NWT

AIR POLLUTION ABATEMENT

IN

PLASTIC OPERATIONS

#234

by

Dr. Joseph A. Brink, Jr.
Manager, Development & Technology
and
Colin N. Dougald
Senior Development Engineer
Brink Systems
Monsanto Enviro-Chem Systems, Inc.
St. Louis, Missouri

4-3667

Prepared for
Society of Plastic Engineers
Vinyl Division
Georgia Institute of Technology
Atlanta, Georgia

February 11, 1971

DSW 587862

STLCOPCB4093198

Vinyl polymers in general, and polyvinyl chloride in particular, have gained widespread market acceptance as versatile and economical materials for a wide variety of products. Processes to produce the finished vinyl products are equally as varied and are being modified and improved continually to meet the varied demands placed on the industry. Similarly, raw materials and formulations are constantly altered and improved.

With the current national concern for environmental preservation comes another challenge to be met. Basic vinyl processing operations have in common one characteristic: heat. High temperatures are required to polymerize plastisol and/or work the plasticized polymer. Accompanying these high processing temperatures is the evolution of plasticizer mists and vapors into the atmosphere.

There are several approaches to controlling the air pollution problems associated with plasticizer organic vapors in the exhaust gases from the various manufacturing processes. One approach is to revise raw materials or the basic process such that the pollutant concentrations are diminished. This approach is the logical first to try, but rarely is completely effective in solving the problems.

STLCOPCB4093199

Another approach is incineration by heating the gases to high temperatures, often in excess of 1500°F., and burning the organics to carbon dioxide and water. This approach often is technically feasible if the plasticizers are hydrocarbons. However, the plasticizers may also contain phosphorus, sulfur, chlorine, nitrogen, etc., in which cases the products of combustion can be much more obnoxious than the original organics. Also, in the interest of safety, new organic fluids are now being manufactured and used which are designed chemically not to burn or explode. Obviously, the incineration of such fire-resistant chemicals is not a sound technical approach.

In addition to technical considerations, incineration has economic disadvantages. The energy requirements for heating exhaust gases to high temperatures can be extremely high. This cost can be reduced if heat recovery equipment such as waste heat boilers are installed; however, heat recovery equipment is expensive and often generates steam in excessive quantities. Additionally, as the cost of energy in the United States escalates, as is predicted for the future decade, operating costs for incineration can be expected to similarly climb.

On some exhaust gases, energy reequirements can be reduced

STLCOPCB4093200

somewhat with catalytic oxidation, but with catalyst present, traces of particulates in the gases may poison the catalyst and prevent effective conversion of hydrocarbons to carbon dioxide and water. Also, the technical questions as to the products of catalytic oxidations must be answered. Are the products of catalytic oxidation more obnoxious than the original organics?

DSW 587865

STLCOPCB4093201

FIBER MIST ELIMINATORS

For several years we have been studying a new systems approach to the recovery of plasticizers. Brink® fiber bed mist eliminators have been functioning to separate with high efficiencies mist from process and effluent gas streams for many years in sulfuric acid, phosphoric acid, chlorine, nitric acid, sulphonic acid and many other process situations. (1,2,3,4). In recent years, applications in other fields affected by the national interest in air pollution are emerging. One such field is the plastics processing field.

Simply stated, a Brink® Mist Eliminator is a fiber bed into which mist laden gases enter, and out of which emerges a clean gas stream and a separated liquid stream. Fiber orientation in the bed is engineered to provide, where required, extremely high separation efficiencies.

Figure 1 shows schematically a Brink® mist eliminator fiber bed. As is indicated, the bed consists of specially oriented fibers, vertically suspended, and enclosed in wire mesh screens. Mist-laden gases enter from the side of the bed and pass in a horizontal direction through the bed. Clean gases emerge from the bed and rise to exit from the mist eliminator. Separated liquids are directed downward and toward the outer screen,

STLCOPCB4093202

and ultimatedly drain down the outer edge of the bed (1). Separated liquids will, as the individual process situation requires, carry any dissolved solids through the bed.

Figure 2 shows a typical Brink® mist eliminator installation. Basic components of this system are the Brink element and the tank. The element consists of two concentrically oriented cylindrical screens containing packed fibers in the annular area (1). The screens are connected to a flange at the top of the element, and the flange in turn is bolted to the tank tube sheet. Mist-laden gases commonly enter the tank at the base and pass through the bed toward the element core. Separated liquids drain downward through the bed, through the drain leg, and are collected at the base of the tank. Clean gases exit at the top of the tank.

