Improving EMS Worker Safety in the Patient Compartment

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Improving EMS Worker Safety in the Patient Compartment

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Table of Contents

Executive Summary

Ambulance crashes are one of many hazards faced by emergency medical services providers (EMSP). Data from the National Institute for Occupational Safety and Health (NIOSH) indicates EMSP experience a fatality rate three times the average national occupational injury rate, and cites ambulance crashes and related vehicle incidents as one of the threats facing EMSP. Studies also found EMSP and patient deaths or serious injuries occurred at a high rate within the patient compartment of the ambulance during transport. These incidents were often related to: EMSP not using restraint systems, such as seatbelts; improperly restrained patients; poorly mounted, unpadded or intrusive equipment that could cause serious head-impact injuries; and structural design deficiencies within the vehicle itself.

EMSP, the Interagency Board (IAB) and national emergency medical services (EMS) associations expressed the need for safer ambulance design standards to the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) First Responders Group (FRG). In an effort to satisfy this request for support, FRG brought together members of the private sector, EMS leaders, and federal research and development partners. Together, this group aimed to design and develop a family of testing methods based on the crash testing of ambulances and their many components to mirror the development of safety standards found in the civilian automobile industry. The goal was to produce test standards and design recommendations that would lead to the next generation ambulance patient compartment and ultimately a safer work and patient care environment.

Acknowledging NIOSH's leadership role in the area of worker safety research, and recognizing the work already underway at NIOSH to develop new safety standards for the patient compartment of an ambulance, FRG chose to partner with NIOSH to support and expand NIOSH's ongoing research program. This support was provided through the funding of two sequential Interagency Agreements: HSHQDC-10-X-00594 and HSHQPM-16-X-00005. The joint research program had three key goals: to develop a family of test methods based on crash testing of an ambulance; to work with national standards development organizations, such as the National Fire Protection Association (NFPA), to have each new test method referenced in bumper-to-bumper ambulance standards; and to provide educational information to ambulance purchasers to inform them of safer ambulance patient compartment designs.

To realize the goals of the program, NIOSH recognized it would require a team approach that brought together those closely associated with the industry. Ultimately, the team would grow to include federal partners, ambulance manufacturers, their supply base and independent testing labs. In developing this industry-government team, NIOSH first partnered with the National Truck Equipment Association's Ambulance Manufacturer's Division (NTEA-AMD). The NTEA-AMD represents the builders of over 90 percent of the new ambulances delivered in North American annually. The NTEA-AMD also counts many of the manufacturers of ambulance components, such as seating, occupant restraints, the patient cot and equipment mounts, as associate members and was able to bring them to the NIOSH industry-government team. Federal partners with a stake in EMSP safety (General

Services Administration, National Highway Traffic Safety Administration and DHS) were actively involved in the industry-government team. The final additions to the NIOSH led team were independent test laboratories. Each of the three independent test laboratories involved in this program (Center for Advanced Product Evaluation, MGA Research, Transportation Research Center) specialize in automotive crash testing. Representatives from each of these entities (government, builders, supply base and testing labs) participated in each of ten test methods development committees co-chaired by NIOSH and the NTEA-AMD.

At the conclusion of this program, the NIOSH-led industry-government team completed a total of ten new published test methods. These test methods were published by the Society for Automotive Engineers International (SAE). Nine of these test methods were published as SAE Recommended Practices and one as an Informational Report. All ten of these new SAE publications have been referenced in two national ambulance standards: the General Services Specification for the Star-of-Life Ambulance (GSA KKK-A-1822F) and the National Fire Protection Association's Automotive Ambulance Standard (NFPA 1917). The first six SAE publications have also been referenced in the Commission for the Accreditation of Ambulance Services Ground Vehicle Standard (CAAS GVS V1.0). It is hoped the remaining four SAE publications will be referenced in the second edition of the CAAS GVS V1.0. Information describing the development of each of the ten SAE publications and the three noted national ambulance standards is contained in an informational video series jointly released by NIOSH and DHS. The video series also includes information regarding EMS worker and patient injuries and fatalities, the development of national bumper-to-bumper ambulance standards by GSA, NFPA and CAAS, as well as the use of the DHS published *Ambulance Patient Compartment Human Factors Design Guidebook* (February 2015).

Improving Emergency Medical Services (EMS) Worker Safety in the Patient Compartment – Final Report

Interagency Agreements: HSHQDC-10-X-00594 and HSHQPM-16-X-00005

Background – Description of Problem

Ambulances are specialty vehicles that due to their size, fall outside most federal motor vehicles safety standards and regulations promulgated by the Department of Transportation's National Highway Traffic Safety Administration (NHTSA). This includes those standards and regulations specifically targeting worker and patient safety in the patient compartment. Absent the federal regulation of an ambulance, many states have stepped in to develop guidance for public and private ambulance services operating in their states.

In the mid-1970s, the federal government's General Services Administration (GSA) drafted the first semblance of a standard when they published the GSA KKK-A-1822 Purchase Specification for the Star-of-Life Ambulance.[1] Over time, the GSA KKK-A-1822 has become the "de facto" standard for the ambulance industry. In the 1980s, ambulance manufacturers, through the National Truck Equipment Association's Ambulance Manufacturer's Division (NTEA-AMD), began developing test standards. The goal was to improve vehicle quality and provide buyers with some assurance that their vehicles met the functional requirements specified in the GSA Purchase Specification. The relationship between GSA and NTEA-AMD remains in place today. The GSA Purchase Specification is now on version F, and is referenced as GSA KKK-A-1822F. Individual Change Notices are released annually to ensure the Purchase Specification remains up-to-date as advances in science and equipment are made.

Unfortunately, despite the best efforts of GSA and the NTEA-AMD, studies by the National Institute for Occupational Safety and Health (NIOSH), NHTSA and other researchers reviewing data over the last 30 years have shown that few workers wear the restraint systems provided in the patient compartment, which is generally a two-point lap belt.[2,3,4,5] Research conducted by NIOSH from 2001 - 2009 also showed that safety concerns could be found with most structural items contained in an ambulance patient compartment.[6,7,8,9,10] Key items of concern included worker seating, the patient cot, equipment mounts, the retention of contents in cabinets and the patient compartment body itself. Each of these items were found to be an issue in a crash due to the lack of testing standards.

