Russian Petroleum Refinery
Handbook

Mikhail G. Rudin
Senior Engineering Advisor
Raytheon Engineers & Constructors

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Preface

This Russian Petroleum Refinery Handbook is a compilation of information related to refining industry in the former USSR (FSU).

The author of this book and editors agreed that what is needed is a comprehensive collection of data that concentrates on "what", "where", and "when" of the FSU petroleum refinery industry: what do the refineries look like? what processes are used in petroleum refining? what scientific and engineering companies are involved? what kinds of equipment and materials are employed in the construction of plants and who is manufacturing the equipment in the FSU? what products are produced in FSU refineries and what are the existing specifications for these products? what norms and regulations are effective in the FSU for safe operation?

In preparation of this book Author utilizes latest information including reports of oil companies and refineries, governmental decrees, orders of Russian Ministry of Fuel and Energy and analogous bodies of other Republics, program "Fuel and Energy," approved by Russian Government in 1996.

This book will be of interest and value to contractors, manufacturers, consulting engineers, and scientists, in both their home and office libraries, and financial institutions.

Grateful acknowledgment is made to the production staff of Begell House, inc., who have exercised extreme patience and understanding in helping bring to completion the process of producing this volume.

RUSSIAN PETROLEUM REFINERY HANDBOOK

Mikhail G. Rudin

This volume is a complete source of information on petroleum refining industry in Russia and the former USSR (FSU). It contains:

- comprehensive collection of up-to-date intelligence on former USSR refineries, including history, process flow description, list of process units, design and actual (as of 1996) capacity;
- review of research and engineering companies involved in petroleum refinery and petrochemistry business, including listing of their activity fields;
- the evaluation of FSU crude oils and a survey of commercial petroleum products made by petroleum refineries and allied petrochemical plants, including up-to-date Russian specifications on these products and comparison of Russian and US specifications;
- description of refinery process units, including data on flow diagrams, on difference between Western and domestic technology, on energy consumption, and listings of FSU so-called "typical" units;
- characteristics of off-site facilities (crude and commercial products storage and shipment, heat and power supply, water supply, sewer systems, fuel, air and nitrogen supply systems).

The big part of the handbook is devoted to equipment and materials employed in the FSU petroleum refineries; the reader can find description of processing equipment (furnaces, distillation columns and trays, heat exchangers, pumps and compressors, tanks and vessels) to be manufactured by FSU machinery plants, including sizing, names and numbers of standards and specifications the equipment is manufactured accordingly; the list of FSU machinery plants.

The handbook represents also specifications and regulations which are effective in the Russia for personnel and plant safety, and environmental specifications.

The author Mikhail G. Rudin has been a senior engineering advisor at Raytheon Engineers and Constructors Inc. since 1994. He was previously with Lengiproneftekhim, Russia, as a technical manager. He has extensive experience in refinery engineering, and has written more than 17 textbooks and reference books on the chemistry and technology of petroleum and gas.

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Basic Description of Refineries in the Former USSR

In the seventeenth century, the distillation of oil and the production of illuminating oil, or photogene took place in West Ukraine and Transcaucasia. From 1821 to 1823 the first industrial oil distillation plant was constructed in the city of Mozdok (North Caucasus Mountain area). The main unit of this plant was a batch still. Illuminating kerosene was the only target product. Gasoline and heavy residue were burned because no use was found for them. Part of the heavy oil was used as a wheel lubricant.

The rapid growth of the petroleum industry in Russia started in the last half of the nineteenth century. In 1869, in Baku, on the western shore of the Caspian Sea, 23 small plants were refining crude oil from local fields. During the late 1870s a new refinery area in Russia, near the Volga River, was established. Refineries in this region began to produce lube oils from petroleum feedstock. Near the end of the nineteenth century and at the beginning of the twentieth century, producing fields and refineries were started up in new areas – Grozny (North Caucasus Mountain area) and Fergana (now Uzbekistan). In 1913, before the First World War, the Russian Empire was producing and refining more than nine million tons of crude annually. Fifty-nine refineries, consisting of batch stills and continuous still batteries, were operating in the Baku and Grozny areas.

