INSURANCE INSTITUTE
FOR HIGHWAY SAFETY

NEWS RELEASE

November 14, 2004

VNR: **Monday, Nov. 15, 2004 at 10-10:30 a.m. EST (C) IA 5/Trans. 19;**
again 11/15 at 1-1:30 p.m. EST (C) IA 5/Trans. 19; fed in rotation

NEW DYNAMIC TESTS OF SEATS & HEAD RESTRAINTS IN CARS:

FEW SEAT/HEAD RESTRAINT COMBINATIONS DO A GOOD JOB OF PROTECTING PEOPLE FROM NECK INJURY IN REAR-END CRASHES; MOST ARE RATED POOR

INSURERS JOIN IN 1ST INTERNATIONAL RELEASE OF VEHICLE SAFETY INFORMATION

ARLINGTON, VA — Using a new dynamic test and a dummy designed especially for rear impact testing, the Insurance Institute for Highway Safety has rated 73 seat/head restraint combinations available in 63 car models sold in the U.S. market. The ratings of good, acceptable, marginal, or poor indicate the range of occupant protection from whiplash injury in rear-end crashes at low to moderate speeds.

Starting points for the ratings are the evaluations of head restraint geometry the Institute has been conducting since 1995. Now seats with head restraints that have good or acceptable geometry are being tested dynamically to compare their protection against neck injury in rear impacts. These seat/head restraint combinations earn overall ratings based on both geometry and dynamic test results. The Institute isn't testing seats with head restraints rated marginal or poor for geometry because such seats won't protect taller people. These seat/head restraint combinations are rated poor overall, based on geometry.

Only 8 of the 73 seat/head restraints that were dynamically tested earned overall ratings of good. Sixteen are acceptable, and 19 are rated marginal. The other 30 seat/head restraint combinations that were tested are rated poor, as are 24 seats that weren't tested because of inadequate geometry. (Attachment 1 lists the ratings of seat/head restraints that were dynamically tested. Attachment 2 lists the seats rated poor overall based on restraint geometry.) The seat/head restraints that were dynamically tested together with those

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that weren't represent available seats in current car models the Institute has evaluated in its high-speed frontal offset crash test program.

The Institute's ratings of seats and head restraints in cars sold in the U.S. market are part of an international program that includes ratings of additional seat/head restraints sold in the Canadian, Australian, and European markets. Results of these ratings also are being released today (see p.4-5).

"Consumers in markets worldwide can use the new ratings to buy cars that provide better protection in rear-end crashes," says Adrian Lund, the Institute's chief operating officer.

Winners and losers: Among the seat/head restraints that were tested dynamically, the winners are the ones in Volvos (all models) and Saab 9-2X and 9-3 models. These are rated good. So are the seat/head restraints in the Jaguar S-Type, Subaru Impreza, and some Volkswagen New Beetles. The dynamic test performance of the 2004 Toyota Corolla's seat/head restraint also was good, but this car's overall rating is acceptable because the head restraint's geometry is rated acceptable.

A total of 54 seat/head restraint combinations are rated poor overall.

"It's obvious that some automakers are doing a better job than others of designing seats and head restraints to protect their customers' necks in rear crashes," Lund says. "Especially disappointing is that so many car models still have head restraints with poor or marginal geometry. Good geometry is a simple and necessary first step toward adequate protection, and seats with bad geometry cannot begin to protect many taller occupants." Two-thirds of the 24 seats that weren't tested dynamically because of inadequate head restraint geometry are in General Motors cars.

Neck injuries sustained in rear-end crashes seldom are life-threatening, but they can be painful. They occur frequently and are expensive. In the United States alone, they cost at least $7 billion in insurance claims per year.

Importance of a good seat/head restraint: When a vehicle is struck in the rear and driven forward, the vehicle seats accelerate occupants' torsos forward. Unsupported, the occupants' heads will lag behind the forward movement of their torsos. This differential motion causes the neck to bend back and stretch. The higher the torso acceleration the more sudden the motion, the higher the forces on the neck, and the more likely a neck injury is to occur.

