Enclosure 1

Date: August 17, 1998
(Finalized November 4, 1998)

Subject: Site Visit--Devro-Teepak, Danville, Illinois
NESHAP for Miscellaneous Cellulose Manufacturing Industries
EPA Contract No. 68-D6-0012; Task Order No. 0021; ESD No. 97/06
MRI Project No. 4801-21

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I. Purpose

The purpose of the site visit to Devro-Teepak, Incorporated in Danville, Illinois, was to obtain information on: (1) the manufacturing processes used to produce cellulose food casings, (2) emissions of any hazardous air pollutants (HAP), and (3) any methods employed by the plant to prevent or reduce HAP emissions. This information will be used in developing a maximum achievable control technology (MACT) standard for the miscellaneous cellulose manufacturing industry.

II. Place and Date

Devro-Teepak, Incorporated
915 North Michigan Avenue
Danville, Illinois 61832

May 7, 1998

III. Attendees

Devro-Teepak, Incorporated (Devro-Teepak)

Ray Coon, Technician--Environmental Group
John Ramsey, Manager--Environmental, Maintenance, and Quality Control
Jack Webster, Manager--Regulatory Affairs

Illinois Environmental Protection Agency (Illinois EPA)

David Ramirez, Environmental Protection Engineer, Field Operations Section

U. S. Environmental Protection Agency (U. S. EPA)

William Schrock, Environmental Engineer

Midwest Research Institute (MRI)

Thomas Holloway, Staff Environmental Scientist
Rebecca Nicholson, Senior Environmental Engineer

IV. Discussion

A. Background

Devro-Teepak's plant in Danville, Illinois, is the company's only cellulose food casing plant in the United States and is the largest cellulose food casings plant in the world. Devro-Teepak has an additional cellulose food casings plant in Lommel, Belgium, and an edible food casings plant in Sandy Run, South Carolina. (The edible food casings plant has a different Standard Industrial Classification code than the cellulose food casing plant and is not covered under the miscellaneous cellulose MACT project.)

The Devro-Teepak plant in Danville began operations in November 1957. The plant currently has approximately 750 employees, which includes employees involved in food casings production, research and development, and accounting. This number also includes 100 employees involved in the plastics operation collocated at the plant. The employees in the plastics operation are involved in flexible food packaging, including laminating and printing. The plant is ISO 9002 certified and has attained Voluntary Protection Program (VPP) Star status from the Occupational Safety and Health Administration (OSHA).

The Devro-Teepak cellulose plant operates continuously for 24 hours per day, 365 days per year. Part of the employee rotation at the plant is straight-shift, part is rotating shift. Production at the plant has been consistent for the last several years. *Information on the approximate percent utilization of the casings extrusion machines is contained in the confidential addendum, item 1.* The plant has two casings production processes--"Wienie-Pak®" and "Flat Goods." *Information on the production capacity and percent utilization of the Wienie-Pak® and Flat Goods processes in 1997 is contained in the confidential addendum, item 2. Information on the amounts of Wienie-Pak® and Flat Goods casings sold by the Devro-Teepak plant in 1997 is contained in the confidential addendum, item 3.* Sales revenue for the plant has been down over the last few years as a result of increasing competition from foreign plants.

In addition to the Wienie-Pak® and Flat Goods process machines, the plant also has a research machine (process machine 10.5), which is located next to one of the Flat Goods process machines. The research machine is used by the plant to test out new ideas (e.g., new types of food casings). There are some carbon disulfide (CS_2) emissions from this machine. The plant also has its own oven, packing operation, and smokehouse, which allow the plant to check the quality of its food casings with various meat products.

Mr. John Ramsey, Environmental Manager, provided an overview of the food casings process. Following the overview, Devro-Teepak personnel provided a tour of the facility. The following process description includes information from the process overview, the plant tour, and Devro-Teepak's Section 114 survey response.

B. Process Description

Attachment 1 presents a flow diagram of the viscose production process at the Devro-Teepak plant. The viscose production process begins by reacting cellulose (in the form of wood pulp sheets) with sodium hydroxide (NaOH) in a steeping operation to produce alkali cellulose. The alkali cellulose is then shredded and aged. The aged alkali cellulose is fed to a batch xanthator, or baratte, where it is reacted with CS_2 to form cellulose xanthate. The cellulose xanthate is subsequently dumped into a cold dilute solution of NaOH in a batch slurrying process and fed to a batch vissolver to form the viscose. Batches from the vissolver are combined in a continuous blending process to obtain a consistent mix of viscose. Continuous filtration follows to remove any material that was not xanthated or vissolved. The viscose is then aged or "ripened" in continuous viscose ripening tanks. After ripening, any remaining fine particles of unreacted alkali cellulose are filtered out continuously, and entrained air in the viscose is removed under vacuum in a continuous deaerator.

The viscose is used in one of two casing production processes at the plant--"Wienie-Pak®" and "Flat Goods." Attachments 2 and 3 present flow diagrams for the Wienie-Pak® and Flat Goods operations, respectively.

