Research Council for Automobile Repairs

RCAR Newsletter

www.rcar.org

June 2002

# Crash Testing Review Underway

The review of the RCAR Low Speed Crash Testing Standard is now well underway. The second meeting of the review working group (RCAR engineers from JKC Japan, Thatcham UK, AZT Germany, CESVI France, CESVIMAP Spain, and IIHS USA) took place at CESVI France's research facility in Poitiers, France. They were joined by GDV Germany who organise the German Insurance Rating System and use the RCAR Standard.

It was agreed at the first meeting held in Munich that the working group members would conduct a number of crash tests at differing angles of impact. For example, AZT inclined the barrier 15º towards the car, whilst other centres carried out impacts at different angles. CESVIMAP, for example, conducted four tests with vehicles at 0º and 25º. There were clear differences between individual car performances under these varied test angles and the initial results to date demonstrated that more work was needed. Performance was noted in terms of repair costs to return the vehicle to its pre-accident condition. In future tests a moderate degree of submarining (under-ride) of the vehicle front will be incorporated.

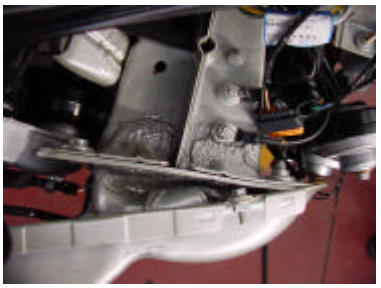
This important work continues and some preliminary findings will be presented by the review working group at the forthcoming RCAR Conference in Stockholm.

**Special points of interest:**

- *News from 10 RCAR Centres.*
- *Crash Test Review.*
- *News Sources and Forthcoming Events.*
- *Repair of Hydrogen Fuel Cell Vehicles*

**Inside this issue:**





**Testing At Different Impact Angles 0º (left) Compared With A 25º Barrier**

This vehicle's crash box performs well in both cases.

# News From The Centres

## Centro Zaragoza – Spain

The centre has issued two editions of their magazine recently. Contents of the March 2002 edition included articles on aluminium welding; damageability and reparability; the variation in impact resistance of plastic as a function of temperature; more common damage or defects in paint finishing; automatic gearboxes; the key without a key or keyless entry and vehicle starting. EuroNCAP is covered together with industry at Zaragoza Centre News.

Topics in the June issue of the Centro Zaragoza Magazine included: bench repair of vehicle structural damage detailing pulling vectors; repairs to damaged dashboards (front

fascias); mica and Pearlescent painting finishes; the measurement of repair times; steering mechanisms; lighting systems; classification of vehicles on the basis of theft resistance; crash helmets; trucks carrying large loads; industry and centre news; and a note from Antonio Dalda of Opel España introducing AUTOnomy, the new fuel cell concept car from General Motors (Note: members may have seen the introduction reported in English in February 2002 SAE Magazine "Automotive Engineering International". See also the article on Fuel Cells in this issue of RCAR Newsletter.)

**(Centro Zaragoza is at: www.centro-zaragoza.com)**

## Thatcham UK

A range of publications has been distributed by Thatcham recently including Methods Manuals for Toyota MR2, Citroën Xsara Picasso MPV and Land Rover, Range Rover 2002 (new format), 17 Technical Newsletters and a number of training publications. In the area of Training, Thatcham have extended their regional training programme to ten locations within the UK.

Work on Thatcham's Hyper-G Sled test facility is shown here. The installation will be completed shortly and will be reported upon at the RCAR meeting in Stockholm.

The centre has strengthened its R&D Team by recruiting a new Research Manager, Eugene Incerti, who takes over from Barry Sangster. Eugene, a graduate and Chartered Engineer with a Masters in Engineering Project Management, has worked previously with BTR Automotive and Avon Automotive. Barry Sangster moves to head up the new Group Rating operation. Jason Moseley also joins the team to run the new crash parts accreditation programme.

Jason is a graduate of Coventry University with previous experience with BMW, Toyota, Nissan and Land Rover. Commenting on the new members of the Thatcham R&D Team, Ken Roberts said: "The appointment of these new managers will strengthen Thatcham's position as the leading supplier of essential repair and crash data to the motor and insurance industries. With the introduction of the parts accreditation programme, repairers, insurers and the motoring public will be assured of an alternative supply of high quality, cost effective panels and parts that will reduce the cost of accident damage repairs and help to control the frequency of written off vehicles."

**Eugene Incerti**

**Barry Sangster**

**Jason Moseley**

**(Thatcham is at: www.thatcham.org)**

# News From The Centres

## CESVIMAP Spain

A number of Descriptive Repair Manuals have been produced recently. The first 2002 issue of the CESVIMAP CD – Manuales Descriptivos y de Reparabilidad contains five motorcycles and fourteen vehicles. The following Technical Data Sheets have also been issued recently:

TECNA INVERVER MF, Resistance Welder
SMART
Aluminium Repairs PEGASO
2K High Solid NEXA AUTOCOLOUR
FORD Intelligent Protection System
Facia Repairs RENAULT Laguna 11
Paint Drying
Painting Equipment Maintenance
Automotive Lubricants
Steering Systems
Inspection of Motorcycle Damage
Pretensioners
Cab Repairs to SCANIA CR-19

The CESVIMAP Magazine has been distributed within RCAR. Issue 39 March 2002 contains a number of articles, including Rust Proofing, Painting by Computer, Valuation of Damage in Trucks, Quad Motorcycles, the Chrysler Voyager, a new Inspection manual, Lessons of Repair and a number of workshop notes on SAC4000 aligned with Sun Mobile girder and TECHNA SPOT 3450 resistance spot welding. The magazine (Revista) is at www.revistacesvimap.com in English and Spanish.

**(CESVIMAP is at: www.cesvimap.com)**

## CESTAR Italy

CESTAR's manual, "The Car Body: Repair Technician" was issued in February. It is targeted at Assessors, Adjusters and Bodyshop people. The manual includes the fundamental principles of technical repair, in particular the correct working operations for repairing and painting the panels, and the body control with electronic gauge.

