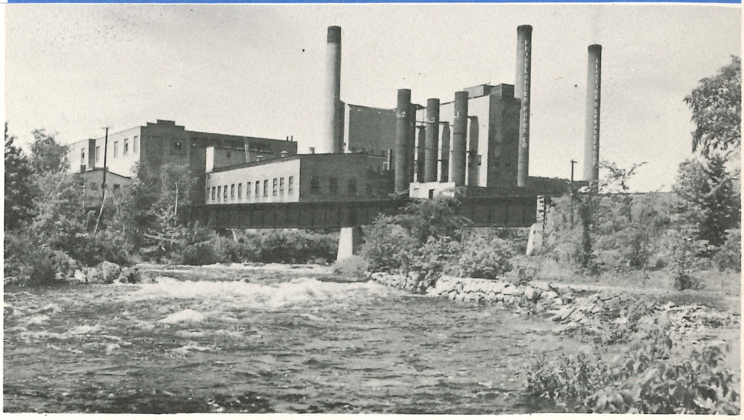
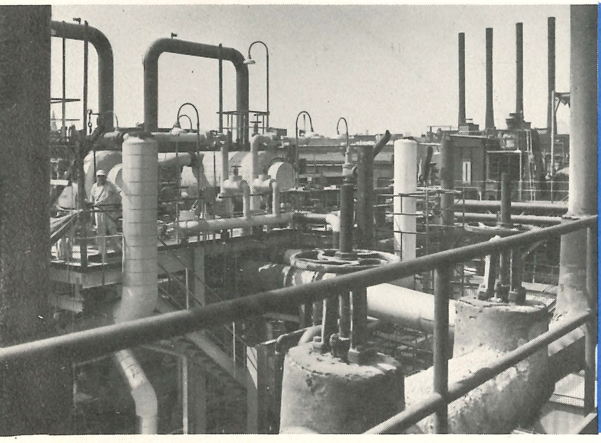
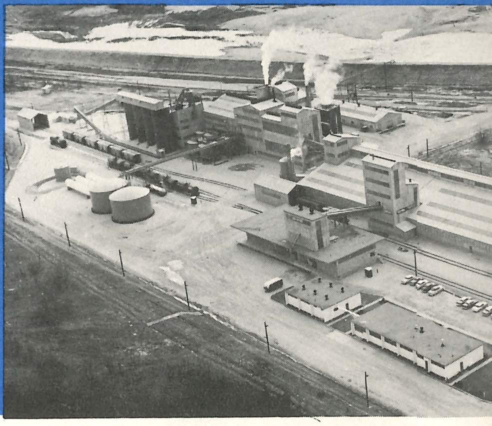


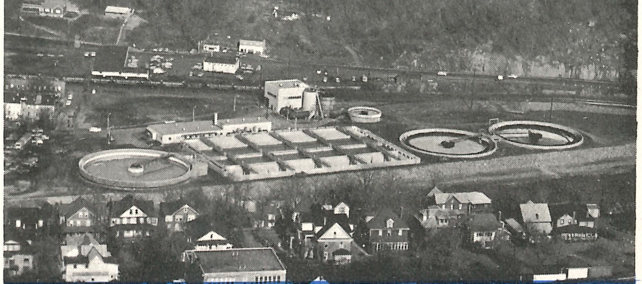
*Proceedings of the Sixth Annual*

# AIR AND WATER POLLUTION CONFERENCE


Ralph H. Luebbers, Editor, P.E.
Professor of Chemical Engineering





**November 15, 1960**
**Columbia, Missouri**


ENGINEERING SERIES BULLETIN NO. 53 • ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF MISSOURI BULLETIN

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THE UNIVERSITY OF MISSOURI BULLETIN

VOL. 62, NO. 25 ENGINEERING EXPERIMENT STATION SERIES NO. 53

Published by the University of Missouri at the Office of Publications, Columbia, Missouri. Entered as second-class matter, January 2, 1914, at post office at Columbia, Missouri, under Act of Congress of August 24, 1912. Issued five times monthly.

1,300
May 27, 1961

*Proceedings of the Sixth Annual*

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Ralph H. Luebbers, Editor, P.E.
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November 15, 1960 Columbia, Missouri

**Engineering Series Bulletin No. 53** **Engineering Experiment Station**

# PROCEEDINGS OF THE SIXTH ANNUAL AIR AND WATER POLLUTION CONFERENCE

*November 16, 1960 University of Missouri, Columbia, Missouri*

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*The Seventh Annual Air and Water Pollution Conference will be held on Tuesday, November 14, 1961 in the Student Union on the Campus in Columbia.*

# THE MISSOURI WATER POLLUTION CONTROL PROGRAM

*by Freeman Johnson**

The 67th General Assembly enacted Missouri's first comprehensive water pollution law in 1957. Prior to this time the Division of Health (under health regulations) carried out a commendable pollution abatement program relating primarily to public health. While public health objectives cover other water uses, the health regulations were inadequate to protect water uses such as agriculture, fish and wildlife, recreation, industry and mining. The present Water Pollution Law, Chapter 204, Revised Statutes of Missouri, Cumulative Supplement, 1957, requires consideration of *all* legitimate water uses.

On April 15, 1958, the six-man board, appointed by Governor James T. Blair, Jr., to administer the Water Pollution Control Program met and organized. To assure due consideration of all water uses, the law specifies that the following interests shall be represented: The public at large; recreation and wildlife; industry; municipal; mining; and, agriculture. Serving on the board and representing the above interests respectively are: Messrs. Harvey A. Jones, Independence; Raymond Krebs, Springfield; Harry H. Hilliker, St. Louis; Freeman R. Johnson, Joplin; J. Marshall Thompson, DeSoto; and, A. Perry Phillips, Columbia, Missouri. By October 1, 1958, regulations pertaining to the issuance of permits and conduct of open public hearings had been developed and were placed into effect.

During the period April 15, 1958 to October 1, 1959, the Board used professional and clerical employees of the Division of Health. It became apparent after the legislature adjourned in 1959 that the Board was to be held responsible for the enforcement provisions of the law with administrative control of the program, and funds appropriated for water pollution control were to be used in general health programs. The Board requested—and the Governor directed—that all matters pertaining to water pollution be placed directly under the administrative control of the Water Pollution Board.

Since October 1, 1959, the Board has been a separate unit of government within the Department of Public Health and Welfare. With only $15,000 state funds and $54,300 federal funds available, it was necessary to curtail many of the services necessary for a water pollution abatement program. The following is a statement of expenditures for water pollution control within the Division of Health:

| Fiscal Year | State Funds | Federal Funds | Total |
|---|---|---|---|
| 1957 | $ 44,537 | $33,148 | $ 77,685 |
| 1958 | 76,588 | 62,596 | 139,184 |
| 1959 | 118,534 | 62,196 | 180,730 |
| 1960 | *146,624 | 57,900 | 204,524 |
| 1961 | *159,547 | 00 | 159,547 |

*Amounts requested by the Division of Health.

The legislature actually appropriated for the biennium the same amount per year as had been appropriated the previous year. On this basis, then, $118,534 in state funds should have been available for water pollution control. Since the appropriation bill as finally passed by the legislature carried a *line item* of $15,000 per year for special studies and enforcement procedures, such activities being beyond the normal activities of the Division of Health, these were the only state funds made available to the Board.

With the limited funds available the Board employed an executive secretary, three professional sanitary engineers, a sewage works supervisor, a clerk-stenographer and a clerk-typist. A second clerk-typist was employed August 1 of this year. With this extremely small staff, the following statistics are indeed noteworthy.

For the period July 1, 1959 to June 30, 1960:

1. Processed 27 applications for federal grants for sewage treatment works. The total grant requests for the year amounted to $1,572,146. (Total available to Missouri per year $1,060,000.) Total project costs for the 27 projects, not including lateral sewers, amounted to $11,657,209. As soon as President Eisenhower signs the Appropriation Bill, the Board will issue Priority Certifications for 18 municipal projects which will take all of the current allocation to Missouri.
2. Plans reviewed and construction permits issued for 1,538,731 feet of sanitary sewer (approximately 291 miles).
3. Plans reviewed and construction permits issued for 123 waste stabilization lagoons, serving a total population of 87,210 persons.
4. Plans reviewed and construction permits issued for 45 mechanical sewage treatment plants serving 20,327 persons.
5. Final inspection and operating permits issued for 701,459 feet of sanitary sewers.
6. Final inspection and operating permits issued for 52 waste stabilization lagoons serving 45,075 persons.
7. Final inspection and operating permits issued for 32 mechanical sewage treatment plants serving 49,145 persons.
8. Completed five regional training schools for sewage works operators.
9. On-the-job training given at eight new sewage treatment plants.
10. Contacted 167 industries and small businesses regarding water pollution abatement.

*Member Water Pollution Board. Representing Municipalities. Joplin.

11. Inspected 60 sewage treatment works and submitted written reports to owners.

For your information, I will review the responsibilities of the Board under the law and to what degree these responsibilities are being carried out.

1. It is incumbent upon the Board to issue operating permits for all existing sewerage systems discharging into waters of the state. Where treatment works are satisfactory, the permit is issued upon receipt of an application stating the volume and strength of waste discharged. Where treatment works are inadequate, a reasonable timetable for correction is required prior to issuance of operating permits. Issuance of operating permits for existing facilities is approximately fifty percent complete. To determine whether or not sewage treatment works are properly and efficiently operating, at least *annual inspections* are necessary. Semi-annual inspections are desirable. Where treatment facilities are not efficiently operated, after due notice has been given by the board, operating permits may be revoked. During the past year, only twenty percent of the treatment works have been inspected.
2. It is necessary under the law for *any person, city* or *industry* desiring to construct, alter or modify any system for the disposal of sewage or industrial waste with the discharge to the waters of the state, to obtain a construction permit. Prior to issuance of such permits, it is necessary for the owner to submit an engineering report, outlining characteristics of the waste both before and after treatment, and the probable effect of these discharges upon the receiving stream. Upon approval of the engineering report, detailed plans and specifications are submitted to the Board for review and issuance of a construction permit. The staff must review these plans to determine whether or not the water quality objectives for the receiving stream will be met. One of the early actions of the Water Pollution Board was to instruct the professional staff that due consideration must be given to the economy of design and operation of all proposed systems for collection and treatment of sewage and industrial waste. To our knowledge, we are the only water pollution control board giving consideration to the cost of such works. The Board cannot refuse a permit based on excessive cost; however, they can and propose to advise the owner of the Board's opinion. We believe this item alone justifies the small cost of administering the water pollution control program. It is estimated that we are fulfilling 98 percent of our responsibility in reviewing plans and issuing construction permits.
3. Act in the interest of citizens to *restore* and *maintain* a reasonable degree of purity in the waters of the state. This is only partially being carried out, primarily because of the insufficient staff to make at least annual inspections of existing sewage treatment works. The full time of one engineer is needed to work with municipal officials and owners of resorts in the Lake of the Ozarks, Lake Taneycomo and Table Rock areas to control present pollution and to prevent additional pollution to these important recreational areas.
4. Encourage voluntary cooperation by all persons in the state in restoring and maintaining a reasonable degree of purity in the waters of the state. To only a very limited extent are we now able to carry out this provision of the law. With all known polluters, we encourage voluntary cooperation. However, nothing has yet been done to obtain the cooperation of municipal and industrial employees who are responsible for waste conservation and accidental discharges that render ineffective pollution abatement works and cause serious damage to downstream water users. A full-time staff employee is needed to carry out this important activity. The water pollution abatement program will not be effective even with each waste discharge preceded by adequate treatment works until we have the cooperation of all persons responsible for any discharge to the sewage collection system.
5. Survey the waters of the state to determine the extent, character and effects of existing pollution. There are 44 major drainage basins in the state. These basins contain a total of about 5,215 stream miles. To date, only a portion of one drainage basin has been surveyed. Information obtained in a stream survey includes chemical, biological, radiological, bacteriological and stream flow data. Such information is valuable to: (1) industrial interests intending to locate in Missouri; (2) cities looking for additional sources to implement their water supply to satisfy an ever increasing demand; (3) agricultural interests for irrigation; (4) recreational industries in locating suitable sites. During the past year the staff contacted 167 industries and small businesses on water pollution matters. This is a 100 percent increase over the preceding year. There is every reason to believe that the number of industries and businesses seeking assistance will continue to increase at the same rate during the next two years. During the past 2½ years, new industries in Missouri have increased 63 percent over the preceding four years and during the same 2½ years there has been a 60 percent increase in expansion of existing industries for the preceding four years. Each indus-

trial waste is a separate and distinct problem as contrasted to strictly domestic waste which has more or less standard characteristics. Recent activities in iron and oil exploration and developments will require additional assistance and information in preventing both surface and underground pollution. It appears certain that Missouri will soon have one with a potential of four large pulp and paper industries. To meet the present need of stream surveys of six selected drainage basins, at least two additional engineers are needed.

6. Prepare and develop a general comprehensive plan for the prevention of any further pollution and the reduction of existing pollution after a thorough study of existing practices and available research. A comprehensive plan has been developed for prevention and reduction of existing pollution. The staff will continue to re-evaluate and modify the plan as new information and research become available. In this connection, studies and investigations by the staff have led to widespread use of waste stabilization lagoons. This low cost treatment device, requiring minimal operational cost, has resulted in savings to cities, industries and small businesses of over $9 million (in first cost alone) for the period 1953 to June 30, 1960.
7. Administer and request enforcement of the laws of the state relating to the prevention and control of pollution. The Board has requested state or federal enforcement procedures at the following locations: Jefferson County; St. Joseph; and, Kansas City. It is the Board's policy to use educational methods for correcting pollution problems wherever possible; however, when this fails, enforcement procedures will be inaugurated.
8. Adopt rules and regulations necessary for administration of the law. This the Board carried out prior to October 1, 1958. In the near future, regulations pertaining to control of pollution of sub-surface waters will be necessary. This will require considerable study and investigation in a field where little has been done by others. Expanded activities in iron and oil exploration and development point up this need.
9. Hold hearings to determine whether or not an alleged pollution is contrary to the public interest. The Board has assisted the federal government in hearings at St. Joseph and Kansas City. When educational and cooperative efforts fail, additional hearings will be necessary. To provide for witness fees and court reporting, at least $5,000 per year is requested.
10. As necessary, establish or revise standards of water purity for any waters of the state. To date, no standards of water purity have been set by the Board. In later years, such standards may be necessary until such time as requests for funds or personnel are not deemed necessary.
11. Conduct investigations the Board finds necessary for the discharge of its duties. To date, no special investigations have been made by the Board; none are contemplated for the ensuing two years.
12. Conduct or cooperate in research for the purpose of developing economical and practical methods of preventing and controlling pollution. During the past year nothing has been done in this field by the Water Pollution Board staff. There is a great need to find a solution to the problem of pollution caused by abandoned coal mines. New developments in sewage pumping and treatment devices need to be investigated and evaluated in order to reduce first cost and operating cost. To accomplish this, the services of one additional engineer are needed.
13. Cooperate with the federal government and with state and municipal agencies in preventing and controlling pollution. The Board has done this and will continue to do so to the extent possible. As of June 30, 1960, Missouri ranked *SECOND* in the nation in the number of sewage treatment projects completed (46) and *FOURTH* in the nation in the total number of approved projects (82) since the federal grant program began in 1957 Fiscal Year. This clearly demonstrates Missouri's acceptance of the challenge to reduce pollution and to make available for re-use water needed by others.

So far, I have told you about the make-up of the Water Pollution Board, what is required under the law —what we have done—and, *now,* I want to point up the needs in personnel, equipment and legislation.

To carry out the minimum provisions of the law, render the necessary services to cities and industries, and make a minimum of six drainage basin surveys per year, we will need five additional engineers, a station wagon, field test kits and two additional clerk-typists. The total cost of all this is $148 thousand per year. This is a request of $32,730 less than used by the Division of Health in Fiscal Year 1959. We plan a more complete and efficient program and at less cost. The total cost of the administration of the proposed pollution abatement program is less than five cents per person per year. It is an established fact that water pollution abatement programs hold a key position in the economic development of the country. Missouri is no exception. The chemical, food processing, pulp and paper industries offer economic advancement but, unless properly constructed and adequate treatment works are provided for waste discharges, our recreational industry is bound to suffer.

In the field of legislation, our present law should be modified to be sure that the water pollution control program will always be administered by the Board, as was the intention of the legislators who passed the law in 1957. We need modification of the present law relating to the disposal of the dead animals which permits disposal of such animals in the Missouri and Mississippi Rivers. We also need an amendment to the present water pollution law which will permit regulation of sewage discharge from boats equipped with marine toilets.

In the interest of protecting the investment of $22 million in existing municipal sewage treatment works, it is estimated that in five years the value of all municipal sewage treatment works will be no less than $70 million (treatment works *only*—does not include lift stations, force mains and sewer system). I believe it to be essential to upgrade the operators of sewage treatment plants. Competent personnel are definitely needed to protect the communities' investment and to protect the waters of our state from pollution due to malfunctioning treatment works. To give emphasis to this important phase of municipal responsibility, I urge you to support a mandatory licensing program for qualified operators. Members of our staff have seen numerous installations throughout the state that have served only a fraction of their life expectancy because of little or no maintenance. On the other hand, we have seen treatment plants handle fifty percent overloads effectively because of good operation. Unquestionably, good maintenance and skilled operation will extend the capacity and life of treatment facilities.

