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PDA: A PC-based Expert System for Analysis of DOE Nuclear Energy Performance Indicator Data

J.T. Fong (*),
B. Bernstein (**),
J.J. Filliben (***).

(*) U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards
and Technology
Applied and Computational
Mathematics Division
Gaithersburg, MD 20899

(**) Illinois Institute of Technology
Department of Mathematics
Chicago, IL 60616

(***) U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards
and Technology
Statistical Engineering Division
Gaithersburg, MD 20899

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J. T. Fong*, B. Bernstein**, and J. J. Filliben***

Abstract

A personal computer (PC)-based expert system is developed as a front end to commercially-available MS-DOS-based software and a public-domain statistical package named DATAPLOT (v. 92.2). Coded in micro-PROLOG (v. 1.4), the expert system PDA is designed to (1) facilitate the analysis of the so-called performance indicator data by the technical staff of the Office of Nuclear Energy (NE), U.S. Department of Energy (DOE); (2) enhance the analysis and database management capability of an engineer or scientist through a series of tutorial exercises; and (3) encourage the modification of the Prolog code of PDA or the English-based codes of the DATAPLOT macros by users interested in customizing the system for new or proprietary applications. To achieve these objectives, the system includes three special features: (i) A temporary exit to access any MS-DOS-based packages such as LOTUS-1-2-3, etc. (ii) More than twenty built-in DATAPLOT macros for a user to obtain, *at a single key stroke,* simple plots such as histograms, pie charts, Pareto charts, C-charts (count charts), P-charts (proportion charts), lag plots, autocorrelation plots, box plots, scatter plots, etc., as well as statistical tests to identify data distributions such as normal, lognormal, uniform, logistic, exponential, Cauchy, Poisson, Gamma, Beta, Weibull, extreme value types I and II, and binomial. (iii) A direct access to DATAPLOT for users to write their own macros to conduct a full-range of statistical tests, analysis, and experimental design. The minimum requirements of the PC computing environment for running PDA are: 80386SX-16 CPU, 8/16-MHz, 2MB-RAM, 40MB-Hard disk, math-coprocessor, 1.44-MB 3.5" or 1.2-MB 5.25" high density floppy drive, MS-DOS 3.3, and a properly installed version of DATAPLOT (v. 92.2).

Keywords: Artificial intelligence; computational mathematics; data analysis; DATAPLOT; engineering expert system; expert system; micro-PROLOG; nuclear energy; PC computing; performance indicator; statistical engineering.

*Applied & Computational Mathematics Division, National Institute of Standards & Technology, Gaithersburg, MD 20899.
**Department of Mathematics, Illinois Institute of Technology, Chicago, IL 60616.
***Statistical Engineering Division, National Institute of Standards & Technology, Gaithersburg, MD 20899.

Disclaimer

The mention of computer systems or software products in this document implies neither approval nor endorsement of all such systems or products by the authors or the institutions they are affiliated with.

Acknowledgment

This report, together with a 3.5-inch 1.44-MB floppy named 92330FONG-1 and a 386SX/386/486 copy of DATAPLOT as installed in a personal computer located at the Germantown, Maryland Office of the U. S. Department of Energy (DOE), constitutes the complete documentation of the work by the U. S. National Institute of Standards and Technology (NIST) in response to an interagency procurement request, 0191NE-20413.0001, dated Sep. 30, 1991.

The authors wish to thank **Mr. I-Ling Chow** of DOE Office of Nuclear Energy Self-Assessment for the initial invitation and the subsequent technical discussions that led to the creation of the expert system PDA. In addition, the authors would like to acknowledge the technical or administrative assistance given by the following individuals during the course of this investigation:

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Table of Contents

Table of Contents *(Continued)*

Table of Contents *(Continued)*

Note on Prolog Copyrighted Materials & Version Conversion

The attached floppy 92330FONG-1 (see listing in Appendix A), contains six Prolog (v. 1.4, Lisp-like Standard syntax) system files that are copyrighted by Logic Programming Associates (LPA), Ltd., Studio 4, The Royal Victoria Patriotic Bldg., Trinity Road, London, SW18 3SX, United Kingdom. The names of the six Standard-syntax files are: APP.MOD; FIGURE.SYS; LINKER.SYS; LOADER.SYS; PROLOG.EXE; and PROLOG.SYS. They were contained in a micro-PROLOG software package purchased in March 1987 by one of the authors (B. Bernstein) through Programming Logic Systems, Inc., Milford, CT, then U.S. distributor which has since gone out of business.

On June 10, 1991, the first author of this report (J. Fong) contacted **Ms. Carrie DuBois** of the Quintus Corporation of Palo Alto, CA, the current U.S. distributor of Prolog, for information on upgrading the Bernstein's copy of micro-Prolog (v. 1.4). Fong was told that micro-Prolog has since been renamed DOS Prolog and the new version supports a different syntax known as the Edinburgh syntax. Fong purchased a copy of the new DOS Prolog (v. 3.0) and requested help in version conversion as well as inquired about the status of the above six files regarding their distribution to unlicensed Prolog users such as the DOE staff for demonstration, tutorial, and limited application purposes.

On June 13, 1991, Fong was informed by **Ms. DuBois** of Quintus Corp. that LPA will assist in converting customer's Standard syntax codes to the Edinburgh ones. In a message to Quintus in response to Fong's request, **Mr. Brian Steel** of LPA, London, U.K., wrote that the version conversion

> *"depends on what the program is doing. Anything which is pretty conventional Prolog will convert and run first time around 90% of the time. If the program is heavily into structure-specific meta-programming, there could be some problems (but not big ones).*
>
> *"The converter was pretty intelligent, replacing calls to micro-PROLOG predicates with equivalent Edinburgh ones, and adjusting arguments as necessary, but when it got stuck, it simply allowed the micro-PROLOG predicate through, and embedded a warning comment in the file.*
>
> *"Because the micro-PROLOG predicates still exist in DOS Prolog, such code works, and the remaining conversion can be done at leisure ... before attempting a further porting to 386-PROLOG, which does *not* include the micro-PROLOG predicates.*
>
> *"The class of programs where the manual stage of conversion is a bore includes those which expect program clauses to look like lists of lists: a lot of list<->tuple conversion, with calls to -.. (univ) is required in Edinburgh Prolog, but was completely unnecessary in micro-PROLOG. Likewise, I/O which assumes Standard (lisp-like) syntax for special purposes may need a little work porting."*

On Sep. 30, 1991, **Ms. Diane Reeve** of LPA, London, U.K., sent Fong a converter disk which was subsequently used by Fong to demonstrate the version conversion of a simple test code during a visit he made to the Quintus Corporation on Oct. 14-18, 1991. During the same visit, Fong was told that since the Standard syntax of micro-Prolog is no longer supported, Quintus Corporation had no objection to our intention to distribute those six Standard-syntax files for the purposes stated, pending a written permission from LPA following a review of the specific utilization of those files as described in this report.

Executive Summary

Based on a proprietary expert system language, a PC-based program named PDA is coded as a user-friendly front end to a developmental statistical analysis package named DATAPLOT.

DATAPLOT is a general-purpose statistical analysis software program undergoing development by the National Institute of Standards and Technology (NIST). PDA is designed to facilitate the technical staff of the Office of Nuclear Energy (NE), U. S. Department of Energy (DOE), to conduct statistical analysis of the DOE NE Performance Indicator (PI) data. PDA may also serve a much larger group which includes other government agencies and the general public since the work contains many generic features such that non-DOE users may easily create their own databases to conduct state-of-the-art analysis in a PC environment.

Coded in micro-PROLOG (v. 1.4), PDA consists of a series of interactive window menus. The opening menu allows a user either to choose a DOE-NE-based application or a generic one to be named by the user. After an application is chosen, another window menu with five options is displayed: (a) **indata** for data input, (b) **lists** for data listing, (c) **disco** for temporary exit to disk operating system (DOS) with special features for saving data on files, (d) **analysis** for executing DATAPLOT macros with customized graphics, and (e) **clean** for housekeeping chores including permanent exit to DOS. To facilitate data analysis, three special features of the system are included:

(1) A temporary exit feature under option **disco** to access any MS-DOS-based packages such as LOTUS-1-2-3, dBASE, ORACLE, etc. provided an effective memory manager is in place.

(2) Built-in DATAPLOT macros under option **analysis** for a user to obtain, *at a single stroke,* simple plots such as histograms, pie charts, Pareto charts, C-charts (count charts), P-charts (proportion charts), lag plots, autocorrelation plots, box plots, scatter plots, etc., as well as statistical tests to identify data distributions such as normal, lognormal, uniform, logistic, exponential, Cauchy, Poisson, Gamma, Beta, Weibull, extreme value types I and II, and binomial.

(3) A direct access to DATAPLOT under option **analysis** for users to write their own macros to conduct a full range of statistical tests, analysis, and experimental design.

The minimum requirements of the PC computing environment for running PDA on floppy drive "A" are: 80386SX-16 CPU, 8/16-MHz, 2MB-RAM, a 40MB-hard disk drive "C", a math-coprocessor, a 1.44-MB 3.5" or 1.2-MB 5.25" high density floppy drive, and MS-DOS 3.3; a NIST-developed software package named DATAPLOT (v. 92.2), a proprietary Fortran-77 run time library and memory manager named OTG/DBOS, and a proprietary Tektronix terminal emulator named PLOTDEV, all installed on drive "C"; and a floppy diskette named 92330FONG-1 which contains the source code of the expert system PDA and six proprietary micro-PROLOG system files needed to execute PDA. Pending written permission from Logical Programming Associates (LPA), Ltd., the developer of micro-PROLOG, the diskette 92330FONG-1 is available on a loan basis only to participants of tutorials conducted for users of the expert system PDA. DATAPLOT for PC's is not approved for public release but is available on a case-by-case basis upon request (see Appendix D, Section 2).

DOE Facility Naming Convention

According to a DOE Guidance Document (Ref. [2], p. A1-4), 35 contractors and 118 facilities under the cognizance of five Program Senior Officials (PSO's) are required to participate in the DOE Performance Indicator (PI) Program. For the Phase 1 design of the expert system PDA, a sample data diskette (Ref. [15]) containing PI data reported by 7 contractors and 23 facilities of the Office of Nuclear Energy (NE), one of the five PSO's, was furnished to NIST on Nov. 1, 1991. The following is a naming convention for each of the 7 contractors and 23 facilities as identified in Ref. [15] and PDA (v. 92.2):

Database (Location/Contractor)	**Naming Convention & Window Display**
F1. CH-AN (Chicago/Argonne)	F11 - CONT (Contractor)
	F12 - EBR (Experimental Breeder Reactor - II)
	F13 - FMF (Fuel Manufacturing Facility)
	F14 - HFEF (Hot Fuel Examination Facility)
	F15 - JANU (JANUS)
	F16 - NRAD (Neutron Radiography Facility)
	F17 - TREA (Transient Reactor Test)
F2. CH-BN (Chicago/Brookhaven)	F21 - BMRR (Brookhaven Medical Research Reactor)
	F22 - CONT (Contractor)
	F23 - HFBR (High Flux Beam Reactor)
F3. IDAHO (Idaho & Alburquerque/EG&G)	F31 - AMCF *(Adv React Meas Fac & Coupled Fast RMF)*
	F32 - ATR (Advanced Test Reactor)
	F33 - CONT (Contractor)
	F34 - MD50 (Alpha Fuels Fac - Mound Plant/Bldg 50)
	F35 - TRHC (Test Reactor Hot Cell Facility)
F4. OAKRI (Oak Ridge/Martin Marietta)	F41 - CONT (Contractor)
	F42 - HFIR (High Flux Isotope Reactor)
	F43 - PADU (Paducah Gaseous Diffusion Plant)
	F44 - PORT (Portsmouth Gaseous Diffusion Plant)
	F45 - REDC (Radiochemical Engineering Dev. Ctr.)
	F46 - TSR (Tower Shielding Reactor)
F5. RL-WH (Richland/Westinghouse-Hanford)	F51 - B308 (Building 308)
	F52 - CONT (Contractor)
	F53 - FFTF (Fast Flux Test Facility)
	F54 - FMEF (Fuels & Materials Examination Facility)
	F55 - MASF (Maintenance & Storage Facility)
F6. SF-LL (San Francisco/Lawr. Livermore)	F61 - AVLI (AVLIS)
	F62 - CONT (Contractor)
F7. SF-RI (San Francisco/Rockwell Int'l)	F71 - CONT (Contractor)
	F72 - ETEC (Energy Technology Engineering Center)

Labelling of DOE Performance Indicators (PI)

Label	PI No.	PI Title	Unit (Number)	Unit (Others)
1100	1.1	Collective Radiation Dose		(person-rem)
1200	1.2	Skin Contaminations	(No. of events)	
1300	1.3	Internal Contaminations	(No. of events)	
1400	1.4	Radioactive or Hazardous Material Overexposures	(No. of events)	
		1410 Root cause Material (Data in Table 2*)		
		1420 Root cause Procedures (Data in Table 2*)		
		1430 Root cause Personnel (Data in Table 2*)		
		1440 Root cause Management (Data in Table 2*)		
		1450 Root cause Design (Data in Table 2*)		
		1460 Root cause Training (Data in Table 2*)		
		1470 Root cause Other (Data in Table 2*)		
1520	1.5.1	Lost Work Day Cases	(No. of events)	
1530	1.5.2	Total Hours Worked, by facility		(hour)
	1.5	Lost Work Days (Lost Time Accident Rate), calculated by Rate = (200,000 hrs x Data-1520) / (Data-1530)		
1620	1.6.1	Recordable Injuries/Illnesses	(No. of events)	
		---- 7 Data Points in Table 1* ----		
2100	2.1	Environmental Incidents	(No. of events)	
2200	2.2	Unplanned Safety Function Actuations	(No. of events)	
2300	2.3	Violations of Operating Procedures	(No. of events)	
2400	2.4	OSHA Violations	(No. of events)	
2500	2.5	Unplanned Shutdowns	(No. of events)	
2600	2.6	Emergency and Unusual Occurrences	(No. of events)	
		---- 6 Data Points in Table 1* ----		

*Tables 1 and 2 refer to datafiles contained in a DOE diskette (Ref. [15]) furnished to NIST on Nov. 1, 1991.

Labelling of DOE Performance Indicators (PI) - Continued

Label	PI No.	PI Title	Unit (Number)	Unit (Others)
3110	3.1.1	Radionuclide Effluent Releases, Airborne		(curie)
3120	3.1.2	Radionuclide Effluent Releases, Liquid		(curie)
3210	3.2.1	Hazardous Substance/Regulated Pollutant Effluent Releases, Airborne		(pound)
3220	3.2.2	Hazardous Substance/Regulated Pollutant Effluent Releases, Liquid		(1,000-gallon)
		---- 4 Data Points in Table 1 (See Footnote on Previous Page) ----		
4100	4.1	Open DOE Audit Issues	(No. of issues)	
4200	4.2	Open External Organization Recommendations	(No. of recommendations)	
4300	4.3	Occurrence Reports with Open Corrective Actions	(No. of reports)	
	4.4	***Corrective Maintenance Backlog***		
4420	4.4.1	No. of Open Items > 3 months old	(No. of items)	
4430	4.4.2	Total number of open items	(No. of items)	
	4.5	***Preventive Maintenance Overdue***		
4520	4.5.1	No. of items not completed	(No. of items)	
4530	4.5.2	Total items scheduled	(No. of items)	
4600	4.6	Substance Abuse Incidents	(No. of events)	
	4.7	***Volume of Solid Low Level Radioactive and/or Hazardous Waste Generated***		
4711	4.7.1.1	Radioactive Waste (RW), volume generated		(cubic feet)
4712	4.7.1.2	RW, volume in final form, pending shipment		(cubic feet)
4713	4.7.1.3	RW, volume shipped for disposal		(cubic feet)
4721	4.7.2.1	Hazardous Waste (HW), volume generated		(cubic feet)
4722	4.7.2.2	HW, volume in final form, pending shipment		(cubic feet)
4723	4.7.2.3	HW, volume shipped for disposal		(cubic feet)
4731	4.7.3.1	Mixed Waste (MW), volume generated		(cubic feet)
4732	4.7.3.2	MW, volume in final form, pending shipment		(cubic feet)
4733	4.7.3.3	MW, volume shipped for disposal		(cubic feet)
		---- 17 Data Points in Table 1 (See Footnote on Previous Page) ----		

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Chapter 1 - Introduction

In Jan. 1991, Admiral James D. Watkins, USN (Retired), Secretary of U. S. Department of Energy (DOE), issued a directive, SEN-29-91 [1][1] to establish a uniform data-reporting program, to be known as the Performance Indicator (PI) Program, for trending and analyzing operational data of all DOE facilities except those under the Naval Nuclear Propulsion Program.

The purpose of the PI Program is to help assess and support progress in improving performance and in strengthening line management control of operations relating to environmental, safety, and health activities. The Assistant Secretary for Nuclear Energy (NE) was assigned the responsibility to develop this trending system, to conduct Departmentwide training sessions, and to prepare guidance documents necessary to implement it. Admiral Watkins' directive [1] also laid out a schedule for the implementation of the PI Program:

> *"... The trending system is to be operational by June 1991. After that date, each Operations Office Manager shall submit quarterly reports to the relevant program office. Program offices shall then complete their analyses and submit summary trend reports of the performance indicators to the Office of the Secretary within 3 weeks from receipt of the report from the Operations Offices."*

In Apr. 1991, the DOE Office of NE issued a guidance document [2] in which it stated

> *"... the intent of establishing this program is to enhance the safety culture in both DOE and contractor organizations by using PIs to improve performance. It is expected that active management involvement with facility operations will include using PIs, so that potential problems and/or deteriorating conditions related to environment, safety, and health activities can be readily identified and promptly corrected. In addition, good practices should be identified which can be applied to benefit other DOE operational areas.*

[1]Figure in square brackets denotes a reference listed at the end of this report.

> *"An objective of this program is to provide trends and analyses of operational data that will be useful to both DOE and its contractors. As directed in SEN-29-91, each program office shall maintain direct responsibility for ensuring the preparation and accuracy of the PI data for the activities under their cognizance.*
>
> *"It is a requirement that all data reported in this program be unclassified."*

There are four appendices in the guidance document [2]: Appendix 1 lists the names of the 35 contractors and 118 major facilities included in this program, Appendix 2 provides the definitions of the 22 performance indicators in four categories, and Appendix 3 describes the report format and content. In Appendix 4, the guidance document [2] specifies that

> *"... the general methodology for trending and analyzing data gathered under the DOE Performance Indicator Program combines numerical methods to organize the data with engineering management knowledge and insights concerning the process operations.*
>
> *"DOE and DOE contractor line management are required to assess and quantify the information for each PI using data distribution and control charts.*
>
> *"The analysis itself is not a problem solving tool. It can assist in determining the cause of variations in operations, which is essential in selecting appropriate managerial actions to effect improvements."*

Three types of charts are singled out as required for reporting: the so-called Pareto distribution chart, the C-chart (i.e., count chart), and the P-chart (i.e., proportion chart).

The problem of engineering plant performance or inservice data reporting and analysis is not new. In 1978, the American Society of Mechanical Engineers (ASME) sponsored a symposium to address that subject for a specific sector involving the use of pressure vessels, piping, pumps, and valves [3, 4]. The relevance of the inservice data, a uniform reporting standard, and the use of state-of-the-art statistical analysis techniques to the improvement of engineering reliability and the making of day-to-day engineering decisions, was addressed in a series of papers by Fong [5-9]. Subsequently, the availability of increasingly powerful personal computers (PCs) and PC-based system and analysis software packages motivated Fong and his colleagues at the National Institute of Standards and Technology (NIST) to pursue research and prototype expert system development for engineering applications [10-12], where inservice or laboratory testing data are stored, reviewed, analysed and interpreted for decision making.

The above-mentioned on-going research at NIST prompted the DOE Office of Nuclear Energy, through Mr. Owen W. Lowe, Director of the DOE Office of Nuclear Safety Self-Assessment, and Mr. I-Ling Chow of DOE Nuclear Performance Evaluation Division, to invite

Fong to consider providing DOE with technical assistance in support of the PI Program.

On May 1, 1991, Fong visited the Germantown office of DOE and made a presentation on the subject of engineering expert systems for managing and analyzing performance data. A letter of agreement between DOE and NIST was initiated in June 1991 and signed in Sep. 1991 together with a procurement request (No. 0191NE-20413.0001) stating that NIST will conduct research to develop a PC-based expert system for DOE-specific and generic applications in support of the PI Program. This expert system, using an artificial intelligence language named Micro-Prolog and a NIST-developed statistical data analysis named DATAPLOT, will:

(1) Perform state-of-the-art statistical analyses on compiled PI data and generate the graphics for PI reports as required by SEN-29-91 [1].

(2) Test the validity of the underlying assumptions and determine the best-fitted distributional model of the data reported as one of the following: normal, lognormal, uniform, logistic, exponential, Cauchy, Extreme Value Types I and II, Gamma, Beta, Weibull, Binomial, Geometric, and Poisson.

Under this agreement, two members of the NIST staff (Fong and Filliben) and a NIST contractor (Bernstein) will carry out the necessary research to accomplish the above objectives with a partial reimbursement of the total cost by DOE. The duration of this work, jointly sponsored by DOE and NIST, was initially set at five months (Oct. 1, 1991 to Feb. 28, 1992) and subsequently extended to Apr. 15, 1992 at no additional cost to DOE to account for the inclusion of tutorial exercises based on DOE-generated data.

In Chapter 2, we present a brief overview of the use of expert systems in engineering data analysis and the rationale for selecting Micro-Prolog (version 1.4, standard syntax) as the programming language and DATAPLOT (PC version 92.2) as the statistical analysis package for both generic and DOE-specific applications. Based on two DOE reports [13, 14], a datafile diskette [15] and a hardcopy listing of selected data [16], all furnished by Mr. I-Ling Chow of DOE, we present in Chapter 3 the design specification of a PC-based expert system named PDA, which stands for **P**erformance Indicator **D**ata **A**nalysis System.

Chapters 4 to 6 are tutorials, with which a user may learn how to create a database and perform a statistical analysis on data to be entered either via the keyboard or a DOS file. The significance and limitations of the expert system, PDA, version 92.2, are discussed in Chapters 7 & 8. A list of 41 references, four appendices, i.e., (A) listing of a system diskette named 92330FONG-1 containing 103 files and one subdirectory, (B) listing of the source code for the expert system under the filename of PDA.LOG, (C) listing of 869 DATAPLOT commands or reserved words, (D) listing of the service contacts for software packages Prolog and DATAPLOT, and an index of 85 DATAPLOT commands selected for first-time users and invoked in 20 macros for tutorial purposes, are included at the end of this report.

Chapter 2 - An Expert System Approach to Data Analysis

In response to the DOE request for a short-term technical assistance in support of a safety-related multi-facility performance data analysis and trending program, we observe that the time frame of 5-6 months necessitated a practical solution through the re-use of as much as possible the basic research results and computer codes we developed at NIST on the generic subject of PC-based expert systems for engineering data analysis [11, 12].

However, before we embark on a software re-use project in support of the DOE Performance Indicator (PI) Program, we like to answer the following three basic questions:

Question 1 Why do we select DATAPLOT (v. 92.2) as the data analysis package?

Question 2 Why do we adopt an expert system approach to data analysis?

Question 3 Why do we select Micro-Prolog (v. 1.4) for coding the expert system?

To answer Question 1, we recall that during the early 1960's, mainframe computers were widely available to engineers and scientists for computational modeling and data analysis. Among the first to devise a user-friendly approach to data analysis was a research group at NIST, then the National Bureau of Standards (NBS). Headed by Hilsenrath [17], the group designed a programming language named OMNITAB using a worksheet concept and very simple English-like instructions to perform scientific calculations on data in columns of the worksheet. The language has since gone through several version enhancements with the latest implemented on a variety of platforms from mainframes [18] to personal computers[2].

Inspired by OMNITAB, the computer-assisted approach to data analysis mushroomed in the 1970s. By 1979, when the American Statistical Association (ASA) Committee on Statistical Program Packages initiated a survey [19], the developers of 117 packages responded with short summaries of their basic features and self-ratings. During the same period, a new approach to data analysis appeared on the scene. Pioneered by Tukey [20], the approach divided our analysis obligation to a given set of data into three stages:

Stage 1 Exploratory Data Analysis *"We need to explore the data flexibly -- here flexibility can be enhanced by simplicity without exhaustiveness."* - Tukey [20].

[2]The PC version of OMNITAB and an addendum to the 1986 manual [18] are expected to be released in May 1992.

Stage 2 Exhaustive Data Analysis *"We need to carry out the chosen analyses carefully and exhaustively -- especially if we are to use them in a controversy[3]."* - Tukey [20].

Stage 3 Confirmatory Data Analysis This is the stage where most of the packages surveyed by ASA [19] were designed. Simply stated, the goals of the confirmatory data analysis are (a) to look at a sample and at what that sample has told us about the population from which it came, and (b) to assess the precision with which our inference from sample to population is made. *"We can no longer get along without confirmatory data analysis. But we need not start with it,"* - Tukey [20].

Recognizing the need of a companion tool to implement Stages 1 & 2, which were new, and Stage 3, which was addressed by OMNITAB with discrete graphics, another group of researchers at NIST began developing a new package named DATAPLOT. Headed by Filliben [21, 22], a co-author of this report, the group introduced numerous new features such as:

Feature (1) - Continuous and Report-Quality Graphics.

Feature (2) - Exploratory Data Analysis (after Tukey [20]).

Feature (3) - Non-Linear Fitting.

Feature (4) - Experimental Design (after Box et al [23]).

Feature (5) - Statistical Process Control (after Ishikawa [24]).

Feature (6) - Special analysis codes such as BLOCK PLOT, BOX-COX NORMALITY PLOT, and a sophisticated test of normality plot named PPCC [25].

Undoubtedly, one may find a large number of commercially-available packages, e.g., MLAB [26], SYSTAT [27], etc., having many if not all of the above features, but we select DATAPLOT as the primary data analysis package because of two additional features, namely, (7) portability, and (8) public-domain. Feature (7), as documented in Appendix D, implies that DATAPLOT codes written for one computer can run virtually unchanged in many other platforms ranging from UNIX-based supercomputers to 386-based personal computers. This is useful to DOE when data are gathered over 118 facilities each with its own database platforms. Feature (8) is relevant when the cost of installing a proprietary package on many computers at each of the 118 DOE facilities is a critical factor for Departmentwide acceptance.

[3] *"All publication is potentially part of a controversy, just as all use as evidence is potentially part of an adversary position,"* Tukey [20, Preface].

Having answered Question 1 on the selection of DATAPLOT, we observe that the 3-stage approach to data analysis [20] implies that both a subject-domain specialist and a statistician need to be available to assist a user to interpret first the results of the exploratory analysis (Stage 1) before undertaking the exhaustive analysis (Stage 2), and then the results of the Stage 2 analysis before going for a final confirmatory analysis (Stage 3). With DATAPLOT, this translates into a requirement for an on-line help module where some "resident help opinions" are dispensed at various junctions along the journey of a multi-stage analysis path.

Clearly, the diversity of the data analysis problem makes the implementation of a general help module extremely difficult if not impossible. Nevertheless, Filliben and Fong [28] were able to demonstrate in 1984 that for a limited class of domain-specific problems, this so-called expert system approach was feasible. Furthermore, when a prototype system [29] was developed and tested among a broad spectrum of users, the response was favorable especially among users who were domain experts but not statisticians.

The timing of our expert system approach to data analysis coincided with that of two new developments in expert system computing, namely, the availability of commerical expert system building tools [30-33], and that of the expert system programming languages such as Prolog [34-40]. In 1987, when we began our research on the first prototype expert system for an engineering application [11], we chose Micro-Prolog (v. 1.4, standard Lisp-like syntax) as the programming language instead of one of those building tools, commonly known as expert system shells, primarily for the following three reasons:

Performance. Compared to a basic language such as Prolog [35], an expert system shell is a higher-level language designed for a domain specialist to develop an application by specifying rules for data analysis and interpretation. Generally speaking, a shell-based expert system performs less efficiently than a Prolog-based system because the latter can be custom-made and optimized for a single application.

