FIA
CSI

CONSIDERATIONS ON CIRCUIT DESIGN AND SAFETY IN MOTORING SPORT

SURVEY MADE BY THE SUB-COMMISSION OF CIRCUITS AND SAFETY

CONSIDERATIONS SUR LA CONCEPTION DES CIRCUITS ET LA SECURITE EN SPORT AUTOMOBILE

ETUDE PREPAREE PAR LA SOUS-COMMISSION DES CIRCUITS ET DE LA SECURITE

"Motoring sport is dangerous" says a sign at the entrance of every racing circuit in the country which is generally considered as the "paradise" of automobile competition.

Indeed danger can never be completely eliminated from this sport but it should nevertheless be considered the duty of everyone participating in any manner in automobile sporting events or their organization to reduce the risks of accidents to an absolute minimum.

The FIA has been well aware of this and, as early as in 1958, set up a special Commission for Circuit Inspection. During the last few years it was felt, however, that the working field of this Sub-Commission was too limited and it was decided to entrust the Sub-Commission with a survey on all the aspects of both circuit design and general safety in motoring sport, with the intention to compile the conclusions of this study in a document which would be a guide-line for anyone directly or indirectly concerned with safety.

Although far from completed, the conclusions of this survey up to now are already very important in the field of circuit design, fire-prevention, practical organization of sporting events, etc, etc, and it was thus considered essential to publish whatever information is available at the moment.

It was found that sometimes the conclusions were in contradiction with the established practices and rules of the FIA, a problem which is at present being thoroughly examined within the FIA. Consequently, except when a specific rule already enforced by the CSI and indicated as such is concerned the findings of this study have a purely advisory character.

The four most important fields which can be distinguished are:

I—Circuit design and installations,
II—Car manufacturing and car preparation,
III—Preventive safety measures for drivers,
IV—Organization of sporting events: —regulations
—communications and services

I—CIRCUIT DESIGN AND CIRCUIT INSTALLATIONS

The space available in this Year Book does not permit us to include in full the findings of the Sub-Commission on this subject. The complete text of this chapter, which can be obtained from the FIA Secretariat (see order-card) gives considerations on general circuit design, circuit installations such as the pits, and measures for driver and spectator safety which can be found on a modern racing circuit.

II—CAR MANUFACTURING AND CAR PREPARATION

Appendix "J" has cast its shadow on all discussions concerning this problem, to such an extent that even a clear line had to be drawn between safety considerations which affected the fundamentals of Appendix "J" and vehicle design in general and those which would be applicable in conformity with the present Appendix, and even then it was found that sometimes an updating of these regulations would be necessary.

As far as the fundamentals of car design are concerned this problem proved so complex that the co-operation of the BPICA (Bureau Permanent International des Constructeurs Automobiles) was sought and their study is actively being pursued.

Although Appendix "J" already contains a certain number of safety rules and recommendations it is generally found that up to now the voluntary fitting of safety features as described in this chapter has been almost nil. To encourage the more widespread use of anti-fire and driver protection devices and designs, there seems no alternative but to make them mandatory or at least to remove the penalty of a performance disadvantage due to the voluntary provision of the appropriate design features and extra equipment. There will obviously be much difficulty and controversy in framing any legislation on the subject as the expense and complication of the equipment must be weighed against the possible gain in safety, bearing in mind that the danger is very largely to the driver himself who may feel entitled to take a calculated risk.

The Sub-Commission, while being perfectly aware of the fact that the considerations given hereafter concerning the improvement of the passive safety features of competition vehicles do not constitute mandatory rules, expresses the hope that they may be used as a guide-line for the discussions which will undoubtedly be engaged on this subject.

General remarks on car design

It being undeniably established that the percentage of fatal accidents involving drivers remaining in the driver-compartment of a vehicle during an accident is considerably less than those resulting in the ejection of the driver, the following may be remarked:

Closed cars are generally less prone to heavy damage of the cockpit area than open cars.

Construction-wise monocoque units are considered more resistant to accident damage than space-frame designs.

In all cases it is assumed that the driver wears a sufficiently strong safety-harness (see hereafter Chapter III).

Preventive safety measures

The following two main fields may be distinguished:

Preventive measures limiting damage to the driver-compartment in case of accident.

Preventive measures limiting fire-hazards.

