IN-PLANT MODIFICATIONS TO REDUCE POLLUTION

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AND
PRETREATMENT OF MEAT PACKING WASTEWATERS
FOR
DISCHARGE TO MUNICIPAL SYSTEMS

PREPARED
FOR
ENVIRONMENTAL PROTECTION AGENCY
TECHNOLOGY TRANSFER PROGRAM

DESIGN SEMINAR
FOR
UPGRADING
MEAT PACKING FACILITIES
TO REDUCE POLLUTION

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PREFACE

This manual is intended to serve as an information medium for one section of the Environmental Protection Agency Technology Transfer Design Seminar for Upgrading Meat Packing Facilities to Reduce Pollution. No attempt was made to include meat processing at separate locations apart from killing plants (dog food manufacturing, sausage plants, etc.), although much of this information can be applied to them.

This section of the seminar relates to "In-Plant Modifications to Reduce Pollution and the Pretreatment of Meat Packing Wastewaters for Discharge to Municipal Systems." Another technical section covers complete treatment for discharge to a watercourse and also includes a manual. These manuals are particularly oriented toward plant owners, managers, superintendents and their engineering and operating staffs.

Wherever possible, copies of visual aids used during the presentations are reproduced in the manual. The selection of speakers and writers was based upon their familiarity with the technology being presented. Selection of a speaker affiliated with a manufacturer of a specific product, as well as any proprietary material presented herein, does not directly or indirectly imply an endorsement of such product. Other manufacturers of similar products and processes are listed in the Appendix. Cited references and a Bibliography will also be found in the Appendix.

The material in this section will be presented to half of the attendees on each of two separate half-days, concurrently with the other section mentioned above. To provide useful information within these time restrictions, the seminar discussion must necessarily be limited to an overview of the subject matter, but the manual covers each subject in greater depth.

To avoid duplication, biological treatment methods are covered only in the section of this seminar on "Treatment for Discharge to a Watercourse", though it is recognized that many pretreatment systems include biological systems to condition meat packing wastewaters for discharge to municipal systems under municipal regulations.

Discussion of the disposal of solids, such as recovered hog hair, screenings, paunch manure, and floatables and settled solids from grease basins is beyond the scope of this manual, but prevention of discharge of some types of solids and removal of other materials from the waste streams are included.

Subjects discussed in this manual may be studied in greater depth by referring to the Bibliography and the technical literature of manufacturers listed in the Appendix.

ACKNOWLEDGEMENTS

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A. J. Steffen

I. INTRODUCTION

A. GENERAL BACKGROUND.

The importance of in-plant modification to reduce pollution (Sect. II, of this manual) needs no emphasis here. It is a simple economic fact that conservation and in-plant waste saving, along with water recycle and reuse must be considered before any plant undertakes to build pretreatment facilities for discharge to a public sewer, pays a municipal charge for wastewater treatment or builds a complete treatment plant for discharge to a watercourse.

The importance of Section III of this manual, "The Pretreatment of Meat Packing Wastewaters for Discharge to Municipal Systems" becomes evident when we note that a 1967 survey showed that 70% of the wastewater from the meat packing industry was discharged to municipal facilities.(1) Although we have no recent data, it seems likely that this percentage may now be slightly lower with the continuing trend towards decentralization into small plants discharging into independent lagoon systems in semi-rural areas.

Wherever possible, this manual deals with waste conservation in existing plants. However, it will be evident to the reader that many of the methods discussed are applicable largely to new plants and could not readily be retrofitted into existing plants because of space limitations and layout. Thus each manager and engineer can make use of this manual as a guide and "check list", evaluating each waste conservation concept as it applies to his particular plant.

The portion on pretreatment (Section III) discusses the elements of equipment that make up a pretreatment plant, whether it be an expansion of existing pretreatment facilities or an entirely new system.

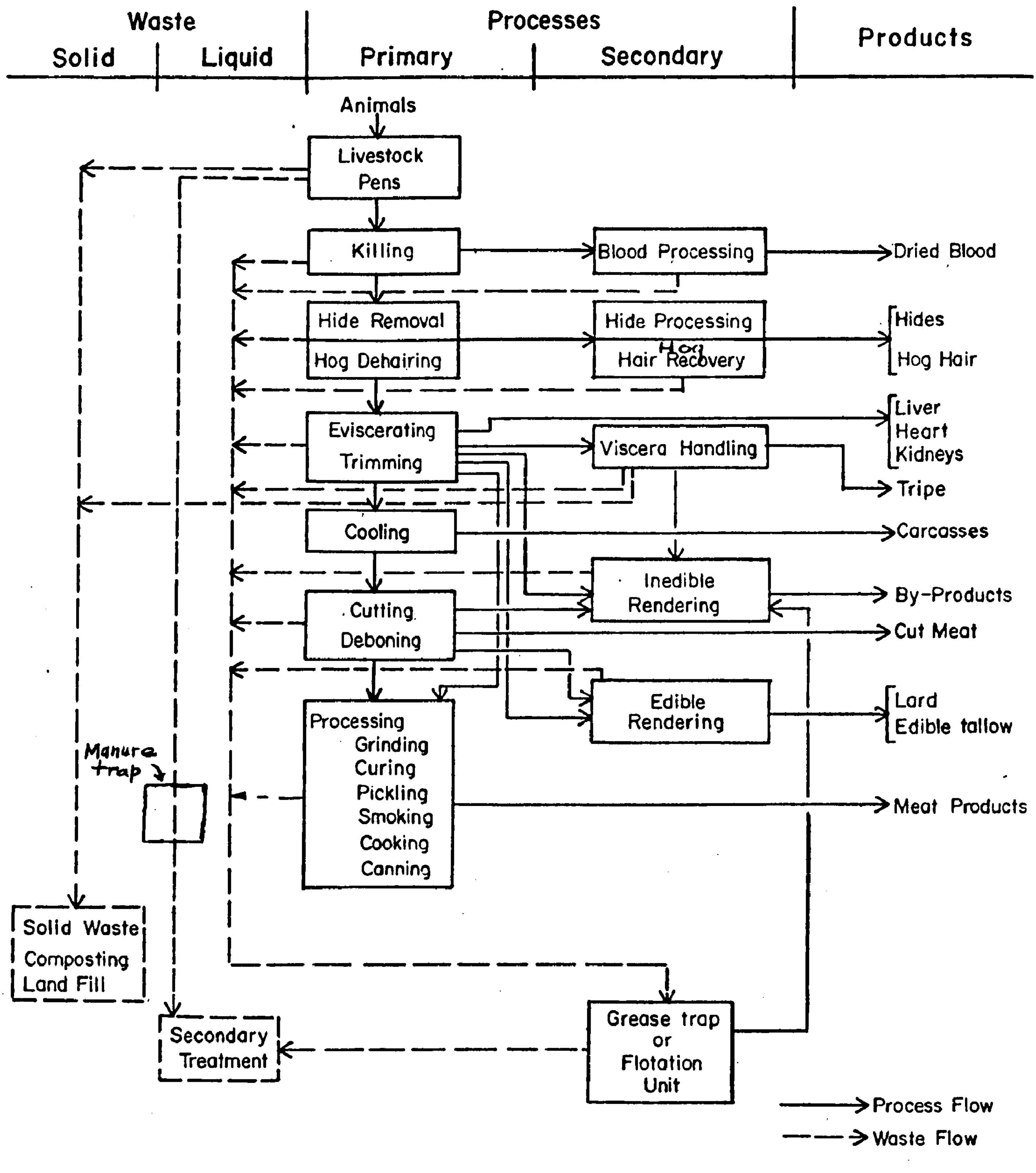
The meat plant owner, operator or engineer does not need a preliminary discussion of the processes in the industry nor does he need a separate set of recommendations for beef kill and hog kill. Accordingly, in the interests of brevity, the assumption is made that the reader is conversant with industry practices. The accompanying flow chart is, however, included for reference.

B. REGULATORY CONSIDERATIONS.

1. Federal. The following discussion is limited to Federal regulations relating to the subject matter of this manual and thus does not include a discussion of permits for discharge to watercourses.

a. Federal Grants Program. Public Law 92-500, amending the Federal Pollution Control Act, was passed by Congress on October 18, 1972, and contains several points of direct interest to industry. In providing grants for new or expanded municipal treatment plants (now amounting to 75% of the construction cost), The Federal government requires that the municipality "has made provision for the payment.... by the industrial user of the treatment works, of that portion of the cost.... allocable to the treatment of such industrial wastes.." for which he is responsible. (Section 204 (b) (1).

The Law also provides that, by April 16, 1973, the EPA shall "issue guidelines applicable to payment of waste treatment cost by industrial and non-industrial recipients of waste treatment services which shall establish (A) classes of users of such services, including categories of industrial users; (B) criteria against which to determine the adequacy of charges imposed on classes and categories of users reflecting factors that influence the cost of waste treatment, including strength, volume, and delivery flow rate characteristics (surges and maximum flows) of wastes; and (C) Model systems and rates of



Flowchart for Packinghouse

(From North Star Research & Development Inst., "Final Report, Industrial Waste Study of the Meat Products Industry", EPA Contract No. 68-01-0031).

user charges typical of various treatment works serving municipal-industrial communities." Thus the EPA will be involved in the rate structure or formula developed for sewage charges for all municipalities (including sanitary districts) where grant funds are allocated, in order to assure repayment of the government's cost in proportion to the cost of the treatment works attributable to the industry's wastewater discharged to the municipal sewer. The accompanying exhibit "Quantity or quality formulas based on total cost or average unit costs" is excerpted from "Federal Guidelines — Equitable Recovery of Industrial Waste Treatment Costs in Municipal Systems" (Oct., 1971). Since this guideline was published prior to the date of enactment of the Act, it serves only as an indication of possible procedures. No guidelines pursuant to the Act have been developed at this writing.

Pretreatment prior to discharge to "publicly owned" (i.e., municipality, sanitary district, county, etc.) treatment works is also regulated under the Act. Sect. 307 (b)(1) requires that the EPA, by April 16, 1973, "publish proposed regulations establishing pretreatment standards for introduction of pollutants into treatment works....,which are publicly owned, for those pollutants which are determined not to be susceptible to treatment by such treatment works or which would interfere with the operation of such treatment works. Not later than 90 days after such publication, and after opportunity for public hearing, the Administrator shall promulgate such pretreatment standards." The Act allows a maximum of three years for compliance by industry and also provides for revision of these standards as new technology warrants.

The limits may be anticipated to be in two general categories: one, prohibited items (such as ashes, hair, whole blood, paunch manure, and similar

Quantity or quality formulas based on total cost or average unit costs.

This method of cost allocation or derivation of industrial charge is computed by several forms of the generalized formula:

$$C_i = v_o V_i + b_o B_i + s_o S_i$$

Note: The principle applies equally well with additional terms (e.g., chlorine feed rates) or less terms (e.g., $v_o V_i$ only).

Where C_i = charge to industrial users, $/yr.

v_o = average unit cost of transport and treatment chargeable to volume, $/gal.

b_o = average unit cost of treatment, chargeable to BOD, $/lb.

s_o = average unit cost of treatment (including sludge treatment) chargeable to SS, $/lb.

V_i = volume of waste water from industrial users, gal./yr.

B_i = weight of BOD from industrial users, lb./yr.

S_i = weight of SS from industrial users, lb./yr.

The terms b_o and s_o above may include charges (surcharges) for concentrated wastes above an established minimum based on normal load criteria.

Inasmuch as it is an objective of the Guidelines to encourage the initiation and use of user charges, this general method of allocation is both preferable and acceptable.

materials untreatable in municipal plants), and the second category, maximum concentrations of such items as BOD, suspended solids and other constituents which, in excess, could interfere with the operation of the municipal plant. Many municipalities will use such maxima in their structure of charges, figuring a volume cost per 1000 gallons per month (perhaps on a sliding scale similar to water billing or, more conveniently, a definite multiplier of the municipal water bill). To this volume cost, surcharges are added for BOD, suspended solids, grease, and possibly other pollutional ingredients at a determined rate in cents per pound of each such pollutional ingredient beyond a certain basic concentration, the base being representative of the concentration of domestic sewage (also see item 3, following item 2 below).

2. State. This discussion will be limited to the state's role in in-plant conservation and pretreatment prior to discharge to public sewers. Recycling and reuse of water and any other major in-plant changes should be reviewed with the state meat inspection agency if the plant is under state, rather than federal inspection.

Approval of plans for pretreatment of wastewaters prior to discharge to public sewers may be a requirement under the state regulations for approval of plans for sewage treatment. States differ on this point.

In some states, the plant may also be required to have a state-licensed wastewater treatment plant operator for such pretreatment facilities.

Municipal ordinances relating to wastewater are generally reviewed by the state stream pollution control authority. Thus ordinances and regulations regarding industrial wastewater and charges and surcharges will most likely be reviewed by the state before passage.

If the city has not passed the legislation required by the EPA for a Federal Grant for sewage treatment construction, the state (which allocates these funds) may advise EPA to withhold a portion of the grant until all requirements are met.

When a new plant is planned for connection to a public sewer and such connection will substantially increase the flow or pollutional characteristics of wastewaters reaching the municipal wastewater treatment plant, the agency owning the sewer is required by federal law to advise the state of such change.

3. Municipal. Municipal ordinances and regulations that are less stringent than those set up under the Federal Act discussed under 1 above, will be required to alter them to conform, but if they exceed the federal standards, they need not be reduced, unless the city elects to do so.

Existing municipal ordinances and regulations covering discharge to the public sewers vary widely. A large number of cities use, as a guide, the so-called Model Ordinance published as part of Manual of Practice No. 3 of the Water Pollution Control Federation. Article V of the Model Ordinance contains an extensive list of limiting characteristics applicable to meat packing wastewaters discharged to public sewers. The background material, along with Article V, are too voluminous to reproduce in this manual. The "Regulation of Sewer Use" (Manual of Practice No. 3) is available at $1.50 ($1.00 to Federation members) from: Water Pollution Control Federation, 3900 Wisconsin Ave., Wash., D. C. 20016. A 15% quantity discount is available in lots of twelve or more copies.

Municipal ordinances generally cover the subject under two headings: Limitations and Surcharges.

a. Limitations.

1) Prohibition of objectionable matter. Various minerals, toxic materials and waste characteristics and materials that are difficult to treat are excluded. The following examples are typical:

a) The Metropolitan Sanitary District of Greater Chicago includes the following exclusions on ingredients that may affect packing plant effluents:

Noxious or malodorous liquids, gases or substances which either singly or by interaction with other wastes are sufficient to create a public nuisance or hazard to life or are sufficient to prevent entry into the sewers for their maintenance and repair,

Solid or viscous wastes which cause obstruction to the flow in sewers or other interference with the proper operation of the sewerage system or sewage treatment works, such as grease, uncomminuted garbage, animal guts or tissues, paunch manure, bone, hair, hides and fleshings.

Waters or waste containing substances which are not amenable to treatment or reduction by the sewage treatment process employed or are amenable to treatment only to such degree that the sewage treatment plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters.

Excessive discoloration.

b) Other cities use similar limiting clauses in their ordinances, often copied from the Manual of Practice No. 3, from which the above wording was adapted in part.

2) Concentration of pollutional characteristics.

a) The Ordinance of the Metropolitan Sanitary District of Greater Chicago provides no top limits for BOD or suspended solids but does include "surcharges" for these items (see 2 a, following). It does, however, limit temperature to a maximum of 150° F. (65° C) and fats, oils or greases (hexane solubles) to a maximum of 100 mg/l These limits are included in many municipal ordinances.

b) Other cities may limit BOD to possibly 300 mg/l and suspended solids to 350 mg/l, more or less. "Catch-all" clauses are also common, such as "The Town Board of Trustees is authorized to prohibit the dumping of wastes into the Town's sewage system which, in its discretion, are deemed harmful to the operation of the sewage works of said Town."

b. Surcharges.

1) The Metropolitan Sanitary District of Greater Chicago charges 2.1 cents per 1000 gallons, 1.4 cents per pound of BOD and 2.4 cents per pound of suspended solids, after deducting the first 10,000 gallons per day (and the BOD and suspended solids it would contain). Also deducted are the sewer district tax (a property type tax) plus 4 mills per day per employee, an allowance for sanitary sewage discharged during the working day.

2) Most of the simpler sewage billing systems are based on the water usage, ranging from about 50% to as high as 125% of the water billing, with maxima for BOD, suspended solids, grease and sometimes other ingredients. These are basic sewer charges applicable to all users, domestic, commercial and industrial and are not classified as surcharges unless they include escalation for BOD, suspended solids, grease, etc. and possibly flows, in excess of a "domestic" base. Thus the surcharge portion of the ordinance might be similar in structure to the Chicago ordinance, but with a charge for flow in excess of a base, and a charge per pound of ingredients above a base represented by discharge from a single residence.

3) Also note the guidelines under 1. Federal (above).

In general, the new Federal Act may radically modify existing municipal ordinances and regulations.

It should also be noted that recycle and reuse of "used water" must be checked by the USDA and any other agency having jurisdiction over product sanitation.

II. IN-PLANT MODIFICATIONS to REDUCE POLLUTION by A. J. Steffen and W. H. Miedaner*

A. PRACTICES in WASTE CONSERVATION in the MEAT PACKING INDUSTRY.

Except for very small slaughtering plants, most plants recover blood, screenable solids and grease by various in-plant systems and devices. Many small packers without blood drying facilities or inedible rendering departments recover such materials for local tank truck pick-up operated by specialized by-products plants in the area.

The quantity of water used varies widely, based on waste conservation practices, blood and solids handling methods and the amount of processing done in the plant. It may range from about 0.5 to 2.0 gallons per pound of live weight killed.

The degree of wastewater conservation, recycle and reuse, and solids and blood recovery in each individual plant depends upon many factors: the age of the plant; the views of management on the subject; whether markets or final disposal facilities for recovered blood, solids and grease are readily available; market prices of the recoverable materials; the local regulations regarding effluent quality and surcharge costs for plants discharging to public sewers; and the first cost, and operating costs of independent treatment if the packer discharges to a watercourse.

The low market price for recovered inedible grease in some localities has forced many packers to dispose of it as feed-grade grease. If the meat packing plant is conveniently located near a soap plant, the possibilities of an improved price will provide special incentives for grease recovery.

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Variations in economics in disposing of the solids and concentrates such as paunch manure, blood, hair, casing slimes and concentrated stick (in wet rendering) inevitably affect the diligence with which these pollutional solids are kept out of the sewer.

However, the limitations and surcharge regulations for wastes discharged to city sewers, or the cost of complete treatment if the plant discharges to a watercourse must be carefully evaluated to establish the level of waste conservation appropriate to the packing plant. For example, a plant discharging to its own anaerobic-aerobic pond system may find that some floatable inert solids such as stock-pen bedding can improve the insulating scum blanket on the anaerobic lagoon. Then, neglect in recovery of such materials would not be important. On the other hand, a packing plant in Springfield, Mo., faced with a municipal waste treatment charge of $1,400 a month, modified its production processes (including solids recovery), so that the monthly payment dropped to $225.

In processing and in quality control, the meat industry finds water an essential tool to help cleanse the product and to convey and remove unwanted materials. But in wastewater handling, water becomes a problem — a diluter that flushes and dissolves organic matter and carries it to the sewer. Wastewater treatment is basically nothing more than a processing system to again separate the organic and inorganic matter from the water that picked it up.

The goal of every wastewater engineer is to remove organic solids "dry" without discharging to the sewer, and then use an absolute minimum of water for the essentials of sanitation. The closer we come to this goal, the simpler becomes the wastewater problem. This goal provides the pattern in waste conservation in the plant, and can be briefly summarized in the following axioms:

1. Use water wisely — only enough to get the job done.
2. Keep waste solids in bulk whenever possible, for disposal as a solid or as a concentrated sludge, without discharging to the sewer.
3. Clean with high pressure and minimum water volume (small hoses). Use the right detergents in the right proportions to clean well with minimum rinsing.
4. Recycle water as much as possible, within the limits of USDA regulations. Some reconditioning, such as cooling or screening, may be necessary for recycling in some instances.
5. Use the minimum pressure and volume for washing product, consistent with quality control. High pressure in washing product may drive soil into the product and also wash away valuable edible protein and fat.
6. Control volume, temperature and pressure automatically. Dependence upon manual regulation can lead to waste.
7. Use valves that shut off automatically when the water is not needed. For example, photo-electric cells are used in Japan to turn water on when product is in a washing position.
8. Study each process independently. General rules alone will not do the job.

B. SEGREGATION of WASTE STREAMS.

In meat packing, it has been common practice to provide separate sewer systems for grease wastes; non-grease (variously termed "manure" sewer or "red" sewer); clear waters from chilling, condensing and cooling operations; surface and roof water (surface drainage); stock-pen wastes and sanitary wastes. However, for new plants, further segregation is often desirable in order to permit removal of pollutional ingredients before the wastewaters mingle with other plant waters. Screening equipment can be smaller and can be designed for the special solids present. In some cases, such segregated waters may be sufficiently dilute to use for recycling.

In the interests of dry or semi-dry manure separation, a separate manure sewer should be provided in new plants for all sources of manure. This waste can be pretreated by screening, followed by dissolved air flotation. The floated solids can be analyzed for fats and wet rendered if warranted.

The grease sewer should receive only those wastes that contain grease. If the color of the rendered tallow is a factor, special diligence must be exercised that all manure-bearing wastes be kept out of the sewer. The settled solids should be discharged over a screen, dried and utilized in feeds, if possible. They contain an appreciable amount of grease. Basically, the grease sewer should receive wastes from boning, cutting, edible and inedible rendering, casing washing (after manure and slime have been removed), canning, sausage manufacturing, slicing, prepackaging, smoking and smoked meats hanging, cooking, tank car loading and washing, carcass coolers, lard and grease storage areas, equipment washrooms, pickling areas and the like.

The conventional non-grease sewer receives wastes from hog scalding, de-hairing, tripe washing, chitterling washing, and kill drains up to and including the polisher. It also receives the flow from manure recovery systems when a separate manure screen is not provided.

Hide processing waters are commonly recirculated either with or without screening for solids reduction. If these waters must be dumped, they should be screened separately and then discharged to the non-grease sewer.

Vapors from cooking and rendering operations can be cooled and condensed through heat exchangers and recycled to dryers, or sent to the grease sewer.

All clear water (jacket cooling water, air conditioner water, steam condensate and chill water) should be carefully separated for reuse.

Curing pickle (undiluted) has a very high BOD and should be reused whenever possible. Run-off pickle from processing should be caught in recycling pan systems as part of the injection equipment. In a recent study, it was found that only 25% of the pickle produced was retained in the product, the rest was lost by general leakage and spilled from the injection machines. The BOD of pickle varies but the dextrose alone has a BOD of about 660,000 mg/l.

Sanitary wastes are, of course, discharged directly to the city sewer or to a separate treatment system, and should not enter any pretreatment elements.

C. PLANT WASTE CONSERVATION SURVEY.

The first step in waste conservation is a well-organized and well-executed waste conservation survey, backed by management. The following elements would be part of the basic survey described by Gurnham & Associates in the Manual, "Basics of Pollution", distributed and discussed earlier at this seminar.

First the engineer should collect data on the volume, nature and general facilities of the business. If he is a company employee, he already has this information. In addition, he should know all plans for future construction. He should attempt to develop a 10-year forecast of business. If the wastewaters discharge to a city sewer, he should know something about population trends in the area and the possibilities of industrial growth and whether such growth will add load to the municipal plant. Whether the wastewaters discharge to a public sewer system or to the packer's private treatment plant, he should be familiar with the system and the sewage treatment plant and the requirements for the receiving stream.

The approach to wastewater control need not be complicated or expensive. The principal effort applied should be in the direction of preventing product (and contaminants) from entering the waste stream and to reduce water use to a minimum. High waste load areas should be probed first. Accurate sampling, chemical analysis and flow measurements need not be performed initially, but can be deferred until after the gross problems have been solved.

Since most suspended solids in meat wastewaters are organic, their removal results in a reduction of BOD. Suspended solids concentrations (after screening) are a rough measure of BOD and can be easily and quickly measured. Dissolved solids can be measured with a conductivity meter. Red color indicates the presence of blood, a very large contributor of BOD. A simple jar test will give some information. During the initial phase of in-plant waste control, approximate figures are sufficient. Flows must be measured at the time of sampling. Flows can be estimated or simply catch the flow in a pail or 50 gal. drum for a period of time. The gallons per minute can be calculated. In some instances it may be necessary to break into a sewer line or disconnect a pipe to obtain a sample or flow measurement.

Solids per unit volume, with associated water consumption will give a measure of the pounds of organic wastes generated. Problem areas can then be studied for methods of control. In many cases, a small outlay of money will effect substantial waste control. Records should be kept to follow progress.

The following waste load ranges are listed to provide a rough guide line. They cover a broad range because they include small and large operations; some small plants with no inedible rendering and no blood recovery, and others with a broad line of meat processing, with inedible rendering and blood recovery.

TYPICAL PLANT WASTE GENERATED
PER
1000 lbs LWK (Live Weight Kill -- all species)

BOD	4 to 18 lbs per 1000 lbs LWK
SUSPENDED SOLIDS	3 to 17 lbs per 1000 lbs LWK
GREASE	1.5 to 12 lbs per 1000 lbs LWK
FLOW	600 to 2000 gals. of water per 1000 lbs LWK

The following equation can be used to convert laboratory analyses and flow to pounds per 1000 lbs LWK.

$$\text{Pounds of pollutant per 1000 lbs LWK} = \frac{\text{Flow in gallons} \times 8.34 \times \text{mg/l}}{\text{1000 lbs LWK} \times 1{,}000{,}000}$$

where mg/l = milligrams per liter (from laboratory data).

Anyone interested in typical flow, BOD, suspended solids and grease from various processing operations will find useful data in Reference No. 3 (see Appendix). These values vary widely from plant to plant; thus in this manual, it will be most useful to cite methods of correction without attaching specific values to each process or process change. The order of priorities for in-plant waste conservation will vary depending upon the results of the waste conservation survey in each individual plant.

D. RECOVERY of SOLIDS and BY-PRODUCTS.

1. Blood has the highest BOD of any liquid material emanating from meat processing. It has an ultimate BOD (approximately 20-day) of 405,000 mg/l.[2] Customary analytical methods for 5-day BOD are not sufficiently accurate in these high ranges, but are estimated to average from 150,000 to 200,000 mg/l. Considering that one head of cattle contains approximately 49 lbs. of blood, the 5-day BOD of blood from a single animal is about 10 lbs., as against about 0.2 lbs. 5-day BOD discharged per person per day.

