Mechanicals

Experiences in Building a Strong Vintage Race Engine

(a.k.a. "Masochism is My Middle Name")

Fred Crowley (Team Healey Texas), North Texas AHC

In developing a vintage racer from my basically street-stock Healey, I started to construct lists to keep track of all the "umpteen" little things I needed to do. Over a period of several years, I constructed a number of lists because I kept forgetting to make note on my latest list where I had left my previous lists. To compensate, I started to develop lists which were a continuation of previous lists. This was getting almost as complicated as trying to do the work in the first place. As a result, whenever I was asked about specifics of any modifications, the responses were not always guaranteed to be consistent. This was a bit frustrating to me as I've always prided myself on having a mind just like a steel trap. Of course, as Jeanice so adroitly stated "Just how good a memory did I think a steel trap had?"

Here's a list of modifications and things to look out for in putting together a pretty good competition engine for the Big Healey. This list is not intended to be comprehensive and of course assumes that if you're weird enough to attempt a rebuild such as this in the first place, you're weird enough to accept whatever consequences may result.

ENGINE/DRIVETRAIN

The base engine (a 2912 cc engine with stock crank, standard bore, stock rods, cam, etc.) was already in pretty decent shape. My fundamental objective was to direct efforts (and limited $$) towards more power while retaining reliability. As with most Healey people, the original objective faded into a distant memory, and the resulting engine digested considerably more $$, but also put forth considerably more grunt than I had planned on. While I haven't put the engine on a dynamometer, the basic specs. I ended up with were....

11:1 compression ratio, bored + 30 thou, crank turned 10 thou, stage 2 cam, 11 pound aluminum flywheel, triple DCOE40 Webers, headers, extensive headwork (combustion chamber, intake and exhaust ports, valves and springs, etc.) on a flow bench.

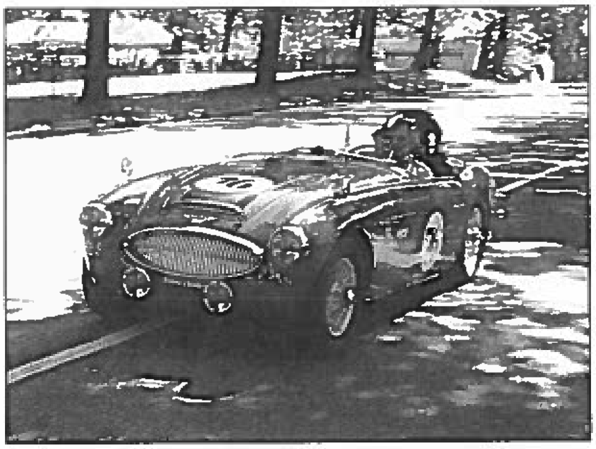
Some of the specifics....

Ignition

I kept the stock configuration, but rebuilt the distributor, and used a hotter coil. Timing seems to work pretty good at about 34 degrees.

Installing copper core plug wires helps to ensure a good spark. After having incorrectly reinstalled plug wires when I've been checking out mixtures, etc. between races, I use plastic wire wraps (the number of individual wraps per wire corresponding to the cylinder) to ID which wire goes to which plug (1 wrap — plug 1, 2 wraps — plug 2, etc.).

... if you're weird enough to attempt a rebuild such as this (competition engine) in the first place, you're weird enough to accept whatever consequences may result.



Exhaust Pipes

A key criteria was that the car had to sound good. By pure coincidence, it was possible to accomplish this while also dramatically improving the breathing of the engine. Denis Welch manufactures a set of headers for the Big Healeys which works great. Additionally, I was fortunate to have a local race car exhaust wizard available who suggested that the collector pipe be disassembled and smooth out the flow a bit more. Also, on my Healey, the rear header collector pipe had to be modified to clear the left front frame outrigger.

This same guy then made a set of 2" pipes which followed the original routing to the back of the car. This was a work of art in that all the pipes were mandrel bent, with pipes connected together using tabs similar to techniques used in the aircraft industry (as opposed to being welded). Two approaches to routing of the pipes are to first route the pipes out just in front of the left-rear wheel. This seems to have a positive impact on power at the higher rev. ranges (eg: > 5500), while running the pipes on the original route out to the back helps the torque at lower-end revs. (eg: 2500-3000). I opted for this latter approach, which seems to work very well in those corners where the stock gearing seems to invariably leave me stranded. Of course having more torque available at the low-end of the rev. range is a benefit in gymkhanas (another benefit as opposed to the side exhaust, is that I've seen the side exhaust literally blow a gymkhana cone over — a tough way to lose 2 seconds)

This exhaust system has really helped performance, and the Healey sure sounds good. I also noted that the guy who did the work sported a great tan a few weeks later, and he commented that he enjoyed his trip to the Caribbean — thank you very much!

Oil Pan

The oil pan on my Healey (as with most Healeys) looked like it had been worked on with a sledge hammer. Fortunately it's made of pressed steel and it's not too hard to hammer out the dents. Doing this then allows you the opportunity to freshen up your welding techniques to repair all the blasted little pin holes and tears from hammering out the dents. Ahh well, no one said life would be easy.

While I had the pan out, I welded in an oil surge plate to fit around the oil pump (to keep the oil from moving away from the oil pump under hard braking/cornering).

Since I was also going to use an oil temperature gauge, I mounted the oil temperature gauge fitting on the right side of the pan making sure it cleared the internal oil surge plate.

Most sanctioning bodies require that all drain plugs be safety-wired (some groups will accept an index mark to easily identify whether the plug has loosened — check it out).

Oil Breather Catch Tank

All fluids must have a catch tank (generally at least one quart). I already had one mounted for the radiator (this is a good idea even for street use — especially in hot weather, as the overflow when you switch off will eventually lower your radiator level, obviously contributing to overheating). Units for the radiator are available from almost any auto parts house, and most folks mount the catch bottle on the right side of the engine compartment, just in front of the passenger foot-well bulkhead.

To handle the crankcase ventilation, I mounted a high temperature plastic catch bottle under the right front fender frame brace.

I used copper tubing from the side access panel on the block to the T-vent fitting on the valve cover (motivated by that priceless piece of advice — "if you're not the fastest at least look good!").

The 6-cylinder Healeys don't like to have any positive crankcase pressure (one of the key contributors to oil leaks) and the stock ventilation is pretty marginal. Therefore it's a good idea to add another crankcase vent tube to relieve the internal pressure . A second side access plate (just like the rear access plate), replacing the centre lifter access plate, connected to a second T-fitting on the valve cover does the trick. However, be careful before you drill into the valve cover to make sure you know where and how to attach the second T-fitting. First, you don't want it to interfere with the valve train, and secondly, you don't want the inside nut to fall off and bounce around amongst all the expensive valve springs, valves, etc.

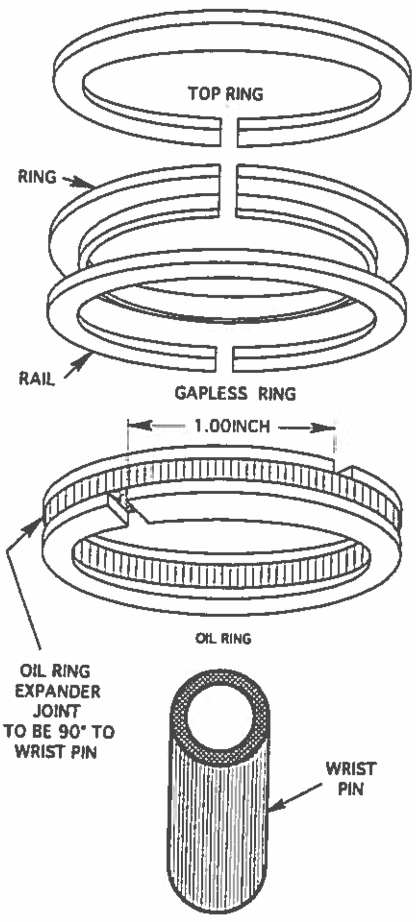
Engine Internal

There is a phenomenal amount of work that can be done to the engine (most is associated with the head), and all of it costing a fair chunk of change.

Unless the engine has recently been rebored, it is usually worthwhile to bore it out to +30 thou. It is strongly recommended that you order the pistons before boring the block. That way the machinist can accurately set the clearances. The block can be re-sleeved and re-bored. My block had been re-sleeved some time in the distant past and was a stock bore. We just re-bored it + 30 thou.

If the compression ratio is to be changed, then you should plan on doing combustion chamber work at the same time. The compression ratio is generally changed using domed pistons. Shaving the head is fine for up to about a ½ point increase. When ordering the pistons, the manufacturer will want to know the details as to the car's engine, bore size, combustion chamber size, and planned compression ratio. I planned on a 55 cc combustion chamber with a 10.5:1 compression ratio. To determine the combustion chamber size, we first determined what we had to start with (59/60 ccs). We figured on skimming the head and block to give a flat surface, coupled with fixing up the chamber and thus concluded that 55 cc was a reasonable target to work for. I ordered my pistons from Venolia giving them these specs. and had the pistons in a couple of weeks. The final result with all the head work completed, valves installed, etc. was measured at 10.8:1.

"Total Seal"® Rings
(placement on piston)



When going to a higher compression ratio on the Big Healey block, we found that it is absolutely essential to have as smooth a finish as possible on the block and head surfaces. Be careful here. Many engine rebuilders don't have the equipment to handle a block as long as the Healey's and the result often is not perfectly flat. Their equipment may work fine with a good ol' Chevy 350 block, but you'll have major headaches to get a Healey head gasket to seal properly, if things aren't perfectly flat and smooth. Pay attention to this and save yourself a lot of grief! I used the stock copper sandwich head gasket with no leakage problems after a year of racing.

I used the stock connecting rods, but had them magnafluxed, cleaned up, polished and balanced. If you've got the $$ go with Carillo rods.

The crank was magnafluxed, shot-peened, which required it to be turned 10 thou., (anymore and you might want to consider getting an unturned replacement), and then balanced.

While everything is out, it's always a good idea to check the line bore. Line boring ensures that the crankshaft sets perfectly square in every bearing support. Two key specs. that are not easily obtainable for line boring are:

Main bearing housing bore: 2.521"-2.5215"

Rod housing bore: 2.114"-2.1145"

These specs are the bores without the bearings installed, and should be considered in conjunction with the final journal diameter of the crank, and the bearing thickness to give the desired clearances.

Obviously all the main and con rod bearings were replaced. Every time you take the oil pan off it's not a bad idea to check the bearings (plastigauge is real cheap and it's simple to use — check the clearances!). Use lots of assembly lube on the bearings — it's cheap!

I was dissatisfied with the stock oil pump, especially at higher revs, so I installed a high-volume oil pump from Denis Welch — oil pressure is now 55-65# hot — approx. 35-40# at idle. A caution: With this oil pump, watch your oil pressure like a hawk — especially when the oil is cold. It is real easy to exceed the pressure relief valve's capability and thus drive the pressure to 80+ pounds. This can mess up your timing chain tensioner, as well as any other oil seals and lines. Once the oil is warmed up, the problem of course disappears.

It's also a good idea to replace all flexible oil lines with steel braided lines. Check out any hydraulic/automotive/aircraft hose supplier, or you can make your own (eg: using Aeroquip lines and fittings). Some fittings on the Healeys are metric, so you may want to double check to make sure that the right fittings have been supplied prior to tightening things up a few notches because it "doesn't feel right!"

I used a "Stage 2" cam to give me a broader rev. range. (I planned on using a 5500 rev limit to help on reliability). The cam specs selected were:

	open	**close**	**lift**
Intake	29 BTDC	63 ABDC	.414"
Exhaust	63 BTDC	27 ABDC	.414"

with a duration of 270 degrees.

