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Soviet Needs for Western Petroleum Technology and Equipment

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A Research Paper

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SOV 86-10013
April 1986

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Soviet Needs for Western Petroleum Technology and Equipment [redacted]

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A Research Paper

This paper was prepared by [redacted] Office of Soviet Analysis. Comments and queries are welcome and may be directed to the Chief, Economic Performance Division, SOVA [redacted] 25X1

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Soviet Needs for Western Petroleum Technology and Equipment 25X1

Key Judgments

Information available as of 31 December 1985 was used in this report.

The exploration and development of new oil and gas deposits in the USSR during the 1986-2000 period will pose increasingly complex technical challenges. Because Soviet industry will remain unable to supply the technology and high-quality equipment required for critical applications, the importance of Western equipment to the Soviet effort will increase markedly. In particular, deeper drilling in offshore and onshore exploration and development, as well as the exploitation of corrosive ("sour") oil and gas deposits, will require Western technology and equipment. 25X1

Moscow will find it increasingly difficult to fund the purchase of Western technology and equipment. Hard currency earnings are shrinking rapidly due to the fall in world oil prices and declining oil output in the USSR. Proposals for the purchase of Western oil and gas equipment, moreover, will be competing with requirements of the high-priority industrial modernization program as well as with equipment needs critical to the coal and natural gas development programs. 25X1

Gorbachev's regime is effectively caught up in a "catch-22" situation; until the Soviets achieve greater interfuel substitution and energy conservation, oil (which accounted for over 35 percent of primary energy output in 1985) will remain the USSR's prime energy product and a major source of hard currency. This dual primacy creates tremendous pressure to sustain oil output, even at very high cost, possibly including the expenditure of scarce foreign exchange resources. 25X1

While Western technology and equipment could reduce some bottlenecks, from a technological standpoint they are not critical for most current Soviet oilfield operations. For these, improvement in the quality and availability of domestically produced oil country tubular goods (that is, well casing, tubing, drillpipe, drill collars, and linepipe) and equipment—particularly if higher quality-control standards are applied in metallurgy and in fabrication of equipment—could boost productivity. But the record of the Soviet oil and gas equipment industry suggests that, even with added investment and high-level emphasis on productivity and quality, substantial improvement could take many years. 25X1

The degree to which Moscow is willing to increase reliance on the West for oil and gas equipment is not clear. For some time, Moscow has been sending mixed signals concerning its intentions with respect to the importation of Western petroleum technology and equipment. Soviet officials have made inquiries to Western suppliers concerning a broad range of equipment, and the Soviet press has stressed the need for better technology and higher quality equipment in all phases of petroleum-industry operations. Imports, however, have been concentrated largely on a few projects such as gas-pipeline construction and exploitation of sour oil and gas deposits. Moreover, the themes of several of General Secretary Gorbachev's speeches suggest that revitalization of domestic industry through investment in civilian machine building and intensified application of science and technology are the key to improving the general supply and quality of standard oil and gas equipment. [redacted] 25X1

The drastic fall in world oil market prices over the past year has slashed Soviet hard currency revenues, forcing Soviet officials to reevaluate plans to import technology. Oil Minister Dinkov reportedly said in January 1986 that most planned purchases of oil and gas equipment would be postponed or canceled because of hard currency shortages. [redacted] 25X1
[redacted] many negotiations are progressing, including a major 25X1
equipment contract for the Karachaganak sour gas project. [redacted] 25X1

Moscow is also seeking to ease the hard currency pinch by exerting pressure on Western suppliers to change payment terms from cash to credit. Some of the Soviets' negative comments about the prospect for imports may reflect a desire to motivate Western suppliers to accede to requests for credit or for more favorable credit terms than were offered in the past. [redacted] 25X1

While the future course of Soviet reliance on the West to redress current production problems and face new challenges in exploration and development is yet to be determined, we expect that the Soviets will continue to purchase from the West the more sophisticated and highly specialized equipment for critical operations. As exploration and development move increasingly to deeper onshore and offshore fields, the demand for these purchases is likely to rise. Specifically, indigenous technology and equipment will become increasingly inefficient and uneconomic relative to the more demanding technical requirements of the late 1980s—particularly in deep drilling and producing. Moreover, skilled manpower and technical services to cope with those requirements will remain in short supply. Unless Moscow turns to the West for more equipment and technical services, the decline in oil production will accelerate. [redacted] 25X1

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[redacted] 25X1

Major purchases are now being negotiated, primarily with French and West German firms, for the specialized corrosion-resistant equipment and processing plants essential to exploitation of the deep, high-sulfur oil and gas fields of the Pre-Caspian Depression. As exploration and development activity shifts increasingly to offshore fields (especially if in the arctic seas), the Soviets will need more Western technology and equipment. Moscow, moreover, has been negotiating for the purchase of plants to manufacture oil country tubular goods, wellhead equipment, and drilling rigs for onshore and offshore service. [redacted] 25X1

Although the Soviets are beginning to manufacture large-diameter high-pressure pipe, they are likely to continue purchasing large quantities of Western pipe for gas pipeline construction at least until 1990. These purchases will result not only from technical requirements for gas pipeline construction but also from Moscow's interest in engaging the support of West European steel producers for additional West European purchases of Soviet gas. [redacted] 25X1

Moscow will also probably continue to purchase from the West a wide range of other items—from drilling, producing, and processing equipment to heavy-duty pipelayers and pipeline valves and control systems. Kremlin planners can choose among many sources for needed oil and gas equipment. A global network of suppliers can provide the varying levels of technology and inventories of equipment appropriate to the range of operating requirements in the USSR. West European suppliers for North Sea offshore operations are eager to sell to the USSR. The Japanese are marketing a list of items that continues to grow. Third World countries (Brazil, Argentina, South Korea, and Singapore) are also competing for sales, especially in tubular steel products. Nonaligned countries (Finland, Austria, and India) are demonstrating growing capability and capacity. Each year, as more state-owned or subsidized industry comes on line, the network becomes larger and the competition stiffer. [redacted] 25X1

Some of the Western oil and gas technology and equipment likely to be sought by the USSR has potential military and naval applications. For example, much of that used in geophysical exploration for petroleum involves image and signal-data processing with realtime analysis—techniques that have applicability in command, control, communications, and intelligence operations. The technologies that are used in making production equipment corrosion resistant and capable of operation at high

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pressure and high temperature are applicable to development of conventional and nuclear weapons, particularly nuclear propulsion systems for submarines and other naval vessels and jet engines for aircraft and rockets. The metallurgy used in many oilfield goods has wide application in defense engineering and production activities. Integration technology—the functional coordination of finished hardware components, increasingly by means of sophisticated computer software—could also help Soviet military research. [redacted] 25X1

If the United States and the other COCOM countries were to expand substantially the list of dual-use items denied to the USSR, the Soviets would probably find ways to maintain gas production, but oil output would slip more rapidly after a year or so. Although an effective embargo would halt sour gas development, the Soviets could obtain additional gas from the Tyumen' deposits at lower production cost, despite the difficulties inherent in arctic development and the somewhat higher cost of transporting the gas a greater distance. With respect to oil, however, the situation is more complex. For the development of relatively shallow deposits of noncorrosive oil and gas condensate, the Soviets can, at greater resource costs, use their own less efficient equipment. Also, more-than-adequate alternatives are available outside COCOM—for some items, even from less-developed countries in Asia and Latin America. However, for the extensive, rapid, efficient exploration and the greatly expanded development of deep deposits that would be necessary to substantially reduce the rate of decline in Soviet oil output in the decade ahead, the Soviets need state-of-the-art technology and equipment. This technology and equipment is, with few exceptions, frequently available only from US firms or their affiliates and licensees in COCOM countries. [redacted] 25X1

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Overview of Soviet Energy Development

Trends in Energy Production

Since 1960, output of primary energy—crude oil, natural gas, coal, hydroelectric power, nuclear power, and minor fuels—has tripled, but growth has been uneven among the major fuels:

- ***Coal*** was the main fuel for the national economy before the mid-1960s; by 1985, however, its share of primary energy production was only 21 percent (see figure 2).

- ***Oil*** output soared from 2.95 million barrels per day (b/d) in 1960 to 12.33 million b/d in 1983, before declining to 12.22 million b/d in 1984 and 11.90 million b/d in 1985. Oil's share in primary energy is over 35 percent.

- ***Natural gas*** output has grown even more rapidly—from 45 billion cubic meters (m^3) in 1960 to 643 billion m^3, or 33 percent of primary energy, in 1985.

Expanding energy production has required an ever-increasing share of industrial investment—up from 28 percent in 1975 to 35 percent in 1984 (table 1). Because of the continuing emphasis on oil production, nearly half of energy investment has been allocated to the oil industry since 1981. This emphasis has cut into the resources available for the coal and electric power industries, thereby contributing to the stagnation of coal production and the marginal inadequacy of electric power supply. The burdensome nature of oil production is illustrated by the relationship of changes in investment and output between 1975 and 1984. Oil investment rose by some 135 percent while oil output increased 25 percent. The gas industry, in contrast, presented a remarkable success story: investment up 75 percent and output doubled.

Factors Affecting the Outlook for Primary Energy Production

Soviet energy production is affected by the quantity and quality of exploitable resources, the quality and availability of equipment and technology, and the supply and utilization of skilled management and labor (table 2). 25X1

The most urgent problems center on oil production, largely because of oil's preeminence as an export commodity and source of hard currency. Although Western experts have estimated Soviet oil reserves at roughly 50-70 billion barrels, Moscow's effort to sustain oil output at a high level is encountering serious difficulties and increasing costs that reflect:

- Emphasis on production at the expense of exploration.
- Effects of years of excessive rates of production at giant fields.
- Increasing reliance on development of smaller fields that have lower new-well flow rates.
- Increasing amount of water in output of older wells.
- Severe operating conditions in subarctic West Siberia. 25X1
- Endemic problems with the supply and quality of domestic equipment. 25X1

The age and size distribution of developed reserves in West Siberia also contributes to Moscow's difficulties in maintaining high oil output. The new fields tapped there since 1979 have been smaller by an order of magnitude and have lower flow rates than those brought on line in the previous decade. Moreover, the older, larger fields are already declining in production. Attempts to sustain output by drilling a large number of wells in the smaller, less productive fields lead to a steep rise in investment. 25X1

The USSR's reserves of natural gas—estimated at some 34 trillion m^3—comprise about 40 percent of the world's proven reserves and are relatively accessible, in the Soviets' view, for rapid development. However, 25X1

Figure 1
Major Petroleum Basins and Pipelines

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the arctic conditions under which the clean and relatively shallow Tyumen' gas deposits must be worked are difficult, and the extraction and processing of the toxic and corrosive sour gas from the deep deposits of the Pre-Caspian Depression entail severe dangers and technical problems.[1]

Much of the long-term substitution of other fuels for oil, which is intended to reduce oil consumption in the domestic economy, depends on substantial increases in the availability of coal. Soviet coal reserves are huge (about 170 billion tons in standard fuel equivalent) but coal production has been held back by the depletion of the better quality reserves in the western USSR, the low energy content and remoteness of coal supplies from Kazakhstan and East Siberia, and investment policies that for many years have favored oil. 25X1

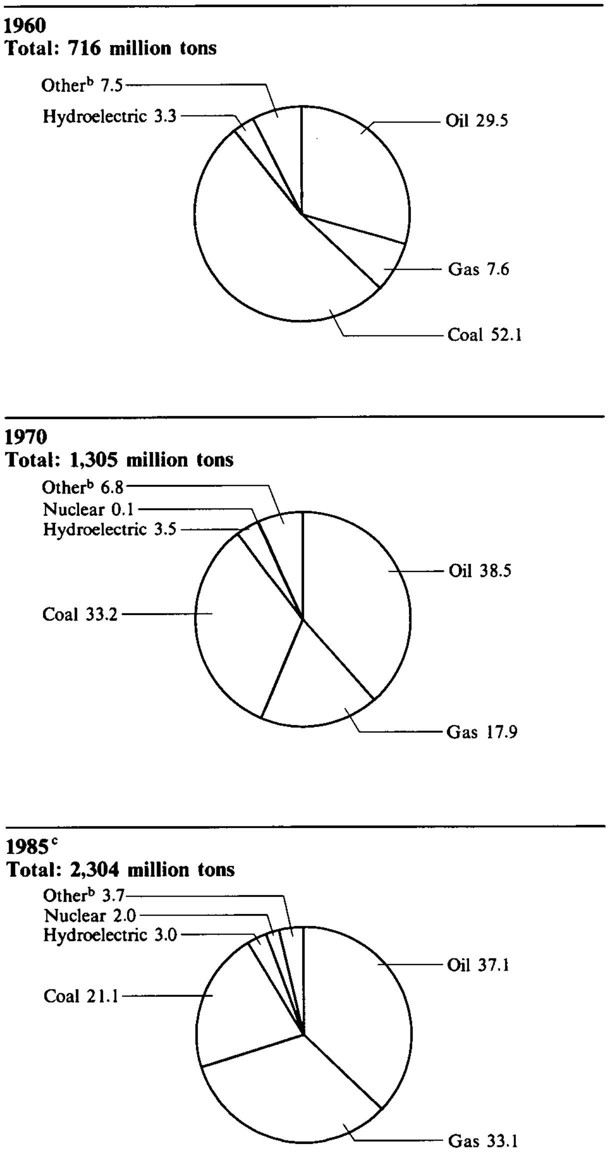
The Past Role of Western Technology and Equipment 25X1

The USSR has achieved its present status as the world's leading producer of oil and natural gas largely through the use of domestically manufactured equipment. It has turned to the West for selected technology and high-quality, state-of-the-art equipment to obtain higher operating performance and more reliable service, as well as to overcome shortages of key items and to supply projects for which Soviet equipment is inadequate (for example, sour-gas development). Last year, the Soviets undertook a program to

[1] See appendix B for a brief glossary of technical terms. 25X1

Figure 2
USSR: Primary Energy Production[a]

Percent



[a] Standard fuel equivalent.
[b] Includes peat, oil shale, fuelwood, geothermal, and solar.
[c] Values for 1985 estimated.