In the Wienie-Pak® process, the viscose is extruded up through a die and onto a mandrel in a "B" tank. The viscose is coagulated and regenerated in the presence of dilute sulfuric acid (H_2SO_4) and sodium sulfate (Na_2SO_4), which neutralize the NaOH in the viscose and produce a gel-like tubing. The tubing is carried to a series of wash tanks. The initial tanks contain dilute H_2SO_4 to complete the regeneration. The remaining wash tanks use warm water to wash the CS_2 out of the casing. Glycerin and dyes are added to the casing in the final two stages. The regenerated film is then sent through drying and conditioning processes; the resulting flat stock is converted to finished product in the finishing department. The finished product is then shipped to customers.

In the Flat Goods process, hemp fiber paper is used as the substrate for the viscose. The paper is mechanically formed into a tube and moved downward to where viscose is forced into the paper fiber. The viscose and the paper tube are then coagulated and regenerated in a "B" tank in the presence of dilute H_2SO_4, ammonium sulfate (NH_4SO_4), and Na_2SO_4. Further regeneration occurs in the H_2SO_4 baths. The regenerated casing is then sent through a wash area to wash the CS_2 out of the casing. Glycerin is added to the casing in the final stage, and the casing is sent through drying and conditioning processes. The fibrous flat stock is then sent to the packaging area prior to being shipped to service centers. There are no finishing operations onsite for fibrous casings; they are all done offsite. The following sections describe the processing steps and associated equipment in more detail.

1. Raw Material Storage and Handling. Primary raw materials used in the manufacture of cellulose food casings at the Devro-Teepak plant include: cellulose (in the form of highly refined wood pulp sheets), high-purity hemp fiber paper (for fibrous casings), NaOH, CS_2, H_2SO_4, anhydrous ammonia (NH_3) (to form NH_4SO_4), and glycerin (a plasticizer). Each of these materials is shipped in and stored onsite. Bales of wood pulp (300 pounds each) are obtained from Buckeye Cellulose, which manufactures the pulp from Florida pine. The hemp fiber paper is the plant's most expensive raw material.

Carbon disulfide is the only raw material used at the Devro-Teepak plant that is considered a HAP. Liquid CS_2 is shipped to the Devro-Teepak plant by jumbo railcar once per week. The CS_2 in the railcar is unloaded from the top of the railcar using a stainless steel flex hose. A nitrogen unloading system is used to prevent gaseous CS_2 from being emitted from the railcar. This system was installed in 1997; before the nitrogen unloading system was installed, a water unloading system was used. However, because CS_2 is slightly soluble in water, part of the CS_2 that dissolved would have either generated fugitive emissions or been transferred to the wastewater treatment plant after the railcars were emptied of water. By the summer of 1998, as part of its risk management program, the plant will pave the railcar unloading area with concrete; the concrete apron will slope toward the plant's drainage system to facilitate containment of any CS_2 spills from the railcars.

The liquid CS_2 is stored onsite in two 19,000-gallon storage tanks. (Each tank is the same size as one jumbo railcar.) The tanks are submerged in water in a rectangular concrete pool. The water pool is a safety measure. If any CS_2 leaked from the tanks, it would drop to the bottom of the pool because of the higher density of the liquid CS_2 and its limited solubility in water. Each storage tank is padded with water inside. (Plant personnel stated that, because of the way the current storage tanks are designed, the tanks cannot be padded with nitrogen.) When a tank is loaded with CS_2, the water pad in the tank is displaced into the pool. The pool has a milky appearance. There is an overflow system that sends water from the pool to an onsite lagoon. Once every 3 years, the plant drops the water level in the pool in order to repaint the storage tanks (which helps to prevent corrosion of the tanks). The water level in the pool is kept full during the winter months, and the water is heated to keep it from freezing.

According to Devro-Teepak's survey response, the density of the CS_2 is 10.53 pounds per gallon. *Information on the annual throughput of the CS_2 storage tanks is contained in the confidential addendum, item 4.* Most of the components of the CS_2 storage tanks and CS_2 charging lines to the barattes are located outside; those components inside are located in a room that exhausts through Stacks B-1 and B-2 (described in the following section).

2. Production of Alkali Cellulose and Viscose. Attachment 1 presents a flow diagram of the production process for alkali cellulose and viscose at the Devro-Teepak plant. The

production of cellulose food casings begins by reacting the highly refined wood pulp sheets with a solution of 19 percent NaOH in one of five steeping presses. The cellulose sheets are manually loaded into each press and are steeped in the NaOH for a specified period of time at a set temperature. *Information on the steeping time is contained in the confidential addendum, item 5.* After steeping, the NaOH is recovered, and the alkali cellulose is dropped through a chute into a shredder. Over a specified period of time, the shredder mechanically shreds the pulp and helps to distribute the NaOH more evenly. *Information on the shredding time is contained in the confidential addendum, item 6.* After shredding, a batch of alkali cellulose is fed into an aging "can," where it is aged over a specified period of time. *Information about the size of each batch and the aging time is contained in the confidential addendum, item 7.* The aging process controls the degree of breakage of the cellulose chains to obtain a more uniform distribution of the alkali cellulose.

