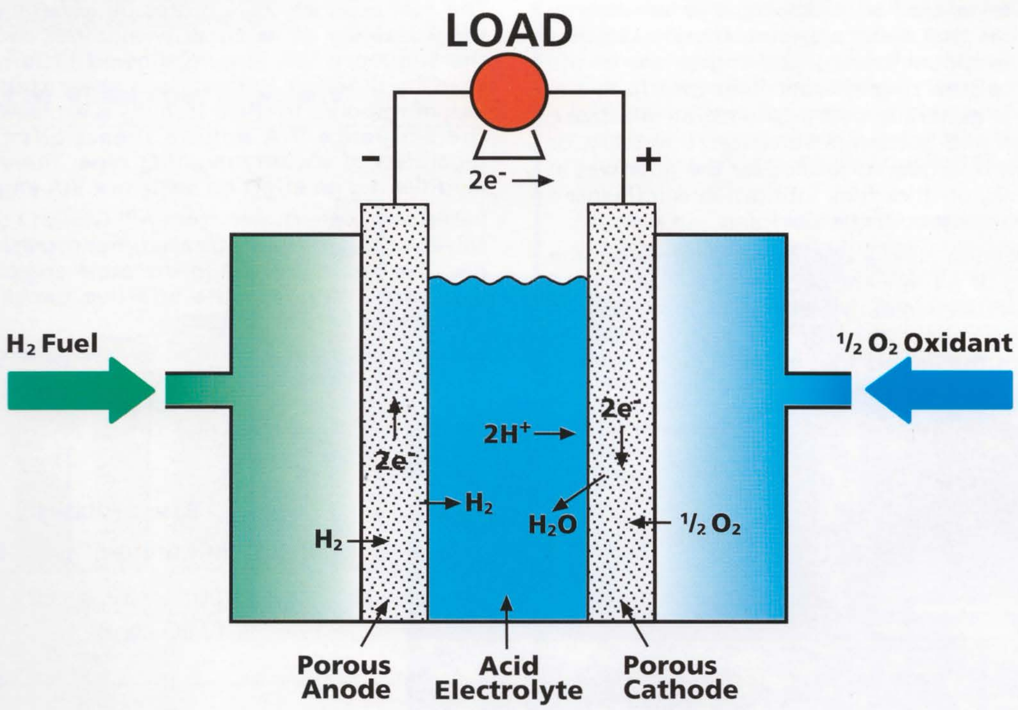
LUBETECH
NO.5

The Hydrogen Fuel Cell

Definition: "An electrical cell that converts the intrinsic chemical free energy of a fuel directly into direct-current electrical energy in a continuous catalytic process."

DIAGRAM SHOWING THE PRINCIPLE OF OPERATION OF A FUEL CELL



A.J. Appleby and F.R. Foulkes, Fuel Cell Handbook, *Van Niostrand Reinhold,* 1989.

The technical process of the modern automotive fuel cell is as follows, the gases hydrogen (from fuel or as a pressurised gas) and oxygen (usually from air) are fed to a stacked array of fuel cells. Each cell is comprised of a polymer electrolyte membrane combined with a catalyst - usually platinum. The stacked array, which needs to be kept humidified, has various other connections for services etc. The electrolyte only allows one of these two gases to pass through it as electrically charged ions; hydrogen negatively charged electrons remain on one side of the cell with a positive charge being generated on the oxygen supply side. The cell is provided with a porous anode and cathode which allow the reaction between the gases and the electrolyte which generates a stream of electrons (as an electric current) which pass between them. This is used to externally power the electric load. In the case of motor cars, the vehicles motive power source is an electric motor(s) plus in some cases a separate capacitor – used like a battery for rapid electric storage and discharge during acceleration. Electrical energy can also be stored in the capacitor from that produced from braking or deceleration.

In a typical thermal power conversion process, the heat of combustion of the fuel is turned into electrical work via a Carnot heat-engine cycle, coupled with a rotating electrical generator.

H_2 (g) + $\frac{1}{2}$ O_2 (g) $\rightarrow H_2O$ (l)

Under standard conditions of temperature and pressure, 25(C (77(F) and 1 atm (100 kilopascals) the reaction takes place with a free-energy change (G = -56.69 Kcal (237 kilojoules) per mol of water. Since the formation of water involves two electrons, this value corresponds to -1.23 electronvolts (1eV = 23.06 Kcal/equivalent). Thus at thermodynamic equilibrium (zero current) the cell voltage should be 1.23V, yielding a theoretical efficiency based on the heat of combustion [(H for H_2O = -1.48 eV] of 83.1%.

