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Report No. AMXTH-TE-CR-86091

# Installation Restoration General Environmental Technology Development

Contract DAAK 11-82-C-0017 (Task Order 9)

# Field Demonstration of Incinerator Feed System For Explosives-Contaminated Soils

## Volume 1 - Technical Report



January 1987

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Prepared for:
U.S. ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY
Aberdeen Proving Ground (Edgewood Area), Maryland 21010



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| Incineration | Feed Conveyor | Screw Conveyor Tongue |
| Feed System | Soil Excavation | Motor Current |
| Materials Handling | Soil Preparation | Explosives Concentrations |
| Live Bottom Hopper | Soil Feedrate | Soil Size Distribution |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of field demonstration project to evaluate the suitability of an incinerator feed system for conveying explosives-contaminated soils. The project was conducted at the Louisiana Army Ammunition Plant from 30 June to 10 July 1986. This report presents the test variables, schedule of tests and runs, data analysis, and conclusions and recommendations for future field implementation.

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FIGURES





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## TABLES

## 1. EXECUTIVE SUMMARY

1.1 Background. A field demonstration project was conducted at Louisiana Army Ammunition Plant (LAAP) near Shreveport, Louisiana to evaluate the suitability of an incinerator feed system for conveying explosives-contaminated soils. The field demonstration project was conducted from 30 June to 10 July 1986. Explosives-contaminated soils were excavated from Lagoon No. 4 at LAAP for testing. (Total explosives content typically ranged from 10 to 22 percent by weight.) In addition, uncontaminated background soils from Cornhusker Army Ammunition plant (CHAAP) near Grand Island, Nebraska were also excavated and transported to LAPP for testing. Soils discharged from the system were deposited in Lagoon No. 12 at LAAP.

The incinerator feed system consisted of the following three major components:

(a) Live bottom hopper - The live bottom hopper consisted of a loading bin with four cone metering screws in the bottom to control the soil feed rate.
(b) Cross conveyor - The soil from the live bottom hopper discharged into a twin-screw cross conveyor which transferred the soil horizontally from the live bottom hopper to the feed conveyor.
(c) Feed conveyor - In future applications, a water-jacketed twin-screw conveyor will directly feed a rotary kiln incinerator. However, for this testing program, the feed conveyor discharged into an excavation container for transport of the soils back to the lagoon at LAAP.

The field testing evaluated three levels of soil feed rate (i.e., 4,000 lb/hr, 8,000 lb/hr, and 12,000 lb/hr) and two test durations (i.e., 4-hour runs and one 8-hour steady-state run for each soil type). In addition, testing was also performed under upset and/or failure-mode conditions.

This testing program successfully demonstrated the capability of the feed system to consistently deliver 50 percent, 100 percent, and 150 percent of the 8,000 lb/hr design feed rate with two very different soil types. The feed system proved to be capable of conveying solid debris in the soil (i.e., chunks of concrete) up to 6 inches x 6 inches x 6 inches in dimension without jamming the system. The failure mode testing successfully demonstrated that the control system responded as designed to all simulated jams and motor overload conditions.

## 2. INTRODUCTION

2.1 Background. As a result of past munitions-handling operations, the U.S. Army has numerous lagoons which contain varying amounts of explosives-contaminated sludge. Rotary kiln incineration has been identified and demonstrated as a treatment technology for explosives-contaminated sludge. Prior to the performance of this task order, no safety-approved feed system existed for explosives-contaminated sludge. However, a safety-approved feed system will be required before incineration can be used in the field to decontaminate these sludges.

This report describes the full-scale field demonstration of the safety-approved feed system completed in July 1986. However, the incinerator feed system development was initiated in September 1982 under WESTON's Task Order No. 2 which involved the field demonstration of a pilot scale incineration system for explosives-contaminated soils. To document the chronology of the feed system development, Table 1 presents a list of appendices provided in Volume 2 of this report.

In addition to these appendices, three specific documents directly related to this project were prepared by WESTON and were submitted to USATHAMA. These documents are included by reference only:

| Document title | Date submitted to USATHAMA |
|---|---|
| Test Plan for Propagation and Flame Testing of Explosives-Contaminated Lagoon Soil at Los Alamos National Laboratory (LANL) | March 1985 |
| Safety Plan for a Materials Handling System Test of Explosives-Contaminted Soils at the Louisiana Army Ammunition Plant (LAAP) | June 1985 |

TABLE 1. LIST/DESCRIPTION OF APPENDICES IN VOLUME II

| Appendix | | Title/description |
|---|---|---|
| A | Title: | Summary of Incinerator Feed System Development<br><br>Letter from P. J. Marks to W. E. Sisk dated 20 February 1985. This letter (with attachments) provides an overview of the various designs considered and describes the planned development and testing activities. |
| B | Title: | Tests for Propagation of Explosions in Explosives-Contaminated Lagoon Soils<br><br>This report presents the results of propagation testing conducted by Los Alamos National Laboratories (LANL) on explosives-contaminated lagoon soils from Louisiana Army Ammunition Plant (LAAP), Cornhusker Army Ammunition Plant (CHAAP), and Savanna Army Depot Activity (SADA). This testing was performed to determine if the contaminated soils will propagate an explosive event. |
| C | Title: | Flame Testing of Incinerator Feed System Handling Explosives-Contaminated Lagoon Soils<br><br>This report presents the results of flame testing conducted by LANL on explosives-contaminated lagoon soils from LAAP. The purpose of this testing was to investigate the potential for fire or explosion to occur in the feed system due to exposure to the incinerator environment during upset conditions. |

TABLE 1. (CONTINUED)

| Appendix | | Title/description |
|---|---|---|
| D | Title: | Hazards Analysis of Incinerator Feed System |
| | | This document presents the results of a Subsystem Hazard Analysis (SSHA) of the incinerator feed system to ensure that the explosives-contaminated lagoon soils can safely be fed to an incinerator while minimizing the risk of injury to operating personnel and equipment damage. This report was supported by sensitivity tests of dried explosives-contaminated lagoon sludges from LAAP, CHAAP, and SADA. |

2.2 Purpose. The purpose of this report is to present the results and conclusions of a field demonstration project that evaluated an incinerator feed system for handling explosives-contaminated soils. A description of test conditions and process equipment is contained herein.

2.3 Objectives. The primary objective of the field demonstration project was to evaluate the suitability of the materials handling feed system for feeding explosives-contaminted soils into a rotary kiln incinerator. Secondary objectives included the following:

(a) Determination of the impact on system performance of varying design parameters (e.g., soil feed rate, soil moisture content, soil composition, and maximum soil topsize).
(b) Determination of the optimum range of operational parameters.
(c) Determination of equipment limitations and failure modes to identify a clear envelope of safe and practical system operation.
(d) Identification of equipment modifications that would improve system performance, reliability, and/or operational safety.

2.4 Criteria for successful demonstration. The success of the field demonstration project was based upon the ability of the materials handling and feed system to safely and reliably process a minimum of 8,000 lb/hr of explosives-contaminated soils from two installations: LAAP and CHAPP.

2.5 Test site description. The field demonstration project was conducted at LAAP in Shreveport, Louisiana. The location of the test site and the pink water lagoons is shown on Figure 1.

Originally, field demonstration projects were also to be conducted at CAAP near Grand Island, Nebraska and SADA near Savanna, Illinois. However, demonstrations at these installations were not conducted for the following reasons:

(a) Full erection and disassembly of the feed system at each location would be too costly and time-consuming.
(b) LAAP soils represented "worst case" conditions, as follows:
    (1) The LAAP soils were the most highly contaminated, exhibiting explosives concentations as high as 45 percent by weight.
    (2) The high concentration of explosives made it undesirable to transport LAAP soils to another site for testing.

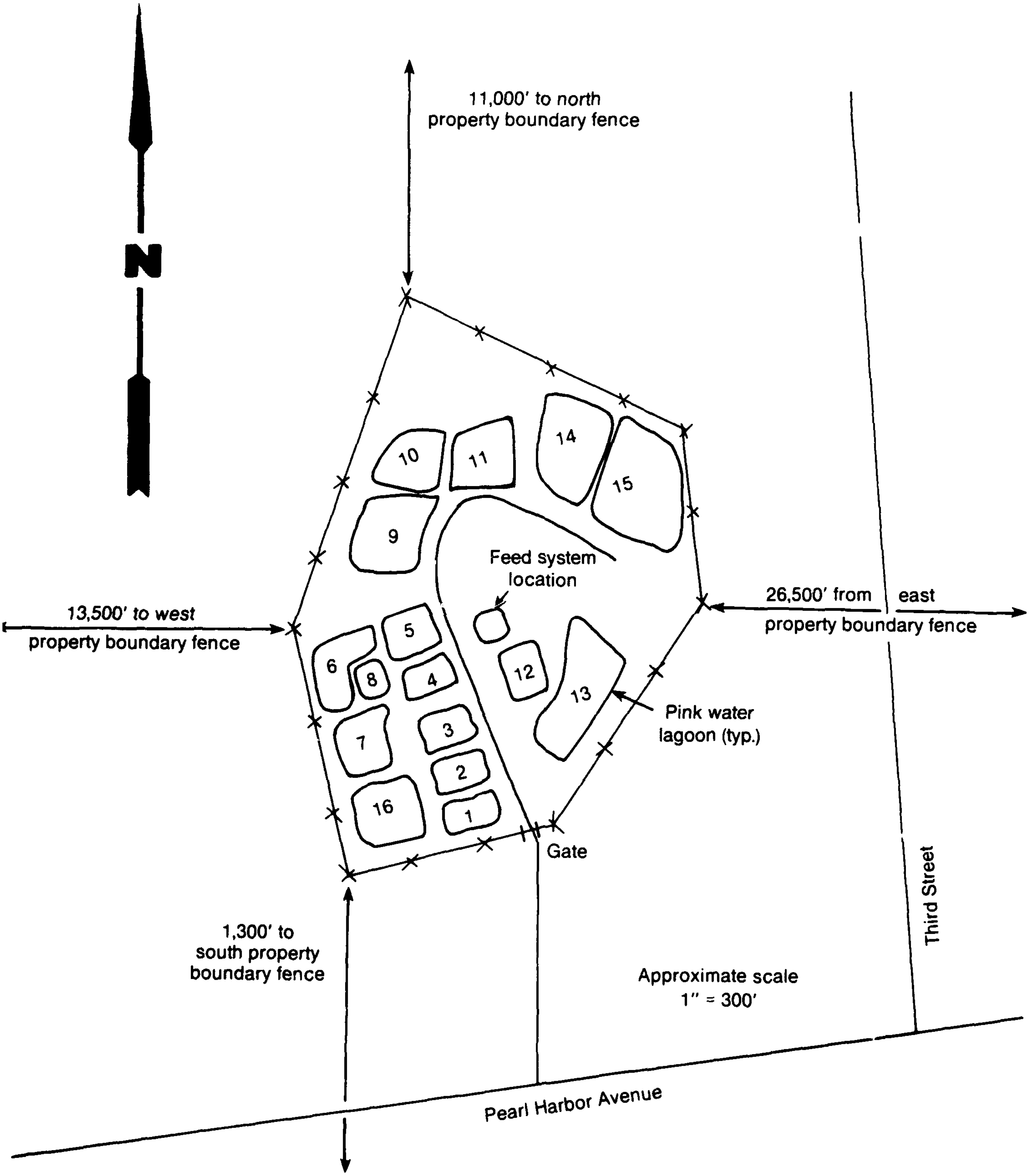


**Figure 1. Test Site.**

(3) The physical properties of LAAP soils (i.e., highly plastic clay) presented the greatest materials handling challenge to the feed system.

(c) Although testing was not to be conducted at CHAAP, soils from CHAAP had to be tested because this installation is an immediate candidate for cleanup via rotary-kiln incineration. However, due to potential regulatory delays involved with transporting explosives-contaminated soils, background (uncontaminated) soils were transported to LAAP for testing.

(d) SADA soils were not tested because there was no apparent advantage in doing so. SADA soils are sandy; therefore, they would not present a significant materials handling problem (as compared to the highly plastic clay soils at LAAP). In addition, explosives concentrations were much lower than those associated with LAAP soils.

2.6 Test equipment. The incinerator feed system consisted of the following three major components:

(a) Live-bottom hopper.
(b) Cross conveyor.
(c) Feed conveyor.

A photograph of the incinerator feed system installed at LAAP is presented in Figure 2. A description of each component, specifications, and construction details are contained in the following subsections.

2.6.1 Live bottom hopper. Excavated soils were fed to the live bottom hopper using a tracked excavator (see Appendix E). The bottom of the hopper was equipped with four cone metering screws. The cone metering screws were selected because they have been proven in other applications to provide the most consistent and reliable method of feed rate control and to minimize the potential for hopper bridging. The hopper was designed to handle a maximum of 18,000 pounds of soil per hour. A photograph of the four metering screws in the bottom of the live bottom hopper is shown in Figure 3. The specification and construction of the hopper are described as follows:

- Screws were 12 inches in diameter and of the "cone" displacement design with solid flights on the cone and ribbon flights on the balance of the screws. Ribbon flights were selected since they have proven to be the most reliable for handling clay soils. The screw shaft was 5-inch Schedule 120 (1/2-inch wall) bushed to 3 15/16-inch shaft size. The ribbon flights were 2 1/2 inch x 1/2 inch thick; posts were 2 inch x 1/2 inch at 120 degrees around the shaft. The ribbon was hard-faced with stellite on the outer edge and face.

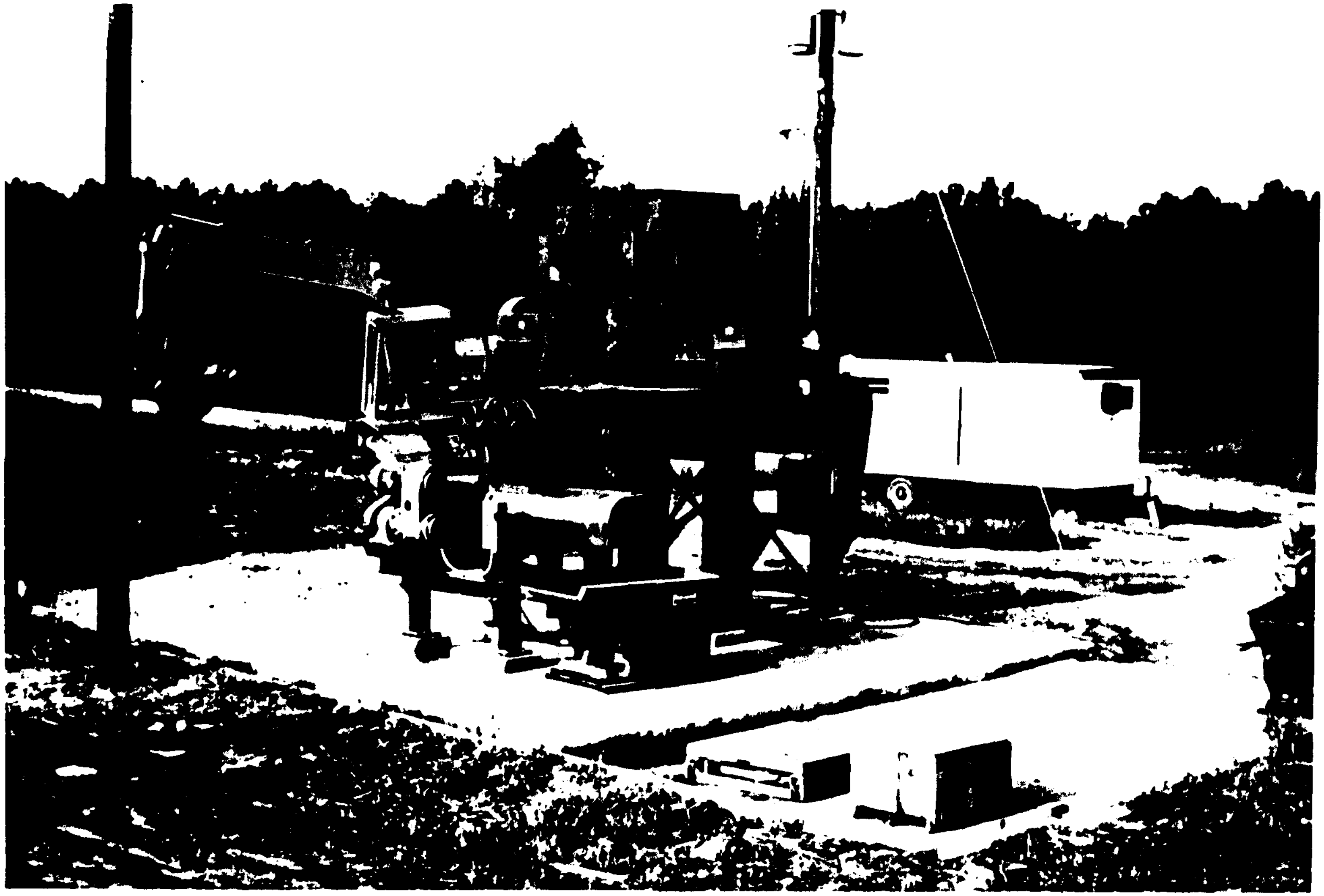

Figure 2. Incinerator feed system.

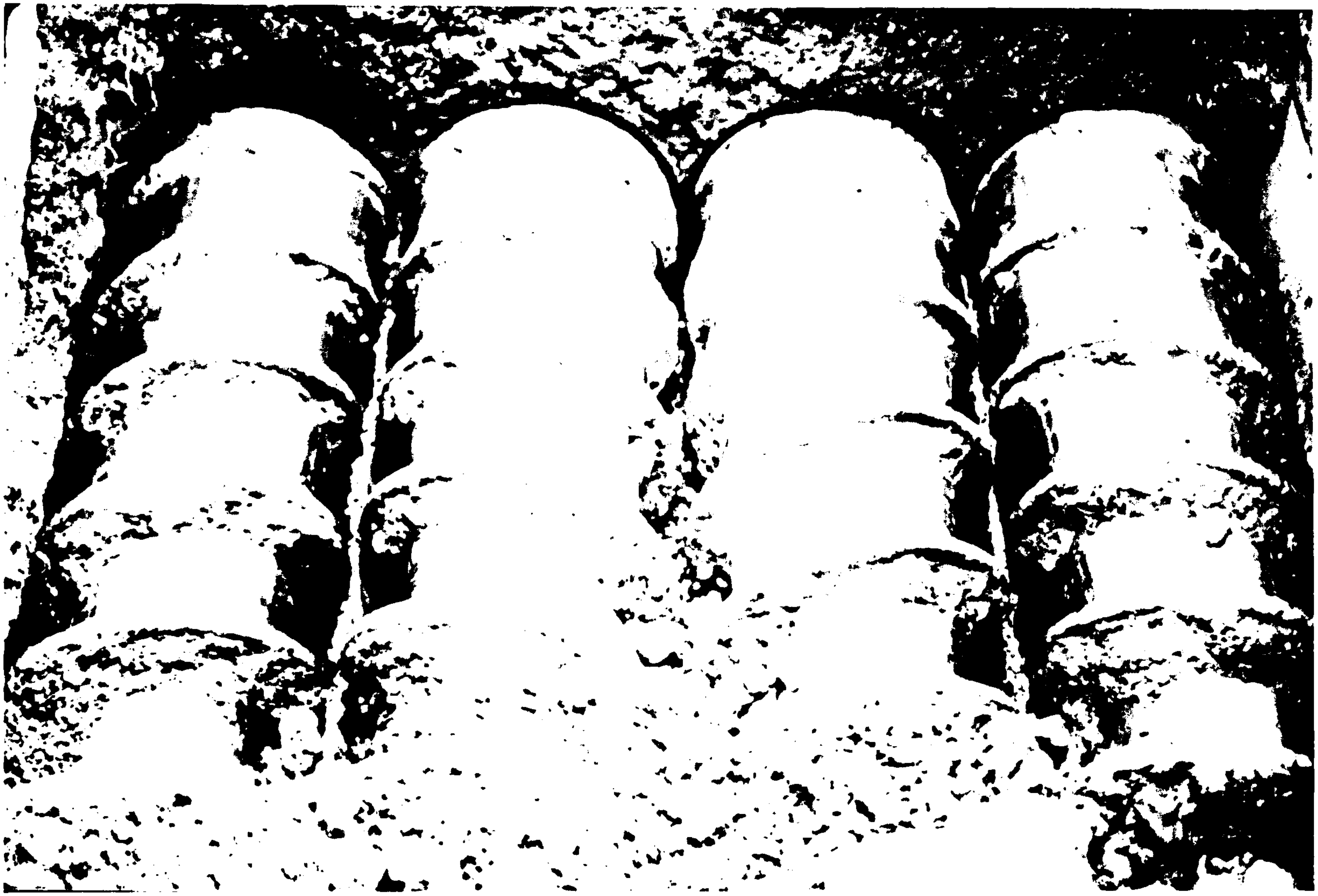

Figure 3. Internal view of live bottom hopper.

