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HAMILTON STANDARD

**FUEL GAS FROM AN
ENVIRONMENTAL FEEDLOT**

CONTRACT NO. EG-77-C-01-4015

PROGRESS FROM MAY 1 TO SEPTEMBER 30, 1979

**PREPARED FOR THE
QUARTERLY COORDINATION MEETING**

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MASTER

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Summary

Since May, successful fermentations were established at both 122°F and 131°F. Due to lower than anticipated manure quantities, a result of low feedlot cattle population, the contents of the two fermentors were blended together in one tank which is presently operating at 131°F. It is evident from the data that an adaptation time of a minimum of 30 days is necessary before the onset of significant fermentation. Specific methane production of more than 3.5 cubic feet per pound of volatile solids loaded has been attained. The present limitation to increased gas production and the restart of the second fermentor is the lack of cattle in the feedlot. This situation is expected to improve slowly over the next several months.

Background

The facility was first placed in operation in February, 1979. The only fermentor operated at that time was fermentor #1. Due to equipment problems, temperature stability was poor. In addition, control of pH was not as good as desired. Proper fermentation was never established and, although temperature and pH stability were thought to contribute, investigation of the problem pointed to the presence of Rumensin in the residue as the major cause. Experiments performed by Dr. Perry McCarty indicated that Rumensin was highly inhibitory. Experiments by Dr. Richard Speece also showed this but also indicated that adaptation was possible. The following is a description of subsequent system operation starting in May. Data covering the operation is displayed in figures 1 through 9.

Fermentor Performance - #2 Fermentor

Fermentor #2 was loaded on 5/5/79 to attempt a new start-up at 122°F. Volatile solids concentration in the tank started out at 2.05%. It was thought that a more careful control of temperature and chemistry, along with sufficient time to allow for adaptation to Rumensin, would result in a successful start-up. It was also decided that the only chemical control which would be exercised would be one of pH control. This was accomplished by repeated additions of lime and sodium bicarbonate during the first few days of operation. A total of 3,400 lb sodium bicarbonate and 2,550 lb lime were added to the tank. One exception was made to restricting chemical control to pH modification. On May 29, 50 ppm iron were added in the form of FeCl_3 as it was suspected that the fermentor was iron deficient. On June 9, a positive indication of gas production was seen on the flare gas meter. The exact value of gas production is not known because the gas meter is not accurate below 1,500 CFH. The start of gas production was followed by a sharp drop in TVA from about 5,000 mg/l to about 1,500 mg/l. Daily loading of the fermentor was initiated on June 12. This brought the TVA back up into the 2,000 range followed by a general decline to nearly 1,000 mg/l over a period of a month. The

pH reacted predictably to the changes in TVA resulting in a pH of about 7.4 by the middle of July. The lowest pH reached prior to this was 6.46 which was measured on May 7.

From 7/11/79 to 7/21/79 gas flow measurements were taken by means of timing pressure rise in the tank with the gas outflow valve closed. The average daily gas production measured in this way was 11,500 cu ft STP (dry). During this period, retention time was constant at 20 days and the tank liquid volume was 23,400 cu ft. Specific methane production was calculated using the same data. The average of the data is 3.77 cu ft/lb.

Fermentor #1 was started in early June and by mid-July it was evident that there was not enough residue available to operate both tanks. As a result of this and the fact that the level gage in tank #2 needed modification, the contents of tank #2 were transferred to fermentor #1 on July 24. When the tank was opened, it was found that a large amount of the chemicals used for pH control never dissolved.

It is evident from the performance of fermentor #2 that the patient control of fermentation conditions is at least one way of achieving start-up. Presumably the process needed about 30 days to adapt to whatever it was that was blocking gas production. This assumption is based on the successful rapid start-up of our fermentor at Kaplan 4 years ago. The only significant difference between the residue then and now is the use of Rumensin in the present feed ration.

Fermentor Performance - #1 Fermentor

Fermentor #1 was loaded on 6/5/79 to attempt a start-up at 131°F. Start-up of this unit was to be similar to start-up of fermentor #2 except that no chemical control was attempted. Volatile solids concentration in the tank was initially 0.9%. pH started out at 6.66. It dropped to a low of 6.30 on June 16 and then began a slow rise. TVA started out at approximately 2,000 mg/l and dropped slowly. By June 28 pH had reached 6.61 and TVA was down to 1,141 mg/l. Methane concentration in the gas was up to 47.3%, although gas production was essentially undetected by the gas meter. Since this fermentor was very lightly loaded, it was felt that significant fermentation had begun but that the light loading was keeping the gas production from being large enough to measure. It was therefore decided that daily loadings of residue should be started. This was started at 0.5 ft/day which, except for the fact that daily withdrawals were not started at this time, translates to a retention time of 34 days. pH remained steady at about 6.7 and TVA rose to a high of 1,680 mg/l. Significant gas production was first recorded on July 6. As was the case with fermentor #2, the exact gas production is not known as the gas flow was far below the flow range where the gas meter is accurate. After 3 days TVA had dropped to 1,140 mg/l and pH had risen to 7.04. On July 16 the loading was doubled.

