6/13/88

AUTHOR: R. C. BENJAMIN

DEPARTMENT: PROCESS TECHNOLOGY & DEVELOPMENT

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PROJECT NO. 0302

G-7A IN-LINE AMMONIATION PROCESS

OBJECT: To evaluate the process control capability and economic benefits of implementing a G-7A In-Line Process.

SUMMARY: A Level I Engineering Study estimated an annual savings of $ 3.06 MM, with a ROI of 55 % to replace the current G-7A process with an in-line ammoniation process. Approximately 90% of these savings results from reduction in labor costs.

A statistical study was conducted on the process variables of the G-7A In-Line Porous Belt Process. The study indicated that the primary variables controlling residual ammonia in G-7A were the process reaction time and the level of ammonia in the process air.

STATUS: Because of the significant influence of the level of ammonia in the treater on G-7A, an ammonia analyzer has been recommended and is being purchased for the G-7A production process at Plant 605.

KEYWORDS: NS G-7A, In-Line Ammoniation, Porous Belt, Specific Ammonia (7664-41-7), Humidity (7732-18-5), Temperature, Tobacco Processing, Sensory Evaluation, Rotary Drum, Ammonia Analyzer, RC0319, RC0320.

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INTRODUCTION

The G-7A Pilot Line was installed at Shed 181 in October, 1986. It is an alternative G-7A process that can ammoniate G-7 in-line with the G-7 Pilot Line. In-line ammoniation of G-7 is generally considered to be a more cost effective process than the current off-line G-7A production process. In 1988, RDM-108 indicated that G-7A made by the in-line ammoniation process was not different from the G-7A made by the current G-7A process at Plant 605. This report will discuss the cost advantages and process control capability of an in-line ammoniation process.

DISCUSSION

Process Technology and Development initiated the Engineering Study No.0073 (see Appendix A) to determine the cost advantages of producing G-7A in-line with the G-7 production processes. A porous belt process and a rotary drum process were the two different systems that were included in the study. The porous belt unit was a prototype of the equipment used at the G-7A Pilot Line, and the rotary drum unit was similar to the treater drums currently used in the G-7A process at Plant 605.

Both systems could offer economic benefits over the current off-line G-7A production process. Labor costs could be greatly reduced because the in-line system would not require separate or additional personnel like the current off-line production process. Additionally, the shipping and handling costs, now incurred by transporting G-7 to Plant 605 for ammoniation, could be eliminated by the in-line system.

The porous belt system consisted of a stainless steel porous conveyor with an 80% open area. In the in-line operational mode, G-7 would be conveyed from the dicer in the G-7 Plants to the inlet airlock of the porous belt treater. After entering the treater, the G-7 falls on the porous conveyor which controls the time the tobacco spends in the treater. The G-7 is ammoniated as a gaseous stream of ammonia and air passes up through the porous conveyor. This system has been installed at Shed 181 and operates in conjunction with the G-7 Pilot Line.

The rotary drum system is similar to the porous belt process except it uses a rotating stainless steel cylinder as the ammoniation treater. The G-7 tumbles through the drum and mixes with the anhydrous ammonia that enters the drum through a series of nozzles. After ammoniation, the product drops into an exiting airlock and is conveyed to the tersa bale packer at which 750 pounds of the material is packed in tersa bales. The equipment for this system is currently in operation at Plant 605, in an off-line G-7A production process.

The Engineering Study, that was conducted on both systems, was a Level I Feasiblilty Study. It was conducted by Ms. J. W. Hopkins and Mr. S. M. Norman. They were in several meetings with Tobacco Processing and Process Technology and Development to assure that the study would be based on the best available processing data.

EXPERIMENTAL

In addition to assessing the economic incentives of implementing an in-line ammoniation facility, evaluating the process control capability of such a system was also conducted. This was done with the help of Dr. M. J. Morton who designed a statistical study on the process variables of the G-7A In-Line Pilot Unit. The objective of the study was to determine the degree of process control needed for an in-line ammoniation system and the specific process parameters which control the level of residual ammonia in G-7A.

The process parameters that were included in the study were: 1. incoming G-7 moisture level, 2. percent of ammonia in the treater, 3. temperature, 4. humidity, 5. residence time, and 6. air rate. The G-7 Pilot Line received G-7 pulp from Plant 603 and processed it at three different moisture levels: 1). 8 - 10 %, 2). 11 - 13 %, and 3). 14 - 16 %. This was done to determine the impact of moisture variations in G-7 on the in-line ammoniation process. The other process parameters were controlled by the G-7A Pilot Line which received G-7 directly from the G-7 Pilot Line. Listed below are the three levels of process conditions that were used for the nineteen test parts:

Process Parameters	Low Level	Medium Level	High Level
NH_3 (%)	2.5 - 3.5	5 - 6	7.5 - 8.0
Temp. (Celsius)	13	55	55
Humidity (%)	28 - 32	30 - 55	100
Residence Time (min.)	0.42	1.25	8.33
Air Rate (cfm)	325	465	610

The ammonia level in the process air was measured by a Beckman Model 865 NDIR Ammonia Analyzer. The analyzer can measure up to 10 % NH_3 in air with a precision of 1 % of full scale. The process ammonia / air mixture was continuously measured by the analyzer, and a record of the values was printed every 45 seconds.

RESULTS

O Economic Evaluation

A Level I estimate of the capital costs to implement an in-line ammoniation system (rotary drums or porous belt conveyors) in all three G-7 Plants is $4,445,000 to $6,667,000 (includes the 50% tolerance associated with Level I estimates). The annual savings are $3,062,000 and the total first year savings are $1,458,000. This yields an after-tax ROI of 37% to 55 %. Although the required G-7A production could be met by installing an in-line process at only two of the G-7 Plants, the Level I estimates are based on installing the process at all three plants. This would provide maximum flexibility and reliability.

Both systems (rotary drums or porous belt conveyors) require architectural modifications to correct height restrictions at Plants 90-1 and 92-1. These modifications require cutting a channel in the ceiling at 90-1 and a channel in the roof at 92-1 and adding a penthouse. This would allow the same system to be installed at all three plants. See Appendix A.

O Process Control Capability (G-7A Pilot In-Line System)

The primary process variables which influence the residual ammonia level in G-7A are the residence time in the treater, the level of ammonia in the treater, and the moisture level of G-7. See Appendix B. The statistical model developed for the process predicts that small fluctuations in the moisture level of G-7 will not greatly influence the residual ammonia level. For instance, for a 1 % increase in moisture, the model predicts a 0.028 absolute percentage increase in residual ammonia. This can be corrected by decreasing the ammonia level in the air by 0.5% or by decreasing the residence time by 45 seconds.

Although the statistical study was designed only to determine the main effects of the process variables on residual ammonia, the product analyses indicate that the residual ammonia specification (0.70 - 1.00 % NH_3) for G-7A can be met with several combinations of process variables. See Appendix B. For example, Run 9 meets the specification with a residence time of 8.33 minutes and an ammonia level of 3.1%. Run 13 comes very close in meeting the specification with a residence time of 0.42 minutes and an ammonia level of 7.8%. The study also indicated that PT&D and Analytical R&D product measurements for ammonia and moisture are well correlated.

O Safety

The hazardous aspects of ammonia have to be addressed by any in-line ammoniation system. Both of the treater airlocks should have direct outlets to remove ammonia / air pockets with an exhaust fan. Good ventilation in hooded conveyors and in the bale packing area will also reduce discomfort resulting from ammonia in work areas.

In addition to maintaining a comfortable work area, steps should also be taken to avoid the explosive range (16 - 23 % by volume) of ammonia in air. This can be done by an interlock system utilizing an on-line ammonia analyzer which would continuously monitor the ammonia level in the process treater.

CONCLUSIONS

Implementing a G-7A in-line ammoniation system in the G-7 Plants can be economically justified. The system can also be designed with sufficient process control to consistently meet the current product specifications for G-7A.

RECOMMENDATIONS

1. It has been recommended to Tobacco Processing to install an ammonia analyzer for the G-7A production process at Plant 605. The recommendation has been received and the analyzer is in the process of being purchased. It will be very similar to the one currently in operation at the G-7A Pilot Line and will be installed by July, 1988. The analyzer will be used to monitor the ammonia level within the treater and will thereby aid in controlling residual ammonia in G-7A.

2. The design of any in-line ammoniation facility should include the flexibility of controlling both the tobacco residence time in the treater and the level of ammonia in the treater. Both of these process variables would provide the maximum process control that may be needed when moisture variations occur in G-7. Unlike a rotary drum system, a porous belt unit can unquestionably provide instantaneous control of the tobacco residence time in the treater.

Robert Benjamin
Robert C. Benjamin

Robert A. Merricks
Recommended: Robert A. Merricks 6-8-88

John L McKenzie 8 June 1988
Accepted: John L. Mckenzie

Dan R Pugh
Approved: Dan R. Pugh 6/13/88

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Mr. T. W. Brown

APPENDIX

A

Req. 7/20/87 cc: IES/JFM

Assign to CWS

R. J. REYNOLDS TOBACCO COMPANY

Request For Engineering Services

Project No.: 73

Budget I.D. No.:

TO: VICE PRESIDENT ENGINEERING

Requested By: Robert C. Benjamin Robert Benjamin (Signature) Process Tech. & Dev. (Department) 6/25/87 (Date)

Approved By: [signature] (Signature) Process Tech. & Dev. (Department) 7/6/87 (Date)

Requested Completion: ______ (Date) Client Representative: Robert C. Benjamin (Name) 3-4539

Type of Engineering Report: Feasibility ☒ Preliminary ☐ Detailed ☐

Vice-President of Engineering ______ (Signature) ______ (Date)

Scope Narrative:

Process Technology and Development requests a Level I estimate for an ammoniation production facility. This production unit will be used to ammoniate various types of tobacco.

The following work shall be performed:

Determine the technical and economic feasibility of installing a porous belt treater in all three G-7 plants to perform "in-line" G-7 ammoniation. Also determine the feasibility of installing an enclosed rotary drum in the G-7 plants to perform "in-line" G-7 ammoniation. The economic analysis is based on eliminating G-7A processing at Bldg. 605.

(attach additional sheets if necessary) 225

To be completed by the Project Manager

Title: AMMONIATION FACILITY

Project Manager: J. L. WIDEMAN / S. M. NORMAN

Scheduled Completion Date: 12/31/87 Estimated Cost of Report: $18,900

To be completed by Requestor and returned to Project Manager

☑ PROCEED ☐ CANCEL

Requested By: ______ (Signature) ______ (Date)

Approved By: [signature] (Signature) 8-12-87 (Date)

RJRT Form 7350 — Rev. 7/83

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ENGINEERING REPORT
R. J. REYNOLDS TOBACCO COMPANY
WINSTON-SALEM, N. C.

REQUESTER Robert C. Benjamin

PROJ. NO. 0073

ASSIGNED TO: J.W.Hopkins/S.M.Norman

TITLE: G-7 In-Line Ammoniation Facility

EXECUTIVE SUMMARY:

Study #0073 was initiated by Process Technology & Development (PT&D) to evaluate the feasibility of implementing either a porous belt treater or a rotary drum at the G-7 plants (between the dicer and the packer) to ammoniate G-7 and thus produce G-7A. Alternative G-7A processes are being considered because the existing G-7A process equipment at Building 605 is approaching the end of its useful life and would require extensive replacement. Because the alternative processes can be implemented within the G-7 plant after the G-7 process ("in-line"), the advantages of the "in-line" processes are as follows:

- A separate processing step at Building 605 could be eliminated and therefore save processing costs.
- Transportation costs can be saved by eliminating the transport of G-7 to 605-1 for ammoniation.

The feasibility analysis compared the technical and economic feasibility of several "in-line" ammoniation process options listed as follows:

- Option 1 - Porous Belt Treater - Single-pass
- Option 2 - Porous Belt Treater - Two-pass
- Option 3 - Rotary Treater Drum

There are space limitations within the 3 G-7 plants: A single-pass treater will fit at 90 & 92, however, not at 603; A two-pass treater will fit at 603, however not at 90 & 92 (height restrictions). If architectural modifications are performed at the two downtown plants (cut a channel in the ceiling at 90-1 and a channel in the roof at 92-1 and adding a penthouse), similarly designed two-pass treaters or rotary drums can be implemented at all three plants. Because the material handling aspects of the process are critical, this needs to be examined in more detail to ensure the total "in-line" system is workable (will be confirmed in a later report once preliminary layouts are done), however, from a preliminary analysis, a material handling system can be developed for the process.

Of the alternatives evaluated, the rotary drum is preferable for the following reasons:

- Requires lower capital expense.
- Can implement the same type drum at all 3 G-7 plants (compatible equipment).
- Is known and proven technology.
- Plants are more familiar with operating and maintaining rotary drums.

The Level I estimated cost to implement rotary treater drums at all 3 G-7 plants is $4,445,000. The savings (processing and transportation) from the "in-line" ammoniation process are $3,062,000/year (1990 dollars) yielding an ROI of approximately 55%.

Originator | Date

J.W.Hopkins S.M.Norman 1/5/88
J.W.Hopkins/S.M.Norman

Reviewed By

Jeff E [signature] 1/5/88
John D. Potter 1/6/88
C E Scott III 1/7/88

2359m

cc: R. A. Merricks
D. L. Snyder
J. S. Thomasson

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ENGINEERING REPORT
R. J. REYNOLDS TOBACCO COMPANY
WINSTON-SALEM, N. C.

PROJ.REF.
NO.

STUDY NO. 0073
REPORT No.

