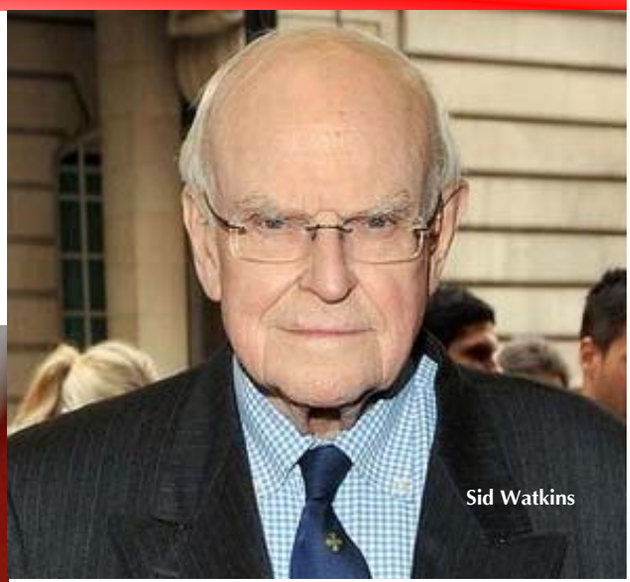
Crash Safety

by Frank Catt >>

A continuation of the crash safety issue.

Formula 1 was rocked by a series of accidents in 1994 and 1995, among them the deaths of Ayrton Senna and Roland Ratzenberger on 30th April and 1st May 1994. A series of huge improvements, to increase survivability, were brought about by imposed developments, insisted on by the FIA President, Max Mosely, and the ideas led by Professor Sid Watkins, Formula 1s Chief Medical Officer.



Sid Watkins

Few people who were in Monte Carlo on Thursday, 12th May really appreciated how serious Formula 1 driver Carl Wendlinger's accident was. Near the end of the morning practice session the 25 year old Austrian had spun going into the chicane and slid sideways into a water filled plastic, barrel-shaped barrier at the ridiculously low speed of 30mph.

But soon the seriousness of the accident became apparent. In the impact, Wendlinger sustained a brain contusion and subsequently was kept in a stable condition in hospital in a medically induced coma. He would remain comatose for 18 days. His career as a driver was effectively ended; Wendlinger was never the same again. Worse still, at Imola, Roland Ratzenberger and Ayrton Senna had been killed, Formula 1's first fatalities since Elio de Angelis lost his life in 1986.

Significant changes were introduced to the cars in the wake of the Imola and Monaco tragedies, but Formula 1 doctor Sid Watkins knew they weren't enough. He was deeply worried by what happened to a driver's head in the immediate aftermath of a violent accident. FIA President Max Mosley created what he called an Expert Advisory Group, to research and develop greater safety measures. Chaired by Watkins, it asked the Motor Industries Research Association (MIRA) to study the forces likely to be suffered by a driver in the cockpit in the event of an impact, using high-G sled testing of a McLaren chassis and specially instrumented dummies. The first tests simulated a frontal crash at 11.4 metres per second, giving a crash pulse of 23G at close to 25mph.

Watkins recruited FIA technical supremo Charlie Whiting, FIA advisor Peter Wright, Dr Harvey Postlethwaite, race director Roland Bruynseraede and Gerhard Berger to his advisory group, and together this team set to work to calculate the threshold at which a head injury would be sustained. They came up with a complex figure for head injury criterion (HIC). The threshold was deemed to be an impact of 80G over 3ms, giving a head injury criterion of 1000.

HEAD INJURY CRITERION (HIC) is a measure of the likelihood of head injury arising from impact. At a HIC of 1000, 1 in 6 average adults will suffer life-threatening injury to their brain. More accurately, an 18% probability of severe head injury, 55% probability of serious injury and a 90% probability of moderate head injury.

HIC	Level Of Brain Concussion and Head Injury
135-519	Headache or dizziness
520-899	Unconscious <1 hour, linear fracture
900-1254	Unconscious 1-6 hours, depressed fracture
1255-1574	Unconscious 6-24 hours, open fracture
1575-1859	Unconscious >25 hours, large haematoma
>1860	Non survivable

Unsurprisingly, it was declared that current Formula 1 cockpits, and many other race car formulas, offered insufficient protection to drivers.

After the Expert Advisory Group's findings were published, raised cockpit sides of specific dimensions, lined with a horseshoe-shaped foam collar, were

made mandatory from the start of the 1996 season, despite strong opposition from many teams, who argued that performance would be compromised.

Watkins ignored the complaints.

But there was much debate as to the material the collar should be made from. A search began for suitable material that would provide energy absorption around the edges of the cockpit to protect the driver's head in both rear and lateral impacts (see HANS sidebar).

The answer came in a Confor® foam collar. This foam is relatively soft when touched, but when subject to a severe blow the foam hardens to absorb the load and is then slow to bounce back. This characteristic protects the driver from both the initial blow and any whiplash response. A thickness of 75mm was found to be optimal and the device was attached to the cockpit sides, level with the centre of gravity of the driver's helmet. Early tests results were highly encouraging, indicating that, with forward impact of 54G, rearward of 83G and side impact of 35G and a HIC figure of 388, the accident was easily survivable.

Confor® collar around cockpit edges

Proof that Watkins had acted just in time was emphasised in 1995, when Mark Blundell and Mika Hakkinen had life threatening accidents when they hit their heads hard before the collar was introduced. Fortunately both survived - Hakkinen only just. But the collar saved a life almost immediately; Martin Brundle in a Jordan put the cockpit collar through an empirical crash test at his dramatic first lap accident in the 1996 Australian GP in Melbourne, sending him barrel-rolling into a gravel trap.

