

Status of NHTSA's Ejection Mitigation Research

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Ejection Mitigation

Problem Definition

- **51,700 Annual Ejections (1997-2002)**
 - 1% of all crash-involved occupants
- **10,600 Annual Ejected Fatalities**
 - 32% of all fatalities
 - 6,200 through side windows
- **10,900 Annual Rollover Fatalities**
 - 3,900 ejected through side windows

Ejection Mitigation Research Program Goals

- **Demonstrate Countermeasure Feasibility**
 - Evaluate ejection mitigation capability
 - Evaluate injury-causing potential
- **Develop Occupant Retention Test**
 - Full-scale rollover tests not repeatable
- **Develop Rollover Sensor Performance Test**

Ejection Mitigation Dynamic Rollover Fixture (DRF)

- **Research Tool to Evaluate Countermeasures**
- **Produces Repeatable Full-Dummy Ejections**
 - Allows dummy response measurements
- **Produces Realistic Roll Rates**
 - Up to 360 deg/sec
- **Variable Occupant-to-Window Speeds**
 - 15 to 30 kmph
- **Variable Occupant Trajectories and Impact Locations**
- **Does Not Simulate Lateral Vehicle Accelerations**



Ejection Mitigation Countermeasure Candidates

- **Inflatable Systems**
 - Advanced Head Protection System (AHPS): Original & Beltline Systems
 - Zodiac Automotive US
 - Prototype Window Curtain
 - TRW Automotive
- **Advanced Side Glazings**
 - Bi-laminate
 - Tri-laminate
 - Modified door frame
- **Inflatable/Glazing Combination**
 - Less door frame modifications



Ejection Mitigation

DRF Testing

- **Window Treatments**
 - Open window
 - Inflatables, glazings, combination
- **Dummy Sizes**
 - 50th male
 - 5th female
 - 6 year-old
- **Seated Positions**
 - Behind steering wheel
 - Inboard

Ejection Mitigation

DRF Testing Results – Dummy Containment

- **Open Window**
 - Complete ejection in every case
- **TRW and Original AHPS Inflatable Systems**
 - Prevented complete ejections
 - Shoulders & arms escaped below bag
- **Beltline AHPS Inflatable System**
 - Prevented complete and partial ejections
- **Advanced Glazing**
 - Prevented complete and partial ejections
- **Combination Systems**
 - Prevented complete and partial ejections

Ejection Mitigation

DRF Testing Results – AHPS Systems



Original



Beltline

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DRF Testing Results – Dummy Responses

- **Low Head Injury Potential**
 - Maximum $HIC_{36} = 121$
- **Low Neck Tension**
 - Maximum - 33% IARV (per FMVSS 208)
- **Generally Low Neck Compression**
 - Maximum - 82% IARV (per FMVSS 208)
 - All the rest below 60%
 - Higher values from contact with side roof rail while engaged with countermeasure