The most effective means of achieving the strengthening of the driver-compartment and the protection of the driver in case of a turn-over is the mounting of a safety roll bar (or better: crash bar) in open cars and an elaborate coachwork strengthening roll-cage inside closed cars. Appendix "J" lays down minimum requirements which, if observed to the letter with the only intention of getting through scrutineering, are obviously inadequate.

Before going deeper into the details of crash-bar construction acknowledgement should be made to Mr Frank Costin, the Sports Car Club of America and NASCAR for having put their very complete information at the disposal of the Sub-Commission.

The following general design considerations are based on the SCCA rules, the specifications concerning open cars on Mr Frank Costin's proposal and the specifications concerning closed cars on NASCAR rules.

General design considerations on crash-bars or roll-cages

1 — The basic purpose of such devices is to protect the driver if the car turns over or is involved in a serious accident. This purpose should always be borne in mind.

2 — All junctions of tubes must be strengthened. This strengthening may be obtained for instance by using gusset plates of a length of 6 cm on each leg and 5 mm thickness.

3 — The basic crash-bar hoops and all braces may be seamless mild steel tubing, normally used for space-frame constructions. It must be noted that certain chromium alloys present difficulties in welding and in that case a normalizing of the structure would be advisable.

4 — When determining the size of tubing used, a basic distinction should be made between crash bars for open cars which have to absorb a direct shock and roll-cages which are primarily intended to strengthen the driver compartment, (see hereafter).

5 — If mounting plates are used, they should be of a sufficient thickness (eg 5 mm, as for the gussets).

6 — Whenever bolts and nuts are used, they should be of a sufficient minimum diameter, according to the number used. They should be of the highest possible quality (preferably aircraft). Square head bolts and nuts should not be used.

7 — One continuous length of tubing should be used for the main structure with smooth continuous bends and no evidence of crimping or wall failure.

8 — All welding should be of the highest possible quality with full penetration (preferably arc welding and in particular heliarc). Although good outside appearance of a weld does not necessarily guarantee its quality, poor looking welds are never a sign of good workmanship.

9 — Braces should preferably be of the same size tubing as used for the main structure.

10 — For space-frame constructions it is important that crash-bar structures are attached to cars in such a way as to spread the loads over a wide area. It is not sufficient to simply attach the roll-bar to a single tube or junction of tubes. The roll-bar should be designed in such a way as to be an extension of the frame itself, not simply an attachment to the frame.

Considerable care should be attached to the necessary strengthening of the basic structure, for instance by adding reinforcement bars or plates so as to properly distribute the loads.

11 — For monocoque constructions, consideration should be given to using a roll-bar hoop of 360 degrees completely around the inside of the car, and attached with suitable mounting plates. This type of roll-bar then becomes a substitute for the frame.

Open single- and two-seater vehicles

The British car designer Mr Frank Costin has developed certain very interesting ideas about crash-bars (or crash pylons as he calls them) for open single-seater racing cars, which could be easily adapted to open two-seater cars.

His ideas certainly deserve our attention, and taking into consideration the general remarks on construction mentioned hereabove it would certainly be possible to find an acceptable solution in practice.

1 — Assuming the weight of the car to be the starting line weight (with driver aboard), the crash-bar structure should be capable of withstanding three simultaneously applied loads: these to be:

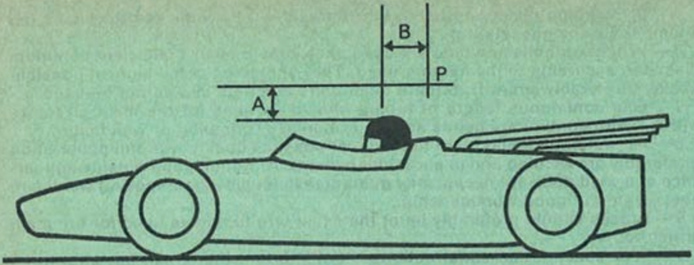
1.5 G lateral
3.5 G fore and aft
7.5 G vertical—the induced loads to be shown to carry over into the primary structure.

That the point of application "P" of these loads be a minimum of a=14 cm above the surface of the crash helmet when worn by the nominated driver of the vehicle at scrutineering, ie, designed for the size of the driver sitting at the wheel.

NB: Another method of measuring the overall height is given by the United States Auto Club: the minimum height is 36 inches (91 cm) measured on a line equivalent to the driver's spine from the metal seat to the top of the bar.

