

## SURVIVAL IN MOTOR SPORTS ACCIDENTS

A Paper by Doctor W N Thomson

Although there may be an element of "luck" in the time and place, once an accident becomes inevitable its outcome can be predicted using simple formulae known to every third-year schoolboy. The kinetic energy of a moving vehicle is expressed as  $0.5 M.V^2$  where M is its weight and  $V^2$  is the square of the speed. In normal stopping this energy is dissipated as heat by the brakes but in an accident situation it goes on to deform the structure of the vehicle - or its occupant! The outcome of any accident depends on the rate at which this energy is released and hence accidents which can be spread over many yards usually have a more favourable outcome than those which occur in a few feet. A vehicle travelling at 30 mph which is brought to a halt in 18" sustains a deceleration of approximately 20G (Gravity = 32' per second/per second). This is also the deceleration sustained by the driver if he is securely belted into the vehicle, whereas an un-belted occupant will continue at 30 mph until he contacts the windscreen or fascia and may then be halted in, say, 2" producing a deceleration equal to 200G.

In 1951 Stapp (see Ref 1) in experiments with rocket-driven sledges and volunteers showed that certain levels of deceleration could be consistent with survival provided the deceleration was of short duration. Subsequent analysis of accidents in the air, on the road and in the home has confirmed this under-lying principle and suggests that the following figures are on the whole consistent with survival:

20G for 3 seconds ) After this, "hydraulic" effects cause tissue  
25G for 0.25 second ) rupture.  
50G is about the limit for head injuries.  
1,000G for 1,000th of a second is about the absolute limit.

Peter Jowitt, the RAC MSA Chief Scrutineer, has analysed many accidents in Formula 1 Motor Racing and has produced a graph (see Ref 2) to predict the outcome of any accident involving barrier contact. There is a relatively narrow area of unpredictability between the totally safe and certainly fatal situations. Basically a barrier contact, at an angle of less than 20 degrees and at less than 120 mph, should lead to healthy survival. This is a fact to be borne in mind by all those responsible for the siting of Amco and speed reducing catch-fencing.

Peter Jowitt in his analysis of Formula 1 accidents (see Ref 3) came to the conclusion that the safest place to have an accident was in the driving seat of a modern Formula 1 car which seldom turns over and where the close fitting cockpit provides useful restraint for the arms and legs. It is the marginal case which goes to prove the rule. At Long Beach the brake pedal of Clay Regazzoni's Ensign broke at the end of a fast straight. Clay took to the escape road but was projected into the air by a Brabham which had been abandoned there earlier and after ploughing through a tyre wall came to rest against a four ton concrete block which was moved about 5 feet. Clay survived but with spinal injuries. A car in the air does not decelerate and his final impact speed was probably around 130 mph.

Nearer/

Nearer home, whilst attempting to qualify for the 1979 British Grand Prix, David Purley went head-on into the sleepers at Becketts Corner at a speed in the region of 115 mph. The monocoque was reduced in length to little more than that of the DFV engine. David's survival was purely due to the determination of the medical and first-aid services on the spot and to his own spirit. The deformed monocoque is on display in the Donington Museum.

Catch-fencing has been valuable in slowing cars and reducing speed gradually before the final impact. At Hockenheim catch-fencing was erected in error parallel to the track and Mark Donoghue was hit on the head by a catch-fence pole. This damaged his crash helmet and produced a fracture of the skull. Although the driver appeared to have escaped major injury, after the accident he developed an increasing headache, became unconscious and died in a few hours due to intra-cranial haemorrhage. I believe no seemingly uninjured driver should be allowed to leave a circuit soon after an accident and should be instructed to report to the medical officer before departing.

The modern five or six point harness is more effective in retaining the driver within the car. It is designed to stretch without elastic recoil and in so doing increases the stopping distance of the driver, perhaps by a vital one or two inches. The mounting must be secure since loads on the belt are very high and a driver ejected from a vehicle has little chance of survival (ie Villeneuve). Jochen Rindt was reported not to have a six point harness at the time of his fatal accident but on that occasion the nose of his Lotus ran under the lower rail of a metal barrier which was mounted too high and the car was brought to rest by a supporting wooden post, impaling the driver on the steering column. Stapp showed that a shoulder harness was only useful up to about 17G whereas a full harness was valuable to about 35G.

