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Supplemental to this issue:

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Technology Forum: Refining Equipment and Services—refiners worldwide grapple with keeping their process units fit and running as capacity utilization remains at record levels. Which technology resources will they utilize to ensure their plants' reliability? The latest options are reviewed.

The first phase of the Sakhalin-1 project, one of the world's most ambitious developments, reached peak production of 250,000 barrels of oil per day in the first quarter of 2007. *Sakhalin-1, a New Frontier* details this pioneering development from its formative stages on the remote Sakhalin shelf in the Russian sub-Arctic in the early 1990s. Operated by Exxon Neftegas Limited on behalf of a five-company international consortium, Sakhalin-1 is expected to continue reaping benefits for Russia, the Asia-Pacific and an energy-hungry world for at least the next 40 years.

Scorpion Offshore, established in 2005, is building five premium jackup rigs in Brownsville, Texas, the first of which will be delivered the first half of 2007. *The Relentless Pursuit of Performance Excellence* presents the company's operating, engineering and recruitment, training and retention philosophies as it prepares to take delivery of its new rigs, which are being marketed internationally.

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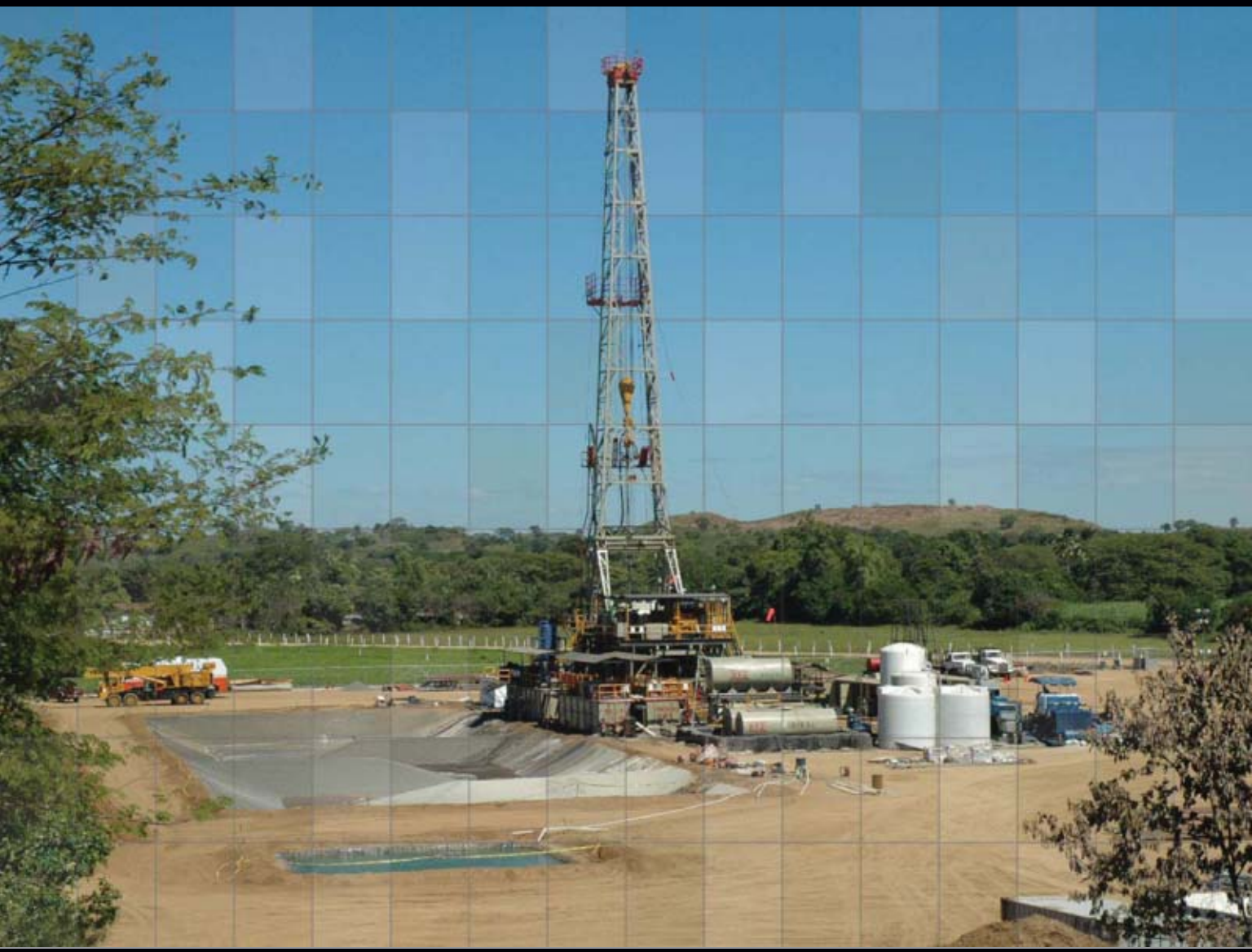

Exploration and Development Frontiers

International oil firms adjust as national oil firms expand
Procedure calculates base gas compressibility factors
Iran becoming mega petchem producer, natural gas consumer
New API publication gives integrity management guidance

atural Gas

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Mar. 26, 2007
Volume 105.12

EXPLORATION AND DEVELOPMENT FRONTIERS

Exploration spreads into numerous remote and nonproducing basins 33
Alan Petzet

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COVER

San Bartolo Rodriquez Cano-1 is an indicated discovery in the Sandino basin in northwestern Nicaragua. The well encountered gas-condensate and light oil in eight zones below 6,000 ft in Paleocene Brito formation turbidites. Though not tested as of late March, it could signal the Central American country's first hydrocarbon production capability. It was drilled with a rig from Mexico and other services provided from the US and Canada. OGJ's E&D Frontiers report starts on p. 33. Photo courtesy of Norwood Resources Ltd.

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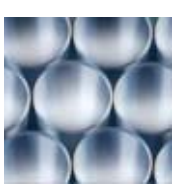

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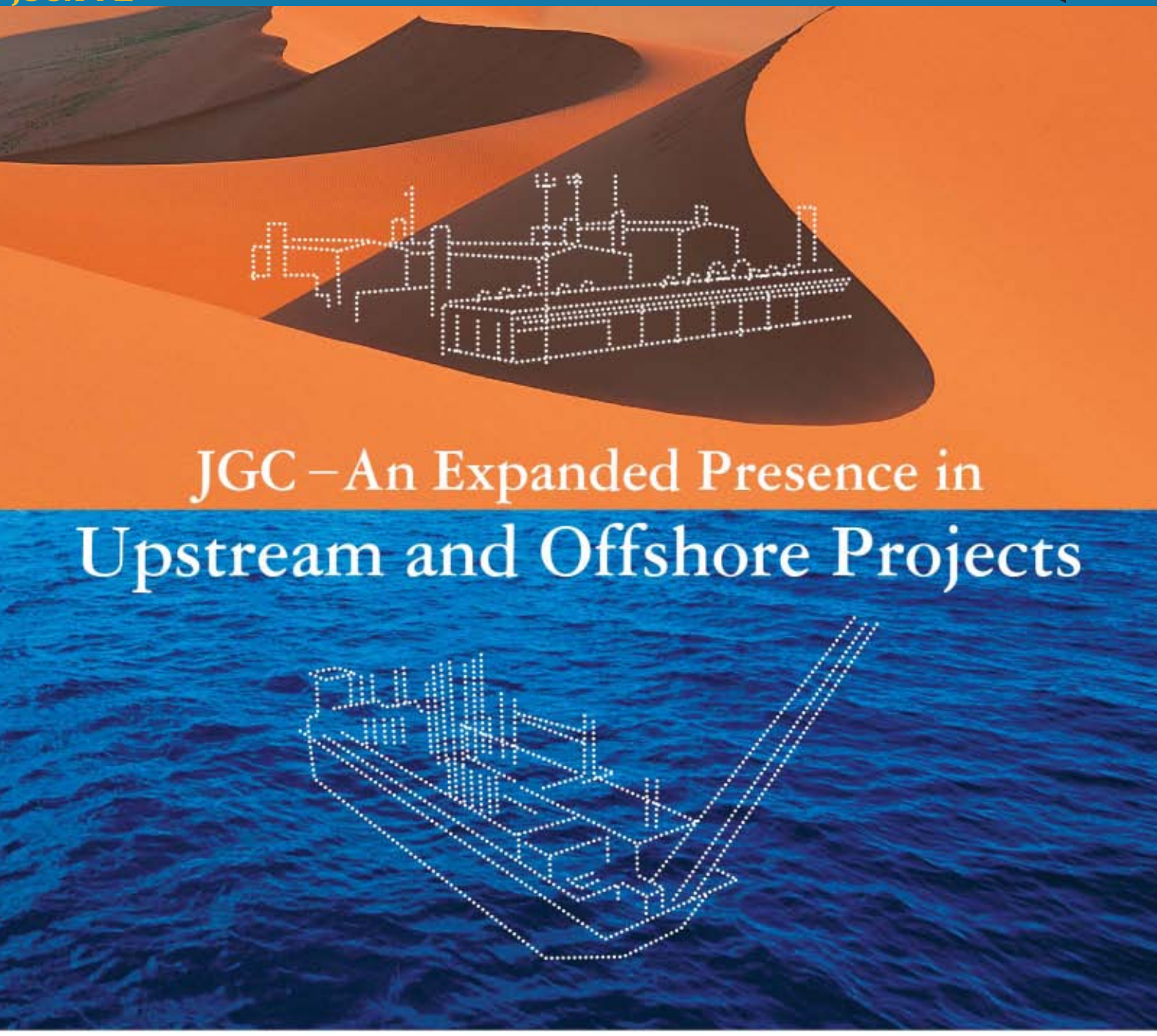

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OGJ Newsletter

Mar. 26, 2007

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General Interest — Quick Takes

Senator proposes extension on 1998, 1999 leases

US Sen. Pete V. Domenici (R-NM) reported plans to propose 3-year extensions of federal Gulf of Mexico deepwater leases issued in 1998 and 1999 without price thresholds if the leaseholders agree to new terms including such a provision.

During a Senate Interior Appropriations Subcommittee hearing on Mar. 20, Domenici, who is chief minority member of the Energy and Natural Resources Committee, said he is open to other ideas to bring leaseholders to the negotiating table, but added that offering an extension in exchange for price thresholds deserves a closer look.

Noting that the omission of price thresholds in the original leases could cost the federal government as much as $10 billion, Domenici said, "I recognize that this will not entirely solve the problem and make the Treasury 100% whole, but the bottom line is that this was a major mistake by [the administration of former President Bill Clinton] that has already cost the government nearly $1 billion. As I have said, I am open to other solutions that would withstand legal challenges, but we must act soon."

US House members have proposed either prohibiting holders in future federal lease sales if they are unwilling to voluntarily renegotiate terms, or requiring them to pay "resource conservation fees" to make up royalties which would be suspended under the original leases.

The US Minerals Management Service has tried to get holders of such leases to voluntarily renegotiate terms. Six have signed new agreements already, C. Stephen Allred, assistant Interior secretary for lands and minerals management, told the Senate Energy and Natural Resources Committee on Jan. 18.

At the Senate appropriations subcommittee hearing, US Sec. of Interior Dirk A. Kempthorne said he would work with Domenici and other senators to reach a solution. He also pledged that President George W. Bush's administration would not omit price thresholds from oil and gas leases.

North, South Korea make energy pact

South Korea will provide North Korea the energy equivalent of as much as 50,000 tonnes of fuel oil in exchange for taking initial denuclearization steps under the so-called Six-Party Framework Agreement, which involves North and South Korea, the US, China, Japan, and Russia.

Junichi Ihara, deputy director-general of the Japanese Foreign Ministry's Asian and Oceania Affairs Bureau, told reporters that the decision was reached Mar. 15 in Beijing at the meeting of the Six-Party Talks' working group on economic and energy assistance to North Korea.

According to Joon Yung-woo, South Korea's chief nuclear negotiator, the task of the working group is to determine detailed plans and specific means of providing economic, energy, and humanitarian assistance to the North as agreed in the Feb. 13 agreement.

He was referring to the nuclear deal signed in Beijing, under which North Korea—in exchange for heavy fuel oil or equivalent aid—agreed to shut down and seal its nuclear reactors.

One of the main priorities of the working group is to decide how the countries will sequence the provision of energy aid to the north with the communist nation's shutdown of its nuclear facilities. South Korean officials, speaking anonymously, said the actions would have to take place "simultaneously."

European gas execs reject market consolidation

Gas executives at European energy companies do not want further consolidation within Europe's energy markets according to a survey carried out by Deloitte at the FLAME gas conference in Amsterdam Mar. 14.

Only 6% of delegates surveyed believed Europe's competitive strength in global energy markets would be improved through further consolidation. Respondents would prefer to enhance Europe's competitive position by harmonizing standards for cross-border trading (44%), followed by ownership unbundling of networks (30%), and the creation of a European regulator (20%).

Neither are delegates optimistic that all gas customers across Europe can choose their supplier by the July 2007 deadline given by the European Commission—83% of respondents said the deadline will not be met.

"Many executives across the industry are comfortable with the prospect of working in a more-competitive market environment," said Deloitte oil and gas leader Peter Newman. "They seem more persuaded by the arguments of the EU Commission in favor of greater liberalization, as the best way to achieve diversification and new investment, than of those of some of the national policy makers who continue to emphasize the role of 'national champions.' It is quite possible that the EU's strong new focus on energy emissions and efficiency may divert its attention away from the further liberalization and regulation measures that form part of a single European energy market."

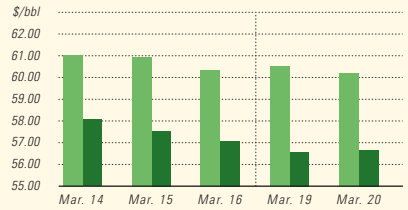
ODAC: UK was net oil importer in 2006

The UK became a net importer of oil for most of 2006, according to the Oil Depletion Analysis Centre (ODAC) in Aberdeen. "It is time for the UK government to let go of the idea that the UK will be a net oil exporter until 2010 and accept we are now dependent on imports," ODAC said.

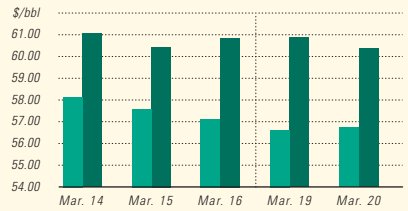
Data published by the UK Department for Trade and Industry showed that the UK imported oil during every month in 2006

Industry Scoreboard

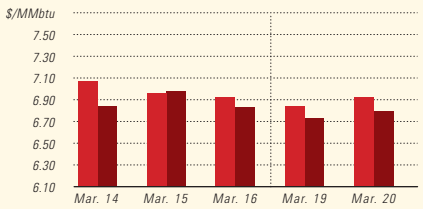
IPE BRENT / NYMEX LIGHT SWEET CRUDE



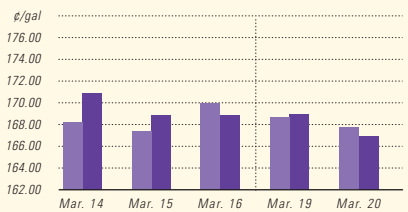
WTI CUSHING / BRENT SPOT



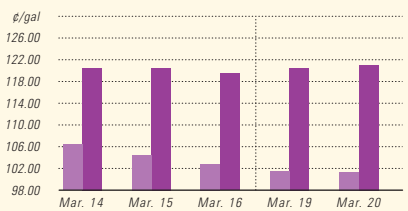
NYMEX NATURAL GAS / SPOT GAS - HENRY HUB



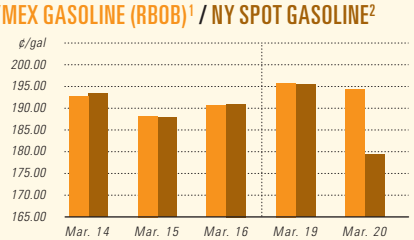
IPE GAS OIL / NYMEX HEATING OIL



PROPANE - MT. BELVIEU / BUTANE - MT. BELVIEU



NYMEX GASOLINE (RBOB)[1] / NY SPOT GASOLINE[2]



[1]Reformulated gasoline blendstock for oxygen blending
[2]Nonoxygenated regular unleaded.

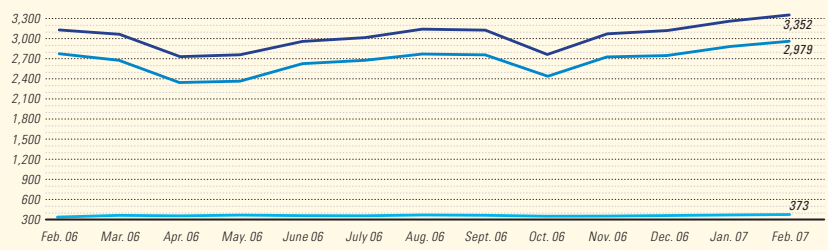
US INDUSTRY SCOREBOARD — 3/26

Latest week 3/16	4 wk. average	4 wk. avg. year ago[1]	Change, %	YTD average[1]	YTD avg. year ago[1]	Change, %
Demand, 1,000 b/d						
Motor gasoline	9,086	9,004	0.9	9,081	8,897	2.1
Distillate	4,469	4,411	1.3	4,419	4,320	2.3
Jet fuel	1,625	1,555	4.5	1,639	1,545	6.1
Residual	906	806	12.4	720	821	–12.3
Other products	5,242	4,757	10.2	5,012	4,790	4.6
TOTAL DEMAND	21,327	20,533	3.9	20,871	20,374	2.4
Supply, 1,000 b/d						
Crude production	5,291	5,030	5.2	5,304	5,037	5.3
NGL production	2,442	1,683	45.1	2,413	1,683	43.4
Crude imports	9,743	9,852	–1.1	9,681	9,806	–1.3
Product imports	3,013	3,215	–6.3	3,065	3,449	–11.1
Other supply[2]	887	1,114	–20.4	959	1,182	–18.9
TOTAL SUPPLY	21,376	20,894	2.3	21,423	21,157	1.3
Refining, 1,000 b/d						
Crude runs to stills	14,373	14,580	–1.4	14,604	14,658	–0.4
Input to crude stills	14,840	14,946	–0.7	15,038	14,995	0.3
% utilization	85.6	86.0	—	86.7	86.4	—

Latest week 3/16	Latest week	Previous week[1]	Change	Same week year ago[1]	Change	Change, %
Stocks, 1,000 bbl						
Crude oil	329,357	323,692	5,665	338,112	–8,755	–2.6
Motor gasoline	204,694	203,941	753	217,470	–12,776	–5.9
Distillate	123,342	123,510	–168	126,297	–2,955	–2.3
Jet fuel	38,617	39,433	–816	42,552	–3,935	–9.2
Residual	38,427	38,509	–82	38,182	245	0.6
Stock cover (days)[3] **3/9**			**Change, %**		**Change, %**	
Crude	22.3	22.1	0.9	23.7	–5.9	
Motor gasoline	23.3	23.7	–1.7	24.8	–6.0	
Distillate	26.2	26.4	–0.8	29.3	–10.6	
Propane	17.2	16.6	–3.6	21.3	–19.2	
Futures prices[4] **3/16**			**Change**		**Change**	**Change, %**
Light sweet crude, $/bbl	57.69	61.05	–3.36	62.68	–4.99	–8.0
Natural gas, $/MMbtu	6.95	7.28	–0.33	7.13	–0.18	–2.5

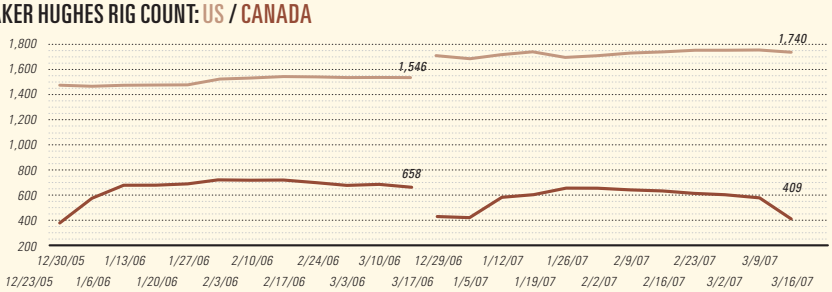
[1]Based on revised figures. [2]Includes other hydrocarbons and alcohol, refinery processing gain, and unaccounted for crude oil.
[3]Stocks divided by average daily product supplied for the prior 4 weeks. [4]Weekly average of daily closing futures prices.
Sources: Energy Information Administration, American Petroleum Institute, Wall Street Journal.

BAKER HUGHES INTERNATIONAL RIG COUNT: TOTAL WORLD / TOTAL ONSHORE / TOTAL OFFSHORE



Note: Monthly average count

BAKER HUGHES RIG COUNT: US / CANADA



Note: End of week average count

except for June. DTI forecasts that the UK will export oil for a few months during 2007 and see a decline in domestic oil production. From 2008, the International Energy Agency and the US Energy Information Administration expect the UK to be a net oil importer.

In May 2006 the UK imported its highest net volume over that year of 1.357 million tonnes of oil compared with 100,000 tonnes of oil in March, which was the lowest volume. In June the UK exported 298,000 tonnes.

A spokeswoman for the UK Offshore Operators' Association said the difference in oil imports and indigenous production in 2006 was small. "Last year's dip can be attributed to lower-than-expected North Sea production, owing in part to delays in new fields coming on stream, reservoir performance, and maintenance programs. Global constraints on resources, including equipment and personnel, also had an impact on activity levels in the UK."

Crude oil production in the UK in 2006 was an estimated 1.6 million b/d, while consumption was an estimated 1.7 million b/d.

"Based on the most recent information given to us by our members, we believe it now likely that the UK will become a net importer of oil from 2009 onwards. However, indigenous production could still provide 90% of the UK's oil needs in 2010," the UKOOA spokeswoman said. ✦

Exploration & Development — *Quick Takes*

CNOOC makes oil, gas discovery in Bohai Bay

CNOOC Ltd. found oil and gas with a discovery well drilled in the Yellow River Mouth Sag of Bohai Bay. The well, Bozhong (BZ) 28-2E-1, was drilled south of Structure BZ 28-2E between BZ 28-1 and BZ 28-2S oil fields.

The well penetrated oil pay zones with 35 m total thickness and gas sections of 35 m. The well was drilled to 2,575 m total depth in 20 m of water.

On test, the well flowed an average 1,600 b/d of oil through 7.14-mm and 14.29-mm chokes, and 10 MMcfd of gas through a 15.08-mm choke.

Since 2006, CNOOC has made four discoveries in the Yellow River Mouth Sag, the company said.

Statoil finds gas, condensate on Biotitt prospect

Statoil ASA has proved gas and condensate on the Biotitt prospect in the Norwegian North Sea, 20 km northeast of the Sleipner field.

Seadrill Ltd.'s ultralarge West Epsilon jack up drilled the well to a TD of 2,360 m, targeting Cretaceous rock, with gas and condensate being proved in the Heimdal formation of Tertiary age.

Statoil will investigate whether it will produce the find using the Sleipner platform. Statoil said it would carry out an evaluation and analysis of the gathered data to determine the find's resource potential and that a joint development with the 16/7-2 find south of Biotitt could be an option.

West Epsilon will drill the Ermintrude prospect on Block 15/6 in production license 303, 10 km north of Sleipner field.

The licensees in exploration license 339, awarded in 2004, are Statoil with a 70% share and ExxonMobil Corp. with 30%.

Statoil to shoot seismic survey in Libya

Statoil plans to shoot a 2,000 km, 2D seismic survey in the Kufra license in the southeastern part of Libya for the first time in the country under its work program for the two licenses it was awarded last year.

Statoil shares its Kufra 171 license on a 50-50 basis with BG Group, and they plan to drill two exploration wells once they have finished processing the seismic data. The license spans 10,000 sq km in the desert.

Statoil also plans to shoot a 3,000 km, 2D seismic survey for its Cyrenaica 94 license in April. It has full ownership of the license and will drill one exploration well. The license lies in the north of Libya, near the Egyptian border.

Statoil said the desert areas are little-explored in relation to petroleum resources. A few wells have been drilled in the area, but that was in the 1960s and 70s.

During the second half of 2008, Statoil will drill the first exploration well in Libya.

MMS issues final notice for Lease Sale 202

The US Minerals Management Service issued a final notice for OCS Lease Sale 202, covering 8.7 million acres off Alaska's northern coast in the Beaufort Sea. The sale will be held Apr. 18 in Anchorage, MMS said.

The sale area extends from the Canadian border on the east to the Barrow area on the west, but excludes offshore areas near Barrow and Kaktovik, which the Inupiat Natives use for bowhead whale subsistence hunts.

Any offshore oil and gas activity in the entire sale area will have to be coordinated with the Inupiat whalers during their subsistence hunt, MMS Regional Director John Goll noted in Anchorage. Stipulations for this sale were developed after consultations with several interested parties and groups, he added.

The sale's lease terms are the same as those used for MMS's last Beaufort Sea leasing, Sale 195, held in March 2005.

MMS estimates that the Beaufort Sea could contain about 7 billion bbl of oil and 32 tcf of gas on a mean conventionally recoverable basis.

GeoPark redeveloping Chile's Fell gas block

GeoPark Holdings Ltd. is reestablishing gas production at the Fell Block in Chile's Tierra del Fuego region and plans to sign a long-term gas supply contract to supply the nearby Methanex Corp. methanol plant at Punta Arenas.

The two companies signed a memorandum of understanding under which GeoPark would supply gas for 10 years starting in May. The agreement provides incentives for volume growth up to 100 MMcfd of gas and includes provisions for the financing of development operations and the potential joint acquisition of new hydrocarbon blocks in Chile.

GeoPark began operating the Fell Block in September 2005 and

began producing from the block in May 2006 from Molino, Ovejero, and Nika fields. It reactivated the first well in Santiago Norte field in December 2006 at 3.2 MMcfd and 50 b/d of condensate and recently completed an $8 million 3D seismic program on the Fell Block.

Gas is piped to Methanex, and Chile's state ENAP buys the condensate. ✦

Drilling & Production — *Quick Takes*

Gas production starts from Bibiyana field

Chevron Corp. has brought on production from Bibiyana gas field on Block 12 in the Habiganj district of northeast Bangladesh.

The field is expected to initially produce 200 MMcfd of gas and peak at 500 MMcfd by 2010. At that time, Bibiyana would be the largest producing gas field in the country.

The field development project includes 12 development wells, a gas plant, a gas pipeline, and a condensate pipeline. The gas plant's full capacity of 600 MMcfd is scheduled to be reached later this year.

Due to the 2005 Chevron and Unocal Corp. merger, Chevron has a gas sales agreement with state-owned Petrobangla. Under that contract minimum volumes of 200 MMcfd will increase to 400 MMcfd at the end of 2008 (OGJ, Dec. 6, 2004, p. 44).

Chevron holds a 98% interest in the field.

Maersk expands Al Shaheen work off Qatar

Maersk Oil Qatar AS has let an engineering, procurement, installation, and construction contract to National Petroleum Construction Co. (NPCC) of Abu Dhabi for platforms in Al Shaheen oil and gas field off Qatar.

The work is part of a development effort that will raise the field's oil production to 525,000 b/d from 240,000 b/d (OGJ, Aug. 14, 2006, Newsletter).

NPCC will build and install wellhead, process, and flare platforms in the G area of Block B; a process platform and bridge in the E area; and three interconnecting bridges.

It is building jackets, bridges, risers, and pipelines under two EPIC contracts awarded last year.

Maersk holds a 100% interest in Block B, which lies in 52-70 m of water, under a production-sharing agreement with Qatar Petroleum.

Marathon unit orders semi rig for GOM

A subsidiary of Marathon Oil Corp. has signed a letter of intent (LOI) with Noble Drilling Services Inc. for Noble's new Bingo 9000 Rig 4 semisubmersible hull for drilling in the Gulf of Mexico, Noble said.

The semi, which will be renamed Noble Jim Day, will follow the operational design of the Noble Danny Adkins currently under construction at the Jurong Shipyard in Singapore. Noble Jim Day will be completed as a dynamically positioned (DPS-3) unit designed to operate in 12,000 ft of water, and it will have living accommodations for 200 people.

The rig's expected delivery date is during fourth quarter 2009.

The LOI is contingent upon execution of a definitive drilling contract that includes an option for Marathon to extend the 2-year primary term to 4 years.

Murphy taps Tanjung for jack up in Malaysia

Murphy Sarawak Oil Co. Ltd. has awarded a $122.7 million contract to Tanjung Offshore Services Sdn. Bhd. subsidiary Tanjung Offshore Bhd. to provide a jack up drilling rig.

