NIOSH TESTING & STANDARDS DEVELOPMENT SUMMARY:

Presented By: Jim Green (NIOSH)

VA EMS Transportation Committee Meeting : July 28, 2014

NIOSH 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.

Ambulance Design - Then

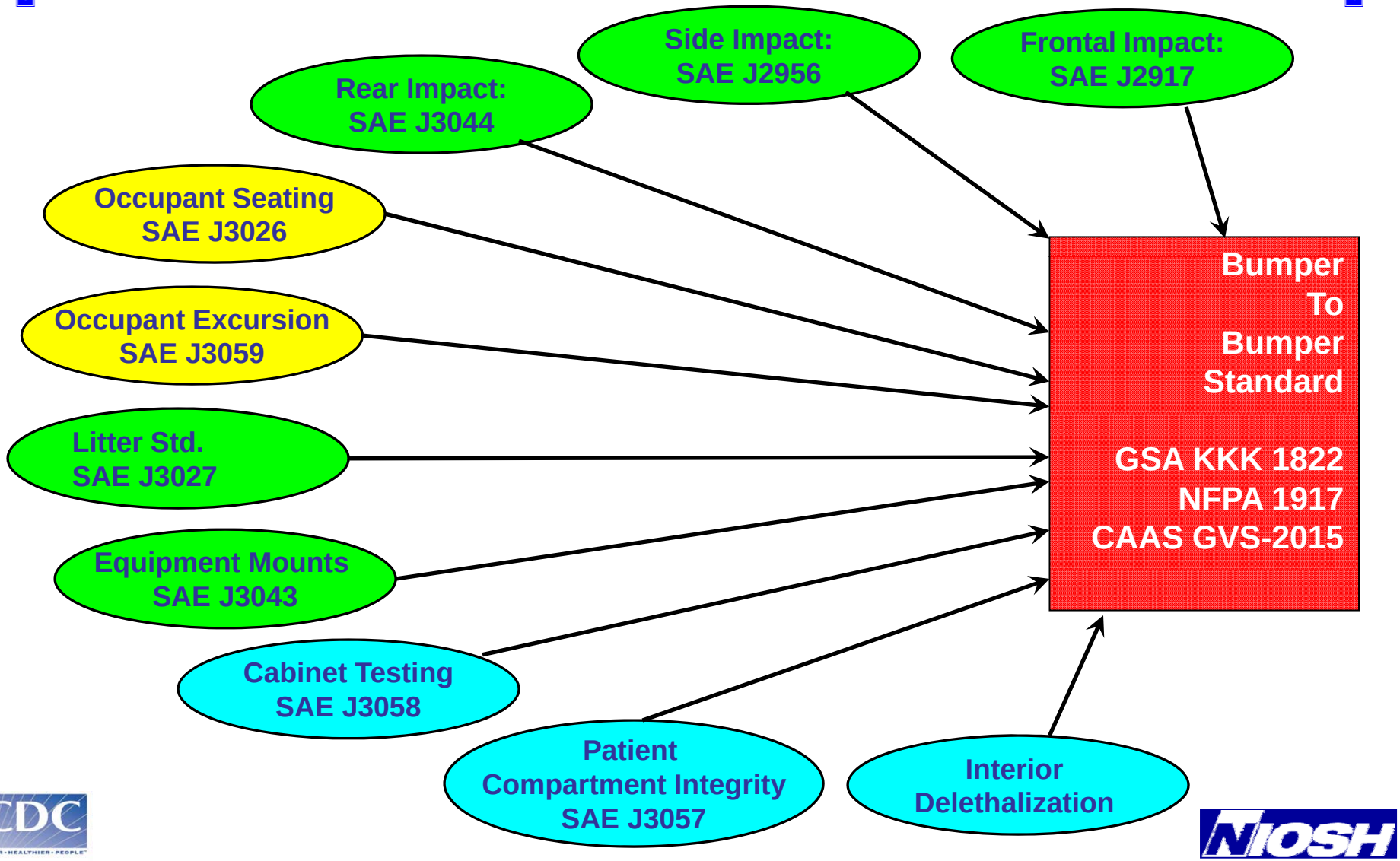
Ambulance Design - Now

Why do we seek opportunities for improvement?

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

Post crash (rollover) equipment and gurney positions drastically changed

Standards Landscape Tomorrow



Crash Standard Development

Vehicle Response Provides Foundation for Future Work

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

CDC SAFER · HEALTHIER · PEOPLE

NIOSH

We needed 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

CDC SAFER·HEALTHIER·PEOPLE

NIOSH

Testing Criteria – Frontal, Side & Rear Impact

- NIOSH conducted 3 frontal (2003), 4 side (2010), 2 rear (2013) impact tests, and 3 roll tests (2013/14)
- Used test data to define vehicle response as a test corridor - published as SAE Recommended Practices
- Corridors used by test facilities to evaluate seating, litters, equipment mounts under repeatable conditions

Frontal, Side & Rear Impact Provide Underlying Testing Criteria

- Frontal crash loading matched Federal Standard for passenger vehicles – 30 mph full frontal impact
- Side and rear impact tests matched the Insurance Institute for Highway Safety Side Impact Test
  - Impact velocity 50 Kph – 31 mph
  - 3300 lb moving deformable barrier
- Collected vehicle response on frame, floor, and roof to understand internal reactions of vehicle during impact

Forward Barrier Crash, 30 mph, 1999 Type III, Unrestrained and Lap Belts

Unrestrained and LBO Bench Seat Occupants

** Lap belts should always be used in conjunction with net **

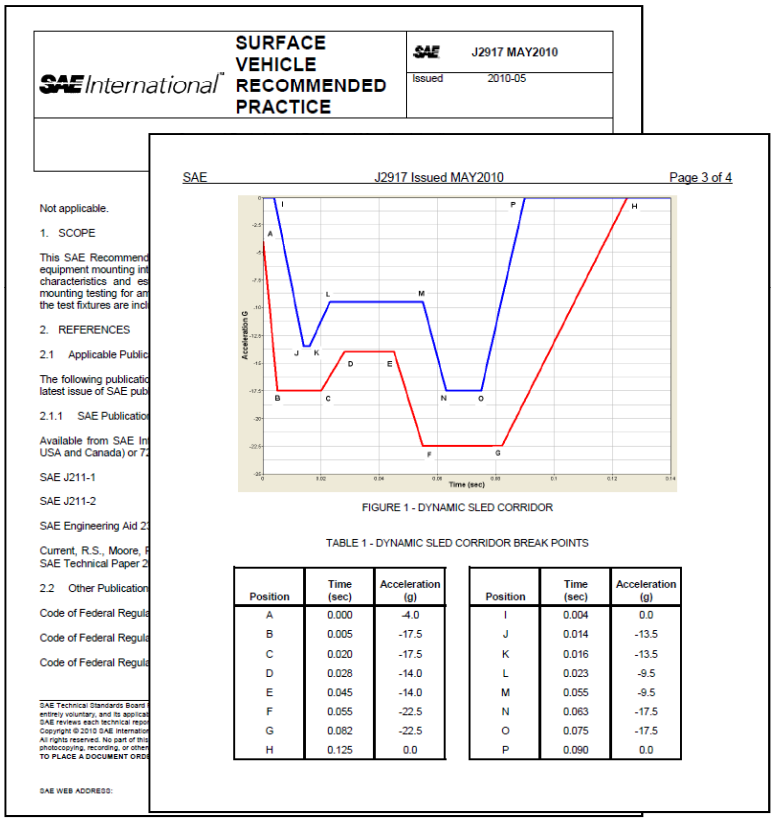
Testing Criteria – Side Impact – Type II

