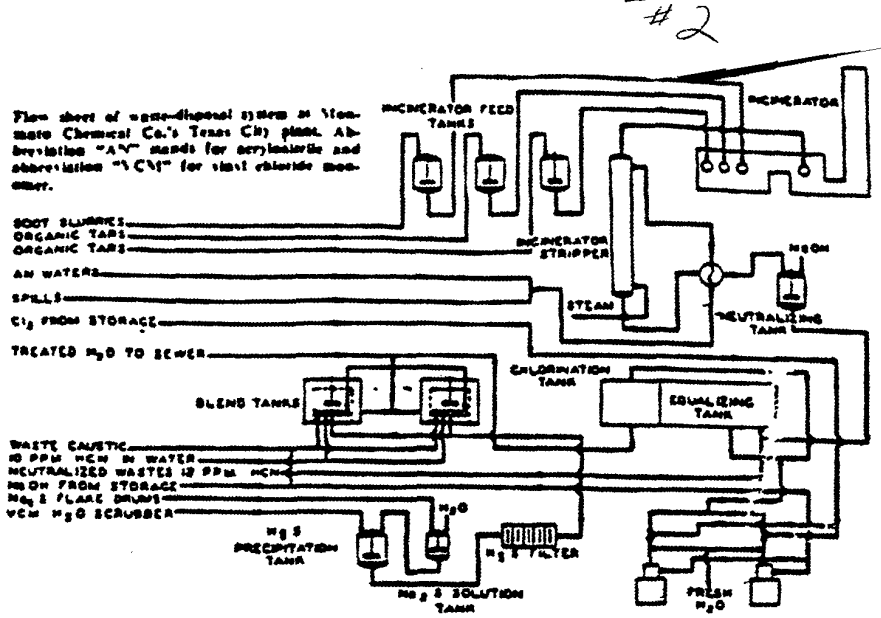
DEFENDANT'S EXHIBIT #2



Flow sheet of waste-disposal system at Monsanto Chemical Co.'s Texas City plant. Abbreviation "AN" stands for acrylonitrile and abbreviation "VCM" for vinyl chloride monomer.

Wastes Are Burned . . .

"Why so many flares?" This question may be one of the first asked by the visitor to Monsanto's Texas City, Tex., plant. The answer lies in Monsanto's waste-disposal program. All organic wastes at this plant are burned insofar as is possible.

Monsanto has invested at Texas City nearly $1,000,000 in equipment for its waste-control program. Operating costs for the waste disposal are about $25,000 per month.

From natural gas and propane Monsanto presently makes ethylene and acetylene at Texas City. These then go into production of styrene, vinyl chloride, and acrylonitrile. Some waste-disposal problems faced by Monsanto (1) how to treat waste catalysts, (2) what to do about soot formation accompanying acetylene production, (3) how to handle cyanide wastes, and (4) how to solve the problem of acrylonitrile leaks spills.

Here are some of Monsanto's thods (1) A "leak committee" ps operators on the alert for s (2) dilution takes care of some ies, (3) azeotropic distillation is to recover hydrocarbons from water, and (4) steam stripping ployed to remove acrylonitrile

ese methods plus plenty of inion have insured Monsanto operations and a satisfaclationship with the Texas Department and Texas Game sh Commission

How Monsanto Controls Air and Water Pollution

6/28/54

by Dr. H. E. Morris

THE plant of Monsanto Chem... Co., at Texas City is l... Galveston Bay adjacent to ... the port fac...ties. The first ... plant went on stream late in ... the production of styrene monomer ... the Office of R...er Reserve, which owned the plant, with Monsanto as operators.

...are largely ... Consequently any ... sewer could be detected ... will be described later.

Wastes from Styrene Manufacture

The process for the production of styrene is comparatively simple but it does involve handling large quantities of materials which could be troublesome if not controlled. In the initial design it was agreed that insofar as possible all organic wastes would be burned. Most process vents were piped to flare stacks and liquid wastes were burned as fuel in plant boilers.

The ethylene plant presents few problems. The waste gases are burned as fuel and most of the liquid by-products can be sold. Since the purification unit operates under pressure, all relief valves are piped to a flare stack.

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Waste-catalyst problem . . . The second step in the process involves the reaction of ethylene with benzene in the presence of an aluminum chloride catalyst. The disposal of waste catalyst presented quite a problem. In our process the catalyst is washed with water to decompose the complex giving an aqueous solution of aluminum chloride, which was sewered. Although the hourly quantities were comparatively small, the alkalinity of the bay water promptly precipitated an aluminum hydroxide floc producing a milky appearance in our main outfall. It was alleged that this floc would plug fish gills although we were never able to demonstrate this in experimental work.

What happens to the fish? . . . There were some data on the effect of aluminum chloride on fresh-water fauna but very little in salt or brackish water. As a consequence we made a grant in aid

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> "Our experience would indicate that it is advisable to obtain toxicological data on marine life indigenous to the area in exactly the type of water characteristic of the plant outfalls. If such tests cannot be run at the plant site, they should at least be made on water from the area."