Once the desired cellulose chain length has been obtained through the aging process, the alkali cellulose is fed into to one of nine batch xanthators, or "barattes." A specified amount of liquid CS_2 is measured into the baratte via a mass flow meter; the CS_2 is measured to within 0.1 pounds. *Information on the amount of CS2 measured into the baratte is contained in the confidential addendum, item 8.* The CS_2 is charged into the baratte under vacuum; as a safety measure, the CS_2 is not charged unless there is sufficient vacuum and no leaks are verified. Each baratte is also enclosed with drop curtains. The baratte slowly rotates to mix the alkali cellulose and CS_2. The CS_2 reacts with the alkali cellulose to form a dissolvable cellulose derivative, referred to as sodium cellulose xanthate. (Reaction of the CS_2 allows the material to dissolve in cold dilute NaOH, added later in the batch slurrying process.) The xanthation process is computer-controlled and is timed to last a specified period of time. *Information on the xanthation time is contained in the confidential addendum, item 9.* During the xanthation process, the temperature, pressure, and length of the cycle are monitored.

At the end of the cycle, when most of the CS_2 has been reacted, the pressure drops. The baratte is placed under vacuum for 5 minutes and is then purged with air for 6 minutes to remove as much unreacted CS_2 vapors as possible before dumping the batch. There are two Nash vacuum pumps for this purpose. The levels of CS_2 are highest at the beginning of the evacuation and drop off as the evacuation and purge progress. These two steps (evacuation and purge) are taken to remove the potentially explosive CS_2 concentration in the baratte at the completion of the reaction and to reduce operator exposure during the baratte unloading and charging to the slurry tanks. (Regulations from OSHA require the plant to keep worker exposure to CS_2 below 20 parts per million [ppm]. This exposure level is in the process of being significantly reduced by OSHA.) The emissions from the Nash vacuum pumps are manifolded together and discharged into the exhaust line going to Stack S-3. One of the two baratte sill vent fans (B-1 or B-2) continuously picks up fugitive emissions after each baratte is dumped; the fans for the baratte sill vents usually operate one at a time. The sill vent exhaust also contains the entire baratte room exhaust. The sill vent exhaust gases go directly to atmosphere.

Following the xanthation process, a batch of cellulose xanthate from the baratte is dumped into a slurry tank; each baratte has its own slurry tank. In the slurry tank, the cellulose xanthate is slowly mixed with a cold solution of dilute NaOH. Two batches from the batch slurrying process are then combined and mixed in a batch vissolver for a specified period of time to form the viscose. *Information on the vissolving time is contained in the confidential addendum, item 10.* Following the vissolver, 10 slurry batches are combined and fed to a blending tank for continuous blending. The continuous blending helps to ensure a consistent mix of viscose. Exhaust gases from the slurry tanks, vissolvers, and blending tanks are manifolded together and vented through Stack S-3. Some unreacted CS_2 from the xanthation reaction is exhausted at the slurry tanks, and the levels of CS_2 increase as the cellulose xanthate is dumped into the slurry tanks. By the time the cellulose xanthate reaches the vissolver, there is little CS_2 being emitted because most of the CS_2 has reacted and bonded to the cellulose.

The viscose from the blending tanks is then continuously filtered (down to 25 microns) using Brunswick filters. The continuous filtration is performed to remove any material that was not xanthated or dissolved. The viscose is then aged or “ripened” in continuous viscose ripening tanks. The ripening tanks are filled and emptied in sequence. After ripening, there is an opportunity for CS_2 emissions when the ripening tanks are vented after the viscose is discharged. Entrained air in the viscose discharged from the ripening tanks is removed under vacuum in one of three continuous deaerators. Some water in the viscose is also removed (as vapor). Finally, any remaining fine particles of unreacted alkali cellulose are continuously filtered out (down to 20 microns). The filters used are fully enclosed and under high pressure. Once the viscose has been ripened, deaerated, and filtered, it is ready for the extrusion process.

3. Wienie-Pak® Process. Attachment 2 presents a flow diagram of the Wienie-Pak® process at the Devro-Teepak plant. In the Wienie-Pak® process, the ripened viscose is metered to one of seven extrusion machines. Each Wienie-Pak® machine is a collection of individually extruded lines. *Information on the number of lines in each machine is contained in the confidential addendum, item 11.* In each line, the viscose is extruded up through a die and onto a mandrel in a “B” tank. There is one “B” tank for each line. The viscose is coagulated and regenerated in the presence of dilute H_2SO_4 and Na_2SO_4, which neutralize the NaOH in the viscose and produce a gel-like tubing. The tubing is carried to a series of wash tanks. The initial tanks contain dilute H_2SO_4 to complete the regeneration. The remaining wash tanks use warm water to wash the CS_2 out of the casing. The wash water runs countercurrent to the casings in the wash area; the water is warmest at the end of the line. Spent acid streams from the regeneration and washing processes are sent to acid recovery to be recycled. Any casing waste from the processes is sent to a landfill.

During the regeneration process, the acid in the baths reacts with the xanthate, causing the cellulose to regenerate and causing hydrogen sulfide (H_2S) and CS_2 gases to evolve. Regeneration starts on both sides of the casing (inside and outside) and proceeds to the center of the casing. At the beginning of the regeneration process (up to the third tank), both H_2S and CS_2 evolve. Later in the process, only CS_2 evolves. In order to release excess liquid or gas that builds up inside the casings and to maintain the size of the casing, operators will periodically cut a slit in the continuous tube of casing.