- The screws were counter-rotating, right- and left-hand flighting driven by steel spur gears, No. 3 diametrical pitch (DP) with a 3-inch face mounted on 3 15/16-inch drive shafts. Counter-rotating twin screws were also selected since they have proven to be the most reliable for handling clay soils. Final screw speed was 5 rpm maximum with a 9 to 1 turndown.

- The trough for the quad screw feeder was 1/4-inch plate with external reinforcing ribs and bracing. The inside of the trough had "hip-roof" dividers between the screws.

- The trough ends were 3/8-inch plate, with external pedestals for the bearing supports. The spur gears were straddle-mounted by bearings.

- The drive was a 15-hp, totally enclosed, fan cooled (TEFC) with a 9 to 1 variable speed reducer coupled to an in-line reducer. A chain drive connected the reducer and one of the center feed-screw drive shafts. The drive was mounted directly to the feeder and included all Occupational Safety and Health Act (OSHA) approved guards for the gears and the chain drive.

- A bin was permanently mounted over the top of the four metering screws as part of the live bottom hopper. This bin was 4 feet x 6 feet x 4 feet. The bin walls tapered to provide at least 2 degrees negative pitch to prevent bridging in the hopper. The walls were reinforced by ribbing and by 3-inch x 3-inch x 3/8-inch angles. A "breaker bar" grid was placed near the top of the bin to break large lumps and to protect personnel.

- The entire feeder and bin were mounted on 8-inch x 31 lb H beams that supported this equipment approximately 9 feet above the base plate of the support columns. The support steel was all of bolted construction.

- The equipment was completely assembled and tested in the fabricator's plant prior to shipping. The equipment received one coat of primer and a finish coat of epoxy paint.

- All screw conveyor shaft seals where the shafts penetrated the conveyor housing were oil purged to prevent the migration of explosives into the bearing assemblies.

2.6.2 Cross conveyor. Soils were discharged from the live bottom hopper and dropped approximately 2 feet to the feed end of the cross conveyor. This 2-foot drop at conveyor transfer points was included in the design to preclude the propagation of an explosion from one conveyor to another. The twin screw cross conveyor was equipped with right- and left-hand counter-rotating screws. The screws were 12 inches in diameter and 12-1/2 feet long. The components of the cross conveyor were as follows:

- 12-inch diameter ribbon flights, 2-1/2 inch x 1/2-inch ribbon-mounted on 5-inch Schedule 120 pipe bushed for 3-inch diameter shafts. No internal hanger bearing.

- The screws were driven by steel spur gears, 3-inch DP with a 3-inch face.

- The trough was 1/4-inch plate with a 3/16-inch plate cover.

- Trough ends were 3/8-inch plate, outboard pedestal-bearing supports, and straddle-mounted bearings at the spur gears.

- The drive was a 7 1/2-hp TEFC U.S. Reliance varispeed drive. There was a No. 100 chain drive to the screw conveyor drive shaft. Final top speed of the screw was 15 rpm with a 9 to 1 turndown.

- Complete motor mount was provided and directly fastened to the conveyor. The gearing and the chain drive had OSHA guards.

- All screw conveyor shaft seals where the shafts penetrated the conveyor housing were oil purged to prevent the migration of explosives into the bearing assemblies.

2.6.3 Feed conveyor. Soils discharged from the cross conveyor and dropped approximately 2 feet to the feed end of the feed conveyor. This twin-screw feeder will ultimately feed soils to a rotary kiln incinerator. For the field demonstration program, however, the feed conveyor discharged soils into self-dumping steel hoppers for transport back to the lagoon (see Appendix F). The components of the feed conveyor were as follows:

- The construction and specifications for the feed conveyor are the same as those presented for the cross conveyor (as discussed in Subsection 2.6.2). The unit was 6 feet in length and was fabricated of Inconel 625.

- The inner and the outer housings were 1/4-inch plate. Interior baffles between the inner housing and the outer jacket were designed to direct the water in a circular pattern, starting at the feed end and returning through the inside of the screw shafts from the discharge end of the conveyor.

- The two screws had water-cooled center pipes (the axles). The connection was a Johnson coupling with input and output through the same end. No cooling water was circulated for this project.

- The screws were driven by a 15-hp TEFC varispeed motor and reducer identical to the unit described for the live-bottom hopper, except that the maximum speed was 15 rpm with a 9 to 1 turndown.

- The screws were overhung from the two bearings on the drive end. They also had a stabilizing bearing on the inside of the discharge end which was a dry sleeve bearing made of carbon-ceramic material suitable for very high temperatures. The shaft riding in this sleeve bearing was Inconel 625 with an overlap of stellite. These bearings had renewable inserts and were only for stabilizing the discharge end by absorbing some of the side thrust.

- All screw conveyor shaft seals where the shafts penetrated the conveyor housing were oil purged to prevent the migration of explosives into the bearing assemblies.

3. TEST VARIABLES

The variables of the testing program can be classified as follows:

(a) Independent variables. Those whose value was fixed for test operations. No attempts were made to modify or control independent variables.
(b) Control variables. Those whose value was selected and maintained during test operations.
(c) Response variables. Those whose value was a function of the selected operating conditions.

Table 2 provides a summary of test variables for the incinerator feed system field demonstration program.

3.1 Independent variables. As shown in Table 2, there were two independent variables associated with the field demonstration program at each potential remedial action site: soil explosives concentration and soil composition. A summary of the soil explosives concentrations and compositions for each of the two installations based upon previous data appears in Table 3. Again, although CHAAP soils are contaminated, soils chosen for testing were uncontaminated. Soil physical properties, however, were very similar for both.

3.2 Control variables.

3.2.1 Held constant for all tests. As shown in Table 2, two control variables (soil excavation and soil preparation) were held constant for all of the tests.

3.2.1.1 Soil excavation.

3.2.1.1.1 LAAP soil. The selection of LAAP Lagoon No. 4 for excavation the soil for the testing program was based upon the following criteria:

- LAAP Lagoon No. 4 had free-standing water which ensured that the soil was saturated and minimized the risk of potential functioning of the explosives-contaminated soil during excavation.

- LAAP Lagoon No. 4 had adequate access for excavation operations and an adequate supply of uncontaminated water available nearby for washdown and equipment decontamination.

- LAAP Lagoon No. 4 was located as close as practical to the selected site for installation of the feed system to minimize transportation distances.

WESTON

TABLE 2. SUMMARY OF FEED SYSTEM EXPERIMENTAL VARIABLES

A. INDEPENDENT VARIABLES

- Soil explosives concentration
- Soil composition

B. CONTROL VARIABLES

- Held constant for all tests
  - Soil excavation
  - Soil preparation
- Controlled at various levels
  - Soil feed rate
  - Duration of test

C. RESPONSE VARIABLES

- Rotational speed of screw conveyors
  - Live-bottom hopper
  - Cross conveyor
  - Feed conveyor
- Screw conveyor torque (i.e., motor amps)
  - Live-bottom hopper
  - Cros conveyor
  - Feed conveyor
- Physical observations

TABLE 3. CHARACTERISTICS OF EXPLOSIVES-CONTAMINATED SOILS

| Description | Cornhusker Army Ammunition Plant[1,2] (CHAAP) | Louisiana Army Ammunition Plant[3] (LAAP) |
|---|---|---|
| Soil matrix | Silty clay | Clay |
| Moisture content | Unknown | 25 - 30% |
| Ash content (as received) | Unknown | 54 - 66% |
| Explosives content (dry basis) | | |
| - TNT | <3.8% | 5 - 14% |
| - RDX | Not detected | 3 - 10% |
| - HMX | Not detected | 0.6 - 1.4% |
| - Other | <0.2% | <0.06% |
| - Total explosives | <4% | 10 - 22% |
| Heating value | Unknown | 600 - 1,200 Btu/lb |

[1]Based on sampling results from "Cornhusker Army Ammunition Plant," Final Report, Report No. DRXTH-AS-CR-82155, August 1982.
[2]Note: Uncontaminated soils from CHAAP exhibiting similar physical characteristics were used for testing the feed system.
[3]Based on sampling results from "Task 2. Incineration Test of Explosives-Contaminated Soils at Savanna Army Depot Activity, Savanna, Illinois," Final Report, Report Number DRXTH-TE-CR-84277, April 1984.

A photograph of LAAP Lagoon No. 4 is shown in Figure 4. the saturated soil was removed from Lagoon No. 4 using a tracked excavator (see Appendix E). The tracked excavator loaded the saturated soil into a 12-cubic yard capacity dump truck. The dump truck bed was elevated at an approximate 20-degree angle to promote draining of free liquid through the tail gate, allowing the liquid to drain directly back into Lagoon No. 4. After allowing adequate time for drainage of free liquid (typically overnight), the truck dumped the excavated soil into the bermed feed soil staging area adjacent to the test site.

3.2.1.1.2 CHAAP Soil. CHAAP soil was excavated and transported to the LAAP site in two 12-cubic yard capacity dump trucks. To avoid potential regulatory delays due to transporting explosives-contaminated soils, uncontaminated background soil was used. The soil was dumped at a staging area near the test site and covered with visquene to minimize moisture loss or gain. Prior to beginning the testing program the soil was loaded into the dump truck using the tracked excavator and transported to a separate bermed staging area adjacent to the test site.

3.2.1.2 Soil preparation. From this point on, the LAAP and CHAAP soils were handled in exactly the same manner. The soils were reclaimed from the feed soil staging area by the tracked excavator. The operator used the bucket of the tracked excavator to sift through the soil and identify any large debris that would require removal. A technician assisted the operator by manually removing any oversized debris. The technician also collected a grab sample from each bucket load to form a composite feed sample for each test run. The purpose of the composite feed sample was to allow analysis of feed soil moisture content, soil size distribution, and explosives content (LAAP soils only).

The tracked excavator then loaded the reclaimed feed soil directly into the live-bottom hopper. Soil spills were quickly washed into a drainage trench using a fire hose. The drainage trench discharged directly into pink water Lagoon No. 12. As an explosion and fire hazard safety precaution, the fire hose was also used to ensure that all mechanical equipment in contact with the explosives-contaminated soil remained wet.

3.2.2 Controlled at various levels. The two variables that were controlled at various levels to evaluate the impact upon system performance were soil feed rate and duration of the testing period.

**Figure 4. LAAP lagoon no. 4.**

3.2.2.1 Soil feed rate. The design soil feed rate for the materials handling feed system was 8,000 lb/hr. However, to fully evaluate the performance of the system, response variables were also measured at soil feed rates of 50 percent of the design rate (4,000 lb/hr) and 150 percent of the design rate (12,000 lb/hr). This allowed evaluation of system performance over the expected range of operation.

3.2.2.2 Duration of testing period. Generally, the test duration was 4 hours of continuous operation. For both soil types, however, one test run was conducted at the design feed rate (8,000 lb/hr) for 8 hours of continuous operation. The purpose of this longer duration testing was to evaluate how the system would perform over a typical operating shift rotation.

3.3 Response variables. Two response variables were measured separately for each of the three major system components, as shown in Table 2. They were the rotational speed of the screw conveyors and the screw conveyor torques (measured as motor amps) for each of the following:

(a) Live bottom hopper.
(b) Cross conveyor.
(c) Feed conveyor.

3.3.1 Rotational speed of screw conveyors. The rotational speed of the screw conveyors is an important parameter since it relates directly to the conveyor tip speed. Allegany Ballistics Laboratory (see Appendix D) recommended that the conveyor tip speeds be maintained below 2 feet per second when handling explosives-contaminated soils. A summary of the potential rotational speeds and design operating range for each conveyor section of the feed system is provided below:

| Description | Live bottom hopper | Cross conveyor | Feed conveyor |
|---|---|---|---|
| Range of settings for variable speed drive | 0 - 7 | 0 - 7 | 0 - 7 |

| Description | Live bottom hopper | Cross conveyor | Feed conveyor |
|---|---|---|---|
| Conveyor rotation speeds corresponding to the foregoing variable speed drive setting: | | | |
| Revolutions per minute (rpm) | 0.6 - 4.2 | 16 - 88 | 18 - 106 |
| Conveyor tip speed (ft/sec) | 0.03 - 0.21 | 0.8 - 4.4 | 0.9 - 5.3 |
| Conveyor rotational speeds used during the testing program: | | | |
| Revolutions per minute (rpm) | 1.0 - 3.2 | 16 - 26 | 18 - 32 |
| Conveyor tip speed (ft/sec) | 0.03 - 0.17 | 0.8 - 1.3 | 0.9 - 1.6 |

Due to the relatively slow rotational speed of the screw conveyors, this response variable was measured by direct visual observation. Physical observation (i.e., counting the revolutions), combined with use of a stop watch to ensure accurate timing, allowed accurate estimation of screw conveyor rotational speeds.

3.3.2 Screw conveyor torque. Torque for each of the conveyors was measured indirectly by recording the respective drive motor current readings (in amperes) directly from the meters for each drive motor located on the control panel.

## 4. SCHEDULE OF TESTS AND RUNS

To maximize the information gained and minimize the downtime during the pilot study, the schedule of testing activities was carefully planned. The objective of this section is to outline the following:

(a) Overall test schedule.
(b) Test run sequence/schedule of daily activities.

4.1 Overall test schedule. A schedule of test runs and soil type, feed rate, and test duration are shown on Table 4. As shown, test run No. 2 was not completed. During operation, a limit switch on the cross conveyor malfunctioned (i.e., indicated motor amps on cross conveyor were above the set point) and resulted in repeated shutdowns of the hopper conveyor. The reason for the shutdowns was not immediately apparent and much time was spent in investigating the problem. Consequently, there was insufficient time to complete a 4-hour test run. It was decided to rerun this test at the end of the project (as Test Run No. 8). The limit switch was properly adjusted and resulted in no further system shutdowns. In retrospect, although the problem resulted in downtime, it demonstrated the effectiveness of the system for safely discontinuing soil feed in the event of a system failure and the need for panel indicator lights to remain lighted after the warning annuniciator is silenced to determine which limit switch caused the shutdown.

Note that a 4-hour test run for LAAP soil was also not completed. Originally, as with the CHAAP soil, two test runs were to be evaluated for the 8,000 lb/hr feed rate, a 4-hour run and an 8-hour steady-state run. The steady-state run presented a greater challenge to the feed system and, since nothing significant was learned when both the short and long duration runs were conducted on CHAAP soil, the short test run for LAAP soil was deleted from the schedule.

4.2 Test run sequence/schedule of daily activities. The typical daily schedule for system testing during the 4-hour test runs was as follows:

## TABLE 4. SCHEDULE OF TEST RUNS

| Test run number | Date (1986) | Soil type | Feed rate (lb/hr) | Test run duration (hours) | |
|---|---|---|---|---|---|
| | | | | Target | Actual |
| 1 | June 30 | CHAAP | 4,000 | 4 | 4 |
| 2 | June 31 | CHAAP | 12,000 | 4 | 2* |
| 3 | July 1 | CHAAP | 8,000 | 4 | 4 |
| 4 | July 2 | CHAAP | 8,000 | 8 | 8 |
| 5 | July 8 | LAAP | 4,000 | 4 | 5 |
| 6 | July 8 | LAAP | 12,000 | 4 | 4.5 |
| 7 | July 9 | LAAP | 8,000 | 8 | 8 |
| 8 | July 10 | CHAAP | 12,000 | 4 | 4.5 |

*Test Run No. 2 was not completed. This test was repeated as Test Run No. 8.

| Activity | Duration |
| --- | --- |
| Feed uncontaminated soil | 1 hour |
| Feed contaminated soil | 4 hours |
| Feed uncontaminated soil | 1 hour |
| Equipment cleanup/decontamination | 2 hours |
| Total | 8 hours |

The typical daily schedule for system testing during the 8-hour test runs was as follows:

| Activity | Duration |
| --- | --- |
| Feed uncontaminated soil | 1 hour |
| Feed contaminated soil | 8 hours |
| Feed uncontaminated soil | 1 hour |
| Equipment cleanup/decontamination | 2 hours |
| Total | 12 hours |

Testing was also performed under upset- and/or failure-mode conditions. The objective of this phase of testing was to check all of the alarm systems.

A summary of the alarm systems tested, the simulated cause of the alarm, the system response, and the appropriate operator response is provided in Table 5.

TABLE 5. FEED SYSTEMS OPERATIONAL SAFETY CONTROLS
UPSET- AND/OR FAILURE-MODE TESTING

| Description | Potential cause | System response | Operator response |
|---|---|---|---|
| 1. Low motor amps in live bottom hopper | Hopper empty or at very low level.<br><br>Bridging in hopper. | Alarm. | If hopper is empty or at very low level, feed background soil.<br><br>If not, shut down system and clear bridging in hopper. |
| 2. High motor amps in live bottom hopper | Hopper overloaded.<br><br>Partial jamming of screws. | Alarm. | Continue operating without feeding any more soil to hopper.<br><br>Monitor motor amps closely. |
| 3. High-high motor amps in live bottom hopper | Jam in live bottom hopper screws. | Alarm.<br><br>Screws will automatically reverse partial revolution and attempt to restart.<br><br>If jam persists, prior procedures will repeat once, then live bottom hopper will shut down. | If live bottom hopper shuts down, remove access door and clear jam.<br><br>Restart system and monitor motor amps closely. |

TABLE 5. (CONTINUED)

| Description | Potential cause | System response | Operator response |
|---|---|---|---|
| 4. High motor amps in cross conveyor | Conveyor over-loaded.<br><br>Partial jamming of screws. | Alarm.<br><br>Live bottom hopper will shut down.<br><br>Live bottom hopper must be manually restart-ed once cross conveyor motor amps decrease to acceptable level. | Monitor motor amps closely.<br><br>Restart live bottom hopper once motor amps decrease to acceptable level. |
| 5. High-high motor amps in cross conveyor | Jam in cross conveyor screws. | Alarm<br><br>Live bottom hopper will shut down.<br><br>Cross conveyor screws will automatically reverse partial revolution and attempt to restart.<br><br>Live bottom hopper must be manually restart-ed once cross conveyor motor amps decrease to acceptable level.<br><br>If jam persists, prior procedure will repeat once, then cross conveyor will shut down. | Monitor motor amps closely.<br><br>Restart live bottom hopper once motor amps decrease to acceptable level.<br><br>If jam persists and cross conveyor shuts down, shut down system and clear the jam.<br><br>Restart cross conveyor, then live bottom hopper, and monitor motor amps closely. |

TABLE 5. (CONTINUED)

| Description | Potential cause | System response | Operator response |
|---|---|---|---|
| 6. High motor amps in feed conveyor | Conveyor overloaded.<br><br>Partial jamming of screws. | Alarm.<br><br>Live bottom hopper and cross conveyor will shut down.<br><br>Cross conveyor then live bottom hopper must be restarted manually once feed conveyor motor amps decrease to acceptable level. | Monitor motor amps closely.<br><br>Restart cross conveyor, then live bottom hopper once feed conveyor motor amps decrease to acceptable level. |
| 7. High-high motor amps in feed conveyor | Jam in feed conveyor screws. | Alarm.<br><br>Live bottom hopper and cross conveyor will shut down.<br><br>Feed conveyor screws will automatically reverse partial revolution and attempt to restart.<br><br>Cross conveyor, then live bottom hopper must be manually restarted once feed conveyor motor amps decrease to acceptable level. | Monitor motor amps closely.<br><br>Restart cross conveyor, then live bottom hopper once motor amps decrease to acceptable level.<br><br>If jam persists and feed conveyor shuts down, shut down system and clear the jam.<br><br>Restart feed conveyor, then restart cross conveyor and live bottom hopper and monitor motor amps closely. |

TABLE 5. (CONTINUED)

| Description | Potential cause | System response | Operator response |
|---|---|---|---|
| | | If jam persists, prior procedure will repeat once, then feed conveyor will shut down. | |
| 8. Emergency shutdown | Loss of electrical power. | Alarm. | Determine reason for shutdown. |
| | Operator hits "panic" button. | System will shut down automatically.<br><br>System must be manually restarted once the reason for shutdown has been corrected. | If due to loss of electrical power, ensure that electrical power is reinstated prior to attempting to restart system.<br><br>If due to operator initiation, ensure that the reason for shutdown has been corrected.<br><br>Initiate equipment startup procedures. |

# 5. DATA ANALYSIS

## 5.1 Presentation of CHAAP Data

5.1.1 4,000-lb/hr feed system test (Test Run No. 1). The data for the 4,000-lb/hr CHAAP feed system test (Run No. 1) are summarized in Table 6. Figure 5 is a graphic plot of the variation in actual feed rate during Test Run No. 1 compared to the target feed rate of 4,000 lb/hr. Figure 6 provides a graphic plot of the variation in motor amps for the hopper conveyor, cross conveyor, and feed conveyor during Test Run No. 1.

5.1.2 8,000 lb/hr feed system test (Test Run Nos 3 and 4). The data for the 4-hour, 8,000-lb/hr CHAAP feed system (Run No. 3) are summarized in Table 7. Graphic plots of the variation in actual feed rates and motor amps during Test Run No. 3 are presented in Figures 7 and 8, respectively.

