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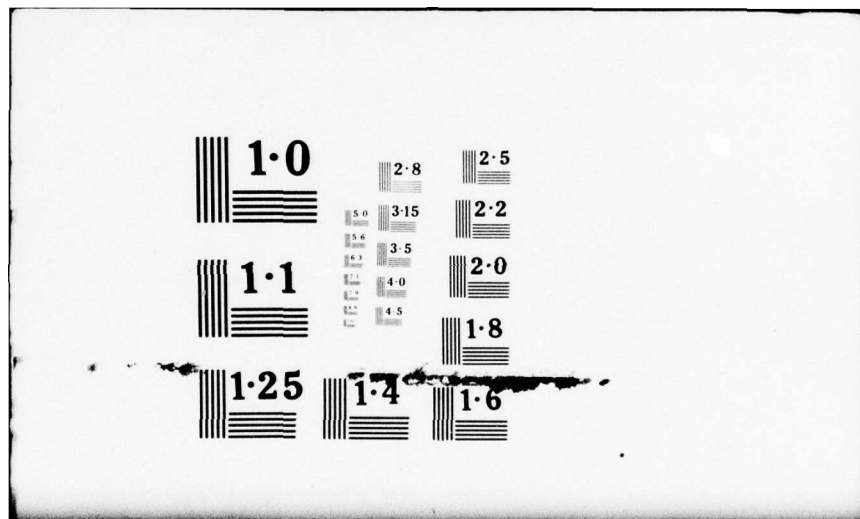
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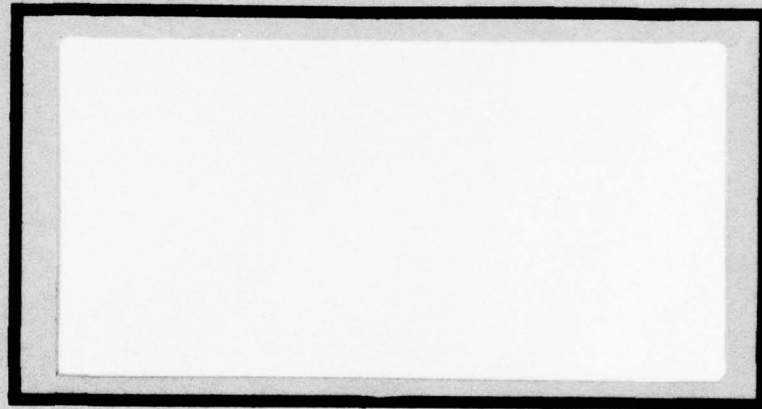


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**CORROSION PREDICTABILITY IN F-4
AIRCRAFT ASSIGNED TO THE
PACIFIC AIR FORCES**

**Jerrold B. Harrington, Captain, USAF
Jacob Teomy, Captain, IAF**

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Corrosion has become a serious problem in PACAF due to inadequate management attention in the areas of facilities, training, and manning. The purpose of this study was to construct a mathematical model useful for predicting base-level corrosion control man-hours. The utility of such a model would allow the manager to forecast his requirements for corrosion maintenance. Statistical analysis involved least squares multiple linear regression. Independent variables included: (1) aircraft historical data such as airframe hours, age, assignment history, and MDS; (2) maintenance data such as PDM hours, contract corrosion control hours, and time since last PDM; and (3) corrosion severity indices. Data on the variables used in the analysis were gathered from the AFLC GO-98 computer data bank and at Headquarters PACAF. Studied in this research were F-4 aircraft at four PACAF bases: (1) Kadena AB, Japan; (2) Clark AB, P.I.; (3) Kunsan AB, Korea; and (3) Osan AB, Korea. The results showed a statistically significant regression model; however, a relatively high standard error of the estimate limited its usefulness.

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**CORROSION PREDICTABILITY IN F-4 AIRCRAFT
ASSIGNED TO THE PACIFIC AIR FORCES**

A Thesis

**Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology**

Air University

**In Partial Fulfillment of the Requirements for the
Degrees of Master of Science in Logistics Management
and Master of Science in Facilities Management**

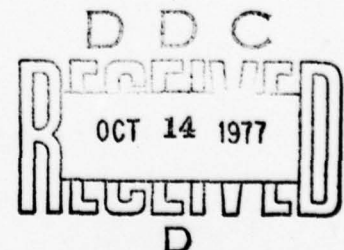
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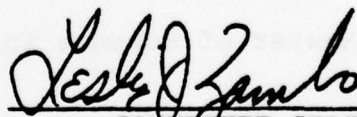
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MASTER OF SCIENCE IN FACILITIES MANAGEMENT
(Captain Jerrold B. Harrington)

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(Captain Jacob Teomy)

DATE: 15 June 1977



COMMITTEE CHAIRMAN

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Chapter 1

INTRODUCTION

Statement of the Problem

Corrosion is one major wear-out phenomenon which significantly influences the cost of ownership of Air Force systems.

This problem is neither new nor unique to Air Force equipment; however, it must be faced and solved more effectively than it has been in the past. If programs are to succeed in this era of high and growing operating and support costs, managers must be aware of the long-term cost implications of corrosion, as well as interested in the prevention and solution of these problems. This problem is too important to be left solely for engineering specialists to solve, and management must involve itself in the issues which such problems raise [27:13].

With these words, the U.S. Air Force Inspector General touched upon the major weakness of the AF corrosion control and prevention program--lack of effective management! When the corrosion control program is not effectively managed, backlogs of work pile up creating a serious situation. Corrosion, left untreated, gets progressively worse with the passage of time. The longer it remains undetected or untreated, the longer it takes to repair and the higher the expense incurred. More critical than this, untreated corrosion weakens structural members to the point of catastrophic failure, endangering the lives of crew members and others. Experience has shown that corrosion

control catch-up is an expensive alternative to a sound corrosion prevention program (10:36).

For a manager to be effective, he must have some means of planning for the future needs of his organization. In corrosion management, it would be beneficial to be able to isolate and quantify those factors which are useful in predicting corrosion damage. With this information, a predictive model could be devised which would aid the manager in forecasting requirements for inspection, maintenance, training, facilities, and manning (19:1).

Background

Air Force Technical Order 1-1-2 states:

Corrosion or deterioration of metal starts the instant the fabrication or manufacturing process is completed and continues until the material is exhausted or salvaged. The speed of the deterioration or corrosion will depend on many factors but primarily on the type or chemistry of the material used; environment to which it is exposed; fabrication and/or assembly methods used; heat treatment; and degree or method of protection or preventive measures including such things as shot peening, etc., taken to retard the corrosion process. The design or project engineer will be concerned with all the design factors, i.e. mission, reliability, maintainability, cost, and corrosion which can have a detrimental effect on the equipment. On the other hand, maintenance personnel will be concerned with sustaining the features built in by the design engineer at a reasonable cost. Maintenance personnel in accomplishing structural repair will find that about 50 percent or more of actions or work will be related to corrosion or deterioration in some way [22:1-1].

Table 1 shows the most common types of corrosion found in Air Force equipment.

Table 1
Common Types of Corrosion Found
on AF Aircraft¹

Type	Description
A. Uniform attack	Occurs over the entire surface of a metal and is caused by direct action with the environment.
B. Pitting	A form of severe localized attack which can completely penetrate a metal or alloy. This type of corrosion is most destructive because the pits are small and hard to detect.
C. Intergranular (exfoliation)	A concentrated attack on the grain boundaries of a metal. It can be caused by differences in composition between the grain boundary and the interior of the grain or by impurities which gather at the grain boundaries.
D. Galvanic	Occurs when dissimilar metals or alloys are in contact and a conductive solution is present.
E. Crevice corrosion	A type of localized attack occurring wherever crevices are formed, i.e. under gaskets, bolt heads, rivets, etc. This type is difficult to detect because of its location.
F. Stress corrosion cracking	The result of constant tensile stress and corrosion occurring simultaneously. This type is a serious problem for the Air Force because it is generally difficult to recognize before safety factors have been exceeded.

¹For a more extensive discussion of the various types of corrosion, see bibliographical entries: 5, 21, and 22.

Table 1 (continued)

Type	Description
G. Corrosion fatigue	A special case of stress corrosion in which the stress is cyclic in nature. The material fails due to a reduction of the fatigue limit as a result of corrosion.
H. Filiform corrosion	Gets its name from the numerous threadlike filaments which are formed when water and oxygen get under an organic coating.

[21:24-26]

General recognition by the United States military and the American scientific communities of corrosion as a significant problem can be traced to the period during World War II (8:vii). While corrosion has always been a problem with which we have lived, it was not until this period that destruction of equipment to such a great extent was witnessed.

The theaters of operation in World War II, which encompassed virtually every extreme in climate, provided conditions which led to deterioration of equipment on a scale never before experienced by any major military organization [17:2].

Since this time, the Department of Defense has focused a great deal of attention on the corrosion problem.

In the early 1940's, the National Defense Research Committee created the Army-Navy Deterioration Steering Committee to mount a coordinated attack on corrosion. In 1943, the Tropical Deterioration Information Center was established. In 1945, the usefulness of these organizations was recognized which led to the creation of more permanent organizations: the Joint Army-Navy Deterioration Prevention Committee and the Prevention of Deterioration Center under contract with the National Research Council of the National Academy of Sciences. The Department of the Air Force joined ranks with the Army and Navy in supporting research into the prevention of corrosion when it became a separate service in 1947 (8:vii-viii).

With the trend toward smaller defense budgets expressed as a percentage of Gross National Product and the resulting need to reduce maintenance costs while simultaneously maintaining military effectiveness, the costs associated with corrosion damage have continued to draw attention. In 1974, the Air Force established the Maintenance Posture Improvement Program (MPIP) with the stated goal to initiate ". . . a program to reduce maintenance manpower and material costs and increase effectiveness of mission support [28:1]." The Air Staff directed that MPIP be expanded to include all aspects of the corrosion problem (17:3).

Tasking will include working level panels . . . to actively probe, evaluate, and present recommendations on all possible means/alternatives available to promote and develop a more effective [corrosion prevention] program for the Air Force. All efforts will be focused on identifying changes and improvements that will produce reductions in corrosion damage and associated costs [24].

Justification

Research in the area of corrosion predictability can be justified for several reasons. Air Force policy states:

An effective corrosion prevention and control program will be continuously pursued throughout all maintenance activities to enhance safety, extend service life, and to reduce costs, repair man-hours, and systems and equipment downtime.

Corrosion prevention and control will be a primary design criterion in the development, acquisition, and modification of weapon systems and subsystems [23:1].

Being able to predict the rate of corrosion at each air base would enhance stated Air Force policy by helping to prolong the life of our present aircraft resources through efficient scheduling of corrosion prevention measures. Research in corrosion prediction could also result in increased accuracy in our present life cycle cost (LCC) models. Lastly, corrosion prediction will help the manager forecast more accurately his resource requirements.

Resource conservation. Given the economic constraints and long lead-times associated with new military acquisitions, a great deal of emphasis has been placed on prolonging the lives of many of the weapon systems currently in use. Major modifications have been made to extend the operational life of aircraft, such as the B-52, far longer than envisioned when they were acquired (18:10).

Colonel L. C. Setter points out the effect corrosion has on the lifetime of aircraft:

We used to think the major problem regarding continued airworthiness of our aircraft was the condition of wear or wearout. Since many of our weapons systems were increasing with age, we now have B-52's that are roughly 20 years old, F-4's that are fifteen, even our C-5's are showing signs of old age; we thought the wear problem was a very serious one and we thought that was the reason we brought airplanes into the depot. Our technical evaluations over the past few years revealed that wear is not nearly as destructive a factor as corrosion. Corrosion presents a greater problem than wear due to the unknown factors which weigh in the situation and our inability to track or predict corrosion. We don't know how to project that an airplane is going to be corroded [18:10].

Since 60 percent of repair costs are corrosion related and total man-hour costs, exclusive of repair parts, amount to one-half billion dollars annually, there is considerable incentive to seek improved procedures (19:1). Basing inspection and programmed maintenance intervals upon the predicted risk of corrosion is one method which could decrease these expenditures. Thus, research in corrosion predictability could result in lower overall maintenance costs and, would also contribute to lower life cycle costs.

Improved life cycle cost models. Techniques to estimate the total cost of a system from inception to disposal have come about due to Congressional and Defense Department demands for more visibility and control of systems cost during acquisition and operation. Included in these life cycle costs is the amount spent for operation and maintenance (O&M) of the system. Since O&M costs can account for as much as 60 to 70 percent of the total cost for these systems, accurate modeling of these costs are essential for valid LCC estimation (3:20-28). Moore encapsulates a problem with present LCC models as follows:

. . . , a very powerful tool for creating understanding of the importance of corrosion is Life Cycle Costing, particularly when LCC models are designed to be sensitive to failure modes and correctly allocate costs. However, the models which we are presently using do not seem sensitive to corrosion or fatigue, and work needs to be done in our modeling techniques to enable us to make decisions on program finish systems, design details, and how they will influence total system cost [14:27].

