Hodges Exh. 6

MONSANTO CHEMICAL COMPANY

WILLOW ISLAND PLANT
ORGANIC CHEMICALS DIVISION
MONSANTO ILLINOIS

July 29, 1957

Mr. Carl Grace, Sanitary Engineer
Illinois Sanitary Water Board
State Capitol Building
Springfield, Illinois

Dear Carl:

When we last met in Jack Garrett's office, you mentioned that you would like to have a copy of the talk I made at the recent Industrial Waste Conference in Kansas City, Missouri. This talk is enclosed - it is shortened somewhat and simplified because references to the slides shown were deleted. These slides showed some of the gadgets developed and pictures of some of the actual waste reduction projects. I would appreciate any suggestions you may have on the talk or on our program for waste reduction.

I enjoyed visiting with you in Jack's office. Please feel free to drop in any time you're down this way.

Sincerely yours,

Paul B. Hodges

Paul B. Hodges
Pollution Control Engineer

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WASTE REDUCTION IN A CHEMICAL PLANT

These are the experiences of a large chemical plant in its waste reduction program. Many types of industries, other than chemical, will receive copies of this paper. However, the same principles and the same techniques that we have found useful can be applied to most industrial waste reduction programs.

Background

Let's look at the background of our plant with respect to the stream pollution problem. The W. G. Krummrich Plant of Monsanto Chemical Company is situated opposite St. Louis on the Illinois side of the Mississippi River about one mile from the river. We produce about 65 chemical products simultaneously, derived mostly from the basic raw materials salt, sulfur, and benzene. From salt we produce chlorine and sodium hydroxide, from sulfur we produce large quantities of sulfuric acid. From benzene and the caustic, chlorine and nitric and sulfuric acids are derived the wide variety of organic intermediates that make up most of our production.

In most chemical processes, besides the products desired, come by-products, often useless or in quantities so small that recovery is not economically justified. Also, usually an excess of one or more of the ingredients must be added to make the chemical reaction proceed smoothly so the final product must be separated from both the by-products and the unreacted ingredients. Chemical plants normally, therefore, have highly complex problems of waste disposal involving several times the number of different materials actually produced for sale.

Like most chemical plants, we use fairly large quantities of water for cooling and processing so that these waste materials are usually quite diluted. This, of course, makes recovery and reuse very difficult.

We have always been interested in minimizing wastes and recovering by-products because that's good business. With the stiff competition since the end of the war, it has been necessary to continually increase the output of finished goods from a given quantity of raw materials in order to meet this competition. Yields which were considered quite acceptable a number of years ago are now substandard.

Monsanto as a company has always strived to be a good neighbor and to be accepted in all of the communities in which we operate. In our plant we have been careful to treat known toxic wastes such as cyanides to make them harmless before sewering, and to minimize sewering of any wastes which might be objectionable.

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Our wastes are discharged through four main sewers into the sewer system of the industrial municipality (Monsanto Village) of which we are a part. The village sewer flows are collected at a pumping station which discharges into the Mississippi River.

The Mississippi River in the St. Louis Metropolitan area is a highly valuable asset serving a number of purposes. It is a source of public and industrial water supplies, it is an important artery of transportation, it is a playground above St. Louis and it also serves a very necessary function as the waste disposal facility for the entire Metropolitan area. Both municipal and industrial wastes, largely untreated, are presently discharged into the river from about 200 outfalls.

The Mississippi River is very large -- its average flow at St. Louis is 167,000 cubic feet per second; so dilution of the wastes is great and any deleterious effects from the wastes are not too obvious. However, there was a general realization that a pollution problem existed in the Mississippi. There had been complaints from commercial fishermen south of St. Louis that they couldn't sell their fish because of an off-flavor and the fishing industry almost died out. A number of the municipal water treating plants in the St. Louis area had complaints on odor and taste and could not remove the odor by conventional treating methods. The floating solids and sludge banks were unsightly and were smelly in the summer time.

In 1949, Missouri and Illinois formed the "Bi-State Development Agency" for the planning and development of the St. Louis Metropolitan Area. The Bi-State Agency took on the job of studying pollution in the Mississippi. It was assisted by the U. S. Public Health Service, the Illinois Sanitary Water Board and the Missouri Division of Health. The study was made over a two year period in 1951 and 1952. They took regular samples at points in the river over a 35 mile stretch. They sampled and tested many of the sewer outfalls. They tested the bacteria and studied the marine plants and animals in the river. They even set up aquaria where they put test fish along with water from the river or from sewer outfalls. They cooked and taste tested the fish to try to see where the off-flavors were picked up.

