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Cost accounting in the oil refining industry

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NATIONAL ASSOCIATION
of
COST ACCOUNTANTS

Affiliated with The Canadian Society
of Cost Accountants



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Cost Accounting in the
Oil Refining Industry

BUSH TERMINAL BUILDING
130 WEST 42nd STREET, NEW YORK

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67 BROAD STREET
NEW YORK

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130 WEST 42nd STREET, NEW YORK CITY

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NATIONAL ASSOCIATION OF
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National Association of Cost Accountants

COST ACCOUNTING IN THE OIL REFINING INDUSTRY

Some articles have been published dealing with accounting for oil or crude petroleum producers, but little has been written about accounting for oil refiners. Yet in this branch of the oil industry, accounting, and particularly cost accounting, is very essential to the success of the enterprise, and no oil refinery operates without some sort of cost keeping system.

The rapid conversion of the raw material to the finished state and the consequent quick turnover of the product, the uncertainty of and frequent changes in the market prices and as a result the necessity of having accurate production and cost figures at all times, are reasons which make the cost accounting department an extremely important one in the oil refining industry.

A detailed description of a complete oil refinery accounting system will not be attempted in this article owing to the lack of space, but the discussion will be limited to a general description of the production and cost records, and certain important features peculiar to the industry will be emphasized. The method of handling accounts other than cost and production, such as purchases and sales, and activities not connected with the refinery, will be omitted as these are similar to those in use in most manufacturing enterprises.

The particular system which is described is one used in a large refinery which produces various grades of fuel oils, gasoline and coke. Some refineries produce a much wider range of commodities, such as various grades of lubricants, paraffin, etc., but the principles underlying the accumulation of costs in either case are the same.

PHASES OF THE OIL REFINING OPERATIONS

Oil refining, as compared with other convertive industries, presents many peculiar features, which have an important bearing upon cost accounting, and in these respects, the cost systems in this industry differ essentially from those in the majority of other industries.

The crude petroleum, after being taken from the wells, is transported to the refinery, and by means of distilling and other treating processes is converted into the products desired. For example, in the production of gasoline from heavy petroleum, the crude oil is run through a distilling process which produces a product known as crude naphtha (later treated to produce gasoline), and a residual is left which is further treated to produce another commodity known as gas oil. The second process in turn

leaves a residual which is further treated to produce still another commodity and so on until the final production of low grade commodities such as coke and asphalt is reached. To what extent these processes are carried, is of course under the control of the management, which will produce the commodity which brings the largest return. In this case the market conditions determine the managerial policy, even to the extent of sometimes making it advisable to scrap an entire section of the plant, and construct new equipment to produce a different commodity which is commanding a sufficiently higher price than the product previously made. Market values determine the proportionate cost values chargeable to the different products, as will be explained later.

As a rule, in refineries where the products are mainly fuels of one sort or another, the cost of labor and operating the plant is extraordinarily small as compared with the value and the volume of raw material or crude oil used. In certain refineries, the processing of 1,000,000 gallons daily (worth about \$50,000.00 at current prices for average grade crude oil) requires a force of less than 300 operatives. It is not uncommon to find the number of men in the construction and maintenance divisions nearly equal to the number in the operating division. Depreciation and particularly obsolescence are extremely important in cost accounting for oil refineries. Processes are continually being improved, necessitating construction of new types of equipment, and in some processes the equipment burns out rapidly and has to be renewed very frequently.

The crude oil is received from tankers or pipe lines and stored in crude oil storage tanks. It is then pumped to either of the main operating processes, the topping stills or the coking stills. From the topping stills is produced fuel oil, which is either carried into storage and later sold, or used as fuel in the plant, or run to the coking stills for further processing. The crude naphtha which is also produced is carried to the steam and fire stills and agitators to be transformed into gasoline. Gas oil produced is put through the rerun stills to obtain flashed gas oil. The coking stills yield gas oil and crude naphtha which are reprocessed as explained for the same products from the topping stills. The coke which remains is stored awaiting delivery. Burning oil distillate is obtained from the rerun stills and the steam and fire stills. The sludge from the agitators is put through the cooking kettles to obtain 50° acid and plant fuel. A part of the fuel used is in the form of gas obtained from some of the processes.

The above description of refining processes is purposely made in general terms for the benefit of readers who are not familiar with this industry, and is not intended as a detailed description of oil refining methods.

