Safely Covered or Dangerously Exposed: Analyzing the Safety Vest Code of Compliance

Sophie Stewart
California Polytechnic State University
San Luis Obispo, California

As the construction industry transitions to reflect a more diverse population, it is essential that personal protective equipment (PPE) accommodates this shift in demographics. In particular, the "One size fits all" approach is no longer an appropriate metric of fit for the safety vest. Previous student research reflected an overwhelming consensus that construction workers do not have vests which appropriately fit them. In response, the Cal Poly Construction Management Department hosted the first ever Verifying Everyone's Safety Together (VEST) Hackathon. This two-day event fostered a space for industry members, students, and faculty to discuss and develop several prototypes which better accommodate a diverse population of people. Several common themes were brought up in conversation and interviews at the Hackathon event. This research will discuss the general demand for properly fitting high visibility safety vests as identified by hackathon participants and how the code of standards for this piece of PPE may be inhibiting the ability to accommodate this demand. Developing a more narrowly tailored definition of proper fit so the code can simultaneously cover the risk of low visibility of workers on site is essential in fostering a safer work environment.

Key Words: Construction Vest, Proper Fit, Code, Compliance, Hackathon, Safety

Introduction

"If the personal protective equipment does not fit properly, it can make the difference between being safely covered or dangerously exposed" (OSHA, 1978). With such an overt statement by the governing body for a safe and healthy workplace, properly fitting PPE should be a fundamental aspect of a construction company's safety program. However, it seems as though there is complacency that an improper-fitting vest simply comes with the job of being in a "man's world". Yet, the concept of the construction industry lacking diversity is beginning to diminish as demographics within the construction industry become more diverse. With this increase in diversity comes the need to fit a safety vest to all body types which walk the site.

Fostering a culture of diversity and inclusion has become an important topic amongst top construction companies, challenging the industry to make efforts in supporting this movement. In an article published by the Construction Dive focusing on the future of diversity in construction, representatives from construction companies XL, PCL, and Turner all spoke on behalf of their continual efforts in implementing standards to develop a culture of diversity and inclusion (Bousquin, 2021). Each of the three large companies discussed the daily routines and assurances they work to put in place to diversify the faces of their workforce. Many of the solutions presented within this article take an

interpersonal approach to creating a culture of belonging yet miss one obvious solution: a properly fitted safety vest. If the uniform fits, then the person in their occupation fits.
Following research conducted by Galvez (2021), it was found that the traditional safety vest lacks the ability to effectively accommodate a diverse range of body types (Galvez, 2020). The concept of an improperly fitting safety vest may seem easy to remedy but there are much deeper considerations than knowing how to use a sewing machine. The largest inhibitor of designing a vest is the code governing the design and compliance to the ANSI/ISEA 105-2017 standard, which was adopted by OSHA to regulate the standards for high visibility (hi-vis) accessories and apparel. The ANSI/ISEA 105-2017 sets standards for the safety vest which consider and improve worker visibility to equipment and machine operators in any lighting condition and from any angle (ISEA, 2015).
Stringent minimum material requirements as set forth by the ANSI/ISEA 107-2015 standards impedes the ability to produce a vest that can properly fit to a wide range of body types, especially those of smaller stature. An improperly fitting vest greatly exposes the user to safety risks associated with snag and catch points on a construction site, potentially leading users to be caught on equipment or materials, creating a safety hazard.

As a result of Galvez's (2021) research Cal Poly hosted the Verifying Everyone's Safety Together (VEST) Hackathon event which fostered a space for industry professionals, students, and faculty of Cal Poly to discuss these concerns and develop potential solutions. This event uncovered how developing a code of compliance which accounts for low visibility and proper fit is fundamental in improving diversity and inclusion within the construction industry. Taking into account the generalized consensus of how the "one size fits all" safety vest does not fit all, this research will discuss the importance in developing a more narrowly tailored definition of "proper fit" that can be applied to the set of standards which governs the design of the construction vest. The purpose of this paper is to discuss how the ANSI/ISEA 107-2015 code of compliance for high visibility safety vests impedes on the ability to appropriately fit all body types.

Literature Review

This literature review will investigate several pieces of research materials and the ANSI/ISEA 107-2015 standard for high visibility safety apparel and accessories to provide an account of how "proper fit" governs current industry standards for the traditional safety vest. This will be used as a tool to highlight the current code and the limitations it might encounter when attempting to provide individuals with proper fitting PPE.

