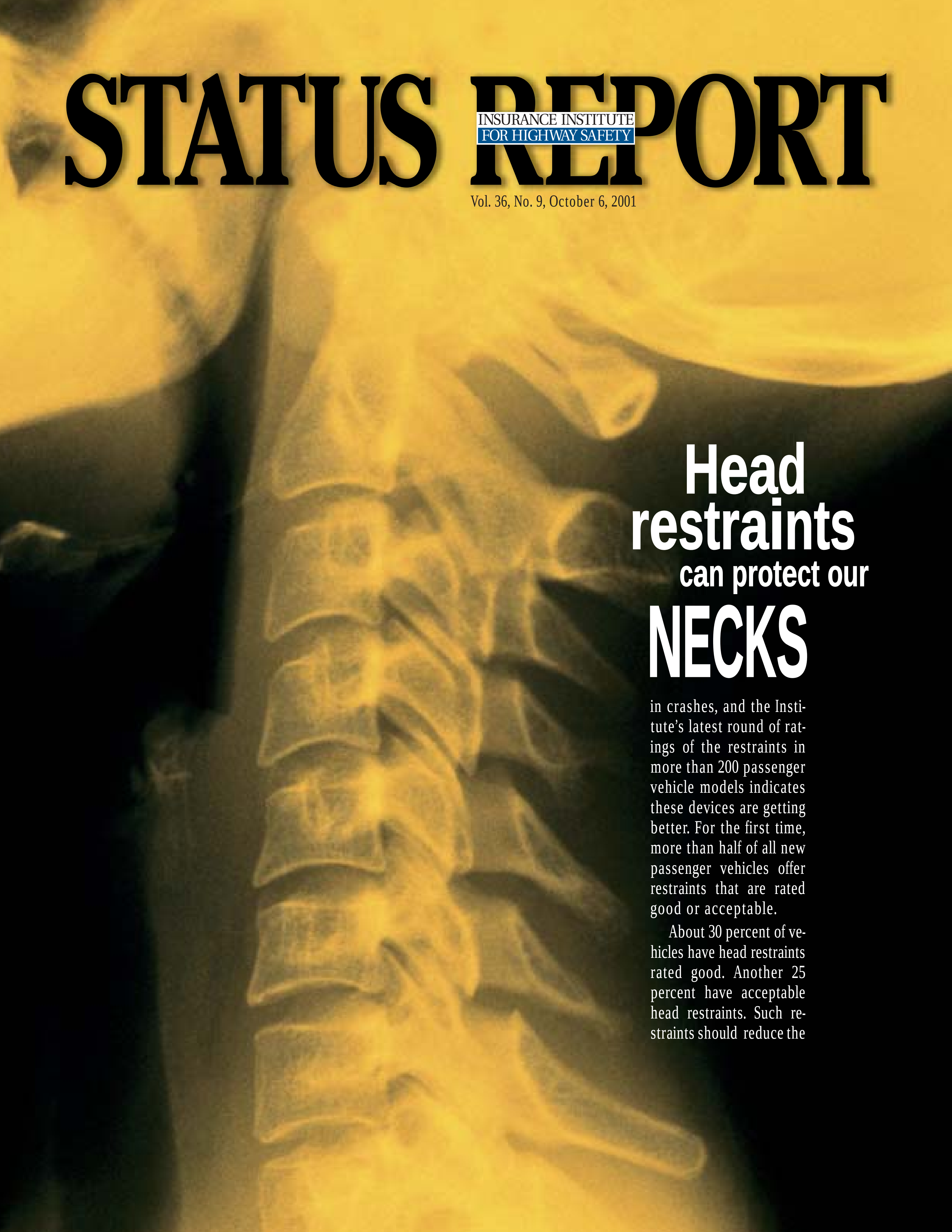
STATUS REPORT

INSURANCE INSTITUTE FOR HIGHWAY SAFETY

Vol. 36, No. 9, October 6, 2001



Head restraints can protect our NECKS

in crashes, and the Institute's latest round of ratings of the restraints in more than 200 passenger vehicle models indicates these devices are getting better. For the first time, more than half of all new passenger vehicles offer restraints that are rated good or acceptable.

About 30 percent of vehicles have head restraints rated good. Another 25 percent have acceptable head restraints. Such restraints should reduce the risk of whiplash injury by meeting positioning requirements in relation to drivers' heads — that is, the restraints would be positioned high enough and close enough to the backs of occupants' heads in a rear-end crash to mitigate neck injury.