The findings from the survey were completed and published in 1955. There were many findings but the most important ones were:

1. The lateral zones were the most polluted and mixing in the river was poor. A pollutant going into the river from a sewer outfall would go for many miles before it became well mixed through the river.

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2. There was a wide range of industrial wastes. The most important effects at present were in the tastes and odors of the fish and water taken from the river.

3. There had been a sharp reduction (about 75%) in commercial fishing since 1947 -- mostly due to economic conditions rather than pollution. However, the stream conditions were not favorable for fish food and propagation.

4. The industrial municipality sewer to which we contribute discharged phenolic pollution which is considered objectionable -- very small amounts of phenols, especially chlorophenols, are believed to give a bad taste to water and fish.

There were a large number of recommendations in the report but the ones most significant were:

1. General recommendation - that all wastes should be in such condition that they would not harm the river as a source of domestic and industrial water supply or for navigation, fish and wild life, recreation, agriculture and other normal stream use.

2. That sanitary sewage and storm water should be settled to remove the solids.

3. That phenolic chemical wastes should be treated so that the phenol content of the river at any point after original dilution was not over 2 p.p.b. average or 5 p.p.b. maximum.

4. By way of action, they recommended that the industries and municipalities take definite steps toward correction. They should base the treatment works on the minimum average monthly flow we should expect every 10 years.

That was the challenge issued by the Bi-State Agency and it was supported by the Illinois Sanitary Water Board, the water pollution control agency for Illinois.

With the increasing emphasis on projection of water resources throughout the country and the likelihood that the municipalities and industries in the local area would eventually move to comply with the stated recommendations we now had additional reasons beyond the economic factors for reducing wastes. We therefore intensified our efforts in this direction and entered into a formal program in early 1956. That was the background of our situation 1-1/2 years ago and here is the story of what we have done since then.

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Correction of Pollution Problems

Correction of a pollution problem in a plant normally takes two courses. First -- include in the design of any new installation, adequate facilities to dispose of wastes in a manner which will not create new pollution problems. This is a recognized policy of Monsanto and we adhere to it rigidly. In the research work necessary to develop a new product, alternate processes are usually possible and are evaluated. The final choice of process may be strongly influenced by the amount of waste created and the difficulties in disposal of the waste. In the design stage of the project, adequate disposal facilities are provided and the cost of these facilities is considered part of the manufacturing cost of the new product.

The second and often a very difficult and expensive course is to correct pollution caused by existing processes. The first step in solving an existing pollution problem is just like solving most problems -- get the facts. Find out the size, character, and composition of the waste streams. This is necessary for three reasons:

1. To show the size and extent of present pollution problems.
2. To establish a base line by which to measure progress in abatement.
3. To be able to discuss the problem intelligently with control agency officials.

One man should be assigned the job of getting the facts and directing and coordinating waste control efforts. A common practice is to assign this man both the stream and air pollution problems because they are closely related. This was done at Monsanto. The man selected should be a technical man well acquainted with the plant. He will probably need education in waste control practices and terminology. An excellent way to receive this training is by study of books and magazines, attendance at pollution control seminars and conferences and, especially, the two week training program given by the Robert A. Taft Sanitary Engineering Center at Cincinnati, Ohio. This schooling is under the U. S. Public Health Service and is designed mostly for control agency officials. However, industry representatives are welcome and will receive much of the necessary background training in pollution control work. Three men from Monsanto have received this training and all found it very helpful. The course is given once per year and the next session is in March, 1958.

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Sampling Wastes

Now we have the man with a minimum amount of training and he is ready to go to work. His first big job will probably be to decide how to sample the wastes. If waste water volume is reasonably constant, 24 hours continuous samplers can be used. If the volume of wastes vary considerably, a proportional-to-flow continuous sampler will be necessary. If peak discharges from batchwise operations are an obvious problem, additional grab samples should be taken as judgement indicates.

Based on our experience, suitable commercial samplers may not be available. Study of our sewer map showed that at the four places we needed to sample, the sewers were deep, none were close to electric power and with damp, corrosive conditions present we weren't sure we wanted electric power. So - we devised and built a low cost continuous vacuum sampler using a stainless steel oxygen tank out of an airplane (see Figure 1).