In 2009, the Department of Homeland Security's Science and Technology Directorate (DHS S&T) hosted a stakeholder meeting of their First Responder Resource Group (FRRG). The FRRG is comprised of first responders from the various responder disciplines from across the United States. The goal of the FRRG meeting was to identify research priorities to improve responder and civilian safety while responders

are performing their duties. The discussions concentrated on four distinct first responder worker groups: law enforcement, firefighting, emergency medical services and interoperability ((i.e., Command, Control and Communications (C3)). During this process, an issue identified by the emergency medical response subcommittee was the lack of safety standards for an ambulance. Specifically, the group noted there were no science-based testing requirements for vehicles, seating, cots or the ambulance body itself.

Interagency Agreement Summary

As noted above, NIOSH initiated its investigation into ambulance patient compartment safety in 2001, and continued with internally funded studies in 2005 and 2009. As a part of the 2009 study, NIOSH began laying the groundwork to develop new safety standards for seating and the patient cot. This led to NIOSH's participation in the development of the first national consensus standard for an ambulance. This American National Standards Institute (ANSI) accredited process was hosted by the National Fire Protection Association (NFPA). When initially conceived, the NFPA 1917 "Standard for Automotive Ambulances" (NFPA 1917) was expected to replace the GSA Purchase Specification.[11] The NFPA 1917 committee consists of more than 30 voting members and includes representatives from the emergency medical services (EMS) end user community, ambulance and component manufacturers, state regulators, and the federal government. The Department of Homeland Security's Office of Health Affairs was, and still is, represented on the NFPA committee. It was through this committee that NIOSH and DHS connected. Shortly after the first NFPA committee meeting, the NIOSH lead was introduced to DHS S&T and made aware of the FRRG's interest in ambulance safety and the development of ambulance safety standards.

Recognizing NIOSH had a significant head start in this area of research, DHS made the decision to move the bulk of the proposed DHS research effort and funding to NIOSH, with funds allocated to NIOSH under Interagency Agreement (IAA) HSHQDC-10-X-00594. DHS cited the Economy Act as providing the authority to allocate funding to NIOSH for this research effort. The first IAA between DHS and NIOSH was signed in September 2010 using multi-year funds with a prospective timeline of five years. The funding provided under the IAA supplemented NIOSH funding set to run from FY 2009 – FY 2012. Due to research and publication course adjustments (see the *Project Objectives* section of this report), a small follow-on IAA was signed in FY2016 to cover the final two years of this effort. The follow-on IAA, HSHQPM-16-X-00005, was limited to two years with a closing date of September 30, 2017.

Project Objectives

The overarching goal of this effort was to develop a family of testing standards that would provide EMS workers and their patients with the same level of crash protection

as is provided in a passenger vehicle. To accomplish this goal, four key sub-goals were identified:

(1) Development and validation of individual test methods quantifying crash test energy and strength requirements for patient compartment components;

(2) Creation of new components that were designed and tested to meet the new testing requirements;

(3) Publication of the new testing requirements in a nationally recognized, bumper-to-bumper ambulance standard; and

(4) Creation of a communication plan to encourage and expedite adoption of the new testing methods and standards.

Project Execution

To realize the goals of the program, NIOSH recognized it would require a team approach that brought together those closely associated with the industry. Ultimately, the industry-government team would grow to include federal partners, ambulance manufacturers, their supply base and independent testing labs. In developing this industry-government team, NIOSH first partnered with the NTEA-AMD. The NTEA-AMD represents the builders of over 90 percent of the new ambulances delivered in North American annually. The NTEA-AMD also counts many of the manufacturers of ambulance components, such as seating, occupant restraints, the patient cot and equipment mounts, as associate members and was able to bring them to the NIOSH industry-government team. Federal partners with a stake in emergency medical services providers (EMSP) safety (GSA, NHTSA and DHS) were actively involved in the industry-government team. The final additions to the NIOSH-led team were independent test laboratories. Each of the three independent test laboratories involved in this program (Center for Advanced Product Evaluation, MGA Research, Transportation Research Center) specialize in automotive crash testing. Representatives from each of these entities (government, builders, supply base and testing labs) participated in each of ten test methods development committees co-chaired by NIOSH and the NTEA-AMD.

In the effort to develop new component specific test standards or test methods for ambulances, the team first had to understand how energy is transferred through the ambulance to the patient compartment in front, side and rear impacts. Once the energy transfer was characterized, individual testing methods could be developed for components such as seating, cots, equipment mounts, cabinets and the patient compartment body.

Therefore, the first testing and validation processes focused on the characterization and documentation of three unique crash pulses or energy curves, representing each of three crash impact modes (front, side and rear). All testing was conducted using the same impact velocity (30 mph) as required in Federal Motor Vehicle Safety Standards for an automobile. Once crash energy was characterized and published for the front

and side impacts in 2010 and 2011, respectively, individual testing programs were created for seating, the patient cot and cot mounts, equipment mounts, cabinetry and storage devices, and finally the patient compartment structure itself.[12,13] The energy curves or pulses became the input energy for each subsequent testing effort. The requirement for rear impact testing was included in all testing of components like seating and the patient cot, while concurrently making its way through the Society for Automotive Engineers International (SAE) process in advance of its publication in 2014.[14]

The NIOSH industry-government team also understood that the development of testing methods or standards alone would not ensure their use by the EMS community of buyers and end users. To increase the opportunity to accelerate the publication of new test methods and introduce new, safer products to the end user community, NIOSH made the decision to work directly with manufacturing partners to develop and test new products concurrently with the creation of the new testing methods or standards. Recognizing the government did not have the funding or expertise available to complete this project alone, NIOSH formed partnerships with ambulance builders through the NTEA-AMD, both U.S. ambulance cot manufacturers (Ferno and Stryker), four ambulance seating manufacturers (EVS, Serenity, Wise and Jany) and three occupant restraint system manufacturers (IMMI, Intertek and Takata). These relationships were formalized through Research Collaboration Agreements signed with each private sector partner. At the conclusion of the testing program, NIOSH and the partner teams could show that:

(a) The two U.S. cot manufacturers (Ferno and Stryker) produced and validated five different cot and cot mount systems between them, ranging from standard manually loaded cots to fully automated lifting and loading cots.