The 208 rig is required for Murphy Oil's 2007-10 development drilling programs in Malaysian waters, Tanjung said. The contract, effective from Nov. 30, is for a firm 3-year period, with an option to extend for a further 2 years. ✦

Processing — *Quick Takes*

Williams to pay $2.2 million for pollution charges

Williams Refining Co. agreed to pay $2.2 million to settle charges that it violated Clean Air Act provisions at its Memphis refinery, the US Department of Justice and Environmental Protection Agency jointly announced.

The Mar. 14 settlement agreement resolves allegations that the Williams Cos. Inc. subsidiary, which owned and operated the plant from the mid-1980s until its sale to Premcor Refining Group Inc. in March 2003, did not comply with regulations intended to prevent benzene emissions. Valero Energy Corp. acquired Premcor in 2005.

Williams Refining's settlement also resolves allegations that it did not follow leak detection and repair regulations for the refinery's equipment as specified in the CAA. Additionally, the agreement resolves assertions that the company did not properly store hazardous waste, as required under the Resource Conservation and Recovery Act, and one violation of the Clean Water Act for an oil pipeline rupture, EPA said.

EPA said it initiated an investigation of the refinery after it became suspicious of Williams Refining's report of less than 10 Mg of benzene emissions based on the plant's size. The CAA requires refineries that discharge more than 10 Mg/year to manage their wastewater in compliance with the Benzene National Standards for Hazardous Air Pollutants.

EPA said that the CAA also requires refinery operators to monitor pumps and valves for leaks, and to report any which are discovered. It said that it discovered more violations during an inspection on Nov. 5 and 6, 2002, and as a result of a Feb. 2, 2002, pipeline rupture.

CSB investigates fire at Valero's McKee refinery

The US Chemical Safety Board is investigating a Feb. 16 propane fire at Valero Energy Corp.'s McKee refinery in Sunray, Tex. The

blaze seriously burned three workers and forced the facility to shut down (OGJ Online, Feb. 21, 2007).

CSB investigators began working at the site a few days later, interviewing witnesses and examining the area where the fire began. "The exact mechanical failure that led to the propane release remains to be identified. Further modeling and testing of piping, valves, and flanges will be needed to determine precisely what happened," lead investigator Jim Lay said on Mar. 9.

He said Valero has cooperated with the investigation and has provided drawings, written procedures, and inspection records in response to CSB's document requests.

PDVSA to convert refinery for heavy oil

State-owned Petroleos de Venezuela SA (PDVSA) will work with Japan's JGC Corp. on basic engineering for a deep conversion project at PDVSA's 200,000 b/d refinery at Puerto la Cruz.

In a statement, PDVSA said the project—to be completed in 2008—involves adding new technology to enable the refinery to process extraheavy oil from the Orinoco tar belt instead of the lighter crude oil it now processes.

PDVSA said the Puerto la Cruz expansion, estimated to cost $1.7 billion, will enable the facility to refine an additional 80,000-90,000 b/d of heavy crude.

The government of Venezuelan President Hugo Chavez has been implementing a program to nationalize the country's oil industry, including sectors producing the heavy crude to be processed at Puerto la Cruz.

The government warned it will assume control of operations unilaterally if the companies do not cooperate by May 1. "If by the deadline there is no agreement, we will take direct control of all these operations," said Energy Minister Rafael Ramírez.

On Mar. 12 ExxonMobil said it would participate in a transition committee to oversee the transfer of its control of the Cerro Negro heavy crude facilities in the Orinoco belt. The facilities, which convert tar oil into high-value synthetic crude, are valued at $31 billion.

ExxonMobil and PDVSA each own a 41.7% stake in the venture, with the remaining 16.6% held by BP. ✦

Transportation — *Quick Takes*

QP, ExxonMobil complete RasGas LNG Train 5

Qatar Petroleum and ExxonMobil Corp. announced the completion of RasGas LNG Train 5 in Doha.

Completed in 29 months, Train 5 has a designed capacity of 4.7 million tonnes/year of LNG and will supply gas to northern Europe.

RasGas currently operates five trains in Ras Laffan; Trains 6 and 7 are currently under construction. Those two trains, each with capacity to process 7.8 million tonnes/year of LNG, are expected to start-up in 2008 and 2009, respectively.

RasGas Co. Ltd. is a joint venture of QP and ExxonMobil RasGas Inc.

Kozmino terminal given environmental nod

Russia's environmental oversight agency Rostekhnadzor said a projected oil terminal at Kozmino, on Russia's Pacific Coast, will present no threat to its surroundings when constructed.

Head of Rostekhnadzor Konstantin Pulikovsky said plans were ecologically safe for the oil port at Kozmino, selected as the export terminus of the planned 4,300-km East Siberia Pacific Ocean (ESPO) pipeline.

Kozmino will be capable of receiving deepwater tankers and handle crude exports of as much as 80 million tonnes/year—the pipeline's largest projected throughput.

The pipeline route has already been altered following criticism by Russian President Vladimir Putin and environmental activists. State pipeline monopoly OAO Transneft last year agreed to reroute the pipeline away from Lake Baikal (OGJ Online, May 25, 2006).

Gassco assesses gas pipeline routes to Europe

Norway's state-owned Gassco AS is evaluating pipeline routes to bring Norwegian North Sea gas to Europe. The company will publish its concept selection in May, a senior Gassco official said Mar. 9. The company will make a final investment decision in December.

Speaking at a press briefing in London, Jan Hauge, Gassco's executive vice-president for product management, said the three possible landing points for the pipeline are St. Fergus in northeast Scotland, Zeebrugge in Belgium, or Den Helder in the Netherlands. St. Fergus would be the cheapest option as it is the shortest distance.

Gassco wants to take gas from Troll field, but the proposal is proving controversial because Troll partner Norsk Hydro ASA is worried that gas production would reduce pressure needed for recovering oil from the field. Gassco is investigating the design challenges inherent in increasing gas production without having a negative effect on Troll's oil production. "It will require sophisticated technological work," Hauge added.

Hydro plans to increase oil production by more than 30% to 2 billion bbl and has developed Troll's oil resources using more than 110 horizontal wells. Hydro is also assessing whether it is possible to accelerate gas recovery from the eastern part of Troll field while simultaneously preparing for increased oil recovery from the western section.

Hauge declined to give estimates on the capacity of the pipeline or its length, saying information is being assessed and will be published in May. Gassco representatives also said there has been much political interest in the pipeline, particularly from the UK, as security of supply in Europe is a top priority. One of the other issues to determine would be tariff levels in each landing point.

A possible start-up date for operations is 2011, although Hauge stressed that the pipeline could be postponed if conditions are not right. ✦

Calendar

✦ Denotes new listing or a change in previously published information.

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MARCH

NPRA International Petrochemical Conference, San Antonio, (202) 457-0480, (202) 457-0486 (fax), e-mail: info@npra.org, website: www.npra.org. 25-27.

American Chemical Society National Meeting & Exposition, Chicago, (202) 872-4600, (202) 872-4615 (fax), e-mail: natlmtgs@acs.org, website: www.acs.org. 25-29.

Turkish Oil & Gas Exhibition and Conference, Ankara, +44 (0) 207 596 5233, +44 (0) 207 596 5106 (fax), e-mail: oilgas@ite-exhibitions.com, website: www.ite-exhibitions.com. 27-29.

Offshore Mediterranean Conference, Ravenna, +39 0544 219418, +39 0544 39347 (fax), e-mail: conference@omc.it, website: www.omc.it. 28-30.

SPE Production and Operations Symposium, Oklahoma City, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. Mar. 31-Apr. 3.

APRIL

SPE Hydrocarbon Economics and Evaluation Symposium, Dallas, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 1-3.

AAPG Annual Convention and Exhibition, Long Beach (918) 584-2555, (918) 560-2694 (fax), e-mail: postmaster@aapg.org, website: www.aapg.org. 1-4.

PIRA Natural Gas and LNG Markets Conference, Houston, 212-686-6808, 212-686-6628 (Fax), e-mail: sales@pira.com, website: www.pira.com. 2-3.

China International Oil & Gas Conference, Beijing, +44 (0) 207 596 5233, +44 (0) 207 596 5106 (fax), e-mail: oilgas@ite-exhibitions.com, website: www.ite-exhibitions.com. 3-4.

IADC/SPE Managed Pressure Drilling & Underbalanced Operations Conference, Galveston, Tex., (713) 292-1945, (713) 292-1946 (fax), e-mail: info@iadc.org, website: www.iadc.org. 3-4.

IADC Environmental Conference & Exhibition, Amsterdam, (713) 292-1945, (713) 292-1946 (fax); e-mail: info@iadc.org, website: www.iadc.org. 3-4.

Instrumentation Systems Automation Show & Conference, Calgary, Alta., (403) 209-3555, (403) 245-8649 (fax), website: www.petroleumshow.com. 11-12.

SPE Digital Energy Conference and Exhibition, Houston, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 11-12.

ENTELEC Annual Conference & Expo, Houston, (888) 503-8700, e-mail: blaine@entelec.org, website: www.entelec.org. 11-13.

Kazakhstan Petroleum Technology Conference, Atyrau, +44 (0) 207 596 5233, +44 (0) 207 596 5106 (fax),e-mail: oilgas@ite-exhibitions.com,

website: www.ite-exhibitions.com. 11-13.

Molecular Structure of Heavy Oils and Coal Liquefaction Products International Conference, Lyon, +33 1 47 52 67 13, +33 1 47 52 70 96 (fax), e-mail: frederique.leandri@ifp.fr, website: www.events.ifp.fr. 12-13.

Middle East Petroleum & Gas Conference, Dubai, 65 62220230, 65 62220121 (fax), e-mail: info@cconnection.org, website: www.cconnection.org. 15-17.

SPE Latin American & Caribbean Petroleum Engineering Conference, Buenos Aires, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 15-18.

Society of Petrophysicists and Well Log Analysts (SPWLA) Middle East Regional Symposium, Abu Dhabi, (713) 947-8727, (713) 947-7181 (fax), e-mail: info@spwla.org, website: www.spwla.org. 15-19.

International Pipeline Conference & Exhibition, Moscow, +43 1 402 89 54 12, +43 1 402 89 54 54 (fax), e-mail: pipeline@msi-fairs.com, website: www.msi-fairs.com. 16-17.

Russia & CIS Refining & Petrochemicals Equipment Conference & Exhibition, Moscow, +44 (0) 20 7357 8394, e-mail: Conference@EuroPetro.com, website: www.europetro.com. 16-17.

API Spring Refining and Equipment Standards Meeting, Seattle, (202) 682-8000, (202) 682-8222 (fax), website: www.api.org. 16-18.

ERTC Coking and Gasification Conference, Paris, 44 1737 365100, +44 1737 365101 (fax), e-mail: events@gtforum.com, website: www.gtforum.com. 16-18.

SPE Rocky Mountain Oil & Gas Technology Symposium, Denver, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 16-18.

Pipeline Technology Conference & Exhibition, Hannover, +49 511 89 31240, +49 511 89 32626 (fax), e-mail: info@messe.de, website: www.hannovermesse.de. 16-20.

API/NPRA Spring Operating Practices Symposium, Seattle, (202) 682-8000, (202) 682-8222 (fax), website: www.api.org. 17.

TAML MultiLateral Knowledge-Sharing Conference, Singapore, +44 (0) 1483 598000, e-mail: info@taml.net, website: www.taml.net. 17.

IADC Drilling HSE Middle East Conference & Exhibition, Bahrain, (713) 292-1945, (713) 292-1946 (fax); e-mail: info@iadc.org, website: www.iadc.org. 17-18.

API Annual Pipeline Conference, Albuquerque, (202) 682-8000, (202) 682-8222 (fax), website: www.api.org. 17-18.

ETF Expandable Technology Forum Technical Conference, Singapore, +44 (0) 1483 598000, +44 (0) 1483 598010 (fax), e-mail: sally.marriage@otmnet.com, website: www.expandableforum.com. 18-19.

Russia & CIS Bottom of the Barrel Technology Conference & Exhibition, Moscow, +44 (0) 20 7357 8394, e-mail: Conference@EuroPetro.com, website: www.europetro.com. 18-19.

GPA Midcontinent Annual Meeting, Oklahoma City, (918) 493-3872, (918) 493-3875 (fax), website: www.gasprocessors.com. 19.

American Institute of Chemical Engineers Spring National Meeting, Houston, (212) 591-8100, (212) 591-8888 (fax), website: www.aiche.org. 22-26.

EnviroArabia Environmental Progress in Oil & Petrochemical Conference, Bahrain, +973 17 729819, +973 17 729819 (fax), e-mail: bseng@batelco.com.bh, website: www.mohandis.org. 23-25.

IPAA OGIS East, New York, (202) 857-4722, (202) 857-4799 (fax), website: www.ipaa.org/meetings. 23-25.

Completion Engineering Association Perforating Symposium, Houston, +44 1483 598 000, +44 1483 598 010 (fax), e-mail: crispin.keanie@otmnet.com, website: www.completionengineeringassociation.com. 24-25.

International Conference & Exhibition on Liquefied Natural Gas, Barcelona, +34 93 417 28 04, +34 93 418 62 19 (fax), e-mail: lng15@lng15.com, website: www.lng15.com. 24-27.

Pipeline Pigging and Integrity Management Conference, Kuala Lumpur, +44 (0) 1494 675139, +44 (0) 1494 670155 (fax), e-mail: jtiratsoo@pipemag.com. 25-26.

SPE Research and Development Conference, San Antonio, (972) 952-9393, (972) 952-9435 (fax), e-mail: spedal@spe.org, website: www.spe.org. 26-27.

Williston Basin Petroleum Conference & Prospect Expo, Regina, (306) 787-0169, (306) 787-4608 (fax), e-mail: enickel@ir.gov.sk.ca, website: www.wbpc.ca. Apr. 29-May 1.

Offshore Technology Conference (OTC), Houston, (972) 952-9494, (972) 952-9435 (fax), e-mail: service@otcnet.org, website: www.otcnet.org. Apr. 30-May 3.

MAY

PIRA Canadian Energy Conference, Calgary, 212-686-6808, 212-686-6628 (fax), e-mail: sales@pira.com, website: www.pira.com. 2.

NPRA National Safety Conference, The Woodlands, Tex., (202) 457-0480, (202) 457-0486 (fax), e-mail: info@npra.org, website: www.npra.org. 2-3.

IOGCC Midyear Meeting, Point Clear, Ala., (405) 525-3556, (405) 525-3592 (fax), e-mail: iogcc@iogcc.state.ok.us, website: www.iogcc.state.ok.us. 6-8.

GPA Permian Basin Annual Meeting, Midland, Tex., (918) 493-3872, (918) 493-3875 (fax), website: www.gasprocessors.com. 8.

Annual Oil and Gas Pipelines in the Middle East Conference, Abu Dhabi, +44 (0) 1242 529 090, +44 (0) 1242 060 (fax), e-mail: wra@theenergyexchange.co.uk, website: www.theenergyexchange.co.uk. 14-15.

AchemAsia Exhibition and Conference, Beijing, +49 (0) 69 7564 249, +49 (0) 69 7564 201 (fax), e-mail: achemasia@dechema.de, website: www.achemasia.de. 14-18.

International School of Hydrocarbon Measurement, Norman, Okla., (405) 325-1217, (405) 325-1388 (fax), e-mail: lcrowley@ou.edu, website: www.ishm.info. 15-17.

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Frontier exploration lamp is lit

Alan Petzet
Chief Editor-Exploration

Large and small operators are moving to explore many of the world's remote and nonproducing regions.

While some energy companies prefer to drill blanket plays in the middle of traditional basins, others devote at least part of their capital budgets to rank wildcatting. A number of the latter are described in OGJ's E&D Frontiers report, which starts on p. 33.

Here are a few more programs in various stages of progress.

Indonesia and Russia

Lundin Petroleum AB, Stockholm, has a $230 million exploration budget in 2007 that includes the drilling of 19 exploration wells in the UK, Norway, Russia, Sudan, and Indonesia.

The company plans to drill five exploration wells in Indonesia and two wells on the Lagansky Block in the northwestern Caspian Sea off Russia.

PetroChina International and Lundin will drill all five Indonesia wells on the Salawati Basin and Island production licenses (see map, OGJ, Aug. 1, 2005, p. 32). Lundin said the blocks have large remaining land and offshore exploration potential, and that several large structures have been identified in the Sele straits.

Lundin plans to drill Morskaya-1 and a second well on the Lagansky Block, acquired with Valkyries Petroleum Corp. in late 2006. A barge-mounted rig built in Astrakhan will be used to drill the shallow-water Caspian wells. Lundin also plans to shoot 700 km of 2D and 3D seismic.

Sandakan basin

Two groups are exploring blocks in Philippine waters of the southwestern Sulu Sea in the Sandakan basin, which has no offshore production.

Esso Exploration International Ltd. took a farmout from Mitra Energy Ltd. of Malaysia to earn a 50% interest in 2 million acre, deepwater SC 56.

Mitra was acquiring 2,400 line-km of 2D seismic data in late 2006 and planned to shoot a 1,600 sq km 3D seismic survey in the first quarter of 2007 (OGJ Online, Dec. 6, 2006).

Salamander Energy PLC, London, took a farmout from Tap Oil Ltd., Perth, to earn a 35% interest in 4,820 sq km SC 41 in the Sandakan basin off Borneo Island.

Tap Oil retains a 50% interest and operatorship. Water is 200-2,000 m deep on the block.

The SC 41 joint venture agreed to boost the size of the 2007 3D seismic survey to a minimum of 600 sq km (OGJ Online, Feb. 9, 2007).

Existing 2D seismic data reveal the prospectivity of SC 41 to consist of a number of leads interpreted to have the potential for 50-150 million bbl oil accumulations on trend from the Wildebeest-1 exploration well, which discovered 40° gravity oil in 2000.

The Sandakan basin has only 25 wells, and Wildebeest-1 is its only deepwater well.

Alaska North Slope

Brooks Range Petroleum Corp. spudded the Sak River-1 well in mid-March 2007 on the Central North Slope.

It is to be deviated northeasterly from an onshore ice pad to a true vertical depth of 11,500 ft subsea (13,100 ft measured depth) to test Kuparuk and Ivishak formation oil prospects that underlie Gwydyr Bay. If successful, it will be retained as a development well.

The Sak River-1 drillsite is at the end of a six-mile ice road extending north from the Prudhoe Bay Unit S Pad drillsite. The most recent exploration well in the area was drilled in 1997.

The joint venture, which controls 47,866 acres, is also drilling the North Shore Prospect and acquiring 3D seismic surveys to evaluate leads analogous to both prospects.

Chad basins

CNPC International (Chad) Ltd., a subsidiary of China National Petroleum Corp, took over EnCana Corp.'s holdings in Chad in early 2007 for $202.5 million (OGJ Online, Jan. 15, 2007).

EnCana said it had drilled 11 exploration wells with encouraging results on the holdings, which initially covered more than 108 million acres in seven basins: Lake Chad, Bongor, Logone-Birni, West Doba, Doseo, Salamat, and Erdis.

More than half the acreage is in the southwestern and southern parts of the country bordering Niger, Nigeria, Cameroon, and Central African Republic. The rest borders Libya and Sudan in northeastern Chad.

The deal represented EnCana's withdrawal from Africa. CNPC has a large and growing presence in Africa with participation in Algeria, Libya, Mauritania, Nigeria, Niger, Sudan, and Tunisia.

Chad's only oil production is the ExxonMobil-operated Chad-Cameroon project in the southwestern part of the country (OGJ Online, Aug. 7, 2006). ✦

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Editorial

Technology surge ahead

It is the business of energy forms not now much in use to await technological breakthrough. Hydrogen as a major contributor to energy supply awaits a breakthrough enabling the cheap decomposition of water or hydrocarbons. Ethanol awaits the cheap decomposition of cellulose. Oil shale has awaited the cheap decomposition of kerogen for years. While these breakthroughs might someday occur, their timing is uncertain. Around the world, governments are spending money to accelerate technological progress for uneconomic energy forms. They have no assurance of success.

More certain is an imminent surge of technological progress for energy forms already dominant in the supply mix. Drivers for new breakthroughs in oil and gas technology are in place. They include:

• Cost reduction. Many modern oil field methods, including horizontal drilling, multilateral completions, and sophisticated seismic imaging, came into widespread use as cost-cutting tools after the collapse of crude oil prices in the late 1980s. Nothing stimulates the development and adoption of technology like the need to cut costs, which oil and gas prices lingering at abysmal levels into the mid-1990s made extreme.

Although oil and gas prices are hardly abysmal now, costs are leaping. Increased activity is pushing demand for services and supplies against system capacity limits. In its Annual Energy Outlook 2007, the US Energy Information Administration reports, "While iron and steel prices increased by 72% from May 2002 to June 2006, onshore drilling costs increased by 100% and rental rates for offshore drilling rigs by 200% or more." Activity will abate in response; indeed, projects are being canceled and delayed. But cost pressures will stimulate technological development, as they did before.

• Access to opportunities. As the article on p. 18 reports, international oil and gas companies must adapt in profound ways to the new activism and financial strength of national oil companies. Companies work increasingly as nonoperating partners with state-owned counterparts as providers of technology and capital. More than ever, therefore, leadership with technology is crucial for access to international upstream opportunities. Companies that appropriately see technology as a vital dimension of competitive advantage will spend money to acquire it.

• Regulation. No let-up is in prospect in regulation of the environmental performance of the oil and gas industry and its products. In response to government fuel specifications, refiners have found ways to sustain gasoline octane without adding lead, to reduce the sulfur content of gasoline and diesel, to remove toxic substances from fuels, and to slash vehicle emissions of various air pollutants. Similarly, upstream operators have cut air and water pollution associated with their work while diminishing surface disturbance from drilling and production. Technology produced many of the industry's environmental gains, which can and must continue.

In some combination, technology and regulation also will answer concerns about greenhouse gases and climate change. Advances will be vital to future use not only of oil and gas but also of coal. Unless global economic development stalls for some reason, all three energy forms will be needed in growing amounts, along with nonfossil supplements. Real success in the moderation of greenhouse gas emissions depends on the extent to which regulation accommodates economic imperatives. It will result more from technological progress with all energy forms than from mandates about emission levels and consumption.

Technological breakthroughs with oil, gas, and coal will occur. They'll make fossil fuels cheaper to produce and cleaner to use. And they'll occur by building on past advances, sustained by the economic superiority of these fuels, in their major applications, relative to others.

Breakthroughs essential to hydrogen, ethanol, shale oil, and other energy forms requiring government subsidy might occur. Prudent investment by governments in this hope therefore makes sense. But "prudent" here means accommodating the risk that payoff in terms of commercial energy will be small, relative to total demand, or nonexistent within a reasonable investment period.

Altogether insensible would be policies that tried to retard progress for oil and gas to make way for nonfossil energy alternatives. Oil and gas advances won't cease. Doubters will find the next few years interesting. ✦

Part 1: Oil companies adjust as government roles expand

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In the energy industry, the world is not flat. Concentration of oil and gas resources in a handful of small, powerful, and resource-nationalistic governments and their respective national oil companies (NOCs) has created an uneven playing field for international oil companies (IOCs). The rules of the game are being challenged and altered in midcourse by NOCs at host-government direction. The changing competitive landscape will transform the role of traditional IOCs, completing a process that began 40 years ago with a shift in the balance of power favoring NOCs and resource holders.

Since 2003, high oil prices have provided NOCs the financing needed to pursue expansion at home and overseas. A class of NOCs that we call entrepreneurial NOCs (or commercial NOCs) has benefited particularly, moving aggressively overseas and in downstream activities. For traditional NOCs, such as Petroleos Mexicanos (Pemex) and Petroleos de Venezuela SA (PDVSA), high oil prices have provided governments a windfall for activities unrelated to oil but have not necessarily boosted oil investment.

NOC decisions about business and political strategies will affect oil and gas markets for years. NOC goals and priorities will differ from those of IOCs. In response, IOCs have sought to strengthen their ties with NOCs, but results are mixed.

Changing IOC roles

IOC access to equity oil and gas reserves decreased over the past 40 years, first due to nationalizations in the early 1970s and 1980s and then due to tougher exploration and development terms in the 1990s and 2000s. Currently, IOCs are finding it increasingly challenging to acquire new oil and

PRODUCTION AND RESERVES* BY COMPANY TYPE

Table 1

No.	Region	Country	E&P company	Gas, bcf Production	Gas, bcf Reserves	Oil, million bbl Production	Oil, million bbl Reserves
National oil companies (NOCs)							
1	Middle East	Saudi Arabia	Saudi Aramco	2,873	239,500	3,322	259,800
2	Middle East	Iran	NIOC	3,200	940,000	1,416	125,800
3	Middle East	Iraq	Iraq NOC	66	110,000	661	115,000
4	Middle East	Kuwait	KPC	347	55,000	886	99,000
5	Middle East	Abu Dhabi	ADNOC	1,649	198,000	748	92,200
6	South America	Venezuela	PDVSA	639	150,000	1,128	77,200
7	Africa	Libya	Libya NOC	258	52,000	599	39,000
8	Africa	Nigeria	NNPC	814	176,000	879	35,255
9	Middle East	Qatar	Qatar Petroleum	1,211	910,000	279	15,207
10	FSU	Russia	Gazprom	19,349	102,700	110	13,797
11	South Amierca	Mexico	Pemex	1,759	14,557	1,372	13,671
12	Asia-Pacific Rim	China	PetroChina	1,120	48,123	823	11,536
13	Asia-Pacific Rim	India	ONGC	811	21,035	193	4,120
14	Asia-Pacific Rim	China	CNOOC	155	5,431	127	1,457
Total NOCs				**34,250**	**3,022,846**	**12,542**	**903,044**
Entrepreneurial NOCs							
1	FSU	Russia	Lukoil	267	25,298	664	16,114
2	South America	Brazil	Petrobras	758	14,841	674	11,365
3	Asia-Pacific Rim	Malaysia	Petrobras	1,881	102,200	247	7,600
4	Europe	Norway	Statoil	953	15,939	256	1,761
Total entrepreneurial NOCs				**3,859**	**158,278**	**1,841**	**36,840**
International oil companies (IOCs)							
1	North America	US	Chevron	1,553	2,968	609	8,000
2	North America	US	ExxonMobil	2,819	33,355	782	7,813
3	Europe	UK	BP	3,880	48,238	984	7,591
4	Europe	France	Total	1,745	24,750	592	6,592
5	North America	US	ConocoPhillips	1,355	19,061	449	6,168
6	Europe	Netherlands	Shell	3,032	39,616	729	4,636
7	Europe	Italy	Eni	1,292	17,591	404	3,773
Total IOCs				**14,123**	**182,611**	**3,940**	**36,573**
Total NOCs, entrepreneurial NOCs, and IOCs				**52,231**	**3,363,735**	**18,323**	**976,457**
World, %				**53**	**55**	**70**	**76**

*Production for 2005; reserves as of Jan. 1, 2006.
Sources: OGJ, Sept. 4 and Dec. 18, 2006; IEA 2006 World Energy Outlook; SAIC analysis

gas reserves, and many of the promising worldwide basins for exploration and development are firmly under the control of NOCs. IOCs appear to be realigning their business strategies and may have to move away from their traditional role of full equity developers of oil and gas fields, to pursuing a variety of commercial arrangements with host countries and governments—from full equity interest to partial equity sharing and fee-for-services.

As their power and wealth grew, NOCs began to assert themselves in world energy markets, expanding their upstream as well as downstream footprints. Now, some NOCs are searching outside their home countries for equity oil and gas and are forming joint ventures and alliances with IOCs. NOCs need IOC technology and oil-field management expertise and are inviting IOCs to serve as contractors for field development—a role formerly filled by service companies. Recently, Gazprom rejected all partner and equity development bids from IOCs to develop giant Shtokman gas field off arctic Russia but apparently will bring in Statoil as a contractor.