... the Department of Ma... Biology ... University of Houston to determine ... minimum lethal concentration of ... salt on marine fauna in Galveston ... while we sought other ways of ...ding the nuisance.

The data from the university project ...dicated that most marine animals ...uld tolerate surprising quantities of ...minum chloride but were more sen...ve to the acidity which it produced ... present in large amounts. The re...lts showed that our effluent was nor...lly innocuous if not too clear. Lim... were set at about 10 per cent of the ...ported minimum lethal concentration ...d checked by regular analyses for ...minum in the outfall. During the ...urse of this work it was found that ...st of this aqueous solution could be ...posed of in another manner and ...oid practically all of this pollution.

Dilution . . . The alkylate from this ...thyl benzene) unit is washed with ...ater to remove the acidic components. While the amount of acidity is very ... and readily neutralized by caustic, this water does contain dissolved aromatic hydrocarbons. Here again we had a problem since these materials are known to be toxic and are not too readily decomposed by biological oxidation. Fortunately we were able to depend upon dilution to keep the level down. This plant used bay water for cooling on a once-thorough basis, hence we had plenty of water for dilution.

Aromatic hydrocarbons . . . Since these were present in most of the plant it was essential that we keep a close survey on all sewers. To this end our research group developed an extremely sensitive chemical method for the determination of aromatic hydrocarbons in water. This method was used for routine surveys of all plant sewers. This program was supplemented by a leak committee which made frequent plant-wide inspections checking up on all possible sources of leaks which might contribute to pollution. Possible trouble spots such as pump packing glands, sample valves, exchanger cooling water, etc., were checked for aromatics. This proved to be a fruitful method of keeping operators alert to watch for such leaks.

Azeotropic distillation . . . The catalytic dehydrogenation of ethyl benzene to styrene is carried out in the presence of large quantities of steam. When condensed this water is saturated with almost 0.1 per cent aromatic hydrocarbons. This represented a potentially serious source of pollution. It was finally decided that pollution could be avoided on a breakeven basis by carrying out an azeotropic distillation on this water to recover the hydrocarbons. The contaminated water is fed to a stripping column and sparged steam removes the aromatics which are returned to the separator. The still bottoms are sufficiently stripped to be suitable for reuse for steam generation.

New Problems—Acrylonitrile and Vinyl Chloride

In 1952 Monsanto built plants in Texas City for the production of acrylonitrile and vinyl chloride. These operations brought with them a whole series of new disposal problems. We have adopted the policy that no process is complete unless it can be operated without pollution of air or water. These new operations posed some severe problems and after a little over a year of operation we can say with reasonable assurance that the program to be outlined is workable.

The new plants involved units for the production of oxygen, acetylene, hydrogen cyanide, acrylonitrile, ethylene dichloride, hydrogen chloride, and vinyl chloride. Of these only the oxygen plant involved no disposal problems!

One of our research chemists spent considerable time at the Texas Game and Fish Commission Marine Laboratories at Rockport, determining the minimum lethal concentrations on a wide variety of possible pollutants on marine fauna typical of the Gulf Coast area. This work pointed up the variations which may exist in different qualities of water. Data obtained in fresh water or sea water may not be applicable in brackish waters which characterize many of the plant sites along the gulf.

Study local waters . . . Our experience would indicate that it is advisable to obtain toxicological data on marine life indigenous to the area in exactly the type of water characteristic of the plant outfalls. If such tests cannot be run at the plant site, they should at least be made on water from the area. There are too many variables involved to accept reputable work done in California, Minnesota, or New York—such data are good for that locale but they may or may not hold for gulf waters.

Some of the compounds tested in ... work included acrylonitrile, lactonit... hydrogen cyanide, and acetaldeh... Most of these results were publis... by F. M. Daugherty, Jr., of the T... Game and Fish Commission Lab... Jones, and J. T. Garrett, of Monsa... in the Texas Journal of Science. S... further work was completed on chl... nated aliphatic compounds which ... not been published to date.

Acetylene Production and the S... Problem

Processes for the production ... acetylene by the partial combustion ... natural gas almost invariably inv... the formation of soot. Most rea... are well aware of the air-pollu... problems involved in the productio... carbon black from natural gas. W... the processes have different objecti... the chemistry is similar, and we c... not have clouds of soot blowing arou... We were also aware of the probl... encountered in some of the synthe... rubber copolymer plants which ad... carbon black to the polymeriza... process. The black suspended in w... created a mean pollution problem. I... ing these facts we knew we had ... dispose of soot without air or w... pollution.

Burn the soot . . . While carbon ... quite combustible there are times w... it is quite refractory and to add to ... problems the soot particles are extre... ly fine—electron microscope studies ... dicated we had particle sizes in ... range of 10A° to 20A°. Burning of ... soot was the only feasible solution ... after prolonged discussions with in... erator designers, a design evolved wi... it was hoped would handle soot slu... without a wisp of black smoke. W... not certain that this was the first ... installation but the furrowed brow... the designers indicated that it was ... usual and we're happy to report ... it works. In-plant mishandling of s... streams has, at times, messed up ... piping color-code system, but bey... our fences neither people nor fish ... bothered by the fact that we make ... in our processes.