There's a dramatic comparison between these results with those from the 1995 model year, when the Institute began evaluating head restraints. It was almost impossible to find a good head restraint in a 1995 model. Those in just five cars were rated good, and three of the five cars were Volvo models (see *Status Report*, Sept. 16, 1995).

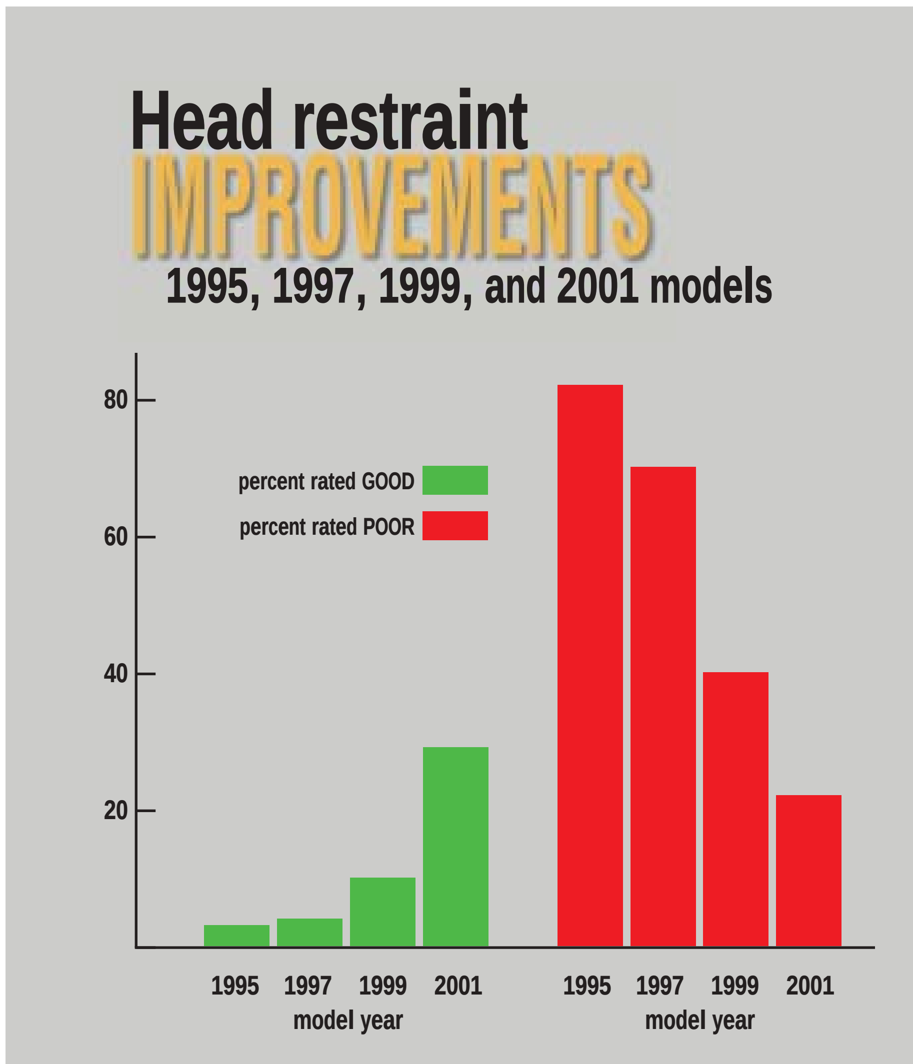
By the 1997 model year, good and acceptable head restraints were easier to find but still in fewer than one-fourth of the cars in which Institute researchers measured head restraint geometry (see *Status Report*, April 12, 1997). Among 1999 models, fewer than a third of the restraints measured were rated good or acceptable (see *Status Report*, May 22, 1999; on the web at www.highwaysafety.org).

"More and more automakers are finally getting the message," says Institute chief operating officer Adrian Lund. "In 1995, unless you were short it was hard to find a car with a head restraint high enough to provide protection. But now, even taller people have a good chance of getting head restraints that will protect them. This marks a sea change."

Head restraints are improving not only in cars but also in sport utility vehicles and pickup trucks, though good and acceptable restraints aren't in more than half of these vehicles. Forty-eight percent of 2001 model SUVs and 50 percent of pickups offer head restraints rated good or acceptable. Comparable proportions for 1997 models are 13 percent (SUVs) and 21 percent (pickups).

Ratings begin with restraint geometry: A necessary first step to lessen whiplash injury risk in a rear-end crash is a head restraint that can be positioned behind and close to the back of an occupant's head. These two criteria — the height of a head restraint and its backset — form the basis of the Institute's rating system.