Very recently there have been some very encouraging events. Some weeks ago bond elections were held in portions of the Metropolitan St. Louis Sewer District. Gravois Creek bond issue was voted in the amount of $4,750,000 general obligation bonds. Coldwater Creek bond issue was voted in the amount of $10,896,000 revenue bonds. These two issues will provide a total of 24½ miles of sewers and complete treatment serving 140,000 people.

More recently, North Kansas City voted a $2,500,000 bond issue both general and revenue bonds to supply sewers and primary treatment—

And, of course, by far the biggest single step forward in cleaning up pollution of the Missouri River was the result of the election last Tuesday when, as you know, Kansas City voted $75,000,000 in bonds to provide complete eradication of pollution by Kansas City.

It seems that with understanding of a problem, the voters will solve it.

# POLLUTION CONTROL MEASURES OF MONSANTO CHEMICAL COMPANY

*by C. N. Stutz**

The water pollution control activities of the Monsanto Chemical Company have been centered largely in the Organic Chemicals Division. The reason for this is that most of the water pollution problems are associated with the production of organic chemicals.

During the past few years an intensive survey program has been in progress at all Organic Division plants. The program has been aimed primarily at assessing the problem and reducing waste load going to the sewers.

The pollution control activities of the Organic Division can be divided into five general categories.

1. Departmental surveys with sampling and testing of individual waste streams to determine sources and characteristics of individual pollution.
2. Investigation into possible improvements in design and operational procedures for individual manufacturing units to bring about a reduction in waste load.
3. Separation of wastes in departments for separate methods of disposal.
4. Outfall sewer sampling, testing and waste treatment studies.
5. Cooperative programs with other industries and governmental agencies for overall pollution control.

## Departmental Surveys and Sampling

This program is being carried on in all Organic Division plants. Individual manufacturing units are surveyed for possible contributions to the waste load which can be prevented by improved operation, more frequent maintenance, or minor changes in design. Such items as pipe joint and pump packing leakage, overflow of storage and batching tanks, spills of raw or finished product, disposal of spoiled batches, etc., are covered in these surveys.

Many of these items can be detected by frequent visits to a department and visual observation. Others require the setting up of continuous sampling devices and chemical analyses of effluents. Both types of surveys are presently being made.

This phase of the program, to be successful, requires the full cooperation of the operating personnel. Frequent meetings are necessary between the pollution control engineer and the manufacturing superintendents, and between manufacturing superintendents and operating personnel to keep all informed of the overall pollution control program. In most instances the meetings between the pollution control engineer and the manufacturing superintendents are most successful when held under the direction of the plant manager. This gives status and importance to the program and insures cooperation.

This program is a continuing program and is never finished. Some companies, in order to secure cooperation from the manufacturing superintendents, have established a charge system for waste treatment to each manufacturing unit on the basis of waste load. This charge is against the cost of manufacturing and acts as an incentive to keep the wastes going to the sewers to a minimum. We have given consideration to this system and may adopt it at some of our plants.

## Investigation of Possible Improvements in Design and Operation

The possibility of improving methods of manufacture so as to cut down on waste loads going to the sewer offers many opportunities. Often the use of additional recovery steps even though not attractive economically by themselves may prove to be economical when compared with the cost of removing the lost material in a waste treatment plant. Possibilities along these lines apply to almost every manufacturing process.

This program is being carried on to a limited extent in all of our plants. The need for improved design or a change in operating procedures is often established from data collected in a departmental waste survey.

When a continuous sampling program is set up on a department and measurements are made of waste stream flows and product losses, the data are often very revealing. The data, if significant, are presented to the manufacturing superintendent and an investigation is started to determine why the losses are occurring. Out of the surveys and investigations that have been made to date many improvements resulted. Such improvements as dust collectors to replace drowning legs, product recovery systems, improved washing facilities, added cooling and condensing facilities, etc., to recover product going to the sewer have been made. In some instances investigations into entirely different process which would produce less waste products have been undertaken with beneficial results.

Most surveys of this type are very time consuming. Ingenious methods are needed for collecting representative samples from individual waste streams and for measuring the rates of flow. Often the manufacturing process is a batch-type using various cycles for charging, heating, distillation, cooling, washing, drying, etc., with a variable type and quantity of waste leaving the unit with each change of operation. This all adds to the difficulty

*Sanitary Engineer, Organic Chemicals Division, Engineering Department, Monsanto Chemical Company, St. Louis.

of collecting representative samples from each operation and determining the quantity of flow from each step. For example the characteristics of the wash water from a stepped washing operation will vary in composition with each type of wash and throughout the length of each wash.

Even with all the difficulties of sampling and testing, valuable data can be collected to indicate approximate losses of materials and possible need for improvement. From data secured over the past three years in the Organic Division plants, improvements have been made to manufacturing processes which have cost over a million dollars. Many of these improvements, although made for pollution control purposes, have been self supporting. The value of products recovered have paid for the cost of the improvement. Future projects, however, will in most instances be of a more marginal nature and a profitable return will be questionable. The more obvious projects have already been completed.

The cost of many of the future product recovery projects will have to be compared with the cost of waste treatment and the most economical method adopted. For evaluation purpose we have been using 0.5 cents per pound to neutralize acids and 3 cents per pound to oxidize organic materials in a waste treatment plant. The acid is in terms of calcium carbonate equivalent and the organic matter in terms of C.O.D. equivalent.

Our company has adopted the policy in the Organic Division of reviewing the waste disposal needs for all proposed new manufacturing units. In making this review an estimate is made of the cost for waste treatment which is included in the cost of manufacturing. In cases where an excessively high cost is indicated for waste treatment, research work is undertaken prior to design on methods that might be employed to reduce the waste load. Any improvements that can be developed along these lines are incorporated into the design for the new plant.

This phase of the waste control program also has unlimited possibilities. It can involve research work on new methods for manufacture and possible uses for waste products. It touches every manufacturing process. It will be a continuing phase of the pollution control program in our company.

### Separation of Wastes

This program has been in operation to a limited extent at all plants for a number of years. Certain materials are drawn off into drums or tank trucks at individual departments and hauled to dumps for disposal. Others are piped to incinerators or flare towers for burning.

Departmental surveys on individual waste streams permit a more close examination of the materials leaving a department and an evaluation of the most economical methods of disposal. Separate sewer systems for different types of liquid wastes have not been used to any great extent in our Organic Division plants. The reason for this has been that treatment has not been provided and the need for separation was not apparent.

Now that treatment is under study at a number of our plants, economic studies are being made on various types of separation for ease of treatment. These studies involve the separation of uncontaminated cooling water from contaminated water, separation of inorganic acid contaminated wastes from organic contaminated wastes, and the separation of wastes which are toxic to biological treatment from wastes which are amiable to treatment by biological means.

Studies are also being made on the cost of disposing of certain individual wastes which are presently being sewered but which could be disposed of by dumping at sanitary land fills or incinerated. Work on this phase of the problem has been under way at all of our plants and a number of individual waste streams have been removed from the sewers and are being disposed of by incineration or dumping.

**Fig. 1—Flare tower used for burning waste hydrogen sulfide gas.**

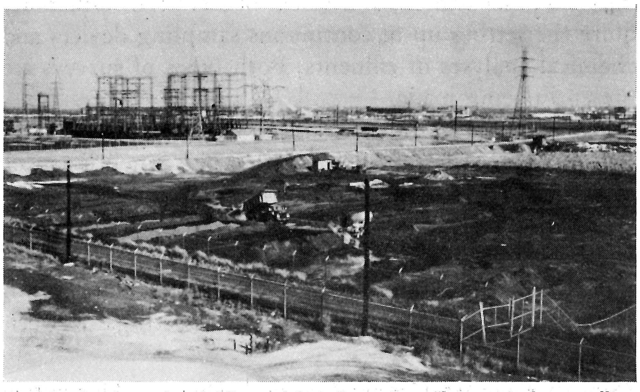


**Fig. 2—Sanitary land fill used for disposing of tars and crystalline residues.**

## Outfall Sewer Sampling and Testing

Before any waste treatment program can be undertaken it is necessary to secure data on the quantity and characteristics of the wastes to be treated. Our Organic Division plants are made up of a great number of manufacturing units. Many varieties and kinds of products are handled and manufactured at each plant. Each process has different batching, washing, stripping, drying, etc. cycles. As a result the wastes vary in quantity and composition from hour to hour, day to day and even month to month since some items are made only seasonally.

Any sampling and testing program to be of value must therefore extend over several months duration and be on a continuous basis. This type of program has been carried on at each of our plants so that we now have a fairly complete record of the quantity and composition of the wastes leaving each plant.

As would be expected the composition of the wastes from each plant is very different. Standard treatment design methods normally do not apply to these types of wastes. Because of this, laboratory studies were undertaken to investigate various methods of treatment for the wastes from each of our plants. This work was contracted out to various firms specializing in industrial waste treatment work. In all instances a biological treatment method was developed which would satisfactorily treat each of the plant wastes. The ease of treatment of course varied from plant to plant but in all cases a biological growth was developed which would live upon the organic pollutants in the waste.

In two instances chemical oxidation methods of treatment were investigated. Ozone and chlorine dioxide were used as oxidizing agents. These materials provided satisfactory treatment but were prohibitive in cost.

Laboratory tests were conducted on composite samples of the wastes containing the significant ingredients in proportion to the amounts present under average conditions. For example, if the waste normally contained 100 ppm of phenol but the quantity varied from day to day, between 10 and 200 ppm, the sample used for investigation purposes would be one containing near 100 ppm of phenol. And so on with other significant ingredients. Acclimated growth was developed from domestic sewage organisms. In some instances several months were required to acclimate the organisms to the wastes because of toxic substances being present. However in all cases a satisfactory growth was developed.

The next phase of the investigation was to pilot plant test the wastes to establish design and operating data. This has been done at two of the plants and is under way at others. The pilot plant is designed to handle a continuous flow from the sewer outfall and provides neutralization, nutrient additions, scum and solids separation, biological treatment and secondary settling.

The units are sized so that flows up to 3 gpm can be handled. Normally, however, for the strength of wastes being tested, the rate of flow has been less than 1 gpm.

The pilot plants are of a uniform design developed by Monsanto. The units can be taken down, shipped and re-assembled. The pilot plants have proved to be quite trouble free and sufficiently flexible for obtaining design and operating data.

One interesting pilot plant study involved the securing a sample of the waste from a sewer 18 ft. below the ground, storing it and hauling the sample to the pilot plant for treatment. A hydraulic ejector is used for lifting the sample from the sewer to the receiving tanks. The sample is collected on a continuous basis and at a rate required to operate the pilot plant.

The wastes are stored in wooden tanks and neutralized with lime prior to hauling to the pilot plant for testing. The wastes are hauled by tank truck and unloaded into two wooden tanks which supply the pilot plant. The attached pictures show part of this operation.

The pilot plant consists of a measuring weir, primary settling tank, aeration tank and secondary settling tank for activated sludge treatment and measuring weir and 1/10 acre pond for lagoon treatment.

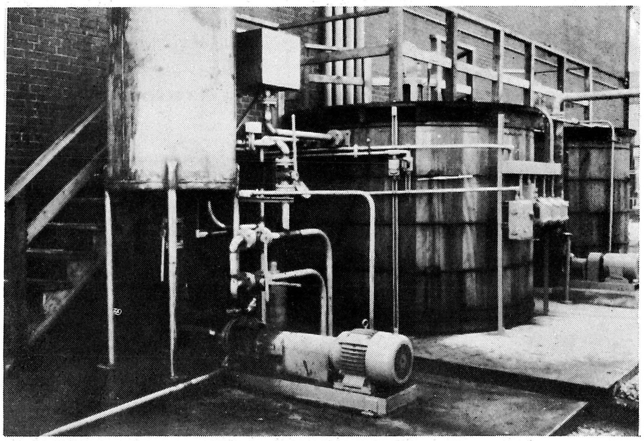


**Fig. 3—Receiving facilities for wastes taken from sewer prior to hauling waste treatment pilot plant.**

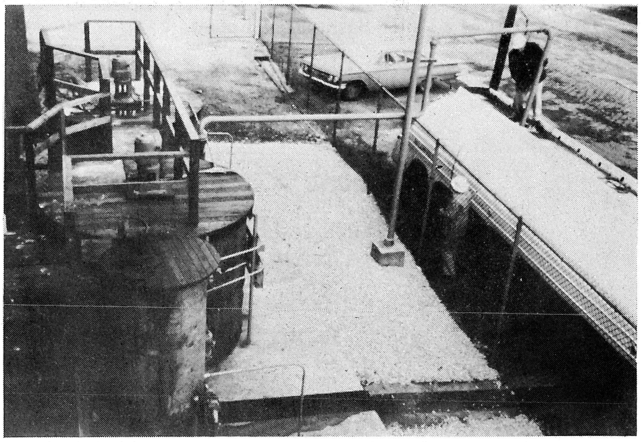


**Fig. 4—Loading wastes into tank truck for hauling to pilot plant.**

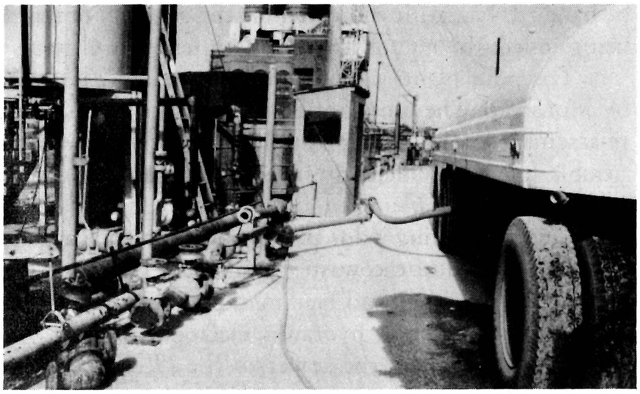


**Fig. 5—Tank truck being unloaded at waste treatment pilot plant.**

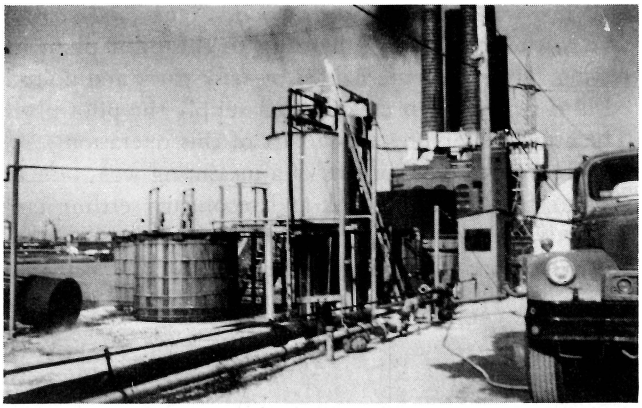


**Fig. 6—Waste treatment pilot plant consisting of receiving tanks and aeration facilities.**

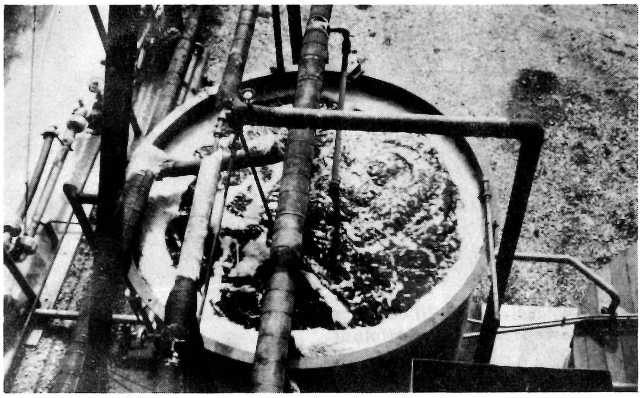


**Fig. 7—Top view of aeration basin at pilot plant.**

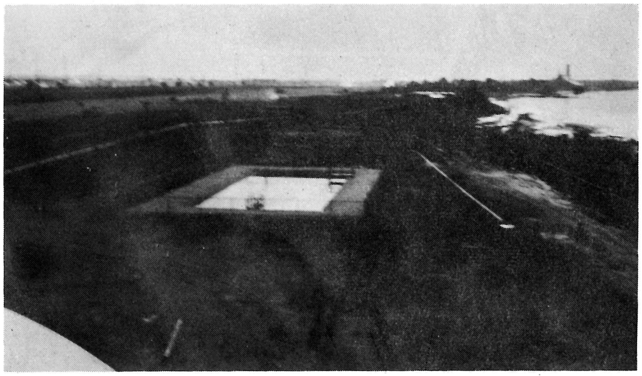


**Fig. 8—Waste treatment pilot plant lagoon, one tenth acre and three feet deep.**

The wastes are lifted from the sewer by means of a hydraulic ejector actuated by the pump in the foreground. The wastes are discharged into the stainless steel tank above the pump. The wastes overflow into the weir box attached to the tank where a portion is diverted to the wooden hold tanks and the remainder returned to the sewer. Suction for the pump operating the ejector is from the stainless steel receiving tank. The wooden hold tanks are equipped with agitators. The wastes are neutralized by hand before they are loaded into the tank truck for hauling to the waste treatment pilot plant. The far pump is used for loading the wastes into the tank truck.