Improper Fit

Limited statistical data around safety vest related injuries to yield a large enough pool of evidence. Much of the consensus of this lacking design is tied to qualitative data of personal accounts. Although, Galvez's (2021) survey of over 200 industry professionals and student interns takes a quantitative approach to fill this gap in information. Results of the survey yielded an overwhelming conclusion that the "one size fits all" approach to the safety vest does not support the increasingly diverse construction industry (Galvez, 2020). When respondents of the survey were asked how their

safety vest fits them, only one-third reported the vest fitting ‘just right.’ with the other two thirds majority of respondents saying that the shoulders, waist, and hips have the least satisfaction for comfort and fit (Galvez, 2020With the question of elements that are of importance on a construction site, just under 95% of respondents reporting safety as “extremely important” and just under 85% of respondents reporting that a vest that fits is “extremely/somewhat important” (Galvez, 2020).

When considering how construction is one of the riskiest industries globally, with upward of 60,000 fatalities in the US a year (Sehash, 2020), it is no surprise that safety is at the forefront of importance. As excess material on a vest is more likely to catch or snag on handrails, doors, and equipment it becomes a serious safety hazard which is frequently overlooked. Galvez, in concluding her analysis of her survey states: “The implementation of a safety vest that considers varying body types is crucial for personal and professional growth in the construction industry, and directly impacts their safety if neglected” (Galvez, 2020). Highlighting the importance of a proper fitting vest reaching beyond the constraints of comfort and into the realm of safety.

“Proper Fit”

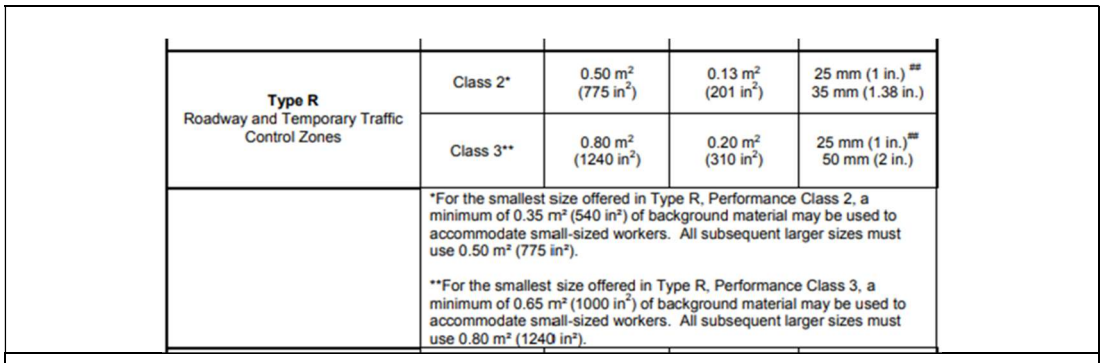
OSHA is the federal governing body for all workplaces to provide a safe and healthy working environment for all employees. OSHA speaks directly to how an employer shall choose to outfit their employees in PPE in 1910.132 of General Requirements when stating: “Select PPE that properly fits each affected employee” (OSHA, 2016). The organization establishes the importance of proper fit but does not provide a metric for how this definition is to be interpreted. Instead, they defer this definition to be at the discretion of ANSI/ISEA codes which work to develop and test PPE which will serve the purpose of covering the employee from a foreseeable risk. Although, when it comes to the safety vest, ANSI/ISEA also doesn’t define “proper fit.” ANSI/ISEA 107-2015 code utilizes this broad definition as the code states: “Garments that are not properly sized to fit can expose workers to catch hazards or interfere with other protective gear, potentially compromising worker safety” (ISEA, 2015). Both sets of standards utilize “proper fit” to describe the wearability of a piece of PPE and specifically the safety vest yet neither OSHA nor ANSI/ISEA provides a metric of guidance. This leaves the interpretation of what “proper fit” means to be at the discretion of anyone’s judgment. Which may often be clouded by their specific role and relationship to PPE. Where inspectors may have a different definition, employers may simply use this to provide the least expensive options claiming that a different spread of sizes accommodates these criteria, employees may use it as an excuse to not wear the PPE at all.