Maintenance. For government applications such as the DOE Nuclear Energy Performance Indicator Program, the requirements for an expert system application are seldom fixed at the beginning of its development. Experience shows that as soon as the users gain some insight into the first version of an expert system, they may wish to change some old or add some new requirements. This leads to a software maintenance problem, which, in general, is easier to handle by a user if the expert system is coded in Prolog rather than a shell language.

Re-Usability. An expert system coded in Prolog can easily serve as the take-off point for a similar or more complicated system. By re-using a code for a variety of applications thus enhancing software productivity, Prolog has an advantage that no shell language can claim.

Chapter 3 - Design of Expert System *PDA (v. 92.2)*

The re-usability feature of a Prolog code assumes that the language does not undergo a major version change. In our two previous applications [11, 12], we developed codes using the standard Lisp-like syntax of the LPA PROLOG Professional (version 1.4), which was marketed in the United States under the trade name of micro-PROLOG. As documented in Appendix D, Section 1, the standard syntax is ideal for writing programs for data analysis because it treats data and analysis subroutines alike as a single data type -- the list. Two alternatives, i.e., the Edinburgh and the Simple syntax, are also available on version 1.4, but are more restrictive, because terms and lists are of different types, and goals, argument lists and bodies cannot be represented in source code by Prolog variables [38]. Furthermore, the standard syntax is the only syntax directly understood by micro-PROLOG, and programs written in any other syntax are compiled sentence by sentence into the standard syntax as they are entered [37, p.249].

Having selected the standard syntax to code our two previous Prolog applications and agreed to develop a new system for DOE in a short time frame by re-using the old codes [11, 12], we discovered in June 1991 that the new 3.0 version of micro-PROLOG [39, 40], since renamed DOS Prolog, supports only the Edinburgh but not the standard syntax[4]. To make the matter worse, some of the primitives available in the old version and used in our previous applications were dropped in the new version, so the tasks of (a) converting our old codes to a new set of instructions capable to running in the 3.0 version environment, and (b) modifying the new code to meet the DOE application requirements, are far more time-consuming than originally perceived and agreed upon between DOE and NIST.

After some careful considerations, we conclude that at least during the first phase of this consulting assignment, the primary goal is to acquaint DOE staff with the exploratory data analysis capability of DATAPLOT. To accomplish this, we need a two-prong effort where we first develop an expert system named ***PDA*** (for **P**erformance Indicator **D**ata **A**nalysis) by re-using and modifying the old Prolog code (version 1.4) and then concentrate on preparing a good documentation including easy-to-understand tutorials where some of the most useful DATAPLOT commands are taught by examples rather than by description. During the next phase, comments by DOE staff will be considered to improve the first version of the expert system and an attempt will be made to convert the 1.4-version code to a new one capable of running in the Prolog 3.0-version environment using only the Edinburgh syntax. During the final phase, an interactive help module with "resident expert opinions" will be developed to help a user undergoing the 3-stage data analysis effort. The following is a recommended time-table for the completion of the expert system research and development project:

[4]See page vi for a "Note on Prolog Copyrighted Materials & Version Conversion."

Phase	Primary Goal	Duration of Work *(Future Est.)*
1 (This report)	Design of ***PDA*** (v. 92.2) with Example-Driven Tutorials on DATAPLOT.	Oct. 1991 - Mar. 1992 (6 months). *Total labor (3 investigators) = 16 pers.-wks. 7.0 pers.-wks reimbursed by DOE; rest by NIST.*
2 (Future)	*Prolog Version Conversion (v. 1.4 to 3.0) and Addition of Modules to PDA (v. 93.x).*	*(6-9 months).*
3 (Future)	*Upgrading of PDA (v. 94.x) to include Help Module for Exploratory Data Analysis.*	*(9-12 months).*

What follows is a description of the Phase 1 design specifications and the implementation of the design using micro-PROLOG (v. 1.4) as the programming language and DATAPLOT (v. 92.2) as the primary data analysis software package.

Before we begin the Phase 1 design of PDA as a software re-use project, we need to list the key features of two previous projects named NDD [11] and CFD [12], and compare the listing with those of PDA in order to assess how much of the old codes can be retained and what types of new codes need to be added. The following table summarizes the comparison on a feature-by-feature basis:

Feature	NDD [11]	CFD [12]	PDA	Tutorial
1. DATAPLOT in drive "C".	---	---	Yes (New).	4.1.
2. Expert System in drive "A".	Yes.	Yes.	Yes.	4.2.
3. Generic Applications.	---	Yes.	Yes.	4.3 & 4.5.
4. DOE-Specific Applications.	---	---	Yes (New).	5.1.
5. Menu with Exit to DOS Option.	Yes.	Yes.	Yes.	5.3.
6. Menu with Datafile Partition Option.	---	---	Yes (New).	5.4.
7. Data Input (Indata) by Keyboard.	Yes.	Yes.	Yes.	5.5.
8. Old Data Review or Revise Option.	Yes.	Yes.	Yes.	5.6 & 5.7.

Feature *(Continued)*	NDD [11]	CFD [12]	PDA	Tutorial
9. Selective Deletion of Old Data.	---	---	Yes (New).	5.8.
10. Data Input (Indata) by File.	---	Yes.	Yes.	5.9.
11. Listing of Old Data (Lists).	Yes.	Yes.	Yes.	5.10.
12. Save Input Data in a DOS File.	Yes.	Yes.	Yes.	5.11.
13. Save Input Data as a DATAPLOT File.	---	---	Yes (New).	5.12.
14. Selective Retrieval of Input Data and Save as a DATAPLOT File.	---	---	Yes (New).	5.13.
15. Menu with Analysis Option.	---	Yes.	Yes.	5.14.
16. Analysis with DATAPLOT Option.	---	---	Yes (New).	6.1 - 6.14.
17. Exit with Restart Option.	---	Yes.	Yes.	4.4.
18. Exit with System Code Save Option.	Yes.	Yes.	Yes.	5.2.
19. micro-PROLOG (v. 1.4) code in standard Lisp-like syntax.	Yes.	Yes.	Yes[5].	---
20. micro-PROLOG (v. 1.4) code in modular structure.	No.	No.	No[5].	---

Of the seven new features, two (4 and 6) are required for DOE applications, and four (1, 13, 14, and 16) are DATAPLOT-related. Of the DATAPLOT-related features, one (16) demands most of our time and effort since it is the ease of applying DATAPLOT to the DOE PI Program that lies at the heart of this project. Consequently, we worked very closely with the DOE staff to come up with a design requiring a total of 40 DATAPLOT macros, of which 20 are implemented for Phase 1 as shown below:

Analysis Option	Data File	Phase 1	Phase 2	Tutorial
1. Histogram.	DOE_1COL.DAT	Yes.	Yes.	6.1.
2. Pie Chart.	DOE_2CLB.DAT	Yes.	Yes.	6.2.
3. Pareto Chart.	DOE_2CLB.DAT	Yes.	Yes.	6.3.

[5]Conversion from standard syntax (v. 1.4) to Edinburgh syntax (v. 3.0) and from flat to modular structure are planned for Phase 2 design of PDA. See pp. 7-8 for more details.

Analysis Option	Data File	Phase 1	Phase 2	Tutorial
4. PI Data for 4 quarters and 7 groups.	DOE_3COL.DAT	Yes.	Yes.	6.4.
5. 2D Plot and Linear Fit.	ASTM_2CL.DAT	Yes.	Yes.	6.5.
6. Count Chart or C-Chart.	DOE_2CLA.DAT	Yes.	Yes.	6.6.
7. P-Chart.	DOE_3COL.DAT	Yes.	Yes.	6.7.
8. Lag Plot.	DOE_1COL.DAT	Yes.	Yes.	6.8.
9. Autocorrelation Plot.	DOE_1COL.DAT	Yes.	Yes.	6.9.
10. P-Chart with Modeling-1.	DOE_3COL.DAT	Yes.	Yes.	6.10.
11. P-Chart with Modeling-2.	DOE_3COL.DAT	Yes.	Yes.	6.11.
12. Tests/Box Plot.		No[6].	Yes.	---
13. Tests/Scatter Plot.		No[6].	Yes.	---
14. Tests/Summary-4-Plot.	ASTM_1CL.DAT	Yes.	Yes.	6.12.
15. Tests/Sum'ry Tabulation.	ASTM_1CL.DAT	Yes.	Yes.	6.12.
16. Tests/Lambda Test.	ASTM_1CL.DAT	Yes.	Yes.	6.12.
17. Tests/Weibull Test.	ASTM_1CL.DAT	Yes.	Yes.	6.12.
18. Tests/Extrm. Value Test.	ASTM_1CL.DAT	Yes.	Yes.	6.12.
19. Tests/Box-Cox Transf.	ASTM_1CL.DAT	Yes.	Yes.	6.12.
20. Tests/t-test.		No[6].	Yes.	---
21. Tests/ANOVA.	ASTM_3CL.DAT	Yes.	Yes.	6.13.
22. Tests/Chi-Squared Test.		No[6].	Yes.	---
23. Tests/F-test.		No[6].	Yes.	---
24. Distribut./Normal	ASTM_1CL.DAT	Yes.	Yes.	6.14.
25. Distribut./Uniform		No[6].	Yes.	---
26. Distribut./Logistic		No[6].	Yes.	---
27. Distribut./Cauchy		No[6].	Yes.	---
28. Distribut./Lognormal		No[6].	Yes.	---
29. Distribut./Exponential		No[6].	Yes.	---
30. Distribut./Extrm Value Type 1		No[6].	Yes.	---
31. Distribut./Tukey Lambda		No[6].	Yes.	---
32. Distribut./Students t		No[6].	Yes.	---
33. Distribut./Chi Squared		No[6].	Yes.	---
34. Distribut./Gamma		No[6].	Yes.	---
35. Distribut./Beta		No[6].	Yes.	---
36. Distribut./Weibull	ASTM_1CL.DAT	Yes.	Yes.	6.14.
37. Distribut./Extrm Value Type 2		No[6].	Yes.	---
38. Distribut./Binomial		No[6].	Yes.	---
39. Distribut./Geometric		No[6].	Yes.	---
40. Distribut./Poisson		No[6].	Yes.	---

[6]For Phase 1 design, the DATAPLOT macro for this analysis option is left to the reader as an exercise.

Chapter 4 - Tutorial Notes on *Generic Applications*

In this chapter, we begin a series of tutorials aimed at helping a PC user in becoming proficient in executing the expert system PDA (v. 92.2) as a front end to a data analysis package named DATAPLOT (v. 92.2). We shall begin with a list of minimum requirements:

Hardware	H-1.	80386SX-16 CPU-based Personal Computer (PC).
	H-2.	2MB-RAM.
	H-3.	40MB-Hard Disk.
	H-4.	Mathematical Coprocessor.
	H-5.	1.44-MB 3.5" or 1.2-MB 5.25" high density floppy drive.
	H-6.	VGA or EGA monitor.
Software	S-1.	MS-DOS 3.3 or up; or DR-DOS 5.0 or up.
	S-2.	A proprietary package named OTG/DBOS[7], which is a FORTRAN-77 run time library/virtual memory manager for 386/486 PC's. [Est. Cost: $105.00].
	S-3.	A proprietary Tektronix emulator named PLOTDEV[8], which translates DATAPLOT Tektronix 4014 output to VGA or EGA. [Est. Cost: $50.00].
	S-4.	A public-domain package named DATAPLOT (v. 92.2 or up), available from NIST as described in Section 2 of Appendix D.
	S-5.	A public-domain package named PDA.LOG (v. 3-12-92), six proprietary Prolog system files named APP.MOD, FIGURE.SYS, LINKER.SYS, LOADER.SYS, PROLOG.EXE, PROLOG.SYS[9], and 92 additional files contained in a floppy diskette named 92330FONG-1, available from NIST as described in Appendix A.

Requirements S-1 through S-4 must be properly installed in the hard disk drive "C" before proceeding to the first tutorial of this chapter, Section 4.1.

[7]OTG Systems Inc., P. O. Box 239, Suite 300, Rts. 106 & 374, Clifford, PA 18413-0239 Tel. 717-222-9100.
[8]Microplot System Co., 1897 Red Fern Drive, Columbus, OH 43229 Tel. 614-882-4786.
[9]See page vi for "Note on Prolog Copyrighted Materials & Version Conversion."

Section 4.1 - Preliminary Tasks on Hard Disk Drive "C"

At this point, you must have successfully installed in the hard disk drive "C" not only the operating system (MS-DOS or DR-DOS), but also OTG/DBOS, PLOTDEV, and DATAPLOT. A listing of your drive "C" must show a file named DBOSSWAP and three subdirectories named DATAPLOT, OTG (with 36 files) and PLOTDEV (with 7 files).

Before one can run the DATAPLOT code, one must first activate the memory manager DBOS by rebooting using a specific set of batch files named AUTOEXEC.DP and CONFIG.DP in place of the AUTOEXEC.BAT and CONFIG.SYS currently resident in drive "C". If those two files with extension .DP are not installed in your subdirectory C:\DATAPLOT, you should install them now together with two batch files named DPBOOT.BAT and RSBOOT.BAT as listed below:

AUTOEXEC.DP

```
@ECHO OFF
CLS
PATH=C:\;C:\DOS;C:\DATAPLOT;C:\OTG
PROMPT $P$G
MODE LPT1:,,P
SET DATAPLO$=C:\DATAPLOT\
SETSYS CACHEOFF
DBOS/VDISK
COMSPACE D'100000'
CD D:\DATAPLOT
```

CONFIG.DP

```
FILES=50
BUFFERS=50
DEVICE=C:\PLOTDEV\PLOTDEV.SYS
SHELL=COMMAND.COM /E:288 /P
```

DPBOOT.BAT

```
@ECHO OFF
COPY C:\AUTOEXEC.BAT                C:\AUTOEXEC.JJF
COPY C:\CONFIG.SYS                  C:\CONFIG.JJF
COPY C:\DATAPLOT\AUTOEXEC.DP        C:\AUTOEXEC.BAT
COPY C:\DATAPLOT\CONFIG.DP          C:\CONFIG.SYS
@ECHO ****************************************
@ECHO *  PLEASE MANUALLY REBOOT SYSTEM.  *
@ECHO *  UPON REBOOTING, ENTER  DP       *
@ECHO *  TO EXECUTE DATAPLOT.            *
@ECHO ****************************************
```

RSBOOT.BAT

```
@ECHO OFF
COPY C:\AUTOEXEC.JJF                C:\AUTOEXEC.BAT
COPY C:\CONFIG.JJF                  C:\CONFIG.SYS
KILL_DBOS
@ECHO ****************************************
@ECHO *  PLEASE MANUALLY REBOOT SYSTEM.  *
@ECHO ****************************************
```

PC Hard Disk Drive "C" - *Activating "DATAPLOT"*

```
C:\>   cd DATAPLOT

C:\DATAPLOT>   DPBOOT

        1 File(s) copied
        1 File(s) copied
        1 File(s) copied
        1 File(s) copied
**************************************
*  PLEASE MANUALLY REBOOT SYSTEM.    *
*  UPON REBOOTING,  ENTER   DP       *
*  TO EXECUTE DATAPLOT.              *
**************************************
C:\DATAPLOT>
```

PC Hard Disk Drive "C" - *De-activating "DATAPLOT"*

```
C:\DATAPLOT> rsboot

        1 File(s) copied
        1 File(s) copied
DBOS removed from memory
**************************************
*  PLEASE MANUALLY REBOOT SYSTEM.  *
**************************************
C:\DATAPLOT>
```

PC Hard Disk Drive "C" - *Subdirectory "DATAPLOT"*

```
C:\DATAPLOT> chkdsk/f
Volume  created 11 Oct 1991 4:41

 42,539,008 bytes total disk space
     59,392 bytes in 3 hidden files
    243,712 bytes in 102 directories
 40,890,368 bytes in 1761 user files
  1,345,536 bytes available on disk

    655,360 bytes total memory
    460,736 bytes available


C:\DATAPLOT> dir dataplot.exe

 Volume in drive C is
 Directory of C:\DATAPLOT

DATAPLOT EXE 11843488   2-26-92   7:01p
       1 File(s)   1345536 bytes free
```

Section 4.2 - Activating *PDA* at Floppy Drive "A"

In the last tutorial, we assumed that DATAPLOT has been properly installed in drive "C" and we must first activate the memory manager DBOS before we could run DATAPLOT. In this section, we assume that DBOS has been activated as shown on page 13 and we are ready to activate the expert system PDA by inserting the floppy 92330FONG-1 into drive "A".

Before activating PDA, we have two more system chores to do. The first is to check the compatibility of the COMMAND.COM file in both the floppy 92330FONG-1 and the hard disk. This is done on page 17 by simply copying the COMMAND.COM file in drive "C" onto the floppy 92330FONG-1 as inserted in drive "A". The second is to load the datafiles from the floppy 92330FONG-1 into the harddisk under the subdirectory c:\DATAPLOT. This is accomplished by again using the COPY command as shown below:

Step	Action Item	Screen Display
1	Activate DATAPLOT and insert diskette 92330FONG-1 into floppy drive "a".	c:\DATAPLOT>
2	Type ***copy a:\dpdata*.****	c:\DATAPLOT>copy a:\dpdata*.*
3	Type ***a:*** to change disk drive.	c:\DATAPLOT> a:
4	Type ***pda*** to activate PDA.	a:\> pda
5	Wait for display of PDA menu.	(See p. 18.)

Once you are inside the expert system PDA, you may make a mistake in typing a command and run into a situation where you would like to return to a "ground" state without a permanent exit to DOS. In this regard, we have provided a convenient way for you to do this if you simply type two words separated by a blank character as follows:

6	Type ***be nice*** to return to a "ground" state without exit.	

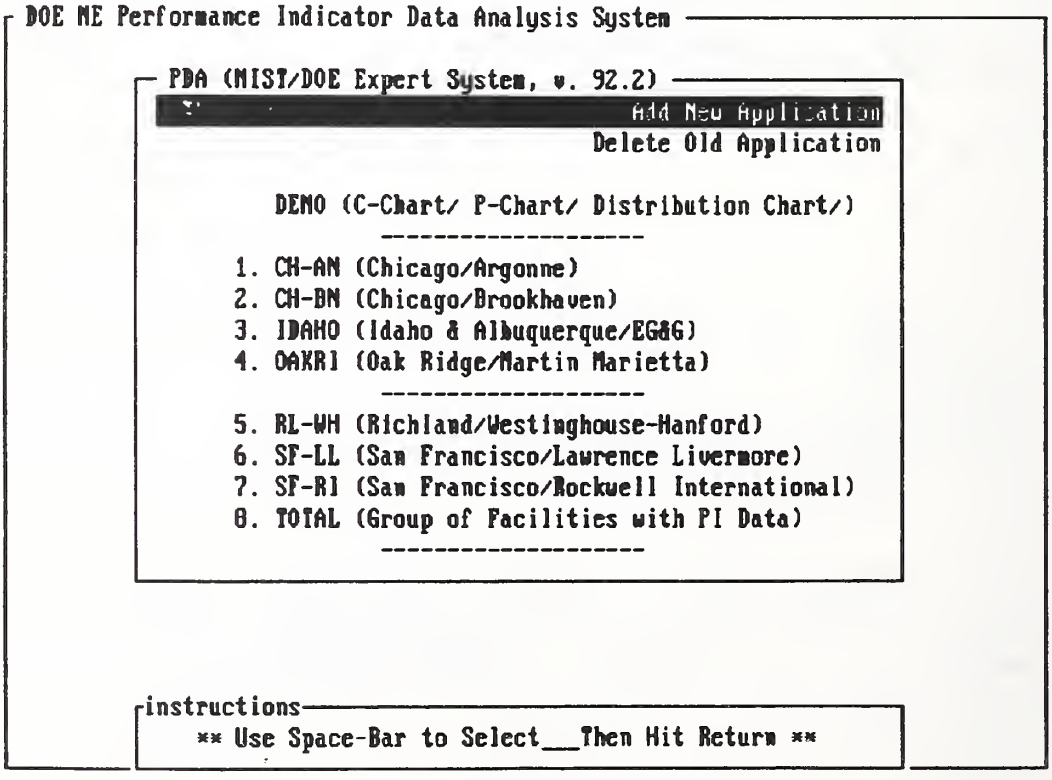
Finally, if step 6 does not work or if you see an error message, the only alternative is to reboot by invoking simultaneously the keys of Control, Alternate, and Delete. A list of some of the most common numbered error messages generated by Micro-Prolog is given on page 19. For a complete list of error messages in Micro-Prolog, the reader is advised to consult pp. C-1 through C-9 of the reference manual by McCabe, et al [38].

PC Floppy Drive "A" - *Copying Command.Com from* Drive "C"

```
C:\>   dir command.com

 Volume in drive C is
 Directory of C:\

COMMAND  COM    32496   8-14-90   5:00a
       1 File(s)   1306624 bytes free


C:\>   copy command.com a:
       1 File(s) copied


C:\>   dir a:command.com

 Volume in drive A is 92226-FOMG5
 Directory of A:\

COMMAND  COM    32496   8-14-90   5:00a
       1 File(s)    597504 bytes free
```

PC Floppy Drive "A" - *Activating Expert System PDA*

```
C:\DATAPLOT> a:
A:\> pda


LPA PROLOG Professional Interpreter 1.4 - 02 Feb 1987
Copyright (c) 1987 - Logic Programming Associates Ltd
64446 Evl, 8190 Num, 63488 Txt, 256000 Prg Bytes Free

&
```



Micro-Prolog Error Messages - Selected List

According to McCabe, et al [38], there are three types of errors in LPA PROLOG Professional: numbered errors, message errors and initialization errors. A definition of each of the three types and a list of some of the most commonly occurring errors with messages are listed below:

Numbered Errors — These are the errors that can occur while a PROLOG program is running, and can be recovered from by LPA PROLOG Professional programs using the user defined error handler "?ERROR?".

3 **Control Error.** The built-in primitives in LPA PROLOG Professional often require a minimum number of arguments to be bound at the time of the call. If the arguments to a call to such a primitive are underspecified, this error occurs. The error is also signalled if the evaluation encounters any goal which is not of the correct form, such as a number, or list without a constant as its first element.

5 **File Handling Error.** This error is signalled when an error arises during a file operation. For example, if you try to open a file using a filename which is also the name of a program relation you will get this error. Other examples include creating a file that is already open, trying to SEEK to one of the special files like "TRM:", or performing an i/o operation with an unopened file.

7 **Files Open on Drive.** You will get this error if you try to change the current drive (using the DRIVE primitive) with files on the current disk still open. It is a good idea to call DRIVE before changing disks to check that there are no files left open on the current one.

8 **Path Not Found.** This error occurs when you specify an invalid path name. For example, it occurs if you try to change directory to a non-existent directory.

10 **Disk or Directory Full.** You get this error if the disk becomes full, or no more directory space is available for a new file.

16 **Window Handling Error.** This error occurs when there is an illegal use of windows. It occurs if you try to create a window with a name that already refers to a defined relation, or a currently loaded module, or an open file, or another window. It also occurs if you attempt to CLOSE the current window.

18 **Not Enough Memory.** This occurs when there is no program memory left. Program memory is external to PROLOG, and is used not only for program storage, but also for the window buffers, and by EXEC to execute other programs. Progrm memory is distinct from the evaluation space (which is used for evaluating queries). This error will occur when there is insufficient memory to create a window, or to all a clause, or to EXEC a command.

25 **Fixed Format Error.** The formatted I/O primitives (FW, FR and FS) invoke this error when the type of terms conflict with the format specification, or when an output field is too narrow for the term being written.

Message Errors — Except for the "Internal Error", which should never occur (see below), these errors are a result of one of the internal memory areas becoming full. When these errors occur, a message is displayed and the evaluation aborts. Message errors can not be recovered because any recovery program would probably need to use more of the memory resource that was already full and had signalled the error.

Internal Error hhhh, **Trying** ppppp: **Exit to DOS (y/n)?**

Internal Error hhhh, **Trying** ppppp: **Exit to DOS (y/n)?**

This error should not normally arise, and occurs when LPA PROLOG Professional detects an internal inconsistency within the system. It may mean that a vital internal data structure has been corrupted, or that DOS has returned an unexpected error code after a file operation. Note that a four digit hexadecimal address hhhh is given stating where the error was discovered, and usually so is the name of the program ppppp that signalled the error.

Initialization Errors Before LPA PROLOG Professional can begin to execute commands and queries, a number of internal initialization must be carried out. These include loading the supervisor programs, setting up window, edit and file buffers, and moving relocatable code to appropriate places in memory. Any errors that occur duing the initialization process lead to a short diagnostic message fllowing by a "System Abort" to DOS. Examples of these errors are:

Not Enough Memory For PROLOG - System Abort

This self explanatory message is issued whenever PROLOG is unable to obtain enough memory to install its data areas. Possible remedies are: start again, but rquest less evaluation, number, text and/or buffer space; check there are no memory-resident programs (Sidekick, Ram Disk Software, etc.) using up too much memory, or buy more RAM(!).

Error During DOS Memory Allocation - System Abort

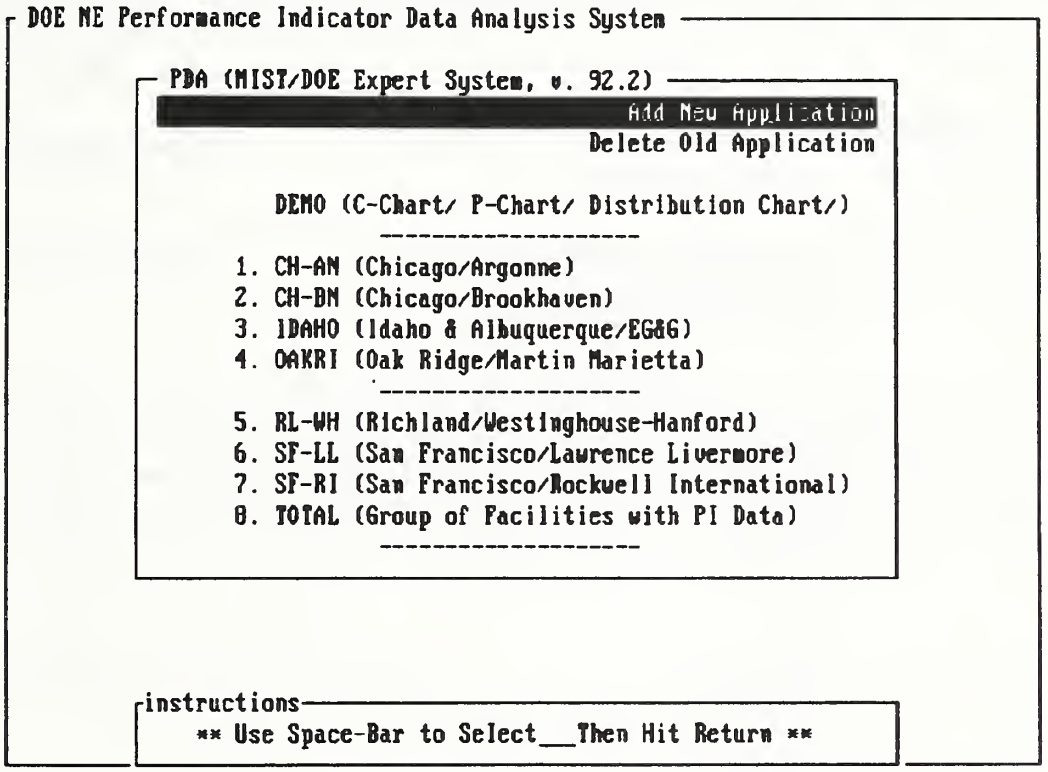
This error occurs when DOS is unable to allocate blocks of memory for the supervisor programs, and is related to the "Not Enough Memory" error. Remedies are the same.