The extrusion machines are enclosed in furan “cabs” to prevent the evolved CS_2 and H_2S gases from entering the general work area, thereby maintaining low CS_2 exposure levels for the operators (in accordance with OSHA regulations). The older machines (process machines 1 through 6) have multiple tanks per cab, while the newest machine (process machine 7-A) has a separate cab for each tank. At times, it is necessary for an operator to enter an extrusion machine to adjust a casing, repair a line break, etc. Each of the cabs is color-coded to indicate whether a supplied air respirator is required. If a cab has yellow doors, the concentration of CS_2 inside the cab requires that a respirator be used. If there is no yellow door, the operator may enter without a respirator.

Each extrusion machine has its own ventilation system and its own H_2S scrubber, to which the exhaust gas from each machine is vented. Fresh air is pulled into each extrusion machine and into the wash areas. Because most of the H_2S has evolved by the third tank, the exhaust gases from the first three tanks are vented to the H_2S scrubber prior to going to the stack; the exhaust gases from the remaining tanks go straight to the stack. In general, three extrusion machines are connected to a single stack. Stack S-2 vents the emissions from process machines 1 through 3, while Stack S-1 vents the emissions from process machines 4 through 6. Stack S-4 vents the emissions from process machine 7-A, as well as unscrubbed emissions from the Flat Goods process machines (described in the following section).

In the final two stages after washing, plasticizer (glycerin) and dyes are added to the casing. The plasticizer is added to make the casing more supple. The regenerated film is then sent through drying and conditioning processes, where it emerges as flat stock; prior to drying, the casing is composed of 20 percent cellulose, 60 percent water, and 20 percent glycerin. Any casing waste from the drying and conditioning processes is sent to a landfill. The flat stock from the drying and conditioning processes is converted to finished product in the finishing department. The finished product is then shipped to customers.

4. Flat Goods Process. Attachment 3 presents a flow diagram of the Flat Goods process at the Devro-Teepak plant. In the Flat Goods process, the ripened viscose is metered to one of three extrusion machines--process machines 9 and 10, which produce the fibrous casings, and process machine 8, which produces the Deli-Pak® casings. Fibrous casings are produced using high-purity hemp fiber paper as the substrate for the viscose. No paper is used to produce the Deli-Pak® casings. The Deli-Pak® casings are similar to Wienie-Pak® casings, except that the diameter of the Deli-Pak® casings is larger. The methods used to produce the Deli-Pak® and Wienie-Pak® casings are also similar. For both Deli-Pak® and Wienie-Pak® casings, the viscose is extruded up at the start of the process. Because the diameter of the Deli-Pak® casings is larger, more gases evolve inside the casings during regeneration, resulting in a larger "slug" of gas and liquid that requires operators to exercise greater care when slitting the casings. See the discussion of the Wienie-Pak® process in the previous section for further information about the method used to produce Deli-Pak® casings. The method used to produce fibrous casings is discussed below.

At the start of the Flat Goods (fibrous) process, the hemp paper is unwound from rolls. The paper is then mechanically moved downward and formed into a tube. Viscose is metered out and forced into the paper fiber. The viscose is applied to both the inside and outside of the paper tube. Pigments may also be applied to the paper tube at this point. The viscose and the paper tube are then coagulated and regenerated in a "B" tank in the presence of dilute H_2SO_4, NH_4SO_4, and Na_2SO_4. Additional acid contact occurs in the initial wash tanks. The acid/salt solution (H_2SO_4, NH_4SO_4, and Na_2SO_4) used in coagulation for the Flat Goods (fibrous) process is different from the acid/salt solution (H_2SO_4 and Na_2SO_4) used in coagulation for the Wienie-Pak® process. The two processes also differ in the number of lines per "B" tank. In the Wienie-Pak® process, there is one "B" tank per line, while in the Flat Goods (fibrous) process, there are a number of lines that go into each "B" tank. Following regeneration, the fibrous casing is sent through a wash area to wash the CS_2 out of the casing. Any casing waste from the regeneration and washing processes is sent to a landfill.

As in the Wienie-Pak® process, the Flat Goods extrusion machines are enclosed in furan cabs to prevent the evolved CS_2 and H_2S gases from entering the general work area, thereby maintaining low CS_2 exposure levels for the operators (in accordance with OSHA regulations). Each extrusion machine has its own ventilation system and its own H_2S scrubber, to which the exhaust gas from each machine is vented. Fresh air is pulled into each extrusion machine and into the wash areas. As with the Wienie-Pak® process, most of the H_2S from the Flat Goods process has evolved by the third tank; consequently, the exhaust gases from the first three tanks are vented to the H_2S scrubber prior to going to the stack; the exhaust gases from the remaining tanks go straight to the stack. Stack S-4 vents the unscrubbed emissions from process machines 8 through 10, as well as the emissions from the Wienie-Pak® process machine 7-A. Stack S-3 vents the scrubbed emissions from process machines 8 through 10, as well as the emissions from the research machine (process machine 10.5), the viscose process, and the acid systems.

In the final wash stages, a plasticizer (glycerin) is added to the fibrous casing to make it more supple, and the casing is sent through dryers, where it emerges as flat stock. Any casing waste from the dryers is sent to a landfill. The fibrous flat stock from the dryers is sent to the packaging area prior to being shipped to service centers. There are no finishing operations onsite for fibrous casings; they are all done offsite.

