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ELIMINATION OF WATER POLLUTION BY PACKINGHOUSE ANIMAL PAUNCH AND BLOOD

U.S. ENVIRONMENTAL PROTECTION AGENCY

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ELIMINATION OF WATER POLLUTION BY
PACKINGHOUSE ANIMAL PAUNCH
AND BLOOD

by

Beefland International, Inc.
2700 23rd Avenue
Council Bluffs, Iowa 51501

for the

Office of Research and Monitoring

ENVIRONMENTAL PROTECTION AGENCY

Project #12060 FDS

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ABSTRACT

The operation of two dehydrating machines, for the drying of cattle whole blood as well as paunch contents (rumen), at the Beefland International, Inc., slaughtering plant at Council Bluffs, Iowa, was studied.

The BOD_5 and COD of the blood and rumen were established. The mean BOD_5 of the whole blood and rumen was determined as 156,500 ppm and 50,200 ppm, respectively. The mean COD of the blood and rumen was established as 218,300 ppm and 177,300 ppm, respectively.

The economics of the drying process in costs per ton of dried product, per 1000 lbs live kill weight (LWK), and per animal were determined. The dehydrating costs per ton of dehydrated product were found to be $43.75/ton for blood and $38.46/ton for rumen. The average cost (blood) and rumen) was $40.93/ton.

Laboratory studies were carried out on the dried whole blood and rumen with a view toward their actual and potential use as legally accepted feeds or feed additives. Percent moisture, protein, fat, carbohydrate, and other analyses of the dried products are reported.

This report was submitted in fulfillment of Project Number 12060 FDS under the (partial) sponsorship of the Water Quality Office, Environmental Protection Agency.

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SECTION I

CONCLUSIONS

1. Dehydration of cattle whole blood and rumen by gas-fired dryers is an economically feasible method of handling these materials in a beef-slaughtering operation.

2. The return on the sale of dried blood alone was greater than the combined dehydration costs of the whole blood and rumen.

3. The average weight of 32.5 lbs of wet blood generated per beef animal ($\sim$1100 lbs LWK) gives rise to 6.0 lbs of dried blood (5% moisture); while the average weight of 54 lbs of wet rumen gives rise to 8.5 lbs of dried rumen (7% moisture) per beef animal.

4. The dehydration of 92.4% of the blood and 75% of the rumen (the additional 25% of the rumen either hauled away or rendered) represented a recovery of 82.4% of the total COD and 86.4% of the total BOD_5 generated by these materials.

5. The mean BOD_5 of the whole blood and rumen was determined as 156,500 ppm and 50,200 ppm, respectively. The mean COD of the blood and rumen was established as 218,300 ppm and 177,300 ppm, respectively.

6. The BOD_5 of cattle whole blood is nearly twice the BOD_5 of the rumen per animal. The liquid and readily soluble phase of the rumen constitutes 59% of the total BOD_5 of the material.

7. The dehydrating costs per ton of dehydrated product were established to be $43.75 for blood and $38.46 for rumen. The average cost (blood and rumen) was $40.93/ton.

8. The dehydration cost for drying the rumen only was established as 16¢ per animal, as compared to the wet dumping cost of 15¢ per animal when disposed of by means of a hauling contract from the plant.

9. The cost of BOD_5 removal or elimination by the dehydration process of whole blood and rumen was determined as 2½¢/lb for blood BOD_5 and 8¢/lb for rumen BOD_5. The mean cost was 4¢/lb of total BOD_5 eliminated.

10. The recovery of the blood and rumen by separate flow of these materials in the slaughtering operation with subsequent dehydration served to maintain the BOD_5 of the plant waste water at such levels that treatment of the waste water by a commercial sedimentation-clarifier followed by an aerobic lagoon gave rise to a plant effluent of an acceptable low BOD_5 level.

11. Dried rumen is comprised of 12.7% protein on the basis of nitrogen determination by the Kjeldahl method. The material should serve a demand as a protein source in animal feeds. However, a strong market does not exist for this product. A ready market exists for dried whole blood.

12. The complete separation and dehydration of the whole blood and rumen eliminates the potential of these materials as water pollutants. There was no evidence to indicate that any appreciable air pollution resulted in the drying of these materials.

SECTION II

RECOMMENDATIONS

The dehydrating process for whole blood and rumen should be continued at the Beefland International, Inc., plant as this phase of the slaughtering operation has been demonstrated to be economically profitable. In addition, it has provided a method of disposal of blood and rumen in a manner which eliminates these slaughtehouse by-products as potential pollutants to water quality.

As the dehydrated blood is the more valuable of the two products, greater precautionary practices should be taken to minimize any loss of whole blood in its flow from kill floor to the dehydrator. Additional holding-tank capacity should be provided for wet blood to eliminate the need of dumping of wet blood during emergency shutdowns or repairs of the dryer. Practical reasons would likely limit the total holding capacity for wet blood to one day's production.

All rumen generated should be dried. A greater storage capacity for wet rumen should be provided and the drying time extended in order to dehydrate each day's production completely.

At the same time, greater time and effort should be expended to establish a market for dried rumen. Such a market would include industries involved in formulation of animal feeds of all kinds, as well as feeders of fish, fowl, and mammals. Continued participation and support of research on the use of dried rumen as an animal feed additive should be carried out by the industry. The results of a feeding program of this material to hogs in which Beefland is currently participating should be carefully analyzed when completed. A continuation of this type of research under the direction of competent animal feed nutritionists is recommended.

The general recommendation is made to any existing or planned beef slaughtering plant to consider installation of dehydrating equipment for blood and rumen as a demonstrated profitable aspect of plant operation. Such installations should provide sufficient storage capacity for the wet materials corresponding to one day's full production and one week's production of the dehydrated products.

Although there has not been any quantitative measurements made on the extent of particulate emissions from the stacks of the dehydrators, this has not appeared to have been of serious consequence. There have been citizen complaints of odors, however, and provisions should be made in new installations for scrubbers or other types of particulate and fume controls to minimize or eliminate release of particulate matter and odors into the atmosphere.

SECTION III

INTRODUCTION

Beefland International, Inc., a public company organized for the purpose of slaughter of beef cattle and production of high quality beef, constructed its physical plant a few miles southwest of the city of Council Bluffs, Iowa, in late 1968 and 1969 on a commercial tract of the city. It went into production of beef carcasses in January 1970. It has the highest rated kill capacity for a beef slaughtering operation ever approved by the U.S. Department of Agriculture.

The kill capacity for cattle at the Beefland plant is 250 animals per hour. In a ten-hour day this represents a possible kill of 2500 animals and the production of a tremendous quantity of blood, paunch, and manure, which must be disposed of in such a way so as not to further tax the waste-carrying capacity of the nearby Missouri River or to increase the ever growing problem of pollution of air, land, and water.

To handle this waste problem which was anticipated to run as high as 50 lbs of blood, 50 lbs of paunch, and 40 lbs of manure per animal, Beefland International, Inc., proposed to install facilities for the drying of the whole blood and the paunch contents or rumen generated in the slaughtering operation. The manure would be disposed of directly for agricultural fertilizer.

A proposal by Beefland International, Inc., was submitted to the Federal Water Pollution Control Administration, Department of Interior, in the latter part of 1969, for partial support of the dehydration project of blood and rumen. The proposal was approved by FWPCA officials for an eighteen-month study period extending from October 1, 1969 to April 1, 1971. The program was titled Project Number 12060 FDS.

The project budget included construction of a dehydration facility with installation of two dryers, one for whole blood and one for rumen. A laboratory facility to carry out the necessary tests was included in the project costs. It included also technical services, operation and maintenance, administrative and contingency costs. The total budget was $375,770.

The objectives of the project were to demonstrate the economic and technical feasibility of completely separating the blood and rumen generated in the slaughter operation, and drying of these materials with a view toward the sale of the dehydrated products as animal feeds or for feed additives. Three economics were to be shown, that is, the costs of dehydrating the blood and rumen separately, as well as the costs, in terms of 1000 lbs live-kill weight (LWK) and per ton of dehydrated product, for the combined dehydrating process. The COD and BOD_5 equivalents of the blood and rumen generated were to be established by the laboratory work carried out to give an indication of the pollution abatement aspects of this type of treatment of these slaughterhouse products. Analytical work was also carried out on both the dehydrated blood and rumen as to protein content, percent moisture, and other analyses with a view toward their use or development as legal animal feed additives.

The goals set in the proposal submitted by Beefland International, Inc., were to be achieved in an eighteen-month period and were to be developed in three phases or stages.

Phase I included the period for the design, purchase, and installation of the appropriate dryers to carry out the dehydration of the whole blood and rumen. As these dryers were large pieces of equipment for which space was not included in the original designs of the main slaughtering plant, a separate building to house the dryers was required.

The design and construction of a separate laboratory building and facilities were also carried out during the initial phase of the project. All equipment, chemicals, and apparatus required for the supporting laboratory work of the project were purchased specifically for the study. Hiring of the necessary personnel to operate the dryers and to carry out the chemical analyses was also part of this first phase.

Phase II of the project involved the training of the labor personnel in the operation of the dehydrators and the development of the optimum conditions for drying the whole blood and the rumen. Modifications of the dryers and equipment were made during this period. A market for the sale of the dehydrated products was to be established, particularly that of the dehydrated rumen.

Phase III of the project was a period of operation and keeping of exact records to establish costs of the dehydration process for both whole blood and rumen. Records were kept on cattle kill, kill weight, consumption of utilities, and weights of dehydrated materials produced. Labor costs and drying times required daily and monthly were duly recorded. Several carefully controlled weight studies were made to establish the average weight of blood and rumen recovered per animal. Laboratory results were established on the COD and BOD_5 characteristics of fresh blood and rumen, as well as pertinent data on the chemical makeup of the dehydrated products. Reports summarizing the data as collected were submitted to the Project Officer of the FWPCA monthly, beginning in March 1970, by the project director and technical advisor.