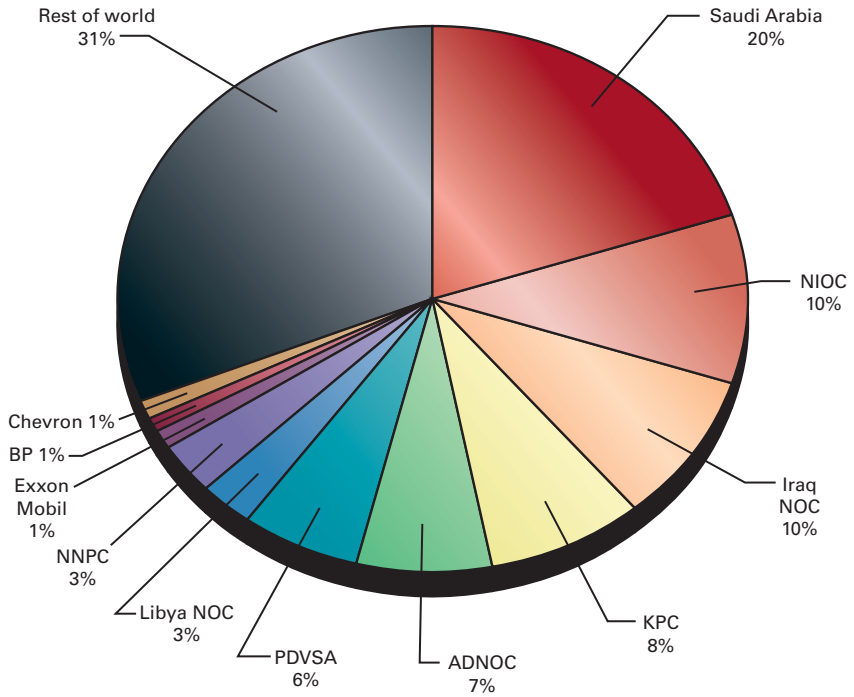
Shrinkage of equity oil and gas owned by IOCs is dramatic. In the 1960s, 85% of global oil and gas reserves was fully open to IOCs' equity participation, 14% was held by Soviet Russia, and the NOCs controlled less than 1%. This split has reversed, with the IOCs' full open access falling to around 16% while NOC access to reserves has increased to 65%. IOCs still have limited access to reserves in places such as Russia and China that were previously off-limits, but even this access might fall victim to resource-nationalistic energy policies.

For example, both Shell and BP have been pressured to reduce their equity stakes in Russian oil and gas fields, which will benefit Russian companies such as Lukoil and Gazprom. Shell recently gave up its operator status in Sakhalin-2 after it reduced its interest from 55% to 25%, selling its share to Gazprom.

The dramatic decrease in access to oil and gas reserves for IOCs has impaired their ability to replace reserves. Reserve replacement ratios (RRRs) for almost all IOCs were higher than 100% between 1990 and 2004. Expected RRRs for 2005-10 are less than 100% for IOCs. Despite record revenues due to high oil and gas prices, IOCs are finding it increasingly difficult to find potential high-yield prospects, given the commercial and political risk inherent in many countries. This trend suggests that even more equity reserves will become concentrated in NOCs.

THE WORLD'S TOP RESERVES HOLDERS

Fig. 1



Source: US Energy Information Administration's International Energy Annual, SAIC anylysis

Expanding NOC roles

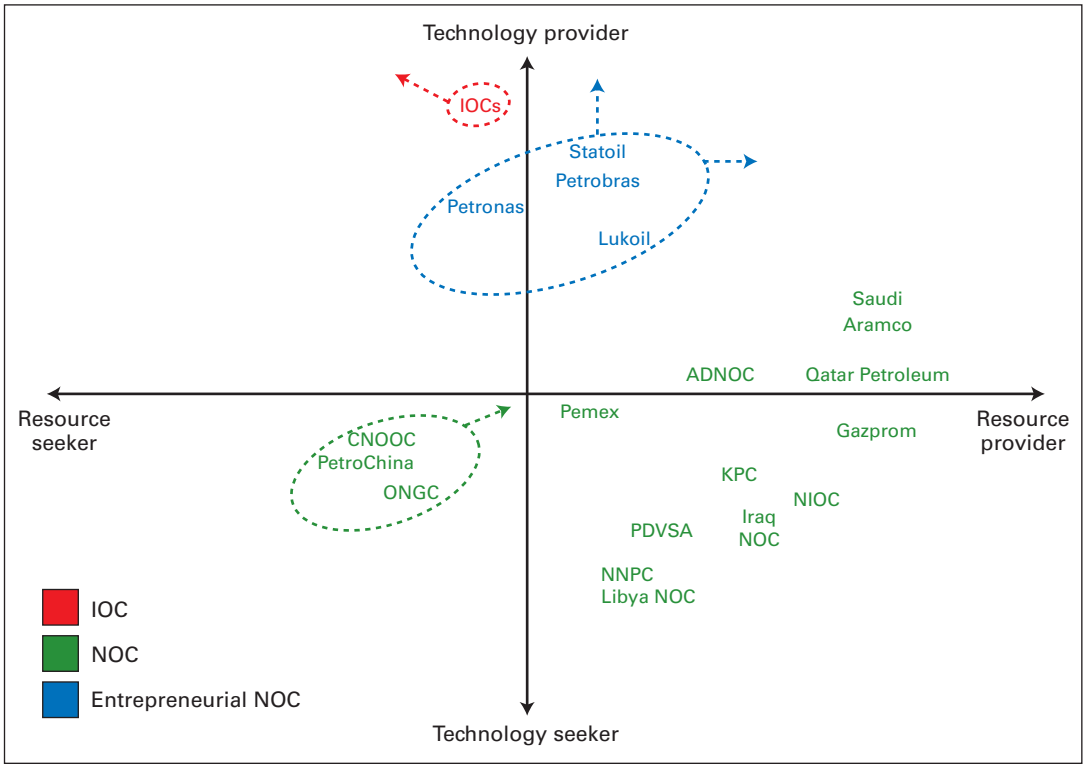
As the role of IOCs has changed, the NOCs have been busy transforming themselves from domestic, sovereign companies into global competitors. Asian and Russian NOCs are competing with IOCs for resources in Central Asia and Africa. Nationalizations are sweeping across South America. Political volatility in places such as Nigeria is making it difficult for IOCs to participate in equity development. Recent violence in the Niger Delta has dampened enthusiasm for several major oil and gas projects, including, for example, Brass LNG.

Today, over 100 NOCs control over three fourths of the world's oil reserves and production. Over half of the NOCs own reserves outside their home countries, and they are vigorously acquiring more. In regions readily available for full ownership by IOCs, such as the Arctic, the deep waters of the Gulf of Mexico, West Africa, the US, and Canada, NOCs are increasingly competitive. For example, Lukoil has entered downstream refining and retail operations in the US; PDVSA has been active in the US for many years through its Citgo subsidiary; and Petrobras is active in deepwater areas of the Gulf of Mexico.

A fading bright spot for IOCs is Russia, holder of 5% of the world's oil reserves and around 28% of gas

NOC, IOC RESOURCE AND TECHNOLOGY MAPPING

Fig. 2



Source: SAIC analysis

reserves. Privatization in the 1990s created opportunities for IOCs to actively participate in oil and gas development without restriction on equity participation. Recently, however, the Russian government has exerted greater control over resource development.

Unlike some NOCs, IOCs have no ability to influence oil prices and diminished ability to bring large new quantities of oil and gas to market. Fig. 1 shows that the world's top eight holders of oil reserves are NOCs. Saudi Aramco is by far the largest, with a 20% share. The largest IOCs, ExxonMobil, BP, and Chevron, each has less than 1%. The largest IOCs rank higher in terms of global production (Table 1).

The 25 companies in Table 1 hold over 70% of worldwide oil production and reserves and over 50% of worldwide gas production and reserves. In the classification scheme used here, "entrepreneurial NOCs" are those that have been partially privatized and are run like commercial entities, typically venturing abroad in search of equity oil and gas.

Strategies and priorities

This analysis classifies NOCs and IOCs according to their goals and strategic directions and priorities. NOCs' strategic priorities include optimization of resource development, revenue growth, supply security, and economic development. Many NOCs also have political priorities and are expected to execute government policies, which are sometimes in harmony and sometimes at odds with commercial strategies. Priorities for IOCs and entrepreneurial NOCs include increasing stockholder value, deploying technology, and expanding market access.

The classification scheme has four dimensions: resource, technology, finance, and markets. NOCs and IOCs can be either providers or seekers of resources and technology. They also can be either finance or market seekers, depending upon their cash flows, credit ratings, and market access. Here are the categories:

- *Resource providers—companies that possess reserves sufficient to meet in-country demand and serve as primary exporters of oil and gas.* These companies are generally national asset owners and usually are not actively involved in acquiring additional overseas reserves. Examples include big NOC oil exporters such as Saudi Aramco, National Iranian Oil Co. (NIOC), PDVSA, and Gazprom.
- *Resource seekers—companies with indigenous reserves insufficient to meet in-country demand that are active in domestic exploration and acquiring equity reserves overseas.* These companies are generally NOCs, such as Oil & Natural Gas Corp. of India, PetroChina, and China National Offshore Oil Corp. (CNOOC), whose mission is to find and develop reserves at home and overseas to secure supply. Resource seekers include IOCs, which must add reserves to maintain company value.
- *Technology providers—companies highly adept at technology development and deployment.* Companies in this category are willing and able to bring their technologies to the global exploration and production (E&P) marketplace. IOCs and entrepreneurial NOCs are becoming technology providers rather than equity developers. An example is Gazprom's overture to Statoil to develop Shtokman field to benefit from Statoil's expertise in operating in arctic offshore environments. Statoil will act as a prime contractor on the project rather than equity

Jostein Jaasund, Tenaris logistics manager in Norway, coordinates pipe and accessory deliveries for the offshore operations.

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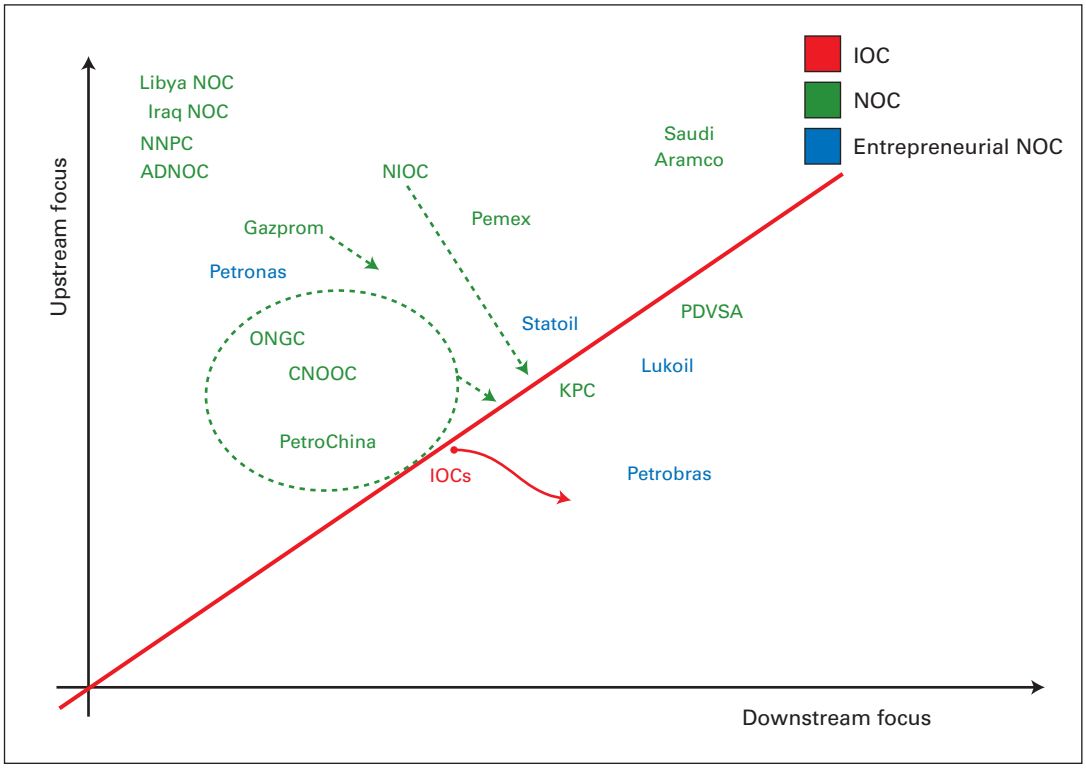
IOC, AND NOC FOCUS: UPSTREAM VS. DOWNSTREAM

Fig. 3



Source: SAIC analysis

partner. Other technology providers include IOCs ExxonMobil, Chevron, ConocoPhillips, Shell, BP, and Total and entrepreneurial NOCs such as Petronas and Petrobras.

- *Technology seekers—companies that are less adept with technology and need advanced technologies to explore and develop the resources they control.* Companies in this category generally are resource rich NOCs such as Nigerian National Petroleum Corp. (NNPC), NIOC, Kuwait Petroleum Corp. (KPC), PDVSA, and Gazprom.
- *Market seekers—companies that actively seek markets in which to sell indigenous or overseas equity oil and gas for maximum value.* IOCs routinely look for the best prices for oil and gas from their global operations and can be considered market seekers. Most large NOCs also are market seekers; however, some, such as NNPC and PetroChina, focus more on domestic markets.
- *Finance seekers—companies that have access to resources sufficient to meet in-country demand but that lack finances for exploration and development.* These companies generally have difficulty raising capital from international markets because they lack a transparent and creditworthy economic system. Large resource-provider NOCs such as Pemex, PDVSA, NNPC, and NIOC can be categorized as finance seekers.

Fig. 2 illustrates the classification scheme for selected NOCs and IOCs, providing general insights into the roles and relative attractiveness of companies in the global oil industry. The figure shows the location of companies on the technology and resource spectrum.

The competitively best-positioned companies are both resource providers and technology providers and appear in the top right quadrant. The worst-positioned companies are those in the bottom left quadrant, which seek both resources and technology. IOCs are very strong technology providers but also are resource seekers. Eight of the 14 NOCs are resource providers but are technologically challenged (bottom right quadrant). The entrepreneurial NOCs generally fare the best, being resource holders as well as technology providers.

NOCs and IOCs have mutual interest in marrying technology and resources. Despite this apparent alignment of interests, host-government national policies and politics often limit cooperation.

Arrows in Fig. 2 indicate the direction some of the NOCs, entrepreneurial NOCs, and IOCs are likely to take. IOCs will tend to move to the left, indicating their strong technology but continued weakening resource positions. Entrepreneurial NOCs will move higher to the top right quadrant, indicating greater technological expertise and their ability to access new resources. The bottom left quadrant companies probably will find it difficult to move out of their position but would work hard to move to the top right quadrant. For the time being, major NOCs will likely stay in the bottom right quadrant, obtaining technologies from IOCs and entrepreneurial IOCs. NOCs and IOCs will have to find innovative ways to cooperate to make this work.

Fig. 3 indicates the upstream and downstream focus of NOCs and IOCs. Companies next to the 45° line possess a relatively balanced portfolio of upstream and downstream assets. Most IOCs fall in this category. In addition, large resource-provider NOCs such as PDVSA also are well-balanced with respect to upstream

and downstream focus.

Most other NOCs—such as NNPC, Libya's National Oil Corp., Iraq National Oil Co., and Abu Dhabi National Oil Co. (ADNOC)—emphasize upstream operations, in some cases because other companies operate refineries. These NOCs and entrepreneurial NOCs may not change focus dramatically in the near term.

The potential upstream-downstream shift of IOCs, Asian NOCs, Gazprom, and NIOC is shown by arrows in Fig. 3. Most refinery capacity expansions will be in energy-hungry Asian economies—China and India—where IOCs may be able to bring their technologies to work when they collaborate with NOCs. In addition, NIOC may need to expand refinery capacity in order to meet Iran's growing demand for petroleum. Gazprom is gearing up for more downstream activity as well.

Strategic focus

Among the many strategic thrusts of NOCs and IOCs, four will be highlighted here: natural gas projects (including LNG and GTL), deepwater E&P, oil sands and heavy oil, and global refining.

Gas projects

With Europe, North America, and Asia facing natural gas shortages and with gas demand expected to grow, most IOCs and NOCs are investing in future supply and LNG infrastructure.

Crucial to meeting global gas demand is the Middle East, which can serve Asian, European, and North American markets and where NOCs are taking the lead. Qatar Petroleum soon will be the world's largest LNG exporter, tripling its LNG capacity to 77 million tonnes/year (tpy) by 2010. NIOC recently signed a 25-year deal with GAIL (India) Ltd. for delivery of LNG and is in discussions with CNOOC and others to develop giant North Pars gas field off Iran. LNG export terminals also are under development in Yemen and Oman. Most major IOCs have investments in Middle East LNG terminals and are acting as technology providers.

West Africa is another area of major gas development where NOCs are taking the lead using IOC technology. Almost 30 million tpy of LNG export capacity is under development in Nigeria, Equatorial Guinea, and Angola. In West Africa, IOCs generally have negotiated favorable production-sharing agreements with NOCs and are acting as technology providers and resource holders.

Europe receives gas from the Middle

East, North Africa, the North Sea, and Russia. Gas supplies from North Africa and the Middle East are predominantly NOC-owned, while supplies from the North Sea are predominantly from IOCs. Russia's Gazprom recently has been seeking to capture value for its exports by raising prices to former Soviet republics toward parity with European gas prices.

The International Energy Agency reports that by 2010 around 167 million tpy of gas liquefaction capacity is planned, representing close to $73 billion of investment. If "proposed" terminals are considered, the worldwide investment in liquefaction capacity can reach close to $100 billion by 2010. Nearly half of the planned capacity will occur in the Middle East and North Africa. Most of the planned LNG is destined for Asia, Europe, and North America.

IOCs and NOCs have dedicated a small portion of their investment to gas-to-liquids technology. Shell and Chevron have a plant each, and Chevron teamed with Sasol for a GTL plant in Qatar that came online in 2006. Chevron also is working with NNPC on a 34,000 b/d GTL plant in Nigeria.

Two other GTL plants are in advanced planning stages and can be operational by 2010. One is a Shell joint venture with Qatar Petroleum for the Qatar GTL Pearl 1 plant. The other is Sonatrach's GTL plant in Tinhert, Algeria.

Estimated costs for GTL plants have leaped to $84,000 per b/d of capacity from $20,000-30,000 per b/d a few years ago. Increasing costs have resulted in ExxonMobil's pulling out of its Qatari GTL project. Others may follow due to increased costs of the technology.

Deepwater E&P

In deep water, IOCs enjoy a strong technological advantage and are expected to quadruple spending over the next several years. Deepwater prospects are in some of the few regions where IOCs can operate relatively unhindered by NOC terms and conditions and can obtain full equity participation. In addition, deepwater prospects offer hope for the large discoveries that IOCs need to replace production.

The term "deep water" generally means more than 1,000 ft. The Gulf of Mexico, where water-depth records are continually broken, is the focus of future deepwater activity. Deepwater production in the gulf has shown average growth rates of over 16%/year since 1985 for oil and over 20%/year for natural gas. In 2006, the deepwater gulf produced 293 million bbl of oil and almost 1 tcf of gas—72% of the gulf's oil production and 40% of its gas.

Other areas of deepwater development include the Norwegian and UK North Sea and offshore Brazil, West Africa, and Australia.

IOCs lead in deepwater investments. Chevron is involved in some of the world's most challenging deepwater projects. Its Jack 2 well on Walker Ridge Block 758 in the Gulf of Mexico is in 7,000 ft of water. Three of its five biggest projects under development are in deep water: the Tahiti project on Gulf of Mexico Green Canyon Block 640; the Benguela Belize-Lobito Tomboco (BBLT) project off Angola; and the Agbami project off Nigeria, where Chevron is collaborating with Statoil, Petrobras, and NNPC. Shell is active in Nigeria's Bonga field in the Niger Delta in water more than 3,000 ft deep. Companies such as BHP, Eni, and Total also are active in deep water, as are large independent producers such as Anadarko Petroleum, especially in the Gulf of Mexico.

Petrobras is by far the dominant NOC involved in deepwater activities, mostly off Brazil but also in the Gulf of Mexico and off West Africa. Petrobras is working in four deepwater areas of the Gulf of Mexico, where it plans to spend close to $1.5 billion by 2011. A key area is the ultradeepwater Desoto Canyon region, where Petrobras is applying technologies developed off Brazil, including floating production, storage, and offloading (FPSO) systems.

Nonconventional oil

Most oil sands and heavy oil projects are in Canada and Venezuela. Of 10 such projects to be completed by 2010, eight are oil sands projects in Canada, and two are heavy oil projects in Venezuela.

These capital-intensive projects are well-suited to IOC participation. IEA estimates the cost of a Canadian oil-sands mining operation at $45,000-60,000 b/d of capacity, with in situ projects about half that.

ConocoPhillips has teamed with Canadian independent EnCana to develop oil sands in the Foster Creek, Christina Lake, and Borealis projects. ConocoPhillips also is involved with Syncrude's third phase at Fort McMurray, Alta., where an upgrader expansion will boost capacity from 2005 levels by 50%. Shell expects to increase production in the Athabasca region to 500,000 b/d from 155,000 b/d by 2010.

In eastern Venezuela, PDVSA estimates that over 235 billion bbl of oil reserves exist in the Orinoco heavy oil belt.

A key to full realization of the potential of these nonconventional resources will be technology and, more precisely, how to improve recovery rates at acceptable costs. This is a role IOCs can fill. An issue of heavy oil and bitumen development in Venezuela will be the extent to which nationalist policies deter IOC participation.

Global refining

With worldwide spare refining capacity rapidly diminishing, new capacity will be critical as demand grows for oil products and the crude slate becomes increasingly heavy and sour.

Low and uncertain refining returns discouraged IOCs from investing in capacity expansion until recently. The average refinery margin worldwide has improved to over $8/bbl in recent years, high enough to encourage investment. IEA expects average refinery spending to increase to $300 billion/year in the next 5 years from $215

billion/year in the last 5 years. Most greenfield investment will be in China, India, and the Middle East.

In partnership with international companies with specific expertise, Saudi Aramco is exploring the possibility of building two grassroots export refineries in Saudi Arabia. It has signed an agreement with Sumitomo Chemical Co. of Japan to transform its Rabigh refinery through joint venture PetroRabigh into a fully integrated petrochemical complex. And it is exploring plans to develop joint-venture petrochemical complexes integrated with the Ras Tanura and Yanbu refineries.

In Kuwait, KPC plans to spend over $5 billion through 2010 to upgrade its refining industry and to increase capacity to process its heavy and sour crude. Outside Kuwait, KPC's strategy is to expand refining and marketing outlets in high-growth areas, especially in China and India, through downstream joint ventures with NOCs as well as IOCs such as Shell and BP.

PetroChina also has invested heavily in refinery upgrades and expansions while reducing capacity through selected plant and facility closures. It is trying to better match product yields to the Chinese market.

Entrepreneurial NOC Lukoil plans to upgrade refineries to produce high-quality products matching Euro-3 and Euro-4 standards. Eni is investing in conversion capacity to raise its refining system's yields of middle distillates and to achieve greater vertical integration with its E&P activities.

In the US, Chevron is expanding its Pascagoula refinery and plans to increase capacity for gasoline production by 15% by 2008. ConocoPhillips expects to invest $4-5 billion over the next several years at 9 of its 12 US refineries, increasing its output of clean fuels by 15%. This increase is the equivalent of adding a world-scale refinery.

Elsewhere, ConocoPhillips last year acquired the 275,000 b/d Wilhelmshaven, Germany, refinery and among other things, plans investments to increase the facility's ability process heavy crudes such as Russian export blends.

Acknowledgment

The authors prepared this article for information and discussion purposes only. The authors' views and opinions do not necessarily state or reflect those of SAIC. ✦

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CSB's final report cites 'broken safety culture' at BP

Paula Dittrick
Senior Staff Writer

BP PLC had a "broken safety culture" at the time of the Mar. 23, 2005, fire and explosion at its 460,000 b/d Texas City, Tex., refinery that killed 15 people and injured 180 others, the US Chemical Safety Board (CSB) said at a news conference Mar. 20 outlining details of its final report.

The CSB board voted 5-0 late on Mar. 20 to approve the final report at a public meeting in Texas City. BP issued a statement saying it was in disagreement with parts of the report, but it did not elaborate.

CSB said many safety issues that led to the accident were recurring safety problems previously identified in BP internal audits, reports, and investigations. BP acquired the refinery when it merged with Amoco Corp. in 1999.

The report found that "cost-cutting in the 1990s by Amoco and then BP left the Texas City refinery vulnerable to a catastrophe." Over a 30-year period spanning the refinery's ownership by Amoco and BP, 23 workers died there, not counting the 15 workers killed in March 2005, CSB said.

"Among other things, cost considerations discouraged refinery officials from replacing the blowdown drum with a flare system, which the CSB previously determined would have prevented or greatly minimized the severity of the accident," CSB investigators said. The explosion involved a C5-C6 isomerization unit with "antiquated equipment," they said.

Hydrocarbons originated from liquid overflow from an F-20 blowdown drum, BP Products North America Inc. has said in its incident investigation report that was released on Dec. 9, 2005. The fire and explosion occurred on the isom unit and involved the raffinate splitter and blowdown drum (OGJ, Jan. 23, 2006, p. 51). Flammable liquid hydrocarbons vented directly

into the atmosphere.

"A geyser-like release of highly flammable liquid and vapor" was emitted, and a diesel pickup truck idling nearby ignited the vapor, causing the explosion and fire that resulted in fatalities and injuries in and around work trailers placed "too close" to the isom unit, the CSB report said.

CSB investigator Mark Kasniak developed a vapor and blast model. He calculates 7,600 gal of flammable liquid hydrocarbons was released in less than 2 min. Carolyn W. Merritt, CSB chairwoman and chief executive officer, called the explosion avoidable, saying it was "the inevitable result of a series of actions" by BP executives and its corporate board.

"Among other things, they cut costs that affected maintenance and safety [and] they ignored the implications of previous incidents that were red warning flags," Merritt said. "There was a broken safety culture at BP. The company has, since the accident, taken steps to improve process safety and to change their safety culture."

CSB concluded the Texas City refinery accident stemmed from organizational and safety deficiencies at all levels of BP.

"The boards of directors of oil and chemical companies should examine every detail of their process safety programs to ensure that another terrible tragedy like the one at BP does not occur," Merritt said. She advocates "a new standard of care for corporate boards of directors and CEOs throughout the world."

Process safety programs deserve the same level of attention, investment, and scrutiny as companies now dedicate to maintaining their financial controls, she said. Fielding questions from reporters about industry's reports of improved safety at refineries, Merritt said BP measured its safety record by the number of injuries to individuals at plants. This involves personal safety like slips, falls, and vehicle accidents. Industry needs to better measure risk factors to facilities, she said.

CSB recommends the Occupational Safety and Health Administration increase its petrochemical inspections and enforce safety regulations at refineries and chemical plants.

OSHA inspections

OSHA conducted only one planned Process Safety Management (PSM) inspection at the Texas City refinery in 1998 even though the refinery experienced fatal accidents from 1985 to 2005, said CSB supervisory investigator Don Holmstrom.

"OSHA's national focus is on inspecting facilities with high injury rates. While that is important, it has resulted in reduced attention to preventing less-frequent but catastrophic process safety incidents such as the one at Texas City," Holmstrom said. "Available evidence indicates that OSHA has an insufficient number of qualified inspectors to enforce the PSM standard at oil and chemical facilities," he said.

The report calls on OSHA to identify plants at the greatest risk of a catastrophic accident and then to conduct comprehensive inspections at those plants. It also recommends that OSHA hire or train new, specialized inspectors and expand its national PSM training curriculum. CSB concluded that existing rules likely could have prevented the Texas City accident.

"But if a company is not following those rules, year-in and year-out, it is ultimately the responsibility of the federal government to enforce good safety practices before more lives are lost," Merritt said. "These facilities simply have too many potentially catastrophic hazards to be overlooked."

CSB is an independent federal agency that investigates industrial chemical accidents, including the root causes of the accident such as equipment failure as well as regulations. It does not issue citations or fines but makes safety recommendations to plants, industry organizations, labor groups, and regulatory agencies.

The report recommends BP appoint an additional board member having expertise in process safety, and it also calls for BP senior executives to establish an improved incident reporting program and to use new indicators to measure safety performance.

An independent panel commissioned by BP and led by former US Sec. of State James A. Baker III raised similar issues that the industry needs to address, Holmstrom and Merritt said.

The CSB team recommends that the American Petroleum Institute and the United Steelworkers International Union work together to develop standards to prevent employee fatigue in the oil and chemical industry. API officials said US refiners already are applying lessons learned from the Texas City refinery (See related story, p. 27).

Investigators said a valve allowing liquid to drain into storage tanks was left closed for over 3 hr during the isom unit startup on Mar. 23, contrary to unit start-up procedures. CSB concluded that human factors, including fatigue, led to this error.

"By Mar. 23, operators had been working 12-hr shifts for 29 or more consecutive days," CSB investigators said, adding "There are no fatigue-prevention guidelines that are widely used and accepted in the oil and chemical sector." The transportation industry has such regulations.

Earlier incidents

The report said BP had failed to investigate previous abnormal isom unit start-ups, and that a Mar. 23 decision by a control board operator to keep the drain valve closed was influenced by ineffective communication and by false instrument readings.