The top of a restraint ideally should be as high as the top of an occupant's head. The backset, or distance between the back of an occupant's head and the front of the head restraint, should be as small as possible (see p.4). The Institute rates most head restraint designs good, acceptable, marginal, or poor based on how a restraint meets these two criteria for an average male.



Active restraints earn good ratings: The restraints in some vehicles are active. That is, they're designed to move into position during a rear impact. Such head restraints are rated good by both the Institute and the Research Council for Automobile Repairs, a consortium of international research centers. The automatic good ratings will continue until comparative dynamic tests for whiplash protection are available. The Institute and others are planning such tests (see. p.6).

"We're crediting the advanced systems and giving them good ratings until we have a dynamic test protocol in place," Lund says. "Our testing to date indicates such ratings are warranted."

For example, in 1999 the Institute crash tested a 1999 Saab 9-5 with an active head restraint design, finding low risk of neck injury. Saab recently published its own study comparing crash outcomes in models with and without active head restraints, reporting much lower whiplash injury rates in cars with active systems. Other advanced designs feature seatbacks that control the acceleration of an occupant's torso in a rear-end crash. However, these designs don't automatically earn good ratings.

Who's offering advanced designs? Saab's active restraint and General Motors "catcher's mitt" design both feature a head restraint that moves up and forward as an occupant's torso loads the seatback in a rear-end collision. All Saabs since the 1999 model year have such restraints, as do current Buick LeSabre, Pontiac Bonneville, and Oldsmobile Aurora models. Nissan offers a similar active head restraint design in its Maxima and Infiniti I30, Q45, and QX4 models.

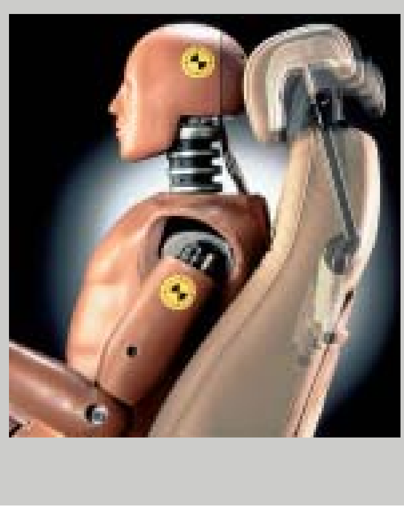
While active seatback designs don't automatically qualify for good ratings, they do control the acceleration of the torso, which is thought to be important in reducing whiplash injuries. Volvo, which equips all of its models with fixed head restraints rated good, also installs a whiplash injury prevention system — the seatback yields and partially rotates when loaded by an occupant's torso in a rear impact. This design is intended to reduce the forward acceleration of the torso, so even the limited *(continues on p.6)*

How they've IMPROVED

Some head restraints have better geometry, others are active designs

IMPROVED GEOMETRY: Some vehicle models that used to have head restraints rated poor now are being equipped with good or acceptable restraints. For example, the head restraints in older Taurus models (1995 model, above left) weren't high enough to protect many occupants from whiplash injury. (The measuring device in the vehicle seat is the size of an average male.) In contrast, the restraints in 2001 Taurus models (above right) extend higher and fit closer to the back of the head.

ADVANCED DESIGNS: More and more new cars are being equipped with active head restraints like those in 1999 and later model Saab 9-5s (right) that automatically move up and closer to occupants' heads in rear-end collisions. These restraints automatically earn good ratings. Other advanced head restraint designs in newer models feature seatbacks that control the acceleration of an occupant's torso in a rear-end crash but, unlike active head restraints, these don't automatically earn good ratings.



How the Institute rates head restraints good, acceptable, marginal, or poor

Restraint geometry is basis for most ratings; good ratings awarded to active head restraint designs

Head restraint evaluations are based on two criteria. The first is the distance down from the top of the head of an average-size male to the top of the restraint. A head restraint should be at least as high as the head's center of gravity, or about 3½ inches below the top of the head.