- **Impact Velocity 50 km/hr = 31.1 mph**
- **Weight of Impacting MDB: 1500 kg = 3300 lbs**

Testing Criteria – Rear Impact – Type III

- Impact Velocity 50 km/hr = 31.1 mph
- Weight of Impacting MDB: 1500 kg = 3300 lbs

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

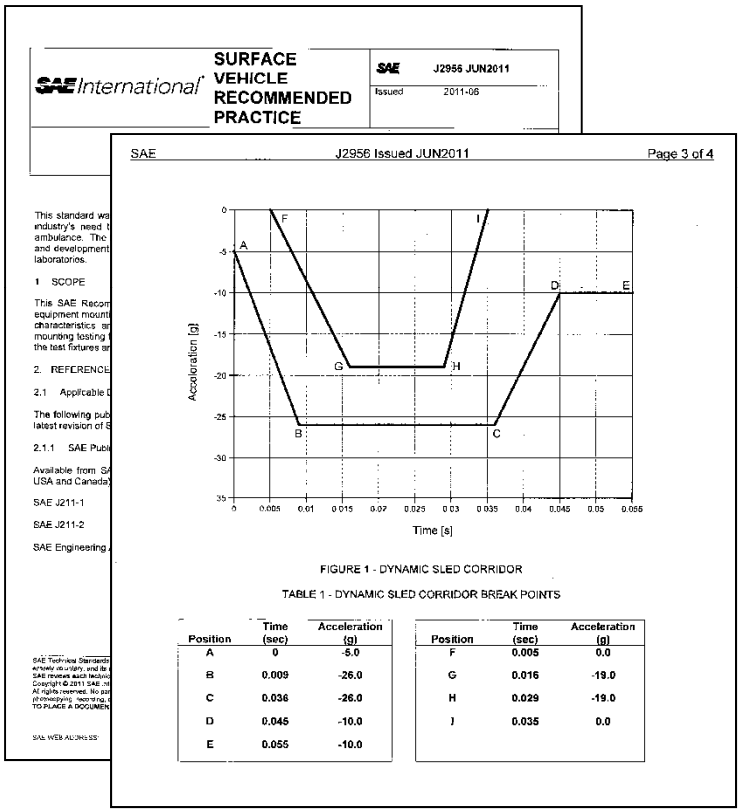
FIGURE 1 - DYNAMIC SLED CORRIDOR

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

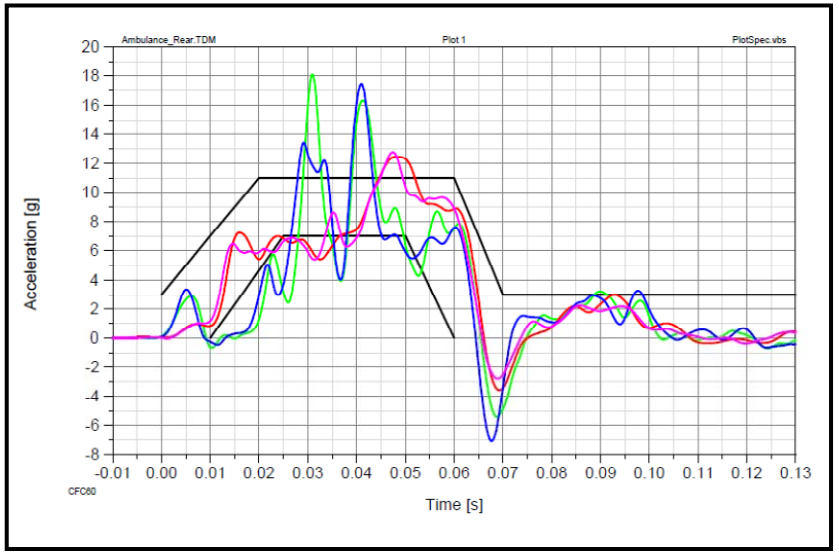
Position	Time (sec)	Acceleration (g)
F	0.005	0.0
G	0.016	-19.0
H	0.029	-19.0
I	0.035	0.0

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

Testing Criteria – Rear Impact

Crash response of two vehicles used to develop new SAE J3044 Recommended Practice for Rear Impact Testing

SAE J3044
Published in June 2014



SAE International

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.

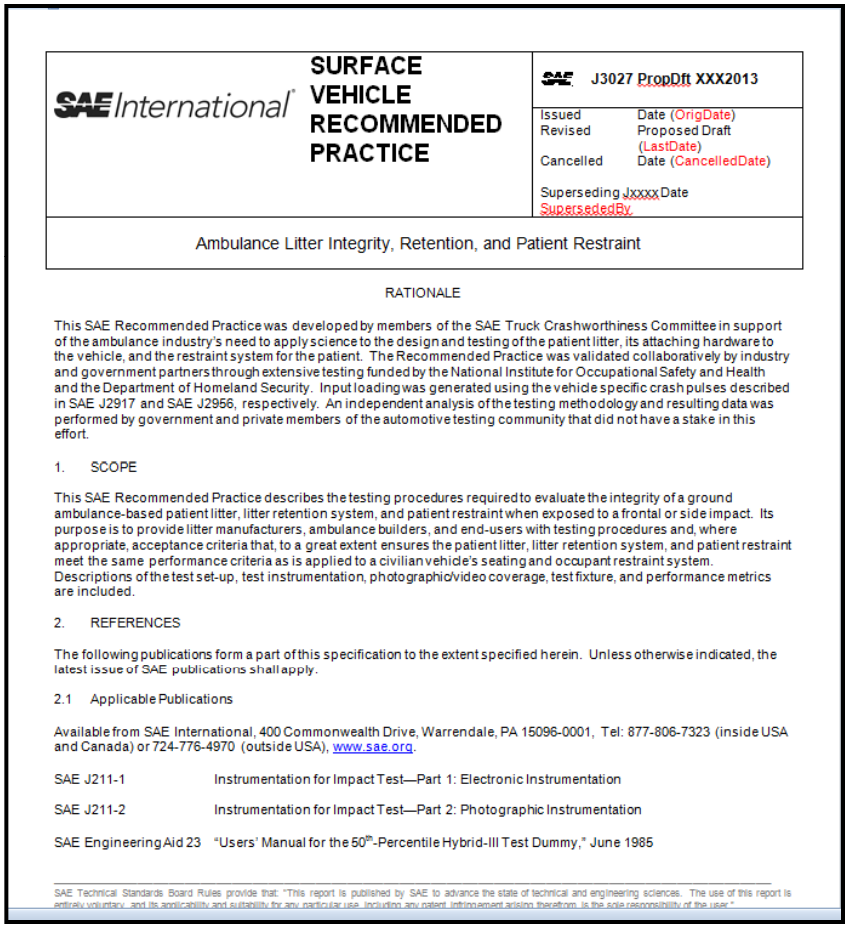
Code of Federal Regulations, Title 49, Part 572