The three basic mechanisms for mist separation can best be described by considering the following. Consider a gas stream containing mist particles moving towards a fiber which is perpendicular to the direction of flow. As is depicted in Figure 3, the gas streamlines around the fiber. The momentum of larger particles, greater than about 1 micron, makes them deviate from the gas streamline and head

STLCOPCB4093203

for the fiber. The larger particles are thus separated through the principal of inertial impaction.

Smaller particles, generally smaller than one micron in diameter, tend to follow the gas streamline around obstacles. However, as is shown in Figure 3, they show considerable Brownian movement and thus diffuse from the gas to the surface of the fiber. A particle having a 0.1 micron diameter will have approximately five times the Brownian displacement of a 1.0 micron particle and about 15 times the Brownian displacement of a 5.0 micron particle. Through proper fiber bed design, submicron particles can thus be effectively collected. With Brownian movement, the collection efficiency increases as the particle size decreases because the Brownian displacement actually increases with smaller particle size (5).

Particles may be collected also by direct interception. The particle may follow a gas streamline and be collected without inertial impaction or Brownian diffusion if the streamline is relatively close to the fiber. Consider a particle with a diameter of 1 micron. If it follows a gas streamline which passes within 0.5 microns of the fiber, the particle will touch the fiber and be collected.

STLCOPCB4093204

The three mechanisms previously discussed make Brink® mist eliminators highly efficient mechanical type liquid entrainment separators. While their primary purpose is to remove low micron and submicron liquid particles, they will also handle large particles at higher efficiencies. They can also handle either large quantities of soluble solids or small quantities of insoluble solids providing the particles are very small and there is sufficient liquid in the gas stream to flush the solids through the fiber beds. Small quantities of very large particles can be handled by collection on the surface of the bed.

Essentially 100% collection efficiencies are achieved with Brink® mist eliminators for those particles larger than 3 microns and, depending on design, up to 99.98% for those particles which are 3 microns and smaller in size. Most actual installations are designed for 94 to 99% collection efficiency on mist particles smaller than 3 microns in size since higher efficiencies cost more and cannot be justified except in rare cases (3).

An interesting feature of the Brink fiber bed systems is that, with submicron particles, the collection efficiencies are actually increased slightly as the gas flow rate through the bed is reduced. This results because at reduced flow

STLCOPCB4093205

rates there is a greater residence time in the bed and thus greater exposure time to the fibers (1). Probability of contact of the particles with the individual fibers through Brownian Movement is thus increased. This is in direct contrast with the typical high energy type collection where efficiencies fall off sharply at reduced rates.

STLCOPCB4093206

NEW RECOVERY SYSTEMS

In order for the Brink® mist eliminator to separate pollutants, the pollutants must be in the liquid phase as they pass through the fiber bed. In many cases, this is accomplished with no external cooling. In others, an inexpensive water spray in the exhaust ducting or a water cooled heat exchanger is necessary to provide cooling. Generally, gas inlet temperatures to the Brink element must be a maximum of 90° to 120°F. to insure efficient gas cleanup.

Figure 4 is a generalized flow diagram for vinyl processes where the exhaust gas is at or close to ambient temperature or where pollutants are primarily in the liquid phase, such as would be found in systems employing exhaust hoods. In this system exhaust gases are delivered directly to the Brink® mist eliminator where plasticizer mists are separated. Here clean gases are exhausted to the atmosphere and the separated plasticizers are collected for, as the individual situation allows, further processing and potential reuse. Depending on the cost of purifying the recovered plasticizers and their value, a part or all of the air pollution system may be justified on economic grounds.

STLCOPCB4093207

Shown in Figure 5 is the generalized flow diagram for vinyl operations where gas cooling is necessary, such as in plastisol units utilizing high temperature curing ovens. With this type operation, the exhaust gases must be cooled through a water spray chamber or other cooling device to condense the vapors prior to entrance into the Brink® mist eliminators. The water-plasticizer effluent from this operation is delivered to a settling tank to separate the water and oil phases. The water, draining from the base of the tank, can normally be recycled back to the spray chamber to be reused as a spray coolant. The recovered plasticizer, drained off the top of the settling tank, is recovered for re-use as the individual situation permits.

STLCOPCB4093208

FIRST PLANT INSTALLATION

The first large plant installation of the new system was started up at GAF Corporation's Whitehall plant at Fullerton, Pennsylvania in October, 1969. The GAF plant manufactures vinyl flooring products for offices and homes for a rapidly expanding market (6,7). The vinyl flooring process involves preparing a continuous blank sheet with a vinyl polymer coating, printing with a pattern, and then coating the sheet with a wear-resistant layer of vinyl polymer. The wet sheeting is cured in long ovens where monomers polymerize to yield a clear, wear-resistant coating. The exhaust gases from the ovens contain hot plasticizer vapors which formed dense white plumes when the stack gases were cooled in the atmosphere. The white plumes often filled the valley in which the plant is located with a haze that severely reduced visibility. The organics in the atmosphere smelled like a lubricating oil and citizens in the surrounding area complained that the odor made them sick.

