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Cover photo of BP's oil production vessel Seillean at Belfast prior to its naming ceremony. Photograph courtesy of British Petroleum.

## 6 December

**A Japanese-US consortium led by Kawasaki Heavy Industries Ltd is negotiating with Hungary to build an ethylene plant in Leninvaros.**

## 7 December

**Texaco Oil Development Co reported that West Australian Petroleum Pty Ltd has initiated production from the Saladin oil field offshore Western Australia.**

**Esso Belgium SA has awarded a contract to Foster Wheeler Energy Ltd for the engineering and construction of a new \$50m alkylation and higher olefin facilities at its Antwerp refinery.**

**Recoverable oil reserves in the Oseberg field have been increased 10% by operator Norsk Hydro following development drilling in the north of the area.**

## 8 December

**Kuwait has proposed the setting up of a large oil depot in Thailand's southern region.**

## 11 December

**Foreign Ministers of Australia and Indonesia have signed the controversial Timor Gap accord detailing drilling, taxes, profit-sharing, customs and other operational aspects in the area of joint development.**

## 12 December

**Shell Nigeria announced the discovery of three new oil and gas wells with estimated reserves of 10m barrels of oil, 320 cu feet of gas and 13m barrels of condensate.**

**Soviet oil and natural gas liquids production are reported to be below 12m b/d.**

## 13 December

**A UK gas discovery, believed to be the first onshore in the Rotliegendes formation, has been made by Kelt Energy. The well, near Bridlington, flowed up to 10.5m cu feet a day.**

**Oil and gas drilling in Nigeria rose in 1989, with the sinking of 100 appraisal and exploration wells against 88 in 1988.**

## 14 December

**Canada's petroleum industry capital spending fell by 20% in the first half of 1989 according to the Petroleum Monitoring Agency.**

**Mobil Corp signed a Kwacha 48m three-year agreement with the Zambian government for hydrocarbon exploration in the Zambesi valley after failing to strike oil there in 1987/88.**

## 15 December

**Phillips Petroleum has confirmed a successful well result on its Judy prospect in the North Sea and expects to select a development for the J-Block area in the first half of this year.**

## 18 December

**Netherlands Refining BV has reduced the crude oil distillation capacity at one of its two refineries in the Rotterdam area by 44% to facilitate the integration of its operations with the other plant.**

**Iran will export about 1m barrels of oil and 1bn cu metres of natural gas a year to Romania under an agreement signed in Tehran.**

**The Taiwanese government has decided on US\$700m tripling of the island's capacity to import LNG even before a current expansion programme is complete.**

## 19 December

**Chevron's El Segundo, California, refinery was shut down after a fire.**

## 20 December

**Petronas will step up exploration and drilling work on new oil wells to maintain Malaysia's long-term petroleum production.**

## 21 December

**Total CFP agreed to take a 30% interest in Thailand's B-Structure Gas Field, which is due to produce natural gas and condensate from 1993.**

## 27 December

**Santos Ltd has signed an agreement to buy Elf Aquitaine Exploration Australia Pty Ltd for an undisclosed sum.**

**Total-CFP Plans to develop a network of 40 service stations in Hungary within the next three years, in its first move into Eastern Europe.**

## 28 December

**Guyana's search for sources of crude oil has been stepped up with the granting of an exploration and production licence to Guyana Hunt Oil.**

## 29 December

**Total-CFP will begin drilling for oil offshore Vietnam. The Total Chairman said that if the first well was successful then Total planned to bore up to two more sites this year.**

**Egypt and Libya have signed a bilateral energy cooperation agreement which would unify the national grid of both states.**

## 2 January 1990

**Iraq announced the opening of a**

**new 1.65m b/d oil export pipeline through Saudi Arabia.**

**Nigerian Oil Minister and OPEC President Rilwanu Lukman was replaced in a major Nigerian Cabinet reshuffle.**

## 3 January

**The first oil cargo from BHP's Challis field off Australia is due to be loaded for export to Japan.**

**Ultramar and Union Texas have taken over as operators of Huffco, the major Indonesian gas venture.**

## 4 January

**Maxus Energy Corp has received an offshore petroleum exploration permit covering area T89-4 offshore Western Tasmania.**

**Exxon Chemical plans to spend \$200m over the next two years expanding its existing large plant at Notre Dame de Gravenchon in Normandy.**

## 5 January

**Neste Corporation Oy will invest about US\$20-30m to set up a resin plant in Sarawak, Malaysia.**

**Coastal Corp said it is negotiating with four parties to supply crude oil to its newly acquired refinery in Aruba, Netherlands Antilles.**

## 8 January

**Bow Valley Industries Ltd plans to develop a gas discovery in the Dutch North Sea.**

## 9 January

**Iran has proposed the construction of a 3,300km gas pipeline between its southern gas field and Calcutta.**

**British Gas named BHP Petroleum and Atlantic Richfield as its partners in joint venture oil and gas exploration in the Gulf of Mexico and Gulf Coast areas.**

## 10 January

**Woodside Petroleum has found crude oil at the Cossack-1 well offshore north western Australia.**

## 11 January

**Norway is to supply West Germany with an additional 80bn to 100bn cu metres of gas in a deal which could be worth as much as £6.6bn.**

## 12 January

**The West German operating unit of British Petroleum Plc said it has agreed in principle to establish its first service station in East Germany.**

## EXPLORATION AND PRODUCTION DISCUSSION GROUP

The next meeting of the E & P Discussion Group will be held at the Institute of Petroleum on Thursday, **22nd February 1990** starting at **5.30 pm**. (Tea and biscuits will be available from 5.00 pm).

### The Future of the Independent Oil Companies

Speaker: **Mr G J Hearne**, Chief Executive, Enterprise Oil plc

If you would like to attend this meeting please contact **Mr A E Lodge**, Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Tel: (01) 636 1004 ext 326.

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# Be ready for new rules, warns Lloyd's

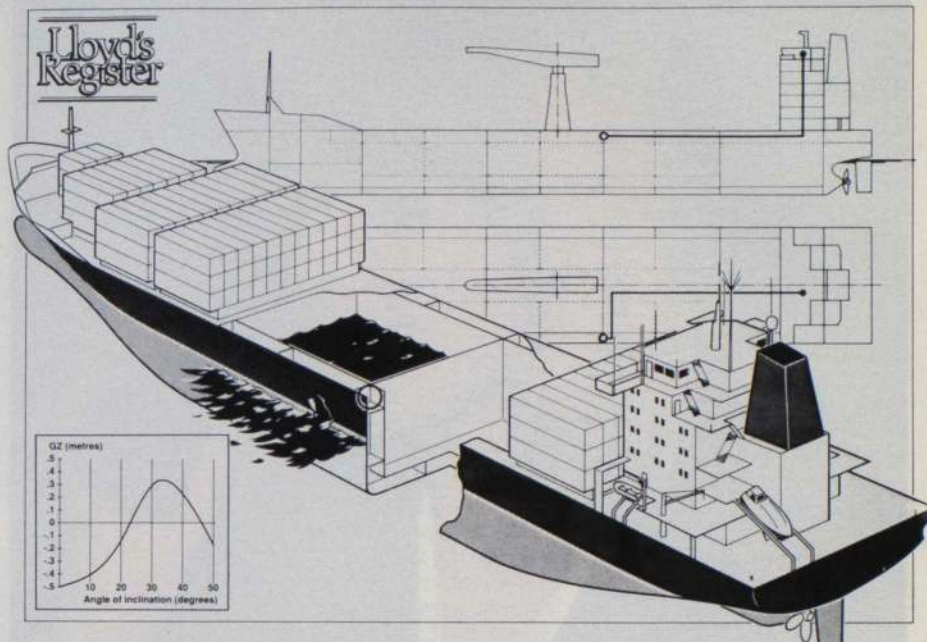
SHIPOWNERS and shipbuilders who may be considering new dry cargo ships need to plan now for important new developments which will affect the way they are designed, advises Lloyd's Register, the leading international ship classification society.

Major legislation which will establish, for the first time, requirements for the subdivision and damage stability of dry cargo ships, including ro-ro's, is scheduled for entry into force by the International Maritime Organisation on 1 February 1992.

The requirements, which will apply to ships of 100 metres and more in length whose keels are laid on or after that date, are among the most far reaching to come from IMO in recent years. They will have an impact on the watertight compartmentation and position of bulkheads, so anyone planning new tonnage will need to examine the proposals as soon as possible since these are matters which can be changed more easily on paper than in the year, LR says.

A major change from previous damage stability legislation is that the new requirements are based on probabilistic concepts; a much more complex methodology than the deterministic procedures specified by existing international codes and conventions.

Lloyd's Register has been working closely with national maritime auth-



One of up to 100 possible damage scenarios to be investigated.

orities and the IMO working party on dry cargo ship damage stability. As a result of that work, Mike Magill, in charge of LR's stability and tonnage department, has produced an introduction to the subject which explains the probabilistic concepts and associated calculation procedures, together with some interpretations for the requirements which have been discussed with

the appropriate flag administrations for prospective newbuildings.

The requirements for damage stability of dry cargo ships have yet to be formally adopted by IMO's Maritime Safety Committee, says LR, but the technical content is not expected to change in any significant way although some areas of interpretation remain to be clarified.

## Smit, Brown & Root contractor

LAST month two of the world's largest companies in the marine and energy sectors, Smit International and Brown and Root, launched a major new global offshore contracting company in Aberdeen, the centre of the offshore industry.

The new company will be one of the largest marine and subsea engineering contractors, with an estimated annual turnover in excess of \$200 million (£125 million). A workforce of over 2,000 will be engaged in offshore projects worldwide, operating from a network of international facilities including Aberdeen (North Sea headquarters) and Rotterdam.

## British Gas in joint US venture

BRITISH GAS is to launch joint exploration ventures with two US companies in the US Gulf of Mexico and Gulf Coast Region.

A letter of intent covering on and offshore Texas exploration has been finalised with BHP Petroleum (Americas), a Division of Broken Hill Proprietary of Australia. A second letter of intent for exploration and development on and offshore Louisiana and Alabama has also been completed with Atlantic Richfield Company (ARCO).

These new exploration and development initiatives, the first to be mounted by British Gas in the United States, will be carried out by a British Gas subsidiary, BG Exploration America, Inc., located in Houston, Texas and recently set up as a springboard into the US market.

The programme is likely to involve drilling around 20 exploratory wildcats strategically located throughout the Gulf Coast area. British Gas will also participate in the development of Miocene gas fields operated by ARCO in the offshore Alabama area.

## PNG drilling

ESSO Petroleum and Conoco Limited, a subsidiary of Du Pont, have been named as farm-in partners for a big onshore exploration drilling programme in the foothills of Papua New Guinea. The majors will each hold a 35 percent interest.

Victoria Petroleum, which before the farm-in held a 33.3 percent interest and operatorship, has negotiated a 6.67 percent to 8.33 percent carried interest through four wells, with all finance and development costs paid out of production. Similar interests have been agreed for the other participants, Trident Petroleum and First Australian Resources.

# World merchant fleet up

LATEST figures published by Lloyd's Register in its Statistical Tables for 1989 show the world merchant fleet increased by 7.1 million gross tonnage from 1988 and now stands at 410.5 m gt. This is the first increase following a continued downward trend since 1982, when the highest ever figure of 424.7 m gt was recorded.

Liberia, with a total tonnage of 47.9 m gt (down by 1.8 m gt), remains at the top of the world fleet league table. In second place, with just 527,000 gt separating the two biggest fleets, is Panama, which in the past 10 years has more than doubled its fleet. In the 12 months to the end of June 1989, Panama increased its fleet by a further 2.8 m gt to 47.4 m gt. Between them, Liberia and Panama account for over 23.2 percent of the world fleet.

In third place is Japan, which has suffered the biggest drop in its total tonnage to 28 m gt, down by 4.0 m gt from 1988. It is followed by USSR, Greece, USA, People's Republic of China, Taiwan, Cyprus, Norway, Bahamas, Philippines, South Korea and the United Kingdom.

By far the biggest increase is shown by Norway, up 6.2 m gt from the previous year, reflecting the success of the Norwegian

International Ship Register. At 15.6 m gt, the Norwegian flag fleet is now 3.8 percent of the total and represents an increase of 250 percent over the last two years.

Increases are also shown by Bahamas (up 2.6 m gt), Kuwait (up 1.1 m gt), Malta (up 0.6 m gt) and Saint Vincent (up 0.6 m gt). Among countries with substantial reductions in their fleets are Hong Kong (down 1.2 m gt) and Greece (down 0.7 m gt).

The total tonnage registered in the United Kingdom is 7.6 m gt (2,053 ships), compared with 8.3 m gt (2,142 ships) in 1988. The 1989 total tonnage is less than half of the corresponding figure of 15.9 m gt (2,468 ships) five years ago and down by more than 20 m gt since 1979. The UK fleet reached 33.2 m gt (3,622 ships) in 1975, its highest ever level in terms of tonnage.

An analysis of the world fleet in terms of age shows that 36 percent of the total tonnage is under 10 years old, compared with 48 percent in 1984 and 62 percent in 1979. Of the world tanker tonnage, only 27 percent of the fleet is now under 10 years old, compared with 53 percent in 1984 and 72 percent in 1979.

## Ninian increase

CHEVRON UK Limited, operator of the Ninian oilfield, has announced an upgrading of the field's recoverable reserves of between 55 to 155 million barrels of oil.

Ultimate recovery from Ninian, the third largest oilfield in the UK sector of the North Sea, is now forecast to be in the range 1.1 to 1.2 billion barrels depending on future operating and economic conditions.

## Transatlantic

PROTEUS Petroleum is to become the UK's first independent brand to be launched in Canada. Under a deal with Nor-Sphere Inc, a Toronto-based trading company, two sites have already been secured and four more are expected to be signed up shortly.

## Floyd for Amoco

AMOCO (UK) Exploration Company has acquired Floyd Oil Limited, a subsidiary of Ferrum Holdings PLC.

## Moroccan coast oil spill

AN EXPLOSION on the Iranian-owned tanker, the **Kharg 5**, on 19 December prompted scares of ecological disaster throughout the New Year. It is estimated that over 70,000 tonnes of oil escaped from the 284,000 tonne load of crude carried by the tanker.

The accident happened 400 miles north of the Canary Islands, with oil coming within 12 miles of the Moroccan Atlantic Coast. The oil slick covered an area up to 185 miles long and was sprayed with 60,000 litres of dispersants.

But by 4 January, a Moroccan government statement said that winds and currents had swept the oil slick out to sea and that most of its toxic elements had evaporated.

The Kharg 5 incident ended the worst year for oil spills since 1980. The International Tanker Owners' Pollution Federation listed 12 major tanker disasters for 1989, amounting to 1.2 million barrels of oil lost.

## Mobil in Zimbabwe

A UNIT of Mobil Corporation, Mobil Exploration Zimbabwe Inc. has signed a production sharing agreement with the Government of Zimbabwe, completing the first step leading to exploration for oil on a 7.5 million-acre tract in the Zambezi River Valley.

The agreement commits Mobil to perform gravity/magnetic and seismic surveys to assess the possible existence of hydrocarbons within the Mid-Zambezi Rift. The Rift is 500 miles in length and straddles the international boundaries of portions of Zimbabwe, Zambia and Mozambique.

During the initial four-year term of the contract, Mobil will spend almost \$6 million for the acquisition of geological and geophysical information. If the analysis of the data is encouraging, test wells may be drilled and expenditures could reach \$30 million or more, depending upon the success of these efforts. Throughout each phase of the exploration Mobil will assume 100 percent of the investment risk.

Mobil has been operating in Zimbabwe since 1911 through its marketing affiliate, Mobil Oil Zimbabwe (Pvt) Ltd.

## Scottish Shale Museum

WORK is due to start in April of this year on a new £450,000 museum development which will tell the story of the Scottish shale oil industry.

It is often forgotten that several years before the world's first oil well was drilled in Pennsylvania, petroleum products were being commercially produced from oil shales in the Lothians of Scotland. Through the technical and entrepreneurial talents of James 'paraffin' Young and his contemporaries, the Scottish industry blossomed and by 1865 accounted for half of the world's petroleum production.

Based in Livingston, close to the centre of the former shale oil field, the Scottish shale oil museum has received generous support from Livingston Development Corporation, West Lothian District Council and the European Regional Development Fund, which will allow the first phase of the development to be opened to the public by April 1991.

# Busy bee to start work



BP's OPV (oil production vessel) *Seillean* at sea off the coast of Scotland.

Photograph courtesy of British Petroleum

BP's new floating oil production vessel *Seillean* is expected to begin work this month. The monohull vessel has been developed to produce oil from the North Sea's smaller and less certain accumulations which would not merit a production platform for economic or technical reasons. This type of production system is known as SWOPS.

The *Seillean* (Gaelic for bee, to denote the hard work required for the accumulation of valuable material) is a 45,000 tonnes dwt vessel which carries and deploys all the equipment necessary to produce up to 16,500 barrels of oil per day in waters between 75 metres and 200 metres deep, without the help of divers.

Although superficially *Seillean* resembles a conventional tanker, she is fitted with a flare stack and derrick. Without a rudder, she depends on the use of thrusters to navigate to and from the oilfields and to hold her in position over the wellhead during production. The computer operated 'dynamic positioning' system controlling seven directional thrusters will allow her to remain on station in gale conditions up

to Force 9. She has the capacity to store 300,000 barrels of oil — roughly 20 days production — before having to disengage from the wellhead and discharge at a shore terminal.

The £110 million ship was built by Harland and Wolff at their Belfast yard in a joint venture with BP. A naming ceremony was held in September before the ship was sent out for sea trials lasting 29 days.

The early part of the trials consisted of the commissioning and integration of the seven steerable and retractable thrusters and the testing of the computer controlled power management system controlling three gas turbine generators and three diesel generators which power the ship. The vessel uses the supply of separated gas from the oil well to fuel the gas turbines during production.

These tests were followed by a period of subsea well head trials in the Sound of Jura, off the west coast of Scotland, during which a series of connections and disconnections were made between the ship and well head, including simulation of the emergency

disconnection procedures.

The *Seillean* has been berthed in Invergordon since 19 December where additional equipment, such as wire lines, is being installed at BP's request. This work was scheduled to be completed by the end of January after which the ship is expected to begin work.

Her first job will be to develop either the Cyrus field, 160 miles north of Aberdeen, or the North West Lobe of the Forties field.

At the naming ceremony, Mr John Browne, BP Exploration's Managing Director and Chief Executive Officer, said, 'In terms of shipbuilding achievement and of technological advancement, the *Seillean* is a landmark in oil industry history, pointing the way forward for the development of marginal fields. The North Sea is now a mature hydrocarbon province and as the costs of producing oil from the smaller fields increases, technology such as SWOPS, allied with rigorous management and cost control, will help to extend the life of the area well into the next century.'

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IVIII

# Sheikh Yamani opens up in London

**H**is Excellency Sheikh Ahmed Zaki Yamani, Saudi Arabia's former oil and minerals minister, is the founder and chairman of the new Centre for Global Energy Studies in London. In an interview with *Petroleum Review* he discloses that the formation of an objective, non-profit making body to study and provide information on energy problems has long been his desire.

In the discussion Sheikh Yamani:

- explains why occasional shortages in oil supply could arise at any time, particularly through a lack of refinery development in the United States; but
- believes that if the present price of oil, taken at \$18 a barrel, rises with inflation and perhaps moves to reflect the international value of the dollar, from 1991 onwards, then investment could avert a supply crisis.
- Sheikh Yamani has caught wide attention by propounding an interesting arrangement to help this, whereby OPEC suppliers, downstream oil companies and the governments of consuming countries would have tripartite contractual agreements to ensure price stability through investment in oil production.

**Geoffrey Mayhew: Why, at your initiative, has the Centre for Global Energy Studies been established?**

**Sheikh Yamani:** I lived through the 1970s and 1980s and observed the various mistakes committed either by consumers or by producers in OPEC. I knew that misunderstandings, lack of information and short-sighted views of problems had caused what happened. The turbulent fluctuations in the price of oil up and down, with all the bad side effects, happened because the various parties did not really have a chance to know more of the realities or to have a quiet place in which to exchange views. As a minister at that time, I knew that to present something useful to the parties would be impossible; being a minister, no one would take me seriously and think I was being objective; they would think I was representing only the interests of producers, although most of what I did in my official capacity was done to try to deal with the problem from a global point of view. After I left government I thought I would be in a position to play that role. That was the original concept.

**Are you pleased with the support the Centre has already received from very important persons willing to serve on the Governing Body and the International Advisory Council?**

I am very pleased, and very grateful, because I am sure their contribution will be so important to the success of the centre in achieving all our objectives.

**Do you think the Centre will soon become a body of considerable influence?**

We are not really looking for influence as much as contributions; we want to produce high quality studies which I think in themselves will influence the various parties.

**Will the distinguished supporters help you in those studies?**

Yes. Of course we will have our own staff. We already have some of them and we will have more in the coming few months. We have engaged the services of many well-known experts on an *ad hoc* basis.

We decided to form two committees at our initial meeting — one to study the Gulf's production capacity and the other the impact of what is happening in East Europe. We will also produce a bi-monthly report which will be presented to the Council, which will review and study it and argue upon it. So, the work of the Council will be reflected in the bi-monthly report and in the other activities we undertake.

**Will these studies be purchased or given to governments or individuals?**

The bi-monthly report will be available to a limited number of subscribers at an annual fee which will cover part of the cost, not all. We did not decide how to deal with the studies to be done by the two committees. The matter will be brought before the Governing Board for a decision as to whether we sell it to a number of institutions, companies or governments or whether we publish it in a book and sell it in the market.

**Are you a non-profit making organisation?**

Yes. By the laws of this entity it is non-profit making.

**To date, are there any organisations or governments who have asked for information to be made available or studies to be done by you?**

No, and I do not think we are in the consultancy business.

**Was London chosen as the Centre's headquarters to make your role easier internationally?**

Yes. I think London is very well situated from a geographical point of view. It offers all we need when it comes to database, libraries and professionals. From everywhere London is a very suitable place.



Sheikh Ahmed Zaki Yamani

**The danger of an oil industry supply crisis through a run-down in capacity, of which the public at large is probably unaware, is at the top of your agenda in your studies here?**

Yes, that is a possibility, and a great deal depends on two factors: one is the need for investment to increase production capacity, and the other is the price of oil. If we keep the price of oil at a very low level for a long period of time, we will be heading for another crisis.

If we do not make available the large amounts of money needed to invest in increased production capacity, we will also be heading for another energy crisis.

However, if we raise the price of oil every year from now onwards, we will be pushing towards a surplus in the

supply of oil, which could bring the price down, as happened in the 1980s: this would bring about another price increase, and so on, so the role of the price of oil is very important.

**Ideally, where would you see the price of oil being in the mid 1990s?**

According to the studies, if we keep it as it is for 1990, probably 1991, and maintain it in real terms for a good number of years going towards the end of the decade, maybe that will be the best scenario to avoid an energy crisis.

**Would that mean it would go up by no more than the rate of inflation?**

The rate of inflation, yes, and you would probably have to consider also the fluctuations in the value of the dollar.

**Are you already studying the impact on energy of *perestroika* in Eastern Europe and the USSR?**

Yes. We formed a committee to consider this, and as a matter of fact we have a very famous Russian expert sitting downstairs discussing the subject right now – Professor Alexander Arbatov. He will be a member of the group making the study; and we have so many other experts on the subject, together with our own staff.

**At first glance, do you think that one impact of the changes in Eastern Europe will be a considerable rise in energy demand amongst those countries within a fairly short time?**

No. They do not have the money to buy the oil in those countries. It will take some time for them to achieve any rate of growth.

**Possibly within a decade?**

Yes; probably there will be some impact. In the past, we used to eliminate the Communist world from our supply picture, except for the amount of oil exported by the Russians, but from now on they are integrated. If they implement what they have already announced, that oil from Russia will be sold to Eastern European countries as well as to the West for payment in dollars. That will be a different situation.

**Would that have a positive effect regarding your fears for an energy supply crisis? Would it put it off rather than bring it forward?**

I do not think so. The fear that a crisis might arise derives from the possibility that we do not manage prices as we should, nor invest in production capacity, but if we do both I am not afraid of a crisis; a crisis should not really come.

**It is a case of production and distribution facilities having run down perhaps?**

Production capacity and prices.

**A study of the Soviet Union's production will be very important?**

Extremely important.

**Do you have a number of special projects you are looking into currently, or are going to look into?**

We have two major studies, but in our bi-monthly reports we will have

## Centre for Global Energy Studies

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- Dr Alirio Parra, Managing  
Director, Petroleos de  
Venezuela Europe SA
- Fadhil J Al Chalabi, Former  
Deputy Secretary General,  
OPEC
- Sheikh Ali Khalifa Al Sabah,  
Minister of Oil, Kuwait
- James Schlesinger, Former US  
Secretary of State for Defence,  
Former Secretary of State for  
Energy
- Sir Peter Walters, Outgoing  
Chairman of BP
- Wilbert Hopper, Chairman,  
Petro-Canada
- Prof. Alexander A. Arbatov,  
USSR Academy of Sciences
- Ian Seymour, Editor, Middle  
East Economic Survey

many topics which are presently under consideration.

#### **Is one of them going to be the effect of the energy industry on the greenhouse issue?**

I think this will be one of our major studies which we will do in association with other institutions in the coming few years. These two studies are for 1990. In 1991 there will be additional topics to be studied.

#### **Is there also the question of the ageing ocean tankers and the state of world refining?**

These are two very important problems. The ocean tanker fleet is ageing and much needs to be done in this area. First of all, we have to upgrade many of the existing refineries in Europe and the United States. We have to find ways and means to build more refineries in the United States, because that is where the problem has already started; much needs to be invested in that area, and the lead time is also a problem.

#### **How soon will the refining problem really impinge on production? Will that problem become critical within a short time?**

So much depends on whether we have some additional accidents in the existing refineries in the United States. If you remember, in 1989 we had a few accidents, and if we have a few more accidents I think the problem will start immediately.

#### **The effect of a few more refinery accidents would lead to what?**

A shortage. I do not know to what extent it could be compensated for by Europe and the Middle East.

**On the subject of shortage, what is very interesting is your proposal that there might be a new type of contractual arrangement between OPEC suppliers, oil companies with downstream assets and technical expertise in production, and consuming countries' governments, with the object of increasing production capacity to meet future levels of demand.**

Yes. I was thinking mostly about capacity and the possibility of exploring for more oil and the development of new fields.