Ejection Mitigation

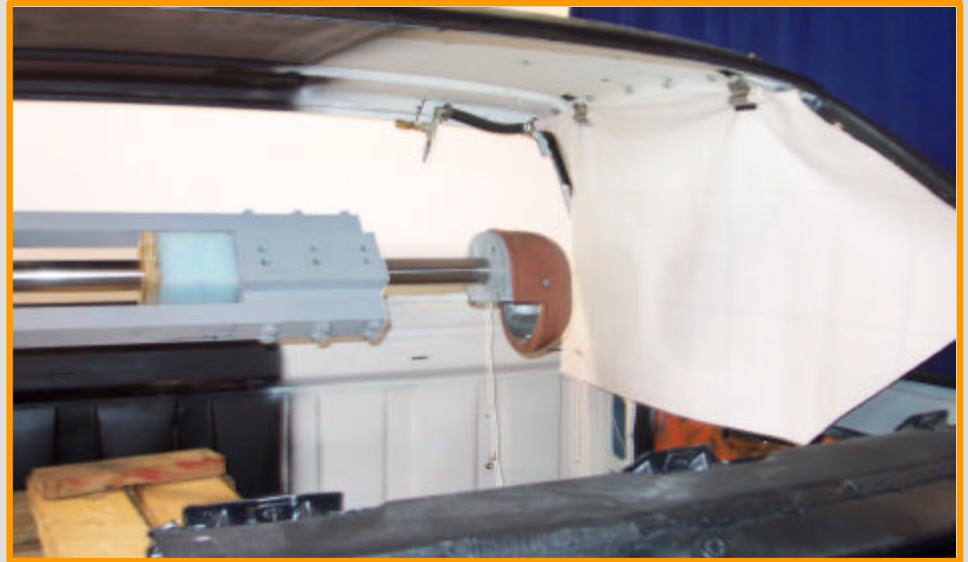
DRF Testing Results – Dummy Responses

Lateral Neck Loading

- **Maximum Shear Loads**
 - 50th male – 1020 N
 - 5th female – 754 N
- **Maximum Bending Moments**
 - 50th male – 68 N-m
 - 5th female – 42 N-m
- **No Established Injury Criteria**

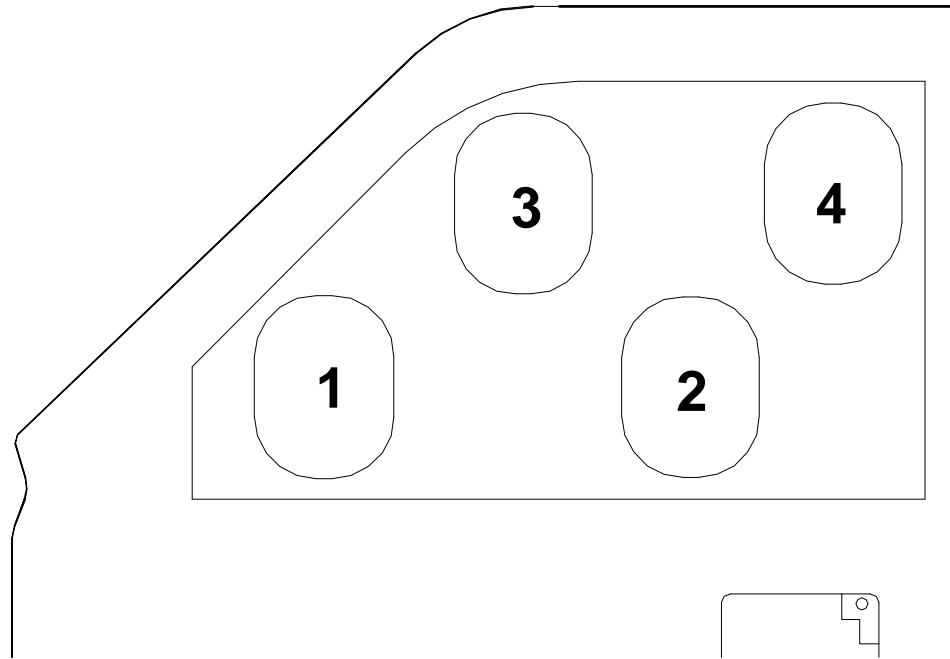
Ejection Mitigation Guided Impactor

- **18 kg Mass**
- **Featureless Headform**
 - Average of front & side of head geometries
 - Better approximation of head/shoulder loading area
- **Measures Displacement**
- **Positioned Inside Vehicle**
- **Impact a Variety of Locations**



Ejection Mitigation

Side Window Impact Locations



Ejection Mitigation Bag Test Pressures

- **TRW**
 - 1.5 seconds = 62 kPa
 - 6 seconds = 28 kPa
- **Zodiac**
 - 1.5 seconds = 79 kPa
 - 6 seconds = 49 kPa

