Collaborative Development of Ambulance Crash Safety Standards: A Progress Report

Presented by: Jim Green, NIOSH, Safety Engineer

National Association of State EMS Officials: Sept. 18, 2013

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Presentation Overview

- Background & Participants
- Review Crash Test Standard Development
  - Crash Pulses
  - Seating and Restraints
  - Patient Cot and Restraint
  - Equipment Mounts
  - Body Integrity
- Incorporation of Standards – The Future?
  - GSA KKK-A-1822
  - NFPA 1917

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Background & Participants

Bringing the right expertise to address the problems to be solved:

Improving Occupant Safety

Overarching Goals of this Research Partnership (NIOSH and AMD)

- Provide patient compartment occupants with the same level of crash protection as passenger vehicles
- Work with end users to ensure designs meet needs
- Near Term: Develop system specific standards for publication to be referenced nationally or internationally
- Long Term: Incorporate changes into one or more bumper-to-bumper ambulance national standards

*** Most Importantly - Ensure all proposed standards are based on actual test data ***

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Automotive Testing Expertise Applied

- Testing performed by three private companies at five different crash test facilities from Wisconsin to Virginia
  - Center for Advanced Product Evaluation (CAPE)
  - MGA Research
  - Transportation Research Center
- Government research support
  - National Highway Traffic Safety Administration's
    - Vehicle Research Test Center, East Liberty, Ohio
    - Office of Vehicle Crashworthiness Research, Washington, DC
  - Federal Aviation Administration's
    - Crash Dynamics, FAA Aviation Safety
    - Civil Aerospace Medical Institute

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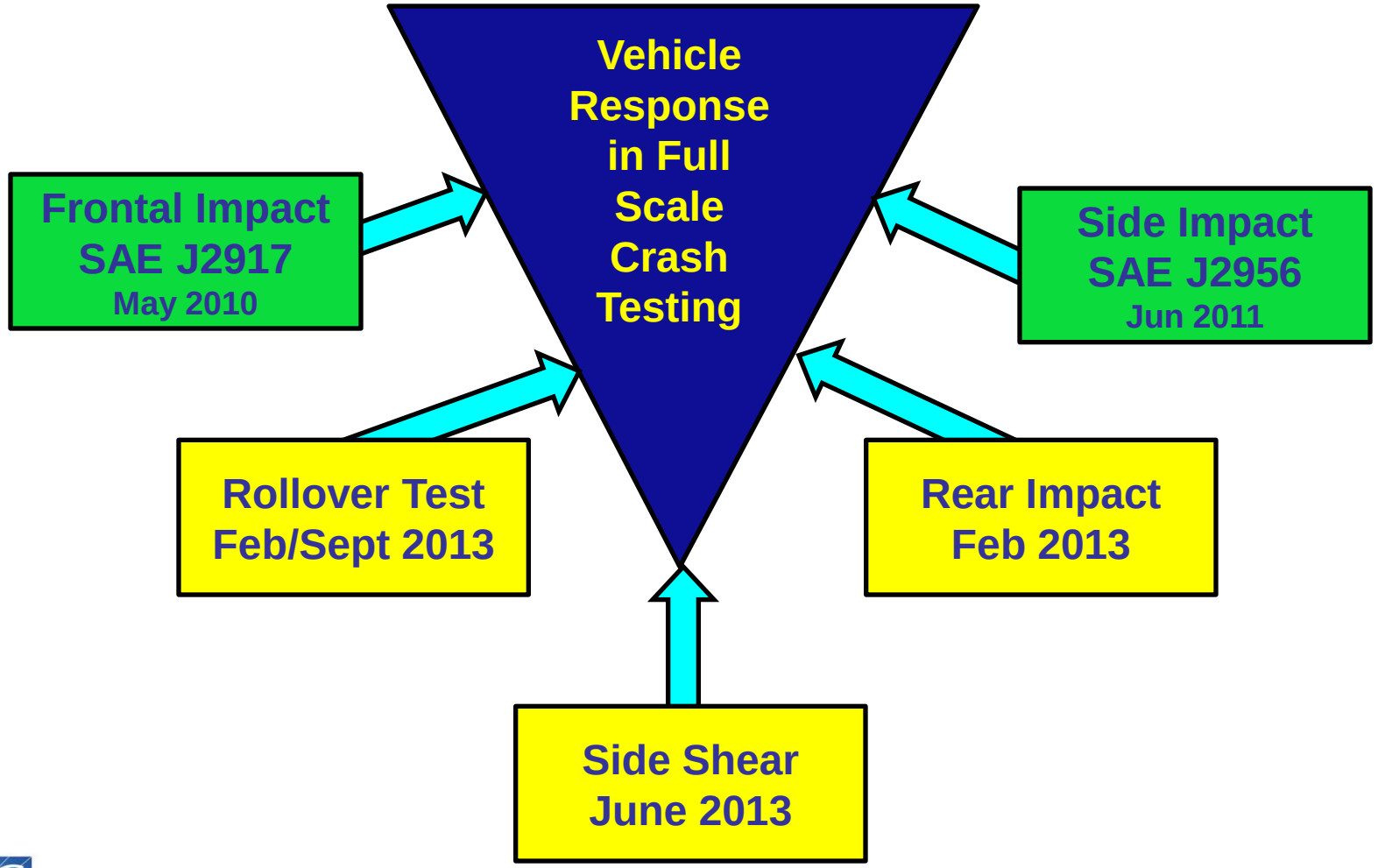
Auto Testing Principals & Tools Utilized

- Anthropometric Test Devices (crash test dummies)
  - Hybrid III for frontal impact testing
  - ES2-re for side impact testing
  - Utilized the same human injury tolerances values as required in Federal Motor Vehicle Safety Standards (FMVSS)
- NHTSA FMVSS Frontal Crash Impact Velocities
- Insurance Institute for Highway Safety (IIHS) Side Impact Crashworthiness Evaluation Crash Test Protocol
- IIHS Moving Deformable Barrier – Side and Rear Impacts

