Development of An Assessment Method for Airbag Noise in Modern Vehicles

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Outline

- **Benefits of Airbags**
- **Assessment Method**
  - **Previous Work**
  - **ISO/TC22/SC10/WG3 and SAE Impulse Noise Task Force Work**
    - Weissach Tests at Porsche
  - **Ford Motor Company Test Plan**
- **Summary**

Benefits of Airbags

- **US - NHTSA Final Economic Assessment of FMVSS 208 Advanced Airbags Rule:**
  - **Lives Saved By Airbags**
    - 5303 from 1987 to March 2000
    - 842 in 1997 with airbags in:
      - 36% of passenger cars
      - 28% of light trucks and vans
    - 3253 annually in a 100% pre-1998 airbag fleet

Benefits of Airbags

- **US - NHTSA Final Economic Assessment of FMVSS 208 Advanced Airbags Rule:**
  - **MAIS = 1 injuries**
    - Minimal effect on reducing these injuries
  - **MAIS 2-5 injuries**
    - Estimated reduction of 29007 injuries annually in a 100% pre-1998 airbag fleet

Assessment Method

- **Previous Work**
  - **Measurement Procedure***
    - Test Procedure
      - In-vehicle with windows up
    - Instrumentation Requirements
      - Microphones vs Pressure Transducers
      - Data acquisition system frequency response

* (Source: Rouhana et al, 1994)

Assessment Method

- **Previous Work**
  - **Parameter Study***
    - Noise due to driver vs passenger airbag
    - Effect of bag material
    - Vented vs unvented bags
    - Pyrotechnic vs Hybrid inflators
    - Aspirated inflators
    - Effects of vehicle volume

* (Source: Rouhana et al, 1994)

Assessment Method

- **Previous Work**
  - **Injury Risk Study Using ARL Ear Model****
    - Evaluation of previous criteria
    - In-vehicle noise in a crash without airbags
    - Description of feline model validation results
    - Evaluation of Model from Practitioners View
      - Repeatability
      - Hazard prediction
      - Observational Analyses

** (Source: Rouhana et al, 1998)

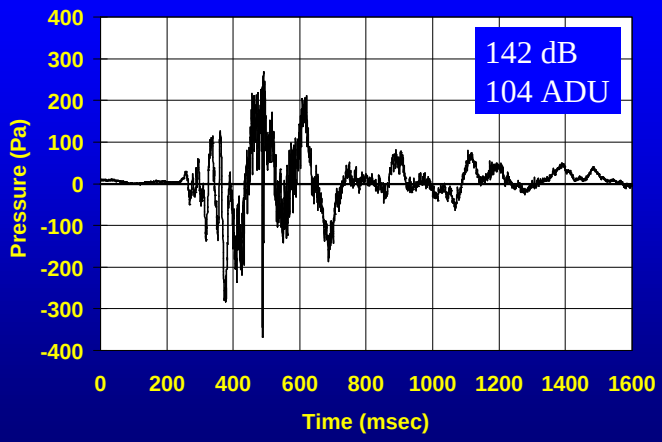
Assessment Method

- **Previous Work**
  - **Injury Risk Study Using ARL Ear Model****
    - Results from Previous Human Volunteer Experiments
      - Nixon (1969)
      - Sommer and Nixon (1973)
    - Field Observations
    - Fleet Evaluation with AHAAH
      - 35 vehicles from 18 manufacturers

** (Source: Rouhana et al, 1998)

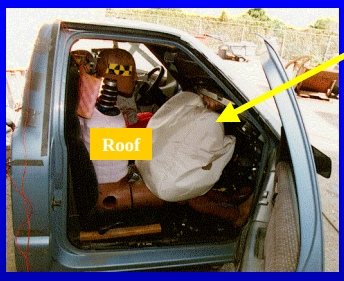
Results of Previous Work

Crash Noise - No Airbag



Results of Previous Work

Open Vs Closed



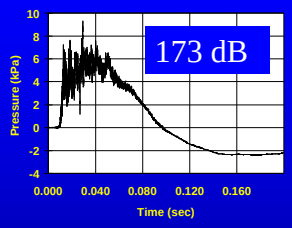
Small Pickup Cab
For Tests With Roof
(Doors Closed for Test)

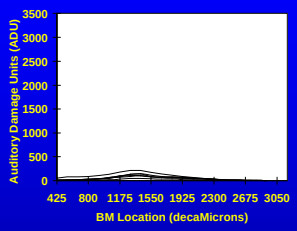
Roof Sawed Off
For Tests With No Roof
(Doors Open for Test)

Results of Previous Work

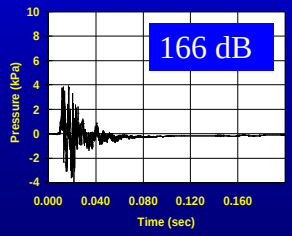
Open Vs Closed

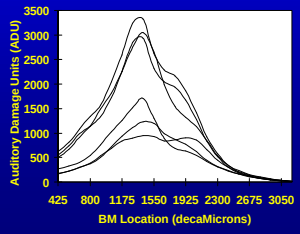
Roof





No Roof





Results of Previous Work

Sommer & Nixon Study (1973)

- **Exposures of 10 Human Subjects**

	SPL (dB)	TTS
Low Frequency	165	None
High Frequency	153	3 dB
Low + High Frequency	165	1 dB

Results of Previous Work
Field Reports

• Nixon (1969)*	1/91 (1.1%)
• Saunders, et al. (1995)	6
• McFeely, et al. (1998)	20
• Buckley, et al. in U.K.(1999)	2
• Huelke, et al. (1999)	3/177 (1.7%)
• Yaremchuk (1999)	60

*Experimental study, not a field report

Why Don't We See More ?