An interesting(!) point came to light prior to installing the cam. I wanted to verify the actual cam numbers rather than taking the cam grinder at his word, so I had the cam checked elsewhere. We found out that there was a variance of +/- 6 degrees on each cam lobe (specs call for approx. several tenths of a degree variance!). The original grinder expressed surprise and offered several reasons/excuses and provided a replacement (which did meet spec). I prefer to find out these things while the engine is apart rather than on the track.

The number one most important engine building tip... **CHECK EVERY COMPONENT OF THE ENGINE AGAINST ITS SPECS. GO HAVE A CUP OF COFFEE AND RECHECK AGAIN BEFORE INSTALLATION!**

I used "Total Seal" rings for the pistons. These are "gapless" rings which substantially reduce blowby and give much better leakdown numbers. They are considerably more expensive than standard iron rings, but seal extremely well. Before ordering rings, check the bore diameter, and the ring groove thickness in your pistons carefully. Typically there are two groove thicknesses that are used for the top rings — either 1/16" (1.6mm) or 1.5mm. The oil ring is typically 5/32" (4mm). Check carefully which size of grooves are used in your pistons to give a ring side clearance of 2-4 thou. When the rings are being installed, the rings need to be filed to give a ring gap in the top ring of 10-12 thou. and ring gaps in the bottom 2 rings of approx. 10 thou. The stock spec is 13-18 thou., but we have found this to be too much. With these rings installed, and after 6 races, the compression ranges between 190 and 200 for all cylinders.

I ordered a set of "competition" valves domestically, and they were junk! I subsequently ordered a set of valves and springs from Denis Welch, and they were beautiful — a work of art! When installing the valves, shim the valve springs to equalize the valve head pressure. If you haven't already done so, I highly recommend installing hardened valve seats, and of course bronze valve guides.

The freeze plugs are like a ticking time bomb in most Healey engines. They may appear okay, but most have almost rusted through, and generally will let go when you least prefer them to. Change them out whenever you can — they're not expensive. Using a 160 degree thermostat after doing the above completely solved any overheating problems.

Engine Mounts

The poor engine mounts suffer from a lot of stress in trying to cope with the weight and torque of that hunk of cast iron. It's not uncommon to see the frame cracked around the mounts.

If the frame is cracked, re-weld and gusset the mounts (it's virtually impossible to do this with the engine in place). Replace the front engine mounts, as well as the transmission mounts — they aren't that expensive, and you'll eliminate the worry of having the engine fall out of the car.

(To be continued next month.)

About the author: Fred Crowley has been vice president of racing for the AHCA over the past two years. He is also chairman of the Corinthian Racing Group as well as successfully campaigning his Healey 3000.

Mechanicals

Experiences in Building a Strong Vintage Race Engine – Part II

(a.k.a. "Masochism is My Middle Name")

Fred Crowley (Team Healey Texas), North Texas AHC

This article is continued from Part 1, which began in the last issue of CHATTER. *The listing highlights modifications and things to look out for in putting together a pretty good competition engine for the Big Healey. This list is not intended to be comprehensive and of course assumes that if you're weird enough to attempt a rebuild such as this in the first place, you're weird enough to accept whatever consequences may result.*

Transmission/Overdrive

Nothing beats a light flywheel to help the engine spin up real quick. The stock flywheel is real heavy, and all that weight is not really necessary. The flywheel can be turned down to reduce weight (this is a pretty common procedure), or you can go the ultimate route and use an aluminum one.

I installed an aluminum flywheel (weighs approx. 11# — has a bronze clutch plate facing, and steel ring gear pinned to the flywheel). A basic problem with an aluminum flywheel is in the mounting of the ring gear. Being of dissimilar metals, the ring gear, while heat shrunk onto the flywheel, needs to also be pinned. The problem is that if care is not taken when drilling the holes for the pin, the drill bit will tend to wander over to the softer metal of the flywheel. When the pin is inserted, it really is not forming an effective lock between the ring gear and flywheel. I had some big problems with the pins working their way out on my system, subsequently allowing the ring gear to turn on the flywheel when the starter was engaged (the point was also not lost on me when someone noted that there's nothing like having a loose ring gear whirring around at 5500 rpm and 12" from extremely important anatomy to liven up the day). We solved the problem by using a milling machine to accurately drill and tap holes for bolts to fasten the ring gear to the flywheel. Be careful to check that the heads of these bolts, which are at the back of the flywheel (between the flywheel and the engine block — see diagram), clear the bolts holding the engine back plate in place. We countersunk the bolt heads holding the ring gear in place, and then ground the heads down to ensure that sufficient clearance was maintained with the engine back plate bolts.

The stock clutch and clutch release bearing were retained.

The stock accumulator piston in the overdrive unit is slow to shift when everything is hot and you're pushing the car hard. A larger piston and spring is available from Denis Welch. This change results in a dramatic improvement in the speed of overdrive engagement (when driving on the street, I use the clutch to ease the shift — not necessary on the track). The piston can be replaced with the transmission in the car. Once the solenoid cover and lever are removed, the accumulator piston can be withdrawn. Pull out the spring first, and then use an allen wrench wedged into the end of the piston and with the proper combination of four-letter words, the piston can be removed. It's a piece of cake to slide the new one in — just make sure to keep everything clean!

I refilled the transmission/overdrive with Redline 50 weight racing transmission oil (approx. $6 a quart, but good stuff). While I was messing around with the overdrive, I also drilled the drain plugs for safety wire.

Oil Cooler

The oil in your engine gets hot — real hot. In general the oil temperature and water temperature should be approximately the same. Without an oil cooler the oil temperature is a good 30 degrees hotter than the water temperature. While most folks cut a slot in the lower shroud under the radiator grill, it's possible to mount the cooler at an angle just behind the bottom edge of the lower front shroud, and the steering arm. This is not quite as effective as mounting it vertically, but works well for spirited road driving. In addition to making up some brackets, you may want to invest in some expanded metal grillwork from your local hardware store to keep stones and small children and animals out of the cooling fins.

The mounting brackets can be bolted to the front of the two brackets supporting the lower front shroud (these extend from the front of the two longitudinal frame members).

I strongly recommend using braided steel oil lines between cooler and engine (eg: Aeroquip).

Carburetors

I installed set of tri-carb Webers (40DCOE) because they were available at a bargain price. While this certainly isn't a cheap option, the difference in perfor-

The finished result in Fred's Healey. Note "swan neck" intake manifolds; two reservoirs for the dual master cylinder (see CHATTER *May 1995); twin crankcase vents on valve cover.*

mance is awesome. DCOE45s are a better match to the engine, however the manifolds they use require a modification to the pedal box on left-hand drive cars. Also, the ver-tical shroud support just behind the stock master cylinder reservoir in the front left of the engine compartment will need to be modified. The DCOE40s are available with a swan-neck intake manifold which doesn't require any body mods. Webers can be a pain to set up, but once you've done it, they basically don't need to be touched. Triple 2" SUs work very well but surprisingly are just about as expensive as the Webers when you include the manifolds. If you're looking for good competition intake manifolds for a tri-carb SU set-up, Denis Welch manufactures them for 3/4" SUs (these can also be opened up for the two inchers).

Moss Motors in California, as well as TVM, sell both 40DCOEs and 45DCOEs for left-hand drive Healeys. The linkage is available from TVM.

Due to the vibration, it is recommended that soft mounts (also from TVM) be used. These help to dampen the vibration within the float bowls of the carbs. To help get things going on cold mornings at the track, I installed a choke cable. I used a generic unit from Chief Auto Parts and mounted a knob on the steering wheel shaft bracket under the dash.

The jetting that I use in my DCOE40s are:

Main Jet	130
Air Correction	190
Venturiis	30

Spin-on Oil Filter

If you're pushing the car hard in hot weather, you need to change the filter frequently. I change the oil in the Healey after every race. A NAPA spin-on filter costs $5 (NAPA 1515). While some folks may balk at approximately 7 quarts of oil, it's not nearly as bad as changing the oil in my Dodge pick-em-up with the Cummins Turbo diesel. That engine requires 15 quarts each oil change. Don Lenschow (NTAHC) makes a simple and inexpensive adapter — cheap oil filter changes and better filtering. There is not much clearance between the starter and the oil filter. I rotated the starter 180 degrees so that the positive terminal clears the oil filter. This change however requires a new 12V lead.

The Bottom Line

The engine runs great! A red-line of 5500 is quite conservative, and on occasions I've run the engine up to 6 grand with plenty of power still on tap. After a season of racing, the compression is at 190-200# for each cylinder. I use a 60/40 mixture of 110 octane/93 octane gas with good results. The engine is reliable. Now if the driver was just as reliable we'd be in great shape!

Vendor List:

Venolia Pistons & Rods,
Long Beach, CA
310-531-8463

Total Seal Piston Rings
Phoenix, AZ
800-874-2753

TVM Induction, California
1-805-967-9478

Denis Welch Motors, UK
011-44-1543-472-214

Don Lenschow, Texas
817-433-8276

About the author: Fred Crowley has been vice president of racing for the AHCA over the past two years. He is also chairman of the Corinthian Racing Group as well as successfully campaigning his Healey 3000.

HEALEY UPGRADES

By: *Steve Day*
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Welcome back - again!

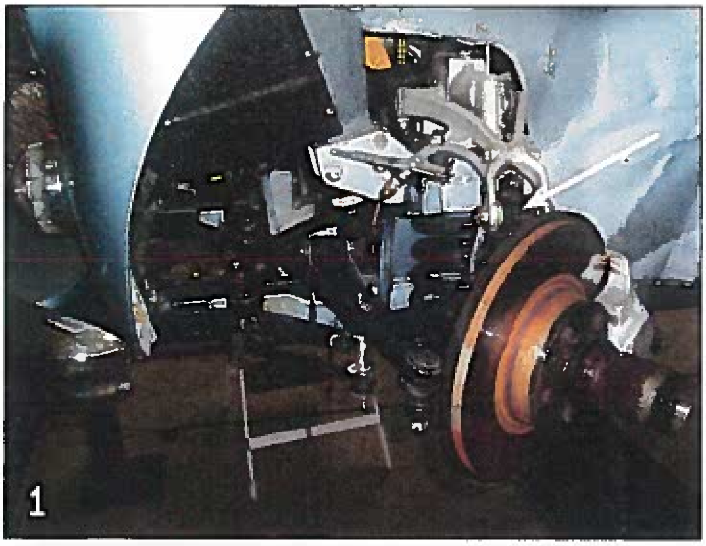
This past June I presented a tech session at Rendezvous Tahoe on the 18 most common safety and dependability upgrades I'm asked to do for my clients. This is the third and final recap of that session, which will cover the last 4.

If you have been following along in the first two articles, you will remember that the list is presented in the order of difficulty, easiest first, moving on to these last 4 upgrades that require an increasing amount of technical skill and effort.

Remember, only qualified people should attempt to work on the Healey's brake and electrical systems! I am not advocating you begin your learning with these upgrades; rather, trust them to your mechanic to safely install them.

I have the handout created for the Tahoe Tech Sessions on my web page, and it lists all the vendors and part numbers for these upgrades, along with some detailed tech articles to assist your mechanic in the installation procedure.