During the First World War and the Civil War (1914–1922) most of the oil fields and refineries were destroyed. Rehabilitation of the oil industry began in 1921 and was completed by 1930. Between 1930 and 1935, the former Soviet Union (FSU) refineries constructed the first tube still atmospheric distillation units, instead of still batteries, and the first thermal cracking units.

Many FSU refineries included crude units and thermal cracking units by US companies (Badger, Winkler-Koch, Lummus etc.). New oil fields near the Volga-Ural area were discovered from 1935 to 1941. Simultaneously, new refineries were constructed in this area at Ufa and Saratov. At approximately the same time in the FSU construction of new

refineries also started in regions adjacent to where there was a large demand for oil products. Just before the Second World War, new refineries in Moscow, Odessa (Ukraine), and Khabarovsk (Far East) started up.

At the beginning of the Second World War, some plants from the west of the FSU were relocated to the east. During the war, construction of new refineries in the FSU continued. A large number of units for new refineries were supplied from the United States under the Lend-Lease program.

Major growth of the FSU petroleum refinery industry took place after the Second World War between 1945 and 1967, when more than 20 new refineries in various regions were put on stream. More than 400 units were constructed at FSU refineries, including the first catalytic crackers, hydroformers, catalytic reformers, and alkylation and polymerization units. Volumes of oil production and refinery capacity were increased by approximately 10 times during this period, which established the FSU as second in the world in this category. Later (1965–1995), new refineries and new process units were constructed.

Even with these additional modifications, essentially all refineries are characterized by relatively low levels of conversion to more valuable products and a high consumption of energy.

The FSU refining industry now consists of 48 refineries, located in various regions. The distribution of refineries among former Soviet republics, now independent countries is shown in Table 1.1. Six of the republics of the FSU have no refineries.

The total capacity of FSU refineries is now more than 500 MMTA (millions metric tons per annum). For the remainder of this book, "attained capacity" is called the "potential capacity". The real volume of refined crude at present is substantially less, and depending on the region, equal to 40–80% of the potential level. The capacity of the refineries varies from 2–28 MMTA. The largest two refineries are the NAFTAN refinery at Novopolotsk, Belarus (25.6 MMTA), and the Omsk refinery, West Siberia (28 MMTA). Only four refineries have a capacity of less then 3 MMTA. The average capacity of a refinery in the FSU

Table 1.1 Location of Refineries

Countries (Republics)	Number of refineries	Capacity MMTA/Mbpd
Commonwealth of Independent States (CIS)		
Armenia	–	–
Azerbaijan	2	22.1/442
Belarus	2	41.2/824
Georgia	1	5.3/106
Kazakhstan	3	19.3/386
Kyrgyzstan	–	–
Moldova	–	–
Russia	29	321.2/6424
Tajikistan	–	–
Turkmenistan	2	11.9/238
Ukraine	6	61.5/1230
Uzbekistan	2	8.0/160
Baltic states		
Estonia	–	–
Latvia	–	–
Lithuania	1	13.0/260

Table 1.2 Refinery Size Comparison

	Former USSR	USA	Japan
Less than 2.5 MMTA			
Number	4	72	5
%	8.5	42.4	12.8
2.5–5 MMTA			
Number	4	43	10
%	8.5	25.3	25.6
5–12.5 MMTA			
Number	24	46	22
%	51.1	27	56.4
12.5–20 MMTA			
Number	9	6	2
%	19.1	3.5	5.2
More than 20 MMTA			
Number	6	3	–
%	12.8	1.8	–

