Seat with Bottom Cushion Airbag for Vertical Emergency Load Attenuation

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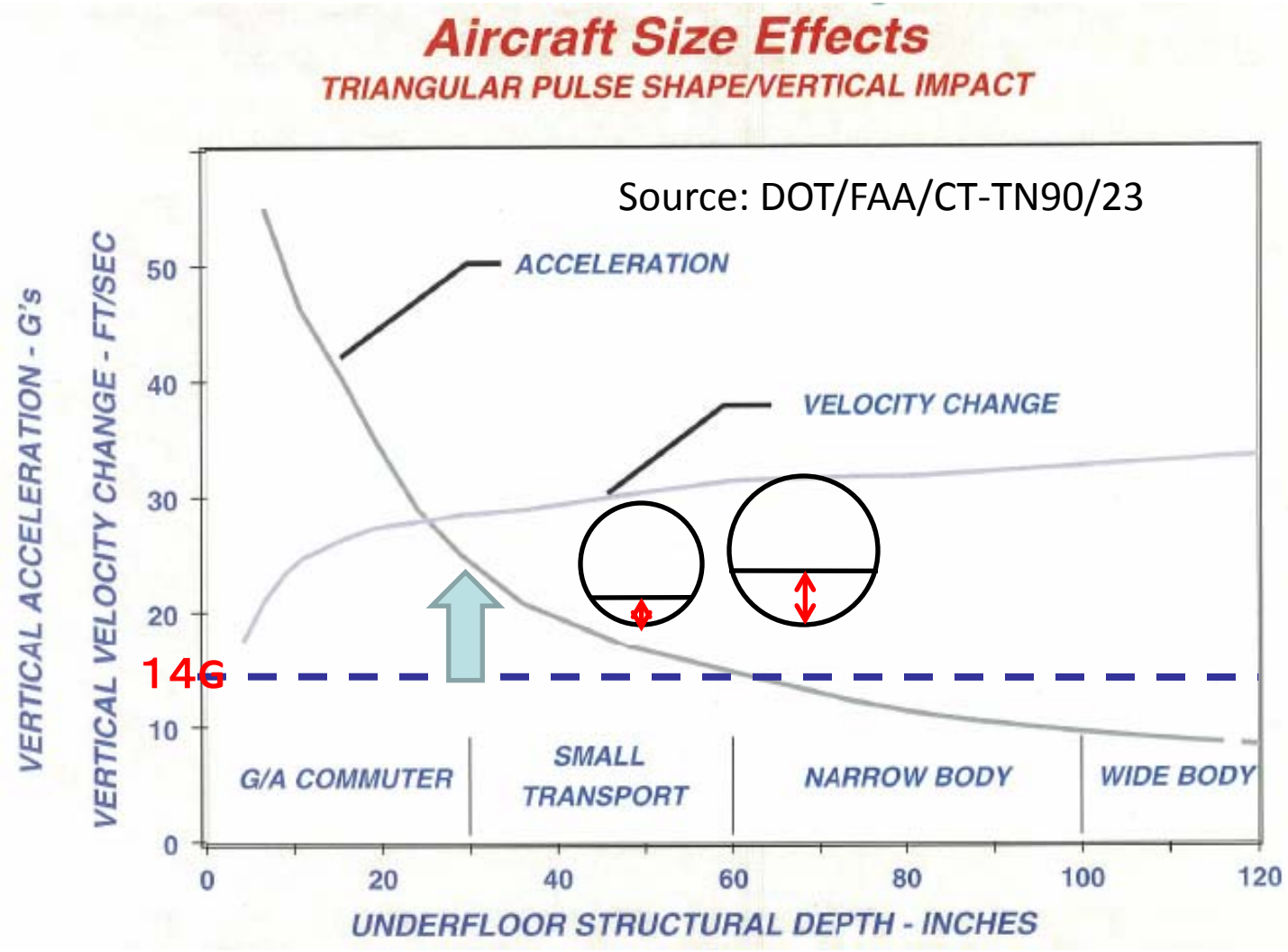
Background



Small transport has severer vertical load environment than the regulation requirement environment in emergency landing condition.

Background(2)

Motivation

- Small transport has severer vertical load environment than the regulation requirement environment in emergency landing condition.
- Retrofit old seat to the current regulation
- In the near future, many airbags will be in use in the cabin like automobiles.

