

LAB TO TRACK

Motorsport's latest fuel and lubricants are benefiting from rapid advances being made in the laboratory. By **Chris Pickering**

MANKIND has an enduring love affair with oil. Be it directly or indirectly, most of civilisation is powered by this curiously versatile organic substance. We use it to fuel us, we use it to heat us, and increasingly we even fight wars over it. Its applications in motorsport are almost as numerous (although fortunately not quite as violent...) and in one form or another it remains the backbone of virtually all racing.

Even trying to define exactly what it is can be a little tricky. Increasingly some or all of the components found in fuels and lubricants are artificially synthesised chemicals, rather than simply a refined form of the crude oil you might find underground. This has been driven by cost, by dwindling supplies and by the never ending quest for purity and performance.

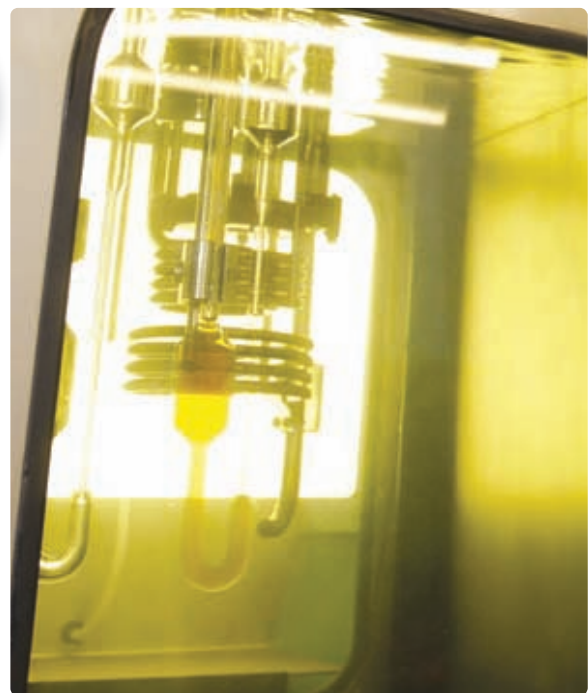
The role of oil as a fuel has gone through a steady process of evolution over the years. Technically speaking, gasoline (or petrol) consists largely of aliphatic hydrocarbons (those which do not contain aromatic rings) enhanced with octane-boosters such as iso-octane, toluene or benzene. Increasingly both pump and race fuels feature some degree of ethanol to oxygenate it, leading to higher octane numbers and cleaner emissions.

For many years lead additives were used to improve fuels' resistance to detonation, and this was also found to provide an additional lubricating effect on

the valve seats. However, the advent of catalytic converters, along with environmental and health concerns, led to these being phased out – at least for mainstream pump fuels – in most countries by the early '90s. The petrochemical industry has since turned to aromatic hydrocarbons, ethers and alcohol for their replacement, but some race series continue to use leaded fuel, particularly in the United States.

On the lubrication side it's much the same process of small, but often significant advances. Much like fuels, lubricants tend to be largely comprised of base oils with various additives dropped in to enhance their performance. These include viscosity index modifiers, dispersants and detergents to clean the engine and prevent sludge build up, corrosion inhibitors and alkaline additives to neutralise the acidic oxidation products of the oil.

Anti-wear and friction-reducing additives are also a small but very important part of the mixture. Traditionally this role has been fulfilled by adding small amounts of zinc dialkyldithiophosphates (better known as ZDDPs), which act as anti-wear film during metal-to-metal contact. Recently, however, much like leaded fuel, these have started being phased out for environmental reasons. In their wake a whole new generation of solid additives has sprung up, such as molybdenum disulphide and PTFE, as well as some more novel solutions.