One advanced example of this process was recently unveiled by Mazda of Japan, its the Demio FCEV (Fuel Cell Electric Vehicle) and a picture of it is shown below. This experimental prototype car is

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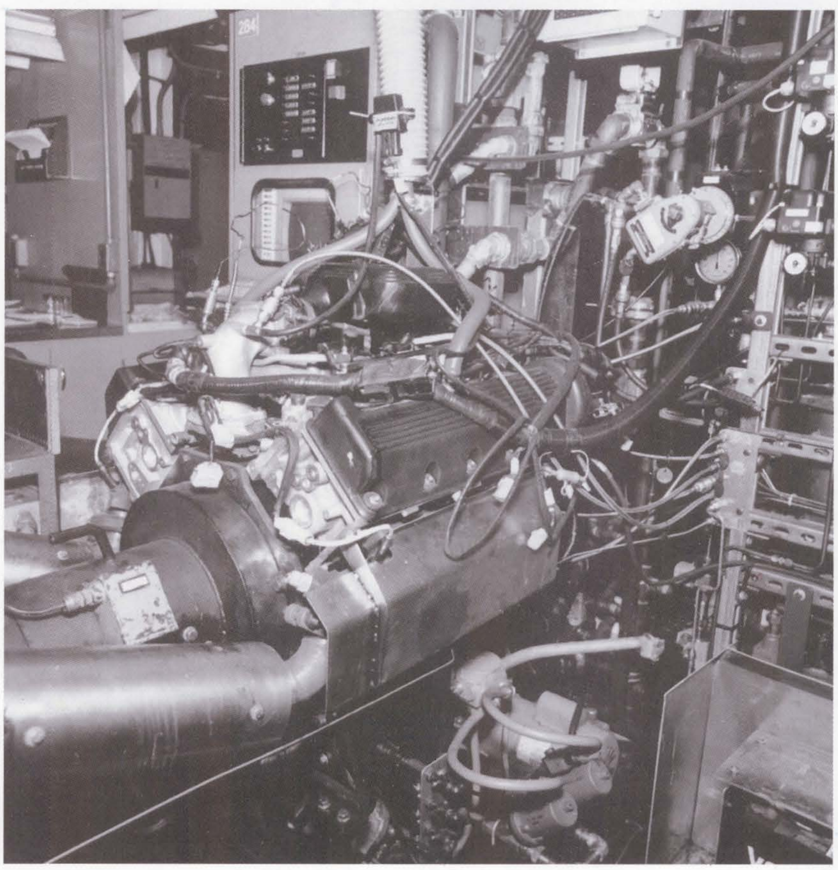
LUBE-TECH

Fuel Economy Measurements in the Sequence VI A Test

Lubrizol tests demonstrate viscosity modifiers have little impact on fuel economy, while high VI base oils improve it.

One way to improve vehicle fuel efficiency is to use energy conserving motor oils that reduce engine friction. Studies show that 44% of frictional losses in an engine are in the piston area. At the piston ring/cylinder liner interface, the lubrication regime is generally hydrodynamic at midstroke and boundary at top and bottom dead center. Boundary, or thin film, lubrication is largely controlled by the additives in the oil. Hydrodynamic, or thick film, lubrication is influenced by the viscosity characteristics of the lubricant.

Hydrodynamic lubrication plays a key role in determining the fuel economy rating of a lubricant because the engine used in the Sequence VIA fuel economy test spends more time in this regime than its predecessor. For this reason, Lubrizol conducted a study of the impact that viscosity modifiers and base oils have on the hydrodynamic lubrication regime.



Sequence VIA test stand.

The fuel economy of a motor oil generally improves as the shear stability of its viscosity modifier decreases. However, the Sequence VIA engine showed little response to using viscosity modifier with various shear stability indexes. The lack of response to shear stability is explained by the fact that the Sequence VIA engine shears oils to similar levels, regardless of viscosity modifier type. Therefore, the viscosity modifier has no effect on Sequence VIA engine performance.