Section 4.3 - Add a New Application of *PDA*

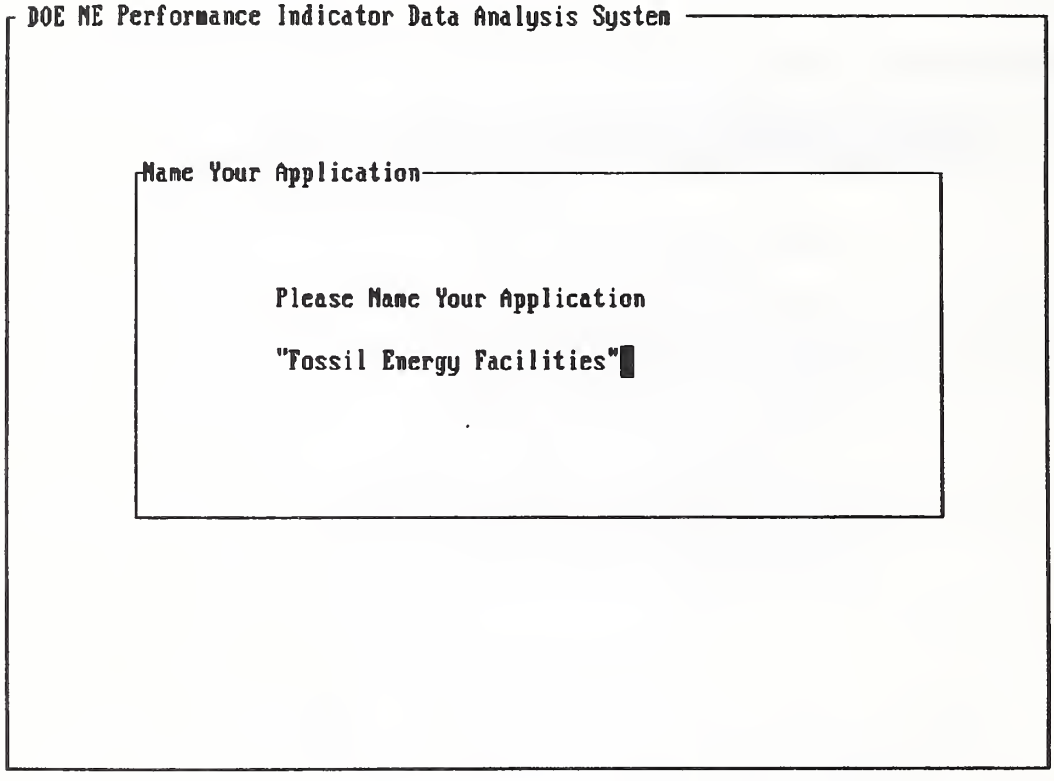
At the last tutorial, we learned how to activate the expert system PDA on drive "A". If you wish to activate PDA on a floppy drive named "B", you need to request a different version of the floppy 92330FONG-1 because the Prolog code for PDA explicitly identifies which floppy drive the code PDA.LOG resides.

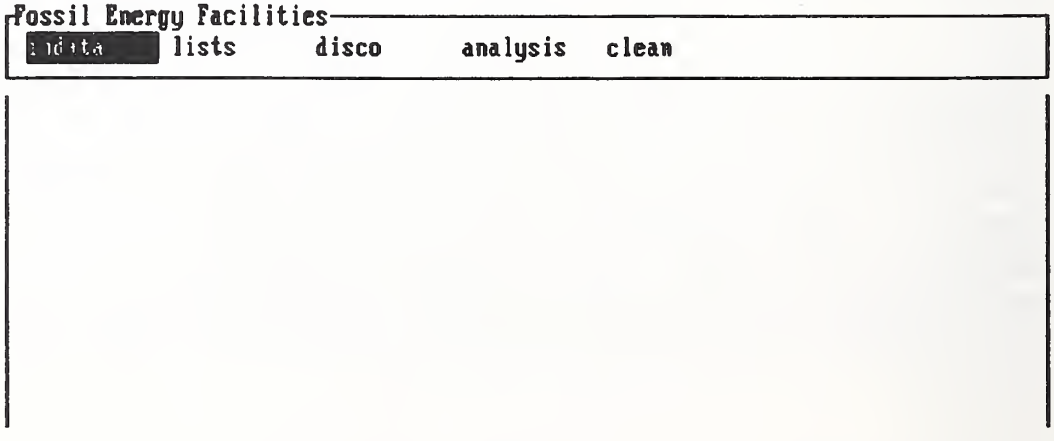
Once you enter the PDA system, you will see a menu on the screen as shown on page 21. Please read the instructions on the bottom of the screen where it says "Use Space-Bar to Select___Then Hit Return." If you wish to add a new application, you may do so with a carriage return because the cursor (the black strip) is already on the option "Add New Application." On page 22, you will be asked to name your application. Please use quotation marks if your application name consists of more than one word. Otherwise, you may type in a word and hit the carriage return to activate a 5-option menu as shown on the bottom of page 22. You have now created a brand new empty database named "Fossil Energy Facilities."

PDA Menu for *Generic Applications*



PDA Menu for *Generic Applications* - *Continuation Sheet*





Section 4.4 - *Exit* or *Re-start* from Old Application of *PDA*

At the last tutorial, we learned how to create a new application of PDA by creating a database named "Fossil Energy Facilities." We now wish to leave the database by either returning to floppy drive "A" (a permanent exit), or go back to the opening menu (re-start). As shown on page 24, we need to learn how to move the cursor within or outside the window. The ground rules are:

Within a window	Rule R-1:	Use Space-Bar to change option, and use Backspace to negate the change.
Choose an option	Rule R-2:	Use Carriage-Return to activate a new window under a chosen option, and use the Escape Key to negate.

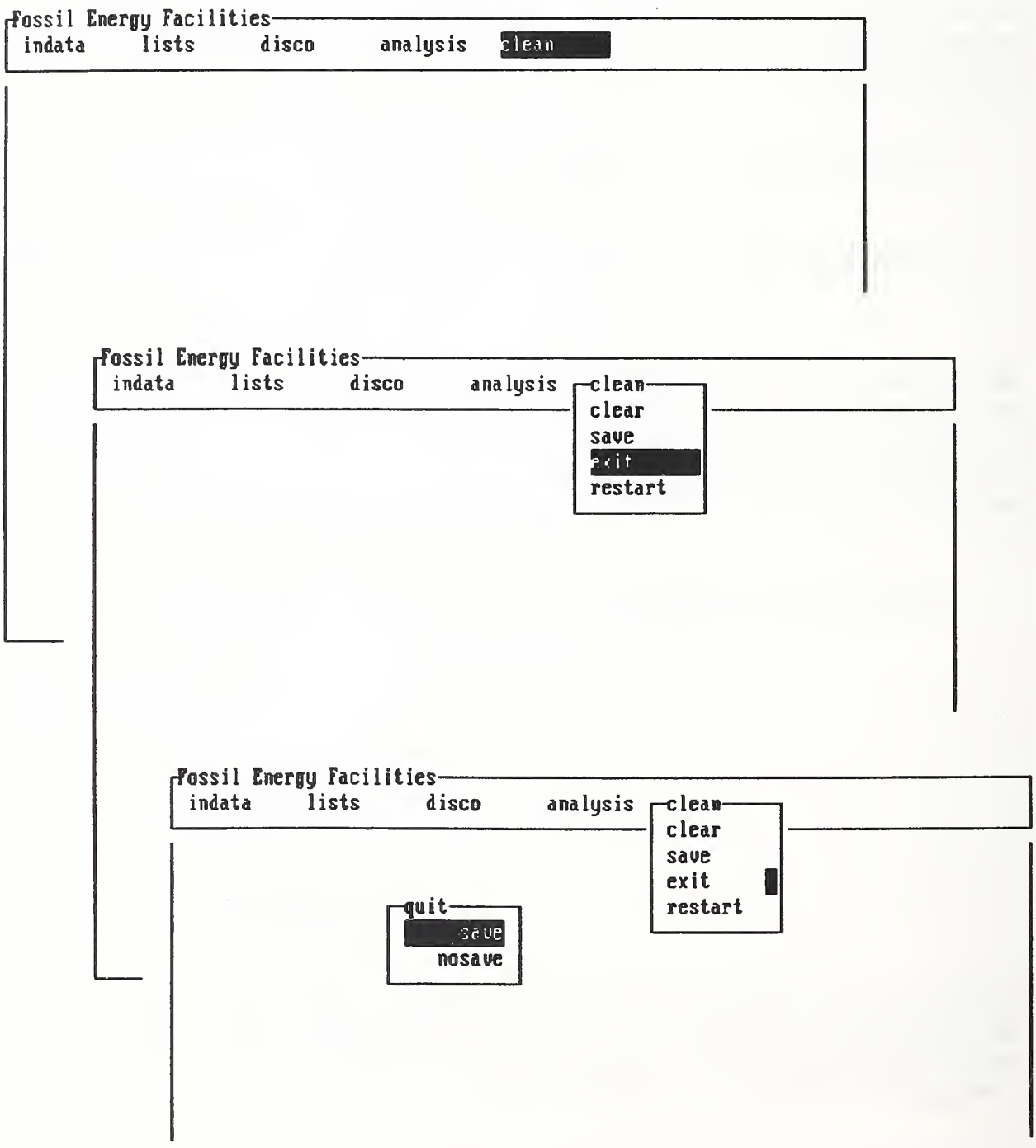
Let us try those two rules to learn how to exit or re-start from an old application of PDA. As shown in the top frame on page 24, we have just used the Space-Bar four times to move from the cursor from the option "indata" to the option "clean." We next use the Carriage-Return to activate a new window under the option "clean." We are now faced with four choices. One of the four is the option "exit." So to exit from PDA and return to floppy drive "A", one needs to

Exit to Drive "A" without Save

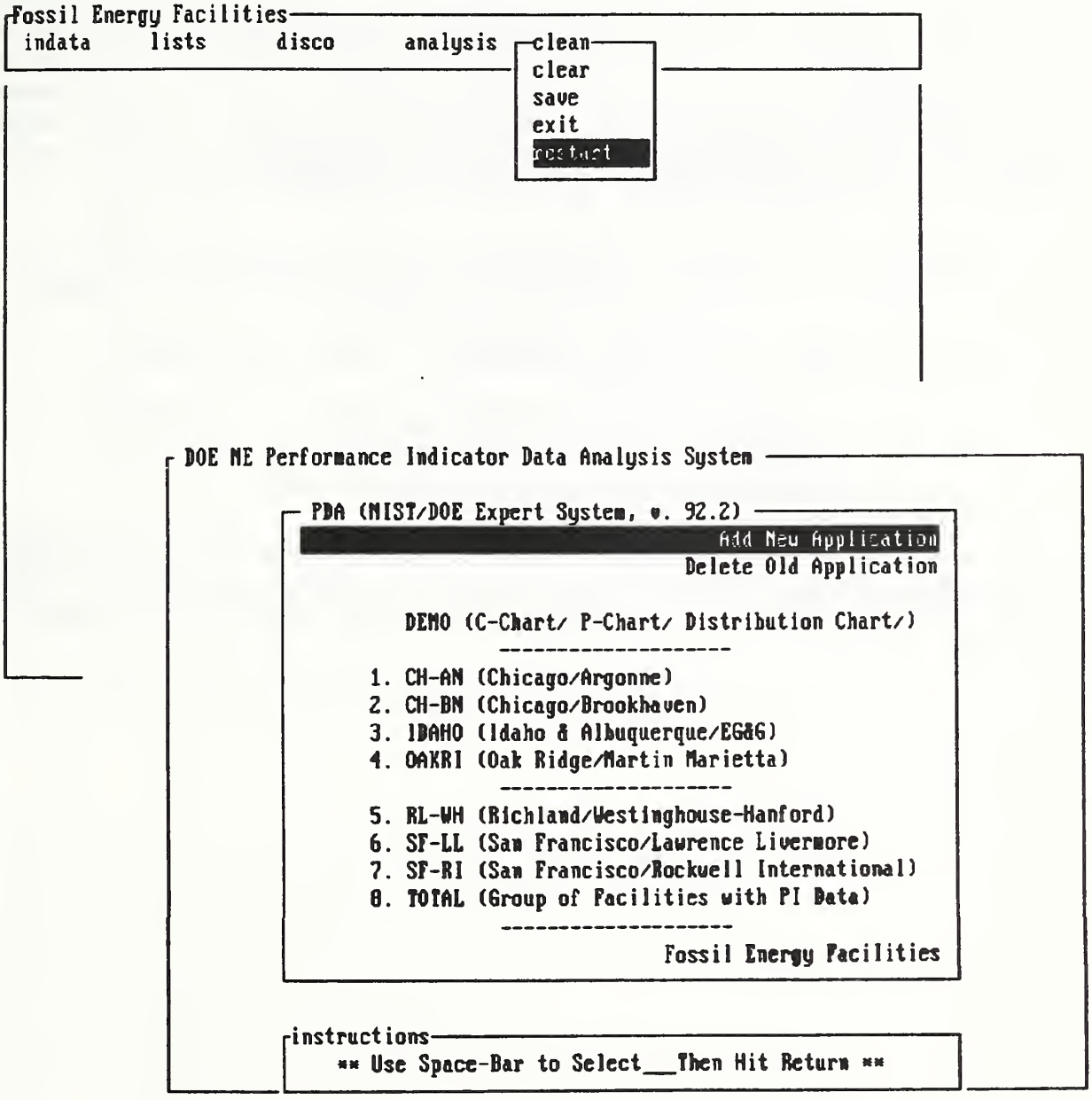
1. Use Space-Bar twice to move the cursor to the option "exit."
2. Use Carriage-Return to activate another window with two choices, namely, "save" or "nosave."
3. Use Space-Bar once to move the cursor to the option "nosave."
4. Use Carriage-Return to exit permanently to floppy drive "A".

If you do not wish to exit permanently, do not take step 4. Instead, use Escape Key to negate the window named "quit" and return to the window named "clean." When your cursor is active in the window named "clean", move it to the option "restart" as shown on page 25, and hit Carriage-Return to return to the opening menu.

PDA Menu for *option clean*



PDA Menu for *option clean* - *Continuation Sheet*



Section 4.5 - Delete an Old Application of *PDA*

At the last tutorial, we learned how to return to the opening menu where a new entry named "Fossil Energy Facilities" has just been added. We now wish to learn how to delete an old application. On page 27, we note that we have added two applications to the opening menu, namely, "Fossil Energy Facilities" and "Solar Energy Facilities." Our goal is to delete the "Fossil Energy Facilities." To do that, use the Space-Bar to move the cursor to the option named "Delete Old Application." Use the Carriage-Return to active a window named "Application to Delete." This window consists of two frames with the first one given on the top half of page 28. Read the instructions on the bottom of the first frame, which say:

1. Move arrow with space-bar or backspace key. The second frame will show up if one moves the arrow down far enough as shown on the lower half of page 28.

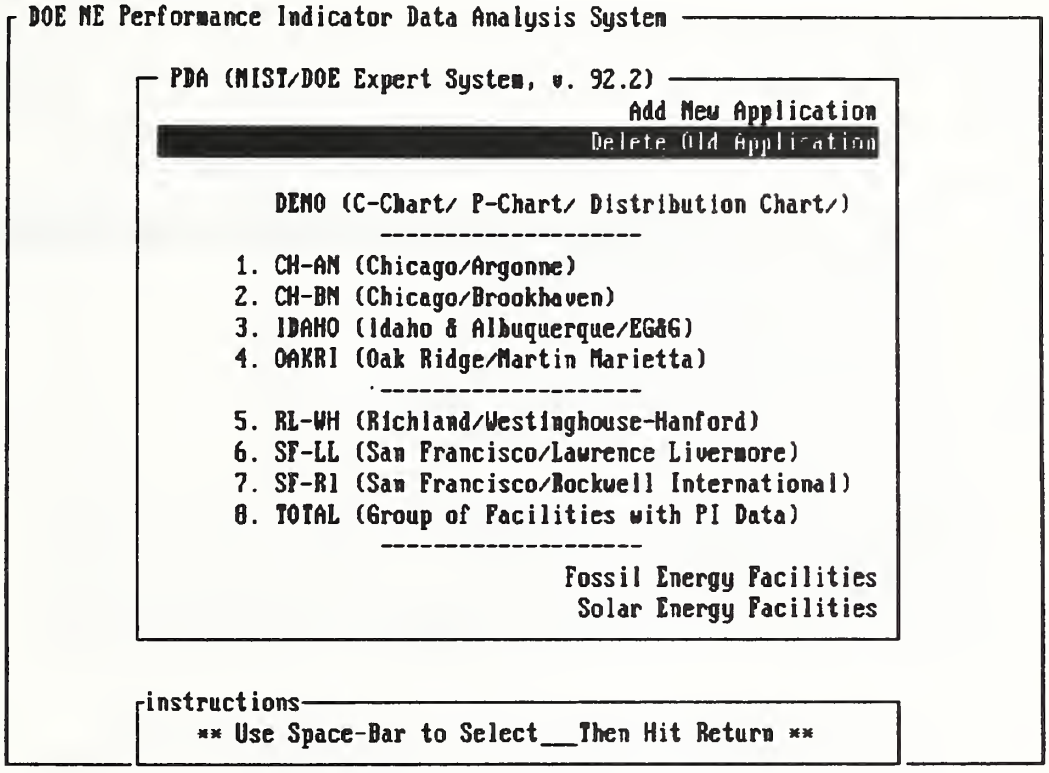
2. Select by hitting the plus sign on the keyboard. A black strip will appear.

3. De-select by hitting the minor sign. The cursor (black strip) will disappear.

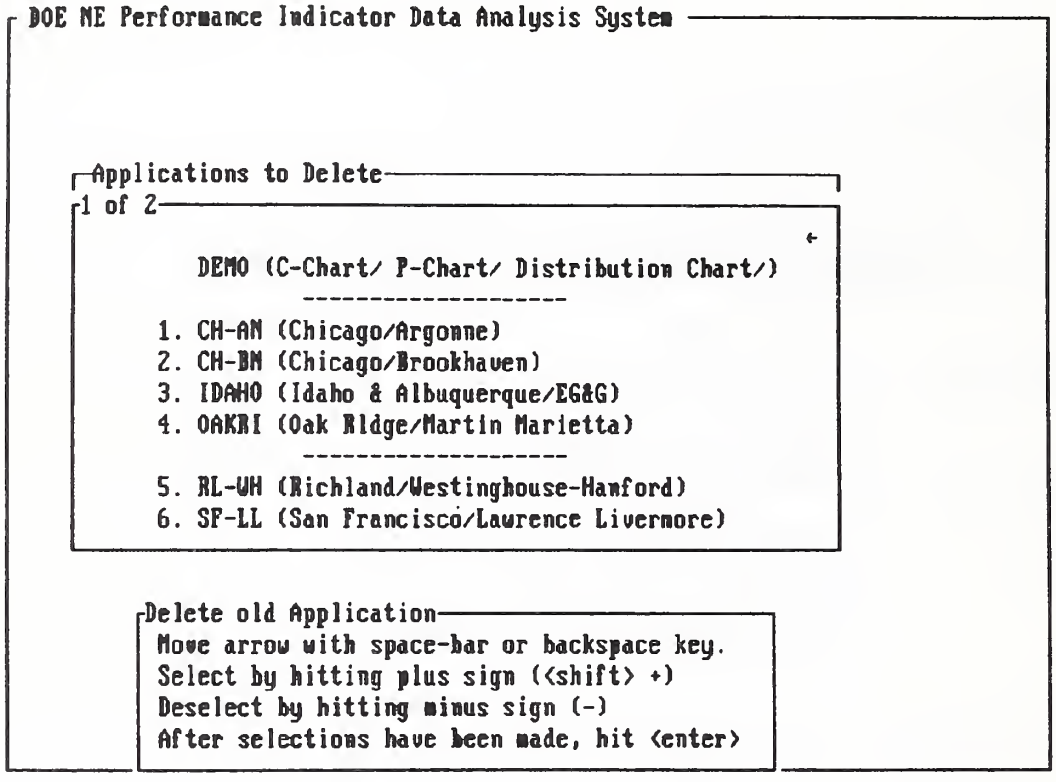
4. After selection(s) are made, hit the Carriage-Return to delete.

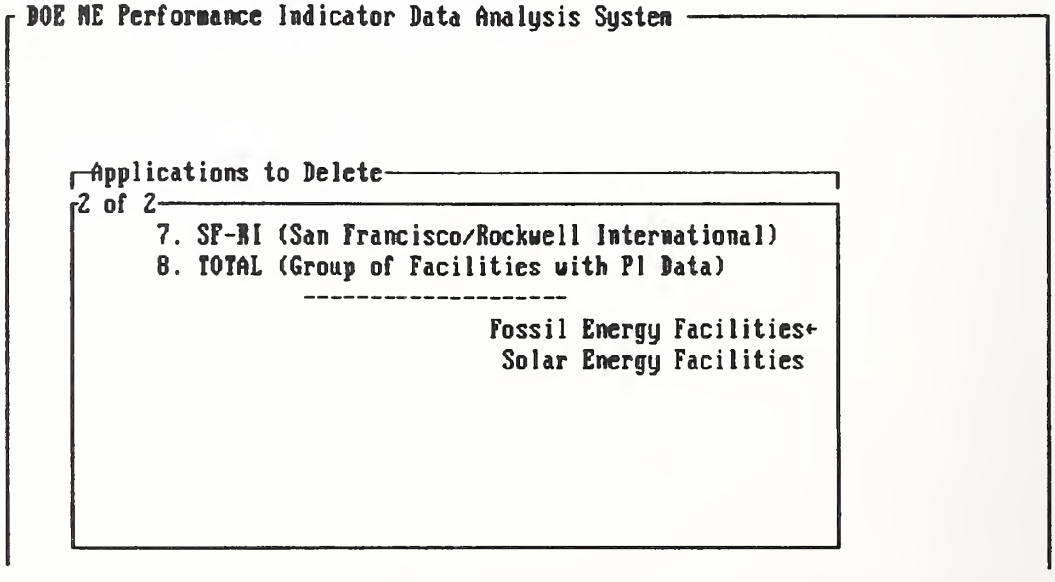
You will note, as shown on the bottom half of page 29, that the database named "Fossil Energy Facilities" has been deleted. Repeat the same procedure to remove the database named "Solar Energy Facilities," and you will end up with the original opening menu as shown on pages 19 and 30.

PDA Menu for *Generic Applications*

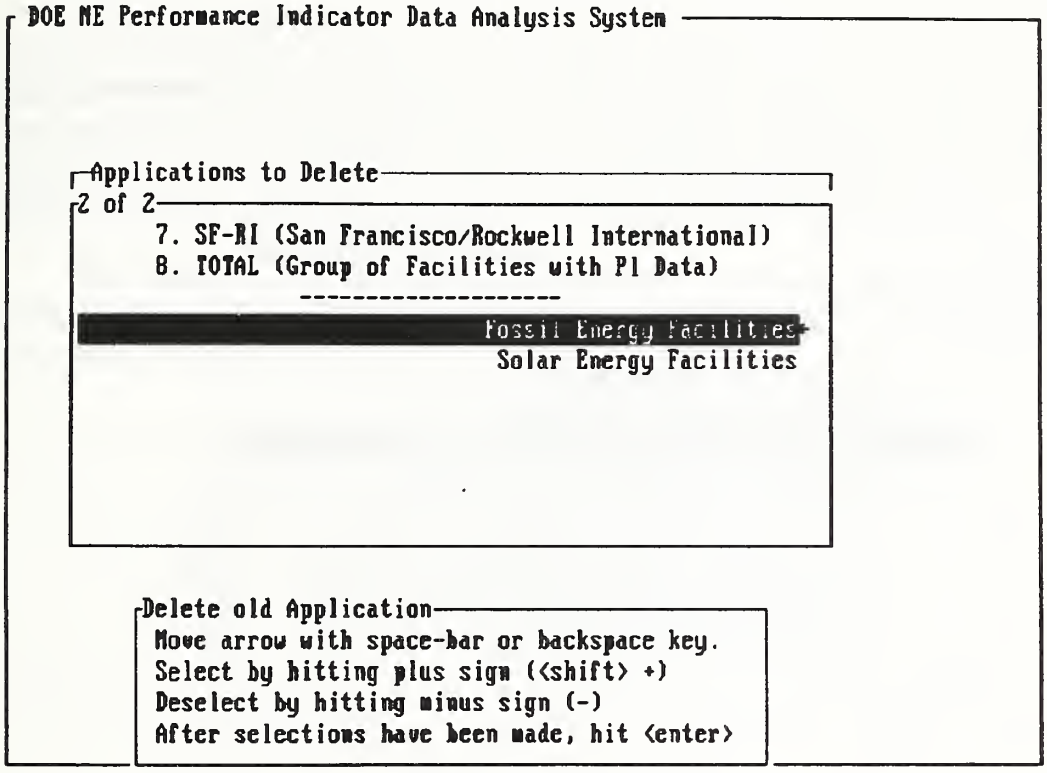


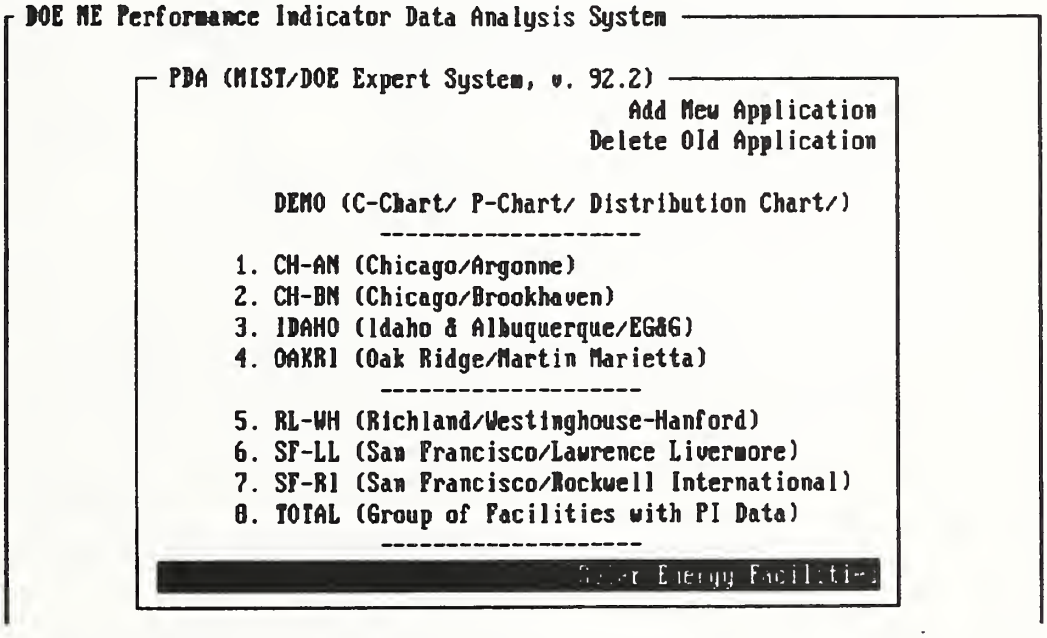
PDA Menu for *Generic Applications* - *Continuation Sheet*



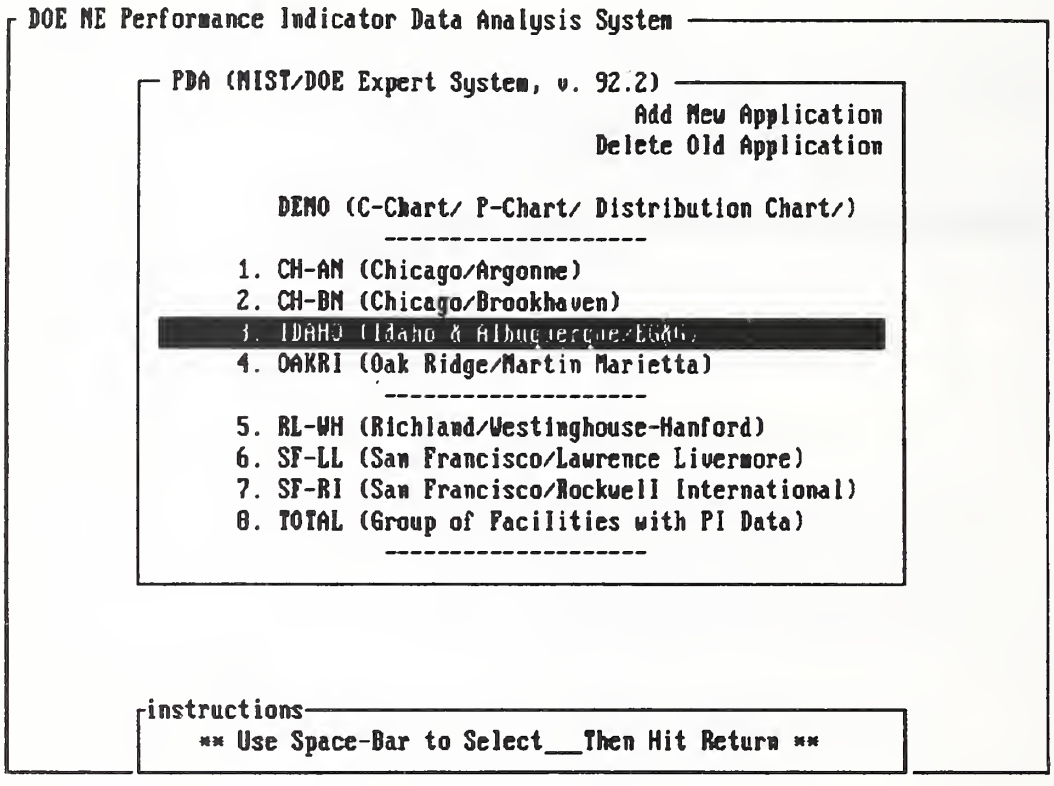


PDA Menu for *Generic Applications* - *Continuation Sheet*





PDA Menu for *Generic Applications* - *Continuation Sheet*



Chapter 5 - Tutorial Notes on *DOE Applications*

In the last chapter, we learned how to create and delete a database that has nothing in it except a name given by a user. In this chapter, we shall learn how to input data and generate files that eventually can be processed by analysis codes for specific purposes. Since this project arose from a consulting request from the U. S. Department of Energy (DOE), we shall design the tutorials around the DOE applications even though everything we say here applies to a non-DOE application.