2 — That the distance measured horizontally "B" from the centre or apex of the helmet to the point of application of the load "P" be not greater than 30 cm (see drawing no 1). Alternatively, that it can be shown that any other part of the major structure "D" on the opposite side of the driver shall be at least c=11.5 cm clear of the surface of the crash helmet (see drawing no 2).

The most difficult point would obviously be the control of the load-resistance minima given. Mr Costin suggests that stress calculations should be submitted for each crash-bar type but it must be borne in mind that guide-lines for crash-bar construction are not only meant for the established racing car manufacturers



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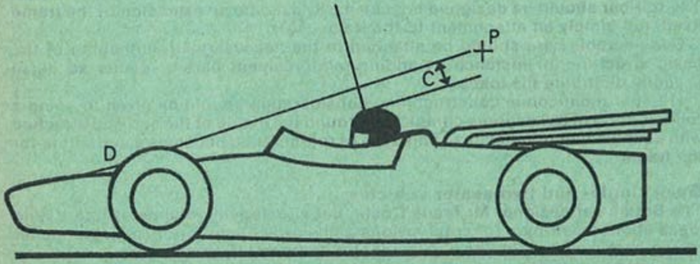

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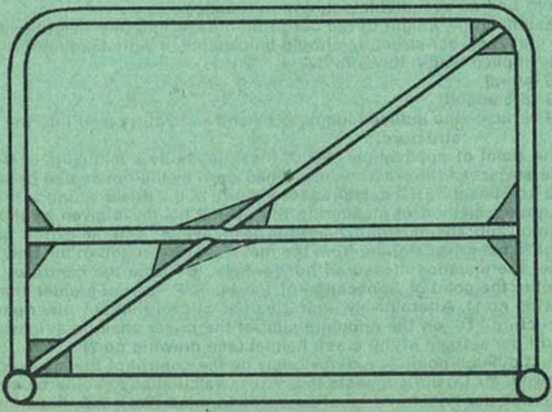


Dessin/drawing No. 3

but also for the amateur. However, empirically established tube sizes (based perhaps on the weight considerations given hereafter for closed vehicles) minimum curve radiuses and the following indications concerning minimum width may well be the solution.

For single-seater open cars the two vertical members forming the sides of the hoop shall be at least 38 cm apart (measured on the inside).

For two-seater open cars the two vertical members shall be at least 76 cm apart (inside dimension).

All roll-bars must be braced for fore-and-aft loads. If one brace is used, it should be attached within the top third of the hoop at an angle of not more than 60° to the horizontal. However, it is strongly recommended to use two braces whenever possible, parallel to the sides of the car and attached to the outer extremities of the hoop.

Braces should be to the rear whenever possible. It is recommended to increase the vertical load-resistance of a crash-bar by fitting a transverse brace from the bottom of the hoop on one side to the top of the hoop on the other side.

Roll-cages for closed cars

The roll-cage described hereafter has one inconvenience, ie, it conflicts with Appendix "J" regulations in so far that it hinders the normal access to seats. This problem is presently being studied by the FIA.

The main structure of the roll-cage consists of two transverse hoops, one behind and above the driver's head and the other supporting the front pillars of the windscreen.

They should preferably be mounted on a basic, large-bore, tube structure in U-form, the two legs of which point forwards around the outside of the seats.

Mounting plates used for fixing the base-structure or the hoops to the floor panel should distribute the load over the largest possible area. A back-up plate of equal size and thickness should be used on the opposite side of the panel with the plates through-bolted together.

Two horizontal connecting bars should link the two hoops at each side of the top. The rear hoop should have two transverse reinforcing bars as shown in drawing no 3 (on condition a U-form basic structure is used, if not an additional transverse connecting bar should be added at floor level.)

Furthermore, a diagonal longitudinal bar extending rearwards from the top of the rear-hoop under an angle of approximately 60° with the horizontal to the floor-panel (through the rear seat cushion, if necessary) should be added.

Tube sizes may be established as follows:

over 2,000 lb car weight, minimum 1¾ inch (4.5 cm) overall diameter with 0.120 inch (3 mm) wall thickness,

over 1,500 lb car weight, minimum 1½ inch (4 cm) overall diameter with 0.090 inch (2 mm) wall thickness,

over 1,000 lb car weight, minimum 1¼ inch (3 cm) overall diameter with 0.090 inch (2 mm) wall thickness,

under 1,000 lb car weight, minimum 1 inch (2.5 cm) overall diameter with 0.060 inch (1.5 mm) wall thickness.