Life cycle cost prediction for military systems has all the usual problems of economic forecasting, plus those of predicting cost associated with corrosion. When the service life of components subject to corrosion can be predicted with the accuracy which fatigue life predictions can be reached, more accurate life cycle cost estimation will result (13:52,53). Research in corrosion prediction should assist in increasing the accuracy of our LCC models.

Increased management efficiency. In addition to enhancing LCC techniques and scheduling efficiency, the ability to predict the order of magnitude of the corrosion prevention and control effort at each base will help increase the efficiency of our managers. The efforts of the Air Force in general and PACAF in particular have been less than adequate in managing the corrosion problem. This may stem from the belief at base level that all but the most routine corrosion maintenance should be carried forward until that aircraft is scheduled for major overhaul at the programmed depot maintenance (PDM) facility. This, in turn, may be due to the extensive downtime required for corrosion repairs (12:2). Whatever the reason, the best policy is to prevent corrosion. If ignored, it becomes progressively worse, spreading to the very core of affected structural members. In PACAF, the situation presently rivals that which faced SAC in 1973 with its B-52s in Guam.

The extent and severity of B-52 corrosion first became known in mid-1973 when the 43 SW Anderson AFB, Guam, requested depot assistance to overcome a corrosion backlog of 41,000 man-hours.

. . . The costly depot and field team corrosion programs, begun in 1973, ultimately required the in-house resources of two depots plus field teams from four depots working simultaneously by mid-1974 to keep abreast of scheduled and unscheduled workloads. Heavy B-52 depot corrosion work continued through 1975 and the first half of 1976. Since the B-52G corrosion program was completed 20 July 1976, the remaining depot corrosion repairs are accomplished during programmed depot maintenance (PDM) [10:34].

This is an example of the excessive costs which can be incurred for not keeping on top of the corrosion problem. In PACAF, the backlog of corrosion repairs on F-4 aircraft is extensive and has been caused by lack of effective management in the following areas:

1. Facilities. PACAF Regulation 66-19 states:

It is the PACAF goal to establish adequate corrosion control facilities at every active base in theater within the next 5 years. Bases will establish construction programs to upgrade existing facilities or to construct new facilities to meet this end.

a. Three facilities are required at each active base:

(1) An aircraft wash rack(s) (as required) conforming to Air Force Definitive Drawing AD39-01-83 capable of sustaining aircraft wash operations year-round.

(2) A corrosion control shop facility meeting the requirements of AFM 86-2, section F.

(3) An enclosed aircraft paint hangar capable of sustaining touchup paint operations on assigned aircraft year-round.

b. Each facility must meet minimum Occupational Safety and Health Act (OSHA)/Environmental Protection Agency (EPA) requirements, and must be equipped with requisite ventilation, lighting, wiring, utilities, dip tanks, drain systems, spray booths, air conditioning systems, fire suppression, personnel safety, and pollution control systems to meet normal corrosion control operational requirements [25:4].

This regulation was published 3 December 1976, and defines an overall corrosion control program for PACAF. The publication of PACAFR 66-19 shows that the present USAF upper level management is acutely aware of the present corrosion situation and has taken steps to improve it. A great deal of work is needed in the facilities area as the current situation reveals.

The present corrosion control facilities at the four F-4 bases are in need of major repair/updating.

The corrosion control facilities at Kunsan AB and Osan AB, Korea have no area for the painting of aircraft. Washrack facilities have inadequate heating systems for washing aircraft in winter months and installed equipment for washing aircraft is unserviceable. Drainage and skim tanks for wash/paint strip residue is nonexistent. Facilities at Clark AB, P.I. are also inadequate. The lack of a covered washrack coupled with the existing environmental conditions prevent effective cleaning of aircraft/AGE. The extensive rainfall, high temperature, and humidity curtails painting and corrosion control maintenance in an unprotected environment. Facilities that meet (OSHA) standards must be constructed.

The facility at Kadena AB, Okinawa meets all (OSHA) standards; however, the location of the washrack is uneconomical. Towing aircraft two miles, across two active runways, for washing costs excessive man-hours and creates a safety hazard. Construction of a covered washrack in the immediate area of the aircraft is needed [12:3].

The upgrading/construction of corrosion control facilities must be given immediate attention. Effective corrosion control maintenance can not be accomplished in sub-standard facilities (12:3; 7).

2. Training. One of the main reasons why the current backlog of major corrosion maintenance actions

exists in PACAF is the lack of adequate training given to personnel in inspection, detection, and documentation of corrosion. This does not apply so much to the corrosion control specialists as it does to other flight line personnel who are not familiar with the various forms of corrosion. Such personnel as quality control inspectors, fuel systems and egress technicians, and crew chiefs need training in detecting corrosion where it actually occurs on the aircraft at their base and in documenting these discrepancies correctly on the AFTO Form 349 (see Appendix D).

PACAF has taken action to overcome the shortcoming in the training of personnel with regard to corrosion identification, detection, and documentation. PACAFR 66-19 establishes a training program which includes corrosion prevention and control familiarization for all incoming maintenance personnel. It states:

This one-time course should be 6-8 hours in length, when course materials are available to justify the length, and should be tailored to the specific functional area(s) in which the personnel will work. Particular emphasis will be placed on peculiar system corrosion problems, and will also cover corrosion identification, prevention, responsibilities, techniques, reporting, and documentation procedures, and technical data [25:4].

This training program is slated to be in operation by June 1977, and should greatly increase the effectiveness of the corrosion control program at each PACAF base.

3. Manning. Prior to the early 1970's, much of the corrosion work in PACAF was done by commercial contractors.

Low labor rates made contracting more economical than constructing modern base corrosion facilities, therefore no action was taken to update facilities to meet minimum (OSHA) standards. Authorized manning did not reflect the quantity of aircraft and support equipment requiring corrosion treatment. Special tools, and equipment, were not requisitioned for an effective corrosion facility at base level.

In the early 1970's our corrosion problems began to surface. Contractual labor cost continued to increase to an uneconomical rate. Base corrosion facilities were inadequate for effective corrosion control maintenance. Authorized and assigned manning did not reflect the manpower required to effectively maintain corrosion on aircraft and support equipment [12:2].

This is still a problem because PACAF does not have sufficient manpower to alleviate the huge backlog of F-4 corrosion. Under these conditions, it is difficult to document the need for additional permanent manning.

The present manning may be adequate to maintain the fleet if all the aircraft were in good condition but, we are so far behind in repairing major corrosion damage, we can't tell [7].

It would be possible to reduce the scope of these problems if the needs for manning, training, and facilities at each base could be accurately forecast. If the man-hours required to carry out the corrosion control program at a base in future years could be accurately forecast based on readily available parameters, requests for additional manning and facilities could be justified and plans could be made for the required training.

Related Research

Corrosion is the process by which materials deteriorate to a more thermodynamically stable condition through electrochemical interaction with their environment (13:48). The Armed Forces and private industry spend millions each year combatting the effects of corrosion (5:2). Various efforts, both past and ongoing, have been funded to arrive at a method to predict corrosion rates. Some of the Air Force efforts will be discussed in this section.

One project, known as PACER LIME, has as its aim to derive a corrosion severity factor (CF) for each USAF base. As a first approximation of the values of these CFs, an interim value was assigned to each air base predicated on qualitative observations as to how weather conditions affect corrosion rates. Values of those interim CFs for the PACAF bases of interest to this research effort are shown in Table 2. In project PACER LIME, tests are presently being conducted to validate these subjective values of the corrosion severity factor through experiments performed with several aircraft alloys at various locations worldwide. The experiments entail exposing bare plates of alloys to the elements and measuring their weight loss over time due to corrosion. The results of these tests along with climatological and air pollution data will be used to determine new values for the CFs (9:2). The Air Force uses

the present interim CFs to determine wash cycles and corrosion inspection intervals for aircraft and equipment at each base (23:22).

Table 2
Corrosion Severity Factors
(PACER LIME)

Base	CF
Kadena AB, Japan	1.83
Clark AB, PI	2.00
Osan AB, Korea	2.50
Kunsan AB, Korea	1.83

[9:36]

Dr. Robert Summitt is conducting a research effort at Michigan State University designed to develop a method for scheduling depot maintenance and predicting costs to replace PDM. Dr. Summitt's study entails correlating C-141 maintenance data and various other environmental factors to develop improved models for predicting the nature and frequency of corrosion-related repair as well as guidelines for minimizing corrosion damage (20:1-3).

Attention has also been directed at determining the relationship between environmental factors and variable corrosion damage experience. A preliminary study by

Major Thomas Moore compared maintenance man-hour costs for the F-4E engine starter and the KC-135 Doppler radar at three midwestern bases. Despite similar weather conditions, significant differences among the bases were found, suggesting atmospheric pollution may have an important role. Major Moore's results indicate that it is possible to predict repair costs and needs if the appropriate risk factors are known and quantified (15:17-24).

Objectives and Scope

The objectives of this research are threefold. The first is to establish if a linear relationship exists between base-level corrosion control man-hours and selected independent variables. The second objective is to formulate a regression model, based on these independent variables, which will be useful in forecasting base-level corrosion man-hours for each of the four PACAF F-4 bases. As a third objective, the variables will be identified whose net or marginal contributions to the explanatory power of the model are significant.

In order to develop a study of manageable proportions and in a reasonable time period, it was necessary to restrict the scope of the research. Because of command interest in corrosion predictability and the availability of data, the study was limited to PACAF assigned F-4 aircraft.

Research Hypothesis

A number of variables exist which can be used to predict the yearly base-level maintenance man-hours expended on corrosion.

Chapter 2

METHODOLOGY

The basic approach used in this research effort consisted of ascertaining which variables have an effect on corrosion control man-hour costs. The data on selected variables were collected, analyzed, and used to develop a multiple linear regression model. The relationships found among the variables were used to develop a model for predicting base level corrosion man-hour costs. It was expected that the results of the analysis would provide a statistically significant mathematical model.

Population

The population was defined as all present and future F-4 aircraft in the U.S. Air Force inventory. The F-4 aircraft is a twin engine jet fighter which is deployed worldwide. Mission design series of the F-4 in the USAF inventory include the F-4C, F-4D, F-4E, and RF-4C, the latter being used in a reconnaissance role.

Sample

The sample selected for study consisted of a census of all F-4 aircraft assigned to the Pacific Air Forces during the time period 1974-1976. The decision was made to

limit the sample in this manner due to the command interest shown by PACAF and the availability of data to conduct the analysis. However, since aircraft from other commands and operating locations were not included in the sample, no attempt was made to make inferences to the population based on the results of this research.

The original sample of 170 aircraft was reduced because of data considerations. PDM and contract corrosion control (CCC) records were incomplete. Aircraft for which data was not available were eliminated from the sample. In addition, since base-level corrosion control man-hours in CY 1976 was the dependent variable, all aircraft which underwent PDM during that year were eliminated from the sample. The resulting sample consisted of eighty F-4C, F-4D, F-4E, and RF-4C aircraft from four PACAF air bases.

Data Acquisition

The data used to describe the variables in the multiple linear regression analysis (MLR) were obtained from sources within the Air Force. The corrosion factors (CF) for all USAF bases were acquired from the Air Force Logistics Command (AFLC) Corrosion Management Office. The CFs are interim values taken from the PACER LIME project.

Base-level corrosion maintenance man-hours and PDM dates were obtained from the GO-98 computer data bank at the San Antonio Air Logistics Center at Kelley AFB, Texas.

Data on the remaining predictor variables such as age, airframe hours, the number of months each aircraft was assigned to the different PACAF bases, PDM and contract corrosion control man-hours, etc., were obtained at PACAF Headquarters, Hickam AFB, Hawaii.

Data Description and
Validity

Sufficient data to conduct the analysis was obtained with considerable difficulty. Variables which were constructed from the data are defined and described below. Next is a discussion of the data which, for several reasons, was not obtained, and what impact the exclusion of this data would have on the results of the analysis.

Base-level corrosion control man-hours. This was chosen as the dependent variable. Historically, there have been problems in collecting this type of maintenance data. There are only two how-malfunctioned codes (AFM 66-1) which apply to corrosion maintenance: 170--corroded, mild to moderate, and 667--corroded, severe. Dr. Summitt and others have found, however, that when maintenance technicians document corrosion-caused damage, they either do not recognize it as such and code it on the AFTO Form 349 as some other how-malfunction code or they believe that corrosion was only a contributing factor, with the same result (20:9-10). Air Force Technical Order 1-1-2 cautions:

Corrosion is often ignored as the cause for the maintenance action; and when reported (AFM 66-1), another reason is often given for accomplishing the work. Many times the reason for such reporting is that corrosion is not an obvious factor to the mechanic performing the work. This can be attributed to a lack of training or the complexity of the process. Stress corrosion cracking and corrosion fatigue are two types of failure that are often improperly reported. It is often impossible to determine by visual examination the cause of the crack. It may be stress corrosion, corrosion fatigue, simple overload, improper heat treatment, or a combination of these causes. If corrosion is evident in the area of the crack, it is usually an accelerating factor, and the failure should be reported as corrosion [22:1-1].

An even more damaging practice in recording maintenance history on the AFTO Form 349 is the failure of the technician to look up the how-malfunction code. The technician instead enters the code for "general maintenance."