After the October start-up, the highly visible organic plumes were eliminated and GAF even received a phone call from a lady who said "I'm sure glad you finally shut that place down." The lady caller was astounded to hear that the plant, far from being closed, was running at full

DSW 587873

STLCOPCB4093209

production (6). At the Whitehall plant, two parallel lines of pollution control equipment were installed. In each line the exhaust gases from ovens are first cooled in a cooler which is a combination of direct water cooling and surface heat exchangers. The gases leaving the cooler contain primarily submicron organic mist particles. These are removed with Brink® fiber mist eliminators designed for essentially 100% efficieny on particles larger than 3 microns in diameter and 99% on particles 3 microns and smaller. The Brink® elements which are used are constructed from special glass fibers and 316 stainless steel and are 2 feet in diameter and 10 feet tall. A total of 24 such elements are used in 2 tanks.

A total of 33,000 C.F.M. is moved through the two lines of equipment by two blowers which require a total of 175 h.p. The liquid draining from the mist eliminators and the condensate from the cooler are pumped to settling tanks where the heavier water phase seaprates from the lighter plasticizer fraction. GAF sends the plasticizer recovered back to its supplier for reprocessing. Hence, this system of recovery should help defray some of the costs of correcting a difficult air pollution problem.

STLCOPCB4093210

FURTHER PLANT INSTALLATIONS

More recently, in October of 1970, a Brink® mist eliminator was placed on line in a vinyl sheeting extrusion operation at Monsanto's Trenton, Michigan plant. Prior to installation of the Brink® mist eliminator, an impaction type collection device was on line in the 12,000 ACFM exhaust stream and yielding poor collection efficiencies. Again, plasticizer mists were carried out the process stacks and resulted in a plume. Additionally, fallout from the plume was causing considerable damage to the roofing area and other adjacent physical structures. Objectionable odors from the plasticizer carry-over were present in the surrounding area.

As a total solution to these problems, a decision was made to install a Brink® mist eliminator system in the exhaust stream. Because the exhaust stream temperatures were close to ambient, no cooling was needed. The exhaust gases were thus transferred directly from the extruder to the Brink® mist eliminator. Figure 6 is a sketch of the installation at Trenton. As shown, a tank approximately 20 feet tall by 10 feet in diameter houses 10 Brink® elements. Materials of construction are carbon steel elements

STLCOPCB4093211

and a Heresite lined carbon steel tank. Liquid drains from the elements to the base of the tank where it is periodically bled off.

Following the October, 1970 start-up, the plume and objectionable plasticizer fall-out were completely eliminated. The objectionable odor associated with the extrusion operation also has disappeared. Techniques for recovering the collected plasticizer are under study, and it is expected that additional gains will be made in this area.

The management of the Trenton plant has expressed complete satisfaction with the performance of the Brink® mist eliminator and estimate that it is removing over 99% of plasticizer.

The third plant installation will be a 32,000 C.F.M. system. This is now being constructed for a large flooring manufacturer and start-up should take place within a couple of months. Over six other pollution problems associated with similar plastic operations are now being studied and we expect additional installations in the coming year.

STLCOPCB4093212

LITERATURE CITED

1. Brink, J. A., Jr., W. F. Burggrabe, and L. E. Greenwell, Chem. Eng. Progr., 64, p.82 (1968).

2. Gossett, J. W., Chemical Processing, 30, p. 86, (1967).

3. Brink, J. A., Jr., "Removal of Phosphoric Acid Mists," Chap. 15 Part B, in "Gas Purification Processes", George Newnes, Ltd., London (1964).