Photos 1 & 2 - Two of these upgrades are tied closely together in the front suspension and steering: Torrington bearings and adjustable camber upper trunion bushes.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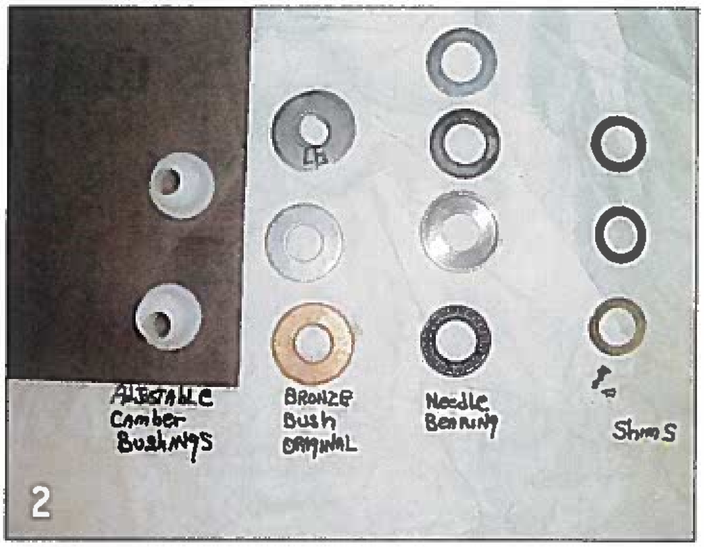
When you turn the steering wheel to turn the car, the weight of the car is pivoting on an oil soaked sintered bronze bushing located above the king pin in the upper trunion, and requires overcoming considerable friction at low parking lot speeds. Especially if you have tires wider than the original 560-15's the bushings were designed to work with. Looking



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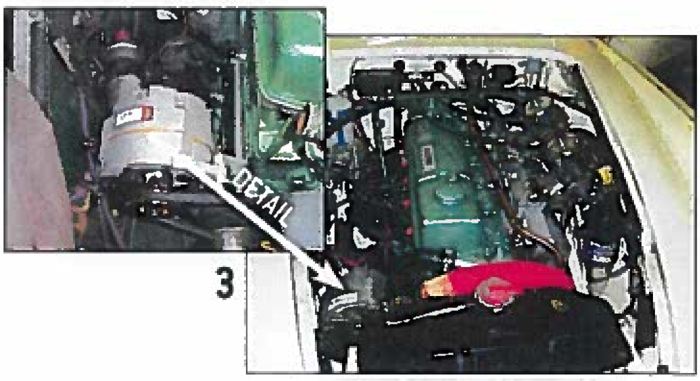
at the picture, you can see that the Torrington is a series of radial needle bearings that would greatly reduce the turning effort when installed, shimmed properly and greased.

The stock rubber upper trunion bushes provide no adjustment for camber, and quite frequently, our Healey's with modern radial tires can benefit from being able to adjust that camber, resulting in better ride, easier steering and less tire wear. By replacing those rubber bushes with the new polyurethane adjustable bushes, that is accomplished. That adjustment is provided by making the hole in the poly bush off-center, so by rotating it in the trunion assembly to different positions, you receive different amounts of king pin tilt, which controls camber angle. After installation, you must have the car put on a front-end rack and have an alignment machine attached to make sure the angles are correct and equal on both sides. This is also the time to make sure the toe in angle is set correctly too.

Photos 3 & 4 - You knew it had to be in the list somewhere, the upgrading of the stock generator to a modern alternator! Again, this is not a how to article, rather an overview of the possible benefits of installing this, or any of these 18 upgrades.

When and why would you even consider such a visible departure from stock?

The stock generator does an adequate job providing electricity to run the accessories and keep the battery charged, providing it is maintained and in good shape. It's when you add modern electrical devices to the car that it



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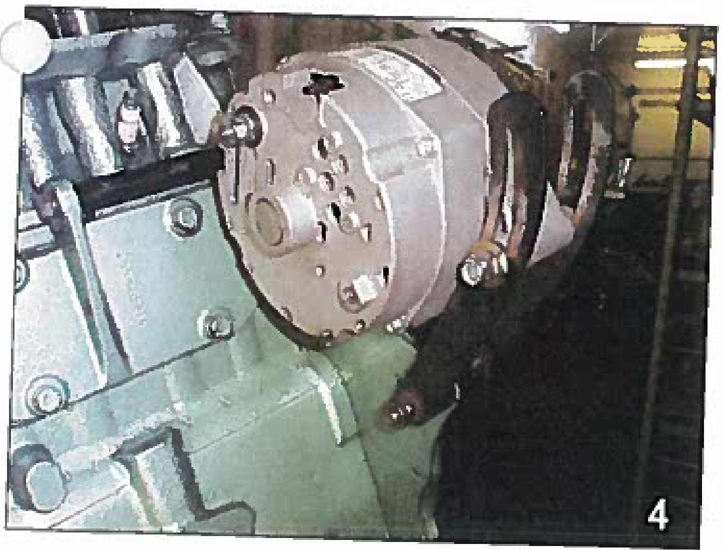

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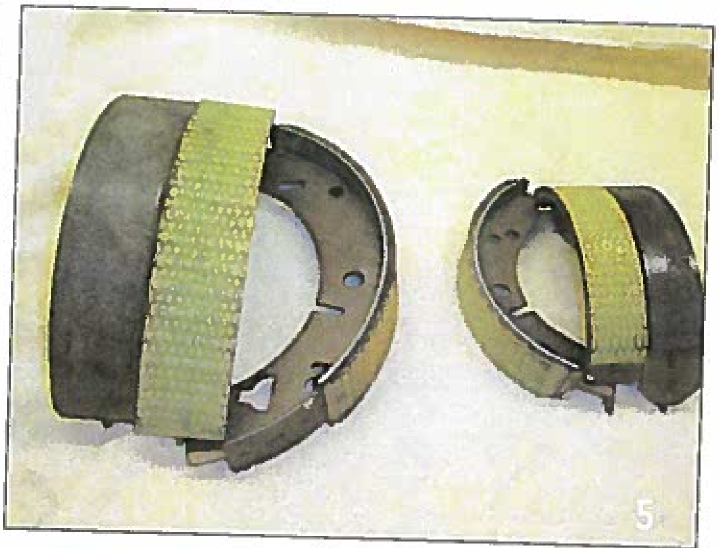

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can over tax the capacity of the generator. Like halogen headlights, stereo system, driving lights, GPS devices, cell phone chargers, interior lights and so on. On a dark rainy night with wipers, lights and driving lights on, heater on and listening to the stereo, the demand is more than the generator can deliver, drawing down the battery and eventually resulting in a dead battery and ignition failure.

So the first guideline question would be, have you added accessories?

Second, have you changed the car to negative ground?

Third, do you love modern technology, and want it integrated to your Healey?

Fourth, has your generator failed and needs a total rebuild, field coils and all.

A yes to any of these could justify an upgrade to an alternator. The alternator reacts more quickly, and supplies more electricity to run added loads on the car. The generators on our Healey`s put out between 22 and 32 amps, an alternator can be chosen with outputs of from 40 to 100 amps!

Photos 5 - The last one on the list, is the upgrading of the rear brake shoes on our Healey`s. The need to consider this upgrade comes from the combination of age, wear, and poor repair procedures in the past and inconsistent quality of replacement parts.

By now, it would be easy to agree that every piece of the rear brake system has worn and should have been replaced, but many brake jobs have only included replacing the shoes. Even when the parts are replaced, the quality of the replacements can be short of the exact tolerances of the original design. For instance, new shoes that can measure .020 to .060 undersize, and drums that can be .040 to .060 undersize, right out of the box! Or, even when you reuse the drums, and turn them undersize to smooth out the rubbing surface, these all "build in" problems to getting good brake response!

The solution I have gone to, is to use the services of a local industrial friction relining company to re-line the rear brake shoes to the exact needed thickness and diameter for the car I am working on, which restores the original working tolerances and provides much better braking efficiency. I even have a choice of the quality and stopping power of the lining used in the process.

Small print: because of the obvious safety nature of working on the cars braking system, make sure the mechanic you choose is qualified for the task!

A more detailed description of the problem and the steps involved in the solution, are on my website, www.britishcarranch.homestead.com, in the technical section, so your trusted mechanic can duplicate this solution for you.

That concludes the list; I hope it has offered you some ideas, if you are considering doing safety or dependability upgrades for your baby! I welcome questions or comments on the AHCUSA forum site or direct at britishcarranch@hotmail.com , until next time.

ALUMINUM HEAD FOR THE HEALEY HUNDRED

Dave Russell
Boise, Idaho

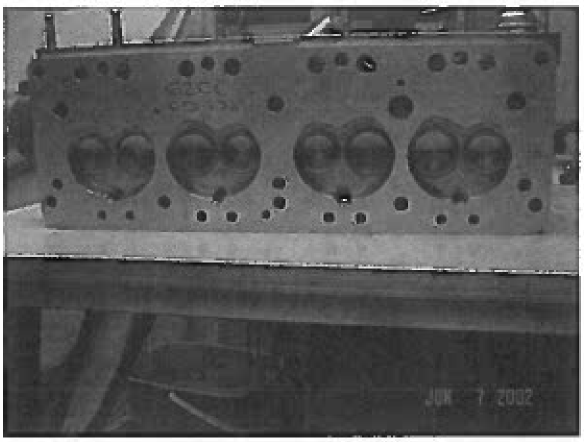
A previous owner of my 100 converted the engine to 100M specs. When I decided to do a valve job I discovered that the iron head was a bit much to lift over the shroud without possibly damaging the paint. My old back isn't what it used to be. I then rationalised that an aluminium head would be some 25 pounds lighter and thus much easier to lift back into place. I really didn't need much justification. Just a little.

The engine with head off.

When I asked Jonathan at Denis Welch Racing (DWR) about whether I should fill my oversize intake manifolds or taper/enlarge the head ports to match, and he emphatically said not to change the head ports. The manifolds were filled with "JB Weld" and ground to match the smaller head ports. I have used JB Weld for years to fill and reshape the intake ports of Chevy race heads and Triumph motorcycle heads. The filler has never come loose or shown any degradation from heat.

The original head had been "ported" by a previous owner and had huge ports but also still had the humps and bumps of the original exhaust port design. The 100M intake manifolds had been enlarged accordingly and tapered from the 1.75-inch carb bores to nearly two inches at the ports.

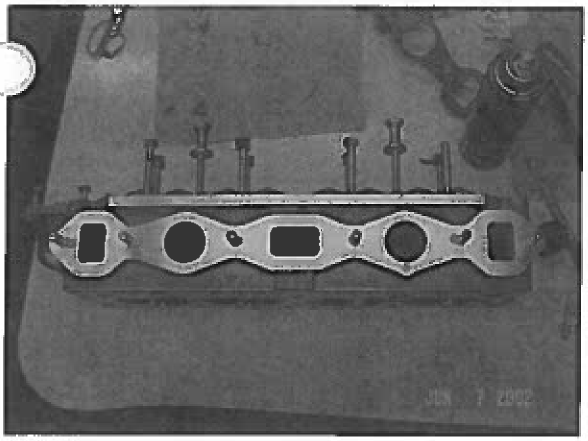
This is all very good for a high RPM engine, but of no benefit to the long stroke 100 which I feel should be limited to about 5,500 RPM with the stock crankshaft and rods. During investigation of the Denis Welch aluminum full-race head, I discovered that it was designed with relatively small and reshaped ports for good gas velocities and torque boost at low and mid RPM. This head is truly well designed and machined. It uses six-cylinder valves, bronze guides with machining for modern press over valve stem seals, single high tension valve springs, and aluminum spring retainers. It has been rigorously dyno tested for reliability, optimum coolant flow and performance. The ports are straighter and without the stock obstructions. I placed an order and the head arrived within two weeks.

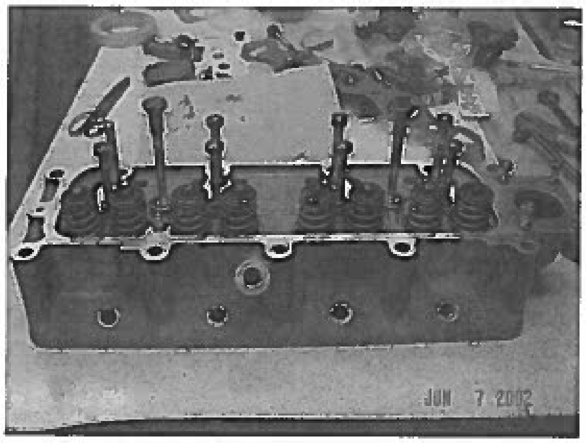


The bottom of head.

