MERCEDES AMG PETRONAS F1 W05 Technical Specification

Chassis

Monocoque	Moulded carbon fibre and honeycomb composite structure
Bodywork	Carbon fibre composite including engine cover, sidepods, floor, nose, front wing and rear wing
Cockpit	Removable driver's seat made of anatomically formed carbon composite, Sabelt six-point driver safety harness, HANS system
Safety structures	Cockpit survival cell incorporating impact resistant construction and penetration panels, front impact structure, prescribed side impact structures, integrated rear impact structure, front and rear roll structures
Front Suspension	Carbon fibre wishbone and pushrod activated torsion springs and rockers
Rear Suspension	Carbon fibre wishbone and pullrod activated torsion springs and rockers
Dampers	Penske
Wheels	Advanti forged magnesium
Tyres	Pirelli
Brake system	Carbon / carbon discs and pads with rear brake-by-wire
Brake calipers	Brembo
Steering	Power assisted rack and pinion
Steering wheel	Carbon-fibre construction
Electronics	FIA standard ECU and FIA homologated electronic and electrical system
Instrumentation	McLaren Electronic Systems (MES)
Fuel system	ATL Kevlar-reinforced rubber bladder
Lubricants & fluids	PETRONAS Tutela

Transmission

Gearbox	Eight-speed forward, one reverse unit with carbon fibre maincase
Gear selection	Sequential, semi-automatic, hydraulic activation
Clutch	Carbon plate

Dimensions

Overall length	4800mm
Overall width	1800mm
Overall height	950mm
Overall weight	691 kg

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Mercedes-Benz PU106A Hybrid Technical Specification

Power Unit Specification

Type:	Mercedes-Benz PU106A Hybrid
Minimum weight:	145 kg
Power Unit Perimeter:	Internal Combustion Engine (ICE) Motor Generator Unit – Kinetic (MGU-K) Motor Generator Unit – Heat (MGU-H) Energy Store (ES) Turbocharger (TC) Control Electronics (CE)
Power Unit Allocation:	Five Power Units per driver per season

Internal Combustion Engine

Capacity:	1.6 litres
Cylinders:	Six
Bank angle:	90
No of valves:	24
Max rpm ICE:	15,000 rpm
Max fuel flow rate:	100 kg/hour (above 10,500 rpm)
Fuel injection:	High-pressure direct injection (max 500 bar, one injector/cylinder)
Pressure charging:	Single-stage compressor and exhaust turbine on a common shaft
Max rpm exhaust turbine:	125,000 rpm

Energy Recovery System

Architecture:	Integrated Hybrid energy recovery via electrical Motor Generator Units
Energy Store:	Lithium-Ion battery solution, between 20 and 25 kg
Max energy storage/lap:	4 MJ
Max rpm MGU-K:	50,000 rpm
Max power MGU-K:	120 kW (161 hp)
Max energy recovery/lap MGU-K:	2 MJ
Max energy deployment/lap MGU-K:	4 MJ (33.3 s at full power)
Max rpm MGU-H:	125,000 rpm
Max power MGU-H:	Unlimited
Max energy recovery/lap MGU-H:	Unlimited
Max energy deployment/lap MGU-H:	Unlimited

Fuel & Lubricants

Fuel	PETRONAS Primax
Lubricants	PETRONAS Syntium

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2014 Technical Q&A with Paddy Lowe

How significant is the change in technical regulations for the 2014 season?
Paddy Lowe: For 2014 we have probably the greatest change in regulations in Formula One history. The headline is 'efficiency'. The fact that we can run a full race on 100kg rather than 150kg of fuel sends a great message about the technology we can deliver for Formula One – and gives an important message to the automotive world in general. It's not simply about the fuel saved per car on a Sunday afternoon, it's about the technology itself. Over the years, we have seen how relatively small things filter through to the production world, not just in terms of the cars themselves but also what is seen as attractive. We are part of that and it is what Formula One should be doing. It's a great opportunity for Mercedes-Benz and PETRONAS to take those regulations and show we can do better than our competitors. The coming weeks will tell if we have managed that or not.

