Builder's Guide

Revision 2 - Last Update 10/4/23

Ma7da has been running for four years now and car builders and competitors have learned much about these great little cars during this time. Written with a combination of input from teams, individual drivers and specialists, the purpose of this guide is to share knowledge and tips to assist in the building of new Ma7da race cars and provide guidance for preparation and reliability going forward.

It does not contain any setup information, nor is it an official technical or regulation document. Competitors should satisfy themselves that any work carried out is to a suitable and safe standard, and the onus is always on the driver to ensure that their vehicle complies with both Motorsport UK Blue Book regulations, and the Ma7da Championship Technical Regulations.

www.motorsportuk.org/resource-centre

www.750mc.co.uk/formulae/ma7da/regulations

- The ethos of the formula is to provide close, evenly-matched racing, with easy to maintain and cost-effective equipment, and to enable this the regulations are very specific and tightly controlled. The Formula Rep and Technical Working Group will work closely with 750 Motor Club and Motorsport UK Scrutineers to help improve regulations, to ensure fair play and safe racing.

- In the 'Introduction' section of regulations it states *"it should be clearly understood that if the following texts do not clearly specify that you can do it, you must work on the principle that you cannot."* Please keep this in the forefront of your thinking when building and preparing your car.

- The "Locost Novice Pack" (www.750mc.co.uk/ugc-1/1/28/0/2018_locost_novice_pack.pdf) on the Locost page of the 750MC website also contains some useful information. Ma7da is an offshoot from the original Locost formula, so much of the information contained in this

document is common to both formulae. Ma7da use different tyres, brakes, engine, gearbox and engine management systems, so bear this in mind when using this document.

Contents: (The following tips and guidance follow the approximate order laid out in regulations):

Chassis:

It's fair to say that the Mazda engine and gearbox are a tight squeeze into the Locost chassis, and regulations have been updated a little over the years to make installation a little easier.

With sump and chassis ride heights set as they are it is important to get the engine as high as possible within the chassis, so that sump does not hang below chassis too far. It is possible to mount the engine such that the sump projects no more than 20 – 30mm below the chassis, but this does mean that starter motor solenoid may foul on the driver's side engine bay diagonal if engine is mounted centrally. To overcome this you now have two options:

1) Mount engine so that it is at a slight angle to the chassis centre line with front offset towards passenger side. See regulations for maximum dimension of this offset and angle of engine to centre line. Offsetting the engine in this way does not appear to adversely affect the performance and weight distribution of the car or cause excessive wear to prop shaft joints.
2) Fit engine centrally but move the driver's side engine bay diagonal chassis member ('R' on drawing 3 in regulations) outwards slightly at the bulkhead end to prevent starter solenoid fouling. See regulations for distance this member can be moved. It will also need reinforcing, as described in regulations – the photo below shows an example of a gusset reinforcement carried out by a driver:

The tail shaft of gearbox can also foul on the sides of gearbox tunnel. To prevent this the tunnel can be altered at the point where it flairs, in line with chassis members B2 (see Drawing 3 in regulations). This can be done by either widening tunnel at this point or replacing vertical box sections with flat plate. Again, see regs for relevant description and dimensions for this alteration. The photo below shows vertical box replaced with plate, as well as cross piece moved forward to avoid gear stick.

TOP TIPS: *Ensure the starter motor is fitted when offering up engine to ensure it does not foul on engine bay diagonal. It's also worth checking that alternator, exhaust manifold and clutch master cylinder fit without obstruction.*

Consider size and location of pedal box before widening tunnel into driver compartment. Widening to passenger side or using plate in lieu of box may be necessary to avoid impinging on driver foot well.

Bodywork:

Air Filters:

Many competitors fitted air filters protruding through bonnets/nose cones during the 2020 season to improve induction. The 2021 and subsequent regulations have been amended to eliminate unsightly adaptions, so please read carefully before mounting your air filters.

Engine:

As mentioned above there is very little that can be done to a standard Mazda engine, with the exception of routine maintenance with standard or standard pattern parts and minimal (0.008”) head skim. These engines are very easy to check, so please don’t be tempted to carry out any alterations that are not specifically described within regulations.