TITLE: G-7 In-Line Ammoniation Facility

REPORT: ENGINEERING ANALYSIS

INTRODUCTION

G-7 is produced at three plants, 90-3, 92-2, and 603-1. Approximately 60% of the G-7 produced is ammoniated at Building 605-1 where it is treated with anhydrous ammonia in large rotary treater drums. The 605-1 facility is old and major processing equipment (treaters, mill feeders, etc.) is approaching the end of its useful life and would require replacement in the near future to continue processing at this facility. Also, occasional equipment malfunctions and process metering inaccuracies cause inconsistent end product results. Ammoniation alternatives to the 605-1 process are being considered to establish means of producing G-7A indefinitely and to realize the following economic benefits of an "in-line" process:

- An entire separate processing step at 605-1 could be eliminated resulting in process savings.
- Improved control of the ammoniation process would produce a more consistent G-7A product.
- Transportation costs could be reduced by eliminating the transport of G-7 to 605-1 for ammoniation.

The feasibility analysis evaluated the following "in-line" ammoniation options to determine the most feasible from a technical, economic, and operational standpoint:

- Option 1 - Porous Belt Treater - Single-pass
- Option 2 - Porous Belt Treater - Two-pass
- Option 3 - Rotary Treater Drum

TITLE: G-7 In-Line Ammoniation Facility

REPORT: ENGINEERING ANALYSIS

ALTERNATIVES EVALUATED

The following assumptions were used in the feasibility analysis:

- The maximum product flow rate is 12,000 lbs/hr. (proposed G-7 production increase plus blendback).
- A retention time of 30 seconds in the porous belt treater with a bed depth of 2" is sufficient for the ammoniation reaction.
- A retention time of 3 minutes in the rotary drum is sufficient for the ammoniation reaction.
- The percent loading in the rotary drum should range from 20-30%.
- The "in-line" ammoniation reaction will be controlled by using an ammonia analyzer (with a mass flow meter, ratio controller and control valve) to maintain a specified anhydrous ammonia in air concentration.
- No additional QA personnel will be required at the G-7 plants to perform additional ammoniation tests.
- G-7A production capability will be installed at all 3 G-7 plants.
- The location of the ammoniator and the material-handling requirements assumes a tersa-bale packer will be implemented at 603-1 and at 90-1 (see preliminary engineering drawings SK-7123MH04 & SK-7255MH04) and that a tersa-bale packer will not be implemented at 92-1.

With input from Tobacco Processing (TP), a location for the process in each G-7 facility was identified (see Appendix A). Because the process handles diced G-7, the process must be located after the dicer, but before the packer.

Option 1: Single Pass Porous Belt Treater - is comprised of a stainless steel outer chamber of dimensions 50' long, 12' wide, and 8' high. Diced G-7 product is conveyed to the top of the treater into a rotary air lock and into the chamber. The product drops out of the rotary airlock onto a stainless steel mesh belt conveyor. An anhydrous ammonia and air mixture is blown through the product and mesh belt causing the ammoniation reaction to occur. The conveyor belt length and speed are designed to give the required residence time in the treater. When the product reaches the end of the belt, it is conveyed into an exiting rotary airlock and then through a series of covered and hooded conveyors to the packer. The treater design is similar to the pilot porous belt treater process located at 181 shed.

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Option 2: Two Pass Porous Belt Treater -
is similar to the single-pass unit except that there are two conveyors stacked on top of each other inside the chamber, where the G-7 product is treated on the upper belt, then drops onto a lower belt where treatment with the anhydrous NH3 and air mixture continues. This option allows the overall length of the treater unit to be decreased while maintaining the same residence time. The dimensions of this unit are 35' long, 12' wide, and 15' high.

Several space limitations exist within the G-7 plants that affect implementation of a porous belt treater (combined with its necessary infeed system):

- The location identified at 603 for the process (see sketch) is not long enough to accommodate a single-pass porous belt treater unit and infeed system. Because the 603 facility has sufficient vertical height, a two-pass treater unit can fit into the facility (two-pass unit is shorter in length, but taller in height) along with the infeed system.
- At Buildings 90 & 92 sufficient length exists to accommodate a single-pass treater unit and infeed system, however not enough height exists to accommodate a two-pass treater unless architectural modifications are made to the buildings.

Option 3: Rotary Drum -
is comprised of a rotating stainless steel cylinder of approximate dimensions 7' diameter, 34' long, and 14' high (includes drum, infeed chute and rotary airlock and positioned on a 0.5"/ft slope to give adequate residence time and drum loading. The diced G-7 product enters a rotary airlock, into an entry chute, and into the rotary drum. The product is tumbled through an anhydrous ammonia and air environment (NH3 is piped into the drum through a series of nozzles) and the ammoniation reaction occurs. At the end of the drum, the product drops into an exiting rotary airlock and then through a series of covered and hooded conveyors to the packer. The rotary treatment process is existing technology and is very similar to the treater drums utilized at 605-1 in the present G-7 ammoniation process (except that the drums that would be implemented in the G-7 plants would be less than half the length of the drums at 605).

The height of the rotary drum with infeed system is too tall to fit into both 90-1 and 92-1 but can fit into 603. The only way these two facilities can accommodate the rotary drum is to cut a channel through the ceiling or roof (and allow a portion of the system to extend into the floor above for 90-1 and build a penthouse on the roof for 92-1).

Consultation with the Civil, Structural & Architectural (CSA) Design section indicated that the architectural modifications on the two facilities can be performed if certain steps are taken (see memo from CSA in Appendix A).

TITLE: G-7 In-Line Ammoniation Facility

REPORT: ENGINEERING ANALYSIS

ALTERNATIVE SELECTED

Because Option 1, single-pass porous belt treater, cannot be accommodated in the location selected at 603 (length restricted) and the desire of plant operations to implement the same type of process (compatible equipment) at all three G-7 plants, Option 1 is not recommended.

Option 2, two-pass porous belt treater, can be accommodated at all three facilities by making architectural modifications at the two downtown plants (90-1, cutting a channel in the ceiling of the first floor; 92-1, cutting a channel into the roof and building a penthouse). This option is the most costly of the three and doesn't provide any advantage over the rotary drum from a yield standpoint (because feeders have to be used with the porous belt treater to spread the product on the belt and feeders create some degradation). The porous belt process also doesn't provide and advantages from a control standpoint. Therefore, Option 2 is not recommended.

Option 3, rotary drum, is the best alternative for "in-line" ammoniation for the following reasons:

- Requires the lowest capital expenditure.
- Rotary drums are known and proven technology for the G-7A process from experience at the 605-1 facility.
- A large amount of plant experience exists with the mechanical operation of drums and their required maintenance.
- Simplicity of equipment and operation

Because the process handles diced product, it should be located after the dicer, but before the packer. Because of space limitations within the existing G-7 plants and the limitations imposed by the existing conveying system, the material handling aspects of conveying product into and out of the drum are critical. From a preliminary analysis, it appears possible to design an adequate material handling system; however, it needs to be examined in greater detail to ensure that enough space exists to accommodate the material handling conveyors (Material Handling Design will perform equipment layouts to confirm that the material handling barriers can be overcome in January 1988 and an addendum to the report will be issued).

Material Handling Design shall consider conveyor design so that the product can be conveyed to the primary packer or the back-up packer or bypass the drum when G-7 would not be ammoniated.

Because of the location of the process at 603-1, the rotary drum and conveyors limit access to an equipment elevator (see sketch). The maximum clearance directly in front of the elevator would be approximately 5'7". Also, the additional conveyors would use some of the area presently allocated for equipment storage.

TITLE: G-7 In-Line Ammoniation Facility

REPORT: ENGINEERING ANALYSIS

ENVIRONMENTAL ISSUES

Ammoniation in the G-7 manufacturing facilities has raised some concerns about ammonia vapors in the work environment. Study 40, "G-7A Alternatives", recommended testing the ammoniated extract alternative in a G-7 facility to determine this environmental impact. The test is scheduled for the December/January time frame and will be coordinated by Tobacco Processing. This test could also provide valuable information for the "in-line" ammoniation alternative, such as the degree of ammonia buildup in the packer area. The following steps can be taken to minimize ammonia concentration in the work environment:

- Drums shall have adequate seals to prevent leaks.
- Airlock pockets shall be evacuated of ammonia/air vapors.
- Drum infeed system should be hooded and exhausted.
- Conveyors exiting the drum should be covered and exhausted.
- Ammoniated exhaust may require scrubbing before being discharged to atmosphere.
- Add exhaust fans in packing areas.

Since the ammonia application rate is unknown at this time, use of a scrubber was assumed necessary and the cost included in the estimate. Once the ammonia application rate is known, a material balance can be performed to determine ammonia concentration and then a decision made as to whether a scrubber is required.

Consultation was received from the Environmental and Industrial Hygiene Groups concerning the need for a NH_3 monitor and alarm system for the safety of plant personnel. They concluded a monitor and alarm system is not required for the following reasons:

- System has very low reliability (susceptible to dust contamination)
- Personnel can detect ammonia more reliably than a monitoring system
- System is costly

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TITLE: G-7 In-Line Ammoniation Facility

REPORT: ENGINEERING ANALYSIS

IMPLEMENTATION

See Appendix D for the G-7A Alternatives Master Project Schedule. If the rotary drum ammoniation alternative is selected, we recommend the installation at one G-7 facility initially. After the system is operating properly and producing satisfactory product, we then recommend the installation at the other two G-7 facilities. We recommend that testing be performed to determine the required residence time of G-7 in the drum for a successful ammoniation reaction and that optimization be performed to minimize the size of the drum.

ECONOMIC ANALYSIS

A Level I estimate (see Appendix B) of the capital costs to implement the rotary drum in all three G-7 plants is $4,445,000 to $6,667,000 (includes the +50% tolerance associated with Level I estimates). Savings (See Appendix C) from an in-line ammoniation process are as follows:

- Processing savings = cost avoidance of ammoniating G-7 at 605 = $3,319,000/year (1990 dollars).
- Transportation savings = elimination of transporting the G-7 to 605 for ammoniation (since ammoniation will be performed in-line with G-7 production) = $131,000/year (1990 dollars).

Annual net savings (less in-line ammoniation processing costs) are $3,062,000 and total first year savings (1989) are $1,458,000. This yields an after-tax ROI of 37% to 55%.

The cost/lb. comparisons of several G-7A processes are as follows:

	Raw Material	Processing	Total
G-7	$ .32	$ .27	$ .59
G-7A (605-1)	$ .59	$ .05	$ .63
G-7A (Extract Ammoniation)	$ .59	$ .0036	$ .59
G-7A (Porous Belt)	$ .59	$ .0044	$ .59

The cost per lb. raw material and processing costs were obtained from Tobacco Processing Comptrollers. The processing cost for the G-7A rotary drum alternative was calculated as shown in Appendix C.

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R. J. REYNOLDS TOBACCO COMPANY
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TITLE: G-7 In-Line Ammoniation Facility

REPORT: ENGINEERING ANALYSIS

CONCLUSIONS AND RECOMMENDATIONS

Due to height restrictions in the two downtown G-7 facilities architectural modifications have to be performed on buildings 90-1 and 92-1 to accommodate a similarly designed "in-line" ammoniation process at all three G-7 plants. The required G-7A production could be met by installing the "in-line" process at only two of the G-7 plants, however installation of "in-line" ammoniation at three plants provides the greatest flexibility and reliability. Of the three alternatives evaluated, the implementation of rotary drums for "in-line" ammoniation is preferable from an economic and operational standpoint.

There are three major methods for continuing G-7A production: (1) Centralizing G-7A production by upgrading 605, (2) & (3) Decentralizing G-7A production (into the three G-7 plants) utilizing either extract ammoniation or "in-line" ammoniation with rotary drums. An economic comparison was done between decentralizing G-7A production by installing rotary drums in the three G-7 plants vs centralizing G-7A production at 605-1 and upgrading the facility and equipment. The Level I estimated cost to upgrade 605-1 is $937,000 higher than implementing "in-line" ammoniation at the three plants. "In-line" ammoniation also offers the benefits of processing savings and transportation savings that makes the process ROI justified (55%). Therefore, economic incentives exist for decentralizing G-7A production.

The optimal decentralized G-7A process from an economic standpoint is extract ammoniation; however, until the sensory issues are resolved, the viability of the process is indeterminable. It is recommended that preliminary engineering be performed on "in-line" ammoniation utilizing a rotary drum only if a decision is made not to implement extract ammoniation.

Listed in Table I in Appendix C is the ROI and payback period broken down by facility. In determining whether the rotary drum process should be implemented in the downtown facilities (90-1 and 92-1), the payback period versus the length of time the facility will be in operation should be considered.

APPENDIX

A

51259 8066

December 3, 1987

MR. J. W. HOPKINS

SUBJECT: Bldg. Nos. 90-1 & 92-1, Proposed Locations for Rotary Drum Installation

C/S/A Design has completed its investigation of the proposed two locations, the second floor of Bldg. No. 92-1 and the basement of Bldg. No. 90-1, and we have found either location to be adequate. The following steps can be used as guidelines.

Bldg. No. 90-1

- Shore exist. beams 4' from north wall
- Remove concrete slab between Col. Lines (11) through (14) and (L) through (M)
- Remove all but 5' of beams at north wall of building at Lines (12), (13) and (14) between Lines (L) and (M)
- Saw cut to a finished edge
- Remove shoring

Bldg. No. 92-1

- A set of structural drawings for the area showing existing conditions needs to be developed since there are none in the RJRT files.
- Remove existing penthouse, grating, and caged ladder between Lines (11) - (13) and (D) - (E) at roof
- Provide support system for proposed penthouse to be located from Lines (7) - (12) between Line (D) and (E) and construct penthouse.
- Remove existing roof deck from Col. Lines (7) - (12) and timber beams on Lines 8-11 between Lines (D) and (E) at roof.

Should an alternate location be determined, C/S/A recommends the following guidelines:

- Interior bays be used for the slot.
- Timber buildings should not be considered due to their being near the end of their expected service lives and the risk of decay.
- The longer dimension of the slot should be parallel to the support beams for concrete slabs.