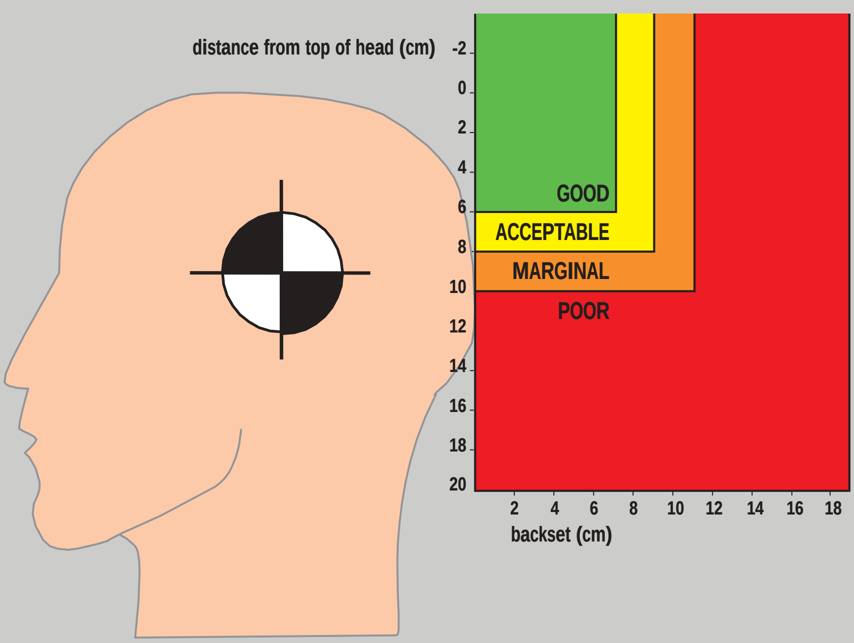
The second criterion is backset, the distance from the back of an average-size male's head to the front of the restraint. Backsets of more than about 4 inches have been associated with increased symptoms of neck injury in crashes.

Each head restraint is classified into one of four geometric zones — good, acceptable, marginal, or poor — according to its height and backset (see diagram). Marginal head restraints have the minimum height necessary to protect an average-size male from whiplash injury. Acceptable and good restraints are high enough to protect taller occupants as well as people of average height and shorter. Good and acceptable head restraints also have smaller backsets, which benefit occupants of all heights.

The rating for a fixed head restraint is straightforward. The zone into which its height and backset place it also defines its rating.

Rating adjustable head restraints that don't lock in their adjusted positions is equally straightforward — the rating is defined by the zone for height and backset in the down and/or rear position. For adjustable restraints that lock in position when adjusted, the rating is based on the midpoint of the best (highest and closest) and worst (lowest and farthest) positions in relation to an average-size male.

This measurement and rating system is an international protocol available from the Research Council for Automobile Repairs (on the web at www.rcar.org/papers/rcar.pdf).



Head restraint RATINGS

2001 PASSENGER CARS

Model	Rating
Acura CL/TL/RL	Red
Acura Integra	Yellow
Audi A4/S4	Green / Yellow
Audi A6	Green
Audi A8	Yellow
Audi Allroad Quattro	Green
Audi TT Roadster Quattro	Green
BMW 3 series	Yellow
BMW 5 series	Green
BMW 7 series	Green
BMW M3	Orange
BMW Z3 Roadster	Yellow
Buick Century	Orange / Red
Buick LeSabre	Green ✓
Buick Park Avenue	Red
Buick Regal	Red
Cadillac Catera	Yellow
Cadillac DeVille	Orange / Red
Cadillac Eldorado	Red
Cadillac Seville	Red
Chevrolet Astro	Orange
Chevrolet Camaro	Red
Chevrolet Cavalier	Red
Chevrolet Corvette	Yellow / Orange
Chevrolet Impala	Orange / Red
Chevrolet Malibu	Orange / Red
Chevrolet Monte Carlo	Orange
Chevrolet Prizm	Red
Chevrolet Venture	Yellow
Chrysler 300M	Orange
Chrysler Concorde	Red
Chrysler LHS	Yellow
Chrysler Prowler	Yellow
Chrysler PT Cruiser	Green
Chrysler Sebring	Orange / Red
Chrysler Town & Country	Yellow / Red
Chrysler Voyager	Orange / Red
Daewoo Lanos	Orange
Daewoo Leganza	Yellow
Daewoo Nubira	Yellow
Dodge Grand Caravan	Green / Yellow
Dodge Intrepid	Green
Dodge Neon	Green / Yellow
Dodge Stratus	Green / Red

Note: Since our print publication date, some ratings shown here have been corrected and/or updated.