C. Acid Recovery

Attachment 4 presents a flow diagram of the acid systems at the Devro-Teepak plant. Spent acid streams (H_2SO_4) from the extrusion/regeneration process are recovered in the plant's acid systems. As shown in the diagram, the spent acid is first sent to a basement acid system, where it is combined with acid from storage, as well as an acid/salt solution from acid recovery. The Wienie-Pak® and Flat Goods processes each have their own separate basement system. For Flat Goods operations only, anhydrous ammonia is also added to the basement system. The process acid tanks in the basement system contain dissolved CS_2 and H_2S; consequently, CS_2 and H_2S are present in the exhaust from this system. The ventilation system that exhausts the process acid tanks is divided into an east and west exhaust system. The ventilation system is designed to control worker exposure in the area. Emissions from the basement system are vented to a chemical H_2S scrubber, prior to being discharged to the atmosphere through Stack S-3.

A solution of acid, salt, and water from the basement system is sent to the acid recovery system. The Wienie-Pak® and Flat Goods processes each have their own separate acid recovery system. The acid recovery system uses an evaporator to remove water from the system and increase the acid/salt concentration. The condensed steam and vapor from the evaporator is sent to one of two cooling towers. Any residual CS_2 or H_2S in the acid/salt solution would be exhausted through the tower. The remainder of the acid/salt solution is sent back to the acid recovery system or to a batch crystallizer to recover the salt. The recovered Na_2SO_4 salt is sent to the anhydrous department to be dried; the anhydrous salt is then sold. Although there are separate acid recovery systems (evaporators, crystallizers) for the Wienie-Pak® and Flat Goods processes, there is only one anhydrous department for the entire plant. Emissions from the anhydrous department (i.e., particulate matter) are controlled through particulate wet scrubbers. Acid/salt solution from the acid recovery system is sent back to the basement system to feed back to the extrusion/regeneration process. Liquid waste streams from acid recovery, basement systems, and the anhydrous department are sent to the plant's wastewater lagoon system. Air emissions from these areas are sent through the chemical H_2S scrubber and exhausted through Stack S-3.

D. Wastewater Treatment

Attachment 5 presents a flow diagram of the wastewater lagoon system at the Devro-Teepak plant. Separate waste streams from viscose production, extrusion/regeneration, and the acid systems (acid recovery, basement systems, anhydrous department) are collected at the plant's mixing basin. Either NaOH or H_2SO_4 is added at that point to neutralize the combined waste stream. The neutralized waste stream is then sent to two lagoons onsite at the plant. The overflow system for the CS_2 storage tank pit also feeds into the lagoon system. The wastewater is directed through the two lagoons in series--first to the North Lagoon, then to the South Lagoon. The lagoons are essentially large settling basins, with dimensions of 100 feet by 200 feet by 12 or 14 feet. Wastewater treatment at the Devro-Teepak plant consists primarily of pH adjustment. The pH of the wastewater is measured prior to the North Lagoon. As required in the plant's permit, the pH is adjusted to between 6.5 and 11.0 before it is sent for offsite treatment at a local publicly owned treatment works (POTW).

Typically about 700,000 to 800,000 gallons per day of wastewater are pretreated at the Devro-Teepak plant. In its survey response, Devro-Teepak estimated that the annual wastewater flow rate for 1997 at the plant was 276 million gallons per year. On a monthly basis, the plant measures the CS_2 concentration in the wastewater at the outlet to the lagoon system; the outlet CS_2 concentration is typically 15 ppm. Every 3 months, the plant also measures the CS_2 concentration in the wastewater at the inlet to the lagoon system; the inlet CS_2 concentration typically ranges from 30 to 35 ppm. In its survey response, Devro-Teepak estimated that 78,948 pounds of CS_2 were present in the wastewater at the plant during 1997. The process stream containing wastewater from the extrusion and basement acids area is the primary source of the dissolved CS_2 and is the highest volume flow.

Two exhaust stacks (LA-1 and LA-2) have been installed at the onsite lagoons. One stack, LA-1, reduces operator exposure to emissions at the mixing basin prior to the lagoons by collecting and discharging fugitive emissions found there. For the same reason, a small vent stack, LA-2, was also added at the discharge basin, where flow totalization and discharge sampling occurs following the lagoons. The discharge basin feeds into the line to the local POTW. In its survey response, Devro-Teepak estimated that, for 1997, CS_2 emissions from the LA-1 and LA-2 stacks were 13,200 and 2,015 pounds per year, respectively. The CS_2 concentrations in the LA-1 and LA-2 stacks were estimated to be 24 ppm and 12 ppm, respectively. A significant source of CS_2 emissions from these stacks was eliminated when the nitrogen unloading system for the CS_2 storage tanks was installed; the new unloading system eliminated the practice of sending CS_2-saturated water to the wastewater treatment plant after each time the CS_2 railcars were emptied.

E. Emissions

Carbon disulfide is the only HAP that is reported as being emitted from the Devro-Teepak plant. A non-HAP, H_2S, also is emitted along with the CS_2. The following sections describe the emission points and emission estimates for the Devro-Teepak plant.

1. Emission Points. Attachments 1 through 4 show the emission points from the viscose production, extrusion/regeneration processes, and acid systems. Exhaust gases from the baratte sill vent go directly to atmosphere at Stacks B-1 and B-2. The fans for the baratte sill vents usually operate one at a time. According to Devro-Teepak's survey response, the fan for sill vent B-1 handles an average air flow of 19,270 actual cubic feet per minute (acfm) and an average CS_2 concentration of 17 ppm; the fan for sill vent B-2 handles an average air flow of 24,000 acfm and an average CS_2 concentration of 14 ppm.

