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WORKSHOP ON IN-PLANT WASTE REDUCTION IN THE MEAT INDUSTRY

Held at

University of Wisconsin, Madison

December 13-14, 1973

Compiled by

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U.S. ENVIRONMENTAL PROTECTION AGENCY
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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

"Workshop on In-Plant Waste Reduction in the Meat Industry" summarizes the experiences and needs of the meat industry in terms of in-plant waste reduction. This document is for use by industry and government as supportive information for application of éffective in-plant waste management or development for research projects. For further information on the subject contact the Food and Wood Products Branch, Industrial Environmental Research Laboratory--Cincinnati.

This report resulted from a workshop on in-plant control of wastes in the meat industry. The workshop was held on the University of Wisconsin Campus and was attended by food waste specialists. The material presented and discussed there has been organized and presented herein.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

Presented are the proceedings of a workshop on in-plant waste reduction in the meat industry. Forty-five participants from industry, government, and private firms exchanged ideas and experiences on waste reduction during the two-day session. Topics covered were: pens, blood conservation and processing, hide and hair removal and processing, eviscerating and edible offal processing, paunch and viscera handling, rendering and plant clean-up operations. Case histories are presented on water conservation in a meat packing plant and in a hog processing plant.

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SECTION I
CONCLUSIONS

This document summarizes the experiences and needs of the meat industry in terms of in-plant waste reduction.

Success of in-plant waste reduction practices depends on the attitude of both the management and production personnel and their respect of the person coordinating the waste reduction measures.

Key areas of in-plant waste reduction are blood conservation, paunch handling, and cleaning the pens. Blood conservation and its processing provide an excellent marketing opportunity to the industry in terms of the protein demand in the world. Dry dump handling of paunch contents is the system of choice from both an economical and environmental viewpoint. The production of soil conditioners by surface and/or subsurface spreading and the production of feeds by ensilage or drying appear to be the most feasible measures for utilizing paunch contents. Dry-cleaning the pens by the use of vacuum systems coupled with pen design and land disposal of the solids can effectively control the wastes originating from this area.

A hide curing operation will discharge nearly 1.8 kilograms (4 pounds) of salt per hide cured, and when combined with a slaughter plant effluent, results in a concentration ranging between 750 and 1000 mg/l. The eventual solution to the brine disposal problem will be for the hide processor to produce either a pickled or tanned hide.

This document can be used by industry and government as supportive information for application of effective in-plant waste management or for development of research projects.

There is a need in the meat industry for a periodic bibliography as a reference source of information so that those involved with waste management could readily locate past developments.

SECTION II
INTRODUCTION
by
James E. Kerrigan

In December, 1973, a workshop entitled, "In-Plant Waste Reduction in the Meat Industry" was held at the University of Wisconsin-Madison.

The purpose of the workshop was to bring together a broad range of specialists informed in the area of slaughtering and the associated by-product and waste management operations.

Participants at the workshop represented the following of plant operations: meat quality control and health inspection; by-product recovery and waste collection, handling and disposal. Because economic production, meat quality protection and effective waste management are interdependent, it is essential in minimizing waste to consider all these aspects when recommending changes in a slaughtering plant operation. Effluent limitation guidelines promulgated under the Federal Water Pollution Control Act of 1972 were proposed at the time of the workshop. They were issued by the Environmental Protection Agency on February 28, 1974. By-product recovery, waste collection and water conservation practices within plants are expected to receive renewed emphasis because of the guidelines. It was considered timely to identify alternative activities that might be useful in reducing in-plant waste and avoid the expensive waste treatment costs that are associated with producing high quality water effluents.

Forty-five participants exchanged ideas and shared experiences with one another during a two-day session. The format of the workshop was designed to encourage dialogue between those attending with selected session leaders directing discussion on ten specific topics. To provide adequate time for exchanging ideas, the topics were restricted to the processes within the slaughtering operations. The topics were: pens, blood conservation and processing, hide and hair removal and processing, eviscerating and edible offal processing, paunch and viscera handling, rendering and plant clean-up operations.

The program was developed in cooperation with representatives of the American Meat Institute, the National Independent Meat Packers Association, the Western States Meat Packer's Association, Inc., the National Renderers Association, Industrial Waste Branch, Environmental Protection Agency, Corvallis, Oregon, and from the University of Wisconsin. The meat industry associations were responsible for encouraging their members to participate in the workshop. Their efforts were effective, for the principal waste control engineers and managers from fifteen different firms were present, including two representatives from major consulting engineering firms. Similar success resulted from the efforts of the Environmental Protection Agency in inviting federal agency representatives to participate. Four members of EPA, all from separate regions, attended the workshop, as well as representatives from the Meat and Physical Facilities Inspection Division of the U.S. Department of Agriculture, the Division of Veterinary Medical Review of the Food and Drug Administration, DHEW, and the Agriculture Research Service, USDA. To complete the group, faculty members from four different disciplines and a representative of the Iowa Department of Environmental Quality attended.

The basic concept of the workshop was to examine the various divisions within the slaughtering operation to see where opportunities exist for reducing waste. Among the questions asked are: What are the current practices? What regulations or controls should be added or deleted? What should be done that is not now being done?

This publication collates the different areas discussed at the workshop and its purpose is to:

1. Identify for the people in the industry the opportunities for in-plant reduction techniques.

2. Give the U.S. Environmental Protection Agency a consensus from a broad segment, of what research and demonstration activities are most critical within the slaughtering process of the meat industry.

3. Identify for individuals in government some of the proposed modifications that may be considered in waste reduction areas.

4. Identify companion studies to insure that meat quality is maintained at its present high standard. The control of high meat quality and development of new methods for protection of the environment must be accomplished hand-in-hand.

SECTION III
PENS
Monitored
by
W. James Wells, Jr.

The purpose of this section is to review the matter of handling of wastes from pens. This is probably one area where wastes are most easily segregated from the other waste streams of the plant. There are some differences on the handling of wastes from different animals, but for the purpose of this discussion, they were reviewed collectively. Generally, most pen floors are concrete and are washed down daily. The frequency with which pen floors need to be washed vary between plants and in part, depend on the concerns of the plant inspector.

Pen design is very important in regard to the effectiveness in cleaning the pens. Experience has proven the waffle type pattern in the concrete pens requires additional time keeping them clean. Rectangular pens result in thirty percent of the area unusable. The fan-shape pen has been found to be very effective. In this design, the cattle enter and exit at opposite ends. Total area of the rectangular pens is from 2 to 2 1/2 times that required for the fan-shaped design. Advantages to the fan design, in addition to reduced area, are the less wastes entering the treatment system and reduced water consumption.

Covered pens appear to be a matter of preference to the meat-packer. Generally most of the hog pens are covered. For open cattle pens, there exists the problem of storm-water runoff during heavy rainfall which adds considerably to the waste handling problem. One of the main reasons for covering pens is to protect the livestock from rain and snow so as not to have wet cattle or sheep going into the kill which presents problems with mud and contamination.

For pen cleaning, a system used with some degree of success is settling basins. These are designed with floors sloped at a five percent grade to permit pen wastes hosed down to be settled in these basins and allow a front-end loader to remove these wastes. Some of the problems result in infrequent cleaning, thus allowing the basin to become filled with solids, thereby losing its effect. These settling basins are capable of removing 40 percent of the BOD_5. The wastes also tend to liquify and become difficult to dispose. The ultimate disposal must be to a land fill or on agricultural land.

Some pens are cleaned mechanically with the aid of front loaders and the claims are that as long as bedding was adequate and pens were cleaned frequently no problems resulted. Bedding materials used are wood chips and/or sawdust. Pens should be dry-cleaned two or three times daily, the bedding and waste mixtures accumulated and hauled to land fill.

Vacuum type cleaning systems using septic tank pumps with an intake nozzle similar to a vacuum cleaner can reduce the BOD_5 by 25 percent. This is a quick operation and can be effective all winter without washing, but in the summer, the pens need to be washed at least twice a week. The vacuum system is most effective when the pens are designed for this type of equipment. This includes the fan-shaped design and gates that swing out to allow a full sweep of the area by the vacuum system.

Truck cleaning is necessary to control hog cholera and for meat-packing plants to meet export requirements. The truck should first be dry cleaned prior to wash down with the dry material going to suitable land disposal.

A method of handling the wastes from dairy holding pens that appears promising is a collapsible dam at the top of sloping pens. Large quantities of water, i.e., five thousand gallons, are suddenly released when the dame is collapsed. The water flushes through the pens picking up the bedding and manure. Sometimes two or three of these collapsible dams are set in series along the slope. The final point is a sump pit and a chopper pump. The flushed materials are then chopped and pumped to a field where a rotating nozzle spreads this mixture over agricultural field. The system reduces manpower requirements, but needs to be carefully designed.

SECTION IV
BLOOD CONSERVATION
Monitored
by
John Killebrew

Blood has the highest BOD of any liquid produced in a meat processing plant. One cattle contains approximately 50 pounds of blood which if discharged into the sewer contributes a pollution load equivalent to that of fifty people.

The important aspects of a good blood conservation program will be discussed below.

Blood first presents itself in the plant on the kill floor in the sticking or bleeding area. This area should be curbed and equipped with combination blood and water floor drains. During operation and before cleanup periods, the blood must be carefully squeeged to the blood side of the drain, minimizing blood loss to the sewer when the drain plate is changed. In many plants, the floor of the bleeding area is given an initial rinse with a fine spray nozzle under high pressure which is sent to the blood sewer. The cost of removing this small amount of water from the blood is probably less than removing the blood from the waste treatment system. It is believed that no investigation has been made as to how many gallons of water are actually flushed down the drain for this purpose, but it is felt that it is less than 75 gallons. The bleeding area varies in size from plant to plant - from very small to very extensive. Killing floors with insufficient bleeding areas usually lose a lot of blood to the sewer because the cattle continue to bleed as they travel across the floor. Management should always be alert to see that the flow of cattle through the bleeding area allows ample time for thorough bleeding, and that operators do not hurry up the process to gain extra breaks for themselves, etc. They should also see that floor clean-up is done often enough that blood does not coagulate on the floor requiring large amounts of water to remove it. Meters should be installed on all water sources to quantify and thus control water use in this area.

The extension of the use of combination of water and blood floor drains around the various points of the dressing chain route has also been discussed. Care must be exercised so that the gutter does not cause the worker, with knife in hand to trip. This potential danger requires that the blood be continuously washed away during the operating day.

Various operations along the dressing chain route, such as head washing and brisket opening, result in large amounts of blood being spilled on the floor and then washed down the sewer. Attempts should be made to design or alter these areas so this blood can be saved. This seems to be easier to accomplish on hog killing floors than it is in beef killing floors. Several plants have extended blood troughs on their hog killing floors from the sticking area to the scalding tubs. One plant has troughs below the dressing tables starting at the head dropper and extending completely around the dressing chain route so that blood drippage never finds its way to the floor and to the sewer. Much of the blood coagulates in the hot water of the scalding tubs and this is lost as far as recovery is concerned. However opportunities do exist as to minimize the amounts of blood and sludge released to the sewers by allowing the scalding tub contents to settle before draining. Dumping the scald tub, immediately after the kill, should be avoided. After allowing approximately one-hour settling time, the water can be decanted from the top of the tub in a slow manner. The remaining heavy sludge can then be dumped into a truck and spread with pen manure.

A firm in Sweden is marketing a hollow sticking knife, designed to collect blood from cattle or hogs for edible purposes. These knives are connected to a vacuum collection system using artifical sausage casings (which are cheap and disposable) instead of rubber hoses. This would serve two purposes: the blood could be kept off the floor and it could possibly be sold as a more valuable product with a greater return. Of course, the problem of maintaining blood identity does exist. One has to decide how much blood he is willing to lose if a condemned animal is found on the killing floor. Some plants separate the blood into groups consisting of blood from ten animals. This quantity would then be sent to the rendering if a condemned animal was found in that group.

Blood lost to the sewer in a meat packing plant can be on the order of 30%, despite collection systems specifically installed for its recovery. Two methods of removing it from the waste stream consist of the use of lignosulfonic acid (LSA) (1) process and electrocoagulation (2).

In the LSA process, raw wastewater is chemically treated with sulfuric acid and lignosulfonic acid. This treatment precipitates soluble proteins, forming a flocculent mass suspended in the wastewater. The mixture is then subjected to dissolved-air flotation that separates the precipitate and other suspended organic matter from the wastewater. The clarified waste is then neutralized with lime. The effluent has greatly reduced levels of nitrogen, grease, suspended solids, biochemical oxygen demand and live organisms. Sludge from the flotation unit contains about 40 percent protein (dwb) and can be sold as an animal feed ingredient.

Alwatech A/S, an Oslo, Norway, based company, developed the process. In Kalmar, Sweden, a small integrated pork and beef plant has a full plant LSA process in operation which is economically selfsupporting.

Electrocoagulation, another clarification process, has possibilities in reducing the effect of blood lost to the sewer when used in conjunction with chemical treatment. Developed by Swift & Company for use in the meat packing industry, the process electrolytically neutralizes the negatively charged particles in the wastewater. Passage of a direct current through the wastewater forms large quantities of microbubbles of oxygen and hydrogen in the wastewater due to electrolysis. The addition of coagulant aids, such as ferric sulfate and an anionic polymer plus calcium hydroxide for pH adjustment prior to electrocoagulation, are necessary to remove the proteinaceous organics contained in the blood.

Both processes, LSA and electrocoagulation with chemical treatment, increase the protein content of the waste sludge to a level such that by-product recovery alone might make the process economically desirable in addition to allowing the plant to meet effluent requirements.

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SECTION V

BLOOD PROCESSING

Monitored

by

C. J. Carlson

Generally every plant does something in regard to blood processing and has been doing so for years. The methods may not have been too effective, but nevertheless it was being saved to make some final use of the blood.

Probably the initial way of handling blood resulted when Purdue University came up with the idea that this blood could be used in animal feed and was excellent for hogs replacing corn in the diet. This was early in 1900 and more or less took blood out of the fertilizer category and put it into the feed category resulting in a better gross return to the packer. The accepted way of drying blood then was to store it in a coagulating tank, inject live steam to coagulate it, put a cart underneath to draw off all the free serum, and transfer the coagulated mass to a dryer. While this method was crude, it is still being done the same way in some plants.

Another way was to pump the blood into a conventional dry melter which resulted in less loss and a dry product. It was an improvement but presented an odor problem. The big problem was quality control and it was difficult to obtain a consistent product as far as temperature was concerned. An addition of bone or other solid had to be added to prevent blood build-up on the sides of the melter, which in turn would cut down on the heat transfer and increase the drying time.

A tremendous amount of horsepower was needed to net a small amount of the product. At one point in the operation, the entire mass becomes practically adhesive and at that time the horsepower demand greatly increases to hasten the drying process. In the summer fans are kept blowing on the heaters on the motors just to keep them in operation during this critical glue state. This idea of blood processing reflects the type of thinking people in the rendering business had for many years without much thought to cost economics or saleable items.

In the situation today, many of these old plants are still in operation, but several innovations have taken place in the past ten years which are a definite improvement. One is the use of spray dryers, this blood has a high degree of solubility. Its big impetus was in the fifties when the demand for blood was used by the adhesive industry. Also these sprayers were available from the dairy industry, and were relatively cheap.

The feed industry tended to back away from dried blood because of its solubility, it was very dusty, difficult to handle in bulk form. Problems were encountered in operating this equipment because the yields were low, only 18% solids and if at first an attempt was made to evaporate the product and increase the concentration up to 35 or 40%--the evaporation had to be done at a low temperature. This is due to the disasterous effect of coagulation within the evaporator. The second problem was collection. In a small community where this type of operation was run, the dust collectors were 99% efficient, but the 1% caused problems. A red film covered everything and it had a unique capability in its reaction to paint. On one occassion six houses had to be painted because they all turned a pastel color.

From that system evolved the famous ring dryer, it is essentially a spray dryer which agitates to keep the product from too much coagulation From the dryer the blood is pumped through a coagulator, then on to a small type of expeller which squeezes out the free serum. The solids are again fed back at the start of the system and then into a disintegrator which sizes the materials and feeds it into a manifold where it is mixed with high temperature air (900°F) from the gas-fired furnace. The air velocity picks up the product that travels in the ring and as it dries the product migrates to the top of the air flow and is syphoned off into a cyclone where it is separated and drops into storage tanks. The water material continues to recycle until it is dried. The advantages of this system are that the blood is high quality with no contamination in it and is an excellent product from a nutritional standpoint. The disadvantages are that it is a great air polluter. Dust conditions within the room are bad. It is difficult to load because of its fluffiness and small particle size.

Another system is the DeLaval centriblood system, which improves the recovery of solids after coagulation. Instead of going over a shaker screen--the product goes through the conventional DeLaval decanter which is effective in extracting the serum water.

The economics of drying blood should be thoroughly considered as it has fluctuated considerably. In July 1972, it was $120/ton or six cents/pound and had been in that area, plus or minus $10-$20 for about 20 years. When the protein shortage developed, blood prices rose in July 1973 to $452/ton or 22.6 cents/pound and the December 1973 price was $288/ton or 14.4 cents/pound. In the hog processing , the gross value to the packer has been varied, from ten cents to thirty-five cents per hog. Drying costs by conventional drying methods run about five cents per hog. Operating costs are $80 to $100 per ton to dry the blood so the return grosses about 25 cents per hog. At a kill of 20,000 hogs per week a gross return of about $5,000 net is obtained from dried blood. The opportunity for packers in regards to drying blood economics is better now than it has ever been. Lysine availability which to the average processor means little, but will become important when future major feed manufacturers will buy blood not on protein but lysine availability. Blood now is being quoted in two different ranges, regular product and high-lysine product.

Buyers from three major companies report that in the near future, quality programs are to be established, setting up price standards based on lysine availability rather than on the percentage of protein and dry blood.

Today, high-lysine commands about $125/ton premium over regular dried blood. Normally produced dried blood in which the heat is not controlled, allows the lysine to become denatured and is not biologically available from a nutritional standpoint. Whole blood normally contains about 7 or 8% lysine and via regular processing contains up to 48-50% lysine. Drying through a ring dryer brings the lysine availability to 90%. Eventually the marketability of blood will be on strictly lysine availability and the regular blood economic returns will be disappointing.

Another alternative which should be looked at is the blood being relegated into animal feed and its nutritional value. It has high protein so should be more valuable than just animal or pet foods.

Fractionation of blood is not difficult. It requires immediately upon collection the addition of an anti-coagulant agent, usually sodium cytrate. It is then put through a centrifuge where the red blood cells are extracted from the plasma resulting in 35% solids red cells and the plasma has 10% solid red cells. Red blood cells dry nicely in the dryer removing the glue portion. The product in dry or frozen form has excellent color. Assuming three pounds blood per hog recovered by fractionation results in about thirty cents per pound just for the blood cells.

In Europe, blood plasma is highly regarded as an ingredient in sausage making. It has emulsifying properties and can be whipped like egg white albumin.

The plasma has shown good results in the calf-milk replacer industry. When blended with soluble proteins it gives an end product that exceeds the casein quality of milk in terms of protein efficiency rating.

The blood plasma is now selling at 55 to 60 cents per pound. One plant finds that the net per hog is about 58 cents which is an additional 33 cents per hog and an additional $5,000 a week on a 20,000 hog kill. This utilization of blood plasma has a potential of over a quarter million dollars for the industry. Industry has been very lax in exploring the potential in this area. There have been campaigns to get this included in the manual of meat products and in the 1973 edition it is listed under Meat Byproducts.

The industry has to become more mature in its thinking in using blood as an edible wholesome food product. Much more testing is required in these areas. Maintainance of the dust level is difficult and is something that has to be engineered out as well as the odor problem. Studies were done using a steam tube dryer. They are effective due to the temperature control nature of the system. The economics of fractionalization are promising with dried blood at 14.4/cents pound--serum dried blood at 27 cents/pound--almost double plus the $1.00 per pound for dry plasma.

SECTION VI
ASPECTS OF POLLUTION FROM THE BRINE CURING OPERATION

Monitored
by

Jimmie A. Chittenden

INTRODUCTION

To the beef man it is the package that holds the meat together; to the tanner it is a rather imperfect raw material full of blemishes and unwanted by-products that take all of his extensive skills to produce a valuable end product; to the pollution man it presents nightmares of virtually insolvable problems. The beef hide is all of the above and more. This paper will concern itself with the pollutional aspects of handling and brine curing the beef hide and suggest some alternatives to solving the problems presented herein.

HIDE PROCESSING

Although there are probably as many methods for handling hides as there are beef slaughter plants, most of the processes have many similarities. This discussion will address itself to the modern brine curing process using raceways. This process involves contacting the hide with a concentrated brine solution to "cure" the hide, making it stable against spoilage until it can be processed by a tanner.

Washing and Defleshing

For the purposes of this discussion, it will be assumed that the average hide dropped from the kill floor will weigh 81 pounds. This average will naturally depend upon the type and weight of the animal and to some extent the time of the year. Of this 81 pounds, there will be, on the average, 5 pounds of mud and manure clinging to the hair side of the hide. In addition, there will be around 11.5 pounds of flesh remaining on the flesh sides of the hide before curing.

After the hide drops from the kill floor, it is run through a hide washer. The standard design of hide washer involves using a forty foot, horizontal perforated drum rotating at 9 rpm. The interior of the drums has pegs that act to propell the hide to the discharge end as a result of the drum rotation. In most systems the first two-thirds of the drum has water sprays using recycled water at a rate of 365 gpm. The last one-third of the drum uses fresh water at 40 gpm.

The hide washer is not effective in removing the large cakes of manure, but it does remove the loose sand and much of the blood from the flesh side of the hide.

After washing, the hide is then run through the demanuring and defleshing machine. This machine has a high-speed, bladed cylinder that contacts the flesh side of the hide and scrapes away the flesh remaining from the hide removal process. The flesh is dropped below the cylinder and is water-flushed to a collection screw at the edge of the machine. This flesh must be collected and sent to the rendering department. The water flush adds as much as 10 pounds per hide of water to be evaporated, but sewering this water would greatly increase the pollutional load from the operation.

The demanuring side of the defleshing machine consists of a dull-bladed cylinder that contacts the hair side of the hide. This cylinder is effective in removing the manure caked on the hide. The manure drops into a trough (separate from the fleshings) below the machine and is flushed to the solids removal systems with the overflow water from the hide washer. After this operation, the hide edges are trimmed to a standard specification resulting in an average of 4 pounds of trim per hide. These trimmings are generally combined with the fleshings for transport to the rendering operation.

After flushing through the demanuring trough, the hide wash water is passed over a static screen. The screen is fitted with 0.04000 inch openings which are sufficient to remove a large portion of the manure and hair in the water. The solids removed are landfilled. After the screen, a pump recycles a portion of the flow back to the hide washer to flush the incoming hides. The excess water, which is equal to the fresh water added to the last 1/3 of the hide washer, is sent directly the the slaughter waste treatment system.

Extreme care must be taken to keep the water in the washing and flushing area segregated from the brine curing area drains. As will be shown later, fresh water must be completely eliminated from the brine drains.

Brine Curing Operation

There are several methods for curing of hides. These range from the old salt pack system that required 30 days to cure the hide to the more modern methods that require 16 to 20 hours to produce a stable product. Each of the processes have the same objective: produce a hide that will be stable in storage for up to one year.

The raceway system contacts the hide with a concentrated brine solution contained in an oval track raceway to accomplish the curing. THe raceway is eight feet wide, eight feet deep, and approximately 100 feet in centerline perimeter. Two paddle wheels fitted with 10 horsepower motors operating at 18 rpm keep the hide moving and assure intimate contact with the brine.

Brine is continually recirculated from the raceway back to the brine makeup unit to keep the slat concentration at 95% of saturation.

The hides are transported from the fleshing machine to the raceway by a cable conveyor. The raceways are sized to hold a maximum of 1200 hides. After the raceway is filled, the hides are allowed to recirculate at least 18 hours in the concentrated brine.

After 18 hours, the hides are removed by hand from the raceway and loaded onto a cable conveyor for transport to the hide wringer. The hide will carry an average of 40 pounds of brine out of the raceway. The hide is conveyed through the wringer on heavy wool felt belts. The hide, sandwiched between the felt belts, passes through two hard rubber rollers and the excess brine is pressed from the hide. The wringer brine is pumped to the brine makeup unit and returned to the raceway.

After wringing, the hide is then graded, folded, and weighed and placed on a pallet. As the hides are folded, 1 1/2 pounds of salt are added to the hide as a curing safety measure during storage and shipment. The pallets are stored until carload quantities and accumulated for shipment.

At the time of shipment, the hides are depalletized, re-weighed, and loaded into box cars for shipment to the tanner. At this time, approximately 50 percent of all U.S. hides are sold for export to foreign countries, so it is readily apparent that the hide must be well-cured to survive the shipment to these tanneries.

Mechanics of Hide Curing

In order to determine the mechanics of the hide curing process, an attempt was made to duplicate the hide curing process in the laboratory. The curing approximated the hide curing process fairly well, but the full scale operation produced a better cured hide than did the lab process as measured by the final ash content of the cured hide.