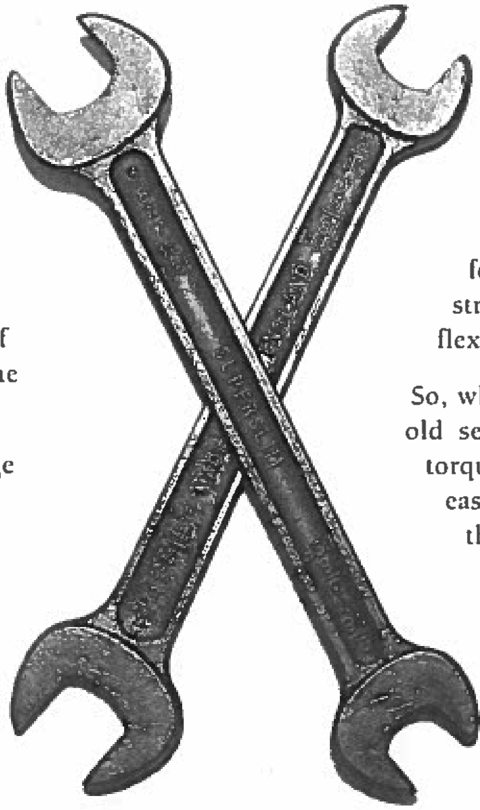
Along with the new head I also got the DWR high-strength head studs, nuts, and hardened washers. The suggested head gasket was faced on both sides with copper and is torqued to 75 ft lbs. To top things off, I got the DWR three-into-two header with two-inlet muffler and single two-inch tail pipe. The header needed some hot bending to perfectly align with the head ports and the rear carb fitting for the vacuum advance line had to be changed to a 90 degree fitting, but otherwise was installed without problem.

Since the previous owner had installed the 100M manifolds and H6 carbs, but used the useless Stelling type oiled horse hair type air filters, I went with the DWR repro cold air box, rectangular-to-round air hose adapter, and 4.5-inch hose. The adapter is designed to fit a truncated cone-type foam air filter inside of the hose at the hose-to-box junction. This collection of parts created a whole new set of problems. The 4.5-inch adapter required a much greater offset of the shroud support bracket, the hose could not be routed to the


The port side of head.



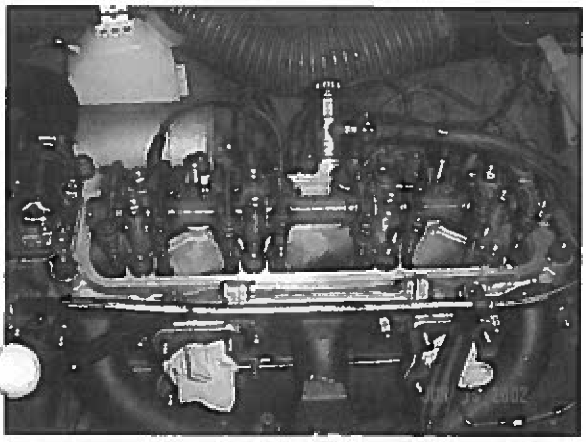
The top of head.

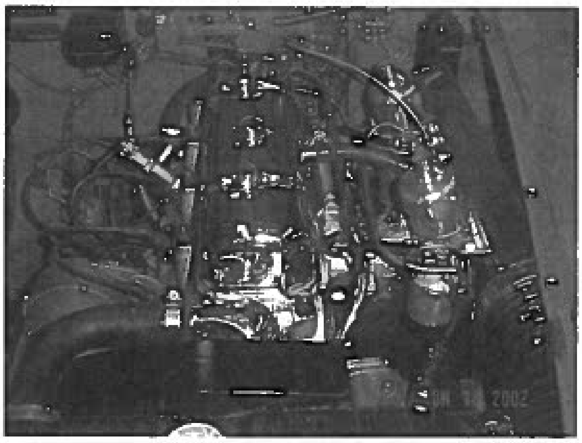


front without removing the radiator-to-wheel-well bracket, and worst of all, the foam filter was too restrictive to allow the engine to rev much over 5,000 RPM. Jonathan at DWR confirmed that the filter would not handle an engine of over 150 horsepower, but I think the 150 number was overly optimistic.

The final solution was to install a large KandN type cone filter on the front end of the hose and just behind the grill. On the 100 the grill can be removed by removing five nuts across the top and lifting it out. I replaced the top nuts with wing nuts and can now reach in from the wheel wells to remove the nuts and grill with the wheels in place. The massive 4.5-inch air hose was constructed with double spiral wrapped reinforcing and was of very stiff industrial strength. I replaced it with a much more flexible air hose from J.C. Whitney.

So, what is the bottom line? Compared to the old set-up, the engine now has much more torque from 2,000 to 5,000 RPM and will pull easily to 6,000. It matches up perfectly with the 3.54:1 axle ratio and 28 percent overdrive. It cruises easily with 3,000 RPM being nearly 80 MPH. There have been no oil or coolant leak problems and I couldn't ask for a more trouble-free engine.


The header and manifolds.


The engine all together.

How to Upgrade Healey Suspension for Track or Street

by Fred Crowley
North Texas AHC

Continuing from May, 1995, CHATTER *with some of the modifications to the '62 BT7, a few tips to help in the handling department are shown below.*

Front Anti-Sway Bar

Another real simple bolt-on option that significantly improves the handling of the Healey is the addition of a 7/8" anti-sway bar (available from a number of Healey suppliers that advertise in *CHATTER*). Make sure you use urethane mounting bushings to minimize any slack. This is a straight bolt-on job. However, one weak point that I have encountered is the anti-sway bar link. I have found that with gymkhanas, rough railway tracks, etc., that the ends of the stock end-link bolts are somewhat fragile under spirited use, and these links periodically snap (especially using the heavier anti-sway bar).

Stronger End-link Bolt:

A cheap, bullet-proof alternative to the stock end link is to use grade 8 bolts 3/8" x 24 x 5". Using two grade 8 nuts and two 1.25" exterior diameter washers with urethane bushings gives an appropriate spacing between the end of the anti-sway bar and the mounting plate on the lower A-arm. Mount the bolts with the bolt-head down, and there will be nothing to catch on any off-track excursions, rocks, driveways, etc. (See diagram.)

Total cost including bushings was less than $10 from an auto parts store.

A Super, Inexpensive Way to Lower the Front-End

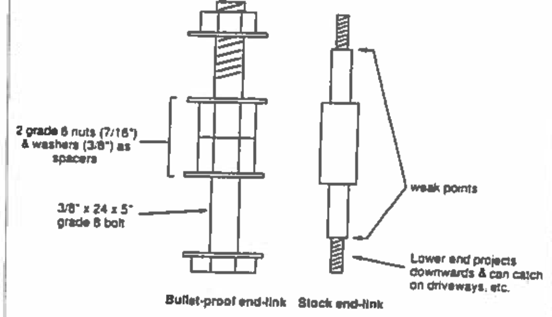
Lowering the front-end on a big Healey may seem a bit weird considering that the clearance is minimal in the first place. However, the handling and general "feel" of the car, especially at higher speeds, is significantly improved by lowering the front about 1". The cost of the approach described is that of two bolts and appropriate nuts and washers.

To accomplish this, it is necessary to insert spacers between the coil spring pan and the lower A-arms.

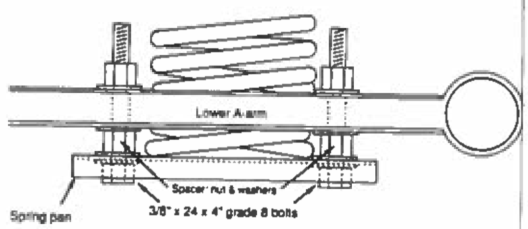
1. First remove the front coil spring. While spring compressors will obviously work, I didn't have any so I did it the easy way. I placed a floor jack under the spring pan, and undid the four bolts holding it in place. Lowering the jack took the tension off the spring, and the pan and coil spring were removed.

2. Since I didn't have a spring compressor, I found a simple way to bolt the spring pan back on and compress the coil spring. I replaced the four stock bolts with four grade 8 bolts, 3/8" x 24 x 4". As with the end-link set-up, I mounted the bolts with the bolt head down (so that it would not stick out to catch on anything). Using a nut and two washers as spacers (total depth of 5/8") lowered the front end approximately 1".

3. Replacing the spring pan and coil spring was a snap, as the 4" bolts were long enough to loosely bolt everything together. Tightening all four bolts equally brought everything up snug.



BULLET-PROOF ANTI-SWAY BAR END-LINK



LOWERING THE FRONT SUSPENSION

SCCA CLUB RACING

2003 EDITION

PRODUCTION CATEGORY SPECIFICATIONS

Sports Car Club Of America, Inc.
Club Racing Department
Building 300
Topeka Air Industrial Park
at Forbes Field
Topeka, Kansas 66619

16. Floor pans shall be altered only to recess mufflers. All other parts of the exhaust system (i.e., headers, tailpipes, etc.) shall not be recessed, nor shall any modifications be made to the bodywork for that purpose.

17. Non-metallic floor boards may be replaced with metal floor boards of a minimum .060" thickness, having the same overall dimensions and in the same location as the original component.

b. Integrity of Structure: All permitted alterations, modifications, components, or safety structure installations are understood to be additions to the basic vehicle. No part of the body/frame or unibody shall be altered or substituted unless specifically authorized by these rules or by the vehicle's specification line.

10. Driver/Passenger Compartment - Trunk

a. Seating: The driver's seat shall be replaced with a one-piece bucket-type race seat. Such seat shall be installed so that a second seat of the same dimensions could be simultaneously fitted to the passenger's side of the car (no center seating). All seat mountings shall be reinforced per GCR Section 18.3.5 and Section 18.1.2. All other seats may be removed.

1. All cars registered after July 1, 1985 shall have the driver seated on the left when the car is viewed from the rear.

b. Gauges and Accessories: The instrument panel may be altered or replaced to permit the installation of gauges, switches, indicators, safety equipment, and/or roll cage structure. Any mirrors may be used and shall comply with GCR Section 11.2.1.R.

c. Interior Modifications: Modifications may be made to the driver/passenger compartment to improve the comfort of and control accessibility to the driver, and to permit the installation of required safety equipment. Covers for all equipment located in the driver/passenger compartment forward of the rear most portion of the door opening shall not extend higher than six (6) inches below the highest point of the door. Exceptions to this rule shall be noted on the vehicle specification line. Alternatively, the dry sump tank cover may be located within 18" of the front or rear cowl and no higher than the cowl.

1. All interior trim, floor covering, and upholstery panels may be removed.

2. A metal bulkhead shall be installed between the driver/passenger compartment and the compartment or area where the fuel cell or fuel tank is located. All bulkheads shall meet the requirements of GCR Section 19., "Fuel Cells."

11. Safety

11.1 Roll Cages (Section 18 of GCR pertaining to Production)

All automobiles shall have full width roll cages. Roll cages may be of two (2) designs, low front hoop or high front hoop. Specific installations are subject to approval by the Technical and Safety Inspectors at each event. The Technical Staff of Club Racing, with the concurrence of the Competition Board, shall have the responsibility to ensure specification compliance with SCCA safety standards. Alternate structures which do not meet the following criteria will not be considered.

a. Main Hoop:

1. The main hoop (behind the driver) shall be full width of the cockpit. The main hoop shall be as near the roof as possible on closed automobiles and not less than two (2) inches above the driver's helmet on open automobiles with the driver seated normally and restrained by the seatbelt/shoulder harness.