Table 1.3 Refining History

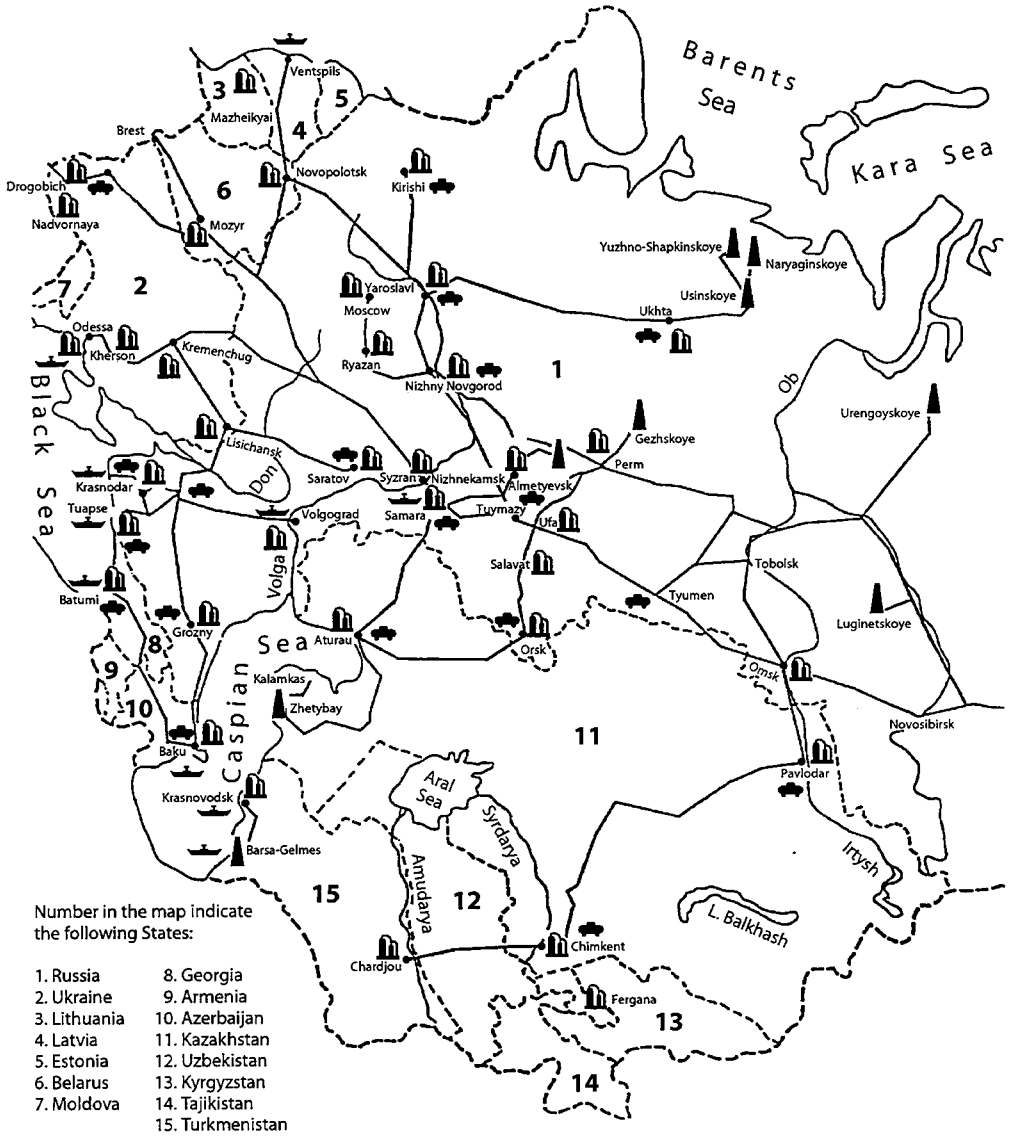
	Before 1945	1945–1960	1961–1975	After 1975
Number of refineries	17	18	5	8
Total capacity, MMTA	138.2	205.6	80.7	79.0
Share,% – on number	35.4	37.5	10.4	16.7
Share,% – on total capacity	27.4	40.8	16.0	15.8

is approximately 2.3 times more than in the United States and 1.8 times more than in Japan (see Table 1.2). In the United States, more than 65 percent of the total number of refineries have a capacity of less than 5 MMTA. In the FSU, more than 80% of the refineries have a capacity of more than 5 MMTA. Fourteen refineries have a capacity of more than 13 MMTA and could refine more than 60% of the total refinery volume.

In addition to products produced at the 48 refineries, gasoline, diesel, and fuel oils are also produced at Astrakhan and Surgut gas plants and at some small refineries (100–500 MTA, thousands tons per annum) in West Siberia, Sakhalin, Tatarstan, and Dagestan. In St. Petersburg, Moscow, Riga, Orenburg, and some other cities there are 9 small plants manufacturing finished lube oils from imported base lubricating oils and additives.