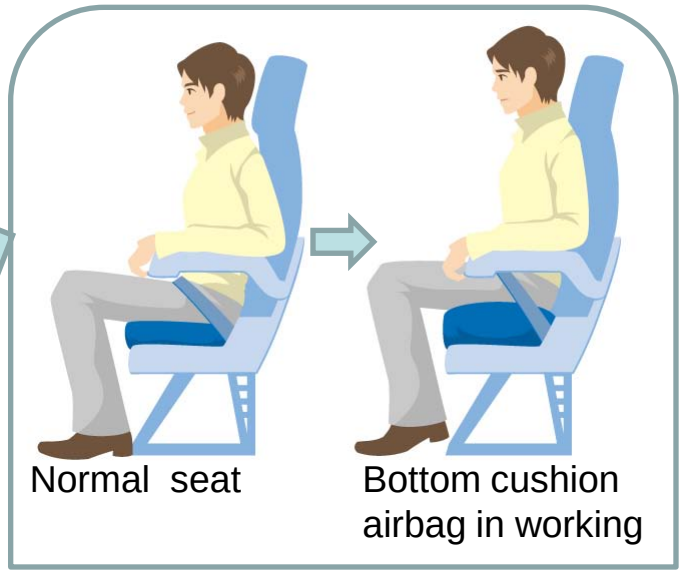
Purpose

Using airbag in bottom section of seats for attenuation vertical direction load

R & D

1st concept:
using airbag under the seat pan

2nd concept:
install airbag in bottom cushion



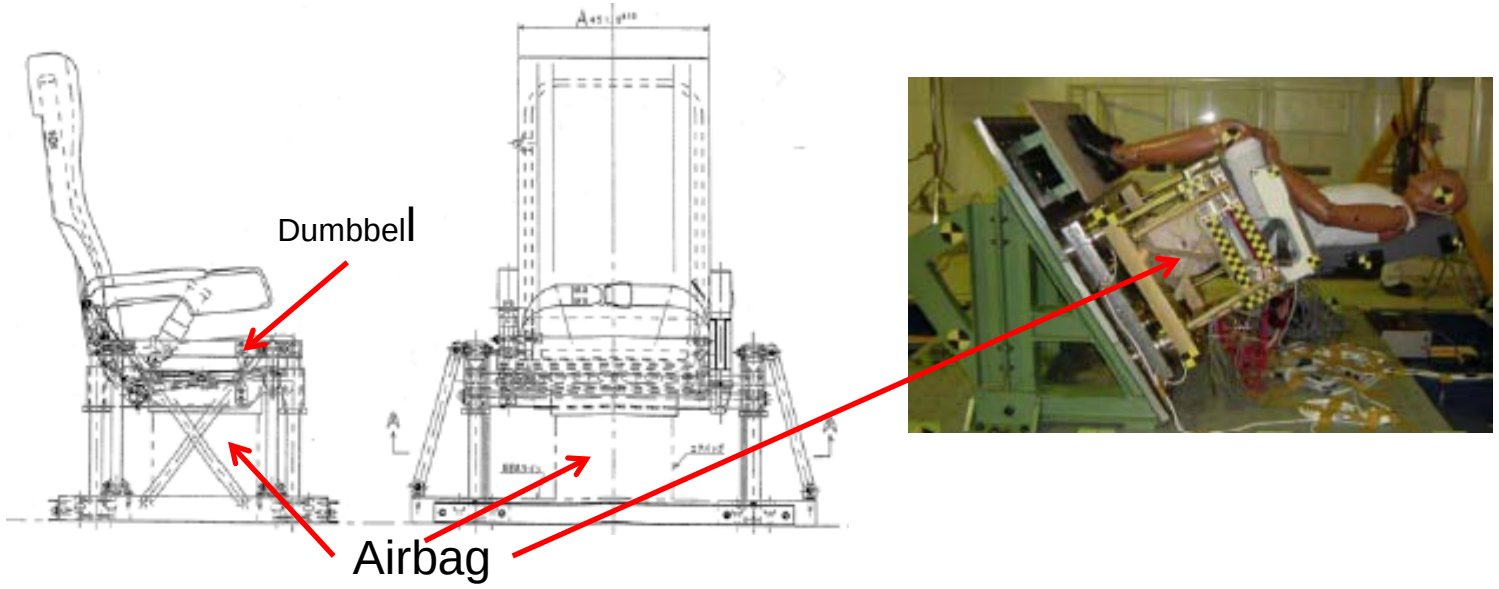
1st Concept seat

Purpose

Investigate effect of airbag without inflator for vertical emergency load

Concept

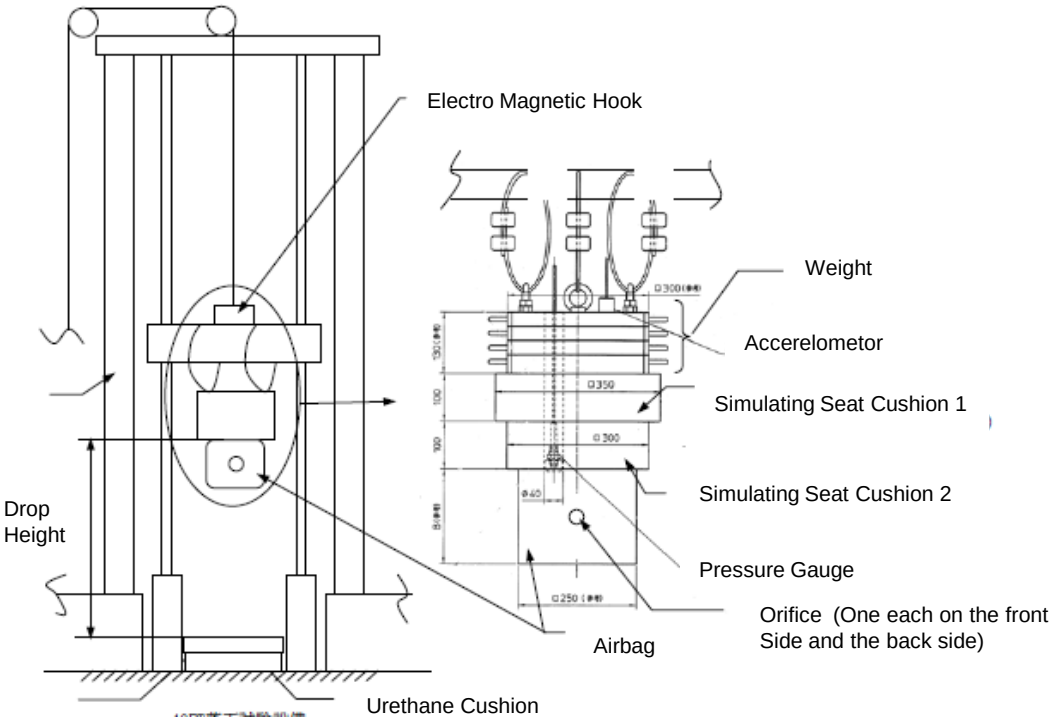
- An airbag support the upper part above the seat pan in emergency
- The upper part above the seat pan slide down along supporting columns in emergency



Basic research for 1st Concept

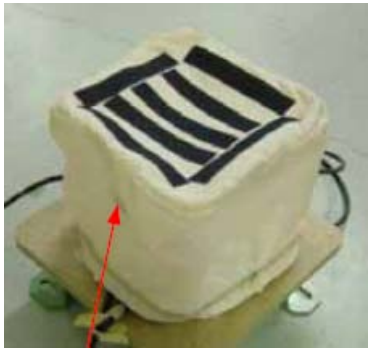
Purpose Determine design parameters for airbag without inflator