Operation of the sampler is as follows.

The tank (1) is evacuated to 20 mm. Hg. (or less) by taking the unit, which is readily portable, to a vacuum source such as a laboratory pump or multi-stage steam ejectors and connecting hose (3) to the source. The evacuated unit is returned to the sampling site and connected to the filter flask (13) which should be suspended in the sewer manhole out of direct sunlight. The polyethylene tube (15) from the sewer runs through the side arm into the flask so that the water flow rate is readily visible and so that siphoning cannot occur. The filter flask is then evacuated by means of the hand pump (10) to the point where water barely starts to drip from the tip of the tubing (15). Too high vacuum can be relieved slowly by the needle valve vent (9) until the desired flow is attained. Valve (6) is closed and the sampling continues by displacement of air through the sight feed bubbler with needle valve (5) into the vacuum tank (1). The needle valve (5) is adjusted to give the flow desired. This adjustment need never be changed unless dirt or water is inadvertently drawn into the valve.

With the unit shown, sample sizes can be controlled from one to three liters in 24 hours. If larger samples are desired, larger vacuum tanks should be used. In order that the sampling rate be reasonably constant over the 24 hour period, the vacuum tank volume should be greater than twice the sample size desired and the filter flask should be protected from extreme temperature changes.

To discourage tampering, the hand vacuum pump can be disconnected daily and a cover locked over the bubbler, valves and gage.

Total materials cost for each unit, including the hand vacuum pump, were about $55.

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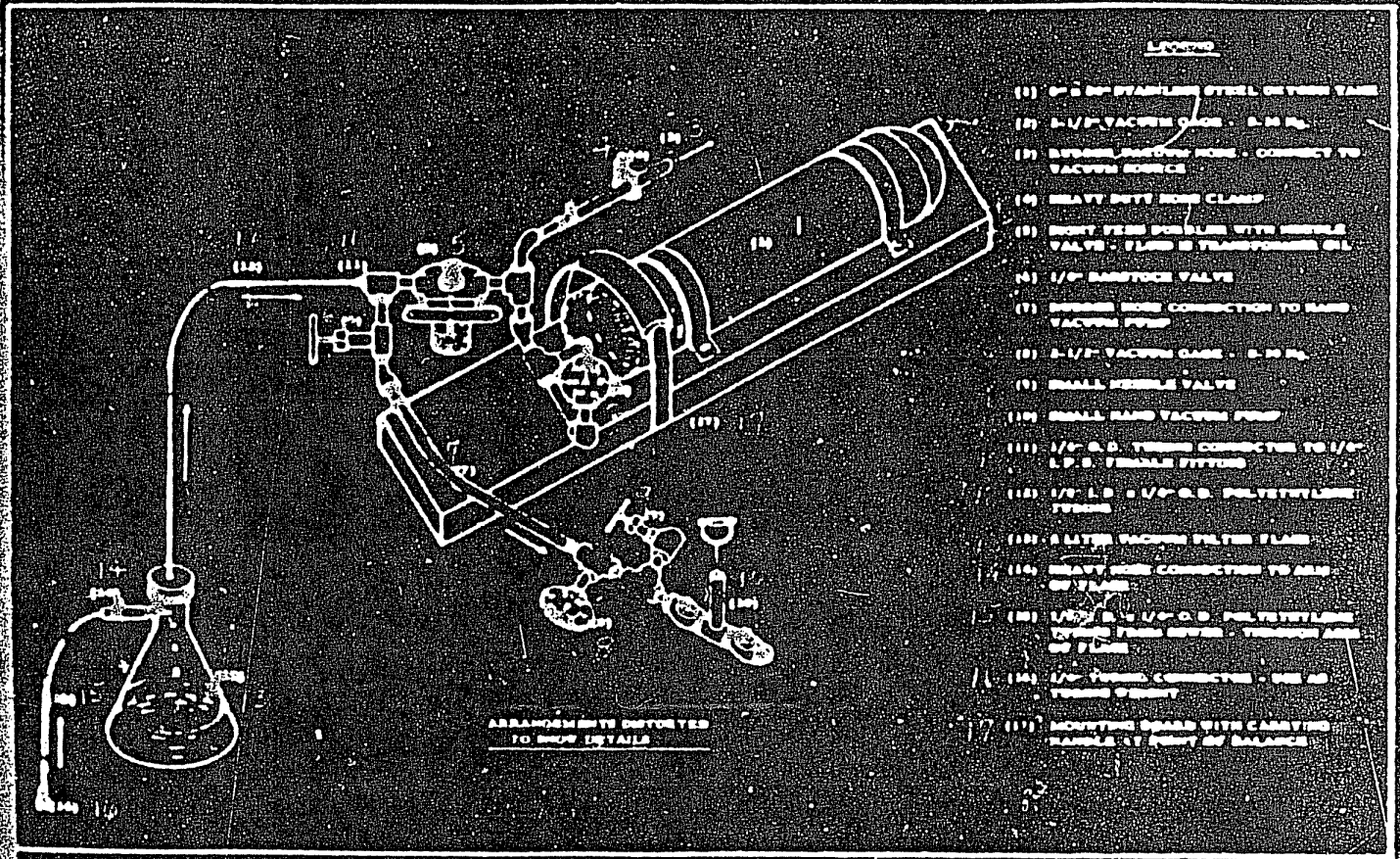

