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The Development and Evaluation of Programmatic Performance Indicators Associated with Maintenance at Nuclear Power Plants

Appendices

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Science Applications International Corporation

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Abstract

This report summarizes the development and evaluation of programmatic performance indicators of maintenance. These indicators were selected by: (1) creating a formal framework of plant processes; (2) identifying features of plant behavior considered important to safety; (3) evaluating existing indicators against these features; and (4) performing statistical analyses for the selected indicators. The report recommends additional testing.

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Appendix A, Synopsis of Process Model

A.1 Functional Units

The following are summary descriptions of the principal functional units within a typical nuclear power plant that are included in Figure 3.2.

1. Operations

The operations unit comprises the power plant staff who are responsible for ensuring that the plant is as close to the targeted economic power-production state as safety and equipment constraints permit. This unit includes the control-room crew (shift supervisors, senior reactor operators, and reactor operators) and the plant area operators. This unit is almost always a separate, self-contained administrative unit within the plant.

2. Maintenance

The maintenance unit comprises the staff responsible for assuring the availability and operability of plant systems to ensure that targeted levels of economic power production are achieved with the required level of safety. Maintenance tasks include diagnosing and repairing component failures, performing preventive maintenance, and performing surveillance testing. In a sense, the maintenance unit's responsibility is to preserve and enhance the "assets" of the plant--the physical equipment. This unit is again usually a separate administrative unit within the plant; in a broad sense, some of the other functional units may be considered part of maintenance, including, for example, performance analysis.

3. Training

The training unit is a service unit, either part of the corporate (headquarters) structure or part of the site organization, that is responsible for transferring knowledge and skills to the staff in the other areas, including operators and maintenance personnel. Training includes classroom instruction, practice with mock-ups, and practice with simulators (for operations staff).

4. Quality Assurance

Quality assurance (QA) is a unit in the utility whose function is to provide an independent appraisal of safety-related work by maintenance, operations, health physics, and other groups affecting safety. QA performs this function in two basically similar ways; it typically reviews and checks work in progress by maintenance personnel at identified check points, and it monitors and audits performance by other groups, including operations, health physics, etc., on a periodic basis. QA is required to provide reports independently to a senior utility manager, but typically provides liaison with site management in order to provide opportunities for direct problem resolution.

5. Performance Analysis

The performance analysis group is responsible for monitoring, tracking and recordkeeping of plant performance (including station generating performance), and equipment performance. This group may be located administratively in one of several groups, including operations or plant engineering, or may be a separate group within the plant.

6. Plant Engineering (On-site)

This group is responsible for performing technical evaluations of systems' performance, such as heat-loss calculations, fuel burnup, and equipment reliability tracking. Root-cause analyses of unusual or repeated equipment failures will be performed here. This group is also responsible for identifying plant modifications needed to eliminate problem areas or perform moderate upgrades to systems in conjunction with corporate engineering staff. Staff assigned as Shift Technical Advisors and other emergency response staff will usually be part of this group. This group will be an independent unit on site.

7. Purchasing/Construction (On-site)

The purchasing/construction group perform the tasks of ordering and purchasing new equipment for plant modifications, and for carrying out their installation. For major modifications, this group will work in conjunction with corporate staff and vendor installation teams. This group may be part of other administrative departments or a separate department. At some plants, this group may be split into purchasing and construction, each of which is part of another department.

8. Site Management

The site management is responsible to the corporate management for the safe, economic operation of the plant. It accomplishes this by (in a formal sense) the allocation of resources, the setting of department goals and the evaluation of performance; management also largely functions through continuous informal and semiformal discussions with the other groups, and the coordination and sharing of information. This group (at the top level) is a separate unit (station manager, etc.); at the lower levels, department managers are both part of the site management group and members of the other various groups.

9. Other Plant Functions

There are several groups that are involved in plant operations, including health physics, chemistry, security, and so on, that are grouped together for the purposes of this study. In addition, there are numerous administrative support groups that are located at the site. For this study, they are treated as an additional functional area for completeness but are not believed to have a major interface with training or maintenance in terms of their safety roles.

A.2. Primary Function Interfaces

The following are the primary interfaces between the most important functional activities:

1. Maintenance

(a) Site Management: Site management provides the maintenance unit with goals and resources. In some plants the goals may be formalized such as the reduction of forced outages due to maintenance error to less than " x per fuel cycle" or some similar set of goals. In some plants, explicit maintenance goals may not be set. The resources are primarily manpower and dollar budgets. Such resources may identify overtime requirements explicitly or implicitly.

(b) Operations: The primary interface with operations is through the processing of maintenance work requests (MWRs). These are packages that provide coordination of removing equipment from service (e.g. tagging out by operators), providing or recording clearance by health physics and quality assurance groups, and identifying the groups) within maintenance (electrical, mechanical, etc.) that are responsible for performing the work. MWRs may be initiated by operations (for equipment failed in service or during operational testing) or by maintenance (scheduled maintenance or equipment failed during surveillance testing). MWR packages provide the major data items fro work by maintenance groups. MWRs are prioritized by their impact on safety availability and license conditions. It is not uncommon for minor items to be postponed by refueling outages without any direct influence on safety.

(c) Training: Training provides specialist skills, knowledge and practice to maintenance staff. Maintenance personnel are usually experienced in performing maintenance function on power plant equipment before they are recruited by a plant; such experience may have been gained from the nuclear navy or from fossil plants. The purpose of the plant-specific training is to acquaint personnel with new equipment, or with new techniques in maintenance such as the use of condition-monitoring equipment. Training needs may also be identified by evaluation of equipment and plant performance--see training interfaces below.

(d) Quality Assurance: The role of quality assurance is to provide an independent checker on the adequacy and completeness of work associated with plant safety. Its interface with maintenance is principally associated with specifying "hold and check" points during repair and restoration to service following maintenance. These may be specified as part of the MWR package or as a separate requirement.

(e) Plant Engineering/Support: The interface with the plant engineering/support group is concerned with the lessons learned from equipment failures and performance-especially root cause analyses of problems. This information identifies implicitly needed changes in maintenance activities to avoid the repetition of plant problems.

(f) Purchasing/Construction: The interface is associated with describing maintenance requirements and practices associated with new equipment. It will provide (in parallel to training) manuals and other documentation associated with maintenance of new equipment; it may also include manufacturer-based training for certain types of new equipment. In addition, maintenance may provide requirement to purchasing/construction concerning the maintainability of planned purchases.

(g) Physical Plant: The interfaces with the physical plant are the monitoring and repair of plant equipment. Monitoring includes both the formal testing and surveillance checks as well as the informal observations by maintenance personnel whilst in plant areas.

2. Training

(a) Operations: Training provides the operations group with specific skills rules and knowledge associated with all phases of the plant operations, including startup and shutdown, steady-state power control, refueling and emergency scenarios. Skills are acquired largely through practicing drills in training simulators; rules are provided in the form of operating procedures; and knowledge is provided through classroom instruction. Some fraction of operators joining a power plant have nuclear operating experience (either from the nuclear navy or from another plant) and therefore initial training achieves a plant orientation for others, training provides a more broad basic in nuclear technology as well as plant specific information. Once qualified operators are retrained on a provided basis, with emphasis on skill retention and knowledge associated with recent significant operating events.

In addition, operations many request specific training activities typically for new or difficult maneuvers, or because of identified performance problems. These training needs are from operations into training.

(b) Maintenance: See above.

(c) Site Management:--Site management's interface with training is primarily the allocation of goals and resources to the training group; these may include identified numbers of trainees and associated budgets.

(d) Plant Engineering/Support: This interface is to identify training needs directly into training as a result of identified problems in systems performance or, more frequently, because of changes in operating practices such as in response to new NRC requirements (as happened with the NRC's post-TMI action plan).

(e) Purchasing/Construction: As new equipment is purchased and installed, the purchasing/construction group may supply (or arrange the supply of) new training materials, manuals, etc. to the training group for incorporation in the training process. In addition, changes in the plant need to be represented in the training simulator, such as modifications to the simulator software, the panel layouts, and related system descriptions.

3. Operations

(a) Maintenance: See above

(b) Training: See above

(c) Site Management: The interface with site management is principally the goals and resources for operations (such as the number of operating shifts, the targeted availability and cumulative generation, and so on) and the reporting by operations of the commercial plant performance (daily during management meetings, and, more formally, on a weekly or monthly basis).

(d) Quality Assurance: The interface between operations and quality assurance is the reporting checks of the status of safety systems through test schedules and control-room status logs.

(e) Performance Analysis: Performance analysis provides operations with summaries of systems performance. These summaries may include thermal-hydraulic data (flows, heat balances, etc.) and reliability data (trends in failures, etc.).

(f) Other Plant Functions: The primary interface with other plant groups is with health physics (HP) in requesting and receiving clearances for access to potentially or actually contaminated zones or other areas where significant radiation may be present. Operation may coordinate HP clearances for maintenance work (as part of the MWR process) as well as for operational access.

A secondary interface exists with security and safeguards to obtain access to designated plant areas (usually through a key card system, but sometimes through guard monitors--especially during refueling).

(g) Physical Plant Systems: Most of the day-to-day interactions by operations is with the plant hardware through controlling changes in plant-state, monitoring equipment performance and performing operability tests on safety-related equipment. Such activities are performed both from the control room, from local control stations and at the equipment locations.

4. Quality Assurance

(a) Corporate Management: Quality assurance normally reports to a senior manager (sometimes a QA designated vice president, sometimes the president directly) in the corporate management off-site. QA reports identified non-conformances and deficiencies in plant performance related to safety independently of the operations-management chain, to provide a check-and-balance on plant administration.

(b) Site Management: Information sent by the QA group to the corporate management is usually provided to site management in parallel for information.

(c) Maintenance: See above

(d) Operations: See above

5. Performance Analysis

(a) Site Management: Site management provides the goals and resources for the performance analysis group. Often the performance analysis group is administratively part of another unit (plant engineering or operations) so this interface is comparatively weak.

(b) Operations: See above

(c) Plant Engineering/Support: Performance analysis provides the plant engineering/support group with summaries of equipment performance data that can be used as a basis to identify plant problem areas for analysis.

(d) Physical Plant Systems: Performance analysis obtains information from logsheets or computer monitoring systems that periodically record equipment status, flows, etc.

Log sheets may be obtained physically from operations or performance analysis personnel may take separate logs of the plant.

6. Plant Engineering/Support

(a) Site Management: Site management provides the goals and resources for the plant engineering/support group. These may include specific medium and long term operational problems requiring resolution, implementing new NRC requirements, etc. Plant engineering/support provides additional perspectives on plant performance to site (and thence to corporate management). These perspectives are usually more analytically oriented then those provided by operations, etc. For example, they would include analyses of significant events and trends in performance, and utility-specific performance indicators.

(b) Purchasing/Construction: The plant engineering support function identifies engineering requirements and specifications to the purchasing/construction group as an input to the purchasing process.

(c) Training: As above.

(d) Operations: As above.

(c) Maintenance: As above.

7. Purchasing/Construction

(a) Corporate Management: Purchasing/construction interfaces with corporate management principally as a means of obtaining funds for large-scale projects that exceed site management authorizations.

(b) Plant Engineering/Support: See above.

(c) Training: See above.

(d) Maintenance: See above.

(e) Operations: See above.

8. Site Management

(a) Other Plant Functions: As with the other site-management interfaces, this interface supplies the goals and resources to the other plant functions.

(b) Training: As above.

(c) Operations: As above.

(d) Performance Analysis: As above.

(e) Plant Engineering/Support: As above.

(f) Corporate Management: Corporate management provides the site management with the overall goals and resources of the utility, usually in the form of financial and operational goals and overall budgetary resources. Implicitly the corporate management

provides the "cultural" environment for the utility, including the site management and staff.

In addition, site management provides the corporate management with information about the overall plant performance, including economic and safety-related data.

9. Other Plant Functions

(a) Physical Plant Systems: These interfaces are information concerning radiation and dose readings (HP), water quality, etc., (chemistry), access logs (safeguards), and so on.

Appendix B, Detailed Results of Statistical Analysis

Detailed Results for Plant A

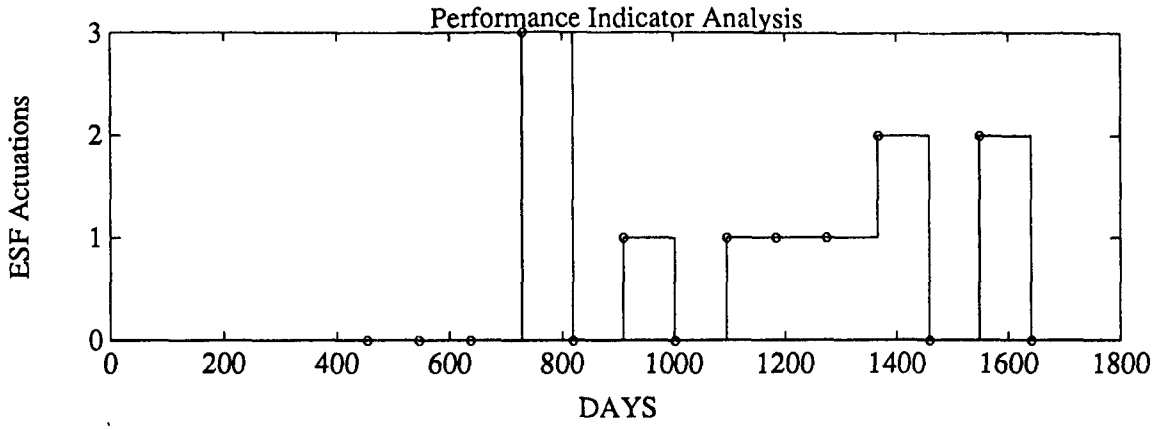
Maintenance Indicators vs. Measures of Safety

	RANK	1SCRTL	1SCRHI	1SCRLO	2SSA	3SE	4SSF	5FOR	7EFO	CRITHOUR	SALP-M	FRATE	AVAIL
1PMTOTM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2CMB	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3PMOVER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4MNTTO1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5REWORK1*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6DEFIC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7CMWRPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7DBOPMT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9MTSERV*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N/A	NS	NS
CSCRAM* [Zero events in relevant time scale]											N/A		
8ASSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8BSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8CSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8DSSPI [Zero events in relevant time scale]											N/A		
BAHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BBHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BCHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BDHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BEHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BFHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BGHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CBSCRAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GHR*	NS	NS	NS	NS	NS	NS	S	S	NS	NS	N/A	S	NS
WPE*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N/A	NS	NS
REALE* [Zero events in relevant time scale]											N/A		
BACKECN*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WRONGT/U*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ESFACT*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N/A	NS	S

Note: Indicators marked with an "*" are SAIC indicators

Significant Maintenance Indicator/Measure of Safety Relationships

Indicator	Measure of Safety	Time Shift	Confidence
ESFACT	AVAIL	+1	80%
GHR	SSF	0	82%
GHR	EFO	0	96%
GHR	FRATE	0	90%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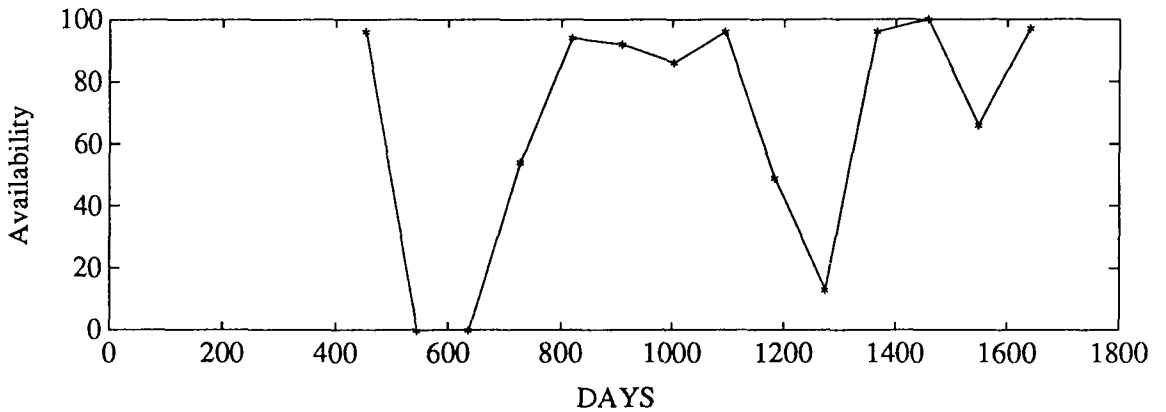
ESF Actuations
DAYS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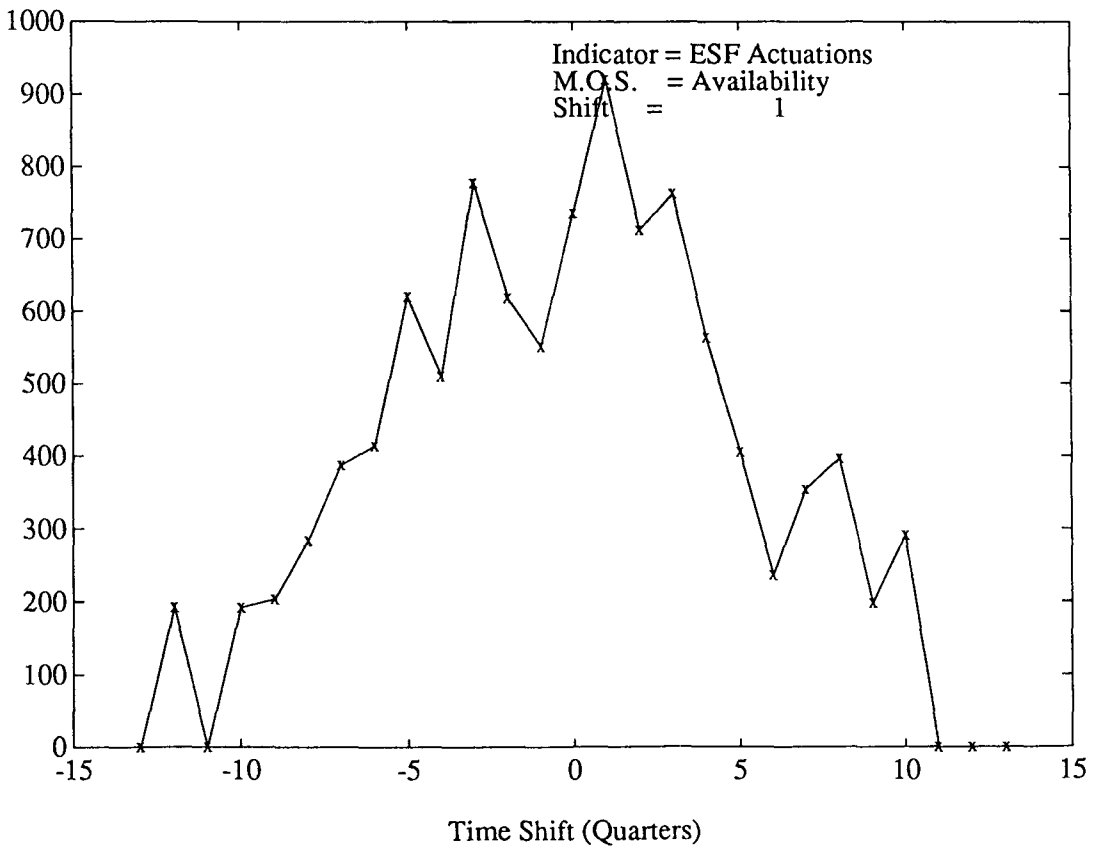
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M.O.S. = Availability
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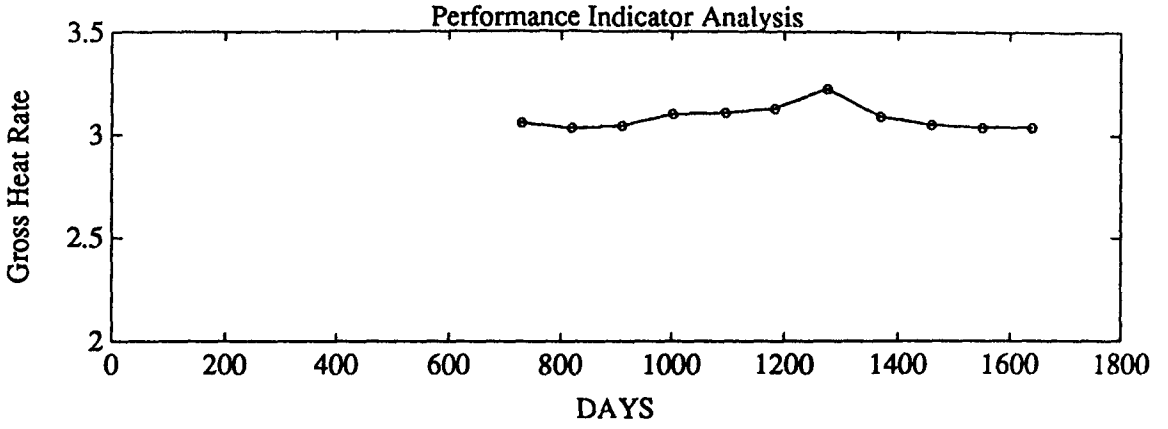
Time Shift (Quarters)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3
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600
800
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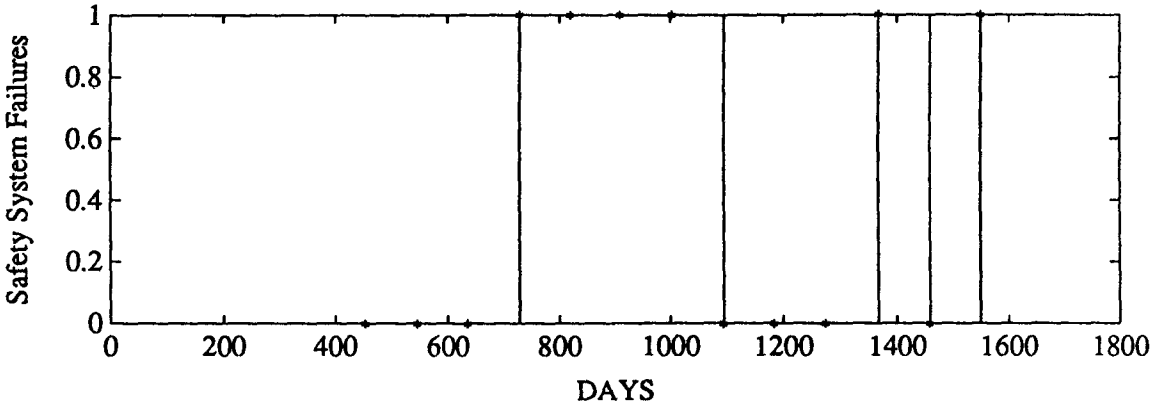
1600
1800
DAYS


Safety System Failures
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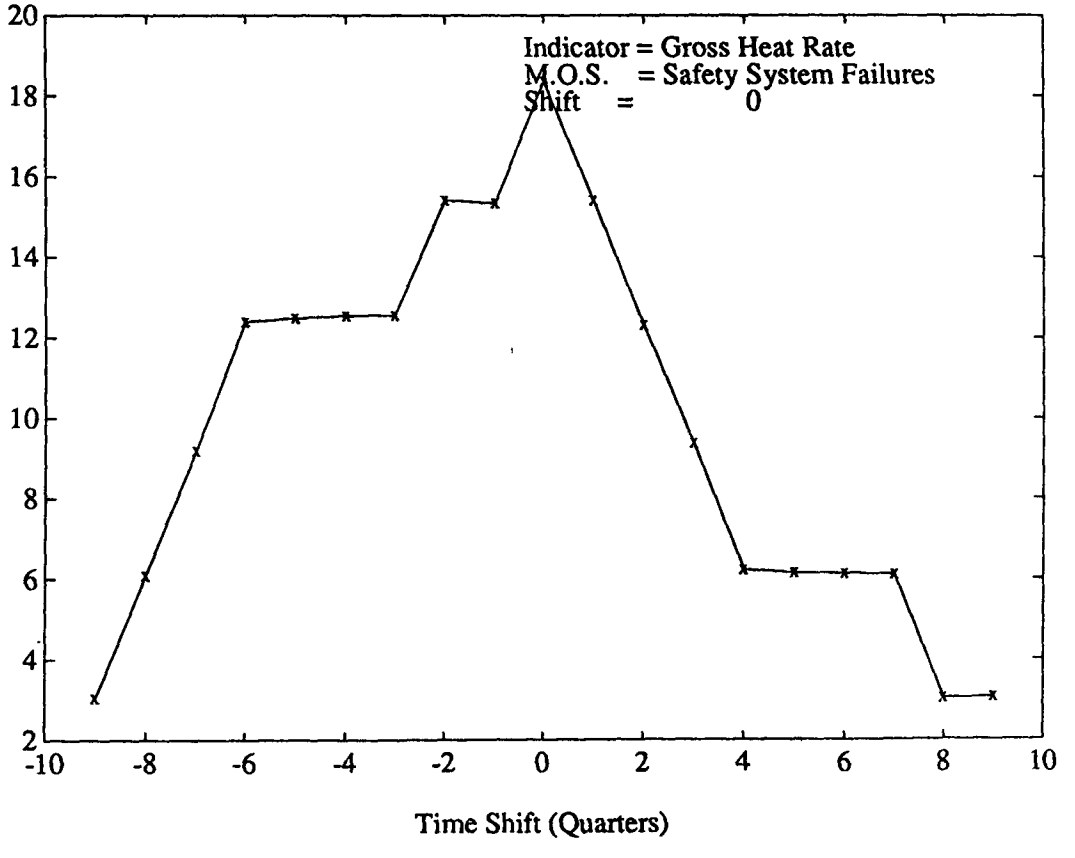
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M.O.S. = Safety System Failures
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18
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8
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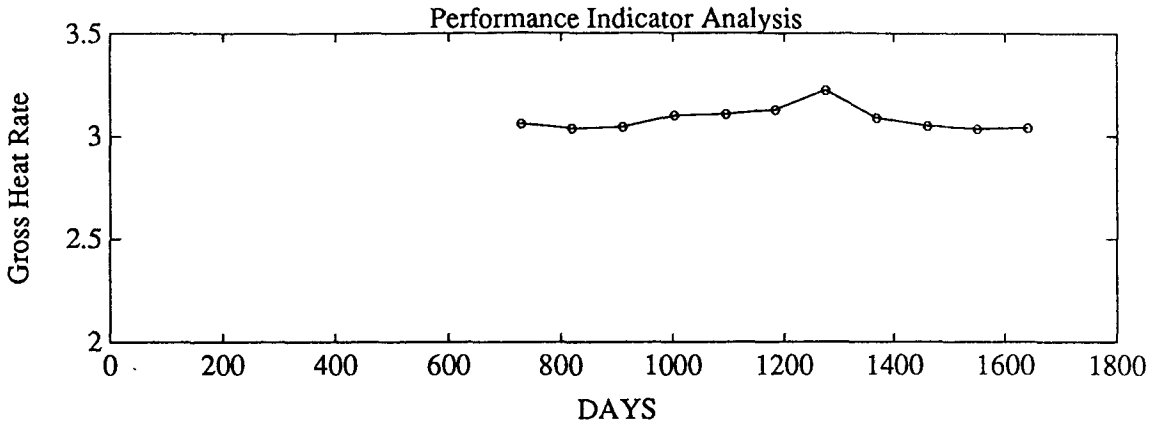
Time Shift (Quarters)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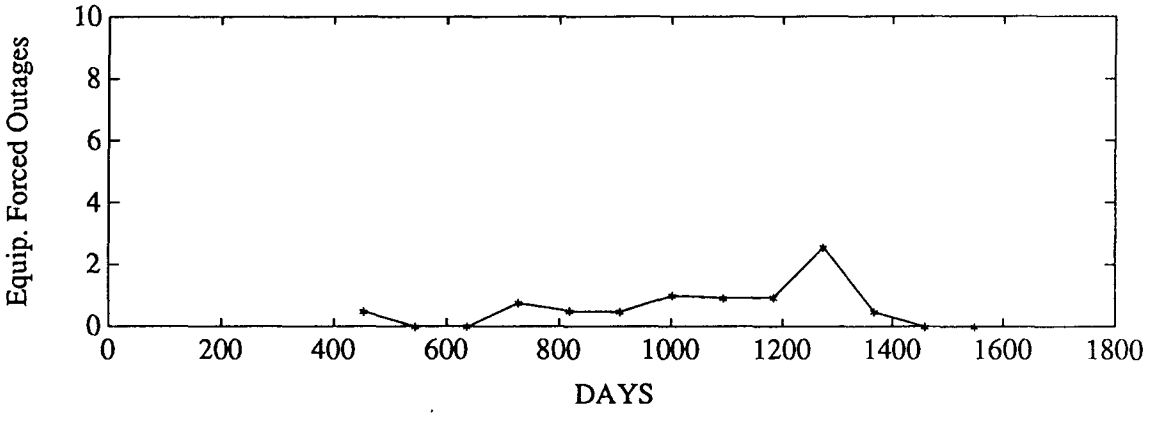
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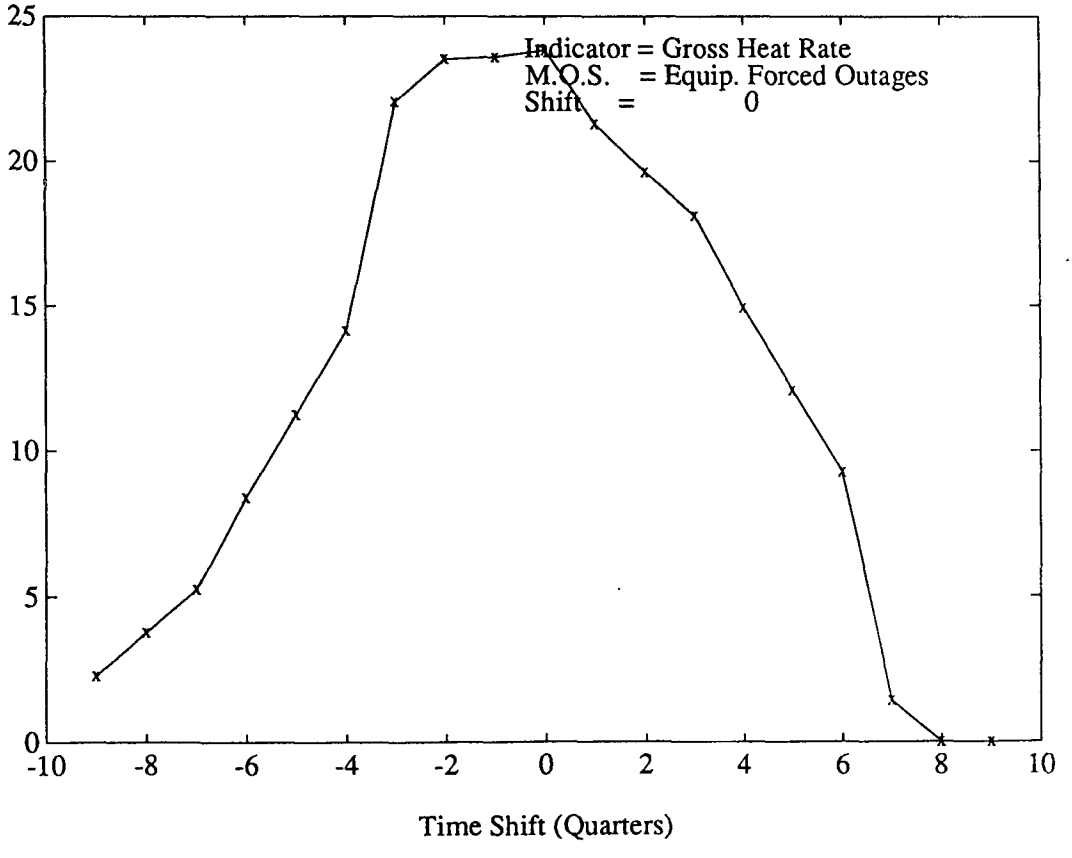
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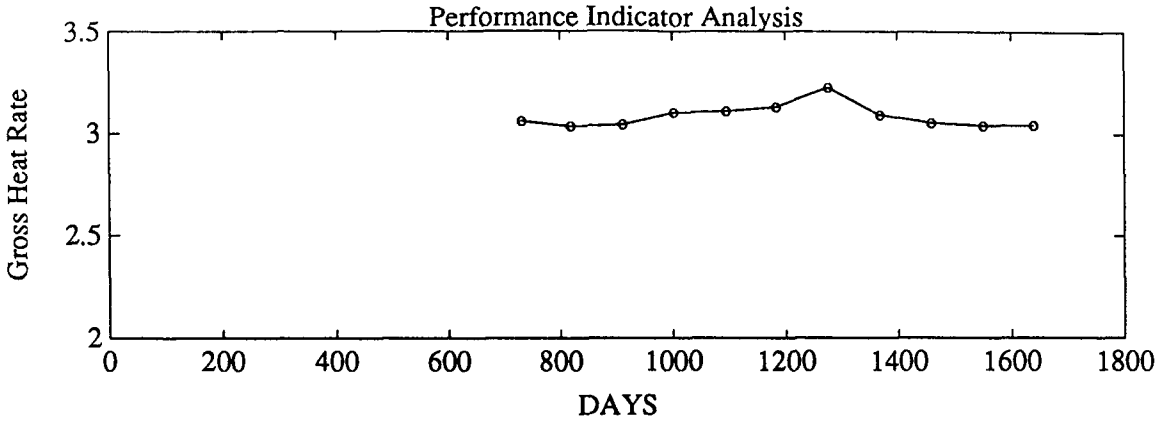
Time Shift (Quarters)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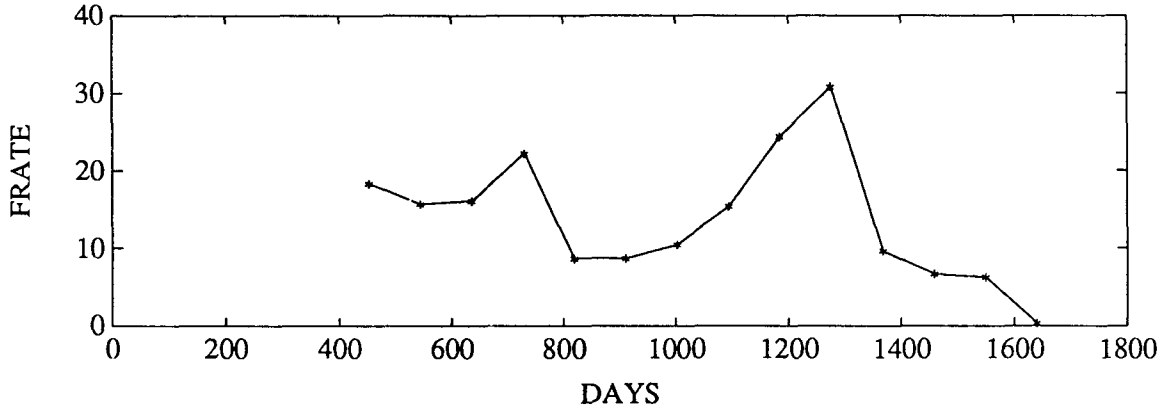
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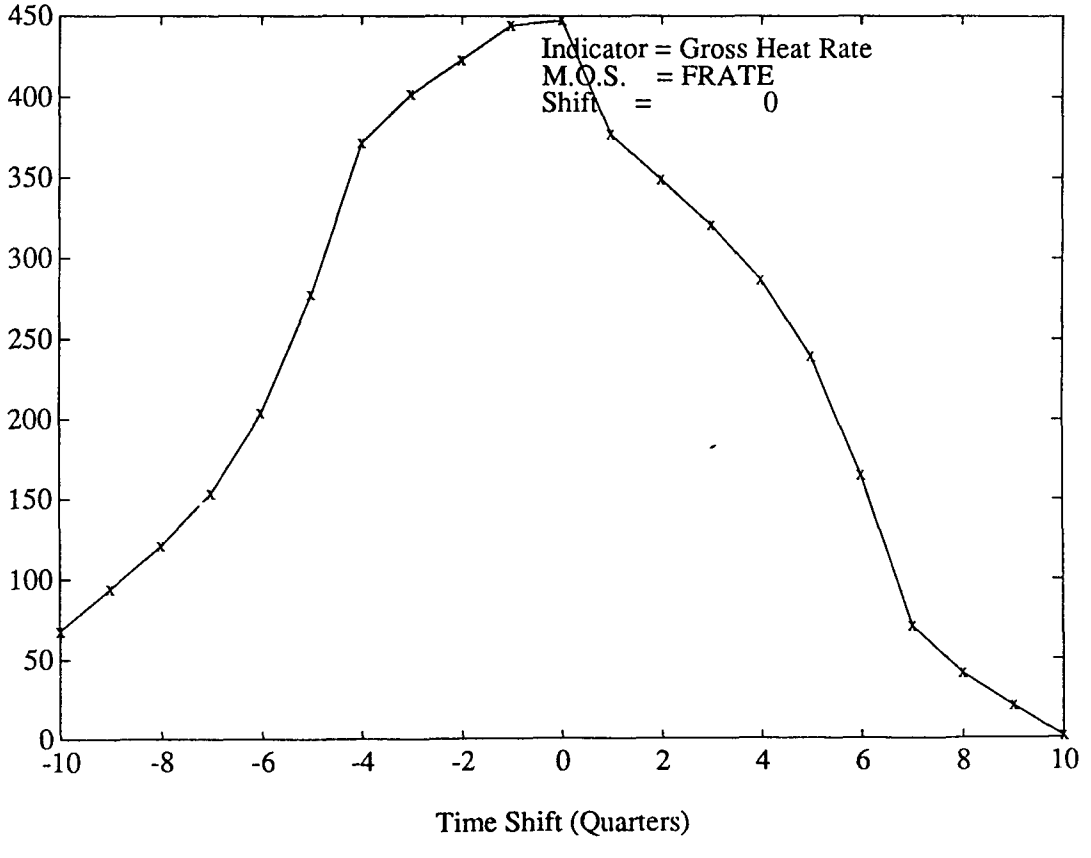
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M.O.S. = FRATE
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150
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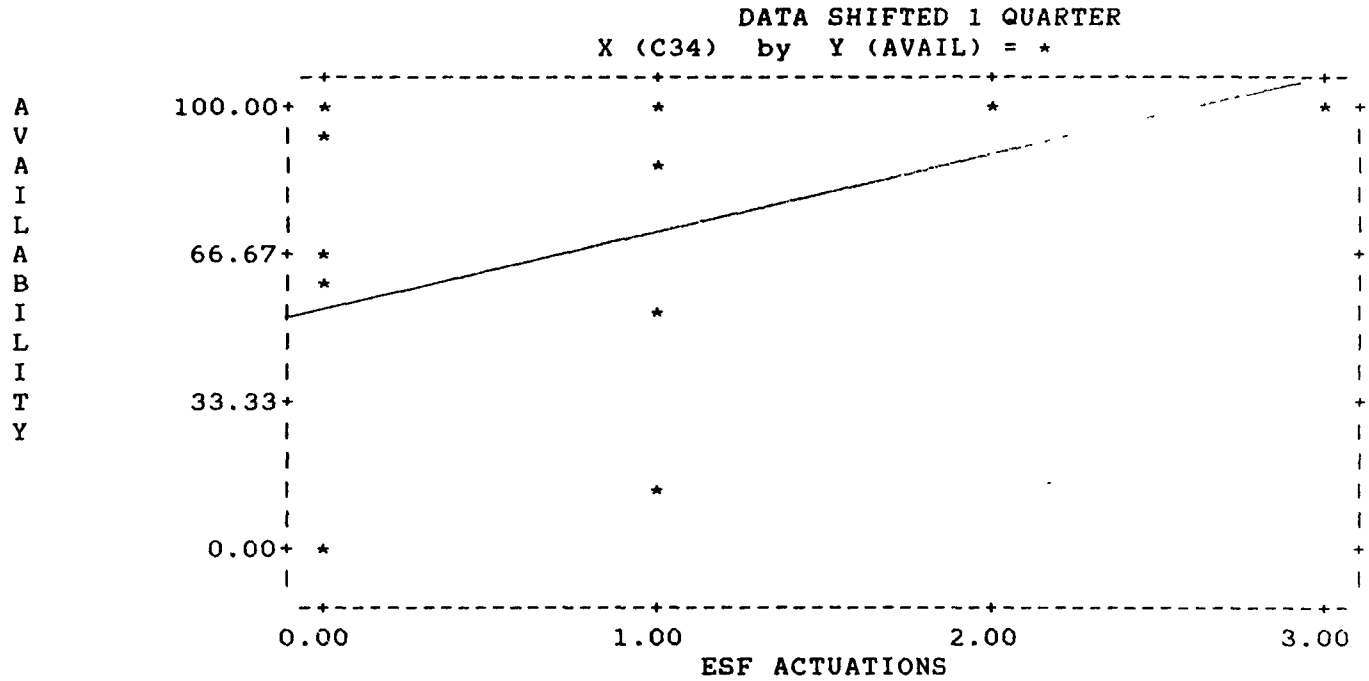
0
-10
-8
-6
-4
-2
0
2
4
6
8
10
Time Shift (Quarters)

----------Scatter Plots----------

Date/Time 10-25-1988 13:27:12
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



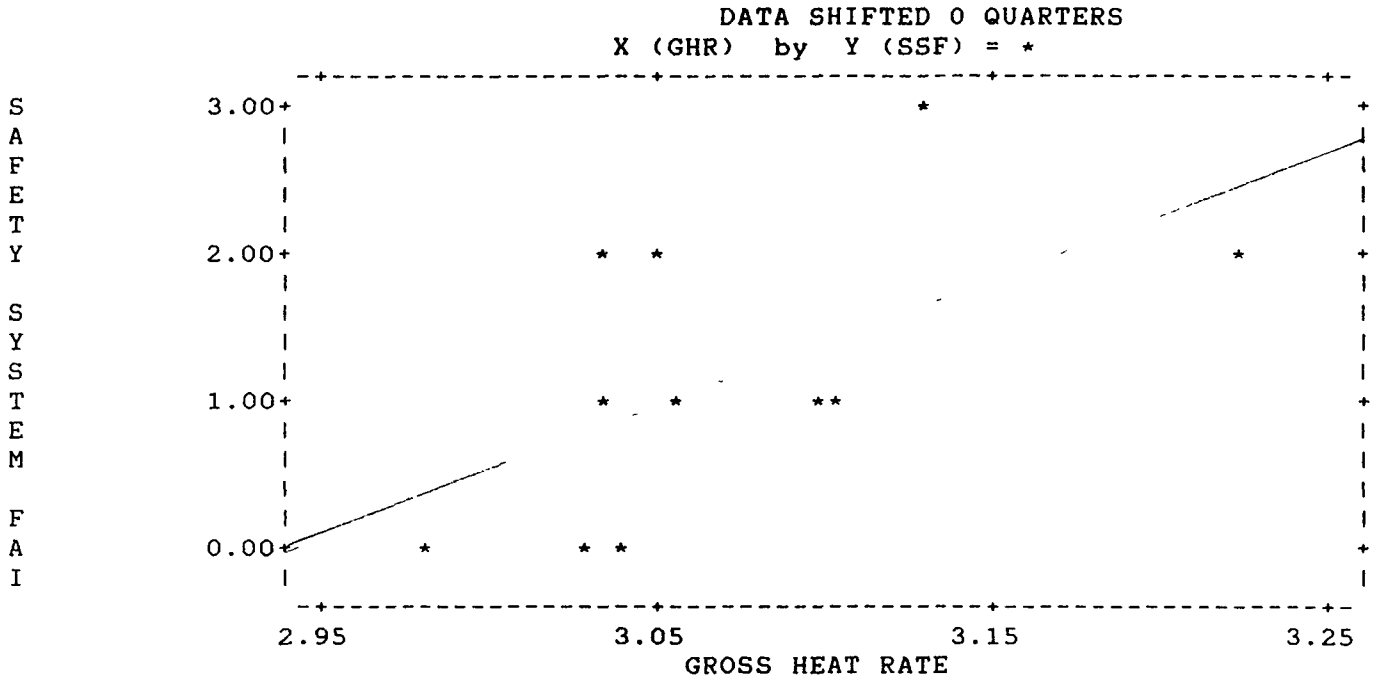
w Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	0
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 13:19:12
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



w Accounting Report

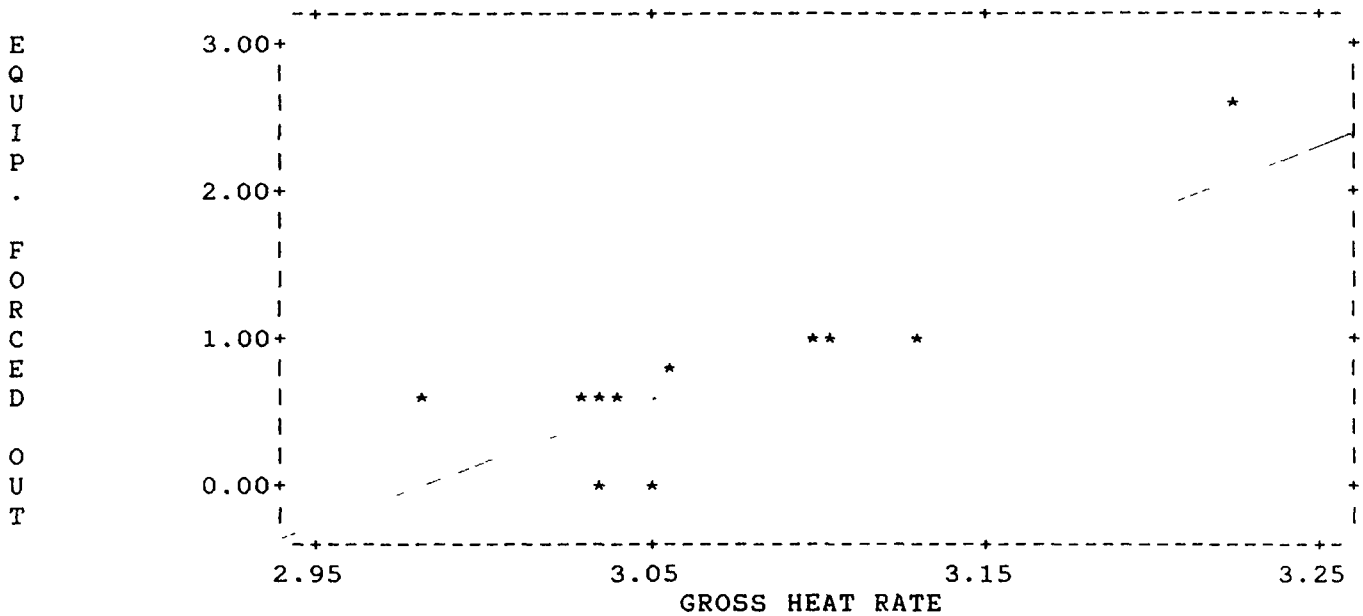
Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	2	(Y) :	1
Number of points plotted	:	11		

----------Scatter Plots----------

Date/Time 10-25-1988 13:21:17
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots

DATA SHIFTED 0 QUARTERS
X (GHR) by Y (EFO) = *



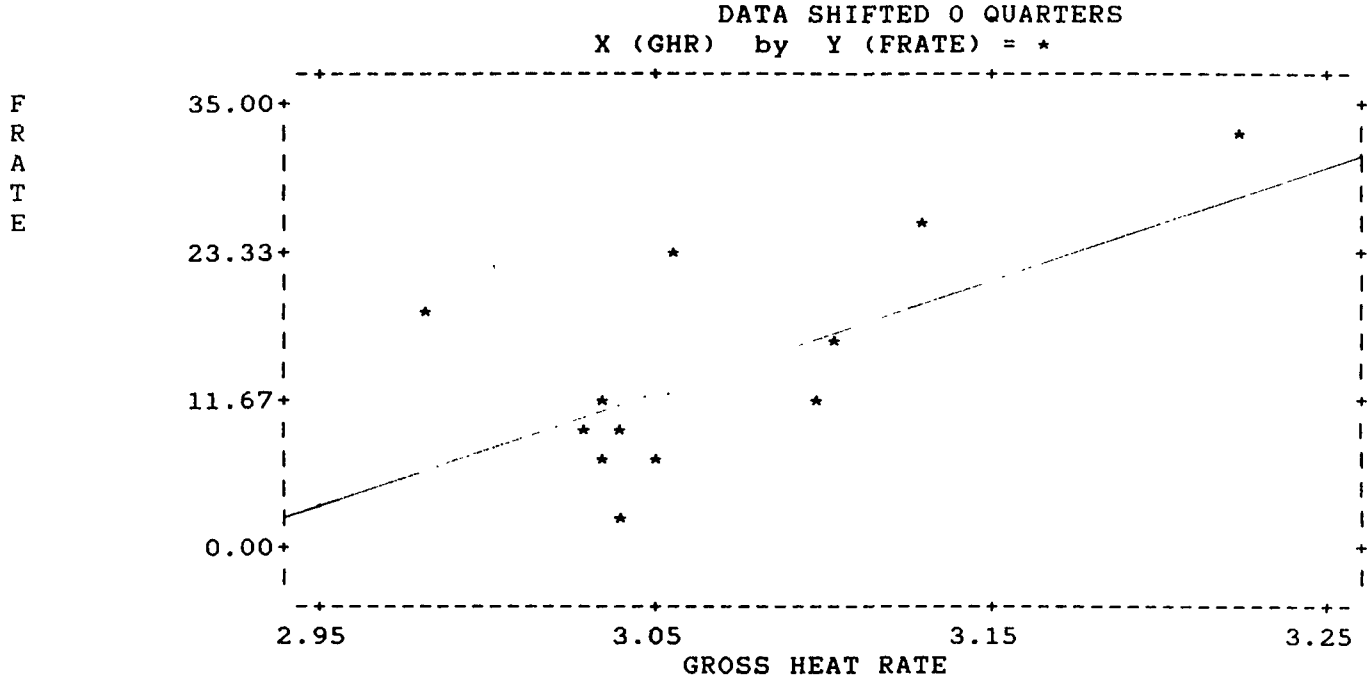
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	2	(Y) :	1
Number of points plotted	:	11		

----------Scatter Plots----------

Date/Time 10-25-1988 13:21:55
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	2	(Y) :	0
Number of points plotted	:	12		

Detailed Results for Plant B

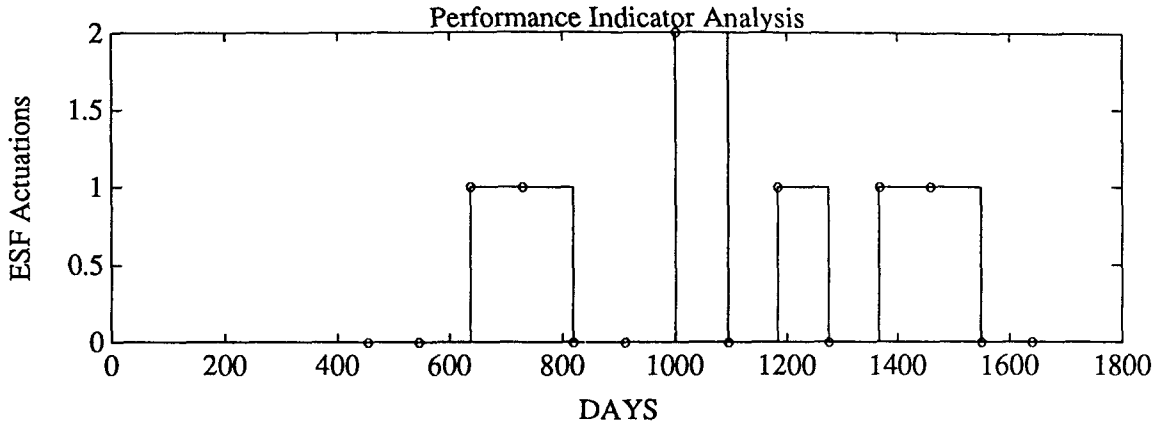
Maintenance Indicators vs. Measures of Safety

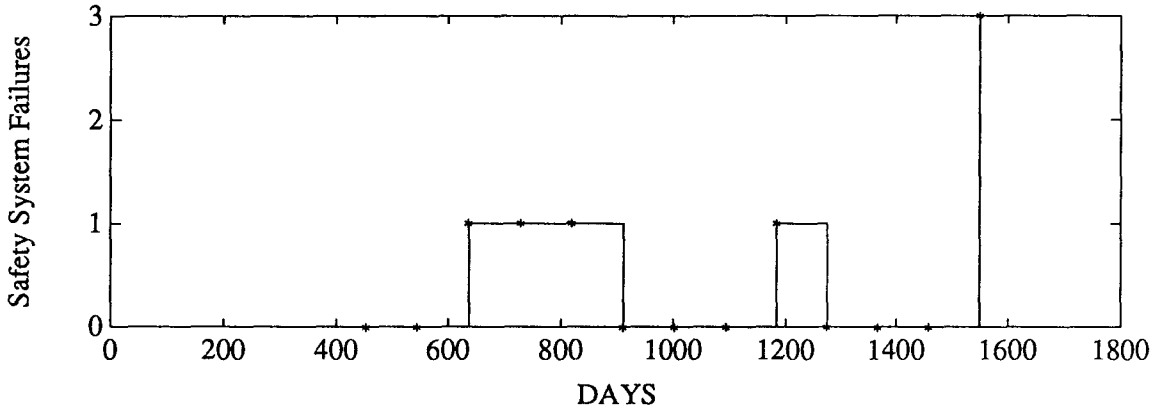
	RANK	1SCRTL	1SCRHI	1SCRLO	2SSA	3SE	4SSF	5FOR	7EFO	CRITHOUR	SALP-M	FRATE	AVAIL
1PMTOTM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2CMB	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3PMOVER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4MNTTO1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5REWORK1*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6DEFIC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7CMWRPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7DBOPMT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9MTSERV*	NS	NS	NS	N/A	NS	NS	NS	NS	NS	NS	N/A	NS	NS
CSCRAM*	NS	NS	NS	N/A	NS	NS	NS	NS	NS	NS	N/A	NS	NS
8ASSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8BSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8CSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8DSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BAHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BBHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BCHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BDHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BEHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BFHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BGHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CBSCRAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GHR*	NS	NS	NS	N/A	NS	NS	NS	NS	NS	NS	N/A	NS	NS
WPE*	NS	NS	NS	N/A	NS	NS	NS	NS	NS	NS	N/A	NS	NS
REALE*	[Zero events in relevant time scale]										N/A		
BACKECN*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WRONGT/U*	[Zero events in relevant time scale]												
ESFACT*	NS	NS	NS	N/A	NS	NS	S	NS	S	NS	N/A	NS	NS

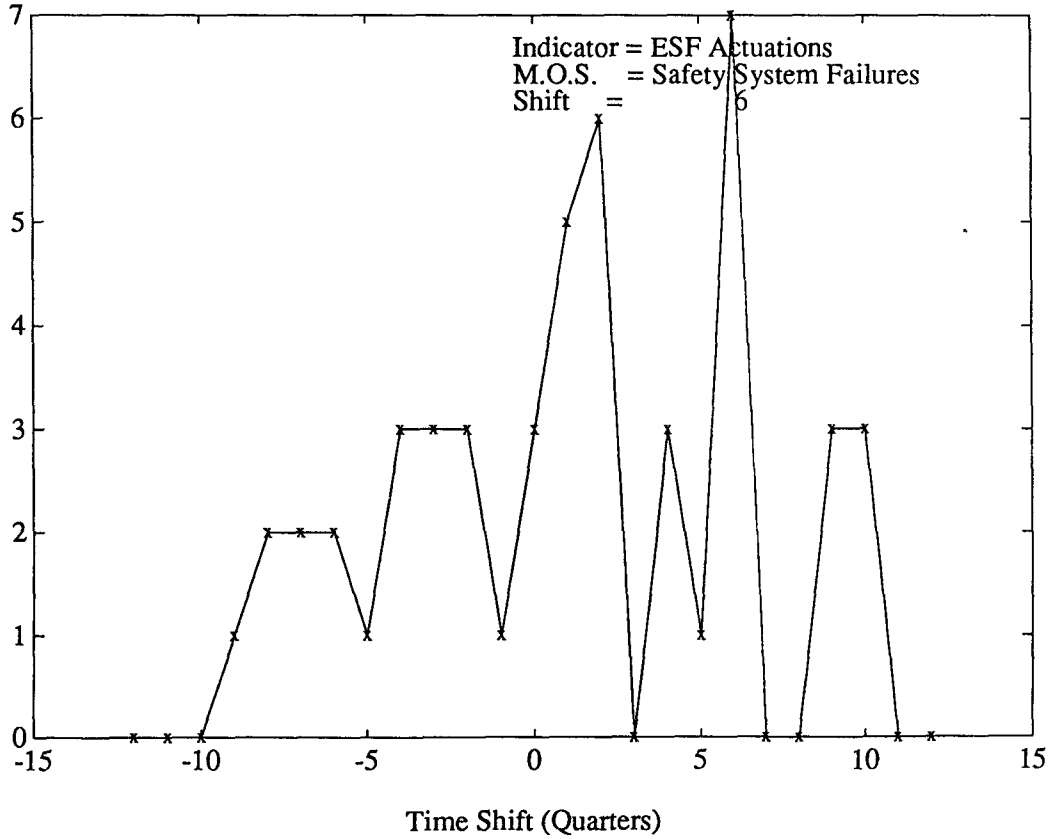
Note: Indicators marked with an "*" are SAIC indicators

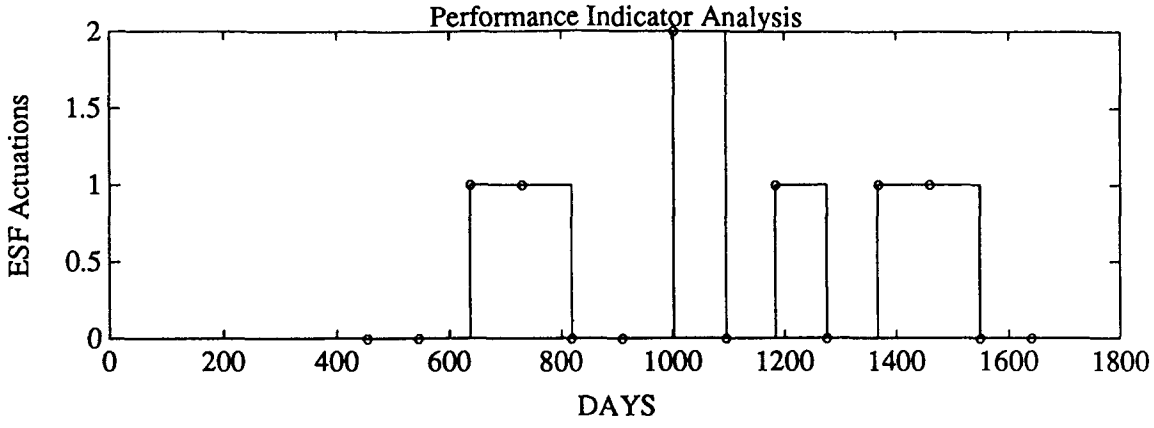
Significant Maintenance Indicator/Measure of Safety Relationships

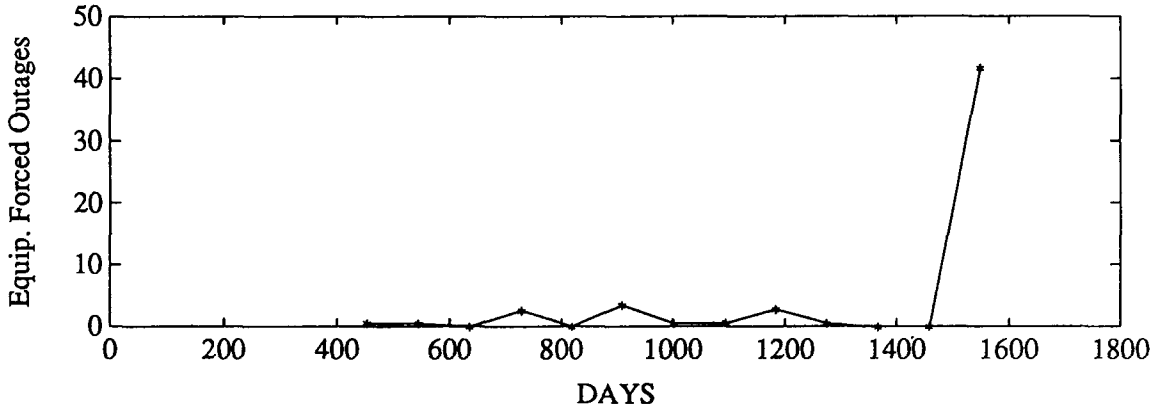
Indicator	Measure of Safety	Time Shift	Confidence
ESFACT	SSF	+6	94%
ESFACT	EFO	+6	89%

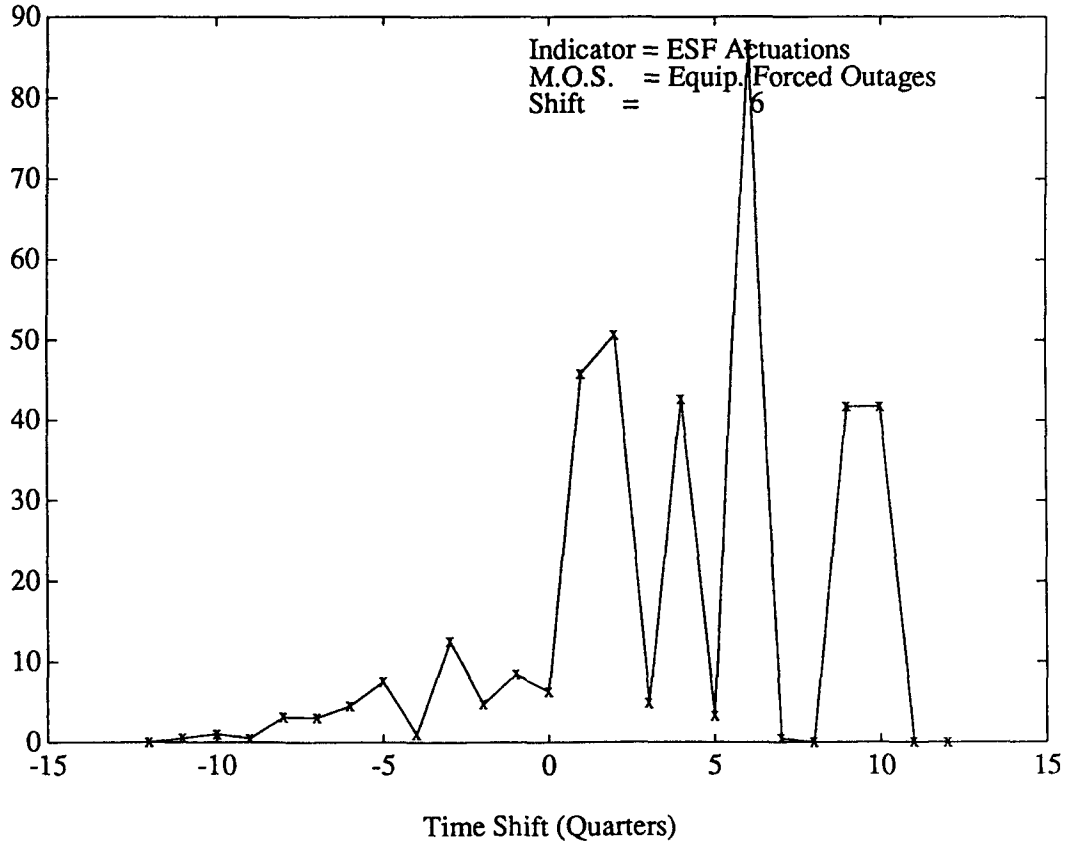

Performance Indicator Analysis
ESF Actuations
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Safety System Failures
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = ESF Actuations
M.O.S. = Safety System Failures
Shift = 6
7
6
5
4
3
2
1
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

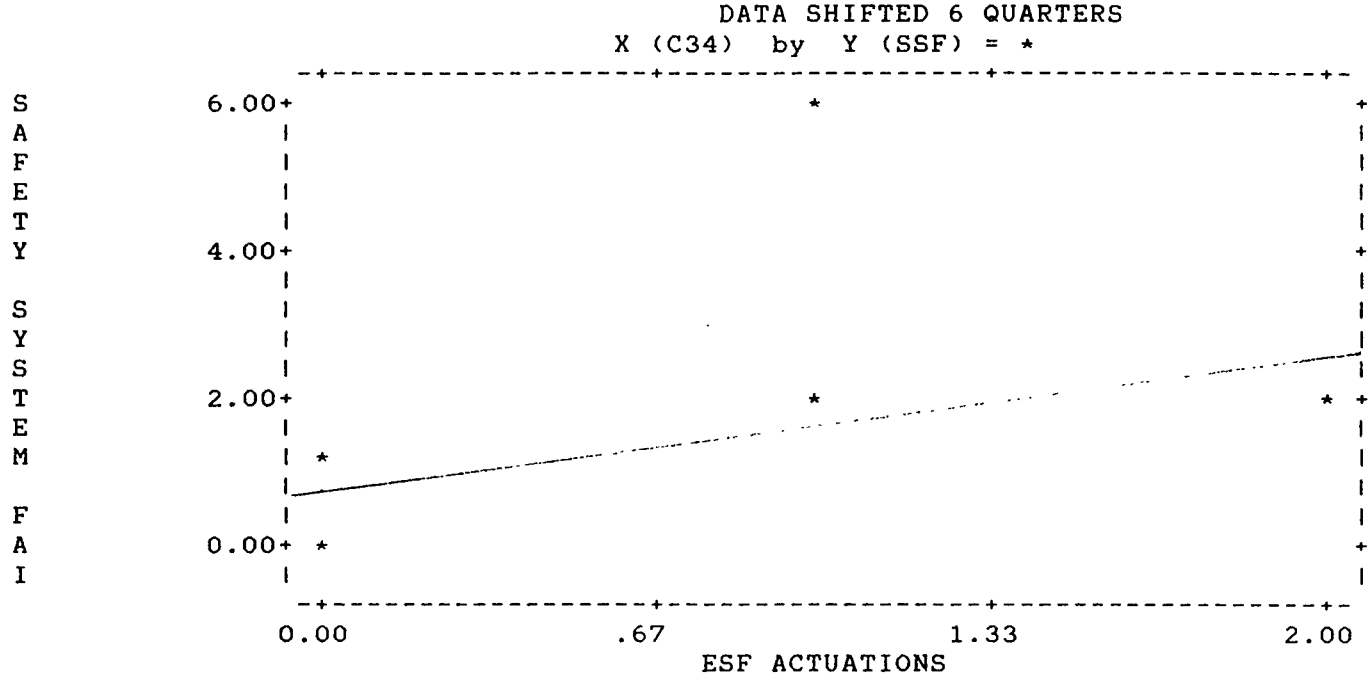

Performance Indicator Analysis
ESF Actuations
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Equip. Forced Outages
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = ESF Actuations
M.O.S. = Equip. Forced Outages
Shift = 6
90
80
70
60
50
40
30
20
10
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

----------Scatter Plots----------
Date/Time 10-25-1988 13:30:18
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



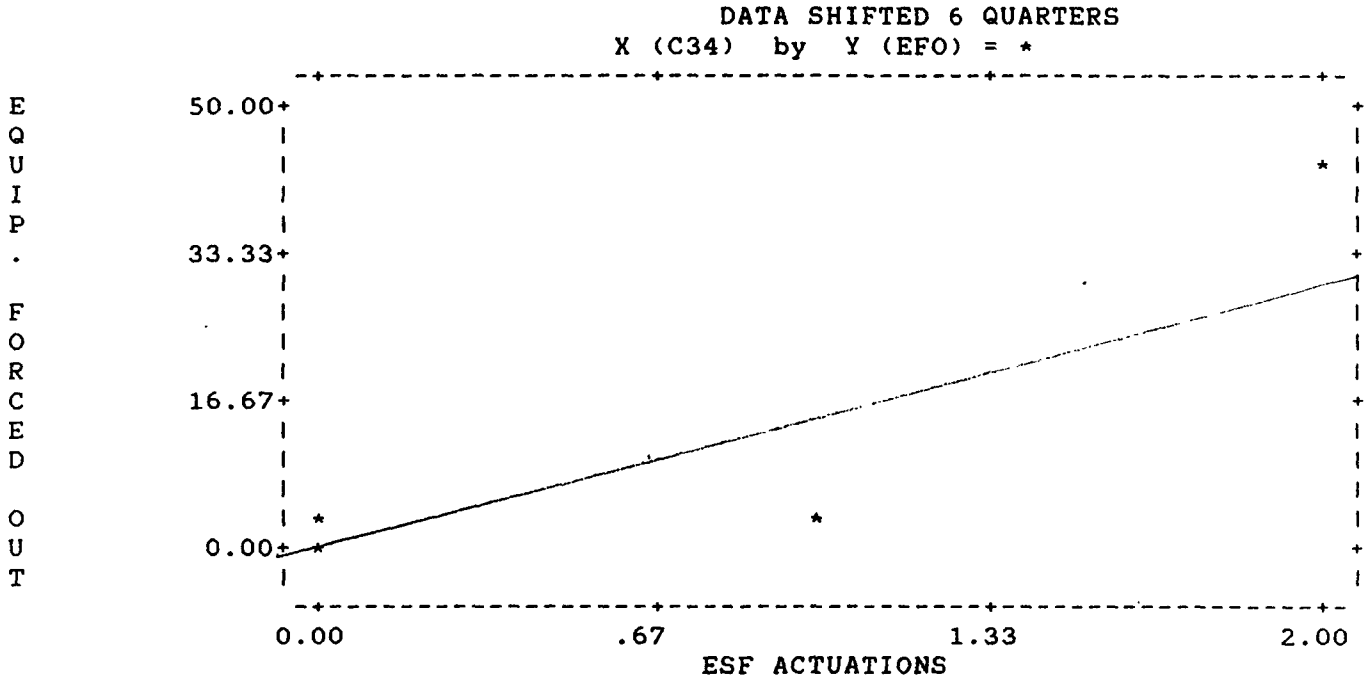
ew Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	6	(Y) :	1
Number of points plotted	:	7		

----------Scatter Plots----------

Date/Time 10-25-1988 13:30:58
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



. ow Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	6	(Y) :	1
Number of points plotted	:	7		

Detailed Results for Plant C

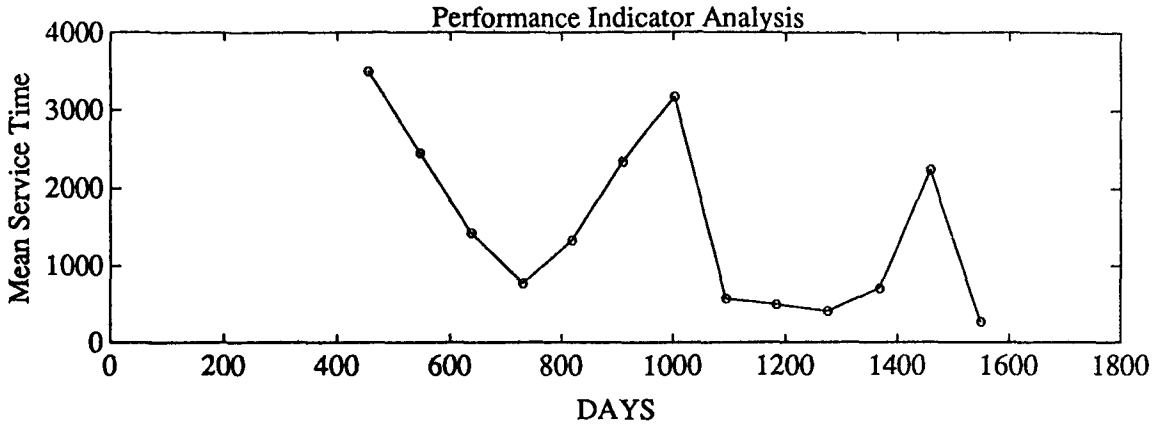
Maintenance Indicators vs. Measures of Safety

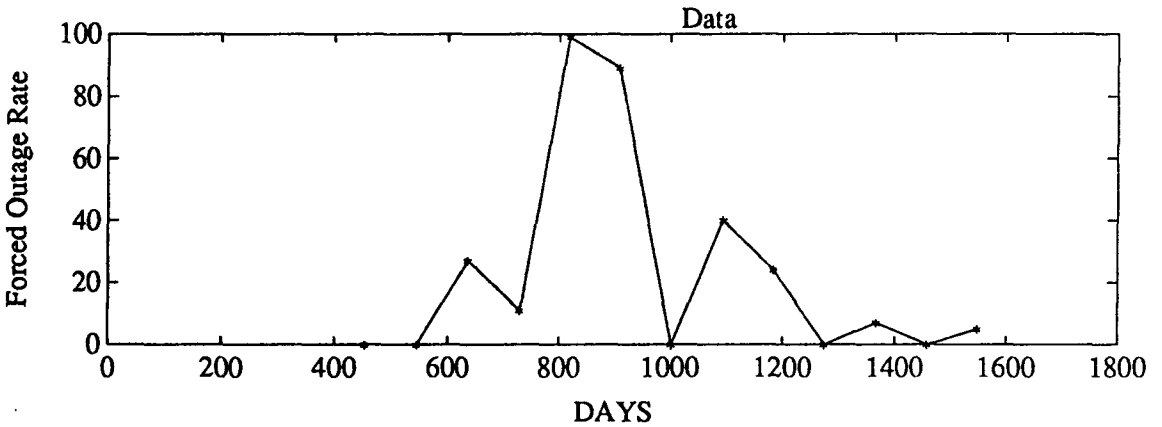
	RANK	1SCRTL	1SCRHI	1SCRLO	2SSA	3SE	4SSF	5FOR	7EFO	CRITHOUR	SALP-M	FRATE	AVAIL
1PMTOTM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2CMB	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3PMOVER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4MNTTO1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5REWORK1*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6DEFIC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7CMWRPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7OBOPMT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9MTSERV*	NS	NS	NS	NS	NS	NS	NS	S	NS	NS	N/A	NS	NS
CSCRAM*	N/A	S	NS	N/A	NS	NS	NS	NS	NS	NS	N/A	NS	NS
8ASSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8BSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8CSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8DSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BAHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BBHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BCHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BDHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BEHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BFHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BGHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CBSCRAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GHR*	NS	NS	NS	N/A	NS	NS	NS	NS	NS	NS	N/A	NS	NS
WPE*	[Zero events in relevant time scale]												
REALE*	[Zero events in relevant time scale]												
BACKECN*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WRONGT/U*	[Zero events in relevant time scale]												
ESFACT*	NS	NS	NS	N/A	NS	NS	NS	S	S	S	N/A	NS	S

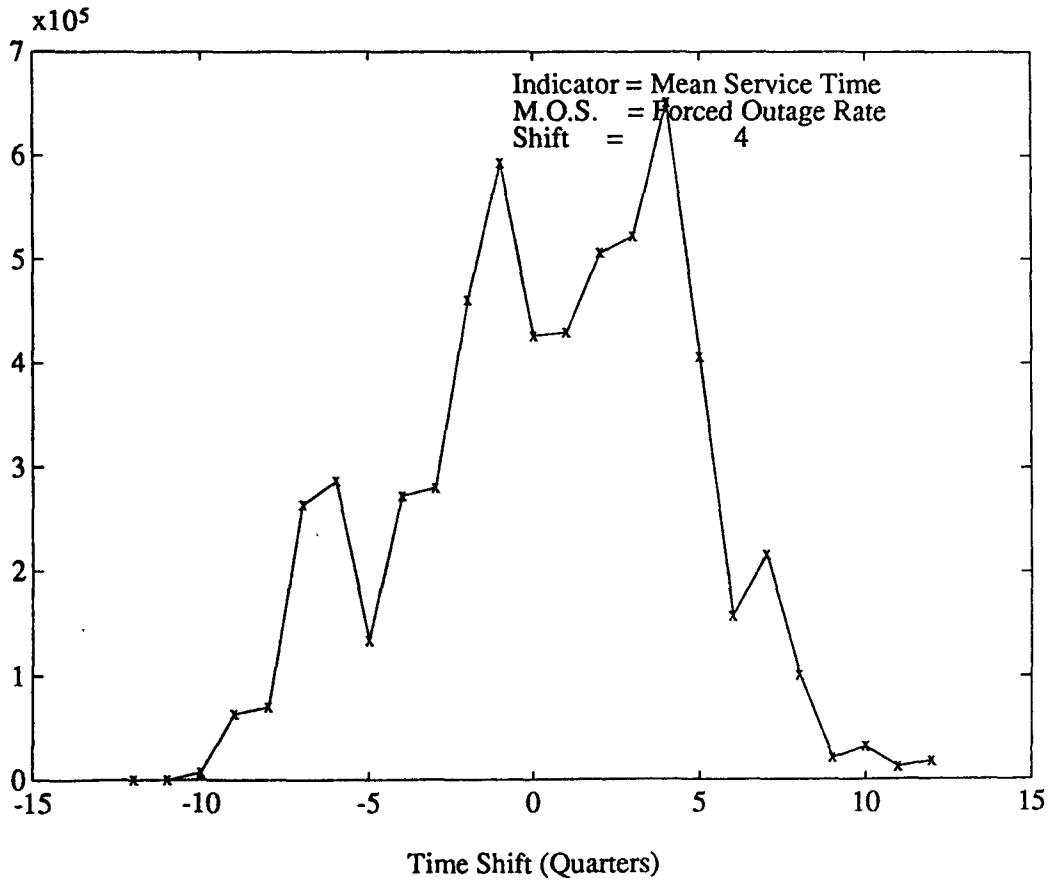
Note: Indicators marked with an "*" are SAIC indicators

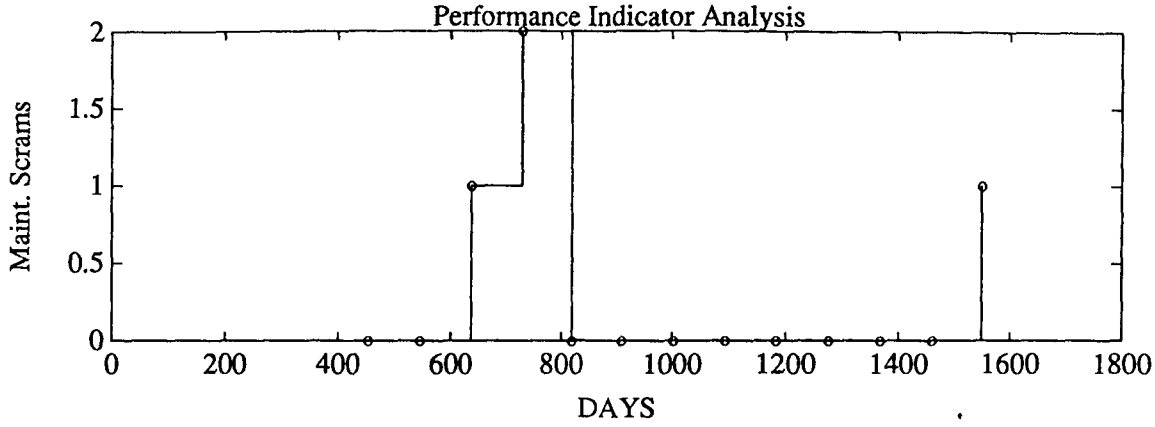
Significant Maintenance Indicator/Measure of Safety Relationships

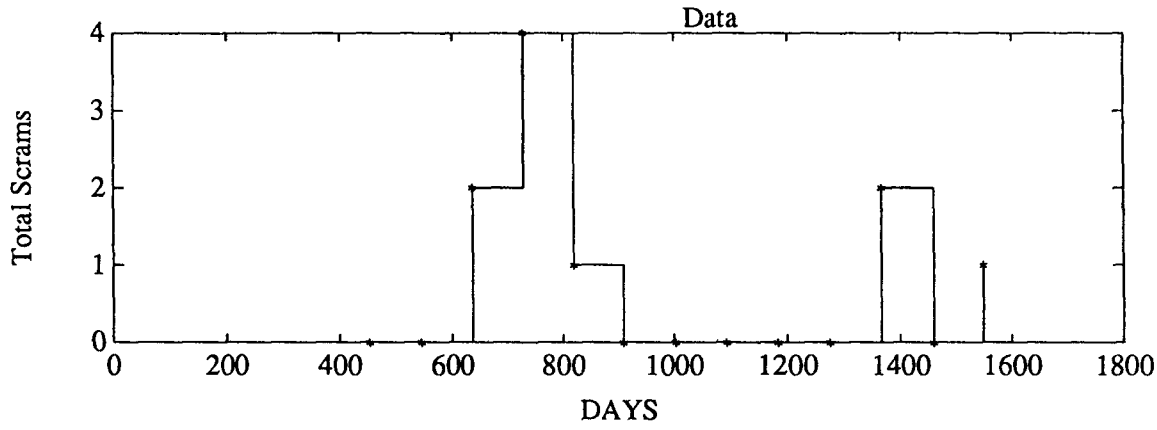
Indicator	Measure of Safety	Time Shift	Confidence
ESFACT	FOR	+2	80%
ESFACT	EFO	+2	80%
ESFACT	AVAIL	+4	89%
ESFACT	CRIT	+4	91%
9MTSERV	FOR	+4	87%
CSCRAM	SCRTL	+3	90%

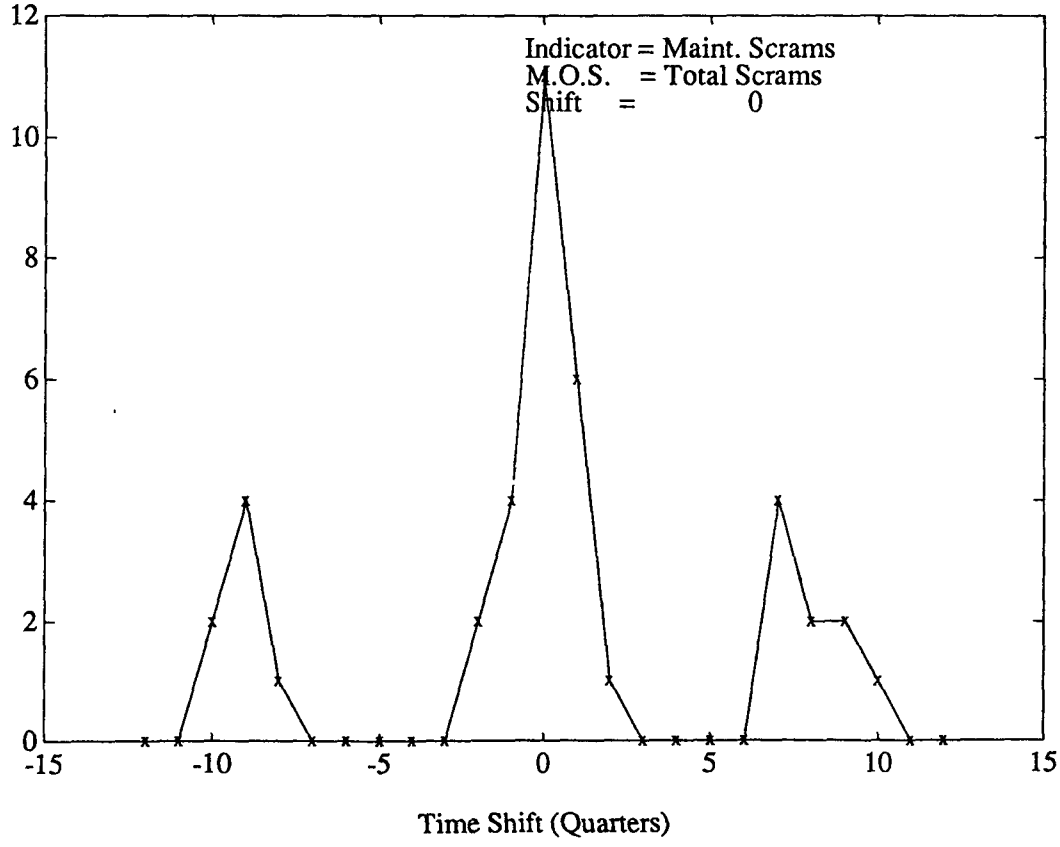

Performance Indicator Analysis
Mean Service Time
4000
3000
2000
1000
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

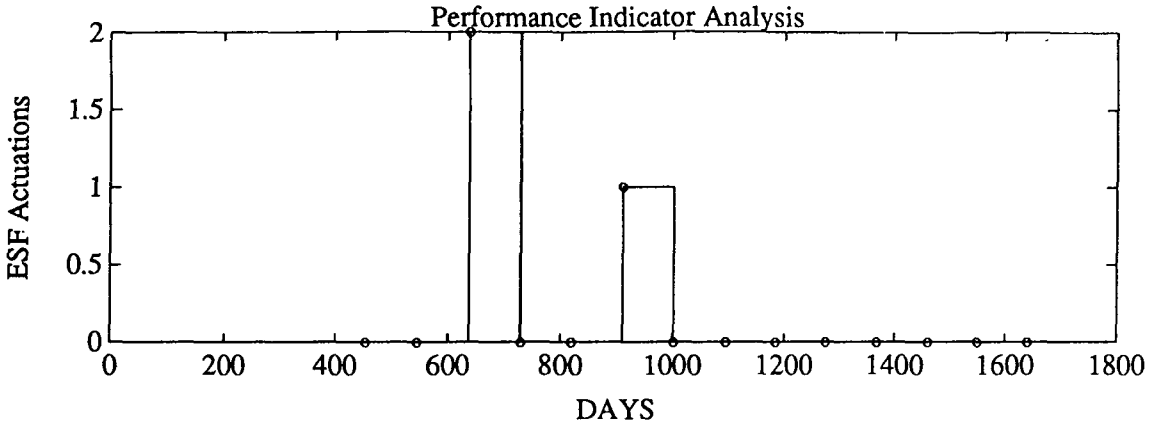

Data
Forced Outage Rate
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

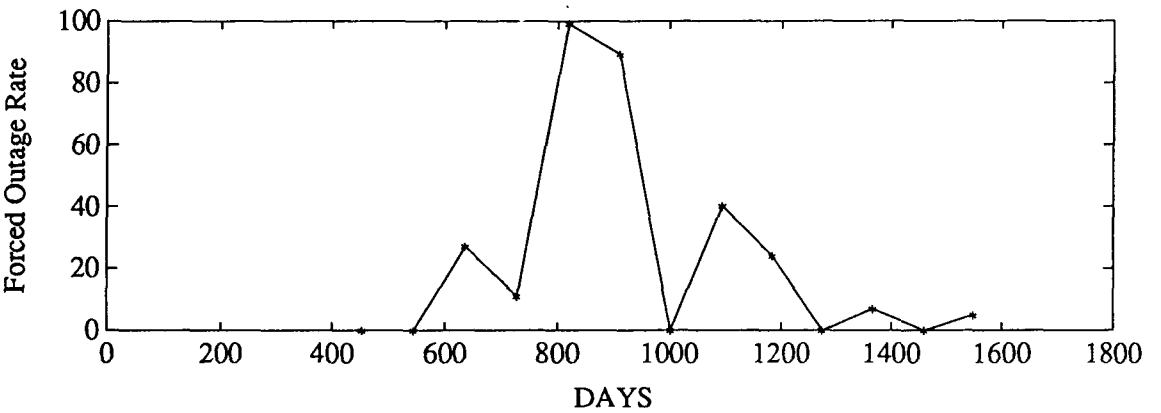

x10^5
7
6
5
4
3
2
1
0
Indicator = Mean Service Time
M.O.S. = Forced Outage Rate
Shift = 4
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

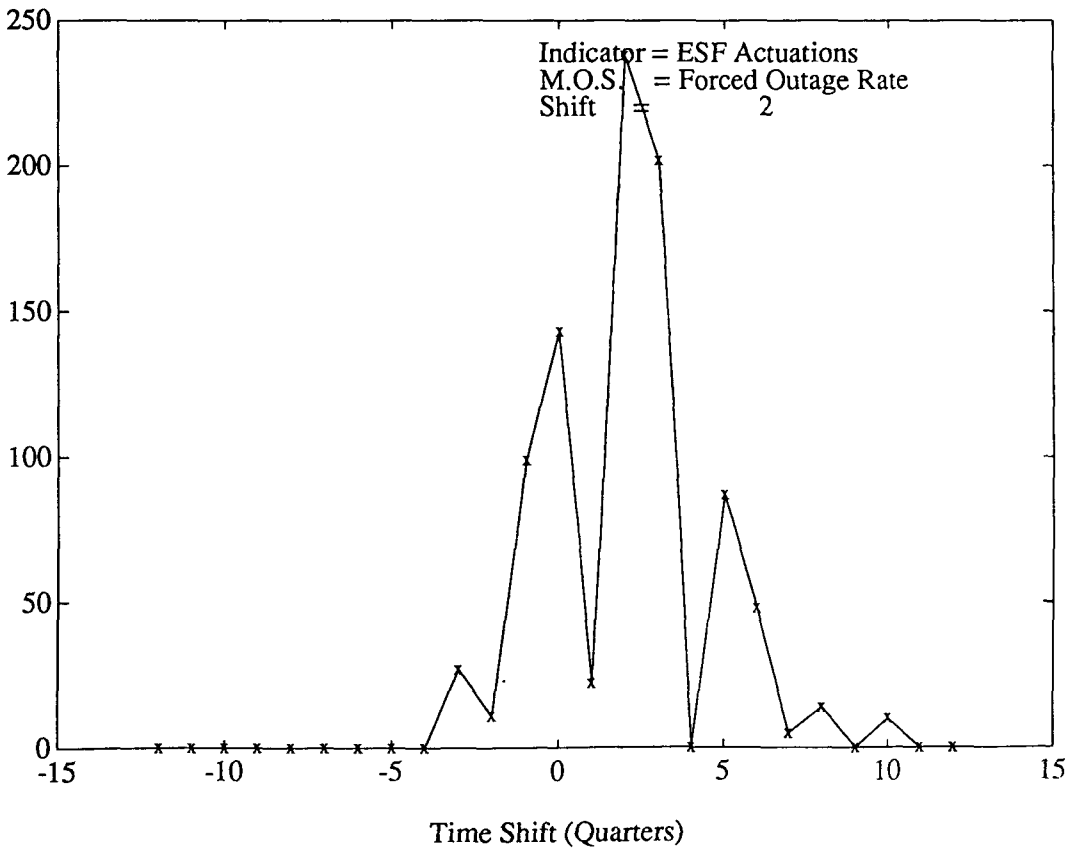

Performance Indicator Analysis
Maint. Scrams
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