ABOVE The nano technology of Millers Oils being put to the test, in extreme conditions, in Arena Motorsport's successful BTCC Ford Focus (Photo: BTCC)



ABOVE Millers Oils is one of the companies making a direct link between the laboratory and the racetrack

“We're venturing into the unknown to some extent because the technology is so new”



MILLERS OILS

Our rundown of the fuels and lubricants sector starts with a familiar name. Here at Race Tech we've been following the development of Millers Oils' nano technology since the beginning. Its application in the company's gearbox oil impressed us so much that it scooped the Most Innovative New Product award at last year's Race Tech World Motorsport Symposium, and now the firm is looking to extend this innovative additive technology to its engine oils.

The principle revolves around a family of carbon allotropes known as inorganic fullerenes. At a molecular level their structures resemble hollow spheres, and this allows them to act like ball bearings between two surfaces, dramatically reducing friction over standard lubricants. Millers Oils claims its laboratory tests have shown their coefficient of friction is nearly 50 per cent lower and the unique chemistry of the nano technology lubricants makes them far more resistant to the effects of temperature and pressure changes than conventional solid lubricants. Meanwhile the lack of free sulphide atoms makes them highly resistant to oxidation and virtually – perhaps even literally – chemically inert.

The reason this technology particularly suits gear oils is its performance under extreme pressure conditions, such as the interface between two gear teeth. At first glance its application inside the engine is less obvious; lubrication in the bottom end is largely provided by hydrodynamic oil films built up in the bearings, which rely on an entirely different principle. However, the top end of the engine does exhibit extreme pressure conditions in the valvetrain and block, such as at the top dead centre point on the cylinder liners where the piston rings change direction.

“In theory, if the engine is running under the right loads and speeds you don't even need additives in the oil for bottom end lubrication, but it's the areas where you have high point contact that are the issue,” explains Millers Oils' technical director Martyn Mann. “Nano technology can be used to supplement the lubrication where high contact pressure exists, such as the valvetrain and piston rings at TDC/BDC, and even reduce frictional losses further to release more power.”

It all sounds good in theory, but there are obstacles to bringing this technology into the engine. An engine oil formulation is a balance of additives, designed in the long term, for ▶



“There are about 200 constituent parts in a fuel recipe”

ABOVE & BELOW Shell's trackside analysis service was pioneered in Formula One but has now been extended to other categories

reliability. For a two-hour race duration the formulation could bear little resemblance to a commercially available retail product. We have to incorporate detergents and dispersants to keep engine internals clean and prevent the formation of sludge, lacquers and oxidation. On many engines the oil is actively used to cool areas such as the underside of pistons, which can easily exceed 300 deg C, and turbochargers where it's not unusual to see them glowing cherry red at more than 400 deg C.

The base oil selection is very important as certain additives are surface active and bond to metal surfaces in order to work efficiently. The correct selection of base oils is therefore important to maximise the additive performance. This has led the company to develop a new blend of base oils and additives (including nano technology) to give the best anti-wear performance and frictional reduction characteristics. "We're venturing into the unknown to some extent, because the technology is so new," comments Mann. "We've conducted industry-standard anti-wear tests, which have shown them to be far superior in the valvetrain and liners."

SHELL

Shell is something of a giant in the world of fuels and lubricants. The company has been dealing with oil since the 19th century and its logo – slowly evolving as time goes on – has been a common sight at circuits since the very birth of motorsport. These days its presence is as strong as ever, with an active role in Formula One, NASCAR, sportscar racing and virtually everything in between. Recent firsts for the company include the introduction of trackside analysis and advanced biofuels to Formula One, the development of fuel friction modifier technology for both race and road engines, and introduction of cellulosic ethanol to the Le Mans 24 Hours.



Along with many companies in the petrochemical industry, Shell's expertise spans both fuels and lubricants. First on the agenda as Race Tech catches up with Richard Karlstetter, Shell Global Solutions' Global Technology Manager for Racing Fuels, is fuel. And the secret apparently lies in the details. "Race fuel technology requires extensive research and development expertise," he tells us. "There are about 200 constituent parts in a fuel recipe. Some are adapted specifically for the extremes of motorsport, because refinements that would not matter to a street car can be vital in racing. We have extensive experience developing custom and specialty race fuels for the world of motorsport and we understand the science and technology behind the fuel that can help give racers the competitive advantage."