The Club and Technical Working Group will be working closely with scrutineers to assist policing of regulations in relation to the above.

It is the competitor’s responsibility to ensure that their engine complies with the regulations and that modifications have not been carried out that would deem it ineligible.

This is often difficult when using an engine from a scrapped car that may have had work done by previous owner(s), often unknown. It is worth finding out as much about the donor car as possible, scrap dealers / breakers often have documentation that may detail works previously carried out. Such information is usually more comprehensive when buying engine or donor car from a private seller.

A good indicator whether a cylinder head has been skimmed is the casting/wear blocks on the outer edges of the bottom of the head; there are two on the inlet side and one on the exhaust side. On an untouched head these should be intact, as photo below and the bottom machined faced of the head should be 0.040” (+ or – 0.003”) proud of these (see arrow). This can be checked with feeler gauge without the need to remove cylinder head.

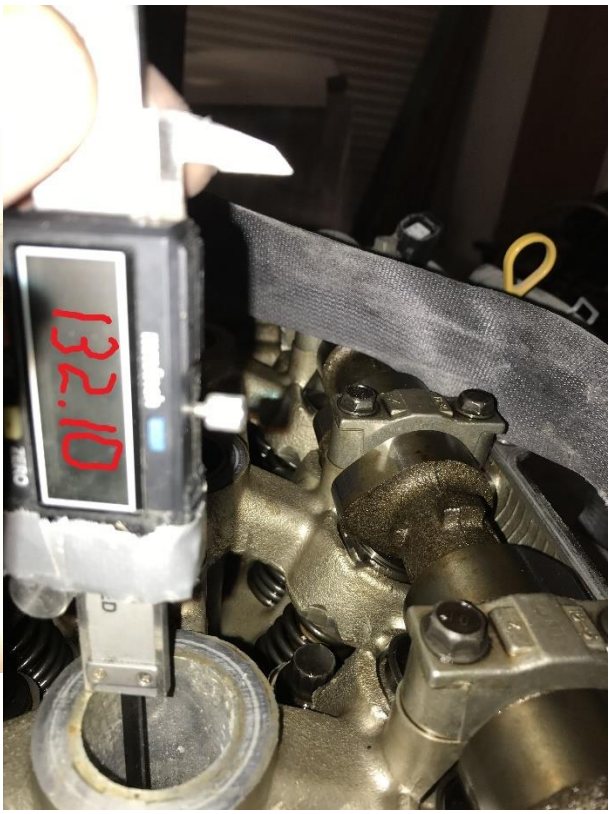
Another useful check is to measure the depth from top face of cylinder head to top of piston at top dead centre. A standard engine leaves the Mazda factory with a cylinder head 133.8 – 134mm deep, a head gasket with compressed thickness of 0.75mm (0.030” + or - .003” or 0.07mm) and a deck height of 2.45mm from top of piston to top face of block. Therefore, the minimum stock dimension from top of cylinder head to top of piston should be 132.10mm (i.e. 133.8 + 0.75 – 2.45 = 132.10mm). If this dimension is any less than this figure there’s a chance that either cylinder head has been skimmed, non-standard gasket has been used, non-standard pistons/rods have been fitted or block has been skimmed; any one of which would render the engine non-compliant.

This depth can be checked with the use of a depth gauge (similar to left hand photo below) or even vernier calipers (as right-hand photo), although this is a little fiddly as the body of vernier doesn’t sit nicely on the head. On a good head the machined face around the plug hole should be in exactly the same plane as the rest of top of head but if this is not clean, has been damaged in any way or head is warped it could affect measurement, so do some checks first. Excessive carbon build-up on the top of the piston can also create a false reading, so it’s worth taking a look at piston crown before measuring. A cheap (£20 ish) endoscope is a great tool for this. Readings may vary very slightly from one cylinder to another, so it’s worth measuring all 4 cylinders and base conclusions on the average reading.