Design Parameters Airbag height, Orifice diameter, Orifice seal material



40ft Drop Tower in Daicel Chemical Industries

After drop test



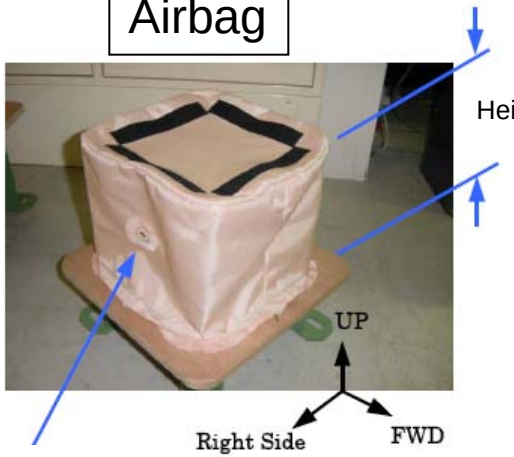
Airbag:
250mmW X 250mmD X 200mmH

Sled Test of 1st Concept

At Tenryu Sled Seat Test Facility
Test Condition: FAR 25.562 (b)(1)

Tenryu 9G Normal Seat

Airbag

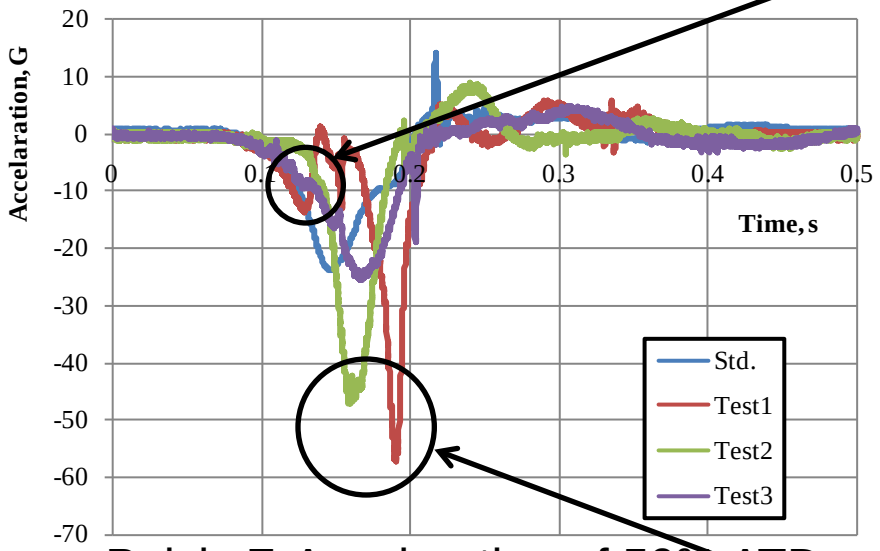


Orifice

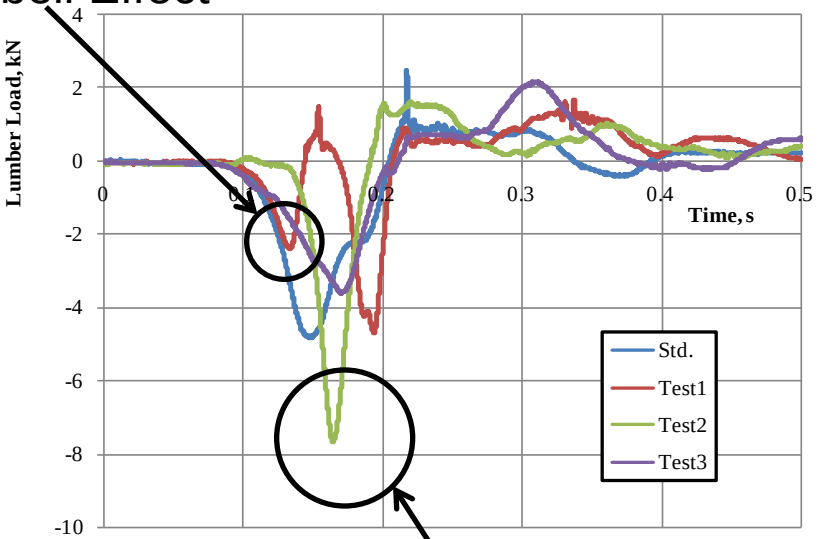
	Airbag				Dumbbell
	Size (W X D X H), mm	Orifice		Initial Pressure	
		Diameter, mm	Seal Type		
Test 1	250 X 250 X 200	10	Aluminum Tape	Atmospheric Pressure	Use
Test 2	250 X 250 X 200	10	Silicon Rubber Sheet of 0.3mm Thickness	Atmospheric Pressure	Not Use
Test 3	250 X 250 X 200	20	Aluminum Plate of 30μm Thickness	0.039 Mpa	Not Use

Sled Test Results of 1st Concept

Dumbbell Effect



Pelvis Z-Acceleration of 50% ATD



Lumber Load of 50% ATD

	Maximum Pelvis Z-Acceleration, G	Maximum Lumber Load, kN (lbs)	Maximum Airbag Pressure, Mpa
Standard 9G	23	4.7(1060)	-
Test 1	57	4.7(1050)	0.15
Test 2	47	7.7(1721)	0.26
Test 3	23.4	3.6(810)	0.179
		1500 lbs=6.67 kN	

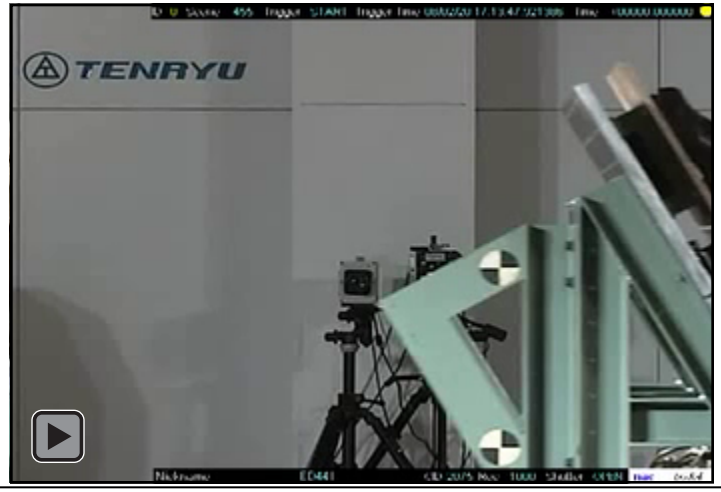
After seat leg stroke 0

Airbag seal not teared

Sled Test of 1st Concept(2)

