is intended for use on a variety of different forklift models (as per product specification number nine) which have a variety of different power sources, such as propane, electrical, etc.... Therefore, the solution cannot rely on using power generated by the forklift itself because then it would only be able to work with forklifts with the same type of power source.

13. Each solution will not weigh more than 700 pounds.

This value was derived from Mr. Ascoli's explanation that adding anything weighing more than 700 pounds behind the front wheel centerline of a forklift would have the potential to affect the load capacity of the forklift. Adding an extra 700 pounds would also unsafely increase the distance that it takes to stop the forklift.

14. The solution will be mechanically driven or will contain parts that can be replaced.

Mechanically driven means that the design relies mainly on mechanical engineering.

The purpose for this spec is to make any maintenance that needs to be done on the solution device be relatively simple for someone to troubleshoot and fix the source of potential problems.

15. If the solution requires maintenance, then such maintenance will not be required more frequently than once every 250 working hours.

The number 250 is derived from the average amount of working hours that a forklift is used between maintenance jobs, which is 250 hours (this value varies depending on warehouse conditions/environments including but not limited to temperature and floor surface conditions/material). If a forklift with the solution requires maintenance more often than it would had the solution not been implemented, then the business will lose money in the form of more maintenance jobs/workers and the loss of time that the forklift is working.

- Bob Harford, Head Mechanic of Thompson & Johnson Albany Branch

16. The solution will not raise the forklift height by more than seven inches.

According to Mr. Ascoli and Mr. Gorham and Frank R. Benedetto, OSHA certified Safety/Personnel Director of Yank Waste Co.,Inc., it is best not to exceed the forklift height by more than seven inches due to the common occurrence of forklifts entering and exiting loading dock doors.

16.1. The solution can withstand temperatures as high as 134°F.

This value came from the world record outdoor temperature.

"New World's Highest Temperature Declared." Fox News. Fox News Network. LLC. Web. 08 Mar 2013. <http://www.foxnews.com/science/2012/09/14/new-world-hottest-temperature-declared/> (<http://www.foxnews.com/science/2012/09/14/new-world-hottest-temperature-declared/>)

Because many forklifts are used outdoors, the solution would be more viable if it can withstand hot outside temperatures.

16.2. The solution can withstand temperatures as low as -22°F.

This value came from the temperature of an "ultra low temperature walk-in freezer cold storage warehouse.

"How to Choose a Refrigerated Walk-in Cold Storage Warehouse?" Dragon Enterprise CO.,LTD. 2005. Web. 31 Jan. 2013. <http://www.dragon-enterprise.com/cold-room/cold-storage-warehouse-type.htm> (<http://www.dragon-enterprise.com/cold-room/cold-storage-warehouse-type.htm>)

Because many forklifts are used in warehouses that are refrigerated, the solution would be more viable if it can withstand refrigeration temperatures.

Additional Visibility Solution Product Specifications

17. . The solution will be an active-safety solution, as opposed to passive-safety, which will allow the forklift operator to more easily and successfully avoid potential hazards by providing him or her with advance notification of such hazards which would otherwise be outside the operator's field of vision. The solution will not do anything to actively prevent an accident other than alert the operator to potential hazards.

This is a disqualifying specification.

The more advance notification of potential hazards, the more time the forklift operator will have to avoid those obstacles. The visibility solution will not act or intervene in any way to avoid any hazards because of the narrow aisles and tight turns which many warehouse forklifts are required to operate with. Such conditions would prompt many false hazard detections which would result in many unwarranted "corrective" measures on the part of our solution, without the operator's consent. Such a scenario may create productivity problems with forklifts and it may prompt forklift operators to attempt to circumvent the solution. Thus, the team decided that the visibility solution would only aid in an operator's detection of potential hazards and would rely on all corrective actions and decisions to remain in the control of the forklift operator.

18. . The solution, when implemented and used according to the written assembly and operating instructions, will not obstruct the operator's field of vision in other areas.

If the solution were to obstruct the operator's view in any way, then the problem has not been solved.

19. . The minimum distance between the forklift and a hazard must be five meters at the instant that the forklift operator is alerted to said hazard.

Calculations performed by the team have determined that a forklift moving at the reasonable warehouse forklift speed of five miles per hour will take approximately 4.7690 meters to come to a complete stop from the time that the operator spots an obstacle to the time that the forklift stops. These calculations did take into account the reaction time of the operator, .75 seconds.

These calculations can be found in the Forklift Stopping Distance Calculations section of Element E: Application of STEM principles and practices.

Based on these calculations, the team decided that 4.7690 meters would be rounded up to 5 meters to be safe, and that this number would determine the distance between the forklift and any potential hazards which the operator would need to stop or otherwise evade to avoid hitting.

Additional Stability Solution Product Specifications

20. The stability solution will be one of active safety which will prevent tip overs rather than limit the damage of a tip over after one has occurred.

This would more effectively limit the potential for serious injury (see definition of serious injury in the specification 1 explanation) because of the difficulty in designing a practical device to protect a pedestrian from a falling forklift as well as the operator. A more efficient and economical solution would prevent tip overs from occurring in the first place, thereby eliminating both serious injuries and the cost of forklift repairs.

21. The solution will prevent lateral tip overs only.

Side tip overs occur more frequently than frontal tip overs.

- Chip Gorham, Executive Vice President of Thompson and Johnson Equipment Co., Inc.