Vehicle	Rating	Active head restraint
Ford Crown Victoria	Poor	
Ford Escort ZX2	Poor	
Ford Focus	Good	
Ford Mustang	Poor	
Ford Taurus	Good / Acceptable	
Ford Windstar	Good / Acceptable	
GMC Safari	Marginal	
Honda Accord	Acceptable / Marginal	
Honda Civic	Good / Marginal	
Honda Insight	Poor	
Honda Odyssey	Marginal	
Honda Prelude	Marginal	
Honda S2000	Acceptable	
Hyundai Accent	Acceptable	
Hyundai Elantra	Good / Acceptable	
Hyundai Sonata	Acceptable	
Hyundai Tiburon	Acceptable	
Hyundai XG300	Marginal	
Infiniti G20	Poor	
Infiniti I30	Good	✓
Infiniti Q45	Good	✓
Jaguar S type	Acceptable	
Jaguar VDP/XJR	Acceptable	
Jaguar XK8	Marginal	
Kia Optima	Acceptable	
Kia Rio	Acceptable	
Kia Sephia	Marginal	
Kia Spectra	Good	
Lexus ES 300	Acceptable	
Lexus GS 300	Good	
Lexus IS 300	Good	
Lexus LS 430	Good	
Lincoln Continental	Marginal	
Lincoln LS	Marginal	
Lincoln Town Car	Poor	
Mazda 626	Poor	
Mazda Miata	Acceptable / Marginal	
Mazda Millenia	Marginal	
Mazda MPV	Marginal / Poor	
Mazda Protege	Acceptable / Marginal	
Mercedes C class	Good	
Mercedes CLK class	Marginal	
Mercedes E class	Good / Acceptable	
Mercedes S class	Good	
Mercedes SL class	Acceptable	
Mercedes SLK class	Marginal	
Mercury Cougar	Marginal	
Mercury Grand Marquis	Poor	
Mercury Sable	Good	
Mercury Villager	Poor	
Mitsubishi Diamante	Poor	
Mitsubishi Eclipse	Marginal / Poor	
Mitsubishi Galant	Marginal	
Mitsubishi Mirage	Marginal	
Nissan Altima	Poor	
Nissan Maxima	Good	✓
Nissan Quest	Poor	
Nissan Sentra	Marginal	
Oldsmobile Alero	Marginal	
Oldsmobile Aurora	Good	✓
Oldsmobile Intrigue	Poor	
Oldsmobile Silhouette	Acceptable	
Pontiac Bonneville	Good	✓
Pontiac Firebird	Poor	
Pontiac Grand Am	Acceptable	
Pontiac Grand Prix	Marginal	
Pontiac Montana	Good / Acceptable	
Pontiac Sunfire	Poor	
Porsche 911	Acceptable	
Porsche Boxster	Acceptable	
Saab 9-3	Good	✓
Saab 9-5	Good	✓
Saturn LS	Poor	
Saturn LW	Poor	
Saturn SC	Poor	
Saturn SL	Poor	
Subaru Impreza	Marginal	
Subaru Legacy/Outback	Acceptable	
Suzuki Esteem	Marginal	
Toyota Avalon	Acceptable	
Toyota Camry	Marginal	
Toyota Camry Solara	Acceptable	
Toyota Celica	Good	
Toyota Corolla	Marginal	
Toyota Echo	Good	
Toyota MR2	Good	
Toyota Prius	Good	
Toyota Sienna	Marginal	
Volkswagen Golf	Good / Poor	
Volkswagen Jetta	Acceptable / Marginal	
Volkswagen New Beetle	Good	
Volkswagen Passat	Marginal	
Volvo C70	Good	
Volvo S40/V40	Good	
Volvo S60	Good	
Volvo S80	Good	
Volvo V70	Good	