Test No1: 200mm airbag height with dumbbell

Test No2: 200mm airbag height without dumbbell



Test No3: TestNo2 condition + initial Pressure + without broken oriffice

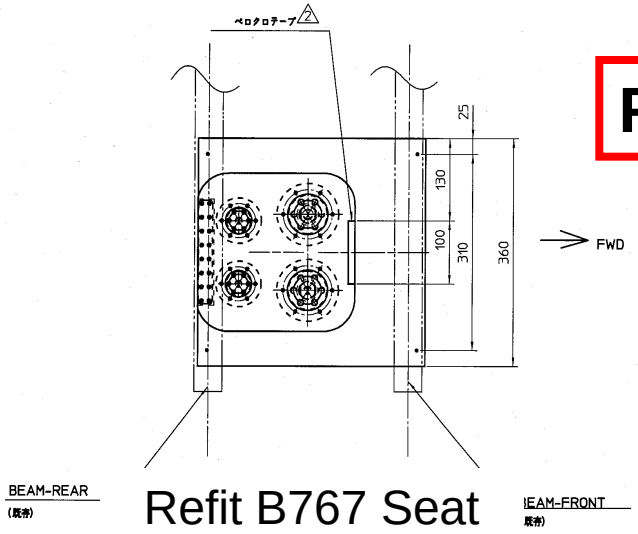
Summary of 1st Concept

- Airbag orifice seal improves ability of shock absorbing Because pressure inside the airbag will be higher and airbag working time will be longer.
- Optimized design of initial pressure value and orifice tearing strength will improve ability of shock absorbing more.
- First concept seat shows effect of attenuation of vertical load by using airbag in the bottom part of seats.
- 1st concept seat results that large moving stroke occur and ATD also move very largely in the vertical direction.
- The large moving cause large deceleration in stopping ATD.
- 1st concept seat is unpractical due to its stroke device and its occupation the space under seats.

2nd concept: Airbag in the bottom seat cushion

2nd Concept

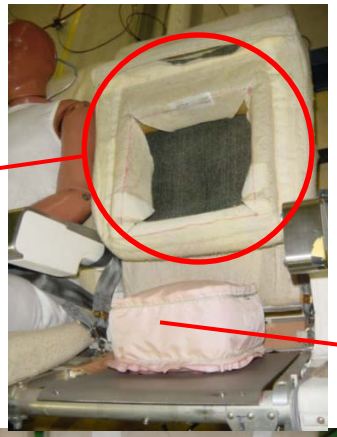
First Step: without inflator, with only initial pressure in the airbag
Second Step: with inflator and initial pressure in the airbag



Refit B767 Seat

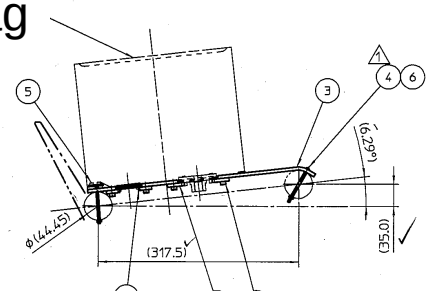
First Step

Hollow the bottom cushion And cover the airbag

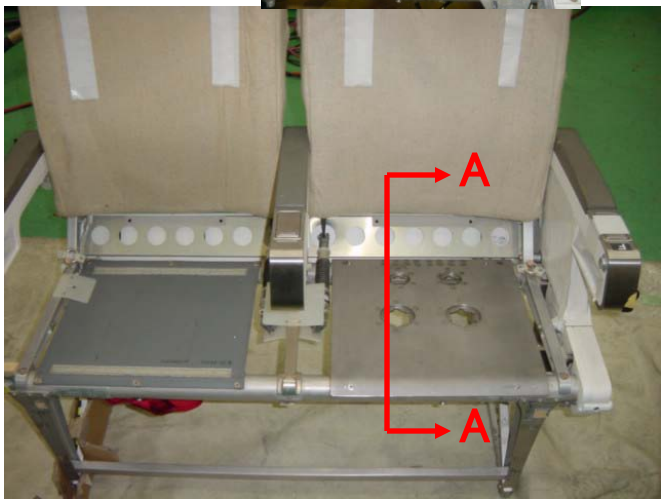


Airbag

Airbag



A-A



Left Seat: Airbag

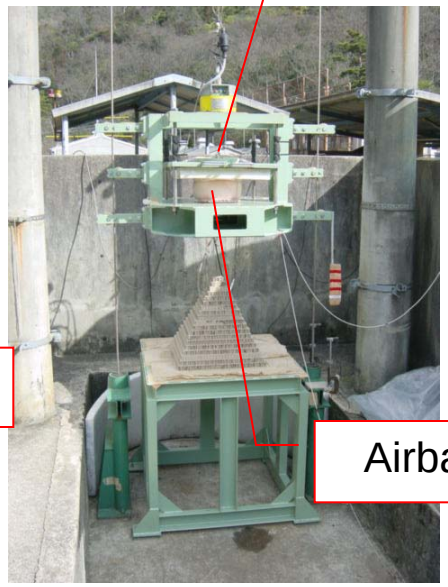
Right Seat: Reference

Basic research for 2nd Concept

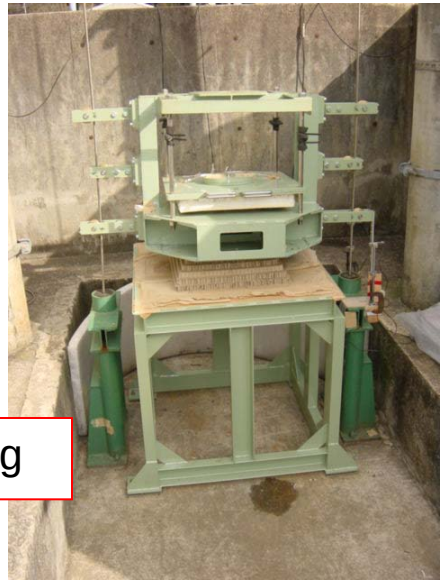
Purpose Determine design parameters for airbag without inflator