PACAFR 66-19 also addressed this problem:

Documentation of maintenance actions in corrosion prevention/control will be accurately coded as to what malfunctioned, how the malfunction occurred, when it was discovered, and how it was corrected. Proper reporting will assure adequate manning, equipping, training, and parts/materials procurement. Of primary concern is the use of how malfunction (How-Mal) codes 170, mild or moderate corrosion, and 667, severe corrosion. Any time equipment requires maintenance as a direct result of corrosion, code 170 or 667 will be used with work unit code of the item requiring treatment. For example, if a cannon plug is shorted because it is corroded, the How-Mal code for the discrepancy will be 170 (corroded), not 615 (shorted). In addition, personnel should guard against use of codes such as 230 (dirty), 117 (deteriorated), 306 (contamination), 520 (pitted), etc., when code 170/667 (corroded) more accurately describes the condition [25:4-5].

The problem of accurate documentation of maintenance history caused Dr. Summitt to use a number of How-Mal

codes to represent what he thought more accurately described the actual corrosion maintenance experienced at base level (20:9-10). For this research, the same collection of How-Mal codes were used and are tabulated in Table 3. Records for each PACAF F-4 for CY 1976 were screened and the summation of the man-hours expended under each of the How-Mal codes was used to represent total man-hours devoted at base-level to corrosion control. Despite the possibility that the data may not be 100 percent accurate, its validity was accepted subjectively until such time as the analysis of the results would suggest otherwise. Dr. Summitt believed . . .

Without question, this "corrosion" file contains some records which are not related to corrosion. Editing the file to remove them appears to be less important, however, than it did earlier in the study for several reasons. Except for the How-Mal "cracked", the number of such records has been found to be small (about 1%) when compared with the total. In the case of the "cracked" category, there is considerable reason to believe that corrosion is a factor in a majority of cases (i.e., stress corrosion cracking and corrosion fatigue). Further, the chronological pattern of the several How-Mal codes parallels fairly well that of those identified specifically as corrosion. Finally, we still are of the opinion that all categories selected are indeed corrosion related, even when non-metallic materials are involved [18:9-13].

Base-level corrosion inspection man-hours. This independent variable was obtained from the same data source used for base-level corrosion maintenance man-hours. The variable represents the total man-hours expended in work unit code (WUC) 2000, corrosion inspection (AFM 66-1). It was

Table 3

How-Malfunction Codes Selected to
Represent Total Base-Level
Corrosion Maintenance

How-Malfunctioned	Description
117	Deteriorated
170	Corroded, mild to moderate
190	Cracked
230	Dirty, contaminated or saturated by foreign material
520	Pitted
605	Crazed
617	Sulphidation
622	Wet, condensation
667	Corroded, severe
846	Delaminated
865	Protective coating, sealant missing
910	Chipped

difficult to predict what affect increased man-hours spent in corrosion inspection would have on total corrosion maintenance man-hours. It could be argued that with less inspection, less corrosion would be found, and less corrosion maintenance would be needed. On the other hand, more inspection would mean that corrosion would be found in its earlier stages when corrective maintenance would not require as many man-hours.

Age. A portion of the tail number of each aircraft designates the year of manufacture. A mid-year convention was used which considered the age of each aircraft as the difference between the middle of the year of manufacture and the middle of 1976, the year in which data for the dependent variable was accumulated. As an example, aircraft #63-00744 was manufactured in 1963. Its age was determined to be 13 years based on the difference between mid-1963 and mid-1976.

Airframe hours. Airframe hours is defined as the total flying hours logged on each aircraft as of 31 December 1976. This data was obtained from flight records maintained by the F-4 monitor at PACAF Headquarters.

Mission design series (MDS). Information concerning MDS was obtained from the aircraft historical records at PACAF Headquarters. The MDS for the four aircraft studied in

this analysis were F-4C, F-4D, F-4E, and RF-4C. Categorical (dummy) variables were used to encode this information in the data file. For example:

$X_a = 1$, if aircraft is an F-4C, 0 otherwise,

$X_b = 1$, if aircraft is an F-4D, 0 otherwise,

$X_c = 1$, if aircraft is an F-4E, 0 otherwise.

If X_a , X_b , and X_c are all zero, the aircraft is an RF-4C. Thus, the RF-4C is considered the basis and any coefficient associated with X_a , X_b , X_c denotes a difference in base-level corrosion man-hours due to the aircraft being other than an RF-4C. It was believed that differences would occur among MDS due to differences in mission profiles and alert requirements.

Months at the various bases. Aircraft historical records listed the base of assignment for each aircraft since the date of its assignment to PACAF. The number of months spent at each of the four F-4 bases and at bases in Thailand (F-4's are no longer stationed there) during the time frame CY 1974 to CY 1976 were included in the data file. The cumulative effects of being stationed at the various locations was expected to have an affect on total corrosion man-hours.

Current base of assignment. This variable was expected to explain any variance in maintenance procedures among bases. Categorical variables were again used with Clark AFB, P.I., being the base variable.

Time since last PDM. Major maintenance and Time Compliance Technical Order actions are often accomplished at periodic programmed depot maintenance (PDM). Table 4 shows the intervals specified for the four MDS used in the analysis. Extensive corrosion maintenance and painting is accomplished during PDM and it was believed that as time elapsed since the last PDM, corrosion would increase. Between FY 73 and FY 76, many aircraft received major contract corrosion control treatment between PDM overhauls. This work was accomplished at the Kadena AB facility in FY 74 and in Tainan, Taiwan, during FY 75 and FY 76. Since this also represented extensive corrosion control work, the date from either the last PDM or from the last contract corrosion control, whichever was later, was used as this predictor variable.

This information was obtained from manual records kept by the contract administrator in Taiwan. Based on interviews with the personnel responsible for tracking, the accuracy and validity of this data were judged to be excellent (7).

Table 4

PDM Cycle (In Months) For
F-4 Aircraft

MDS	FY 77	FY 78	FY 79
RF-4C	54	54	54
F-4C	30	36	36
F-4D	48	48	48
F-4E	36	36	36

[Source: TO 00-25-4]

PDM man-hours. This variable represents the number of man-hours expended on the aircraft during its last PDM. If the aircraft had gone through contract corrosion control since it left PDM last, a zero value was used. It was assumed that the more man-hours expended during PDM, the fewer hours would need to be spent on base-level corrosion control. Ideally, the PDM man-hours should be broken out as expended for corrosion or some other How-Mal code. This procedure was begun only recently (7). The data was obtained from manual records kept in Tainan, Taiwan.

Contract corrosion control (CCC) man-hours. This variable is similar to PDM man-hours except the hours in CCC were tabulated instead.

Corrosion severity factor (CF). This variable was obtained from the interim results of the PACER LIME project. The validity of these factors to predict the environmental effect on corrosion at each base is accepted subjectively due to the dependence on qualitative observation for its determination. This variable was expected to be highly correlated with the categorical variables representing current base of assignment. For this reason, these two variables, base of assignment and corrosion severity factor, were not entered into the program simultaneously. Each was entered separately with the other variables and the one which resulted in the higher explanatory model was chosen.

Description of Variables
Not Examined

The foregoing was a discussion of the variables which were used in the attempt to formulate the predictive model. Following is a discussion of variables which may have potential value as predictors of base-level corrosion man-hours, but for which current data could not be obtained.

Air pollution data. It has been shown that air pollution may have an effect on the rate of corrosion (15). The amounts of sulphur dioxide (SO_2) and hydrocarbons in the air are presently tracked by the Environmental Protection Agency (EPA) in many areas in the United States but, as

yet, no tracking of this data is accomplished in the Pacific areas considered in this study (6). Any future attempts to model corrosion experience should include some consideration for the effects of pollution.

Manning. A study in the prediction of base-level man-hours should take into consideration the manning levels at the various bases. For this study it was assumed that the manning levels were equal for each of the four bases; however, no data was available to confirm this. As historical data on manning in the various Air Force Specialty Codes (AFSC) is retained only six months, data for the time period of this analysis was not on hand (2).

Washing. Aircraft washing is an important facet of the base corrosion prevention program. The man-hours devoted to washing might be helpful in predicting corrosion man-hours. Intuitively, corrosion man-hours should decrease with a greater emphasis on the washing program (29:8-5). PACAFR 66-19 establishes washing intervals based on corrosion severity indices at each base. Unfortunately, these man-hours are not tracked at major command level and are available through the base-level inquiry system (BLIS) for the preceding six months only. The effect of not being able to include these variables in the analysis was expected to lower the explanatory power of the model.

Developing the Model

The research was an attempt to show that a significant linear relationship exists between total yearly base-level corrosion control man-hour expenditures and the predictor variables mentioned above. To accomplish this, a model was constructed using multiple linear regression (MLR).

Overview. Simple linear regression analysis is a tool by which it is possible to fit a curve, representing the behavior of the dependent variable, to data points which correspond to values of an independent variable. MLR is an extension of simple regression to take account of the effect of more than one independent variable on the dependent variable. The main reason for using MLR analysis is to reduce the bias that might result if an uncontrolled independent variable that affects the dependent variable were ignored (30:306).

The general form of the multiple regression model is:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + \dots + B_nX_n$$

where: Y = base-level corrosion control man-hours per aircraft,

X_i = parameters based on aircraft historical data, maintenance data, CFs, etc., and

B_i = the coefficients of regression.

Assumptions. The following assumptions are needed to justify using MLR to fit the curve (regression line) to the independent data points.

1. The error terms which are the vertical distance between each data point and the regression line, are statistically independent.
2. The expected value of these error terms is zero measured with respect to the regression line.
3. The variation of the error terms is constant for each independent variable X.
4. The error terms are distributed normally about the regression line.
5. The number of sample observations is greater than the number of estimated population parameters.
6. Sample observations must be linearly independent.
7. The values of the independent variables are measured without error, that is to say, all measurement error is associated with the dependent variable (11).

Manipulating the Model

A computer program, the Statistical Package for the Social Sciences, commonly known as SPSS, was available for use in constructing the model through MLR analysis. The subprogram regression was used which computes a sequence of linear regression equations in a stepwise manner. At each step, the independent variable is included which contributes most to that portion of the variance in the dependent variable which is explained by the model. This procedure is called forward inclusion (16:345).

Design to Meet Objectives

The objectives of the research were to (1) determine whether a linear relationship of base-level corrosion man-hour expenditures exists with the independent variables associated with aircraft historical data, maintenance data, and corrosion severity factors, (2) develop a predictive model if a linear relationship exists, and (3) identify the independent variables whose net or marginal contributions to explained variation are significant. A classical hypothesis test was performed to show that a relationship exists between the dependent variable, Y , and the independent variables, X_i .

$$H_0: B_1 = B_2 = B_3 = \dots = B_n = 0$$

$$H_1: \text{at least one } B_i \neq 0$$

The hypothesis was tested using the statistical F test. This test compared the F statistic found using:

$$F_{\text{regression}} = \frac{\text{variation explained by regression}}{\text{unexplained variation}}$$

with an F statistic found in the standard statistical tables. This latter value, called F_{critical} , must be absolutely less than $F_{\text{regression}}$ in order to reject H_0 and conclude a statistically significant relationship exists between the dependent and independent variables. The criteria used to determine statistical significance will be a 95 percent level of confidence in the result. This level of confidence is commonly used in statistical analysis

and is specified in AFM 25-5 for use in the Air Force management engineering policies and procedures for developing manpower standards and conducting management advisory studies (26:i). If the overall model is found to be significant, each regression coefficient, B_i , remaining in the model will be tested at the 95 percent level to see if it significantly adds to the explanatory power of the model. This test, also using the statistical F-test, is conducted on the following hypothesis:

$$H_0: B_i = 0$$

$$H_1: B_i \neq 0$$

$$F_{\text{statistic}} = \left[\frac{B_i}{S_{B_i}} \right]^2 = \left[\frac{B_i}{\text{standard error of } B_i} \right]^2$$

To reject the null hypothesis, H_0 , the $F_{\text{statistic}}$ value must be absolutely greater than the F_{critical} value found in the statistical tables for a 95 percent confidence level. Should any regression coefficients prove insignificant under this test, they will be considered for deletion in order to simplify the model. Care will be taken to account for multicollinearity, explanatory power held in common between two or more variables, before eliminating any variable from the model (11).

The criteria used to evaluate the predictive power of the model concerns a subjective test on the coefficient of multiple determination (R^2). This coefficient is calculated as part of the SPSS output and is equal to:

$$R^2 = \frac{\text{variation explained by regression}}{\text{total variation}}$$

An R^2 of .50 is described as a minimum level useful for management engineering program purposes and was used in this effort as a minimum, also (26:6-13).

Assumptions

1. Maintenance data is compiled accurately and within AF regulations.
2. Multiple linear regression techniques, with the underlying assumptions, are appropriate for constructing the model (1:1-17; 30:263-323).
3. Current corrosion man-hour totals represent that which would be required to maintain the F-4 fleet in adequate condition to perform its mission.

Limitations

The model developed will be a preliminary model for predicting future corrosion control man-hour expenditures for the air bases included in the sample. Inferences to an enlarged or similar population must be based on subjective evaluation of the respective situation. Additional research toward a finalized model should be performed when PACAFR 66-19 has been fully implemented and documentation difficulties have been overcome.