**Would that mean that the oil companies who have been excluded from some foreign oilfields would return to them for exploration and development?**

Yes. As a matter of fact, they are now returning to countries like Algeria and elsewhere. We are not proposing another concessionary arrangement; it is out of date. However, production sharing, or anything similar to that, is needed. The oil companies have the expertise, the assets and finance to invest and they have the downstream, so they can play a role; we cannot ignore them.

#### **Would it lead to risks being taken by them in investing in foreign countries? Would there need to be some sort of guarantee about their investments?**

Whenever a guarantee is needed that is also a role that the major consumers can play, but I do not think it is always needed.

#### **Would the Centre play some sort of part in this type of arrangement through the giving of advice?**

It is premature to say but we are prepared and willing to do that.

#### **The Centre is surely going to be a busy one?**

That is why we have established it – to keep it busy. ■

# The tanker market — past, present and future

By Eric F Shawyer, Chairman, E.A. Gibson Shipbrokers Ltd

During the last decade many industries have enjoyed boom trading conditions whilst the tanker market has basically been depressed, apart from one or two high points which unfortunately only lasted for a short time, causing a falsely optimistic situation. In 1979 there was a high wave in the tanker industry, following years of depression which started in 1973 following the upheaval in oil prices.



Eric F Shawyer.

Owners were beginning to believe that the improvement was permanent and started ordering newbuildings in anticipation of the increased demand continuing. Their hopes were not all based on intuition, as there were definite signs that the improvement could be sustained because OPEC crude was again in strong demand and recovering after years of stagnation. Seaborne ton miles were multiplying as short-haul crude no longer imposed its previous threat of increasing its share of the market. Unfortunately, the assumption made on these indications was erroneous and the ordering of newbuildings commenced before they were required, influenced by the temptations shipyards were offering to owners in the way of cheap prices and attractive credit terms. The lack of any long-term period cover exacerbated the already over-tonnaged situation.

In 1979 major oil company fleets were still far in excess of their requirements, having made no serious effort to reduce their overall surplus.

During this period there were still owners with extensive fleets, with many still reaping the benefits of the high-rate period charters they had arranged previously. Conversely,

many of those who depended on the spot market had by now gone out of business, unable to survive the recession without the necessary period cover to generate the funds to operate either their existing or newbuilding vessels.

Unfortunately the improvement in the late-1970s was of very short duration; its demise was brought about by the cut-backs in demand, which were reduced further by embargoes enforced on receivers by producing countries for political reasons. This was compounded by the vast over-abundance of tonnage in most size categories, swollen by surplus oil company relets seeking employment in competition with independent owners. This situation required owners to make a serious reappraisal of their position, to question where they went wrong and what they could do to rectify their mistakes.

Consequently, in the early 1980s the first and most urgent requirement was to remove from the market as much tonnage as possible and to reduce the over-investment which was no longer required in the prevailing conditions.

One of the two most effective ways of achieving this reduction was to commit tonnage into lay-up and, even-

tually, approximately 90 million deadweight tons of tankers were in lay-up in 1983 — a figure which included many oil companies' ships which remained surplus to their requirements (**Table 1**).

The other more effective way of reducing the over-abundance was to scrap those vessels no longer required thus making a finite solution to the problem — 30 million deadweight tons were scrapped in 1985 alone and approximately 150 million deadweight tons from 1979 until the present day, equivalent to approximately 55 per cent of the current fleet of 270 million deadweight tonnes (**Table 2**).

This was necessitated by:

- Low freight rates
- Decreased demand
- Market fragmentation with traders taking business from the majors, fragmenting the market into many small sections, predominantly spot market-orientated.

In the middle 1980s, what did the future hold for owners? Was there to be another false dawn that only lasted months, not years? Or had the medicine of laying-up and scrapping began its cure of correcting the tonnage imbalance? Owners were, at long last, getting to grips with their problems by

reducing manning levels, extending the period between dry-dockings and reducing maintenance to cut back on their inflated running costs. Owners also began to utilise the opportunity of flagging out to the new registries, such as the Norwegian International Ship Register, and availing themselves of the ability to place their vessels with outside management in an effort to cut manning costs in order to remain competitive in the marketplace. Improvements in rate levels in the tanker industry have been mainly brought about by events outside owners' control and not by real growth in demand.

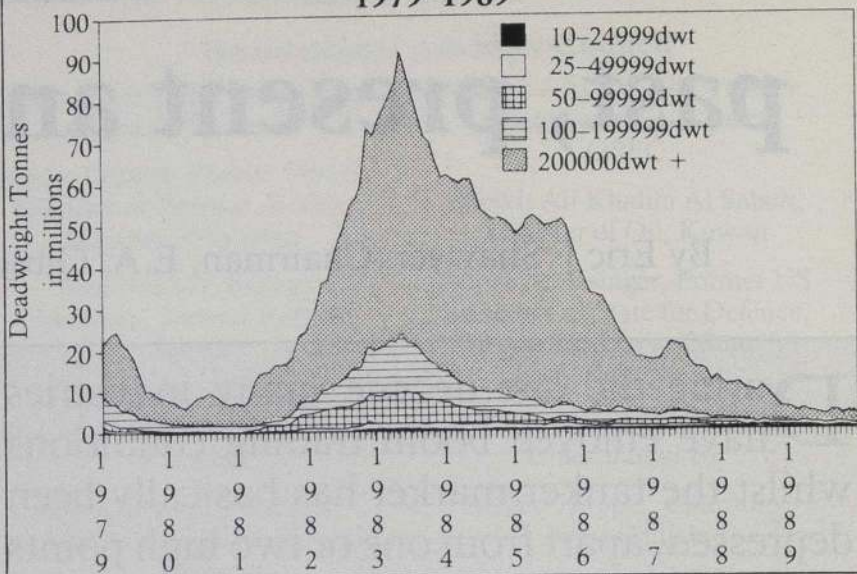
Such instances include the Korean War, the first and second Suez Canal closures, oil embargoes by producing nations and, lastly, the Iran/Iraq War which culminated in the tanker war which enabled those owners willing to take the risk of loading at Kharg Island to reap rich rewards.

Subsequently, oil prices were reduced as suppliers competed to obtain a larger market share for their production. Thus the cycle commenced again of more production — requiring more tonnage — inducing higher rates — which encouraged owners to break lay-up and to trade instead of scrapping. Unfortunately, in many instances, the tonnage attracted out of lay-up had lost the market before they were ready and would have been better advised to remain where they were, as their entry into the market again depressed freight levels and the circle was complete.

Had the situation changed sufficiently by the late 1980s for the tanker market to break out of this vicious circle and make a full recovery and, if so, what are the reasons?

One could be that the world fleet has reduced overall from 320 million deadweight tons in 1979 to 270 million deadweight tons in 1989. The number of vessels on order is not excessive, some 22 million deadweight tons (only 9 percent of the existing fleet) and few of these are for account of major oil companies. There are few owners who can afford today's prices of \$85 million for a VLCC, \$55 million for a million barrel tanker and \$38/40 million for a 40,000-ton product carrier. Only the major owners and those funded in America, as well as the K/S companies in Scandinavia, could consider it without first obtaining long period cover at rates sufficient to make it viable. Such rates are certainly not obtainable at the present time, lagging far behind those required. Such high newbuilding costs are escalating second-hand prices to today's unprecedented levels where a

**Table 1: Tanker and Combined Carrier Inactivity 1979-1989**



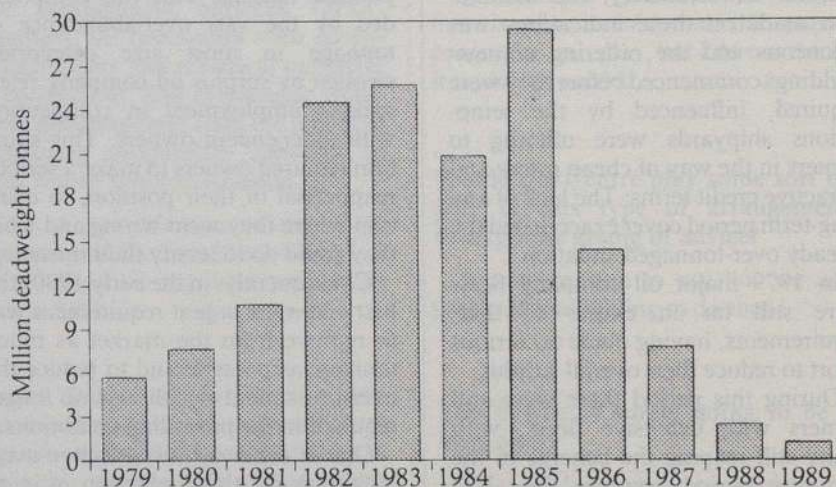
second-hand VLCC can fetch a staggering \$25 million for a 14-year-old vessel. The world's shipyards' current capacity is insufficient to rejuvenate the world's tanker fleet over a short period and yards who were originally willing to accept orders at any price to obtain business have now found that they have had to increase their prices if they are not to go bankrupt following increased labour costs. This applies particularly to Korea, where yards have suffered dire consequences for accepting orders too cheaply.

The majority of oil companies' fleets have been drastically reduced, although the American majors have retained larger fleets in comparison with others, which could be a benefit when increased importation by the United States necessitates additional

tonnage in the long haul trades. Similarly, old established independent owners have, in most instances, reduced their fleets dramatically to be replaced in the last 10 years by a completely new set of owners appearing in the marketplace, financed out of American funds, and the Scandinavian K/S companies were formed for their tax advantages and asset play potential and not for long-term ship-owning. Consequently this is not necessarily the best scenario for the shipping industry.

1988 again saw a short-term boom but of sufficient energy to enable some owners once again to make a great deal of money, encouraging them to reinvest in both newbuildings and second-hand vessels. However, conditions during the first half of 1989 were

**Table 2: Total world tanker and combined carrier scrapping since 1979. As at mid-December 1989**



disappointing, with rates not reaching the levels anticipated. However, the last quarter of the year improved, enabling owners of VLCCs in particular to obtain rate levels comparable with 1988. Our advice to owners is to be cautious in the number of newbuildings they order until such time as the improvement is more permanent.

### Future prospects

Can owners expect steady progress into the next decade? There are many encouraging signs in owners' favour, although it is still far too early to be certain. The world would need to absorb, and OPEC produce around 25 million barrels per day to utilise all the fleet, before rates reach levels sufficient to amortise the vessel and show a profit

on the investment. Whilst timecharter rates have improved, they are still insufficient to justify newbuildings at current prices.

In our opinion the most important point to consider in any eventual recovery in the 1990s is the age of today's fleet, 75 percent of which is now over 10 years old. It is not universally accepted that all the world's tanker fleet can be rejuvenated and that the transformation of a 20-year-old vessel into a five-year-old one is viable despite the amount of work and money put into it. It is accepted that those vessels that have been well maintained during their life can be given a life extension but it is very unlikely that you can do the same thing with every vessel trading today. Eventually a fleet replacement programme must be instituted. Owners would be well advised

to look at the crewing and operational problems which are appearing more and more troublesome as it becomes increasingly difficult to find a sufficient number of the highly trained seamen needed to operate today's vessels.

Additionally, the tanker industry is having to face an ever-increasing amount of governmental interference, as possible restrictions are placed on tonnage trading to certain areas and the prospects of double-skinned vessels becoming mandatory for trading to the United States, combined with unlimited liability for accidents, will cause owners further headaches.

In conclusion, the early 1990s will be a period of reconstruction in the tanker industry, followed by an overall improvement in the second half of the decade. ■



The Institute of Petroleum

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A One-Day Conference Organised by the Energy Economics Group

**Wednesday 4 April 1990**

to be held at

**The Institute of Petroleum**

**Chairman: Dr Cecil French, Ricardo Engineering, and Past-President, The Institution of Mechanical Engineers**

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Mr J A Feltham, Chairman of the CEN Working Group on European Diesel Standards

#### The Economics of Heavy Duty Diesel Vehicles

Mr Per-Sune Berg, Volvo Truck Corporation, Sweden

#### Diesel Engines for Private Transport Vehicles

Dr Ing M Fortnagel, Mercedes-Benz

#### Forecasts of Diesel Demands Including Consumer Attitudes and Fiscal Studies

Mr G A Weale, WEFA Energy

#### Diesel Fuel Quality into the Next Century

Mr R C Hutcheson, Shell International Petroleum Co. Ltd. and Mr C W C van Paassen, Shell International Petroleum Maatschappij BV

#### Diesel Additives

Mr T Coley, Petroleum Quality Consultant

#### The Role of Gas Oil Imports in Satisfying European Diesel Oil Demand

Mr D Long, Oxford Institute of Energy Studies

#### Open Forum Panel

Comprising the chairman, Dr Cecil French, and all speakers.

For a copy of the registration form, please contact **Caroline Little, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Telephone 01-636 1004. Telex: 264380. Fax: 01-255 1472.**

# Oil pollution — recent developments and current issues

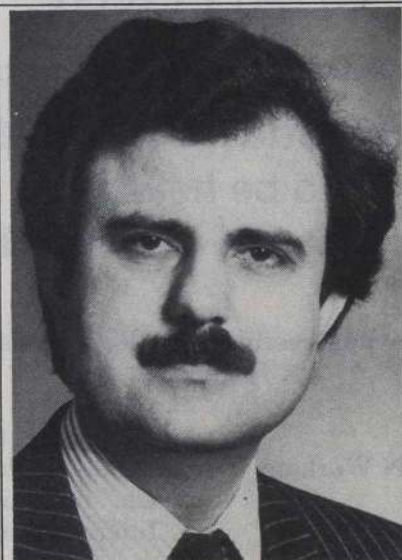
By Patrick O'Donovan, Partner, Bowyer Marine

Only one month into the current Protection and Indemnity year (which runs from 20 February — the notional date of the opening of the Baltic Sea to shipping) the *Exxon Valdez* tore open her cargo tanks on rocks in Prince William Sound, spilling millions of gallons of crude oil. The incident not only presented Exxon with a massive liability bill, only part of which was in any way covered by insurance, but also gave the oil industry in general (and all those involved in the owning, operating and insuring of oil tankers in particular) the fright of their lives. The incident undoubtedly fuelled an environmental debate which had been underway since at least the publication of the Brundtland report.

If anyone in the industry thought that the *Exxon Valdez* represented the bad news for 1989 and that matters could not get much worse, they would have been rudely disabused of that notion by the spectacle of two major pollution incidents off the Moroccan coast at the end of the year, involving the Iranian tanker *Khark 5* and the Spanish vessel *Aragon*. There were familiar scenes, as conflicting claims were made as to the extent of the risk of serious pollution. One again witnessed the transparent unwillingness of coastal states to allow a damaged vessel to have access to repair facilities for fear of their own coastlines being polluted (much to the equally apparent despair of the salvors involved in at least one of the cases, as they endeavoured to deliver the damaged ship and remaining cargo to a place of safety).

## Liability insurance

The liability cover for preventive measures undertaken, third-party damage suffered and the clean-up costs involved in casualties such as these is provided by a vessel's Protection and Indemnity (P&I) insurer — usually one of the Mutual Clubs. Those clubs provide liability insurance for tanker



Patrick O'Donovan.

owners' liabilities up to (in the current policy year) a maximum of \$400 mn — due to rise to \$500 mn from 20 February, with the possibility of a further rise up to a total level of \$750 mn (still far short of the reported costs of liabilities in the *Exxon Valdez* incident).

The clubs obviously cover legal liabilities in tort (or delict) imposed under

municipal law. This presupposes a finding by a competent court of fault on the part of a shipowner, rendering that owner liable to pay damages to the victims of the incident (usually national and local governments involved in clean-up operations, fishermen and those involved in coastal industries such as tourism). In the litigation following the *Amoco Cadiz* incident off Brittany in 1978, a wide range of defendants were sued and found liable, the registered owner being denied the right to limit its liability under US law. The liabilities thus incurred were covered by the owner's P&I Club.

The clubs also specifically cover a shipowner's obligations under the 1969 Civil Liability Convention (CLC), whereby an owner is made strictly liable for pollution damage without proof of fault but is entitled, in many circumstances, to limit his liability up to a maximum figure (currently approximately \$18.3 mn). In cases where CLC does not apply, the vast majority of tanker owners have voluntarily agreed (under TOVALOP — Tanker Owners Voluntary Agreement regarding Liability for Oil Pollution) to accept liability for pollution damage up to a certain figure

(\$16.8 mn) and, in certain circumstances, up to a maximum of \$70 mn under the Supplement to TOVALOP).

Additional compensation is provided by the oil industry (in contradistinction to shipowners and their insurers) under parallel schemes (the 1971 Fund Convention and CRISTAL — Contract Regarding a Supplement to Tanker Liability for Oil Pollution). That additional compensation will be available by operation of law in countries which are parties to the Fund Convention or by voluntary acceptance of liability by the oil industry in cases where the cargo is owned by a member of CRISTAL (and certain other conditions are met). Where applicable, the total available compensation is increased by the Fund Convention to approximately \$78.4 mn and, under CRISTAL, to \$135 mn.

The voluntary industry schemes (TOVALOP and CRISTAL) thus provide compensation markedly higher than those under the International Conventions. In fact, Protocols to those Conventions, signed in 1984, increased the level of compensation payable to levels that are broadly in line with those now available under the industry agreements. The Protocols are not yet in force (and consequently neither of the higher levels of compensation are yet available) in the absence of a sufficient number of ratifications.

## US legislation

Doubts surround the future of the Protocols, however, due in part to the confusion that currently exists in the United States over pending legislation to fix the nature and extent of a shipowner's liability for oil pollution. (Ratification by the United States had been seen as crucial to the success of the Protocols.) The *Exxon Valdez* incident has created a climate in the United States in which demands for the application of the 'polluter pays' principle, irrespective of fault and irrespective of the availability of insurance cover to back up such principle, has cast considerable doubt over the position that the United States will adopt.

For the present, separate bills have been passed by the Senate and the House of Representatives. Attempts have been made to produce a consolidated bill but, for the moment, considerable confusion still exists as to the direction in which the United States will go and whether or not, at the end of the day, the 1984 Protocols will play any part in the liability and compensation regime that emerges.

Obviously, if the legislation that does emerge imposes compulsory levels of liability substantially in excess of that under the 1984 Protocols and in excess of available insurance cover, shipowners will be discouraged (to say the least) from trading to the United States.

It is not entirely certain that the proponents of some of the suggestions that have come forward are fully aware of the consequences of some of their proposals. For example, there is a possibility in the United States of legislation which would result in owners having to fit double-bottoms and possibly double-hulls to tankers trading to US ports. At least one major oil company tanker owner/operator has expressed doubts as to the viability and efficaciousness of such legislation and there seems doubt as well as to world shipbuilding capacity to build suitable tonnage in the short or medium term.

## 'Pollution costs undreamt of a few years ago, save in underwriters' worst nightmares'

Until the situation in the United States is resolved one way or the other, it is impossible to predict what future the protocols have. If draconian legislation is implemented, it could well have repercussions not foreseen by the legislators who saw the events of March 1989 in Prince William Sound and, suitably outraged, felt that 'something must be done.'

### Recent trends

Moving from the 'grand design' to the more particular, one can discern a number of trends developing over the last year or so. Firstly, the factor that has taken most people by surprise is the sheer scale of the costs now involved in any major spill. The costs of the *Exxon Valdez* have been estimated at \$2 bn, a figure undreamt of a few years ago, save in P&I underwriters' worst nightmares. When one learns of the manpower involved in the clean-up operation, one begins to understand how that figure is reached — such a workforce has to be accommodated and transported to and from the operational site. The expenses involved in chartering planes, helicopters, vessels, specialist equipment (and again the cost of transportation to site) all add up inexorably.

At the other end of the scale, even a

bunker spill from a non-tanker can result in large claims and substantial liabilities — witness the *Kowloon Bridge* incident in Ireland and the recent case (October 1989) involving the bulk carrier *Mercantil Maricah* off western Norway where spilt bunkers gave rise to estimated clean-up costs of \$2.9 mn (which not that long ago might have been seen as a fairly serious tanker spill).

Next, there has been a tendency in recent years for governments to submit claims for 'environmental damage', by which is loosely meant damage to natural resources (coral reefs, mangrove swamps, flora and fauna) that are not usually 'owned' in the strict sense by anyone and which have no intrinsic economic value. The legal basis for such claims (where there has been no economic loss and the claims are simply of a theoretical nature) has been hotly debated.

In one of the first cases to come before the courts (the *Zoe Colocotroni* in the United States), the trial judge calculated the number of minute marine organisms killed by the oil spill in question and multiplied that number by their market cost (with reference to prices paid by or to biological supply laboratories) — even though there was never any intention of buying replacement organisms and reintroducing them into the polluted and contaminated environment which would hardly have supported them anyway. The appeal court in that case found that the relevant standard for determining damages in cases of environmental damage was 'the cost reasonably to be incurred by the (state) to restore or rehabilitate the environment in the affected area to its pre-existing condition, or as close thereto as is possible without grossly disproportionate expenditures.'

The problem of damage to the marine environment has been considered in the Soviet Union, where special legislation lays down criteria for the calculation of damages. These are calculated on the assumption that each ton of oil spilled will pollute a certain volume of sea water. Damages are then awarded at an amount equivalent to a given sum per cubic metre of water polluted.

The policy of the International Oil Pollution Compensation (IOPC) Fund

(which is the inter-governmental organisation established to administer the regime of compensation created by the Fund Convention) has determined that assessments for compensation under the Convention 'are not to be made on the basis of an abstract quantification of damage calculated in accordance with theoretical models'.

Recent amendments to the TOVALOP Supplement and CRISTAL also address this matter and limit environmental damage to costs actually incurred in taking reasonable and necessary measures to restore or replace natural resources damaged as

a direct result of an oil spill but specifically exclude any other damage to the environment.

The shipping press last November, in the space of a few days, carried reports of separate proceedings commenced in the United States for damage to natural resources. The first instance concerned a claim by the State of Florida for the sum of \$176,058 for the death of 214 birds. The other claim was by the US Federal Government for damages against a Yugoslav cargoship which ran aground on a coral reef in a marine conservation area, allegedly causing damage to the ecosystem of

the Fort Jefferson National Monument.

Both claims reflect a growing trend worldwide to claim damages not as a means of obtaining compensation but for the purposes of punishment and (possibly) *pour decourager les autres*. Such trends (coupled with the sort of legislation that seems to be emerging in the United States) inevitably bring the civil law closer to criminal law (by the use of what are in effect penal sanctions) and can scarcely encourage owners and, in particular P&I underwriters, to look forward with optimism to the 1990s. ■



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**Fuel Oil — a Return to the Power Generation Market?**  
**Mr Graham A Weale — Manager, WEFA ENERGY**

**The Future Supply of Fuel Oil from the OAPEC Exporting Refineries**

**Mr Abdulelah J Alhabib, OAPEC (Organisation for Arab Petroleum Exporting Countries)**

**Power Generation Options in an Oil Refinery**  
**Mr I M Duguid, Process Engineering Superintendent, Conoco Ltd., Humber Refinery**

**Heavy Residue Gasification Schemes**  
**Mr K M Brady, Licensing Manager, Texaco Development Corporation and Mr Lars Nelson, Managing Director, Skanraff Refinery**

For a copy of the registration form, please contact **Susan Ashton**, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Telephone: 01-636 1004. Telex: 264380. Fax: 01-255 1472.



INFORMATION FOR  
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## OIL PRICE INFORMATION 20 February 1990

The Oil Price Information Seminar has become a popular and regular feature during IP Week. The programme of three papers on aspects of price information combined with an exhibition by suppliers of such information has proved to be a successful formula.

### PROGRAMME

#### **Chairman's Opening Remarks**

Mr Silvan Robinson, CBE, Chairman, Energy and Environmental Programme, Royal Institute of International Affairs

#### **Oil Price Information and Analysis — An Integrated Approach**

Martin J Yates, Managing Director, Saladin Computer Systems Ltd.

#### **Can Past Prices Predict Future Trends?**

Meg Annesley, Oil Consultant

#### **Sentiment as a Market Factor — Does OPEC Really Figure?**

Peter Bild, European Representative, Oil Daily

#### **Exhibits and Displays by Suppliers of Oil Price Information**

#### **Wine Reception**

*Exhibits will be provided by ICIS-LOR, Saladin Computer Systems, Telerate, Petroleum Argus, Reuters.*

For a copy of the registration form, please contact **Mrs J Etherton**, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Telephone: 01-636 1004. Telex: 264380. Fax: 01-255 1472.

# Tanker demand and profitability in the 1990s

By Stephen Hanrahan, Director, Ocean Shipping Consultants

The total volume of oil tankers in the world is currently 234 million dwt, a level which represents a 30 percent decline since the peak year of 1978. Since then, the tanker fleet has declined in every year, with the significant exception of 1988 when a 2 percent increase was noted.

Different sectors of the fleet have recorded different developments over the past decade. While the Very Large Crude Carrier (VLCC) and Ultra Large Crude Carrier (ULCC) sectors have suffered a 41 percent decline, the reduction has been far less marked for the smaller vessels and is somewhere in the region of 8 percent overall. Of the current fleet, VLCCs account for 39 percent of the fleet aggregate, with ULCC tonnage comprising a further 13 percent.

## Age profile

The age profile of the current fleet can be seen in **Figure 1**. This highlights the difference in profile for larger tonnage in relation to smaller vessels. Thus, for the smaller tonnage, around 50 percent was built in the last 10 years, against just 20 percent in the case of VLCCs and 10 percent for the larger tonnage.

## Tanker demand

On the demand side, the total volume of crude oil traded by sea was around 1,060 million tonnes in 1988, a level which was up by 10 percent on the previous year but still some 29 percent below the 1979 peak. While trade levels have fallen considerably since

1976, the decline in tanker demand has been even greater. This has involved a decline in the average haul length for crude shipments from over 7,000 miles to under 5,000 miles.

**Figure 2** presents details of the actual employment of all VLCC vessels in 1988. The most striking feature is the high level of significance of casualty/repair for the upper size classes of VLCC. Whilst these include some vessels undergoing routine maintenance work, it is closely related to the Iran-Iraq war in the Gulf. This category of activity accounted for around 11 percent of VLCC availability during the year.