The normal liquid level in the tower was 6 ½ ft, but the level on Mar. 23 reached 158 ft shortly before the accident. This was unknown to operators. The CSB determined the level transmitter was miscalibrated, using a setting from outdated data sheets that likely had not been updated since 1975. CSB citied "lack of effective preventive maintenance, lack of change reviews and pre-startup reviews, and incomplete hazard analyses."

The refinery only investigated three of eight known previous isom blowdown release incidents where vapor was released from the same blowdown drum involved in the Mar. 23 accident. In 2004 an internal BP audit graded the refinery's analysis of incident information as "poor," CSB said.

CSB also determined that both the blowdown drum and relief-valve disposal piping were undersized. BP was required by federal regulations to conduct a study of the tower's pressure relief system but this study was 13 years overdue by 2005.

The refinery had longstanding process safety deficiencies, Merritt said, but she believes BP and industry in general are learning from this. She said she is confident that chemical and oil industry workplaces will be safer in the future as a result of the CSB recommendations.

BP response

BP said it voluntarily provided CSB more than 6 million pages of documents and made over 300 witnesses available for CSB interviews, including some of its most senior executives.

"Notwithstanding the company's strong disagreement with some of the content of the CSB report, particularly many of the findings and conclusions, BP will give full and careful consideration to CSB's recommendations, in conjunction with the many activities already under way to improve process safety management," the company said in a statement.

BP described itself as "willing and able to achieve the goal of becoming an industry leader in process safety management."

In the 2 years since the accident, BP said it has worked to address the causes of the explosion and to reduce risk and improve process safety management and performance at its five US refineries.

"This effort continues. BP is committed to preventing such a tragedy from occurring again," the company said. ✦

API prepares standards after Texas City plant accident

Nick Snow
Washington Correspondent

US refiners are applying lessons learned from the Mar. 23, 2005, fire and explosion at BP America Inc.'s Texas City, Tex., refinery to improving existing operating practices and standards and developing at least one new recommended procedure, American Petro-

leum Institute officials said Mar. 16.

Their statements to reporters came in a teleconference days before the US Chemical Safety Board's scheduled Mar. 20 release of its final report on the causes of the fire and explosion that killed 15 people and injured another 180. The US House Education and Labor Committee also scheduled a hearing on Mar. 22 to examine the accident and its worker safety implications.

CSB said many of the victims were in and around trailers near an atmosphere ventilation stack, which experienced a geyser-like release after a distillation tower was flooded with highly flammable liquid hydrocarbons. The procedure that API is developing will deal with where trailers and other temporary structures should be located at refineries, said Ron Chittum, API senior refining associate.

"The thrust of the document that's being considered is for companies to consider multiple issues, run a risk analysis, and consider blast and dispersion potential. There's another alternative under consideration where it would be possible to determine, very simplistically, where to site a trailer based on your unit's configuration without going through such an extensive analysis. This is all subject to the committee approval process," he said.

Chittum said the report of an independent panel, commissioned by BP and led by former US Sec. of State James A. Baker III, raised issues that the industry will need to address. He expects CSB's final evaluation will do the same. "Whether these will become recommendations to [the US Occupational Safety and Health Administration] for new regulations will be determined later, and the industry will certainly want to participate in their formulation," he said.

Concern with Congress

In the meantime, said Bob Greco, API's downstream director, the trade association is concerned that Congress might take actions that don't look at the best available data involving refinery configurations and layouts. "We will learn from the Texas City incident and make appropriate changes to our existing suite of standards and practices," Greco said. "Beyond that, we will work with Congress and regulatory agencies. But we also want to educate Congress about the robust nature of our industry standards."

Chittum said pressure-release systems such as the blowdown drum which exploded at BP's refinery are safety devices designed to deal with unplanned pressure buildups. "We think there are situations in a refinery that use of a blowdown drum may be the right approach, and eliminating them in favor of a pipe flaring system may be inappropriate," he said.

Chittum said API does not know how many blowdown drums are still being used at US refineries, but said API has formed a taskforce to address this and other recommendations already made by CSB.

"Companies already are using the Baker report as a mirror against their internal procedures and identifying gaps that need to be filled," Chittum said. "The industry also has set up a multiassociation coalition of experts to discuss what was learned from the Texas City incident, but it's still fairly early." he said.

Greco said US refining is one of the nation's most heavily regulated industries with extensive, and sometimes overlapping, regulations from the Environmental Protection Agency, Department of Transportation, OSHA, and other federal agencies. API has its own standards and practices program on top of that, including 150 recommended procedures dealing with process safety management, he continued.

New safety guidelines

"We are aware that OSHA is planning to roll out a national emphasis program," Chittum said. "Our understanding is that part of that will be increased enforcements and visits to refineries. Obviously, there will be more OSHA inspectors knocking on the door and going through records in detail to make sure everything is being done right. Our members expect that, and will work with them," he said.

Meanwhile, the American Institute of Chemical Engineers' Center for Chemical Process Safety said that it is preparing to issue new safety guidelines later this month to help refinery and chemical plant operators avoid accidents such as the Texas City refinery accident.

The new guidelines will be contained in a book, Guidelines for Risk Based Process Safety, and will address many of CSB's findings as well as BP's internal and independent investigations, CCPS Director Scott Berger said in New York on Mar. 16.

The group was working on the new guidelines before the BP refinery incident occurred with the intention of capturing experience gained during the last 15 years of process safety management, he indicated. "The high degree of openness in the BP, Baker, and CSB investigations enabled CCPS to also incorporate the lessons learned in Texas City as the guideline project progressed," Berger said. ✦

GAO recommends fuller studies of LNG spill impacts

Nick Snow
Washington Correspondent

Government policymakers seeking to determine where new LNG terminals are to be located and how existing facilities and tankers can be protected need additional studies conducted examining potential problems resulting from large LNG spills, said the Government Ac-

countability Office in a new report.

Although past studies have developed modeling assumptions based on small-scale spill data, there have been no large-scale LNG spills or spill experiments, GAO reported. "While there is general agreement on the types of effects from an LNG spill, the results of these models have created what appears to be conflicting assessments of the specific consequences of an LNG spill, creating uncertainties for regulators and the public," the report said.

It said the US Dept. of Energy has funded a study to address large-scale LNG fires, but added that it will address only 3 of the 10 top issues that a panel of GAO-assembled experts identified as potentially affecting public safety. The planned DOE study currently does not plan to address cascading failure of LNG tanks, which its experts ranked second most important after large fire phenomena, GAO said.

For its year-long analysis, the congressional watchdog service assembled 19 LNG experts to discuss potential consequences of a terrorist attack on an LNG tanker. It described the results of 6 unclassified studies of the consequences of an LNG spill that contained new, original research (either experimental or modeling) and clearly described the methodology used. It also interviewed US agencies responsible for LNG regulations and visited all four US onshore LNG import terminals and one export facility.

GAO said the 19 experts agreed that the most likely public safety impact from an LNG spill would be heat from a fire, that explosions are not likely to occur in the wake of a spill unless LNG vapors are in confined spaces, and that some hazards, such as freeze burns and asphyxiation, do not threaten the public.

The experts disagreed with heat impact and cascading tank failure conclusions in a Sandia National Laboratories study the US Coast Guard uses to prepare waterway suitability assessments for applications to construct LNG terminals. Specifically, several of the experts disagreed with the 1,600-m heat impact distance estimate in the Sandia study, and the conclusion that only three of five tanks on an LNG vessel would be involved in a cascading failure.

Urges broader study

To provide the most comprehensive information for assessing public safety risks of LNG tankers traveling to proposed facilities, GAO recommended that the US Energy Secretary ensure that the 10 key issues identified by GAO's panel of experts be incorporated into DOE's study, particularly the potential for cascading failure of LNG tanks, in order to better understand potential damage to the vessel's hull from extreme cold or heat. DOE officials have agreed with the recommendation, GAO said.

The leadership and members of the House Energy and Commerce Committee who requested the GAO report said its release on Mar. 14 coincides with a projected 400% increase in LNG imports over the next 10 years at a time when energy companies have submitted 32 applications to build new terminals in 10 states and at 5 offshore sites. The terminals are regulated onshore by the Federal Energy Regulatory Commission and offshore by the Coast Guard.

Chairman John D. Dingell (D-Mich.) and Ranking Minority Member Joe Barton (R-Tex.) said that the committee would hold hearings on LNG tanker and terminal security and licensing. "In a post 9/11 era, we need answers about the safest way to handle LNG in light of the fact that it is slated to fill 17% of US gas requirements over the next decade," Dingell said. He indicated that in the hearings the committee would review the planned DOE study to ensure that it is conducting the necessary research

WATCHING THE WORLD

Eric Watkins, Senior Correspondent

Indonesian gas figures wobble

Indonesian gas is a hot topic, judging by the number of e-mails crowding my inbox these days. I'm either skewered by sharp-eyed readers over dubious figures or offered contracts to advise on lucrative developments.

Let's get something straight: As a journalist I hear lots of things that sound dubious, and many of them these days come from Indonesian officials talking about their country's gas industry. In a word, we're talking politics now—and economics.

Indonesia has a falling output of oil and imports crude to meet rising domestic demand. We all know what that means: When the price of crude goes up, the government has to pay more to finance the subsidy for the domestic market.

But someone has to do something and do it fast. For many Indonesians, the ministry of oil and gas represents the cavalry—always just over the horizon and ever ready to come to the rescue. And ministry officials have been more than ready to come to the rescue—at least with words.

No explanation

For example, Luluk Sumiarso, director general for oil and gas at the ministry of energy and mineral resources, said Indonesia—despite announcing a shortfall of 300 MMcfd—has sufficient reserves of gas to meet domestic needs as well as export contracts.

Reserves maybe, but Luluk did not explain how Indonesia would actually meet the projected shortfall, and such a lack of official explanation, along with wobbly figures, is driving the world nuts.

Japanese buyers, along with others in Taiwan and South Korea, are among the most exasperated, having contracted for supplies only to be told their contracts are not going to be honored. Singapore and Malaysia also have been told they cannot have any more gas after their current contracts expire.

The wobble rises

But domestic firms also have difficulty. Last week, Indonesia's Upstream Oil and Gas Regulatory Body (BP Migas) threatened to review the special right granted to PT Bakrie & Bros. over a project to build a gas pipeline between East Kalimantan and Central Java if the company fails to start construction by July.

Yet back in January, the same government—after granting B&B the pipeline rights—cast doubts on the feasibility of the project. Vice-President Jusuf Kalla said the project might not be necessary as Java has enough gas reserves to feed itself after a large gas discovery on the Cepu Block in East Java.

Luluk and Jusuf are not alone. The official wobble goes straight to the top.

In January, President Susilo Bambang Yudhoyono told a conference on gas that, "With our new gas policy, and with the increase of new gas production resulting from new contracts, new investments, and new exploration, we can meet the dual objectives of fulfilling the rising domestic needs while supplying the export market."

Certainly there's gas in Indonesia—and not all of it in the ground. ✦

to make sound siting decisions and to examine the positive and negative aspects of locating terminals onshore and offshore.

Barton cited the strong safety record of LNG shipments, noting that more than 40,000 tankers have delivered the fuel over 47 years without a major spill. "In the unlikely event of an LNG tanker fire, most experts surveyed by GAO agree that the protection zones already required for LNG tankers will do the job of protecting the public. That's good news, but given the long history of safety, it's also what we expected. GAO's recommendation for further research is only prudent, however, and I'm confident that FERC will continue to apply the latest science to support its licensing decisions," he said.

Edward J. Markey (D-Mass.), a committee member whose district includes the nation's only urban import terminal for LNG, said that GAO's findings show that further studies clearly are needed, and that DOE needs to expand its current examination immediately to examine all the safety issues GAO's assembled experts identified.

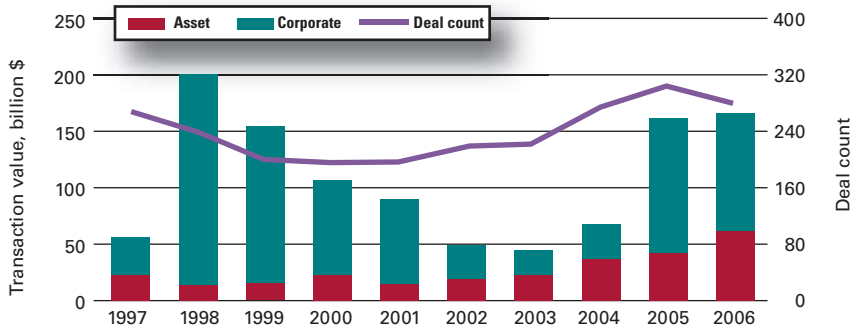
Bart Stupak (D-Mich.), who chairs the committee's Oversight and Investigations Subcommittee, said it plans to examine national security implications of the energy supply system because it is concerned about how the government can best assure that LNG is delivered safely and efficiently, given increasing US reliance on it. ✦

Company sales dominate 2006 global upstream mergers, acquisitions

Paula Dittrick
Senior Staff Writer

Worldwide transaction values for upstream corporate and asset deals totaled more than $166 billion last year compared with more than $160 billion during 2005, consultants said

WORLD UPSTREAM TRANSACTION VALUE



Source: John S. Herold Inc. and Harrison Lovegrove & Co. Ltd.

in an annual report.

John S. Herold Inc. and Harrison Lovegrove & Co. Ltd. on Mar. 15 released highlights of their joint 2007 Global Upstream Mergers and Acquisitions Review.

Total expenditures on corporate transactions last year topped $100 billion, down from more than $120 billion in 2005. Total expenditures for asset deals increased for the fifth consecutive year, soaring 55% to more than $60 billion. The review analyzed more than 280 upstream transactions.

Arthur Smith, John S. Herold chairman and chief executive officer, and Martin Lovegrove, Harrison Lovegrove chief executive, noted this year "could be a frustrating year from the industry" because rising service costs are apt to constrain earnings and cash flow. Meanwhile, oil and gas futures prices appear are to be trending lower than last year.

"Early signs are that assets continue to come to the market in abundance," the executives said. "But should commodity prices stay around existing levels, it is almost certain that deal prices will fall against those seen last year. Some sales will also likely be withdrawn as buyers fail to offer prices that match the expectations of sellers. Indeed, we have already started to see this feature developing."

Falling commodity prices hampered deal activity starting during the second half of 2006, the review said.

Reserves values up

Worldwide proved reserves pricing was up 34% to $12.86/boe during 2006. In the US and Canada, proved reserves pricing was up nearly 20% to $17.89/boe. Worldwide pricing for proved plus probable reserves also hit records, jumping threefold to $5.51/boe.

Although values were higher, the volume of proved reserves bought and sold fell for the second consecutive year. Natural gas accounted for 53% of the total proved reserves involved in 2006 transactions, a 10-year high, the review said.

The two largest corporate transactions in 2006 and four of the top five asset deals were predominantly weighted towards gas, the review said.

The biggest corporate transaction was the $30 billion merger of Norway's Statoil ASA and Norsk Hydro ASA's oil and gas operations, creating the world's largest offshore operator (OGJ, Jan. 1, 2007, p. 29). The largest asset deal was OAO Gazprom's takeover of a majority stake in Sakhalin Energy Investment Co. Ltd. (OGJ, Jan. 1, 2007, p. 29).

Buyers

Africa experienced a breakout year, having four transactions worth more than $1 billion each. That compared with only two such deals during the previous 4 years. Transactions in the US and Canada accounted for more than 55% of total 2006 global transaction value.

Christopher Sheehan, John S. Herold director of M&A research, told OGJ that he expects West Africa, Canadian oil sands, and US unconventional gas plays to be hot spots during 2007. The deepwater Gulf of Mexico also is of keen interest, Sheehan said. Of the 10 largest

US transactions last year, five of them were in the Gulf of Mexico with three of those involving deep water.

National oil companies (NOCs) accounted for a record one third of global upstream M&A spending in 2006. Sheehan expects NOCs will remain active buyers in 2007.✦

Russian oil service outlays to double, analyst says

Expenditures for drilling, seismic surveying, and workover programs in Russia amounted to $11.4 billion in 2006 and is forecast to rise to $22.5 billion by 2011, according to a recent study from energy analyst Douglas-Westwood Ltd.

Just in Eastern Siberia, the growth in expenditures is set to soar at a 43% compound annual growth rate over the next 5 years, according to the study, entitled "Russian Oil Field Services Market Report 2007-11." The report is based on data collated from interviews with key industry entities, including Russian oil companies and indigenous and foreign oil field service contractors.

The report further suggests, however, that the main volume of activity will continue to occur in Western Siberia.

"Western Siberia currently accounts for 70% of overall expenditure, but with significant growth in other areas, this will fall to 51% by 2011," said analyst Rod Westwood.

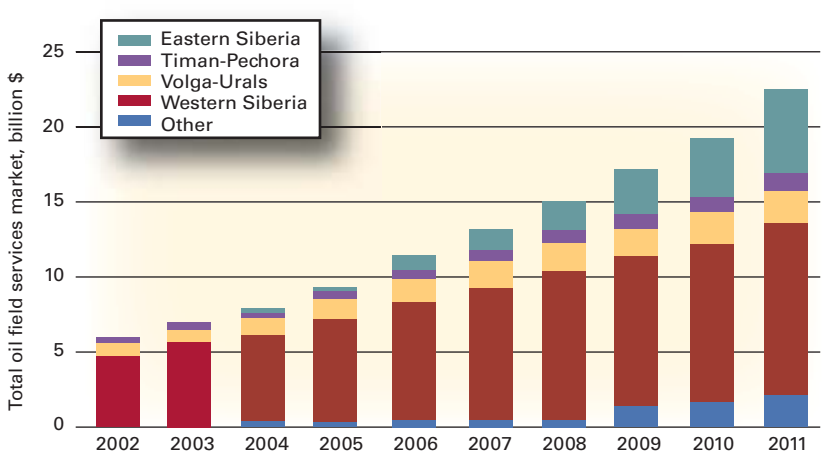
Attributing to this particular region's expenditure outlook is an increased focus on reservoir management and enhanced oil recovery, both in terms of oil field services and major equipment items such as rigs and electrical submersible pumps (ESPs), Westwood said.

"Russia is the world's largest ESP market and our research shows that over 70,000 units are currently active. Many of the country's aging rigs, which have suffered from years of underinvestment, are also due to be replaced, leading to major projected growth in newbuild rig expenditure," he said.

Douglas-Westwood Director Andrew Reid said, "The oil field services industry within Russia has evolved rapidly in recent years, driven by the liberalization of the market and a move to western business models as E&P players have moved to outsource their servicing to specialist contractors in an attempt to further improve their operational efficiency."

The report confirms that Russian E&P companies have been divesting their inhouse oil service capability through disposals, enabling access by third-party providers, and allowing E&P companies to focus on reserves growth and production. ✦

Russian oil field services expenditures trend



Source: Douglas-Westwood Ltd.

Exploration spreads into numerous remote and nonproducing basins

Alan Petzet
Chief Editor-Exploration

Remote and nonproducing basins and areas are pulling in a small but important share of exploration expenditures worldwide.

Almost every continent has examples of seismic surveys, exploratory drilling, or other exploration methods being used in risky attempts at establishing the presence of commercial volumes of hydrocarbons.

The 2007 activity follows the announcement of several important oil and gas discoveries made in remote areas in 2006.

This article contains examples of the activity and various operators' plans for 2007 and beyond.

Africa's status

Exploration in several of East Africa's remote basins almost rivals the excitement that surrounds the burgeoning oil production off West Africa.

Uganda's Albert graben seems primed for eventual commercial production after 2005-06's discoveries near Lake Albert, and explorers have taken up acreage on the Congo (former Zaire) side of the lake.

Heritage Oil Corp., London, said its Kingfisher discovery could reveal the Albert graben to be a world class petroleum basin.

Tony Buckingham, Heritage CEO, said, "All five wells drilled in the Albert basin in the last 15 months have been oil discoveries, which we consider exceptional for a virgin onshore hydrocarbon basin, and Kingfisher is the second well that has produced over 12,000 b/d of oil under test."

The other is Tullow Oil PLC's Waraga-1 well on Block 2. The other discoveries are Mputa-1, Mputa-2, and Nzizi-1 (not tested).

Heritage was seeking a larger rig in early March 2007 to explore deeper formations beneath its Kingfisher discovery. Kingfisher-1A on Block 3A flowed at combined rates of 13,893 b/d of 30-32° gravity oil from a total of 54 m of perforations 1,783-2,344 m (Table 1).

The Kingfisher reservoirs are sandstones of Tertiary age with perme-

FLOW RATES AT UGANDA'S KINGFISHER DISCOVERY

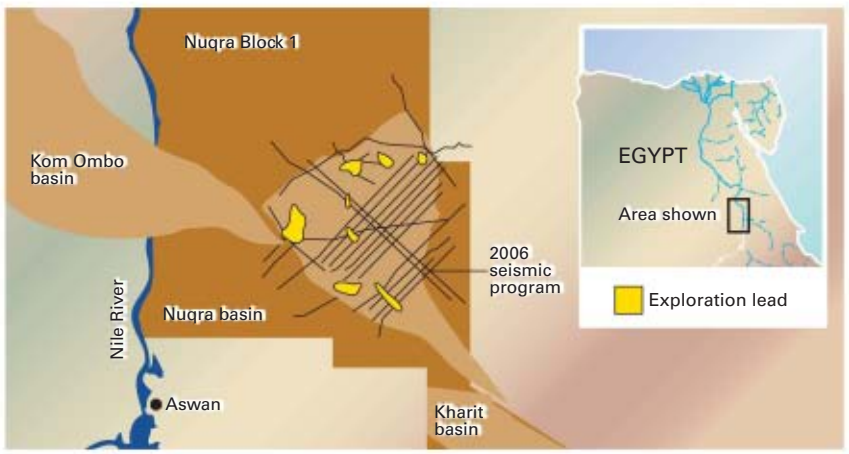
Table 1

Depth, m	Interval thickness, m	Producing rate, b/d	Oil gravity, °API	Flowing wellhead pressure, psig
2,344	21	2,965	32	240
2,290	12	2,254	31	157
2,260	11	4,554	32	360
1,783	10	4,120	30	221
Total	**54**	**13,893**		

Source: Heritage Oil Corp.

Kom Ombo and Nuqra basins, Upper Egypt

Fig. 1



Source: TransGlobe Energy Corp.

abilities up to 2,300 md (OGJ, June 10, 2002, p. 42, and June 17, 2002, p. 36).

The well did not reach the deepest objectives and investigated only part of Kingfisher, which Heritage described as "a very large structural high that is expressed at surface on the bed of Lake Albert. Seismic data indicate an areal extent of up to 70 sq km for the Kingfisher prospect."

Heritage let contracts for a 325 sq km 3D seismic survey over the Kingfisher and Pelican structures on Block 3A and 500 line-km of 2D seismic on Block 1 (see map, OGJ, Sept. 4, 2006, p. 56).

Heritage and partner Tullow Oil hold more than 12,000 sq km in the two Uganda blocks and Tullow-operated Congo blocks 1 and 2.

Uganda's remoteness will challenge the operating groups in declaring commerciality and establishing long-term production.

Farther north in Upper Egypt, a subsidiary of TransGlobe Energy Corp., Calgary, planned to spud on Mar. 24 at a second exploration prospect in the Nuqra/Kom Ombo rift basin near Aswan (Fig. 1).

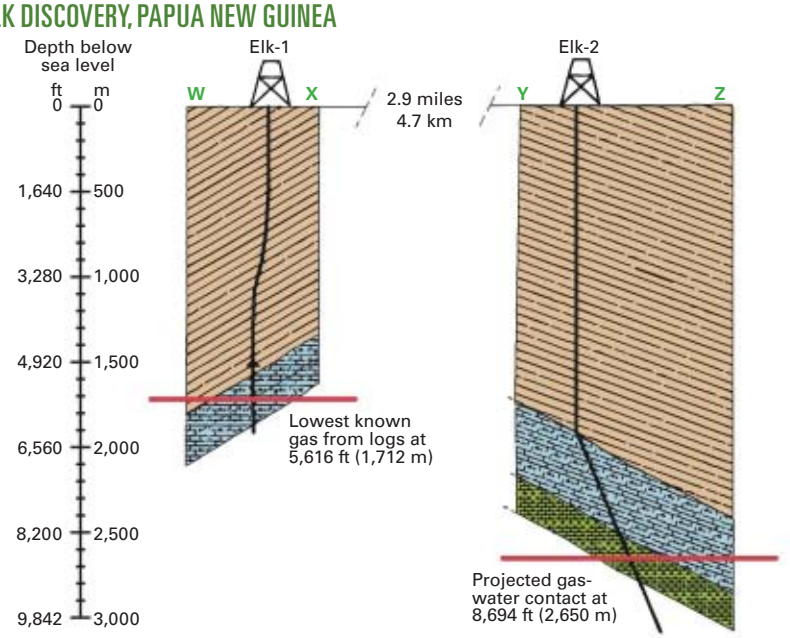
The Narmer-1 was to take 40 days to drill. It is 30 km east of Set-1, the first of the two-well program. Set-1 well, which targeted as much as 30 million bbl of oil, was drilled to 4,500 ft measured depth and encountered no hydrocarbons in Cretaceous or Jurassic sands.

TransGlobe holds 50% working interest and is operator of the 5.5 million acre Nuqra Block 1, which has eight seismically defined leads identified from more than 4,000 line-km of 2D seismic surveys.

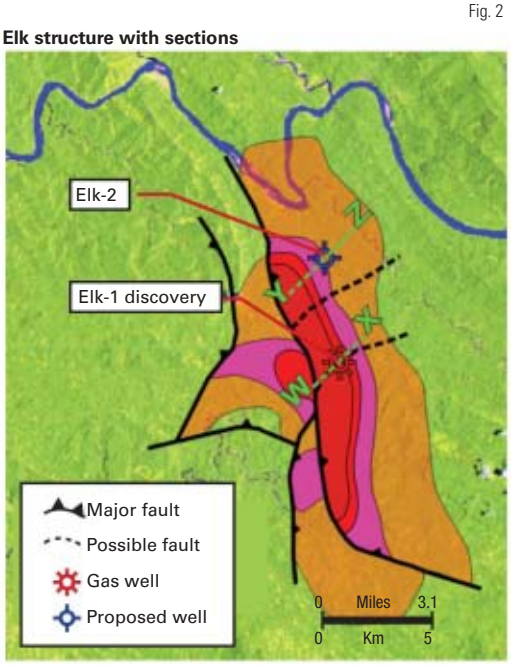
The Kom Ombo rift basin is analogous to the Gulf of Suez basin in Egypt, the Marib basin in Yemen, and the Muglad basin in Sudan, TransGlobe said. All except Kom Ombo contain major reserves. Seismic and well data have confirmed the existence of Jurassic and Cretaceous sediments and the presence

Elk discovery, Papua New Guinea

Fig. 2



Source: InterOil Corp.



INDONESIA FRONTIER BASINS MULTICLIENT GEOSCIENCE SURVEYS

Fig. 3

Source: TGS-NOPEC Geophysical Co.

of a petroleum system, the company said.

In nonproducing Ethiopia, Lundin Petroleum AB signed a production sharing contract in November 2006 that covers blocks 2 and 6 in the Ogaden basin.

The PSC covers more than 24,200 sq km just west of the undeveloped Calub and Hilala oil and gas discoveries.

Lundin Petroleum then held a 100% interest with the government holding an option to participate with up to 10% interest in case of a commercial discovery.

Neither block has been drilled, but the company said indications of light oil, gas, and condensate have been documented in well tests and surface seeps south and east of the blocks.

Australian independent Range Resources Ltd., Perth, completed a farmout to Canmex Minerals Corp., Vancouver, BC, in the Nogal and Darin basins in the Puntland area of nonproducing Somalia. Canmex will be operator and is obligated to spend $45 million for an 80% participating interest and drill at least two wells in each area.

Origin Energy Ltd., Sydney, acquired 3,759 line-km of seismic surveys on blocks L-8 and L-9 in the Indian Ocean off Kenya. Origin is operator with 75% interest.

Seismic over some leads in Origin's permits appear to be associated with direct hydrocarbon indicators (DHIs), the company said. After a minimum of four months' processing time, a decision must be made in the third quarter of 2007 whether to enter the second additional period, which carries drilling commitments.

Rob Willink, Origin's executive general manager exploration, said, "With interests being secured in new permits and new seismic becoming available for interpretation, we are entering a particularly exciting phase in the exploration of our more frontier assets.