Chapter 3

ANALYSIS AND RESULTS

Introduction

It should be noted that the results of any analysis are only as valid as the data used. Predictions based on data collected from the AFM 66-1 system should be judged critically in the light of known inaccuracies in documentation. Since steps have been initiated to improve documentation procedures in PACAF, future predictive models based on such data should be quite reliable.

The analysis of PACAF corrosion man-hours required numerous computer runs in which particular variables were inserted and deleted in an effort to arrive at a model with the greatest explanatory power. What follows is an analysis of four computer runs which showed the most interaction between base-level corrosion man-hours and the selected predictor variables.

Analysis of First Regression

The first model regressed base-level corrosion control man-hours with the selected variables shown in Table 5. The results are tabulated in Table 6. X_{OS} , the number of months spent at Osan between CY 74 and CY 76 was

Table 5
Variables Used in the
First Regression

Variables		
Dependent	Independent	Description
X_{13}		Total base-level CC man-hours
	X_{AG}	Aircraft age (yrs)
	X_T	Time since last PDM (months)
	X_{PDM}	Man-hours in last PDM
	X_{CR}	Man-hours in last contract CC
	X_{AF}	Aircraft airframe hours
	X_{C2}	Inspection man-hours
	X_{D1}	Dummy variable--F-4C
	X_{D2}	Dummy variable--F-4D
	X_{D3}	Dummy variable--F-4E
	X_{KU}	Months in Kunsan
	X_{OS}	Months in Osan
	X_{CL}	Months in Clark
	X_{KA}	Months in Kadena
	X_{TH}	Months in Thailand

Table 6

Results of the First
Regression

Variable	Coefficient	Std Error	F-Statistic	Significance
XKA	10.25509	1.05128	4.856	.95+
XD3	144.79595	85.69602	2.855	.90+
XTH	4.21500	.28710	4.045	.95+
XT	2.98142	1.65717	3.237	.90+
XCR	-0.01892	0.01246	2.306	.90-
XAG	-14.63856	19.64837	0.555	None
XPDM	-0.00327	0.00408	0.642	None
XAF	-0.01111	.02361	0.221	None
XCL	1.62550	2.50658	0.421	None
XKU	2.64166	3.61800	0.533	None
XD5	111.89124	144.11895	0.603	None
XD4	61.84254	93.29672	0.439	None
XC2	.34267	1.77012	0.037	None

CONSTANT TERM: 100.84490 $R^2 = .61271$ F-STATISTIC = 8.03175

DEGREES OF FREEDOM: UPPER: 13 LOWER: 66 STD ERROR: 90.86399

OVERALL REGRESSION SIGNIFICANT AT THE .001 LEVEL

the only variable unable to meet the regression program's minimum F-level to enter the equation. This model gave the highest R^2 of the many combinations tested. The statistical test of the significance of the overall regression (R^2) showed a .999 confidence that a linear relationship exists between C_{13} , the dependent variable representing total yearly base-level corrosion man-hours, and the selected independent variables shown in Table 5. Table 6 shows that not all of the independent variables are statistically significant in helping to explain variation in corrosion control man-hours. Thus, some refinements in this model were attempted with the following results.

Analysis of the Second Regression

Before any nonsignificant variables were deleted from the equation, dummy variables corresponding to current base of assignment were substituted for X_{KU} , X_{CL} , X_{OS} , X_{KA} , and X_{TH} , the variables representing the location of the aircraft between CY 74 and CY 76. This was done because historical record keeping could be eased if this substitution showed an acceptable R^2 . When using regression analysis, tradeoffs must often be made between explanatory power and costs for obtaining data. The results of this model appear in Table 7.

X_{D5} , the dummy variable representing the F-4E MDS and X_{B2} , the dummy variable representing Kadena AB as the

Table 7

Results of the Second
Regression

Variable	Coefficient	Std Error	F-Statistic	Significance
X _{D3}	148.83552	82.91756	3.222	.90+
X _{B1}	140.15576	35.08529	15.958	.9999+
X _{AG}	-16.22164	18.21521	0.793	None
X _{CR}	-0.02548	0.01173	4.721	.95+
X _{B3}	-91.75222	44.12392	4.324	.95+
X _{D4}	-75.67905	37.23832	4.130	.95+
X _T	2.63491	1.61014	2.678	.90-
X _{PDM}	-0.00442	0.00392	1.266	None
X _{C2}	0.94032	1.80337	0.272	None
X _{AF}	-0.00382	0.02273	0.028	None

CONSTANT TERM: 333.60061 $R^2 = .60352$ F-STATISTIC = 10.50296

DEGREES OF FREEDOM: UPPER: 10 LOWER: 69 STD ERROR: 89.91484

OVERALL REGRESSION SIGNIFICANT AT THE .001 LEVEL

current base of assignment, were not able to enter the equation due to failure to meet the minimum regression program F-level test. There was a small decrease in the explanatory power of the model, from .61271 to .60352. This decrease was considered a small tradeoff to make in return for simplifying the model. The new R^2 was also shown to be significant with a confidence in excess of 99.9%. Further simplification of the model was attempted by eliminating some of the independent variables shown to be insignificant in contributing to the explanatory power of the model. The results are described in the section which follows.

Analysis of the Third Regression

X_{AG} , X_{AF} , and X_{C2} were eliminated from the model because they were shown in Table 7 to be nonsignificant in explaining variation in base-level corrosion man-hours. X_{PDM} , man-hours in last PDM, was also shown to be nonsignificant but was allowed to remain in the model for the following reason. Since July 1976, the PDM package which is performed on F-4's in Tainan includes what was previously the midphase contract corrosion control package. Since some of the aircraft have had contract corrosion control last while others have had PDM last, it was believed that one should not be eliminated without the other. Technically,

X_T , time since last PDM or CCC, was not significant either; however, its F-statistic was very close to F-critical at a 90% level of confidence so a subjective determination was made to let it remain in the model.

The results of the third regression are shown in Table 8. Again X_{B2} could not meet the required F-level for admission to the model. The simplified model resulting from the third regression showed a further small decrease in explanatory power. The loss in R^2 of only 0.00665 was considered inconsequential when compared with the advantages gained by reducing the model by three variables. A final attempt was made to simplify the model still further in the fourth regression.

Analysis of the Fourth Regression

In this regression model, X_{PDM} and X_{CR} were eliminated. X_{CR} , man-hours in last contract corrosion control, has been a statistically significant variable up to this point and to delete it from the model requires a conscious decision on the part of the analyst. Had PDM man-hours been broken down into two categories, man-hours devoted to corrosion repair and man-hours devoted to other maintenance overhaul work (TCTOs, modifications, etc), the portion devoted to corrosion would correspond roughly to the man-hours spent in contract corrosion control. Under these circumstances, PDM man-hours, like CCC man-hours, may have

Table 8

Results of the Third
Regression

Variable	Coefficient	Std Error	F-Statistic	Significance
X _{D3}	94.74612	48.72332	3.781	.90+
X _{B1}	127.78990	29.71944	18.489	.999+
X _{D4}	-89.29553	41.21869	4.693	.95+
X _{CR}	-0.02690	0.01197	5.046	.95+
X _{B3}	-87.37285	42.72811	4.181	.95+
X _T	2.91633	1.56222	3.485	.90+
X _{PDM}	-0.00481	0.00395	1.479	None
X _{D5}	19.32659	54.53795	0.126	None

CONSTANT TERM: 189.41722 $R^2 = .59487$ F-STATISTIC = 13.03147

DEGREES OF FREEDOM: UPPER: 8 LOWER: 71 STD ERROR: 89.60076

OVERALL REGRESSION SIGNIFICANT AT THE .001 LEVEL

proved to be statistically significant in explaining base-level corrosion man-hours. In any case, man-hours spent on corrosion control at a contractor's facility are difficult to document and track accurately. Therefore, another judgement was made to eliminate X_{PDM} and X_{CR} from the analysis to determine what effect this action would have on the explanatory ability of the model. The results of this fourth regression appear in Table 9. X_{D5} once again did not enter the model. The R^2 value suffered a loss of about 4 percent. This model represents a simple predictive equation which, based on the available data, would be useful to explain approximately 55 percent of the variation in base-level corrosion maintenance man-hours. This model, run with a variable representing the corrosion index instead of the dummy variables corresponding to the base of assignment, was not as powerful in explaining variation.

Multicollinearity

In an MLR model involving two or more independent variables, inner-correlation may exist between and among variables. The effect of such inner-correlation is to reduce the ability to account for the explanatory power as owing to the presence of particular independent variables in the model. This phenomenon is called multicollinearity (11). One method to observe the extent of the multicollinearity problem as it may exist in a regression

Table 9

Results of the Fourth
Regression

Variable	Coefficient	Std Error	F-Statistic	Significance
X_{D3}	102.54949	48.58901	4.454	.95+
X_{B1}	129.13076	46.35076	7.761	.99+
X_{D4}	-97.95907	42.00776	5.438	.95+
X_{B3}	-81.01608	44.01979	3.387	.90+
X_T	2.39477	1.59866	2.244	.90-
X_{B2}	15.53650	54.48587	0.081	None

CONSTANT TERM: 138.28030 $R^2 = .55643$ F-STATISTIC = 15.26227
 DEGREES OF FREEDOM: UPPER: 6 LOWER: 73 STD ERROR: 92.46190
 OVERALL REGRESSION SIGNIFICANT AT THE .001 LEVEL

model is to examine the correlation matrix of the independent variables. Table 10 shows this matrix, called the Pearson correlation matrix, the output of the Pearson Corr subprogram. Each entry in the matrix is the Pearson correlation coefficient (product-moment), r , and indicates the strength of the linear relationship between each pair of variables. "Its usefulness derives from the fact that r^2 is a measure of the proportion of variance in one variable "explained" by the other [16:279]."

From Table 10, it can be seen that the only two variables which exhibit a strong linear relationship with each other are X_{PDM} , PDM man-hours, and X_{CR} , contract corrosion control man-hours. This can be expected because PDM includes the same corrosion maintenance package previously performed during contract corrosion control as mentioned previously. Since contract corrosion control no longer exists as a separate entity, this problem will not hinder future corrosion prediction models.

Standard Error of the Estimate

The principal objective of most regression analysis applications is the derivation of a mathematical expression with which to predict values for a dependent variable for specified values of the independent variables. The prediction of these values of the dependent variable is

Table 10
Pearson Correlation Matrix for
Selected Variables

Variable	X _{C2}	X _{AG}	X _{AF}	X _T	X _{PDM}	X _{CR}
X _{C2}	1.00	-.2284	-.1182	-.0704	.3209	-.1634
X _{AG}		1.00	.3648	.0516	-.3604	.1064
X _{AF}			1.00	-.0276	.0432	-.1028
X _T				1.00	-.0956	.1051
X _{PDM}					1.00	-.8168
X _{CR}						1.00

subject to two types of errors. The first occurs when a less than perfect relationship exists among the variables. This type of error would likely exist even if all the universe data were considered. Its order of magnitude is suggested by the value of the coefficient of determination, R^2 .

The second source of prediction error is sampling, for the estimators, X_i , are subject to sampling error (4:540). From Tables 6, 7, 8, and 9, it can be seen that previous concern about the accuracy of some of the data has been justified. All four regression models result in relatively high standard errors. For this reason, the utility of these models for the purpose of prediction is doubtful. Appendix C gives a better indication of the extent of this problem. It tabulates predicted and actual values for the dependent variable along with providing a scattergram for each regression. The scattergram shows the amount of dispersion which the actual values of the dependent variable have about the regression line.

Chapter 4

CONCLUSIONS AND RECOMMENDATIONS

Introduction

The objectives of this research were to: (1) establish whether a linear relationship exists between base-level corrosion control man-hours and selected independent variables; (2) construct a model which could be used to predict yearly base-level maintenance man-hours devoted to corrosion control; and (3) identify the variables whose net or marginal contributions to the explanatory power of the model were significant. This final chapter discusses how successful the analysis was in meeting the objectives and makes recommendations for future research in this area.

Meeting the Objectives

Within the confines of the data which were available, the objectives of this research were attained. The first objective was to show if a linear relationship exists between the dependent variable, base-level corrosion control man-hours, and the independent variables selected for the analysis. The hypothesis tested to meet this objective was:

$H_0: R^2 = 0$ which is equivalent to

$$B_1 = B_2 = B_3 = \dots = B_i = 0$$

$H_1: R^2 \neq 0$ which is equivalent to

at least one $B_i \neq 0$.

In Chapter 3, it was shown that the F-statistic was great enough in each regression to express with 99.9 percent confidence that the null hypothesis can be rejected and the conclusion drawn that a statistically significant linear relationship exists between base-level corrosion man-hours and selected predictor variables used in the regression.

The second objective was to construct a model which could be useful in predicting base-level corrosion maintenance man-hours. Numerous models were analyzed with R^2 , a measure of the explanatory power of the model, between .55 and .61 in most cases. While the derived values of R^2 are not as high as may be desired, they exceed the minimum value specified in AFM 25-5 for use in the Air Force Management Engineering Program. While the models discussed in Chapter 3 could possibly be used to predict expected man-hour expenditures in F-4 corrosion maintenance at the four PACAF bases studied, they would be better used as preliminary models only, with refinements being made in the future when current attempts to bring the corrosion problem under control are fruitful.