Fig 1

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In our installation, four samplers were installed and a small gasoline engine powered vacuum pump on a station wagon was provided, eliminating the necessity for moving the samplers. The four sampling stations, although nearly a mile apart, can be tended in a total of about 45 minutes per day including taking the samples to the laboratory. This sampler has proved to be quite dependable, is corrosion resistant and is well suited for our use. It has its obvious limitations -- the flask must be protected from extreme temperature changes, the small sampling tube will not handle large solids and the joints must be kept tight.

Of course, the samples have to be analyzed. These analytical procedures are fairly well standardized and, in many cases, are not very accurate but they at least provide some idea of the extent of the problem. Typical analyses which may be needed for chemical plant wastes are: pH and free acidity or alkalinity, suspended solids, Biochemical oxygen demand or chemical oxygen demand -- both rough measures of the oxygen depleting powers of the wastes, percent phenols or other organics, metals which may be present, inorganic salts, etc.

Flow Measurement of Wastes

Flow measurement of waste is the next step unless it was handled concurrently with sampling. Usual methods are to install Parshall flumes or weirs or to measure directly at outfalls if the outfalls are accessible. Flow recorders can be readily used with flumes or weirs. Flows can be calculated roughly in some cases by formulae using size and slope of the sewers and depth of flow.

In our case, obtaining flow data proved to be almost as difficult as obtaining the continuous sampler. Our sewer system was simply not designed for measuring flows. Installation of flumes or weirs was impractical and would have been very expensive because our sewers are deep and the slope is so small that we just could not stand the necessary drop. Levels changed frequently in the sewers when we knew flows had not changed appreciably so we could not tell much from levels.

Working with our laboratory, we developed a method for injecting a Li Cl solution of known strength at a constant rate into the sewers followed by sampling and measuring of its dilution downstream. From the injection rate and the dilution the sewer flow can be calculated quite accurately. Lithium is foreign to our wastes and it has a unique property in that it can be assayed accurately and quickly by flame spectrophotometry in low concentrations of around 1 p.p.m. The Li Cl solution is stored in a drum and is pumped into the sewer to be measured at a constant rate by means of a Sigmamotor pump. This pump operates by a series of fingers which press on a rubber or plastic tube in such a sequence that the liquid is moved forward in the tube. The pumping rate is adjustable by means of a Reeco infinitely variable speed reducer. After a few minutes pumping, several grab samples are taken downstream for later assay

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for Li Cl concentration so that the dilution and the sewer flow rates can be calculated. We have found that in a fast moving stream, the Li Cl concentration reaches equilibrium very quickly and that only about 10-15 minutes pumping of the solution is necessary. Sodium chloride can be cheaply used for the tracer fluid if chlorides are foreign or at a constant level in the waste stream. Radioactive tracers can be used in some cases but this is no job for an amateur.

Waste Reduction Program

Let's assume that we now have the facts and a pretty good idea of the problems facing us. The next step is a waste reduction program. Most industrial plants are reasonably efficient (and, indeed, they have to be in this day of stiff competition). They don't waste materials needlessly because they can't do that and stay in business. However, no process and no operation is perfect and often very substantial reduction in wastes can be made through an organized program.