Should you need additional information, please contact me.

Trevonia Brown

Trevonia Brown

TCB:mr
(1432r)

51259 8067

APPENDIX

B

ESTIMATE NO. : 1987-179 LEVEL 1 SUMMARY ESTIMATE REPORT 12/11/87 12:22:17 page 1

PROJECT : #0073 G-7 IN-LINE AMMONIATION/Rotary Drum
ARCHITECT : R. J. REYNOLDS TOBACCO COMPANY
QUANTITIES: SMN/EDSU

LOCATION : BUILDING #90-3
OWNER : R. J. REYNOLDS TOBACCO COMPANY
ENTERED BY: JRF

NO.	DIVISION		M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
03	CONCRETE		35	1210	1101	170	3722
19	PROCESS SERVICES	700	1527	551703	46417	9467	646144
20	SPECIAL PROCESSES	800	9572	771247	280838	58854	1.037480
01	GENERAL & ADMINISTRATION	000	4450	2365	186921	0	189286
	ESTIMATE TOTAL :		15584	1326525	515278	68492	1910632

Building modifications 34,000

CAPITAL TOTAL including capital contingency : 1910632
CAPITAL ESTIMATING CONTINGENCY : 172164
EXPENSE TOTAL including expense contingency : 0
EXPENSE ESTIMATING CONTINGENCY : 0
ESTIMATE GRAND TOTAL : 1910632

NOTE:
Estimated Cost Expressed In CURRENT Day Dollars

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51259 8069

ESTIMATE NO. : 1987-179 LEVEL 1 PM ITEMIZED ESTIMATE REPORT 12/11/87 12:25:06 page 1

PROJECT : #0073 G-7 IN-LINE AMMONIATION
ARCHITECT : R. J. REYNOLDS TOBACCO COMPANY
QUANTITIES: SMN/EDSU

LOCATION : BUILDING #90-3
OWNER : R. J. REYNOLDS TOBACCO COMPANY
ENTERED BY: JRF

03 CONCRETE

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3.3 CAST IN PLACE CONCRETE

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
EQUIPMENT BASES	8.00	C.Y.	32.00	1100.00	1000.96	154.88	3384
ESTIMATING CONTINGENCY (DIV. 3)	1.00	LS	3.20	110.00	100.10	15.49	338
SUB TOTAL :			35	1210	1101	170	3722
DIVISION TOTAL :			35	1210	1101	170	3722

NOTE: * indicates expense items.

51259 8070

19 PROCESS SERVICES 700

19.1 ELECTRICAL SYSTEMS 710

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
CONNECT TO POWER (MCC TO LOAD)	85.00	HP	170.00	4675.00	5582.80	0.00	12309
SUB TOTAL :			170	4675	5582	0	12309

19.2 PIPING SYSTEMS 720

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
UNLOADING SYSTEM (RAIL AND TRUCK)	1.00	LS	240.00	11000.00	7140.00	1877.15	20017.15
TANK INSTRUMENTATION	1.00	LS	60.00	1375.00	1970.40	0.00	3345.40
AMMONIA ACCUMULATOR (2'DIA. X 6'H. 1/4"TK.S/S INS.)	1.00	EA	40.00	2200.00	1190.00	312.86	3702.86
AMMONIA TANK	1.00	EA	120.00	18700.00	3569.99	938.58	23208.57
TANK INSTALLATION	1.00	LS	107.87	24200.00	3209.23	843.72	28252.95
AMMONIA VAPORIZER	1.00	LS	200.00	10010.00	5950.00	1564.29	17524.29
STAINLESS STEEL PIPE 2" DIA. (CS-15)	1000.00	LF	205.00	9350.00	6094.00	1606.00	17050.00
PIPING	200.00	LF	28.80	1023.00	858.60	224.40	2106.00
FLOW CONTROL VALVE	1.00	EA	8.00	3499.10	238.00	62.57	3799.67
REDUCING VALVE 90/30 PSIG 2"DIA.S/S	1.00	EA	2.00	1280.40	59.50	15.64	1355.54
INSULATION	300.00	LF	63.90	1461.90	1903.80	498.30	3864.00
INSULATION	200.00	LF	36.40	827.20	1083.00	283.80	2194.00
SUB TOTAL :			1111	84926	33266	6227	126420

19 PROCESS SERVICES 700

19.5 INSTRUMENTATION/CONTROLS 750

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
ANALOG CABLE	700.00	LF	7.70	770.00	252.00	0.00	1022.00
I/P TRANSDUCER	1.00	EA	0.00	2750.00	0.00	0.00	2750.00
CONDUIT 1" DIA.	700.00	LF	79.10	646.80	2601.20	0.00	3248.00
CHART RECORDER (3 PIN)	1.00	EA	4.00	3520.00	119.01	31.28	3670.29
FLOW METER, MICROMOTION (FOR NH3)	1.00	EA	16.00	4510.00	475.99	125.15	5111.14
BECKMAN NH3 ANALYSER	1.00	EA	0.00	45000.00	0.00	0.00	45000.00
CONTROL PANEL	1.00	EA	0.00	8250.00	0.00	0.00	8250.00
CONTROL ROOM PORTABLE	1.00	EA	0.00	16500.00	0.00	0.00	16500.00
		SUB TOTAL :	106	81946	3448	156	85551

19.8 EXHAUST AND VENTILATION 780

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PROCESS EXHAUST SYSTEM (COMPLETE)	25000.00	EA	0.00	363,000	0.00	0.00	363,000
ESTIMATING CONTINGENCY (DIV. 19)	1.00	LS	138.50	50154.80	4120.38	1083.27	58364
		SUB TOTAL :	138	380154	4120	1083	421964
		DIVISION TOTAL :	1527	551703	46417	9467	646144

NOTE: * indicates expense items.

51259 8072

20 SPECIAL PROCESSES 800

20.2 G-7 820

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PIPE INSULATION 1"DIA. X 2"TK.	200.00	LF	36.40	827.20	1084.80	286.00	2198.00
RATIO CONTROLLER, MOORE	1.00	EA	4.00	1430.00	119.01	31.28	1580.29
QA LAB. EQUIPMENT	1.00	LS	16.00	2530.00	475.99	125.15	3131.14
PLANT PERSONNEL TRAINING	1.00	MH	2000.00	0.00	57000.00	0.00	57000.00
(NH3) AMMONIA USE FOR (1) YEAR	1.00	LS	0.00	26999.50	0.00	0.00	26999.50
Rotary Drum (W/AIRLOCK)	1.00	EA	800.00	100000.00	23800.00	6257.16	130057.16
Environmental Conditioning Unit				30000.00	2000.00	0.00	32000.00
COVERS FOR EXISTING CONVEYORS	800.00	SF	1400.00	44000.00	41652.80	10947.20	96600.00
COVERED CONVEYORS	1727.00	SF	4317.50	398937.60	154128.53	40532.00	593598.53
ESTIMATING CONTINGENCY (DIV. 20)	1.00	LS	870.10	70113.40	25885.47	6805.45	94316
		SUB TOTAL :	9572	771247	280838	58854	1037490
		DIVISION TOTAL :	9572	771247	280838	58654	1037490

NOTE: * indicates expense items.

51259 8073

01 GENERAL & ADMINISTRATION 000

1.1 RJR PROJECT ADMINISTRATION 005

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PROJECT MANAGEMENT	1.00	MH	300.00	0.00	12600.00	0.00	12600.00
INSPECTIONS, RJR	1.00	MH	150.00	0.00	6300.00	0.00	6300.00
CONSTRUCTION MANAGEMENT	1.00	MH	300.00	0.00	12600.00	0.00	12600.00
ESTIMATING/SCHEDULING SERVICES	1.00	MH	37.50	0.00	1575.00	0.00	1575.00
PRINT/MICROFILM SERVICES	1.00	MH	8.00	165.00	336.00	0.00	501.00
RECEIVING AND STORAGE	1.00	MH	37.50	0.00	1575.00	0.00	1575.00
TRAVEL AND LIVING	1.00	MH	0.00	2200.00	0.00	0.00	2200.00
ESTIMATING CONTINGENCY	1.00	LS	328.00	0.00	13776.00	0.00	13776.00
		SUB TOTAL :	1161	2365	48762	0	51127

1.6 PRELIMINARY ENG.PHASE, RJR/EDSU 060

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PROJECT MANAGEMENT	1.00	MH	37.50	0.00	1575.00	0.00	1575.00
ELECTRICAL D&E	1.00	MH	40.00	0.00	1680.00	0.00	1680.00
INSTRUMENTATION/CONTROL D&E	1.00	MH	190.00	0.00	7980.00	0.00	7980.00
INSTRUMENTATION/CONTROLS DESIGN & ENGINEERING (PURCHASED)	1.00	MH	60.00	0.00	2520.00	0.00	2520.00
MECHANICAL D&E	1.00	MH	100.00	0.00	4200.00	0.00	4200.00
MECHANICAL D & E (PURCHASED)	1.00	MH	160.00	0.00	6720.00	0.00	6720.00
		SUB TOTAL :	587	0	24675	0	24675

51259 8074

01 GENERAL & ADMINISTRATION 000

1.8 DETAIL ENG. & DESIGN, RJR/EDSU 080

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
ELECTRICAL D&E	1.00	MH	250.00	0.00	10500.00	0.00	10500.00
INSTRUMENTATION/CONTROLS D&E	1.00	MH	100.00	0.00	4200.00	0.00	4200.00
INSTRUMENTATIONS/CONTROLS D&E (PURCHASED)	1.00	MH	342.00	0.00	14364.00	0.00	14364.00
MECHANICAL D&E (PURCHASED)	1.00	MH	1610.00	0.00	67620.00	0.00	67620.00
MECHANICAL D&E	1.00	MH	400.00	0.00	16800.00	0.00	16800.00
		SUB TOTAL :	2702	0	113484	0	113484
		DIVISION TOTAL :	4450	2365	186921	0	189286
		ESTIMATE TOTAL :	15584	1326525	515278	68492	1910296

CAPITAL TOTAL including capital contingency : 1910296

CAPITAL ESTIMATING CONTINGENCY : 172164

EXPENSE TOTAL including expense contingency : 0

EXPENSE ESTIMATING CONTINGENCY : 0

ESTIMATE NO. : 1987-180 LEVEL 1 SUMMARY ESTIMATE REPORT 12/11/87 12:51:01 page 1

PROJECT : #0073 G-7 IN-LINE AMMONIATION / Rotary Drum
ARCHITECT : R. J. REYNOLDS TOBACCO COMPANY
QUANTITIES: SMN/EDSU

LOCATION : BUILDING #92-2
OWNER : R. J. REYNOLDS TOBACCO COMPANY
ENTERED BY: JRF

NO.	DIVISION		M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
03	CONCRETE		35	1210	1101	170	3722
19	PROCESS SERVICES	700	1887	387495	57150	12281	477853
20	SPECIAL PROCESSES	800	6943	583001	204072	38670	723967
01	GENERAL & ADMINISTRATION	000	4534	2365	190449	0	192814
		ESTIMATE TOTAL :	13401	974072	452773	51121	~~1441358~~
	Building Modifications						43005

CAPITAL TOTAL including capital contingency : 1441358
CAPITAL ESTIMATING CONTINGENCY : 135918
EXPENSE TOTAL including expense contingency : 0
EXPENSE ESTIMATING CONTINGENCY : 0
ESTIMATE GRAND TOTAL : 1441358

NOTE:
Estimated Cost Expressed In CURRENT Day Dollars

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51259 8076

19 PROCESS SERVICES 700

19.1 ELECTRICAL SYSTEMS 710

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
CONNECT TO POWER (MCC TO LOAD)	85.00	HP	170.00	4675.00	5582.80	0.00	12309
SUB TOTAL :			170	4675	5582	0	12309

19.2 PIPING SYSTEMS 720

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
AMMONIA TANK	1.00	EA	120.00	18700.00	3569.99	938.58	23208.57
UNLOADING SYSTEM (RAIL AND TRUCK	1.00	LS	240.00	11000.00	7140.00	1877.15	20017.15
TANK INSTRUMENTATION	1.00	LS	60.00	1375.00	1970.40	0.00	3345.40
AMMONIA VAPORIZER	1.00	LS	200.00	10010.00	5950.00	1564.29	17524.29
AMMONIA ACCUMULATOR (2'DIA. X 6'H. 1/4"TK.S/S INS.)	1.00	EA	40.00	2200.00	1190.00	312.86	3702.86
TANK INSTALLATION	1.00	LS	107.87	24200.00	3209.24	843.72	28252.96
PIPING	200.00	LF	28.80	1023.00	858.60	224.40	2106.00
STAINLESS STEEL PIPE 2" DIA. (CS-15)	1350.00	LF	276.75	12622.50	8226.90	2168.10	23017.50
FLOW CONTROL VALVE	1.00	EA	8.00	3499.10	238.00	62.57	3799.67
REDUCING VALVE 90/30 PSIG 2"DIA.S/S	1.00	EA	2.00	1280.40	59.50	15.64	1355.54
INSULATION	1500.00	LF	319.50	7309.50	9519.00	2491.50	19320.00
INSULATION	200.00	LF	36.40	827.20	1083.00	283.80	2194.00
SUB TOTAL :			1439	94046	43014	10782	147843

51259 8077

19 PROCESS SERVICES 700

19.5 INSTRUMENTATION/CONTROLS 750

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
ANALOG CABLE	700.00	LF	7.70	770.00	252.00	0.00	1022.00
I/P TRANSDUCER	1.00	EA	0.00	2750.00	0.00	0.00	2750.00
CONDUIT 1" DIA.	700.00	LF	79.10	646.80	2601.20	0.00	3248.00
FLOW METER, MICROMOTION (FOR NH3)	1.00	EA	16.00	4510.00	475.99	125.15	5111.14
BECKMAN NH3 ANALYZER	1.00	EA	0.00	45000.00	0.00	0.00	45000.00
CHART RECORDER (3 PIN)	1.00	EA	4.00	3520.00	119.01	31.28	3670.29
CONTROL PANEL	1.00	EA	0.00	8250.00	0.00	0.00	8250.00
CONTROL ROOM PORTABLE	1.00	EA	0.00	16500.00	0.00	0.00	16500.00
		SUB TOTAL :	106	81946	3448	156	85551

19.8 EXHAUST AND VENTILATION 780

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PROCESS EXHAUST SYSTEM (COMPLETE)	13000.00	CFM	0.00	198760	0.00	0.00	188760
ESTIMATING CONTINGENCY (DIV. 19)	1.00	LS	171.60	35226.80	5105.10	1342.17	43390.06
		SUB TOTAL :	171	206826	5105	1342	232150
		DIVISION TOTAL :	1887	387495	57150	12281	477953

NOTE: * indicates expense items.