The final objective involved identifying the predictor variables whose net or marginal contributions to

the explanatory power of the model have been shown to be statistically significant. The hypothesis test to show significance was:

$$H_0: B_i = 0$$

$$H_1: B_i \neq 0.$$

A brief discussion of each significant variable follows.

Base. Two of the dummy variables representing the various air bases studied proved to be significant. Clark AB, P.I. was chosen as the base variable and the coefficients of X_{B1} , X_{B2} , and X_{B3} represent man-hours above or below that experienced at Clark by virtue of that aircraft being assigned elsewhere. The results of the analysis show that we are more than 95 percent confident that the net or marginal contribution to explained variation of X_{B1} , Kadena as a base of assignment, is significantly different than zero. The coefficient associated with X_{B1} , 129.13076, means that the expected value of yearly corrosion man-hours for any F-4 assigned to Kadena is about 129 man-hours higher than at Clark. By the same reasoning, corrosion man-hours at Osan AB, Korea, is expected to be about 81 man-hours per year less than that expended at Clark, although we are only 90 percent confident of its significance. The coefficient of X_{B2} was shown to be not significantly different than zero; therefore, it can be concluded that corrosion man-hours are approximately the same at Kunsan

and Clark. The corrosion severity indices for the four PACAF bases under study show Kunsan and Kadena as having the most severe corrosion environment and Osan the least severe which tend to support our findings.

Mission design series. X_{D3} and X_{D4} , dummy variables representing the F-4C and F-4D MDS, were found to have net or marginal contributions significantly different from zero at a 95 percent confidence level. The base-level for this series of dummy variables was the RF-4C. An F-4C, by virtue of its MDS and regardless of any other factor, would be expected to require 102.54949 more man-hours of corrosion maintenance per year than the RF-4C. The F-4D should require 97.95907 man-hours less than the RF-4C for corrosion maintenance. X_{D5} , the F-4E MDS, was shown to have an insignificant net or marginal contribution to explained variation, and therefore, is believed to require approximately the same number of man-hours per year as the RF-4C at base-level for corrosion maintenance.

Man-hours in contract corrosion control. X_{CR} was shown to have a significant net or marginal contribution to the explanatory power of the model at the 95 percent level of confidence. The value of the coefficient of this variable was -0.02690 which means that for an additional 1000

man-hours devoted to corrosion maintenance and prevention at the contractor's facility, about 27 man-hours a year are saved at base level.

Time since last PDM. X_T , the time in months since the last major corrosion rework at either PDM or CCC, was shown to be significant at the 90 percent level in 2 of the 4 regressions. An analysis of its coefficient suggests that for each month that passes since major corrosion rework, yearly base-level corrosion man-hours increases approximately 3 man-hours.

These predictor variables have been identified by this study to be significant in predicting corrosion experience at the base level. Future study in this area should include an analysis of their effects in any proposed model.

Conclusions

The degree of confidence in the results of this study must be tempered with the realization that some of the data may be imprecise due to deficiencies in methods of documentation and collection. Nevertheless, the conclusion can be drawn that multiple regression analysis is a proper tool to use in constructing predictive models of the corrosion experienced at the base-level. Predictive models like these are useful to the manager in forecasting future needs in such areas as facilities, training, and

manning. Failure to manage these areas effectively has resulted in a serious corrosion problem in the PACAF F-4 fleet. With the implementation of PACAFR 66-19, more precise models can be formulated in the future to help manage the corrosion prevention and control effort more effectively.

Recommendations for Further Research

After the problems of data validity have been overcome, additional research in the area of corrosion prediction will likely yield fruitful results. A follow-on study similar to this one should be accomplished by 1979 using data from 1978. By this time frame, much of the imprecision in documentation should have been overcome. In addition, the variables mentioned in Chapter 2, which were not part of this analysis but which appear to be useful factors related to corrosion man-hours, could be incorporated into the analysis. These efforts should result in a regression model which fits the data with an R^2 much better than .55 or .61.

Should the additional efforts fail to find a model of sufficient explanatory power, some nonlinear form of regression should be attempted. Various subprograms for nonlinear regression are readily available and can provide the analyst with the necessary tools for developing the appropriate predictive model.

APPENDICES

APPENDIX A
COMPUTER PROGRAM

```

001##S,R(SL) :,8,16;;;,16
010$:IDENT:WP1191,AFIT/SLG HARRINGTON&-TEOMY
025$:SELECT:SPSS/BIGSPSS
101ORUN NAME;THESIS,REGRESSION
1020VARIABLE LIST;BASE,DEGEM,YEAR,KU,OS,CL,KA,TH,T,PDM,CR
1025;AF,C1,C2,C3
1030VAR LABELS;BASE,BASE/
1035;DEGEM,TYPE/
1040;YEAR,AGE/
1042;KU,KUNSAN/
1045;OS,OSAN/
1046;CL,CLARK/
1047;KA,KADENA/
1048;TH,THILAND/
1049;T,TIME SINCE LAST PDM/
1050;PDM,MHRS IN PDM/
1051;CR,MHRS IN COR. COMT./
1052;AF,AIRFRAME HOURS/
1053;C1,MHRS IN CORR 170+677/
1054;C2,INSPECTION TIME 04141/
1055;C3,MHRS TOTAL
1057INPUT FORMAT;FREEFIELD
1060INPUT MEDIUM;CARD
1070N OF CASES;80
1075COMPUTE;C13=C1+C3
1080COMPUTE;C123=C1+C2+C3
1085COMPUTE;AG=YEAR-1
1090IF;(DEGEM EQ 3)D3=1
1100IF;(DEGEM EQ 4)D4=1
1110IF;(DEGEM EQ 5)D5=1
1112IF;(BASE EQ 1)B1=1
1113IF;(BASE EQ 2)B2=1
1114IF;(BASE EQ 3)B3=1
1120REGRESSION;VARIABLES=D3,D4,D5,KU,OS,CL,KA,TH,T,PDM,CR
1121;AF,C1,C2,C13,B1,B2,B3,AG/
1140;REGRESSION=C13 WITH D3,D4,D5,B1,B2,B3,T
1141;C2,AF(1) RESID=0
1150STATISTICS;2,4,6
1160READ INPUT DATA
1170$:SELECTA:TH12
1190FINISH
9999$:ENDJOB

```


APPENDIX B
INPUT DATA FILE

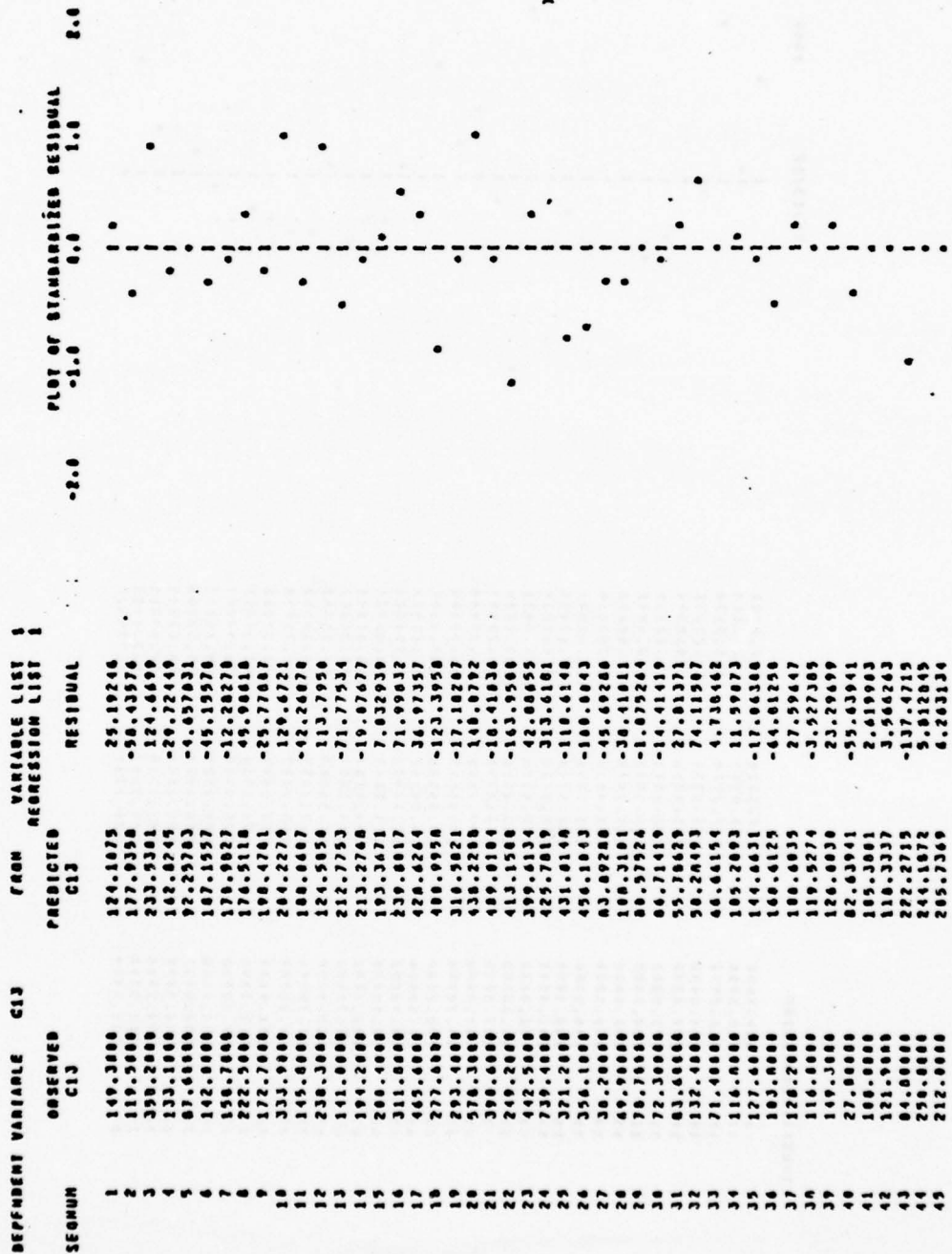
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020	2	4	11	27	0	9	0	0	23	9720	0	3445	.5	22.0	69.4
030	2	4	11	27	0	9	0	0	14	9624	0	3465	2.3	19.1	76.4
040	2	4	11	27	0	9	0	0	17	9560	0	3468	1.9	10.4	70.4
050	2	4	11	27	0	9	0	0	9	11357	0	3573	.5	10.3	83.1
060	2	4	11	27	0	9	0	0	10	16579	0	2604	18.2	27.3	114.2
070	2	4	11	27	0	9	0	0	11	9508	0	3675	2.3	10.3	69.1
080	2	4	11	27	0	9	0	0	19	9762	0	2808	.8	27.5	116.0
090	2	4	11	19	0	1	0	16	26	10830	0	3399	8.9	13.9	118.7
100	2	4	11	19	0	1	0	16	30	9933	0	3227	6.0	34.9	97.8
110	2	4	11	19	0	0	0	17	12	9864	0	4267	3.5	18.5	124.7
120	2	4	11	19	0	0	0	17	15	9549	0	3773	17.4	28.6	98.6
130	2	4	11	19	0	0	0	17	16	9637	0	3337	6.3	25.5	142.5
140	2	4	11	20	0	0	0	16	6	10148	0	3916	1.5	14.2	25.5
150	2	4	11	20	0	0	0	16	25	0	3607	3802	12.1	13.9	95.9
160	2	4	11	27	0	9	0	0	24	10667	0	2295	12.4	14.3	109.5
170	3	5	11	1	27	2	0	6	8	0	4435	2683	2.2	33.1	52.5
180	3	5	10	1	27	2	0	6	13	16357	0	4044	13.9	28.6	181.8
190	3	5	10	1	27	2	0	6	9	9473	0	3790	.5	29.7	80.0
200	3	5	10	1	27	2	0	6	15	16924	0	2702	9.8	32.3	80.2
210	3	5	9	1	27	2	0	6	16	11957	0	2744	5.3	28.7	53.8
220	3	5	8	1	27	2	0	6	26	12274	0	2313	2.5	5.2	104.1
230	3	5	8	1	27	2	0	6	18	12428	0	2077	1.0	37.0	64.7
240	1	4	11	18	0	0	6	12	21	0	4357	3061	13.0	5.8	136.3
250	1	4	11	9	0	14	13	0	20	0	2398	3206	12.3	9.2	107.2
260	1	4	11	0	0	0	13	23	18	8991	0	3570	42.9	6.9	315.3
270	1	4	11	23	0	0	13	0	12	0	2694	3171	8.5	8.4	124.6
280	1	4	11	14	0	0	6	16	6	0	4288	2790	2.0	12.4	85.6
290	1	4	11	0	0	17	13	6	19	9526	0	3868	14.9	6.1	127.1
300	1	4	11	14	0	9	13	0	28	0	4321	3056	44.7	5.8	114
310	1	4	11	14	0	9	13	0	18	12484	0	3526	83.3	4.7	139.2
320	1	4	11	17	0	0	13	6	17	0	2341	2588	11.2	3.0	161.5
330	1	4	11	6	0	0	13	17	11	9970	0	3111	121.7	4.3	212.2
340	1	4	11	14	0	9	13	0	31	0	3997	2996	66.0	9.7	79.8
350	1	4	11	0	0	12	13	11	7	0	4262	3031	34.0	7.2	204.3
360	1	4	11	0	0	0	13	23	6	7053	0	2742	37.4	5.4	103.6
370	1	4	11	0	0	0	13	23	9	9851	0	2771	34.4	8.4	159.8
380	1	4	11	0	0	6	13	17	27	0	4159	3820	52.8	8.7	147.6
390	1	4	11	14	0	2	13	7	31	9577	0	3731	167.0	2.3	144.3
400	1	3	14	0	0	0	36	0	20	6355	0	3448	311.5	10.4	154.1
410	1	3	14	0	0	0	36	0	20	0	2902	2869	58.8	10.6	218.3
420	1	3	14	0	0	0	36	0	9	0	5507	3529	72.3	7.7	221.1
430	1	3	14	0	0	0	36	0	24	6114	0	3738	387.6	10.7	190.7
440	1	3	14	0	0	0	36	0	30	0	3843	3247	35.4	11.2	355.2
450	1	3	14	0	0	0	36	0	11	3109	0	3486	79.3	13.8	169.9
460	1	3	14	0	0	0	36	0	9	6704	0	3267	255.2	18.9	187.3
470	1	3	14	0	0	0	36	0	15	4364	0	2976	557.7	11.3	181.7
480	1	3	13	0	0	0	36	0	12	4096	0	3083	45.1	13.2	276.1