"The potential for very large oil and gas discoveries has been identified, but as always, we remain conscious of the geological risk and high cost associated with exploration, particularly in our deeper water areas. To this end, we have commenced a process of attracting experienced partners to participate in forward activities in these areas."

Elsewhere in the Lamu basin, a group led by Woodside Petroleum Ltd.'s Kenyan subsidiary plugged the Pomboo-1 wildcat in 2,193 m of water on Block L-5 in January 2007 and deferred drilling a planned wildcat on Block L-7 until it could conduct a geologic study that incorporates the Pomboo well results.

Meanwhile, in West Africa, Roc Oil Co. Ltd., Sydney, plans to drill three to six wells on the frontier, 1,073 sq km Cabinda South Block in Angola with a rig that was to have arrived this month. A second rig is to arrive on the block at the end of May 2007.

The block, in the Lower Congo basin, is unexplored since the 1970s. Roc Oil operates the block with 60% interest.

Roc Oil acquired 722 line-km of 2D seismic surveys in 2005 and 416 sq km of 3D seismic surveys in 2005 and 2006, respectively, and a high-resolution aeromagnetic survey covering the entire block in March 2006.

Chevron produces 1.3 million b/d of oil from Block O in the same basin just offshore from the Cabinda South block.

Roc Oil lists the primary presalt reservoirs as the Lucula sandstone of Jurassic to Early Cretaceous age, sealed by Bucomazi shales, and the Chela sandstone of Aptian age sealed by the Loeme salt.

Lucula is equivalent to the main reservoir at M'Boundi field in Congo (Brazzaville), and Chela forms the gas reservoir encountered at the 123-5 well drilled by Gulf Oil (Cabinda) in 1968.

Main reservoir in postsalt plays is the Vermelha sandstone, which accounts for a large part of the offshore production. Secondary reservoirs include Iabe sandstone and Pinda limestones, both of which produce offshore, and sand-

stones in the Lago and Mesa formations

Asian exploration

Papua New Guinea, Indonesia, and Vietnam had important exploration in Southeast Asia.

InterOil Corp., Toronto, is to reach proposed TD of 10,000 ft in April or May 2007 at an appraisal well near its 2006 Elk gas-condensate discovery in the Papuan fold belt in Papua New Guinea.

Elk-2, budgeted at $12.5 million, is 2.9 miles northwest of the Elk-1 discovery on PPL 238. The gas-condensate targets are in the Miocene Puri and Eocene Mendi limestones (Fig. 2).

The appraisal well is programmed to test the entire 2,000-ft limestone section and intersect a postulated oil-water contact below the gas accumulation. The top of the gas target is at about 6,000 ft.

Meanwhile, TGS-NOPEC Geophysical Co. ASA launched 18 months of nonexclusive geoscience surveys of Indonesia's underexplored frontier basins in early 2007 (Fig. 3). First data were to be available in the second quarter of the year.

The project was to cover 1 million sq km in 16 sedimentary basins with 33,000 line-km of new 2D seismic surveys, 419,000 sq km of multibeam seaseep, gravity, and magnetic surveys, 1,500 sediment cores, 4,500 geochemical analyses, and 250 heat flow probes.

A team of geoscientists with extensive knowledge of Indonesian basins and a proven exploration success record in the region is to interpret the data.

Blocks are already in force in some of the basins. For example, Premier Oil PLC, London, was awarded a 3,396 sq km onshore block on the southeastern side of Buton Island, off southeastern Sulawesi, in December 2006.

Five exploration leads have been identified, and the work program calls for shooting 265 line-km of 2D seismic surveys. Premier has a 30% nonoperated interest.

Australian explorers are taking a greater interest in several nonproducing basins, including the Amadeus, Georgina, and Beetaloo basins.

Most of Vietnam's oil production comes from the Cuu Long basin with a small amount coming from the Nam Con Son basin, both off the southeastern part of the country (Fig. 4).

A large 2006 discovery was VRJ's 09-3-DM-1X in the Cuu Long basin, which flowed 3,500 b/d of oil and was initially thought to have identified as much as 500 million bbl of recoverable oil.

OGJ estimated Vietnam's production at 340,000 b/d of oil and 15 bcf/month of gas as of November 2006.

Pogo Producing Co., Houston, acquired 850 sq km of 3D seismic surveys over the shelf portion of 1.48 million acre Block 124 in the Phu Khanh basin and plans to drill two exploratory wells in 2008.

Only one small onshore gas field produces in the Song Hong (Red River) basin in the northern part of the country, but Petrovietnam Investment & Development Co. made a gas discovery on Song Hong offshore Block 107 in 2006. The well gauged 25 MMcfd of gas.

OMV (Vietnam) Exploration GmbH and Edison International SpA completed a noncommercial gas discovery on Block 111 in the offshore Song Hong basin in 2002 on Vietnam's continental shelf generally west of China's Hainan Island.

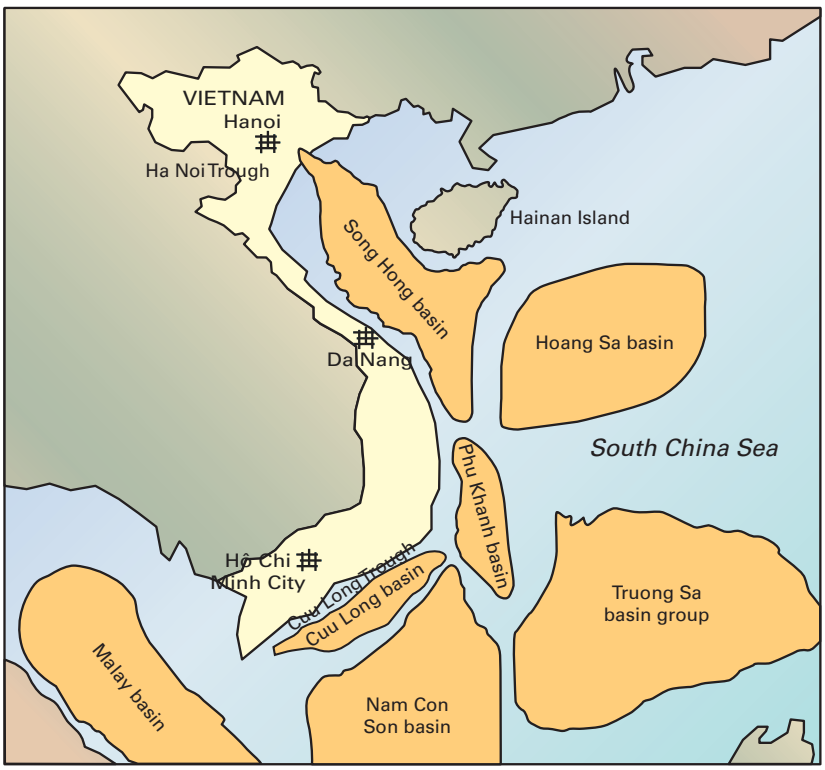
In the Krishna-Godavari basin off India, Reliance Industries Ltd., Mumbai, and Niko Resources Ltd., Calgary, have completed about 20 discoveries in the past several years on Block D6 in the Bay of Bengal. Almost all are in formations of Tertiary age.

In mid-March 2007 the companies revealed the Q1 and P2 discoveries on D6. Q1, 6 km west of P1, found pay in the distal part of the earlier established channel levee systems on D6. P2 found two gas-bearing zones in channel fan complexes.

A mid-2006 discovery, the MA-1 (Dhirubhai 26) exploration well in

VIETNAM'S MAIN BASINS

Fig. 4



Source: Petrovietnam

1,800 m of water, is the block's first Cretaceous find. An appraisal well, MA-2, found a 194-m gross gas-condensate and oil column, the thickest discovered on D6. MA field is declared commercial.

A May 2006 discovery involved a large onshore gas find in northwestern India. SGL-1 is in the Middle Indus basin 25 km from the border with Pakistan. The western Rajasthan discovery in the Shahgarh area of the Jaisalmer district flowed 15 MMcfd of gas from Cretaceous sandstones at 3,100 m, said Focus Energy Ltd., New Delhi (OGJ Online, May 31, 2006). Deeper formations might also be productive, the company said.

Europe's outlook

Greenland's Davis Strait will get perhaps its closest exploratory examination ever, and gas is still being discovered in the Celtic Sea off Ireland.

Greenland government authorities announced in December 2006 that ExxonMobil, Chevron Corp., Husky Oil Ltd., and DONG Energy of Denmark, had applied for exploration and exploitation licenses off West Greenland.

The four companies submitted a total of six bids for the eight blocks offered, and licenses were to be awarded at press time in March 2007 (Fig. 5).

A second phase of the Disko West licensing round is planned from Aug. 1, 2007, to Feb. 1, 2008.

Meanwhile, predevelopment drilling is to start in the second quarter of 2007 at the first new gas discovery in the Celtic Sea for 16 years.

Island Oil & Gas PLC, Dublin, made the 49/23-1 discovery in late 2006 about 25 km east of Kinsale gas field facilities. Island Oil is operator with 100% interest.

The well, on the Old Head of Kinsale prospect, encountered a gross 100-ft gas column in a Lower Cretaceous reservoir sequence. Gas in place is under independent review but was initially estimated at 90-120 bcf over as much as 22 sq km. The discovery occupies parts of blocks 49/17, 49/22, and 49/23.

Norway's Hydro established the presence of oil and gas in the Realgrunnen Group and the Kobbe formation at the Nucula prospect in the Barents Sea 110 km northeast of the Goliat oil discovery and said well testing and more exploration are needed (OGJ Online, Mar. 2, 2007). The well established the presence of a new, functioning petroleum system.

Latin America

Basins in Nicaragua, Chile, and Venezuela are among the remote areas under exploration.

Nicaragua could have its first commercial hydrocarbon discovery near Managua in the Sandino basin.

Norwood Resources Ltd., Vancouver, BC, was drilling a second structure in March 2007 after its first wildcat discovered hydrocarbons below 6,000 ft in Paleocene Brito formation turbidite sands (cover photo, this issue).

Logs from the first well, San Bartolo Rodriquez Cano-1, showed a combined 532 ft of pay, including 232 ft of conventional pay and another 300 ft of naturally fractured low permeability sands in eight zones. Porosities were 17-21% and permeabilities 3 to 30 md.

It is the country's first exploration well in more than 35 years.

The discovery is 300 miles south-southeast of nearest oil production, in Guatemala.

Honduras, desirous of attracting oil and gas exploration, held a geological seminar in Houston in mid-March 2007 to show progress in the aggregation of existing data.

The country would first need to construct an oil law, outline license blocks, and possibly reach agreement on a Caribbean marine border with Nicaragua. JGI Inc., Tokyo, said that source rock geochemical studies indicate promise in deeper-water parts of the Tela basin and in the Mosquitia platform and basin off the country's east coast.

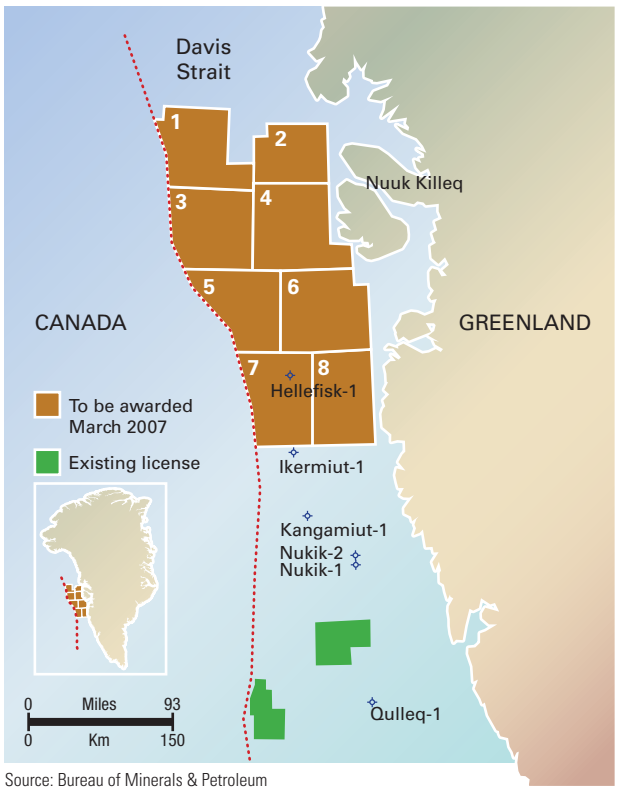
In a remote corner of northernmost Chile, March Resources Corp., Calgary, received Chilean government decrees at the end of January 2007 to explore the Pica North and Pica South blocks that cover 2.5 million acres in the Tamarugal basin.

The company hoped for the first well to spud shortly after signing Special Operations Contracts that define work to be done on the blocks, which are valid for 35 years.

Two objective sandstone horizons at 4,300 ft and 7,000 ft are anticipated. A repeat of the deeper sandstone could be

GREENLAND WEST DISKO PHASE 1 BLOCKS

Fig. 5



Source: Bureau of Minerals & Petroleum

encountered at an estimated 8,470 ft. More sandstone reservoirs are anticipated to a depth of 12,800 ft.

The basin is similar to the Neuquen basin in Argentina and is believed to contain more than 16,000 ft of Jurassic black marine shales.

March Resources signed a letter of understanding in mid-2006 with California Oil & Gas Corp., Calgary, to drill two wells to earn an interest in the blocks.

The blocks, inland of Arica and Iquique, are in the Atacama Desert 400 miles west of production in Bolivia and 550 miles southeast of Camisea, Peru. The blocks are more than 100 miles north of gas pipelines from Argentina to Chile.

Venezuela awarded five exploration blocks in the nonproducing Gulf of Venezuela west of the Paraguana Peninsula.

The blocks are in shallow water east of Colombia's Guajira Peninsula and lie between Lake Maracaibo and the Caribbean Sea. Successful bidders were Chevron, OAO Gazprom (two blocks), Vinccler Oil & Gas CA, a combine of Repsol YPF and Eni, and a combine of Petrobras and Teikoku Oil Co.

Gas, if discovered, could supply the large, two-refinery complex on the peninsula.

Piercing another sort of frontier, Russia's OAO Lukoil, meanwhile, participated in what the company called "the first discovery made by Russian petroleum experts in the Western Hemisphere."

Lukoil and Colombia's Ecopetrol discovered 100 million bbl of oil in the Medina structure on the 3,089 sq km Condor block in the western Llanos basin. Condor-1, ground elevation 1,128 m, went to 4,500 m and is being "prepared for commercial operations," Lukoil said.

North America

E&D frontiers in the deepwater and eastern Gulf of Mexico and several onshore areas are heating up.

US legislators discussed relaxing a ban on exploration in the eastern Gulf of Mexico (OGJ Online, Dec. 11, 2006).

At the southeastern extremity of the area, one dry hole has been drilled in Cuban waters and more drilling is likely.

The western gulf Lower Tertiary deepwater play is in a period of appraisal in 2007 after the stunning extended drillstem test at the Jack-2 appraisal well in 2006.

Jack-2, 270 miles southwest of New Orleans in Walker Ridge Block 758, sustained more than 6,000 b/d of oil from 40% of the total measured net pay of more than 350 ft (see maps, OGJ, Sept. 25, 2006, p. 36).

In the Central Utah thrust belt, one industry source indicates that four to five dozen prospects may await drilling between the Strawberry Reservoir in Wasatch County and the Arizona state line.

Covenant field remains the province's only discovery to date with 10 producing wells that were making a combined 5,700 b/d of oil and 1,700 b/d of water from Jurassic Navajo at 6,200 ft in late 2006. Salt Lake City refinery utilization is at capacity.

Since the Covenant discovery in 2004, operators have drilled seven dry holes exploring for the Navajo. Petro-Hunt Corp., Dallas, was drilling in mid-March 2007 at a wildcat just west of Ephraim, Utah.

Various independents have indicated plans to drill about 12 wells in 2007 and possibly reenter several others.

One explorer said the play's structural complexities are beyond resolving on 2D seismic data, but so far no 3D seismic data has been shot along the Hingeline. One well was inadvertently drilled into an igneous intrusive (OGJ Online, Mar. 2, 2007).

Russia-CIS-China

Many opportunities exist for all sizes of companies and budgets in Russia, which granted 184 oil and gas exploration and development licenses in 2006, said Wood Mackenzie Consultants, Edinburgh.

The year's top bid was Lukoil Komi's $220 million purchase of the Oshski Block in the Timan-Pechora basin, but the number of blocks that went for less than $1 million more than doubled from 2005.

TengizChevroil completed an apparently large discovery at Ansagan-1X in Kazakhstan west of supergiant Tengiz and Korolev fields in late 2006 but has not announced details.

China will benefit from Husky Energy Inc.'s rank Liwan 3-1-1 discovery on Block 29/26 in the South China Sea 250 km south of Hong Kong. In 1,300 m of water, it is the deepest water well drilled off China and confirmed the existence of a new hydrocarbon province, Husky said.

Drilled on 2D seismic, the structure has 60 sq km of closure. The well cut 56 m of net gas pay averaging 20% porosity in two zones. Husky and China National Offshore Oil Corp. have identified a number of similar structures.

Middle East

Saudi Arabia plans to fast-track the $10 billion nonassociated gas development beneath Karan oil field in the Persian Gulf (OGJ Online, Mar. 6, 2007).

The Permian Khuff reservoir at 10,888 ft, discovered in early 2006, is to be producing 1 bcfd in 2011. Saudi Aramco is drilling 11 other deep gas prospects in the Persian Gulf in 5-6 years.

Kuwait reported Umm Niqa-1, a large oil and gas discovery onshore in the Dibdibah subbasin.

National Iranian Oil Co. reported 36 tcf of gas recoverable from its Kish multipay gas discovery in 2006.

DNO ASA made Iraq's first substantial oil discovery since the early 1990s at Tawke-1 in Kurdistan, far northwestern Iraq. ✦

DRILLING MARKET FOCUS

Plenary panel addresses effect of high prices on performance

Nina M. Rach
Drilling Editor

At the International Association of Drilling Contractors conference in Amsterdam, Feb. 20-22, 2007, leaders from two of the world's largest operating companies, the largest offshore drilling contractor, and the largest oil field service company discussed reasons for the high price scenario, their outlooks for the future, and the effects of prices (oil, commodities, rates) on performance.

The four panelists anchored a plenary session, moderated by Stuart Ferguson, senior vice president and chief technology officer at Weatherford International. Panelists included:

- Dave Blackwood, North Sea strategic performance unit leader, BP Exploration Operating Co.
- Jean P. Cahuzac, president, Transocean Inc.
- José Formigli, executive manager of E&P production engineering, Petroleo Brasileiro SA.
- Chakib Sbiti, executive vice-president, Schlumberger Oilfield Services.

QUESTIONS, THIRD PLENARY SESSION Table 1

Q: When do you expect WTI crude to fall below $50/bbl for more than 3 months?	
1. This year, 2007	22%
2. 2008-09	38%
3. 2010-14	19%
4. After 2014, if ever	21%
Q: How do you believe safety performance has changed over the last 2 years?	
1. Noticeably better	31%
2. Stayed the same	44%
3. Noticeably worse	26%
Q: How do you believe nonproductive time (NPT) has changed over the last 2 years?	
1. Noticeably better	15%
2. Stayed the same	37%
3. Noticeably worse	48%
Q: How do you believe attitudes to risk and reward have changed over the last 2 years?	
1. Increased risk-taking to gain higher reward	33%
2. Stayed the same	24%
3. Decreased risk-taking to minimize downside	43%
Q: How important are professional societies (SPE, IADC) to the performance of the industry?	
1. They make a critical contribution	16%
2. Make valuable contribution	53%
3. Make little contribution	19%
4. Waste of time, money	2%

*Audience voting, 500 voting pads, Feb. 22, 2007.

Although the title of the session was "High Prices Prevent High Performance," not all the panelists agreed with that premise.

Cahuzac took an opposing view in his presentation. He said, "present market prices do not prevent high performance. On the contrary, they are required to allow industry to commit to the long-term investments needed to solve technical and cost efficiency challenges."

In addition to the speaker's individual presentations and panel discussion, the audience was also polled on a variety of questions, with touchpad voting results shown immediately in the auditorium (Table 1).

Performance measures

As the demand (and prices) for commodities and services increases, industrial pundits discourse on the ability of suppliers to deliver. The panelists discussed several measures of performance:

- Safety (total recordable incidents; lost-time incidents).
- Nonproductive time.
- Risk aversion.
- Innovation, ability to increase supply.

The industry is expanding at an ever-increasing rate, seen in the activity, projects planned, and amount of capital expenditure money committed in the last several years.

"Present market prices do not prevent high performance. On the contrary, they are required to allow industry to commit to the long-term investments needed to solve technical and cost efficiency challenges."

—Jean Cahuzac, Transocean Inc.

Pricing, rates

Sbiti discussed the cost inflation for key materials. Although some had decreased in cost (HMX, RDX nitroamine explosive powders; ferro-chrome

60-65% carbon steel; et al.) many have increased in cost (Inconel 718, 625 nickel-based alloys; copper, lead, and tungsten powders; et al.).

Sbiti said that almost all complaints fielded in 2005-06 concerned unavailability of services, not the pricing. It is important to have the right equipment and people in the right place. "Fiascos on the rig floor are extremely visible, expensive," he said.

Blackwood thinks the market is "moving toward a softening." Although BP recruited personnel heavily last year, he said that recruiting would be down in 2007.

Transocean was more bullish than BP. Cahuzac sees a strong market for drilling services as China, India, and other countries increase investment to guarantee their own supply. Also, traditional deepwater areas continue to see strong activity. New contracts are running 3-5 years, and Transocean is investing in rigs. He envisions strong demand for deepwater rigs in 2010-11, even with the newbuilds scheduled to enter the market.

Cahuzac noted that the offshore drilling industry will need to recruit more than 5,000 rig supervisors in the next 1-5 years, representing a 30% increase in the present rig supervisor population, and Transocean is gearing up for it now. He said new approaches are needed to support recruiting and training, such as new drilling simulators.

The audience was polled on their expectations for West Texas Intermediate crude prices to fall and stay below $50/bbl for more than 3 months (Table 1). The largest group, 38%, expected this to occur in 2008-09.

Blackwood thinks the industry is in a shoulder period and it should be mindful of price flattening. Asian demand for oil is not as high as anticipated, he said.

Transocean and many other drilling contractors continue to invest in rigs, mostly newbuilds, while watching for opportunities to purchase speculative newbuild units.

Formigli said that Petrobras' focus is to reach self-sufficiency goals set by the government. Its strategic plan is based on average price of $35-40/bbl, but the new development price threshold is $30/bbl.

Petrobras has started renewing rig contracts. The company has $300,000-400,000/day contracts in place for 2009-10 with a new contractor, a great savings from current market price of $400,000-500,000/day.

Safety

Asked how they believe safety performance in the industry has changed over the last two years, the audience predominantly answered that it has stayed the same (44%), with 31% saying it is noticeably better and 26% saying it is noticeably worse (Table 1).

> *"Fiascos on the rig floor are extremely visible and expensive."*
>
> ***—Chakib Sbiti, Schlumberger Oilfield Services***

Workplace safety measures are usually tracked by the total recordable incident rate (TRIR) and the IADC's lost time incident rate (LTIR). TRIR is the total number of recordable incidents x 200,000, divided by the number of work hours. LTIR is the number of lost-time incidents/100 full-time workers for a given reporting period.

From 2001-07 (year to date), both measures have fallen at Transocean (Table 2). TRIR has dropped to 0.62 from 2.11, and LTIR has dropped to 0.09 from 0.95.

But Cahuzac noted that safety performance in the UK has decreased, from a previously great safety record 5 years ago. The company wants incident-free operations. He said there is a focus on taking personal responsibility for individual behavior and preventing major events.

Formigli said that Petrobras does not want another P-36 or Piper Alpha incident, and has learned from the experiences. The company has intensive training courses for new hires. The new generation, he notes, is more aware and has a stricter view of safety.

Schlumberger also emphasizes training. The company hired about 6,000 people in 2006 and offered about 400,000 training days during the year. A new training center in Abu Dhabi will open in March 2007 with the ability to provide an additional 77,000 training days/year.

Sbiti thinks the industry is unfortunately focused on statistics, and that as currently reported, they do not adequately represent actual occurrences in our industry. Contract staffers are seldom counted, for instance, in company reporting. The industry has to evolve, he said, and needs frank talk to avoid glossing over realities.

As an example, he showed data from 2001-06 on industry-recognized fatalities, and Schlumberger-involved fatalities (counts which included contractors), listed in Table 3. This suggests that our current measures underreport incidents by 100-400%. Sbiti thinks the industry should also track all nonwork-related fatalities to capture key knowledge. In 2006, for instance, Schlumberger found that driving and health issues (primarily heart attacks) were the common causes of 36 non-work-related fatalities.

Schlumberger also tracks "service quality events," distinguished as catastrophic, major, serious, light, and near-accident/hazardous. Although there were some increases in three of the five categories from 2005-06, Sbiti said he does not see much pro-rata change, in view of the escalated activity levels.

Nonproductive time

Asked whether nonproductive time (NPT) has changed during the last 2 years, 48% of audience respondents said it has gotten worse (Table 1).

Blackwood said that we do this to ourselves, overestimate how much we can do. Few contractors say they can't do a job, but often equipment doesn't work. The industry should either wait for the experience base to catch up, or admit that it is not very efficient, he said.

Calhuzac acknowledged a widespread reluctance to say no to an operator. But he said his company is making strides, and sold two rigs last year instead of trying to reactivate them and staff with experienced people. Rig performance is steady; equipment downtime has been flat for the last 2-3 years on Transocean's fifth-generation rigs.

Formigli said NPT has stayed the same. He thinks the biggest problem has been in shipyard work and construction. Well engineering and subsea work have been fine; newer projects have been better scheduled

Sbiti looked back even further and said that the supply chain system has broken down many times during the past 4 years, although the industry is trying to improve upstream delivery.

Ferguson asked how the industry can improve NPT. Formigli thinks simple well designs for drilling and completions would help. Petrobras' approach in well engineering is to treat reservoir engineers as the "clients."

TRANSOCEAN SAFETY PERFORMANCE

Table 2

	2001	2004	2005	2006	2007 YTD
LTIR[1]	0.95	0.52	0.45	0.35	0.09
TRIR[2]	2.11	1.29	1.06	0.92	0.62

[1]LTIR = number of lost-time incidents per 100 full-time workers for a given reporting period. [2]TRIR = total number of recordable incidents x 200,000, divided by the number of work hours.

INDUSTRY FATALITIES

Table 3

	2001	2002	2003	2004	2005	2006
Industry-recognized	3	4	3	2	6	7
Schlumberger-involved, including third parties	6	7	12	13	11	15

Risk

Companies face risk technically, politically, and financially.

Ferguson asked BP, if forced to choose a single direction, whether it would focus on either meeting production targets (today) or replacing reserves (tomorrow). Blackwood said the company could never choose; it was necessary to keep both in sync.

Asked how attitudes toward risk and reward have changed during the last 2 years, most of the audience voted that attitudes had stayed the same (24%) or that risk-taking has decreased (43%; Table 1).

Blackwood was surprised by the result. Perhaps there is a perception of an aversion to risk because new players are heavily leveraged and act conservatively, he said.

Sbiti said, "our biggest risk is investing in our R&D portfolio." Customers are too stretched and have no time to enter into novel, collaborative business arrangements. But he sees that they are still entering some new plays, taking on risk.

Cahuzac said that high costs may encourage a more conservative approach for technology development and implementation. Showing data ftom ODS-Petrodata, he noted that the average return on invested capital for the major drilling contractors during 2001-05 was only 4.6%. Those 6 years were a "value-destroying period for shareholders," he said, and drilling contractor's efforts did not return the cost of capital.

Innovation

One of the roles of technology is to increase efficiency. Sbiti noted that seismic has led to improvements in subsalt exploration, and real-time remote drilling connections are becoming standard in the North Sea. Rotary steerable systems are used in increasingly harsher environments.

Research and development spending continues to increase. Schlumberger spent $595 million in 2006, up 17% from $509 million spent in 2005.

Cahuzac noted that long-term investments include not only research and development of new technologies, but also investments in people, in rig upgrades, and newbuilds. Transocean developed and patented innovative dual-activity drilling technology by 1996 and incorporated it in its three Enterprise-class, dynamically positioned drillships. The Discoverer Enterprise was the company's first drillship to have dual-activity capability. The technology has paid off in increased efficiency, allowing parallel drilling operations on a single well.

GlobalSantaFe Corp. later adopted the technology for three of its newest semisubmersibles: Development Driller I, II, and III. In January 2007, a federal district court entered an amended final judgment against GlobalSantaFe for patent infringement.