Design Parameters Orifice diameter, Orifice seal material, Initial pressure and Orifice tearing pressure

40ft Drop Tower in Daicel Chemical Industries



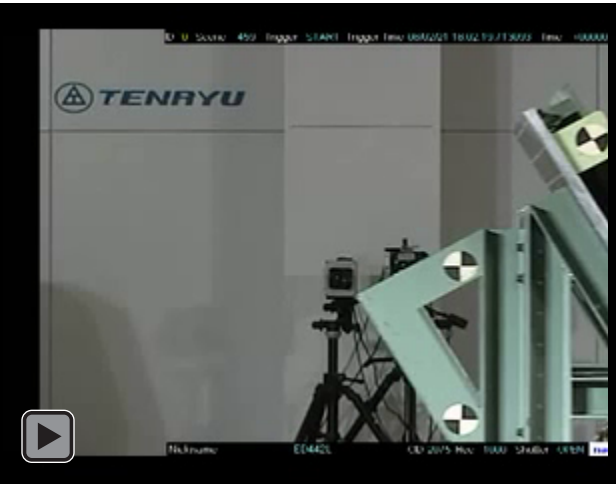
Before Test



After Test

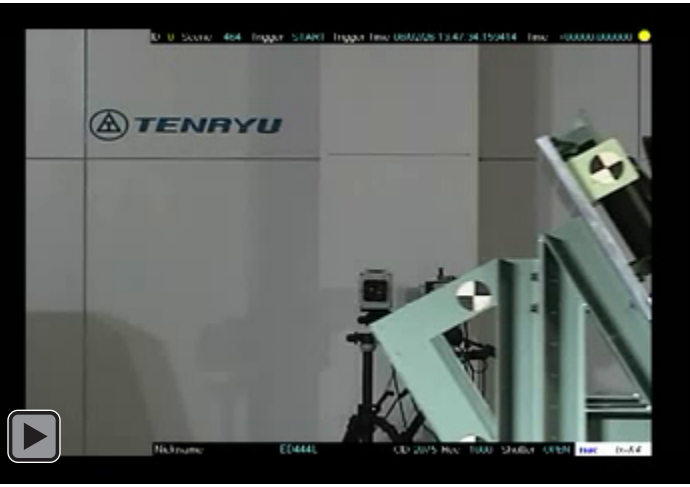
Videos of 2nd Concept without Inflator

	Airbag Height, mm	Orifice Diameter, mm	Initial Pressure, MPa	Orifice Tearing Pressure, Mpa	Aluminum Foil Thickness, μm
Test 1	100	15	0.073	0.198	20
Test 2	100	20	0.069	0.138	20
Test 3	100	15	0.057	0.127	15