To begin with, let us examine the contents of a specific datafile diskette [15] that we received on Nov. 1, 1991 as part of a series of DOE documents. A listing of the diskette and a one-page note accompanying the diskette are given below:

```
        4 File(s)    1297408 bytes free
 Directory of A:\
 Volume in drive A does not have a label
PIQTR1    LST     62632   10-23-91    9:40a
PIQTR1T   LST      8461   10-23-91    9:39a
PIQTR2    LST     80274   10-23-91    9:41a
PIQTR2T   LST      7831   10-23-91    9:39a


NE PI DATA - Quarters 1 & 2

FIELD            FORMAT      DESCRIPTION
---------------  -------     ---------------------------------
TABLE            9(1)        PI data (1) or Root cause data (2)
YEAR             9(2)        Year
QUARTER          9(1)        Quarter
FIELD-OFFICE     A(4)        Field Office
CONTRACTOR       A(4)        Contractor
FACILITY         A(4)        Facility
PINO             9(4)        PI Number
PIVALUE          9(8).9(10)  PI Value

-------------------------------------------------------------------
NOTES

- Files PIQTR1.LST & PIQTR2.LST contain all facilities data.

- Files PIQTR1T.LST & PIQTR2T.LST contain IDAHO & OAK RIDGE totals
  only.  This is the field office data.

- Table 1 is for PI data, Table 2 is for root causes corresponding
  to table 1.

- PIs with no data values were not submitted by field office
```

Notes on DOE datafile diskette (continued):

```
TABLE 1

- PINO field Corresponds to actual PI Number - Example: PI 1.1 = 1100
  with the exception of PIs 1.5,1.6,4.4,4.5.

  For these PIs,    PI 1.5.1 = 1520
                    PI 1.5.2 = 1530
                    PI 1.6.1 = 1620
                    PI 4.4.1 = 4420
                    PI 4.4.2 = 4430
                    PI 4.5.1 = 4520
                    PI 4.5.2 = 4530

- PI 3.2.2/3220 is expressed in thousands, so multiply the data
  value by 1000.
-------------------------------------------------------------------
TABLE 2

- PINO field Corresponds to actual PI Number, and type of root cause.

  Example - PI 1.4 Root cause Material   = 1410
                   Root cause Procedures = 1420
                   Root cause Personnel  = 1430
                   Root cause Management = 1440
                   Root cause Design     = 1450
                   Root cause Training   = 1460
                   Root cause Other      = 1470
```

To design a datafile for DOE applications, we need to examine the row and column structure of a typical collection of data in the given diskette. The following is a character-by-character display of a typical row of data extracted from the file named PIQTR1.LST:

```
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5

1 _ 9 1 _ 1 _ CH _ ANLW _ EB R_ _ 1 5 3 0 _ _ _ _ _ 9 6 9 8 8 . 0 0 0 0 0 0 0 0 0 0

1 _ 9 1 _ 1 _ I D _ EG&G _ AMCF _ 1 5 3 0 _ _ _ _ _ _ 1 8 2 0 . 0 0 0 0 0 0 0 0 0 0
```

Of the 8 fields of values displayed above in each row, the first 6 can be lumped together to identify the table, year, quarter, field-office, contractor, and facility corresponding to all the PI numbers (field no. 7) and their values (field no. 8). The total number of characters occupied by the first 6 fields equals 19 and will be treated in our typical file design as a single column of 19 ascii characters to be retrieved as a single variable X. The second column of our typical file will be reserved for the PI number (4-character) and will be retrieved as the variable Y. The third column under the variable Z is designed to store the PI value with a maximum of 20 characters including ten places of decimals, the decimal point, eight digits between 1 and 99,999,999, and a sign. With a single space separating X, Y, and Z, the width of each row of data becomes (19 + 1 + 4 + 1 + 20) or 45, the same width assigned to each row of data in the DOE diskette. For a complete list of the definitions and units of the PI numbers reported by DOE facilities, see pp. ix-x of this report.

Section 5.1 - *Activating* DOE Application *3. IDAHO*

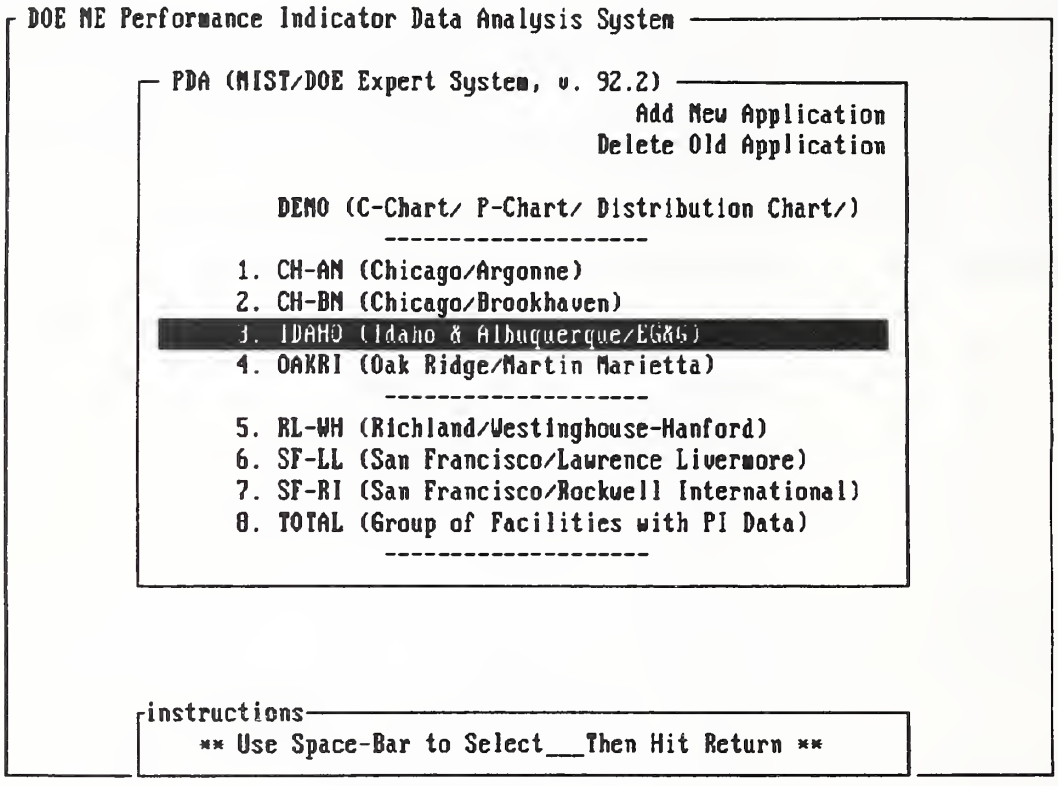
The data files furnished by DOE on Nov. 1, 1991 [15] contain PI data for 23 facilities as reported by 7 contractors for the first and second quarters of 1991. To implement the database feature of the expert system PDA, we follow a naming convention for the 7 contractors and 23 facilities as described on page viii of this report. A two-layer approach is used to satisfy the initial database requirements of this system. The first layer is known as "Application", and the second, the "Database". As shown on the next page, the opening menu of the expert system PDA provides 9 applications for a DOE user:

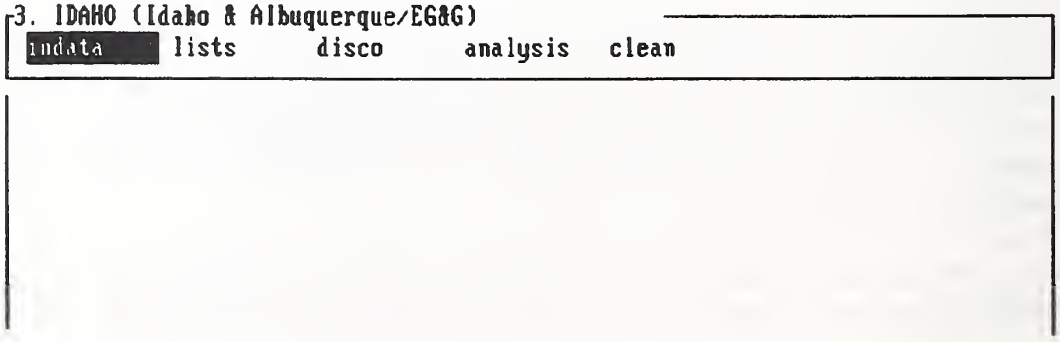
Application No.	Application Title	(City / Contractor's Name)
	DEMO	(C-Chart / P-Chart / Distribution Chart)
F1	CH-AN	(Chicago / Argonne)
F2	CH-BN	(Chicago / Brookhaven)
F3	IDAHO	(Idaho / Albuquerque / EG&G)
F4	OAKRI	(Oak Ridge / Martin Marietta)
F5	RL-WH	(Richland / Westinghouse-Hanford)
F6	SF-LL	(San Francisco / Lawrence Livermore)
F7	SF-RI	(San Francisco / Rockwell International)
8	TOTAL	(Group of Facilities with PI Data)

Note that we created the first application named DEMO specifically to generate a series of temporary databases for learning how to make the three charts required by DOE for reporting the PI data. We then created seven more applications, one for each contractor, for the Phase-1 design of the expert system PDA. After we received a new set of DOE data on Jan. 29, 1992 [16], we modified the design by adding an additional application named TOTAL to facilitate the creation of special databases containing PI data of DOE facilities not necessarily grouped under a single contractor. For aesthetic reasons, we also dropped the prefix "F" in the application numbers F1 through F7.

We are now ready to select a specific application to begin a series of tutorials on PDA. Two keys are used in accomplishing this task: the space-bar to move the cursor and the carriage-return to select. The bottom figure on page 34 shows the result of selecting Application 3.

PDA Menu for *DOE Applications*





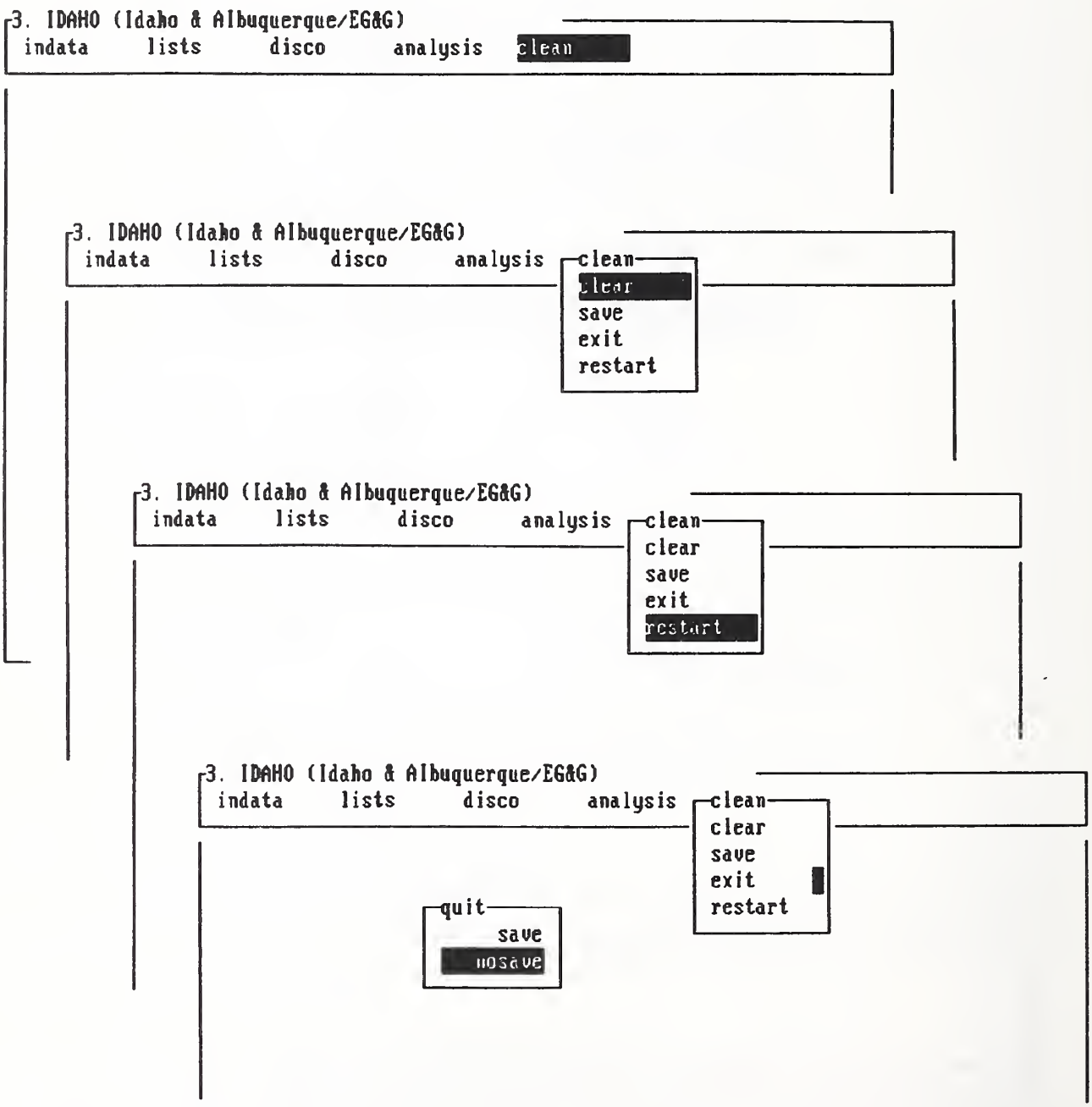
Section 5.2 - *Exit* or *Re-start* from DOE Application *3. IDAHO*

Let us review all the steps we have gone through so far as a DOE user:

Section	Action Item	Screen Display
4.1	1. Turn computer on.	C:\>
	2. Change directory to DATAPLOT.	C:\> cd dataplot C:\DATAPLOT>
	3. Prepare to activate DBOS.	C:\DATAPLOT> dpboot 1 File(s) copied 1 File(s) copied 1 File(s) copied 1 File(s) copied ********** * PLEASE MANUALLY REBOOT SYSTEM.* * UPON REBOOTING, ENTER DP * * TO EXECUTE DATAPLOT. * ********** C:\DATAPLOT>
	4. Control-Alternate-Delete.	C:\DATAPLOT>
4.2	1. Insert diskette 92330FONG-1 in drive "a" and change drive to "a".	C:\DATAPLOT> a: A:\>
	2. Check compatibility on command.com	A:\> copy c:\command.com
	3. Activate expert system PDA.	A:\> pda
		Opening Menu (page 34 top)
5.1	1. Select Application 3. IDAHO.	5-option Bar Menu (page 34 bottom)

As shown on p. 36, we learn how to exit from IDAHO by choosing the "clean" option with the use of the space-bar key. We then use the carriage-return key to bring out a submenu consisting of 4 options, namely, clear, save, exit, and restart. Move the curser to restart and use carriage-return to return to the opening menu. Try a different application and then practice "exit".

PDA Menu for *option clean*



Section 5.3 - *Temporary Access to DOS* using *option disco*

In Sections 5.1 and 5.2, we learned how to enter and leave a DOE application by using the option "clean" in the 5-option bar menu. In this section, we shall learn how to use the option "disco" to make a temporary exit to DOS.

As shown on page 38, we can use the space-bar to move the cursor to the option "disco". We then use the carriage-return key to open up a submenu consisting of five options:

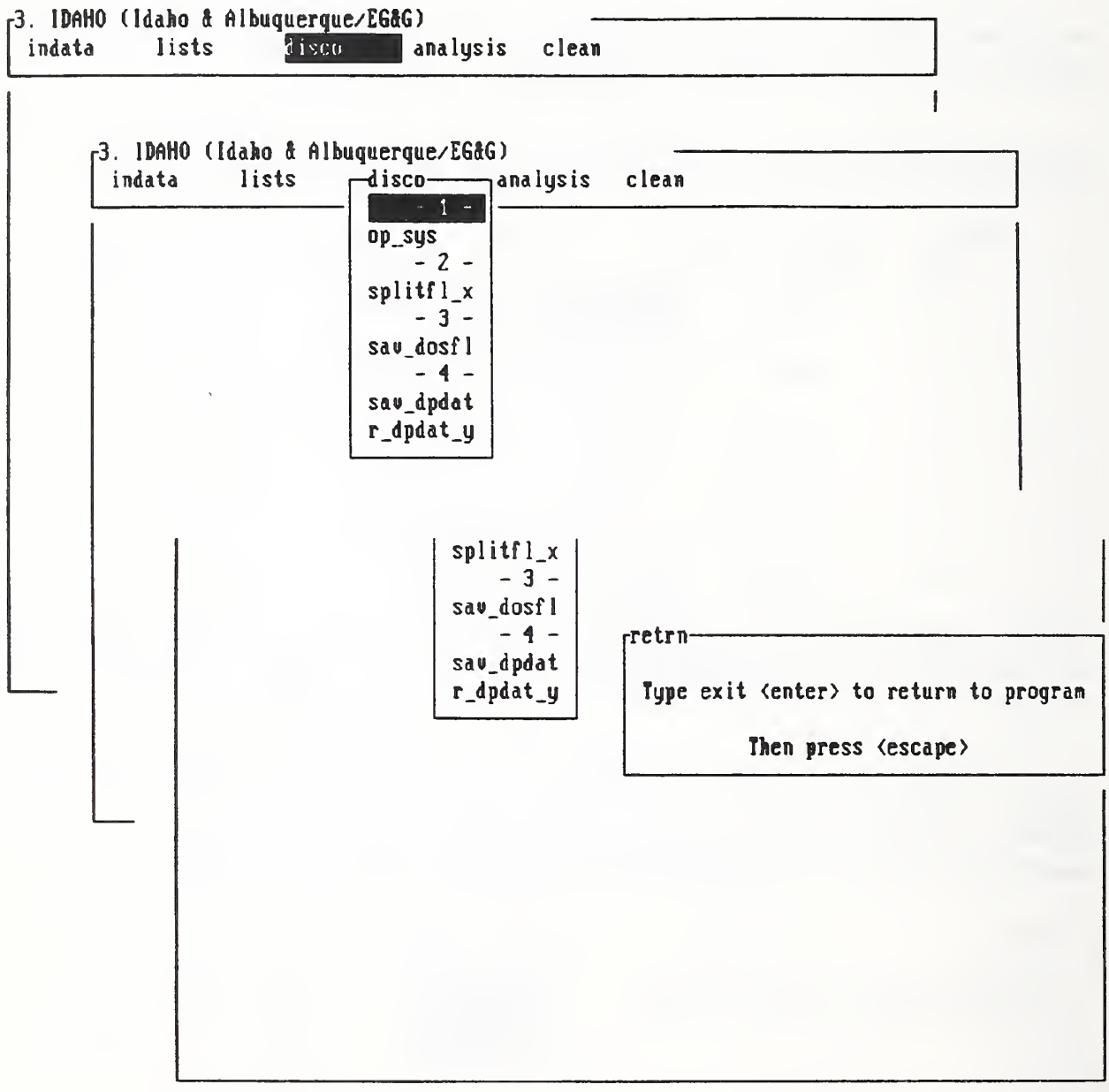
Option	Name of Option	Remarks	Section
1	op_sys	Temporary access to DOS.	(5.3)
2	splitfl_x	File partitioning for common X.	(5.4)
3	sav_dosfl	File save as a dos file.	(5.11)
4a	sav_dpdat	File save as a dataplot file.	(5.12)
4b	r_dpdat_y	File save for common Y.	(5.13)

To activate the first option, we use the space-bar to move the cursor to the option named op_sys and then use the carriage-return to leave PDA for DOS. The result of this maneuver is shown on page 39 where a dispaly of the drive "a" is given on the lower left corner of the screen.

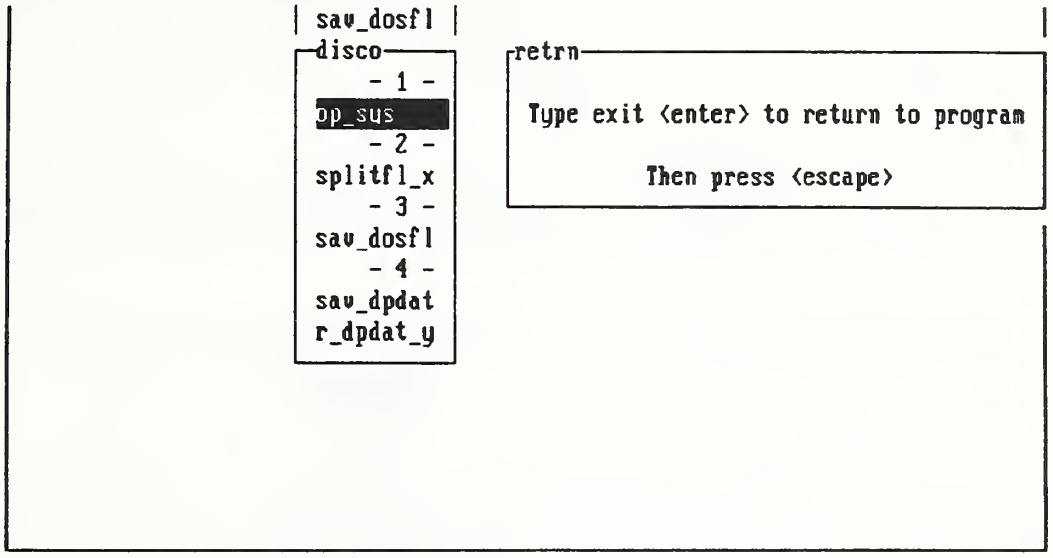
To return to PDA, type exit (see page 39). Use the <ESCAPE> key to clean up the screen. To activate any option in the window menu of PDA, remember to use the carriage-return to open up a new menu, and use <ESCAPE> to close the submenu just opened. In short, let us review the four most important keys in running an expert system:

Goal	Name of Key	Function of Key
Choose an option within a window.	SPACE-BAR	Move cursor forward.
	BACKSPACE	Move cursor backward.
Open or close a window.	CARRIAGE-RETURN	Open up a submenu.
	ESCAPE	Close a submenu.

PDA Menu for *option disco*



PDA Menu for *option disco* - *Continuation Sheet*




```
DR DOS Release 5.0
Copyright (c) 1976,1982,1988,1990 Digital Research Inc. All rights reserved.
Arima Computer Corporation

A:\>
A:\>  exit
```

Section 5.4 - *DOE Data File Partitioning* using *option disco*

On page 31, we learned from the DOE diskette that the files PIQTR1.LST and PIQTR2.LST contain two tables of data, one for PI data and the other for root cause data, as reported by all 23 facilities for the first and second quarters of 1991, respectively. Our task here is to learn how to break each file down first into 14 subfiles, one for each of the two tables and 7 contractors, and then into as many smaller files as there are facilities operated by each contractor such that each smaller file contains the PI data for just a single facility.

In writing the partitioning subroutine in Micro-Prolog, we discovered a system limitation in file management, i.e., Prolog code can only handle filenames of length up to eight characters and without the 3-character extension. Consequently we have to rename the two DOE files as follows:

Original Name of DOE File	New Name of DOE File for Prolog Code	
PIQTR1.LST	PIQTR1_X	(See p. 187).
PIQTR2.LST	PIQTR2_X	(See p. 187).