Basestocks were chosen from API Groups I to IV, representing solvent refined, hydrotreated, hydrocracked and synthetic oils. The tests were run in the same engine stand to reduce test variability, and the additive package and viscosity modifier were held constant.

Base oil ratios were adjusted to meet a target blend viscosity of 10.4 cSt. Two Group I and II oils were tested to ensure that the base oil effect was the same within these groups. Only one Group III and one Group IV oil were tested:

Base Oil Ratios

Blend	BOI Group	Base Oil
A	I	100N/140N
B	I	100N
C	II	100N
D	II	100N/170N
E	III	90N/250N
F	IV	4/8 cSt

Changing base oil in these formulations affected low temperature viscosity; therefore, the Group III and Group IV blends were SAE 0W-30 grades rather than SAE 5W-30 blends.

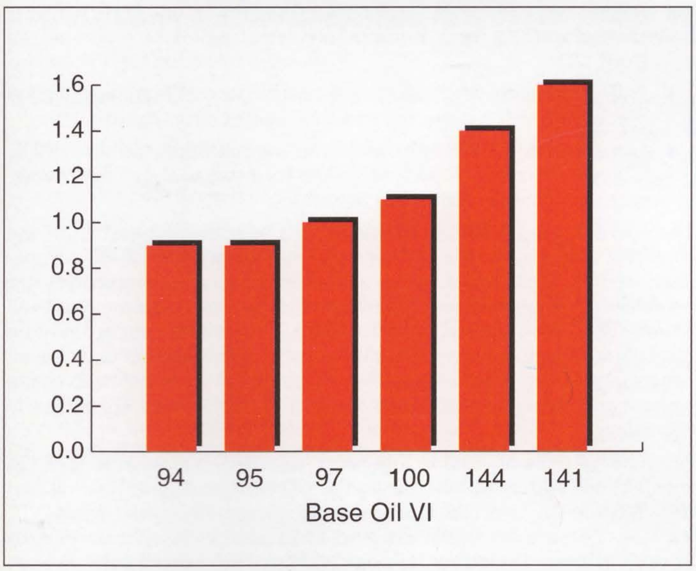
Sequence VIA results indicate that base oil Groups I and II behave similarly while Groups III and IV show improved fuel economy, as expected. The data indicate that oils with higher viscosity index provide a fuel economy advantage:

Blend	BOI Group	SAE Grade	%FEI
A	I	5W-30	0.9
B	I	5W-30	0.9
C	II	5W-30	1.0
D	II	5W-30	1.1
E	III	0W-30	1.4
F	IV	0W-30	1.6

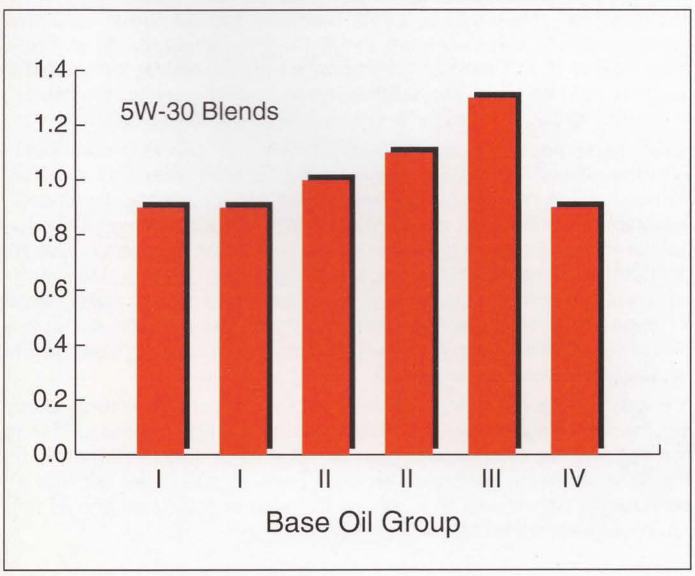
However, from a practical standpoint, higher viscosity index oils drifted out of specification on low temperature properties. Therefore. the Group III and IV oils were reblended to SAE 5W-30 grade so that all oils could be compared as SAE 5W-30 blends. Sequence VIA testing showed a small loss of fuel economy in the Group III stock (1.3% FEI) and a much larger loss in the Group IV stock (0.9% FEI).

