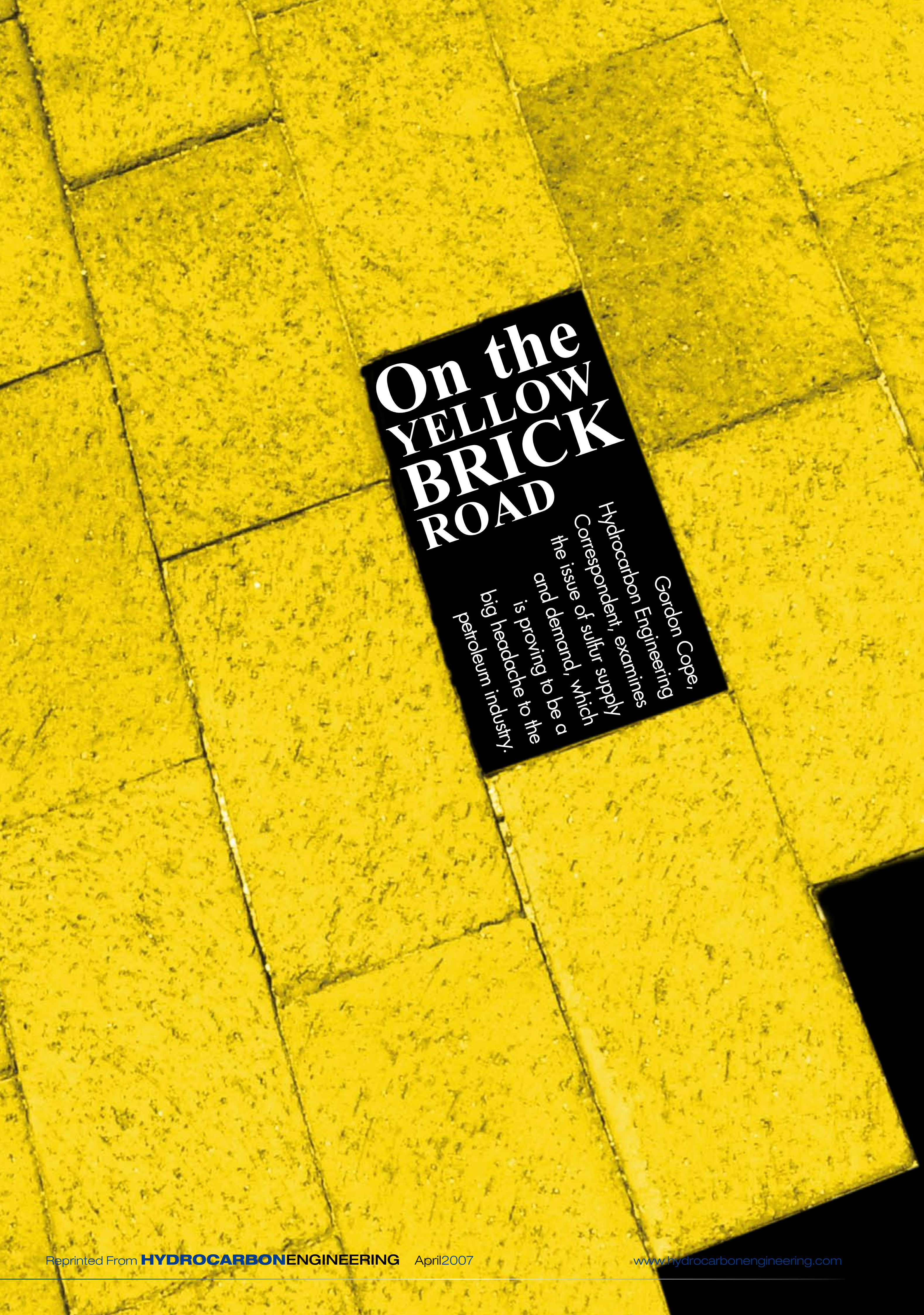

On the YELLOW BRICK ROAD

Gordon Cope, Hydrocarbon Engineering Correspondent, examines the issue of sulfur supply and demand, which is proving to be a big headache to the petroleum industry.

Blend sulfur with a little oxygen and hydrogen and it will eat through the strongest steel. Combine it with hydrogen and it produces a deadly gas. Mix it with phosphorous, nitrogen and potassium, and it will help feed millions of people. To most, sulfur is a wondrous element.

To most, that is, but not all. 'It's a real pain in the butt,' says Ted Stoner, vice president at the Canadian Petroleum Products Institute, and a former refinery operator. The reason, of course, is that for refiners, sulfur is a waste byproduct that must be removed from fuels in order to comply with environmental regulations.

However, it has the potential to become far more than just an expensive nuisance. According to The Sulphur Institute, an international non-profit organisation that promotes the use of sulfur, in 2005, total worldwide production of sulfur was 70 million t, and consumption 68.1 million t. By 2010, however, production could balloon to 85 million tpy, with consumption at 76.5 million t, an 8.5 million t surplus that would accumulate in stockpiles around the world.