ORGANIZATION OF THE COST DEPARTMENT

The plant office force prepares all original records of refinery operations and is generally under the supervision of a chief clerk,

who reports directly to the Comptroller. At the end of the month, summaries are forwarded to the Comptroller's office, where the entries are made in the cost journal and cost ledger, and monthly cost reports are submitted.

Surprisingly few cost clerks are required when the work is properly laid out. For example, a large refinery producing over six million barrels annually would require only the following assistants to the chief clerk in the plant office; an oil production clerk, labor clerk, supplies clerk and transportation clerk. The oil clerk handles the production and inventory records, checking the daily inventories with pumping orders and reports and receipt and delivery reports in order to see that all the oil is accounted for, and prepares the daily stock reports which summarize the receipts and production. The labor clerk checks the time as indicated by the clock cards with foremen's reports, prepares the payrolls and posts the distribution to the labor cost distribution summary. The supplies clerk handles purchase orders for supplies bought locally; checks quantities received from receiving clerk's reports and operates the stores ledger cards, posting requisitions to the stores ledger, and summarizing the cost of supplies used on the supplies used summary. The transportation clerk handles delivery records and prepares the shipment summary.

At the main office, one clerk handles the purchase invoices distribution record, and another makes the cost journal and ledger entries and prepares special and monthly cost reports.

Promptness as well as accuracy in cost work should be insisted upon, and the results of each day's operations must be fully recorded by the following day. The summaries in the plant office are posted daily, and on the last day of the month the footings are forwarded to the main office, which must have the monthly reports completed by the third day of the month following.

CLASSIFICATION OF ACCOUNTS

The detailed cost and inventory accounts are carried into a separate operating ledger, controlled by an account in the general ledger. The following chart gives the detailed cost accounts, classified under inventory, direct operating, indirect operating, production, delivery and miscellaneous. The general ledger accounts affecting costs and sales are also shown.

CHART OF ACCOUNTS (Operating Ledger)

INVENTORY ACCOUNTS

- Fuel Oil
- Crude Naphtha
- Unflashed Gas Oil
- Flashed Gas Oil
- Gasoline—Finished
- Gasoline—Untreated
- Burning Oil Distillate
- Bottoms
- Sludge
- Coke
- Plant Supplies on Hand

DIRECT OPERATING ACCOUNTS

- Topping Stills
- Coking Stills
- Agitators
- Steam Stills
- Mixers
- Cooking Kettles
- Concentrators

INDIRECT OPERATING ACCOUNTS

- General Plant
- Garage
- Office Building
- Superintendence and Office
- Storeroom
- Boiler Plant
- Laboratory
- Engineering Department
- Pumping Plant
- Pipe Lines
- Wharf and Trestle
- Railroad Siding and Loading Rack
- Crude Oil Storage and Handling
- Refined Oil Storage and Handling
- Fire Protection System

PRODUCTION ACCOUNTS

- Fuel Oil
- Crude Naphtha
- Unflashed Gas Oil
- Flashed Gas Oil
- Finished Gasoline
- Untreated Gasoline
- Burning Oil Distillate
- Bottoms
- Sludge
- Coke

DELIVERY ACCOUNTS

- Truck Delivery—Company
- Truck Delivery—Others
- Truck Delivery—Hired
- Steamer or Barge Delivery—Company
- Steamer or Barge Delivery—Others
- Steamer or Barge Delivery—Chartered
- Tank Car Delivery—Company
- Tank Car Delivery—Others
- Tank Car Delivery—Leased
- Fuel Oil Delivery
- Crude Naphtha Delivery
- Finished Gasoline Delivery
- Flashed Gas Oil Delivery
- Coke Delivery

MISCELLANEOUS

- Plant Repairs
- Plant Orders
- Cost of Sales
- General Ledger Control

(GENERAL LEDGER)

- Operating Ledger Control
- Crude Oil in Transit
- Crude Oil Inventory
- Sales
- Accrued Payroll
- Insurance Prepaid
- Liability Insurance Accrued
- Taxes Accrued
- Miscellaneous

ACCUMULATION OF COSTS BY PROCESSES AND DEPARTMENTS

To secure the costs of the products in the various stages of refining, costs are accumulated for each process and department, the costs of the indirect departments being distributed over the direct departments and processes, and the total direct department and process costs plus crude oil cost are distributed over the

products obtained, and finally appear in the cost of sales and finished product inventory accounts. This accumulation of costs follows the oil from the crude state through each process, i. e., to the original cost of the crude oil is added the labor, supplies, and overhead expenses of the first process through which the oil passes, and each resultant product accumulates its share of this total cost, which is carried to the next process, and so on until products are ready for shipment. Special forms are used for the recording of the receipt of crude oil, processing inventory and delivery of finished products.