2001 UTILITY VEHICLES

Vehicle	Rating	Active head restraint
Acura MDX	Marginal	
BMW X5	Acceptable	
Chevrolet Blazer	Acceptable / Poor	
Chevrolet Suburban	Poor	
Chevrolet Tahoe	Poor	
Chevrolet Tracker	Good / Acceptable	
Dodge Durango	Poor	
Ford Escape	Poor	
Ford Excursion	Poor	
Ford Expedition	Marginal	
Ford Explorer	Poor	
Ford Explorer Sport Trac	Marginal / Poor	
GMC Jimmy	Good / Poor	
GMC Yukon	Poor	
GMC Yukon XL	Acceptable / Marginal	
Honda CR-V	Acceptable / Poor	
Honda Passport	Poor	
Hyundai Santa Fe	Good / Acceptable	
Infiniti QX4	Good	✓
Isuzu Rodeo	Acceptable	
Isuzu Rodeo Sport	Acceptable	
Isuzu Trooper	Acceptable	
Jeep Cherokee	Poor	
Jeep Grand Cherokee	Poor	
Jeep Wrangler	Marginal	
Kia Sportage	Marginal	
Land Rover Discovery Series II	Marginal	
Land Rover Range Rover	Marginal	
Lexus LX 470	Good	
Lexus RX 300	Good	
Lincoln Navigator	Poor	
Mazda Tribute	Poor	
Mercedes M class	Acceptable	
Mercury Mountaineer	Poor	
Mitsubishi Montero	Acceptable	
Mitsubishi Montero Sport	Marginal	
Nissan Pathfinder	Marginal / Poor	
Nissan Xterra	Good	
Oldsmobile Bravada	Poor	
Pontiac Aztek	Marginal	
Subaru Forester	Acceptable / Marginal	
Suzuki Grand Vitara	Acceptable	
Suzuki Grand Vitara XL-7	Acceptable	
Toyota 4Runner	Marginal / Poor	
Toyota Highlander	Good	
Toyota Land Cruiser	Good	
Toyota RAV4	Good	
Toyota Sequoia	Good	

2001 PICKUP TRUCKS

Vehicle	Rating
Chevrolet S10/T10	Good / Poor
Chevrolet Silverado 1500	Marginal / Poor
Dodge Dakota	Acceptable / Poor
Dodge Ram 1500	Poor
Dodge Ram 2500	Poor
Ford F-150	Acceptable / Poor
Ford F-250	Marginal
Ford Ranger	Marginal / Poor
GMC Sierra 1500	Acceptable / Poor
GMC Sonoma	Good / Acceptable
Mazda B series	Poor
Nissan Frontier	Acceptable
Toyota Tacoma	Poor
Toyota Tundra	Good

GOOD
ACCEPTABLE
MARGINAL
POOR
SPLIT RATING: depends on seat type

✓ ACTIVE HEAD RESTRAINT

Active head restraint designs, which move into position high and close to an occupant's head in the event of a rear impact, automatically earn good ratings. Testing indicates such ratings are warranted, and they will be assigned until the Institute begins a comprehensive program of dynamic head restraint tests.

(continued from p.3) relative head/torso movement that's allowed by Volvo's good head restraint occurs more gradually than with a conventional seatback.

Toyota's advanced design, called the whiplash injury lessening system, includes a seatback designed with a strong outer frame and little or no cross bracing behind the shoulder blades. In a rear impact, the force applied by the seatback to an occupant's torso is controlled by the foam and other materials that make up the cushioning in the seatback.

Saab and General Motors feature similar seatback designs with their active head restraint systems. In addition, these two automakers include some geometric and cushion specifications that direct occupants downward as they sink into their seatbacks in a rear-end collision, thus counteracting the "ramp up" that has been described in tests with volunteers (an occupant's neck shortens as the torso "ramps up" the seatback and then lengthens during rebound).

Need for dynamic testing: Good head restraint geometry doesn't guarantee good occupant protection in rear-end crashes, but it's an important first step. As more restraints with good geometry are introduced and the number of active head restraint systems increases, there's a need for dynamic testing to assess the overall performance of seats and head restraints in reducing whiplash injury risk. An international insurer group is developing a dynamic test to be used for standard evaluations (see accompanying story, this page). As a member of this group, the Institute will be conducting dynamic tests once it acquires the necessary testing device.

"It's encouraging to track all the manufacturer activity aimed at improving head restraints," Lund says. "Generally speaking, restraints are getting higher and closer to the head, and many more adjustable restraints now come with locks to keep them in position. These improvements, together with the introduction of active head restraints and other advanced designs, bode well. We hope they lead to a decrease in the incidence of whiplash injuries."