So what's new? "Mainly for the US, we have developed the Shell Racing Fuels Unleaded Racing Technology," Karlstetter explains. The range (consisting of URT 100, URT 105 and URT Advanced) is designed for applications where an extreme level of knock resistance is ▶



deliveredontime
location.logistics.specialists

Tel + 44 (0) 20 8890 5511
web www.deliveredontime.com
e-mail sales@deliveredontime.com



film



media

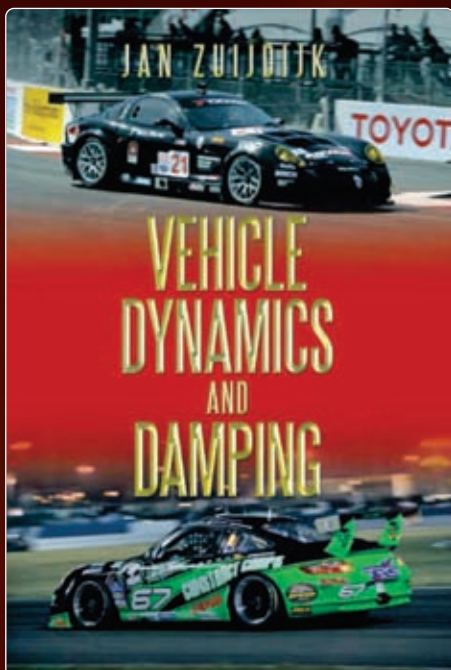


motorsport



events

VEHICLE DYNAMICS & DAMPING BY JAN ZUIJDIJK



£17.50 PLUS P&P

Out now, a vital new book on vehicle dynamics by the renowned Jan Zuijdijk, founder of JRZ Suspension. To order visit our new website at

The author, has been involved with suspension design and development for race and high performance road cars for over 40 years. Starting in the early sixties, suspension components for this kind of applications have evolved from a simple coilover

spring/damper unit to very complex instruments, adjustable in more than four ways. The ride and handling of a racecar is very sensitive to a well tuned damping system which can make the difference between success and failure

www.racetechmag.com

required. These fuels are formulated using unleaded technology that's claimed to provide levels of detonation resistance previously only possible with leaded fuels. Meanwhile, on the other side of the Atlantic, Shell has also introduced a new race fuel specifically designed to meet MSA regulations for use in the UK.

Next up is lubrication, and it's an area which Karlstetter suggests is sometimes misunderstood. "At Shell, we understand that some racers still think 'oil is oil,'" he says. "However, lubricant technology has advanced significantly in recent years, especially on the track. Our global facilities and scientists allow us to work diligently to develop new lubricant technologies for specific racing applications. Our products aren't street oils that have been slightly tweaked; we develop our oils with racing performance and protection in mind."

The company's development is ongoing and its service carries on after the point of sale. "Credibility and success in the motorsport industry requires more than just selling liquids," Karlstetter observes. "You need to combine unique experience, speed and a close integration of cross competencies. Key to ensuring reliable products and to enabling the best reliability is to help with immediate, ideally trackside, services such as fuels and lubricants analysis – especially in a world of growing engine life regulations such as those we're seeing in Formula One, MotoGP and Le Mans."

To this end Shell has introduced what it

refers to as trackside analysis. It's essentially a mobile laboratory that allows chemists to analyse the exact composition of fuel and oil samples to check consistency, diagnose problems and monitor wear. Originally pioneered in Formula One, it has now been extended to Moto GP and Le Mans and provides what Shell colloquially refers to as a blood test for the fuels and lubricants.

ANGLO AMERICAN

The Anglo American Oil Company was formed in Dorset in 1999. It began as a UK distributor for the '76' brand of racing fuels and oils. Most of the 76 range, however, was geared towards the specific requirements of the US market, and this prompted Anglo American to develop its own in-house fuel blends for European applications, sold under the 'R' banner. After 76 withdrew from racing in 2003 Anglo American acquired the European and Middle East distributorship for the Sunoco racing fuel products, which also became the new base-oil source for its own-label blends.