Ejection Mitigation Pre-Broken Glazing



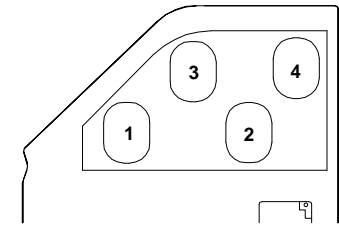
Ejection Mitigation

Guided Impactor Test Results

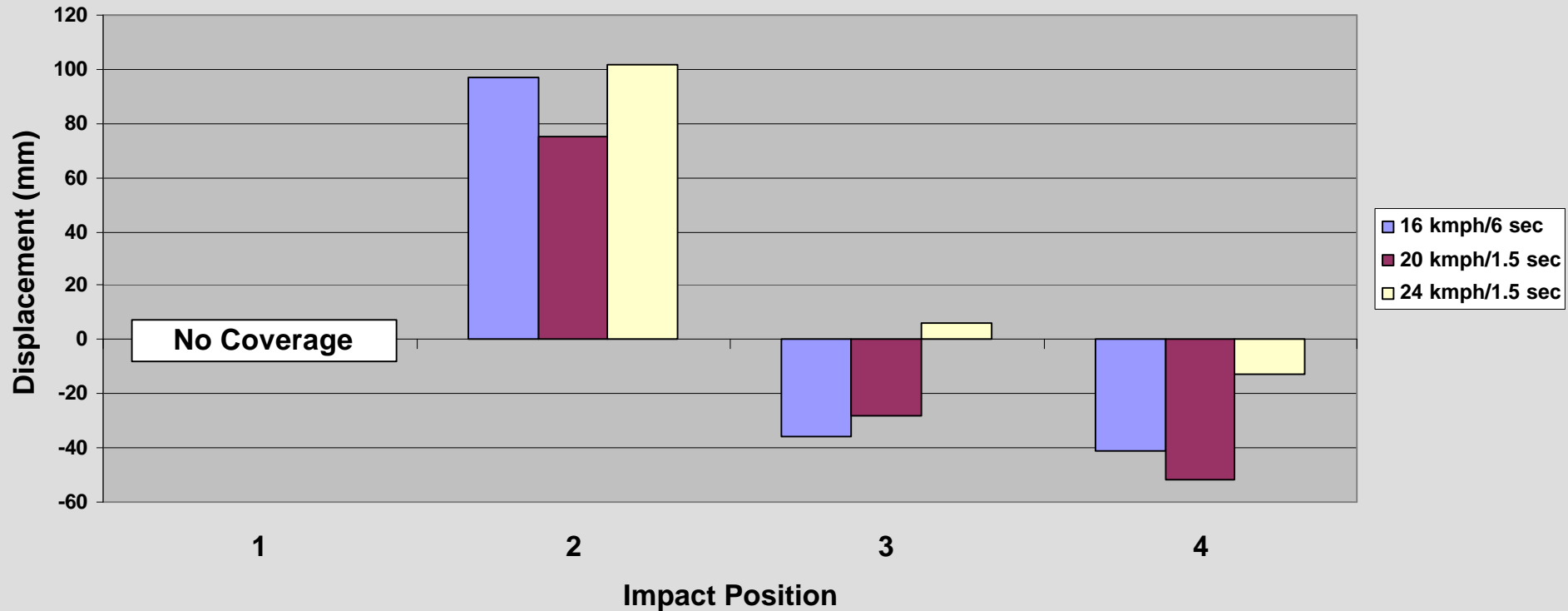
Impactor Deflection Beyond Window Plane (mm)	Impact Location on Side Window Area											
	1			2			3			4		
	16 kmph 6 sec	20 kmph 1.5 sec	24 kmph 1.5 sec	16 kmph 6 sec	20 kmph 1.5 sec	24 kmph 1.5 sec	16 kmph 6 sec	20 kmph 1.5 sec	24 kmph 1.5 sec	16 kmph 6 sec	20 kmph 1.5 sec	24 kmph 1.5 sec
TRW Inflatable Curtain No Glazing	No Data*	No Data*	No Data*	99 97	75	102 82 82	-36	-29	2 6	-41	-52	-13
TRW Inflatable Curtain With HP Laminate (pre-broken)	80	104	182 180	-3	0.4	21	-44	-54	-26 -26	-67	-60 -63	-33 -26
TRW Inflatable Curtain With HP Laminate (unbroken)				-42	-51	-22						
Zodiac Beltline AHPS No Glazing	-0.1	-12	12	0.1	-9	19	No Test	No Test	No Test	No Test	No Test	No Test