The Hydrogen Cyanide Proble...

Hydrogen cyanide is an extrem... toxic compound. Although million...

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"We studied the possibilities of chlorination of the plant stream but found that the chlorine demand might be much too high for economical application and even at low contamination levels would be hard to control. As a consequence we settled on a steam stripping system to remove the contaminants from water."

pounds are made in this country and several other widely used chemicals are actually more toxic, to most people cyanide means poison. Here again we faced real problems for safe in-plant handling as well as innocuous disposal. In contrast to some other toxic chemicals, hydrogen cyanide can be burned completely to harmless products. Since it is reasonably volatile, the disposal of any waste gas stream containing HCN was simple. We verified the fact that gases varying from 100 per cent to low concentrations could be flared safely if necessary. With this knowledge we built a flare stack to handle emergencies or startup problems.

Cyanide waste . . . After an extensive study of several alternates, we settled on the alkaline chlorination of aqueous cyanide wastes for the safe disposal of such streams. This process is well known and is readily controlled by automatic instrumentation. In our experience, this method of disposal has worked effectively. We had some problems with lag but after solving these we have had no difficulties in processing relatively large volumes of low-cyanide waters.

Detecting minute HCN . . . As a part of our plant safety program, we developed a special instrument capable of detecting minute traces of HCN in air. This instrument proved quite effective and is currently in operation in our HCN area. Its primary function is to detect leaks of vapors particularly in the storage area. It is set so that it automatically monitors samples of air drawn from several locations and rings an alarm if the HCN content of the air being sampled exceeds 40 p.p.m. It can be set at a lower level but we have found this level more practical.

Acrylonitrile Problems

The acrylonitrile plant also presented some major problems from the standpoint of water pollution. This product compares with benzene in volatility, is readily burned to harmless products, but contact with the liquid should be avoided because some people develop blisters either from acrylonitrile or the hydrolyses products.

Our studies at the Rockport laboratories indicated that acrylonitrile is not a suitable ingredient to add to the diet of a fish. While it hydrolyses slowly in alkaline waters to harmless products, fish object to waters containing more than 25 p.p.m. This information posed two problems. In the first place we recognized that process waters containing this and related compounds would require treatment, and secondly, since it must be assumed that process leaks or spills will occur even in a clean plant, we had to be in a position to handle even storm-sewer waters if a spill happened during a rain storm.

Steam strip . . . We studied the possibilities of chlorination of the plant stream but found that the chlorine demand might be much too high for economical application and even at low contamination levels would be hard to control. As a consequence we settled on a steam stripping system to remove the contaminants from water. Fortunately the compounds are all reasonably low boiling hence it is possible to steam strip them from water leaving a bottoms product which goes to chlorination and an uncondensed overhead product which is fed directly to the incinerator. Laboratory data indicated that the organics were burned completely to harmless products.

Special sewer system . . . The surface waters from the HCN and acrylonitrile plants are handled in a special sewer system. This water flows through a concrete sump and during normal operation, goes directly to the main sewer. If a spill occurs, a block valve on the exit is closed and a sump pump started which moves this contaminated water to the steam stripper. A hold tank is provided in case the volume of water to be treated exceeds the capacity of the stripper.

Getting rid of copper . . . The acrylonitrile process involves the use of copper which is quite toxic to fish. We also recognized that provision must be made to keep the copper ion below the minimum lethal concentration in case such waters had to be handled. Since we had previously established the minimum of lethal concentration for aluminum, we settled on a displacement system for removing metallic copper from contaminated water. In this system, any water which might contain copper is percolated through a bed of metallic aluminum. The copper deposits out and the aluminum goes into solution and as a consequence a harmless stream of water goes into the plant sewer.

Vinyl chloride operation . . . Here the major pollution problem involved the mercury salts used as catalysts in the system. Although there is not much danger that the mercuric chloride would leave the process it was deemed advisable to provide for this possibility. The vinyl chloride from the reactors is washed with water and these wash waters are sulfide treated to remove any mercury as an insoluble salt which precipitates and is readily removed. Here again we have a very effective method of removing a potentially severe water pollutant.

More incineration . . . The disposal of the high-boiling tars from this operation also involves incineration. This disposal technique has been moderately if not completely successful. These tars have some tendency to form an HCl fog when the humidity is high. The high-boiling residues from acrylonitrile and other plant operations are also handled by burning and as a consequence we have a substantial volume of combustion gases to dilute the total stream. If we have substantial quantities of chlorinated tars to process we watch wind direction and burn any excess when the wind will carry any plume out over the bay. The quantities of material are comparatively small but when the humidity is high, a small quantity of HCl can create quite a cloud.

Oxygen analyzer . . . We have installed a recording oxygen analyzer on our incinerator stack. We need not only good combustion control to assure decomposition of all organic wastes but we also want an excess of oxygen in the effluent. We need more than complete combustion and we have found that an oxygen instrument is more satisfactory as a control measurement than the more usual combustion controls.

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