"The key to reducing whiplash injury risk is to keep the head and torso moving together," Lund explains. "To ensure they move together, a seat and head restraint have to work in concert to support an occupant's neck and head, accelerating them with the torso as the vehicle is driven forward following a rear impact. To accomplish this, the geometry of the head restraint has to be adequate, and so do the stiffness characteristics of the vehicle seat."

A head restraint should extend at least as high as the center of gravity of the head of the tallest expected occupant. A restraint also should be positioned close to the back of an occupant's head so it can contact the head and support it early in a rear-end crash.

"If a head restraint isn't positioned behind an occupant's head, it cannot support the head in a rear impact," Lund adds. "But good head restraint geometry by itself isn't sufficient. A seat also has to be designed so it doesn't rotate backward in a rear impact because this would move the head restraint away from the head. At the same time, a vehicle seat cannot be too stiff. It has to 'give' so an occupant will sink into it, moving the head closer to the restraint. The new evaluation criteria take into account both static restraint geometry and the dynamic performance of seats and head restraints together in tests."

New seat/head restraint ratings differ from previous ratings of restraint geometry: Since 1995 the Institute has been rating the geometry of head restraints in passenger vehicles based on how close the restraints are to the back of the head of an average-size man. In publishing the first ratings, the Institute explained that "good geometry is necessary but not sufficient for good protection. The relative stiffness of the seatbacks also helps determine effectiveness."

MORE

Assessing seatback stiffness and other characteristics of whiplash injury prevention requires crash testing or other dynamic assessments that weren't practical in the mid- to late-1990s. Very few head restraints back then had geometry sufficient to warrant dynamic testing. The geometry of most head restraints was marginal or poor. Such restraints cannot provide adequate protection because they cannot be positioned to support many people's heads during crashes. Another reason dynamic tests weren't conducted is that there wasn't a test dummy with a realistic spine and neck configuration designed for testing in rear-end crashes at low to moderate speeds. Existing dummies in the mid- to late-1990s had rigid spines and necks that weren't designed to produce human-like responses to rear crash forces.

Since then a new test dummy (BioRID) has been developed that's designed specifically for rear crash testing. This dummy, representing an average-size man, is beginning to be widely used. Plus automakers have improved head restraint geometry. The Institute's first evaluations (1995 models) found only 5 seats with good geometry. In contrast, 80 percent of the head restraints in 2004 models have good or acceptable geometry. Some models also are being equipped with new head restraints that are designed to move closer to the backs of people's heads during rear impacts. Dynamic testing is required to evaluate these "active" restraints and seatbacks that are specially designed to reduce acceleration forces.

International release of seat/head restraint ratings: Recognizing the improvements in head restraint geometry and the need to move beyond ratings based solely on geometry, the Institute joined with other whiplash injury prevention experts in late 2000 to organize the International Insurance Whiplash Prevention Group (IIWPG). In addition to the Institute, IIWPG members include the following research organizations supported by automobile insurers: Thatcham in the United Kingdom; Allianz Centre for Technology in Germany and the German Insurance Institute for Traffic Engineering; Folksam Insurance in Sweden; ICBC in Canada; Insurance Australia Group; and CESVIMap in Spain.

MORE

IIWPG conducted extensive research and testing to develop the procedures for the dynamic test and evaluation criteria that have been used by member research groups, including the Institute, to rate the performance of more than 200 seat/head restraint combinations in vehicles sold in a number of world markets. These ratings are being released simultaneously by IIWPG partners in Australia, Canada, Germany, and the United Kingdom as well as by the Institute in the United States.

IIWPG procedures for rating seat/head restraints: Overall seat/head restraint ratings are based on a two-step evaluation. In the first step restraint geometry is rated, using the same procedures as before (see Attachment 3). Seats with good or acceptable geometric ratings then are subjected to a dynamic test conducted on a sled that simulates the forces in a stationary vehicle that's rear-ended by another vehicle of the same weight going 20 mph.

The dynamic test ratings of good, acceptable, marginal, or poor are derived from two seat design parameters (peak acceleration of the dummy's torso and time from impact initiation to head restraint contact with the dummy's head) plus neck tension and shear forces recorded on BioRID during the test. The sooner a restraint contacts the dummy's head and the lower the acceleration of the torso and the forces on the neck, the better the dynamic rating.