Thus, if the blood from a single animal killed in a day is discharged to the sewer, its pollutional load would be equivalent to that of 50 people. Clotted blood (about 70% of the total) has a BOD (ultimate) of about 470,000 mg/l while the liquid portion is about 200,000 mg/l.[2] Comparing these figures with the ultimate BOD of domestic sewage of about 300 mg/l, it is evident that blood conservation pays.

The curbed bleeding area that discharges to the blood tank should be as long as possible and the blood should be squeegeed to the blood tank before the valves are switched to drain to the sewer for the cleanup operation.

The floor and walls should then be cleaned with a minimum of water by use of small diameter hoses. If the water used in the first rinse is held down to 30 to 50 gallons, it can be discharged to the blood tank as an added conservation measure. The additional cost of evaporating this quantity of water will, in most cases, be far less than the cost of treating it as wastewater.

Water is sometimes mixed with blood to facilitate transportation in pipes. The evaporation of this added water in the dryer is an added expense and can often be eliminated if the drain from the bleeding area to the blood tank is large enough and the blood tank is located to permit a straight drop into it. If the blood is pumped to the tank, the piping layout should be checked. If sewer alignment cannot be improved to prevent drains from clogging, de-coagulating electrodes can be installed to prevent coagulation. (Appendix C, 1st item). Troughs to catch and convey blood should be pitched and curved to facilitate squeegeeing before washing.

Blood processing methods are important in waste conservation. For lowest losses to the sewer, continuous dryers are most common, using a jacketed vessel with rotating blades to prevent burn-on. Continuous ring dryers are also popular. They produce a relatively small amount of bloodwater that, in small plants, is usually discharged to the sewers. This bloodwater can be further clarified by discharging it through a small settling tank. This is a waste conservation problem that warrants further study. The older steam coagulation systems are more serious problems in waste conservation, since a substantial amount of fines can be lost when the coagulated blood is screened. A combination of paunch manure solids and bloodwater can be cooked to produce a hydrolyzed hair stick but the process economics should be explored before a packer embarks on such a project.(4) Casing slimes can be added to the blood dryer if desired or can be dried with other product in conventional inedible dry rendering.

2. Paunch Manure is either wet or dry dumped for recovery of tripe.

Wet dumping consists of cutting the paunch open in a water flow, discharging to a mechanical screen and thence to the manure sewer. This washing action carries a large fraction of the BOD from the paunch waste solids into the water phase. Paunch solids are about 75% water, weigh about 50 to 60 lbs. per animal and have a "dry dump" first-stage BOD of over 100,000 mg/l (five-day BOD, slightly less). Eighty percent of this BOD is soluble.

Dry dumping consists of dry discharge of the manure solids down a chute to an inedible area for ultimate disposal as a waste solid or blending to produce a marketable solid. After dry dumping, fines are removed by washing and are discharged into the manure sewer.

Stomach and peck contents may contain undigested grains which contain proteins and fats. An investigation may disclose that these materials can be routed directly to a dryer, unopened, if the resulting product is acceptable as an ingredient in the end product (also see II F 5).

3. Casing-saving operations contribute substantially to pollution.

Waste from the de-slimer should be passed directly to cookers in inedible rendering or dried with the blood. A small catch basin in the immediate casing area will recover sizable amounts of good quality fats. Water should be kept at a minimum. Sprays should be checked for efficiency in volume of water used, proper design, proper direction and maximum spacing.

4. Stockpen wastes are high in nutrients and should be segregated in a manner to allow alternate methods of disposal. Pens should be dry cleaned and the waste should be hauled away for land disposal.

Usually runways and pens are hosed down periodically. Consideration should be given to segregation of this strong liquid waste for disposal by trucking or piping for disposal directly on farm land, within the limits of regulations regarding land disposal.

5. Scraps and Bone Dust. Plant operations in cutting and trimming should be carefully examined for opportunities to intercept waste solids before they enter the sewer. Scraps and liquids from the hog-neck washer should be caught in a container directly beneath the washer. Some form of grease trap can suffice. Collected contents should be routed direct to rendering. Bone dust from sawing operations is an important source of pollution and contains a high concentration of phosphorus. Bone dust is of fine texture and when diluted with water is difficult to recover. It should be recovered intact by catching directly in containers or sweeping up and hauling to the inedible rendering department.

6. Hide curing operations are becoming increasingly involved as segments of tanning operations are transferred from tanneries to beef slaughtering plants. During winter months, a single hide can contain 60 lbs. of attached lumps of manure, mud and ice. In addition, salt, caustic, acids and fleshing waste enter the sewage stream. The washwater should be recycled, or retained for separate treatment (usually screening) if considerable volumes are involved.

7. <u>Disposal of tankwater.</u> If lard is wet rendered or if any inedible wet rendering is in service at the plant, the disposal of tankwater may be a problem (BOD about 22,000 mg/l). In processing lard by low or medium temperature continuous rendering, one process uses about 150 lbs. of water (as steam) per 230 lbs. wet rendered product. However, there is a market in some areas for 50 to 60% edible stickwater produced by evaporating this tankwater. In another process, less water is used and it goes out with the cracklings. In contrast, inedible tankwater is evaporated and is commonly blended with animal feed as inedible stickwater. Under no circumstances can this high BOD waste be discharged to the sewer. In some cases the tankwater can be trucked to a central processing plant for evaporation. It can also be dried with inedible solids.

E. WATER and PRODUCT CONSERVATION.

Water conservation is an essential part of an in-plant wastewater control program. It has been shown that packing plants using the most water per animal generate the most waste per animal. Excessive washing, especially with hot water, removes juices and tissues from product and flushes them into the sewers. Water usage can be reduced at many locations.

The viscera pan sterilizer and the final carcass washer are large water users. These washing operations should be modified so that when the carcass chain stops, the water automatically shuts off. This can be done with solenoid-operated valves under control of the conveyor-chain motor starter. The viscera pan sterilizer uses large amounts of 180° water. This often runs continuously during the work day (and during the clean-up period). Thought should be given to engaging the services of those skilled in spraying techniques — not only to design the sterilizer for economy in water use, but also to design cleaned-in-place (CIP) cleaning systems for the viscera pans (see F 6 following). The sprays on the final carcass washer should be checked for proper spacing, direction, shape of spray, pressure and water consumption.

F. SELECTION and/or MODIFICATION of PROCESS EQUIPMENT for WASTE CONSERVATION.

1. Chitterling washers can be improved by fitting them with limiting orifices and spray nozzles rather than drilled pipes. Water consumption can be reduced from 130 to 70 gpm by proper design of sprays and control of water and pressure on these units.(3)

2. Hog-casing cleaning machines can be modified to recover the slime from the stripper, which amounts to 0.2 lbs. of dry solids per hog.(3)

3. Scalding tub: A means of slow drainage of the scalding tub and separate removal of the sludge will reduce the waste concentration materially. It is reported that 100 hogs, at maximum slaughter rate, produce 11.2 lbs. of BOD and 23.5 lbs. of suspended solids.(3) It may be expected that as much as 30% of the BOD and 80% of the suspended solids will settle in the tub. The scalding tub can be fitted with a perforated riser pipe in the drain, extending about 6" above the floor of the tub. The residual sludge can then be squeegeed through a 12" x 12" square sluice gate at tank floor level and discharged to a truck for disposal as waste solids.

4. Low or medium temperature continuous edible rendering can be accomplished with a limited amount of water discharged to the sewers. This factor should enter the cost analysis when a new system is purchased. (see D 7 above).

5. Hasher-washer screen. It is not uncommon to eliminate the hasher-washer screen. The entire product can be dry rendered if the quality of the rendered product is not a sensitive consideration. The added bulk in dry rendering is small when balanced against increased yield and the elimination of the hasher-washer screen drainage (see preceding D 2).

6. Automated (CIP) Cleaning. For daily cleaning, consideration should be given to automated cleaning of viscera pans, tank trucks, continuous rendering systems, conveyor tables, piping, cookers and dryers. Systems that will conserve water and labor are available from detergent manufacturers.

7. Heart washers. A considerable amount of raw water is used to chill hearts in modern heart washers. A study of this operation may prove that the use of refrigerated chill water will conserve water and result in a better "shelf life" product.

8. Offal areas. In the offal areas, continuous streams of water are sometimes used to aid in moving product down chutes. Special sprays or redesign of chutes will reduce water usage at these points. Any sprays made up of a pipe with drilled orifices are usually inefficient and should be replaced with engineered sprays, designed for minimum water consumption, proper pressure and maximum effective coverage. Master shut-off valves can be used to shut groups of sprays during rest periods. Ball type valves are effective for this service.

9. Knife and sterilizing boxes are often operated with excessive amounts of water and temperature. The use of electric temperature-controlled knife boxes should be considered — particularly in coolers where steam causes condensation problems and refrigeration losses.

10. Sanitary facilities for Personnel. Press-to-open valves (foot or knee-operated) should be used on all lavatories.

Drinking fountains should not run continuously. Refrigerated water fountains will conserve water.

11. Animal drinking water should be minimal but consistent with satisfactory yields. In the past, it was believed that abundant drinking water was necessary for good yields; consequently, drinking troughs flowed continuously. Recent information indicates that animals can go one or two days without water and show negligible yield reduction. Time clock control of the master valve for drinking water supply, programmed for one minute on and four minutes off will reduce water use by 80%.

12. Once-through raw water in refrigeration condensers and compressor cooling jacket water is expensive. Such water should be either reused in plant processes or recycled through a heat exchanging device — cooling towers or evaporative condensers. Evaporative condensers are usually the most feasible.

If possible, blowdown water should be returned to the soil because of its high mineral content. Generally, regulated quantities can be discharged to the city sewer directly without violating limiting regulations. Boiler blowdown water is "soft water" and can be reused in cleanup operations or in fabric wash machines. This requires some experimentation to develop a proper blend of plant water supply with the blowdown water, particularly relating to temperature.

13. Manual washing of meat and offal products can be improved. Washing operations requiring "under-the-spray" time of less than 50%, should have press-to-open sprays. On-site observations have disclosed many hand-washing operations (particularly offal) with time under the spray of not more than 10%. Sprays should not flow unattended at work tables.

In addition to press-to-open spray valves, efficient re-design of spray heads will improve product cleaning and conserve water. Pressures and volume of flow should be controlled with pipe restrictions or locked valves to establish a minimum consistent with quality results. Photo electric cells could serve well as automatic control (see II A 7).

14. In dry rendering systems, many plants mix raw cold water with cooking vapors from rendering dryers to condense vapors and reduce odors. The mixture of vapors and water is discharged to the sewer.

A recent study of a typical operation disclosed that each dryer used 120 to 130 gpm of water and the mixture contained 118 mg/l of BOD and 27 mg/l of grease. The BOD and grease were likely due to carryover from overloaded dryers. The water consumption represented 40% of the entire plant water. A heat exchanger was recommended for direct water condensing to eliminate the cooling water loss. Heat extracted from the vapors can be removed by means of a cooling tower or returned to the plant hot water system. Commonly, cooking operations closely follow killing operations; thus the recovered heat can be reused.

In some instances a portion of dissolved air flotation cell effluent is routed to the inedible cooker vapor condensers. For details on dissolved air flotation, see III C, 2 and 3.

Condensed cooking vapors from dry rendering operations should be routed to the fat-bearing stream if they contain a significant amount of recoverable solids.

G. WATER and WASTE CONSERVATION in CLEANUP OPERATIONS.

Old-fashioned cleanup operations usually use excessive amounts of water - hot and cold. Many cleanup hoses discharge 10 to 20 gpm of high velocity 140 to 180° hot water. Some operators believe that a flood of hot water for cleaning floors and equipment is necessary. Indiscriminate use of hot water is not only undesirable from a wastewater control standpoint, but erodes floors, walls, removes lubrication from equipment, and can cause electrical failures.

It is altogether too common for cleanup men to remove floor drain grates and flush meat scraps down the drain, believing that a screen or catch basin will trap all solids. By the time the scraps are recovered, they have been broken up in the flow and much of the organic matter has been dissolved or suspended in the wastewater to the extent that it cannot be removed without complete treatment — by the packer or by the city. What started as a removable scrap has then become a part of a wastewater treatment load.

Floors and equipment should be "dry cleaned" before hosing and scraps taken to the inedible rendering. This first step in cleanup requires rigid surveillance.

Smaller nozzles on smaller hoses and application of modern cleaning methods will reduce water. For example, a kink-type valve, that is inserted in the hose and opens only when the hose is bent, will automatically stop the water when the operator drops the hose. Water should be automatically controlled to maintain the lowest temperature, lowest volume and highest pressure consistent with each cleaning job. Effective detergents to emulsify fats and lift proteins and soil will reduce the quantity of rinse water required. Well-qualified cleaning consultants are available for guidance.

The use of automated "cleaned-in-place" (CIP) systems will reduce and control water use. (see II F 6 preceding).

III. PRETREATMENT of MEAT PACKING WASTEWATERS for DISCHARGE to MUNICIPAL SYSTEMS

A. INTRODUCTION.

1. Advantages of Pretreatment: Although compliance with municipal regulations regarding the quality of a meat packer's wastewater for discharge to the city's sewer will usually determine the degree of pretreatment, there are some factors that may encourage pretreatment beyond the levels required by ordinance:

a. A higher quality of pretreatment may be economically justified if the city's charges and surcharges are at a level where some additional pretreatment becomes economically advantageous.

b. The meat packer may prefer to assume treatment responsibilities to avoid complaints from the municipality.

c. There may be indications that the future will bring increases in the city's rate structure.

d. Grease and solids may have a good market in the area. Proximity of a soap plant or similar grease market may produce economic advantages for grease recovery or may warrant some expense in improving quality of the finished inedible grease or tallow. Such improvements will also improve the wastewater effluent.

2. There are some Disadvantages:

a. The pretreatment will be placed on the property tax rolls unless state regulations permit tax-free waste treatment for industry.

b. The maintenance, operation and record-keeping may be expensive or burdensome.

c. The burden of good operation increases as the treatment becomes more complex and extensive.

3. Evaluating Needs. After the plant has been completely surveyed and all possible waste conservation and water reuse systems have been catalogued, the necessary pretreatment system must be designed and the cost estimated. Those parts of the treatment attributable to flow (such as grease basins and dissolved air flotation) should be totaled and reduced to a cost per 1000 gallons. Similar "break-outs" in costs per pound can be carried out for grease, suspended solids and BOD.

Then each major in-plant expense for waste conservation, water recycle and reuse can be evaluated based on the estimated reduction in flow, BOD, suspended solids and grease. From such data, priorities can be established for each in-plant waste conservation measure suggested in the survey.

The future planning for the meat packing plant should serve as a guide to determine piping arrangements and suitable locations (and sizes) for projected facilities.

4. Costs. Waste-saving and treatment costs should be charged back to the department from which the flow, BOD, suspended solids and grease emanated. Selected costs of some of the equipment common to pretreatment will be discussed later.

B. FLOW EQUALIZATION.

Equalization facilities consist of a holding tank and pumping equipment designed to reduce the fluctuations of waste streams. They can be economically advantageous whether the industry is treating its own wastes or discharging into a city sewer after some pretreatment. The equalizing tank will store wastewater either to recycle or reuse the wastewater or to feed the flow uniformly to treatment facilities throughout the 24-hour day. The tank is characterized by a varying flow into the tank and a constant flow out. Lagoons may serve as equalizing tanks or the tank may be a simple steel or concrete tank, often without a cover.

Advantages of equalization for the meat packer discharging to a city sewer are:

a. In-plant pretreatment can be smaller, since it can be designed for the 24-hour average, rather than the peak flows.

b. The city may have penalties for high peaks which can be avoided by equalization.

Disadvantages are few:

a. More equipment to maintain and operate.

b. Additional fixed costs.

C. SCREENING and CENTRIFUGING.

1. Introduction. Since so much of the pollutional matter in meat wastes is originally a solid (meat particles and fat), or sludge (manure solids), interception of the waste material by various types of screens and centrifuges is a natural step.

Unfortunately, when these pollutional materials enter the sewage flow and are subjected to turbulence, pumping, and mechanical screening, they break down and release soluble BOD to the flow, along with colloidal and suspended and grease solids. Waste treatment — that is, the removal of soluble, colloidal and suspended organic matter is expensive. It is far simpler and less expensive to keep the solids out of the sewer entirely.

But, because in-plant conservation is, at best, imperfect and people are fallible, final organic solids separation in the main effluent sewer is generally employed. Various combinations of facilities for pretreatment may be selected, including screening, gravity grease and solids separation, dissolved air flotation and biological treatment of various types (this last item is covered in the manual on "Treatment of Meat Packing Wastewaters for Discharge to a Watercourse").

The information in this discussion of screening and centrifuging can be applied both for in-plant waste conservation and waste treatment.

The diagram in Section III C 3 shows where screens might be used throughout the plant. Whereas vibrating screens are shown, other types of screens could be suitable for service in the locations cited. Whenever feasible, pilot scale studies are warranted before selecting a screen, unless specific operating data is available for the specific use intended, in the same solids concentration range and under the same operating conditions.

STATIC SCREENS

Prepared by M. E. Ginaven, V.P. Products and Processes
The Bauer Bros. Co.
Subsidiary of Combustion Engineering, Inc.
Springfield, Ohio

During the past several years, a substantial number of so-called static screens have been installed in many process industries to recover suspended matter from plant effluents or liquid flows within a plant. Highly successful screening operations have been achieved in the meat packing, tanning, canning, textile, and paper and board products industries, as well as in domestic sewage treatment operations. Interesting new developments are underway, such as the treatment of wastes from animal producing farms and poultry processing plants.

In most instances, the installed equipment represents new functions or concepts in recovery and generally involves recycling or some other use of the recovered solids. In many cases, stationary screens are installed as replacements for screens that require moving parts to make a suitable separation of solids from a process stream.

1. Basic Design Concepts:

The primary function of a static screen is to remove "free" or transporting fluids. This can be accomplished by several ways and, in most older concepts, only gravity drainage is involved. A concavely curved screen design using high velocity pressure-feeding was developed and patented in the 1950's for mineral classification and has been adapted to other uses in the process industries. This design employs bar interference to the slurry which knives off thin layers of the flow over the curved surface.

Beginning in 1969, U.S.A. and foreign patents were allowed on a 3-slope static screen made of specially coined curved wires. This concept used the Coanda or wall attachment phenomena to withdraw the fluid from the under layer of a slurry which is stratified by controlled velocity over the screen. This method of operation has been found to be highly effective in handling slurries containing fatty or sticky fibrous suspended matter.

Since the field tests to be reported were conducted on the later design of stationary screen, details of this unit were herein presented. The device is known commercially as a Hydrasieve. A typical installation of a single screen operating on industrial waste water is illustrated in Figure 1.

2. Method of Operation:

The slurry to be screened or thickened is pumped or may flow by gravity into the headbox of the machine. As shown in Figure 2, the incoming fluid overflows the weir above the screen area and is accelerated in velocity and thinned in depth as it approaches the screen. A lightweight hinged baffle is incorporated into the assembly in such a position that it reduces turbulence in the flow. This is accomplished by the shape of the foil which causes the fluid to respond to Bernoulli's theorem through the wedge-shaped entrance. The increasing velocity of fluid draws the baffle toward the surface of the screen.

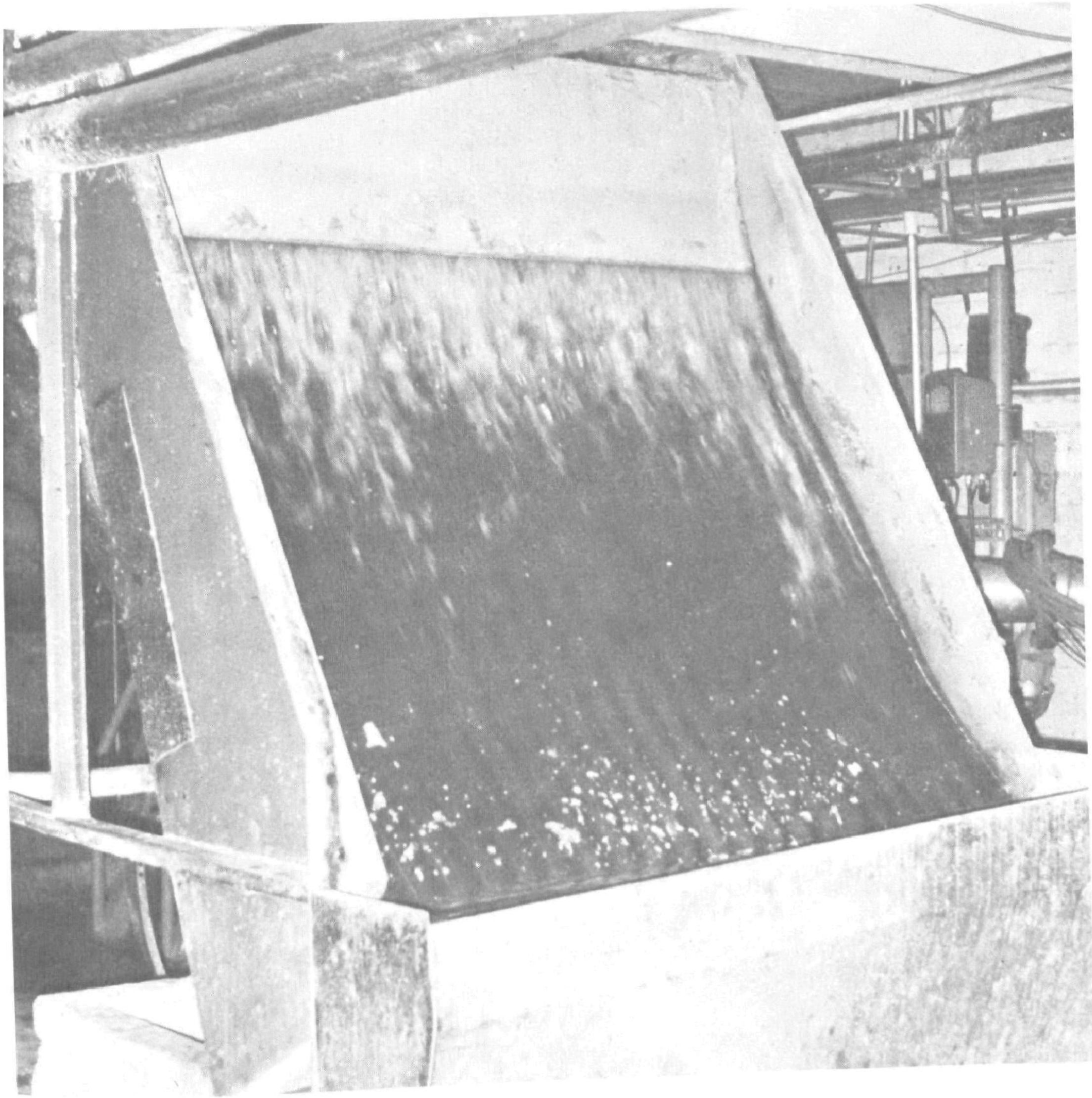


FIGURE 1

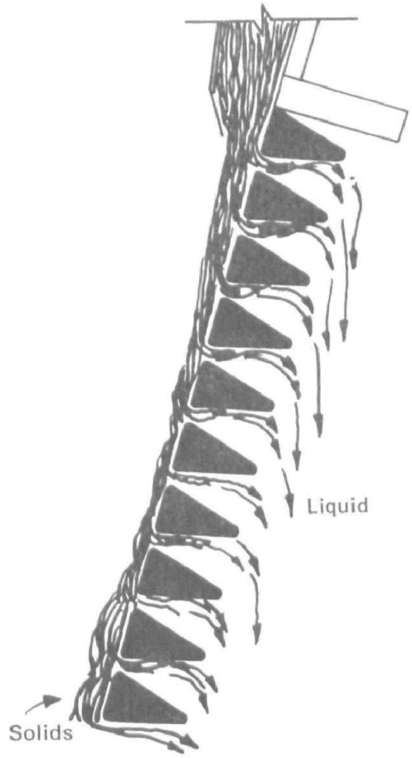


FIGURE 3

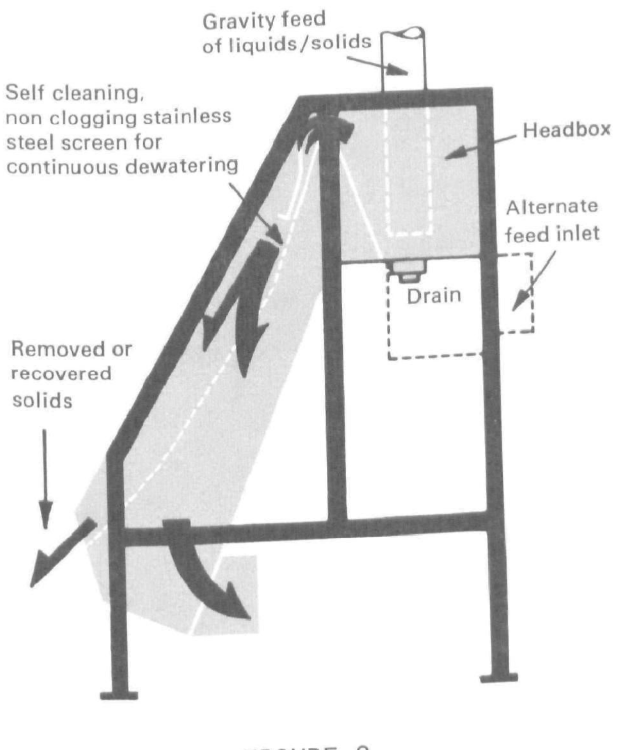


FIGURE 2

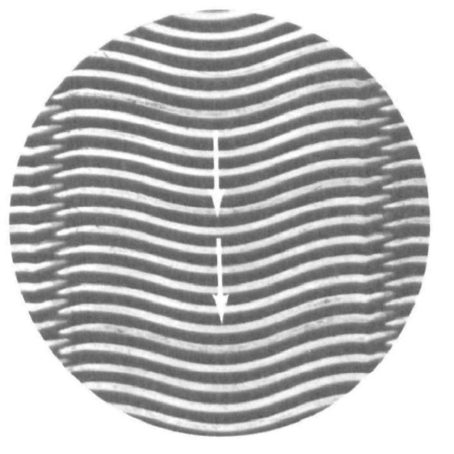


FIGURE 4

Suspended solids tend to stratify in the thin stream, and fibrous materials align themselves lengthwise with the direction of flow. Figure 3 shows a segmental section of the screen wires and the slurry as it contacts the upper end of the Hydrasieve screen. Note that the wall attachment of the fluid to the metal bars or wires draws or bends an under portion of the flow through the openings. Part of the underflow also moves along the arcuate surfaces of the wires and is primarily concentrated at the apex of the downward curve. Here it falls by gravity from the screen back or flows in streams attached to the underside of the wire assembly in a central path between the supports. The screen pattern permits a maximum of fluid extraction based on the limit of flow rate and screen area. Figure 4 illustrates the screen design which is registered under the trademark Mar-Vel'.

