

Case History: Process Licensing

How Union Oil licenses sophisticated crude oil refining internationally; comparisons with domestic licensing

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This paper provides some insight into the licensing of a sophisticated petroleum refining process, called Unicracking, by Union Oil Company of California. International licensing is particularly emphasized.

Licensing of the Unicracking process began about 20 years ago. Since then, 54 Unicracking plants have been committed. Thirty-four of these have been for refineries in the U.S. and 20 for refineries in 12 other countries. License negotiations for several more Unicrackers in other countries are in progress.

Union Oil Company of California is a major, fully integrated U.S. petroleum company. Measured by its sales, Union Oil is the 14th largest oil company in the United States and the 28th largest industrial company.

Union Oil maintains an aggressive research and development program, conducted by Union's Science and Technology Division at the Fred L. Hartley Research Center in Brea, California, a suburb of Los Angeles. The center has a staff of approximately 1,000 scientists, engineers, and supporting personnel.

One of Union's major areas of research and development is petroleum refining. Several outstanding processes and many excellent catalysts have resulted. Unicracking, the world leader in licensed hydrocracking capacity, is one of these.

In technical terminology, Unicracking is a fixed-bed catalytic process for the hydrocracking of feedstocks derived from crude oil, shale oil, coal liquids, and other sources. In less technical terms, hydrocracking is a generic name for the transformation, or conversion of low-value hydrocarbon feedstocks to higher value gasoline, jet fuel, diesel fuel, and petrochemical feedstocks. The oils are processed over catalysts at elevated pressures and temperatures in the presence of hydrogen. Hydrocracking is perhaps technically the most sophisticated of modern refining processes. In the refining industry it qualifies as high-technology. This has certain implications in international licensing and will be discussed later.

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At the heart of any hydrocracking process, including Unicracking, are the catalysts. Recognizing a need for technology to convert low-quality California crude oils to gasoline at its Los Angeles refinery, Union Oil carried out a hydrocracking research program during the 1950s and early 1960s. This pioneering effort culminated in the development of a family of unique hydrocracking catalysts. All of these catalysts contain molecular sieves. Because of this pioneering work in the use of molecular sieves in hydrocracking catalysts, Union Oil acquired an excellent patent position in other countries as well as in the United States. In addition, to round out the technology and the patent structure, Union joined forces with another company in a joint development and licensing program. This relationship was later terminated, and Union Oil has proceeded independently with process development and licensing.

While initial emphasis was on the production of gasoline for the California market, another closely related application was, and is, the production of certain petrochemical plant feedstocks. Unicracking has also been broadened to include efficient production of diesel fuel and jet fuel. The diesel fuel, jet fuel and petrochemical feedstock capabilities are especially significant in the international market because the ratio of gasoline consumption to jet and diesel fuel consumption is much lower in other countries than in the U.S.). See Table 1.

RELATIVE CONSUMPTIONS - GASOLINE AND MID-BARREL FUELS

	Percent of Total		Ratio, Gasoline to Mid-Barrel
	Petroleum Product Demand	Gasoline Mid-Barrel	
United States	41.6	27.0	1.54
West Europe & Japan	21.1	34.0	0.62
Rest of Non-Comm. World	19.9	32.7	0.61

Table 1

The first commercial Unicracking plant was built in Union Oil's Los Angeles refinery, to produce gasoline. It began operation early in 1964. Since then, continued engineering developments, improvement of catalysts, and an aggressive worldwide licensing program have brought the number of Unicracking plants to 54.

The first licensed Unicracking plant was in the United States. It started operation in 1966 at the Wynnewood, Oklahoma, refinery of the Kerr-McGee Corporation, also to make gasoline. Since that time, the list of Unicrackers licensed for United States refineries has been brought to the total of 34 spread among 26 companies including Union Oil and its early partner. With this large number

of companies, there has been a wide variety of domestic licensing experiences, ranging from very small units for small independent refiners to very big units for large, major refiners.

Second Unit

The second licensed Unicracking unit to start operation was at the Bakersfield, California, refinery of the Signal Oil and Gas Company. (The refinery subsequently was acquired by The Oil Shale Corporation, now known as TOSCO.) This was the first of 11 plants for which Unicracking has been licensed to replace other, competing processes for which the plants had been originally designed. Union's molecular sieve-containing hydrocracking catalysts and associated advanced engineering technology have provided a solid basis for this aspect of Union Oil's licensing program, the conversion of existing hydrocrackers to Unicracking, and have resulted in improved operation of these plants.

The first Unicracking plant licensed by Union Oil in the international market was for the Kaohsiung, Taiwan refinery of the Chinese Petroleum Corporation. This Unicracker was built to produce jet fuel and LPG. It began operation in 1976, and was followed by start-up the next year of a Unicracker at the Lingen, Germany, refinery of Wintershall AG. The Wintershall Unicracker was built to produce feedstock for petrochemical production, as well as gasoline. It also produces jet fuel.

The list of internationally licensed Unicrackers has since been brought to the current total of 20. The 12 countries in which these licenses have been sold include Canada, Finland, Iran, Ivory Coast, Tunisia, The Peoples Republic of China, Taiwan, Holland, England, West Germany, Trinidad, and Scotland.

While Union Oil's international licensing program certainly is intended to generate revenue, the company's willingness to make its technology available to other countries has strong overtones of foreign assistance. This is, of course, especially strongly associated with the licensing of technology to third-world countries.