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enhance both the quality and quantity of equipment manufactured domestically, and this effort will continue into the 1990s. Thus far, however, the inefficiencies of the Soviet economic system have hindered both the production of high-quality oil and gas equipment and the assimilation of advanced techniques and equipment acquired from the West. 25X1

During the 1970s the USSR purchased some $5 billion worth of Western oil and gas equipment. The impact of these imports was far greater than their share in the total oil and gas equipment supply would suggest, because they were used to cover shortages and to cope with particularly difficult technical problems. Especially important among these acquisitions were:

- A turnkey plant to produce high-quality drill bits (from the United States).
- Gas-lift equipment for two major oilfields in West Siberia (from France, with most of the critical valves, mandrels, and wireline operating tools provided by a US firm from an offshore plant).
- Assembly yards for producing offshore drilling platforms (from France).
- Large-diameter line pipe, pipelayers, and turbine-compressor sets for the gas pipeline network (from West Germany, Italy, France, Japan, and the United States).
- Equipment and chemical plants for enhanced oil recovery (EOR) projects (from the United States, France, Italy, and West Germany). 25X1

Purchases of Western oil and gas equipment (including pipe) have roughly doubled since 1980 (table 3). Most expenditures were for pipe and for exploration and development equipment; oil refining equipment has accounted for only a very small percentage of imports from the West.[2] According to Soviet trade journals, purchases of Western gas pipeline equipment and linepipe rose sharply in 1982 and accounted for about 85 percent of total purchases of oil and gas equipment in 1982 and 1983. 25X1

[2] The foreign-trade category "pipe" includes large-diameter pipe and oil country tubular goods (drillpipe, drillcollars, wellcasing, tubing, and linepipe). 25X1

Table 1
USSR: Energy Investment in Relation to Total Industrial Investment [a]

	Total Industry	Total Energy	Oil	Gas	Coal	Electric Power
Investment *(billion 1973 rubles)*						
1970	28.5	8.0	2.5	1.0	1.5	3.0
1975	39.7	11.0	3.8	1.8	1.7	3.7
1980	47.6	15.5	6.8	2.1	2.1	4.5
1981	49.5	16.6	8.1	2.0	2.0	4.5
1982	50.9	17.7	8.7	2.3	2.2	4.5
1983	53.7	18.7	9.1	2.7	2.3	4.6
1984	55.3	19.4	9.0	3.2	2.3	4.9
	Energy Investment as a Share of Industrial Investment		Energy Sector Investment as a Share of Total Energy Investment [b]			
			Oil	Gas	Coal	Electric Power
Shares of investment *(percent)*						
1970	28.1		31.2	12.5	18.8	37.5
1975	27.7		34.5	16.4	15.5	33.6
1980	32.6		43.9	13.5	13.5	29.0
1981	33.5		48.8	12.0	12.0	27.1
1982	34.8		49.2	13.0	12.4	25.4
1983	34.8		48.7	14.4	12.3	24.6
1984	35.1		46.4	16.5	11.9	25.3

[a] Excluding investment in natural gas pipelines, oil refining, and minor fuels production.
[b] Shares may not add to 100, because of rounding.

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Soviet purchases of Western oil and gas equipment dropped when supply contracts for the Siberia–to–Western Europe gas pipeline were fulfilled. These contracts had sharply increased exports of oil and gas equipment (excluding pipe and refining equipment) from several COCOM countries to the USSR. The principal Western suppliers also changed: West Germany, France, Italy, and Japan gained contracts; the United States lost contracts. More recently, four sour oil and gas development projects in the Pre-Caspian Depression (although not so large individually as the export pipeline project) collectively are offering the prospect of contracts to Western (mainly French and West German) suppliers totalling well over $5 billion through 1990. Over $1.5 billion of these contracts have already been signed for installations at Astrakhan', Karachaganak, and Tengiz. 25X1

Soviet Energy Plans and Challenges: 1986-2000

The USSR's Long-Term Energy Program sets forth several major changes in the national energy balance:

- Natural gas is to provide nearly all of the increment in total primary energy production into the mid-1990s.
- Coal, after intensive investment in production, processing, and consuming facilities in the 1990s, is to become the dominant fuel in the USSR after 2000.

Table 2
Main Factors Affecting Energy Development

Energy Source	Quality of Reserves	Technology and Equipment Needs	Labor and Infrastructure
Oil	Although West Siberian, Komi, Kazakhstan, and offshore reserves could maintain recent production levels, problems with quality exist.	Heavy and waxy oils are difficult to extract without steam generators; corrosive deposits will require substantial amounts of Western corrosion-resistant equipment.	Major management difficulties: shortages of skilled labor, high labor turnover, multiple projects requiring coordination and phasing.
	Middle Ob' (West Siberia) development is affected by the increasing depth of reservoirs, as well as by lower porosity, less permeability, heavier oil, and lower flow rates.	Development of Western-designed arctic drilling equipment, which is capable of operation at greater depths, to produce oil and to inject water. Lighter, modular designs are easier to transport.	Remote production sites subject to arctic conditions; transportation and basic services problematic; scarce housing.
	Komi development is limited by the arctic environment and heavy, paraffinic oils.	Enhanced oil recovery technology, steam-generating equipment, and chemicals to boost recovery of heavy oils.	Projects are labor- and capital-intensive; many logistic problems.
	Kazakh oils have various drawbacks: some are highly paraffinic; some, heavy; and some, high sulfur and CO_2 content.	Corrosion-resistant producing equipment; enhanced oil-recovery equipment to boost recovery of heavy oils.	Projects are labor- and capital-intensive, but logistic problems are less severe than in West Siberia and Komi.
	Potential offshore reserves (Barents and Kara Seas, offshore Sakhalin, and deeper Caspian Sea may be substantial but are in the early stages of exploration, and their development would involve leadtimes of five to seven years.	Geophysical equipment for offshore exploration and offshore arctic drilling and production platforms and production systems.	Shortage of highly skilled management and labor to operate complex equipment.
Natural gas	Most reserves are of high quality; average wellflow rates among the highest in the world.	Large-diameter linepipe, pipelayers, more efficient turbines and compressors, and gas-processing plants for sour gas.	Largest reserves located in uninhabited Arctic Circle region of West Siberia. Difficulties in production, transportation, and labor recruitment and retention; scarce housing.
	Sour gas deposits in the southern USSR offer tradeoff: more accessible location versus more difficult exploration.	Leak-proof, corrosion-resistant equipment for drilling, well completion and gathering systems, and processing natural gas.	Management and labor skills inadequate; poorly developed infrastructure.
Coal	Depleted reserves west of the Urals.	Specialized equipment to mine thin seams; underground transportation equipment.	High wages needed to attract and retain miners.
	Large but poor-quality reserves east of the Urals.	Coal-cleaning and enrichment plants and synfuels technology and plants.	Harsh Siberian environment, little infrastructure, high labor turnover, labor shortages.
	Shallow deposits east of the Urals can be surface-mined.	Off-road trucks, high-volume rotary and dragline excavators.	
Nuclear energy and hydroelectricity	Uranium reserves sufficient for short-to-medium term; ambitious breeder reactor construction plans assure long-term nuclear fuel supply.	Nuclear power plant components: pipes, valves, pumps, and control instrumentation.	Program expansion planned for 1980s requires many new hires and training; most important component assembly plant, Atommash, must raise productivity. Expansion of hydroplants in East Siberia and Far East is linked to exploitation of untapped raw materials.

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Table 3
Soviet Imports of Oil and Gas Equipment From COCOM Countries, 1980-84, by Type of Equipment and Country of Origin

Million US $

Item	Source	1975	1980	1981	1982	1983	1984
Total	**All COCOM Countries**	**1,639.4**	**1,658.4**	**1,909.7**	**3,137.9**	**3,449.7**	**2,734.4**
Machinery and equipment for geological drilling, well operation, and pipeline operation	Great Britain	2.0	26.6	31.0	88.7	120.3	113.9
	Canada	2.9	4.1	3.0	8.9	24.1	6.6
	United States	49.4	57.5	7.7	26.9	6.5	6.8
	France	23.6	90.2	54.5	57.5	260.8	205.0
	Italy	12.1		5.7	126.1	357.4	209.3
	Japan			21.1	143.2	113.5	78.8
	Federal Republic of Germany	48.0	1.4	36.4	110.5	396.4	287.4
Subtotal		138.0	179.8	159.4	561.8	1,279.0	907.8
Pipe	Italy	375.9	223.7	280.1	442.0	383.7	352.9
	Federal Republic of Germany	589.9	554.2	455.3	628.6	677.8	502.7
	France	158.1	158.5	122.8	148.6	92.0	150.0
	Japan	288.4	524.4	890.5	1,269.2	741.4	653.7
	Belgium	28.6			79.5	228.4	159.5
Subtotal		1,440.9	1,460.8	1,748.7	2,567.9	2,123.3	1,818.8
Oil-refining equipment	Italy	1.2	0.9	1.2	1.2	0.7	
	France	58.4	3.6	0.2	2.1	1.2	1.4
	Japan		13.2				
	Great Britain	0.9	0.1	0.2	0.4	0.2	
	Federal Republic of Germany				4.5	45.3	6.4
Subtotal		60.5	17.8	1.6	8.2	47.4	7.8

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- Nuclear power is to provide substantial additional energy in the 1990s and beyond.

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During the 1986-2000 period, the Soviets expect the share of natural gas in the primary energy balance to expand rapidly; we estimate that it could exceed 40 percent after 1990, while oil's share could shrink to about 30 percent. Natural gas has already replaced oil as the chief incremental source of energy, and we believe that the Soviets can continue to boost gas output using, for the most part, existing domestic equipment and technology. Oil's share in the primary energy balance will decline as a result of gas-for-oil substitution and likely further slippage in oil production.

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The conditions of oil and gas production in the coming decades will inevitably be more rigorous, and they will pose dual challenges: availability and application of technology and equipment. First, the Soviets need to vastly improve the quality and availability of domestically produced oil country tubular goods and equipment, which will, in turn, make most noncritical operations more efficient. Substantial gains in the productivity of oil and gas operations could result if the Soviets applied higher quality-control standards in

Changing Technological Requirements for Oil, Gas, and Coal Production

Oil. *Through 2000, the Soviets expect major energy supply problems to arise in the oil industry, where current long-range plans for maintaining high levels of output are in jeopardy. Exploration and development will focus on deeper onshore and offshore deposits, which are more complicated to exploit. Onshore, exploration and development will involve drilling deeper wells in more complex geologic formations. This requires greatly improved seismic, drilling, and production equipment and technology. The Soviets will need state-of-the-art high-pressure, high-temperature, corrosion-resistant equipment for the deep formations in the Pre-Caspian Depression. Offshore, Soviet equipment is inadequate to develop oilfields in deep water and arctic environments. Without a rapid infusion of state-of-the-art offshore exploration and production technology and equipment, Soviet oil output could face a more rapid decline in the 1990s than would otherwise occur.*

Gas. *The Soviets expect gas output in West Siberia to rise steadily through 2000 with few problems. They will probably continue to rely (albeit to a slowly decreasing degree) on some imports of Western linepipe, valves, and controls for expansion of the natural gas pipeline network and for realization of plans to substitute gas for fuel oil. The rapid growth of gas output will require ongoing investment in gas treatment plants and in gas transmission pipelines. The operational efficiency of these facilities would be substantially enhanced by the use of Western equipment. To develop the sour gas fields and recover natural gas liquids at Astrakhan' and Karachaganak, the USSR will import corrosion-resistant, high-pressure-and-temperature production, processing, and transport equipment. For example, a batch of high-chrome stainless steel tubing was recently ordered from a West German firm for use at Karachaganak.* 25X1

Coal. *Coal output has remained essentially unchanged since 1978. To maintain output, the Soviets will need to increase production from the eastern coal basins to offset declining output at mines in the European USSR.* 25X1

Achieving a dramatic boost in coal production will be difficult. To make transport of coal more efficient, the Soviets could build slurry pipelines or plants to convert coal into gas and liquid fuel. Press reports indicate that the Soviets are currently studying the feasibility of long-distance, high-capacity coal-slurry pipelines for transporting Siberian coal to the Ural region and the European USSR. 25X1 25X1

The Soviets' long-range goal of a major expansion in coal production is unlikely to be accomplished without some Western assistance. Imported equipment and technology will probably play a key role in meeting goals for the construction of slurry pipelines, the rapid expansion of surface mining, and the production of synthetic fuels from coal. The Soviets already are negotiating with Western firms on technology and equipment for these applications. Moscow recently has signed a contract with an Italian firm to provide process technology and engineering services for a prototype 250-km slurry pipeline to transport 3 million tons of Siberian coal annually. 25X1

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metallurgy and fabrication of equipment. Second, they need a substantially increased supply of more advanced technology and equipment to deal with increasingly hostile operating conditions both above and below ground. Meeting this need under the anticipated conditions of stringency in availability of both investment and hard currency will be made even more difficult because the coal industry also has a pressing need for Western advanced technology and equipment.