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

Cot Design – Patient Restraint Team

SAE J3027 Published in July 2014



SAE International

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

CDC SAFER · HEALTHIER · PEOPLE

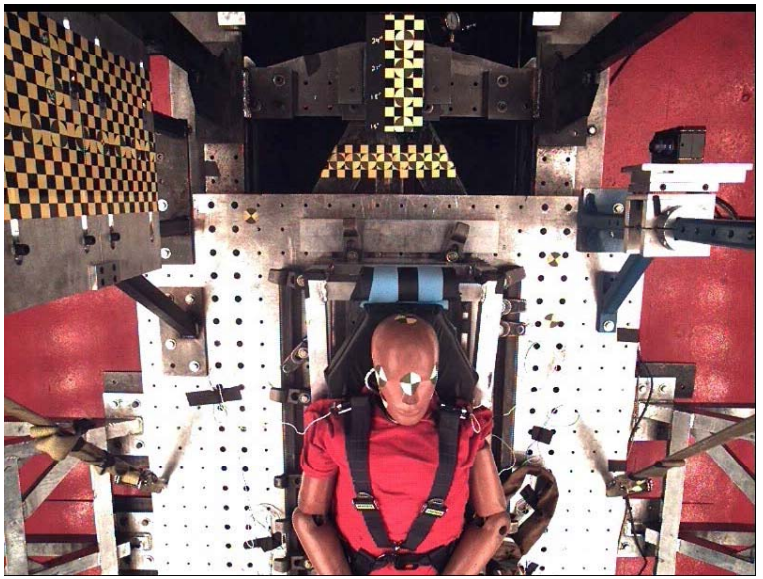
NIOSH

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 with new Restraint Tested Using J2917 (30 mph)

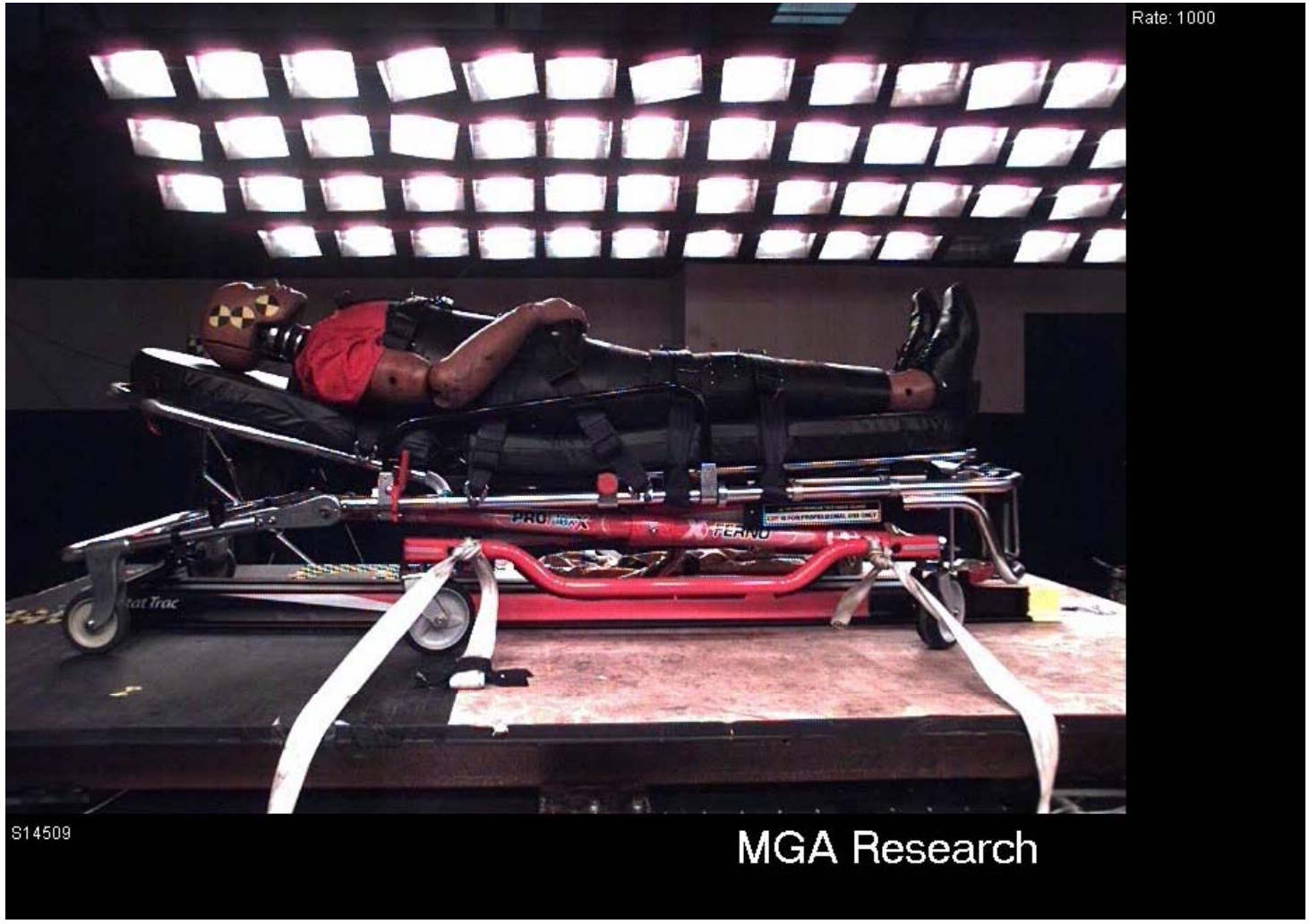


Pre-crash event: rigid cot, new restraint applied directly to shoulder

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

30 MPH Sled Test – Real Time

30 MPH Sled Test – High Speed Video



30 MPH Sled Test – Goal Line Camera

Ramp Roll Test – 30 MPH/48 KPH

Cart Roll Test – 30 MPH/48 KPH

Cot Design – Patient Restraint Team
(SAE J3027 Published in July 2014)