The Code

The ANSI/ISEA 107-2015 High-Visibility Safety Apparel and Accessories is the code that covers standards that address the safety risk of workers' low visibility when working around heavy machinery and equipment. The ANS/ISEA code is written with the understanding that workers must be visible to equipment operators in all lighting conditions at all angles (ISEA, 2015). High-visibility apparel is seen as an essential form of PPE as low visibility of workers is a serious and common safety hazard which any personnel is exposed to while on a construction site. This standard provides

guidance to aid manufacturers, the consumer, and the public in appropriately covering this risk. The ANSI/ISEA 107-2015 is the latest version of a voluntary consensus standards for High-Visibility Safety Apparel and Accessories adopted by OSHA. The code revision was prepared by members of the High-Visibility Products Group of the International Safety Equipment Association (ISEA). This group of members is a consensus of just over twenty manufacturers with a processing and approval committee of over thirty different manufacturing and construction industry companies.

Since the inception of this code in 1999, the standard has been adopted and recognized by federal and state authorities as well as private industry (ISEA, 2015). Within the reface of the code ANSI/ISEA addresses how fit and comfort of safety vests plays an essential role in a worker's willingness to wear PPE in daily activity (ISEA, 2015). The most prominent authority to adopt these standards set forth is OSHA. Various considerations from all different backgrounds of companies involved in the ISEA High-Visibility Products groups play into the revision of the ANSI/ISEA code every five years. Beyond this discussion of how this code may be improved to better suit the construction industry, are the numerous tests that must be undertaken to prove that the risk hazards are appropriately covered.



Type R Roadway and Temporary Traffic Control Zones	Class 2*	0.50 m^2 (775 in^2)	0.13 m^2 (201 in^2)	25 mm (1 in.) ## 35 mm (1.38 in.)
	Class 3**	0.80 m^2 (1240 in^2)	0.20 m^2 (310 in^2)	25 mm (1 in.) ## 50 mm (2 in.)
	*For the smallest size offered in Type R, Performance Class 2, a minimum of 0.35 m^2 (540 in^2) of background material may be used to accommodate small-sized workers. All subsequent larger sizes must use 0.50 m^2 (775 in^2). **For the smallest size offered in Type R, Performance Class 3, a minimum of 0.65 m^2 (1000 in^2) of background material may be used to accommodate small-sized workers. All subsequent larger sizes must use 0.80 m^2 (1240 in^2).			

Figure 1: ANSI/ISEA 107-2015 Code of Minimum Required Material for Type R High Visibility Safety Vest (source: ISEA, 2015)

Figure 1 displays the current ANSI/ISEA 107-2020 code for Type R Class 2 and 3 high visibility safety vests. The most recent revision to the code addresses the concern of an increasingly diverse construction industry by including provisions to the most used safety vest in the construction industry, type R. As displayed in Figure 1 above the background material for the smallest size has been significantly reduced in the most recent version of the ANSI/ISEA code to accommodate smaller body types (ISEA, 2015). This adjustment to this sizing metric is a step in the right direction toward developing a code that takes appropriately fitting PPE into account.

Guidance for better Compliance

Anthropometry is the scientific study of measuring the parts and proportions of the human body, which is an important consideration when outfitting employees in appropriate PPE. However, limited information around the construction vest and its relationship to a diverse anthropometry is available.

Although, various industries have taken the liberty to research this crucial consideration and provide guidance in appropriately outfitting employees.

NASA published an Anthropometric Source Book as guidance for design engineers in any field for design and execution of clothing." (NASA, 1978). This publication is a collection of anthropometries of a widely diverse population of ethnicity and gender. An ideal point of reference for an industry which lacks the foundation of information to appropriately guide how PPE shall be outfitted. NASA identified the most common design flaw was using an average body type metric rather than developing a scale catered to a diverse range of bodies. "The use of average value which may manifest itself in the form of the 'average man'" (NASA, 1978). Even those designs which claim to be addressing a large scope of population, only address the larger side of the sizing spectrum, rarely include size charts, and models used to display the PPE are predominately white males (Flynn, 2017). Reinforcing how often, the population taken into consideration for design purposes does not accurately reflect the actual population of people who will wear the safety vest on a daily basis . Outliers of this underlying metric of design see the implications of how they do not seem to fit into their apparel. NASA continues by addressing: "Individuals below the mean could be accommodated but the garment would fit loosely and, if they were considerably below the mean, they would be definitely hampered by the excess material." The excess material is where the hazard of snagging on construction object materials becomes a concern. Although, this lack of concern with bodies beyond the median size falls on both sides of the spectrum where: "Individuals whose physical size falls above the mean would have a tight-fitting suit to contend with and those so far above the mean would probably not even be able to get the garment on [or not appropriately]" (NASA, 1978). Encompassing how the hi-visibility safety code, utilizing an average scale of body types, lacks consideration for anyone who does not fit the mold for the "average man". Decisions in design metrics must be: "Made with the fit and function of the end item in mind and its relationship matched to user population" (NASA, 1978), thus emphasizing the importance of setting standards which effectively outfit the intended user.