Test 1
Orifice didn't failure

Test 2

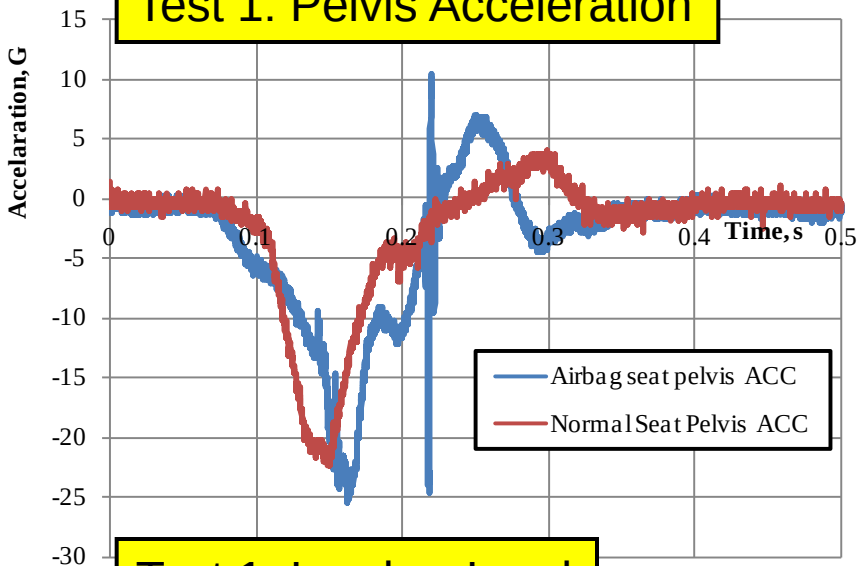


Test 3

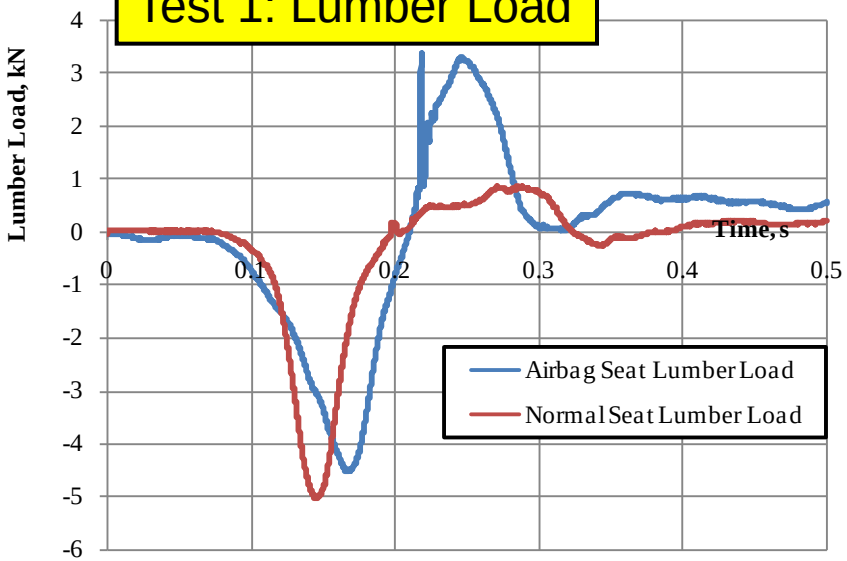
At Tenryu Sled Seat Test Facility

Result of 2nd Concept without Inflator

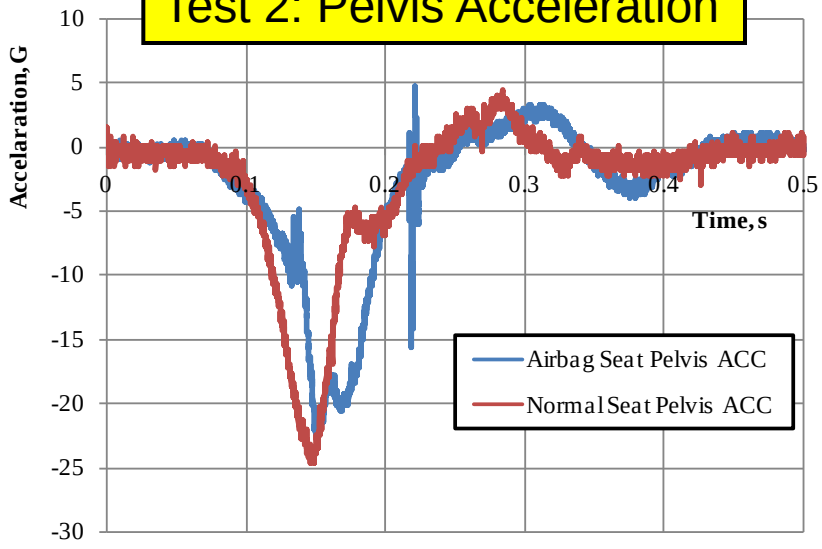
Test 1: Pelvis Acceleration



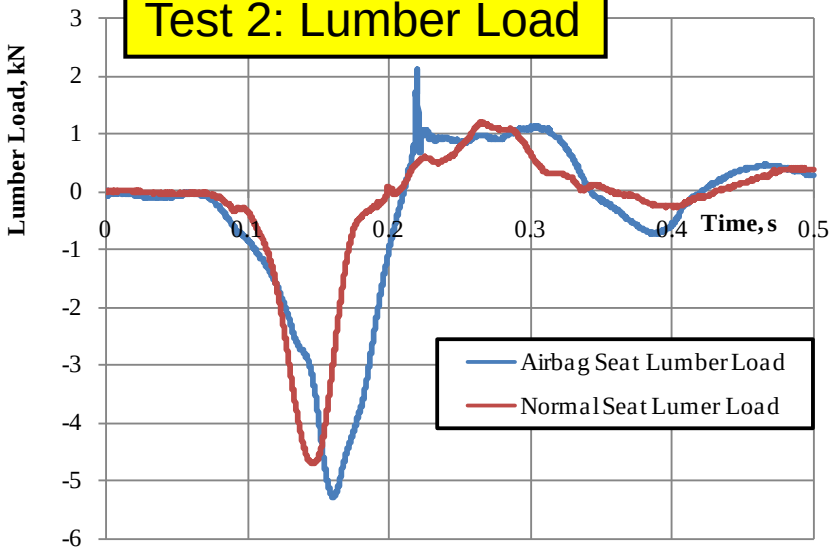
Test 1: Lumber Load



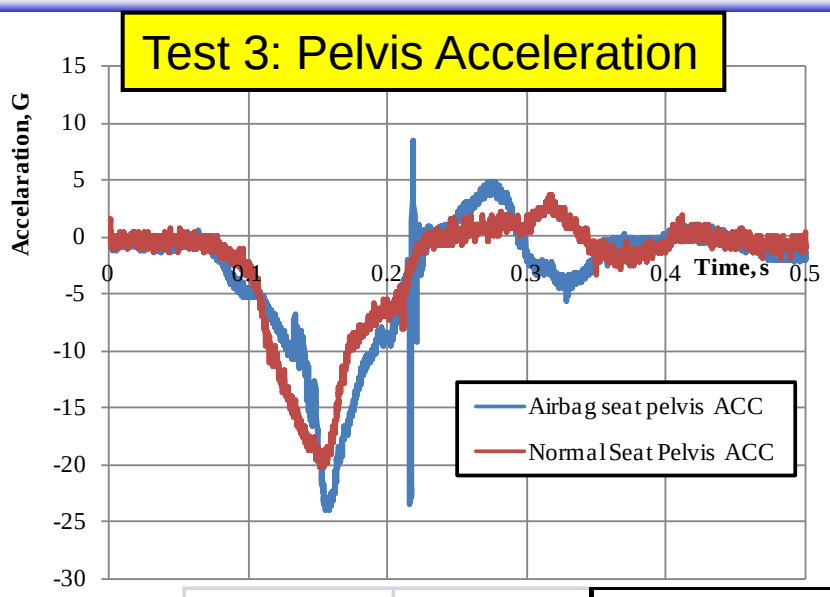
Test 2: Pelvis Acceleration

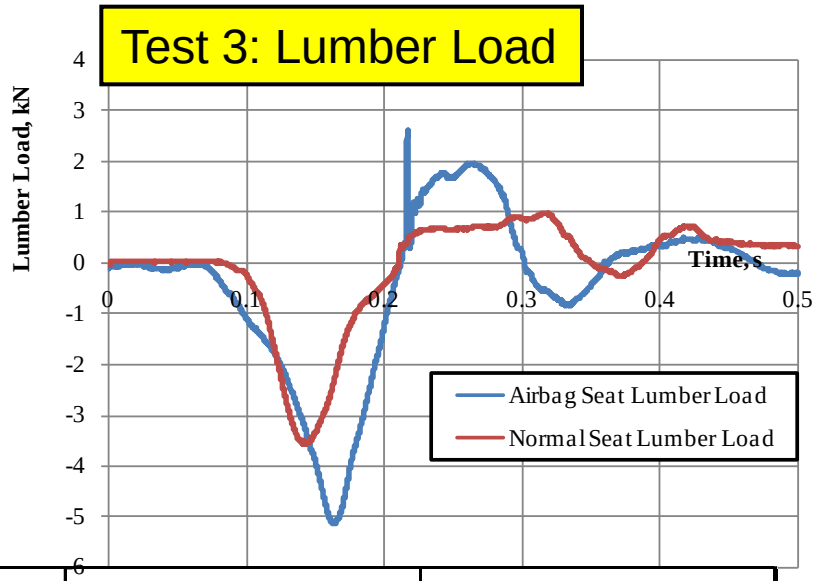


Test 2: Lumber Load



Result of 2nd Concept without Inflator(2)