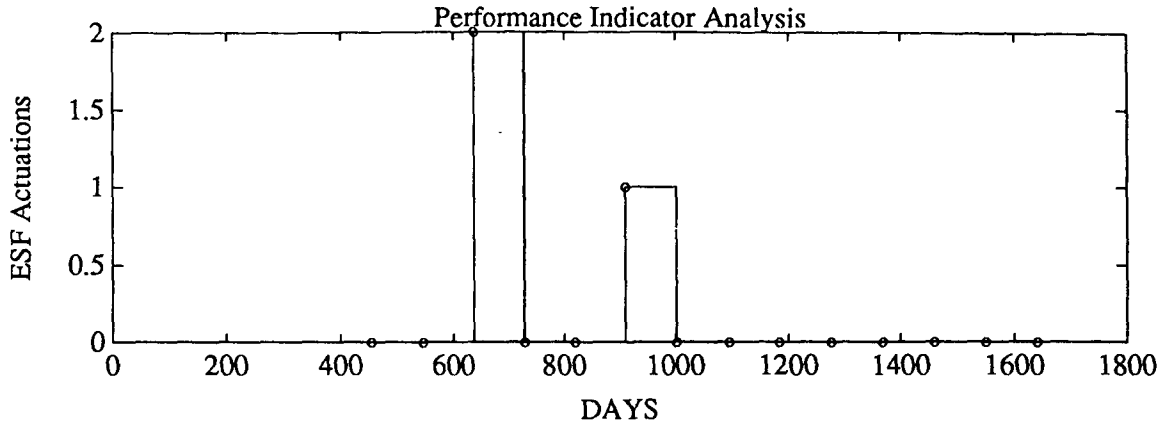

Data
Total Scrams
4
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

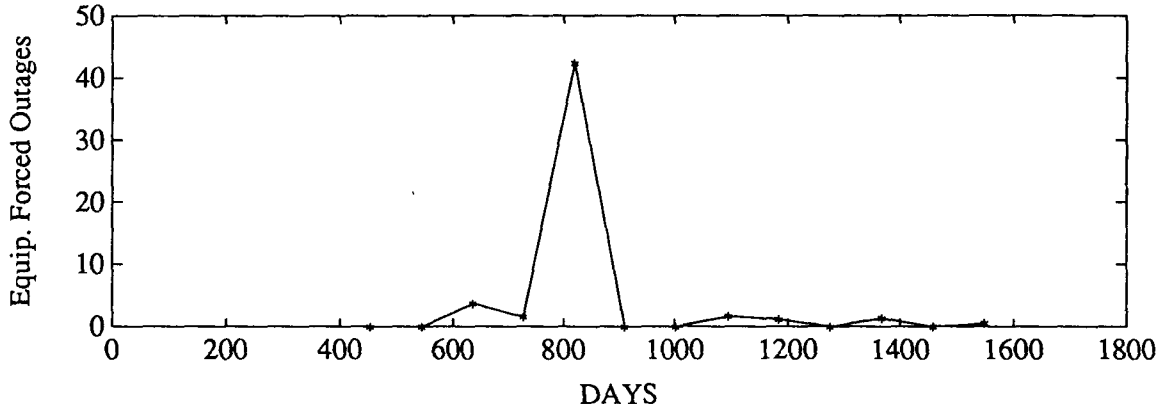

Indicator = Maint. Scrams
M.O.S. = Total Scrams
Shift = 0
12
10
8
6
4
2
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

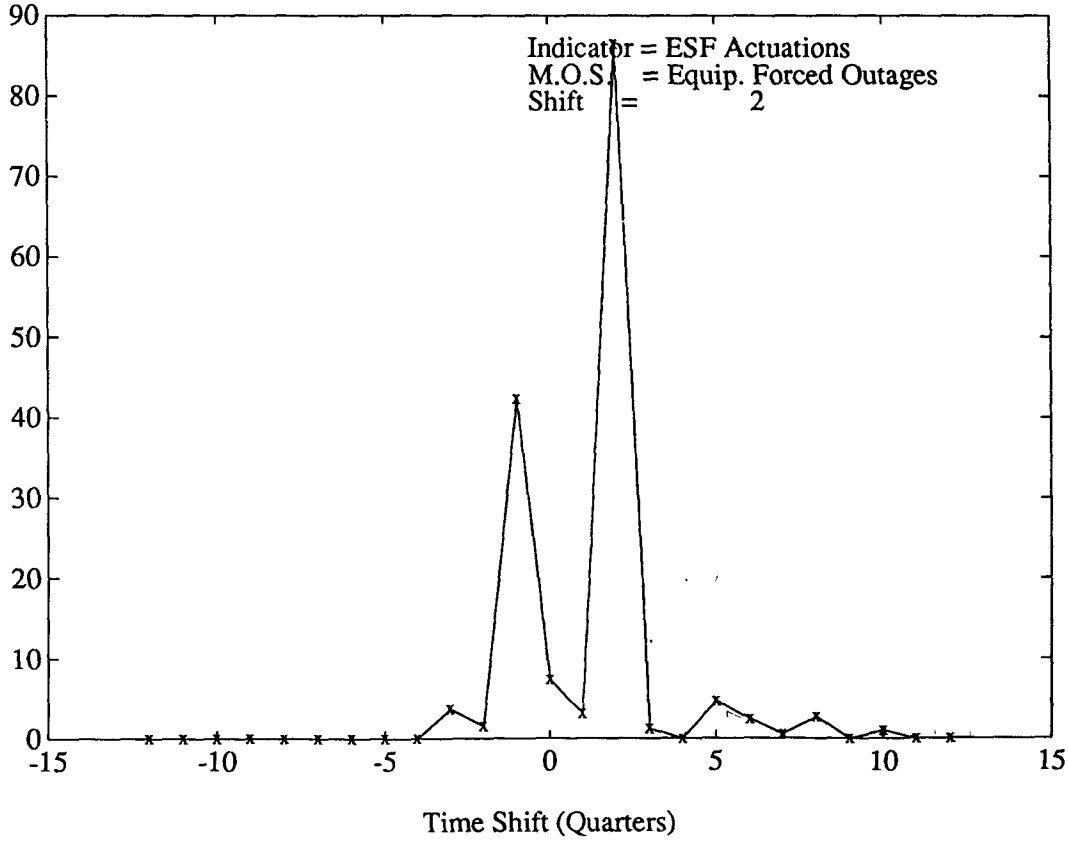

Performance Indicator Analysis
ESF Actuations
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

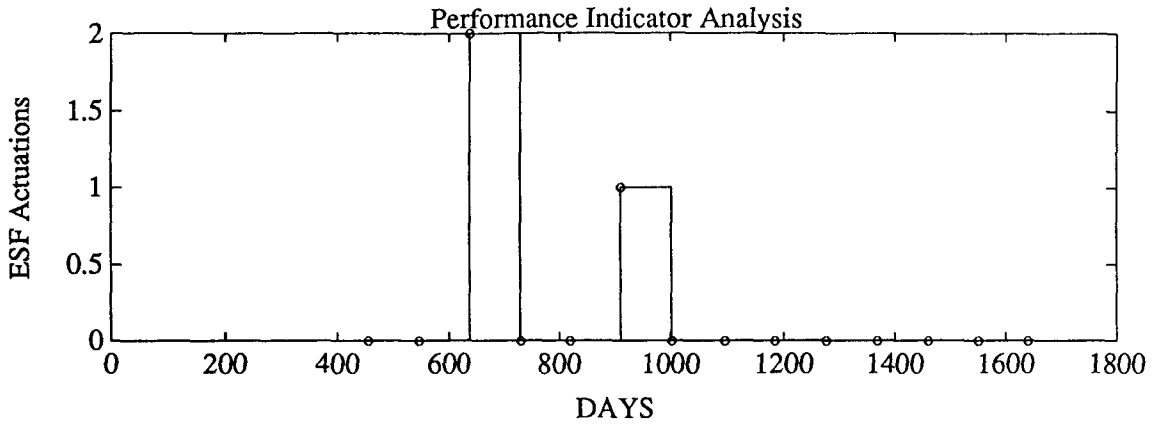

Forced Outage Rate
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

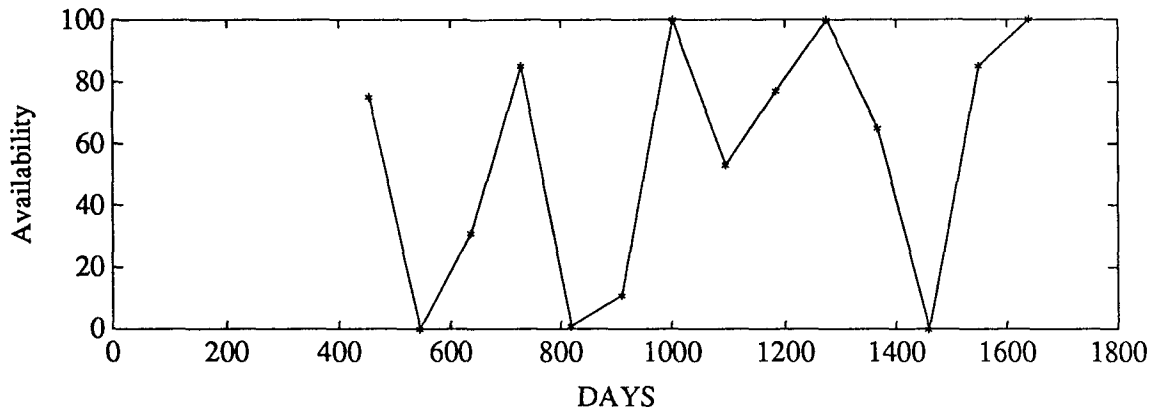

Indicator = ESF Actuations
M.O.S. = Forced Outage Rate
Shift = 2
250
200
150
100
50
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

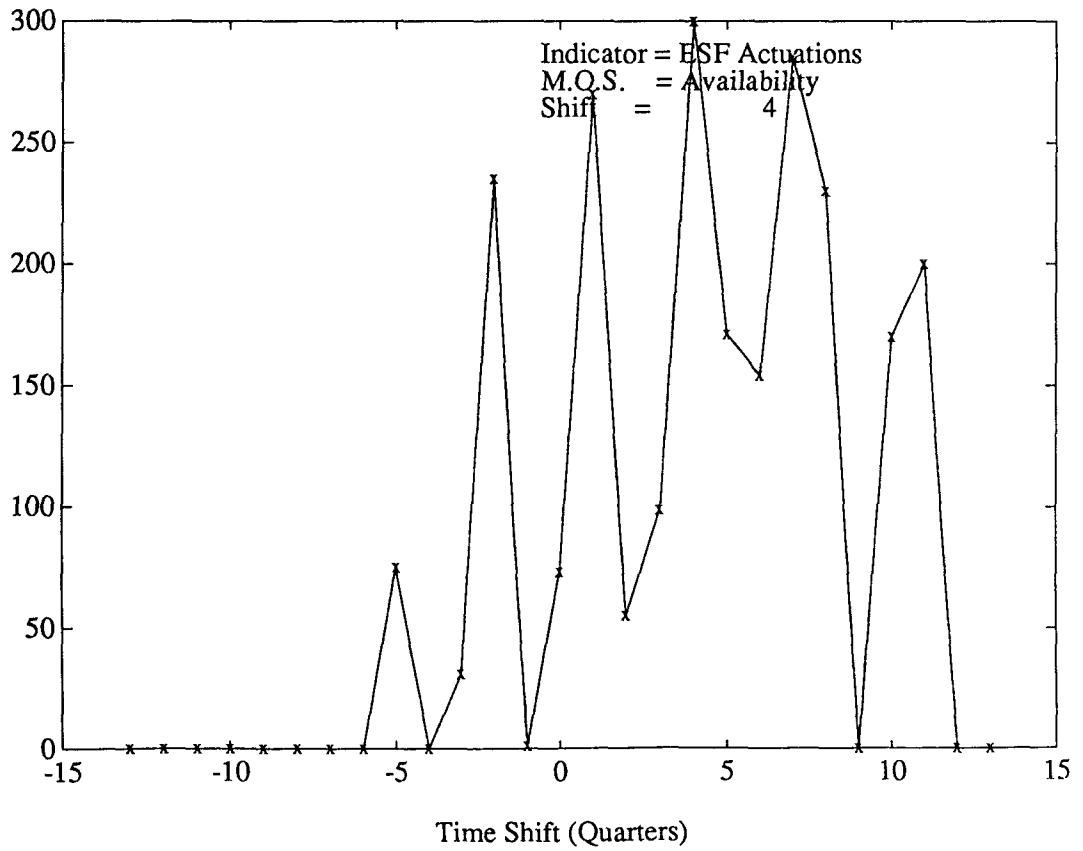

Performance Indicator Analysis
ESF Actuations
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

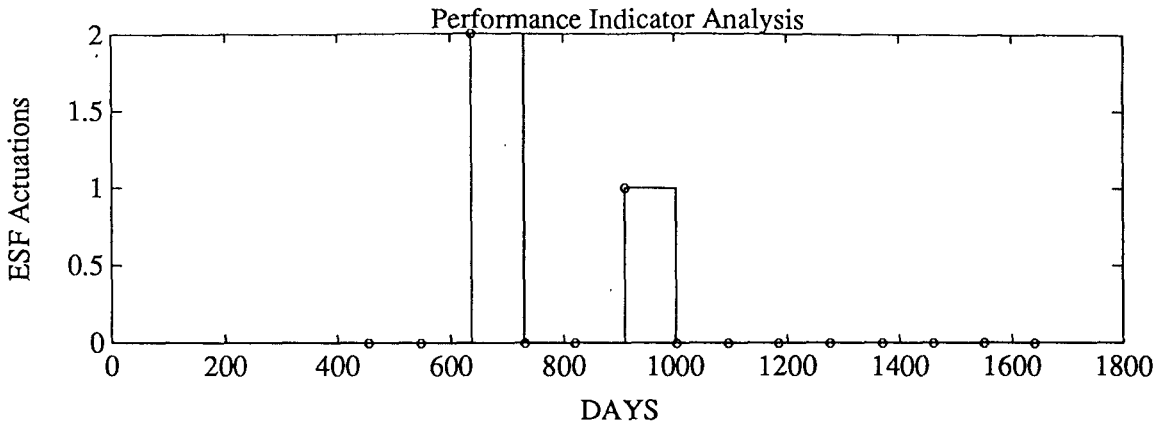

Equip. Forced Outages
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

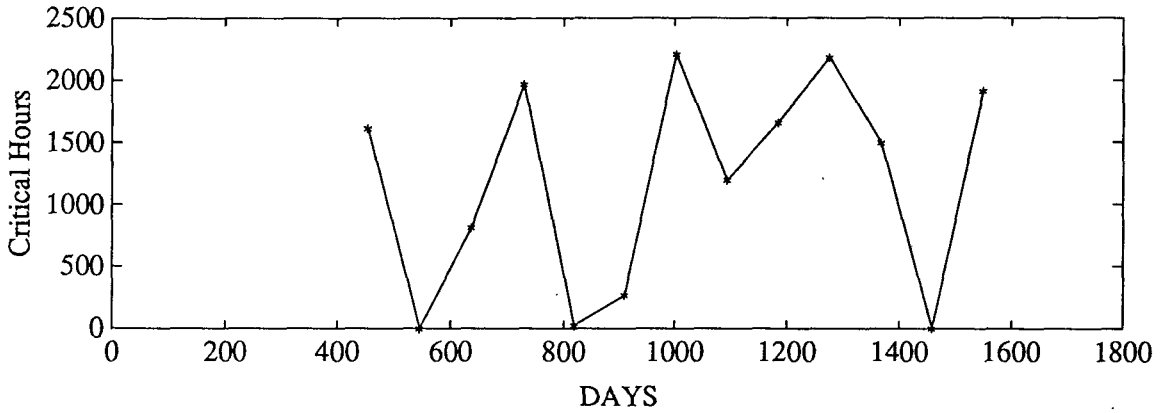

Indicator = ESF Actuations
M.O.S. = Equip. Forced Outages
Shift = 2
90
80
70
60
50
40
30
20
10
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

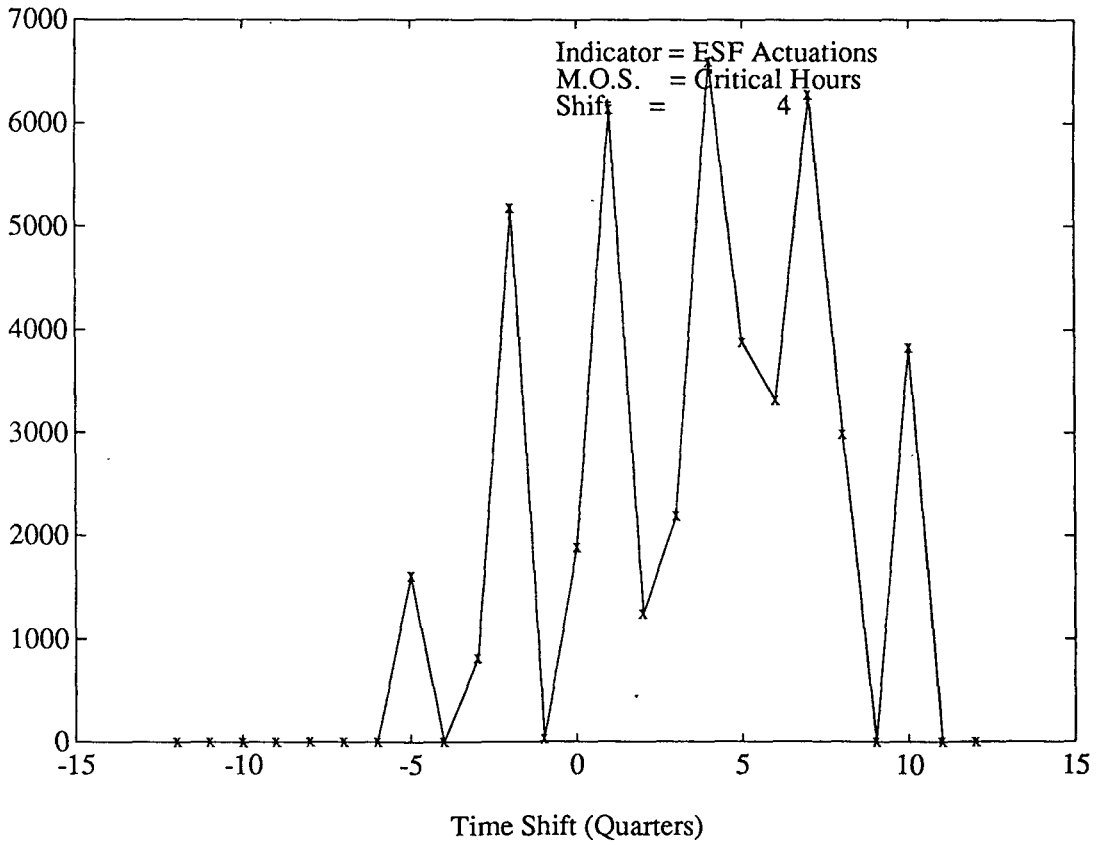

Performance Indicator Analysis
ESF Actuations
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Availability
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = ESF Actuations
M.O.S. = Availability
Shift = 4
300
250
200
150
100
50
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

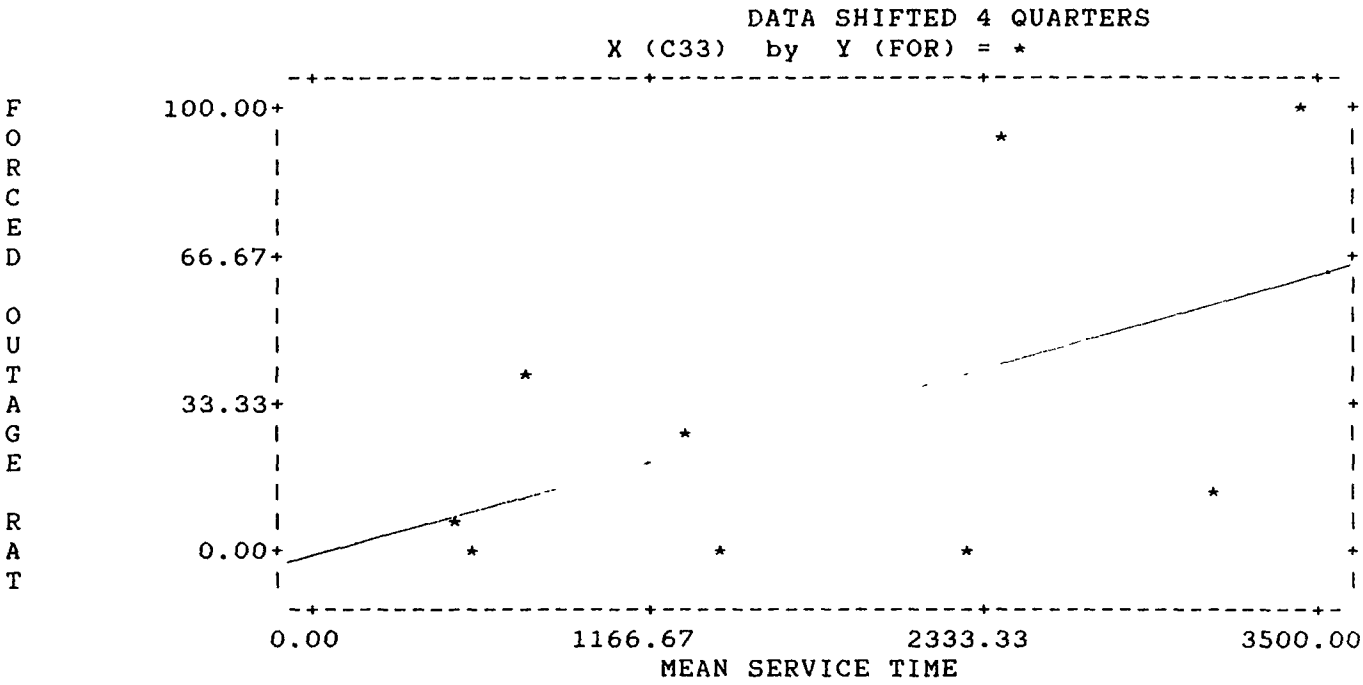

Performance Indicator Analysis
ESF Actuations
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Critical Hours
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = ESF Actuations
M.O.S. = Critical Hours
Shift = 4
7000
6000
5000
4000
3000
2000
1000
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

Date/Time 10-25-1988 13:39:52
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



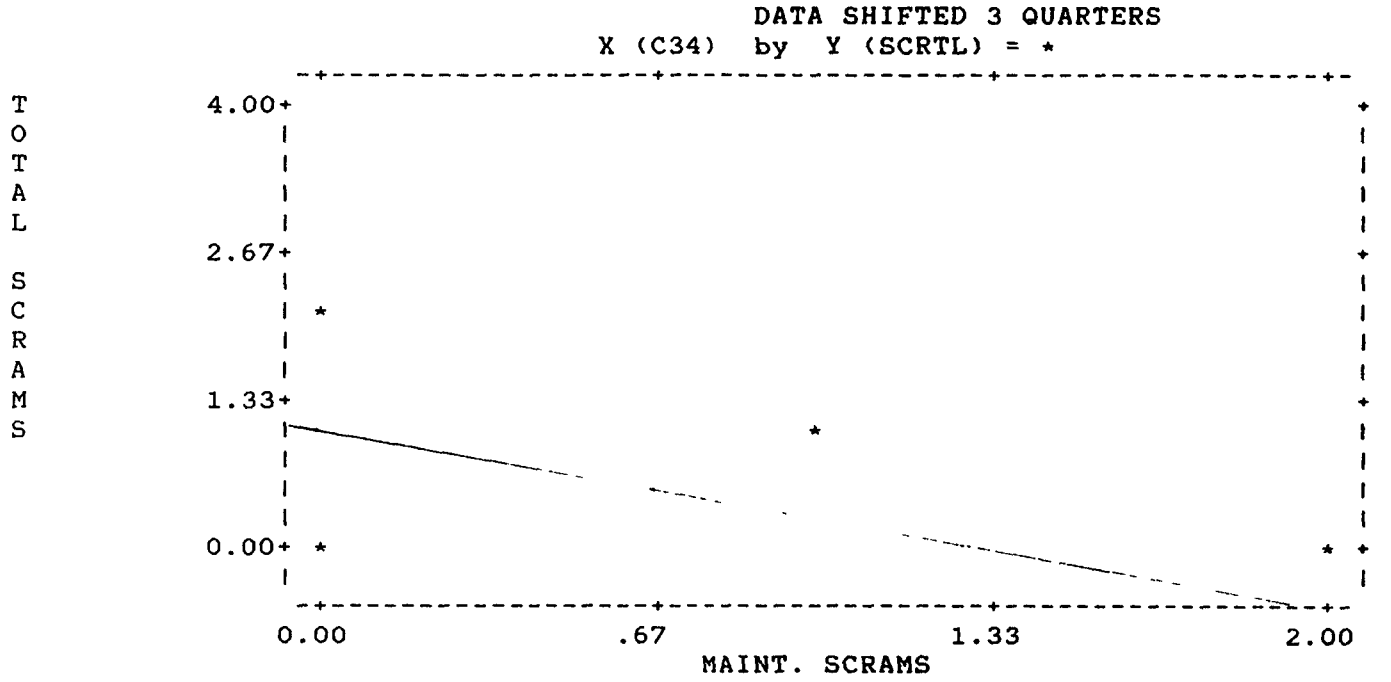
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	4	(Y) :	1
Number of points plotted	:	9		

----------Scatter Plots----------

Date/Time 10-25-1988 13:41:31
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



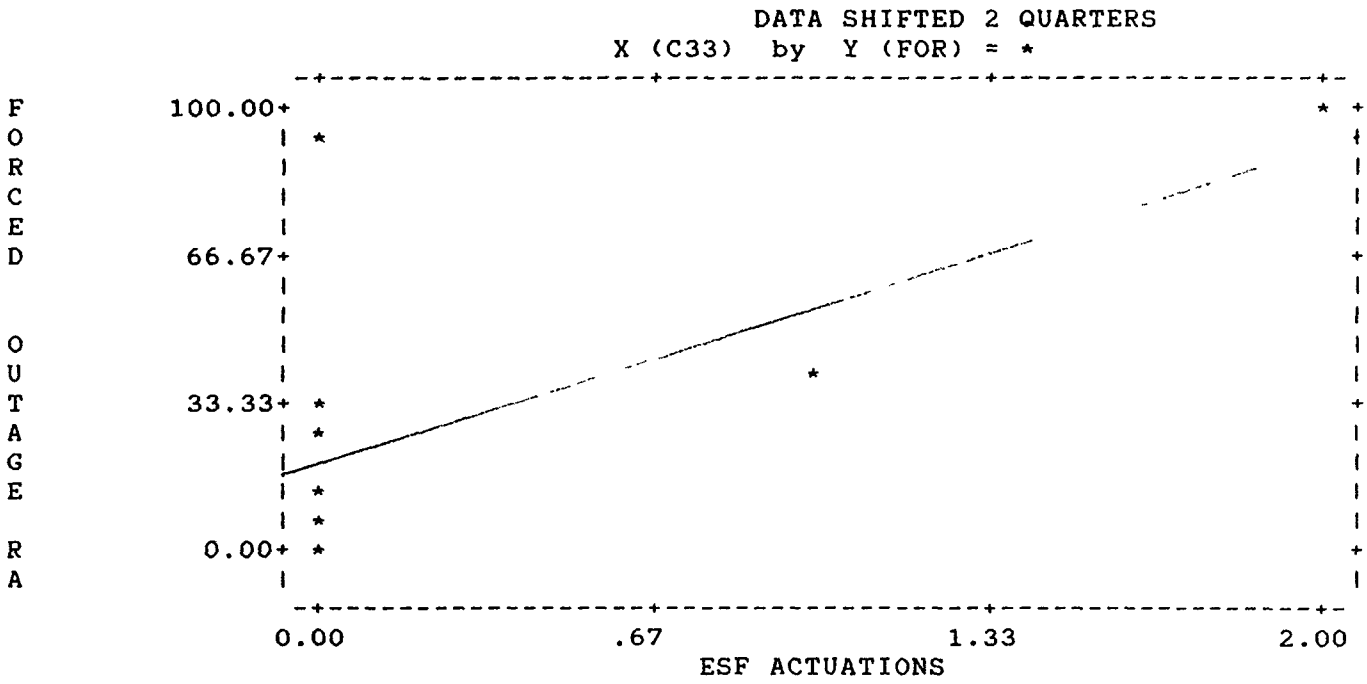
ew Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	7	(Y) :	1
Number of points plotted	:	6		

----------Scatter Plots----------

Date/Time 10-25-1988 13:35:12
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



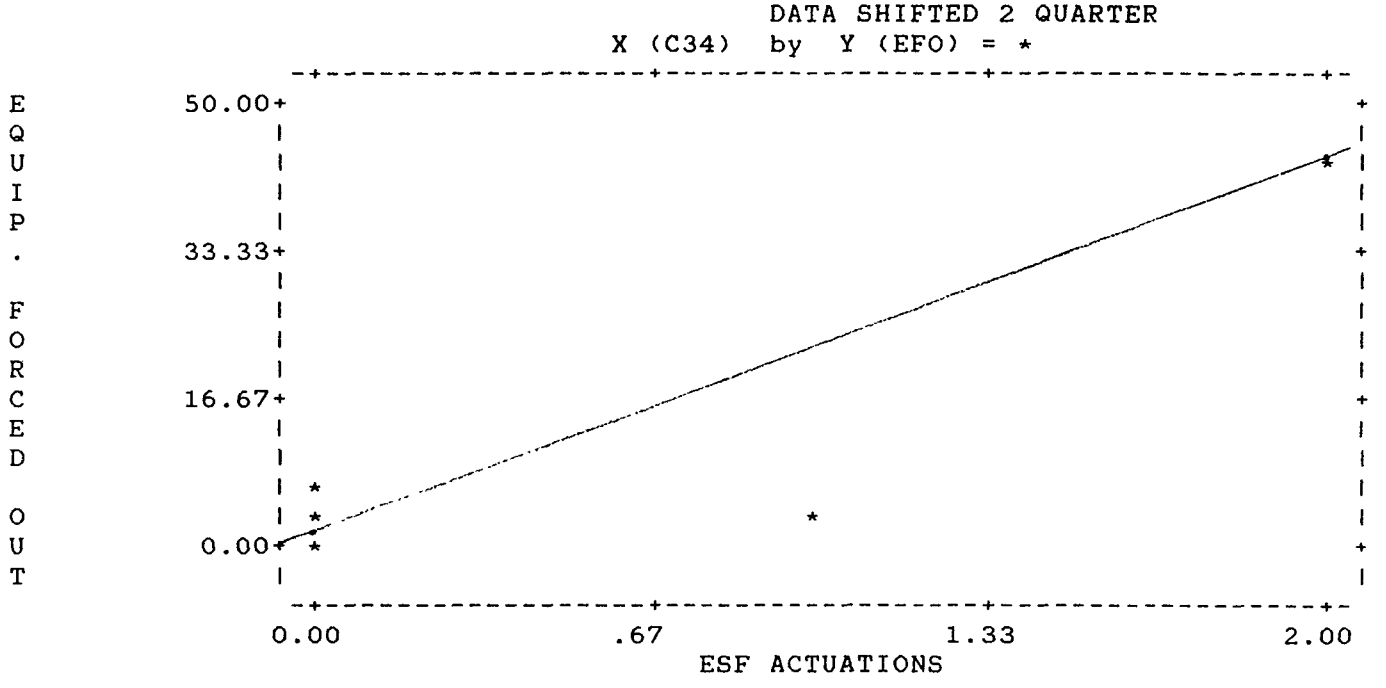
w Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	2	(Y) :	1
Number of points plotted	:	11		

----------Scatter Plots----------

Date/Time 10-25-1988 15:53:11
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



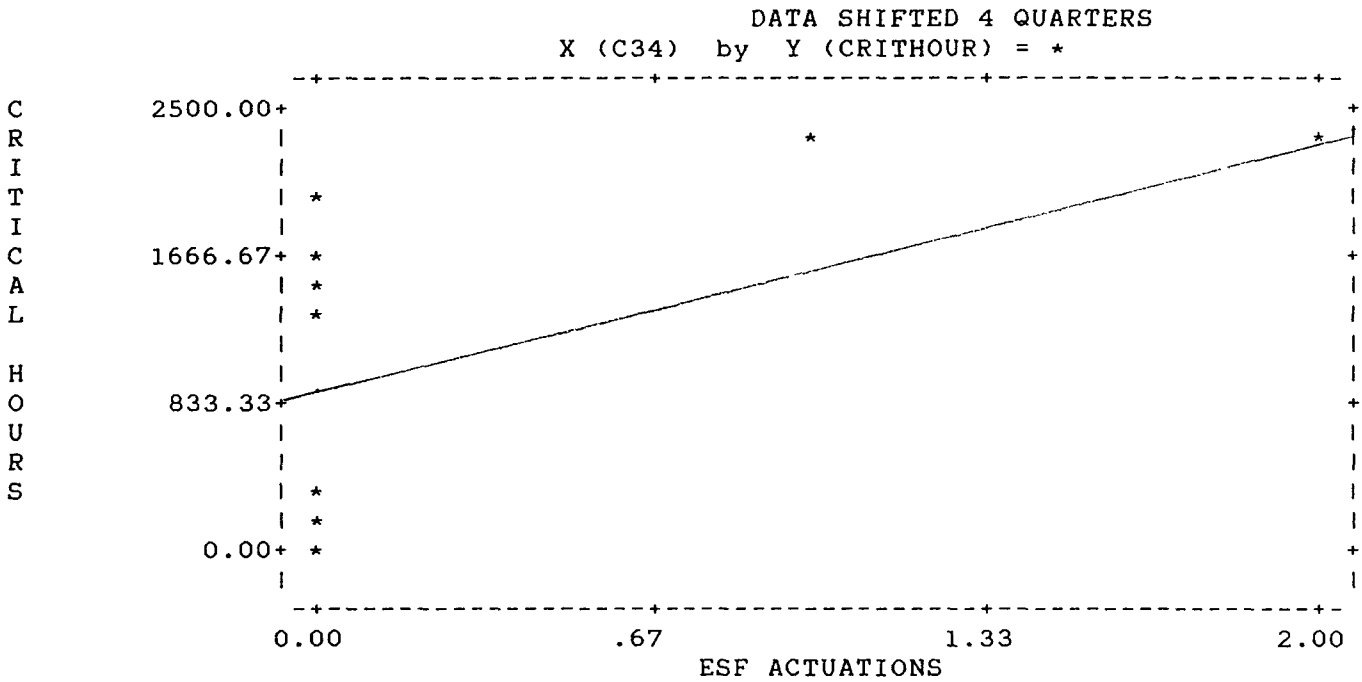
w Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	2	(Y) :	1
Number of points plotted	:	11		

----------Scatter Plots----------

Date/Time 10-25-1988 13:37:34
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	4	(Y) :	1
Number of points plotted	:	9		

Detailed Results for Plant E

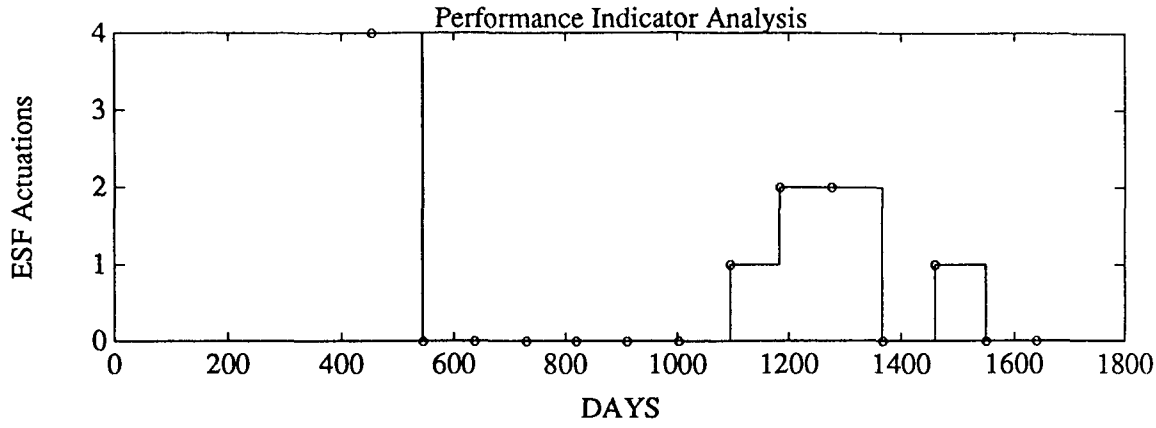
Maintenance Indicators vs. Measures of Safety

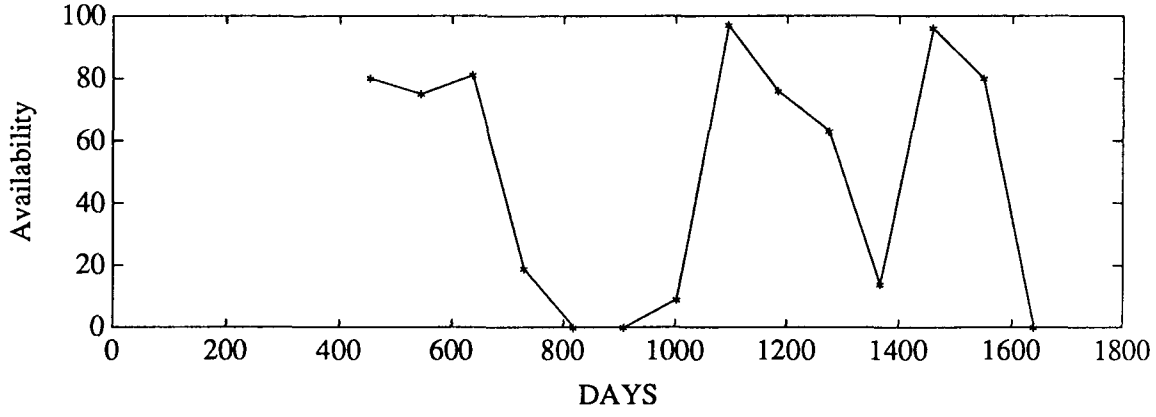
	RANK	1SCRTL	1SCRHI	1SCRLO	2SSA	3SE	4SSF	5FOR	7EFO	CRITHOUR	SALP-M	FRATE	AVAIL
1PMTOTM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2CMB	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3PMOVER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4MNTTO1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5REWORK1*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6DEFIC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7CMWRPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7DBOPMT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9MTSERV*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N/A	NS	NS
CSCRAM*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8ASSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8BSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8CSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8DSSPI [Zero events in relevant time scale]											N/A		
BAHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BBHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BCHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BDHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BEHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BFHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BGHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CBSCRAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GHR*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N/A	NS	S
WPE*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N/A	NS	NS
REALE* [Zero events in relevant time scale]											N/A		
BACKECN*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WRONGT/U*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ESFACT*	NS	S	S	NS	NS	NS	S	S	S	S	N/A	NS	S

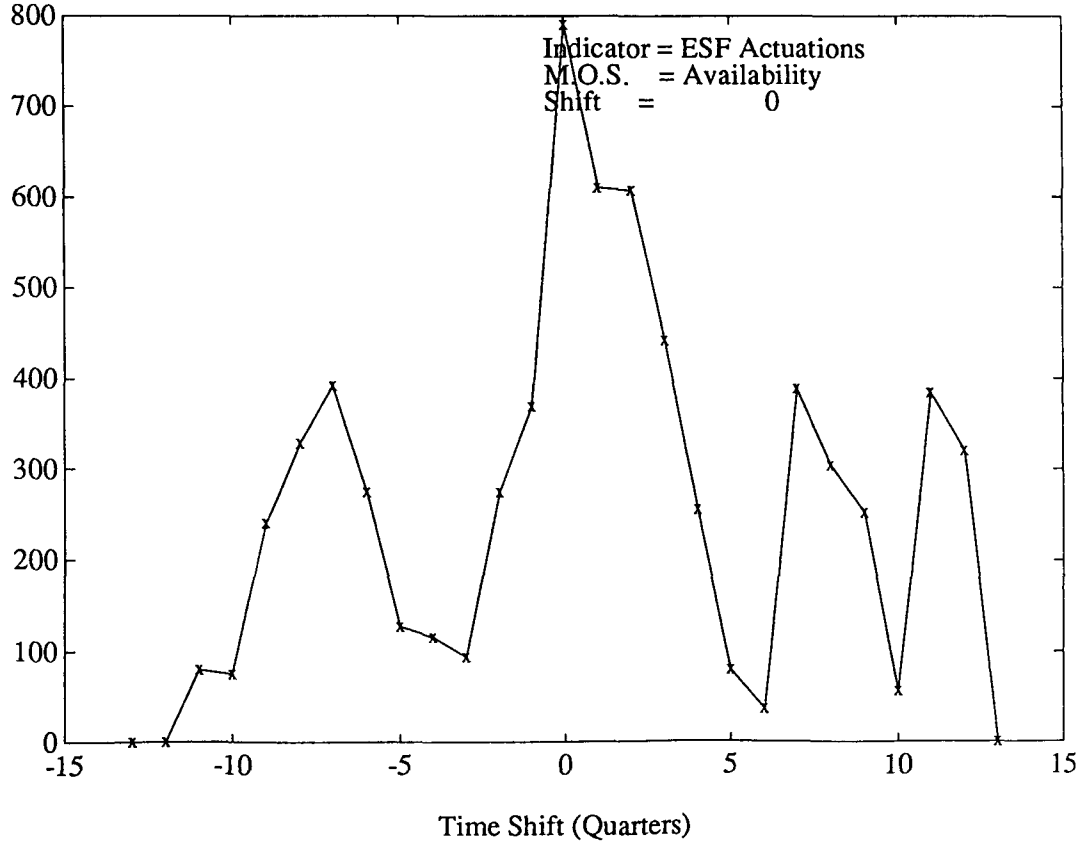
Note: Indicators marked with an "*" are SAIC indicators.

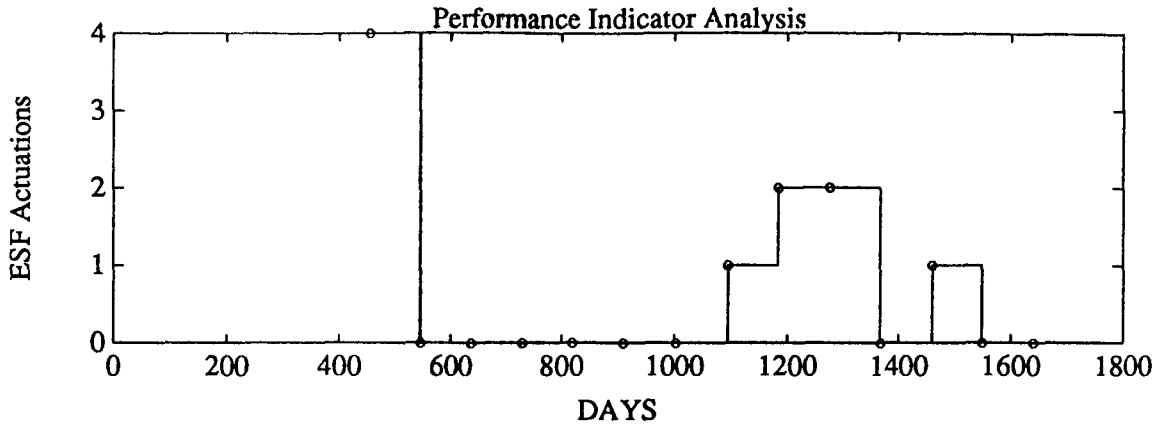
Significant Maintenance Indicator/Measure of Safety Relationships

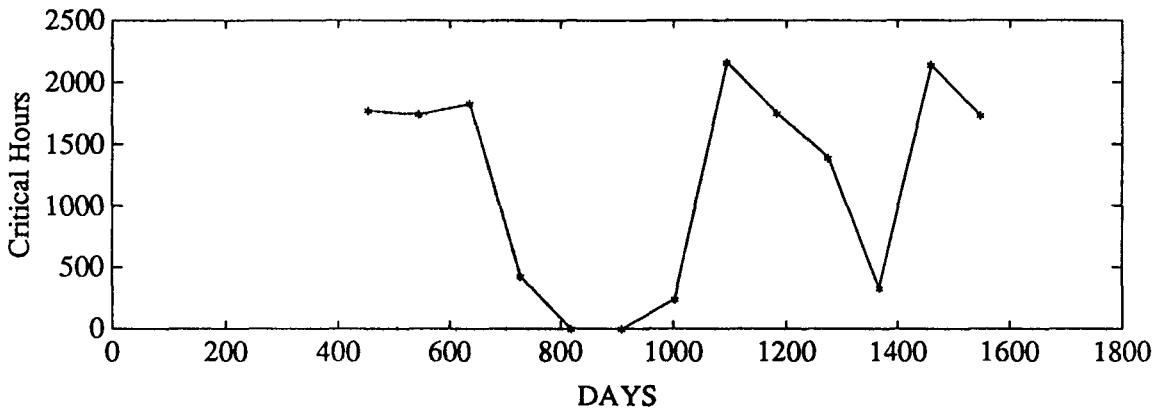
Indicator	Measure of Safety	Time Shift	Confidence
ESFACT	AVAIL	0	80%
ESFACT	CRITHOUR	0	85%
ESFACT	EFO	0	90%
ESFACT	SSF	0	82%
ESFACT	SCRHI	0	96%
ESFACT	SCRTL	0	95%
ESFACT	FOR	+1	80%
GHR	AVAIL	0	99%

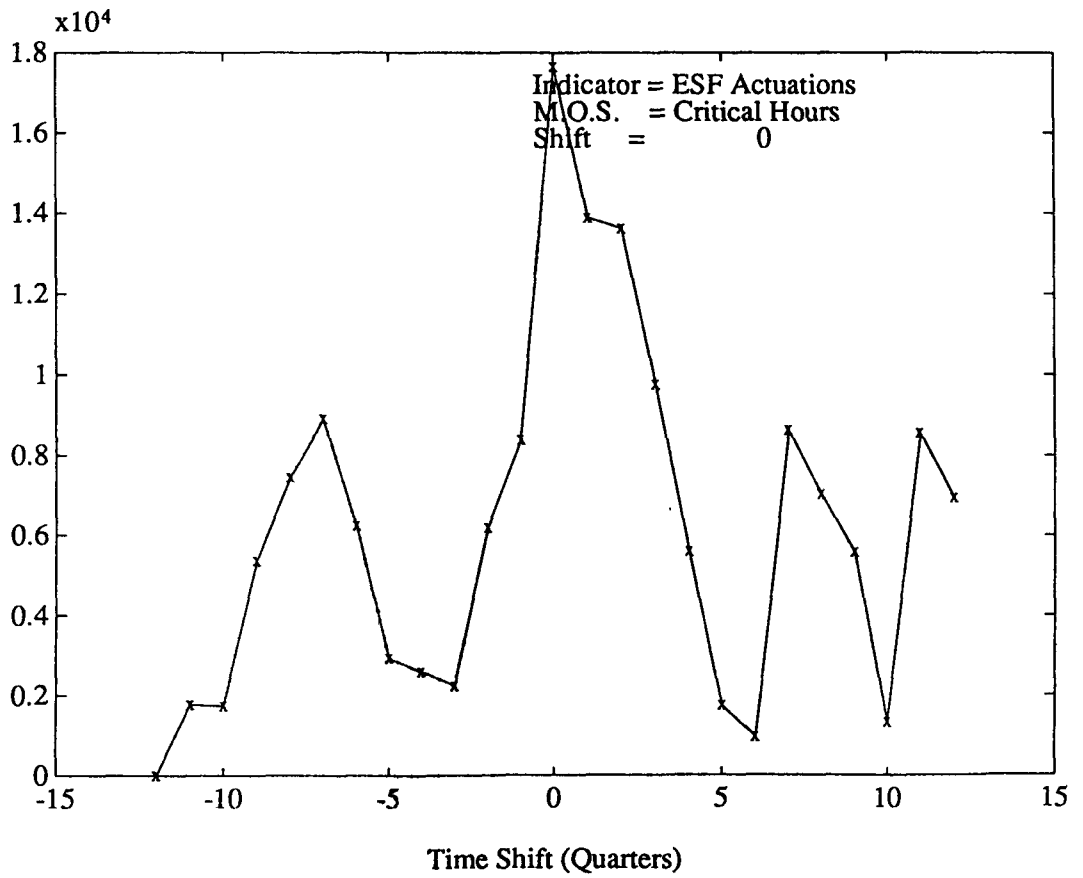

Performance Indicator Analysis
ESF Actuations
DAYS


Availability
DAYS


Indicator = ESF Actuations
M.O.S. = Availability
Shift = 0
Time Shift (Quarters)


Performance Indicator Analysis
ESF Actuations
DAYS

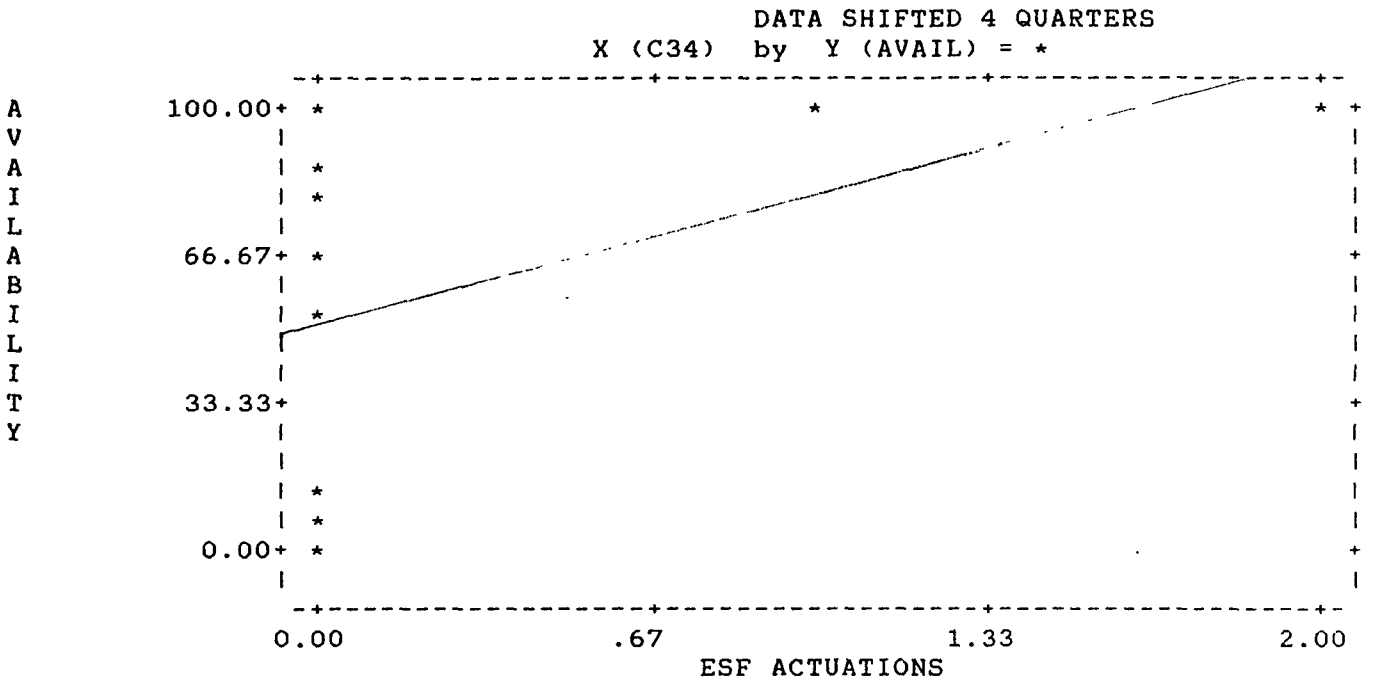

Critical Hours
DAYS


x10^4
Indicator = ESF Actuations
M.O.S. = Critical Hours
Shift = 0
Time Shift (Quarters)

----------Scatter Plots----------

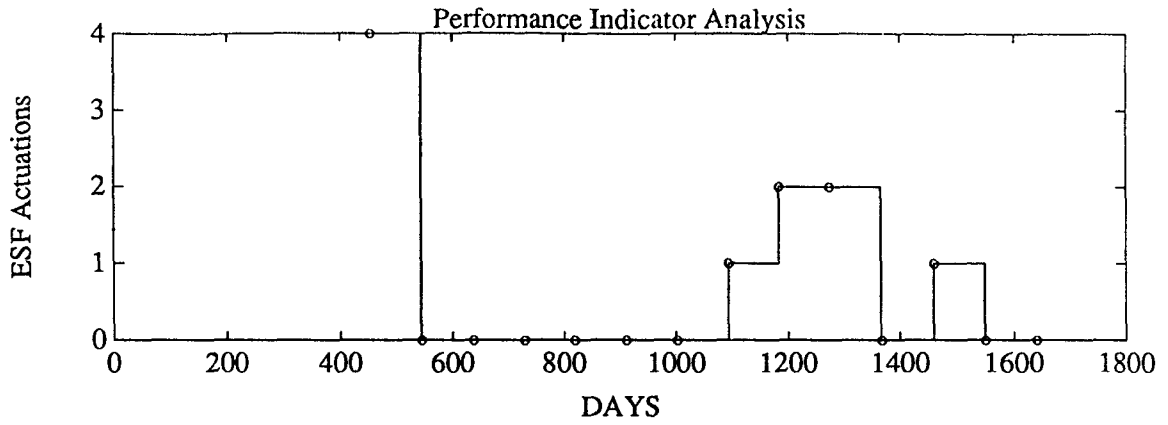
Date/Time 10-25-1988 13:36:53
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

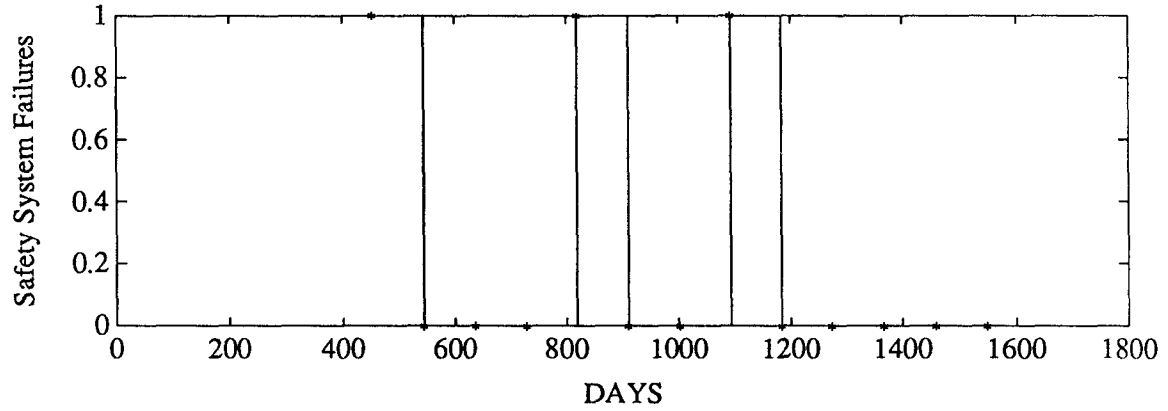
Scatter Plots

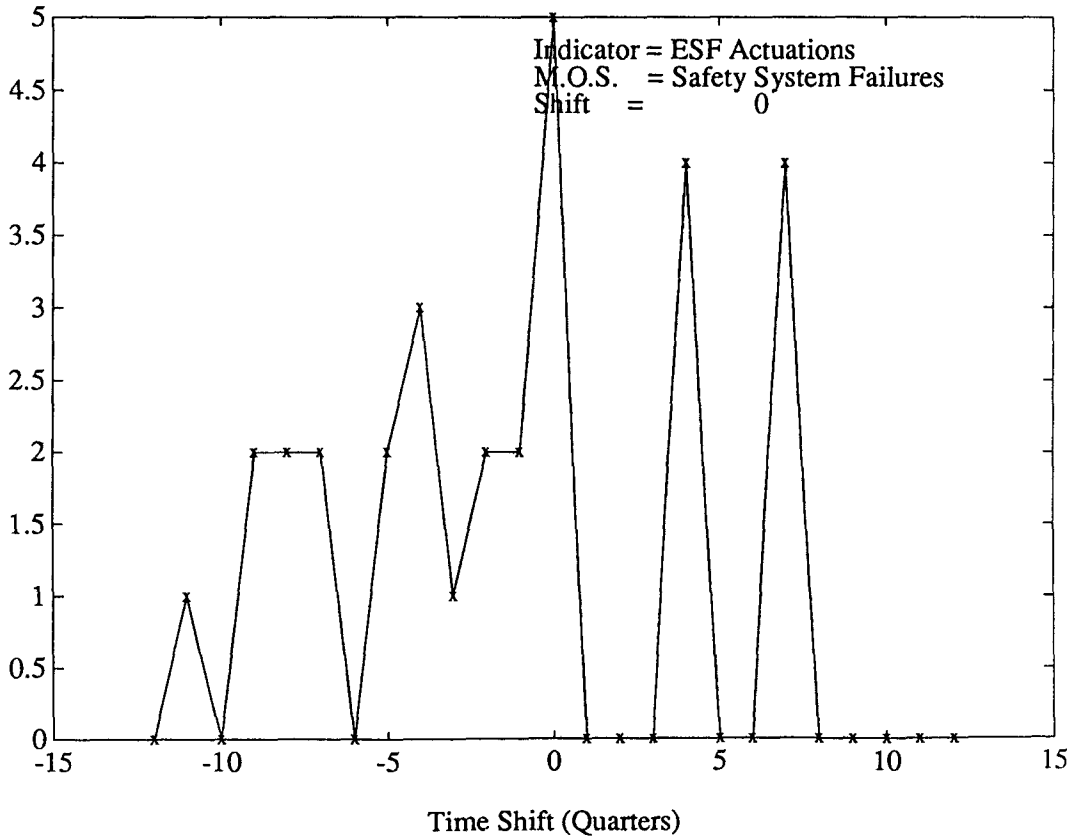


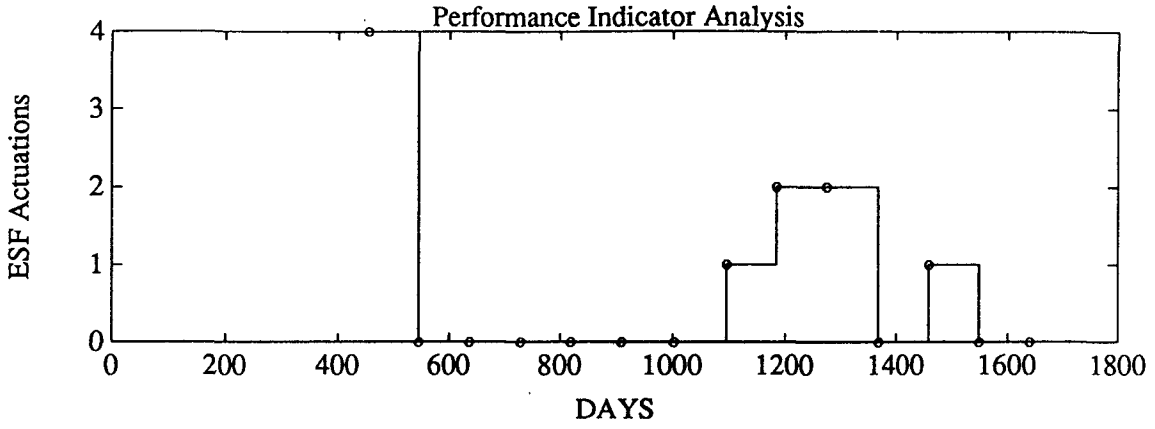
..ow Accounting Report

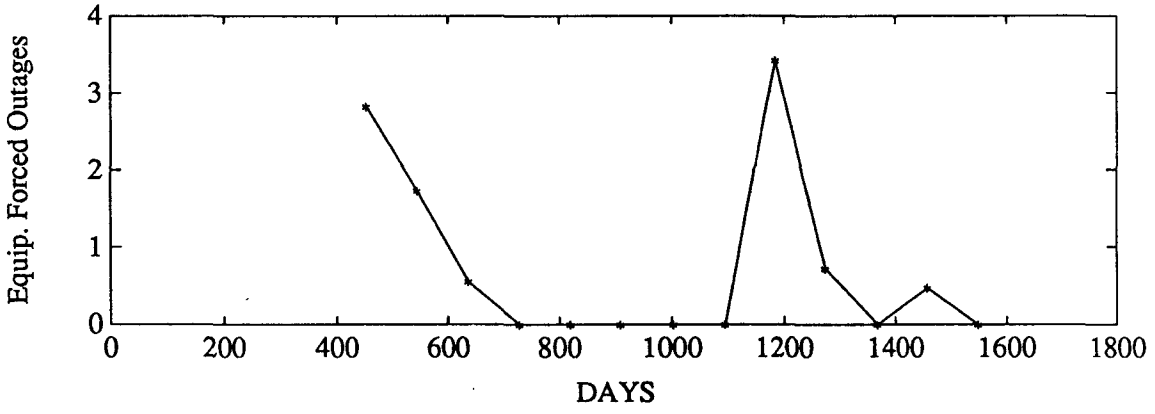
Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	4	(Y) :	0
Number of points plotted	:	10		

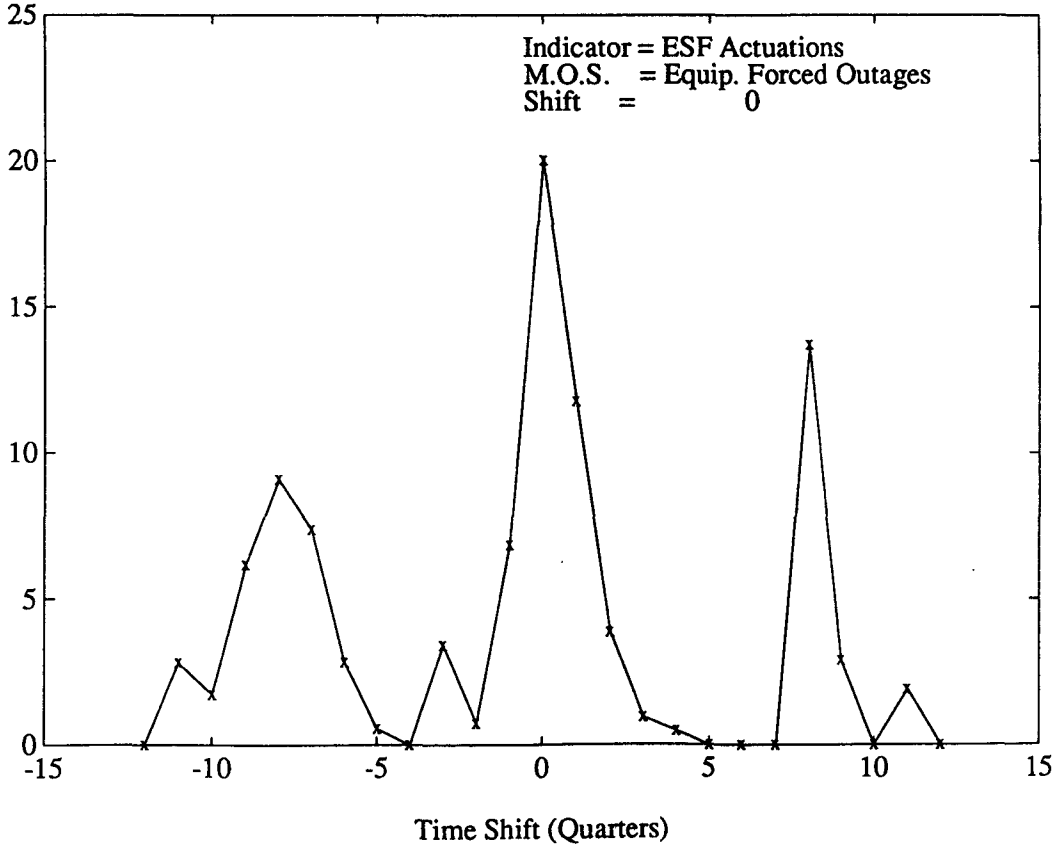

Performance Indicator Analysis
ESF Actuations
0
1
2
3
4
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

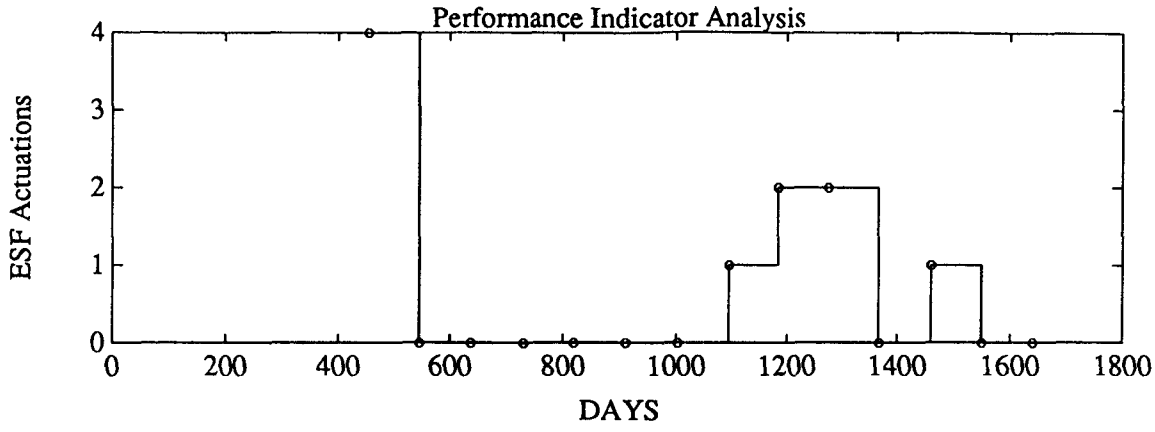

Safety System Failures
0
0.2
0.4
0.6
0.8
1
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

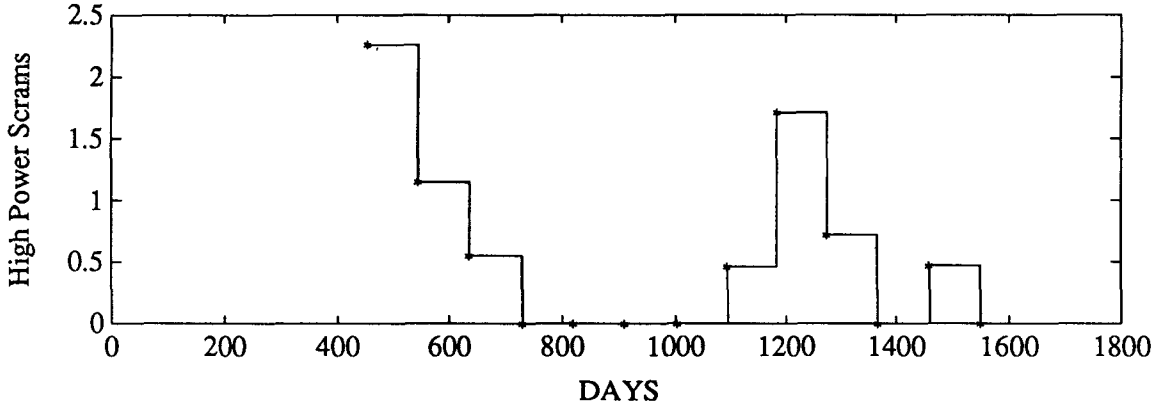

Indicator = ESF Actuations
M.O.S. = Safety System Failures
Shift = 0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

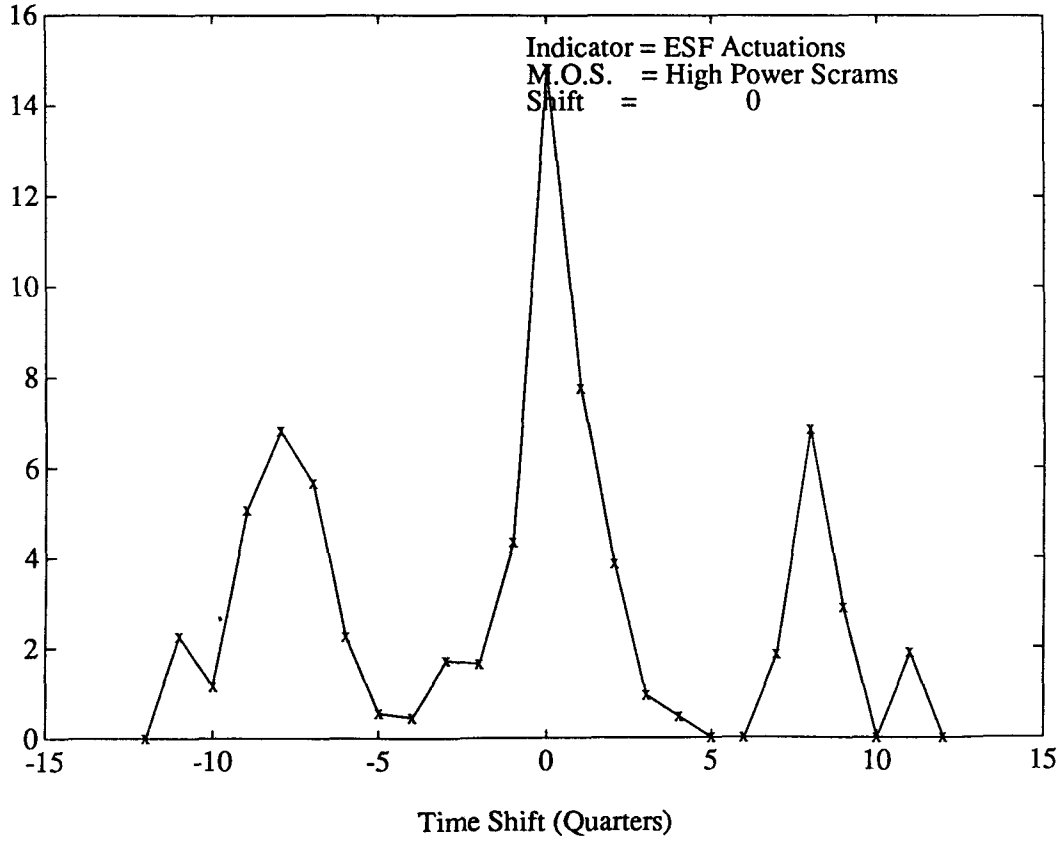

Performance Indicator Analysis
ESF Actuations
0
1
2
3
4
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

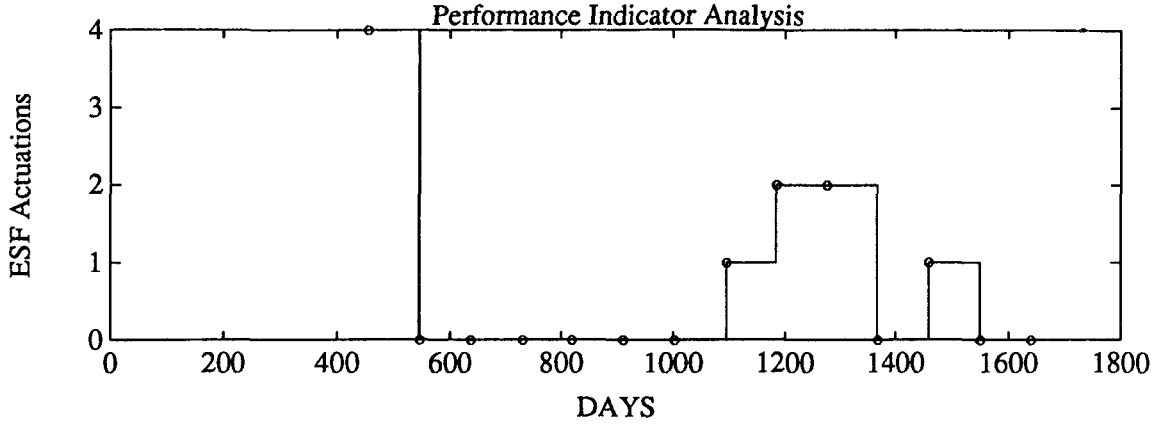

Equip. Forced Outages
0
1
2
3
4
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

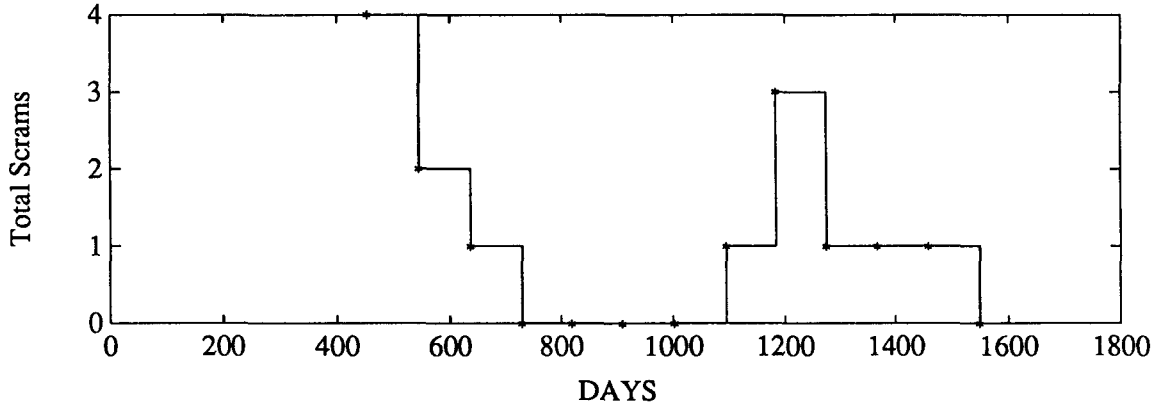

Indicator = ESF Actuations
M.O.S. = Equip. Forced Outages
Shift = 0
0
5
10
15
20
25
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

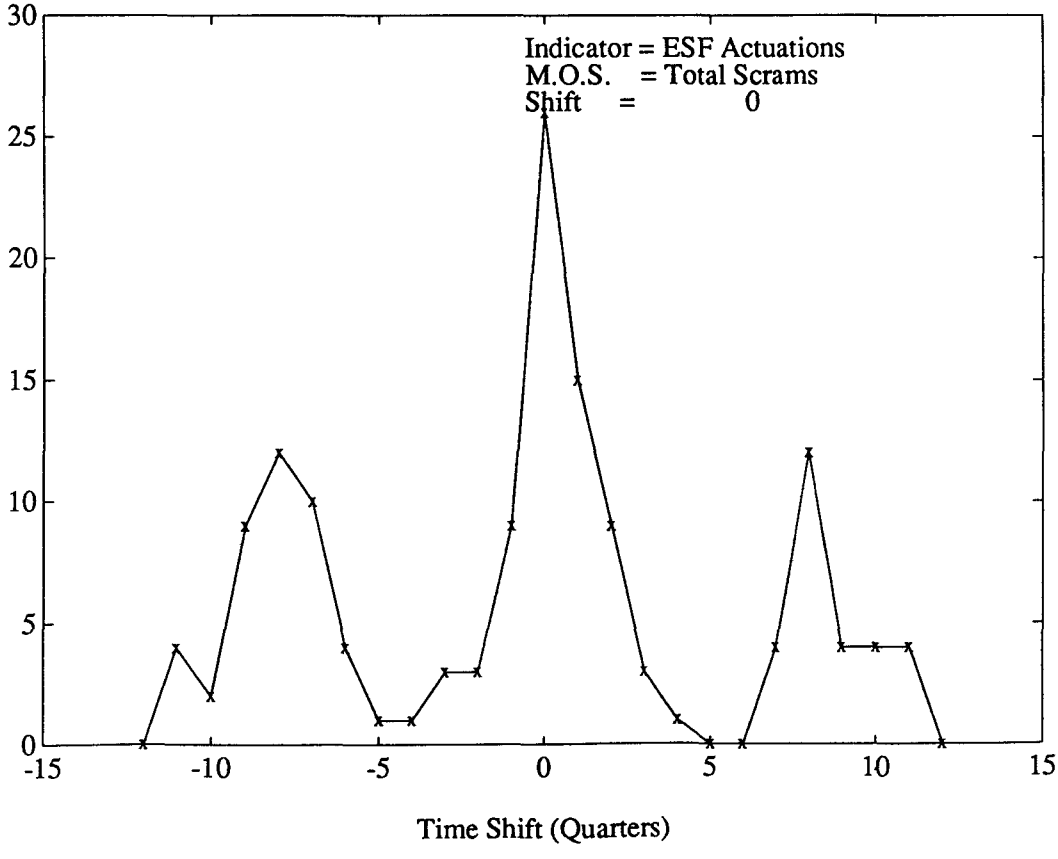

Performance Indicator Analysis
ESF Actuations
DAYS

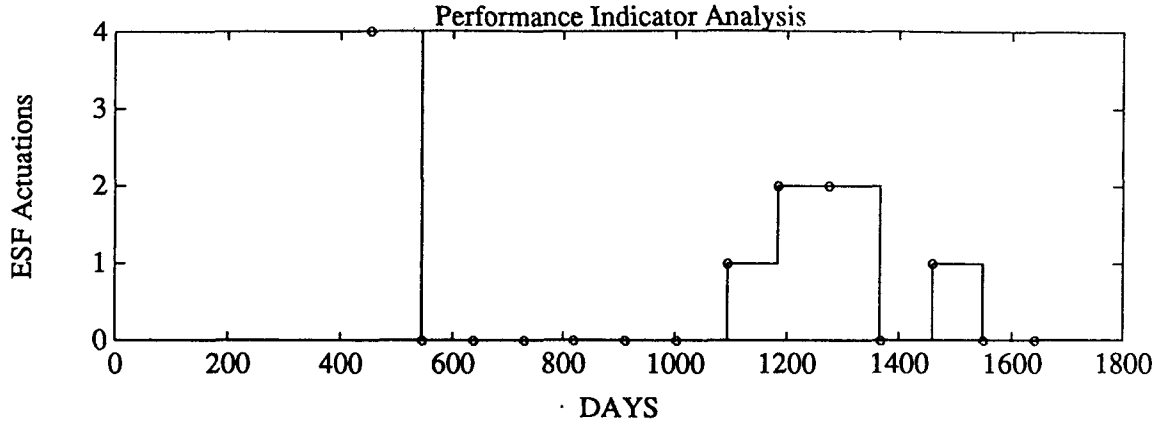

High Power Scrams
DAYS

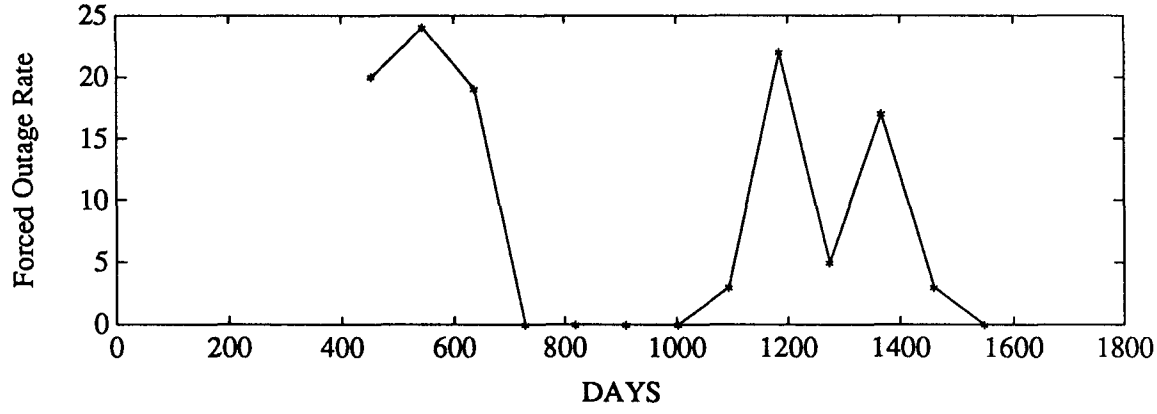

Indicator = ESF Actuations
M.O.S. = High Power Scrams
Shift = 0
Time Shift (Quarters)

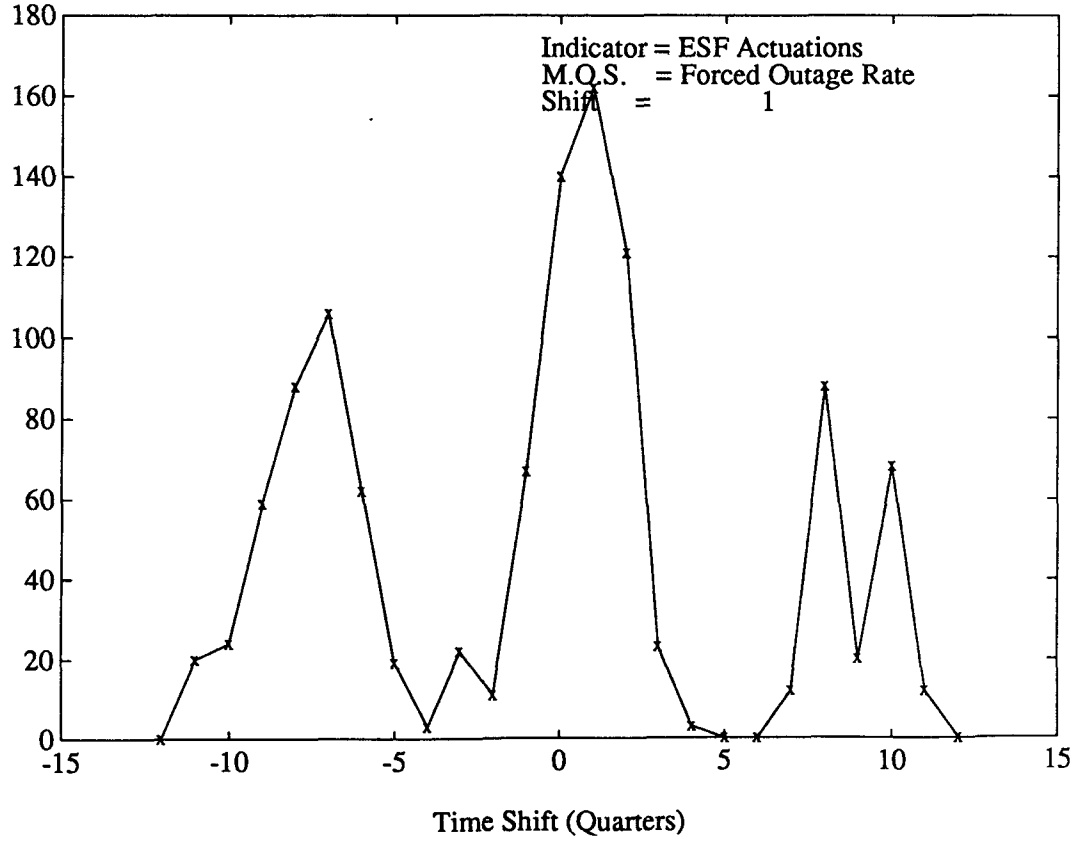

Performance Indicator Analysis
ESF Actuations
0
1
2
3
4
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

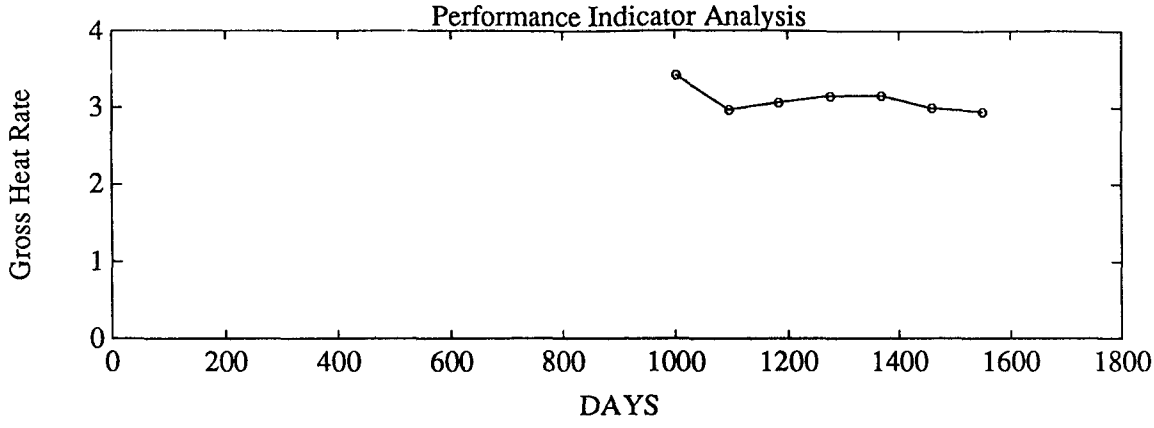

Total Scrams
0
1
2
3
4
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

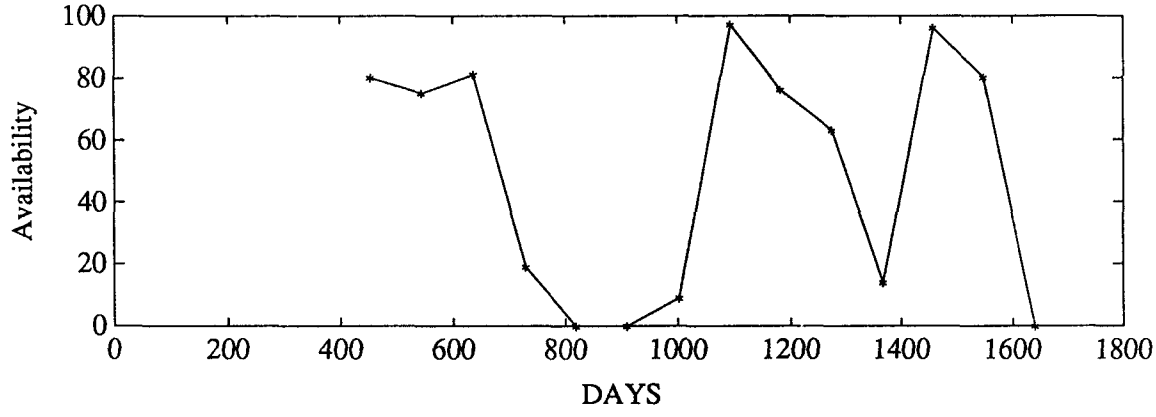

Indicator = ESF Actuations
M.O.S. = Total Scrams
Shift = 0
0
5
10
15
20
25
30
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

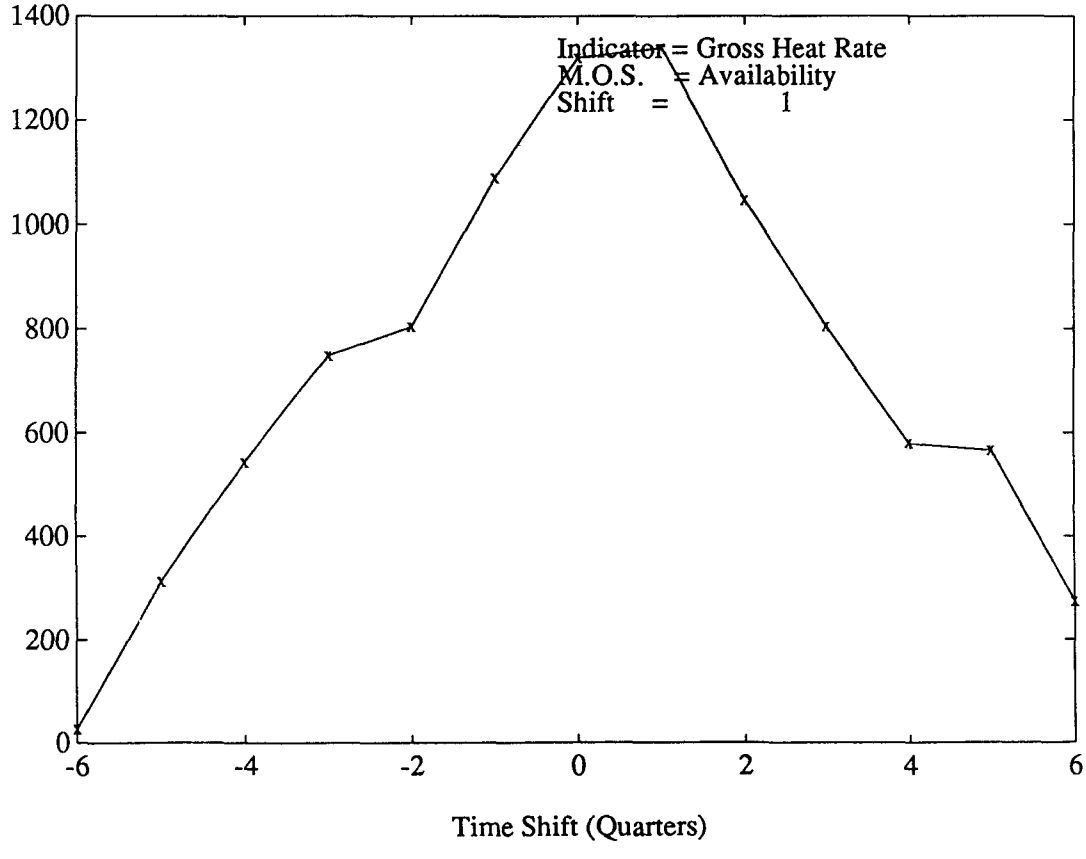

Performance Indicator Analysis
ESF Actuations
DAYS


Forced Outage Rate
DAYS


Indicator = ESF Actuations
M.O.S. = Forced Outage Rate
Shift = 1
Time Shift (Quarters)