51259 8078

01 GENERAL & ADMINISTRATION 000

1.1 RJR PROJECT ADMINISTRATION 005

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PROJECT MANAGEMENT	1.00	MH	300.00	0.00	12600.00	0.00	12600.00
INSPECTIONS, RJR	1.00	MH	150.00	0.00	6300.00	0.00	6300.00
CONSTRUCTION MANAGEMENT	1.00	MH	300.00	0.00	12600.00	0.00	12600.00
ESTIMATING/SCHEDULING SERVICES	1.00	MH	37.50	0.00	1575.00	0.00	1575.00
PRINT/MICROFILM SERVICES	1.00	MH	8.00	165.00	336.00	0.00	501.00
RECEIVING AND STORAGE	1.00	MH	37.50	0.00	1575.00	0.00	1575.00
TRAVEL AND LIVING	1.00	MH	0.00	2200.00	0.00	0.00	2200.00
ESTIMATING CONTINGENCY	1.00	LS	412.00	0.00	17304.00	0.00	17304.00
		SUB TOTAL :	1245	2365	52290	0	54655

1.6 PRELIMINARY ENG.PHASE, RJR/EDSU 060

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PROJECT MANAGEMENT	1.00	MH	37.50	0.00	1575.00	0.00	1575.00
ELECTRICAL D&E	1.00	MH	40.00	0.00	1680.00	0.00	1680.00
INSTRUMENTATION/CONTROL D&E	1.00	MH	190.00	0.00	7980.00	0.00	7980.00
INSTRUMENTATION/CONTROLS DESIGN & ENGINEERING (PURCHASED)	1.00	MH	60.00	0.00	2520.00	0.00	2520.00
MECHANICAL D&E	1.00	MH	100.00	0.00	4200.00	0.00	4200.00
MECHANICAL D & E (PURCHASED)	1.00	MH	160.00	0.00	6720.00	0.00	6720.00
		SUB TOTAL :	587	0	24675	0	24675

51259 8079

01 GENERAL & ADMINISTRATION 000

1.8 DETAIL ENG. & DESIGN, RJR/EDSU 080

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
ELECTRICAL D&E	1.00	MH	250.00	0.00	10500.00	0.00	10500.00
INSTRUMENTATION/CONTROLS D&E	1.00	MH	100.00	0.00	4200.00	0.00	4200.00
INSTRUMENTATIONS/CONTROLS D&E (PURCHASED)	1.00	MH	342.00	0.00	14364.00	0.00	14364.00
MECHANICAL D&E	1.00	MH	400.00	0.00	16800.00	0.00	16800.00
MECHANICAL D&E (PURCHASED)	1.00	MH	1610.00	0.00	67620.00	0.00	67620.00
SUB TOTAL :			2702	0	113484	0	113484
DIVISION TOTAL :			4534	2365	190449	0	192814
ESTIMATE TOTAL :			13401	974072	452773	51121	1477967

CAPITAL TOTAL including capital contingency : 1477967

CAPITAL ESTIMATING CONTINGENCY : 135918

EXPENSE TOTAL including expense contingency : 0

EXPENSE ESTIMATING CONTINGENCY : 0

51259 8080

ESTIMATE NO. : 1987-178 LEVEL 1 SUMMARY ESTIMATE REPORT 12/11/87 11:58:11 page 1

PROJECT : #0073 6-7 IN-LINE AMMONIATION/ Rotary Drum
ARCHITECT : R. J. REYNOLDS TOBACCO COMPANY
QUANTITIES: SMN/EDSU

LOCATION : BUILDING # 603-1
OWNER : R. J. REYNOLDS TOBACCO COMPANY
ENTERED BY: JRF

NO.	DIVISION		M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
03	CONCRETE		22	756	688	106	3722
19	PROCESS SERVICES	700	1545	268641	46790	10075	325506
20	SPECIAL PROCESSES	800	5623	512786	164809	28347	574333
01	GENERAL & ADMINISTRATION	000	4450	2365	186921	0	189286
	ESTIMATE TOTAL :		11642	784549	399209	38529	1,092,847

CAPITAL TOTAL including capital contingency : 1092847
CAPITAL ESTIMATING CONTINGENCY : 141220
EXPENSE TOTAL including expense contingency : 0
EXPENSE ESTIMATING CONTINGENCY : 0
ESTIMATE GRAND TOTAL : 1092847

NOTE:
Estimated Cost Expressed In CURRENT Day Dollars

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ESTIMATE NO. : 1987-178 LEVEL 1 PM ITEMIZED ESTIMATE REPORT 12/11/87 12:00:47 page 1

PROJECT : #0073 G-7 IN-LINE AMMONIATION
ARCHITECT : R. J. REYNOLDS TOBACCO COMPANY
QUANTITIES: SMN/EDSU

LOCATION : BUILDING # 603-1
OWNER : R. J. REYNOLDS TOBACCO COMPANY
ENTERED BY: JRF

03 CONCRETE

NOTED DEC 1 1 1987 Furches

3.3 CAST IN PLACE CONCRETE

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
EQUIPMENT PIERS	5.00	C.Y.	20.00	687.50	625.60	96.80	3384
ESTIMATING CONTINGENCY (DIV. 3)	1.00	LS	2.00	68.75	62.56	9.68	338
SUB TOTAL :			22	756	688	106	3722
DIVISION TOTAL :			22	756	688	106	3722

NOTE: * indicates expense items.

51259 8082

19 PROCESS SERVICES 700

19.1 ELECTRICAL SYSTEMS 710

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
CONNECT TO POWER (MCC TO LOAD)	85.00	HP	170.00	4675.00	5582.80	0.00	10257.80
SUB TOTAL :			170	4675	5582	0	10257

19.2 PIPING SYSTEMS 720

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
AMMONIA ACCUMULATOR (2'DIA. X 6'H. 1/4"TK.S/S INS.)	1.00	EA	40.00	2200.00	1190.00	312.86	3702.86
STAINLESS STEEL PIPE 2" DIA. (CS-15)	1650.00	LF	338.25	15427.50	10055.10	2649.90	28132.50
PIPING	200.00	LF	28.80	1023.00	858.60	224.40	2106.00
FLOW CONTROL VALVE	1.00	EA	8.00	3499.10	238.00	62.57	3799.67
REDUCING VALVE 90/30 PSIG 2"DIA.S/S	1.00	EA	2.00	1280.40	59.50	15.64	1355.54
INSULATION	1650.00	LF	351.45	8040.45	10470.90	2740.65	21252.00
INSULATION	200.00	LF	36.40	827.20	1083.00	283.80	2194.00
SUB TOTAL :			804	32297	23955	6289	62542

19.5 INSTRUMENTATION/CONTROLS 750

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
ANALOG CABLE	700.00	LF	7.70	770.00	252.00	0.00	1022.00
CONDUIT 1" DIA.	700.00	LF	79.10	646.80	2601.20	0.00	3248.00
I/P TRANSDUCER	1.00	EA	0.00	2750.00	0.00	0.00	2750.00
CHART RECORDER (3 PIN)	1.00	EA	6.00	3520.00	178.50	46.93	3745.43

51259 8083

19 PROCESS SERVICES 700

19.5 INSTRUMENTATION/CONTROLS 750

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
BECKMAN NH3 ANALYZER	1.00	EA	0.00	45000.00	0.00	0.00	45000.00
FLOW METER, MICROMOTION (FOR NH3)	1.00	EA	16.00	4510.00	475.99	125.15	5111.14
CONTROL PANEL	1.00	EA	0.00	8250.00	0.00	0.00	8250.00
CONTROL ROOM PORTABLE	1.00	EA	0.00	16500.00	0.00	0.00	16500.00
SUB TOTAL :			108	81946	3507	172	85626

19.8 EXHAUST AND VENTILATION 780

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PROCESS EXHAUST SYSTEM (COMPLETE)	8000.00	EA	0.00	105600.00	0.00	0.00	105600.00
ESTIMATING CONTINGENCY (DIV. 19)	1.00	LS	354.00	21670.00	10531.49	2768.80	34970.29
ESTIMATING OCNTINGENCY (DIV 19)	1.00	LS	108.00	22451.89	3213.01	844.71	26509.61
SUB TOTAL :			462	149721	13744	3613	167079
DIVISION TOTAL :			1545	268641	46790	10075	325506

NOTE: * indicates expense items.

51259 8084

20 SPECIAL PROCESSES 800

20.2 6-7 820

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
RATIO CONTROLLER, MOORE	1.00	EA	4.00	1430.00	119.01	31.28	1580.29
PLANT PERSONNEL TRAINING	1.00	MH	2000.00	0.00	57000.00	0.00	57000.00
PIPE INSULATION 1"DIA. X 2"TK.	200.00	LF	36.40	827.20	1084.80	286.00	2198.00
QA LAB. EQUIPMENT	1.00	LS	16.00	2530.00	475.99	125.15	3131.14
(NH3) AMMONIA USE FOR (1) YEAR	1.00	LS	0.00	54000.10	0.00	0.00	54000.10
Rotary Drum (W/AIR LOCKS) Environmental Conditioning Unit	1.00	EA	800.00	100009.05 30000	23800.00 2000	6257.16	130057.16 32000
COVERED CONVEYORS	759.00	SF	1897.50	146107.50	56448.35	14844.52	217400.37
COVERS FOR EXISTING CONVEYORS	205.00	SF	358.75	11275.00	10673.53	2805.22	24753.75
ESTIMATING CONTINGENCY (DIV. 20)	1.00	LS	511.20	46616.90	15208.18	3998.34	52,212
SUB TOTAL :			5623	512786	164809	28347	574333
DIVISION TOTAL :			5623	512786	164809	28347	574333

NOTE: * indicates expense items.

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01 GENERAL & ADMINISTRATION 000

1.1 RJR PROJECT ADMINISTRATION 005

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PROJECT MANAGEMENT	1.00	MH	300.00	0.00	12600.00	0.00	12600.00
INSPECTIONS, RJR	1.00	MH	150.00	0.00	6300.00	0.00	6300.00
CONSTRUCTION MANAGEMENT	1.00	MH	300.00	0.00	12600.00	0.00	12600.00
ESTIMATING/SCHEDULING SERVICES	1.00	MH	37.50	0.00	1575.00	0.00	1575.00
PRINT/MICROFILM SERVICES	1.00	MH	8.00	165.00	336.00	0.00	501.00
RECEIVING AND STORAGE	1.00	MH	37.50	0.00	1575.00	0.00	1575.00
TRAVEL AND LIVING	1.00	MH	0.00	2200.00	0.00	0.00	2200.00
ESTIMATING CONTINGENCY	1.00	LS	328.00	0.00	13776.00	0.00	13776.00
SUB TOTAL :			1161	2365	48762	0	51127

1.6 PRELIMINARY.ENG.PHASE, RJR/EDSU 060

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
PROJECT MANAGEMENT	1.00	MH	37.50	0.00	1575.00	0.00	1575.00
ELECTRICAL D&E	1.00	MH	40.00	0.00	1680.00	0.00	1680.00
INSTRUMENTATION/CONTROL D&E	1.00	MH	190.00	0.00	7980.00	0.00	7980.00
INSTRUMENTATION/CONTROLS DESIGN & ENGINEERING (PURCHASED)	1.00	MH	60.00	0.00	2520.00	0.00	2520.00
MECHANICAL D & E (PURCHASED)	1.00	MH	160.00	0.00	6720.00	0.00	6720.00
MECHANICAL D&E	1.00	MH	100.00	0.00	4200.00	0.00	4200.00
SUB TOTAL :			587	0	24675	0	24675

01 GENERAL & ADMINISTRATION 000

1.8 DETAIL ENG. & DESIGN, RJR/EDSU 080

DESCRIPTION	QUANTITY	UNIT	M/H	CONTRACT and / or MATERIALS	LABOR	CONST EQUIP	TOTAL
ELECTRICAL D&E	1.00	MH	250.00	0.00	10500.00	0.00	10500.00
INSTRUMENTATIONS/CONTROLS D&E (PURCHASED)	1.00	MH	342.00	0.00	14364.00	0.00	14364.00
INSTRUMENTATION/CONTROLS D&E	1.00	MH	100.00	0.00	4200.00	0.00	4200.00
MECHANICAL D&E (PURCHASED)	1.00	MH	1610.00	0.00	67620.00	0.00	67620.00
MECHANICAL D&E	1.00	MH	400.00	0.00	16800.00	0.00	16800.00
SUB TOTAL :			2702	0	113484	0	113484
DIVISION TOTAL :			4450	2365	186921	0	189286
ESTIMATE TOTAL :			11642	784549	399209	38529	1222287

CAPITAL TOTAL including capital contingency : 1222287

CAPITAL ESTIMATING CONTINGENCY : 141220

EXPENSE TOTAL including expense contingency : 0

EXPENSE ESTIMATING CONTINGENCY : 0

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APPENDIX

C

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Incremental cost of G-7A - Porous belt treater process