On the first (top) slope of the screen most of the fluid is extracted from the bottom of the stream travelling at 25° from the vertical. When the angle of the screen changes to 35° some additional fluid is withdrawn, and usually the massing solids begin to roll on the surface, due to the residual kinetic energy. This action compacts the solids very slightly. On the final slope of the screen, the solids tend to hesitate for simple drainage action, but are always moved off the flat surface by displacement with oncoming material. The effluent is aerated as it passes through the screen in ultra thin ribbons completely exposed to a natural or controlled atmosphere.

3. Unique Features:

The arrangement of transverse wires with unique singular curves in the sense of flow provides a relatively non-clogging surface for dewatering or screening. The screens are precisely made in No. 316 stainless steel and are extremely rugged. Harder, wear resisting stainless alloys may also be used for special purposes.

Openings of 0.010 to 0.060 inches meet normal screening needs. The essential features of the Hydrasieve are covered in U.S. Letters Patents No. 3,452,876 and No. 3,751,555. Other U.S. patents are pending. Patents are also issued and pending in foreign countries.

4 Meat Processing Industry Installations:

A broad range of usage for Hydrasieve screens has been developed for meat processors and related operations, including the feed lots and stockyards as well as the tanning and hide processing industries. In these fields of service the Hydrasieve may be modified to provide a "waterfall" (patent applied for) feed concept which can more effectively cope with high loadings of fat or grease in the slurry being screened. This development resulted from research work done on commercial equipment by the Institute of Leather Technology, Milwaukee, Wisconsin, and it has been widely utilized by the processors of animal hides.

Paunch Manure

Paunch manure, or the residue from cattle stomachs, consists of fluids plus straw, corn and minor miscellaneous solids. The Hydrasieve screen is an excellent device for screening this slurry, and usually a .040" opening screen is used. The solids are readily separated from the carrying stream and a 72 inch Hydrasieve will normally handle a flow of 600 GPM. Solids are usually above 5 per cent.

Hog Stomach Contents

This material is essentially whole and split corn with some hair and the possibility of fat. Usually, a .040" opening screen is employed and flow rates of about 500 GPM are obtained on a 72 inch wide unit.

Hog Hair Recovery

In hog processing, the animals are scalded and dehaired in a beater-scraper type of machine. Material coming from this operation is hair and scurf, a dandruff-type flake. Also present in this operation is foam which is self-generating because of the gelatin which is cooked out of the skins.

Ash from Smoke-Makers

In smoking sausage and other meat products, sawdust is burned to produce smoke. The ash is washed from the smoke-makers and should be removed before going in grease recovery systems, as this is an unwanted product in the rendering. Hydrasieve screens offer a satisfactory means of screening the wash water.

Hog Hair Recovery

Seventy-two inch (72") units with .020" openings are presently in use on this application. Flow is 400-500 GPM with loads to 1,000 GPM when the scalding tub is dumped. Some problems existed in the operation due to foaming, but are solved with proper cold water sprays over the screen and/or anti-foam at 10-20 GPM concentration ahead of the screen.

Hair screening is improved with the stockyard, paunch manure, or stomach contents added to the flow.

Total Waste Flow

The normal total waste flow from a packing plant is quite heavy with respect to flow, solids and fat. Normally, when a packer screens his total flow it is a safety measure used as primary settling, ahead of additional treatment, such as pressurized air floatation. The material from the screen may be rendered.

Presently, a 72 inch unit with .040" screen operates on total waste flow of 500-700 GPM. Sprays are being used and the application is quite successful.

A typical operation on a waste stream from an operation where cattle, hogs and sheep were processed is indicated by the following test data:

No. 552-2 72"x54" Hydrasieve with .040 Marvel Screen

Flow Rate	- 550 GPM
Solids Removed	- 10,000 lb./day (dry)
Solids Passed	- 6,076 lb./day (dry)
(80 minus 30 mesh) Effluent Solids	- 920 PPM
Solids Removal	- 62.5%

Solids Removal from Stick Water

Stick water is product water and condensation water evolved in the process of wet or steam rendering of lard and tallow. Normally, stick water is evaporated to produce a high protein feed additive. Solids in stick water are coarse and fibrous in inedible rendering, and soft and stringy in edible renderings. Normally, stick water is hot (130-160°) as it goes over the screen, eliminating grease blinding.

Expeller Grease Solids Removal

After meat scraps are rendered in melters, grease is drained from the solids. The solids are then pressed in screw-presses and the additional grease is expelled. This grease contains solids which are normally settled out before the grease is filtered. This grease was sent over a .020" test screen and solids were removed to the extent that settling could be eliminated. Flow is low, but separation is also slow. About 5-10 GPM could be sent over a 18" - .020" screen with adequate results. Modifications need to be made so the flow would start at the overflow weir, rather than in a headbox.

Hide Processors

Green (untreated) hides are delivered from the meat packer and are either processed immediately or cured in brine. The first process is to wash the hide in a drum washer where manure and dirt is removed. Some hair and manure balls are also removed and sent to the sewer. The Hydrasieve is used here to permit recycling of the wash water and for preliminary solids removal. A 72 inch unit with a .060" screen permitted processor to reduce his flow from this operation by at least half. Seventy-two inch (72") units are handling 700 GPM effectively.

A fleshing machine is then used to remove tissue particles and tails. Handling this flow, due to its high fat content (5-14%), may be done with a Hydrasieve with the waterfall adapter and periodic cleaning.

To cure the hides, they are saturated in brine solution. The brine is continuously regenerated through a ¯lixator. Brine should be screened on a Hydrasieve to insure proper operation by removing the hair and manure which does accumulate in the brine race-way, or merry-go-round. A .030" screen in a 72 inch unit will handle 450 GPM of this solution.

5 Summary:

Almost every static screen application problem has its own, slightly different, design parameters to be met, and the need for some in-plant evaluations is sometimes required. However, usually experience can be relied upon for an adequate background to engineer a new installation. As a guide, the following brief specifications are suitable for preliminary planning of an installation of effluent screen.

TYPICAL DESIGN INFORMATION FOR STOCKYARD EFFLUENT
BASED ON USE OF .040 INCH SLOT OPENING

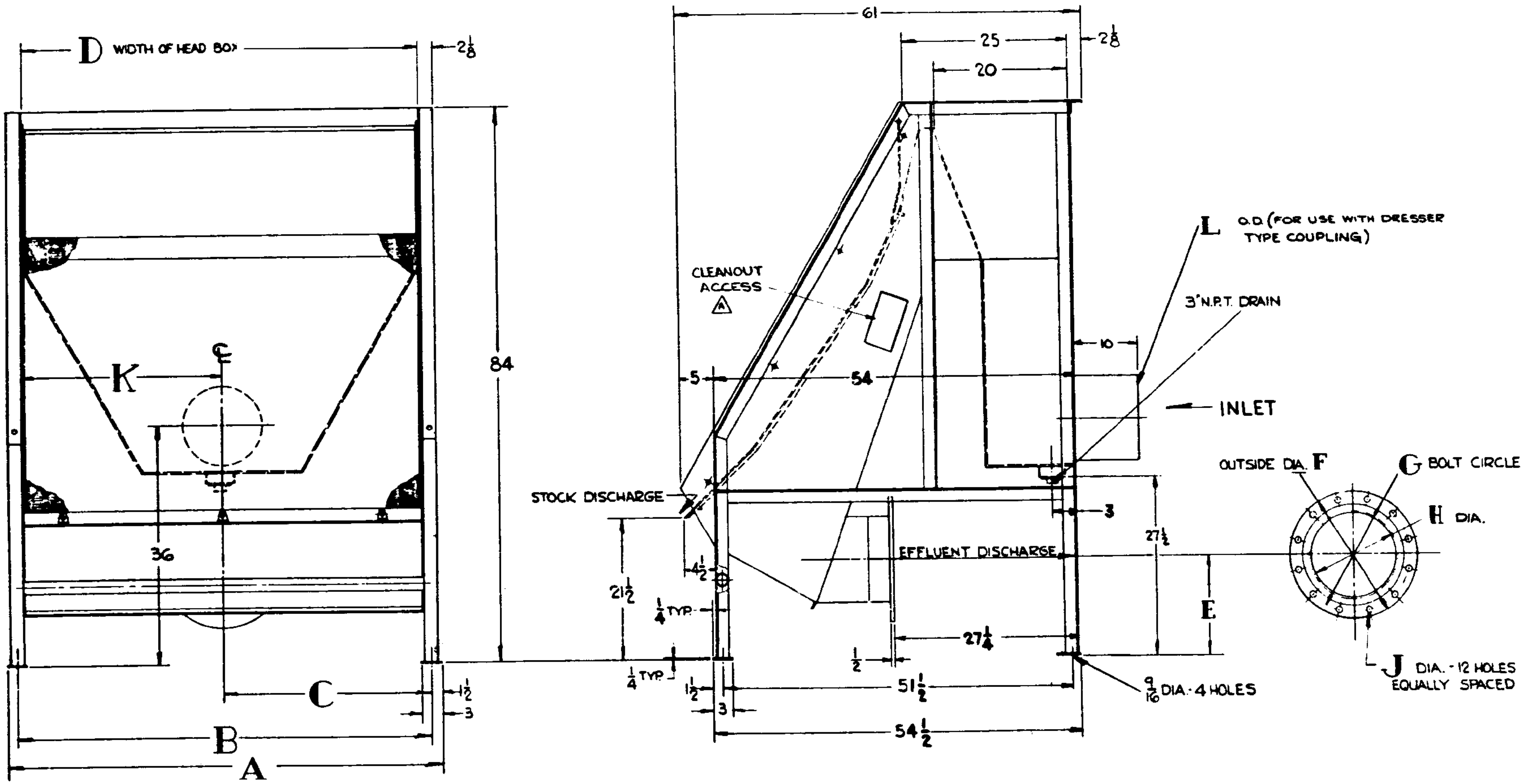
HYDRASIEVE	OVERALL DIMENSIONS - FEET WIDTH	DEPTH	HEIGHT	WEIGHT POUNDS	CAPACITY G.P.M.	PRICE FOR ESTIMATING
No. 552-18"	2	3.5	5	350	75	$ 2,600
No. 552-36"	3.5	4	5	550	150	$ 3,200
No. 552-48"	4.5	5	7	650	300	$ 4,000
No. 552-60"	5.5	5	7	800	400	$ 5,000
No. 552-72"	6.5	5	7	1000	500	$ 6,000
No. 552-72-2	7	9.5	7.3	1800	1000	$10,000
No. 552-72-4	14	9.5	7.3	3600	2000	$20,000
No. 552-72-6	21	9.5	7.3	5400	3000	$30,000
No. 552-72-8	28	9.5	7.3	7200	4000	$40,000
No. 552-72-10	35	9.5	7.3	9000	5000	$50,000

D552115

PART NO.	A	B	C	D	E	F	G	H	J	K	L	SCREEN SIZE	EST. WEIGHT
D552115 MK. 1	53¾	50¾	25⅛	48⅛	14	16	14¼	10½	1"	24 1/16	8⅝	48" X 54"	650 LBS.
D552115 MK. 2	65¾	62¾	31⅛	60⅛	15	19	17	12½	1"	30 1/16	10¾	60" X 54"	800 LBS.
D552115 MK. 3	77¾	74¾	37⅛	72⅛	15⅝	21	18¾	13¾	1⅛	36 1/16	10¾	72" X 54"	950 LBS

D552115

LIST OF MATERIAL



A	5-22-70	RB	6561	ADD ACCESS HOLE

TOLERANCES, UNLESS OTHERWISE SPECIFIED
FOR ANGULAR DIMENSIONS ± 0° – 30'
FOR DECIMAL DIMENSIONS ± .010
FOR HOLE LOCATIONS ± 1/64
FOR OTHER DIMENSIONS ± 1/32
ARE TO BE NON-CUMULATIVE

552
REFERENCE: K3427, K3428, K3248
EST. WT. SEE TAB
SCALE 1½" = 1'-0"

OUTLINE - (FLANGED DISCHARGE & DEEP HEAD BOX) No. 552 HYDRASIEVE

DRN BROWN
CHD BROWN
APP B. MOORE
APP LANDIS
DATE AUG 29, 1969

THE BAUER BROS. CO
SPRINGFIELD, OHIO

D552 115

WAS DEX-00302

C 3. Vibrating Screens - D. M. Lindenmeyer, Tech. Specialist, Vibrating Screens
Link Belt Material Handling Equipment Division
FMC Corp., Chicago, Ill.

Vibrating screens have many uses in a meat packing plant. The accompanying flow diagram illustrates the various areas where they can be used in waste conservation.

This portion of the seminar and manual is intended to acquaint you with the design criteria and the basic theory of vibrating screens.

Vibrating screens are designed to:

a. Convey material retained on the screen surface. This must be done to uncover the opening so that the cloth can pass the undersize material or liquid.

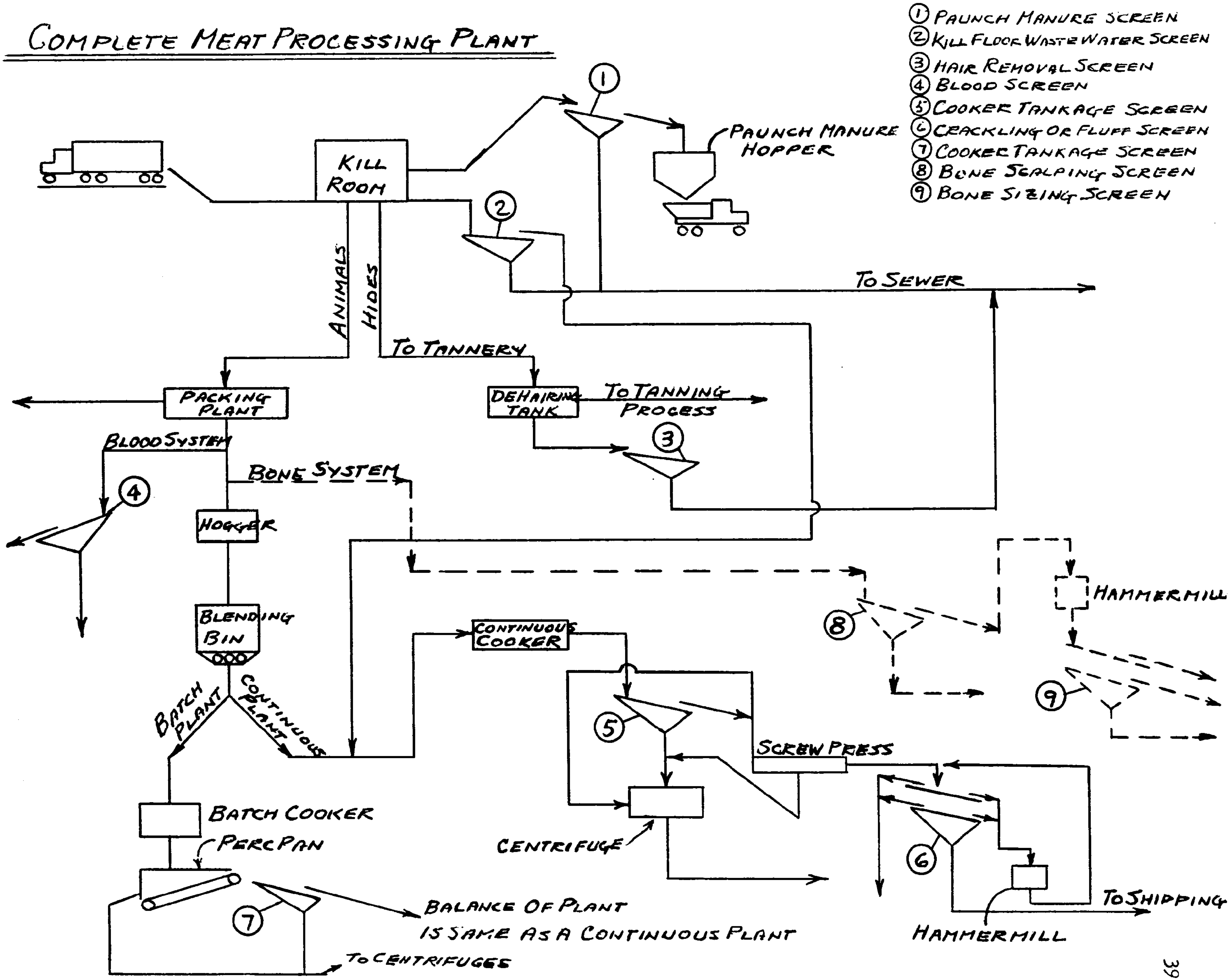
b. Agitate the bed of material on the screen surface. Agitation and stratification are required to open the bed so that the fine particles or liquids can work their way down through the large particles and pass the openings.

c. Dislodgement of particles which stick or wedge in the opening. Particles with dimensions nearly the same size as the opening will clog. The motion of the screen must dislodge the particles.

d. Distribute the material in order to make most efficient use of the entire screening area. The motion of the deck should distribute the material over the deck evenly.

e. Retention of material before discharge. For high efficiency, sizing or removing water from the solids, it is desirable to retain the oversize as long as possible. The material must be moved faster at the feed end to obtain quick distribution and a shallow bed where the volume is the greatest. At the discharge end where the volume is least, the rate of travel should be slowed to allow the remaining fines or liquids to be removed.

COMPLETE MEAT PROCESSING PLANT



Vibrating screens are an economical piece of equipment, varying in size from 2' x 4' to 8' x 20', made up of three major parts:

1) The vibrating frame or as some may call it the box. This is either the welded structure or the bolted assembly that supports the vibrating mechanism and the screening medium, mounted horizontally or declined on isolation springs.
2) The screening medium, cloth, perforated plate or panels.
3) The vibrating mechanism — the heart of the vibrating screen — imparts the motion into the vibrating frame.

The effectiveness of a vibrating screen depends on a rapid motion. Vibrating screens operate between 900 rpm and 1800 rpm; the motion can either be circular or straight line varying from 1/32" to 1/2" total travel. The speed and motion are selected by the screen manufacturer for the particular application.

The vibrating screen is driven by a shaft turning in a pair of bearings. The shaft carries unbalanced weights, either machined into or keyed to the shaft. This assembly is normally driven by a V-belt drive.

When the unbalanced weights are rotated the screen follows the weights through a path. When a vibrator is placed on the top of the box, a slight rocking action will take place, resulting in elliptical motion with the ellipse leaning toward the vibrator. This motion tends to move the material away from the feed and retard it at the discharge end. The screen box is mounted on springs to keep vibration from being transmitted to the supports.

On most vibrating screens the cloth is pulled tightly across longitudinal steel members equipped with rubber caps. The cloth may be easily changed by loosening the tension bolts and sliding the screen cloth out at either end.

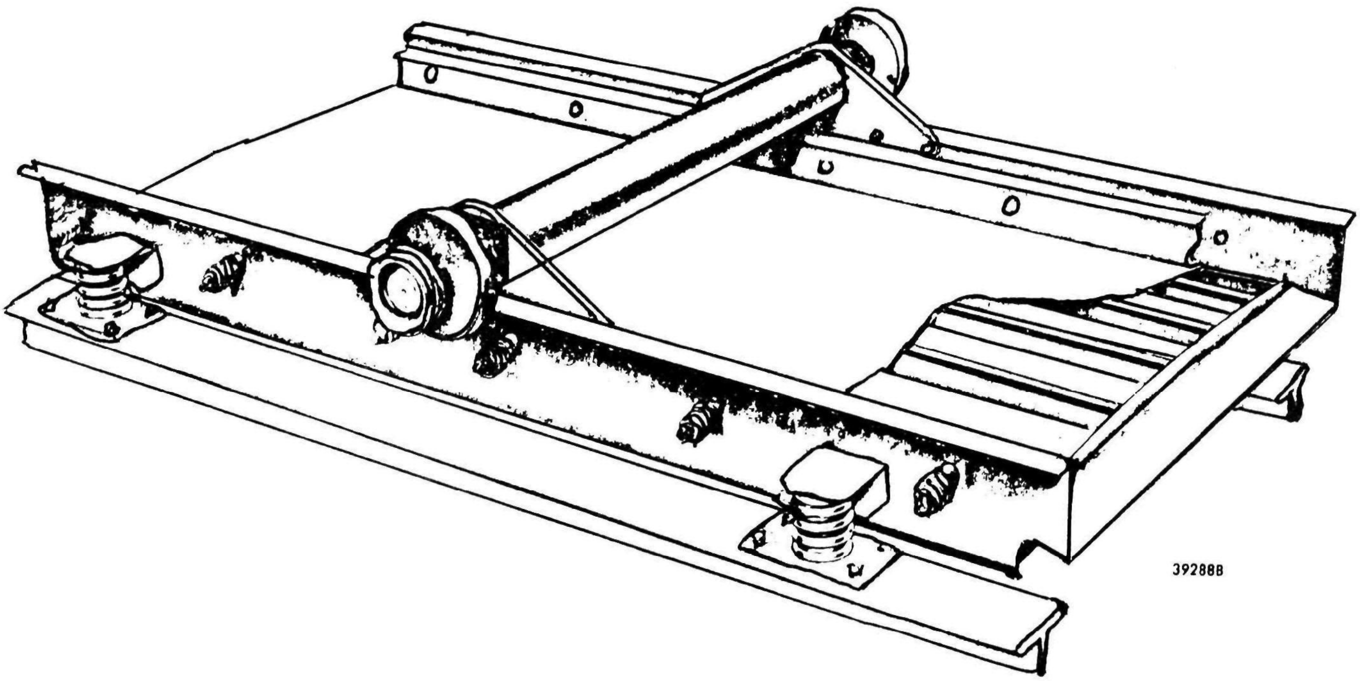
Of prime importance in the selection of a proper vibrating screen is the application of the proper cloth. The capacities on liquid vibrating screens are based on the percent open area of the cloth. With this in mind, cloth should be selected with the proper combination of strength of wire and percent of open area. If the waste solids to be handled are heavy and abrasive, wire of a greater thickness and diameter should be used to assure long life. However, if the material is light or sticky in nature the durability of the screening surface may be the smallest consideration. In such a case, a light wire may be necessary to provide an increased percent of open area.

Screen cloth is woven in a variety of materials, such as black steel, spring steel, all types of stainless steel, monel and brass wire. Normally, on liquid waste applications, a type No. 304 stainless steel wire is used. However, when conditions require other types of metal, special wire cloths can be supplied.

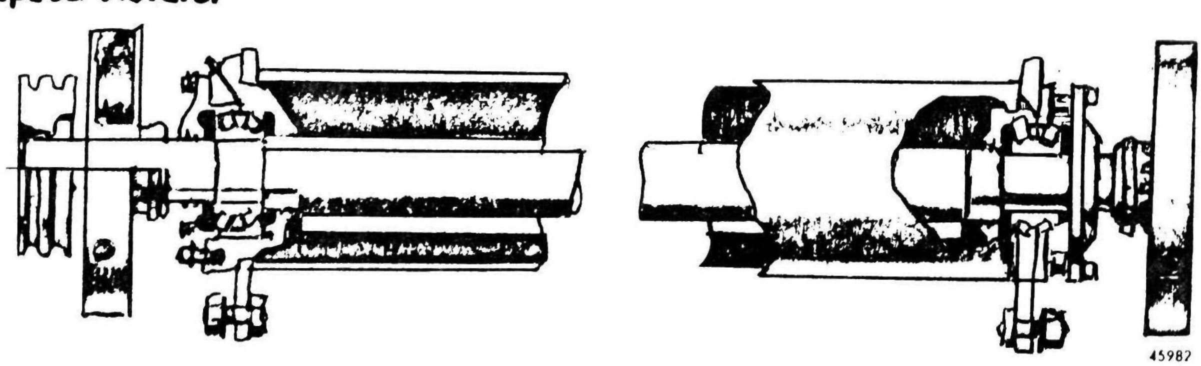
In our discussion of various installations, a term will be used frequently to designate the opening, this term is "mesh". Where mesh is referred to as a number, it refers to the number of openings to the linear inch. The mesh is counted by starting from the center of one wire and counting the number of openings to a one inch distance. If the count does not work out to an even number, the fractional part of the opening should be specified.

Vibrating screens are economical in first cost and in operating costs. The NRM (illustrated) is used in liquid separation extensively and the 4' x 8' unit costs slightly more than $3,000, with feed flume and tank in black steel. Prices vary with feeding arrangements, surface sprays (if any), and other details, such as special metals and coatings.

NRM *liquid vibrating screens*



High-speed Vibrator



FMC/Link Belt

4. Other Solids Removal Systems.

a. Other Screening Devices: Vibrating, rotary and static screens are the most popular screens for separating solids from meat packing plant wastewaters.

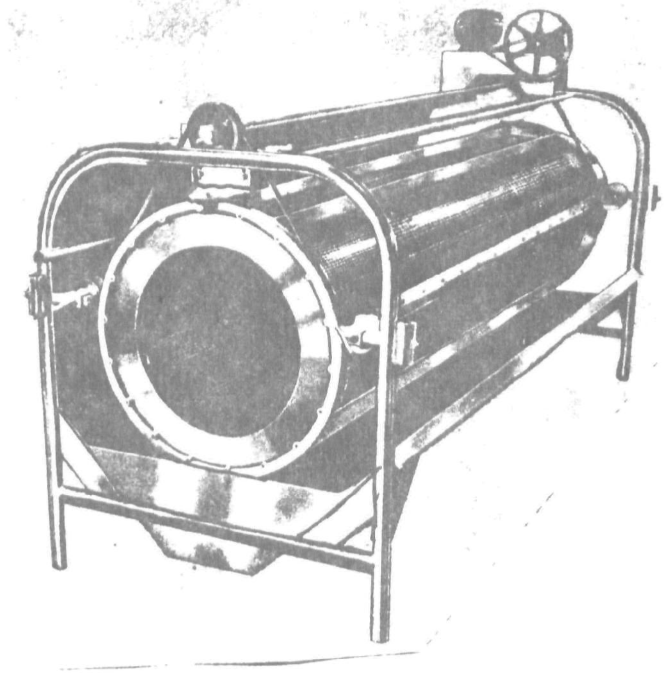
One type of barrel or rotary screen (see Figure "A"), driven by external rollers, receives the wastewater at one open end and discharges the solids at the other open end. The liquid passes outward through the screen (usually stainless steel screen cloth or perforated metal), to a receiving box and effluent sewer mounted below the screen. The screen is usually sprayed continuously by means of a line of external spray nozzles. The screen is usually inclined towards the solids exit end. This type is popular as an offal screen but has not been used to any great extent in secondary "polishing" — that is, in removing solids from waste streams containing low solids concentrations. A screen of this type has been developed for recycle of hide brining waters.