Performance Indicator Analysis
Gross Heat Rate
0
1
2
3
4
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

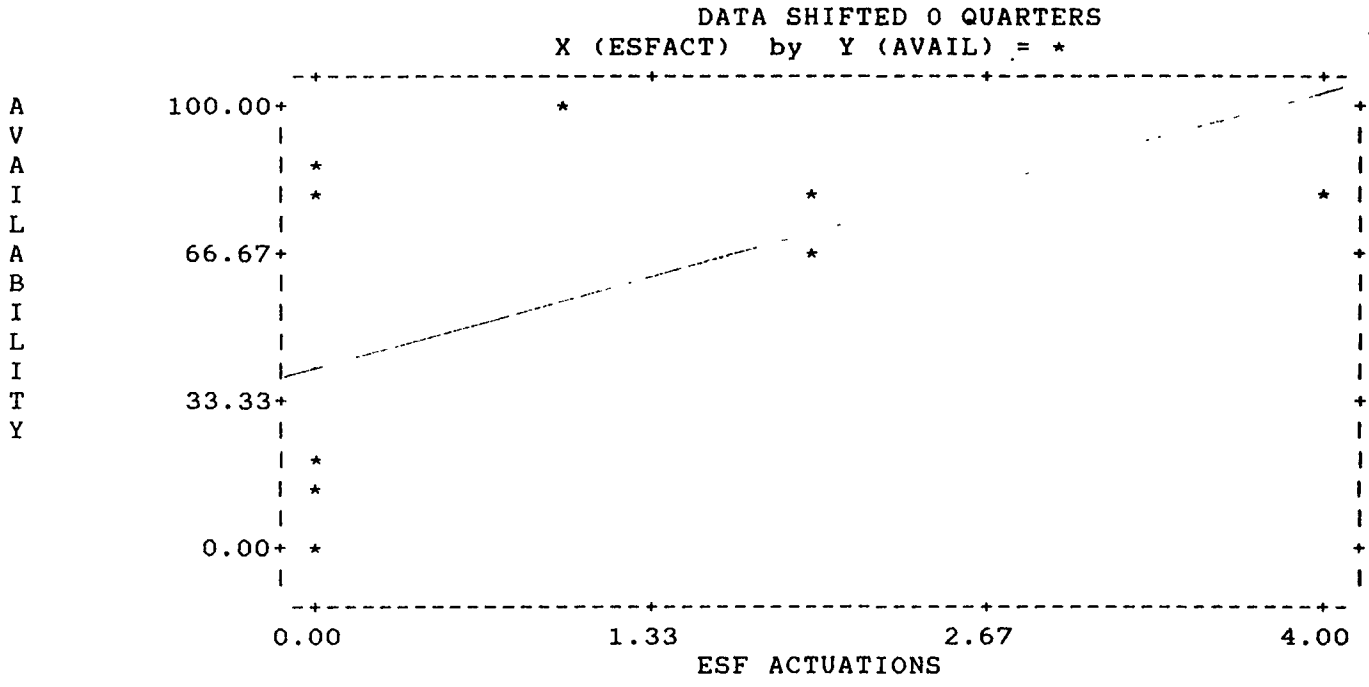

Availability
0
20
40
60
80
100
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = Gross Heat Rate
M.O.S. = Availability
Shift = 1
0
200
400
600
800
1000
1200
1400
-6
-4
-2
0
2
4
6
Time Shift (Quarters)

----------Scatter Plots----------

Date/Time 10-25-1988 13:43:42
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



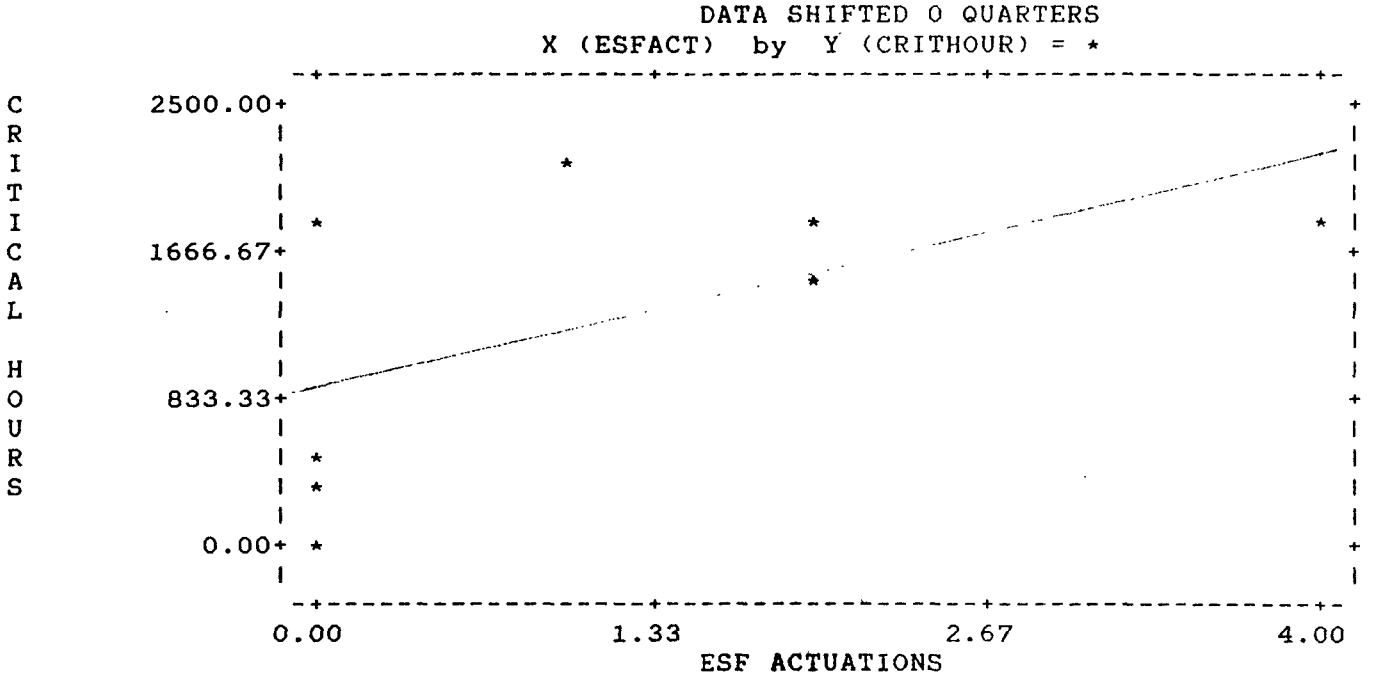
...w Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	0
Number of points plotted	:	14		

----------Scatter Plots----------

Date/Time 10-25-1988 13:44:25
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



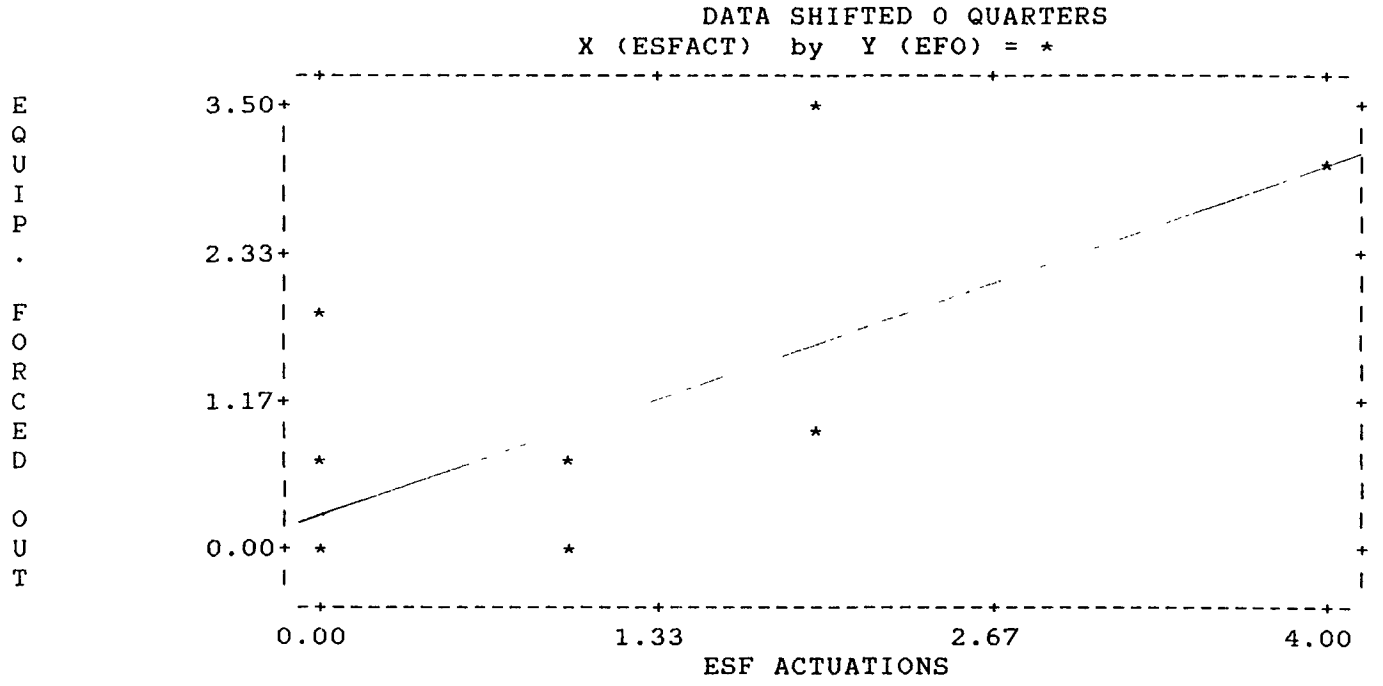
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	1
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 13:45:05
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



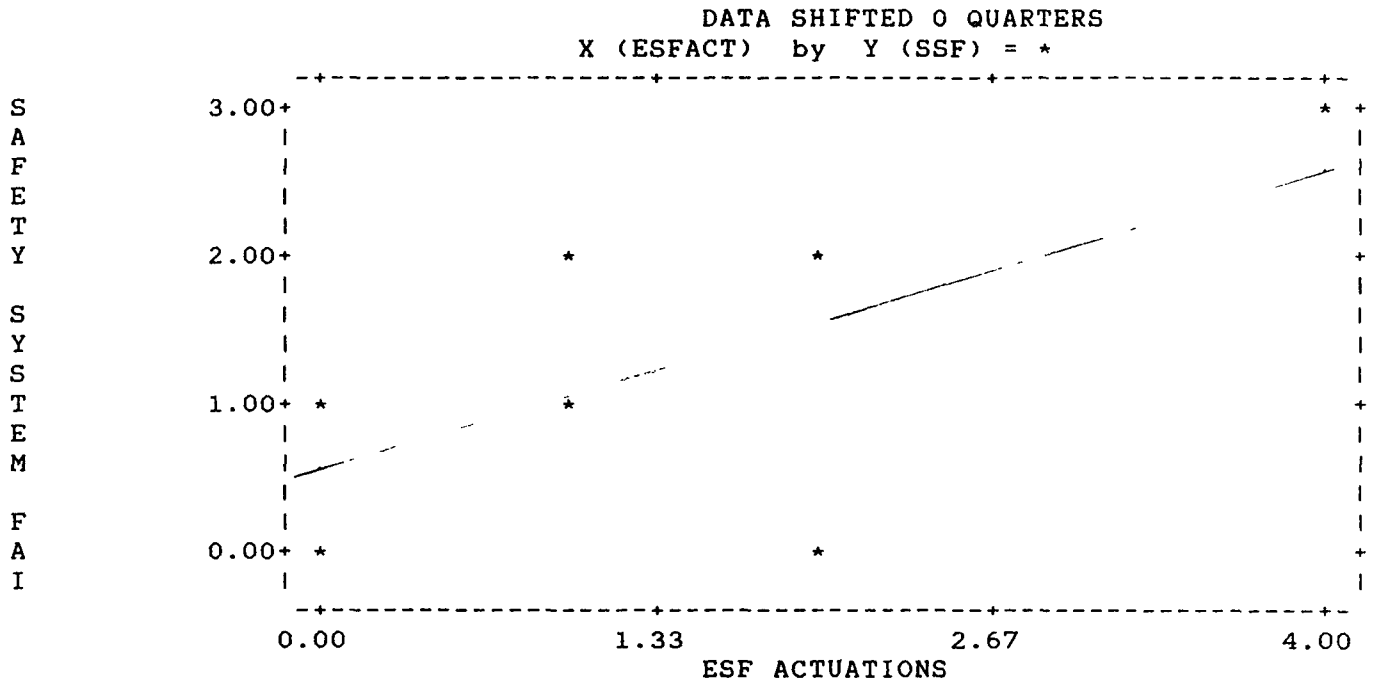
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	1
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 13:45:49
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



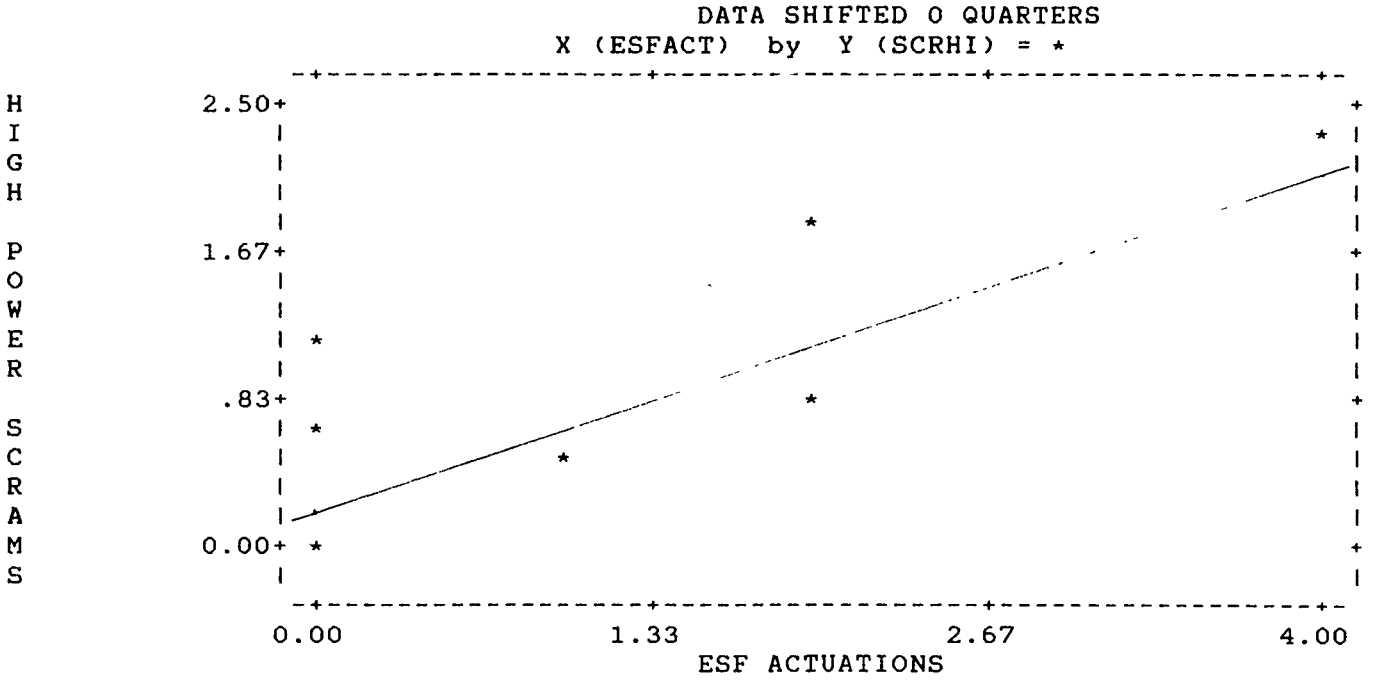
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	1
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 13:46:33
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



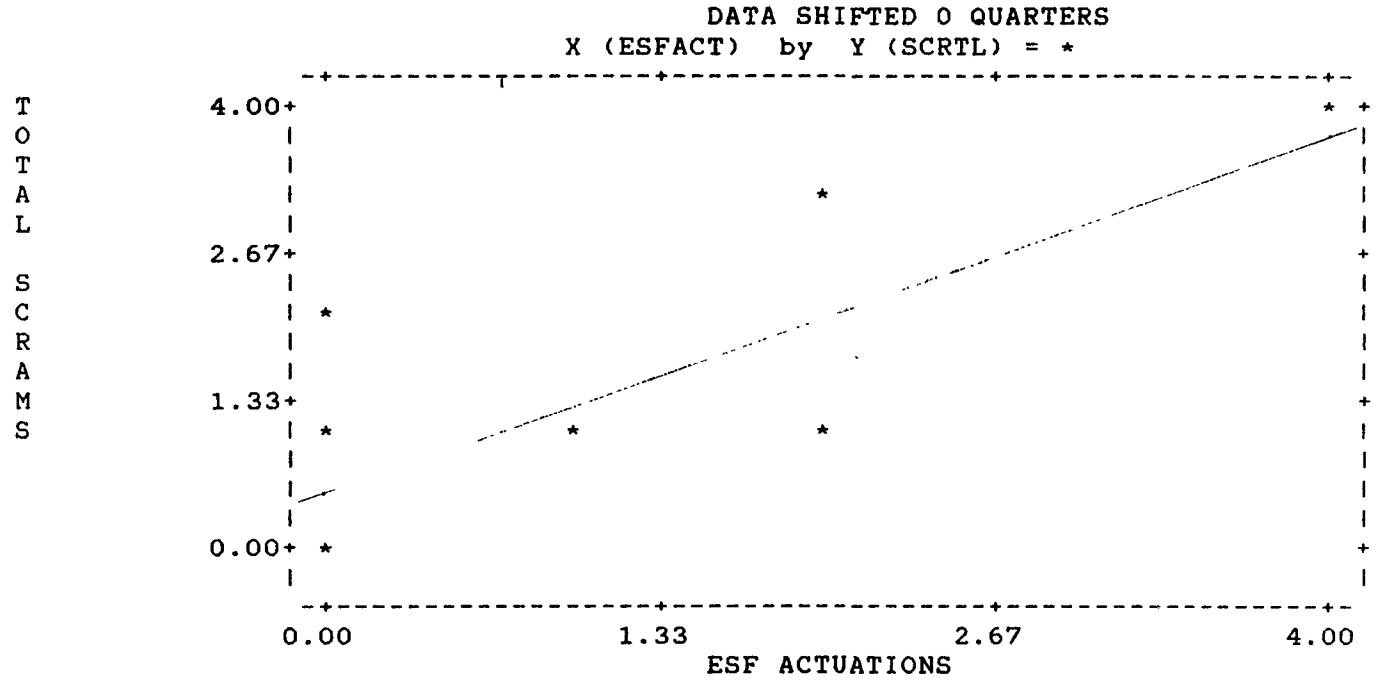
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	1
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 13:47:11
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



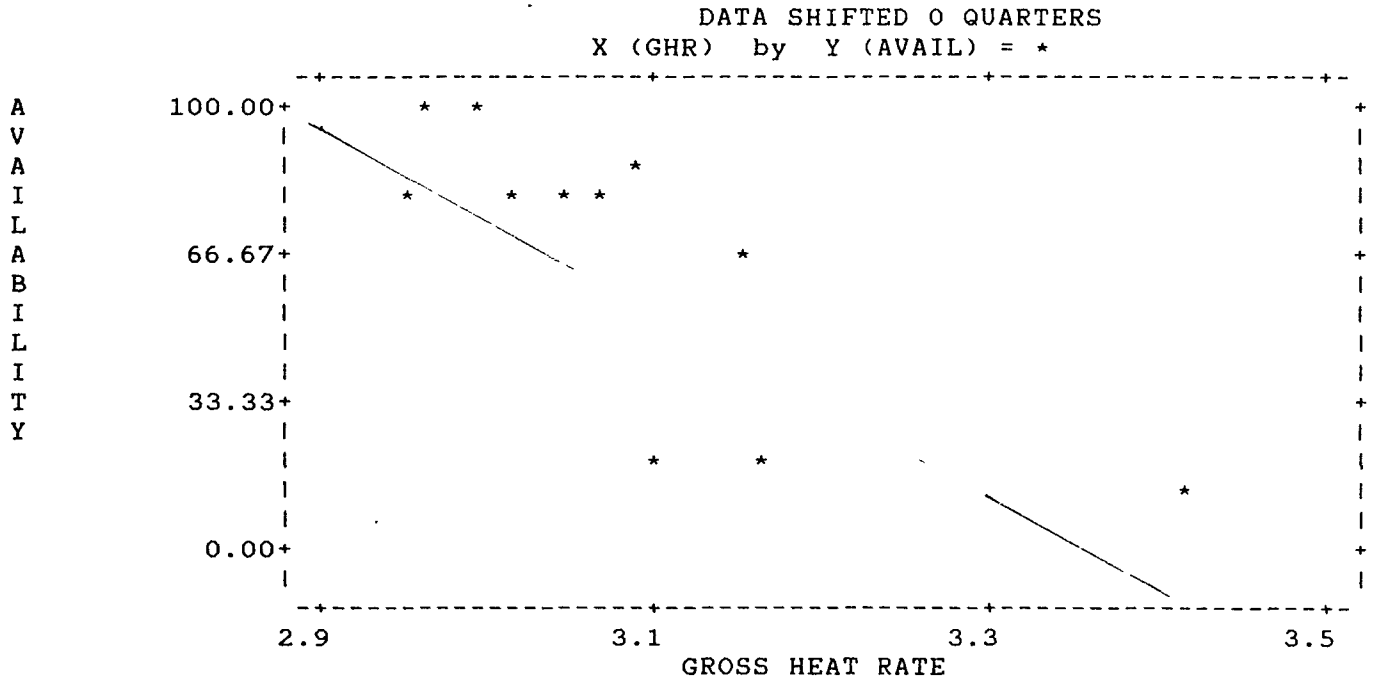
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	1
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 13:49:20
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots

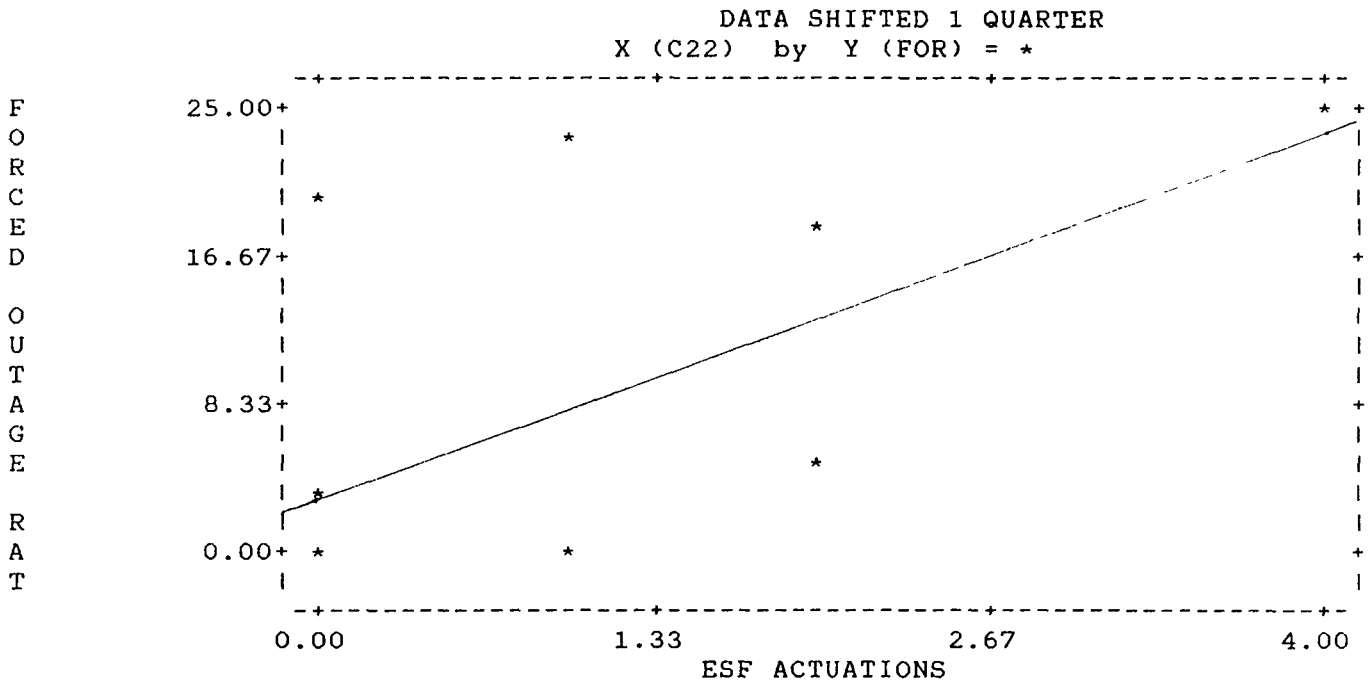


Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	2	(Y) :	0
Number of points plotted	:	11		

Date/Time 10-25-1988 15:50:21
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



Row Accounting Report

ıber of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	1
Number of points plotted	:	12		

Detailed Results for Plant F

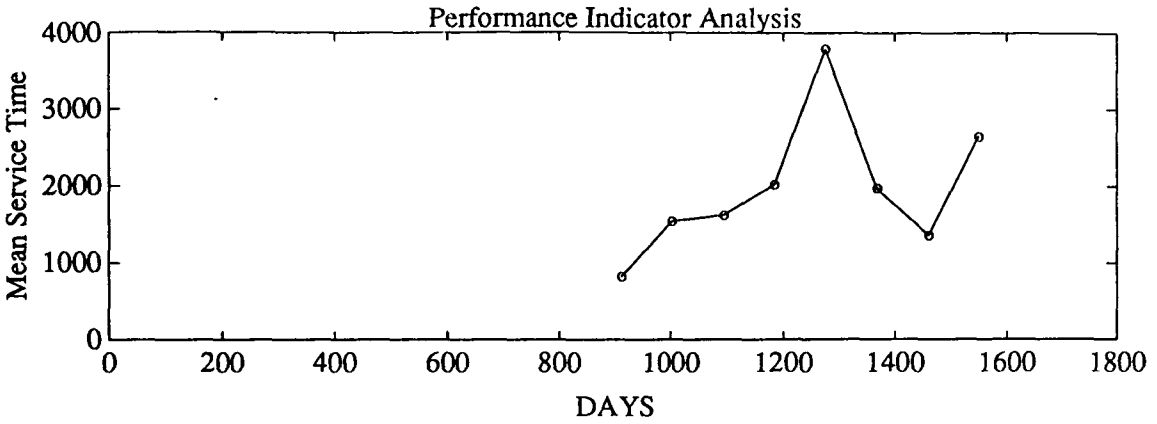
Maintenance Indicators vs. Measures of Safety

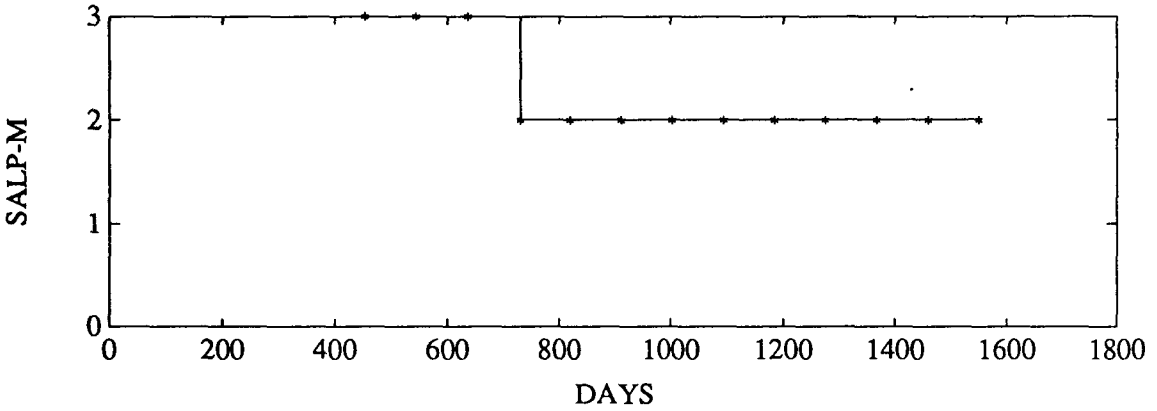
	RANK	1SCRTL	1SCRHI	1SCRLO	2SSA	3SE	4SSF	5FOR	7EFO	CRITHOUR	SALP-M	FRATE	AVAIL
1PMTOTM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2CMB	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3PMOVER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4MNTTO1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5REWORK1*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6DEFIC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7CMWRPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7OBOPMT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9MTSERV*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	S	NS	NS
CSCRAM*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8ASSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8BSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8CSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8DSSPI	[Zero events in relevant time scale]										N/A		
BAHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BBHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BCHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BDHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BEHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BFHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BGHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CBSCRAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GHR*	NS	NS	NS	NS	NS	NS	NS	NS	NS	S	N/A	NS	S
WPE*	[Zero events in relevant time scale]												
REALE*	[Zero events in relevant time scale]										N/A		
BACKECN*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WRONGT/U*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ESFACT*	NS	NS	S	NS	NS	NS	NS	NS	S	NS	N/A	NS	NS

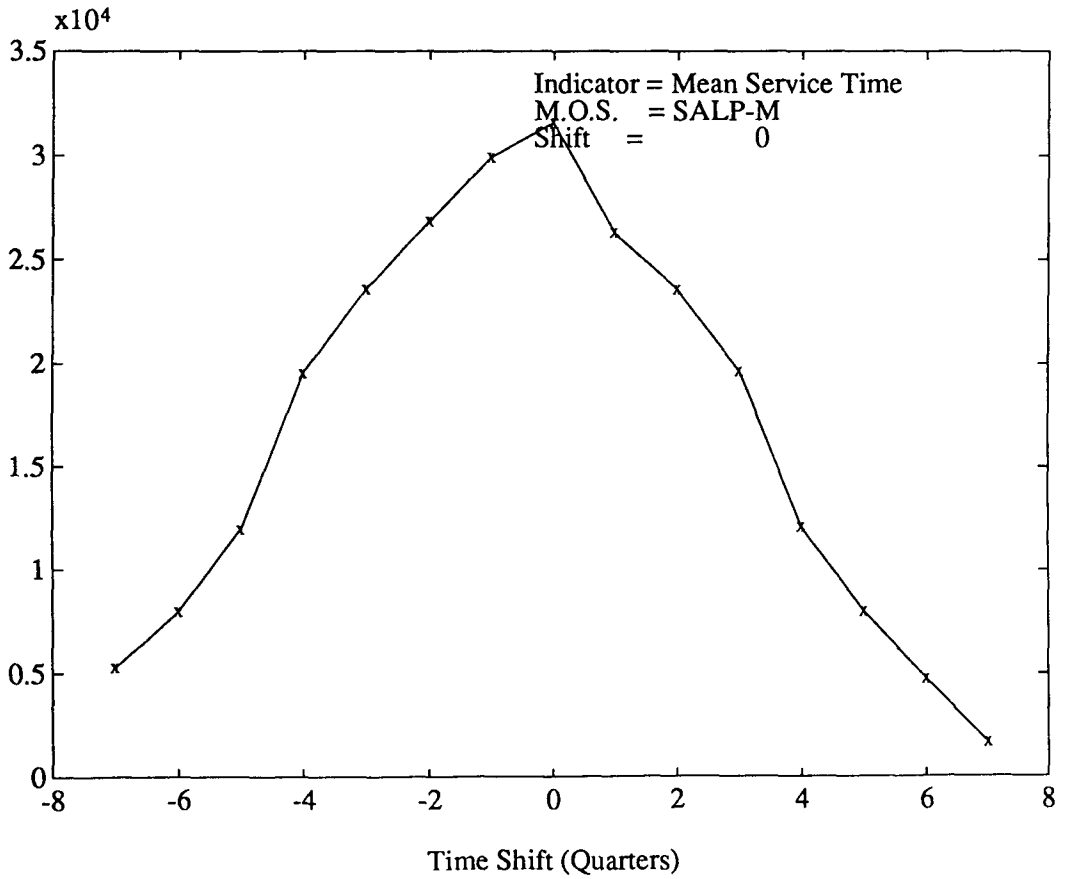
Note: Indicators marked with an "*" are SAIC indicators

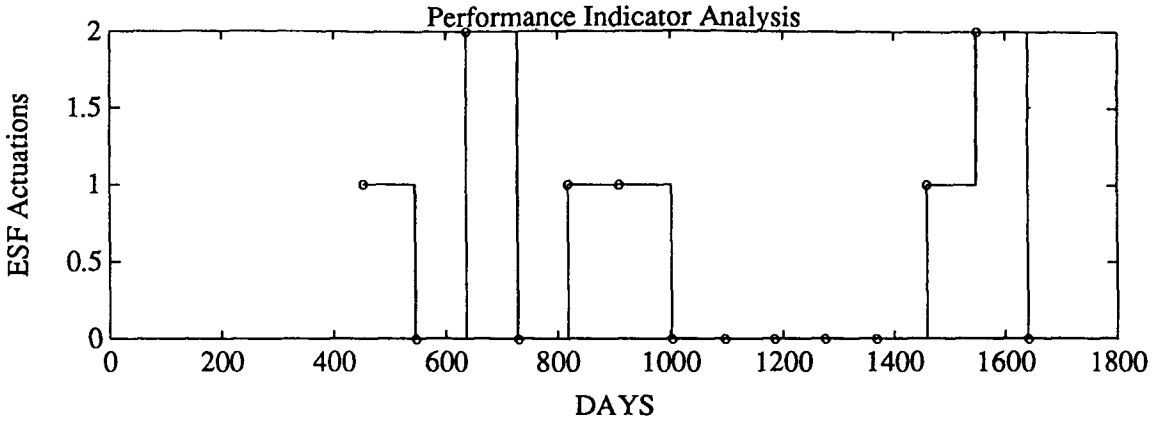
Significant Maintenance Indicator/Measure of Safety Relationships

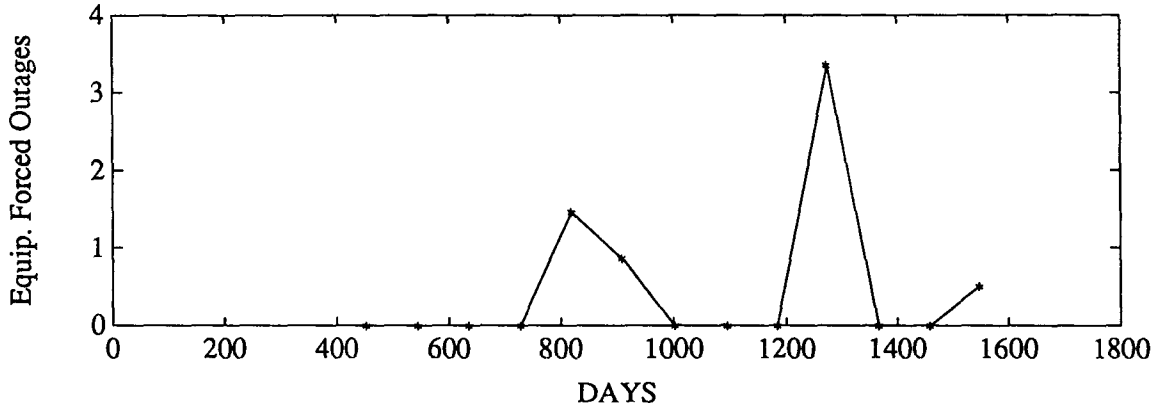
Indicator	Measure of Safety	Time Shift	Confidence
ESFACT	SCRHI	+7	87%
ESFACT	EFO	+7	87%
MTSERV	SALP	0	92%
GHR	AVAIL	0	96%
GHR	CRITHOUR	0	97%

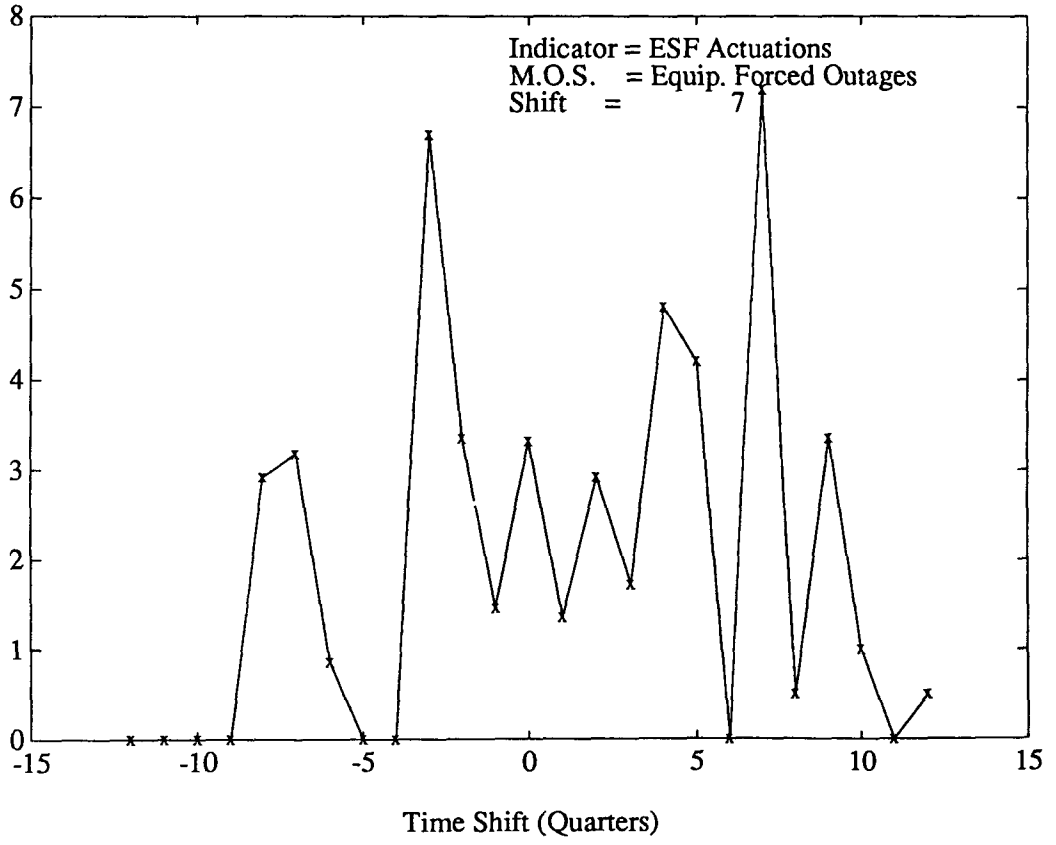

Performance Indicator Analysis
Mean Service Time
4000
3000
2000
1000
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

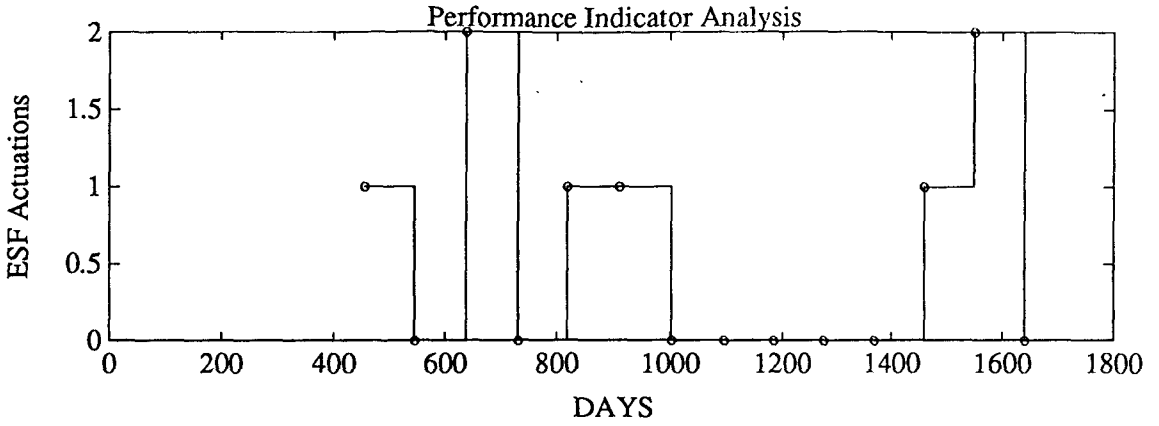

SALP-M
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

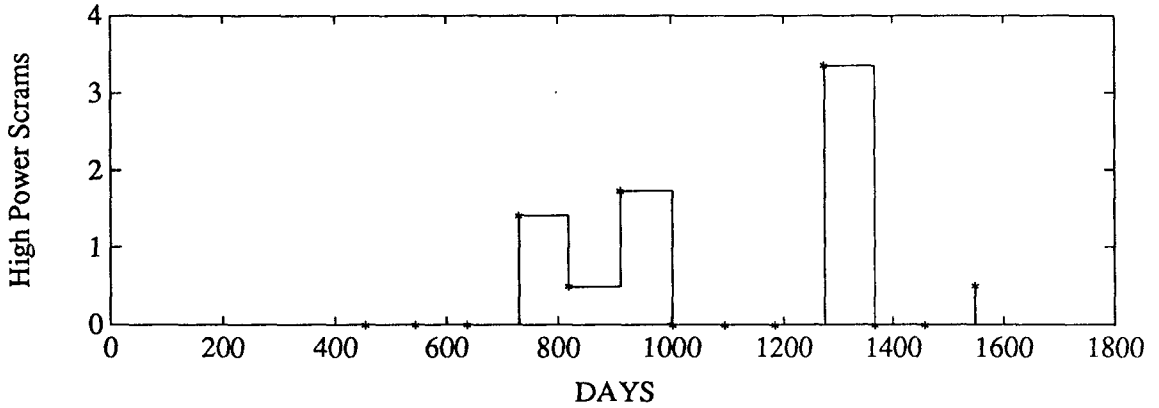

x10⁴
3.5
3
2.5
2
1.5
1
0.5
0
Indicator = Mean Service Time
M.O.S. = SALP-M
Shift = 0
-8
-6
-4
-2
0
2
4
6
8
Time Shift (Quarters)

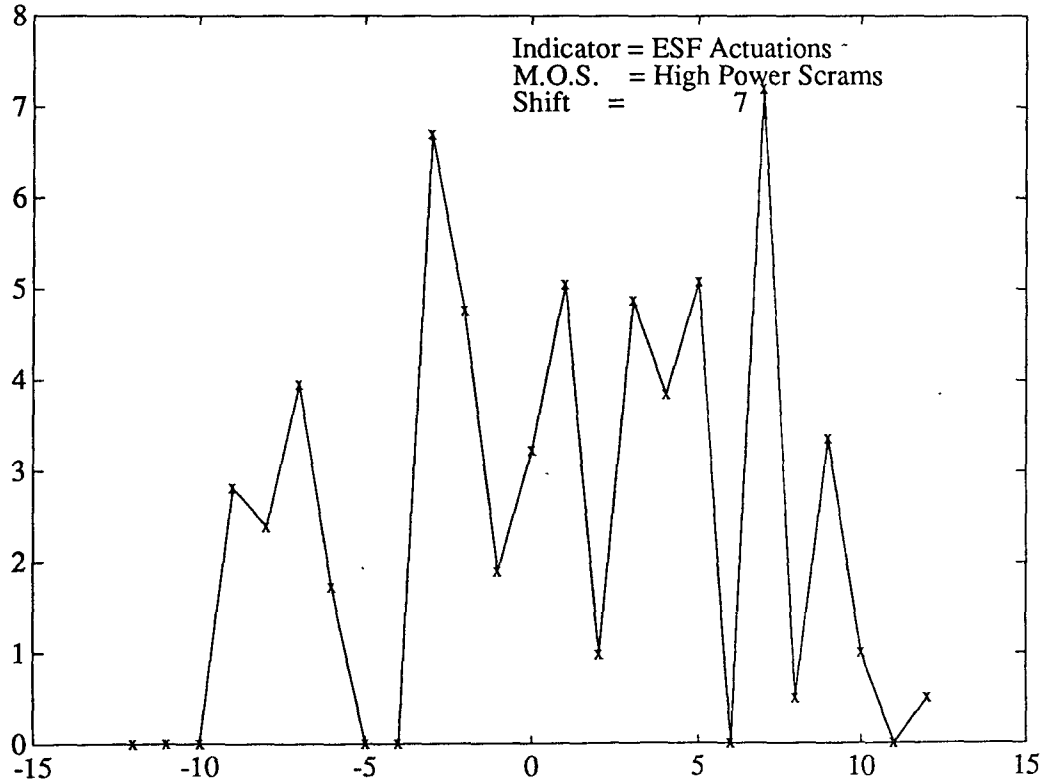

Performance Indicator Analysis
ESF Actuations
DAYS

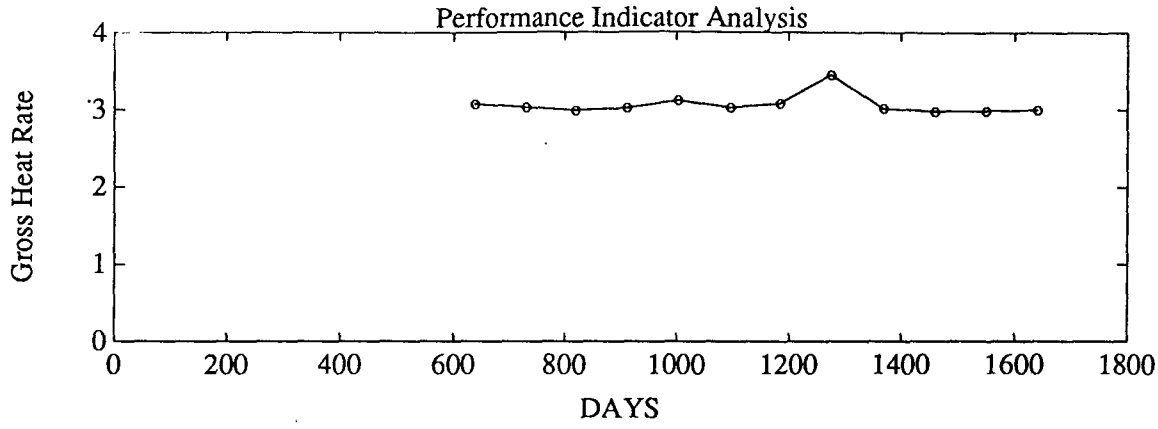

Equip. Forced Outages
DAYS

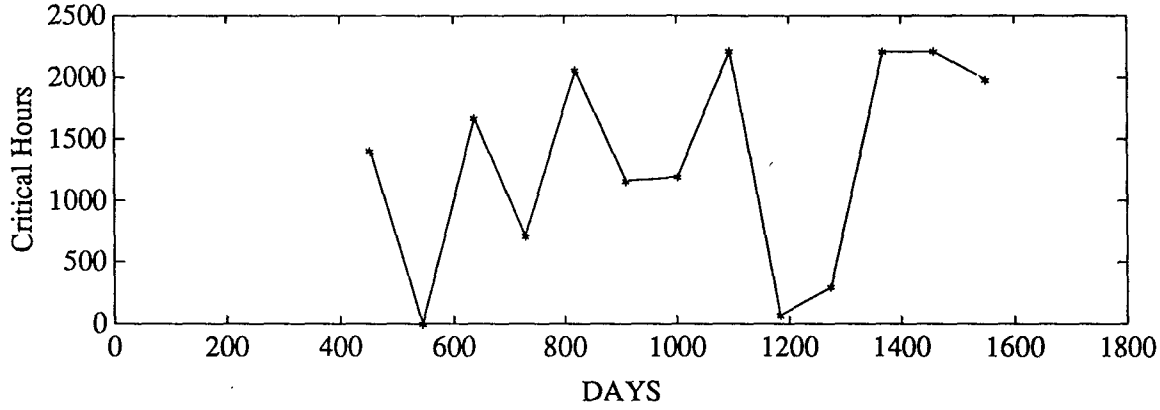

Indicator = ESF Actuations
M.O.S. = Equip. Forced Outages
Shift = 7
Time Shift (Quarters)

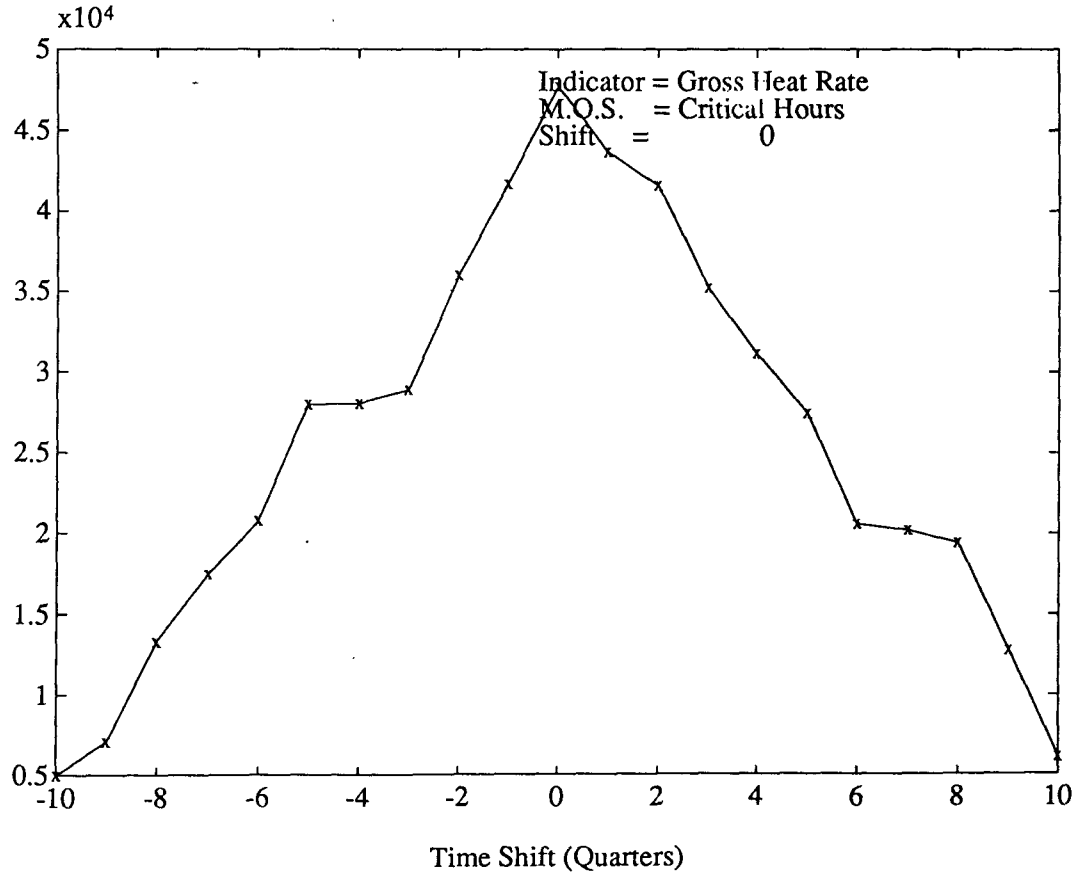

Performance Indicator Analysis
ESF Actuations
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

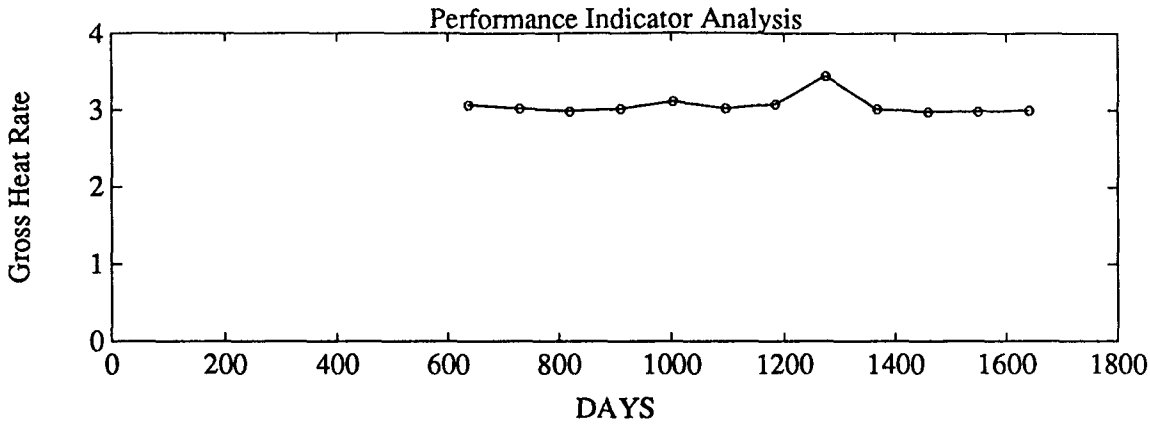

High Power Scrams
4
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

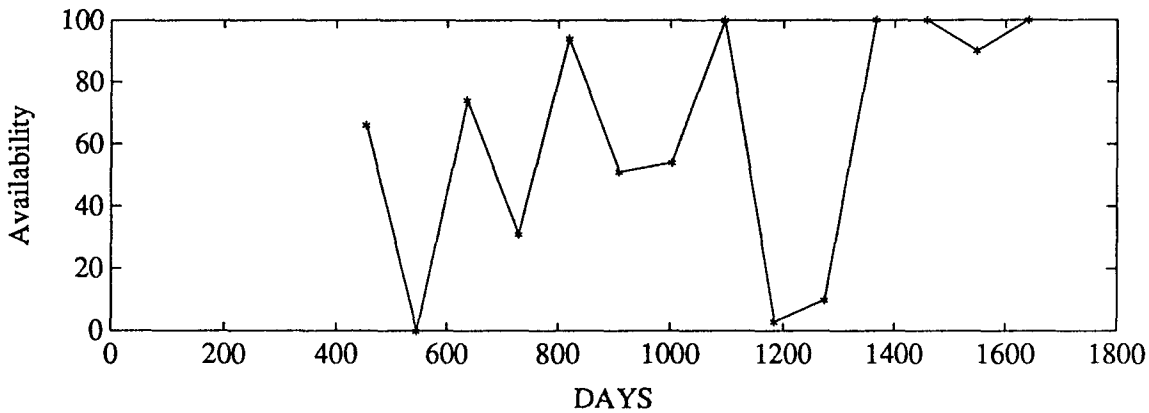

Indicator = ESF Actuations
M.O.S. = High Power Scrams
Shift = 7
8
7
6
5
4
3
2
1
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

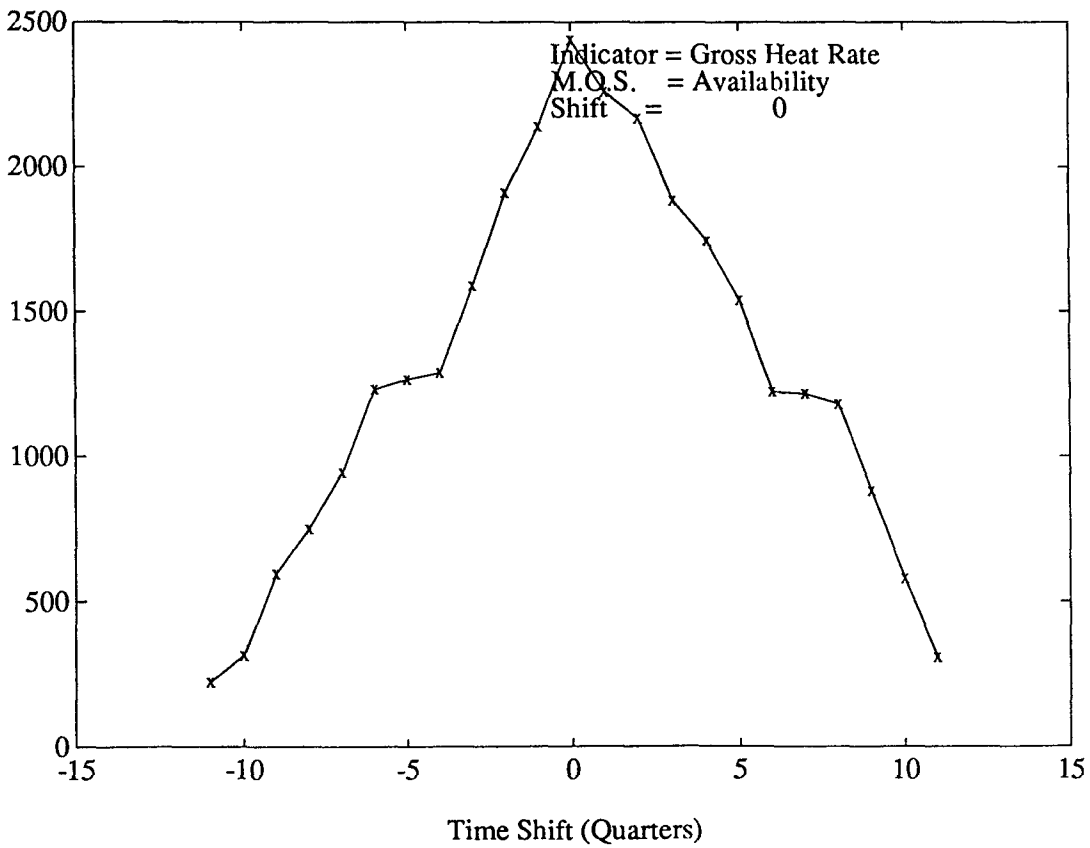

Performance Indicator Analysis
Gross Heat Rate
DAYS


Critical Hours
DAYS


x10^4
Indicator = Gross Heat Rate
M.O.S. = Critical Hours
Shift = 0
Time Shift (Quarters)


Performance Indicator Analysis
Gross Heat Rate
0
1
2
3
4
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Availability
0
20
40
60
80
100
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

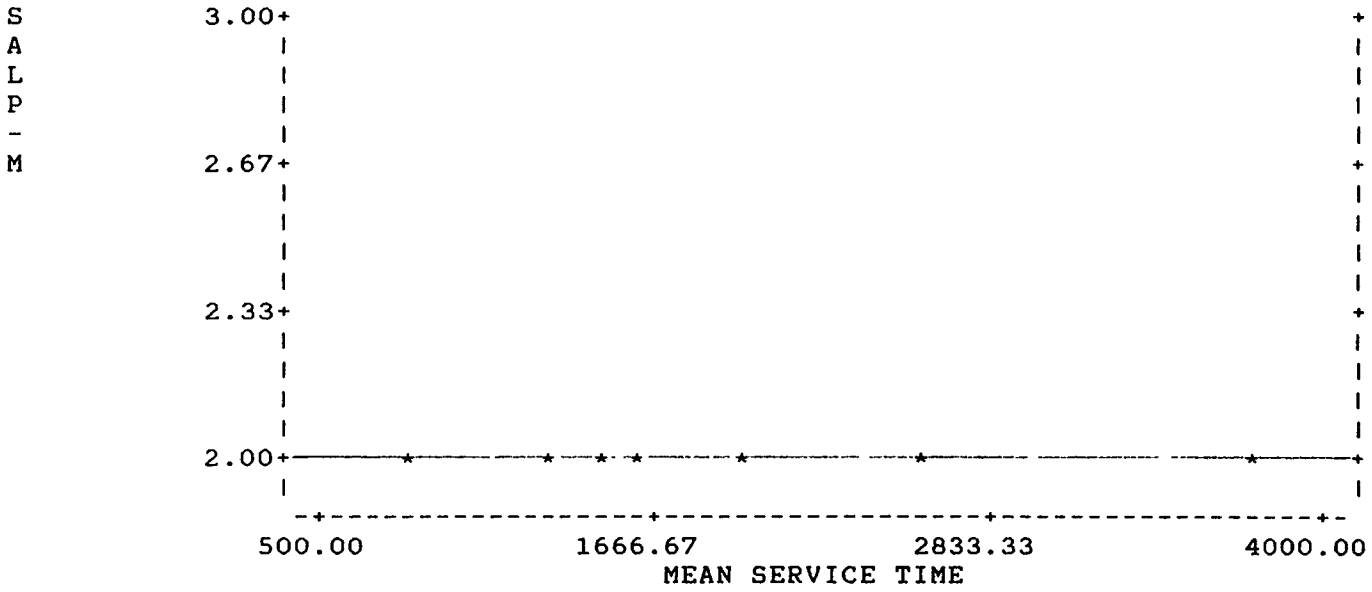

Indicator = Gross Heat Rate
M.O.S. = Availability
Shift = 0
0
500
1000
1500
2000
2500
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

----------Scatter Plots----------

Date/Time 10-25-1988 14:00:06
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots

DATA SHIFTED 0 QUARTERS
X (MTSERV) by Y (SALP) = *



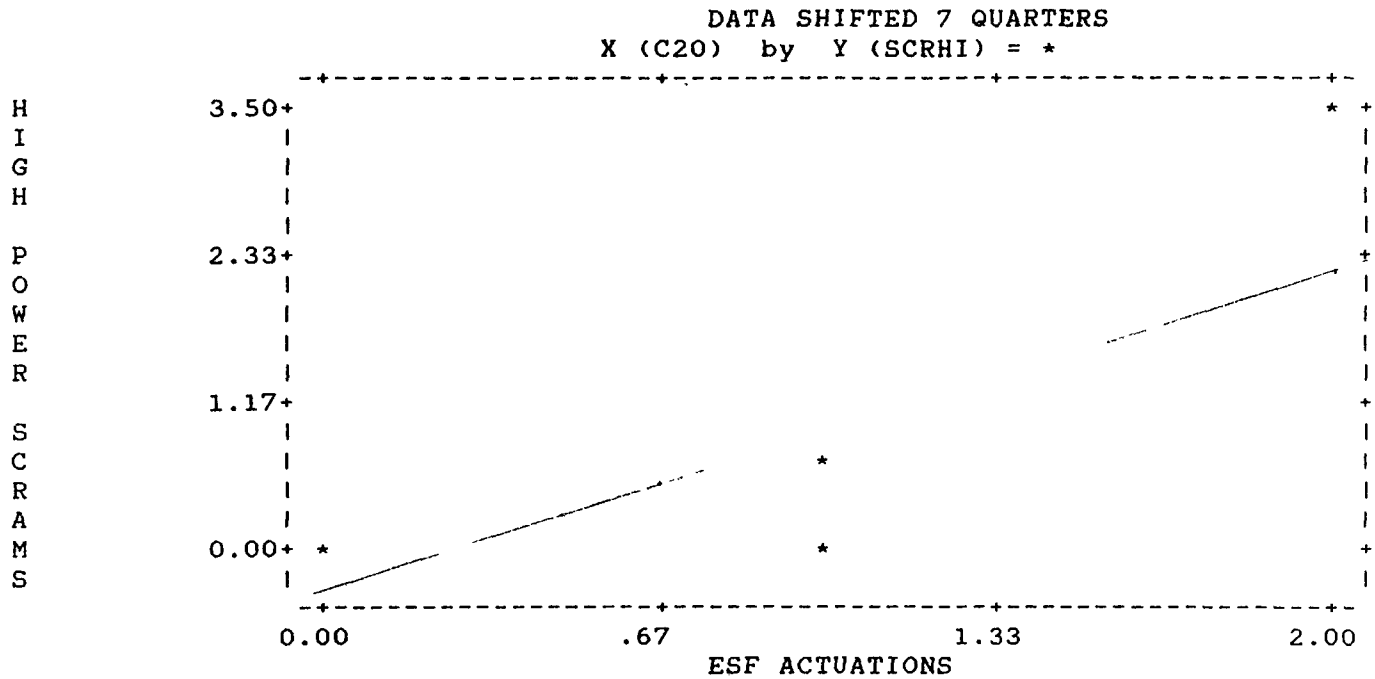
Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	5	(Y) :	0
Number of points plotted	:	8		

----------Scatter Plots----------

Date/Time 10-25-1988 13:58:46
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots

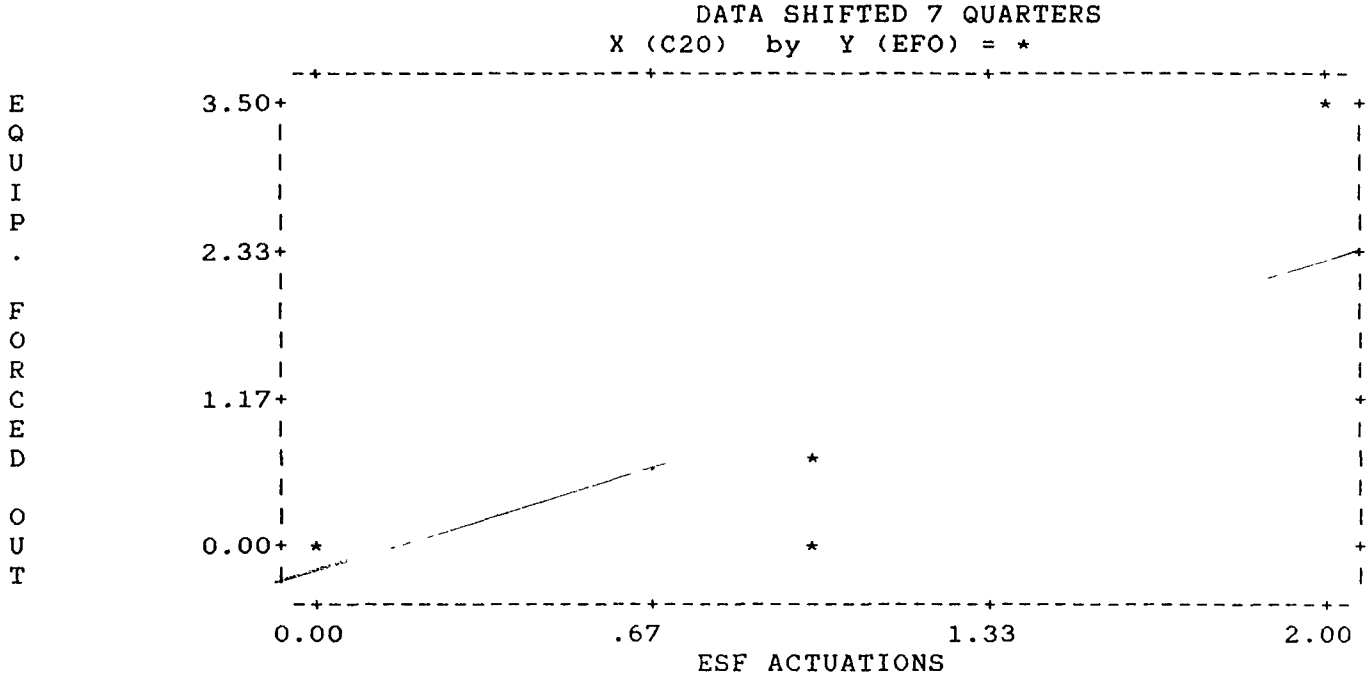


Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	7	(Y) :	1
Number of points plotted	:	6		

-- ----------Scatter Plots----------
Date/Time 10-25-1988 13:59:23
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



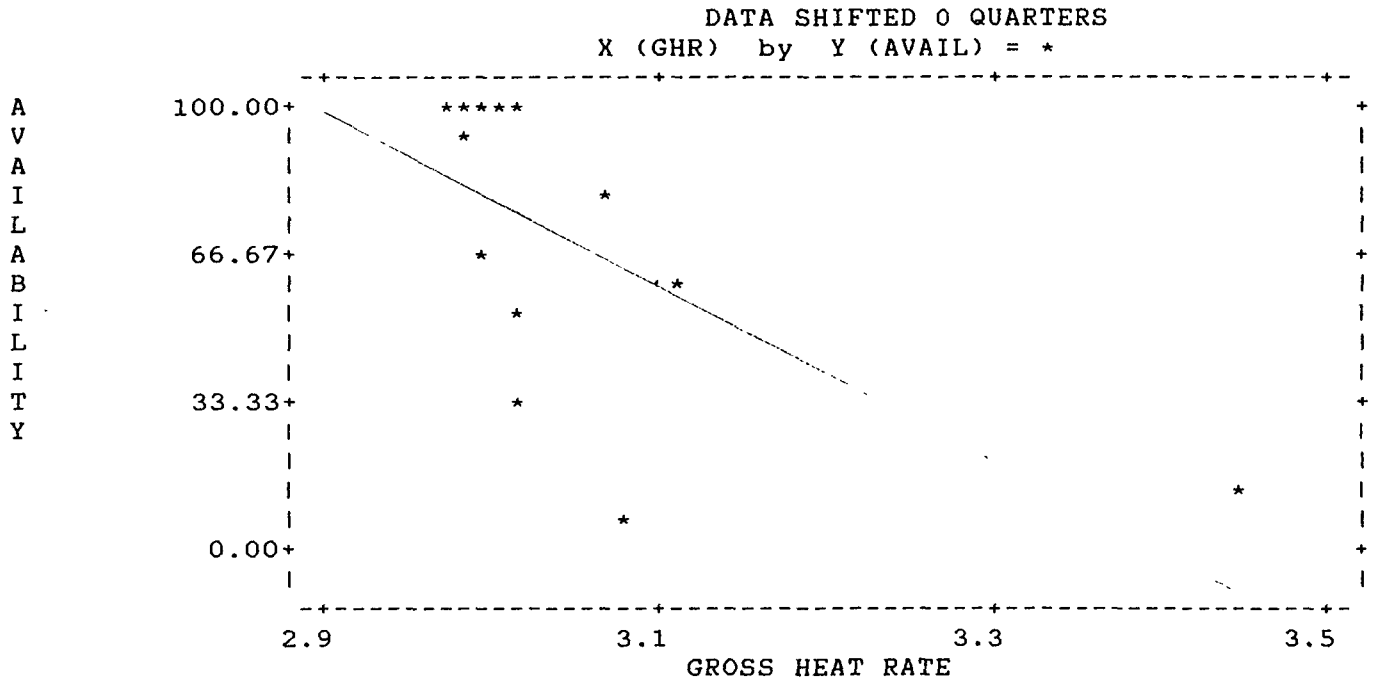
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	7	(Y) :	1
Number of points plotted	:	6		

----------Scatter Plots----------

Date/Time 10-25-1988 14:00:44
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



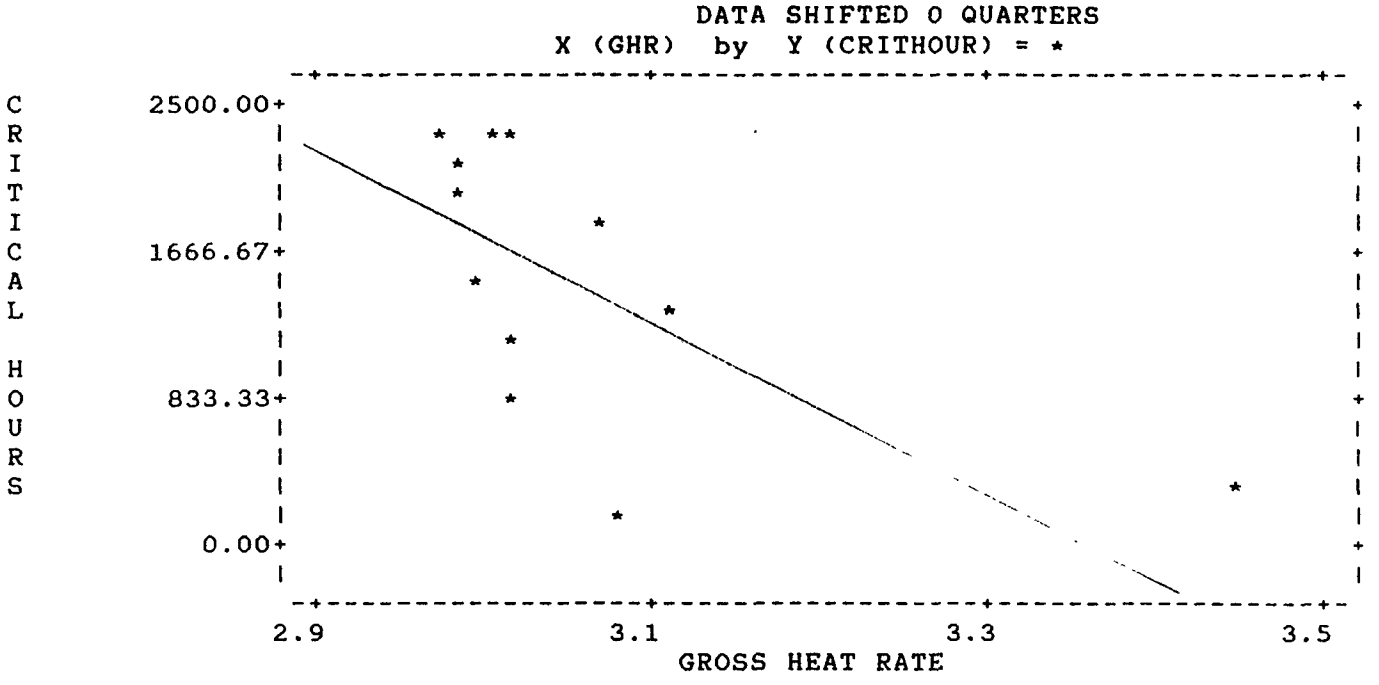
Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	0
Number of points plotted	:	13		

---------Scatter Plots---------

Date/Time 10-25-1988 14:01:10
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	1
Number of points plotted	:	12		

Detailed Results for Plant G

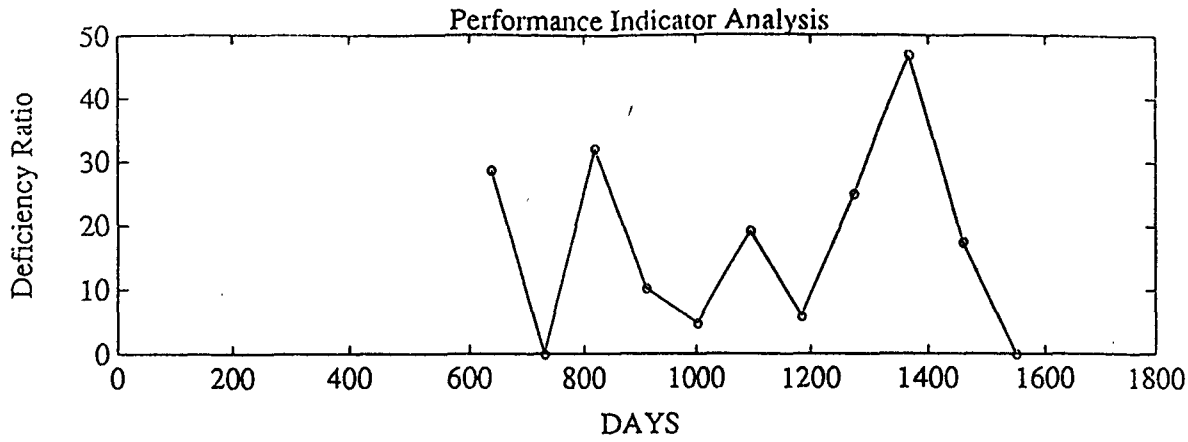
Maintenance Indicators vs. Measures of Safety

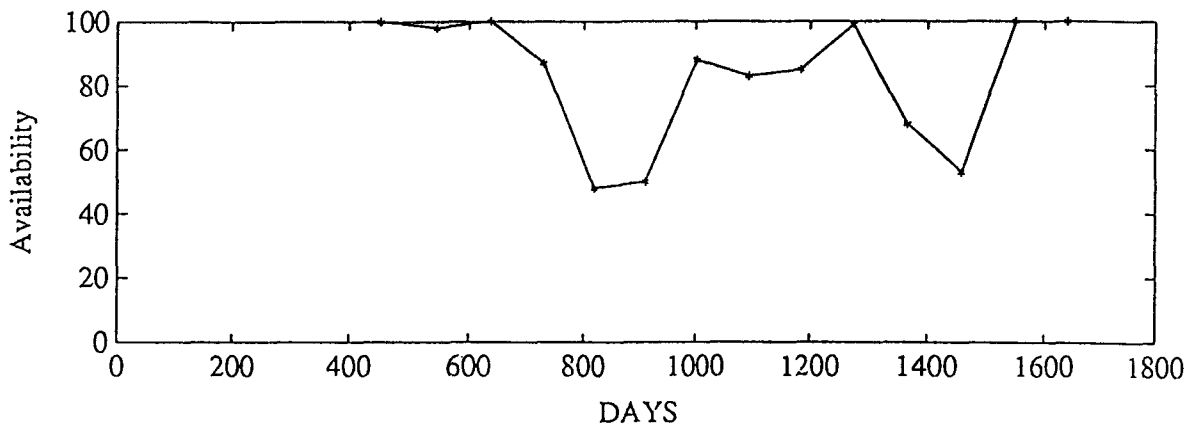
	RANK	1SCRTL	1SCRHI	1SCRLO	2SSA	3SE	4SSF	5FOR	7EFO	CRITHOUR	SALP-M	FRATE	AVAIL
1PMTOTM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2CMB	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3PMOVER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4MNTTO1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5REWORK1*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6DEFIC	NS	NS	NS	N/A	N/A	NS	NS	NS	NS	NS	NS	NS	S
7CMWRPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7OBOPMT	NS	NS	NS	N/A	N/A	NS	NS	NS	NS	NS	NS	S	NS
9MTSERV*	NS	NS	NS	N/A	N/A	NS	NS	NS	NS	NS	NS	NS	NS
CSCRAM*	NS	NS	NS	N/A	N/A	NS	NS	S	NS	NS	NS	S	NS
8ASSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8BSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8CSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8DSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BAHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BBHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BCHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BDHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BEHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BFHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BGHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CBSCRAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GHR*	NS	NS	NS	N/A	N/A	NS	NS	NS	NS	NS	NS	NS	NS
WPE* [Zero events in relevant time scale]													
REALE* [Zero events in relevant time scale]													
BACKECN*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WRONGT/U*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ESFACT* [Zero events in relevant time scale]													

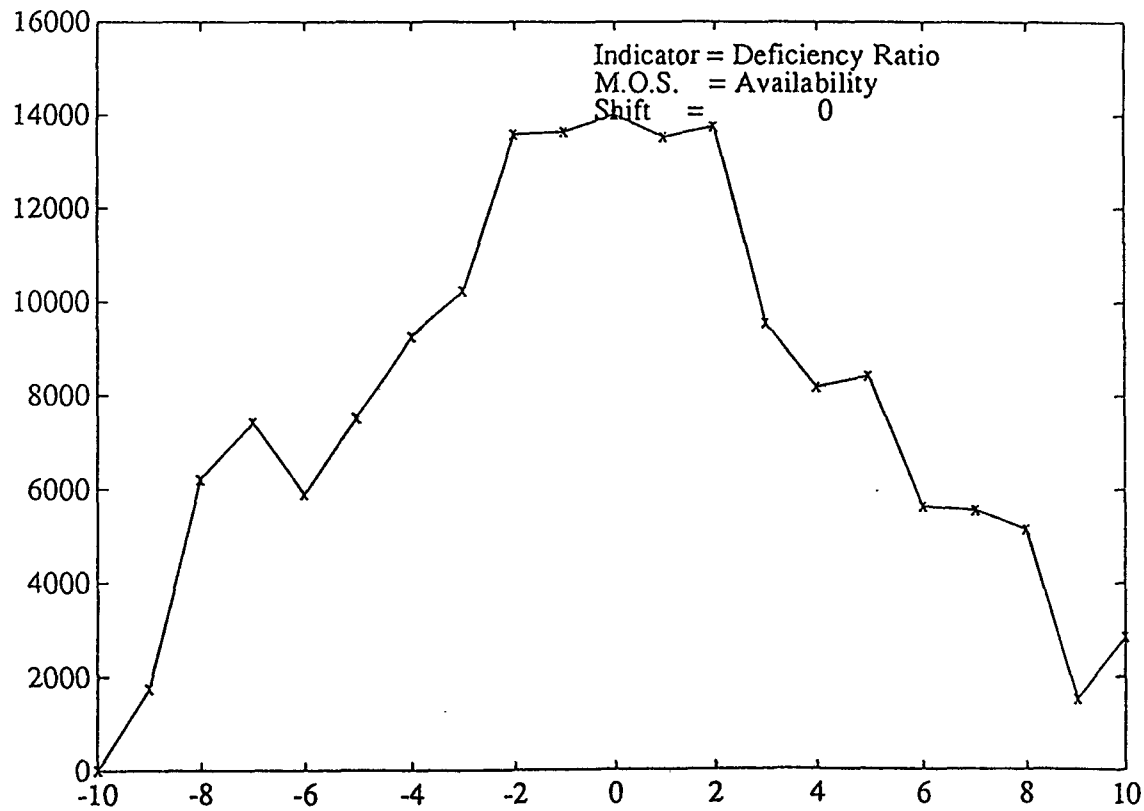
Note: Indicators marked with an "*" are SAIC indicators

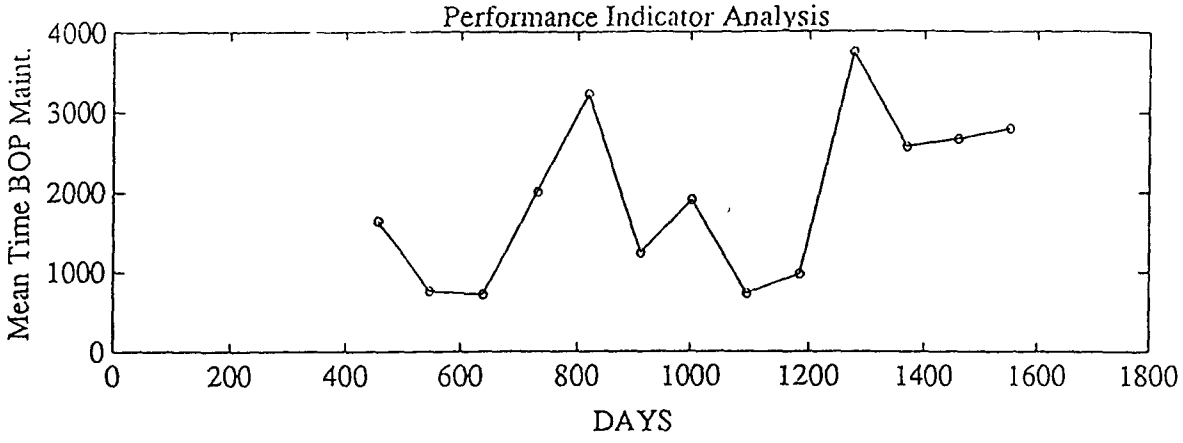
Significant Maintenance Indicator/Measure of Safety Relationships

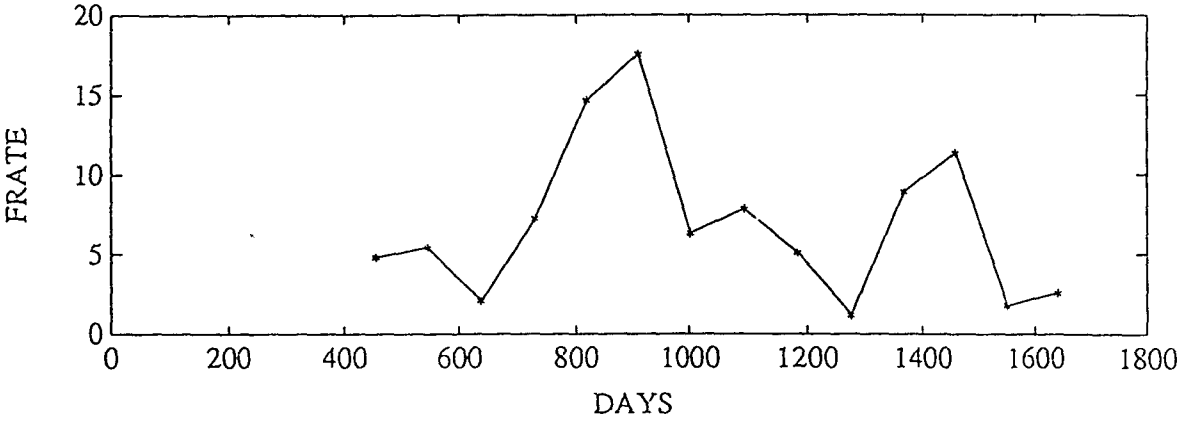
Indicator	Measure of Safety	Time Shift	Confidence
6DEFIC	AVAIL	+2	85%
9DBOPMT	FRATE	+1	82%
CSCRAM	FOR	+1	89%
CSCRAM	FRATE	+1	83%

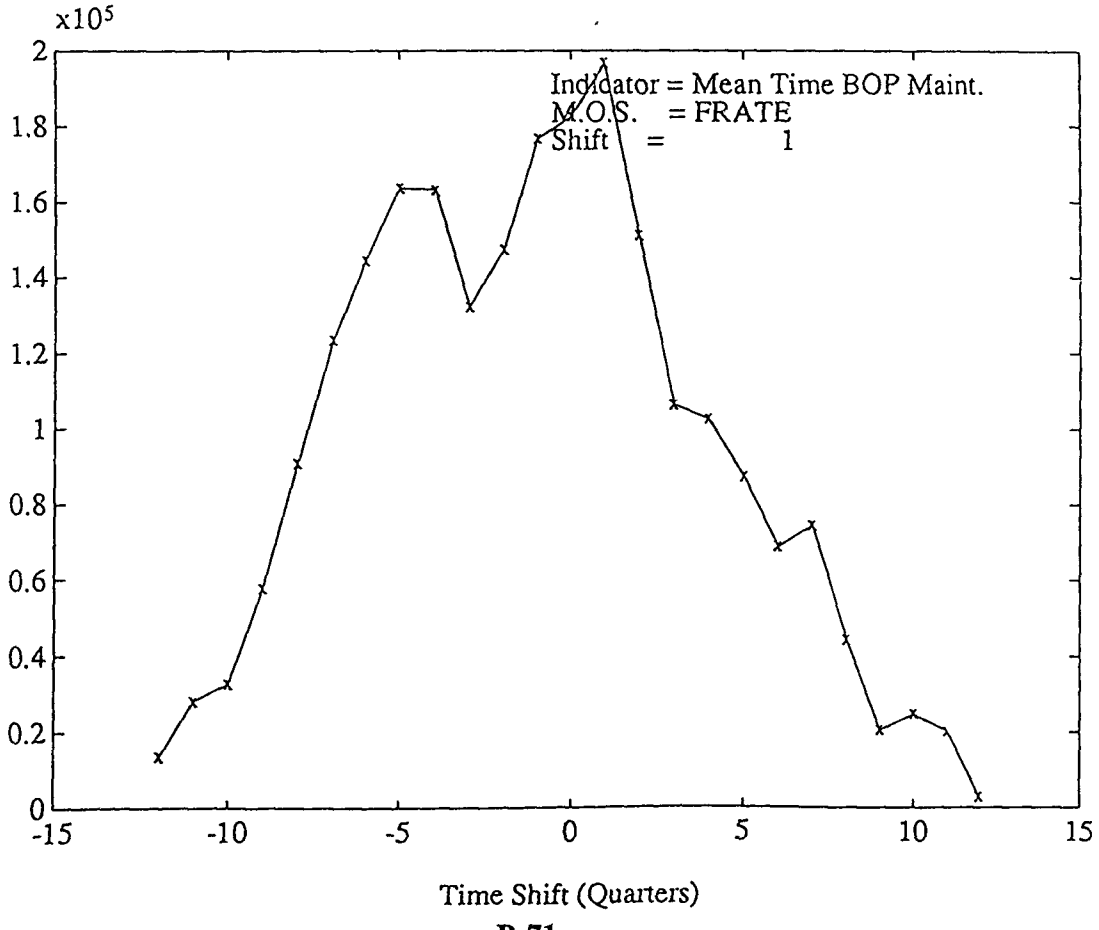

Performance Indicator Analysis
Deficiency Ratio
0
10
20
30
40
50
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

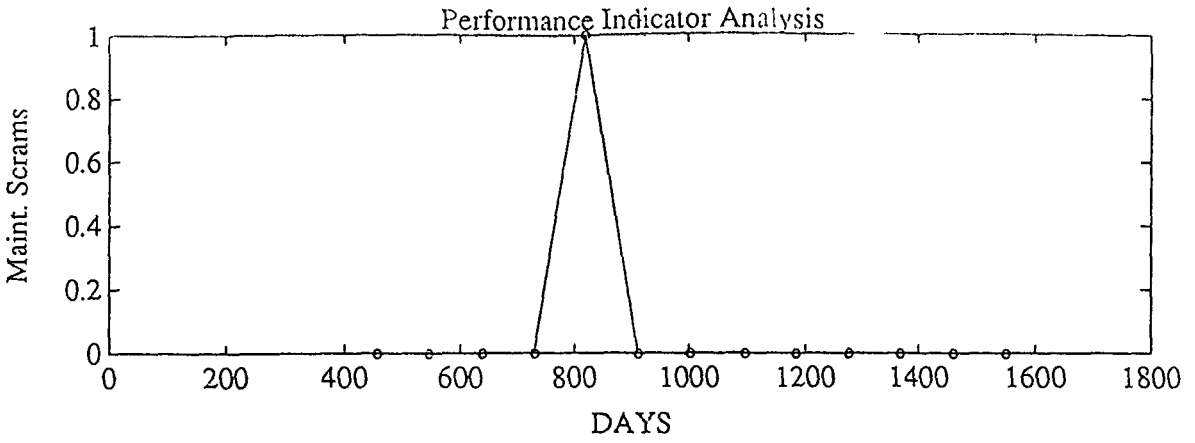

Availability
0
20
40
60
80
100
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