NASCAR-type side bars could be added but would entirely forbid a normal access to the driver's seat and opinions on the absolute necessity of these bars for road-racing type circuits are divided.

With all crash-bars and roll-cages it is essential that a safety harness be worn (see hereafter Preventive measures for driver safety) and that the supports fixing the seat to the floor panel or even to the base structure of the roll-cage are strengthened.

Preventive measures limiting fire-hazards

Acknowledgements must go to the RAC for their very thorough study on this subject.

In the field of car manufacturing and preparation, consideration should be given first of all to the number of car design features and items of equipment which can play an important part in reducing the risk of fire occurring in racing cars. Such features can also reduce the risk of burns to the driver from fire which does break out.

There are two essential prerequisites for a fire-combustible material and a source of ignition.

The principal sources of combustible material to sustain fire in racing cars are the engine fuel, today almost universally petrol, lubricating oil, and, quite recently, magnesium alloy when used for car structures. In this respect it must be pointed out that magnesium if used in thin sheets is very easily inflammable indeed. Experience has taught that the more solid magnesium wheels will ignite in about 1 to 1½ minutes after being exposed to fire.

Petrol is usually the more serious danger, both from the aspect of quantity and speed at which the fire can initiate and develop.

The primary objective in the design of petrol and oil tanks and lines is to contain and convey these liquids in safety by preventing their exposure to sources of ignition. Whilst this objective is automatically met in any car of sound design and construction, there is often much scope for improvement in trying to reduce danger subsequent to crash damage.

There are several possible causes of ignition:

Electrical equipment. Whilst almost any electrical equipment, not necessarily faulty, can produce sparks well capable of igniting petrol vapour, the most serious danger is presented by batteries in conjunction with short-circuits developing in the wiring or being caused through crash damage.

Hot components. The temperature of components such as exhaust pipes is sufficient to cause the spontaneous ignition of lubricating oil and petrol. Perhaps paradoxically, petrol has the higher spontaneous ignition temperature and is, therefore, less likely to be ignited by hot surfaces but, of course, petrol has a relatively low flash point which means that it is comparatively easily ignited by a spark or flame.

Sparks. Apart from electrical equipment, sparks can arise from chassis and bodywork rubbing on the roadway, as may easily occur as a result of crashes and, though less likely, from serious mechanical failure.

Brakes. It has been known for petrol spilling on to disc brakes to ignite. Although the precise means of ignition is not clear, obviously brakes should be considered as potential source.

Fires in racing cars can obviously arise from a wide variety of causes but they can in general be sub-divided into two main types.

(a) **Crash fires,** which term covers fires resulting from damage sustained in crashes. Crash fires are the most common and are likely to be the most serious for the driver, particularly if fuel tanks or pressurised fuel lines are ruptured.

(b) **Engine fires,** which term covers fires breaking out in the engine compartment, usually due to leakage of oil or fuel, while the car is running.

Turning to specific precautions which can be employed to reduce danger from fire by way of equipment and design features on cars, the following are put forward as being the most worthy of consideration.

Use of magnesium parts for manifolds, etc, should be avoided.

It should always be borne in mind that a battery of twin-choke carburettors contains a sufficient amount of fuel to feed a fire in the engine compartment over a prolonged period. In this respect, indirect fuel injection represents several advantages, direct injection being the safest naturally.

A very serious fire hazard for a driver is that resulting from the crash rupture of a tank. This condition can be complicated by possible damage to the cockpit or injury hindering the escape or rescue of the driver.

The danger of tank rupture can be markedly reduced by the use of "bag" type fuel tanks in place of the more conventional metal tanks.

A bag tank consists of a flexible bladder constructed in nylon or dacron woven fabric impregnated and coated with a fuel-resistant elastomer. This bag is enclosed in a container of 20 gauge (0.5 mm) steel, 0.062 inch (1½ mm) aluminium or equivalent thickness fibreglass or plastic.