Another rotary screen commonly used in the meat industry is illustrated in Drawing B and C. This screen is driven by an external pinion gear. The raw flow is discharged into the interior of the screen below center, and solids are removed in a trough and screw conveyor mounted lengthwise at the center line of the barrel. The liquid exits outward through the screen into a box in which the screen is partially submerged. The screen is usually 40 x 40 mesh, with 1/64" openings. Perforated lift paddles mounted lengthwise on the inside surface of the screen assist in lifting the solids to the conveyor trough. This type is also generally sprayed externally to reduce blinding. Grease clogging can be reduced by coating the wire cloth with teflon. Solids removals up to 82% are reported.

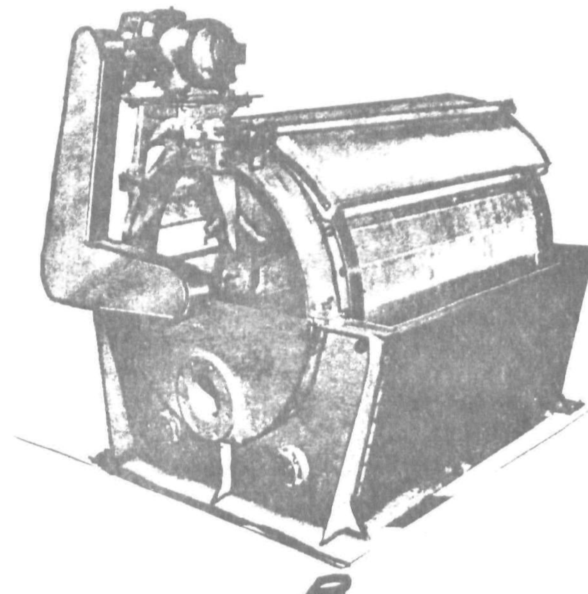
Several other types of mechanical screens have had some application in this field. One is a rotating disc which is partially submerged in the wastewater flow. As it rotates, particles partially adhere and are scalped off above the flow. The screen disc is placed vertically or at a slight angle. Some problems arise in maintaining the seal between the rotating disc and the flow-through box or sewer.

Another type is a circular spring-mounted horizontal screen, driven by a motor located under the screen and equipped with variable eccentric weights. As the motor rotates, the eccentric weights impart multiplaned vibrations to the spring-mounted screen. These units are normally centrally fed at the top, with the liquid discharging through the screen to a pan above the motor and the sludge discharging from a port at the periphery (see sketch "D"). Pilot units (18" dia.) are available on loan. These screens are used in a number of meat packing plants, principally for paunch manure removal, for removing solids from the entire manure sewer flow and for removing solids from the main sewer leaving the plant. Mesh sizes range from 10 mesh for paunch manure to 80 mesh for the main plant sewer. One plant uses three 48" diameter separators with 80 mesh screening to handle a total main plant flow of 800 to 1100 gpm.

A horizontal rotary slowly revolving screen has been developed using wedge bars and the Coanda effect as in the static screen described in III C 2, page 33, but with the wastewater flowing vertically downward through the screen. Some of the advantages claimed for rotary design are that the screen is cleaned in its rotation by means of a doctor blade, can be rinsed with a stationery spray system, and that the vertical downward flow helps backwash the screen as it flows through the screen into the receiving box under the screen drum. Several meat packing applications are reported but no operating data are available to date.

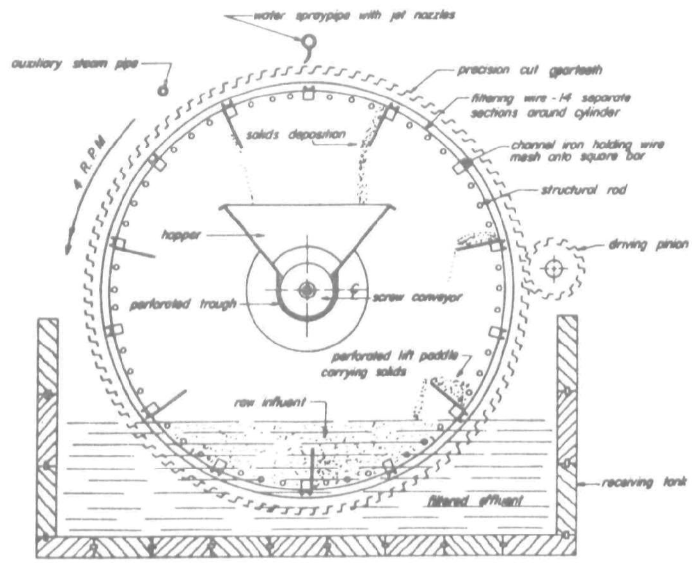


A

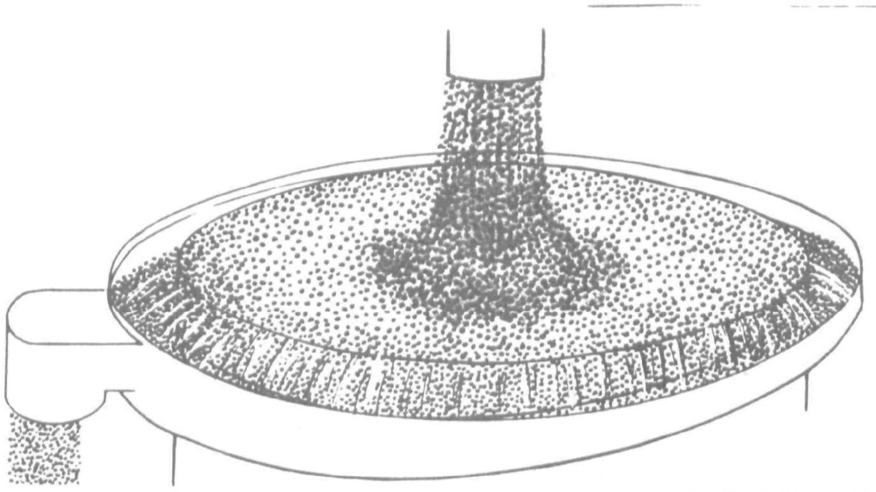


B

C →



CROSS - SECTION OF SEWAGE SCREEN SHOWING CONSTRUCTION & OPERATION



← D

There are many other ingenious mechanical screens. Some, such as a vertical spinning drum, have successfully screened meat waste solids. Other screen systems have been tested and are in limited use. With the impetus on need to improve effluents, testing such devices may be accelerated.

b. Centrifuges have found use in the processing of meat packing wastewater, principally in improving the quality and concentration of grease from grease recovery catch basins and dissolved air flotation.

At one plant, tallow recovery from a catch basin was enhanced by running the skimmings through two centrifuges. At this plant, each centrifuge is of the 3-stage type (separate streams of oil, liquid and solids), has a capacity of 55 gpm, is driven by a 25 H.P. motor, and cost $36,000 plus about $4,000 installation. The yield amounts to 80% of the recoverable tallow, with 0.92% moisture, and a color of 13 to 15. The temperature is raised to 180° F. and is discharged through an 80-mesh eccentrically weighted type 60" circular vibrating screen (see preceding paragraph a, page 44), then heated to 195° F. and centrifuged. The fat is classified as inedible fancy bleachable tallow and brings top market prices. Flow rate is about 30,000 to 40,000 gallons per day and recovered fats run about 5000 lbs. per day.

One system of blood concentration, incorporates a centrifuge to separate the water after coagulation, using a chemical aid. The centrifuge is reported to remove about 80% of the water. The coagulated blood is then dried. This system, however, still produces BOD in the effluent. Drying of whole blood is better for waste conservation.

First cost and power requirements tend to limit the use of centrifuges for waste solids recovery. However, as requirements for effluent quality become more stringent, the centrifuge may be used more frequently to remove residual grease and fine solids from waste streams.

D. SEPARATION of GREASE and SUSPENDED SOLIDS by GRAVITY and FLOTATION.

1. General Comments. The "catch basin" for the separation of grease and solids from meat packing wastewaters was originally developed to recover marketable grease. Since the primary object was grease recovery, all improvements were centered on skimming. Many catch basins were not equipped with automatic bottom sludge removal equipment. These basins could often be completely drained to the sewer and were "sludged out" weekly or at frequencies such that septic conditions would not cause the sludge to rise. Rising sludge was undesirable because it could affect the color and reduce the market value of the grease.

In the past twenty years, with waste treatment gradually becoming an added economic incentive, catch basin design has been improved in the solids removal area as well. In fact, the low market value of inedible grease and tallow has reduced concern about quality of the skimmings, and now the concern is shifting towards overall effluent quality improvement.

As might be expected, the combinations of screening, catch basins and dissolved air flotation in pretreatment vary widely. For example, the Beardstown, Illinois plant of Oscar Mayer & Co., discharges the grease sewer to a flotation tank with 30-minute detention at 30% recycle (no chemicals), and the manure-carrying (non-grease) sewer to a 3' x 8' four-mesh vibrating screen followed by a gravity basin with 50-minute detention prior to lagoon treatment. Overall operating results show 49% BOD removal, 66% suspended solids removal and 76% grease removal.(5)

Other pretreatment systems start with screening the individual waste streams, followed by a gravity catch basin and then may be followed by a dissolved air flotation unit.

Gravity grease recovery systems will remove 20 to 30% of the BOD, 40 to 50% of the suspended solids and 50 to 60% of the grease (hexane solubles).

General removals for dissolved air flotation systems without chemical treatment are about 30 to 35% in BOD, about 60% in suspended solids and 80% (some as high as 90%) in grease (hexane solubles). Combinations of gravity catch basins (about 25 to 30 minutes detention) followed by dissolved air flotation produce somewhat better results because the catch basin removes the larger solids and thereby reduces the requirements imposed upon the flotation unit. (Also see III D 3).

Chemical treatment will improve recovery when installed directly ahead of dissolved air flotation systems. Chemical treatment can also improve gravity separation of greases and solids, but as much as 20 minutes of flocculation may be necessary to effect significant improvements.

The use of chemicals to enhance coagulation and flotation varies widely. Generally, flotation is accomplished without chemicals, unless effluent quality must be improved. Alum as a coagulant with or without a polymer, is used but tends to cause an emulsion problem in the cook tank. Ferric chloride, with or without a polymer, is also used but USDA limitations on iron content in feeds should be checked before selecting this coagulant, if significant amounts are to be used and if the end product will be a feed ingredient. As knowledge of polymers improves, and their use becomes more general, proper polymers at proper pH and under controlled mixing conditions may be effective alone and thus eliminate the problems incident to iron and alum treatment. Zinc chloride has had some success as a coagulant and may be effective in combination with a polymer. The proper pH — an important factor — should be determined by coagulation tests.

Manure carrying sewers are commonly pretreated by means of screens, gravity basins and sometimes dissolved air flotation prior to discharge to the public sewers. If the wastewaters are treated in a separate system for discharge to a watercourse, the type of biological waste treatment may not require the degree of solids removal that may be necessary for discharge to the public sewer.

Simple settling tanks are useful for stockpen flows. They generally consist of shallow concrete trenches, about 3 ft. deep, designed for cleaning with a bulldozer.(6) A simple baffle at the outlet end prevents escape of floatables. One cattle in a feed lot will discharge 10 to 15 times as much BOD as one person in the same period of time.

2. Gravity Grease Separation and Suspended Solids Recovery in Rectangular Basins.*

a. Design elements. Engineers are sharply divided as to the merits of rectangular versus circular separators for various purposes. Many engineers prefer rectangular to circular gravity grease recovery tanks because they believe that, in the circular tank, the grease loses its cohesiveness as the flow proceeds outward in a radial direction, with the scum covering an ever-increasing surface area and thereby becomes thinner as it approaches the scum removal device at the outer periphery. Others claim that the gradually reducing velocity of the flow as it moves radially outward improves grease separation as well as solids separation (a majority of engineers prefer circular tanks for settling flocculent solids). However, it is safe to say that, for gravity recovery of grease, the majority favor rectangular basins. Accordingly, this section will concentrate on this type. In dissolved air flotation systems (see items 3 and 4 of III D), the two factions are about even. In clarification following biological treatment systems, the circular clarifiers have a decided majority.

Size criteria presented in the following are based largely on experience. If individual state standards normally applied to clarifier design are imposed on the meat packer for catch basin design, the regulations must, of course, be followed.

Rate of flow is the most important criterion for design of a gravity unit. About 30 to 40 minutes detention time at one-hour peak flow is a

*The assistance of FMC Corporation, Environmental Equipment Division, Southern Regional Office, Atlanta, Ga., in furnishing information for this section, is gratefully acknowledged.

common sizing factor. A shallow basin, 5 to 6 ft. liquid depth is generally preferred. This produces about one gallon per minute per square foot area. The daily flow has little relationship to the design of grease recovery systems.

Length to width ratio should be at least 3 to 1. Maximum widths are about 20 ft. but heavy sludges may cause an excessive stress on the scrapers at that width. Widths to 12 ft. are safe. Beyond this, stresses should be checked, particularly if the system is operated intermittently.

Temperature variations can develop non-uniform density currents, reducing the efficiency of grease and solids separation. Overnight icing can occur in northern climates. Accordingly, protection against wide variations in temperature should be considered.

The design of inlet and outlet arrangements, as well as scum removal materially affect the basin efficiency.

The bottom (invert) of the influent sewer should be above the liquid level in the basin. The inlet, however, can enter the basin below the liquid surface. Properly baffled, multiple inlets will reduce inlet velocities but can cause backup in the influent sewer or in an upstream receiving box where scum can collect. Design of such a receiving box to overflow at high flow periods could prevent scum accumulation in the box. Surface discharge into the basin, on the other hand, can develop velocity currents in the basin. However, multiple surface inlet openings with adjustable baffles will reduce entrance velocities, permit manual adjustments of distribution of the flow across the basin width, and prevent upstream scum accumulations.

The effluent should be conducted over a weir extending the full width of the basin. Weir overflow rates should not exceed 1500 gallons per lineal foot per hour of maximum flow. A weir trough at the outlet will provide double weir length if necessary.

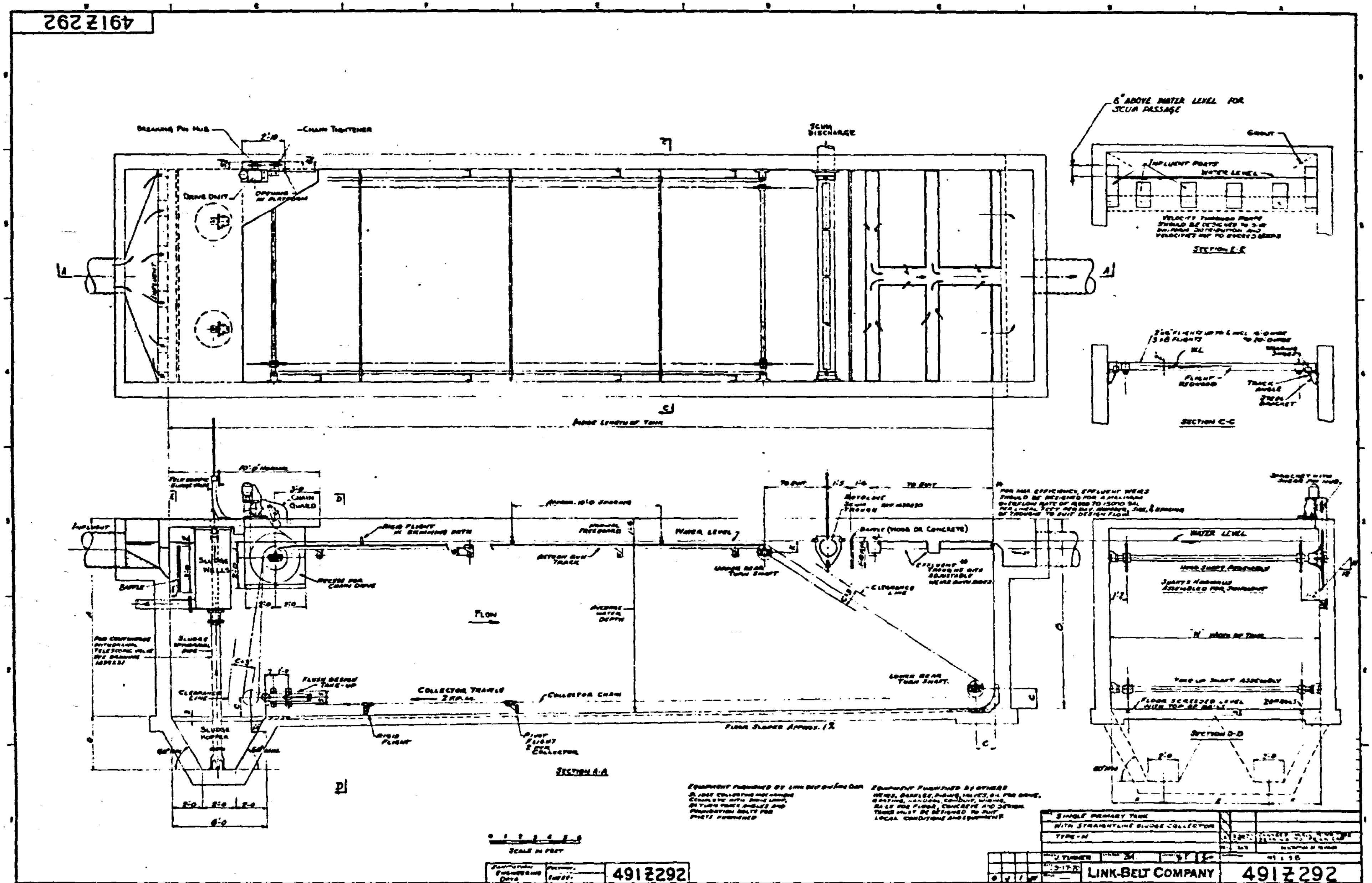
Scum removal equipment is available in several styles:

1) The slotted "swing pipe" scum trough (see Drawing 491 Z 292), is popular in rectangular municipal clarifiers. In operation, it is periodically rotated manually to a point where the slot meets the liquid level, allowing scum to enter the pipe and flow out one end to a receiving box. It is generally inadequate for the quantities of scum encountered in treating meat packing wastewaters.

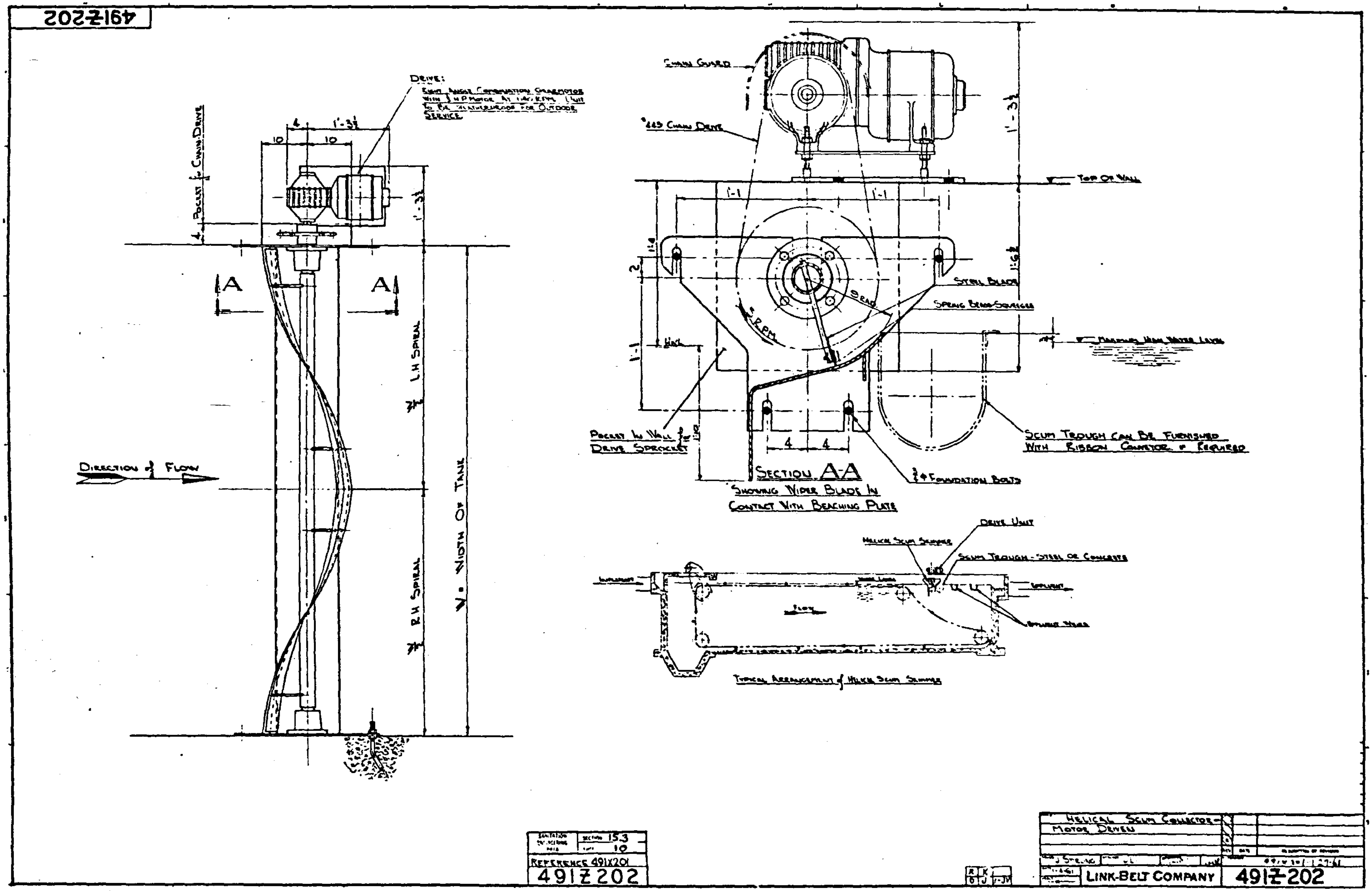
2) A powered helical scum collector (Drawing 491 Z 202) is also available which mechanizes scum pickup. Its dewatering efficiency and its capacity do not usually satisfy the requirements for scum removal in meat packing wastewater systems, but it is a slight improvement over the "swing pipe".

3) A more positive pick up, but using the same four-sprocket sludge and scum scraper system, consists of a scum trough and "beach" with a short flight type skimmer (Drawing 491 Z 113).