The effect of the new collar has been extraordinary. Since 1996 there have been no serious

Head And Neck Support Device

(known as HANS) is a safety item now compulsory in many car racing sports. It reduces the likelihood of head and/or neck injuries such as a basilar skull fracture in the event of a frontal crash.

The device was designed in the early 1980s by Dr Robert Hubbard, a professor of biomechanical engineering at Michigan State University. After talking to his brother-in-law, road racer Jim Dowling, following the death of one of their mutual friends, it was decided that some sort of protection was required to help prevent injuries caused by sudden stops, especially during crash accidents.

A major cause of death amongst drivers during races was through violent head movements, where the body remains in place because of the seat belts, but the momentum keeps the head moving forwards, causing a basilar skull fracture, resulting in serious injury or immediate death.

Notable race car drivers who died from basilar skull fractures include:

- Formula 1 drivers Roland Ratzenberger and Ayrton Senna in 1994.
- Indy 500 drivers Scott Brayton, Bill Vukovich and Tony Bettenhausen.
- NASCAR drivers Adam Petty, Tony Roper, Kenny Irwin, John Nemechek, Dale Earnhart and Cliff Allison, among others.

Whilst death from such injuries is usually immediate, some drivers have survived basilar skull fractures.

Primarily, made of carbon fibre, the HANS device is an inverted U shape, with the back of the U set behind the nape of the neck and the 2 arms lying flat over the top of the chest; the device in general is supported by the shoulders. It is attached only to the helmet, and not to the belts or seat, by 2 anchors on either side of the helmet. In a properly installed 5- or 6-point racing harness, the belts that cross the driver's upper body pass directly over the HANS device on the driver's shoulders and buckle at the centre of the driver's abdomen. Therefore the HANS device is secured by the body of the driver, not the seat or body of the car.

The purpose of the device is to stop the head from whipping forward in a crash, without otherwise restricting movement of the neck. The HANS device maintains the relative position of the head to the body, with the device transferring energy to the much stronger chest, torso, shoulders and seatbelts when the head is decelerated.

After major racing safety companies declined to produce the product, Hubbard and Downing formed a company to develop, manufacture, sell and promote HANS in 1991. However, the product languished until 1994, when Formula 1 showed interest in the wake of the deaths of Ratzeberger and Senna and CART driver Gonzalo Rodriguez, who was also killed by a basilar skull fracture suffered in a crash. At the same time, Mercedes was completing research of HANS on behalf of the FIA for Formula 1, finally deciding that it out-performed their airbag product.

HANS device attached to helmet

head injuries in Formula 1. But despite the success, the crusade for even more safety has continued, funded by the FIA. The Transport Research Laboratory (TRL) replicated some of the more serious incidents for further analysis. Among them Verstappen's accident at Spa, which was not captured on television and therefore received little publicity. TRL analysis revealed that Verstappen had been subject to a force of 180G with a HIC of 1980, yet the energy absorbed by his helmet and the Confor® collar meant that, instead of being rendered unconscious, he was only stunned and able to stand, albeit unsteadily, when he was helped out of the wreckage of his car. In a subsequent medical check-up, a brain scan betrayed no evidence of any injury. Max Mosely says, 'We now have conclusive scientific evidence that, without the cockpit padding, his accident would have been fatal.'

By contrast, Mika Hakkinen, in his accident in Adelaide, experienced a force of 208G and a HIC calculated at 1824. The Finn suffered a fractured skull and was knocked unconscious. Heinz Harold Frentzen suffered mild concussion when a brake disc exploded, experiencing 124G and a HIC of 855; Micheal Schumacher broke his leg at the British GP at Silverstone, hitting the tyre-protected Armco barrier head-on, suffering a G loading of 122G and a HIC of 1070.

All who saw Robert Kubica's monster crash in Canada several years later cannot be unimpressed that these safety systems work. That, almost head-on impact with a concrete wall, was to all intents unsurvivable, but he sustained only minor injuries and needed to miss just one race.

On 18th February 2001, Dale Earnhart was killed in the Daytona 500, the fourth death in NASCAR in 14 months, due to basilar skull fractures.

Formula 1 mandated HANS devices in 2003 after extensive testing, sharing the results with other FIA affiliates. Using that information, CART earlier made the device compulsory in 2001.

Whilst realising that the above is not directly applicable to the concerns over steel 'safety' cages built into GT40 cars, it demonstrates that the human body is frail in any accident circumstance, and that drivers wearing full protective helmets and seat belts are still very vulnerable to massive injury from the forces that can be applied.

In part 3 of this feature, we will look directly at the even greater injuries and possibility of death in any accident in which your unprotected head can impact steelwork within the cockpit. Without head restraint, such as the collars or the HANS device, and with no hard shell helmet on the head, the likelihood of severe injuries will always be possible, if not probable.

We experienced this in a low speed impact in our single-seater race car; the driver was fully belted into the car with a 6-point harness, wearing full face helmet, tightly restrained into the seat by the belts with his head a full arm's length from the steering wheel, but even in a low speed impact, his head touched the steering wheel. This was totally impossible to replicate in tests in the workshop. Luckily, in this instance, the driver remained unharmed in the accident.

CONSIDER YOUR CHANCES IN A CLOSED (GT40) CAR, WITH NONE OF THE ABOVE SAFETY FEATURES, AND YOUR UNPROTECTED HEAD JUST A FEW INCHES FROM A STEEL BAR!

You won't need to worry about roll-over protection, the accident will probably have killed you by then!

In the concluding part of this trilogy we will :

- Investigate direct impact head injury onto internal steel cages, with and without foam cladding (not for the squeamish!).
- Investigate side impact injuries and how to minimise them.
- Propose alternative roll-over protection devices.
- Suggest other general GT40 safety precautions.