The centre planned some training courses to improve the technical knowledge of adjusters involved in the control of the damage appraisals and the body shop networks: the Italian insurance market needs expert professionals to audit the cost of material damages.

CESTAR has also started to do low speed crash tests to introduce in Italy the car insurance classification. Almost all car manufacturers gave their availability to carry out our plan. About 10 tests have been planned by the end of the year 2002.

# News From The Centres

## IIHS – USA


The Institute's March 2002 Status Report provided a comparison of the performance of the European and US specification Volkswagen Beetles. Two tests were conducted involving the fronts of European Beetles striking the rear of European Beetles at 20 mph and similar tests were conducted involving the fronts of US Beetles striking the rear of US Beetles – again at 20 mph. Resulting damage varied greatly with European Beetle total average damage, $7,157, and US Beetle total average damage, $5,122. The Institute comments that the reason for this difference is to be found in the design of the attachment mounts – solid sacrificial crash boxes in the case of the European cars and the energy absorbing (stroking) design of the US attachments. Broadening the testing to a number of other small cars, the Institute conclude that most small cars do not "bump" as well as Beetle bumpers.

Elsewhere in the report poor marks are given to States in improving safety related legislation. However the Institute is able to end on a high note in observing that pedestrian deaths per 100,000 people have reduced in all age groups in the 25 years to year 2000 – overall reduction is 51%. Old people are most affected and here the reduction is 60% from just below 8 to below 4 per 100,000. There is no room for complacency however since pedestrian deaths still account for 11% of all traffic deaths, the majority of which (70%) occur in urban areas.


The main thrust of the Institutes April Status Report is the danger of weight reduction in vehicles without corresponding improvements in safety. Dr Andrew Lund, IIHS COO, reports on his involvement with the National Academy of Science's committee that studied CAFE (corporate average fuel economy). CAFE originated in the US in 1973 setting each auto manufacturer a target of achieving an average 27.5 miles per gallon (mpg) consumption across its fleet by 1985 model year. This target was frozen in 1996 by the US Congress at 27.5 mpg for cars and 20.7 mpg for light trucks. The National Academy's review of CAFE and effects on vehicle occupant safety concluded that it "has clearly contributed to increased fuel economy of the nation's light duty fleet in the last 22 years". Also that "the downweighting and downsizing that occurred in the late 1970s and early 1980s, some of which was due to CAFE standards, probably resulted in an additional 1,300 to 2,600 traffic fatalities in 1993". The National Academy suggest, however, that this need not be the trend if a weight based system was introduced. By this they advocate the reduction in weight of the heaviest vehicles on an indexing basis using gallons of fuel per 100 miles driven by vehicle weight or a similar Index. The use of technology is suggested to improve fuel economy within this weight index structure thus maintaining safety standards for occupants and countering negative safety consequences.

The Institute also reports on the growth of neighbourhood electric vehicles (NEVs), attempts to control their use and speed limit in various States. The Institute see their use as a potential problem as Institute President, Brian O'Neill, put it: "NEVs are a safety problem waiting to happen."

The April issue concludes with the good news that there are fewer airbag deaths with the risk reduced in newer vehicles. Summarising, the Institute says that deaths attributed to inflating airbags have declined in all occupant groups - infant deaths from 9 (1997-98) to 1 (2000-01). During the same period child deaths declined from 54 to 15, driver deaths from 32 to 7, and adult passengers from 8 to 2. A total of 8 airbag deaths occurred last year – so there is still a problem but with education and redesign the problem is much smaller.


The Institute reviewed traffic law enforcement through automation in their May Special Issue report. The point is made that automatic enforcement of traffic laws is routine in many countries; however it is catching on more slowly in the United States. The report summarises the evidence on effectiveness from around the world. The main evidence came from studies carried out in USA, Australia and Singapore, but there were problems over the experimental design of studies and the Institute had to exclude some results. Generally speaking red light cameras reduce injuries but by reducing accidents overall the number of rear-end impacts rose. More cars stopping at red lights at intersections leads logically to more following cars rear-ending the stoppers. Examples of automated controls are cited from other parts of the world, notably London, England, for combined red light/speed violations, the Netherlands and Israel cameras monitor tailgating. Automated cameras can also be used for illegal railway crossings and violations of laws requiring vehicles to stop for school buses. A full report "Effects of red light cameras on violations and crashes: a review of the international literature" by A S Hakket et al is available from Publications, Insurance Institute for Highway Safety, 1005 North Glebe Road, Arlington, VA.22201.

**(IIHS is at www.highwaysafety.org)**

# News From The Centres

## AZT – Germany

Recent research at AZT issued in AZT-News has shown that in the first few minutes after the fire breaks out car occupants can be rescued, generally without danger for the rescuers, as long as the fire does not reach the car's passenger compartment. The scene depicted in the photograph below is more Hollywood than reality as in real world situations fires normally develop more slowly. The research will be presented in full at the forthcoming RCAR meeting in Stockholm.

**(AZT is at: www.allianz-azt.de)**

## CESVI Argentina

The 6 June will mark the broadcast of the 100th chapter of "Crash Test", CESVI Argentina's TV programme. "Crash Test" has run weekly since May 2000 and informs the whole of Latin America about car safety, technology, new cars, defensive driving, etc. The programme takes half an hour and is repeated 4 times a week on the cable signal "América Sport". The audience is increasing in number every month and now ranks 4th in the broadcasting ratings. In September 2001 CESVI Argentina signed an agreement with Motorpress, one of the most important European publishing companies, and our magazine, "Crash Test", and their magazine, "Autotest", are together distributed monthly nationwide in Argentina. We at CESVI Argentina would like to thank all the RCAR centres for their contributions.



CESVI Argentina has exported its assessment system, "Cesvicom 3.1" to El Salvador and Paraguay. La Centro Americana Insurance Company SA has bought a license to use the system in El Salvador, MAPFRE Paraguay has bought 3 licenses for their adjusters, and a group of bodyshops who work for that insurance company have bought another 17 licenses.