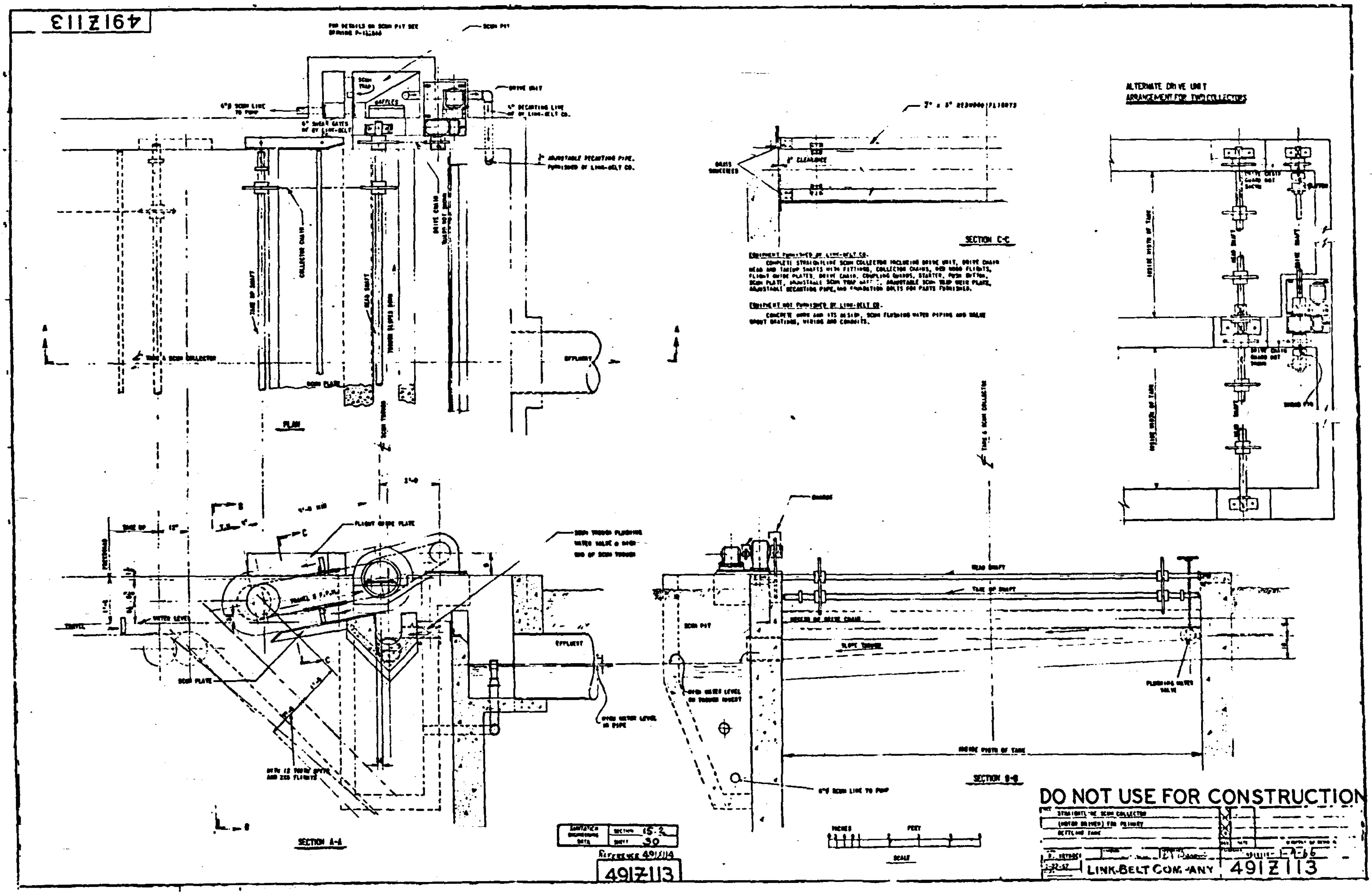
The skimmings trough extends the full width of the basin and should be sloped to discharge to a receiving box where the grease can be decanted from the residual water. In large installations, a screw conveyor in the trough will be useful. In cold climates, the shaft of the screw can be hollow and can be connected to a steam line to keep the scum from freezing in the trough. The scum trough should be several inches above the liquid



4917292
BREAKING PIN HUB
CHAIN TIGHTENER
DRIVE UNIT
SCUM DISCHARGE
6" ABOVE WATER LEVEL FOR SCUM PASSAGE
GROUT
INFLUENT PORTS
WATER LEVEL
SECTION E-E
SECTION C-C
INSIDE LENGTH OF TANK
10'-0" NORMAL
CHAIN GUARD
INFLUENT
BAFFLE
SLUDGE WELLS
RIGID FLIGHT IN SKIMMING PATH
WATER LEVEL
BAFFLE (WOOD OR CONCRETE)
FLOW
AVERAGE WATER DEPTH
CLEARANCE LINE
LOWER REAR TURN SHAFT
FLUSH DESIGN TAKE-UP
COLLECTOR TRAVELS 2 F.P.M.
COLLECTOR CHAIN
SLUDGE HOPPER
RIGID FLIGHT
FLOOR SLOPES APPROX. 1%
SECTION A-A
SECTION D-D
6'-0
SCALE IN FEET
SINGLE PRIMARY TANK WITH STRAIGHTLINE SLUDGE COLLECTOR TYPE-H
J. TURNER
LINK-BELT COMPANY
4917292



491Z202
Drive:
Right Angle Combination Gearmotor With ½ H.P. Motor At 1140 R.P.M. Unit To Be Weatherproof For Outdoor Service
Pocket for Chain Drive
A
A
L.H. Spiral
R.H. Spiral
W = Width Of Tank
Direction of Flow
Chain Guard
#445 Chain Drive
Top Of Wall
Steel Blade
Spring Blade Squeegee
Maximum High Water Level
Pocket In Wall for Drive Sprocket
Section A-A
Showing Wiper Blade In Contact With Beaching Plate
¾ Ø Foundation Bolts
Scum Trough Can Be Furnished With Ribbon Conveyor If Required
Drive Unit
Helical Scum Skimmer
Scum Trough - Steel Or Concrete
Flow
Typical Arrangement of Helical Scum Skimmer
Sanitation Engineering Data
Section 15.3
10
Reference 491X201
491Z202
Helical Scum Collector - Motor Driven
J. Sterling
Link-Belt Company
491Z202

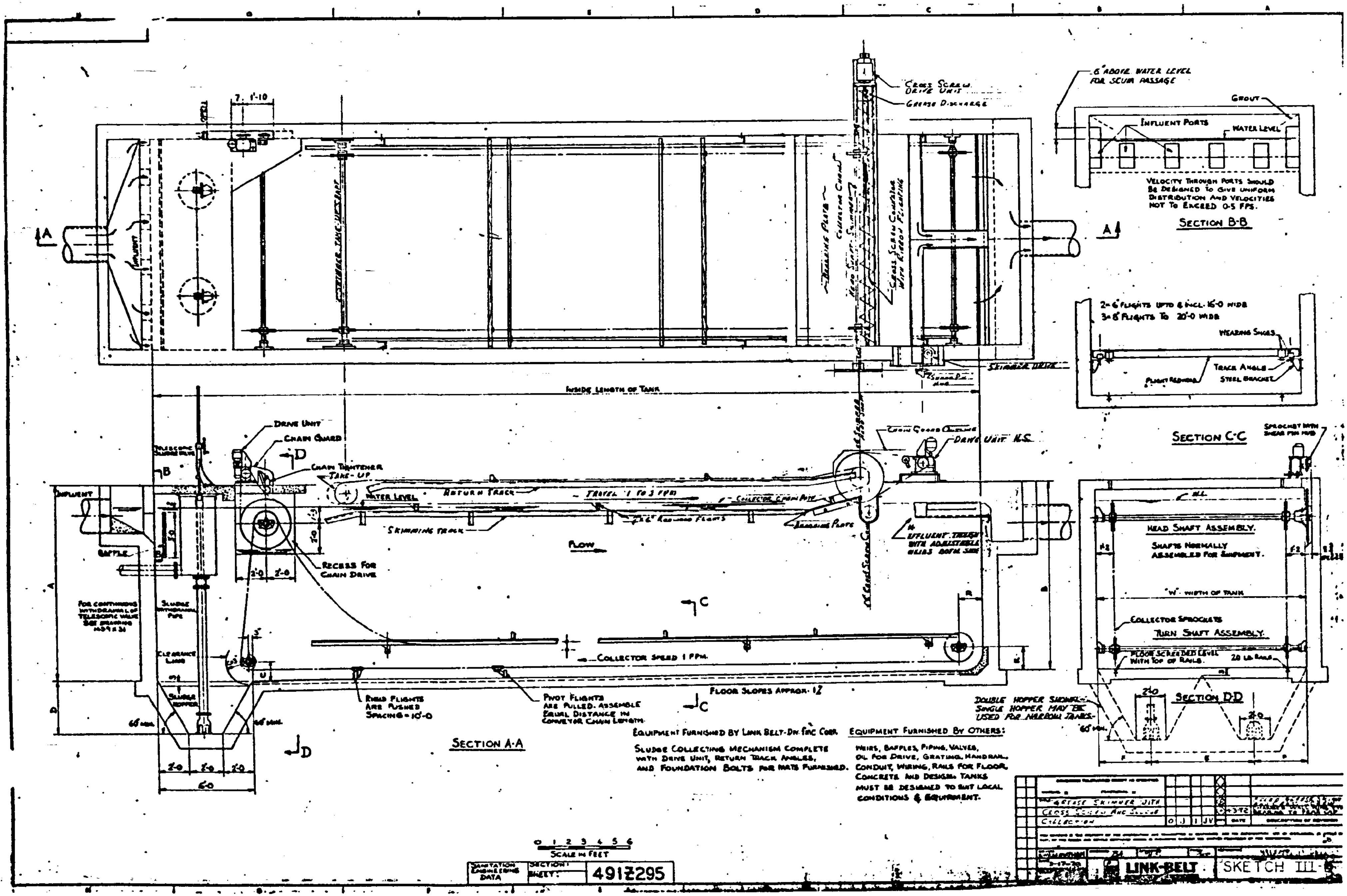


PLAN
SECTION C-C
ALTERNATE DRIVE UNIT ARRANGEMENT FOR TWO COLLECTORS
SECTION A-A
SECTION B-B
DO NOT USE FOR CONSTRUCTION
LINK-BELT COMPANY
491Z113
Reference 491Z114

level. The metal "beach" provided on the upstream side for scum pickup permits some dewatering of the scum on that part of the beach above the water level. A short baffle fastened to the underside of the trough and extending downward will reduce scum loss due to effluent flow moving towards the effluent weir downstream from the trough.

4) All of the skimming arrangements described above permit some grease to escape to the effluent because it adheres to the flights as they pass downward under the skimming device. To eliminate this defect, two sets of scraper flights can be provided as shown in Drawing 491 Z 295 (sketch III). In this system, the sludge is moved independently of scum removal, by a three-sprocket collector. A separate two-sprocket scraper system, operating above the liquid level, moves the scum towards the scum trough and up the beach into the trough. In this arrangement, septic action can be prevented by operating the bottom scrapers continuously. The scum scrapers can also be separately operated on a timer to hold the scum and develop a cohesive dense layer, thereby reducing the liquid content of the skimmings. Normally, about 70% of the scum picked up is water. The two-flight system can reduce the water content about 15 to 20 percent.

A new plant utilizing this type of arrangement has a production day's flow of 620,000 gallons per day and 860 gpm in a maximum hour. This is a large pork plant with complete smoking and sausage manufacturing. Pre-treatment consists of a gravity basin (equipped for adding dissolved air flotation whenever necessary) designed for 28 minutes detention (12 ft. wide, 45 ft. long and 6 ft. side water depth). Estimated raw waste


Cross Screw Drive Unit
Grease Discharge
6" Above Water Level For Scum Passage
Grout
Influent Ports
Water Level
Velocity Through Ports Should Be Designed To Give Uniform Distribution And Velocities Not To Exceed 0.5 FPS.
Section B-B
Influent
Cross Screw Conveyor With Ribbon Flighting
Skimmer Drive
Inside Length of Tank
2-6" Flights Up To & Incl. 16'-0 Wide
3-8" Flights To 20'-0 Wide
Wearing Shoes
Track Angle
Steel Bracket
Flight Rider
Section C-C
Sprocket With Shear Pin Hub
Drive Unit
Chain Guard
Chain Tightener Take-Up
Telescopic Sludge Valve
Drive Unit H.S.
Water Level
Return Track
Travel 1 To 3 FPM
Collector Chain Path
Skimming Track
Flow
Effluent Trough With Adjustable Weirs Both Sides
Recess For Chain Drive
Baffle
For Continuous Withdrawal of Telescopic Valve See Drawing
Sludge Withdrawal Pipe
Clearance Line
Sludge Hopper
Collector Speed 1 FPM.
Head Shaft Assembly.
Shafts Normally Assembled For Shipment.
"W" Width of Tank
Collector Sprockets
Turn Shaft Assembly.
Floor Screeded Level With Top of Rails.
20 Lb Rails
Rigid Flights Are Pushed Spacing = 10'-0
Pivot Flights Are Pulled. Assemble Equal Distance In Conveyor Chain Length.
Floor Slopes Approx. 1%
Double Hopper Shown - Single Hopper May Be Used For Narrow Tanks.
Section D-D
Section A-A
Equipment Furnished By Link Belt-Div. FMC Corp.
Sludge Collecting Mechanism Complete With Drive Unit, Return Track Angles, And Foundation Bolts For Parts Furnished.
Equipment Furnished By Others:
Weirs, Baffles, Piping, Valves, Oil For Drive, Grating, Handrail, Conduit, Wiring, Rails For Floor, Concrete And Design: Tanks Must Be Designed To Suit Local Conditions & Equipment.
0 1 2 3 4 5 6
Scale In Feet
Sanitation Engineering Data
Section
Sheet
4912295
Grease Skimmer With Cross Screw And Sludge Collection
LINK-BELT
SKETCH III-6

concentrations are 450 mg/l BOD, 400 mg/l suspended solids, and 350 mg/l grease. No raw waste operating data are available to date, but effluent samples taken on Jan. 17, 1973, show BOD 250 mg/l, suspended solids 70 mg/l and grease 26 mg/l. Sanitary wastes are included in these figures.

Scraper mechanism for sludge removal may scrape the sludge to one or several submerged hoppers, generally at the inlet end of the basin. The need for several hoppers arises from two design limitations: first, the side slopes for the sludge hoppers should be at least 60° with the horizontal, and second, the flat bottom of the hopper should be no greater than 2' x 2' in size.

In one innovation which eliminates the hoppers and sludge pumps, the effluent end of the basin is built in an incline and the sludge is scraped up the incline into a receiving trough at the top. The sludge is partially dewatered on that portion of the incline that extends above the liquid level. The incline can be as long as necessary to accomplish the desired dewatering before the sludge discharges into the trough. A screw conveyor in the sludge trough is an added convenience to carry the sludge to a truck or receiving box alongside the basin. The effluent weirs and scum removal trough are, of course, upstream from the incline.

b. Basin Arrangement and Materials of Construction.

Usually two identical catch basins, with a common wall, are desirable to permit one to operate whenever the other is down for maintenance or repair. Note that the design example (item c, following) is based on this arrangement.

Concrete tanks have the inherent advantages of lower overall maintenance and more permanence of structure. However, some owners prefer to be able to modify their operation for future expansion or alterations or even relocation.

All-steel tanks have the advantage of being semiportable, more easily field-erected, and more easily modified than concrete tanks. The all-steel tanks, however, require additional maintenance as a result of wear in areas of abrasion.

A tank utilizing all steel walls and concrete bottom is probably the best compromise between the all-steel tank and the all-concrete tank. The advantages are the same as for steel, however, the all-steel tank requires a footing underneath the supporting members, whereas, with the steel wall tank the concrete bottom forms the floor and supporting footings for the tank.

c. Design Example.

Given a flow, at peak hour, of 1,300 gpm, design a rectangular catch basin.

At a selected 40-minute detention, the volume = 52,000 gallons
= 6,950 cu. ft.

Select 6 ft. average water depth; area = 1,160 sq. ft.

Select two basins, with a common wall, each 10 ft. wide, 58 ft. long and 6 ft. average water depth.

d. Cost Estimates for Design Example. All costs are for two basins, with a common wall between them. The following cost estmates are "order of magnitude" prices and should not be used for other than rough approximations. In each particular application, equipment prices and construction costs should be developed for the area where the plant is located and for the specific situation.

Basin Cost, installed		*Type	EQUIPMENT Base Cost	Install. Cost	Total
Concrete	$25,000	I	$12,500	$3,000	$40,500
"	$25,000	II	$23,000	$3,500	$51,500
"	$25,000	III	$32,400	$5,600	$63,000
Steel	$29,000	I	$12,500	$3,000	$44,500
"	$29,000	II	$23,000	$3,500	$55,500
"	$29,000	III	$32,500	$5,500	$67,000
Steel with Concrete floor	$32,000	I	$12,500	$3,000	$47,500
"	$32,000	II	$23,000	$3,500	$58,500
"	$32,000	III	$32,500	$5,500	$70,000

*
I = 4-sprocket collector with rotatable scum pipe.

II = 4-sprocket collector with short flight skimmer without screw conveyor in trough (slightly less with helical scum skimmer).

III = 3-sprocket sludge collector with full-length separate 2-sprocket scum scraper system and with screw conveyor in trough.

e. Maintenance and Operation.

1) General Comments: Most gravity grease recovery units use no chemicals, flocculants or polymers to achieve the grease separation. Therefore, there is no requirement for design or maintenance of a chemical feeding system. The gravity grease recovery unit is quite simple in construction and operation, alleviating the need for sophisticated or highly trained operators.

In gravity grease recovery and separation, as with any system of wastewater treatment, the overall system must be considered in addition to the individual elements. Particular attention should be given to maintaining low turbulence in the flow, and minimizing frequency of pumping.

2) Housekeeping: Each gravity grease recovery system requires a certain amount of housekeeping. After being in operation for a few months, the equipment becomes coated with grease. It is difficult, if not impossible, to maintain the equipment when the parts are not visible. Hence, there is a need for scraping, scrubbing, steam cleaning and in some cases high-pressure hosing, to assist the people responsible for maintenance in keeping the units operational. Cleanliness also helps in the control of odors and elimination of odor-producing bacteria.

3) Mechanical Maintenance: The day-to-day observation and periodic checking of alignment, grease levels in speed reducers, and greasing of bearings are natural requirements for any wastewater equipment. Eventually the chains will

wear and require replacement. This equipment has a wear life proportional to the hours of usage, hence, operation on timers is recommended. A high percentage of grit in the wastewater may accelerate the wearing of the components, since the grease will tend to hold the grit into the wearing part of the unit acting as a lapping compound and accelerating the wear.

f. Pilot Plants. The use of pilot plants for grease recovery and other wastewater treatment design cannot be overemphasized. The most important advantage to be gained from such studies is that the pilot plant can be operated with a relative flow rate and waste characteristics representative of that for which the ultimate plant will be designed. One of the most frequent errors in the use of pilot plants for design purposes is the application of pilot plant data from one meat packing plant to another with different flow pattern, production processes and production equipment.

Most major manufacturers have pilot plant equipment available on a rental basis.

3. TREATMENT OF MEAT PROCESSING WASTE BY DISSOLVED AIR FLOTATION

Charles B. Grimes
Sales Engineer - Industrial Waste Treatment Products
Water Quality Control Division
Envirex Inc.
A Rexnord Company

Dissolved air flotation is a waste treatment process in which oil, grease and other suspended matter is removed from a waste stream. This treatment process has been in use for over fifteen years and has been most successful in removing oil from waste streams. Its early principal use was, and still is, the removal of oil from petroleum refinery waste waters. Another natural area for application of this treatment system has been the removal of contaminents from the food processing plants waste streams. One of the very first applications of this treatment system was for a meat processing application.

Basically, dissolved air flotation is a process for removing suspended matter from waste water using minute air bubbles which upon attachment to a discrete particle reduces the effective specific gravity of the aggregate particle to less than that of water. Reduction of the specific gravity for the aggregate particle causes separation from the carrying liquid in an upward direction. As Figure No. 1 suggests, the particle to be removed may have either a natural tendency to rise or settle. Attachment of the air bubble to the particle induces a vertical rate of rise noted as V_T.

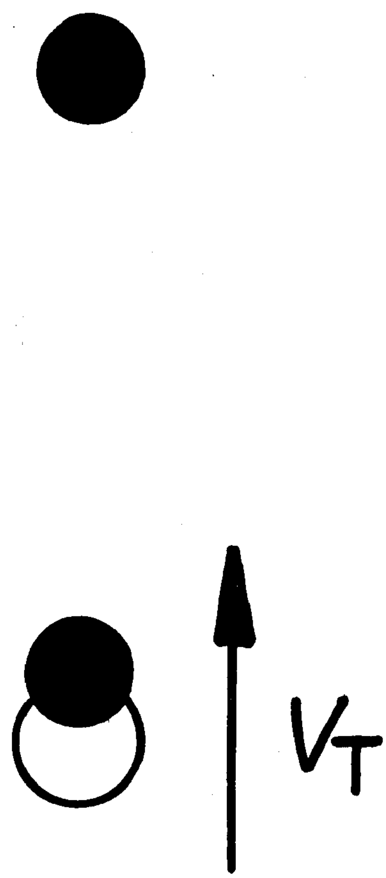


FIGURE 1

Treatment of Meat Processing Waste by Dissolved Air Flotation

Figure No. 2 illustrates the basic design considerations of the flotation unit. The parameter, V_T was discussed above and the measurement of this parameter will be discussed later. Since the waste flow must pass through a treatment unit, the particles to be removed will have a horizontal velocity. Certain criteria have been established for limits of the parameter V_H which sets the width and depth of the treatment unit. Therefore, as Figure No. 2 suggests, the effective length of the treatment unit is directly proportional to the horizontal velocity and depth and inversely proportional to the vertical rate of rise of the particle to be removed.

The mechanics of operation for a dissolved air flotation unit are illustrated in Figure No. 3. It can be noted that a portion of the clarified effluent is pressurized by a recycle pump. This recycled flow is pumped to a pressure tank into which air is injected. In the pressure tank at approximately 40 psig, the recycle flow is almost completely saturated with air. The pressurized recycle flow, containing the dissolved air, leaves the air saturation tank and flows through a pressure reduction valve.

A 40 psig pressure drop occurs at the pressure reduction valve and causes the pressurized flow stream to relinquish its dissolved air in the form of tiny air bubbles. This air-charged recycle flow is then blended with the raw process flow to effect attachment of the air bubbles to the oil and other suspended solids to be removed. The combined flow stream (raw flow plus

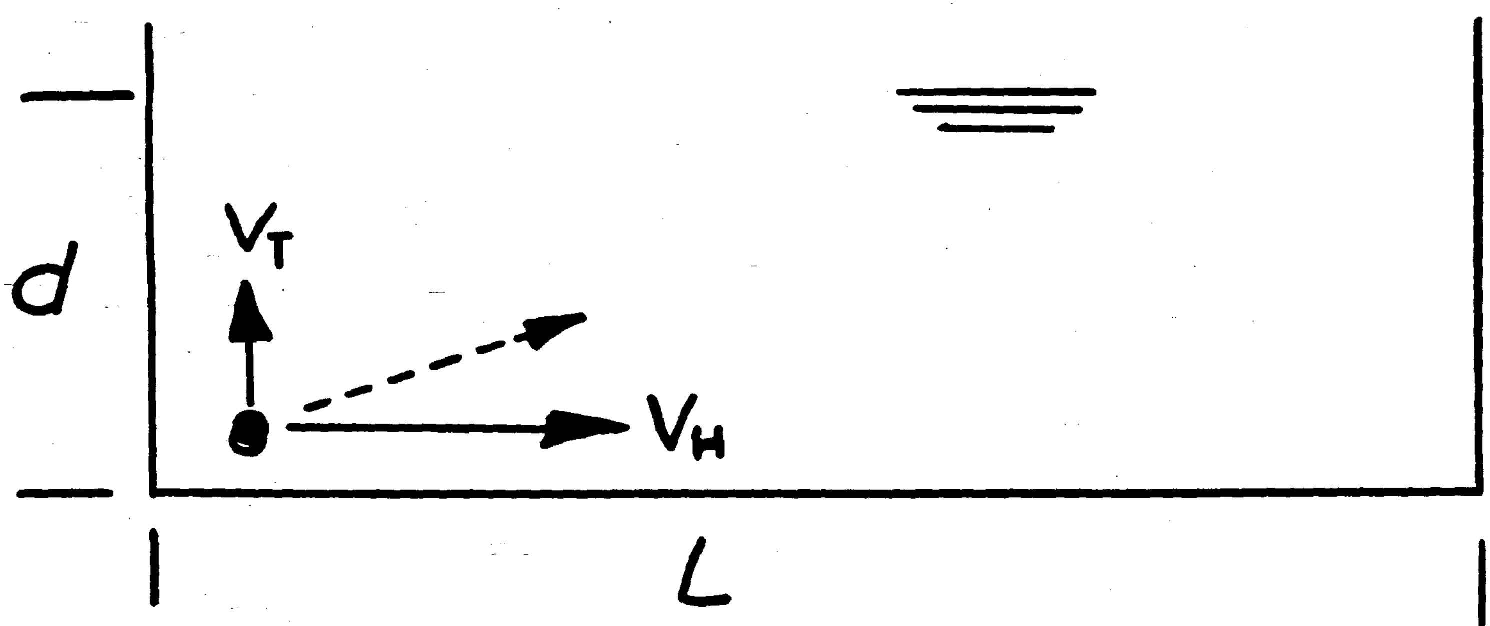


FIGURE 2

FIGURE 3

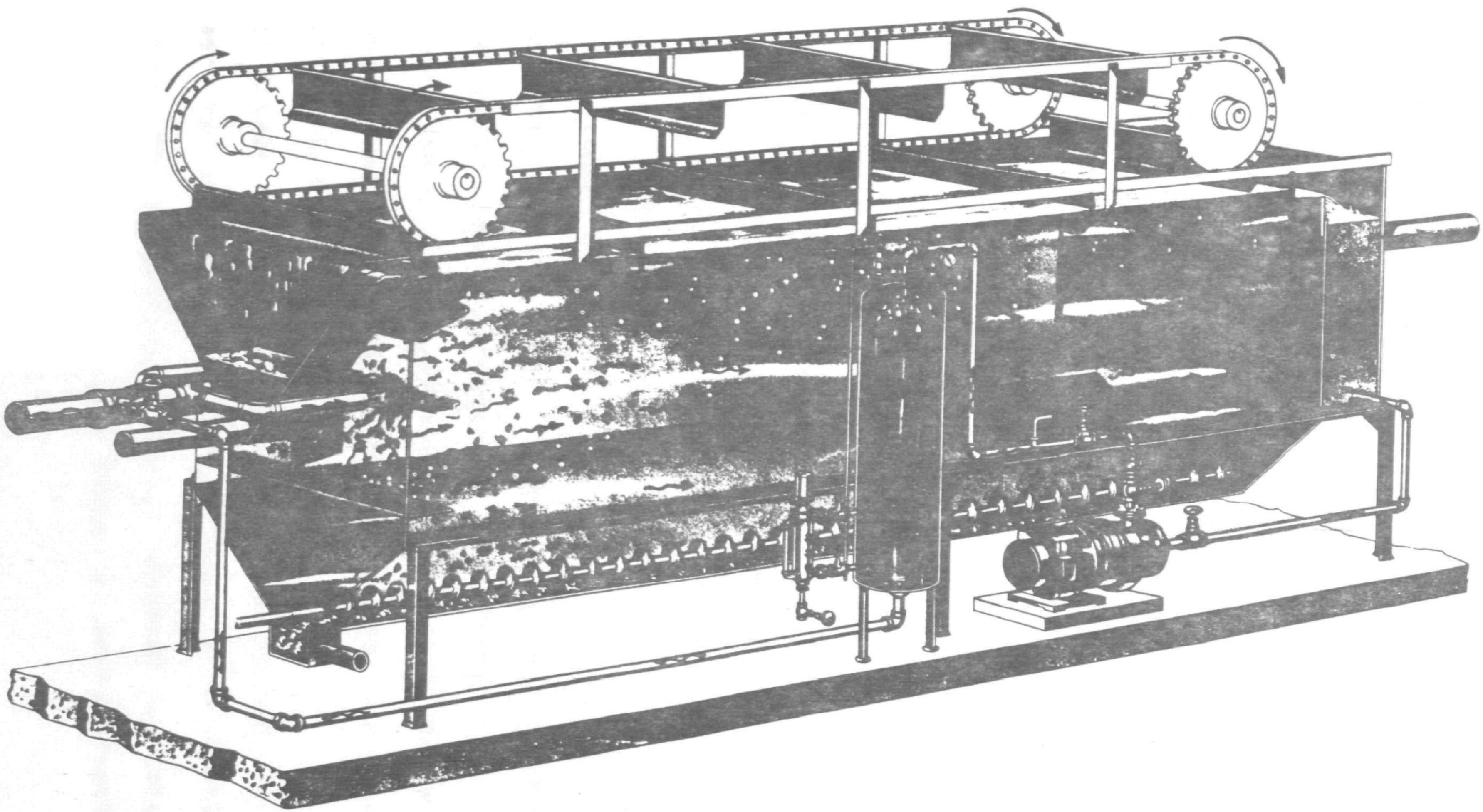


Figure 3

recycle flow containing the air bubbles) is mixed and uniformly distributed over the cross-section of the basin.

As the incoming flow travels to the effluent end of the basin, separation of the oil and solids from the associated liquid occurs. Solids accumulate at the water surface and form an oily sludge blanket. Clarified liquid flows over the effluent weir and into a wet well. From the effluent wet well, a portion of the effluent is recirculated. The remainder of the effluent is removed from the basin for subsequent treatment or discharge. The floated scum blanket of separated solids can be removed from the basin by skimmer flights traveling between two endless strands of chain. Since the influent stream may also contain small amounts of heavy solids, such as grit, which are not amenable to flotation, provision must also be made for solids removal from the bottom of the unit.

The preceding discussion illustrates the recycle method of injecting the air bubbles into the waste stream. Figure No. 4 shows all three methods of dissolved air injection currently used. Total pressurization, as the name implies, is where the total waste flow is pressurized prior to entering the treatment unit. Partial pressurization is a method whereby a portion of the waste flow is pressurized and mixed with the remaining raw flow prior to entering the treatment unit.