The exhaust gases from the ripening tanks also go directly to atmosphere. According to Devro-Teepak's survey response, the average air flow off the ripening tanks is 180 acfm; the average CS_2 concentration is 24 ppm.

Exhaust gases from the Nash vacuum pumps off the baratte are manifolded together and discharged into the exhaust line going to Stack S-3. Exhaust gases from the slurry tanks, vissolvers, and blending tanks are also manifolded together and vented through Stack S-3. According to Devro-Teepak's survey response, the average air flow from the Nash vacuum pumps to Stack S-3 is 7,300 acfm, and the average CS_2 concentration is 470 ppm; the average air flow from the slurry tanks, vissolvers, and blending tanks to Stack S-3 is 7,000 acfm, and the average CS_2 concentration is 30 ppm.

Prior to going to Stack S-3, the exhaust gases from the Nash vacuum pumps, slurry tanks, vissolvers, and blending tanks are combined with exhaust gases from the acid system (basement system and acid recovery) and sent through the chemical H_2S scrubber. The average air flow from the chemical H_2S scrubber to Stack S-3 is 19,900 acfm, and the average CS_2 concentration is 130 ppm.

As stated above in sections IV.B.3 and IV.B.4, each extrusion machine has its own ventilation system and its own H_2S scrubber, to which the exhaust gas from each machine is vented. Fresh air, with a gas flow of 20,000 acfm, is pulled into each extrusion machine and into the wash areas. Because most of the H_2S has evolved by the third tank, the exhaust gases from those tanks are vented to the H_2S scrubber prior to going to the stack; the exhaust gases from the remaining tanks go straight to the stack. In general, three extrusion machines are connected to a single stack. As noted above in sections IV.B.3 and IV.B.4, Stack S-1 vents the emissions from process machines 4 through 6, while Stack S-2 vents the emissions from process machines 1 through 3. Stack S-3 vents the scrubbed emissions from process machines 8 through 10, as well as the emissions from the research machine (process machine 10.5), the viscose process, and the acid systems. Stack S-4 vents the emissions from process machine 7-A and the unscrubbed emissions from process machines 8 through 10.

Each stack has dual fans (eight fans--four operating at any one time). The fans are alternated on a monthly basis to ensure proper operation in case of a fan failure. Each fan is sized to provide a gas flow of approximately 100,000 acfm, for a total gas flow rate of approximately 400,000 acfm from the stacks. According to Devro-Teepak's survey response, the average gas flow rate to each of the stacks is somewhat less than 100,000 acfm. The average gas flow rates to Stacks S-1, S-2, S-3, and S-4 were reported to be 79,540 acfm, 85,480 acfm, 92,500 acfm, and 80,480 acfm, respectively.

All four stacks are monitored for CS_2 and H_2S. The H_2S is measured continuously in each of the stacks using an electromechanical sensor in a Model 5300 MSA analyzer. The H_2S is also measured, along with CS_2, once every 15 minutes (100 times per 24 hours) in each of the stacks using a HNU Model No. 501 gas chromatograph equipped with a photoionization detector. In Devro-Teepak's survey response, the average CS_2 concentrations for Stacks S-1, S-2, S-3, and S-4 were reported to be 103 ppm, 118 ppm, 92 ppm, and 83.6 ppm, respectively.

2. <u>Emission Estimates</u>. Attachment 6 presents the CS_2 and H_2S emission estimates provided in Devro-Teepak's survey response for each stack or process vent. According to Devro-Teepak's survey response, CS_2 emissions from the plant for 1997 were estimated to be approximately 1,903 tons; H_2S emissions were estimated to be approximately 36 tons. The methods used to estimate CS_2 emissions from each of the emission points at the plant are presented below, based on information in Devro-Teepak's survey response.

The CS_2 emissions from viscose production were mostly estimated using CS_2 emission factors related to the number of batches produced at the plant. Emissions from the baratte sill vents, emissions from the Nash vacuum pumps, and manifolded emissions from the slurry tanks, vissolvers, and blend tanks were estimated using specified emission factors (based on the number of batches produced at the plant). *The CS_2 emission factors used are contained in the confidential addendum, item 12.* Emissions from the ripening tanks were estimated using an emission factor of 0.008 pound of CS_2 per tank vent. (The CS_2 emission rate from ripening tanks is dependent on the number of tanks vented per day rather than the number of batches produced at the plant.) All of these emission factors were developed based on the results of a 1995 stack test at the Devro-Teepak plant.