Peoples Republic of China

For example, four Unicracking plants have been licensed for construction in The Peoples Republic of China. Two of these are to produce high-quality truck and airplane fuels from low-quality feedstocks that otherwise would be suitable only for burning as fuel in boilers. Thus, these two Unicrackers are important to the growth of the PRC transportation industry. By contrast, the other two Unicracking units are to produce feedstock for the production of synthetic fibers for use in the textile industry. The resulting synthetic fabrics will reduce the requirement for cotton which, in turn, will release agricultural land for the production of more grains and other food crops. The importance of this is obvious in a country where the land area suitable for farming is very limited. The first PRC Unicracker has been completed, and is operating very well at Maoming. The second will start operation during 1984, and the third and fourth will follow soon thereafter.

In general, international licensing of the Unicracking process has differed from domestic licensing in degree, not in kind. Usually, licensing in other countries has called

for the same types of services from Union Oil, but, in most cases, to a substantially greater extent. This is related to the previously mentioned technical sophistication of hydrocracking and to the more mature status of petroleum refining in the United States, as compared to most other countries, with consequent greater experience of United States refiners in using advanced refining technology.

One of the differences is that substantially more information must be provided by the competing hydrocracking licensors during the proposal and licensor selection phase of the project. To some extent, this necessity is educational because hydrocracking is more complex than the refinery processes with which the prospective licensee has had experience. Also, licensor proposals frequently are requested earlier in the evolution of a project. In most of these cases, proposals are used in the evaluation of hydrocracking relative to alternative refinery processing. In others, alternative feedstocks and/or product objectives are being evaluated. Generally, these evaluations and decisions will have been reached before requests for detailed proposals are issued in United States projects.

Design Information

Another difference is in the amount of design information that must be provided by Union Oil early in a potential project, before the hydrocracking unit is firmly committed. Frequently, Union Oil's engineering must be sufficient for preparation of a detailed cost estimate by the prospective licensee (or its study contractor), to be used as the basis for obtaining funding of the project. Sometimes, this detailed information is required to obtain government approval to proceed. In some cases, an even more comprehensive process engineering package must be provided from which the licensee can obtain fixed price quotations from competing contractors for detailed engineering and construction of the plant.

Still another difference in the international market is in the amount and length of on-site consultation that must be provided during pre-commissioning and start-up of the plant. Union Oil's start-up consultants, who are experienced Unicracking process engineers, have remained at a licensed unit for as short a time as one month and for as long as one year during commissioning of overseas Unicrackers. The long stays have been because of mechanical problems with equipment furnished by the contractors, not because of process problems. In these cases, the engineers have little to do other than be present while the licensee and contractor are working out the mechanical problems. We have supported the licensees by continuing to provide consultation on-site until the plants have attained good mechanical operation as well as the usual trouble-free process performance.

Closely related to the amount of on-site consultation is the training that precedes start-up of the plant. Much more training of technical and operating personnel usually is required. Union Oil does this training in three phases. The first is at the Fred L. Hartley Research Center, where a sophisticated, computerized Unicracking process simulator is used to reproduce actual plant operating experience. The second is at either or both of

Union's operating Unicracking units at Los Angeles or San Francisco. Groups as large as 20 licensee operating personnel have been trained for as long as three months at the Research Center and at one of our Unicrackers. Final pre-start-up training is at the licensee's unit.

Union Oil does not consider its training function to be complete at start-up, however. A senior Unicracking process engineer is assigned to follow performance of each licensed Unicracking unit, and to provide consultation so that top-notch operation is maintained. And, to keep the licensees up-to-date, Union brings representatives from the licensed Unicrackers together every other year in an International Unicracking Conference. Conducted in the Los Angeles area, these conferences consist of prepared papers by Union Oil's experts on the latest Unicracking operating know-how, new catalysts, and related subjects, panel discussions of specific topics, round table discussions of other specific operating topics, and open-floor question-and-answer periods.

In addition to their technical aspects, these international conferences call for a high level of diplomacy from Union Oil's staff. When roughly 100 licensee representatives from the United States, Europe, Africa, the Middle East, Japan, Taiwan, The Peoples Republic of China and other areas are in close contact for three days, thorough preparation and anticipation of potential ideological and political differences are essential. The end results have been friendly, cooperative meetings and discussions, both formal and informal.

Responsibility

Union's Science and Technology Division has total responsibility for the company's worldwide licensing

program. The Technology Sales Department identifies potential licensees, presents the technical and commercial proposals, negotiates the commercial terms of the licenses, and provides commercial follow-up with licensees. The Patent Department is responsible for obtaining patent protection on the technology and for completing the legal agreements to implement the licenses. The Engineering and Development Department is responsible for providing technology and process engineering for a licensed plant, for training, pre-commissioning, and start-up consultation, and for technical service following start-up. The Refining and Products Research Department develops improved catalysts and provides fundamental technical data.

These departments are located at the Fred L. Hartley Research Center where they work closely on a continuing basis. Because of this Union responds quickly to the needs of licensees. Also, because the Los Angeles International Airport is nearby, on-site service by Union Oil personnel is provided quickly anywhere in the world.

In summary, Union Oil Company of California has successfully licensed its Unicracking process worldwide. The 54 Unicracking units committed so far represent a combined design capacity of more than one million barrels of feedstock per day—specifically, 1,023,200 barrels. At today's construction costs, this represents about \$4 billion in plant investment—not counting auxiliary facilities, such as hydrogen plants, that usually are installed along with the Unicracking unit. Licensed capacity amounts to about 900,000 barrels of feedstock per day. The wide range of licensing experiences provides a strong base for handling the unique circumstances and problems associated with each new project.