The laboratory process was conducted using old brine obtained from the hide operation. The salt content was maintained by adding the same type of salt used by the hide company. Several pieces consisting of four-inch squares of hide taken from the backbone area were added to 1000 ml beakers containing the brine. Laboratory stirrers were used to keep the contents of the beaker well mixed during the curing process. The brine strength was measured hourly and salt was added as required to keep the brine concentration near 95% of saturation. At various intervals two pieces of the hide would be removed and analyzed for moisture and ash content so that duplicates were run at each control point.

Figure 1 depicts what happens in the curing process. The green hide has an average moisture content of 63.5%. For the first four hours in the raceway the moisture content drops dramatically to 53.4%. From 4 hours to 12 hours the moisture loss rate decreases and by 16 hours the moisture content has leveled off at around 48.5%. On the same graph, the ash content (or salt content) can be seen to have a correspondingly rapid increase from 0.2% initially to 10.4% after 4 hours. After 16 hours, the salt content has leveled out at near 14.0%.

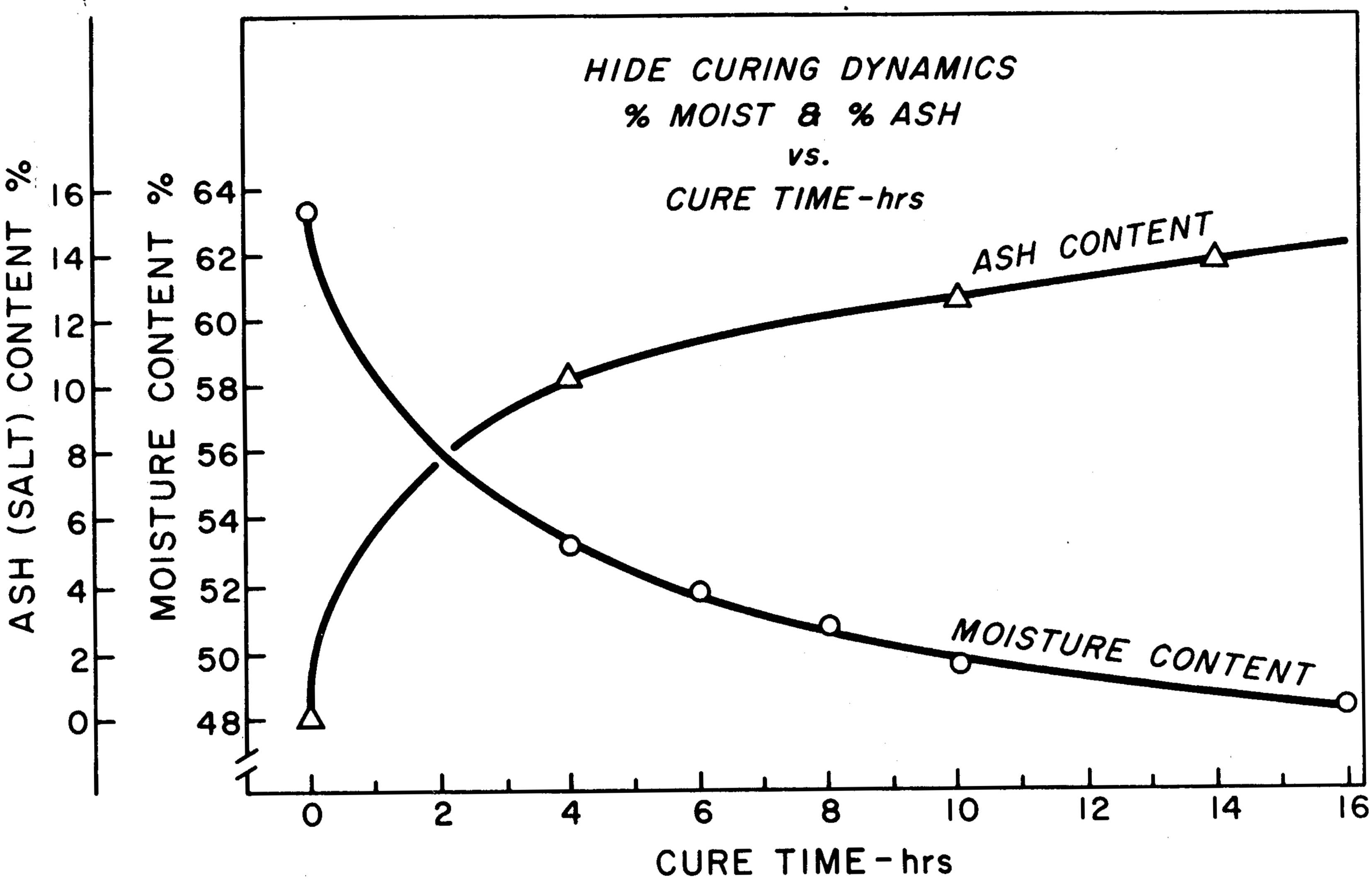

Figure 1. Percent moisture and percent ash versus cure time

In the full scale process, this final salt content will average 15.5% of the total hide weight.

If we resume the example begun in the first part of the paper, that the 81 pound hide coming into the hide plant weighed 60.5 after defleshing, demanuring, and trimming. After the brine cure and wringing, the hide will weigh 58.1 pounds and the salt content will have increased from 0.12 pounds per hide to 9.01 pounds per hide. Therefore, since no hide substance was lost in the curing process, the moisture lost by the hide will amount to (60.5-58.1) + (9.01-0.12) = 11.29 per hide.

This moisture loss occurs during the curing process and, since brine is continually recirculated to keep the raceway concentration at 95% of saturation, the loss shows up as a concentrated brine disposal problem. At concentrations of 95% of saturation, each pound of water holds 0.248 pounds of salt. Then 11.29 pounds of water will contain 2.8 pounds of salt, or stated another way, each hide cured results in a salt loss to the skewers of 2.8 pounds.

As a result of splashing from raceways and drippings from the hide conveyors, large amounts of brine are spilled on the floor of the hide building. A series of gutters carry this brine to a central sump. The contents of this sump are pumped across a static screen and the clarified brine is returned to the raceways after reconstruction.

At the end of the day's operation, it is necessary to wash the facility down to maintain acceptable sanitation conditions. Fresh water is used for washdown. In order to minimize the amount of salt discharged from the operation, the contents of the sump are pumped to the disposal system during this washdown period. The diversion of the floor drains to the disposal system is continued until the accumulation of brine during the last 24 hours has been eliminated.

The best run operations will have an average salt consumption as shown below:

	# Salt/Hide
Salt in Hide Substance	9.01
Salt added to folded Hide	1.50
Salt lost due to Hide Shrinkage	2.80
Miscellaneous Sewer Losses	1.19
Total	14.50 #/Hide

The miscellaneous sewer losses are primarily a result of clean-up operations. The floors must be washed down daily for sanitation reasons. Attempts have been made to use recycled brine for clean-up, but the grease content of the brine made the floors too slippery. So, during the clean-up process the sewers are diverted to the waste treatment system and the fresh water used for clean-up by-passes the salt reconcentrators.

From the above tabulation it is clear, then, that if a hide curing operation uses in excess of 14.5 pounds of salt per hide, there is an opportunity to reduce costs and waste treatment problems.

BRINE DISPOSAL ALTERNATIVES

An average analysis of the brine discharged from the hide operation is shown below:

	Effluent Analysis
Salt%	27.50
Total Solids%	31.04
Suspended Solids mg/l	13,800
Volatile solids mg/l	9,500
Grease mg/l	1,000
B.O.D. mg/l	3,900
C.O.D. mg/l	6,500
Total Nitrogen mg/l	600

The above analysis is sufficient to indicate that this is a difficult waste to handle. With sufficient dilution, the waste can be handled biologically, however, this waste will generally push the chloride concentration of the total slaughter plant effluent to levels between 750 mg/l and 1000 mg/l. At this point, the federal effluent guidelines have not addressed chlorides, but many state water quality standards are pushing for salt concentrations near 250 mg/l. In such cases alternatives must be found for treating the brine waste.

Since salt is completely soluble in water, no chemical means can be used to remove the salt from the brine. The newer developments of reverse osmosis and electrodialysis are suitahble for treating salt concentration of only 2000 mg/l or less and the technology has not been developed for the concentrations encountered in the brine curing discharge.

Two methods of mechanical evaporation have been considered. The first method of evaporation considered was submerged combustion. In this process, brine is contacted directly with the flame and high velocity air. In a pilot plant operation submerged combustion resulted in an extreme foaming problem that very quickly shut the evaporator down. There was a strong odor similar to burning hair that resulted in strenuous objections by those in the proximity of the test area.

A vacuum pan evaporator was also tested for this waste stream. Foaming was also a problem and fouling of the evaporator tubes was indicated to be a problem, but the system could probably be made to work. Our investigations indicated both the installed cost and the operating cost were extremely high and made this an undesirable alternative if any other alternatives were available.

There are two established disposal techniques that have been successful. In the Southwest, lined ponds sized for solar evaporation have been used. If there is a sufficient differential between rainfall and evaporation, the lined evaporation ponds are economical and present little difficulty in maintenance. Asphaltic membranes have apparently been the most successful, but the costs are significantly higher than the plastic membranes that are also marketed for this purpose.

In certain areas, deep disposal wells are also an acceptable disposal technique. There are underground strata that contain brine of compositions near that of the hide company brine waste. In the areas where such a zone is available, this should be the preferred disposal method.

ALTERNATIVES TO BRINE CURING

As indicated in the introduction to this paper, the only purpose of brine curing is to stabilize the hide during storage and shipment. The tanner doesn't want the salt. As can be seen from the previous discussion, he has significantly larger problems than the curing operator because the tanner has to soak out 9 pounds of salt per hide. In view of the increasingly stringent effluent limitations, it would appear that alternatives should be developed for stabilizing the hide.

There has been some work done that indicates that certain bactericides will give the hides a limited (in terms of days) storage life. Still others have worked with freeze drying to reduce the moisture content to levels that will give a good storage life. In South America it is common to let the hide dry naturally in the open air. This has little attraction for U. S. tanners.

The above approaches may work eventually, and maybe the finished product can absorb the additional costs, but, in the final analysis, none of the processes, including brine curing, add to the value of the hide. Added value should be the primary consideration when evaluating the alternatives to solving the pollution problems presented by the hide curing process. In this regard, several companies are bypassing the brine curing process and going to partial or complete tanning the hide.

While this discussion is not intended to be a treatise on the tannery process, a brief description of the process is in order. In the beam house, the hair is removed from the hide under alkaline conditions. An enzyme treatment is also used to remove the remaining bits of fat from the hide substance. The hide is then acid treated to stop the action of the lime, and is a pretreatment to tanning. This operation is called "pickling." At this point, the hide is stable and can be stored for at least 60 days without damage to the hide substance. There is both a domestic and foreign market for pickled hides.

If it is desired, the hide can be further processed through tanning. The tanning process involves treating the hide with a chrome, vegetable, or alum tanning solution to effect a permanent stabilization of the hide substance. The chromed hide must be kept moist, but with that precaution, the hide substance can be kept indefinitely without fear of spoilage.

Recent advances in technology have proven that tannery wastes can be effectively treated. The waste treatment process involves equalization, clarification with coagulant acids, followed by an extended aeration process. Tannery locations, however, must be chosen with care since State Water Quality Standards can preclude the use of even this very effective system.

SUMMARY AND CONCLUSIONS

Even with the best operating practices, a hide curing operation will discharge nearly 4 pounds of salt per hide cured. This salt loading will, when combined with a slaughter plant effluent, result in a combined effluent salt concentration ranging between 750 mg/l and 1000 mg/l, a level exceeding many State Water Quality Standards.

In certain areas, solar evaporation in ponds lined to prevent ground water contamination provides an acceptable disposal method for the brine discharge. In other areas, deep well disposal into brine bearing strata can be adopted.

In areas where neither of the above are possible, vacuum pan evaporation appears to be the best alternative, but the costs involved are extremely high.

It is postulated that the eventual solution to the brine disposal problems of the hide processor and concurrently a solution to the existing tanner/finisher's major waste treatment problem will be for the hide processor to produce either a pickled or tanned hide. In this manner, the majority of the salt problem is eliminated and in doing so, the value of the hide substance has been significantly improved. This added value concept should be a major consideration in this and all pollution control projects.

SECTION VII
HAIR REMOVAL AND PROCESSING
Monitored
by
Leo Orsi

The process of slaughtering hogs is accompanied by hair removal and processing. Generally the procedure is thus, the hog is put through a scalding tub for approximately five minutes at 54°C (130°F) to soften the hair. Next the carcass is run through the dehairing machine which scrapes and rubs the hair off. In this machine a pan or screen on the bottom catches the hair from which it can be disposed. A portion of the hair that comes off in the scalding tub remains there until that tub is dumped.

Some plants install a stationary or static screen to handle the overflow of water from the scalding tub and recover hair and toe nails. This hair mass is either dumped or some plants try to make proteins out of it. The normal way is to put it in a batch-type hydrolizer, break down the hair under pressure, and then dry it. One type of dryer is similar to a feather-type drier used by the poultry industry. Generally not too much water is used in the dehairing operations. The economics of recovering the hair results in a profit. Since the protein values have gone up, this material now sells at $200 a ton.

Various techniques for the removal of hair are being used. The water has to be hot enough to penetrate the hair to the point where it is attached to the skin. The hair is enclosed in the hair follicle socket and held by a glue-like substance which has to be heated and softened to enable the hair to be pulled out. Not too much water is necessary in this process, but a lot of heat is. Some plants add certain chemicals to these scalding tubs to increase the dehair operation. Lime retards the odors and decomposition of wastes in the tubs and allows the use of the scald water longer. The real science is to have good control of the temperature and to see that the equipment is in proper condition. Disposal of the scald tank contents poses a problem; dumping just compounds the problem.

More information needs to be available on the savings that might be had in water and waste management if the hides are pulled rather than dehaired. A substantial saving in hot water and energy might be realized, but plants will not be changed unless it proves to be economically feasible.

SECTION VIII
EVISCERATING, EDIBLE OFFAL AND TRIMMING
Monitored
by
Don Dencker

Past and present practices in the hog kill operation usually entail the use of large quantitites of potable water to wash the product, to maintain cleanliness during production hours, and clean-up of the equipment and work areas. In a typical hog kill operation, certain edible offal and other products are removed which require extensive cleaning and washing to meet the current sanitation requirements of APHIS. The individual quality control requirements of the company may also dictate that significant amounts of washing and sanitation be employed which result in the generation of additional wastewater. Great emphasis is being placed on meatpackers by the EPA to reduce water consumption by practicing extensive dry cleaning methods before hosing and strict management and control over housekeeping and water use practices.

The EPA has established water use guidelines for the "Best Practicable Control Technology Currently Available." The achievement date is July 1, 1977, and by July 1, 1983, more restrictive guidelines to control water usage are to be employed.

It is agreed that water use controls are desirable but the industry questions some of the methods suggested. This is a competitive industry, subject to national union wage scales and it would be extremely difficult to get the management in large plants to substitute labor intensifying practices for water use. Labor intensifying means extra hours of work by a cleanup man and this, because the current hourly rate, including fringes, amounting to $7/hr will cost more money to the company. Using a typical cost for water and sewer charges as $0.16/1000 liters ($0.60/1000 gallons); a plant would have to save 44,300 liters (11,700 gallons) of potable water to justify one additional hour of labor. This is an equivalent saving rate of 738 liters (195 gallons) per minute. A more favorable picture is presented for hot water where the saving rate must be 330 liters (87 gallons) per minute based on $0.36/1,000 liters ($1.35/1,000 gallons). Water saving costs should be built in either initially, or by modification - not by promoting unrealistic labor practices in this competitive industry. Production employees should be expected to turn off all the water outlets when not in use. If it can not be made part of their job, it will be difficult to conserve water.

The following are a few water saving modifications that may be instituted in the plant operations. If there are no objections from APHIS the hog rail polishers should be considered for elimination. This machine does very little to remove hair and consumes large quantities of water. If this is not acceptable, water volume can be reduce by partially closing the manifold valve, using more effective nozzles, and adding a trolly-activated switch so that the water is turned off the chain stops or when no carcass is passing through the polisher. Another suggestion is to relocate shaving area spray nozzles to where they would be more effective. In other words, use the water where and when it is needed. The final carcass showers could be redesigned with more efficient nozzles and the bottom sprays turned off after the large sows have passed through. Self-closing spray nozzles could be provided for stickers and head droppers to reduce the amount of water which gets mixed with blood to be reclaimed. Common sense should be used at the viscera table. Sprays on these pans should be used only for one revolution at the end of the day to rinse the material from the pans, and then be reactivated only at the end of the cleaning and sanitizing operation during evening sanitation. Hearts are currently processed by putting them through a slasher, then through a drum washer, then hand slashed and mechanically washed in a tumble washer. Tests should be conducted to determine if the hearts could be passed through the slasher twice and then put directly in the tumble washing, eliminating the drum washer and the hand slashing operations. This heart washer operation uses huge amounts of water. Operating supervision is needed to insure this is done solely on a full batch basis with less washing time. The automatic neck washer should be modified by using a spray head to spray the carcass directly instead of spraying it with water released through holes in the revolving drum. The water should be turned on only when a carcass is being brushed. These are what may be called after-the-fact modifications.

Equipment modifications have been successful on different operations. Three will be cited. Visera pans are mounted on a moving conveyor. These hold the animal intestines for inspection before processing. Between each use they are initially rinsed to remove clinging meat, sterilized with 82°C (180°F) water and finally chilled. All of this is clean potable water. Another viscera oriented operation is the gut-snatcher which moves along with the viscera pan on a separate moving platform. The operator stands on this and moves with the carcass as he places the viscera in a pan. This moving platform is also continuously sterilized to meet government regulations. These sterilizing operations are loosely designed by the equipment manufacturer and can waste 378 liters (100 gallons) of water a minute. In Madison, at Oscar Mayer, one viscera line was using 738 LPM (195 GPM) of 1/3 hot water and 2/3 cold water and it was modified down to 340 liters (90 gallons) per minute by the selection of proper nozzles. One pan of spray headers had the hot sterilizing spray nozzles only 8 centimeters removed from the cold pan chilling spray nozzles and consequently did not raise pan temperature properly for sterilization. This assembly was replaced with one that greatly decreased the water consumption while concurrently properly sterilizing the pans.

The sterilizing and cooling spray locations were separated about five feet and high-atomizing low-volume nozzles were installed to get better cooling with less water. While making changes, care was exercised to make certain that the production function was not adversely affected.

Washing equipment manufacturing companies and spray nozzle manufacturers are willing to come to the plant to help with particular problems. Their field is small and they are dependent on this type operation.

A second area of water wasteage has been the chitterling processing department. The saving of chitterlings is still carried on in many plants. These are large intestines which are sold for human consumption as edible products to a limited market. Prior to 1959 they were washed manually using 1325 liters (350 gal)/min of primarily cool rinse water. Wages were then $2 to $2.25 per hour as compared to the current $7.00 per hour which was mentioned previously. As wages rose automatic machines were installed and raised the flow volume up to 1892 liters (500 gals)/minute for the same amount of product. Thus 568 liters (150 gal)/minute were added to eliminate a few job positions which was a justifiable saving to management. Attempts to reduce flow by the selecting proper spray nozzles to limit usage and locate them so they would do what was intended cut water use back to 1140 liters (300 gal)/min. One chitterling department in a slaughtering plant still can use up to a quarter million gallons per 8-hour shift and clean-up. This accounts for about 20% of the total flow from a hog slaughtering operation.

A third operation modified was the stomach washer on the kill floor. This operation increased from 170 liters (45 gallons) per minute up to 416 liters (110 gal)/min with automation, or more than double the original flow. With proper nozzles it was reduced back to 303 liters (80 gal)/min. Here is a case where automation, trying to make more profit for industry, caused an increased flow of 132 liters

(35 gal)/min, which in many operations the cumulative effect can be a huge volume. Also, the improper operation of any one unit can offset any savings gained throughout the entire kill floor. Kill floor equipment is not usually designed for water saving and one may be forced into an increased flow system for some time because of a better labor saving operation which has been economically justified.

It is important that direct responsibility be designated to a certain foreman or individual to ensure that all washing sprays are turned off, especially during breaks, lunch periods, etc., because leaving them on for 20 minutes while not operating wastes many hours worth of water saving in other areas. Reducing water consumption is a team effort and has to be done with production and management cooperating. No on individual can do it by himself.

SECTION IX
PAUNCH AND VISCERA HANDLING
Monitored
by
Jack L. Witherow and Stanley Lammers

PAUNCH HANDLING AND PROCESSING

Introduction

Paunch handling and subsequent processing of the paunch manure can result in large financial and environmental costs. The selection of the handling method largely determines costs and the processing techniques. There are three handling systems and over a dozen processing techniques. Though the slaughtering of swine, sheep and beef all require paunch handling, this discussion is limited to the major waste source, beef slaughtering. There are over 35 million head of beef slaughtered annually in the United States which results in over 1.7 billion pounds of paunch manure to be handled and processed per year.

Paunch manure is the partially digested feed contained in the rumen, first stomach. Fresh paunch manure is a yellowish-brown color containing recognizable fiber and grain and has an obnoxious odor. The material is acidic with a pH ranging from 5.6 to 7.0. Even with its 85 percent water content, only minor solid-liquid separation will occur on standing.

Baumann reported[7] the wet weight and dry weight of paunch manure averaged 23 kg (54 lb)/animal and 3.8 kg (8.5 lb)/animal, respectively. On a large number of determinations on paunch manure, mean values were Chemical Oxygen Demand (COD)-177,300 mg/l and five day Biochemical Oxygen Demand (BOD_5)-50,200 mg/l. Standard deviations were 38,500 mg/l for COD and 13,400 mg/l for BOD_5. Other data[33] show a BOD_5 of 40,000 mg/l and a BOD_{33} of 104,00 mg/l with 85 percent of both values resulting from the water soluble portion. The first stage carbonaceous oxygen demand was complete in 33 days after which nitrification began. Dehydrated paunch manure when placed in water had a BOD_5 of 20,000 mg/1000g and a BOD after 131 days of 366,000 mg/1000g of dried material. There was no sign of nitrification at 131 days. Paunch manure has such an extended oxygen demand that the BOD_5 is less than 40 percent of the carbonaceous oxygen demand.

Waste loads from packinghouses are compared on the basis of Live Weight Killed (LWK). All sewered wastes from a packinghouse average 12 kg BOD_5/1000 kg LWK. Paunch manure has a BOD_5 of 2.5 kg/1000 kg LWK and can constitute 20 percent of the waste load from a packinghouse.

Energy measurements on dried paunch material made with a Parr Oxygen Bomb Calorimeter gave an average value of 4000 cal/gm or 7200 BTU/lb[25]. The nutritional analyses on dehydrated paunch[7] are tabulated below:

Composition of Dehydrated Paunch

Item	Mean (%)	Std. Dev.	No. of Dtm's
Moisture	6.8	1.9	96
Protein	12.7	1.5	88
Fat	3.1	0.6	86
Crude Fiber	26.2	3.2	88
Calcium	0.6	0.1	60
Ash	7.2	0.7	88
P_2O_5	1.5	0.3	60
Carbohydrate	40.8	5.3	44

Handling Systems

The method of handling paunch is dependent upon the disposal media. The limitations in handling and disposal are shown in Figure 1. Essentially there are only four places paunch manure can be put, these are: the air, the water, the land or by-products. The systems of paunch handling are classified as no-dump, wet-dump, and dry-dump. All three systems are used in the industry. In the no-dump system the paunch sack is left unopened and both the sack and the paunch manure are sent to rendering. In the wet-dump system, the paunch sack is sliced open and the contents are water flushed from the sack into a sewer. In the dry-dump system the paunch sack is sliced open and the contents are dumped and transported from the plant in a separate non-water carriage system. The emptied sack is then rinsed and the rinse water goes to the sewer. In the wet-dump or dry-dump systems, the sack is sent to rendering or is used to produce tripe.

No-Dump System

When the paunch sack is not dumped, the contents and sack are sent to rendering and become part of the meal by-product. Sending paunch manure to the rendering lowers the protein content of the meal, increases the percent of water to be vaporized, discolors the greases and increases the odor control cost. The potential use of the paunch sack for production of an edible product (tripe) is also lost. Because of these negative economic factors, the no-dump system has been practiced only on condemned paunches which is a minor percent of the viscera rendered.