The two wooden tanks in the foreground are for receiving and holding the wastes prior to treatment. They are equipped with agitators. The wastes are pumped from the hold tanks to a weir box near the top of the treatment plant where measured flows are diverted to the aeration tank and test lagoon. The large tank in the foreground is the aeration unit. It is six feet in diameter and six and one half feet deep. Not shown is a secondary settling tank for recovering the sludge which is returned to the aeration tank for seed.

As can be seen provisions are made for adding steam to the aeration tank for temperature control.

Influent is at one end and overflow at the other. Flow to the lagoon is regulated at the weir box located above the aeration tank. It is possible to discharge the effluent from the secondary settling tank to the lagoon.

Temperature, pH, rate of aeration and rate of feed can be varied to the aeration basin. Rate of feed only can be varied to the lagoon.

The aeration basin is so designed that it can be converted to a trickling filter.

The pilot plant will be operated at different rates of feed and at different temperatures and pH to secure design and operating data for a full scale plant.

One full scale plant has been built from data secured from pilot plant studies. The scaling up factor was approximately 1:2,000. To date the full scale plant is responding according to the performance anticipated from the pilot plant studies.

## Cooperative Programs

At some of the Organic Division plants the company has joined with other industries and governmental agencies in conducting river sampling surveys. This data have been used by pollution control agencies in setting up programs for pollution abatement.

The company's policy has been to be a good neighbor and to cooperate with the pollution control agencies on abatement programs. However, the company has been reluctant to move into any treatment program until the need for such a program has been firmly established and a method for accomplishing the purpose has been developed.

With these two purposes in mind the company has been willing to enter into cooperative programs for establishing needs for pollution abatement programs and investigate various means of waste treatment.

By this means it is hoped that treatment will be required only where it is needed and where it is needed. Only the most economical methods of treatment can be employed.

In summary, it can be stated that our company is moving ahead with a comprehensive pollution abatement program tailored to the needs of each individual plant. The program encompasses departmental surveys, research into improved manufacturing methods, separation of waste streams for different methods of disposal, sampling, testing and pilot plant studies on outfall sewers and cooperation with other industries and governmental agencies for overall pollution control.

# INDUSTRIAL WASTE TREATMENT; AN ESSENTIAL PART OF TRANSWORLD AIRLINES OVERHAUL OPERATIONS

*by Robert L. Garrett**

This is a discussion of the treatment of industrial waste generated by operation of TWA's huge overhaul facility located at Kansas City's new Mid-Continent International Airport. All the overhaul maintenance required on TWA's fleet of aircraft is accomplished at this facility. Each of TWA's 195 aircraft, 28 jets and 167 piston powered, comes to Kansas City to receive its overhaul operations, which includes stripping of paint and refinish. All of TWA's 1031 aircraft engines are overhauled at the facility as are hundreds of other components of the aircraft, such as, generators, radio equipment, wheels and brakes, hydraulic units, instruments, to name only a few. In fact there are very few components of the aircraft that TWA itself does not overhaul. Therefore it may readily be understood that the amount of industrial waste generated by this facility creates an enormous problem.

However, the complete story of the TWA waste treatment plant has to begin with the flood on the Kaw and Missouri Rivers in July 1951.

After the damage to the airline's old overhaul base at Fairfax Airport had been cleared away and the normal overhaul activities resumed, work was begun in planning the new overhaul base at whatever airport facility the municipalities determined would be the future site of expansion in the aviation industry. One thing was certain: The next site of overhaul operations would be on a hill instead of a river bottom; and this was probably the decision which was destined to propell the airline into the field of industrial waste treatment ahead of other industries in the same general area and well in advance of any government legislated regulations enforcing pollution abatement.

Trans World Airlines is, and always has been, in a state of continual change. In fact the business of transportation, particularly commercial aviation, is about the most dynamic industry known. To all of us who have a part, even somewhat removed from the actual flight operation, in making seats available to the air travelers, the sudden and constant changing of processes and methods is a commonplace occurrence in our jobs. It is this change which may cause an entire new operation or department to suddenly come into being as a new essential to the overhaul procedures.

It was just such an innovation which became the next color in the fabric from which the pattern of waste treatment was finally cut. In 1952, it was decided to activate the electro-plating shop. This important phase of engine overhaul had been here-to-fore accomplished by the suppliers of the engines or by other outside concerns. Since the pace of overhaul operations was speeding up, this new department's greatest claim to distinction was in making re-worked parts more readily available without a large bulk of repairable and serviceable parts to fill a pipeline which extended from Kansas City to New England and back. As an interesting sidelight, it is important to note that this new shop was responsible, in its first six months of operation, for an inventory reduction of expensive spare parts equivalent to the entire cost of the installation ($34,000). This new shop, and its million dollar counterpart which was established later at the new overhaul base, became an integral part of the entire overhaul operations, and thus another segment of a separate industry joined in the complex organization of specialties to produce the finished product of base overhaul; namely serviceable aircraft and engines which are the source of our revenue and the reason for our existance as a business enterprise.

Now, as is well known, the plating industry has waste disposal problems, and soon alkaline cleaners, acid pickle solutions, contaminated rinse waters, and other waste of the new plating shop joined the waste oils, solvents, paint strippers, aluminum cleaners, and their kind in one big happy family of industrial waste originating at the overhaul base. But disposal of all this waste was not yet a pressing problem, for was not this base conveniently located on a sand bar adjacent to the juncture of the Missouri and Kaw Rivers which can, and still does, dilute an infinite amount of filth? So, for almost four years, the overhaul base continued operation on the sand bar and the greatest threat to our unpredictable routine was that the creeks would rise, the levee would break, and we would again be faced with a flood washout of our operation.

However, all thought was not of the present. The problem of waste treatment was a matter of record in the plating industry, and as the plans for the new overhaul base went forward, the plating waste, at least, was provided for from the start with provision for a waste disposal plant. Almost integral with the new plating shop (except for its remote location), this new disposal plant was put into operation simultaneously with the activation of the plating shop at Mid-Continent International Airport in March 1957. Except for minor equipment difficulties and the necessity of training operators while actually treating an accumulated backlog of concentrated waste, this disposal unit has been and still is an example of a method widely accepted by the plating industry in all localities of the country. The details of this method of treatment will be described a little later.

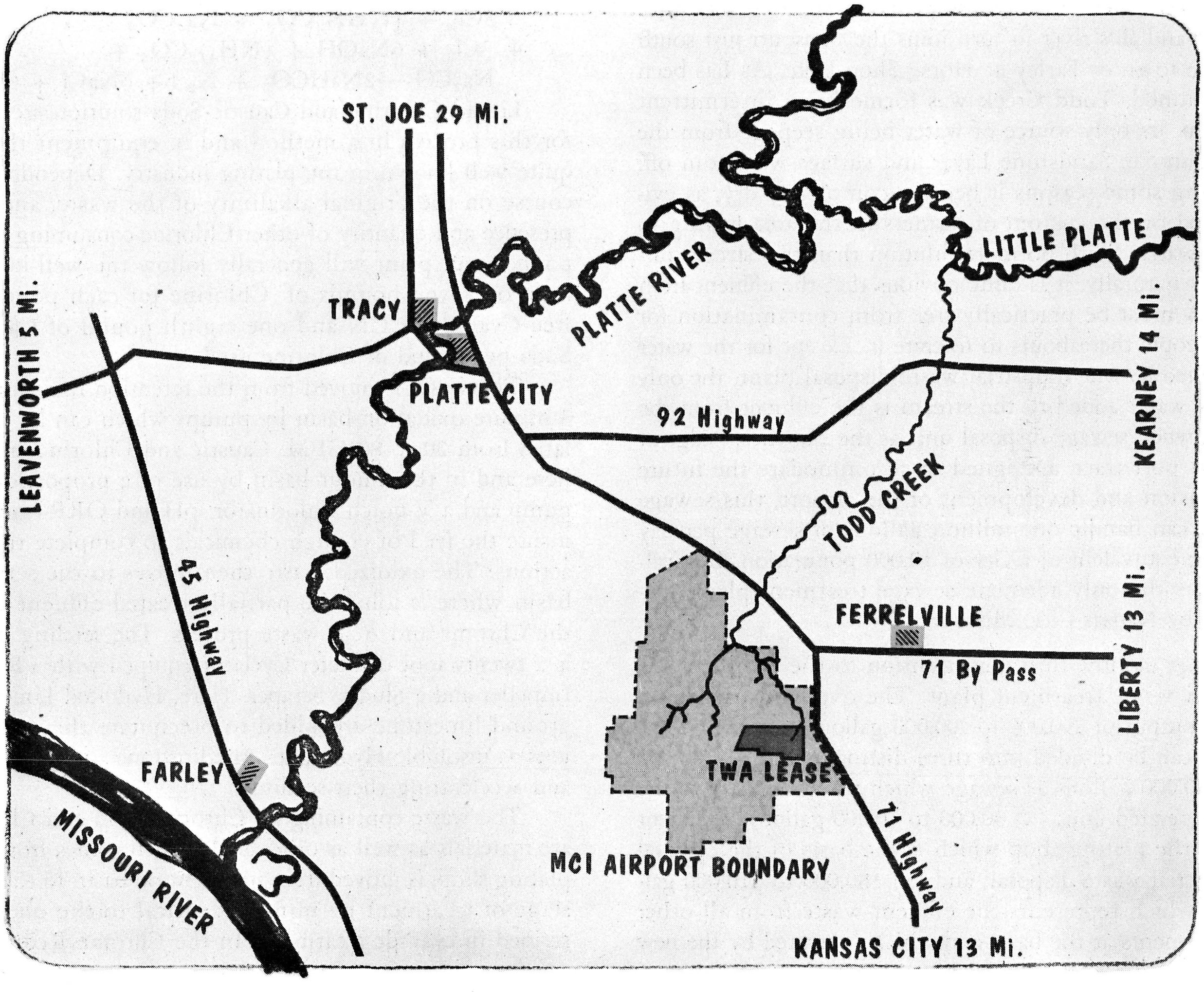
*Chemical Solution Analyst, TWA Overhaul Base, Kansas City.

The rest of the industrial waste from the overhaul base has not been and still is not produced by a finite set of procedures as is waste from a plating shop. As has been inferred previously, the production of such waste is as changeable as the processes which cause them. It was this uncertainity which promoted the planners to adopt a "wait and see" attitude toward the future problem at the new overhaul base. A drainage system and oil interceptors were provided in the new facility, but until cleaning processes and materials could be established and the amounts of waste actually measured, no definite treatment procedure could be specified. Every attempt was made to avoid pollution of Todd Creek, but no one anticipated the rapidity which transformed the little intermittent stream into a modern River Styx. Two dams were thrown up and an attempt was made to retain the worst of the contaminants for disposal, by burning off the floating material at intervals. This procedure had only the effect of transforming the creek into another modern counterpart of the Poet Virgil's mythical Rivers of Hades, the Fiery Phlegthon.

All of this pollution could not be regarded as sheer carelessness, because TWA was and is cognizant of the dangers of water pollution, but in this case it was necessary for a survey to be made and a method devised to properly treat this effluent. Actually the full volume of waste was not known until the entire overhaul base was completed and placed into full operation late in 1957. The oil separators (which were not too successful) and the burning lagoons were stop-gap measures at the best.

The survey was hastened by complaints from neighboring tenants downstream who suggested that the contents of Todd Creek were not useable for irrigating crops or watering livestock. There were no dead animals offered for sale but TWA did subsidize one year's production for a certain tobacco grower and not a single cigar was forthcoming. It was only the promise of immediate action which placated some of the Platte County residents and forestalled more drastic action. The survey and study took on an air of urgency and from it came several possible solutions, from which the present industrial waste disposal method was selected and added to the existing system. The new plant is adjacent and attached to the original plating waste disposal unit, and since the plating waste disposal plant had been successfully operated by plating shop personnel for almost three years, the new unit was given over in the first week of 1960 to those same operators and supervisors. Thus was com-

**Fig. 1—Area map.**



pleted the entire unit as it stands today, accommodating all of the waste from the overhaul base (except sewage) and once again Todd Creek flows through the Platte County countryside as a respectable little stream should do. The stream is not intermittent any more, because it has water from TWA the year 'round; but no foul odors, oil slicks or masses of floating debris mar its meanderings to the Platte River some eight miles away.

Before we look at the actual details of the treatment plant, let us orientate ourselves with regard to the location and situation of the overhaul base. The entire tract of land, owned by the Municipality of Kansas City, Missouri, lies some sixteen miles Northwest of that city in the County of Platte. Approximately three miles wide by four and one half miles, it is situated on the west side of US Highway 71 at the junction of 71 Bypass. Eventually, it will be developed into a large, modern, international type airport, capable of accommodating the largest aircraft in use now or in the foreseeable future. The TWA lease is at the Southwest corner of the tract, with the disposal plant building the closest structure to one of the upper branches of Todd Creek. It can be seen that this stream flows generally North and slightly East, a distance of some eight miles through gently rolling hills until it discharges into the Little Platte River. The Little Platte empties into the Platte River about three miles West and this river in turn joins the Missouri just south of the town of Farley at Horse Shoe Lake. As has been mentioned, Todd Creek was formerly an intermittent stream, its only source of water being seepage from the Tonganoxie Sandstone Layer and surface water run off. During some seasons it became completely dry, as evidenced by the custom of farmers in the area having to haul water. With no more dilution than this stream furnishes naturally, it is quite obvious that the effluent from TWA must be practically free from contamination for the people thereabouts to tolerate it. Except for the water supplied by our Industrial waste disposal plant, the only other water added to the stream is the effluent from the city-owned sewage disposal unit at the Northeast edge of the airport tract. Designed to accommodate the future expansion and development of the airport, this sewage plant can handle one million gallons of sewage per day or the equivalent of a city of 10,000 population. Ironically, it is the only adequate sewage treatment plant operated by Kansas City, Missouri.

Let us now turn our attention to the details of the TWA waste treatment plant. The overhaul base has a daily output of 290,000 to 400,000 gallons of waste waters. This can be divided into three distinct parts; (1) 80,000 to 120,000 gallons as sewage which passes directly to the city operated unit; (2) 30,000 to 70,000 gallons of effluent from the plating shop which is the basis of the original industrial waste disposal; and (3) 180,000 to 210,000 gallons which represents the effluent waste from all other departments at the base, and which is treated by the new installation activated early this year. Remembering that both of these treatments are operated as one by the same personnel, let us discuss them separately.

The plating shop waste which we title as "Chemical Disposal" is treated in the South portion of the building and the South part of the yard. The waste comes from the shop through two 6 inch sewers. All tank overflow and drain lines in the shop are directed into one of these main sewers according to the source and nature of the material. One pipe carries all of the waste containing cyanides and other collects all of those materials which are acid, including Hexavalent Chromium. Although the treatment is classed as a "flow through" type of treatment, there is provided a retention tank for each type of waste. These are located in the basement of that portion of the building which controls this process. Under normal conditions the tanks will retain the effluent from an eight-hour shift of plating operations without treatment. It is our policy to have an operator on duty any time there is any activity in the shop.

The alkaline-cyanide bearing waste is treated by oxidation to cyanate and eventually to Carbon Dioxide, Nitrogen and Chloride by the reactions:

1. $2Cl_2 + 2NaCN \rightarrow 2CuCl + 2NaCl$
2. $2CNCl + 4NaOH \rightarrow 2NaCNO + 2NaCl + 2H_2O$
3. $3Cl_2 + 4H_2O + 2NaCNO \rightarrow$
   $3Cl_2 + (NH_4)_2CO_3 + Na_2CO_3$
4. $3Cl_2 + 6NaOH + (NH_4)_2CO_3 +$
   $Na_2CO_3 \rightarrow 2NaHCO_3 + N_2\uparrow + 6NaCl + 6H_2O$

Liquid Chlorine and Caustic Soda solution are used for this process in a method and in equipment that is quite well known in the plating industry. Depending of course on the original alkalinity of the waste, and the presence and quantity of other Chlorine-consuming compounds, our plant will generally follow the well-known ratio of seven pounds of Chlorine for each pound of free Cyanide as CN and one eighth pound of Caustic Soda per pound of Chlorine used.

The waste is moved from the retention basin to the 3-minute oxidation basin by pumps which can be regulated from 20 to 80 GPM. Caustic and Chlorine are fed here and in the 2-hour basin by use of a proportioning pump and a V-notch Chlorinator. pH and ORP readings insure the feed of enough chemicals to complete the reactions. The oxidized waste then moves to the settling basin where it joins the partially treated effluent from the Chrome and Acid waste process. The settling basin is a twenty foot diameter Cyclator equiped with a Rotor-Impeller and a Sludge Scraper. Here, Hydrated Lime and ground limestone are added to precipitate the metallic ions as insoluble Hydroxides, the limstone adding weight and accelerating their settling.