**(CESVI Argentina is at: www.cesvi.com.ar)**

# News From The Centres

## State Farm – USA

### 'Hybrid cars' getting close look from Vehicle Research Facility

*Unique design of gasoline engine/electric motor cars presents new challenges for State Farm technicians*

They're easy on the gas – some of them get up to 70 miles per gallon. And they're good for the environment because they reduce exhaust emissions that feed air pollution.

But what happens if these new gasoline/electric cars are in a wreck? How easy are they to repair/ How well do they protect drivers and passengers from injury?

These are among the things technicians at State Farm's Vehicle Research Facility (VRF) are finding out about hybrid vehicles, which are powered by a combination of a gasoline engine and an electric motor. Researchers are taking a close look at a Toyota Prius and a Honda Insight, the first two hybrids introduced in the United States.

How they acquired the Prius illustrates one repair problem that will have to be overcome.

"This car had some front-end damage that could have been repaired, but the repair facility people were apprehensive about working around the electrical technology, afraid of being electrocuted," said **Earl Hyser**, Superintendent-Research. "So it was declared a total loss and we obtained it."

It's really not that difficult to shut down the high-voltage battery pack so you can work on the car," said **Tom Hollenstain**, Assistant Research Administrator. "Once that's done, it's no different from a regular gasoline-powered car from a repair standpoint. This car stood up to the crash impact pretty well."

"We were able to save some money on repair costs by using sectioning techniques provided by Toyota in its collision repair manual to replace sections of the frame rather than the entire frame," Earl said.

Now that Earl and Tom have restored the Prius, they will monitor its hybrid technology and the effectiveness of the collision repair techniques they used on it.

In frontal crash tests done by the National Highway Traffic Safety Administration (NHTSA), the Prius received generally good ratings (see www.nhtsa.do.gov/cars/testing/ncap/<http://www.nhtsa.do.go./cars/testing/ncap/> for more information). Its head restraints, which protect against whiplash-type injuries, were rated "good" by the Insurance Institute for Highway Safety (IIHS) (www.highwaysafety.org/safety_facts/head/<http://www.highwaysafety.org/ safety_facts/head/>).

The Insight was donated to State Farm by American Honda Motor Co. The left side of the car has been cut away so it can be used for training purposes.

"From a repair standpoint, the noteworthy thing about the Insight is that it has an all-aluminum body," said **Steve Schmidt**, Associate Research Administrator. "Aluminum can be more challenging to repair than steel; it's not as easy to work with. This can result in replacing more body panels, which is more expensive. The collision repair industry isn't fully prepared to deal with large numbers of vehicles needing aluminum repair."

NHTSA gave the Insight high marks on its frontal and side-impact crash tests, but the IIHS rated its head restraints "poor."

"While these cars are both hybrids, they're quite different in how they operate," Tom said. "The Prius is more of an electric car that uses the gas engine only to recharge the batteries and turn the generator. The Insight is more like a gasoline-powered car that kicks in the electric motor when it's needed, such as for passing, climbing hills or pulling a heavy load."

The same hybrid technology used in the Insight is available starting this year as an option in the 2003 Honda Civic, which has a conventional steel body design.

***(The above article is taken from The State Farm Times, May 2002, and is reproduced with their kind permission.)***

**(State Farm is at: www.statefarm.com)**

# News From The Centres

## Folksam – Sweden

Folksam produced their publication "How Safe is Your Car?" in 2001. The overall assessments are based upon Euro NCAP (European New Car Assessment Programme) taken together with Folksam's own research results. They view car safety as being divided into two categories: crashworthiness and accident avoidance. Crashworthiness covers the protective features the car possesses, ie how it is built and safety devices such as air bags and seal belts. Accident avoidance embraces the features that reduce the risk of an accident, including the car's road-holding ability, tyres and braking system. The Folksam team are focussed upon crashworthiness. The car's drivabiity and driver's behaviour have no bearing on the results in the research.

The concept of "Vision Zero" is introduced. This is the goal adopted for work on road safety at the national level in Sweden. Vision Zero means that a driver complying with current traffic regulations should not be killed or seriously injured as a result of making a mistake in traffic. The car and the road environment should work together sufficiently well to prevent or reduce the severity of the consequences of a collision. Much has to be achieved before this condition is met.

Folksam's Safety Researchers
Sigrun Malm, Anders Kullgren, Malin Cedergren and Anders Ydenius
(Not shown: Maria Krafft and Anders Hägg.)

The Folksam Team produced a series of tables Classified according to size. Size counts and generally speaking larger cars are safer than smaller cars; there are exceptions however.

Folksam comment on the improvements that have taken place in the past 20 years, provide a comparison between Euro NCAP and Folksam testing and outline work they have carried out on "Agressivity". There is a section on protecting child passengers. As a postscript Folksam reveal they are working with Autoliv and Bilprovningen (the Swedish Motor Vehicle Inspection company) and have set up a unique research project in which 10,000 cars were equipped with aftermarket whiplash protection devices. The effectiveness of the system will be evaluated in 2002.

And yes….you want to know the safest car based upon Folksam's assessment! Well the prize for 2001 went to Volvo S70/V70 model from 1998-2000 (which means your Secretary General got something right at least when he bought his last car!).

**(Folksam Safety Information is at: www.folksam.se)**
**(Folksam Auto is at: www.folksamauto.com)**

# News From The Centres

## MPI – Canada

This month Manitoba Public Insurance reports on advancements in panel bonding and the most recent findings of on-going durability tests of bonded roof panels.

**General Motors Technical Bulletin on Panel Bonding**

Years of research and testing of adhesive bonding by adhesive manufacturers and MPI's research group have helped in gaining one original equipment manufacturer's acceptance of adhesive bonding for aftermarket installations. In May 2002 General Motors released their Technical Bulleting 02-08-98-001 that sets out guidelines for adhesive bonding. In this bulletin General Motors recognizes the use of panel bonding as an alternative to MIG welding when replacing exterior panels. The bulletin notes that the process is to be used only on door skins, tail panels, roof outer panels, and quarter panels.