A seat/head restraint's dynamic rating is combined with its geometric rating to produce an overall rating. The 73 overall ratings presented in Attachment 1 represent more seat/head restraint combinations than are listed. When the ratings for a car model's seat options are the same, these ratings are combined.

Attachment 3 provides a more detailed description of how head restraint geometry is measured, how seat/head restraints are tested dynamically, the crash test dummy BioRID, and the crash simulation sled (including photos) on which the dynamic tests are conducted.

Sled test sets tougher standard to earn good or acceptable rating: Nine seat/head restraints rated good for geometry and another 21 with acceptable geometry turned in poor performances in the dynamic test.

"The principal reason for the failing dynamic performances of these seats was that the seatbacks rotated backward in the test," Lund says. "This moved the head restraint farther from the dummy's head, so initial contact with the head restraint took longer. The result was that the dummy's head wasn't supported in time to reduce the differential motion of the head and torso that leads to neck injury. So, although the auto manufacturers have been improving the geometry of the head restraints in their cars, in many cases they need to make further improvements to their seats and head restraints."

Saabs and Volvos are winners: The seat/head restraint combinations in two Saab models and three Volvos are rated good, but the designs of these systems aren't the same. As an occupant's torso sinks into a Saab seat during a rear crash, a mechanism in the seatback is designed to push the head restraint up and toward the back of the head. Volvo took a different approach, designing seatbacks with a special hinge to reduce the forward acceleration of an occupant's torso.

"The designs are different, but the result is the same," Lund points out. "Both Volvo and Saab have found a way to reduce the differential motion of an occupant's head and torso that causes neck injury in rear crashes. This is what we want every automaker to do."

Institute research released in 2002 indicated that fewer neck injury claims are filed for Volvos and Saabs with the advanced seat/head restraint systems, compared with older models of the same cars without such systems.

End of 6-page news release on ratings of 97 seat/head restraints
Attachment 1: Ratings of 73 seats that were dynamically tested
Attachment 2: Ratings of 24 head restraints based on geometry
Attachment 3: Description of test procedures, dummy, and sled

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For more information go to www.iihs.org

ATTACHMENT 1: P.1 OF 5
DYNAMICALLY TESTED SEAT/HEAD RESTRAINTS

Make/model	Seat type	OVERALL RATING	DYNAMIC RATING	GEOMETRY OF SEAT/HEAD RESTRAINT
ACURA TL 2004-05 models	ALL SEATS	M	M	G
ACURA TSX 2004-05 models	ALL SEATS	P	P	G
AUDI A4 2004-05 models	SEATS THAT ADJUST MANUALLY	P	P	G
AUDI A4 2004-05 models	SEATS WITH POWER ADJUSTMENT	P	P	A
AUDI S4 2004-05 models	ALL SEATS	P	P	G
AUDI A6 2005 models	ALL SEATS ACTIVE HEAD RESTRAINTS	A	A	G
BMW 3 SERIES 2002-05 models	ALL SEATS	P	P	A
BMW 5 SERIES 2004-05 models	BASE SEATS	P	P	A
BMW 5 SERIES 2004-05 models	SPORT SEATS ACTIVE HEAD RESTRAINTS	A	A	G
CADILLAC CTS 2003-05 models	SEATS WITHOUT ADJUSTABLE LUMBAR	P	P	A
CHEVROLET MALIBU 2004-05 models	ALL SEATS	A	A	G

Ratings continue on next page . . .

G GOOD
A ACCEPTABLE
M MARGINAL
P POOR

For each seat/head restraint, REAR-END CRASH PROTECTION is an assessment of occupant protection against neck injury in rear impacts at low to moderate speeds. Although such injuries usually aren't serious, they occur frequently.

The OVERALL RATINGS are based on a two-step evaluation. In the first step head restraint geometry (distance behind and below the head of a seated average-size man) is rated good, acceptable, marginal, or poor. Seats with good or acceptable head restraint geometry then are subjected to a dynamic test simulating the forces in a stationary vehicle that's rear-ended by another vehicle of the same weight going 20 mph. Seat/head restraints with marginal or poor geometry aren't tested dynamically because they cannot protect taller people in rear-end crashes. These seats are rated poor overall.