The CS_2 emissions from the Wienie-Pak® and Flat Goods processes were estimated using a CS_2 emission factor based on casing production plus information on the amount of CS_2 charged per batch. The emission factor was developed and revised using data from 1990 and 1991. *The*

CS_2 emission factor for the Wienie-Pak® and Flat Goods processes is contained in the confidential addendum, item 13. The emission factor has been determined by the plant to be within engineering accuracy and, according to the plant, works well. *Information on the amount of CS_2 charged per batch by the plant is contained in the confidential addendum, item 14.* The H_2S emissions from the Wienie-Pak® and Flat Goods processes were estimated using a specified emission factor that is based on a plant material balance. *The H_2S emission factor for the Wienie-Pak® and Flat Goods processes is contained in the confidential addendum, item 15.*

The CS_2 emissions from the acid system at the plant were estimated based on a CS_2 concentration of 200 ppm. This CS_2 concentration is the average concentration from the head space in the trunk line that includes emissions from the basement acid system, acid recovery, fibrous Nash vacuum pump trunk line, and baratte Nash vacuum pump. The H_2S emissions were estimated based on an average H_2S concentration of 140 ppm from the head space in the trunk line.

The CS_2 and H_2S emissions from the LA-1 and LA-2 stacks were estimated based on average CS_2 and H_2S concentrations of 12 ppm and 3 ppm, respectively, measured in a 1995 stack test.

F. Emission Reductions

The following sections discuss the emission controls and process changes employed by the Devro-Teepak plant to reduce emissions.

1. Emission Controls. Attachment 7 presents a diagram of the H_2S scrubber system at the Devro-Teepak plant. As stated above, there is one H_2S scrubber for each extrusion machine, as well as one chemical H_2S scrubber for the chemical systems (i.e., viscose processes and acid systems), for a total of 11 H_2S scrubbers at the Devro-Teepak plant. Each H_2S scrubber has its own associated fan. The H_2S scrubbers are NaOH scrubbers with cross-flow packing. A Provox control computer continuously monitors the differential pressure over each scrubber, the pressure in the main pumping line, and the pH of the continuously circulating scrubber liquid. An alarm sounds if there is a problem. Alkaline sodium sulfide (Na_2S) solution is removed from the system and replaced with NaOH solution on an as-needed basis.

According to Devro-Teepak's survey response, the H_2S control efficiencies for the H_2S scrubbers have been found to range from 93.6 to 96.7 percent. Detector tube samples for H_2S are used on each inlet and outline line to determine the efficiency. On average, the H_2S emission reduction for Stacks S-1 and S-3 is 95 percent; the average H_2S reduction for Stacks S-2 and S-4 is 96.5 percent. The H_2S scrubbers are currently not believed to reduce CS_2 emissions. (However, there is a small amount of data which appears to indicate otherwise; further study is needed to verify and, if true, quantify any CS_2 emission reduction.) Scrubber pressure drops for the H_2S scrubbers have been found to range from 28 to 34 inches of water.

As noted in its survey response, the Devro-Teepak plant has also explored other types of emission controls. Devro-Teepak became aware of the possibility of biotechnology as a pollution control around 1992, the time of the Argonne National Laboratory report on CS_2 removal and recovery, which was co-funded by Devro-Teepak. Devro-Teepak joined with Argonne in a further analysis of potential pollution controls. In the resulting 1995 publication, "Biotechnology for Removal of CS_2 Emissions: Final Report," it was suggested that 104 biofilter units double-stacked on an acre of land could turn Devro-Teepak's daily CS_2 and H_2S emissions into 3 percent H_2SO_4. (Devro-Teepak has run a biofilter pilot unit, the remnants of which are still onsite.) The Devro-Teepak plant cannot use the 3 percent acid by-product from the biofilter. The reuse of any acid below 93 percent would require increased evaporation capacity. The plant also cannot neutralize the acid in the sewer; there are limits from the POTW on the level of sulfates that can be discharged into the sewer. Since the plant would not be able to use the acid, send it to the POTW, or neutralize it and send it to the POTW, an additional treatment step would be required.

Using an Aspen Plus simulation package, Argonne estimated that biofiltration, limestone neutralization, and landfilling might be accomplished at a cost of $8.7 million. However, Devro-Teepak does not believe that it can afford this type of experimentation at a time of increasing foreign competition. The company thinks that this type of pollution control technology would be excessive, and the costs associated with implementing it would be unnecessary. It believes that these implementation costs would put the company at an even greater disadvantage economically. Also, it does not consider biofiltration to be a proven technology, pointing to the operational difficulties of a biofiltration unit installed at a sponge manufacturing plant in Ohio.

2. Process Changes. As stated in its survey response, Devro-Teepak has implemented several process changes that resulted in reduced CS_2 emissions from the plant. In 1997, a bulk nitrogen system was installed at the plant to allow the switch from water unloading to nitrogen unloading of CS_2 railcars. Because CS_2 is slightly soluble in water, part of the amount that dissolved would have either generated fugitive air emissions or remained in the water and been transferred to the POTW after the railcars were emptied of water. This reduction is proportional to the total amount of CS_2 used annually. The capital cost associated with changing from water unloading to nitrogen unloading was $245,000. Operating costs for the tank lease and cost of the nitrogen used are less than $5,000 per year.

In 1991, Devro-Teepak implemented a project in its Flat Goods operations that reduced the amount of viscose added to the inside and outside of the fibrous paper. *Information on the percent viscose reduction is contained in the confidential addendum, item 16.* The rest of the process remained essentially the same. With less viscose being used per unit length of fibrous casing, there was less CS_2 being emitted as it was regenerated. This result was a proportional reduction in CS_2 emissions per unit length of fibrous product.