However, even the mold of "average man" does not seem to fit the model. A study of over 4,000 participants found that just over 1,000 of these participants fit the profile of the "Average Man". With only one third of these average-sized men were also of average sized chest diameter (Daniels, 1952). This study concluded how the metric of averaging sizing based on the "average man" is not all-encompassing of even those individuals in which it is aimed at. Averaging of respective individuals is a common metric amongst many outfitters and is: "The simplest yet, least satisfactory approach is that of limiting the body size range to fit the design of the product" (NASA, 1978), which is a common approach when developing standards, such as the ANSI/ISEA 107-2015 code of compliance.

Methodology

The overwhelming conclusion of Galvez's survey of how the "One Size Fits All" safety vest does not fit most, pointed to an obvious next step. This next step was to create a space to take this data and put into action. In response to the findings presented by Galvez, Cole Bernabie developed an execution plan for the first annual Cal Poly VEST Hackathon event (Bernabie, 2021). A two-day event was developed which brought together industry members, students, and faculty with a common goal of

universalizing the fit of the traditional safety vest. Participants discussed, brainstormed, and developed prototypes with adjustable enhancements to improve the overall fit and utility of the construction vest. Six prototypes utilized drawstring, zippers, Velcro, and pockets to better consider how adjustability creates inclusivity. The ideas executed through each redesign were seemingly simple to implement yet, one hurdle was brought into awareness by participants representing a large safety vest manufacturer: the code of compliance.

To evaluate how the "One Size Fits all Approach" lacks in its ability to appropriately fit all body types within the construction industry and how this may infringe on safety, semi-structured interviews were conducted. Over thirty participants attended the event, representing a diverse population of project engineers, project managers, design specialists, and safety managers. Each participant was made aware of recording of the conversation for future use and data, following IRB protocol and approvals. Following the event, the interview transcripts were reviewed to identify common themes and highlight specific phrases in support of the points brought forth. As a follow up to the event, several informal conversations were conducted via phone and zoom to discuss common themes of the event and procedures moving forward. This form of data collection is ideal because of the nature of "fit" traditionally being a qualitative interpretation rather than quantitative. This qualitative data was then used as a tool to open discussion for how such information should be interpreted within the scope of the code. The data discussed below draws upon common themes expressed throughout the interview process and interpretations following the event.

Theme #1 - Improper Fit as a Hazard

A common theme which arose from many of the interviews held at the Hackathon event was how an improper fitting safety vest isn't safe and how excess material imposes a risk of getting caught on jobsite material.

Participant #1 shared a personal account of their experience with an improperly fitting vest to the entire VEST Hackathon. Participant #1 spent one of their summers as a carpenter apprentice where they were provided a vest by their employer which did not properly fit. The safety vest was too large and additional material hung on either side of their torso. One day, while carrying material past a rebar lay down area, the excess material of the vest was snagged by a protruding edge of rebar. This rebar was adjacent to a large excavation. Had the vest been snagged from a different angle or has she pulled in the wrong direction; the outcome of this instance may have had a much more tragic outcome. "*It could have ended badly, and you know, I could have fallen into that [excavation] or I could have been struck by some piece of machinery.*" This story which was told to the entire crowd of participants at the Hackathon sparked awareness in several other participants who went on to discuss their personal experiences.

Another participant, related to this experience and shared their daily experiences. Participant #2 has spent a majority of their career in a safety vest, starting as a laborer and working their way up to become a high-level executive for a general contractor. They described their personal encounter with the vest as being something they wore *"... all day every day working around heavy equipment and having to crawl under and work around,[the vest] getting snagged on stuff and stuck on things"* The

participant went on to discuss the ideal fit in comparison to the traditional fit when saying: *"it really would be nice if it fit like a shirt instead of two trash bags [sewed] together, with a hole cut in it."* This comparison to the safety vest as a trash bag provides an account of just how improperly the vest may fit when size of person is not taken into consideration.