In the dynamic test, measurements are recorded on a dummy (BioRID) representing an average-size man. BioRID is designed specifically for rear-end testing at low to moderate speeds. The DYNAMIC RATINGS are derived from two seat design parameters (peak acceleration of the dummy's torso and time from impact initiation to head restraint contact with the dummy's head) plus tension and shear forces recorded on BioRID's neck during the test. Overall ratings are based on both geometric measurements and dynamic results.

For more about the procedures for rating seat/head restraints, see Attachment 3.

ATTACHMENT 1: P.2 OF 5
DYNAMICALLY TESTED SEAT/HEAD RESTRAINTS

Make/model	Seat type	OVERALL RATING	DYNAMIC RATING	GEOMETRY OF SEAT/HEAD RESTRAINT
CHRYSLER SEBRING 2003-05 models	SEATS WITH POWER RECLINE	A	A	G
CHRYSLER 300 2005 models	ALL SEATS	A	A	G
DODGE NEON 2001-05 models	SEATS WITH ADJUSTABLE HEAD RESTRAINTS	P	P	A
DODGE STRATUS 2003-05 models	BASE SEATS	P	P	G
DODGE STRATUS 2003-05 models	8-WAY POWER SEATS	A	A	A
FORD FOCUS 2001-05 models	ALL SEATS	M	M	G
FORD TAURUS 2004-05 models	ALL SEATS	M	M	A
FORD CROWN VICTORIA 2003-05 models	SEATS WITH ADJUSTABLE LUMBAR	M	M	G
HONDA CIVIC 2003-05 models	SEATS WITH ADJUSTABLE HEIGHT	P	P	G
HONDA ACCORD 2003-05 models	LX MODELS STANDARD SEATS	P	P	A
HONDA ACCORD 2003-05 models	EX MODELS STANDARD SEATS	P	P	G
HYUNDAI ELANTRA 2001-05 models	ALL SEATS	P	P	A
HYUNDAI SONATA 2001-05 models	GL MODELS	P	P	A
HYUNDAI XG350 2002-05 models	ALL SEATS	P	P	A
INFINITI I35 2002-04 models	ALL SEATS ACTIVE HEAD RESTRAINTS	P	P	A
INFINITI G35 2005 models	ALL SEATS MFG. AFTER 8/2004 ACTIVE HEAD RESTRAINTS	P	P	G
INFINITI Q45 2005 models	ALL SEATS MFG. AFTER 10/2004 ACTIVE HEAD RESTRAINTS	M	M	G

G GOOD
A ACCEPTABLE
M MARGINAL
P POOR

Ratings continue on next page …

ATTACHMENT 1: P.3 OF 5
DYNAMICALLY TESTED SEAT/HEAD RESTRAINTS

Make/model	Seat type	OVERALL RATING	DYNAMIC RATING	GEOMETRY OF SEAT/HEAD RESTRAINT
JAGUAR X-TYPE 2004-05 models	ALL SEATS	P	P	G
JAGUAR S-TYPE 2005 models	ALL SEATS	G	G	G
KIA SPECTRA 2005 models	ALL SEATS ACTIVE HEAD RESTRAINTS	A	A	G
KIA OPTIMA 2001-05 models	SEATS THAT ADJUST MANUALLY	P	P	A
KIA AMANTI 2005 models	ALL SEATS MFG. AFTER 8/2004 ACTIVE HEAD RESTRAINTS	A	A	G
LEXUS IS 2001-05 models	ALL SEATS	M	M	G
LEXUS ES 2004-05 models	ALL SEATS	P	P	A
LEXUS GS 2003-05 models	ALL SEATS	M	M	G
LEXUS LS 2001-05 models	ALL SEATS	M	M	G
LINCOLN LS 2003-05 models	ALL SEATS	A	A	G
LINCOLN TOWN CAR 2003-05 models	ALL SEATS	M	M	A
MAZDA 3 2004-05 models	BASE SEATS	M	M	G
MAZDA 3 2004-05 models	SEATS WITH ADJUSTABLE LUMBAR	M	M	A
MAZDA 6 2003-05 models	SEATS WITHOUT ADJUSTABLE LUMBAR	M	M	G
MAZDA 6 2003-05 models	SEATS WITH ADJUSTABLE LUMBAR	P	P	A
MERCEDES C CLASS 2004-05 models	SEATS WITH HEAD RESTRAINTS THAT ADJUST AUTOMATICALLY	M	M	G
MERCEDES E CLASS 2004-05 models	SEATS WITH HEAD RESTRAINTS THAT ADJUST AUTOMATICALLY	A	A	G