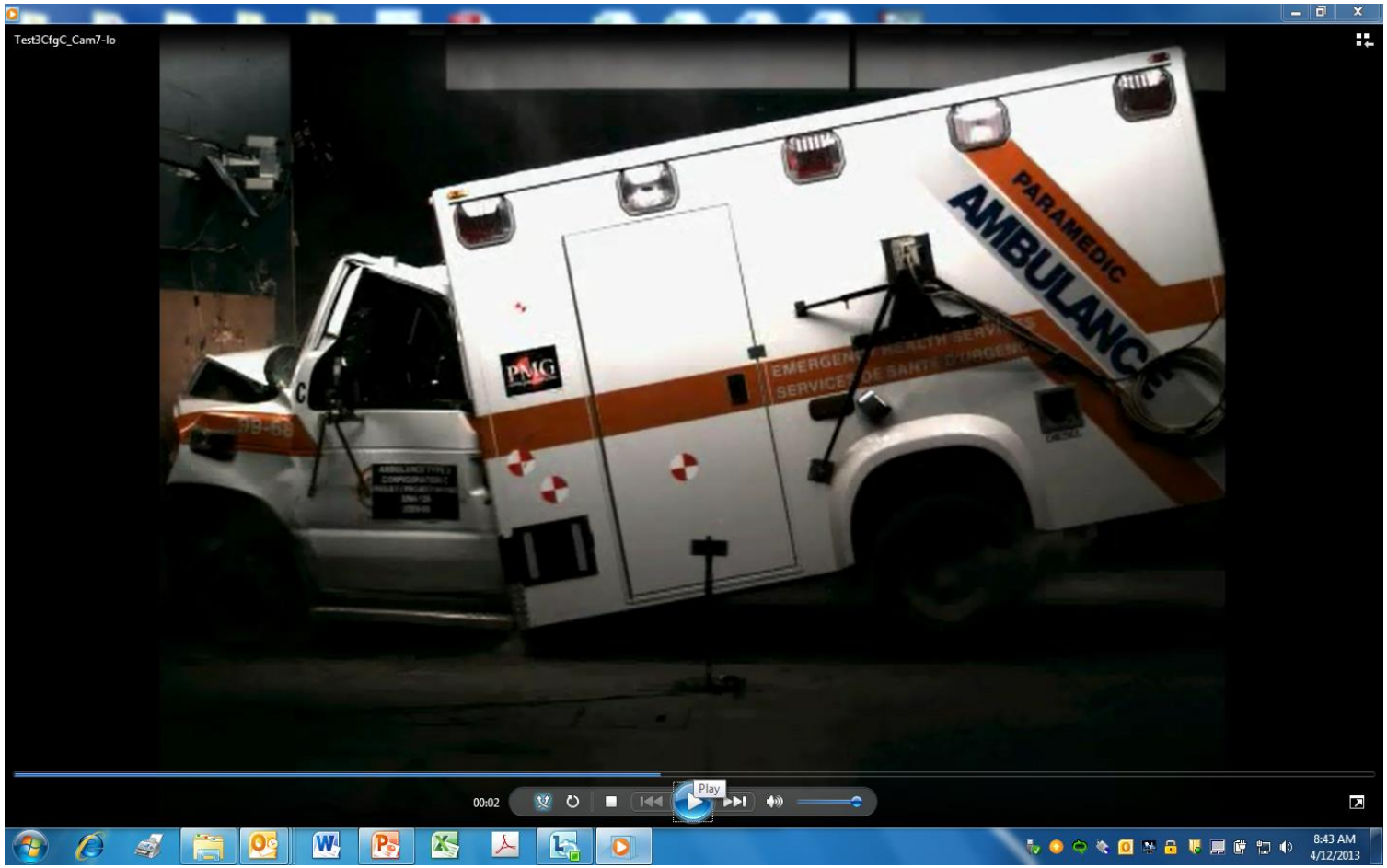
Crash Standard Development

Vehicle Response Provides Foundation for Future Work

Understanding Vehicle Crash Response

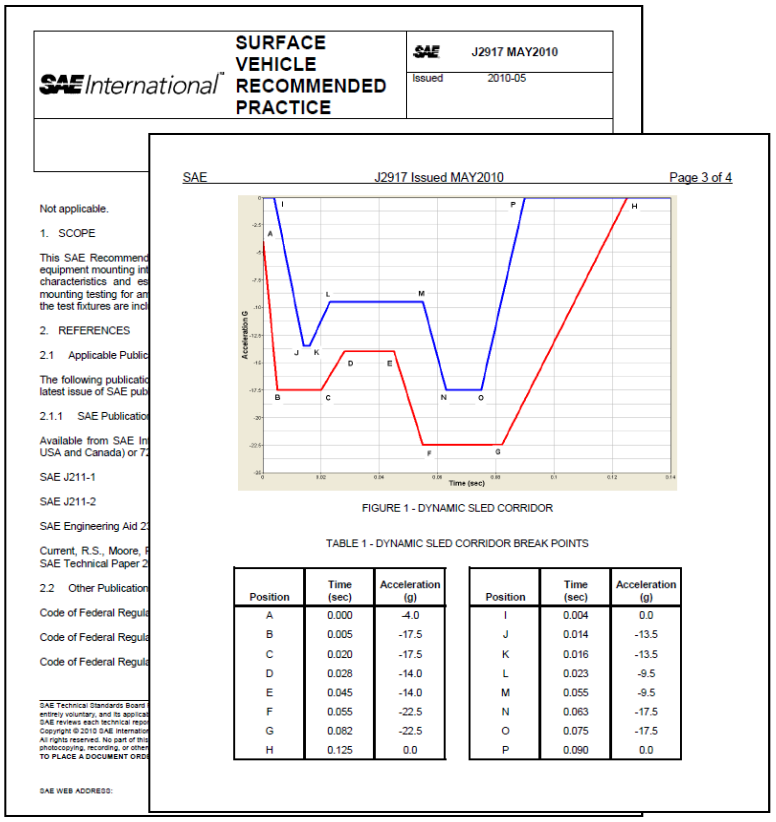


Frontal Impact – 3 Conducted Matches Federal Standard



Side Impact – 4 Conducted Matches IIHS Side Impact Test

Testing Criteria – Frontal & Side Impact



SAE International | SURFACE VEHICLE RECOMMENDED PRACTICE | SAE J2917 MAY2010 | Issued 2010-05

SAE J2917 Issued MAY2010 Page 3 of 4

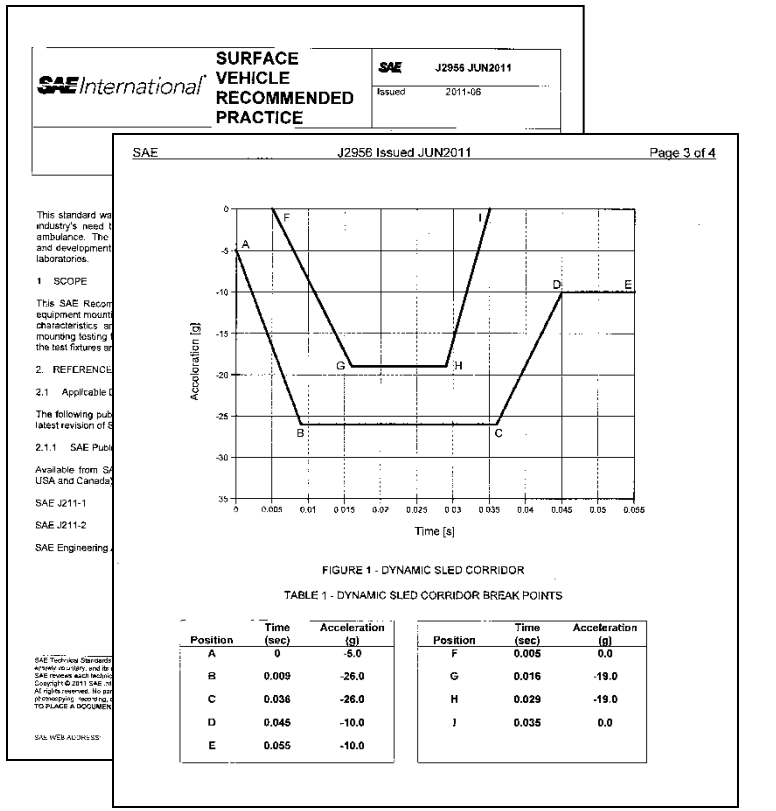
FIGURE 1 - DYNAMIC SLED CORRIDOR

TABLE 1 - DYNAMIC SLED CORRIDOR BREAK POINTS

Position	Time (sec)	Acceleration (g)
A	0.000	-4.0
B	0.005	-17.5
C	0.020	-17.5
D	0.028	-14.0
E	0.045	-14.0
F	0.055	-22.5
G	0.082	-22.5
H	0.125	0.0

Position	Time (sec)	Acceleration (g)
I	0.004	0.0
J	0.014	-13.5
K	0.016	-13.5
L	0.023	-9.5
M	0.055	-9.5
N	0.063	-17.5
O	0.075	-17.5
P	0.090	0.0

SAE J2917- Ambulance Patient Compartment Frontal HYGE Sled Pulse, May 2010



SAE International | SURFACE VEHICLE RECOMMENDED PRACTICE | SAE J2956 JUN2011 | Issued 2011-06