When asked about the importance of the safety vest Participant #3, representing a large general contractor, built upon the ideas set forth by Participant #2, stating: *"...whether it be a male or a female, they're not fitting correctly. So, what's happening is that they work one direction but not the other. And it's causing more of a hazard"* Participant #3 went on to discuss how the safety vest is a hazard some wear all day and: *"the person that's exposed to these hazards all day long. You really want them to be able to have a vest that fits well."*

Participant #5, who spent most of their career on the safety side of construction, alluded to how much more complex the matter of proper fit is when stating: *"Looking at the different body shapes, one size does not fit all is such an understatement, and not all women are the same size and shape either. So, it's good to think about men, women, everyone. How do we make products that fit? Everybody? We're talking specifically about women here, but we're not all the same either."* Demonstrating how consideration of developing a truly universal vest and how the resolution is much broader than developing the "average women's safety vest.

Themes #2 - Improper Fit and Compliance

A second theme which naturally arose when discussing how excess material impedes worker safety was the relationship between code and vest compliance. When participants were asked how the foreseeable issue could potentially be amended Participant #2 responded by saying: *"Helping Cal OSHA get on board with the fact that, if this was a square inch of reflective material, I can still see the guy down the street. So, it doesn't really need to be 200 square inches of shoulder material. Like how about it just fits right? Yeah, that to me is a lot safer than just wearing a trash bag around and hoping you don't get snagged on something."* This participant speaks directly to how the stringent

numbers set forth may impede on the ability for safety.
In bringing the concern of how the code impedes on the ability to properly fit PPE to a diverse range of bodies, it is essential to bring in conversation with design experts. Participant #5 attended the event as a representative of a large safety vest manufacturing company. When discussing the role of the ANSI/ISEA 107-2015 standards they explained: "*So the standard basically calls out different levels of or requirements for the amount of fabric and amount of reflexive material that needs to be included on every vest. And then also some of the design elements as far as how it's balanced out front and back. But that really does restrict some of our design because we must make sure that we comply."* The code becomes more of a hindrance in being able to address many of the "proper fitting" concerns that are laid out by OSHA and brought up by numerous different people. This specific theme is an especially important addition to the research presented throughout this paper as it connects the theme of how code hinders proper fit.

Interpretations and Considerations

To effectively debrief and gain an understanding of how the metric of code compliance and testing standards may be hindering the possibility of a proper fitting vest two post-event conversations were held. Each of the conversations provided insight into a broader understanding of the common themes of the Hackathon event and considerations moving forward. Participant A has worked in developing a compliant safety vest of their own and is currently a member of ISEA group for high visibility safety vest apparel and accessories. Participant B, a Vice President of Health Environment and Safety for a significant general contractor within the industry, provided insight into PPE and what catalyzes change within construction.

When asked what proper fit of PPE meant to Participant B they defined proper fit of PPE as: "*not causing harm in any way"*. The participant added that harm may include, but not be limited to, being caught or snagged by a construction object. They went on to discuss how getting snagged is such a common occurrence yet, something that is paid very little attention to. Participant B addressed how safety risk and human error as part of human nature and how it can never be fully eliminated: *"One solution to one risk may make way for entirely different issues to arise"*. When determining which issues to address at top priority any standard setting agency weighs the likelihood of that safety hazard from arising. Yet oftentimes as Participant B put it: *"Safety incidents are written in blood"*. Meaning, numbers related to injuries and fatalities make the greatest impact. Participant B went on to discuss how there is limited statistical evidence around improper fitting vests because diversity and awareness is a modern concept to the industry. So, what is the importance in taking a preventive action rather than simply being reactive? Participant B alluded to the importance of likelihood of an incident associated with a certain risk.

Participant A, who is currently a member of ISEA group for high visibility safety vest apparel and accessories, clarified the objective of ANSI/ISEA standards as: *"the purpose is to provide individuals with the most amount of protection possible under the requirements set forth by all testing standards"*. The testing standards seem to be the most major hindrance in providing a set of standards which addresses one safety concern while developing potential hazards for another. In particular, the testing requirements serve to ensure metrics of high visibility but do not consider proper fit for the person underneath. Participant A questions whether the current testing requirements address the concern of proper fit and asked whether there can be a test conducted by the human eye: *"what testing methods can be adapted so we can account for the current sizing restraints with the updated code. If I'm looking at a person, can I still see that person just as well and the vest fits their body better than not"*. Participant A concluded her final points by alluding to what OSHA suggests in their opinion piece which is *"Does it make more sense to have a vest someone is willing to wear because it fits, or they don't want to wear it at all because it fits like a cardboard box"*. This conversation with Participant A brought light to the current code of standards and the basis of what compliance means.