The Group III stocks used in this study clearly show a fuel economy advantage over the other stocks tested as SAE 5W-30 blends. Because Group IV stocks have excellent low temperature properties, a significantly heavier base oil mix was required to make the SAE 5W-30 viscosity grade. As expected, the heavier basestocks and lower level of viscosity modifier had a negative impact on hydrodynamic lubrication. Compared as SAE 0W-30 oils, the Group III and IV basestocks produced very similar Sequence VIA results. Comparing all blends tested, the Group III stocks perform best in the Sequence VIA fuel economy test.

Effect of VI on Fuel Economy



Base Oil Effect on Fuel Economy



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being used to evaluate its fuel cell's driveability, control systems and fuel efficiency. Maximum speed capability is expected to be 90km/h while the car's range is 170km per full charge of hydrogen.

The Demio FCEV is powered by a fuel cell system, which generates electricity through the electrochemical reaction described above, using hydrogen and oxygen. The Mazda vehicle's fuel cell system is composed of polymer electrolyte fuel cell stack fed with hydrogen from a metal hydride hydrogen storage tank and a small air compressor to feed oxygen (air into the fuel cell stack).

Once clear advantage with Mazda's fuel cell system is its compactness. This has been achieved by eliminating the external air humidifier. The polymer electrolyte membrane always contains water for its fuel cell operation. In the conventional polymer electrolyte fuel system, hydrogen and air are externally humidified. However, Mazda's fuel cell effectively uses the water, which is produced in the electro-chemical reaction process, and it eliminates the external air humidifier, which normally occupies 15% of the volume of the fuel cell stack.

Mazda has also adopted an ultracapacitor, durable under repetitive use, which provides supplemental electricity by charging and discharging electricity required for acceleration.

The FCEV's claim to be the "next generation"electric vehicle is based on the fact that the car has an on-board electric generator consuming hydrogen as a fuel rather than "conventional"electric vehicles with an on-board battery to store energy. The fuel cell emits only water as a by-product of the electro-chemical reaction. No pollutants such as carbon dioxide and nitrous oxide are emitted since the source of fuel is hydrogen and no combustion activity is involved. Furthermore, higher efficiency in energy conversion is achieved when compared with conventional internal combustion engines since there is less heat loss.

Mazda has a fine track record for being at the forefront of technologically advanced developments and it has been studying the application of hydrogen to power cars for a long time, including the hydrogen rotary engine.

Fuel cells have three key advantages over batteries for electric vehicle. They will cost less, they don't have the range limitations of batteries and their durability isn't limited. In the main, hydrogen fuel is made by the conversion over a catalyst from a range of different fuels, such as methanol or natural gas, plus there is the option of storing pure hydrogen in a metal hydride storage tank. Hydrogen is one of the most widely available elements on our planet, so supplies of this element, though strictly from finite resources, should be almost unlimited and most importantly the process is pollution free. The cell's other main requirement oxygen, is provided from compressed air, again freely available.

Other constituent parts of the cell are not so readily available. Platinum and other precious metals are key components used as catalysts in the fuel cell, so there is an environmental cost to producing this power unit. Currently the manufacturing cost of the cell is many times more per kilowatt of output than for a conventional internal combustion engine, but this is expected to reduce to an acceptable level as production is scaled up.

Rod Parker

LUBE-TECH

DEVELOPING NEW STANDARDS WITHIN THE UK LUBRICANTS INDUSTRY

We are all familiar with the concept of standards, i.e. an accepted or approved example of something against which others are judged or measured, a principle of property, honesty, and integrity, or a level of excellence or quality. The concept of standards is generally associated with products, whereby a level of excellence or quality is defined, which is then formally recognised, in the form of a BS Kite-mark for example.

Why do we use standards?

Briefly, the use of standards provides the basic elements for competitive and cost-effective production. The main elements can be summarised as follows:

- To promote quality of products, processes and services by defining those features and characteristics that govern their ability to satisfy given needs, i.e. fitness for purpose
- To promote improvement in the quality of life, safety, health and the protection of the environment
- To promote the economic use of materials, energy and human resources in the production and exchange of goods
- To promote clear and unambiguous communication between all interested parties, in a form suitable for reference or quotation in legally binding documents
- To promote industrial efficiency through variety control, and last, but not least,
- To promote international trade by the removal of barriers caused by differences in national practices.