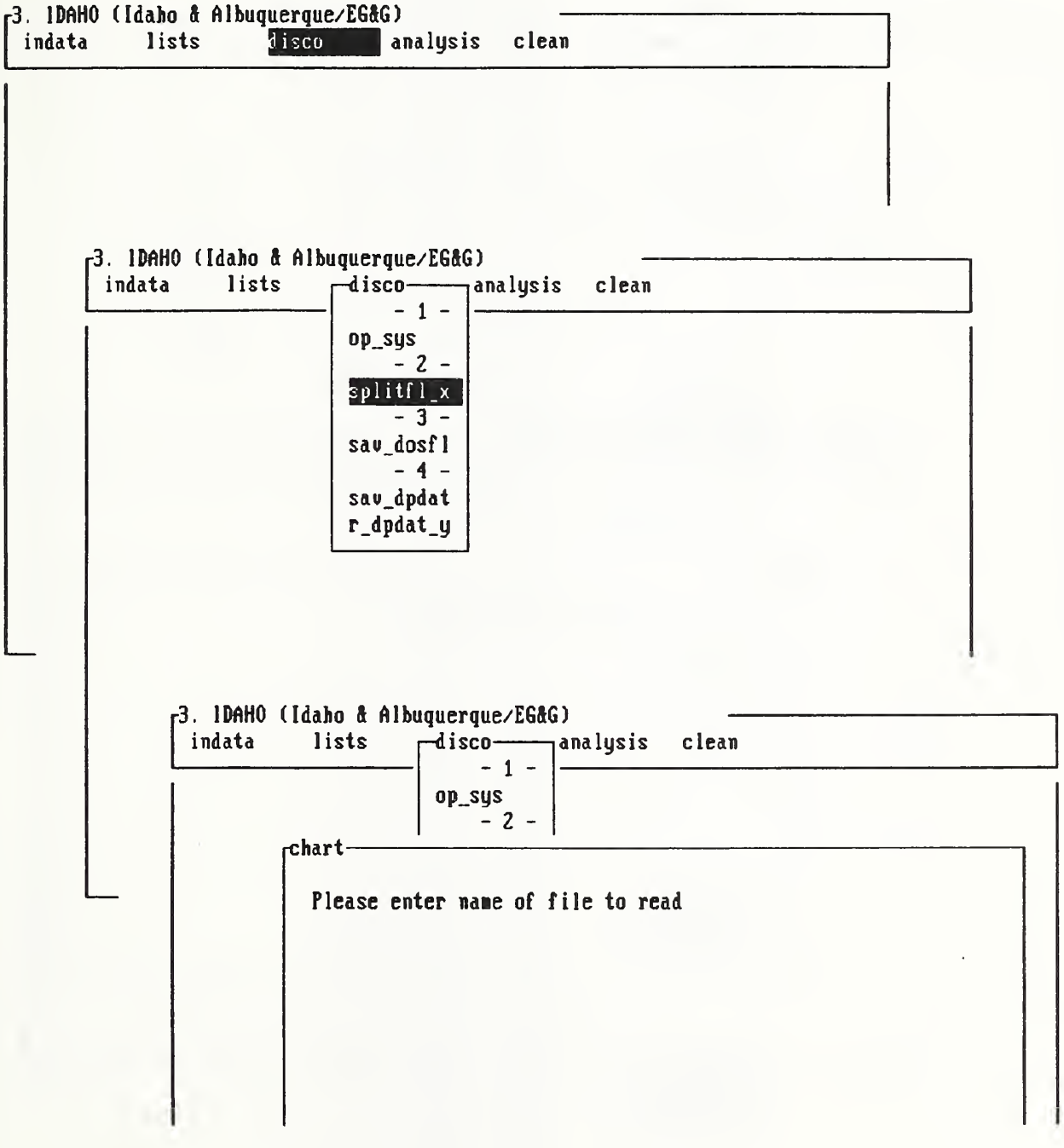
We also found that because of the large size of the DOE files, it is not efficient time-wise to use a Prolog subroutine to perform the first of the two partitioning tasks, namely, the breaking-down of the original DOE file into 14 contractor-and-table-specific files.

To illustrate this, we used a word processing editor to partition the 1991 first quarter DOE file PIQTR1_X into 14 subfiles as follows:

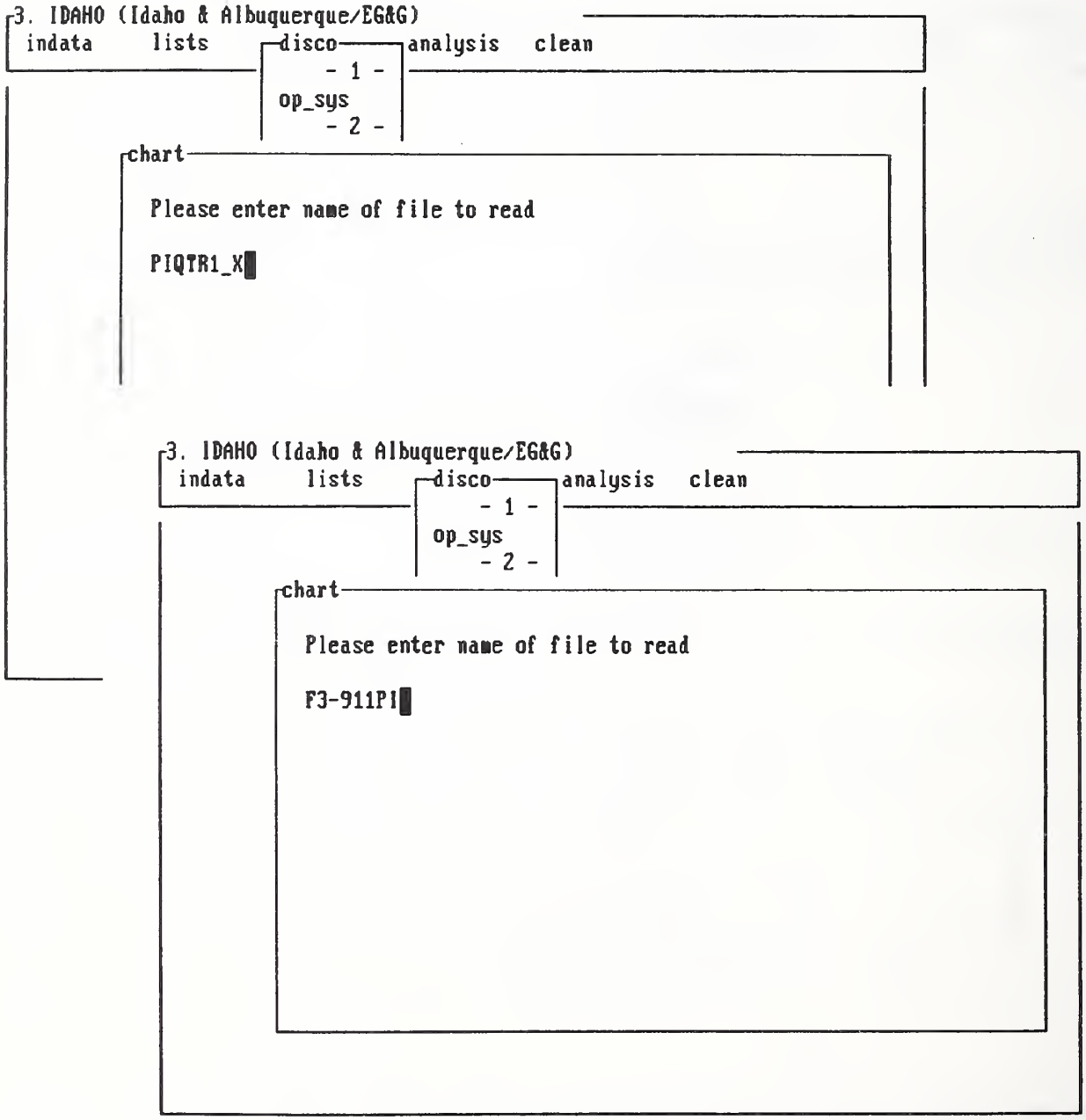
Name of DOE File	Name of Subfile	Name of Contractor	Type of Data
PIQTR1_X	F1-911PI	Chicago/Argonne	PI Data
	F1-911RC	Chicago/Argonne	Root Cause Data.
	F2-911PI	Chicago/Brookhaven	PI Data
	F2-911RC	Chicago/Brookhaven	Root Cause Data.
	F3-911PI	Idaho/Albuquerque/EG&G	PI data
	F3-911RC	Idaho/Albuquerque/EG&G	Root Cause Data
	etc.		

We then used the sub-option "splitfl_x" under the option "disco" to partition each subfile into smaller files as shown on pp. 41-49 for a subfile named F3-911PI. The smaller files were named F31-91-1, F32-91-1, etc. to allow the creation of databases corresponding to each facility under consideration. On pp. 50-55, we did the same for subfile F3-912PI.

PDA Menu for *option disco*



PDA Menu for *option disco* - *Continuation Sheet*



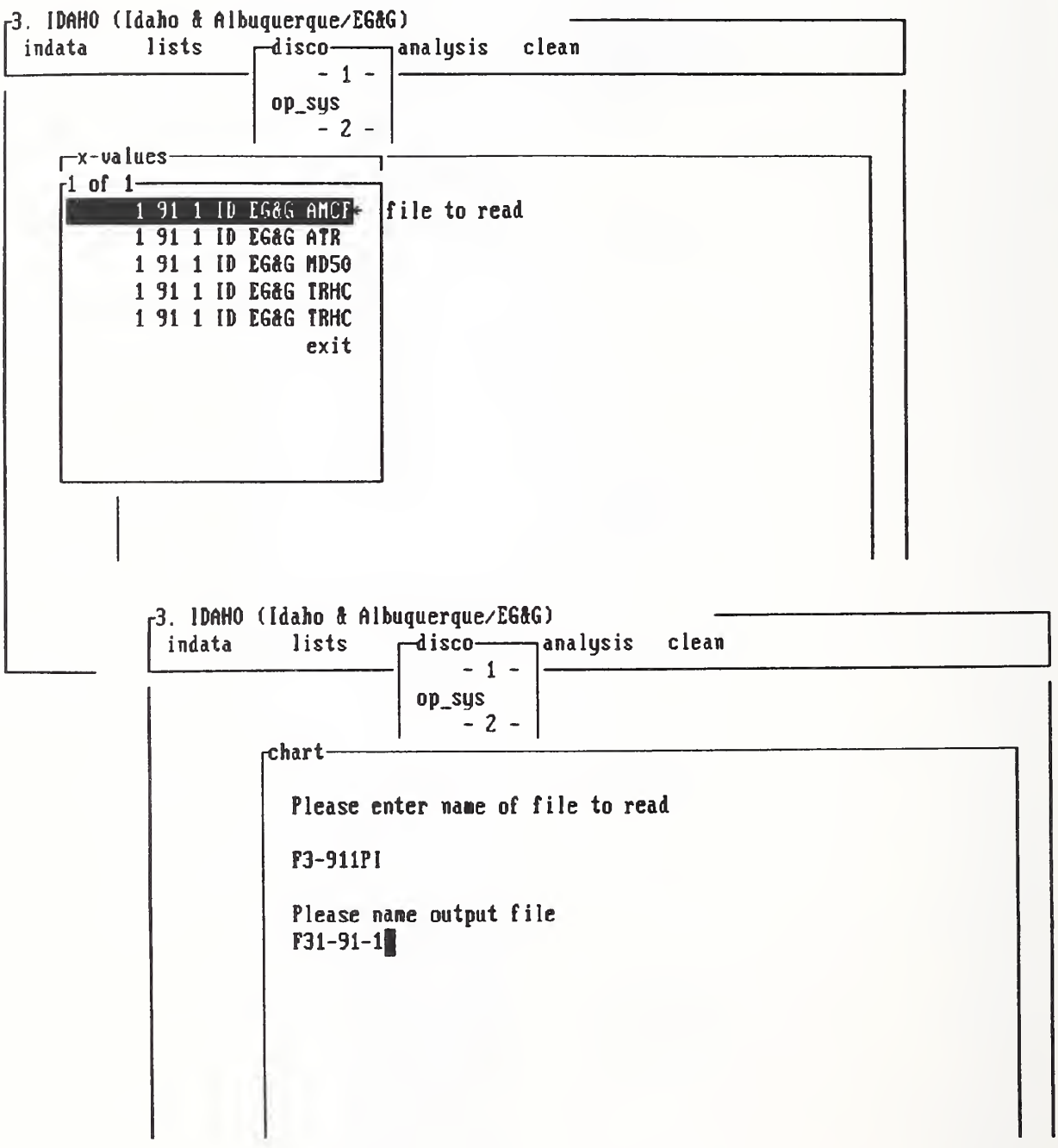
Sample DOE Data - Filename: F3-911PI

```
1 91 1 ID EG&G AMCF 1100
1 91 1 ID EG&G AMCF 1200
1 91 1 ID EG&G AMCF 1300
1 91 1 ID EG&G AMCF 1400
1 91 1 ID EG&G AMCF 1520
1 91 1 ID EG&G AMCF 1530       1820.0000000000
1 91 1 ID EG&G AMCF 1620
1 91 1 ID EG&G AMCF 2100
1 91 1 ID EG&G AMCF 2200
1 91 1 ID EG&G AMCF 2300          1.0000000000
1 91 1 ID EG&G AMCF 2400         38.0000000000
1 91 1 ID EG&G AMCF 2500
1 91 1 ID EG&G AMCF 2600          1.0000000000
1 91 1 ID EG&G AMCF 3110
1 91 1 ID EG&G AMCF 3120
1 91 1 ID EG&G AMCF 3210
1 91 1 ID EG&G AMCF 3220
1 91 1 ID EG&G AMCF 4100
1 91 1 ID EG&G AMCF 4200
1 91 1 ID EG&G AMCF 4300          4.0000000000
1 91 1 ID EG&G AMCF 4420         10.0000000000
1 91 1 ID EG&G AMCF 4430         14.0000000000
1 91 1 ID EG&G AMCF 4520          1.0000000000
1 91 1 ID EG&G AMCF 4530          1.0000000000
1 91 1 ID EG&G AMCF 4600
1 91 1 ID EG&G AMCF 4711         68.0000000000
1 91 1 ID EG&G AMCF 4712
1 91 1 ID EG&G AMCF 4713         68.0000000000
1 91 1 ID EG&G AMCF 4721
1 91 1 ID EG&G AMCF 4722
1 91 1 ID EG&G AMCF 4723
1 91 1 ID EG&G AMCF 4731
1 91 1 ID EG&G AMCF 4732
1 91 1 ID EG&G AMCF 4733
1 91 1 ID EG&G ATR  1100          6.4500000000
1 91 1 ID EG&G ATR  1200          1.0000000000
1 91 1 ID EG&G ATR  1300
1 91 1 ID EG&G ATR  1400
1 91 1 ID EG&G ATR  1520
1 91 1 ID EG&G ATR  1530     128347.0000000000
1 91 1 ID EG&G ATR  1620
1 91 1 ID EG&G ATR  2100
1 91 1 ID EG&G ATR  2200
1 91 1 ID EG&G ATR  2300
1 91 1 ID EG&G ATR  2400
1 91 1 ID EG&G ATR  2500          4.0000000000
1 91 1 ID EG&G ATR  2600          2.0000000000
1 91 1 ID EG&G ATR  3110        932.0000000000
1 91 1 ID EG&G ATR  3120         49.9000000000
1 91 1 ID EG&G ATR  3210
1 91 1 ID EG&G ATR  3220
1 91 1 ID EG&G ATR  4100
1 91 1 ID EG&G ATR  4200
1 91 1 ID EG&G ATR  4300         17.0000000000
1 91 1 ID EG&G ATR  4420         28.0000000000
1 91 1 ID EG&G ATR  4430         69.0000000000
1 91 1 ID EG&G ATR  4520          5.0000000000
1 91 1 ID EG&G ATR  4530        197.0000000000
1 91 1 ID EG&G ATR  4600
```

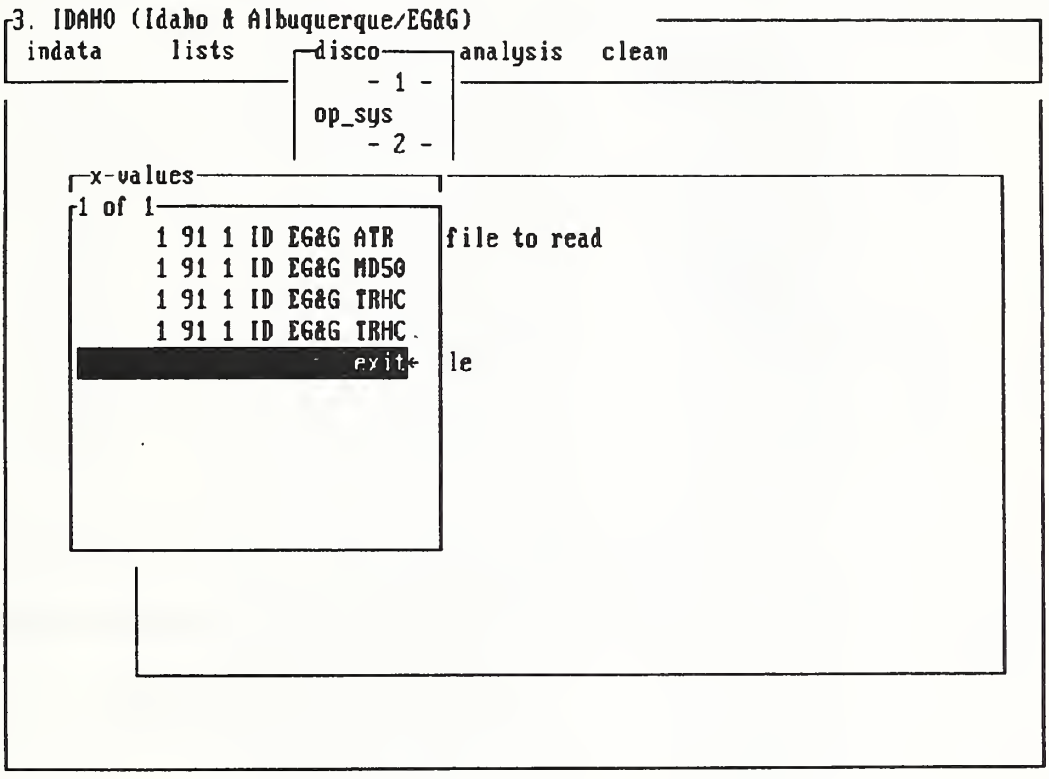
1	91	1	ID	EG&G	ATR 4711	1885.8000000000
1	91	1	ID	EG&G	ATR 4712	
1	91	1	ID	EG&G	ATR 4713	1885.8000000000
1	91	1	ID	EG&G	ATR 4721	
1	91	1	ID	EG&G	ATR 4722	
1	91	1	ID	EG&G	ATR 4723	
1	91	1	ID	EG&G	ATR 4731	
1	91	1	ID	EG&G	ATR 4732	
1	91	1	ID	EG&G	ATR 4733	
1	91	1	ID	EG&G	MD50 1100	.1900000000
1	91	1	ID	EG&G	MD50 1200	
1	91	1	ID	EG&G	MD50 1300	
1	91	1	ID	EG&G	MD50 1400	
1	91	1	ID	EG&G	MD50 1520	
1	91	1	ID	EG&G	MD50 1530	
1	91	1	ID	EG&G	MD50 1620	
1	91	1	ID	EG&G	MD50 2100	
1	91	1	ID	EG&G	MD50 2200	3.0000000000
1	91	1	ID	EG&G	MD50 2300	
1	91	1	ID	EG&G	MD50 2400	
1	91	1	ID	EG&G	MD50 2500	
1	91	1	ID	EG&G	MD50 2600	
1	91	1	ID	EG&G	MD50 3110	
1	91	1	ID	EG&G	MD50 3120	
1	91	1	ID	EG&G	MD50 3210	
1	91	1	ID	EG&G	MD50 3220	
1	91	1	ID	EG&G	MD50 4100	
1	91	1	ID	EG&G	MD50 4200	
1	91	1	ID	EG&G	MD50 4300	
1	91	1	ID	EG&G	MD50 4420	5.0000000000
1	91	1	ID	EG&G	MD50 4430	12.0000000000
1	91	1	ID	EG&G	MD50 4520	
1	91	1	ID	EG&G	MD50 4530	62.0000000000
1	91	1	ID	EG&G	MD50 4600	
1	91	1	ID	EG&G	MD50 4711	
1	91	1	ID	EG&G	MD50 4712	
1	91	1	ID	EG&G	MD50 4713	
1	91	1	ID	EG&G	MD50 4721	
1	91	1	ID	EG&G	MD50 4722	
1	91	1	ID	EG&G	MD50 4723	
1	91	1	ID	EG&G	MD50 4731	
1	91	1	ID	EG&G	MD50 4732	
1	91	1	ID	EG&G	MD50 4733	
1	91	1	ID	EG&G	TRHC 1100	.5000000000
1	91	1	ID	EG&G	TRHC 1200	
1	91	1	ID	EG&G	TRHC 1300	
1	91	1	ID	EG&G	TRHC 1400	
1	91	1	ID	EG&G	TRHC 1520	
1	91	1	ID	EG&G	TRHC 1530	2508.0000000000
1	91	1	ID	EG&G	TRHC 1620	
1	91	1	ID	EG&G	TRHC 2100	
1	91	1	ID	EG&G	TRHC 2200	
1	91	1	ID	EG&G	TRHC 2300	
1	91	1	ID	EG&G	TRHC 2400	7.0000000000
1	91	1	ID	EG&G	TRHC 2500	
1	91	1	ID	EG&G	TRHC 2600	1.0000000000
1	91	1	ID	EG&G	TRHC 3110	.0000000000
1	91	1	ID	EG&G	TRHC 3120	
1	91	1	ID	EG&G	TRHC 3210	
1	91	1	ID	EG&G	TRHC 3220	
1	91	1	ID	EG&G	TRHC 4100	
1	91	1	ID	EG&G	TRHC 4200	
1	91	1	ID	EG&G	TRHC 4300	
1	91	1	ID	EG&G	TRHC 4420	
1	91	1	ID	EG&G	TRHC 4430	1.0000000000

```
1 91 1 ID EG&G TRHC 4520          1.0000000000
1 91 1 ID EG&G TRHC 4530          4.0000000000
1 91 1 ID EG&G TRHC 4600
1 91 1 ID EG&G TRHC 4711        268.0000000000
1 91 1 ID EG&G TRHC 4712
1 91 1 ID EG&G TRHC 4713        268.0000000000
1 91 1 ID EG&G TRHC 4721
1 91 1 ID EG&G TRHC 4722
1 91 1 ID EG&G TRHC 4723
1 91 1 ID EG&G TRHC 4731
1 91 1 ID EG&G TRHC 4732
1 91 1 ID EG&G TRHC 4733
```

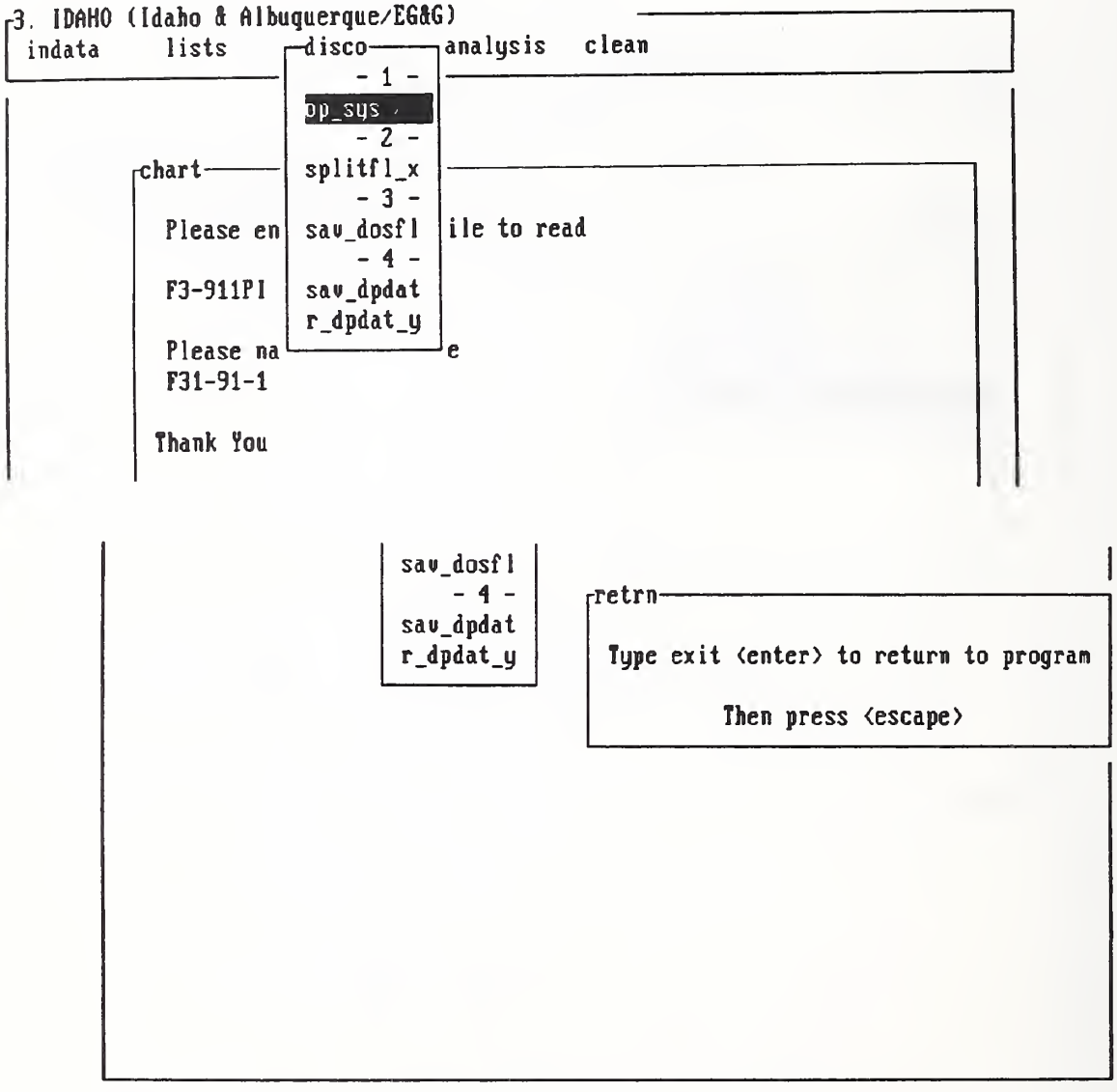
PDA Menu for *option disco* - *Continuation Sheet*



PDA Menu for *option disco* - *Continuation Sheet*



PDA Menu for *option disco* - *Continuation Sheet*



DR DOS Release 5.0
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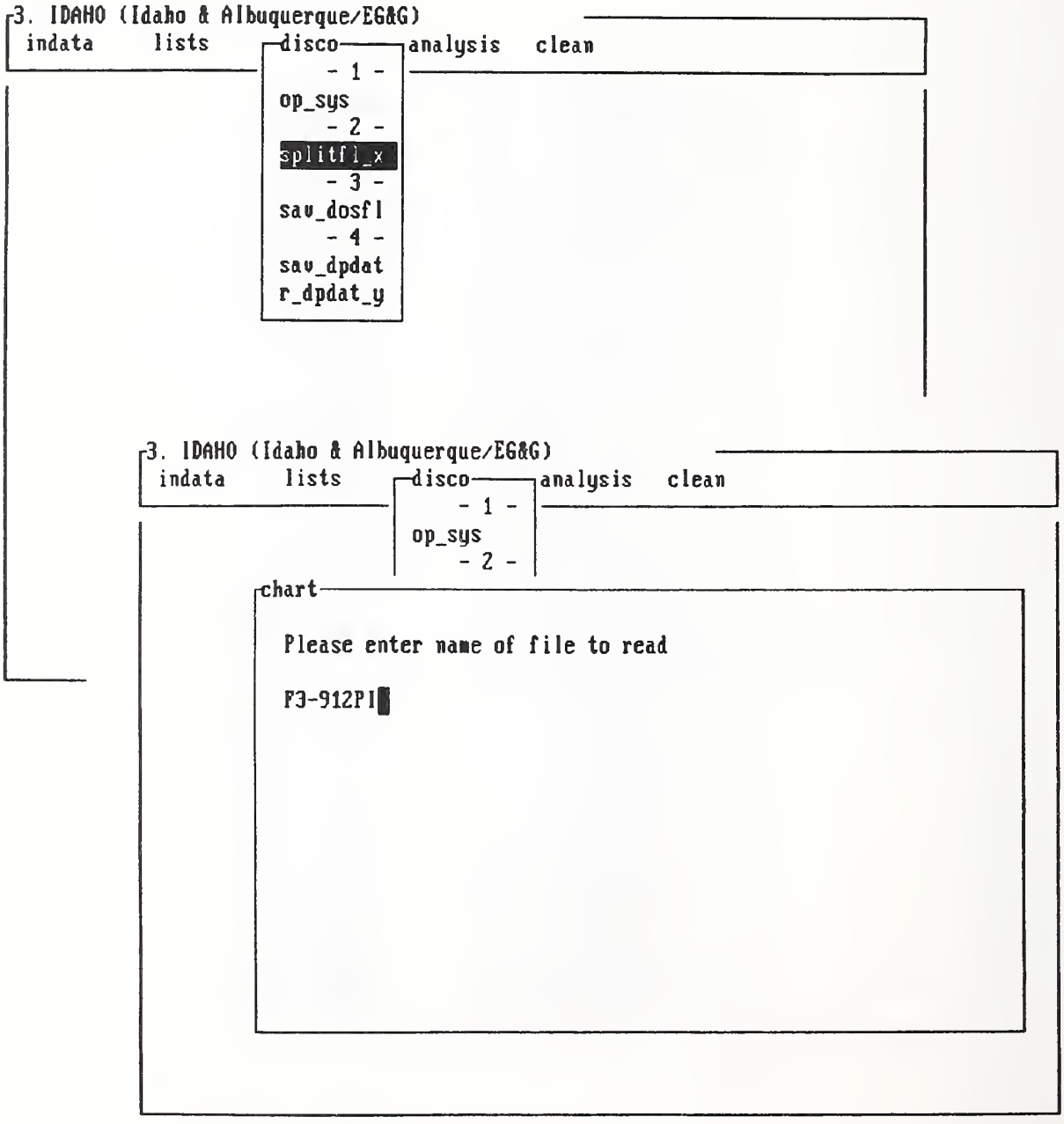
Arima Computer Corporation