This is only a quick check method and if any suspect readings are returned closer inspection (head removal) may be necessary to find the cause.

Please note: - After permitted head skim of 0.008” this depth should be no less than 131.9mm.

- See also note below about piston crown design.



On the crown of an OEM Mazda piston there is a small raised circle, as photo below. If this is not visible non-standard pistons may be fitted or non-permitted modification may have been undertaken to piston crown.

If de-coking pistons be careful not to remove this raised circle (only a few thou” deep), as this is easily checked by scrutineers.

A standard engine has a compression ratio of 10:1 and a healthy engine produces in the region of 150 -160psi compression. If your engine produces significantly more than this it may again indicate that some modification work has been carried out. This is not a reliable stand-alone test however (use in conjunction with other tests detailed above) and readings can vary considerably from one compression test gauge to another.

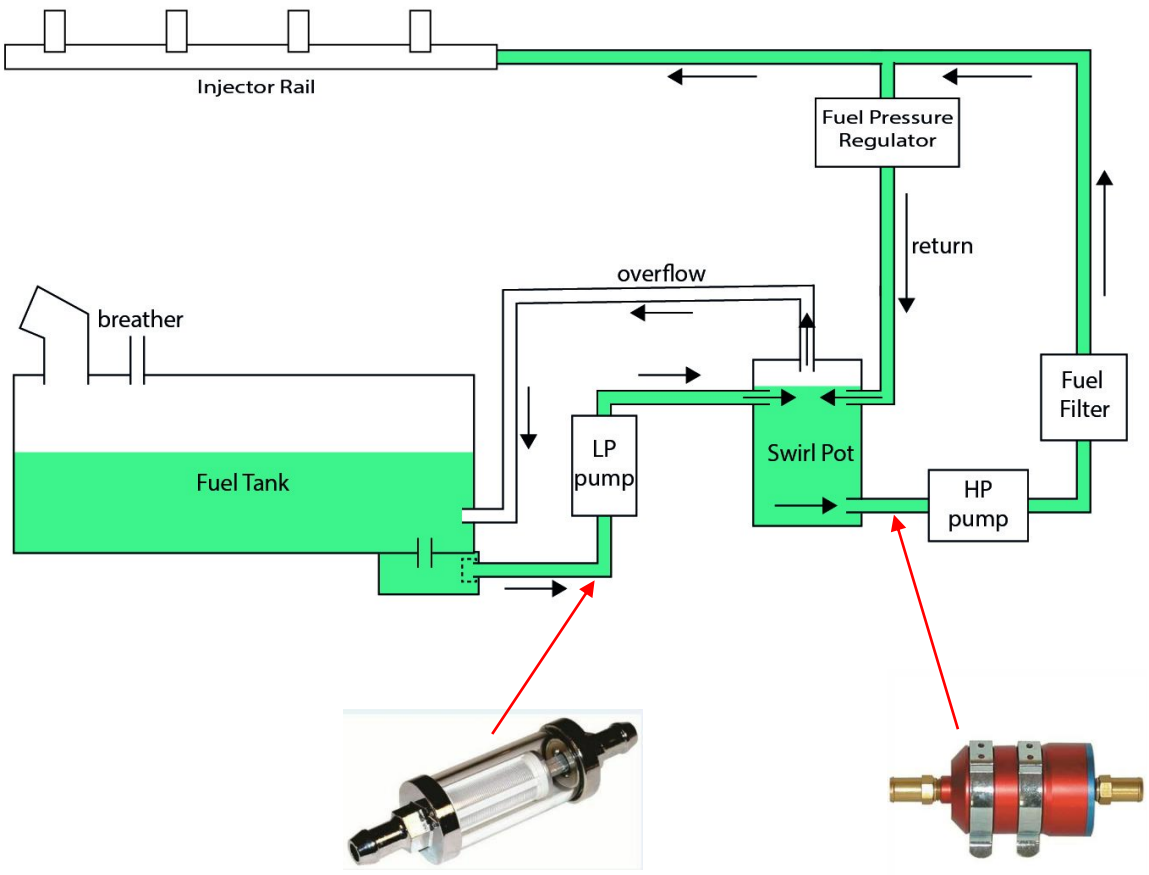
Top Tip: Motorsport UK scrutineers are well aware of all these checks and may well use them as part of their eligibility checks, so PLEASE take special care to ensure your engine is compliant before racing. Engines may also be sealed during the season for stripdown checks at a later date, and cars may also be rolling road tested and/or fitted with 750MC data loggers to measure performance.