Testing Cot and Cot Retention Systems

- Both manufacturers have met the requirements of the draft standard with prototype systems
  - Cot remained attached to floor mounting device without structural failure
  - Patient excursion reduced below 14” goal
  - All measured dummy loading for head, neck, chest below accepted human tolerance limits

Litter Design – Patient Restraint Team


Key Differences Needed to Meet This Standard

- **The traditional antler has been replaced with a center track mounting system**
- **Restraint system modified to engage shoulders of patient immediately**
- **Additional longitudinal restraint member incorporated – with no increase in buckles**
- **No changes to standard sheet required to accommodate new restraint**

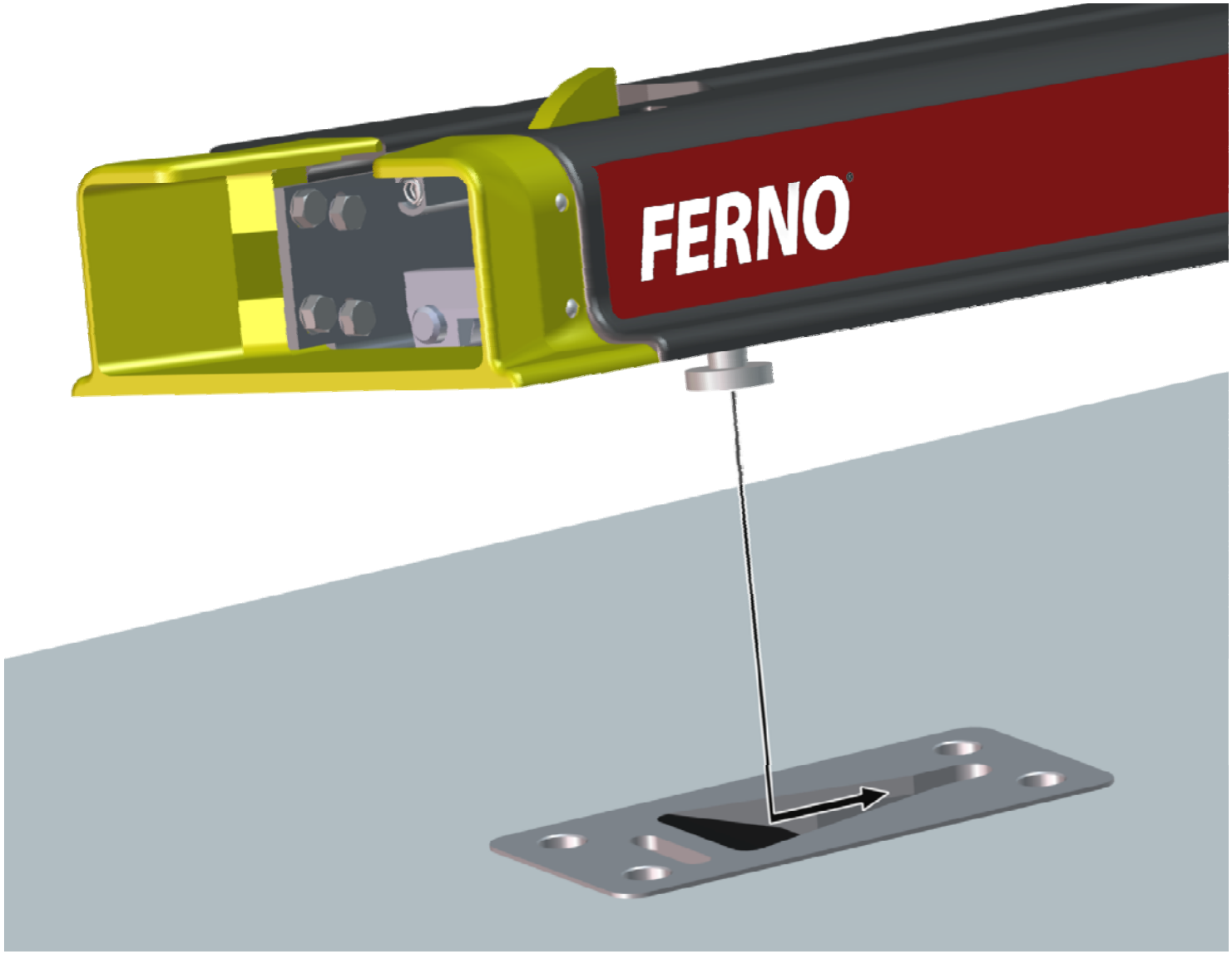
CDC
SAFER • HEALTHIER • PEOPLE

NIOSH

CDC
SAFER • HEALTHIER • PEOPLE™

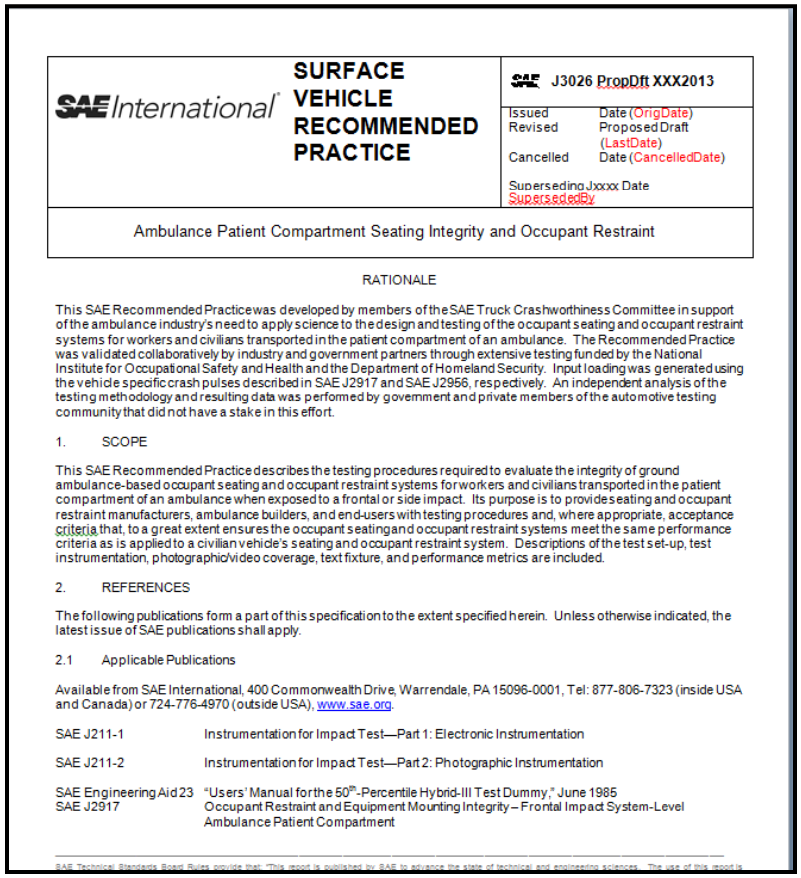
NIOSH


FERNO


FERNO

Seat and Worker Restraint Standard

SAE J3026 in Final Review at SAE and expected to be Published in late August 2014