To obtain optimum treatment with some wastes, it has been necessary to use chemical pretreatment prior to dissolved air flotation. The necessity for use of chemical conditioning is normally associated with a high degree of emulsification of the

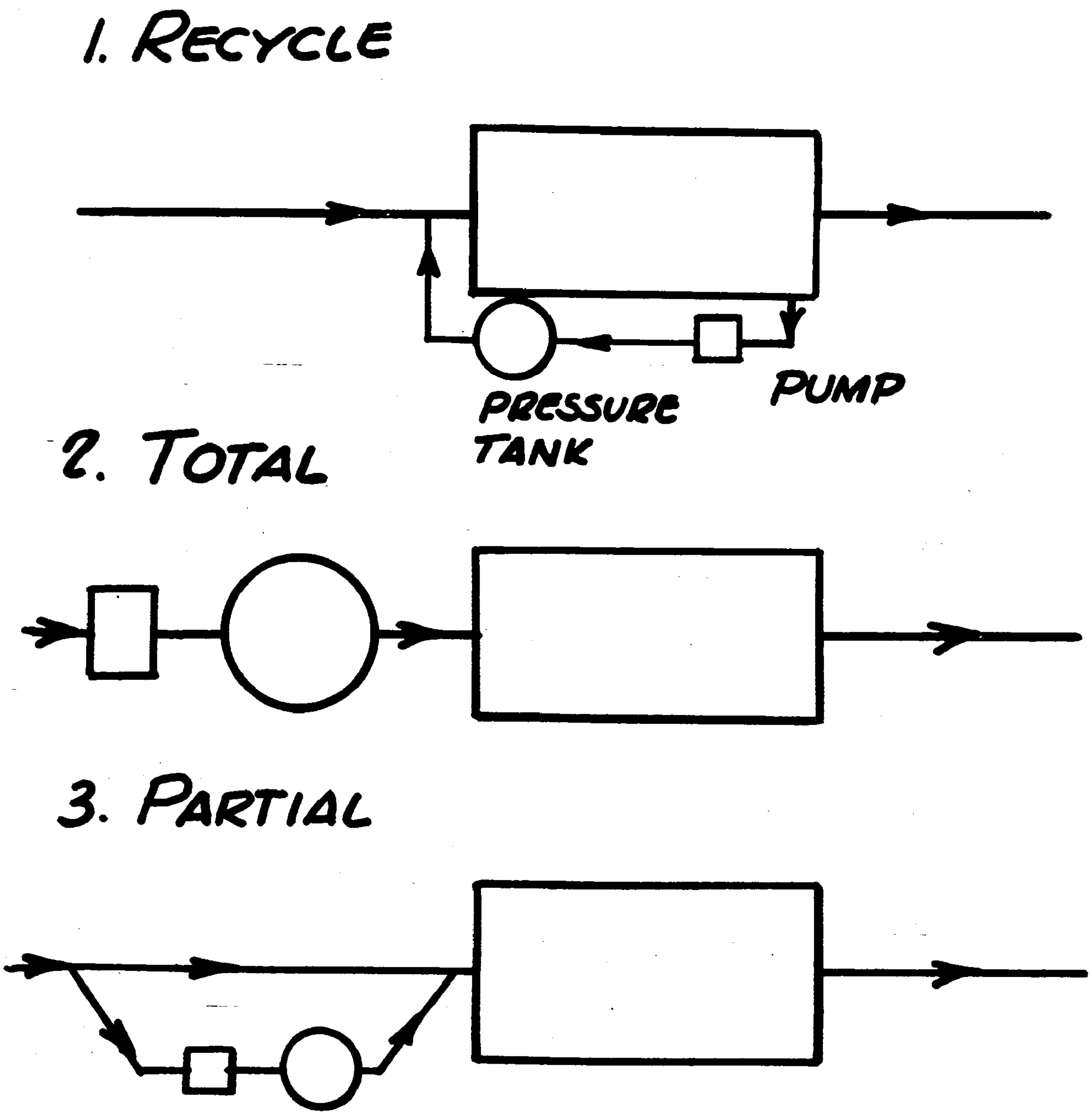


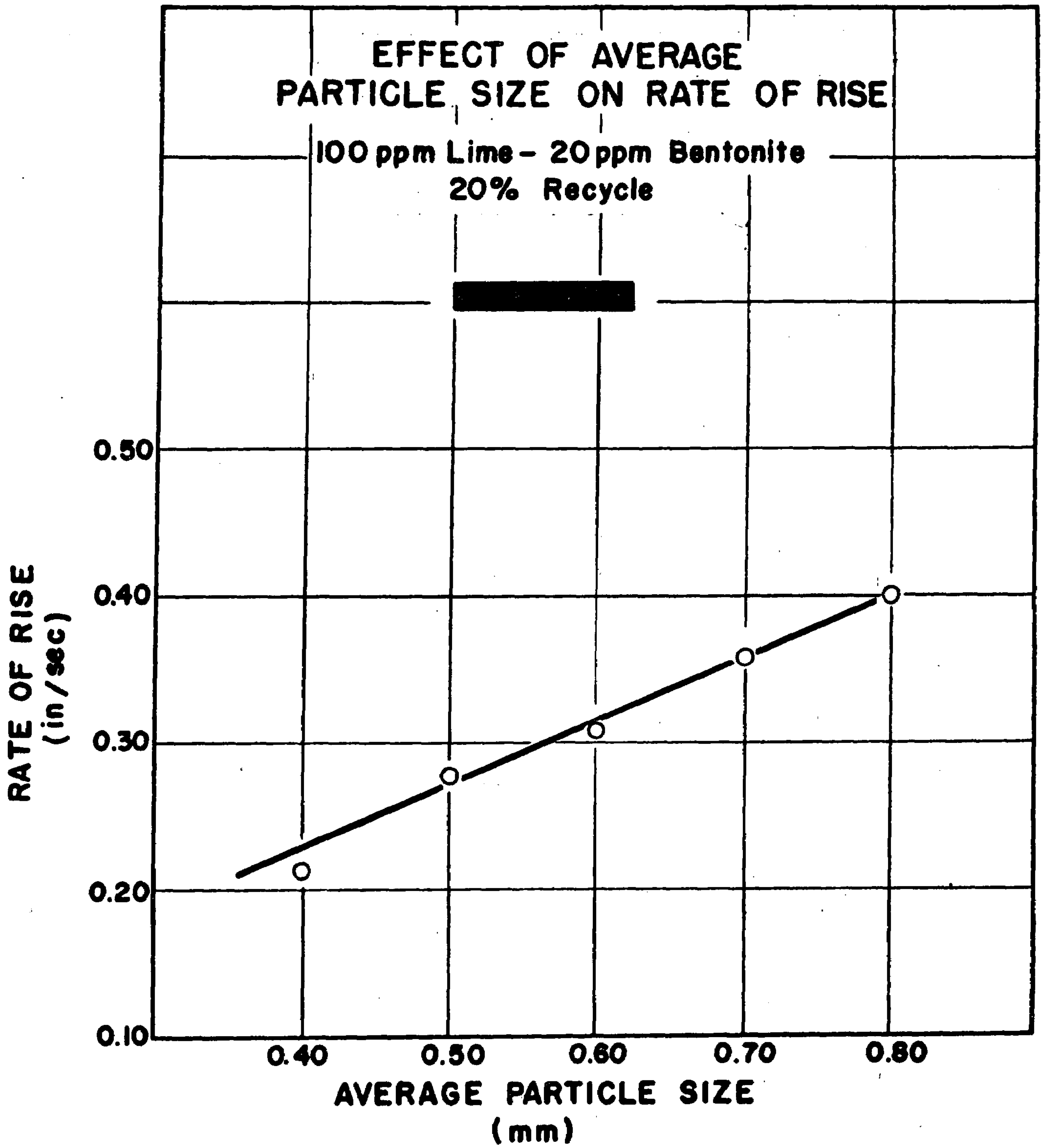
FIGURE 4

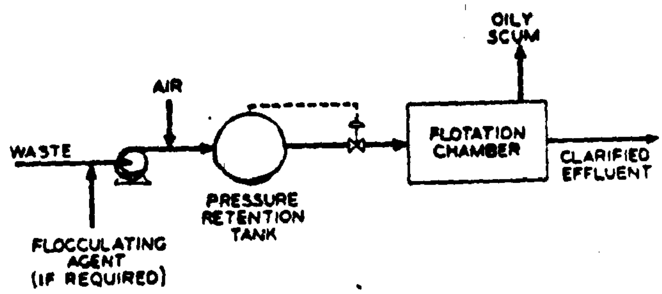
oil or grease matter in waste stream flow. It is, therefore, a requirement to break the emulsion and form a floc to absorb the oil or grease. It has been shown (Figure No. 5) that by increasing the particle size, the rate of separation is increased. Flocculation as a means of promoting particle growth preceding flotation contributes to the effectiveness of the flotation process where chemical conditioning is used. The points of chemical injection and the possible use of flocculation associated with the three methods of air injection are shown in Figure No. 6.

The use of steel package dissolved air flotation units lends itself to application in the meat processing industry. This arrangement provides an economical, flexible design which requires minimal construction cost and area investment.
Most manufacturers of dissolved air flotation units have complete line of steel tanks units to meet a wide variety of flow conditions. Figure No. 7 shows a partial listing of steel package units manufactured by REX. The Model No. 9550A shown would handle a raw waste flow of approximately 800 GPM, the Model No. 8032 handles a raw flow of about 300 GPM, and the Model No. 6020 would handle a raw flow of about 200 GPM. These raw flow figures indicated above were based on a vertical particle rise rate of 0.5 FPM and recycle rate of 33 percent.

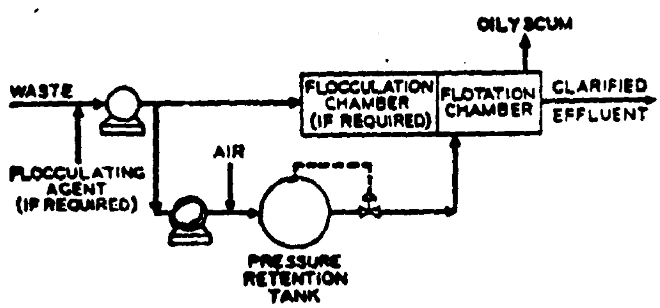
The use of steel package units lends itself equally well to those applications requiring flash mixing and flocculation as a part of chemical pretreatment.

FIGURE 5

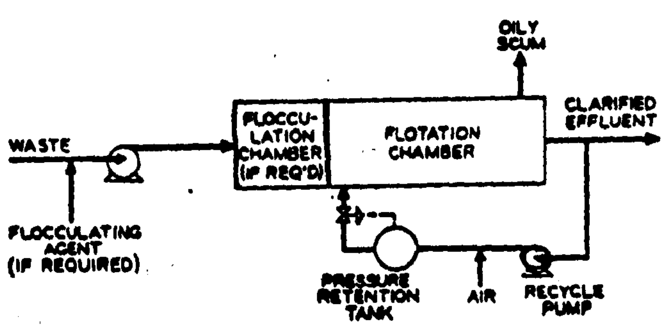

EFFECT OF AVERAGE
PARTICLE SIZE ON RATE OF RISE
100 ppm Lime - 20 ppm Bentonite
20% Recycle
[redacted]
0.50
0.40
0.30
0.20
0.10
RATE OF RISE
(in/sec)
0.40
0.50
0.60
0.70
0.80
AVERAGE PARTICLE SIZE
(mm)



TOTAL



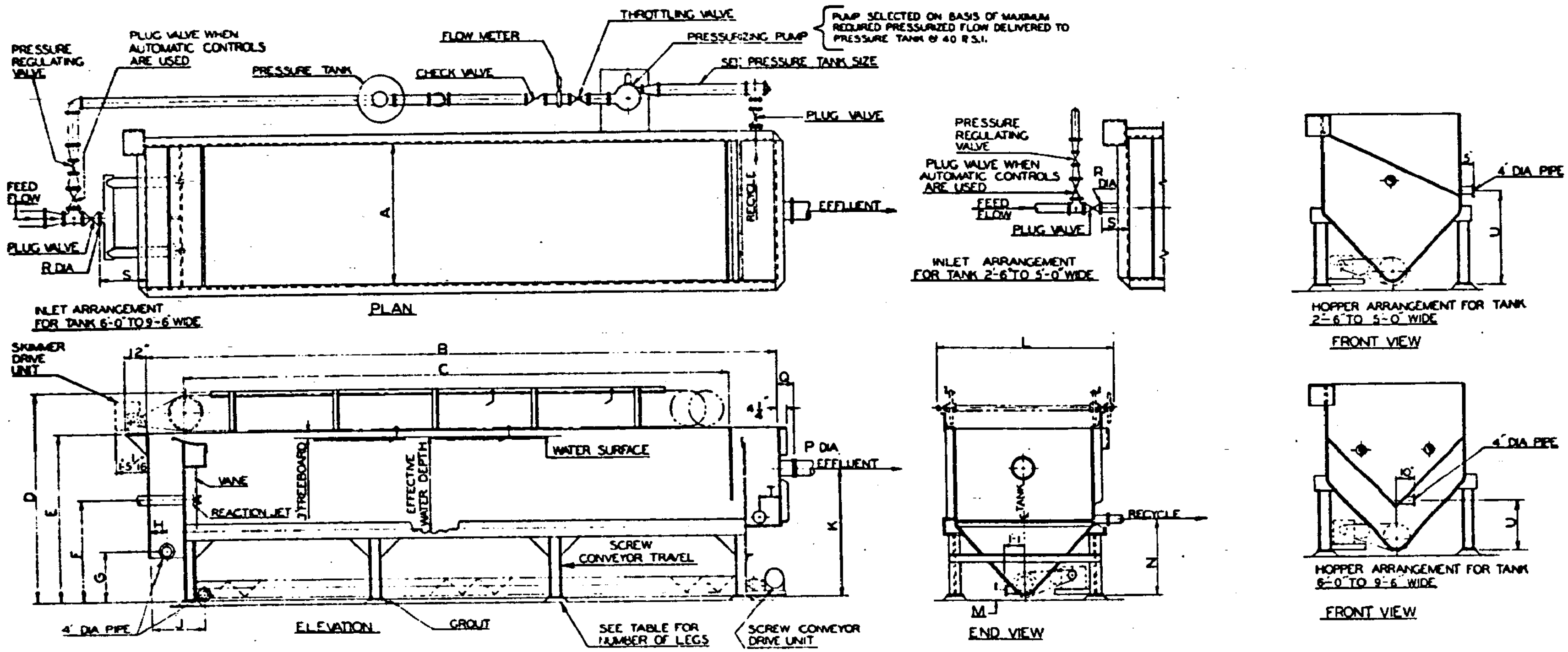
PARTIAL



RECYCLE

FIGURE 6

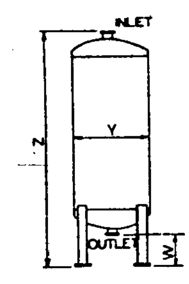
REX CHAINBELT INC.	PRODUCT MANUAL · SANITATION EQUIPMENT CONVEYOR and PROCESS EQUIPMENT DIVISION MILWAUKEE WISCONSIN 53201	Data Sheet No. 315-10.501 Page 1 of 1
SECTION	(10) FLOAT-TREAT	Issued March 1967
SUBJECT	Typical Arrangement-Packaged REX Float-Treat Separator-Steel Tank with Skimmer & Sludge Removal Facilities	Supersedes October 1963



MODEL NUMBER	EFFECTIVE WATER DEPTH	A INSIDE WIDTH	B INSIDE LENGTH	C EFFECTIVE LENGTH	D TOTAL HEIGTH	E TANK HEIGHT	F	G	H	J	K	L	M	N	P DIA.	Q	T	U	SKIMMER DRIVE MOTOR	SCREW CONVEYOR DRIVE MOTOR	TOTAL NUMBER OF LEGS	TANK WEIGHT WITH WATER	TANK WEIGHT EMPTY 3/16 ℄
2511	3-0	2-6	13-6 3/4	11-0	6-9 7/8	5-1	2-11 1/2	2-7	6"	1-4	4-0	4-1 1/4	8 1/2	2-0 1/2	4"	3"	6"	2-7	1/4 HP	1/2 HP	6	11950	5050
3511		3-6	13-6 3/4	11-0	7-0 7/8	5-4	3-2 1/2	2-9			4-3	5-1 1/4		2-3 1/2	4"	3"	6"	2-9				15 450	5450
3516		3-6	18-6 3/4	16-0	7-0 7/8	5-4	3-2 1/2	2-9			4-3	5-1 1/4		2-3 1/2	5"	3 1/2	6"	2-9				20850	6750
5015		5-0	17-6 3/4	15-0	7-9 7/8	6-1	3-11 1/2	3-2			5-1	6-7 1/4		3-0 1/2	6	3 1/2	6	3-2				28150	7400
5020	3-0	5-0	23-0 3/4	20-0	7-9 7/8	6-1	3-11 1/2	3-2	6"	1-4	5-1	6-7 1/4	8 1/2	3-0 1/2	6	3 1/2	9	3-2				36 200	8950
6020	4-0	6-0	23-0 3/4	20-0	9-3 7/8	7-7	4-11 1/2	2-6	9"	1-7	5-10	7-9 1/4	7	3-6 1/2	8	4	9"	2-4				53 650	10600
6024		6-0	27-6 3/4	24-0	9-3 7/8	7-7	4-11 1/2	2-6			5-10	7-9 1/4		3-6 1/2	10"	4"	9		1/4 HP			63 350	12150
8024		8-0	28-0 3/4	24-0	9-9 7/8	8-1	5-5 1/2	2-4			6-4	9-9 1/4		4-0 1/2	10"	4"	1-0		1/2 HP	1/2 HP	6	85 250	13900
8032		8-0	36-6 3/4	32-0	9-9 7/8	8-1	5-5 1/2	2-4			6-4	9-9 1/4		4-0 1/2	12"	4 1/2	1-3			1 HP	8	110 950	16800
9530		9-6	34-6 3/4	30-0	10-3 7/8	8-7	5-11 1/2	2-4			6-10	11-3 1/4		4-7 1/2	14"	5"					8	127 250	17700
9538			42-6 3/4	38-0	10-3 7/8	8-7	5-11 1/2	2-4			6-10				12"	4 1/2					8	158 400	20600
9550	4-0		54-6 3/4	50-0	10-3 7/8	8-7	5-11 1/2	2-4			6-10				14"	5"		2-4			10	205 750	25550
9530 A	5-0		34-6 3/4	30-0	11-3 7/8	9-7	6-5 1/2	2-7			7-4				14"	5"		2-5			8	146 650	18750
9538 A	5-0		42-6 3/4	38-0	11-3 7/8	9-7	6-5 1/2	2-7			7-4				16"	5"		2-5			8	182 900	21800
9550 A	5-0	9-6	54-6 3/4	50-0	11-3 7/8	9-7	6-5 1/2	2-7	9"	1-7	7-4	11-3 1/4	7	4-7 1/2	16"	5"	1-3	2-5	1/2 HP	1 HP	10	237600	27000

150# INLET FLANGE CONNECTION

R DIA	S	FLOW RANGE G P M INCLUDES RECYCLE
3	3"	40-60
4	6"	61-100
5	1-0"	101-160
6	1-0"	161-250
8	1-8"	200-319
10	2-4"	320-499
12	3-2"	500-799
14	4-2"	800-1060



ALTERNATE ARRANGEMENT WITH CROSS SCREW CONVEYOR AVAILABLE FOR SPECIFIC WASTE & DISCHARGE REQUIREMENTS

PRESSURE TANK SIZE MAS-PAC TYPE ONLY

RECYCLE FLOW GPM	Y TANK O D	INLET & OUTLET DIA	Z OVERALL HEIGHT	W
0-50	12	2		
50-75	16	2 1/2	[illegible]	8"
75-115	20	3	9-0 7/8	1-2
50-70	24	4	5-2	
70-100	24	4	6-2	
105-135	24	4	7-0 1/4	
136-160	30	4	7-5 3/4	
161-185	30	4	7-11 3/4	
186-210	30	4	8-5 3/4	
211-250	30	4	9-3 3/4	1-2
251-275	36	6	6-11 7/8	1-6
276-310	36	6	7-8	
311-360	42	6	8-7 3/4	
361-410	42	6	9-1 3/4	
411-455	42	6	9-7 3/4	
456-505	42	6	10-1 3/4	
506-550	42	6	10-7 3/4	1-6"

Form 271-S C.B.Co.

Figure 7

In the following discussion, a steel package Model No. 6020 with flash mix and flocculation compartments has been used to illustrate the costs associated with this type of unit. The capital cost of this unit would be approximately $37,500.00, which would include the following equipment:

1. Flash mixer and drive
2. Flocculator and drive
3. Two-shaft surface skimmer and drive
4. Screw conveyor, sludge collector and drive
5. Complete steel tank
6. Pressure tank and associated air control system
7. Recycle pump
8. Compressor
9. Recycle piping

Chart I lists the operating horsepower included in the above described unit. Based upon a 10 hour per day, 5 day per week operation, costs of running the Model No. 6020 for 52 weeks is shown for electrical costs at $0.01 per KWH and $0.015 per KWH.

To give a full range of capital costs involved with steel package flotation units, the largest unit, Model 9550A, with the

CHART I

OPERATING HORSEPOWER
MODEL 6020

1. FLASH MIXER ---- 1/2
2. FLOCCULATOR --- 1/2
3. SKIMMER ----- 1/2
4. BOTTOM SCREW -- 1/2
5. RECYCLE PUMP -- 7 1/2
6. COMPRESSOR 1 1/2

11.0

BASED ON 10HR/DAY, 5 DAY/WEEK OPERATION, YEARLY OPERATING COST EQUAL

a. $214 @ $0.01/KWH
b. $321 @ $0.015/KWH

same equipment as listed above would cost approximately $57,000. Our Model 2511, the smallest unit, would cost approximately $22,000.00, again, with components listed above.

Charts II and III list operating results from units treating waste of a mixed kill of hogs and cattle and from a ham packing operation. Charts IV and V are results from our bench scale testing of different type of meat processing waste and indicate degrees of treatment obtained in different methods of treatment.

In several of the preceding results, the use of chemicals was necessary to meet treatment objectives. Chart II indicates the use of a catonic polyelectrolyte at a dosage of 0.75 mg/l. Based on the flow of 1600 GPM and a chemical cost of $0.40 per pound, the cost for the chemical for a 12 hour operation would be a little less than $3.00 per day. The cost of a simple polyelectrolyte feed system would be around $6,000.

As is the case with most industrial waste, treatability studies should be conducted to determine not only the design parameters for a flotation unit, but also to determine if chemical treatment is a necessity to meet treatment objectives.

Pilot dissolved air flotation units are available from most manufacturers for treatability studies. The rental cost varies, but the normal rate is approximately $500.00 per month.

A laboratory bench scale test procedure has been developed to simulate the dissolved air flotation process and has been used most successfully in the determination of design parameters for an air flotation unit.

CHART II

PLANT A

TYPE: HOGS AND CATTLE KILLING

FLOW: 1600 GPM

A. UNTREATED SAMPLE

HEXANE SOLUBLE GREASE ------------------------ 3000 mg/l

B. GRAVITY SETTLING (25 MIN. APPROX.)

HEXANE SOLUBLE GREASE ------------------------ 1200 mg/l
(60% REMOVAL)

C. GRAVITY SETTLING FOLLOWED BY DISSOLVED AIR FLOTATION WITH CHEMICAL TREATMENT, 33% PRESSURIZED FLOW (TYPE CHEMICAL - CATIONIC POLYELECTROLYTE DOSAGE 0.75 mg/l)

HEXANE SOLUBLE GREASE ------------------------ 230 mg/l
(80% ADDITIONAL REMOVAL)

(TYPE CHEMICAL - CATIONIC POLYELECTROLYTE DOSAGE - 0.75 mg/l)

HEXANE SOLUBLE GREASE ------------------------ 80 mg/l
(93% ADDITIONAL REMOVAL)

CHART III

PLANT B

TYPE: HAM PACKING
NO KILLING

FLOW: 200 GPM - DESIGN
385 GPM - PRESENT

A. UNTREATED SAMPLE

SUSPENDED SOLIDS	350 mg/l
B.O.D.	1100 mg/l
HEXANE SOLUBLE GREASE	600 mg/l +

B. DISSOLVED AIR FLOTATION, WITHOUT CHEMICALS, 33% PRESSURIZED FLOW

SUSPENDED SOLIDS	300 mg/l (17% REMOVAL)
B.O.D.	400 mg/l (64% REMOVAL)
HEXANE SOLUBLE GREASE	80 mg/l (87% REMOVAL)

CHART IV

PLANT C

TYPE: HOG KILLING

A. UNTREATED SAMPLE

SUSPENDED SOLIDS	3700 mg/l	Composite Removal
B.O.D.	2800 mg/l	
HEXANE SOLUBLE GREASE	3300 mg/l	

B. GRAVITY SETTLING (LAB. TIME TO SIMULATE 30 MINUTES FULL SCALE BASIS)

SUSPENDED SOLIDS ---------------------------- 800 mg/l (78% REMOVAL)

B.O.D. -- 600 mg/l (79% REMOVAL)

HEXANE SOLUBLE GREASE ---------------------- 500 mg/l (85% REMOVAL)

C. GRAVITY SETTLING FOLLOWED BY DISSOLVED-AIR FLOTATION WITHOUT CHEMICALS, USING 33% PRESSURIZED RECYCLE FLOW

SUSPENDED SOLIDS ---------------------------- 440 mg/l (45% ADDITIONAL REMOVAL)

B.O.D. -- 380 mg/l (36% ADDITIONAL REMOVAL)

HEXANE SOLUBLE GREASE ---------------------- 190 mg/l (62% ADDITIONAL REMOVAL)

D. GRAVITY SETTLING FOLLOWED BY DISSOLVED-AIR FLOTATION WITH CHEMICAL TREATMENT USING 200 mg/l OF ALUM AND 1 mg/l OF ANIONIC POLYELECTROLYTE

SUSPENDED SOLIDS ---------------------------- 230 mg/l (71% ADDITIONAL REMOVAL)

B.O.D. -- 210 mg/l (65% ADDITIONAL REMOVAL)

HEXANE SOLUBLE GREASE ---------------------- 55 mg/l (88% ADDITIONAL REMOVAL)

NOTE: RESULTS ARE FOR BENCH SCALE TESTING

CHART V

PLANT D

TYPE: LAMB
KILLING

A. UNTREATED SAMPLE

HEXANE SOLUBLE GREASE ---------------------- 2600 mg/l
(GRAB SAMPLE)

B. DISSOLVED AIR FLOTATION, WITHOUT CHEMICALS, 33% PRESSURIZED FLOW

HEXANE SOLUBLE GREASE ---------------------- 104 mg/l
(96% REMOVAL)

C. DISSOLVED AIR FLOTATION, WITH CHEMICALS, 33% PRESSURIZED FLOW (TYPE - CATIONIC POLYELECTROLYTE DOSAGE - 0.75 mg/l)

HEXANE SOLUBLE GREASE ---------------------- 76 mg/l
(97% REMOVAL)

NOTE: RESULTS ARE FOR BENCH SCALE TESTING

Treatment of Meat Processing Waste
by Dissolved Air Flotation

This flotation test (see photographs) is used to determine the suspended particle rise rate (V_T) which is the most critical design parameter in the design of the flotation unit. This is done by filling the pressure cell with liquid, and to closely simulate the recirculation of the unit effluent of pressurization in a full size unit, the recycle water should be developed by several previous flotation runs. This liquid is then injected with air until a pressure of over 40 psi is obtained and then the cell is shaken vigorously to assure that the air is put into the solution. The pressurized liquid is then introduced into the waste. The exact amount of pressurized liquid is determined by trial and error for best results. As the minute bubbles are released from solution, they attach to the suspended particle and oil and rise to the surface. After flotation is complete, a sample of the effluent is then taken and analyzed. During the test, observation of the rise rate of the major portion of the solid material with respect to time is recorded. From a graphical plot of this data a rise rate can be calculated. This rise rate along with factors for turbulence and short-circuiting are used in the selection of the basin size necessary to accomplish treatment required.