* Bag Provides No Coverage

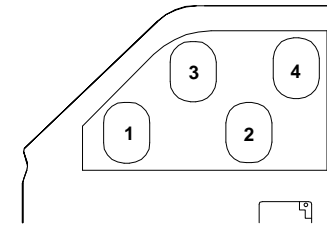
Ejection Mitigation Impactor Results



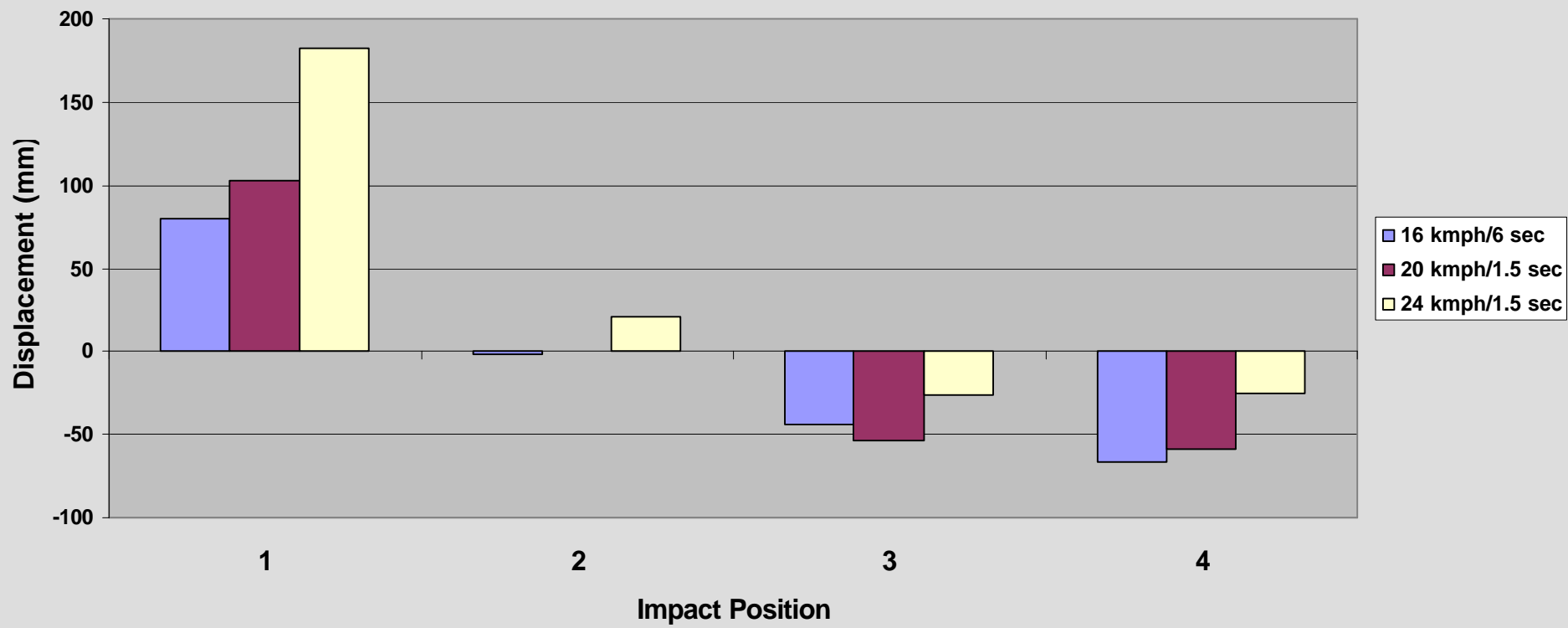
Maximum Excursion Beyond Window Plane TRW - No Glazing