A similar analysis for ULCC tonnage is presented in **Figure 3**. The

significance of storage use and of lay-up is also high, accounting for 17 percent and 12 percent respectively of the sector as a whole, with these percentages far higher for the larger tonnage.

## Future demand

Our forecasts for the development of crude oil trade volumes in the 1990s is presented in **Figure 4**. Growth of some 24 percent is forecast, although the pattern of import volume development is set to differ markedly between different areas. Thus, total import expansion for the United States is projected at 75 percent which is in sharp contrast to a 28 percent decline for Japan.

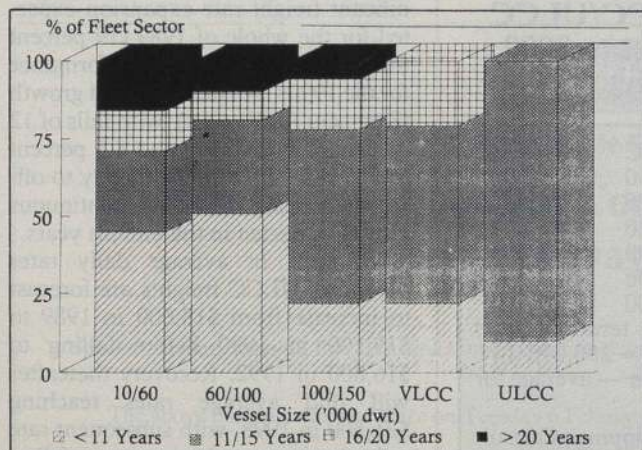


Figure 1: Current Tanker Fleet — Age Analysis

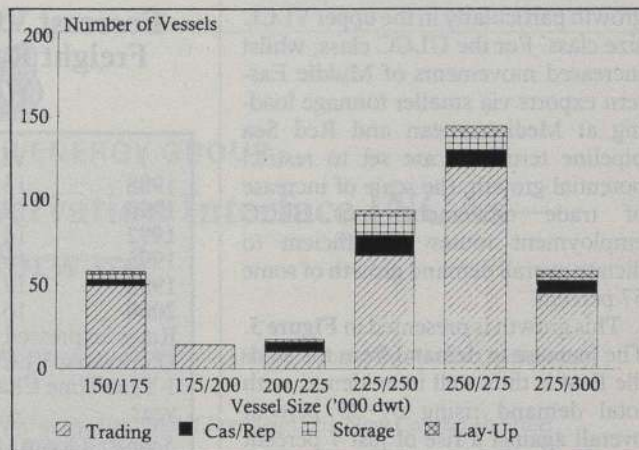


Figure 2: VLCC Patterns of Activity — 1988

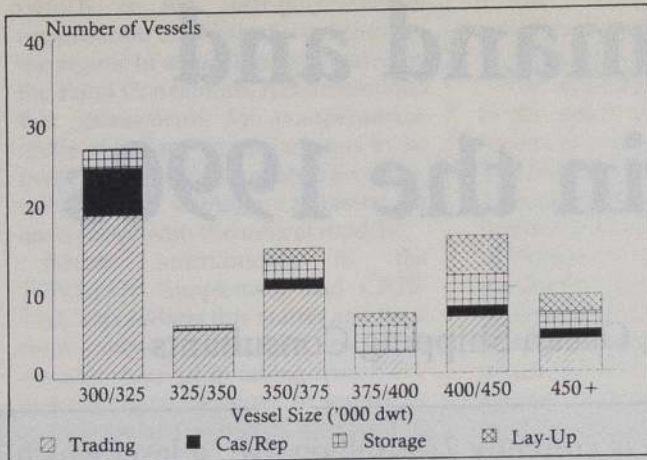


Figure 3: ULCC Patterns of Activity — 1988

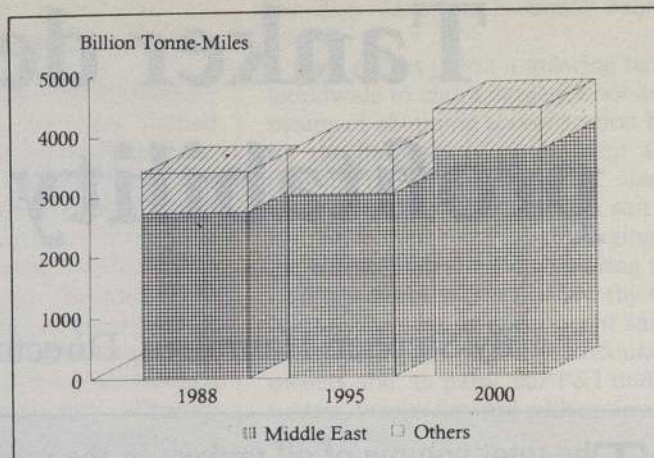


Figure 4: Forecast VLCC/ULCC Demand to 2000

For the trade aggregate, annual average growth of around 1.5 percent is forecast to the middle of the 1990s, taking the world total to almost 1,200 million tonnes in 1995. Growth of around 2 percent per annum thereafter will take the total to over 1,300 million tonnes by 2000. These future volumes are still well below those of the late 1970s, with the forecast volume for 2000 some 12 percent below the 1979 peak.

Whilst trade volumes are forecast to expand by some 24 percent over the forward period, total shipping demand is set to increase by 32 percent, to around 7,000 billion tonne-miles.

For the VLCC and ULCC sectors, the increased use of pipelines in the Middle East and the large decline forecast in Japanese imports are set to impact on demand levels. Against these, however, the large-scale increase in US imports and the increasing global importance of supplies from the Middle East are set to favour higher demand levels. Total demand for VLCC and ULCC tonnage is therefore forecast to rise by 30 percent over the study period, taking the aggregate level to 4,400 billion tonne-miles.

These factors will restrict demand growth particularly in the upper VLCC size class. For the ULCC class, whilst increased movements of Middle Eastern exports via smaller tonnage loading at Mediterranean and Red Sea pipeline terminals are set to restrict potential growth, the scale of increase of trade movements on ULCC employment routes is sufficient to dictate overall demand growth of some 57 percent.

This growth is presented in Figure 5. The increase in demand from the Middle East is thus well in evidence, with total demand rising by 35 percent overall against a rise of just 7 percent for other regions. Exports from the Middle East will therefore account for

84 percent of total VLCC demand in 2000 against 80 percent at present.

### VLCC/ULCC supply

Newbuilding order levels are set to increase almost continuously throughout the 1990s, this after a decline in the early part of the decade in line with demand projections. From the 1989 level of 4.6 million dwt therefore, VLCC deliveries are forecast to exceed 4 million dwt over the next two to three years before falling to around 3.5 million dwt over 1993/94. Continuous expansion thereafter is set to take this total to 6.5/7.0 million dwt per annum by the end of the decade.

Similarly in the ULCC sector, whilst there are no newbuildings currently on order, some deliveries of new tonnage are expected by 1991/92, with a decline in interest causing delivery volumes to fall in the following two years, before increasing throughout the second half of the 1990s. By the year 2000 therefore, annual delivery volumes are expected to reach well over 3 million dwt.

Total deliveries of new VLCC/

### Forecast VLCC/ULCC Freight Rates to 2000 (\$/day)

	VLCC	ULCC
1988	13,150	15,000
1990	14,970	19,100
1992	14,520	16,810
1995	16,300	19,900
1998	17,700	21,500
2000	16,100	19,700

Rates expressed in terms of 1988 US dollars; VLCC = 250,000 dwt 1 Year Time Charter — average for year

Source: Ocean Shipping Consultants

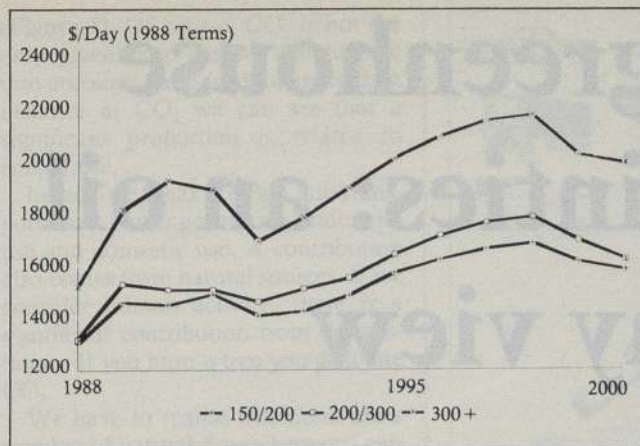
ULCC vessels are thus forecast to increase from the current level of 4.6 million dwt to 10.1 million dwt in 2000.

Total VLCC/ULCC scrapping is expected to rise from 0.9 million dwt in 1989 to over 5.1 million dwt by 1993/94, largely as a result of the high average age within the VLCC/ULCC fleets. The bulk of this aggregate will inevitably arise in the 200/300,000 dwt sector, where annual scrapping volumes are expected to exceed 3.0 million dwt for much of the 1991/95 period.

### Freight rates

The general trend for the forward period is thus to be one of freight expansion, with the exception of the very early and very late years of the decade, when rate declines are expected, in line with the development of demand. Freight movements are likely to be most significant in the larger tonnage sectors — the end-period level for ULCCs some 30 percent higher than the 1988 level, with the corresponding performance for VLCCs equating 21/22 percent. Given the significant freight rate expansion expected for the whole of 1989 (19 percent for ULCCs) the overall performance for the 1990s is of just 3 percent growth (8 percent for VLCCs), with falls of 12 percent (for 1990/92) and 8.5 percent (for 1998/2000) tending largely to offset the considerable and continuous growth expected in the interim years.

In terms of average daily rates therefore, ULCC freights are forecast to increase from \$18,000 in 1989 to \$19,100 in 1990 before falling to \$16,800 in 1992. Recovery thereafter will find average rates reaching \$21,500 in 1998, with subsequent rate softening causing the average to fall to \$19,700 in the year 2000.



**Figure 5: Forecast VLCC/ULCC 12 Month Time Charter Rates**

For VLCCs, the forward period is also set to be expansionary overall, although the 1990/92 and 1998/2000 periods are again set to offset partially the rate expansion of the interim period. Rate declines are less marked than for larger tonnage however, this combining with the slower level of rate expansion over the mid-1990s to produce a far more steady development profile. In terms of average daily rates for 200/300,000 dwt vessels, the mean of \$15,200 in 1989 is set to decline by 3.5 percent (\$450) by 1992. Subsequent rate expansion will see the average reach \$17,700 in 1998, with the end-period level of \$16,100 some 9 percent down on this peak.

### Profits

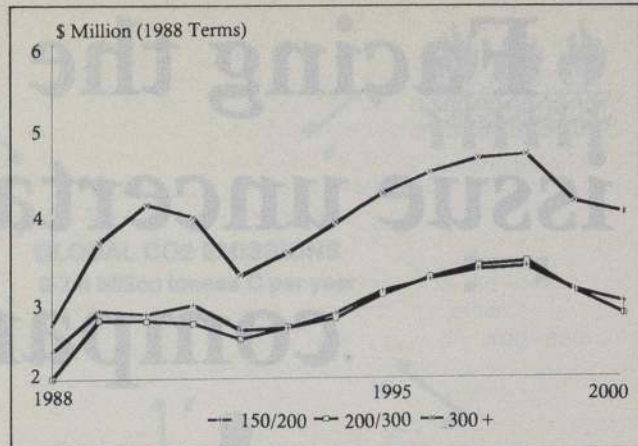
With operating cost aggregates unlikely to exhibit any significant real term development over the period, the profile of annual operating profits is set to trace closely that of freight rates, this being especially the case for ULCC tonnage.

In terms of annual profit levels

therefore, the ULCC sector is set to witness a level of just over \$4 million in 1990, this declining to \$3.23 million in 1992 before growing to over \$4.6 million by 1997. Rate decline in the late 1990s will see this profit performance reduced to the \$4.0 million level by the end of the study period, which is still some 49 percent above that of 1988 and 9 percent higher than the projected level for 1989.

In the VLCC sector, annual operating profits for 200,000 + dwt vessels are set to vary within the \$2.4/3.4 million range throughout the study period, after rising from the \$2 million level of 1988.

The situation for tonnage ordered in 1989 is inevitably less healthy than that for earlier tonnage, given the rise in newbuilding prices noted over 1988/89. For ULCCs, total profits are unlikely to be reached until 1996/97 and are projected to reach a peak of \$0.68 million in 1998 before falling to just over \$0.3 million in each of the following years. Similarly for VLCC tonnage, the higher newbuilding prices dictate that break-even is not attained



**Figure 6: Forecast VLCC/ULCC Operating Profits**

in the study period, with annual losses ranging from the initial \$2.5 million to \$0.25 million in 1998. Total losses for the 1991/2000 period equate \$12.4 million for VLCC and \$4.9 million for ULCC tonnage — these aggregate figures comparing to the \$8.6 million loss and \$0.8 million profit associated with VLCC and ULCC tonnage ordered in 1988.

This serves to emphasize that the prospects for profits over the next decade for tonnage ordered recently this year, are not good. There will be however, some valuable opportunities for relatively low cost purchase during this time.

The recent large-scale movements in freight-rates and prices, also serves to emphasize, that the timing of such purchase or charter action, will be crucial in determining future profits. ■

**The report VLCC Markets to 2000 is available from: Ocean Shipping Consultants, Ocean House, 60 Guildford Street, Chertsey, Surrey KT16 9BE. Price: £385 (US\$695).**



INFORMATION FOR ENERGY GROUP

## The Industry — Nature Conservation Interface INCAs — A way forward

Speaker: **Jeremy Russell**, Royal Institute for International Affairs accompanied by video film produced by Nature Conservancy Council

The above meeting will take place on Tuesday 6 February 1990 at the Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR at 5.45 pm.

Tea available from 5.30 pm. All welcome.

# Facing the greenhouse issue uncertainties: an oil company view

Four senior representatives from Shell International Petroleum, and a fifth, from Shell UK, who are responsible for studying the complexities of the information and attitudes relating to the greenhouse effect discuss the issue in an interview with *Petroleum Review*.

They were:

Dr Ian J Graham-Bryce, Head of Environmental Affairs, Health, Safety and Environment Division, Shell Internationale Petroleum Maatschappij B.V.;  
Peter Bright, International Issues, Group Public Affairs, Shell International Petroleum;  
Ged Davis, Head of Energy Department, Group Planning, Shell International Petroleum;  
Dr Ton Hoff, Science and Technology Analyst in Group Planning, Shell International Petroleum Company; and  
John Wybrew, Public Affairs and Planning Director, Shell UK.

They believe that:

- the greenhouse issue is a most formidable public policy matter which requires an overall energy strategy initiated by governments, and in which technological transfer from developed to underdeveloped countries in energy production and consumption will be necessary;
- but against these essentials, there is little proof of anything except that the greenhouse issue has many uncertainties.
- Meanwhile, there are good prospects for significant measures to contain the rising trend of carbon dioxide emissions — for example, the entry of natural gas and efficient generating technology into the privatised UK power market.

**Geoffrey Mayhew:** Will the greenhouse effect influence the energy industry because of the certainty of severe global warming in about 50 years, or because the world is thought to have no option but to invest in an all-risks insurance policy for survival in case it has such an effect?

**Dr Graham-Bryce:** The first point which catches my attention is your use of the words 'certainty of severe global warming' because we would see that the greenhouse issue is one which is full of uncertainties.

Although there is no doubt that greenhouse gas concentrations, notably CO<sub>2</sub>, have been increasing, the consequences are still very unclear,

and the predictions are based on climatic models which have many limitations. Nevertheless, we would not regard that as a reason for under-rating the importance of the subject.

Indeed, many of the parties involved are increasingly taking the view that it would be prudent to go for reasonable precautionary measures because the magnitude of the risk would justify it.

One therefore comes to the conclusion that the greenhouse issue is very likely to have a considerable influence on the energy industry, both because of effects which may take place but also because of the political interest being generated in the subject which is likely to lead to actions of various sorts.

**Ged Davis:** There are many people who do have concern over the greenhouse effect, and it is an issue which is of global magnitude, and potentially has large consequences.

Equally, the great uncertainty makes it a formidable public policy issue — indeed, perhaps one of the most formidable public policy issues which mankind has had to face.

**What are the emissions which contribute to global warming:**

**Dr Hoff:** I think it would help to answer that question by referring to a chart which breaks down the contributions from different sources of CO<sub>2</sub>.

(Figure 1). Of course, CO<sub>2</sub> is not the only greenhouse gas we should take into account, but if we look in the first instance at CO<sub>2</sub> we can see that a significant proportion is related to energy use.

In fact, we break it down into transportation, power generation, industrial use and domestic use. A contribution also comes from natural sources. If we consider human activity, there is a significant contribution from deforestation. If you burn a tree you generate CO<sub>2</sub>.

We have to realise that there are a number of natural fluxes between carbon reservoirs, primarily the oceans, soil and biota like trees which generate a lot more CO<sub>2</sub>, although in general it is assumed that these fluxes are in equilibrium.

It is the case that most CO<sub>2</sub> production is related to fossil fuel production, but I am talking about the CO<sub>2</sub> production that is leading to an increase in the stock of CO<sub>2</sub> in the atmosphere.

#### How do energy industry emissions relate to greenhouse gases from other sources?

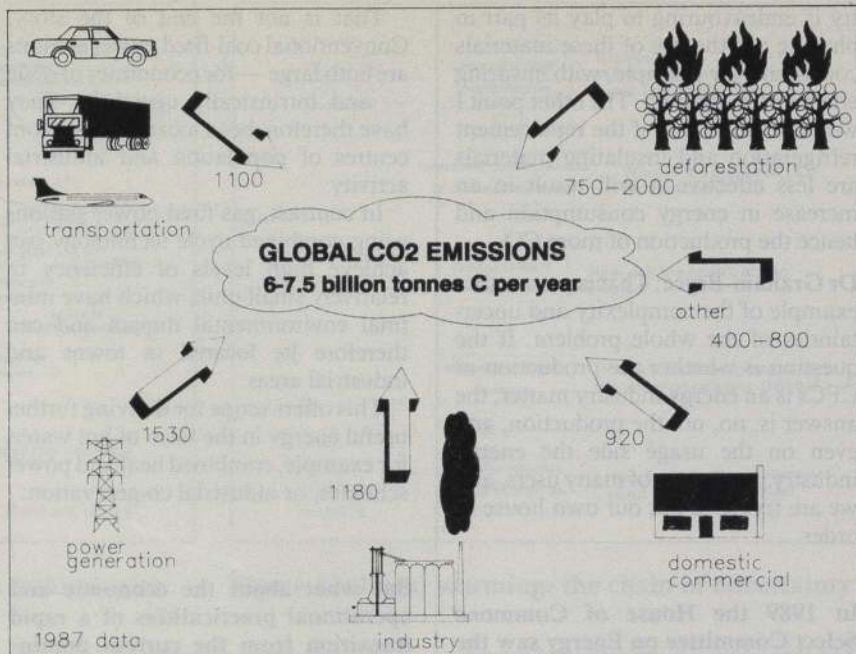
**Dr Hoff:** Besides CO<sub>2</sub> we should take into account a number of other greenhouse gases: methane, chlorofluorocarbons — the so-called CFCs — nitrous oxide and ozone. There are a lot more greenhouse gases, but they provide minor contributions. If you look at the relative contribution of each of those gases, there is significant uncertainty about that as well.

Some people believe that CO<sub>2</sub> accounts for between 40 and 45 percent, and you find figures ranging up to 55 percent. The actual figure is likely to be about 50 percent. Methane accounts for about 20 percent, or perhaps slightly less; CFCs account for some 17 percent, and the remaining 12 percent comes from nitrous oxide and ozone.

If you look at the non-CO<sub>2</sub> greenhouse gases, only a small contribution originates from the energy industry. With methane, for example, a minor part comes from the fossil fuel industry. Methane is a natural gas, and if you produce natural gas you lose part of it in the distribution and production system, but only a very minor part.

Methane is also a byproduct of coal mining. If you produce coal or dig for it, you release methane which has been locked up in the coal seams. Most of the methane being produced, however, comes from rice paddies and also natural sources like swamps, cattle, etc.

Looking at CFCs, the main sources are those gases used in refrigerators, air



**Figure 1.**

conditioners, insulating materials, aerosols and the propellant gases in spray cans.

#### There have been changes in the balance between these contributory factors?

**Dr Hoff:** That is correct. The greenhouse effect was debated 15 or more years ago, mainly in the scientific community, and the discussion then was based largely on the concern about the CO<sub>2</sub> build-up in the atmosphere.

Predictions were made of future energy use. Growth was assumed to be 4 percent per annum, and a doubling of CO<sub>2</sub> was predicted early in the next century. However, two important events took place.

First of all, there was the oil price crisis; the oil price went up steeply, which meant that all the forecasts for energy requirements were changed. The growth prediction was reduced from 4 to 2 percent, and CO<sub>2</sub> seemed to become less important in the greenhouse debate than had been assumed earlier.

The second thing which happened was that, almost in the same period, it was discovered that there were other greenhouse gases like the ones I mentioned which are important.

If you compare the gases on a molecule-for-molecule basis, the CFCs are 10,000 to 20,000 times more potent than CO<sub>2</sub>. And atmospheric lifetimes are quite different for the different greenhouse gases. If you take all of the greenhouse gases into account, then the contribution is about 50-50 between CO<sub>2</sub> and other gases.

Effectively, a doubling of the equivalent CO<sub>2</sub> concentration in the atmosphere was predicted to occur before the middle of the next century, which gave rise to the revival of the greenhouse debate — so it is not a static situation.

#### Is the CO<sub>2</sub> contribution going to increase in that way?

**Dr Hoff:** That is a question which is very difficult to answer, because for that you need to predict future energy use and predict what happens to the production of the other greenhouse gases.

There is already the CFC Treaty (the Montreal Protocol), which has been ratified by a number of countries. The Montreal Protocol is designed to reduce the production of CFCs by 50 percent by the end of the century. It has not been ratified by all the CFC producing countries.

Already a number of debates are taking place to arrive at a complete phasing out of the use of CFCs, not so much because there may be a link to the greenhouse effect, but because these gases are attacking the ozone layer. The Montreal Protocol was therefore set up for different reasons initially but we know that it will be of great help in tackling greenhouse gas emissions.

#### Are CFCs specifically an energy industry matter?

**Peter Bright:** The energy industry is not the main user of CFCs. But we certainly do use CFCs in refrigeration and halons for fire-fighting. The indus-

try is endeavouring to play its part in phasing out the use of these materials consistent, for example, with ensuring effective fire-fighting. The other point I would make is that if the replacement refrigeration and insulating materials are less effective it will result in an increase in energy consumption and hence the production of more CO<sub>2</sub>.

**Dr Graham-Bryce:** That is yet another example of the complexity and uncertainties of the whole problem. If the question is whether the production of CFCs is an energy industry matter, the answer is: no, not the production, and even on the usage side the energy industry is only one of many users, and we are trying to put our own house in order.

**In 1989 the House of Commons Select Committee on Energy saw the practical possibility of a huge reduction in greenhouse gases, chiefly CO<sub>2</sub>, through improvements in energy efficiency among developed nations, and naturally it was concentrating on the UK. What do you think might be done in power generation in this country?**

**John Wybrew:** There is certainly considerable scope for reducing the output of CO<sub>2</sub> from Britain's power generation sector. Bear in mind that nearly a third of all fossil fuel consumed in the UK is burnt in power stations to generate electricity. Moreover, about 80 percent of our electricity is generated from coal in large coal-fired power stations with thermal efficiencies of the order of 35 percent.

Such power stations produce around twice as much CO<sub>2</sub> per unit of electricity generated, as can now be achieved using natural gas as fuel with new generating technology — combined cycle turbines.

In recent years considerable advances have been made in gas turbine technology, mainly as a result of research and development — including the use of new materials — in the field of military and civil aviation. In consequence it is already possible to generate electricity with thermal efficiencies of upwards of 45 percent by using gas turbines in a so-called 'combined cycle' configuration to maximise the conversion from fuel to electricity.

And whereas the maximum thermal efficiency of conventional coal-fired power stations is limited by the laws of physics, it is readily foreseen that the thermal efficiency of combined cycle gas turbines can be pushed above 50 percent.

That is not the end of the story. Conventional coal-fired power stations are both large — for economies of scale — and intrinsically unsightly. They have therefore been located away from centres of population and industrial activity.

In contrast, gas-fired power stations using combined cycle technology can achieve high levels of efficiency in relatively small units which have minimal environmental impact and can therefore be located in towns and industrial areas.

This offers scope for deriving further useful energy in the form of hot water, for example, combined heat and power schemes, or industrial co-generation.

**But what about the economic and operational practicalities of a rapid transition from the current dominance of large conventional coal-fired power stations to gas in combined cycle gas turbine plant?**

**John Wybrew:** There are two aspects of this question. First, the availability of natural gas on a scale to support the continued rapid build-up of combined cycle power stations without inflating the price. Second, the economic case for retiring existing coal-fired plant to be replaced by gas-fired combined cycle plant.

Fortunately, history is on our side.

Today's stock of power stations was built in an intense wave of construction activity in the 1950s and 1960s. Consequently, they are approaching retirement in something of a bunch.

With increasingly stringent sulphur dioxide emission standards already a fact, and with carbon taxes in prospect, the soon-to-be-privatised generating companies — National Power and Power Gen — are bound to think hard before investing to bring their older coal-fired power stations up to the environmental standards foreseen in the 1990s. Meanwhile, plenty of would-be independent generators are keen to enter the liberalised private sector power market with combined cycle gas power stations.

Thus, in Britain, electricity privatisation and the accompanying market restructuring and liberalisation, including the supply of fuels to power stations, is likely to accelerate two trends, both favourable in reducing the output of CO<sub>2</sub>.

The first of these trends is the early replacement of ageing coal-fired power stations with gas in combined cycle power plant. The second is the emergence of a large number of industrial co-generation projects based on gas

and, particularly if encouraged by the government, a growing number of CHP schemes.

**Will the availability of natural gas at the right price be sufficient to sustain a very substantial substitution of gas for coal in the huge power station sector?**

**John Wybrew:** Here again the outlook is favourable. The inventory of undeveloped UK North Sea gas reserves has grown considerably. This apart, there are large reserves of Norwegian gas. And with the Russian economy in dire straits, there will be a strong incentive to export more of the enormous Siberian gas reserves into Western Europe.