Coping With Needs—Domestic Versus Imported Technology and Equipment

For some time Moscow has been sending mixed signals concerning its intentions with respect to the importation of Western petroleum technology and equipment. Many recent articles have stressed the need for better technology and high-quality equipment comparable to those obtainable from the West. However, leadership statements have been ambivalent or have leaned toward a domestic solution. Soviet trade and industry officials have talked with many Western suppliers to elicit technical data and proposals for supply of a wide range of advanced technology and equipment. The actual imports in recent years have comprised mainly pipe and equipment for gas-pipeline construction and development of sour oil and gas deposits (see table 3).

Some events suggest that Soviet decisions not to follow through and order a larger amount of Western equipment reflect, in part, conflicting views within the Soviet bureaucracy about technical alternatives and the choice of supplier: domestic or Western. In 1983, for example, the Soviets negotiated for the purchase of some $40 million of US high-capacity electric submersible pumps, and an export license was approved in January 1984—but the purchase was not completed. Changes in the operating condition of the wells for which these pumps had been planned may have played a part; but, on the basis of indirect and fragmentary evidence, we believe the decision not to purchase was probably influenced by ongoing bureaucratic squabbles over the relative merits of gas-lift systems and high-capacity electric submersible pumps, the allocation of hard currency, and dependency on the West.

Gorbachev in Tyumen': No Hint of a Westward Tack. General Secretary Gorbachev's early September speech to oil workers and party cadres in Tyumen' leaves unclear the outlook for Soviet acquisition of Western oil and gas technology and equipment. His remarks neither addressed the role of Western equipment nor clearly delineated how Soviet industry can be made to achieve timely delivery of the improved equipment he recognizes as needed for the increasingly difficult production conditions (especially for oil) in West Siberia. Yet the decline in oil production and the associated increase in water encroachment in major oilfields underscore the criticality of timely acquisition, either from domestic or foreign suppliers, of high-quality production equipment (especially pumps) and exploration equipment.

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As in his other speeches, Gorbachev stressed heavy reliance on raising efficiency and on accelerating scientific and technological innovation. At Tyumen' he stated that the technological solutions for making work more efficient in the oil and gas fields are available, but that their application is still in the initial stages. He also said that there is no need for further study—the task is to apply greater competence, skill, and knowledge gained from experience, making use of new equipment and processes.

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Gorbachev's remarks suggest that he has grasped the scope and complexity of the problems facing the oil and gas industries: the search for additional oil reserves, poor housing and social conditions for the work force in West Siberia, supply of oilfield equipment and electricity, improvements in oil refining technology, and accelerated efforts in energy conservation. But his prescription—changed attitudes, improved efficiency, and greater application of science and technology—may not be sufficient to bring about the desired results.

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Much of the Soviet-made oil and gas equipment, though far from being state of the art, would be adequate for routine service. It would make a greatly increased contribution to output if it met higher

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quality-control standards and if it were available in sufficient quantity. However, the civilian sector of the Soviet industry has consistently failed to meet these conditions. Whether the measures Gorbachev has publicly advocated will substantially ameliorate these and other problems facing the Soviet oil and gas industries is doubtful. [redacted]

Implications for Purchasing From the West. From the tenor of Gorbachev's remarks, we judge that the Soviets will seek to improve the general supply of equipment to the oil and gas fields mainly by improving the efficiency and technical level of domestic industry. Nonetheless, the Soviets will continue to buy much specialty equipment in the West and may increase some purchases. [redacted]

Some near-term gains in the supply of domestic equipment may result from Gorbachev's campaign to improve worker morale and productivity. Planning and organizational changes may ultimately lead to better planning, better product supply and quality, and prompt deliveries. However, accomplishing such a revolution within the bounds of the Soviet economic system—indeed, even laying the necessary organizational foundations—would require not only many years but also, according to some Western observers, a greater modification of the USSR's economic fabric than would in the end be acceptable to the regime. [redacted]

A domestic solution to the equipment problem is, however, unlikely to be sufficient to offset the rapidly advancing depletion of existing oil deposits. A decision by Moscow to solve its oil production problems by a much greater reliance on Western technology and equipment would require large imports of rotary drilling rigs, oil country tubular goods, and pumping equipment. During 1984-85, the Soviets were negotiating with Western firms for a wide variety of oilfield equipment. Some of the talks probably aimed at obtaining technical information, but some undoubtedly represented serious intent to purchase. The recent collapse of oil prices, with the consequent negative effect on Soviet hard currency earnings, has brought many of these negotiations to a standstill. [redacted]

The Hard Currency Outlook: Bearish

Last year, Soviet hard currency exports fell by over 20 percent, in part reflecting the effect of a $3-4 billion drop in oil sales to the West. This caused Moscow to step up borrowing, increase gold sales, and reduce imports by an estimated $3 billion. In 1986, the drop in hard currency earnings from oil sales to the West may be even steeper. A further decline of 100,000 to 200,000 barrels per day in oil exports to the West, combined with an average price of $17 per barrel (which many market analysts consider optimistic), would cost the USSR some $5 billion. [redacted] 25X1 25X1 25X1

Hard currency scarcity is forcing Soviet officials to reevaluate plans to import technology. In January 1986, Oil Minister Dinkov said that most planned purchases of oil and gas equipment would be postponed or canceled because of hard currency shortages, [redacted] The Minister 25X1
also indicated that most such imported equipment would come from CEMA suppliers during 1986-90. Some Soviet trade officials have indicated that planned purchases of oilfield technology and equipment may be scaled back in proportion to the loss of 25X1
oil revenues. [redacted] 25X1
[redacted] negotiations are continuing on equipment for the 25X1
Karachaganak sour gas project, and in February 1986 the Soviets made inquiries concerning Western arctic-capable drilling rigs. [redacted] 25X1

Moscow probably will continue purchasing items for which there are no suitable domestic or East European substitutes (for example, corrosion-resistant pipe and equipment for sour oil and gas operations, large-diameter pipe for high-pressure gas transmission service, and heavy-duty pipelayers). But the purchase of other Western oil and gas equipment will be carefully scrutinized and weighed in the balance against competing requirements of the high-priority industrial modernization program, as well as against equipment needs critical to the coal and natural gas development 25X1
programs. [redacted] 25X1

In addition to reconsidering the amount of oil and gas equipment to be imported, Moscow is trying to ease the hard currency pinch by exerting pressure on Western suppliers to change payment terms from cash to credit. Some of the Soviets' negative comments about the prospect for imports may reflect a desire to motivate Western suppliers to accede to requests for credit or for more favorable credit terms than were offered in the past.

A reduction in imports of oil and gas equipment will not have significant adverse effects on Soviet oil production over the next year or two, but import cuts—particularly if they affect offshore, deep drilling, and sour oil and gas operations—will make it increasingly difficult over the longer term for Moscow to cope with more complex and challenging problems in exploration and development as it seeks to sustain oil production.

By 1990, the discrepancy between Soviet needs for and ability to supply state-of-the-art petroleum equipment will have acute consequences for oil output (unless the need is attenuated by the immediate discovery of favorably located, easy-to-develop giant oilfields). Indigenous technology and equipment is becoming less efficient and economic relative to the increasingly demanding technical requirements of oil exploration and development—in part because of a limited supply of skilled manpower and technical support. Consequently, the decline in oil production will accelerate unless Moscow turns to the West for more equipment and technical services.

Major Requirements for Oil and Gas Technology and Equipment

At present most of the petroleum technology and equipment used in the USSR is obtained domestically or with some help from the East European countries that are members of the Council for Mutual Economic Assistance (CEMA). As shown in table 4, however, the quality and technical characteristics of CEMA output of nearly all of the items needed for critical applications rate only low to adequate when we compare them against Western standards. Changing operating conditions—deeper drilling onshore and offshore, higher pressures and temperatures, corrosive producing environments, and increasing percentages of associated water production—have rendered most of those items obsolete for an increasing share of operations. 25X1

Several key oil and gas projects scheduled for the 1986-90 period will require Western technology and equipment if development is to proceed on schedule. The first phase (1981-85) of development at Astrakhan' and Karachaganak was based heavily on equipment ordered from French and West German firms. We expect that Moscow will place new orders to Western firms during the second phase of development (1986-90). All the major onshore projects in the Pre-Caspian Depression—Astrakhan', Karachaganak, Tengiz, and Zhanazhol—involve development of deep sour oil and gas deposits. Because of similar geologic conditions, the technology and equipment packages for these projects will be almost identical. Only the depths, pressures, temperatures, and ratios of oil, gas, sulfur, and carbon dioxide are apt to vary. The main high-pressure-and-temperature, corrosion-resistant equipment items needed for these projects are shown in the inset. 25X1

Continued exploration and development of West Siberian onshore oil and gas deposits will require generally similar equipment for deep high-pressure-and-temperature service, but without the special features for coping with high concentrations of hydrogen sulfide (H_2S) and carbon dioxide (CO_2). The need to improve exploration efforts for deeper, harder-to-find petroleum deposits prompted the Politburo in April 1985 to authorize the reequipping of Ministry of Geology field parties with improved seismic and deep-well surveying and drilling equipment. This authorization might result in new orders for Western equipment and plants to produce some of the equipment in the USSR. The Soviets have expressed keen interest in modularized, compact deep-drilling rigs modified for air transport and arctic service, as well as in heavy-duty land rigs for deep drilling at Karachaganak, Astrakhan', Tengiz, and Zhanazhol. 25X1

Table 4
Quality and Availability of Oil and Gas Equipment, by Major Area of Origin [a]

	CEMA		USA	COCOM [b]	Non-COCOM Western Europe	Third World
	USSR	Eastern Europe				
Exploration						
Technology (all phases)	Lo	Lo	X	Hi-X	O-A	O-A
Project feasibility and management studies	Lo	Lo	X	Hi-X	O-A	O-A
Technical integration of hardware and software	Lo	Lo	X	Hi-X	O-Lo	Lo-A
Geophysical equipment (all types)	Lo	Lo	X	A-Hi	Lo	O-Lo
Seismic survey vessels (equipment package excluding hull and boat)	Lo	Lo	X	A-Hi	Lo	O-Lo
Satellite navigation equipment	Lo	Lo	X	Hi	Lo-Hi	O-Lo
Acoustic/ultrasonic sensors and geophysical equipment:						
Geophones for onshore and offshore seismic surveying	Lo	Lo	X	O-Hi	O	O-Lo
Land gravimeters	Lo	Lo	X	O-Hi	O-Hi	
Magneto-telluric systems	Hi	A				
Well-logging equipment	Lo	Lo	X	O-Hi	O	O-Lo
Mud-logging equipment	Lo	Lo	X	O-Hi	O	O-Lo
Monitoring equipment for drilling operations (mud systems and drill-stem testing equipment)	Lo	Lo	X	O-Hi	O	O-Lo
Computer hardware	Lo	Lo	X	A-Hi	O	O-Lo
Drilling and Production						
Technology (all phases)	Lo	Lo	X	Hi	O-Hi	A-Hi
Project feasibility and management studies	Lo	Lo	X	Hi	O-Hi	A-Hi
Technical integration of hardware and software	Lo	Lo	X	Hi	O-Hi	A-Hi
Equipment (all types)	Lo-A	Lo-A	X	Lo-Hi	O-A	O-A
Corrosion-resistant producing equipment (all types)	Lo	Lo	X	Lo-Hi	Lo-A	O-Lo
Christmas trees and blowout preventers	Lo	Lo	X	A-X	O-A	O-Lo
Remote control systems	O	Lo	X	O-X	O-A	O-Lo
Wellheads	Lo	Lo	X	A-Hi	O-Hi	O-Lo
Special steel tubes-casing, tubing, drill collars, drill pipe	Lo	Lo	X	O-Hi	O-Hi	O-Hi

Footnotes appear at end of the table.