490	1	3	13	0	0	0	36	0	23	6822	0	2960	147.0	10.4	209.1
500	1	4	12	6	0	0	18	12	16	0	2461	2392	10.0	1.7	74.8
510	1	4	12	6	0	0	18	12	20	9909	0	3416	19.3	6.5	230.2
520	1	4	12	6	0	0	18	12	7	10517	0	3490	48.8	15.6	163.2
530	1	4	12	6	0	0	18	12	11	9606	0	3445	85.3	3.9	254.1
540	1	4	11	0	0	0	18	18	13	0	2285	4023	43.6	6.9	201.7
550	1	4	11	6	0	0	18	12	16	0	2850	3174	128.9	6.3	287.4
560	1	4	11	0	0	0	18	18	17	9197	0	3566	47.9	11.9	196.7
570	1	4	11	0	0	0	18	18	11	9981	0	3791	29.7	2.3	205.1
580	1	4	11	6	0	0	18	12	10	9926	0	3091	33.5	5.1	138.5
590	1	4	11	0	0	0	18	18	7	10104	0	2913	13.9	5.7	120.2
600	1	4	11	0	0	0	18	18	23	0	3115	3091	14.2	9.5	163.6
610	1	4	11	6	0	0	18	12	14	9330	0	3091	22.0	23.9	227.1
620	1	4	11	0	0	0	18	18	14	0	2319	4097	23.7	5.9	122.8
630	1	1	11	0	0	0	36	0	13	11394	0	4320	38.6	10.0	204.8
640	1	1	11	0	0	0	36	0	11	10233	0	4153	97.9	6.3	183.5
650	1	1	11	0	0	0	36	0	13	10053	0	3096	97.3	14.2	408.7
660	1	1	11	0	0	0	36	0	10	12988	0	2944	7.2	5.2	41.7
670	1	1	9	0	0	0	36	0	7	0	3562	2703	48.2	7.2	209.4
680	1	1	9	0	0	0	36	0	16	5143	0	2370	219.5	5.2	215.3
690	4	5	11	0	0	13	0	23	8	0	4506	3219	13.9	30.1	101.5
700	4	5	10	0	0	13	0	23	15	16875	0	4464	12.9	24.2	64.3
710	4	5	10	0	0	13	0	23	11	0	2352	3323	13.0	18.6	81.1
720	4	5	10	0	0	13	0	23	18	18034	0	4377	18.9	14.2	83.0
730	4	5	10	0	0	13	0	23	12	16769	0	2879	10.0	18.0	102.1
740	4	5	10	0	0	13	0	23	9	17031	0	3604	19.2	17.0	69.3
750	4	5	9	0	0	13	0	23	11	12242	0	3464	18.3	7.2	136.4
760	4	5	9	0	0	13	0	23	18	12219	0	2731	47.2	28.9	185.3
770	4	5	9	0	0	13	0	23	6	5335	0	2706	9.0	17.6	229.8
780	4	5	8	0	0	13	0	23	29	14603	0	2319	5.3	10.1	298.9
790	4	5	8	0	0	13	0	23	17	0	4553	2465	23.3	14.8	279.3
800	4	5	6	0	0	13	0	23	11	16327	0	1092	8.6	19.0	223.4

APPENDIX C

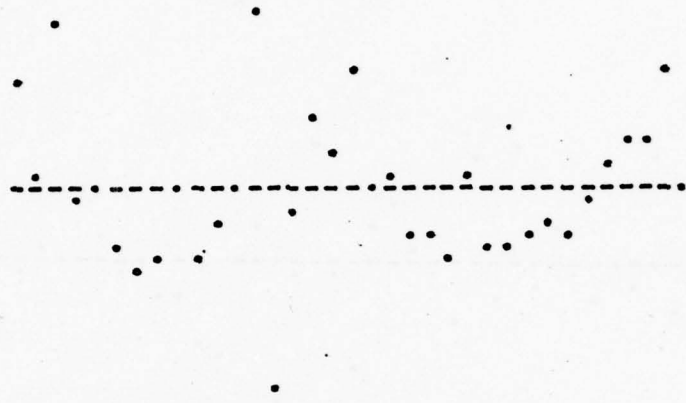
COMPARISON OF OBSERVED VS PREDICTED VALUES
OF THE DEPENDENT VARIABLE, PLOT OF
STANDARDIZED RESIDUALS, AND
SCATTERGRAMS OF THE
FOUR REGRESSIONS

REGRESSION #1



REGRESSION #1

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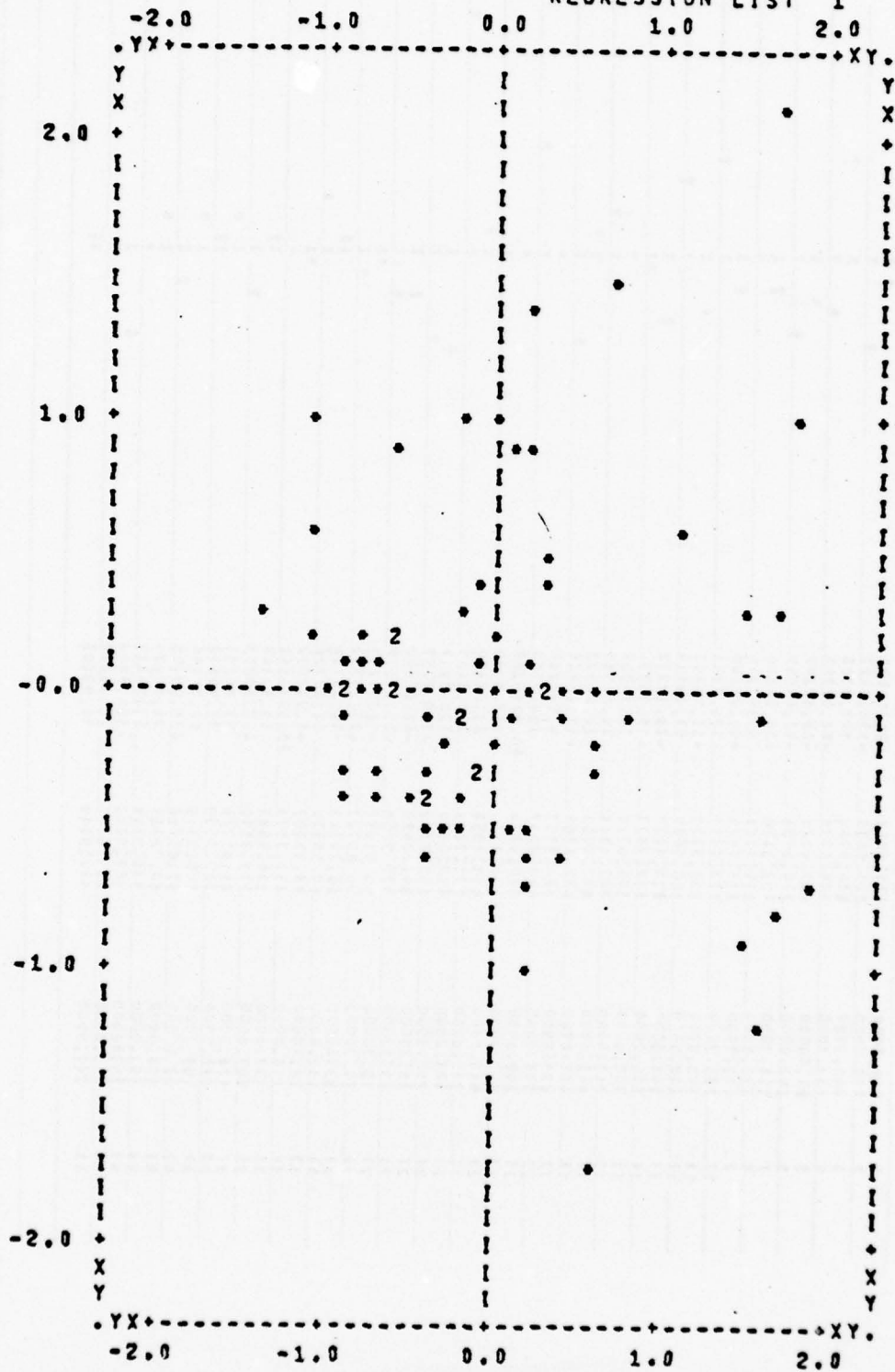


THESIS, REGRESSION

46	339.4000	217.1319	125.2401
47	245.3000	229.9319	15.34814
48	416.3000	227.9924	100.3074
49	244.0000	201.0334	-17.23325
50	234.8000	235.5916	-0.7910346
51	172.0000	232.0071	-60.00715
52	134.1000	234.1042	-106.0042
53	177.0000	255.3028	-77.50494
54	249.1000	252.4038	-3.303024
55	146.5000	231.1251	-64.62500
56	243.4000	206.9746	-37.17444
57	201.4000	276.9400	2.400020
58	506.0000	299.0979	206.0021
59	40.90000	200.0610	-231.1610
60	257.0000	270.8251	-21.22509
61	434.0000	353.7005	01.89940
62	54.70000	10.09092	35.70100
63	195.7000	60.60100	135.0101
64	80.50000	76.80247	4.417577
65	90.00000	62.77923	7.224674
66	55.10000	114.7643	-55.66434
67	106.4000	154.9164	-40.31644
68	65.70000	144.0007	-70.30067
69	115.4000	97.54603	17.85397
70	77.20000	147.3055	-70.10552
71	94.10000	156.0102	-62.71025
72	101.9000	150.0001	-40.10000
73	112.1000	154.1936	-42.09361
74	05.00000	135.9940	-46.09402
75	154.7000	170.4521	-15.75214
76	232.5000	200.9774	25.52244
77	230.0000	190.1146	40.00546
78	304.2000	244.7519	59.44014
79	302.6000	176.5597	132.0403
80	232.0000	270.7701	2.32077

DEPENDENT VARIABLE C13

VARIABLE LIST 1
REGRESSION LIST 1



REGRESSION #2

DEPENDENT VARIABLE C13		FROM VARIABLE LIST REGRESSION LIST 1		PLOT OF STANDARDIZED RESIDUAL				
SECURE	OBSERVED C13	PREDICTED C13	RESIDUAL	-2.0	+1.0	0.0	1.0	2.0
1	149.3000	173.9443	-24.6443					
2	149.5000	123.8632	25.6368					
3	158.2000	136.4284	21.7716					
4	131.1000	154.6238	-23.5238					
5	87.6000	143.4225	-55.8225					
6	162.0000	134.8106	27.1894					
7	151.7000	193.3270	-41.6270					
8	222.5000	119.1044	103.3956					
9	172.7000	113.9428	58.7572					
10	131.9000	112.9117	19.9883					
11	165.8000	113.3827	52.4173					
12	238.3000	160.9089	77.3911					
13	141.0000	115.1227	25.8773					
14	198.2000	113.1821	85.0179					
15	208.4000	194.6258	13.7742					
16	111.8000	143.1348	-31.3348					
17	165.6000	132.9463	32.6537					
18	271.6000	189.4768	82.1232					
19	291.4000	188.8747	102.5253					
20	178.3000	163.7237	14.5763					
21	390.6000	390.9718	-0.3718					
22	249.2000	426.4174	-177.2174					
23	442.5000	111.1051	331.3949					
24	138.4000	131.2119	7.1881					
25	211.2000	142.0419	69.1581					
26	156.1000	156.8759	-0.7759					
27	182.0000	18.3289	163.6711					
28	429.0000	120.9058	308.0942					
29	182.7000	94.6121	88.0879					
30	122.0000	94.6072	27.3928					
31	83.6000	65.9143	17.6857					
32	132.4000	14.5627	117.8373					
33	114.0000	18.3420	95.6580					
34	116.8000	117.7813	-0.9813					
35	127.6000	116.4683	11.1317					
36	103.8000	151.3310	-47.5310					
37	121.2000	94.8226	26.3774					
38	118.0000	102.3530	15.6470					
39	149.3000	106.5318	42.7682					
40	27.0000	12.0814	14.9186					
41	108.0000	16.2216	91.7784					
42	121.9000	116.5180	5.3820					
43	14.8000	189.6442	-174.8442					
44	230.0000	121.6365	108.3635					
45	213.0000	192.9719	20.0281					