The no-dump system does eliminate the cost of transporting, processing, and disposal needed in the other methods of handling. From all sources the inedible dry rendered tankage amounts to 15 kg (33 lbs) per steer (at 16 percent fat plus moisture). Thus the addition of 3.8 kg (8.5

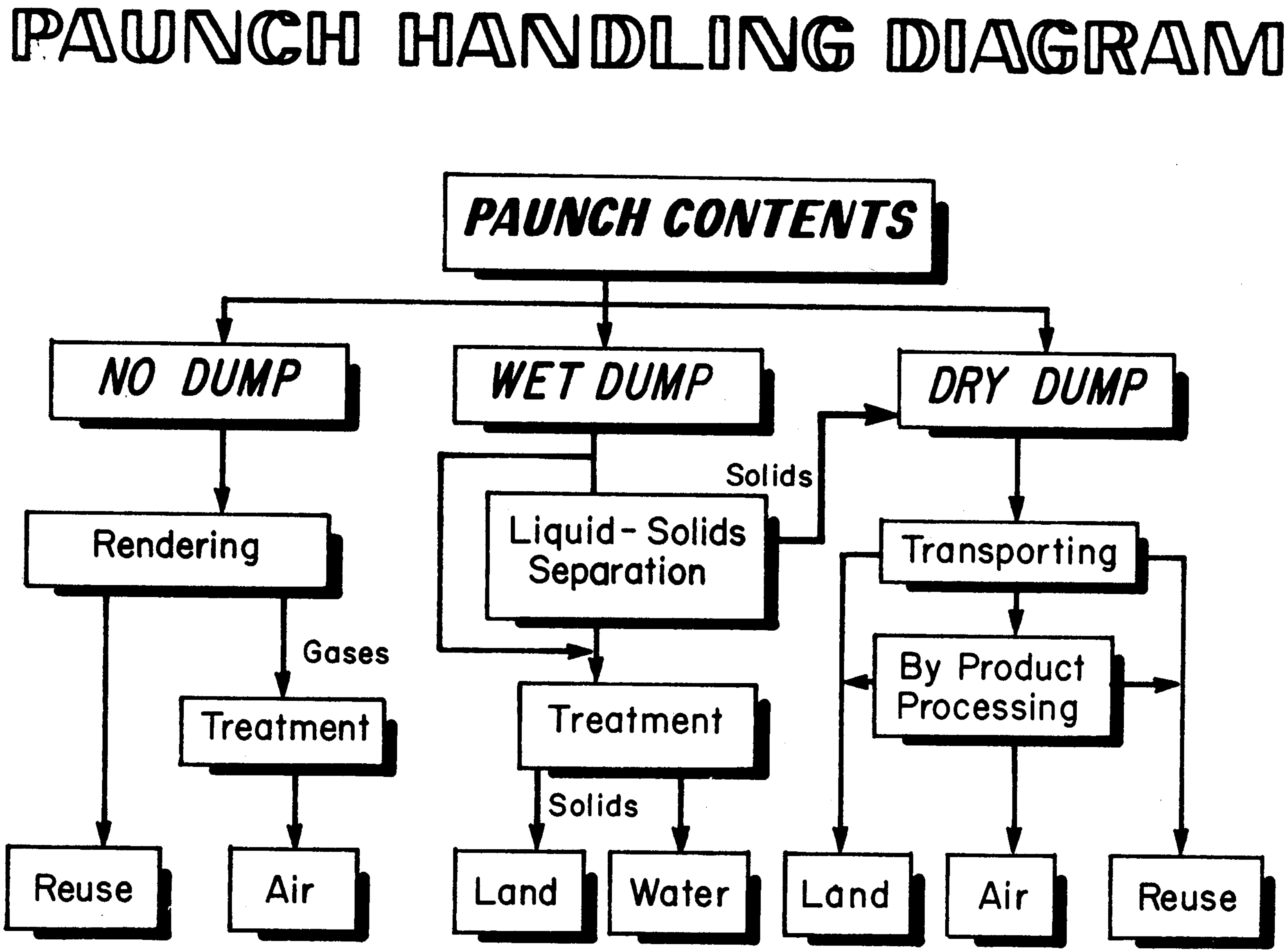

Figure 1. Paunch handling systems

lbs) (at 8 percent moisture) of paunch contents is 25 percent of the meal and reduces the protein content by 7.5 percent. At 6.25 times the nitrogen content, the meat meal is 92 percent protein, and the combined bone and meat meal is 52 percent protein. Cost penalties occur if the protein content of the meal drops below 50 percent. Operation of the rendering units can minimize the discoloring of grease. Thus the loss of an edible product (10 kg (22 lbs) of tripe/steer) and vaporizing of water (21 kg (47 lbs)/steer) are the major economic factors. In plants where tripe is not produced, the no-dump system may offer opportunities especially if other costly paunch processing systems are required.

Wet-Dump System

The sluicing of paunch manure with spray washer is undoubtedly the poorest system from the viewpoint of pollution control. Nevertheless, a 1967 survey by Camin[12] showed that 84 percent of the industry employed the wet-dumping system. Sending all the material for treatment was practiced by 13 percent of the industry. Liquid solid separation with off-site disposal of the solids was practiced by 70 percent. Using a water carriage system will result in between 60 and 85 percent of the BOD_5 and about 5 percent of the fine solids passing through the typical screens used for solid-liquid separation. This material loss to the treatment system will be 2.0 kg. BOD_5/1000 kg LWK and 0.4 kg Susp. Solids/1000 kg LWK.

Paunch manure is untreatable in a conventional sewage treatment plant[18] for the following reasons: (1) the manure solids settle out and tend to harden to the consistency of low density rock, (2) the solids clog hopper bottoms, pits and pump suctions, (3) augering can be required to remove the solids from pipelines; (4) the cellulose material will not decompose in digestors and forms straw blankets which clog and eventually fill digestors, and (5) the entrapped moisture in the cellulose material can not be dewatered by vacuum filters.

The use of vibrating, rotating or stationary screens serve a most valuable function in separating the solids for transport to ultimate disposal. Without screens the wastewater treatment system must include specially designed liquid-solid separation, solids handling and stabilization facilities. A system such as this contained enlarged grit basins with mechanical scrapers, a paunch holding tank to periodically "blow" the paunch solids through an air conveying line and disposal lagoons.

The moisture content of screened solids is essentially the same as dry-dumped paunch manure. The cost of handling the screened solids will be essentially the same as that of dry-dumped solids. However, with the wetdump system, extra costs will be incurred for the water carriage system, the water, the screens, and most significant, the treatment of the soluble BOD. The carriage water must have a high degree of treatment to be discharged to receiving waters. The required treatment will necessitate not only reduction of the oxygen demand, but also separation and disposal of the paunch fines and biological solids produced in treatment. The wet-dump system is no longer the most economical one because of the increased treatment costs.

Dry-Dump System

The dry-dump system is replacing the wet-dump. The dry-dumped paunch will have a moisture content of 85 percent. The elutriated paunch solids in a water carriage system when separated on screen have an 81 to 82 percent moisture content. The dry-dump handling system can incorporate the same transporting and processing methods used for screened paunch solids.

Transporting paunch solids out of the plant has run into problems when pumps and pipelines are involved. The solids tend to plug the line and pump intake facilities. Two transporting methods which have been found satisfactory are a screw conveyor and an air energized system in which the material is intermittently blown through a pipeline. Paunch material has been successfully blown 200 meters (700 feet) with an elevation increase of 14 meters (45 feet). If the material is transported away from the plant site without processing, it is commonly moved in specially designed trailers. The trailer must prevent spillage and is commonly shaped like a tank truck with a covered top to contain odors and a rounded or sloped base to prevent paunch solids from sticking in the corners.

Processing Systems

Though the future for paunch handling is seen as the dry-dump system with auger or "blow" transport systems, the method of processing and disposal media is far from clear. Technology on a series of processes and operations has been developed on paunch manure over the years and the potential is noteworthy for transferring technology from agricultural investigations on animal manures. A tabulation of paunch processing technology with a brief description of individual operations follows:

Paunch Processing Technology

Process	Operation	By-Product
Stabilization:	Surface Spreading	Soil Conditioner
	Subsurface Spreading	Soil Conditioner
Mositure Transfer:	Mixing with Refuse	Land Fill
	Lagooning or stockpiling	Land Fill
	Mixing with Feeds	Feeds
Thermal Drying:	Rendering	Feeds
	Rotary Dryer	Feeds
	Fluid Bed Dryer	Feeds
	Solar & Air Drying	Feeds

Mechanical Dewatering:	Presses	-------
	Screens & Filters	-------
Thermal Conversion	Incineration	Gases & Ash
	Pyrolysis	Fuel & Chemicals
Biological Conversion:	Composting	Soil Conditioner
	Ensilage	Feeds
	Single Cell Protein	Feeds
	Digestion	Methane
Physical Conversion:	Board Mill	Wall Board

Surface Spreading

Chittenden[13] has reported on a surface spreading system containing a screw conveyor, a prebreaker, a blow tank, pipelines, an elevated storage tank and a specially designed spreader truck. The truck has a V bottom tank with a screw in the bottom and a knife valve at the back. A spinning plate below the valve spreads the paunch as the truck moves across an agricultural field. The truck holds 10 tons metric (11 tons) which can be spread in 10 minutes. Application rates of 6.7 tons metric/ha/week (3 ton/acre/week) have been used on one field for up to five months. During the Nebraska winters it is possible to spread on all frozen fields, but in the springtime during muddy conditions, it is necessary to spread on grassland.

Odors and flies are a problem during warm weather. Discing the field and the addition of an insecticide have been helpful. The quality of the surface runoff or ground water from these fields has not been evaluated. The spreading was done by a local landowner at 4 cents/animal until his truck was paid for, after which the cost was reduced to 3 cents/animal.

Subsurface Spreading

Smith and Gald[28] have reported on subsurface injection of sludges and have done work on adapting the equipment to handle paunch manure. The injectors can be operated at depths ranging from 8-25 cm (3-10 inches). Sewage sludges are fully covered with an operating depth of 8 cm at 530 lpm (3" at 140 gpm) discharge and with a depth of 10 cm at 760 lpm (4" at 200 gpm). Application rates up to 100 dry tons metric/ha (45 dry tons/acre) have been achieved in nine applications over a two-month period. The machine has been used with sludges having solids content up to 10 percent and could be adapted for sludges with a 20 percent solids content.

The reported advantages are: elimination of odor and fly problem; minimization of contamination of runoff water; addition of organic matter to the soil; solids can be handled without dilution or drying; and elimination of viewing by the public. The costs range from 2 to 4 cents/1000 liters (8 to 15 cents/1000 gallons) for injections of sludges at a 5 percent solids content. The disadvantage is that injection is not practical in frozen high moisture soils, and paunch holding facilities during winter operations have not been tested. Smith has proposed storage and operational schemes to handle this problem.

Mixing with Refuse

Paunch manure causes problems when placed in sanitary land fills, in that the high moisture content of the material makes the fill unstable and solids come to the surface. Sioux City, Iowa officials have been successful in land filling paunch when it has been incorporated with brush. Paunch mixed with discharged wood chips, used in the holding pens to adsorb droppings, has also been satisfactorily disposed of in land fills. Since paunch manure has a tremendous oxygen demand, land fills in which it is placed should be constructed with ground water protection.

Lagooning or Stockpiling

The South St. Paul, Minnesota municipal treatment plant separated paunch solids in a grit chamber and disposed of the solids in a large lagoon with sealed bottoms and sides. The solids would lose moisture and become firm enough to walk upon. However, the material had to be removed prior to enlargement of the plant as it was not stable enough for construction. The lagoon storage resulted in nuisance complaints due to odors.

Stockpiling is a process of transfer of the moisture to land or air. The moisture content can be lowered by 2 to 5 percent by drainage of free water if stockpiled a few hours, and up to 65 percent by evaporation over several weeks. Odors, flies, and precipitation are problems. Because the major part of the BOD of paunch is water soluble, drainage or precipitation coming from the stockpile must be prevented from entering surface or ground waters.

Mixing with Feeds

Mixing fresh paunch with dry feeds materials utilizes the paunch juices to raise the feed to the desired moisture. This saves the energy required for drying the paunch for feeding. Nutritionists have proposed the feeding of fresh paunch as a part of the animal's diet. Both horses and beef cattle have been observed feeding on fresh paunch manure when dumped in their pasture. An Iowa farmer is reportedly feeding swine on fresh paunch manure. He feeds the material in troughs in a pasture to control nuisance conditions. A longer than normal time period is needed to fatten the swine from 40 to 100 kg (90 to 220 pounds). The known examples of mixing wet paunch with feed materials are to produce silage. Production of silage is both a moisture transfer process and a fermentation process to improve the digestability of the product and is described later in this section.

Rendering

Rendering of paunch manure is essentially dehydration accomplished in dry rendering units. In the no-dump system or when paunch manure is mixed with fatty materials rendering units are necessary. If the paunch manure is dehydrated separately then specially designed dryers are more efficient.

The rendering of paunch most likely brings to mind the unsuccessful application of the Carver-Greenfield process at Omaha, Nebraska. The rendering plant was designed to receive the combined skimmings and the settled solids from the 60,000 m^3/day (16 mgd) of raw wastewater from 19 packinghouses. These materials were ground to a particle size of 13 cm (1/8 inch) or less, slurried with a fluidizing animal oil at a ratio of 6 parts of oil to 1 part dry solids. The slurry was metered to a triple-effect, falling film evaporator where the water was removed under steam heat and vacuum. On leaving the evaporators, the dry fluid slurry of oil and solids entered a separation system. A portion of the separated oil was returned to the fluidizing tank and the other portion to finished oil storage tanks ready for marketing. The solids are transferred to storage silos for use as a feed supplement or fuel. The system fell short of expectation; recovered grease is so degraded that the output is disposed of in a land fill. Omaha's current litigation is not over equipment reliability but over the value of the grease produced.

Rotary Dryers

An EPA demonstration project[7] successfully dried paunch manure in a gas-fired rotary dryer. The total cost was \$38.46/dry ton of paunch or 16¢ per animal. Capital cost for the dryer and housing was \$85/animal slaughtered/day. In terms of the BOD removed, the cost was 8¢/lb of BOD_5. Cost of BOD removal in a waste treatment plant ranges from 5 to 10¢/lb of BOD_5. Two problems of the process were odor control and a limited market for the dried feed material. The packer has installed a scrubber for odor control and a pelletizing machine to increase sale of the dehydrated paunch. The EPA report[7] recommended research on the use of dried rumen as an animal feed additive. The packer, the manufature, and EPA have been carying out separate feeding trials. The packer participated in a feeding program on hogs and reports all the material is now being sold for feed.

An EPA project[30] with Oklahoma State University utilizing dehydrated paunch manure as a feed supplement in channel catfish farming has been completed. The feeds which contained by weight either 10, 20, or 30 percent paunch were formulated to be isonitrogenous and isocaloric. The growth rates of the fish were compared with those that were given standard commercial feed in both pond and cage cultures. In pond culture, the growth rates and the yields per acre of the fish receiving 10 percent and 20 percent paunch-containing feeds compared favorably with that of the control fish. However, growth rate and yield per acre decreased significantly when 30 percent paunch containing feed was used. In cage culture, the only experimental feed used was a floating pellet feed containing 10 percent paunch. Fish in cages where this feed was used also had growth rates and yields which compared favorably with controls where standard commercial floating pellet feed was used.

Monitoring water quality showed that neither the pond culture nor the cage culture had caused deterioration in water quality in the ponds to any appreciable degree in one growing season of 24 weeks.

The manufacturer of the rotary dryer is developing the economic feasibility of drying and feeding a mixture of fresh paunch contents and whole blood[24]. Mixing the two gives a product with a protein content of 43 percent and requires the use of only one dryer for small and medium packers. Feeding trials on the product have been conducted utilizing feedlot cattle[20]. The paunch-blood meal was concluded more valuable than cottonseed meal in cattle feed. The total economic benefit should include not only the resulting feed values but also the cost of otherwise disposing of the paunch. A large packer is presently installing this drying system and will use the product in a cattle feed. Reece and Wesley[26] conducted field and laboratory experiments using blood meal and paunch blend in channel catfish diets and found that the fish readily accept the blend as a principle protein source. The investigator concluded that the blood meal-rumen contents blend has value as a partial or complete substitute for fish meal in commercial catfish rations.

Fluid Bed Dryer

The two common technical problems with dryers are odor problems and fouling of the heat transfer surface with dried material. A manufacturer claims[25] to have successfully piloted a fluid bed dryer that solves both problems. The unit incorporates a cylindrical fluidized bed of silica sand with a fluidized bed of the same material in a jacket around the outside. High temperature gases pass through the outside jacket and transfers heat to the fluidized solids. The wet paunch manure fed to the center of the dryer is dried as the paunch manure floats up through the interior fluidized bed. Thus, the paunch manure is not in direct contact with the heat exchanger surfaces. The gases from the drying operation are deodorized by incineration. The dried material can be used as a fuel or as a feed component.

Solar & Air Drying

Fuel costs for drying paunch manure in a rotary dryer were $8/ton of dehydrated paunch or 3.5¢/animal[7]. Thus if air drying or solar energy replaced this source of heat, fuel costs would be eliminated and the potential for lower total cost increased. Yin and Farmer[34] have reported on pilot investigations of both methods. One common difficulty is the surface layer of the material dries rapidly, forming a crust, after which the underlayer remains wet for a long time and becomes moldy. When turned daily, a 10 cm (4") layer of paunch was air dried within a week and the dehydrated product (16 to 20 percent moisture) was stored in burlap bags for months without spoilage. Problems encountered in air drying were (1) the rewetting of the paunch by precipitation through the open sided drying shed and (2) the production of flies and odors. These problems were elimінted with the construction of a solar still for drying. However, the crust formation still occured and required the development of a mechanical device to turn the material several times a day.

Horsefield[19] tested a small air-supported solar dryer in which fresh dairy manure at 80 percent moisture content was placed. The fan supporting the clear polyethylene cover provided an air exchange of 4 to 6 cfm per square foot of manure surface and at no time was condensation ovserved on the underside of the cover. Stirring several times a day of the extremely wet material was necessary to prevent a crust from forming on the surface. Flies were killed with an electric grid over the exhaust port. During the test, the daily solar radiation was 2000 BTU/sq ft/day and the ambient temperature was 32°C (90°F). The dryer converted 60 percent of the incident solar radiation energy to water vapor. The moisture content of the manure was reduced to less than 10 percent. Drying times and size of the solar dryer computed for the climate in Lafayette, Indiana, indicated economic feasibility.

Presses

In the past, dewatering paunch manure by mechanical means has been considered economically advantageous to thermal drying. For the same reduction in moisture mechanical dewatering is less expensive than fuel fired drying. However, juices which can be pressed from paunch are reported as having a BOD_5[5] of 100,000 mg/l[13]. This is equivalent to .23 kg (0.5 lb) BOD_5/animal for each 10 percent reduction in moisture content obtained. The present sewer charges in Chicago, IL influenced one packer to eliminate presses and go to a dryer.

Paunch solids contain straw and fibers which expand after compression and have a felt-like interlocking texture. These characteristics cause clogging in most dewatering equipment. Among these were presses, screwfeed wringers, and centrifuge mechanisms. Presses used in other industries were tried including paper pulp presses, wine presses, and sugar cane presses. The most successful equipment was a press used by the brewing industry to dewater spent grain. A continuous feed device, it employs two rotating perforated disks. The disks face each other at an angle so that the spacing is wide at the tope and narrow at the bottom. Material fed in at the top is compressed by a wedging action as the disks' rotation carries it downward. Moisture escapes through the perforations. Moisture reduction of up to 30 percent was accomplished.

Another investigator[25] found that both a three roller mill and a modified screw press could dewater paunch manure to a solids content approaching 40 percent. A conventional screw press was field tested, but the machine failed before any dewatered paunch was discharged. Failure was due to an overloaded motor. An improved design, which incorporated an expansion zone to compensate for the paunch swelling action after compression, reduced the drive and motor requirements. This machine was tested on paunch manure (18 percent solids) and dewatered the material to 38 percent solids. The liquid underflow stream contained 3.5 percent solids. A three roller machine was tested and after some development, the solids stream from the rollers reached 37 percent but the liquid discharge contained 6 percent solids. The screw press was selected because of the lower solids concentration in the liquid stream leaving the press.

Filters and Screens

The general use of this equipment is to separate solids from carriage water in a sewer. A laboratory and pilot scale investigation[25] was carried out on a sand filter and screen. Several types of application to the sand filter were investigated, but the increase in the concentration of solids was only 7000 to 8000 mg/l. Utilizing the 10 pounds/square inch of pressure increased the filtration rate from under 0.14 $l/sec/m^2$ to 1.19 $l/sec/m^2$ (0.2 gpm/sq. ft. to 1.75 gpm/sq.ft.), but solids content could not be increased above 19 percent. Evaluation of a static-angled screen showed the paunch solids could be dewatered to 18 percent solids on this equipment. The filter and screen did not significantly increase the solid content of paunch manure above the 15 percent found in the rumen.

Incineration

Paunch incineration has been considered where urban location has resulted in costly or prohibited truck transportation or municipal treatment, or where disposal of several solid wastes is necessary. Omaha officials had an engineering design prepared to utilize a rotary kiln incinerator.[18]

The incinerator was to be operated at 649°C (1200°F) and the exhaust was to be used to preheat the solids. The exhaust was to pass through a scrubber and the ash sluiced to a nearby lagoon. (A subsequent design utilizing a rendering process was selected).

A Chicago packer undertook design and construction of a fluid bed incinerator with 60 percent financing under an EPA demonstration grant. The packer ceased slaughtering prior to construction of the incinerator. A major packing company submitted an application to complete the project. The project incorporated a fluid bed dryer and fluid bed incinerator. The fluidized bed dryer was to operate at 104°C (220°F) and to increase the solid content to 37 percent. The gases from the drier were added to the incinerator above the fluidized bed to destroy odors. The incinerator was designed to burn the dried paunch manure on a one shift/day basis. Pen manure, waste fat, waste paper, trash, etc., were to be burned on other shifts. Incineration is self sustaining when the solid content of paunch manure is over 30 percent; however, auxiliary fuel injection was planned to insure operation at 1350°F. A water scrubber was to be used on the exhaust of combined vapors. An offer of funds was made, but price increases for the paunch dryer, incineration and auxiliary equipment raised capital costs to $400/animal slaughtered/day and the packing company went to a land spreading system. The packer estimated the annual cost for capital and operation of the dryer-incinerator system to be double that of a surface spreading system.

A packer in Louisiana has operated a dual chamber incinerator for several years. This package unit has a rated capacity for 612 kg/hour (1350 lbs/hour) of rubbish at 50 percent mositure and a 7 million Btu/hour heating capacity. A conveyor takes a mixture of solid wastes into the primary fire chamber. Uncombusted solids or gases are burned in a second chamber containing an after-burner. A high speed blower is used to support complete combustion. The incinerated material includes hog hair, flotation skimming, paunch manure and pen manure. The paunch solids are not dried but mixed with other wastes prior to incineration.

Pyrolysis

Pyrolysis differs from incineration in that it involves heating without oxygen. The basic purpose is to decompose complex organics to simpler materials. The major potential of the process is that by-products could be sold to reduce operating costs. A recent pyrolysis study[17] using steer manure separated a variety of alcohols, aldehydes, ketones, acids, amines and phenols. The by-products were valued at 2.2 to 4.4¢/kg (1 to 2¢/lb). Break-even pyrolysis eocnomics would be achieved only if the pyrolysis product has a value of 18¢/kg (8¢/lb). This breakeven point on manure is at 80 percent moisture which is near that of paunch.

Composting

The process is a biological degradation of organic material under aerobic conditions into a relative stable product. The product is most valuable for its moisture retaining and humus forming properties. It contains 2 percent nitrogen, 1 percent phosphoric acid and many trace elements[10]. The controlling parameters for the process are complete mixing, uniform particle size, aeration, moisture content, temperature, pH and carbon/nitrogen ratio in the raw solids. Nell and Krige[22] have successfully composted paunch manure mixed with pen manure. The following conditions were found necessary: (1) moisture conditions of the mixture must not exceed 70 percent; (2) pH of the compost must not exceed 8.5 during the first 2 days; (3) aeration must be controlled to give a residual oxygen concentration between 5 and 10 percent; (4) initial C:N ratio must be between 20:1 and 30:1; (5) fresh pen manure must be used; (6) mixing should not be continuous; (7) prefermentation needs four day detention; and (8) complete maturation occurs in 133 days. Whereas composting does stabilize the material, there is a limited market for the product in the United States. A commercial paunch composting process is in operation near Austin, Minnesota, with-out reported fly or odor problems.

Ensilage

Chittenden[13] reported successful ensilage and refeeding of a mixture of paunch and ground cornstalks. A layer of cornstalks was put in a bunker silo and paunch spread over the top. The mixture was compacted in the silo. Several layers of cornstalk and paunch manure were used to fill the bunker. Paunch was added to bring the mixture up to between 65 and 75 percent moisture. The cornstalks reached a low of 8 percent moisture and considerably more paunch than cornstalks was used on a wet weight basis. Tramp metal in the paunch can present a problem in refeeding, but metal suspension with a magnet has been accomplished. Refeeding of the material required a four to one ratio of cattle on feed to cattle slaughtered per day.

Utilizing cornstalks in the silage restricts the operation to the annual harvest season. To overcome this limitation ensilage of paunch with sugar beet pulp pellets and corn was tried at a 7.5:1.5:1.0 ratio in a bunker silo.[13] The beet pulp expanded as it absorbed the paunch liquids and broke out of the bunker silos a time or two. However, a more serious problem was the limited acceptance by the cattle. The problem was diagnosed as acidosis and solved by the addition of sodium bicarbonate to the silage. Another packing company has proposed the ensilage process utilizing paunch manure and grain (mainly corn) in closed vertical silos. Feeding high moisture corn to feeder cattle is practiced to improve feed conversion efficiencies. The vertical silo offers mixing and handling equipment and a controlled atmosphere.