The process begins at Sunoco's facility in Philadelphia. The US company buys crude oil and refines it in-house to produce a very high grade of fuel known as motor alkylate. This is then put through a second distillation process to remove the sulphur, benzene and aromatics to produce the basis of the race fuel, known as race alkylate. This consists of fast burning single-

bonded hydrocarbons, which can be blended in different quantities and with different chemicals and refinery streams to produce a wide range of race fuels to suit a multitude of applications.

For Anglo American's R range, the design, production and quality control are all carried out in-house. Crucially, the blending is done by weight, in contrast to the conventional practice of doing so by volume. This eliminates the variations that can otherwise be caused by the fuel expanding and contracting with temperature, and helps to maximise its consistency. This, claims Anglo American's managing director Anders Hildebrand, results in very pure fuels, virtually devoid of ▶



ABOVE Anglo American's distillation process is conducted in-house

BELOW Sunoco's racing fuel products, showcased in the Grand-Am series, have become the base-oil source for Anglo American's own-label blends



Your access to a fast moving world !

The only reference books that keep you updated with motor racing



Formula One
Over 550 pages



Motorsports
Over 1000 pages

1990-2010
21 YEARS
OF PUBLICATION

Each new edition 100% researched & updated!

In depth information on the actual major players of the 2010 field
Teams, drivers, cars, key people, engine manufacturers, sponsors,
suppliers, marketing & PR, media, organisers, circuits, officials, etc.
Company details including logos, key people with color portrait pictures and
contact details, addresses,
websites, and lot more.

Order now from our secure website
www.whoworksin.com

Who Works Sports Guides Ltd

2nd Floor
145-157 St John Street
London EC1V 4PY
United Kingdom

Tel : + 44 (0)20 71930 686
Email: sales@whoworksin.com
www.whoworksin.com

Last Name (as on card) : _____ First Name: _____

Address: _____

Postcode: _____ Town: _____ Country: _____

Email*: _____ Phone Number*: _____

PAYMENT METHOD: VISA MasterCard

My card number is _____ Expiry date: ____ / ____

Formula 1 - GBP 55.50 x _____ = _____ + Postage per copy: _____ Total Amount: _____
(Postage fees: UK: GBP 6.00, Europe: GBP 8.00, Rest of the World: GBP 13.00 per copy)

Motorsports - GBP 65.50 x _____ = _____ + Postage per copy: _____ Total Amount: _____
(Postage fees: UK: GBP 7.00, Europe: GBP 10.00, Rest of the World: GBP 16.00 per copy)

*Email address and phone number are mandatory for safety reasons



ABOVE A gas chromatograph is used by VP's chief chemist, Duane Minazzi, to verify that blended fuels contain the correct composition prior to drumming and shipping

by-products, that not only perform well, but also burn very cleanly. "People tend to assume race fuels are dirtier than normal pump fuels, but actually the opposite is true," he says. "It's much, much cleaner, and I suspect this is something people will tend to value more in the future."

In fact the potential already exists to produce even cleaner race fuels, but Hildebrand claims the stumbling block is currently the regulations laid out by the sport's governing bodies. "The problem is that the existing regulations are based on pump fuels. The clean burning alkylate fuels have a far higher motor octane number, so you need to add lower grade hydrocarbon streams to separate the research and motor octane numbers in order to meet the regulations," he says. The resistance, Hildebrand suspects, stems from a concern that the higher compression ratios these fuels would allow could see more money being spent on engine development: "They're worried that only people with lots of money could afford to buy them, but that seems odd when on the other hand they are saying that motorsport needs to be greener."

One area that Hildebrand is particularly

keen to extend the clean-burning alkylate technology to – and one where it would have a particularly dramatic effect – is karting. Most serious karts are still two-strokes and this means they eject around 25 per cent of their fuel mixture unburnt through the exhaust. This leaves a toxic haze behind the kart, ready to be inhaled by other drivers (frequently children and sometimes indoors with limited ventilation). "We have developed a fuel with no aromatics, no benzene and no solvents that would slash the emissions ten-fold," Hildebrand claims. "It wouldn't be difficult to manufacture, but at the moment we couldn't sell it due to the regulations."