Fuel Delivery Systems:

As the Mazda engine is fuel injected fuel needs to be delivered via a high-pressure pump and the fuel delivery system therefore needs to be designed accordingly - it is very different to that fitted in a standard Locost with a low-pressure system feeding a carburettor.

There are effectively two options available, one with external (out of tank) swirl pot fed by low pressure lift pump, or an in tank swirl pot (effectively a baffle) without lift pump. Both systems must incorporate the green control fuel regulator, which must be the last component in the fuel line (can still be fitted in rear of car) before the fuel rail. There are several variations as to how these two options can be installed but to follow are a couple of diagrams that may help.

Option 1) Out of tank swirl pot. A 1-litre swirl pot (e.g. OBP) seems sufficient fed by a basic low pressure lift pump (e.g. FACET 3.0-4.5psi 40105 solid state fuel pump). Swirl pot then gravity feeds a suitable high-pressure pump (e.g. Sytec) and post-pump filter which sends fuel to fuel rail via control regulator. The regulator is plumbed in (side connector) on a spur from the main fuel line, with the return (under side connector) going back to swirl pot. This seems a little odd as fuel does not pass through the regulator on its way to the fuel rail but it does work and excess fuel pressure is released. It is also advisable to put a low pressure (Sytec Pro-Flow) filter before the lift pump and a cleanable high pressure filter (e.g. Sytec) before high pressure pump.

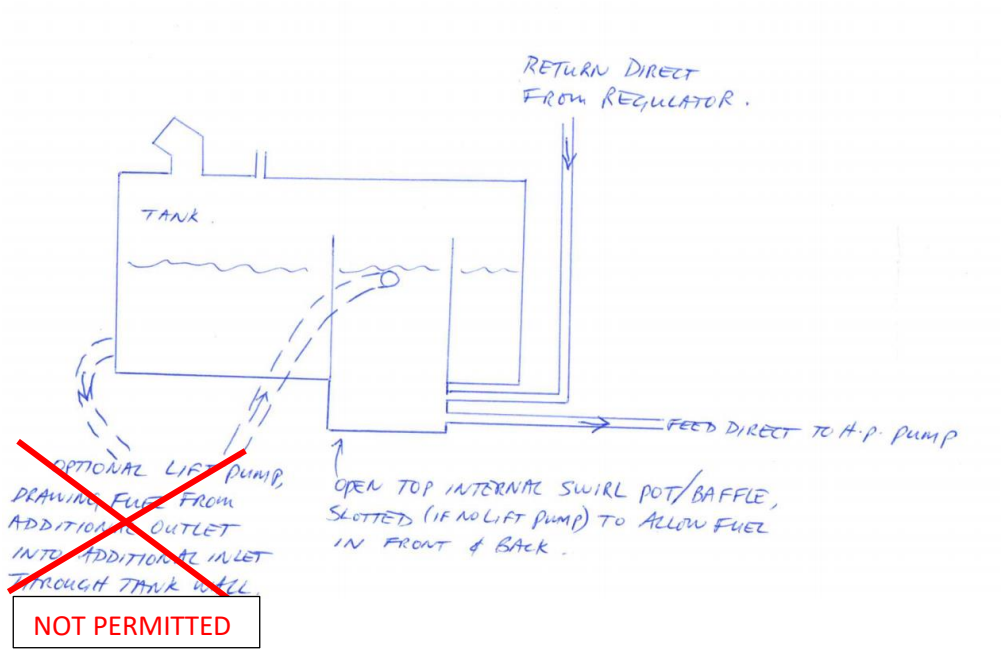


Option 2) In tank swirl pot. Swirl pot can be built into tank so that it feeds directly to high pressure pump and return enters direct from regulator. If designed correctly, slots in the front and back of pot enable fuel to enter the pot, but internal baffles and lack of slots to the sides slow down exit of fuel from pot when cornering. This should ensure there's always sufficient fuel in bottom of swirl pot, even at low fuel level in tank.