Transferring technology developed for cattle manure ensilage offers opportunities. Anthony[5] has demonstrated ensilage of fresh animal manure and ground grass hay in the ratio of 57:43 as a feed for ruminants. Feeding trails have established the value of the silage when used in a feed for fattening yearling steers.

Single Cell Protein Cultures

Bench scale experiments have been encouraging in conversion of food processing waste into single cell protein for animal feeds. The processes usually incorporate sterilization and inoculation with selected biological strains followed by cell growth, cell separation, cell drying and incorporation in an animal feed. The potential of these processes comes from the limited energy costs for cell growth. Sterilization when required, oxygen input, and cell separation are the major technical or economic constraints of the processes. Single cell protein conversion of paunch manure has been accomplished in the laboratory using several strains of Fungi Imperfecti. The larger fungus cells can be more easily separated than bacterial cells. Technical development of a single cell protein culture on animal manure has progressed to the point of a fullscale demonstration by a major corporation[23]. None of the processes has been demonstrated on paunch manure.

Digestion

The digestion of paunch manure was first reported by Boruff[6] in 1933. In a specially designed pilot plant he stabilized cow paunch manure fed continuosly at a rate of 4.5 grams dry weight per day per liter (0.28 lb/cu ft) of digestor capacity. The stabilization of the material furnished 1.3 volumes of combustible gas (61 percent methane)/day/tank volume. The residues withdrawn at the end of the 122 day experiment were not odorous but were very fiberous owing to the presence of undigested cellulosic material. The residues were 12 percent solids on a dry weight basis and constituted 2/3 of paunch manure added. The results of this experiment have been verified many times since 1933. Anaerobic lagoons (digestors) which receive paunch manure are dredged after several years of operation to remove the undigested cellulosic material in order to restore detention times and removal efficiencies. Historically, the value of the gas produced has not warranted the cost of its collection from lagoons.

Board Mill

Production of building material has been explored with food processing waste solids, pen manure and paunch manure. The production of wallboard under the trade name Celotex is produced in large quantities from bagasse. Bagasse is a solid waste from the production of cane sugar. One of the major packers developed a process for production of wallboard from paunch manure. The process was never utilized. The wallboard would give off an odor it if became wet which might occur with a leaky roof or broken waterpipe. The economic size of a board mill required a large concentration of packers which is no longer the case outside of Omaha, Nebraska.

Summary

Paunch manure is a major waste (2.5 kg BOD_5/1000 kg LWK) in beef processing and is equivalent to 20 percent of the average waste load from a packinghouse. This percentage would be higher based on longer term oxygen demand values as the BOD_5 of paunch is less than 40 percent of its carbonaceous oxygen demand.

Between 60 and 85 percent of the BOD in paunch manure is water soluble. Use of the wet-dump handling system even with solids-liquid separation adds 2 kg BOD_5/1000 kg LWK in the water carriage and significantly increases the wastewater treatment costs. Because of these increased costs, dry-dump handling is the system of economic choice.

The constraints in processing paunch manure are the water pollution potential due to the high BOD, the production of odors and flies, the high moisture content, and the low protein content. A number of processes to utilize paunch manure have been investigated in the laboratory, in pilot plants and at fullscale. Of the processes reviewed, the production of soil conditioners by surface and/or subsurface spreading and the production of feeds by ensilage or drying appear to be the most feasible.

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VISCERA HANDLING

In pork slaughtering there is tremendous variation of how the viscera is handled. The stomach, for example, in places is sent entirely unopened into the rendering system. Where it is opened, the contents go directly to the sewer and the membrane then goes to rendering. Such variations bring about tremendous differences in in-plant waste recovery. Presented here are the efforts of one plant in in-plant waste recovery.

Perhaps the biggest headache in viscera handling is the different types of screens. The pork intestine, probably more so than beef is a very difficult thing to handle. It has the ability to wrap itself around mechanical equipment, to hang on, and to plug it up. This causes back-up problems. In plants today viscera screens in some cases are not used merely because of the plugging problems that were experienced in the past.

A grease skimming device is used to handle flow from stomach wash, chitterling wash, wash from the viscera pans, periodic wash of equipment, tables and floors, and carcass rinse. Hot water in the scalding tub should bypass the grease skimmer, as hot water dissolves the grease making separation more difficult. Putting more inlet into the grease skimmer gives the sewage more agitation. This agitation is maintained to keep manure in suspension so it will go out with the effluent. The settlings, which consists of pieces of intestines, the stomach, etc. and the grease which is skimmed off the top are taken to rendering. A mechanical flight system removes these materials from the tank.

In the plant every operation that contributes flow to the skimmer is controlled either by curbing or by sizing the sewer line to limit the capacity. In making the skimmer work, it is critical that it never gets flooded. The operations throughout the plant should keep a constant flow to the sewer. When slugs of several hundred gallons of water are released every few minutes is where the problem begins. In viscera washing the flow must be controlled. It is best to keep the flow constant and essential to prevent someone from pulling a plug and discharging the flow which has accumulated for 30 minutes to an hour. Wherever a batch vessel is dumped the sewer line size controls the flow. The maximum flow capacity will come down the line to the skimmer. The sewer line capacity should be controlled as it is the limiting factor on removal efficiency in the skimmer.

The use of a sump prior to an air flotation unit was found critical to removal efficiency. The sump was designed to receive effluent from the grease skimmer, wastewater from the dehairing process after screens and a recycle stream from the air flotation unit. This recycling keeps the flotation unit operating 24 hours a day, which greatly increases solids removed. The size of the flotation unit should be sized on maximum flow that occurs during a five minute period. To size the unit on an average flow results in floating grease and solids being carried out with the effluent during maximum flows. However, low flow periods then create an operation problem. The sump with a recycle stream results in pumping a more constant amount to the flotation unit. Most of the time the sump pump is recycling flow. The peak flow to average flow is about 200 to 75 gpm which results in actually pumping to the flotation unit 3 or 4 times the daily discharge volume.

An envisioned problem of plugging of the sump pump with toe nails and material in the dehairing wastewater have not materialized. Problems with flooding the sump have not occurred. Increased emulsification of grease with the sump pump over a gravity system in the 32°C (90°F) wastewater was speculated but unnoticed. The efficiency of removal was doubled by changing from a full flow pressurization to a pressurized recycle.

In handling the wastewaters from viscera processing minimum flow can creat a pumping problem. Centrifugal pumps are designed to efficiently operate within narrow limits of capacity, speed and pressure. At minimum flow, two things can happen. One, the pump will dewater and lose its prime. To prime the pump can be difficult and time consuming. Second, the discharge valve can be partially closed to reduce flow commensurate with input flow. This allows solids to jam and pack the outlet and pump. Recirculation of flow is simpler and increases in power costs will be minimal at the optimum operating point of the pump. Other means of handling low flows are variable speed pumps or multi-plumps with autmoatic controls which increase pumping capacity with higher water levels in the sump (wet well).

In the plant itself, the 82°C (180°F) water used on the viscera line is off during 10 minute work breaks. Four fast acting valves shut off water to the entire viscera operation. The concept used is that if it takes work the waste water people aren't going to do it. To be factual about it, all people take the path of least resistance. If the employee is required to close five or six valves with ten or twelve turns of a handle before going to break - it isn't going to happen. Quick-acting valves to shut off the operation are simple and inexpensive. Most of the water used in our plant requires work to get water. Automatic shut off valves are used to keep water from running all the time. The employee that runs the equipment, runs the water. For example, the clean-up hoses have valves which shut off when the hose is released. There is also a need for supervisory control to insure correct usage of the water system.

SECTION X
RENDERING

Monitored
by

Bill Prokop and Carl Immel

This section covers a basic despription of the batch cooker process of the rendering industry and its relationship to odor control and waste treatment of the plant effluent. Also included is a discussion of the two continuous rendering systems: (1) the Duke system manufactured by the Dupps Company in Germantown, Ohio and (2) the Carver-Greenfield (C-G) system manufactured by Anderson IBEC. At the end of the section are process flow diagrams which illustrate each of these three rendering processes.

BATCH COOKER PROCESS

The rendering process consists essentially of two basic steps. First, the raw material is heated and "cooked" to evaporate the moisture, to melt the tallow or grease present in the raw material and finally to condition the animal fibrous tissue. This conditioning process is important to accomplish efficiently the second step, the separation of tallow or grease from the solid proteinaceous material.

This basic process is known as <u>dry</u> rendering and the cooking operation is performed with a horizontal, steam-jacketed cylindrical vessel equipped with an agitator. The term dry rendering is used because the raw material is "cooked" with no addition of steam or water. This vessel is known as a batch cooker because it follows a repetitive cycle: the cooker is charged with the proper amount of raw material, the cook is made under controlled conditions and finally the cooked material is discharged.

The raw material collected by the renderer's trucks is discharged to a receiving bin and then screw conveyed through a crusher or similar device for size reduction. For batch cookers, the raw material is reduced in size to 1 or 2 inches to provide efficient cooking which normally requires 1 1/2 to 2 1/2 hours. The raw material is quite variable depending upon the source and adjustments in the cooking time and temperature required to properly process the material.

After the cooking process is completed, the cooked material is discharged to the "perk" pan which allows the free run tallow to drain and be separated from the protein solids which are known as "tankage." After one or two hours of drainage, the protein solids still contain about 25% tallow and are conveyed to the screw press which completes the separation of the tallow from the solids. The solid protein material discharged from the screen press, known as "cracklings", is normally screened and ground with a hammer mill to produce a product that essentially passes a 12 mesh screen. The tallow or grease discharged from the screw press normally contains fine solid particles which are removed by centrifuging or filtration.

Odor Control

Regarding the basic rendering process, the primary sources of high intensity odor result from the cooking and pressing operations because the material in both cases is heated to temperatures over 104°C (220°F) The age of the raw material is important because older material that has deteriorated appreciably will result in substantially higher odors being generated during the cooking and pressing operations.

During the cooking process, the cooker exhaust essentially at atmospheric pressure contains a high percentage of steam vapor and a small amount of noncondensables. The steam vapors are removed by a condenser and the noncondensables contain high intensity odors that normally are treated. These noncondensables can range in odor intensity from 5000 to 100,000 odor units (ASTM syringe method) depending on the age of the raw materials and other factors affecting the cooking operations. Currently, the barometric or direct contact condenser is being replaced by either a shell and tube condenser or an air-cooled condenser to minimize water usage and wastewater treatment costs.

An important consideration in developing an approach to achieve control of odors is the ability of a particular process to confine the odors within the equipment. Regarding the batch cooker process, the odorous emissions from the cooking and pressing operations can basically be confined and treated. However, the perk pan is open to the atmosphere and cannot be effectively enclosed. The hot cooked material from the batch cooker not only releases odor but also fat aerosol particles tend to become airborne and deposit upon the building wall and floor surfaces, requiring frequent cleanup.

Equipment should be checked frequently during the operation to see that the separator is doing an effective job, the depth of the cooker load and that the exhaust is removed efficiently. The condenser should have adequate water supply, maintaining outlet temperature of 28 to 49°C (100 to 120 °F) so that the noncondensable odors would tend to be minimized.

There are two basic approaches to odor control systems; (1) confine the high intensity odors and treat them by wet scrubbing or incineration; (2) provide a plant ventilating scrubber system that treats all odorous air within the plant. This latter method is considered to be a more complete solution to the overall plant odor problem.

Instead of providing an afterburner for incinceration with the related additional capital and operating costs, it sometimes is feasible to use the boiler firebox to incinerate low volume, high intensity odor gases.

Wet scrubbing with chemical oxidant solutions is also used to control high intensity odors. These solutions include the use of sodium hypochlorite, chlorine, sulfuric acid, caustic soda and soda ash. A combination of a venturi scrubber and packed tower scrubber is used for high intensity odors. The venturi scrubber removes any solid particulate or fat aerosol particles before passing to the packed tower scrubber where the oxidation solution would be expended.

Regarding plant ventilating air scrubber, sufficient ventilating air must pass through the operating area in the summer months to provide sufficient worker comfort since it is desired to keep the doors and windows closed to confine the plant odors within the building before passing through the scrubber system. Plant ventilating air scrubbers consist of two types: (1) packed tower scrubber systems; (2) multistage horizontal banks of spray nozzles that direct a dense spray pattern countercurrent to the air flow. Different chemical solutions are used in the various stages.

Wastewater Treatment

Two sources of wastewater are produced in the basic rendering process. The condensate resulting from the removal of steam vapor from the cooker exhaust is one source. As was discussed before, the type of condensor used will determine the volume of water required for condensing. The air-cooled condenser of course requires no water for condensing. The other wastewater source consists of the washwater used to clean the plant and also to clean the raw material pickup trucks since these are required to be kept reasonably sanitary. Considerably more washwater is usually needed in the batch cooker plant because there is a tendency for more material spills and fat aerosol emissions that require more frequent housekeeping. In the rendering industry, the use of mechanical skimmers and dissolved air flotation cells is common for primary treatment to remove grease and suspended solids and the use of aerobic lagoons for secondary treatment is the usual arrangement.

CONTINUOUS RENDERING SYSTEMS

Continuous rendering has a number of inherent advantages over the batch system. Because a continuous process has the ability to provide an uninterrupted constant flow of material, its process variables usually are more easily controlled and improved control of product quality normally results. Further, the residence time in a continuous system is much less, ranging between 30 to 60 minutes, and improved product quality is obtained due to less exposure to heat. The continuous system is essentially enclosed and is capable of confining the odors and fat aerosol particles within the equipment. However, it must be recognized that the reliability of <u>all</u> process equipment to operate continuously without frequent breakdown and maintenance is an essential requirement. It is important that a thorough preventive maintenance program be active to keep the plant in operation.

Duke System

This system was designed to provide a method of cooker operation similar to that of the batch cooker. The Equacooker is a horizontal, steam-jacketed cylindrical vessel equipped with a rotating shaft to which are attached paddles that lift and move the material horizontally through the cooker. Steam heated coils are also attached to the shaft to provide increased heat transfer. The Equacooker contains three separate compartments which are fitted with baffles to restrict and control the flow of material through the cooker.

The feed rate to the Equacooker is controlled by adjusting the speed of the variable speed drive for the Twin Screw Feeder which establishes the production rate for the system. The discharge rate for the Equacooker is controlled by the speed at which the control wheel rotates. The control wheel contains buckets similar to those used in a bucket elevator that pick up the cooker material from the Equacooker and discharges it to the Drainor. Next to the control wheel is located a sight glass column that visually shows the operating level in the cooker. A photoelectric cell unit is provided to shut off the Twin Screw Feeder when the upper level limit is reached.

The Duke control system essentially confines the odors within the equipment. Recent improvements have been made to provide gasketed seals and locate suction pickup vents for improved collection of odor emissions. The basic odor control system consists of diverting the exhaust vapor from the Equacooker to an entrainment separator to remove solid or fat particles before passing to the Vapor Controller which condenses the steam vapor by contacting the condenser tubes with room air. The Vapor Controller also scrubs the plant ventilating air with water sprays before being exhausted from the plant. Currently, the noncondensables from the Vapor Controller and the odor emission from the Pressors is routed to a wet scrubber entrainment separator to remove solid or fat particles before being incinerated in the afterburner or boiler.

Anderson C-G system

The C-G continuous process is considerably different than other systems. Tallow is recycled to carry the raw material as a pumpable slurry instead of using screw conveyors. A secondary grinding step is used to further reduce the raw material particle sizes. A conventional evaporator system with vacuum is used for moisture control.

Partially ground raw material from the Pre-breaker is fed continuously by the Triple Screw Feeder at a controlled rate. The Fluidizing tank receives this raw material which is mixed and suspended with the recylced tallow at 104°C (220°F), and at a ratio of five pounds of tallow to each pound of raw material. This slurry is pumped to Reitz disintegrators for further size reduction from 1 inch to 1/4 inch pieces. This finely ground slurry is then pumped to the evaporator.

The evaporator system consists of a verticle shell and tube heat exchanger and a vapor chamber. The slurry of solids and tallow is pumped to the top of the heat exchanger and the slurry flows by gravity down through the tubes while steam is injected into the shell to provide heat for moisture evaporation. The water vapor is separated from the dried slurry in the vapor chamber which is under a vacuum of 26 to 28 inches of mercury. The water vapor is condensed with a shell and tube condenser that is connected to a two-stage steam ejectory system with hot well to provide the vacuum. In some cases, a two-stage evaporator system is provided to obtain steam economy especially for raw material with a higher moisture content.

Due to the vacuum provided during evaporation, the C-G system operates at substantially lower temperatures than other systems. This tends to reduce the intensity of certain odor emissions, particularly the noncondensable that discharge from the hot well. In order to confine the odors and fat aerosol particles within the system, it is necessary that suction pickup vents be provided on the process tanks, especially the fluidizing tank where the more volatile odors are emitted as the raw material comes into contact with the hot recycled tallow. The noncondensables and the odor emissions from the process tanks and the Expellers are normally collected and treated by incineration or wet scrubbing.

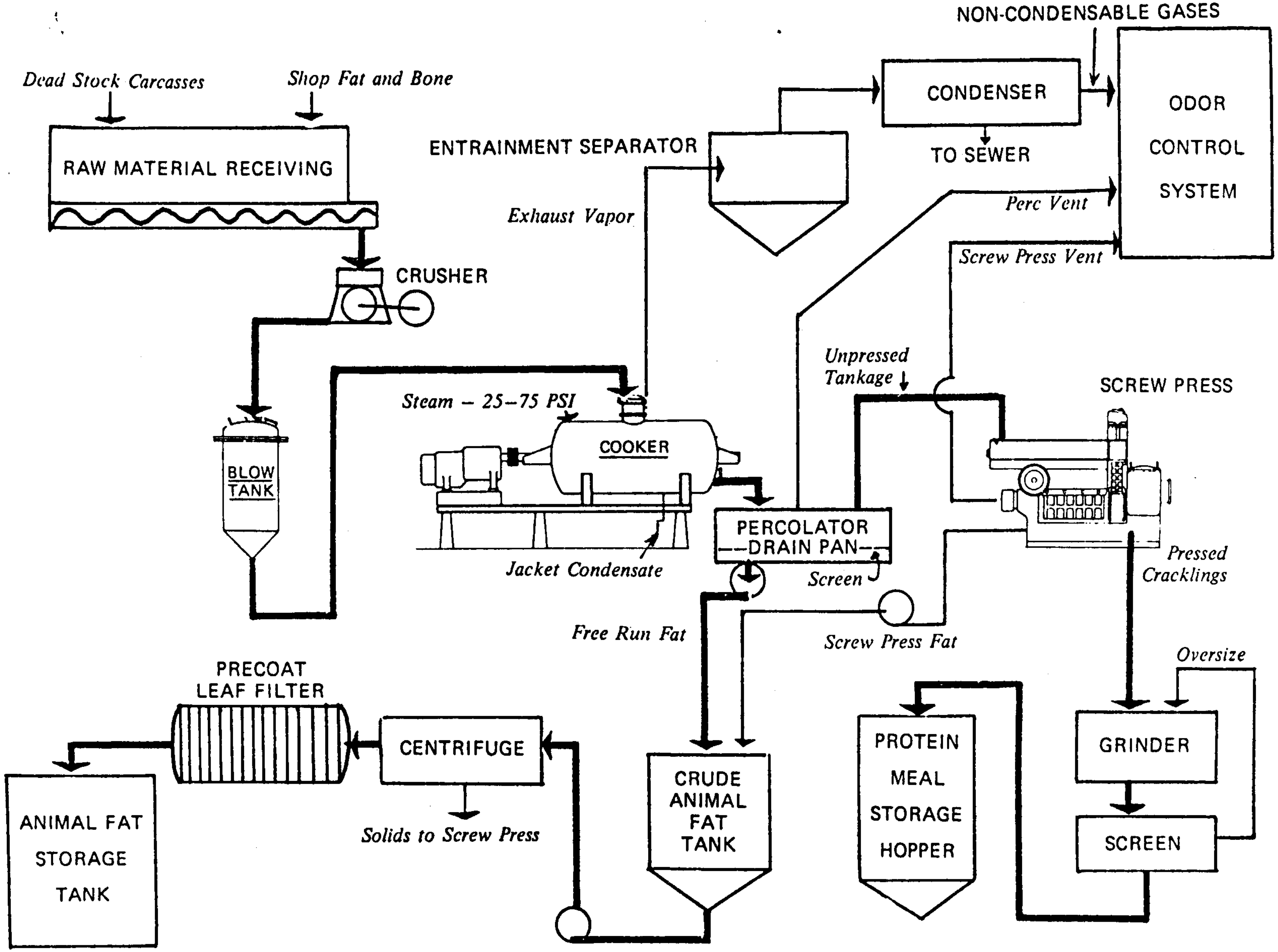

Figure 1. Batch cooker process

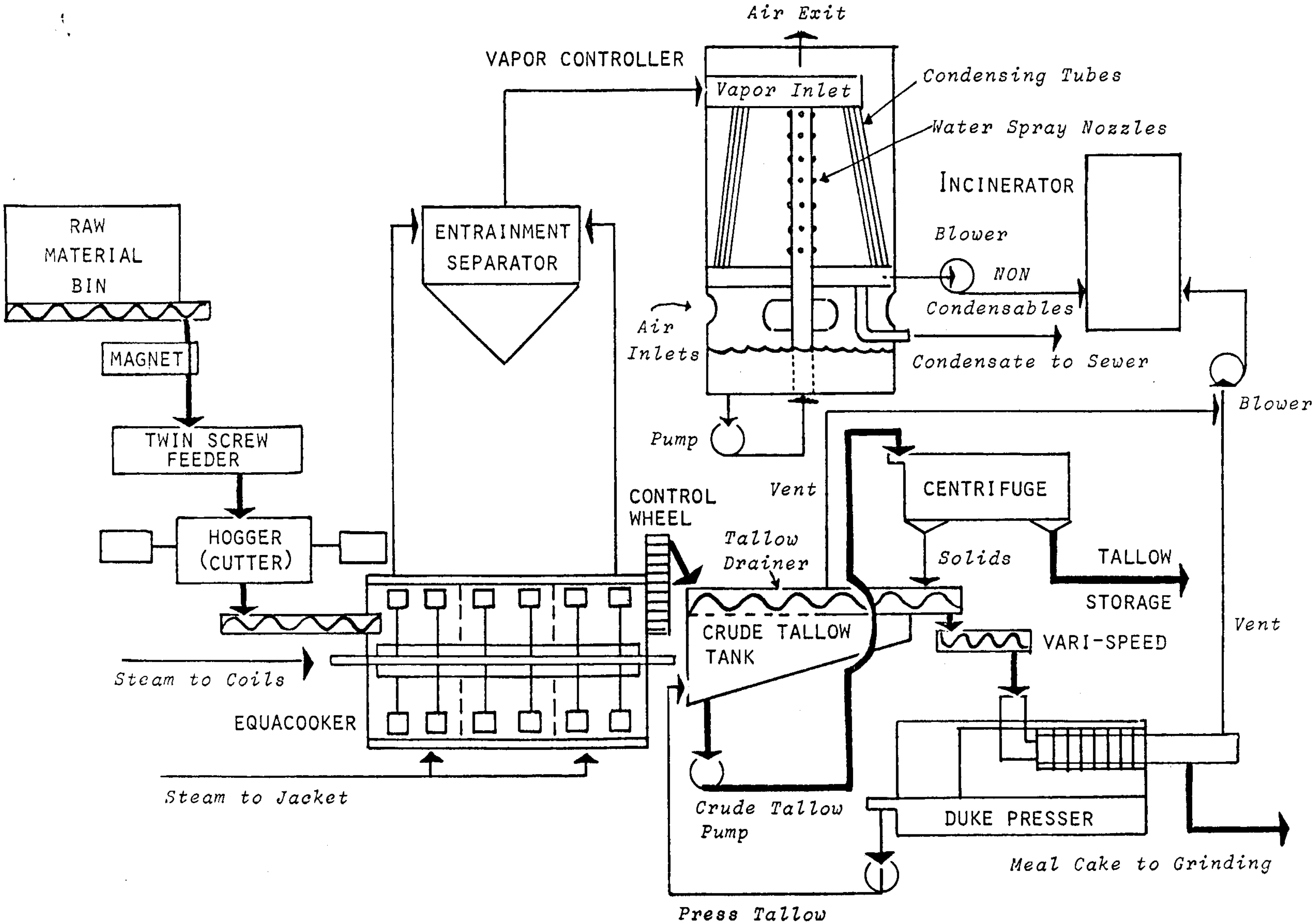

Figure 2. Duke continuous rendering system

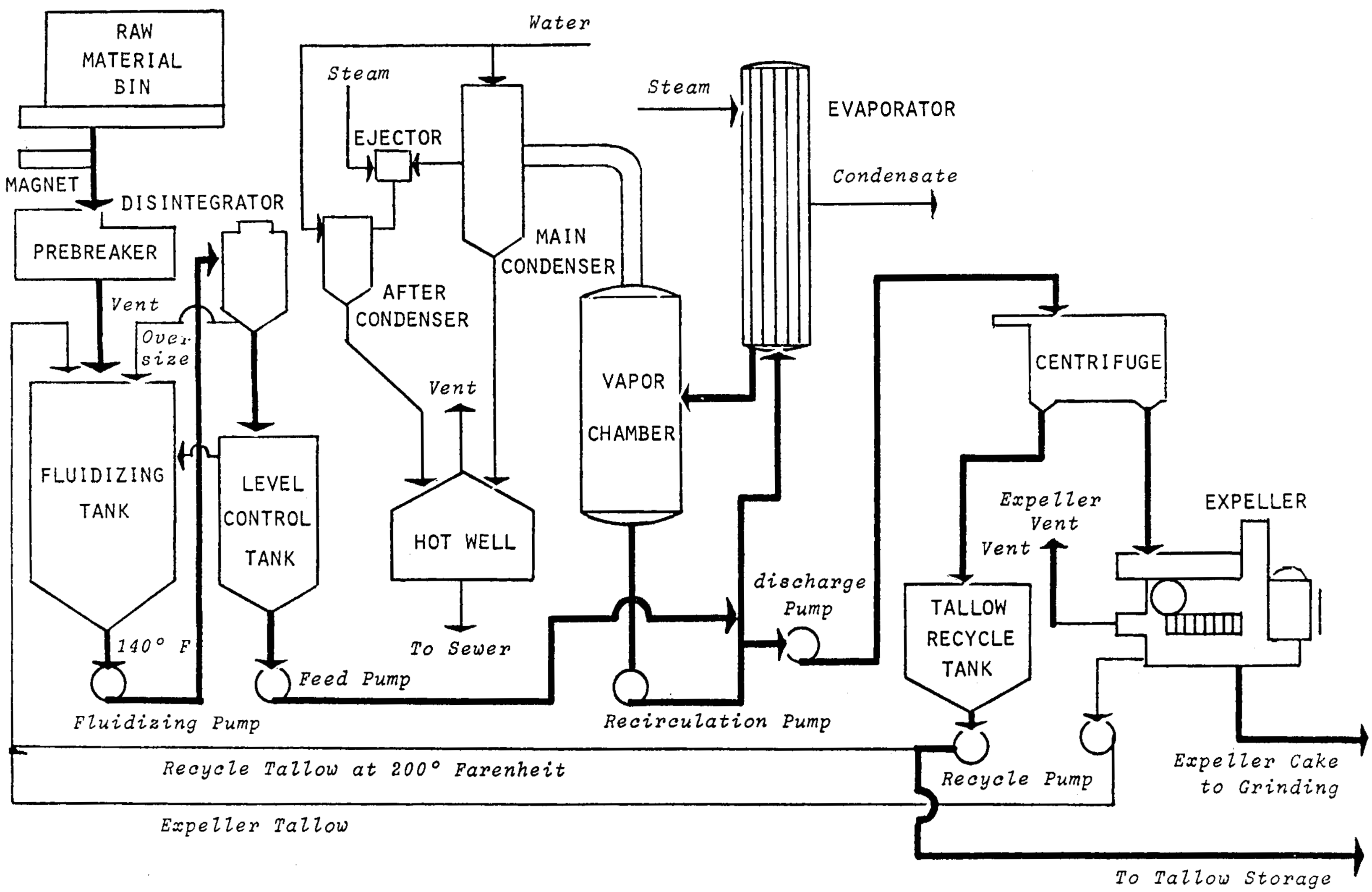

Figure 3. Carver-Greenfield continuous rendering system

SECTION XI
PLANT CLEAN-UP

A major factor in the success of a clean-up operation involves the cooperation of the employees. Unless they are made aware of the significance of the way this operation is handled, a much higher water use and wastewater load will be generated. Therefore, good housekeeping practices must begin with a successful employee awareness program.