The method of measuring quantities and taking inventory needs special comment. As all operations involve movement of oil from one tank to another, by means of pumps, it is a simple matter to calculate how much has been delivered by the pumps from crude oil storage to process, from process to process, or from process to finished product storage. The movement of the oil is directly under the control of the plant superintendent, who issues written pumping orders to the pumping plant. Continuous processes are covered by standing orders, and all other movements by special orders.

The height of the oil in a tank is measured or gauged before and after pumping, thus indicating the amount withdrawn or added. This amount is easily determined from an engineer's chart, called a "tank strap," which shows for each inch or fraction of an inch, the corresponding volume of oil contained in the particular tank. Pumping reports are prepared to show this information for each pumping operation, and in addition, a gauge of all the tanks in the plant is taken at a certain hour each day showing the quantity and character of the contents in each tank. These records furnish a complete history of quantities on hand of each grade of oil at the beginning of the day, receipts, transfers and deliveries during the day, and quantities on hand at the close of the day.

Oil is bought and sold at a price per gallon or barrel at a temperature of 60° F. The word "barrel" is used not in the sense of a container but as a unit of measurement representing forty-two (42) gallons. Heavy oils have to be heated to enable a ready flow, and the heating causes an expansion in the volume. It is necessary, therefore, to take the temperature at each gauging and figure the quantity at 60° F, which will differ from the quantity disclosed by the gauge. This is accomplished by the use of a factor technically known as the "coefficient of expansion" which measures the variance in volume for each degree of temperature. It is possible by use of tables of reciprocals to avoid much labor in these calculations. When oil is purchased by barge or tanker load, it is customary to appoint a licensed and independent inspector to pass upon the quality, and gauge the quantity in the cargo, both the buyer and seller being bound by the inspector's findings. This practice avoids dispute as to quantity since two

different gaugers seldom get exactly the same result, and a slight difference in the height of the oil in a large tank may mean a difference of several hundred barrels.

A running summary record called a "Daily Stock Report" is kept for each grade of oil and shows for each day and for the particular month to date, the inventory, receipts, production and deliveries. Separate reports are prepared for each delivery by tank car, barge or tank truck, from which the customer's invoice is prepared.

The labor records present no unusual feature. The "in and out" clock card system is used as the basis in preparing the payroll. The time is checked by daily reports prepared by the foremen which show the distribution of the time. This distribution is entered by the time office on the reverse side of the clock card, which is ruled for the purpose. From the clock cards the data thereon is posted to a labor cost distribution summary, which shows the time and amounts chargeable to each process or department, plant orders, etc.

Records of purchases and supplies are used to record the purchases of equipment and supplies, and the receipts, issuances and inventories of supplies and equipment. A monthly summary is prepared showing the distribution of the supplies used in each process or department, etc. These forms as well as forms for recording customer's orders and sales, and plant orders for repairs and new construction, are similar to those used in any large manufacturing plant.

SUMMARIZING COSTS

All original records of production and inventory of oil, labor, supplies used, etc., are prepared in the plant office. This office also keeps the monthly summaries posted up, and after the close of business at the end of the month, promptly furnishes the general accounting office with a recapitulation of the charges which are to be made to the various cost accounts as disclosed by the summaries. These recapitulations provide the information necessary for entries in the cost journal, which is arranged in columnar form, the accounts being written on the left and debit and credit columns provided at the right for each month of the year. The use of this form of journal involves considerably less clerical labor than the voucher form, and in addition serves as a convenient record to show comparative results from month to month. The items in the journal are posted to the operating ledger, which provides columns for quantities as well as values.

The "operating ledger control account" carried in the general ledger is charged with purchase invoices for supplies and equipment, oil purchases other than crude oil, and miscellaneous expenses chargeable to the refinery operations. Payrolls are charged to the "Accrued Payroll" account. Purchase invoices for crude oil, and expenses in connection with crude oil, such as insurance and freight, are charged to the "Crude Oil in Transit" account.