Most commodities, faced with such a problem, would resort to cutbacks in production, but sulfur is different. Most comes from two sources; sulfuric acid from smelters (approximately 33.5 million t in 2005, most of which is recycled within the sector or sold for industrial use), and the petroleum industry (46.5 million t).

It is the latter that causes major migraines. Virtually all of it is involuntary production, removed from sour (sulfur laden) oil and gas. Not that removal doesn't have its benefits; in addition to reducing acid rain, which is harmful to health and the ecosystem, it improves the efficiency of catalysts within refineries and vehicles. But for the oil and gas industry, the immense amount of the stuff creates issues of marketing (and disposal) that are only going to get worse.

Elemental sulfur is produced all around the world. The Middle East region accounts for several million tpy, mostly from processing sour gas. The Former Soviet Union and Caspian Sea countries are also major producers, but traditionally, the two largest source countries are Canada and the USA. In Canada, total production in 2005 was over 9 million t; 8 million t came from the petroleum industry, with the bulk from sour gas. In the USA, 2005 production of sulfur in all forms was 8.8 million t, with petroleum accounting for the lion's share of that, some 6.8 million t, predominantly from refineries.

Removing sulfur from liquid fuels is expensive. 'When refinery products go through hydroprocessing, which is being exposed to hydrogen and a catalyst, a byproduct is acid gas, essentially hydrogen sulfide,' says Stoner. Hydrogen sulfide is extremely poisonous, and must be rendered into harmless elemental form through complex treatment. In North America alone, operators spent over US$ 20 billion during the last decade in order to build onsite sulfur plants, also known as Claus process plants. The sulfur plant has a thermal and a catalytic step. In the thermal process, the hydrogen sulfide is heated to 850 °C in the presence of oxygen to produce liquid elemental sulfur and water. This captures about 70% of the sulfur. Most of the rest is captured by running the remaining hydrogen sulfide over activated alumina or titanium oxide catalysts in the presence of sulfur dioxide. 'The molten liquid drops out into a storage pit where it is pumped into tank cars or trucks and shipped in molten form to buyers who make sulfuric acid,' says Stoner.

How much sulfur each refinery produces depends on various factors, including feed and output, but a 100 000 bpd plant with 500 ppm crude feedstock and a mixed production slate of fuels might produce enough

The effects of adding sulfur to fertiliser. Photo courtesy of The Sulphur Institute.

Sulfur asphalt being laid down. Photo courtesy of The Sulphur Institute.

waste each week to fill a 50 t tank car. Multiply that by close to 20 million bpd refined in North America, however, and collectively, refineries produce a huge amount of unwanted sulfur. The challenge is finding it a home.

Fortunately, uses abound. About half of all sulfur is consumed in various industrial, mining and forestry processes, including the production of sulfuric acid, the leaching of minerals from mine ore and the bleaching of pulp and paper.

However, the largest single use of sulfur (about half) is in the fertiliser industry, where sulfur is altered to sulfuric acid and used to convert insoluble phosphate rock into plant usable phosphorous. In fact, one of the biggest saviours of the sulfur market over the last decade has been the tremendous growth of fertiliser use in Asia, especially China.

As recently as 1995, China produced most of its sulfur needs by burning pyrites. That was before The Sulphur Institute explained the value of imports, however. 'We did an economic study in conjunction with the Chinese government comparing pyrites versus elemental sulfur to make sulfuric acid,' says Bob Morris, President of The Sulphur Institute. 'It illustrated that sulfur could be imported economically as compared with the domestic source.' Since then, imports have grown from virtually nothing to 8.6 million tpy in 2006. Although China's appetite for sulfur is still increasing, their import needs for fertiliser and industrial uses are reaching maturity. 'Some industries are toward the end of their growth curve and are beginning to plateau, so we're not seeing the levels of growth that we've seen in the past decade,' says Morris. 'China will also develop additional supply from their own sour gas reserves.'

Brimming stone

Unfortunately, while growth in demand runs at 2.4%, growth in supply runs at 4%. This is due to a number of factors. First, consumption of oil and gas is increasing. The Energy Information Administration (EIA) estimates that world consumption, currently at approximately 100 trillion ft^3/yr, could rise to 134 trillion ft^3/yr by 2015. Oil is on a similar growth curve; current consumption of 84 million bpd could rise to 98 million bpd by 2015.

Secondly, sources of oil and gas are getting more sour. In Venezuela, the Orinoco Belt, which holds several billion barrels of heavy sour crude, is the main supplier of Gulf Coast refineries. In the Middle East, Qatar and Iran are busy converting the North Field, an immense, sour gas laden deposit, into LNG and GTL. 'The Middle East today, in total, is around 9 million tpy,' says Terry Draycott, president and CEO of Prism Sulphur Corp., a sulfur marketer for Canadian producers. 'In 2008, it will be around 10 million tpy, and by 2009, 11.3 million tpy. You will see strong, continued growth.'

In Canada, the oilsands in northern Alberta currently produce slightly over 1 million bpd of oil, and 1.3 million tpy of sulfur. Currently, approximately 600 000 tpy is stored, and the rest is either shipped by pipeline in bitumen form or trucked to market. The Canadian Association of Petroleum Producers (CAPP) predicts that oilsands output could triple by 2015, also tripling sulfur production.