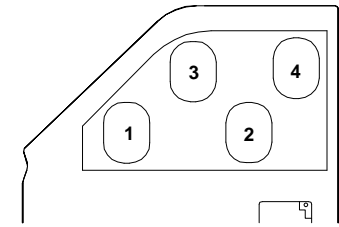
Ejection Mitigation Impactor Results



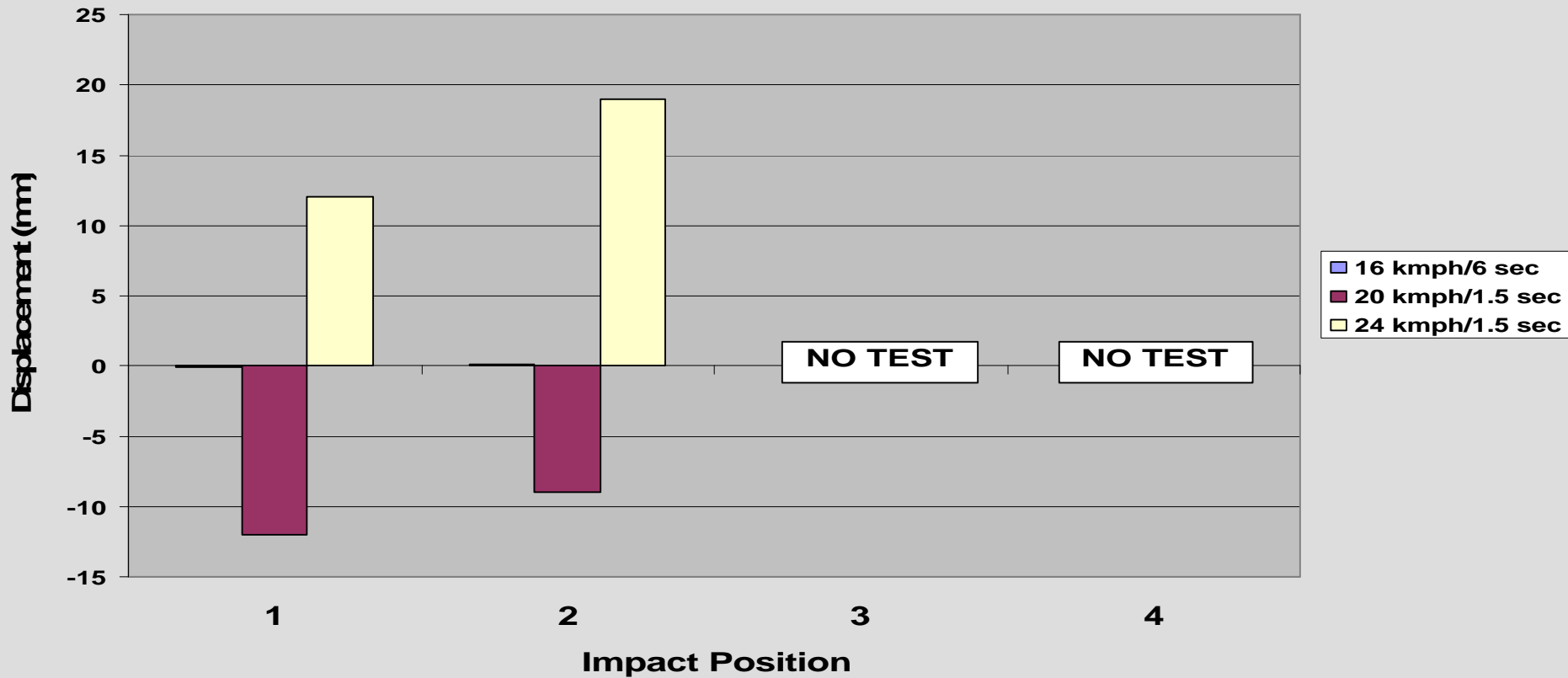
Maximum Excursion Beyond Window Plane
TRW - Pre-Broken HP Laminate