Institute to begin DYNAMIC TESTING with new sled

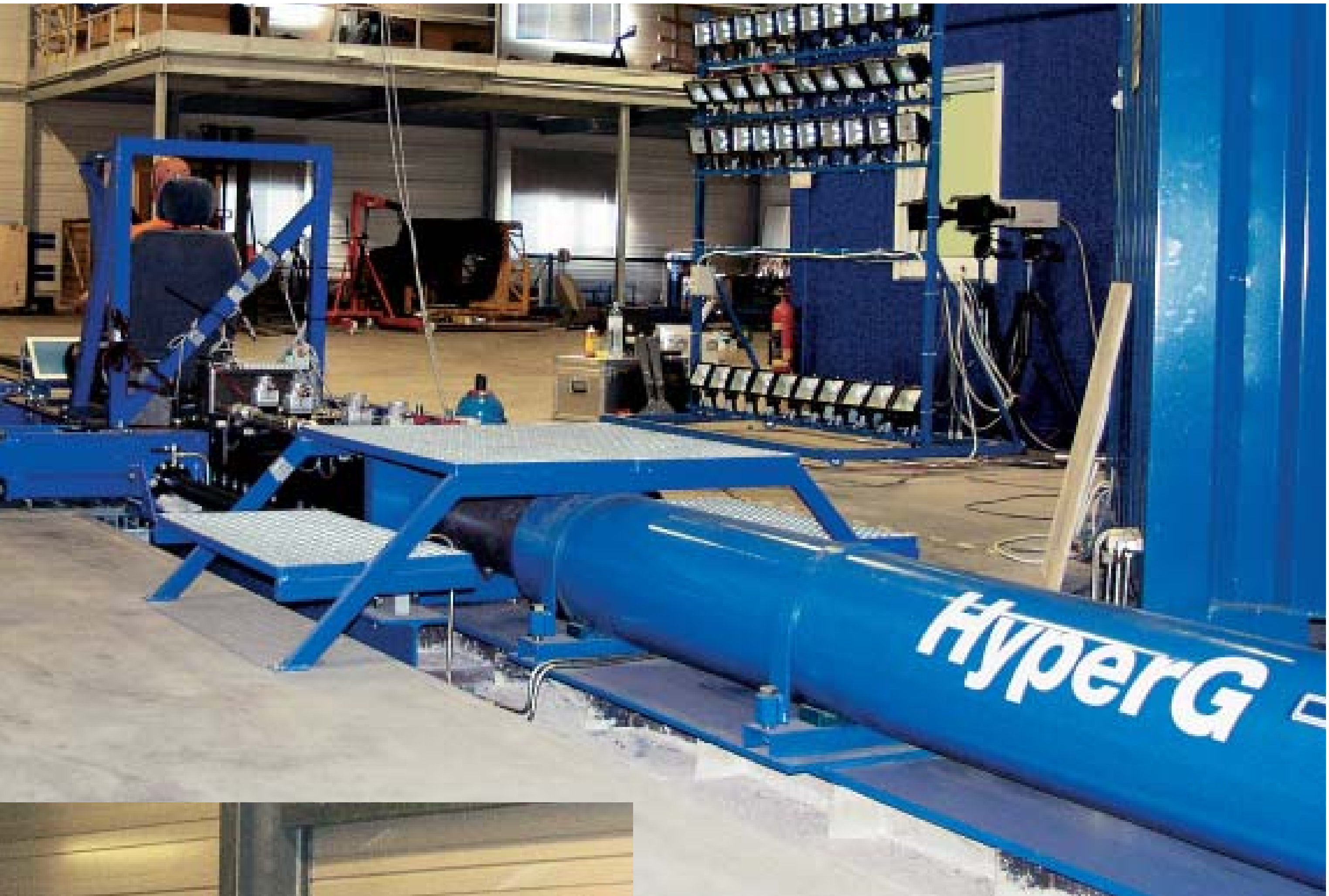
A new crash test sled being installed at the Institute's Vehicle Research Center will facilitate dynamic testing of seats and head restraints without crashing cars. The International Insurance Whiplash Prevention Group, of which the Institute is a member, is at work developing such a test.