General Motors has issued specification GM 6449G that provides test and standards information to adhesive manufacturers and suppliers. This specification provides performance guidelines for adhesives used in aftermarket repair situations. The only adhesives that currently meet the General Motors specifications are Lord Corporation's Fusor #108B/109B Metal Bonding Adhesives (Medium-Set) and Fusor #110B/111B Metal Patch Panel Adhesive Bondline Control (Fast-Set).

Acceptance of panel bonding by an original equipment manufacturer means that it is only a matter of time until flat rates are developed that reflect the cost savings that adhesive bonding provides over the welding process. To assist in developing flat rates for panel bonding, Manitoba Public Insurance's research centre has been asked to provide the results of time studies carried out on full roof replacements.

**Durability Study Update**

In 1999 we undertook durability tests of bonded roof panels. Two vehicles with bonded roof panels, a 1997 Ford F150 and a 1998 Plymouth Breeze, were placed in service and driven over a combination of highway/city roads. The monthly mean temperatures over the three-year period ranged from –18.4º Celsius through winter months to 20.4º Celsius in summer months. In winter conditions, daily minimum temperatures often exceeded -30º Celsius, while summer temperatures reached 38º Celsius. Throughout the three-year study the bond lines were subject to periodic inspections. The accompanying photographs record the most recent inspection that was carried out in May 2002.

Since the start of the study the F150 has logged 68,441 kilometres while the Breeze was driven 43,449 kilometres. This recent inspection confirmed that the bond lines are intact and corrosion free.

Manitoba Public Insurance's research team continues with its investigation of adhesives in panel replacements. At the upcoming RCAR meeting we will report on our investigation into weld-bonding in structural panel replacements.

**(MPI are at www.mpi.mb.ca)**

# Repair of Hydrogen Fuel Cell Vehicles

**Introduction**

The world's motor vehicle manufacturers are actively pursuing the introduction of alternatively fuelled vehicles in order to address environmental concerns over the burning of fossil fuels and the consequential release of $CO_2$. Higher concentrations of man-made $CO_2$ in the atmosphere will accelerate the greenhouse effect, subsequently raising global mean temperatures and changing weather patterns that directly influence everyone. Media coverage relating climate change to $CO_2$ release caused by fossil fuel burning on an industrial scale has increased public awareness to the problem.

Coming with this increased awareness of environmental problems is the willingness of customers to buy vehicles that place a lower burden on the environment during their in-use phase. These, together with changes in government policy and tighter emissions regulations have almost guaranteed a ready-made market for products with a greener image. In turn the vehicle manufacturers have responded, by developing and working on vehicles that are powered by fuels other than conventional petrol or diesel.

The results of the manufacturer's labours are already beginning to bear fruit and we have seen the introduction of a number of new models namely the Toyota Prius petrol-electric hybrid, the Ford Ranger EV and a range of vehicles from most manufacturers based on existing models that are duel-fuelled i.e. can run on either petrol or Liquefied Petroleum Gas. Further derivatives can be run on petrol or Compressed Natural Gas.

However, these vehicles can only be considered a stopgap as they still release $CO_2$ – although in greatly reduced quantities – and therefore cannot be considered a sustainable long-term alternative. A further problem is that fossil fuels are ultimately finite, and secondly the increase in vehicle numbers and usage tends to negate the effects of any fuel efficiency improvements or reduction in $CO_2$ emissions. Coupled to this are the aspirations of countries in Asia, Africa and Latin America who are still industrialising and are determined to gain the benefits such a lifestyle brings. One such benefit is the mobility and freedom of choice the private passenger car offers.This means that the world vehicle population is set to rise if only to meet the aspirations of the peoples of the developing world, and due to the sheer weight of numbers, significant amounts of $CO_2$ and other pollutants would still be emitted from the global vehicle population as a whole even if a significant proportion where hybrid or LPG/CNG powered.

**Fuel Cell Solution**

What is required is a totally $CO_2$ neutral mobile power source, small enough to be installed into a normally sized vehicle. Technology does have an answer to this seemingly intractable problem - namely the hydrogen fuel cell. Invented by Sir William Grove 1839 and up to now used mainly by the aerospace industry and military applications, the fuel cell has all the attributes required to become a successor to the internal combustion engine. These cells work by combining hydrogen and oxygen in an internal chemical reaction to generate electricity with the only by-products being water vapour and heat. Figure 1 shows the basic principle of fuel cell operation when supplied with hydrogen and oxygen as the fuel.

Normally when hydrogen burns it reacts with oxygen in the air producing water, heat and light. Sound can also be produced giving an apt name for the familiar "pop" test used to detect the presence or absence hydrogen. In the fuel cell this chemical reaction is exactly the same, but with electrical energy being produced in place of the heat and light. This process takes place by feeding hydrogen over one electrode and oxygen over the other as shown in Fig. 1. Separating the two electrodes is an electrolyte, a material that allows charged molecules or "ions" to move through it. At a basic level the process can be compared to the reverse of electrolysis where an electric current is passed through water, splitting it into its component hydrogen and oxygen gases. The fuel cell does the opposite; hydrogen and oxygen combine producing water and electricity. The water is normally discarded and the electricity in this application used for traction purposes.

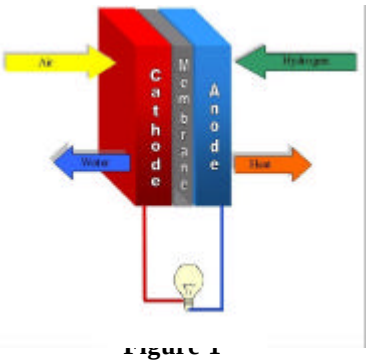



**Figure 1**
**Diagram of Fuel Cell Operation**

A number of different types of fuel cell can be made using various materials for the electrodes and electrolyte and the materials chosen give the name to the particular type of fuel cell. Just as there are different types of conventional battery based on the materials used i.e. lead acid, nickel iron, zinc carbon etc. the same applies to fuel cells. But for motor vehicle use the PEMFC or Proton Exchange Membrane Fuel Cell has shown great promise with high energy densities, low operating temperatures and very rapid start-up times of a few tens of seconds. This fuel cell uses a moist polyperfluorosulphonic acid membrane together with a platinum catalyst. Because of its very good performance and

# Repair of Hydrogen Fuel Cell Vehicles (continued)

tolerance to hydrogen containing small amounts of impurities, all current research programmes for developing fuel cells for automotive use are based on this type. The supply of oxygen necessary for operation is delivered to the fuel cell by feeding normal ambient atmospheric air with 21% oxygen content to the cathode, the hydrogen delivered to the anode comes from on-board high pressure storage within the vehicle however.