Several changes can be made to make the job easier for the employee, thereby increasing the chances of getting cooperation. This includes the use of more sophisticated equipment such as shut-off valves, foot pedals, specialty nozzles, etc. These are changes that can easily be instituted at minimal cost. A low-volume, high pressure water supply is almost mandatory in the difficult areas. This can be supplemented by the use of detergents when the need arises. An alternative to detergents is the use of cleaning jell that is placed on the area to be cleaned prior to rinsing. One arrangement that is said to lower water use is to first scald the equipment using a detergent and then rinse with cold water. A means of reducing water use without changes in operation is simply by installing water gauges on the equipment. This makes the employee aware of the amount of water that he is using and since there is a gauge that will inform supervisory personnel also, he is motivated to shut the water off when it is not needed.

SECTION XII

APPENDICES

NOTE: Appendices A and B are included with the author's approval to show successful application of the many ideas discussed and reported in the previous sections.

Appendix B which was reviewed at the workshop, is an excerpt from a prior publication of the EPA, Region VII, Knasas City, Missouri office.

APPENDIX A
WATER CONSERVATION AND WASTE CONTROL IN A MEAT PACKING PLANT

by

Lawrence D. Lively

John Morrell and Company operates two slaughterhouses in Estherville, Iowa. The plants process 640 cattle and 2400 hogs per day in respective plants. Primal cuts are produced and on-site rendering is performed. Wastewater is discharged to the municipal waste treatment plant after gravity sedimentation.

In 1971, the State of Iowa directed that the City of Estherville upgrade the quality of discharge from the municipal sewage treatment plant. The requirements, 10 mg/l biochemical oxygen demand (BOD), 10 mg/l suspended solids (SS), were consistent with stream classifications. Before the directive could be complied with a 2 mg/l ammonia nitrogen (NH_3-N) effluent requirement was added.

The city engaged a consulting engineering firm to thoroughly investigate means to comply with the State's directive. Review of existing treatment facilities, waste water characteristics and the discharge requirements resulted in recommendation to construct new treatment facilities. The estimated cost was $4,900,000. The cost was increased to $6,900,000 due to inflation and the need to comply with the ammonia nitrogen standard.

John Morrell and Company had agreed to accept responsibility for 45% of the city's cost for the new plant based upon the lower estimate.

The revised cost, however, was considered excessive. Alternatives, therefore, were sought to reduce the company's commitment.

The most logical alternative was to reduce the strength and volume of the slaughterhouse discharge. Typically, slaughterhouse wastewater is high strength with BOD, SS, and Grease (HEM) ranging from 650-2200; 930-3000; 200-1000 mg/l (1) respectively. Water use by slaughterhouses per thousand pounds live weight kill (LWK) average 2650 liters (700 gallons) (2). Waste strength and volume from the two operations was a major factor affecting the size of the new treatment plant. A program, therefore, was developed to minimize the company's waste contribution and thus reduce the cost of the proposed treatment plant.

Operational practices of the two plants were reviewed seeking means to control strength and volume of wastewater. Analytical data showed water use to be 4.96 mℓd (1.31 mgd) or 8.8 m^3 (1,060 gallons)/1,000 lbs. LWK. It was apparent therefore, that a significant reduction in wastewater volume was possible. The data also showed that the BOD was 11.8 kg/1,000 kg LWK compared to the national average 5.8 kg/1,000 kg LWK (2). Other parameters were similarly higher than the national average. Thus, it appeared that the strength could be reduced significantly. In accordance with these conclusions, an in-plant waste control program was devised to reduce the strength and volume of the waste water to an acceptable level.

It was not considered practical to rely solely on the in-plant waste control program to produce the desired degree of waste reduction. Supplemental control through pretreatment processes would be necessary. Dissolved air flotation, an industry standard, was selected as the basic process. Further treatment was to be provided by a biological process.

Guaranteed dissolved air flotation performance of 90% non-emusified HEM and SS reduction was offered by an equipment manufacturer using effluent recycle (3). Attendent BOD removal ranging 35-45% also results in association with SS removal. An additional estimated BOD reduction of 50% from a biological process was considered adequate pretreatment (1).

The city's consultants were furnished projected values for reduced waste strength and flow. Revised estimated cost of the proposed treatment plan was $5,900,000. Treatment costs increased from 5.3¢/1000 liters (20¢/1,000 gals.) to 6.3¢/1000 liters (24¢/1,000 gals.), however, annual costs were decreased by 33%. The company's contribution to the new municipal treatment was reduced to 35%.

If the projected savings was to be assured, unusually low construction cost for the biological treatment process had to be realized. Since the existing municipal waste treatment plant was to be abandoned upon completion of the new plant, it was available for use. After survey of the facilities, an unused concrete tank and pump station was obtained for conversion to a roughing biological trickling filter.

The pretreatment system would consist of dissolved air flotation, screenings, and a trickling filter. Engineering studies showed this combination to be an economical method of reducing the packinghouse waste strength to a satisfactory level. Efficiency of the system with attention to in-plant waste control would reduce the strength comparable to domestic sewage. Estimated cost of the system installed was $350,000.

Table I shows the assigned waste load reduction from in-plant control and pretreatment. Effluent from the trickling filter will not be settled, thus suspended solids through the process are increased.

Table I. Waste Load Reduction

Process	BOD		SS		HEM	
	Pounds	Percent	Pounds	Percent	Pounds	Percent
Raw Waste	13,400	100	10,500	100	5,800	100
Housekeeping	1,400	10	4,200	40	1,450	25
Air Flotation	4,800	36	5.700	54	3,900	67
Trickling Filter	4,200	31	4,400	+41	375	6
Effluent	3,000	23	5,000	48	175	2

Water Conservation: The Company's share of the revised cost of the new municipal treatment plant was predicated on a flow of 4.5 mld (1.2 mgd). The plant was originally sized to accept a 7.6 mld (2.0 mgd) flow from the slaughterhouses to allow for increased production. In order to justify the 4.5 mld (1.2 mgd) flow, a realistic water conservation program had to be developed if the slaughterhouses were to have margin for increased production.

Establish Conservation Attitude. A training program was developed to re-educate personnel to the importance of using only the quantity of water required for a job. The attitude that water was cheap and abundant had to be dispelled and replaced with one reflecting total cost, i.e., initial charge, product loss through excess washing and the cost for waste treatment. Hoses were not be left unattended, taps and sprays should be turned off during breaks and other nonuse periods and press-to-open valves must not be blocked open. Water use was reduced 3-5% following such practices. To sustain any significant savings, it was necessary to continually emphasize importance of the program.

Plant Clean-Up and Equipment. Clean-up operations generally use as much water as that required for processing. Standard equipment is a low pressure high volume hose discharging water at a rate of 0.6-1.3

liters/sec (10-20 gpm) at temperatures of 60-82°C (140-180°F). A flood of hot water is often believed to be necessary for cleaning equipment and floors. In reality, that practice is counterproductive in that equipment breakdown is greater and building erosion is accelerated.

The higher cost of water and waste treatment has caused the packinghouse industry to use more modern and efficient cleaning methods. High-pressure (500 psig) low-volume (3-5 gpm) cleaning systems are being used increasingly. An area can be cleaned faster more effectively with less water and cleaning chemicals. These units are being installed in areas housing difficult to clean equipment. Although not yet realized, water savings of 5-7% is expected.

Use of Sprays and Valves. At various points during processing the product is washed by sprays. Conveying equipment such as viscera pans are also washed and sterilized by sprays. Usually the sprays are left on even though product has cleared that area or production has stopped. To conserve water at such times automated solenoid valves will be installed to open only when the product is in the wash area. Hand washing of product requiring less than 50% under the spray time will be equipped with press-to-open valves. Animal drinking water troughs will be equipped with float operated valves. Hog sprays will be turned on intermittently. Spray heads will be efficiently designed to improve cleaning and to conserve water. This phase of the program has not been fully implemented. Projected water savings is 5%.

Vapor Condensing System-Rendering Plant. The slaughterhouse rendering operations produce grease or tallow, meat scraps and dried blood. The process is conducted in steam jacketed, horizontally mounted cylinderical units. During the cooking cycle the contents are continuously agitated by paddles mounted on a motor driven center shaft. Depending on size, the units are charged with 2.7-4.5 thousand kg (6-10,000 pounds) of offal or blood. Offal is 50-60% water (4) and whole blood is 82% water (5). The units are generally operated under partial vacuum. Steam pressure is 60-75 psig with condensate returned to the boilers.

Barometric condensers supplemented by steam ejectors were used to draw off and condense water and other vapors resulting from the rendering process. The plant has five offal melters and two blood dryers. All of the units were equipped with barometric condensers. The barometrics on the blood dryers used contaminated water for condensing. The offal melter barometrics used potable water at a rate of 50-60 gpm per unit (6).

Calculations indicated that about 363,000 lpd (96,000 gpd) water saving was possible by replacing all of the barometrics with a heat exchanger condensing system. Added benefit from such a system was production of hot potable water required for processing and clean-up operations. Accordingly, an engineering firm was asked to design and install a system based on the following description.

Collect vent gases using a manifold and route through an impingement tank, heat exchanger and wet scrubber before exhausting to the atmosphere. The impingement tank was to remove entrained solids. Provisions were included for removal of condensate midway in the manifold, bottom of the impingement tank and bottom of the heat exchanger. Pneumatic knife valves were installed to allow each cooker to be isolated.

Ammonia condenser water at 20.5 liters/sec (325 gpm), (50-65°F) was used as a feed to the heat exchanger. The heat exchanger effluent was tied to the plant hot water system. During processing hours with the rendering units operating, water temperature ranges 50-60°C (120 to

140°F). The upper limit is controlled automatically with hot water being dumped when temperature exceeds the set point. During clean-up the set point is increased to 77°C (170°F) to produce the required hotter water.

The system has been in operation for over six months. Results have been very satisfactory. Table II shows average daily water and fuel oil use before and after the system was installed. Processing time was also decreased by about 15%.

Table II. Effect of Condensing System on Utilities

Time Period	Water Use	Oil Use
1973 Old System	468,800 gpd	3,552 gpd
1974 New System	312,800 gpd	2,624 gpd
Avg. Daily Savings	156,000 gpd	928 gpd

Discussion

Waste Strength Reduction: Incremental reduction in waste strength as a function of each segment of the waste control program could not be determined without isolation of various process flows. Moreover, various phases of the program were conducted simultaneously making it imposible to determine the actual source of the reduction. A gross effect, therefore, was compiled. Table III shows the reduction in waste strength during the past two years.

Table III. In-Plant Waste Strenght Reduction

Date	BOD	SS	HEM
1972	13,400 lbs.	10,500 lbs	5,800 lbs.
1974	11,300 lbs.	7.700 lbs	4,150 lbs
% Reduction	16	27	28

The factors leading to the improved conditions was discussed in previous sections. The inter-related effect of an effective dry clean-up with decreased water use should be emphasized. A packinghouse corollary is that waste strength is directly related to water use. Past studies have shown that plants with high BOD, SS and HEM invariably are high volume water users (7). Floor washing with hot water tend to render meat particles with attendent break-up into finer pieces. Other factors alluded to were the importance of disposing of unwanted organic solid wastes to land fill rather than to the sewer.

HEM loss was emphasized over BOD and SS due to its value as a saleable product. Although the factors mentioned above had a positive effect on HEM losses, closer attention to operation of the rendering plant was more effective. Losses were also less due to the new condensing system.

Water Conservation. Water use throughout the plant was reduced 29%. Goals and accomplishments of the conservation program are shown in Table IV.

Table IV. Water Conservation Program

	Percent Reduction		
	Goal		Achieved
Obvious Waste	5		
Equipment Modification	10		17
Clean-up Practices	5		
Process Change	18		12
Projected	38	Metered	29

Water savings through correction of obvious waste practices, equipment modification and altered clean-up practices could not be measured separately. A gross improvement was reported instead.

The 12% reduction achieved through process change was from only one of the packinghouses. Thus, the process produced higher results than expected. The calculations used to set the goal did not consider water used when the barometric condensers were not needed. At the present time, hot water is dumped if the demand is not sufficient to maintain temperature below the set point. Plans are to install a hot water reservoir to eliminate that loss.

Gross effect of the water conservation program resulted in reduction of flow from 4.96 mld to 3.52 mld (1.31 mgd to 0.93 mgd). When all facets of the program have been completed, anticipated water use will be 50% of the starting volume.

Summary

The in-plant waste control program has produced significant reduction in strength and volume of the slaughterhouse discharge. Although the dissolved air flotation units and the trickling filter are not yet operational, experience has shown that the projected efficiency can be readily attained. It can be stated with confidence, therefore, that the program was realistic and will be successful.

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APPENDIX B

WATER CONSERVATION AND WASTE LOAD REDUCTION IN A MODERN HOG PACKING PLANT

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S U M M A R Y

The Sioux-Preme Packing Company plant in Sioux Center, Iowa, represents a combination of unique design and good management. Innovations introduced in all phases of the hog slaughter operation have resulted in a savings of water, reduction of waste material generated, and increased by-product recovery. The result is a greater profit per animal and reduced waste treatment costs.

This efficiency is exemplified by process balance shown in Table I. During the five-day study period, 97% of the live weight kill could be recovered from various process operations. The 12.5% represented by the inedible by-products provides an estimated profit of 80 cents per hog.

The process water use, as measured by plant effluent, averaged only 37.4 gallons per hog killed or 163 gallons per 1,000 pounds LWK. This represents about one-fifth of the industry average and is reflected in savings in power costs and in waste treatment. One of the devices that is responsible for much of the water conservation is the blood and scrap auger which transports inedible scrap to the processing area.

The auger and the other modified devices such as the stunner, scald tank, hair scrapers, and singe chamber display the inventiveness exercised in designing the plant process line. This unique equipment, coupled with the fact that 54 of the 62 employees are engaged in the production process, further demonstrates the concept of efficiency incorporated in the plant.

Collection and treatment of the in-plant wastewater is accomplished effectively. For example, the barometric condensers are used to remove vapors from the rendering and blood drying process. Water for the condensers is obtained from the anaerobic lagoon which eliminates plant odors and places the waste load from the vapors in the lagoon. The circulation of lagoon water mixes the anaerobic system and the heat increases the microbial metabolism, increasing treatment efficiency.

During the study period there was no discharge from the final aerobic lagoon which provided the final polishing for the plant waste stream. However, the treatment efficiency, as measured by waste load reductions effected by the air flotation, anaerobic, and first aerobic lagoons, was 97% removal of total suspended solids and 98% removal of BOD_5. There is no doubt that, in this situation, a profit motive is compatible with environmental concerns.

INTRODUCTION

The Sioux-Preme packing plant is located in northwestern Iowa a few miles south of Sioux Center. The plant was built in 1969, is privately owned, and operated by the owner. The production rate is 440,000#LWK/day at approximately 2,000 hogs per day. The plant slaughters and processes by-products but does no meat processing.

The plant was visited several times in 1973 by EPA Regional Office personnel, both to discuss discharge permits and research projects. During these visits, it became obvious that the design and operation of the plant were exemplary and that a documentation of the operation would be of value to other members of the meat packing industry who were seeking to minimize water usage and effluent discharge loads. Mr. Stanley Lammers has cooperated with the Environmental Protection Agency in presenting the results of his work. The survey was designed and conducted by personnel from the Region VII staff, utilizing both the Kansas City, Kansas, Laboratory and EPA Mobile Unit. Production data were supplied by Mr. Lammers.

PLANT DESCRIPTION

The two-level Sioux-Preme plant (Figure 1) has an overall floor space of approximately 25,000 square feet, with a space distribution as follows:

Main Process Area	4,300 Sq. Ft.
Carcass Chiller	4,200 Sq. Ft.
Pre-process Area	1,000 Sq. Ft.
Utilities	1,800 Sq. Ft.
Lard Rendering	450 Sq. Ft.
Offal Package Room (chilled)	600 Sq. Ft.
Offal Freezer	760 Sq. Ft.
Inedible Grease Rendering	1,600 Sq. Ft.

Fig. 1

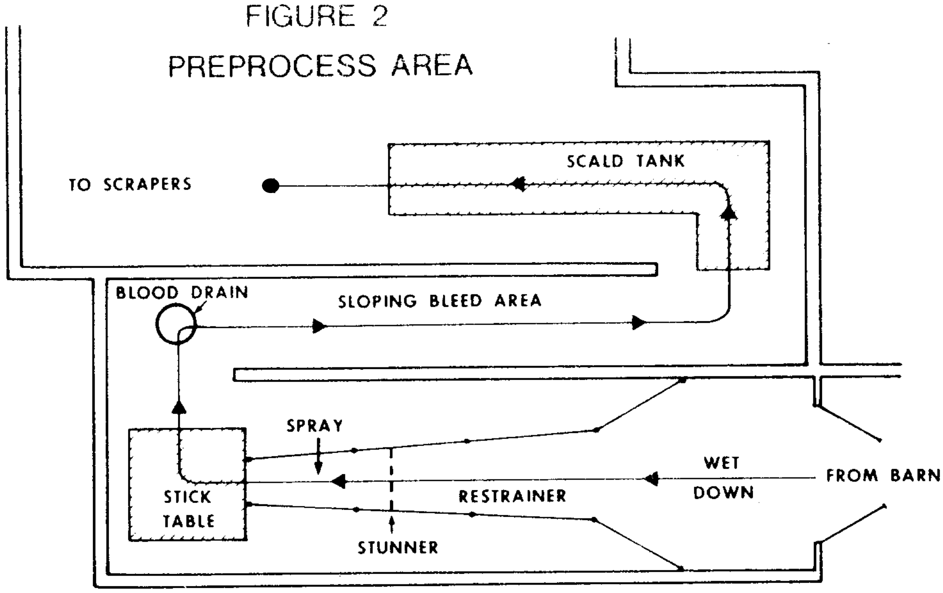
An unloading area, scale, and holding barn are located adjacent to the process plant. Two lagoons are located to the rear at a lower elevation than the plant. There is adequate acreage in back of the lagoons for irrigation, if such an operation becomes advantageous.

Plant personnel total 62, with 54 engaged in the production process. The plant is operated with a single shift of eight hours. Plant maintenance time is equivalent to the full time of four people. Four USDA inspectors are assigned to full-time service at the plant. On interviews, their comments were favorable with water use reduction. "The USDA goal of assurance of a wholesome consumer product was compatible with the water conservation techniques employed in the plant."

PROCESS FLOW

The pre-process flow is shown in Figure 2. Hogs held in the

FIGURE 2
PREPROCESS AREA

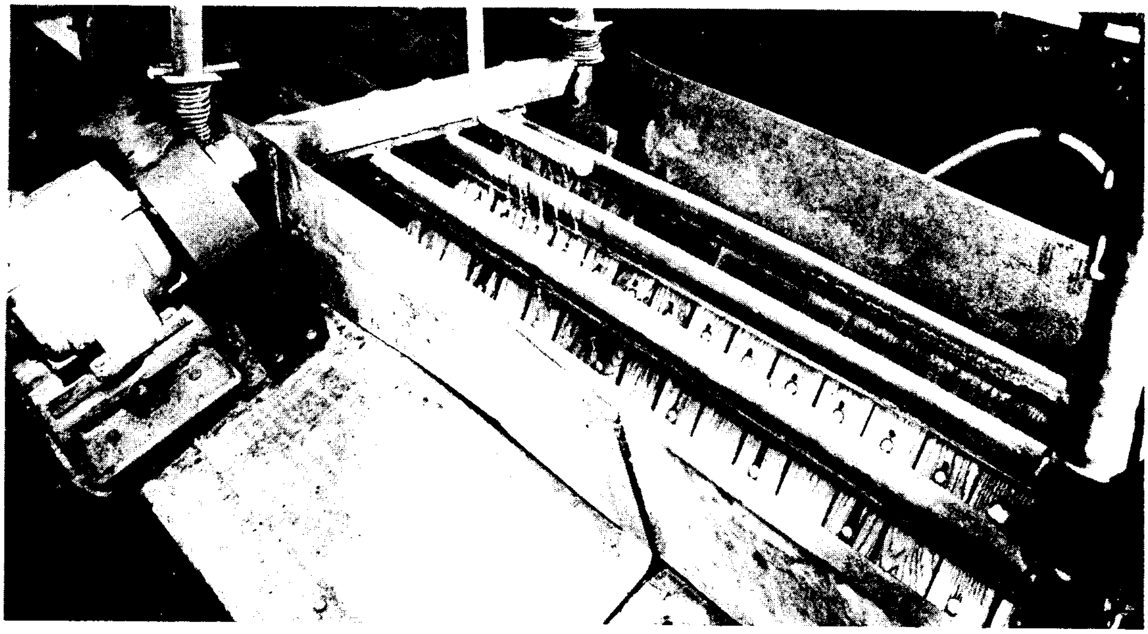


barn (Figure 3) are driven in groups of 20-25 to a wet down area where they are sprayed for about 20 seconds with water from a low-pressure spray. They are then moved through a restrainer (Figure 4)

Fig. 3

in which they are again sprayed with a low-pressure, continuous, water stream immediately prior to stunning. Stunning is accomplished with a custom-built, low-voltage, high-amperage device which has a low incidence of exploding vertebrae.