SECTION (10) FLOAT - TREAT	Issued November 30, 1955
SUBJECT DEMONSTRATION PROCEDURE FOR REX FLOAT - TREAT TEST KIT	Supersedes

See Figure 2 - Data Sheet 315-10.804 for Rex Float-Treat Test Kit.

A. Assume that a recirculation ratio of 0.33/1 is to be tried.

1. Place 750 ml of a representative sample of the waste in a one liter graduated glass cylinder. (See Figure 3, Data Sheet 315-10.804.)

2. Fill the Float-Treat Pressure Cell approximately three-fourths full with liquid. (See Figure 3, Data Sheet 315-10.804.)
   (It is desirable that the operation of the Float-Treat Pressure Cell closely similate the recirculation of effluent as used in the Float-Treat Flotation System. The returned effluent (recycle water) may be developed by repeated flotation of several different portions of raw waste. After the recycle water has been developed and used in the flotation tests, samples may then be withdrawn for chemical analyses.)

3. Secure the cover gasket and cover of the Float-Treat Cell, making certain all the valves are closed.

4. Inject air into the cell until a pressure of 40 psi is attained and maintained during testing. (See Figure 4, Data Sheet 315-10.804.)

5. Shake the cell vigorously for thirty seconds.

6. Release 250 ml of the liquid which has been pressurized into the graduated cylinder. (See Figure 5, Data Sheet 315-10.804.) The volume of liquid in the graduated cylinder then totals 1000 ml (750 ml raw and 250 ml pressurized). The ratio of volumes of recycle water to the raw waste is termed the recycle ratio. This ratio is expressed in percent and is termed the recycle rate. Thus, the recycle rate used in this test is 33%. The most suitable recycle rate can be determined by repeated tests at varying rates of recycle and usually is not less than 20% and no more than 50%. To facilitate the introduction of the air-charged recycle water to the graduated cylinder, a rubber tube may be connected to the petcock on the pressure cell. After clearing the rubber tube of air, (Allow some liquid to escape through the tube by opening petcock. Sufficient liquid should be removed until it has a milky appearance) the air-charged recycle water is introduced through the rubber tube into the graduated cylinder. The end of tube should be placed near bottom of the cylinder. (See Figure 5, Data Sheet 315-10.804.)

The air bubbles rise through liquid in a manner similar to that in the Float-Treat flotation system.

7. Allow the contents of the graduated cylinder to come to rest and observe the flotation. (See Figure 6, Data Sheet 315-10. 805.) Allow sufficient time for the rising solids to come to the surface of the liquid. Usually ten minutes will be sufficient time for the flotation to be completed. (See Figure 7, Data Sheet 315-10. 805.)

8. After the flotation is completed, a sample of the raw waste and treated waste should be taken for analysis. (See Figures 8 and 9, Data Sheet 315-10. 805.) The treated waste should be carefully withdrawn from the graduated cylinder either through the use of a petcock installed in the side and near the bottom of the cylinder or through the use of a siphon inserted in the cylinder. Sufficient liquid should be withdrawn to complete the desired analysis, however, care should be taken to avoid the break up of the skum blanket.

9. Should chemical flocculation with flotation be desired, the chemical may be added into the raw waste after step "1" is completed, flocculation may be carried out, for convenience, in another vessel. Care should be taken not to break up the floc when transferring the waste to the cylinder. Enough time for flocculation should be allowed before introducing the air-charged recycle water. Under appropriate conditions, a floc may be formed by gentle agitation of the waste after the chemical is added. The procedure described above also applies when chemical flocculation is used. When using chemical flocculation, care should be exercised not to break up the floc particles in handling the flocculated waste.

Because of the peculiarities of some floc formations, they will break up readily upon any excessive agitation after being formed. This is most readily noticed when a liquid with a preformed floc is transferred from the cylinder used in the jar mixing test to the cylinder used in the flocculation test. If the floc does break up and does not re-form immediately, it is suggested that the transfer to the flotation cell not be made and that flotation be accomplished in the vessel where the floc was formed. The procedure for running this test are the same. However, withdrawing of the clarified liquid, as described in step "8", will probably be through a siphon.

In flotation of a particular waste, it is quite possible that the test using the recirculation ratio of 0.33/1 may not yield the best results. It may be that some other recirculation ratio would yield the results needed to work in with the economy of a final plant design and effluent requirements. Therefore, the tests described above may be repeated with other recirculation ratios until the optimum ratio is obtained. In these tests the values shown in steps "1" and "6" will be changed accordingly.

When running flotation tests in the Rex Float-Treat demonstration kit, the observed rate of rise of the major portion of the solid material should be recorded. This value can be recorded in terms of inches per minute and will be used in determining the full scale plant requirements.

In order to insure the validity of results obtained, care should be taken that representative samples of waste are obtained before running tests. When results have been obtained, they should be recorded on Questionnaire for Design Data Sheets 315-10.101 and 315-10.102. These completed sheets should be returned to CHAIN Belt Company.

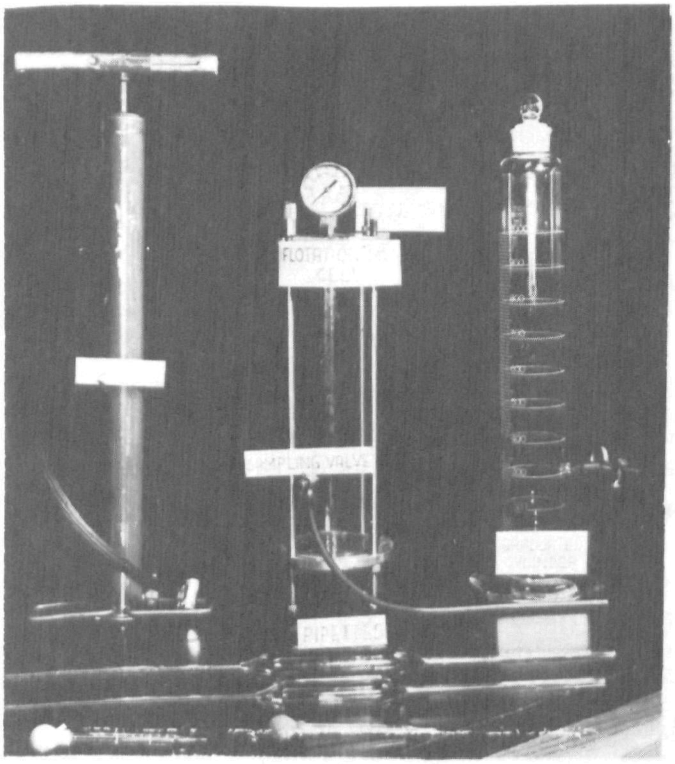


FIGURE 2
COMPONENT PARTS - REX FLOT-AIRE KIT

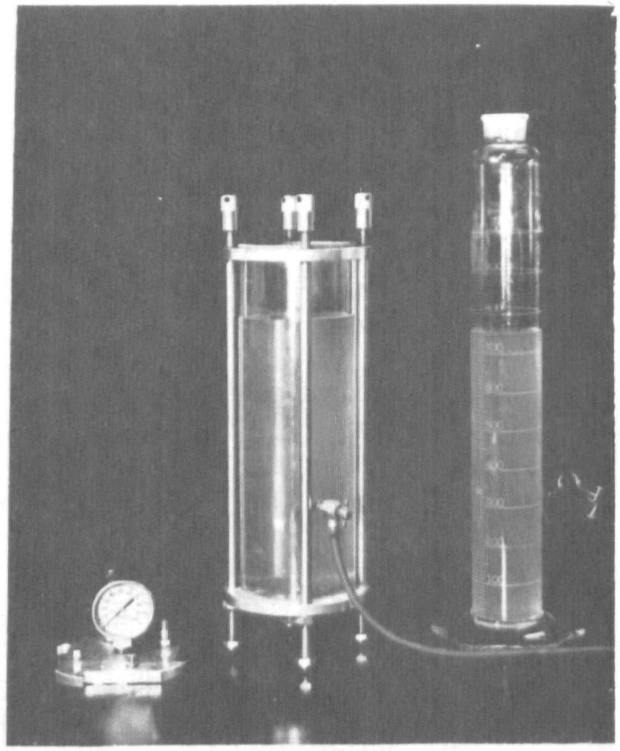


FIGURE 3
FLOT-AIRE PRESSURE CELL WITH CLARIFIED EFFLUENT
GLASS CYLINDER WITH RAW WASTE

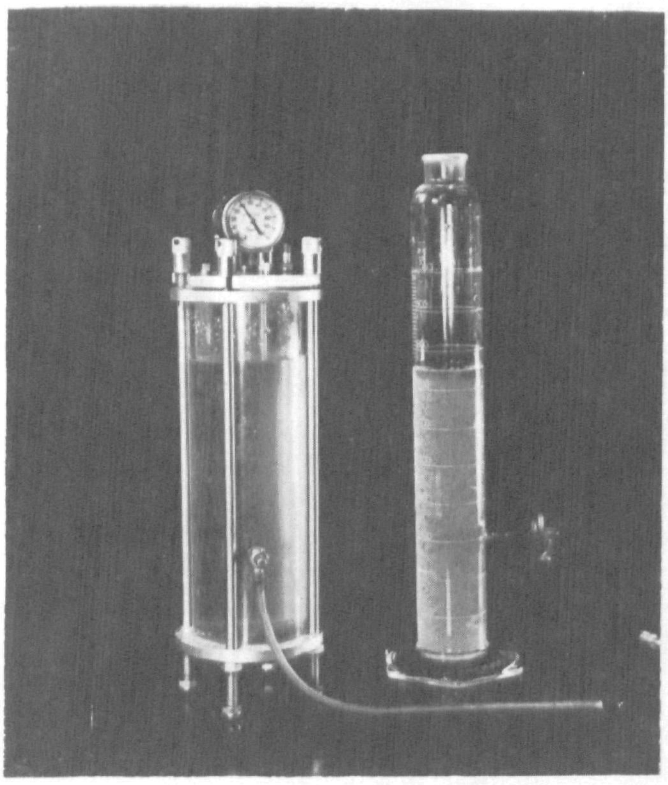


FIGURE 4
CLARIFIED EFFLUENT IN FLOT-AIRE PRESSURE
CELL PRESSURIZED TO 40 psi.

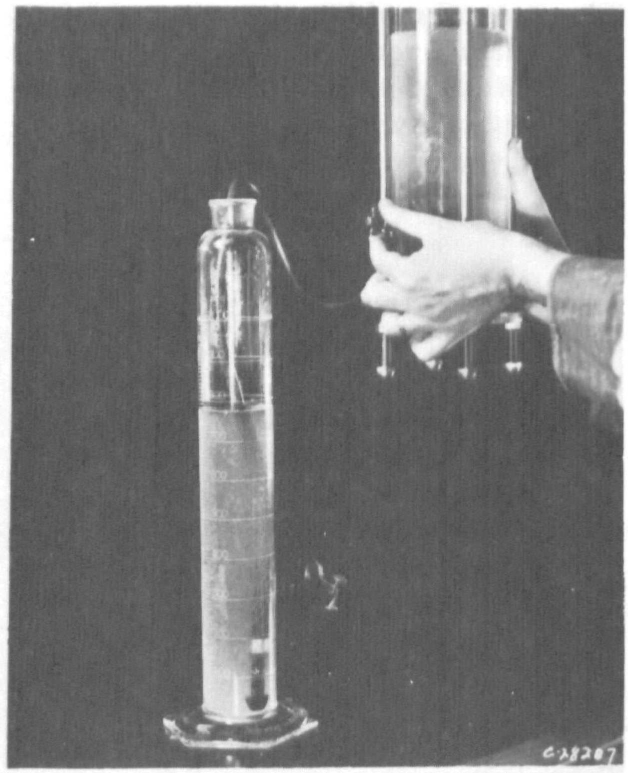


FIGURE 5
PRESSURIZE EFFLUENT INTRODUCED TO RAW WASTE

SECTION (10) FLOAT - TREAT

Issued November 30, 1955

SUBJECT DEMONSTRATION PROCEDURE FOR REX FLOAT-TREAT TEST KIT

Supersedes

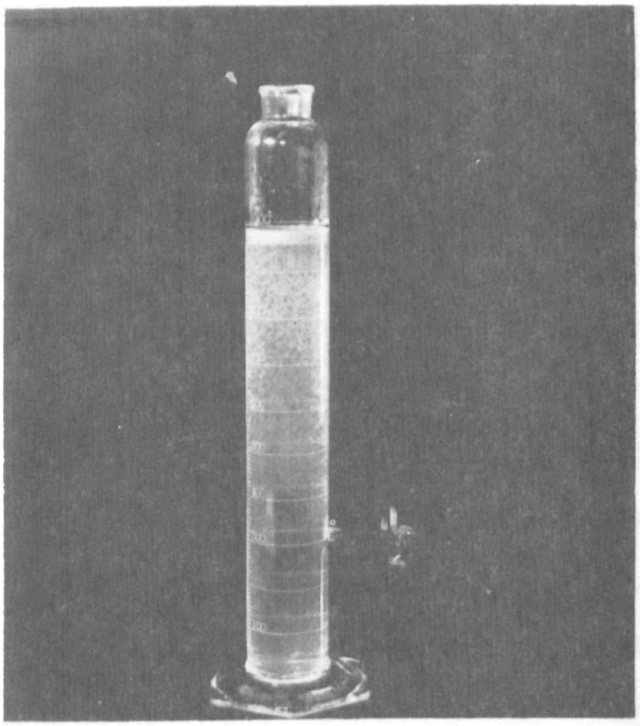


FIGURE 6
MINUTE AIR BUBBLES FLOATING WASTE MATERIAL TO SURFACE OF CYLINDER

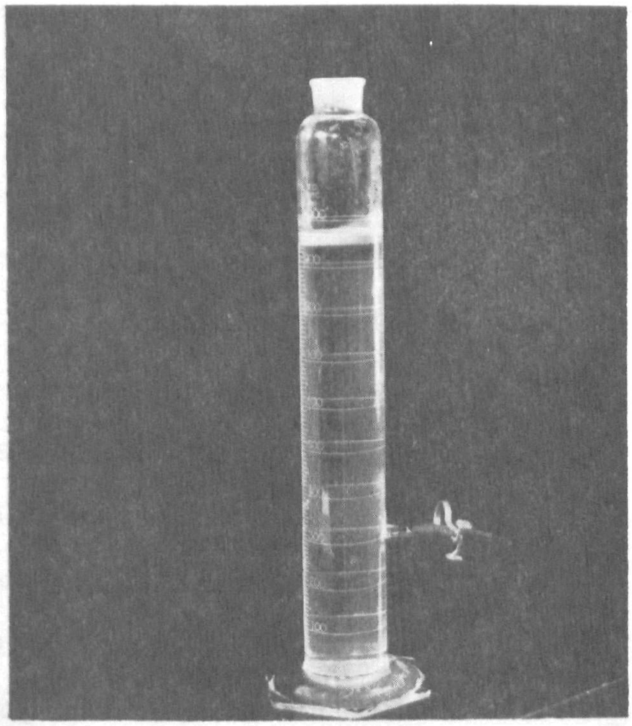


FIGURE 7
FLOTATION COMPLETE IN CYLINDER

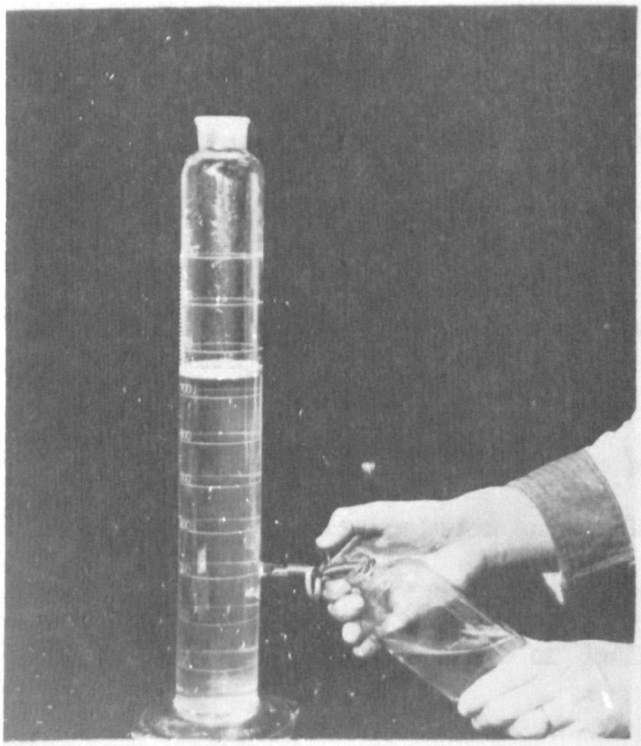


FIGURE 8
CLARIFIED WASTE SAMPLE BEING WITHDRAWN FROM CYLINDER

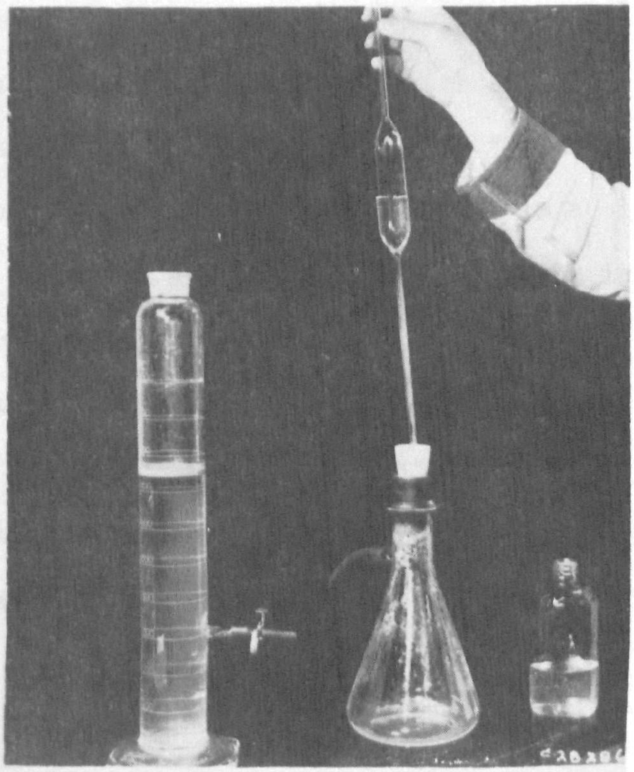


FIGURE 9
ANALYSIS MADE ON CLARIFIED WASTE

4. Other Systems: Whereas the preceding section was limited to a discussion of rectangular dissolved air flotation systems, it should be noted that the same principles are applied to circular-shaped tanks by a number of equipment manufacturers. These tanks are similar to conventional clarifiers with center baffled inlet, peripheral weir, bottom sludge removal scrapers, and surface skimmer arms discharging to a surface scum trough. The pressurized air recycle arrangements are the same as those used in rectangular tank systems. These circular systems average approximately $1,200 per foot of diameter to 20 ft. in diameter, and $1,000 per foot of diameter above 20 ft. These costs include steel tank side sheets, the sludge and scum removal mechanism, pressurizing pump, air saturation tank and air compressor. Installation costs can be estimated at 40% of the equipment costs. Variations between manufacturers lie in proprietary details such as baffling the influent, design of the skimming system, design of the effluent trough, and design of the scraper mechanism.

The accompanying flow diagrams show suggested systems which are applicable to both circular or rectangular flotation units. The "Primary Skim Tank" is a gravity catch basin and the "Sediflotor Clarifier" is a proprietary circular dissolved air flotation system. The systems shown in Flow Diagrams IV and V, with proper chemical treatment, are claimed to produce 90% grease removal and 70 to 90% BOD and suspended solids removal. Drawing No. ND831A, showing a plan view and section of the "Sediflotor Clarifier" is included as an illustration of the circular type of flotation system. This is not to be construed as an endorsement or preference as to manufacturer or details of design.

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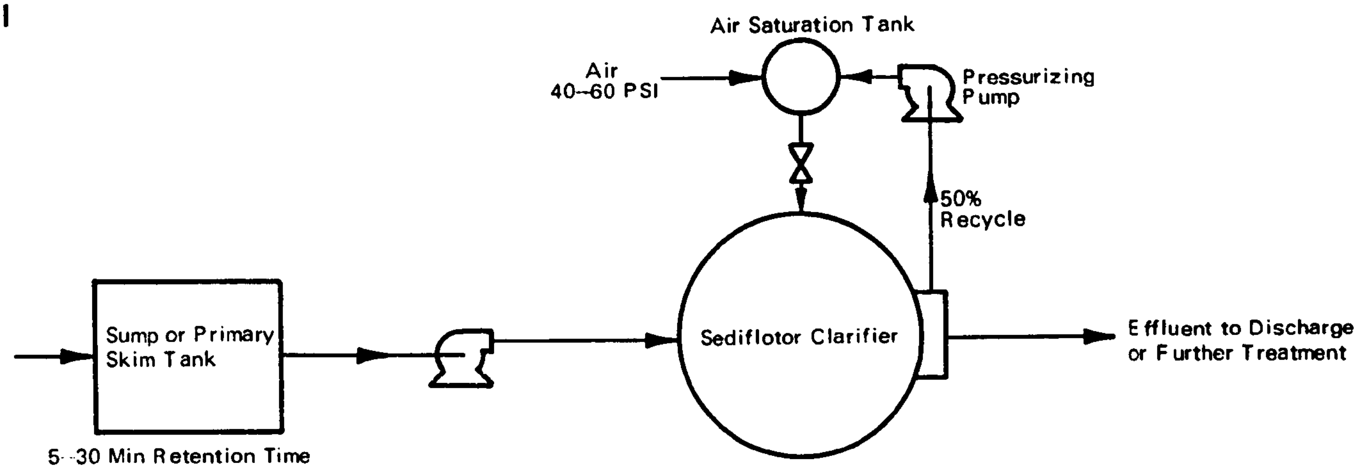
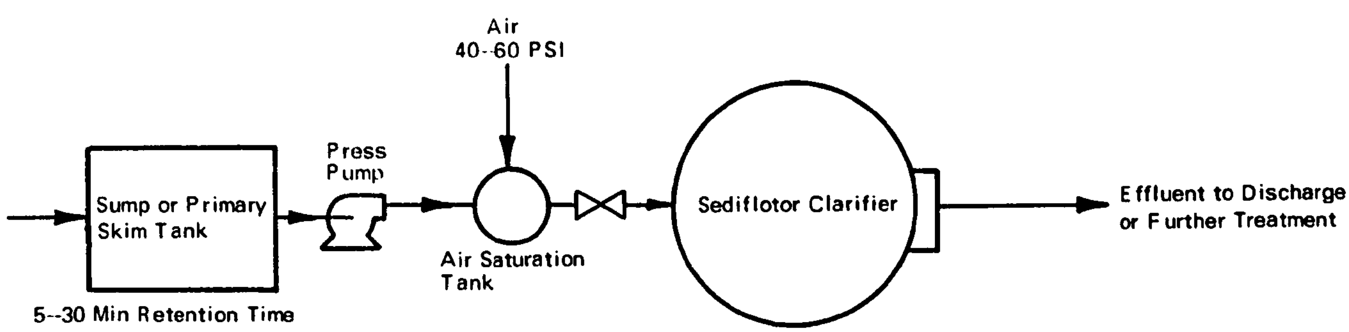
Typical flow sheets meat packing and processing industry