(b) The three U.S. seat manufacturers (EVS, Wise and Serenity) each produced at least one seating system that could meet or exceed all testing requirements. Jany, a European manufacturer, decided to leave the test program prior to validating a new seat to the proposed test standard.

(c) Two of the three restraint system manufacturers (Intertek and Takata) each tested two or more restraint systems for use on a bench seat that could meet or exceed all testing requirements. The third manufacturer (IMMI) chose to discontinue the development of new restraint systems for a bench seat prior to the conclusion of this program.

(d) Multiple NTEA-AMD ambulance builders could meet the new testing requirements for cabinets or storage devices.

(e) A wide range of equipment mounts (oxygen cylinder mounts, defibrillator mounts, fire extinguisher mounts, suction unit mounts, etc.) met the testing requirements.

(f) An ambulance manufacturer, randomly selected for testing, successfully completed the full vehicle impact and roof crush testing.

(g) Three different ambulance builders could pass the floor strength testing requirements.

The NIOSH decision to include the development of new, stronger and, in some cases, more versatile products from commercial vendors in the test method development process paid great dividends for the NIOSH industry-government team in two ways. First, it greatly accelerated the acceptance of the new tests methods by the SAE Truck Crash Worthiness Committee. Second, it eased industry and end user concerns, and therefore objections, that the proposed test standards would be too expensive and onerous to meet. As each testing program was concluded, the validated testing methods were introduced to SAE for publication. Ultimately, the SAE review and publication process averaged approximately 18 months for this project's remaining seven published test methods.[15-21] The 18 month average timeline is relatively short for new test method publication. This shortened time to publication was greatly enhanced by the fact that the team used manufacturing industry partners to design and manufacturer new products and had video from the testing of both the old and new products. The video clearly demonstrated the significant safety improvements achieved when equipment was built using the new test methods.

Once SAE published the ten testing methods, they became potential references available for consideration by the existing national bumper-to-bumper ambulance design standards and specification. When this program was initiated, there were two guidance documents for building ambulances: GSA's KKK-A-1822 Purchase Specification for the Star-of-Life Ambulance and NFPA's 1917 Automotive Ambulance Standard. By 2014, a third organization, the Commission for the Accreditation of Ambulance Services (CAAS), began development of a new bumper-to-bumper ambulance standard to compete with the NFPA 1917 standard.[22] With any of the three ambulance building guidance documents available for reference by individual states (the individual states regulate ambulance design for their states), the NIOSH lead was required to work with all the issuers of all three design standard documents to ensure the SAE published test methods were referenced uniformly in these documents. While this work continues as this IAA driven project comes to a close, the NIOSH industry-government team has had some successes already with the first six SAE publications referenced in all three national standards: GSA, NFPA and CAAS. The status of this work is described in greater detail later in this report.

The final major component of this project was the development of a communication and outreach program to state regulators and end users. This primarily consisted of the development of an informational video series, to be published on a DVD and in a Web-based format, summarizing all of the work of this program. This task was completed in

the spring of 2017 and the videos were released on May 22, 2017. Additional details regarding this effort are provided later in the report.

Standards Publication Path

When this program was initiated, the relationship between GSA and the NTEA-AMD was well understood by most ambulance builders, end users and most state regulators, and had been the backbone for the ambulance industry for decades. As the program progressed, the inclusion of NFPA and later CAAS into the national ambulance standards community extended the program's timeline. The most dramatic change was the additional requirement to publish all of the test methods through SAE, an ANSI accredited standards development organization, rather than to simply publish them as NTEA-AMD standards. The original plan had been to publish all of the 10 unique test methods as AMD Standards. The change can be visualized in the flow chart provided as Figure 1. This change in publication strategy extended the publication of the test methods an average of 18 months, which in turn extended the timeline for completion of this project**.**