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Table 4
Availability and Capability of Oil and Gas Technology and Equipment, by Regions of Origin [a] (continued)

	CEMA		USA	COCOM [b]	Non-COCOM Western Europe	Third World
	USSR	Eastern Europe				
Packers, seals, valves	Lo	Lo	X	O-Hi	O-Lo	O-A
Pump rods	Lo	Lo	X	O-Hi	O-Hi	O-A
Deep submersible pumps (below 600-meter depths)	Lo	Lo	X	O-A	O	O
Manifold systems	Lo	Lo	X	Hi-X	Lo-Hi	O-Hi
Chemical inhibitors	Lo	Lo	X	Hi-X	O-Hi	O-A
High-pressure/temperature production equipment (all types)	Lo	Lo	X	Lo-Hi	O-Lo	O-Lo
Christmas trees and blowout preventers	Lo	A	X	Lo-X	O-A	O-Lo
Remote control systems	O	Lo	X	A-X	O-A	O-Lo
Wellheads	A	A	X	Lo-Hi	O-A	O-Hi
Casing and tubing	Lo	Lo	X	Lo-X	O-Hi	O-Hi
Packers, seals, valves	Lo	Lo	X	O-A	O-Lo	O-A
Deep submersible pumps (below 600-meter depths)	Lo	Lo	X	O-A	O	O
Deep-well drilling rigs and tools (below 3,000-meter depths onshore and offshore)	Lo	Lo	X	Hi	O-Hi	O-Hi
Offshore drilling platforms	Lo	Lo	X	Hi	O-A	O-Hi
Measuring instruments and control systems	Lo	Lo	X	Lo-Hi	O-A	O
Riser and motion compensation systems	Lo	Lo	X	Hi	O	O
Dynamic positioning systems	Lo	Lo	X	A-Hi	O	O
Pipeline Construction						
Technology (all phases)	A	A	X	Hi-X	O-A	O-A
Project feasibility and management studies	A	Lo	X	Hi-X	O-A	O-A
Technical integration of hardware and software	A	Lo	X	Hi-X	O-A	O-Lo
Materials and Equipment (all types)	Lo	Lo	X	Hi-X	O-Lo	O-Lo
Large-diameter pipe (1,020- to 1,420-mm-diameter pipe)	Lo	Lo	Hi	Hi-X	O-Hi	O
Pipe wrapping and coating materials	Lo	Lo	X	A-X	O-Lo	O
Large-diameter valves (1,020- to 1,420-mm bore)	Lo-A	Lo	X	A-X	O	O
Pipeline control systems	Lo	Lo	X	Hi-X	O	O
Turbine drivers and compressors	A	Lo	X	Hi-X	O-Hi	O
Heavy duty pipelayers (over 50-ton load capacity)	A	Lo	X	O-X	O	O

Footnotes appear at end of the table.

Table 4
Availability and Capability of Oil and Gas Technology and Equipment, by Regions of Origin [a] (continued)

	CEMA		USA	COCOM [b]	Non-COCOM Western Europe	Third World
	USSR	Eastern Europe				
Processing and Refining						
Technology (all phases)	Lo	A	X	X	A-Hi	Lo-Hi
Project feasibility and management studies	Lo	A	X	X	A-Hi	Lo-Hi
Equipment (all phases)	Lo-A	Lo	X	X	Lo-A	Lo-Hi
Fluid catalytic cracking (FCC)	Lo-A	Lo	X	X	Lo-A	Lo-Hi
Hydrocracking	Lo	O	X	Lo-Hi	Lo-A	Lo-Hi
Reduced Crude Cracking (alternative to FCC)	O-Lo	O	X	O-X	O	O-Lo
Hydroprocessing	A	Lo	X	X	Lo	Lo-A
Delayed coking and fluid coking	Lo-A	Lo	X	Hi	Lo	O-A
Catalytic reforming	Hi	A	X	X	A	Lo-A
Hydrogen-fluoride alkylation	Lo	O	X	O-A	O	O
Equipment for production of additives for lubes	Lo	Lo	X	Hi-X	A	O-Lo
Gas-processing plants	Lo	Lo	X	Hi	O	O-A

[a] Analysis of data from *Composite Catalog of Oil Field Equipment and Services 1984-85*, Gulf Publishing Company.

Key:
X = Highest or state-of-the-art capability.
Hi = More than adequate for needs.
A = Adequate for most needs.
Lo = Some capability, but inadequate for most needs.
O = No demonstrated capability.
Blank = Unknown.
Listing of more than one code in an entry (for example, Lo-Hi) indicates that some country or countries in the group have the higher capability, while the rest have at least the indicated lower capability.

[b] The 22 items covered by US foreign policy controls and proposed for COCOM control are subsumed in "Exploratory Technology and Equipment" and "Drilling and Production Technology and Equipment." Except for certain turbines, the items covered in "Pipeline Construction Technology, Materials and Equipment" and "Processing and Oil Refining Technology and Equipment" are not subject to US controls.

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A Shopping List of Western Equipment for Exploration and Development of Sour Oil and Gas Deposits

- *State-of-the-art, computer-assisted geophysical surveying equipment, especially seismic equipment.*
- *Deep (6,000 meter) drilling-rig assemblies and blowout preventers. The Soviets recently expressed interest in acquiring 50 deep rigs for sour oil and gas development.*
- *Christmas trees, wellheads, casing, tubing, drill pipe, drill collars, and corrosion inhibitors designed for severe hydrogen sulfide (H_2S) and carbon dioxide (CO_2) service under high pressure and temperature.*
- *Well-workover rigs and tools for maintenance of wells.*
- *Field gathering systems—flowlines, manifold systems, pipelines, valves, monitoring equipment, pump stations, tank farms, corrosion inhibitors.*
- *Field-processing equipment for pretreating and stabilizing corrosive streams of water, oil, gas, condensate (natural gas liquids) with H_2S and CO_2 contaminants.*
- *Plants for processing sour gas and oil, that is, for removing corrosive H_2S and CO_2 from oil, condensate, and natural gas streams before pipeline shipment.*
- *Compressors for pumping and gas injection operations, as well as electric power generation for drilling and production equipment in remote areas.*
- *Mobile drilling fluid laboratories to detect and control on site any strong H_2S gas surges during well-drilling operations in overpressured strata.*
- *Air control systems to monitor toxic gas levels of the air currents around all inhabited communities within a radius of about 50 kilometers of each sour oil or gas field and plant.*
- *Pipeline and flow-line cleaning equipment and tubing inspection equipment, including related wireline cleaning tools.*
- *Plants for the production of drilling-rig assemblies for onshore and offshore service.*
- *Turnkey pipe mill for the production of oil country tubular goods, including drill pipe, casing, and tubing.*
- *A turnkey plant for the production of wellheads, Christmas trees, blowout preventers, and production manifold systems for onshore and seafloor installation.* 25X1

Among the major Soviet offshore projects scheduled for the 1986-90 period, the most difficult will be geophysical surveying and drilling operations in the Barents Sea, Kara Sea, and offshore Sakhalin. Efficient conduct of these operations will call for Western technology, equipment, and training. Western offshore equipment that will be needed includes:

- Geophysical surveying boats capable of conducting simultaneous computerized seismic, magnetic, gravimetric, and hydrocarbon seafloor sampling surveys with online mapping capability.
- Offshore drilling rigs for platform, semi-submersible, and drillship applications such as dynamic positioning, anchoring, and reentry systems; telescopic riser and seafloor connection systems; seafloor wellheads and blowout preventer stacks with remote hydraulic controls; mud-logging laboratories; geophysical well-logging equipment; and drilling monitoring equipment that has online capability.

- Ice-resistant structural and/or hull design may be required for the survey vessels and drillships for service in the arctic seas.

- Offshore production platforms and seafloor production systems (ice-resistant for many areas), such as templates, production manifolds, wellheads and Christmas trees, flow lines, gathering lines, and pipelines. [redacted]

There is no reason to believe that the Soviets can modernize plants and produce all the new equipment that they will need through the 1990s. In the USSR, the introduction of new technology, or even minor modification of an existing product, is usually a time-consuming process involving research institutes, design bureaus, ministries, and, finally, the manufacturing enterprise. Changes in production schedules, improvements in metallurgy, and introduction of new methods of metalworking for new or improved equipment production at existing Soviet and East European plants usually proceed at glacial speed. Gorbachev's moves to streamline the ministerial system and better coordinate the complex activities of research institutes, design bureaus, and production units are likely to have only slight impact on these conditions for at least several years. However, if some of the new production is assigned to the defense industries, lead times for production of many new or improved items probably could be reduced materially. [redacted]

Needs for Specific Categories of Foreign Technology and Equipment

Soviet needs for high-quality technology and equipment now available only from suppliers in the non-Communist world are identified by specific projects and major development regions in table 5. Considerations relating to indigenous and Western capabilities are discussed by major functional category in the following paragraphs. The potential military application of some Western equipment and Western efforts to control transfer of the technology through export control are discussed in the final sections of the paper. [redacted]

Oil and Gas Exploration

Applications. Exploration for oil is more urgent than exploration for natural gas. Gas production is facilitated by undeveloped arctic onshore reserves of natural gas that are huge and high in quality. Oil production, in contrast, is adversely affected by the declining average quality of reserves being tapped. Barring the unlikely discovery of a new supergiant oilfield—a second Samotlor—most future oil discoveries in the USSR will probably be in deeper, smaller, geologically more complex formations and, possibly, increasingly offshore. Efficient exploration of these formations calls for Western equipment, some of which embodies high technology. [redacted] 25X1

Indigenous Capability. Soviet exploration technology and equipment are rated low by Western standards. Although technically competent, Soviet petroleum geologists use poor equipment, which limits accuracy and hinders their progress. Hungary and Romania produce some equipment that has slightly better capabilities but they have only limited capacity for production. Moreover, the Soviet Union lags behind the West in state-of-the-art computer technology—an essential component of any advanced exploration system. Rapid improvement in Soviet capabilities to supply needed exploration equipment is unlikely. [redacted] 25X1

Western Availability. State-of-the-art exploration technology is available in the United States, France, and the United Kingdom; the other COCOM countries have high-level technology (table 5 and appendix A).[3] Austria and several Latin American countries have adequate technology. The United States has state-of-the-art capability for producing most types of exploration equipment, and Canada, France, and the United Kingdom have high capability. The other COCOM nations have production capabilities and 25X1

[redacted] 25X1

25X1

25X1

Table 5
Soviet Needs for Western Oil and Gas Equipment and Technology for Key Projects, 1985-2000

	Offshore			Onshore				
	Barents Sea	Sakhalin	Caspian Sea	Astrakhan' Gas/ Condensate	Tengiz Oil/Gas	Karachaganak Gas/ Condensate	Zhanazhol Oil/Gas	N. Tyumen' Oil/Gas
Exploration								
Technology (all phases)	*	*	*					
Project feasibility and management studies	*	*	*	*	*	*	*	
Technical integration of hardware and software	*	*	*	*	*	*	*	*
Geophysical equipment (all types)	*	*	*					
Seismic survey vessels (equipment package-excluding hull and boat)	*	*	*					
Satellite navigation equipment	*	*	*					
Acoustic/ultrasonic sensors and geophysical equipment:								
Geophones for onshore and offshore seismic surveying	*	*	*	*	*	*	*	*
Land gravimeters	*	*	*	*	*	*	*	
Magneto-telluric systems								
Well-logging equipment	*	*	*	*	*	*	*	*
Mud-logging equipment	*	*	*	*	*	*	*	*
Monitoring equipment for drilling operations (mud systems and drill-stem testing equipment)	*	*	*	*	*	*	*	*
Computer hardware	*	*	*	*	*	*	*	*
Drilling and Production								
Technology (all phases)	*	*	*					
Project feasibility and management studies	*	*	*	*	*	*	*	*
Technical integration of hardware and software	*	*	*	*	*	*	*	*
Equipment (all types)	*	*	*					
Corrosion-resistant producing equipment (all types) [a]	*	*	*	*	*	*	*	*
Christmas trees and blowout preventers	*	*	*	*	*	*	*	*
Remote control systems	*	*	*	*	*	*	*	*
Wellheads	*	*	*	*	*	*	*	*

Footnotes appear at end of the table.

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Table 5
Soviet Needs for Western Oil and Gas Equipment and Technology for Key Projects, 1985-2000 (continued)

	Offshore			Onshore				
	Barents Sea	Sakhalin	Caspian Sea	Astrakhan' Gas/ Condensate	Tengiz Oil/Gas	Karachaganak Gas/ Condensate	Zhanazhol Oil/Gas	N. Tyumen' Oil/Gas
Special steel tubes—casing, tubing, drill collars, drill pipe	*	*	*	*	*	*	*	*
Packers, seals, valves	*	*	*	*	*	*	*	*
Pump rods	*	*	*		*		*	*
Deep submersible pumps (below 600-meter depths)	*	*	*		*		*	*
Manifold systems	*	*	*	*	*	*	*	*
Chemical inhibitors	*	*	*	*	*	*	*	*
High-pressure/temperature production equipment (all types)				*	*	*	*	*
Christmas trees and blowout preventers	*		*	*	*	*	*	*
Remote control systems	*	*	*	*	*	*	*	*
Wellheads	*	*	*	*	*	*	*	
Casing and tubing	*	*	*	*	*	*	*	*
Packers, seals, valves	*	*	*	*	*	*	*	*
Deep submersible pumps (below 600-meter depths)	*	*	*		*		*	*
Deep-well drilling rigs and tools (below 3,000-meter depths onshore and offshore)	*	*	*	*	*	*	*	*
Offshore drilling platforms	*	*	*					
Measuring instruments and control systems	*	*	*	*	*	*	*	*
Riser and motion compensation systems	*	*	*					
Dynamic positioning systems	*	*	*					
Pipeline Construction								
Technology (all phases)								
Project feasibility and management studies	*	*	*					
Technical integration of hardware and software	*	*	*					
Materials and equipment (all types)								
Large-diameter pipe (1,020- to 1,420-mm-diameter pipe)	*			*		*		*

Footnotes appear at end of the table.