A:\> TYPE F31-91-1 | MORE

PDA Menu for *option disco* - *Continuation Sheet*

```
1 91 1 ID EG&G AMCF 1100          0.0000000000
1 91 1 ID EG&G AMCF 1200          0.0000000000
1 91 1 ID EG&G AMCF 1300          0.0000000000
1 91 1 ID EG&G AMCF 1400          0.0000000000
1 91 1 ID EG&G AMCF 1520          0.0000000000
1 91 1 ID EG&G AMCF 1530       1820.0000000000
1 91 1 ID EG&G AMCF 1620          0.0000000000
1 91 1 ID EG&G AMCF 2100          0.0000000000
1 91 1 ID EG&G AMCF 2200          0.0000000000
1 91 1 ID EG&G AMCF 2300          1.0000000000
1 91 1 ID EG&G AMCF 2400         38.0000000000
1 91 1 ID EG&G AMCF 2500          0.0000000000
1 91 1 ID EG&G AMCF 2600          1.0000000000
1 91 1 ID EG&G AMCF 3110          0.0000000000
1 91 1 ID EG&G AMCF 3120          0.0000000000
1 91 1 ID EG&G AMCF 3210          0.0000000000
1 91 1 ID EG&G AMCF 3220          0.0000000000
1 91 1 ID EG&G AMCF 4100          0.0000000000
1 91 1 ID EG&G AMCF 4200          0.0000000000
1 91 1 ID EG&G AMCF 4300          4.0000000000
1 91 1 ID EG&G AMCF 4420         10.0000000000
1 91 1 ID EG&G AMCF 4430         14.0000000000
1 91 1 ID EG&G AMCF 4520          1.0000000000
1 91 1 ID EG&G AMCF 4530          1.0000000000
1 91 1 ID EG&G AMCF 4600          0.0000000000
1 91 1 ID EG&G AMCF 4711         68.0000000000
1 91 1 ID EG&G AMCF 4712          0.0000000000
1 91 1 ID EG&G AMCF 4713         68.0000000000
1 91 1 ID EG&G AMCF 4721          0.0000000000
1 91 1 ID EG&G AMCF 4722          0.0000000000
1 91 1 ID EG&G AMCF 4723          0.0000000000
1 91 1 ID EG&G AMCF 4731          0.0000000000
1 91 1 ID EG&G AMCF 4732          0.0000000000
1 91 1 ID EG&G AMCF 4733          0.0000000000

A:\>
```

PDA Menu for *option disco* - *Continuation Sheet*

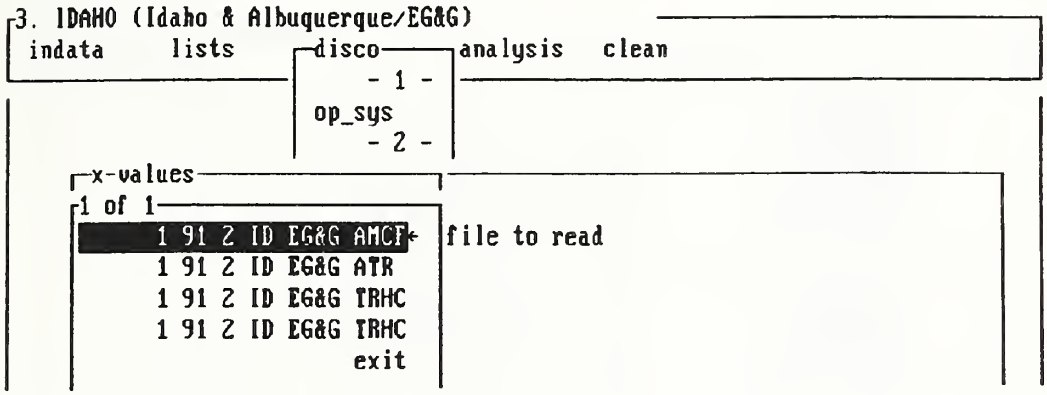


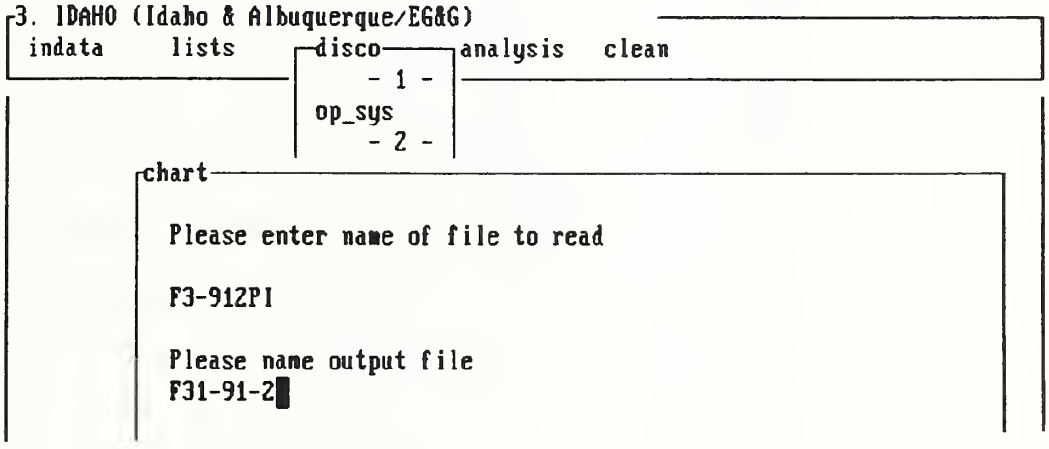
Sample DOE Data - Filename: F3-912PI

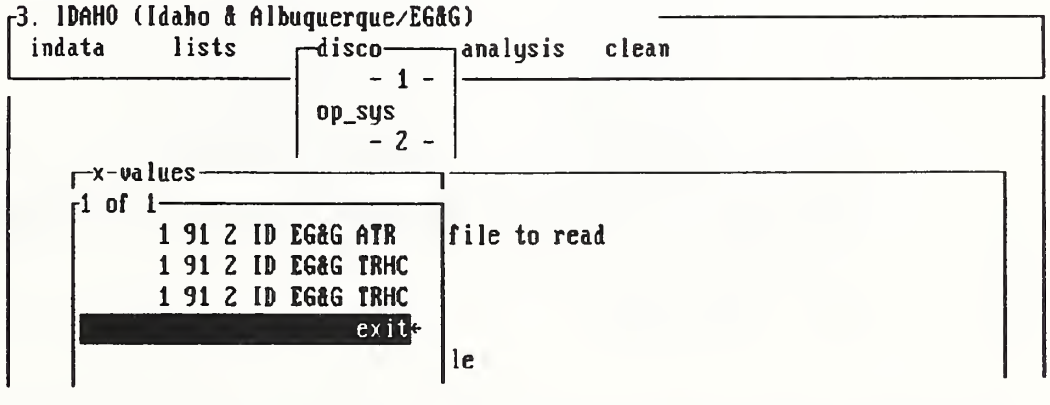
```
1 91 2 ID EG&G AMCF 1100          0.0000000000
1 91 2 ID EG&G AMCF 1200          0.0000000000
1 91 2 ID EG&G AMCF 1300          0.0000000000
1 91 2 ID EG&G AMCF 1400          0.0000000000
1 91 2 ID EG&G AMCF 1520          0.0000000000
1 91 2 ID EG&G AMCF 1530       3891.0000000000
1 91 2 ID EG&G AMCF 1620          0.0000000000
1 91 2 ID EG&G AMCF 2100          0.0000000000
1 91 2 ID EG&G AMCF 2200          0.0000000000
1 91 2 ID EG&G AMCF 2300          0.0000000000
1 91 2 ID EG&G AMCF 2400          3.0000000000
1 91 2 ID EG&G AMCF 2500          0.0000000000
1 91 2 ID EG&G AMCF 2600          0.0000000000
1 91 2 ID EG&G AMCF 3110          0.0000000000
1 91 2 ID EG&G AMCF 3120          0.0000000000
1 91 2 ID EG&G AMCF 3210          0.0000000000
1 91 2 ID EG&G AMCF 3220          0.0000000000
1 91 2 ID EG&G AMCF 4100          1.0000000000
1 91 2 ID EG&G AMCF 4200          0.0000000000
1 91 2 ID EG&G AMCF 4300          3.0000000000
1 91 2 ID EG&G AMCF 4420         11.0000000000
1 91 2 ID EG&G AMCF 4430         18.0000000000
1 91 2 ID EG&G AMCF 4520          0.0000000000
1 91 2 ID EG&G AMCF 4530          0.0000000000
1 91 2 ID EG&G AMCF 4600          0.0000000000
1 91 2 ID EG&G AMCF 4711          0.0000000000
1 91 2 ID EG&G AMCF 4712          0.0000000000
1 91 2 ID EG&G AMCF 4713          0.0000000000
1 91 2 ID EG&G AMCF 4721          0.0000000000
1 91 2 ID EG&G AMCF 4722          0.0000000000
1 91 2 ID EG&G AMCF 4723          0.0000000000
1 91 2 ID EG&G AMCF 4731          0.0000000000
1 91 2 ID EG&G AMCF 4732          0.0000000000
1 91 2 ID EG&G AMCF 4733          0.0000000000
1 91 2 ID EG&G ATR  1100          5.4200000000
1 91 2 ID EG&G ATR  1200          1.0000000000
1 91 2 ID EG&G ATR  1300          0.0000000000
1 91 2 ID EG&G ATR  1400          0.0000000000
1 91 2 ID EG&G ATR  1520          0.0000000000
1 91 2 ID EG&G ATR  1530     142772.0000000000
1 91 2 ID EG&G ATR  1620          3.0000000000
1 91 2 ID EG&G ATR  2100          0.0000000000
1 91 2 ID EG&G ATR  2200          0.0000000000
1 91 2 ID EG&G ATR  2300          0.0000000000
1 91 2 ID EG&G ATR  2400         69.0000000000
1 91 2 ID EG&G ATR  2500          6.0000000000
1 91 2 ID EG&G ATR  2600          3.0000000000
1 91 2 ID EG&G ATR  3110        978.3000000000
1 91 2 ID EG&G ATR  3120         31.6500000000
1 91 2 ID EG&G ATR  3210          0.0000000000
1 91 2 ID EG&G ATR  3220          0.0000000000
1 91 2 ID EG&G ATR  4100          6.0000000000
1 91 2 ID EG&G ATR  4200          0.0000000000
1 91 2 ID EG&G ATR  4300          0.0000000000
1 91 2 ID EG&G ATR  4420         27.0000000000
1 91 2 ID EG&G ATR  4430         60.0000000000
1 91 2 ID EG&G ATR  4520          9.0000000000
1 91 2 ID EG&G ATR  4530        134.0000000000
1 91 2 ID EG&G ATR  4600          0.0000000000
```

1	91	2	ID	EG&G	ATR	4711	2782.0000000000
1	91	2	ID	EG&G	ATR	4712	0.0000000000
1	91	2	ID	EG&G	ATR	4713	2782.0000000000
1	91	2	ID	EG&G	ATR	4721	0.0000000000
1	91	2	ID	EG&G	ATR	4722	0.0000000000
1	91	2	ID	EG&G	ATR	4723	0.0000000000
1	91	2	ID	EG&G	ATR	4731	0.0000000000
1	91	2	ID	EG&G	ATR	4732	0.0000000000
1	91	2	ID	EG&G	ATR	4733	0.0000000000
1	91	2	ID	EG&G	TRHC	1100	0.9700000000
1	91	2	ID	EG&G	TRHC	1200	0.0000000000
1	91	2	ID	EG&G	TRHC	1300	0.0000000000
1	91	2	ID	EG&G	TRHC	1400	0.0000000000
1	91	2	ID	EG&G	TRHC	1520	0.0000000000
1	91	2	ID	EG&G	TRHC	1530	2038.0000000000
1	91	2	ID	EG&G	TRHC	1620	0.0000000000
1	91	2	ID	EG&G	TRHC	2100	0.0000000000
1	91	2	ID	EG&G	TRHC	2200	0.0000000000
1	91	2	ID	EG&G	TRHC	2300	0.0000000000
1	91	2	ID	EG&G	TRHC	2400	0.0000000000
1	91	2	ID	EG&G	TRHC	2500	0.0000000000
1	91	2	ID	EG&G	TRHC	2600	0.0000000000
1	91	2	ID	EG&G	TRHC	3110	0.0000000000
1	91	2	ID	EG&G	TRHC	3120	0.0000000000
1	91	2	ID	EG&G	TRHC	3210	0.0000000000
1	91	2	ID	EG&G	TRHC	3220	0.0000000000
1	91	2	ID	EG&G	TRHC	4100	0.0000000000
1	91	2	ID	EG&G	TRHC	4200	0.0000000000
1	91	2	ID	EG&G	TRHC	4300	2.0000000000
1	91	2	ID	EG&G	TRHC	4420	1.0000000000
1	91	2	ID	EG&G	TRHC	4430	1.0000000000
1	91	2	ID	EG&G	TRHC	4520	0.0000000000
1	91	2	ID	EG&G	TRHC	4530	4.0000000000
1	91	2	ID	EG&G	TRHC	4600	0.0000000000
1	91	2	ID	EG&G	TRHC	4711	384.0000000000
1	91	2	ID	EG&G	TRHC	4712	0.0000000000
1	91	2	ID	EG&G	TRHC	4713	384.0000000000
1	91	2	ID	EG&G	TRHC	4721	0.0000000000
1	91	2	ID	EG&G	TRHC	4722	0.0000000000
1	91	2	ID	EG&G	TRHC	4723	0.0000000000
1	91	2	ID	EG&G	TRHC	4731	0.0000000000
1	91	2	ID	EG&G	TRHC	4732	0.0000000000
1	91	2	ID	EG&G	TRHC	4733	0.0000000000

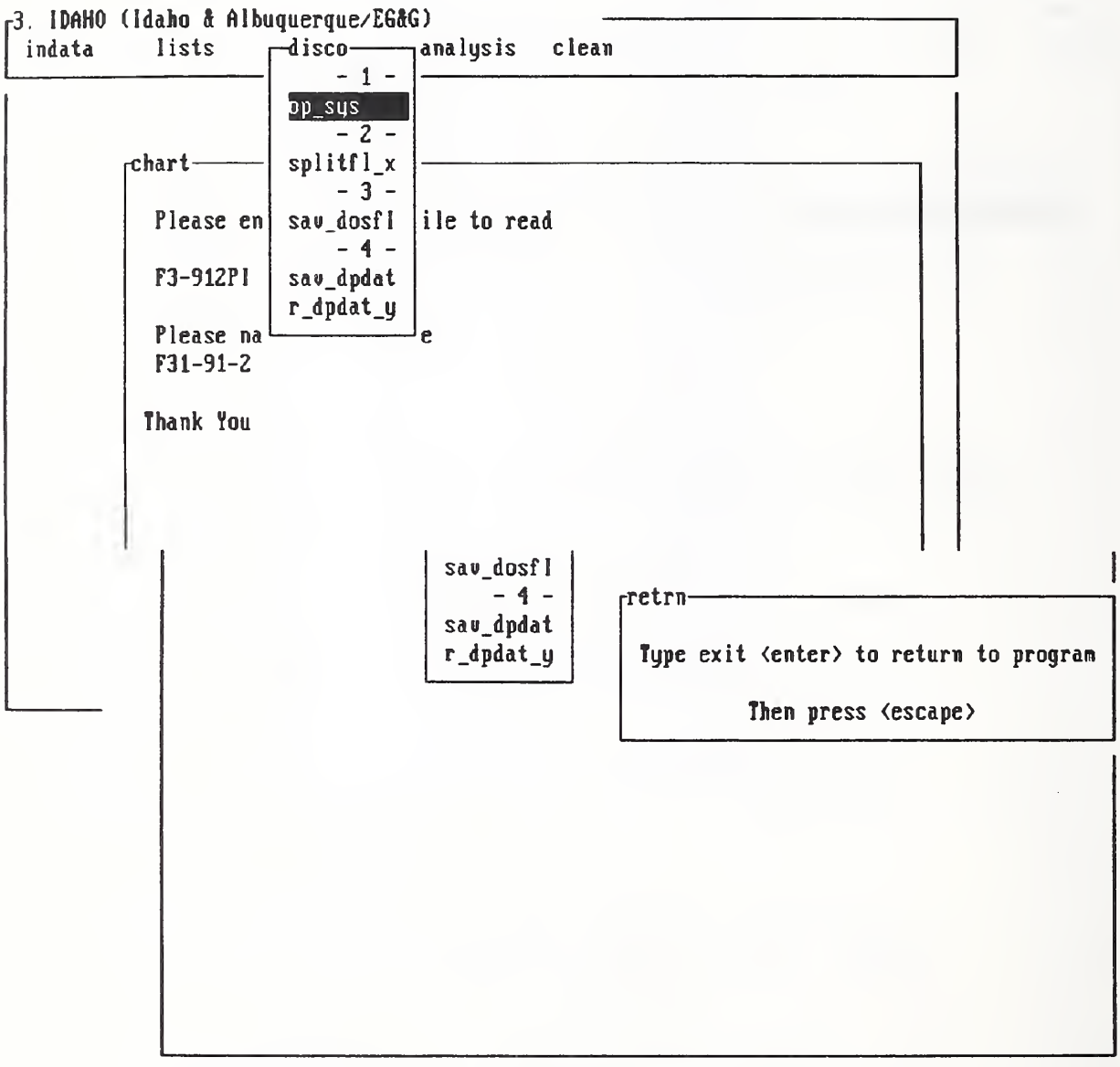
PDA Menu for *option disco* - *Continuation Sheet*







PDA Menu for *option disco* - *Continuation Sheet*



PDA Menu for *option disco* - *Continuation Sheet*

```
1 91 2 ID EG&G AMCF 1100          0.0000000000
1 91 2 ID EG&G AMCF 1200          0.0000000000
1 91 2 ID EG&G AMCF 1300          0.0000000000
1 91 2 ID EG&G AMCF 1400          0.0000000000
1 91 2 ID EG&G AMCF 1520          0.0000000000
1 91 2 ID EG&G AMCF 1530       3891.0000000000
1 91 2 ID EG&G AMCF 1620          0.0000000000
1 91 2 ID EG&G AMCF 2100          0.0000000000
1 91 2 ID EG&G AMCF 2200          0.0000000000
1 91 2 ID EG&G AMCF 2300          0.0000000000
1 91 2 ID EG&G AMCF 2400          3.0000000000
1 91 2 ID EG&G AMCF 2500          0.0000000000
1 91 2 ID EG&G AMCF 2600          0.0000000000
1 91 2 ID EG&G AMCF 3110          0.0000000000
1 91 2 ID EG&G AMCF 3120          0.0000000000
1 91 2 ID EG&G AMCF 3210          0.0000000000
1 91 2 ID EG&G AMCF 3220          0.0000000000
1 91 2 ID EG&G AMCF 4100          1.0000000000
1 91 2 ID EG&G AMCF 4200          0.0000000000
1 91 2 ID EG&G AMCF 4300          3.0000000000
1 91 2 ID EG&G AMCF 4420         11.0000000000
1 91 2 ID EG&G AMCF 4430         18.0000000000
1 91 2 ID EG&G AMCF 4520          0.0000000000
1 91 2 ID EG&G AMCF 4530          0.0000000000
1 91 2 ID EG&G AMCF 4600          0.0000000000
1 91 2 ID EG&G AMCF 4711          0.0000000000
1 91 2 ID EG&G AMCF 4712          0.0000000000
1 91 2 ID EG&G AMCF 4713          0.0000000000
1 91 2 ID EG&G AMCF 4721          0.0000000000
1 91 2 ID EG&G AMCF 4722          0.0000000000
1 91 2 ID EG&G AMCF 4723          0.0000000000
1 91 2 ID EG&G AMCF 4731          0.0000000000
1 91 2 ID EG&G AMCF 4732          0.0000000000
1 91 2 ID EG&G AMCF 4733          0.0000000000

A:\>
```

Section 5.5 - *Keyboard Input of New Data* using *option indata*

With this section, we begin a series of 5 tutorials on how to store new and manage old data in a database that has already been created within a specific DOE or non-DOE application. The five tutorials are:

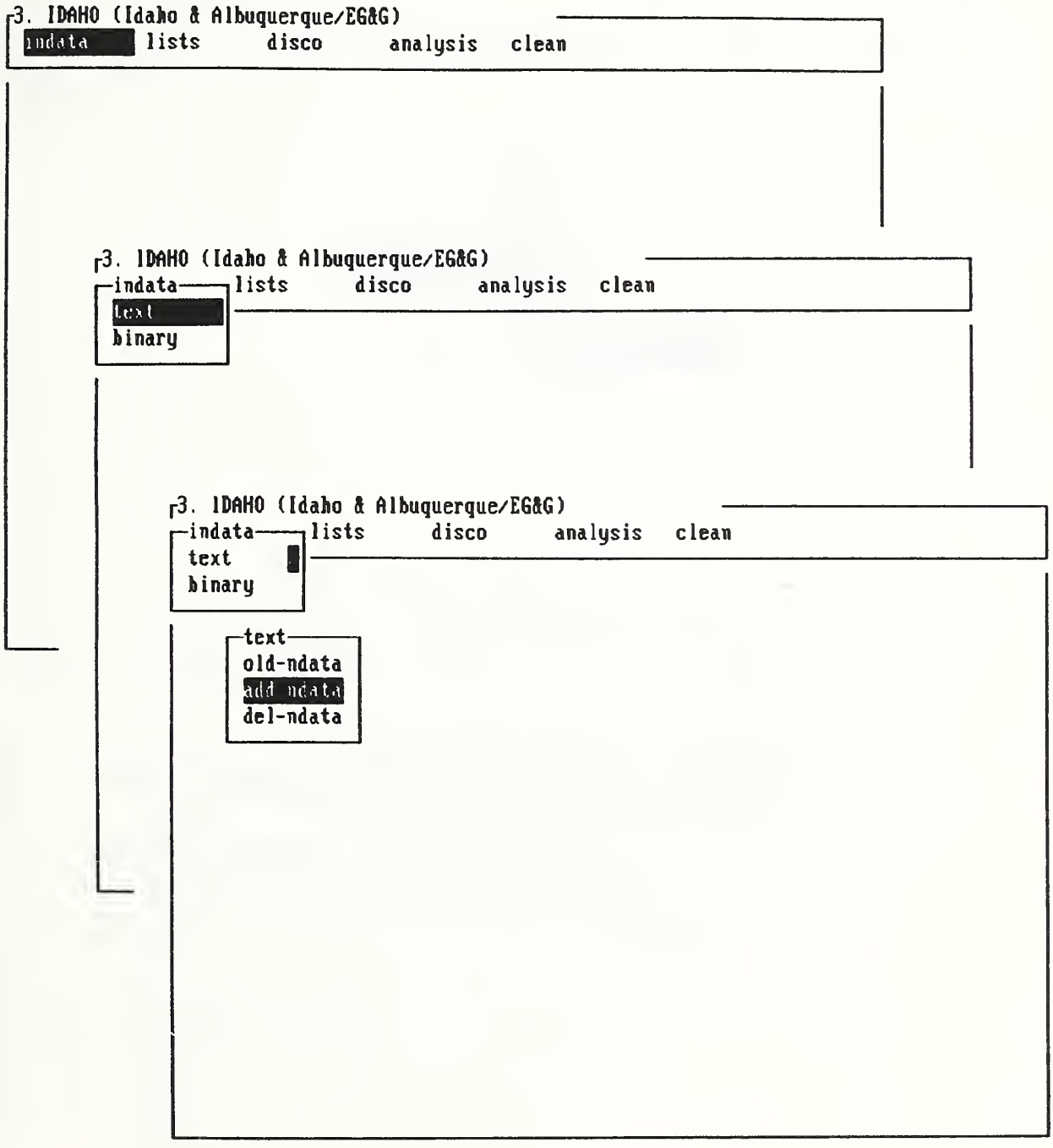
Section	Objective using option "indata"	Reference
5.5	Keyboard input of New Data.	pp. 56-61.
5.6	Review of Old Data.	pp. 62-63.
5.7	Revision of Old Data.	pp. 64-66.
5.8	Deletion of Old Data.	pp. 67-70.
5.9	File Input of New Data.	pp. 71-73.

For ease of displaying a multiple-window format on an 80-character-wide screen, we design a typical data point as a single row of characters not to exceed 73 spaces after we take into account of the necessary clearances between data and window frames. Since this project is co-sponsored by the Department of Energy, we settled on a design that will accomodate the 3-column Performance Indicator (P.I.) data as described on page 32. For every such 3-column P.I. data, we need to tag it with two more columns of information, namely, one for a user-defined database identifier (I.D.) and the other for a user-defined data I.D. The resulting 5-column format for a typical row in a PDA database is shown below:

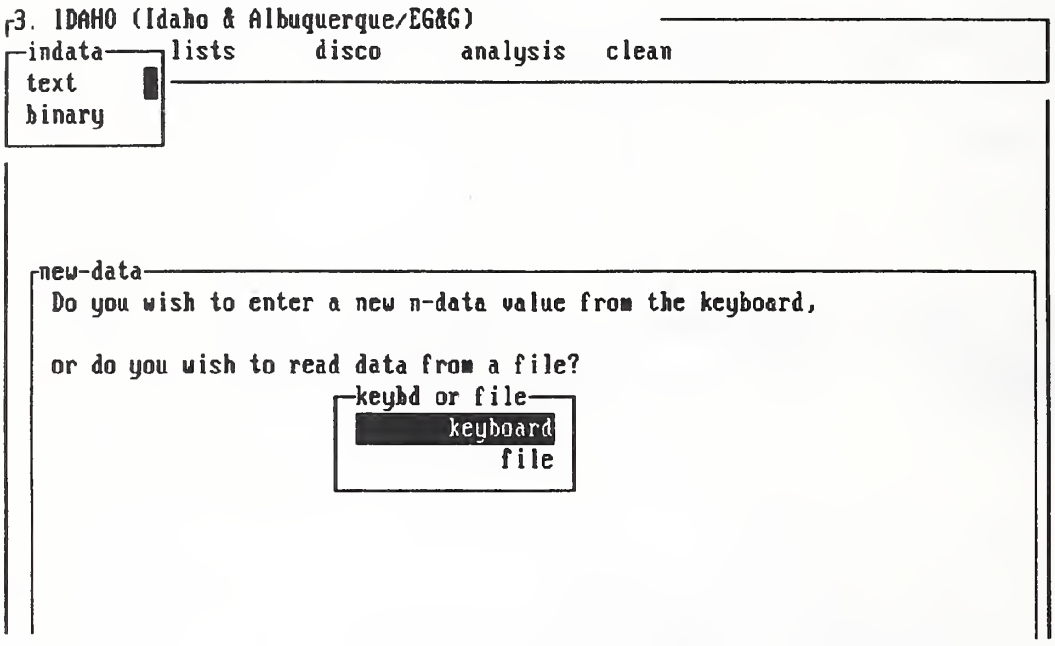
	Column 1		Column 2		Column 3		Column 4		Column 5
	User-Defined Database I.D.		X (Facility I.D.)		Y (P.I. No.)		Z (P.I. Value)		User-Defined Data I.D.
[w1] =	[15 char.]		[19 char.]		[5 char.]		[18 char.]		[4 char.]
{w2} =		[3 char.]		[4 char.]		[3 char.]		[2 char.]	