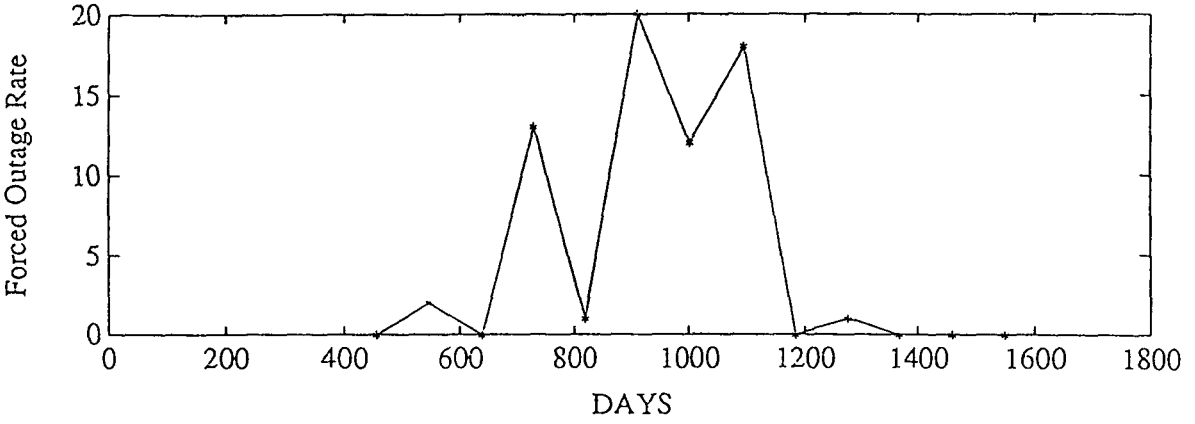

Indicator = Deficiency Ratio
M.O.S. = Availability
Shift = 0
0
2000
4000
6000
8000
10000
12000
14000
16000
-10
-8
-6
-4
-2
0
2
4
6
8
10
Time Shift (Quarters)

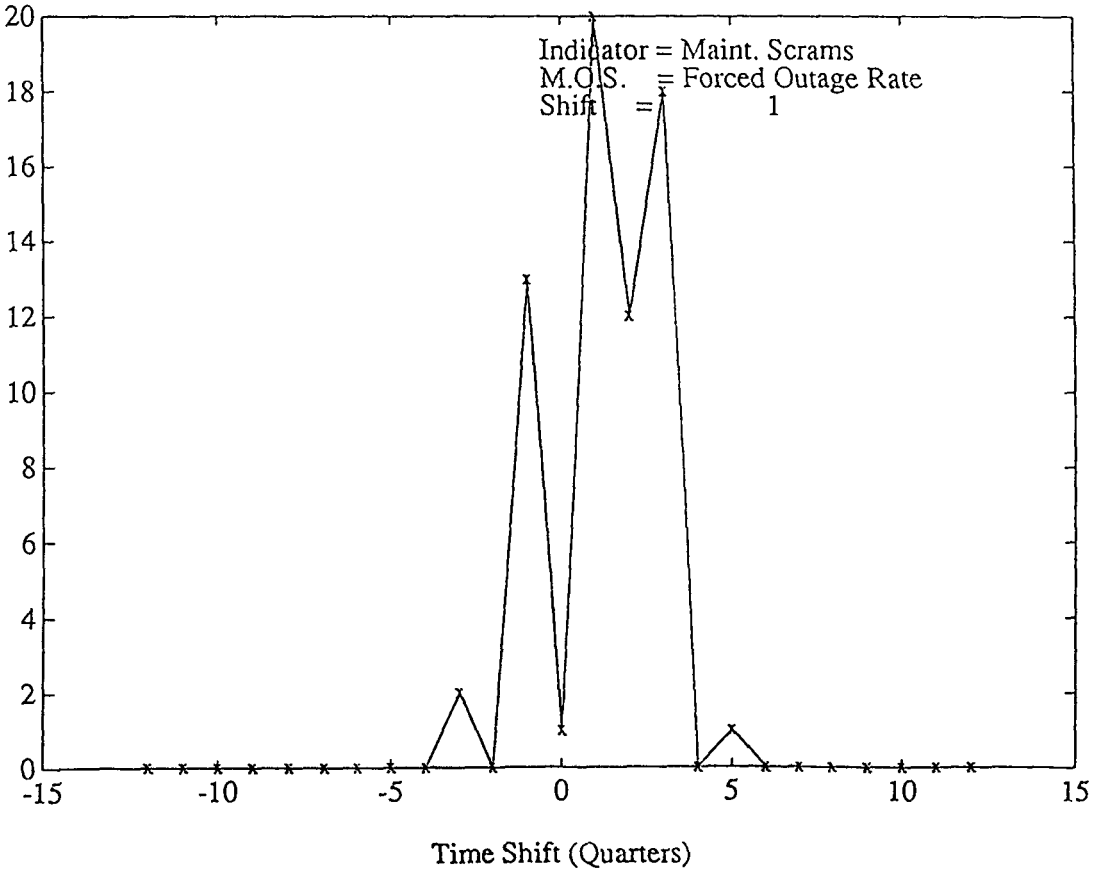

Performance Indicator Analysis
Mean Time BOP Maint.
4000
3000
2000
1000
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

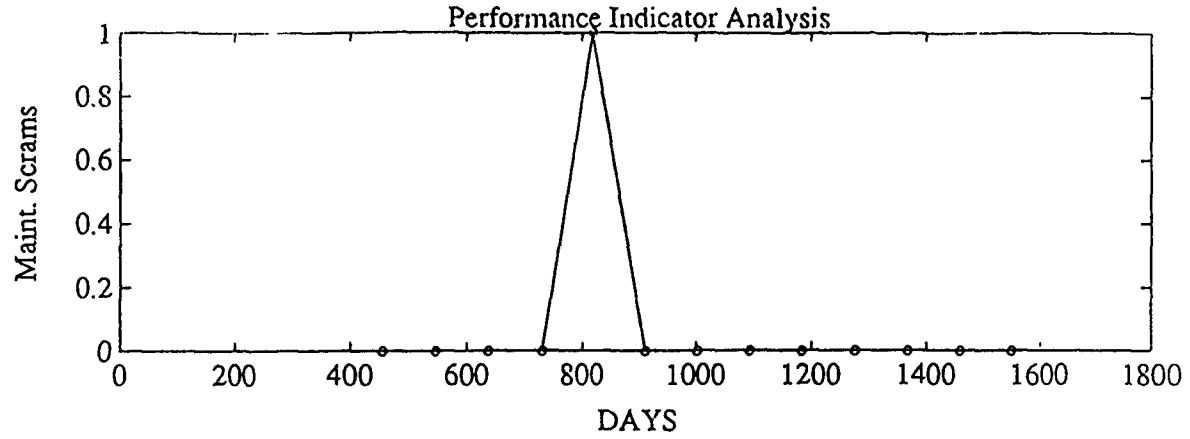

FRATE
20
15
10
5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

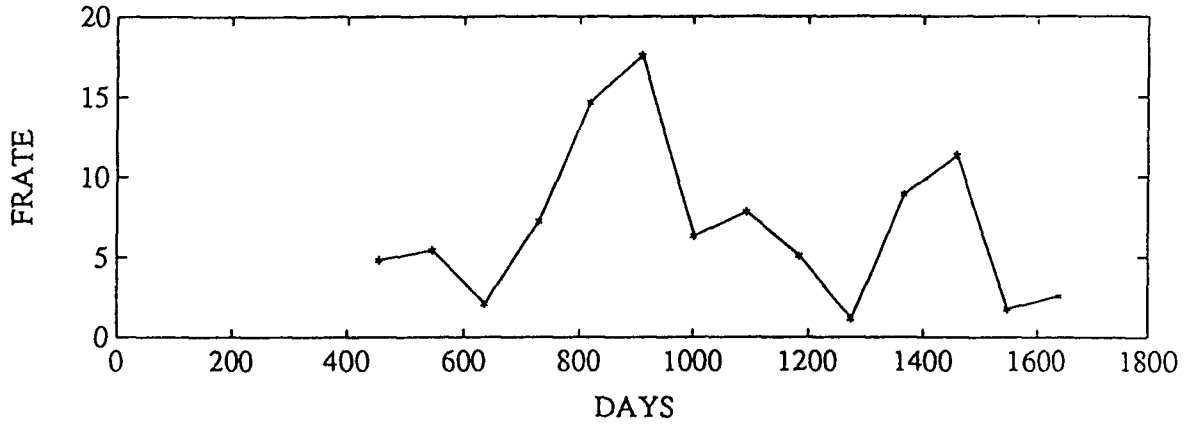

x10^5
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Indicator = Mean Time BOP Maint.
M.O.S. = FRATE
Shift = 1
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

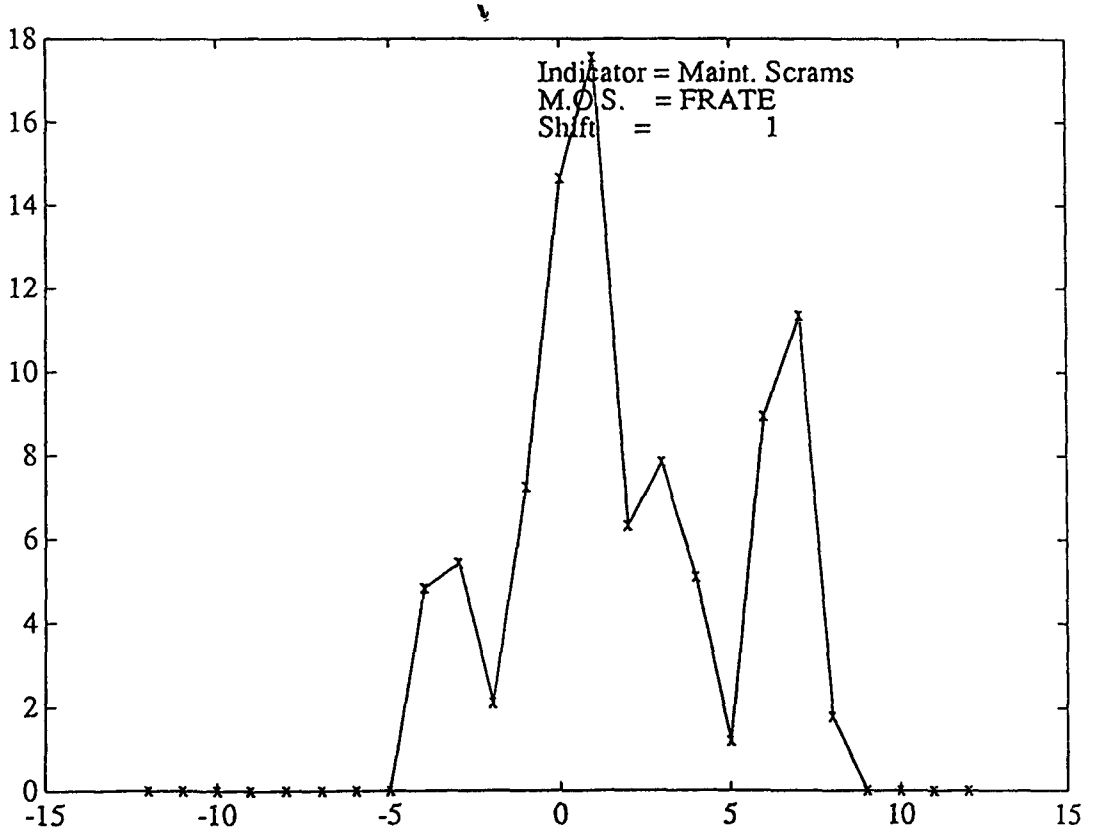

Performance Indicator Analysis
Maint. Scrams
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Forced Outage Rate
20
15
10
5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = Maint. Scrams
M.O.S. = Forced Outage Rate
Shift = 1
20
18
16
14
12
10
8
6
4
2
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)


Performance Indicator Analysis
Maint. Scrams
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

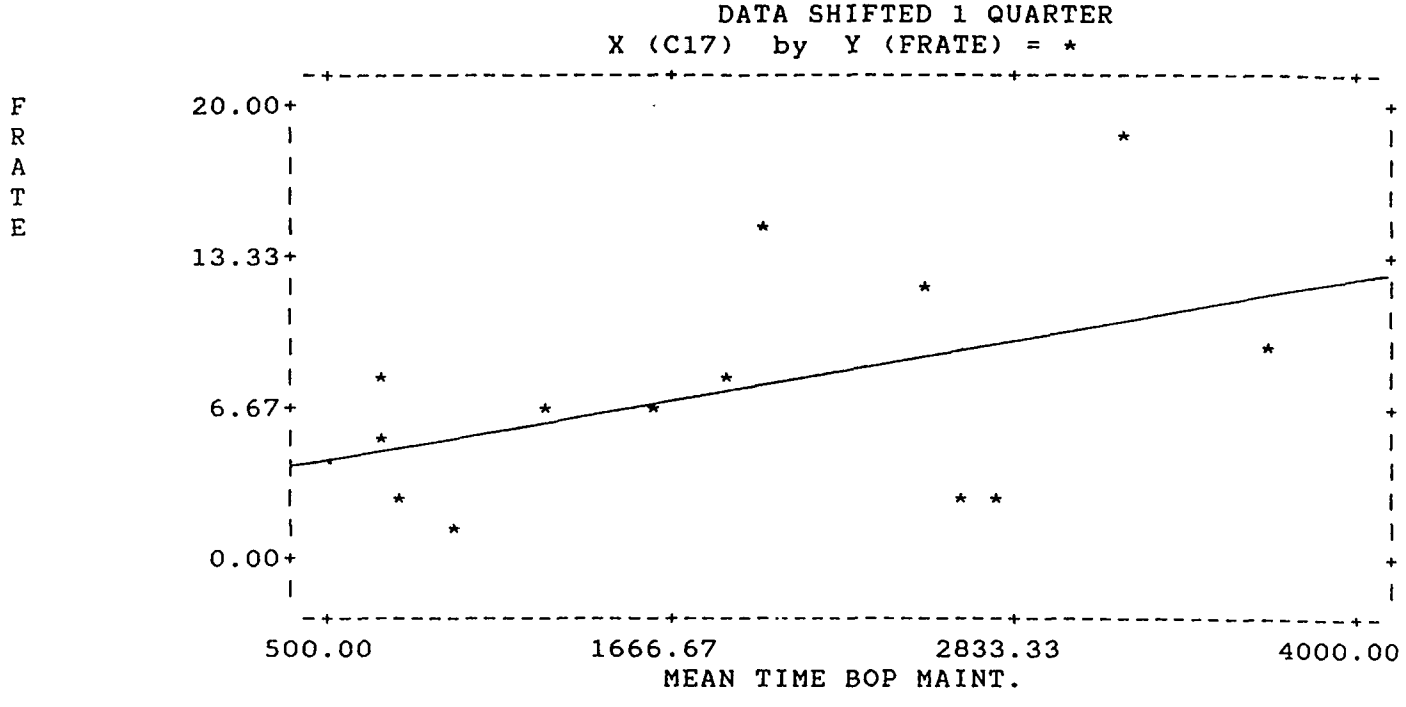

FRATE
20
15
10
5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = Maint. Scrams
M.O.S. = FRATE
Shift = 1
18
16
14
12
10
8
6
4
2
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

----------Scatter Plots----------

Date/Time 10-25-1988 14:06:24
Data Base Name C:\NCSS\
Description Imported from E:\matlab\trdata\

Scatter Plots



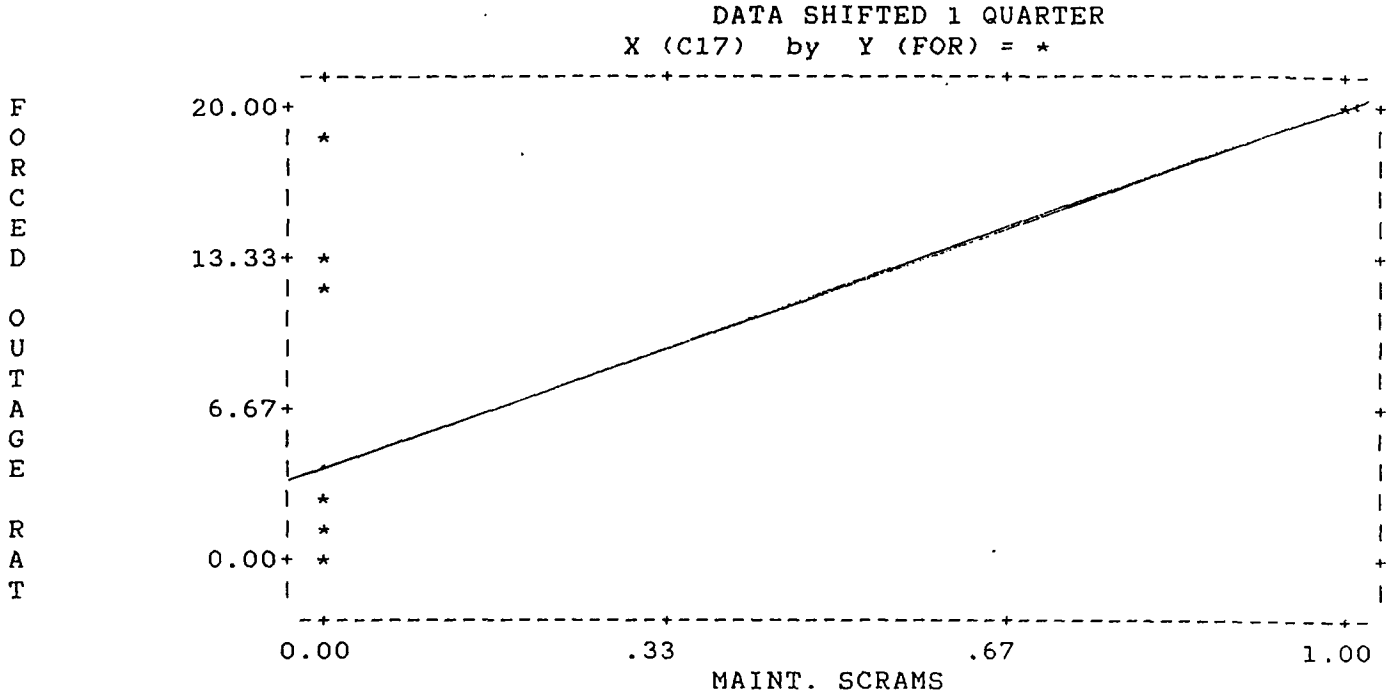
Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	0
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 14:07:22
Data Base Name C:\NCSS\
Description Imported from E:\matlab\trdata\

Scatter Plots



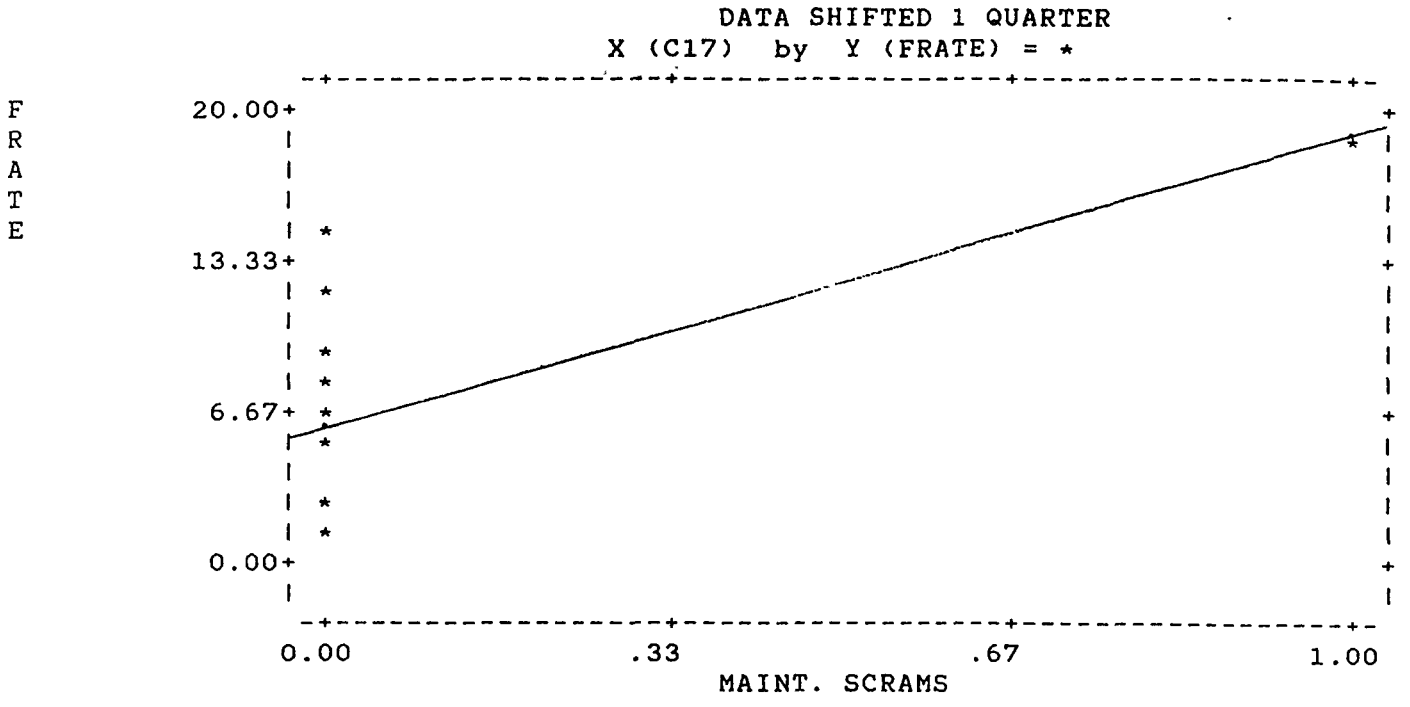
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	1
Number of points plotted	:	12		

----------Scatter Plots----------

Date/Time 10-25-1988 14:07:56
Data Base Name C:\NCSS\
Description Imported from E:\matlab\trdata\

Scatter Plots



Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	0
Number of points plotted	:	13		

Detailed Results for Plant H

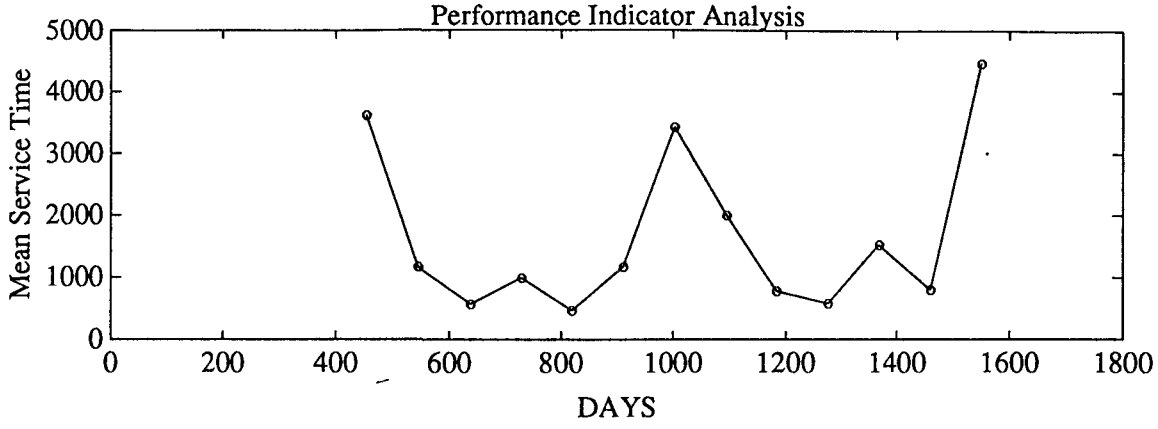
Maintenance Indicators vs. Measures of Safety

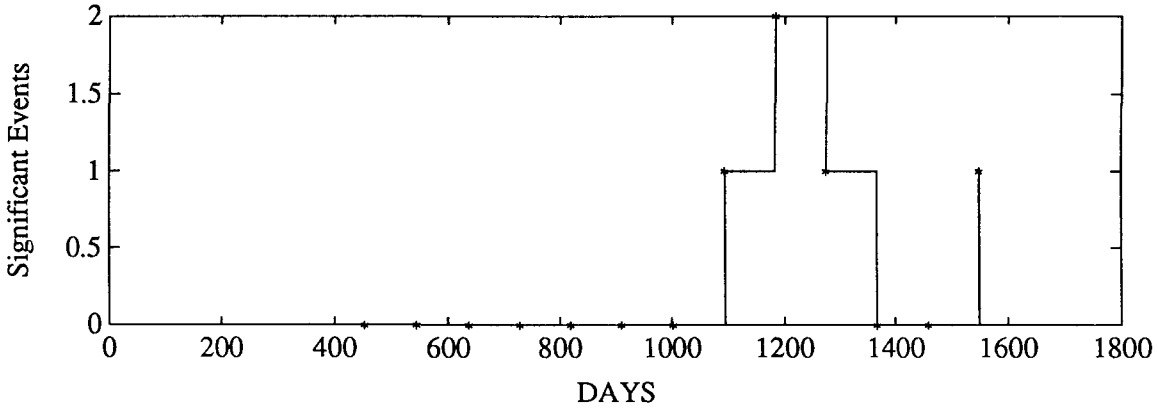
	RANK	1SCRTL	1SCRHI	1SCRLO	2SSA	3SE	4SSF	5FOR	7EFO	CRITHOUR	SALP-M	FRATE	AVAIL
1PMTOTM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2CMB	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3PMOVER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4MNTTO1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5REWORK1*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6DEFIC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7CMWRPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7DBOPMT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9MTSERV*	NS	S	S	NS	NS	NS	NS	NS	NS	NS	N/A	S	NS
CSCRAM*	NS	S	NS	NS	NS	NS	NS	S	NS	NS	N/A	NS	NS
8ASSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8BSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8CSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8DSSPI	[Zero events in relevant time scale]										N/A		
BAHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BBHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BCHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BDHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BEHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BFHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BGHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CBSCRAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GHR*	S	NS	NS	NS	NS	NS	NS	NS	S	NS	N/A	NS	NS
WPE*	[Zero events in relevant time scale]												
REALE*	[Zero events in relevant time scale]										N/A		
BACKECN*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WRONGT/U*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ESFACT*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N/A	NS	NS

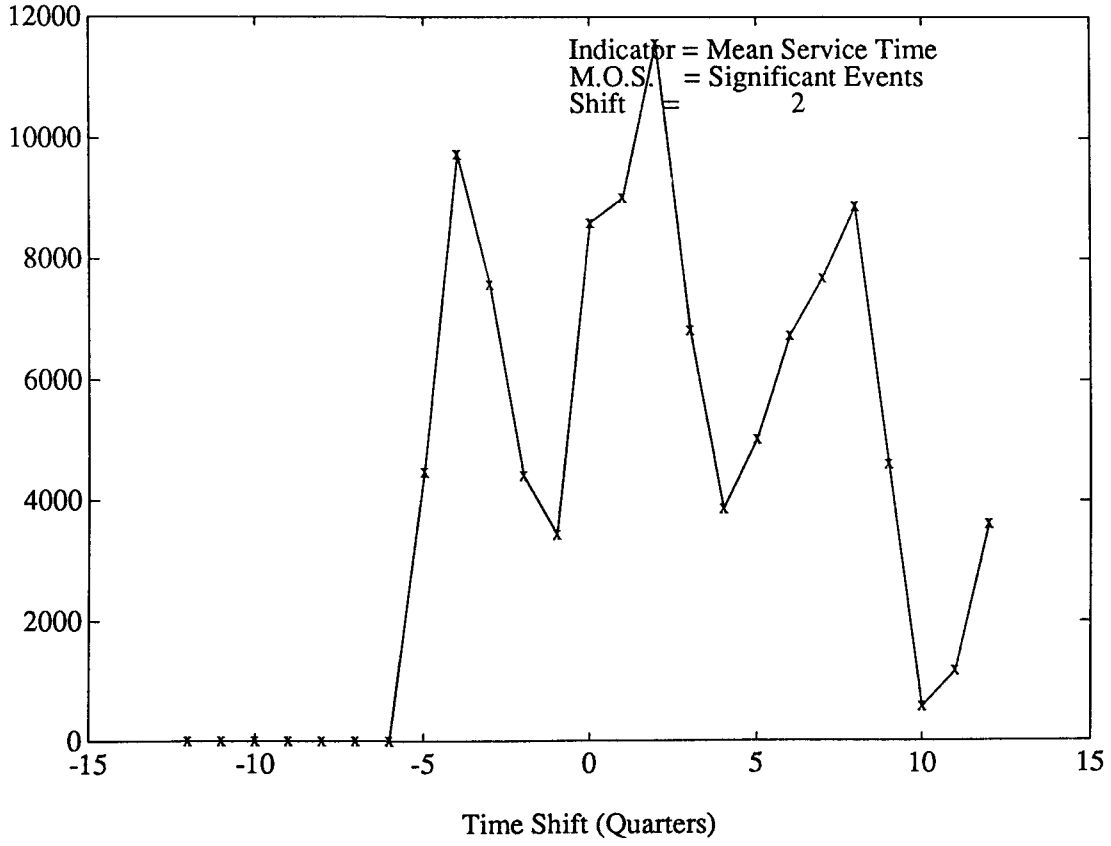
Note: Indicators marked with an "*" are SAIC indicators

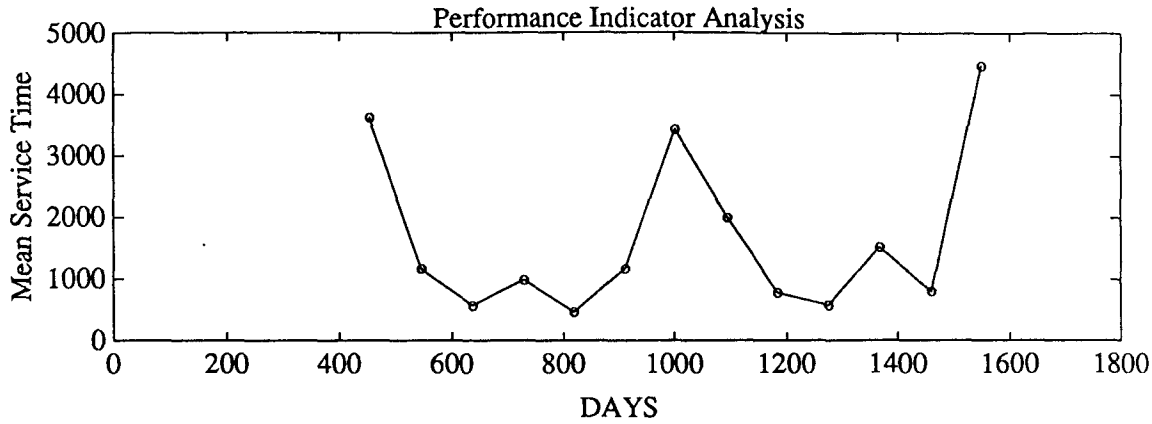
Significant Maintenance Indicator/Measure of Safety Relationships

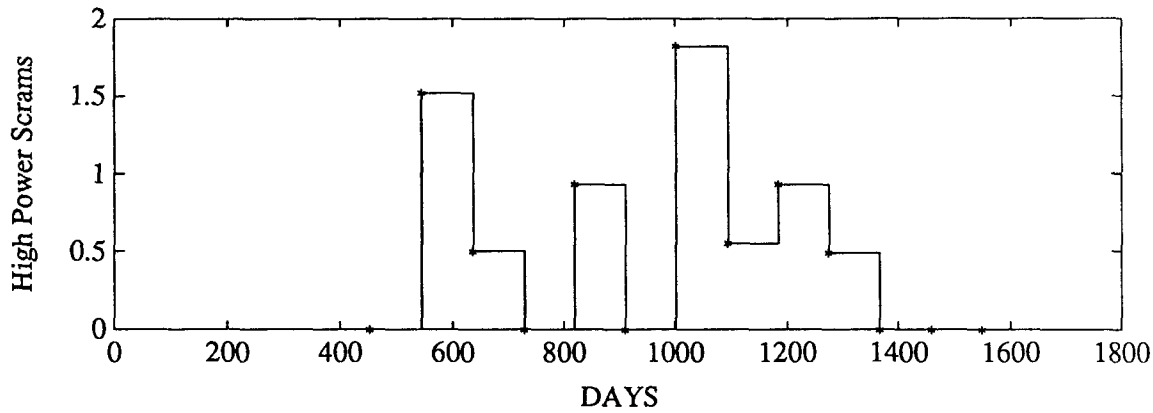
Indicator	Measure of Safety	Time Shift	Confidence
9MTSERV	FRATE	0	80%
9MTSERV	SCRHI	+1	96%
9MTSERV	SCRTL	+1	95%
GHR	RANK	0	90%
GHR	EFO	0	80%
CSCRAM	SCRTL	0	82%
CSCRAM	FOR	0	82%

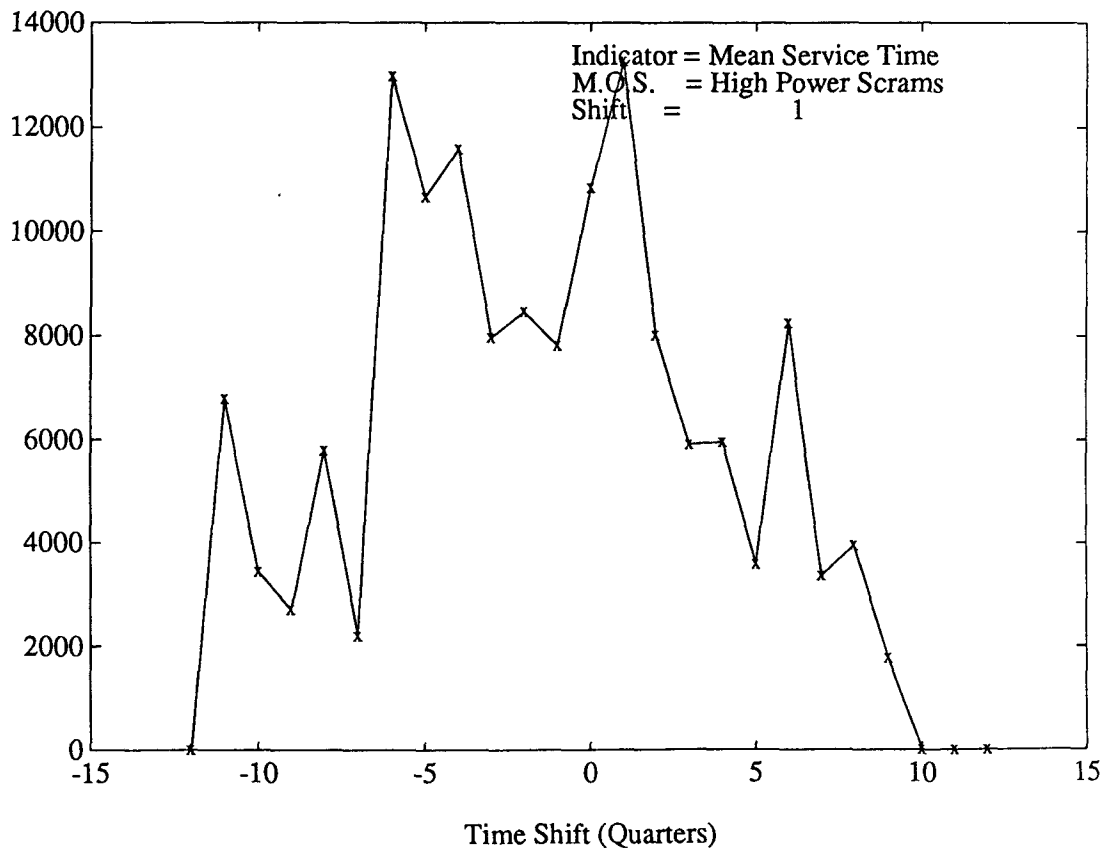

Performance Indicator Analysis
Mean Service Time
5000
4000
3000
2000
1000
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

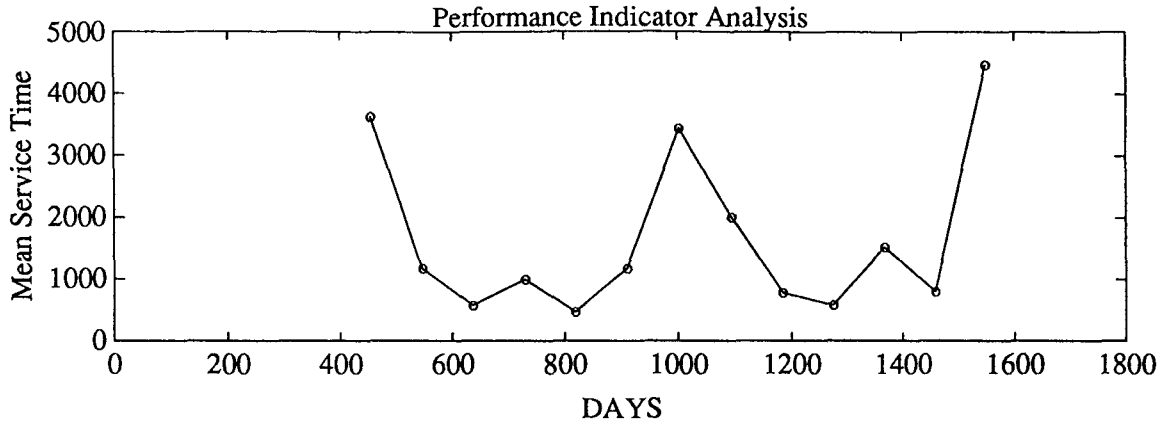

Significant Events
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

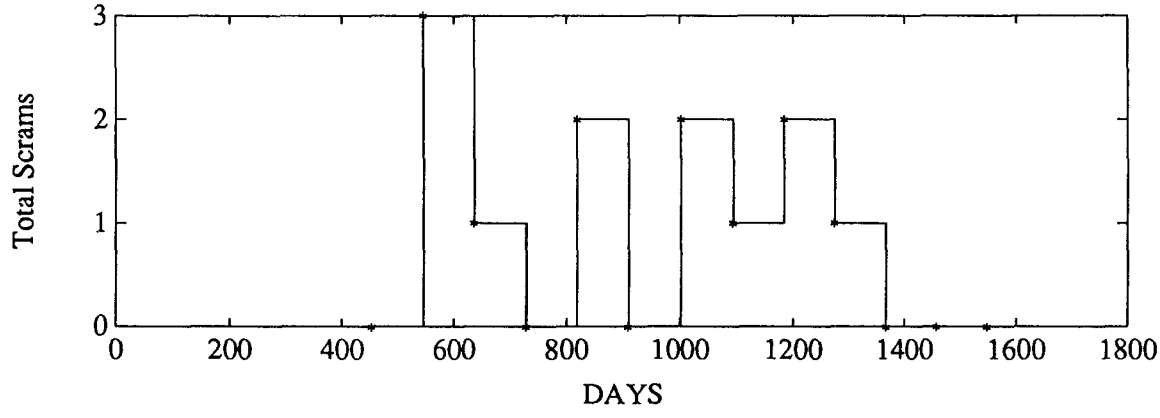

Indicator = Mean Service Time
M.O.S. = Significant Events
Shift = 2
12000
10000
8000
6000
4000
2000
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

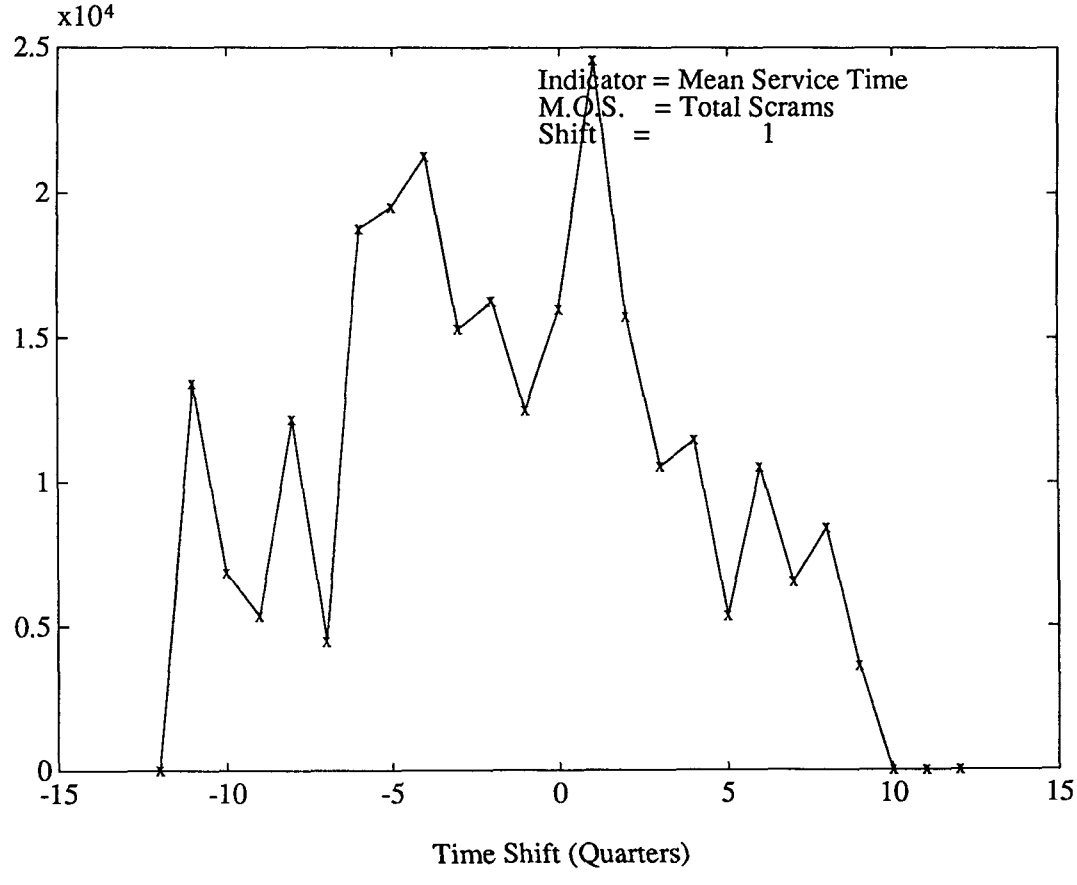

Performance Indicator Analysis
Mean Service Time
5000
4000
3000
2000
1000
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

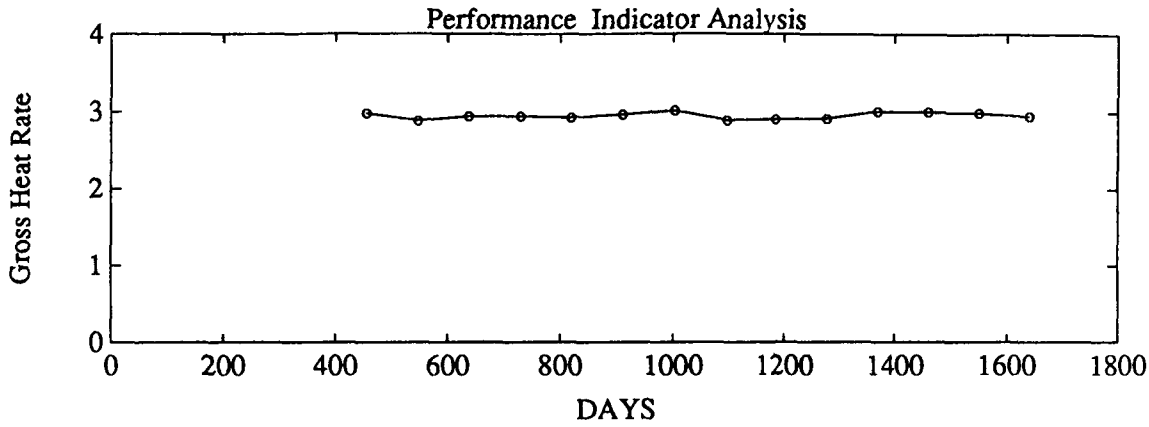

High Power Scrams
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

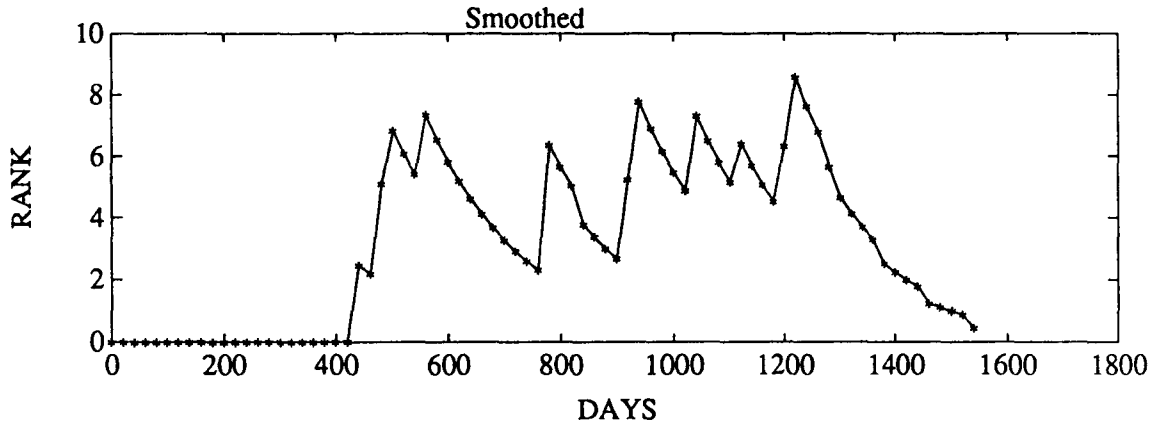

Indicator = Mean Service Time
M.O.S. = High Power Scrams
Shift = 1
14000
12000
10000
8000
6000
4000
2000
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

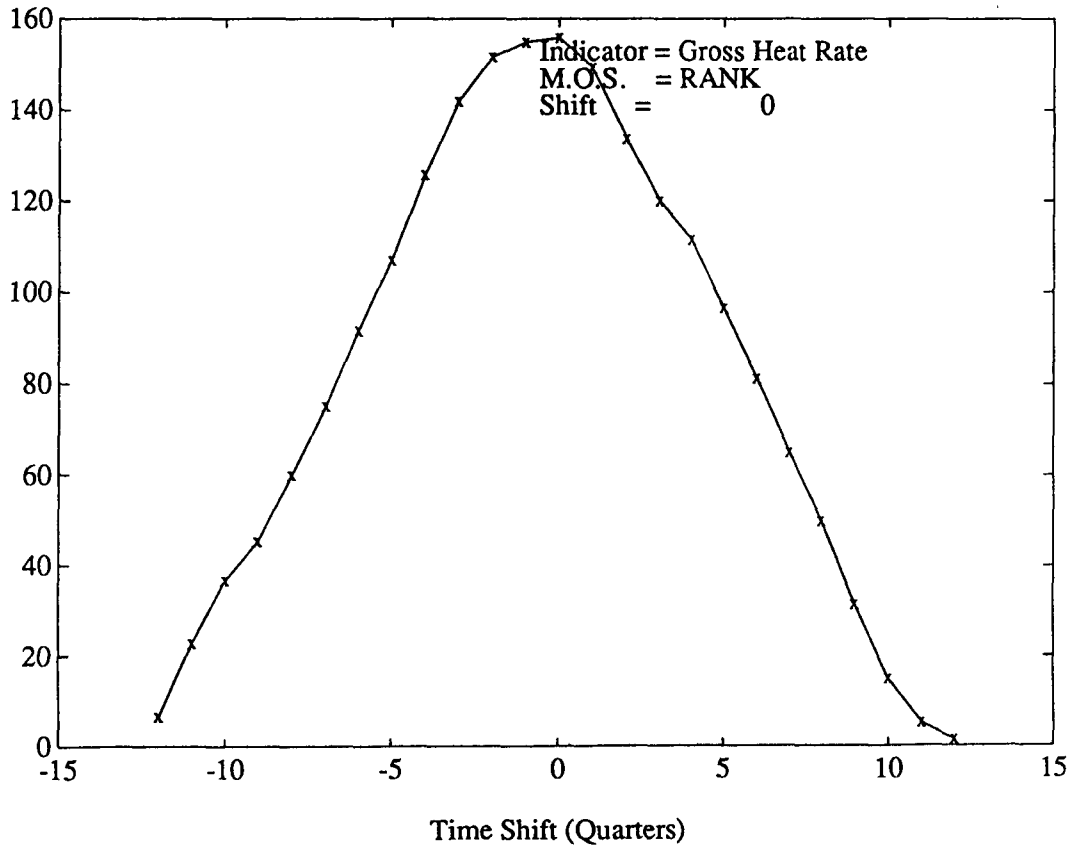

Performance Indicator Analysis
Mean Service Time
5000
4000
3000
2000
1000
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

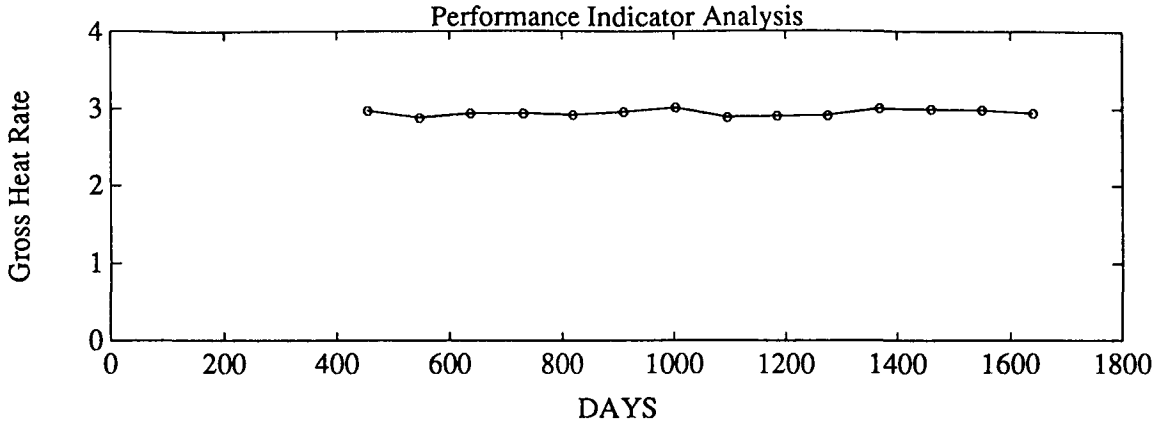

Total Scrams
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

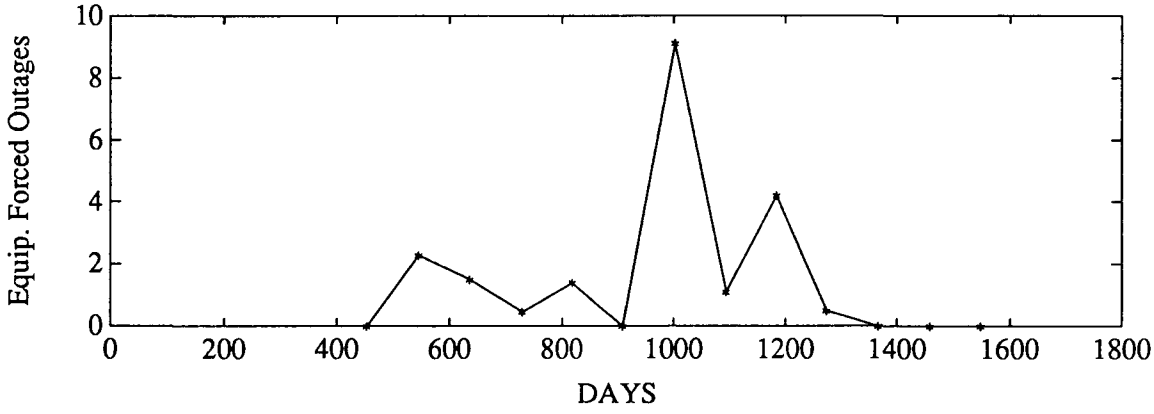

x10⁴
2.5
2
1.5
1
0.5
0
Indicator = Mean Service Time
M.O.S. = Total Scrams
Shift = 1
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

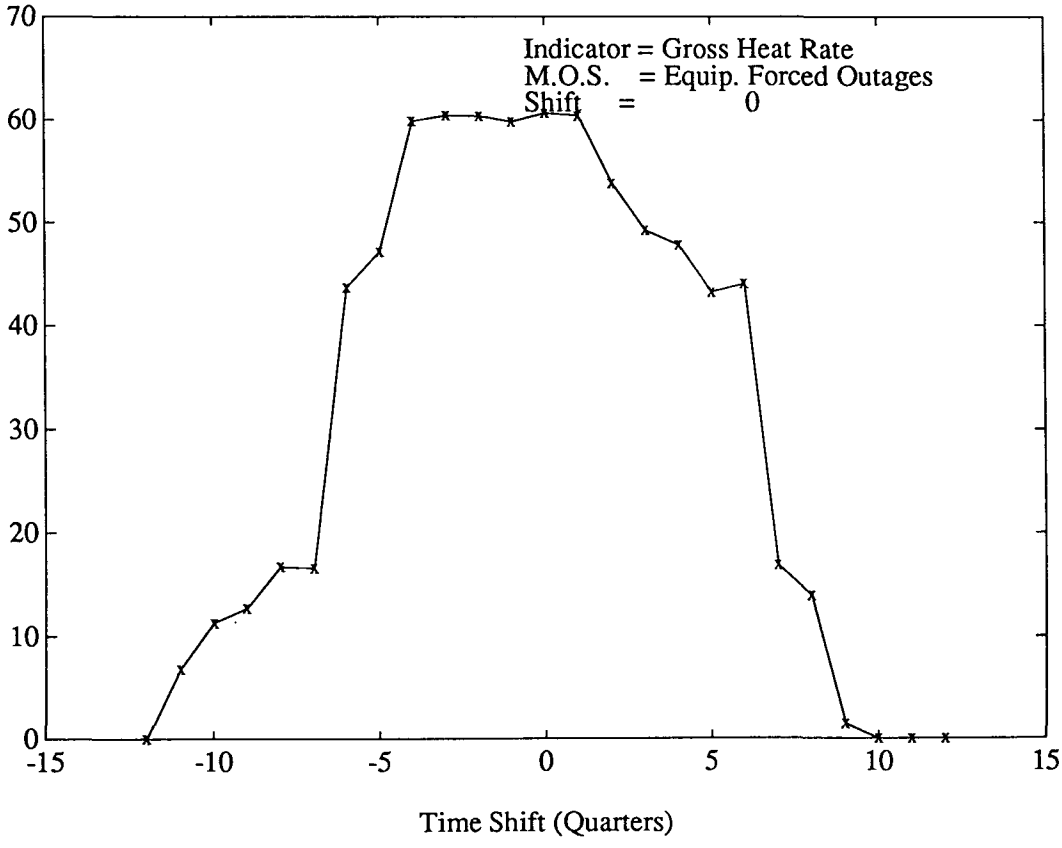

Performance Indicator Analysis
Gross Heat Rate
DAYS

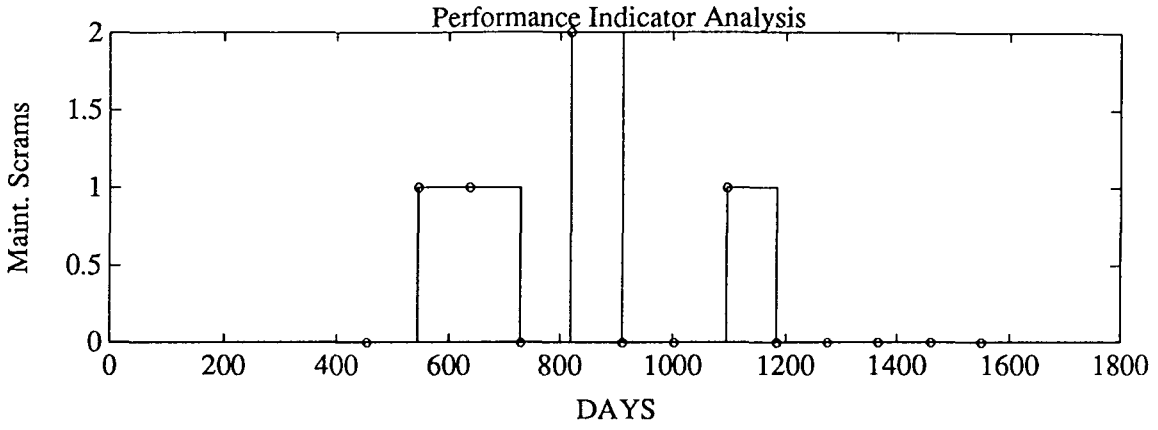

Smoothed
RANK
DAYS

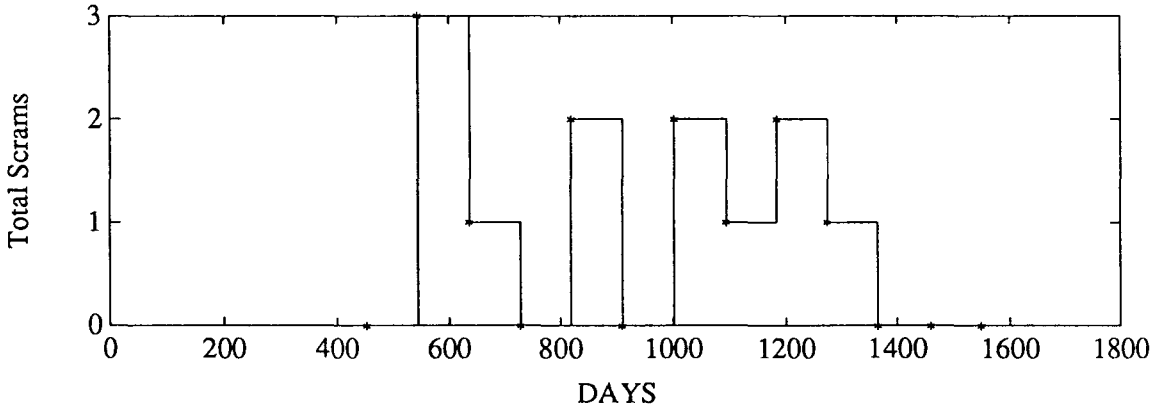

Indicator = Gross Heat Rate
M.O.S. = RANK
Shift = 0
Time Shift (Quarters)

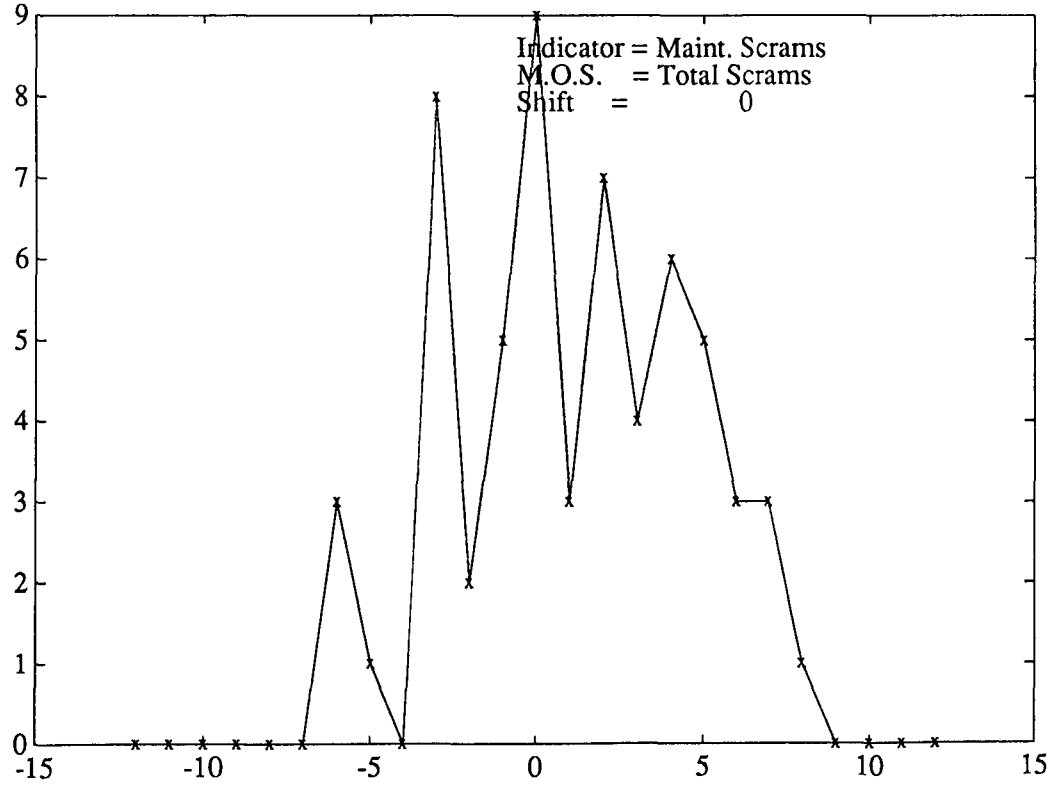

Performance Indicator Analysis
Gross Heat Rate
DAYS

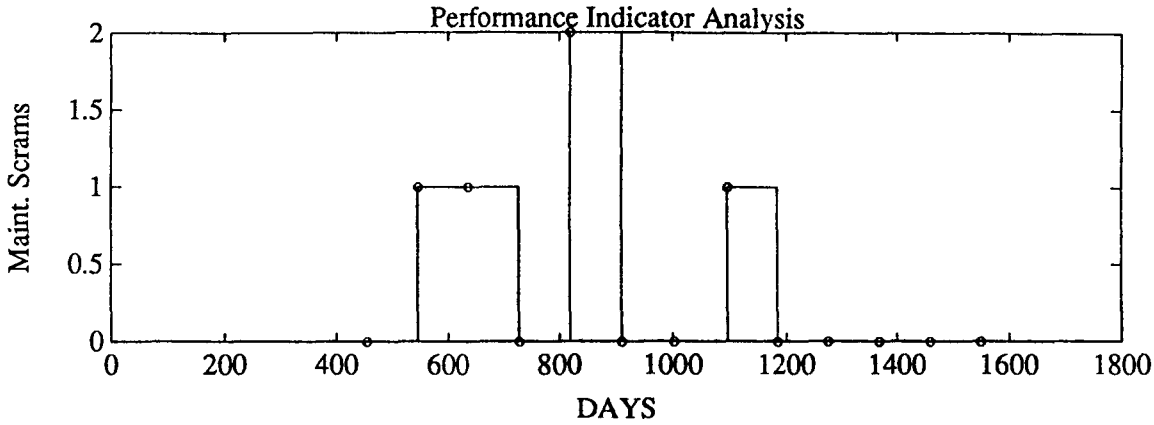

Equip. Forced Outages
DAYS

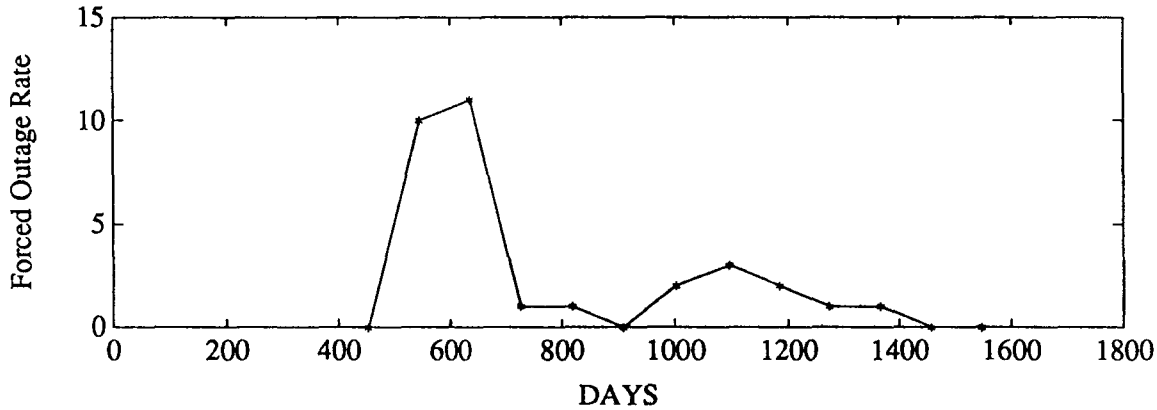

Indicator = Gross Heat Rate
M.O.S. = Equip. Forced Outages
Shift = 0
Time Shift (Quarters)

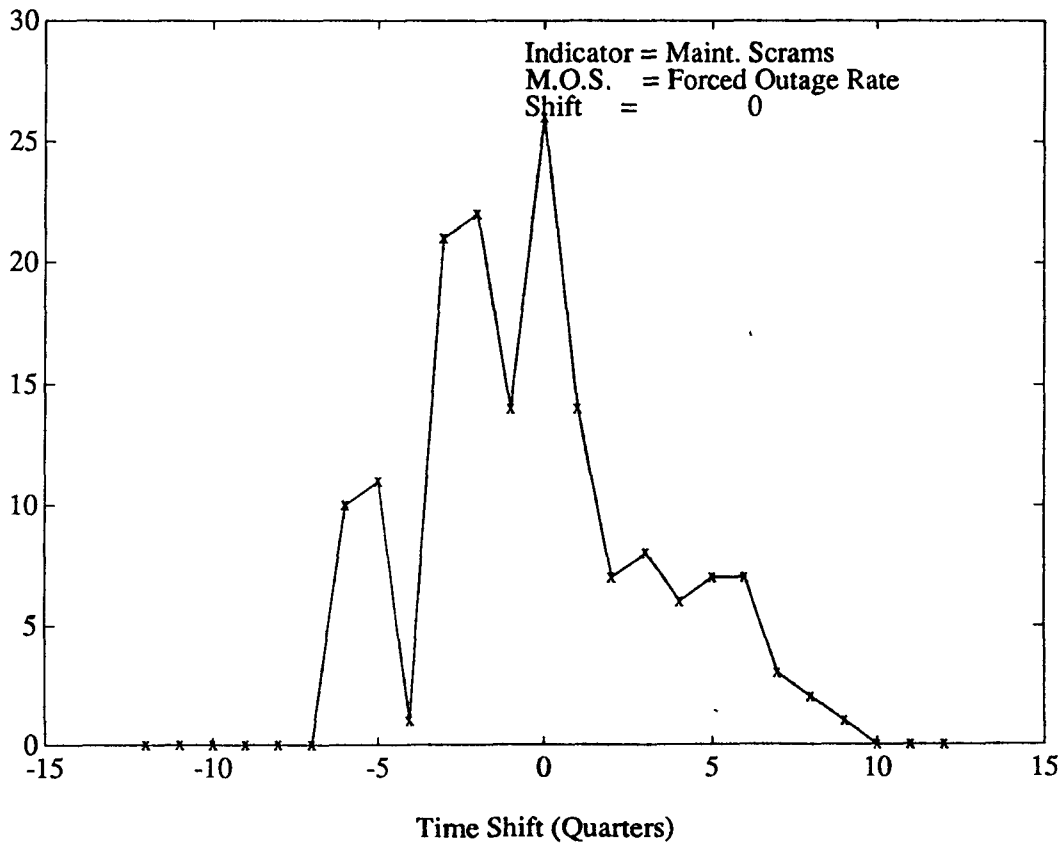

Performance Indicator Analysis
Maint. Scrams
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Total Scrams
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = Maint. Scrams
M.O.S. = Total Scrams
Shift = 0
9
8
7
6
5
4
3
2
1
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)


Performance Indicator Analysis
Maint. Scrams
2
1.5
1
0.5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

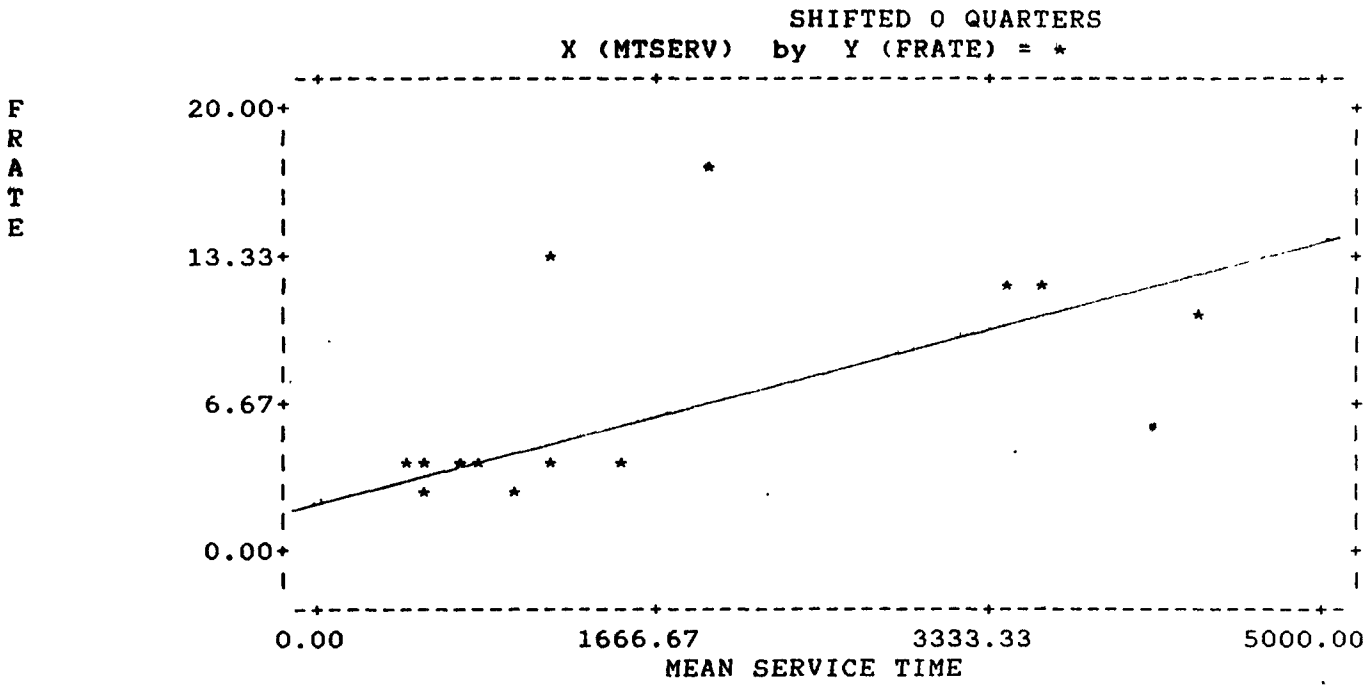

Forced Outage Rate
15
10
5
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = Maint. Scrams
M.O.S. = Forced Outage Rate
Shift = 0
30
25
20
15
10
5
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

----------Scatter Plots----------

Date/Time 10-25-1988 14:09:16
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



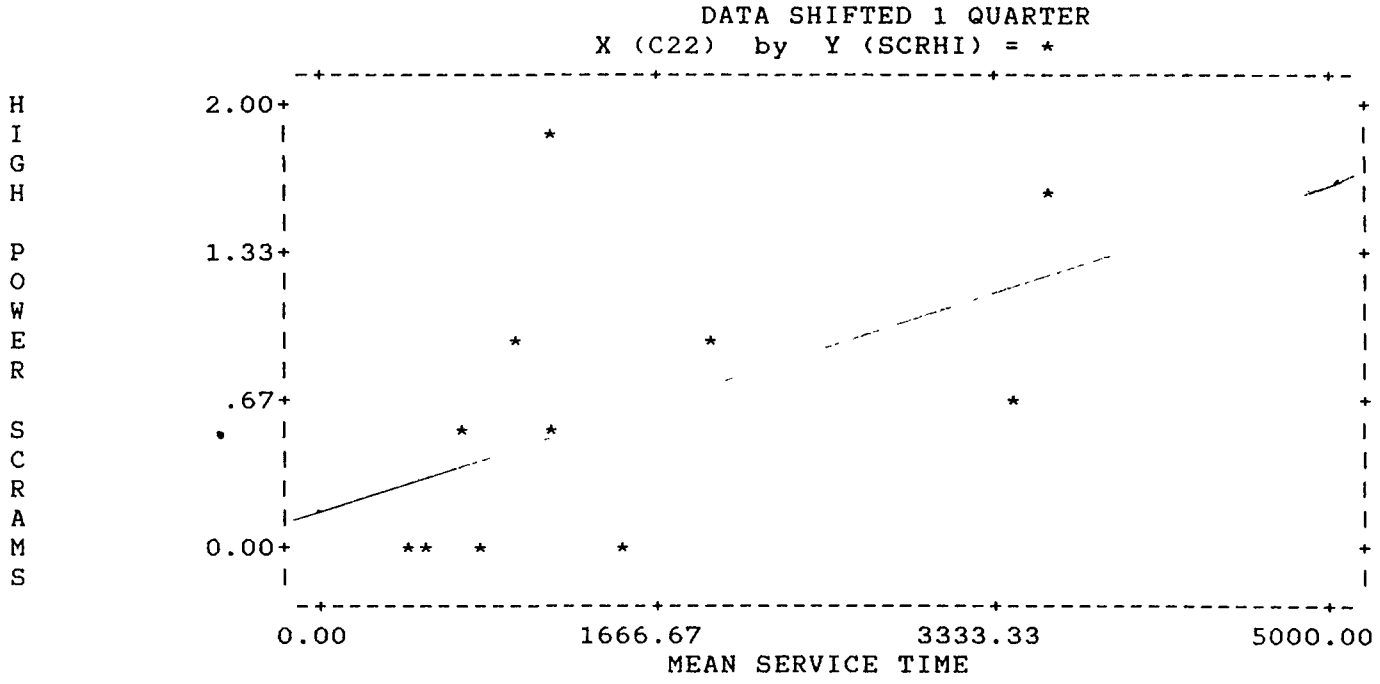
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	0
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 14:10:41
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



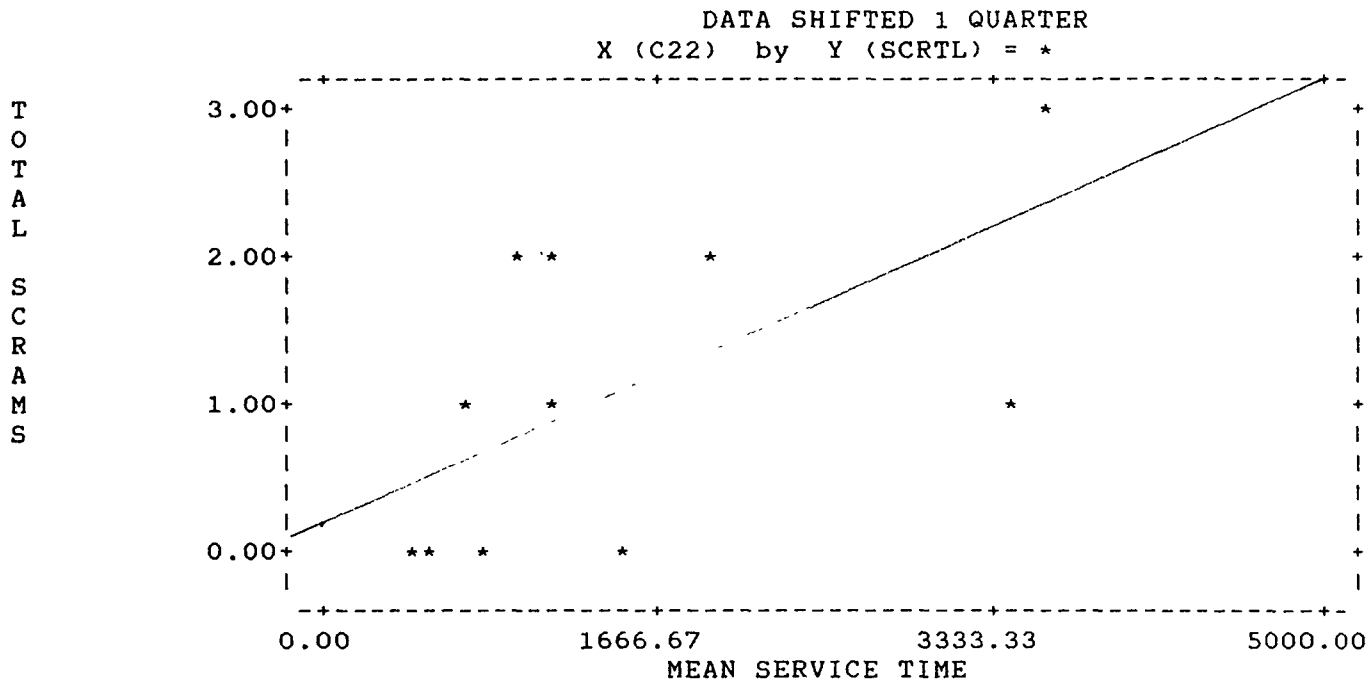
how Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	1
Number of points plotted	:	12		

----------Scatter Plots----------

Date/Time 10-25-1988 14:11:09
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



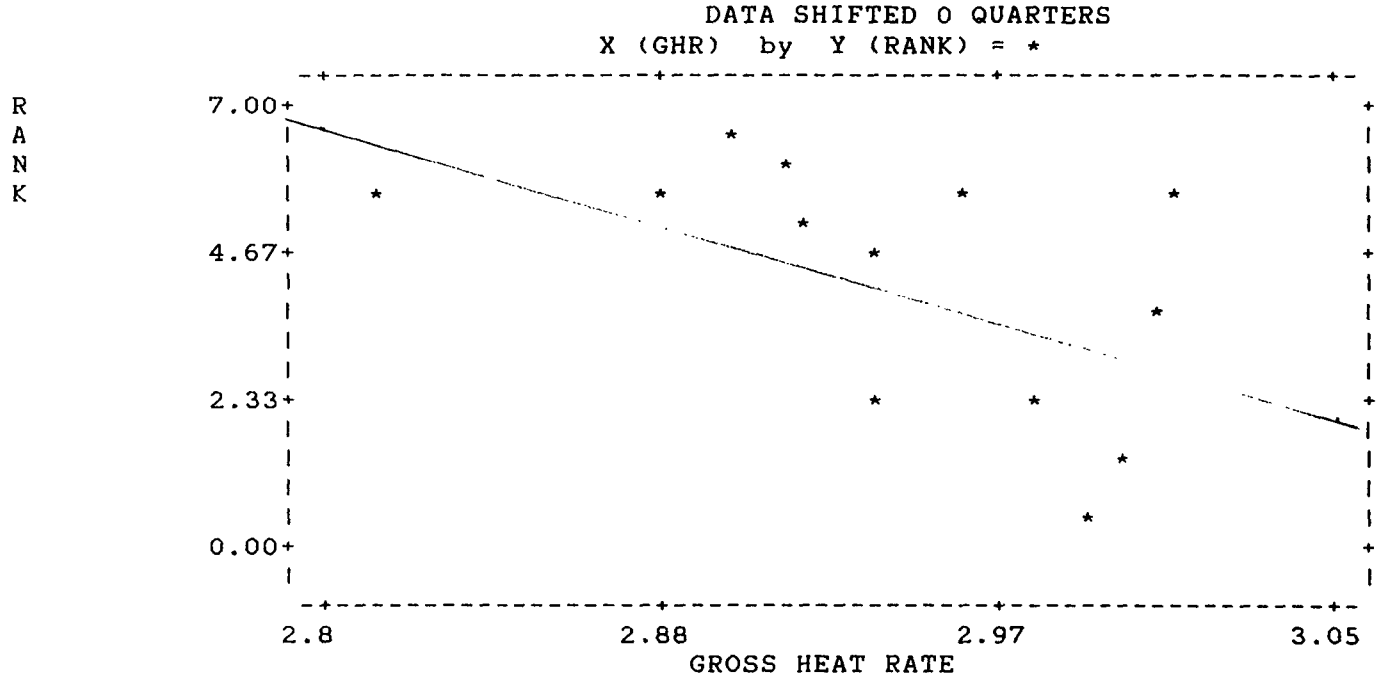
Flow Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	1
Number of points plotted	:	12		

----------Scatter Plots----------

Date/Time 10-25-1988 14:12:03
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



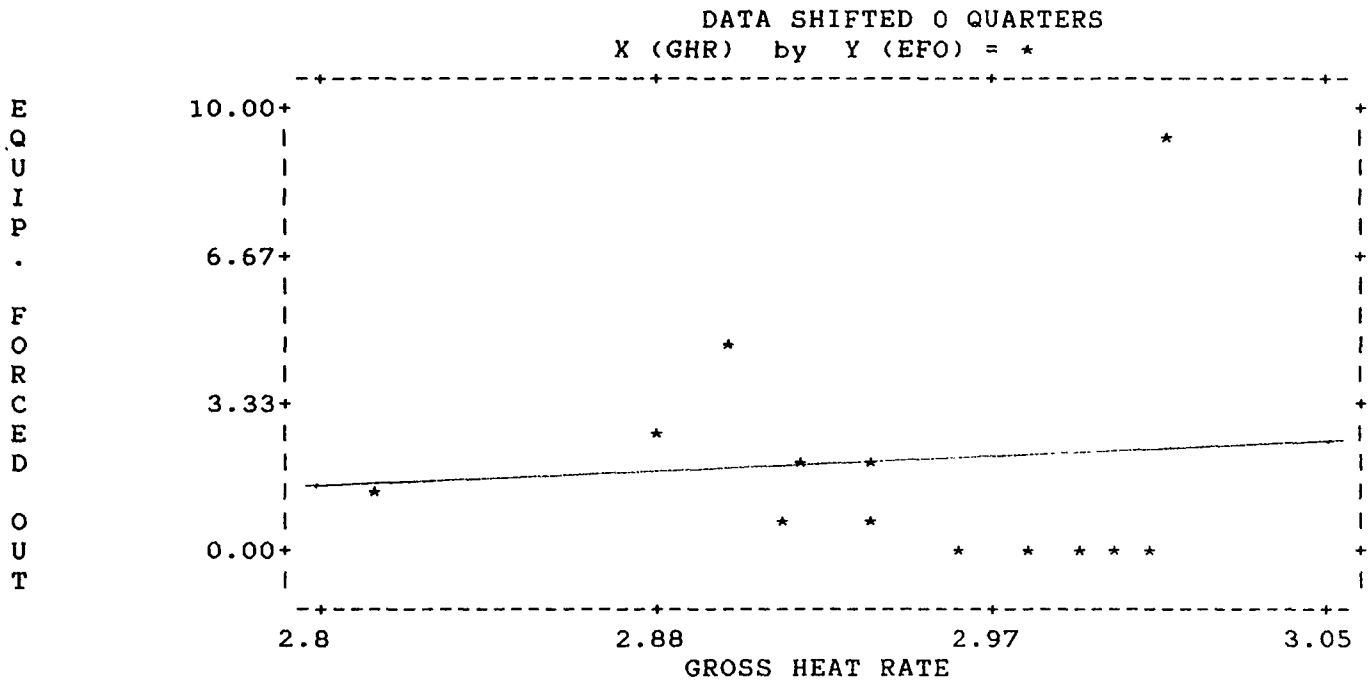
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	0
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 14:12:32
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



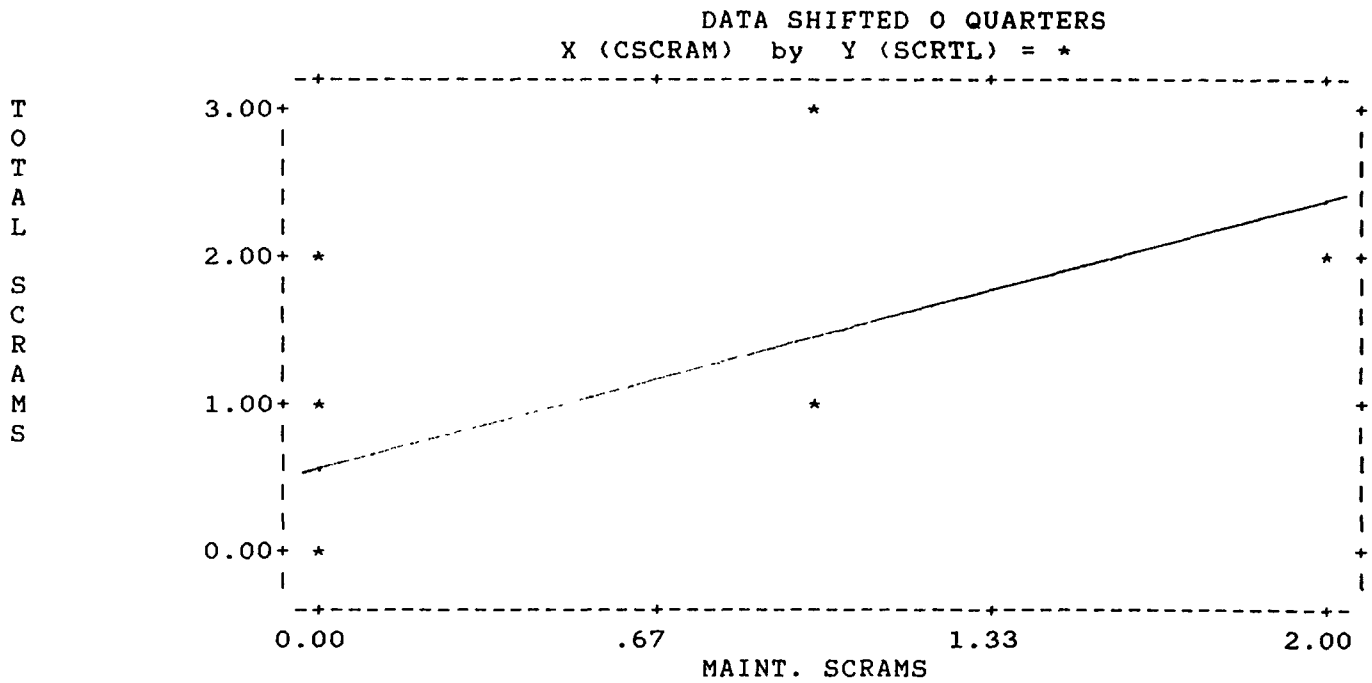
Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	1
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 14:13:23
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



...w Accounting Report

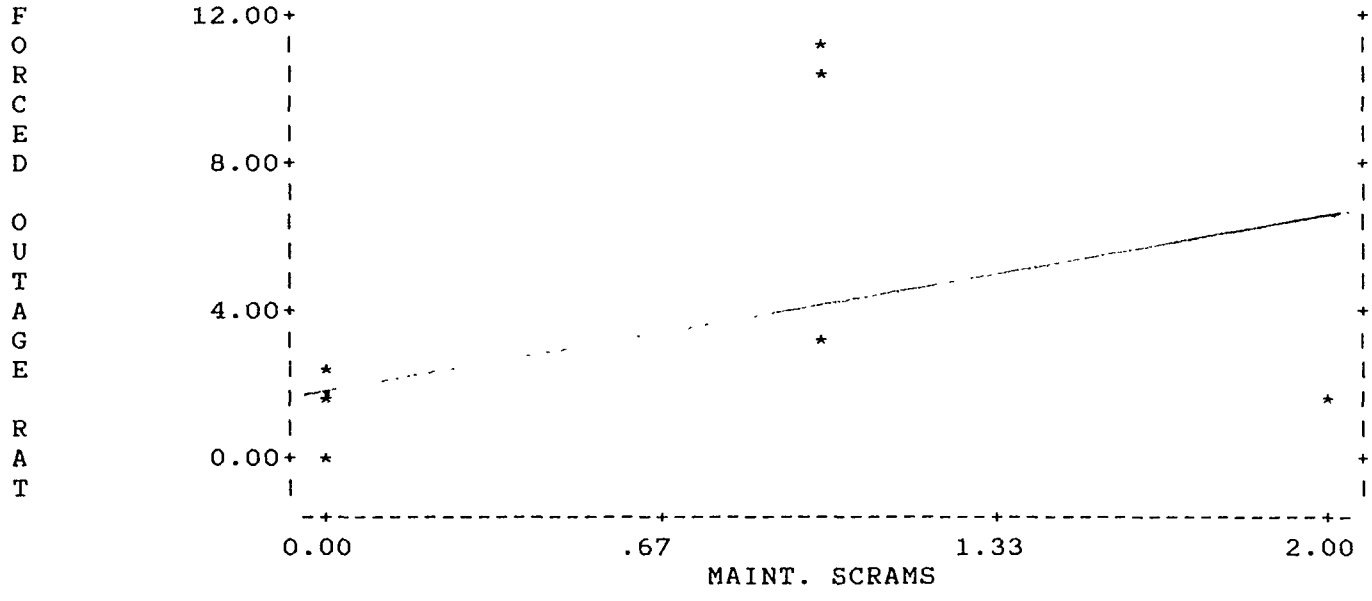
Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	0
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 14:13:47
Data Base Name C:\NCSS\
Description *Imported from* E:\MATLAB\TRDATA\

Scatter Plots

DATA SHIFTED 0 QUARTERS
X (CSCRAM) by Y (FOR) = *



...ow Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	0
Number of points plotted	:	13		

Detailed Results for Plant J

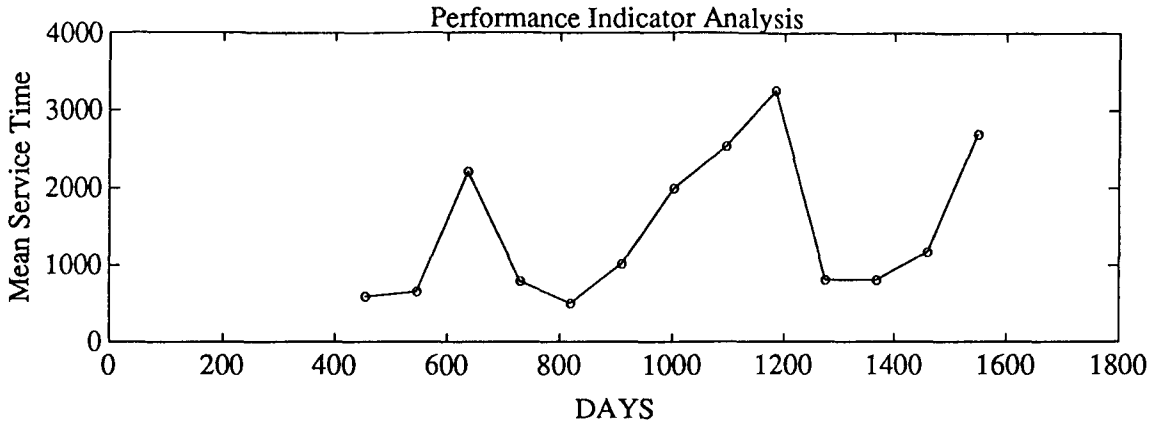
Maintenance Indicators vs. Measures of Safety