Previously there have been strategic and security reasons for limiting Western Europe's dependence on Soviet gas. In the light of recent developments in the Communist Bloc, such limitations are less likely to continue through the 1990s.

**What do you think about the practical possibility of a huge reduction in greenhouse gases, chiefly CO<sub>2</sub>, over a wider range of countries?**

**Ged Davis:** We derive 85 percent of total energy needs from chemical energy and a significant component is the combustion of carbon.

If the greenhouse effect is a real problem, we will have to find options to replace the combustion of carbon.

What options are there? One obvious option is the more efficient use of chemical energy. We know that energy efficiency has an important role to play — specifically the improved efficiency of energy using artefacts like boilers, cars, electrical appliances and so on, and beyond artefacts the efficiency of wider systems such as transport as a whole.

The other obvious option arises when one looks at the burning of fossil fuels. Recognising that these fuels contain both hydrogen and carbon, one could promote those fuels with a higher hydrogen to carbon ratio, which in simple terms implies that one might prefer methane as a fuel to coal when one considers only the production of CO<sub>2</sub>.

However, there will be other factors involved when one comes to make decisions on fuel selection.

A third option is to examine the possibilities of providing this basic end use energy in a way which does not require chemical energy as its basic source. These possibilities include nuclear fission, wind power, hydro-

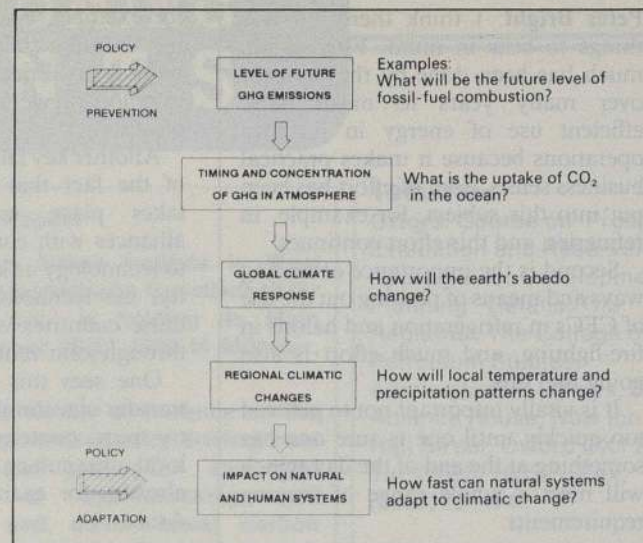
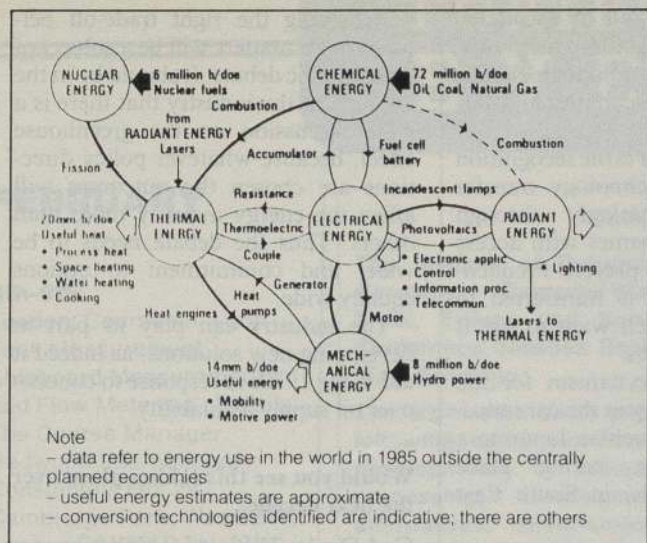


Figure 2. Energy use and conversion technologies

Figure 3. Global warming: the chain of uncertainty

electric power and photovoltaic systems. There are other options under examination which we could discuss.

**In power generation there is a strong move towards the use of natural gas. Will that be healthy internationally?**

**Ged Davis:** Clearly, whether it is 'healthy' and indeed, feasible, depends on the specific country. If we look at different countries, power generation involves the use of different fuels and depends in many cases on the local availability of fuels. The question of security of supply is very important. Many countries have located their power stations near cheap, easily available fuels, like coal.

Since the 1950s, nuclear energy has been seen to be an important source of electricity for the obvious reason that much of the concern regarding security of supply can be resolved using nuclear energy.

It is clear that gas has an important role to play in electricity generation. The introduction of combined cycle gas plants is a good option today — with prevailing economics.

One would qualify this by saying one first has to have the necessary infrastructure in place. Gas in large quantities is not always found near the markets it could serve, so infrastructure development is very important and may be the critical restraint.

**Dr Hoff:** In any switch of fossil fuels it is important to improve the efficiency of use of the fuel. An example of new technology is coal gasification which can make a significant contribution.

**Ged Davis:** To add one point, it must be recognised that there are many parts

of the world which are heavily dependent on coal; they have built up their energy industries on the basis of coal. Some developing countries will be strongly dependent on coal development to put in place the basic industrial infrastructure they will need for development. China is an obvious example.

Therefore, any contribution made to improved efficiency in the way we combust and use coal will clearly make a contribution both to global environmental needs as well as consumers' needs for useful energy, because it is clear such countries will have to develop their coal industries to achieve economic development.

**Dr Graham-Bryce:** I think we need a comprehensive strategy in which all these factors are weighed up and the best options are developed.

**Who would develop that strategy?**

**Dr Graham-Bryce:** I think it has to be developed by governments in collaboration, obviously taking advice from industry and other experts.

**Can emissions be reduced, or are emissions the penalty of an industrialised world?**

**Ged Davis:** The first thing to recognise is that in some countries emissions of various types have been reduced. They have been reduced because there has been public support that this is desirable, there has been consultation with industry about what might be achieved and incentives have been put in place to encourage the various actors to achieve these reductions.

A good example is in the UK, where the government's tax incentive has

persuaded drivers to use unleaded gasoline. There was a public desire to reduce the amount of lead going into the atmosphere and government has put in place the relevant incentives. Industry assisted by making sure the fuel could be made available.

Looking at car development, it is certainly possible to envisage much more efficient engines and lighter cars. Looking 20 years ahead, it is possible that the average efficiency of new cars entering the markets of the developed countries will be upwards of 50 or 60 mpg.

**Would the motorist have to pay more for this efficiency?**

**Ged Davis:** Possibly, but there are studies which indicate that a particular car averaging 30 mpg could be redesigned to operate at 50 mpg. The increased costs of the car would be largely offset by reduced fuel costs.

**Power generation might be a different story?**

**Ged Davis:** If we consider the greenhouse effect to be the major policy issue of the 1990s, we will have to look very carefully at possible increased costs and trade them off against other policy objectives. These costs will include more than just the power plant, but the full cost of fuel supply.

This is an area which will require much discussion. Inevitably, it could mean a major shift in priorities to tackle the greenhouse effect and have important implications for the energy scene.

**What is your view about what the energy industry is doing to reduce greenhouse gas emissions?**

**Peter Bright:** I think there are two things to bear in mind. First of all, much has been done by the industry over many years to make more efficient use of energy in its own operations because it makes practical business sense. A lot of effort has been put into this subject, for example, in refineries, and this effort continues.

Second is the importance of finding ways and means of phasing out the use of CFCs in refrigeration and halons in fire-fighting, and much effort is also going into this.

It is vitally important not to proceed too quickly until one is sure one has something at the end of the day which will meet a whole range of varying requirements.

### **Are countries of the south able to afford the technological changes developed in the north?**

**Ged Davis:** The important starting point is to recognise that as countries develop they have an increasing need for infrastructure, such as roads and rail and a desire to build cities. These activities require energy-intensive materials — which leads to a rapid increase in total energy requirements, and in particular, as economies develop, there is a need for transport.

The development process will require more energy but it is equally true that over time as technology develops we will find more efficient industrial processes, and so on.

In the context of the greenhouse effect, if governments begin to put policies in place some time in the 1990s, then a major challenge will be how those policies can be framed so that developing countries can achieve the sort of societies they wish to achieve *and* also tackle the greenhouse issue.

Probably an important element in any greenhouse policy is to ensure that energy prices properly reflect the environmental cost in some way and that incentives are given to industry and to consumers to act in ways which will ameliorate the greenhouse problem. In some countries just adjusting prices in line with present costs would be a step forward.

### **The price of products?**

**Ged Davis:** Yes. It might be sensible to envisage prices which reflect all costs, including environmental costs.

There will almost certainly be a lot of debate about how prices might be modified: for example, governments might decide, in some cases, to disallow the burning of a particular fuel,

for example, coal, and to encourage the burning of another fuel, say, natural gas. Prices would then change to reflect prevailing scarcities and surpluses.

Another key factor is the recognition of the fact that technology transfer takes place increasingly through alliances with companies with access to technology as key players. Frequently, the technology is transferred to those countries which want to use it through joint ventures.

One sees this mechanism for the transfer of technology in the car industry from countries such as Japan to a local manufacturer, taking place already, for example, in South East Asia.

**Dr Hoff:** You have talked only of the north-south division as far as the greenhouse effect is concerned, but we must also look at the east-west division, because if we look at the so-called centrally planned economies, their societies have developed in a completely different way from our own, and their greenhouse gas emissions, measuring them per unit of GNP, are much higher than in Western Europe or the United States.

### **How does Shell see the way ahead internationally in monitoring and measuring the greenhouse effect from the energy industry, and in enlisting public support for the changes which may become necessary?**

**Dr Graham-Bryce:** We began by emphasising the uncertainties of the situation, and we have to keep doing so. However, we see the issue as something to be taken very seriously and we have given our reasons for that.

Therefore, we would see it as being in the interests of all sectors, including the energy industry, that the uncertainties are eliminated as far as possible and appropriate policies are developed.

Clearly, we would want to contribute our knowledge and expertise to the development of those policies and to inform the debate in the ways in which we have particular expertise — that would include some of the implications of policy options.

**Ged Davis:** I agree with what Ian has said. I think it important to add one or two points. First of all, this is a policy issue of large magnitude and it must be placed in the context of the fact that governments deal with a wide range of concerns; for example, they are concerned with security, with economic welfare and, increasingly, environmental matters.

Achieving the right trade-off between those matters will be a subject of much public debate. It should be in the interests of the industry that there is a wide discussion on the greenhouse effect, because whatever policy directions are chosen the outcomes will affect the energy industry more than others. Thus the debate needs to be wide, and commitment to options equally wide.

The industry can play its part in developing new solutions, as indeed it did in the 1970s in response to concern over oil supply availability.

### **Would you see this taking place over the next decade?**

**Ged Davis:** The very fact that we are sitting here indicates there is a major interest and concern. Some governments are considering targets to maintain CO<sub>2</sub> emissions at present levels by 2000 and the Toronto targets imply a 20 percent decline by 2005. I think 1990 will be a warm year for us!

**Dr Hoff:** At the same time, it is fair to say there is still so much scientific uncertainty on the subject that, whatever policies are put forward, primarily they will be those policies which will give rise to programmes which do not have downside risks: in other words, primarily they will be energy efficiency improvements which will be better from the economic point of view in the long run, rather than forcibly switching from one fuel to another.

**Peter Bright:** I believe the problem we are talking about is not just one for industry, because everybody uses energy. Government and the public are big users of energy. The solution must lie with everybody.

There is the whole question of gaining a balanced understanding of what the problem is, so that on the one hand people are not panicked into doing things which have not been thought through properly; and, on the other hand, that the public can put the appropriate pressure on governments to make some of the difficult decisions which will have to be made.

To help the public play its part it will be up to business and governments together to find ways and means of making energy available to them in a more environmentally acceptable and efficient way.

Presentation and policy should be such as to enable the public to make sensible choices between different types of services and goods — sensible both economically and environmentally. ■

# FORTHCOMING EVENTS

## FEBRUARY

### 5th-9th

**London:** Course on 'Land Tank Measurement, Shipboard Measurement and Flow Metering'. Details: The Course Manager, Redwood International Consultants Ltd, 29 Cambridge Park, Wanstead, London E11 2PU. Tel: (01) 989 5191.

### 6th-7th

**Houston, Texas:** Conference 'The New Era: Energy, The Environment, and Global Strategies'. Details: Simi Edelstein, Vanguard Communications, 1835 K Street, NW Suite 805, Washington, DC 20006.

### 6th-8th

**London:** Forecourt Retailing and Equipment Exhibition. Details: MGB Exhibitions Ltd, Marlowe House, 109 Station Road, Sidcup, Kent DA15 7ET. Tel: (01) 302 8585.

### 7th-9th

**London:** Conference on 'Undersea Defence Technology'. Details: Microwave Exhibitions & Publishers Ltd, 90 Calverley Road, Tunbridge Wells, Kent TN1 2UN. Tel: (0892) 544027. Fax: (0892) 541023.

### 7th-10th

**Singapore:** International Conference and Exhibition for the Maritime Industry 'SingaPort '90'. Details: The Conference Manager (SingaPort '90), Times Centre, 1 New Industrial Road, Singapore 1953. Tel: (65) 2848822. Fax: (65) 2881186.

### 8th-9th

**Paris:** Conference on 'Offshore Pipeline Technology'. Details: Nadia Ellis, IBC Technical Services Limited, IBC House, Canada Road Industrial Estate, Byfleet, Surrey KT14 7JL. Tel: (01) 236 4080.

### Call for Papers

The Institute of Petroleum's fellow Institute in West Germany — 'Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V.' is holding its Main Conference between September 20-21 1990 in Münster, West Germany.

The organisers invite papers for the conference on the following topics: new developments in deep drilling; new developments in natural gas production and field processing; renaissance of hydrocracking and alternatives; environment and motor fuels; carbon technology (production and application of carbon products) and new materials in catalysts.

Papers should be submitted by 28 February 1990 to:

KE Klinskyk  
DGMK  
Steinstrasse 7  
D-2000 Hamburg 1  
West Germany  
Tel: (40) 321512.

### 12th

**London:** Conference on 'Salvage'. Details: Conference Department, Lloyd's of London Press Limited, One Singer Street, London EC2A 4LQ. Tel: (01) 250 1500. Fax: (01) 253 9907.

### 12th-13th

**Singapore:** Conference on 'Commercial Aviation in the Asia-Pacific Region to the End of the Century and Beyond'. Details: Financial Times Conference Organisation, Commercial Aviation in the Asia-Pacific Region, 126 Jermyn Street, London SW1Y 4UJ. Tel: (01) 925 2323. Fax: (01) 925 2125.

### 13th-15th

**London:** Course on 'Introduction to Petroleum Exploration for Non-Geologists'. Details: JAPEC Secretary, c/o The Geological Society, Burlington House, Piccadilly, London W1V 0JU. Tel: (01) 434 9944. Fax: (01) 439 8975.

### 14th

**London:** Lecture on 'Emergency Shutdown Facilities for New & Operating Pipelines' by Dr RK Jain, Brown & Root Vickers Ltd. Details: The

Pipelines Industries Guild, 17 Grosvenor Crescent, London SW1X 7ES. Tel: (01) 235 7938.

### 16th

**London:** Seminar on 'Shipping Pools'. Details: Linda McKay, Legal Studies and Services Limited, Bath House, 3F, 56 Holborn Viaduct, London EC1A 2EX. Tel: (01) 236 4080. Fax: (01) 489 0849.

### 19th

**London:** Conference on 'New Opportunities for Fuel Oil in Power Generation'. Details: Miss Susan Ashton, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Tel: (01) 636 1004. Fax: (01) 255 1472.

### 19th-23rd

**Aberdeen:** Course on 'Petroleum Exploration and Development Economics'. Details: DCA Consultants Ltd, Rosewall Cottage, Main Road, Aberuthven, Perthshire PH3 1HB. Tel: (0764) 63936.

### 19th-23rd

**Oxford:** Course on 'Prospect Evaluation and Reservoir Appraisal for Development Planning'. Details: The Registrar, The College of Petroleum Studies, Administrative Offices, Sun Alliance House, New Inn Hall Street, Oxford OX1 2QD. Tel: (0865) 205521. Fax: (0865) 791474.

### 20th

**London:** Conference on 'Managing Risks in the North Sea'. Details: European Study Conferences Limited, Douglas House, Queen's Square, Corby, Northants NN17 1PL. Tel: (0536) 204224. Fax: (0536) 204218.

### 20th

**London:** Conference on 'Oil Price Information'. Details: Mrs Jean Etherton, Institute of Petroleum.

### 20th

**Solihull:** Seminar on 'Vibration Analysis for Condition Monitoring Techniques in Use and User Experience'. Details: Conference Department, British Institute of Non-Destructive Testing, 1 Spencer Parade, Northampton NN1 5AA. Tel: (0604) 30124. Fax: (0604) 231489.

### 20th-22nd

**London:** Course on 'Offshore Pipeline Engineering'. Details: Nadia Ellis, IBC Technical Services Ltd, Bath House (3rd Floor), 56 Holborn Viaduct, London EC1A 2EX. Tel: (01) 236 4080. Fax: (01) 489 0849.

### 21st


**London:** Institute of Petroleum Annual Dinner. Details: Caroline Little, Institute of Petroleum.

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# FORTHCOMING EVENTS

## 26th

**Birmingham:** Electrical and electronics exhibition 'ELECTREX '90'. Details: James Watts, General Manager, Electrex Limited, Wix Hill House, West Horsley, Surrey KT24 6DZ. Tel: (0483) 222888.

## 26th-2nd March

**Lausanne:** 7th Advanced International Petroleum Economics Seminar (AIPES '90). Details: Dr Bob Gale, Seminar Manager, Petroleum Economics Limited, 17-19 Barter Street, London WC1A 2AQ.

## 28th-1st March

**London:** Conference on 'Flow Measurement of Commercially Important Fluids'. Details: Carol Gerrard, IBC Technical Services Ltd, Bath House (3rd Floor), 56 Holborn Viaduct, London EC1A 2EX. Tel: (01) 236 4080.

## MARCH

### 1st

**London:** Conference on 'Subsea Safety'. Details: Knighton Enterprises Limited, PO Box 213, Swindon SN6 8UA. Tel: (079371) 303. Fax: (079371) 433.

### 5th-6th

**Cairo:** 'The 4th JIME International Symposium'. Details: The Japanese Institute of Middle Eastern Economies, Diamond Plaza Bldg. 5F, Ichibancho 35, Chiyoda-ku, Tokyo, 102, Japan. Tel: (03) 264 3141. Fax: (02) 234 1437.

### 5th-6th

**London:** Conference 'Tanker '90'. Details: Linda McKay, Legal Studies and Services Limited, Bath House, 3F, 56 Holborn Viaduct, London EC1A 2EX. Tel: (01) 236 4080. Fax: (01) 489 0849.

### 5th-7th

**Kristiansand S, Norway:** Conference on

'Developments in Geophysical Techniques related to finding the Subtle Trap'. Details: Norwegian Petroleum Society, PO Box 1897 — Vika, N-0124 Oslo 1, Norway. Tel: (47) 2833130. Fax: (47) 2830547.

### 5th-8th

**Cranfield:** Course on 'Instrumentation Systems for Engineers in the Process Industries'. Details: The Course Administrator, Short Course Unit, School of Mechanical Engineering, Cranfield Institute of Technology, Bedford MK43 0AL. Tel: (0234) 752766. Fax: (0234) 750728.

### 6th-9th

**Brighton:** Conference and Exhibition on 'Defence Oceanology International'. Details: Judith Patten Public Relations, Rowe House, 55-59 Fife Road, Kingston upon Thames, Surrey KT1 1TA. Tel: (01) 547 1566. Fax: (01) 547 1143.

### 8th

**London:** Conference on 'Iraq in the 1990s'. Details: Royal Institute of International Affairs, 10 St James's Square, London SW1Y 4LE. Tel: (01) 930 2233.

### 12th-14th

**Bahrain:** 'The First Middle East International Quality Assurance Conference — The Quality Challenge'. Details: The Quality Challenge Conference Secretary, The Institute of Quality Assurance, 10 Grosvenor Gardens, London SW1W 0DQ. Tel: (01) 730 7154. Fax: (01) 824 8030.

### 13th-14th

**Dubai:** Seminar 'A New Phase of Chemical Development in the Middle East'. Details: Mr J Raquet, Consultant, Chem Systems Limited, 28 St James's Square, London SW1Y 4JH.

Tel: (01) 839 4652. Fax: (01) 930 1504.

### 19th-21st

**Bergen, Norway:** 'Underwater Technology Conference'. Details: Norwegian Petroleum Society, PO Box 95, N-5049 SANDSLI, Norway. Tel: (475) 22 48 85. Fax: (475) 22 48 86.

### 20th

**London:** Lecture on 'Drag Reducing Agents in Pipeline Systems' by S Ubels and M J Monahan, Conoco Ltd. Details: The Pipelines Industries Guild, 17 Grosvenor Crescent, London SW1X 7ES. Tel: (01) 235 7938.

### 20th

**London: Conference on 'Energy Information for 1992'. Details: Caroline Little, The Institute of Petroleum.**

### 22nd-23rd

**Guildford:** Conference on '25 Years of the North Sea'. Details: Mr David Hawdon, Surrey Economics Centre, University of Surrey, Guildford, Surrey GU2 5XH. Tel: (0483) 571281.

### 25th-31st

**Dundee:** Conference on 'International Aspects of Energy Law'. Details: Marjorie Meek, Assistant Director, Courses Department, The British Council, 65 Davies Street, London W1Y 2AA. Tel: (01) 930 8466. Fax: (01) 493 5035.

### 26th-30th

**Leeds:** Conference on 'Diesel Particulates'. Details: Mrs C. Shirley, Senior Administrative Assistant, Department of Continued Professional Education, The University of Leeds, Leeds LS2 9JT. Tel: (0532) 431751. Fax: (0532) 336017.

### 27th-29th

**Aberdeen:** Conference 'Offshore Abandonment and Removal 90'. Details: Offshore Conferences and Exhibitions, Rowe House, 55/59 Fife Road, Kingston upon Thames, Surrey KT1 1TA. Tel (01) 549 5831. Fax: (01) 541 5657.

## April

### 2nd-3rd

**London:** Conference on 'Quality Assurance for the Oil and Gas Industry'. Details: Nadia Ellis, IBC Technical Services Ltd, Bath House (3rd Floor), 56 Holborn Viaduct, London EC1A 2EX. Tel: (01) 236 4080. Fax: (01) 489 0849.

### 4th

**London: Conference on 'The European Auto-Diesel Challenge'. Details: Caroline Little, The Institute of Petroleum.**

### 5th

**London:** Conference on 'Gasoline Specifications — Challenges and Opportunities for Refiners'. Details: WEFA, Ebury Gate, 23 Lower Belgrave Street, London SW1W 0NW. Tel: (01) 730 8171. Fax: (01) 730 1400.

### 24th-26th

**London:** Conference on 'Safety at Sea and Marine Electronics Exhibition'. Details: Safety at Sea International, Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS. Tel: (0737) 768611. Fax: (0737) 760564.

### 25th

**London: Conference on 'Microbiological Risk Assessments for COSHH'. Details: Caroline Little, The Institute of Petroleum.**

# A new fuel arrives — Orimulsion

By Carol Reader

A totally new fuel is a rare event. To many people, even in the oil industry, Orimulsion is still unknown. Enlightened commentators can tell you that it is the trade name for an emulsion of water, bitumen and surfactants, based on the extra heavy bituminous crudes found in Venezuela. The experimental stages on the new product have been passed successfully and now it is set to come to market, principally as boiler fuel.

The name of the new fuel reflects its origins in the Orinoco Belt around the extensive delta of the Orinoco River in the northeast of Venezuela. Here, in an area the size of Denmark, are vast reserves of heavy crude. These virtually solid materials are so viscous (8° API) that until the last decade they were ignored, with oil production concentrated on light and medium gravity crudes, found in other parts of the country.

The theoretical potential for Orimulsion, which is 70 percent bitumen and 30 percent water, is vast, given the size of the reserves in place in the Orinoco Belt. Worldwide, there are some 500 billion barrels of proven recoverable reserves of extra heavy crudes and natural bitumens. Of this total, over half are found in Venezuela, with most of the bitumen in the Orinoco Belt. This area contains some 1,200 billion barrels of bitumen, of which the enormous volume of 267 billion barrels (more than 700 years at 1 million b/d) are estimated to be recoverable with known technology. Moreover, these figures are based on a recovery rate of 22 percent, which is fairly conservative. It is claimed that with continuous steam injection a recovery rate of 30 percent is possible — which would make the reserves figures even larger.

The development of this new fuel is being carried out by a subsidiary of the state oil company, Petroleos de Venezuela SA. Some eight years ago its research affiliate, Intevp, joined with BP Research International, and investigate the formulation of oil-in-water



Orinoco heavy crude.



Orimulsion.

emulsions and their transport. BP was interested in the project because it was operator on the heavy oil Wolf Lake project in Canada. The research centred on emulsions and new methods of transport rather than using heat or

costly diluents. These methods were not favoured because of the substantial investment necessary and the transport problems. Instead, by 1983/84 the researchers came up with an emulsification process which yielded a less viscous mixture that could more easily be pumped, stored and transported with only minor adjustments to conventional equipment.

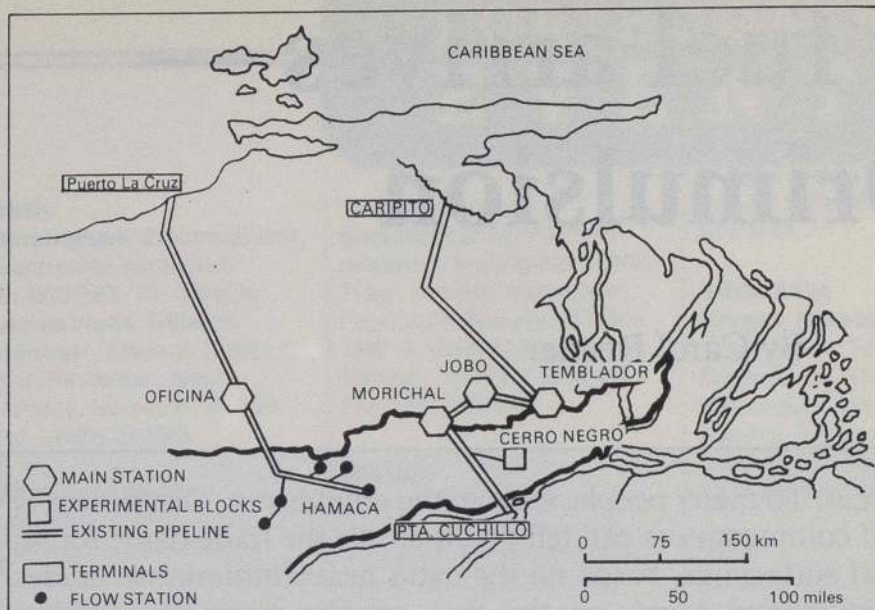
Subsequently, both companies discovered that unrefined bitumen in emulsion form could be burnt with a very high efficiency in the large boilers of power generation plant.