The improved safety comes from the sufficient strength of the reinforced bladder to resist puncture, while the flexibility and elasticity provides resistance to rupture under conditions of extreme deformation of the tank and its containing space. There is some divergence in British and US practice, the former relying more on flexibility and elasticity while the latter favours tougher but less flexible bladders. Additionally, the bladders may be filled with a sponge-like foam material which has advantages in respect of suppressing fuel surge, acting as a flame trap, so preventing any possibility of tank explosions, and maintaining tank shape as it is emptied. Foam does have the disadvantage of reducing effective capacity by about 3 to 5%. but some of the newly developed foams (Goodyear and Firestone Companies in particular) appear to significantly reduce sudden splash effects in the event of rupture.

The mere use of bag tanks is a valuable contribution to safety but they can only be of maximum benefit if installed in the car to the best advantage.

NB: As an indication, the USAC specifications concerning bladder-type tanks are given hereafter:

All fuel tanks must have inserts conforming to the following specifications:

1 — The insert must have at least a one ply inner liner and a one ply outer liner of Nylon or Dacron fabric, coated with a nitrile type of fuel resistant elastomer.

2 — A lap of at least ¾ inch shall be used in all seams and splices.

3 — The inner liner must be nitrile type of fuel resistant elastomer with physical properties as follows:

Tensile	Warp	400 pounds minimum
	Fill	400 pounds minimum
Tear	Warp	25 pounds minimum
	Fill	25 pounds minimum
Puncture	Warp	25 pounds minimum
	Fill	25 pounds minimum

4 — All fittings must be built into the insert and cured under pressure making them an integral part when vulcanized.

5 — All metal insert fittings must be of the single flange fabric and nitrile moulded type using aluminium castings with cast-in nuts or studs, or plate aluminium with pressed in steel inserts. The gasket surface shall be fabric and nitrile moulded integral with the total product, or a metal face fabric flange used with a bulkhead fitting and sealed with a rubber "O" ring.

6 — All nipple fittings shall be of a moulded type with the hose clamp area fabrics wrapped to resist cold flow of rubber when under clamp pressure.

Preventing spillage

There are some obvious possible precautions which can be taken in the mounting of all fuel tanks, such as providing liquid-tight barriers between tanks and the cockpit, avoiding tank locations where they are unduly exposed to possible crash damage and avoiding the location of suspension arms in a position where abnormal thrust causing mechanical failures, eg, from the crash impact on a road wheel, may cause a tank puncture.

Fuel tank fillers should be liquid tight under all foreseeable conditions such as fuel surge within the tank and should be of a design providing a positive locking action which will both minimise their accidental opening, even as a result of crash damage, and possibility of human error in ensuring their proper fastening, even under conditions of a hurried pit stop.

Secondly fillers should be sited away from regions of the car which are vulnerable to crash damage and the connecting pipes to the tank should be able to cater for deformation in the event of crash damage in order to minimise the chances of rupture. Many touring cars with an exposed filler at the rear connected by relatively rigid pipes to the tank are bad examples. Connecting pipes to the tank affording flexibility are desirable or, better still, the fuel filler can be protected by resiting within the luggage space. In Formula cars, fuel fillers must mandatorily not protrude beyond bodywork and this should clearly only be considered as a minimum standard of protection.

As a fuel tank is emptied, air is normally drawn in to occupy the ullage space together with fuel vapour. This fuel-air mixture will be near saturated with fuel vapour and consequently outside the limits of explosivity on the rich side. Dilution with extra air will be necessary for combustion to occur and, of course, the necessary degree of dilution could be provided in the event of a tank rupture so producing a quantity of readily ignitable fuel-air mixture.

As a consequence, obviously desirable design features of fuel systems are that all components should be positioned or routed to minimise risk of crash damage and should be positioned or shielded to reduce any leakage into the cockpit or on to the driver. Such precautions are all the more important in the case of pressurised fuel lines. There have been several fires which have been more serious and prolonged due to fuel escaping under pressure to feed the fire. Also, in the event of even a slight fire, plastic fuel lines can readily suffer damage so possibly increasing the size of the fire. Therefore armoured linings (aircraft-type) should preferably be used.

Protecting fuel lines and electrical wiring

It follows that fuel lines, particularly those which are pressurised, should be routed outside the cockpit or encased through the cockpit in metal ducts. Lines and fuel pumps should be positioned so as to be relatively protected from crash damage and vents and overflows should be positioned to ensure any escaping fuel falls clear of the car and well away from potential sources of ignition such as electrical equipment and exhaust pipes.