Analysis

The consensus of the interviews as discussed above is that the traditional safety vest lacks the authority to effectively and safely outfit the population in which it is intended to protect, potentially exposing any person who falls outside of the scope which vests are designed to fit to be at risk of snag and catch hazards. Various points of comparison such as a “black trash bag" as discussed by Participant #2 and a “brown box " as discussed by Participant A alludes to how the vest simply does not fit all body types. Such comparisons foster a perception that there is seemingly no regard to how the vest fits the person underneath it. The primary goal of the ANSI/ISEA 107-2015 standard is to improve visibility, which it does so effectively, but at what cost?

Participant B shed light on the fact that safety hazard mitigation is an opportunity cost. Reducing one safety hazard frequently induces another, noting that when deciding which to prioritize it is common to look to the one which occurs most frequently and has the greatest chance of fatality. Yet, the interviews held at the VEST Hackathon event seem to conclude how an improper fitting vest fulfills the metrics of commonality and of being a valid safety concern. Even so, it seems as though there is opportunity for the safety vest to serve its purpose to improve visibility while considering the increasingly diverse population of the construction industry.
Participant A and Participant #5 both addressed how the testing metrics which govern the code prevent the ability to develop codes which address compliance and fit. Participant A questioned how a differing testing metric may potentially amend this issue and what these metrics would look like.
The code of compliance for safety vests is effective in providing high visibility but has opened another safety exposure for people working within close proximity of objects susceptible to catching and snagging vests. ANSI/ISEA 107-2015 set of standards which governs the design of a compliant vest seems to be the largest hurdle in addressing the issue of improper fit. Under the current metrics of testing within this standard, it prevents a safety vest which both accommodates all body types and limits the concern of material being snagged.

Conclusion

This study brought to light the gap that exists between the ANSI/ISEA 107-2015 standards, and the safety concerns associated with improper fitting safety vest as perceived by VEST Hackathon participants. Previous research alludes to the fact that the improper fit of the construction safety vest is a common theme within the construction industry. This research took this information into account and evaluated interviews held at the VEST Hackathon. The several interviews conducted at and a following the event alluded to how the ANSI/ISEA code of compliance restricts the ability to develop a universal fitting safety vest. Thus, bringing to light how the code of compliance testing metrics prohibit the ability to address the improper fit of a safety vest.

In an industry where diversity and inclusion have received greater attention, limited quantitative information exists to effectively support the concept of improper fit imposing safety hazards even though previous surveys and qualitative evidence above supports this concept. With the consensus of how an improper fitting safety vest is not safe, it is essential to enhance the code of compliance so that it is inclusive of all body types. Not only does this ensure a safer working environment but a more inclusive environment in general.

NASA has released reports specifically catered to studies conducted in the field of outfitting a diverse population for proper fit. Such information can serve as a point of reference in appropriately outfitting PPE to the population in which it is intended to serve. Beyond taking consideration of these studies taken by various industries, the code of compliance can look at differing metrics of testing to verify compliance. A proposed metric is to build a code based on a ratio of background and reflective material to the dimension of the human torso. An alternative is to implement adjustability options to the vest on a basis of visual standard conformance. If the employee is fully covered with background material and reflective striping at 360-degree range, then it seems as though the code could effectively cover the risk of low visibility while greatly decreasing the potential risk for snagging and catching of the vest from excess material.

Following the research conducted within this paper, the next steps to be taken are to develop a narrowly tailored definition of "proper fit." This definition should be one that maintains the integrity of the original purpose of the vest, as a tool to increase visibility, while taking into consideration the unique shape and sizing of differing body types. A definition of "proper fit" built on consideration of all body types will reduce the safety impacts associated with the lacking definition. The concern of improper fit, if not addressed, will only continue to raise more concerns, and yield greater safety incidents as diversity of the construction workforce increases. As the construction industry grows in diversity, it is essential that the safety vest appropriately fits a universal range of body types to ensure every single person is safely covered, rather than dangerously exposed. The next best step in achieving this goal is to evaluate how the ANSI/ISEA 107-2015 code of compliance can address current safety hazards imposed by an improper fitting safety vest.

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