How has the chassis team had to adapt to the change in Power Unit?
PL: The Power Unit (PU) has a completely different shape and requirements to its predecessor and it is the biggest change in packaging in Formula One for many years. There is a lot more equipment to cool: more Hybrid systems plus the intercooler for the charge air from the turbocharger. That has both a packaging and an aerodynamic dimension. Then there is the weight challenge. Although the minimum weight has been raised to 691 kg, it is far more difficult to achieve than last year's target because of the extra equipment in the Power Unit and its associated systems, plus the cooling demand and the new, heavier side impact structures prescribed by the FIA. Yet another aspect is the thermal challenge. With the introduction of a turbocharger, managing the heat around the exhaust system is important for both car integrity and also for performance. If losses can be minimised in the primaries between the engine block and turbo, that is energy that can be recovered and used for car performance. So there is a big insulation and heat management challenge for both integrity and performance reasons.

What impact have the increased energy recovery requirements had for the chassis team?
PL: We have doubled the amount of kinetic energy that is permitted to be recovered through the rear axle relative to the previous KERS systems. This means that rear brake duty, and therefore the quantity of heat generated, will be far lower. We have automatic systems recovering the energy and so, in order to maintain a driveable brake balance, the rear brakes are permitted to be controlled electronically. We have designed a 'brake-by-wire' system for the rear wheels. When the driver presses the pedal, the system manages the rear brake circuit and the energy recovery requirements together so that the total rear braking effort and the net front-to-rear brake balance matches the driver's demand. The most important aspect to get right with brake-by-wire is failure management. It is obviously a safety critical system and most of our work has been focused around ensuring the right levels of failure control.

Reliability has been spoken about often in connection with the Power Units. Does this present any challenges on the chassis side?
PL: We do have new durability targets to meet, most particularly in relation to the gearbox. It is an entirely new design: it now includes eight speeds, the lower engine speed means a new regime of reduction ratios, there is significantly more torque and the gear ratios must be nominated for the entire season. That means we are not just being stretched in terms of new functionality but also in terms of endurance. Previously, we would re-optimise gear ratios every weekend. The new PU has a wide range of workable engine speeds, which means that ratio choice is nothing like as critical as it was in the past. But the more difficult part is making the physical ratios last for six races instead of one – and indeed making the whole gearbox system last for six races, compared to five last year.

The aerodynamic regulations have also seen significant changes for the new season…
PL: The package of aerodynamic modifications is probably as significant as the changes introduced for the start of the 2009 season. It comprises three main elements. First, the front wing has been narrowed, which has a fundamental effect on the flow field of the car, because the wake from the front wing is its first defining point. Second, at the rear, we have been affected by the loss of exhaust blowing, which was a very significant aspect of car performance in the past three seasons. With the single central exit tailpipe, it has been a challenge to recover the driveability which was very strong as the drivers came on throttle on corner exit. Finally, the rear wing has been altered with the elimination of the lower rear wing and about a 10% reduction in the 'legality box' for the upper rear wing, from 220 mm to 200 mm. At the rear of the car, the floor, lower rear wing and upper wing previously worked as a set and that has now changed, which presents a challenge. Overall, we are obliged to run broadly

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the same level of wing that we would previously have run at Spa in a 'low-drag' configuration. This will mean reduced cornering speeds but also higher straightline speeds.

The Sporting Regulations also now include restrictions on wind tunnel usage. Can you explain their impact?
PL: The teams have policed restrictions on wind tunnel and computational fluid dynamics (CFD) usage for several years now. For 2014 this practice has been written into the Sporting Regulations and will be policed by the FIA. Furthermore the amount of permitted testing has been severely reduced in order to save costs: wind tunnel occupancy is restricted to 60 hours per week (teams had typically been running 24x7), we can only run 80 wind tunnel tests per week, the trading combination between wind tunnel and CFD usage has been further restricted (so-called '30/30' rule) and we have lost the ability to perform full-scale aerodynamic tests in the wind tunnel or on runways. In real terms, that represents an overall reduction in aerodynamic testing of around two thirds.