As short circuits, which can readily be caused by crash damage, are a major source of ignition to start a fire, electrical systems should be designed so as to avoid wiring and components being unnecessarily exposed to possible crash damage. Again electrical equipment should be sited, as far as practical, away from fuel system components where leakage might easily occur in the event of damage.

Circuit-breakers

It being already mandatory to fit a general electric circuit-breaker (Appendix "J", Art. 253) or even two in the case of closed cars, which are meant to cut off the ignition system, the pumps or indeed to isolate the battery, one step further would be the adoption of automatically operated switches.

Highly developed switches are available from the aircraft industry. They operate under inertia or "g" from crash impact and have proved to be very effective.

Fire-extinguishers

Another important preventive measure is the carrying on board of a light but effective fire-extinguisher (BCF, BTM, carbon dioxide or dry-powder) of at least 1 kg. Better still would be an automatically operated fire-extinguishing system, triggered off by fire detectors and capable of simultaneous action at various places.

Several types of fire-detectors are known:

1 — Firewire and pyrotechnic cord sensing systems.*

The firewire sensing element is a stainless steel capillary tube of any desired length, with a central co-axial electrode separated from the capillary wall by a filling material which conducts electricity with great ease when overheated. Such heating along any part of the tube completes an electric circuit and initiates a warning and/or automatic fire-extinguishing system as required.

The pyrotechnic cord detector system consists of a capillary tube, filled by a wick impregnated with black powder and nitrocellulose. When any part of this tube is heated to over 250°C the mixture "fires" and a gas wave passes back along the tube to a plunger which, as it is shot home, operates electrical contacts.

2 — Optical sensing devices calibrated to operate when exposed to the infra-red radiation of a flame.

A detector model of this type known at present is about 1½ inch long by 1 inch diameter and weighs approximately 350 grams. The working angle of such detectors is usually 120° (three-dimensional).**

As far as automatic fire-extinguishing systems are concerned it must be noted that up to now BCF and dry-powder type extinguishers have to be in a certain position or will not work. In accidents involving overturning, this may be a serious disadvantage.

From the great amount of experience in aviation with the problem of engine fires, it is evident that the most successful way of dealing with engine fires is by cowling, thus confining the fire and protecting the driver from flames possibly eddying into the cockpit or on to the driver while the car is moving. Complete bodywork around the engine is, therefore, highly desirable, with air intakes and vents suitably sited or fitted with flame traps.

Only under these conditions can an automatic fire-extinguishing system be of sufficient effect, especially in a rapidly moving car.

III—PREVENTIVE SAFETY MEASURES FOR DRIVERS

The field of safety measures and devices which are the direct responsibility of the driver himself is a difficult one for, to repeat what has been said before, in a slightly different manner: to what extent can the international motor sport governing body compel the drivers to protect themselves?

Although it is envisaged that in the near future certain equipment additional to crash helmets will be made mandatory, the entire responsibility will always befall the driver himself.

As before, safety equipment can be divided into two basic fields:

that equipment intended to limit injuries due to crash impacts;

equipment intended to limit or delay injuries due to fire.

Helmets. Crash helmets are intended to limit skull injuries and to dampen abrupt shocks due to crash impacts.

They are always a compromise between lightness, which will limit the loading on the vertebrae when the head plus helmet are violently thrown forward (supposing the body is restrained by a safety harness), and shock absorption capacity, which will tend to make them heavier and bulkier.

Throughout the world, crash helmets are subjected to tests by the various laboratories or foundations and according to the different national standards. The standards of the following laboratories are considered to come the closest to the special requirements of automobile racing:

British Standards Institution (GB)
Snell Foundation (USA)
Standards Association of Australia (AUS)
Swedish Standards Commission (S)

**Supplied by Graviner (Colnbrook) Ltd., Poyle Mill Works, Colnbrook, Slough, Bucks, England.*
***Supplied by Pyrotector Inc, 349 Lincoln Street, Hingham, Mass, USA.*

Moreover, there are a number of general considerations which should not be forgotten:

(a) the outer shell of the crash helmet should not be of metal or compressed paper and should be completely smooth and free from unnecessary projections (visors should therefore be designed to fly off even at very slight shocks),

(b) the helmet should cover the largest possible area, ie, the temples, around the ears, the lower back of the head. Spinal injuries, sometimes feared to be caused by the lower edge of the helmet, have in practice occurred very rarely and are virtually non-existent when a fully reclining driving position is adopted or when a suitable head-rest is available (even non-padded),

(c) the suspensory harness or compressible lining material carrying the helmet should be a proper fit or else loads will not be adequately distributed,

(d) the straps should be of the highest possible quality. A chin cup is preferable as it locks the helmet very efficiently on the head. Means of adjustment and buckles should be simple.