SAE J2956 Issued JUN2011 Page 3 of 4

FIGURE 1 - DYNAMIC SLED CORRIDOR

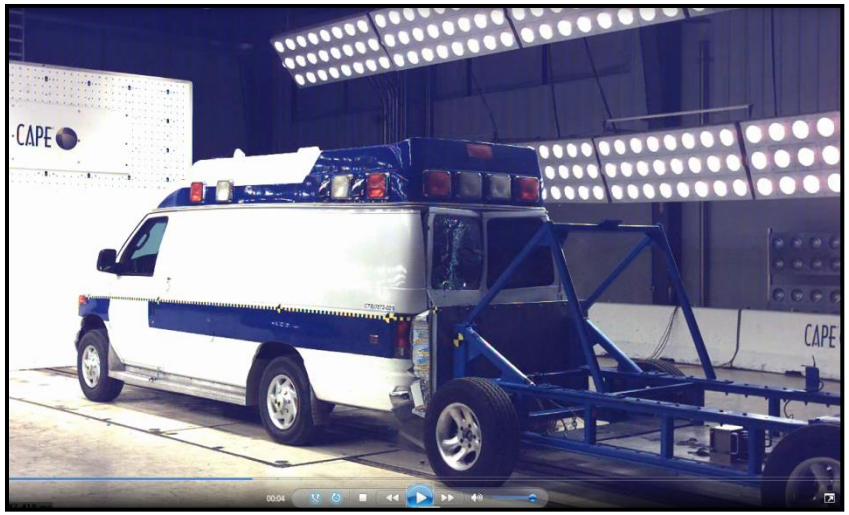
TABLE 1 - DYNAMIC SLED CORRIDOR BREAK POINTS

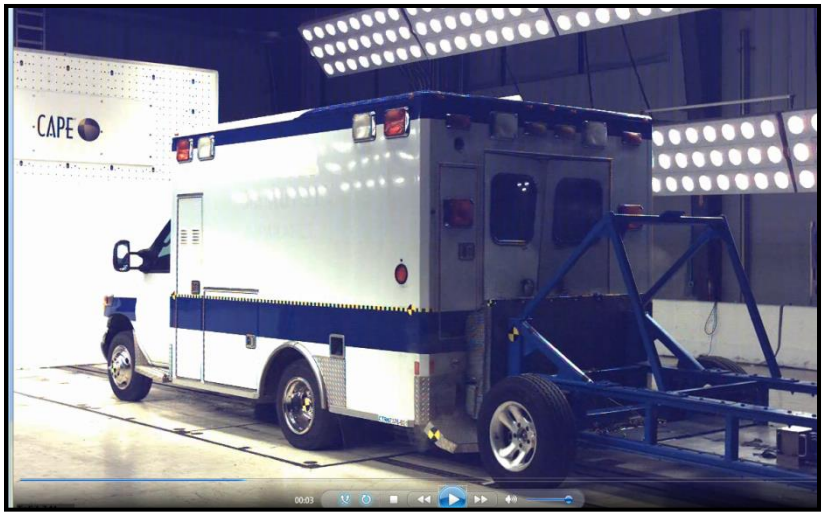
Position	Time (sec)	Acceleration (g)
A	0	-5.0
B	0.009	-26.0
C	0.036	-26.0
D	0.045	-10.0
E	0.055	-10.0

Position	Time (sec)	Acceleration (g)
F	0.005	0.0
G	0.016	-19.0
H	0.029	-19.0
I	0.035	0.0

SAE J2956- Ambulance Patient Compartment Lateral HYGE Sled Pulse, June 2011

Rear Impact – 2 Tests Measured Vehicle Response at Impact

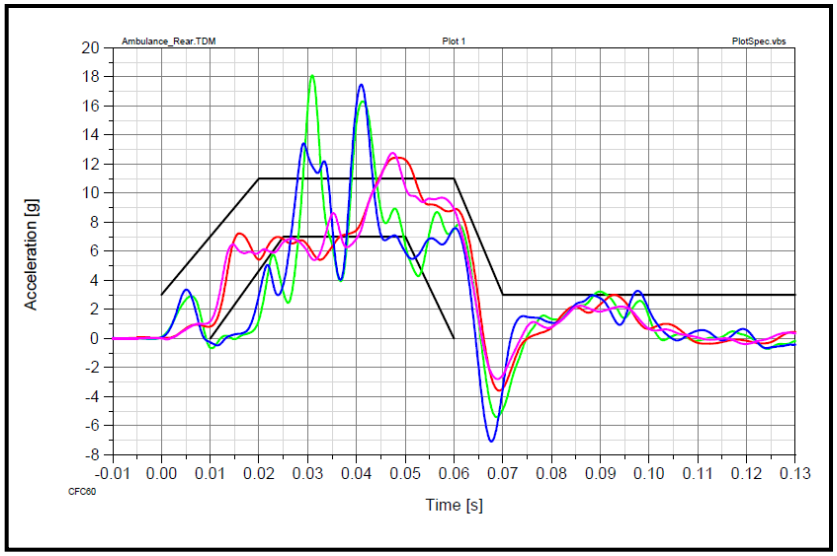




- **Both tests utilized the IIHS moving deformable barrier**
  - **MDB weight was 1,500 kg or 3,300 lbs.**
  - **Impact velocity 50 kph or 31 mph**
  - **Vehicle instrumentation package described in SAE 2007-01-4267**
  - **E350 Type II weighed 8,840 lbs. while the E350 Type III weighed 9,975**

Testing Criteria – Rear Impact

Crash response of two vehicles used to develop new SAE Recommended Practice for Rear Impact Testing



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SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J3044 PropDft XXX2013

Issued Date (OrigDate)
Revised Proposed Draft (LastDate)
Cancelled Date (CancelledDate)

Superseding Jxxxx Date
SupersededBy

Occupant Restraint and Equipment Mounting Integrity –
Rear Impact System-Level Ambulance Patient Compartment

RATIONALE

Not Applicable

1. Scope—This SAE Recommended Practice describes the test procedures for conducting frontal impact occupant restraint and equipment mounting integrity tests for ambulance patient compartment applications. Its purpose is to describe crash pulse characteristics and establish recommended test procedures that will standardize restraint system and equipment mount testing for ambulances. Descriptions of the test set-up, test instrumentation, photographic/video coverage, and the test fixtures are included.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J211-1—Instrumentation for Impact Test—Part 1: Electronic Instrumentation
SAE J211-2—Instrumentation for Impact Test—Part 2: Photographic Instrumentation
SAE Engineering Aid 23—"Users' Manual for the 50th-Percentile Hybrid-III Test Dummy," June 1985

2.2 Other Publications

Code of Federal Regulations, Title 49, Part 571.208.

Code of Federal Regulations, Title 49, Part 571.214.