The data for the 8-hour, 8,000-lb/hr CHAAP feed system test (Run No. 4) are summarized in Table 8. Graphic plots of the variation in actual feed rates and motor amps during Test Run No. 3 are presented in Figures 9 and 10, respectively.

5.1.3 12,000-lb/hr feed system test (Test Run No. 8). The data for the 12,000-lb/hr CHAAP feed system test (Run No. 8) are summarized in Table 9. Graphic plots of the variation in actual feed rates and motor amps during Test run No. 8 are presented in Figures 11 and 12, respectively.

## 5.2 Presentation of LAAP data

5.2.1 4,000-lb/hr feed system test (Test Run No. 5). The data for the 4,000-lb/hr LAAP feed system test (Test Run No. 5) are summarized in Table 10. Graphic plots of the variation in actual feed rates and motor amps are presented in Figures 13 and 14, respectively.

5.2.2. 8,000-lb/hr feed system test (Test Run No. 7). The data for the 8-hour, 8,000-lb/hr LAAP feed system test (Run No. 7) are summarized in Table 11. Graphic plots of the variation in actual feed rates and motor amps during Test Run No. 7 are presented in Figures 15 and 16, respectively.

5.2.3 12,000-lb/hr feed system test (Test Run No. 6). The data for the 12,000-lb/hr LAAP feed system test (Run No. 6) are summarized in Table 12. Graphic plots of the variation in actual feed rates and motor amps during Test Run No. 6 are presented in Figures 17 and 18, respectively.

TABLE [illegible]. SUMMARY OF TEST DATA FOR TEST RUN NO. 1, CHAAP SOIL, 4,000-LB/HR

RUN 1
6/30/86
CHAAP SOIL
TARGET FEED: 4,000 LB/HR

| Time (min-utes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor (%)[1] | Feed conveyor Motor amps | Cross conveyor (%)[1] | Cross conveyor Motor amps | Live bottom hopper (%)[1] | Live bottom hopper Motor amps | Feed conveyor Drive setting | Feed conveyor Speed (ppm) | Feed conveyor (%)[2] | Cross Conveyor Drive setting | Cross Conveyor Speed (rpm) | Cross Conveyor (%)[2] | Live bottom hopper Drive setting | Live bottom hopper Speed (rpm) | Live bottom hopper (%)[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | 25 | 10.5 | 30 | 6.6 | 28 | 11.76 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 15 | | | | 25 | 10.5 | 31 | 6.82 | 28 | 11.76 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 20 | 20 | 1,411 | 4,233 | | | | | | | | | | | | | | | |
| 30 | | | | 25 | 10.5 | 31 | 6.82 | 28 | 11.76 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 40 | 20 | 1,305 | 3,915 | | | | | | | | | | | | | | | |
| 45 | | | | 25 | 10.5 | 31 | 6.82 | 28 | 11.76 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 55 | 15 | 899 | 3,596 | | | | | | | | | | | | | | | |
| 60 | | | | 25 | 10.5 | 32 | 7.04 | 29 | 12.18 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 75 | 20 | 1,337 | 4,011 | 25 | 10.5 | 32 | 7.04 | 28 | 11.76 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 90 | | | | 25 | 10.5 | 31 | 6.82 | 28 | 11.76 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 95 | 20 | 1,361 | 4,053 | | | | | | | | | | | | | | | |
| 105 | | | | 25 | 10.5 | 32 | 7.04 | 29 | 12.18 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 120 | 25 | 1,683 | 4,039 | 25 | 10.5 | 33 | 7.26 | 29 | 12.18 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 135 | | | | 25 | 10.5 | 34 | 7.48 | 30 | 12.6 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 140 | 20 | 1,219 | 3,651 | | | | | | | | | | | | | | | |
| 150 | | | | 25 | 10.5 | 33 | 7.26 | 30 | 12.6 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 160 | 20 | 1,433 | 4,299 | | | | | | | | | | | | | | | |
| 165 | | | | 25 | 10.5 | 33 | 7.26 | 30 | 12.6 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 180 | 20 | 1,196 | 3,588 | 26 | 10.92 | 33 | 7.26 | 29 | 12.18 | 0.4 | 21 | 52 | 0 | 14.5 | 36 | 1 | 1 | 2.5 |
| 195 | | | | 26 | 10.92 | 37 | 8.14 | 29 | 12.18 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1 | 1 | 2.5 |
| 200 | 20 | 1,238 | 3,714 | | | | | | | | | | | | | | | |
| 210 | | | | 25 | 10.5 | 38 | 8.36 | 28 | 11.76 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1 | 1 | 2.5 |
| 220 | 20 | 1,342 | 4,026 | | | | | | | | | | | | | | | |
| 225 | | | | 25 | 10.5 | 38 | 8.36 | 28 | 11.76 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1 | 1 | 2.5 |
| 240 | 20 | 1,253 | 3,759 | 25 | 10.5 | 37 | 8.14 | 28 | 11.76 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1 | 1 | 2.5 |

[1](%) indicates percent of full load motor amps. Full load motor amps are as follows: feed conveyor - 42 amps, cross conveyor - 22 amps, and hopper conveyor - 42 amps.
[2](%) indicates percent of maximum safe conveyor tip speed of 2 feet per second (40 rpm).

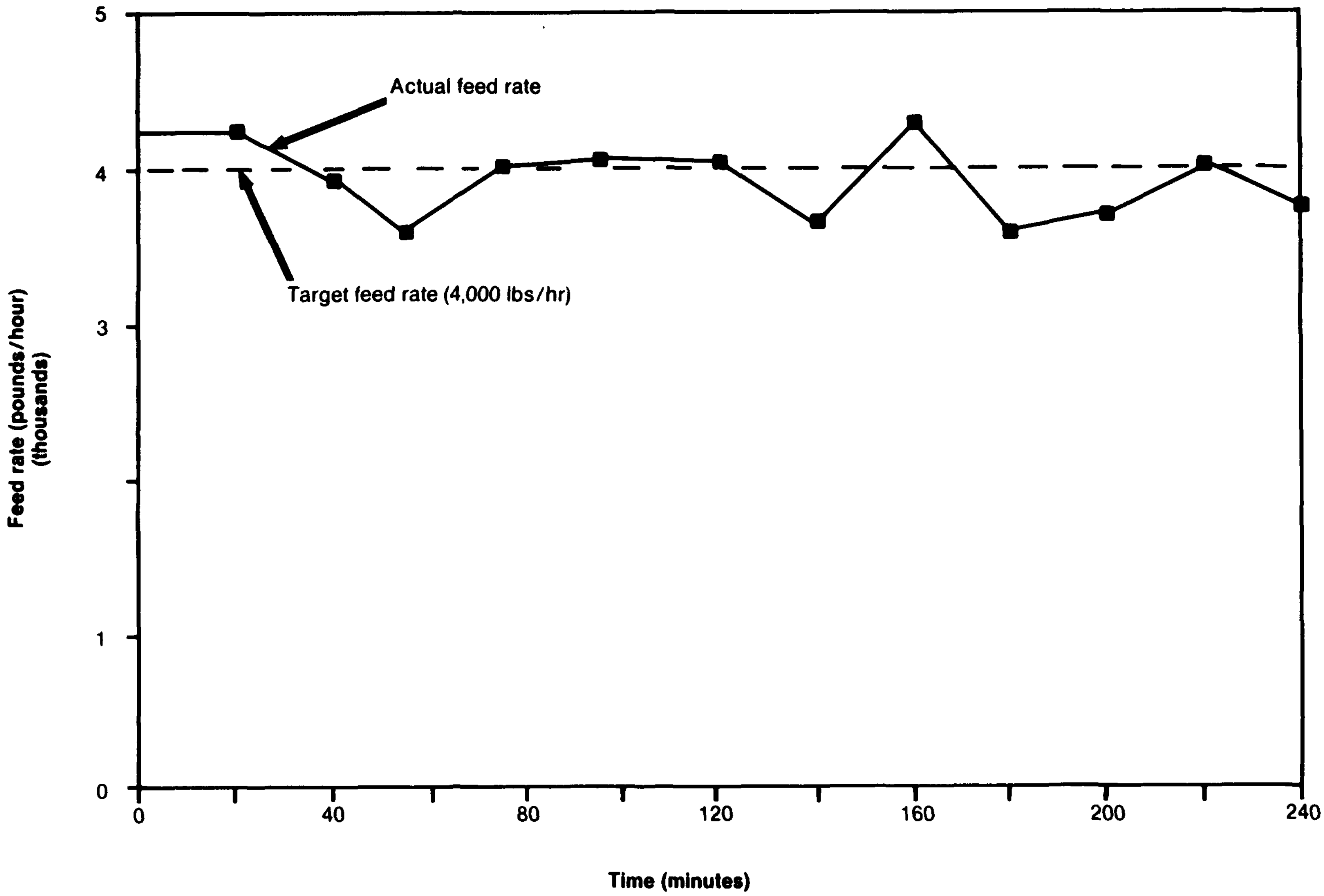


Figure 5. Feed rate during test run no. 1, CHAAP soil, 4,000 lb./hr.

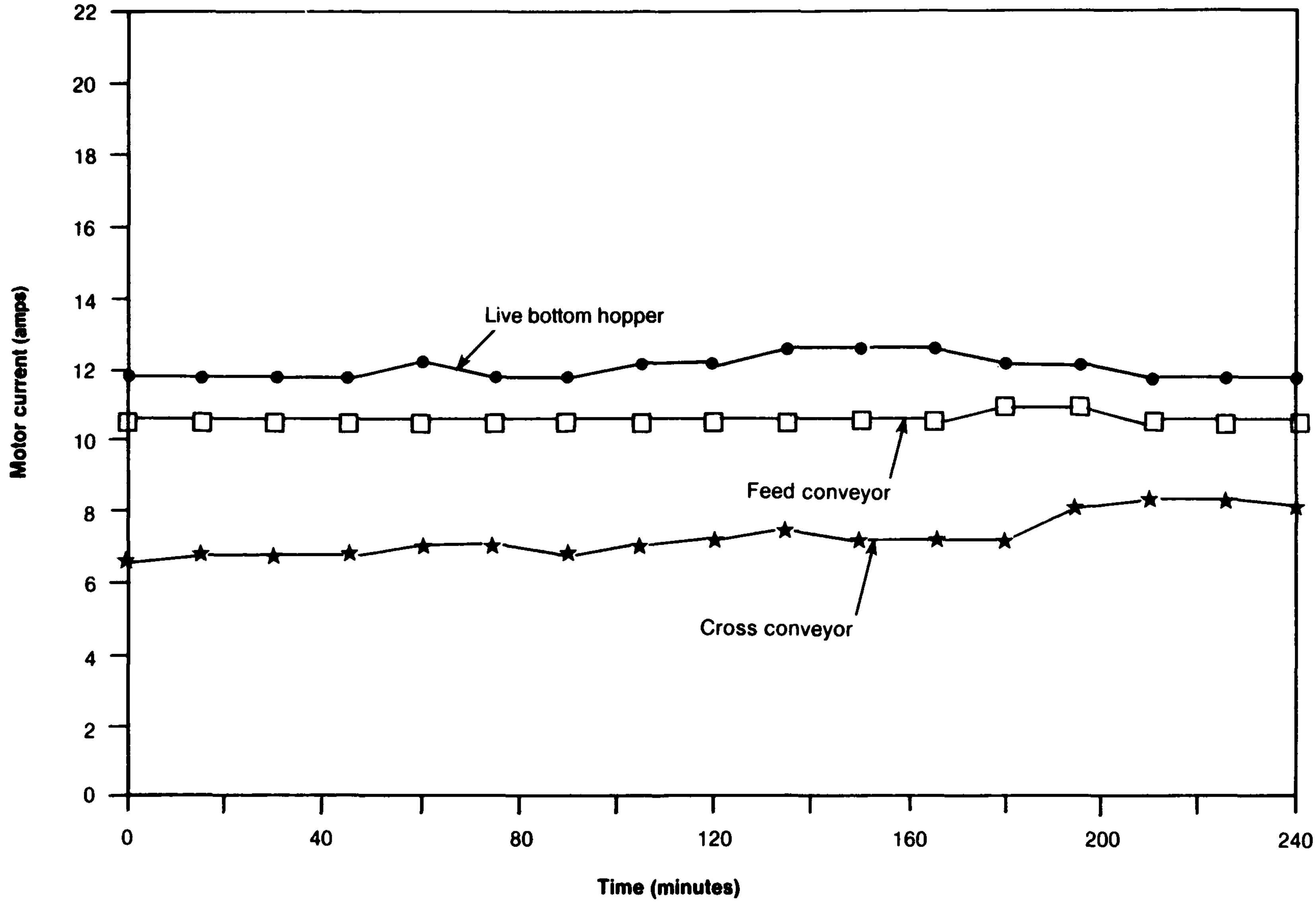


**Figure 6. Motor current during test run no. 1, CHAAP soil, 4,000 lb./hr.**

TABLE 7. SUMMARY OF TEST DATA FOR TEST RUN NO. 3, CHAAP SOIL, 8,000-LB/HR, 4-HOUR TEST

RUN 3
7/1/86
CHAAP SOIL
TARGET FEED: 8,000 LB/HR (4-HOUR RUN)

| Time (min-utes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor (%) | Feed conveyor Motor amps | Cross conveyor (%) | Cross conveyor Motor amps | Live bottom hopper (%) | Live bottom hopper Motor amps | Feed conveyor Drive setting | Feed conveyor Speed (ppm) | Feed conveyor (%) | Cross Conveyor Drive setting | Cross Conveyor Speed (rpm) | Cross Conveyor (%) | Live bottom hopper Drive setting | Live bottom hopper Speed (rpm) | Live bottom hopper (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | 25 | 10.5 | 40 | 8.8 | 31 | 13.02 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 10 | 10 | 1,325 | 7,950 | | | | | | | | | | | | | | | |
| 15 | | | | 25 | 10.5 | 42 | 9.24 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 20 | 10 | 1,374 | 8,244 | | | | | | | | | | | | | | | |
| 30 | 10 | 1,381 | 8,286 | 25 | 10.5 | 43 | 9.46 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 40 | 10 | 1,403 | 8,418 | | | | | | | | | | | | | | | |
| 45 | | | | 25 | 10.5 | 40 | 8.8 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 50 | 10 | 1,326 | 7,956 | | | | | | | | | | | | | | | |
| 60 | 10 | 1,331 | 7,986 | 25 | 10.5 | 40 | 8.8 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 71 | 11 | 1,468 | 7,920 | | | | | | | | | | | | | | | |
| 75 | | | | 25 | 10.5 | 40 | 8.8 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 80 | 9 | 1,195 | 7,967 | | | | | | | | | | | | | | | |
| 90 | | | | 25 | 10.5 | 40 | 8.8 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 91 | 11 | 1,451 | 7,915 | | | | | | | | | | | | | | | |
| 100 | 9 | 1,166 | 7,773 | | | | | | | | | | | | | | | |
| 105 | | | | 26 | 10.92 | 40 | 8.8 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 111 | 11 | 1,457 | 7,947 | | | | | | | | | | | | | | | |
| 120 | | | | 26 | 10.92 | 42 | 9.24 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 121 | 10 | 1,381 | 8,286 | | | | | | | | | | | | | | | |
| 130 | 9 | 1,167 | 7,780 | | | | | | | | | | | | | | | |
| 135 | | | | 26 | 10.92 | 42 | 9.24 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 140 | 10 | 1,223 | 7,338 | | | | | | | | | | | | | | | |
| 150 | 10 | 1,320 | 7,926 | 26 | 10.92 | 41 | 9.02 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 160 | 10 | 1,239 | 7,434 | | | | | | | | | | | | | | | |
| 165 | | | | 26 | 10.92 | 42 | 9.24 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 170 | 10 | 1,320 | 8,220 | | | | | | | | | | | | | | | |
| 179 | 9 | 1,226 | 8,173 | | | | | | | | | | | | | | | |
| 180 | | | | 26 | 10.92 | 41 | 9.02 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 190 | 11 | 1,406 | 7,669 | | | | | | | | | | | | | | | |
| 195 | | | | 26 | 10.92 | 42 | 9.24 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 200 | 10 | 1,321 | 7,926 | | | | | | | | | | | | | | | |
| 210 | 10 | 1,334 | 8,004 | 26 | 10.92 | 43 | 9.46 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 220 | 10 | 1,282 | 7,692 | | | | | | | | | | | | | | | |
| 225 | | | | 27 | 11.34 | 44 | 9.68 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 230 | 10 | 1,384 | 8,304 | | | | | | | | | | | | | | | |
| 240 | 10 | 1,353 | 8,118 | 27 | 11.34 | 43 | 9.46 | 29 | 12.18 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |



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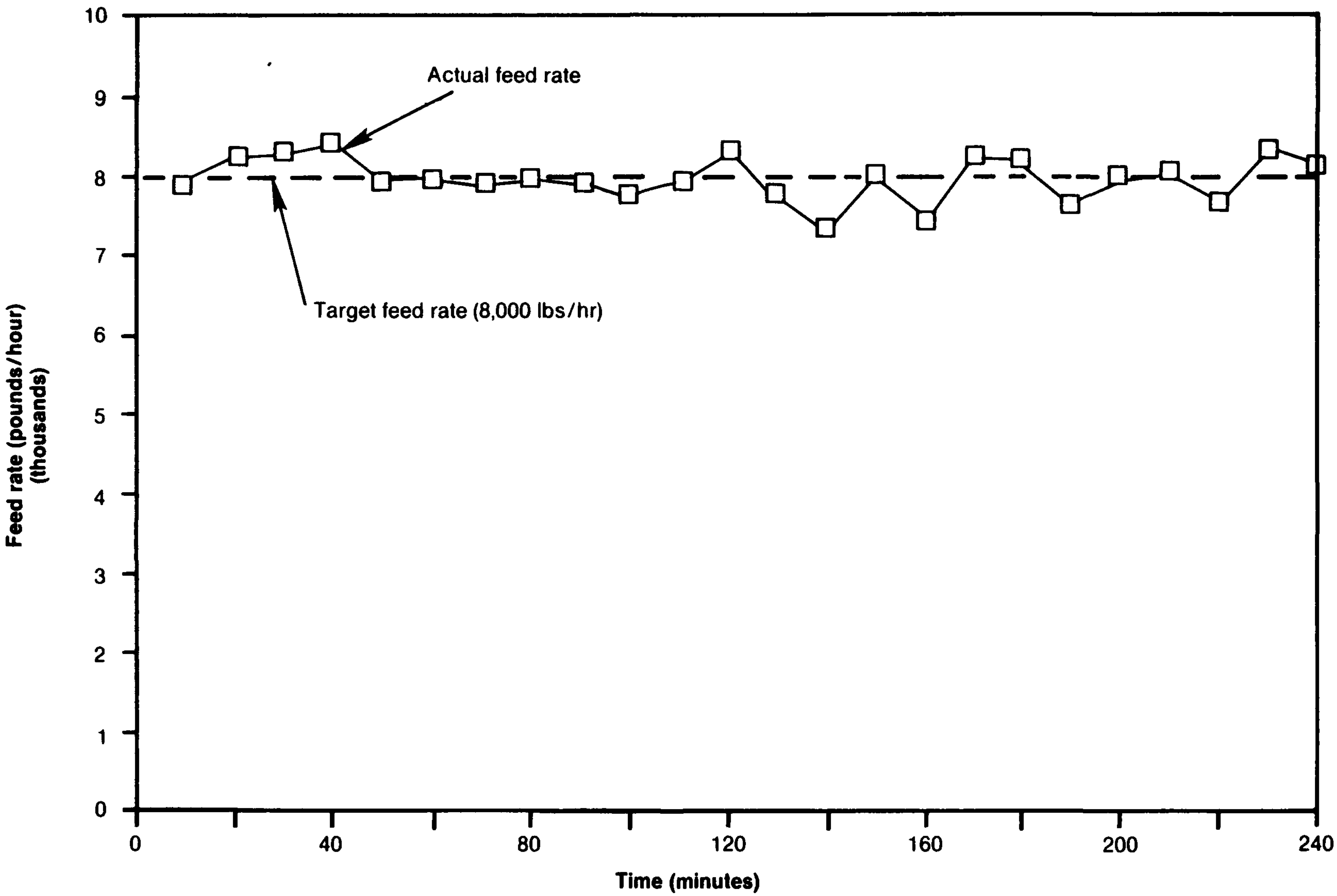


Figure 7. Feed during test run no. 3, CHAAP soil, 8,000 lb./hr., 4-hour test.