Later pilot and commercial testings have shown that not only can the new fuel be substituted for coal but with minor changes to plant it can also be utilized at oil-fired power stations. Changes to oil-fired plant are so minimal that heavy fuel oil and Orimulsion can both be used.

## Testing

After tests by boiler manufacturers, the first commercial testing of Orimulsion took place in Canada at New Brunswick Power's Dalhousie power station where 150,000 tonnes have been used over 12 months. These tests, which have produced good results, are still continuing and are expected to be followed by a long-term supply agreement, subject to acceptable terms.

More recently, tests have been carried out for the UK Central Electricity Generating Board at Ince B, near Liverpool, where the 500 MW plant has been supplied with 44,000 tonnes of the fuel. These tests have



Orinoco Belt area of Venezuela

been entirely satisfactory and it is now hoped that long-term commercial contracts will follow.

## Production and transport

Production capacity is now 50,000 b/d. Those involved in the project are cautious in their forecasts but others speculate on the possibility of this figure eventually being tripled or more. The marketers talk of Orimulsion aiming at 10 percent of the future growth in steam coal use in the power industry.

Venezuela itself sells coal in modest quantities, is a large seller of heavy fuel oil — and is now introducing Orimulsion to the world.

Production is by the 'steam soak' method, with the help of down-hole emulsification. What reaches the surface is an emulsion of very heavy hydrocarbons, containing a small amount of gas. This primary emulsion is then degassed and stored at the collecting station and then is pumped the 20 km to the processing plant at Morichal. Here the primary emulsion is broken up. The pure, desalted natural bitumen is then turned into Orimulsion by a special process which mixes in 30 percent water with surfactant, which is then stored ready for pumping to Punta Cuchillo on the Orinoco River for export. If demand warrants it, future plans include the reactivation of a disused crude pipeline to the main tanker port of Puerto la Cruz where larger tankers could be accommodated than at Punta Cuchillo.

The transport of the new fuel presents few problems. Standard crude

or fuel oil tankers can be used, although some heating may be necessary — the required temperature range is 30–40°C. For the two trial shipments to the United Kingdom, the emulsion was shipped in the *Lagoven Ambrosio* and *Lagoven Sinamaica* centre tanks, with heated fuel oil in the other tanks.

## Creating a market

Spokesmen for the two companies are insistent that Orimulsion is not oil;

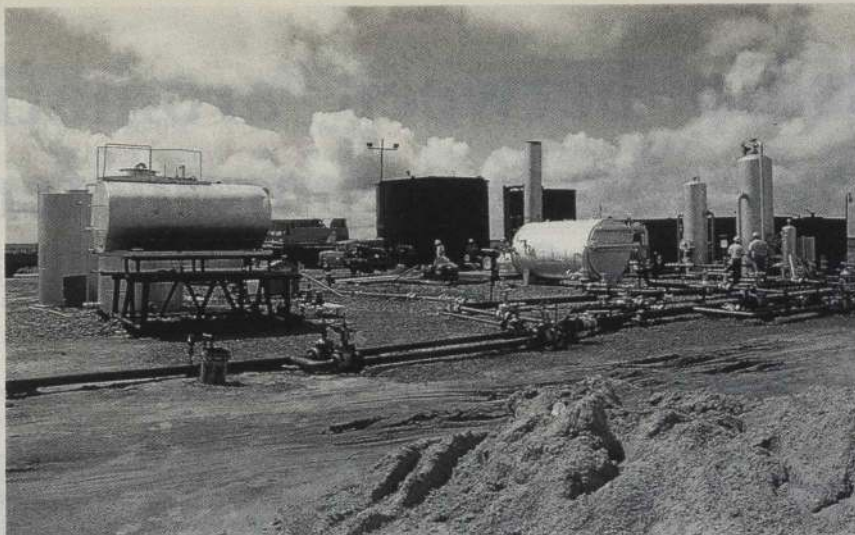
after all, it is not the product of a refinery. They say that it is the product of technological advances — an entirely new concept — which will compete with coal rather than fuel oil.

The stage has now come to market the new fuel. The time-scale is unknown and possible sales levels difficult to predict. Petroleos de Venezuela has set up a new subsidiary company, Bitumenes Orinoco SA (BITOR), which will be responsible for producing and marketing Orimulsion throughout the world. The main aim is to fill the gap in supplies to power stations left by the decreasing use of heavy fuel oil. It will thus be competing with coal as a base-fuel.

Less and less heavy fuel oil has been used in recent years, because it was not long competitive, with the result that a lot of oil-fired capacity is either under utilized, used only for peak shaving or even totally idle. In its place, more emphasis was placed on coal and nuclear power. Figures for 1985 show that the load factor for oil-fired capacity in IEA countries was only 20 percent; the comparable figures for the EEC was 26 percent. In the United Kingdom, consumption of heavy fuel oil dropped from a peak of 26.4 million tonnes coal equivalent in 1984 to 10 million tce in 1988. However, it is not expected that the new fuel will make any inroads into existing heavy fuel oil markets.

Table 1: Characteristics of Orimulsion™

Water content % w/w	29.0 ± 2
Median droplet size, µm	< 30
% droplets > 100 µm	< 2
Density (15°C), kgm <sup>-3</sup>	1002–1013
Apparent viscosity, mPas (max. values)	
30°C, 20s <sup>-1</sup>	1100
30°C, 100s <sup>-1</sup>	900
70°C, 20s <sup>-1</sup>	500
70°C, 100s <sup>-1</sup>	400
GCV, MJkg <sup>-1</sup> (min)	29.0
NCV, MJkg <sup>-1</sup> (min)	27.0
Sulphur, % w/w (max)	3.0
Ash, % w/w (max)	0.3
Vanadium, ppm (max)	360
Sodium, ppm (max)	90
Magnesium, ppm (max)	500
Flash point, °C (min)	122
Pour point, °C	2–5



Emulsification plant at Morichal

Interest in oil-fired power generation is still not keen, being restricted to peak-loading, because the price of heavy fuel oil looks uncertain and is generally expected to remain above that of coal. Since there exists considerable under-used oil-fired capacity, those responsible for the marketing of Orimulsion see an opening for their new fuel to bring it back into service. They believe that Orimulsion is well placed since it is priced relative to coal and will be available on long-term contracts, perhaps 15–20 years.

IEA forecasts see coal accounting for the bulk of the 2.4 percent annual growth rate for electricity in the OECD up to the year 2000, with a rate of 3 percent for OECD Europe. It therefore looks possible that Orimulsion could find a niche for itself as fuel for plant that is presently oil-fired but idle, as an alternative to building new plant.

## Marketing

Six months ago BITOR formed a joint venture with BP, called BP Bitor, to be entrusted with the marketing of Orimulsion to the power generation and industrial markets in the EEC and other European countries. This London-based company will search out the big customers in power generation, while BP's national companies will be looking to sign up industrial customers, for example in cement or steel. BP Bitor is engaged in negotiating a number of contracts, mainly aiming at power plants that were running on heavy fuel oil until it became too expensive. For instance, Orimulsion may be considered for one mothballed plant in Scotland and by ICI. Similarly, Ince has been operating at a very low level — it was originally built to run on fuel oil from the nearby Stanlow refinery.

To market the new fuel elsewhere, BITOR has made other arrangements. A direct subsidiary is responsible for marketing in North and South America, while in Japan an agency agreement has been reached with Mitsubishi.

The main target at present is to obtain acceptance for this non-conventional fuel. Current production capacity for Orimulsion is 3 million tonnes annually, rising to about 12 million tonnes in 1992, with perhaps 8 million tonnes available for European sales in the same year. These are relatively modest targets — if the new 'liquid coal' really took off, production could be relatively quickly increased to cope. The marketers see Western Europe and the United States as their best opportunities. For instance, in Sweden, Orimulsion may benefit from the current unpopularity of nuclear power. In Japan and the Far East, where electricity demand is forecast to jump, competition with other fuels may well be more intense. In addition, the high transport costs to the Far East markets may limit sales potential.

At present Petroleos de Venezuela has the Orimulsion market to itself. Another possible supplier is Canada but the tarsands there are remote — transport costs would be high — and production costs are also thought to be more than Venezuela's.

The ease of conversion and the costs of conversion are obviously vital. Analysts believe that capital investment and operating costs for an Orimulsion-fired plant would be lower than for a high-sulphur coal-fired plant. The relative costs for low-sulphur coal would be more evenly matched, because the Orimulsion plant would require rather more flue gas desulphurization investment. Where a previously oil-fired plant is being con-

verted, Orimulsion has a distinct advantage over coal.

## Emissions

The carbon dioxide emissions from the use of Orimulsion are some 10–15 percent lower than with coal but a little higher than with heavy fuel oil. Thus, there are benefits on the greenhouse effect score versus coal.

NO<sub>x</sub> emissions, also, should not present a problem, since they are much the same as for heavy fuel oil and the use of low NO<sub>x</sub> burners should ensure that NO<sub>x</sub> levels are below the limits proposed by the EEC for 1996 onwards.

On the other hand, particulates are more of a problem and precipitators will probably be needed. This was confirmed by the tests at Ince B power station, where a precipitator would be required for the long-term use of Orimulsion.

The main emission concern arises because of the fairly high level of sulphur in Orimulsion. Therefore, the extra cost of flue gas desulphurisation (FGD) has to be added to any conversion, except where such facilities already exist. However, advocates of Orimulsion point out that with the likelihood of stricter EEC regulations, FGD facilities are going to become necessary for almost all sulphur-containing fuels — coal, heavy fuel oil or Orimulsion. Without emission control equipment, many plants could face closure. Given the uncertainty of heavy fuel oil prices, oil-fired plants are unlikely to want to face additional expenditure on such facilities. It seems that coal-fired plant would receive more attention, because coal prices are more stable and the cost of emission control facilities could be spread over a long period.

According to the calculations of BP Bitor, it is cheaper to convert an oil-fired unit to Orimulsion with a FGD than to convert to low-sulphur coal without a FGD.

Alternatively, Orimulsion could be used in advanced combustion or gasification systems, such as the integrated gasification combined cycle plant. The latter could well prove an important market, if companies are forced by new regulations into reducing CO<sub>2</sub> emissions.

Thus, Orimulsion now has to get acceptance as a new fuel — not an easy task. After that, with the right price, the future stretches before it. ■

Orimulsion is a registered trade mark, belonging to Bitumenes Orinoco SA.

# The relationship between aromatic content and specification parameters in diesel fuels

By CJS Bartlett, BP Research

At a time when regulations regarding gaseous and particulate emissions from vehicle exhausts are being tightened in both Europe and the United States, the quality of automotive diesel fuel is receiving much attention.

It has been claimed that the aromatic species in diesel fuel play a significant role in the formation of particulates and there are proposals in some areas to limit the aromatic content of automotive diesel fuel.

The Institute of Petroleum has developed two new Methods for determining the aromatic content of diesel fuels: Total Aromatic Content by High Performance Liquid Chromatography (HPLC) with Refractive Index Detection IP391/90 and Aromatic Carbon Content by High Resolution <sup>13</sup>C-Nuclear Magnetic Resonance (NMR) Spectroscopy IP392/90.

We believe that the aromatic content of a fuel may be related to traditional specification parameters such as density, viscosity and cetane index since these are all related to fuel chemistry. In the laboratory at BP Research Centre, Sunbury, a wide range of refinery diesel components and finished fuels (52 in total) representative of many different crude sources and refineries were analysed by both Methods and data were also obtained on the density, viscosity and distillation characteristics of each (Table 1). The aim was to determine two equations relating total aromatics content [TAR (%vol) — Equation 1] and aromatic carbon content [CAR (mole %) — Equation 2] to these traditional fuel quality parameters. To this end, a computer regression was performed using all the available data.

As a result it was determined that the equations require only two terms, namely density and a log-viscosity variable [ $\log_{10}(KV_{40} + 0.7)$ ]. The cetane index became unimportant once these two terms were included.

$$\%TAR = 0.4358 d - 32.67 \log_{10}(KV_{40} + 0.7) - 321.6 \quad \text{Equation 1}$$

$$\%CAR = 0.3495 d - 32.19 \log_{10}(KV_{40} + 0.7) - 259.3 \quad \text{Equation 2}$$

Table 1: Inspection data for fuels and components used in diesel aromatics correlation exercise

Sample Type	Density at 15°C (kg/m <sup>3</sup> )	Kinematic viscosity at 40°C (cSt)	Cetane index (IP380)	Total aromatics by HPLC (% vol) IP391	Aromatic carbon by NMR (mole %) IP392
Far East LGO 1	873.5	4.25	46.9	35.3	24.2
Far East LGO 2	865.6	4.11	47.9	29.2	17.1
Far East LGO 3	844.5	4.42	58.7	21.3	12.0
Middle East LGO 1	849.0	4.38	57.9	23.3	13.6
Middle East LGO 2	852.2	4.50	56.5	27.2	15.3
Middle East LGO 3	829.5	2.65	55.9	23.3	14.3
Middle East LGO 4	837.2	2.88	53.9	23.2	12.9
Middle East LGO 5	842.5	3.81	58.1	22.6	14.1
Middle East LGO 6	850.5	4.22	55.8	24.1	14.2
Middle East LGO 7	863.0	5.53	55.2	28.2	16.5
Middle East LGO 8	856.5	5.04	58.4	29.0	17.3
North Sea LGO 1	848.1	3.21	51.7	27.0	16.6
North Sea LGO 2	853.8	3.77	53.2	27.2	16.1
North Sea LGO 3	853.2	4.06	54.2	28.5	16.8
W African LGO	878.5	4.51	42.4	32.6	17.0
N African LGO	827.0	2.76	57.1	17.2	10.8
Australian LGO	841.6	4.38	62.4	21.6	13.9
Hydrofined Cycle Oil	909.8	2.41	29.5	71.6	45.8
Blended Auto Diesel 1	860.9	2.45	41.7	40.7	27.2
" " " 2	852.1	2.63	46.1	33.7	22.3
" " " 3	853.2	2.48	46.5	32.7	22.3
" " " 4	848.8	2.86	48.5	28.9	18.8
" " " 5	847.5	3.21	50.4	26.2	17.4
" " " 6	862.7	4.96	50.2	28.2	18.5
" " " 7	870.4	4.92	46.6	32.5	20.0
" " " 8	846.8	3.16	50.8	29.4	17.4
" " " 9	860.1	3.01	45.6	33.1	23.5
" " " 10	875.1	2.89	40.0	41.4	31.4
" " " 11	852.9	3.80	49.2	33.5	18.3
" " " 12	861.9	3.72	45.8	26.9	21.8
" " " 13	878.9	3.70	40.5	33.7	27.8
Blended Kerosine	806.5	1.21	40.9	22.2	15.4
Refinery A Kero	783.3	1.04	47.4	20.8	12.8
" " HSLGO	880.6	10.43	40.7	33.2	18.3
" " LSLGO 1	842.5	3.14	53.8	20.8	14.6
" " LSLGO 2	848.1	3.83	55.2	30.8	15.7
" " HGO	886.5	16.42	63.6	27.9	13.5
Refinery B Kero	817.1	1.44	44.6	23.9	16.2
" " HGO	880.0	11.21	64.5	31.9	16.2
" " LGO	853.7	3.85	53.6	30.6	15.8
Refinery C NAPHTHA	804.2	1.04	33.0	18.5	11.9
" " LGO	875.6	4.45	44.6	32.5	16.3
" " HGO	898.9	12.32	48.2	34.3	18.4
" " VAC GO	903.9	12.09	46.9	37.7	19.3
" " LCO	944.1	5.98	27.1	60.4	48.5
" " IMPORT GO	836.4	2.99	53.3	24.2	13.1
Refinery D KERO	793.8	1.16	46.4	16.7	12.2
" " HSLGO	855.8	4.65	55.9	29.3	15.7
" " LSLGO	855.9	3.80	50.4	35.2	18.3
Refinery E KERO	808.6	1.37	45.2	21.0	13.4
" " LGO	849.2	4.04	56.1	24.2	15.4
" " HGO	886.3	15.35	62.6	23.6	13.8

LGO — Light gas oil  
LSLGO — Low sulphur light gas oil  
HSLGO — High sulphur light gas oil

HGO — Heavy gas oil  
VAC GO — Vacuum gas oil  
LCO — Light cycle oil

Where  $d$  is density at 15°C in kg/m<sup>3</sup> and KV<sub>40</sub> is kinematic viscosity at 40°C in cSt. It should be noted that, as in other equations of this type, density is the dominant variable, viscosity only having a minor function.

Figures 1 and 2 show plots of measured versus calculated values for both %TAR and %CAR. It is perhaps remarkable that in both cases the regression line has a slope of 1. For both equations, the statistics are shown in Table 2 where SDR is the standard deviation about the regression line, SDB is the standard deviation of the biases and SE<sup>2</sup> (the average squared bias) = Mean<sup>2</sup> + SDB<sup>2</sup>. From a consideration of the statistical analysis, we believe that both equations are of acceptable accuracy.

The use of these equations therefore enables the calculation of the aromatic content of a diesel fuel from a knowledge of readily available density and kinematic viscosity parameters.

Where both density and viscosity are controlled in a diesel fuel specification, such as in BS 2869 Part 1, the UK specification for automotive diesel fuel, and probably in the eventual CEN diesel fuel specification, it is apparent that a

Number of Fuels	Equation	Correlation Coefficient	Bias		Regression Slope		
			Mean	SDB	SE	SDR	
52	% TAR	0.92	0.00	3.60	3.60	1.00	3.64
52	% CAR	0.94	0.00	2.42	2.42	1.00	2.45

Table 2: Statistical analysis of equations for calculation of aromatic content of diesel fuels

control on aromatics content already exists. The need for a separate control on aromatic content is thus questionable.

Using Equation 1 and substituting the BS 2869 density maximum and viscosity minimum, respectively 865 kg/m<sup>3</sup> and 1.5 cSt, gives a total aromatics content 44.2 %vol. It is of interest to observe that this result does not differ markedly from the figure of 40 percent maximum discussed recently by the EEC for possible inclusion in the CEN diesel fuel specification.

As has already been noted, cetane index is not a significant term in the equations for aromatic content. This is borne out by the very poor correlation between measured aromatic content and calculated cetane index by IP380, as demonstrated in Figure 3 and 4. In other as yet unpublished work in our laboratory, we

have found that IP380 cetane index gives a better correlation with ignition delay measured under highly accurate conditions in a single cylinder research engine than does ASTM D613 cetane number.

We conclude therefore that diesel fuel aromaticity chemistry may be accurately described by functions of density and viscosity, but that diesel fuel ignition performance is best described by a function of density and volatility. Specification control of density, viscosity and volatility (in terms of distillation recovery over the 10 to 90 percent range) should therefore be sufficient to ensure acceptable diesel fuel quality without resorting to chemical characterisation. As researchers, however, we will continue to investigate the chemical subtleties of diesel fuel with a view to a better understanding of performance effects. ■

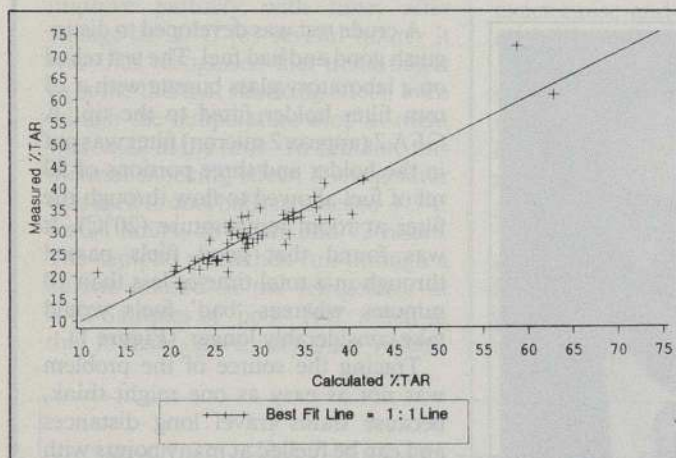


Figure 1: Relationship between measured and calculated total aromatics for 52 gas oils

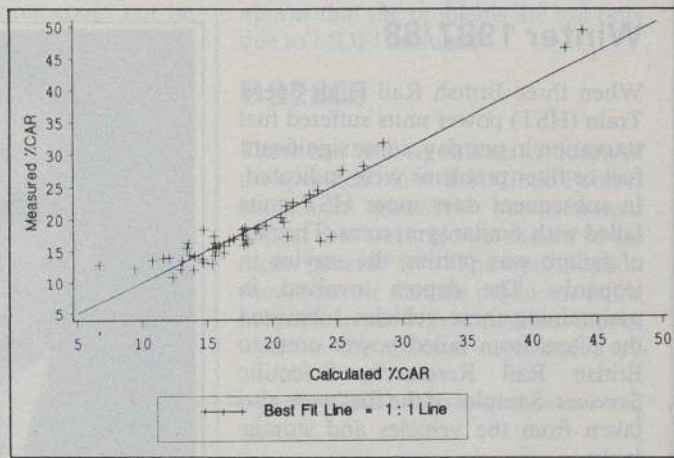


Figure 2: Relationship between measured and calculated aromatic carbon for 52 gas oils

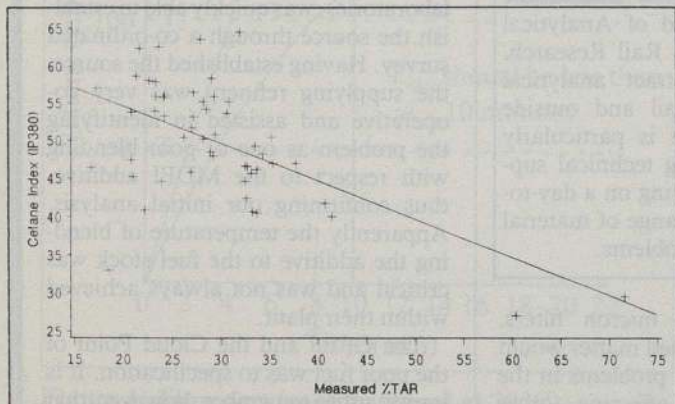


Figure 3: Relationship between cetane index and total aromatics for 52 gas oils

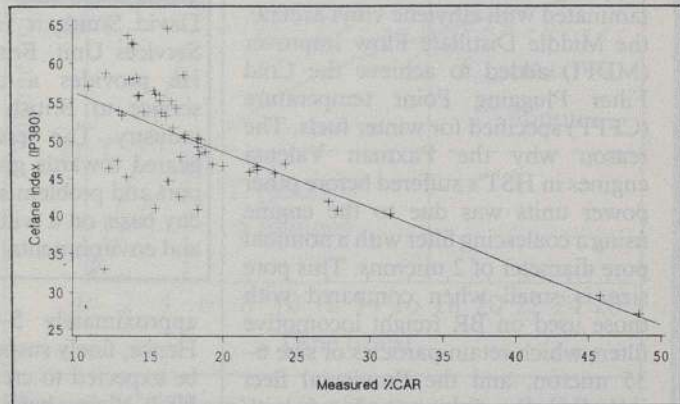


Figure 4: Relationship between cetane index and aromatic carbon for 52 gas oils

# Poor diesel fuel quality: a British Rail experience

By David Smith, Head of Analytical Services Unit, British Rail Research

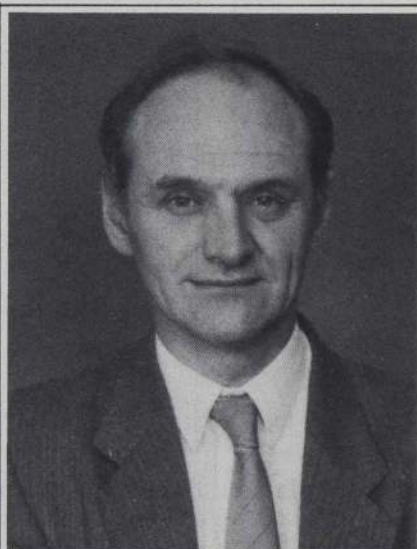
In the winters of 1987/88 and 1988/89 British Rail suffered fuel starvation problems on some of its diesel power units, even though the weather was relatively mild. The reasons for the problems were different and in both cases the fuels met BS2869: 1988 Part 2 Class A2\*.

British Rail buys about £80 million of Class A2 diesel fuel (gas oil) every year, mainly for its fleets of locomotives and multiple units. Fuel bought to BS2869: 1988 and its predecessor BS2869: 1983\*\* had not previously caused significant problems except through waxing in cold winters such as that of 1986/87. That fuels supplied to specification should cause a problem in mild winters is alarming. Investigation into the cause of the problems gave justification for this concern.

## Winter 1987/88

When three British Rail High Speed Train (HST) power units suffered fuel starvation in one day, some significant fuel or filter problems were indicated. In subsequent days more HST units failed with similar symptoms. The rate of failure was putting the service in jeopardy. The depots involved in maintaining these vehicles submitted the filters from failed power units to British Rail Research, Scientific Services. Samples of the fuel were also taken from the vehicles and storage tanks.

The filters were examined (using fourier transform infrared spectroscopy) and found to be heavily contaminated with ethylene vinyl acetate, the Middle Distillate Flow Improver (MDFI) added to achieve the Cold Filter Plugging Point temperature (CFPP) specified for winter fuels. The reason why the Paxman Valenta engines in HST's suffered before other power units was due to the engine using a coalescing filter with a nominal pore diameter of 2 microns. This pore size is small when compared with those used on BR freight locomotive filters which retain particles of size 6–35 micron, and the Provincial fleet including the Sprinters, fitted with Cummins engines, which have



David Smith is Head of Analytical Services Unit, British Rail Research. He provides a contract analytical service to British Rail and outside industry. The service is particularly geared towards giving technical support and problem solving on a day-to-day basis on a wide range of material and environmental problems.

approximately 5–10 micron filters. Hence, finely suspended matter would be expected to create problems in the HST fleet before affecting other vehicles.