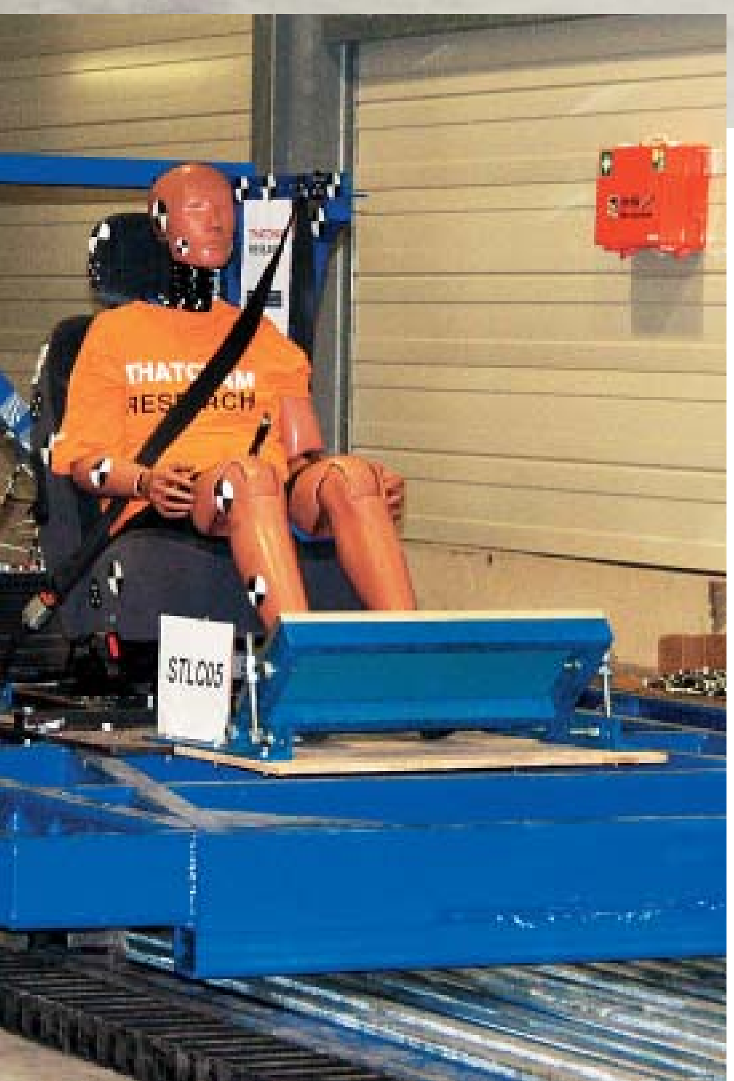
Benefits of dynamic testing: Since 1995 results of the Institute's high-speed frontal offset crash tests have helped consumers assess the overall crashworthiness of passenger vehicles. Even more important, these tests have prompted improvements across the vehicle fleet (see *Status Report*, March 20, 2001; on the web at www.highwaysafety.org).

A sled test program focusing on head restraints holds equal promise. Good geometry is the necessary first step in assessing static head restraints, but seat characteristics such as stiffness also can influence whiplash injury risk. Such characteristics can only be evaluated dynamically. And when it comes to active head restraints, geometric measurements aren't relevant. These designs can only be assessed in dynamic tests. For these reasons, "sled testing is the next logical step in the Institute's program of evaluating head restraints," says Institute chief operating officer Adrian Lund. Sled tests also will be used to conduct crash simulations to evaluate other safety components like child restraints and belt/airbag systems.

Versatility of sled testing: Crash test sleds run on fixed rails. Vehicle bodies, called bucks, can be mounted on top of the sleds in different orientations, as can individual vehicle components like seats.

Sleds simulate crash forces, re-creating the accelerations (side or rear impacts) or decelerations (frontal crashes) that occur inside occupant compartments during full-vehicle crashes. The changing acceleration or deceleration over the time duration of a crash is referred to as a crash pulse. The key aspect of crash sleds is their ability to be programmed to produce specific crash pulses and thereby simulate corresponding full-vehicle crashes.





The Institute's new sled, which will be installed at the Vehicle Research Center, is similar to this one designed by DSD of Linz, Austria. In addition to testing seats and head restraints, the Institute's sled will be used to evaluate other vehicle parts and components such as child restraints.

Multiple test capability: Because sled tests don't involve damage to vehicles, they're much less time-consuming and expensive to conduct than full-scale crash tests. Repeated testing becomes more feasible. This is especially important when repeated tests over a range of crash severities are needed to evaluate performance. For instance, no single test speed or crash severity is optimum for evaluating whiplash injury risk. Ideally, good performance of a seat/head restraint should occur in a range of impacts from low to moderate speeds. Conducting a wide range of tests would be prohibitively expensive if each test involved crashing a new vehicle, but conducting multiple tests on a sled involves minimal costs per test.

Similarly, child restraints don't have to be evaluated in full-vehicle tests. Simulation with appropriate crash decelerations is sufficient. Although multiple tests normally wouldn't be required to assess child restraint performance, the issues of restraint durability and replacement after relatively minor collisions can be thoroughly investigated in repeated sled tests.

Installation of the new sled test device at the Institute's Vehicle Research Center requires a major expansion of the facility. The design-and-build phase will be complete by April 2002.

STATUS REPORT
INSURANCE INSTITUTE FOR HIGHWAY SAFETY

1005 N. Glebe Rd., Arlington, VA 22201
703/247-1500 Fax 247-1588
Internet: www.highwaysafety.org

Vol. 36, No. 9, October 6, 2001

On the inside

ISSN 0018-988X