SECTION IV

DESIGN, CONSTRUCTION, AND INSTALLATION PHASE

As the approval for Project 12060 FDS was received well after the design and completion of the major portion of the physical plant at Beefland, adaptations were necessarily made in the design and location of the dehydrator building and equipment for the proposed drying process for whole blood and rumen. The laboratory, which initially was planned for location within the main building of the plant just off the kill floor, was finally housed in a separate building behind the main plant but within reasonable distance of all sampling sites.

The following sections describe the blood and rumen flow design, as well as that of the waste water flow. Although the latter had no effect on the dehydration process, its capacity would have been affected seriously had the dehydration of the major portion of the blood and rumen not been carried out. The dehydration facilities are described in detail. Information is also given in the following sections on the general sewage system with its lift station, SEDIFLOTOR Clarifier, and lagoon or aeration basin through which the plant effluent passes prior to discharge into the city sewage system.

Blood and Rumen Flow

The blood of the cattle flow through several openings on the kill floor directly to a holding tank below, from which it is periodically blown over into holding tanks adjacent to the blood dryer in the dehydrator building. Similarly, the rumen from each paunch is emptied into a hopper on the kill floor into a holding tank below. From the tank it is likewise blown over periodically by means of air pressure through an overhead line to a second holding tank adjacent to the rumen dryer in the dehydrator building. The wet rumen is gravity fed into the dryer from the holding tank. In the case of the blood, it is pumped from a bottom line from the blood holding tanks into a manifold situated above the firebox of the dryer, where it is coagulated with steam and then augured into the dryer. Figure 1 is a schematic diagram which shows this flow of blood and rumen from kill floor to the dryers.

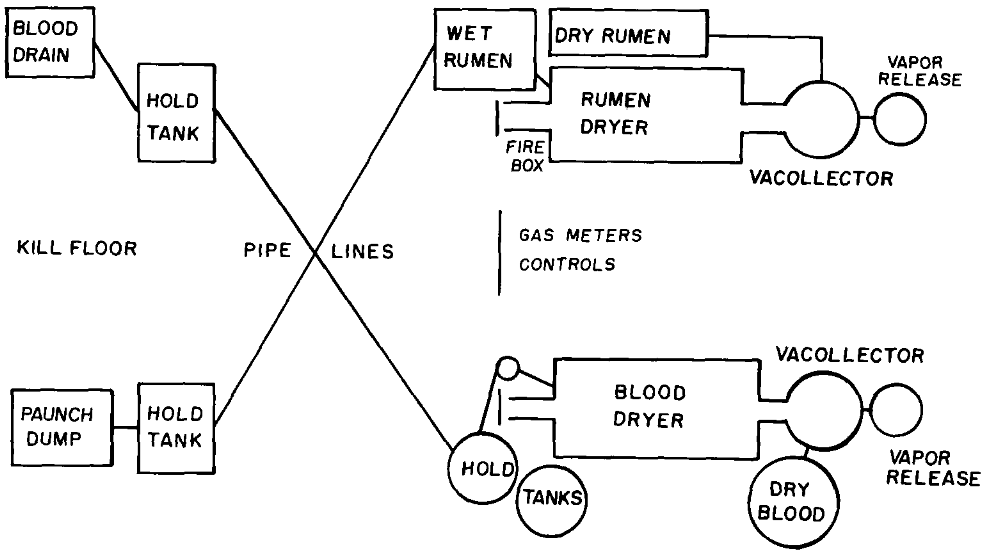

FIGURE 1. BLOOD AND RUMEN FLOW

Waste Water Flow

The waste water of the plant, which arises from many sources inside and outside of the main kill-floor area, flows into a central sump. That which arises from the slaughtering and processing operation on the kill floor includes the water used in the periodic hosing down of all sections during and at the completion of the day's operation, as well as that used in the washing of carcasses and organs. The amount of blood in this waste water varies during production hours with a peak at the final clean-up period when the blood-drain area is scrubbed down. The waste water from the cleaning of the outside holding pens for incoming cattle similarly flows into the central sump. It is pumped continuously from the sump to the SEDIFLOTOR Clarifier installation. The effluent of the SEDIFLOTOR Clarifier flows by gravity into the plant lagoon. Details of these components of the raw waste water treatment are given in sections of the report that follows. The general waste-water flow of the plant is shown in Figure 2.

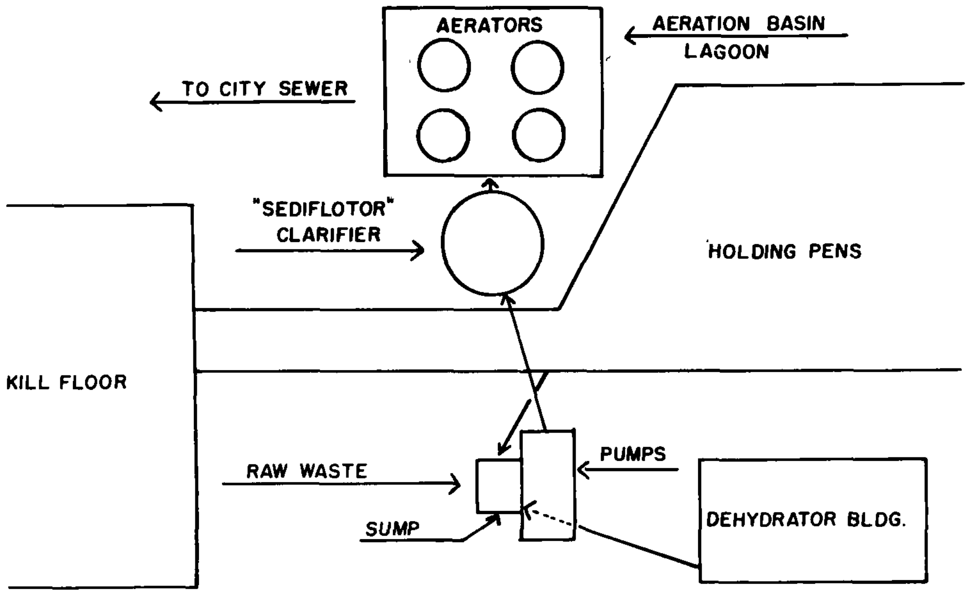

FIGURE 2. WASTE-WATER FLOW

Dehydrator Building and Equipment

The separate building housing the dehydrators is a 40'x80'x36' Kirey building with corrugated metal sheets covering a metal framework. The cost of the building erected was $21,500.00. The installation of the foundations for the dryers and the concrete apron around the building gave a total cost of $32,934.00 for the dehydration building.

Beefland International, Inc., entered into a sales agreement with the American Pollution Prevention Company of Minneapolis, Minn., in December 1969, for the installation of two No. V9-820 McGehee Dryers with Vacollectors delivered and installed to utilities. The separate cost of these dehydrators was $52,000.00 for the blood dryer, which was a "used" model, and $62,000.00 for the new rumen dryer. All of the additional installations required, such as pumps, blowers, lines for transport of blood and rumen from holding tanks below the kill floor, installations of meters, etc., added an additional $34,272.05 to the cost of the equipment and its installation. The total cost of dehydrator equipment and installation was $148,272.05. Table 1 is a summary of these costs.

Table 1

DEHYDRATOR BUILDING AND EQUIPMENT COSTS

Building

Item	Description	Cost
1.	One 40'x80'x36' Kirey Bldg (in color)	$21,500.00
2.	Installation of Dryer Foundations	8,234.00
3.	Building Apron (concrete)	3,200.00
	Total	$32,934.00

Equipment

Item	Description	Cost
1.	One V9-820 McGehee Blood Dryer	$52,000.00
2.	One V9-820 McGehee Paunch Dryer (Each of the above dryers equipped with vacollector, storage tanks, stack and connecting parts installed to utilities)	62,000.00
3.	Charges by American Pollution Prevention Company Relating to Blood or Rumen Dehydrator or Both	9,500.54
4.	One PEGIA-Z Marlow Pump (3-HP Motor) Freight Charge	1,147.29 41.76
5.	American Pollution Prevention Co.--Misc.	99.46
6.	B. Grunwald--Blood Lines	4,632.78
7.	F. J. Merwald--Rumen Chute	1,428.54
8.	B. Grunwald--Rumen Lines	13,695.05
9.	Swift and Company--Blower	1,590.00
10.	Peoples Natural Gas--Meters	2,136.63
	Total	$148,272.05

Each of the McGehee dehydrator units has a drum diameter of 8 ft with a length of 20 ft. The drum revolves on four sets of ordinary 700x15, 8-ply pneumatic tires (three tires per set) which are motor driven and located at the four corners of the drum. A ten-foot long air-cooled firebox is located at the front of each drum with a radial gas burner of 15,000,000 BTU capacity at 50 psi. An adjustable sleeve located between the other end of the drum and vacollector allows for the control of the moisture content of the product. Each dehydrator is equipped with a vacollector and gas release system. The stacks extend only a few feet above the roof of the building.

The blood dehydrating system was equipped with a 12,000 lb holding tank for wet blood and a 30,000 lb storage tank complete with unloading facilities for the dried product. The rumen dehydrating system included a wet surge feed bin of 250 cu ft capacity for the wet paunch contents and a storage bin for the dried rumen of 1,250 cu ft capacity with unloading facilities.

The first of the dehydrators (for whole blood) was put into operation in mid-March 1970. The second unit (for the dehydration of rumen) became operational May 1, 1970. Figure 3 through Figure 7 show views of the dehydrator building and of the dehydrators.