SAE International

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

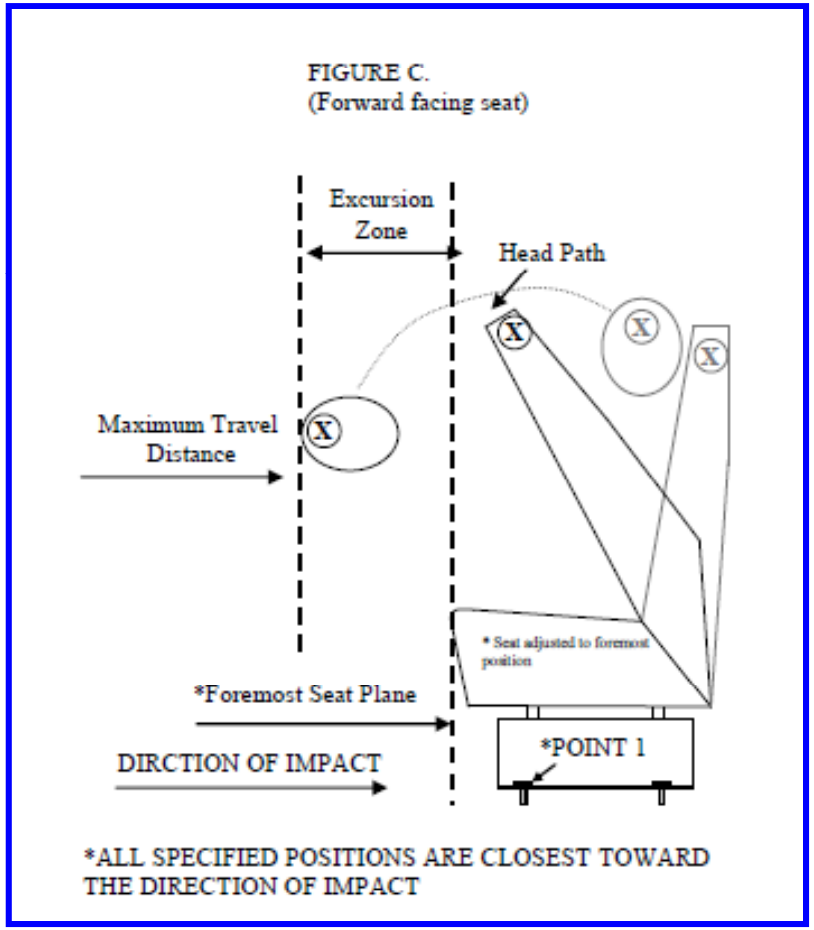
- Dynamic, crash testing is required
- Seat and restraint systems must protect occupants to same crash standard as automotive seating
- Occupant excursion mapped during dynamic test (now SAE J3059)