(1) Ammonia cost - (annual)

Estimated use for in-line ammoniation

Bldg.	Cost
603	$ 54,000
92	$ 27,000
90	$ 27,000
TOTAL	$108,000

(2) Electricity cost (annual)

Material-handling conveyor motors	150 HP
Rotary drum motors	60 HP
Packing area ventilation fans	60 HP
Air-handling unit for hooded systems	180 HP
Air lock motors	60 HP
Scrubber motors	90 HP
	600 HP

$600 \text{ HP} * \frac{5 \text{ days}}{\text{week}} * \frac{24 \text{ hrs}}{\text{day}} * \frac{48 \text{ weeks}}{\text{yr.}} \times .6 * .746 \frac{\text{KW}}{\text{HP}} \times \$.06/\text{kwh}$

$= \$92,814/\text{year}$

(3) Steam usage cost = steam usage for heating ammonia tanks = 10,000,000 lbs. $\frac{\text{LP Steam}}{\text{year}}$

$= 10,000,000 \frac{\text{lbs}}{\text{yr.}} \text{ LP} \times \frac{\$5.236}{1000 \text{ lbs LP}} = \$52,360/\text{year}$

(4) Maintenance cost = Ammonia maintenance cost + rotary drum system maintenance cost. $= 3 \text{ plants} * \frac{16 \text{ hrs}}{\text{Plant}} * \frac{12 \text{ months}}{\text{year}} * \frac{\$42}{\text{hr.}} = \$24,192$

Total cost per year = $277,366

Incremental cost/lb G-7A $= \frac{\$277,366}{63,000,000 \text{ lbs.}} = \$.0044/\text{lb.}$

2359m

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SAVINGS FROM THE G-7 IN-LINE AMMONIATION PROCESS

1. Process Savings
   Cost to ammoniate G-7 at 605 = $.0455/lb. (includes labor, fringe, over-time, maintenance, ammonia and utilities and fixed costs)

   $$\text{Process Savings} = \frac{63{,}000{,}000 \text{ lbs. G-7A}}{\text{year}} \times \frac{\$.0455}{\text{lb.}} = \$2{,}867{,}000/\text{year}$$

2. Transporation Savings
   Elimination of transport of G-7 to 605 for ammoniation (assume transportation costs of G-7A to Grower's Warehouse is equivalent)

   Shipping cost of G-7 = $1.439/1000 lbs. G-7

   $$\text{Transportation savings} = \frac{\$1.439}{1000 \text{ lbs.}} \times \frac{63{,}000{,}000 \text{ lbs.}}{\text{year}} - 80\% \text{ utilization of trucks}$$

   $$= \$113{,}000/\text{year}$$

Based on the Proposed Schedule for Implementing In-Line G-7A Ammoniation, Savings will be Realized as follows:

	% of Total Production (63 MM lbs.) Per Facility				% of Total Savings Realized in the Given Year
Year	605	603	92-3	90-2	Process & Transportation *
1989	50%	50%	0%	0%	50% = $1,642,725
1990	0%	50%	25%	25%	100% = $3,449,723
1991	0%	50%	25%	25%	100% = $3,622,209

* Inflation rate of 5%

2145m

TITLE: G-7A IN-LINE AMMONIATION FEASIBILITY/ROTARY DRUM

Year* A	Capital Expenditure B	Savings C	Project Expense D	PT&I E	Tax Depreciation F	Pretax Earnings G	Income Taxes H	Aftax Earnings I	Net Cashflow J	Cumulative Cashflow K
1988	(1,092,847)	0			0	0	0	0	(1,092,847)	(1,092,847)
1989	(3,351,990)	1,458,056	0	0	(156,059)	1,301,997	(572,879)	729,119	(2,466,813)	(3,559,660)
1990		3,061,918	0	(13,606)	(746,412)	2,301,900	(874,722)	1,427,178	2,173,590	(1,386,070)
1991		3,215,014	0	(55,338)	(1,012,376)	2,147,299	(815,974)	1,331,325	2,343,702	957,632
1992		3,375,765	0	(55,338)	(722,760)	2,597,667	(987,113)	1,610,553	2,333,313	3,290,945
1993		3,544,553	0	(55,338)	(516,255)	2,972,960	(1,129,725)	1,843,235	2,359,490	5,650,435
1994		3,721,780	0	(55,338)	(396,815)	3,269,628	(1,242,458)	2,027,169	2,423,984	8,074,419
1995		3,907,869	0	(55,338)	(396,479)	3,456,052	(1,313,300)	2,142,752	2,539,232	10,613,650
1996		4,103,263	0	(55,338)	(347,848)	3,700,077	(1,406,029)	2,294,048	2,641,895	13,255,546
1997		4,308,426	0	(55,338)	(149,834)	4,103,254	(1,559,236)	2,544,017	2,693,851	15,949,397
1998		4,523,847	0	(55,338)		4,468,509	(1,698,033)	2,770,476	2,770,476	18,719,873
1999		4,750,040	0	(55,338)		4,694,702	(1,783,987)	2,910,715	2,910,715	21,630,588

ROI 55%

PAYBACK 3 YEARS

TABLE I

ROI BREAKDOWN BY PLANT

(for "in-line" ammoniation process installation using a rotary drum)

PLANT	ROI	PAYBACK
603-1	90%	2 Years
92-2	41%	3 Years
90-3	31%	4 Years

2359m

G-7A ALTERNATIVES-MASTER SCHEDULE*

ITEM	START DATE	END DATE
Feasibility Study - On-line Extract Ammoniation	4/24/87	8/30/87
Feasibility Study - In-line Porous Belt or Rotary Drum	8/17/87	12/31/87
Pilot Plant - Product and Process Evaluations and Administrative Approvals	9/01/87	3/31/88
Preliminary Engineering (and Level II Estimate) for on-line Extract Ammoniation Process at one G-7 Plant.	12/01/87	3/15/88
Test Ammoniated Extract in a G-7 Plant to determine the environmental impact	12/01/87	12/31/87
Evaluate G-7A Alternative Processes and recommend the best based on sensories and economics	......	3/31/88
Obtain Authorization Request Approvals for Implementing the Alternate G-7A Process in all the G-7 Plants	4/01/88	5/15/88
Perform Detail Design for Implementing the Process in the 603-1 G-7 Plant	5/15/88	8/31/88
Implement the G-7A Process at 603-1	9/01/88	12/01/88
Operate New Ammoniation Process at 603-1	1/01/89	.....
Perform Detail Design for Implementing the Process at the 90-3 and the 92-2 G-7 Plants	1/01/89	6/01/89
Implement the G-7A Process at 90-3 and 92-2	7/01/89	12/01/89
Operate the New Ammoniation Process at 90-3 and 92-2	1/01/90	.....

*Projected schedule for evaluating and implementing a G-7A process alternative.

4215A

APPENDIX

B

APPENDIX

B

PROJECT NAME: Analysis of Designed Test of G-7A Process

STATISTICIAN NAME: Michael J. Morton

CLIENT NAME: Robert C. Benjamin

COMPLETION DATE: April 26, 1988

This is the statistical analysis of data from a designed test of the G-7A pilot line (with a porous conveyor). The line is at the 181 Shed. The design variables under examination were:

1. incoming moisture level
2. percent of NH_3 at the reactor [redacted]
3. temperature
4. humidity
5. residence time
6. air rate

The level of hot water solubles, though not a design variable, was also measured and is included for consideration in the regression models below.

In Table 1 we show the design for the test. It was originally a 2^{7-3} design—originally tobacco flow rate was also a variable, but it could not be changed as much as had been hoped, so was omitted as a design variable leaving the 6 factors described above. In Table 2 we show the actual levels that were achieved together with the level of residual ammonia in the tobacco.[1] The PT&D ammonia is the online reading and the R&D ammonia is the reading from the R&D lab. Likewise with moisture and hot water solubles (HWS). In Figure 1 we show a plot of the two ammonia measurements against one another and we see that they are relatively well correlated ($r = .96$). However the ammonia levels they give are different. In Figure 2 we show a plot of the difference of the two versus the average of the two. Interestingly the higher the average ammonia level, the greater the difference between the ammonia levels. In general the PT&D level is higher than the R&D level. Whether these reflect method differences or simply a loss of ammonia before the R&D analysis is carried out is unknown. Similar plots are shown for moisture and hot water solubles in Figures 3-6. The moistures are reasonably well correlated ($r = .85$) and there is no significant difference between the two. For hot water solubles, the correlation is low[2] ($r = .59$) and the PT&D method gives a consistently larger value (by about 4 units). For simplicity, we only discuss results in terms of the PT&D methods. Generally there is little, if any, difference in the answer according to which measurement is used.

First we investigate which of the design variables influences the residual ammonia level. Table 3 shows tha analysis of variance table for residual ammonia. It shows that the primary factors influencing the residual ammonia level are the residence time in the treater, the level of ammonia in the treater, and the moisture level. Temperature and the level of hot water solubles also appear to play a marginal role. Humidity and air rate have no detectable effect. The model

[1] The data in the Table are the mean values of the runs. In Table 2 there are 20 runs, whereas in Table 1 there are 19 runs. That is because the 1st run was duplicated.

[2] The raw size of the correlations may be misleading here, since the hot water solubles range is relatively low, whereas the ammonia and moisture ranges are by design relatively large.

with only the significant variables included is given in Table 4. Also included in Table 4 are partial correlation coefficients which show the correlations of the variables with residual ammonia after controlling for the effects of the other independent variables.

One of the concerns before running this test was that the residual ammonia level might be so sensitive to moisture that small fluctuations in the moisture level would greatly influence the residual ammonia level and/or would cause changes in the residual ammonia level that could not be easily counteracted by the other control variables. Based on the estimates in Table 4 that does not appear to be the case. For instance, for every 1% change in moisture the model predicts a .028 shift in residual ammonia. That can be compensated for by adjusting the ammonia level in the air by about .5% ((.028/.053)%) or by adjusting the residence time by about 45 seconds (.028/.037 minutes) or some similar combination of the two. In short, from this preliminary work it appears that the control variables investigated here will be adequate to control fluctuations in the residual ammonia level caused by fluctuations in the moisture level.[3]

In addition to the readings that were taken immediately after ammoniation, aging data were also gathered 3 weeks and 8 weeks after ammoniation. Those data are listed in Table 5.[4] In Figures 7-10 are plots of the reducing sugar and total sugar levels after 3 and 8 weeks versus residual ammonia. As would be expected the higher the residual ammonia level the lower the sugar levels. There is also some indication that the higher the moisture level the lower the sugar level—this effect is not nearly so strong.

SUMMARY

This report has summarized the statistical analysis that was conducted on data from a designed test of the G-7A process. The variables that were important in determining the residual ammonia level were the residence time in the treater, the ammonia level in the treater, and the moisture level with temperature and hot water solubles level also playing a marginal role. We also looked at data from the tobacco after 3 and 8 weeks aging to determine the impact of the parameters on the level of sugars in the aged product. Not unexpectedly, the residual ammonia level was the primary factor influencing the level of sugars in the aged product. We did note that the moisture level also appears to have a marginal effect on the level of sugars in the aged product.

Michael J. Morton

cc: John L. McKenzie
W. Doug Young
Robert A. Merricks
Thomas W. Brown

[3] These computations are all based on the coefficient estimates given in Table 4. It would be desirable to refine those estimates either through additional test runs or by monitoring the effect on the process of making adjustments such as those computed above.

[4] Again the readings given are averages. There were 3 readings taken of each.

	Incoming Moisture	% NH_3	Temperature °C	Humidity	Belt Speed	Air Flow CFM
1	M	M	M	M	M	M
2	L	L	H	H	L	H
3	L	L	H	H	H	L
4	H	H	L	L	L	H
5	H	H	L	L	H	L
6	L	H	H	L	H	H
7	L	H	H	L	L	L
8	H	L	L	H	L	L
9	H	L	L	H	H	H
10	M	M	M	M	M	M
11	H	H	H	H	L	L
12	H	H	H	H	H	H
13	L	H	L	H	H	L
14	L	H	L	H	L	H
15	L	L	L	L	L	L
16	L	L	L	L	H	H
17	H	L	H	L	L	H
18	H	L	H	L	H	L
19	M	M	M	M	M	M
	L=8-10%	L=2.5-3.5	L=13.5	L=Room	L=3 fpm	L=325
	M=11-13%	M=5-6	M=Room	M=Room	M=20 fpm	M=465
	H=14-16%	H=8-9	H=75	H=Dew pt.	H=60 fpm	H=600

Table 1. Listing of Design.

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Run	PT&D Tobacco Ammon. (%)	R&D Tobacco Ammon. (%)	Resid. Time (min.)	PT&D Moist. (%)	R&D Moist. (%)	Ammon. in Air (%)	Temp. (°C)	Humidity (%)	Air Flow (CFM)	PT&D HWS	R&D HWS
1	.83	.64	1.25	13.4	14.5	5.4	22	30	465	37.4	35.3
2	.74	.56	1.25	10.8	11.5	5.4	24	28	465	39.7	34.7
3	.89	.66	8.33	10.0	11.7	3.3	55	100	610	39.6	35.1
4	.61	.52	.42	9.3	10.7	3.2	55	100	325	39.8	34.9
5	1.20	.81	8.33	14.6	13.5	7.4	10	30	610	40.9	35.8
6	.78	.58	.42	15.6	13.6	7.5	10	30	325	39.7	34.2
7	.68	.52	.42	8.6	8.4	7.5	55	31	610	40.8	35.6
8	1.11	.76	8.33	9.3	8.9	7.9	55	31	325	40.3	35.9
9	.89	.70	8.33	15.1	15.9	3.1	16	100	325	40.6	37.2
10	.54	.48	.42	14.9	13.3	3.0	16	100	610	40.6	36.3
11	.69	.58	1.25	12.5	11.0	5.7	30	55	465	40.5	38.2
12	1.10	.75	8.33	14.9	14.0	7.9	55	100	325	40.2	37.2
13	1.04	.67	.42	15.0	14.8	7.8	55	100	610	40.8	37.1
14	.52	.48	.42	8.5	10.6	7.9	15	100	325	39.9	35.5
15	.90	.64	8.33	9.1	11.0	7.5	15	100	610	39.8	34.8
16	.64	.51	8.33	9.8	11.6	3.2	10	32	325	41.8	38.7
17	.36	.34	.42	10.1	11.3	3.2	10	32	610	41.7	37.9
18	.77	.63	8.33	14.6	12.5	3.2	55	32	610	41.7	35.7
19	.60	.50	.42	15.5	16.6	3.4	55	32	325	41.0	36.9
20	.64	.59	1.25	11.7	13.6	5.7	23	30	465	40.8	36.3

Table 2. Listing of Data from Immediately after Run.