In 1996, Devro-Teepak implemented a process change that reduced the amount of CS_2 xanthated in the barattes, resulting in a CS_2 emission reduction in the three processes it influenced, i.e., viscose production, Wienie-Pak® operations, and Flat Goods operations. *Information on the percent CS_2 reduction in the barattes and in the three associated processes is contained in the confidential addendum, item 17.* This reduction would also be quantified in reduced CS_2 emissions per unit length of product. However, these emission reductions were completely offset by an increase in emissions resulting from an increase in extrusion machine speed during that time, which increased production.

In 1997, Devro-Teepak began implementing a project to stretch its Wienie-Pak® casings. Devro-Teepak has applied for a patent for this process and still has not fully implemented it. After the casing has been extruded and before it enters the dryer, the casing is stretched, primarily longitudinally. This orients the film and provides different properties in the final product vis-à-vis unstretched material. When stretched longitudinally, it also yields more meters of casing per amount of viscose extruded. Devro-Teepak is still in the process of implementing the project. *Information on the initial and current percent reduction in* CS_2 *usage resulting from implementation of the project is contained in the confidential addendum, item 18.* This reduction can best be expressed in reduced CS_2 emissions per unit length of final product. There have been some operational problems in the dryers, but overall the process seems to work.

G. Emission Standards

Emissions from the Devro-Teepak plant are limited by the plant's State operating permit. In the operating permit issued in May 1997, plant process emissions of CS_2 are not allowed to exceed 6.0 tons per day and 1,911 tons per year (tons/yr). Plant process emissions of H_2S are not allowed to exceed 15 pounds per hour and 66 tons/yr. Process machine 7-A is covered under an initial prevention of significant deterioration (PSD) construction permit and a recent PSD increase construction permit and has its own specific emission limitation. Emissions of CS_2 from process machine 7-A are not allowed to exceed 68 pounds per hour, 1,632 pounds per day, 25.3 tons per month, and 289 tons/yr. Emissions of H_2S from process machine 7-A are not allowed to exceed 1.4 pounds per hour. Under its permit, the plant is also required to maintain and operate the H_2S monitors on the four stacks and perform periodic measurements to verify that the H_2S scrubbers are being operated properly.

In December 1995, a permit was granted to Devro-Teepak to allow it to construct another new machine (process machine 7-B), which would have the potential to emit 68 pounds of CS_2 per hour and 289 tons of CS_2 per year. Devro-Teepak has recently decided not to construct the new machine and will instead ask the State to allow the plant to switch the approved CS_2 emissions (i.e., 68 pounds per hour and 289 tons/yr) from the new construction back to existing machines (i.e., process machines 8 through 10). This construction permit was issued on August 19, 1998.

The Devro-Teepak plant is also required to comply with OSHA standards regarding workplace exposure to CS_2. The plant is currently subject to an OSHA standard of 20 ppm for CS_2; OSHA had previously tightened the standard to 4 ppm before this standard was repealed. However, the plant still meets the 4 ppm level. The ventilation system at the plant is designed with the goal of lowering worker exposure to CS_2. Consequently, the plant produces large volumes of process and building exhaust air to dilute emissions from the more concentrated CS_2 emission points. The plant did not need to make any major changes to its ventilation system when the OSHA standard changed to 4 ppm. However, the plant would have trouble complying with a new OSHA standard much below that level.

To reduce worker exposure to CS_2 in the baratte room, each baratte is enclosed with drop curtains. At the end of each baratte cycle, the baratte is also evacuated and purged with air to remove as much unreacted CS_2 vapors as possible before dumping the batch. Baratte sill vents also continuously pick up fugitive emissions after each baratte is dumped. To reduce worker exposure to CS_2 in the casing production area, the regeneration and washing areas are totally enclosed in vertical cabs, and fresh air is pulled into each extrusion machine and into the wash areas.

The CS_2 storage tanks and CS_2 charging lines to the barattes are not subject to any Federal, State, or voluntary leak detection and repair programs. Most of the components of these systems are located outside; those components inside are located in a room that exhausts through Stacks B-1 and B-2.

7 Attachments

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Attachment 6

1997 CS_2 and H_2S Emission Estimates

Emission point	Emissions, pounds per year (1997)	
	CS_2	H_2S
Stack S-1 ▸ Wienie-Pak® process machines 4-6	919,800	15,593
Stack S-2 ▸ Wienie-Pak® process machines 1-3	1,144,056	14,279
Stack S-3 ▸ Flat Goods process machines 8-10 (scrubbed) ▸ Baratte Nash vacuum pumps (viscose production) ▸ Slurry tanks, vissolvers, blending tanks (viscose production) ▸ Acid systems (basement systems, acid recovery) ▸ Research machine 10.5	962,724	21,988
Stack S-4 ▸ Wienie-Pak® process machine 7-A ▸ Flat Goods process machines 8-10 (unscrubbed)	755,988	16,732
Ripening (viscose production)	39	--
Baratte sill vent B-1 (viscose production)	3,758	--
Baratte sill vent B-2 (viscose production)	3,758	--
Stack LA-1 (mixing basin)	13,200	3,600
Stack LA-2 (discharge basin)	2,015	260
Total emissions	3,805,338 pounds per year = 1,903 tons per year	72,452 pounds per year = 36 tons per year

NOTE: The total does not include fugitive CS_2 emissions from CS_2 unloading, storage, and transfer, which were not estimated by the plant.