		Maximum Pelvis Z-Acceleration, G	Maximum Lumber Load, kN (lbs)	Maximum Airbag Pressure, Mpa
Test 1	Airbag	22.6	4.5	0.197
	Normal	21.5	5.0	-
Test 2	Airbag	21.0	5.3	0.182
	Normal	24.0	4.7	-
Test 3	Airbag	21.6	5.1	0.176
	Normal	21.0	3.6	-

Shock absorbing ability of 2nd Concept without inflator is equivalent to that of normal seat

2nd Concept with Inflator

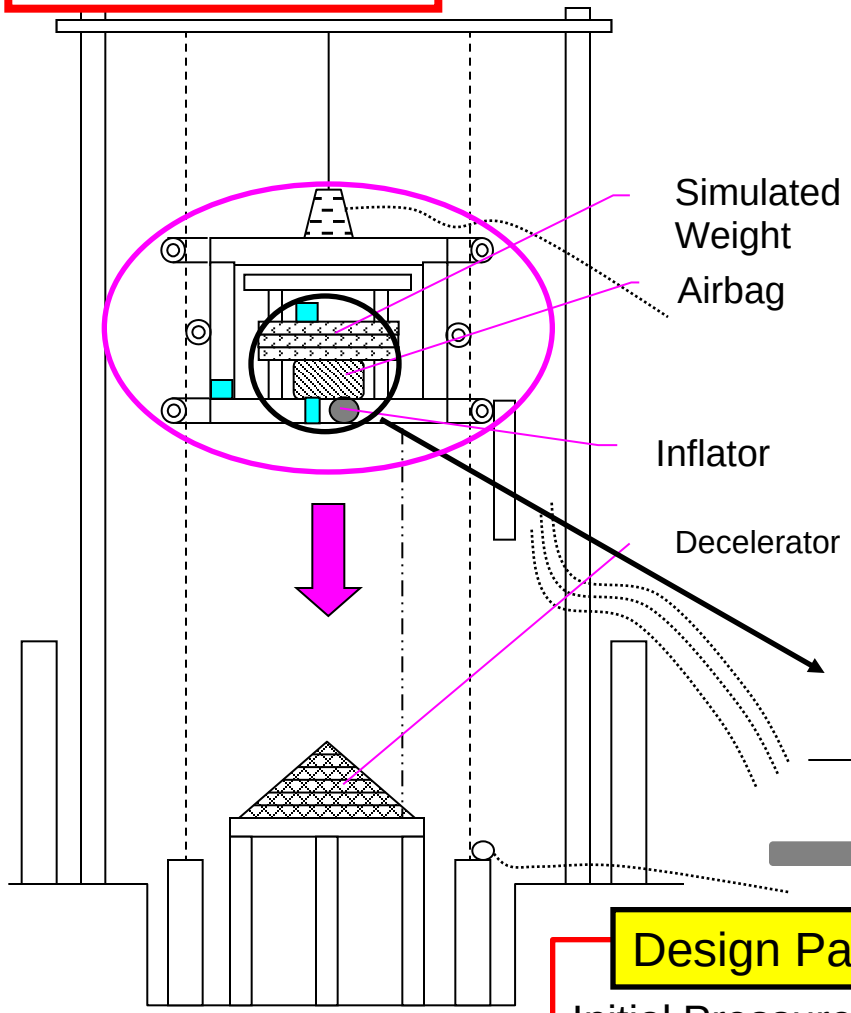
Shock absorbing ability of 2nd Concept without inflator is equivalent to that of normal seat

Inflator : airbag will keep longer working time will control of airbag pressure

Effective on attenuation of lumber load?