How satisfied are you with the F1 W05 as a response to the new regulations?
PL: The team has done a fantastic job on each aspect of the project. We have hit our milestones and also our own internal targets. The car is an elegant response to the new regulations but also an aggressive design and, as is often the way, its beauty is much more than skin deep; the internal engineering is extremely innovative and intelligent. I am very proud of the work that has gone into the project so far, which is a huge credit to Bob Bell, Aldo Costa, Geoff Willis, Rob Thomas and the engineering team. Of course everybody is also well aware of how much remains to be done throughout the season; we are only just beginning!

How critical will in-season development prove to be this year, in your opinion?
PL: Formula One is always a development race. The team that can extract the most lap-time benefit from the new wind tunnel restrictions will be rewarded for it, especially so early in a new set of regulations when the development curve is at its steepest. But it won't just be about aerodynamics: owing to the fuel restrictions, the efficiency challenge is possibly the biggest one of all. This is where, for example, our technology partnership with PETRONAS can and will make a significant difference. And finally we must not forget reliability. We are breaking new ground with a number of the technologies in the car but they are of little use if we do not make it to the finish line at each race. So we will be fighting on every front to meet technical and durability challenges this year. And that is exactly what Formula One should be about: adopting and stretching innovative technologies in the most aggressive and ambitious way possible.

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2014 Technical Q&A with Andy Cowell

Andy, what was the thinking behind the new Power Unit regulations?
Andy Cowell: The initial discussions between the FIA and the engine manufacturers were focused on delivering a more efficient internal combustion engine and more potent Hybrid systems. Both sides were keen to move the sport in this direction. With a normally aspirated engine, the power potential is controlled by the flow of air into the engine via the capacity and the rpm it can be run at. However, the automotive industry is focused not on air consumption but on fuel consumption – and the CO2 emissions this generates. The sport has therefore turned the rules on their head with a formula where the performance is restricted by two fuel mechanisms: a maximum fuel flow rate of 100 kg/hr and a maximum race fuel allowance of 100 kg. The fundamental challenge is to convert as much of the chemical energy in the fuel, into mechanical energy, as efficiently as possible at the prescribed flow rate. Conversion efficiency is now the key.

What technologies have been used to achieve that step in efficiency?
AC: To achieve the step change in efficiency required in order to maintain performance levels, we have developed technologies that break new ground not just in racing but also in the wider automotive world. When the regulations were written, it was decided to fix aspects such as the engine configuration, bore size and crankshaft centre line height, to stop the engineers spending time on areas that we are familiar with but where there's no efficiency gain to be had. So instead you focus on areas such as the waste energy in the exhaust flow from the Internal Combustion Engine (ICE), where you can put in a turbine to recover some of that energy, use it to drive the compressor and improve the efficiency of the ICE. Likewise, any excess energy can be put into the battery via an electric motor for use to minimise turbo lag and therefore make the car faster. Equally, we recover kinetic energy under braking, through another electric motor connected to the battery. And having that motor coupled with the ICE allows us to maximise shaft power during acceleration. We have achieved an efficiency gain of over 30% - in other words, we are producing over 30% more power for every unit of fuel consumed compared with last year's V8 engine.

How big a change is this in absolute terms?
AC: I don't think we have ever had such a large change that was mandated in the regulations. The move from the V10 to V8 was compulsory but we were still dealing with a naturally aspirated engine, even with the restrictions that were put in place. KERS in 2009 was not compulsory but rather a performance opportunity to be taken if you could make it work. This change is of an altogether different order of magnitude.