A crude test was developed to distinguish good and bad fuel. The test relied on a laboratory glass burette with a 25 mm filter holder fitted to the tip. A GFA 2 (approx 2 micron) filter was put in the holder and three portions of 50 ml of fuel allowed to flow through the filter at room temperature (20°C). It was found that good fuels passed through in a total time of less than 10 minutes whereas 'bad' fuels would take considerably longer. (Figure 1).

Tracing the source of the problem was not as easy as one might think, because trains travel long distances and can be fuelled at many points with fuel from different suppliers/refineries. In this respect, British Rail Research's network of Scientific Services laboratories, was quickly able to establish the source through a co-ordinated survey. Having established the source, the supplying refinery was very co-operative and assisted in identifying the problem as one of poor blending with respect to the MDFI additive, thus confirming our initial analysis. Apparently the temperature of blending the additive to the fuel stock was critical and was not always achieved within their plant.

The CFPP and the Cloud Point of the poor fuel was to specification. It is important to remember, however, that the CFPP relies on a test where the

temperature, at which a 45 micron filter is blocked, is recorded. The Cloud Point relies on a visible cloud or haze of wax crystals appearing at the bottom of a test jar when the oil is cooled under prescribed conditions.

## Winter 1988/89

An increase in fuel starvation was again noted by the HST fleet but in this case some multiple units were affected — in particular the Sprinter units fitted with Cummins engines. At first it was thought that the problems were similar to those of the previous winter. Although some ethylene vinyl acetate was detected on filters, there also appeared to be a lot of long chain wax present which had not been detected in the previous year. As before, the suspect fuel had a satisfactory CFPP and Cloud Point.

As in the previous winter, samples were tested using the burette flow test procedure. With the criteria of 10 minutes as a pass, it was found that the fuels, as supplied by the refinery during the 1988/89 winter period, were quite acceptable. Fuels sampled from British Rail Depot storage tanks took considerably longer than 10 minutes. Moreover, poor samples seemed to improve partially with time, after storage at 20°C for several hours. It was thus recognised that there might be some thermal shocking effect, even though the temperature drop at night was small at the time. To simulate this thermal shocking effect, a refrigerator was used to cool bulk samples to +3°C for 24 hours, 48 hours and 72 hours. The samples were then run through a burette housed in the refrigerator at 3°C. Samples of 'poor' fuel, tested in this manner, gave very poor results,

whereas the majority of supplies to BR performed satisfactorily. (Figure 2 and Table 1).

As a result of our initial work, the suppliers commissioned their own investigation and were able to show that the problem was due to a heavy wax component added to the blend. This component was added to promote the MDFI effect and is an established refinery practice. In this particular case the wax compound contained too many long chain waxes and was not correctly solubilised. As before, prompt action in identifying the cause and source of the problem enabled BR's fleet to operate satisfactorily for the rest of the winter.

## Current position

The two problems left BR worried that the quality of diesel fuel might lead to future operability difficulties. This was in part confirmed by the suppliers of the poor quality fuel, who indicated that their formulations were not unique and other refineries may produce similar inferior fuels. In fact BR did note a number of other problems with supplies of fuel such as increased microbial growth and more suspended matter in the fuel but the exact cause and source could not be established.

Following collaborative work with some suppliers in the petroleum industry, the laboratory refrigerator test has been replaced by a new test. This test relies on a jacketed burette which is cooled by glycol/water circulating at +3°C. Samples of fuel that have been maintained at +3°C for 24 hours, after being conditioned at room temperature, are filtered as before. The time of flow of 3 portions ( $T_1$ ,  $T_2$  and

$T_3$ ) are recorded. If  $T_3$  exceeds 5 mins or the Average Differential Time (ADT) is excessive then the fuel is rejected. The ADT is a measure of the blocking tendency as time progresses and is calculated as follows:

$$ADT = \frac{1}{2} \frac{T_3 - T_1}{T_2} \times 100$$

For example when: —

$$T_1 = 120 \text{ seconds}$$

$$T_2 = 180 \text{ seconds} \text{ Then ADT} = 50$$

$$T_3 = 300 \text{ seconds}$$

Although the test has not been further refined, it is our experience that good fuels will have an ADT of less than 10, whereas poor fuels will exceed 15.

Ideally, BR would like fuels to meet a performance specification and hence be fit for purpose in the typical cold weather climate conditions that Britain experiences. In the absence of any such assurance, BR have adopted the filter test for screening fuels and have since demonstrated that the problems found in 1987/88 and 1988/89 were not unique. A number of fuels tested in the winter 1989/90 have been found to fail this test (including a sample of A1 Derv), although it would appear that the problems are not only due to MDFI and wax.

## BS2869

There has been significant criticism of the specification in that Cloud Point is no longer quoted\*\*\* but it would appear that the criticism should be far more general\*\*\*\*. The specification should ensure that the product is fit for purpose. In our view a fuel that blocks filters in the manner experienced by

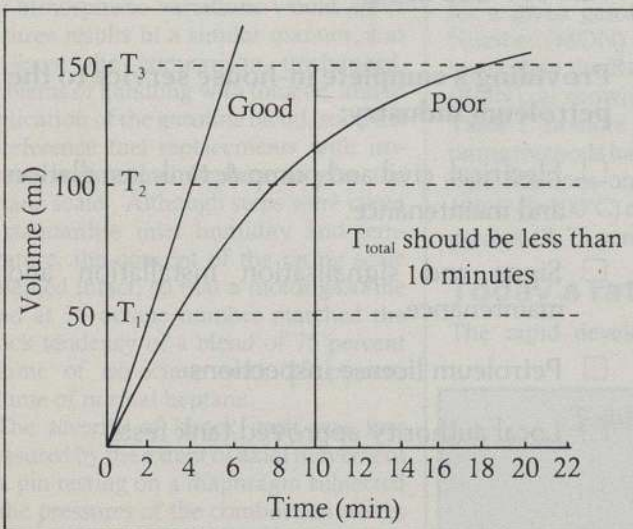


Figure 1: Flow test (sample stored at 20°C)

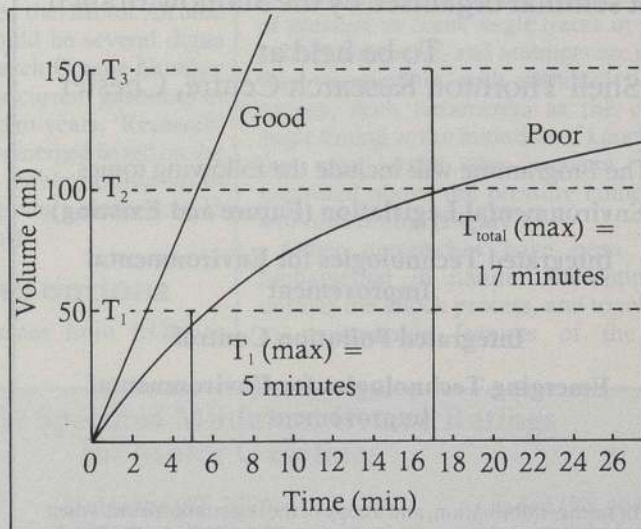


Figure 2: 'Coolflow' — (sample stored at +3°C for 24 hours)

ourselves is not fit for purpose and the specification should take note of this deficiency. It is not sufficient that the product as produced at the refinery is satisfactory but that the product is fit for purpose when discharged from a clean storage tank some days later. With current design of modern diesel engines using much finer filtration than in the past, the CFPP method may not be entirely relevant, as this uses a very coarse mesh. It is certainly possible, as shown by BR, that small crystals exist which will block fuel filters at temperatures considerably above 0°C.

With the constant change in formulation of fuel, there is a need to consider a number of aspects. The current fuel supplied is very different, in the case of most suppliers, to that produced even a few years ago. The fuel of today can be more reactive and likely to degrade than distilled products of the past and so it may not be possible to store it for long periods. The addition of certain additives, although beneficial in some ways, could have an adverse effect on the user. For

**Table 1: Typical Results of Poor and Good Fuel**

Samples	(Flow time in seconds)	
	1 (Poor)	2 (Good)
T <sub>1</sub>	175	193
T <sub>2</sub>	224	197
T <sub>3</sub>	467	216
Total	866	605
ADT	65	6

example, suspending agents containing nitrogen may encourage bacteriological problems and may also cause the mixing of deposited materials from old fuel tanks. Both of these problems which appear to have been experienced by BR, could be of concern to the user.

All the above indicates that it is time to review BS2869: 1988 (and the test methods to which it refers), despite its recent publication, to ensure that the user can rely on this standard when specifying his fuel grade and quality. ■

\*British Standards Institution; British Standard Specification for Fuel oils for oil engines and burners for non-marine use, BS 2869 (Part 2: 1988), BSI 1988.

\*\*British Standards Institution; British Standard Specification for Fuel oils for oil engines and burners for non-marine use, BS 2869: 1983; BSI 1983.

\*\*\*Transport Engineer; Diesel Fuels Analysed, Transport Engineer April 1988.

\*\*\*\*King, S C; Russell, T J; Premium Diesel Fuels in Europe, Ille Symposium CEC 1989.

**Acknowledgement**

The author would like to thank the Director of Research, British Rail Research for his permission to publish this work.

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# How does octane rate today?

## A spontaneous ignition response

By Dr Eric Goodger, Consultant in Fuel Technology Training

The emergence of the spark-ignition engine as a practicable power unit at the turn of the last century, was accompanied by unavoidable birth pangs in the form of unnerving expensive-sounding noises from the combustion chamber, sometimes heralding catastrophic engine failures. As is customary in such circumstances, several theories were propounded, compared and put to the test. Pioneering breakthroughs eventually identified one cause as spark knock initiated by the spontaneous ignition of the unburnt 'end gases'.

### Measuring knock

The need for measurement of the knock phenomenon led to Ricardo's definition of the 'highest useful compression ratio' coinciding with the onset of knock. Although effective as a comparison between fuels tested at given conditions, the results unfortunately varied with day-to-day changes in atmospheric pressure, temperature and humidity. Ricardo's solution was the 'toluene scale', based on comparing the knock tendency of the test sample with that of upper and lower reference fuels (toluene and a low anti-knock gasoline respectively), on the basis that any atmospheric variations would affect all three results in a similar manner, and so leave the comparison unchanged. Problems of handling with toluene, and of duplication of the gasoline blend, soon led to reference fuel replacements with iso-octane and normal heptane to give the 'octane scale'. Although steps were taken to standardise inlet humidity and temperature, the concept of the rating scale remained intact, so that a motor gasoline rated at 75 octane number matched the knock tendency of a blend of 75 percent volume of iso-octane with 25 percent volume of normal heptane.

The severity of knock itself was first measured by the extent of axial movement of a pin resting on a diaphragm subjected to the pressures of the combustion waves in the chamber, the upper end of the pin closing switch contacts in an electrical circuit. This was eventually replaced by a magnetostrictive transducer electrically-

sensitive to its distortion by knock vibrations. The first test method, designated 'Research', was introduced in 1930 with operating conditions incorporating a modest speed (to encourage knock) of 600 rev/min, and a mild, uncontrolled mixture temperature in the region of 32°C.

However, a discrepancy soon appeared between laboratory results and vehicle performance on the road, so in 1932 the 'Motor' method was devised, with operation at 900 rev/min but at the much higher mixture temperature of 149°C in an attempt to approach closer to service conditions. Despite the higher speed, the higher mixture temperature meant that, for a given gasoline, the Motor Octane Number (MON) would be several digits lower than the Research Octane Number (RON), as shown for current gasolines in Table 1. In more recent years, 'Research' rating methods have emerged based on the light fractions only, either boiling up to 100°C (R 100°C) or giving a recovery of 75 percent (R 75 percent).

### Today's rating options

The rapid development from RON to

MON in the early 1930s, signalled the inability of the first attempt at knock rating to match fuel performance in engines of the day. Over the intervening years, interest has swung from MON to RON, partly back again, and to variants applied to the light fuel fractions only, as the variety and complexity of vehicle engine designs have themselves increased manyfold. Other variants of the octane number scale have also been devised in order to match more closely laboratory and road performance, and the perennial question 'Which rating methods apply today?' does not always gain an answer that is convincing or in any way international.

In automotive engines, the wide range of differences in the design, octane requirement, ignition settings and even the road handling probably means that the collation and statistical analysis of a vast amount of performance data is a prerequisite to any satisfactory solution. The many attempts made to predict automotive knock performance include those shown in Table 2.

Recent advances in electronic instrumentation have permitted the production of pressure vs crank angle traces in particularly fine detail, and attempts are under way to compare with standard octane ratings, such parameters as the crank-angle timing at the initiation of knock and the area under the pressure curve measured above the pressure coincident with this timing (Figure 1).

Other approaches have been more fundamental in nature, attempting to unravel the knock process, and to relate it to recognisable features of the fuel

**Table 1: Specified Minimum Octane Ratings for Motor Gasolines**

	Unleaded (BS 7070) Max lead 0.013 g/l			Leaded (BS 4040) Max lead 0.15 g/l
	Regular	Premium	Super Plus	4 star
RON	90	95	97	97
MON	80	85	86	86

**Table 2: Schemes of Octane Rating**

Rating	Significance	Typical ranges
RON	Knock freedom at moderate-speed cruising (worldwide)	97-100
MON	Knock freedom at high-speed/high-load, particularly with unleaded fuel (Europe)	85-90
Sensitivity (RON-MON)	Effect on knock tendency of mixture temperature, particularly with unleaded fuel	8-12
Antiknock index (RON + MON)	Knock freedom in a wide variety of engines (USA)	90-94
$R_{100^{\circ}C}$	Knock freedom from segregation of excess light fractions in cylinders during full-throttle acceleration from low speed	88-92
$\Delta R$ (RON-R $100^{\circ}C$ )	Knock tendency from segregation of excess light fractions in cylinders during full-throttle acceleration from low speed	6-10

molecular structure. Difficulties arise here owing to the variables imposed by the engine, and by the fuel droplets themselves as they are metered into the input air stream. These practical variables include the following:

- cyclic variations within each cylinder;
- differences in ignition timing between individual cylinders;
- differences in valve timing between individual cylinders;
- differences in pulsations within the manifolds at valve opening;
- in carburetted engines, maldistribution of mixture between cylinders;

- in injection engines, differences in mean diameter, diameter distribution and droplet velocities within the fuel sprays.

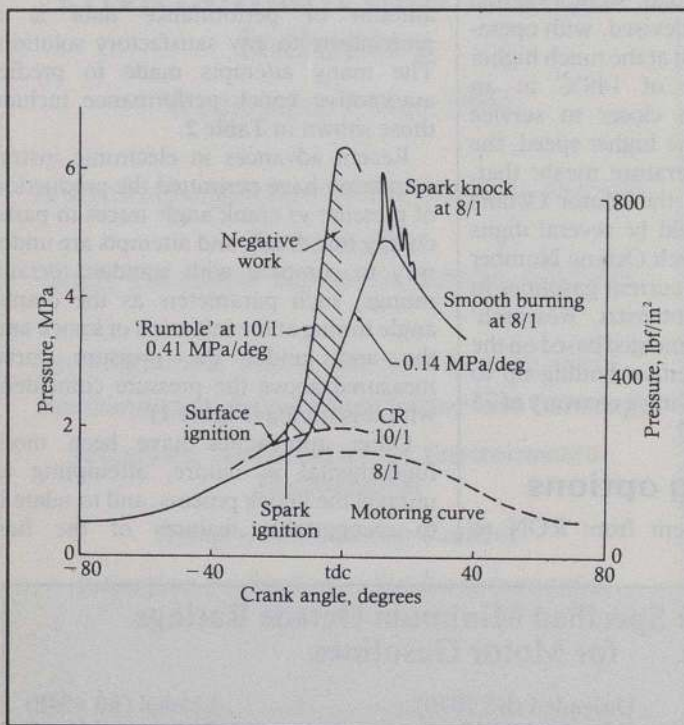
**Run-on**

In the United States during the 1950s, engines were sometimes found to generate heavy 'rumbling' noises, and also to continue firing at much the same speed after the ignition was switched off. These two related phenomena were traced to pre-ignition of the charge, caused by glowing surfaces arising from overheated plugs, valves or combustion deposits (see **Figure**

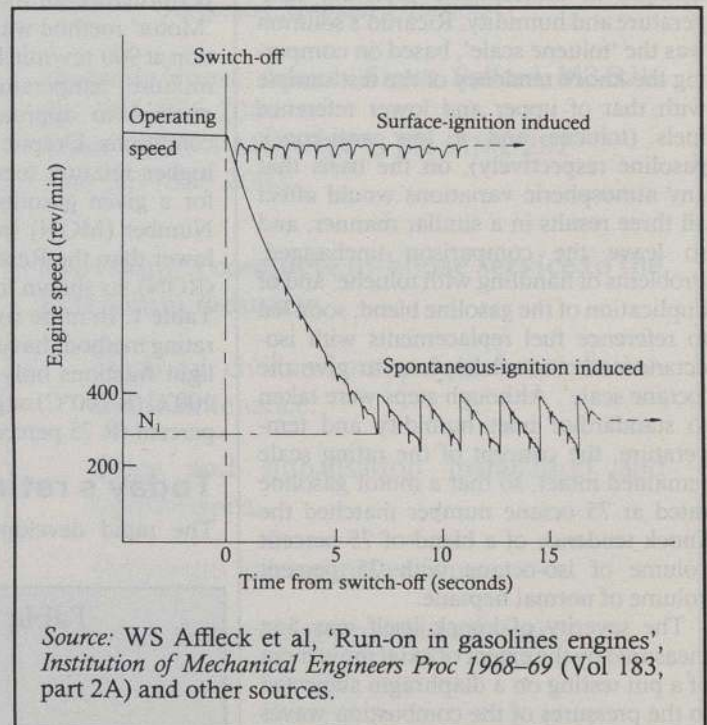
1). In the latter case, the presence of lead and its scavengers in the carbon increased the tendency to glow. Research showed that iso-octane was able to resist this phenomenon, whereas aromatics and alcohols, despite their higher anti-knock ratings, behaved poorly.

This indicates the differences between results obtained under conditions of high-pressure spontaneous ignition (knock) and low-pressure forced ignition (pre-ignition). Additives based on phosphorus and boron proved to be effective ignition controllers but subsequent improvements in engine materials, together with progressive reductions in lead additives and their scavengers, have virtually eliminated the pre-ignition problem. An alternative, engine-based, solution of this problem is the use of a fuel cut-off valve operated at ignition switch off.

In Europe during the same period, the existing low-speed erratic run-on problems disappeared with the introduction of high-octane fuels, although they have now re-appeared with the rise in operating temperature. The cause was traced to spontaneous ignition of the charge, as the engine slowed to a speed giving sufficient time for the ignition pre-reactions to occur. The subsequent re-fire gave insufficient time for further ignitions, so the engine slowed again, once more reaching a speed promoting re-fire (**Figure 2**). Hence this form of run-on is both low-speed and erratic. In comparison with iso-octane, both aromatics and alcohols show improved resistance to run-on, as reflected



**Figure 1: Pressure vs crank angle for normal and abnormal combustion in the spark-ignition piston on engine.**



**Figure 2: Typical variations of engine speed with run-on.**

Source: WS Affleck et al, 'Run-on in gasoline engines', *Institution of Mechanical Engineers Proc 1968-69* (Vol 183, part 2A) and other sources.



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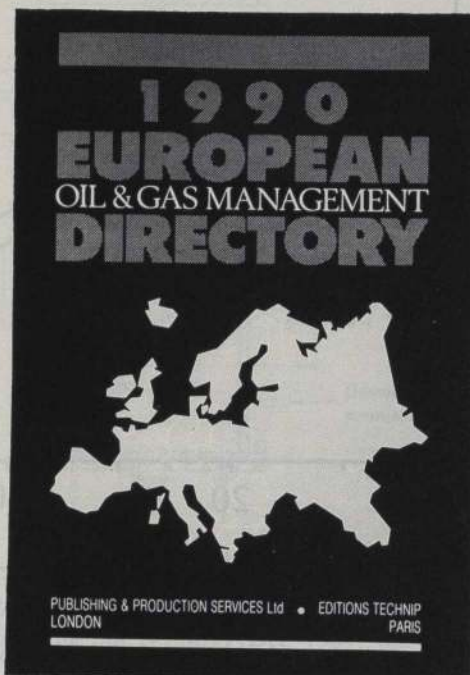
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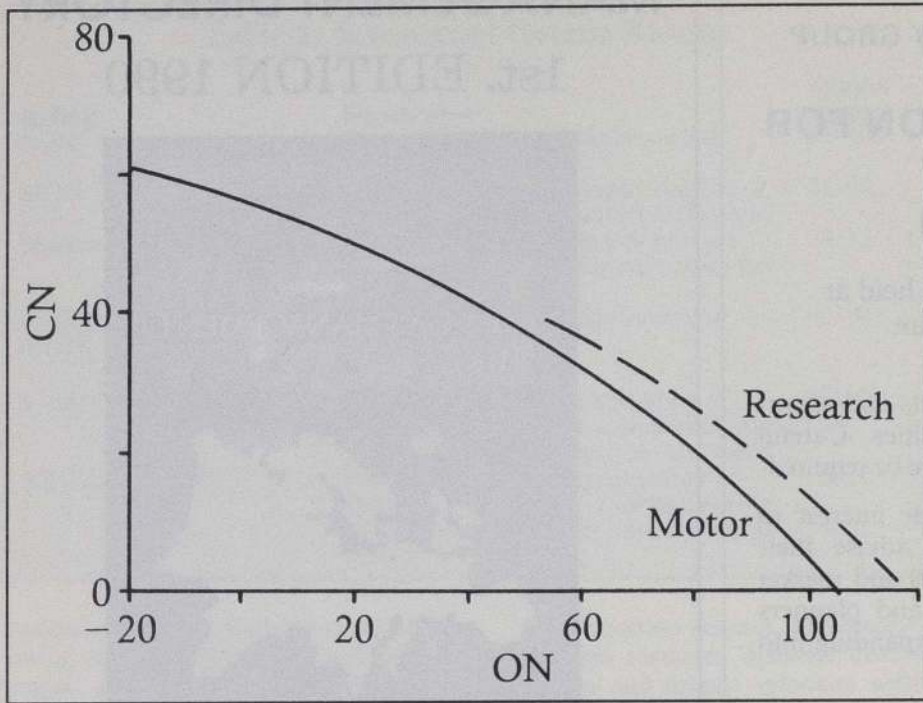


Figure 3: Representative relationships between octane and cetane numbers.

in their anti-knock levels. Thus, the use of these materials as blending agents is now more attractive, giving octane boosting with minimal pre-ignition penalties.

It is worth noting in passing that the compression-ignition engine relies entirely on spontaneous ignition for it to operate, hence its relatively high level of compression ratio, and that 'diesel knock' results if the ignition delay following injection is excessive. For satisfactory combustion, therefore, a diesel-engine fuel (gas oil) must be highly ignitable, whereas a spark-ignition engine fuel (gasoline) must be poorly ignitable. It also follows that octane rating bears an inverse relationship with cetane rating (Figure 3), and that no one fuel can excel on both counts.

It is seen that the three major combustion phenomena within the current European motoring scene — spark knock, run-on and diesel knock — are all dependent on spontaneous ignition; consequently, knowledge of the spontaneous-ignition characteristics of fuel is fundamental to the understanding and control of piston-engine combustion.

### Spontaneous ignition

In view of the above conclusions regarding the prime significance of spontaneous ignition in the fuel-engine partnership, a suite of test procedures could be designed to establish, first, the sole effects of fuel characteristics and, second, the complicating influences of related practical engine factors, considered progressively, as in the following:

- spontaneous ignition of a single droplet of fuel (both gasoline and gas oil);
- spontaneous ignition of a fuel spray of known and repeatable droplet

characteristics (both gasoline and gas oil);

- combustion performance with this fuel spray in single-cylinder test engines (both spark- and compression-ignition types); and
- combustion performance with similar fuel sprays in the related multi-cylinder engine (both spark- and compression-ignition types).

This approach would establish the relative importance of the effects of fuel and engine, and indicate those directions meriting further research effort.

### Single droplets

A wide-ranging review of methods of measuring spontaneous-ignition temperatures and delays is presented in EM Goodger & AFM Eissa, 'Spontaneous ignition research; review of experimental data', *Journal of the Institute of Energy*, June 1987, pp. 84-94. This study attempted to rationalise the whole field of published experimental data, by selecting clearly-defined regimes of ignition delay into which the various sets of results could be grouped.

The recognised standard test for the minimum spontaneous-ignition temperature and its associated maximum delay, is the ASTM method E659 involv-

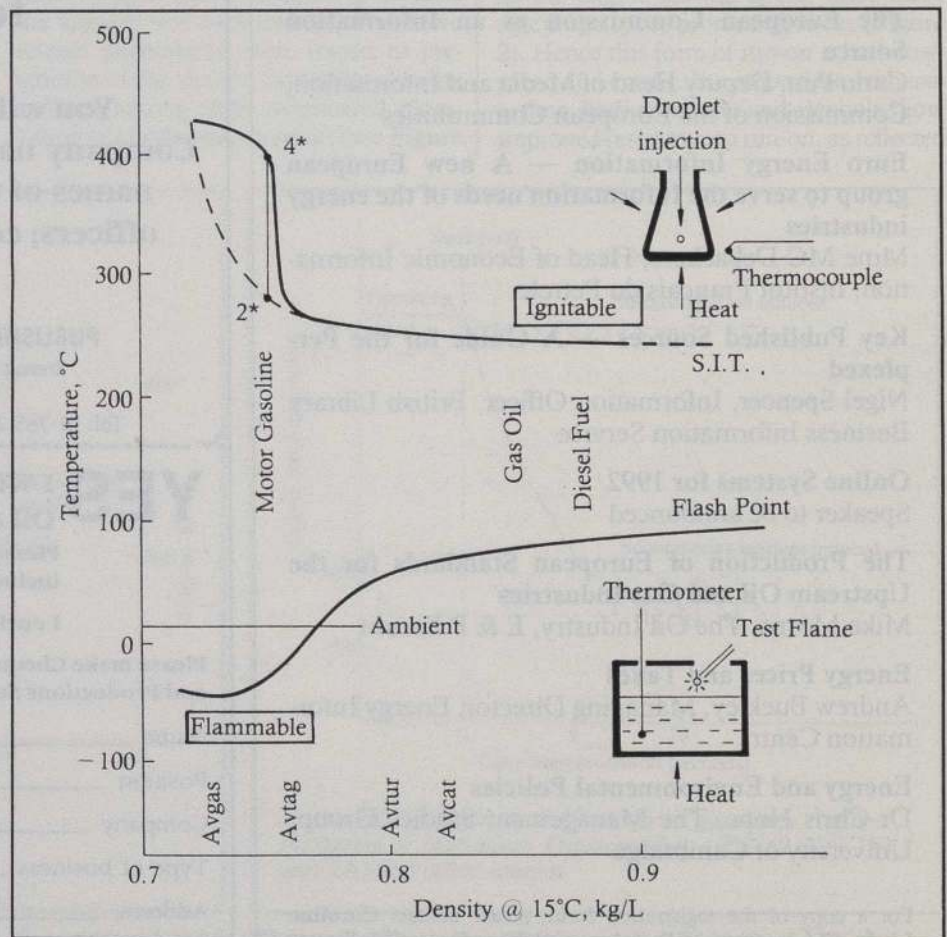


Figure 4: Comparison of spontaneous ignition temperature and flashpoint variations with petroleum fuel type.

ing an open heated flask into which a small charge of liquid fuel is introduced (delivered *in toto* by means of a syringe, and therefore approximating to a droplet). The procedure consists of measurements of delays at progressively reducing temperatures, until the minimum temperature is found to promote ignition (the spontaneous-ignition temperature, or SIT).