4. Nichols, J. H., Brink, J. A., Jr., Electro Chemical Technology, 2, No. 7-8, p. 233 (1964).

5. Brink, J. A., Jr., Can. J. Chem. Eng., 41, p. 134 (1963).

6. Environmental Science & Technology, 4, p. 107, (February, 1970).

7. Monsanto Magazine, Volume L, No. 1, p. 11, (Spring, 1970).

DSW 587877

STLCOPCB4093213

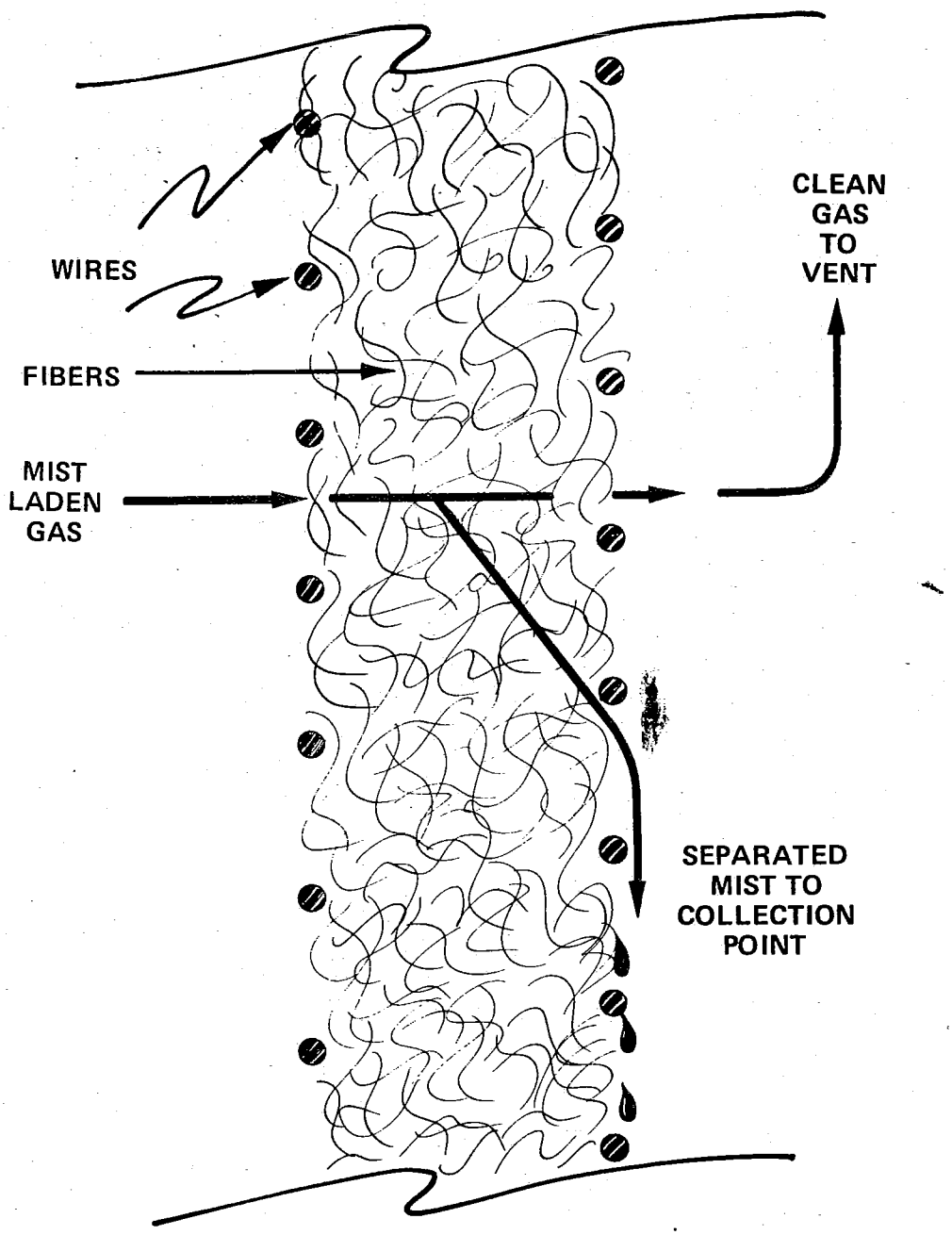

Figure 1. Single Stage Vertical Fiber Bed

DSW 587878

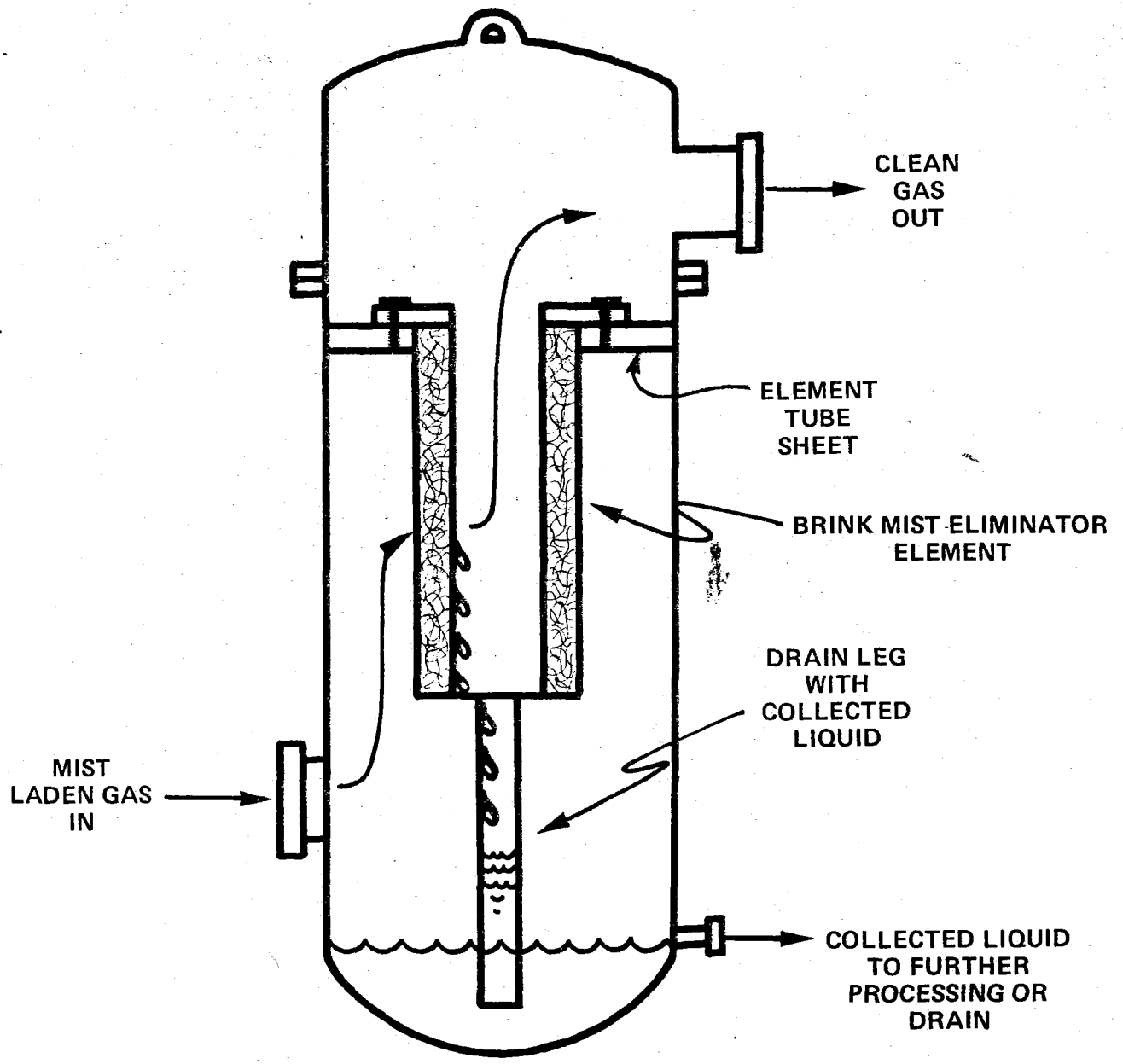