The waste containing all Chromic Acid and Chromate materials as well as other acids which comes from the plating shop, is moved from its retention basin to the first stage of treatment by pumps identical to the ones described in cyanide treatment. In the Chrome Reduction

Basin the Hexavalent Chrome is reduced to the Trivalent state by the addition of Ferrous Sulfate from a dry chemical feeder and Sulfuric Acid from a proportioning pump. (1) $6FeSO_4 \cdot 7H_2O + 6H_2SO_4 + 2H_2CrO_4 \rightarrow Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 50H_2O$, (2) $Cr_2(SO_4)_3 + 3Fc_2(SO_4)_4 + 12Ca(OH)_2 \rightarrow 2Cr(OH)_3 \downarrow + 6Fe(OH)_3 \downarrow + 12CaSO_4$. This reaction is also controlled by pH and ORP readings. In the lime mixing basin, hydrated lime is added which precipitates Iron and Trivalent Chromium as insoluble hydroxides. From here, the flow is into the same settling basin previously mentioned where further lime and limestone completes the settling. The sludge from the bottom of the Cyclator is withdrawn thru an automatic sludge valve of the double diaphragm timer actuated type and delivered to the sludge lagoons, while the treated effluent runs to Todd Creek. Recently a system has been devised to divert some of this water for use in the dry chemical feeders thereby effecting a considerable saving on city water used.

As the plating shop produces the waste, the disposal plant treats it in a semi-automatic "flow-through" fashion. The operator begins by determining the approximate strength of the waste in the retention basins by means of a suitable spot test or visual colormetric estimation. He then activates all of the meters and alarm system and adjusts the chemical feeders to bring all instrument readings into their respective limits. When all this is satisfactory, he starts the pumps at a flow rate which is calculated to treat the water at the same or a little faster pace than the shop is producing it. The streams are continuously monitored by pH meters and ORP cells which record their values on charts at the master control panel. Both visual and audible alarms are activated the instant any reading reaches the set limit for its particular value. An immediate adjustment of feeding equipment can either increase the addition of chemicals for a rise in concentration or reduce the treatment materials as the waste becomes more dilute. The operator is in constant contact with the plating shop, by telephone and two-way intercom, and is advised in advance of the contemplated disposal of any concentrated material such as a spent cleaner, stripping solution, spillage or an unusual amount of contaminated rinse waters. This enables him to calculate a dilution factor and arrive at a new approximation of concentration and readjust his chemical feed. If needed, these dumps may be scheduled two to three days in advance, making for more uniform operation.

One instance of the value of this co-ordination between the shop and the treatment plant must be mentioned. An alkaline, non-cyanide cleaner can be released to the acid waste line simultaneously with some spent acid material, thereby using each to neutralize the other and reducing the amount of chemicals that would otherwise have to be added. This is proper waste treatment just as much as the more complex process of oxidation-reduction. There have been many instances when the success of this type of multiple disposal has shown without question that the most valuable piece of control equipment is the alert and well-trained operator himself.

When the construction of the additional disposal facility was completed and turned over to the plating shop for operation, it was titled "Petroleum Waste Disposal" to distinguish it from the "Chemical Waste Disposal". Its control and feed equipment is housed in the North wing of the building and its basins in the North yard. The treatment is concerned with a single stream of waste which is composed of many and varied materials from both buildings of the overhaul base. Waste engine oil, solvent decarbonizers, alkaline and solvent paint strippers, plane washing compounds, floor cleaning compounds, aluminum brightening chemicals, and many others are gathered in the collector system and delivered in one sixteen-inch sewer to the disposal plant.

A look at the complete flow diagram shows us that the Petroleum Waste Treatment Plant consists of three distinct steps or stages of treatment. The first step is simply gravity separation to remove free oil and readily settleable solids. The second step covers the application of a trivalent coagulant and acid to help "spring" further oily materials from solution or emulsion. Gravity separation is also employed here to aid in the removal of contaminants. The pH is then returned to the alkaline range by the addition of lime. The third step is a solids-contact treatment where more coagulent, a coagulant aid, and limestone are utilized along with the necessary additional amount of lime to adjust the pH to the desired value for the plant effluent. The solids-contact unit can be considered the polishing stage, since it removes the oily portions of the waste down to trace amounts and accomplishes final clarification and pH adjustment.

As the waste stream enters the treatment plant, it passes first through a conveyor screen which strains any large solid material and foreign objects from the liquid. This is an absolute necessity since gaskets, bits of safety wire, cotter pins, rivets, nuts and bolts do not contribute to smooth operation of mechanical pumps. A water spray keeps the screens from clogging with oil and all the objects strained out fall into a hopper. Since some waste may flow in this sewer system at all times, this conveyor screen and the next two pieces of equipment are fully automatic, whether the rest of the treatment is in operation or not. The waste next enters one of the two pneumatic ejectors in the basement of the building. These have a capacity of 300 gallons each and they alternate in filling and discharging the strained waste into the first stage of treatment or Free Oil Clarifier.

Free oil rises to the top of this twenty-foot diameter basin and is skimmed into a pipe which carries it to an underground storage tank. The clarifier is also equipped with scrapers on the bottom which bring any settleable sludge into sump. A manually operated sludge blow-off

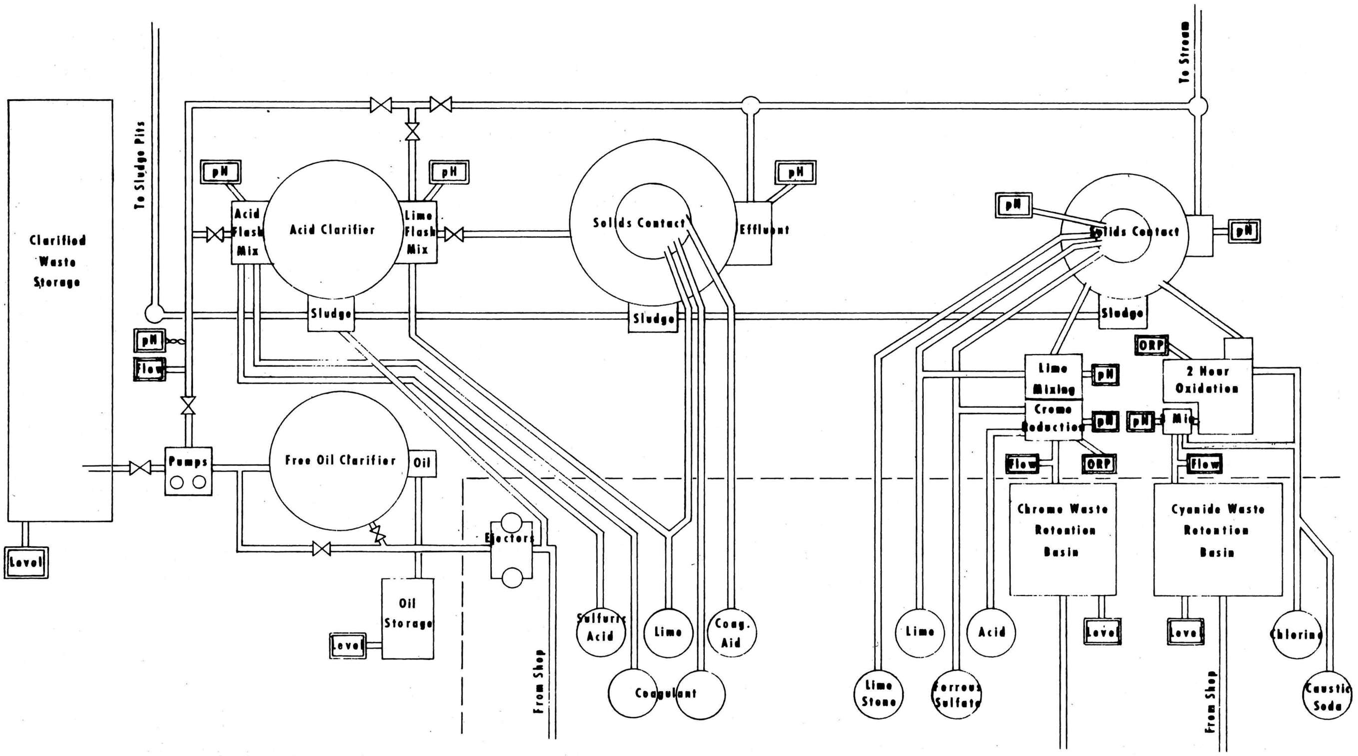



**Fig. 2—Flow diagram for waste treatment plant.**

valve delivers the sludge into the line to the sludge lagoons. The clarified waste flows under a scum baffle to the pump station wet well which connects to a storage lagoon by means of an equalization piping arrangement. A capacity of 500,000 gallons in the clarified waste storage lagoon makes it possible for the process thus far to proceed unattended for limited periods, such as the third shift and over week ends.

The next step and subsequent ones are semi-automatic, and must be controlled by an operator. The waste from the wet well and storage lagoon is moved on to further treatment by means of the two pumps at the lift station. A pneumatically controlled valve regulates the flow rate at which the waste is fed into the Acid Vorti-Mixer. The pumps have a maximum output of over 500 GPM, but we have determined that a constant flow rate of 264 GPM maintained 10 to 14 hours a day will keep us even or slightly ahead of the production of the waste. The flow rate of 264 GPM will probably raise a question in the minds of some as to why this seemingly unusual figure is used. The explanation is actually quite simple. Translated into the Metric Units of Measurement, this is 1000 Liters per minute. It is fairly simple to take a 10, 20, 30, or even 60 second sample of any of the chemicals being fed by the dry feeders or proportioning pumps. The number of grams of dry chemicals or the number of milliliters of liquid per minute in a flow of 1000 Liters per minute is parts per million (PPM).

In the Acid Vorti-Mix Basin, Aluminum Sulfate is added by a manually adjusted dry chemical feeder at a pre-determined rate. The pH is reduced to 4.0 with Sulfuric Acid from a proportioning pump which is regulated

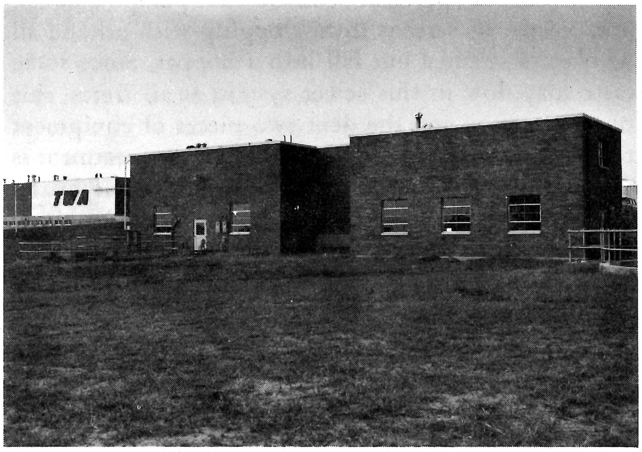



**Fig. 3—Control building for waste treatment plant.**

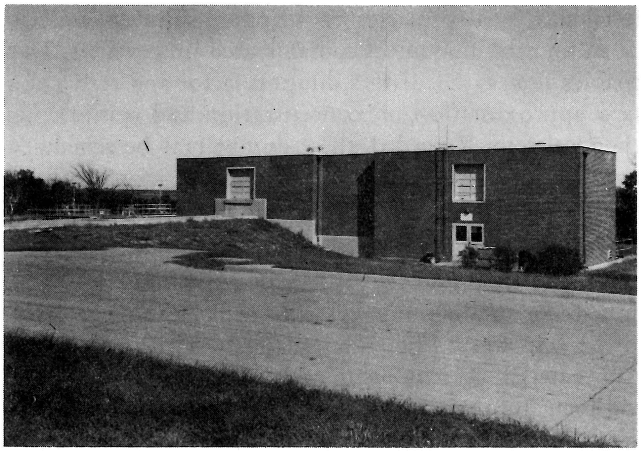


**Fig. 4—Opposite side of control building for waste treatment plant.**

by an automatic controller and activated by a pH meter. The waste flows to the center portion of the Acid Clarifier where a float containing emulsified oil breaks to the surface. A skimming device removes the float while scrapers and a sludge blow-off remove any settleable solids in a manner identical to that described for the Free Oil Clarifier. The effluent from this separation passes underneath a baffle to the Lime Vorti-Mix Basin. Hydrated lime from a dry chemical feeder and controlled by an automatic pH meter raises the pH to 8.3 as it enters the center of the third stage of treatment, the Solids-Contact Basin.

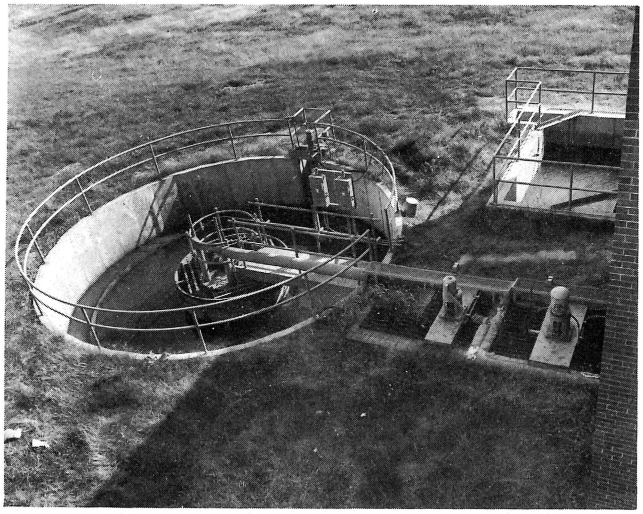


**Fig. 5—Solid contact basin adjacent to building.**

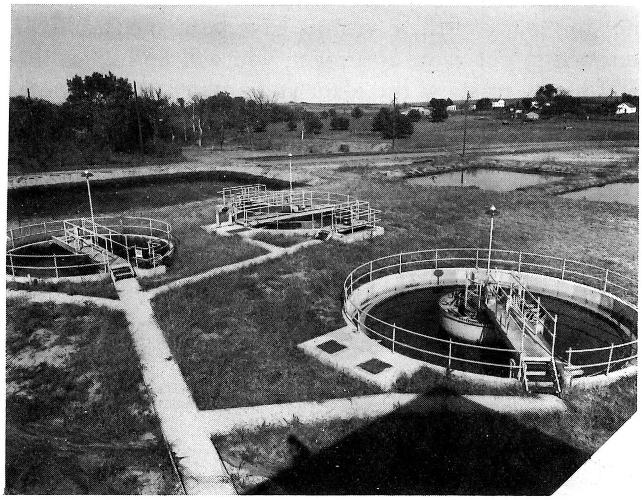


**Fig. 6—Two clarifiers and solids—contact basin with storage lagoons in background.**

The Solids Contact basin, like the Settling basin of the Chemical Waste Treatment, is a Cyclator Clarifier. Thirty feet in diameter, it is equipped with a Rotor-Impeller, a sludge scraper, and a hydraulic skimmer. Additional coagulant (Alum), lime and ground limestone are fed into the primary mixing zone at the bottom of the draft tube, while a polyelectrolyte type of coagulant aid is added just above the impeller in the secondary mixing zone. The coagulant aid is prepared in mixing tanks located on the upper floor of the building, and is fed by a manually adjusted proportioning pump as a 1% stock solution. Usually 1 to 2 parts per million is sufficient to effect complete coagulation. Proper adjustment of the impeller speed and the two gates at the bottom of the tube results in the solids being drawn into the sludge sumps for discharge to the sludge lagoons. The clear effluent passes over the weir and joins the effluent from the Chemical Waste Treatment at the manhole junction where salvage water is taken for use in the dry chemical feeders of both treatment processes.

All of the dry chemicals used in both treatment processes are delivered directly to the upper floor of the building and stored on wooden skids. These skids were especially designed to utilize the space between the hoppers which are extensions of the feeders into the second floor. The hoppers are refilled once a day and the operator maintains a running inventory of all chemicals. There is sufficient storage space to accommodate a supply of materials that will last through a month of normal treatment even if regular deliveries are interrupted for any reason.