Code of Federal Regulations, Title 49, Part 572

Current, R., Moore, P., Green, J., Yannaccone, J., et. al., "Crash Testing of Ambulance Chassis Cab Vehicles", SAE Technical Paper 2007-01-4267 – 2007, doi: 10.4271/2007-01-4267

CAPE Report CTR07376 - Type III Ambulance Rear Impact, NTIS Accession Number PB2013XXXXX

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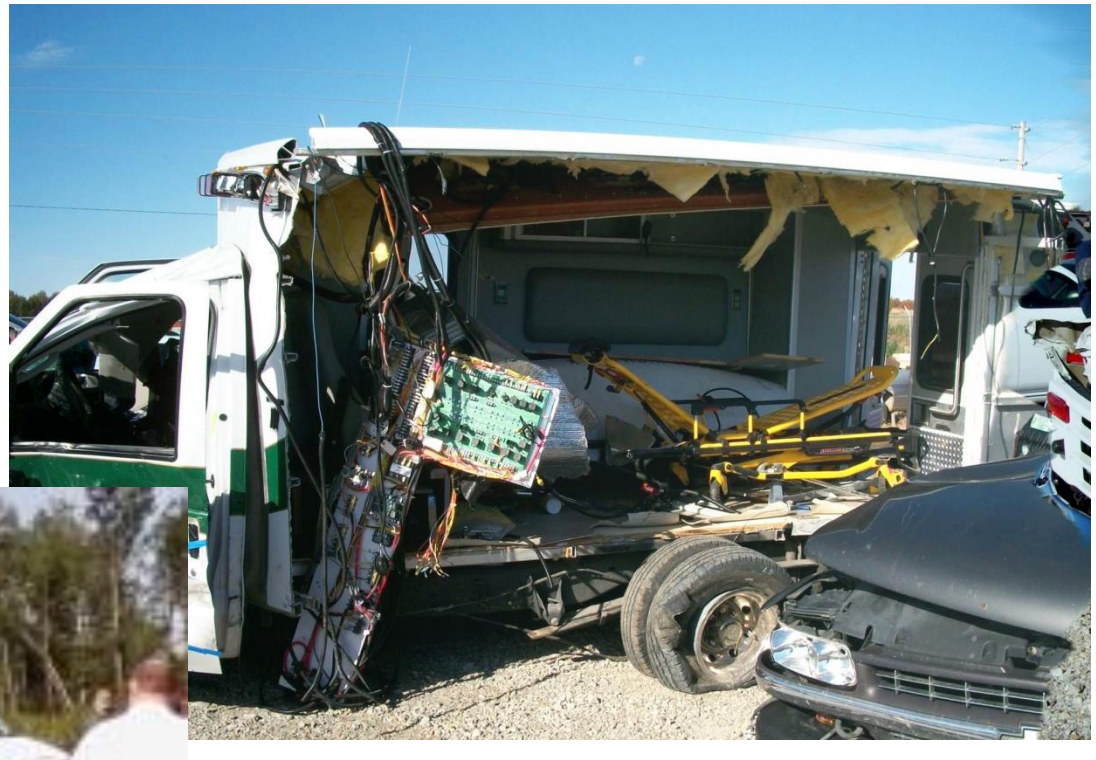
Body Integrity and Mounting Standards

- Front corner of patient compartment absorbed impact
- Side was sheared off
- Very different from pure side impact



Goal is to understand side shear and vehicle rollover loading on body

We need to understand the loading applied to the ambulance body at impact

≈ 30 mph – likely survivable

≈ 60 mph – likely not survivable

"Ride of your Life: What you Can't Afford Not to Know About Ambulance Safety", Levick, N. Presented at TSJC/RETAC EMS Symposium "Making A Difference" February 11, 2012, Alamosa, Colorado

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Ramp Roll Test – 30 MPH/48 KPH

Barrier Impact Test – 30 MPH/48 KPH

Body Integrity and Mounting Standards Development Team

Progress to date: 60% Complete

- Can we devise a test to ensure patient compartment structural integrity – especially during side shearing events or under rollover conditions?
- Conducted two rollover tests and two shear tests
- Results from the four tests will be used to create and execute repeatable quasi-static test (the committee met this morning to start this final process)
- This test will be translated to SAE document Spring 2014

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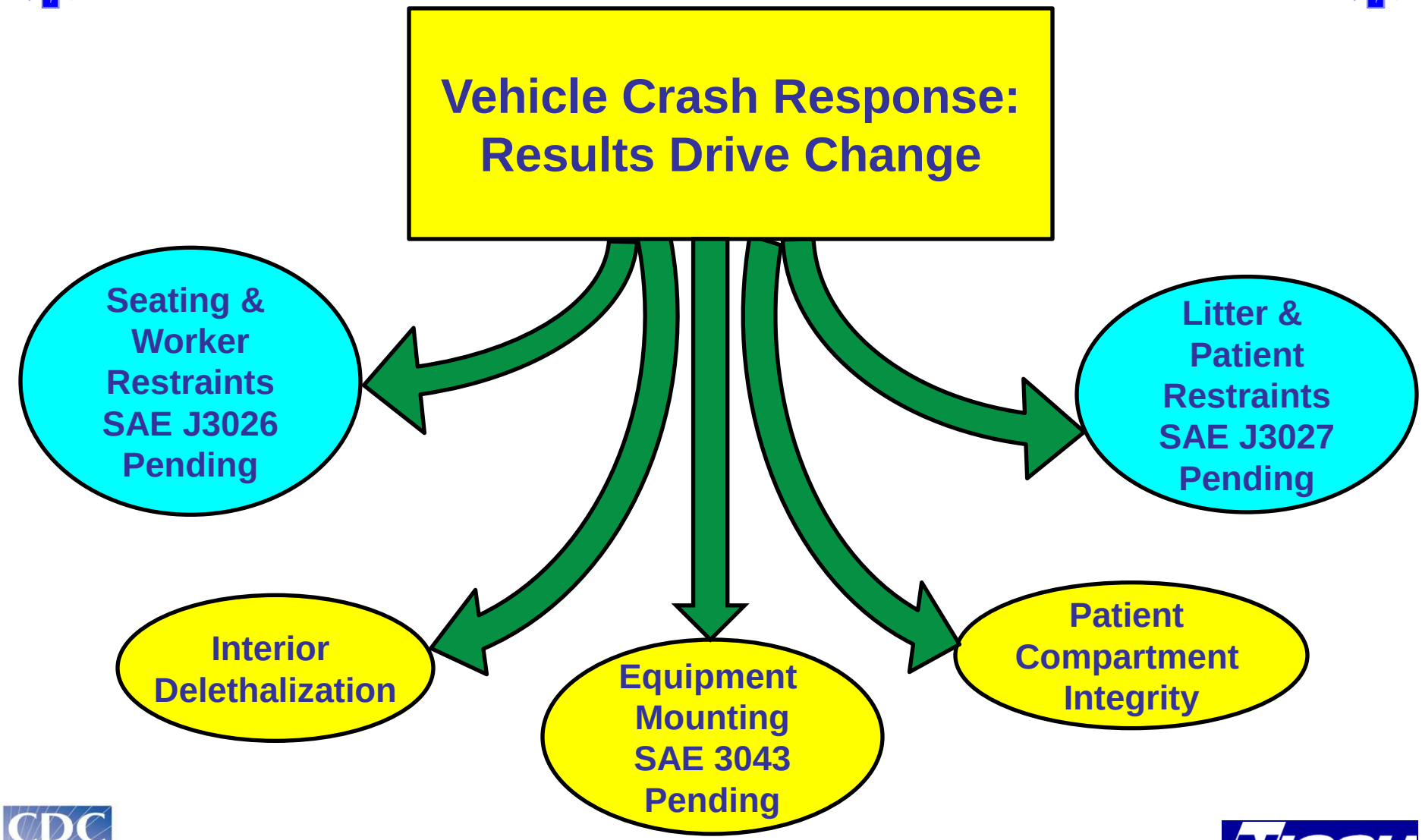
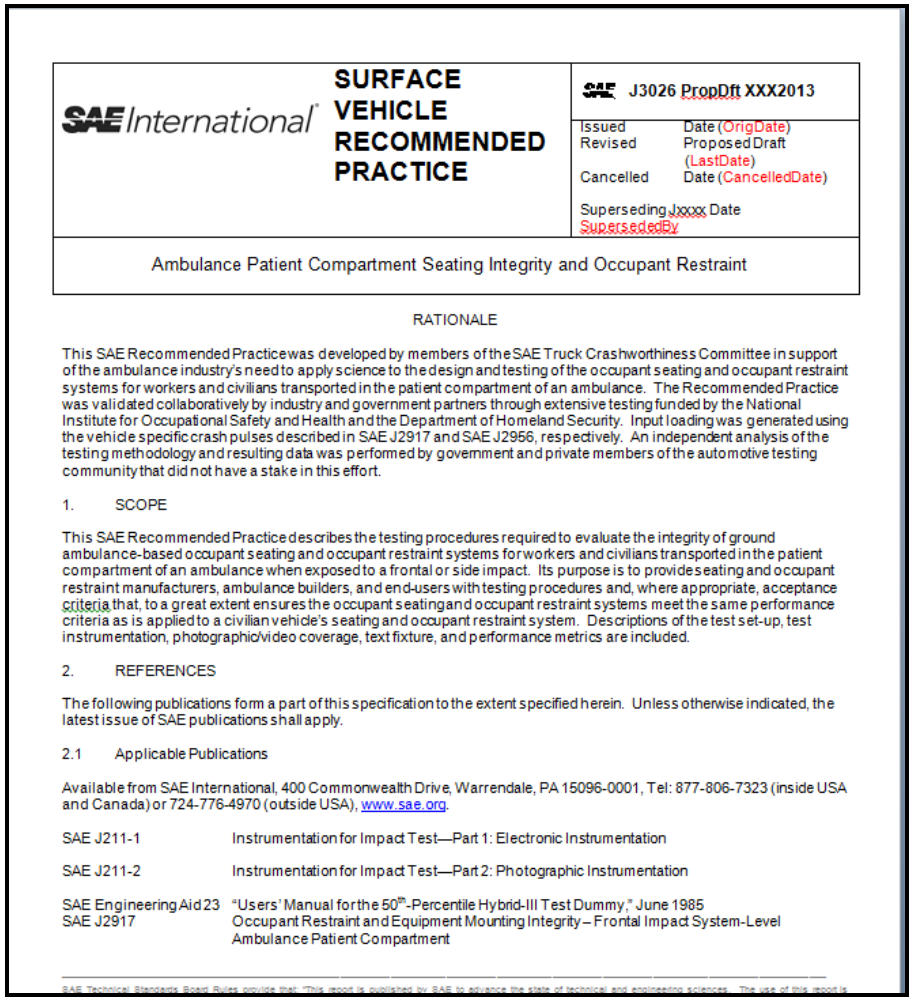
Standards Development Activities