VP RACING

VP Racing's Jerome Duche is a man on a mission. Brought in this May to increase the Texan company's range of products in the European market, he's looking to shake things up with a new approach. Where the company's fuels were previously developed for America and then exported to Europe only when the applications overlapped, they're now specifically formulated for their individual markets. It's a philosophy that has

already started to bear fruit, with fuels supplied to Super 2000 rally competitors and Formula One teams on the continent.

Behind this new strategy, the same fundamentals exist that made the brand popular in the States. Duche believes the first priority is to get the basics right and this begins with making a choice. "There are essentially two ways of producing race fuel," he explains. "One option is to start from natural crude oil and then introduce various different additives, but the problem with this approach is that the oil's properties vary subtly depending on the time of the year and the exact location it's extracted from. This means you never get a completely consistent base fuel from which to start. The other option is to purchase near-pure compounds from the chemical companies; these are still mineral-based but they're controlled to a far greater extent, ensuring much improved consistency."

From there the next question is how specifically you plan to use the fuel. If you try to make it in large quantities and target a whole championship then the immediate priority is always to produce a fuel that will suit everybody. Power, energy content and so on all play second fiddle to a blend that ▶

DRIVING TECHNOLOGY INTO POLE POSITION

RACE TECH

INTERNATIONAL



12 Issues for the price of 10!

	12 (one year)	24 (two years)	Back Issues
UK	£ 49.50	£ 99.00	£5.95 + p&p
USA	\$ 127.50	\$ 255.00	\$12.00 + p&p
EUROPE	E 82.00	E 164.00	E 8.90 + p&p
REST OF WORLD	£ 80.00	£ 160.00	£5.95 + p&p
INSTITUTIONS	£ 94.80	£ 190.60	£5.95 + p&p

Student discount of 10%

RACE TECH

RACE TECH magazine is the only independent, technology led motorsport magazine that focuses on every aspect of racing car engineering. Totally international in its outlook, it covers everything that can be found competing on the track from Formula One to the Clubman's single-seaters, from NASCAR to the Silver Crown cars and from sports racing cars to the weekend hillclimb specials.

Topics covered include Engine Components, Aerodynamics, Brake Technology, CAD/CAM, CFD and simulation software, Coatings, Composites, Connectors, Cooling Systems, Control Systems, Data Acquisition, Drivetrain, Chassis and Transmission Dynos, Electronics, Fabrication, Fluid Systems, Gauges and Instrument Panels, Ignition Systems, Lubricants, Machine Tools, Materials, Powertrain, Radiators, Safety Equipment, Simulation, Suspension Systems, Testing, Track equipment, Transmissions, Tyres, Water Pumps and Wind Tunnels. If you want to reach those parts of the industry that no other publication can, then look no further than RACE TECH.

Subscribe online
and get 40% off
www.racetechmag.com

Payment by cheque/bankers draft/money order in Pound Sterling to **Racecar Graphic Ltd**; please indicate which is enclosed in the Card No. Box

<p>Card Number <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Name: _____</p> <p>Job Title: _____</p> <p>Subscription Address: _____ _____ _____</p> <p>Telephone _____</p> <p>Fax: _____</p> <p>e-mail: _____</p>	<p>Valid From <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Expiry Date <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Security Code (Found on the signature strip) <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Switch Issue Number <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Amount £ US\$ ⇄ <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/></p> <p>Cardholders signature _____</p>
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Faxback this form on +44 (0) 208 446 2191

Racecar Graphic are leading publishers of motor racing books and periodicals, and organisers of specialist workshops for the industry. Racecar Graphic publish the monthly Race Tech magazine.