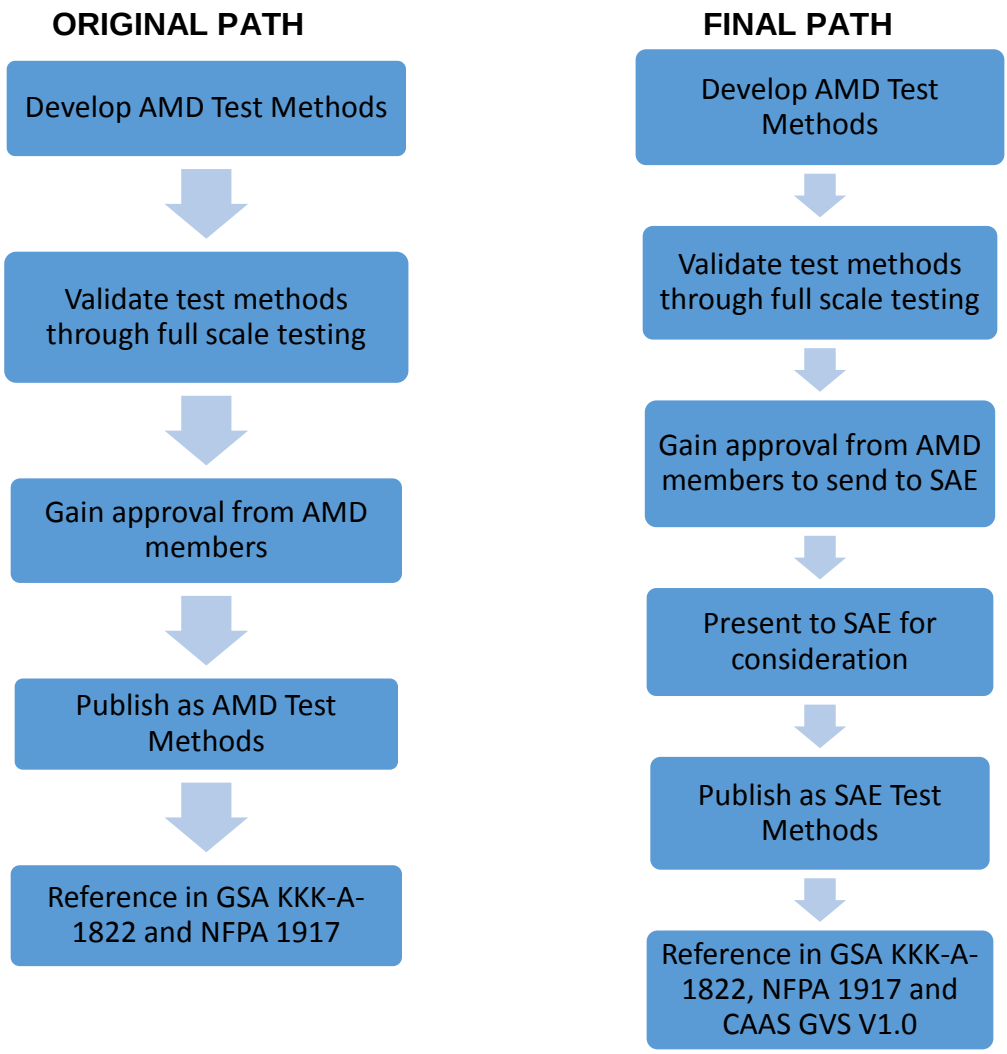


Figure 1: Publication process for individual tests to national standards

Development of SAE Recommended Practices and Information Report

Over the course of this program, NIOSH led the development of nine SAE Recommended Practices and one Informational Report. Publication of the first SAE Recommended Practice (SAE J2917) was in 2010 and was based on earlier testing completed by NIOSH. SAE J2917 was followed by the publication of SAE J2956 in 2010 and SAE J3026, J3027, J3043 and J3044 in 2014. All but SAE J3043 was revised and published as a second revision in 2016. SAE J3058 was published in 2016 and the remaining three (SAE J3057, J3059 and J3102) were published in 2017. A brief description of each publication is provided below.

SAE J2917: *Occupant Restraint and Equipment Mounting Integrity - Frontal Impact System-Level Ambulance Patient Compartment*. During our full vehicle crash testing, we measured the energy transferred to the patient compartment using accelerometers. The input velocity for the vehicle was 30 mph, which

matches frontal impact testing for a passenger vehicle as required by the Federal Motor Vehicle Safety Standards (FMVSS). Accelerometer data is plotted as acceleration over time. The plot is often referred to as the “crash pulse.” A “crash pulse” can be recreated in a lab to test individual components like a seat, the patient cot or an equipment mount. Using a “crash pulse” in a lab is far cheaper than crashing whole vehicles repeatedly. This SAE Recommended Practice characterizes the “crash pulse” for an ambulance frontal crash impact.

SAE J2956: ***Occupant Restraint and Equipment Mounting Integrity - Side Impact System-Level Ambulance Patient Compartment***. This SAE Recommended Practice characterizes the “crash pulse” for a side crash impact. Because the side impact testing required under FMVSS is specifically focused on intrusion to the driver side door, the NIOSH-led industry-government team chose to use the Side Impact Test Protocol published by the Insurance Institute for Highway Safety (IIHS). The IIHS test uses a moving deformable barrier (MDB) weighing 3300 lb. and traveling at 50 kilometers (km) per hour to impact the side of the vehicle at a 90 degree angle.

SAE J3026: ***Ambulance Patient Compartment Seating Integrity and Occupant Restraint***. The testing requirements for all occupant seating in the patient compartment is provided in this SAE Recommended Practice. It requires testing with a 50th percentile male anthropometric test device (crash test dummy). It also includes and describes the pass/fail criteria. It uses the crash pulses described in SAE J2917, SAE J2956 and SAE J3044 for the input energy for testing to represent front, side and rear impacts.

SAE J3027: ***Ambulance Litter Integrity, Retention, and Patient Restraint***. The testing requirements for the patient cot, cot floor mount and patient restraint systems are described in this SAE Recommended Practice. It requires testing with a 50th percentile male anthropometric test device (crash test dummy). It also includes the pass fail criteria. It uses the crash pulses described in SAE J2917, SAE J2956 and SAE J3044 for the input energy for testing to represent front, side and rear impacts.

SAE J3043: Ambulance Equipment Mount Device or Systems. This SAE Recommended Practice provides the testing requirements for all equipment mounted in the patient compartment. The goal of this new SAE Recommended Practice is to reduce or eliminate EMS workers from placing loose equipment on work surfaces or adjacent seating, and instead placing them in tested mount systems. This equipment could include oxygen (O_2) cylinders, fire extinguishers, defibrillators, suction units, etc. It uses the crash pulses described in SAE J2917, SAE J2956 and SAE J3044 for the input energy for testing to represent front, side and rear impacts.

SAE J3044: ***Occupant Restraint and Equipment Mounting Integrity - Rear Impact System-Level Ambulance Patient Compartment.*** The “crash pulse” for a rear crash impact is characterized in this SAE Recommended Practice.

SAE J3057: ***Ambulance Modular Body Evaluation-Quasi-Static Loading for Type I and Type III Modular Ambulance Bodies***. The testing requirements for the entire modular ambulance body structure is provided in this SAE Recommended Practice. It does not cover van style ambulance bodies, as they already fall under Federal Motor Vehicle Safety Standards testing requirements since their weight is under 10,000 lb. The test for the modular body is a two part test. The first phase includes an impact at the roof line to simulate a rolling impact hitting the ground. The second phase of the test includes a roof crush test with a load applied directly to the roof of the now damaged box, which simulates the modular body coming to rest on its roof.