A waste reduction program has certain needs which must be met before it can be successful -- first, an attitude of management of wanting and being willing to pay for waste reduction. A good waste control program can usually be made to pay overall, but frequently the cost of recovery of a pollutant is far greater than its value. Most top management personnel are well informed and realize the need for waste reduction. If they are kept well informed through regular progress reports, they will usually continue to support the program. The support of first line and middle management can be obtained by good communications -- keep them well informed and let them know of the progress and benefits. At the Monsanto Krummrich Plant we have talked to operating and maintenance supervision about pollution problems and waste reduction programs in their regular staff meetings and have been rewarded with real support for our work.

The second need is the cooperation and help of every operator and maintenance man. Much waste reduction can often be accomplished through ordinary good housekeeping. Here again, good communications pay -- advertise the accomplishments and talk to the men about the program. Many of them are fishermen or own boats and they have a real interest in stream purity. They will appreciate the work being done and will cooperate. We have not yet spoken to the operator and maintenance worker groups in formal meetings but we plan to in the near future. We have printed two articles in our plant newspaper describing the problems and the program.

The third need is to analyze each step in each operation to determine with reasonable accuracy the loss at each step. Besides making balances on the main materials, sample and analyze the waste streams and measure the waste flows. With the application of chemical engineering principles, processes and equipment can be altered to reduce the waste down to a practical minimum.

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Let's look at several of the waste reduction projects on which we are working or which have been recently developed to show typical ways to reduce waste.

In one department which flakes a quite objectionable organic material, the dust from the Flakers is being drowned to the sewer by means of water jets. The product is insoluble in water and it was thought that the amount of material sewered was insignificant. We constructed a sampler designed to sample streams containing fair amounts of settleable solids.

With analysis of the samples obtained and direct measurement of the flow at the outfall we found that the amount of material lost is much higher than expected and represents a real contribution to the pollution problem. Because the amount is large it is also attractive financially to recover the product and we are now working on means to do just that. We will probably capture the dust in a caustic solution and return the solution to the process.

In the same department another fine dust from ventilating ducts was being drowned and sewered in a Schneible tower. A Schneible tower is a type of wet gas washer. Also, a bag filter installation was being used to collect dust from another part of the same process. The bag filter was not operating properly, creating an air pollution problem and high maintenance costs. We decided to replace the bag filter with a new Schneible tower. We included in the design of the new tower facilities to completely recirculate the water used for washing and to return this water to process where the dissolved material could be recovered. We made arrangements at the same time to use this same water for circulating over the original Schneible tower and thereby recovered the material we had been sewering. We therefore, in this one project solved a stream pollution problem, an air pollution problem, decreased maintenance costs and are recovering substantial amounts of valuable material.

Again, in this same production department, hydrochloric acid gas is a by-product of the reaction. This gas is recovered for sale as hydrochloric acid. The first step in purification of this gas involves scrubbing it with strong sulfuric acid to remove the bulk of the organic material in the acid gas. This sulfuric acid is periodically sewered when it becomes no longer effective. Now the sulfuric acid itself doesn't contribute much to stream pollution as the Mississippi River is normally alkaline but the organics contained in the acid are objectionable. We arranged with our Research Department to test this spent acid for possible fertilizer manufacture. They found that despite its poor color and objectionable smell, the acid made perfectly good fertilizer. We are now making arrangements for sale of this acid at a reduced price which will barely cover the cost of handling but we will have overcome another stream pollution problem.

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Another example - in another department where an organic intermediate is reacted with chlorine on a batchwise basis. HCl gas is given off as a by-product and had been sewered. The gas as evolved from the chlorinator was quite hot and carried along with it substantial amounts of the organic material in vapor form. We installed a gas scrubber containing cold raw material for the following chlorinator batch. This cold raw material absorbs the organic vapors from the gas stream and the HCl now leaves the scrubber with negligible organic content.

Another job we are presently working on also involves a combined air and stream pollution problem. An oily sludge residue from a reaction is presently sewered in quite small amounts. It reacts slowly with water in the sewer and makes a most objectionable smell. We are working in the laboratory to react the waste with live steam and recover the volatile materials which have some value. The steam stripped oil sludge will lose its objectionable smell and the oil layer can be easily collected for burning.

In yet another department, formation of useless by-products was quite large. The Research Department worked extensively on the process and found that the manner in which the ingredients were added to the main reactor strongly influenced the formation of by-products. Optimum conditions were determined and the equipment was revised to fit the new process. The loss of by-products was sharply reduced, the pollution problem was minimized and the project is paying handsome returns.