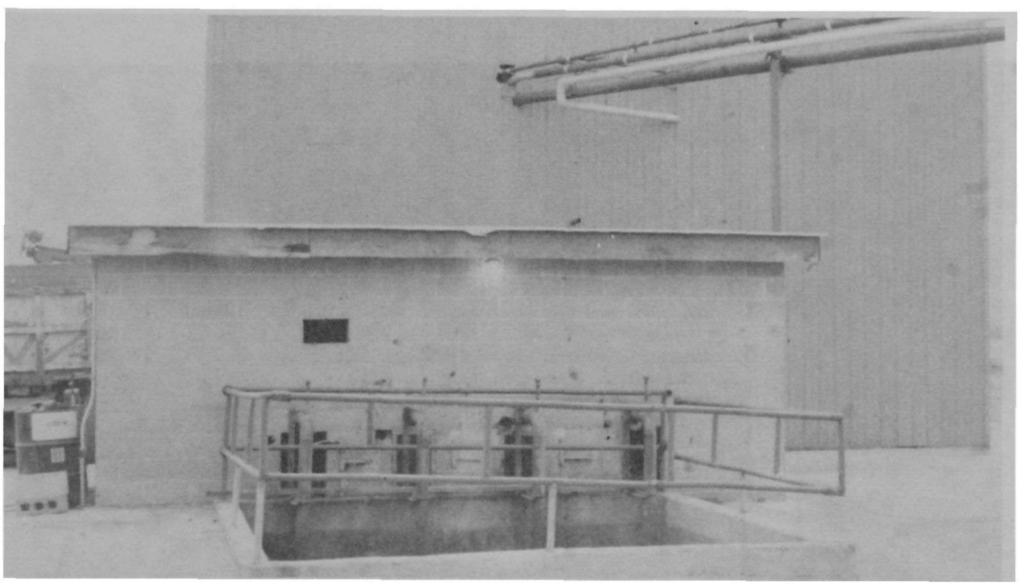

FIGURE 3. DEHYDRATOR BUILDING WITH SUMP AND LIFT STATION IN FOREGROUND; OVERHEAD RUMEN AND BLOOD LINES

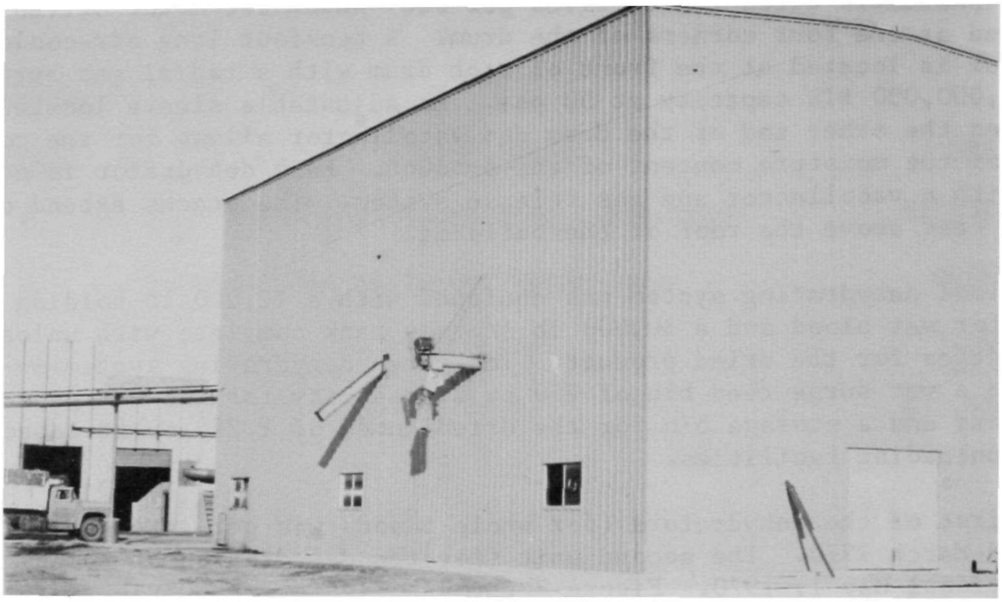

FIGURE 4. DEHYDRATOR BUILDING; MAIN PLANT IN BACKGROUND

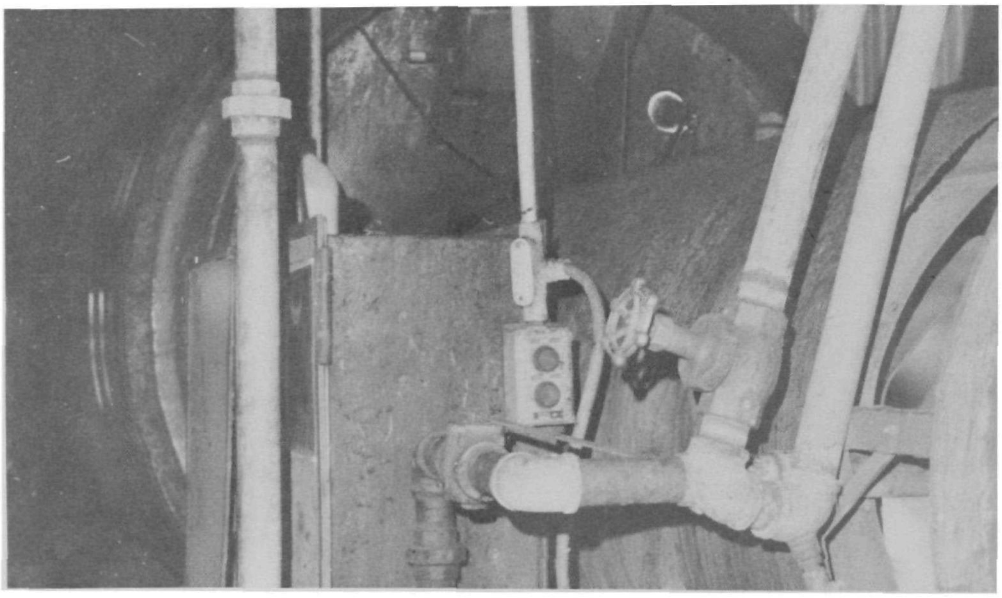

FIGURE 5. BLOOD DRYER FROM FIREBOX END

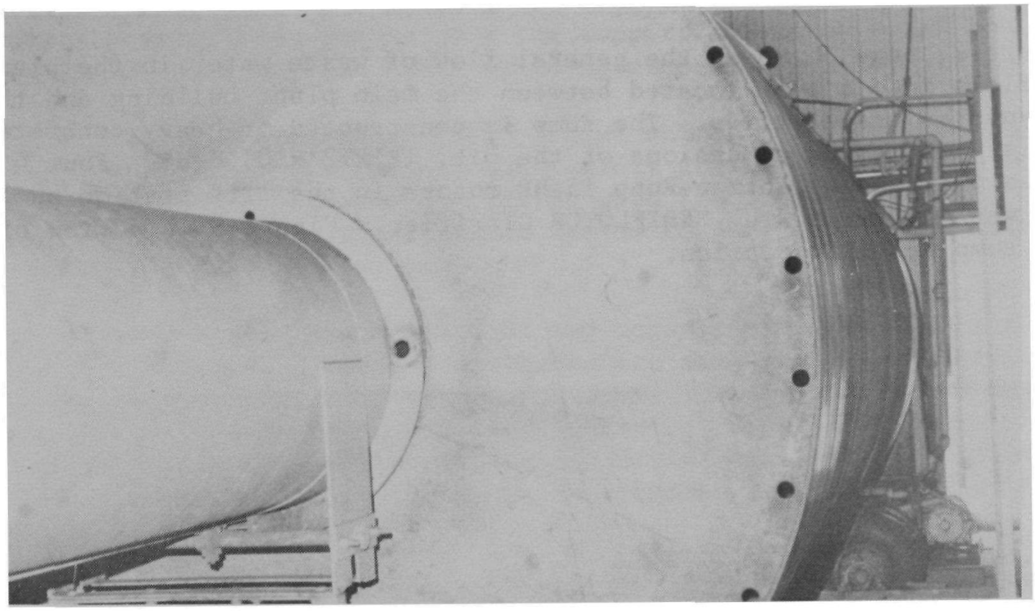

FIGURE 6. BLOOD DRYER FROM ADJUSTABLE SLEEVE END

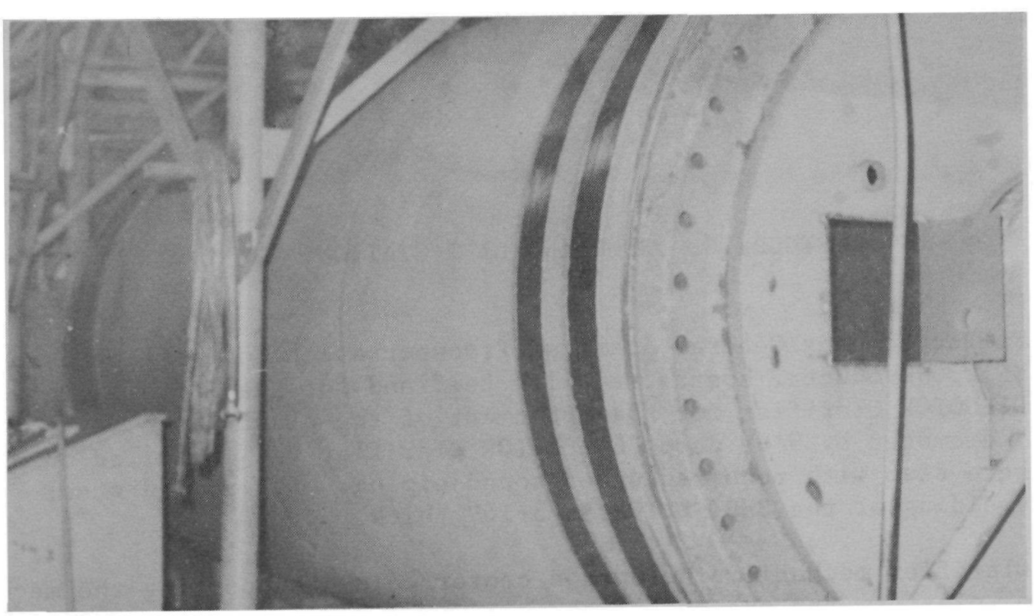

FIGURE 7. RUMEN DRYER VIEW TOWARD FIREBOX END

Waste-Water System--Sump, Clarifier, Lagoon

Figure 2, page 9, shows the general flow of waste water in the plant. It flows into a sump located between the main plant building and the dehydrator installation. The sump is constructed of heavy concrete walls with inside dimensions of the pit, 12'x12'x10' deep. Four 4" lines operated by Gorman-Rupp 15-HP motors in the lift station pump the waste water to the SEDIFLOTOR Clarifier. Figure 8 is a view of the sump and lift station.