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DEP VARIABLE: RESIDUAL AMMONIA

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	7	0.79309551	0.11329936	12.121	0.0001
ERROR	12	0.11216849	0.009347374		
C TOTAL	19	0.90526400			

ROOT MSE	0.09668182	R-SQUARE	0.8761
DEP MEAN	0.776	ADJ R-SQ	0.8038
C.V.	12.459		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEPT	1	1.96945986	1.00529977	1.959	0.0738
AMM IN AIR	1	0.05325061	0.01116748	4.768	0.0005
RES. TIME	1	0.03723555	0.005929738	6.279	0.0001
MOISTURE	1	0.02835279	0.008274863	3.426	0.0050
TEMPERATURE	1	0.00241926	0.001130652	2.140	0.0536
HUMIDITY	1	-0.000199753	0.0006742696	-0.296	0.7721
AIR RATE	1	0.0001534009	0.0001717865	0.893	0.3894
HOT WATER SOL	1	-0.052161	0.02456606	-2.123	0.0552

TABLE 3. ANOVA TABLE FOR RESIDUAL AMMONIA WITH ALL TERMS IN MODEL.

DEP VARIABLE: RESIDUAL AMMONIA

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	5	0.78498245	0.15699649	18.273	0.0001
ERROR	14	0.12028155	0.008591539		
C TOTAL	19	0.90526400			

ROOT MSE	0.09269056	R-SQUARE	0.8671
DEP MEAN	0.776	ADJ R-SQ	0.8197
C.V.	11.94466		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	PARTIAL CORR
INTERCEPT	1	1.84359775	0.93276216	1.976	0.0681	.
AMM IN AIR	1	0.05342274	0.01068928	4.998	0.0002	0.64082177
RES. TIME	1	0.03684981	0.005619161	6.558	0.0001	0.75441123
MOISTURE	1	0.0281475	0.007929318	3.550	0.0032	0.47370570
TEMPERATURE	1	0.002369222	0.001072864	2.208	0.0444	0.25834302
HOT WATER SOL	1	-0.0474506	0.02274864	-2.086	0.0558	-0.23709205

TABLE 4. ANOVA TABLE FOR RESIDUAL AMMONIA WITH ONLY IMPORTANT TERMS IN MODEL.

Run	PT&D Ammon.	R&D Ammon.	PT&D Moist.	R&D Moist.	Reducing Sugar	Total Sugar
			After 3 Weeks			
1	.56	.48	8.7	10.5	4.67	5.27
2	.69	.61	11.0	13.5	3.93	4.80
3	.75	.67	11.3	11.8	3.67	4.67
4	.58	.49	9.6	11.8	4.23	5.33
5	1.09	.89	12.2	14.5	2.43	2.97
6	.59	.54	11.8	13.7	3.83	4.57
7	.60	.65	8.2	10.0	4.60	5.00
8	.65	.62	8.5	10.3	3.63	4.00
9	.78	.67	13.8	17.1	3.60	3.77
10	.54	.43	11.5	14.3	4.77	4.97
11	.62	.49	9.6	11.3	5.27	5.43
12	.88	.76	13.7	15.4	2.93	3.20
13	.83	.63	13.9	15.5	3.97	4.60
14	.48	.40	7.8	9.3	5.80	6.13
15	.73	.61	8.3	10.0	4.57	4.80
16	.51	.45	9.0	8.8	4.70	4.83
17	.22	.25	9.0	8.7	4.80	5.03
18	.69	.60	11.1	11.8	4.43	4.73
19	.47	.45	12.5	12.9	5.07	5.47
20	.56	.52	11.3	11.0	4.70	5.00
			After 8 Weeks			
1	.62	.61	11.3	11.5	4.20	4.37
2	.74	.63	11.6	12.2	4.67	5.10
3	.82	.64	10.9	11.2	3.93	4.30
4	.52	.47	8.9	10.2	5.07	5.33
5	.98	.79	12.2	12.4	1.87	2.03
6	.56	.50	11.8	11.9	3.33	3.57
7	.52	.48	7.6	8.5	4.27	4.77
8	.72	.67	8.2	8.8	2.93	3.47
9	.81	.69	12.3	15.8	3.10	3.33
10	.44	.42	11.7	12.6	4.47	4.77
11	.56	.50	9.1	9.7	4.17	4.70
12	.89	.74	13.3	12.8	2.77	3.17
13	.69	.62	13.4	12.8	3.43	3.83
14	.42	.45	7.4	7.3	5.53	5.73
15	.60	.52	7.6	8.0	3.83	4.00
16	.48	.44	8.3	8.7	4.20	4.37
17	.28	.26	8.3	8.8	4.80	4.93
18	.72	.58	11.1	11.6	4.00	4.30
19	.44	.44	12.8	12.0	4.80	4.97
20	.50	.50	10.3	10.1	4.37	4.47

Table 5. Listing of Data after Aging.

FIGURE 1. R&D LAB AMMONIA VERSUS PT&D AMMONIA.

51259 8104

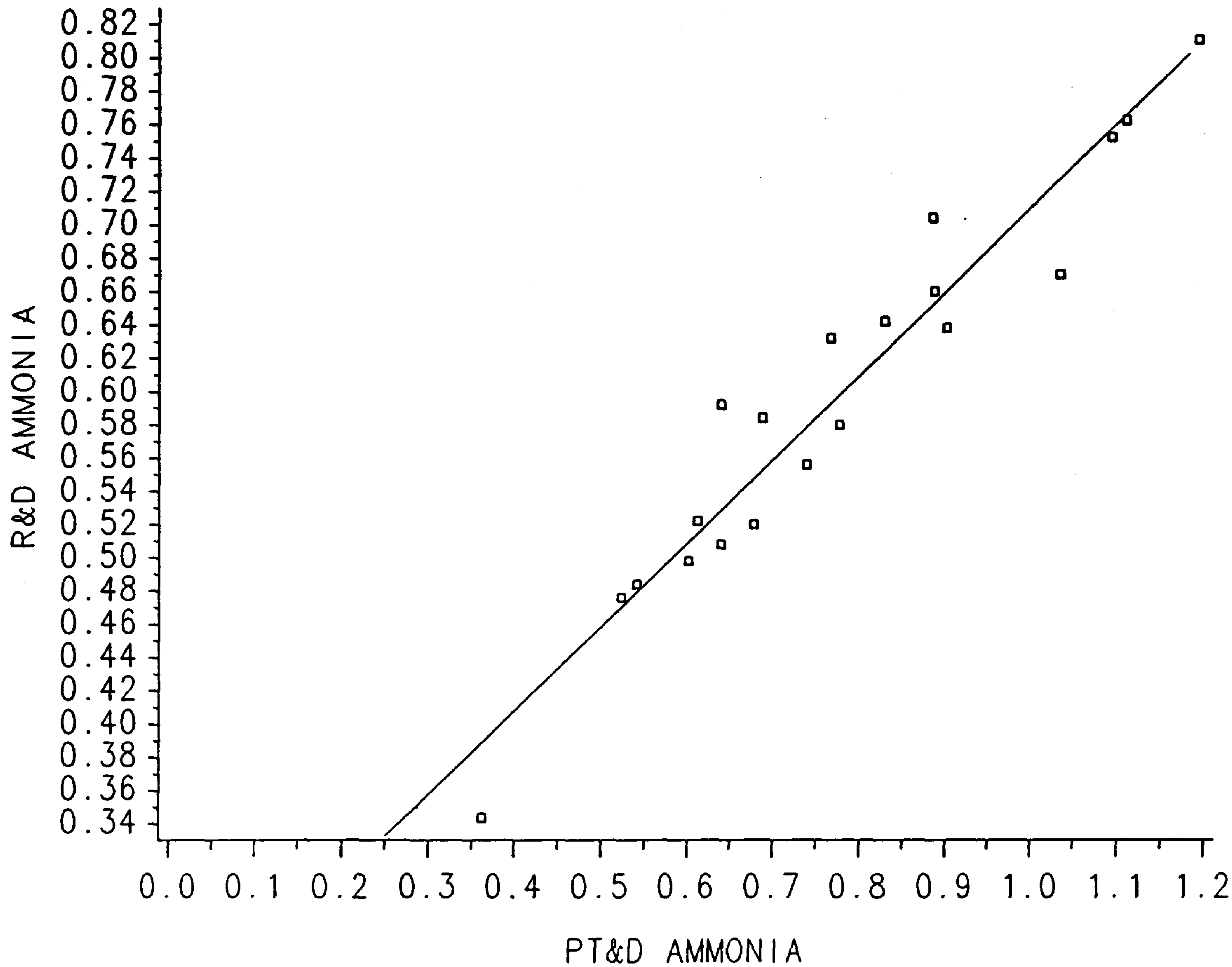

FIGURE 2. PT&D AMMONIA MINUS R&D AMMONIA VERSUS AVERAGE AMMONIA.

51259 8105

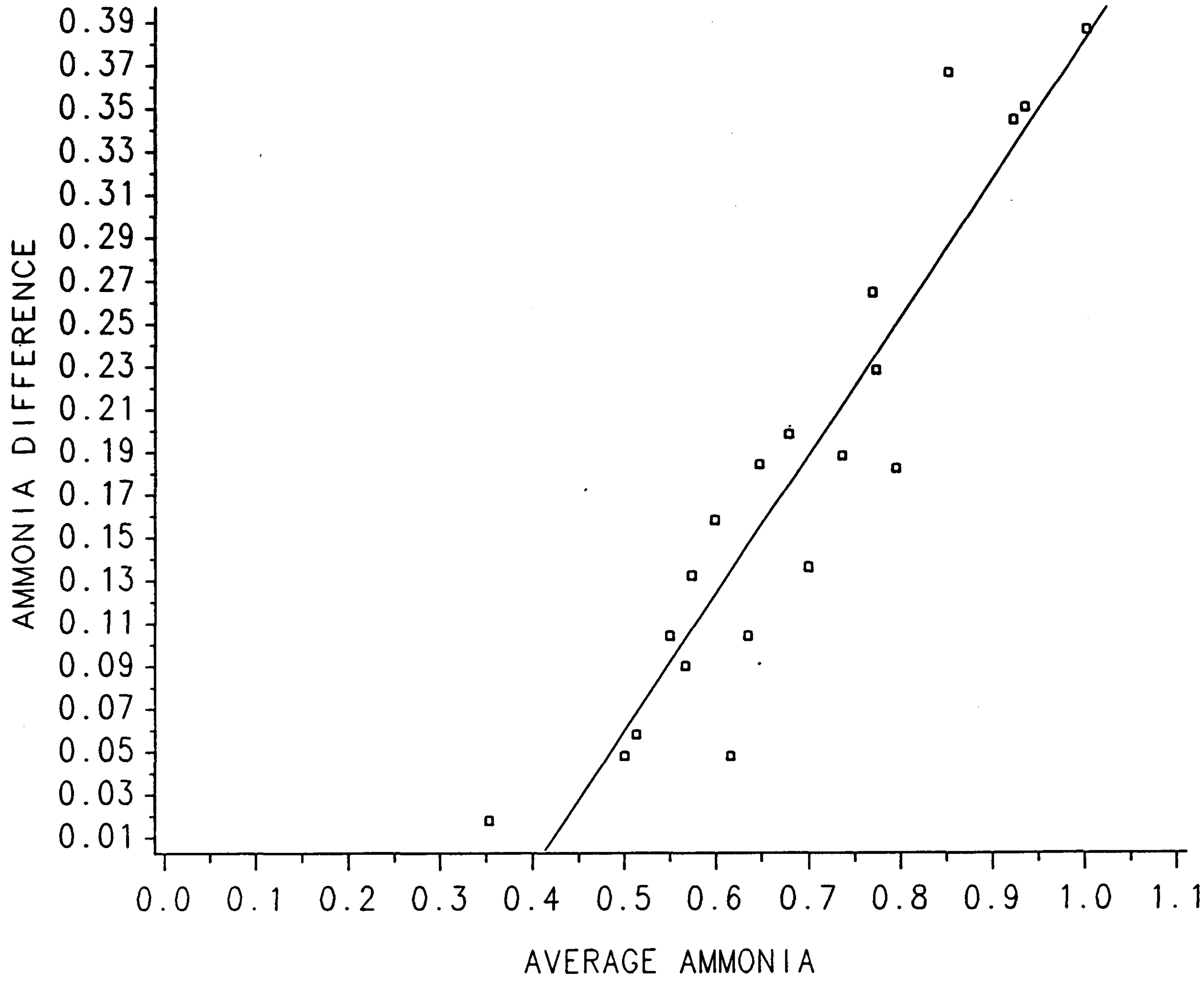

FIGURE 3. R&D LAB MOISTURE VERSUS PT&D OVEN MOISTURE.