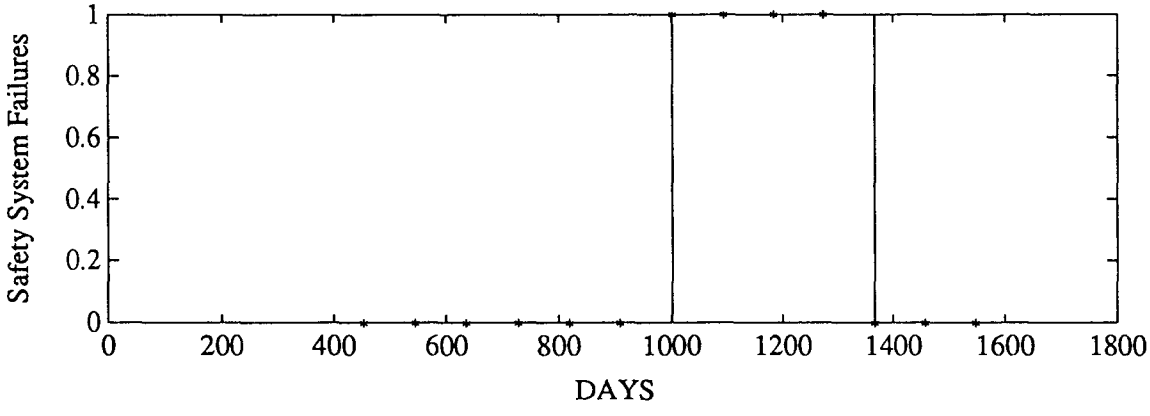
	RANK	1SCRTL	1SCRHI	1SCRLO	2SSA	3SE	4SSF	5FOR	7EFO	CRITHOUR	SALP-M	FRATE	AVAIL
1PMTOTM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2CMB	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3PMOVER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4MNTTO1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5REWORK1*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6DEFIC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7CMWRPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7D8OPMT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9MTSERV*	NS	NS	NS	NS	NS	S	S	NS	NS	NS	N/A	NS	NS
CSCRAM*	NS	NS	NS	S	NS	NS	NS	NS	NS	NS	N/A	NS	NS
8ASSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8BSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8CSSPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8DSSPI [Zero events in relevant time scale]											N/A		
BAHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BBHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BCHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BDHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BEHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BFHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BGHRNA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CBSCRAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GHR*	NS	NS	NS	NS	NS	NS	S	S	NS	NS	S	S	S
WPE* [Zero events in relevant time scale]													
REALE* [Zero events in relevant time scale]													
BACKECN*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WRONGT/U*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ESFACT*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N/A	NS	NS

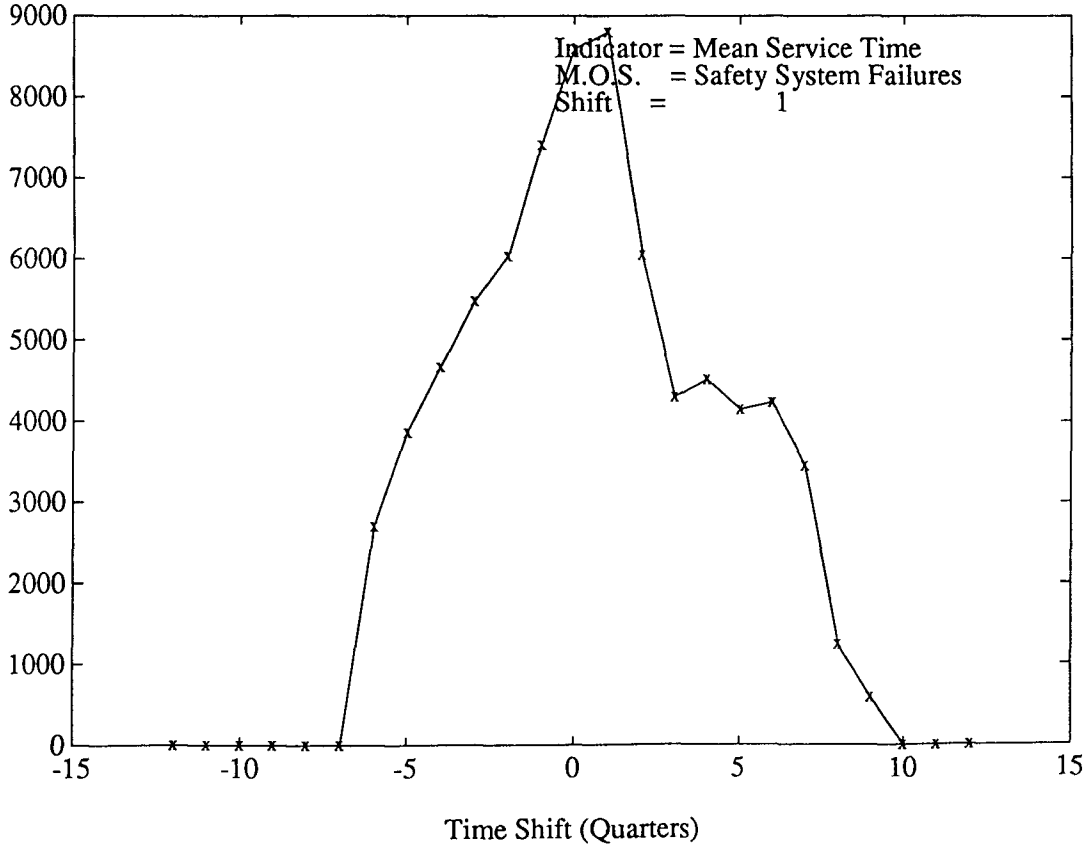
Note: Indicators marked with an "*" are SAIC indicators

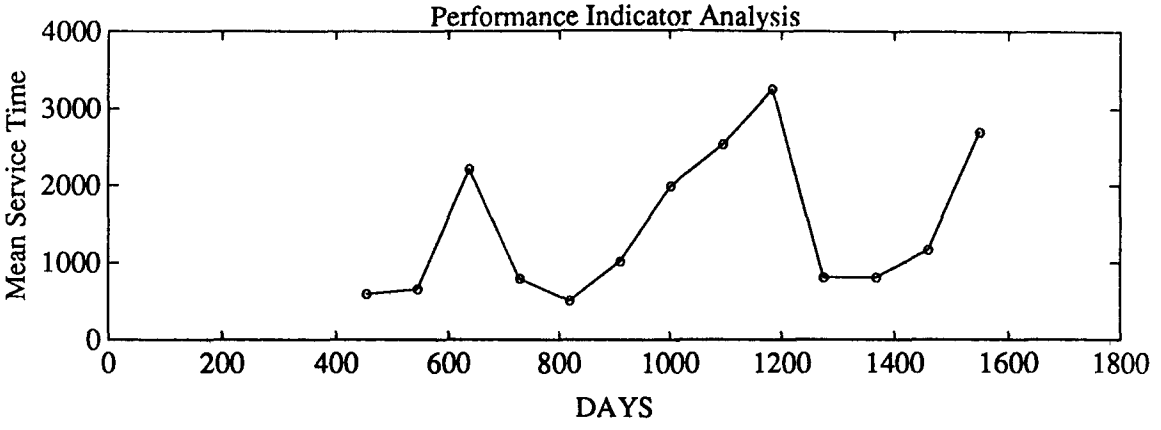
Significant Maintenance Indicator/Measure of Safety Relationships

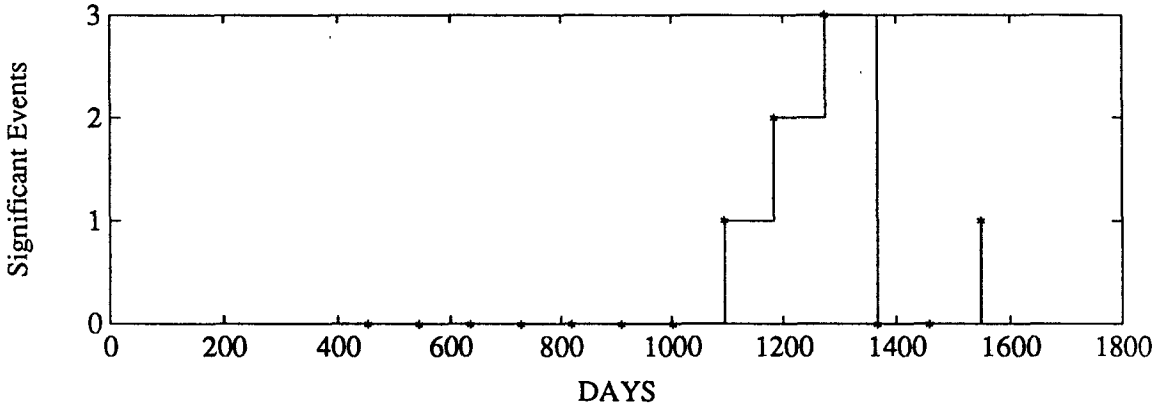
Indicator	Measure of Safety	Time Shift	Confidence
9MTSERV	SSF	+1	86%
9MTSERV	SE	+1	90%
GHR	SALP	0	86%
GHR	FRATE	0	85%
GHR	AVAIL	+1	95%
GHR	SSF	+1	80%
GHR	SE	+1	95%
CSCRAM	SCRLO	0	99%

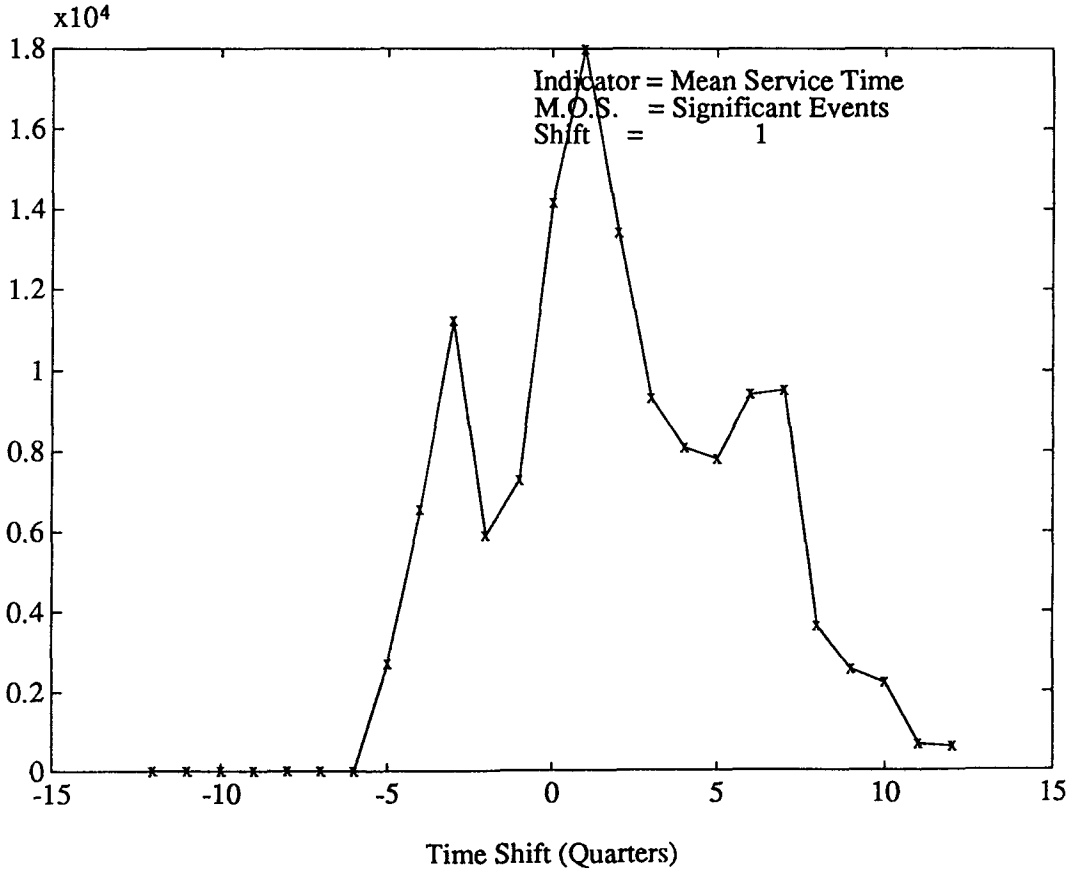

Performance Indicator Analysis
Mean Service Time
4000
3000
2000
1000
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

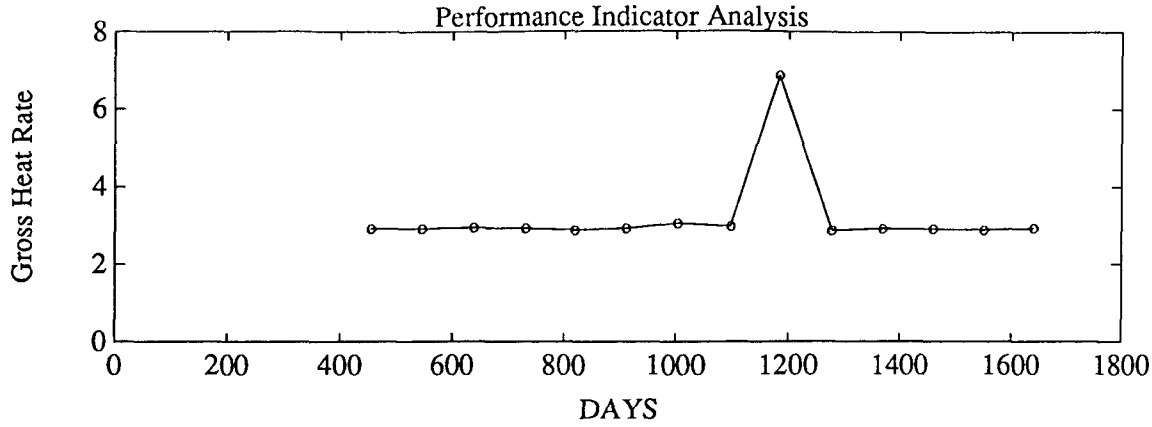

Safety System Failures
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

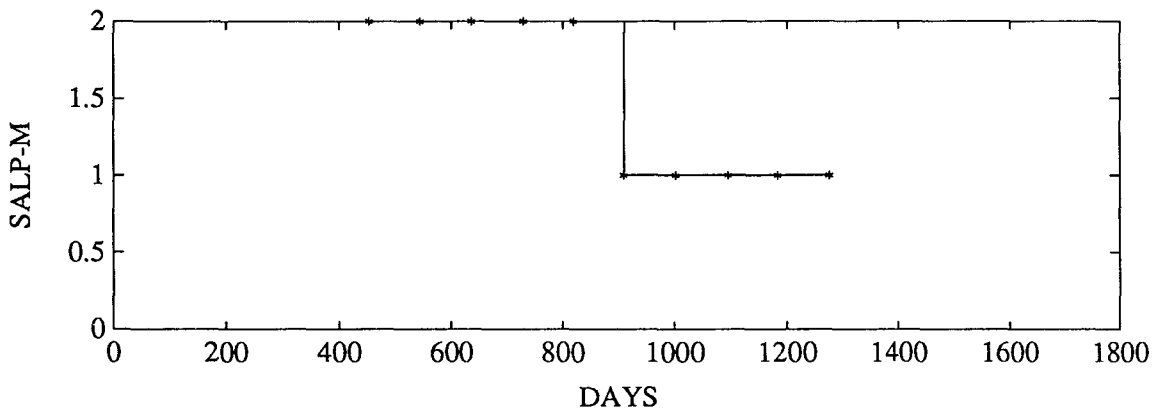

Indicator = Mean Service Time
M.O.S. = Safety System Failures
Shift = 1
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

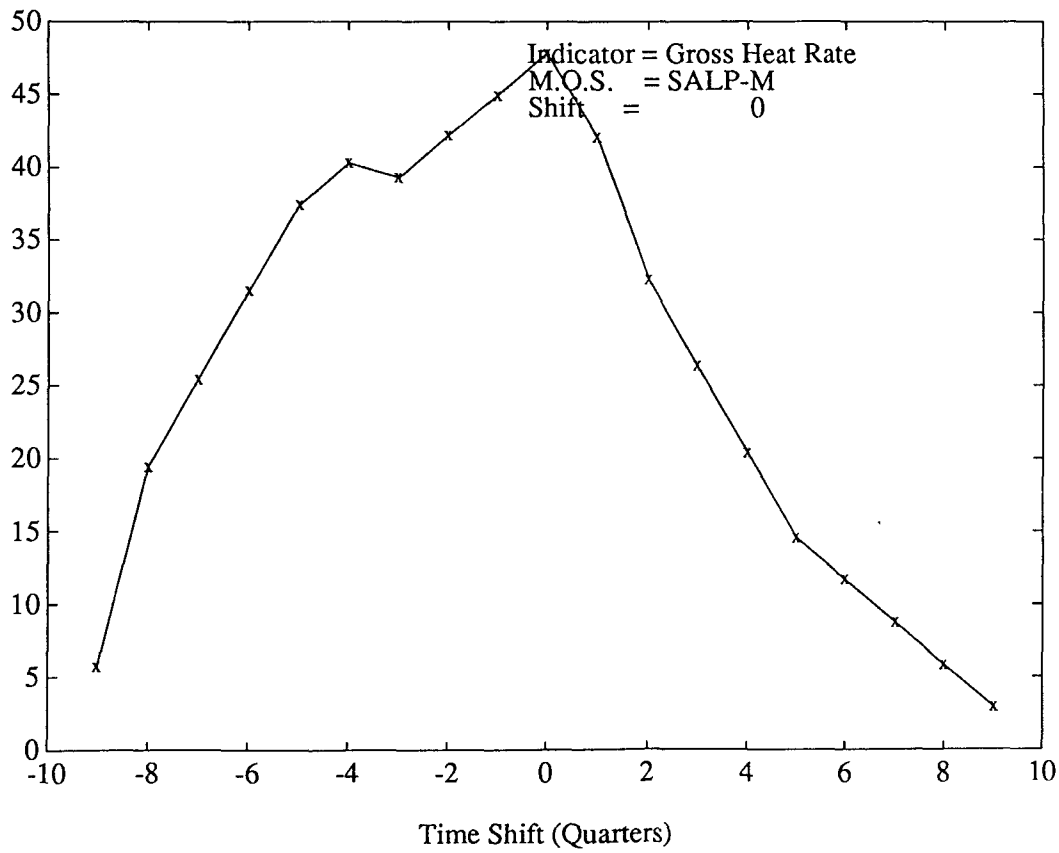

Performance Indicator Analysis
Mean Service Time
4000
3000
2000
1000
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

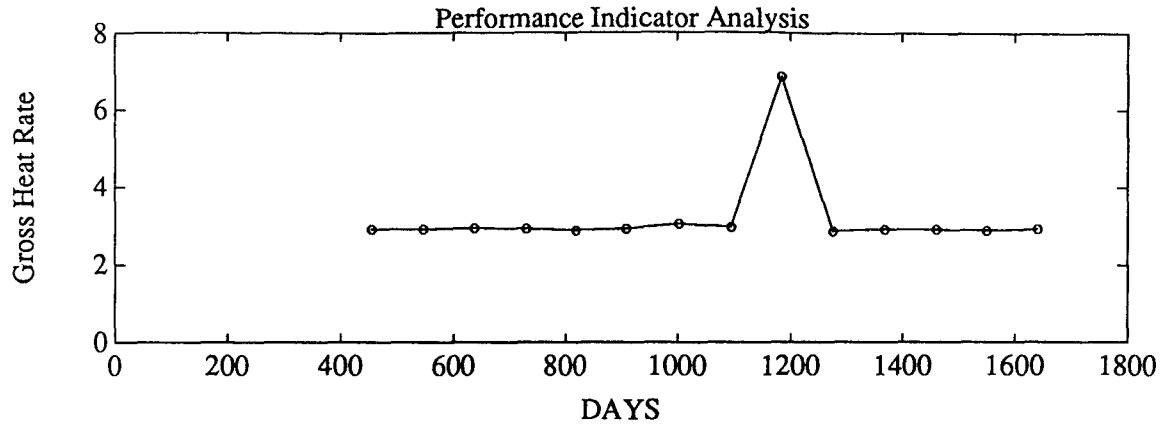

Significant Events
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

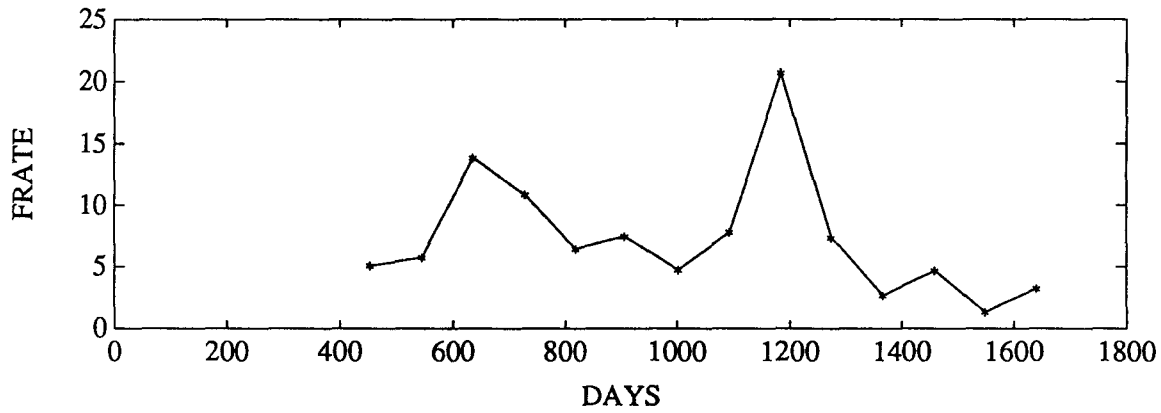

x10⁴
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Indicator = Mean Service Time
M.O.S. = Significant Events
Shift = 1
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

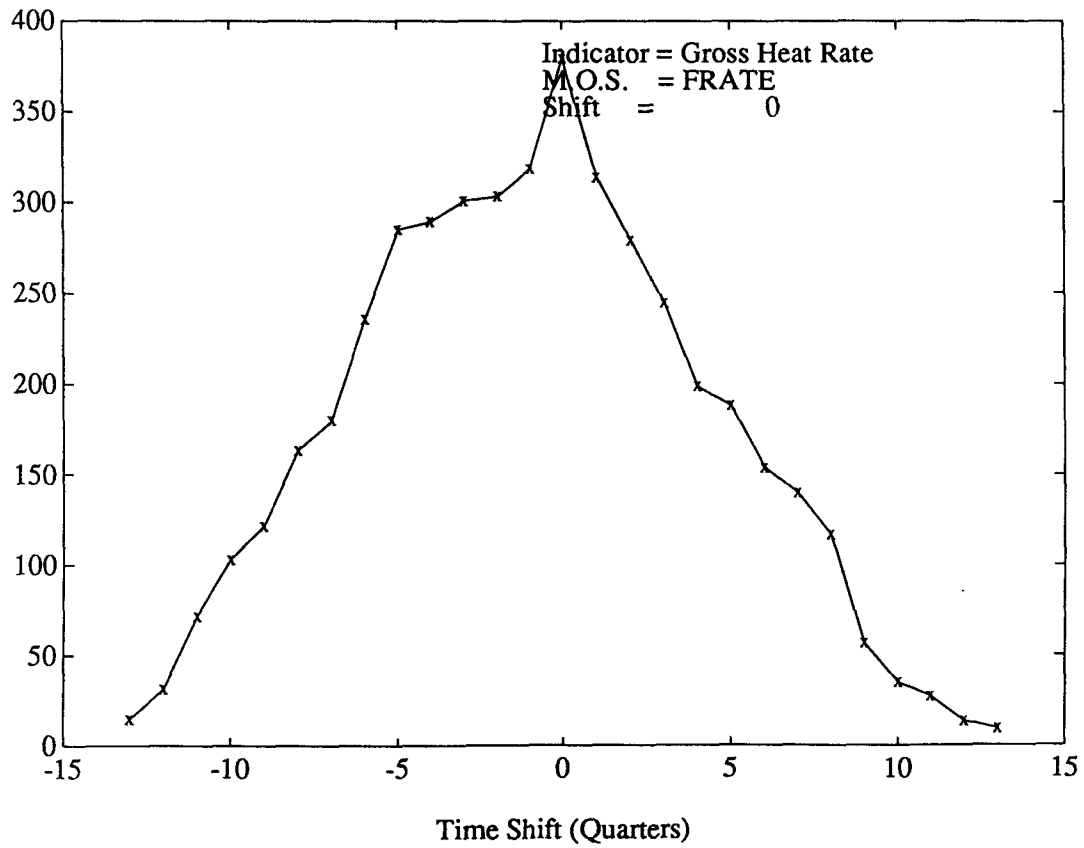

Performance Indicator Analysis
Gross Heat Rate
0
2
4
6
8
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

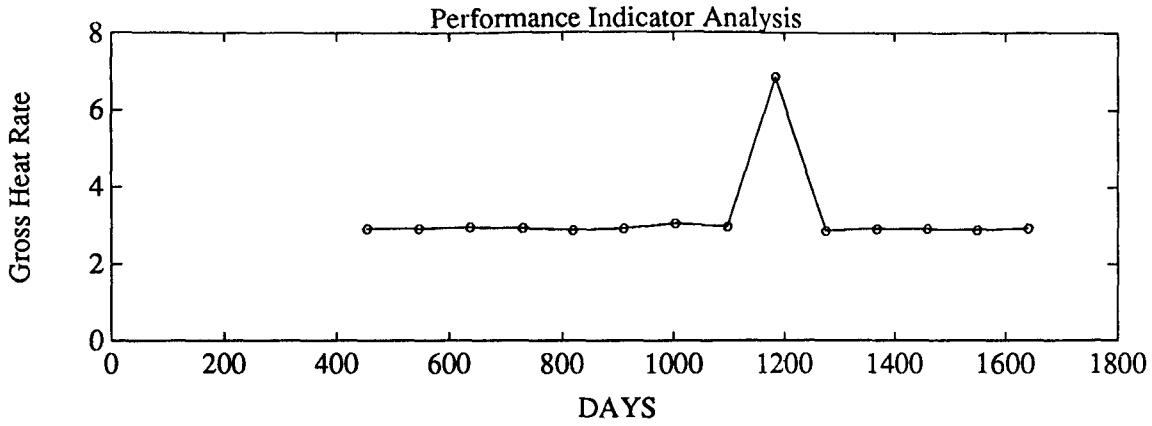

SALP-M
0
0.5
1
1.5
2
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

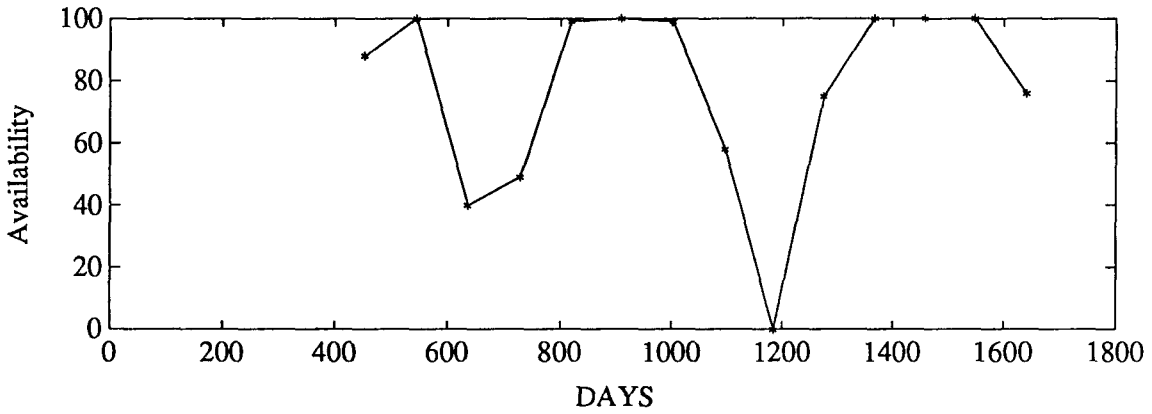

Indicator = Gross Heat Rate
M.O.S. = SALP-M
Shift = 0
0
5
10
15
20
25
30
35
40
45
50
-10
-8
-6
-4
-2
0
2
4
6
8
10
Time Shift (Quarters)

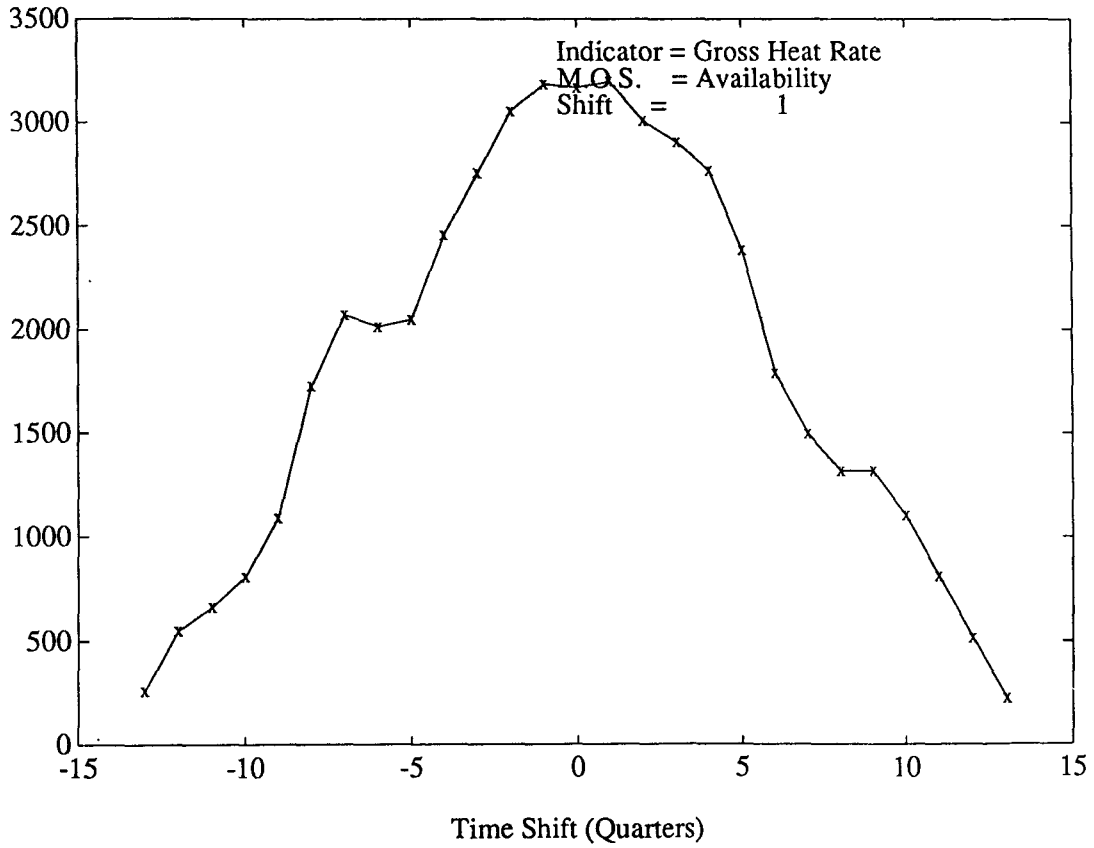

Performance Indicator Analysis
Gross Heat Rate
0
2
4
6
8
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

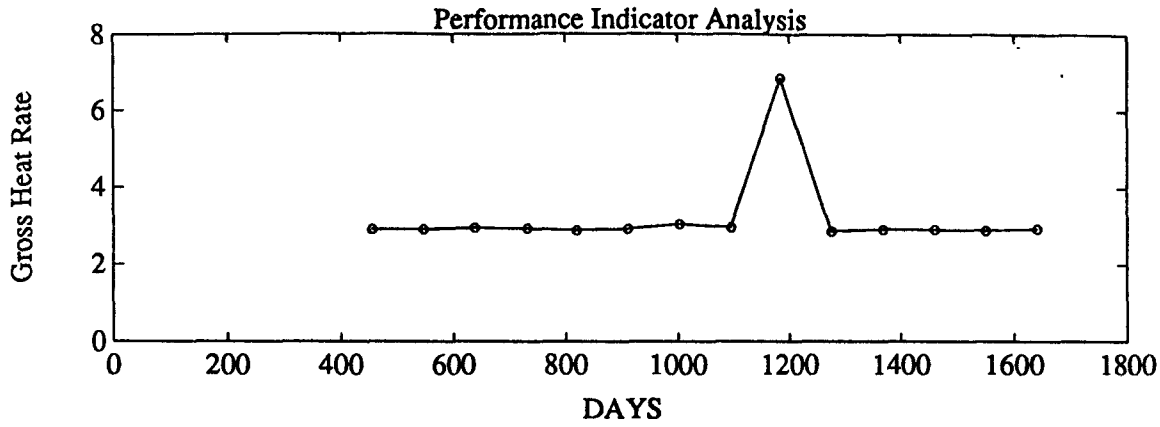

FRATE
0
5
10
15
20
25
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

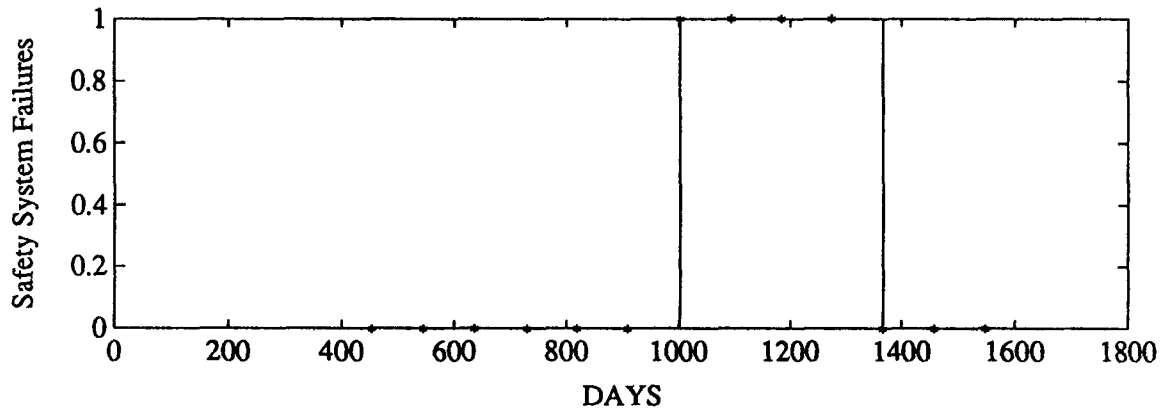

Indicator = Gross Heat Rate
M.O.S. = FRATE
Shift = 0
0
50
100
150
200
250
300
350
400
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

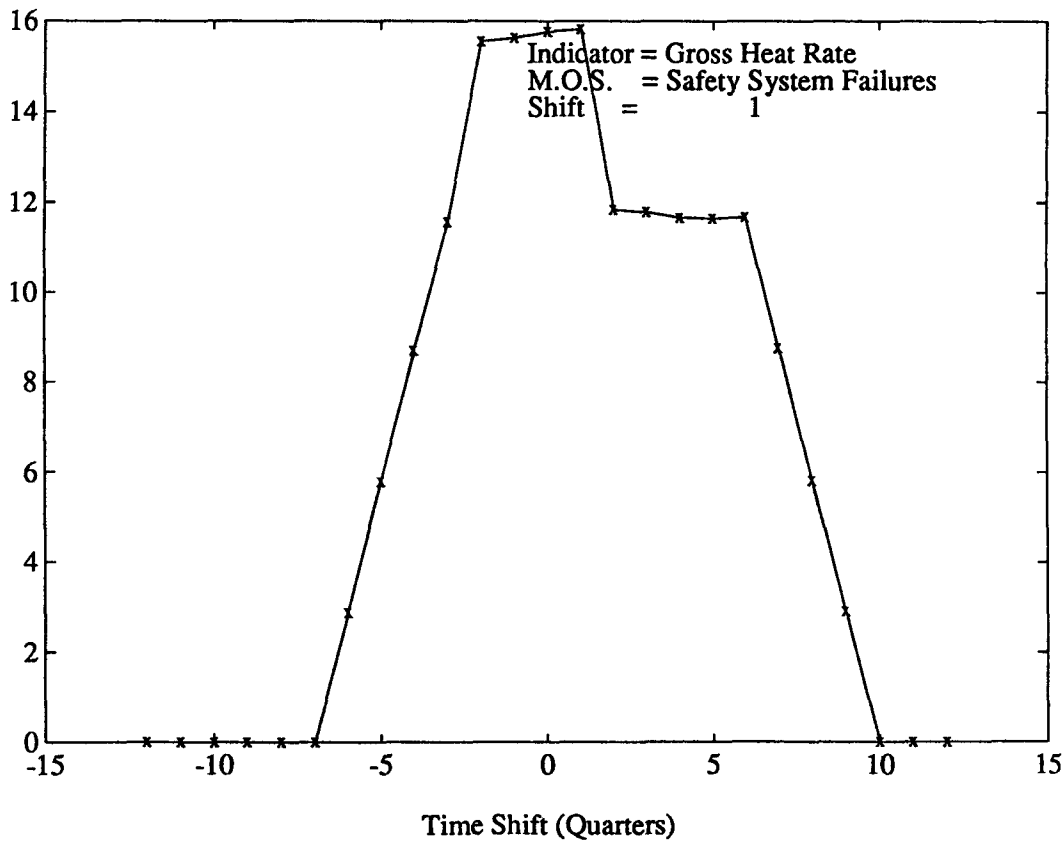

Performance Indicator Analysis
Gross Heat Rate
0
2
4
6
8
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

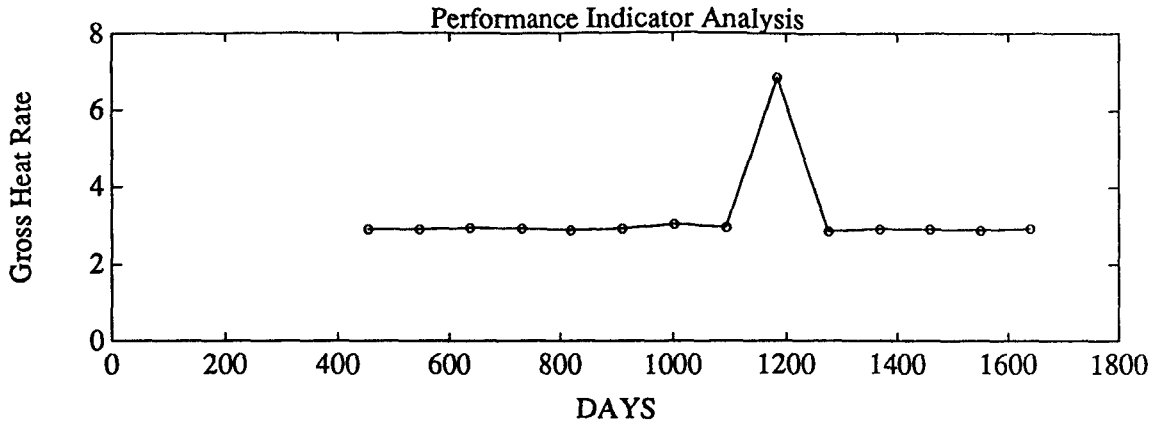

Availability
0
20
40
60
80
100
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

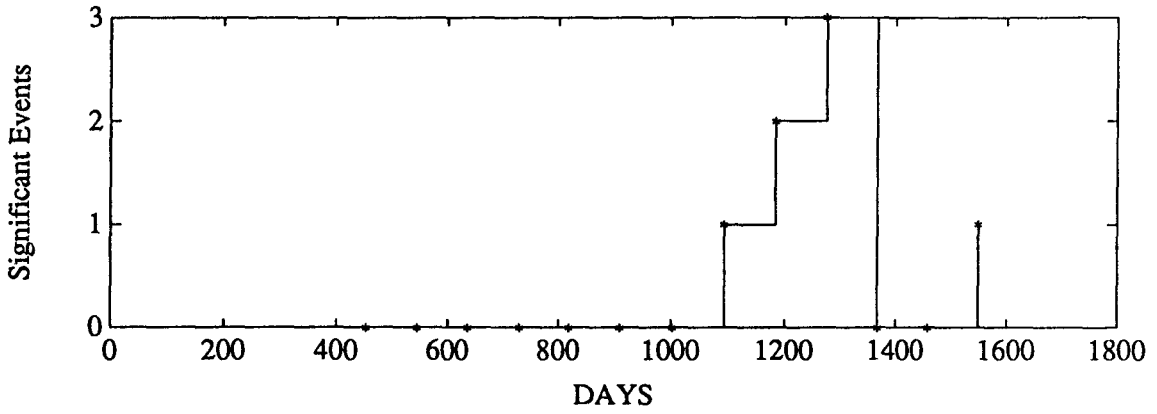

Indicator = Gross Heat Rate
M.O.S. = Availability
Shift = 1
0
500
1000
1500
2000
2500
3000
3500
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

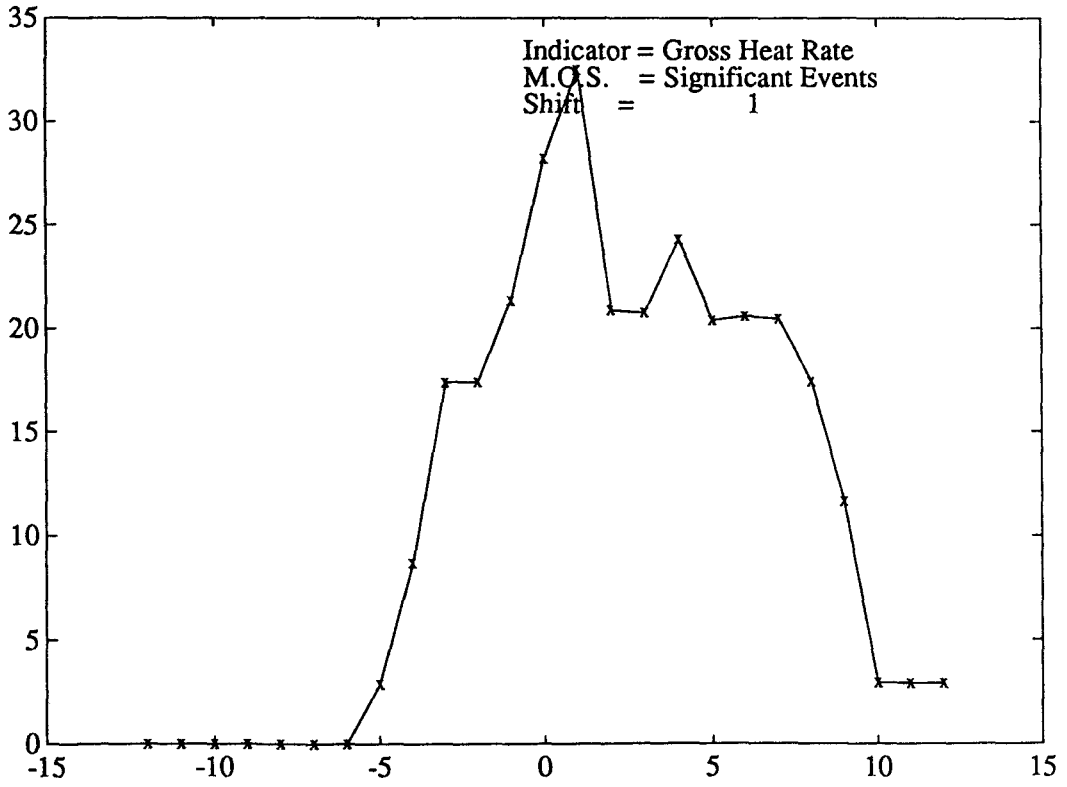

Performance Indicator Analysis
Gross Heat Rate
0
2
4
6
8
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

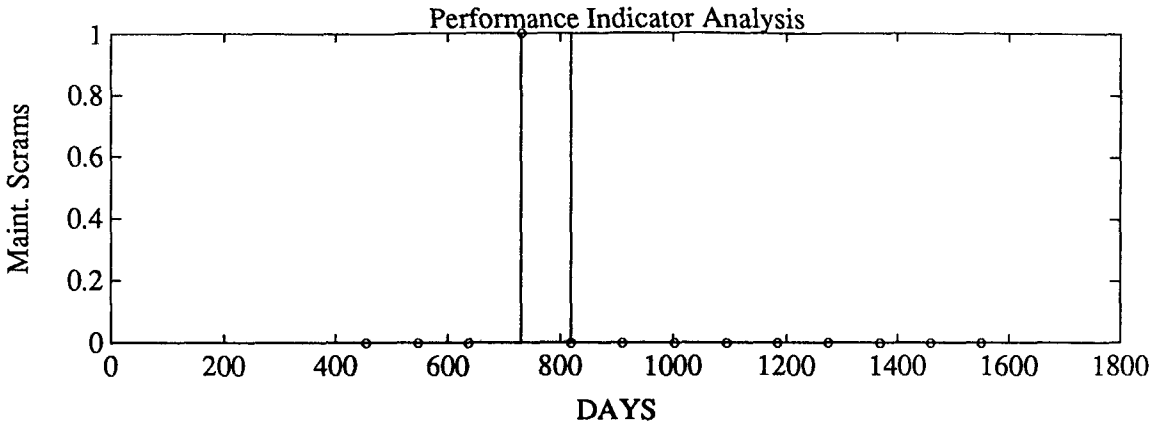

Safety System Failures
0
0.2
0.4
0.6
0.8
1
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

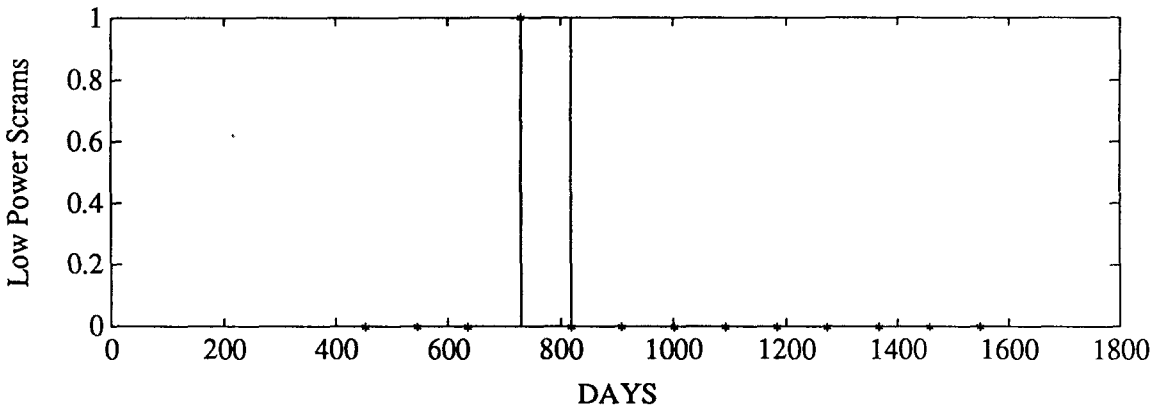

Indicator = Gross Heat Rate
M.O.S. = Safety System Failures
Shift = 1
0
2
4
6
8
10
12
14
16
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

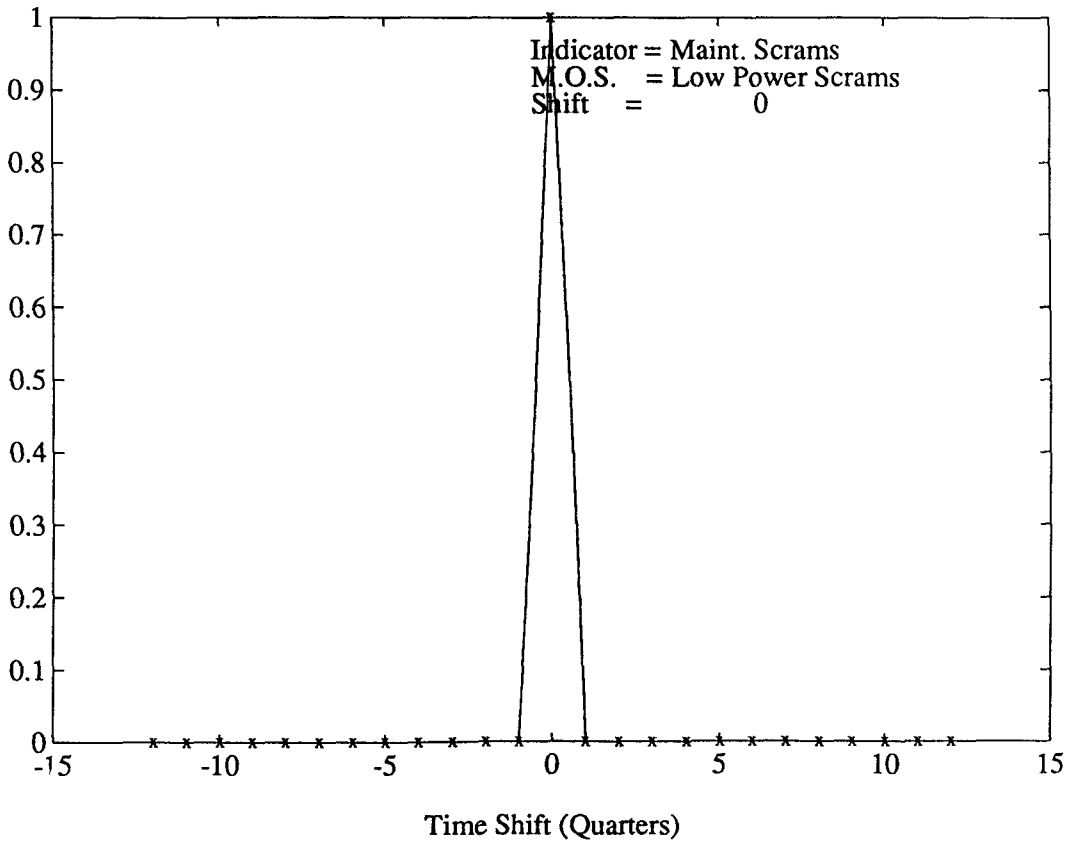

Performance Indicator Analysis
Gross Heat Rate
8
6
4
2
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Significant Events
3
2
1
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Indicator = Gross Heat Rate
M.C.S. = Significant Events
Shift = 1
35
30
25
20
15
10
5
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)


Performance Indicator Analysis
Maint. Scrams
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS


Low Power Scrams
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
1400
1600
1800
DAYS

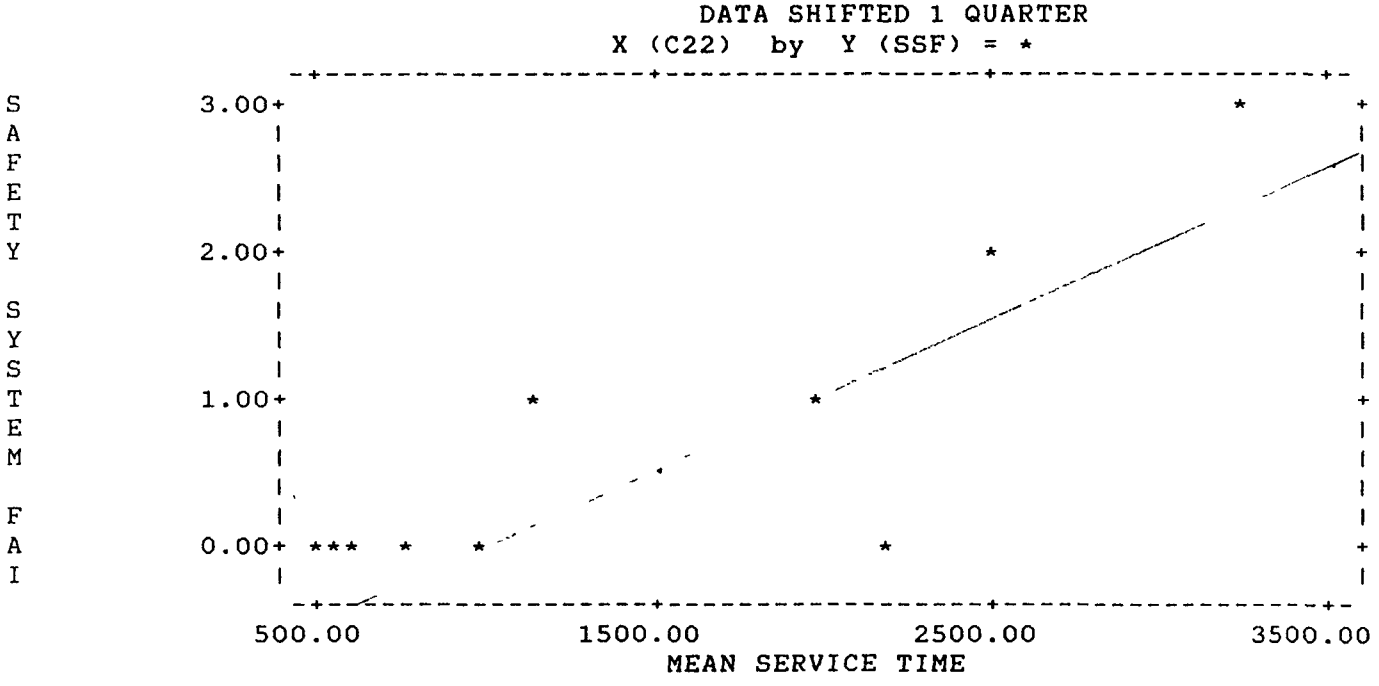

Indicator = Maint. Scrams
M.O.S. = Low Power Scrams
Shift = 0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-15
-10
-5
0
5
10
15
Time Shift (Quarters)

Attachment 1, Signal Processing Analysis of Daily Power Loss Indicator

----------Scatter Plots----------

Date/Time 10-25-1988 14:16:08
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



Row Accounting Report

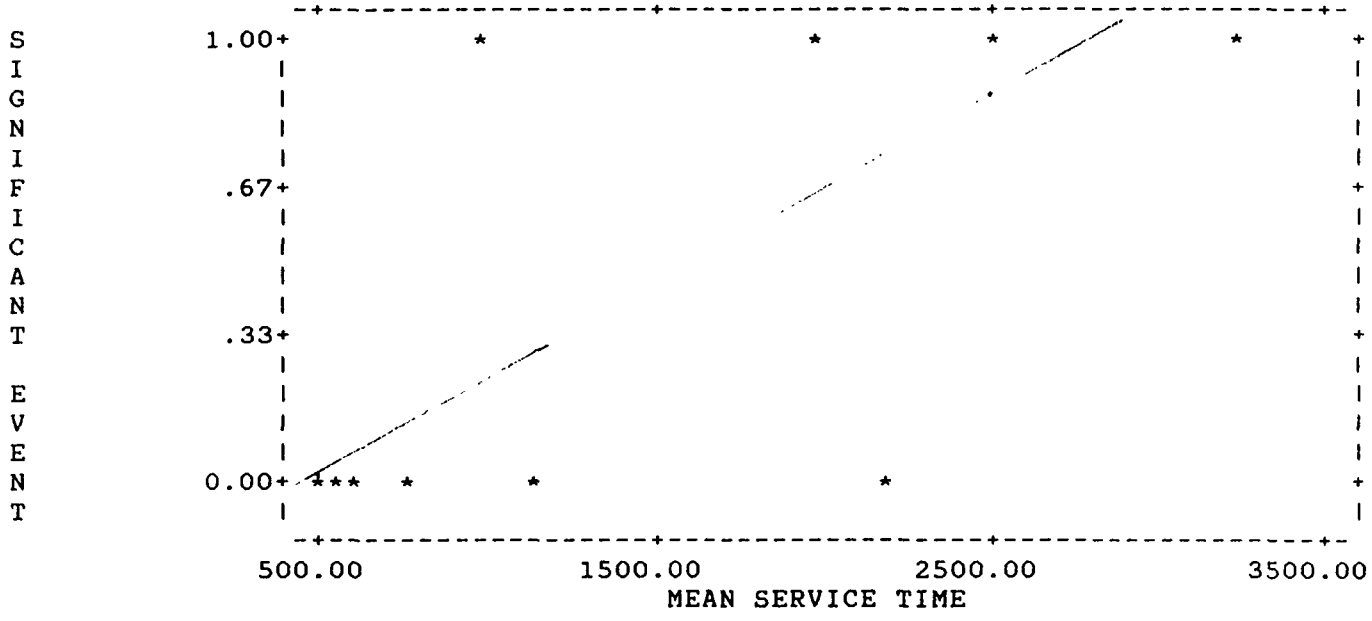
Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	1
Number of points plotted	:	12		

----------Scatter Plots----------

Date/Time 10-25-1988 14:16:39
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots

DATA SHIFTED 1 QUARTER
X (C22) by Y (SE) = *



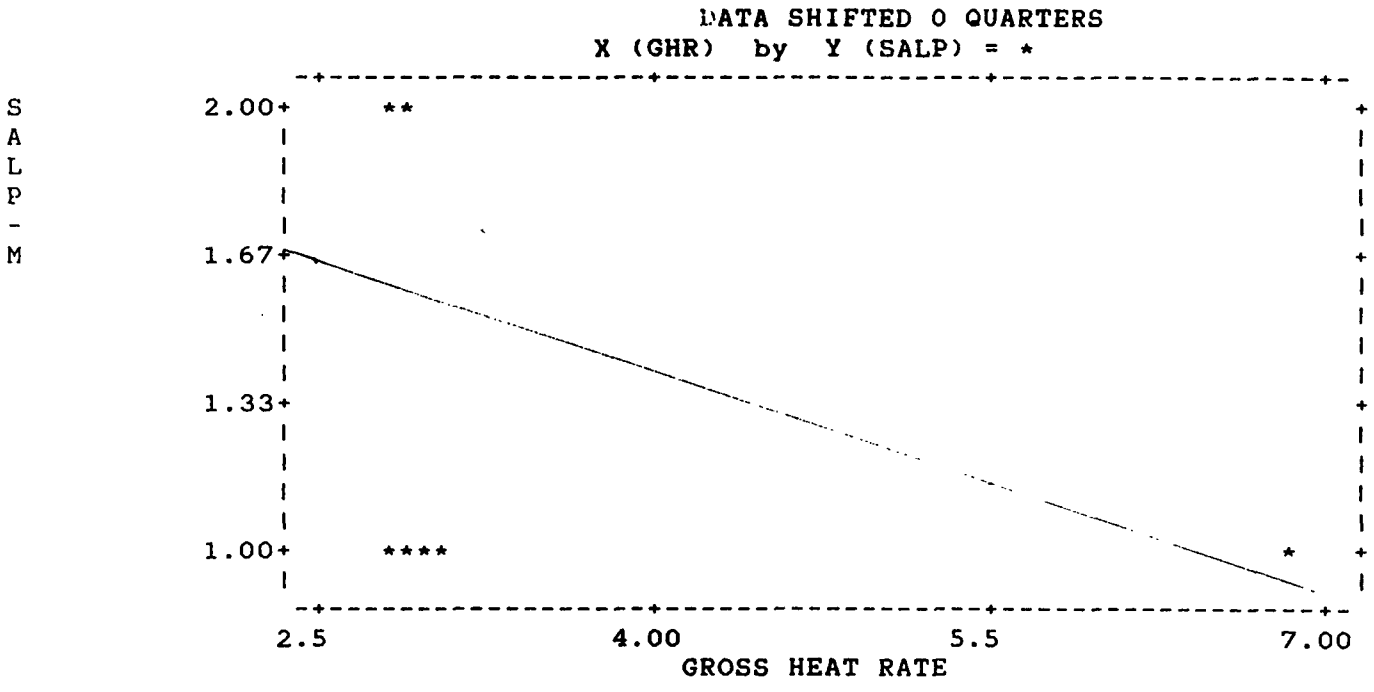
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	1
Number of points plotted	:	12		

----------Scatter Plots----------

Date/Time 10-25-1988 14:17:52
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



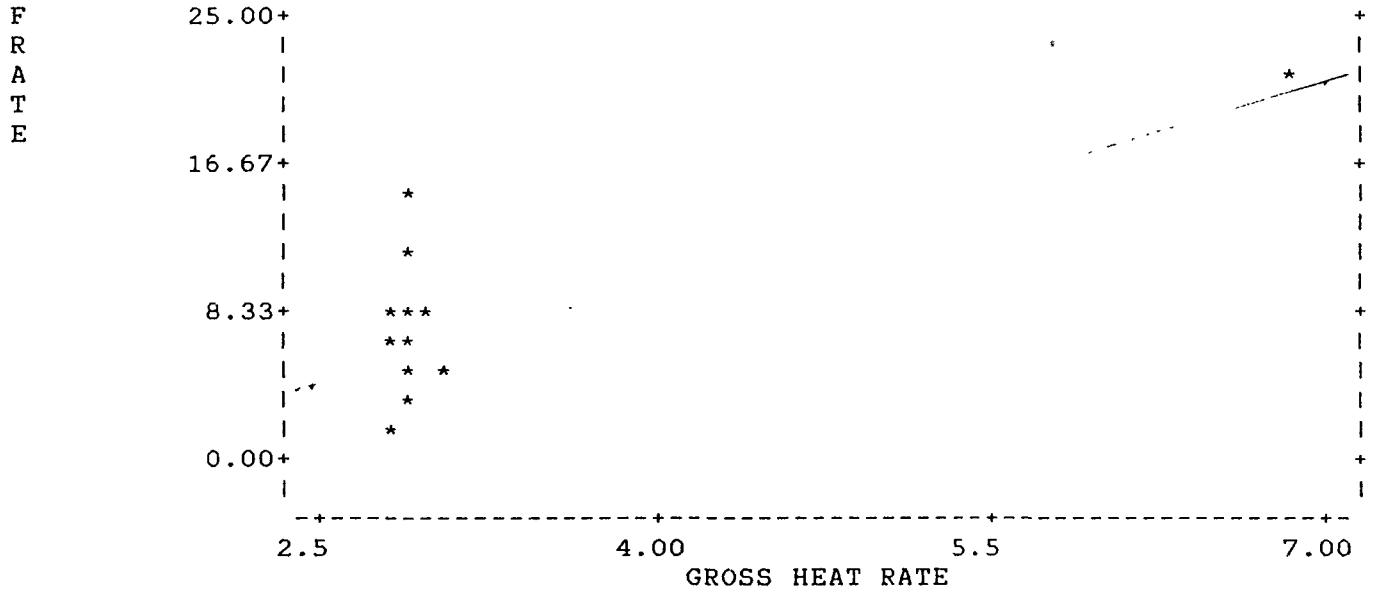
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	4
Number of points plotted	:	10		

----------Scatter Plots----------
Date/Time 10-25-1988 14:18:15
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots

DATA SHIFTED 0 QUARTERS
X (GHR) by Y (FRATE) = *



Row Accounting Report

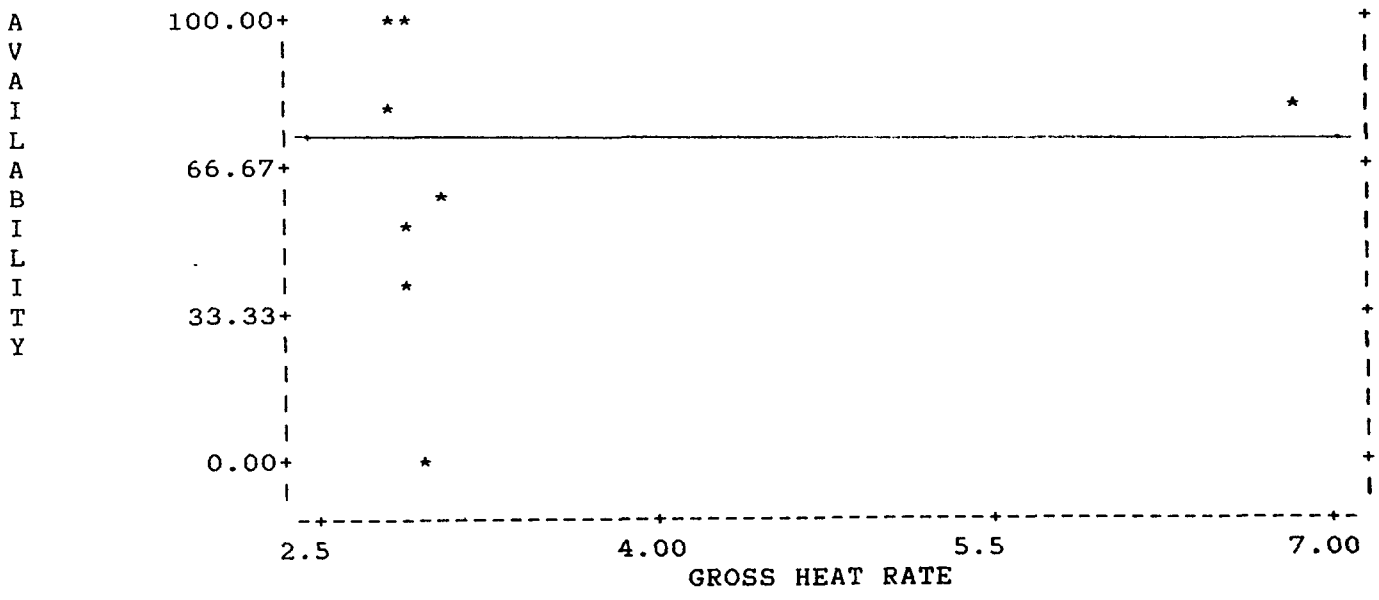
Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	0
Number of points plotted	:	14		

----------Scatter Plots----------

Date/Time 10-25-1988 14:18:58
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots

DATA SHIFTED 1 QUARTER
X (C22) by Y (AVAIL) = *



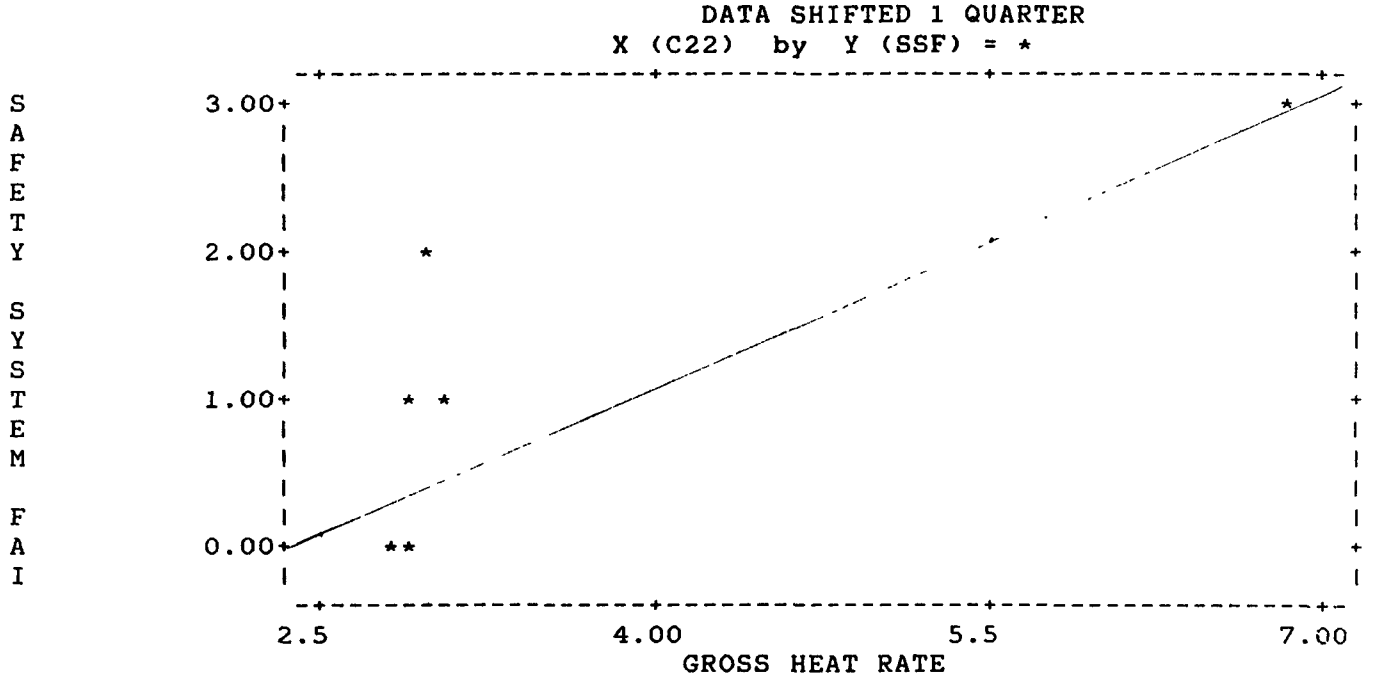
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	0
Number of points plotted	:	13		

----------Scatter Plots----------

Date/Time 10-25-1988 14:19:26
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



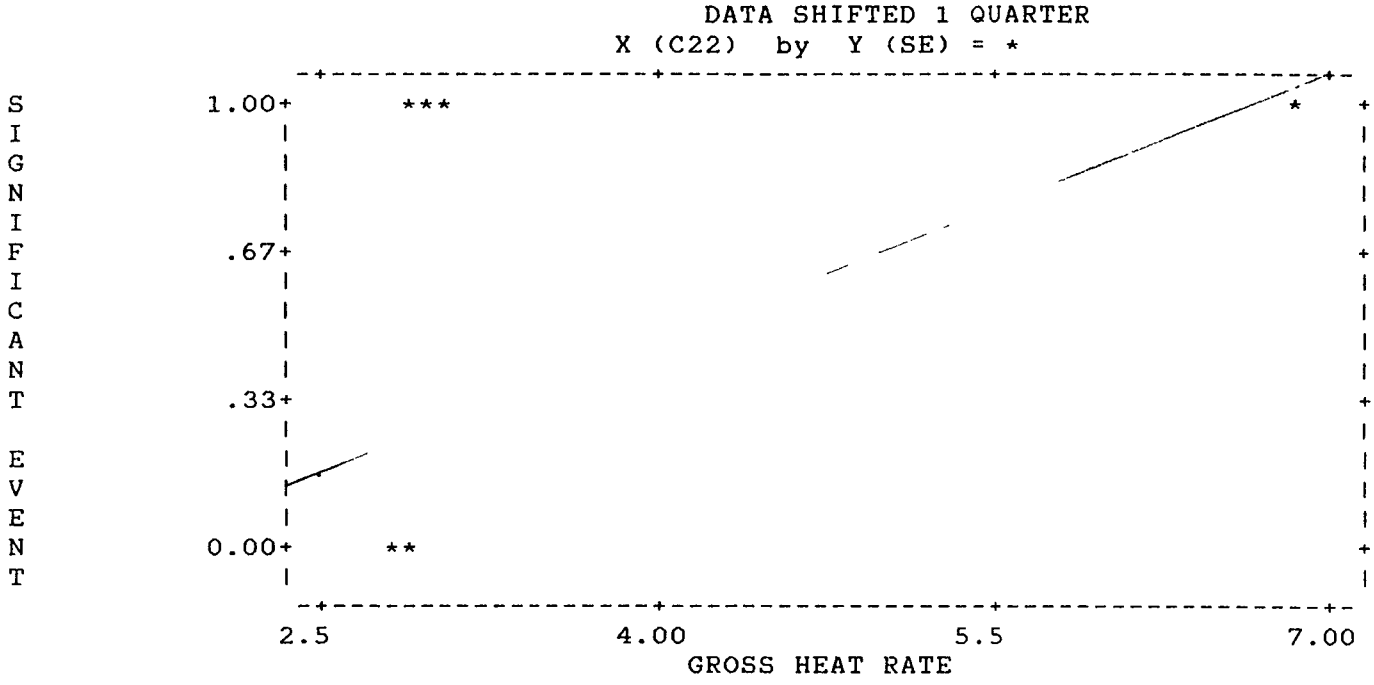
Row Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	1
Number of points plotted	:	12		

----------Scatter Plots----------

Date/Time 10-25-1988 14:20:07
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots

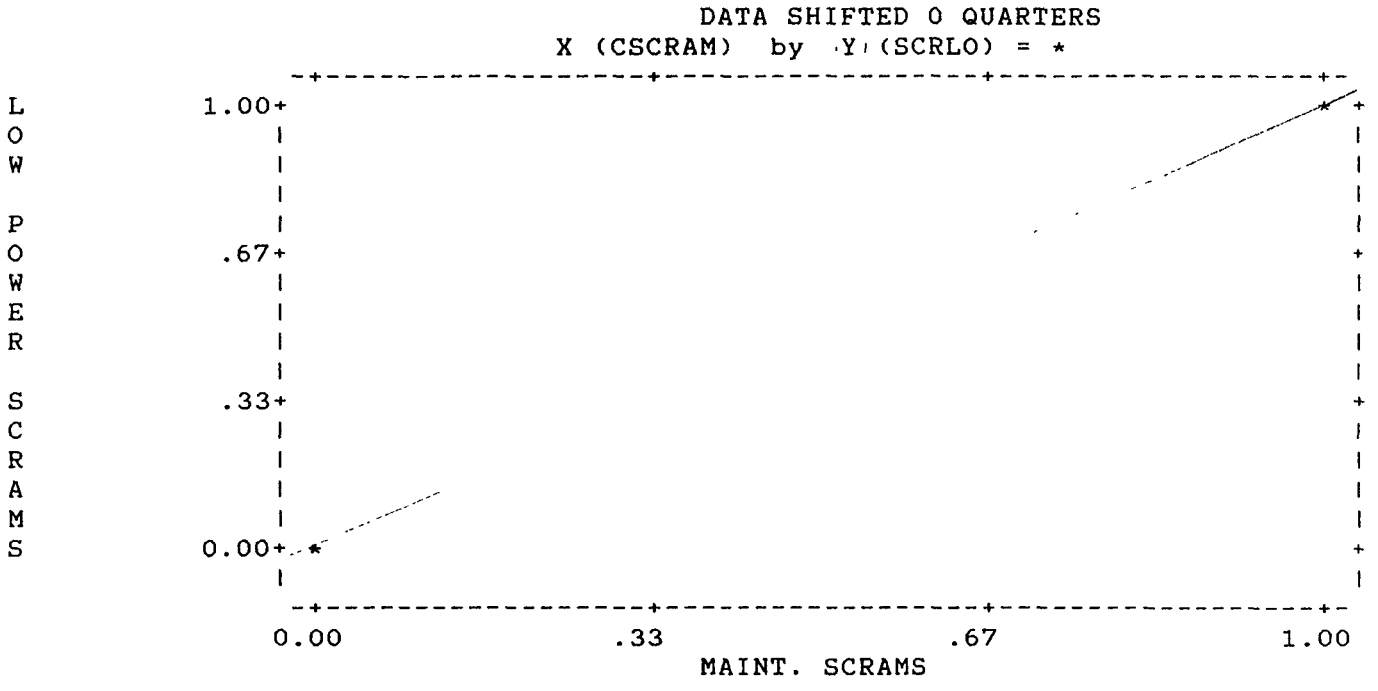


w Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	1	(Y) :	1
Number of points plotted	:	12		

----------Scatter Plots----------
Date/Time 10-25-1988 14:21:16
Data Base Name C:\NCSS\
Description Imported from E:\MATLAB\TRDATA\

Scatter Plots



w Accounting Report

Number of points below minimum	(X) :	0	(Y) :	0
Number of points above maximum	(X) :	0	(Y) :	0
Number of points with missing values	(X) :	0	(Y) :	0
Number of points plotted	:	13		

ATTACHMENT 1

POTENTIAL PERFORMANCE INDICATORS RELATED TO THERMAL EFFICIENCY

1.0 DEVELOPMENT OF A THERMAL-EFFICIENCY-RELATED COMPREHENSIVE MAINTENANCE INDICATOR

1.1 Gross Heat Rate or Thermal Efficiency Indicators

Previous work on the maintenance performance indicators program led to gross heat rate being proposed as a promising leading indicator of nuclear plant safety trends. Gross heat rate, the electrical generation industry's conventional way of expressing the overall thermal efficiency of a thermal power plant, is defined as the ratio of the total thermal energy input to the plant, to its total electrical energy output during some interval of time. For nuclear plants, the thermal input is the heat energy produced by the reactor core. (Since heat rate is the algebraic reciprocal of thermal efficiency if consistent units are used, the two quantities are equivalent, and the terms will be used interchangeably below.)

The rationale for thermal efficiency as a trending indicator of nuclear plant safety is that over the long term, both safety and thermal efficiency depend on high-quality plant maintenance (broadly defined to include maintenance, operations, engineering, management,and all other plant functions which help to preserve operability), so trends in plant safety should follow trends in thermal efficiency. In fact, thermal efficiency should be more sensitive to maintenance quality than safety, for two reasons. First, the non-safety-related portion of the plant continuously generates information on its own status during operation, while safety depends on either passive features (e.g., containment) or standby systems whose status is only known intermittently. Therefore, declining efficiency will presumably be noticed and corrected first. Second, for business reasons the licensee presumably places at least as much priority on thermal efficiency as safety. In other words, long-term neglect of the maintenance needed for the plant to fulfill its basic mission -- generating electrical energy efficiently -- may indicate even greater neglect of the nuclear safety functions which are secondary to the plant's reason for being (however critical they may be from the NRC perspective). It is also a well established fact that reactor SCRAMS and safety system challanges are mainly attributable to BOP system and component failures. Thus it was suggested that gross heat rate would be a comprehensive indicator of maintenance performance in its broadest sense.

However, gross heat rate or thermal efficiency per se, while suggestive, has three deficiencies as an overall indicator of maintenance quality. First, heat rate is essentially meaningless when the plant is shut down. Second, a power plant has its maximum thermal efficiency at its design load, so extended off-design loading for reasons external to the plant (e.g., transmission grid problems or low power demand) could produce a misleading decline in efficiency. Third, the NRC is not currently collecting the data required to calculate heat rate. The ideal indicator would reflect thermal efficiency, deal realistically with shutdowns and load fluctuations, and preferably be based on data the NRC is already receiving in licensees' monthly operating reports.

1.2 Average Daily Power Level as an Indicator

Monthly operating reports contain only one piece of information which relates to thermal efficiency and is reported on a daily basis so it can be trended over the short term. This is the average daily power level (ADP), defined as the quotient of total electrical energy output in MWh during the 24-hour period divided by 24 hours. Unfortunately, ADP is no more an ideal maintenance indicator than heat rate, because non-maintenance factors such as planned refueling outages and load changes can affect it. However, ADP has the advantage of tracking another maintenance-related parameter in addition to thermal efficiency, the incidence of forced outages of major equipment in the plant, because virtually any major equipment failure precipitates at least a power reduction if not a shutdown. Therefore, ADP -- or some parameter closely related to it -- should be an integrated indicator of both plant thermal efficiency and the availability of major equipment, and hence a more sensitive indicator of trends in maintenance quality than thermal efficiency alone. SAIC therefore concentrated on attempting to extract meaningful maintenance quality indications from patterns discernible in ADP data.

1.3 "Daily Power Loss"

For several reasons which will be discussed below, SAIC found it more convenient to analyze a parameter which we call "daily power loss" (DPL) rather than working directly with ADP. Daily power loss is a normalized, inverse measure of average daily power level defined as follows:

$$DPL_n = \frac{MDC - ADP_n}{MDC} - ADP_{ave}$$

$$ADP_{ave} = \frac{1}{(N)(MDC)} \sum_{n=0}^{N} MDC - ADP_n$$

where DPL is the daily power loss for day n,

MDCn is the maximum dependable net capacity of the plant as given in the monthly operating report,

ADP_n is the average daily power level for day n,

ADP_{ave} is the average of all ADPs for N days, and

N is the number of days in the interval being analyzed.

DPL is equivalent to ADP in terms of information content, and has the following three advantages. First, higher DPL relates to poorer performance, which is consistent with the sense of the other indicators being considered. Second, the normalization by plant MDC eliminates two irrelevant plant-specific factors, plant capacity and design heat rate, so DPL is consistent from plant to plant. Third, the DPL waveform is symmetrical about the horizontal axis, which reduces the computation load by making the coefficients of all even-numbered terms in the Fourier series representation of the waveform zero. (See below for a discussion of Fourier analysis.)

2.0 ANALYSIS AND EVALUATION OF DAILY POWER LOSS AS A MAINTENANCE PERFORMANCE INDICATOR

2.1 Data Acquisition and Units Covered

The first step in the attempt to extract maintenance performance trends from DPL data comprised data acquisition. SAIC obtained 1985-1987 monthly operating reports for eight units, selected to obtain a representative sample of plant designs, nuclear steam supply system (NSSS) suppliers, and "good" and "bad" plants. The table below lists the units considered in the study, with their reactor types, NSSS suppliers, and architect/engineer firms (A/Es).

TABLE 1. UNITS INCLUDED IN STUDY

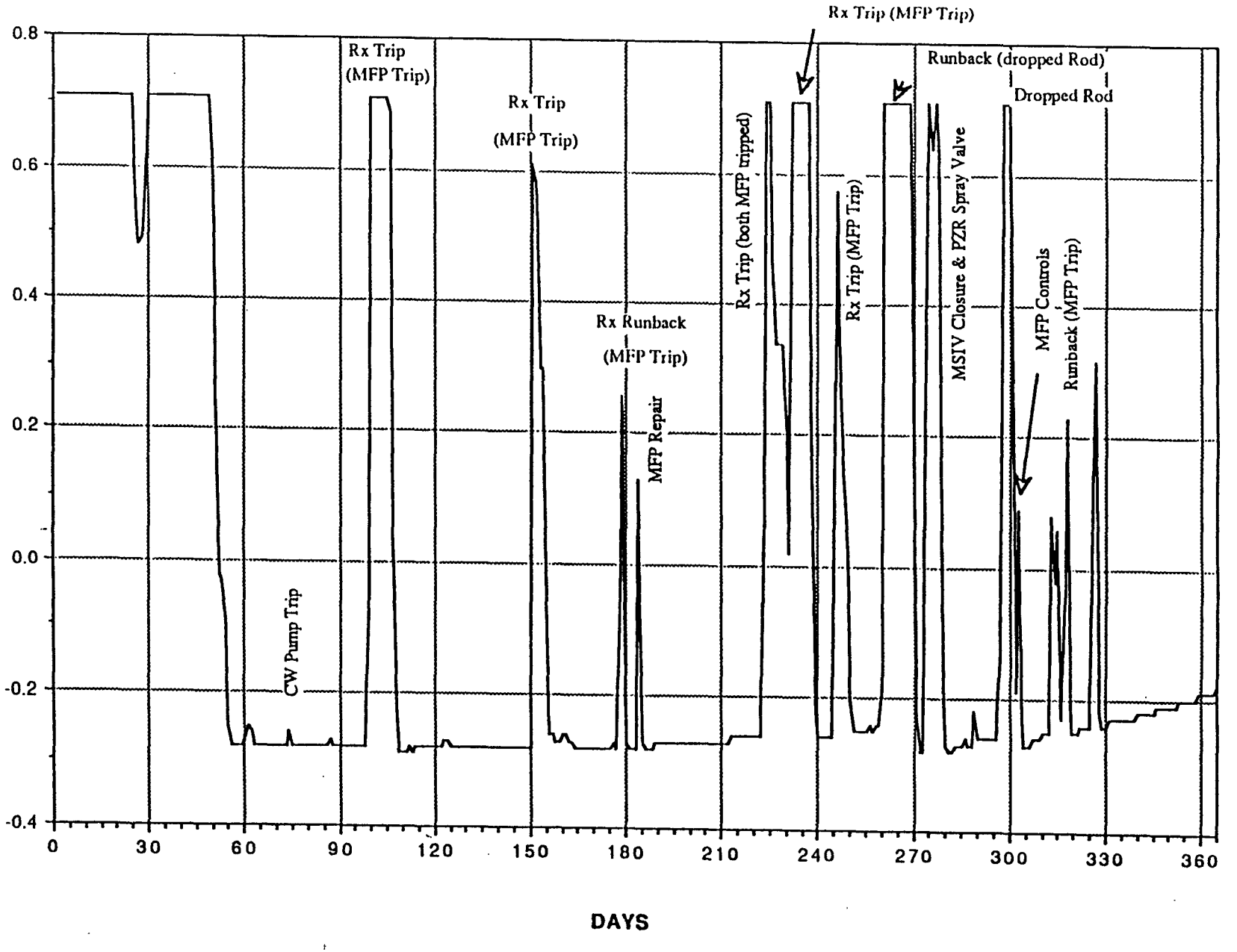
Plant	Reactor Type	NSSS Supplier	A/E
S	PWR	B&W	Bechtel
T	BWR	GE	UE&C
U	PWR	B&W	Bechtel
V	PWR	Westinghouse	UE&C
W	BWR	GE	S&L
X	PWR	B&W	Duke Power/ Bechtel
Y	PWR	CE	Bechtel
Z	PWR	Westinghouse	Bechtel

2.2 Preliminary Analytical Approach

2.2.1 Daily Power Loss Versus Time

Plant S was selected as the pathfinder unit for the analysis. The first step consisted of plotting the Daily Power Loss versus time for Plant S to determine if any patterns related to maintenance quality could be discerned. Figures 1-3 show these plots for 1985 through 1987 for Plant S, together with notes identifying all of the incidents that precipitated changes in power level that were identifiable from monthly operating reports and LERs. Apart from the long "flat" interval during the extended

Detailed Results for Plant S



1985

Figure 1

Att-1-15

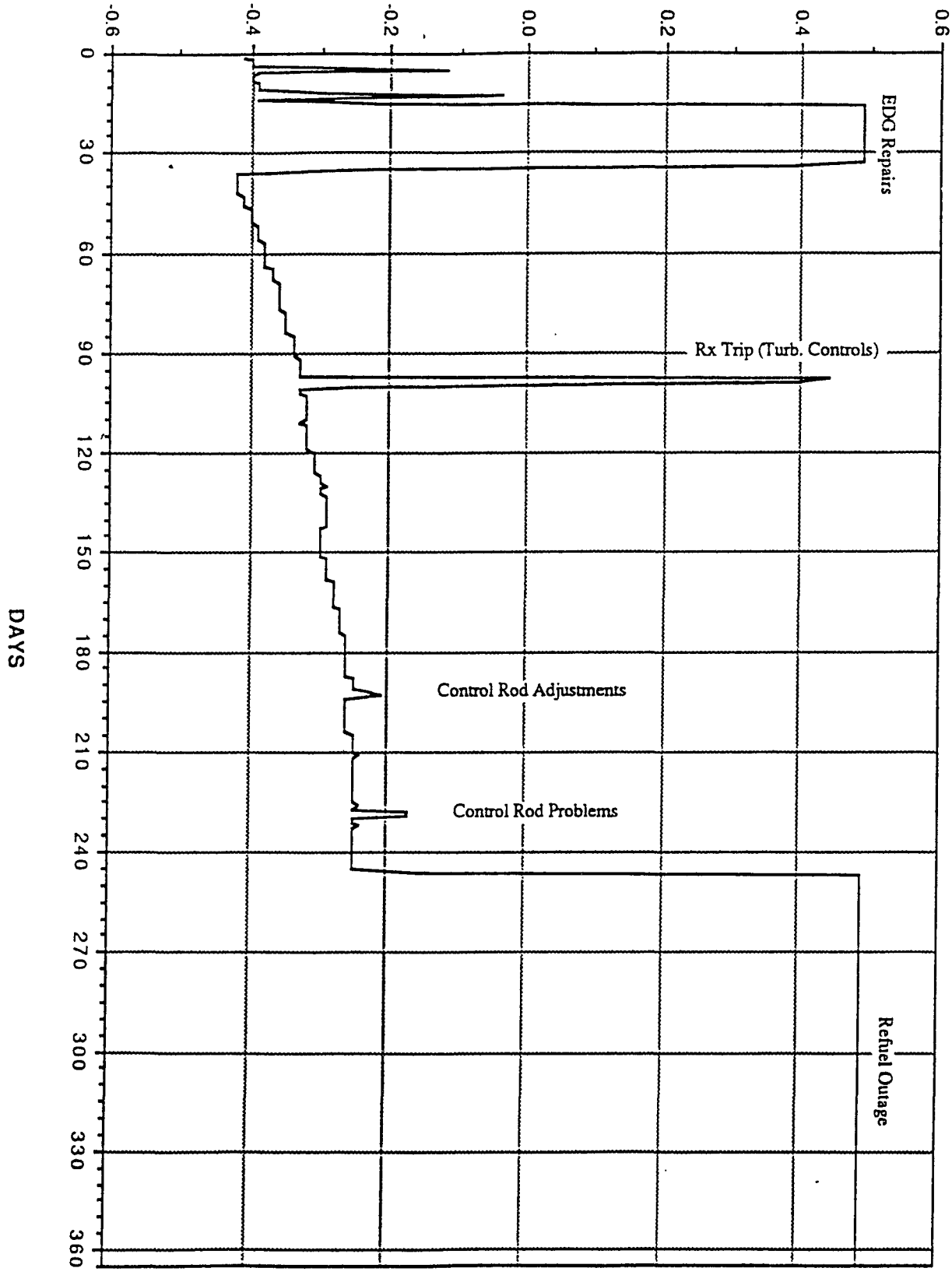

-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0
30
60
90
120
150
180
210
240
270
300
330
360
DAYS
EDG Repairs
Rx Trip (Turb. Controls)
Control Rod Adjustments
Control Rod Problems
Refuel Outage

Figure 2

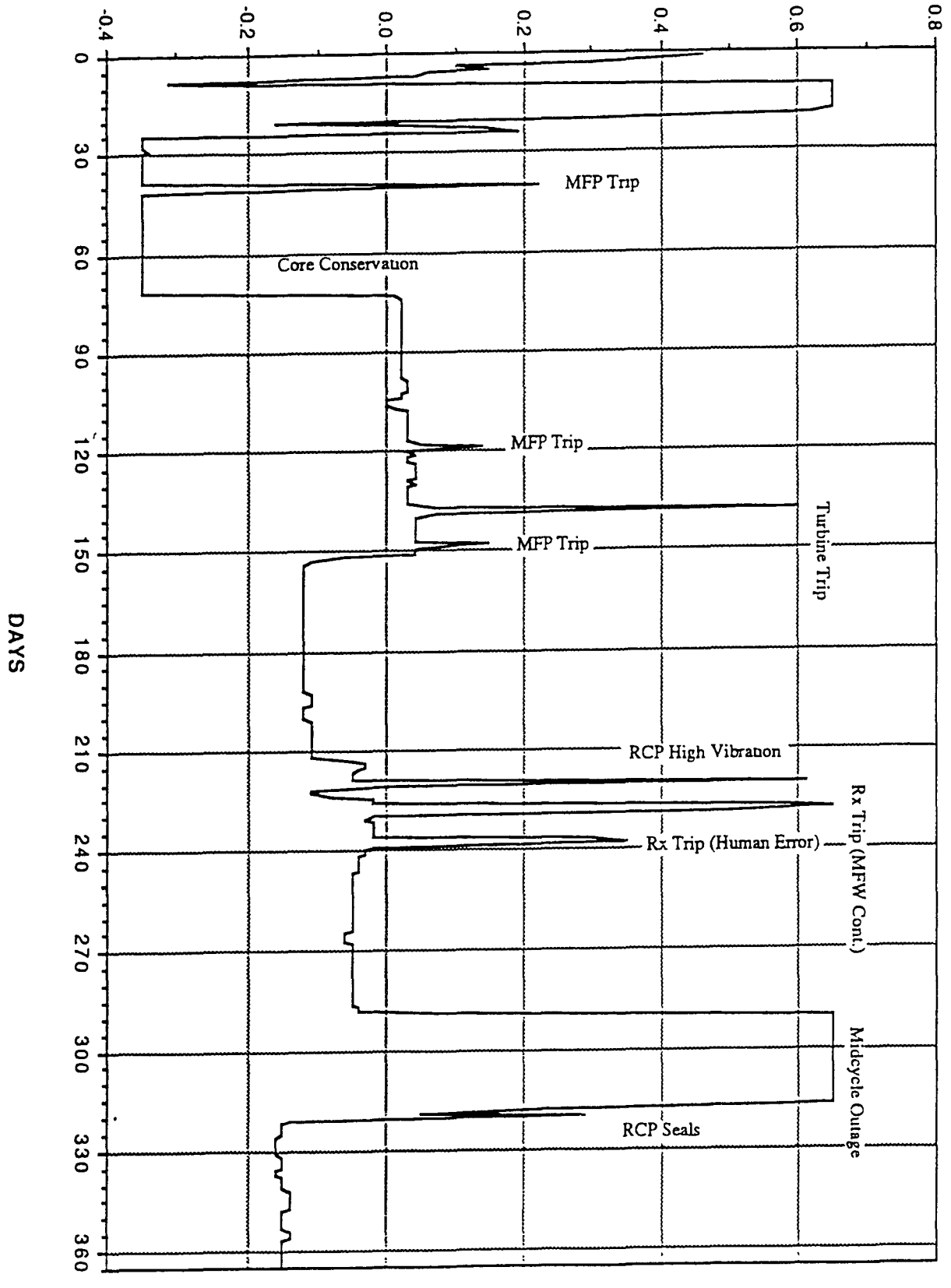

-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
0
30
60
90
120
150
180
210
240
270
300
330
360
DAYS
MFP Trip
Core Conservation
MFP Trip
MFP Trip
Turbine Trip
RCP High Vibration
Rx Trip (Human Error)
Rx Trip (MFW Cont.)
RCP Seals
Midcycle Outage

Figure 3

outage in 1986, no pattern is apparent. If maintenance-related patterns exist, they must be subtle, obscured by irrelevant information, or both. The same observation applies to the DPL data from the other seven plants, whose DPL-time plots appear in Appendix 1. The problem then is to process the data in order either to detect and amplify any patterns which actually exist or to eliminate the hypothesis that patterns do exist.