SAE J3058: ***Ambulance Interior Storage Compartment Integrity***. This SAE Recommended Practice is a companion to SAE J3043. The goal of this Recommended Practice is to ensure any storage device (for example, an interior cabinet) remains closed during a crash so that equipment and supplies do not become projectiles that could injure workers or patients. It uses the crash pulses described in SAE J2917, SAE J2956 and SAE J3044 for the input energy for testing to represent front, side and rear impacts.

SAE J3059: ***Ambulance Patient Compartment Seated Occupant Excursion Zone Evaluation***. This SAE Information Report describes the testing and reporting procedures that may be used to evaluate and document the excursion (i.e., travel) of a worker or civilian when transported in a seated and restrained position in the patient compartment of a ground ambulance when exposed to a front, side or rear impact. The goal of the document is to provide seating and occupant restraint manufacturers, ambulance builders and end-users with testing procedures and documentation methods needed to identify head travel paths in crash loading events. If the head travel paths are known, an ambulance interior can be designed to reduce or perhaps eliminate head impacts on equipment or internal storage devices. These measurements should be taken when completing SAE J3026 testing so no additional testing is needed.

SAE J3102: ***Ambulance Patient Compartment Structural Integrity Test to Support SAE J3027 Compliant Litter Systems***. This SAE Recommended Practice describes the dynamic and static testing procedures required to evaluate the integrity of the ambulance substructure to support the safe mounting of an SAE J3027 compliant litter retention device or system when exposed to a frontal, side or rear impact (i.e., a crash impact). This testing ensures the floor substructure is strong enough to retain the crashworthy cot system. It can be completed concurrently with SAE J3027 or as a standalone test.

Incorporation of SAE Documents into National Standards – Progress to Date

These new SAE documents are now being adopted into each of three national, bumper-to-bumper ambulance standards. As previously mentioned, these bumper-to-bumper standards are published by the GSA, NFPA and CAAS. So far, the first six SAE Recommended Practice documents that were published (SAE J2917, J2956, J3026, J3027, J3043 and J3044) are referenced in all three ambulance standards documents. The remaining four SAE documents (SAE J3057, J3058, J3059 and J3102) were published from November 2016 to April 2017. Each of the four new SAE documents has been referenced in the July 1, 2017, Change Notice to the GSA Purchase Specification (GSA KKK-A-1822F). These four documents are also referenced in the 2019 Edition (in draft) of the NFPA Automotive Ambulance Standard (NFPA 1917), which is scheduled for publication in late 2018. CAAS is expected to begin the revision of their Ground Vehicle Standard (GVS V1.0) in the fall of 2017. It is hoped they, too, will consider adopting SAE J3057, J3058, J3059 and J3102 in their 2nd Edition.

In the U.S., individual states regulate the building and licensing of an ambulance. Therefore, the final step in this ambulance standards development process will be the adoption of one of the new bumper-to-bumper standards into each state's regulatory language. Today, thirty states reference the GSA Purchase Specification in some form, though some are referencing earlier revisions only. As part of this effort, the NIOSH representative has worked very closely with the National Association of State EMS Officials (NASEMSO) to educate its members. While some states (Virginia, North Carolina and Pennsylvania) are clearly onboard with the goals of this project, many are still far behind when it comes to recognizing the gaps in their states' regulatory language and direction to EMS providers.

Anthropometry Study

Human sizing data can be used to develop properly fitting personal protective clothing for unique professions, such as EMS. It can also be used, in a broader sense, to design a better workstation to improve worker safety and efficiency; in this case, an ambulance patient compartment. This anthropometry study was conducted by NIOSH with funding support from DHS, to determine whether or not the EMS population fits within the existing general population sizing data. The survey was conducted from November 2014 through May 2016, and covered eight cities around the country (Richmond, Virginia; Tallahassee, Florida; Ft. Worth, Texas; Phoenix, Arizona; Boise, Idaho; Mount View, Minnesota; Columbus, Ohio; and Hartford, Connecticut). A total of 40 manual measurements were taken from 632 human subjects (472 males) using traditional manual measurement techniques. A total of 553 subjects were also measured using a whole body scanning system. Scanning system failure prevented scanning of human subjects at the Ft. Worth, Texas, site. Thirteen key body dimensions were compared between this dataset and the Civilian American and

European Surface Anthropometry Resource Project (CAESAR; the most comprehensive source for body measurement data). The comparison showed that the male emergency medical technicians (EMTs) were significantly larger than the average U.S. males in 11 (out of 13) dimensions, while the female EMTs were significantly larger than the average U.S. females in 9 (out of 13) dimensions. The dataset has convincingly shown that the EMS population falls outside the general population in physical dimensions. This finding would have important applications to the workstation design in the ambulance patient compartment. This data could be used to update the data utilized in the *Ambulance Patient Compartment Human Factors Design Guidebook* should an update to that document be commissioned. Results from this study can be found at the following site: https://www.cdc.gov/niosh/data/datasets/rd-1008-2016-0/default.html.

Development and Distribution of the Informational Video Series

NIOSH has developed a seven module, 70-minute video series covering a significant portion of the ambulance crash safety related work conducted by the federal government over the last 15 years. The video series includes input from projects conducted by the NHTSA Office of EMS and their Special Crash Investigation Division, the National Institute of Standards and Technology (NIST) with DHS S&T support, and other components of NIOSH outside of those research tasks covered by the NIOSH/DHS IAAs. The video series also provides a detailed review of the 10 SAE documents developed and published under the NIOSH/DHS IAAs. The goal of the video series is to provide EMS officials, end users and vehicle purchasers with the information they need to better understand the risks inherent in the operation of an ambulance, as well as the great opportunities available to increase EMS worker efficiency and occupant safety. The seven video modules are titled as follows:

Video 1: Ambulance History, Injury Statistics & Standards

Video 2: Crash Testing an Ambulance

Video 3: Patient Compartment Seating & Restraints

Video 4: Patient Cot, Cot Mount & Patient Restraint

Video 5: Equipment Mount & Storage Device Testing

Video 6: Building a Stronger Patient Compartment

Video 7: Using the Ambulance Patient Compartment Human Factors Design Guidebook

The video series was completed during the first week of May 2017, and was released to the public on the NIOSH website during National EMS Week, May 22 – 27, 2017. In addition to the release of the videos online, NIOSH has also conducted an extensive outreach program through social media to enhance awareness of the availability of these videos. Finally,

NIOSH printed 300 copies of the DVD and mailed them, along with a copy of the Infographic (Appendix 1), to each state EMS Director and Medical Director, as well as federal partners and manufacturing partners.