The variation in such ignitability results for different fuels may not be immediately apparent, in contrast to the flammability results from the flash point test, in which a flame is introduced into the vapour-air space above the heated liquid sample to find the minimum temperature to give momentary combustion. In the latter case, it is intuitive to accept the rise in flash point with density, due to the reducing volatility (Figure 4). Furthermore, the classification of the low density fuels as flammable accords well with general experience.

To appreciate the corresponding change in SIT, however, some thought must be given to the structure of the fuel molecule and the nature of the ignition process. In order to ignite spontaneously, a fuel molecule must first absorb sufficient energy to disrupt the bonds between its constituent atoms, before they themselves can form new bonds with atmospheric oxygen to start chemical reaction chains, releasing enough energy to promote ignition. This disrupting energy is supplied by the hot air into which the fuel droplet is injected and it becomes clear that the larger, complicated molecules are more liable to disruption under this thermal agitation. Consequently, the high-density fuels have low levels of SIT and are ignitable, in contrast to those hydrocarbon molecules that are small (eg, gasoline

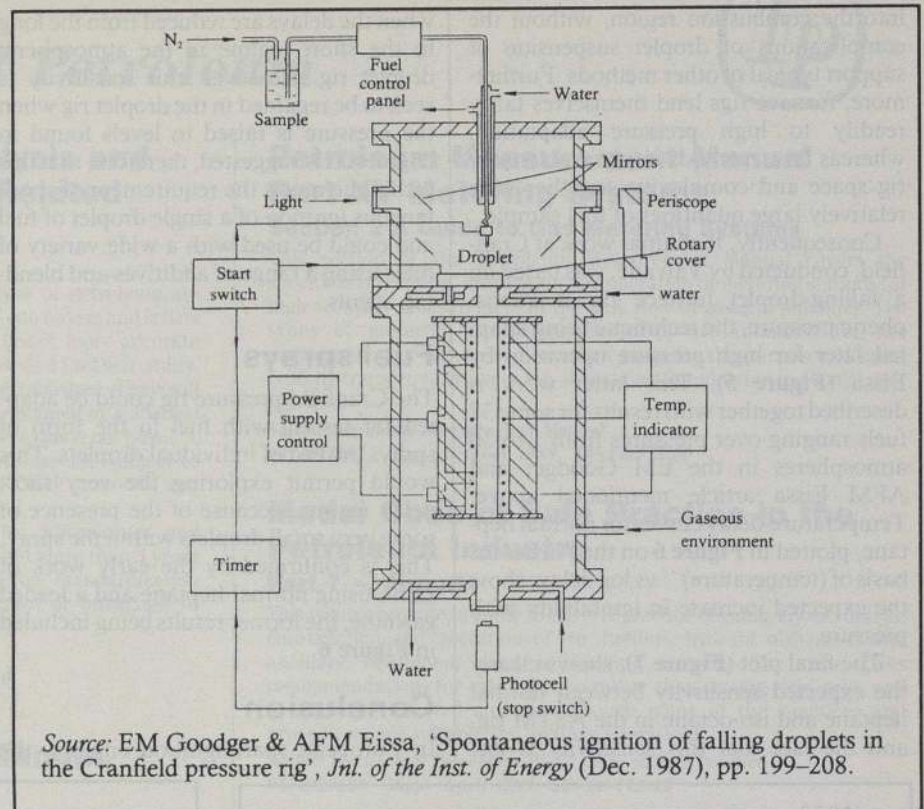


Figure 5: Schematic of the Cranfield Mk II falling-droplet ignition rig.

components), or are rearranged into more compact shapes (eg, iso-octane), which exhibit high levels of SIT.

Hence, gasoline, although extremely flammable, is poorly ignitable. Gas oil, although poorly flammable, is actively ignitable.

Flash point is of major concern as a measure of fire safety in handling, whereas SIT relates to combustion performance in engines. Considering that the

SIT test takes place at 1 atmosphere, with ignition delays of approximately 20 seconds, it is perhaps remarkable that the resulting ignitabilities rate in much the same order as would be expected in a spark-ignition piston engine, where the cylinder pressures approach 30 to 40 atmospheres, and the periods available for delay are 1 or 2 milliseconds only, ie, in the 'very short' regime. Clearly there is need for a simple laboratory test achieving much closer matching with engine levels of both pressure and delay.

Inspection of the experimental methods mentioned above, indicate several possibilities of measuring delays of this low order, involving droplet streams or sprays, as shown in Table 3. Ideally, however, results are required for individual droplets within the very-short delay regime at pressures in the region of 30 atmospheres. The methods of Sangiovanni and Ogasawara involved streams of droplets rather than individuals, at a pressure of 1 atmosphere. Although the results from Lonn, Mullins and Spadaccini were obtained at high pressure, the fuel samples were introduced as sprays in each case.

Since individual droplets did not figure in any of the above methods, attention turned to the adjacent regime of short delays. Of the methods available in this regime, the optimal appeared to depend on a single droplet falling under gravity into a furnace, since this represented closely the movement of a droplet sprayed

Table 3: Spontaneous-ignition Test Methods

Regime (Delay, ms)	Pressure (atm)	Method	Author
Very Short (1 to 40)	1	Droplet stream injected into flame products	Sangiovanni
	1	Droplet stream falling into furnace	Ogasawara
	1 to 40	Spray injected into furnace	Lonn
	0.33 to 3.76	Spray injected into heated air flow	Mullins
Short (40 to 300)	6.8 to 30	Spray injected into heated air flow	Spadaccini
	1	Single droplet suspended in heated air flow	El-Wakil
	1	Single droplet supported in furnace	Long
	1	Droplet stream falling into heated air flow	Wood
	1	Single droplet falling into furnace	Valvade*
	1	Vapour injected into heated air flow	Freeman

\*Research undertaken at Cranfield Institute of Technology (IP 80-002, 1980)

into the combustion region, without the complications of droplet suspension or support typical of other methods. Furthermore, furnace rigs lend themselves fairly readily to high pressure adaptation, whereas flow methods imply problems of rig space and complexity, together with relatively large quantities of fuel sample.

Consequently, the initial work at Cranfield, conducted by Valvade, was based on a falling-droplet furnace rig at atmospheric pressure, the technique being adapted later for high pressure operation by Eissa (Figure 5). This latter work is described together with results for some 32 fuels ranging over pressures from 1 to 30 atmospheres in the EM Goodger and AFM Eissa article mentioned above. Temperature-delay curves for normal heptane, plotted in Figure 6 on the Arrhenius basis of  $(\text{temperature})^{-1}$  vs log delay, show the expected increase in ignitability with pressure.

The final plot (Figure 7), shows clearly the expected sensitivity between normal heptane and iso-octane in the ASTM rig, and the fact that this sensitivity is lost

when the delays are reduced from the long to the short regime in the atmospheric droplet rig. However, this sensitivity is seen to be regained in the droplet rig when the pressure is raised to levels found in engines. It is suggested, therefore, that this technique meets the requirement of spontaneous ignition of a single droplet of fuel and could be used with a wide variety of fuels using a range of additives and blending agents.

## Fuel sprays

The Cranfield pressure rig could be adapted for testing with fuel in the form of sprays instead of individual droplets. This would permit exploring the very short delay regime, because of the presence of some very small droplets within the spray. This is confirmed by the early work of Lonn using normal heptane and a leaded gasoline, the former results being included in Figure 6.

## Conclusion

In European spark-ignition engines, the

major abnormal combustion phenomena are spark knock and run-on, both of which are initiated by spontaneous ignition. This process is also the key factor in the operation of compression-ignition engines, and the onset of diesel knock. A suggested suite of tests involving the spontaneous ignition of individual droplets and sprays, together with single- and multi-cylinder engines, would serve to separate and identify the contributions of fuel, spray and engine parameters on the processes comprising these two phenomena.

Correlation would then be sought with conventional octane and cetane ratings, followed by road-test data. Experience may show the relatively simple droplet technique, requiring small quantities only of sample fuel, to provide a preliminary assessment of ignition behaviour in engines.

The author wishes to acknowledge gratefully advice provided by Mr K Owen, Automotive Fuels Consultant.

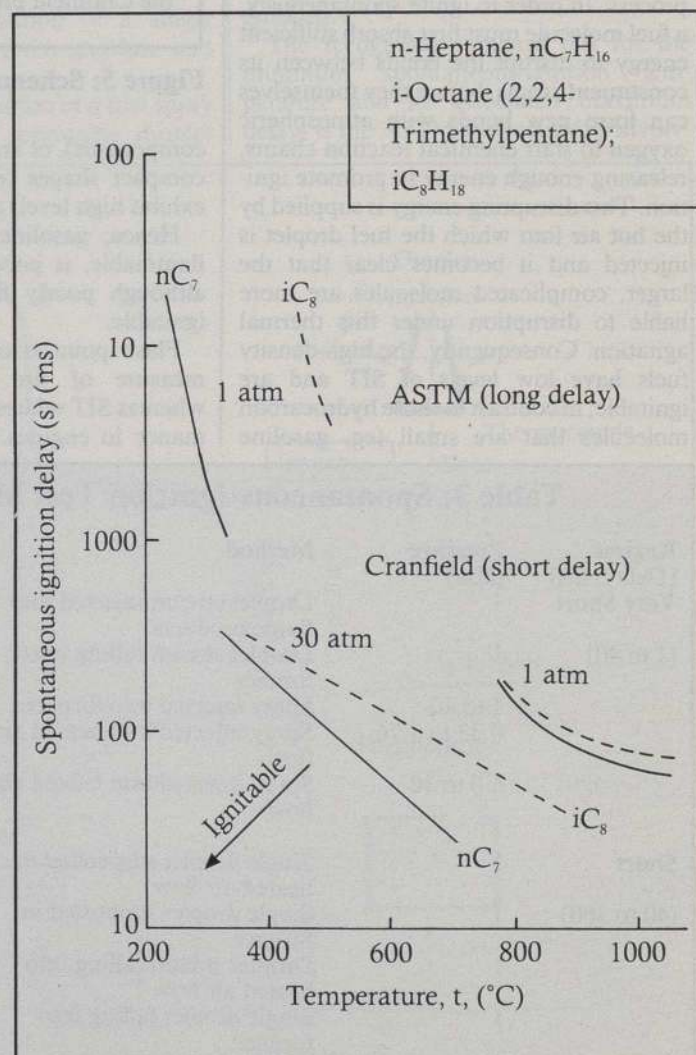
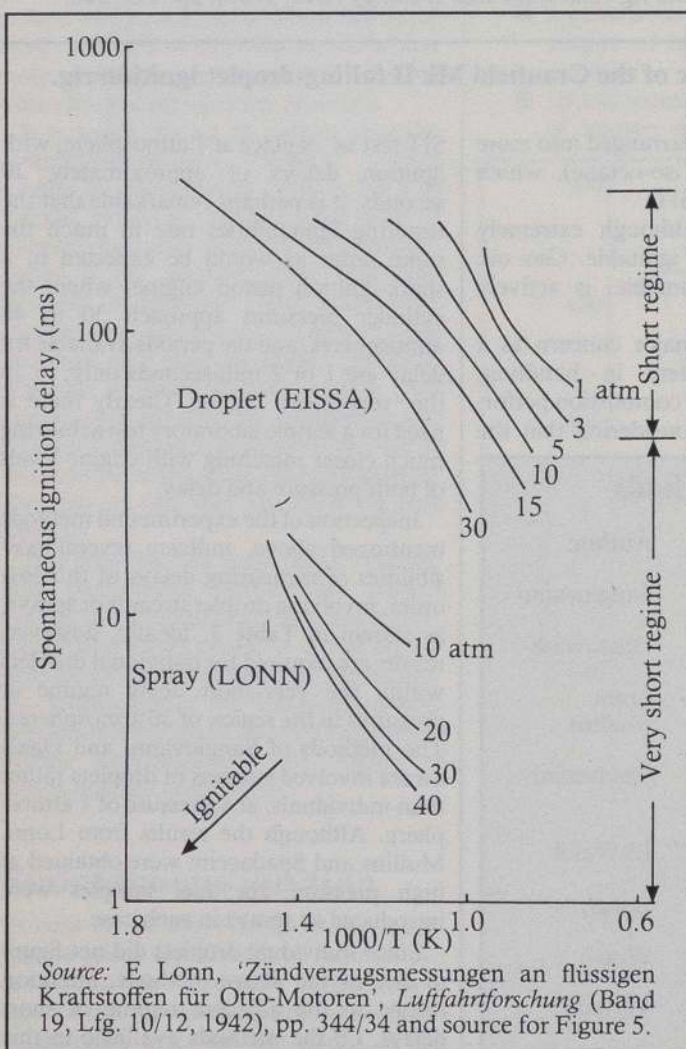


Figure 6: Influence of pressure on ignition delay-temperature relationship for n-heptane — Arrhenius plot.

Figure 7: Influence of pressure on ignition delay-temperature relationships for n-heptane and i-octane — Arrhenius plot.

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0471924628 56pp August 1989 £36.00/\$66.23

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Edited by B.M. DICKS, International Tanker Owners Pollution Federation, London, UK

The Oil Pollution Research Unit (OPRU) of the Field Studies Council is a group of about twenty scientists with considerable expertise in marine and coastal ecology and the impacts of pollution, especially by oil. This book focuses on the findings of OPRU's research into the impacts of discharges upon the marine and coastal environment.

0471921939 326pp February 1989 £80.00/\$153.65

## The Remote Sensing of Oil Slicks

Edited by A.E. LODGE

This book discusses the monitoring and regulatory use of existing and future remote sensing systems for oil detection in inshore and offshore environments. It is the result of a symposium held at the Institute of Petroleum during 1988.

Series: *Proceedings of the Institute of Petroleum*

0471920436 176pp August 1989 £61.00/\$112.25

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## Management lessons from two decades of turbulence

Lawrence M Urquhart, Chief Executive, The Burmah Oil plc, addressed the West of Scotland Branch of the IP on 24 October 1989. He said, in part:

Burmah Oil is a product of the Scottish entrepreneurial spirit of the 19th century. Its story has unique relevance now, as conglomerates put together in the 1960s and 1970s are unbundled. Our experience is both a warning beacon on a difficult and dangerous coast and a guide to navigating through the difficult rocks ahead.

In February 1974, Burmah enjoyed blue chip status in the investment community and had a market capitalisation of £700 million. Twelve months later, this had dropped to £55 million as the Burmah share price fell 92 percent from 486 pence to 37 pence. How did all this come about?

In the late 1960s, the most important constituents of the Burmah Group were its 23 percent investment in BP and its 3 percent holding in Shell; these outweighed both Burmah's declining Indian operations and the newly acquired Castrol lubricants business, and provided over 65 percent of the group's earnings per share in 1969. To provide balance and cashflow, the group embarked on an ambitious acquisition programme downstream from its core activity of oil exploration and production. Between 1969 and 1974 Burmah spent approximately £450 million on acquiring companies ranging from Rawlplug, the industrial and do-it-yourself fixing company, to petrol chains, bicycle and car accessories shops, a crane company, a luxury caravan manufacturer and a major car parts manufacturing business. It is now clear that the company had failed to identify its own skills, and made acquisitions in areas about which it knew relatively little.

### 'Burmah has learnt a great deal from its past'

Further to this downstream acquisition programme, Burmah embarked upon a rapid and substantial involvement in shipping operations, an almost entirely new area. A New York company was set up in 1971 to ship crude to Burmah's Ellesmere Port refinery and to operate a profitable tanker chartering business. By 1973, Burmah had 21 vessels under ownership or charter, and, by 1974, 42 tankers on its books. As if these forays into a new area of business were not proceeding rapidly enough, Burmah sought and was awarded a contract in October 1972 to ship liquefied natural gas from Algeria to the eastern United States, involving the construction of three LNG carriers.

Within a year, a further LNG transportation project from Indonesia to Japan was effectively in place, and a further five vessels ordered. This rapid growth of a new business reflected the then optimistic assumptions about world growth and oil demand. Unfortunately, it did not allow for the uncertainties of international politics or for a world in which oil prices rose and the demand for oil and for shipping slumped.

A third major investment area was in Burmah's traditional business of oil and gas exploration and production. In January 1974, Signal Oil and Gas Co was acquired for \$480 million, bringing with it an interest in the North Sea's Thistle field. Even in areas in which it had considerable skills and experience, Burmah had become seriously overextended.

The Burmah management, impelled by justifiable concern about the structure of their group, had built an unwieldy conglomerate — still with large stakes in BP and Shell, with a large number of acquisitions only partially digested, and with very considerable cash calls around the corner from its newly acquired exploration and production assets, the Bahamas terminal and the LNG fleet. Very suddenly, a sleepy company had woken, leapt into action and built a juggernaut. Even more suddenly, as 1974 progressed, the wheels fell off. Within less than a year of the Signal acquisition, the vehicle was an almost complete wreck.

### Problems emerge

During 1974, other projects were still being considered including the acquisition of Gulf's European assets, an increase in the size of the various LNG projects, and a plan to build a refinery in Kent. A successful oil strike in the Ninian field brought Burmah's cash needs for the North Sea, including its share of Thistle, to around £450 million. All this, however, was taking place against a rapidly worsening international and domestic background. The value of Burmah's holding in BP fell by 60 percent, and the banks which had lent the company money to buy Signal, insisted on renegotiating. The rapidly grown tanker fleet, managed from New York, began to lose large amounts of money and the company found itself in a serious cash squeeze.

The Board decided to sell assets to raise money but on Christmas Eve, 1974, the Bank of England was informed of impending difficulties over the American loan. On 31 December, the company found itself in potential breach of covenants on these loans. The Bank agreed to guarantee the loans and provide a much needed transfusion of sterling, with unpledged holdings in Shell and BP as security.

The rest of the story is well known: massive asset divestiture, totalling £850 million and, including the BP shareholding, most of the oil and gas interests in the North Sea (to the fledgling BNOG, later Britoil, now part of BP), and the cancellation of as many shipbuilding contracts as possible. The immediate crisis lasted until September 1976, when an LNG transportation agreement was signed with Indonesia, allowing the company to obtain United States government subsidies on the building of five vessels and ensuring their ultimate employment. It is likely that Burmah was almost as close to complete bankruptcy in August 1976 as it was in January 1974. By the late 1970s, however, cash began to flow from the North Sea and the Indonesia-Japan LNG project. Bank of England support continued in some form until 1980 and a dividend was paid for the first time in January that year.

In spite of this relative upturn in Burmah's fortunes, both the financial performance of the group, and its share price, were lacklustre throughout the late 1970s and early 1980s. Further radical restructuring was again called for and, in the early 1980s, the group decided to concentrate on three key areas — lubricants, speciality chemicals and LNG transportation.

This involved another round of disposals, as the company decided to concentrate on core businesses in which it had undoubted expertise, to strengthen the balance sheet, and to eliminate businesses which the management did not fully understand or which were making unsatisfactory returns on the capital invested in them.

## Learning the lessons

The history lesson is over. Now I want to consider some of the management lessons to be learnt from this sorry catalogue of vaulting ambition:

- Know yourself: appraise strengths and weaknesses honestly;
- Elaborate a credible strategy; don't plan on best-case forecasts;
- Retain flexibility in your planning and operations;
- Recruit high grade personnel of independent mind; give them clear objectives; incentivise them generously;
- Secure your financial base through effective financial and treasury controls and uphold the highest possible professional standards in management and reporting.

These lessons are easy to spell out but difficult to put into practice. In Burmah's case, these strengths today include an extensive network of companies across Europe and around the world; management with many years experience of lubricants; and strict acquisition strategies and investment criteria which are rigorously enforced.

It is easy to form too high an estimate of your own abilities. I think it is clear from my description, that Burmah in the early 1970s, was taking on too many tasks and too disparate a range of problems. Few managers in the group understood retailing in the automotive industry but we bought Halfords and Quinton Hazell; few knew anything about shipping but we assembled a fleet of 40 tankers, built a major transshipment terminal and entered into massive commitments for LNG vessels. In both cases, potentially profitable investments were undermined by the failure to provide adequate management in depth.

This whole issue boils down to knowing what and how much you can do and not reaching beyond known areas nor being greedy or impatient.

## 'Never stint on the quality of managers'

Building a credible strategy means that, having identified strengths and limitations, we must optimise our performance by developing projects which must use our strengths and which make fewest demands on skills with which we are less fully endowed. When strategies are formulated and turned into numbers, it is important that management looks at both best and worst cases and tries to build a strategy which is productive in both instances. The strategy should be robust — it should be able to withstand likely economic or political changes.

We are all tremendously prone to believe the most favourable of a range of forecasts and to act accordingly. I am not suggesting that we could have predicted the complex sequence of events that led to the surge in oil prices and recession in the middle 1970s but I am sure that Burmah's strategies depended far too much on best case forecasting. Our strategies were not robust; there were no escape routes.

It is important that in formulating plans for the future, managers think laterally about their business and the changing business environment. A great many facts had to be looked hard in the face before we could convince ourselves to close Ellesmere Port and become an oil company without a refinery. Even after the traumas that I have described, there was a tendency for Burmah to assume that it had to remain in oil and gas exploration and production. But, the heart of the company was by then in Castrol — and I am sure we were right to sell our exploration and production division to Premier.

This brings me to another key issue: the importance of employing top quality people. It can never be acceptable to sustain or protect people who are second rate. Control overheads,

by all means, but never stint on the quality of managers; in the long term the best are cheapest through their superior productivity and independence of view.

It is also essential, in my view, that managements are not panicked into improving earnings at the cost of long term growth. The health of their company, and of the economy, is at stake here. In Burmah, I am convinced that generous incentives to managers were one reason that Castrol moved off its profit plateau in the early 1980s to sustained growth over recent years. I am also a firm believer in equity participation at every level, both as a form of long-term incentivisation and as a means of increasing the employees' identification with the company's business objectives.

Whoever runs a business, the formal structures and disciplines within which they run it, remain important. There is always a conflict between autonomy and supervision, at however exalted a level; and there is often too great a tendency to leave matters in the hands of someone regarded as expert. There seems very little doubt, in retrospect, that the Burmah board as a whole allowed itself in the early 1970s to be led along a path of which they were unsure by the enthusiasm and energy of one or two members. There can be little doubt that Burmah's shipping activities were inadequately supervised by the parent company — that they were an almost entirely autonomous unit, at arms' length in New York, which did not even produce proper management accounts.

Although it is not a lesson I drew from Burmah's history, there is one other area I would like to mention, and that is communication. Many companies have found to their cost that good strategies and effective management are not enough. Public companies are to some degree dependent on a wide range of groups, including politicians and civil servants, investing institutions and bankers, stockbrokers and journalists — as well, obviously, as their own customers and employees. It is essential that any company should explain itself tirelessly to these audiences — again and again, if necessary: to explain what it is doing, and why, with due emphasis on the negative aspects as well as the positive ones. It is important that these audiences, particularly in the City, have realistic expectations; inflated expectations are likely to lead to disappointment and sudden collapses in a share price, with consequential opportunities for predators, but pessimistic views lead even more surely to the same end.

## Transition and growth

Burmah's attitude to outside observers had, until the late 1960s, traditionally been very defensive and unforthcoming. The emergence of shareholders' ginger groups both before and after the crisis began to change this. Burmah is now more communicative than the majority of public companies.

After all the traumas of near bankruptcy and after bid rumours without numbers, Burmah did survive to celebrate its centenary in 1986. In fact, it did more than merely survive and is now enjoying renewed growth. In retrospect, many have considered Burmah's management unlucky to be caught by so severe a conjunction of events as the oil crisis and tanker slump at the same time as a stockmarket collapse. Equally valid, however, is the view that Burmah was lucky to escape at all.

Burmah has learnt a great deal from its past and we are probably better equipped than most to understand the dangers of over-expansion and poor management. It has taken almost 15 years to build a coherent company out of the wreckage and the scars inevitably linger on.

I think we are now entitled, however, to regard ourselves as a success story. What matters now to Burmah, is that we have learnt the lessons of the past, we have taken our own medicine, and we have evolved into a financially strong, well focused and, I believe, well-managed company. But now, as Alistair Down, then Chairman and Chief Executive, put it at Burmah's 1978 Annual General Meeting, 'We should seek, so far as possible, to put the past behind us, and get on with the job of building for the future.'

# Environmental stress monitoring

SHELL has begun operating what it calls the most complete system yet for measuring the global loads produced by the environment on a North Sea platform.

The £700,000 system has been installed to monitor through direct measurement the total effect of environmental loads on an entire steel platform. It is on the Shell and Esso Tern platform, 93 miles (150 kilometres) north-east of Shetland in a water depth of 548 feet (167 metres).

It will provide data not previously available about the loads produced on Tern by waves and currents. The information will play an important part in planning inspection schedules, extend-

ing the life of existing structures and the design of future platforms.