- Other Injuries May Overshadow HL
- Physicians May Not Recognize Potential Association with Airbag
- Most Hearing Loss Probably Unnoticed
  - Ear tuned for speech/hunting (30-70 dB)
  - Cannot distinguish noise of crash vs noise of airbag
  - Most people do not realize they have a hearing loss if below 25 dB

ISO and SAE Work

- Work Items Opened in ISO & SAE
  - ca. 1995
  - Same individuals in Europe and US
  - Goal to draft ISO Standard and SAE Recommended Practice
  - Committees identified issues in need of addressing before such standards could be completed

Major Issues Remaining

- Do we need a chamber or in-vehicle test?
- At what seating position(s) should measurements be made?
- Should measurements be made with vehicle windows up or down?
- Should measurements be made with a head form?
- Can measurements be made using a mannequin instead of crash dummy?

Major Issues Remaining

- **Should the ARL Ear Model be used with middle ear muscles warned or unwarned?**
- **Is the human validation of the ear model acceptable?**
- **What are the injury risk curves for noise-induced threshold shift as a function of Auditory Damage Units?**

ISO and SAE Work

- **Weissach Tests**
  - **1998 SAE Impulse Noise Task Force tests at Porsche to resolve:**
    - Selection of a head form for testing
    - Measurements in a chamber vs in-vehicle
- **SAE Information Report J1531**
  - **Draft now in accelerated review**
- **Ford Motor Company Tests**
  - **2001 Program to resolve remaining issues**

Ford Motor Company Tests

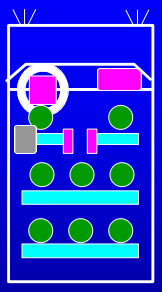
- **Goal:**
  - **To perform the research necessary to establish test procedures that will enable:**
    - assessment of the risk of noise-induced threshold shifts from deployment of inflatable devices in motor vehicles, and
    - development of industry standards
    - supplier airbag development programs that address issues relative to inflatable device deployment

Ford Motor Company Tests

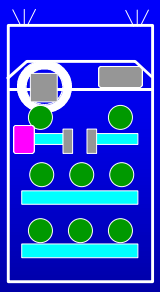
- **How does noise/pressure/risk vary within a vehicle during deployment of inflatable devices?**
  - **Horizontal variation (Seating position)**
  - **Vertical variation (Occupant seated height)**

Horizontal Variation

Frontal Airbag System



Side Airbag System



Measurements at up to 8 locations in 10 different vehicles

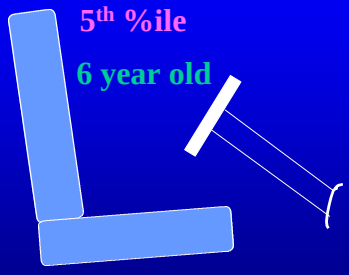
Vertical Variation

95th %ile

50th %ile

5th %ile

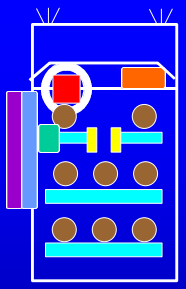
6 year old



Ford Motor Company Tests

- **How does the risk change when multiple devices are deployed?**
  - **Simultaneously**
  - **Staggered deployment**

Multiple Devices



Driver Airbag

Passenger Airbag

Pretensioner

Side Impact Airbag

SI curtain airbag or Rollover curtain airbag

Impact Type	DAB	PAB	PreT	SAB	SI Curtain	R/O Curtain	Comments
Frontal (208)							
Side (R95)							
Hi Speed SI							1
							1
							1
Pure R/O							
SI + R/O							2
							2
							2

Comments:

1) **Simultaneous or staggered? Test both scenarios?**
2) **Probably not simultaneous ==> Test individually?**

Ford Motor Company Tests

- What components contribute most to the risk of noise-induced hearing loss?
- Can we modify components to reduce noise while still preserving the crash performance of the system?
- How does the risk from depowered airbags compare to previous results?

Summary

- We thank Dr. Hohmann and Switzerland for focusing attention on this issue in this forum
- Valid assessment methods have not been available in the past
- Use of inappropriate methods could lead to greater risk

Summary

- Airbags are effective devices at reducing risk of fatality and serious injury
- While hearing loss is an important issue, methods to reduce noise must be balanced by the inflatable device's primary life-saving and injury-reducing function
- With the ARL Ear Model it may now be possible to achieve both

Summary

- Regulatory action is premature at this time:
  - Need peer-review of criterion and model human validation
  - Need to complete experimental study to finalize recommended measurement practice
- Regulations may need longer phase-in due to challenges associated with maintaining crash performance while addressing noise


Grazi
Merci
Danke
Gracias
Arigato
Thank You
СПАСИБО
Tack
Shukran
Shia-shia