Completed Communication Dissemination Efforts

To promote the video series and support video viewing, NIOSH used a strategic, multi-channel approach to reach and engage its stakeholders, partners and the EMS community. To do this, NIOSH coincided its communication dissemination efforts with the National EMS Week Health and Safety Observance. NIOSH communications during this week leveraged Web, press, email, electronic newsletters and bulletins, an infographic (Appendix 1), and a host of social media messages. To gauge effectiveness, NIOSH continues to measure the impact of its outreach program through social media metrics (Appendix 2). A complete list of these communications is provided below:

- Ambulance Video Series: https://www.cdc.gov/niosh/topics/ems/videos.html
- NIOSH Press Release: https://www.cdc.gov/niosh/updates/upd-05-22-17.html
- NIOSH Homepage Banner with link to Video Series (posted 5/22-5/30; banner pictured below)

- NIOSH EMS Topic Page 'What's New' feature: https://www.cdc.gov/niosh/topics/ems/default.html
- CDC Features Article: https://www.cdc.gov/features/ambulance-test-methods/index.html
- NIOSH Science Blog: https://blogs.cdc.gov/niosh-science-blog/2017/05/22/ambulance-safety/
- Ambulance Test Methods Infographic: https://www.cdc.gov/niosh/topics/ems/pdfs/Ambulance-INFOGRAPHIC-051617.pdf
- Colleague Email: Sent email with link to video series to ~250 professional contacts
- Research Rounds Article
- NIOSH eNews Announcement

- Social Media:
  - Facebook – @niosh – 3 posts
  - Twitter – @NIOSH – 10 tweets
  - Instagram – @nioshusa – 3 posts

Summary

When this program was initiated, the primary focus was the development of a family of new standards for the design and testing of an ambulance. The underlying goal for each new standard was to improve worker safety, while enhancing a worker's ability to effectively care for his or her patient. As the government's team reviewed the needs and opportunities, internal decisions were made to partner with the ambulance manufacturing industry to develop new products concurrent with the development of new standards. This approach allowed the publication of the new standards to proceed expeditiously, and also accelerated the introduction of new and safer worker seating and patient cots to the market.

At the conclusion of this project, the NIOSH-led industry-government team authored and published 10 new test methods through the Society of Automotive Engineers. Each of the 10 SAE publications was referenced in national ambulance standards published by the GSA and NFPA. In addition, CAAS has referenced the first six SAE publications. Finally, the DHS and NIOSH partnership has jointly released a 70 minute video series covering all aspect of this project on the Web. Since ambulances are regulated at the state level, work will need to continue within individual states to ensure these new standards are adopted.

References

1. U.S. General Services Administration. (2007). Federal Specification for the Star-of-Life Ambulance (KKK-A-1822F, with Change Notices 1 - 10). https://www.nasemso.org/Projects/AgencyAndVehicleLicensure/documents/KKK-A-1822F-08.01.2007_000.pdf
2. Proudfoot SL, Romano NT, Bobick TG, Moore PH. Ambulance Crash-Related Injuries Among Emergency Medical Service Workers, United States, 1991- 2002. Div. of Safety Research, National Institute for Occupational Safety and Health, CDC, Morbidity and Mortality Weekly Report, February 28, 2003, Vol. 52, No. 8. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5208a3.htm
3. Larmon B, LeGassick TF, Schriger DL. "Differential front and back seat safety belt use by prehospital care providers." Am J Emerg Med 1993;11:595—9.
4. Reichard, A., Marsh, S., Moore, P. (2011). Fatal and Nonfatal Injuries Among Emergency Medical Technicians and Paramedics. Prehospital Emergency Care, Volume 15/Number 4. http://www.tandfonline.com/doi/full/10.3109/10903127.2011.598610
5. NHTSA (2014). The National Highway Traffic Safety Administration and Ground Ambulance Crashes. April 2014. Presentation. https://www.ems.gov/pdf/GroundAmbulanceCrashesPresentation.pdf
6. NIOSH (2004). "Evaluation of Emergency Service Vehicle Occupant Safety", National Association of State EMS Directors, Park City, UT. (Green JD October Presentation
7. NIOSH (2006). "Ambulance Crash Injuries Among EMS Workers", Fire-Rescue-Med 2006, Las Vegas, NV. (Moore, PH) April 1, 2006. Presentation.
8. NIOSH (2007) "Ambulance Research at NIOSH: Improving EMS Worker Safety." Havre de Grace Ambulance Corps, Inc., Havre de Grace, MD. (Green JD) April 14, 2007. Presentation.
9. NIOSH (2008). "EMS Worker Safety Research At NIOSH," Ambulance Manufacturers Division of the National Truck Equipment Association, Dearborn, MI. (Green JD) October 2, 2008. Presentation.
10. NIOSH (2009). "Development of Standards for Ambulance Passenger Compartment Design to Enhance the Performance and Safety of Patients and EMS Personnel." Department of Homeland Security, First Responders Working Group, Arlington, VA. (Green JD) March 9, 2009. Presentation.
11. NFPA. (2016). Standard for Automotive Ambulances (NFPA 1917). National Fire Protection Agency. http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1917
12. SAE (2016). SAE J2917, Occupant Restraint and Equipment Mounting Integrity – Frontal Impact System-Level Ambulance Patient Compartment. Society of Automotive Engineers. http://standards.sae.org/j2917_201005/
13. SAE (2016). SAE J2956, Occupant Restraint and Equipment Mounting Integrity – Side Impact System-Level Ambulance Patient Compartment. Society of Automotive Engineers. http://standards.sae.org/j2956_201608/