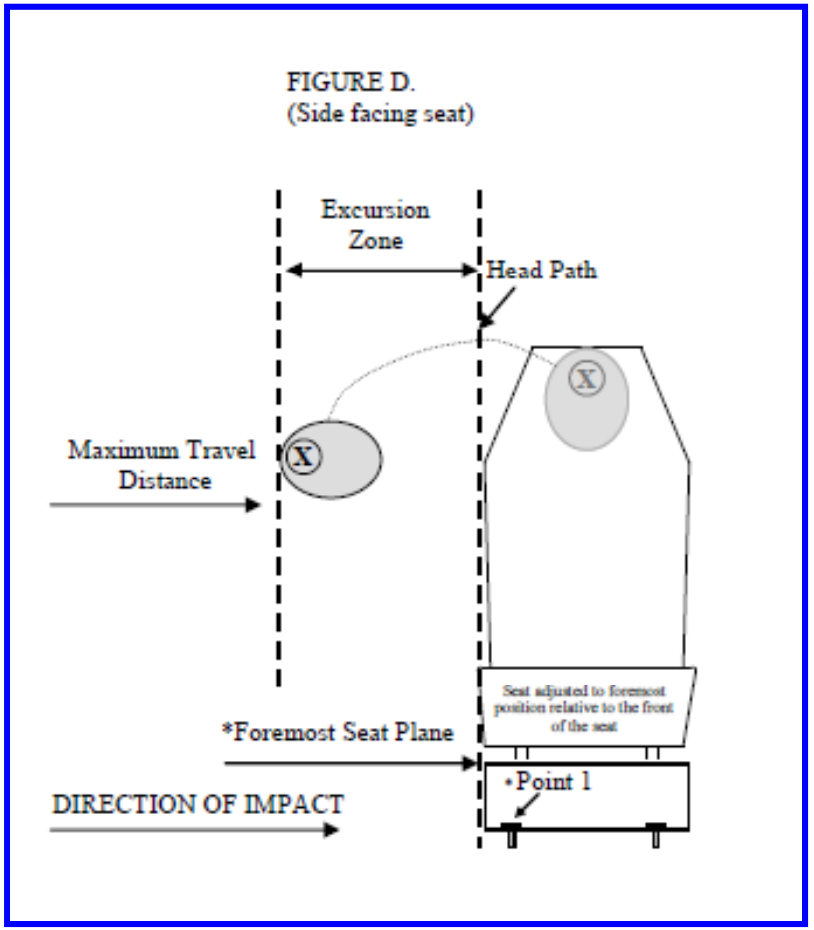
CDC SAFER·HEALTHIER·PEOPLE™

NIOSH

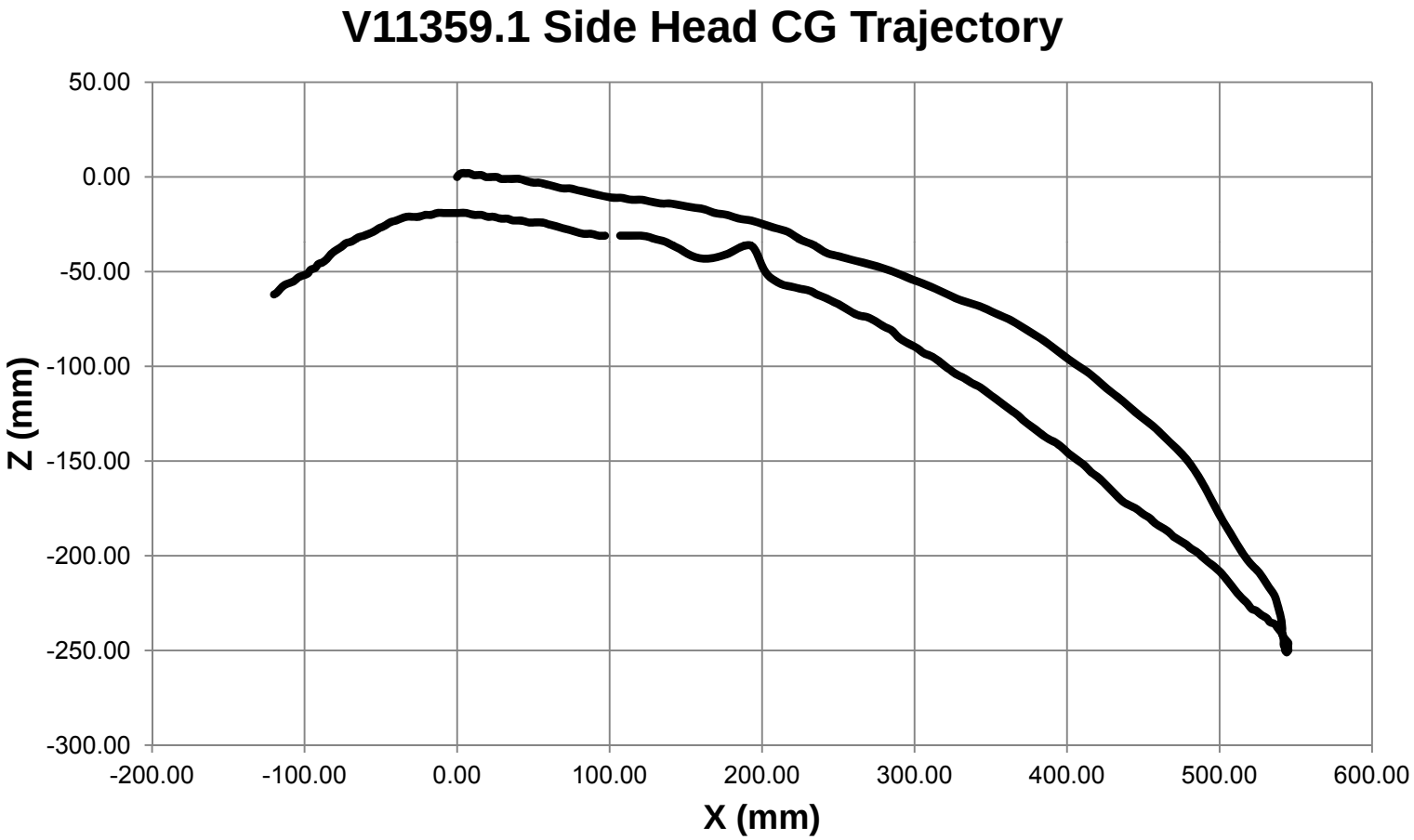
Demo: Frontal Impact, Forward and Rear Facing Seating

Mapping Occupant Excursion





Head Path During Frontal Impact



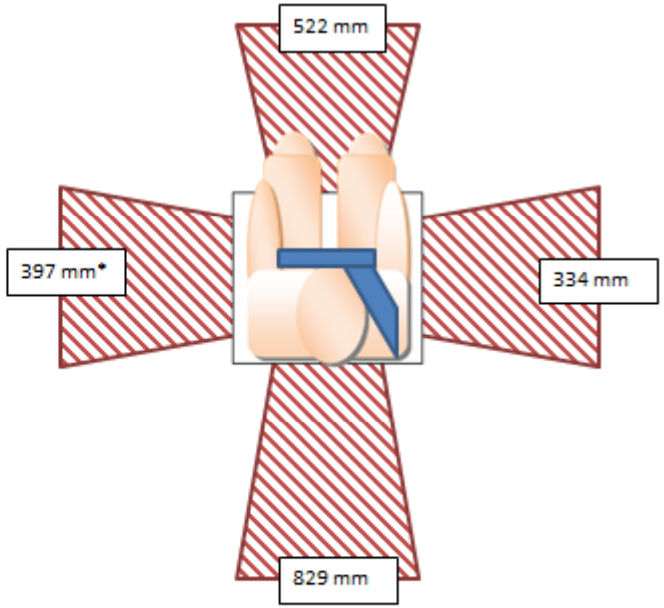
Seating and Restraint Data Sheet

Seat Model #1 Stay-Away-Zone

Units are in millimeters. Drawings are not to scale.

Measurements are from the *foremost seat plane* in each direction.

*Side impact pulse data



Seat Attitude	Pulse	Max Excursion (mm)	Peak Velocity (m/s)	Excursion @ Peak Vel (mm)	Vel @ 0mm (m/s)	Vel @ 50mm (m/s)	Vel @ 100mm (m/s)	Vel @ 150mm (m/s)	Vel @ 200mm (m/s)	Vel @ 250mm (m/s)	Vel @ 300mm (m/s)
Fwd	J2917	522	11.3	380	6.8	7.9	8.8	9.5	10.0	10.0	10.8
Side	J2917	334	13.4	189	9.6	10.3	11.1	12.2	13.1	11.8	12.5
Rear	J2917	829	15.7	309	9.9	11.1	11.1	12.8	13.3	14.1	15.3
Side	J2956	397	8.8	16	8.5	8.5	8.3	8.4	8.5	8.2	8.6