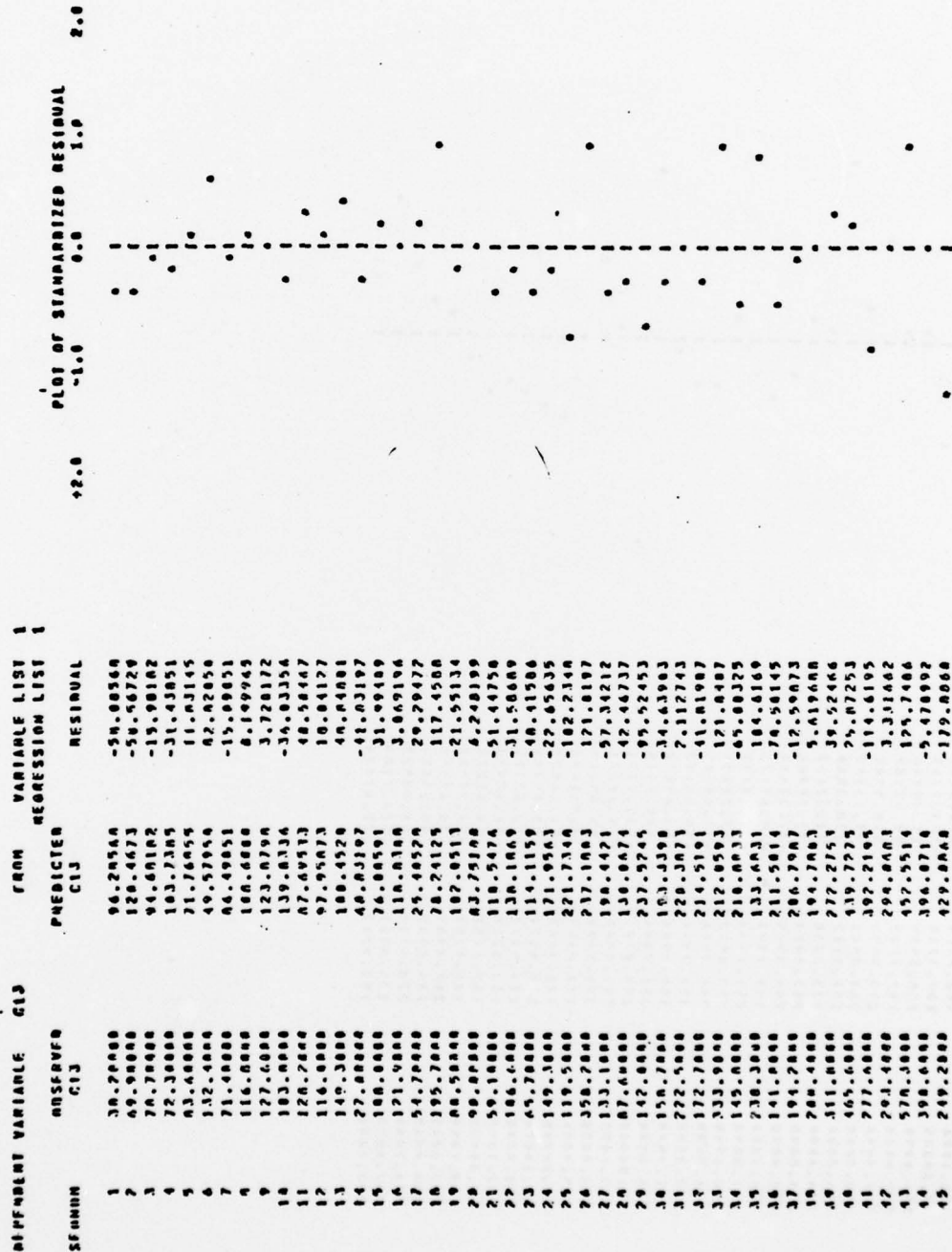
REGRESSION #2

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THEIR REGRESSION

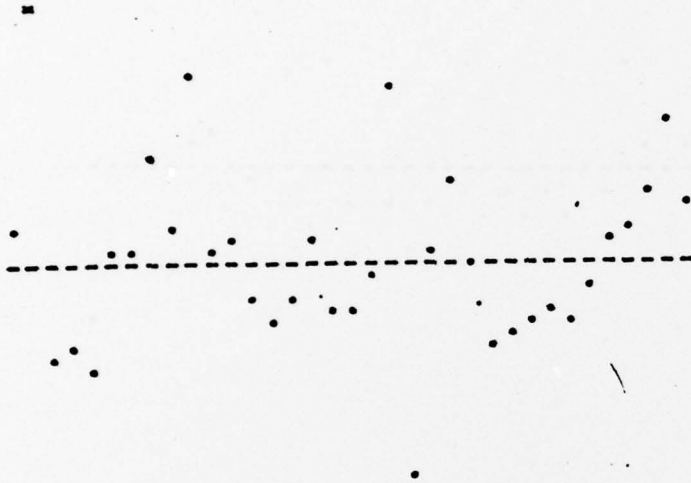
41	139.4000	126.7046	182.8919	I	.
42	143.3000	126.0118	182.8857	I	.
43	146.3000	125.2010	177.9179	I	.
44	149.6000	124.6018	6.998130	I	.
45	152.8000	124.4412	24.35416	I	.
46	156.0000	111.3398	-33.35151	I	.
47	159.1000	104.9117	-69.81168	I	.
48	162.1000	111.2224	-36.42244	I	.
49	165.1000	142.2892	6.890771	I	.
50	168.5000	103.3370	-31.05696	I	.
51	171.6000	100.3710	-58.97104	I	.
52	174.4000	105.3619	-3.667946	I	.
53	177.0000	102.9204	203.0798	I	.
54	180.9000	114.1728	223.2738	I	.
55	183.6000	108.1185	13.51853	I	.
56	186.8000	137.3309	77.94910	I	.
57	189.7000	8.581312	44.10409	I	.
58	192.7000	61.10443	126.5936	I	.
59	195.5000	11.15378	-18.65378	I	.
60	198.0000	41.15949	8.840309	I	.
61	201.0000	11.9332	-58.83117	I	.
62	204.6000	135.4512	-32.05416	I	.
63	207.7000	181.6331	261.99903	I	.
64	210.4000	93.66530	21.73850	I	.
65	213.2000	120.1302	-81.10615	I	.
66	216.1000	161.4570	-67.13703	I	.
67	219.9000	152.0228	232.12382	I	.
68	222.1000	131.0981	-38.39612	I	.
69	225.0000	130.1288	232.12483	I	.
70	228.7000	172.2811	-11.56132	I	.
71	232.5000	115.0380	18.46123	I	.
72	236.8000	102.2810	34.31499	I	.
73	240.1000	123.6113	15.38653	I	.
74	243.6000	133.1928	189.2375	I	.
75	247.0000	120.6817	147.1328	I	.

REGRESSION #3



DEPENDENT VARIABLE	CI3	FROM	VARIABLE LIST	1	FROM	REGRESSION LIST	1	RESIDUAL
SEMIUM	CI3	PREDICTED	CI3	RESIDUAL				
1	38.20000	96.20544		-58.00560				
2	69.90000	128.4673		-58.56729				
3	70.70000	94.60102		-19.90102				
4	72.30000	103.7305		-31.43051				
5	83.60000	71.76055		11.83145				
6	132.4000	49.57954		82.82050				
7	71.40000	64.40051		-15.00051				
8	116.0000	100.4000		6.60000				
9	127.6000	123.8794		3.720172				
10	103.0000	139.8334		-36.83334				
11	126.2000	87.40533		48.79467				
12	114.0000	97.95073		16.04927				
13	140.3000	100.4520		40.84801				
14	27.00000	48.83197		-21.83197				
15	100.0000	76.00591		23.99409				
16	121.0000	118.8300		2.169700				
17	54.70000	25.40520		29.29477				
18	195.7000	78.24129		117.4580				
19	80.50000	102.0513		-21.55134				
20	90.00000	82.75100		7.24899				
21	59.10000	118.5474		-51.44750				
22	100.0000	130.1069		-31.10689				
23	65.70000	114.1159		-48.41500				
24	149.3000	171.9563		-22.65635				
25	119.5000	221.7340		-102.2340				
26	358.2000	217.1003		141.1007				
27	133.1000	198.4421		-65.34212				
28	87.60000	130.0674		-42.46737				
29	142.0000	237.9245		-95.92453				
30	150.7000	103.4390		47.26090				
31	272.5000	220.3073		52.19273				
32	172.7000	214.5101		-41.81007				
33	333.9000	212.0593		121.8407				
34	149.0000	210.0033		-61.00325				
35	230.3000	133.6031		96.69689				
36	141.0000	211.5014		-70.50145				
37	194.2000	206.7907		-12.59073				
38	200.4000	194.7003		5.69997				
39	311.0000	277.2753		33.72466				
40	465.0000	439.7775		25.22253				
41	277.0000	292.2105		-15.21050				
42	204.4000	294.0401		-89.64001				
43	570.3000	452.5514		117.7486				
44	300.0000	394.0710		-94.07100				
45	249.2000	429.0000		-179.8000				