G GOOD
A ACCEPTABLE
M MARGINAL
P POOR

Ratings continue on next page …

ATTACHMENT 1: P.4 OF 5
DYNAMICALLY TESTED SEAT/HEAD RESTRAINTS

Make/model	Seat type	OVERALL RATING	DYNAMIC RATING	GEOMETRY OF SEAT/HEAD RESTRAINT
MERCURY SABLE 2004-05 models	ALL SEATS	P	P	A
MERCURY GRAND MARQUIS 2003-05 models	ALL SEATS	M	M	A
MINI COOPER 2002-05 models	ALL SEATS	M	M	G
MITSUBISHI LANCER 2002-05 models	ALL SEATS	M	M	G
MITSUBISHI GALANT 2004-05 models	CLOTH SEATS	P	P	A
NISSAN ALTIMA 2005 models	ALL SEATS MFG. AFTER 8/2004 ACTIVE HEAD RESTRAINTS	A	A	A
SAAB 9-2X 2005 models	ALL SEATS MFG. AFTER 9/2004 ACTIVE HEAD RESTRAINTS	G	G	G
SAAB 9-3 2005 models	ALL SEATS ACTIVE HEAD RESTRAINTS	G	G	G
SAAB 9-5 2005 models	ALL SEATS MFG. AFTER 9/2004 ACTIVE HEAD RESTRAINTS	A	A	G
SATURN ION 2003-05 models	CLOTH SEATS	P	P	G
SATURN ION 2003-05 models	LEATHER SEATS	P	P	A
SUBARU IMPREZA 2005 models	ALL SEATS MFG. AFTER 9/2004 ACTIVE HEAD RESTRAINTS	G	G	G
SUBARU IMPREZA WRX 2004-05 models	ALL SEATS	M	M	G
SUBARU LEGACY 2005 models	ALL SEATS ACTIVE HEAD RESTRAINTS	A	A	G
SUBARU OUTBACK 2005 models	ALL SEATS ACTIVE HEAD RESTRAINTS	A	A	G

G GOOD
A ACCEPTABLE
M MARGINAL
P POOR

Ratings continue on next page . . .

ATTACHMENT 1: P.5 OF 5
DYNAMICALLY TESTED SEAT/HEAD RESTRAINTS

Make/model	Seat type	OVERALL RATING	DYNAMIC RATING	GEOMETRY OF SEAT/HEAD RESTRAINT
SUZUKI AERIO 2002-05 models	ALL SEATS	M	M	G
SUZUKI FORENZA 2004 models	ALL SEATS	P	P	A
SUZUKI VERONA 2004-05 models	ALL SEATS	P	P	A
TOYOTA COROLLA 2003-04 models	ALL SEATS	A	G	A
TOYOTA COROLLA 2005 models	ALL SEATS	P	P	A
TOYOTA CAMRY 2002-04 models	CLOTH SEATS	M	M	G
TOYOTA CAMRY 2002-04 models	LEATHER SEATS	P	P	A
TOYOTA AVALON 2001-04 models	ALL SEATS	P	P	A
VOLKSWAGEN NEW BEETLE 2004-05 models	SEATS WITHOUT ADJUSTABLE LUMBAR ACTIVE HEAD RESTRAINTS	A	A	G
VOLKSWAGEN NEW BEETLE 2004-05 models	SEATS WITH ADJUSTABLE LUMBAR ACTIVE HEAD RESTRAINTS	G	G	G
VOLVO S40 2004-05 models	ALL SEATS MFG. AFTER 2/2004	G	G	G
VOLVO S60 2003-05 models	ALL SEATS	G	G	G
VOLVO S80 2003-05 models	ALL SEATS	G	G	G

G GOOD
A ACCEPTABLE
M MARGINAL
P POOR

Ratings continue on next page . . .