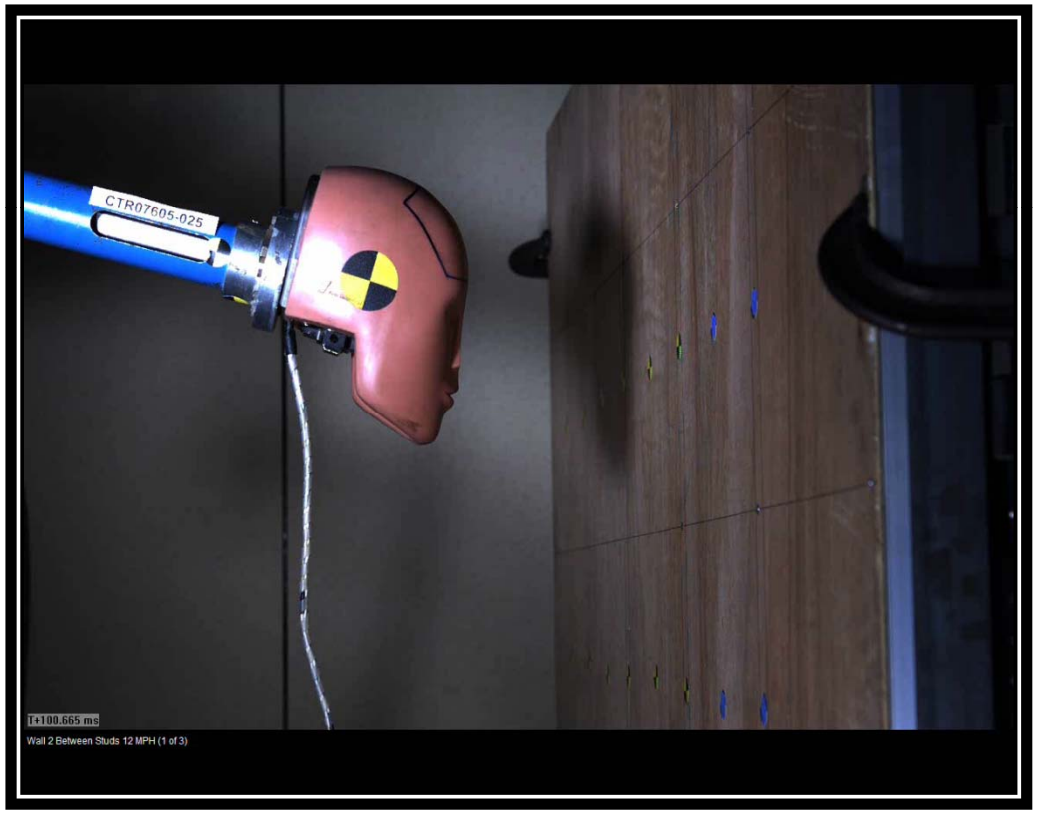
Interior Surface Delethalization: Design Guidance

Progress to date: 30% Complete – Test Contract in Draft

- AMD is now forming a committee to develop guidance document
- Goal is to provide information to ambulance builders to reduce likelihood of injury when impacting interior surfaces
- Will investigate construction methods, padding, airbags
- This work goes hand-in-hand with seat and cot excursion zones definition
- Contract signed in Sept. 2012 – Testing began in spring 2013

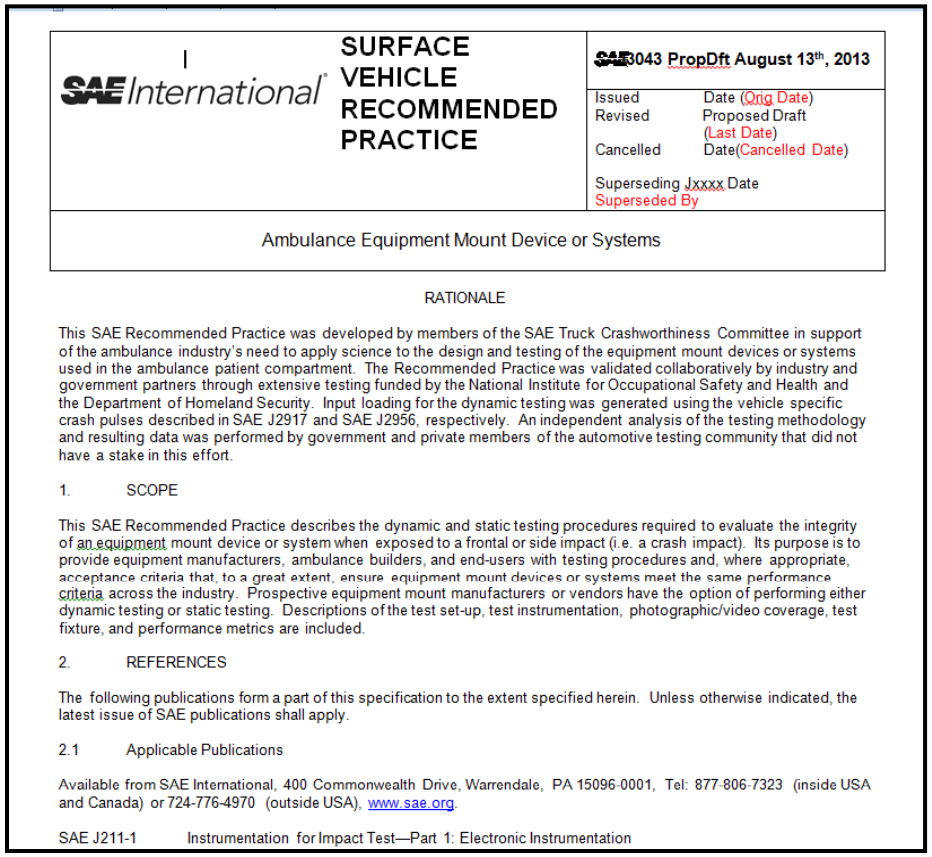
Interior Surface Delethalization: Patient to Overhead Cabinet Contact

Interior Surface Delethalization: Patient to Overhead Cabinet Contact



Equipment Mounting: Static and Dynamic Test Options

SAE J3043 Published in July 2014



SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J3043 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
- Static test in lieu of dynamic test is also an option
- Innovative conversion from dynamic to static test loading offered