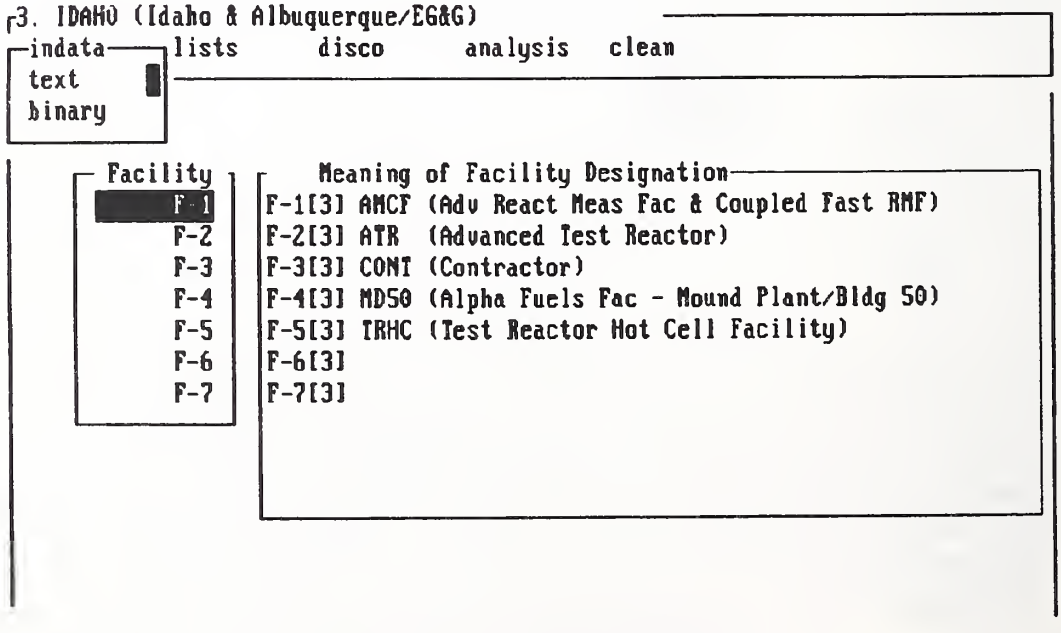
Note that the 73-character row width of each data point is divided into segments of five w1's and four w2's where w1 denotes the number of characters in each column of data and w2 the number of spaces between every two neighboring columns. Following a series of steps for a menu-driven input routine as shown on page 57, a DOE-user will first select the keyboard option (page 58, top), then select the name of a database from a table (page 58, bottom), the year and quarter also from a table (page 59, top), type in the I.D. of a data point (page 59, bottom), and finally type in the values of a 3-column data (page 60, top). An example of a typical data point so generated is given in the bottom figure of page 60.

PDA Menu for *option indata*

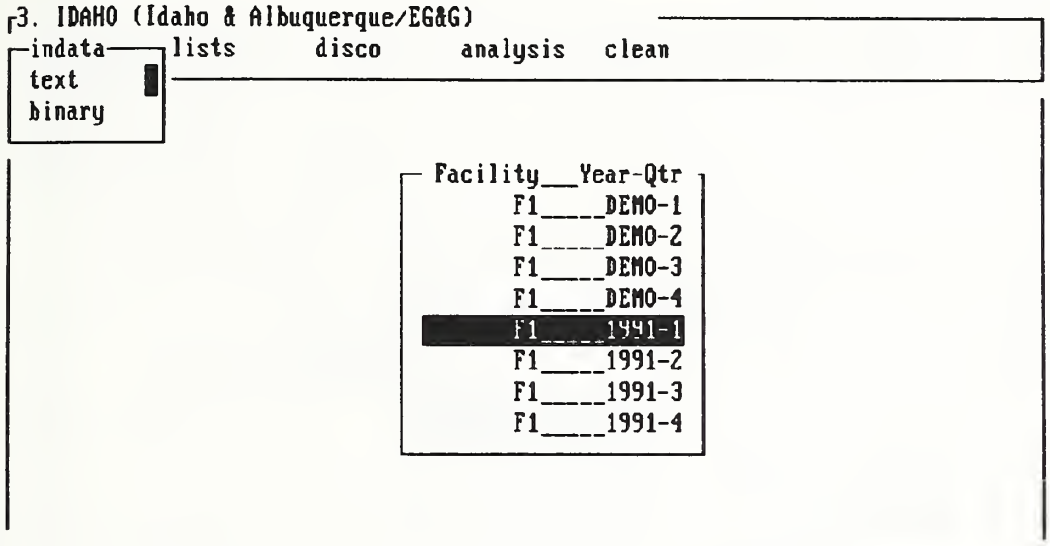


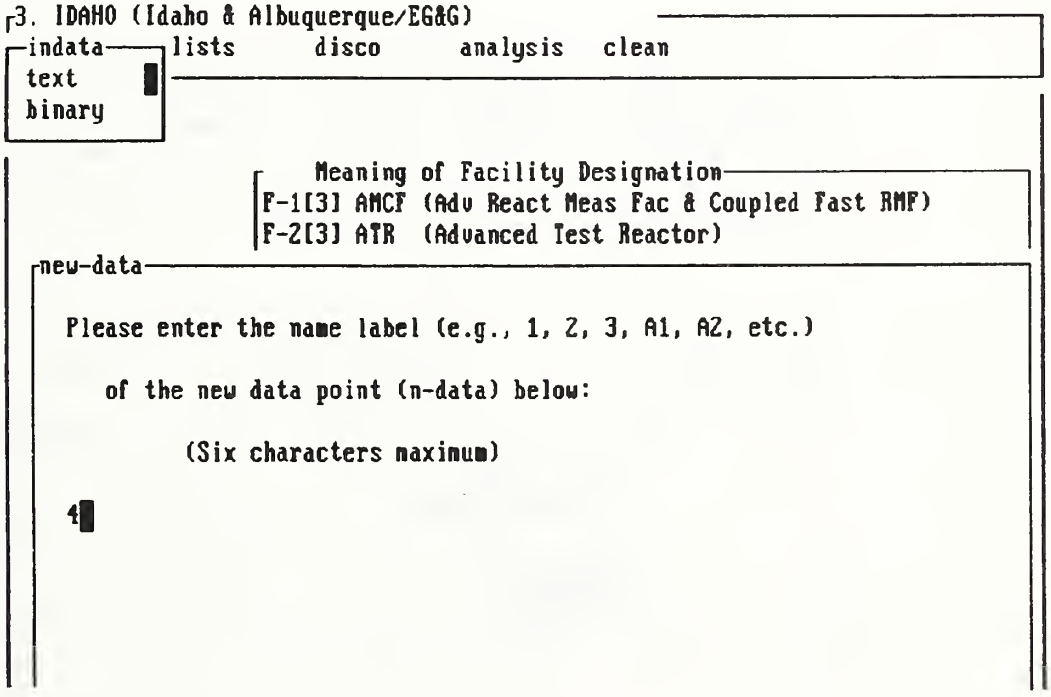
PDA Menu for *option indata* - *Continuation Sheet*





PDA Menu for *option indata* - *Continuation Sheet*



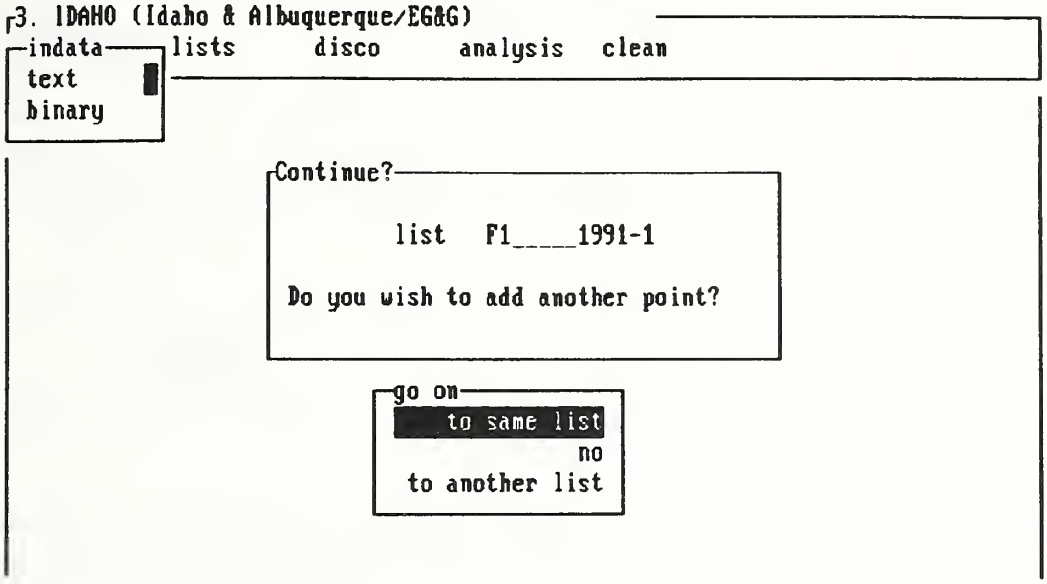


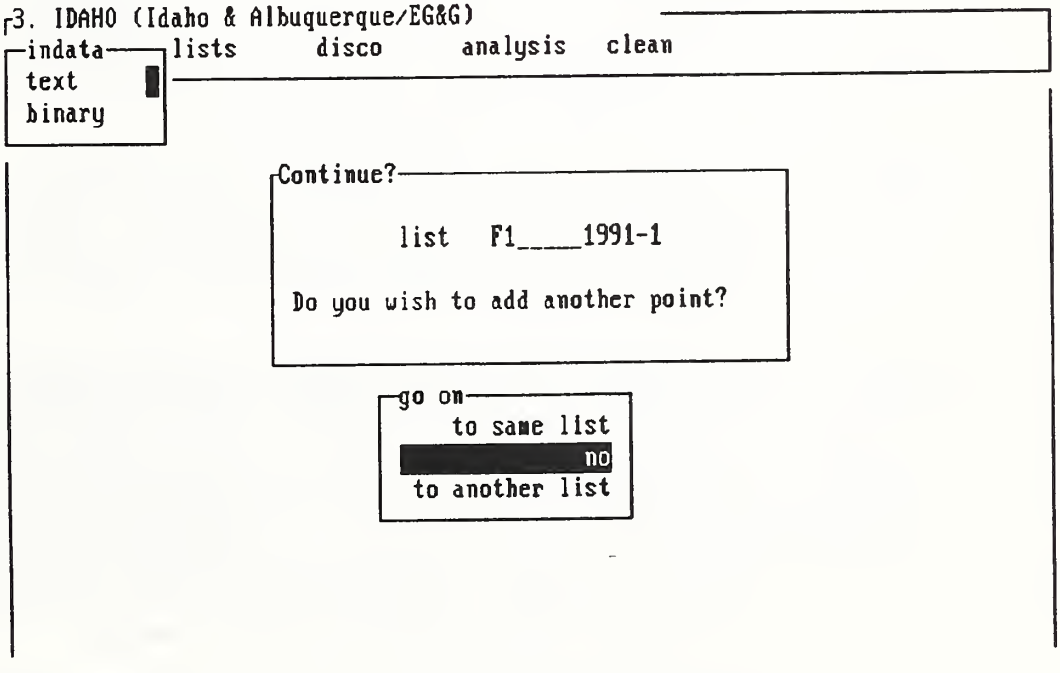
PDA Menu for *option indata* - *Continuation Sheet*

```
3. IDAHO (Idaho & Albuquerque/EG&G)
indata    lists     disco     analysis   clean
text
binary

old-data
DOE Facility No. 1          old observation          n-data

  F1____1991-1                    0        0        0.0000000000     4

Please enter new observed x-data 44

Please enter new observed y-data 55

Please enter new observed z-data 66
```

```
3. IDAHO (Idaho & Albuquerque/EG&G)
indata    lists     disco     analysis   clean
text
binary

new-data
DOE Facility No. 1          new observation          n-data

  F1____1991-1                   44       55        66.0000000000     4

          entry
            enter
            repeat
```

PDA Menu for *option indata* - *Continuation Sheet*





Section 5.6 - *Review Old Data* using *option indata*

In Section 5.5, we learned to use the keyboard to input new data by invoking the "indata" option of the 5-option bar menu that is standard for each application.

In this section, we like to know whether the newly-input data points have been correctly stored. There are two ways to do this, one through the first option "indata" and the other through the second option "lists". Since we have just invoked "indata", it would be easier to stay with it, review the content of the database, and make corrections if needed. Using the second option "lists", as described in Section 5.10, does not allow on to make changes.

On page 63, we show an abbreviated sequence of steps to review old data after we hit carriage-return to open a submenu under the option "indata" as described below:

Step 1 — For the submenu under "indata" with two options, "text" and "binary", choose "text" by hitting the carriage-return again.

Step 2 — For the submenu under "text" with 3 options, "old-ndata", "add-ndata", and "del-ndata", choose "old-ndata" by hitting the carriage-return. At this point, we need to go to page 58 (bottom figure) to see a menu of facilities.

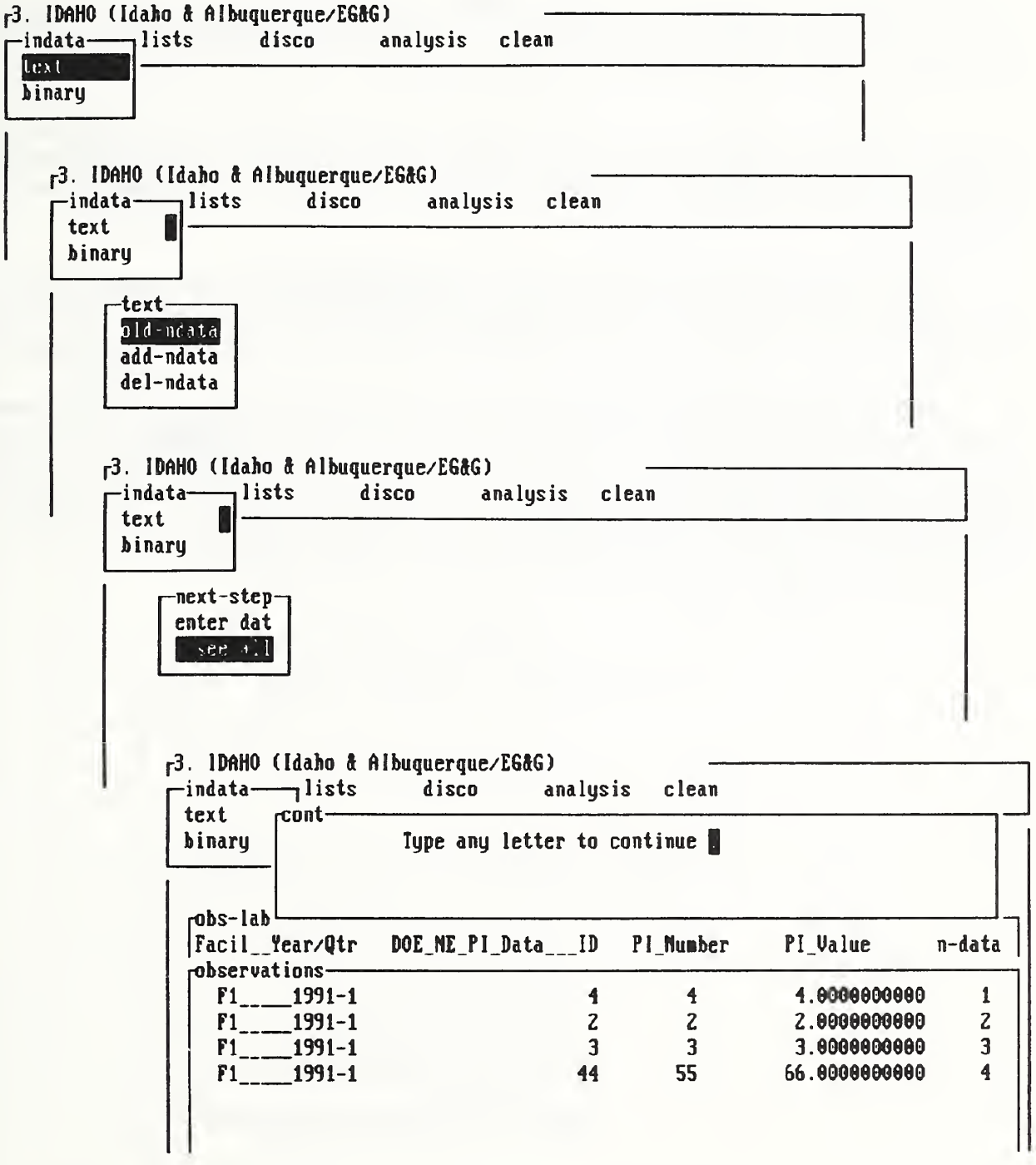
Step 3 — Use space-bar to select the facility and hit carriage-return to display another menu with choices on the year and quarter of the database.

Step 4 — Use space-bar to select the year and quarter of the database. Hit carriage-return to open the database for the specific facility, year, and quarter.

Step 5 — At this point, you have two choices. Either the database is empty and you will be told so, and the control returns to the option "indata". If the database is not empty, there will be a display of a menu named "next-step" with two options, "enter dat" or "see all", as shown on page 63.

Step 6 — Use space-bar to select the option "see all" and hit carriage-return. A 5-column display of all the data in the database for the specific facility, year, and quarter, appears on the screen. If the screen is not big enough to display all the data, use any key to see the next page until the database is fully displayed. After you review the data, type any letter to return control again to "next step". If the data are correctly entered, type "escape" to go back to "indata". Otherwise, select "enter dat", and hit carriage-return to revise the data as described in the next section.

PDA Menu for *option indata*



Section 5.7 - *Revise Old Data* using *option indata*

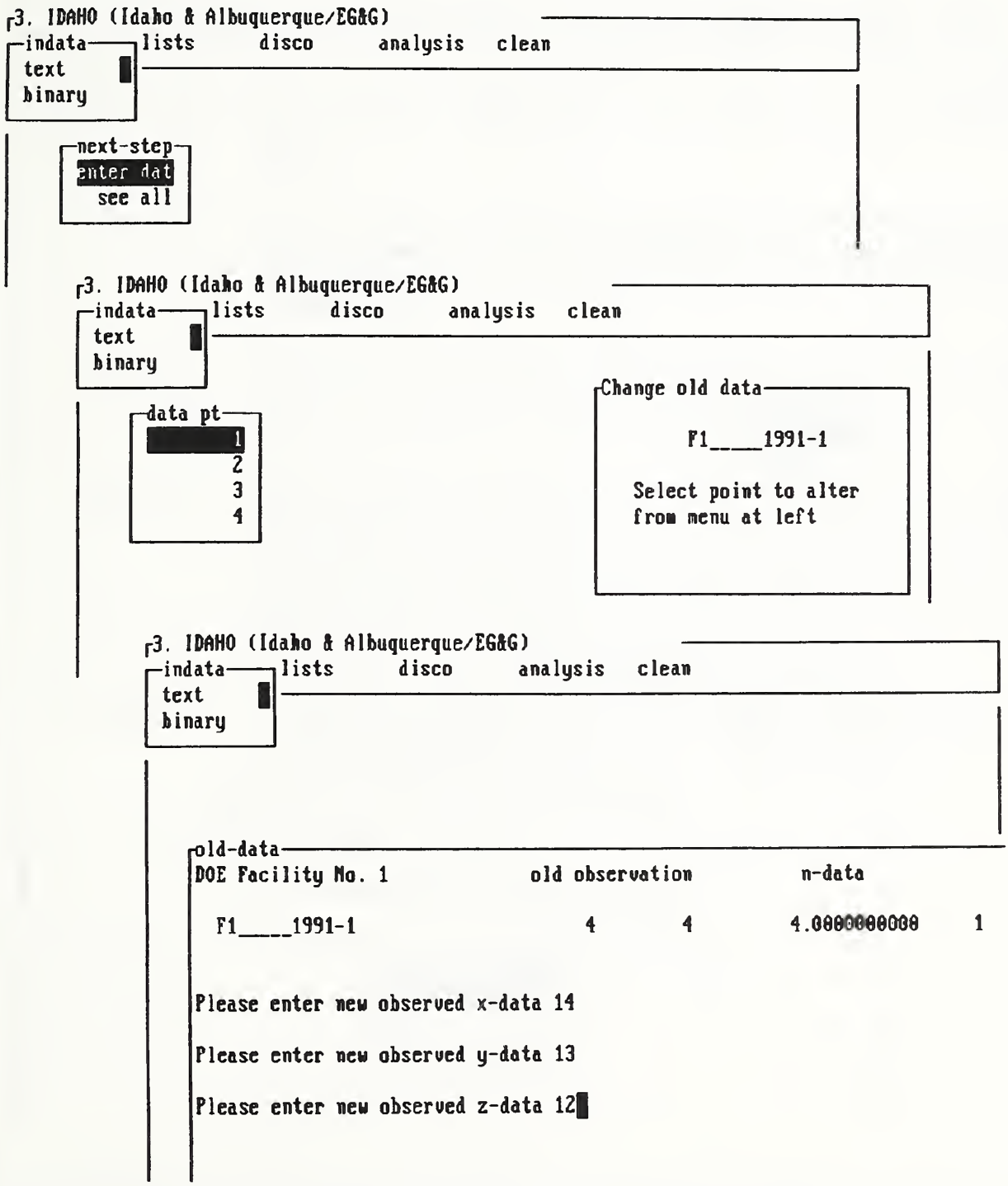
To revise old data using the option "indata", we essentially follow the same first five steps as described in the last section where we were given a submenu named "next-step" with two choices, "enter dat" or "see all".

As shown on page 65, we select "enter dat" and hit carriage-return to reveal two windows, one on the left showing a listing of data point identifiers and the other on the right showing the database identifier. This is a safety feature to ensure that the database you are making changes to is the correct one.

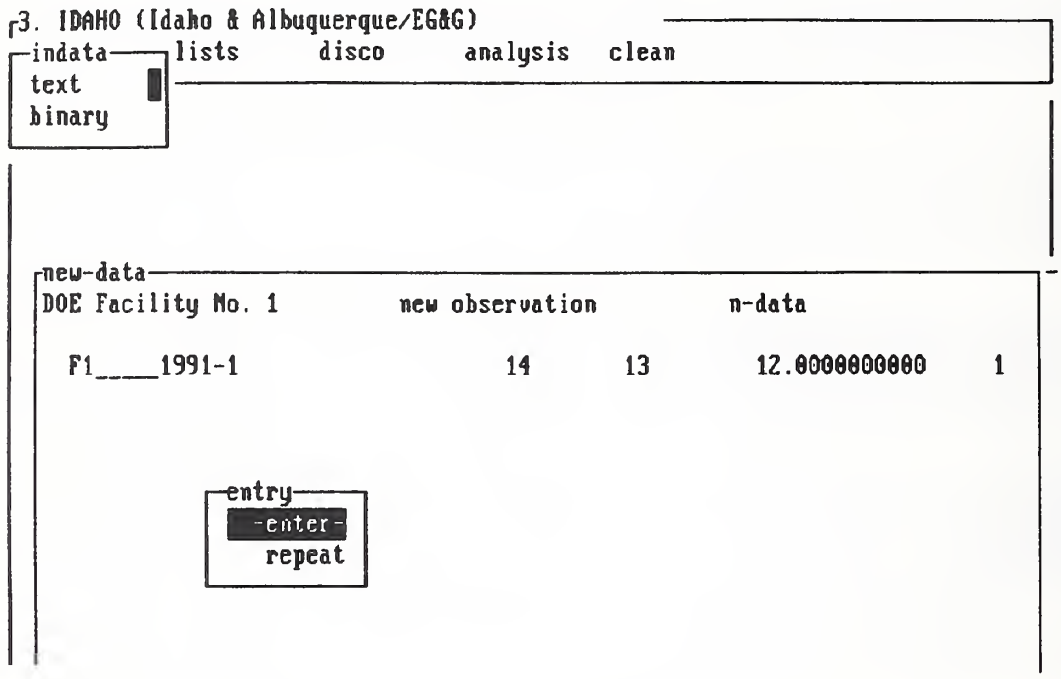
Use the space-bar to select a data point in the left window menu. Hit carriage-return to see a display of the old data as entered in the correct database. You are now free to enter a set of revised values for the 3-column data, X, Y. Z, as shown on the bottom figure of page 65.

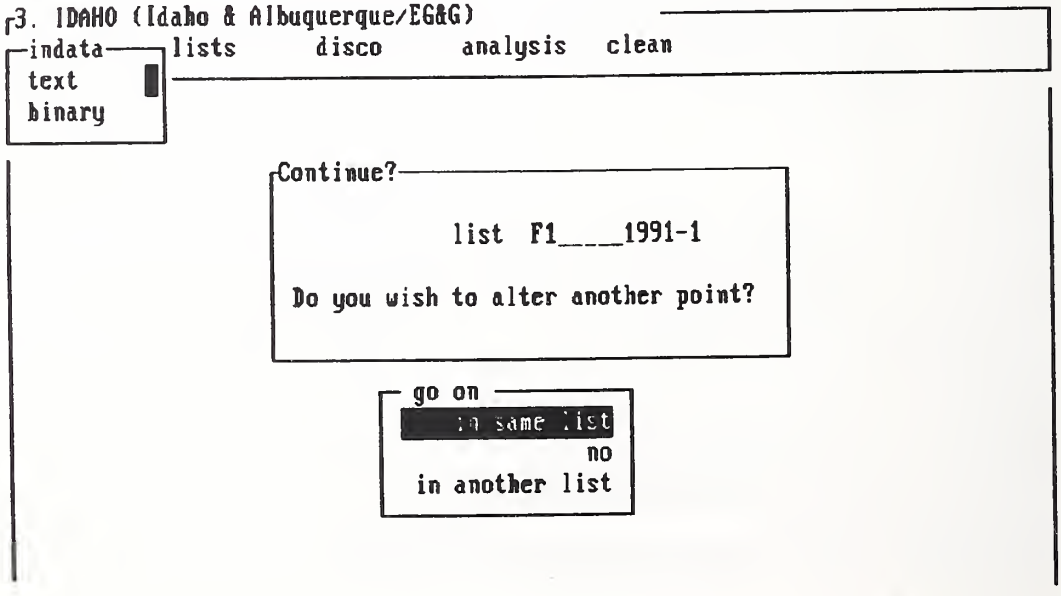
When you finish entering the revised data, you will be asked to activate an option named "enter" to actually commit the change. If you happen to have made an error in your data entry, you can select the option "repeat" to return to the previous step so that no change to your database will occur. After the correct revision is committed, you will be asked, as shown on page 66, whether you wish to alter another data point. Follow the instructions and you can revise as many data points as you wish until you are completely satisfied.

PDA Menu for *option indata*



PDA Menu for *option indata* - *Continuation Sheet*





Section 5.8 - *Delete Old Data* using *option indata*

To delete old data using option "indata", we following a sequence of steps after we hit carriage-return to open a submenu as shown on pp. 68-69 and described below:

Step 1 — For the submenu under "indata" with two options, "text" and "binary", choose "text" by positioning the cursor there and hitting the carriage-return.