51259 8106

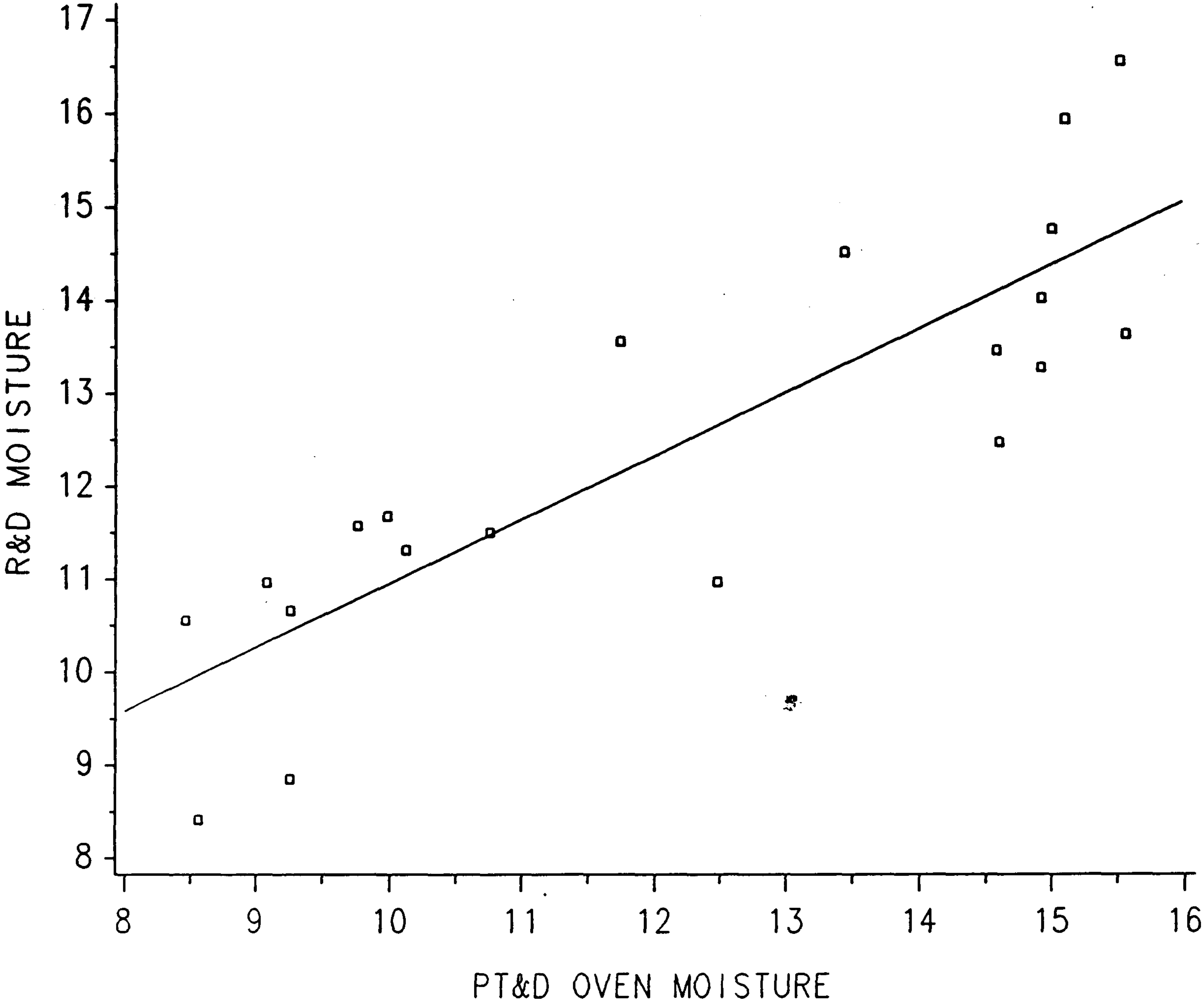

FIGURE 4. PT&D MOISTURE MINUS R&D MOISTURE VERSUS AVERAGE MOISTURE.

51259 8107

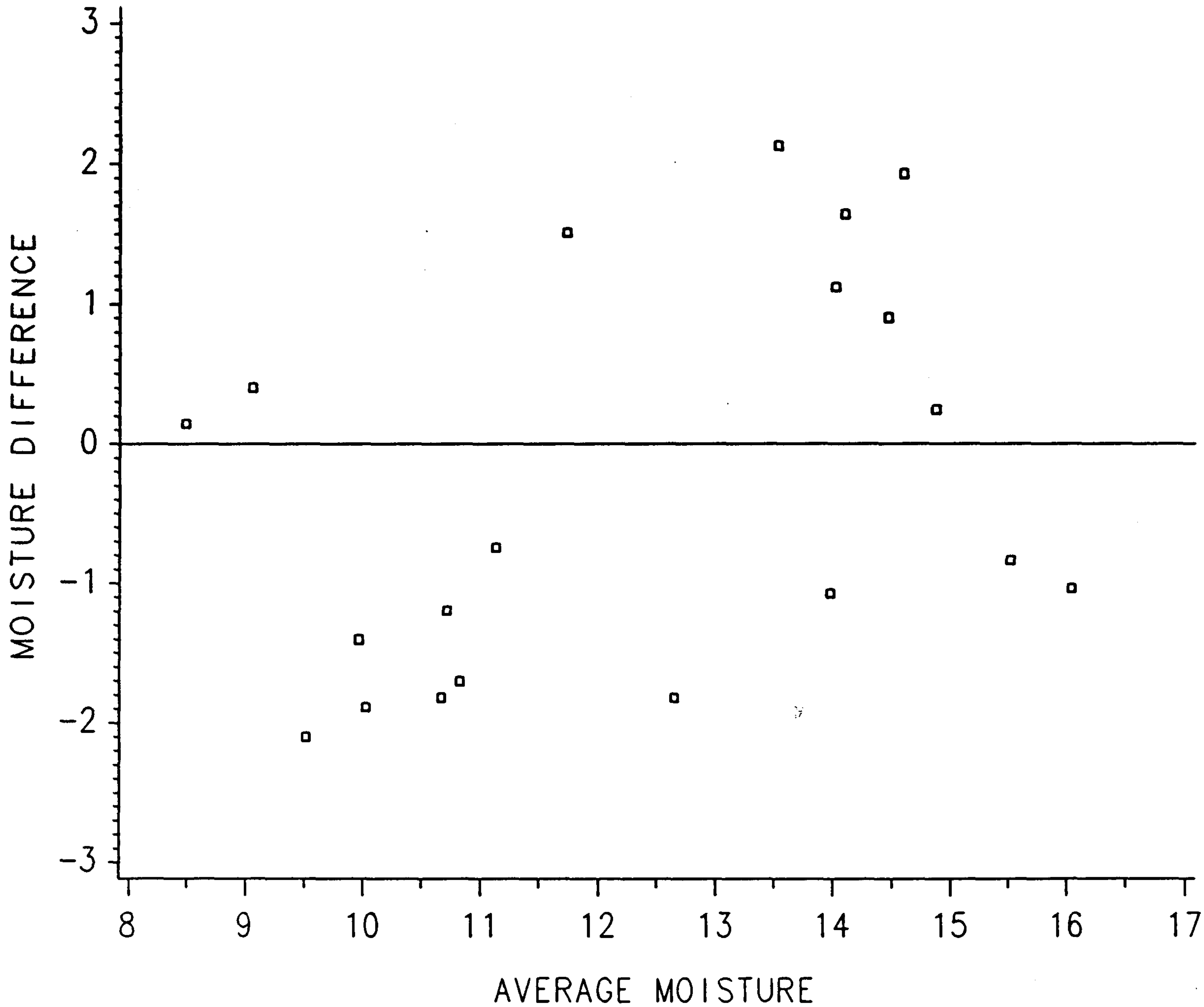

FIGURE 5. R&D LAB HWS VERSUS PT&D HWS.

51259 8108

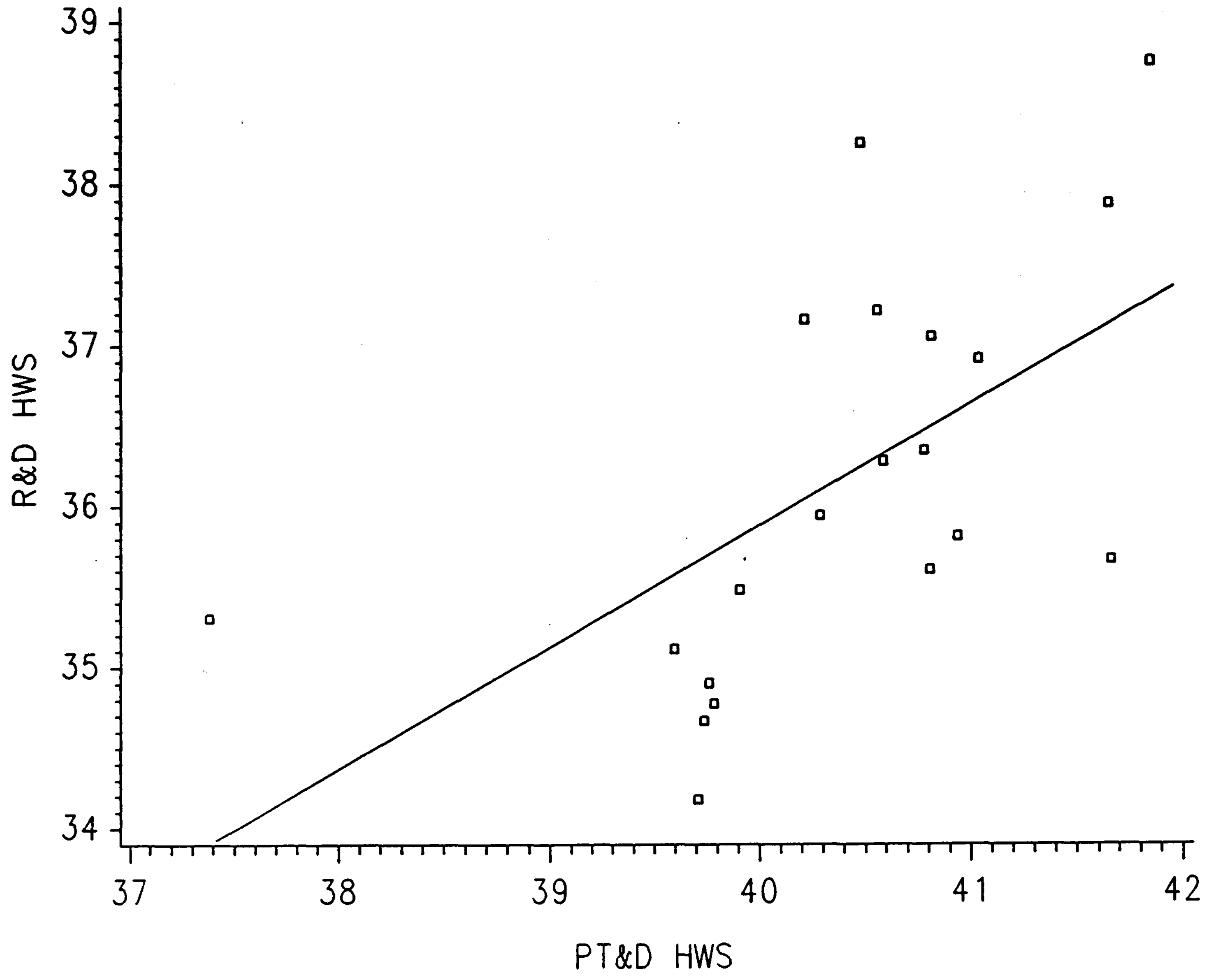

FIGURE 6. PT&D HWS MINUS R&D HWS VERSUS AVERAGE HWS.

51259 8109

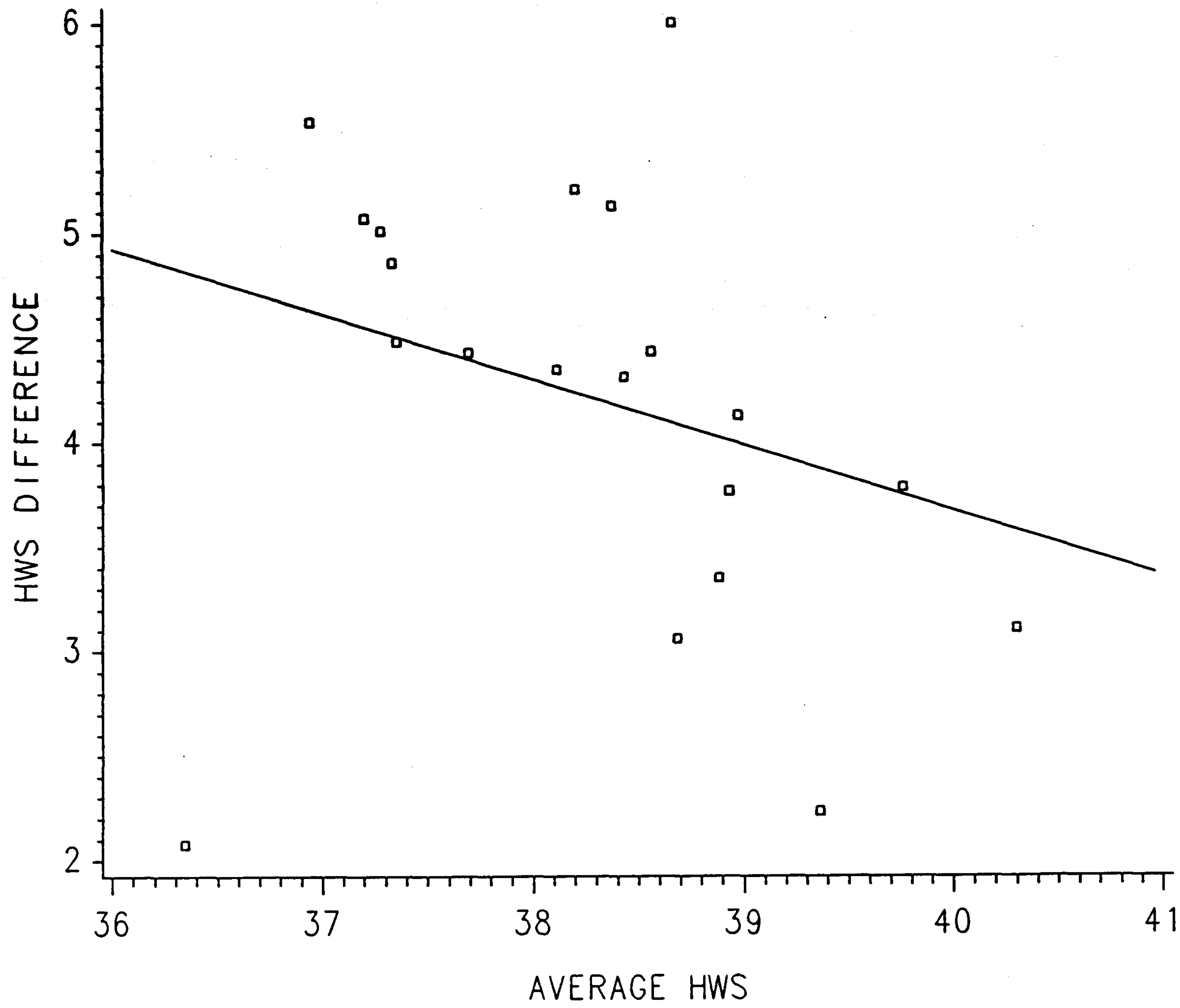

FIGURE 7. REDUCING SUGARS AFTER 3 WEEKS VERSUS RESIDUAL AMMONIA.