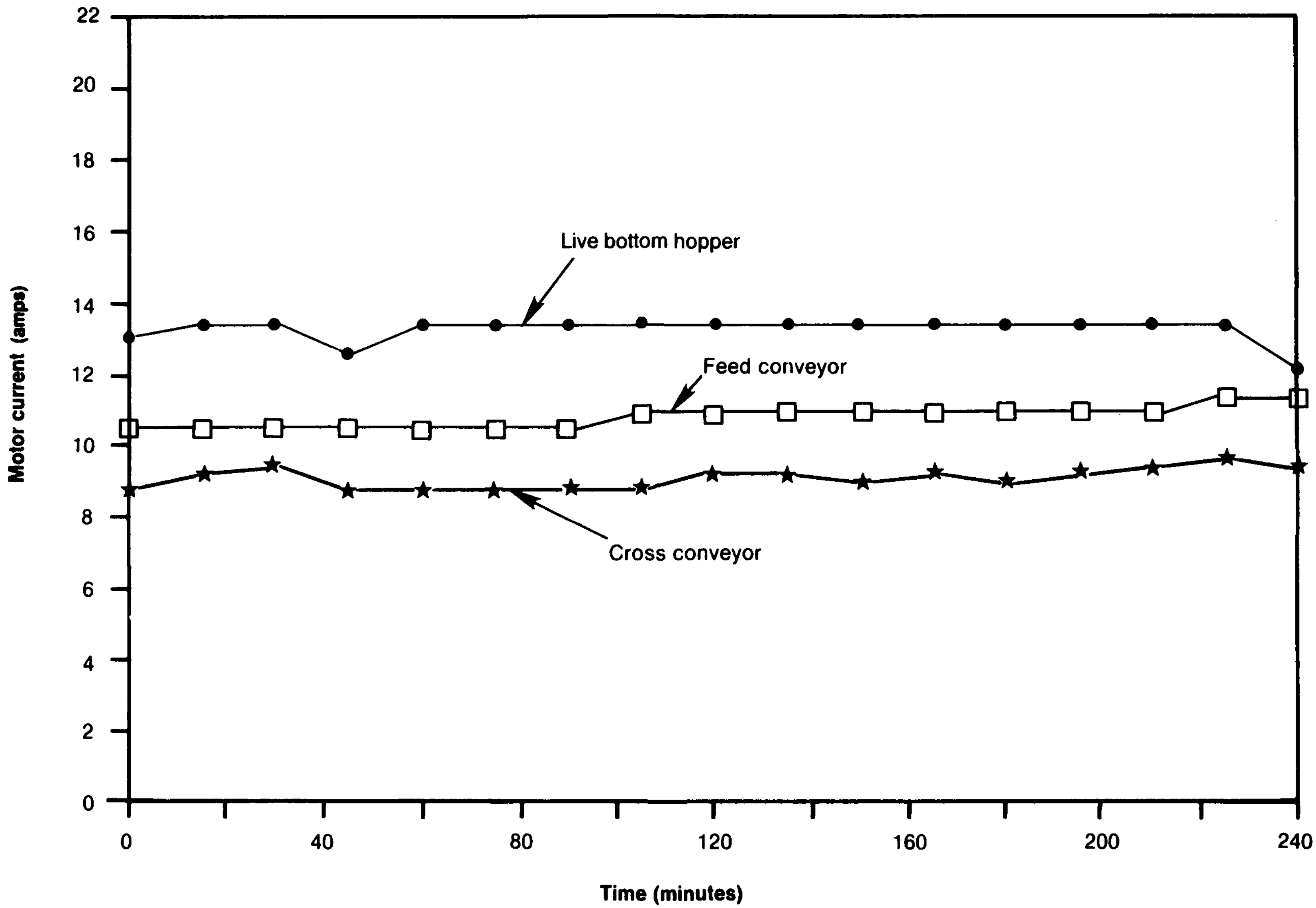


**Figure 8. Motor current during test run no. 3, CHAAP soil, 8,000 lb./hr., 4-hour test.**

RUN 4
7/2/86
CHAAP SOIL
TARGET FEED: 8,000 LB/HR (8-HOUR RUN)

| Time (min-utes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor (%) | Feed conveyor Motor amps | Cross conveyor (%) | Cross conveyor Motor amps | Live bottom hopper (%) | Live bottom hopper Motor amps | Feed conveyor Drive setting | Feed conveyor Speed (ppm) | Feed conveyor (%) | Cross Conveyor Drive setting | Cross Conveyor Speed (rpm) | Cross Conveyor (%) | Live bottom hopper Drive setting | Live bottom hopper Speed (rpm) | Live bottom hopper (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | 25 | 10.5 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 10 | 10 | 1,302 | 7,812 | | | | | | | | | | | | | | | |
| 15 | | | | 25 | 10.5 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 20 | 10 | 1,275 | 7,650 | | | | | | | | | | | | | | | |
| 30 | 10 | 1,378 | 8,268 | 25 | 10.5 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 40 | 10 | 1,375 | 8,250 | | | | | | | | | | | | | | | |
| 45 | | | | 25 | 10.5 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 50 | 10 | 1,180 | 7,080 | | | | | | | | | | | | | | | |
| 60 | 10 | 1,241 | 7,446 | 25 | 10.5 | 48 | 10.56 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 70 | 10 | 1,214 | 7,284 | | | | | | | | | | | | | | | |
| 75 | | | | 25 | 10.5 | 50 | 11.0 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 80 | 10 | 1,151 | 6,906 | | | | | | | | | | | | | | | |
| 90 | | | | 25 | 10.5 | 50 | 11.0 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.8 | 2.5 | 6.2 |
| 91 | 11 | 1,327 | 7,238 | | | | | | | | | | | | | | | |
| 100 | 9 | 1,176 | 7,840 | | | | | | | | | | | | | | | |
| 105 | | | | 25 | 10.5 | 49 | 10.78 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.8 | 2.5 | 6.2 |
| 111 | 11 | 1,289 | 7,030 | | | | | | | | | | | | | | | |
| 120 | 9 | 1,053 | 7,020 | 25 | 10.5 | 50 | 11.0 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.0 | 2.75 | 6.9 |
| 130 | 10 | 1,417 | 8,502 | | | | | | | | | | | | | | | |
| 135 | | | | 25 | 10.5 | 55 | 12.1 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.0 | 2.75 | 6.9 |
| 138 | 8 | 1,281 | 9,608 | | | | | | | | | | | | | | | |
| 147 | 9 | 1,373 | 9,153 | | | | | | | | | | | | | | | |
| 150 | | | | 26 | 10.92 | 50 | 11.0 | 33 | 13.86 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.7 | 2.33 | 5.8 |
| 156 | 9 | 1,318 | 8,787 | | | | | | | | | | | | | | | |
| 165 | 9 | 1,396 | 9,306 | 26 | 10.92 | 49 | 10.78 | 33 | 13.86 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.7 | 2.33 | 5.8 |
| 176 | 11 | 1,2[illegible]6 | 7,410 | | | | | | | | | | | | | | | |
| 180 | | | | 26 | 10.92 | 50 | 11.0 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.0 | 2 | 5 |
| 187 | 11 | 1,395 | 7,609 | | | | | | | | | | | | | | | |
| 195 | | | | 26 | 10.92 | 51 | 11.22 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.2 | 2.2 | 5.5 |
| 198 | 11 | 1,202 | 8,013 | | | | | | | | | | | | | | | |
| 207 | 9 | 1,200 | 8,000 | | | | | | | | | | | | | | | |
| 210 | | | | 25 | 10.5 | 50 | 11.0 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.2 | 2.2 | 5.5 |
| 216 | 9 | 1,156 | 7,706 | | | | | | | | | | | | | | | |

TABLE 8. (CONTINUED)

RUN 4
7/2/86
CHAAP SOIL
TARGET FEED: 8,000 LB/HR (8-HOUR RUN)

| Time (min-utes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor (%) | Feed conveyor Motor amps | Cross conveyor (%) | Cross conveyor Motor amps | Live bottom hopper (%) | Live bottom hopper Motor amps | Feed conveyor Drive setting | Feed conveyor Speed (ppm) | Feed conveyor (%) | Cross Conveyor Drive setting | Cross Conveyor Speed (rpm) | Cross Conveyor (%) | Live bottom hopper Drive setting | Live bottom hopper Speed (rpm) | Live bottom hopper (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 225 | 9 | 1,086 | 7,240 | 27 | 11.34 | 52 | 11.44 | 29 | 12.18 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.2 | 2.2 | 5.5 |
| 234 | 9 | 1,053 | 7,020 | | | | | | | | | | | | | | | |
| 240 | | | | 27 | 11.34 | 52 | 11.44 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.2 | 2.2 | 5.5 |
| 244 | 10 | 1,111 | 6,666 | | | | | | | | | | | | | | | |
| 253 | 9 | 1,102 | 7,347 | | | | | | | | | | | | | | | |
| 255 | | | | 26 | 10.92 | 55 | 12.1 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.2 | 2.2 | 5.5 |
| 262 | 9 | 1,150 | 7,667 | | | | | | | | | | | | | | | |
| 270 | | | | 26 | 10.92 | 53 | 11.66 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.2 | 2.2 | 5.5 |
| 271 | 9 | 1,099 | 7,326 | | | | | | | | | | | | | | | |
| 280 | 9 | 1,060 | 7,067 | | | | | | | | | | | | | | | |
| 285 | | | | 26 | 10.92 | 55 | 12.1 | 31 | 13.02 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.6 | 2.4 | 6.0 |
| 290 | 10 | 1,268 | 7,608 | | | | | | | | | | | | | | | |
| 300 | 10 | 1,198 | 7,188 | 26 | 10.92 | 63 | 13.86 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.6 | 2.4 | 6.0 |
| 310 | 10 | 1,170 | 7,020 | | | | | | | | | | | | | | | |
| 315 | | | | 26 | 10.92 | 63 | 13.86 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 320 | 10 | 1,229 | 7,334 | | | | | | | | | | | | | | | |
| 330 | 10 | 1,363 | 8,178 | 26 | 10.92 | 63 | 13.86 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 340 | 10 | 1,486 | 8,916 | | | | | | | | | | | | | | | |
| 345 | | | | | | | | | | | | | | | | | | |
| 350 | 10 | 1,472 | 8,832 | 26 | 10.92 | 60 | 13.2 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 360 | 10 | 1,581 | 9,486 | 27 | 11.34 | 48 | 10.56 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 370 | 10 | 1,314 | 7,884 | | | | | | | | | | | | | | | |
| 375 | | | | 28 | 11.76 | 53 | 11.66 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 380 | 10 | 1,504 | 9,024 | | | | | | | | | | | | | | | |
| 390 | 10 | 1,512 | 9,072 | 29 | 12.18 | 53 | 11.66 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 400 | 10 | 1,437 | 8,622 | | | | | | | | | | | | | | | |
| 405 | | | | 28 | 11.76 | 53 | 11.66 | 28 | 11.76 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 410 | 10 | 1,390 | 8,340 | | | | | | | | | | | | | | | |
| 420 | 10 | 1,454 | 8,724 | 27 | 11.34 | 53 | 11.66 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 430 | 10 | 1,431 | 8,586 | | | | | | | | | | | | | | | |
| 435 | | | | 27 | 11.34 | 54 | 11.88 | 33 | 13.86 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 440 | 10 | 1,422 | 8,532 | | | | | | | | | | | | | | | |
| 450 | 10 | 1,379 | 8,274 | 28 | 11.76 | 55 | 12.1 | 32 | 13.44 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 460 | 10 | 1,303 | 7,818 | | | | | | | | | | | | | | | |
| 465 | | | | 29 | 12.18 | 55 | 12.1 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |
| 470 | 10 | 1,240 | 7,440 | | | | | | | | | | | | | | | |
| 480 | 10 | 1,343 | 8,058 | 28 | 11.76 | 56 | 12.32 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 3.9 | 2.6 | 6.5 |



0492B

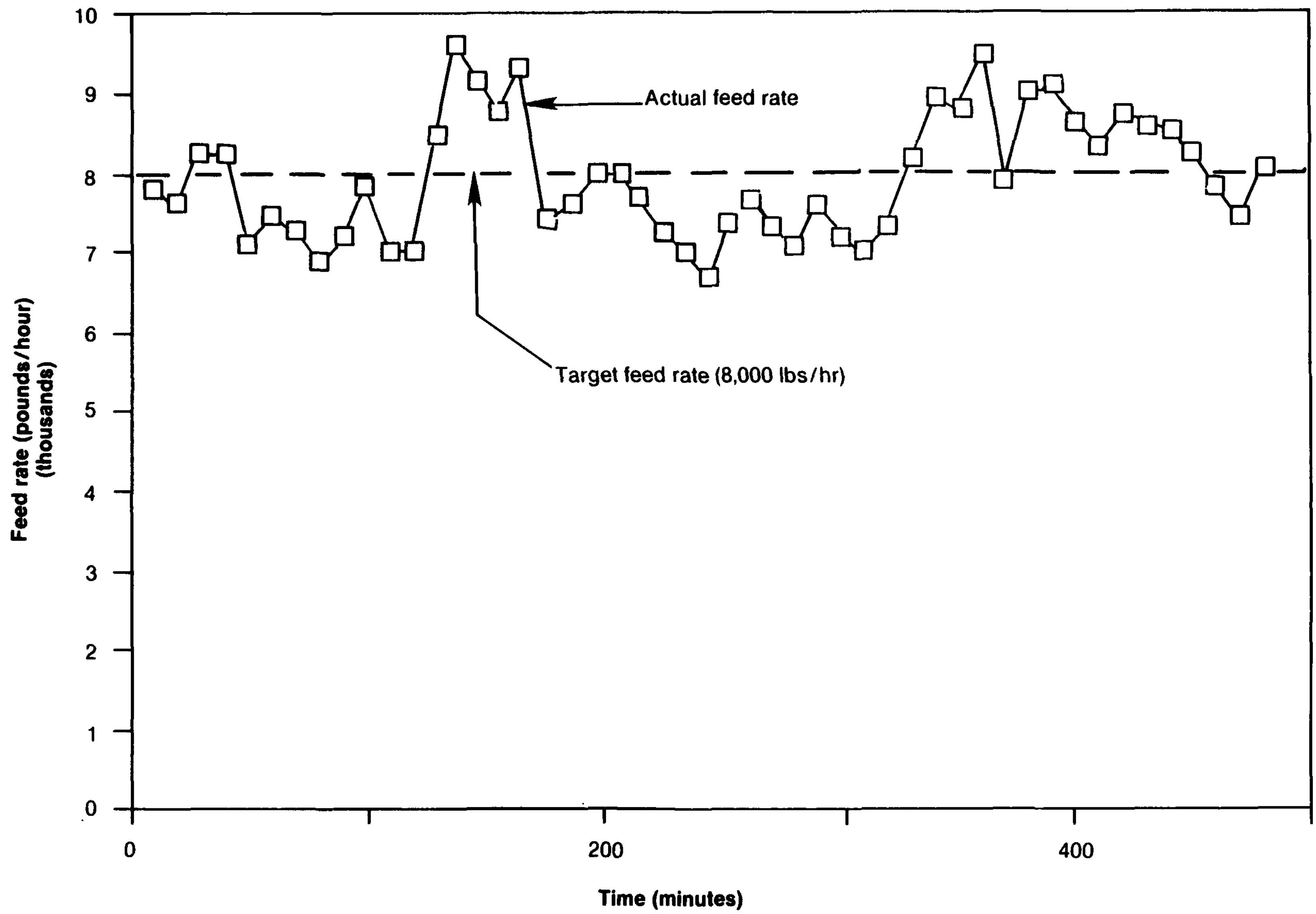


**Figure 9. Feed rate during test run no. 4, CHAAP soil, 8,000 lb./hr., 8-hour test.**

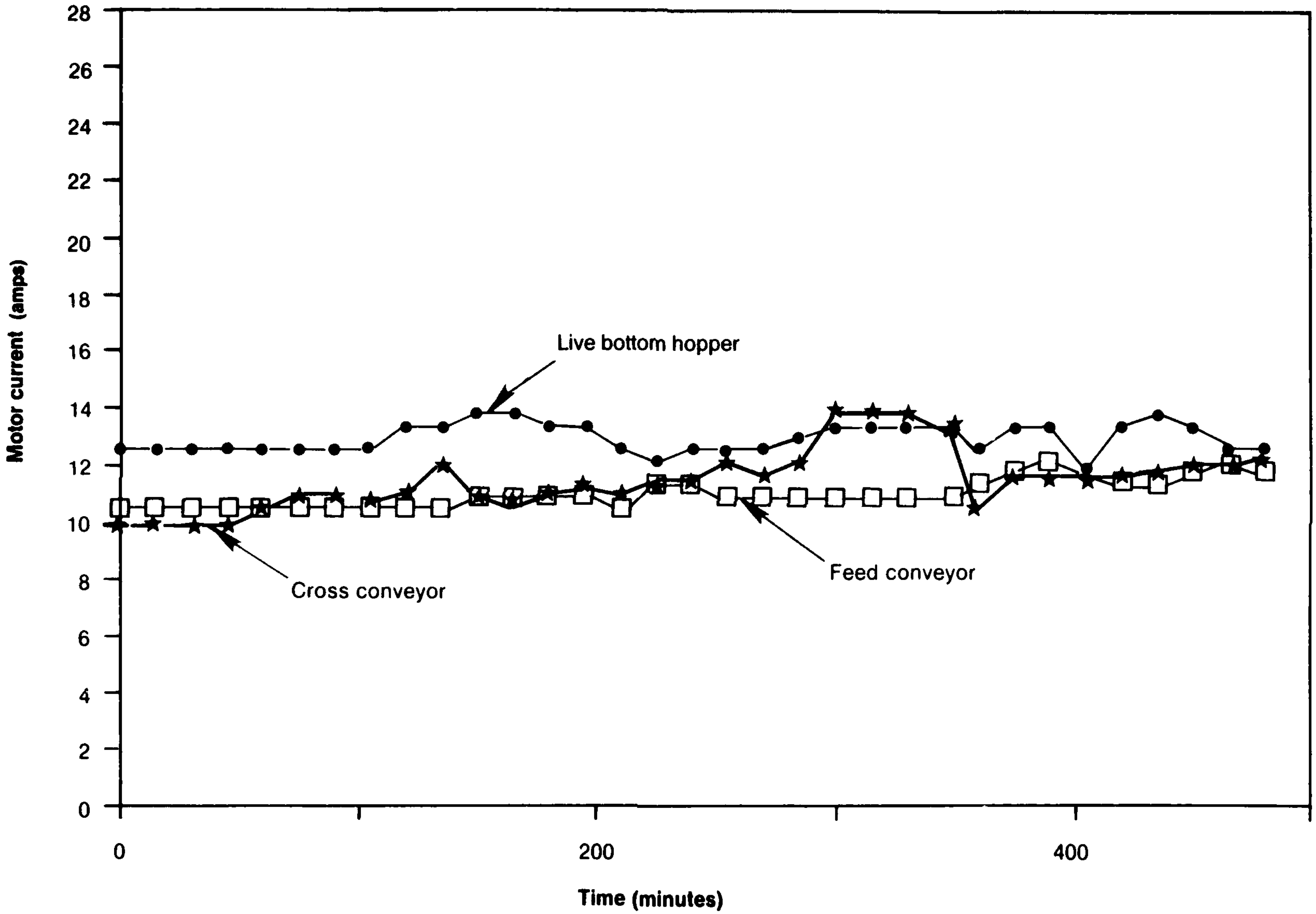


**Figure 10. Motor current during test run no. 4, CHAAP soil, 8,000 lb./hr., 8-hour test.**

## TABLE 9. SUMMARY OF TEST DATA FOR TEST RUN NO. 8, CHAAP SOIL, 12,000-LB/HR

RUN 8
7/10/86
CHAAP SOIL
TARGET FEED: 12,000 LB/HR

| Time (min-utes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor (%) | Feed conveyor Motor amps | Cross conveyor (%) | Cross conveyor Motor amps | Live bottom hopper (%) | Live bottom hopper Motor amps | Feed conveyor Drive setting | Feed conveyor Speed (ppm) | Feed conveyor (%) | Cross Conveyor Drive setting | Cross Conveyor Speed (rpm) | Cross Conveyor (%) | Live bottom hopper Drive setting | Live bottom hopper Speed (rpm) | Live bottom hopper (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | 25 | 10.5 | 45 | 9.9 | 38 | 15.96 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.0 | 2.7 | 6.8 |
| 9 | 9 | 1,678 | 11,187 | | | | | | | | | | | | | | | |
| 15 | | | | 30 | 12.6 | 47 | 10.34 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.0 | 2.7 | 6.8 |
| 17 | 8 | 1,546 | 11,595 | | | | | | | | | | | | | | | |
| 26 | 9 | 1,819 | 12,127 | | | | | | | | | | | | | | | |
| 30 | | | | 30 | 12.6 | 47 | 10.34 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.0 | 2.7 | 6.8 |
| 35 | 9 | 1,660 | 11,067 | | | | | | | | | | | | | | | |
| 45 | 10 | 2,007 | 12,042 | 30 | 12.6 | 50 | 11.0 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.0 | 2.7 | 6.8 |
| 54 | 9 | 1,662 | 11,080 | | | | | | | | | | | | | | | |
| 60 | | | | 27 | 11.34 | 45 | 9.9 | 27 | 11.34 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.0 | 2.7 | 6.8 |
| 63 | 9 | 1,783 | 11,886 | | | | | | | | | | | | | | | |
| 72 | 9 | 1,661 | 11,073 | | | | | | | | | | | | | | | |
| 83 | 11 | 1,818 | 9,916 | | | | | | | | | | | | | | | |
| 90 | | | | 28 | 11.76 | 45 | 9.9 | 27 | 11.34 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.35 | 2.8 | 7.0 |
| 92 | 9 | 1,718 | 11,453 | | | | | | | | | | | | | | | |
| 102 | 10 | 1,922 | 11,532 | | | | | | | | | | | | | | | |
| 105 | | | | 30 | 12.6 | 52 | 11.44 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.4 | 2.85 | 7.1 |
| 111 | 9 | 1,681 | 11,207 | | | | | | | | | | | | | | | |
| 120 | 9 | 1,880 | 12,533 | 30 | 12.6 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.5 | 2.9 | 7.2 |
| 129 | 9 | 1,759 | 11,727 | | | | | | | | | | | | | | | |
| 138 | 9 | 1,849 | 12,327 | | | | | | | | | | | | | | | |
| 147 | 9 | 1,776 | 11,840 | | | | | | | | | | | | | | | |
| 150 | | | | 30 | 12.6 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.5 | 2.9 | 7.2 |
| 156 | 9 | 1,824 | 12,160 | | | | | | | | | | | | | | | |
| 165 | 9 | 1,763 | 11,753 | 30 | 12.6 | 40 | 8.8 | 33 | 13.86 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.5 | 2.9 | 7.2 |
| 174 | 9 | 1,747 | 11,647 | | | | | | | | | | | | | | | |
| 180 | | | | 30 | 12.6 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.5 | 2.9 | 7.2 |
| 183 | 9 | 1,735 | 11,566 | | | | | | | | | | | | | | | |
| 192 | 9 | 1,747 | 11,647 | | | | | | | | | | | | | | | |
| 202 | 10 | 1,818 | 10,908 | | | | | | | | | | | | | | | |
| 210 | | | | 30 | 12.6 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.5 | 2.9 | 7.2 |
| 212 | 10 | 1,964 | 11,784 | | | | | | | | | | | | | | | |
| 215 | | | | 30 | 12.6 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.5 | 2.9 | 7.2 |
| 222 | 10 | 1,867 | 11,202 | | | | | | | | | | | | | | | |
| 220 | | | | 30 | 12.6 | 45 | 9.9 | 30 | 12.6 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 4.5 | 2.9 | 7.2 |
| 232 | 10 | 1,952 | 11,712 | | | | | | | | | | | | | | | |
| 242 | 10 | 1,567 | 9,402 | | | | | | | | | | | | | | | |
| 252 | 10 | 1,802 | 10,812 | | | | | | | | | | | | | | | |