2. The main hoop shall be one continuous length of tubing with smooth continuous bends with no evidence of crimping or wall failure. The minimum radius for all bends shall be three (3) times the tube diameter measured from the tube centerline. Whenever possible, the roll hoops should start from the floor of the automobile, and, in the case of tube frame construction, be attached to the tubes by means of gussets or metal webs in order to distribute the loads. On automobiles of frameless construction, consideration should be given to using a vertical roll hoop of 360 degrees completely around the inside of the automobile and attached with suitable mounting plates.

3. All main hoops shall incorporate a diagonal brace (same diameter and wall thickness as main hoop) to prevent lateral distortion of the main hoop. A horizontal bar connecting the sides of the main hoop is highly recommended.

4. Main hoops shall have two (2) braces extending to the rear, attaching to the frame or chassis. Braces shall be attached

as near as possible to the top of the main hoop (not more than six (6) inches below the top) and at an included angle of at least thirty (30) degrees. Open cars with a low front hoop shall have two braces extending from the main hoop to the low front hoop **(Effective 1/1/99).** These braces shall be mounted no lower than six inches below the top of the main hoop as illustrated.

b. Front Hoop:

1. High front hoops shall follow the line of the front pillars to the top of the windshield and be connected, by horizontal bars, to the top of the main hoop on each side (as close to the roof as possible). Low front hoops shall be cowl height, or at a minimum, a straight line drawn from the top of the main hoop to the top of the front hoop shall pass over the driver's helmet.

2. Two (2) side hoops following the line of the front pillars to the top of the main hoop may be used. These two (2) side hoops are to be connected by a horizontal bar over the top of the windshield. (See Figure 6), or

3. A top "halo" hoop following the roof line from the main hoop to the windshield with forward down tubes following the line of the front pillars to the floor.

4. It is recommended the hoop extend to the belly pan. If not, it shall be attached to the chassis with gussets and triangulation in order to spread the loads

5. It is recommended that the vertical bars of the front hoop be connected by a horizontal bar at a point above the driver's legs.

6. There shall be two (2) braces extending forward from the front hoop to protect the driver's legs. It is recommended that this bracing extend to the bulkhead in front of the driver's feet; but, in any case, it shall be integrated into the frame or chassis to provide substantial support for the front hoop.

c. Side Protection:

1. .The minimum side protection shall consist of a horizontal side tube connecting the front and rear hoops across both

the door openings. Additionally, there shall also be either a diagonal tube from the front hoop to the rear hoop bisecting the door opening below the horizontal side tube, or not less than two (2) horizontal side tubes. Additional tubing may be added. NASCAR-style door bars are recommended.

2. Interior door panels may be altered, replaced, or removed. When door panels are removed, all sharp edges or projections shall be protected.

d. Mounting Plates:

1. The thickness of mounting plates bolted to the structure of the car shall not be less than the thickness of the roll hoop or brace that they attach and shall be backed-up with a plate of equal dimensions on the opposite side of the panel, with the plates through-bolted together. A minimum of three (3) bolts per mounting plate is required for bolted mounting plates. All hardware (bolts) shall be Grade 5 or better with 5/16" diameter minimum. Mounting plates welded to the structure of the car shall not be less than .080" thick. Whenever possible the mounting plates should extend onto a vertical section of the structure (such as door pillar).

e. Minimum tubing sizes (All dimensions in inches):

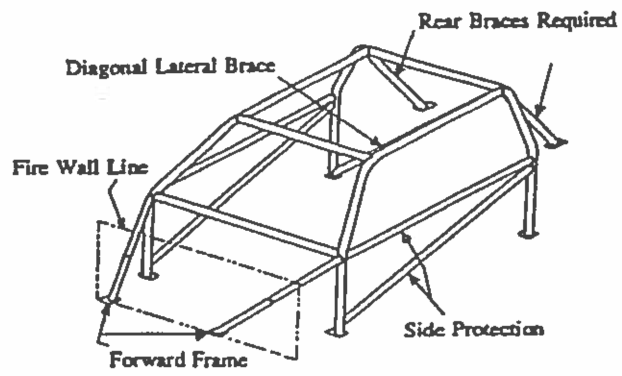
Vehicle Weight Without Drive	Mild Steel	Material Alloy Steel
Up to 1500 lbs.	1.375 x .095	1.375 x .080
1500-2500 lbs.	1.50 x .095	1.375 x .095
Over 2500 lbs.	1.50 x .120 *1.625 x .120* 1.75 x .095	1.50 x .095

11.2 Fuel Cells: Fuel cells are required on all Production Category vehicles. Cells, their mounting, location, fill equipment, and venting, shall meet the specifications of the GCR.

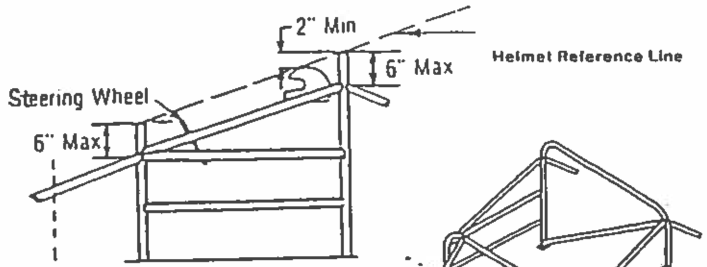
11.3 Safety Harness: Systems shall meet the specifications of GCR Section 17. Window nets meeting the requirements of the GCR.

11.4 On-board fire systems shall be required on all Production Category cars.

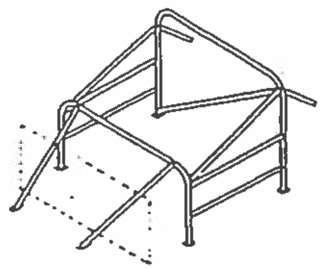
Recommended Roll Cage
High Front Hoop

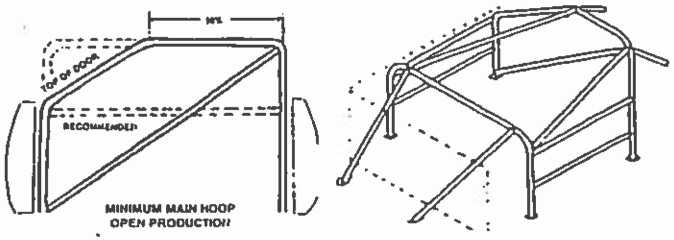


Recommended Roll Cage
Low Front Hoop
Open-top Cars



Side View – Low Front Hoop
Forward Bracing & Side Protection





Note: A low front hoop may only be used in open-top cars without a windshield.

NOTES:

EPc	Engine Type	Bore x Stroke mm / (in.)	Displ. cc / (ci)	Block Mat'l	Head / PN & Mat'l	Valves IN & EX mm / (in.)	Carb. No. & Type	Wheelbase mm / (in.)	Track (F/ R) mm / (in.)	Wheels	Trans. Speeds
Alfa Romeo Spider Duetto & 1750 Spider (thru 1971)	4 Cyl. DOHC	78.0 x 82.0 (3.07x3.23) 80.0 x 88.4 (3.15x3.48)	1570 (96.0) 1779 (108.5)	Alum	Alum	(I) 41.1 / (1.62) (E) 37.1 / (1.46)	(2) Weber 40 DCOE 27, (2) Weber 40 DCOE 32, (2) Weber 45 DCOE w/ 38mm choke(s), (2) Zenith 75 CDSE	2250 (88.6)	1415 / 1359 (55.7/53.5)	14 x 7 15 x 7	5
Austin-Healey 3000 Mk. I, II, III	6 Cyl OHV	83.3 x 88.9 (3.28x3.50)	2912 (177.6)	Iron	Iron	(I) 44.5 / (1.75) (E) 39.6 / (1.56)	(2) 1.75in SU or Stromberg or (3) 1.75in SU or Stromberg on stock 3-carb intake manifold	2329 (91.7)	1359 / 1384 (53.5/54.5)	15 x 7	4
BMW 2002 / 2002tii	4 Cyl SOHC	89.0 x 80.0 (3.50x3.15)	1990 (121.5)	Iron	Alum	(I) 46.0 / (1.81) (E) 38.0 / (1.50)	(1) 40 DCN, DCNF, IDF w/ 34mm choke(s), (2) Auto-type sidedraft w/ 32mm choke(s) on I.R. manifold, 32/36 DGV/DGAV, or original-type fuel injection.	2499 (98.4)	1430 / 1430 (56.3/56.3)	13 x 7 15 x 7	4
BMW 318i & 320i	4 Cyl SOHC	89.0 x 80.0 (3.50x3.15)	1990 (121.5)	Iron	Alum	(I) 46.0 / (1.81) (E) 38.0 / (1.50)	(1) 40 DCN, DCNF, IDF w/ 34mm choke(s), (2) Auto-type sidedraft w/ 32mm choke(s) on I.R. manifold, 32/36 DGV/DGAV, or original-type fuel injection.	2563 (100.9)	1481 / 1494 (58.3/58.8)	13 x 7 15 x 7	4 or 5
BMW Z3 1.9L	4 Cyl DOHC	85.1 x 83.6 (3.35x3.29)	1895 (115.6)	Iron	Alum	(I) 33.0 / (1.30) (E) 30.5 / (1.20)	(2) Auto-type sidedrafts w/ 30mm choke(s), or original-type fuel injection w/ stock unmodified F.I. throttle body.	2446 (96.3)	1481 / 1565 (58.3/61.6)	15 x 7	5

EPD	Brakes Std. (mm / (in.)	Brakes Alt.: mm/(in.)	Weight lbs. / (kg)	[illegible]s:
Alfa Romeo Spider Duetto & 1750 Spider (thru 1971)	(F) 264 (10.4) Disc (R) 246 (9.7) Disc	(F & R) 264 (10.4) Disc (F) 272 (10.7) Disc (R) 267 (10.5) Disc	1920 (870.7)	Niki Lauda Edition rear spoiler
Austin-Healey 3000 Mk. I, II, III	(F) 286 (11.3) Disc (R) 279 (11.0) Drum	Rear Disc: #H82462	2400 (1088.4)	Laycock overdrive: .88, .82, .79. May use 5 speed gearbox w/o overdrive.
BMW 2002/2002tii	(F) 256 (10.1) Disc (R) 230 x 40 (9.1 x 1.6) Drum		2100 (952.4)	
BMW 318i & 320i	(F) 254 (10.0) Disc (R) 249 x 41 (9.8 x 1.6) Drum		2100 (952.4)	Trunk mounted fuel cell allowed. 1800cc engine from 318i allowed
BMW Z3 1.9L	(F) 286 (11.3) Disc (R) 280 (11.0) Disc		2100 (952.4)	Comp Ratio limited to 12.0:1. Cylinder head prep per I.T. specifications except that head may be milled to achieve max compression ratio (I.e. no porting, stock valve job, no chamber mods). Valve lift: .500" max. Restrictions: Alternate (synchro) transmission, add 50lbs. alt. dog-ring transmission, add 100lbs. Restricted suspension preparation only (refer to PCS Section 17.1.1.D.6., Restricted Suspensions for allowable suspension modifications.)

SCCA CLUB RACING

2003 EDITION

GENERAL COMPETITION RULES

Sports Car Club of America, Inc.
Club Racing Department
Building 300
Topeka Air Industrial Park
at Forbes Field
Topeka, Kansas 66619

18. ROLL CAGES

These general specifications are for all automobiles. Roll cages are required in all automobiles.

Roll cages may be of two (2) designs, low front hoop (top of steering wheel) or high front hoop (top of windshield). Specific installations are subject to approval by the Technical and Safety Inspectors at each event.