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Table 5
Soviet Needs for Western Oil and Gas Equipment and Technology for Key Projects, 1985-2000 (continued)

	Offshore			Onshore				
	Barents Sea	Sakhalin	Caspian Sea	Astrakhan' Gas/ Condensate	Tengiz Oil/Gas	Karachaganak Gas/ Condensate	Zhanazhol Oil/Gas	N. Tyumen' Oil/Gas
Pipe wrapping and coating materials	*	*	*	*	*	*	*	*
Large-diameter valves (1,020- to 1,420-mm-bore)	*	*	*	*		*		*
Pipeline control systems	*	*	*	*	*	*	*	*
Turbine drivers and compressors (aeroderivative; turbines)	*	*	*					
Heavy duty pipelayers (over 50-ton load capacity)				*	*	*	*	*
Gas Processing and Oil Refining								
Technology (all phases)								
Project feasibility and management studies	*	*	*	*	*	*	*	*
Technical integration of hardware and software	*	*	*	*	*	*	*	*
Equipment								
Fluid catalytic cracking (FCC)								
Hydrocracking								
Reduced crude cracking (alternative to FCC)								
Hydroprocessing								
Delayed coking and fluid coking								
Catalytic reforming								
Hydrogen fluoride alkylation								
Equipment for production of additives for lubes								
Gas processing plants	*	*	*	*	*	*	*	*

[a] Corrosion-resistant equipment is essential for operations in the sour oil and gas deposits of the Pre-Caspian Depression; elsewhere, it would greatly reduce the need for frequent replacement of downhole tubing and wellhead equipment.

25X1

capacities that are adequate or less than adequate for most of the surveys now being conducted, but they probably would not be adequate for much of the work that needs to be accomplished in new areas. Latin American and non-COCOM Asian suppliers have no demonstrated ability to produce advanced exploration equipment. [redacted]

Oil and Gas Drilling and Production

Applications. Most Soviet oil and gas drilling and production projects are in the central and northern reaches of West Siberia, where operations are difficult because of climate, terrain, and the lack of adequate logistic support. From 1986 to 2000, operating problems in West Siberia will multiply as drilling requirements spiral upward because of increasing well depths and the greater number of wells required to compensate for lower new-well flow rates. More pumps will be required to cope with rising water production, and the number of well repairs will rise dramatically. The planned exploration and development of sour oil and gas resources in the Pre-Caspian Depression and Central Asia require drilling to substantially greater depths under much higher pressures and temperatures than have been experienced in other operating areas. Drillers tapping into these deposits also have to cope with high-pressure flows of the toxic, corrosive gases, H_2S and CO_2. Offshore activity in the Caspian Sea will require platforms and equipment capable of operating in waters much deeper than those explored in the last decade. If deposits are found in the Barents and Kara Seas, arctic ice conditions could pose challenges more severe than those encountered offshore Sakhalin. [redacted]

Under these conditions, the quality of both the technology and equipment available becomes paramount. As the length of the drill string, column of production tubing, or casing increases, the importance of high-strength steel and product quality control in the fabrication of oil country tubular goods rises exponentially. Corrosion-resistant, reliable tubing is essential to the exploitation of sour oil and gas deposits, and deep-drilling equipment has to withstand extreme pressures of 10,000 psi or more. Adequate equipment is unavailable in Eastern Europe and other CEMA countries. When many of these requirements are superimposed on the complicated task of operating offshore in deep waters (perhaps with ice conditions), other technical questions (such as the compatibility of components in integrated systems) must be added to those of quality and individual levels of technology. [redacted] 25X1

Indigenous Capability. We rate Soviet drilling and production technology, as well as the capability to produce the equipment, low. Romania and Hungary have slightly better capabilities, but neither can produce in sufficient volume to meet Soviet needs. None of the CEMA countries has more than a low capability for offshore operations or for deep sour oil and gas development under operating conditions that require resistance to high pressures and high temperatures. By the mid-1990s, the Soviets may be able to improve their capability somewhat, but they are unlikely in the near term to attain substantial improvements in either the design or supply of equipment. The lack of special alloys, indifferent quality control, and unresponsiveness of equipment producers to the changing technical needs of operators are likely to continue. [redacted] 25X1

25X1

Western Availability. State-of-the-art drilling and production technology is available in the United States; most other COCOM countries—as well as Austria, Brazil, Mexico, Venezuela, and Singapore—can provide high-level technology. Norway has recently advanced its offshore drilling capability through the development of dynamic positioning systems and remote-control systems for operation of subsea blowout preventer stacks and other wellhead equipment. Mexico has acquired considerable experience in the production of deep sour oil, gas, and condensate onshore and offshore. Brazil is a leader in the emerging technology for seafloor completion of oil and gas wells and related seafloor production systems. Argentina, India, Peru, and Taiwan can provide adequate technology. The United States can produce in large volume the state-of-the-art high pressure-temperature, corrosion-resistant drilling and producing equipment required for severe service (high pressure and temperature, corrosive environment). Several other COCOM countries have high capability to produce some items in limited quantities. Elsewhere in the West, the capability and capacity to produce these items is quite low. [redacted] 25X1

25X1

Pipeline-Construction Technology, Materials, and Equipment

Applications. Substantial replacement, but little expansion, of the USSR's oil pipeline system is likely during 1985-2000. The long-distance gas transmission pipeline system will continue to grow through 2000. During 1986-90, the Soviets plan to build six new 1,420-mm-diameter pipelines averaging more than 3,000 kilometers in length and having a probable 75-atmosphere rating. In the construction of these pipelines, problems associated with lower ambient temperatures and more severe permafrost conditions will be encountered as gas production moves farther north from Urengoy to Yamburg and beyond. The Soviets want to increase the efficiency of the gas pipeline system by introducing electronic controls requiring enhanced computer hardware and software capabilities and by improving the reliability and efficiency of the equipment used. [redacted]

Indigenous Capability. Soviet arctic pipeline construction technology is adequate for most current oil and gas needs and superior to that available in Eastern Europe. None of the CEMA countries has demonstrated any capability to match Western offshore pipeline construction. Soviet materials and equipment are adequate to meet the requirements for most oil pipelines. In contrast, the Soviets have not demonstrated a capability to produce significant quantities of large-diameter pipe suitable for high-pressure gas pipeline service, although they recently have claimed some capacity. Eastern Europe has almost no capability to produce pipe over 820 mm in diameter. [redacted]

Moscow, having had to import over 16 million tons of large-diameter (1,020 to 1,420 mm) linepipe since 1970, is acutely aware of the problem of low-quality domestic linepipe and is attempting to upgrade existing pipe-mill capacity. Limited production capability has been achieved by using a spiral-weld, multilayer manufacturing process and an alternative dual longitudinal welding process, which joins two "U" shaped sheets of steel plate to form the pipe. Although these processes appear cumbersome and archaic to Western industry experts, they can provide a usable product. The unproven multiwall Soviet pipe will not, however, be easy to work with; it is heavier, shorter in length, and it will require 3 or 4 times as much welding in the field as conventional Western linepipe. [redacted] 25X1

Linepipe imported from the West accounts for nearly all of the 23,000 kilometers of 1,420-mm-diameter gas pipeline laid in the USSR during 1981-85. Japan, West Germany, and Italy were the principal suppliers. [redacted] 25X1

During 1986-90, the USSR is apt to depend even less on the West for gas turbines than in the past, largely because of increased domestic turbine production, a leveling off in the pace of Soviet construction of large-diameter gas pipelines, and availability of other power sources. Faced with the prospect that the US December 1981–November 1982 embargo would delay delivery of the Western gas turbines ordered for the gas 25X1 export pipeline, the Soviets initiated a crash program during 1982 and 1983 to produce 16-megawatt (MW) and 25-MW industrial turbines. We estimate that Soviet production of large industrial gas turbines has increased sufficiently to meet nearly all needs of the 1986-90 pipeline construction program. This increase appears to reflect primarily success of the 16-MW aeroderivative turbine. West of the Urals, moreover, several compressor stations are being equipped with Soviet 12.5-MW electric motors. [redacted] 25X1

The stepped-up program to produce turbines for large-diameter pipeline service has entailed a shift 25X1 from heavy-duty industrial turbines toward aeroderivative turbines. Many of the latter have been manufactured from the gas generators of retired engines 25X1 25X1 from TU-154 aircraft. [redacted] in 1984 the Soviets installed substantial numbers of 16-MW aeroderivative gas turbines on major domestic gas pipelines. We estimate that aeroderivatives account for at least 40 percent of current Soviet production of turbines suitable for use on large-diameter gas pipelines. [redacted] 25X1

Other equipment and materials. The USSR, which has purchased over 5,000 heavy-duty pipelayers from the West since 1970, reportedly has had some success in producing a prototype capable of handling 1,420-mm-diameter pipe. This new pipelayer, however, may not be suitable for use under arctic conditions nor is it being mass produced, as far as we can tell. Poor metallurgy and excessive tolerances of critical engine parts, together with a shortage of proper low-temperature lubricants, result in rapid engine wear and unreliable operation in extremely cold conditions. Short engine life and high maintenance requirements considerably exacerbate the problems of pipeline construction and operation in the arctic. Ministry of Gas officials have indicated that the USSR will probably import about 2,000 pieces of heavy equipment for gas pipeline construction (pipelayers, bulldozers, and tractors) during 1986-90—somewhat less than during 1981-85. (During 1981 and 1982, the USSR imported about 2,000 pieces of heavy equipment from a Japanese firm.) To enhance the efficiency of the pipeline system, the USSR has also purchased several pipeline control systems, as well as large quantities of pipeline valves and pipeline coating and wrapping materials. [redacted]

Western Availability. State-of-the-art pipeline technology is available from the United States and Canada; high-level technology, from other COCOM countries. Adequate technology is widely available outside COCOM from Austria, Argentina, Brazil, Mexico, Venezuela, India, and Singapore. State-of-the-art and high-level pipeline equipment and linepipe are generally available from the larger COCOM countries; Sweden and Switzerland also produce gas turbines for pipeline and industrial service (see appendix A). [redacted]

Specialized state-of-the-art pipeline materials and equipment for arctic and offshore installation are available from the United States and, for most items, from Canada. Although several Latin American oil-producing countries, India, and Singapore have some technical capability, they produce little if any of the materials and equipment. [redacted] 25X1

West Germany, Italy, Japan, and France have exported most of the large-diameter linepipe (Sweden has sold some), turbine-compressors, valves, and pipeline control systems purchased by the USSR. Both the United States and Japan have supplied pipelayers, but Japan has filled nearly all orders since 1979. [redacted] 25X1

Oil-Refining and Gas-Processing Technology and Equipment

Applications. Meeting the requirements for gasoline, jet fuel, and diesel fuel during the 1986-2000 period will require expansion of secondary refining capacity so that more light products can be extracted from each barrel of oil processed.[4] The crude oil supply is likely to fall off while the domestic demand for light products continues to rise. Moreover, the demand for *mazut* (heavy fuel oils) is expected to decline as gas and, ultimately, coal replace it as boiler fuel. [redacted] 25X1

The prospects for expansion of secondary refining will be influenced by several additional factors. The crude oil supply available to domestic refiners includes an increasing share of West Siberian oil, which yields a larger portion of light products from primary distillation than do the crudes from the older oil regions. 25X1 *Mazut* not needed for domestic electric power and industrial use because of interfuel substitution and conservation may be exported as feedstock for West European refineries, if the oil market is favorable. To the extent that *mazut* exports can satisfy hard currency needs, crude oil that otherwise would be exported can be processed through the primary refining stills to yield added supplies of light products for the domestic market. Moreover, the expected large increases in Soviet natural gas production will boost the supply of gas condensate, which can be commingled with the crude oil stream piped to refineries to yield a somewhat lighter product mix after primary distillation. 25X1 [redacted] 25X1

[redacted] 25X1

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Although several factors suggest less near-term need for added secondary refining capacity in the USSR, the Soviet Long-Term Energy Program refers to the use of methanol and synthetic fuel to help meet rising demand for liquid fuels. This reference implies that pressure will intensify for an increased supply of light petroleum products after 1990 and, consequently, for deeper refining of the available oil supply. [redacted]

The continued rapid increase in natural gas production will require construction of additional gas-processing plants. The natural gas in northern Tyumen' is relatively clean and dry, although the average natural-gas-liquid content will increase somewhat as deeper gas deposits are exploited. Gas-processing requirements in Tyumen' thus will probably remain relatively simple. The technology and equipment required for processing sour gas from deposits in the Pre-Caspian Depression and Central Asia are, however, much more complex because of the toxic and corrosive properties of the gas being processed. [redacted]