14. SAE (2016). SAE J3044, Occupant Restraint and Equipment Mounting Integrity – Rear Impact System-Level Ambulance Patient Compartment. Society of Automotive Engineers. http://standards.sae.org/j3044_201608/

15. SAE (2016). SAE J3026, Ambulance Patient Compartment Seating Integrity and Occupant Restraint. Society of Automotive Engineers. http://standards.sae.org/j3026_201611/

16. SAE (2016). SAE J3027, Ambulance Litter Integrity, Retention, and Patient Restraint. Society of Automotive Engineers. http://standards.sae.org/j3027_201611/

17. SAE (2014). SAE J3043 Ambulance Equipment Mount Device or Systems. Society of Automotive Engineers. http://standards.sae.org/j3043_201407/

18. SAE (2016). SAE J3057, Ambulance Modular Body Evaluation-Quasi-Static Loading for Type I and Type III Modular Ambulance Bodies. Society of Automotive Engineers. http://standards.sae.org/j3057_201702/

19. SAE (2016). SAE J3058, Ambulance Interior Storage Compartment Integrity. Society of Automotive Engineers. http://standards.sae.org/j3058_201611/

20. SAE (2016). SAE J3059, Ambulance Patient Compartment Seated Occupant Excursion Zone Evaluation. Society of Automotive Engineers. http://standards.sae.org/j3059_201704/

21. SAE (2016). SAE J3102, Ambulance Patient Compartment Structural Integrity Test to Support SAE J3027 Compliant Litter Systems. Society of Automotive Engineers. http://standards.sae.org/j3102_201703/

22. CAAS (2016). Ground Vehicle Standard, (GVS V1.0). Commission for the Accreditation of Ambulance Services. http://www.groundvehiclestandard.org/wp-content/uploads/2016/03/CAAS_GVS_v_1_0_FinalwDates.pdf

23. DHS (2015). Department of Homeland Security, Science & Technology Directorate, First Responders Group, "Ambulance Patient Compartment Human Factors Design Guidebook," February 2015. https://www.dhs.gov/sites/default/files/publications/Ambulance%20Patient%20Compartment%20Human%20Factors%20Design%20Guidebook.pdf

24. U.S. General Services Administration. (2007). Federal Specification for the Star-of-Life Ambulance (KKK-A-1822F, with Change Notices 1 - 10). https://www.nasemso.org/Projects/AgencyAndVehicleLicensure/documents/KKK-A-1822F-08.01.2007_000.pdf

25. Proudfoot SL, Romano NT, Bobick TG, Moore PH. Ambulance Crash-Related Injuries Among Emergency Medical Service Workers, United States, 1991- 2002. Div. of Safety Research, National Institute for Occupational Safety and Health, CDC, Morbidity and Mortality Weekly Report, February 28, 2003, Vol. 52, No. 8. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5208a3.htm

26. Larmon B, LeGassick TF, Schriger DL. "Differential front and back seat safety belt use by prehospital care providers." Am J Emerg Med 1993;11:595—9.

27. Reichard, A., Marsh, S., Moore, P. (2011). Fatal and Nonfatal Injuries Among Emergency Medical Technicians and Paramedics. Prehospital Emergency Care, Volume 15/Number 4. http://www.tandfonline.com/doi/full/10.3109/10903127.2011.598610

28. NHTSA (2014). The National Highway Traffic Safety Administration and Ground Ambulance Crashes. April 2014. Presentation. https://www.ems.gov/pdf/GroundAmbulanceCrashesPresentation.pdf

29. NIOSH (2004). "Evaluation of Emergency Service Vehicle Occupant Safety", National Association of State EMS Directors, Park City, UT. (Green JD October Presentation

30. NIOSH (2006). "Ambulance Crash Injuries Among EMS Workers", Fire-Rescue-Med 2006, Las Vegas, NV. (Moore, PH) April 1, 2006. Presentation.

31. NIOSH (2007) "Ambulance Research at NIOSH: Improving EMS Worker Safety." Havre de Grace Ambulance Corps, Inc., Havre de Grace, MD. (Green JD) April 14, 2007. Presentation.

32. NIOSH (2008). "EMS Worker Safety Research At NIOSH," Ambulance Manufacturers Division of the National Truck Equipment Association, Dearborn, MI. (Green JD) October 2, 2008. Presentation.

33. NIOSH (2009). "Development of Standards for Ambulance Passenger Compartment Design to Enhance the Performance and Safety of Patients and EMS Personnel." Department of Homeland Security, First Responders Working Group, Arlington, VA. (Green JD) March 9, 2009. Presentation.

34. NFPA. (2016). Standard for Automotive Ambulances (NFPA 1917). National Fire Protection Agency. http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1917

35. SAE (2016). SAE J2917, Occupant Restraint and Equipment Mounting Integrity – Frontal Impact System-Level Ambulance Patient Compartment. Society of Automotive Engineers. http://standards.sae.org/j2917_201005/

36. SAE (2016). SAE J2956, Occupant Restraint and Equipment Mounting Integrity – Side Impact System-Level Ambulance Patient Compartment. Society of Automotive Engineers. http://standards.sae.org/j2956_201608/

37. SAE (2016). SAE J3044, Occupant Restraint and Equipment Mounting Integrity – Rear Impact System-Level Ambulance Patient Compartment. Society of Automotive Engineers. http://standards.sae.org/j3044_201608/

38. SAE (2016). SAE J3026, Ambulance Patient Compartment Seating Integrity and Occupant Restraint. Society of Automotive Engineers. http://standards.sae.org/j3026_201611/

39. SAE (2016). SAE J3027, Ambulance Litter Integrity, Retention, and Patient Restraint. Society of Automotive Engineers. http://standards.sae.org/j3027_201611/

40. SAE (2014). SAE J3043 Ambulance Equipment Mount Device or Systems. Society of Automotive Engineers. http://standards.sae.org/j3043_201407/

41. SAE (2016). SAE J3057, Ambulance Modular Body Evaluation-Quasi-Static Loading for Type I and Type III Modular Ambulance Bodies. Society of Automotive Engineers. http://standards.sae.org/j3057_201702/