Seat and Worker Restraint Standard



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SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J3026 PropDft XXX2013

Issued Date (OrigDate)
Revised Proposed Draft (LastDate)
Cancelled Date (CancelledDate)

Superseding Jxxxx Date
SupersededBy

Ambulance Patient Compartment Seating Integrity and Occupant Restraint

RATIONALE

This SAE Recommended Practice was developed by members of the SAE Truck Crashworthiness Committee in support of the ambulance industry's need to apply science to the design and testing of the occupant seating and occupant restraint systems for workers and civilians transported in the patient compartment of an ambulance. The Recommended Practice was validated collaboratively by industry and government partners through extensive testing funded by the National Institute for Occupational Safety and Health and the Department of Homeland Security. Input loading was generated using the vehicle specific crash pulses described in SAE J2917 and SAE J2956, respectively. An independent analysis of the testing methodology and resulting data was performed by government and private members of the automotive testing community that did not have a stake in this effort.

1. SCOPE

This SAE Recommended Practice describes the testing procedures required to evaluate the integrity of ground ambulance-based occupant seating and occupant restraint systems for workers and civilians transported in the patient compartment of an ambulance when exposed to a frontal or side impact. Its purpose is to provide seating and occupant restraint manufacturers, ambulance builders, and end-users with testing procedures and, where appropriate, acceptance criteria that, to a great extent ensures the occupant seating and occupant restraint systems meet the same performance criteria as is applied to a civilian vehicle's seating and occupant restraint system. Descriptions of the test set-up, test instrumentation, photographic/video coverage, text fixture, and performance metrics are included.

2. REFERENCES

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1 Applicable Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-806-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J211-1 Instrumentation for Impact Test—Part 1: Electronic Instrumentation

SAE J211-2 Instrumentation for Impact Test—Part 2: Photographic Instrumentation

SAE Engineering Aid 23 "Users' Manual for the 50th-Percentile Hybrid-III Test Dummy," June 1985

SAE J2917 Occupant Restraint and Equipment Mounting Integrity – Frontal Impact System-Level Ambulance Patient Compartment

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is

Key Elements in Recommended Practice

- Dynamic, crash testing is required
- Seat and restraint systems must protect occupants to same crash standard as automotive seating
- Occupant excursion mapped during dynamic test