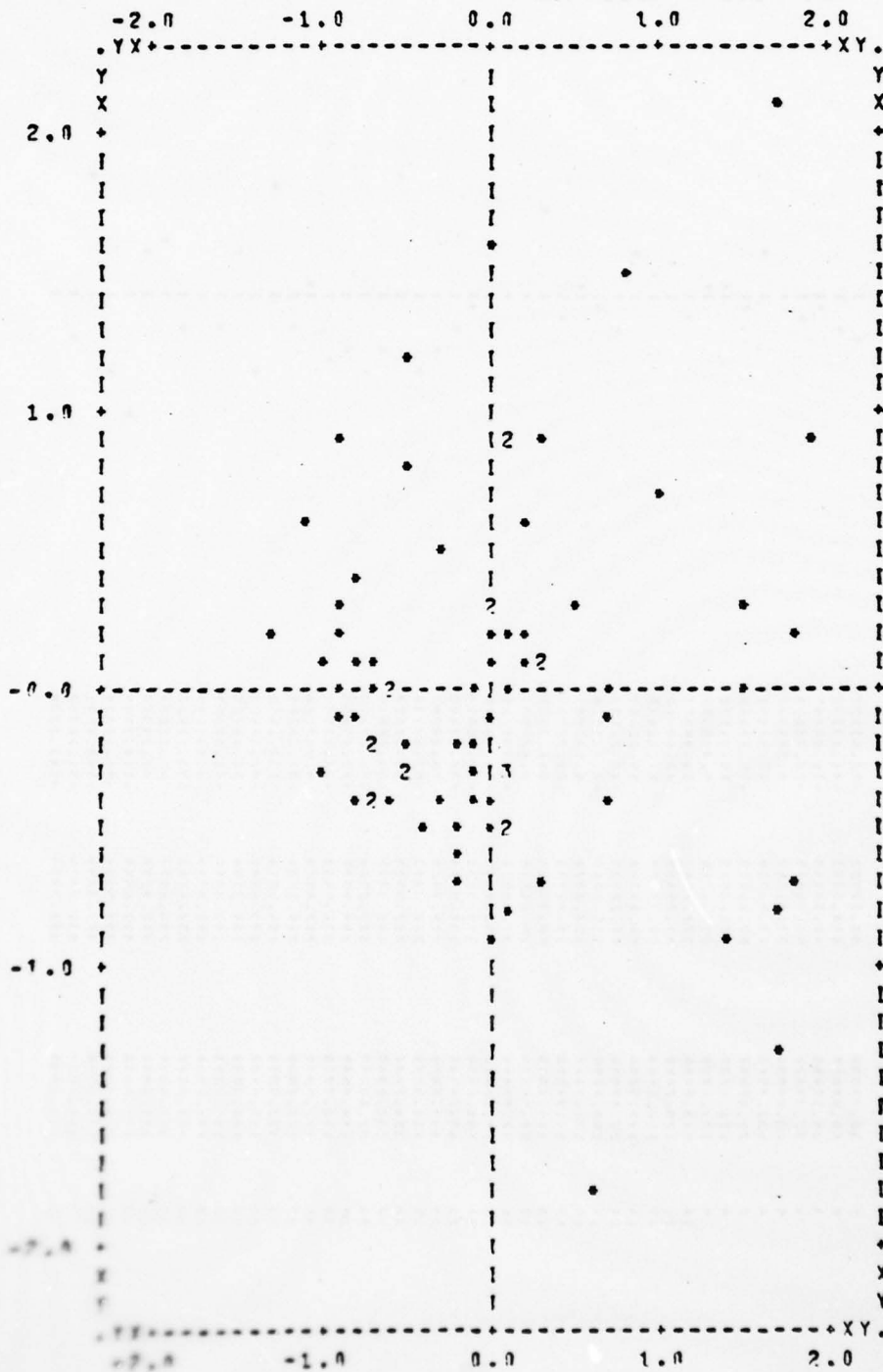
REGRESSION #3



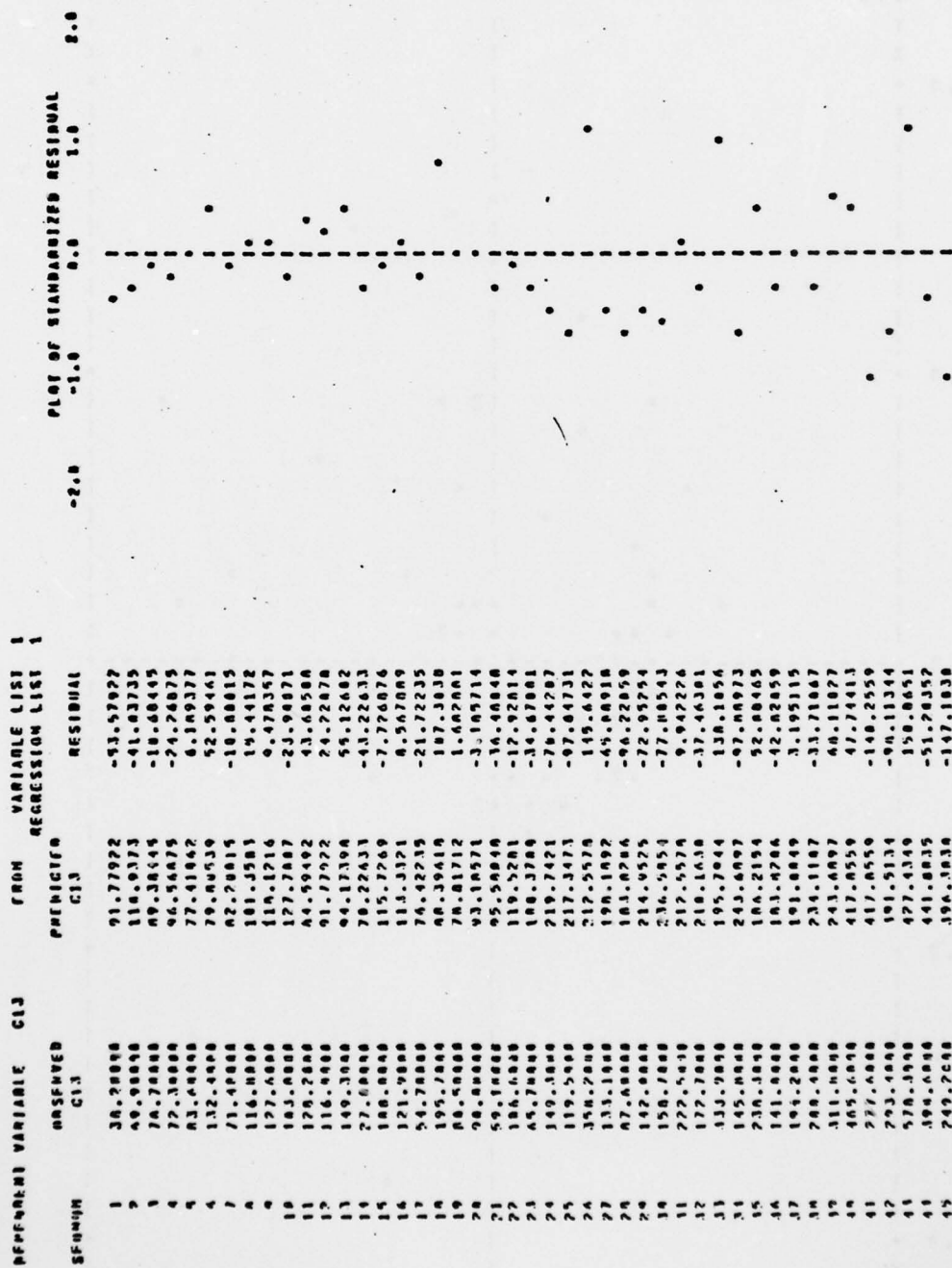
44	442.5000	485.9700	36.53005
45	739.4000	434.7176	-106.6572
46	321.2000	427.2572	-98.13131
47	556.1000	446.7313	-123.5749
48	84.80000	286.3749	11.40846
49	24.80000	238.5795	14.23502
50	212.9000	192.7442	125.5987
51	339.5000	213.8893	48.93993
52	245.1000	284.3661	218.3000
53	416.3000	197.9112	11.32643
54	244.6000	233.2736	22.70160
55	234.8000	217.8864	-37.35449
56	172.8000	289.3544	-65.69773
57	134.1000	199.7497	-33.19737
58	177.8000	211.1974	25.21484
59	749.1000	223.8852	-59.68185
60	146.5000	286.3418	-96.64143
61	243.4000	308.3414	-18.69848
62	281.4000	308.0984	199.2114
63	586.0000	386.7884	-235.8291
64	48.90000	283.9791	15.79271
65	757.6000	241.8878	95.65715
66	434.8000	339.1429	4.531684
67	115.4000	118.8681	-94.16823
68	77.20000	171.3682	-83.45741
69	94.10000	177.5574	-72.63719
70	181.9000	174.5372	-51.82883
71	112.1000	161.1288	-44.11224
72	89.80000	155.1122	-27.26868
73	154.7000	181.9686	38.88558
74	232.5000	282.4935	38.28884
75	238.8000	288.5932	81.88028
76	384.2000	223.1118	148.7489
77	382.8000	135.0511	72.87434
78	232.8000	159.9757	

DEPENDENT VARIABLE C13

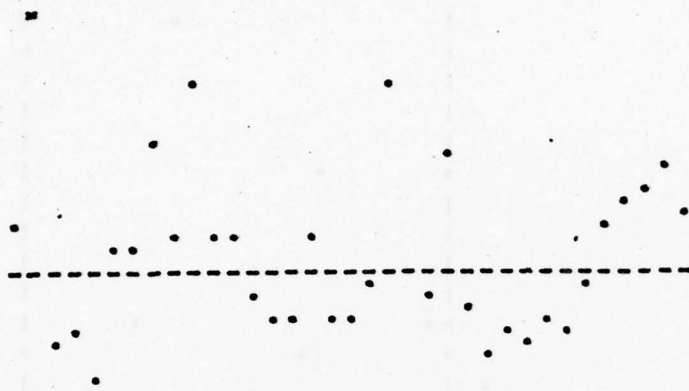
VARIABLE LIST 1
REGRESSION LIST 1



REGRESSION #4



REGRESSION #4

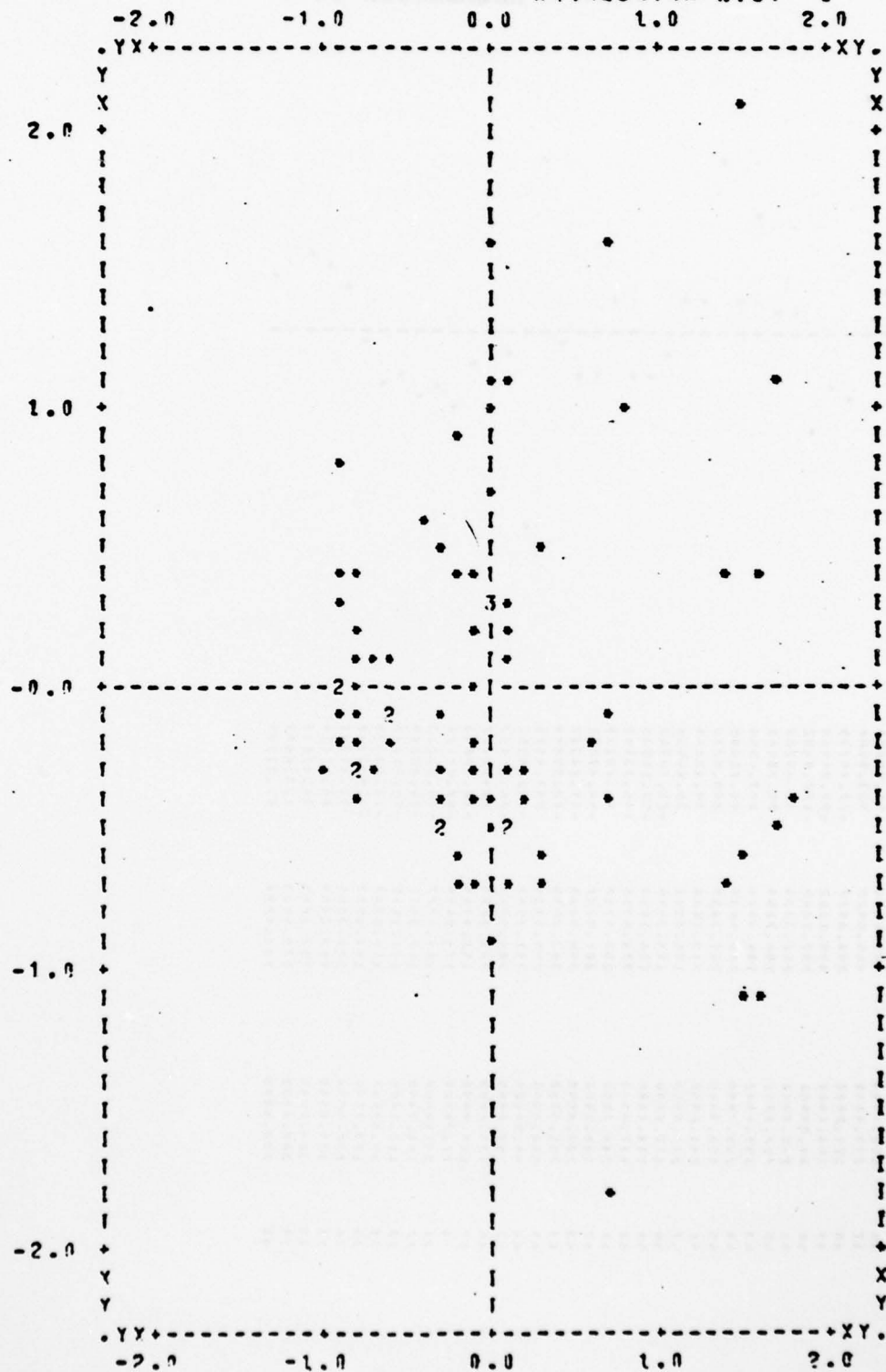


44	442.0000	191.9134	90.90056
45	739.1000	405.0428	333.9100
46	321.2000	398.6972	-77.49775
47	356.1000	425.8482	-48.94816
48	64.80000	207.7682	-177.9482
49	290.0000	212.3473	32.65269
50	212.0000	164.2154	25.70465
51	239.4000	195.7844	147.6856
52	416.1000	200.5829	44.71085
53	234.8000	207.7682	208.9318
54	234.8000	218.1638	34.43899
55	234.8000	185.7944	39.88559
56	172.0000	191.3994	-21.39965
57	134.1000	186.2154	-57.11535
58	172.0000	224.5314	-46.73140
59	739.1000	207.9787	44.12129
60	146.5000	207.9787	-56.47871
61	291.4000	298.5439	-55.14302
62	291.4000	291.7535	-12.35349
63	986.0000	298.5439	207.4970
64	48.90000	291.3587	-242.4587
65	227.6000	281.1714	-76.57443
66	434.0000	305.7273	129.8777
67	119.4000	157.4164	-42.83043
68	77.20000	174.2019	-97.80179
69	94.10000	164.6277	-76.52273
70	101.9000	181.3861	-70.48689
71	112.1000	167.6175	-54.91749
72	89.80000	159.6332	-76.83320
73	154.7000	164.6277	-9.922728
74	232.5000	141.3861	91.11381
75	234.8000	152.6489	84.15118
76	384.2000	207.7285	94.47149
77	382.4000	170.9913	123.6007
78	232.8000	164.4777	67.37777

DEPENDENT VARIABLE C13

VARIABLE LIST 1

REGRESSION LIST 1



APPENDIX D
AFTO FORM 349

MAINTENANCE DATA COLLECTION RECORD														OMB NO. 21-80227	
1. JOB CONTROL NO.	2. WORK CENTER	3. I.D. NO./SERIAL NO.	4. MOS	5. EQ/CL	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION							
10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME OPC REQ	18. JOB STD.							
19. FSC	20. PART NUMBER		21. SER. NO./OPER. TIME		22. TAG NO.	23. INST. ITEM PART NO.		24. SERIAL NUMBER		25. OPER. TIME					
A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER		
1															
2															
3															
4															
5															
26. DISCREPANCY															
27. CORRECTIVE ACTION															
												28. RECORDS ACTION			

AFTO 59A⁴ 349 TEST

AFLC-WPAFB-JAN 75 400

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