This method is much neater and has fewer working parts to go wrong than Option 1. However, it may not be as reliable at picking up fuel, so you may need to maintain a higher fuel level to avoid fuel surge.

We'd recommend using a specialist tank designer/manufacturer, as poor design can create fuel surge problems.

The diagram below shows an optional lift pump but this is not permitted by current regs.



NOT PERMITTED

Induction:

Inlet Plenum:

The GBS inlet has been omitted from regs for 2023 and it is now mandatory to use an unmodified "flat top type" inlet manifold assembly from a UK Mazda BP-6D engine.

All redundant holes / pipes on the inlet (eg. EGR valve port, vacuum take off pipes) should be blocked off to prevent unwanted air leakage.

It is permitted to install a brace to the inlet. This may be worth considering, as excessive resonance has been known to contribute to throttle spindle failures. There are two small brace on the inlet, which are beneficial to retain, as it thought these can help reduce effects of said resonance. One is fitted between the upper section of inlet, close to Throttle body mounting and front of lower section of inlet and the another is fitted between upper section of inlet (again near TB) and fuel rail.

The restrictor plate used during 2022 and previous seasons is now obsolete.

Throttle Body:

One or two issues have been encountered with butterfly spindles and MX-5 cup cars have had problems with such for some while. These can be a point of weakness and if they break it is usually where one of the holes for butterfly retaining grub screws is drilled into spindle. This can result in the throttle butterfly jamming (usually open) and grub screw(s) coming free and entering the plenum or engine, thus making the failure of a minor part a potentially major issue.

The spindle passes through a sleeve on either side of the throttle body and if these are worn can create excessive play in the spindle, which can create flex, thus causing them to break at the weakest point - usually grub screw holes. It's therefore worth checking the play in spindle. It is permitted to insert new brass bushes into the sides of throttle bodies to eliminate excessive play.

It's also worth ensuring that throttle mechanism stops are correctly set, so that excessive force cannot be applied to spindle, through the cable at full throttle. This also prevents cable stretching.

If you fit a long travel throttle mechanism (e.g. long lever pedal or increased diameter spindle wheel) for increased throttle sensitivity this can potentially increase the load on spindle.

TOP TIP: *A blob of Araldite epoxy resin on grub screws can prevent these coming free and entering plenum in the event of a spindle failure.*

Air Filters:

Cooler air is better for induction so think carefully about how to mount your air filter and how best to ensure a good supply of cool air by appropriate use of shields and ducting. See also Bodywork section above.

Exhaust:

Manifold:

Please see Control Parts section below. GBS manifolds have been improved upon over the last few years but may still be a cause for concern, hence introduction of alternative part from JP Exhausts, available via the club. 2021 and subsequent regulations have been amended to allow some alterations to manifolds, to improve strength and gas flow. Again, please be sure to read the regulations very carefully before carrying out any alteration work.

Catalytic Converter:

Cats were a problem in the early days with numerous failures. These were thought to be as a result of vibration/resonance, excessive heat or a combination of the two. We have identified several contributing factors and potential remedies, as below:

- Whilst a good quality cat should be able to cope with the heat produced (typically having a target heat range to function correctly) it may be worth reducing heat as much as possible. Suggestions include locating cat as close to silencer (as opposed to manifold) as possible and ensuring the pipe from manifold does not penetrate too far into the cat. It should terminate at the straight entrance section - if this penetrates past the straight section of pipe into the taper section, it reduces the expansion effect of the taper and will direct heat towards the central part of mantle material.
- Cats are designed to operate best at an optimum temperature but It is not known where best to locate cat (i.e. distance from manifold) to achieve this. It may be worth consulting the manufacturer of your chosen cat.
- Vibration and resonance are suspected to be a bigger factor in cat failures. Suggestions to reduce such include using an exhaust flexible connector between the manifold and cat, as well as flexible (rubber bobbins etc) rather than rigid mounts for the silencer. Flexible engine mounts are also worth consideration rather than solid mounting but there is a performance issue to consider with these also.
- Cheaper cats appear to fail more frequently, and it may therefore be worth upping the budget a little for this item. The Jetex Universal High Flow Cat (https://www.demon-tweeks.com/uk/jetex-universal-high-flow-catalytic-converters-244012/) has been tested and appears to be a durable product, whilst metallic cats appear more durable again, but more costly.

- Stuart at Team Sellars Racing can also supply a 100-cell mantle built into silencer, which may be worth considering. Please remember that as per the regulations, it must be possible to inspect the cat internals at one end, so there must be a removeable connection.

Drivetrain:

Differential:

Diffs have also been cause for concern. Alternatives have been investigated but as there is no direct replacement for the current open diff the Club have decided not to change regulations but this will be kept under review for the future. See note below regarding increased capacity reservoirs and axle tube baffles, which have been added to regs for 2023 and are thought to be reliability improvements.

Whilst the current diff – correctly set up and in good condition - should be good for outputs well in excess of the Mazda engine, research suggests that there are many other factors that affect the loadings through the rear drivetrain, including track design, topography and surface, weather conditions, tyre grip/traction and driving style. For example, an aggressive driver (heavy on throttle, using lots of kerb), using new tyres at optimum operating temperature, on a hot day on a circuit with grippy, bumpy surface may put a lot more load through the axle than a gentler driver, with less grip/traction on a more forgiving circuit in low grip conditions. However it is also known that excessive wheelspin (either from kerb usage, aggressive warming up or wet conditions) also contributes to diff failure on such open differentials.

In addition to this the second-hand diffs that we are currently using are up to 50 years old and often of unknown quality when purchased. It is therefore thought that comprehensive overhaul prior to use is advisable.

The use of a solid (non-crushable) pinion bearing spacer has been suggested and correct set up of pretension and backlash appears to be of great importance.

How to carry out the above overhaul and preparation is beyond the scope of this guide and unless you have appropriate knowledge on the subject we suggest the use of a specialist engineer to carry this out. If you require recommendations please contact Formula Rep, Technical Rep or any member of the Technical Working Group.

New for 2023 is the permitted addition of enlarged diff reservoir and axle baffles, as item 5.9:3 on regulations. Take care that any new reservoir doesn't foul on panhard rod. Location of filler plug is free, so it may be worth fitting this on the left side (looking from rear) of reservoir to aid clearance and make access easier. Location can also be altered to increase oil capacity.

A drain plug can also be fitted (location free) for ease of oil change.

Baffles in axles tubes are also permitted to help prevent oil surge and subsequent starvation to diff.

Engine Management & Electrics:

Alternators:

You can use an alternator for Mk1, 1.6 or 1.8-litre car, which are both self-regulating and suitable for use with the Emerald K6 ECU. The 1.6 model has the wrong (V profile) pulley, so this will need changing before use. The 1.8 model has the correct (grooved profile) pulley, so is directly compatible with the crank pulley on the BP-6D/BP-Z3 engine.

New, standard pattern alternators can be purchased, eg. https://www.mx5parts.co.uk/alternator-aftermarket-mk1-1993-1998-p-2969.html at reasonable price.

WARNING: DO NOT BE TEMPTED TO USE A MK2.5 ALTERNATOR AS FITTED TO THE MA7DA DONOR ENGINE, THIS IS NOT SELF REGULATING AND WILL OVER CHARGE. AS THE EMERALD ECU DOES NOT HAVE A REGULATOR FUNCTION BUILT IN, THIS WILL CAUSE SIGNIFICANT DAMAGE TO ECU.