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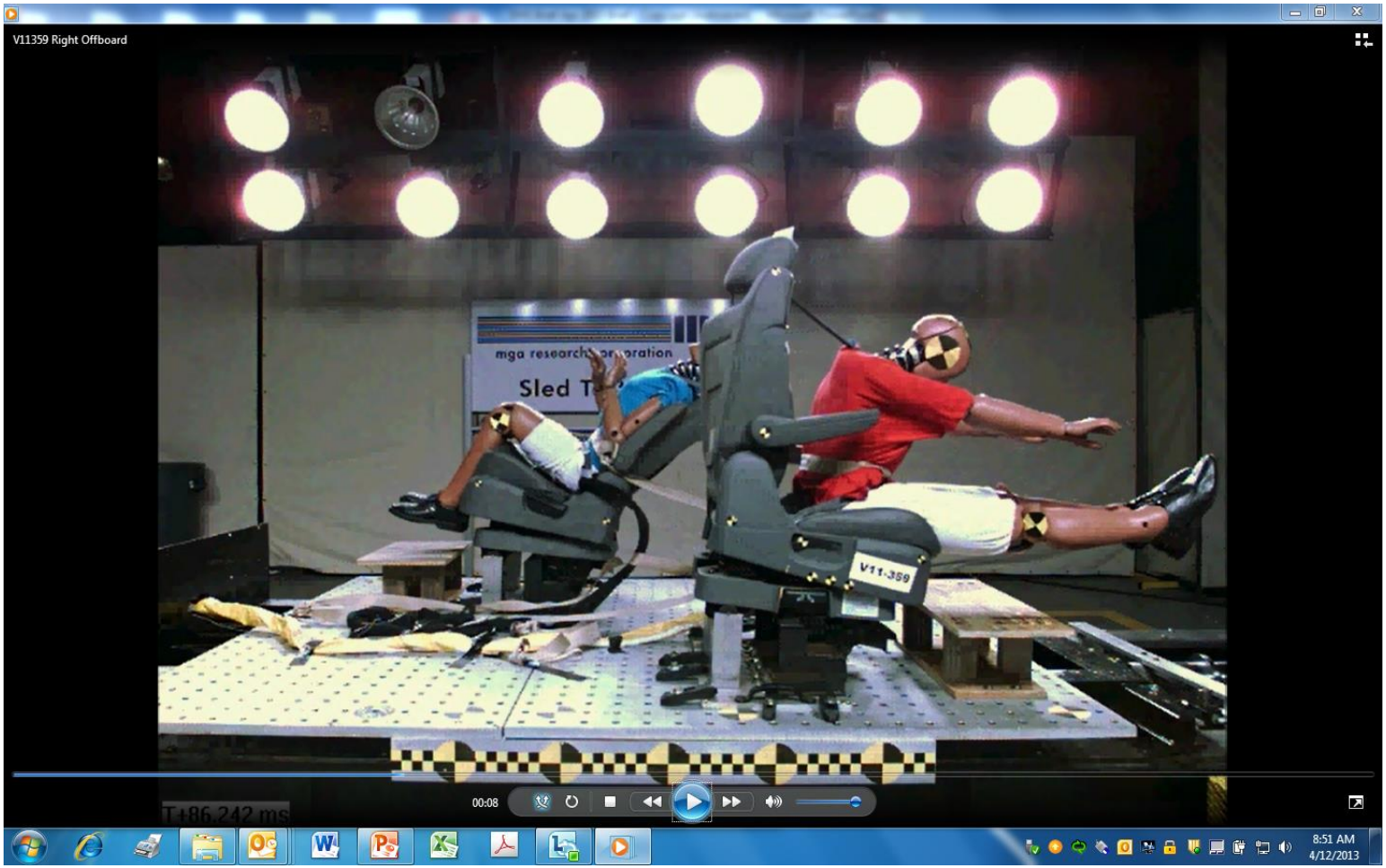
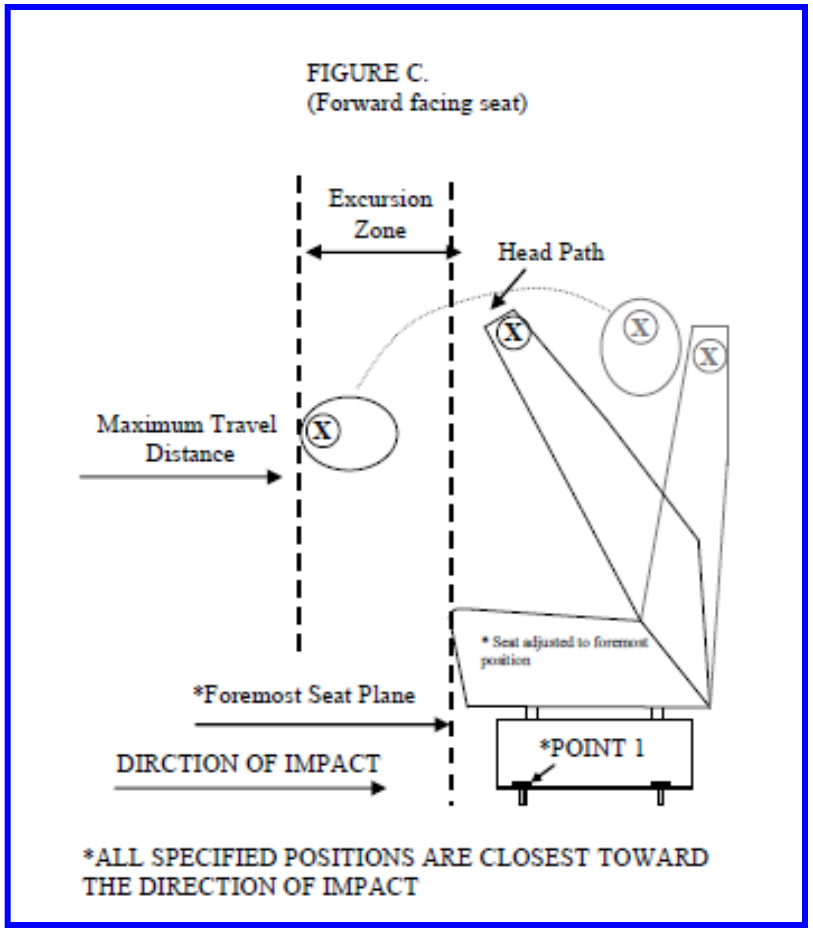
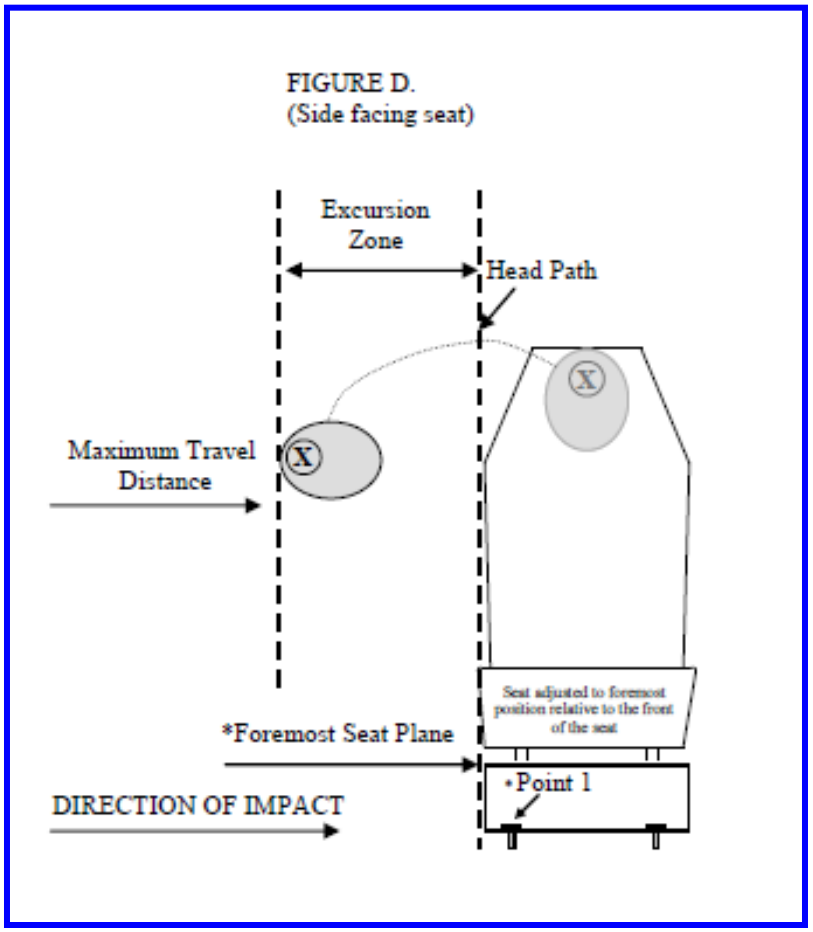
Demo: Frontal Impact, Forward and Rear Facing Seating