Fig. 4



The hogs are shackled and hung on an endless conveyor after stunning. The conveyor moves from the stick table (Figure 5), through

Fig. 5

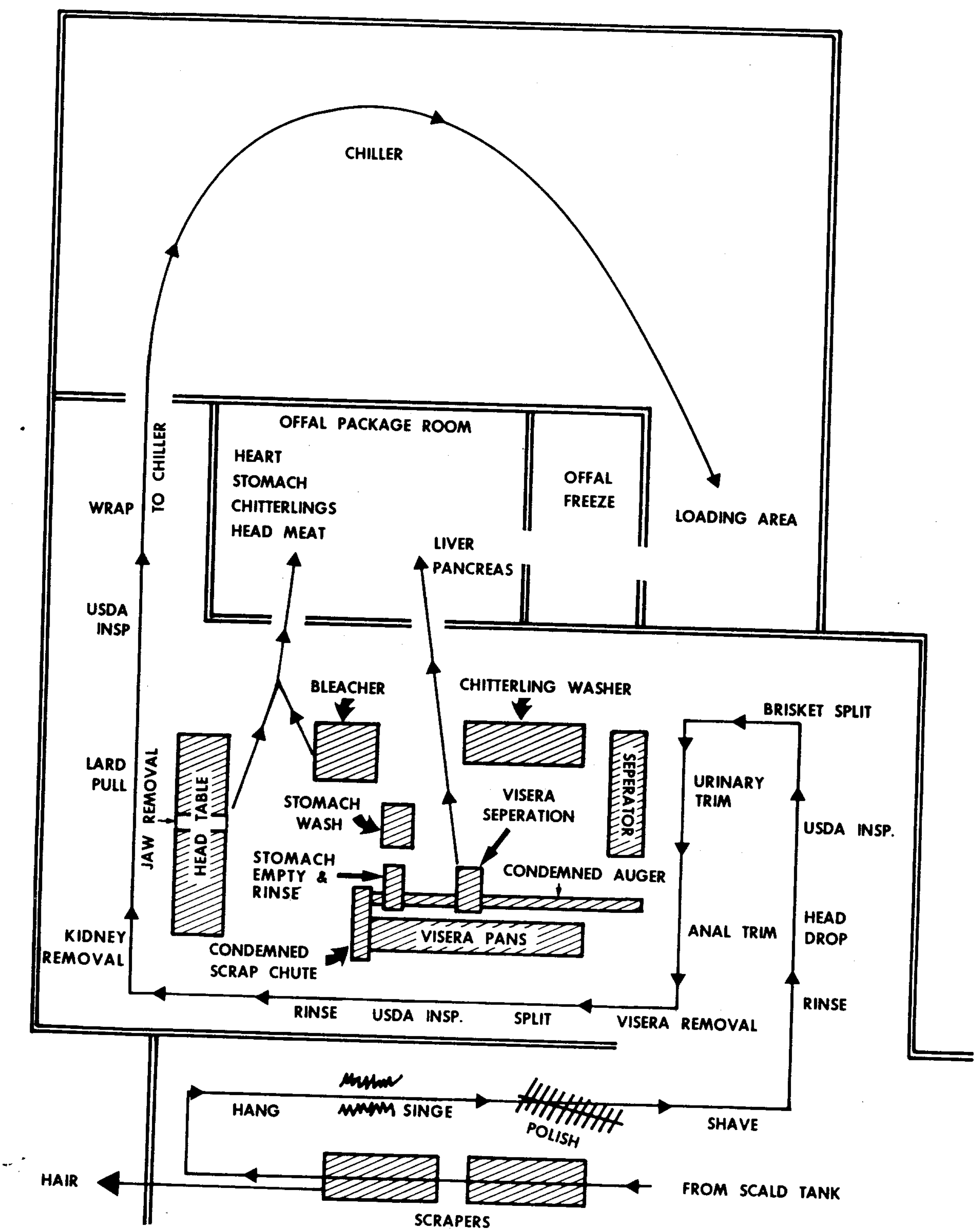
a bleed area (Figure 6) for 10 minutes, then carries to an elevated L-shaped scald tank (Figure 7). This tank is heated by direct steam injection which is controlled automatically. Subsequent process flow is shown in Figure 8.

Fig.
6
7

On emergence from the scald tank, the hogs move through two scrapers (Figure 9) that have been modified to reduce water consumption. The rotating action of the scraper moves the hogs through dehairing. The conveyor emerging from the scald tank loops back to the stick table.

When the hogs roll out of the scrapers, they fall on a slatted conveyor belt. The hind legs are then cut to receive the gambrel sticks (Figure 10) and are hung for eight minutes over the second bleeding area (Figure 11).

FIGURE 8
PROCESS MEAT FLOW



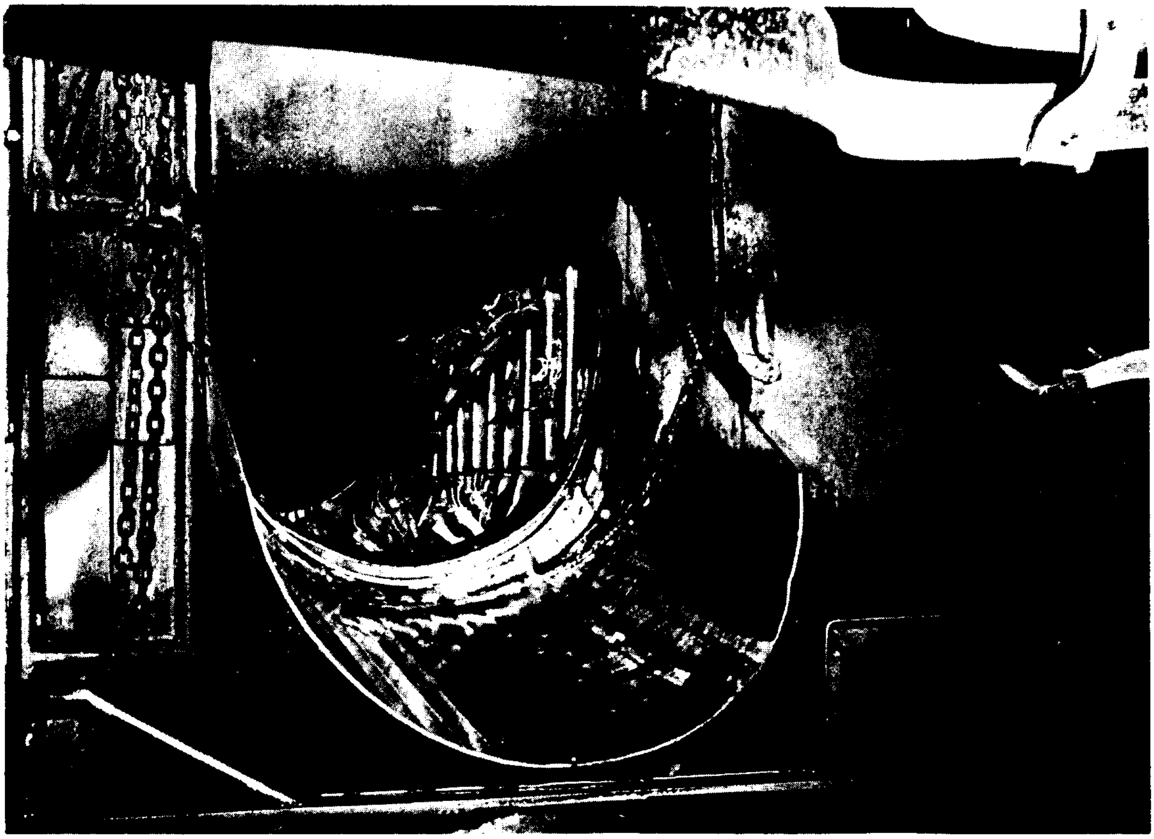


Fig. 9

Fig. 10

Fig.
11

A second chain conveyor then engages the gambrel sticks and carries the hogs into the singe chamber. Two shower head nozzles wet the ears prior to singeing. Twenty-two fabricated nozzles, each producing a brushy flame, are set alternately in a vertical line on either side of the chamber and produce a curtain of flame through which the hogs pass (Figure 12).

The carcass is polished with a single, long-rotating fiber brush (Figure 13). The brush is set at an angle to the floor so that the brush rotates the hog while polishing. The brush initially contacts the hindquarters and, as the hog is dragged past the brush, contact progresses to the front end of the hog. A slow continuous stream of water drips on the hogs as they move past the polishing brush.

After mechanical polishing, the carcass is carried to an area where a finish shaving is conducted manually. At this point eyelids, hoofs, and hide scars are trimmed (Figure 14). The trimmings drop to the floor. This area is manually scrapped every two and one-half hours, and the trimmings are carried to the inedible scrap auger. If the carcass does not meet house inspection standards and requires additional trimming or complete rejection, it can be sidetracked. Other sidetracks function to take up overrun from the scald tank, thus, permitting an accurately timed scalding period. Hold up in this tank could cook the carcass, in addition to loosening the hair.

The carcass is then rinsed by a high-pressure, low-volume spray that employs 14 duckbill nozzles (Figure 15).

The head is then almost completely severed but remains with the carcass. Heads are inspected by the USDA at this point. The next

Fig.
12
13

Fig.
14
15

operation splits the brisket by hand. Urinary and anal area trim follows. A trough placed under these two operations catches all scraps, blood, and other drippings. The trough is channeled to the inedible meat chute via the auger.

Viscera are removed in the next operation (Figure 16). The

Fig. 16

viscera are dropped into a 24-inch square stainless steel pan. The pans have their separate conveyor belt that moves synchronous with the originating carcass. Viscera are inspected by the USDA at this point. Subsequently, the viscera and carcass move in separate paths. The carcass is split by hand with a supported, weight-balanced circular saw (Figure 17). The halved carcass is then further trimmed and the leaf lard and kidneys are loosened. A second carcass rinse follows (Figure 18) with subsequent head, kidney, and lard removal. After a final USDA inspection of the carcass halves, they are wrapped and conveyed into the main chill room.

Leaf lard on removal from carcass drops to a lower level where it is rendered by standard processes. The kidneys are rinsed, drained, and packaged separately. Heads, when dropped, are trimmed on a separate table (Figure 19) that is equipped with a mechanical jaw

Fig.
17

Fig.
18
19

separator. Head trimmings then move to the packaging and freezing room.

The viscera, in pans, follows another path. Heart, pancreas, liver, and diaphragm are separated (Figure 20). The liver and pancreas are conveyed to the packaging room by chute (Figure 21) and rinsed there. The heart and diaphragm are stored in 30-gallon stainless steel barrels, batch-washed, and trucked into the packaging room.

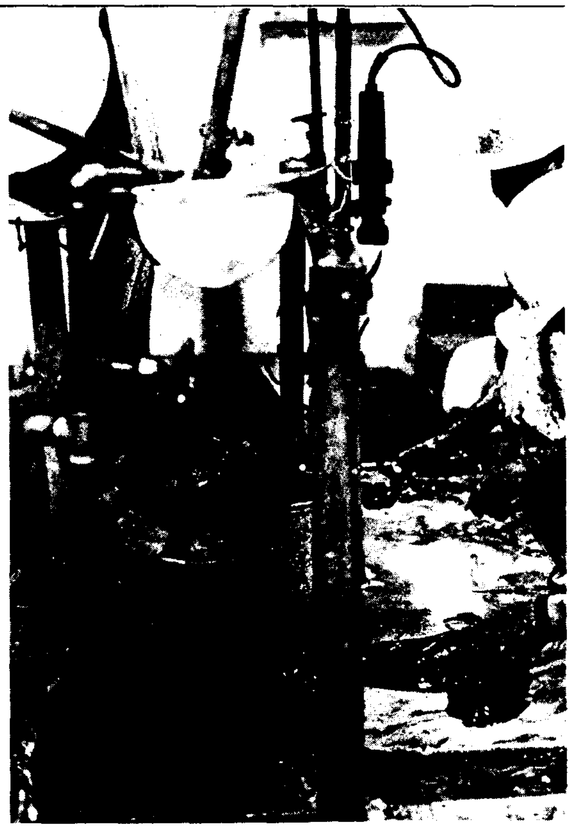


Fig.
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21

Lungs and gullets are dropped directly to storage at the lower level. Lungs are sprayed for cooling periodically during storage. Chitterlings are sent via a trough to a special table for straightening (Figure 22) and fed to a specially designed chitterling washer. Stomach contents are dumped into the inedible scrap auger, and the stomach is rinsed at this point (Figure 23). The stomaches are washed in a shortened version of a conventional beef stomach washer.

Fig.
22

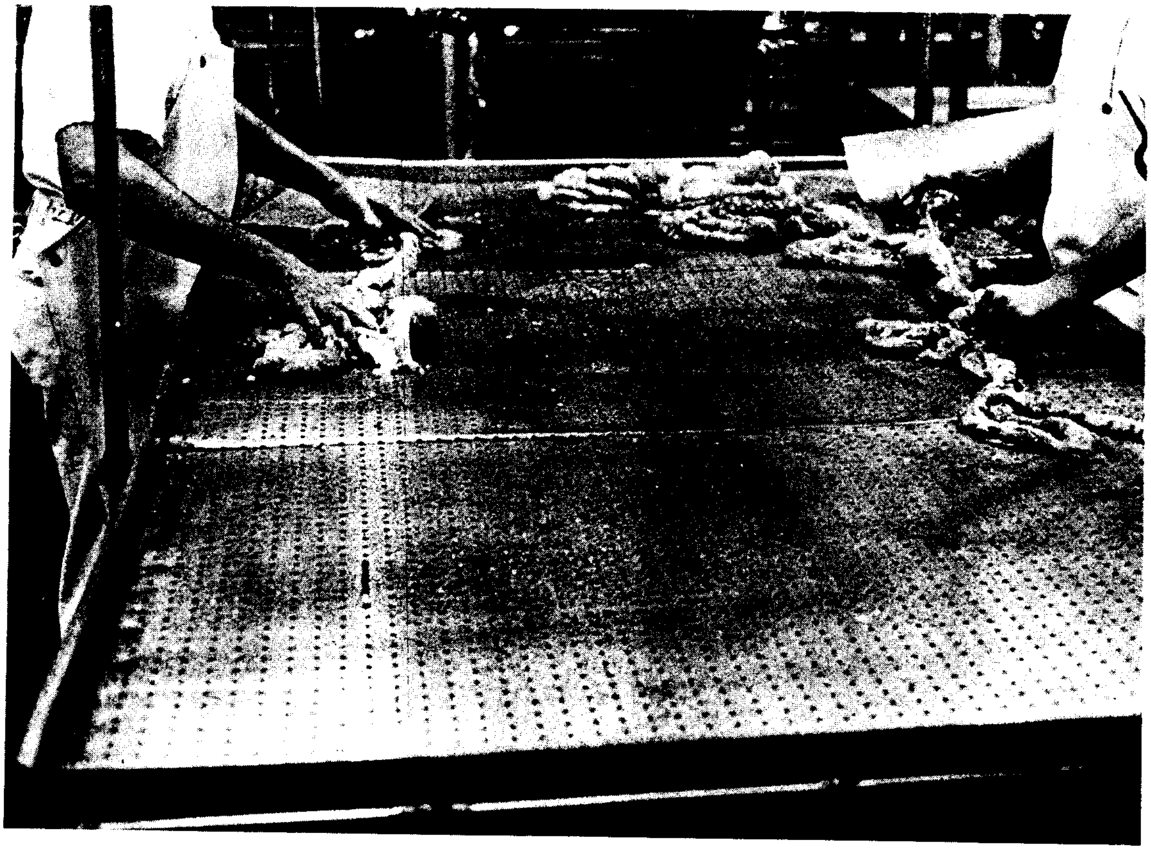


Fig.
23

Hearts, washed stomaches, and washed chitterlings all go through an additional scalding or "bleaching" in the mechanical washer shown in Figure 24. The bleaching solution contains considerable salt. To prevent slug discharge from the washer, it is surrounded by a curbing and the contained area has a small drain.

In accordance with USDA regulations, wastewater discharging from the chitterling washer, the stomach rinse, the stomach washer, and the viscera separation table discharges to a separate drain that must drain freely at all times without forming a pool on the floor.

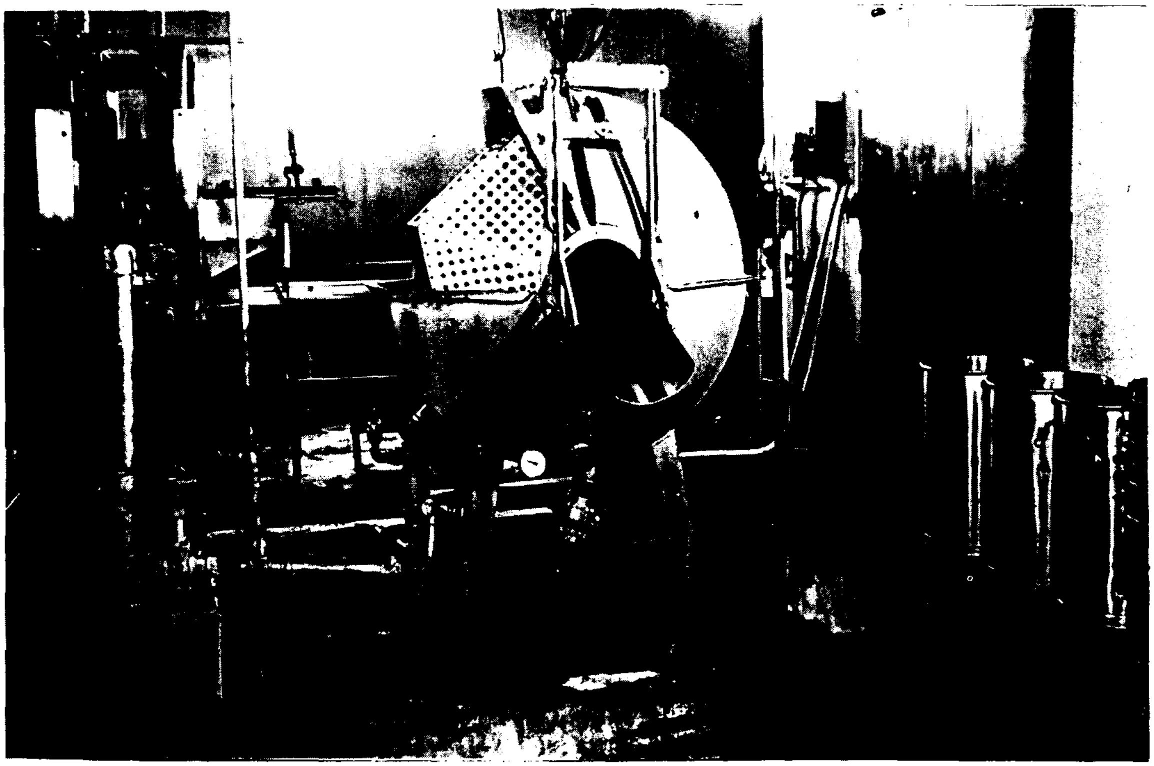


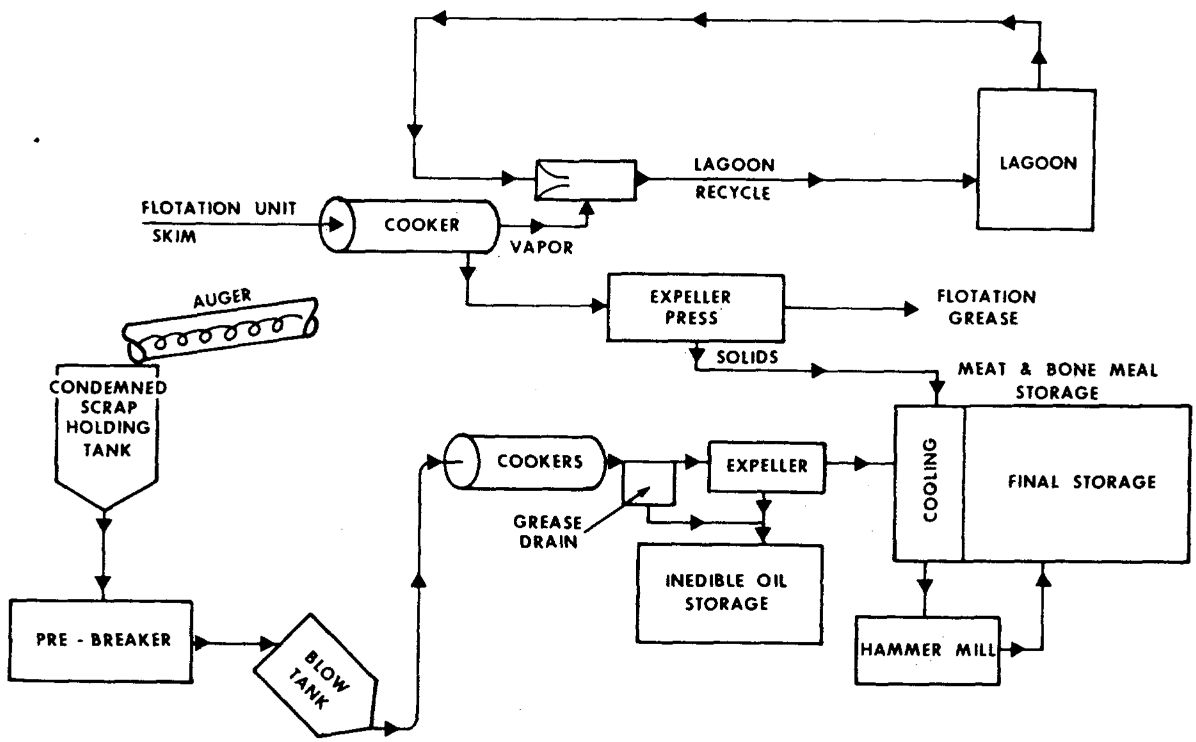
Fig. 24

After all usable organs are taken from the viscera pans, the remaining viscera are dumped in the inedible scrap chute and the pans cycle back under the pan conveyor. Here, pans are first rinsed with a cold spray from six duckbill nozzles; next sprayed with hot, 120 PSIG water from eight nozzles; and again sprayed with cold water from four nozzles.

A key feature of the plant design and management is the system (Figure 25) for handling scraps, blood, and other fluids that are destined for animal feed (inedible scrap). A 40-foot long, 12-inch auger parallels the viscera pan conveyor. This empties into an

FIGURE 25

OIL AND MEAT BY-PRODUCTS FLOW



inedible scrap chute that dumps into a holding tank at the lower level. Added to scraps carried by the auger are trimmed skulls, rejected viscera, other trimmings, and whole carcasses, if they are rejected. Inedible scrap from the holding tank is passed through a rough grinder or "prebreaker" and then to a blow tank that is used to fill the two inedible dry cookers. The cookers are evacuated by barometric condensers that operate on recycled anaerobic lagoon water. Inedible oil is expressed from the cooked scrap, after which the scrap is cooled and passed through a hammer mill and stored as "meat and bone meal."

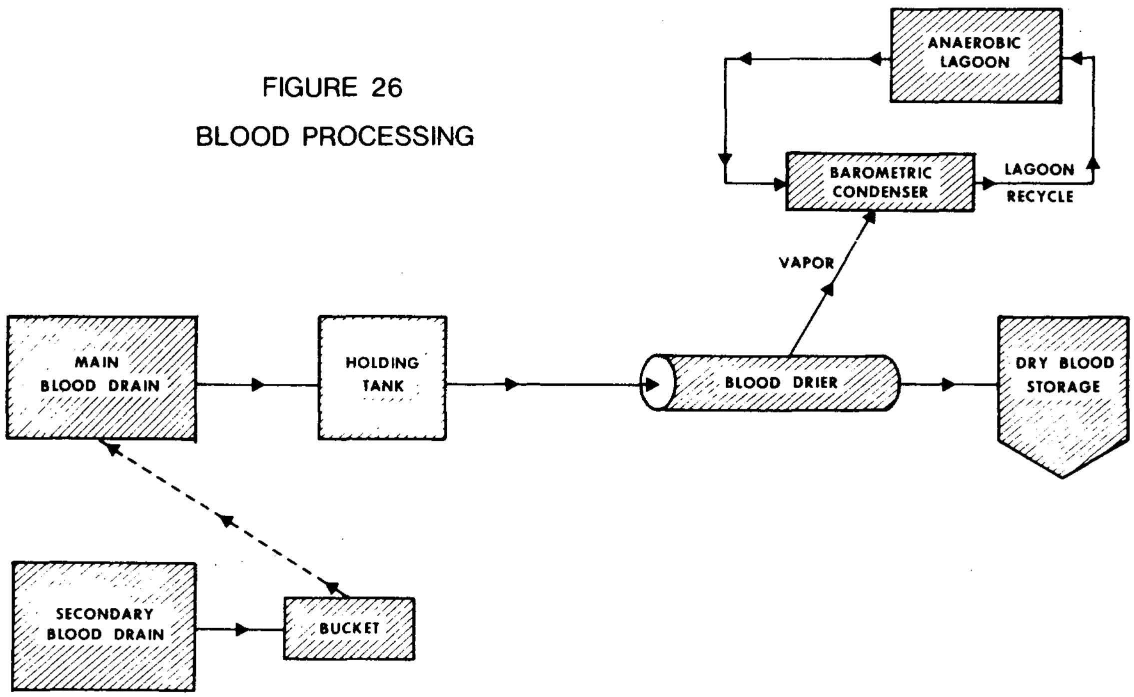
Skimmings from the air flotation unit are cooked and dried separately in vacuum. Flotation grease is expressed from the solids, and remaining solids are incorporated with the inedible scrap prior to milling. Vapor from the grease cooker is condensed by recycled water from the anaerobic lagoon. This grease is sold as an animal feed additive.