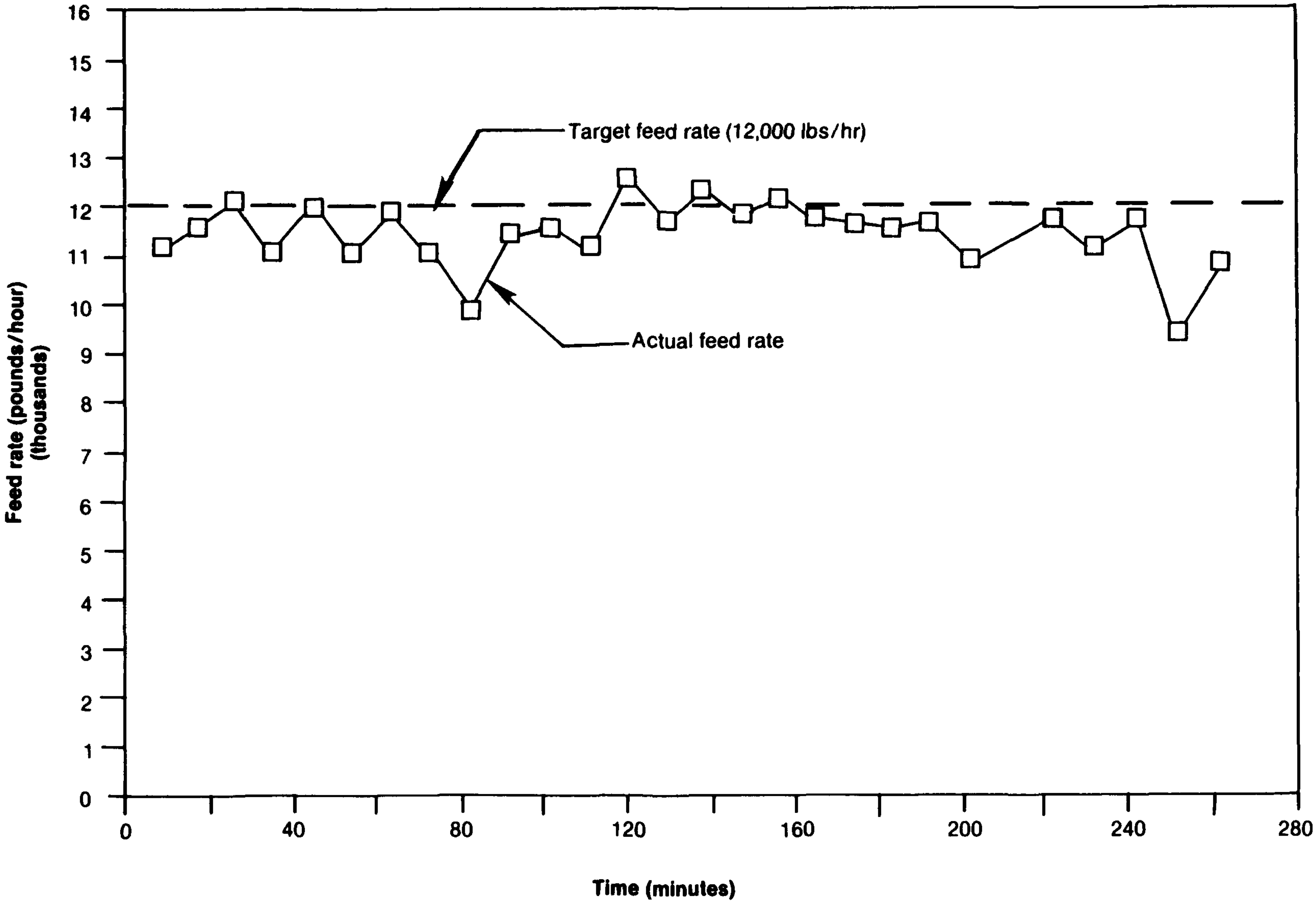


**Figure 11. Feed rate during test run no. 8, CHAAP soil, 12,000 lb./hr.**

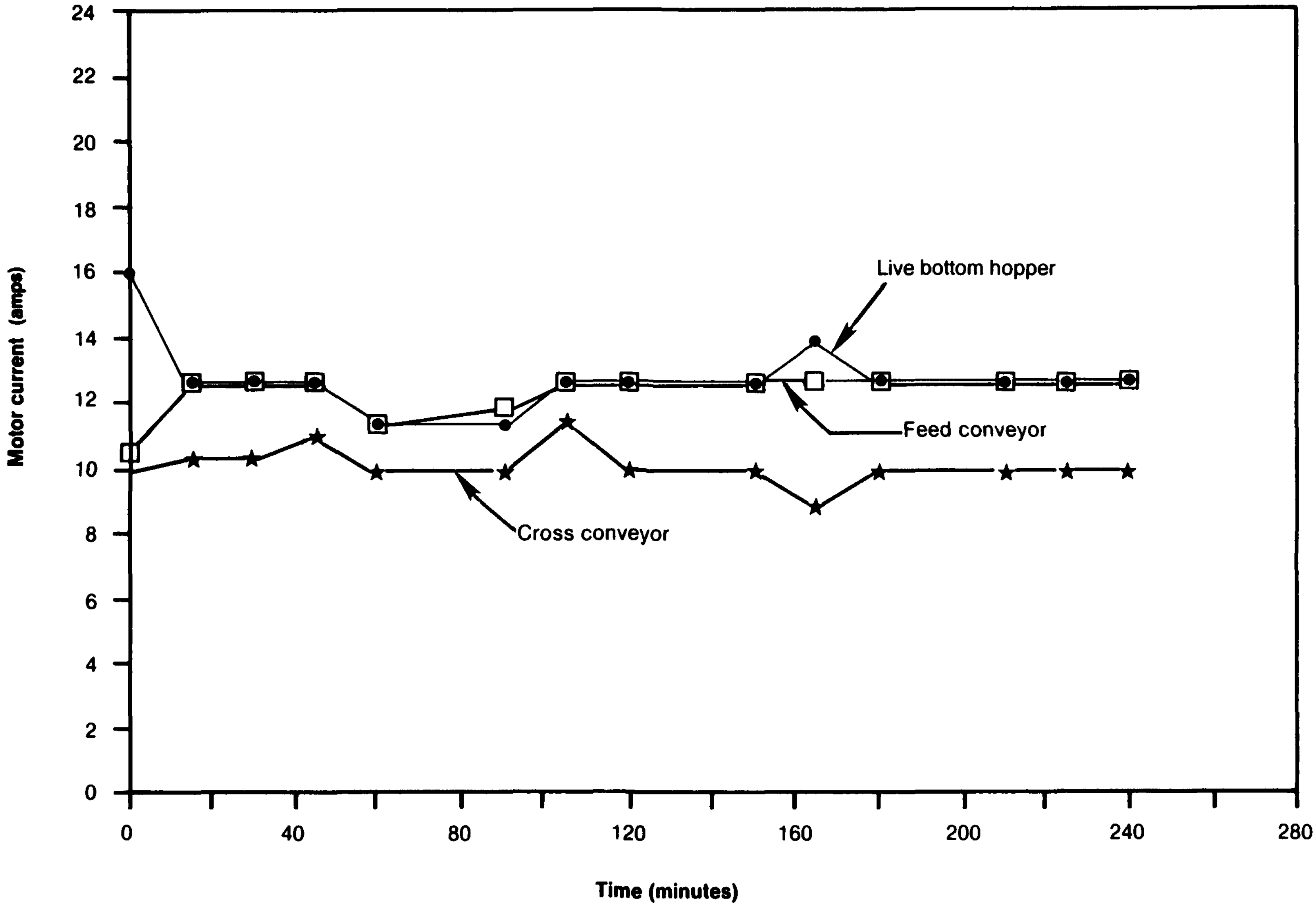


**Figure 12. Motor current during test run no. 8, CHAAP soil, 12,000 lb./hr.**

TABLE 10. SUMMARY OF TEST DATA FOR TEST RUN NO. 5, LAAP SOIL, 4,000-LB/HR

RUN 5
7/8/86
LAAP SOIL
TARGET FEED: 4,000 LB/HR (8-HOUR RUN)

| Time (min-utes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor (%) | Feed conveyor Motor amps | Cross conveyor (%) | Cross conveyor Motor amps | Live bottom hopper (%) | Live bottom hopper Motor amps | Feed conveyor Drive setting | Feed conveyor Speed (ppm) | Feed conveyor (%) | Cross Conveyor Drive setting | Cross Conveyor Speed (rpm) | Cross Conveyor (%) | Live bottom hopper Drive setting | Live bottom hopper Speed (rpm) | Live bottom hopper (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.1 | 1.0 | 2.5 |
| 10 | 10 | 1,466 | 8,760 | | | | | | | | | | | | | | | |
| 18 | 8 | 1,240 | 9,018 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.6 | 0.9 | 2.2 |
| 30 | 12 | 1,185 | 6,051 | | | | | | | | | | | | | | | |
| 40 | 10 | 1,142 | 6,852 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.5 | 0.8 | 2.0 |
| 52 | 12 | 1,121 | 5,605 | | | | | | | | | | | | | | | |
| 62 | 10 | 803 | 4,818 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.4 | 0.75 | 1.9 |
| 77 | 15 | 1,217 | 4,868 | | | | | | | | | | | | | | | |
| 92 | 15 | 1,428 | 5,712 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.38 | 0.7 | 1.8 |
| 107 | 15 | 1,288 | 5,152 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.35 | 0.7 | 1.8 |
| 122 | 15 | 1,106 | 4,424 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.25 | 0.65 | 1.6 |
| 137 | 15 | 1,007 | 4,028 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.1 | 0.6 | 1.5 |
| 143 | | | | 25 | 10.5 | 29 | 6.38 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.0 | 0.6 | 1.5 |
| 152 | 15 | 1,013 | 4,052 | | | | | | | | | | | | | | | |
| 172 | 20 | 1,288 | 3,864 | | | | | | | | | | | | | | | |
| 188 | | | | 25 | 10.5 | 27 | 5.94 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.2 | 0.65 | 1.6 |
| 192 | 20 | 1,462 | 4,386 | | | | | | | | | | | | | | | |
| 212 | 20 | 1,201 | 3,603 | | | | | | | | | | | | | | | |
| 218 | | | | 25 | 10.5 | 27 | 5.94 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.0 | 0.6 | 1.5 |
| 232 | 20 | 1,176 | 3,528 | | | | | | | | | | | | | | | |
| 272 | 40 | 1,787 | 2,681 | | | | | | | | | | | | | | | |
| 292 | 20 | 1,582 | 4,746 | | | | | | | | | | | | | | | |
| 302 | 10 | 790 | 4,740 | | | | | | | | | | | | | | | |

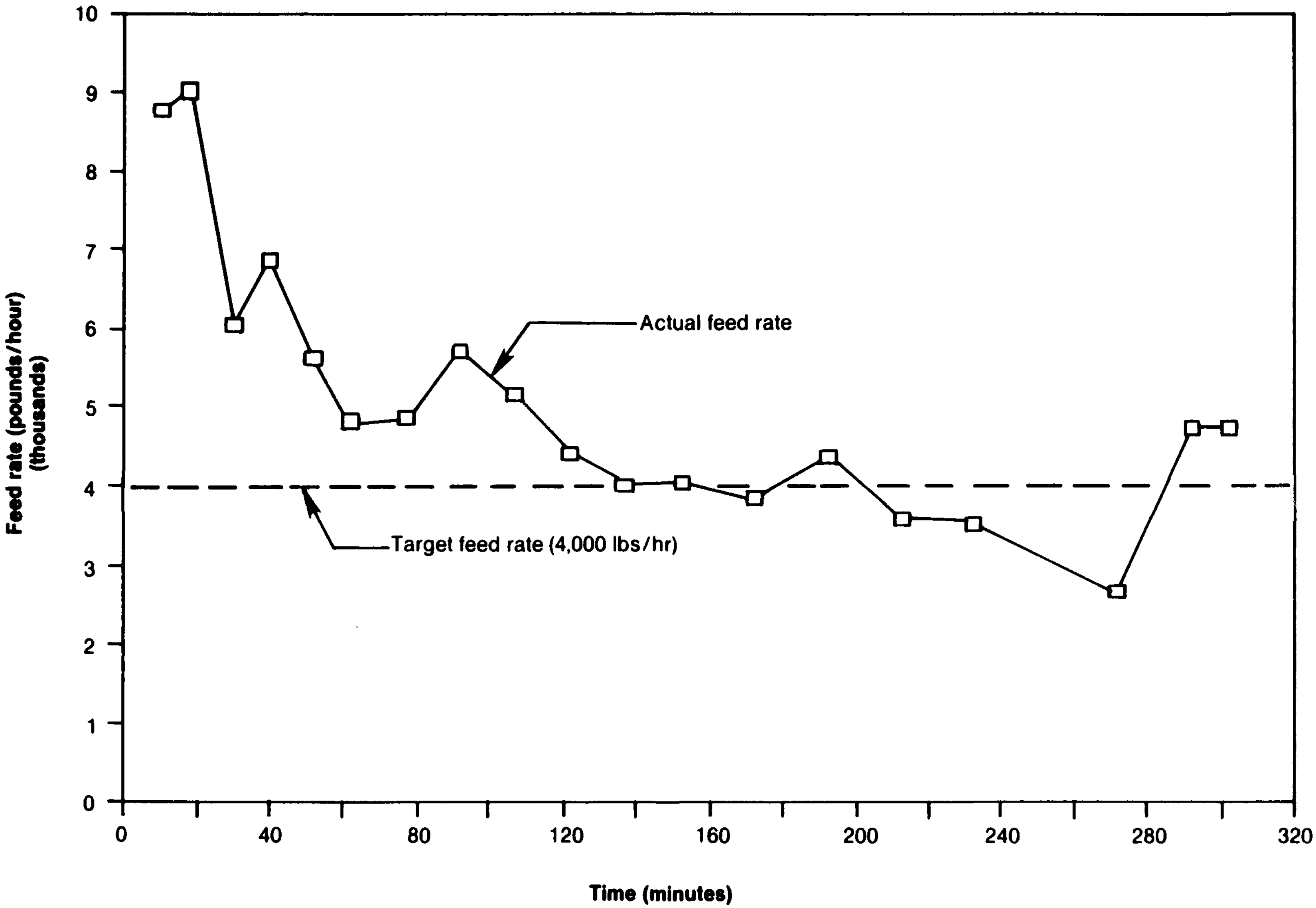


**Figure 13. Feed rate during test run no. 5, LAAP soil, 4,000 lb./hr.**

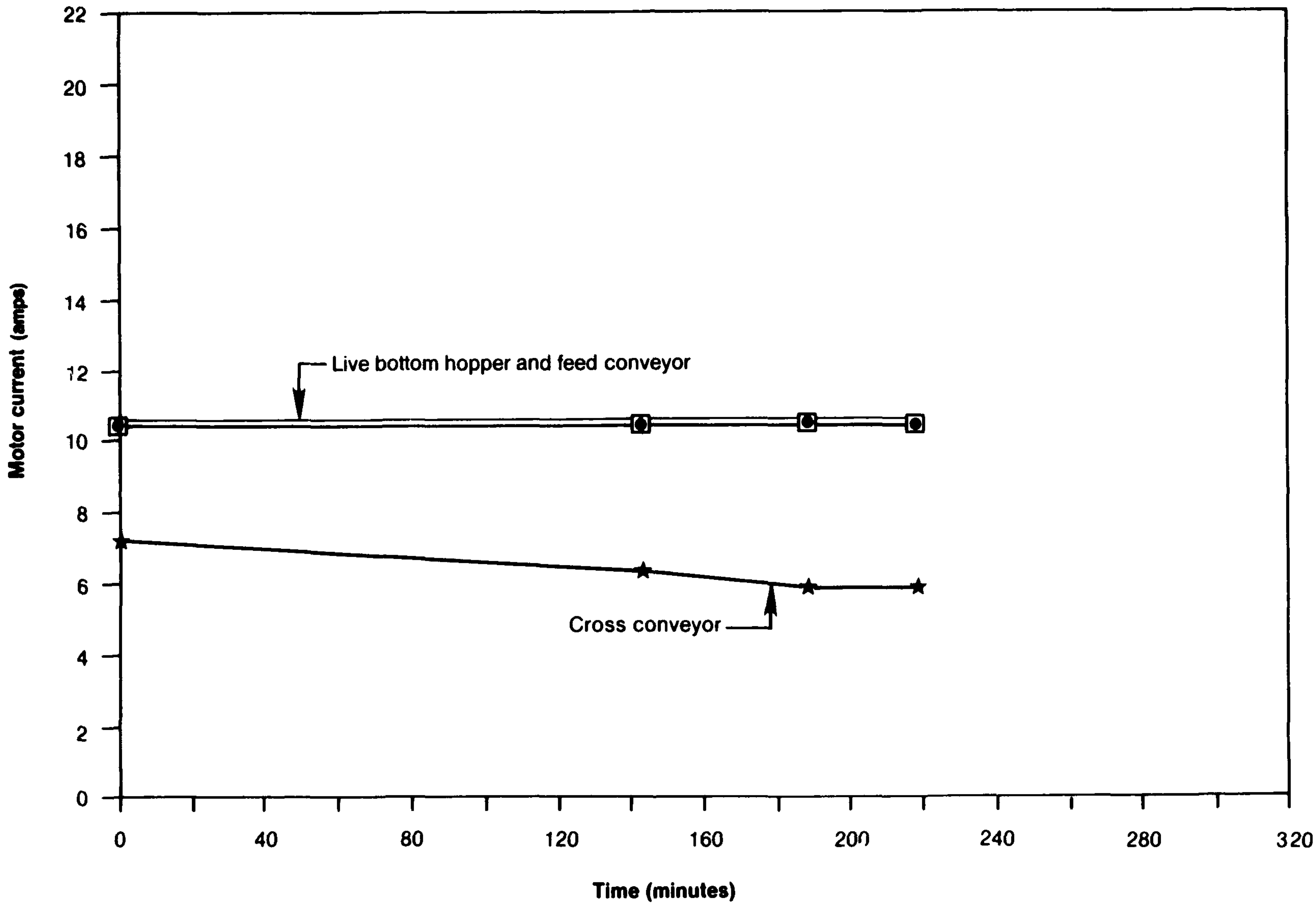


**Figure 14. Motor current during test run no. 5, LAAP soil, 4,000 lb./hr.**

RUN 7
7/9/86
LAAP SOIL
TARGET FEED: 8,000 LB/HR (8-HOUR RUN)

| Time (min-utes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor | | Cross conveyor | | Live bottom hopper | | Feed conveyor | | | Cross Conveyor | | | Live bottom hopper | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (%) | Motor amps | (%) | Motor amps | (%) | Motor amps | Drive setting | Speed (ppm) | (%) | Drive setting | Speed (rpm) | (%) | Drive setting | Speed (rpm) | (%) |
| 0 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.5 | 0.8 | 2.0 |
| 10 | 10 | 2,083 | 12,498 | | | | | | | | | | | | | | | |
| 15 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | | | |
| 22 | 12 | 1,718 | 10,308 | | | | | | | | | | | | | | | |
| 30 | | | | 25 | 10.5 | 30 | 6.6 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.4 | 0.75 | 1.9 |
| 32 | 10 | 2,094 | 12,564 | | | | | | | | | | | | | | | |
| 42 | 10 | 1,728 | 10,368 | | | | | | | | | | | | | | | |
| 45 | | | | 25 | 10.5 | 30 | 6.6 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 52 | 10 | 1,198 | 7,188 | | | | | | | | | | | | | | | |
| 60 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 62 | 10 | 1,489 | 8,934 | | | | | | | | | | | | | | | |
| 75 | 13 | 2,169 | 8,676 | | | | | | | | | | | | | | | |
| 90 | 15 | 2,131 | 8,524 | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 105 | 15 | 2,168 | 8,672 | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 121 | 16 | 2,160 | 8,100 | | | | | | | | | | | | | | | |
| 135 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 141 | 20 | 2,658 | 7,974 | | | | | | | | | | | | | | | |
| 151 | 10 | 1,429 | 8,574 | | | | | | | | | | | | | | | |
| 169 | 18 | 2,448 | 8,160 | | | | | | | | | | | | | | | |
| 180 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 183 | 14 | 1,781 | 7,633 | | | | | | | | | | | | | | | |
| 203 | 20 | 2,442 | 7,326 | | | | | | | | | | | | | | | |
| 210 | | | | 25 | 10.5 | 30 | 6.6 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 223 | 20 | 2,828 | 8,484 | | | | | | | | | | | | | | | |
| 240 | | | | 25 | 10.5 | 30 | 6.6 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 243 | 20 | 2,651 | 7,953 | | | | | | | | | | | | | | | |
| 263 | 20 | 2,707 | 8,121 | | | | | | | | | | | | | | | |
| 270 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 284 | 21 | 2,515 | 7,600 | | | | | | | | | | | | | | | |