These six examples given are typical of the projects either finished, underway or planned for the waste reduction program. In each case the approach is about the same:

1st - Sample, analyze and measure to get the facts on extent of the problem.

2nd - Develop a project to abate the problem in the most economical manner. This can involve process changes, sale of substandard material at reduced price, improved collection equipment, reuse of waste materials, improved cooling of gas streams, incineration or many other means.

3rd - Assist the operating department in taking full advantage of the change.

At our Krummrich Plant we are frankly proud of the job we are doing on waste reduction. In the last 18 months we have completed 20 waste reduction projects costing almost $200,000. These projects have resulted in very significant decreases in our waste discharge of both organic and inorganic materials. The discharge of phenolic materials, for example, has been reduced by 1/3 in the past six months. Not all the projects are self supporting but these completed projects will pay their way financially when considered as a group. This is normal at the start of a waste reduction program -- naturally, we first worked

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on the problems involving the largest amounts of wastes and, of course, these larger wastes offer the best prospects for financial return. We have been skimming the cream of the crop of waste problems.

In construction and in active design stage we have 12 projects which will cost another $200,000. These projects offer less returns on both pollution abatement and money bases than the 20 completed projects. Future planned projects will be even more expensive and will offer continually decreasing return.

Under needs of a waste reduction program, we have discussed the need of management support, support of the worker personnel and the need to analyze and develop projects for improvement. The fourth and possibly the greatest need is to fix responsibility in the operating group for waste reduction. The pollution control engineer can lead and point the way, he can measure and analyze and he can develop projects for the equipment and process changes but the operating group eventually has to do the job. Pollution control is everybody's business.

In one large department we are assisting operating supervision of the department by monitoring their sewered wastes. We have five small samplers in operation at this particular department in order to pin point any losses to definite areas. These samplers consist of Roll Flex pumps which are plastic tube pumps. A nylon roller in a planetary motion presses against the tube inside the pump and thus forces liquid through the tube. The pump is driven by a Revco speed reducer which is in turn driven by a small, inexpensive totally enclosed shaded pole motor. The sampling rate can be adjusted down to as little as 1/2 gallon per day. This makes an excellent sampling pump for plant use. The assembly includes a clock timer which moves the discharge tube slowly around a trough divided into nine spaces. From each space a tube leads to a sample jar receiver. The clock makes only one revolution per week and each one of the divisions in the trough represents one eight hour shift of sampling. With the nine sample jar receivers we can set the timer on Friday morning and on Monday morning pick up the nine week end shift samples. Because there are five samplers in use and the three samples per day would make fifteen samples to be analyzed, we composite the three shift samples at each station daily. If the assay of the composite sample is high, the individual samples are run to determine on exactly which shift and in which area the loss occurred.

We show the results of the sampling graphically in the department supervisors office on a large chart so that trends can be readily noticed and corrective action can be promptly taken.

We plan to use about the same techniques in other parts of the plant in order to help supervision maintain the tight control that is needed if wastes are to be held to an absolute minimum.

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Treatment vs. Waste Reduction

After the wastes have been reduced to an economical minimum -- then's the time to consider building a waste treatment plant. Very frequently, if the receiving stream is large and the waste reduction has been successful, there will be no need for a treatment plant. A stream in good condition has marvelous self purification powers and can assimilate large amounts of some pollutants with little harm. Waste-treatment plants are very expensive to build and expensive to operate. They should generally be built only if waste reduction efforts won't do the job.

We don't have time to discuss treatment of chemical wastes -- that's a big subject and extensive research work is going on around the country to find cheaper and more effective ways to treat. There are often several ways to render a specific waste harmless. Let's take phenol for example - it can be oxidized destructively by excess treatment with chlorine, chlorine dioxide or ozone, or by bacteria using lagoons, biofilters or activated sludge treatments - a new development along this line is use of cooling towers for the bacterial oxidation. The phenol can be burned in incinerators or low temperature catalytic combustion furnaces. There are many ways but so far they are all very costly -- destruction of the phenol usually costs several times what it is worth as a pure material.

I hope that in this report I have given you some idea of the problems and the approaches used to solve those problems by a typical chemical plant in its efforts to help preserve our water resources. The chemical industries are aware of their responsibilities and are progressing at a rapid rate. We must realize that a vast expenditure of effort and money and a lot of time will be necessary to do this job.

P. B. Hodges

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