Indigenous Capability. The USSR, if we include its imports from Eastern Europe, has generally been self-sufficient in most of the primary and secondary processing equipment installed in its oil refineries. [redacted]

Soviet industry, however, has had serious difficulty in producing hydrocracking equipment (for the processing of heavy feedstocks into lighter hydrocarbon fuels) and hydrogen-fluoride alkylation equipment (for the production of high-octane gasoline). Hydrocracking technology would allow the USSR to process larger amounts of heavy fuel oil (otherwise suitable primarily for use in power plants and heating boilers) into more valuable light products such as gasoline, kerosene, and diesel fuel. Under proper operating conditions, hydrocracking permits concentration on the output of any one of the light products and provides greater flexibility in range of output than catalytic cracking. [redacted]

The Soviets began construction of a commercial hydrocracker in 1977, and it reportedly was completed in late summer of 1985. (In the West, such units are usually finished within two years.) This hydrocracker is patterned after one installed at the Ufa refinery by a French firm during 1974-75. Generally, the Soviets use sulfuric acid alkylation to produce alkylate for blending into high-octane motor gasoline. However, hydrogen fluoride alkylation technology would be more efficient. [redacted] 25X1

The USSR has built fluid catalytic cracking (FCC) units, but only two of the FCC units have been 25X1
installed since 1977. An accelerated pace of construction would probably require Western assistance. [redacted] 25X1

On average, Soviet technology and equipment for gas processing are rated low in relation to future needs. The USSR has constructed plants that can process relatively clean gas (specifically, that from the northern Tyumen' deposits), but even there the Soviets have had to use imported equipment for refrigeration and other special needs. They have not had similar success with domestic technology in developing the sour gas deposits of Orenburg, the Pre-Caspian Depression, 25X1
and Central Asia. Their attempts in the late 1960s to develop the Central Asian sour gas fields with domestic equipment experienced major setbacks from accidents involving H_2S. In 1976 the Soviets finally turned to the West for sulfur-removal technology and for equipment that would enable them to produce and 25X1
process sour gas on a commercial basis at the Orenburg gas complex. [redacted] 25X1

Western Availability. In the West, state-of-the-art oil refining technology is available from all of the larger COCOM countries; high-level, from Austria and Singapore; and an adequate level, from Latin American and non-COCOM Asian countries. The larger COCOM countries also offer state-of-the-art refinery equipment, although not all countries produce all types of equipment. Firms in Japan, France, West Germany, the United Kingdom, and Canada can provide the technology and equipment for the hydrocracking process. Canada and Western Europe have some capability to manufacture equipment and to 25X1
install the hydrogen-fluoride alkylation process. Singapore has high overall capability for production of refinery equipment, but the capability of most of the

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other Asian and Latin American sources is low, except for Mexico and Venezuela, which have high capability to produce fluid catalytic crackers.

The United States has state-of-the-art gas-processing plants. Other COCOM countries—West Germany, France, the Netherlands, Italy, and the United States—can supply comparable high-level equipment; Mexico and Venezuela, adequate equipment. The Soviets have purchased technology and equipment for the major sour oil and gas development projects in the Pre-Caspian Depression mainly from French and West German firms.

Synthetic Fuel From Coal To Supplement the Liquid-Fuel Supply

Applications. Soviet long-range planning for the coal industry is based on a major expansion of open-pit operations. Much of the coal to be mined is poor in heat content, and some cannot be shipped for long distances because its high moisture content results in spontaneous combustion. Consequently, new solutions are needed to facilitate the long-distance transportation of energy from coal, including possibly the development of a synfuels industry. The Soviets hope to be largely self-sufficient in surface-mining equipment; but, until the heavy equipment plant at Krasnoyarsk goes into full production in the late 1980s, Moscow will continue to purchase from East Germany and from Western suppliers.

In recognition of the difficulty of supplying increasing amounts of liquid fuels at a time when oil production is faltering, the Soviet Long-Term Energy Program included reference to development of synfuels production from coal. Moscow has targeted "commercial-scale" production for the mid-1990s; we believe that this goal means several million tons of liquid fuel from coal annually.

Indigenous Capability. The synfuels research program has focused on development of two technologies that yield synthetic liquid fuels: pyrolysis and direct coal conversion. The Soviets probably will not need substantial Western technical assistance to construct commercial-scale pyrolysis facilities; a demonstration plant was completed in 1983. However, the Soviet effort to improve the Bergius direct-conversion process (a technology pirated from Germany at the end of World War II) has met with only limited success. 25X1 25X1

If the USSR decides to build a commercial-scale direct-conversion facility during the 1990s, we believe that substantial Western technology and equipment would be required. 25X1

Western Availability. Most of the proven direct-conversion technology for pilot plants with operating capacities greater than 5 tons a day (coal) originated in the United States. The West German firms Ruhrkohle and Veba operate the only significant direct-conversion plants located outside the United States. Ruhrkohle also has a financial interest in the so-called EDS and H-Coal processes developed in the United States and has rights to the technology. The USSR is unlikely to purchase equipment for a synfuels industry in the near term because it does not plan to build commercial-scale liquefaction facilities until after 1990. 25X1 25X1

Potential Military Applications for Desired Technology and Equipment

The greatest potential for benefit to Soviet military development from diversion of Western petroleum technology and equipment is in the category of state-of-the-art, or "high-level," offshore hardware and software. Much of present Western offshore technology was derived from the explosion of new developments in microelectronics, computerization, and miniaturization of hardware for aerospace applications in the 1960s. Western offshore naval and marine technologies have benefited from the US oil industry's pioneering efforts in the development of motion-compensation and dynamic-positioning systems for offshore drilling and for the design, fabrication, and installation of huge offshore production installations. 25X1 25X1

Recent Western breakthroughs in offshore computer-assisted geophysical exploration and the integration of related hardware and software offer perhaps the greatest potential for a wide array of military applications, especially in command, control, communications, and intelligence.

Much of the technology and equipment used in geophysical exploration has broad military-naval applications. Computer processing of imagery and signal data, together with real-time analysis, can be used for strategic and tactical warfare applications (particularly targeting, mapping, and locating). The advanced geophysical devices for magnetic, acoustic, and ultrasonic sensing, together with state-of-the-art, computer-assisted technology, have greatly improved Western capability for strategic and tactical warfare. Gravimeters are used for missile guidance; magnetotelluric systems, for underground low-frequency military communications; magnetometers, for upgraded magnetic anomaly detection (MAD) systems (locating and mapping areas with natural magnetic anomalies on the seafloor that could be used to conceal submarines); and magnetometers and acoustic sensors, for locating, identifying, and tracking missile-launching and conventional tactical submarines and for conducting ASW operations. For example, modern seismic surveying vessels—which have equipment for hydrocarbon analysis of water samples, in addition to seismograph, gravimeter, magnetometer, and subbottom profiling equipment—can detect organic waste jettisoned by submarines. The minicomputers used for well logging and mud logging and for monitoring drilling operations were borrowed originally from military hardware; they are still designed to meet military specifications for arctic, desert, and naval use.

The metallurgical technologies embodied in corrosion-resistant production equipment and in equipment for high-pressure, high-temperature operating conditions are applicable to conventional and nuclear weapons development, nuclear propulsion systems for submarines and other naval vessels, and military rocket and jet engines. Casing and tubing (which use special steels for high resistance to collapse in deep-well service), packers, downhole subsurface safety valves, and seals (which use high chromium-nickel steel and diffusion coating for high-temperature and high-pressure service) have application in underground nuclear testing and weapons emplacement silos. The specialized metallurgical and metal-processing technology has application for armor, gun barrels, cutting surfaces, and bearings. 25X1

Most Western state-of-the-art and high-level drilling and production equipment packages integrate sophisticated hardware and software capable of performance under severe operating conditions. The components of these packages and their technologies could be useful to Soviet military and defense-industry research:

- Properties of the hardware, such as the tensile and yield strengths of pipe and the integrity and sealing of pipe connections under high pressure and temperature.
- The cutting and bearing technology used to make drill bits.
- Other metallurgy used to make drill bits and tungsten-carbide inserts, drill pipe, collars, casing, tubing, and pump rods.

For example, US state-of-the-art technology for manufacturing drill-string components—drill pipe and drill collars and the connecting tool-joints for each—employs precision rotary forging, a process that results in a refined grain structure for optimum heat-treatment response. This process could be used to manufacture various kinds of pipe and seamless tubes (including gun barrels for artillery) that can withstand severe torquing and other stressing, high pressure, high temperature, and corrosion. Some could be used in nuclear propulsion plants for submarines, for nuclear research, in nuclear weapons plants, and possibly in military rocket and jet engines. 25X1

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Submersible pumps capable of operating at depths greater than 600 meters can be used for recovery of strategic petroleum reserves stored underground. US pumps offer greater lift capacity and reliability than Soviet pumps. The pipes, valves, and fittings used in Western petroleum refinery equipment frequently contain stainless steels in the American Iron and Steel Institute (AISI) austenitic 300 series and ferritic 400 series; those in nuclear power plants use grade 316 stainless steel pipes and valves. Thus, Western refinery grade steel is often able to withstand higher pressure and temperature than the steel used in some Soviet nuclear plants.

Soviet Purchasing From the West

Substantial changes have occurred in the pattern of Soviet purchases of oil and gas equipment from the COCOM countries. In the mid-1970s, Soviet production of oil and gas was expanding rapidly, and the United States was one of the USSR's principal suppliers of machinery and equipment for petroleum exploration, production, and pipeline operation. After 1979, West Germany, Italy, and France became the USSR's main suppliers. At least partly because of increasingly restrictive US trade sanctions in response to Soviet actions in Afghanistan and Poland, Soviet imports of US petroleum equipment dropped sharply, from about one-third of total imports in this category to less than 1 percent in 1984. Japan has become the USSR's principal supplier of pipeline construction equipment (especially heavy-duty pipelayers) and since 1982 it has been the largest supplier of large-diameter linepipe.

The US embargo imposed in late 1981 on delivery of oil and gas equipment and technology to the USSR disrupted plans for supplying the Siberia–to–Western Europe gas export pipeline project. However, the embargo apparently spurred the Soviets to accelerate pipeline construction and the development of domestically manufactured 16-MW and 25-MW gas turbines. Moreover, because the sanctions were not fully supported by the other COCOM countries, the Soviets obtained most of the equipment on order from Western Europe and Japan after some delay. Large-diameter linepipe was excluded from all embargo discussions and negotiations.

All of Moscow's options for timely acquisition of sophisticated petroleum equipment and technology involve increased reliance on the West. Specifically, the Soviets will need to continue purchasing Western linepipe, pipelayers, pipeline valves and control systems, and drilling, producing, and processing equipment. The major projects begun in the 1981-85 period—Astrakhan', Karachaganak, Tengiz, Zhanazhol, along with Caspian and Barents Seas projects— 25X1
are still moving forward, albeit at a pace somewhat slower than planned. We believe that a lull in negotiations over the past year reflects domestic political changes affecting planning. 25X1

The 1986-90 Five-Year Plan was redrafted at Gorbachev's instruction to include more ambitious growth goals. The goal for oil production of 625-640 million tons in 1990 appears to be thoroughly unrealistic, while the goal for gas production of 835-850 billion cubic meters is realistic—perhaps even conservative. We cannot begin to project the number and scale of new project orders until more information on investment priorities and allocations is published. However, the Soviets have begun negotiations—primarily with French and West German firms—for the sour-oil-and-gas processing plants for the second phase of the Astrakhan' and Karachaganak projects and for the first phase of the Tengiz oil project. Because of the leadtime involved, the Soviets have discussed processing plants and have left negotiations on the field wells, 25X1
gathering lines, and manifolds until later. 25X1

To meet their broader oil and gas equipment needs in coming years, Kremlin planners can choose among many sources. A global network of suppliers can provide the varying levels of technology and inventories of equipment appropriate to the range of operating requirements in the USSR. West European suppliers for North Sea offshore operations are eager to sell to the USSR. The Japanese are marketing a list of items that continues to grow. Third World countries (such as Brazil, Argentina, South Korea, and Singapore) are also competing for sales, especially in tubular steel products (oil well casing, tubing, drill pipe, and drill collars). Nonaligned countries (such as 25X1
Finland, Austria, and India) are demonstrating growing capability and capacity. Each year, as more state-owned or subsidized industry comes on line, the network becomes larger and the competition stiffer.
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The Impact of Export Controls