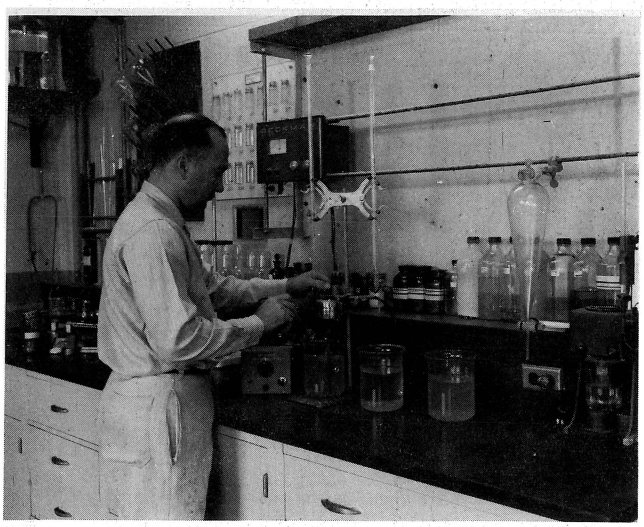


**Fig. 7—Analytical laboratory in which analysis and bench scale tests are made.**

Testing and control in the Petroleum Waste Treatment is just as much of a fine art as was mentioned in connection with the treatment of plating waste. It may be considered by some persons even more so. All equipment is controlled from the main switch panel where lights indicate which equipment is in operation. Duplicates of these lights appear on the large indicating panel which is actually a schematic diagram of the entire process. All pH readings are recorded on the large strip chart, and the flow rate is recorded on the smaller one. Oil storage tank level and clarified waste storage in the lagoon are visible at all times. Sulfuric Acid and Hydrated Lime feed controllers are shown as well as the visual and audible alarm systems. All other feeders are adjusted manually after the operator has performed jar

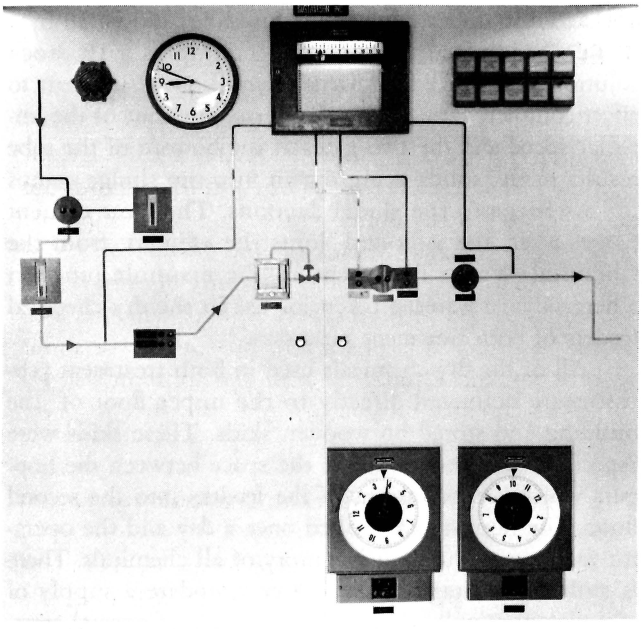


**Fig. 8—Schematic diagram type control panel.**

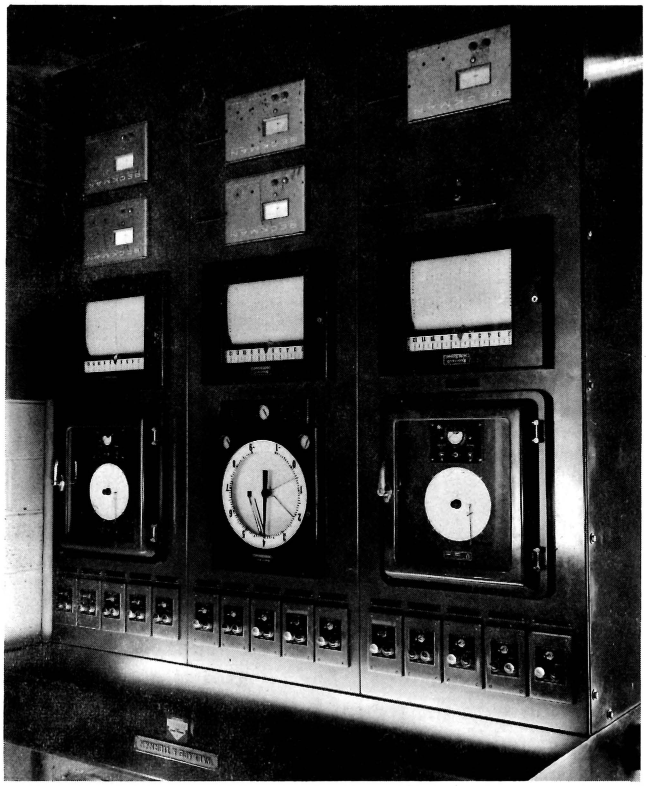


**Fig. 9—Main switch panel.**

tests to determine the settings which will produce the most satisfactory coagulation and settling. Regular tests with a Jackson Candle Turbidimeter show that we are able to release an effluent with a turbidity of less than 25 units.

As was mentioned earlier, the waste treated in this process is somewhat changeable, due to changes in materials and methods used in the overhaul operations. We are at the present time studying a new condition which has just recently been caused by an innovation in the process of brightening the exterior of the aircraft. A chemical, rather than a mechanical procedure, is being used with the number of man-hours being reduced from 350 to 50, but the concoction, known as "Witches' Brew" plays havoc with the proper separation of the free oil. In addition to our own testing, we have also sought the assistance of both the suppliers of chemicals and of waste treatment equipment. We confidently expect a proper solution for this new condition to be found and any necessary changes, either in treatment or equipment lay-out, will be made. Another study worth mentioning at this time is the one which will determine the advisability of constructing a dam and creating a small lake capable of retaining all effluent waters on a thirty-day basis. This is temporarily delayed while the city is constructing a new road to the airport, but when the road is completed, a suitable site for the dam and lake will be selected.

We have spoken only briefly on many of the details that are essential to the successful operation of such a plant. The structures and equipment represents a total investment of $500,000.00, and it costs on an average of $25,000.00 annually in materials and manpower to operate it. We, in TWA, are proud that we are one of the first industries in this area to recognize our responsibility to include proper waste treatment as a function of other activities. We also call your attention to the fact that since the new base was opened, more than 5,000 visitors have been conducted on tours of the facilities. While not too many of these visitors have been specifically interested in our waste treatment, you will find us willing and happy to show the plant and answer any questions about its operation.

Sincere thanks must be given to Mr. E. T. Phillips, Managing Architect and Engineer; Mr. Wilbur Macey, Plant Engineer; Mr. M. R. Callow and his efficient staff in Publications and Services; all fellow TWA'ers who contributed to the preparation of this paper and the visual aids which supplement it; and to Mr. L. C. Webb of Infilco, Incorporated who advised and assisted in this presentation.

# WHAT A PULP AND PAPER MILL COULD MEAN TO MISSOURI'S FOREST ECONOMY

*by Robert A. Ralston**

My assignment today is to set the stage for the paper to follow. I am happy to be here, for like the proverbial gentleman from California, I am always ready to talk about the opportunity for pulp and paper manufacturing in Missouri. In addition to industrial opportunity, there is also an urgent need for a hardwood pulpwood market from a land management standpoint, to permit us to bring our 15 million acres of commercial forest land into full production.

In a sense, I wish it were not necessary to introduce the subject. I would rather we could talk about results. But as you know, Missouri does not have a single full scale pulp mill at this time. Thus, we have no pollution problem from this source. And, of course, we need not have a problem in the future either, but Mr. Warrick's topic requires some introduction.

### Why Doesn't Missouri Have Any Pulp Mills?

The complete answer is complicated, but basically it is because we lack sufficient volume of softwoods, the traditional pulping species such as the spruces, firs, pines, and hemlocks. These longer-fibered species have always been preferred by the industry.

In recent years technological advances in pulp and paper making have opened the way for the use of both dense hardwoods such as Missouri's oaks and hickories and less dense hardwoods such as cottonwood and willow.

Hardwoods have relatively short wood fibers which yield low-strength paper when used alone in most of the older processes. However, when mixed in the proper proportions with softwoods, hardwoods add both quality and strength to the resulting paper. Too, the yield of pulp from hardwoods may be as much as 40 percent greater than from softwoods. And, of course, new methods of paper making permit the use of hardwoods alone without sacrificing yield or quality.

Most of the existing plants in the northern states were built 30 to 40 years ago to use spruce and hemlock wood. As the spruce supply diminished they were able to switch over to pine and fir. Reduced local supply of all conifers has made aspen the principal species and now the industry is turning to oak, maple, and birch.

Right now, for example, aspen—one of the less dense hardwoods—is the most heavily used single species in Wisconsin. Wisconsin is one of the leading states in the nation in pulp and paper manufacture. It has 29 wood pulp mills which consume about 2.5 million cords of wood each year. Of this, about 1 million cords are harvested within the State, while the rest is imported mainly from Canada, Michigan, and Minnesota. Missouri, on the other hand, harvests only about 12,000 cords of pulpwood each year, very little of which is used within the State. Wisconsin and Missouri have about the same amount of forest land, so it is apparent that we have a vast resource waiting to be tapped. But, what are the prospects?

### What is the General Market Outlook for Forest Products?

Wood is now holding its own in the market place with competing building materials. Even if it does not improve its present position in our economy, the demand for wood may be 83 percent greater in the year 2000 than it is today, because we will have more people. This assumes our population will be 275 million by then. If our population should increase to 360 million by 2000, the demand for wood might be double today's use.

On the other hand, if wood prices rise faster than competing materials, there will be less wood used per person than there is today. Even so, our demand for wood may be 46 percent greater than that of today, even at the lower population estimate.

This is the story nationally and for wood products generally. However, the outlook for paper and paperboard is only for greater per capita consumption in the future. We now use over 400 pounds of paper and paperboard per person each year, and use is growing every year. To meet our expected needs by 1975, the nation will require about 270 more pulp mills of 300-ton-per-day capacity, or their equivalent, than were operating in 1955. Missouri is bound to share some day in this expected expansion of the pulp and paper industry.

Many of our neighboring states in the North Central Region, including Illinois, Indiana, Iowa, Kansas, and Nebraska, are large consumers of paper and other forest products, yet have relatively small forest areas from which to supply their needs. Missouri is in a strategic position from the raw material standpoint to supply part of the requirements of these states.

### What of the Forest Resource?

Periodically the Forest Service, in cooperation with local agencies and landowners, takes an inventory of the timber resources in each state. The last previous Missouri forest survey was made in 1946 and the present resurvey will be completed this year. Preliminary estimates for the Southeast Ozarks show some striking advances since 1946 and also some serious deficiencies. For exam-

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ple, the area of sawtimber stands, those primarily of trees large enough to be utilized for lumber and flooring, has doubled since the last survey. Significantly, the area of shortleaf pine timber and the pine volume has doubled since 1946. However, pine occupies only about 10 percent of the commercial forest area in the Southeast Ozarks, which, like the rest of the State, is primarily covered with oak forests. Thus we still lack a sufficient supply of pine for pulp. Also, our present markets for pine, including posts, poles, and lumber, easily consume all available trees.

### Looking Again at Supply and Demand

Presently softwoods—the pines, spruces, firs, and hemlocks—are the major source of raw material used to manufacture paper and paperboard countrywide. Hardwoods supply only about 20 percent of the total pulpwood harvest. In view of anticipated needs in the future, however, neither domestic supplies nor expected imports of softwood pulp or pulpwood will be able to meet the expected demand. Hardwoods will have to be used to a greater extent than now. It is estimated that more than 40 percent of our pulpwood will be obtained from hardwood species by the year 2000, as compared to less than 20 percent now.

The Lake States pulp mills are already using 40 percent hardwoods, and the Central and Northeastern States also depend on hardwoods. Even in the South and far-West, which produce the greatest volume of pulp and where hardwoods make up less than 15 percent of the raw material, the use of hardwoods is increasing. Many companies are considering new plant locations where there is a long time supply of hardwood species.

### Research Leads the Way

Many trees in Missouri's forests need to be harvested to stimulate the growth of the remaining trees and to encourage the establishment and development of new seedlings. Research results by the School of Forestry and the Forest Service show that the net timber growth of hardwood timber stands brought under scientific management can be more than doubled over an 80-year rotation. And don't forget that this growth will be mainly in higher quality, more valuable trees which are in demand by the backbone of our forest products industry—tie and lumber, flooring, and staves. Thus a market for pulpwood-sized material goes hand in hand with quality sawlog and stavebolt production.

### Opportunities for Forest Management are Bright

Forest and land managers view this outlook for the hardwood forest resource with great interest. The use of hardwoods for pulp makes it possible to utilize trees that should be cut early in order to pursue good hardwood and pine management. Thinnings are needed in all of our hardwood stands to stimulate the growth of the higher quality trees. The soil will produce just so much wood fiber, and foresters have learned that it is good business to add all of the growth possible to fewer, better trees. Young pine trees stagnating in the shade of low quality hardwoods can be released to grow unfettered at a profit through a pulpwood market. Otherwise, they must be released at a cost of $2-$10 per acre through noncommercial operations.

In addition, trees and portions of trees not suitable for lumber can be utilized for the manufacture of pulp and paper. Not that the pulp industry can use decayed wood to make paper. They can't. However, the pulping process requires chipping or grinding of the wood. This permits the use of smaller sized trees, both in diameter and length, than needed for sawlogs.

It has been estimated that for the Ozarks as a whole our timber harvest could be nearly tripled with an adequate market for smaller trees and bolts. All this could be done under sound forestry practices without sacrificing any of our other uses of the forest—outdoor recreation, water, wildlife habitat and range. In fact, without a market for our hardwood thinnings, foresters are greatly handicapped and landowners have little inducement to manage their woodlands, since the needed silvicultural practices become an out-of-pocket cost. With a strong pulpwood market these costs can be turned into a profit.

Interest in Missouri is high among the pulp and paper manufacturers. This is reflected by the number of inquiries received from industry and their representation at the Governor's Conference at Montauk Park last spring. This Conference was sponsored jointly by the Missouri Legislature's Interim Committee on Forestry, Missouri Resources and Development Commission, the Missouri Conservation Commission, the University of Missouri, and the U. S. Forest Service. These agencies and others are constantly on the alert to promote the advantages of Missouri among the pulp and paper industry.

### The Pulp and Paper Industry Holds Great Promise for Missouri

Recently John Farrell, a Forest Economist on the staff of the Columbia Research Center, made an analysis of what a single pulp mill of 200 tons of pulp per day production could mean to the local economy. This would be a small-to-medium-sized mill. In addition to a multimillion dollar investment in land and plant, it would support a 500-man labor force and produce about 10 million dollars worth of paper each year.

The pulp and paper industry is expanding nationally and hardwoods are becoming of increasing importance. Missouri's forests can support several hardwood pulp mills. This would result in increased employment, new investment money, new timber markets for landowners, greater community development, and an opportunity to begin scientific forest management not now considered possible on several million acres of private woodlands. It is not practical to practice forest management without markets for all sizes and types of trees.

# SOLVING POLLUTION PROBLEMS OF PULP AND PAPER MILLS

*by Louis F. Warrick**

## Introduction

Interest in establishment of a pulp and paper industry in Missouri has brought up consideration of possible pollution problems from mill effluents. Chemicals, fibers and other potential pollutants may cause difficulties if not properly controlled. The intent, therefore, of this presentation is to briefly describe various wood pulping processes, paper and paperbound productions, and to indicate the nature of wastes that need effective control in preventing objectionable pollution.

Progress in solving water and air pollution problems of the industry has been accomplished mainly through improvements in processes, in chemical recovery systems, and through other in-plant technological advancements to reduce waste. However, treatment and disposal methods for the wastes are increasingly being developed and employed to control pollution. The aim is to indicate some of these developments, particularly as regards control of the liquid wastes which may adversely affect the quality of our water resources.

## Processes

*Sulfite Process:* The sulfite process for pulping wood involves "cooking" chips in a digester at high temperatures and pressures along with a solution of sulfurous acid in which lime or some other base is dissolved. The cellulose fibers are separated from lignin, hemicelluloses, and other cementing materials. Calcium bisulfite in the cooking liquor reacts with the lignin in the wood to form soluble calcium lignosulfonate. Wood gums are also hydrolyzed in the acid cooking liquor at high temperatures. The soluble materials present in the spent liquor are drained away from the fibers at the end of the cook, the liquid effluent being designated as sulfite waste liquor (SWL) or spent sulfite liquor (SSL).

Soluble products of digestion in the sulfite waste liquor comprise about 50% of the weight of the wood. For every ton of sulfite pulp, about a ton of soluble material is discharged to streams in about 2500 gallons of waste digestor liquor, more or less diluted with wash waters and other mill wastes. As normally reported, SSL contains 10% solids, mostly lignin and carbohydrates. The quantities vary according to the woods used and method of cook.

From analyses of calcium base sulfite spent liquor at the University of Washington and other data, Felicetta and McCarthy (1) have provided estimates shown in Table I of the average proportion in which the major components in a typical spent liquor are present, based on 10% solids.

The tabulations show that lignin, carbohydrates, and sulfur dioxide combined with lignin comprise the major constituents of the waste. These constituents are our primary concern in waste utilization, or treatment and disposal, in effecting stream improvement.