ATTACHMENT 2: P.1 OF 2
SEAT/HEAD RESTRAINTS NOT DYNAMICALLY TESTED BECAUSE OF INADEQUATE GEOMETRY

Make/model	Seat type	OVERALL RATING	DYNAMIC RATING	GEOMETRY OF SEAT/HEAD RESTRAINT
ACURA RL 2001-04 models	ALL SEATS	P	not tested (see note)	P
BUICK CENTURY 2001-05 models	CLOTH SEATS	P	not tested (see note)	M
BUICK CENTURY 2001-05 models	LEATHER SEATS	P	not tested (see note)	P
BUICK REGAL 2001-04 models	ALL SEATS	P	not tested (see note)	P
BUICK LESABRE 2003-05 models	ALL SEATS ACTIVE HEAD RESTRAINTS	P	not tested (see note)	P
BUICK PARK AVENUE 2003-05 models	ALL SEATS	P	not tested (see note)	P
CADILLAC SEVILLE 2001-04 models	ALL SEATS	P	not tested (see note)	P
CHEVROLET CAVALIER 2001-05 models	ALL SEATS	P	not tested (see note)	P
CHEVROLET CLASSIC (formerly Malibu) 2003-05 models	CLOTH SEATS	P	not tested (see note)	M
CHEVROLET CLASSIC (formerly Malibu) 2003-05 models	LEATHER SEATS	P	not tested (see note)	P
CHEVROLET IMPALA 2001-05 models	CLOTH BUCKET SEATS	P	not tested (see note)	M
CHEVROLET IMPALA 2001-05 models	LEATHER BUCKET SEATS	P	not tested (see note)	P
CHRYSLER SEBRING 2003-05 models	SEATS THAT RECLINE MANUALLY	P	not tested (see note)	M
HONDA CIVIC 2003-05 models	BASE SEATS	P	not tested (see note)	M
MITSUBISHI GALANT 2004-05 models	LEATHER SEATS	P	not tested (see note)	M

Ratings continue on next page . . .

G GOOD
A ACCEPTABLE
M MARGINAL
P POOR

Note: Seat/head restraints with marginal or poor geometry aren't tested dynamically because they cannot protect taller people in rear-end crashes. These seats are rated poor overall. Seat/head restraints with good or acceptable geometry are tested dynamically (see Attachment 1).

ATTACHMENT 2: P.2 OF 2
SEAT/HEAD RESTRAINTS NOT DYNAMICALLY TESTED BECAUSE OF INADEQUATE GEOMETRY

Make/model	Seat type	OVERALL RATING	DYNAMIC RATING	GEOMETRY OF SEAT/HEAD RESTRAINT
NISSAN SENTRA 2002-05 models	BASE SEATS	P	not tested (see note)	P
NISSAN MAXIMA 2004 models	CLOTH SEATS ACTIVE HEAD RESTRAINTS	P	not tested (see note)	P
NISSAN MAXIMA 2004 models	LEATHER SEATS ACTIVE HEAD RESTRAINTS	P	not tested (see note)	M
PONTIAC GRAND AM 2001-05 models	CLOTH SEATS	P	not tested (see note)	M
PONTIAC GRAND PRIX 2004 models	ALL SEATS	P	not tested (see note)	M
PONTIAC BONNEVILLE 2003-05 models	BENCH SEATS ACTIVE HEAD RESTRAINTS	P	not tested (see note)	P
PONTIAC BONNEVILLE 2003-05 models	LEATHER SEATS ACTIVE HEAD RESTRAINTS	P	not tested (see note)	M
SATURN L SERIES 2001-05 models	ALL SEATS	P	not tested (see note)	P
VOLKSWAGEN PASSAT 2001-05 models	ALL SEATS	P	not tested (see note)	M