42. SAE (2016). SAE J3058, Ambulance Interior Storage Compartment Integrity. Society of Automotive Engineers. http://standards.sae.org/j3058_201611/

43. SAE (2016). SAE J3059, Ambulance Patient Compartment Seated Occupant Excursion Zone Evaluation. Society of Automotive Engineers. http://standards.sae.org/j3059_201704/

44. SAE (2016). SAE J3102, Ambulance Patient Compartment Structural Integrity Test to Support SAE J3027 Compliant Litter Systems. Society of Automotive Engineers. http://standards.sae.org/j3102_201703/

45. CAAS (2016). Ground Vehicle Standard, (GVS V1.0). Commission for the Accreditation of Ambulance Services. http://www.groundvehiclestandard.org/wp-content/uploads/2016/03/CAAS_GVS_v_1_0_FinalwDates.pdf

46. DHS (2015). Department of Homeland Security, Science & Technology Directorate, First Responders Group, "Ambulance Patient Compartment Human Factors Design Guidebook," February 2015. https://www.dhs.gov/sites/default/files/publications/Ambulance%20Patient%20Compartment%20Human%20Factors%20Design%20Guidebook.pdf

Disclaimer: Mention of company names or products does not imply endorsement by the National Institute for Occupational Safety and Health or the Department of Homeland Security.

Appendix 1: NIOSH Ambulance Infographic

Ambulance Crash Test Methods

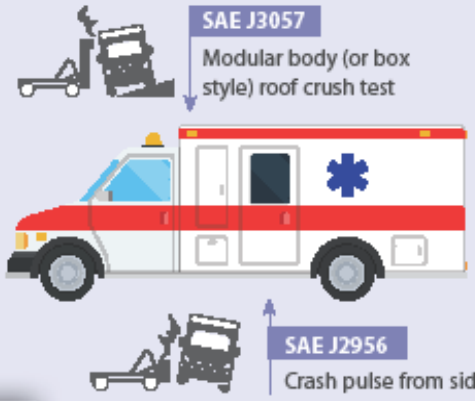
Keeping Emergency Medical Services Workers Safe on the Job

NIOSH and the Department of Homeland Security's Science and Technology Directorate partnered with other federal agencies and the ambulance manufacturing industry to conduct ambulance crash testing to reduce and eliminate crash-related injuries and deaths to Emergency Medical Services (EMS) workers in the patient compartment. These dynamic crash tests contributed to the development of 10 test methods published by the Society of Automotive Engineers (SAE).

DYNAMIC CRASH TESTS

17	15	60+	100+	150	400
full vehicle crash tests	storage cabinet tests	patient cot tests	equipment mount tests	seat and restraint tests	head impact tests

TEST METHODS – EXTERIOR



SAE J3057
Modular body (or box style) roof crush test

SAE J2917
Crash pulse from frontal impact

SAE J3044
Crash pulse from rear impact

SAE J2956
Crash pulse from side impact

TEST METHODS – INTERIOR

SAE J3026
EMS worker seating and restraints

SAE J3027
Patient cot, floor mount, and restraint system integrity test

SAE J3043
Ambulance equipment mount devices and systems integrity test

SAE J3058
Storage device integrity test

SAE J3059
Measurement of EMS worker head movement during a crash event

SAE J3102
Patient cot subfloor integrity test

Watch our video series to learn more about the many changes impacting ambulance design, testing, and manufacture: www.cdc.gov/niosh/topics/ems/videos.html

CDC Workplace Safety & Health NIOSH

Homeland Security
Science and Technology

Appendix 2: Ambulance Video Series Metrics – May 21-27, 2017

Ambulance Video Series:

Improving EMS Worker Safety Through Ambulance Design and Testing

Metrics Report for National EMS Week: May 21-27

Background

NIOSH partnered with Department of Homeland Security's Science and Technology Directorate as well as other federal agencies and the ambulance industry to develop a seven-part video series that covers new crash test methods. The series highlights changes impacting ambulance design, testing, and manufacture to improve safety for EMS workers and their patients.

Objectives

- Inform the EMS community and ambulance industry about the availability of the video series
- Encourage video viewing among the EMS community and ambulance industry to improve knowledge and familiarity of the new test standards impacting ambulance design, testing, and manufacture

Results

Web (month of May)

2,006 Page Visits

EMS Videos

Social Media (most popular)

3,240 Impressions

It's #NationalEMSWeek Watch NIOSH & @dhsscitech new video series on improving ambulance safety https://t.co/DIYTLGnRor https://t.co/uZCRJSsfMQ (included video cover image)

10,127 Reach

Did you know that NIOSH and DHS Science and Technology Directorate partnered with the ambulance manufacturing industry and other federal agencies to conduct ambulance crash tests? Testing efforts contributed to 10 new test methods published by the Society of Automotive Engineers (SAE). #NationalEMSWeek http://go.usa.gov/xN845 (included infographic image)

Earned Media

EMS1.com
EMS World
Occupational Health & Safety Online
NSC Safety + Health
SUN News

Campaign Codes (top channels)

212 clicks to video page from **eNews**

208 clicks to video page from **homepage banner**

Communications Plan

~ **250** Emails to State & Medical Directors
250 DVDs mailed to EMS leaders
12 Tweets*
3 Facebook Posts*
3 Instagram Posts*
1 NIOSH Homepage Banner
1 CDC Features Article
1 NIOSH Update
1 NIOSH Science Blog
1 Behind the Wheel at Work (June)
1 NIOSH Research Rounds (June)
1 NIOSH eNews (June)

*Does not include additional social messaging efforts by the NIOSH Communications Office

NEW Communication Product

NIOSH-DHS co-branded infographic

Industry Praise

"I think that the videos are very valuable, especially for communicating with Emergency Personnel. They get much more out of a simply communicated video than with having to read pages of text..."

- FEMA employee

Want more information about NIOSH promotion related to this effort? Contact Sydney Webb, PhD, at yht4@cdc.gov

Division of Safety Research

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