**Theory into Practice**

The voltage obtained from a single fuel cell is insufficient for motor vehicle traction purposes and so the cells are arranged in 'stacks' to increase voltage and current output to useable levels. Acceptable acceleration and top speed performance requires power in the region of 50 to 65kW to drive a full-size vehicle, and this is obtained from 150 to 200 fuel cells giving an output voltage of 150 to 300 Volts DC. As with most vehicle systems, packaging is always a problem in that the cells must occupy as small a volume as possible due to the limited space available. Individual cells are therefore clamped together in 'stacks' that allow the passage of gases equally to each cell and make the necessary electrical and coolant connections. The stacks are then connected in series/parallel combinations to obtain the desired electrical power and voltage output. The total package size using this arrangement can be reduced to approximately 50 litres. Figure 2 shows an assembled stack of fuel cells with through-bolts and electrical connections. Figure 3 shows a completed fuel cell containing a number of stacks and of a size suitable for installation in a vehicle.

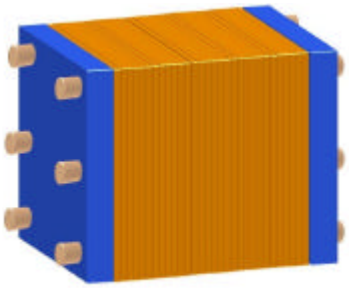


**Figure 2**
**Stack Arrangement of Fuel Cells**

**Figure 3**
**Fuel Cell In-Vehicle Packaging**

The 300V DC output from the fuel cell must be converted into variable frequency AC to enable speed control of the traction motor or motors. The traction motor shown in Figure 4 is a liquid cooled AC machine rated at 65kW peak, 45 kW continuous, and has an integrated inverter and drive electronics pack used for speed control. The assembly also houses a single ratio reduction gearbox allowing the unit to be connected directly onto the final drive or differential housing via a short prop-shaft.

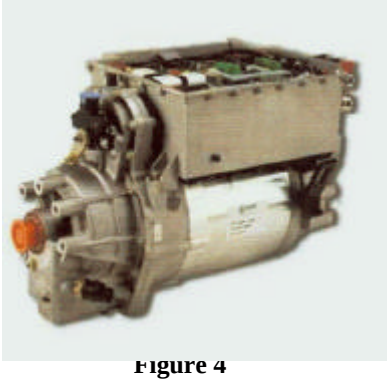


**Figure 4**
**Combined Traction Motor and Gearbox**

# Repair of Hydrogen Fuel Cell Vehicles (continued)

**Gas Side**

So far, most of the components used in a hydrogen fuel cell vehicle have been explained with some photographed examples in current manufacture. Figure 5 shows how the various gas-side components of the system work together delivering hydrogen and oxygen to the fuel cell in order to produce electricity.

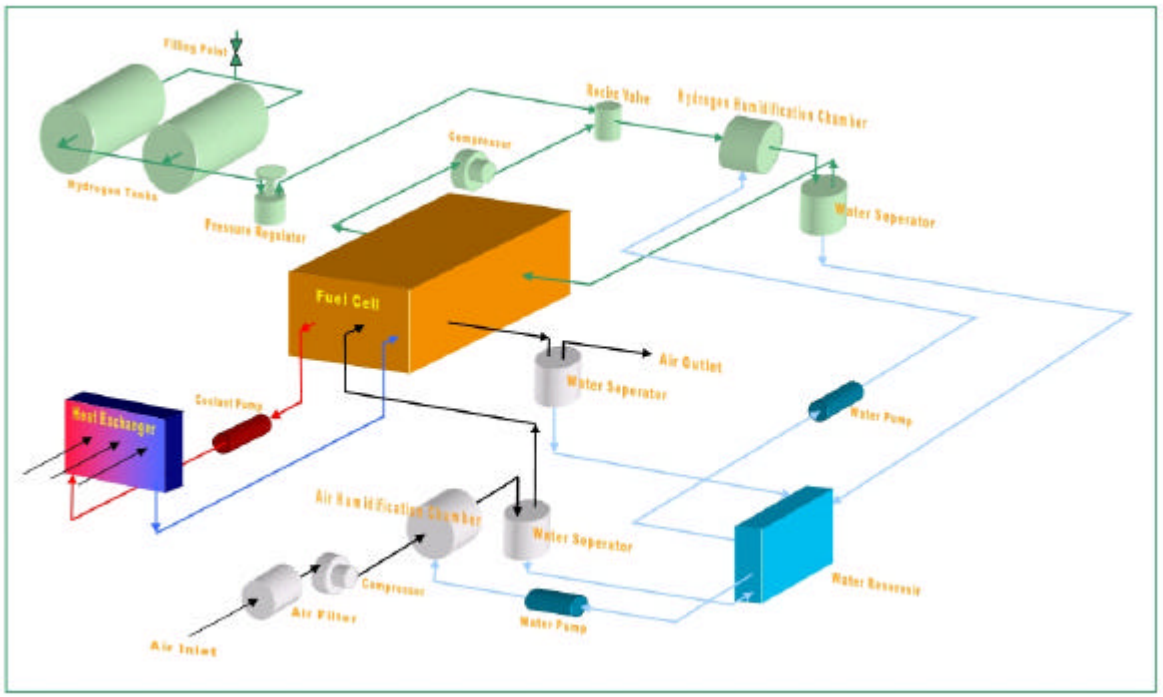



**Figure 5**
**Diagram of Fuel Cell Gas Feeds**

As explained earlier normal atmospheric oxygen is drawn-in using a roots type compressor past a filter to remove dust and grit particles and then delivered to the fuel cell via a humidification chamber. It is necessary to humidify both the hydrogen and oxygen to a certain level in order to keep the ion exchange membrane in the fuel cell conductive. De-ionised water is used for this purpose, coming via a pump from an on-board storage tank. Immediately following the air humidification chamber is a water separator that prevents any water droplets being carried over into the cell. The air containing oxygen is passed into the fuel cell casing and presented to the cathodes of the fuel cell stack where it is used in the chemical reaction. The air leaves the fuel cell after picking up some more water vapour produced as part of the electrical generation process and passes through a further water separator before returning to atmosphere through a small grill or opening at the rear of the vehicle. The recovered de-ionised water from this separator returns to the water reservoir.