The concept underlying our current analytical approach is to look at the power plant as a "signal generator." The series of DPLs from the monthly operating reports can be considered as a set of equal-interval samples of a continuous time-varying signal which is susceptible to the signal-processing techniques developed to derive meaningful information from noisy signals in the communications field. The signal processing technique which is now under consideration is Fourier analysis.

2.2.2 Review of Fourier Analysis Principles

By way of review, Fourier analysis depends on the principle that any periodic mathematical function, no matter how complicated, is the sum of a possibly infinite series of sinusoidal terms. The simplest formulation of the Fourier series is as follows:

$$f(t) = A_0 + \sum_{n=1}^{\infty} A_n \sin(2\pi F_n t + \theta_n)$$

where f(t) is the mathematical function representing the time-varying periodic signal to be decomposed,

A_n is the amplitude (peak magnitude) of component n,

F_n is the frequency of component n, and

θ_n is the phase angle of component n (relative to an arbitrary reference).

That is, if a complicated signal can be represented by a periodic function, it can be decomposed into a series of simple sine-waves, each characterized by an amplitude, a frequency, and a phase angle. Thus Fourier analysis is a very useful tool for identifying and quantifying periodically occurring patterns in a noisy signal, because the frequency

components which contribute significantly to the composite signal have relatively large amplitudes. The analysis involves determining the amplitudes and phase angles corresponding to each frequency. (The frequencies do not need to be determined, because the mathematics requires them to be integral multiples of the frequency of the periodic waveform.)

As an alternative to the expression above, the Fourier series can be written in exponential form with complex numbers as the coefficients of each term, as shown below. In this form, the relation between the real and imaginary parts of the coefficients expresses the phase-angle information. (In this equation i is the square root of -1.)

$$f(t) = C_0 + \sum_{n=1}^{\infty} C_n \exp (i 2 \pi F_n t)$$

$$\theta_n = \tan^{-1} \left[Im (C_n) / Re (C_n) \right]$$

From the rigorous mathematical standpoint, the Fourier series exists only for periodic functions. Although the function represented by the series of DPLs from a nuclear power plant is not periodic, for the purpose of the Fourier analysis it is permissible to assume that it is, with a period at least equal to the "window" of time over which the signal is to be analyzed. As noted above, the frequencies of the Fourier series components are determined by the period of the signal, which in this case is more or less arbitrarily assumed. Thus the specific frequencies of the components are artifacts of the analytical approach, and are not necessarily significant.

The most convenient way to obtain the Fourier coefficients of a series of discrete equal-interval samples of a periodic function is the Fast Fourier Transform (FFT), a numerical method which lends itself to computer implementation. SAIC used the FFT routine of MATLAB™, a commercial mathematical analysis software package running on an IBM-PC-AT personal computer, to process the DPL data from the various plants.

For each plant, the DPL data for each of the years 1985 through 1987 was analyzed by the FFT routine. One calendar year was selected as a first-trial time "window" for convenience in data entry; the effect of choosing other analysis intervals remains an open question.

The final step in the analysis performed to date was to convert the series of complex Fourier coefficients to a power spectral density profile, which can be plotted as a graph of power versus frequency. In a conventional communications signal processing application, this is an expression of the signal power contained by each Fourier component. In the current analysis, the power spectral density simply highlights the frequency components which are the most important contributors to the total DPL waveform.

2.2.3 Objectives of the Fourier Analysis

As noted above, Fourier analysis is a good technique for identifying periodic elements of a signal which are masked by random "noise." SAIC hypothesized that the DPL data from nuclear power plants contains the two types of periodicities discussed below, both of which should be found and addressed.

(1) Periodic DPL fluctuations caused by regularly-occurring external phenomena such as seasonal power demand variations are spurious signals from the maintenance performance standpoint, and should be identified as such so they can be filtered out of the indicator signal.

(2) Periodic fluctuations which are <u>not</u> attributable to external phenomena presumably represent a regular pattern of major equipment outages or deratings, suggestive of a continuing failure of plant maintenance (as broadly defined) to diagnose and correct them. These periodic elements should be identified and highlighted.

2.3 Results and Preliminary Interpretation

2.3.1 Power Spectral Density (PSD) Profiles

The PSD plots for Plant S for calendar years 1985, 1986 and 1987 are shown in Figures 4,5, and 6 respectively, and the plots for the other seven units and the same years are reproduced in Appendix 1. The plots show several salient features which may be related to maintenance performance, and appear to justify further investigation.

(1) Extended plant outages during the analysis interval -- planned or forced -- appear to correlate with most of the "power" being concentrated in one or a very few low-frequency Fourier components on the PSD plot.

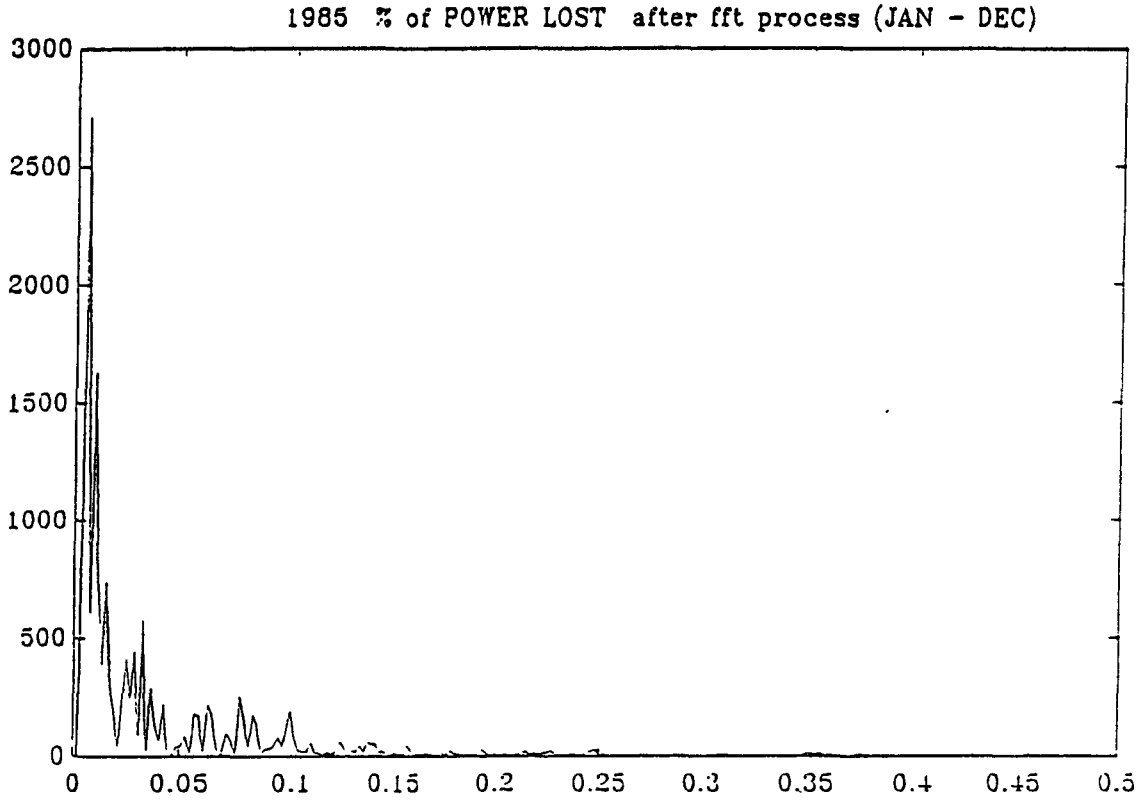

1985 % of POWER LOST after fft process (JAN - DEC)
3000
2500
2000
1500
1000
500
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

Figure 4

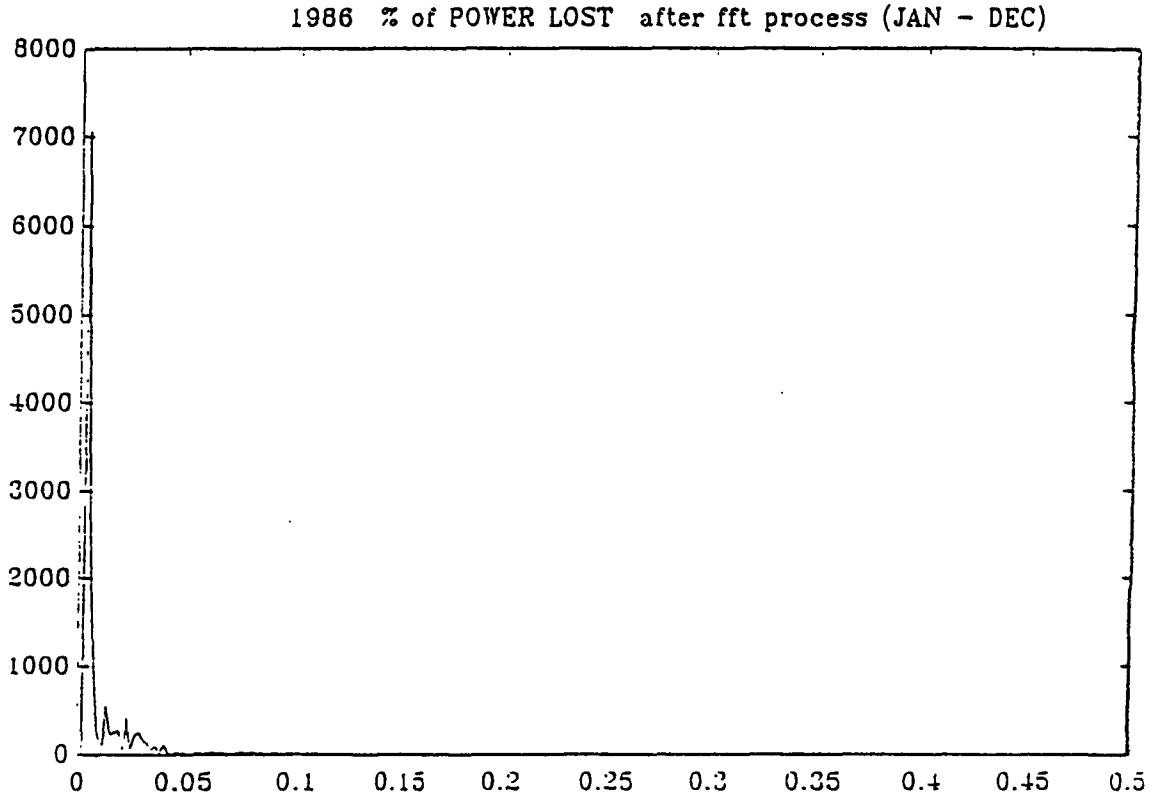

1986 % of POWER LOST after fft process (JAN - DEC)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

Figure 5

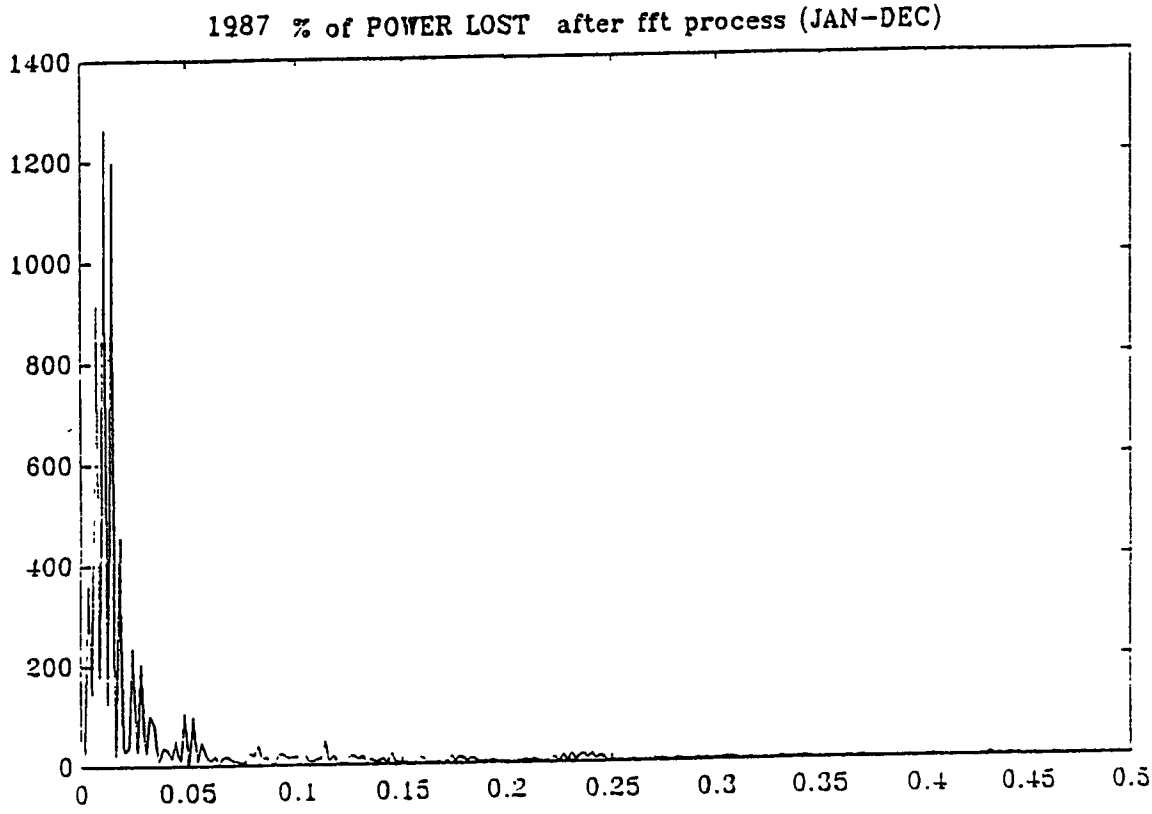

1987 % of POWER LOST after fft process (JAN-DEC)
1400
1200
1000
800
600
400
200
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

Figure 6

(2) Many short-duration fluctuations in DPL, denoting many outage events, appear to correlate with a broader, but still concentrated distribution of "power" among Fourier components in the PSD plot.

(3) A "good" operating year, without extended outages or numerous incidents leading to power level changes, appears correlated with a relatively flat "power" distribution.

DATA FOR COSINE PLOTS OF YEARLY FREQUENCIES

PLANT	YEAR	FIRST AMPLITUDE	SECOND AMPLITUDE	THIRD AMPLITUDE	FIRST FREQUENCY	SECOND FREQUENCY	THIRD FREQUENCY
S	1985	2710 E+4	.1629 E+4	.7357 E+3	5859 E-2	.9766 E-2	.1563 E-1
	1986	.7060 E+4	.8390 E+3	.5513 E+3	.3906 E-2	.7813 E-2	.1367 E-1
	1987	1268 E+4	.1196 E+4	.9148 E+3	.1172 E-1	.1563 E-1	.7813 E-2
T	1985	.4124 E+4	.9345 E+3	.4503 E+3	.3906 E-2	.1172 E-1	.1758 E-1
	1986	.4780 E+3	.4128 E+3	4691 E+3	9766 E-2	.1367 E-1	.3711 E-1
	1987	.9530 E+4	.5378 E+3	.9543 E+2	3906 E-2	.1367 E-1	.1758 E-1
U	1985	5181 E+4	2144 E+4	2940 E+3	3906 E-2	.1367 E-1	.2743 E-1
	1986 (1)	.1322 E+1	.1322 E+1	.1321 E+1	.1953 E-2	.3906 E-2	.5859 E-2
	1987	.1683 E+4	.7065 E+3	.4571 E+3	9766 E-2	.3906 E-2	.1758 E-1
V	1985	.7081 E+4	.1221 E+4	.3832 E+3	5859 E-2	.1172 E-1	.2539 E-2
	1986	6969 E+4	.1616 E+4	.4817 E+3	5859 E-2	.1367 E-1	.1758 E-1
	1987	9686 E+4	.5013 E+3	.5102 E+3	5859 E-2	.1367 E-1	.2148 E-1
W	1985	2329 E+4	.2294 E+4	.1212 E+4	3906 E-2	.9766 E-2	.2148 E-1
	1986	.7704 E+4	.2169 E+3	.1392 E+3	.3906 E-2	.1563 E-1	.2930 E-1
	1987	4078 E+4	.5053 E+3	.1683 E+3	5859 E-2	.2539 E-1	.1758 E-1

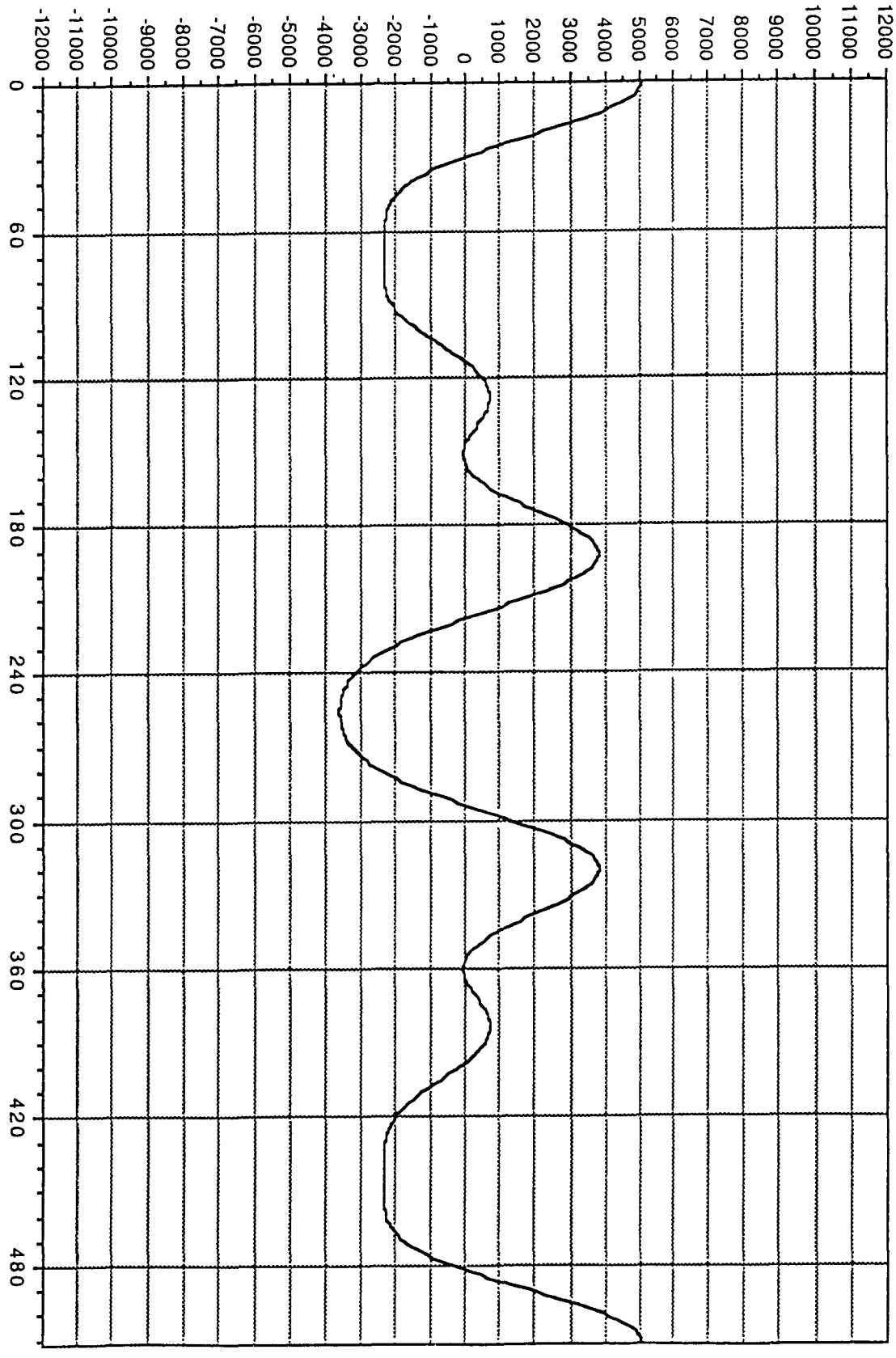
DATA FOR COSINE PLOTS OF YEARLY FREQUENCIES

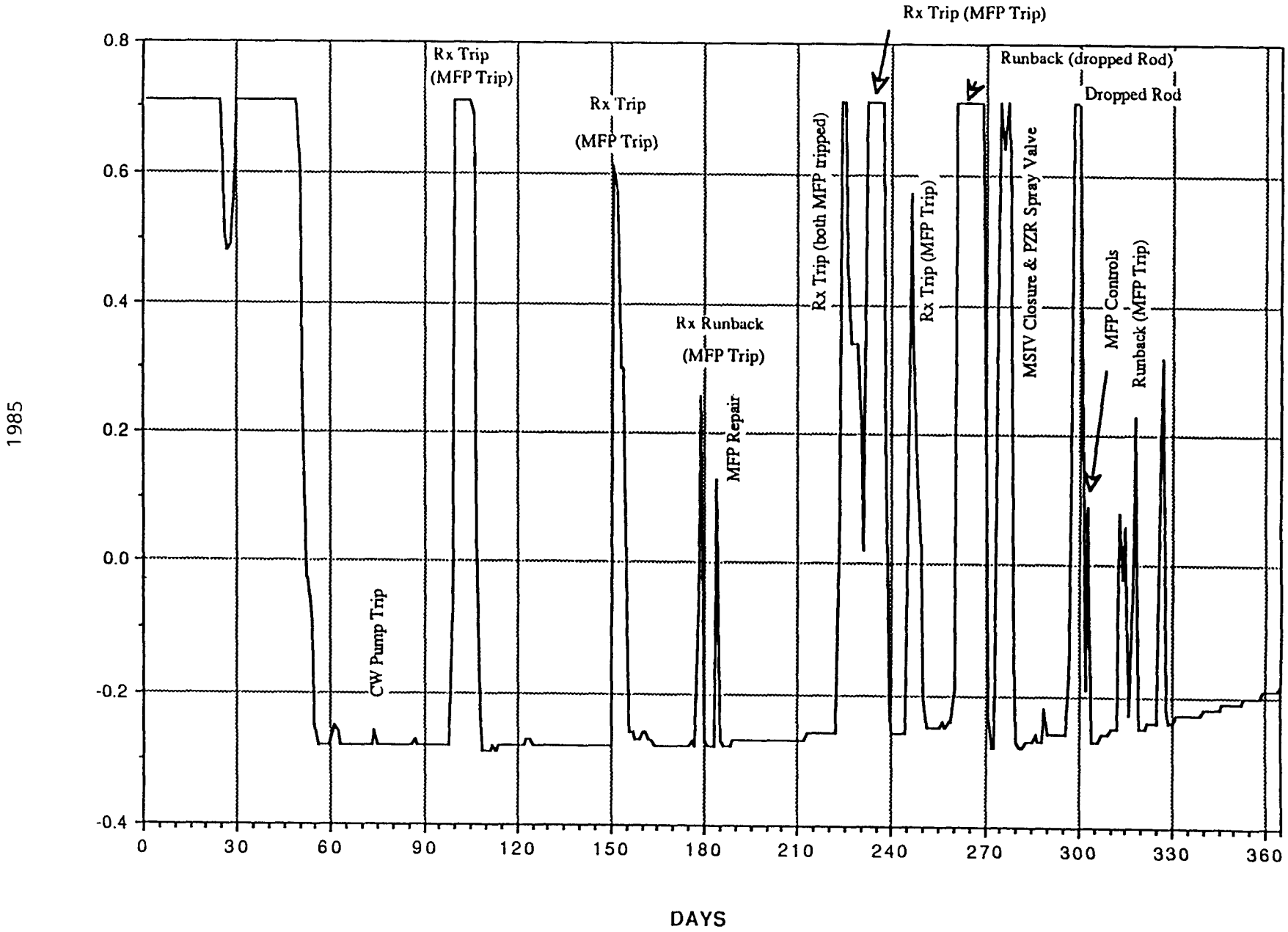
PLANT	YEAR	FIRST AMPLITUDE	SECOND AMPLITUDE	THIRD AMPLITUDE	FIRST FREQUENCY	SECOND FREQUENCY	THIRD FREQUENCY
X	1985	.1905 E+3	.1721 E+3	.1304 E+3	.7813 E-2	.1367 E-1	.2539 E-1
	1986	.5118 E+4	.3257 E+4	.1068 E+4	.7813 E-2	.3906 E-2	.1563 E-2
	1987 ②	.2955 E+4	.1387 E+4	.4734 E+3	.7813 E-2	.1172 E-1	.1758 E-1
Y	1985	.1951 E+4	.1912 E+4	.1094 E+4	.3906 E-2	.9766 E-2	.1758 E-1
	1986	.1739 E+4	.2136 E+3	.1040 E+2	.5859 E-2	.3125 E-1	.4492 E-1
	1987	.3478 E+4	.1176 E+4	.8373 E+3	.5859 E-2	.9766 E-2	.1953 E-1
Z	1985	.4319 E+4	.1278 E+4	.3548 E+3	.5859 E-2	.9766 E-2	.2148 E-1
	1986	.4025 E+4	.3463 E+3	.3182 E+3	.5859 E-2	.2539 E-1	.4102 E-1
	1987	.8957 E+4	.1973 E+4	.4691 E+3	.5859 E-2	.9766 E-2	.1758 E-1
	1985						
	1986						
	1987						

NOTES: ① Operated for only 5 days in the calendar year

② Several days estimated due to quality of hardcopy data

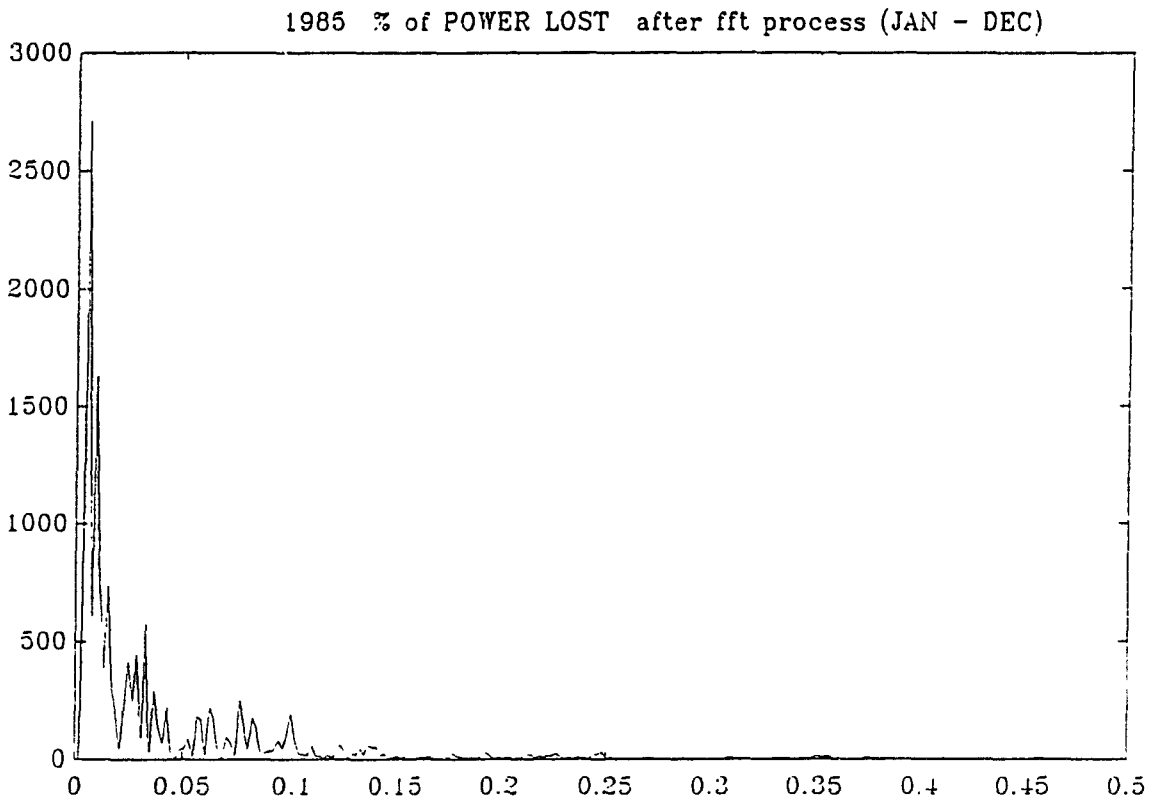
1985

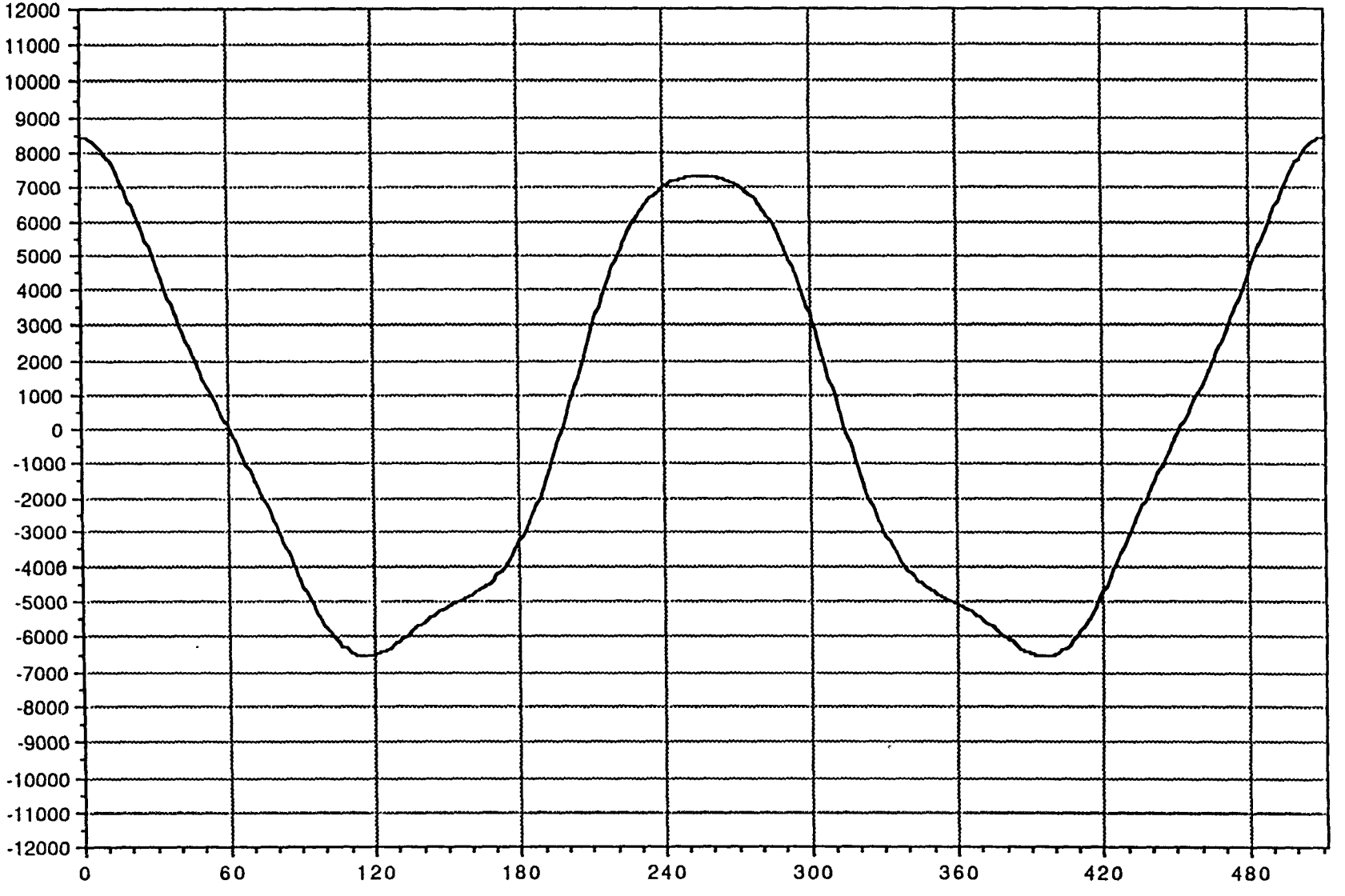

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

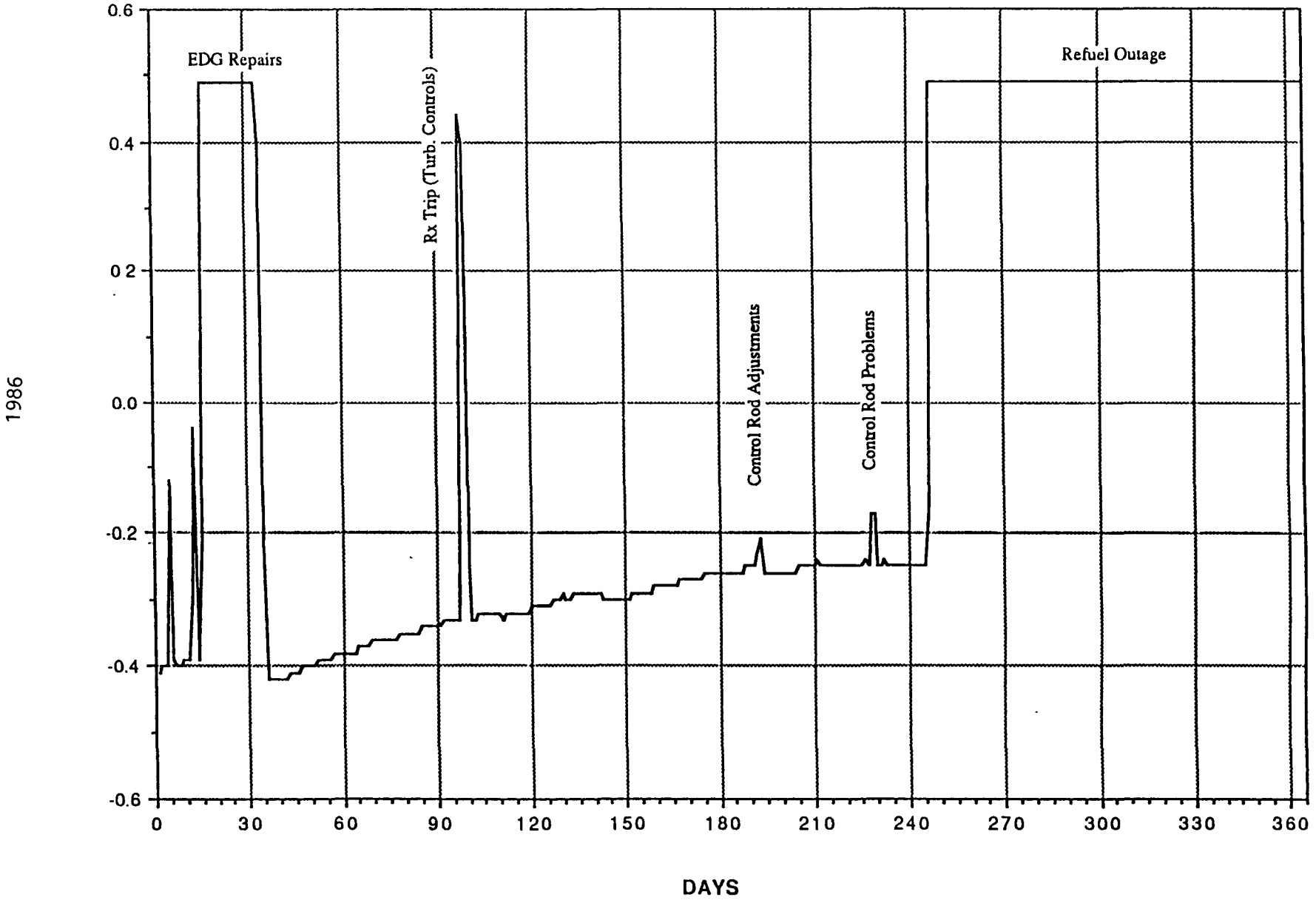

Rx Trip (MFP Trip)
Rx Trip (MFP Trip)
Rx Trip (MFP Trip)
Rx Runback (MFP Trip)
MFP Repair
Rx Trip (both MFP tripped)
Rx Trip (MFP Trip)
Runback (dropped Rod)
Dropped Rod
MSIV Closure & PZR Spray Valve
MFP Controls
Runback (MFP Trip)
CW Pump Trip
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0
30
60
90
120
150
180
210
240
270
300
330
360
DAYS

1985

Att-1-28

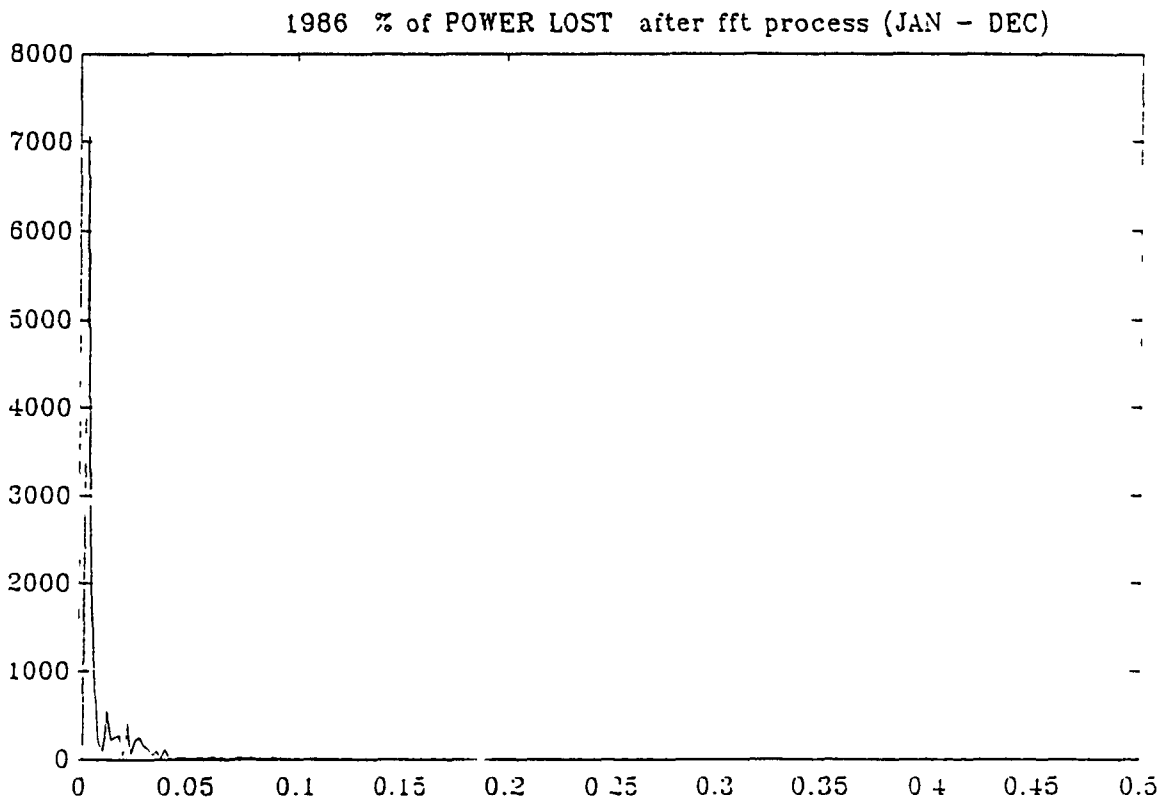

1985 % of POWER LOST after fft process (JAN - DEC)
3000
2500
2000
1500
1000
500
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

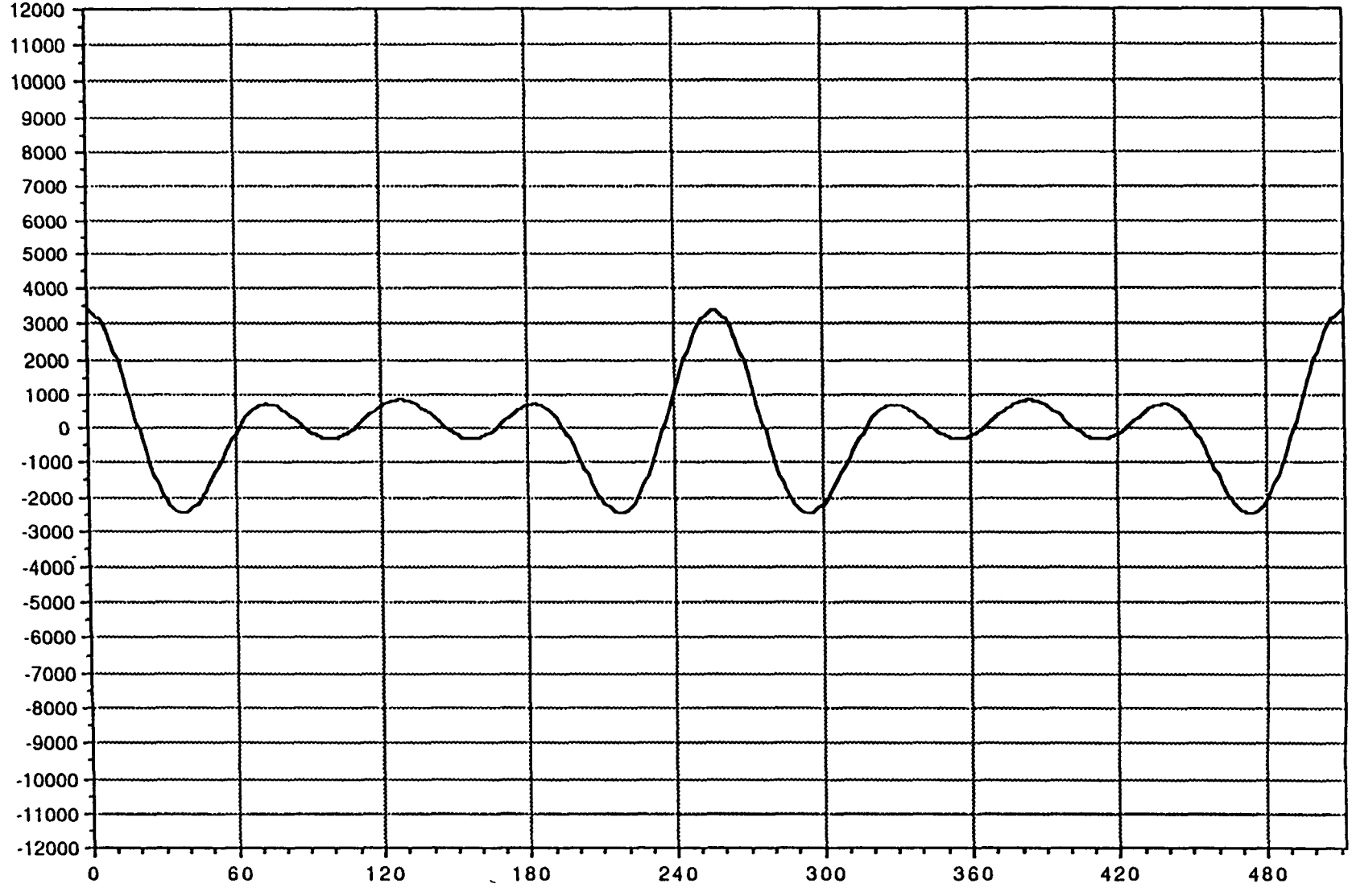

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480
1986
Att-1-30


0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
30
60
90
120
150
180
210
240
270
300
330
360
DAYS
EDG Repairs
Rx Trip (Turb. Controls)
Control Rod Adjustments
Control Rod Problems
Refuel Outage

1986

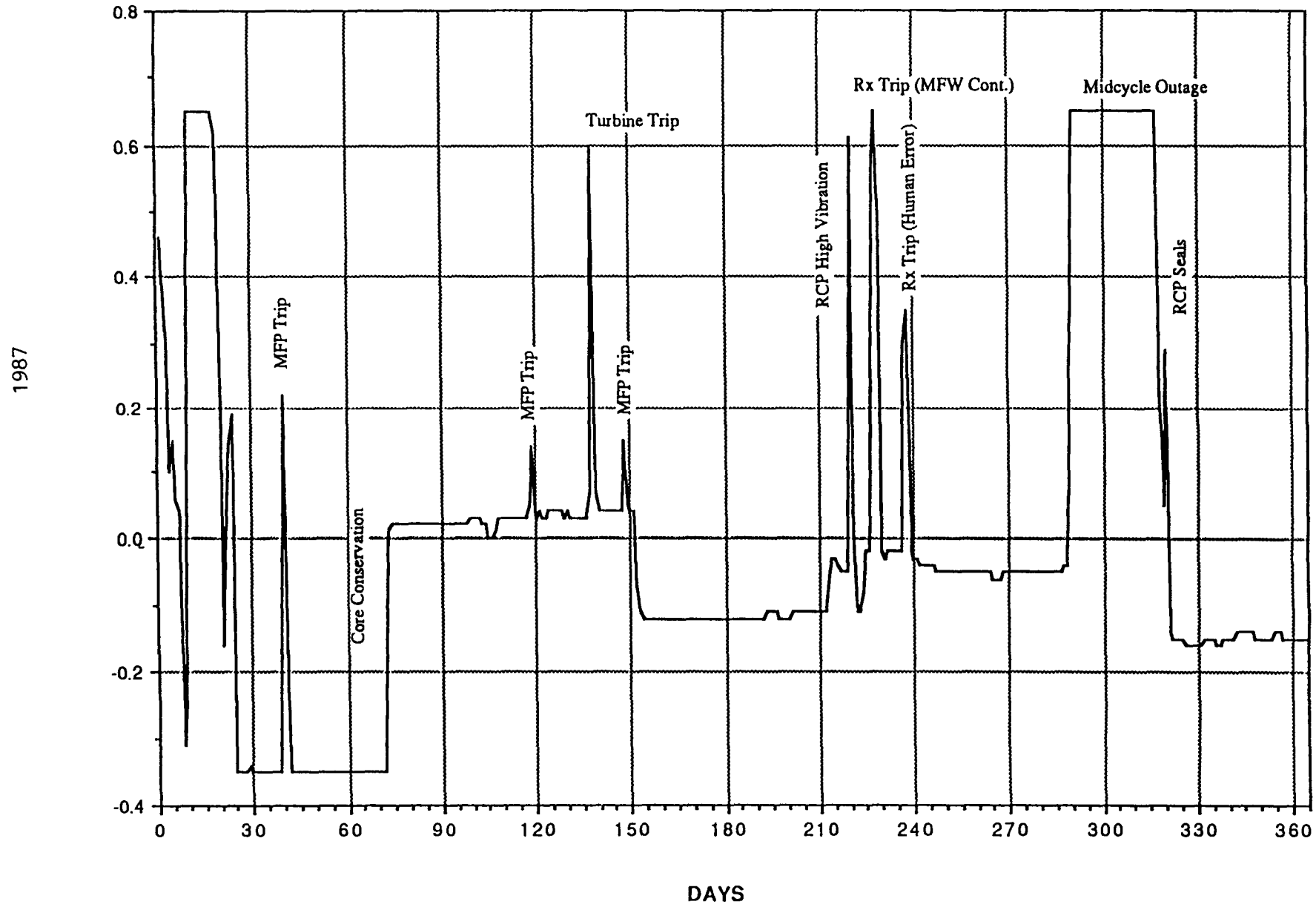
Att-1-31


1986 % of POWER LOST after fft process (JAN - DEC)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5


12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

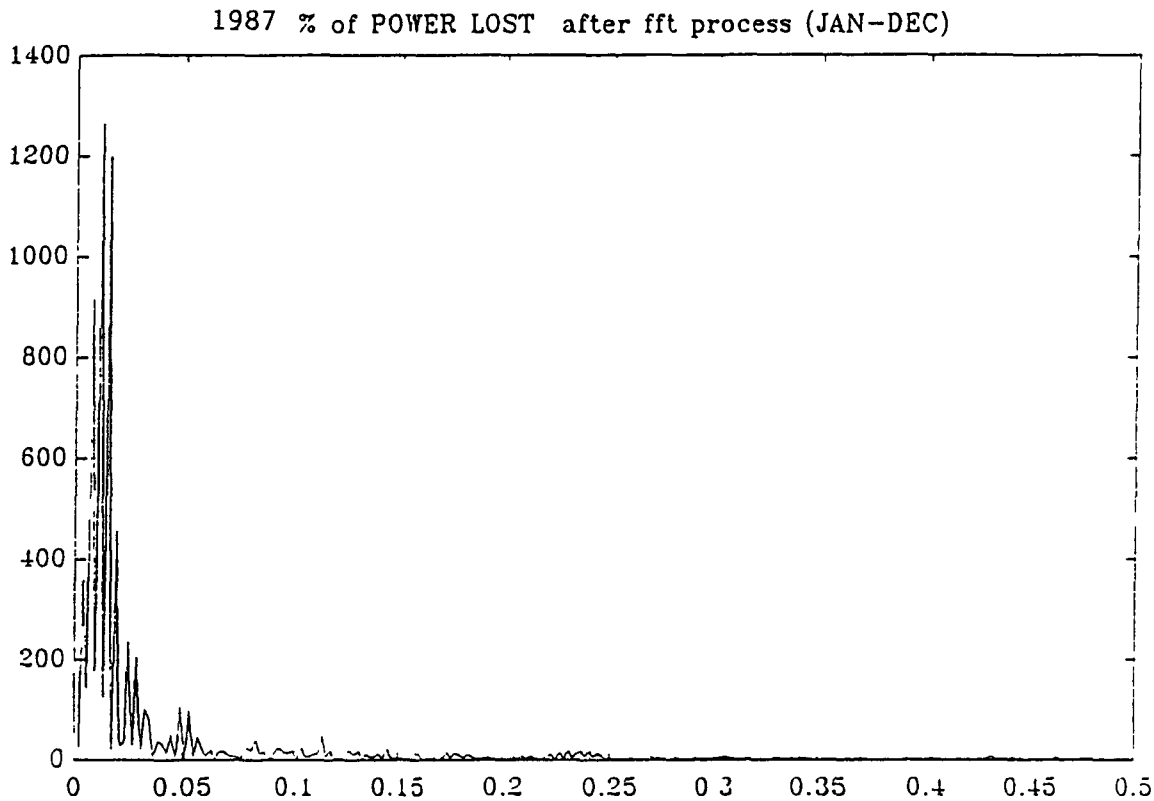
1987

Att-1-33


0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0
30
60
90
120
150
180
210
240
270
300
330
360
DAYS
MFP Trip
Core Conservation
MFP Trip
Turbine Trip
MFP Trip
RCP High Vibration
Rx Trip (MFW Cont.)
Rx Trip (Human Error)
Midcycle Outage
RCP Seals

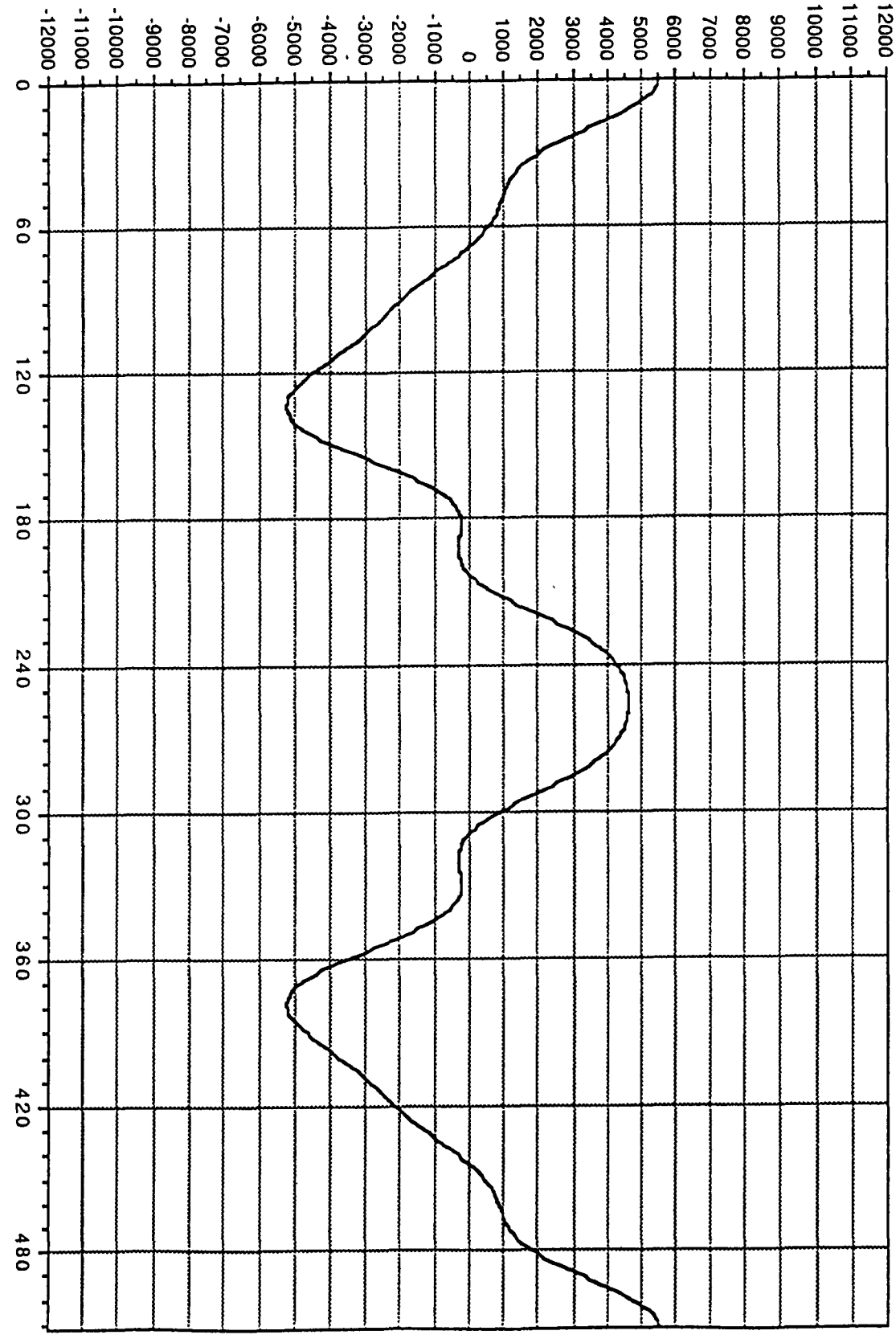
1987

Att-1-34

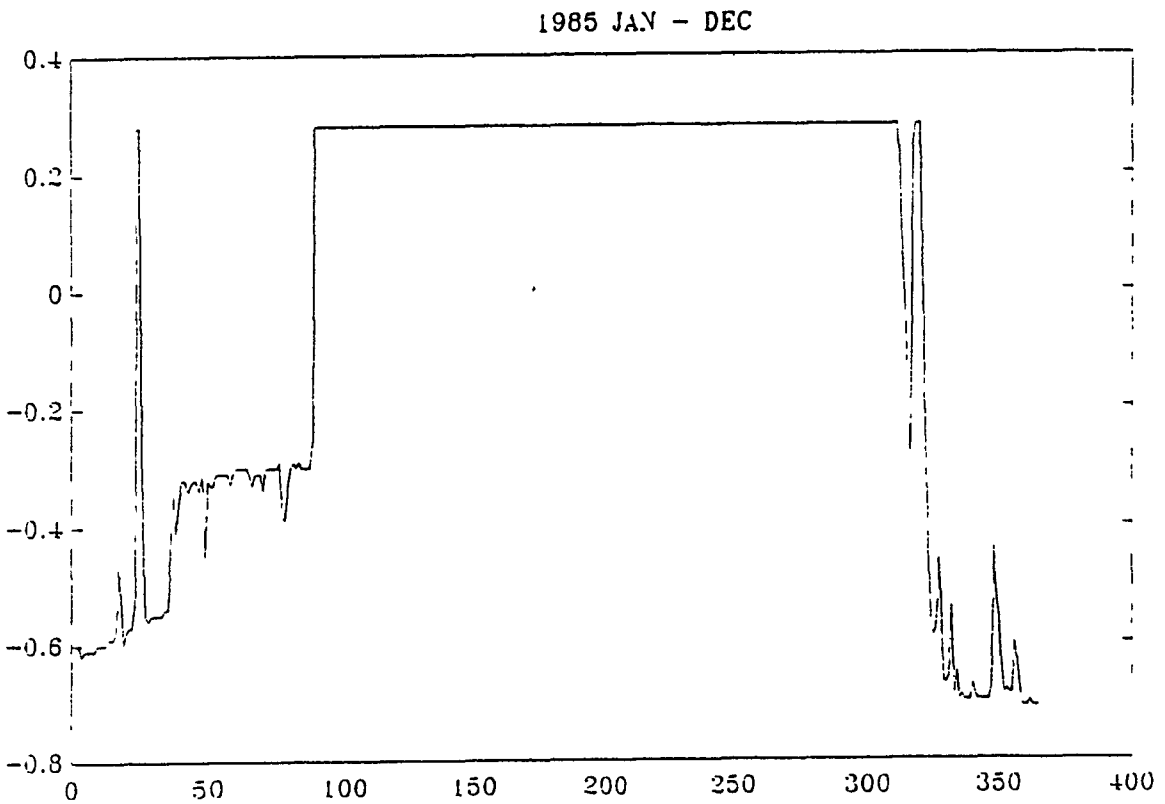

1987 % of POWER LOST after fft process (JAN-DEC)
1400
1200
1000
800
600
400
200
0
0
0.05
0.1
0.15
0.2
0.25
0 3
0.35
0.4
0.45
0.5

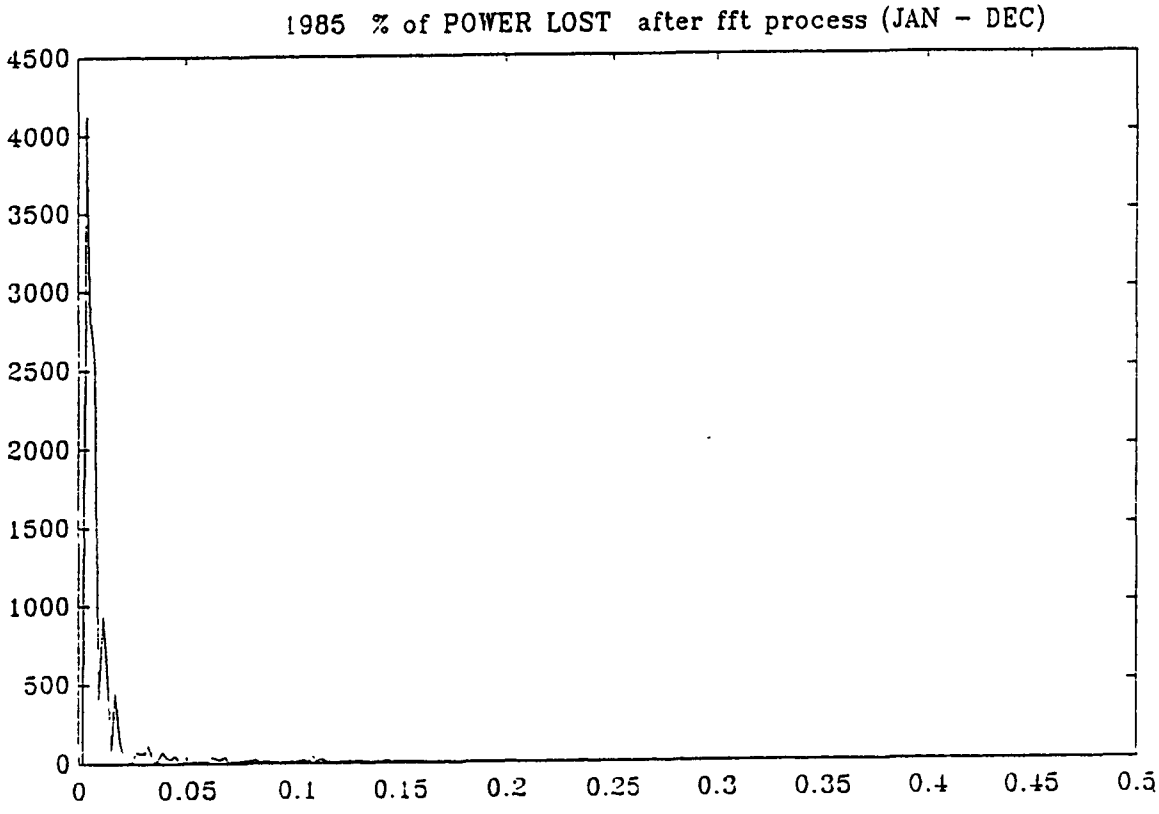
Detailed Results for Plant T

1985

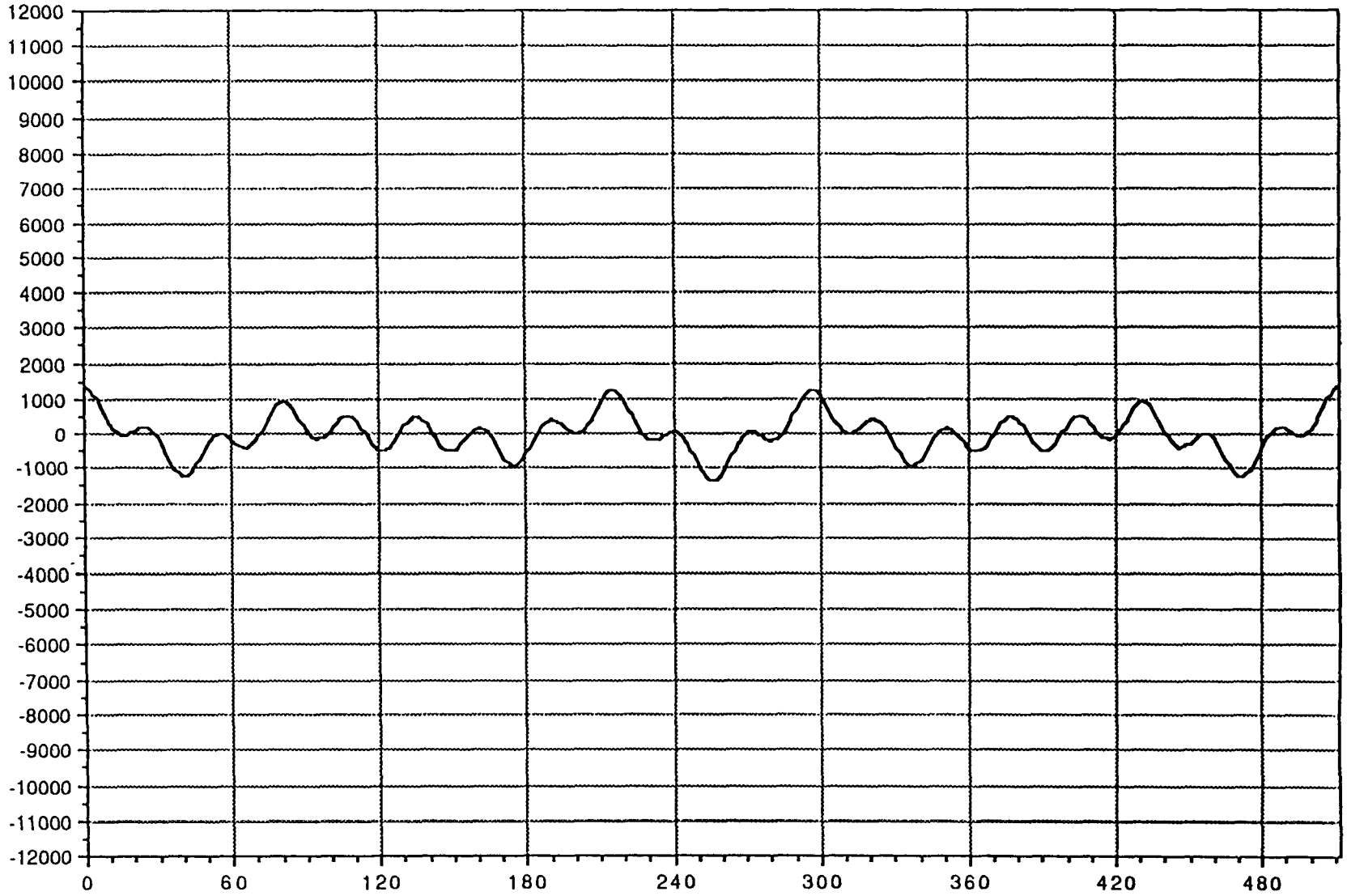

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

Att-1-37

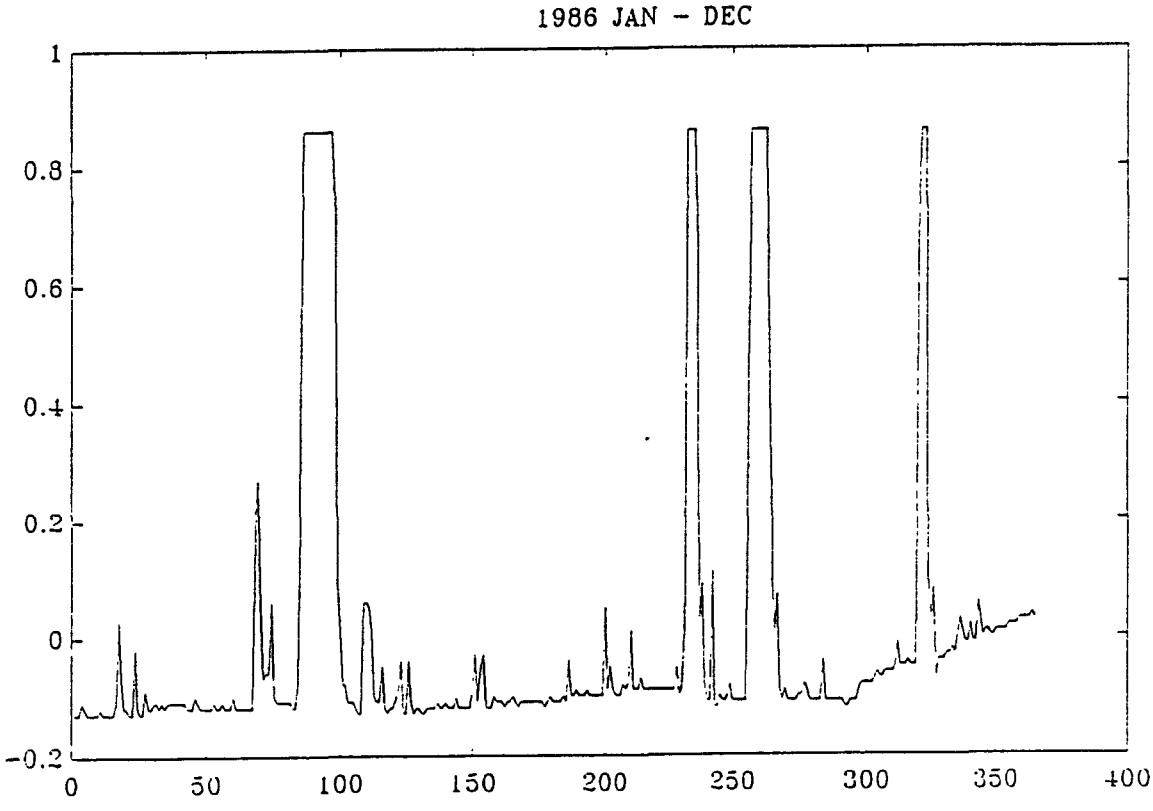

1985 JAN - DEC
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
50
100
150
200
250
300
350
400

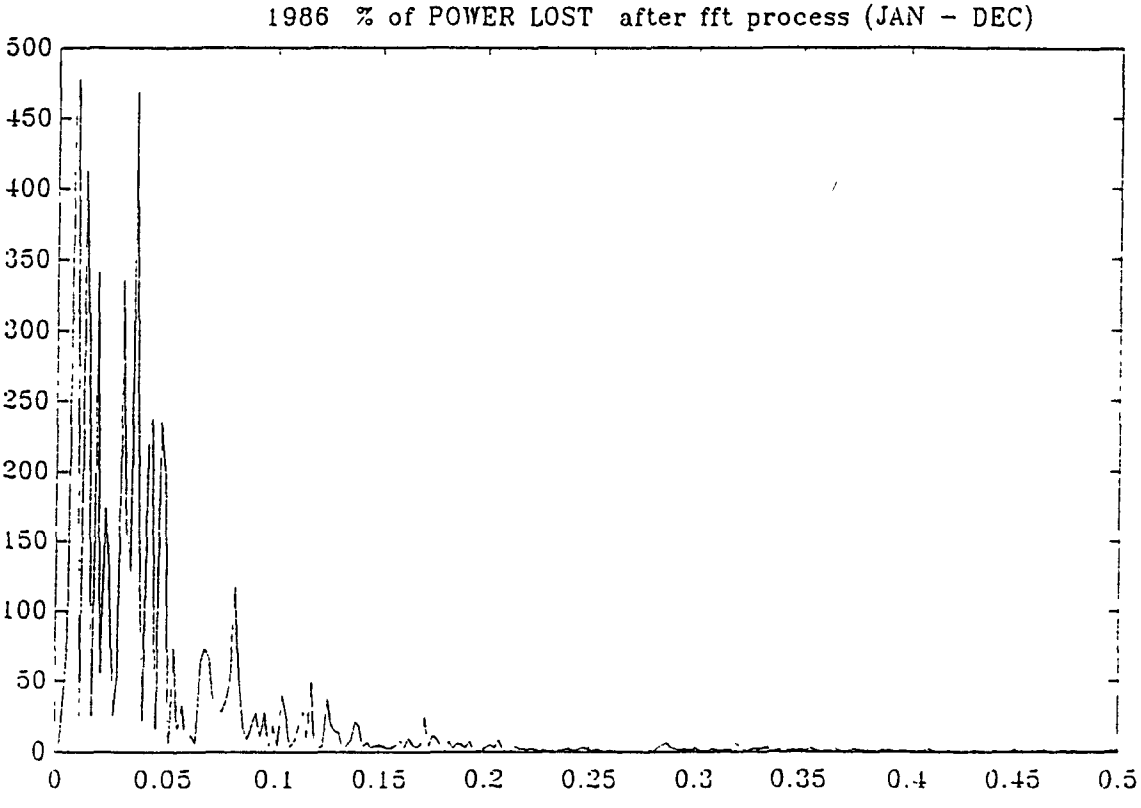

1985 % of POWER LOST after fft process (JAN - DEC)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

1986

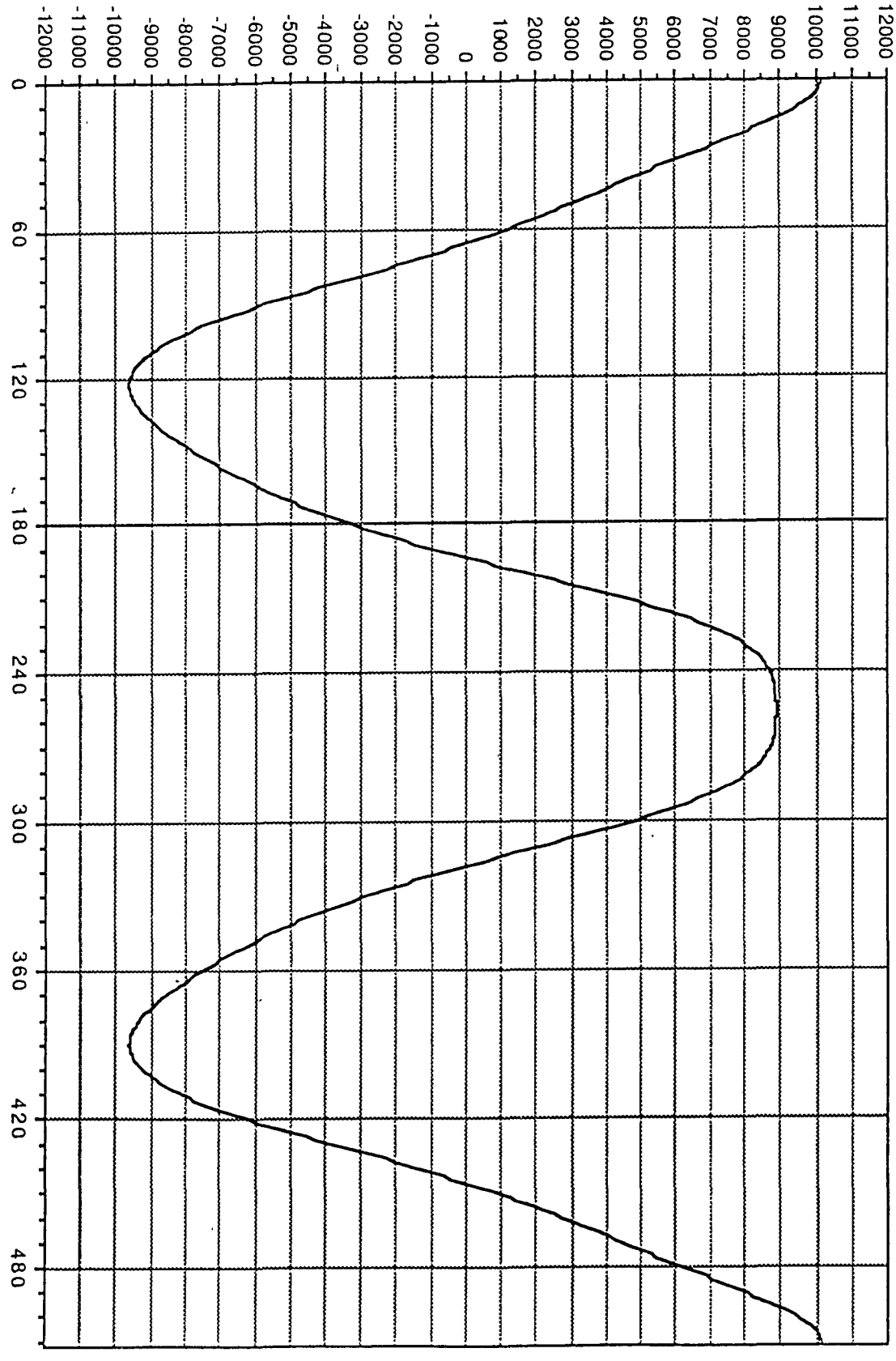

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

Att-1-40

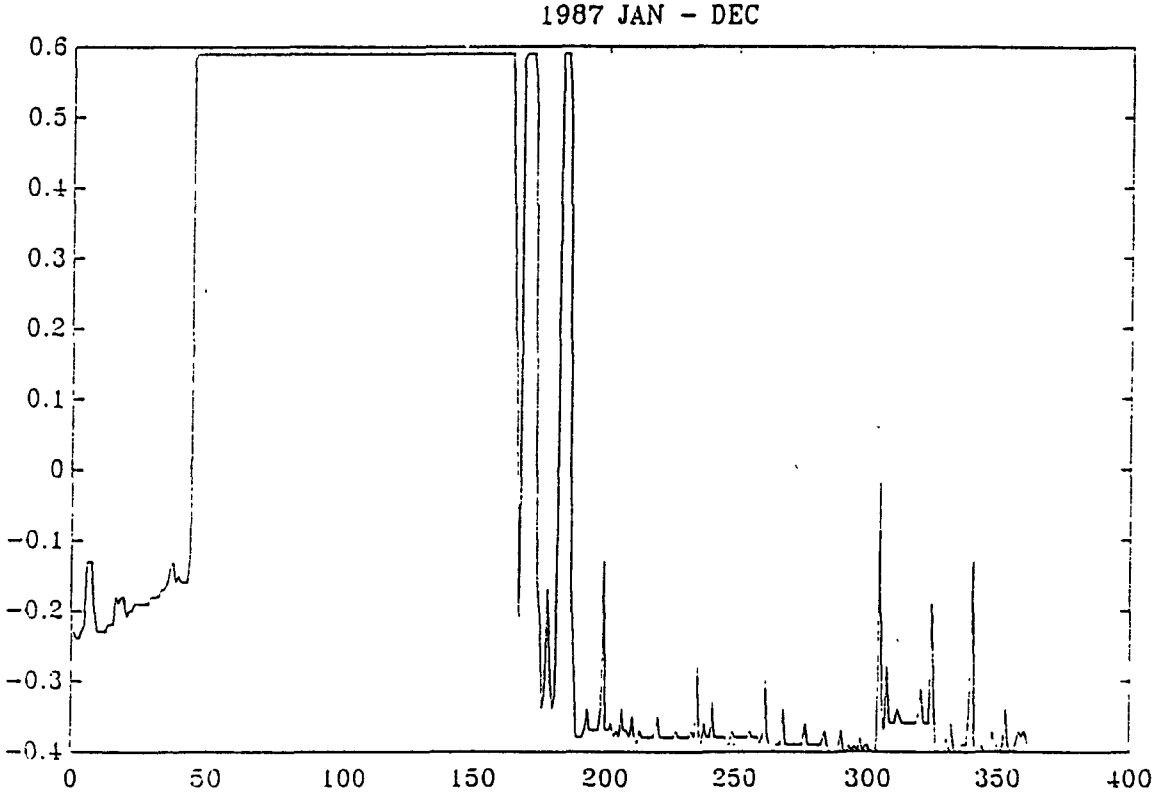

1986 JAN - DEC
1
0.8
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
250
300
350
400

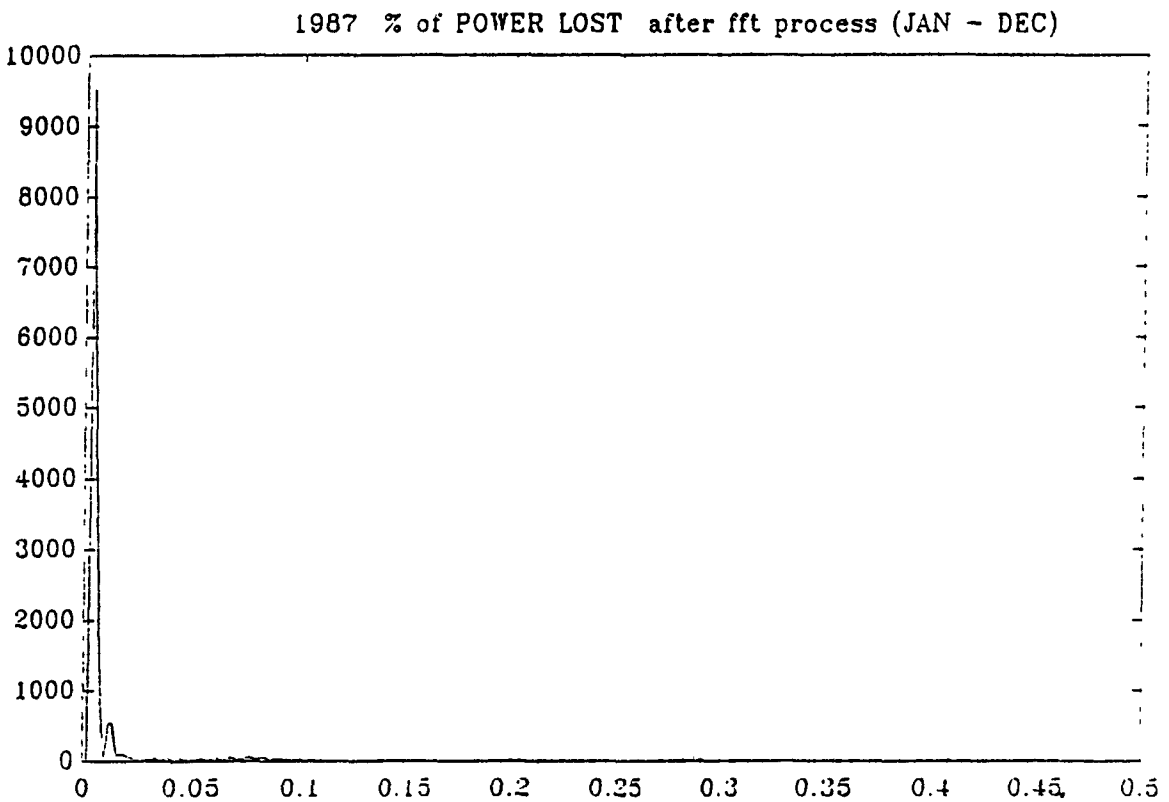

1986 % of POWER LOST after fft process (JAN - DEC)
500
450
400
350
300
250
200
150
100
50
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

1987


12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

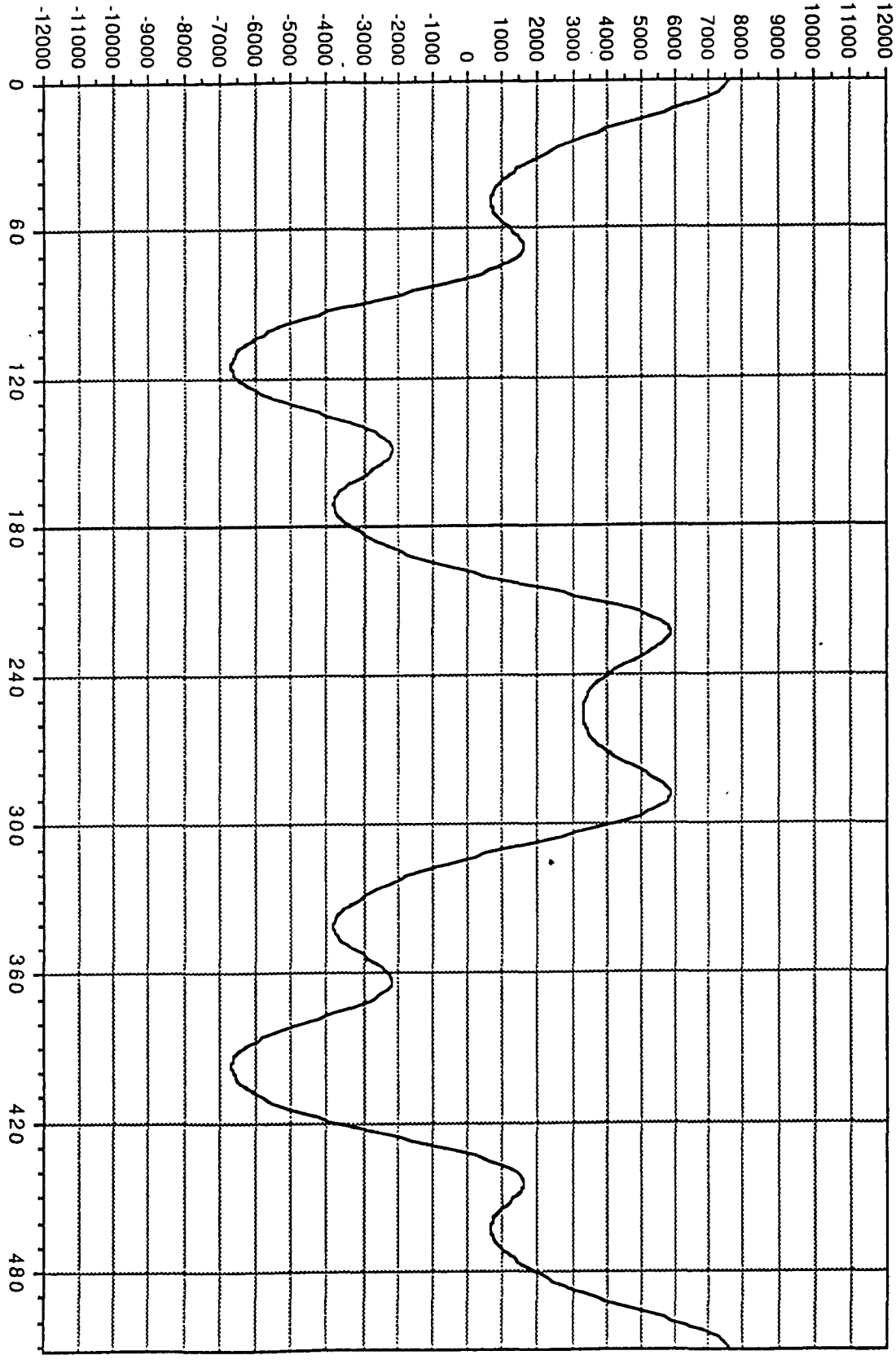
Att-1-43

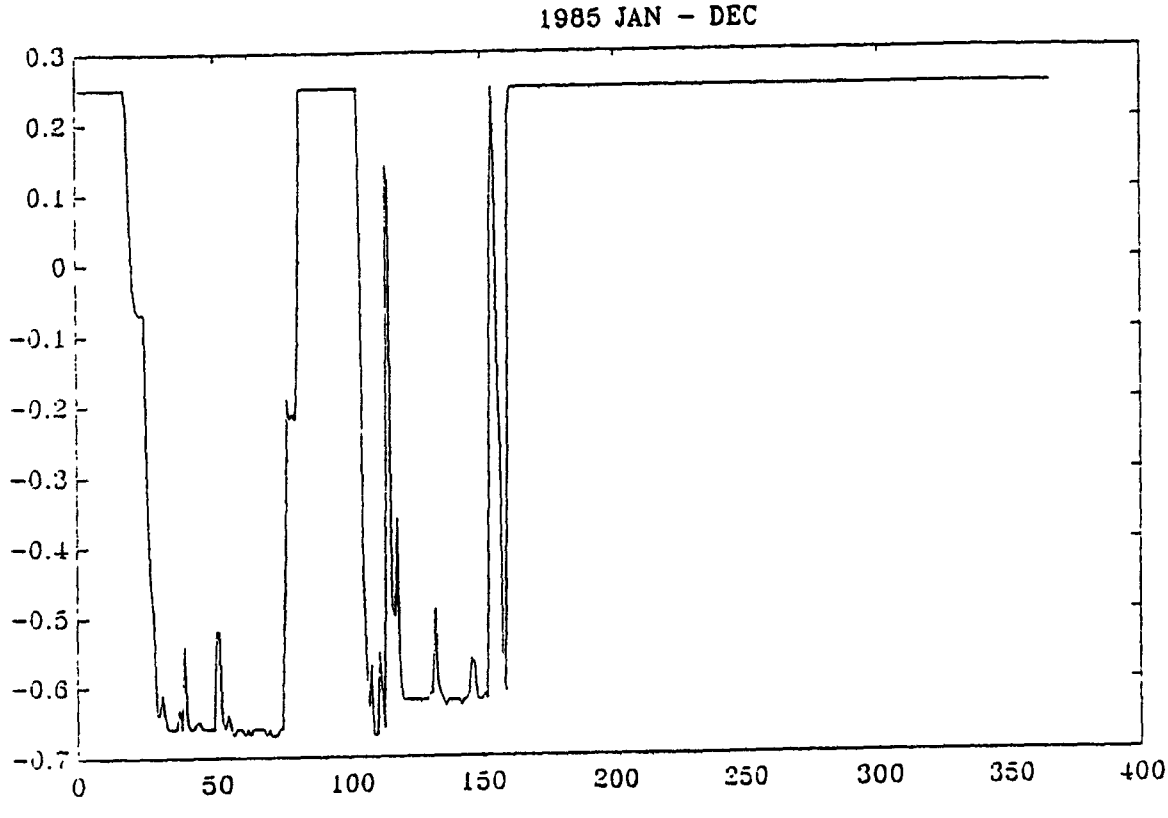

1987 JAN - DEC
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
50
100
150
200
250
300
350
400

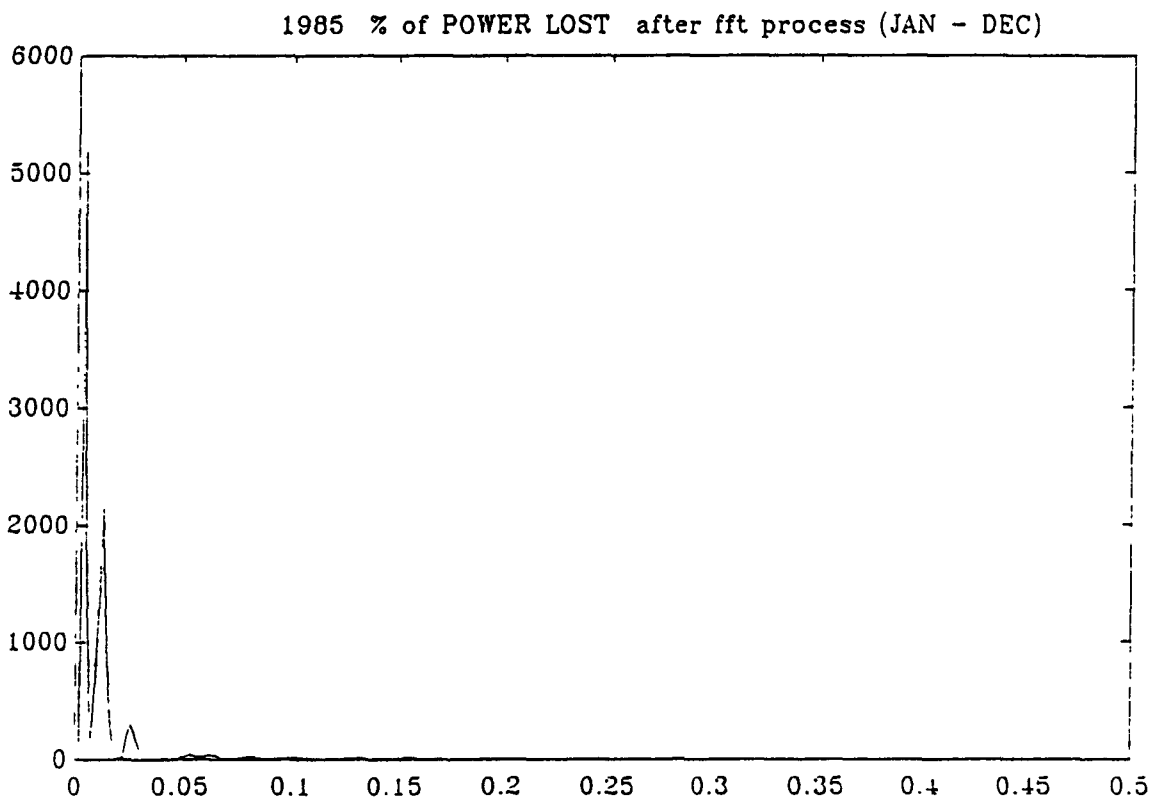

1987 % of POWER LOST after fft process (JAN - DEC)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