The Technical Staff of Club Racing shall have the responsibility to ensure specification compliance with SCCA safety standards. To that end, the Technical Staff of Club Racing may or may not accept alternate construction standards from any source that significantly vary from SCCA standards of protection.

18.1. BASIC DESIGN CONSIDERATIONS

1. The basic purpose of the roll cage is to protect the driver if the car turns over, runs into an obstacle such as a guardrail or catch fence, or is struck by another car. It shall be designed to withstand compression forces from the weight of the car coming down on the rollover structure and to take fore/aft and lateral loads resulting from the car skidding along on its rollover structure.

2. A system of head restraint to prevent whiplash and rebound, and also to prevent the driver's head from striking the underside of the main hoop shall be installed on all vehicles. Racing seats with integral headrests shall also meet this requirement and have a support to the main hoop. *Seats homologated to, and mounted in accordance with FIA standard 8855-1999 or higher need not have the seat back attached to the roll structure.* The head restraint on non-integral seats shall have a minimum area of thirty-six (36) square inches and be padded with a non-resilient material such as Ethafoam® Ensolite®, or other similiar material with a minimum thickness of one (1) inch. *Padding meeting SFI spec 45.1 is recommended.* The head restraint shall be capable of withstanding a force of two-hundred (200) lbs., in a rearward direction. The head restraint support shall be such that it continues rearward or upward from the top edge in a way that the driver's helmet can not hook over the pad. The padded surface shall touch the helmet; it shall not be under fiberglass or other hard material.

3. Forward braces and portions of the main hoop subject to contact by the driver's helmet (as seated normally and restrained by seatbelt/shoulder harness) shall be padded with non-resilient material such as Ethafoam® or Ensolite®, or other similar material with a minimum thickness of one-half (1/2) inch. *Padding meeting SFI spec 45.1 is recommended.*

4. No portion of the safety roll cage shall have an aerodynamic effect by creating a vertical thrust.

5. Roll cage or chassis design shall prevent engine intrusion into the driver compartment.

6. Material:

   A. Seamless, or DOM (Drawn Over Mandrel) mild steel tubing (SAE 1010, 1020, 1025) or equivalent, or alloy steel tubing (SAE, 4130) shall be used for all roll cage structures. Proof of use of alloy steel is the responsibility of the entrant.

   B. Minimum tubing sizes (all Formula, Sports Racing, GT, and Production Category automobiles, and all automobiles registered prior to June 1, 1994) for all required roll cage elements (All dimensions in inches):

Vehicle Weight Without Driver	Material Mild Steel	Alloy Steel
Up to 1500 lbs.	1.375 x .095	1.375 x .080
1500-2500 lbs.	1.50 x .095	1.375 x .095
Over 2500 lbs.	1.50 x .120 1.625 x .120 or 1.75 x .095	1.50 x .095

   C. Minimum tubing sizes for (all Showroom Stock, Touring and Improved Touring Category automobiles registered after June 1, 1994) for all required roll cage elements (All dimensions in inches):

Up to 1500 lbs	1.375 x .095 DOM / Seamless / Alloy
1501-2200 lbs	1.500 x .095 DOM / Seamless / Alloy
2201-3000 lbs	1.500 x .120 DOM / Seamless / Alloy 1.625 x .120 DOM / Seamless / Alloy 1.750 x .095 DOM / Seamless / Alloy

   (American Sedans may construct to these specifications regardless of weight.)

3001-4000 lbs	1.750 x .120 DOM / Seamless / Alloy
Over 4000 lbs	2.000 x .120 DOM / Seamless / Alloy

Note: ERW tubing is not permitted in any car registered with SCCA after of 01/01/2003.

Main hoop: 4 bends maximum, totaling 180 degrees ± 10 degrees.
Front hoop: 4 bends maximum or Front downtubes: 2 bends maximum.
Rear hoop supports: No bends.

If any of the above bend requirements cannot be met, all components of the roll cage shall be fabricated from the tubing size(s) listed for the next heavier category of automobiles.

D. For purposes of determining tubing sizes, the vehicle weight is as raced without fuel and driver. The minus tolerance for wall thickness should not be less than .010" below the nominal thickness. Improved Touring roll cage tubing sizes are to be calculated based on the published vehicle weight minus 180 lbs.

E. An inspection hole at least 3/16 inch diameter, *but no greater than 1/4 inch diameter* shall be drilled in a non-critical area of all tubes with a specified size to facilitate verification of wall thickness.

7. General Construction

A. One (1) continuous length of tubing shall be used for the main hoop member with smooth continuous bends and no evidence of crimping or wall failure. The radius of bends in the roll cage hoop (measured at centerline of tubing) shall not be less than three (3) times the diameter of the tubing.Whenever possible, the roll cage hoop should start from the floor of the car, and, in the case of tube frame construction, be attached to the chassis tubes by means of gussets or sheet metal webs with support tubes beneath the joints to distribute the loads. It is recommended that gussets be used

B. Welding shall conform to American Welding Society D1.1, Structural Welding Code, Chapter 10, Tubular Structures. Welds shall be continuous around the entire tubular structure.

All welds shall be visually inspected and shall be acceptable if the following conditions are satisfied:

1. The weld shall have no cracks.

2. Thorough fusion shall exist between weld metal and base metal.

3. All craters shall be filled to the cross section of the weld.

4. Undercut shall be no more than 0.01 inch deep.

C. Aluminum bronze or silicon bronze welding technique is permitted, but extreme care shall be used in preparation of parts before bronze welding and in the design of the attaching joints.

18.2. SHOWROOM STOCK ROLL CAGE

1. Full width roll cages are required in all Showroom Stock automobiles. Roll cages installed in Showroom Stock automobiles are for driver safety and shall be contained entirely within the driver/passenger compartment without removing any panel or accessory not specifically authorized in these rules. The carpet/padding may be cut around the mounting base plates.

A. The cage need not be removable. It shall be bolted and/or welded to the car.

B. It shall attach to the car at no more than eight (8) points, consisting of the basic cage with six (6) points and two optional braces.

C. The forward part of the cage shall be mounted to the floor of the vehicle. In addition, if the two optional braces referred to in 18.2.1.B are utilized they shall be mounted, one on either side, from the forward section of the cage to the firewall or front fender wells (see GCR Section 18.2., Figure 1). No braces shall pass through the front firewall.

2. Removable roll cages and braces shall be very carefully designed and constructed to be at least as strong as a permanent installation. If one tube fits inside another tube to facilitate removal, the removable portion shall fit tightly and shall bottom by design and

at least two (2) bolts shall be used to secure each such joint. The telescope section shall be at least eight (8) inches in length. Minimum bolt diameter is 3/8 inches.

3. For tubing sizes for front and main hoop and all required bracing, see 18.1.6.C.

4. Main Roll Hoop:

   A. Main roll hoop (behind the driver) shall extend the full width of the driver/passenger compartment and shall be as near the roof as possible. It shall incorporate a diagonal lateral brace to prevent lateral distortion of the hoop (See Figure 1). Any number of additional reinforcing bars are permitted within the structure of the cage. It is required that the horizontal brace behind the driver's seat (described in Section 18.2.10) continue from the diagonal to the passenger side main hoop upright or that a second diagonal be installed in the main hoop.

5. Front Roll Hoops:

   A. The front or side hoops shall follow the line of the front pillars to the top of the windshield (as close to the roof as possible) then horizontally to the rear attaching to the main hoop. These two side hoops are to be connected together by a tube over the top of the windshield, or

   B. A front hoop following the line of the front pillars and connected by horizontal bars to the main hoop on each side at the top may be used, or

   C. A top "halo" hoop following the roof line from the main hoop to the windshield with forward down tubes following the line of the front pillars to the floor.

   D. The front or side hoops may extend through the dash pad. This includes the forward part of the door panel if it is an extension of the dash panel.

   E. One (1) bar is recommended in a horizontal plane between forward cage braces in the dash area.

6. Bracing:

   The main roll hoop shall have two braces extending to the rear attaching to the frame or chassis. Braces shall be attached as near as possible to the top of the main hoop not more than six (6) inches below the top and at an included angle of at least thirty (30) degrees. On cars where the rear window/bulkhead prohibits the installation of rear braces (e.g., Honda del Sol), the main hoop shall be attached to the body by plates welded to the cage and bolted to the stock shoulder harness mounting points. This installation design must also incorporate a diagonal bar connecting the top of the main hoop to the lower front passenger side mounting point ("Petty Bar").

7. Side Protection:

   A side tube connecting the front and rear hoops across the driver's door opening is mandatory and across the passenger's door opening is allowed (recommended). The telescope section should be at least four (4) inches in length. Minimum bolt diameter 3/8 inches. The driver's window safety net may be mounted to this side tube and the top cage tube. Driver's door side tubes may extend into the door. NASCAR-style side protection is permitted. The driver's door window glass, window operating mechanism, inner door trim panel, armrest, map pockets, and inside door latch/lock operating mechanism may be removed and the inner door structural panel may be modified, but not removed to facilitate this type of side protection. The stock side impact beam and the outside door latch/lock operating mechanism shall not be removed or modified.

8. Mounting Plates:

   A. Each mounting plate shall be at least .080 thick if welded and 3/16" thick (with appropriate backing plates) if bolted. There shall be a minimum of three (3) bolts per mounting plate if bolted.

   B. Each mounting plate shall not be greater than 100 square inches and shall be no greater than twelve (12) inches or less than two (2) inches on a side.

   C. Whenever possible, mounting plates shall extend onto a vertical section of the structure (such as a rocker box).

D. The mounting plate may be multi-angled but must not exceed these dimensions in a flat plane.

E. Any number of tubes may attach to the plate or each other.

9. Hardware: (Bolts)

All hardware shall be Grade 5 or better. 5/16" minimum diameter.

10. *In order to provide a secure seat back support a section of tubing equal to the roll bar shall be installed horizontally from the main hoop upright to the diagonal brace. This tube shall be no higher than shoulder height.* The driver's seat shall be firmly mounted to the structure of the car. In cars where the seat is upright, the back of the seat shall be firmly attached to the main roll hoop, or it's cross bracing.

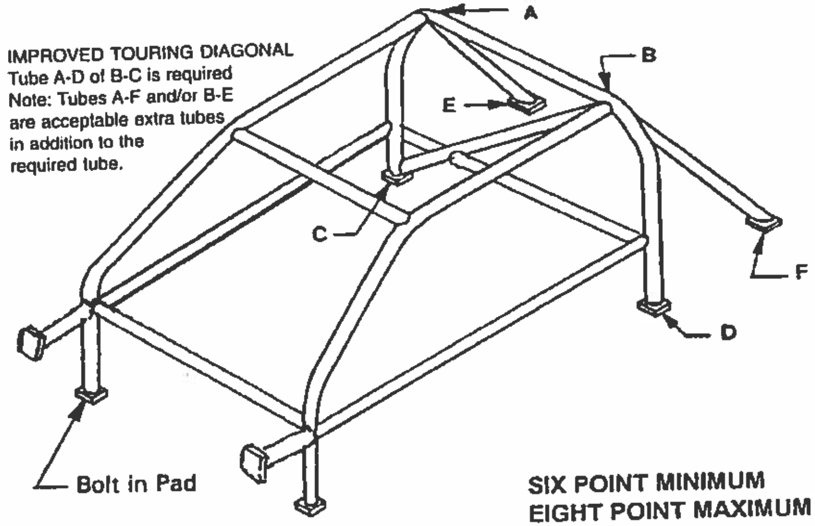
Seats homologated to and mounted in accordance with FIA standard 8855-1999 or higher need not have the seat back attached to the roll structure. The homologation labels must be visible. Seat supports shall be of the type listed on FIA technical list No.12 (lateral, bottom, etc).