The new Power Unit has been developed hand-in-hand with, and for, the new F1 W05 race car. What have been the advantages of conducting this project as a full works team?
AC: We can go all the way back to the discussions around these regulations, before they were finalised, evaluating their impact. Those conversations happened with our colleagues in Brackley. From the first simulation exercise, we have worked on delivering the fastest possible race car within the regulations to score the most championship points. Everything has been done as one group of engineers. Having that relationship right from the start is a huge benefit because your level of understanding, reasoning and discussion builds from the same point. We haven't lost time with one system team catching up with another, which makes the development journey more efficient. It also keeps the spirit and ethos constant so that, when it comes to hurdles, we have good balance in our decision-making process around what can be compromised and what must not be. It has resulted in a highly integrated assembly with good common understanding of what makes a fast and reliable race car. That spirit of teamwork has also extended to our Research and Development colleagues in Stuttgart, who have made an invaluable contribution to the project in specific areas, such as the turbocharger. It has been a true team effort to develop the best possible technology that Mercedes-Benz can deliver.

How pleased are you with the final result and the level of vehicle integration that has been achieved?
AC: The integration of the Power Unit has been an interesting journey over the past few years. We have gone from initial schemes where you look at the PU in scale compared with the aero surfaces of a racing car and think: "How is that going to be done?" That's where we started the journey and, by working together, you can make those trade-offs in a completely open way. It's been one group of engineers all working to make this Silver Arrow as fast as possible.

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One of the major changes comes in the form of a significantly more powerful Hybrid Energy Recovery System (ERS). What learnings were taken from KERS into the new system?
AC: Our learning during the KERS project was the bedrock for building ERS. But we are talking about a big step not just in absolute power but probably more significantly in terms of duty cycle, in other words the percentage of the time around a lap that it is operation. You could in theory combine two of last year's KERS motors on a single shaft to achieve the maximum power of 120 kW. But instead of using the motor for just short of seven seconds per lap as we did last year, now it's on for over 30 seconds of every lap. And there is also a much greater reliability requirement, because there are only five of these motors per driver per championship. So it's more power, a harder duty cycle and significantly greater reliability demands. What's more, it's no longer something that's 'nice to have' – given the power and the duty cycle, the car will be seconds slower without the MGU-K working, so you need it to do laps. Stitching all of that together with an absolute deadline is a big challenge, probably to an order of ten times more challenging. And that's just one of the six parts of the Power Unit we are producing.

The 2014 rules contain both a maximum race fuel allowance and a maximum fuel rate. In a formula where fuel is now the controlling performance parameter, how important has the contribution of PETRONAS been to delivering the new Power Unit?
AC: PETRONAS have been a really significant partner with huge input into the project. They have been pivotal to the fuel engineering and combustion engineering. The characteristics of the Primax fuel and the way it performs during combustion are key to an efficient and therefore powerful and reliable ICE. The regulations on what can be done with the fuel are pretty tight and they essentially define a regulation window. With a high-revving normally aspirated engine, you end up in one corner of that window; I'd say we are now in a completely opposite corner. The PETRONAS Syntium lubricant also plays a crucial role, with regards to low friction and achieving good life, especially in the new areas of the Power Unit, such as the turbocharger, that require quite different lubricants. It has been invaluable having PETRONAS as a partner right from the start of the project.

Reliability is being widely talked about as the biggest obstacle to success for this season. What is the scale of the challenge?
AC: Change typically risks reliability. If it's the introduction of something totally new like turbochargers, with electric machines connected to them revving to over 100,000 rpm, that is doubly challenging – and therefore a bigger risk to reliability. There are dozens of topics – some technology, some all about detail – that could potentially compromise reliability. And that's the same thing that we have always had in motorsport. There will be hard choices to be made against serious opponents who will push us right to the edge – and there may be mistakes. But we are still talking about getting to the end of a race, faster than anybody else, using the least amount of fuel, on a knife-edge of reliability. That's motor racing; and that's what makes it such a passionate and exciting sport to work in.