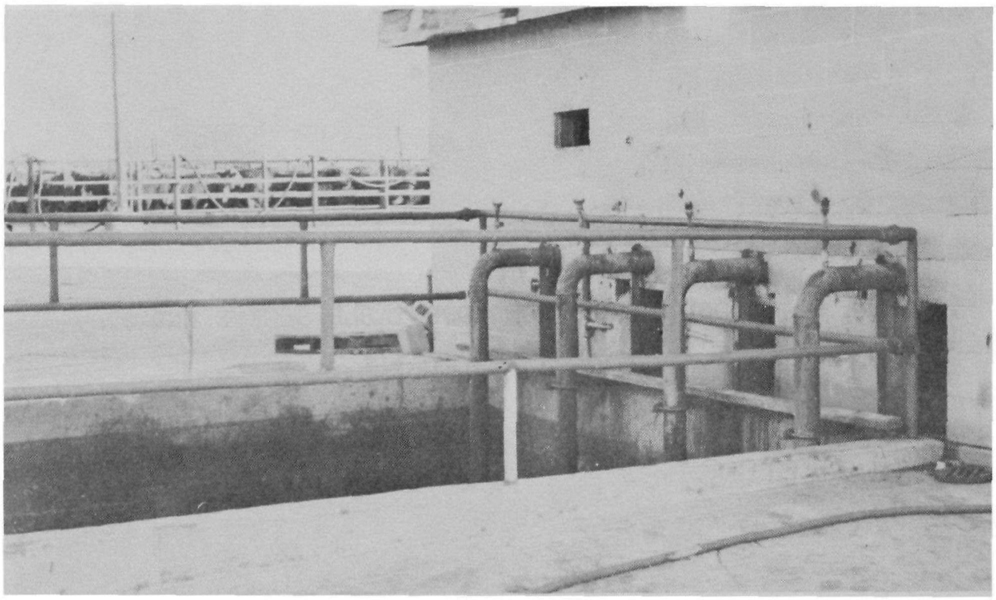

FIGURE 8. SUMP AND LIFT STATION

The Fuller Company/General American Transportation Corporation, vendor of INFILCO Products, contracted with Beefland for the installation of a SEDIFLOTOR Clarifier for the treatment of the plant waste water. The 50'0" diameter by 9'9" deep SEDIFLOTOR Clarifier was installed on a concrete slab with required underground piping. The rolled steel plate siding of the SEDIFLOTOR is 3/16" thick.

The Clarifier mechanism includes a center column supporting the mechanism, platform and one end of the access walkway. Checkerplate and handrailing are provided for the walkway and platform so that the drive mechanism is accessible from all sides. The drive mechanism consists of a ½-HP, totally enclosed, 230/460-volt, 60-cycle, 3-phase motor and enclosed reducer. A pinion keyed to the output shaft of the reducer drives a ring gear mounted on antifriction bearings and is arranged to rotate a drive cage surrounding the support column to which the bottom sludge scrapers and the float skimming mechanism are attached.

The skimming mechanism consists of four skimmer arms terminating at the inboard end with a common hub rigidly affixed to the drive cage. The fabricated steel arms are fitted with flexible wiper edges and are hinged in such a manner as to follow the contour of the scum trough when passing over it.

The scraper mechanism consists of two scraper arms, each with a series of scraper blades. The blades are straight with a steel angle along the top edge to provide rigidity and each bottom edge fitted with bronze squeegees adjustable for proper clearance. The scraper blades are affixed to the structural steel members attached to the inlet well which, in turn, is attached to and driven by the vertical drive cage.

A rotatable inlet well is located centrally at the bottom of the tank surrounding the raw waste inlet diffuser and pressurized recycle inlet diffuser. The raw waste inlet consists of a slotted inlet diffuser in the lower portion of the support column.

The scum draw-off trough extends inward from the effluent curtain baffle and has a bottom sloping from the horizontal. It includes an approach ramp and skimmer blade let-down strips. A peripheral curtain baffle extending below the liquid level is fitted within the tank to provide a submerged weir for the uniform take-off of the clarified effluent.

A 7'0" diameter by 8'6" steel air saturation tank constructed in accordance with ASME Code for 75 psi working pressure was set up close by the Clarifier. This is furnished with inlet, outlet bottom drain, access air outlet with air bleed-off. The air saturation system includes air injection devices utilizing atmospheric air. Two 40-HP pressurizing pumps, having a maximum capacity of 1000 gpm each and with a totally enclosed motor, are used in conjunction with the air saturation of the waste water. There is no chemical treatment carried out in the Clarifier. Figures 9 and 10 are two different views of the SEDIFLOTOR Clarifier. Figures 11 and 12 are two views of the top assemblies of the Clarifier.