It is this last element which is particularly important to BLF Members who are involved in cross-border trade. Crucial to the success of the UK in world markets is a strong voice in the preparation of International and European standards. These essential documents underpin trade and the greater the influence that can be brought to bear on their development and final content, the more easily UK industry can conduct trade in overseas markets. Thus, it is essential that the standards when formulated do not provide any advantages or unfair competitive edge to any of the individual countries that would enable them to enjoy a commercial advantage as a result.

Understanding the standards-making process for the UK lubricants industry.

Technical committees such as the BSI Committee PTI/7, which covers classifications and specifications, and PTI/13, which covers test methods, draft standards for lubricants in the UK. Bodies such as trade and research associations, professional bodies, central and local government, academic bodies, and user and consumer groups nominate members of technical committees. BSI arranges the Secretariats and ensures that committees are suitably representative. The BLF is represented on PTI/13 and also on other organisations. These include, The Institute of Petroleum, The Ministry of Defence, The Ball and Roller Bearing Manufacturers Assoc., British Steel, British Coal, British Rail (now Railtrack), London Regional Transport, The Electricity Assoc., The Engineering Equipment and Users Assoc., The British Gear Assoc., etc.

Proposals for new and revised standards originate from many sources but mainly from industry. Each proposal is carefully examined against its contribution to national needs, existing work programmes, the availability of internal and external resources, the availability of an initial draft and the required timescale to publish the standard. If the work is accepted it is allocated to a relevant technical committee or a new committee is constituted. The draft standard is circulated for public comment and the committee considers any proposal made at this stage for appropriateness and possible inclusion.

In addition to the procedure for British Standards. BSI is the UK Member of the following two key international and European standards bodies respectively:

International Organisation for Standardisation (ISO)
European Committee for Standardisation (CEN)

An international standard is the result of an agreement between the member bodies of ISO. This process of agreement normally consists of a number of stages.

- A new work item proposal, accompanied by an initial draft for consideration, is submitted for a three-month letter ballot of the committee members.
- If there is a majority approval, and five member bodies agree to participate actively, the item is assigned to the appropriate Technical Committee (TC), the voting members of which are the national bodies which have expressed an interest in active participation in the work of a given committee.
- A final working draft is prepared from the initial draft which is then presented for a three month letter ballot as a Committee Draft (CD)
- From comments received, a Draft International Standard (DIS) is prepared which is subjected to a five months letter ballot.
- From the ballot results, a Final Draft International Standard (FDIS) is produced which is then subjected to a two month Yes/No vote, with no further modification permitted.

The entire process, from the formation of a TC to the publication of the final text of the International Standard, must take place within a three-year period. Most standards require periodic revision and ISO has established the general rule that all ISO standards should be reviewed at intervals of not more than five years. The whole process may be considered overly bureaucratic and lengthy, but it is essential that all organisations that have an interest in a particular standard have ample opportunity to ensure at every stage that their views are properly represented.

Much of the work relating to lubricants' standards is now undertaken at the ISO level with PTI/7 monitoring the ISO work and co-ordinating and deciding the UK technical input. The ISO committee involved is ISO/TC 28/SC4 'Petroleum Products and Lubricants/Classification and Specifications', the secretariat of which is held by the BSI French counterpart, AFNOR - based in Paris.

Participation by the BLF In Committees PTI/7 and PTI/13, where the federation is represented by its Technical Officer, David Margaroni, ensures that the UK Lubricants industry has an input into the development of UK, European and International standards at every stage. Views of BLF members are solicited by circulating copies of the drafts to members who could be expected to have a particular interest in the subject.

However, response to such circulated drafts has been extremely poor, with the majority of those receiving copies of draft standards not even acknowledging receipt, let alone contributing any positive comments. Admittedly, the basis on which the circulation lists has been drawn up has been somewhat arbitrary, since it would be a massive task to circulate all members with copies of every standard at every stage. With some product groups, e.g. greases, it is a relatively simple matter, since a comparatively small number of manufacturers are involved, but in the case of standards for e.g. automotive oils, a process of selection is necessary to reduce the workload.

It is entirely possible that those selected to comment on standards are not the most suitable, and a different approach is now proposed in that the BLF invites all member companies with a specific interest in standards covering particular product areas to notify the Secretariat accordingly, whereupon they will be included in the circulation of any future relevant standards.