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PETRONAS: Technical Partner for Fluid Technology Solutions

Since the modern era of the Silver Arrows began in 2010, PETRONAS has been the Fluid Technology Solutions Partner of the MERCEDES AMG PETRONAS Formula One Team, maximising the potential of lubricant and fuel technology to provide differentiated performance.

For 2014, this relationship has been significantly enhanced, with PETRONAS and the Mercedes-Benz teams in Brackley and Brixworth working hand in hand to develop a high-performance racing machine within the new parameters of FIA regulations. If the Power Unit is the heart of the new Silver Arrow, its lifeblood is the tailor-made fuel and lubricant developed by PETRONAS' technology.

This year, fuel energy density has become one of the controlling performance parameters for the sport and improving efficiency is now fully aligned with improving performance. In this context, lubricants and fuels have a crucial role to play in a number of different ways.

PETRONAS technologists have applied their expertise, honed through optimising PETRONAS Syntium for turbo-charged, direct fuel injection engines in everyday cars, to design and co-develop new lubricants to meet the new challenges posed by the Power Unit.

A key challenge is the downsizing of the Formula 1 engines from V8, 2.4 litre engines to V6, 1.6 litre engines. The smaller Internal Combustion Engine (ICE) and increased power per litre mean that the new engine runs hotter. Oil thins at higher temperatures and thus a hotter engine needs a thicker oil to stop metal components from rubbing together and failing.

However, the hotter conditions and reduced quantity of oil in the ICE (reduced from almost seven litres for the V8 to fewer than three litres for the V6) also mean that the oil must contribute more to cooling the engine. This requires thinner, faster flowing oil.

Additionally, the regulation changes restrict the quantity of fuel that can be consumed per race to 100 kg, which means that the oil needs to help conserve energy by minimising friction. Again, this requires thinner oil.

In order to meet these complex and contradicting requirements, the new engine oil for the 2014 car is a precisely balanced mixture of advanced, thinner synthetic base oils to help cooling and polymer viscosity boosters (which kick-in at higher temperatures) to thicken the oil. Friction-reducing oil components, which make it easier for metal surfaces to slide past each other, have also been used to improve overall fuel economy.

Another consideration is that the higher temperatures also make it more likely that the oil itself will stop working properly. High performance additives have been included to stop the oil from breaking down under these extreme conditions.

Energy losses in the gearbox can also have a significant impact on fuel economy. To address this, PETRONAS technologists have also produced precision gearbox lubricants for the 2014 car to ensure that energy losses in the transmission are kept to a minimum, whilst making sure that the gearbox is protected from failure.

With regard to fuel, a direct injection turbocharged ICE has special requirements in terms of fuel characteristics, for example it is very important that the injector nozzles are not blocked by deposits that come from the fuel.

On top of that, the limits set by FIA with regard to maximum fuel quantity allowed (100 kg) and flow rate (100 kg/hour) mean that every single component in the fuel has to contribute to performance. PETRONAS scientists have developed a new fuel for the 2014 Power Unit molecule-by-molecule, balancing characteristics such as energy density, octane number and volatility with careful consideration of the mandatory fraction of the fuel that must be of bio-origin.

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This poses a unique challenge in itself as some of the best components for delivering high, smooth power are also those that likely lead to deposit build-up in injector nozzles. An extensive development programme involving chemists and engineers testing new fuels in real engines has resulted in a new generation fuel for the V6 that promises to deliver a significant gain in performance.

The contribution of PETRONAS in delivering total Fluid Technology Solutions has been essential to the delivery of the 2014 Power Unit. Never before in the history of Formula One have a Power Unit and its lifeblood been developed so closely. In meeting a challenge almost diametrically opposed to that of the V8 engine, the PETRONAS technical partnership will be an integral factor in success.

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