The process on the hydrogen side is similar except that this gas is held in pressurised storage tanks on board the vehicle, as it cannot be derived from the air like the oxygen. It will be noticed from Fig 5 that the hydrogen is re-circulated in a loop through the fuel cell using a compressor and re-circulation valve. This valve only admits hydrogen from the main tanks when pressure in this loop falls due to hydrogen travelling across the cell membrane and combining with the oxygen to make electricity and water. A similar humidification process as used on the oxygen side also takes place here.

An interesting point is that the fuel cell powered vehicle still needs a conventional radiator and cooling system. As explained earlier the chemical reaction of combining oxygen and hydrogen releases heat that must be removed from the cell and rejected to the air. The electronics pack used to control the vehicle speed and regenerative braking, in addition to the traction motor or motors can also take advantage and use this cooling loop if required to dissipate excess heat.

One further component unique to fuel celled vehicles is the high pressure hydrogen storage tanks shown in Fig 5, together with the all-important filling point enabling replenishment from an external source when required. The size of the tanks and their maximum pressure determines the amount of hydrogen held and hence the vehicle's range. Proposed tanks will operate at a pressure of up to 340 Bar and be of carbon fibre structure with inert polyethylene liners.

# Repair of Hydrogen Fuel Cell Vehicles (continued)

**Electrical Side**

The electrical system of fuel cell vehicles is as equally specialized as the gas side. The main consumer is of course the traction motor that relies a sophisticated DC to AC converter to effect 'fly by wire' speed control of the vehicle. But additionally there are many other smaller electrical loads, ranging from in-car entertainment units, through to vehicle lights, security, signalling, instruments and climate control systems that require electrical power. One problem here is that the nominal output of the fuel cell is 300 volts and it would be difficult to obtain electrical equipment such as power steering, lights, radios, fans, motors, etc. specially made to operate at this voltage. Initially at least these components will be sourced from existing electrical supplier's product lists with a nominal 12 Volt rating for reasons of commonality and lower costs. These smaller electrical loads are supplied using DC-to-DC converters that change the 300 Volt output from the fuel cell down to 12 Volt for these items. There is also an ordinary lead-acid battery connected to the system providing stored electrical energy when the main fuel cell is switched off. It must be remembered that a fuel cell is not like a battery it does not store electrical energy – if there are no gases flowing, there is no electrical output.

Therefore there is a requirement to store electrical energy on board the vehicle enabling things like central locking, security systems, in-car entertainment and even parking lights to operate under situations when the fuel cell is shut down. This list also includes initiating the opening of solenoid valves and running the gas compressors to enable start-up of the fuel cell following overnight parking or temporary halts.

A further advantage of using a DC-to-DC converter to supply these auxiliary loads is that they are stabilized against voltage fluctuations caused by the large and varying current taken by the traction motor. It would be particularly annoying if the headlight brilliance fluctuated with throttle demand for example. A further reason is safety as having 300 Volt lurking at the rear of a radio could give repair staff a nasty surprise. A diagram of the essential electrical system components is shown in figure 6

**Repair Industry Role**

So how will the repair industry cope with this radical new technology and what safety measures, equipment and training need to be implemented so that a repair shop can carry on its business?

**Safety**

This must be the primary consideration with any repair operation especially as the fuel cell vehicle has its fair share of hazards that must be properly managed to remain safe. These include flammable gas, pressurized gas, high voltage electricity and low voltage high current electricity.

**Flammability**

Taking the flammable gas issue first, any vehicle involved in a collision, unless relatively minor, must be treated as though the gas integrity of the on board components has been compromised. The hydrogen tanks themselves have a solenoid valve fitted to the outlets and configured to normally close whenever the electrical power to them is interrupted. Closure of the valves are effected whenever the 'ignition' switch is turned off, or under the control of an inertia switch as used on current fuel injected vehicles to interrupt the power to the fuel pump in the event of a collision. The solenoid valves prevent the bulk hydrogen escaping from the storage tanks and any gas trapped in pipes in the remainder of the system will escape through any breeches in the pipe work.

Clearly any gas remaining in the storage tanks must be removed before commencing repair work and this will involve either recovery i.e. discharging into another pressure vessel, or by controlled flaring. A separate building devoted to this function would probably be needed, open on all sides to aid ventilation and prevent gas build-up. It would also need to be equipped with flame detection cameras and hydrogen gas sensors alerting personnel of any fires or gas build-up. Any equipment used in the de-gassing process must be electrically grounded, as must the vehicle, and all personnel working in the area must be take static precautions when working in the vicinity. Once declared free of stored gas the vehicle can be passed to a normal repair shop to receive attention. But even here flame detection cameras and hydrogen detectors should be installed in case gas trapped inside components is released during any subsequent dismantling.

**Pressure**

The only very high-pressure components are of course the hydrogen gas storage tanks and owing to the specialized construction method the recommendation would be to scrap any tanks showing signs of external damage. As for testing tanks that do not have any visible damage, then the best method would be to return them to the vehicle or tank manufacturer for unit exchange. These tanks would come under the pressure vessels regulations and may need to be subjected to a regular inspection to assess their integrity.