This drove the TVA to about 2,500 mg/l just prior to the mixing of the fermentors on July 24.

Specific methane production (as determined by measuring gas flow by timing pressure rise) averaged 3.89 cu ft/lb between July 11 and July 24.

After completion of adding tank #2 contents to tank #1, the conditions were as follows:

pH	7.27
TVA	2,377 mg/l
alkalinity	4,796 mg/l
volatile solids concentration	2.27%

At this point the fermentor was completely full (36.7 ft) and loading was resumed at a rate of 1 ft/day (retention time of 36.7 days). On July 30 loading was increased to 2 ft/day (retention time of 18.4 days) and kept at this level with few exceptions through August. By the end of August conditions in the fermentor were as follows:

pH	7.4
TVA	1,050 mg/l
alkalinity	5,196 mg/l
volatile solids concentration	2.23%

During the month of August the dry, air-free methane concentration averaged 60.8% (STD DEV 1.75%) and the specific methane production averaged 3.49 cu ft/lb (STD DEV 1.52 cu ft/lb).

Operation of fermentor #1 appears stable except for the wide variations of the quality and quantity of the residue. The mode of operation will be maintained until such time as more residue becomes available.

Residue Characteristics

Retention time is controlled at fixed levels on a day to day basis as shown in figure 8. The spike near the end of July occurred for a few days following the transfer of fermentor #2 contents to fermentor #1. The varying loading rate, on the other hand, has been a direct result of the wide fluctuations in the volatile solids content of the residue. Figure 9 is a plot of fermentor #1 loading rate for the month of August. During August the retention time was constant. The loading rate; however, varied from about .04 to about .22 lb vs/cf/day. The fluctuation of the volatile solids content of the residue appears to be due to four major causes:

. rainwater infiltration

- . feedlot structure
- . cattle population
- . cattle weight

Although the feed lot is basically a roofed over structure, the roofing actually consists of slats. In addition, there is essentially no overhang at the edges. For these reasons some amount of rain water enters the system every time it rains causing large fluctuations in the volatile matter content of the residue. Furthermore, there has been wind damage to the roofing exposing a considerable number of pens to direct rain. Due to settling of the ground there has also been a few areas where surface water has drained directly into the pen area. To a great extent these problems have been fixed over the last few months; however, there are still two other sources of water in the feed lot. First, there are several hundred waterers for the cattle. No direct water from these enters the residue collection system except when one or more malfunction. Second, the cables which draw the scrapers in the pits under the pens are kept clean by jets of water applied during operation. The size of these jets was recently reduced to cut down on this source of dilution. The last two items, cattle population and weight, affect the residue dilution problem in the same way. Compared with operation on a pilot plant basis at the feed lot four years ago, the total quantity of residue is much lower. This is because the total cattle population and the weight of the cattle are significantly lower due to the present economics of the cattle market. The net effect is that rain water and cable wash water have a much greater impact on the solids content of the residue.

This problem has not been totally resolved at this point. It is hoped that increases in cattle population will bring improvement. Meanwhile, all possible sources of water infiltration will be monitored and corrective action taken where possible.

Product Utilization

Product gas is used in the fermentation system boiler except for periods of high demand. No problems have been encountered in this application. Final preparations for utilizing the product gas in the meat packing plant boiler neared completion. In addition, the engine generator was placed on order.

Since the system is not yet operating at the ten day retention time design point, no effort has been expended on protein recovery.

Plans for Next Quarter

Early next quarter the packing house boiler experiments with fermentor gas will begin.

Fermentor #1 will be brought to a ten day retention time and experiments in protein recovery will commence. As the quarter proceeds, fermentor #2 will also be brought to design point. If no unforeseen problems occur, limited feeding trials will start before the end of the year.

FIGURE 1

JUNE
FERMENTOR NO. 2

FIGURE 2

JULY

FERMENTOR NO. 2

11490 CF/DAY 3.77 CF CH₄/LB VS R. T. 20 DAYS

FIGURE 3.

JUNE
FERMENTOR NO. 1

FIGURE 4

JULY

FERMENTOR NO. 1

11230 CF/DAY 3.89 CF CH₄/LB VS R.T. 29 DAYS

FIGURE 5

AUGUST

FERMENTOR NO. 1

28620 CF/DAY 3.49 CF CH₄/LB VS R. T. 18 DAYS

FIGURE 6

SEPTEMBER

FERMENTOR NO. 1 (WITH SOME NO. 2)

26260 CF/DAY 3,76 CF CH₄/LB VS R. T. 18 DAYS

FIGURE 7

B 20

FERMENTOR NO. 1
RETENTION TIME (DAYS)

FIGURE 8

FERMENTOR NO. 1 LOADING RATE

POSSIBLE CAUSES OF FLUCTUATION :

- RAIN WATER INFILTRATION
- FEEDLOT STRUCTURE
- CATTLE POPULATION
- CATTLE WEIGHT

FIGURE 9