FSU refineries can be divided into four groups (generations): first-generation refineries, constructed before and during the Second World War; second-generation refineries, constructed between 1945 and 1960; third-generation refineries, constructed between 1961 and 1975; and fourth-generation refineries, started up after 1975. A summary of the growth of the refining industry during this period is presented in Table 1.3. First-generation refineries are characterized by being small, old units that generally have unsatisfactory offsite facilities. These refineries (Ukhta, Komsomolsk, Khabarovsk, Atyrau, Drogobich) are most likely to require a full renovation.

Second-generation refineries (Novo-Ufa, Novokuibishevsk, Omsk, Perm, Ryazan) refine more than 40% of the total crude in the FSU. These plants were constructed on the



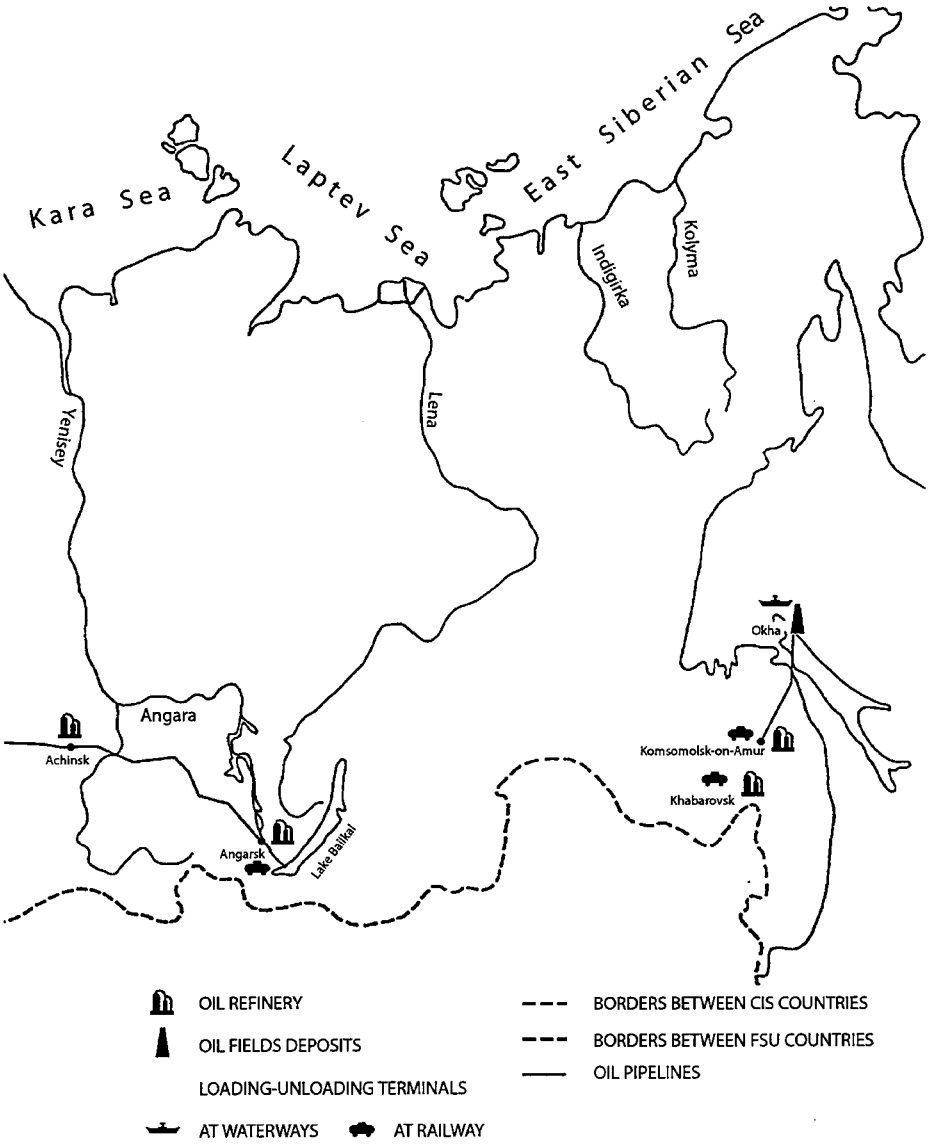
Number in the map indicate the following States:

1. Russia
2. Ukraine
3. Lithuania
4. Latvia
5. Estonia
6. Belarus
7. Moldova
8. Georgia
9. Armenia
10. Azerbaijan
11. Kazakhstan
12. Uzbekistan
13. Kyrgyzstan
14. Tajikistan
15. Turkmenistan

Figure 1.1 Petroleum refineries of the former USSR.

basis of using so-called "typical units". Some of these typical units, constructed from 1950 to 1965, were relatively small, and because of this, second-generation refineries consisted of 40 or more process units. The number of workers at each of these refineries is more, than 4,000. From 1950 to 1953 two huge petrochemical combines were started up in Angarsk, East Siberia, and Salavat, Bashkortostan. These combines consist of the refinery, ethylene units, polyolefin, and oxo-synthesis plants. Second-generation refineries also require significant reconstruction.

Third generation refineries (Kirishi, Kremenchug, Novopolotsk, Novo-Yaroslavl) were completed from units of high capacity, including crude units with capacities of 3–6



MMTA; reformers with capacities of 0.6–1.0 MMTA; and hydrotreaters with capacities of 1.2–2.0 MMTA.

The more recent refinery constructions, which are fourth generation plants (Achinsk, Mozyr, Mazheikyai, Pavlodar, Chimkent) were based on the design concept of integrating a hydroskimming processing scheme of 6 MMTA capacity with a Soviet standardized engineering concept. Two of these refineries (Pavlodar, Mazheikyai) were also designed to integrate a conversion complex, based on FCC (fluid catalytic cracking unit) and other auxiliary processes.

In the FSU, refineries are commonly classified, according to the range of products and the technological layout, into fuel, fuel-lube oil, and those with petrochemical production.

Plants are also grouped in conformity with the level of conversion. Figure 1.1 maps the FSU refineries.

Russia

Russia has 1,500 oil fields, 800 of which are under development; 143,000 oil wells; 50,000 km of trunk pipeline; and more than 1,000 oil bases. Russia holds 13% of the world oil reserves and accounts for 9.9% of global production, and 8.5% of oil exports. The total production of oil and gas condensate in Russia in 1996 was 304.0 MMTA. Oil was produced by vertical integrated concerns (VIC) and other producers. There are 11 VIC consisting of production companies, refineries, and product-distributing enterprises. The volume of oil produced in Russia in 1996 was as follows, millions metric tons (MMT):

LUKOil	53.8	Tatneft	24.8
YUKOS	35.2	Bashneft	16.3
Surgutneftegaz	33.3	Other State controlled producers	10.1
SIDANKO	20.8	Other oil producers	4.9
Tyumen Oil company	21.5		
Sibneft	18.6		
Slavneft	12.9		
Rosneft	13.0		
Joint Ventures	15.5		
Eastern Oil Company	11.2		
ONAKO	7.9		
Komi-TEK	4.2		
Total VIC	247.9		

The refining industry of Russia incorporates 29 refineries with 321 MMTA crude capacity. The oil production slump in recent years has resulted in a processing reduction of Russian refineries from 309 MMTA in 1985 to 176.2 MMTA in 1996. The output of main petroleum products is as follows (MTA)

	1991	1994	1996
Automotive gasoline	38,400	26,100	26,400
Diesel fuel	71,500	43,900	45,800
Heavy fuel oil	96,900	65,100	61,400
Lubricating oils	4,700	2,150	2,330

It is noteworthy that the petroleum production in Russia is much in excess of its processing. In 1995 Russia refined only 62% of produced oil and gas condensate at domestic plants.

Angarsk Petrochemical Company

This enterprise is located in Angarsk, Irkutsk region in Eastern Siberia, 4,200 km from Moscow, and is part of SIDANKO. Its previous names are Combine No. 16, Production Association "Angarsknefteorgsintes". The plant construction started after the Second World War. The first phase was put into operation in 1950. Initially, it was set up with use