"Wide Spectrum" Embargoes. A multilateral US/COCOM embargo of the 22 items of oil and gas technology and equipment and other high technology proposed by the United States could limit Soviet oil and gas development to relatively shallow (less than 3,000 meters deep) onshore petroleum deposits for the next four to five years (table 6). An embargo *that includes pipe sales* (large-diameter linepipe, well casing, tubing, drill pipe, and drill collars) would have a severe impact on both the oil and gas industries. The Soviets' ability to substitute gas for oil, as planned, would be impaired because of the lack of linepipe to build gas pipelines. Moreover, Soviet oil production would decline probably more rapidly over the next decade if Western seamless tubular steel were not available. An embargo *that did not include pipe sales* would allow the gas industry to expand at about the planned rate, but with slightly higher investment costs. The extensive development of a number of shallow gas pools would be more costly than intensive development of the deeper zones of two or three large gasfields. Because the Soviets usually carry at least a year's inventory of equipment and spare parts, oil output would suffer little immediate decline. After a year or so, adverse consequences from lack of deep drilling equipment, blowout preventers and other wellhead equipment, and artificial lift equipment would have an increasingly negative impact on oil output. The denial of advanced exploration equipment would substantially reduce the potential for improvement in the effectiveness of Soviet petroleum exploration. [redacted]

Although certain natural gas projects are highly vulnerable to denial of Western technology and equipment, *Soviet gas production as a whole is not vulnerable.* For example, shutting down the sour gas projects in the Pre-Caspian Depression and Central Asia would lead to more rapid exploitation of the huge reserves at Urengoy, Yamburg, and the Yamal Peninsula. The size and quality of the Tyumen' natural gas reserves permit a relatively small number of gas wells to produce a large amount of energy. Soviet equipment and technology are adequate for the development of gas reserves in northern Tyumen'. The USSR thus probably can produce sufficient gas to accommodate planned domestic consumption and to offer greater volumes for export through the 1985-2000 period. The outlook for additional discoveries of natural gas, possibly in the Barents and Kara Seas, appears favorable; in addition, immeasurably large reserves probably are trapped in the gas-hydrate formations rimming the arctic seas to the east. [redacted] 25X1

The USSR is rapidly becoming self-sufficient in most of the components necessary for construction of long-distance gas transmission pipelines. Some progress in producing large-diameter pipe for high-pressure gas-line service may be forthcoming, and development of a heavy-duty pipelayer capable of handling large-diameter pipe (though possibly not under arctic conditions) could prove successful. Nevertheless, the USSR still imports large tonnages of pipe and large numbers of Japanese pipelayers. As a result of the accelerated development of large (16-MW and 25-MW) gas turbines during the 1981-82 US embargo, the USSR now appears capable of supplying all or nearly all of its basic needs for turbines and compressors for gas transmission pipeline service. The Soviets still covet Western turbines for their economy and reliability—especially when favorable credit terms are available. Although automated control systems, high-quality pipe coating and wrapping, and state-of-the-art corrosion-prevention systems increase the efficiency and longevity of pipelines, their absence does not prevent effective operation. [redacted] 25X1

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Embargo limited to hardware for offshore development. For the next several years at least, USSR energy production would suffer little from a limited US/COCOM embargo of Western technology and equipment for offshore petroleum development. Most of the impact of the embargo would fall on long-term oil production—and only if the US/COCOM countries continued to cooperate in maintaining the embargo. An embargo—if it included dynamic-positioning equipment, motion-compensation systems, seafloor blowout preventers, and marine Christmas trees—would limit Soviet ability to expand offshore exploration efforts such as those in the Barents Sea

Table 6
Status of US Oil and Gas/Other High-Technology Proposals in COCOM

Item	COCOM Status	US Control Status
Inventory of emerging technologies (structure and modalities are in place, awaiting additions of specific technologies).	Ad Hoc Group agreed to recommend (2 countries *ad referendum*).	Further consideration pending. Three items—ultrasensitive detectors using certain biopolymers, biotechnology industrial-processing programs, and photochemical enhancement of ignition and combustion processes in air-breathing engines—were added to COCOM inventory list controls on 1 February 1985.
Categories of equipment and technology proposed for COCOM controls:		
Deep submersible pumps	Not accepted by the Ad Hoc Group	No US control.
Seismic survey vessels	Deferred for further definition (if needed).	Individual items of concern require a US-validated license for export. For example, crucial portions covered as software are controlled by IL-1566 and computer equipment and peripherals by IL-1565. Installation of these items in a vessel does not remove the need for an export license.
Satellite navigation equipment	Accepted during the List Review.	If aboard the satellite, it is controlled by the ITAR; the ground portion that was controlled by COCOM under IL-1510 on 1 February 1985, is not currently unilaterally controlled.
Acoustic/ultrasonic underwater equipment		
Geophones (certain types)	Accepted during the List Review.	Both underwater and land-use geophones at the capability levels of concern were controlled by all COCOM members under IL-1510 on 1 February 1985.
Other	Deferred for further definition.	Some items could be controlled, if they meet the descriptions in the Commodity Control List (CCL) items 6598F (oil exploration systems), 6191F, or 6391F (oil production use). Otherwise, US unilateral controls apply.
Land gravimeters (certain types)	Accepted during the List Review.	United States does not have unilateral controls on these items; certain items of concern controlled under IL-1571 on 1 February 1985.
Corrosion-resistant oil and gas equipment	Withdrawn.	Controlled unilaterally under CCL 6191F and/or 6391F.
High-pressure/temperature oil and gas equipment	Withdrawn.	Controlled unilaterally under CCL 6191F and/or 6391F.
Deep-well drilling rigs	Withdrawn.	Controlled unilaterally under CCL 6191F and/or 6391 F.
Magneto-telluric systems Well-logging equipment Mud-logging equipment	Magnetometer already covered under IL-1571; other crucial portions, such as software and computer equipment and peripherals used in these systems and well- and mud-logging equipment are already covered by IL-1566 and 1565.	US control on exports to the USSR applies to portions of magneto-telluric systems other than the magnetometer under CCL 6598F.
Feasibility studies	Withdrawn; Ad Hoc Group recommended that member governments take care to ensure that embargoed technology is not transferred through such studies.	US controls on technology of concern apply. COCOM agreement covering tangible technology and related programs involving embargoed technology provided under service contracts was implemented on 15 November 1985.

Table 6
Status of US Oil and Gas/Other High-Technology Proposals in COCOM (continued)

Item	COCOM Status	US Control Status
Technology for integration of:		
a. Magneto-telluric systems	Deferred pending List Review results on software and on the West German technology list.	US technical-data regulations apply to items a through i; this technology is unilaterally controlled under section 379 of the export administration regulations.
b. Seismic survey vessels	Items b through e were deferred on the same basis as a.	
c. Submersible vehicle systems		
d. Offshore positioning and navigation systems		
e. Deep-well drilling rigs and systems		
f. High-pressure/temperature, corrosion-resistant oil and gas production equipment		
Technology for the design, development and production of:		
g. Deep submersible pumps	The United States is reconsidering, following discussion on pump materials, which may already be covered.	
h. High-pressure/temperature oil and gas systems	Items h and i are being reconsidered by the United States on the same basis as g.	
i. Corrosion resistant oil and gas systems		

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and offshore Sakhalin. An embargo lasting three to four years would greatly impede Soviet efforts to find and develop new offshore oil reserves. Soviet industry would probably need at least five to 10 years to develop functionally comparable offshore equipment.

The importance to the Soviets of offshore exploration and development is underscored by the shrinking number of accessible onshore alternatives remaining to be developed. The true oil potential of the best of those may not be realized in this century due to their remote, inaccessible location and geologic depth. In East Siberia, for example, much of the vast land area has potential for oil accumulation but is virtually unexplored—in part because of the forbidding terrain.

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Two options for embargoing technology. A *US/COCOM limited embargo on technology* for manufacturing selected petroleum equipment might retard the USSR's efforts to reduce its dependence on the West over the long run if close multilateral cooperation could be maintained. The Soviets' recent purchases of plants to produce drill bits and tubular steel and their acquisition of installations for constructing offshore drilling platforms and production platforms give them critical Western technology that could materially contribute to the eventual development of petroleum deposits onshore in Tyumen' and offshore in the Caspian, Baltic, and Barents Seas. However, additional Western help will be needed for these areas' development, especially the deep, onshore sour oil and gas deposits in the Pre-Caspian Depression. An embargo on the necessary technology could force Moscow to immediately reallocate domestic resources for the development of the necessary technology. [redacted]

The United States and COCOM might achieve a more immediate impact on the Soviet oil and gas industries by dropping the rubric of "oil and gas equipment and technology" that has been used in past proposals. This terminology in the 1983 US proposal of 22 items proved unacceptable to some of the other COCOM countries, because, they argued, it smacked of "economic warfare." Selective raising and lowering of criteria for COCOM control of electronic instruments, computer technology, and the metallurgy and metal-working processes that are used for producing oil and gas equipment—but without specifying the relationship to that equipment—might achieve better cooperation by COCOM countries. Tighter controls for electronics and metallurgy probably would cover most of the items listed in the US proposal. If such a COCOM initiative were carefully pursued, the effect might be as broad as that of a product-specific embargo, and it would slow the tempo of Soviet oil and gas development. [redacted]

Unilateral US embargo. *A unilateral US embargo* of oil and gas technology and equipment to the USSR and other Warsaw Pact countries probably would achieve limited success for about one year. After that, the effect would be diluted by the widespread availability and continuing development of hardware and technology in Western Europe and Japan, and to a lesser degree, in several Third World nations. Also, as in the past, new production facilities would soon be built overseas for most embargoed items. Thus, the principal long-run effect of a unilateral US embargo where strong foreign competition exists or threatens would be abandonment of the world market to non-US producers. For the United States, adverse consequences of an embargo might extend beyond the direct losses of sales and employment in US industry. Subsequent to the relaxation or elimination of unilateral US restrictions, the USSR and other CEMA countries might continue moving toward new commercial relationships with non-US suppliers as a hedge against future restrictions. Moreover, they would actively boycott US suppliers calling the United States an "unreliable supplier." Thus, even if the Soviet oil and gas industries were to turn again to the United States after the embargo was lifted, that trade would probably not reach as high a level as in the absence of the embargo. [redacted]

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A Full-Decontrol Scenario. If existing US/COCOM controls were removed from all Western oil and gas technology and equipment sought by the Soviet Union, we would expect (barring major improvement in US-Soviet relations) that:

- The Soviets would continue to exercise caution in selecting US firms as prime contractors for major development projects in the Barents Sea or the Pre-Caspian Depression. They would also continue their recent policy of limiting US participation to subcontracting through overseas subsidiaries and licensees.
- The Soviets would probably press forward without US help on all currently planned projects, seeking to use West European and Japanese contractors and equipment when possible. The lack of US help would cause few significant slowdowns in development, except in the Barents Sea. [redacted]

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Even if US-Soviet relations were to improve substantially, the Soviets might not turn immediately to US firms, because West European and Japanese banks offer better financial terms. Moscow is also likely to look to supplier countries that are running trade deficits with the USSR. Nevertheless, the Soviets might seek US help for the Barents Sea project, because of the magnitude of the financial and technical resources needed; US participation could as much as halve the expected leadtime of eight to 10 years.

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Appendix A

Worldwide Availability of Oil and Gas Technology and Equipment [a]