Figure 2. Typical Brink Mist Eliminator Assembly

DSW 587879

STLCOPCB4093215

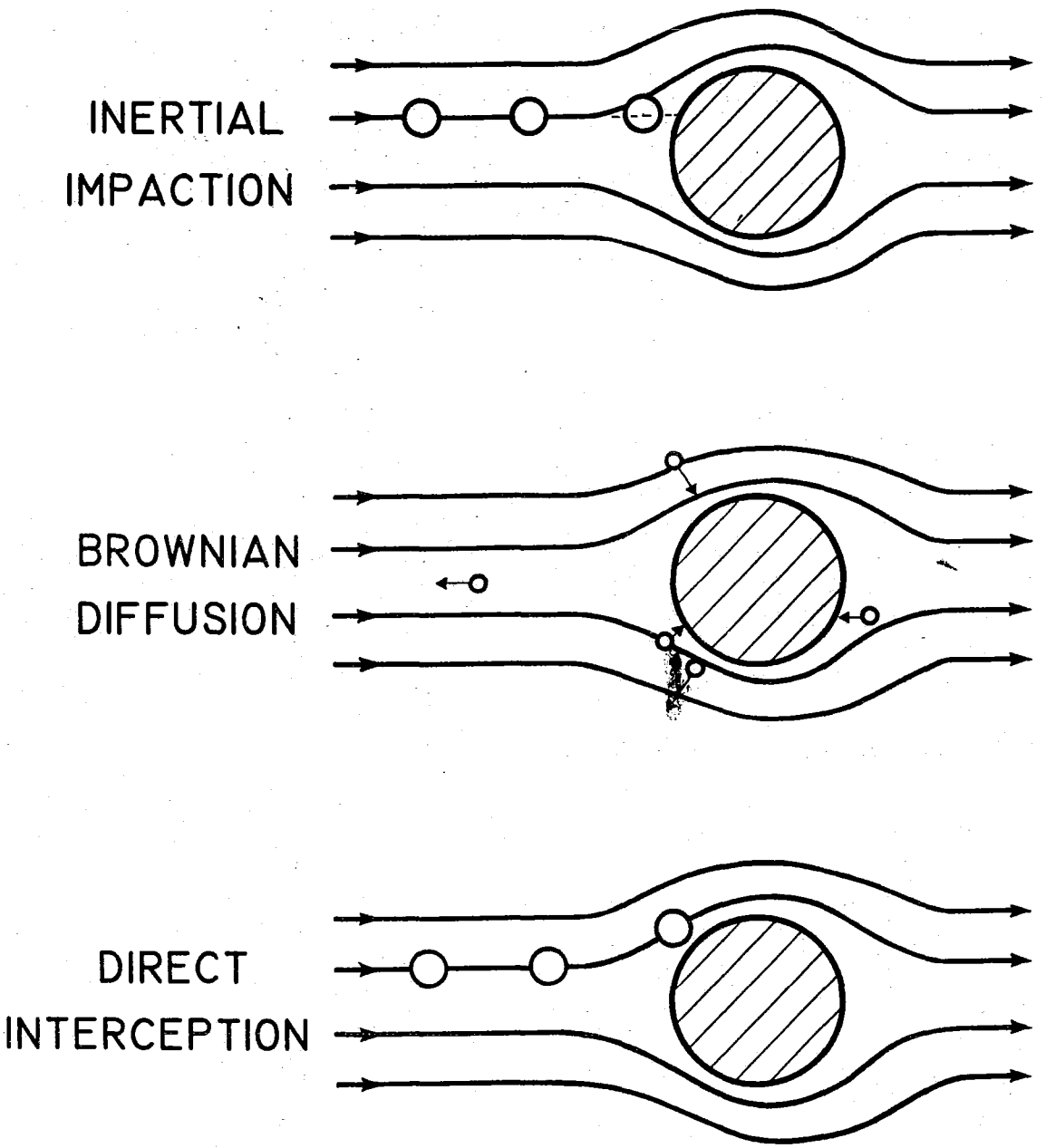

Figure 3. Mechanisms for Mist Collection on Fib

DSW 587880

STLCOPCB4093216

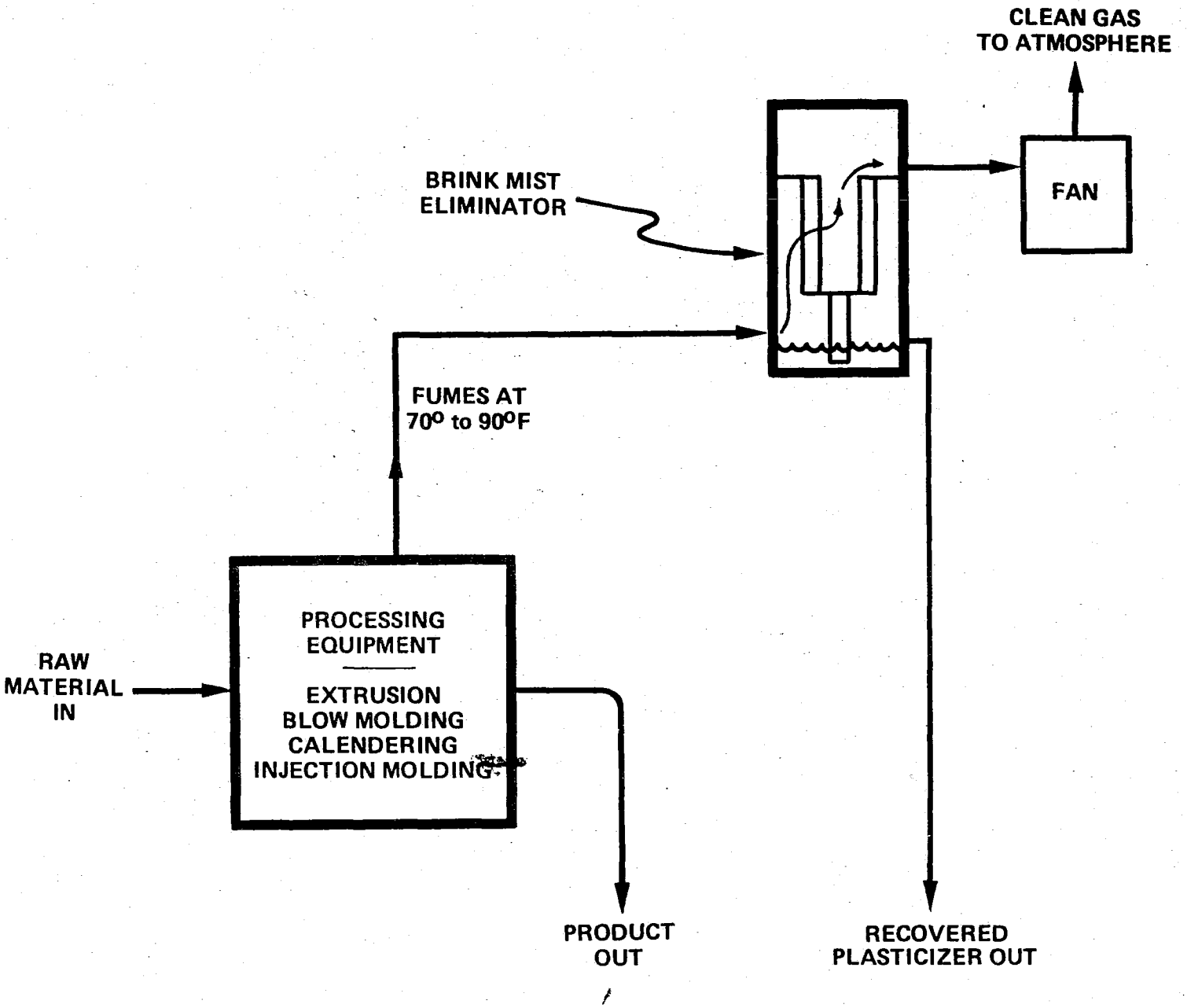