# Repair of Hydrogen Fuel Cell Vehicles (continued)

The remainder of the hydrogen piping system can be leak-checked following any disconnection or repair by filling to the rated pressure with nitrogen and measuring the leak-back rate over time. This method has its disadvantages, as ambient temperature changes during testing will mask the effect of any leakage. An alternative method would be to use a small capacity vacuum pump to pull a hard vacuum on a pipe or component in a similar procedure to that used by the refrigeration industry. The final vacuum (i.e. lowest air pressure) achieved by the pump and monitored by a gauge would be a measure of the line's integrity – any leaks would prevent a hard vacuum being formed.

**Electrical**

The 300V output from the fuel cell is conveyed to various on-board electrical systems by suitably rated and insulated cables. Of chief concern here will be the condition of the insulation following any collision damage and preventing further damage caused by heat if welding is carried out as part of the repair process. The cables can be tested using an insulation tester that imposes a higher than normal voltage on the cable (up to 1000V) and a direct reading of insulation resistance obtained using this standard method. Due to the high voltage used it is essential that any electrical equipment supplied by the cables is disconnected first or damage may occur to any semiconductor devices contained within.

Figure 6 shows that a large number of electrical modules are necessary for correct control and operation of the various on board systems. For ease of manufacture and maintainability these will be grouped together where possible in one central location and will allow the running of diagnostic routines similar to today's engine management systems to speed up and simplify faultfinding and repair. The most likely scenario maintenance would be a module exchange system run by the vehicle manufacturer whereby defective electronic units are returned in exchange for a new or re-manufactured unit.

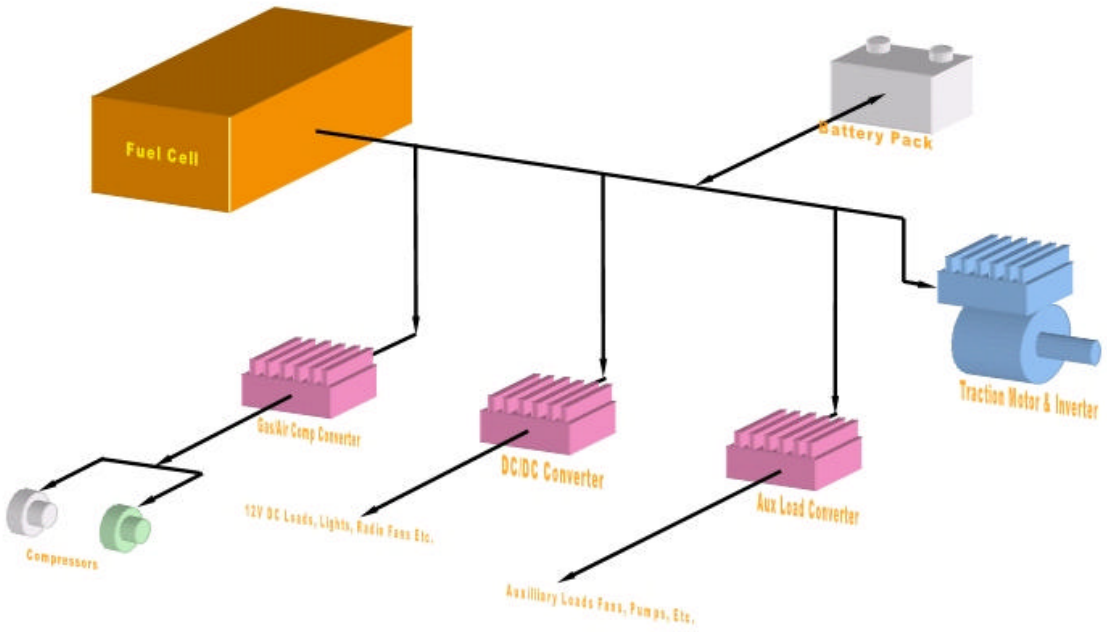



**Figure 6**
**Diagram of Electrical System**

A similar manufacturer's exchange scheme will need to be run for the traction motor and drive electronics pack as initially there will be no third-party vendors for exchange units. This contrasts with today where numerous independent engine-remanufacturing workshops exist offering a plentiful supply and range of exchange units. The vehicle manufacturers will be the sole source of replacement traction motors and the other electronics modules mentioned above until sufficient expertise, knowledge and spare parts cascade down to third parties and a repair industry gradually built up. This may make it difficult to offer a keen price for carrying out a repair job and when competing for business between rival repair firms.

# Repair of Hydrogen Fuel Cell Vehicles (continued)

**Collision damage**

As mentioned earlier the output from the fuel cell will be in the order of 65kW and is not overly large by today's standards, being roughly equivalent to a 1.6 Litre gasoline engine. To make best use of this power and to maximise range the vehicle weight must be reduced by the use of light alloys and composite materials not only for panels i.e. doors, bonnet and boot lid, but in larger sections for load-bearing structural members. Workshops engaged in the repair of these vehicles need to be well versed in the both the finishing and jointing techniques necessary to carry out satisfactorily repairs whilst still maintaining crash protection.

**Staff Training**

This is perhaps the most important aspect of any repair operation and is particularly so in the case of fuel cell vehicles because of the diverse range of technologies involved. The range of skills, knowledge and awareness required would include:

- Electrical power control.
- AC/DC theory.
- Electronics faultfinding.
- Pipe work, valves, pressure regulators and vessels.
- Flammable gas handling precautions and operations i.e. charging, discharging, and purging tanks, components.

This would be in addition to normal mechanical skills required to repair suspension, steering and braking systems that will be similar to conventional vehicles and it would be difficult to find personnel with this cross-section of skills and knowledge. It would seem therefore that there would be a need to train specialists in the same way we currently train auto-electricians or engine management specialists. The vehicle manufacturers have their part to play, as do the component suppliers, by offering training courses and instruction on their particular products.

**Key Drivers towards a Hydrogen Future**

The path towards the hydrogen fuel cell vehicle has taken its first steps and has proved to be a feasible alternative to conventional fuels. Further development is required to improve on-board storage methods to increase capacity and hence extend range. One very large obstacle remains – the total lack of infrastructure necessary to manufacture and distribute a supply of hydrogen gas on an industrial scale.