## TABLE 11. (CONTINUED)

RUN 7
7/9/86
LAAP SOIL
TARGET FEED: 8,000 LB/HR (8-HOUR RUN)

| Time (min-utes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor (%) | Feed conveyor Motor amps | Cross conveyor (%) | Cross conveyor Motor amps | Live bottom hopper (%) | Live bottom hopper Motor amps | Feed conveyor Drive setting | Feed conveyor Speed (ppm) | Feed conveyor (%) | Cross Conveyor Drive setting | Cross Conveyor Speed (rpm) | Cross Conveyor (%) | Live bottom hopper Drive setting | Live bottom hopper Speed (rpm) | Live bottom hopper (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 300 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 304 | 20 | 3,052 | 9,156 | | | | | | | | | | | | | | | |
| 324 | 20 | 2,477 | 7,431 | | | | | | | | | | | | | | | |
| 330 | | | | 25 | 10.5 | 43 | 9.46 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 344 | 20 | 2,866 | 8,598 | | | | | | | | | | | | | | | |
| 355 | | | | 25 | 10.5 | 45 | 9.9 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 364 | 20 | 2,674 | 8,022 | | | | | | | | | | | | | | | |
| 375 | | | | 25 | 10.5 | 42 | 9.24 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 384 | 20 | 2,714 | 8,142 | | | | | | | | | | | | | | | |
| 390 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 404 | 20 | 2,566 | 7,698 | | | | | | | | | | | | | | | |
| 405 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 424 | 20 | 2,806 | 8,418 | | | | | | | | | | | | | | | |
| 425 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 444 | 20 | 2,906 | 8,718 | | | | | | | | | | | | | | | |
| 445 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 464 | 20 | 2,454 | 7,362 | | | | | | | | | | | | | | | |
| 465 | | | | 25 | 10.5 | 48 | 10.56 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 485 | | | | 25 | 10.5 | 35 | 7.7 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |
| 486 | 22 | 2,932 | 7,996 | | | | | | | | | | | | | | | |
| 496 | 10 | 1,174 | 7,044 | | | | | | | | | | | | | | | |
| 500 | | | | 25 | 10.5 | 40 | 8.8 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 0.3 | 0.7 | 1.8 |

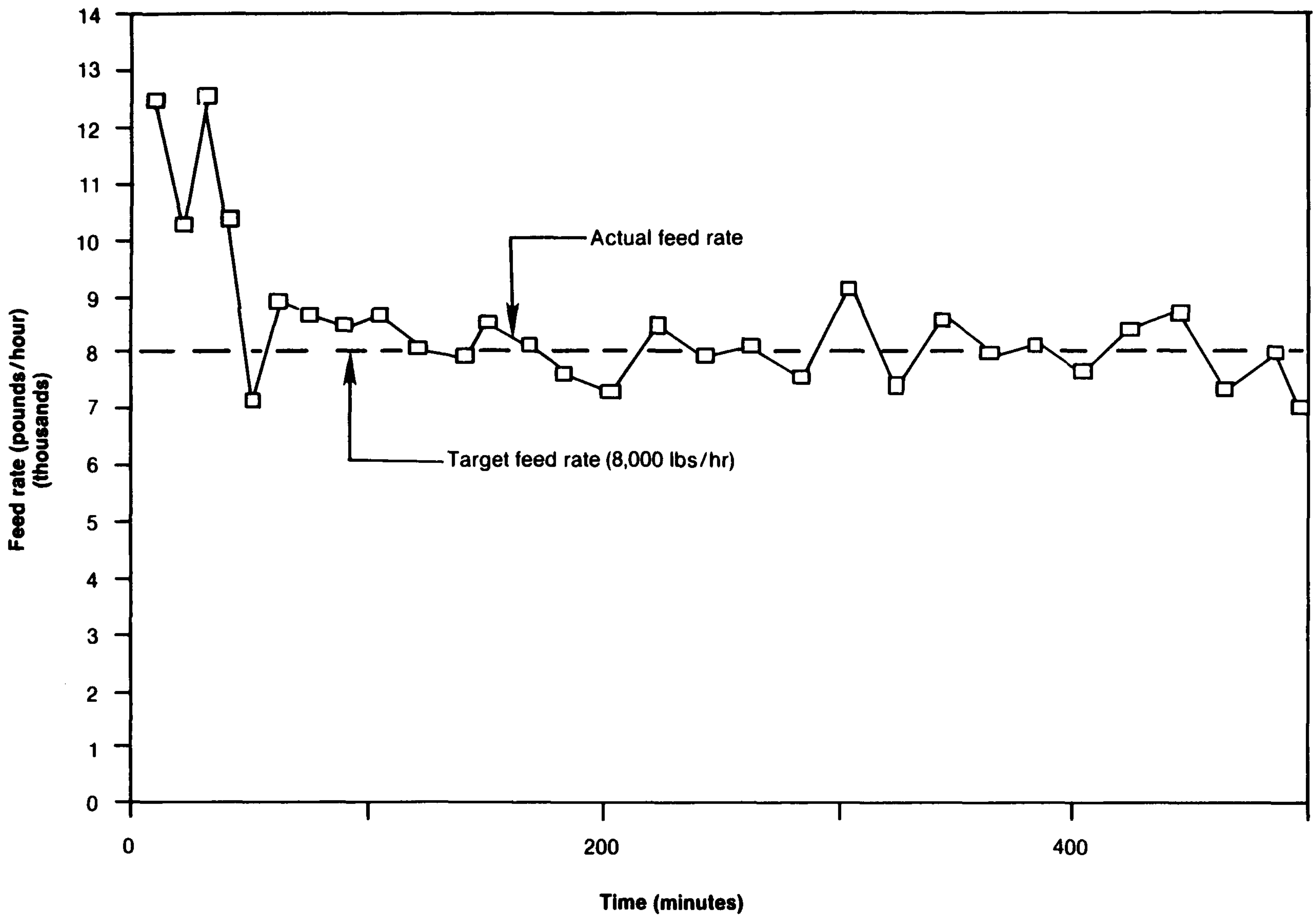


Figure 15. Feed rate during test run no. 7, LAAP soil, 8,000 lb./hr., 8-hour test.

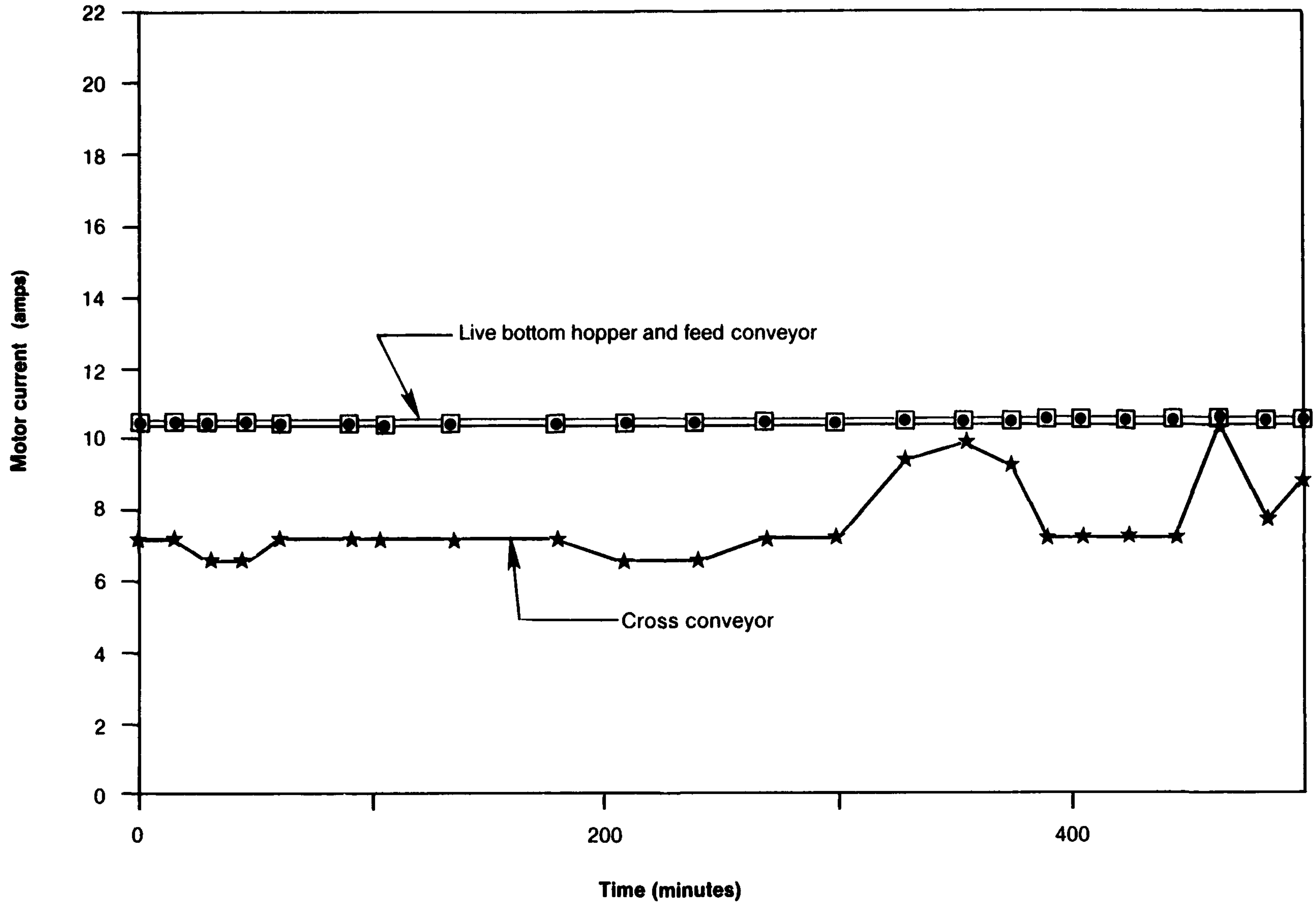


Figure 16. Motor current during test run no. 7, LAAP soil, 8,000 lb./hr., 8-hour test.

RUN 6
7/8/86
LAAP SOIL
TARGET FEED: 12,000 LB/HR

| Time (minutes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor (%) | Feed conveyor Motor amps | Cross conveyor (%) | Cross conveyor Motor amps | Live bottom hopper (%) | Live bottom hopper Motor amps | Feed conveyor Drive setting | Feed conveyor Speed (ppm) | Feed conveyor (%) | Cross Conveyor Drive setting | Cross Conveyor Speed (rpm) | Cross Conveyor (%) | Live bottom hopper Drive setting | Live bottom hopper Speed (rpm) | Live bottom hopper (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 7 | 7 | 1,801 | 15,437 | | | | | | | | | | | | | | | |
| 14 | 7 | 1,157 | 9,917 | | | | | | | | | | | | | | | |
| 21 | 7 | 1,220 | 10,457 | | | | | | | | | | | | | | | |
| 28 | 7 | 1,583 | 13,568 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.4 | 1.35 | 3.4 |
| 35 | 7 | 1,342 | 11,503 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.35 | 1.3 | 3.2 |
| 45 | 10 | 1,317 | 7,902 | | | | | | | | | | | | | | | |
| 55 | 10 | 1,723 | 10,338 | | | | | | | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.4 | 1.35 | 3.4 |
| 63 | 8 | 2,069 | 15,517 | | | | | | | | | | | | | | | |
| 70 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.4 | 1.35 | 3.4 |
| 73 | 10 | 2,242 | 13,452 | | | | | | | | | | | | | | | |
| 80 | | | | 25 | 10.5 | 40 | 8.8 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.35 | 1.3 | 3.2 |
| 82 | 9 | 1,911 | 12,740 | | | | | | | | | | | | | | | |
| 90 | | | | 25 | 10.5 | 50 | 11. | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.35 | 1.3 | 3.2 |
| 92 | 10 | 1,446 | 8,676 | | | | | | | | | | | | | | | |
| 100 | | | | 25 | 10.5 | 35 | 7.7 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.35 | 1.3 | 3.2 |
| 102 | 10 | 2,233 | 13,398 | | | | | | | | | | | | | | | |
| 111 | 9 | 2,540 | 16,933 | | | | | | | | | | | | | | | |
| 120 | | | | 25 | 10.5 | 42 | 9.24 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 121 | 10 | 2,308 | 13,848 | | | | | | | | | | | | | | | |
| 131 | 10 | 1,943 | 11,658 | | | | | | | | | | | | | | | |
| 135 | | | | 25 | 10.5 | 35 | 7.7 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 141 | 10 | 1,868 | 11,208 | | | | | | | | | | | | | | | |
| 150 | | | | 25 | 10.5 | 39 | 8.58 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 151 | 10 | 1,093 | 6,558 | | | | | | | | | | | | | | | |
| 159 | 8 | 2,480 | 18,600 | | | | | | | | | | | | | | | |
| 165 | | | | 25 | 10.5 | 40 | 8.8 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |

TABLE 12. (CONTINUED)

RUN 6
7/8/86
LAAP SOIL
TARGET FEED: 12,000 LB/HR

| Time (min-utes) | Duration of hopper fill cycle (minutes) | Net weight of soil in hopper (lb) | Feed rate (lb/hr) | Feed conveyor (%) | Feed conveyor Motor amps | Cross conveyor (%) | Cross conveyor Motor amps | Live bottom hopper (%) | Live bottom hopper Motor amps | Feed conveyor Drive setting | Feed conveyor Speed (ppm) | Feed conveyor (%) | Cross Conveyor Drive setting | Cross Conveyor Speed (rpm) | Cross Conveyor (%) | Live bottom hopper Drive setting | Live bottom hopper Speed (rpm) | Live bottom hopper (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 171 | 12 | 2,280 | 11,400 | | | | | | | | | | | | | | | |
| 179 | 8 | 2,320 | 17,400 | | | | | | | | | | | | | | | |
| 180 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 189 | 10 | 1,808 | 10,848 | | | | | | | | | | | | | | | |
| 195 | | | | 25 | 10.5 | 33 | 7.26 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 199 | 10 | 2,526 | 15,156 | | | | | | | | | | | | | | | |
| 209 | 10 | 2,182 | 13,092 | | | | | | | | | | | | | | | |
| 210 | | | | 25 | 10.5 | 45 | 9.9 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 219 | 10 | 1,932 | 11,597 | | | | | | | | | | | | | | | |
| 225 | | | | 25 | 10.5 | 50 | 11.0 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 229 | 10 | 2,033 | 12,198 | | | | | | | | | | | | | | | |
| 239 | 10 | 2,239 | 13,434 | | | | | | | | | | | | | | | |
| 240 | | | | 25 | 10.5 | 50 | 11.0 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 249 | 10 | 2,418 | 14,500 | | | | | | | | | | | | | | | |
| 260 | 11 | 2,458 | 13,407 | 25 | 10.5 | 50 | 11.0 | 25 | 10.5 | 1.1 | 30 | 75 | 1.0 | 26 | 65 | 1.3 | 1.3 | 3.2 |
| 270 | 10 | 2,005 | 12,030 | | | | | | | | | | | | | | | |
| 280 | 10 | 1,940 | 11,640 | | | | | | | | | | | | | | | |



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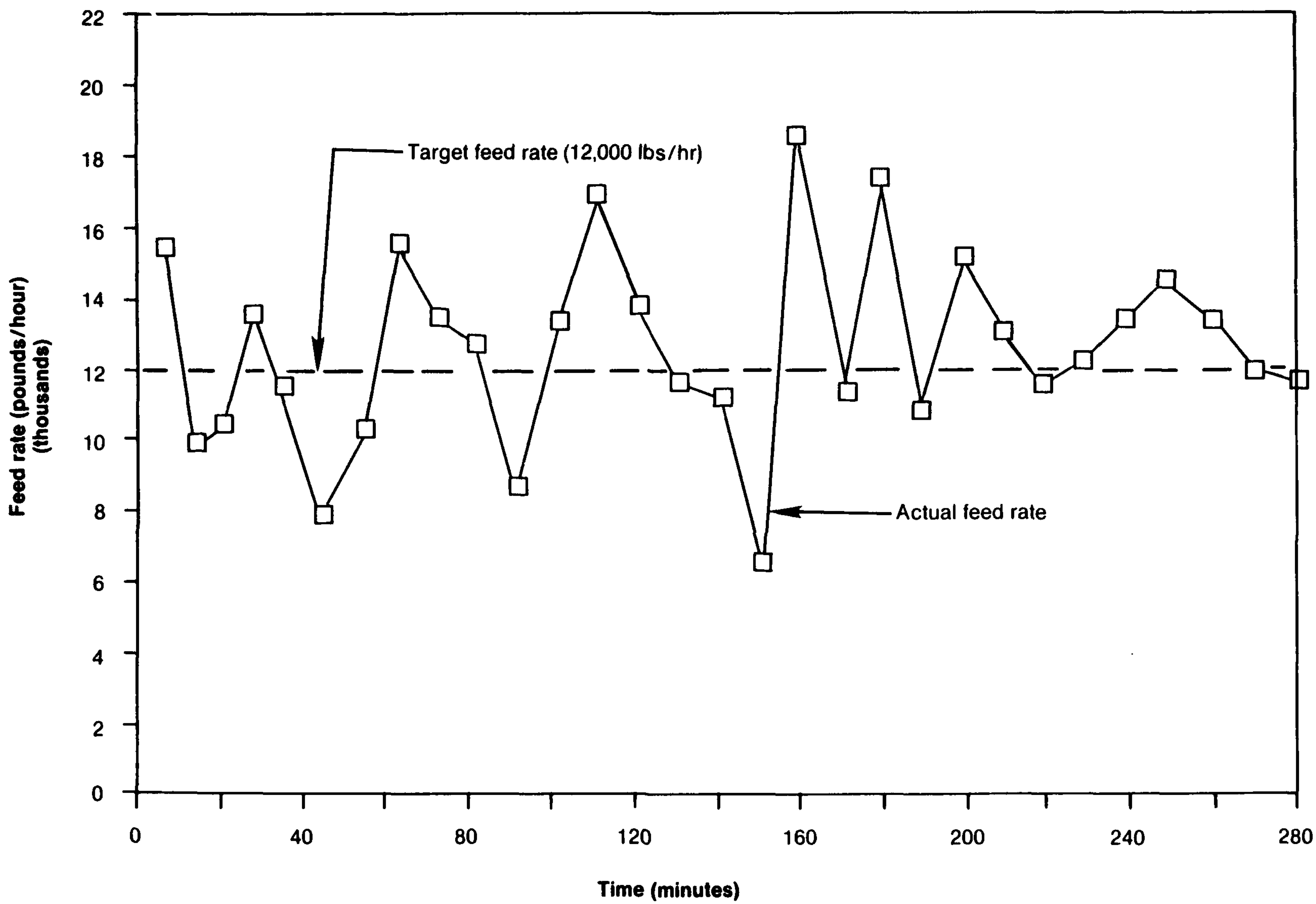


Figure 17. Feed rate during test run no. 6, LAAP soil, 12,000 lb./hr.