At the end of the month, the value of the cargoes actually received is charged to the "Crude Oil Inventory" account and credits are made to "Crude Oil in Transit" account. The "Crude Oil Inventory" account is also charged with the expense of storage and handling at the refinery, this charge being made from the cost journal.

In the cost journal, an entry is made for labor expended, crediting "General Ledger—Accrued Payroll" and charging operating accounts, delivery accounts, plant orders, etc. The supplies used are credited to "Plant Supplies on Hand" and charged to the various cost accounts. From the summary of plant repairs, an entry is made charging operating or other cost accounts and crediting "Plant Repairs" account. From the summary of plant orders completed, an entry is made charging General Ledger ("Plant Account" for betterments and "Reserve for Depreciation" for replacements) and crediting "Plant Orders" account. In charging the process accounts for the cost of crude oil used, an average cost per barrel is obtained by dividing the total cost by the total number of barrels.

DISTRIBUTION OF INDIRECT EXPENSES AND INDIRECT DEPARTMENT EXPENSES

After the direct charges for crude oil used, labor, supplies, etc., have been made to the department and delivery accounts, the charges for indirect expenses are recorded. Then the indirect department expenses are distributed over the direct processes and departments. The basis of distribution in each case depends upon the nature of the expense, the most equitable basis being adopted, although it may be said of course that practicability is the governing factor. Insurance is charged to each department according to insurable values of buildings and equipment in the particular department; Taxes Expense according to taxable values; and Depreciation according to depreciable values in the department.

For every indirect expense and indirect department, an apportionment schedule is prepared, showing the details of the distribution made. For example, in the depreciation apportionment schedule, the various items of building and equipment are listed according to department, showing the total cost, rate of depreciation per year (determined by engineers), depreciation amount per year and depreciation amount per month.

Boiler Plant expense is distributed to departments according to the amount of steam used, as shown by meter readings.

Two storage and handling accounts are carried, one for crude oil, and the other for refined oils. To these accounts and also to the delivery accounts are distributed the pumping plant expense, upon the basis of the number of barrels passing through the pumps; pipe lines expense, upon the basis of the number of barrels passing through the pipe lines; and wharf and trestle expense, upon the basis of the number of barrels passing over the wharf. The information as to the number of barrels is readily obtained from the

monthly production and shipment summaries. The crude oil storage and handling expense account is apportioned between the crude oil inventory accounts, if more than one grade of crude oil is carried. The refined oil storage and handling account is apportioned to the various production accounts. An average method of apportionment is used, the expense being distributed according to the proportion that the daily average inventory of each grade bears to the daily average inventory of the total. This daily average is obtained by listing each day the inventory of each grade, and then obtaining an average daily inventory by dividing the summation of the inventory totals by the number of days in the month.

Garage expense is distributed between Truck Delivery expense and Superintendence and Office expense upon the basis of the space occupied by tank trucks and officials' cars. Office Building expense is proportioned between departments using the office space, upon the basis of space occupied by each. Storeroom expense is distributed to departments upon the basis of value of supplies requisitioned. Laboratory expense is distributed according to work done in connection with various products, being charged to the production accounts.

APPORTIONMENT OF PROCESS COSTS

After the process accounts have been charged with all direct and indirect costs applicable, the next step is to distribute the total cost to the various products obtained, or to production accounts.

The method employed in the oil refining industry of applying the process costs to the products obtained by the process is of particular interest as embodying a certain principle not usually encountered in cost accounting. Briefly stated the principle is to apportion the total cost of the oil at the end of each process (i. e., the value of the oil before processing, plus the process costs) over the products obtained by that process, according to the proportion which the market value of each product bears to the total market value of all the products.

The reasons for adopting this method seem logical. It is evident that the total cost of all the products obtained, is the sum of the cost of the oil put in, plus process costs consisting of labor, supplies used and overhead expense. If but one product were obtained, the cost value per barrel would be the quotient of the total cost as above, divided by the number of barrels produced. However, a number of products are usually obtained, which differ greatly in quality and value. It is necessary, therefore, to distribute the total cost equitably between the different products, and obviously this cannot be done by merely using the quantity produced of each product as compared with the total quantity produced, which would result in showing the cost of a high value product as being the same as that of a low value product. To do this would mean a large profit on some products and possibly a

loss on others, and the inventories of some products might be stated at an amount exceeding the sales value.