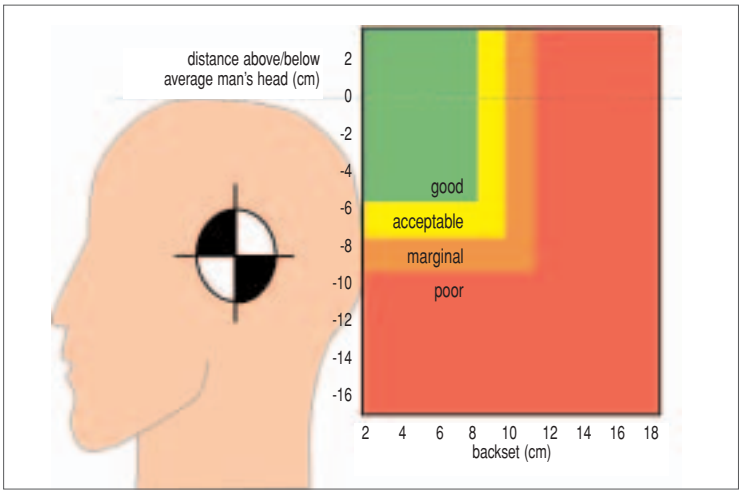
G **GOOD**
A **ACCEPTABLE**
M **MARGINAL**
P **POOR**

Note: Seat/head restraints with marginal or poor geometry aren't tested dynamically because they cannot protect taller people in rear-end crashes. These seats are rated poor overall. Seat/head restraints with good or acceptable geometry are tested dynamically (see Attachment 1).

End of ratings

PROCEDURES FOR RATING SEAT/HEAD RESTRAINTS

The International Insurance Whiplash Prevention Group developed the dynamic test criteria to rate the performance of the seat/head restraints listed in Attachment 1. The two-step rating procedure, which includes geometric measurements and a dynamic test, is described below.



The geometry of head restraints is measured in relation to the head of an average-size adult man (top photo shows measuring device). On the basis of these measurements, head restraint geometry is rated good, acceptable, marginal, or poor (above). These geometric measurements are the first step toward overall ratings of seat/head restraint combinations.

Geometric ratings: A head restraint prevents neck injury by supporting an occupant's head and neck so they can be accelerated together with the torso as the seat is accelerated forward in a rear-end crash. To accomplish this, a head restraint must be close to an occupant's head. Therefore, the first step in rating a seat/head restraint is to measure the height of the restraint and its horizontal distance to the back of the head (backset), using a test device that represents an average-size adult man. For adjustable head restraints that lock in position, measurements are taken in both the highest and lowest positions. The middle of these two positions is used to determine the geometric rating. Procedures for deriving the geometric ratings of good, acceptable, marginal, or poor are specified in the Research Council for Automotive Repairs publication, *Procedures for Evaluating Motor Vehicle Head Restraints* (2001).

Seats with head restraints that are rated marginal or poor, based on geometry, aren't evaluated any further. They're assigned overall ratings of poor because their geometry is inadequate.

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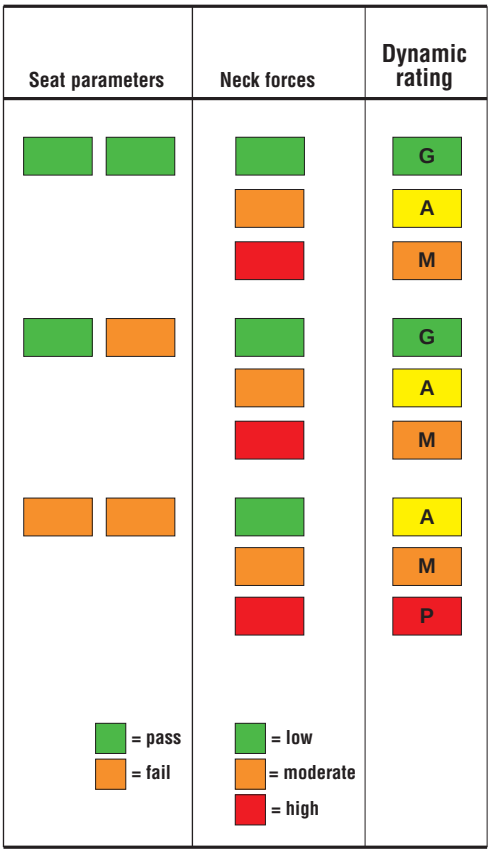
Dynamic ratings: Seat/head restraints with geometry rated good or acceptable are tested in a simulated rear impact conducted on a sled to assess how well the seats support the torso, neck, and head of a BioRID dummy (see next page). The test simulates a rear-end crash with a velocity change of 10 mph, approximately equivalent to a stationary vehicle being struck at 20 mph by a vehicle of the same weight.