Previous studies (1) have shown that lignin sulfonates comprise about sixty-five per cent of the solids in spent liquors. Hemicellulose derivatives are also present as a mixture of hexose and pentose sugars amounting to twenty per cent or so of the total solids. These sugars contain characteristic carbonyl or "reducing" groups which can be determined analytically and the "total reducing sugar" results for the existing mixture of sugars are conveniently calculated in terms of the particular sugar, glucose. Some of the sugars such as glucose or mannose are of such chemical structure that they can readily be fermented by yeast organisms and these "fermentable sugars" may amount to about fifteen per cent of the total solids. Other sugars may be present as carboxylate or sulfonate derivatives which are not "reducing" and these substances, together with small amounts of acetic and formic acids, furfural, terpenes, etc., are represented in Table I as amounting to about eight per cent of the total solids. The total sulfur present in spent liquors, about seven or eight per cent of the total solids, is mostly attached to the lignin in sulfonate groups, but also exists, in small proportion, as sulfate and "free $SO_2$" and "combined $SO_2$" and other derivatives. The calcium, or another cation such as magnesium or ammonium or sodium, is present in ionic form to complement the sulfonate and other anions and the calcium present (as CaO) usually is six or seven per cent of the total solids.

Sulfite waste liquor (calcium base process) is usually discharged into adjacent waterways without further

TABLE 1-ESTIMATED COMPOSITION OF CALCIUM SPENT SULFITE LIQUOR

| | Composition | |
|---|---|---|
| Component | Liquor Basis (%) | Total Solids Basis (%) |
| Total Solids | | |
| Lignin sulfonic acids | 6.5 | 65.0 |
| Fermentable sugars | (1.5) | (15.0) |
| Non-fermentable sugars | (0.5) | (5.0) |
| Total reducing sugars | 2.0 | 20.0 |
| Calcium (as CaO) | 0.7 | 6.7 |
| Other compounds | 0.8 | 8.3 |
| | 10.0 | 100.0% |
| Water | 90.0 | |
| Calcium spent sulfite liquor | 100.0% | |

*Technical Services Consultant, Water Supply and Pollution Control Division, U. S. Public Health Service, Washington, D. C.

treatment. After extensive investigations on a pilot-plant scale by three different companies, the first commercial installation of a special recovery process for the chemicals and organic matter normally discharged as waste was made about 12 years ago at the Weyerhaeuser Timber Company Sulfite Mill at Longview, Washington.

*MgO Sulfite Process:* In this modified sulfite process magnesium oxide is used in place of the lime which customarily has been employed as the base for the cooking liquor. The process is generally referred to as the magnesium base sulfite process. Because of the necessity to recover in excess of 95 per cent of the magnesium oxide for economical operation, the waste liquor is removed as completely as possible from the pulp by countercurrent vacuum washers. The washings as well as the waste liquor drained from the pulp are evaporated to about 60 percent total solids and burned in a waste liquor recovery boiler.

In addition to the recovery of the magnesium oxide, most of the sulphur and the fuel value of the organic solids, are recovered. The waste heat boiler supplies the steam required for cooking, evaporation of the liquor, and other requirements of the pulp mill in addition to supplying as a by-product much of the electric power needed in the plant.

The 5-day B.O.D. of the spent sulfite liquor varies considerably, depending on the type of "cook," woods used, and other conditions. Analytical results of sulfite mills in the Pacific Northwest have indicated that the 5-day B.O.D. values have exceeded 600 pounds per ton of pulp. Such results are somewhat greater than the average. Tyler (2) reports the following approximate contributions of components of SSL to the over-all 5-day B.O.D. of the liquor:

| Component | Per Cent of Actual B.O.D. |
|---|---|
| $SO_2$ (Immediate Chemical Demand) | 11 |
| Sugars | 63 |
| Acetic Acid | 12 |
| Alcohol | 1 |
| Lignin furfural, etc. | 13 |

Aside from the sulfur dioxide ($SO_2$) responsible for the immediate demand on the dissolved oxygen resources of the stream receiving the SSL, the principle ingredients of concern from the water pollution point of view are the sugars.

The sugars under suitable stream conditions tend to stimulate heavy growths of an aquatic organism, *Sphaerotilus natans.* This slimy growth has been reported by fishermen to seriously interfer with operation of gill nets along the Columbia River below sulfite pulp mills. This matter is discussed more in detail in a separate section of this report.

*Sulfate (Kraft) Process:* In the sulfate wood pulping process, or the kraft process, a recovery system for the cooking liquor in an integral part of the mill. Unlike the sulfite process, the cooking liquors used in these processes are strongly alkaline. Most of the substances extracted from the wood in the digesters are concentrated in evaporators and burned in incinerators of the chemical recovery plant. The process depends economically on efficient reclaiming of the spent cooking liquor and reuse of its chemicals. Chemical recovery is not complete. An appreciable amount of alkali and extracted substances from the wood escapes in the so-called black liquor lost in the process. The losses in the liquid wastes are principally in the final pulp washings. The condensate from the evaporators, the digester degassing condensates, and the blowdown condensate from the digester have all been found to contain polluting material.

The major waste from the pulping operation is overflow from the decker seal pit. This effluent contains traces of chemicals and wood substances remaining in the pulp after the washing operation. The greatest improvement in this part of the process has come through the elimination of wash water effluent. Development of closed countercurrent vacuum washing systems has been responsible for this advance which has led to both higher recovery efficiency as well as a reduction of the B.O.D. load in the effluent of between 50 and 75 per cent. Decker seal pit discharge varies between 200 and 500 ppm. of 5-day oxygen demand. Other pulp mill discharges are digester relief and blowdown condensates, together with log wash water, turpentine decanter water and floor washings. These are low in volume as compared to the decker seal pit overflow and generally have a lower oxygen demand. They are significant, however, in that the condensates, decanter water and floor washings contain substances such as sulfides, resin acids and mercaptans that are potentially toxic to aquatic life. When danger of reaching toxic levels in the receiving waters exists, the condensates are stripped of objectionable substances in packed towers by power plant stack gases.

In the heat and chemical recovery system of the kraft process the major effluent is the condensate from the evaporators. Where surface evaporators are employed the volume of this discharge is low and the B.O.D. value relatively high. Barometric condensers produce an effluent very low in oxygen demand, but voluminous, due to the quantity of water required by the jets. Application of long tube evaporators in as many as seven effects has greatly reduced carry over with the resulting high losses formerly occurring in this operation. Improved foam control and trapping devices have further reduced carry-over of liquor into the condensers. A better appreciation of evaporator capacity requirements in relation to losses has also done much to reduce the concentration of organic matter and salts in this discharge. Other waste waters emanating from this part of the process are minor in both volume and pollutional load. Processing differences, plant equipment and production all affect the volume of effluent discharged, but a fair average range would be between twenty and forty thousand gallons per ton.

Kraft pulp mill wastes may add some color, odors and possibly cause some foaming in the stream below the mill waste outlets. Under certain conditions some wood fiber may be deposited on the bottom of quiescent areas of the stream, some of which may later rise to the surface. The high fiber recovery efficiency attainable in modern mills, however, tends to minimize this possibility.

Certain constituents in kraft pulp mill wastes have been shown to be toxic to fish and other aquatic organisms when present in sufficient concentration in a stream. Dimick and associates (3) have demonstrated that the effluent from three different kraft mills when diluted 1:20 did not kill silver salmon under laboratory conditions. The process and chemical recovery system, involving burning of organics in the spent cooking liquor, produces an effluent containing much less nutrient for aquatic slime growths than the sulfite process.

*Other Pulping Processes:* In recent years, kraft pulp production has been increasingly accompanied with semi-chemical pulp production. The latter process has facilitated pulp manufacture from hardwoods. Integration of the chemical recovery systems of the two processes is also practical which is a definite advantage from the point of view of reduction of water pollution.

There are a number of cooking methods used in semi-chemical pulping of wood. In general, the term semi-chemical refers to processes in which wood chips are cooked in solutions of chemicals more dilute than commonly employed for pulping by usual processes. The treatment really softens the wood chips rather than pulping them preparatory to being defibrinated in attrition mills. Though soda, kraft, and sulfite cooking liquors can be used, the most common procedure is the so-called neutral sulfite process. This utilizes a cooking liquor prepared from sodium bicarbonate and sulfur dioxide.

When semi-chemical operations are associated with kraft pulp mills, it is possible to dispose of the spent semi-chemical liquor as make-up in the kraft recovery system in a ratio of as much as 1 to 4 on the pulp basis. Unless the process is associated with a kraft pulp mill, recovery of the cooking chemicals has occasioned problems for the Industry.

Replacement of acid sulfite with semi-chemical pulping will reduce pollution on the B.O.D. basis about 75 percent. Investigations conducted by the National Council for Stream Improvement at Virginia Polytechnic Institute have indicated that about 75 percent of the oxygen demand of neutral sulfite semi-chemical waste is due to sodium salts of the lower fatty acids, mainly acetic. From 5 to 10 percent of the 5-day B.O.D. of the waste is immediate demand due mainly to residual sulfites and associated compounds. Other cellulose degredation products, and wood residues, account for the remaining 20 to 25 percent.

The color is caused by lignins and tannins which have little if any oxygen demand. Since the waste is substantially neutral and does not appear to contain any strongly toxic materials, color and oxygen demand are the major problems as regards stream pollution.

Components of the spent liquors from semi-chemical processes are similar to, but less in amount than, those found in liquors from the usual sulfite, kraft, and soda processes. Oxygen demands are four to six times that of a kraft pulp mill per ton of product. The lignin, though less than in SSL, is sufficient to add color to waters receiving the wastes, the degree varying with pH from pale straw color to black at high pH values. Tannates present add to the color, particularly if iron is present in the surface waters. Organics tend to stimulate aquatic slime growths. Accordingly, some method of waste reclamation or reduction is important. Integration of semi-chemical pulping operations with kraft pulp production makes it possible to utilize the chemical recovery facilities in minimizing such pollution.

Mechanically defibered pulping covers methods which do not depend on chemicals in the cooking processes, but which suitably soften the pulp woods prior to defibrinating in attrition mills. Most of the wood components remain in the product. The wastes, accordingly, are comparatively of much less importance as regards oxygen demand and other pollutional characteristics. Minimizing fiber loss is important, as in the case of all of the previously described processes.

Since the ground wood pulping process employs only a mechanical grinding of wood, the effluent from this process carries in solution only a very small amount of water-soluble material extracted from the wood. Also carried in suspension is a small amount of fine wood fibers which pass through the wire screens used in dewatering the pulp.

*Pulp Bleaching:* Pulp bleaching is an essential step, irrespective of the pulping process used, in the manufacture of high-grade pulp and paper products. No matter how rigorous the pulping process, whether produced by the acid sulfite or alkaline processes, there is always associated with the cellulose a portion of the liquor or incrusting matter ordinarily present in the raw fiber. Such colored impurities are not removed by washing or mechanical treatment. A chemical bleaching process is necessary.

The purpose in bleaching practice in the paper industry is to thoroughly treat the pulp with suitable bleaching agents to turn out a product of maximum whiteness and purity, which will remain white indefinitely and yet not impair the strength and natural properties of the fiber, not cause too much shrinkage in weight and volume, and not have excessive consumption of the bleaching materials.

Bleaching is primarily an oxidizing reaction. Chlorine is the most common bleaching agent, and in its various forms is extensively used by the Industry. Initially, single-stage bleaching was employed, with the washing away of the soluble waste products from the insoluble bleached pulp. This practice has gradually been superseded by multi-stage bleaching where strengths of the chlorine and chlorine compounds are just sufficient to take out part of the solubles in each stage, thereby securing maximum pulp yields of good quality, with minimum chemical usage.

The washings between each chemical treatment stage in the bleaching process, containing such solubles as removed in this oxidation process, constitute the principle effluent. The volume and strength of such effluents will vary widely depending in considerable measure on the quality of the pulp used and grade of paper products to be produced.

No attempt will be made to go into any detailed account of converting the pulp into paper products. To provide some understanding of the procedures employed and waste ingredients, the following brief outline of paper manufacture is presented:

### Paper Production Effluents

In the paper-making process, the sheet is formed by filtering the fibers from a water suspension on a fine-mesh wire screen of the Fourdrinier, or, paper machine. In the formation of the paper sheet, the water passing through the screen (white water) carries a considerable quantity of fiber. In order to avoid large losses of fiber, this white water is recirculated through the system. In other words, instead of adding fresh water for washing and dilution of pulp stock, the white water is added for this purpose. However, it usually results that there is a surplus of white water over that needed for make-up and the unused portion, after passing through filters or settling tanks, is discharged into the mill effluent. In addition to the cellulose fibers, white water effluent from paper mills may contain some clay or other mineral fillers, alum, rosin-size, and dye used in the manufacture of various kinds of paper. The quantities of suspended solids in the effluent from both pulp and paper mills may vary considerably among individual mills. This is a result of the different products being manufactured, the process used, type of equipment available, and method of operation.

The so-called 'white water' wastes, applied to the fiber and other paper-making materials in suspension, are kept at a minimum by recirculation. Save-all equipment is employed to remove the paper-making solids in the white water before discharge from mills. There is usually some type of filtering or clarifying device designed to return the reclaimed material to the pulp and paper making process. Utilizing more recent equipment, the losses of fiber may be reduced below a half pound per thousand gallons of effluent.

### Paperboard Mills

In general the principles employed in reduction of white water wastes in paper mills are being followed in decreasing fiber losses in the manufacture of paperboard. The trend is toward recirculation of as much of the white water as possible without causing processing difficulties. This closing or partial closing of board mill white-water systems has increased the problem of slime control. As in paper mills, the situation has been met by use of antislime materials in the water, such as chlorine, chloramine, pentachlorophenate, and other compounds for suppressing biological growths. It is important to maintain careful control of such antislime compounds, or special processing wastes, that may contain enough free phenol to impart tastes to downstream water supplies.

Filtration, settling, and precipitation systems have been utilized to remove suspended solids from board mill wastes. For such solids as cannot be effectively and economically returned for use in the mill, disposal in lagoons may be the answer from the point of view of stream improvement.

### Waste Treatment

Process and equipment improvements have resulted in a definite trend downwards in the volume and strength of pulp and paper mill effluents. The strength of the wastes on an oxygen demand basis has been decreased as much as 75 percent by such improvements, with attendant reductions in chemical requirements, and other gains. Monitoring equipment is proving of value in avoiding occasional increases in sewer losses. The work on waste reduction is nearing an irreducible minimum, however, and further reductions necessitate consideration of treatment and disposal methods.

The Forest Service, U. S. Department of Agriculture, reported (3) approximate B.O.D. values for various pulping processes, expressed in terms of pounds of oxygen per ton of pulp produced, as shown in the following tabulation:

| Process: | B.O.D. |
|---|---|
| Groundwood pulping | 3- 8 |
| Sulfate pulping | 55- 70 |
| Cold-soda pulping* | 50-100 |
| Deinking plant wastes* | **60-100 |
| Semichemical neutral sulfite pulping* | 125-350 |
| Sulfite pulping* | 500-600 |

Even though some pulp mill effluents today are considerably weaker in pollutional characteristics than they were a few years ago, effluent disposal may involve more than dilution to avoid impairing the quality of the receiving waters. Such measures for treatment and disposal as have been employed in recent years with kraft mill wastes, have been directed toward reduction of waste components toxic to fish life as well as reduction in oxygen demand (4-5). In-plant improvements have removed a large portion of toxic sulphides and mercaptans from the composite mixture of blow steam condensate, evaporator condensate, and digester relief condensate following separation of the turpentine which is usually marketed or burned.

Usually when the effluents are controlled to maintain adequate dissolved oxygen in the receiving stream, problems of toxicity to fish will be satisfactorily overcome. Also with adequate stream dilutions at pulp mill sites there should be no appreciable effect on the quality of the waters for irrigation purposes (6).

Treatment procedures are usually necessitated by insufficient dilution being available in the receiving waters. The need and type of treatment is related to stream use. It may be seasonal or continuous. Ponding or lagooning of wastes may be employed, or other more recently developed methods for the solution of special problems, can be applied.

Lagooning has been utilized with beneficial results in reducing the strength of kraft mill wastes, and in equalizing the flow and variations to be expected in strength of mill wastes. The use of lagoons of suitable capacity for effluents, therefore, gives flexibility in handling of wastes to avoid objectionable conditions during periods of low stream flow and highest water temperatures (7-8). Special studies in recent years to increase the efficiency of lagoons have been conducted by the Industry through their National Council for Stream Improvement, and much information is available on performance of this method for treatment and disposal of kraft mill effluents.

Biological methods of treatment practiced by some kraft pulp and paper mills include oxidation ponds, other natural purification procedures, and the accelerated aeration process. A natural purification method of increasing popularity in the southern United States consists of passing the mill effluent down a natural or man-made waterway before discharge into the receiving stream. The accelerated aeration method which consists of effluent oxidation in an aeration tank by means of biological sludge or floe was experimentally developed by the National Council for Stream Improvement. A mill at Covington, Virginia, treats all of its wastes from wood preparation through bleaching operations by the accelerated aeration process and accomplishes high reduction of the oxygen demand of the mill effluent (9-10-11).

Progress is being made in the removal of color from kraft mill wastes (12). Color may be removed by treatment of the effluents with high dosages of hydrated lime. This treatment produces large volumes of hydrous sludges which are difficult to de-water. In view of the amount of lime required for good results, it is necessary for economic reasons to recover the calcium content of the sludges for re-use. Promising methods of the sludge treatment, employing carbonation and heat, are being developed (13).