Fig. 18.2.10.A

FIA Standard 8855 -1999
ABC Seats Ltd.
Model: Super Champion 1996
Homologation N° CS.OO1.96
Date of Manufacture: June 1996

Letters must be at least 8mm high
Sample FIA seat homologation label

SHOWROOM STOCK REMOVABLE ROLL CAGE
Tubing Joints - See Figures 2, 3, and 4



SIX POINT MINIMUM
EIGHT POINT MAXIMUM

Figure 1

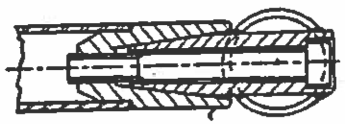


Figure 2

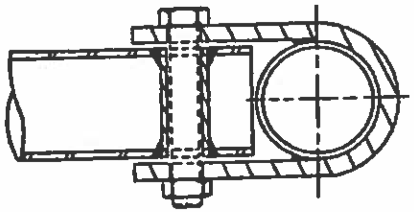


Figure 3

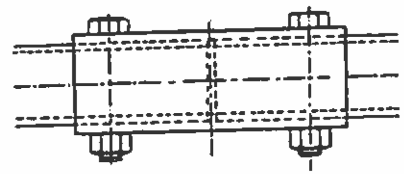


Figure 4

18.3. GT AUTOMOBILES ROLL CAGES

All GT automobiles shall have full width roll cages. Open automobiles without full windshields may have a low front hoop. All closed automobiles shall have full height (top of windshield) front hoops.

18.3.1. Main and Front Hoops

A. Main Hoop:

The main hoop (behind the driver) shall be full width of the cockpit. The main hoop shall be as near to the roof as possible on closed automobiles and not less than two (2) inches above the driver's helmet on open automobiles, with the driver seated normally and restrained by seat belt/shoulder harness. Low front hoops shall be cowl height, or at a minimum, a straight line drawn from the top of the main hoop to the top of the front hoop shall pass over the driver's helmet.

B. Front Hoop:

1. The front hoop shall follow the line of the front pillars to the top of the windshield and be connected, by horizontal bars, to the top of the main hoop on each side (as close to the roof as possible).
2. Two (2) side hoops following the line of the front pillars to the top of the main hoop may be used. These two (2) side hoops are to be connected by a horizontal bar over the top of the windshield. (See Figure 6), or
3. A top "halo" hoop following the roof line from the main hoop to the windshield with forward down tubes following the line of the front pillars to the floor.
4. Double "ear-type" joints are allowed, provided that they are fully welded at all mating surfaces.

C. Fabrication:

The main hoop shall be one continuous length of tubing with smooth continuous bends with no evidence of crimping or wall failure. The minimum radius for all bends shall be three (3) times the tube diameter

measured from the tube centerline. Whenever possible, the roll hoops should start from the floor of the automobile, and, in the case of tube frame construction, be attached to the tubes by means of gussets or metal webs in order to distribute the loads. On automobiles of frameless construction, consideration should be given to using a vertical roll hoop of 360 degrees completely around the inside of the automobile and attached with suitable mounting plates.

18.3.2. Bracing

All required bracing shall be the same diameter and wall thickness as listed in 18.1.6., Material. (Main and Front Hoops)

All main hoops shall incorporate a diagonal brace (same diameter and wall thickness as main hoop) to prevent lateral distortion of the main hoop.

A. Main Hoop Bracing:

Main hoops shall have two (2) braces extending to the rear, attaching to the frame or chassis. Braces shall be attached as near as possible to the top of the main hoop (not more than six (6) inches below the top) and at an included angle of at least thirty (30) degrees. Open cars with a low front hoop shall have **(Effective 1/1/99)** two braces extending from the main hoop to the low front hoop. These braces shall be mounted no lower than six inches below the top of the main hoop as illustrated in Figure 7.

B. Removable Bracing:

Removable bracing shall incorporate connectors of the double lug, tapered, or muff-type as shown in Figures 9, 10, and 11. The double-lug type shall include a doubler, gusset, or capping arrangement so as to avoid distortion or excessive strain caused by welding.

C. Front Hoop Bracing:

There shall be two (2) braces extending forward from the front hoop to protect the driver's legs. It is recommended that this bracing extend to the bulkhead in front of the driver's feet; but, in any case, it shall be integrated into the frame or chassis to provide substantial support for the front hoop.

18.3.3. Side Protection - Open and Closed Automobiles

A. The minimum side protection shall consist of a side tube connecting the front and rear hoops across both the door openings. Additionally, there shall also be either a diagonal tube from the front hoop to the rear hoop bisecting the door opening below the horizontal side tube, or not less than two (2) horizontal side tubes. Additional tubing may be added. NASCAR-style door bars are recommended.

B. In automobiles with full roll cage installations including side bars, interior door panels may be altered, replaced, or removed. When door panels are removed, all sharp edges or projections shall be protected.

18.3.4. Mounting Plates:

The thickness of mounting plates bolted to the structure of the car shall not be less than the thickness of the roll hoop or brace that they attach and shall be backed-up with a plate of equal dimensions on the opposite side of the panel, with the plates through-bolted together. A minimum of three (3) bolts per mounting plate is required for bolted mounting plates. All hardware (bolts) shall be Grade 5 or better with 5/16" diameter minimum. Mounting plates welded to the structure of the car shall not be less than .080" thick. Whenever possible the mounting plates should extend onto a vertical section of the structure (such as door pillar).

18.3.5. Driver's Seat

The driver's seat shall be firmly mounted to the structure of the car. In cars where the seat is upright, the back of the seat shall be firmly attached to the main roll hoop, or it's cross bracing. Bulkheads, firewalls, rear decks, or similar structures of suitable strength may be used as a substitute for the main roll hoop or cross bracing to provide the required seat back support.

Seats homologated to and mounted in accordance with FIA standard 8855-1999 or higher need not have the seat back attached to the roll structure. The homologation labels must be visible. Seat supports shall be of the type listed on FIA technical list No.12 (lateral, bottom, etc).

Fig. 18.3.5.A

FIA Standard 8855 -1999

ABC Seats Ltd.

Model: Super Champion 1996

Homologation N° CS.OO1.96

Date of Manufacture: June 1996

Letters must be at least 8mm high

Sample FIA seat homologation label

18.4. ROLL CAGES, FORMULA AND SPORTS RACING AUTOMOBILES

All Formula and Sports Racing automobiles are required to have full roll cages. Cage may be of two designs, low front hoop (top of steering wheel) or high front hoop (equal to rear hoop) but with no diagonal brace. Two (2) seat Sports Racers shall have full cockpit width cages per Figure 7. All tube frame automobiles shall have both front and rear hoops formed of tubing per 18.1.6. On automobiles of full monocoque construction, a fabricated sheet metal front hoop structure may be approved upon specific application to the SCCA. All Formula Car and Sports Racing roll cage tubing specifications must meet the current GCR specifications, effective 1/1/98.

18.4.1. Main Hoop

The main hoop shall be constructed of tubing per 18.1.6. The minimum bend radius shall not be less than three (3) times the tube diameter measured from the tube centerline. The main hoop shall not be less than two (2) inches above the driver's helmet, seated normally and restrained by seat belt/shoulder harness. A straight line drawn from the top of the main hoop to the top of the front hoop shall pass over the driver's helmet. On Formula cars and single seat Sports Racers the vertical members of the main hoop shall not be less than fifteen (15) inches apart (inside dimension) at their attachment to the chassis. If the hoop does not go to the belly pan, proper gussets and tube triangulation shall be used under its attachment. On monocoque chassis the main hoop shall be welded to mounting plates not less than .080" thick. It is important that these plates be attached to the chassis in such a way as to spread the loads over a wide area. There shall be a plate of equal thickness on the inside of the monocoque with solid rivets or bolts (5/16" minimum bolt diameter) through the non-ferrous material.

18.4.2. Front Hoop

Low front hoops must be no lower than the top of the steering wheel. It is recommended the hoop extend to the belly pan. If not, it shall be attached to the chassis with gussets and triangulation in order to spread the loads. In automobiles of full height (top of the steering wheel) monocoque or composite construction, a steel cap plate, not less than .080" thick must be attached as a rub block.

18.4.3. Roll Cage Bracing

A. The main hoop must have two forward braces extending from the hoop and attached to the frame, monocoque, or front hoop. Braces must be attached as near as possible to the top of the hoop but must not be more than six (6) inches below the top and at an included angle of at least thirty (30) degrees. If these braces do not extend to the front hoop, an additional brace or gusset (14 gauge - .078" minimum thickness) must be installed between the lower frame rail and the upper frame rail at the point of attachment of the forward hoop brace. If these braces do not extend to the front hoop, an additional brace or gusset must be installed at the point of attachment to the main rear hoop or lower frame rail or other major frame member in such a manner as to reinforce the attachment point to help prevent collapse of the frame rail at the point of attachment. These tubes shall be 1" x .080" minimum and gussets shall be 14 gauge - .078" minimum thickness.

   Two seat Sports Racers with full width main hoops must incorporate a lateral brace to prevent lateral distortion of the hoop (See Figure 7). All bracing on full width cages must be the same diameter and wall thickness as the main hoop. Formula and single seat Sports Racers under 1500 lbs., may use bracing with a minimum dimension of 1.0" diameter by .080" wall thickness. Braces attached to monocoque chassis must be welded to plates not less than .080" thick and backed up on the inner side by plates of equal thickness using bolts of Grade 5 or better with 5/16" minimum diameter.

B. The front hoop must have two (2) braces near its top extending forward to protect the driver's legs. It is recommended that this bracing extend to the bulkhead in front of the driver's feet; but in

any case it must be integrated into the chassis to provide substantial support for the front hoop. Full width front hoop bracing shall be a minimum dimension of 1.0" diameter by .080" wall thickness tubing.

   Formula and single seat Sports Racers under 1500 lbs., may use tubing with a minimum dimension of 1.0" diameter by .080" wall thickness. When monocoque construction is used as bracing for the front hoop, it must be approved on an individual basis. If a high front hoop is used, it must be similar in shape to the rear hoop and have two horizontal tubes connecting the top of the front hoop to the top of the main hoop. The bracing for the main hoop remains the same.

C. Removable bracing must incorporate connectors of the double-lug, tapered, or muff-type as shown in Figures 9, 10, and 11. The double-lug type must include a doubler, gusset, or capping arrangement so as to avoid distortion or excessive strain caused by welding.

18.4.4. Composite Chassis Safety Structures

A. The basic purpose of safety structures is to protect the driver. This purpose is the primary design consideration.

B. All cars must have at least two (2) roll over structures, but the use of titanium is prohibited.

   The first roll over structure must be in front of the steering wheel, not more than 25cm forward of the steering wheel rim, and at least as high as the top of the steering wheel rim.

   The second roll over structure must not be less than 50cm behind the first. It must be high enough for a line extending from the top of the front structure to the top of the rear structure to pass over the driver's helmet when he is seated normally in the car with his helmet on and the seat belt fastened. This second structure behind the seat must be symmetrical about the lengthwise centerline of the car and comply with the following dimensions: The top of the roll bar must be at least two (2) inches (5cm) above the driver's helmet when the driver is seated in a normal driving position. No second roll structure on a composite chassis will be considered unless it contains a main hoop having a minimum tubing size of 1.375" x .080" wall thickness. Supplemental braces must have a minimum tubing size of 1.00" x .080" wall thickness.

The roll bar must be capable of withstanding the following stress loading applied simultaneously to the top of the roll bar:

1.5 (X) laterally
5.5 (X) longitudinally in either direction.
7.5 (X) vertically
where (X) = the minimum weight of the car.

The induced loads must be carried over into the primary structure of the chassis.