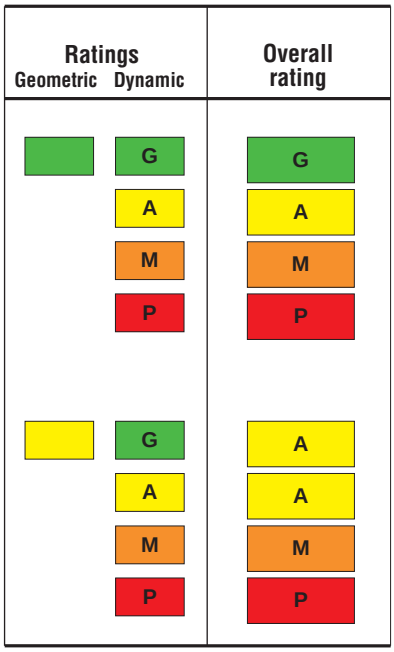
A seat/head restraint's dynamic rating depends on performance in the sled test. There are two sets of criteria for evaluating performance. The first criteria are the two seat design parameters, time to head restraint contact (must be ≤ 70 ms to pass) and torso acceleration (must be ≤ 9.5 g to pass). The second set of evaluation criteria are the maximum neck shear force and maximum neck tension measured on BioRID during the test. These neck forces (classified low, moderate, or high) indicate how well or how poorly an occupant's head and neck would be supported in a rear impact at low to moderate speed. A seat that passes at least one of the seat design parameters and has low neck forces earns a dynamic rating of good. The chart (below left) shows how a dynamic rating is derived from the measures recorded during the sled test.

Overall ratings: Then the geometric rating (see previous page) and the dynamic rating are combined to produce a seat/head restraint combination's overall evaluation (below right). As noted on the previous page, seats with head restraints rated marginal or poor for geometry aren't tested dynamically. They're assigned overall ratings of poor because of inadequate geometry.

DYNAMIC RATINGS
Derived from seat parameter and neck force results



OVERALL RATINGS
Derived from both geometric and dynamic ratings



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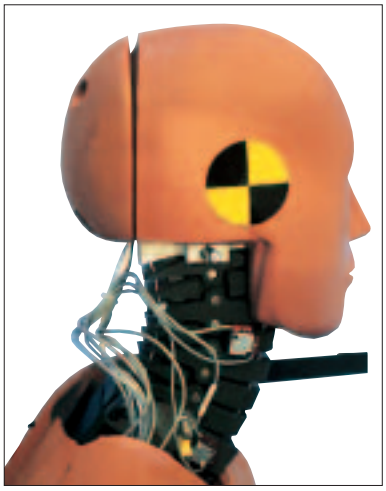
BIORID TEST DUMMY

Dynamic testing of seat/head restraints requires a dummy with a realistic spine and neck. Until the development of BioRID, or biofidelic rear impact dummy, existing dummies had rigid spines and necks that didn't interact with vehicle seats the way human spines and necks do. BioRID was developed for rear testing by a consortium of Chalmers University, restraint maker Autoliv, Saab, and Volvo. This dummy, representing an average-size man, has a spine composed of 24 vertebra-like pieces. The spine interacts with vehicle seats during tests in much the same way as a human spine. Plus BioRID's segmented neck can produce the motion observed by human necks in real-world crashes in which vehicles are struck from behind.



CRASH SIMULATION SLED

The device on which dynamic tests of seat/head restraints are conducted is a steel flatbed sled that runs on fixed rails. The sled is moved to simulate vehicle crash accelerations, re-creating the forces on occupants inside vehicles during real-world crashes. The changing acceleration or deceleration over the time duration of a crash is referred to as a crash pulse, and the key aspect of a sled is that it can be programmed to produce specific crash pulses. To evaluate seat/head restraints, vehicle seats and their attached restraints are fixed to the sled, which is accelerated to simulate a stationary vehicle that's rear-ended by another vehicle of the same weight going 20 mph. To accomplish this, compressed air is pumped into a special cylinder, thrusting a ram forward in a pre-programmed pattern of acceleration (crash pulse). Peak acceleration in the sled test is 10 g (5 g mean acceleration), and the duration is 91 ms.