Both companies announced the terms of a settlement on Feb. 20, 2007, 2 days before the plenary session. GlobalSantaFe will pay Transocean about $15 million and future licensing fees when operating in an area where Transocean has dual-activity patent rights. The fees include 3% of future revenues from the three Development Driller semisubs and 5% of revenues from any other rigs that GlobalSantaFe may acquire which incorporate the dual activity technology.

Societies

Asked how important the effect of professional societies such as IADC and SPE are on the industry, most of the audience said they make a valuable contribution (53%; Table 1).

Blackwood thinks we need to give people time to make professional society interactions work. "We can derive a lot of power from people coming together," he said.

Formigli believes that societies make a valuable contribution. He noted that it was difficult in the past for SPE to gain a foothold in Brazil, when Petrobras was the sole operator and served the same role as an association, disseminating information and training. But since the monopoly was broken in 1998, he said there is more support for SPE as a mechanism for sharing knowledge.

Sbiti said there are too many industry events, and we could do with fewer, with better overall quality. He thinks that a company should have a strategy on how to participate and collaborate.

Future

Companies are recruiting new workers. Schlumberger envisions high growth in the next 5 years, and needs to hire 5,000-6,000 engineers and technical staff. Petrobras hired 5,000 for upstream in 2006 and "will maintain this level," stressing that the company also has to staff new refineries. So far, Formigli says Petrobras has 20 applicants for each position. Transocean continues to recruit and sees a need to focus more on evaluating competency as well as providing training.

Blackwood said, "we need to continue projecting high-growth," but wondered, "is there a better way to manage boom-bust cyclicity?" ✦

Procedure calculates base gas compressibility factors

Nelson Menendez
Empresa Nacional del Petróleo (ENAP)
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This article presents an easy and simple spreadsheet procedure for custody-transfer calculations of the base compressibility factor for any pair of pressure and temperature conditions.

The procedure uses the second virial coefficient data source from Reference 1. The calculated compressibility factors are similar with values obtained from the AGA 8 compressibility equation of state.[2]

Metering

In gas industry metering applications, the base (or standard) conditions for pressure and temperature vary, not only with the geographical region but among gas sales contracts.

In the US, the common base or standard reference conditions are 60° F. and 14.73 psia. In Europe, the normal reference conditions are 0° C. and 101.325 kPa, while the standard conditions are 15° C. and 101.325 kPa. Argentina also uses 15° C. and 101.325 kPa, while Mexico uses 20° C. and 1 kg/sq cm absolute.

Calculations of real gas heating value, density, base density, base volume, and Wobbe index require compressibility factors at base conditions. Tables list these properties but only as ideal gas values.

For custody-transfer, the procedure has to adjust these values by including a calculated compressibility factor at the appropriate base conditions.

References provide data tables and methods for obtaining the compressibility factor at base conditions, such as GPA 2145, although these data generally are only true for one of most used base conditions, which are 60° F. and 14.73 or 14.696 psia.

Anyone using other base conditions has to find another method besides that provided by the tables.

One solution is to use AGA 8 program (last version), but this option requires complex algorithms and time-consuming computer programming or third-party software.

This article presents a spreadsheet procedure to calculate, at custody-transfer-level requirements, a compressibility factor at base conditions for any pair of pressure and temperature conditions.

Compressibility factor

At conditions near ambient, pressure less than 16 psia, the truncated virial equation of state (Equation 1 in the equation box) satisfactorily represents the volumetric behavior of natural gas.

In Equation 1, the nomenclature is:

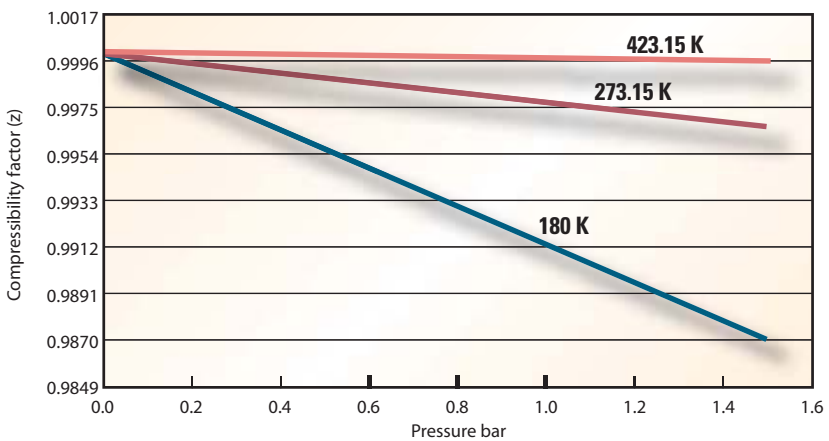
- Z = Compressibility factor at base conditions.
- B = Second virial coefficient.
- R = Gas constant
- P = Absolute pressure at base condition.
- T = Absolute pressure at temperature condition.

For natural gas, the compressibility factor value at base conditions is nearly 1, such as 0.99, so that B has to be negative (Fig. 1).

Equation 2 shows the second virial coefficient for a mixture. In the equation, $B_{ij} = B_{ji}$ is the second interaction (cross) virial coefficient for component

METHANE LOW-PRESSURE COMRESSIBILITY FACTOR

Fig. 1



From Reference 4

SECOND VIRIAL COEFFICIENTS (B), CC/MOL

Table 1

No.	Component	0° C.*	15° C.	60° F.	20° C.	30° C.*
1	Methane,	–53.60	–47.35	–47.12	–45.27	–41.10
2	Ethane	–222.20	–200.99	–200.20	–193.92	–179.78
3	Propane	–464.00	–415.65	–413.86	–399.53	–367.30
4	i-Butane	–828.00	–746.00	–742.96	–718.67	–664.00
5	n-Butane	–918.00	–813.00	–809.11	–778.00	–708.50
6	i-Pentane	–1,320.00	–1,185.00	–1,180.00	–1,140.00	–1,050.00
7	n-Pentane	–1,680.00	–1,451.50	–1,443.04	–1,375.33	–1,223.00
8	n-Hexane	–2,412.00	–2,096.00	–2,084.15	–1,989.33	–1,776.00
9	n-Heptane	–3,810.00	–3,245.00	–3,224.07	–3,056.67	–2,680.00
10	n-Octane	–5,800.00	–4,850.00	–4,814.81	–4,533.33	–3,900.00
11	Nitrogen	–10.60	–7.40	–7.28	–6.33	–4.20
12	Carbon dioxide	–149.70	–134.80	–134.25	–129.83	–119.90

*The coefficients for 0° C. and 30° C. are from DIN 1871. The other values are from interpolation.

i and j, and B_{ii} is second virial coefficient for pure component i. The second virial coefficients are functions of temperature.

Equation 3 provides an alternative expression for B that is more convenient for hand calculations, is satisfactory for custody-transfer applications, and is more useful and clearer. In the equation the square root of B_i is the summation factor, a common term found in the literature.[1 3 4]

Values for the summation factor at 60° F. appear frequently in tables, but there are no tables that list summation factors for other base temperatures. That is the problem and the goal of this article is to present a procedure to obtain the compressibility factor at any temperature.

This procedure does not use the summation-factor method but the second virial coefficient that is more useful and clearer.

Equation 3 assumes that Equation 4 is correct. Two examples explain the use of this equation.

Methane (B_1) and ethane (B_2) have B factors at 0° C. of −53.28 and −219.38, respectively. A methane and ethane mixture (B_{12}) would than have a B factor that is the square-root of the product of B_1 times B_2 (Equation 4) or −108.11. Experimental datum is −111.86, which is close enough for practical purposes.[5]

Propane (B_3) has a B factor at 0° C. of −470. A methane and propane mixture (B_{13}) than would have a B factor (Equation 4) of −158. Experimental datum is −156.[5]

Equation 4 is the key for obtaining the simplified expression in Equation 3 and reducing the number of variables in the calculation.

Table 1 lists the second virial coefficients of pure hydrocarbon and inert gases in custody range pressures and temperatures.

DIN 1871 includes data only for two temperatures (0° C. and 30° C.), but says that linear interpolation with Equation 5 can provide the values for other temperatures.

B values in Table 1 for other temperatures were calculated in this manner. This procedure can be used for any base temperature.

Table 2 shows calculations for two gas mixtures at 0° C. and 60° F. at a base pressure less than 16 psia ✦

EXAMPLE CALCULATIONS

Table 2

No.	Component	Mole, %	B_i* at 0° C., cc/mol	B from Equation 3	Mole, %	B_i* at 60° F., cc/mol	B from Equation 3
1	Methane,	90.8945	–53.6	6.6546	83.02	–47.1	5.6987
2	Ethane	5.2203	–222.2	0.7782	7.45	–200.2	1.0541
3	Propane	1.4701	–464	0.3167	4.39	–413.9	0.8931
4	i-Butane	0.2700	–828	0.0777	0.83	–743.0	0.2262
5	n-Butane	0.3900	–918	0.1182	1.08	–809.1	0.3072
6	i-Pentane	0.1250	–1,320	0.0454	0.31	–1,180.0	0.1065
7	n-Pentane	0.1000	–1,680	0.0410	0.25	–1,443.0	0.0950
8	n-Hexane	0.0700	–2,416	0.0344	0.30	–2,084.1	0.1370
9	n-Heptane	0.0900	–3,810	0.5560	0.00	–3,224.1	0.0000
10	n-Octane	0.0000	–5,800	0.0000	0.00	–4,814.8	0.0000
11	Nitrogen	1.0301	–10.6	0.0335	0.35	–7.3	0.0094
12	Carbon dioxide	0.3400	–149.7	0.0416	2.02	–134.2	0.2340
Total		**100.0000**		**8.1968**	**100.00**		**8.7613**
				B = 67.1868			**B = 76.7602**
Calculating Z from Equation 1							
R, kg/sq cm-cc/mol-K				84.784	R, psia-cc/mol-K		1,205.91
T, K				273.15	T, K		288.71
P, kg/sq cm				1.00	P, psia		14.696
B negative				–67.1868	B negative		–76.7602
Compressibility factor (Z)				0.9971	Compressibility factor (Z)		0.9968
Z from AGA 8 calculations				0.9971	Z from AGA 8 calculations		0.9968

*From DIN 1871.

EQUATIONS

$$Z = 1 + BP/RT \quad (1)$$

$$B = \sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j B_{ij} = x_1 x_1 B_{11} + x_1 x_2 B_{12} + \ldots + x_n x_n B_{nn} \quad (2)$$

$$B = \sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j B_{ij} \approx \left(\sum_{i=1}^{n} x_i \sqrt{B_i}\right)^2 \quad (3)$$

$$B_{ij} = \sqrt{B_i B_j} \quad (4)$$

$$B_{(T)} = B_{(0°C.)} + [B_{(30°C.)} - B_{(0°C.)}] \times T_{(°C.)}/30 \quad (5)$$

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Iran becoming mega petchem producer, natural gas consumer

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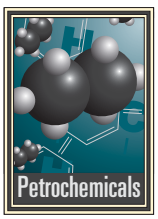


Iran's government is moving away from an oil-export based economy by increasing the priority of its gas resources development, including the expansion of its petrochemical industry. Access to large quantities of ethane recoverable from natural gas reserves guarantees low-cost ethylene production and sustainability. Iran is therefore currently constructing massive new petrochemical production capacity that is approximately the combined current ethylene capacity of Japan, Korea, Taiwan, and China.

The petrochemical industry is one of the most capital-intensive industries in Iran. Feedstock is supplied from the by-products of oil and gas exploitation, including NGL and condensate, as well as refined products such as naphtha, natural gas, and ethane.

The first and also one of the biggest petrochemical plants in Iran—Shiraz—began operations in 1959, followed by the Kharg petrochemical complex located on Kharg Island, which was established in 1966 with a capacity of 1,000 tonnes/year (tpy).

Before Iran's revolution in 1979, some plants such as the Razi and Bandar Imam petrochemical complex came into operation as well. After the Iran-Iraq war, petrochemical production accelerated. Iran currently produces approximately 24 million tpy of petrochemical products.

Rise in petchem production

Production and investment in Iran's petrochemical industry have grown significantly in recent years. In 1995, petrochemical production was 8.7 million tonnes. The total volume of petrochemicals produced at National Iranian Petrochemical Co. (NIPC) increased at an average of 6%/year during 1995-2005 and reached 15.8 million tonnes in 2005.

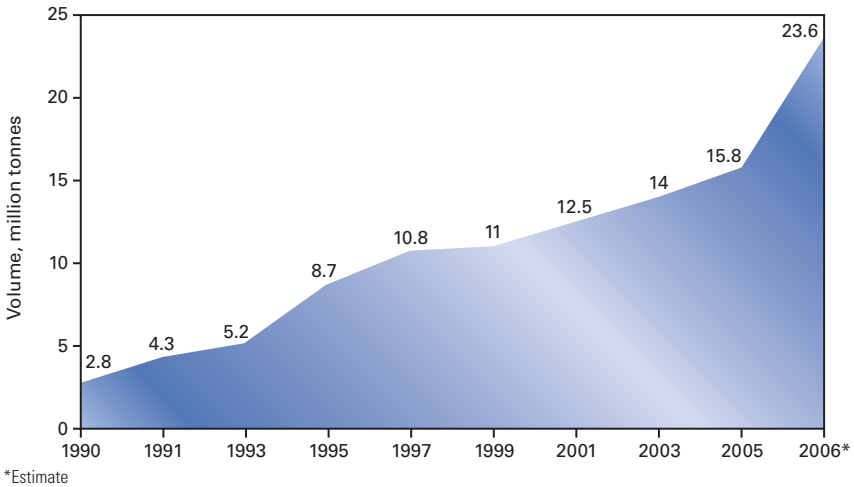
The production from all petrochemical complexes will be 23.6 million tonnes in 2006.

Fig. 1 shows total petrochemical production for 1990-2006.

The average growth rate of total petrochemical production for 1990-2006 is 14.3%/year. The largest increase in production occurred during 1993-95 with an average growth of 30%/year due to the start-up of the second phases of the Arak and Bandar Imam petrochemical plants. During 1998-99, production growth was the lowest because

IRAN PETROCHEMICAL PRODUCTION

Fig. 1



*Estimate

the Shiraz and Razi refineries were being revamped; this left the second and third-largest petrochemical complexes with little feedstock.

With the commencement of the South Pars gas field development in 2001, NIPC started planning for large gas-based petrochemical plants, many of which came online in 2003-06. Some of these include new petrochemical companies such as Amir Kabir Petrochemical Co., Bu Ali Sina Petrochemical Co., Fan Avaran Petrochemical Co., Bisotoon Petrochemical Co., and Khuzestan Petrochemical Co. Production growth during this period was about 30%/year.

Demand, export growth

In terms of domestic demand for petrochemical products, growth during 1990-2006 averaged 10.5%/year and 5.3%/year during 1996-2006.

Fig. 2 shows domestic petrochemical demand for 1990-2006. This is rather moderate compared with the overall growth of the petrochemical sector, leaving substantial volumes for exports.

As previously mentioned, the Iranian government's policy is to move away from crude oil exports to the export of non-crude and especially petrochemical products. The policies have been drafted to achieve these objectives by encouraging the private sector to export products; expanding the marketing efforts beyond Iran; improving product quality, packaging, and after sales services; and supporting local export establishments.

In 2006, about 78% of total annual production was exported (Fig. 3), which brought in revenue of about $3 billion; a substantial increase from $35 million in 1990. Although the export values pale in comparison with crude sales, which were about $50 billion in 2006, it is still a substantial contribution, being the second-largest revenue generating sector in Iran.

Massive plans, investments

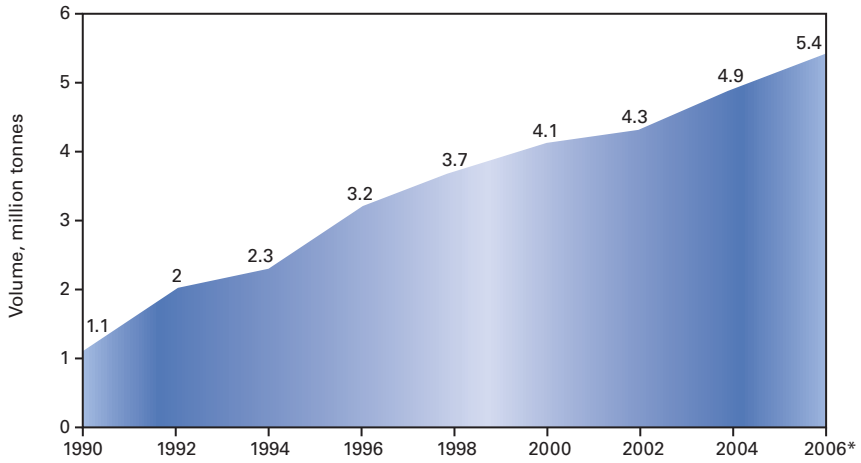
Iran has abundantly inexpensive energy resources. Feed gas, which is currently sold domestically at 20¢/MMbtu, became the main feedstock for petrochemical units. This sector has huge export potential, with investments in the petrochemical industry in Iran growing exponentially.

To accumulate the huge amounts of capital needed for developing the industry, promoting petrochemical export, and transferring modern technology in this field, the Ministry of Petroleum and NIPC introduced measures to package long-term investments more attractively for international companies. To encourage domestic and foreign investors in the petrochemical industry, Iran has provided tax holidays for its petrochemical zones.

Currently, NIPC has appointed domestic and foreign lenders to lead the financing of petrochemical projects. Joint ventures have also been formed to develop the industry; there are currently four foreign joint ventures in Iran's

IRAN PETROCHEMICAL DEMAND

Fig. 2



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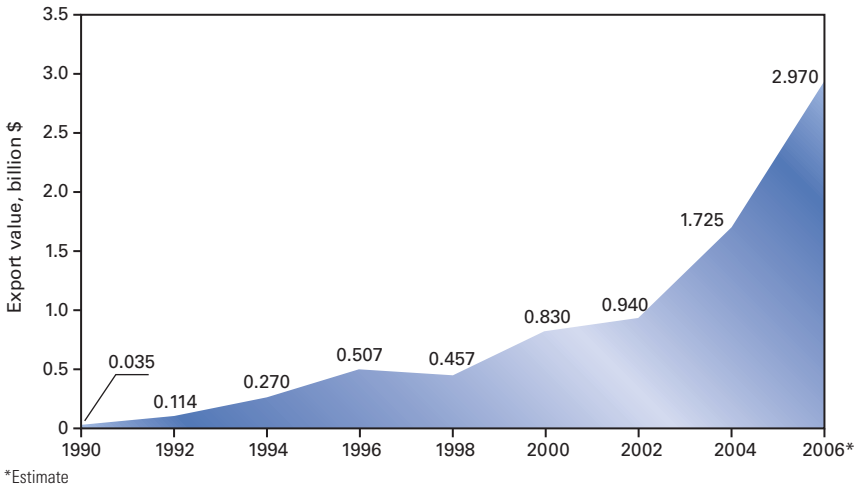
IRAN PETCHEM PROJECTS, PRECOMMISSIONING

Table 1

Project	Expected start-up	Capacity, 1,000 tpy	Progress as of September 2006, % complete
Acetic acid and carbon monoxide	First-quarter 2007	150	99.74
Zagros Petrochemical (4th methanol)	January 2007	1,650	99.15
4th urea and ammonia	First-quarter 2007	1,760	98.00
Laleh Petrochemical (low-density) polyethylene	Second-quarter 2007	300	97.76
Borzuyeh	First-quarter 2007	4,500	97.25
Jam Petrochemical (10th olefin)	Second-quarter 2007	3,707	96.89
2nd polyethylene terephthalate, purified terephthalic acid	First-quarter 2007	750	96.97
1st ammonia (Razi Petrochemical)	Second-quarter 2007	677	95.39
Arya-Sasol Petrochemical (9th olefin)	Second-quarter 2007	1,690	95.24
Karoon Petrochemical (Isocyanates project)	Second-quarter 2007	80	94.10
5th urea and ammonia (Kermanshah)	First-quarter 2007	1,056	95.25
Total		**16,320**	

IRAN PETROCHEMICAL EXPORTS

Fig. 3



*Estimate

WEST ETHYLENE PIPELINE

Fig. 4

petrochemical projects, namely the Olefin No. 9 (NIPC 50%, Sasol 50%), low-density polyethylene unit (NIPC 45%, Pooshineh Baft Co. 25%, and Sabic Euro Petrochemical Co. 30%), isocyanates (NIPC 40%, Chematur Engineering of Sweden 30%, Petroleum Industries Investment Co 20%, Hansa Chemie of Germany 10%), and polyvinyl chloride Hamedan (NIPC 33% , Industrie Generali of Italy 10%, others 57%).

Current investment in Iran's petrochemical industry will bring online during 2007-10 about 27 million tonnes of new capacity for the production of ethylene, propylene, methanol, benzene, ammonia, and urea. More than half (16 million tonnes) of the new capacity will be completed by second-quarter 2007, bringing yet another wave of production and exports (Table 1).

Projects amounting to approximately 10.5 million tonnes, currently being constructed by NIPC and several domestic and international companies will be completed during 2007-10 (Table 2).

West Ethylene Pipeline

A 2,163-km pipeline currently under construction will run from Assaluyeh in the south of Iran to northwest Iran (Fig. 4). The pipeline will transport ethylene to meet the feed requirements of the new ethylene derivative petrochemical complexes in the cities of Gachsaran, Khoramabad, Kermanshah, Sanandaj, and Mahabad.

Construction of the pipeline began in 2003 and is currently 40% complete (targeted for completion in 2009-10). The initial plan for the West Ethylene Pipeline was to transport 1.5 million tonnes for 1,500 km to feed five planned petrochemical complexes. The Iranian Parliament, however, instructed the Petroleum Ministry to build five more complexes in the cities of Andimeshk, Dehdasht, Hamedan, Kermanshah, and Miyandoab as a means to boost production in the less-developed parts of the country. The pipeline's length, therefore, was extended to 2,163 km and capacity increased to 2.8 million tonnes.

Olefin plants in Assaluyeh and the Bandar Imam special economic petrochemical zone in Mahshahr City will supply ethylene, the feedstock for petrochemical complexes in the Western provinces.

Bakhtar Petrochemical Co. which is currently constructing the pipeline is a private joint stock holding company whose shareholders include:

- NIPC 30%.
- Petroleum Ministry Pension Fund 20%.
- Arak Petrochemical Co. 10%.
- Esfahan Petrochemical Co. 5%.
- Bank Melli Investment Co. 5%.
- Social Security Organization Investment Co. 5%.
- National Pension Funds Investment Co. 5%.

- Ghadir Investment Co. 5%.
- Petrochemical Industries Investment Co. 5%.
- Modabber Investment Co. 5%.
- Iran Industrial Development Investment Co. 2.5%.
- Rena Investment Co. 2.5%.

Pars petrochemical port

Iran is currently building the Pars petrochemical port to cope with increasing production and exports. This project consists of 15 jetties; seven for solid products and eight for liquid products.

Currently, the construction status stands at 95% complete with jetty No. 14 in operation, jetty No. 5 near completion, and the rest of the 13 jetties to be completed by yearend 2007. Jetty No. 5 is earmarked for the export of products from Borzuyeh Petrochemical Co.'s aromatic No. 4, while the rest of the jetties will cater to the export of petrochemical products produced in the Pars petrochemical zone.

The port will have an export capacity of 24 million tonnes of liquid products and 6 million tonnes of solid products for a total of 30 million tpy. It can also accommodate tankers and vessels of up to 70,000 deadweight tonnes.

The port currently harbors two ships/month of 44,000-45,000 tonnes of LPG produced from Phases 4 and 5 of the South Pars gas field. Completion of the Pars petrochemical port is scheduled for second-quarter 2007.

Feed-gas requirements

In 2005, petrochemical industry alone consumed around 750 MMscfd (more than 5 million tonnes of LNG equivalent) of fuel and feed gas. Due to massive investment in polyethylene production, there is significant growth potential for gas demand within the country's petrochemical industry during 2007-10.

The Iranian government has included the petrochemical industry as part of its economic development plan, which is categorized into 5 stages—Plans 1 to 5. The economy is currently in Plan 4.

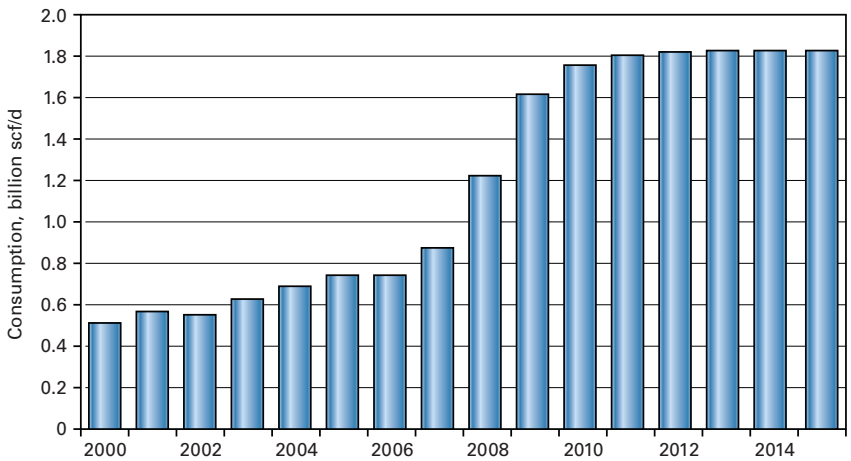
IRAN PETCHEM PROJECTS, UNDER CONSTRUCTION

Table 2

Project	Capacity, 1,000 tpy	Progress as of September 2006, % complete
6th urea and ammonia (Ghadir 2nd urea and ammonia)	1,150	90
Ghadir polyvinyl chloride	120	88
6th methanol (Zagross 2nd methanol)	1,650	84
Polyvinyl chloride (Arvand Petrochemical)	1,500	72
5th olefin (Morvarid Petrochemical)	500	52
13th olefin (Ilam Petrochemical)	750	44
Low-density polyethylene (Amir Kabir Petrochemical)	300	36
High-density polyethylene (Mehr Petrochemical)	300	20
11th olefin (Kavian Petrochemical)	2,000	—
8th urea and ammonia	1,050	—
High-density polyethylene (Kermanshah Petrochemical)	300	18
Linear low-density polyethylene (Mahabad Petrochemical)	300	—
Low-density polyethylene (Lorestan Petrochemical)	300	—
Linear low-density polyethylene (Kordestan Petrochemical)	300	—
Total	**10,520**	

IRAN PETCHEM GAS CONSUMPTION

Fig. 5



Plans 4 and 5 include about $24 billion for the petrochemical industry in which much gas-fed capacity will be brought online: 8 million tpy of ethylene, 1.5 million tpy of propylene, 5.1 million tpy of polymers, 14.8 million tpy of methanol, 760,000 tpy of benzene, 5-8 million tpy of ammonia, and 4-7 million tpy of urea. The country is also actively recruiting outside investors, further emphasizing the significance of using energy resources domestically.

Because most of the plants will be gas-based, gas supplies will be diverted away from exports. This further emphasizes our view that Iran will continue to see escalating domestic gas demand and, therefore, less gas available for LNG exports. The demand for natural gas for the Iran petrochemicals should reach 1.8 billion scfd (13 million tonnes of LNG equivalent) by 2015 (Fig. 5).

Many of these projects are based on borrowed capital and in the event that export markets suffer, debt servicing

may become an issue.

The philosophy behind the explosive petrochemical projects is to carve a major niche for Iran in the international petrochemical market. Presumably, these projects will force the projects in the consuming countries out of business, due to expensive gas or naphtha. Although this theory may prove correct in the long run, consumer countries may retaliate by imposing tariffs and punitive dumping regulations to protect their own industries. This may prove to be a risky strategy, but one that will transform the global petrochemical industry.

It is highly likely that newer projects will have to buy feed gas at higher prices—about 50¢/MMbtu. Iran watches the Saudi market closely; when Saudi Arabia raised its feed-gas pries to 75¢/MMbtu, Iran planned to do the same.

In addition, with international prices paid for condensate at Borzuyeh, there is pressure to increase domestic gas prices. But the price hikes are being put on hold to encourage industry development.

Meanwhile, although Iran cannot easily increase prices, it will experience continual pressure to do so, especially because the Saudis are trying to raise feed-gas prices for future projects given the shortage of gas. It is, however, understood that even if the Iranians raised the feed-gas price to $1.00-1.30/MMbtu, new projects will be economical, although less attractive, compared with the Saudis who currently charge less at 75¢/MMbtu. ✦

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New API publication gives IM guidance

Carl Mikkola
Enbridge Energy Partners LP
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API Publication 353, released in November 2006, provides an organized approach to facility integrity management and provides examples of two different methods for performing a risk assessment. This article provides further guidance regarding weighting a risk assessment to reflect the core beliefs and corporate factors that affect a company's decision making. It also presents guidance on the ranking and prioritization of risks inherent in any integrity-management program.