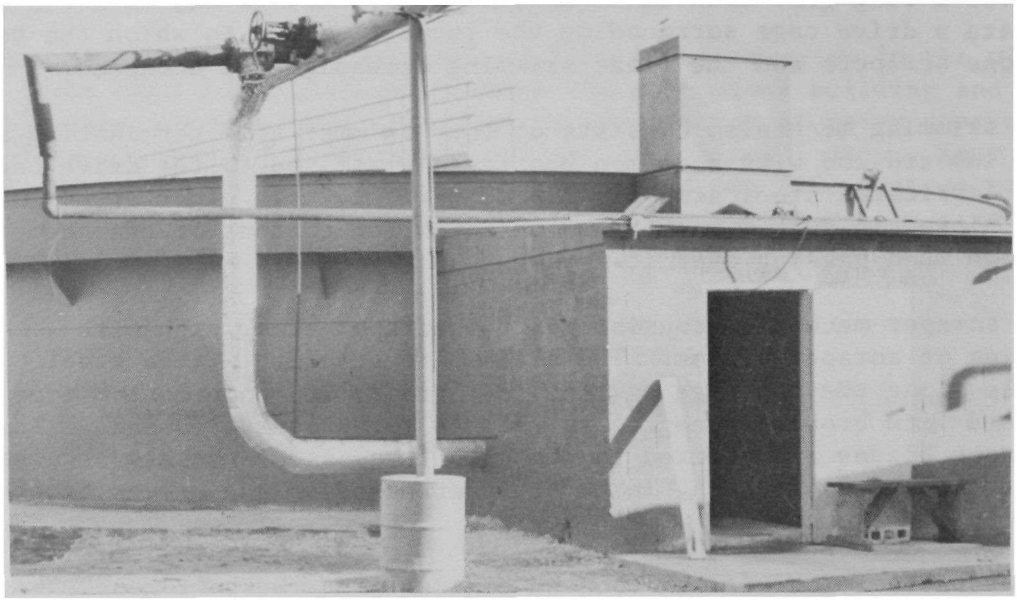

FIGURE 9. SEDIFLOTOR CLARIFIER WITH GREASE RETURN LINE

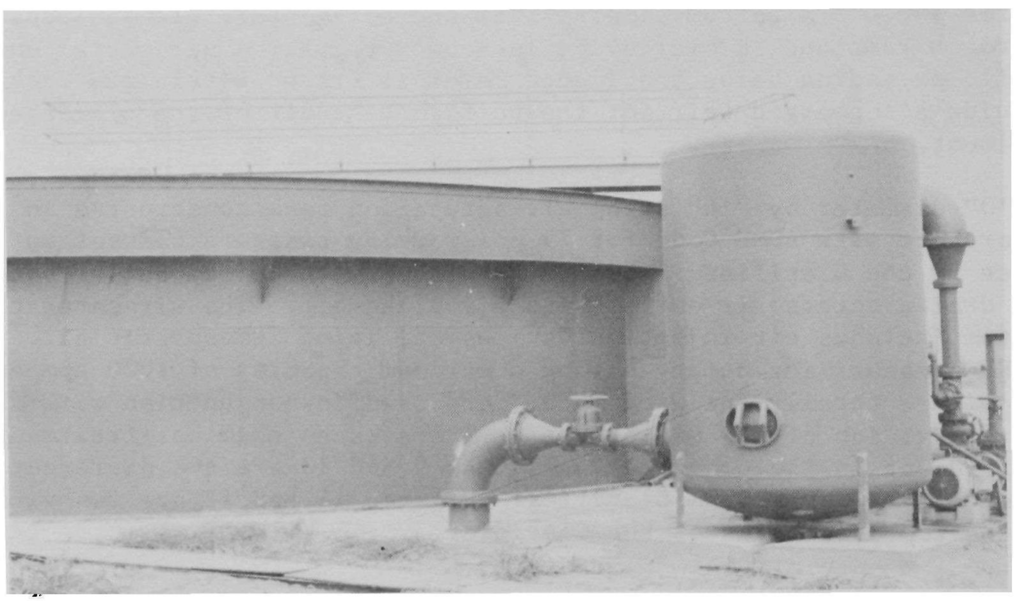

FIGURE 10. SEDIFLOTOR CLARIFIER WITH AIR SATURATION TANK

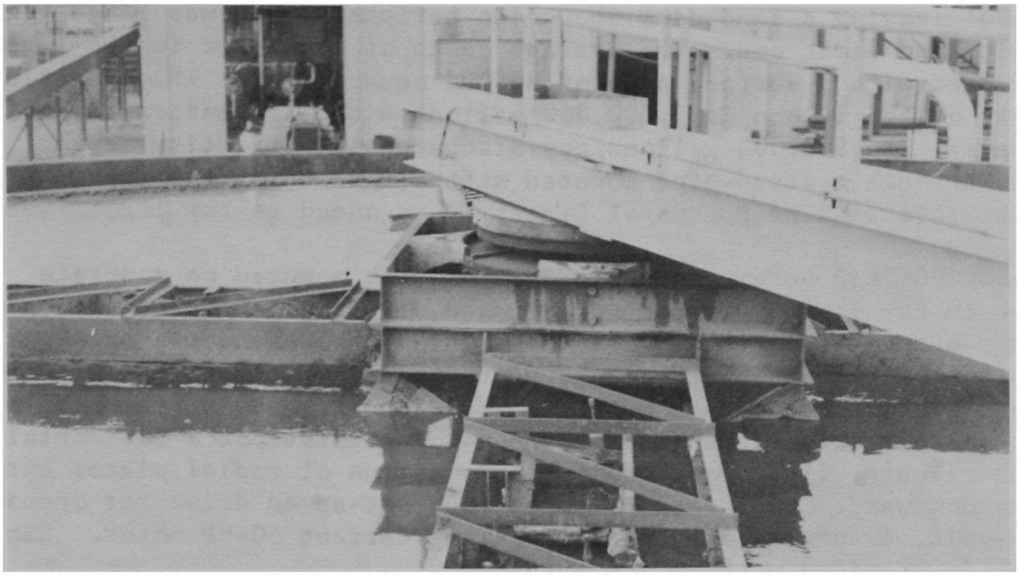

FIGURE 11. SEDIFLOTOR CLARIFIER SHOWING SKIMMER MECHANISM

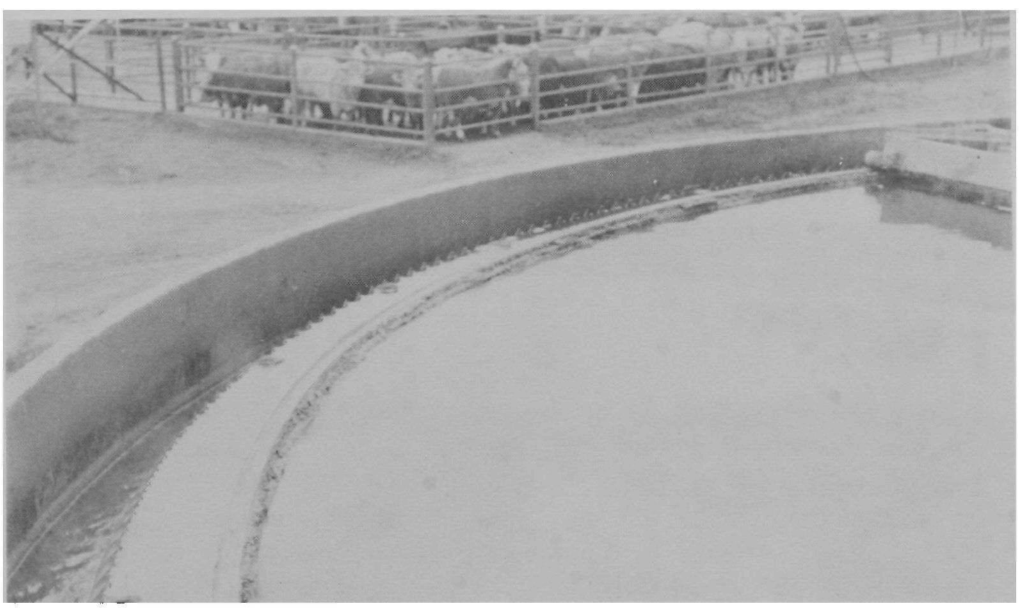

FIGURE 12. SEDIFLOTOR CLARIFIER SHOWING EFFLUENT WEIR

The effluent from the Clarifier flows by gravity into the lagoon or aeration basin. The lagoon was formed by excavating an area of about 200'x400' leaving a sand dike about its periphery. It was lined with bentonite and limestone. The average depth of the water in the lagoon is six feet with a surface area of 80,000 square feet. The operating capacity of the lagoon is 3,600,000 gallons with a retention time of four days. The 900,000 gallons/day discharge into the city sewage line is through a stand-pipe located at the far end of the lagoon from the inlet. Nine pounds of Digest II is added to the lagoon weekly.

Four 500V VORTAIR burgine surface aerators are mounted on concrete columns in the lagoon. These entrain and disperse atmospheric oxygen in large quantities of the waste water which the aerators pump from the bottom of the basin and discharge radially. Each of these INFILCO aerators consist of a 50-HP motor, speed reducer, base plate, couplings, shaft, and a turbine-type rotor. The rotor consists of a horizontally mounted circular flat plate from which a series of radial plates extend rigidly downward. Each aerator has a constant-speed drive for operation on 220-volt, 60-cycle, 3-phase alternating current 50-HP motor. Each aerator is provided with an ice shield.

At the time of the construction of the lagoon provision was made by construction of additional concrete piers for later installation of four additional aerators if required. Figure 13 is a view of the lagoon with two of the operating aerators. Figure 14 gives a panoramic view of the lagoon taken from atop the Clarifier.

The cost of the entire waste-water system as described--sump, clarifier, and lagoon--including all foundations, equipment, piping, and installation totaled $176,608.00.

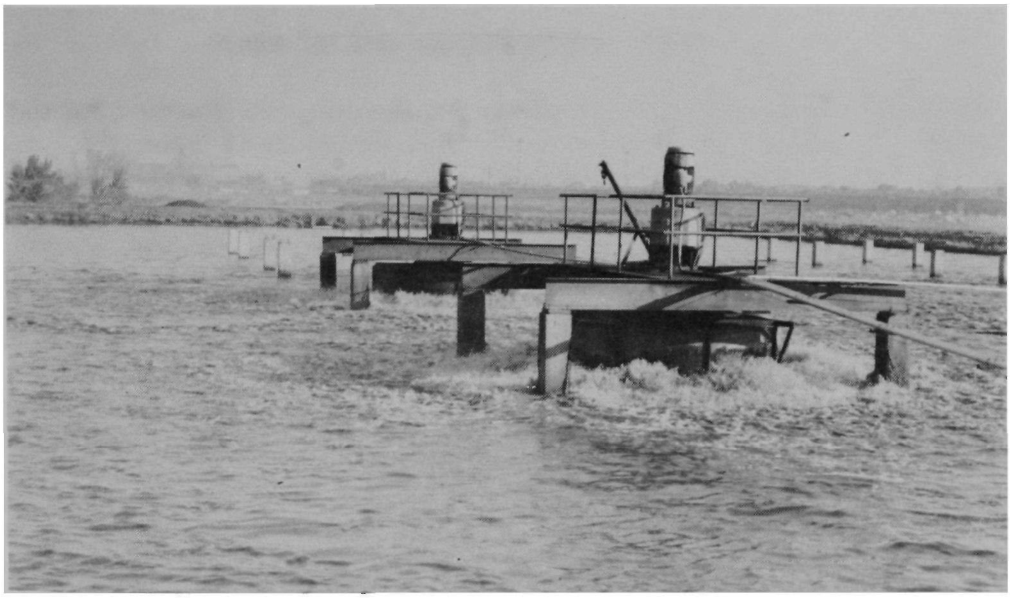

FIGURE 13. LAGOON AND TWO AERATORS

FIGURE 14. LAGOON VIEW FROM ATOP CLARIFIER

SECTION V

START UP AND MODIFICATION PHASE

This period, which for purpose of categorizing the development of the project, extended from early 1970 to the close of the year. During this period, modifications of the dehydration equipment were carried out which would give the most economical, efficient, and trouble-free drying procedures for blood and rumen. The dehydrator work force learned these procedures by trial and error working initially with the engineer, Mr. W. L. McGehee, who designed and directed the installation of the dryers.

The chemist employed for the analytical work of the project followed the analytical procedures selected for use in FWPCA Laboratories for the chemical analysis of water and waste samples (1,2). As part of the work of the project involved chemical analysis of the dehydrated blood and rumen with a view toward their use as feed or feed additives, official AOAC methods were applied for the analysis of these materials by the chemist (3). Quality control procedures as outlined in "Laboratory Quality Control Manual" were generally followed (4).

Dehydrator Equipment and Procedures

A major difficulty encountered early in the dehydration process was in the pumping system that had been installed to transfer the blood and rumen respectively from the hold tanks below the kill floor to the hold tanks for the wet materials in the dehydrator building. The distance separating these hold tanks is approximately 300 feet. The pump system for transfer of these materials was changed after several months of operation by modification of the hold tanks below the kill floor to allow for periodic "blow" of the wet materials to the open hold tanks in the dehydrator building by means of air pressure. A minimum of 40-50 pounds of air pressure is needed.

Initially the engineer attempted to dry the blood by pumping the wet blood directly from the hold tank to the dryer at a particular rate. This procedure was soon shown to be impractical because the blood baked onto and adhered to the inside lining of the drum. Steam was then introduced into the 2" blood line prior to its entry into the dryer, but plugging of the line with coagulated blood required a shut-down two or three times daily to clean the line.

A trouble-free and readily controlled procedure for feeding the blood into the dryer evolved by installing a six-foot length of 3" pipe in the blood line above the firebox of the dryer. Into this "manifold" are tapped six short ½" pipes along its length from a six-foot length of 2" pipe steam line above it. Steam is introduced into manifold in place of a Rober gear-style pump originally installed completed the modification. Figure 15 shows the blood "manifold" located above the firebox of the dryer with the blood hold tanks in the background.

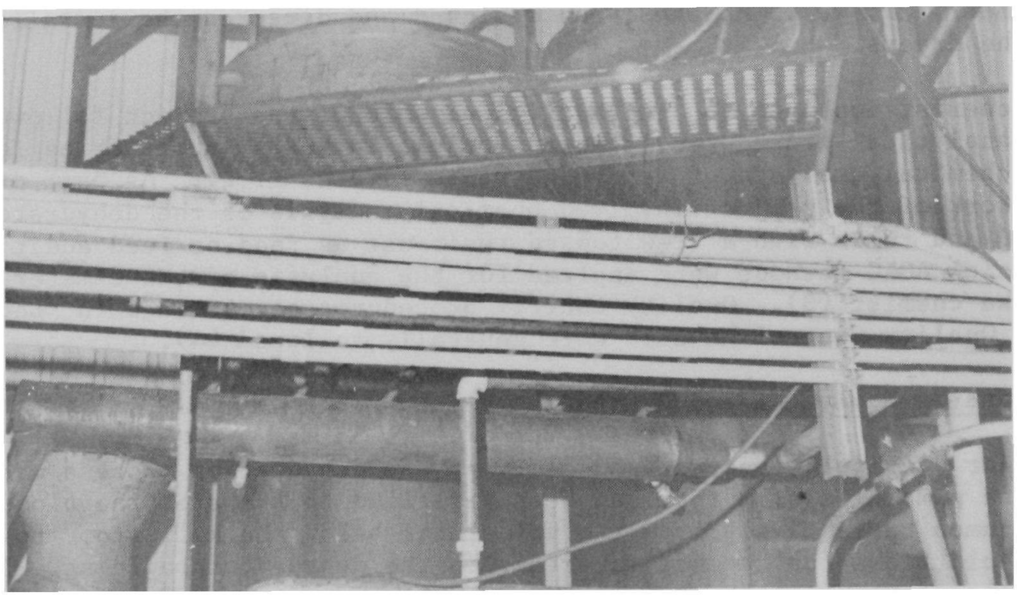

FIGURE 15. BLOOD MANIFOLD AND HOLD TANKS

The hold tank for the wet blood is shown in Figure 15 as two separate tanks or sections. This was a modification made several months after the initial installation of a single holding tank for the wet blood having the dimensions of 4' diameter by 32' height with a 10' false bottom. The false bottom was lowered to 2' from the floor and the upper section of the high tank separated and installed with connecting lines adjacent to the bottom section of the original tank. This gave two 16' high tanks which allowed for a much simpler clean-up operation of the wet blood hold tanks which is required at the end of each day's operation.