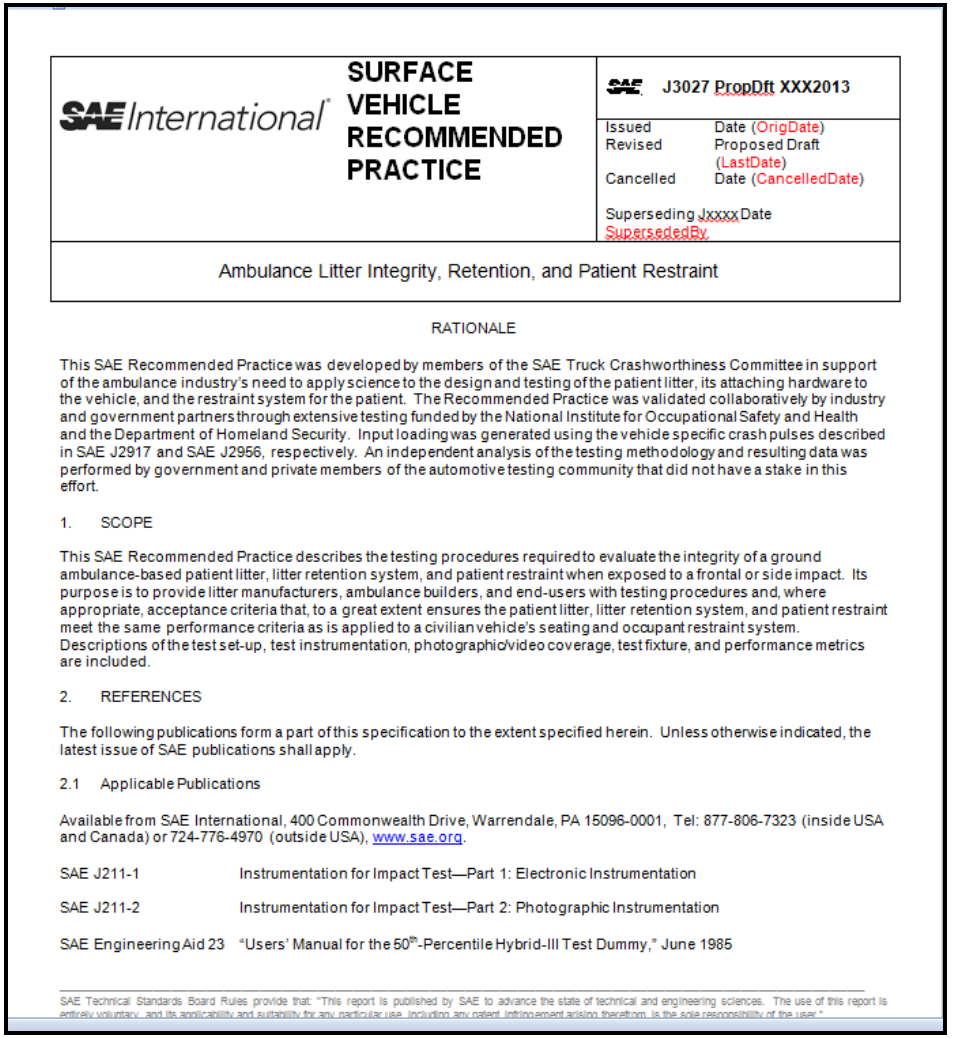


Mapping Occupant Excursion





Litter Design – Patient Restraint Team



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SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J3027 PropDft XXX2013

Issued Date (OrigDate)
Revised Proposed Draft (LastDate)
Cancelled Date (CancelledDate)

Superseding Jxxxx Date
SupersededBy

Ambulance Litter Integrity, Retention, and Patient Restraint

RATIONALE

This SAE Recommended Practice was developed by members of the SAE Truck Crashworthiness Committee in support of the ambulance industry's need to apply science to the design and testing of the patient litter, its attaching hardware to the vehicle, and the restraint system for the patient. The Recommended Practice was validated collaboratively by industry and government partners through extensive testing funded by the National Institute for Occupational Safety and Health and the Department of Homeland Security. Input loading was generated using the vehicle specific crash pulses described in SAE J2917 and SAE J2956, respectively. An independent analysis of the testing methodology and resulting data was performed by government and private members of the automotive testing community that did not have a stake in this effort.

1. SCOPE

This SAE Recommended Practice describes the testing procedures required to evaluate the integrity of a ground ambulance-based patient litter, litter retention system, and patient restraint when exposed to a frontal or side impact. Its purpose is to provide litter manufacturers, ambulance builders, and end-users with testing procedures and, where appropriate, acceptance criteria that, to a great extent ensures the patient litter, litter retention system, and patient restraint meet the same performance criteria as is applied to a civilian vehicle's seating and occupant restraint system. Descriptions of the test set-up, test instrumentation, photographic/video coverage, test fixture, and performance metrics are included.

2. REFERENCES

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1 Applicable Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-806-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J211-1 Instrumentation for Impact Test—Part 1: Electronic Instrumentation

SAE J211-2 Instrumentation for Impact Test—Part 2: Photographic Instrumentation

SAE Engineering Aid 23 "Users' Manual for the 50th-Percentile Hybrid-III Test Dummy," June 1985

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

Key Elements in Recommended Practice

- Dynamic, crash testing is required
- Cot, cot mounting and restraints structurally sound during simulated crash loading
- Occupant excursion reduced to less than 14 inches

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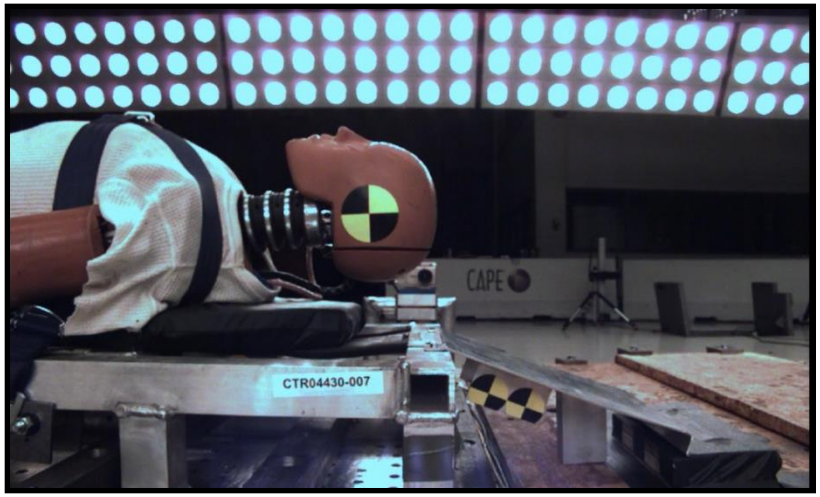
Standard Gurney – 30 mph Impact

Pre-crash event: standard cot, restraint and antler floor fastener

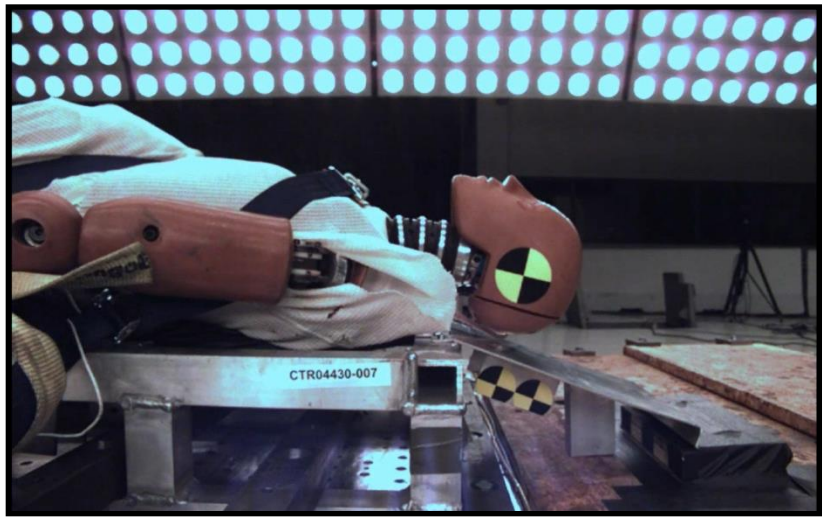
Mid-crash event: patient excursion exceeds 30 inches or 76 cm

Rigid Cot and with new Restraint Tested Using J2917 (30 mph)

Pre-crash event: rigid cot, new restraint applied directly to shoulder



Mid-crash event: total head excursion of 7.8 in / 20 cm



Equipment Mounting: Static and Dynamic Test Options

SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE3043 PropDft August 13th, 2013

Issued Date (Orig Date)
Revised Proposed Draft (Last Date)
Cancelled Date(Cancelled Date)

Superseding Jxxxx Date
Superseded By

Ambulance Equipment Mount Device or Systems

RATIONALE

This SAE Recommended Practice was developed by members of the SAE Truck Crashworthiness Committee in support of the ambulance industry's need to apply science to the design and testing of the equipment mount devices or systems used in the ambulance patient compartment. The Recommended Practice was validated collaboratively by industry and government partners through extensive testing funded by the National Institute for Occupational Safety and Health and the Department of Homeland Security. Input loading for the dynamic testing was generated using the vehicle specific crash pulses described in SAE J2917 and SAE J2956, respectively. An independent analysis of the testing methodology and resulting data was performed by government and private members of the automotive testing community that did not have a stake in this effort.