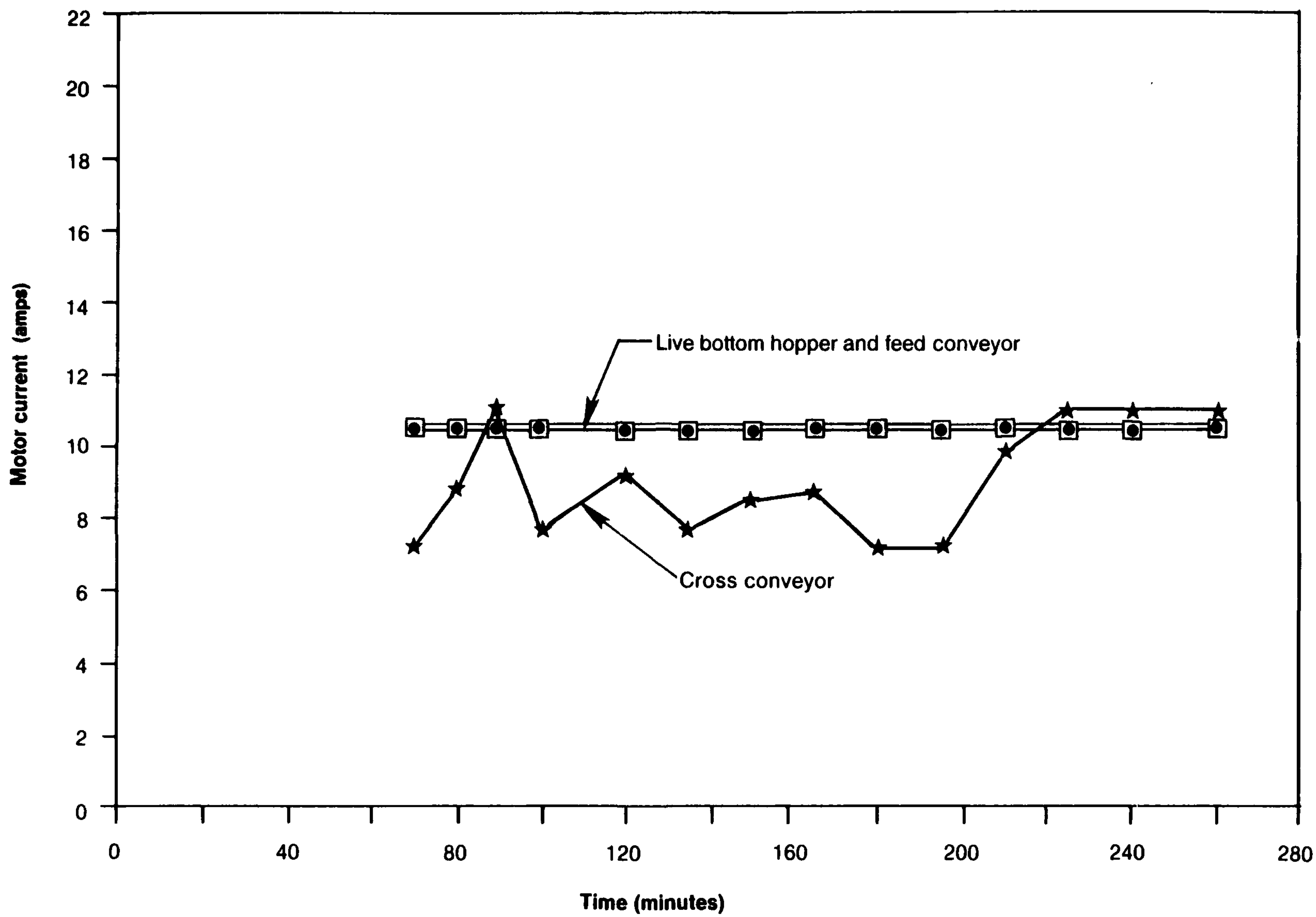


Figure 18. Motor current during test run no. 6, LAAP soil, 12,000 lb./hr.

5.3 Analysis of test data. This section provides an analysis of the following system parameters:

- Soil feed rate.
- Soil moisture content and bulk density.
- Soil size distribution.
- Rotational speed of screw conveyors.
- Screw conveyor motor current.
- LAAP soil explosives concentrations.

5.3.1 Soil feed rate. A summary of the average and range feed rate data for each of the test runs is provided below:

| Soil type | Run no. | Target feed rate (lb/hr) | Actual feed rate (average) (lb/hr) | Actual feed rate (average) (% of target) | Range of feed rates (lb/hr) | Range of feed rates (% of target) |
|---|---|---|---|---|---|---|
| CHAAP | 1 | 4,000 | 3,907 | 97.7 | 3,596- 4,299 | 89.9-107.5 |
| CHAAP | 3 | 8,000 | 7,967 | 99.6 | 7,434- 8,418 | 92.9-105.2 |
| CHAAP | 4 | 8,000 | 7,791 | 97.4 | 6,666- 9,608 | 83.3-120.1 |
| CHAAP | 8 | 12,000 | 11,451 | 95.4 | 9,402-12,533 | 78.4-104.4 |
| LAAP | 5 | 4,000 | 5,099 | 127.5 | 2,681- 9,018 | 67.0-225.4 |
| LAAP | 7 | 8,000 | 8,541 | 106.7 | 7,044-12,498 | 88.0-156.2 |
| LAAP | 6 | 12,000 | 12,617 | 105.1 | 6,558-18,600 | 54.6-155.0 |

As shown in this summary, the full range of target feed rates (i.e., 4,000-12,000 lb/hr) was achieved for the CHAAP and LAAP soils. The feed system maintained feed rates very close to the target values for the CHAAP soils (i.e., average feed rate 95.4-99.6 percent of the target values). The instantaneous variations in CHAAP feed rates were typically within ±10 percent and in the most extreme cases still within ±20 percent of the target values. With the exception of Test Run No. 5, which is misleading due to operator error (the feed rate was decreased seven times during the test run before the feed rate was below 4,000 lb/hr), the feed system also maintained feed rates very close to the target values for the LAAP soils (i.e., 105.1-106.7 percent of the target values). However, for the LAAP soils, the instantaneous variations in feed rates were more significant with typical variations within ±20 percent and extreme variations as much as ±50 percent of the target values. The reason for the wider range of variations for the LAAP soils is discussed in Subsection 5.4.

5.3.2 Soil moisture content and bulk densities. The soil moisture content and soil bulk densities for the test runs are summarized as follows:

| Soil type | Run no. | Feed soil or processed soil | Soil moisture content (%) | Soil bulk density |
|---|---|---|---|---|
| CHAAP | 1 | Feed soil | 16.4 | --- |
| CHAAP | 1 | Processed soil | 17.5 | 77 $lb/ft^3$ |
| CHAAP | 3 | Feed soil | 16.7 | --- |
| CHAAP | 3 | Processed soil | 16.4 | 71 $lb/ft^3$ |
| CHAAP | 4 | Feed soil | 15.2 | --- |
| CHAAP | 4 | Processed soil | 15.9 | 70 $lb/ft^3$ |
| CHAAP | 8 | Feed soil | 16.1 | --- |
| CHAAP | 8 | Processed soil | 17.4 | 78 $lb/ft^3$ |
| LAAP | 5 | Feed soil | * | --- |
| LAAP | 5 | Processed soil | * | 107 $lb/ft^3$ |
| LAAP | 7 | Feed soil | * | --- |
| LAAP | 7 | Processed soil | * | 116 $lb/ft^3$ |
| LAAP | 6 | Feed soil | * | --- |
| LAAP | 6 | Processed soil | * | 118 $lb/ft^3$ |

*Soil moisture content data were not available for the draft technical report. These data will be provided in the final report.

The CHAAP soil moisture content ranged from 15.2-17.5 percent with an average of 16.4 percent. The CHAAP soil bulk density for the processed soil (discharged from the feed system) ranged from 70-78 $lb/ft^3$ with an average of 74 $lb/ft^3$.

The LAAP soil moisture content data were not available for this report due to difficulty in locating a subcontractor that was willing to perform moisture content and size distribution testing on explosives-contaminated soils. These samples have been submitted to the Allegany Ballistics Laboratory, and the results will be submitted as an addendum to this report. The LAAP soil bulk density for the processed soil ranged from 107-118 $lb/ft^3$ with an average of 114 $lb/ft^3$.

5.3.3 Soil size distribution. The soil size distribution data for the CHAAP test runs are summarized in Table 13. The actual soil gradation curves for the feed soil and processed soil for each CHAAP run are presented in Appendix G. As shown in Table 13, the CHAAP soil size distribution data are very consistent. These results are summarized below:

| Soil classification | | Size range | Percentages | |
|---|---|---|---|---|
| | | | Average | Range |
| Cobbles | | >3" | 0 | 0 |
| Gravel | - coarse | 3" - 3/4" | 0 | 0 |
| | - fine | 3/4" - 4 mesh | 0 | 0 |
| Sand | - coarse | 4 - 10 mesh | 1.6 | 1-3 |
| | - medium | 10 - 40 mesh | 4.9 | 4-6 |
| | - fine | 40 - 200 mesh | 16.3 | 13-19 |
| Silt or clay | | <200 mesh | 77.2 | 75-82 |

5.3.4 Rotational speed of screw conveyor. Figure 19 provides a graphical plot of the relationship between the Reeves variable speed drive setting and the measured live bottom hopper screw speed (in rpm) and screw tip speed (in feet per second). As shown in Figure 19, this is a relatively linear relationship. It is important to note that even at the maximum variable speed drive setting of "7.0," that the screw tip speed is nearly an order of magnitude below the recommended maximum tip speed for explosives-contaminated soils of 2 feet per second.

Figure 20 provides a similar graphical plot for the cross conveyor and feed conveyor. Again, the relationships are linear. However, these conveyors are capable of exceeding the recommended maximum tip speed of 2 feet per second for explosives-contaminated soils.

The relationships presented in Figures 19 and 20 are totally independent of the type of soil being fed. They simply illustrate the mechanical relationship of the gear drive settings to the rotational speed of the respective screws. Actual corresponding feed rates are dependent upon soil density and material handling characteristics. Subsection 6.2 provides recommendations relative to maintaining conveyor tip speed below the 2-foot-per-second safety criterion.

# TABLE 13. SUMMARY OF SOIL SIZE DISTRIBUTION DATA FOR THE CHAAP TEST RUNS

| | Percent by weight in each size classification | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Gravel | | Sand | | | Silt or | |
| CHAAP run no. | Cob-bles >3" | Coarse 3"-3/4" | Fine 3/4"-4 mesh | Coarse 4-10 mesh | Medium 10-40 mesh | Fine 40-200 mesh | clay <200 mesh | To-tal |
| 1 - Feed | 0 | 0 | 0 | 3 | 4 | 17 | 76 | 100 |
| 1 - Processed | 0 | 0 | 0 | 2 | 5 | 18 | 75 | 100 |
| 3 - Feed | 0 | 0 | 0 | 1 | 5 | 19 | 75 | 100 |
| 3 - Processed | 0 | 0 | 0 | 1 | 5 | 16 | 78 | 100 |
| 4 - Feed | 0 | 0 | 0 | 1 | 6 | 15 | 78 | 100 |
| 4 - Processed | 0 | 0 | 0 | 1 | 6 | 16 | 77 | 100 |
| 8 - Feed | 0 | 0 | 0 | 1 | 4 | 13 | 82 | 100 |
| 8 - Processed | 0 | 0 | 0 | 2 | 5 | 16 | 77 | 100 |

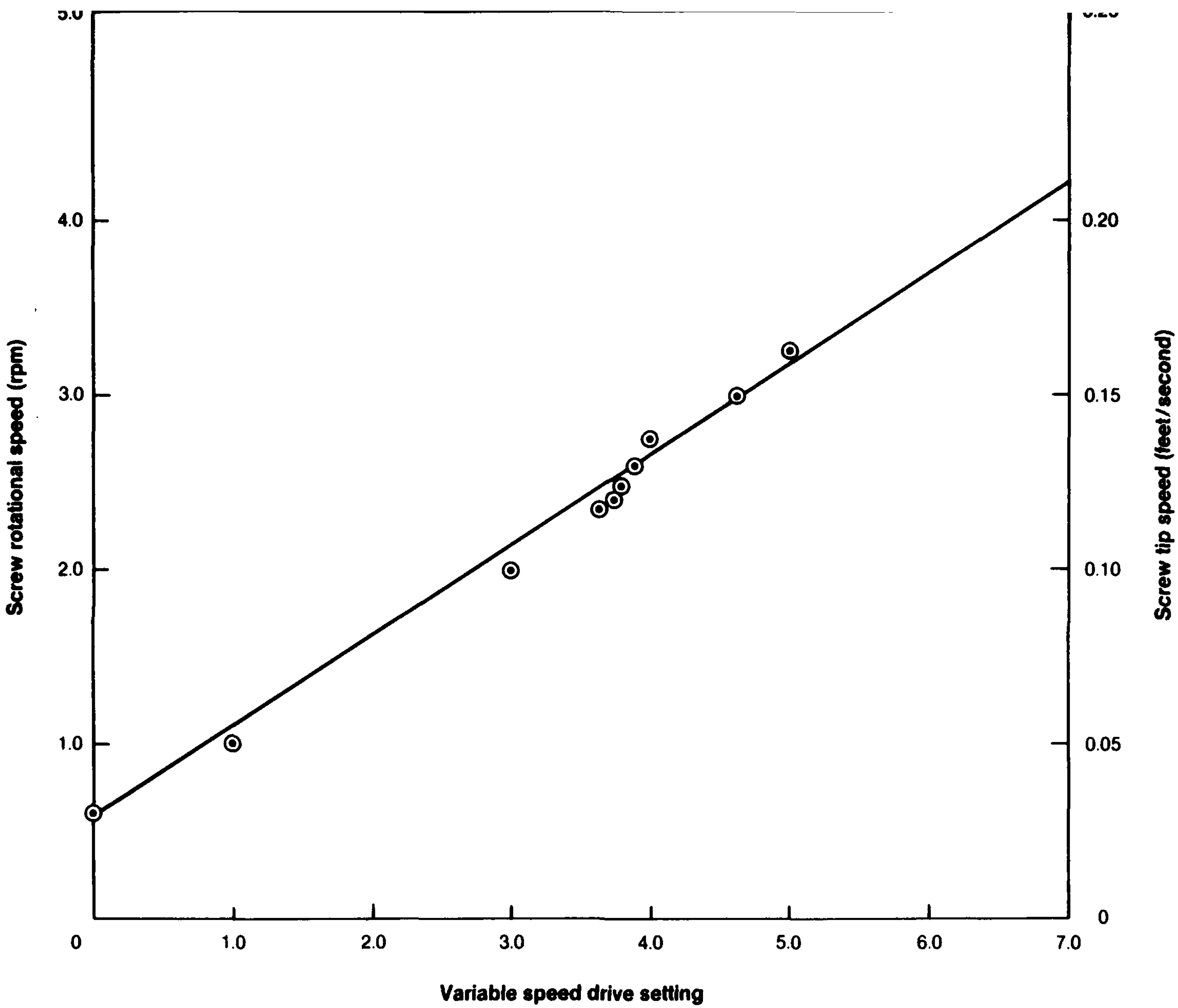


**Figure 19. Relationship between live bottom hopper screw speed and variable speed drive settings for all types of soil.**

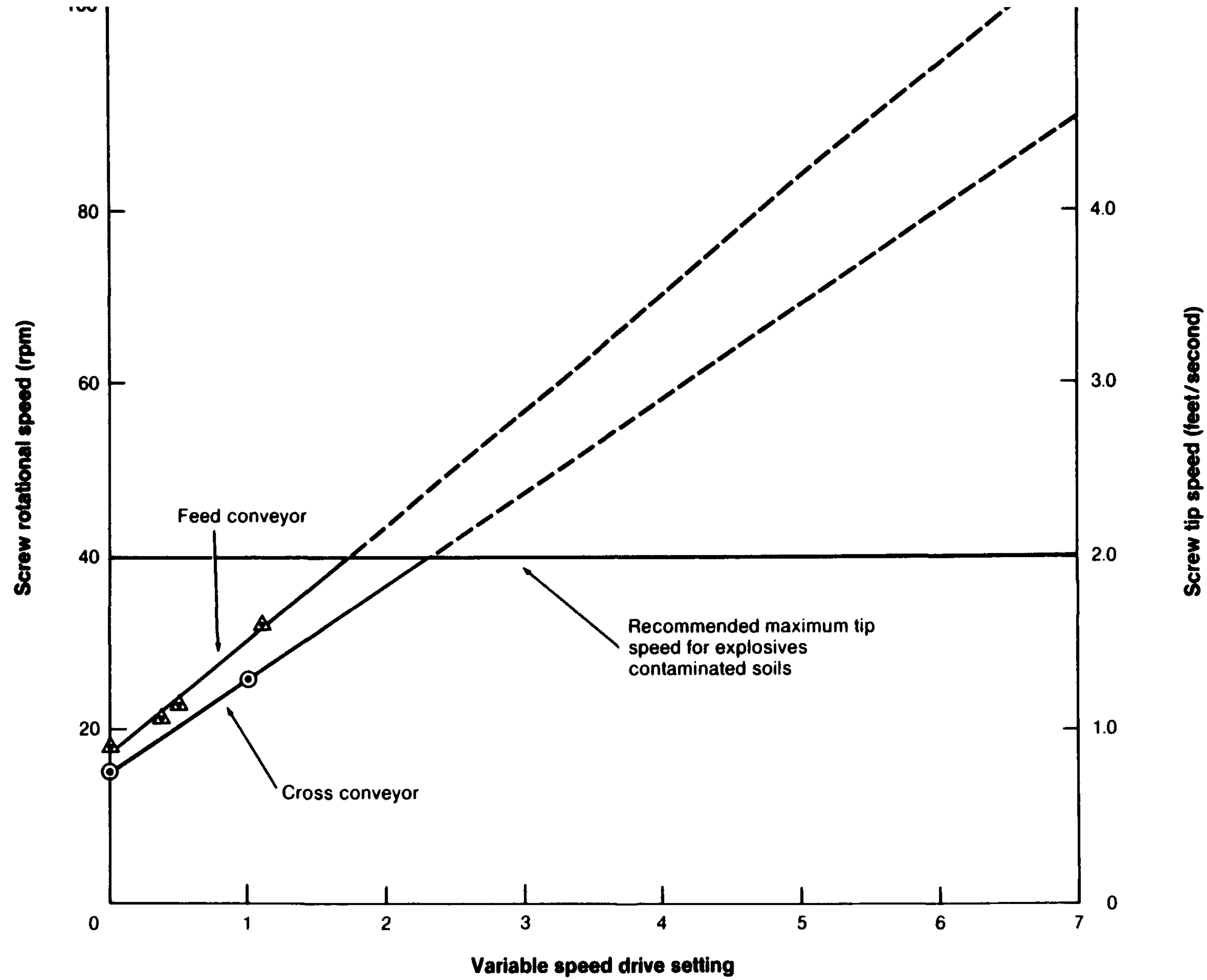


**Figure 20. Relationship between conveyor and feed conveyor screw speeds and variable speed drive settings for all types of soil.**

5.3.5 Screw conveyor motor current. The live bottom conveyor, cross conveyor, and feed conveyor motor current (both average and range data) are graphically presented for each CHAAP soil test run in Figure 21. A similar graphical plot for the LAAP soil test runs is presented in Figure 22.

5.3.6 LAAP soils explosives concentrations. A summary of the feed soil and processed soil explosives concentrations is provided in Table 14. In addition, after Run No. 7, the 8-hour run at 8,000 lb/hr, samples were taken from several points in the system where soil was compacted in the cross conveyor trough. The reason for this testing was to evaluate whether explosives have a tendency to concentrate within the feed system. This sample is labeled "Run No. 7-Accumulated." As shown in Table 14, the explosives concentrations for "Run No. 7-Accumulated" were somewhat lower than for "Run No. 7-Processed," which indicates no tendency of explosives to concentrate within the feed system. However, there was such a high degree of variability between explosives concentrations in "Run No. 7-Feed" and "Run No. 7-Processed" that these results must be considered inconclusive.

5.4 Physical observations. The field testing activities can be broken down into seven major areas:

(1) Soil excavation, staging, and feeding to the hopper.
(2) Live bottom hopper operation.
(3) Cross conveyor operation.
(4) Feed soil characteristics.
(5) Feed conveyor operation.
(6) Control system operation.
(7) Shaft seal purge system operation.

This section provides a summary of physical observations regarding each of the foregoing areas.

5.4.1 Soil excavation, staging, and feeding to the hopper. The method used for soil excavation, staging, and feeding to the hopper for the LAAP soil was in accordance with the proposed future full-scale operational procedures. The procedure worked very well. The only problem was the inability of the tracked-excavator operator to observe the level of soil in the hopper.