A 3/4" air line was installed in each of the blood hold tanks to keep the blood agitated. Also, the plant operator has found that the addition of a few gallons of melted tallow to each tank daily serves as an excellent anti-foaming agent for the blood.

Modifications of the blood dryer involved the installation of twelve ¼"x18"x36" steel lifter plates within the drum at strategic positions to obtain more agitation of the drying blood as the drum turns. Several bars were also installed at a position within the dryer which serve to break up the wet coagulated blood as it enters.

The dry blood storage bin is a circular tank 48" in diameter and 32' in height. The internal bottom of the storage tank is located midway up its height or 16' from the floor. A slide gate has been installed in the original divider to allow for storage of dry blood in the bottom section. A screw conveyer was installed to empty the bottom section. The top section is emptied by a simple gravity chute.

Because of the considerable number of complaints of odors purportedly originating from the dehydrator plant by residents of the city in nearby residential areas during the first excessively warm period in August 1970, a deodorizing system was installed in the stack of both dryers. The system, installed by Rocket Dispensers and Fluids, Inc., of Aurora, Illinois, injects an aerosol mist of a masking agent having a propylene glycol base directly into each stack through four small jets operated by air pressure. The cost of the chemical used is approximately ten cents per hour of dryer operation. This provision has reduced the odor problem but has not entirely eliminated it.

The major modifications made in the rumen dryer was the installation of larger lifters than those in the original equipment. Eight ¼"x18"x24" steel plates were installed for this purpose. A number of additional steel plates were installed to act as plows within the dryer to keep the drying rumen toward the front end of the dryer for a longer period of time. A recirculating screw was installed to transfer a desired quantity of dried rumen back to the front of the dryer. This mixing of dry rumen with the entering wet material as it is gravity fed into the drum improves the drying action, particularly when excessively wet rumen is being dried. Break-up plates and bars were also installed in the drum where the material enters the dryer from the wet rumen hold tank.

With the particular design of the vacollector (a cyclone separator) used, a considerable amount of particulate matter escaped from the stack of the rumen dryer during drying operations. This loss was almost entirely eliminated with the installation of a 52" cylindrical duct with a bottom opening of 36" as an extension into the vacollector at its discharge outlet leading to the stack.

Laboratory Equipment and Procedures

No major changes in the laboratory from the original plans or design were required. However, it was soon realized when the initial analytical work on dehydrated rumen was carried out that the material required preliminary treatment for uniform samples and reproducibility of results.

Dried rumen has a coarse texture with hay and other fibrous materials up to several centimeters in length being evident in the material as it emerges from the cyclone separator. Grain fragments are abundant and even whole kernels of corn are found in the dried product. Originally, a regular meat grinder with a butter-nut attachment was used to prepare the dried rumen for analysis. When such a prepared sample was sorted with a set of standard sieves, 78% of the sample passed through the 20-mesh sieve size, but only 9% passed through the 100-mesh sieve after shaking with a manual circular motion. None of the sample passed through the 200-mesh sieve. Forty-two percent of the sample was retained on the 40-mesh sieve. A Sargent-Welch hammer-type pulverizer with six interchangeable screens (20 to 125 mesh) was acquired and subsequently used in sample preparation for all dried rumen analyses. The pulverizer was also used in the preparation of dried blood samples for analyses. In both cases, the material that passed through the 125-mesh screen was used. All analyses made on the dehydrated products were those given in "Official Methods of Analysis of the Association of Official Agricultural Chemists," 10th Edition, 1965 (3).

As a major objective of the project was to ascertain the chemical oxygen demand and the biochemical oxygen demand of the blood and rumen generated, a great part of the time spent in the early stages of the analytical work was devoted to the development of procedures and techniques for the determination of COD and 20°C, 5-day BOD of these materials. The best sampling sites had to be determined for the dried products, as well as for fresh blood and rumen sampling. The appropriate "seeding" and necessary dilutions had to be determined for the BOD_5 measurements on both fresh whole blood and rumen.

The COD determination posed no particular problems. The 1969 FWPCA method for high-level COD was followed (1). Mercuric sulfate was not used to tie up chloride ion, as it was demonstrated that the concentration of this ion in the rumen was too low to affect the measurement within its limit of accuracy. The rumen samples for COD determination were separated into their solid and liquid components for the establishment of the COD value of each phase. The weighed sample of fresh rumen was filtered through a modified Buchner funnel containing a 200-mesh screen and washed successively with several 50-ml portions of distilled water to extract the readily soluble components. The liquid portion and all washings were combined and diluted to a given volume (2,000 ml) and the COD determination was made on aliquots of this solution. The solid, washed portion of the sample was dried overnight at 105°C. After pulverizing the dried solid (125-mesh screen), portions were used for the COD determination of the solid. The COD of both phases, as well as total COD could then be reported.

The COD determination of the fresh blood was made directly with given volumes of blood samples. The initial sampling site for the blood was from the blood holding tank below the kill floor, but more consistent results were obtained when the blood samples were collected directly from the animal as it drained. The samples of fresh rumen were collected at the point where the paunches were opened and emptied into the holding tank below. A mixed sample from five or more paunches would be collected from which the test sample was taken.

The matter of finding the appropriate "seed" for the BOD analysis was of major importance. Attempts at determining BOD of blood and rumen without initial seeding were unsuccessful.

The best seed for BOD determination of the blood was found to be the effluent of the plant's aerobic-type lagoon collected at the discharge point. When 25 ml of the lagoon water was diluted to 1000 ml with dilution water (doubly distilled followed by aeration), the 40-fold dilution resulted in a 60% to 80% depletion of dissolved oxygen (DO) after five days of incubation at 20°C. This appeared to have the desired characteristics as a "seed" for the blood BOD. The most satisfactory results were obtained for the blood BOD by making an original 60-fold dilution of the blood sample with dilution water. A 5-ml portion of this first blood dilution combined with 10 ml of aerated lagoon water was then diluted to 2000 ml with dilution water. BOD bottles of 300 ml were then filled for incubation. The method of determination of DO on all blanks and incubated samples was the Winkler method using the modified Azide-Iodide procedure (1).

Lagoon water was also used as the seed in the BOD determination of the sump waste water. The usual dilution made was 1 ml of sump waste water and 2 ml of aerated lagoon water diluted to a total of 1000 ml with dilution water. The BOD determination of the SEDIFLOTOR Clarifier effluent (where it drained to pass directly to the lagoon) did not require seeding. The dilution with which the BOD bottles for incubation were filled was made by diluting a 5-ml sample of the effluent directly to 1000 ml with dilution water.

The BOD determination of the fresh rumen posed several problems. First, there was the matter of determining the appropriate seeding material; the second difficulty was the technique to be used in the determination of the BOD of the dried solid phase. The samples of rumen were handled in the manner described earlier in the procedure for COD of fresh rumen. The liquid plus soluble portion were separated from the solid portion. The latter was dried overnight. The liquid plus washings were diluted in each analysis to an exact volume of 2000 ml. Both COD and BOD measurements were then carried out with portions of this solution.

Some settleable solids were always observed in the 2000 ml dilution and agitation of the solution was always done prior to taking aliquots for analysis.

The best seed for the BOD of fresh rumen was finally developed by using the liquid drainage material from the cattle holding pens. This material was aerated continuously, and periodically there was added to it portions of the liquid phase of the fresh rumen. It took several months of nurturing this seeding material before consistent results for BOD of the liquid phase of the fresh rumen were obtained. The seeding solution was always filtered prior to its use.

The BOD of the solid phase was the most difficult technique to master. It was finally done by the single bottle technique with introduction of a very small weighed amount of the pulverized solid (10-13 mg) directly into each individual empty BOD bottle. The bottle was then carefully filled with seeded dilution water prepared by mixing 5-10 ml of the rumen seed described above to 2000 ml with dilution water. The initial DO of the seeded dilution water was determined on a filled bottle without solid rumen. The DO demand of the seeded dilution water alone without solid sample added upon incubation was negligible.

Several attempts to run total BOD on fresh rumen on homogenized blended samples of the material always gave lower, as well as erratic data, as compared to the values obtained by determination of BOD on the separate phases. It was of interest to establish the BOD of the liquid and soluble portions of the fresh rumen which would likely pass directly into the sewer lines in other methods of handling the rumen waste problem.

Confirmation of the BOD of fresh rumen using a blended sample by the oxygen probe method was initiated but not completed. The probe was made available to the chemist only two months before the completion of the project, which was insufficient time to calibrate the instrument and to master the technique required for the determination.

SECTION VI

RECORDS AND STUDY PHASE

This phase of the project is considered as represented by the six-month period from January 1, 1971 to June 30, 1971, at which latter date the project was completed. During this period accurate records were kept of cattle slaughtered, percent of the rumen and blood that was dried, drying time required, utilities used, labor required; all other factors that would enter into the determination of costs in the dehydrating procedures were established.

COD and BOD_5 analyses of the fresh rumen and whole blood continued into and throughout this phase of the project. Weight studies were carried out during this phase to establish an accurate statistical average of the fresh rumen and whole blood generated per animal of the type slaughtered at the Beefland plant. A total of 10,638 head was used to determine the average rumen content of the paunch by weight and 7,324 head were used to determine the amount of blood that was readily recoverable per animal.