For further information please contact Racecar Graphic Limited e-mail: info@racetechmag.com
 841 High Road, London, N12 8PT, UK, Tel +44 (0) 208 446 2100 Fax +44 (0) 208 446 2191
 E-mail: info@racetechmag.com. Website: www.racetechmag.com



BELOW A partnership with the Great American Stock Car Series could prove an outlet for Swift's 110 race fuel



“We’ve seen a 7 to 15 per cent reduction in fuel consumption on a test engine”

will work with a range of a compression ratios, turbo pressures, ignition timings, etc. There’s sound commercial reasoning behind this, but it is by definition a compromise and this inevitably means there are greater benefits to be found. In response to this, VP Racing has begun developing fuels for individual customers.

It’s what Duche refers to as “an à la carte” approach, allowing engineers to pick and choose the individual attributes (and hence composition) they require. There are various additives on the menu: detergents to remove deposits from the cylinders; agents which improve atomisation in order to increase the surface contact between the fuel droplets and the air, leading to better combustion; lubricants; and charge cooling additives.

“It all depends on the customer requirements,” explains Duche. “For example, we found at a recent World Superbike meeting that one customer was having temperature issues, which we were

able to cure with additives, enabling them to produce more power.” The same goes for the base oil. Some, for example, have an extremely rapid burn rate, which could be crucial in a very high-revving engine, but largely irrelevant in a rally unit that produces its maximum torque at 4,000 rpm.

VP has taken this approach a stage further in its Formula One fuel, where the company now develops different blends for different circuits. “Some are biased more towards low end torque, others towards top end power,” says Duche. “If, for example, there are a lot of short curves, then you need a lot of power at low rpm and very good transient response, but long straights tend to favour sustained high rpm output.”

SWIFT ENTERPRISES

It seems everywhere you go in motorsport people are talking about alternative fuels. But making the switch isn’t always easy – they can be costly, they usually require

some degree of re-calibration of the engine and they frequently need changes to the fuel hardware (both on and off the car). Indiana-based Swift Enterprises may just have the answer, however, in the form of a process originally developed for the production of aviation fuel, but which is now coming to the racetrack.

Swift 110, as the fuel is known, is described as a second or third generation biofuel (depending on whose definition you use). First generation fuels such as bioethanol or biodiesel are produced by fermenting an alcohol. This is a process which requires a large energy input due to the high proof alcohol that needs to be distilled and, once it’s done, the final product still needs to be combined with petroleum to some extent before it’s ready to be used in a conventional engine.

Swift Enterprises claims to have addressed both these issues, and its 110 biofuel is thought to be the only direct ‘drop in’ replacement for high-octane gasoline on the

market. The reason, explains the company's vice president of renewable fuels, Jon Ziulkowski, is that it's been cheaper to use alternative methods until now. The key to unlocking this process, he claims, is the 'selective novel catalyst' technology employed by Swift Enterprises.

"The process begins with waste biomass, that's used to extract sugar either directly or via a lignum type process," explains Ziulkowski. "Next, instead of fermenting it straight into ethanol, we use it to produce acetone, which acts as an intermediate component. This is carried out in a bio-process, similar to the acetone stage of the old ABE acetone-butanol-ethanol (ABE) fermentation process, only without the other two products. It produces 100% bio-derived acetone which is then run through a gas-phase reaction system, during which it is passed over a catalytic bed in a gaseous state. The catalyst is specifically designed to produce the desired hydrocarbons; effectively it splits the molecules of acetone and collects the resulting compounds when they condense on the other side of the reaction system. These form the basis of the fuel."

Ziulkowski claims that this results in an extremely pure output, with less than one per cent by-product. The only waste products are water and un-reacted acetone and these are cycled straight back into the process. This purity, he claims, is one of the key features of the process: "In the mainstream petrochemical industry people tend to produce hydrocarbons in a group – be it higher aromatics or amenes – they don't try and specifically produce, say, isooctane or isoheptane. What we produce is essentially the same as what you'd end up with if you refined petroleum into its constituent hydrocarbons. If we tried to do so from petroleum by distillation it would be hugely expensive – \$60 or \$70 a gallon for each component – yet we can manufacture them synthetically for less than a dollar per US gallon."