Thirdly, even though sulfur legislation in Europe and North America has already seen the reduction of on-road gasoline and diesel fuels to levels of 15 ppm and less, several significant fuel sectors have yet to be addressed. All non-road diesel (used by train engines), which averages 500 ppm, must reach the 15 ppm level by 2012. Home heating oil (popular in the US northeast) can be as high as 5000 ppm, and is increasingly coming under the scrutiny of state law. Bunker fuel, used by deepwater vessels, can currently have as much as 45 000 ppm sulfur content, a figure that is capped by the International Marine Organisation (IMO). Already, SOx emission control areas

Sulfur pellets. Photo courtesy of Shell Canada.

The sulfur terminal in Vancouver.

(SECA) exist in the North Sea and the Baltic, where the cap is 1.5%, or 15 000 ppm. 'The EPA could petition the IMO to make North America a SECA zone,' says Al Mannato, fuels issues manager for the American Petroleum Institute. 'This could be enacted over the next decade.'

So far, the impact of a sulfur surplus on prices has been subdued in relation to previous reactions. 'In the late 1980s, sulfur reached historical highs of US$ 140 (fob Vancouver),' says Draycott. 'In 2002, they were less than US$ 20. They then began a steady climb to 2006, when they were US$ 63. Now, they're back down to around US$ 50.'

In order to keep prices steady, some producers can stockpile. At one point in the late 1980s, Canada had 22 million t sitting in blocks adjacent to producing fields. But those fields are located in rural areas. Most refineries are located in urban areas and do not have the luxury of room to park sulfur. Back in 2000, when the phosphate market slowed, demand for sulfur dropped, and refiners had to store it in railway cars because there was no place for them to send it. If the market for sulfur becomes glutted to the point where prices collapse, it would accumulate around US refineries at the rate of over 130 000 t per week. 'The issue is so important that people have to plan,' says Morris. 'What would refineries do if no one purchased their sulfur?'

Down the yellow brick road

If you can't decrease supply, then the answer lies in increasing demand. Fortunately, there are several promising areas. Recent worldwide demand for base metals, such as nickel and cobalt, has increased the use of acid leaching in new mines in Latin America and Asia. Also, fertiliser demand is picking up in India, where the populous nation seeks to help feed its citizens. Both trends would add several million tpy consumption.

Another promising use is mixing sulfur into fertiliser to create sulfur enhanced fertiliser (SEF). 'Fertilisers contain nitrogen, phosphorous and potassium, which are nutrients that plants need to grow,' says Larry Marks, vice president of marketing and transportation for Shell Canada Energy. 'But they also need sulfur to grow well. Because of the cleanup of smokestacks and the leaching of soils, sulfur is becoming deficient. This reduces the efficiency of a plant's take-up of nutrients. Adding sulfur makes plant roots more efficient, which means they are able to grow more on the same tract of land.' Shell has been working in conjunction with major fertiliser makers to create techniques to incorporate micron sized sulfur pellets into the fertiliser mix. They are also conducting field tests in Canada, the USA, Brazil, China, Australia and India.

The Sulphur Institute has also been working with the Indian government for the last 10 years to address non-technical fertiliser issues. 'There are a lot of roadblocks (regulations, permitting) and many have been removed,' says Morris. 'Our efforts are just reaching fruition, but there's a lot of education and promotion that still needs to be done. We see the market there for 2 million tpy. We see demand in China for an additional 2 million t. Worldwide, the market potential is for around 10 million t.'

For several decades, Shell Canada has been investigating sulfur enhanced asphalt modifier (SEAM), in which sulfur in pellet form displaces a portion of the asphalt as a binding agent. 'It's better for the road and is lower in cost,' says Marks. Not only does the road last significantly longer, but it saves GHG emissions because it forms under lower temperature conditions and takes less steamrolling to compact. 'Conservatively, it may use 1 - 2 million tpy globally, but it could be bigger,' says Marks. While the technology is there to make SEA work today, there is a lot of municipal culture and contractor resistance to overcome before its use becomes widespread, and industry observers give this use a 10 year time spread before it receives significant acceptance.

Sulfur also has potential as an additive to concrete. Elemental sulfur and polymers are mixed into concrete to create a concoction that shows very high resistance to corrosion, high strength, low water permeability and fast curing time. 'It adds strength and is good in marine environments that are exposed to water, such as causeways and dams,' says Marks. Sulfur concrete also has an ecological advantage over Portland cement; the production of the latter requires the emission of approximately one tonne of CO_2 for every ton of cement produced 'The market potential is huge, but there's still some R&D necessary,' says Marks. 'I see a 10 year timeline.'

Whether sulfur retains its current good fortunes or becomes an anvil around the neck of the oil and gas sector depends a lot on how stakeholders address the issue today. 'The supply demand situation needs much greater attention in the oil and gas industry than it has in the past,' says Morris. 'We'd like to see industry engage in more activities to develop demand. Everyone needs to work on a solution together.'