The system is the result of three years planning by Shell UK Exploration and Production, the operator for Shell and Esso, in conjunction with the Glasgow based consultants WA Fairhurst and Partners.

'The industry has been gathering environmental information on a large scale since the North Sea operation began,' said Mr Jan Vugts, Aberdeen based Marine Technology Manager for Shell UK Exploration and Production. 'But since North Sea production started in 1975, only limited information on the effects of the environment on platforms has been obtained.'

'Companies have run extensive and ambitious projects and there have also been some joint industry and government sponsored programmes but so far most of them have achieved only limited results, for a variety of reasons. Measurement is both difficult and costly. We hope that the Tern system will for the first time give direct and realistic measurements of the loads on a complete platform, which has not been attempted in the same way before. The difficulties are considerable but if we achieve our objectives, it will be an outstanding contribution to the future of the North Sea.'



The 2,500 dwt Brabourne is one of two new identical vessels, introduced into service last year by Crescent Shipping. Both were designed to incorporate specifications suggested by the company's clients. Particular emphasis was paid to the care of product — with coated tanks, for instance — while deepwell pumps in each tank ensure a faster than usual discharge rate to the last drop of product loaded. Each vessel is highly automated, with the latest safety measures including an enclosed free-fall lifeboat (shown in photograph above). Such a level of sophistication means that the vessels can be crewed by only six men. These two coastal traders normally operate out of the Bristol Channel, carrying clean products.

With a long-established estuarial trade, Crescent Shipping, which is now part of the Hays Marine Services group of companies, has moved over the last 10 years into the longer coastal and short sea business. At present it has 30 vessels for both dry and tanker trade. Its tanker business comes from oil companies, large and small, who generally sign up one-year contracts. Operating mainly out of the Thames and the Bristol Channel, the tankers carry both clean and dirty products all round the United Kingdom, to and from the Continent (especially Rotterdam), Ireland and the Channel Islands. Cargoes mainly consist of deliveries from refineries to distribution depots.

## Pitas award

THE PETROLEUM Industry Training Association Scotland is one of six associations which help to form the Petroleum Training Federation. PITAS is the Scottish arm of the PTF. The PITAS Management Committee and membership is drawn from major oil companies, distributors, lub oil companies independent storage companies and hauliers.

The objective of the PITAS award is to improve the standard of operation and safety consciousness of staff engaged in any aspect of distribution of petroleum products in Scotland, by rewarding good performance.

Nominations will be accepted from any person working towards the distribution of petroleum products in Scotland. It is expected that an employee of a company will be nominated by the Chief Executive or his nominee. Nominations must be accompanied by a short explanation of the reasons why the candidate is being nominated and should be lodged by 28th February. Nomination forms and details can be obtained from the Association Secretary, PITAS, 27 North Lodge Road, Blythswood, Renfrew. PA4 9AS. Tel: 041 886 3913.

## Sofresid refinery

JOHN BROWN associate company, Sofresid, has won a £17m (FF 165 million) turnkey contract from CRD-TOTAL for a gasoline isomerisation unit for its Normandy Refinery. The unit, located at Gonfreville, France, will produce high octane content gasoline to meet the rapid development of the sale of Total Premier lead-free petrol.

## Alkylation/higher olefins project



Aerial view of Esso Belgium's refinery in Antwerp.

ESSO Belgium has awarded Foster Wheeler Energy Limited of Reading, England, a contract for the engineering, procurement and construction for new \$50 million Alkylation/Higher Olefins facilities for its Antwerp refinery in Belgium.

The contract will be 'fast track' and the project is scheduled for completion at the end of 1990.

The purpose of the project is to convert LPG to lead free (96 Octane) mogas and chemical components. The conversion processes will use Exxon's own process technologies, viz alkylation with sulphuric acid.

The new facilities will utilise LPG from both the Antwerp Refinery FCC unit and also the Rotterdam Refinery Flexicoker unit. The products will be transferred to other Esso facilities, including Esso Fawley, UK for final blending or further processing.

## Mobil/Badger plants for Shell

SHELL has selected the Mobil/Badger ethylbenzene technology for two major plants in Europe: one with a capacity of 363,000mtpa for Shell Nederland Chemie BV at Moerdijk, the Netherlands and one with a capacity of 160,000mtpa for Shell UK Ltd at Stanlow, UK.

The plant at Moerdijk is fed with polymer grade ethylene and will supply the ethylbenzene requirements for the existing propylene oxide/styrene monomer plant. The Stanlow plant will operate on a dilute ethylene feed stream from the catalytic cracking unit.

These two new plants join two existing Mobil/Badger ethylbenzene plants for companies of the Royal Dutch/Shell Group.

The Mobil/Badger ethylbenzene process has dominated the market place since its commercialisation in 1980. To date 20 individual plants, representing over 6.5 million mta of ethylbenzene capacity, have been licensed worldwide.

## Hazardous Area Logic System

GARD 1000 Hazardous Area Logic System (HALS), is a compact intelligent control and data collection system designed for use in explosive, hazardous or hostile environments — such as oil and gas production platforms, refineries, pipeline installations, chemical and pharmaceutical processes.

The GARD 1000 HALS all-in-one unit

— containing power supplies, intrinsically safe input and output signal cards, data communication ports and central processor — is located directly in the hazardous area, eliminating the need for safe rooms and substantially reducing costs of cable, installation, design, construction and maintenance. Weight and space savings produce significant economies.

## Barnacles at bay

BATTELLE is developing an environmentally safe method of keeping barnacles and other organisms from attaching themselves to submerged surfaces.

Battelle hope that their anti-fouling technology could result in new material — such as coatings, composites, concrete, plastics, and rubbers — to replace those now used on the bottoms of ships and other submerged surfaces to prevent organisms from attaching themselves.

'Our new anti-fouling technology can create a polymer made with organic materials that doesn't have to actively degrade to be effective,' said Richard Dick of Battelle's Polymer Science and Technology Department. 'The toxicity level is very low but also very effective in making organisms so uncomfortable that they will not attach to a surface containing our polymer.'

The technology allows the polymer to be either painted onto a surface or actually built into the material. Composites with the polymer incorporated into them could be used to build ships, pipes, docks, or water intakes.

## Rockwater offshore contractors

A NEW marine and subsea contracting company, Rockwater, was launched last month by Smit International and Halliburton Company, its joint owners. Rockwater is the result of a merger between 2W Taylor, a subsidiary of Halliburton Company, and Smit Offshore Contractors, a division of the Smit International Group. Rockwater has a worldwide network of facilities, a skilled workforce of over 1,000 and assets of some \$150 million. The executive board of Rockwater will include board members of Brown & Root (UK) Limited and Smit International NV. Rockwater intends to fulfil the growing industry demand for enhanced capability in the spheres of underwater construction and maintenance and to play a large role in the development of the next generation of marginal and satellite fields.



## 1990 Standard Methods book

The 1990 IP Standard Methods for Analysis and Testing will be published in March. This edition contains over 250 methods for analysis and testing of crude oil, petroleum and petroleum related products and sees the first IP Methods written in ISO format. This is the start of a programme to have the majority of the methods written in this form, over the next three to four years, thereby enabling them to be put forward for acceptance as European and International Standards in their entirety.

When this programme was begun, the importance was recognised of continuing the very close relationship the IP has with the ASTM in developing and publishing technically equivalent joint methods. The first, in this new format, Oxidation Stability of Distillate Fuel Oils IP388/90 ASTM 2274/88, will appear this year.

Other new methods in this edition are:

- 'Wax Appearance Temperature (WAT) of Middle Distillate Fuels by Differential Thermal Analysis (DTA) or Differential Scanning Calorimetry (DSC) IP389/90'
- 'Standard Procedures for the Ageing of Residual Fuels IP390/90'
- 'Aromatic Hydrocarbon Types in Diesel Fuels and Petroleum Distillates by HPLC with Refractive Index Detection IP391/90'
- 'Aromatic Hydrogen and Aromatic Carbon Contents of Hydrocarbon Oils by High Resolution Nuclear Magnetic Resonance Spectroscopy IP392/90'
- One new proposed method, 'Aluminium and Silicon in Fuel Oils by Ashing, Fusion, Atomic Absorption Spectroscopy (AAS) and Inductively Coupled Plasma Emission (ICP) PM-BF,' also appears.

This edition also sees the revision of some 40 methods. These include:

- a) Three methods rewritten in ISO format:
  - 'Asphaltenes Precipitation with Normal Heptane IP143'
  - 'Flash Point by the Abel Apparatus IP170'
  - 'Determination of Water in Crude Oil by Distillation IP358'
- b) Deletion of °F (degrees Fahrenheit) and the change of pressure and dimensions into SI units for a number of Methods.
- c) Change in the term 'Normality' to 'Molarity' in the methods for:
  - 'Acidity of Petroleum Products Neutralization Number IPI'
  - 'Neutralization Number by Potentiometric Titration IP177'
  - 'Saponification Number of Petroleum Products IP136' and 'Acidity, Inorganic, of Petroleum Products Colour Indicator Titration Method IP182'
- d) Editorial changes to a number of test methods.

### Methods proposed for withdrawal

A number of methods have been added to the list of Methods which are proposed for withdrawal:

IP33/59(84)	Flash Point by the Abel Apparatus Petroleum (Consolidation) Act 1928 Method
IP171/84	Vapour Pressure Micro Method
IP191/83	Distillation of Natural Gasoline

IP195/81	Distillation Range of Volatile Organic Liquids
IP250/69	Petroleum Measurement Tables based on a Reference Temperature of 20°C
PM-AK	Chlorine in Liquid Petroleum Products

The Notice of Withdrawal of Methods section is intended to bring to the notice of readers the intention to withdraw those methods that in the opinion of the Standardisation Committee no longer have relevance to present-day petroleum technology.

However, there is provision and time for any person to protest and present a case against such a withdrawal during the notice period.

Attention is also drawn to the reasons for publishing the Proposed Methods. These are presented for information and in order to receive comments of others not involved with their formation.

Comments on Proposed Methods, those Scheduled for Withdrawal and other Test Methods will be most welcome and should be sent to the Technical Officer (Standardisation) who will direct them to the relevant panel or sub committee responsible for the Test Method.

## CEC activities

The Co-ordinating European Council for the Development of Performance Tests for Lubricants and Engine Fuels, CEC, has been working on a number of projects and the following documents will be published by them during 1990:

- 1) Code of Practice CEC M-11-T-89  
'The low temperature performance of diesel fuels.'
- 2) Test method CEC L-42-T-89  
(based upon heavy duty diesel engine OM364A)  
'High temperature piston deposits and cylinder bore polish.'

A number of working groups were formed during the second half of 1989:

- 1) IF-7  
This group will investigate the effects of fuel upon the cleanliness of engine intake and combustion systems.
- 2) PF-28  
This project group was set up to define a code of practice for the measurement of octane rating increases.
- 3) PT-6  
This project group was set up to devise a test method for the measurement of transmission lubricant shear stability by means of a taper-roller bearing rig.  
For further information regarding the work of CEC, please contact John Heritage's office at the IP.

## Around the Branches

### Aberdeen

13 Feb: Annual General Meeting.  
13 Mar: 'Controlling North Sea Air Traffic', Eric Melvin, Air Traffic Control, Aberdeen.

### Edinburgh & South-east Scotland

15 Feb: 'The Escort Project', R Sargent, PA Consultants.  
15 Mar: Spouses' Evening: 'Natural History and Conservation in the Forth Valley', Miss N Gordon, The Nature Conservancy Council.

### Essex

14 Feb: Annual General Meeting followed by 'Operation of the Harbour Master and Thames Navigation Service', Capt. J Fisher.  
14 Mar: 'Road Tanker and Loading Racks Safety Systems', Mr JD Snook, Esso Petroleum Co. Ltd.

### Humber

8 Feb: Annual General Meeting.  
2 Mar: Annual Dinner, venue — Beachomber, Humberston.  
29 Mar: '1992' speaker Peter Crampton, Member of the European Parliament.

### London

20 Feb: 'Unleaded Gasoline — The Future', N Pattison, Shell UK Oil.  
14 Mar: 'The Changing Role of the Independent Oil Company', A Cluff, Cluff Oil Resources plc, the meeting will be preceded by the Annual General Meeting at the IP.

### Midlands

14 Feb: Film Night, Annual General Meeting and Supper.

### Northern

13 Feb: Annual General Meeting followed by talk on 'Hydraulic Oils', Mr M Holder, Edgar Vaughan UK Ltd, 6.30 p.m. Belfrey Hotel.

### Shetland

8 Feb: Annual General Meeting, Shetland Hotel.

### South Wales

22 Feb: Annual General Meeting & 'Holiday 90', Thomas Cook Group Ltd., Stradey Park Hotel, Llanelli.  
22 Mar: 'Wind Energy — The Carmarthen Bay Project', WL Birch, CEGB, University College, Swansea.

### Stanlow Branch

Feb: 'European Automotive Catalysts', R Searles, Johnson Matthey Plc. Venue: Hoole Hall, Chester.

### Yorkshire

13 Feb: Annual General Meeting/Hot Pot Supper and Guest Speaker.  
13 Mar: Joint Meeting with the Institute of Energy — 'Energy Management', RD Tinson, Chairman, Emstar.

Bernard Soulsby received the Institute of Petroleum Award of Council last autumn for outstanding service to the Institute of Petroleum Humber Branch which has just celebrated its 25th anniversary.

Bernard was a founder member of the Branch and its first Honorary Treasurer, but soon became Honorary Secretary, a post he held for more than 20 years. He is still an active member of the committee.

Bernard is a Director and General Manager of Webb Brothers Limited.



## Council Appointments

**John Brothwood**, Chief Medical Adviser and Manager, Esso UK plc, **Geoff Crump**, a standardization consultant formerly with Shell Research Ltd and **Leonard Rea**, a director of Smith Rea Energy Associates Ltd, have been reappointed to Council for terms of three years as Ordinary Members. **Peter Barlow**, Manager, Environment Development for Shell UK Oil, has been appointed to Council for the first time, for a term of 3 years. Peter was Honorary Secretary of the IP Stanlow Branch for seven years, before moving to Shell in London, in 1985.

## New Fellows

**Revd. I Lloyd Jones**, MA (Cantab), is a non-stipendiary minister of the Church of England and a Fellow of the British Institute of Management and also of the Institute of Directors. His career in the oil industry spans 36 years, including 25 years with Shell, seeing service in Kenya, Tanzania, Uganda, Sierra Leone and Singapore, and as General Trading Manager, Economics and Trading, with Shell UK.

For the past 11 years he has served with Union Texas Petroleum Limited, as Director of Marketing, then Director of Marketing and Commercial Development and, most recently, as Deputy Managing Director.

**Mr PI Bijur** became Chairman of Texaco Limited last year, and is also Vice-President, Texaco Inc.

After obtaining a BA in Political Science and an MBA in Marketing, Mr Bijur joined Texaco Inc in 1966. In 1981 he was appointed Assistant to the Chairman of the Board and in 1983 became Vice-President, Texaco Inc. The next year he was appointed President, Texaco Oil Trading and Supply Company, and in 1987 President and Chief Executive Officer of Texaco Canada Inc.

As Chairman of Texaco Limited, Texaco Inc's largest wholly-owned foreign subsidiary, Mr Bijur is responsible for the Texaco Group of Companies' operating and holding interests in exploration, production, refining, supply, transportation and marketing operations in the United Kingdom.

**Mr RW Dean** has a BSc (Eng) and an MSE and has chaired various of the Petroleum Measurement sub-committees, as well as the Petroleum Measurement Committee itself.

In his present position of Specialist Instrument Engineer, Chevron Petroleum (UK) Ltd, Mr Dean led the audit team for fiscal metering, Sullom Voe Terminal, in 1984 and 1987 and was a member of the audit team, Ninian Pipeline Metering, from 1984 to 1986. He is currently engaged in design work for projects on the Ninian platforms.

Mr Dean has published several papers on various aspects of measurement, including articles in *Petroleum Review* on Trends in Automatic Sampling and Mass Measurements, in 1986 and 1988, respectively. He is also author of a metering manual for liquid hydrocarbons for Chevron Petroleum (UK) Ltd.

**Mr D Jamieson** has worked with BP since graduating from Cambridge in 1960. His career in personnel and training has covered the upstream, downstream and chemical sectors in the UK, Trinidad, Greece and Singapore.

He is currently Personnel Manager, with special responsibilities, in BP Exploration UK Headquarters in Glasgow. He has been involved in the integration of BPX and Britoil, in the areas of staff consultation, job evaluation, educational links and equal opportunities.

# Institute News

Mr Jamieson has made a very valuable contribution to the Institute, as Chairman of the Education and Training Committee, as a member of Council and as a Committee member of the West of Scotland Branch.

## New Collective Member

**Topas UK Limited** is a leading computer software house specialising in the petroleum industry. As well as providing bespoke and package software solutions, Topas offer a range of professional consultancy services and provide complete solutions (hardware, software, project management) to large multi-national organisations and smaller distributor businesses.

Established 12 years ago, Topas has built up considerable expertise in this sector of the market and is leading the way in the development of sophisticated processing, scheduling and distribution management systems.

Topas has built a reputation, with its world wide user base, for providing software solutions that work and a high level of support and project management.

## New Members

- Adams, Miss HC, Petresearch, 100-104 Upper Richmond Road, London SW15 2SP  
Ahlefeldt-Laurvic, CW, Flat F, 103 Sutherland Avenue, London W9 2QH  
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Al-Shatti, AK, Kuwait Aviation Fuelling Company, PO Box 1654 Safat, State of Kuwait 13017, ZKUW  
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Barron, PA, Silver Wings, Picton Holywell, Clwyd CH8 9JD  
Bennett, JB, 58 Tattershall, Toothill, Swindon, Wiltshire SN5 8BX  
Blake, J, 'Roma', Summerhill, Althorne, Essex CM3 3BY  
Brooks, JC, Pewcol Engineering Consultants, 20 Grosvenor Place, London SW1X 7HP  
Bryan, SR, Rods Oils Ltd, Two Gates Industrial Estate, Tamworth, Staffordshire B77 5AE  
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Colter, VS, Aberdeen Petroleum plc, 40 George Street, London W1H 5RE  
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Dunn, RJ, Dewco House, 587 Hertford Road, Enfield Wash, Middlesex EN3 5UL  
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Godfree, SJB, Leaf Coppin Publishing, 34 Rue Belvallette, Boulogne-sur-Mer, 62200 France ZFRA  
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Medd, D, Global Marine Drilling, Unit 2 Wellhead Crescent, Dyce Industrial Park, Dyce, Aberdeen AB2 0GA  
Millar, DE, 13 Belmont Avenue, Palmers Green, London N13 4HD  
Mills, SW, Rosemount, 9 Clockstone Road, Galston, Ayrshire KA4 8LW  
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Mitchell, C, Ms, 35 Stansfield Road, London SW9 9RY  
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O'Donovan, MJ, Seahorse Ltd, Mainport, Monahan Road, Cork, Eire  
Osterwald, EJ, 1 Lansdale House, 81-85 Tufton Street, London SW1P 3QX  
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Owens, PJ, 17 Fry's Lane, Yateley, Camberley, Surrey GU17 7TJ  
Patrick, A, Ms, Pemem Services Europe, 4-5 Grosvenor Place, London SW1X 7HJ  
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Phillips, JT, 21 Beech Tree Close, Oakley, Basingstoke, Hahts RG23 7EF  
Phillis, MJ, Michael Phillis Chartered Surveyors, Pembroke House, Lotts Avenue, Backwell, Bristol BS19 3HD  
Pillay, R, Apartment BLK 138, 02-117, Lorong AH500, Singapore ZSIN  
Poytress, JN, Conder Products, Worthy Road, Winchester, Hampshire 3023 75H  
Prazak, VC, 40 Youngs Court, Charlotte Despard Avenue, Battersea, London SW11 5JD  
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Roussel, JAH, 14 Willa de Hameau, 78400 Chatou, France 78400  
Shah, N, Normond Instruments, Hydrex House, Garden Road, Richmond, Surrey TW9 4NR  
Shawyer, EF, E.A. Gibson Shipbrokers Ltd, PO Box 278, Audrey House, 16/20 Ely Place, London EC1P 1HP  
Smith, ID, 10 The Crofts, Great Wakering, Southend-on-Sea S53 0JS  
Smith, VV, Peko Petroleum (UK) Limited, 22-25A Sackville Street, London W1X 1DE

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 Stigant, B, Wayne Europe — United Kingdom, Dresser UK Ltd, Imperial Way, Wortongrange, Reading RG2 0DW  
 Sullivan, SJ, Saybolt UK Ltd, Oliver Close, Riverside Estate, West Thurrock, Grays, Essex RM16 1ED  
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## Students

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 Petrusev, CD, 12/7 Bathfield, Cromwell Court, Edinburgh EH6 4ED  
 Philip, Miss AA, Flat B 3.1/1.3 St Mark's Flats, Raglan Road, Leeds LS2 9EL

## Deaths

We report with much regret the deaths of the following members:

	Born
RFC Bates, Maidenhead, Berks	1912
IL Connell, Beaconsfield, Bucks	1928
WG Crafer, Sevenoaks	1912
R Edwards, Sutton Coldfield, W Midlands	1911
A Goldie, North Berwick, E Lothian	1904
CL Goodacre, London	1909
HSJ Hegg, Connahs Quay, Clwyd	1928

## TRENDS IN WORLD NATURAL GAS TRADE

Proceedings of a Conference held on  
25 October 1989

The worldwide use of natural gas as a fuel has been growing steadily, over the past three decades.

Until recently, the prices at which gas could be sold tended to be significantly lower than those for oil and NGL. The very large capital costs incurred in setting up either major pipeline systems or gas liquefaction projects inhibited the development of all but the largest fields, if the project was destined for export.

As a result of economic uncertainties and technological advances, these constraints are becoming less important than they were hitherto. The use of imported gas as a means of diversifying both fuel and feedstock sources and the development of gas reserves as a route to obtaining a reliable source of income in relatively stable currencies has led to an expanding trade in countries as far apart as Norway and Australia.

At the conference, which followed shortly after the first deliveries from the Australian Northwest Shelf to Japan, papers were presented on trends in natural gas trade around the world.

**Price: UK £25.00. Overseas £30.00.**

**Please send remittance with order.**

This publication is available from The Library, The Institute of Petroleum.

## Petroleum Review Index

The 1989 annual index to *Petroleum Review* is now available. Please apply to: Library, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Tel: 01-636 1004

## Deliveries into Consumption

UK deliveries into inland consumption of major petroleum products — Tonnes

Products	November 1988†	November 1989*	Jan–Nov 1988†	Jan–Nov 1989*	% change
Naphtha/LDF	253,380	375,000	2,928,890	3,076,950	+5.1
ATF—Kerosine	477,650	477,170	5,744,450	6,093,590	+6.1
Motor Spirit	1,964,950	2,030,340	21,254,360	21,963,260	+3.3
of which unleaded	48,600	575,110	194,730	4,086,580	+1998.6
Burning Oil	232,170	213,970	1,772,490	1,680,400	-5.2
Derv Fuel	860,610	933,740	8,616,210	9,334,670	+8.3
Gas/Diesel Oil	868,280	773,710	7,759,500	7,584,690	-2.3
Fuel Oil	1,178,600	1,105,960	9,945,530	9,297,890	-6.5
Lubricating Oil	76,100	74,060	791,930	814,650	+2.9
Other Products	640,790	569,870	6,403,480	6,075,410	-5.1
<b>Total above</b>	<b>6,552,530</b>	<b>6,563,820</b>	<b>65,216,840</b>	<b>65,921,510</b>	<b>+1.1</b>
Refinery Consumption	457,450	495,430	4,966,420	5,301,350	+6.7
<b>Total all products</b>	<b>7,009,980</b>	<b>7,059,250</b>	<b>70,183,260</b>	<b>71,222,860</b>	<b>+1.5</b>

†Revised \*Preliminary



The Institute of Petroleum

## BACKGROUND COURSES

### INTRODUCTION TO OIL INDUSTRY OPERATIONS

WEDNESDAY 27 JUNE —  
FRIDAY 29 JUNE 1990

This course is designed as a general introduction to the upstream and downstream activities of the oil industry and may be particularly valuable to companies who do not hold their own in-house induction courses covering this subject. It is likely to be appropriate for:

Participants from within the oil industry whose experience is limited to one function of the industry and who require a wider perspective of the industry's activities.

Participants from financial institutions, government, other energy industries and the supply and service industries who require to obtain an informed and concise 'bird's eye view' of the oil industry.

Topics to be covered during the three days will include:

- Changing Perspectives in the International Oil Industry
- Basic Concepts of Drilling
- Petroleum Production
- Supply
- Refining
- Petrochemicals
- Research Activities in the Oil Industry
- Introduction to Marketing and Distribution
- The Retail Market

This is a self-contained course but is followed by:

### INTRODUCTION TO PETROLEUM ECONOMICS

MONDAY 2 JULY —  
WEDNESDAY 4 JULY 1990

This course is designed as a general introduction to the economics of the oil industry and may be particularly valuable to companies who do not hold their own in-house induction courses covering this subject. It is likely to be appropriate for:

Participants from within the oil industry whose experience is limited to one function of the industry and who require a broader perspective of the economic factors affecting the industry.

Participants from financial institutions, government, other energy industries and the supply and service industries who require to obtain an informed and concise introduction to the economic and commercial background to the industry.

For copies of the registration forms for both courses which will be available shortly, please contact **Caroline Little**, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Telephone: **01-636 1004**. Telex: **264380**. Fax: **01-255 1472**.

## CONSULTANTS

### PETROLEUM INDUSTRY

We are seeking freelance consultants to work either in UK or overseas within the following areas of expertise.

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### IP WORKSHOP

## 'Problem Areas in Crude Oil Loss Claims'

at the Institute of Petroleum

**TUESDAY 13 MARCH 1990**

(09.30 am to 3.30 pm)

**Chairman: Capt D L Smith,**  
Manager Cargo & Casualty Liaison,  
Shell International Marine Limited.

Topics to be covered include statistical approach to claims, ownership of undischarged oil, cargo retention clauses.

There will be short presentations on the above topics followed by informal discussion by participants.

Registration fee: £90 (members), £115 (non-members), including buffet lunch.

If you would like to attend the Workshop please contact **Caroline Little**, Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Tel: **(01) 636 1004 ext 231**. Telex: **264380**. Fax: **01-255 1472**.