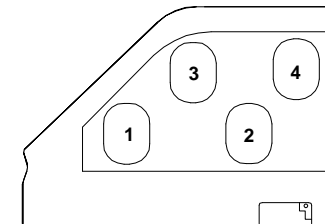
Ejection Mitigation Impactor Results



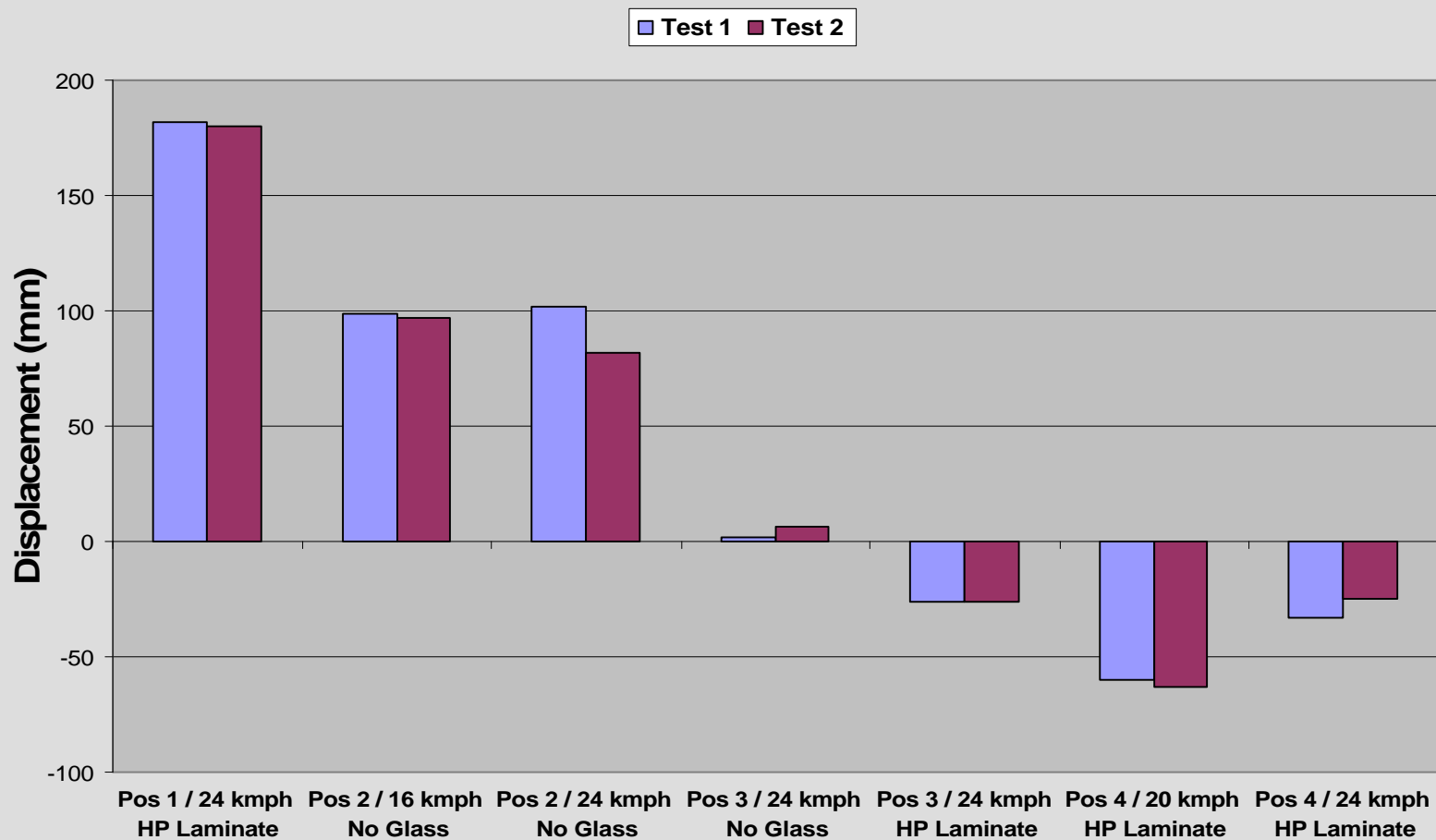
Maximum Excursion Beyond Window Plane Zodiac AHPS(beltline) - No Glazing



Ejection Mitigation Impactor Test Repeatability



Impactor Test Excursion Repeatability



Ejection Mitigation

Ongoing Research

- **Evaluate Countermeasures and Continue Test Procedure Development**
 - Continue DRF testing, especially with 6YO
 - Expand to rear side windows
 - Develop/adopt method to pre-break glazing
- **Develop Rollover Sensor Performance Test**

Ejection Mitigation Acknowledgement

We wish to thank

**TRW Automotive
and**

Zodiac Automotive US

for their cooperation in this research

THE END