BLOOD PROCESSING

The overall scheme for blood processing is shown in Figure 26. The stick table (Figure 5) and primary bleeding area are sloped to a common drain. The drain flows into a holding tank with a capacity of 1,000 gallons (equivalent to 1,200 hogs). The trough from the secondary bleeding area drains into a 5-gallon bucket (Figure 11) that is manually emptied into the blood drain, as necessary.

Whole blood is pumped from the holding tank into one of two

FIGURE 26
BLOOD PROCESSING



blood cookers and dryers (Figure 27) in batches. The cooker is filled to capacity. The moisture is removed while heating under vacuum and then additional raw blood is added without emptying. Cooker capacity is about 300 gallons and 30 to 45 minutes are required for processing each fill.

After drying the blood is transferred to a 22-ton overhead storage bin outside the building. The bin can be emptied by gravity into trucks.

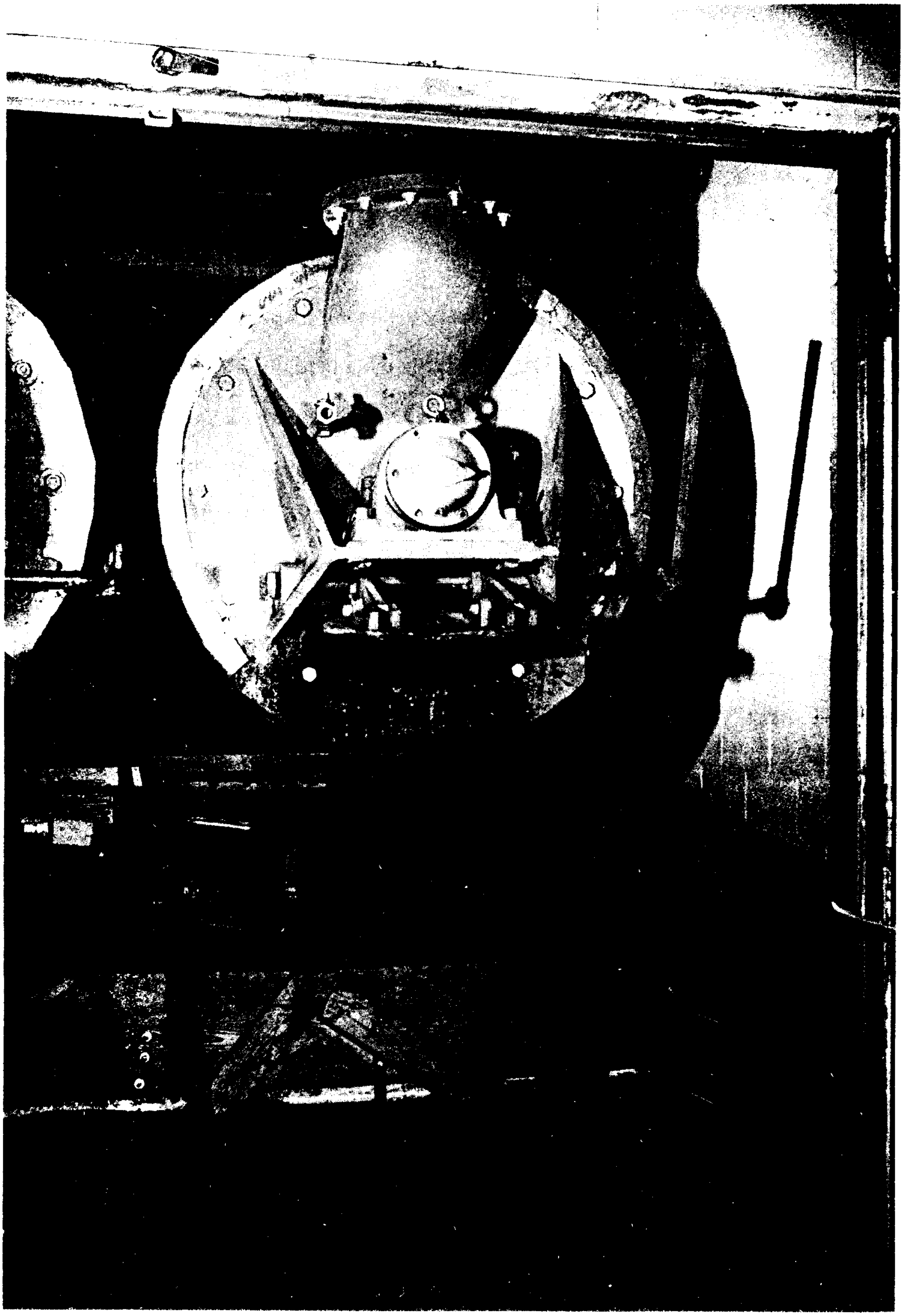


Fig. 27

PROCESS BALANCE

During the five-day period of study 9,620 hogs were processed. Average daily live weight was 441,141 pounds. Live weight is weight on delivery to the slaughterhouse and does not reflect the estimated 5% weight loss on holding without feed prior to slaughter.

The main product is hanging, dressed, halved carcasses with hide intact sans head. Dressed carcass weight averages 73.1% of live weight. Other products sold for human consumption are organs, tongues, head trimmings, and rendered lard. Organs are shipped frozen. All other by-products find a market as animal feed or inedible grease. Lungs and gullets are sold separately as wet, inedible products.

The skull and other trimmings, as well as any rejected organs and carcasses, are ground, cooked, and dried. Blood is cooked and dried separately. Inedible grease includes trimmed fat, grease from the meat and bone meal cooker, and grease concentrated by the grease skimmer and the air flotation unit. Some cooked grease is intentionally hauled to the anaerobic lagoon to function as a cover. Process flow is carefully measured daily. Table I lists the weight balance over the five-day study period.

TABLE I

PROCESS BALANCE

	Weight (lbs.)	Percent
Dressed Carcass Weight	322,801	73.2
Other Edibles	19,478	4.4
Lard (Edible Oil)	7,199	1.6
Meat and Bone Meal	11,518	2.6
Inedible Grease	8,639	2.0
Dried Blood	2,880	0.7
Moisture Evaporated from Blood	18,370	4.2
Moisture Evaporated from Meal*	13,608	3.1
Live Barn Shrink*	22,057	5.0
Sewered Wastes*	1,551	0.4
	428,101	97.04
Live Weight Killed	441,141	

*Estimated

VALUE OF BY-PRODUCT RECOVERY

The cost analysis shown in Table II demonstrates the value of inedible by-product recovery. Of the live weight of the hog, 12.5% is recovered as profitable product for nonhuman consumption. Added to the sale price of this product would be the nondisposal benefits.

TABLE II

PRODUCT PROCESS COST FOR INEDIBLES

(Cents Per Head)

	GAS	ELECTRICITY	
Inedible Oil	1.31	0.45	
Meal	1.31	0.60	
Blood	0.93	0.37	
	3.55	1.42	= $0.05

The cost of disposal by landfill is estimated at $4.75/ton or 6.8 cents per hog for the undried material. Thus, dry blood at $155/ton, inedible oil at $146/ton, and meal at $135/ton bring an additional $0.85 per hog on the market. Net profit on this operation is estimated at $0.80 per hog as follows:

Sale Price For Inedibles	$0.85/Hog
Operating Costs	-$0.05
Capital Costs	-$0.05
Maintenance Costs	-$0.02
Non-Disposal Benefit	$0.07
NET PROFIT	$0.80/Hog

WATER SUPPLY

The plant is supplied with process water from two wells located approximately 600 feet from the plant and 100 feet apart. Water is drawn from them alternately. The well water, as drawn, meets PHS standards. Boiler water is softened, the remainder receives no additional treatment.

The inlet water is restricted to limit flow to a maximum of 275 gal/min. At an average line pressure of 35 psi, the water use per eight-hour shift is limited to 150,000 gal/day. Prior to distribution in the plant, the inlet water is used as a heat sink for the refrigeration system.

Process water use is minimized through recirculation and conservation practices within the plant. During the five-day study, period process effluent averaged 37.4 gallons per hog killed or 163 gallons per 1,000 pounds live weight kill. The daily process effluent balance is shown in Table III.

TABLE III

WASTEWATER BALANCE

TEST DAY	HOGS PROCESSED PER DAY	1000# LWK	PLANT EFFLUENT 1000 GPD	EFFLUENT PER HOG GALLONS	EFFLUENT PER 1000# LWK-GAL
1	2280	507.9	81	35.5	159
2	1624	379.7	69	42.5	182
3	1219	272.9	51	41.8	187
4	2158	501.1	71	32.9	142
5	2339	544.1	80	34.2	147
Daily Average	1924	444.1	70.4	37.4	163

SPECIFIC DEVICES

Stunner - This custom-built device employed a low-voltage, high-amperage charge for stunning. A key feature is the large area of contact for the electrodes. As a consequence of the low-voltage, the incidence of exploding vertebrae is very much decreased.

Scald Tank - The L-shaped scald tank is approximately 70 feet long, 4 feet wide, and 2 1/2 feet deep (Figure 7). The conveyor belt drags the hog into the tank and two power actuated dunkers submerge the hogs. The tank is heated by 11 direct steam jets that are controlled by a thermostat. There is a continuous water feed to the tank that causes sufficient overflow to prevent scum buildup. Sanfax Hog Scald (Oxford Chemical Company) is added to the tank at the rate of 36 to 50 lbs/day. The rate of addition of chemical is matched with the seasonal variation in hog hair growth.

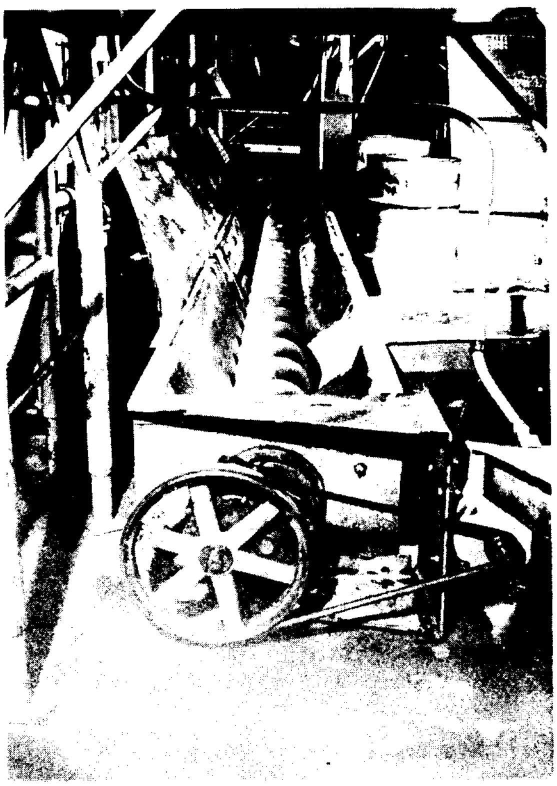
Hair Scrapers - Two commercial hog scrapers have been modified to minimize water consumption. These rotating drums usually operate with a flood of water. At this plant a high-pressure, low-volume spray is employed. The drums are equipped with a two-speed drive, one speed for operation and a lower speed to facilitate cleaning (Figure 9).

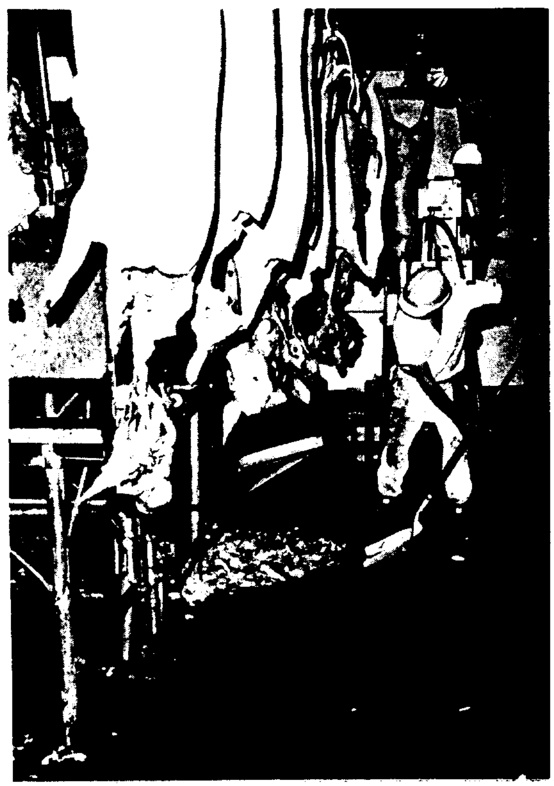
Singe Chamber - Two metal panels, about six feet wide, run from floor to ceiling in the singe chamber. They are placed three feet apart and at the top are covered with a metal hood that vents to an outside stack. A series of 22 fabricated gas jets are placed, 11 on each side to produce a curtain of flame through which the hogs pass. The jets were fabricated from black, iron pipe.

Carcass Polisher - Hogs move past a single 24-inch diameter brush, 150 inches long, which is set at a 30-degree angle to the floor and a 10-degree angle to the conveyor (Figure 13).

Condemned Scrap Auger - A key feature of the plant design is a centrally located auger that mechanically carries all scrap from the kill floor to a holding bin at the lower level without use of water. This is shown with covers removed in Figure 28. All trimmings and rejected products can be placed directly into the auger from the work location or are carried by chute to the auger. The kill floor is dry scraped every two and one-half hours and before daily wash down with the scrapings added to the auger (Figure 29).

Fig.
28
29





Duckbill Nozzles - All rinse devices employ the high-pressure spray produced by the duckbill nozzles shown in Figure 30.

Shutoff Valves - All hand-operated washes are controlled by automatic shutoff valves such as shown in Figures 31 and 32. Wash down hoses have in-line "kink" valves that shut off flow automatically when the hose is dropped. Figure 33 shows how the cleanup man must take positive action to operate the hose.

Stomach Washer - This device is a cut down version of the commercial beef stomach washer with a reworked spray system (Figure 34).

Chitterling Washer - This device was custom-built according to Mr. Lammer's design (Figure 35). Water use is only 40 gallons per minute.

Fig. 30 31 32

Primary Skimmer - A skimmer with trapezoidal vertical cross section is equipped with a drag conveyor as shown in Figure 36. Inlet is slightly submerged and the outlet at the opposite side from the inlet is medially placed. Surface overflow rate is 2,000 to 3,000 gallons per square foot per day.

* NOTE: All measurements are approximate.

Fig. 33

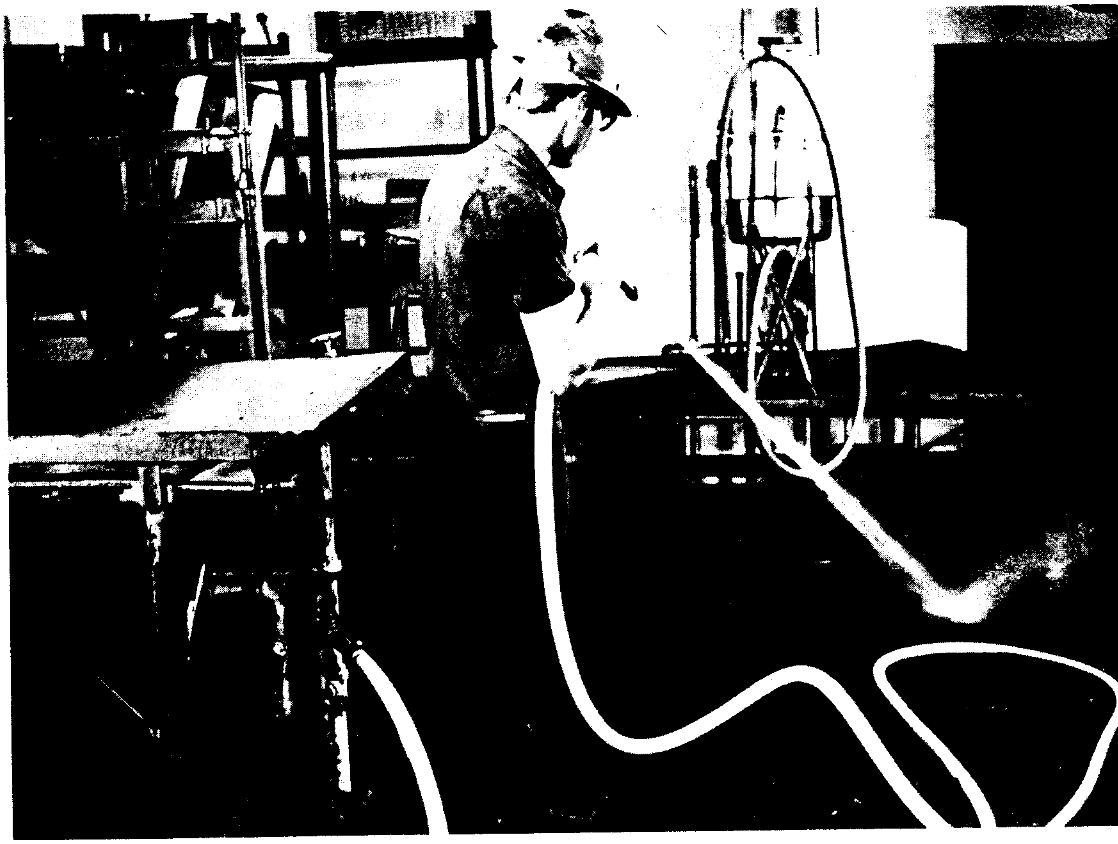
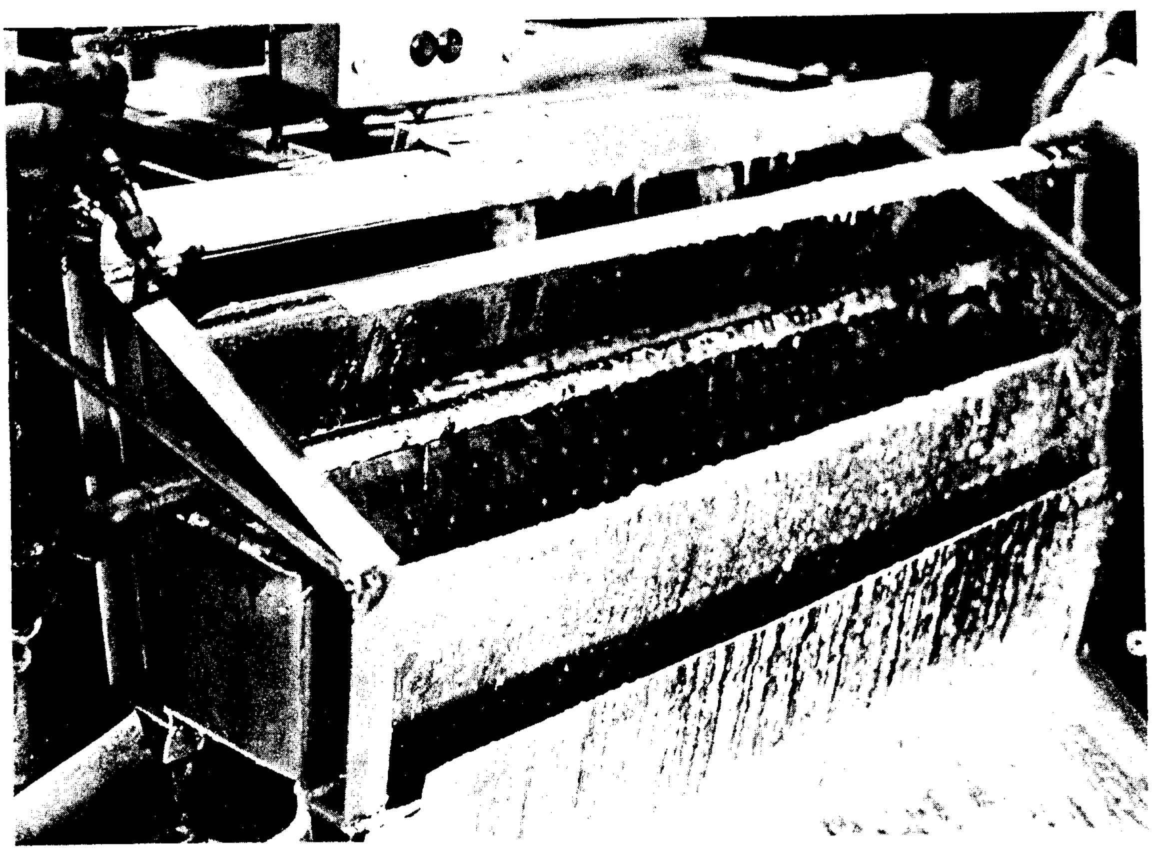