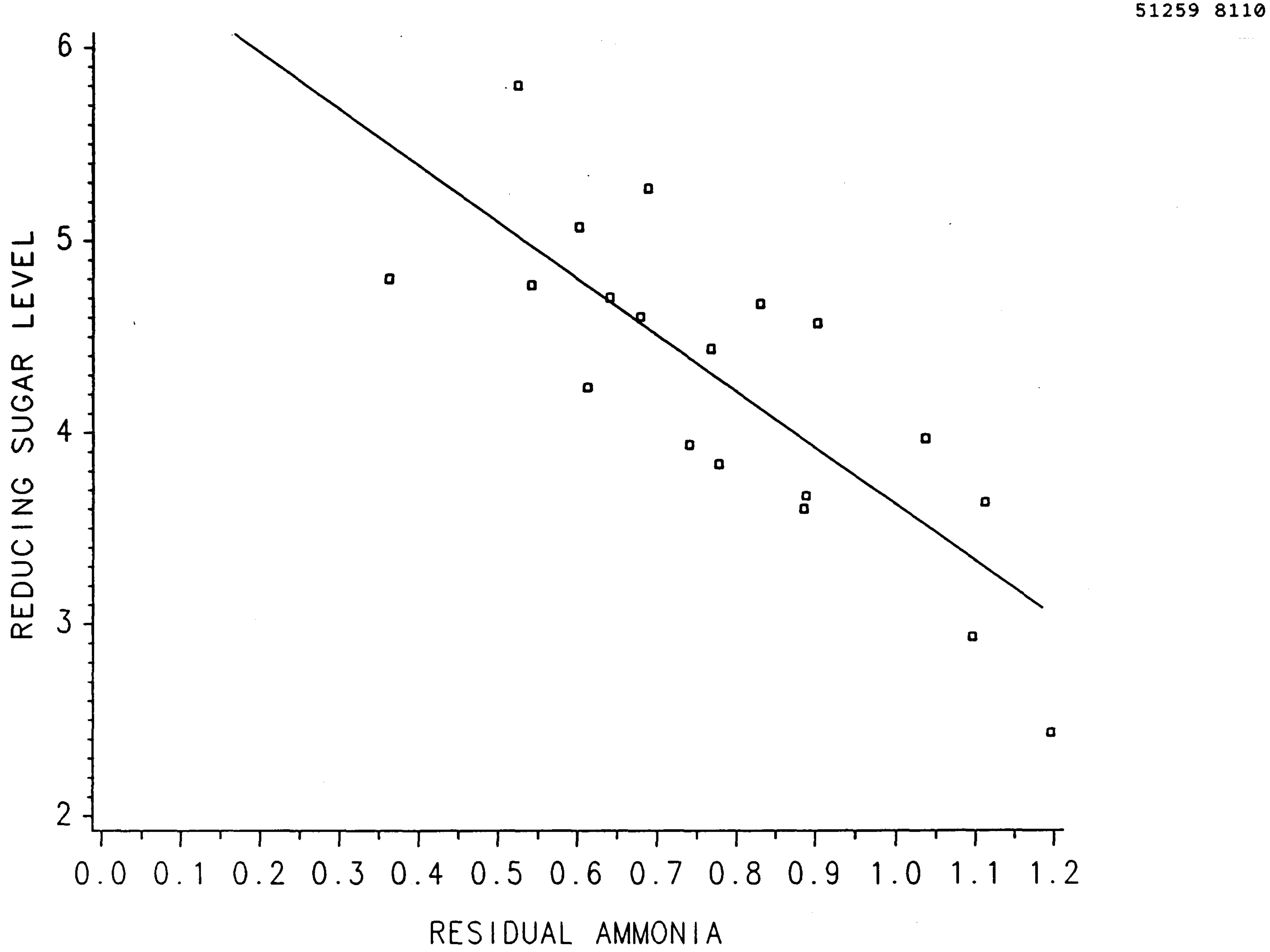

FIGURE 8. TOTAL SUGARS AFTER 3 WEEKS VERSUS RESIDUAL AMMONIA.

51259 8111

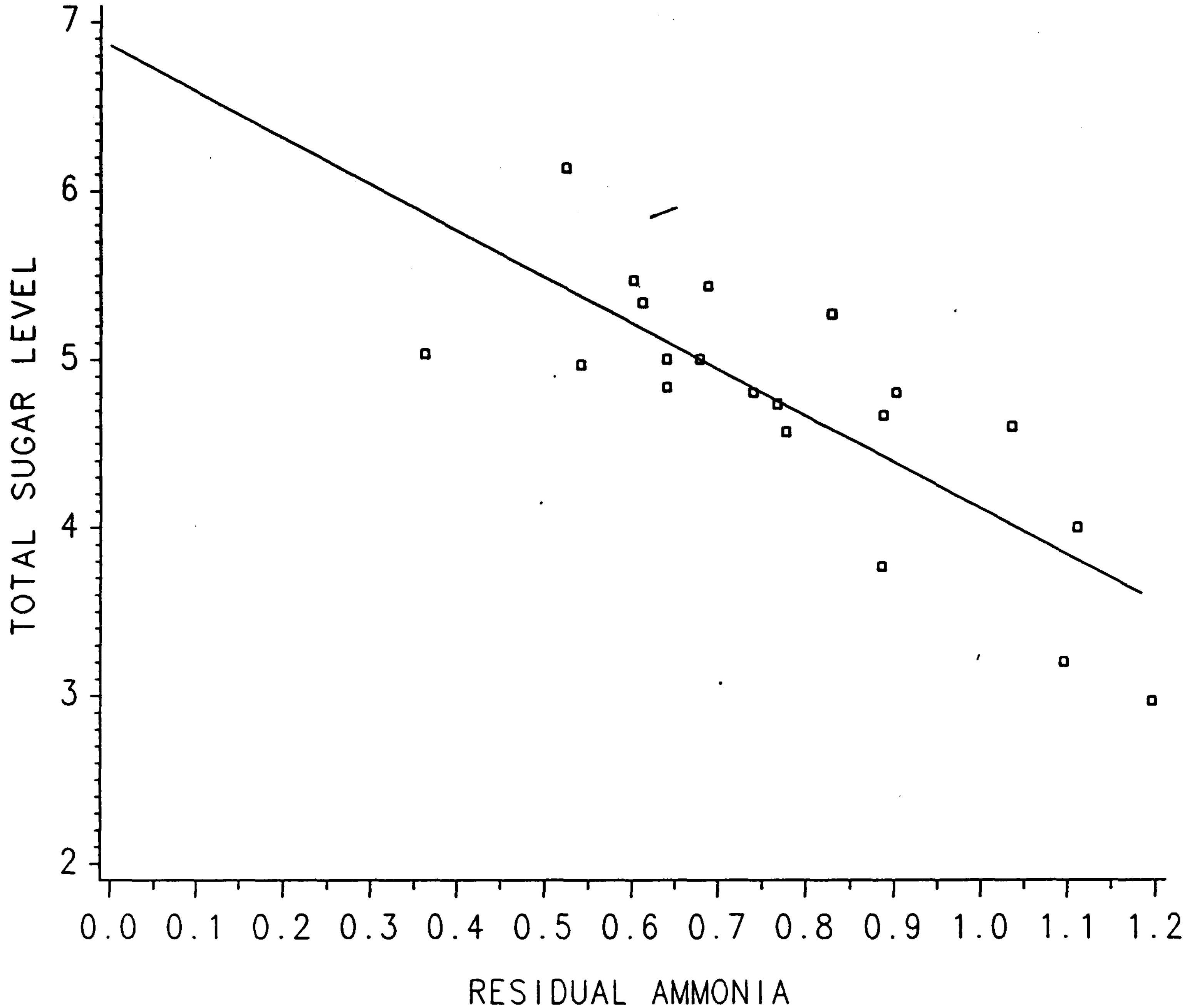

FIGURE 9. REDUCING SUGARS AFTER 8 WEEKS VERSUS RESIDUAL AMMONIA.

51259 8112

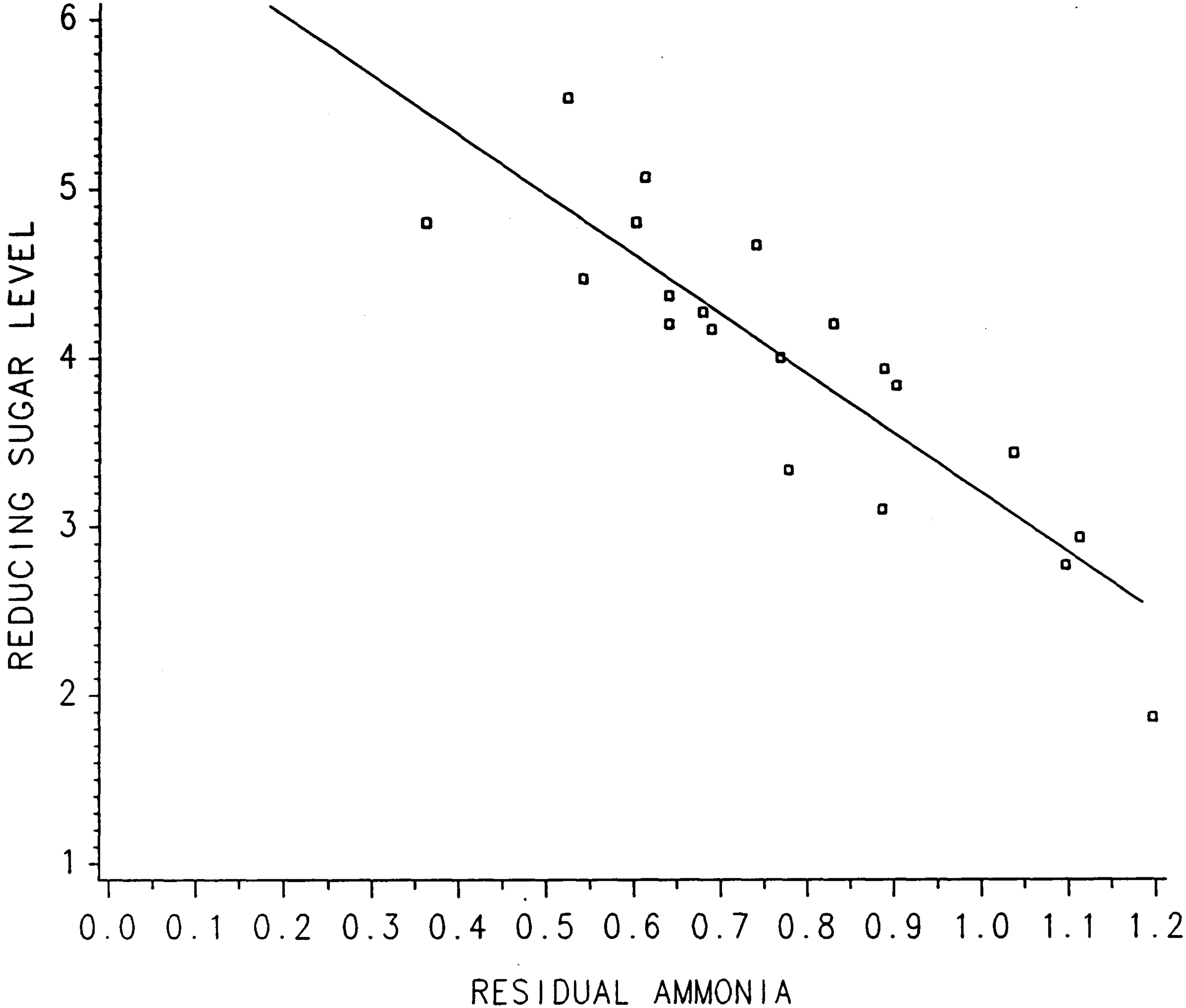

FIGURE 10. TOTAL SUGARS AFTER 8 WEEKS VERSUS RESIDUAL AMMONIA.

51259 8113