1. SCOPE

This SAE Recommended Practice describes the dynamic and static testing procedures required to evaluate the integrity of an equipment mount device or system when exposed to a frontal or side impact (i.e. a crash impact). Its purpose is to provide equipment manufacturers, ambulance builders, and end-users with testing procedures and, where appropriate, acceptance criteria that, to a great extent, ensure equipment mount devices or systems meet the same performance criteria across the industry. Prospective equipment mount manufacturers or vendors have the option of performing either dynamic testing or static testing. Descriptions of the test set-up, test instrumentation, photographic/video coverage, test fixture, and performance metrics are included.

2. REFERENCES

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1 Applicable Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-806-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J211-1 Instrumentation for Impact Test—Part 1: Electronic Instrumentation

Key Elements in Recommended Practice

- Dynamic testing based on published pulses is an option
- Optional static test in lieu of dynamic test is an option
- Innovative conversion from dynamic to static test loading offered

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Equipment Mount Integrity

Prior to crash equipment and gurney either mounted or stowed in cabinets

Post crash (rollover) equipment and gurney positions drastically changed

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Additional Work Underway

- **Interior Surface Delethalization – making impact surfaces less likely to injure the worker or patient**
- **Cabinet and cabinet latch integrity standard – will ensure cabinets retain equipment using established crash pulses**
- **EMS Worker Anthropometry Study – Assessing body sizes and shapes (600 human subjects to be measured)**
- **Development of a prototype ambulance based on this work plus companion research at the National Institute of Standards and Technology (NIST) dealing with patient compartment layout**
- **Production of an informational DVD to be provided to all EMS services nationwide**

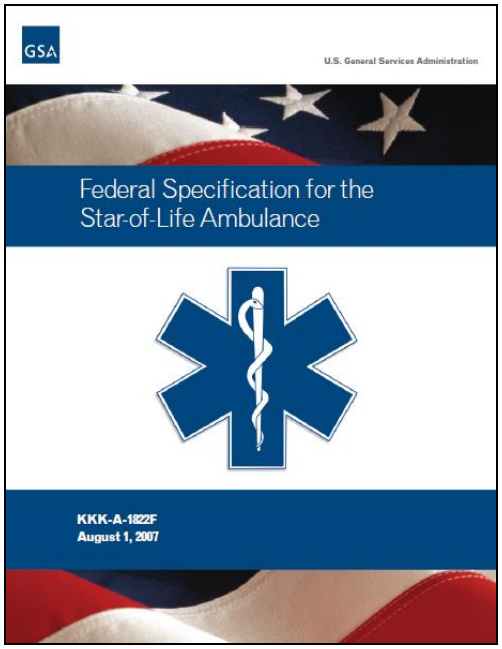
Incorporation of Crash Safety Standards

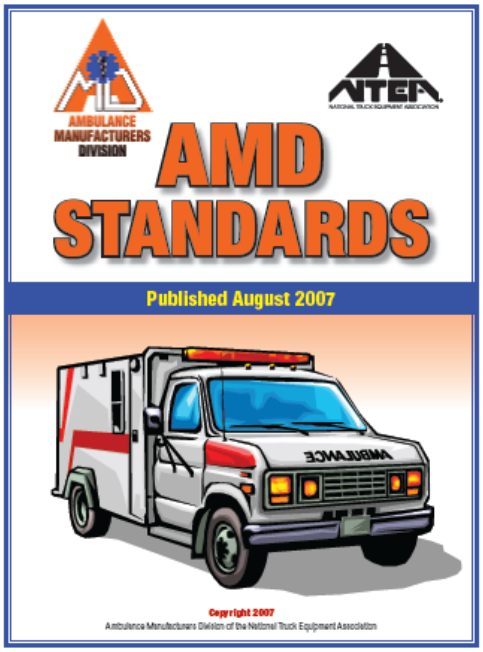
What is the Future?

GSA KKK-A-1822 ?

NFPA 1917 ?

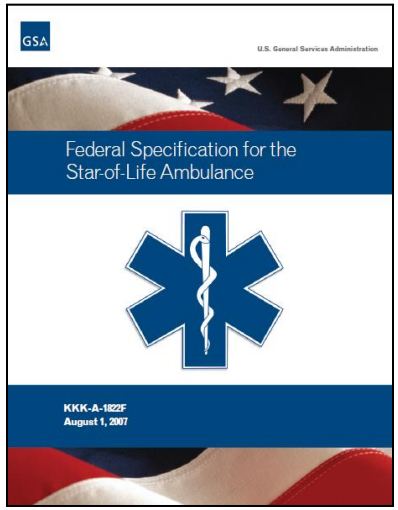
Specs and Standards Today

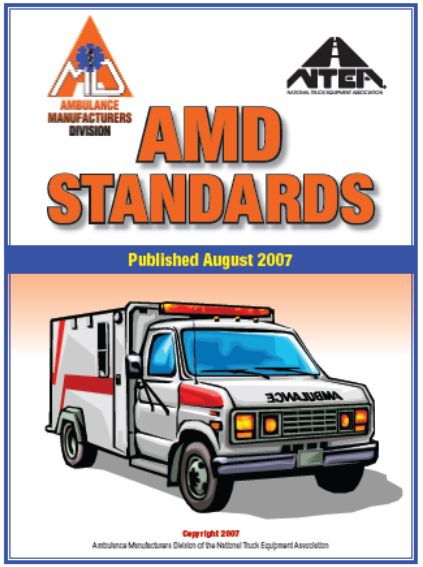




The Ambulance Manufacturers Division of the National Truck Equipment Association began developing test standards in 1985. Today, there are 25 AMD test standards. Each is incorporated by reference in the GSA Federal Specification for the Star of Life Ambulance KKK-A-1822F.

Specs and Standards Tomorrow: Path 1





SAE Standards:

Test Pulses, Seats, Cots, Equipment Mounts, Cabinets, Body Structure

Existing AMD standards will continue to be referenced in KKK.

New SAE Standards will be added to KKK as published beginning in FY2014.

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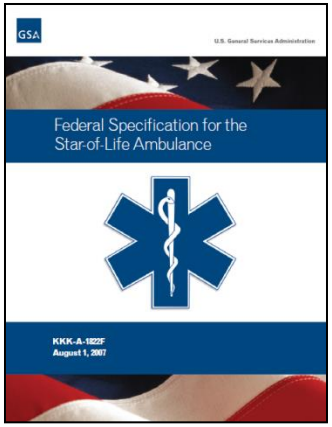
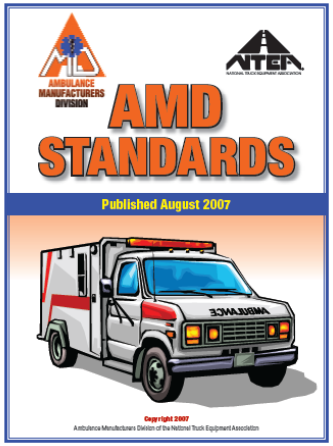
Specs and Standards Tomorrow: Path 2





SAE Standards:

Test Pulses, Seats, Cots, Equipment Mounts, Cabinets, Body Structure

NFPA 1917 Standard for Automotive Ambulances 2016 2nd Edition

Suggestions for NASEMSO Members

- Participate in the NFPA 1917 process – the committee needs to understand and appreciate your state's needs and potential limitations
- Know the purchasing and licensing requirements that exist within your state today
    - How will they need to evolve in this changing environment?
- Understand the limits of the science today, but more importantly work to separate fact from fiction

Contact Information

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Disclaimer: *The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.*