Fig. 34



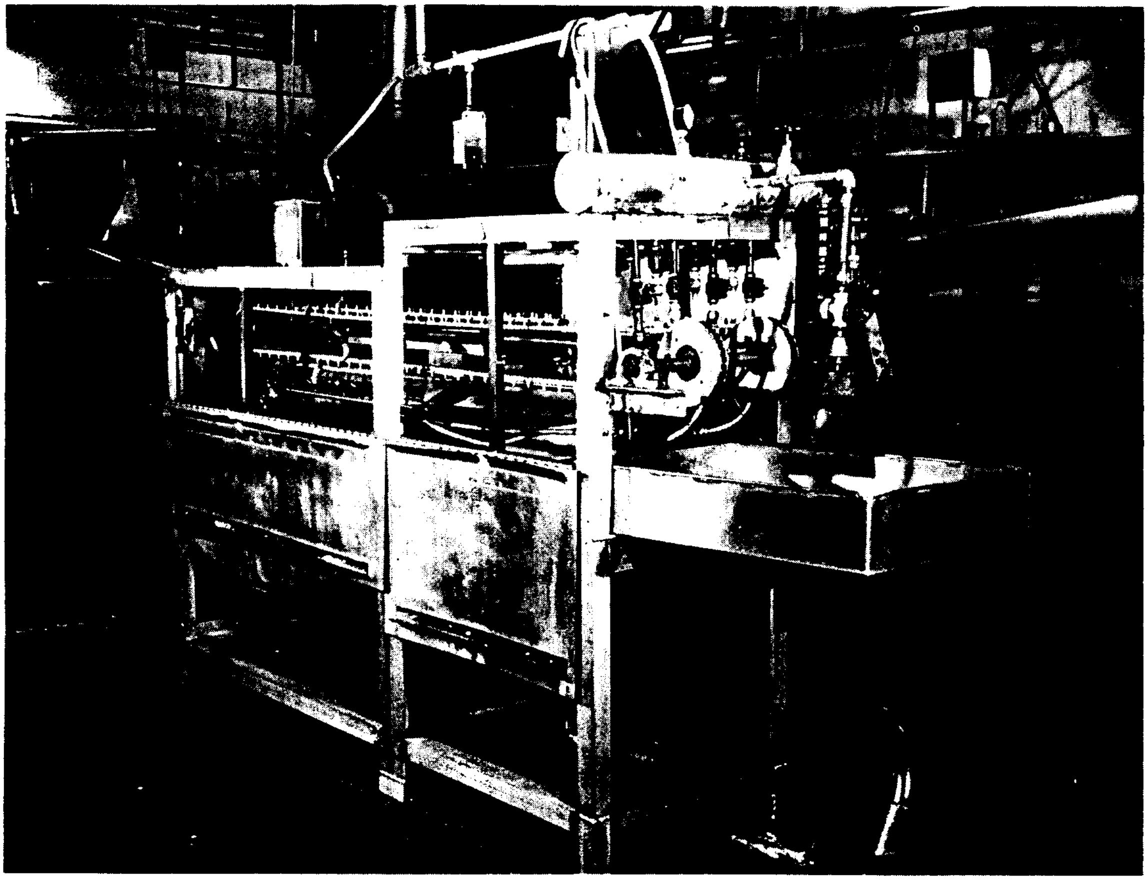


Fig. 35

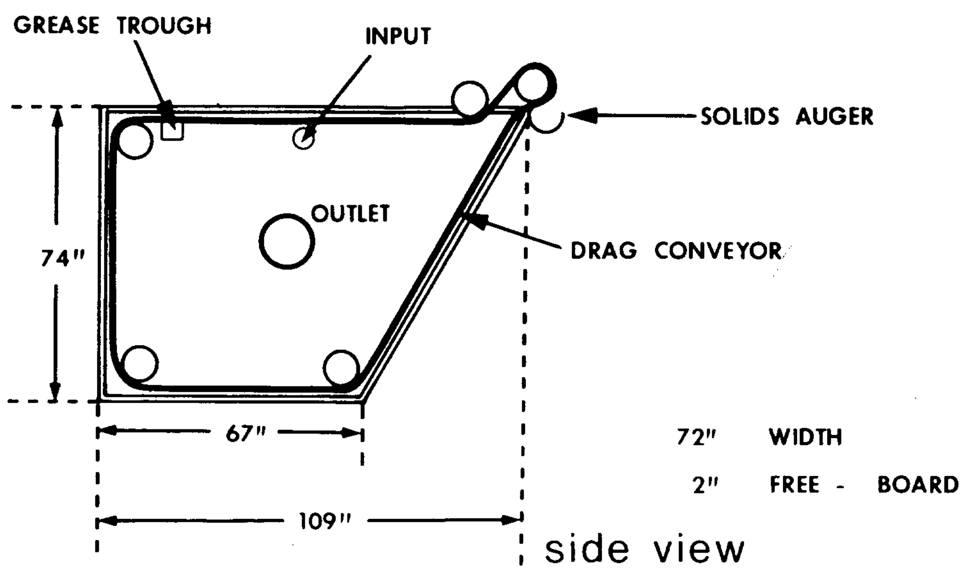


FIGURE 36

SCHEMATIC FOR PRIMARY GREASE SKIMMER

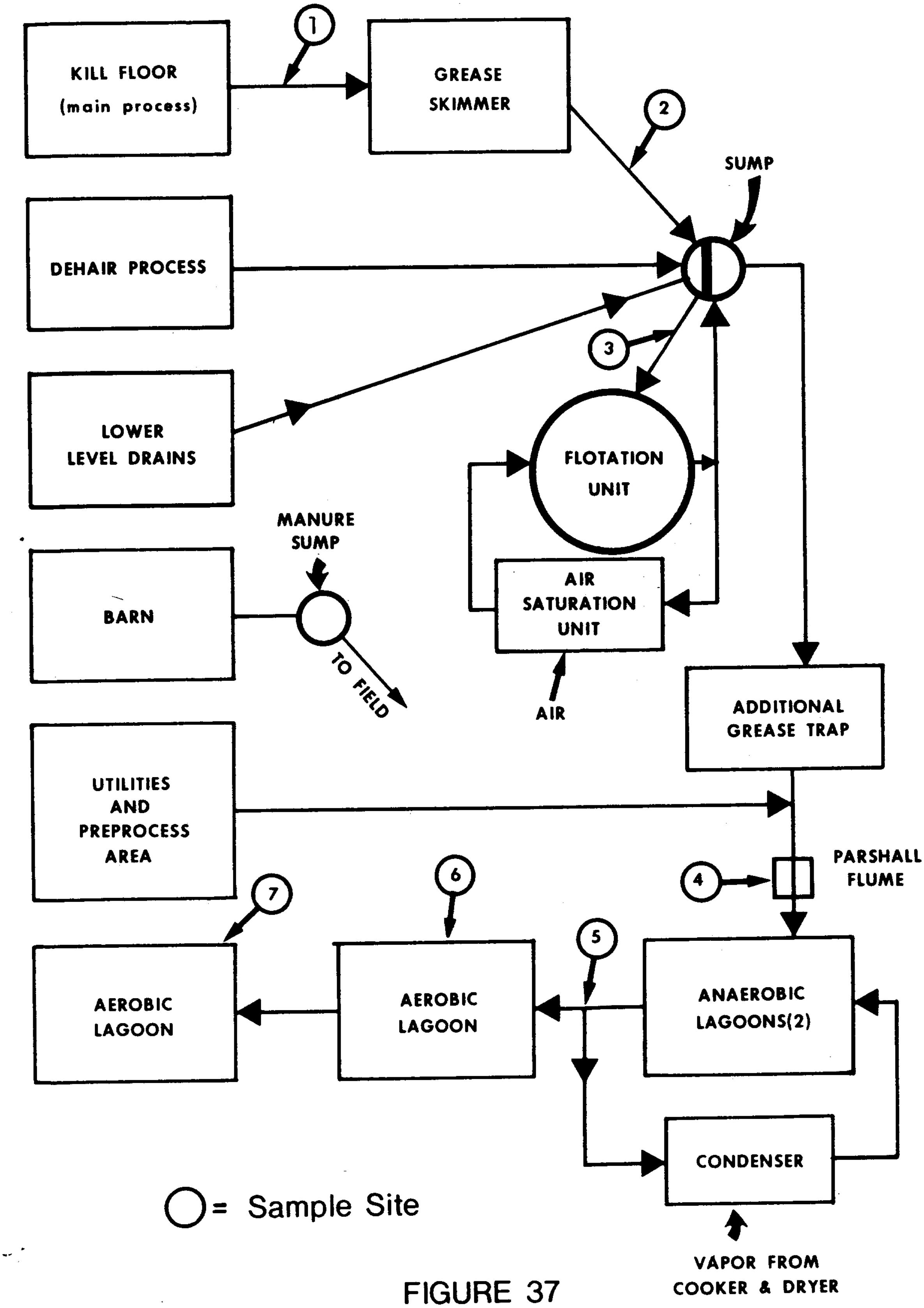


FIGURE 37
WASTE WATER FLOW

Wastewater flow in the plant is depicted schematically in Figure 37. Manure, as well as wash from the barn, is retained separately in a sump from which it is periodically hauled by a "honey wagon" to adjacent fields. The pre-process area is sewered directly into the anaerobic lagoon. Also sewered directly is the blood pump cooling

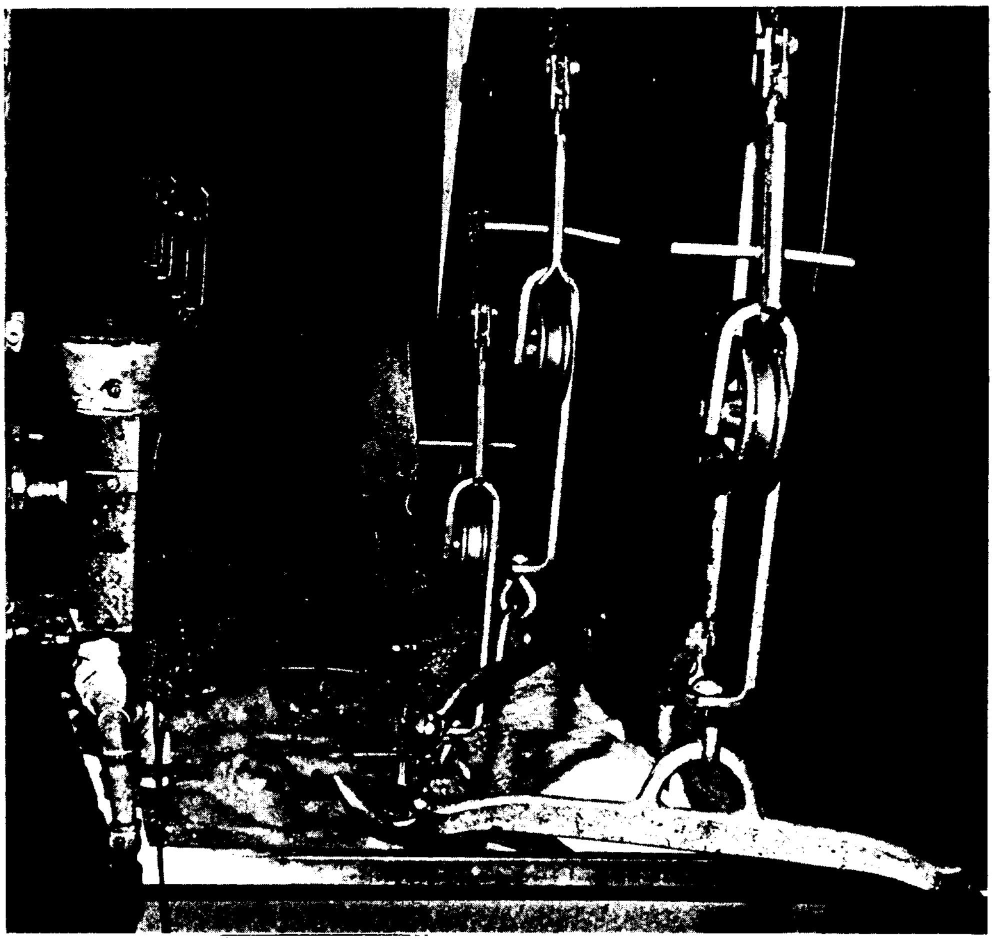


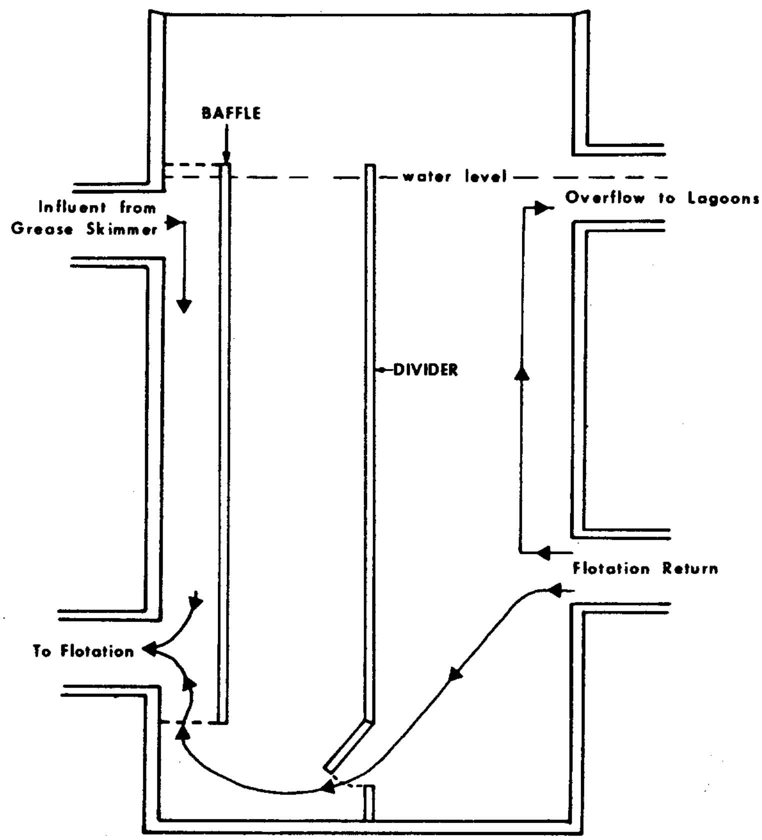
Fig. 38

water, wastewaters from the gambrel stick wash (Figure 38) and rinse area, and drainage from the utilities area. The drainage water includes boiler blowdown and zeolite regeneration waters. Lavatory wastes pass through a septic tank and then flow separately to the anaerobic lagoon.

All drainage from the kill floor passes through the grease skimmer (Figure 36). This includes two carcass rinses, stomach wash, chitterling wash, and wash from the viscera pans, as well as periodic flushing of equipment, tables, and floors. Effluent from the submerged outlet of the grease skimmer flows by gravity to the main sump.

FIGURE 39

MAIN SUMP



The sump also collects drainage from the dehairing process after screening and drainage from the lower level drains. The latter includes spray used to wet down lungs and wash down from lower level equipment. The cylindrical sump is divided into two sections that function to buffer flow. See Figure 39 for the design. Note that recycle from the air flotation unit is used to keep up the level of sump and, hence, a constant flow to the air flotation unit.

The air flotation unit, shown in Figure 40, is a standard Infilco unit. Approximately 20% of the effluent flow is used to dissolve 0.75 scfm of air, and the remainder of the effluent returns to one section of the main sump where it either functions as a flow ballast for the input to the flotation unit or overflows into the main sewer. An additional grease collector has been installed in the main sewer

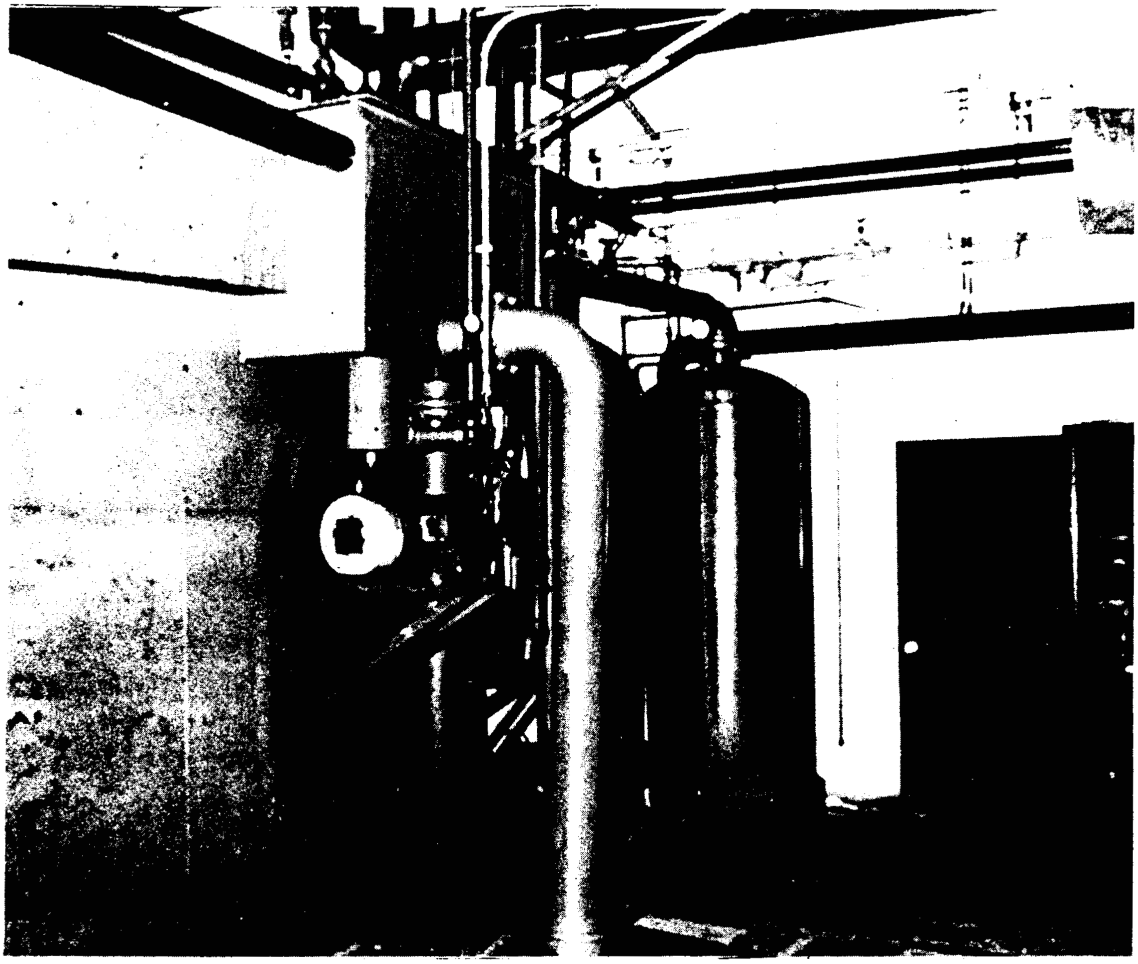


Fig. 40

line. It is periodically emptied manually.

There are two anaerobic lagoons (Figure 41), each covering one-half acre. They are 18 feet deep with 3 feet of free board. Each lagoon can hold 1.2 million gallons or the equivalent to about two weeks flow. The lagoons were originally designed on an expected 2.0 pounds of BOD and a hydraulic loading of 240 gallons per head. Design

BOD reduction was at 85% on a detention of 5.6 days. Actual detention time is 27 days and BOD reduction achieved is 92%. The two lagoons are piped in parallel and operated simultaneously except in case of lagoon malfunction. The effluent from the lagoons is recycled by a 600 gpm pump through the barometric condensers, completely circulating the lagoon supernatant at a rate of once every 2.3 days.

Fig. 41

Combined effluent from the two anaerobic lagoons then flows into two sequential oxidation ponds. The first, with a design load of 40 pounds BOD/acre, covers 11.7 acres; the second, with a design load of 35 pounds BOD/acre, covers 3.3 acres. Each is 6 feet deep. Actual performance data during the period of study showed the load on the first lagoon to be 7.8 pounds BOD/acre with an 80% efficiency at a detention time of at least 321 days. There was no effluent discharge from the aerobic lagoons at the time of the study.

A spray irrigation system is being constructed that will permit the use of final effluent on adjacent corn and alfalfa fields. This provides the option of disposal of effluent by either irrigation or discharge to the nearby creek.

A key feature in plant operation is a single individual who reports directly to management and has authority to take immediate action in problems of water and wastewater use and processing.

Seven wastestream sampling stations were selected to characterize the wastewater flow. These stations were:

1. Wastewater from the kill floor.
2. Effluent from the grease skimmer.
3. Effluent from the main sump.
4. Total plant effluent.
5. Anaerobic lagoon effluent.
6. First aerobic lagoon contents.
7. Second aerobic lagoon contents.

The sampling stations are shown on Figure 37 and analytical data are shown in Tables IV through XIV with a summary of the raw waste load on Table XV.

Table IV

BIOCHEMICAL OXYGEN DEMAND

Test Day	Sample Station	Flow 1000 GPD	BOD MG/L	BOD #/Hog	BOD #/1000#LWK
3	2	18	1750	0.22	0.96
3	4	51	1920	0.67	2.99
3	5	51	133	0.05	0.21
3	6	51	24	0.008	0.04
4	2	32	1670	0.21	0.89
4	4	71	1610	0.44	1.90
4	5	71	170	0.05	0.20
4	6	71	30	0.008	0.04
5	2	35	2300	0.29	1.23
5	4	80	2400	0.69	2.94
5	5	80	150	0.04	0.18
5	6	80	36	0.01	0.04

TABLE V

CHEMICAL OXYGEN DEMAND

TEST DAY	SAMPLE STATION	FLOW 1000 GPD	COD MG/L	COD #/HOG	COD #/1000#LWK
1	4	81	2760	0.82	3.67
1	5	81	316	0.094	0.42
1	7	81	81	0.024	0.11
2	4	69	2397	0.85	3.64
2	5	69	392	0.14	0.59
2	7	69	138	0.049	0.21
3	4	51	2431	0.85	3.79
3	5	51	262	0.091	0.41
3	6	51	66	0.023	0.10
4	4	71	2183	0.60	2.58
4	5	71	276	0.076	0.33
4	6	71	91	0.025	0.11
5	4	80	2547	0.73	3.13
5	5	80	270	0.77	0.33
5	6	80	95	0.27	0.12

Table VI

TOTAL SOLIDS (TS)

Test Day	Sample Station	Flow 1000 GPD	TS MG/L	TS #/HOG	TS #/1000#LWK
1	2	34	2150	0.27	1.20
1	3	55	1990	0.40	1.80
1	4	81	2230	0.66	2.97
1	5	81	1150	0.34	1.53
1	7	81	830	0.25	1.10
2	2	24	1860	0.23	0.98
2	3	55	4190	1.18	5.07
2	4	69	1650	0.59	2.50
2	5	69	1130	0.40	1.71
2	7	69	884	0.31	1.34
3	2	18	1710	0.21	0.94
3	3	55	3750	1.41	6.31
3	4	51	3390	1.18	5.29
3	5	51	1110	0.39	1.73
3	6	51	826	0.29	1.29
4	2	32	2480	0.31	1.32
4	3	55	2320	0.49	2.13
4	4	71	1540	0.42	1.82
4	5	71	1160	0.32	1.37
4	6	71	1060	0.29	1.25
5	2	35	2220	0.28	1.19
5	3	55	1850	0.36	1.56
5	4	80	2050	0.59	2.52
5	5	80	1130	0.32	1.39
5	6	80	1060	0.30	1.30

Table VII

TOTAL SUSPENDED SOLIDS (TSS)

Test Day	Sample Station	Flow 1000 GPD	TSS MG/L	TSS #/HOG	TSS #/1000#LWK
1	2	34	1030	0.13	0.58
1	3	55	960	0.19	0.87
1	4	81	665	0.20	0.89
1	5	81	78	0.023	0.10
1	7	81	18	0.005	0.023
2	2	24	870	0.11	0.46
2	3	55	2440	0.69	2.95
2	4	69	570	0.20	0.86
2	5	69	64	0.023	0.097
2	7	69	50	0.018	0.076
3	2	18	690	0.085	0.38
3	3	55	2550	0.96	4.29
3	4	51	720	0.25	1.22
3	5	51	66	0.023	0.10
3	6	51	16	0.006	0.024
4	2	32	1110	0.14	0.59
4	3	55	1020	0.22	0.93
4	4	71	546	0.15	0.64
4	5	71	64	0.018	0.076
4	6	71	16	0.004	0.019
5	2	35	780	0.097	0.42
5	3	55	800	0.16	0.67
5	4	80	600	0.17	0.80
5	5	80	72	0.021	0.096
5	6	80	18	0.005	0.024

TABLE VIII

TOTAL VOLATILE SOLIDS (TVS)

TEST DAY	SAMPLE STATION	FLOW 1000 GPD	TVS MG/L	TVS #/HOG	TVS #/1000#LWK
1	4	81	1110	0.33	1.47
1	5	81	202	0.06	0.27
2	4	69	856	0.30	1.3
2	5	69	192	0.068	0.27
3	4	51	1050	0.366	1.63
3	5	51	196	0.068	0.31
4	4	71	690	0.189	0.814
4	5	71	226	0.081	0.267
5	4	80	1190	0.33	1.46
5	5	80	202	0.058	0.247

Table IX

VOLATILE SUSPENDED SOLIDS (VSS)

Test Day	Sample Station	Flow 1000 GPD	VSS MG/L	VSS #/HOG	VSS #/1000#LWK
1	5	81	52	0.013	0.070
2	4	69	420	0.14	0.63
2	5	69	48	0.017	0.072
3	4	51	510	0.17	0.79
3	5	51	52	0.018	0.08
4	4	71	390	0.10	0.46
5	4	80	460	0.128	0.56

Table X

OIL AND GREASE

Test Day	Sample Station	Flow 1000 GPD	Oil & Grease MG/L	Oil & Grease #/HOG	Oil & Grease #/1000#LWK
1	1	34	90	0.011	0.05
1	2	34	98	0.012	0.055
1	3	55	134	0.027	0.12
1	4	81	188	0.056	0.25
1	5	81	14	0.004	0.019
1	7	81	<1	-----	-----
2	1	24	406	0.05	0.21
2	2	24	383	0.047	0.20
2	3	55	352	0.10	0.43
2	4	69	139	0.05	0.21
2	5	69	20	0.007	0.03
2	7	69	2	0.0007	0.003
3	1	18	574	0.03	0.14
3	2	18	231	0.028	0.127
3	3	55	461	0.17	0.75
3	4	51	293	0.10	0.46
3	5	51	19	0.006	0.03
3	6	51	5	0.0017	0.0078
4	1	32	341	0.04	0.18
4	2	32	446	0.055	0.24
4	3	55	826	0.18	0.76
4	4	71	90	0.02	0.106
4	5	71	11	0.003	0.013
4	6	71	4	0.001	0.005
5	2	35	452	0.05	0.24
5	3	55	459	0.09	0.39
5	4	80	891	0.25	1.09

TABLE XI

OIL AND GREASE

	SAMPLE STATION	FLOW 1000 GPD	OIL & GREASE MG/L	OIL & GREASE #/HOG	OIL & GREASE #/1000#LWK
Average	1	27	353	0.033	0.145
Average	2	27	322	0.038	0.17
Average	3	55	446	0.11	0.49
Average	4	70	320	0.095	0.42
Average	5	68	16	0.005	0.023
Average	6 & 7	68	2.8	0.0009	0.004

Table XII

TOTAL KJELDAHL NITROGEN (TKN)

Test Day	Sample Station	Flow 1000 GPD	TKN MG/L	TKN #/HOG	TKN #/1000#LWK
1	2	34	116	0.014	0.065
1	3	55	132	0.027	0.119
1	4	81	122	0.036	0.162
1	5	81	142	0.042	0.189
1	7	81	4.2	0.001	0.006
2	2	24	100	0.012	0.053
2	3	55	105	0.030	0.127
2	4	69	116	0.041	0.176
2	5	69	115	0.041	0.174
2	7	69	5.0	0.002	0.010
3	2	18	102	0.013	0.056
3	3	55	153	0.058	0.257
3	4	51	109	0.038	0.170
3	5	51	---	-----	-----
3	6	51	4.5	0.002	0.007
4	2	32	98	0.012	0.052
4	3	55	133	0.028	0.121
4	4	71	106	0.029	0.125
4	5	71	116	0.032	0.137
4	6	71	5.8	0.002	0.007
5	2	35	94	0.012	0.050
5	3	55	136	0.027	0.115
5	4	80	117	0.023	0.098
5	5	80	115	0.033	0.141
5	6	80	5.8	0.002	0.007

TABLE XIII

BACTERIA COUNT
(5-DAY AVERAGE)

SAMPLE STATION	FECAL COLIFORM MF/100ML	FECAL STREPTOCOCCI MF/100ML
6	186	440
5	419×10^3	144×10^3
4	25×10^6	3×10^6

TABLE XIV

NUTRIENTS IN OXIDATION POND (AEROBIC LAGOON)

NUTRIENTS (MG/L)

TEST DAY	AEROBIC LAGOON	TKN	NO_2-NO_3	NH_3-N	TOTAL P
1	2nd	4.2	3.1	0.7	1.0
2	2nd	5.0	2.3	1.2	---
3	1st	4.5	2.0	0.8	---
4	1st	5.8	23	2.0	2.0
5	1st	5.8	23	3.1	---

Phosphate analyses of two samples
of plant effluent averaged 19.4 MG/l - P

TABLE XV

SUMMARY OF PLANT EFFLUENT ANALYSES

(SAMPLE STATION #4)

ANALYSIS

	BOD	COD	TS	TSS	TVS	VSS	TKN	O&G
Conc., MG/L	1976	2464	2172	618	979	445	114	320
Per Hog, #'s	0.61	0.77	0.66	0.19	0.30	0.14	0.035	0.095
Per 1000#LWK,#'s	2.61	3.36	2.87	0.88	1.33	0.61	0.151	0.42