API Publication 340 provides a list of control measures a company may use to reduce the risks inherent in operating its facilities.

Background

Risk management or integrity management provides the means to improve decision making by objectively defining the type and magnitude of the risks at facilities. It provides the tools to reduce the risks to the environment, population, and business from potential releases by applying mitigation strategies to those risks deemed by management to be unacceptably high.

Implementation of an overall integrity management plan designed to establish procedures and processes to identify, assess, analyze, mitigate, and manage the inherent risks in operating facilities accomplishes the provisions of these tools.

A risk assessment is the cornerstone of a program to identify, quantify and mitigate the likelihood of failure (LOF) and the consequences of failure (COF) from a specific piece of equipment (e.g., tank, piping, loading area) or from a specific operation.

API developed Publication 353, "Managing Systems Integrity of Terminal and Tank Facilities, Managing the Risk of Liquid Petroleum Releases," to guide management of terminal and tank facilities in a manner allowing for cost-effective protection of the environment and safety of workers and the public. It is intended for petroleum terminal and tank facilities associated with marketing, pipeline, and other similar facilities covered by API Standard 2610, and may be used as a resource and management guide by those responsible for, or working at, such facilities.

The document presents an industry approach to the management practices necessary to implement principles of risk management and risk assessment at terminal and tank operations. It is intended to be consistent with, but not a substitute for, any applicable local, state, or federal regulations.

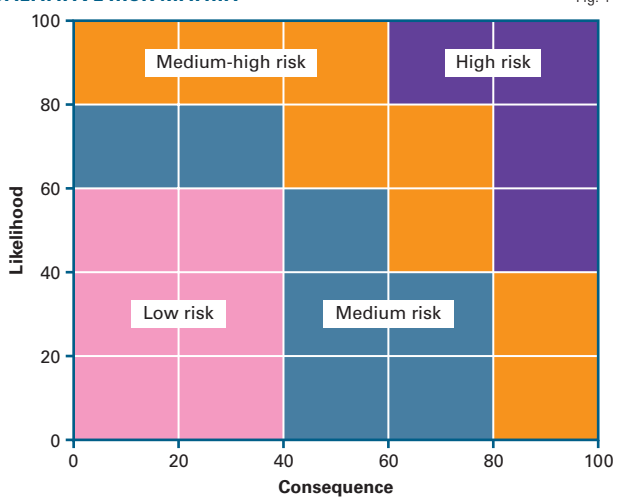
API Publication 353 provides an overall approach for risk management at aboveground liquid storage facilities. It describes the process elements that a user would need to follow to develop a risk management program at a facility, while at the same time providing flexibility to develop unique corporate risk-management programs.

Publication 353 does not require the user to proscriptively apply the programs and procedures it outlines. Instead it offers guidance by consolidating in one place the information necessary for a user to develop a program. Discussion of the principles of risk management, the elements of an integrity management program, the different approaches to risk assessment, the methods for risk prioritization, and mitigation of risk through application of risk-based decision making accomplish this goal.

API Publication 353 serves as an extension of an earlier document, API

QUALITATIVE RISK MATRIX

Fig. 1



Publication 340. It therefore provides examples on mitigation of risk through selection of available control technologies presented in API Publication 340.

API Publication 353 addresses the major equipment at petroleum facilities, including aboveground and belowground piping, loading and unloading areas, aboveground storage tanks, and ancillary facility equipment.

This article discusses, as an example, one approach to computing the risk of a tank release using an approach described in API Publication 353. This article does not discuss in detail other aspects of a formal facility integrity management plan; e.g., integrity assessment plans, performance measures plans, etc.

This article's approach can also compute the risk of releases from other facility equipment, including aboveground and belowground piping, or loading and unloading areas.

Risk concepts

Risk is the product of two factors: likelihood and consequence. Risk analysis evaluates two factors for discrete events: the likelihood of a specific event occurring (e.g., likelihood of a tank overfill) and the consequences of that event occurring.

Several different ways exist for displaying the results of this analysis. Two common approaches for computing risk are the qualitative approach and the quantitative approach.

The qualitative approach uses categorical values for likelihood and consequences. It could, for example, describe the likelihood of a tank overfill relatively as a 60% likelihood of occurrence when compared to other specific events. It could also describe the consequences of this event relatively as a 50% impact when compared to other specific events.

This approach uses variables defined categorically by the user. These values can be weighted numerical values or descriptive tags such as low, medium, and high. Analyzing these variables systematically develops a categorical result for overall risk for the specific event (e.g., low, medium, high).

Fig. 1 illustrates a qualitative risk matrix used to display risk results for different events using this approach.

The quantitative approach to computing risk uses specific numeric values for likelihood and consequences. This approach requires that specific numerical values be developed for each event. For example, for Event 1—Tank Overfill, the likelihood could be expressed as 1.0×10^{-4} events/tank fill/year/tank. The consequences of this event could be expressed as an $80,000 average cost for lost product, business effects, and environmental costs.

Fig. 2 illustrates a quantitative risk matrix for displaying risk results for different events using this approach.

A formal analysis of specific facility risks provides a means to measure the potential loss in terms of both the incident likelihood of occurrence and the magnitude of the consequences. Individuals can then use this analysis to create and manage facility integrity.

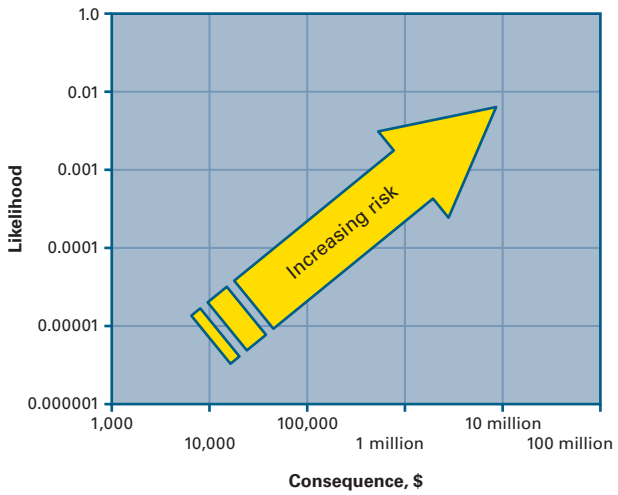
Integrity overview

A formal integrity management program (IMP) consists of a comprehensive suite of individual programs that work together to reduce or mitigate risks to the potentially affected local population (population risk), environment (environmental risk) and company (business risk).

A risk-assessment plan identifies the likelihood of failure and consequence of failure variables used in performing

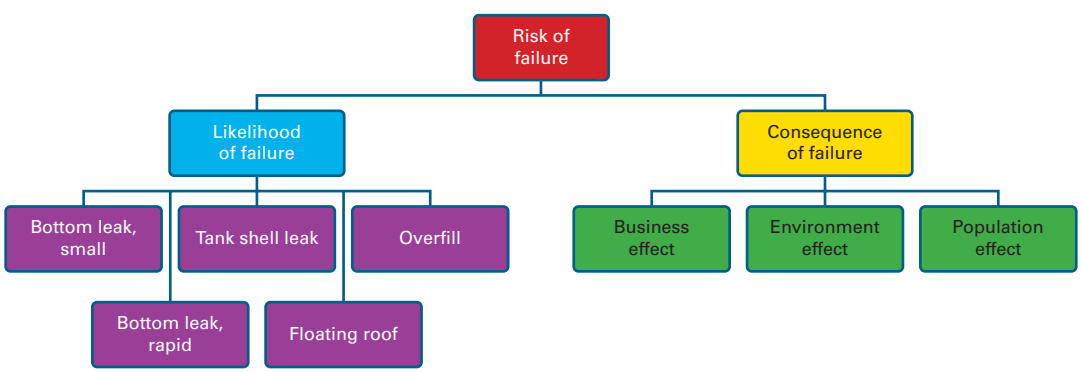
QUANTITATIVE RISK ANALYSIS

Fig. 2



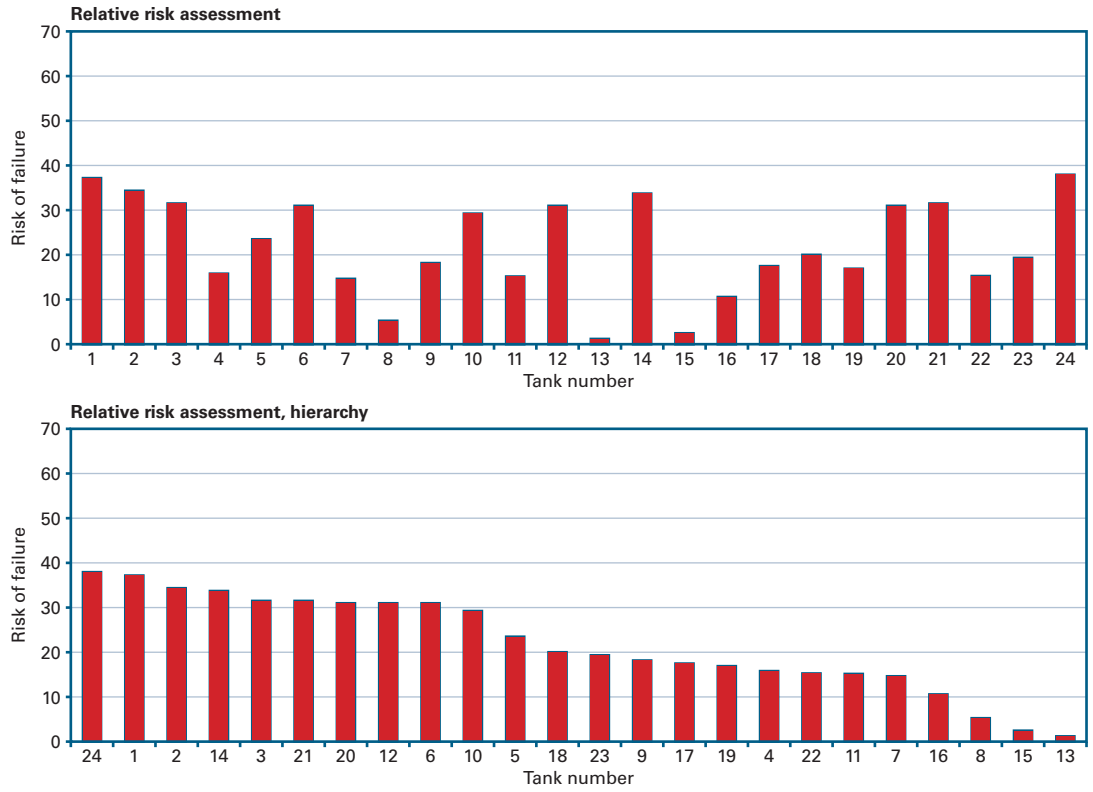
RISK ALGORITHM

Fig. 3



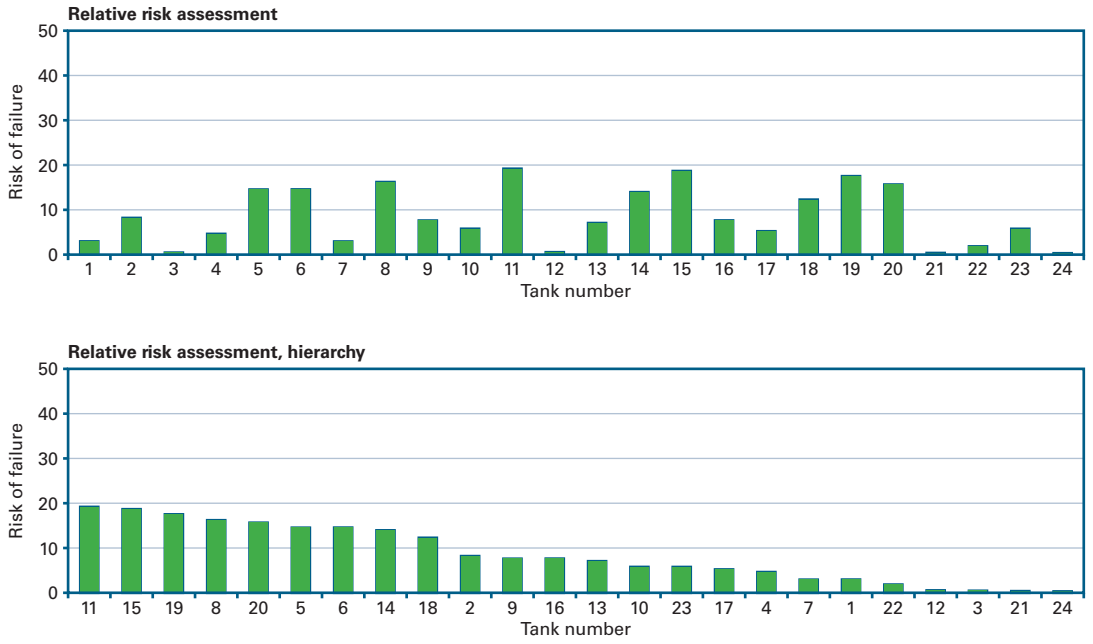
TANK HOSE FAILURE RISK

Fig. 4



TANK OVERFILL RISK

Fig. 5



the risk assessment. It includes a plan for collecting and reviewing applicable system design, construction, operations, and integrity data and a plan for integrating this information into a risk model to analyze risk. Results of the risk analysis can guide the allocation of resources and the development of other plans aimed at reducing risk.

The integrity assessment plan evaluates the structural reliability of a pipeline, tank, pressure vessel, and piping system using integrity verification methods such as planned and documented inspections, hydrostatic testing, or other methods of inspection, testing, or evaluation.

Assessments using inspection or equivalent technology will likely generate lists of conditions that are likely to affect population, environment, or business. These conditions may require repair or monitoring to help improve protection of the public and environment. The repair and remediation plan specifies which conditions are to be repaired and within what time period these repairs are to be made. The plan includes:

- Review and analysis of assessment results.
- Qualification of personnel evaluating assessment results.
- Discovery of conditions leading to repair.

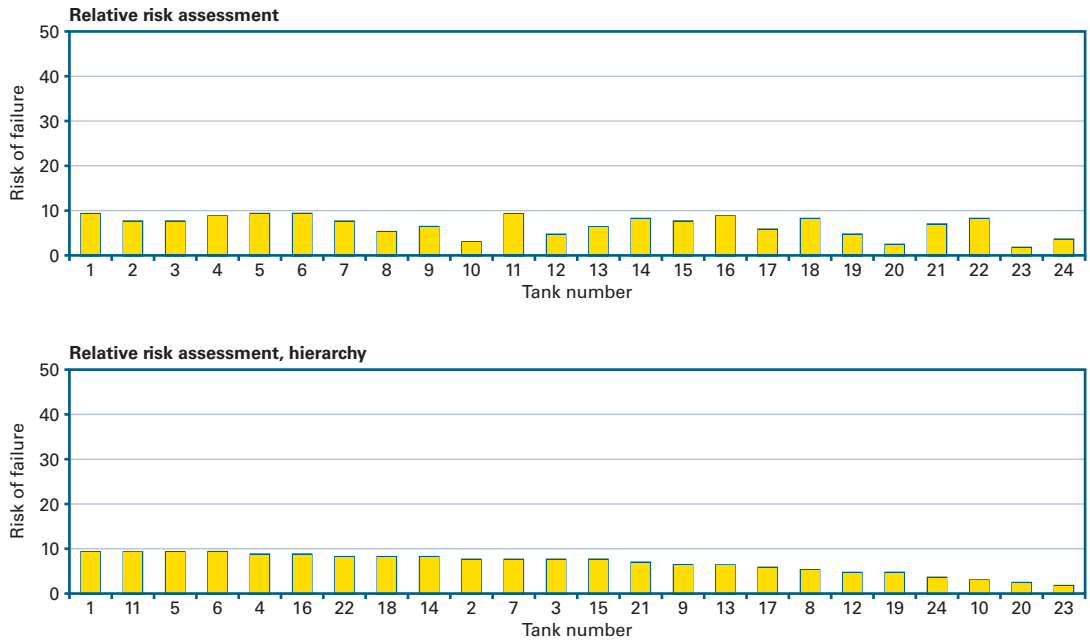
• Evaluation of repair results.
• Repair-remediation scheduling requirements.
• Repair-remediation criteria.
• Repair methods.
• Permitting and access requirements.
• Documentation requirements.
• Alterations to the plan based upon implementation feedback.

The reassessment plan involves integrity evaluations on the system; e.g., tank, piping, etc. Results of the evaluation support any reranking of these systems for assessment. The reranking will determine if a reassessment is warranted.

Trending and analysis of data gathered through integrity activities can improve the effectiveness of assessment plans. Key trends will provide guidance for plan development and will assist in the scheduling of integrity management activities.

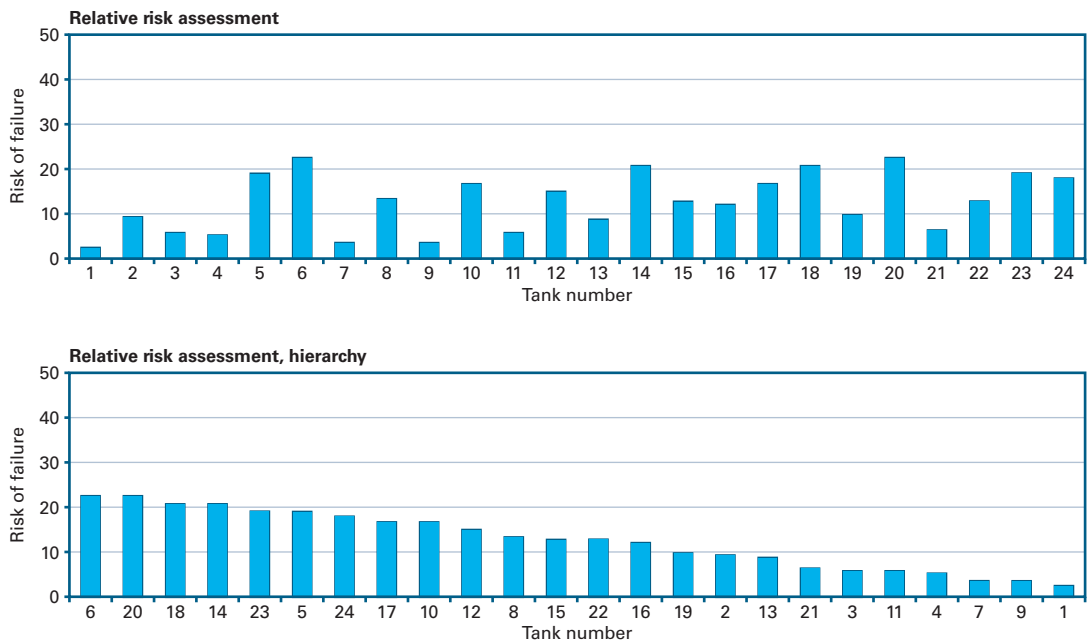
TANK SHELL FAILURE RISK

Fig. 6



TANK BOTTOM FAILURE RISK

Fig. 7



The prevention plan looks at preventative and mitigative measures available to mitigate risk by reducing the likelihood of failure and-or consequence of failure; e.g. development of assessment and repair plans, corrosion mitigation plans, improved training, or a combination of these or other approaches.

The performance measures plan evaluates IMP performance and helps the company ask performance-based questions.

Performance measures fall into three groups:

• Process measures evaluate prevention or mitigation activities.
• Operational measures assess how well the system is responding to the IMP.
• Direct measures rely on actual field data and include lagging and leading

TANK FAILURE, COMBINED RISK

Fig. 8

indicators, which are reactive and proactive, respectively, to IMP performance.

A lagging indicator, for example, could be the number of tank roof drain hose failures and a leading indicator could be measurement and trending of cathodic protection potential.

The quality control plan (QCP) provides documented confirmation that the company is meeting the requirements of its IMP. The requirements of a QCP include auditing the documentation, implementation, and maintenance of the IMP.

The management of change plan identifies and considers the effect of proposed changes to the systems and their potential effect on system integrity.

A management of change process includes:

- Reason for the change.
- Authority for approving changes.
- Analysis of the implications of the change.
- Acquisition of required permits.
- Communication of the change.
- Time limitations for the change.
- Qualification of staff performing the review and implementing the change.

The documentation plan compiles a list of documentation required to fully implement the IMP, including type of documentation required, the location(s) of the records, responsibility for completion of documentation, and frequency of any required updates.

The communications plan keeps appropriate company personnel, jurisdictional authorities, and the public informed about the company's efforts to help ensure the safety of the public and protection of the environment through its IMP activities.

Risk assessment

Performing a risk assessment provides a starting point for decision making in the facility integrity-management program. Risk assessments can follow many different forms and level of detail.

This section presents a relative risk approach to managing systems integrity of aboveground storage tanks, similar to the approach presented in API Publication 353.

In this approach, an individual or group of people with experience in risk analysis and knowledge of data pertaining to the facility assign scores. This example uses a facility aboveground storage tank as the object of a formal risk assessment.

Fig. 3 illustrates the approach used

EQUATIONS

$LOF_{tank\#}$ = Σ [of the individual tank failure events]
or
$LOF_{tank\#}$ = Σ [bottom leak (small) category score + bottom leak (rapid) category score + tank shell category score + floating roof category score + overfill category score] (1)

Bottom leak (small) category score = category weighting × Σ (subcategory weighting × subcategory score) + (subcategory weighting × subcategory score) +...] (2)

Bottom leak (rapid) category score = category weighting × Σ [(subcategory weighting × subcategory score) + (subcategory weighting × subcategory score) +...] (3)

Tank shell category score = category weighting × Σ (subcategory weighting × subcategory score) + (subcategory weighting x subcategory score) +...] (4)

Floating roof leak category score = category weighting × Σ [(subcategory weighting × subcategory score) + (subcategory weighting × subcategory score) +...] (5)

Overfill category score = category weighting × Σ [(subcategory weighting × subcategory score) + (subcategory weighting × subcategory score) +...] (6)

$COF_{tank\#}$ = Σ [of the individual consequences of a tank failure]
or
$COF_{tank\#}$ = Σ [impact to population category score + impact to environment category score + impact to business category score] (7)

Effect to population category score = category weighting × Σ [(subcategory weighting × subcategory score) + (subcategory weighting × subcategory score) +...] (8)

Effect to environment category score = category weighting × Σ [(subcategory weighting × subcategory score) + (subcategory weighting × subcategory score) +...] (9)

Effect to business category score = category weighting × Σ [(subcategory weighting × subcategory score) + (subcategory weighting × subcategory score) +...] (10)

RoF = RoF (bottom failure) + RoF (tank shell leak) + RoF (roof drain leak) + RoF (overfill) (11)

RoF (bottom failure) = [SUM(category score (small bottom leak + rapid bottom leak)] × SUM[category score (effect to population + effect to environment + effect to business)] (12)

RoF (tank shell leak) = category score (tank shell leak) × SUM[category score (effect to population + effect to environment + effect to business)] (13)

RoF (roof drain leak) = category score (roof drain leak) × SUM[category score (effect to population + effect to environment + effect to business)] (14)

RoF (overfill) = category score (overfill) × SUM[category score (effect to population + effect to environment + effect to business)] (15)

in computing the risk of a tank release. This illustration divides the likelihood of failure into different release scenarios (events).

It likewise divides the consequence of failure into different types of consequences.

To calculate the likelihood of failure, the user needs to develop or rely on data from others for the likelihood (probability) of a specific event occurring. API Publication 353 provides two methods for determining the likelihood of failure.

In Appendix A, for a tank release, Equation 1 (see equation box) expresses the LOF.

Users can apply API Publication 353 Appendix A or Appendix B methods, or they can develop any defendable approach that meets their needs.

The example used here—the LOF of an aboveground storage tank—applies a modification to the API Publication 353 Appendix A method.

This example illustrates an algorithm that applies a user-defined weighting factor to each category and subcategory for a specific event.

Equations 2-6 calculate the LOF of each category.

In this example, the user can define or apply a weighting factor to each subcategory and category. The application of the weighting factors allows the user to reflect the company's operating experience and core values or tolerances to certain types of risks.

In order to calculate the COF, the user also needs to develop or rely on information from others for the consequences of a specific event occurring. API Publication 353 provides two methods for determining the COF. The user, however, can develop any defendable approach that meets its needs.

Equation 7 expresses API Publication 353 Appendix A COF for a tank release.

The example in this article computes the COF of an aboveground storage tank using an algorithm that allows a user to apply weighting factors to each category or subcategory for a specific event.

Equations 8-10 express the approach for computing the COF of an aboveground storage tank using these weighting factors.

Application of the weighting factors allows the user to reflect the company's operating experience and core values or tolerances to certain types of risks.

The risk of failure is the product of the LOF and the COF. Equation 11 represents the overall risk of failure of an aboveground storage tank. Equations 12-15 express the specific risks for each scenario.

Risk results

Many ways of presenting the results of a risk analysis are available. Data can be looked at individually or in total. The organization and presentation of the data will depend upon the ultimate use of the data.

One method helpful in prioritizing maintenance, inspection, and mitigation

activities is performance of a relative-risk ranking. This approach compares the risk of failure of each system to that of every other system at that facility, providing perspective on which system is at higher risk than another. A tank farm with multiple tanks could rank the various risks for specific events and then organize them to reveal the higher risk tanks.

Figs. 4-7 illustrate this approach for each tank-release event. Fig. 8 illustrates how the individual events can be combined to show a total risk of failure with respect to each system at that facility.

A similar approach can be used for piping systems, loading and unloading areas, and ancillary facility equipment. ✦

Bibliography

API Publication 340, Liquid Release Prevention Measures for Terminal and Tank Facilities, October 1997.

API Publication 353, Managing Systems Integrity of Tank and Terminal Facilities, Managing the Risk of Liquid Petroleum Releases, November 2006.

The authors

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Joe Burke is the president of SPEC Consulting LLC. He has more than 20 years' experience in the design, operation, and inspection of terminal and tank facilities. He has worked extensively in the petrochemical field, designing, inspecting, and auditing terminal and tank facilities. He serves as a consultant and technical writer to the oil industry and has developed several industry standards and publications. Burke holds a BS in civil-ocean engineering from the University of Rhode Island and an ME in civil engineering from Rensselaer Polytechnic Institute, Troy, NY. He is a licensed professional engineer in more than 20 states and US territories and is a board certified safety professional in engineering aspects.

Weld purge monitor complies with RoHS directive

Following changes to the procedures and materials used in the production of weld purge monitors, this firm says its MkV weld purge monitor meets the requirement for restriction of hazardous substances (RoHS) compliance.

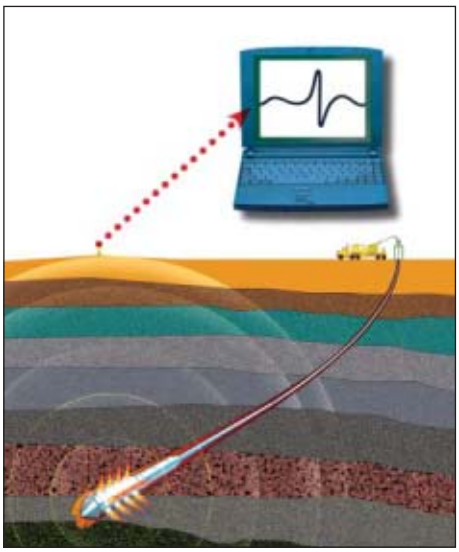
The 2006 directive from the European Parliament, which went into effect on July 1 last year, relates to restrictions on the use of certain hazardous substances in electrical and electronic equipment.

Source: **Huntingdon Fusion Techniques Ltd.**, Stukeley Meadow, Burry Port, Carmarthenshire, SA16 0BU, UK.

New tool detects, records downhole perforation shots

The new Gun Shot is a wireless system that detects and records the sound of perforation shots made downhole.

The self-contained system records the sound of perforation shots downhole that normally can't be heard at the surface. It then transfers the readings produced to a file located on the technician's laptop.



The system's on-board memory stores data and prevents it from being lost in the event of a power failure or radio transmission problem. Its cable-free feature also means that the data are of high integrity, as there is no risk of losing data as the result of damage to cables.

The system makes it possible to detect readings as low as 10 hz, which is suited for perforating. It then records these signals into a sound file on the technician's laptop where they can be played back, printed, and signed off.

Because the system is wireless, it is simple and quick to install. To install and operate the system, the user simply stabs the geophone into the ground, switches it on, heads over to the receiving unit, and begins logging data.