Figure 4. Flow Diagram for Plastic Operation Pollution Abatement System. Low Temperature Vent Gases

DSW 587881

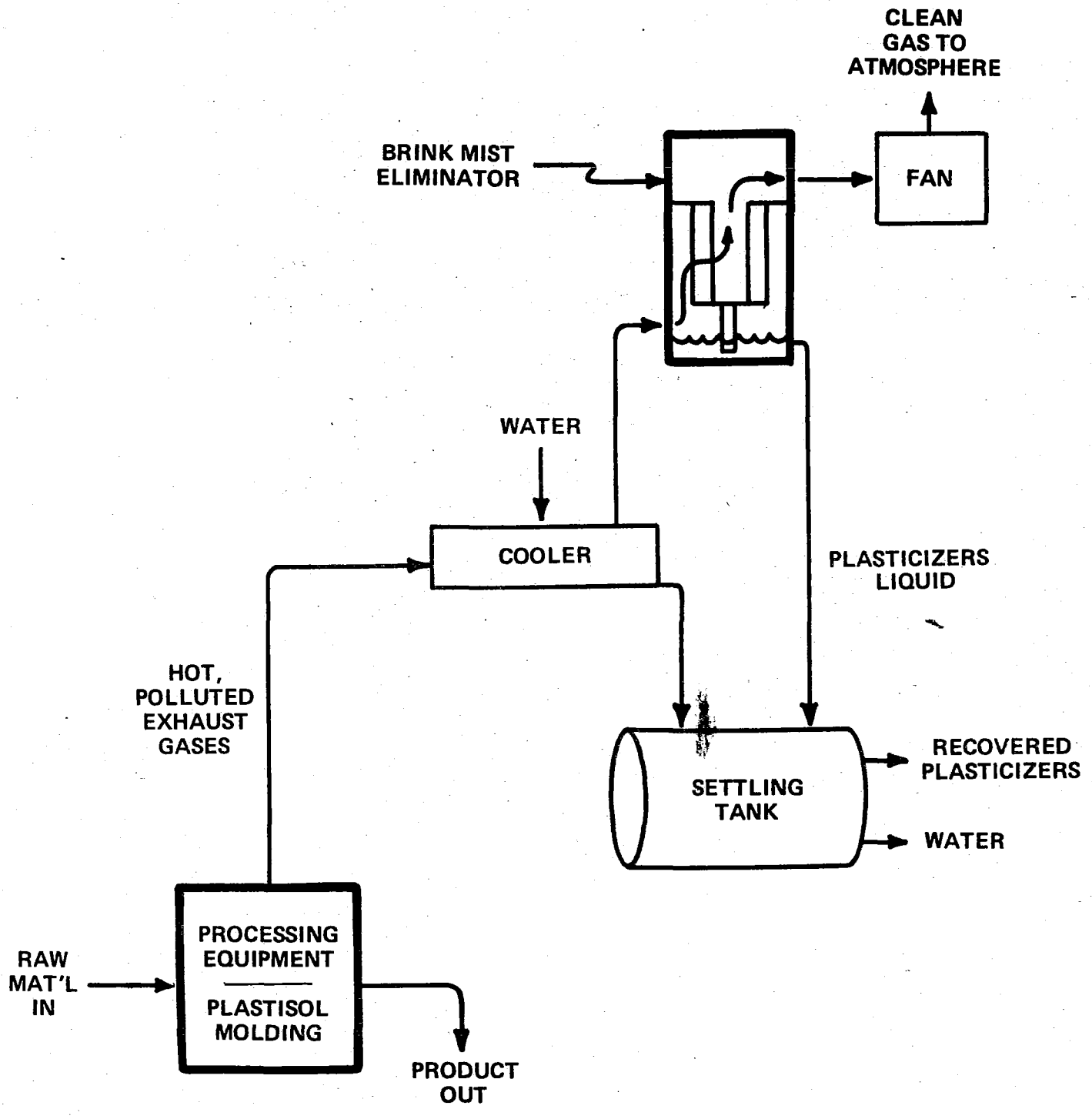

Figure 5. Flow Diagram for Plastic Operation Pollution Abatement System. High Temperature Vent Gases