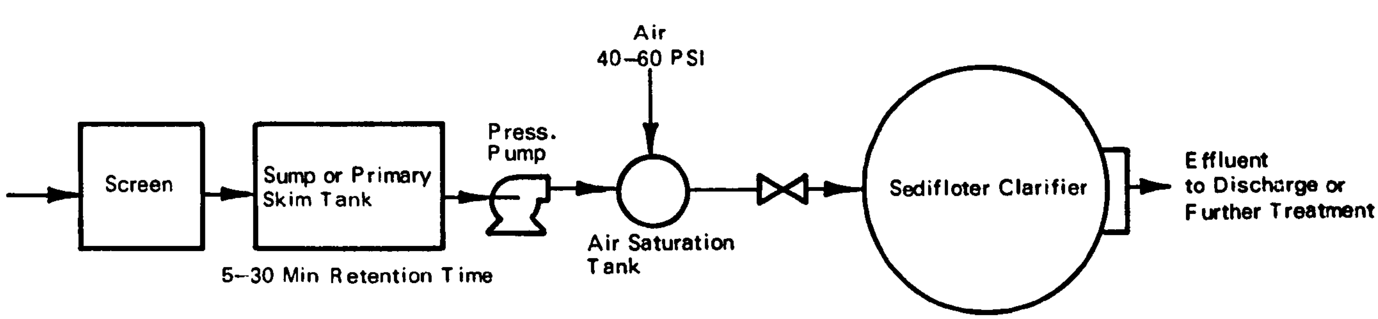
I



II



III



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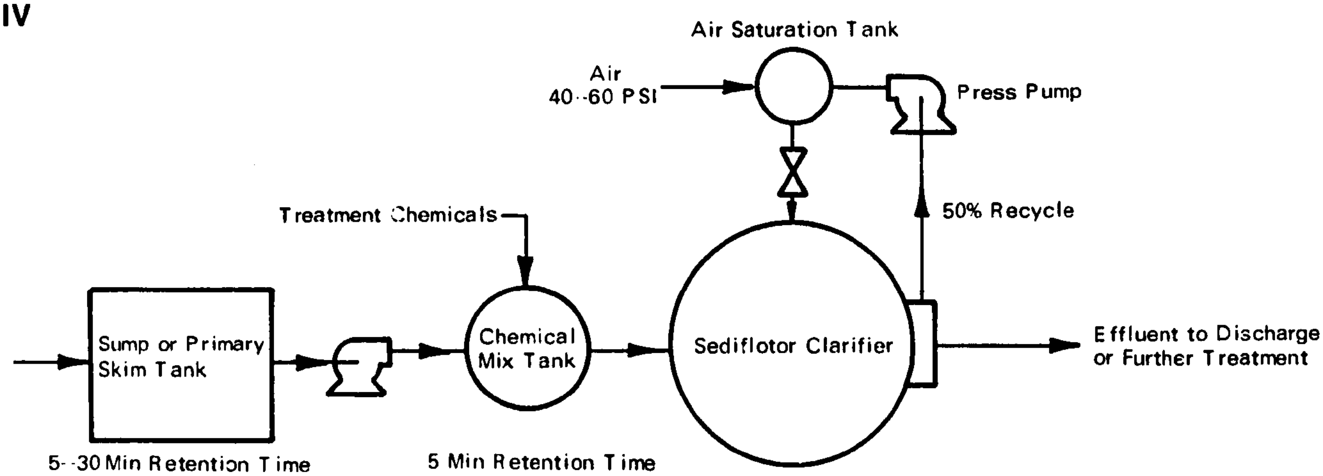
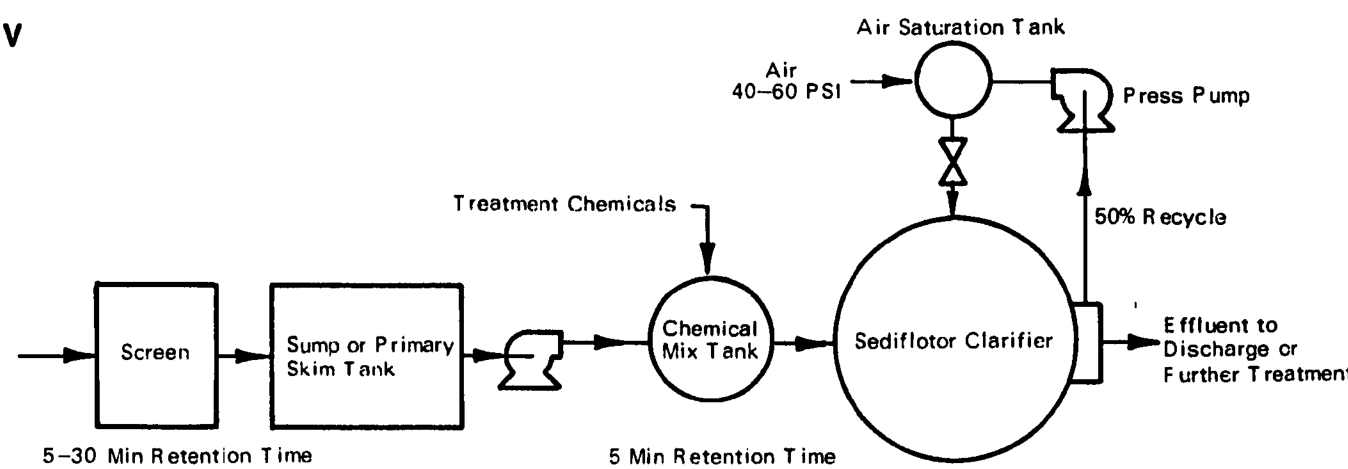
Typical flow sheets meat packing and processing industry

IV



V



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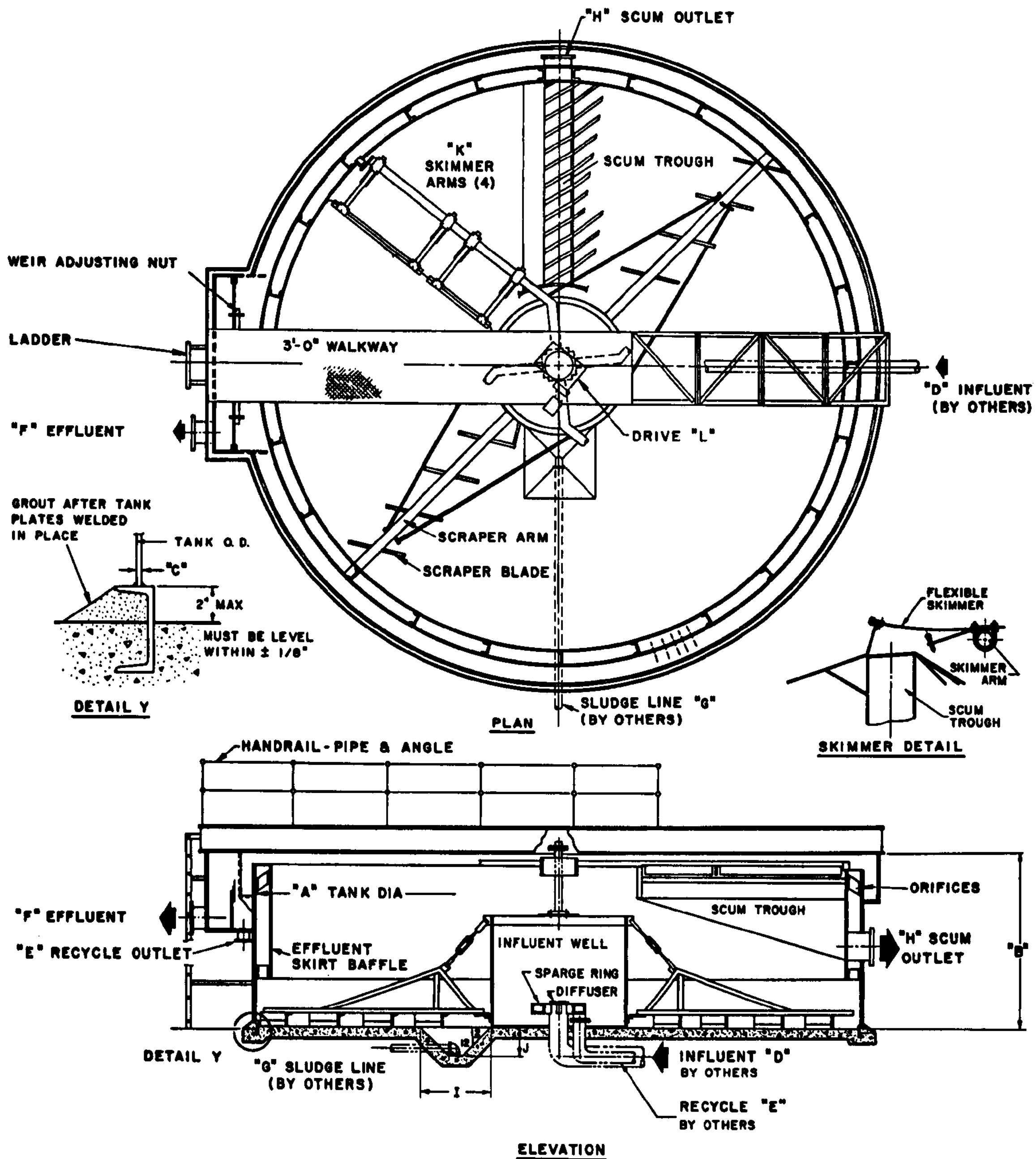
INFILCO SEDIFLOTOR® CLARIFIER



DIMENSION		
A	TANK DIAMETER	
B	SIDESHEET HEIGHT	
C	SIDESHEET THICKNESS	
D	INFLUENT	
E	RECYCLE	
F	EFFLUENT	
G	SLUDGE BLOWOFF	
H	SCUM OUTLET	
I	SLUDGE SUMP, WIDTH	
J	SLUDGE SUMP, DEPTH	
K	NUMBER OF SKIMMERS	
L	DRIVE HORSEPOWER	

Westinghouse Electric Corporation
Infilco Division

ND 831 A

The following data is reported for these systems:

PLANT	PRODUCT	HEAD per DAY	FLOW SHEET	SYSTEM CAPACITY gpm	DIAMETER FLOTATION UNIT
A	Beef	1100	I	1000	35'-9"
C	Beef	1000	I	1500	50'-0"
J	Pork	300	V	100	17'-6"

Operating Results Reported from these Plants:

PLANT	CHEMICALS ADDED	POLLUTANT	INFLUENT mg/l	EFFLUENT mg/l	% REMOVED
A	None	Grease	1150	150	87
C	None	Grease	2150	213	90
J	—	—	—	—	—
A	—	—	—	—	—
C	None	BOD	1710	760	55
J	$Fe_2(SO_4)_3$	BOD	1306	200	85
A	—	—	—	—	—
C	None	Suspended Solids	6200	410	93
J	$Fe_2(SO_4)_3$	Suspended Solids	1380	60	95

There are numerous other proprietary devices, processes and mechanical details for which claims are made to enhance the efficiency of gravity separation and dissolved air flotation — too many to recount here. Again, it must be stressed that the system must operate, in pilot scale, on the wastewaters from the packing plant for several months before its value can be established for the particular plant in question.

IV. CASE HISTORIES in WASTE CONSERVATION and PRETREATMENT

A. A hog killing plant of medium size in Iowa, producing fresh pork with no further processing other than edible and inedible rendering, has, mainly by way of water conservation, reduced BOD to 2.5 to 3.0 lbs. per 1000 lbs. live weight kill. The plant kills about 504,000 lbs. live weight using only 58,000 gallons of water. Peak kill reaches 544,000 lbs. and peak water use 78,000 gallons per day, with a minimum of 33,000 gallons on any operational day.

Yards and pens are all dry cleaned, using a manure spreader for direct disposal on farmland. The blood floor is pre-rinsed with a small diameter hose equipped with a fan nozzle using water at 600 lbs. pressure. The small amount of rinse water, 35 to 50 gallons per day, goes to the blood tank. All blood is dried. The extra drying cost for the pre-rinse water is small compared to the cost saving in BOD reduction in final cleanup.

The plant is equipped with edible and inedible dry rendering, but paunches and edible stomachs are washed, and the wastewater is discharged to the sewer. The possibilities of further improvement in waste conservation by dry dumping have not been explored.

The plant produces a substantial saving in solids and BOD by their procedure in dumping the scalding tub. The tub is fitted with a drain 6 inches above the bottom of the tub, draining through a 2-inch line. The slow drain permits the sludge to settle. Then the residual sludge is scraped and shovelled to a large sluice gate that is kept closed during drainage. The sludge is hauled to farm fields.

The de-hairing operation uses only 6 gallons per hog at 250 hogs per hour, with five men shaving and trimming. The wet hair is sold.

The grease sewer discharges to a small gravity catch basin 5 ft. wide and 6.5 ft. long, with a sloping end. A single scraper chain mechanism serves to drag the bottom sludge up the sloping end to a trough and also pushes the scum to a scum trough. The scrapers ride up a beach at the scum trough and thence over the trough to complete the circuit. Bottom solids and skimmings go to rendering.

The effluent of this basin joins the non-grease sewer at a 12 ft. diameter holding sump, from which a 400 gpm pump discharges to a circular dissolved air flotation unit also rated at 400 gpm. Recycle is one-part recycle to four-parts raw flow. No chemicals are used. The effluent flow is then discharged to a portion of the pump sump, walled off to carry the effluent to lagoon treatment (the wastewater could be considered ready for discharge to a city sewer at this point). The walled portion of the pump sump is arranged to recycle effluent through the flotation unit, during low flow periods, to insure uniform treatment in the flotation unit.

The plant is washed down by a contract janitorial service, after plant personnel dry-clean the floors and equipment to remove scraps. The initial rinse on the blood floor is done by plant personnel. All dryers are equipped with sprays for cleaning-in-place (CIP).

The owner gives major credit to water conservation for his overall success in reducing BOD as well as water consumption.

It should be noted that the operations at this plant are limited to slaughtering and rendering. Since individual process wastes in the meat industry have not been systematically evaluated, it is impossible to predict the effect of additional processing on the results of these wastewater conservation data.

B. A large meat packing plant, killing 470,000 lbs. live weight beef and 1,380,000 lbs. live weight hogs, operates a complete pork processing system, including smoking, sausage manufacturing and curing, as well as sliced luncheon meat, canned meats and lard manufacturing. It discharges less than 4 million gallons of wastewater daily and recycles 1,100,000 gallons of wastewater daily for various pruposes in the plant. Blood is coagulated and the bloodwater is evaporated. Hides are sold green. Three-quarters of the hog hair is sold, the remainder going to landfill. Paunches are washed and the manure is removed from the wastewater by screening before joining the major wastewater stream. They operate a laundry for shrouds and work clothes, and washing facilities for all rail cars. Tripe and stomachs are washed but casings and chitterlings are tanked direct. Viscera are hashed and washed. Wet rendering is practiced for continuous edible rendering and for inedible rendering of skimmings. Pretreatment consists of screens, gravity catch basins and dissolved air flotation. Manure sewer wastewaters are separately screened. The raw BOD is 1600 mg/l, suspended solids 1750 mg/l and grease 800 mg/l. After pretreatment, these respective data drop to 850 mg/l (47% BOD removal), 500 mg/l (71% suspended solids removal), and 150 mg/l (81% grease removal).

V. SUMMARY

In any effort to improve the quality of the wastewaters from a meat packing plant, the first step must be a complete evaluation of in-plant waste conservation opportunities. These include recovery of product; removing solid wastes and inedibles at the source (dry, whenever possible); recycling waters such as cooling water and can quenching; and reuse of wastewater for inedible purposes such as condenser water in the tank house. These and others are detailed in this manual.

In the offing, and possibly already inaugurated in many communities, are new regulations setting forth pretreatment requirements and surcharge systems to charge back to the meat packer those costs of municipal treatment for which he is responsible. The cost of purchased water, plus the cost of waste treatment (pretreatment costs plus municipal surcharges) and possibly the value of recoverable by-products offer economic incentives for waste conservation. After all feasible steps in waste conservation have been taken, the degree of "pretreatment" of the various waste flows must be determined, first to satisfy regulations and second, to determine whether pretreatment beyond that required legally will produce economic advantages. Whereas the basic pretreatment will be required by law, any pretreatment beyond this base is an economic decision. Thus there is an economic breakpoint where the pretreatment can stop. Possibly the legal requirements are the stopping point and nothing can be gained by going further.

Other variables enter the picture: the possibilities for increases in municipal surcharges; the adequacy of the municipal plant to treat the wastewaters, and the general growth potential of the community, both in industry and in population. The meat packer must also consider his own future business plans, such as changes in processing, additional processing, overall expansion, or possibly, reduction in operations. If wastewaters are treated by the packer for direct discharge to a watercourse, he must consider obsolescence of the treatment plant, possible changes in legal requirements and the costs that are part of a wholly owned facility (taxes, maintenance, operation, amortization, etc.).

Within these elusive variables, the meat packer must determine:

1. The amount of in-plant waste conservation he should economically undertake. It should be noted here, however, that a substantial amount of waste conservation can often be accomplished at insignificant expense.

2. The degree of pretreatment (for each of the segregated plant waste streams) that he should undertake in order to arrive at an economic breakpoint. For example, he may find that a small amount of biological treatment, beyond the physical and chemical treatment discussed in this manual, will drop the BOD and suspended solids to a level equivalent to domestic sewage, and surcharges that the city has levied based on plant wastewater concentrations beyond the level of domestic sewage will drop to zero.

3. Whether the long-range possibilities for increases in municipal surcharges may warrant consideration of a completely independent wastewater treatment system, discharging to a watercourse, thereby eliminating all dependence upon the municipal system.

Most of the biological treatment systems discussed in the section of this seminar on "Treatment for Discharge to a Watercourse" are also applicable to treatment prior to discharge to a city sewer, should such treatment become necessary to satisfy municipal regulations or become economically feasible.

The following outline suggests procedures for developing a decision matrix for waste conservation and pretreatment prior to discharge to a public sewer:

1. Employ a waste conservation supervisor. In a small plant, he may have other duties such as safety engineer and have responsibility for compliance with Occupational Safety and Health Act (OSHA). In a large plant, a full-time waste conservation supervisor should be employed. He should have some engineering background, preferably in environmental engineering. He will be responsible for waste conservation surveys, flow measurement, sampling surveys, cost analyses of waste conservation and treatment and continuing surveillance of the waste conservation and treatment program, including supervision over the operation of any treatment facilities.

2. Install flow measuring and automatic sampling to collect and analyze wastewater samples at sufficient frequencies and over a sufficient length of time to develop data on flow during the maximum hour and the maximum day, as well as averages.

3. Make an in-plant waste conservation survey as detailed in this manual. Develop annual costs for each possible change to include:

   a. Amortized cost of improvements, installed.

   b. Power costs such as heating, cooling, and pumping for recycling and water reuse.

   c. Chemical costs if some in-house treatment is required in recycling a waste stream.

   d. Labor cost (maintenance and operation).

4. Make a study of possible pretreatment systems, with annual costs developed as in item 3 above.

5. Determine the annual cost of municipal surcharges if wastewaters are discharged to the city sewers, and select in-plant improvements on a comparative cost basis. If wastewaters are discharged to a private treatment facility for disposal to a watercourse, the same type of cost analysis should be made.

6. Select the elements of 3 and 4 that are economically justified.

7. Design selected improvements to achieve the required results, considering such elements as:

   a. Flexibility, for alteration and expansion.

   b. Operating skills required.

   c. Quantity of residual solids and grease and feasible means of disposal.

VI. APPENDIX

APPENDIX A: REFERENCES

(1) "Industrial Waste Profile No. 8 — Meat Products." Series: The Cost of Clean Water, Federal Water Pollution Control Administration (1967) p. 53.

(2) Witherow, J. L., "Meat Packing Waste Management Research Program", 65th Annual Meeting, American Meat Institute, Chicago, Ill., (October 1970).

(3) Gurnham, C. F. (Ed.), Industrial Wastewater Control, (Johnson, A. S., "Chap. 2. Meat"). Academic Press, New York (1965) p. 36.

(4) Beefland International, Inc., Elimination of Water Pollution by Packinghouse Animal Paunch and Blood, EPA Proj.: 12060 Fds (Nov. 1971).

(5) Dencker, D. O., "Some Solutions to Packinghouse Waste Problems." Presented at 15th Wastes Eng'g Conf., Univ. of Minn. (Dec. 1968).

(6) Wells, W. J., Jr., "How Plants Can Cut Waste Treatment Expense." The National Provisioner (July 4, 1970).

APPENDIX B: BIBLIOGRAPHY.

In addition to the above references, cited in the text of the Manual by number, the following sources may be useful:

1. _____, "An Industrial Waste Guide to the Meat Industry." U.S. Public Health Service Publication No. 386. Revised 1965.

2. Brammer, H. C. and Motz, D. J., "An Overview of Industrial Water Costs." Industrial Water Engineering (March 1969).

3. Miedaner, W. H., "In-Plant Wastewater Control." Presented at Univ. of Wis. Extension Program, Wastewater Treatment in the Meat Industry (April 1972).

4. Miedaner, W. H., "In-Plant Waste Control." The National Provisioner (August 19, 1972).

5. Nemerow, Nelson Leonard, Theories and Practices of Industrial Waste Treatment, Syracuse, N. Y., Addison-Wesley Publ. Co. Inc. (1963).

6. Steffen, A. J., "Waste Disposal in the Meat Industry, A Comprehensive Review." Proceedings, Meat Industry Research Conference, American Meat Institute Foundation, Univ. of Chicago (March 1969).

APPENDIX C

LIST of EQUIPMENT TRADE NAMES*

The following is a list of trade names of the equipment discussed in this Manual. The types of equipment are listed in the order in which they are presented. Any mention of products or services here or elsewhere in the Manual is for information only, is not selective unless it is used to illustrate a point, and is not to be construed as an endorsement of the product or service by the EPA or the authors.

Although the lists are intended to be complete, some oversights may have crept in. Such oversights are not to be construed as reflecting on the merits of the product or service.

The author will appreciate being advised of errata, in order to improve subsequent editions of this list.

BLOOD COAGULATION PREVENTION SYSTEM. (Sect. II E).

Chemical and Eng'g Group (Swift Research & Development Laboratories)

STATIC SCREENS (WEDGE BAR) (Sect. III C 2).

Bauer Hydrasieve
Dorr-Oliver
Hendricks
Hydrocyclonics
Peabody Welles
Static Sieves (F. J. Clawson & Assoc., Inc.)

VIBRATING SCREENS (Sect. III C 3).

Allis Chalmers
DeLaval
Envirex
Link Belt
"Selectro", "Gyroset", "Kelly" (Production Equipment Corp.)
Simplicity Engineering

ROTARY BARREL SCREENS (Sect. III C 4).

Allison Screen for Hide Brining (Green Bay Foundry & Machine Works)
Dorr-Oliver
Envirex
Link Belt
North Green Bay Screen (Green Bay Foundry & Machine Works)

*For addresses, see last 2 pages.

ROTATING DISC SCREENS (Sect. III C 4).

Envirex
Link Belt

ECCENTRIC-WEIGHTED HORIZONTAL DISC SCREENS (Sect. III C 4).

Aero Vibe (Allis Chalmers)
Hydrocyclonics
Kason
Sweco
Syncro-Matic (Eriez)

CENTRIFUGES. (Sect. III C 4b).

Beloit
Bird
DeLaval
Dorr-Oliver "Merco Bowl"
Eimco (Envirotech Corp.)
Sharples (Pennwalt Corp.)

GRAVITY GREASE RECOVERY & SEPARATION (Sect. III D 2).

Belco
Beloit-Passavant
Carter
Chicago Pump
Clow Yeomans
Crane
Dorr-Oliver
Dravo
Envirex
Environmental Services
Envirotech
Graver
Hardinge
Infilco
Jeffrey
Keene
Lakeside
Link Belt
Walker Process
Zurn

DISSOLVED AIR FLOTATION (Sect. III D 3 and 4) (Rectangular and/or Circular).

Aeroflotor (Graver)
Beloit-Passavant
Black-Clawson
Envirex
Environmental Systems
Envirotech
Infilco
Keene
Komline-Sanderson
Pacific (Carborundum Co.)
Permutit

For addresses, see following pages.

ADDRESSES of MANUFACTURERS
of Trade Name Items
Listed in Preceding Pages

Allis-Chalmers Mfg. Co.
1126 S. 70th St., Milwaukee, Wis. 53214

Bauer Bros. Co., Subsid. Combustion Eng'g. Inc.
P.O. Box 968, Springfield, Ohio 45501

Belco Pollution Control Corp.
100 Pennsylvania Ave., Paterson, N.J. 07509

Beloit-Passavant Corp.
P.O. Box 997, Janesville, Wis. 53545

Bird Machine Co.
South Walpole, Mass. 02071

Black-Clawson Co.
Middletown, Ohio 45042

Carborundum Co.
Buffalo Ave., Niagara Falls, N.Y. 14302

Carter, Ralph B., Co.
192 Atlantic St., Hackensack, N.J. 07601

Chicago Pump Div., FMC Corp.
622 Diversey Parkway, Chicago, Ill. 60614

Clawson, F. J. & Assoc.
6956 Highway 100, Nashville, Tenn. 37205

Clow Corp., Waste Treatment Div.
1999 N. Ruby St., Melrose Park, Ill. 60160

Crane Co., Environmental Systems Div.
Box 191, King of Prussia, Penn. 19406

DeLaval Separator Co.
Poughkeepsie, New York 12600

Dorr-Oliver, Inc.
Havemeyer Lane, Stamford, Conn. 06904

Dravo Corp.
One Oliver Plaza, Pittsburgh, Penn. 15222

Envirex, Inc., A Rexnord Company, Water Quality Control Div. (formerly RexChainbelt)
1901 S. Prairie, Waukesha, Wis. 53186

Environmental Services, Inc.
1319 Mt. Rose Ave., York, Penn. 17403

Environmental Systems, Div. of Litton Industries, Inc.
354 Dawson Drive, Camarillo, Calif. 93010

Envirotech Corp., Municipal Equipment Div.
100 Valley Drive, Brisbane, Calif. 95005

Eriez Synchro-Matic
1401 Magnet Drive, Erie, Penn. 16512

Graver, Div. of Ecodyne Corp.
U.S. Highway 22, Union, N.J. 07083

Green Bay Foundry and Machine Works
Box 2328, Green Bay, Wis. 54306

Hardinge Co., Metal Products Div., Koppers Co., Inc.
York, Penn. 17405

Hendricks Mfg. Co.
Carbondale, Penn. 18407

Hydrocyclonics Corp.
968 North Shore Drive, Lake Bluff, Ill. 60044

Infilco Division, Westinghouse Electric Co.
901 S. Campbell St., Tucson, Ariz. 85719

Jeffrey Mfg. Co.
961 N. 4th St., Columbus, Ohio 43216

Kason Corp.
231 Johnson Ave., Newark, New Jersey 07108

Keene Corp., Fluid Handling Division
Cookeville, Tenn. 38501

Komline-Sanderson Engineering Corp.
Peapack, New Jersey 07977

Lakeside Equipment Co.
1022 E. Devon Ave., Bartlett, Ill. 60103

Link Belt Environmental Equipment, FMC Corp. (Gravity and Flotation)
Prudential Plaza, Chicago, Ill. 60601

Link Belt Material Handling Division, FMC Corp. (Screens)
300 Pershing Road, Chicago, Ill. 60609

Peabody Welles
Roscoe, Ill. 61073

Pennwalt Corp., Sharples-Stokes Division
955 Mearns Road, Warminster, Penn. 18974

Permutit Co., Div. of Sybron Corp.
E. 49 Midland Ave., Paramus, New Jersey 07652

Productive Equipment Corp.
2924 W. Lake St., Chicago, Ill. 60612

Simplicity Engineering Co.
Durand, Mich. 48429

Sweco, Inc.
6033 E. Bandini Blvd., Los Angeles, Calif. 90054

Swift Research & Development Laboratories, Chemical & Eng'g Group
119 Swift Drive, Oak Brook, Ill. 60521

Walker Process Equipment, Inc., Div. Chicago Bridge & Iron Co.
Box 266, Aurora, Ill. 60507

Zurn Industries, Inc.
1422 East Ave., Erie, Penn. 16503