Chemical analysis on the dehydrated products was also continued into this phase. In addition, BOD determinations were carried out repeatedly on the lagoon effluent in connection with the use of this material as seed for BOD determinations. BOD values for the SEDIFLOTOR Clarifier effluent and the sump waste water were also established to follow BOD reduction in the waste water flow.

Production Data

The six-month production data is given in Table 2 on the following page. The weight of wet rumen generated and recoverable per animal was ascertained by a combination of data covering several study periods and by two different approaches. A total of 10,638 head of cattle was involved. One approach to determine the average of the paunch content was the direct measurement of the weight of the rumen content of the paunch at the site where the contents are emptied into the hopper leading to the hold tank below the kill floor. The contents of each paunch were emptied into a container and weighed. These measurements were carried out until twenty-five or fifty were made and a mean weight established. The other approach was the determination of the exact weight of the dehydrated product obtained for one week's production. Official scale weights were obtained. From the known kill of that week and the exact number of paunches condemned (contents not dried), the number of paunch contents dried was known. This information, along with moisture content of both the fresh and dried rumen, allowed the calculation of rumen generated for the week and per animal. The average weight of the rumen content of the paunch per animal of 54.0 lbs falls well within the range of 40 to 60 lb per head as reported by A. J. Steffen (5).

Table 2

SIX MONTH PRODUCTION DATA

Total number of animals slaughtered	184,702 head
Total live weight	201,277,291 lbs
Production hours on kill-floor	1,159 hrs
Production days	135 days
Average daily slaughter	1,368 head
Average live weight/animal	1,090 lbs
Total weight of wet rumen generated	9,973,908 lbs
Total weight of wet blood generated	6,002,815 lbs

	Blood Dehydration	Rumen Dehydration
Weight of wet material recoverable/animal	32.5 lbs	54.0 lbs
Weight of dried product recoverable/animal	6.0 lbs	8.5 lbs
Weight of dried product produced	512 ton	588 ton
Percent of wet material dried	92.4%	75%
Drying time required	1,242 hrs	1,260 hrs
Man-hours of labor required	1,897 hrs	1,816 hrs
Gas consumption	8,427.0 MCF	8,540.4 MCF
Electricity consumption	57,231.4 KWH	46,443.6 KWH
Steam consumption	600 lbs/hr	none
Water consumption	891,000 gals	none
Total sales	$49,404.00	Unreported

Only 75% of the rumen generated (138,500 paunches) was dried. The contents of condemned paunches were sent directly to the rendering cookers, and the balance of the undried rumen was hauled away from the plant by contract at fifteen cents per paunch.

The weight of wet blood recoverable per animal was also determined during a week's production of known kill and all blood generated being dried and official weight of the dried product obtained. From the moisture content of both the wet whole blood and dried product, the weight of blood obtained per animal was ascertained. During the six-month period only 92.4% of the blood generated was dried (based on total sales). Periodic shutdowns of the blood dryer and inadvertent losses readily account for this yield as compared to that obtainable on the basis of the study period.

Gas consumption for both dryers was metered. As there were no meters installed to determine the electricity usage, these values were based on the measured usage of each dryer during operation by the Plant Engineer. The blood dryer averaged 46.08 kilowatts per hour of drying time, while the rumen dryer required 36.86 kilowatts per hour. Steam use was also established by gauge pressure and flow while the water consumption for cleanup of the blood holding tanks, floor, etc., was estimated as 1% of plant use.

<u>Undehydrated Blood and Rumen</u>

Table 3 and Table 4 which follow summarize the chemical investigation on fresh whole blood and undehydrated rumen. The data used to establish the mean was that obtained after analytical procedures were well established, and consistent results were obtained with each procedure. The pH, % moisture, COD, and BOD are reported. Standard deviation for each mean value is given, as well as the number of separate determinations for each type of analysis counting back from the last one made at the end of the project.

Table 3

DATA ON FRESH WHOLE BLOOD

	Mean	Std. Dev.	No. of Detm's
pH	7.34	0.14	37
% Moisture	82.4	3.4	39
COD (ppm)	218,300	35,700	70
BOD_5 (ppm)	156,500	58,000	35

Table 4

DATA ON UNDEHYDRATED RUMEN

	Mean	Std. Dev.	No. of Detm's
pH	6.54	0.56	57
% Moisture	84.7	3.4	58
COD (ppm)			114
Liquid Portion	51,940	12,800	
(% Liquid)	(88.4)	(3.3)	
Solid Portion	1,138,000	82,000	
(% Solid	(11.6)	(3.3)	
Total COD	177,300	38,500	
% COD from Liquid	26.7		
% COD from Solid	73.3		
BOD_5 (ppm)			
Liquid Portion	28,240	11,410	88
Solid Portion	151,900	40,800	40
Total BOD_5	50,200	13,400	
% BOD from Liquid	59.1		
% BOD from Solid	40.9		

COD and BOD_5 of Rumen and Blood

From the six-month production data and the COD and BOD values obtained experimentally for undehydrated rumen and blood, the COD and BOD values in terms of daily production, per animal, or per 1000 lbs live-kill weight can be calculated. Table 5 summarizes this data and type of calculation.

Table 5

COD AND BOD_5 OF RUMEN AND BLOOD

Rumen

Total COD of Rumen	177,300 ppm
Total BOD_5 of Rumen	50,200 ppm
BOD_5/COD Ratio of Rumen	0.283
Weight of Rumen Generated (54 lbs/animal)	9,973,908 lbs
Total Rumen COD Generated	1,768,400 lbs
Total Rumen BOD_5 Generated	500,690 lbs

	Per Day	Per Animal	Per 1000 lbs LWK
Rumen COD	13,100 lbs	9.57 lbs	8.78 lbs
Rumen BOD_5	3,708 lbs	2.71	2.49 lbs

(As only 75% of the rumen generated was dried, any of the above values multiplied by 0.75 give the recovered figure.)

Blood

Total COD of Blood	218,300 ppm
Total BOD_5 of Blood	156,500 ppm
BOD_5/COD Ratio of Blood	0.717
Weight of Blood Generated (32.5 lbs/animal)	6,002,815 lbs
Total Blood COD Generated	1,310,400 lbs
Total Blood BOD_5 Generated	939,440 lbs

	Per Day	Per Animal	Per 1000 lbs LWK
Blood COD	9,707 lbs	7.10 lbs	6.51 lbs
Blood BOD_5	6,959 lbs	5.09 lbs	4.67 lbs

(As only 92.4% of the blood generated was dried, any of the above values multiplied by 0.924 give the recovered figure.)

Table 6 relates total COD and BOD_5 in the same units as above for rumen and blood combined in terms of amount generated and recovered as determined during the six-month study period.

Table 6

TOTAL COD AND BOD_5 OF RUMEN AND BLOOD COMBINED

Generated	Per Day	Per Animal	Per 1000 lbs LWK
Total COD	22,810 lbs	16.67 lbs	15.29 lbs
Total BOD_5	10,667 lbs	7.80 lbs	7.16 lbs
Recovered			
Total COD	18,800 lbs	13.74 lbs	12.60 lbs
Total BOD_5	9,210 lbs	6.74 lbs	6.18 lbs

It can be readily shown from the data of Table 6, using any of the units in which it is expressed, that dehydration of 75% of the rumen and 92.4% of the blood that was generated gave a recovery of 82.4% of the COD generated and 86.4% of the BOD_5 generated.

It should not be concluded, however, that the balance of the COD and BOD_5 entered the waste-water system. The 25% of the rumen that was not dehydrated either went through the rendering plant or was hauled from the plant as wet rumen. Presumably, the 7.6% of the undehydrated blood entered the waste-water flow. The BOD_5 of this lost blood would represent a waste-water loading of 0.387 lbs of BOD_5/animal or 0.355 lbs of BOD_5/1000 lbs LWK.

BOD_5 of Plant Waste Water

Although the determination of BOD of waste water along different parts of the flow from kill floor to final discharge into the sewer was not part of the stated objective of the project, it was carried out on samples taken at three different sampling sites along its flow.

It was determined early in the experimental phase that the lagoon effluent collected at the discharge point into the municipal sewer line constituted an excellent seed for blood BOD. In order to determine the BOD reduction in the aerobic lagoon by aeration, BOD determinations were made on samples of the Clarifier effluent taken at the point where it flowed over the weir prior to discharge to the lagoon.

Samples of the waste water taken directly from the sump were also collected for BOD determinations. This was under constant turbulence due to flow from different sources. Foam and large pieces of fat were usually evident on parts of the surface. Inclusion of these were avoided in the collection of samples from the sump. Table 7 summarizes the data on BOD of samples of the plant waste water taken from these sampling sites.

Table 7

PLANT WASTE WATER--BOD_5 (ppm)

	Mean	Std. Dev.	No. of Detm's
Sump Water	1,220	300	36
SEDIFLOTOR-Clarifier Effluent	850	150	40
Lagoon Effluent	214	119	75

Analysis of Dehydrated Products

The chemical analysis of the dehydrated products was the first type of analytical work carried out in the project and continued throughout the project period. Initially, the samples of the dried products taken for analysis were composite samples collected periodically during a particular day. Later, after consistent drying procedures were established and products of quite uniform moisture content were obtained, the composite sampling was extended to two days' production and even to an entire week toward the end of the project. Table 8 summarizes the data on the dehydrated blood and rumen.

Table 8

ANALYSIS OF DEHYDRATED PRODUCTS

	Mean	Std. Dev.	No. of Detm's
Dehydrated Blood			
% Moisture	5.3	1.7	110
% Protein	89.2	4.1	100
Dehydrated Rumen			
% Moisture	6.8	1.9	96
% Protein	12.7	1.5	88
% Fat	3.1	0.6	86
% Crude Fiber	26.2	3.2	88
% Calcium	0.59	0.09	60
% Ash	7.2	0.7	88
% P_2O_5	1.47	0.25	60
% Carbohydrate	40.8	5.3	44

(The % carbohydrate was calculated by subtracting total percentage of moisture, protein, fat, crude fiber, and ash from 100 for each sample as advised by Mr. Whitson of the Iowa Agricultural Laboratory in Des Moines, Iowa. % Protein based on Kjeldahl nitrogen.)