	CEMA		North America and Western Europe: COCOM Countries								Western Europe: Non-COCOM Countries				Asia: COCOM Country	Latin America: Non-COCOM Countries					Asia: Non-COCOM Countries			
	USSR	Eastern Europe	United States	Canada	BENELUX [b]	France	West Germany	Italy	Norway	United Kingdom [c]	Austria	Finland	Sweden	Switzerland	Japan	Argentina	Brazil	Mexico	Peru	Venezuela	India	Singapore	South Korea	Taiwan
Exploration																								
Technology (all phases)	Lo	Lo	X	Hi	Hi	X	Hi	Hi	Hi	X	A	O	O		Hi	A	A	A	A	A	Lo	Lo	O	O
Project feasibility and management studies	Lo	Lo	X	Hi	Hi	X	Hi	Hi	Hi	X	A	O	O		Hi	A	A	A	A	A	A	Lo	O	O
Technical integration of hardware and software	Lo	Lo	X	Hi	Hi	X	Hi	Hi	Hi	X	A	O	Lo		Hi	A	A	A	A	A	Lo	A	O	Lo
Geophysical equipment (all types)	Lo	Lo	X	Hi	A	Hi	A	A	A	Hi	Lo	Lo	Lo		Lo	O	O	O	O	O	O	Lo	O	Lo
Seismic survey vessels (equipment package excluding hull and boat)	Lo	Lo	X	Hi	A	Hi	A	A	A	Hi	Lo	Lo	Lo		Lo	O	O	O	O	O	O	Lo	O	Lo
Satellite navigation equipment	Lo	Lo	X	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Lo	Hi	Hi		Hi	O	Lo	O	O	O	O	Lo	O	Lo
Acoustic/ultrasonic sensors and geophysical equipment:																								
Geophones for onshore and offshore seismic surveying	Lo	Lo	X	A	A	A	A	O	O	Hi	O	O	O		O	O	O	O	O	O	O	Lo	O	Lo
Land gravimeters	Lo	Lo	X	A	A	A	A	O	O	Hi	O	O	X		O	O	O	O	O	O	O	Lo	O	Lo
Magneto-telluric systems	Hi	A																						
Well-logging equipment	Lo	Lo	X	A	A	A	A	O	O	Hi	O	O	O		O	O	O	O	O	O	O	Lo	O	O
Mud-logging equipment	Lo	Lo	X	A	A	A	A	O	O	Hi	O	O	O		A	O	O	O	O	O	O	Lo	O	O
Monitoring equipment for drilling operations (mud systems and drill-stem testing equipment)	Lo	Lo	X	A	A	Hi	A	O	A	Hi	O	O	O		A	O	O	O	O	O	O	Lo	O	O
Computer hardware	Lo	Lo	X	A	Hi	Hi	Hi	Hi	A	Hi	O	O	O		Hi	O	O	O	O	O	O	Lo	O	Lo
Drilling and Production																								
Technology (all phases)	Lo	Lo	X	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	O	O		Hi	A	Hi	Hi	A	Hi	A	Hi	O	A
Project feasibility and management studies	Lo	Lo	X	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	O	O		Hi	A	Hi	Hi	A	Hi	A	Hi	O	A
Technical integration of hardware and software	Lo	Lo	X	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	O	O		Hi	A	Hi	Hi	A	Hi	A	Hi	O	A
Equipment (all types)	Lo-A	Lo-A	X	Hi	Lo	Hi	Hi	Hi	Lo	Hi	A	Lo	O		Hi	Lo	Lo	Lo	Lo	Lo	Lo	A	O	Lo
Corrosion-resistant producing equipment (all types)	Lo	Lo	X	Hi	A	Hi	Hi	Hi	Lo	Hi	A	Lo	Lo		Lo	Lo	Lo	Lo	O	Lo	Lo	Lo	O	O
Christmas trees and blowout preventers	Lo	Lo	X	X	A	Hi	Hi	Hi	O	Hi	A	O	O		Lo	Lo	Lo	Lo	Lo	Lo	O	Lo	O	O
Remote control systems	O	Lo	X	X	O	Hi	O	O	Hi	Hi	A	A	O		O	O	O	O	Lo	O	O	O	O	O
Wellheads	Lo	Lo	X	X	A	Hi	Hi	Hi	A	Hi	Hi	O	O		Lo	Lo	Lo	Lo	Lo	Lo	O	Lo	O	O
Special steel tubes—casing, tubing, drill collars, drill pipe	Lo	Lo	X	Hi	Lo	Hi	Hi	Hi	O	Lo	Hi	O	Hi		Hi	Hi	Hi	A	O	A	O	Hi	Lo	O
Packers, seals, valves	Lo	Lo	X	A	O	A	Lo	Lo	O	Hi	Lo	O	O		O	Lo	A	A	O	A	O	O	O	O
Pump rods	Lo	Lo	X	A	O	A	Hi	A	O	A	Hi	O	O		A	A	O	O	O	O	O	Lo	O	O
Deep submersible pumps (below 600-meter depths)	Lo	Lo	X	O	O	A	O	O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O
Manifold systems	Lo	Lo	X	X	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Lo	Lo		Hi	A	Hi	Hi	O	Hi	A	A	O	Lo
Chemical inhibitors	Lo	Lo	X	X	Hi	Hi	Hi	Hi	Hi	Hi	Hi	O	O		A	A	A	A	O	A	A	A	O	O
High-pressure/temperature production equipment (all types)	Lo	Lo	X	Hi	Lo	Hi	Hi	Hi	Lo	Hi	Lo	O	Lo		Lo	Lo	Lo	Lo	O	Lo	Lo	Lo	O	O
Christmas trees and blowout preventers	Lo	A	X	X	Lo	Hi	Hi	Hi	Lo	Hi	A	O	O		Lo	Lo	Lo	Lo	Lo	Lo	Lo	Lo	O	O
Remote control systems	O	Lo	X	X	A	Hi	A	A	Hi	Hi	A	A	O		A	O	O	O	Lo	O	O	O	O	O
Well heads	A	A	X	Hi	Hi	Hi	Hi	Hi	Lo	Hi	A	O	Lo		Hi	Lo	A	Hi	Lo	A	A	A	Lo	O
Casing and tubing	Lo	Lo	X	X	Hi	Hi	Hi	Hi	Lo	Hi	Hi	O	Hi		Hi	Hi	Hi	Hi	O	A	A	Hi	Hi	O
Packers, seals, valves	Lo	Lo	X	A	O	A	Lo	Lo	O	Hi	Lo	O	O		O	Lo	A	A	O	A	O	Lo	O	O
Deep submersible pumps (below 600-meter depths)	Lo	Lo	X	O	O	A	O	O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O
Deep-well drilling rigs (below 3,000-meters depths) and tools	Lo	Lo	X	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	A	O		Hi	A	A	A	O	O	O	Hi	O	O
Offshore drilling platforms	Lo	Lo	X	Hi	Hi	Hi	Hi	Hi	Hi	Hi	O	A	A		Hi	A	A	A	O	A	A	Hi	Hi	O
Measuring instruments and control systems	Lo	Lo	X	Hi	A	Hi	Hi	A	Lo	A	A	O	O		Hi	O	O	O	O	O	O	O	O	O
Riser and motion compensation systems	Lo	Lo	X	Hi	Hi	Hi	Hi	Hi	Hi	Hi	O	O	O		Hi	O	O	O	O	O	O	O	O	O
Dynamic positioning systems	Lo	Lo	X	A	Hi	Hi	Hi	Hi	Hi	Hi	O	O	O		Hi	O	O	O	O	O	O	O	O	O
Pipeline Construction																								
Technology (all phases)	A	A	X	X	Hi	Hi	Hi	Hi	Hi	Hi	A	O	O		Hi	A	A	A	Lo	A	A	A	O	O
Project feasibility and management studies	A	Lo	X	X	Hi	Hi	Hi	Hi	Hi	Hi	A	O	O		Hi	A	A	A	Lo	A	A	A	O	O
Technical integration of hardware and software	A	Lo	X	X	Hi	Hi	Hi	Hi	Hi	Hi	A	O	O		Hi	A	A	A	Lo	Lo	Lo	Lo	O	O
Materials and equipment (all types)	Lo	Lo	X	X	Hi	Hi	Hi	Hi	Lo	Hi	Lo	O	Lo		Hi	Lo	Lo	Lo	O	O	O	O	O	O
Large-diameter pipe (1,020- to 1,420-mm-diameter pipe)	Lo	Lo	Hi	X	Hi	Hi	X	X	O	Hi	A	O	Hi		X	O	O	O	O	O	O	O	O	O
Pipe wrapping and coating materials	Lo	Lo	X	X	A	Hi	X	Hi	Lo	Hi	Lo	O	O		Hi	O	O	O	O	O	O	O	O	O
Large-diameter valves (1,020- to 1,420-mm bore)	Lo-A	Lo	X	Hi	X	X	X	X	O	Hi	O	O	O		X	O	O	O	O	O	O	O	O	O
Pipeline control systems	Lo	Lo	X	X	X	X	X	X	Hi	X	O	O	O		Hi	O	O	O	O	O	O	O	O	O
Turbine drivers and compressors	A	Lo	X	Hi	Hi	Hi	Hi	Hi	O	X	O	O	Hi	Hi	Hi	O	O	O	O	O	O	O	O	O
Heavy-duty pipelayers (over 50-ton load capacity)	A	Lo	X	O	O	O	O	X	O	O	O	O	O		X	O	O	O	O					
Processing and Refining																								
Technology (all phases)	Lo	A	X	X	X	X	X	X	A	X	Hi	A	A		X	A	A	A	Lo	A	A	Hi	A	A
Project feasibility and management studies	Lo	A	X	X	X	X	X	X	A	X	Hi	A	A		X	A	A	A	Lo	A	A	Hi	A	A
Equipment (all phases)	Lo-A	Lo	X	X	X	X	X	X	Lo	X	A	Lo	A		X	Lo	Lo	Lo	Lo	Lo	Lo	Hi	Lo	Lo
Fluid catalytic cracking (FCC)	Lo-A	Lo	X	X	X	X	X	X	Lo	X	A	Lo	A		X	Lo	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Lo
Hydrocracking	Lo	O	X	Hi	Hi	A	Hi	Lo	Lo	Hi	A	Lo	A		Hi	Lo	Lo	Lo	Lo	Lo	Lo	Hi	Lo	Lo
Reduced crude cracking (alternative to FCC)	O-Lo	O	X	O	O	O	O	O	O	O	O	O	O		X	O	O	O	O	Lo	O	O	O	O
Hydroprocessing	A	Lo	X	X	X	X	X	X	Lo	X	Lo	Lo	Lo		X	Lo	Lo	Lo	Lo	A	Lo	A	Lo	Lo
Delayed coking and fluid coking	Lo-A	Lo	X	Hi	Hi	Hi	Hi	Hi	O	Hi	Lo	Lo	Lo		Hi	Lo	Lo	Lo	O	A	Lo	A	Lo	Lo
Catalytic reforming	Hi	A	X	X	X	X	X	X	O	X	A	A	A		X	A	A	A	Lo					
Hydrogen-fluoride alkylation	Lo	O	X	A	A	A	Lo	Lo	O	A	O	O	O		Lo	O	O	O	O	O	O	O	O	O
Equipment for production of additives for lubes	Lo	Lo	X	Hi	X	Hi	Hi	Hi	A	X	A	A	A		Hi	Lo	Lo	Lo	O	Lo	Lo	Lo	Lo	O
Gas-processing plants	Lo	Lo	X	Hi	Hi	Hi	Hi	Hi		Hi					Hi			A		A				

[a] Listing of more than one code in an entry (for example, Lo-Hi) indicates that some country or countries in the group have the higher capability, while the rest have at least the indicated lower capability.
[b] State-of-the-art and high ratings largely reflect the R&D capabilities of Shell Oil.
[c] State-of-the-art and high ratings reflect the R&D capabilities of British Petroleum.

Key:

X = Highest or state-of-the-art capability.
Hi = More than adequate for needs.
A = Adequate for most needs.
Lo = Some capability, but inadequate for most needs.
O = No demonstrated capability.
Blank = Unknown.

Appendix B

Glossary

General

Blowout preventer	A wellhead installation to prevent uncontrolled high-pressure flows of oil and gas.
Christmas trees	The surface installations placed over individual wells to test and control flow of oil and gas. Marine Christmas trees are used for offshore service above water on platform decks (dry) or for seafloor installation and underwater service (wet).
Compressor station	An installation that uses a power source (for example, electric motors or gas turbines) to drive compressors that pump gas through pipelines.
Feedstock	A hydrocarbon stream used in the manufacture of a refinery product or chemical product.
Gas lift	A method of artificial lift for operating oil wells where large volumes of fluid are extracted by injecting high-pressure gas at the bottom of the well to stimulate the flow of the oil, gas, and water mixture to the surface.
Methane	The major hydrocarbon component of natural gas streams.
Methanol	Methyl alcohol, a flammable liquid often derived from methane; used as an intermediate chemical product, antifreeze, and increasingly as a fuel.
Mud log	A running analysis of drilling fluid samples taken during the course of drilling a well.
Oil country tubular goods	Seamless steel tubes for oil and gas well use; includes well casing, tubing, drill pipe, drill collars, and linepipe.
Paraffin	A waxy component of certain crude oils that often reduces their flow properties.
Permeability	The degree to which the rock pores are interconnected; thus an indicator of the rate at which oil, or gas, can flow through these pores.
Porosity	The pore space, or voidage, in the rock matrix of an oil-gas reservoir.
Production manifolds	Surface installations that collect the output from several wells, flow lines, or gathering systems prior to treatment.
Pyrolysis	Process of breaking down heavy, high-boiling hydrocarbons into simpler and lighter ones by the use of high temperatures.
Real-time	Instantaneous readout and analysis of data being acquired.

Sour oil, sour gas	Oil and gas streams that contain corrosive and toxic admixtures of hydrogen sulfide (H_2S) and carbon dioxide (CO_2).
Sour-service trim	The coatings or finish applied to exposed equipment surfaces used in the production of oil or gas containing H_2S and CO_2.
Standard fuel equivalent	A common denominator of the heat content of various fuels, expressed in terms of a reference fuel, for example, coal containing 7,000 kilocalories per kilogram.

Oil Refining

Primary distillation	The first step in refining, which achieves a rough separation of petroleum constituents in some form of closed apparatus by the application of heat at atmospheric pressure.
Secondary processing	General category for refining of various oil fractions after primary distillation to provide a higher yield of the lighter products and to upgrade produce quality.
Alkylation	A process of combining light hydrocarbon molecules in the presence of a catalyst to form high-octane blending components for production of motor gasoline.
Cracking	A process by which large oil molecules are decomposed into smaller, lower-boiling molecules; used for production of gasoline and diesel fuel from heavy fuel oil.
Catalytic cracking	Conversion of high-boiling-point hydrocarbons into lower boiling ones by means of heat and a catalyst that may be used in a fixed bed, moving bed, or fluid bed.
Fluid catalytic cracking	A catalytic cracking process in which the oil is cracked in the presence of a finely divided catalyst maintained in a fluid state by oil vapors.
Hydrocracking	Conversion of high-boiling hydrocarbon into lower boiling ones by the use of heat and a catalyst with the addition of hydrogen.
Thermal cracking	A refining process that decomposes, rearranges, or combines hydrocarbon molecules by the application of heat.

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