In a great many processes, no one of the products obtained can be termed the principal product, and therefore the so-called "by-product method"¹ of finding the cost of the principal product cannot be applied.

An apportionment schedule is prepared for each process, showing the costs in detail, and the distribution of the cost over the products obtained, using the market value percentages. The following table illustrates the apportionment of the topping stills cost over production:

APPORTIONMENT OF TOPPING STILLS COST

Crude Oil run to Stills 500,000 bbls. @ \$1.50.....	\$750,000.
Topping Stills operating expenses	50,000.
Total Cost 500,000 bbls. @ \$1.60.....	\$800,000.

Product	Quantity Produced	Market Price Per Bbl.	Total Market Value	Percent to Total	Apportionment of Total Cost	Cost per Bbl.
Fuel Oil	370,000	1.40	\$ 518,000	51.32	\$410,560	\$1.109
Crude Naptha	110,000	4.20	462,000	45.77	366,160	3.329
Gas Oil	10,000	2.94	29,400	2.91	23,280	2.328
Total	490,000		\$1,009,400	100.00	\$800,000	\$1.600

The market values used are not usually revised more than once in six months in order that the comparative feature may be retained.

The production accounts showing the cost of each product are transferred to the debit of the inventory accounts. The inventory accounts are credited and the "Cost of Sales" charged with the cost of products sold.

DELIVERY COST RECORDS

Great importance is attached to delivery cost records, some refineries having a considerable investment in transportation equipment, such as steamers and barges, tank cars, tank trucks, etc. Detailed records are kept of the cost of operating delivery equipment, and costs per mile and per barrel are obtained for each type of equipment.

Delivery accounts are carried as to type of equipment, and these costs are distributed over delivery accounts as to the kind of product, being later transferred to Cost of Sales.

¹In the operation of a small topping plant running a heavy crude oil, about ninety percent of the production would probably be sold as fuel oil. The operation would give about a seven percent yield of gasoline ordinarily (that is after treating) and the value of the gasoline would be deducted from the cost of operation, leaving the remaining cost to be applied to the fuel oil production. Obviously in larger refineries running a high grade crude oil no one product would be of sufficient value to call the other products by-products.

STATEMENTS AND REPORTS

As previously explained, the ease with which daily inventories and production information are obtained, makes it possible to provide the management promptly each morning with a report of the previous day's operations. These daily reports show for each grade of crude and refined products the inventories at the beginning of the day, receipts, production and deliveries during the day, and inventories at the close of the day. The same information is also shown for the particular month to date.

Daily sales summaries are also furnished, showing deliveries made (by quantities and sales value) on each sales contract for the day and month to date.

In addition to monthly balance sheets and profit and loss statements which need no description here, monthly reports of the cost of production and deliveries, and purchases and sales reports, are furnished. The cost of production report would include exhibits showing crude oil cargoes received in quantities and values, and refined oil deliveries showing quantities of each grade and cost of delivery by type of equipment. The main section of the report would be devoted to exhibits of the process costs and production obtained and detailed department costs. In the process cost exhibits, the quantity and cost of oil used, labor, supplies, expenses, etc., used are shown with the production obtained. All exhibits are figured to show costs of each item of expense per barrel, for ready comparison with results of previous months. Since many of the purchases of crude oil and sales of refined oil product are covered by long term contracts, monthly exhibits are prepared to show quantities taken or sold on each contract for the period and to date, and balances remaining.

CONCLUSION

As previously stated, this article has been confined to the records of a refinery producing comparatively few different commodities, but it is hoped that it will serve as an introduction and that it will be followed by publications treating of further developments in the cost accounting for this industry. It is believed that a logical outgrowth will be towards the use of standard or predetermined rates for obtaining process and handling costs.

Although the oil industry in this country, until comparatively recent times, was practically controlled by one large organization, during the last fifteen years, however, a large number of strong, independent companies have been formed. In addition to the new fields in the Southern and Southwestern States, oil lands have been extensively developed in Mexico, and large projects are being pushed in South America. The large number of refineries now in process of construction or contemplated is bound to increase the interest in accounting for this rapidly growing industry.

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