The ability of the roll bar to bear and distribute the load through the chassis must be demonstrated satisfactorily in test conditions to the SCCA. In conjunction with SCCA, manufacturers of cars utilizing carbon fiber composite survival cell construction will be required to designate repair locations capable of proper evaluation and damage repair. In the event of damage to the chassis, repairs can only be made at these locations.

Proper documentation must be made in the vehicle logbook. No car will be allowed to compete after damage without following this procedure.

18.4.5. *Exceptions for Formula Cars and Sports Racers*

Any roll hoop design which does not comply with the specifications in 18.4., will only be considered if it is accompanied by engineering specifications signed by a registered engineer. No alternate roll hoop will be considered unless it contains a main hoop having a minimum tubing size of 1.375" x .080" wall thickness. The roll bar must be capable of withstanding the following stress loading applied simultaneously to the top of the roll bar: 1.5 (X) laterally, 5.5 (X) longitudinally in both the fore and aft directions, and 7.5 (X) vertically, where (X) = the minimum weight of the car.

18.5. *TOURING ROLL CAGES*

1. *All cars registered after 1/1/03 shall conform to these roll cage rules. Effective 1/1/08 all Touring cars shall conform to these roll cage rules. Full width roll cages are required in all Touring automobiles. Roll cages installed in Touring automobiles are for driver safety and shall be contained entirely within the driver/passenger compartment without removing any panel or accessory not specifically authorized in these rules. The carpet/padding may be cut around the mounting base plates.*

   A. *The cage shall be welded to the car.*

   B. *It shall attach to the car at no more than eight (8) points, with the forward section of the cage attaching to the front bulkhead or front fender wells (see GCR Section 18.2., Figure 1).*

   C. *The front down tubes of the cage shall be mounted to the floor of the vehicle.*

2. *For tubing sizes for front hoop, main hoop, and all required bracing, see GCR Section 18.1.6.C. It is recommended that gussets (flat steel, tubing, etc.) be utilized to strengthen the joints of all required cage elements.*

3. *Main Roll Hoop:*
   The main roll hoop (behind the driver) shall extend the full width of the driver/passenger compartment and shall be as near the roof as possible. It shall incorporate a diagonal lateral brace to prevent lateral distortion of the hoop (See Figure 1). Any number of additional tubes/braces are permitted within the structure of the cage. It is required that the horizontal brace behind the driver's seat (described in Section 18.2.10) continue from the diagonal to the passenger side main hoop upright or that a second diagonal be installed in the mainhoop.

4. *Front Roll Hoops:*

   A. *The front or side hoops shall follow the line of the front pillars to the top of the windshield (as close to the roof as possible) then horizontally to the rear attaching to the main hoop. These two side hoops are to be connected together by a tube over the top of the windshield, or*

   B. *A front hoop following the line of the front pillars and connected by horizontal bars to the main hoop on each side at the top may be used, or*

   C. *A top "halo" hoop following the roofline from the main hoop to the windshield with forward down tubes following the line of the front pillars to the floor.*

   D. *The front or side hoops may extend through the dash pad. This includes the forward part of the door panel if it is an extension of the dash panel.*

   E. *One (1) bar is required in a horizontal plane between forward cage braces in the dash area.*

5. *Bracing:*
The main roll hoop shall have two braces extending to the rear attaching to the frame or chassis. Braces shall be attached as near as possible to the top of the main hoop but, not more than six (6) inches below the top and at an included angle of at least thirty (30) degrees. On cars where the rear window/bulkhead prohibits the installation of rear braces (e.g., Honda del Sol), the main hoop shall be attached to the body by plates welded to the cage and bolted to the stock shoulder harness mounting points. This installation design must also incorporate a diagonal bar connecting the top of the main hoop to the lower front passenger side mounting point ("Petty Bar").

6. *Side Protection:*
NASCAR-style side protection is required on the driver's side and is optional on the passenger side. The driver's window safety net may be mounted to this side protection and the top cage tube NASCAR-style side protection tubes shall extend into the door. The door window glass, window operating mechanism, inner door trim panel, armrest, map pockets, and inside door latch/lock operating mechanism may be removed only if it interfered with the installation of NASCAR-style side protection tubes. The inner door structural panel may be modified, but not removed to facilitate this type of side protection. The stock side impact beam and the outside door latch/lock operating mechanism shall not be removed or modified.

7. *Mounting Plates:*

   A. *Each mounting plate shall be at least .080 thick.*

   B. *Each mounting plate shall not be greater than 100 square inches and shall be no greater than twelve (12) inches or less than two (2) inches on a side.*

   C. *Whenever possible, mounting plates shall extend onto a vertical section of the structure (such as a rocker box).*

   D. *The mounting plate may be multi-angled but must not exceed these dimensions in a flat plane.*

   E. *Any number of tubes may attach to the plate or each other.*

8. *The driver's seat shall be firmly mounted to the structure of the car. In cars where the seat is upright the back of the seat shall be firmly attached to the main roll hoop, or it's cross bracing, so as to provide aft and lateral support. Seats homologated to and mounted in accordance with FIA standard 8855-1999 or higher need not have the seat back attached to the roll structure. The homologation labels must be visible. Seat supports shall be of the type listed on FIA technical list No.12 (lateral, bottom, etc).*

18.6. APPENDAGES

The following procedures are approved for modification to roll bars/cages that do not meet the two (2) inch required minimum: The old main hoop may be cut off near the chassis mounting and a new main hoop of equal tube size or a section of equal tubing size may be added, and inner tube(s) must be used to mate all sections together. All braces must be minimum distance from top of hoop per GCR Section 18. All welding for this modification must be arc welded (min.). The inner tube(s) must be rosette welded three (3) places near top and bottom.

Figure 5

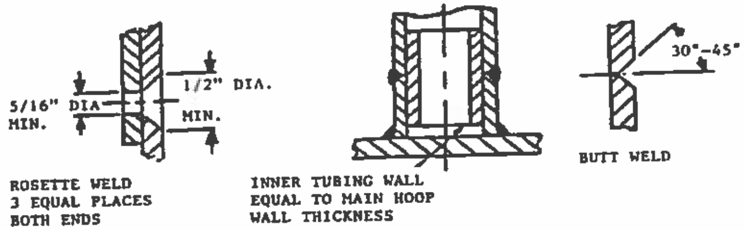


Figure 6: RECOMMENDED ROLL CAGE HIGH FRONT HOOP OPEN AND CLOSED, GT

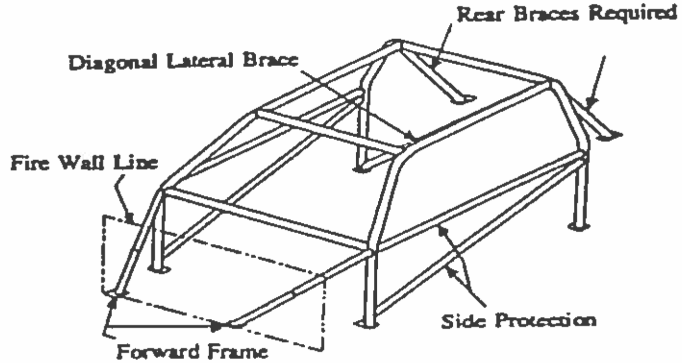
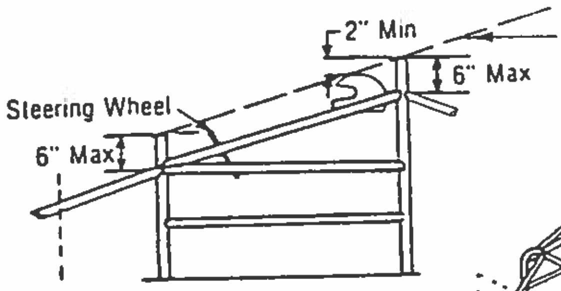
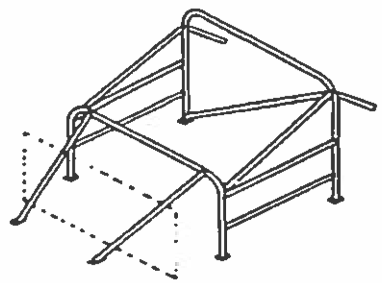


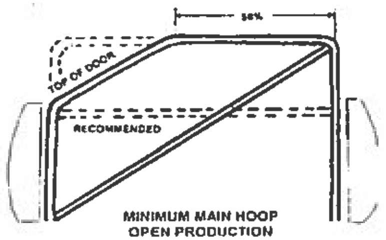
Figure 7: RECOMMENDED ROLL CAGE OPEN-TOP CARS

NOTE: A low front hoop may only be used in open-top cars without a windshield.



Side View - Low Front Hoop
Forward Bracing & Side Protection





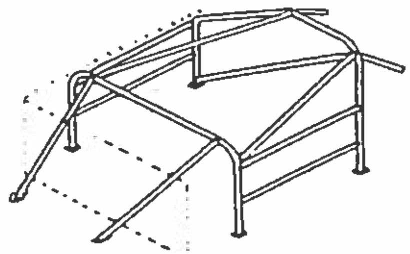


FIGURE 7

FORMULA CARS

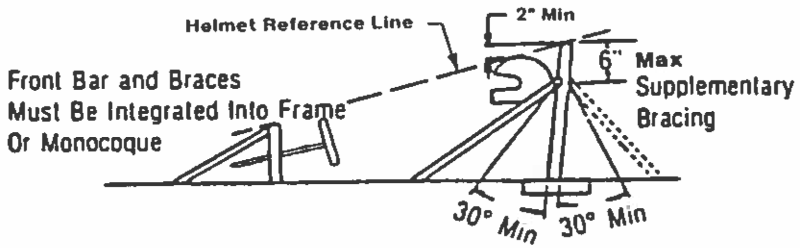


FIGURE 8

Figure 8

REMOVABLE ROLL BAR BRACES ATTACHMENT DETAILS

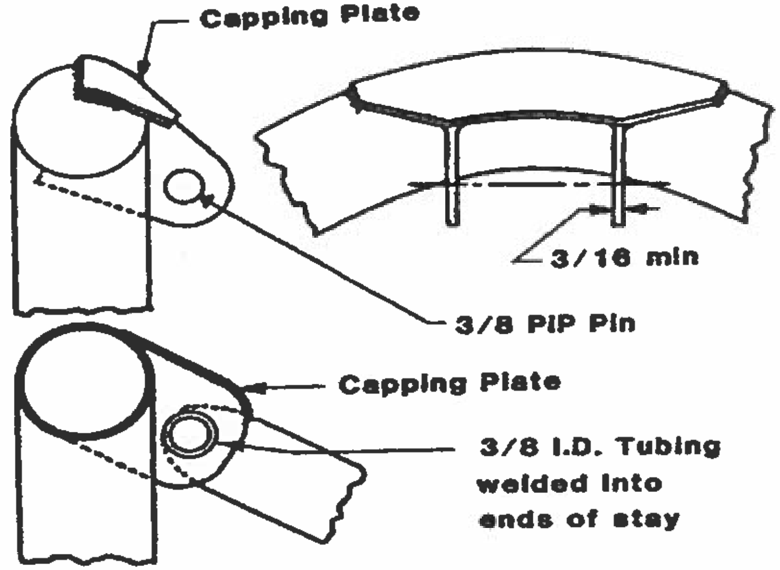


FIGURE 9

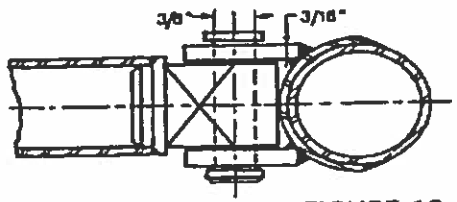


FIGURE 10

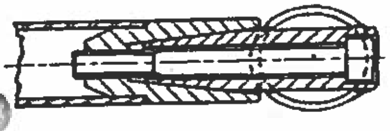


FIGURE 11