Source: **AnTech Ltd.**, Unit 7, Newbery Centre, Airport Business Park, Exeter, EX5 2UL, England, UK.

API IMPORTS OF CRUDE AND PRODUCTS

	Districts 1-4		District 5		Total US		
	3-16 2007	[1]3-9 2007	3-16 2007	[1]3-9 2007	3-16 2007	[1]3-9 2007	3-17 2006
	1,000 b/d						
Total motor gasoline	335	321	42	0	377	321	362
Mo. gas. blending comp.	382	562	94	78	476	640	328
Distillate[2]	316	295	46	52	362	347	252
Residual	334	255	84	43	418	298	194
Jet fuel-kerosine	80	68	84	274	164	342	194
LPG	199	284	3	1	202	285	291
Unfinished oils	453	586	17	101	470	687	590
Other	421	277	9	99	430	376	392
Total products	**2,520**	**2,648**	**379**	**648**	**2,899**	**3,296**	**2,603**
Canadian crude	1,533	1,580	103	89	1,636	1,669	1,523
Other foreign	7,848	7,678	679	744	8,527	8,422	8,196
Total crude	**9,381**	**9,258**	**782**	**833**	**10,163**	**10,091**	**9,719**
Total imports	**11,901**	**11,906**	**1,161**	**1,481**	**13,062**	**13,387**	**12,322**

[1]Revised. [2]Includes No. 4 fuel oil.
Source: American Petroleum Institute.
Data available in OGJ Online Research Center.

Additional analysis of market trends is available through **OGJ Online**, *Oil & Gas Journal's* electronic information source, at http://www.ogjonline.com.

OIL&GAS JOURNAL online research center

OGJ CRACK SPREAD

	*3-16-07	*3-17-06	Change	Change, %
	$/bbl			
SPOT PRICES				
Product value	76.58	75.57	1.01	1.3
Brent crude	60.75	62.23	–1.48	–2.4
Crack spread	15.83	13.34	2.49	18.6
FUTURES MARKET PRICES				
One month				
Product value	76.60	76.25	0.35	0.5
Light sweet crude	57.93	62.68	–4.75	–7.6
Crack spread	18.67	13.57	5.10	37.5
Six month				
Product value	76.22	76.92	–0.70	–0.9
Light sweet crude	63.56	66.65	–3.09	–4.6
Crack spread	12.66	10.27	2.39	23.3

*Average for week ending
Source: Oil & Gas Journal.
Data available in OGJ Online Research Center.

API CRUDE AND PRODUCT STOCKS

	Crude oil	Motor gasoline		Jet fuel	Fuel oils		Unfinished oils
		Total	Blending comp.[1]	Kerosine	Distillate	Residual	
	1,000 bbl						
PAD I	14,836	54,097	26,375	9,393	45,309	13,880	7,596
PAD II	71,891	50,576	16,183	7,684	27,807	1,536	14,402
PAD III	174,154	65,842	28,335	12,783	34,193	16,454	44,345
PAD IV	13,905	6,483	1,842	502	3,380	442	2,689
PAD V	[1]54,571	27,696	20,911	8,255	12,653	6,115	21,276
Mar. 16, 2007	**[1]329,357**	**204,694**	**93,646**	**38,617**	**123,342**	**38,427**	**90,308**
Mar. 9, 2007[3]	**323,692**	**203,941**	**92,386**	**39,433**	**123,510**	**38,509**	**90,838**
Mar. 17, 2006	**338,112**	**217,470**	**83,386**	**42,552**	**126,297**	**38,182**	**89,285**

[1]Included in total motor gasoline. [2]Includes 3.745 million bbl of Alaskan crude in transit by water. [3]Revised.
Source: American Petroleum Institute.
Data available in OGJ Online Research Center.

API REFINERY REPORT—MAR. 16, 2007

	REFINERY OPERATIONS					REFINERY OUTPUT			
	Total refinery input	Crude runs	Input to crude stills	Operable capacity	Percent operated	Total motor gasoline	Jet fuel, kerosine	Fuel oils: Distillate	Fuel oils: Residual
District	1,000 b/d								
East Coast	3,004	1,199	1,217	1,618	75.2	1,486	67	531	141
App. Dist. 1	75	69	70	95	73.7	34	0	16	0
Dist. 1 total	**3,079**	**1,268**	**1,287**	**1,713**	**75.1**	**1,520**	**67**	**547**	**141**
Ind., Ill., Ky.	2,177	2,061	2,172	2,355	92.2	1,186	146	572	31
Minn., Wis., Dak.	360	355	356	442	80.5	284	27	119	10
Okla., Kan., Mo.	670	565	573	786	72.9	382	29	200	2
Dist. 2 total	**3,207**	**2,981**	**3,101**	**3,583**	**86.6**	**1,852**	**202**	**891**	**43**
Inland Texas	927	576	612	647	94.6	459	34	172	6
Texas Gulf Coast	3,809	3,461	3,536	4,031	87.7	1,381	298	907	216
La. Gulf Coast	3,393	3,121	3,192	3,264	97.8	1,327	414	881	141
N. La. and Ark.	225	179	188	215	87.4	99	11	48	5
New Mexico	156	94	94	113	83.2	110	0	34	0
Dist. 3 total	**8,510**	**7,431**	**7,622**	**8,270**	**92.2**	**3,376**	**757**	**2,042**	**368**
Dist. 4 total	**665**	**551**	**551**	**596**	**92.5**	**263**	**23**	**159**	**14**
Dist. 5 total	**2,570**	**2,179**	**2,376**	**3,173**	**74.9**	**1,626**	**306**	**476**	**96**
Mar 16, 2007	**18,031**	**14,410**	**14,937**	**17,335**	**86.2**	**8,637**	**1,355**	**4,115**	**662**
Mar. 9, 2007*	**18,276**	**14,369**	**14,917**	**17,335**	**86.1**	**8,601**	**1,398**	**3,908**	**643**
Mar. 17, 2006	**16,917**	**14,731**	**14,944**	**17,115**	**87.3**	**8,078**	**1,415**	**3,787**	**669**

*Revised.
Source: American Petroleum Institute.
Data available in OGJ Online Research Center.

Statistics

OGJ GASOLINE PRICES

	Price ex tax 3-14-07	Pump price* 3-14-07	Pump price 3-15-06
	¢/gal		
(Approx. prices for self-service unleaded gasoline)			
Atlanta	211.7	251.4	234.2
Baltimore	207.8	249.7	232.2
Boston	205.1	247.0	226.8
Buffalo	205.3	265.4	243.2
Miami	216.6	266.9	252.3
Newark	207.8	240.7	218.8
New York	197.6	257.7	244.3
Norfolk	201.9	239.5	224.5
Philadelphia	213.9	264.6	241.0
Pittsburgh	202.9	253.6	232.0
Wash., DC	214.1	252.5	245.8
PAD I avg.	207.7	253.5	235.9
Chicago	225.7	276.6	265.9
Cleveland	201.1	247.5	236.6
Des Moines	202.3	242.7	229.5
Detroit	204.4	253.6	240.8
Indianapolis	205.7	250.7	243.1
Kansas City	205.9	241.9	225.8
Louisville	210.6	247.5	237.6
Memphis	199.8	239.6	227.0
Milwaukee	201.5	252.8	242.7
Minn.-St. Paul	210.2	250.6	241.5
Oklahoma City	205.3	240.7	224.5
Omaha	206.1	252.5	238.1
St. Louis	204.9	240.9	220.7
Tulsa	203.2	238.6	225.0
Wichita	199.6	243.0	230.9
PAD II avg.	205.8	248.0	235.3
Albuquerque	208.9	245.3	238.4
Birmingham	201.7	240.4	227.7
Dallas-Fort Worth	203.2	241.6	235.0
Houston	200.9	239.3	227.7
Little Rock	201.3	241.5	227.0
New Orleans	203.1	241.5	235.6
San Antonio	194.4	232.8	224.3
PAD III avg.	201.9	240.3	230.8
Cheyenne	195.1	227.5	217.4
Denver	201.1	241.5	227.6
Salt Lake City	187.1	230.0	224.9
PAD IV avg.	194.5	233.0	223.3
Los Angeles	246.9	305.4	260.1
Phoenix	220.0	257.4	234.8
Portland	238.2	281.5	235.1
San Diego	254.1	312.6	266.1
San Francisco	273.8	332.3	260.1
Seattle	229.3	281.7	242.9
PAD V avg.	243.7	295.1	249.9
Week's avg.	**210.2**	**253.8**	**235.9**
Feb. avg.	**184.4**	**228.0**	**229.6**
Jan. avg.	**181.7**	**225.3**	**227.3**
2007 to date	**187.4**	**231.0**	—
2006 to date	**187.0**	**229.4**	—

*Includes state and federal motor fuel taxes and state sales tax. Local governments may impose additional taxes.
Source: Oil & Gas Journal.
Data available in OGJ Online Research Center.

REFINED PRODUCT PRICES

	3-9-07 ¢/gal		3-9-07 ¢/gal
Spot market product prices			
Motor gasoline (Conventional-regular)		Heating oil No. 2	
New York Harbor	186.75	New York Harbor	171.22
Gulf Coast	178.75	Gulf Coast	167.09
Los Angeles	237.50	Gas oil	
Amsterdam-Rotterdam-Antwerp (ARA)	173.51	ARA	170.57
Singapore	184.52	Singapore	174.76
Motor gasoline (Reformulated-regular)		Residual fuel oil	
New York Harbor	189.00	New York Harbor	99.71
Gulf Coast	178.75	Gulf Coast	100.00
Los Angeles	248.50	Los Angeles	131.92
		ARA	98.75
		Singapore	111.81

Source: DOE Weekly Petroleum Status Report.
Data available in OGJ Online Research Center.

BAKER HUGHES RIG COUNT

	3-16-07	3-17-06
Alabama	2	3
Alaska	10	10
Arkansas	45	20
California	30	37
Land	28	31
Offshore	2	6
Colorado	96	82
Florida	0	0
Illinois	0	0
Indiana	1	0
Kansas	15	5
Kentucky	10	6
Louisiana	192	179
N. Land	58	57
S. Inland waters	25	19
S. Land	41	37
Offshore	68	66
Maryland	0	0
Michigan	2	2
Mississippi	16	8
Montana	21	24
Nebraska	0	0
New Mexico	72	97
New York	8	3
North Dakota	30	28
Ohio	13	2
Oklahoma	185	165
Pennsylvania	15	15
South Dakota	1	0
Texas	825	696
Offshore	6	14
Inland waters	1	3
Dist. 1	28	18
Dist. 2	33	22
Dist. 3	56	64
Dist. 4	95	69
Dist. 5	158	120
Dist. 6	123	113
Dist. 7B	44	35
Dist. 7C	56	37
Dist. 8	104	74
Dist. 8A	28	29
Dist. 9	29	29
Dist. 10	64	69
Utah	39	38
West Virginia	29	26
Wyoming	74	98
Others—ID-1; NV-2; TN-4; VA-2	9	2
Total US	**1,740**	**1,546**
Total Canada	**409**	**658**
Grand total	**2,149**	**2,204**
Oil rigs	282	249
Gas rigs	1,453	1,295
Total offshore	76	86
Total cum. avg. YTD	**1,732**	**1,512**

Rotary rigs from spudding in to total depth.
Definitions, see OGJ Sept. 18, 2006, p. 46.

Source: Baker Hughes Inc.
Data available in OGJ Online Research Center.

SMITH RIG COUNT

Proposed depth, ft	3-16-07 Rig count	3-16-07 Percent footage*	3-17-06 Rig count	3-17-06 Percent footage*
0-2,500	69	4.3	55	3.6
2,501-5,000	109	60.5	110	40.9
5,001-7,500	227	22.0	210	14.7
7,501-10,000	427	3.2	322	2.4
10,001-12,500	421	3.5	358	1.6
12,501-15,000	271	0.3	274	—
15,001-17,500	106	1.8	118	0.8
17,501-20,000	77	—	73	—
20,001-over	32	—	19	—
Total	**1,739**	**8.6**	**1,539**	**6.0**
INLAND	44		40	
LAND	1,637		1,437	
OFFSHORE	58		62	

*Rigs employed under footage contracts.
Definitions, see OGJ, Sept. 18, 2006, p. 42.

Source: Smith International Inc.
Data available in OGJ Online Research Center.

OGJ PRODUCTION REPORT

	[1]3-16-07	[2]3-17-06
	1,000 b/d	
(Crude oil and lease condensate)		
Alabama	18	21
Alaska	779	800
California	680	684
Colorado	51	60
Florida	6	6
Illinois	30	28
Kansas	94	91
Louisiana	1,367	1,194
Michigan	14	14
Mississippi	52	46
Montana	91	98
New Mexico	163	157
North Dakota	100	105
Oklahoma	170	172
Texas	1,340	1,289
Utah	43	45
Wyoming	140	142
All others	63	71
Total	**5,201**	**5,023**

[1]OGJ estimate. [2]Revised.

Source: Oil & Gas Journal.
Data available in OGJ Online Research Center.

US CRUDE PRICES

$/bbl*	3-16-07
Alaska-North Slope 27°	44.93
South Louisiana Sweet	58.25
California-Kern River 13°	45.85
Lost Hills 30°	53.75
Wyoming Sweet	53.11
East Texas Sweet	55.25
West Texas Sour 34°	47.65
West Texas Intermediate	53.75
Oklahoma Sweet	53.75
Texas Upper Gulf Coast	50.50
Michigan Sour	46.75
Kansas Common	52.50
North Dakota Sweet	46.75

*Current major refiner's posted prices except North Slope lags 2 months. 40° gravity crude unless differing gravity is shown.

Source: Oil & Gas Journal.
Data available in OGJ Online Research Center.

WORLD CRUDE PRICES

$/bbl[1]	3-9-07
United Kingdom-Brent 38°	60.74
Russia-Urals 32°	56.84
Saudi Light 34°	57.07
Dubai Fateh 32°	58.63
Algeria Saharan 44°	62.69
Nigeria-Bonny Light 37°	63.47
Indonesia-Minas 34°	62.38
Venezuela-Tia Juana Light 31°	56.34
Mexico-Isthmus 33°	56.23
OPEC basket	59.54
Total OPEC[2]	58.30
Total non-OPEC[2]	57.72
Total world[2]	58.04
US imports[3]	55.53

[1]Estimated contract prices. [2]Average price (FOB) weighted by estimated export volume. [3]Average price (FOB) weighted by estimated import volume.

Source: DOE Weekly Petroleum Status Report.
Data available in OGJ Online Research Center.

US NATURAL GAS STORAGE[1]

	3-9-07	3-2-07	Change
	Bcf		
Producing region	564	586	–22
Consuming region east	728	820	–92
Consuming region west	224	225	–1
Total US	**1,516**	**1,631**	**–115**
	Dec. 06	**Dec. 05**	**Change, %**
Total US[2]	**3,070**	**2,635**	**16.5**

[1]Working gas. [2]At end of period.
Note: Current data not available.
Source: Energy Information Administration
Data available in OGJ Online Research Center

World oil balance

	2006 3rd qtr.	2006 2nd qtr.	2006 1st qtr.	2005 4th qtr.	2005 3rd qtr.	2005 2nd qtr.
	Million b/d					
DEMAND						
OECD						
US & Territories	21.15	20.88	20.76	21.16	21.24	21.02
Canada	2.27	2.14	2.18	2.26	2.28	2.24
Mexico	1.99	2.02	2.08	2.10	2.06	2.11
Japan	4.81	4.78	5.96	5.46	5.03	4.94
South Korea	2.02	2.03	2.28	2.23	2.01	2.07
France	1.95	1.89	2.10	1.96	2.00	1.93
Italy	1.66	1.63	1.86	1.78	1.68	1.69
United Kingdom	1.76	1.81	1.90	1.84	1.82	1.79
Germany	2.71	2.55	2.56	2.63	2.75	2.55
Other OECD Europe	7.36	7.16	7.35	7.49	7.30	7.22
Australia & New Zealand	1.07	1.06	1.06	1.10	1.04	1.06
Total OECD	**48.75**	**47.95**	**50.09**	**50.01**	**49.21**	**48.62**
NON-OECD						
China	7.39	7.34	7.15	7.14	6.93	6.89
FSU	4.39	4.15	4.68	4.60	4.04	3.81
Non-OECD Europe	0.64	0.69	0.74	0.69	0.64	0.69
Other Asia	8.58	8.81	8.43	9.06	8.43	8.71
Other non-OECD	14.70	14.45	14.39	14.14	14.14	13.91
Total non-OECD	**35.70**	**35.44**	**35.39**	**35.63**	**34.18**	**34.01**
TOTAL DEMAND	**84.45**	**83.39**	**85.48**	**85.64**	**83.39**	**82.63**
SUPPLY						
OECD						
US	8.48	8.35	8.18	7.74	7.95	8.84
Canada	3.32	3.16	3.29	3.28	3.02	3.06
Mexico	3.71	3.79	3.80	3.75	3.72	3.89
North Sea	4.51	4.71	5.11	5.05	4.95	5.22
Other OECD	1.52	1.41	1.41	1.51	1.55	1.57
Total OECD	**21.54**	**21.42**	**21.79**	**21.33**	**21.19**	**22.58**
NON-OECD						
FSU	12.18	11.96	11.74	11.97	11.72	11.62
China	3.83	3.85	3.83	3.75	3.80	3.76
Other non-OECD	13.44	13.11	12.99	13.20	13.19	12.83
Total non-OECD, non-OPEC	**29.45**	**28.92**	**28.56**	**28.92**	**28.71**	**28.21**
OPEC	**34.19**	**33.83**	**33.90**	**34.30**	**34.55**	**34.25**
TOTAL SUPPLY	**85.18**	**84.17**	**84.25**	**84.55**	**84.45**	**85.04**
Stock change	**0.73**	**0.78**	**–1.23**	**–1.09**	**1.06**	**2.41**

Source: DOE International Petroleum Monthly.
Data available in OGJ Online Research Center.

OECD total net oil imports

	Nov. 2006	Oct. 2006	Sept. 2006	Nov. 2005	Chg. vs. previous year Volume	Chg. vs. previous year %
	Million b/d					
Canada	–1,345	–1,297	–1,116	–897	–448	49.9
US	11,568	11,804	12,791	13,135	–1,567	–11.9
Mexico	–1,650	–1,549	–1,713	–1,848	198	–10.7
France	1,943	1,860	1,588	1,794	149	8.3
Germany	2,505	2,605	2,656	2,449	56	2.3
Italy	1,749	1,678	1,646	1,799	–50	–2.8
Netherlands	830	1,071	1,171	1,152	–322	–28.0
Spain	1,631	1,518	1,598	1,555	76	4.9
Other importers	3,997	4,064	4,313	3,934	63	1.6
Norway	–2,540	–2,614	–2,582	–1,803	–737	40.9
United Kingdom	336	248	132	–8	344	–4,300.0
Total OECD Europe	**10,451**	**10,430**	**10,522**	**10,872**	**–421**	**–3.9**
Japan	5,180	4,888	4,809	5,052	128	2.5
South Korea	2,322	1,903	2,071	2,020	302	15.0
Other OECD	715	647	650	835	–120	–14.4
Total OECD	**27,241**	**26,826**	**28,014**	**29,169**	**–1,928**	**–6.6**

Source: DOE International Petroleum Monthly
Data available in OGJ Online Research Center.

OECD* total gross imports from OPEC

	Nov. 2006	Oct. 2006	Sept. 2006	Nov. 2005	Chg. vs. previous year Volume	Chg. vs. previous year %
	Million b/d					
Canada	456	357	420	503	–47	–9.3
US	5,153	5,525	5,838	5,383	–230	–4.3
Mexico	33	10	10	21	12	57.1
France	764	836	767	883	–119	–13.5
Germany	440	490	474	471	–31	–6.6
Italy	1,399	1,387	1,285	1,448	–49	–3.4
Netherlands	700	582	601	637	63	9.9
Spain	744	798	762	832	–88	–10.6
Other importers	1,259	1,351	1,446	1,379	–120	–8.7
United Kingdom	294	220	277	191	103	53.9
Total OECD Europe	**5,600**	**5,664**	**5,612**	**5,841**	**–241**	**–4.1**
Japan	4,480	4,181	4,457	4,522	–42	–0.9
South Korea	2,476	2,181	2,409	2,285	191	8.4
Other OECD	714	688	788	486	228	46.9
Total OECD	**18,912**	**18,606**	**19,534**	**19,041**	**–129**	**–0.7**

*Organization for Economic Cooperation and Development.
Source: DOE International Petroleum Monthly.
Data available in OGJ Online Research Center.

US petroleum imports from source country

	Nov. 2006	Oct. 2006	Average YTD 2006	Average YTD 2005	Chg. vs. previous year Volume	Chg. vs. previous year %
	1,000 b/d					
Algeria	462	813	648	485	163	33.6
Kuwait	259	239	185	239	–54	–22.6
Nigeria	972	1,088	1,124	1,158	–34	–2.9
Saudi Arabia	1,491	1,382	1,459	1,543	–84	–5.4
Venezuela	1,275	1,354	1,421	1,529	–108	–7.1
Other OPEC	694	649	687	648	39	6.0
Total OPEC	**5,153**	**5,525**	**5,524**	**5,602**	**–78**	**–1.4**
Angola	521	536	526	476	50	10.5
Canada	2,598	2,144	2,293	2,149	144	6.7
Mexico	1,584	1,646	1,731	1,650	81	4.9
Norway	174	181	197	239	–42	–17.6
United Kingdom	291	205	277	410	–133	–32.4
Virgin Islands	331	335	325	327	–2	–0.6
Other non-OPEC	2,303	2,753	2,823	2,877	–54	–1.9
Total non-OPEC	**7,802**	**7,800**	**8,172**	**8,128**	**44**	**0.5**
TOTAL IMPORTS	**12,955**	**13,325**	**13,696**	**13,730**	**–34**	**–0.2**

Source: DOE Monthly Energy Review.
Data available in OGJ Online Research Center.

Oil stocks in OECD countries*

	Nov. 2006	Oct. 2006	Sept 2006	Nov. 2005	Chg. vs. previous year Volume	Chg. vs. previous year %
	Million bbl					
France	190	188	188	198	–8	–4.0
Germany	277	278	279	274	3	1.1
Italy	133	130	134	135	–2	–1.5
United Kingdom	104	103	97	101	3	3.0
Other OECD Europe	663	669	675	644	19	3.0
Total OECD Europe	**1,367**	**1,368**	**1,373**	**1,352**	**15**	**1.1**
Canada	173	178	179	179	–6	–3.4
US	1,746	1,767	1,786	1,729	17	1.0
Japan	650	654	649	639	11	1.7
South Korea	158	156	160	144	14	9.7
Other OECD	109	110	109	108	1	0.9
Total OECD	**4,203**	**4,233**	**4,256**	**4,151**	**52**	**1.3**

*End of period.
Source: DOE International Petroleum Monthly Report.
Data available in OGJ Online Research Center.

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Stop the press: Scientists doubt Gore's alarms

It's newsworthy when the mainstream press takes notice of unfrenzied approaches to climate change.

The New York Times made such news in a Mar. 13 article by William J. Broad.

The essence: Celebrated alarms raised by former US Vice-President Al Gore have fallen subject to scientific scrutiny and come up short.

Broad quotes an impressive range of

The Editor's Perspective

by Bob Tippee, Editor

scientists who see inaccuracies in Gore's horror movie about global warming, An Inconvenient Truth.

Some of the quoted scientists agree with Gore that humankind needs to change behavior or face catastrophic warming. Others aren't sure about that but favor lesser precaution. Yet others argue that climate changes attributable to people are too small to do anything about.

Members of the group quoted by Broad, largely can be said to disagree about the politics of global warming but to agree that Gore has the science, to varying degrees, wrong. One obviously sympathetic scientist expressed worry that Gore was "overselling our certainty about knowing the future" but praised him for "getting the message out." To some participants in the global warming issue, propaganda comes before fact.

In Broad's piece, Gore's facts—the melting ice, the vanishing coasts, the ravaging storms—receive the doubt they deserve.

Even better, the article gives a rare and thorough airing to the possibility that at least some observed warming might be part of natural cycles.

In an e-mail exchange reported by Broad, Gore characteristically asserted, "The degree of scientific consensus on global warming has never been stronger." Against the variety of views presented in the article, however, that deception looks flimsier than ever.

Responding to concerns about the accuracy of what he presented as fact, Gore argued that his movie dealt with the most important aspects of global warming even if it shirked "some nuances and distinctions" important to scientists.

There's his central error. Truth about global warming and wisdom of response lie in the very complexities Gore wants everyone to ignore.

The right response to global warming probably falls somewhere between no response and blind response. Broad's article offers the refreshing prospect that between the extremes, reasonable discussion remains possible.

(Online Mar. 16, 2007; author's e-mail: bobt@ogjonline.com)

Market Journal

by Sam Fletcher, Senior Writer

OPEC takes no action

As expected, ministers of the Organization of Petroleum Exporting Countries made no move either to reduce or to increase production at their Mar. 15 meeting in Vienna, vowing instead to monitor the world oil market until they next meet in June.

Last October, the 10 OPEC members other than Iraq voted to reduce their total production by 1.2 million b/d to 26.3 million b/d effective Nov. 1 to stop a run-up in crude prices. At their Dec. 14 special meeting in Abuja, Nigeria, the same 10 members agreed to shave an additional 500,000 b/d to 25.8 million b/d effective Feb. 1 "to balance supply and demand." Analysts estimate OPEC actually has cut production by nearly 1 million b/d, while OPEC officials claim 1.2 million b/d. At any rate, crude prices have fallen from record highs in December to $58-62/bbl in recent weeks, although still subject to volatile swings.

At the end of their brief March meeting, OPEC ministers said, "Although all indicators clearly show that the market remains well supplied with crude oil and that the Organization for Economic Cooperation and Development [countries'] commercial oil stocks are healthy, overall oil market volatility is likely to continue." Meanwhile, they said the world economy in 2007 is expected to remain relatively firm, growing slightly slower than in 2006 because of higher interest rates.

OPEC also issued its Monthly Oil Market Report for March in which it said a combination of moderating demand growth and increasing distillate and conversion capacity should lead to an increase in spare refinery capacity this year.

With the end of winter and fewer concerns about the summer driving season, market attention is expected to shift to crude oil developments in the coming months, the report said. "As a result, aside from potential downside risks to the world economic outlook, other factors such as non-OPEC supply, the pace of incremental demand and nonfundamental factors including geopolitics warrant close monitoring as they are expected to be the main drivers behind crude oil price movements in the coming months," the report said.

"Overall, refiners are sitting on comfortable stock levels across the world, and with the completion of US refinery maintenance schedules, gasoline stocks in the US could rebound from the recent draw ahead of the driving season," OPEC said.

The report increased its estimate of world oil demand growth for 2007 by 100,000 b/d to 1.3 million b/d, or 1.5%, primarily because of increased North American demand this winter. Non-OPEC output is expected to average 50.6 million b/d in 2007, an increase of 1.2 million b/d over the previous year and a downward revision of 46,000 b/d from the last assessment. Preliminary data for February put non-OPEC supply at 50.5 million b/d. In February, OPEC crude production averaged 29.96 million b/d, broadly unchanged from the previous month. In 2007, demand for OPEC crude is expected to average 30.4 million b/d, broadly unchanged from the previous year.

Psychological difference

On Mar. 14, the day before the latest meeting, the average price for OPEC's basket of 11 benchmark crudes dropped 11¢ to $57.14/bbl, compared with $57/bbl at the start of the December meeting in Abuja. "While the value of the OPEC basket is little changed since Abuja, psychologically there is of course a huge difference between December's weakening $57/bbl and the current $57/bbl, having recovered from a January low below $48/bbl," said Paul Horsnell at Barclays Capital Inc., London.

Much of the underlying market sentiment, "particularly among speculative funds, is somewhat negative just as it was in December," Horsnell said. However, the market's focus "has perhaps shifted from more immediate direct concerns about the possibility of slowing oil demand and rising oil supply to less defined concerns about macroeconomic growth prospects derived from factors as diverse and as distanced from the oil market as the subprime mortgage market and equity market performance," he said. "In other words, sentiment remains fairly negative but is perhaps now centered on features that OPEC has less direct control over."

Prices and speculative sentiment might not have changed much over the past 3 months, but OECD inventories have fallen faster than the usual seasonal pattern, and crude supplies have tightened. "Market balances going forward look tighter than they did previously under all the main forecast models. That tightening has been due to the reduction in OPEC output combined with the general move to more pessimistic views on non-OPEC supply growth and the relative solidity in the views held of demand," said Horsnell.

(Online Mar. 19, 2007; author's e-mail: samf@ogjonline.com)

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