ADVANCED RESTRAINT SYSTEMS

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First Seat Belt Patent
Gustave-Désiré Lebeau
May 11, 1903
Driver Injuries without Airbag Deployment

Driver Injuries with Airbag Deployment

SIGNIFICANT DIFFERENCES

Face  
AIS1+ - 36.7%  
AIS2+ - 87.4%  
AIS3+ -  

Head  
AIS1+ - 38.7%  
AIS2+ - 55.2%  
AIS3+ - 61.4%
**Force Limited Belt**

**Function:** Seat belt restraint designed to limit belt forces to predetermined level

**Effect:** Limits the maximum force applied to the body and allows the body to move more within the occupant compartment and over the ground, extracting a great amount of kinetic energy

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**Advanced Restraint Systems**

**Thorax Bag**

- Integrated in seat therefore independent of seat position
- Protective effect obtained by keeping the occupant away from the impact zone, and dampening the blow from the intruding side of the vehicle
- Bag is inflated within 12 thousandths of a second, four times faster than a frontal airbag
Advanced Restraint Systems
Head Thorax Bag
- Extension of thorax bag - greater volume
- In sewn version pressure from interaction causes head portion to inflate quicker

Advanced Restraint Systems
Inflatable tubular structure (ITS)
- Side impact protection, activates together with thorax bag
- Front occupant protection only
- Installed in the headliner above the frontal doors
- Inflates to a diameter of about 15 centimetres (5 inches).

Advanced Restraint Systems
Inflatable Curtain
- Head protection in side impacts & rollovers
- Attached along roof rail and stowed behind trim panels
- Protects both front and rear passengers
- Potential to prevent partial and full ejection
- Deployment time 30ms

Advanced Restraint Systems
Anti-submarining/ Leg Bag
- Reduce the risk of submarining in a crash
- Keep the occupant's knees and legs safe distance from instrument panel
- Improve protection offered by frontal airbag and seat belt by keeping occupant in a more upright position.

Advanced Restraint Systems
Knee Bolster
- Reduces loading to foot, ankle and lower leg by moving them away from toeboard before intrusion
- Acts as cushion to reduce acceleration of foot (heel), force and bending moments of lower leg (tibia)
- Keeps backward rotation motion within tolerable range by lifting heels away from toeboard
- Inflated in 20ms

Advanced Restraint Systems
Inflatable carpet Systems
Advanced Restraint Systems

• More bags per seating position
• Front, side in door, side in seat, knee bolster, footwell, bag in belt, curtain, ITS, seat back

Crash Speeds in Frontal Impacts
Front Seat Passengers: MAIS 2 - 6

Who is an average adult person?
### REAL WORLD VARIATIONS

- **PRE-CRASH PHASE**
- **CRASH PHASE**
- **POST-CRASH PHASE**

### PRE CRASH VARIABLES

- Height, Weight, BMI, Sex, Age
- Pre-existing Medical Conditions
- Biomechanical Tolerance, Muscle Tone
- Stomach & Bladder Contents
- Alcohol, Drugs, Clothing, Restraint Use
- Belt Position, Pre-impact braking
- Sitting Position, Posture

### CRASH VARIABLES

- Impact Direction, Velocity Change, Peak Vehicle Deceleration, Pulse Duration
- Peak Belt Load, Posture at Peak Load, Airbag Interactions, Point in Heart Cycle
- Loads and Durations of Localised Contacts
- Rear Loading, Interactions with Other Occupants

### POST-CRASH VARIABLES

- Type and Severity of Injuries
- Combinations of Injuries
- Response Times of EMS
- Quality and Speed of Diagnosis of Injuries
- Quality of Treatment
- Resulting Disabilities
Advanced Restraint Systems
• Adaptive systems
  • Adapt to crash scenario
    – Multi stage inflators
    – 2 stage load limiters
  • Adapt to both crash scenario & occupant
    – Adaptive venting
    – Adaptive generator
    – Adaptive load limiter
• Adapt to occupant characteristics
  – Airbag on/off switch
  – Adaptive load limiter
  – Adaptive venting
  – Adaptive tear seams

Advanced Restraint Systems
• Crash Adaptive Systems
  – Multi stage inflators
    • Normally two stages
      • single stage - low severity crashes
      • dual stage - high severity crashes
      • All propellant dispelled!!!
  – 2 stage load limiter
    • In initial onset of the crash, occupant only restrained by the belt, restraining force of the seat belt held at a relatively high, constant level.
    • As occupant moves forward and into the airbag, load limiter switches to "the second gear" – a lower restraining force
    • Prevent the risk of peak load
    • even load on the occupant’s chest during the whole crash

THE FUTURE
• More sensing of occupant position
• Sensing of occupant’s weight, bone density
• Smart key codes
• Greater variability of belt characteristics
• Greater variability of bag characteristics

The Next Breakthrough –
Pre-Crash Sensing Proximity Radar