In normal road driving the absence of side and rear under-run protection on commercial vehicles reduces the safety factor of a full harness and user compliance has made the inertia reel belt more or less universal. However it takes about 0.3 second and a stop of 0.3G to trigger the locking mechanism (see Ref 4) - a deceleration which may not be achieved on ice!

From the survival point of view there is nothing equal to the current monocoque type of construction. Space frames tend to buckle and trap the driver (ie Bill Stein at Brands Hatch) and they provide poor mounting points for roll-bars. Without a roll-bar, belts are worse than useless. In saloon car racing the Lotus, with the back-bone chassis, is perhaps the worst case. In this vehicle there is no protection against side impact. Cars which are made from GRP can prove surprisingly safe. These vehicles tend to disintegrate on impact and thus absorb much of the energy which might otherwise have gone to injure the driver. Injury to the driver seems to be increased if the vehicle bounces back and re-impacts (ie Stirling Moss at Goodwood).

Solid objects beside the track, particularly trees, produce high point loading and the outcome of any accident involving these is totally unpredictable. A well prepared rally car is undoubtedly a sturdy vehicle but the occupants do seem to have an exaggerated sense of their own immortality. The navigator should have grab-handles for stabilisation of his limbs in the event of an accident.

Fire/

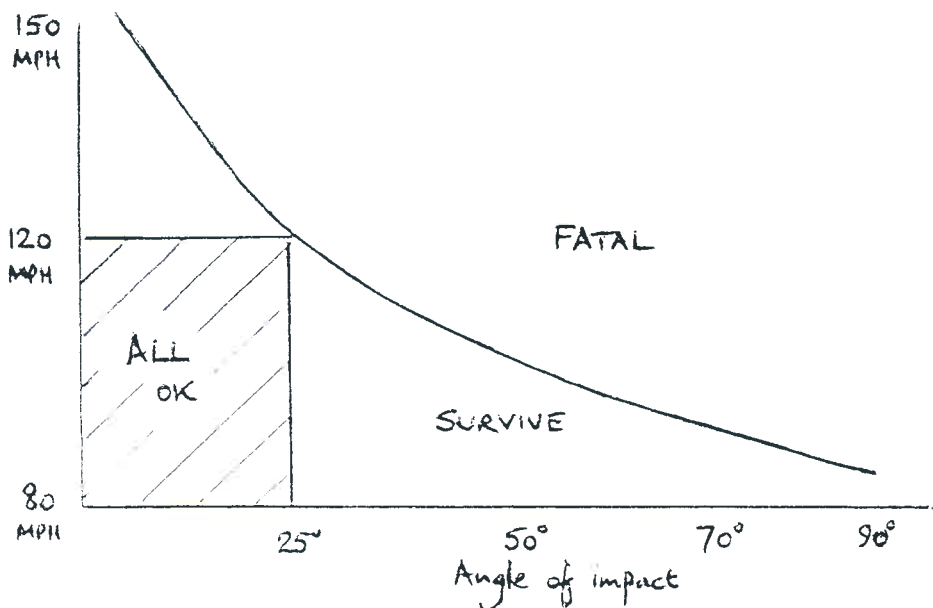
Fire is still the greatest cause of death in motor racing accidents and regulations require that seepage of fuel after an accident is at a minimum (ie bag tanks in an adequate enclosure go a long way to the control of fuel fires). The use of self-sealing couplings in fuel lines has proved of value (ie John Watson at Monza). Ignition and fuel pump cut-outs are also mandatory and automatic fire extinguishers can serve a useful purpose. In circuit racing in particular, a supply of medical air within the helmet is essential to give the marshals the vital 30 seconds to reach the scene with their extinguishers. Oxygen should not however be used - this turns body hair into gun cotton. In a sheltered location a vehicle surrounded by burning fuel is in a zone of intense heat and little oxygen. Such a fire must be swept up from the periphery if it is to be killed quickly and permanently. Despite all temptations to the contrary the RAC MSA recommended fire drill is the most efficient.

Components made from magnesium alloy should be at least 3mm thick, otherwise the fire risk is greatly increased and titanium should never be used for suspension parts since the very hot spark produced by titanium rubbing along the track is sufficient to ignite even frozen paraffin.

References

1. Stapp P. Human Tolerance to Deceleration. Jour. Aviation MED 1951.

2.



After Jowitt.

3. Jowitt P. RAC/ACU Motor Sports Training Trust Symposium 1981.

4. Neilson I D. Transport and Road Research Lab. Report TL32