Small daily losses of fiber from a pulp and paper mill may result in an extensive accumulation of fiber with time on the bottom of a receiving stream. It is especially true with a slow moving river or a fairly quiescent area such as a reservoir. Such a mat of fiber tends to smother the aquatic organisms on which fish feed and will undergo slow decomposition which contributes to the benthal or stream bottom oxygen demand. Modern "save-all" equipment, such as vacuum filters, and water recycling systems, properly installed and operated should adequately take care of the fiber problem.

## Conclusion

Obviously there are many aspects of pulp, paper and paperbound production relating to wastes and disposal of effluents that have not been covered in the foregoing discussion. Water pollution has been given primary consideration, since this is the principal subject of concern in current inquiries into suitable mill sites in Missouri. Air pollution control may also be realized in construction of modern mills. Due to research and development activities in recent years the Industry is in much better position to 'build-out' both water and air pollution in future installations.

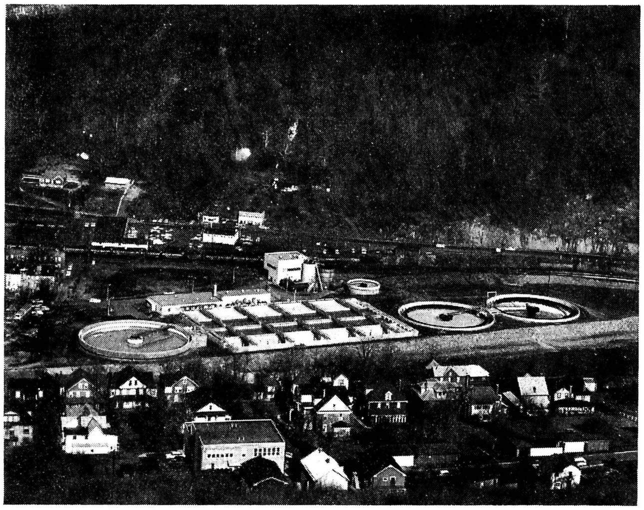

**Fig. 1—A recently completed activated sludge plant at Western Port, Md. which treats the waste from a large pulp and paper well and also from the adjacent town. An example of industrial-municipal cooperation of benefit to both.**

# EFFLUENT DISPOSAL CONSIDERATIONS IN POSSILBE PULP AND PAPER MILL DEVELOPMENTS IN SOUTHEASTERN MISSOURI

*Below are the "Summary and Conclusions" from a report on this subject prepared by the Water Supply and Pollution Control Division of the Public Health Service, U.S. Department of Health, Education and Welfare, Washington, D.C., 1960.*

1. Extensive timber resources exist in Missouri, particularly in the south and southeastern portion, or Ozark region, of the state. Forest land in the Eastern Ozarks, now predominantly covered by hardwoods, comprises about three-fourths of the land area. Increasing demands for pulp and paper products and technological developments in recent years have resulted in marked increase in pulping of hardwoods. This has brought forest resources in Missouri under active consideration for pulp and paper production. In considering possible sites for mills, water needs and extent of pollution of the streams by wastes from such mills is an important factor requiring careful attention.
2. Application of modern forest management in the eastern Ozarks, is not only tending to better timber production and quality, but has resulted in almost doubling the growth stock of softwoods over the past twelve years—a noteworthy trend as regards future supply of pulpwood. In the Mississippi River Border area there are substantial amounts of cottonwood and other so-called soft hardwoods, which are relatively fast growing and a good source of pulpwood.
3. Consideration of pulpwood resources in relation to potential pumping processes at mills in Missouri, indicates hardwood sulphate, or kraft, pulping, along with neutral sulfite semi-chemical, cold soda, and other of the more recent processes for pulping hardwoods will be employed. Chemigroundwood and groundwood pulping will be utilized at such mills. Although other type mills may be considered in the future, this survey or study is limited to generally evaluating the pollution effects of the processes mentioned.
4. The introduction of pulp mill wastes into a stream will have some effect on the character or quality of the water in it. Unless adequately controlled, their impact on a stream may include removal of dissolved oxygen, fiber bottom deposits, toxicities to fish and fish foods, color, tastes, and odors, foaming, and stimulation of *Sphaerotilus* growths. The important consideration is whether such changes as may occur will adversely affect existing and future desirable uses of the stream below the pulp mill and the extent or degree of any detrimental effects on such water uses.
5. It is expected that the minimum size mill to be established would have a capacity of 50 tons of pulp per day. Economic and other factors might indicate need for more than doubling this output. Furthermore, since semi-chemical and groundwood pulps should not be allowed to dry before conversion into paper products, such pulping processes generally will be integrated with paper manufacture. In this study it is assumed mills constructed will employ modern methods for keeping waste loads at a minimum.
6. Suitable effluent diffusion facilities will be essential to assure effective mixing of mill used waters with stream flow. In addition, protection of streams against overloads can be provided by installation of suitable facilities to enable regulated discharge during periods of low stream flow.
7. Such analytical work as performed during the field work involved in this study indicated most waters were at or near saturation for dissolved oxygen at the prevailing temperatures, with stream conditions observed being generally favorable as regards existing water quality.
8. It was evident from the study that there is very limited basic water quality data for the streams in Missouri. There is need for a comprehensive program to supply this necessary water quality information.
9. Water quality objectives have been developed and adopted January 7, 1954, by the Engineering Section of the Missouri Basin Health Council, for use as a guide for the pollution control program along the Missouri River. Other such objectives are being utilized along the Mississippi River. These guides, copies appended, have been employed by the State of Missouri in the development of its part of comprehensive pollution control activities for these particular rivers, and have been used as fundamental information in preparing this report.
10. There are a number of other factors besides water resources to meet mill needs that will require careful analysis before proceeding with possible pulp and paper developments. Considerations such as possibilities of atmospheric odor problems developing need to be given attention, with proximity to residential areas and factors that influence the

strength and direction of travel of plant odors being studied in relation to suitable control methods.

11. Data and information regarding allowable mill capacities in areas along streams included in this study have been prepared on the premises and limitations set forth in this report, and should be considered only in accordance with this information:
    a. The Gasconade River near Rich Fountain, Missouri can support a 90-ton-per-day semi-chemical, or hardwood kraft, pulp mill, with chemical recovery system, and integrated paper production.
    b. The Gasconade River near Jerome, Missouri, has adequate water resources to provide for an 80-ton-per-day semi-chemical, or hardwood kraft mill, with chemical recovery, and conversion of pulp to paper products.
    c. The water resources of the Current River in (1) the sector from below the mouth of Jacks Fork near Eminence, to Van Buren, Missouri, could take care of the needs of a 120-ton-per-day semi-chemical, or integrated hardwood kraft pulp mill, with chemical recovery system, and paper production; or (2) the sector from below Van Buren and Big Spring to the vicinity of Doniphan, Missouri, could take care of requirements for a 240-ton-per-day pulp and paper mill employing the above hardwood pulping processes. Existing and proposed park and recreational developments in the scenic Current River Valley augur strongly against mill developments in this area.
    d. Near Poplar Bluff, Missouri, on the Black River, it would be practical to build a 65-ton-per-day semi-chemical, or integrated hardwood kraft, pulp and paper mill.
    e. The St. Francis River in the vicinity of Fisk, Missouri, would have inadequate assimilative capacity to accommodate a pulp and paper mill of minimum capacity for economic operation.
    f. The Mississippi River in areas near (1) New Madrid, (2) Birds Point, (3) Cape Girardeau, and (4) Sainte Genevieve, would be able to take care of effluents from each of the processes that might be employed for pulping hardwoods found in the river border area and Eastern Ozarks, with any mill having such daily capacity as might be considered economic for installation in these areas.
    g. The Big River in the Leadwood-DeSoto, Missouri, sector does not have the assimilative capacity needed to absorb the effluent from a pulp and paper mill of minimum economic size.
    h. The Meramec River in the sector from Steelville to St. Clair is not satisfactory for receiving the effluent from a minimum economic size pulp and paper mill. Despite exceptional measures taken to minimize and treat any mill effluent, extensive recreational use of this river would make it undesirable to locate a mill along this section. Downstream from the indicated sector the river is used as the source for Kirkwood and St. Louis County water supplies.

The foregoing findings are the results of field observations and study which included (1) assembly and analysis of hydrologic and climatologic information, estimated waste discharge, and available water quality data; and (2) correlation of collected information in terms of appropriate water quality objectives, as appended. The study necessitated the evaluation of future dissolved oxygen conditions in the waters of sections of streams indicated in southeastern Missouri, forecast under low flow, warm weather conditions with indicated types of pulp and paper production with mills of 50 tons, or greater, (3) daily capacity located along the portions of streams covered by the survey; and consideration of the anticipated effects of the effluents on other stream characteristics related to present and anticipated future uses.

# EXPERIENCES WITH COMBINED REFUSE INCINERATION IN ST. LOUIS, MISSOURI

*by Earl W. Deering, P.E., and C. M. Copley, Jr., P.E.**

The City of St. Louis has heretofore made separate collections of unwrapped garbage and rubbish. Each householder was given three garbage collections and one rubbish collection each week. Garbage was disposed of by sale to hog feeders. The garbage that was not sold was ground in a large central grinding plant which discharges into a large trunk sewer that empties into the Mississippi River. Prior to July, 1953 some 70 to 80 percent of the garbage was sold to hog feeders. In 1950, 76,000 tons of garbage was collected with 52,500 tons being sold and 23,500 tons being ground with discharge into the river.

An epidemic of vesicular exanthema broke out in hogs. It was determined that the major cause of transmission of this disease was due to the feeding of raw garbage to hogs. A State Law was enacted, that went into effect July 1, 1952, which provided that garbage must be cooked before being fed to hogs. Since this law went into effect the sale of garbage has dropped to practically nothing and consequently since 1953 it has been necessary to dispose of practically all of the collected garbage by grinding with discharge into the Mississippi River.

The City investigated installation of locations to cook garbage with the idea of selling cooked garbage to hog feeders. It was determined that the garbage could not be cooked at the present disposal site due to odors emanating from cooking and that the extra haul to a plant site that could be used would cost more than revenue derived from the sales of garbage. Consequently it continued to be disposed of by grinding, with discharge into the river. In 1958, 56,700 tons of garbage were collected and only 804 tons were sold to hog feeders with approved cookers.

Rubbish collection was inaugurated in St. Louis in March, 1949. A survey of landfill sites made prior to the start of rubbish collection disclosed that the dumping spaces available for sanitary landfill disposal of rubbish were limited and that it would be necessary to build incinerators in order to conserve the available landfill space for ash disposal. However, due to public demand, it was decided to start rubbish collection with disposal in landfills until the incinerators, which were to be placed under construction at once, could be built. Delay upon delay occurred in starting the construction at the incinerators and it was February, 1953, before construction of the South Incinerator was started. The South Incinerator was placed in operation in February, 1955. The North Incinerator went into operation September 15, 1958.

A conference was held in St. Louis on March 4, 1958 by representatives of the Surgeon General of the United States and other officials of the United States Public Health Service with representatives from the Missouri Division of Health, the Illinois Sanitary Water Board, the Bi-State Development Agency, the Metropolitan Sewer District and the City of St. Louis. This conference, the first step under the Federal Water Pollution Law, concerned itself with the pollution of the Mississippi River in the St. Louis Metropolitan Area. The Conference recommended that St. Louis have an engineering study made of the unsatisfactory practice of disposal of garbage by grinding with discharge into the Mississippi River without treatment with a view toward finding a more satisfactory method which could be earlier applied before the general water pollution control measures also requested would become effective.

In accordance with this recommendation, a consulting sanitary engineering firm was retained to make a study and report on possible methods of garbage disposal other than by grinding with discharge into the Mississippi River. The consulting engineers investigated practices in many other cities and also made studies of disposal by composting and by cooking for sale to hog feeders. The recommendation of the consulting engineers was that the most practical and economical solution would be for the City to provide one combined collection of garbage and rubbish per week with disposal by incineration at an estimated annual savings of approximately $600,000.00 per year.

The City of St. Louis has two incinerators for destruction of combustible rubbish, one located in the south half of the city and one located in the north half of the city.

The design capacity of each incinerator is 500 tons per day—an overall capacity of 1,000 tons per day. The plants have consistently operated at 25% over design capacity, thus giving a potential capacity of 1,200 tons per day. The daily load of combined wastes to be destroyed averages approximately 900 tons per day.

Under normal conditions there is no difficulty in satisfactorily burning all of the present load of combined garbage and combustible rubbish. However, in wet weather, considerable difficulty has been experienced in burning due to failure of householders to properly prepare and protect the wastes by placing same in legal containers with watertight covers. This difficulty in burning has been experienced in burning of rubbish only for several days after heavy rains have occurred. The difficulty in burning is experienced on about 20 to 25 days a year. The need of auxiliary fuel to improve burning on those days is indicated.

The incinerators are of what is commonly termed "The Conventional Rectangular Furnace Type". The

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*Refuse Commissioner and Deputy Health Commissioner Respectively, St. Louis.

combustion chambers are located at one end of the rectangular furnace chamber. The combustion chambers discharge into an enlarged or expanded section of the flues, located outside and along the entire depth of the building. This section which is termed the Expansion Chamber discharges into the stacks or chimneys.

The important bases of design of each plant are:

1. Design capacity—500 tons per 24 hours.
2. Four furnaces provide about 15 cubic foot of volume per ton of capacity.
3. Combustion chambers provide about 30 cubic feet of volume per tons of capacity.
4. Estimated average rate of combustion is 50 lbs. per square foot of grate area per hour.
5. Flues are designed to limit gas velocities to a maximum of 25 feet per second with a temperature of 1800°F.
6. The Expansion Chamber is designed to reduce the velocities of the gases to 7 to 8 feet per second to settle out the fly ash.
7. Stacks are 175 feet high with minimum inside diameter of 9.75 feet. They provide about 0.37 sq. feet per ton of capacity.
8. Grates are hydraulically operated rocker type.
9. Forced draft fans provide about 8.5 lbs. of air per pound of rubbish burned at 1800°F.
10. Normal operating temperatures are about 1600° to 1700°F. in the furnance chambers, about 1500° F. in the combusion chambers, and 800° to 1000° F at entrance to stack.

Fly ash removal is accomplished by impingment and changing directions of the flow of the gases in the combustion chamber and expansion chamber. The gases from each furnace impingn against the walls and change direction of flow 5 times before entering stack. Fly ash removal is also facilitated by providing an expansion chamber in which gas velocities are reduced from 25 feet per second to 7½ feet per second.

Shortly after the consulting engineer's report had been presented to the Mayor and President of the Board of Public Service, the Health Commissioner was questioned by the press as to whether the City's implementing the recommendations of the consulting engineer would effect the health aspects of garbage disposal. Upon reviewing the recommendations the Health Division Staff raised questions as to possible undesirable effects on residential premise sanitation because of the long interval (one week) between garbage collections with possible fly, odor and other sanitary problems. Also there were the questions of whether a sanitary ash could be produced by the city's incinerators to preclude ash disposal problems and whether any significant air pollution might result.

Conferences of the concerned officials were held and it was concluded that the answers to some of these problems could best be obtained by a trial of combined premise storage and collection in a pilot area of the city. Such a trial would enable the Refuse Collection Division to observe effects on collection procedures and on incinerator operation. Concurrently the Health Division could make field surveys to evaluate effects on premise sanitation conditions.

Further conferences were held to select a suitable pilot area for the trial. It was believed that an older, densely populated and relatively insanitary part of the city would provide an experiment under more difficult conditions, thus more readily revealing problems in changing citizen's practices in handling and storing rubbish and garbage which could result in increased sanitary problems with the new method. It was also believed best to select the pilot area in the southern half of the city so as to use the older south side incinerator which lacked certain design improvements found in the more recently constructed north side incinerator and thus would give a better test of difficulties in burning combined refuse.

However the complexities of altering collection schedules and routes and the need for a time concentration of the combined material for incinerator feed required that an existing single day's rubbish collection area be selected which also met as nearly as possible the other criteria. Furthermore using an existing schedule would enable evaluation of the ability of collection crews to absorb the increased load.

The pilot area selected consisted of one half of the regular south side Tuesday rubbish collection area located just south of the industrial Mill Creek central valley of the City extending southward about 15 blocks. It consisted of 292 blocks containing about 16,700 dwelling units.

The plan included the following steps:

1. Development of a survey method to evaluate premise sanitation conditions.
2. Application of the survey to selected sample blocks prior to the trial of combined collection.
3. Notification with instructions to residents of the trial area that a trial was to be made.
4. Initiating combined collection in the pilot area and incineration of the refuse collected.
5. A resurvey after a period of a few weeks had allowed the public to become familiar with the new practice.
6. Evaluation of the surveys and incineration operation.