Detailed Results for Plant U

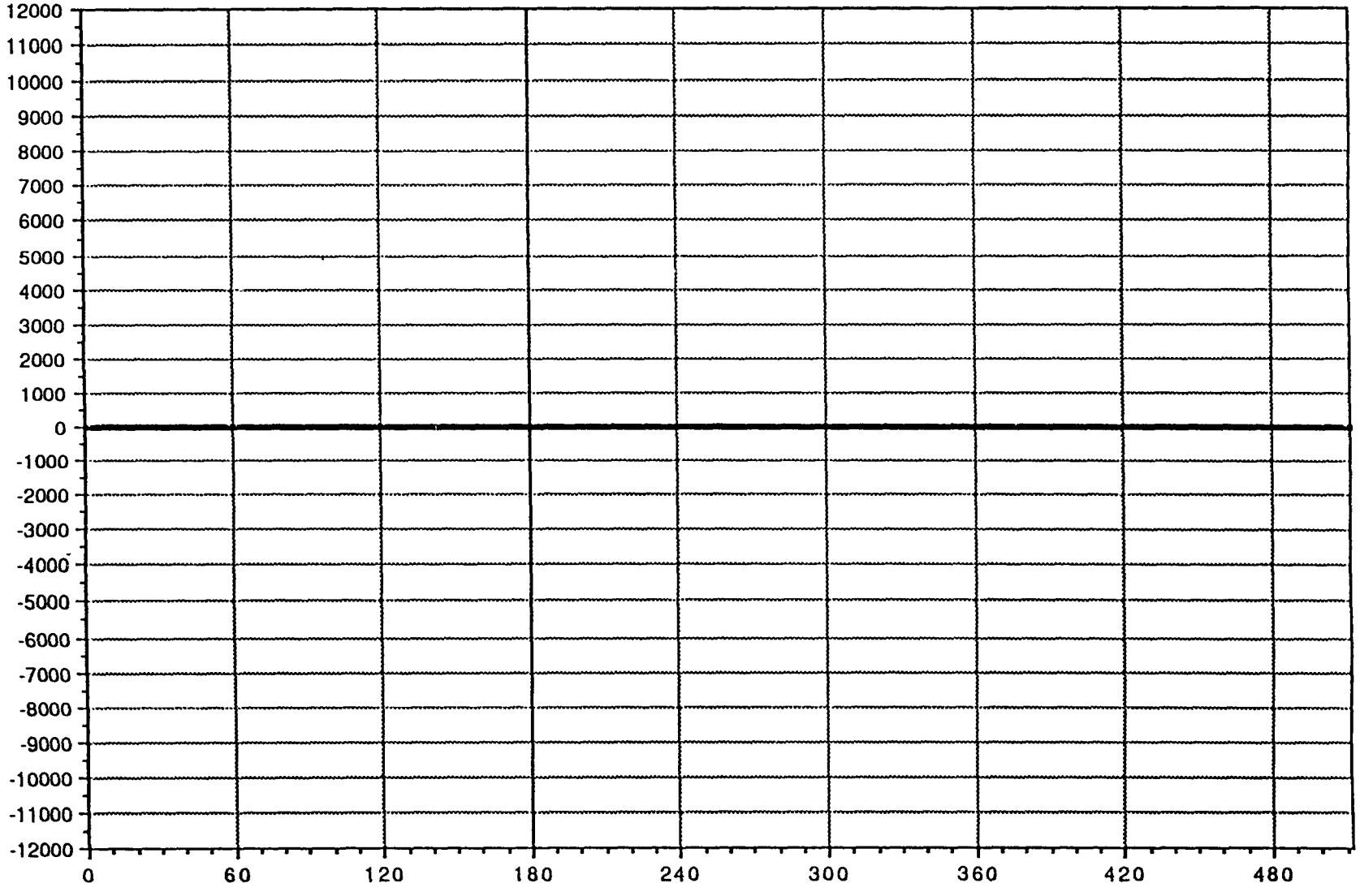
1985


12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480


1985 JAN - DEC
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
0
50
100
150
200
250
300
350
400

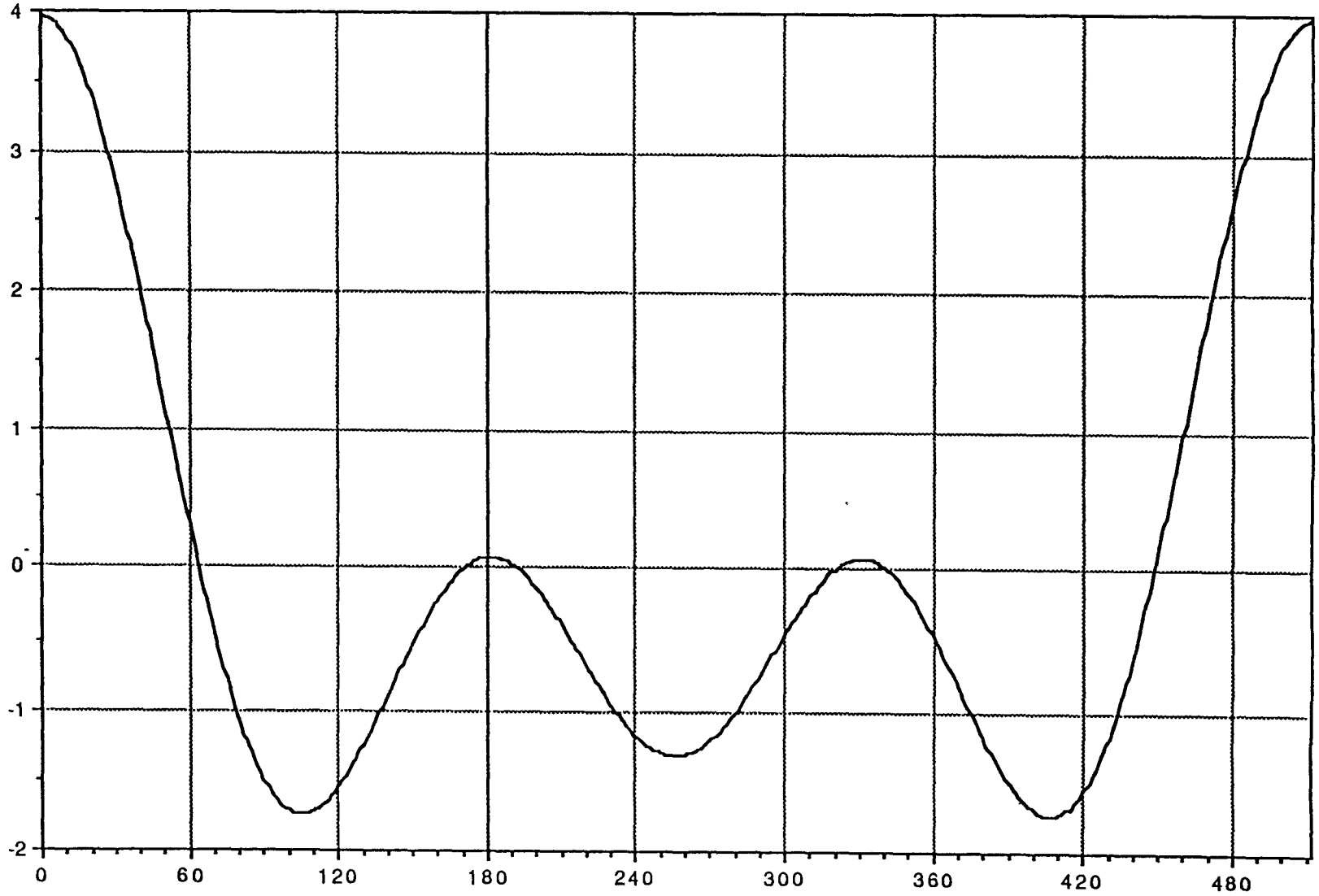

1985 % of POWER LOST after fft process (JAN - DEC)
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

1986

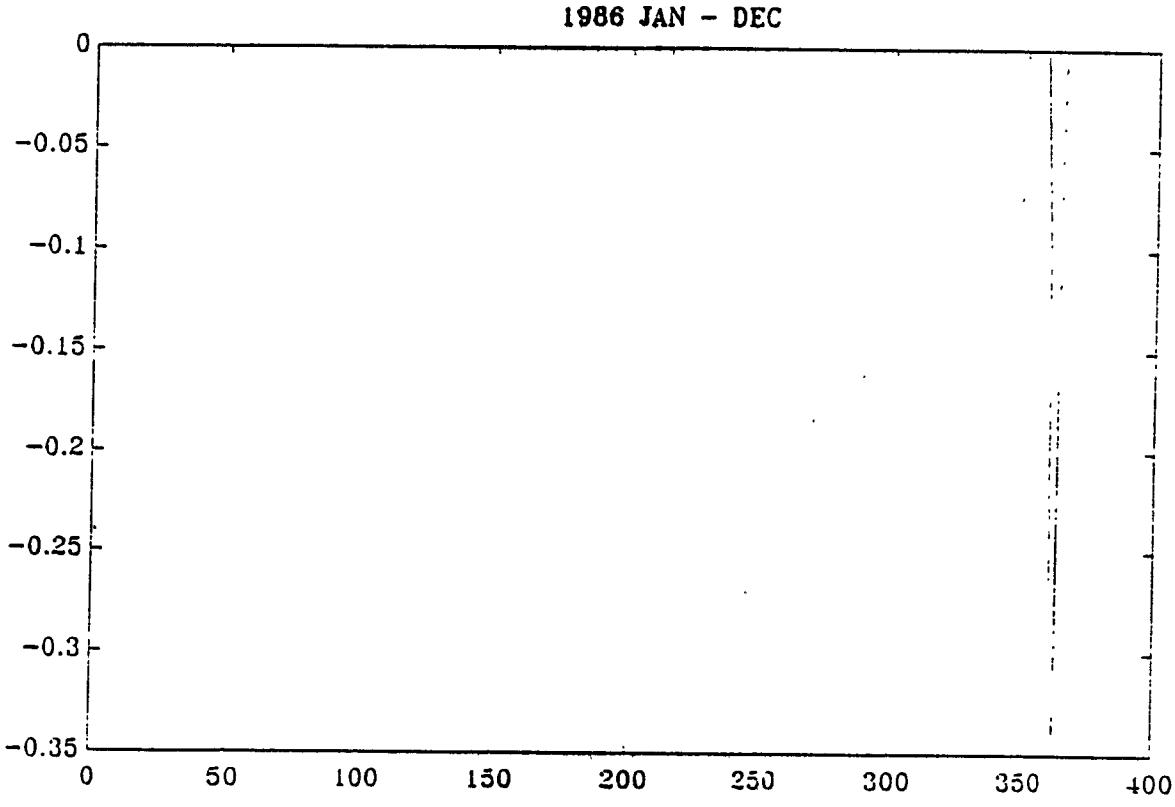

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

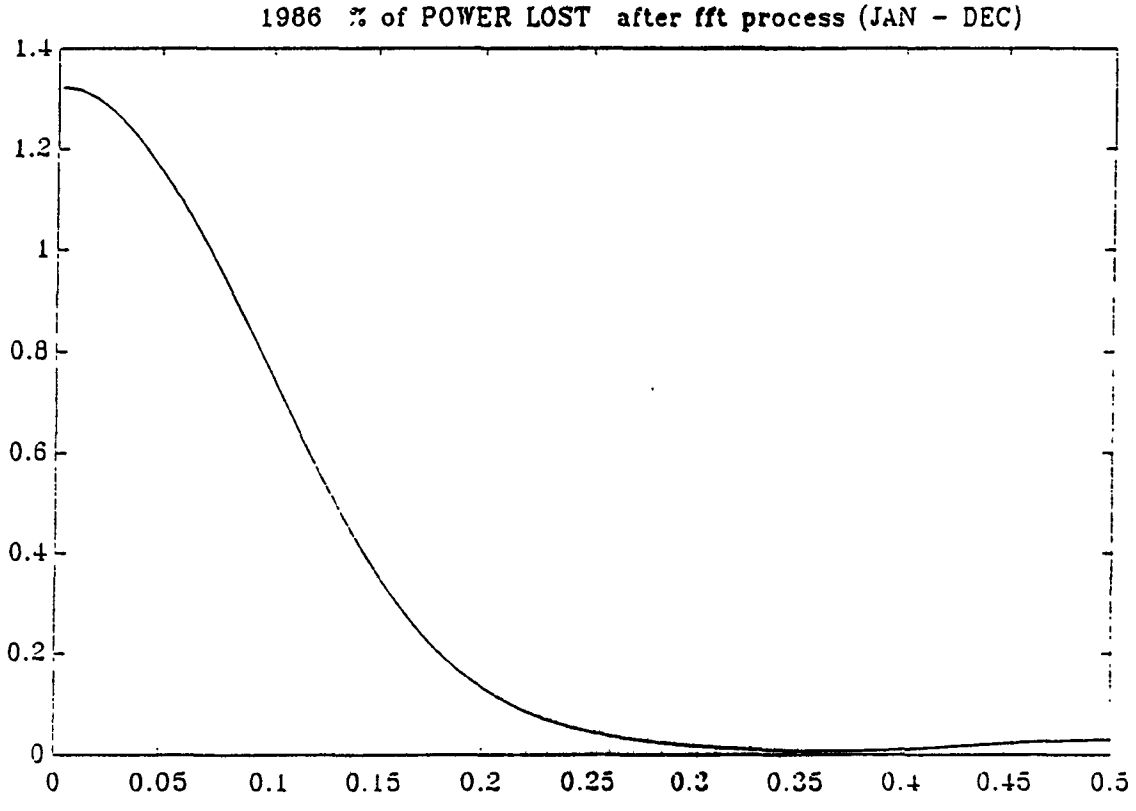
Att-1-50

1986

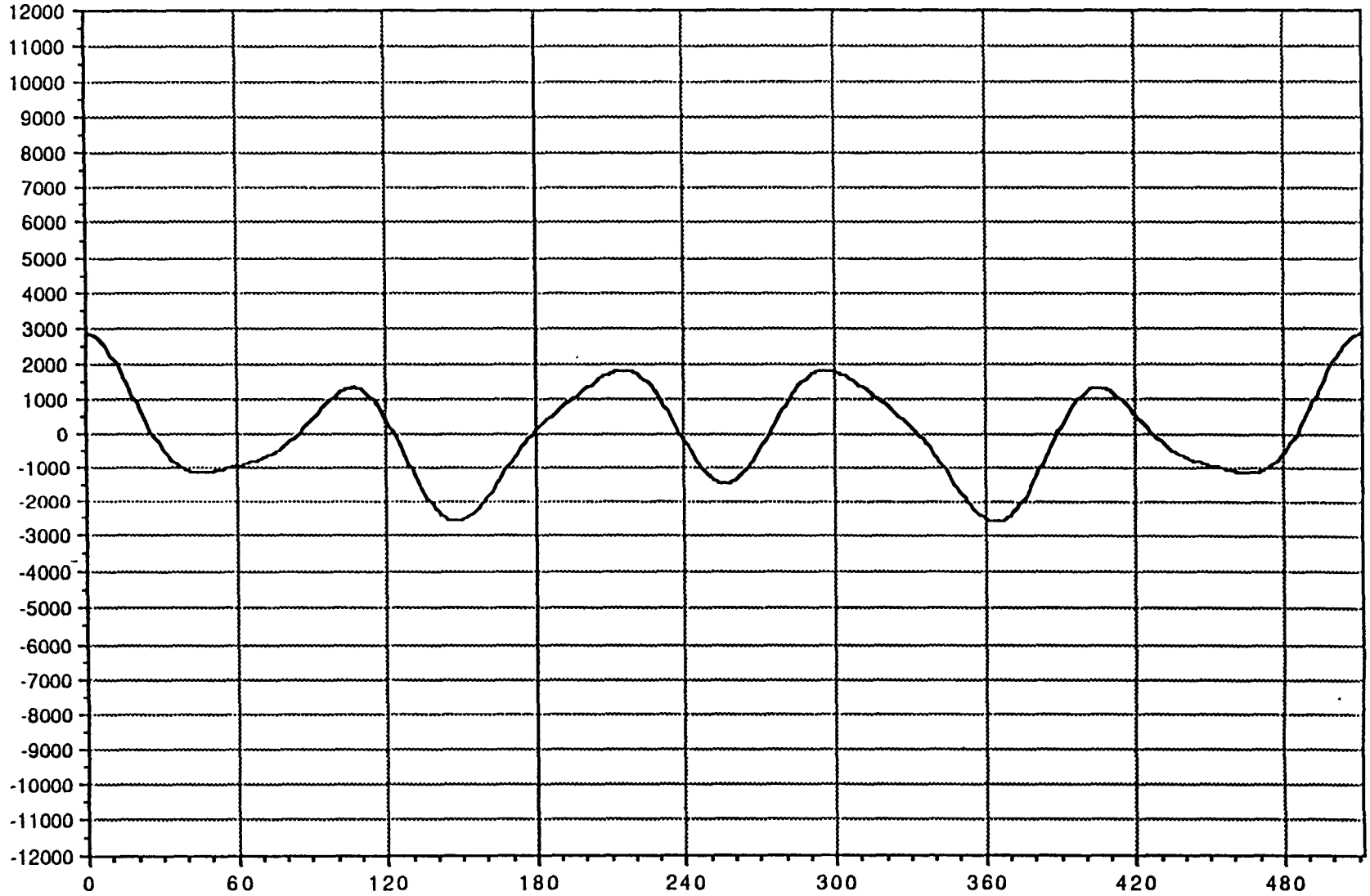


Att-1-51

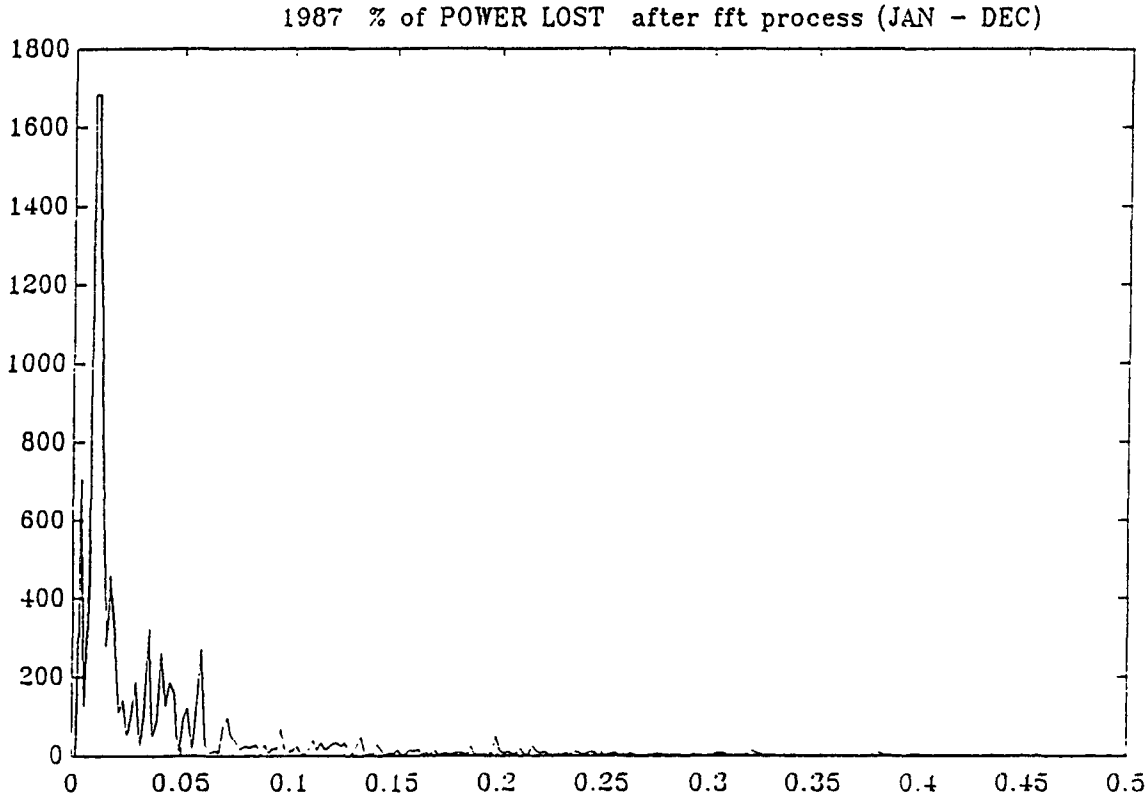

1986 JAN - DEC
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
0
50
100
150
200
250
300
350
400

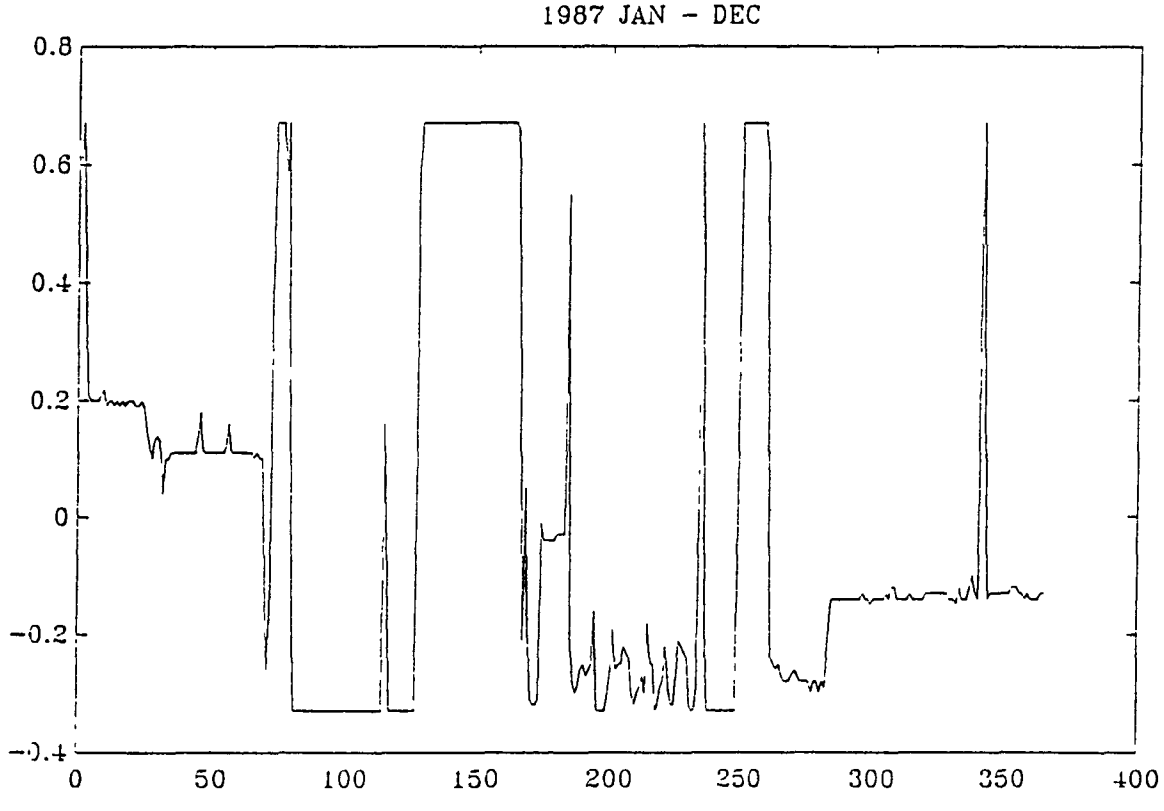

1986 % of POWER LOST after fft process (JAN - DEC)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

1987


12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

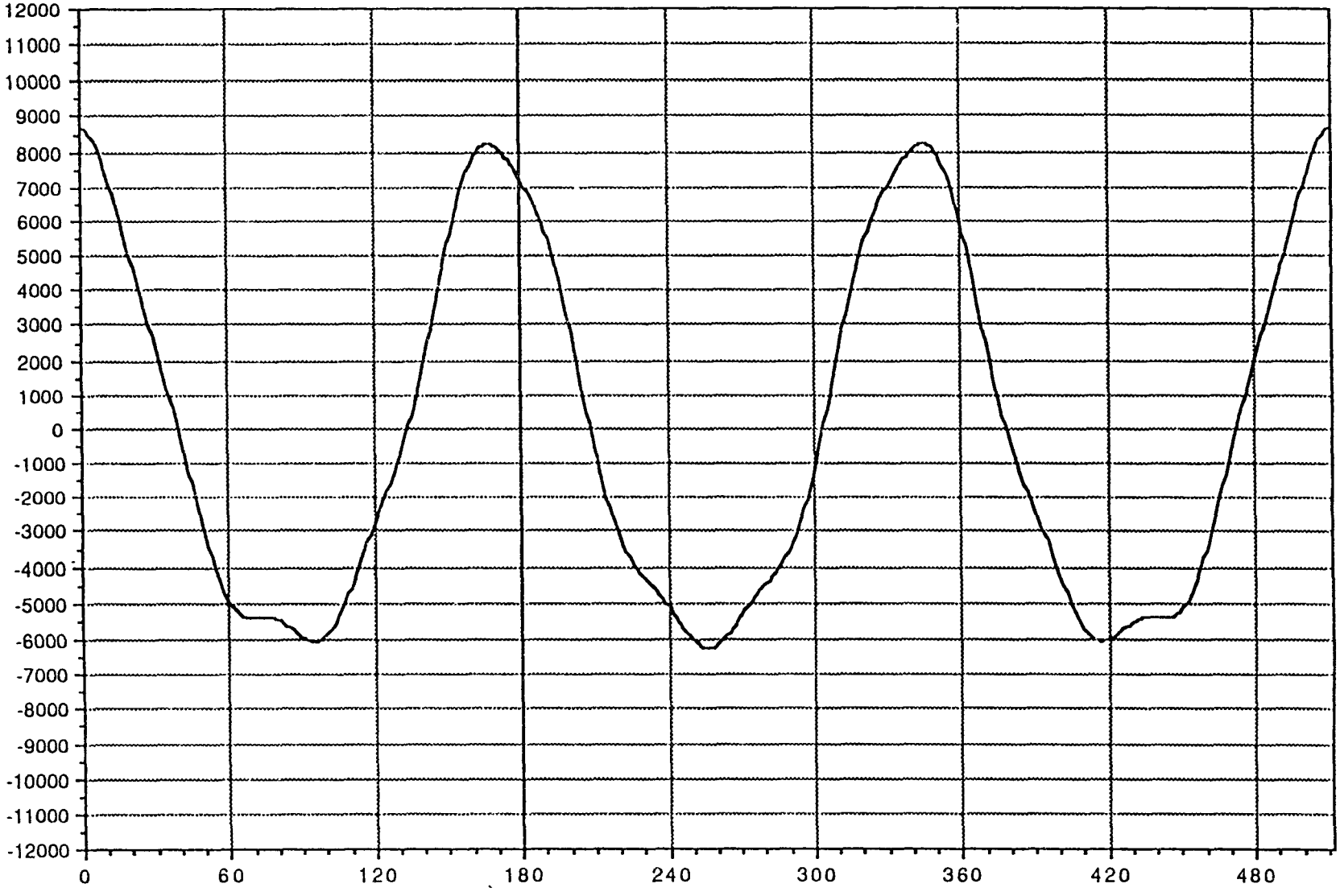
Att-1-54


1987 % of POWER LOST after fft process (JAN - DEC)
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

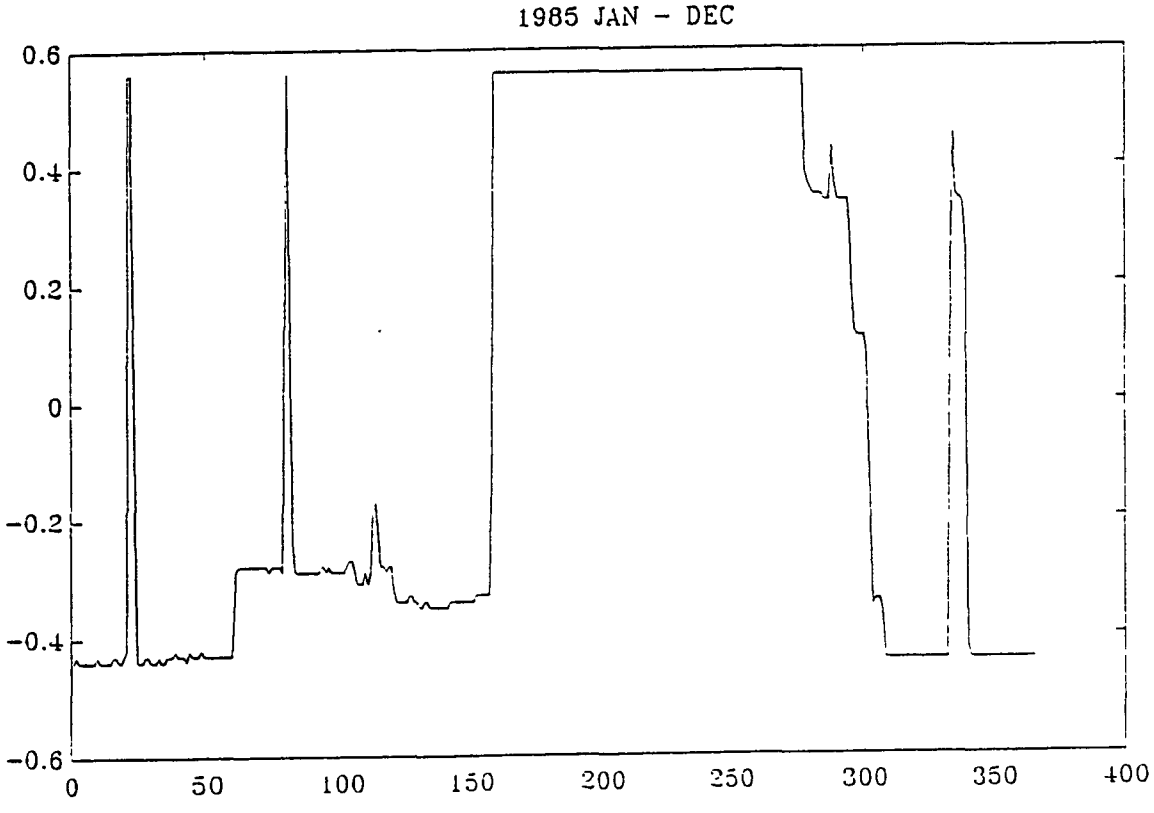

1987 JAN - DEC
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
50
100
150
200
250
300
350
400

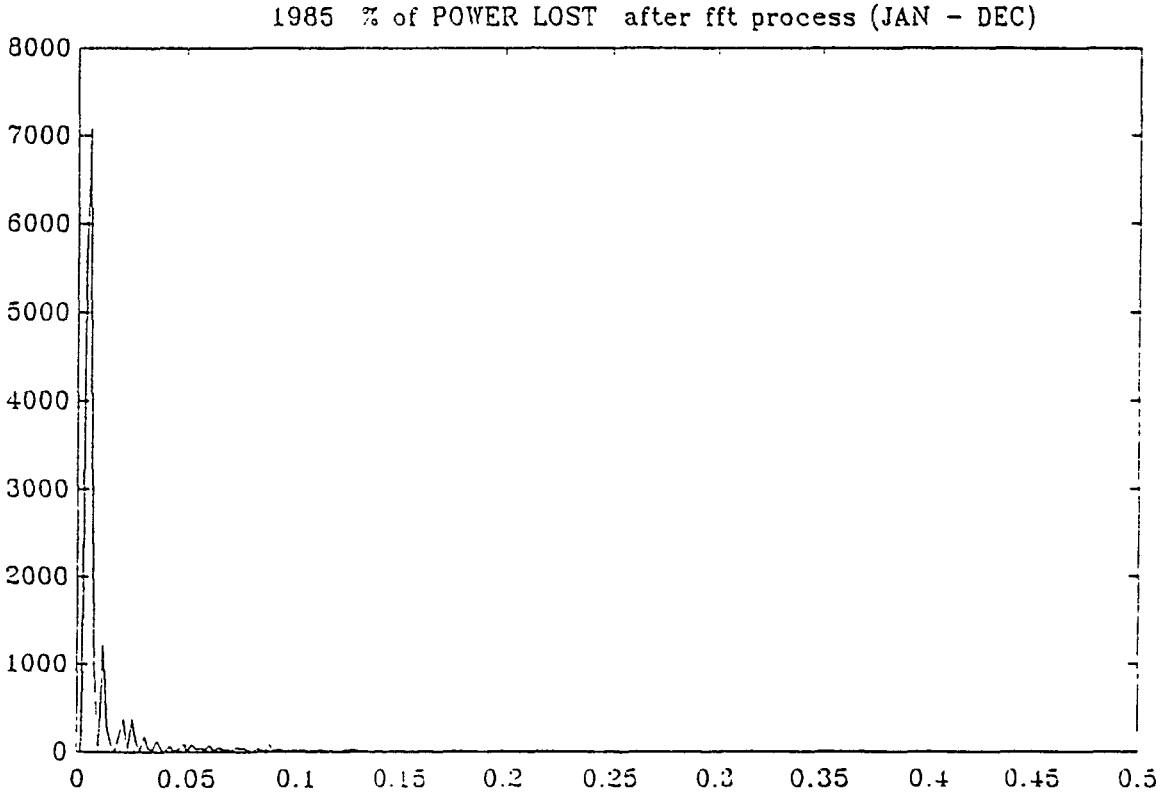
Detailed Results for Plant V

1985

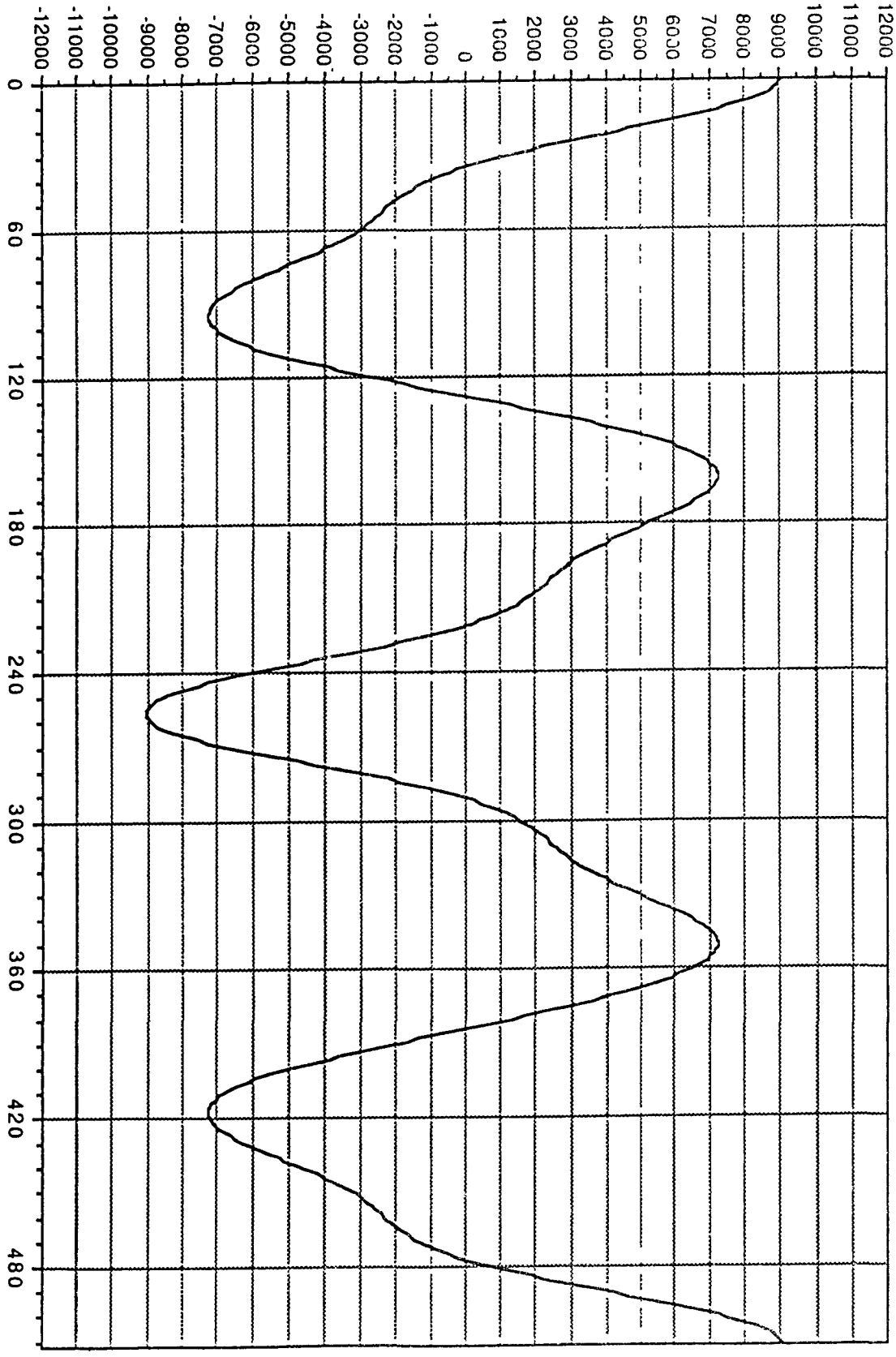

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

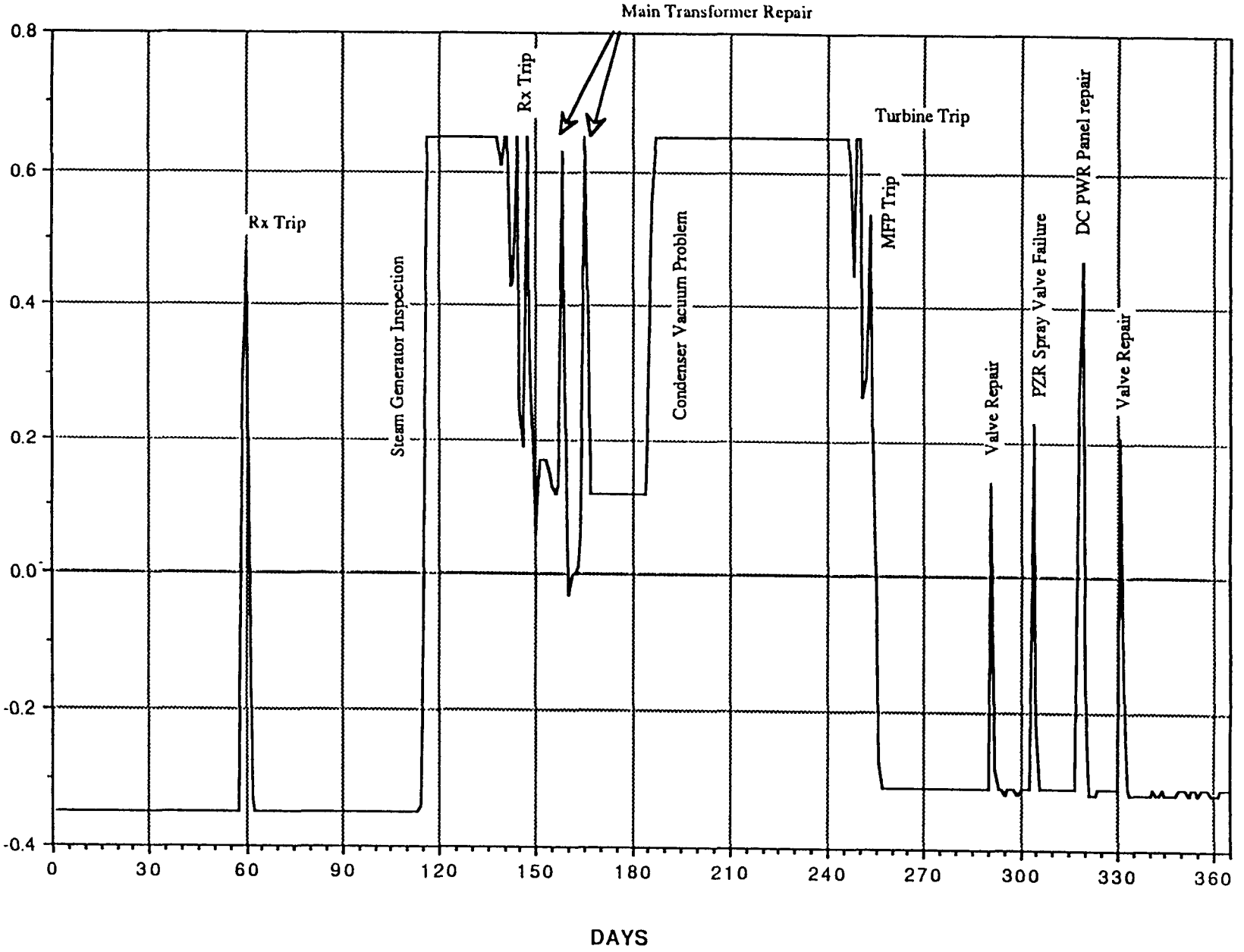
Att-1-58


1985 JAN - DEC
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
50
100
150
200
250
300
350
400


1985 % of POWER LOST after fft process (JAN - DEC)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

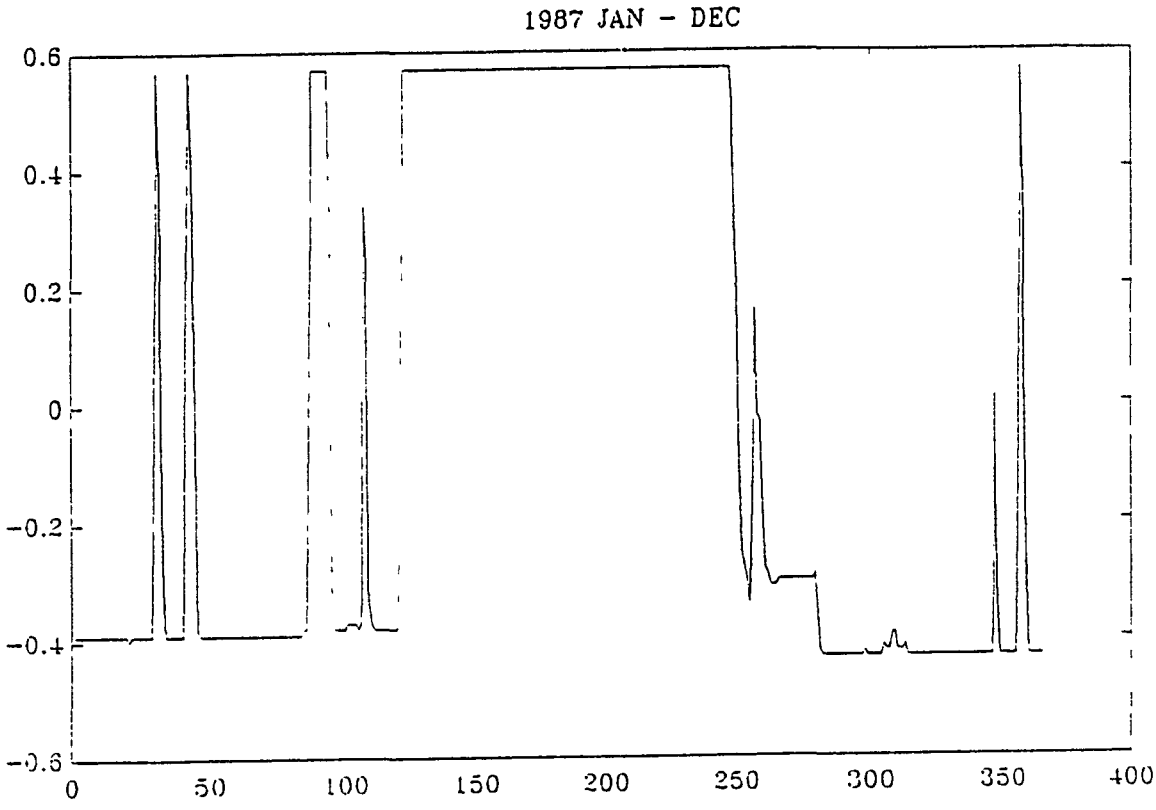
1986

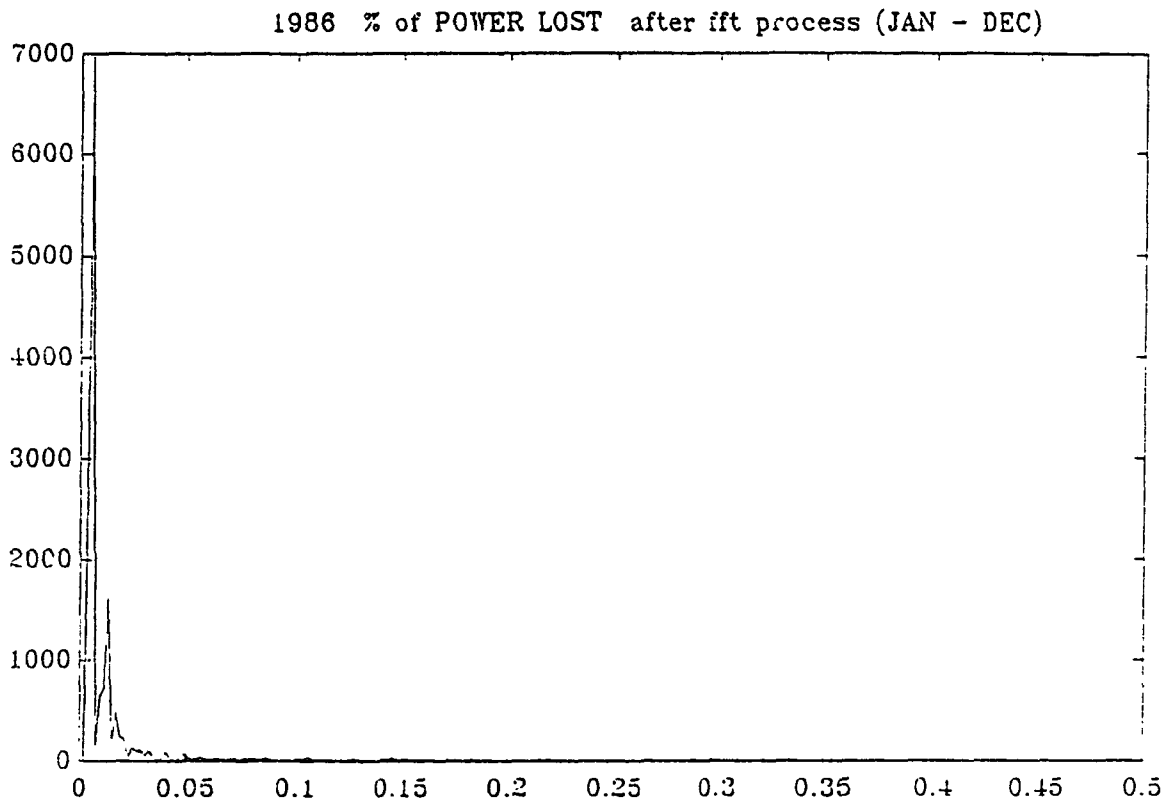

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480


Main Transformer Repair
Rx Trip
Rx Trip
Steam Generator Inspection
Condenser Vacuum Problem
Turbine Trip
MFP Trip
Valve Repair
PZR Spray Valve Failure
DC PWR Panel repair
Valve Repair
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0
30
60
90
120
150
180
210
240
270
300
330
360
DAYS

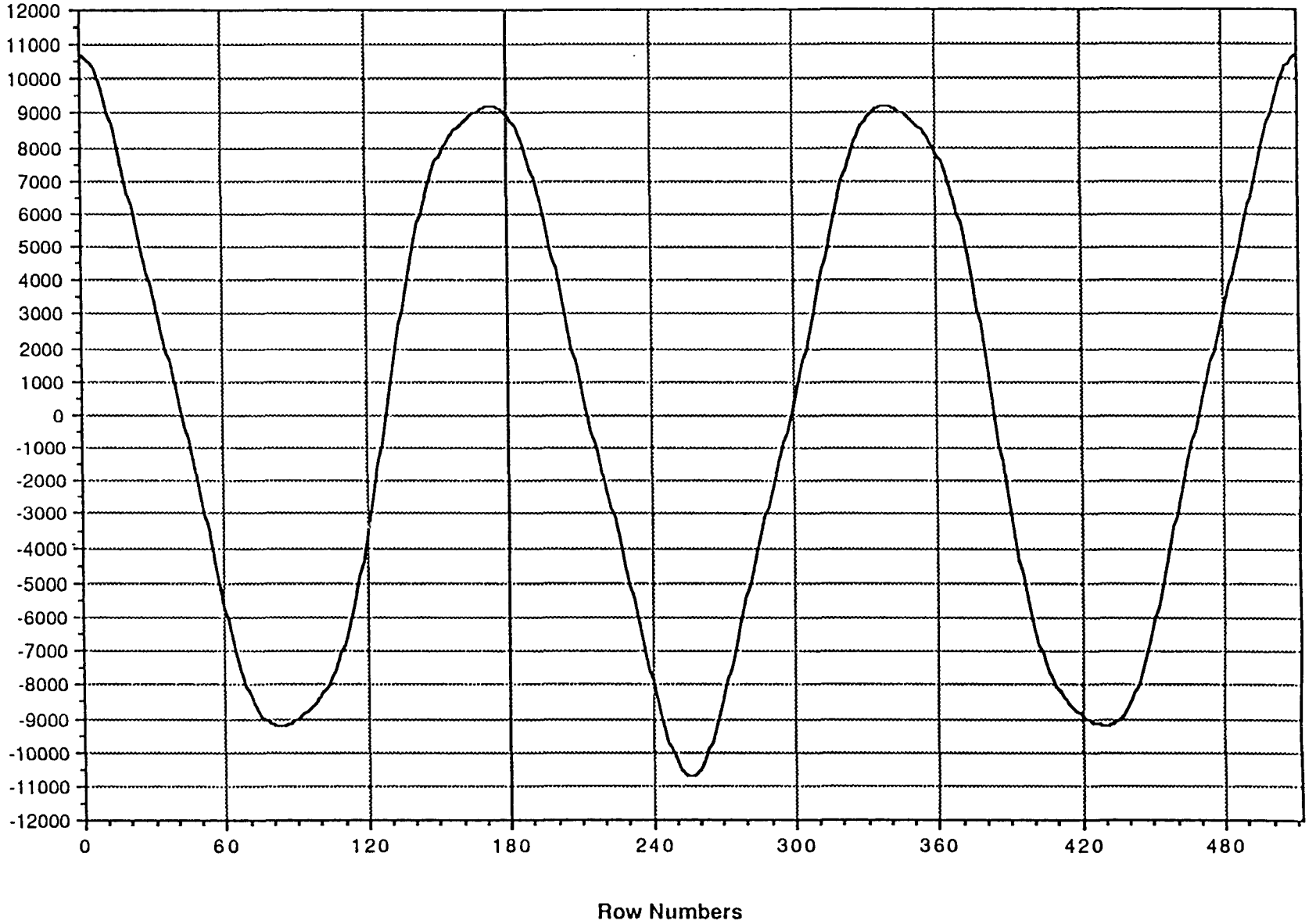
1986

Att-1-62

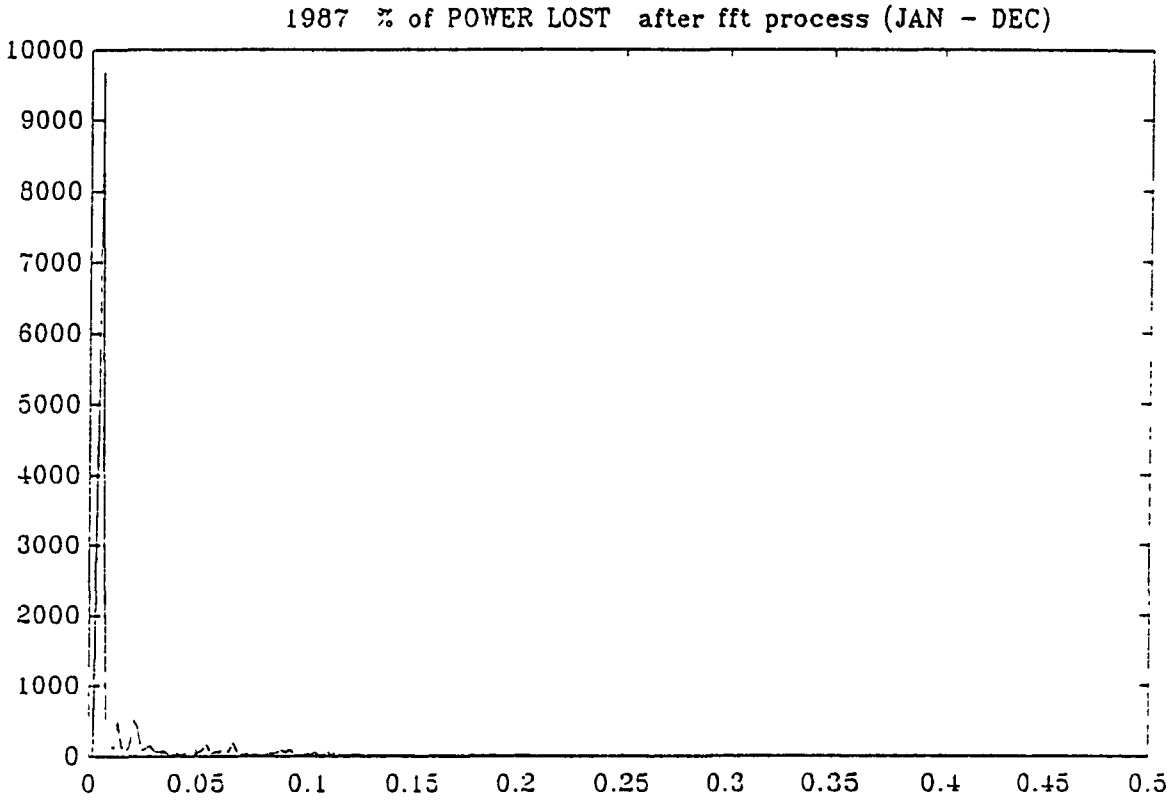

1987 JAN - DEC
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
50
100
150
200
250
300
350
400


1986 % of POWER LOST after fft process (JAN - DEC)
7000
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

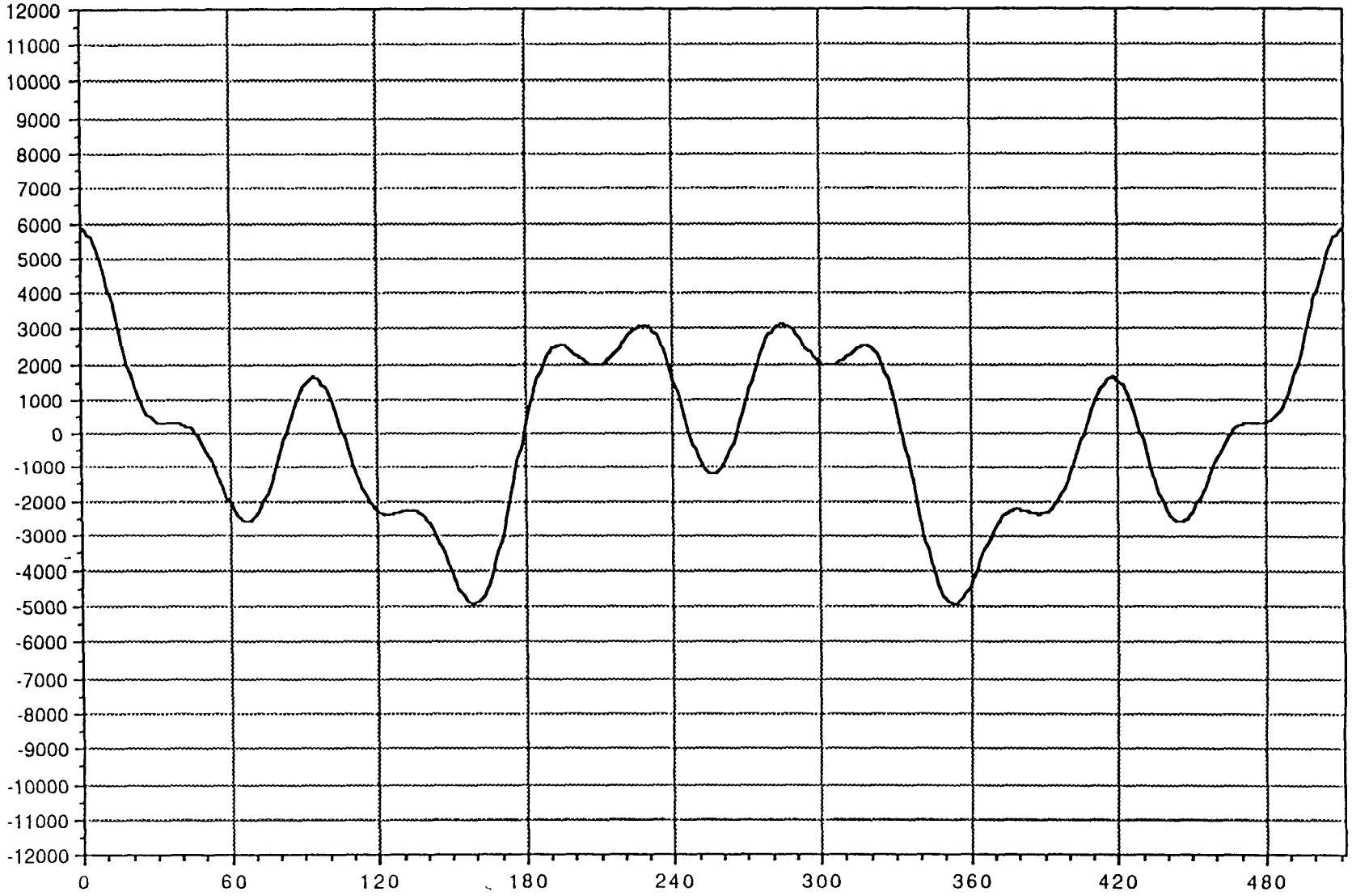
1987


12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480
Row Numbers

Att-1-65

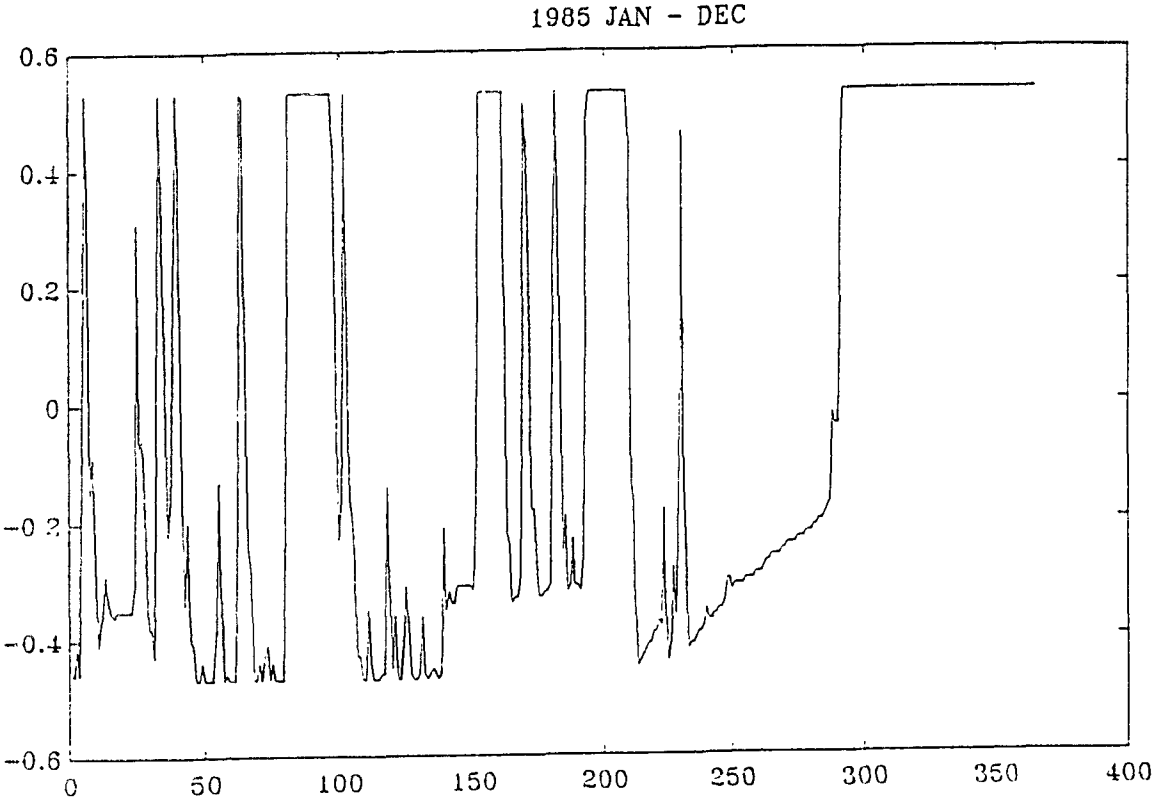

1987 % of POWER LOST after fft process (JAN - DEC)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

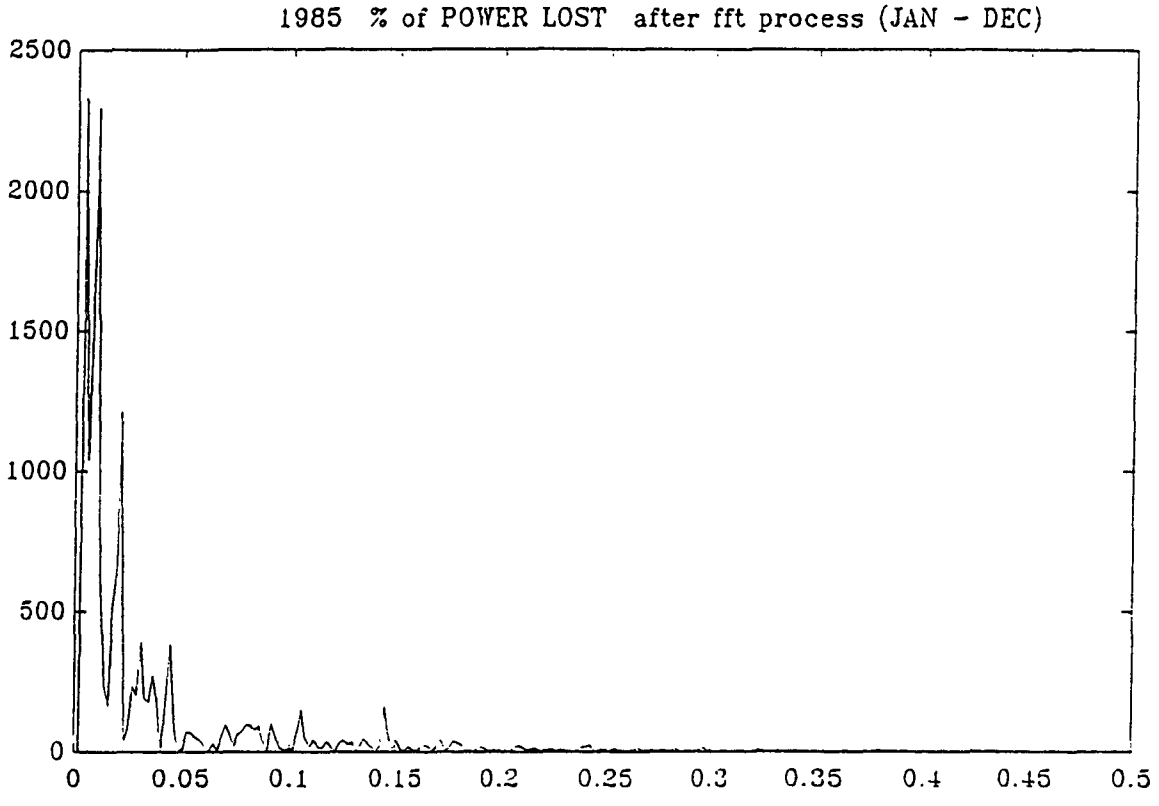
Detailed Results for Plant W

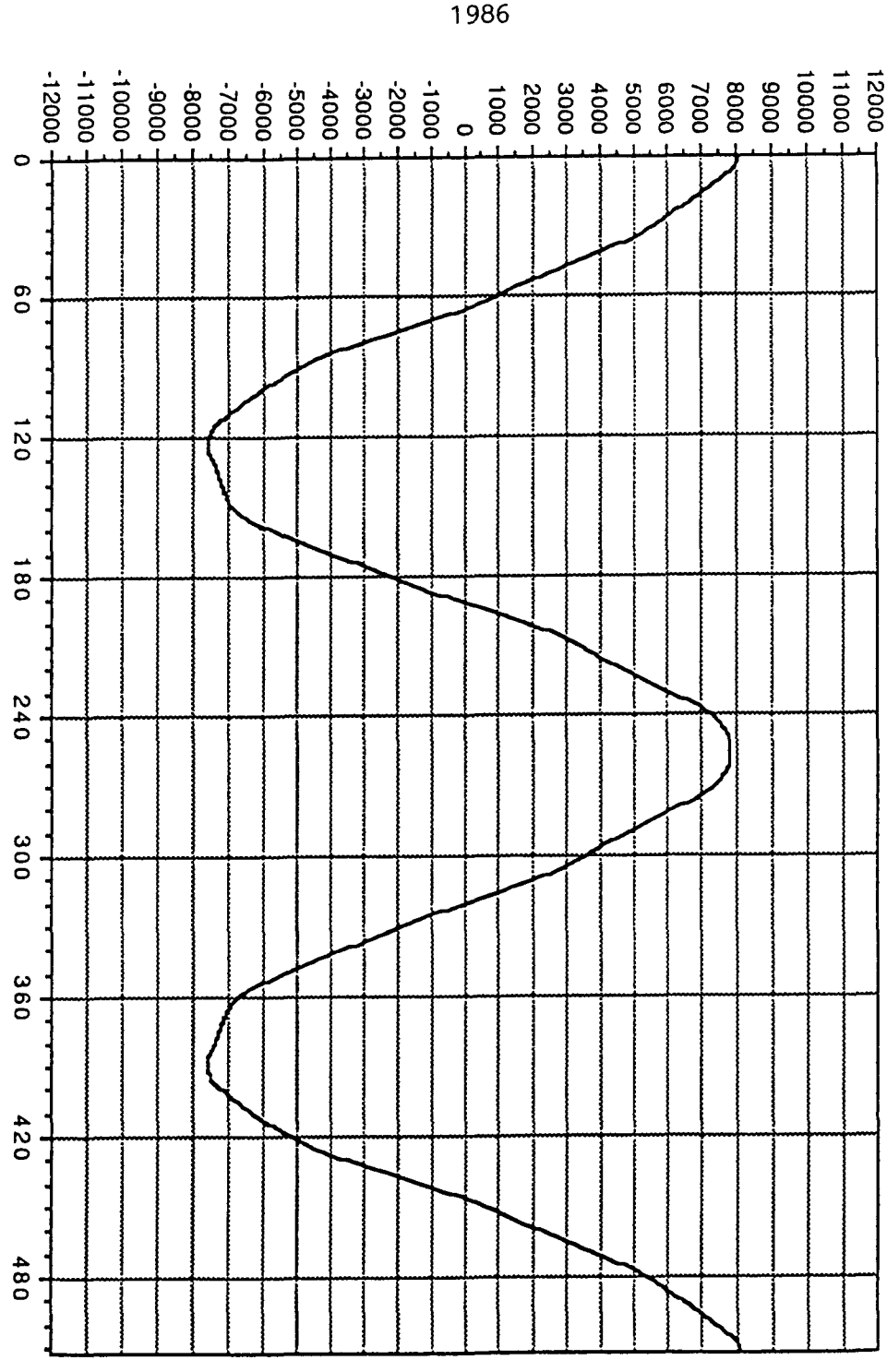

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

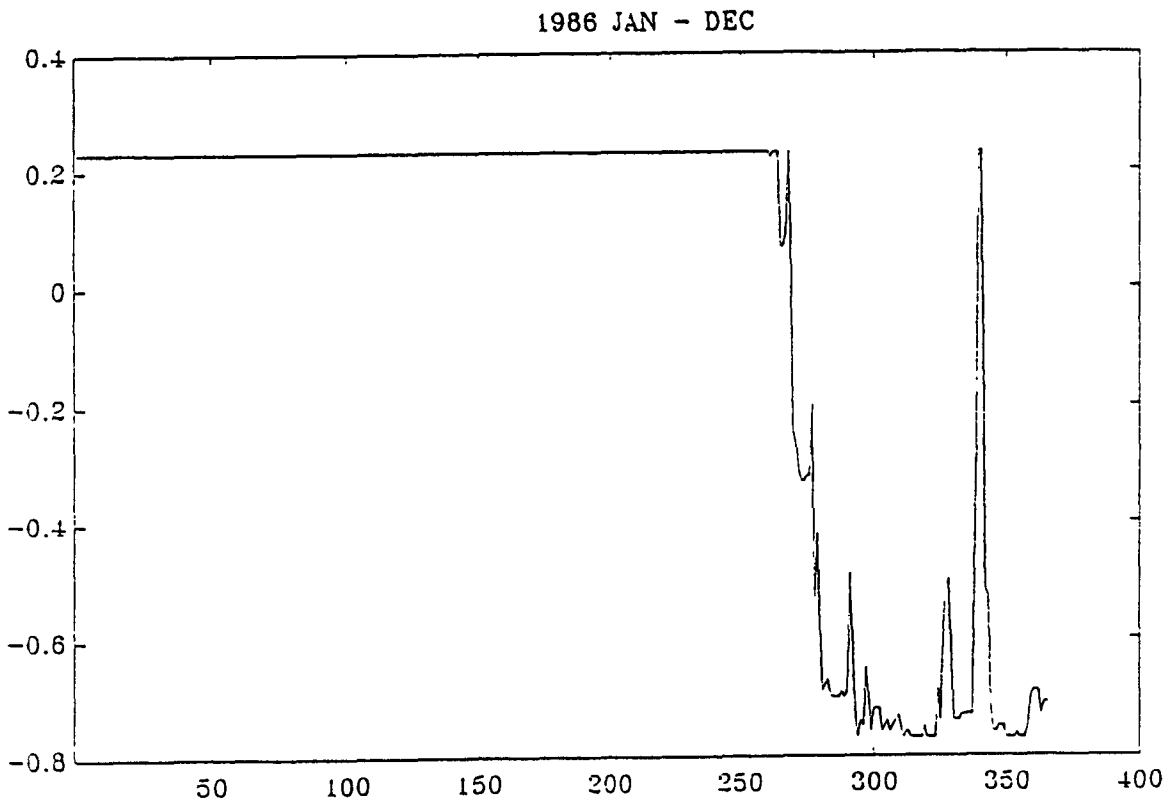
1985

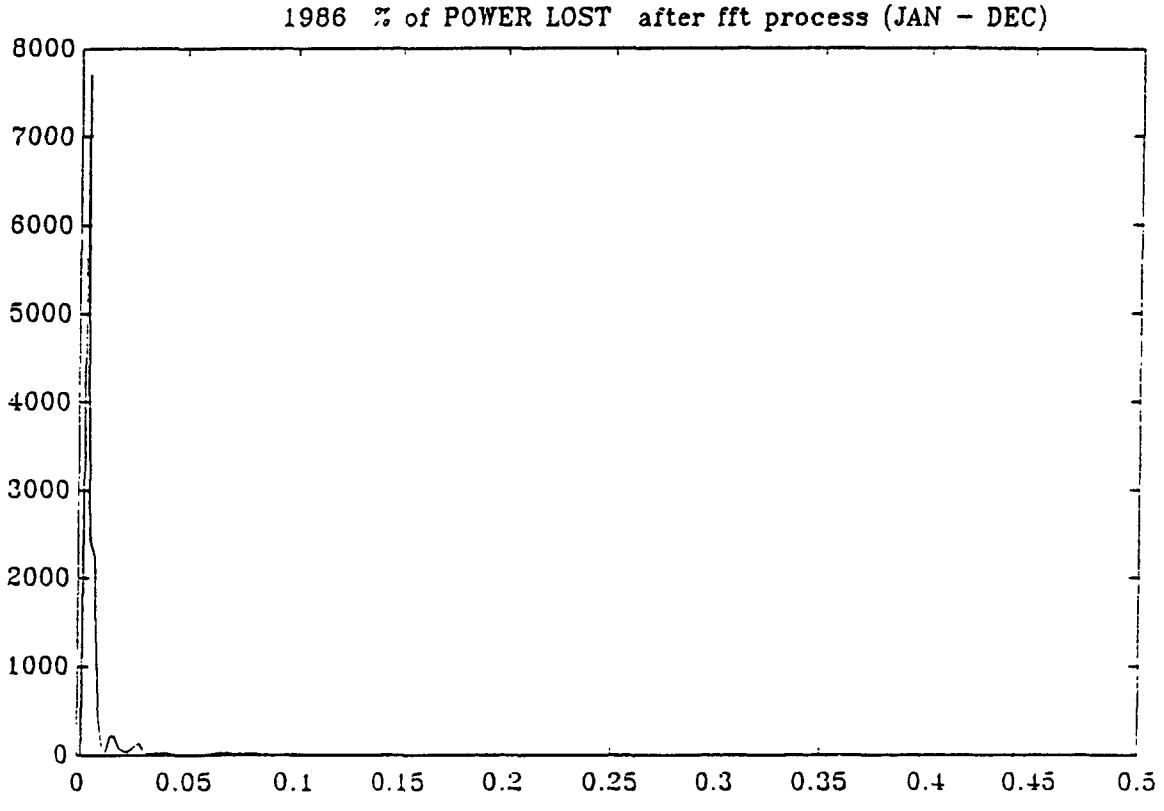
Att-1-68

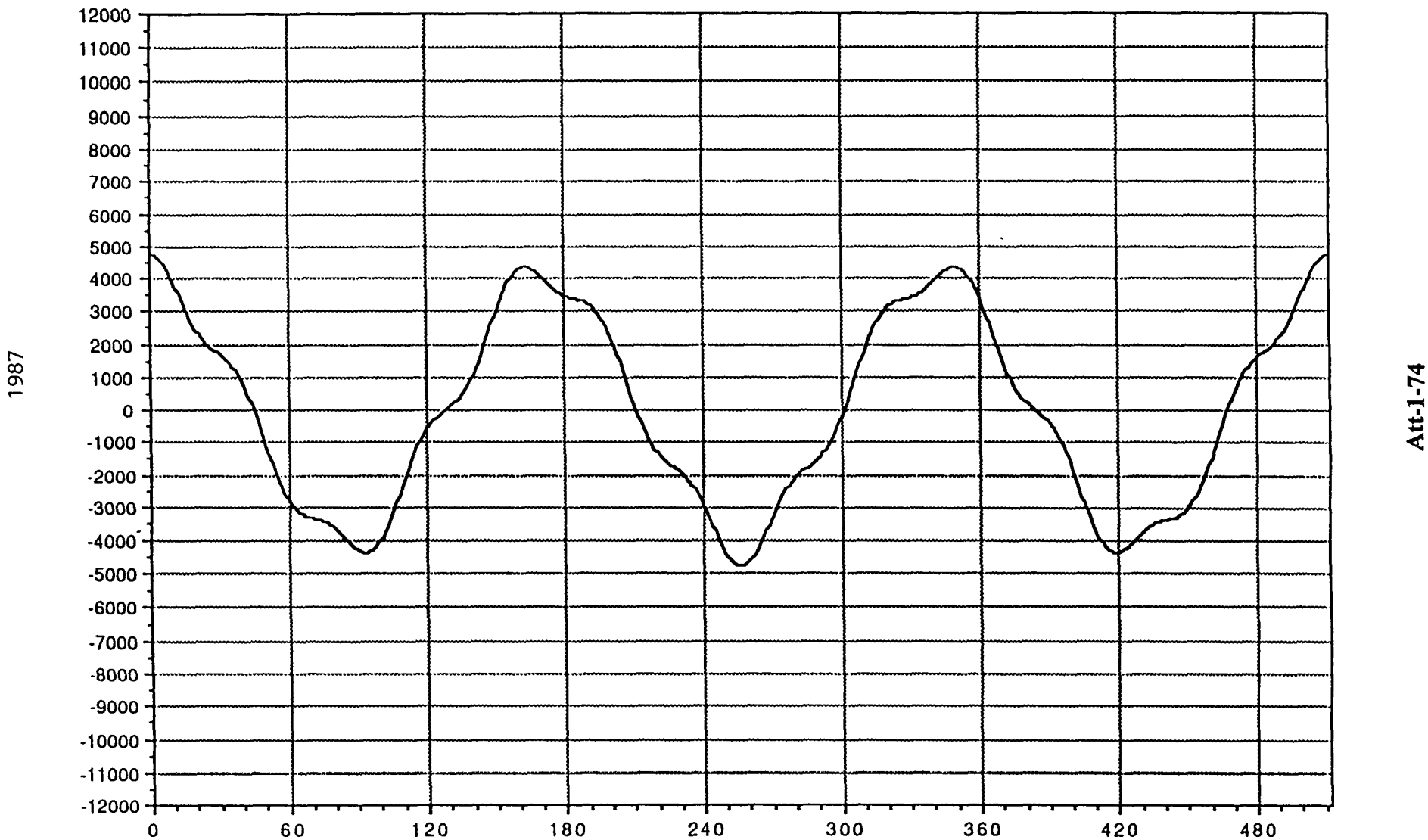

1985 JAN - DEC
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
50
100
150
200
250
300
350
400


1985 % of POWER LOST after fft process (JAN - DEC)
2500
2000
1500
1000
500
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

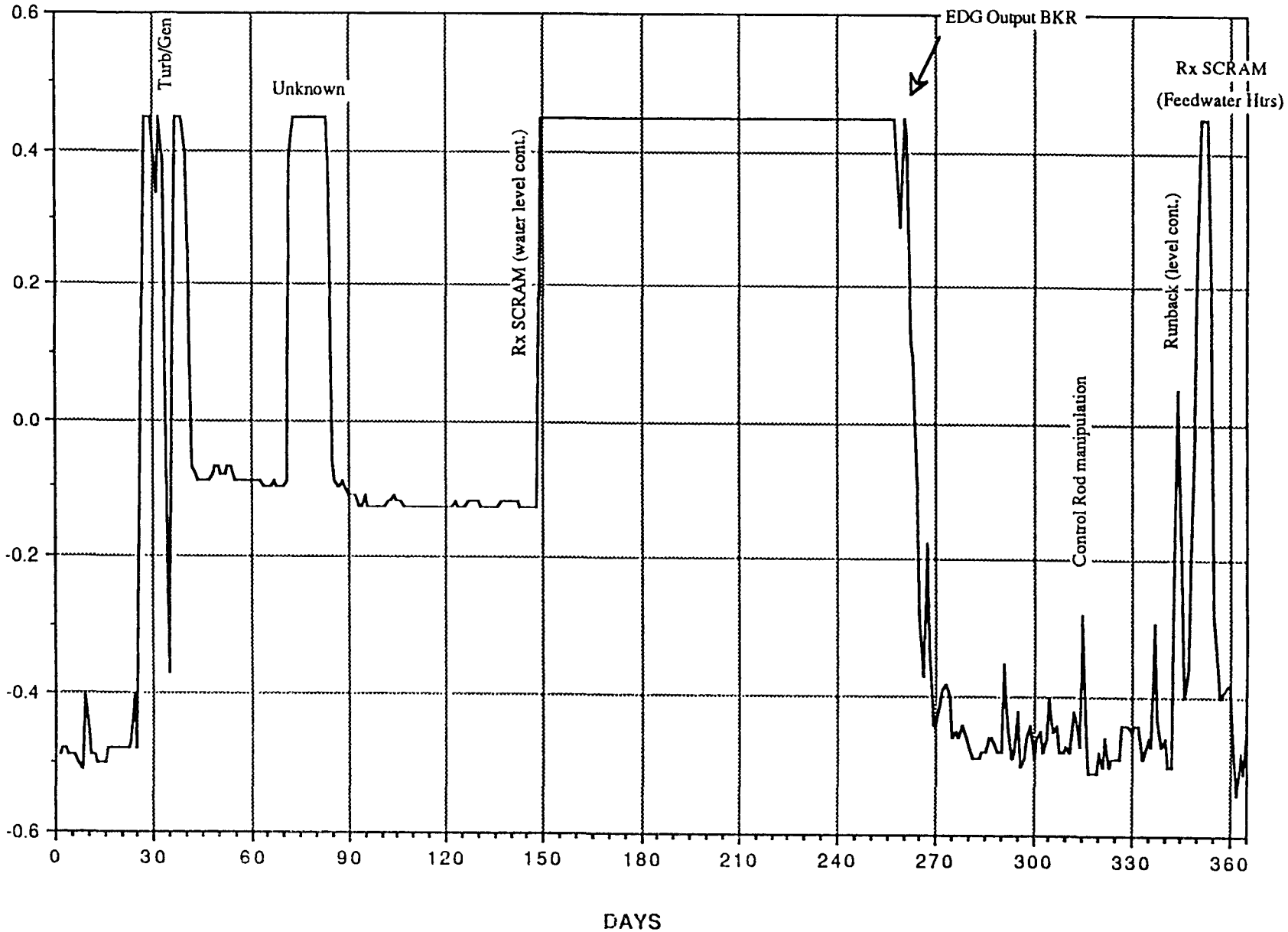

1986
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480


1986 JAN - DEC
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
50
100
150
200
250
300
350
400


1986 % of POWER LOST after fft process (JAN - DEC)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

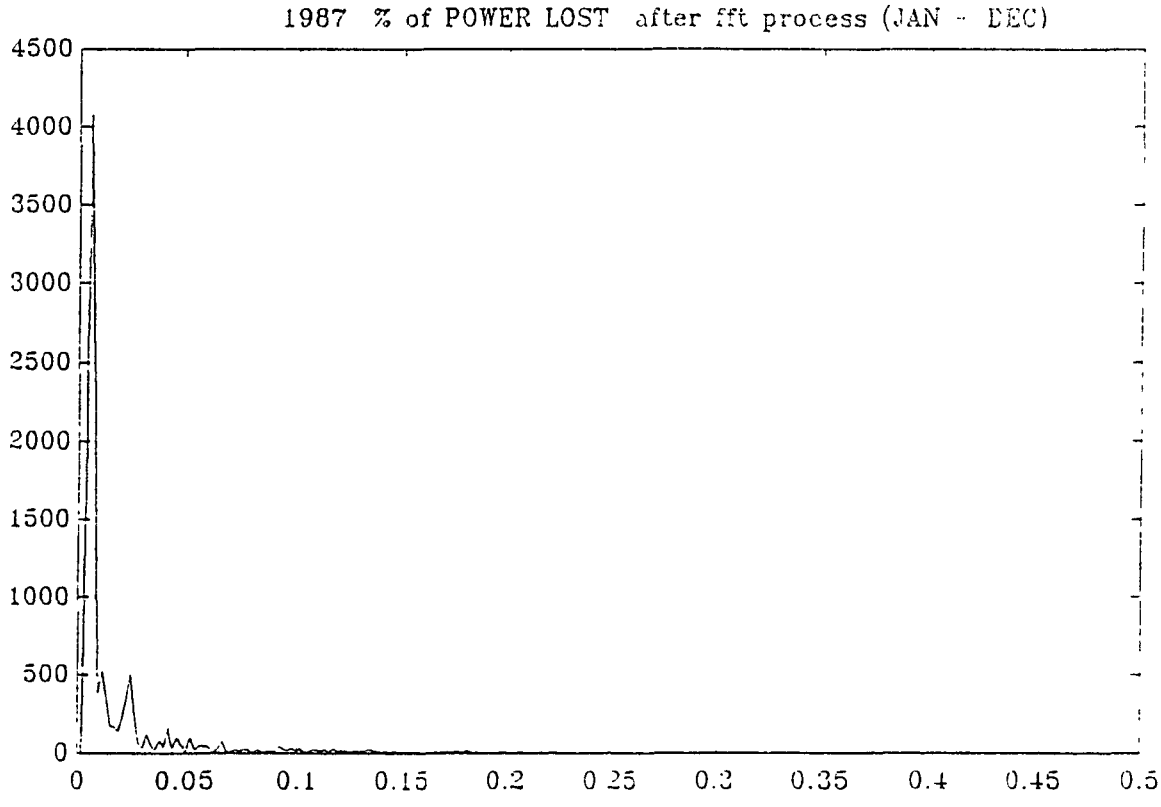

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480
1987

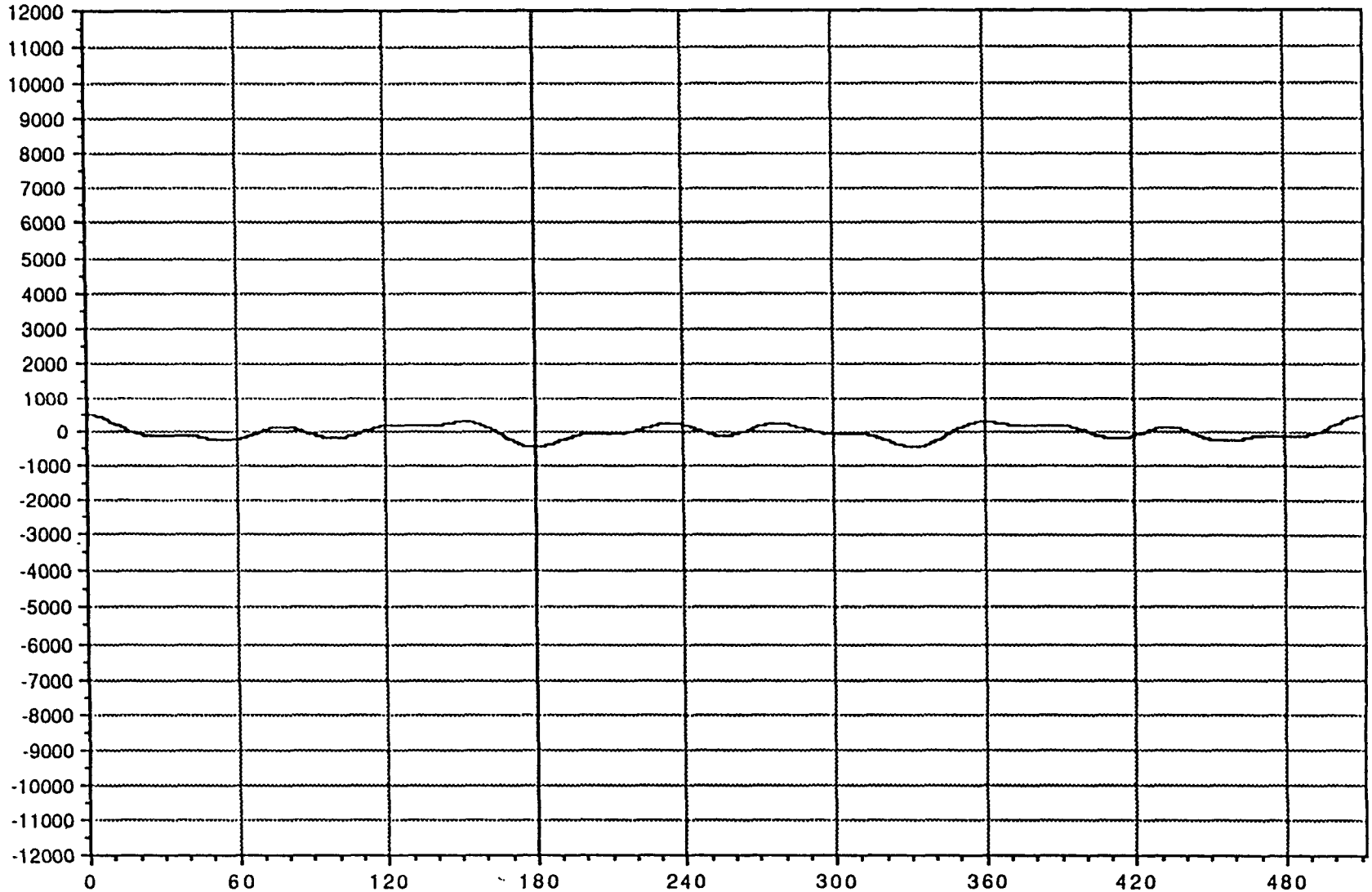
Att-1-74


0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
30
60
90
120
150
180
210
240
270
300
330
360
DAYS
Turb/Gen
Unknown
Rx SCRAM (water level cont.)
EDG Output BKR
Control Rod manipulation
Runback (level cont.)
Rx SCRAM
(Feedwater Hrs)