DSW 587882

STLCOPCB4093218

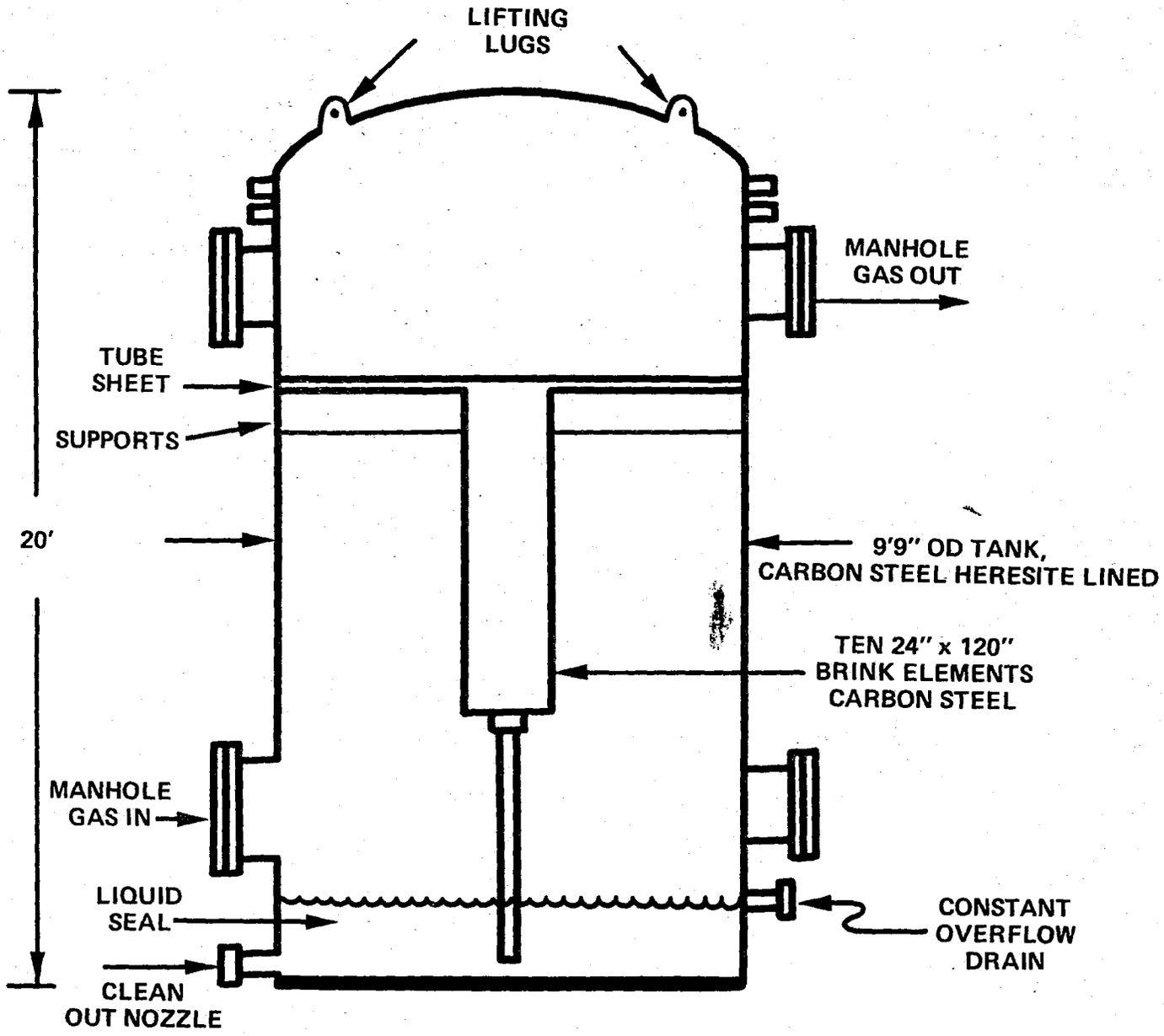

Figure 6. Brink Mist Eliminator - Vinyl Extrusion Operation
Monsanto - Trenton, Michigan

DSW 587883