Goggles and visors. Goggles should always have shatterproof distortion-free lenses and their frames should be soft.

Safety-harnesses and their fitting. The cause of the safety-harness needs no more pleading, whether it concerns closed or open cars. Those drivers who prefer not to wear it should not even worry about crash-bars and roll-cages which become completely useless if the driver is not tightly held in his seat during crash impact.

Before going deeper into this subject, special acknowledgement should be made to Dr Michael Henderson and the United States Auto Club for their extensive survey on this problem and for having authorized the FIA to use their material.

A safety-harness is intended to keep the driver tightly in his seat and its form and attachment points thus depend on the reclining position of this seat.

(a) If the spinal axis of the driver forms an angle of approximately 60° to 80° with the horizontal (see drawing no 4) a combination of seat-belt and double over-the-shoulder harness should be used, with one quick-release metal-to-metal mechanism forming a single release point for the entire restraint system.

The seat-belt should be worn in such a manner that it passes round the pelvic area at a point below the anterior superior iliac spines. Under no conditions should it be worn over the area of the intestines and abdomen.

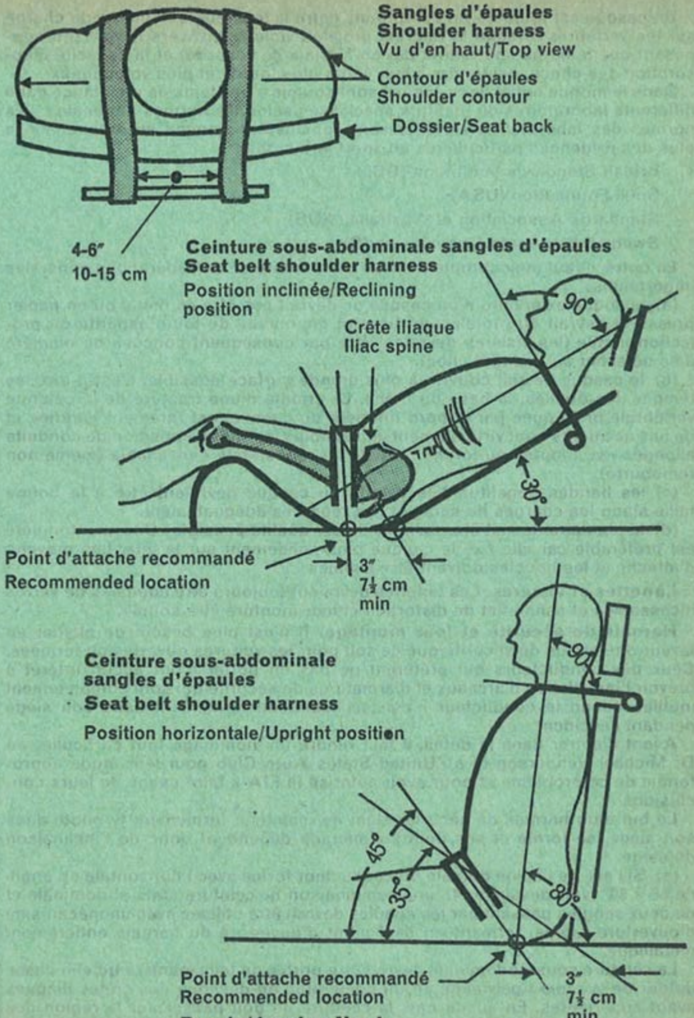
The seat-belts, while of the smallest possible length, should not pass over the sides of the seat, but should, if possible, pass through the sides of the seat in order to wrap and hold the pelvic area over the greatest possible surface. Care must be taken that the belts cannot be damaged through chafing against metal edges.

(b) If the spinal axis of the driver forms an angle of approximately 30° with the horizontal, the problem of the driver sliding forwards during a crash impact makes the problem more complex and the combination of a seat-belt-shoulder-harness, although effective, is not considered as perfect.

In addition to this restraint system, fitted as indicated on drawing no 4, a crutch restraint system should be added. The best type of crutch restraint is a double strap arrangement, curling round each hip like a parachute harness. These straps which wind away down between the legs bear on the strong pubic bones and *not* on the genital organs (see drawing no 5).