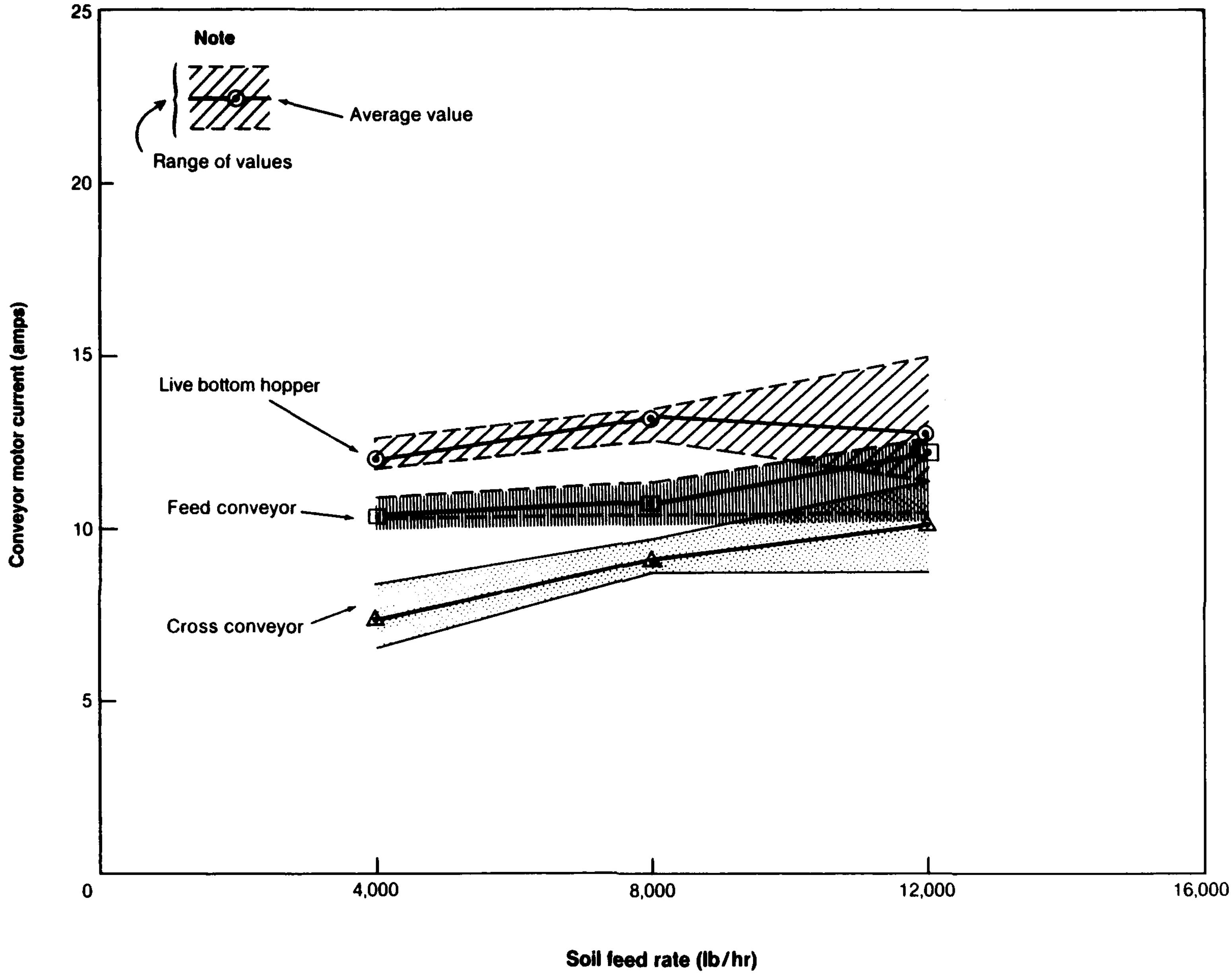


Figure 21. Motor current for CHAAP soil test runs.

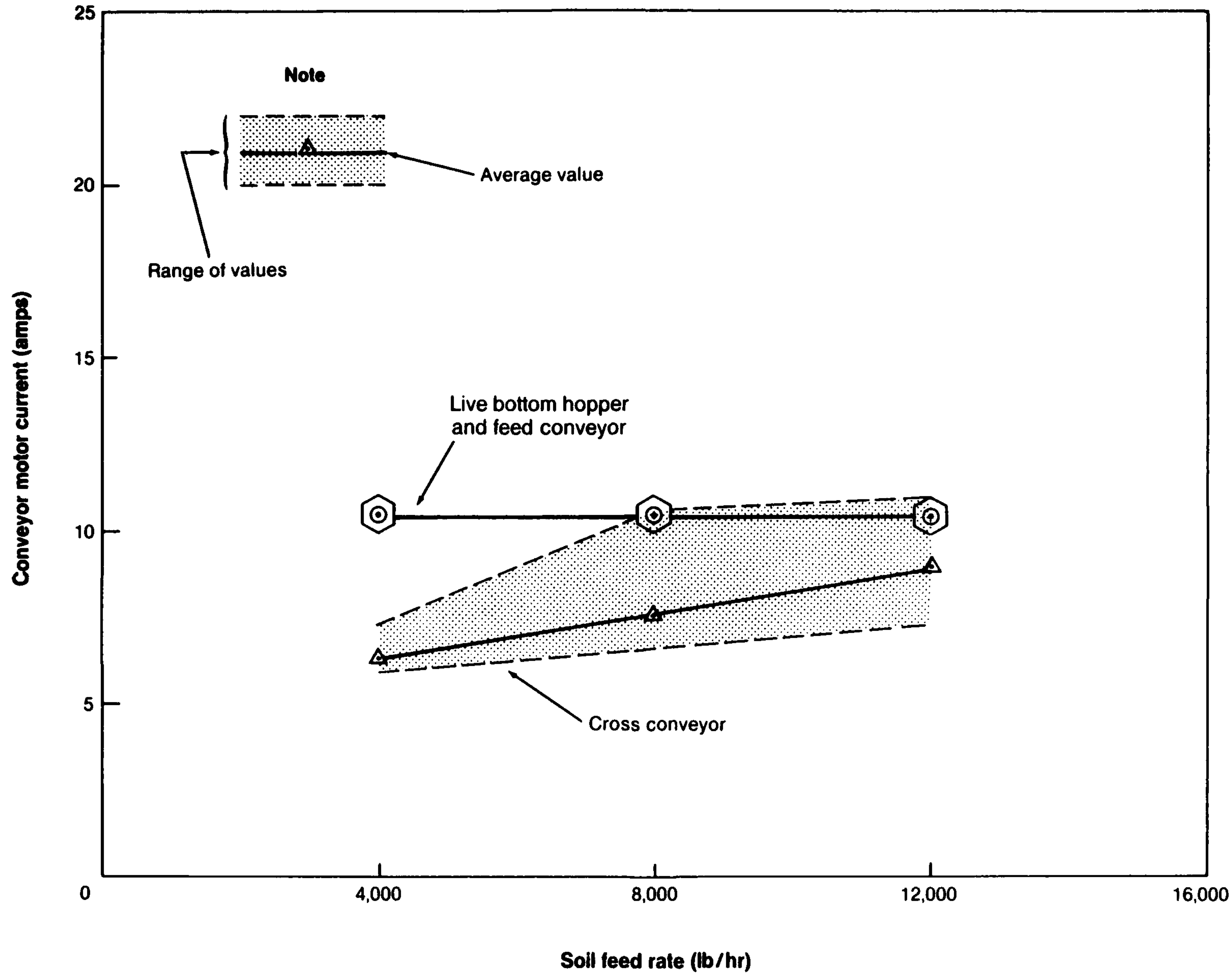


Figure 22. Motor current for LAAP soil test runs.

TABLE 14. SUMMARY OF SOIL EXPLOSIVES CONCENTRATIONS FOR THE LAAP TEST RUNS

| | Explosives concentration[1] (ppm, dry basis) | | | | | |
|---|---|---|---|---|---|---|
| LAAP run no. | 2,4,6-TNT | RDX | HMX | Tetryl | Others | Totals |
| 5 - Feed | 5,833 | 3,357 | 824 | --- | 77 | 10,091 |
| 5 - Processed | 8,918 | 4,290 | 1,232 | 47 | 59 | 14,546 |
| 6 - Feed | 169,900 | 26,540 | 6,300 | 3,290 | 60 | 206,090 |
| 6 - Processed | 74,690 | 16,570 | 4,040 | 250 | --- | 95,550 |
| 7 - Feed | 93,990 | 20,141 | 4,830 | 320 | --- | 119,281 |
| 7 - Processed | 163,000 | 93,500 | 21,730 | --- | --- | 278,230 |
| 7 - Accumulated | 160,900 | 31,840 | 6,820 | 1,040 | --- | 200,600 |
| Detection limits[2] | 1.0 | 0.8 | 1.4 | 0.8 | 0.6 | --- |

[1] Legend

2,4,6-TNT - 2,4,6 Trinitrotoluene
RDX - 1,3,5-Trinitro-Hexahydro-1,3,5-Triazine
HMX - 1,3,5,7-Tetranitro-Octahydro-1,3,5,7-Tetracyclooctane
Tetryl - Tetrahitromethylaniline
Others - 1,3,5-Trinitrobenzene, 1,3-Dinitrobenzene, Nitrobenzene, 2,6-Dinitrotoluene, and 2,4-Dinitrotoluene. (All numbers are reported as 1,3,5-Trinitrobenzene.)

[2] Analyzed by high performance liquid chromatography (HPLC) using USATHAMA Method 8H.

5.4.2 Live bottom hopper operation. The live bottom hopper proved to be a very effective and reliable metering device for maintaining system feed rate. During the formal test runs more than 300,000 pounds of soil were processed with no downtime due to hopper bridging, jams, or equipment malfunction. Control of system feed rate was provided exclusively by the live bottom hopper. The cross conveyor and feed conveyor were set at rotational speeds nearly an order of magnitude faster than the live bottom hopper. This approach was taken to minimize the potential for soil buildup and potential jamming in the cross conveyor and feed conveyor.

There was a slight tendency for bridging at the front of the live bottom hopper due to the recessed lip of the access doors. This could be corrected by building up the faces of these doors to eliminate the recess.

All feed rate conditions for both soil types were achieved without exceeding 75 percent of the maximum recommended conveyor tip speed of 2 feet per second.

5.4.3 Cross conveyor operation. The cross conveyor operated flawlessly for the CHAAP soils. For the LAAP soils, there was a slight tendency for buildup of the sticky plastic clay to the conveyor flights. However, the clay soils would only build up to a certain level at which time the twin, counter-rotating, ribbon flight screws tended to self-clean. The net result was instantaneous decreased and increased feed rates as the material was building up or breaking free, respectively. However, over longer averaging periods (i.e., 20-40 minutes), the average feed rates were relatively stable.

All feed rate conditions for both soil types were achieved without exceeding 65 percent of the maximum recommended conveyor tip speed of 2 feet per second.

5.4.4 Feed conveyor operation. The feed conveyor operated flawlessly for both CHAAP and LAAP soils. It was not possible to observe whether similar buildups were experienced for the LAAP soil as for the cross conveyor. It is assumed that similar buildup did occur. However, due to the short length of the feed conveyor compared to the cross conveyor, the net impact was much less significant.

All feed rate conditions for both soil types were achieved without exceeding 10 percent of the maximum recommended conveyor tip speed of 2 feet per second.

5.4.5 Feed soil characteristics. The CHAAP soil had much lower moisture content than the LAAP soil. As a result, the CHAAP soil discharging from the feed conveyor was broken up into rather consistent lumps ranging from 0 to 1 inch in diameter. The LAAP soil discharging from the feed conveyor came out as considerably larger clumps of wet plastic clay. Both of the material consistencies would be quite acceptable for introduction into the rotary kiln.

5.4.6 Control system operation. All control system functions were tested while processing uncontaminated CHAAP soil. Jams were simulated individually in all three conveyors by lowering the motor amp limit switches. Lowering the "high" limit switch for each conveyor until it tripped simulated an overloaded condition for the conveyor. This condition simply alarms the operator and shuts down upstream conveyors until the overload condition clears. At this time, the upstream conveyors become permissive and the operator can manually restart them. Lowering the "high-high" limit switch for each conveyor until it tripped simulated a jam for the conveyor. This condition alarms the operator, shuts down upstream conveyors, and automatically reverses the conveyor for 3/4 of a revolution. The conveyor then automatically attempts to restart in a forward direction. If it jams again, this procedure automatically repeats. If it jams again, the conveyor automatically shuts down. Once the jam is cleared the conveyor and upstream conveyor become permissive and the operator can manually restart them.

All of the alarm conditions specified previously in Table 5 were tested as discussed above and functioned properly.

5.4.7 Shaft purge system operation. A shaft seal purge system was installed to preclude migration of explosives-contaminated material into the seals. The shaft bearings are all outboard of the material flow path. The shaft seals are compression seals filled with braided Teflon®. Originally, a compressed air purge was to be installed. However, during installation, it was decided that a low pressure (i.e., gravity feed) oil seal purge system was more advantageous for the following reasons:

(a) A compressed air purge could over-pressurize the seal, causing the opening of a free path for contamination into the seal.
(b) The compression seals are not well suited for compressed air purge.
(c) The flow of air through the seal would tend to dry the seal internals, resulting in a potentially hazardous situation due to explosives sensitivity.

(d) If a fire were to propagate within the feed system, introducing air through the seals would introduce oxygen which may promote the fire.

Therefore, a gravity oil seal purge system was installed which performed very well.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

(a) The feed system successfully demonstrated the ability to safely and reliably process 50 to 150 percent of the design feed rate (8,000 lb/hr) of explosives-contaminated soils. During the formal test runs more than 300,000 pounds of soil were processed.

(b) With the exception of lump size reduction for the CHAAP soil, the feed system did not significantly affect the feed soil grain size distribution.

(c) Curves were developed which correlate variable speed drive settings with conveyor rotational speeds (in rpms) and tip speeds (in feet per second).

(d) Curves were developed which correlate conveyor motor amps with soil feed rate. Variations in motor amps do not appear to be significant enough to serve as a basis for predicting or controlling the feed rate.

(e) A practical soil excavation, staging, and feeding technique was developed for full-scale field operations.

(f) The live-bottom hopper proved to be a very reliable and effective metering device for maintaining system feed rate.

(g) The control system was fully tested and functioned properly.

(h) The gravity oil seal purge system performed very well. It was easy to monitor and to maintain.

(i) Analysis of soils compacted in the conveyor trough after Test Run No. 7 demonstrated no tendency for explosives to accumulate in the system during operation. However, due to the short duration of the test and the variability of explosives concentration in the feed and processed soils, these results are inconclusive.

(j) Table 15 provides a summary of the recommendations from the "Hazards Analysis of Incinerator Feed System (see Appendix D) conducted by Allegany Ballistics Laboratory (ABL) and how the recommendations were applied during actual field tests of the feed system.

TABLE 15. RECOMMENDATIONS FROM THE ABL'S HAZARDS ANALYSIS OF INCINERATOR FEED SYSTEM (APPENDIX D)

| Recommendations | How applied during the field tests of the feed system |
|---|---|
| **The mandatory recommendations are:** | Responses to Mandatory Recommendations |
| 1. The incinerator feed system (IFS) must be operated remotely (unattended) when handling explosives-contaminated soils. The separation between the operating unit and personnel must be based on standard distance tables which take into consideration the hopper's capacity, compaction, explosive concentration, the potential blast overpressure, thermal radiation from a fire ball, and primary fragment dispersion from an explosion. | 1. The control panel was located approximately 100 feet from the feed system to allow remote operation. Video cameras were installed to allow observation of the feed system remotely. Personnel access was minimized to the fullest extent practical when processing the LAAP explosives-contaminated soils. Fire hoses were used to continuously wet the entire test area and lagoon soils to reduce soil sensitivity. |
| 2. Wooden "bang" boards must be installed on the top flanges of the hopper to prevent accidental metal-to-metal contact of the dumper and hopper. | 2. Wooden "bang" boards were installed on the top flanges of the hopper. Also, plywood sheets were installed on the weigh scale and concrete pad areas where the self-dumping hoppers were staged to reduce potential for metal-to-metal or metal-to-concrete friction. |
| 3. Procedures and rules must be established calling out acceptable tools and techniques for clearing hopper bridging and screw jams. Nonsparking metal tools may not be adequate or proper due to the impact process potentials of the materials. | 3. In addition to using nonsparking tools, the standard procedure for cleaning hopper bridging (which never happened) or screw jams was to first deluge the area with the fire hose to reduce the material sensitivity. |
| The nonmandatory recommendations are: | Responses to Nonmandatory Recommendations |
| 1. Lagoon material should be inspected prior to dumping to assure it is damp, and does not contain rocks or foreign metal materials. | 1. Lagoon material was inspected manually and oversize rocks and foreign metal materials were removed. |
| 2. Rock, frozen, or dried lumps should not be fed to the IFS. | 2. All LAAP lagoon soils were saturated with water prior to feeding to the system. |
| 3. Adequate water should be available for dampening lagoon material, remote fire fighting, wash out, and initiation suppression. | 3. Water supply at the LAAP site was more than adequate. |
| 4. Jams in screw conveyors should be washed to remove all possible contamination before attempting repairs. | 4. See Note 3 above. This was standard operating procedure. |
| 5. Washings of the IFS should be collected for disposal or directed back to the lagoon to prevent contaminating additional soil. | 5. All washings were dircted to lagoon No. 12, which was adjacent to the test site. |
| 6. All area tools should be accounted for prior to starting or resuming operation of the IFS. | 6. All area tools were accounted for prior to starting or resuming system operation. |

TABLE 15. (CONTINUED)

| Recommendations | How applied during the field tests of the feed system |
|---|---|
| 7. Consideration should be given to using wooden, plastic, or fiberglass materials of construction for shovels, rakes, hoes, and hopper bridge clearing rods. | 7. Shovels and tools to be used for cleaning bridging were either wood and brass or plastic. |
| 8. A combustion products infrared analyzer with samplers located above the hopper and at the final screw outlet may detect early signs of decomposition or initiation and allow for shutdown and the addition of quenching water. | 8. This system was not applicable for the field test since the system was not actually feeding an incinerator. Video monitors were used to allow remote observation of smoke or fire. |
| 9. Personnel in the area should be protected with flame-resistant cloth coveralls. | 9. Personnel exposed to the explosives-contaminated soils wore Tyvek overalls. Due to high ambient temperatures, heavy flame-resistant cloth overalls were not recommended. |

## 6.2 Recommendations

(a) It is recommended that the feed system (incorporating the modifications described herein) be made available to DOD contractors for use on incineration remedial action projects.

(b) It is recommended that the live-bottom hopper variable speed drive be used to manually control system feed rate. The cross conveyor and feed conveyor should be run at 25 and 30 rpm, respectively. This will preclude material buildup in these conveyors while operating at speeds below the recommended maximum tip speeds.

(c) It is recommended that a warning sign and a physical stop (i.e., bolt) be placed on the variable speed drives for the cross conveyor and feed conveyors to limit conveyor tip speeds to no more than 2 feet per second. The recommended maximum variable speed drive setting for the feed conveyor is 1.5 and 2.0 for the cross conveyor.

(d) It is recommended that a large convex mirror be placed above the live-bottom hopper to allow the tracked excavation operator visual observation of the soil level in the hopper.

(e) It is recommended that the live-bottom hopper doors be built up with a metal plate to provide a smooth internal surface and preclude bridging in the hopper.

(f) It is recommended that the control system be modified so that the system diagnostic warning lights on the control panel remain on after the annunciator is silenced.

(g) Based on ABL's recommendations, additional testing should be considered to determine whether the higher concentrations of explosives such as found in the LAAP sludge will respond with sustained burning and transition to an explosion at energy levels above those in the process, and which exceed the equivalent energy levels of the sensitivity tests, but which are much lower than the energy levels associated with propagation tests.

(h) Upon review of this report, the Department of Defense Explosives Safety Board (DDESB) and the U.S. Army Armament, Munitions and Chemical Command Field Safety Activity (FSA) have determined the following:

(1) The incinerator feed system test has demonstrated the capability of the feed system to safely transport the explosives-contaminated soils that were used during the test. However, because of the nonhomogeneity of lagoon sediments, operational procedures should be established to ensure that the explosives content of the sediment is less than 25 percent dry weight before it is

introduced into the feed system. In lieu of this, operation protection must be provided against hazardous fragments and overpressure, assuming the maximum credible event to be a detonation involving the total amount of explosives in the feed system and the incinerator.

(2) All sediment at an operational site should be adequately wetted to preclude the initiation of a fire or detonation prior to introduction of the sediment into the incinerator, i.e., within the feed system. A capability should be established to maintain an adequate sediment moisture content in the feed system during periods of extended shutdown.

(3) An integrated systems test of the feed system and the incinerator should be conducted under actual operating conditions before system parameters are finalized. A site plan and safety submission for this test should be prepared and submitted to DDESB and FSA for approval prior to the start of the test. The results of this test will provide the basis for a DDESB review of the site plans and safety submissions required for sediment decontamination operations at selected Army installations.