1987

Att-1-75

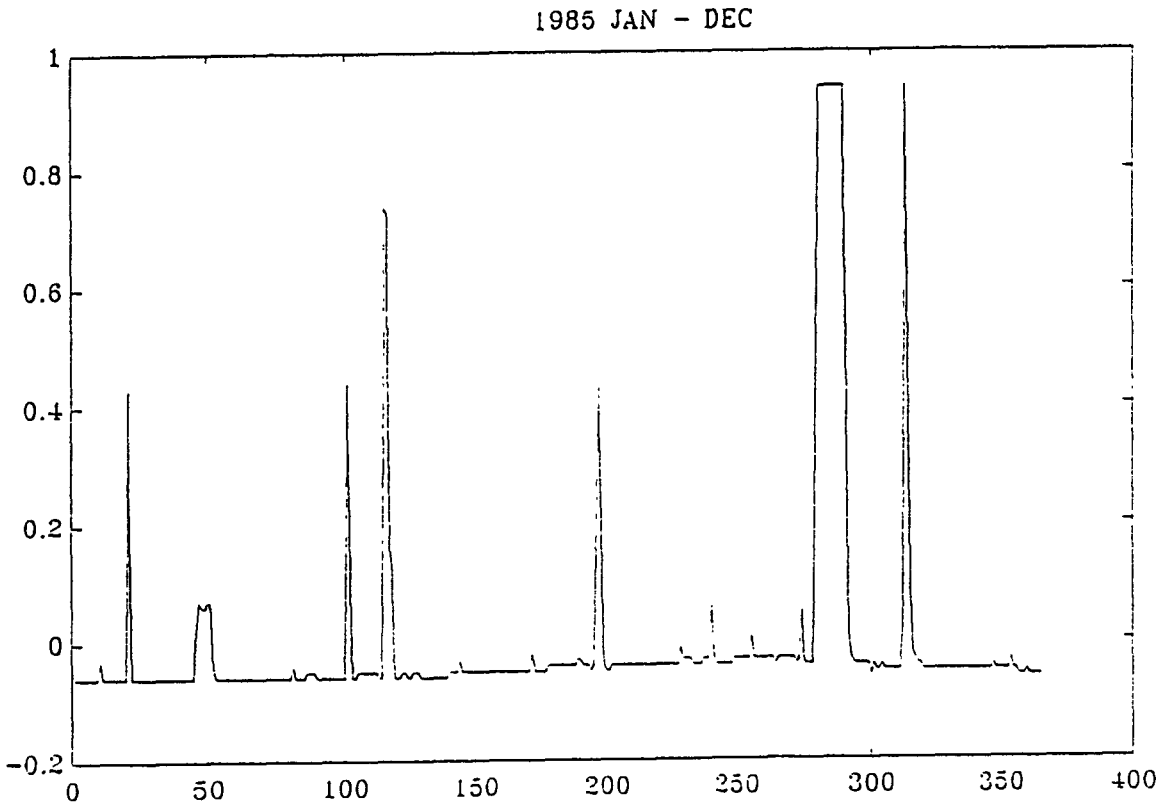

1987 % of POWER LOST after fft process (JAN - DEC)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

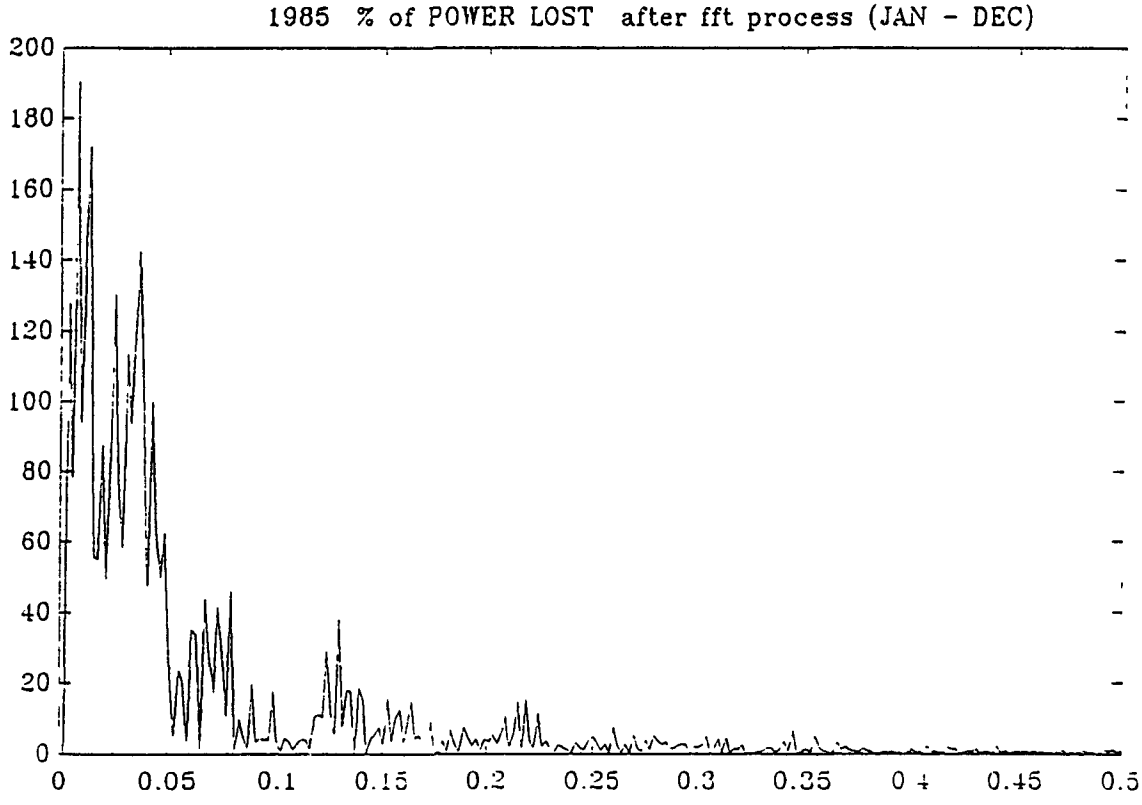

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

1985

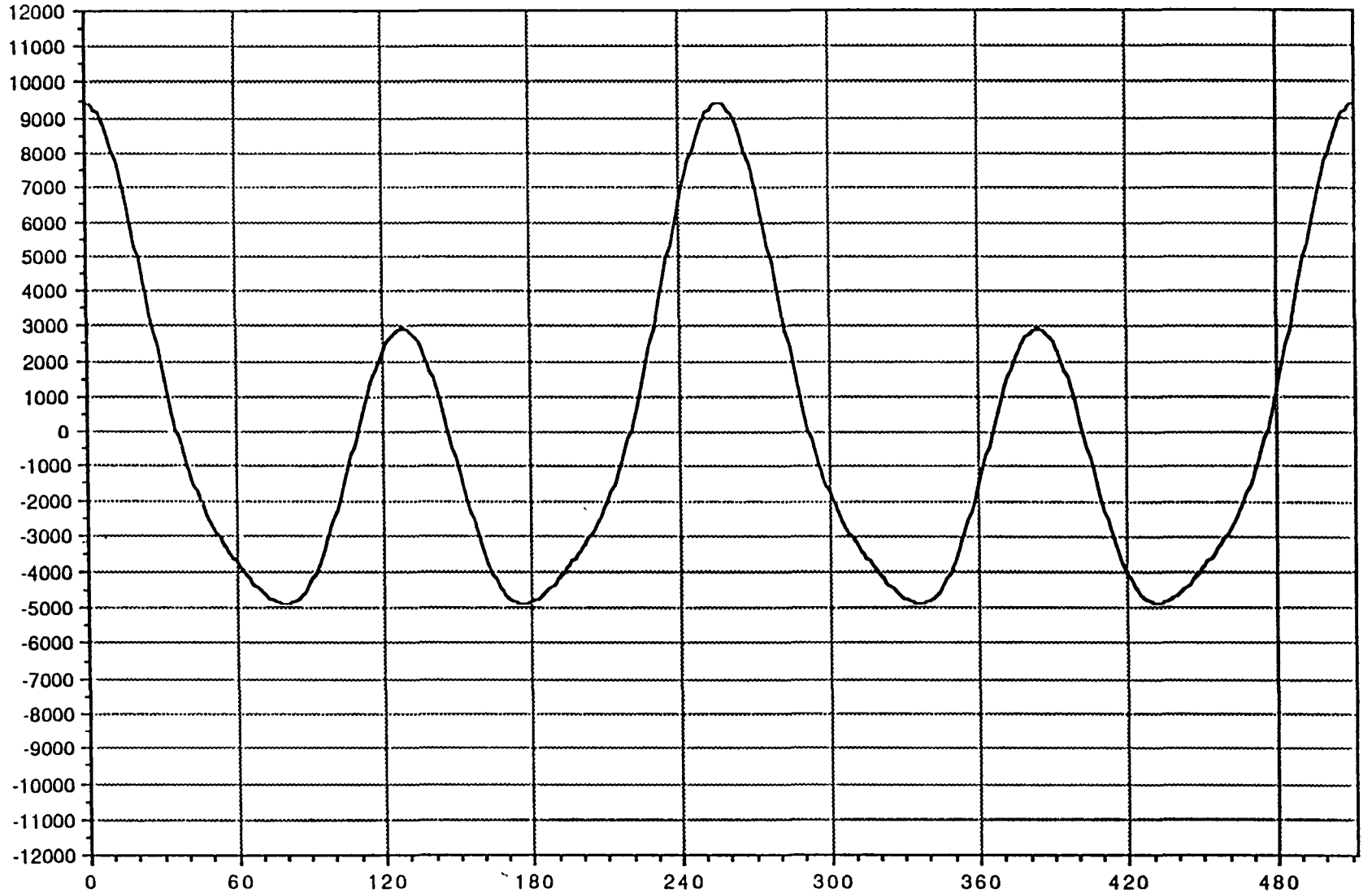
Att-1-78

Detailed Results for Plant X

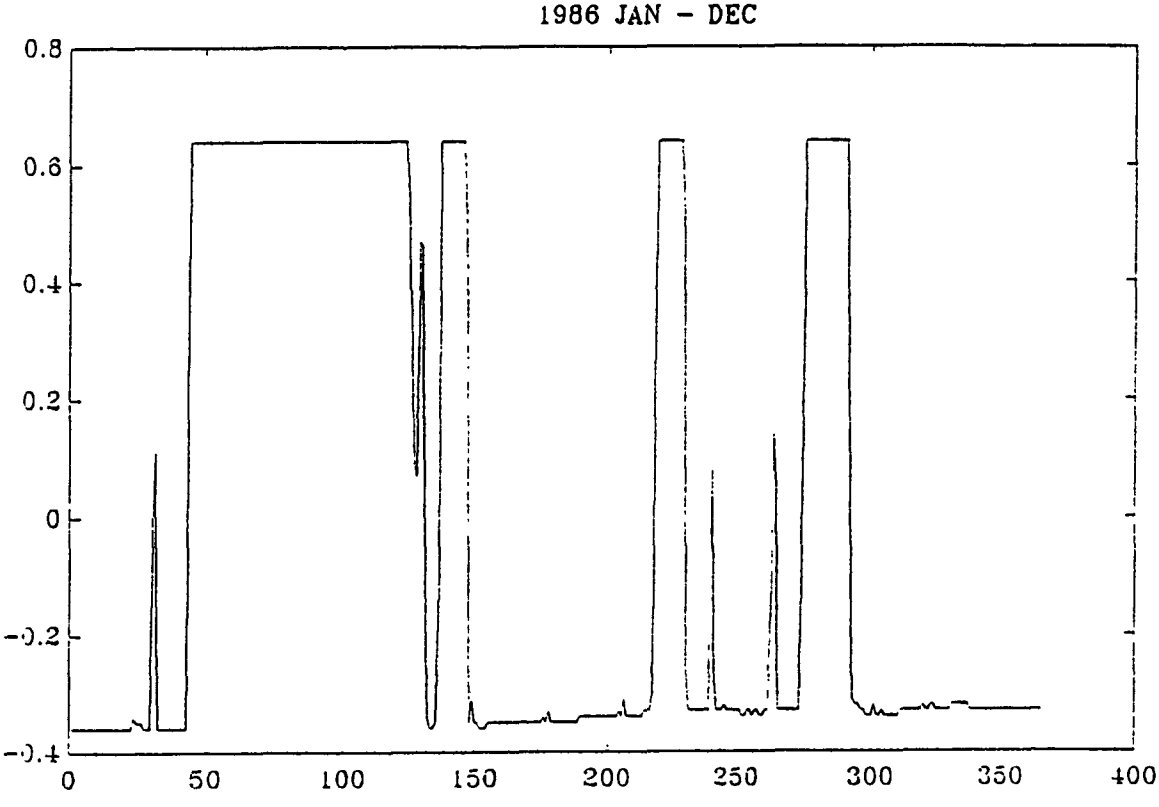

1985 JAN - DEC
1
0.8
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
250
300
350
400

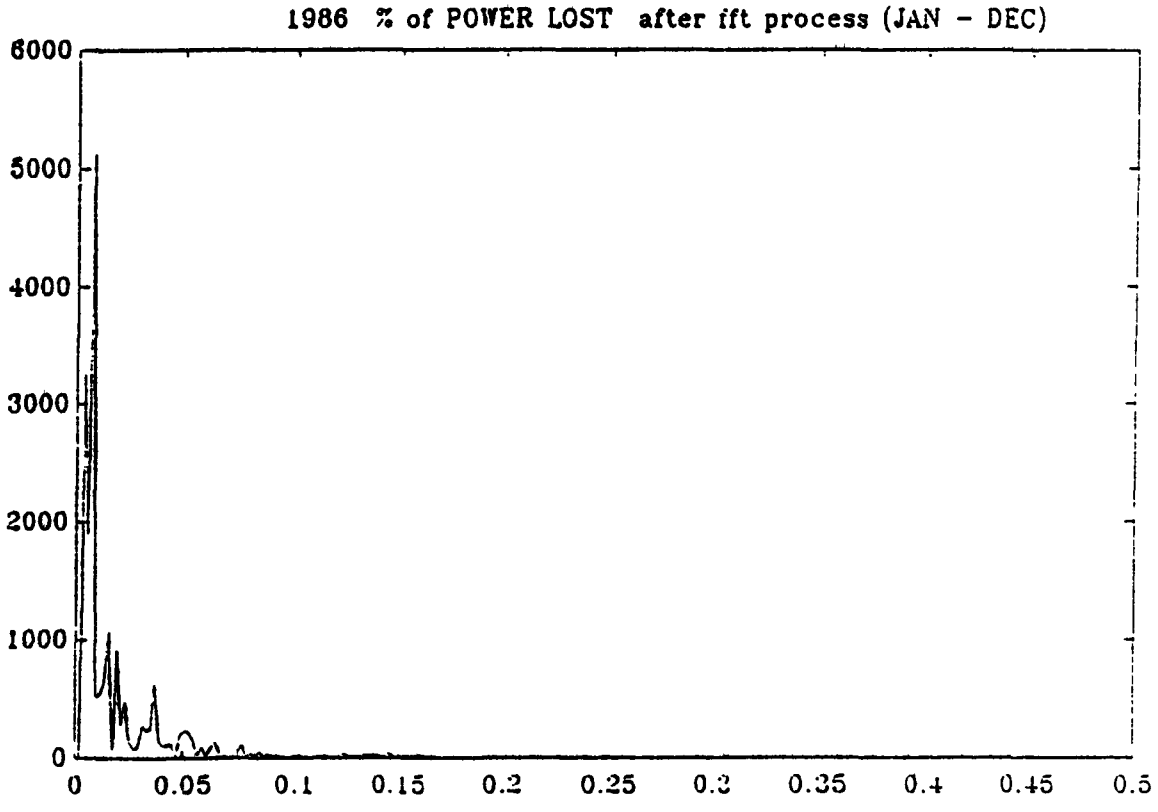

1985 % of POWER LOST after fft process (JAN - DEC)
200
180
160
140
120
100
80
60
40
20
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

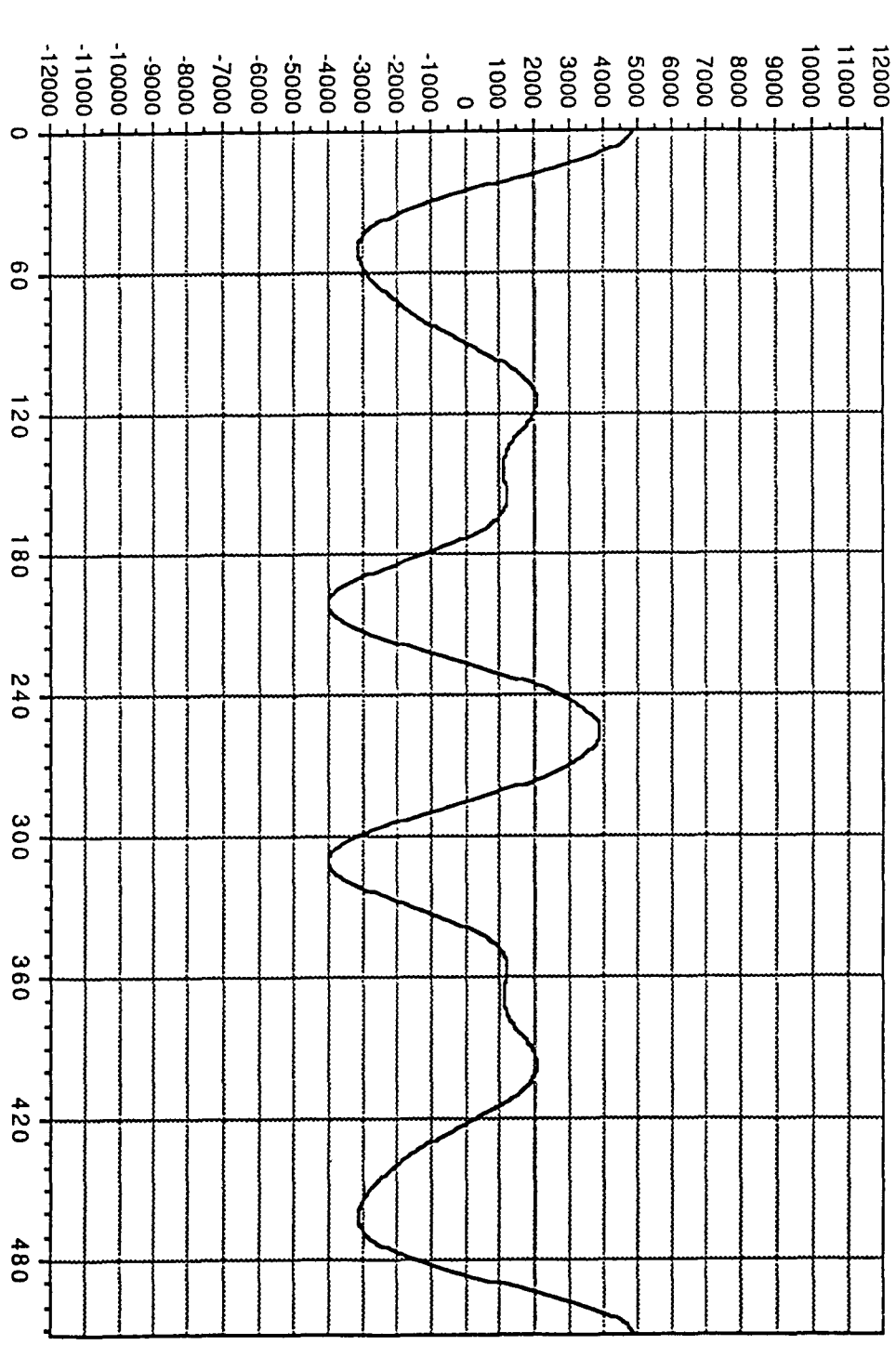
1986

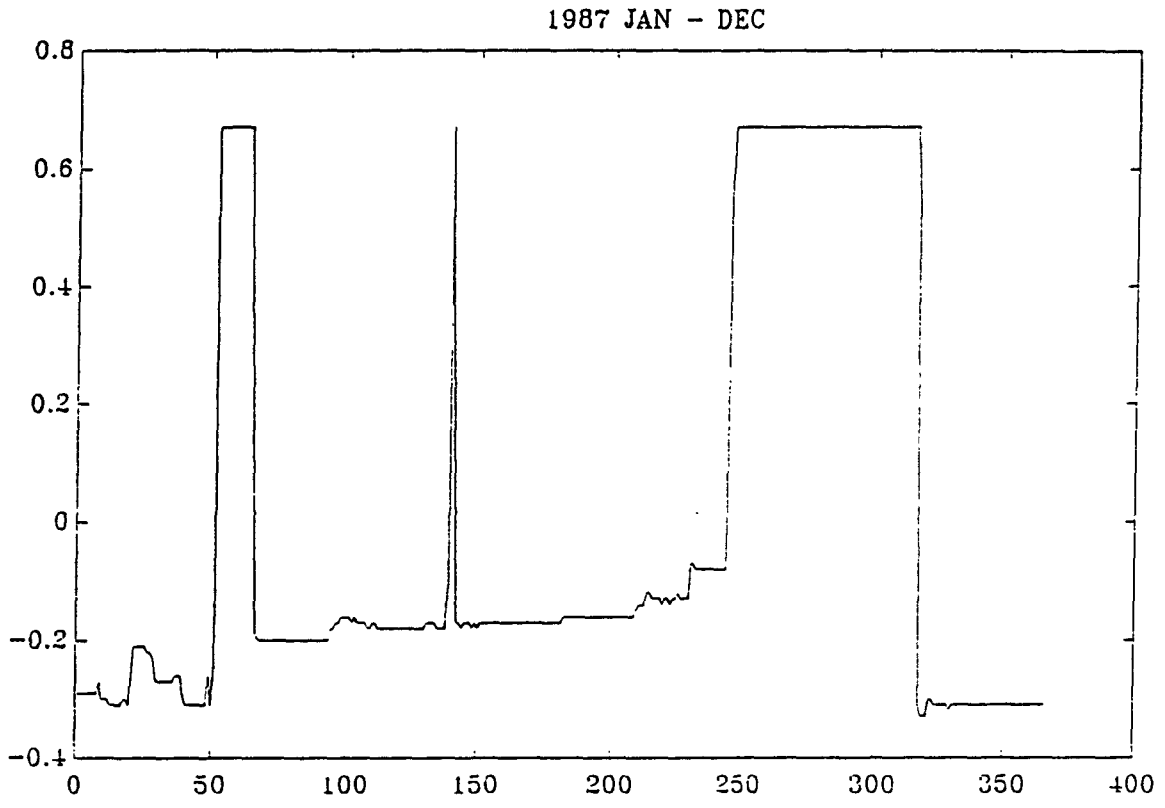

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

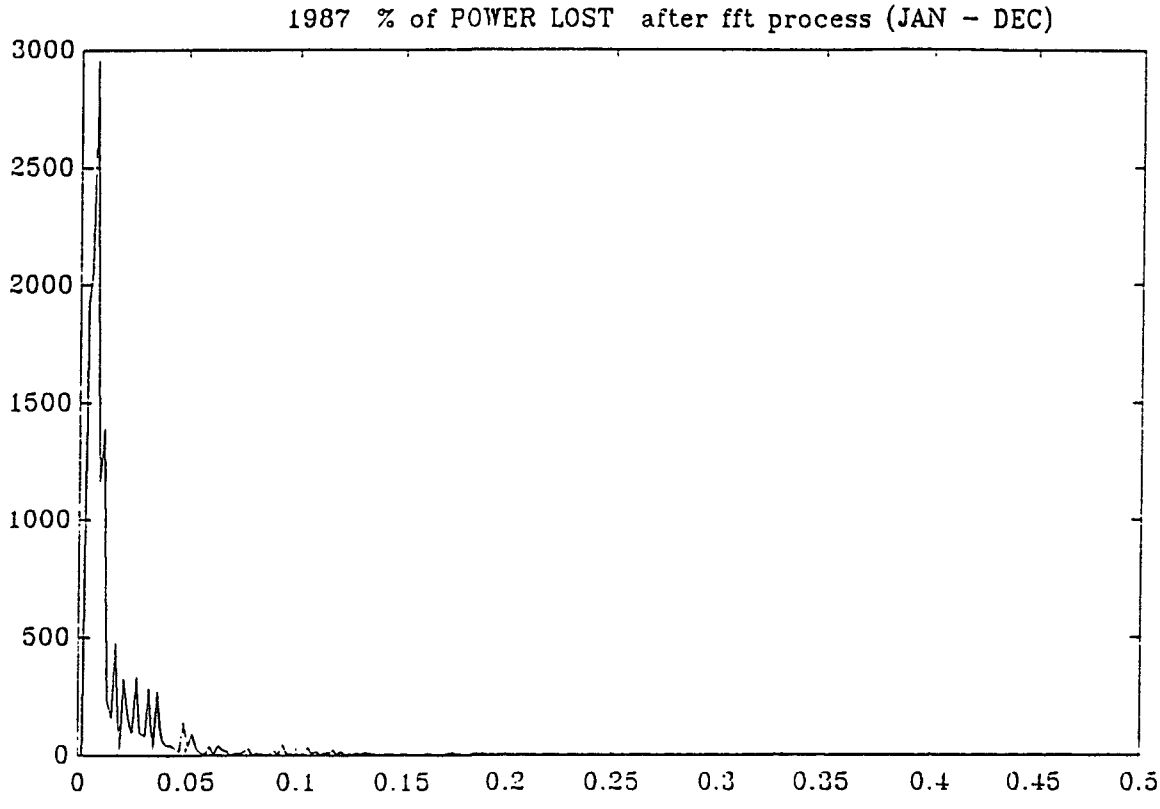
Att-1-81


1986 JAN - DEC
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
50
100
150
200
250
300
350
400

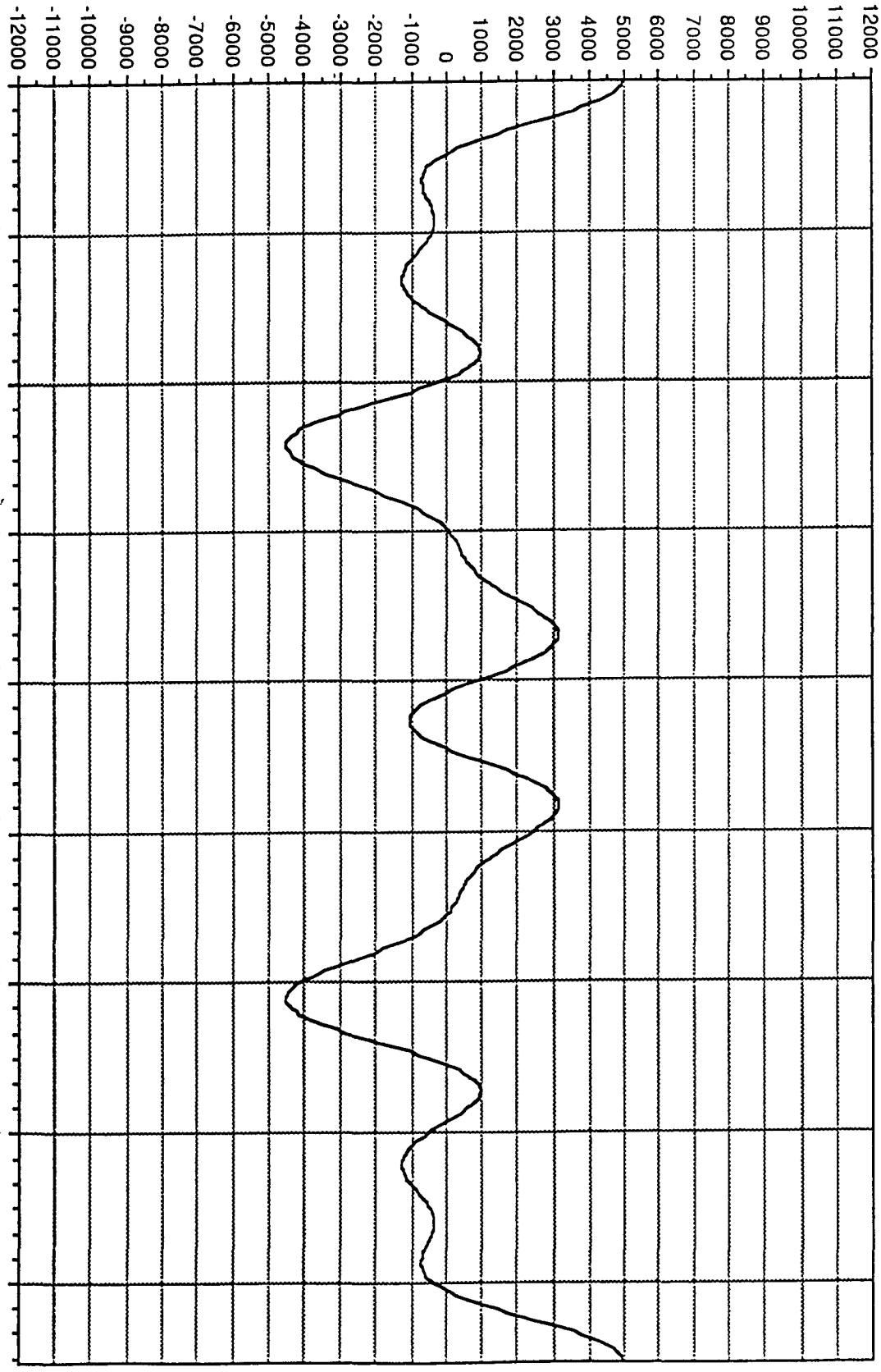

1986 % of POWER LOST after fft process (JAN - DEC)
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5


1987
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

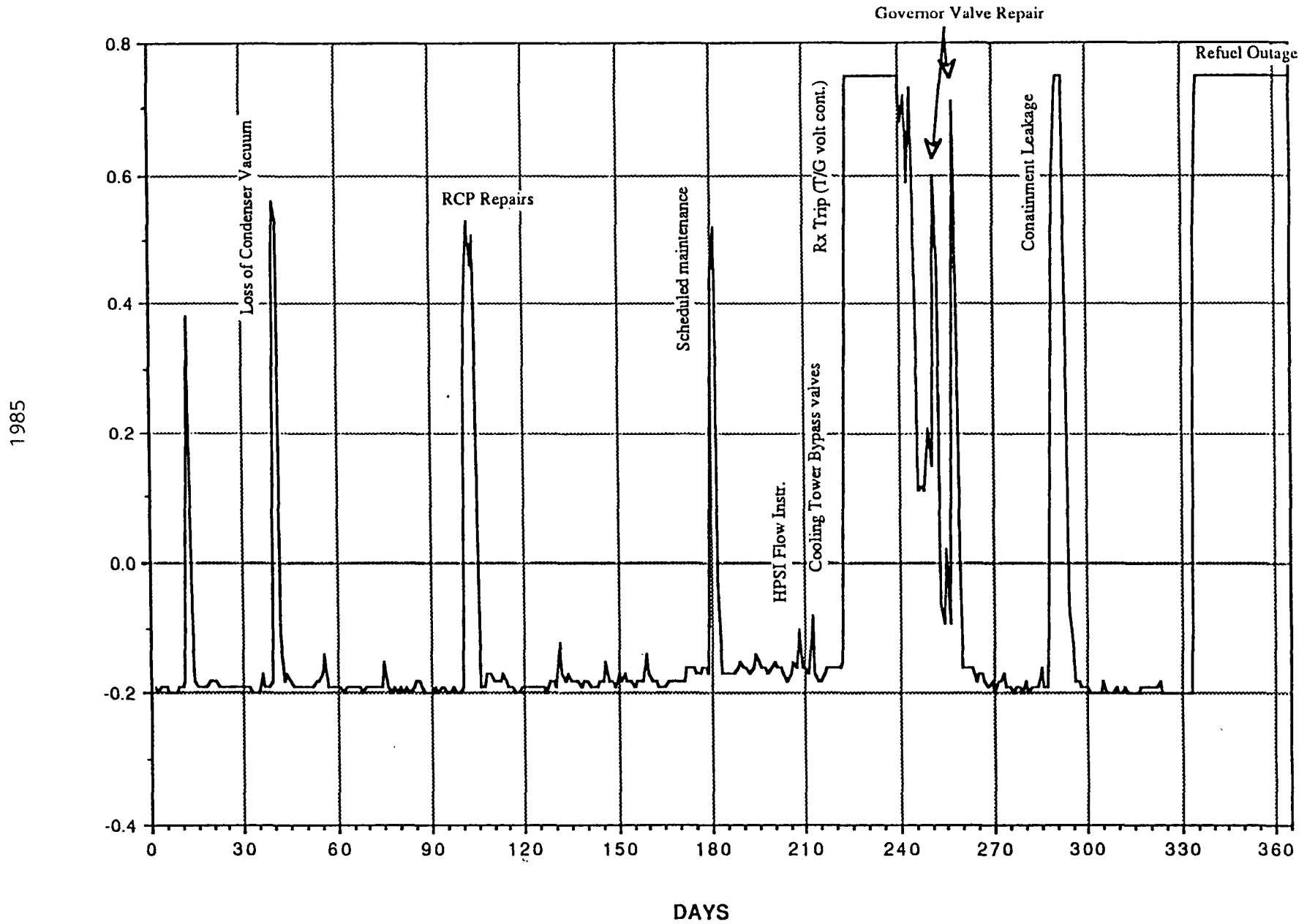

1987 JAN - DEC
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
50
100
150
200
250
300
350
400


1987 % of POWER LOST after fft process (JAN - DEC)
3000
2500
2000
1500
1000
500
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

1985

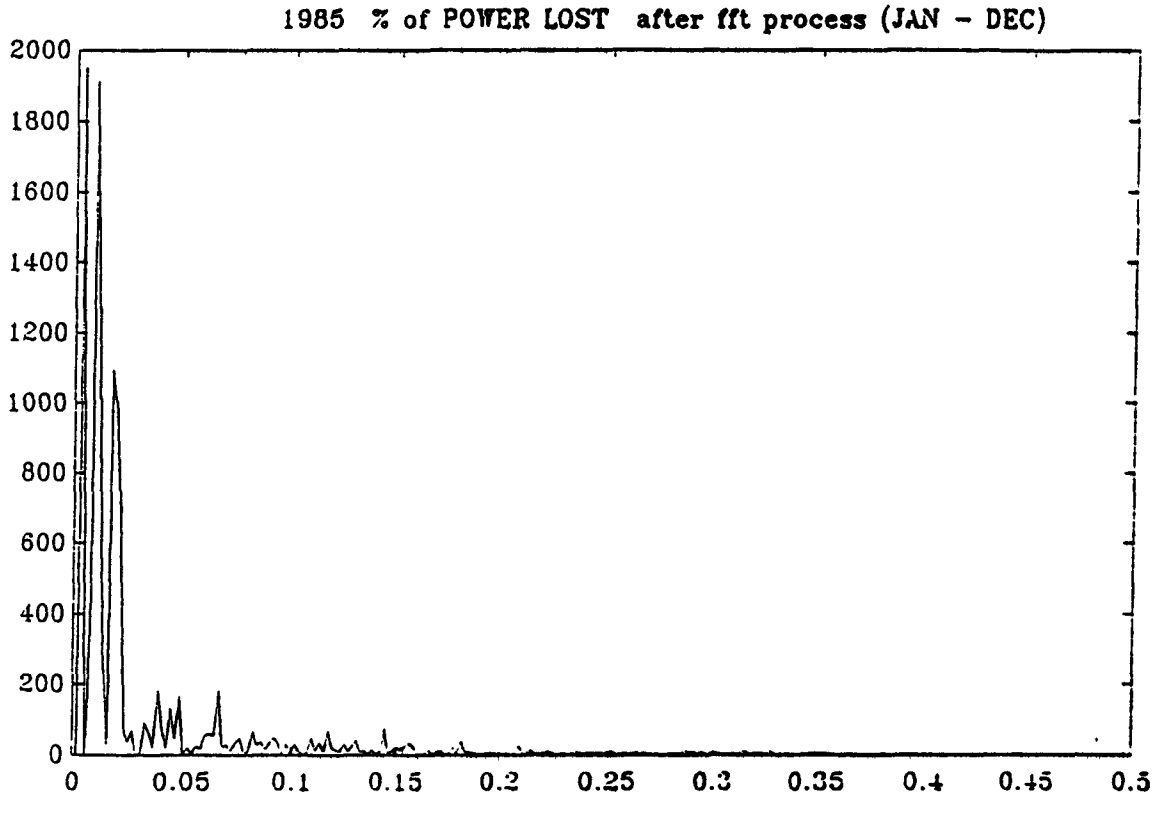

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

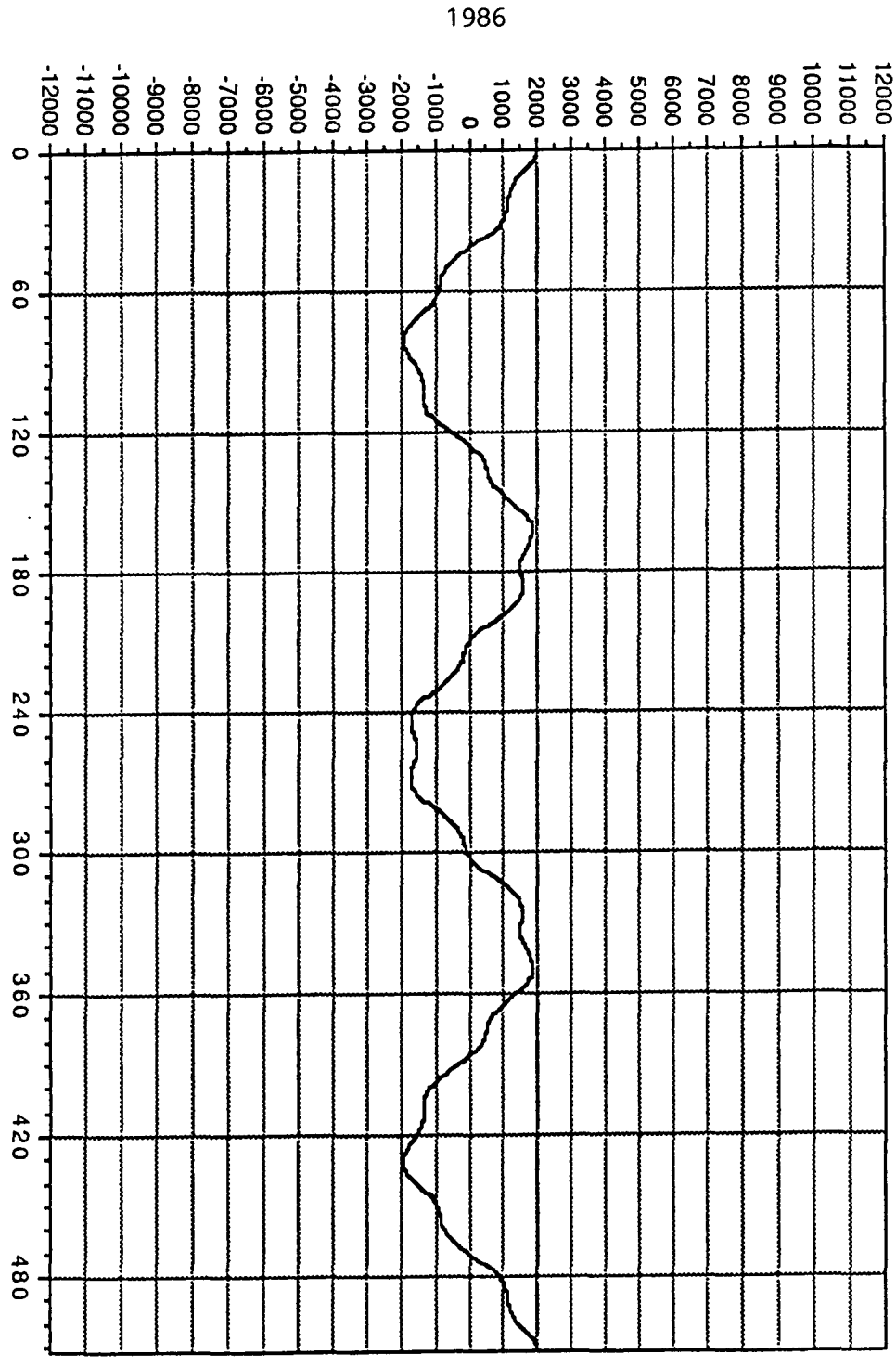
Detailed Results for Plant Y

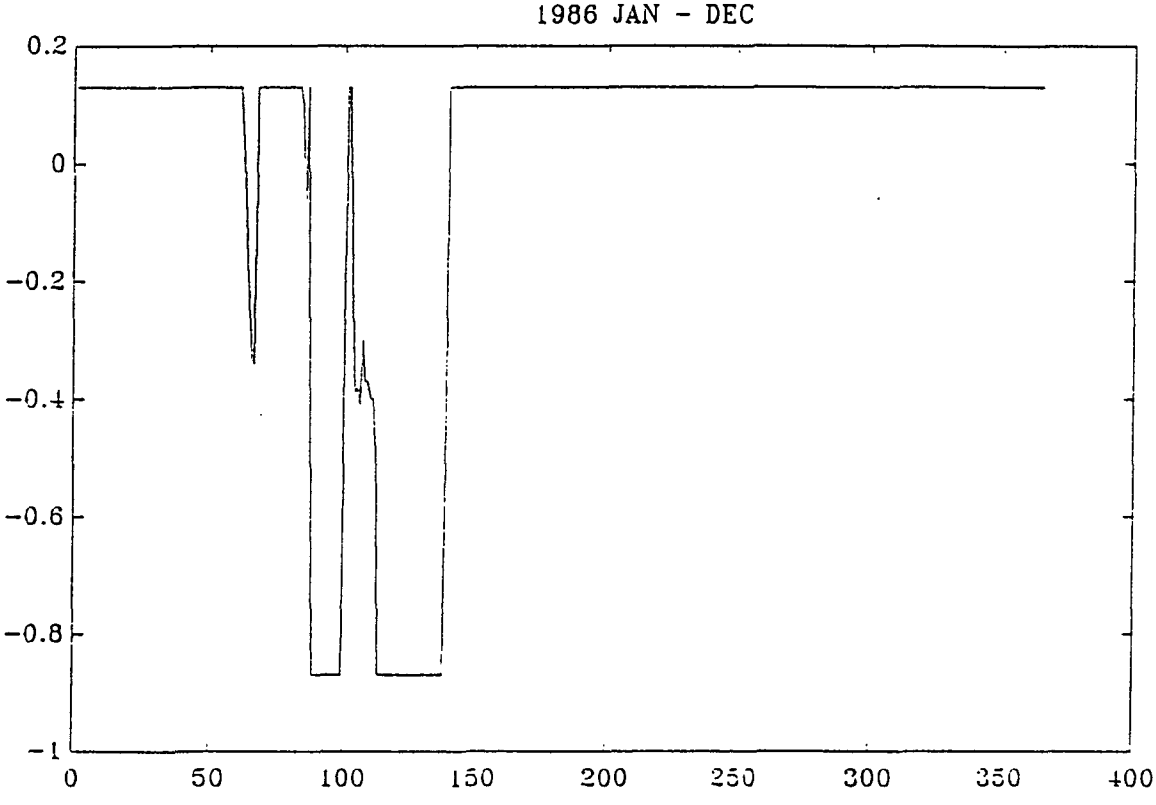

Governor Valve Repair
Refuel Outage
Loss of Condenser Vacuum
RCP Repairs
Scheduled maintenance
HPSI Flow Instr.
Cooling Tower Bypass valves
Rx Trip (T/G volt cont.)
Containment Leakage
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0
30
60
90
120
150
180
210
240
270
300
330
360
DAYS

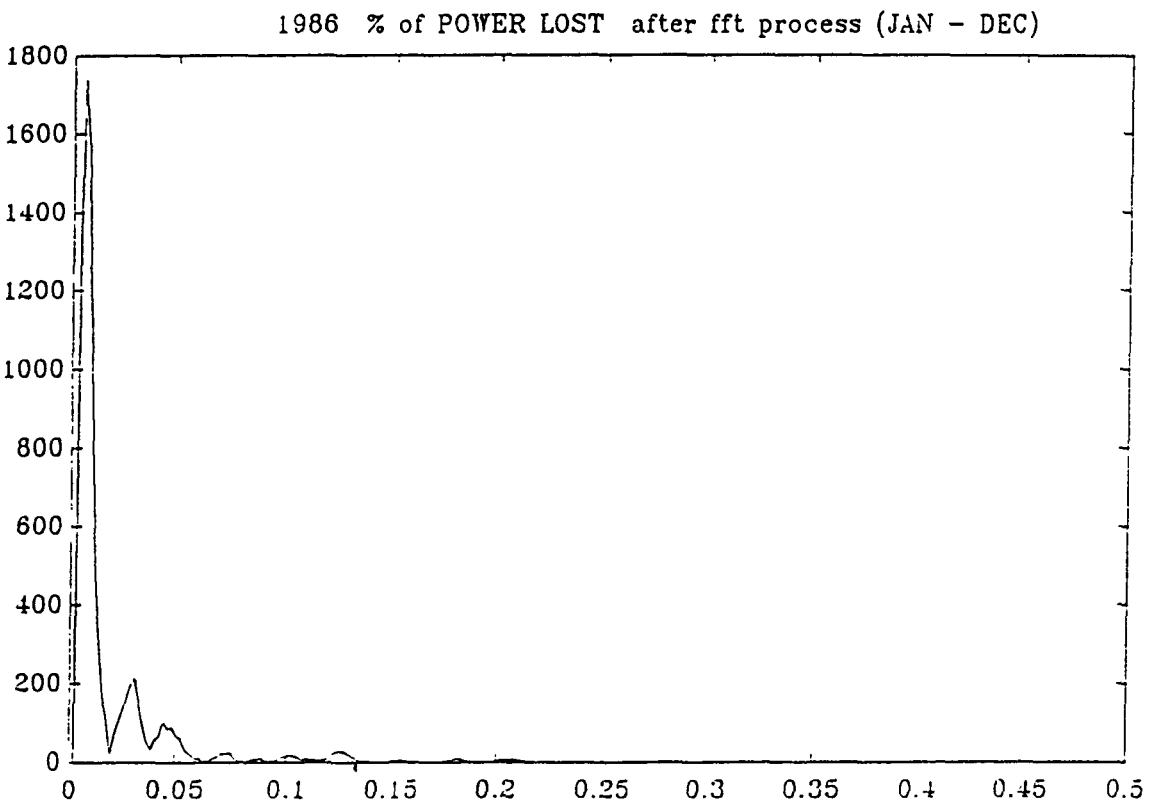
1985

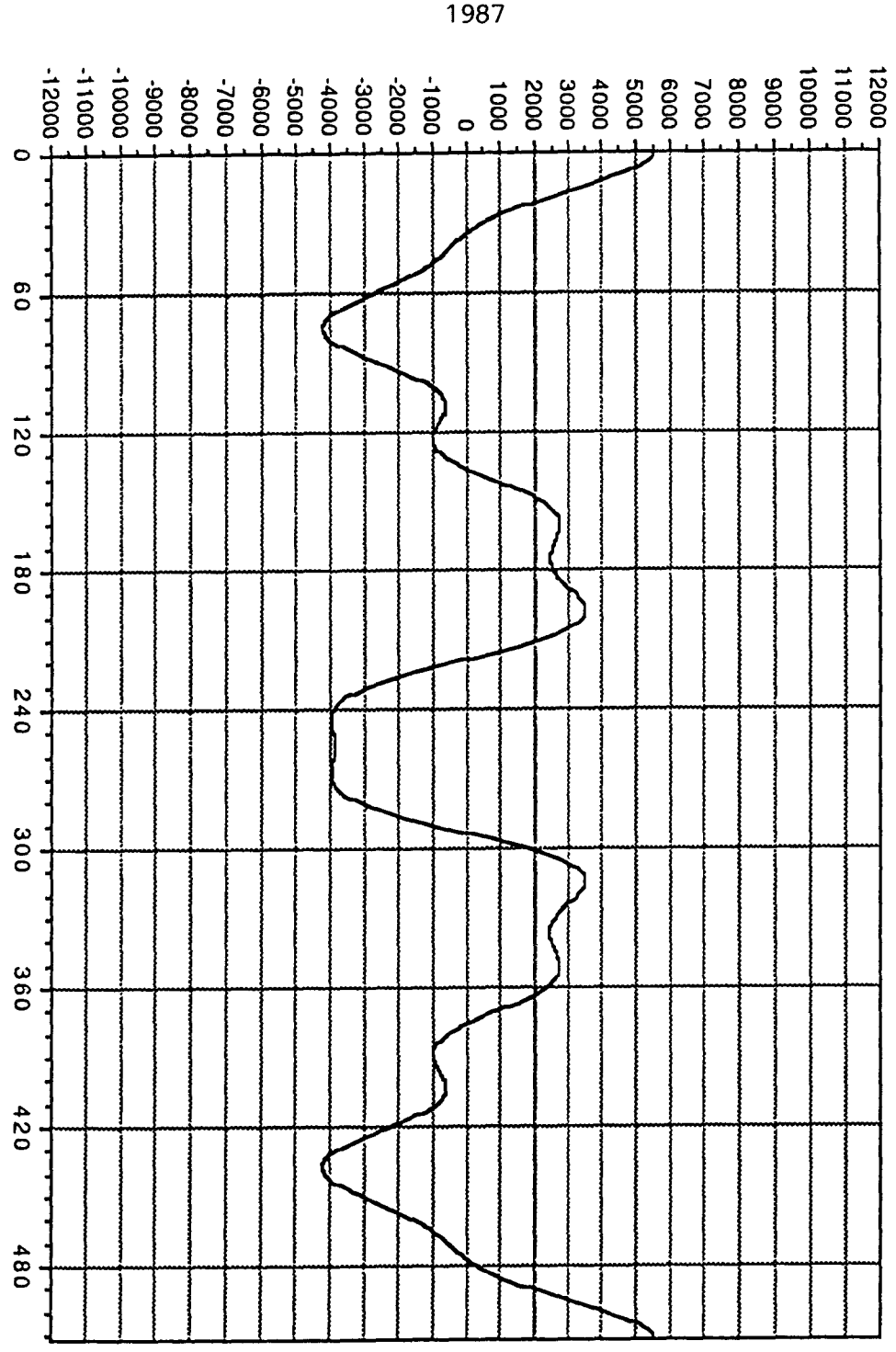
Att-1-89

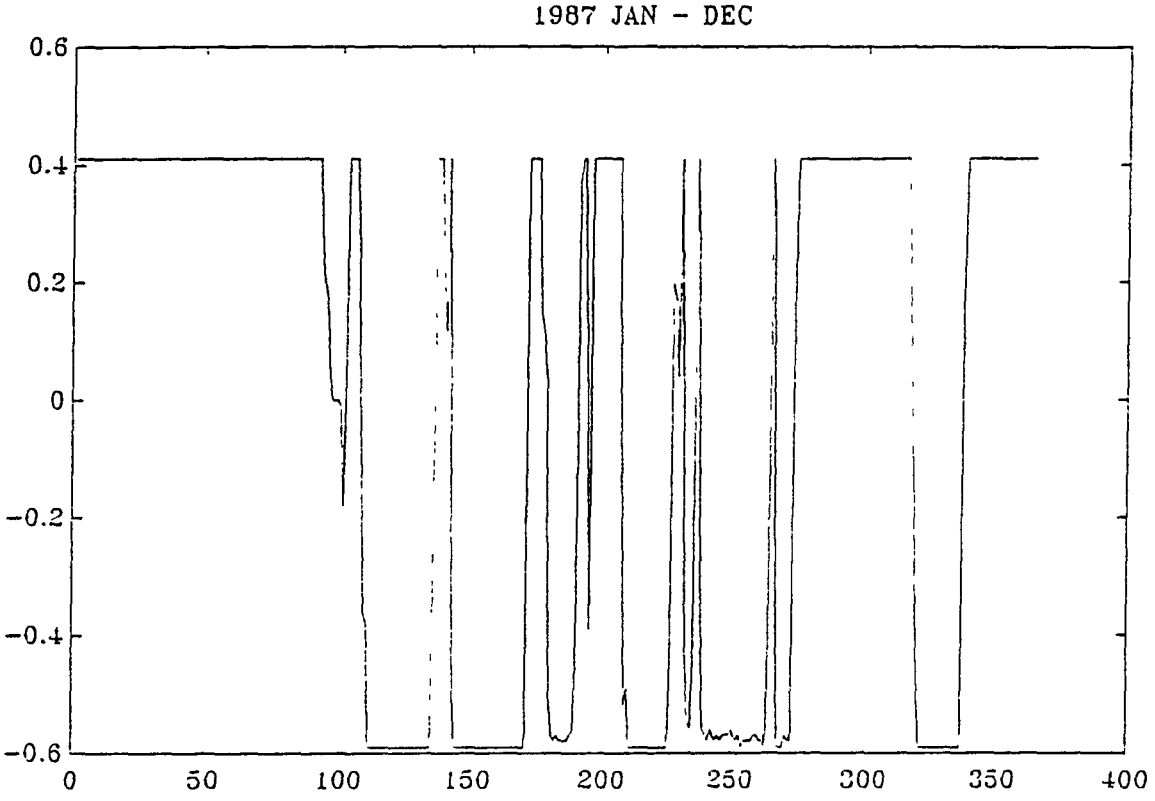

1985 % of POWER LOST after fft process (JAN - DEC)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

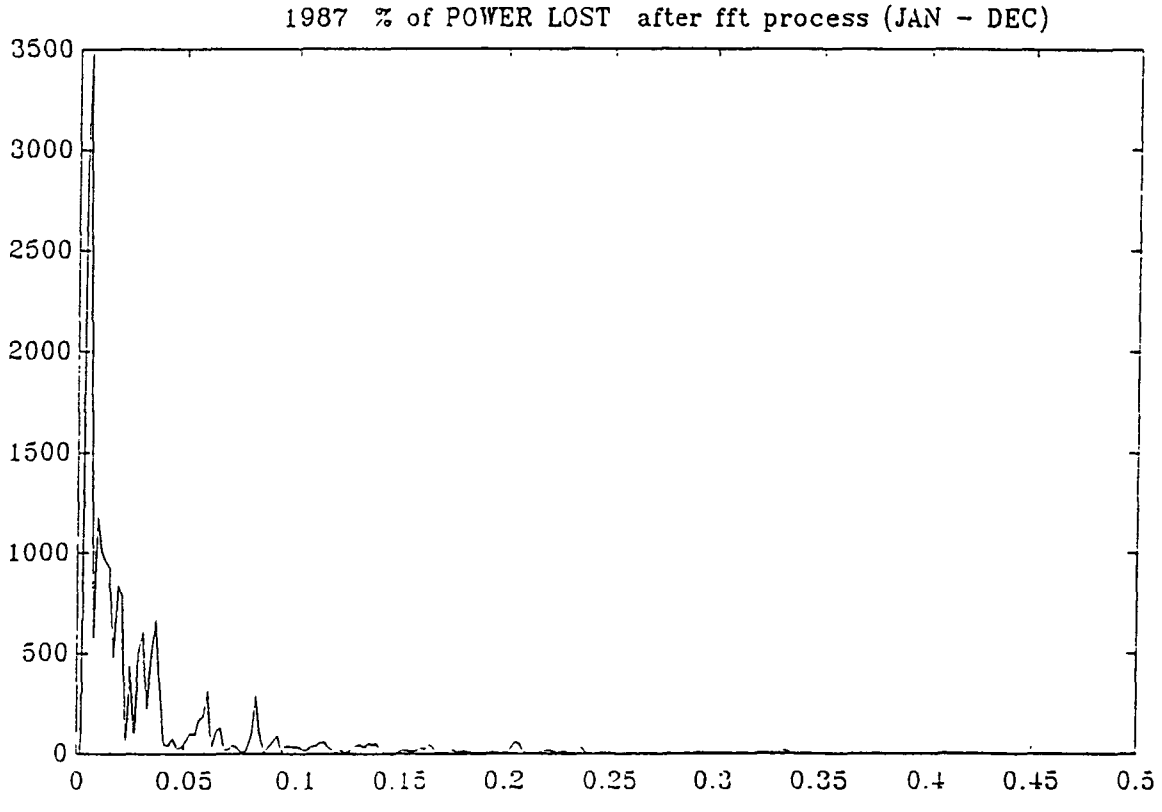

1986
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480


1986 JAN - DEC
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
50
100
150
200
250
300
350
400

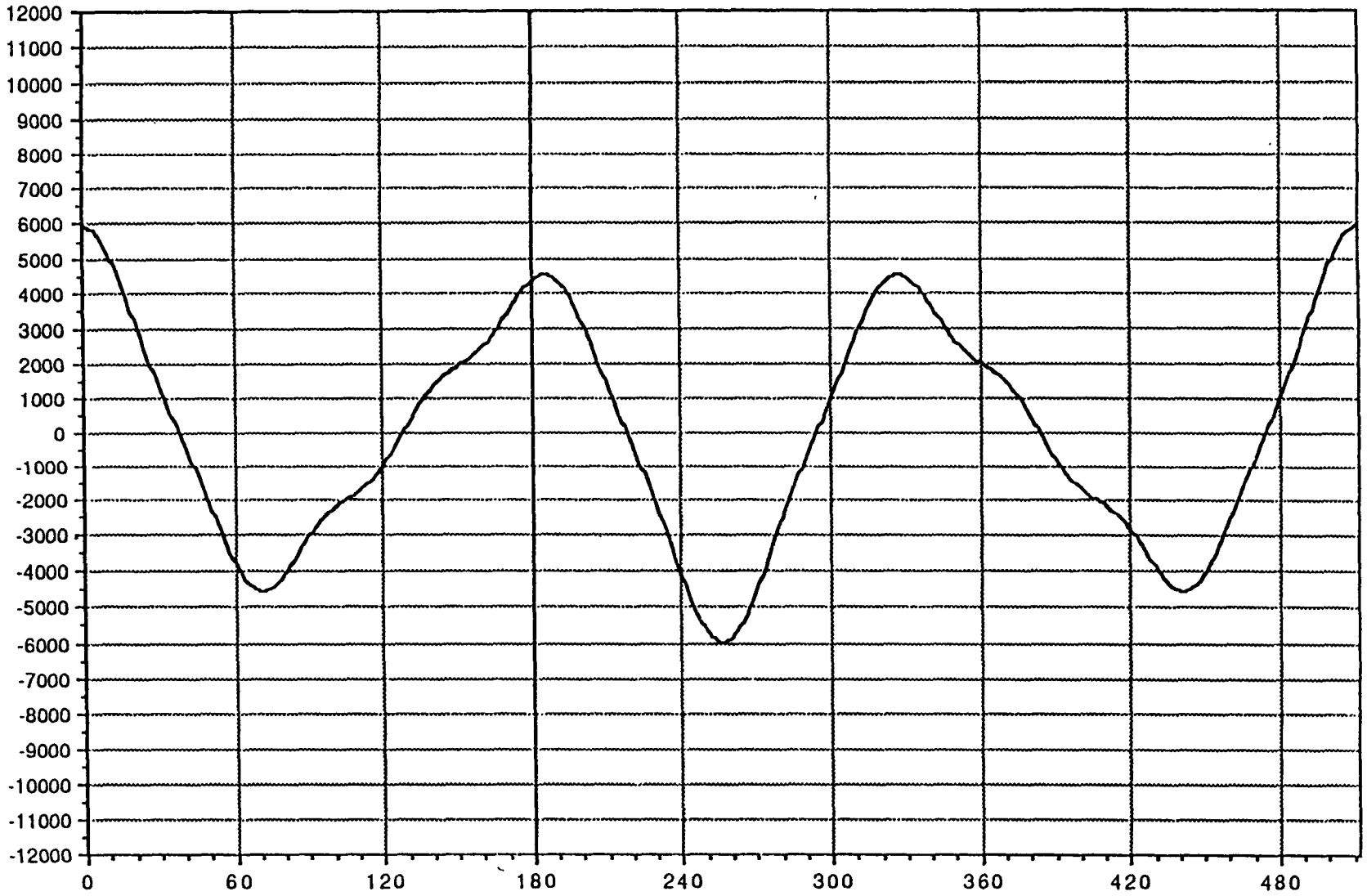

1986 % of POWER LOST after fft process (JAN - DEC)
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5


1987
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480


1987 JAN - DEC
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
50
100
150
200
250
300
350
400

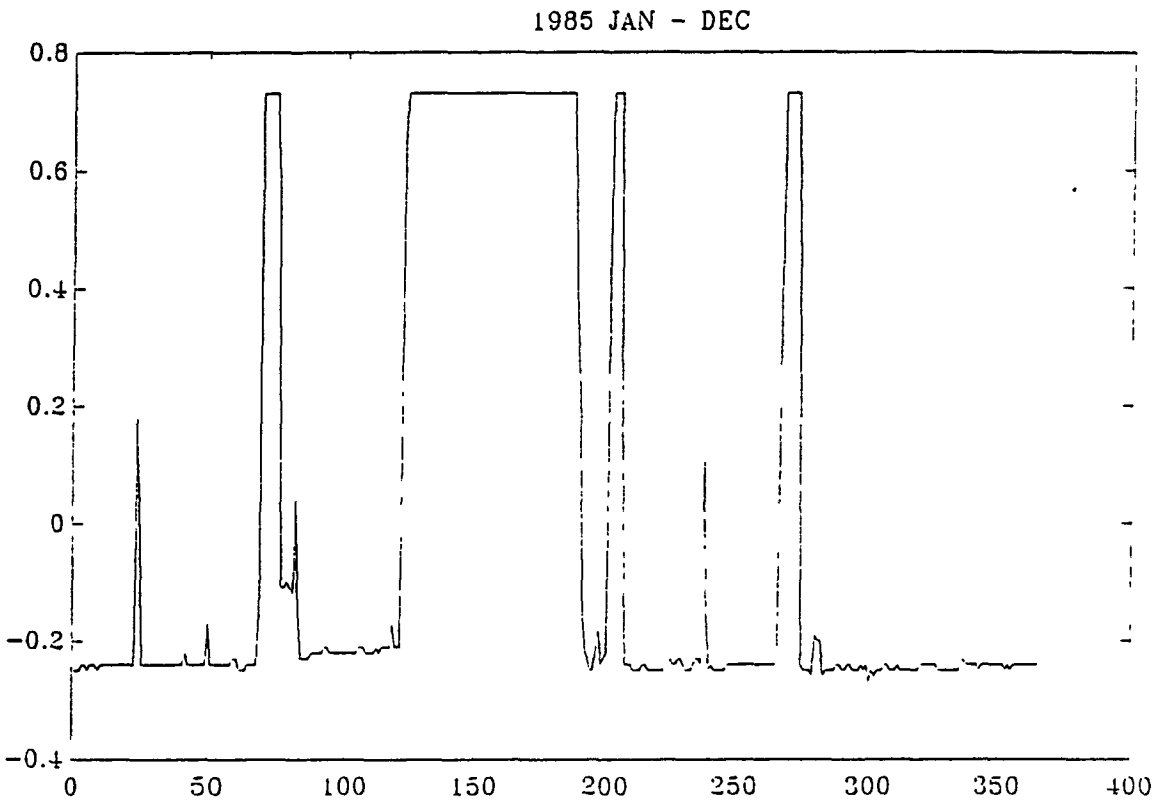

1987 % of POWER LOST after fft process (JAN - DEC)
3500
3000
2500
2000
1500
1000
500
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

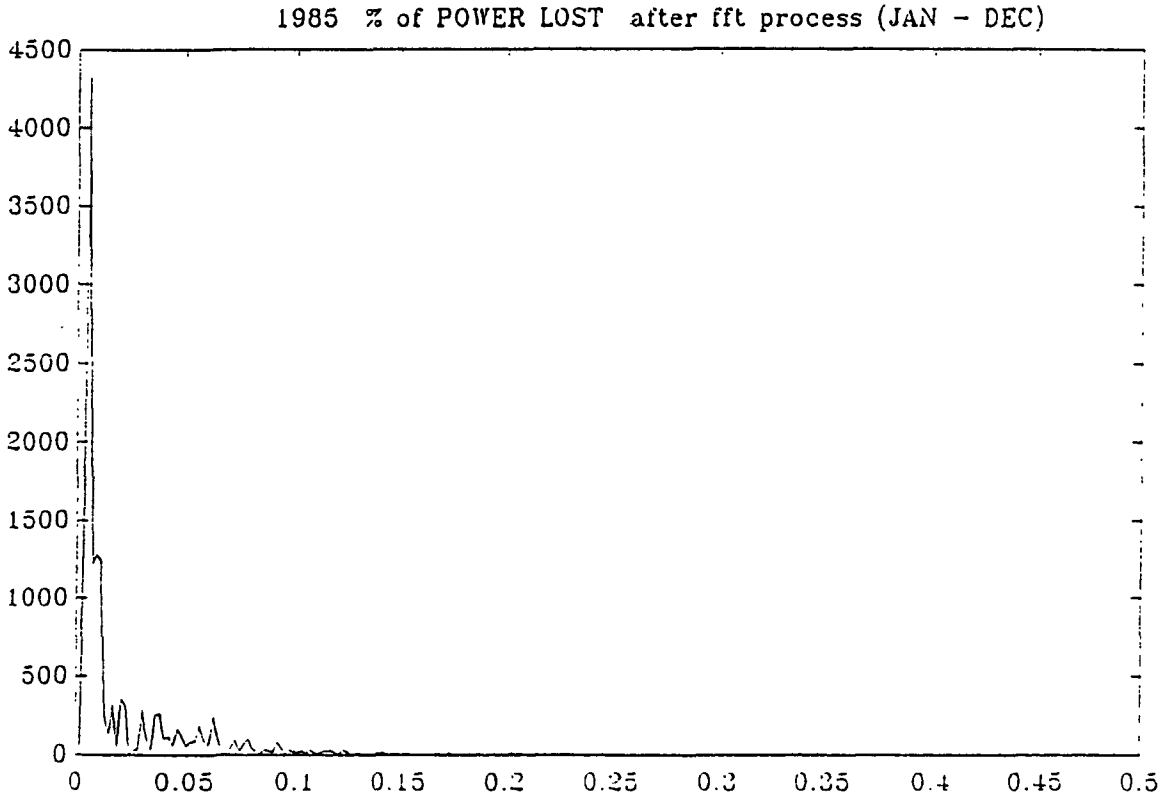
Detailed Results for Plant Z


12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
0
60
120
180
240
300
360
420
480

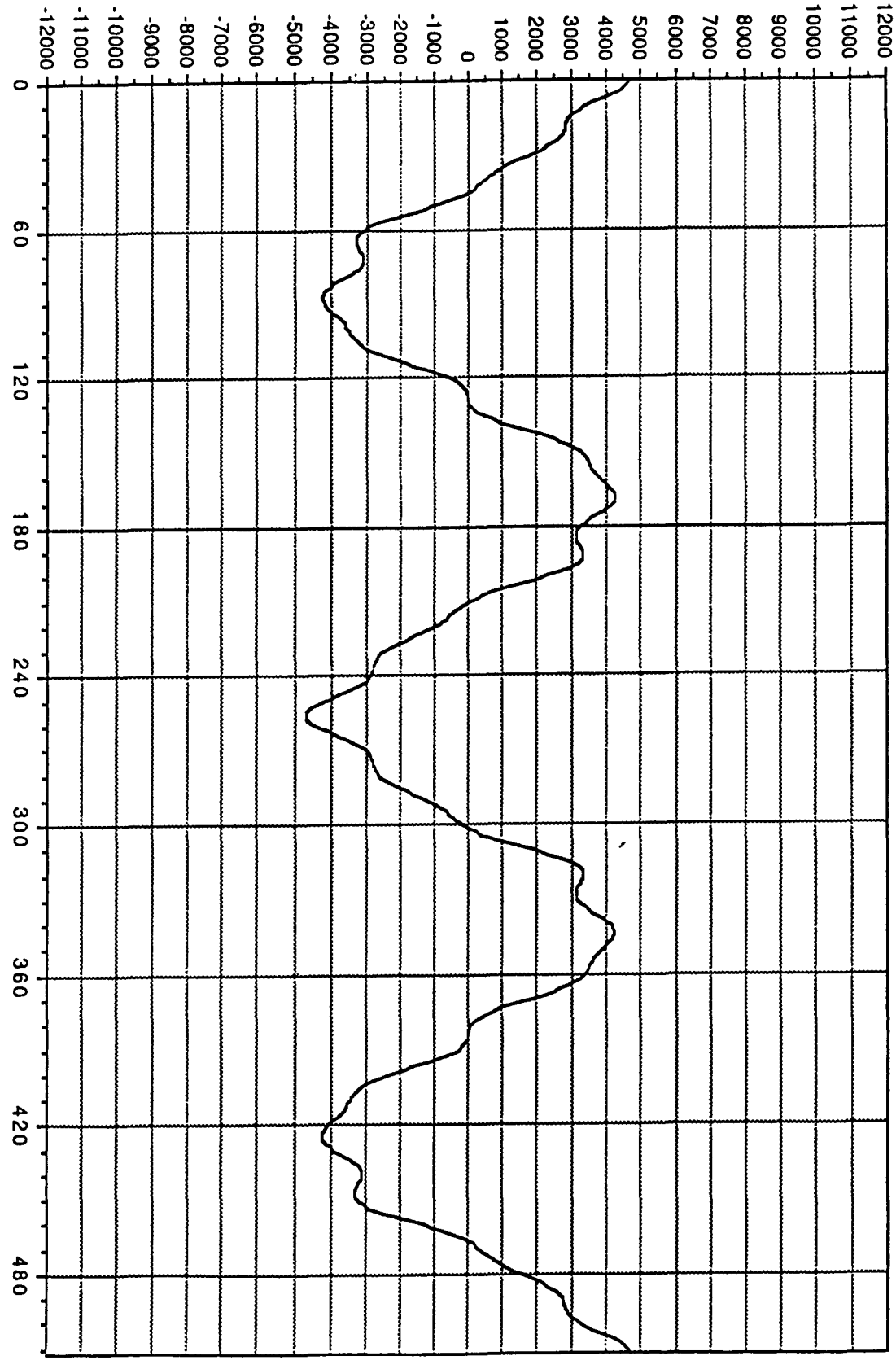
1985

Att-1-98

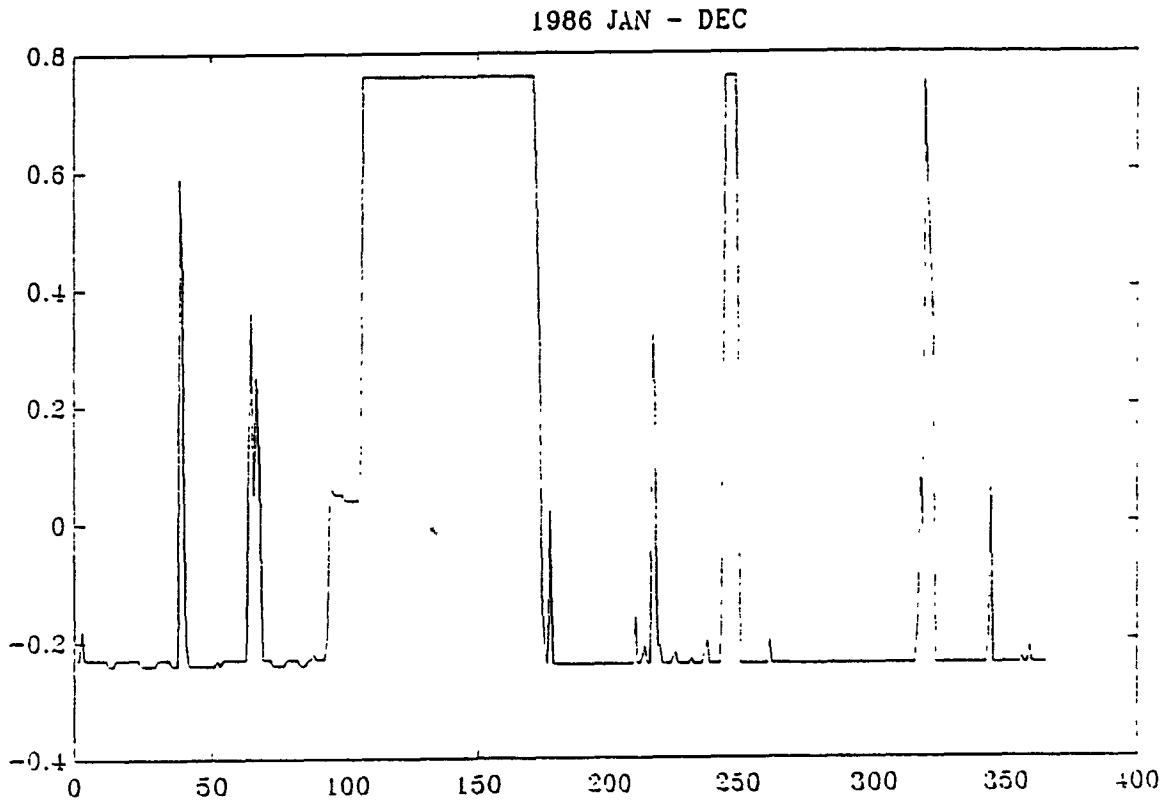

1985 JAN - DEC
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
50
100
150
200
250
300
350
400

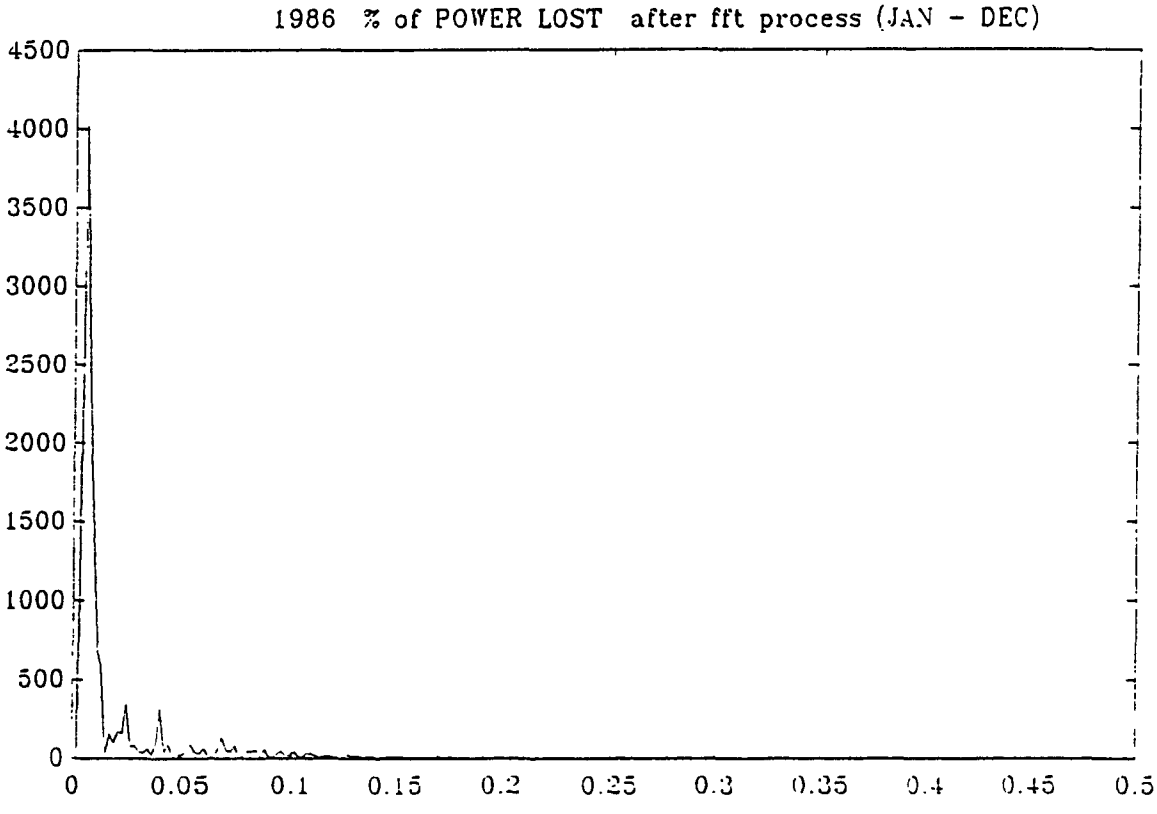

1985 % of POWER LOST after fft process (JAN - DEC)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

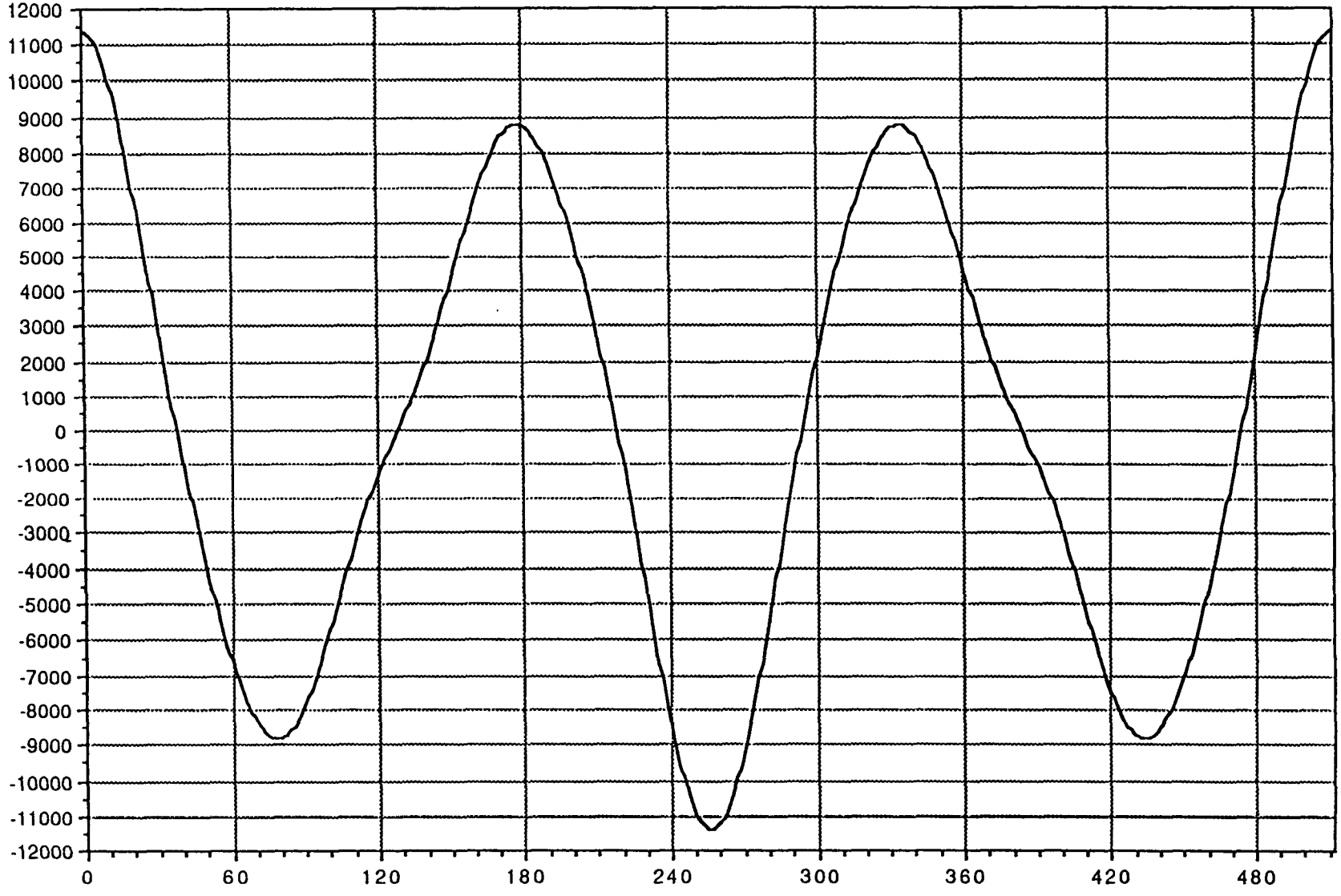
1986



Att-1-101

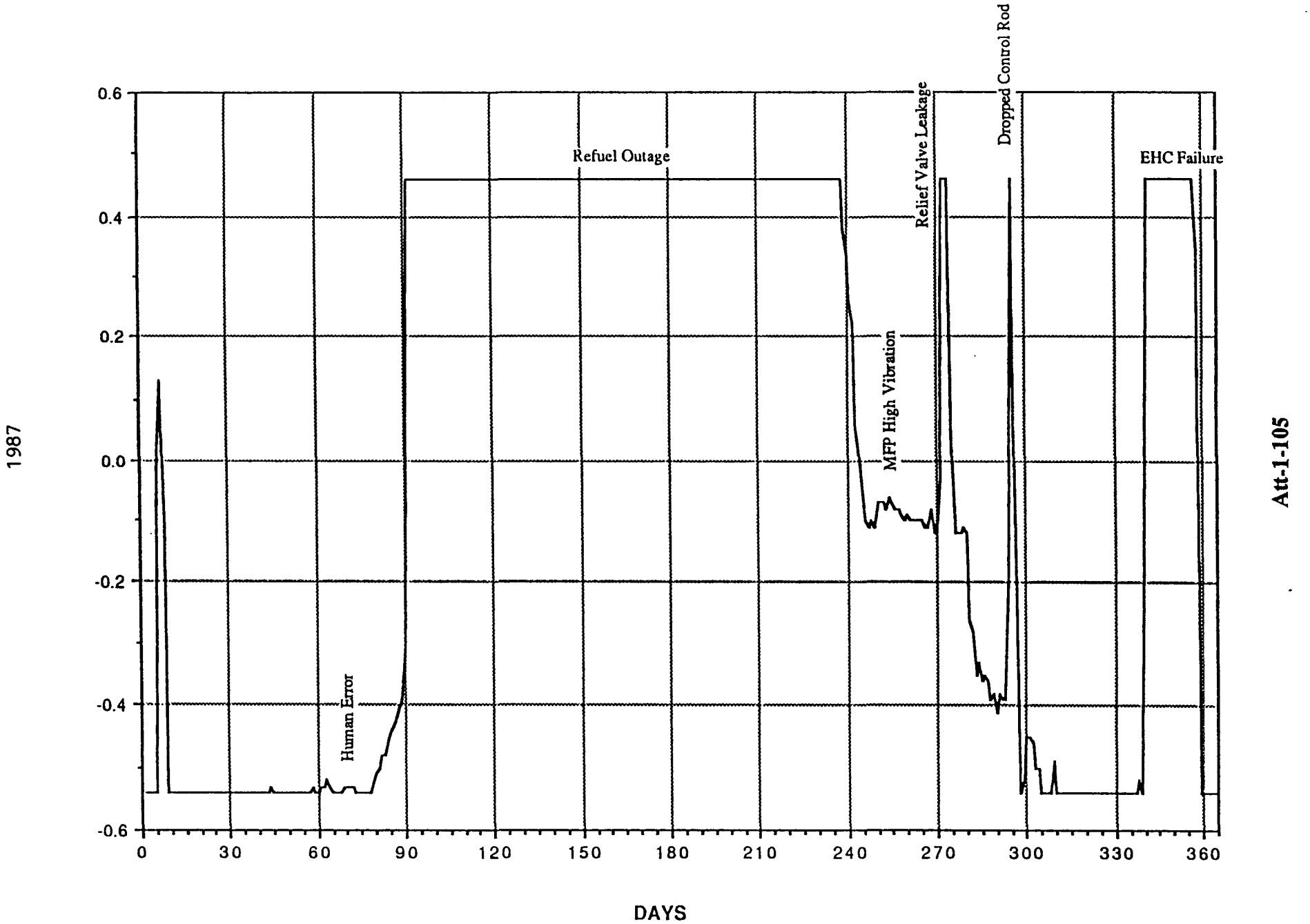

1986 JAN - DEC
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
50
100
150
200
250
300
350
400


1986 % of POWER LOST after fft process (JAN - DEC)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

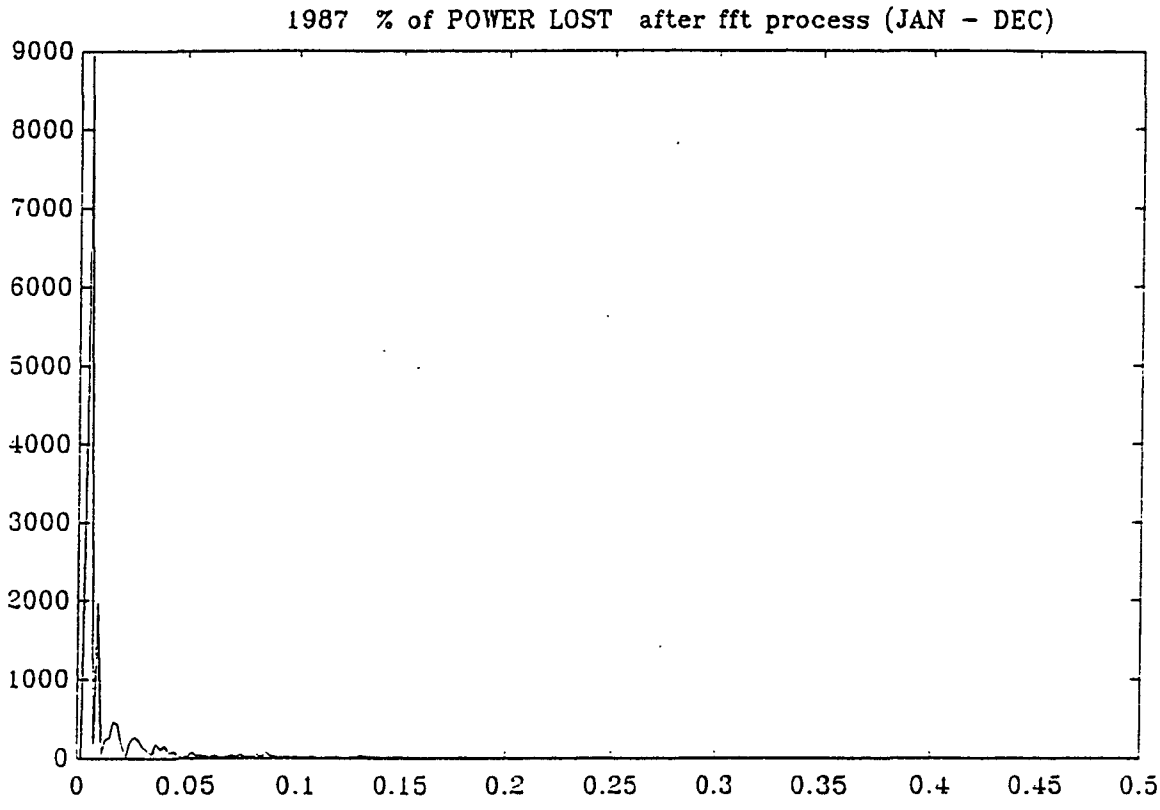


1987

Att-1-104


0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
30
60
90
120
150
180
210
240
270
300
330
360
DAYS
Human Error
Refuel Outage
MFP High Vibration
Relief Valve Leakage
Dropped Control Rod
EHC Failure
1987

Att-1-105


1987 % of POWER LOST after fft process (JAN - DEC)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5