SECTION VII

ECONOMIC EVALUATION

Annual Capital Costs

The capital investment in the dehydrator building and equipment was itemized in detail in Table 1, page 10 of this report. The depreciation schedule followed by Beefland International, Inc., is a straight-line method without residual book value based on a twelve-year schedule for the building and a ten-year schedule for the equipment. The amortization schedule (interest and reduction of principal) is based on a 9% annual interest rate.

Annual tax charged as a capital cost is based on the 1971 assessment of $220,000.00 on a net property and equipment valuation for the Beefland plant of $5,854,450.00. The 1971 book value of the dehydrator building and equipment was 2.795% of the total. Annual insurance cost is calculated as 2.795% of the total plant insurance premium for 1971 of $31,000.00. Despite an annually reduced book value for the building and equipment, it is assumed that the annual tax and insurance costs for the next ten-year period will remain essentially constant. Table 9 summarizes the above data.

Table 9

ANNUAL CAPITAL COSTS

	Building	Equipment
Capital Investment	$32,934.00	$148,272.05
Depreciation Period	12 years	10 years
Capital Costs (annual)		
Amortization (9% annual interest)	$ 4,599.00	$ 23,103.00
Taxes	1,134.49	5,014.51
Insurance	159.86	706.59
Totals	$ 5,893.35	$ 28,824.10
Annual Capital Cost		$ 34,717.45

Dehydration Costs

The operating costs of dehydrating whole blood and rumen is based on the production data for the six-month study period as given in Table 2, page 28 of this report. Labor and administrative costs, as well as cost of utilities and maintenance of equipment are included. Combination of operating costs as experienced during the project along with estimated maintenance costs and the semi-annual capital costs allows a determination of dehydration costs and costs for the BOD_5 removal. These data and cost figures are shown in Table 10 on opposing page.

Discussion of Dehydration Costs

For the sake of clarity certain of the data of Table 10 is explained in detail in the statements that follow.

Labor cost, as expected, was the single largest item under operating costs and was determined from payroll records for the six-month period for all operators in the dehydrating process. The administrative, supervisory, and secretarial cost was the best estimate of the administrator who acted as the Project Director.

The unit cost or rates of utilities were as shown in the tabulation. The rate for gas increased from $0.37/MCF to $0.4082/MCF midway through the study period (April 1, 1971). The gas and electricity costs included a demand charge (DC) made monthly. In the case of gas, this was determined by the fraction of gas used in the dehydration process times the total demand charge for the plant for the month. The amount of the demand charge for gas varied between $300 to $725 monthly during the study period. The demand charge was prorated for each dehydrator on the basis of the gas usage of each. The monthly demand charge for electricity was constant. The demand charge for electricity for the blood dryer was $86.40 monthly and $115.20 monthly for the rumen dryer.

The maintenance allowance for the dryers of $2,000 annually for each is five times the amount estimated by the manufacturer to keep the machines in good repair for a life expectancy of 25 to 30 years. This generous allowance, however, would allow for relining of the dryers, particularly the blood dryer, with corrosion resistant stainless steel, every three or four years as required. Although the allowance is indicated as the same for each dryer, the blood dryer would likely have a greater maintenance cost than that of the rumen dryer because of the greater corrosive action of wet blood. In addition to the eventual expense of relining the dryers, maintenance costs that have been incurred are those of replaced bearings, rubber tires, corroded blood lines and break-up bars.

The semi-annual capital cost of $17,358.72 was not equally divided

Table 10

DEHYDRATION COSTS FOR WHOLE BLOOD AND RUMEN

Operating Costs	Blood Dehydration	Rumen Dehydration	Total Costs
Labor ($3.05/hr)	$ 5,785.85	$ 5,538.80	$11,324.65
Administration and Supervision (10% of the salary of one secretary, administrator, and supervisor)	900.00	900.00	1,800.00
Utilities			
Gas ($0.4082/MCF plus DC)	4,799.65	4,939.94	9,739.59
Electricity ($0.0055/KWH plus DC)	833.17	946.64	1,799.81
Steam ($0.42/hr drying time	521.64	--	521.64
Water ($0.000273/gal)	243.24	--	243.24
Masking Chemicals ($0.10/hr drying time)	124.20	126.00	250.20
Maintenance of Dryers (Est.) ($2,000/yr--each dryer)	1,000.00	1,000.00	2,000.00
Total Operating Costs	$14,207.75	$13,451.38	$27,659.13
Capital Costs (semi-annual)	8,193.32	9,165.40	17,358.72
Total Dehydration Costs	$22,401.07	$22,616.78	$45,017.85
Dehydration cost/ton	$43.75	$38.46	$40.93
Dehydration cost/animal	$ 0.12	$ 0.16	$ 0.28
Dehydration cost/1000 lbs LWK	$ 0.11	$ 0.15	$ 0.26
Cost/lb of BOD_5 eliminated	$ 0.025	$ 0.08	$ 0.04

between the blood and rumen dryer, as the blood dryer cost $10,000.00 less (a used model) than the rumen dryer in the Beefland project. (See Table 1, page 10). Forty-seven and two-tenths percent of the semi-annual capital cost was assigned to the blood dehydration and the remainder as the capital cost share of the rumen dehydration.

The dehydration cost per ton of dried blood was based on the total six-month production of 512 ton. On the basis of 184,702 head of cattle slaughtered, the cost per animal is 12¢ and the cost per 1000 lbs LWK is 11¢. The dehydration cost per ton of dried rumen was based on the total production of 588 ton. On the basis of only 75% of the paunch contents dried (138,500 paunches), the cost per animal is 16¢ and the cost per 1000 lbs LWK is 15¢. The cost per ton of dehydrated material (blood and rumen) was based on the total tonnage of 1100 ton and total costs.

The total receipts of $49,404.00 for the sale of dried blood during the six-month study period represented a return of $4,386.15 over the total dehydration cost of both blood and rumen during the same period. Information on the exact amount of dried rumen sold was not available. A portion of the dried rumen was sold for $20.00/ton. A considerable amount was used for feed trials by both cattle and hog feeders in the area. Some of the dried rumen was used as a soil conditioner.

It should be noted that a return of $20.00/ton for the dehydrated rumen would represent a return of 8.5¢ per animal or approximately 53% of the dehydration cost of 16¢ per animal. The 16¢ dehydration cost per paunch content should be compared to the 15¢ hauling cost per animal paid by Beefland for the wet rumen that was not dried. Sales of 12% of the dehydrated rumen at the minimal price of $20.00/ton would represent a break-even point between the cost of dehydrating the rumen and the cost of wet dumping as a separate operation from the drying of blood.

Consideration of the data as given in Tables 5, 6, and 10 allows for a determination of the costs of BOD removal or elimination by the dehydrating process. These values are given in Table 10 as 2½¢ per pound for blood BOD and 8¢ per pound for rumen BOD. The mean cost is 4¢ per pound of BOD eliminated. The FWPCA publication, "The Cost of Clean Water" (6), is an excellent reference to compare the reduction of BOD loading of plant waste water in the industry by various processes of handling blood, rumen, grease, etc. Costs of the processes described are not readily comparable with the dehydrating costs as established in this study.

SECTION VIII

ACKNOWLEDGMENTS

This report was written by Dr. Donald J. Baumann, who acted as Technical Director of Project 12060 FDS during the eighteen-month study. The author wishes to acknowledge the assistance given him by the initial Project Director, Mr. Ray C. Burke, who held the position of Vice President of Transportation and Marketing with Beefland International, Inc., and under whose guidance the project was initiated. Upon the resignation of Mr. Burke, Mr. James S. Gardner, Director of Personnel at Beefland, was named to replace him as Project Director. Mr. Gardner's assistance and cooperation in the progress of the study since August 1970 is gratefully acknowledged.

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Mr. Jack Brashear	--	Plant Engineer
Mr. Joe Gardella	--	Accountant
Miss Connie R. Osborne	--	Secretary
Mr. Merlin Hicks	--	Operator, Dehydration Plant

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Mr. Otmar O. Olson of the Kansas City EPA Office and Regional Director of Water Quality Research and Development Office was the Project Officer. His guidance and assistance during and following the project period have been gratefully received.

SECTION IX

REFERENCES

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5. Report Date **November, 1971**

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7. Author(s)

Baumann, Donald J.

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9. Organization

Beefland International, Inc.
Council Bluffs, Iowa

11. Contract/Grant No.

13. Type of Report and Period Covered

10-1-1969 to 6-30-1971

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15. Supplementary Notes

16. Abstract The operation of two dehydrating machines, for the drying of cattle whole blood as well as paunch contents (rumen), at the Beefland International, Inc., slaughtering plant at Council Bluffs, Iowa, was studied.

The BOD_5 and COD of the blood and rumen were established. The mean BOD_5 of the whole blood and rumen was determined as 156,500 ppm and 50,200 ppm, respectively. The mean COD of the blood and rumen was established as 218,300 ppm and 177,300 ppm, respectively.

The economics of the drying process in costs per ton of dried product, per 1000 lbs live kill weight (LWK), and per animal were determined. The dehydrating costs per ton of dehydrated product were found to be $43.75/ton for blood and $38.46/ton for rumen. The average cost (blood) and rumen) was $40.93/ton.

Laboratory studies were carried out on the dried whole blood and rumen with a view toward their actual and potential use as legally accepted feeds or feed additives. Percent moisture, protein, fat, carbohydrate, and other analyses of the dried products are reported. (Baumann--Creighton)

17a. Descriptors

*Dehydration, *Cattle, *Chemical Oxygen Demand, *Biochemical Oxygen Demand, *Economics, Chemical Analysis, Water Pollution, Moisture Content, Oxidation Lagoons, Proteins, Waste Disposal

17b. Identifiers

*Dehydrators, *Blood, *Paunch, *Rumen, *Slaughtering Plants, Dryers, Dehydration Costs, Feed Additives

17c. COWRR Field & Group

18. Availability

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