2nd Concept with Inflator

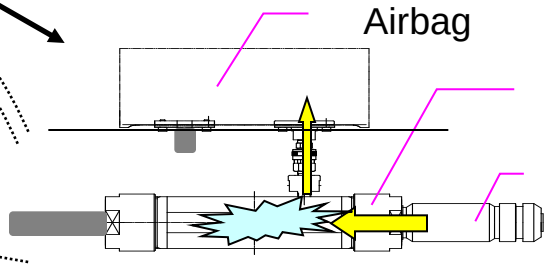
Second Step



Basic Test Setup

Before Test

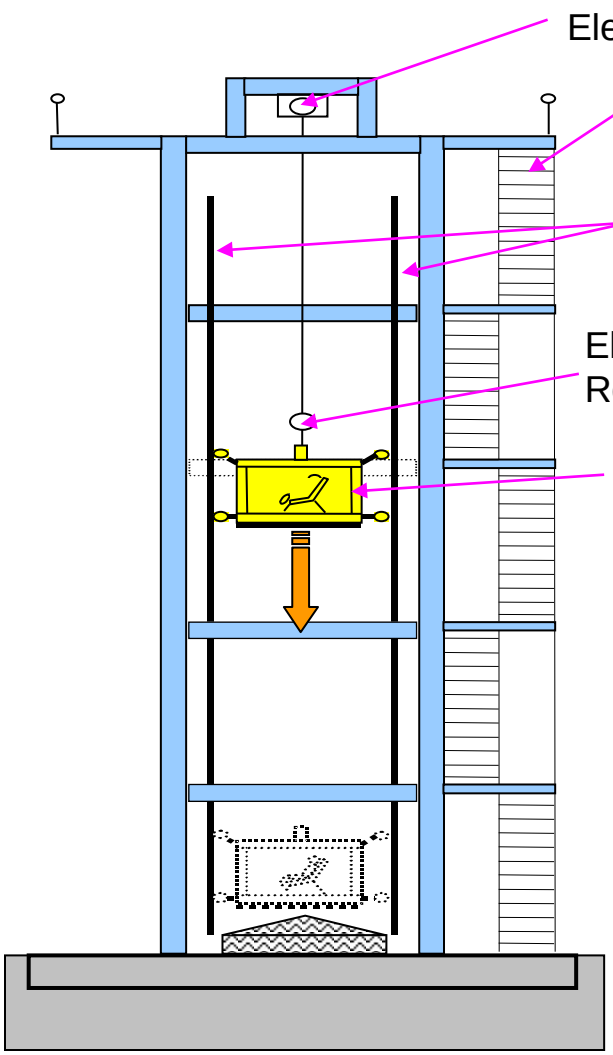
After Test



Design Parameters

Initial Pressure, Orifice Diameter, Orifice Seal Thickness, Orifice Tearing Strength, Air Supplying Time & Timing

Daicel DropTest Tower Facility



Accumulator & Inflator

Airbag

Videos of 2nd Concept with Inflator

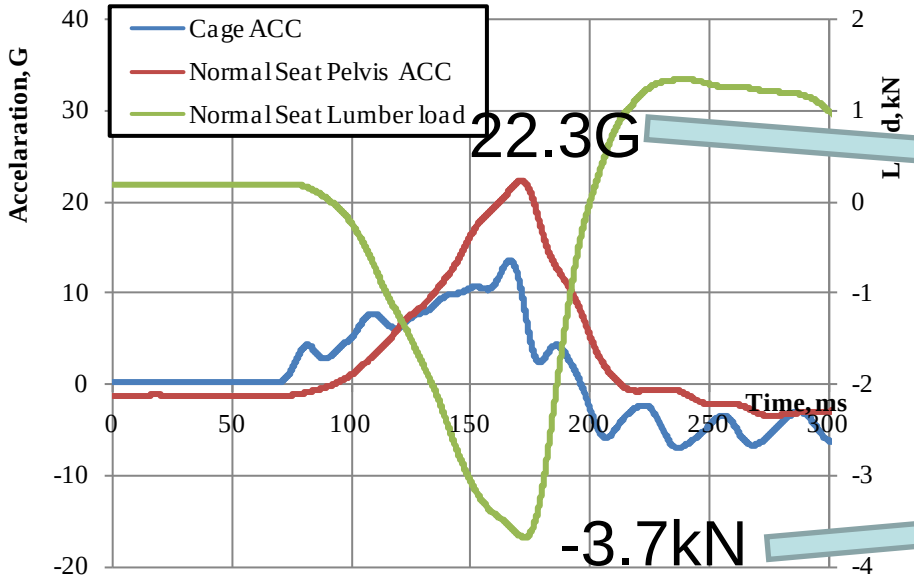
At Daicel DropTest Tower Facility

Test No1

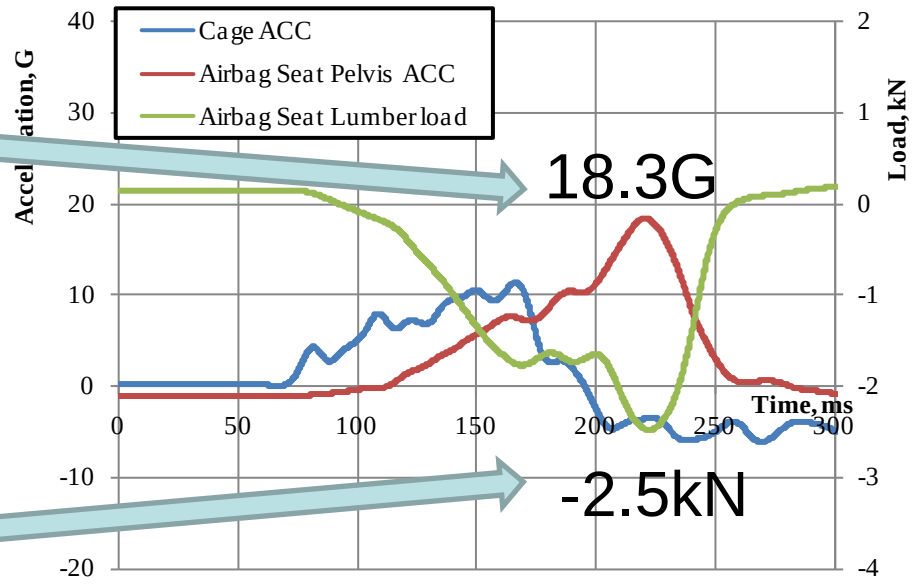
Normal Seat
9G Seat for B767

Test No2
Initial Pressure: 0.057MPa
Orifice Diameter: 20mm
Orifice Seal Thickness: 20μm
Seal Tearing Pressure: 0.17MPa
Accumulator Orifice Diameter: 2mm
Inflator Fire Timing: -30ms

Result of 2nd Concept with Inflator



Test 1: Normal Seat Case Result



Test 2: Airbag Seat Case Result

Airbag seat with inflator attenuate vertical load drastically although cage impact pulses are little different between normal seat case and airbag seat case.

Summary

- Airbag orifice seal improves ability of shock absorbing
  Because pressure inside the airbag will be higher and airbag working time will be longer.
- Optimized design of initial pressure value and orifice tearing strength will improve ability of shock absorbing more.
- First concept seat shows effect of attenuation of vertical load by using airbag in the bottom part of seats.
- Shock absorbing ability of 2nd concept without inflator is equivalent to that of normal seat.
- **Airbag seat with inflator attenuate vertical load drastically**
- **Seat with bottom cushion airbag is effect on attenuation of vertical emergency load**
  (although there are many practical problems on the system)