With the assistance of Officials from the Missouri Division of Health a survey technique was developed and given preliminary field trials. The method provided that each premise would be evaluated for the following facts:

1. Type of premise
2. Number of dwelling units
3. Outside rat infestation
4. Ashpits—presence and use
5. Burning of rubbish
6. Storage method for garbage—neat or wrapped

7. Quality, legality, number and adequacy of refuse containers
8. Loose refuse for which cans were needed.

Field trials were used to test the method and train 15 sanitarians and 4 supervisors in its use. Then on early Tuesday, January 13, 1959, the survey was made of 30 randomly selected blocks in the pilot area. During the same week a handbill was left at every dwelling unit in the pilot area notifying the people that the trial was to be made, instructing them to drain and wrap all garbage for placement with their other rubbish and urging them to provide adequate legal refuse storage on their premise. The collected material was dumped by the trucks into one end of the incinerator storage pit so as to provide feed for one or two of the four furnaces without admixture with regular uncombined combustible rubbish. Five weeks later the resurvey was made on February 17.

Some of the findings were as follows. About 16% of the premises were illegally burning combustible rubbish in their yards. Only half of them began to drain and wrap garbage as requested. The mixing of garbage in with rubbish did not result in increased attention to proper storage methods. About 40% of the premises still had cans without lids, 17% more cans were needed to hold loose rubbish on the ground and 40% of the cans in use were also unsatisfactory for reasons other than lack of lids. Altogether about 58% additional cans would have been needed to replace illegal ones and also hold excess loose rubbish. For the pilot area this would mean that householders would have to purchase about 14,000 additional 20 gallon rubbish cans to provide proper storage.

A significant conclusion resulting from the above data was that the pilot area was so poor in its conditions and practices to start with and changed so little after combined collection that little change either for better or worse could be noted.

Other information indicated there was little citizen complaint in this area about the new program with only a few concerned with possible summer odor problems in the future. Some criticized the handling of their cans by city collection crews who allegedly damaged them. Also lack of adequate education and enforcement for proper premise sanitation was very evident. A key point in the consulting engineer's report had been the need of proper cans and storage methods to exclude moisture and prevent nuisances under a once-a-week collection with incineration.

Two other large mid-west cities visited by the writers during the course of the planning of the new program appeared to achieve much better compliance with storage requirements on premises. A significant factor in this achievement was apparently a much higher degree of collection supervision. These cities (Louisville and Cincinnati) had only 4 or 5 crews per supervisor compared to St. Louis' 15 crews per supervisor and in addition the supervisors were invested with notification and enforcement authority to supplement educational efforts to correct unsatisfactory refuse storage situations.

Apparently our educational efforts by handbill, press and radio did not reach many people in the pilot area since so many did not wrap and drain the garbage. Few appeared attentive to the increased significance of garbage mixed in with conbustible rubbish and held over for a week's time. Lids were not used frequently even when available.

It was found that combined collection presented no problems to the collection crews. The combination of garbage with the combustible refuse did not result in a significant increase in volume over that of the combustible rubbish when previously collected separately apparently because the moist garbage when mixed into the combustible rubbish resulted in greater compaction being achieved by the packer type loader. Consequently the weight per load increased about 1,000 lbs. to 1,500 lbs. with the same volume per load.

No difficulties in maintaining acceptable incinerator furnace temperatures were encountered as a result of the garbage moisture content. Under normal moisture conditions combustion chamber temperatures were readily maintained at 1500°F. with the gases entering the stack at from 800°F. to 1000°F. This precludes any problem of odor from the stack gases. However severe problems in obtaining an adequate burn continued to occur during rainy weather because of the rubbish being received in a wet condition as a result of the widespread failure of householders to have proper lids on refuse cans. This had always been a problem on approximately 25 days each year even before garbage was included. Use of supplementary fuel thus seemed to be desirable under these conditions. Direct addition of fuel oil to refuse in the storage pit by spraying was tried but found of little value since the equipment available for addition of the oil was of insufficient capacity. The costs of this procedure also would apparently be excessive.

The fireboxes of the south incinerator were originally designed for fixed grates but were modified for stoker-type grates before construction. The refuse is charged above the center of the sloping grates and when a thick bed of refuse is carried on the grates some of the unburned combustibles break off the bed when the dump grate at the front of the furnace is operated, resulting in unburned material passing into the ash hopper. The significance of this defect was increased by the presence of garbage, some of which thus got into the ash without being burned.

The original pilot area was primarily of very poor housing type with many multiple family dwellings, rooming houses, and generally, income-type property. This had resulted in our not being able to evaluate the impact of combined collection on an area where there were many home owners who would practice better premise sanitation and comply to a greater degree with instructions and legal requirements. Immediately to the south of the original pilot area was an area which constituted one half of the Monday rubbish collections and consisted of much better residential-type property mostly occupied by middle and working class families with a high percentage of resident owners and many single and two-family buildings. In August of 1959 it was decided to expand the combined collection service into this area. Since winter shortly followed this expansion little, could be concluded as to problems that might occur during sustained warm weather. There were only a few complaints from the residents of the new area regarding the changed collection method.

In the early spring of 1960 it was decided to expand the program further into the highest types of residential area and also into the northern half of the city so as to provide combined refuse for the north incinerator which was of improved design. The north incinerator furnaces have longer fire boxes with charging further to the rear of the grates which reduces the problem of combustibles reaching the ashpit that had been encountered in the older south furnaces. A better test of public acceptance and compliance could be expected in this type of area.

A district in southwest St. Louis, the other half of the Monday rubbish collections, and the northern Friday collection district encompassing that part of the city north of Natural Bridge Avenue were chosen. Both areas were predominately of high quality housing with many single family residences and a high percentage of home ownership. Complaints about the new procedures began to be received immediately and increased with warm weather. Most of the complaints alleged that once-a-week collection was resulting in odors and increased fly population. Many complained that city services were being cut to save expense at the same time that their taxes were recently raised by the regular property reassessment program of the city. Many complainants recommended more frequent collection service particularly during the summer. Most complainants were not objecting to combining refuse and garbage but only to the once-a-week frequency of service. A few complainants objected to the additional chore of draining and wrapping garbage before placing it in the refuse can.

Investigation of many of these complaints revealed that improved sanitary practices on the premise, particularly having tightly fitting lids kept on the cans, would have materially reduced the odor problem. However there was undoubtedly some increase in odors coming from the cans when not tightly covered and around the can storage area. No quantitative evaluation of fly population prior to the new collection program was available for comparison with conditions after the new program was initiated. Complaints have thus far been received from approximately 500 families of the estimated 85,000 families now receiving combined collection service. Almost all have been received from the two better residential areas added to the program most recently.

A number of complaints were received from a residential area near the south incinerator alleging deposition of fly ash and particulate matter in the neighborhood from the incinerator stacks. The Hon. James H. Carter, Smoke Commissioner, therefore undertook a study of this alleged air pollution. Since settled dust and particulate matter was complained of, it was decided that rather than make an expensive dust loading test of the chimney gases, collection in the neighborhood of the complaints of settled dust samples under varying wind conditions would provide a simpler and adequate test which would also be much more easily understood by a layman.

Swatches of "sticky paper", a flexible plastic film coated on one side with an excellent adhesive, were exposed in various locations in the neighborhood when the wind blew from the incinerator stacks toward the sampling site and also from other directions. Upwind exposures were also coupled with downwind exposures in the neighborhood of the incinerator. The Smoke Commissioner's report of the study concluded that although there was some fine particulate matter fallout from the stacks under certain wind conditions, the amount was not enough to constitute a nuisance and was less than the fallout regularly received on east winds in this neighborhood which apparently originated from industrial areas across the Mississippi River in Illinois.

No appreciable fallout of particles occurred from winds passing over other areas of St. Louis before reaching this neighborhood. This data illustrate the interstate nature of some air pollution problems in the St. Louis Metropolitan Area. The heavily industrialized Illinois part of the Metropolitan area has not been as active in air pollution control legislation and programs as the City of St. Louis has been for many years.

At the present time about 85,000 or ⅓ of the families in the city are receiving combined collection service once each week. Plans are currently being prepared to reconstruct one of the furnaces at the south incinerator to provide a deeper firebox, increase the capacity, and reduce the problem of loss of freshly charged material through the dumping grate. Plans for improving crane facilities at the south incinerator are also being considered. The need for supplemental fuel at certain times is evident but a practical method for the use of supplemented fuel has not yet been discovered and the economics of its use determined. There is apparently no problem from odors or particulate matter in the incinerator stack gases.

It has been concluded that the combined collection and incineration of garbage and combustible rubbish is a satisfactory and economical disposal method for St. Louis and the program will be extended in the future to the balance of the city.

Since the Refuse Commissioner has estimated that collection on a twice a week basis instead of once weekly would prevent realizing the approximately $600,000 savings estimated by the consulting engineer, officials of the City are presently weighing the public complaints, the conditions arising, and the economics before arriving at a final decision on the frequency of service to be provided.

# POLLUTION ABATEMENT IN THE FERTILIZER INDUSTRY

*Paper by Q. D. Bowers**
*Read by Walter R. Horn***

## Introduction

According to data provided by the Missouri Agricultural Experiment Station, more than 900,000 tons of fertilizer were used by Missouri farmers last year. This tonnage is almost 700% above figures for the year 1945 and serves to illustrate the increasingly important role of fertilizer in the farm economy.

The word fertilizer is a very general term applied to any material containing one or more of the primary plant neutrients, nitrogen, phosphorous, or potassium in a form available to plants. For our purpose here, we can classify fertilizers as follows:

1. *Nitrogen fertilizers*
   Some examples of nitrogen fertilizers are ammonium nitrate, urea, ammonia, sodium nitrate and ammonium sulfate.
2. *Phosphatic fertilizers*
   The most important phosphatic fertilizers are normal superphosphate, triple superphosphate, and phosphoric acid. Phosphoric acid is not widely used as such, but is converted into other important fertilizer products.
3. *Potassiac fertilizers*
   The common potassic fertilizers are potassium chloride and potassium sulfate.
4. *Organic fertilizers*
   Organic fertilizers include processed sewage, ureaforms, manure, etc.
5. *Mixed fertilizers*
   Well over 50% of the fertilizer used by the farmer is in the form of mixed fertilizers. As the name implies, these fertilizers contain a mixture of two or three plant food ingredients. These fertilizers are available in a wide range of plant food ratios and concentrations; forty-seven different grades were sold last year in Missouri and 1,611 different fertilizer formulations were sold during the same year in the United States. Along with the large number of mixed fertilizers there is a wide variety of manufacturing processes used to produce them. It can be seen from the above that fertilizer manufacturing is a multiple process industry. The double limitation of both time and knowledge of the writer does not permit at this time an all inclusive discussion of pollution abatement in the fertilizer industry. We will, therefore, confine our discussion here to phosphatic fertilizers and to mixed fertilizers.

Dorr-Oliver Incorporated has been closely associated with the problems of pollution abatement as a result of their activity in the design of wet process phosphoric acid, triple superphosphate and ammonium phosphate plants.

## Pollution Abatement In Wet Process Phosphoric Acid Manufacture

The principle pollution hazard encountered in the manufacture of wet process phosphoric acid is from fluorine evolution into the atmosphere and fluorine contamination of plant waste water. Briefly, the production process involves the initial treatment of ground phosphate rocks with sulfuric acid which reacts to produce phosphoric acid solution and gypsum. The gypsum is separated from the phosphoric acid by filtration and the resulting phosphoric acid solution is then concentrated by evaporation to the desired strength for use in the manufacture of a variety of fertilizer compounds. The phosphate rock used in the process invariably contains about 3.5% fluorine. About 5% of the fluorine in the phosphate rock is liberated during the initial reaction with sulfuric acid. Approximately 35% of the fluorine is separated out with the gypsum in insoluble form; the remaining 60% stays in solution with the phosphoric acid. If the phosphoric acid is concentrated, more fluorine is evolved and escapes with the evaporated vapors. The fluorine in all cases is actually present in the form of silicon tetrafluoride gas. Fortunately this gas is soluble in water and forms a stable solution. Effective water scrubbing of the plant gas streams can thus virtually eliminate atmospheric contamination by fluorine.

Several scrubbers are available which will do an effective job of fluorine scrubbing. One such unit, known as the "Doyle" scrubber, was developed by the Consolidated Mining and Smelting Company especially for fluorine scrubbing service and it has received wide acceptance in the fertilizer industry. The scrubbing principle of the "Doyle" consists of a high velocity gas stream impinging at right angles into the surface of a bed of scrubbing water. Excellent liquid-gas contact is obtained by the high velocity impingment principle and scrubbing efficiencies in excess of 95% can be obtained from single stage scrubbing. The required pressure drop across the scrubber is in the order of seven inches of water.

Although atmospheric fluorine pollution can be eliminated with suitable scrubbing equipment, there remains the problem of what to do with plant waste waters containing appreciable quantities of fluorine. In this case the answer is not so simple. Three methods are now in use to combat this problem. They are: (1) Lime treat-

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ment of waste water; (2) Fluorine recovery; and (3) Closed circuit recycle.

The fluorine concentration in waste waters can be reduced to about 15 ppm by single stage lime treatment and clarification. Further reduction of the fluorine concentration to about 5 ppm or less can be accomplished by a second stage lime treatment and clarification. The lime treatment method is effective but is fairly expensive. The lime requirement for complete neutralization of all phosphoric acid plant waste water may exceed 10% of the plant's $P_2O_5$ production capacity.

A process has been developed by the Swenson Evaporator Company for the recovery of fluorine from evaporator condenser water. The feasibility of fluorine recovery and processing into a commercially salable product depends on the size of the plant and the market conditions for the fluosilicate product. The trend over the last few years to fluoridization of municipal water supplies has greatly improved the market for fluosilicate chemicals, however, the supply generally still exceeds the demand.

At least one plant in the Florida phosphate area has resorted to a closed system recycle of waste water in order to avoid discharge of fluorine containing wastes. Briefly the system involves discharging all plant waste streams, including by-product gypsum, into a large impounded area. Here solids in the waste are allowed to settle and the water is cooled by natural evaporation. The clarified water is then pumped back to process for reuse. Since no lime treatment is involved, the acid concentration in the water gradually increases making it necessary to use corrosion resistant lines and equipment for handling the water.

## Pollution Abatement in Manufacture of Normal and Triple Superphosphate

Normal superphosphate is produced by treatment of phosphate rock with sufficient sulfuric acid to convert the phosphate rock into gypsum and monocalcium phosphate. Triple superphosphate is prepared similarly by substituting phosphoric acid in place of sulfuric acid. During the reaction approximately 30% of the fluorine present in the phosphate rock is liberated as silicon tetrafluoride gas. The gas can be collected and scrubbed in the same manner as described previously. The scrubber water may be recycled and concentrated and recovered as sodium or potassium fluosilicate or alternately treated with lime and discharged to waste.

## Pollution Abatement in Mixed Fertilizer Manufacture

Mixed fertilizer plant processes in use today vary widely in complexity and type of product manufactured. The simplest plant may include equipment only for batch blending of various proportions of dry nitrogen, phosphatic and potassium containing materials. These plants are generally small and due to the nature of the operation there is little chance for pollution problems to occur.

A second process for production of mixed fertilizers is the TVA process. This process, developed by the Tennessee Valley Authority, is widely used throughout the United States for the production of mixed fertilizers.

Basically, the TVA process involves ammoniation and granulation of one or more of the following materials: normal superphosphate, triple superphosphate, sulfuric acid and phosphoric acid. In addition, the product may also contain ammonium nitrate, urea and potassium chloride. The principle pollution problems associated with this type plant are dust, fume, and ammonia losses carried in the air stream discharged from the ammoniator drum, and from the drier. Ammonia can be readily recovered in a scrubber fed with dilute sulfuric or phosphoric acid. Cyclones will effectively remove dust particles larger than 5-10 microns. Wet scrubbers such as the Doyle previously mentioned are highly efficient for scrubbing out dust particles larger than one micron. Sub micron dust and fumes are not frequently encountered but are difficult to eliminate by scrubbing techniques. High pressure drop venturi scrubbers work effectively but operating power requirements are excessive since pressure drops as great as 50 inches may be required to effect good scrubbing efficiency.

For those here who may want to pursue the subject of scrubbers in more detail, it is suggested you obtain a copy of proceedings No. 49 of the Fertilizer Society located at 44 Russell Square, London, England. The title of the paper is "Gaseous Effluents from Granulation Plants."

Another type process for the manufacture of high analysis ammonium phosphates and mixed fertilizer compounds has been adopted by a number of fertilizer manufacturers. This process involves neutralization of phosphoric acid with anhydrous ammonia to produce an ammonium phosphate slurry. The resulting slurry is then continuously mixed with dry recirculated fine fertilizer. The surface coating of slurry is dried in a drier and then screened. Undersize material is returned for another slurry crating and oversize is crushed and returned also for recoating. Potash can be added conveniently to give a complete fertilizer. Pollution problems associated with this process are ammonia in the off gases from the neutralization and dust from the drier gases. The ammonia gas is easily recovered in dilute acid scrubbing. Dust is recovered by cyclones and wet scrubbers. The scrubber solution is returned to the process.

This discussion has provided only a very limited picture of pollution problems and their control. The industry is aware of its responsibility to the public to guard the purity of our air and our water resources. Considerable money and effort have been, and is being each year, spent by the Industry to find improved methods to curb pollution.

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