They do not cause any pain or discomfort, Dr Henderson says, as, after all, parachutists take up to 20 "g" through these straps alone when their parachute opens.

The only inconvenience at present with crutch restraint systems is that it is very difficult to find a means of simultaneously releasing all straps of the harness.



Dessin/drawing No. 4

Until the rather expensive aircraft type release buckles become more reasonable in price, two releasing systems should be accepted.

General remarks

Two shoulder belts joining in a Y form, behind the neck, so as to form one strap, should not be used.

Minimum width of the straps should be 2 inches (5 cm). Ideally, however, the lap straps should be 3 inches wide (7.5 cm). Minimum thickness of the webbing should be ⅛ inch.

Adjustment arrangements should be provided for in both shoulder straps and the lap strap (always tighten lap strap first!).

The harness should be worn as tight as comfort allows.

Mounting points should be reinforced with the same care as for roll-cages and crash-bars. It is very difficult to give precise guidance on this subject but if we consider a harness fixed at 4 points (of which, however, in case of extremely reclining seats almost all the load may well be exercised on only two points), each point should be capable of sustaining around 2,000 pounds without breaking away.

Fire protective clothes

Contrary to belief, the presently known clothing used for race-overalls does burn away in fire. In fact, when exposed to open fire, it only gives the driver, if conscious, a couple of seconds to escape the fire. It follows that a single layer of fire-protective fabric on the naked skin (even "Nomex", the "miracle" fabric) is totally insufficient. There should be two layers of cloth at least over any part of the body. If this principle is followed, care should be taken to cover the whole body from neck to the ankles and wrists.

Leather shoes and woollen or other fire-resistant material socks should be worn.

Gloves may be of leather or fire-resistant material and should extend well over the wrist.

Face-shields (again a double-layer!) are considered effective.

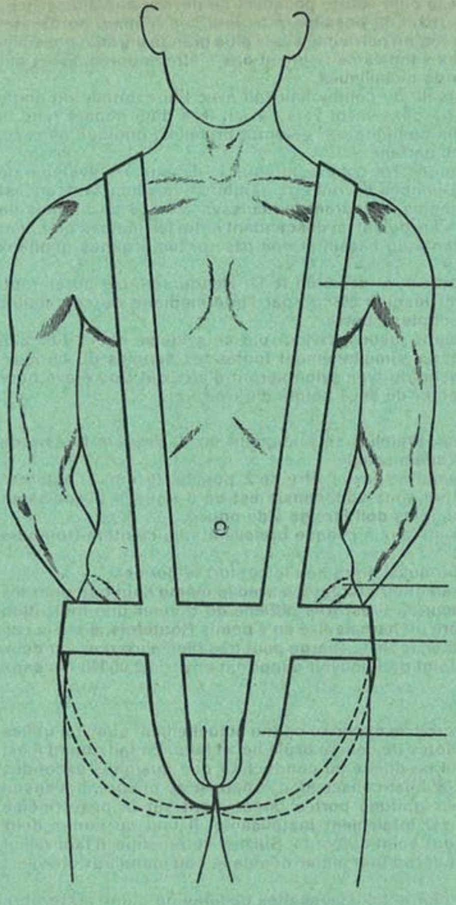
Nylon is certainly not fire-resistant and tends to form hot droplets which can severely burn the skin.

Recently, a type of clothing, normally used by firemen (aluminised asbestos) has been tried out for race-overalls. Apart from its relative heaviness and stiffness, it is considered that its complete impermeability to heat and water can cause serious physical troubles.

The considerations mentioned in this chapter on safety equipment for drivers had to remain practical. Anybody who wishes to be informed on the physical aspects of motor racing should read the excellent, analytic book of Dr Michael Henderson, "Motor Racing in Safety", published by Patrick Stephens Limited, 9 Ely Place, London EC1, price 36s.

IV—ORGANIZATION OF SPORTING EVENTS

For the same reasons as indicated in chapter I, the complete text concerning this subject could not be included in the Sporting Year Book. Again it may be obtained on request from the FIA Secretariat (see enclosed order card).



Dessin/drawing No. 5

Harnais de sécurité pour maintien complet en position de conduite très inclinée.
Safety harness for full restraint in an extremely reclining position.