Once the component hydrocarbons have been produced they can then be blended together in varying ratios to promote different properties in the final product. "If we needed to, say, boost the vapour pressure we know from experience which components to increase," notes Ziulkowski. "These adjustments tend to have a knock on effect elsewhere, so you then find yourself trying to compensate for them,

making it a pretty fine balance."

It may be a tricky balancing act, but it's one Swift Enterprises claims to have down to a fine art. Of the 44 parameters set by the ASTM for aviation fuel – motor octane number, research octane, supercharger number, Reid vapour pressure, auto ignition temperature and so on – it matches regular gasoline on 42. According to Ziulkowski the only parameters it doesn't meet are those specifically set for petroleum based-fuels.

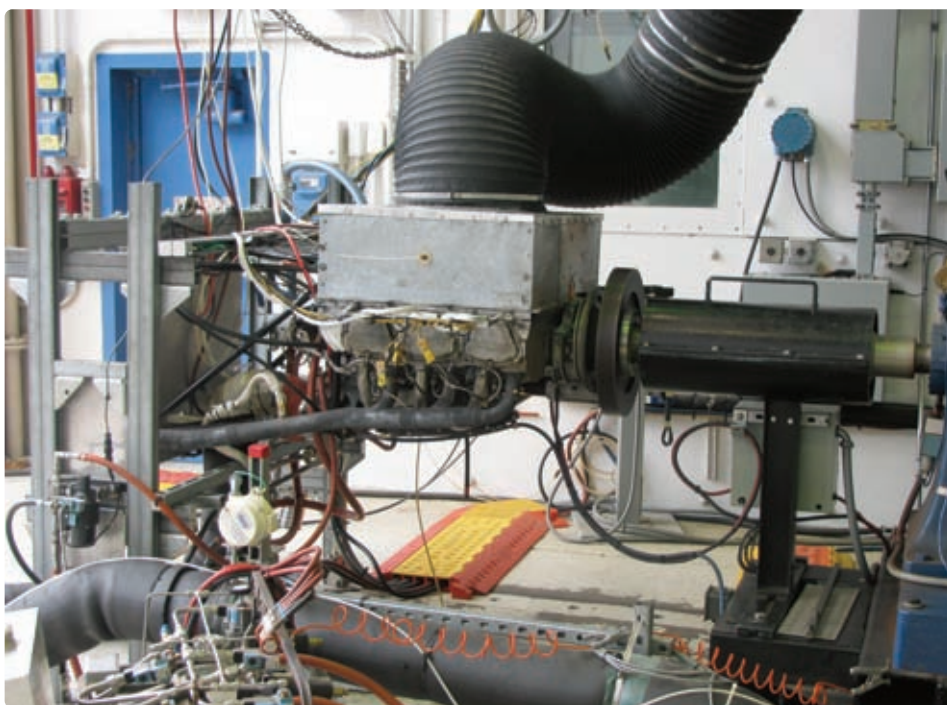
"One of them, for example, was a point on the distillation curve, which doesn't really affect the performance of the fuel," he notes.

It's claimed that the benefits of using pure synthetic base stock extend to emissions as well. "We've proven (along with the FAA) that you get an overall reduction of around 50 per cent in vital greenhouse gasses such

as CO₂ and NO_x," Ziulkowski continues.

"The reason for this is simply that there is far less waste product. Conventional gasoline has anywhere between 70 and 100 different hydrocarbons in it; our fuel only has two or three components. It means that far more of the fuel mixture is combustible. We've also seen a 7 to 15 per cent reduction in fuel consumption on a test engine – simply because there's more energy per gallon in our synthetic fuel than there is in normal racing gasoline."

Development is still continuing on the Swift 110 race fuel, but proof of the company's claims is edging closer. It has struck up a partnership with the Great American Stock Car Series that's currently testing its fuels in individual cars with a view to widespread introduction next season. **RT**



ABOVE & LEFT Swift Enterprises' expertise in aviation technology could now be heading for the racetrack