Formerly the main drivers for change concerning pollution levels have been legislative, either by fuel taxation forcing the development of more economical vehicles, or by lowering exhaust emission levels. More recently however, other drivers have appeared and these are; concern over permanent climatic change i.e. global warming, and the realisation that fossil fuels are finite and will become increasingly expensive. But perhaps the most important is the buying public's reaction that when offered a choice they will choose lower polluting, alternatively fuelled vehicles over conventionally fuelled vehicles, providing they offer similar performance, convenience and range. This change in public awareness could be enough to tip the balance towards the hydrogen economy.



# From The Secretary General

Our June 2002 Newsletter contains news from ten of our 24 Research Centres and covers the full range of RCAR activities. There is also an update on the work of the Crash Standard Working Party but this is brief and does not contain contributions from Thatcham and IIHS. There will be a presentation and full discussion at the forthcoming conference in Stockholm, but there is still a great deal of work to do.

I am also pleased to say that there is a major technical article on Fuel Cells. I most indebted to the author, who is a colleague in the research division of one of our major vehicle manufacturers. He does not write under his company banner and in this way he is able to talk freely on this somewhat sensitive and very competitive emerging technology.

There is a great deal of activity in the research community and with vehicle manufacturers. To cite just two recent initiatives, General Motors produced their fuel-cell concept vehicle, AUTOnomy, at the North American International Auto Show (see details February 2002 SAE Automotive Engineering), and Ford Motor Company announced that it is planning to produce five fuel-cell cars this year, which will be put through a vigorous testing programme.

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## The RCAR Network

Of the 24 RCAR Centres in 17 countries, 19 have web sites. Addresses are to be found on www.rcar.org. However, for convenience, web sites are also listed below.

| | |
|---|---|
| AZT | www.allianz-azt.de |
| Centro Zaragoza | www.centro-zaragoza.com |
| Cesvimap | www.cesvimap.com |
| Cesvi Argentina | www.cesvi.com.ar |
| Cesvi Brasil | www.cesvibrasil.br |
| Cesvi Colombia | www.cesvicolombia.com |
| Cesvi Mexico | www.cesvimexico.com.mx |
| Folksam Auto | www.folksamauto.com |
| ICBC | www.icbc.com |
| IIHS | www.highwaysafety.org |
| JKC | www.jikencenter.co.jp |
| KART | www.kidi.co.kr |
| KTI | www.k-t-i.de |
| Lansforsakringar | www.lansforsakringar.se |
| MPI | www.mpi.mb.ca |
| NRMA | www.nrma.com.au |
| State Farm | www.statefarm.com |
| Tech-Cor | www.tech-cor.com |
| Thatcham | www.thatcham.org |

## Dates For Your Diary

**International Bodyshop Industry Symposium (IBIS)** is to be held at the Montreux Palace Hotel, Geneva, 18-20 September 2002.

**Annual RCAR Conference 2002** is to be held in Stockholm, Sweden. 22-27 September 2002, and will be hosted by Folksam Auto.

**46th Annual Conference of the Association for the Advancement of Automotive Medicine (AAAM)** Tempe, Arizona, 29 September to 2 October 2002
Details: http://www.carcrash.org

**46th STAPP Car Crash Conference** is to be held at Sawgrass Marriot Resort, Ponte Vedra, Florida.
11-13 November 2002.
Details: http://www.stapp.org.

**NACE 2002** is to be held in Dallas, Texas,
5-8 December 2002.
Details: http://www.naceexpo.com

## From The Secretary General (continued)

These will be examples of the latest Focus FCV, one of the new breed of hybridised fuel-cell vehicles optimising range and performance of hybrid technology with the benefits of fuel cell motive power (see UK's IMechE June 2002 Automotive Engineer). It is interesting to note the State Farm News on hybrid vehicles which mirror the experience of ICBC in their work presented at Seoul in October last year. Clearly it is an interesting and developing area and the technical article in this newsletter is therefore timely.

At present I am preparing for the annual RCAR Conference in Stockholm, 22-27 September 2002. Egon Bergman and his colleagues at Folksam have put together an excellent programme for delegates and partners and I am starting to work on the Technical Programme. Most centres have responded to the "call for papers" and on the basis of these Members can look forward to a full and challenging conference programme. Details will be despatched to delegates directly by Folksam Auto in July/August.

I certainly look forward to seeing delegates and their partners in Stockholm in September.

Best wishes,

Michael Smith

## News, News...

It is not the intention to provide the latest automotive or insurance industry news in this Newsletter. However there are some excellent sources available on the Web and members may find the following sites useful.

| | |
|---|---|
| Automotive Online. | http://www.automotive-online.com |
| Automotive.com | http://www.automotive.com |
| AM-online | http://www.am-online.com |
| Associated Press. | http://www.ap.org |
| AutomotiveNewsWire. | http://www.brgtownsend.com |
| Bloomberg. | http://www.bloomberg.com |
| CeBIT | http://www.cebit.de |
| Cisco Systems | http://www.cisco.com |
| CMGI | http://www.cmgi.com |
| CNN. | http://cnn.com |
| Far East Newsletter. | http://www.feer.com |
| Financial Times. | http://www.ft.com |
| Fleet NewsNet. | http://www.automotive.co.uk |
| JUST-AUTO | http://just-auto.com |
| MSN. | http://www.msn.com |
| New York Times. | http://www.nytimes.com |
| Newspage. | http://www.newspage.com |
| ODETTE | http://www.odette.org |
| PRNewswire | http://www.prnewswire.com |
| REUTERS. | http://www.reuters.com |
| Roadtransport. | http://www.roadtransport.net |
| Silicon. | http://www.silicon.com |
| Slate. | http://www.slate.com |
| Wired. | http://www.wired.com |
| Wall Street Journal. | http://www.interactive.wsj.com |
| Yahoo! | http://uk.yahoo.com |
| ZD. | http://cgi.zdnet.com |