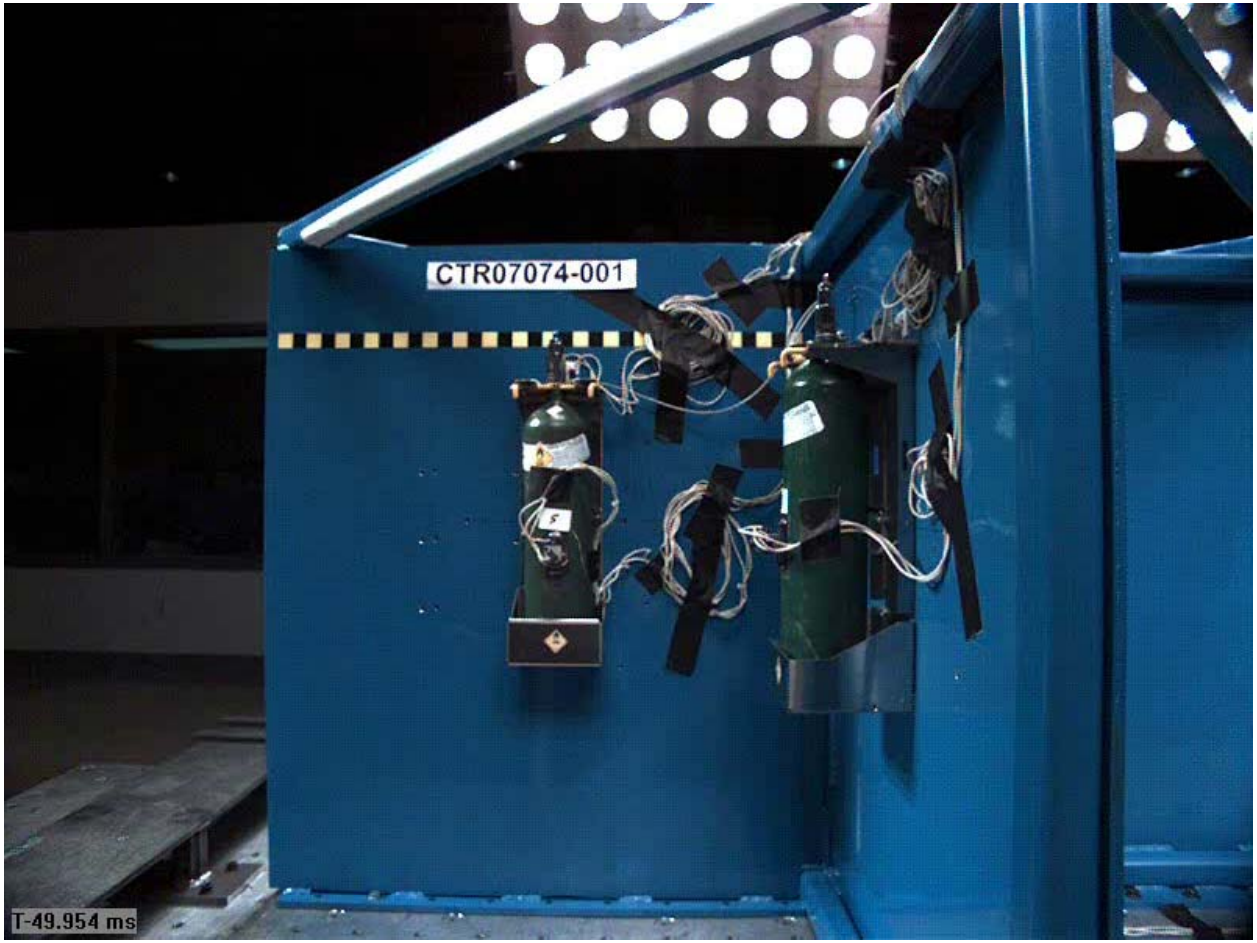
CDC SAFER · HEALTHIER · PEOPLE

NIOSH

Equipment Mount Test Standard

Equipment Mount Test Standard

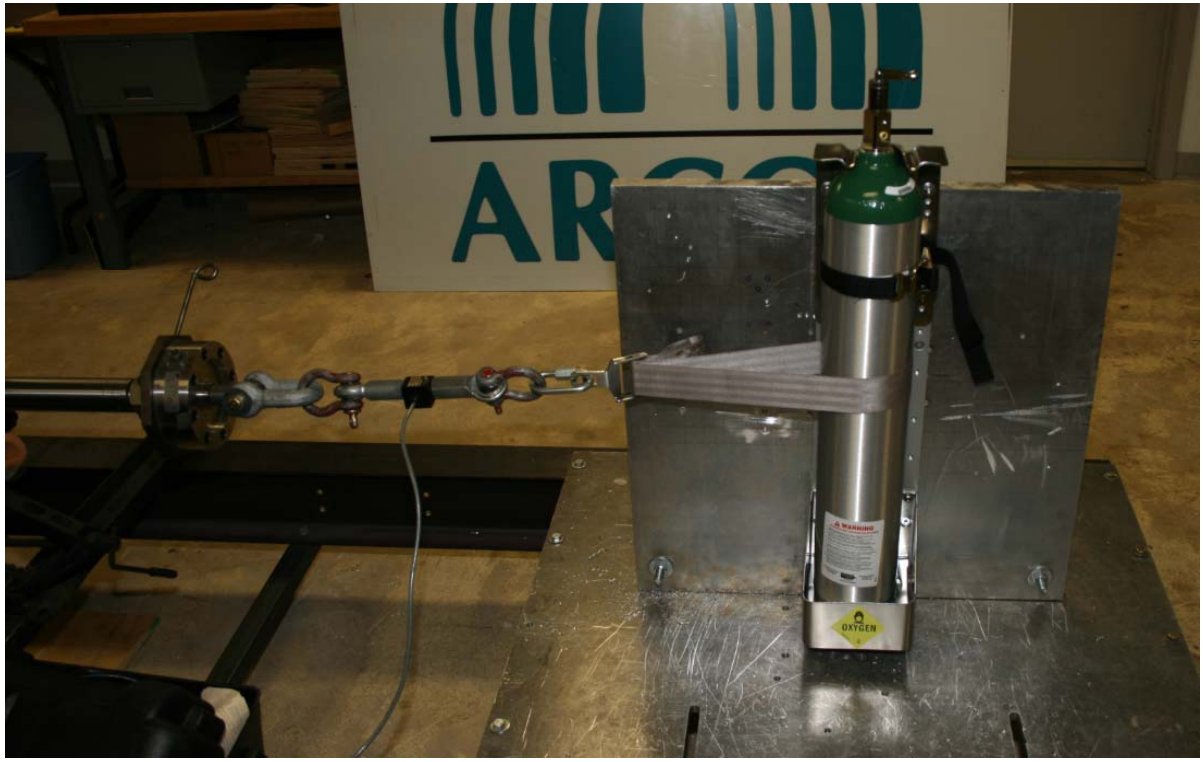
Utilizes Front and Side Impact Pulses



Equipment Mount Test Standard

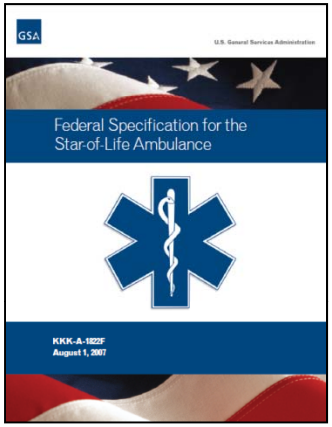
Static Test Option

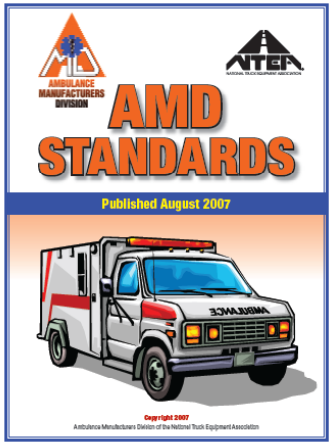
Steadily increasing load applied one axis at a time



Static Load = Peak G x Weight x 1.5 amp factor

Specs and Standards Tomorrow ??





SAE Standards:

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

NFPA 1917 Standard for Automotive Ambulances Effective 2016 2nd Edition

CAAS GVS-2014 Ambulances Standard Effective 2016 1st Edition

Contact Information

Jim Green

NIOSH

304-285-5857

jgreen@cdc.gov

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.*