Without alternator protection (eg. Shunt resistor) fitted to allow alternator to ground safely, ECU damage can occur if car is switched off at high revs from the kill switch, as a result of a huge power surge to the ECU. The solution is ensure alternator protection is fitted (resistor usually comes with kill switch) or just avoid switching off from kill switch, especially from high revs. This may not be possible of cause if you're stuck on the side of track and Marshalls need to kill your engine and ECU with it, so suitable protection is recommended.

Wiring Loom:

Building a loom has been a major challenge for many car builders, without good electrical skills and knowledge. Plugs are difficult to source new and are often therefore sourced from a donor car.

For those not wishing to take on the challenge ready-made looms can be purchased from Great British Sportscars (AKA Kit Spares) or Team Sellars Racing.

ECU:

The Emerald K6 ECU has proved to be an excellent product but doesn't like excessive damp on open cars, so be careful to mount it where it is unlikely to get wet during storage, transportation or on track.

The pins in the loom connection plug can also be a little fragile if repeatedly unplugged and can become dislodged or bent, which can create a difficult to find fault, possibly resulting in loss of ignition. Avoid unplugging and reconnecting unless absolutely necessary and be careful when doing so, making sure the plug attaches squarely to the ECU port.

Scrutineers may also wish to check the serial number on your ECU, so make sure this is visible, so as to avoid the need to remove ECU in scrutineering bay or Parc Ferme.

A new ECU map has been implemented for 2023 and one or two competitors have experienced problems with fuelling (low Air Fuel Ratio) at idle. This is due to a Throttle Position Sensor set up anomaly. If you experience any issues with this please contact Dave or Carl at Emerald (01953 889110), they can rectify this remotely, via Team Viewer, with access to a laptop plugged into ECU with Comms lead.

Brakes:

Front discs:

Many competitors experienced problems when using vented front discs with the widened M16 calliper. It is not clear why this was but those using unvented discs experienced far fewer problems and brake fade as a result of over-heating did not appear to be a major concern. Just something to consider when designing your braking.

Rear Disc Brakes:

Some competitors have experienced issues with rear disc brakes. Pad knock off was an issue for some, which appears to have been caused by fluid drain back pulling pads away from the disc. This may well be caused by the fact that callipers are higher than the master cylinders and fluid naturally drains away from the caliper, back into master cylinder reservoir when pressure is released from brake pedal. The amount of knock off often varied from corner to corner resulting in an unpredictable brake pedal and the need to tap pedal to return pads to correct position between braking zones.

Possible solutions include the installation of residual pressure valves in the brake line or lifting of fluid reservoirs onto bulkhead, so as increase the head of pressure at master cylinder end.

Fitting shims between pad and piston can also help to reduce the amount of knock off.

Some rear calipers are also difficult to bleed due to the high point in the brake line where it passes over the diff. This can sometimes result in trapped air in this raised section of pipe. This can be removed by bleeding from the three-way T-joint where the pipe divides to go to each wheel. It may even be worth installing a four-way join here and adding a bleed nipple.

Different calipers behaved differently, so it's worth doing some research (speak to other competitors) to find the most suitable product.

Mysteriously, the use of bolt on, as opposed to weld on, calliper brackets appears to reduce knock off. There's no obvious reason for this (ability to flex perhaps) but it may be worth considering when designing brake system.

Tyres:

The control tyre introduced for 2023 is the Toyo R888R. This tyre is thought to be very similar to the previously use Yokahama A048 but there will be a learning curve for all competitors.

Control Parts:

These currently include:

Ma7da-specific exhaust manifold and fuel regulator, which are available from GBS/Kitspares at:

https://www.kitspares.co.uk/index.php?route=product/category&path=43_59&car=43

An alternative exhaust manifold manufactured by JP exhausts, is also now permitted and must be purchased from the club.

Locked Ma7da Emerald ECU and wideband lambda sensor kit, which is available from 750 Motor Club:

https://www.750mc.co.uk/store/products,ma7da-championship-ecu-wideband-lambda-kit_116.htm

TOP TIP: We advise against use of cork gasket for throttle body, as these compress too easily and cause throttle body nuts to come loose and then gasket deforms when re-tightened. Metal gaskets are much better .