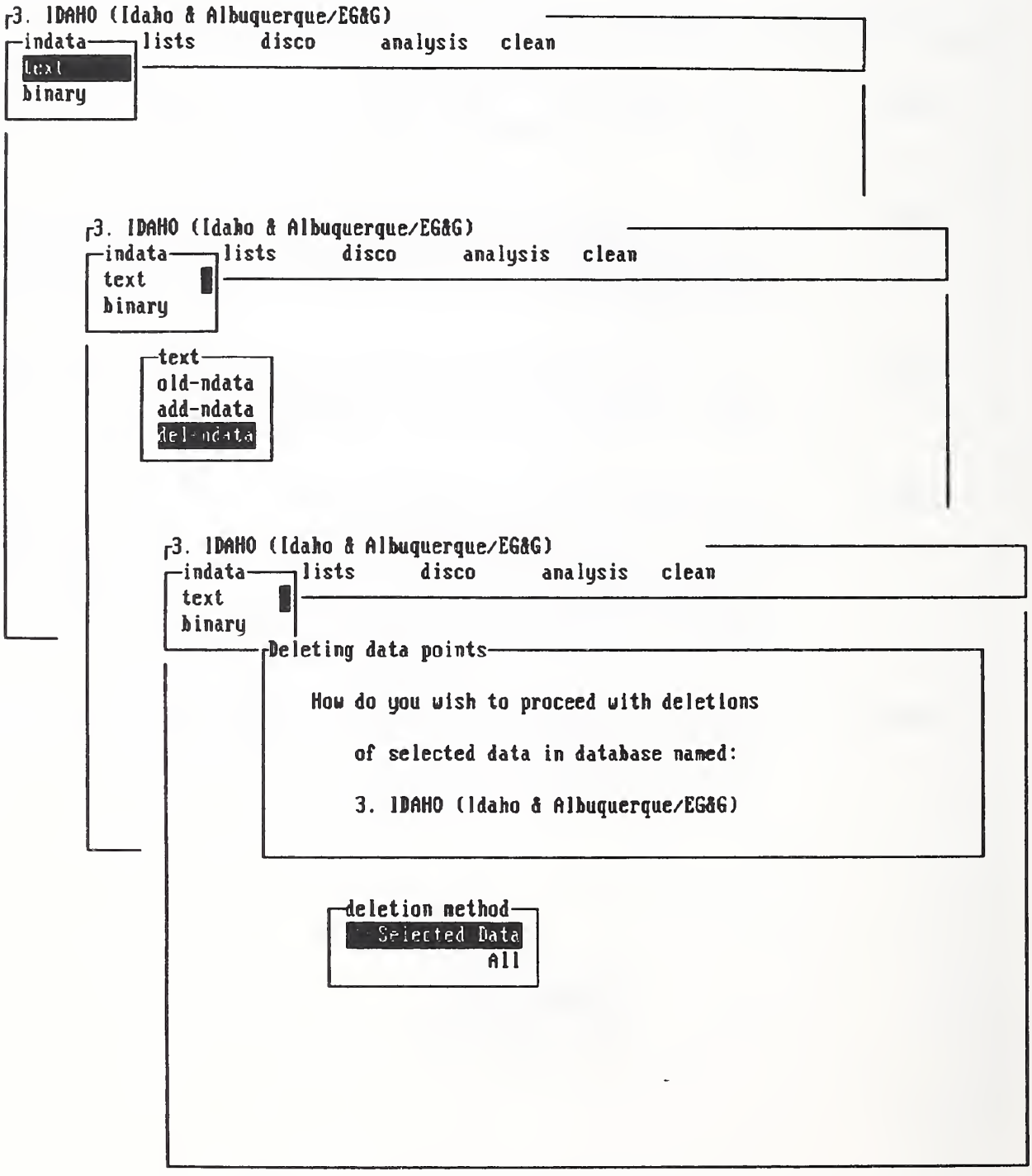
Step 2 — For the submenu under "text" with 3 options, "old-ndata", "add-ndata", and "del-ndata", use space-bar to position cursor on the option "del-ndata" and hit carriage-return to reveal two window menu as shown on page 68 (bottom figure).

Step 3 — For the window menu named "deletion method", use space-bar to position cursor to either the two options, "Selected Data" or "All". For this tutorial, we choose to work with the option "Selected Data".

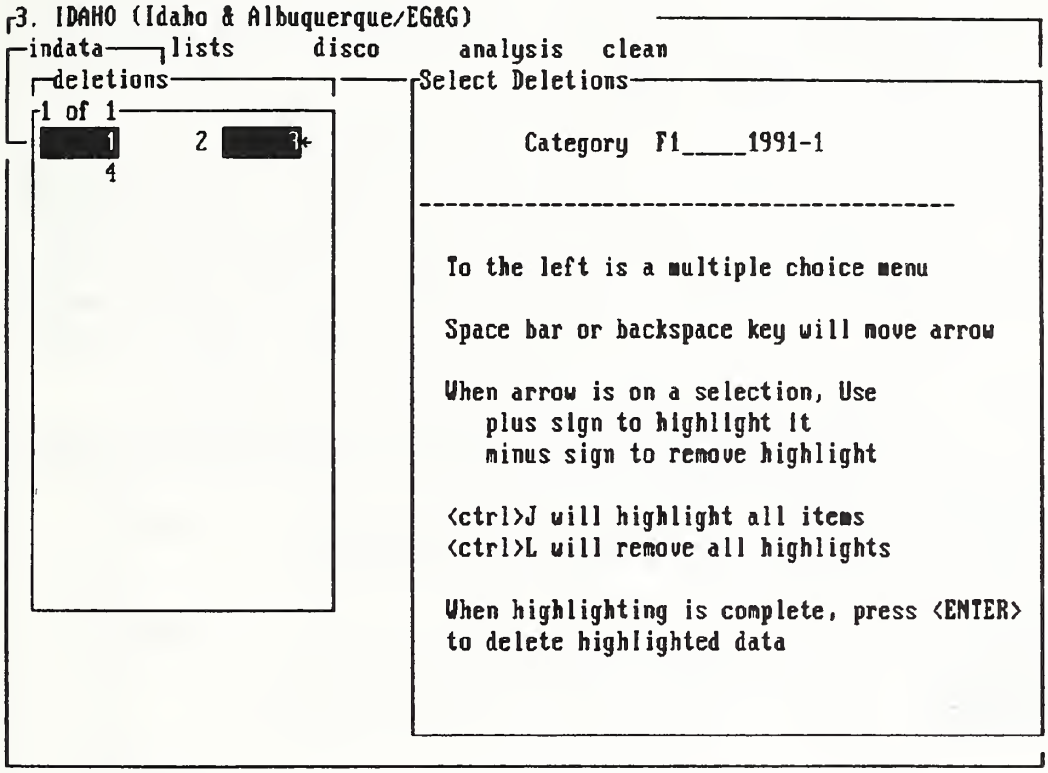
Step 4 — Hit the carriage return after selected the option "Selected Data". On page 69, you will see a display of two window menus, one on the left with a choice of data points to be deleted, and the other on the right containing the name of the database and instructions on how to select and delete. Read the instructions carefully before deleting any data because all steps of deletion are, once committed, irreversible.

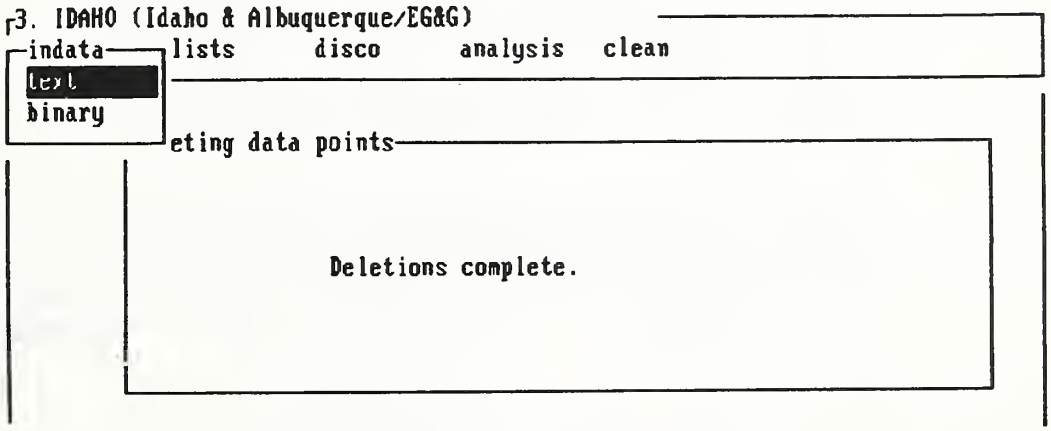
Step 5 — On page 70, we repeat the steps described in Section 5.6 to review the old data in a database after we have made a deletion to verify whether the content of the database is correct.

PDA Menu for *option indata*

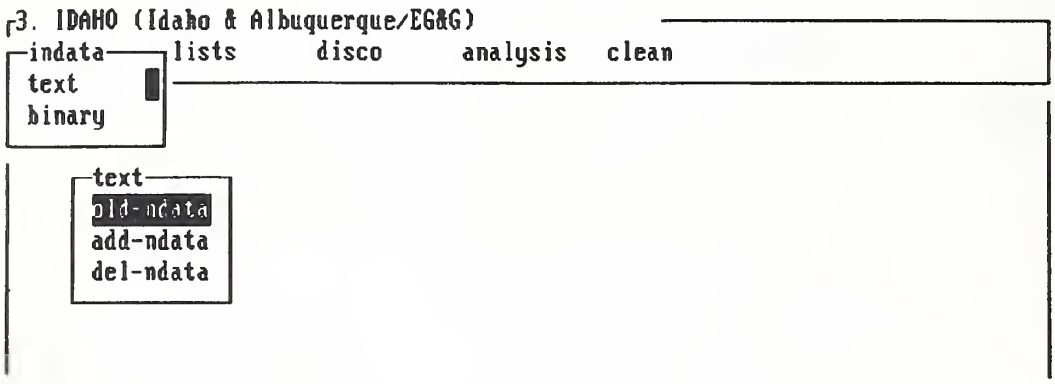


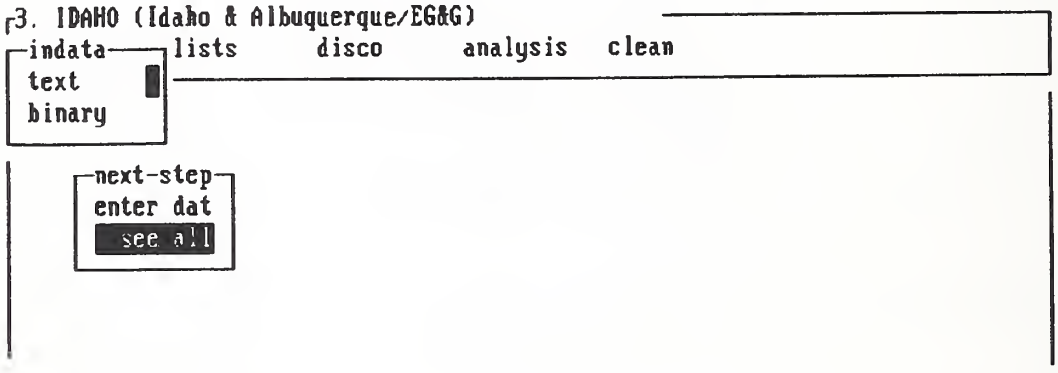
PDA Menu for *option indata* - *Continuation Sheet*

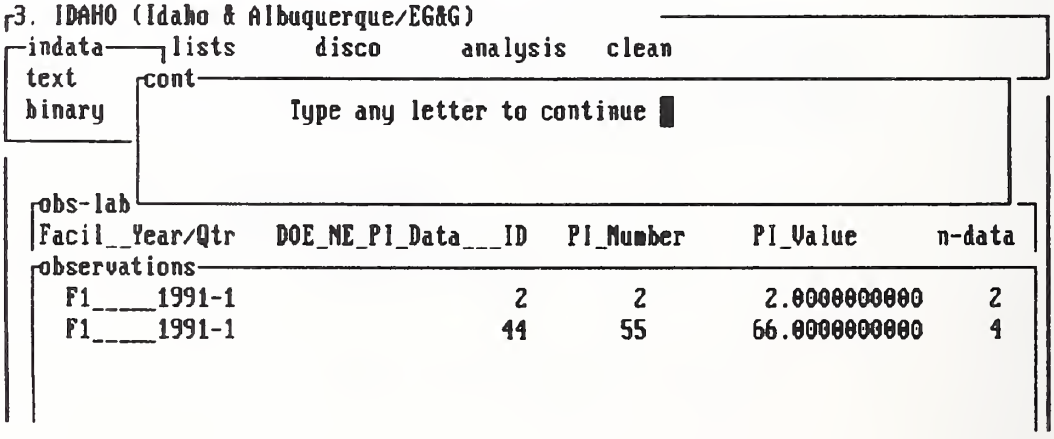




PDA Menu for *option indata* - *Continuation Sheet*







Section 5.9 - *File Input of New Data* using *option indata*

In Sections 5.5 through 5.8, we learned to invoke the option "indata" to input new data by keyboard, and to review, revise, and delete old data from a non-empty database.

In this section, we shall learn how a DOE user can input new data by making the computer read a pre-formatted 3-column data file as discused on page 32. More specifically, the format of the 3-column data file consists of a 19-character-wide Column 1 (X for quarter-year-table-city-contractor-facility label), followed by a 4-character-wide Column 2 (Y for PI number), and a 20-character-wide Column 3 (Z for PI value). There is a one-character-separator between each of the two neighboring columns. An example of the DOE-specific data file format is given on page 49 where the filename is F31-91-1.

The following is a sequence of steps for a DOE-user to input new data from a file by first opening a submenu from the option "indata" as described on pp. 72-73:

Step 1 — For the submenu under "indata" with two options, "text" and "binary", choose "text" by hitting the carriage-return again.

Step 2 — For the submenu with 3 options, "old-ndata", "add-ndata", and "del-ndata", use the space-bar to position cursor on the option "new-ndata", and then hit carriage-return to display a submenu named "keybd or file".

Step 3 — Use the space-bar to choose the option "file" and hit carriage-return. At this point, go to page 58 (bottom figure) to see a menu of facilities.

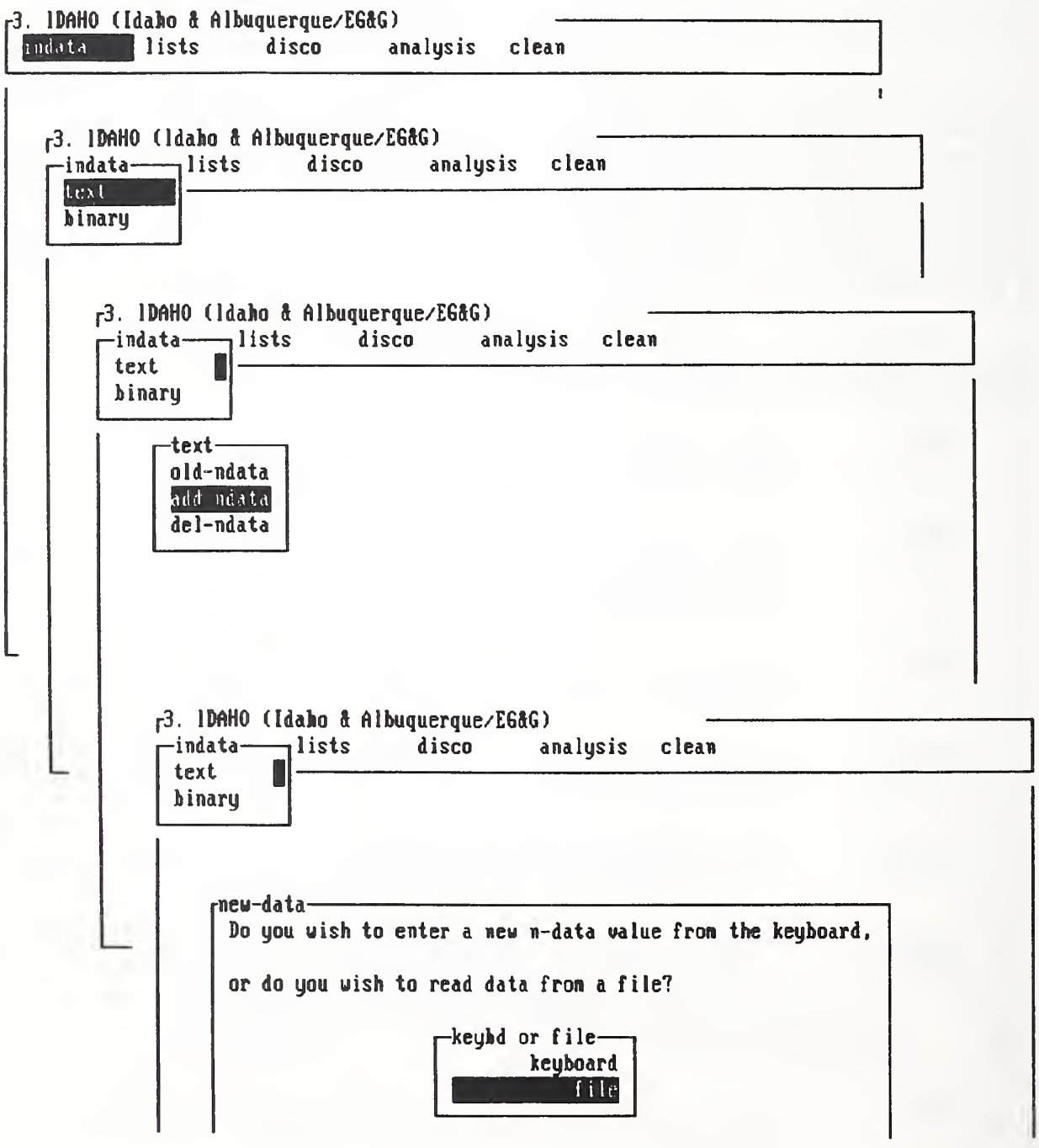
Step 4 — Use space-bar to select the facility and hit carriage-return to display another menu with choices on the year and quarter of the database.

Step 5 — Use space-bar to select the year and quarter of the database. Hit carriage-return to open the database for the specific facility, year and quarter.

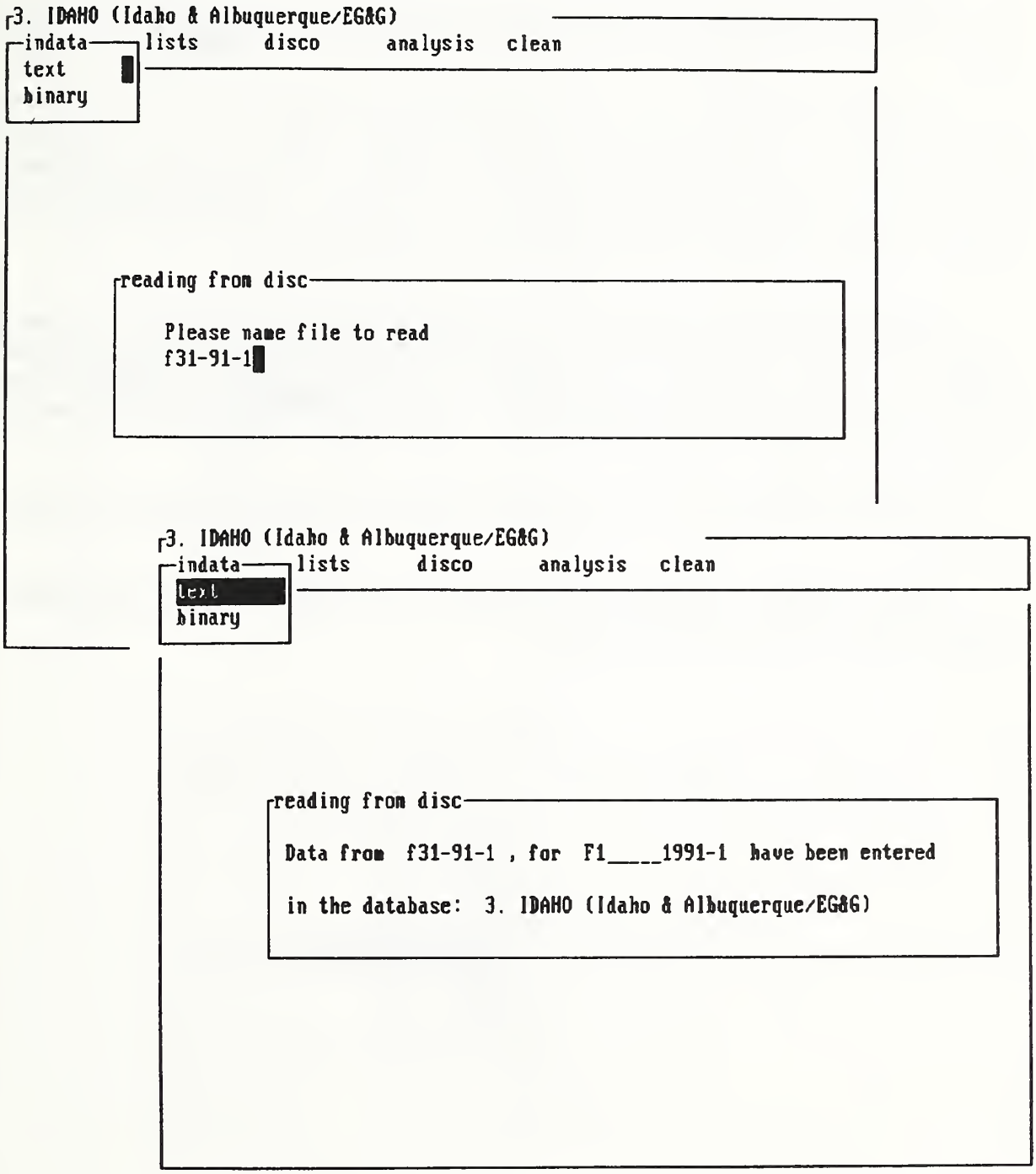
Step 6 — On page 73 top, we see a window menu named "reading from disc" with a request for us to name the file to be read. The filename is restricted to no longe than 8 characters and without the extension afte rthe period. In our example, we type the name of a data file as f31-91-1.

Step 7 — On page 73 bottom, we receive a message saying that the data from file f31-91-1 for the database F1, year 1991, quarter 1, have been read into the database.

PDA Menu for *option indata*



PDA Menu for *option indata* - *Continuation Sheet*



Section 5.10 - *List Old Data* using *option lists*

Being the second of a five-option menu, "lists" is a very simple feature where the only purpose is to let the user see the content of an existing database.

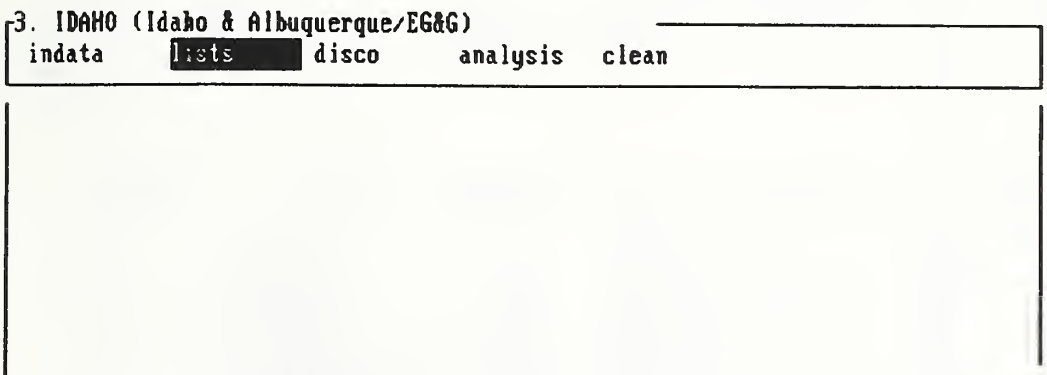
As shown on page 75, a user first use the space bar to position the cursor on the option "lists" and then hit the carriage-return to display a menu of 7 facility labels, F-1 through F-7. For application 3, IDAHO (Idaho & Albuquerque/EG&G), those labels denote facilities F31 through F37 as carefully deciphered on page viii of this report. A similar explanation is given on page 58 (bottom figure) in the form of a window menu under the option "indata". For brevity, a similar display under the option "lists" is not implemented.

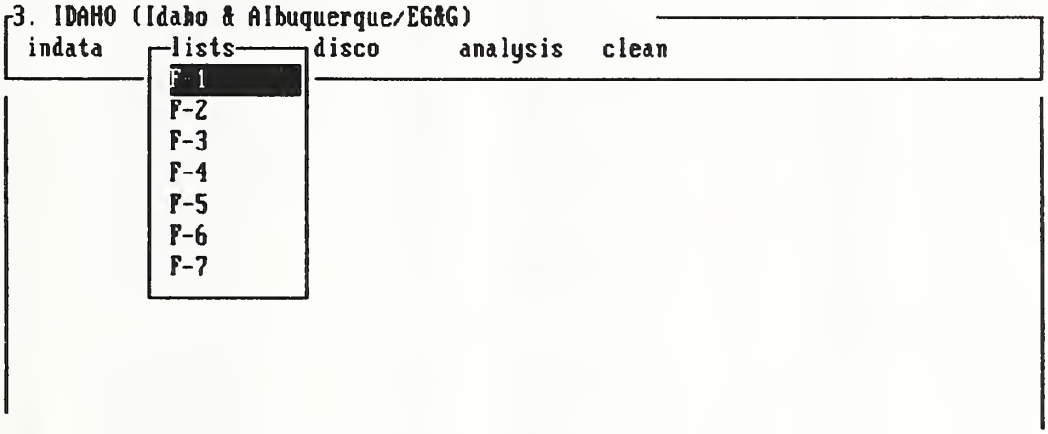
After the facility label, say, F1, is selected, hit the carriage-return to display another submenu with 8 year-quarter options, namely, F1_____DEMO-1 through F1_____DEMO-4, and F1_____1991-1 through F1_____1991-4. Use space-bar to select a year-quarter option, say, F1_____1991-1, and hit carriage-return. A listing of the complete database for facility F1, year 1991, quarter 1, is displayed as shown on page 76.

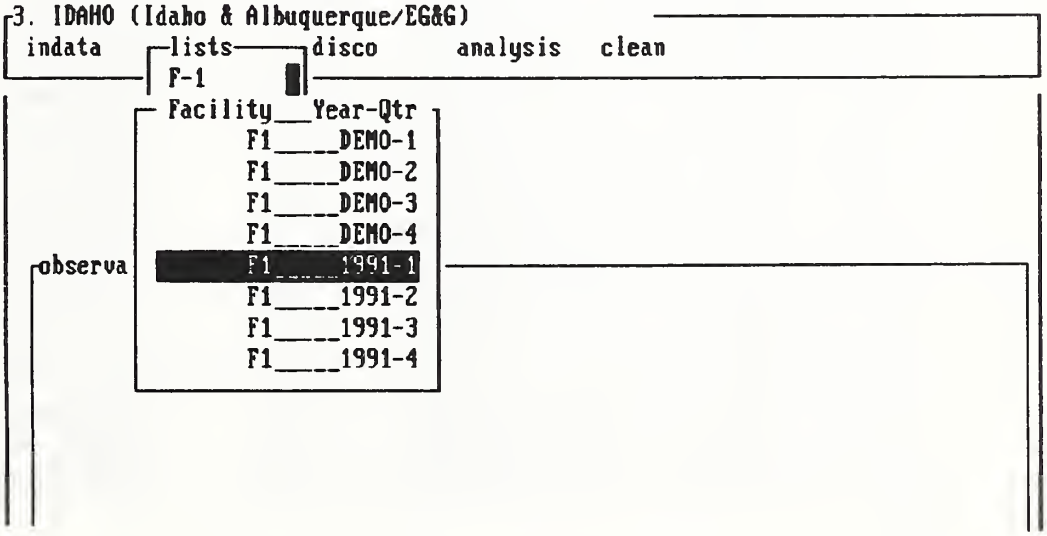
A similar exercise to list the database for facility F1, year 1991, quarter 2 is given on pp. 77-78.

When the user is satisfied with the review of the content of a specific database, a carriage-return will end the listing exercise.

PDA Menu for *option lists*







PDA Menu for *option lists* - *Continuation Sheet*

3. IDAHO (Idaho & Albuquerque/EG&G)

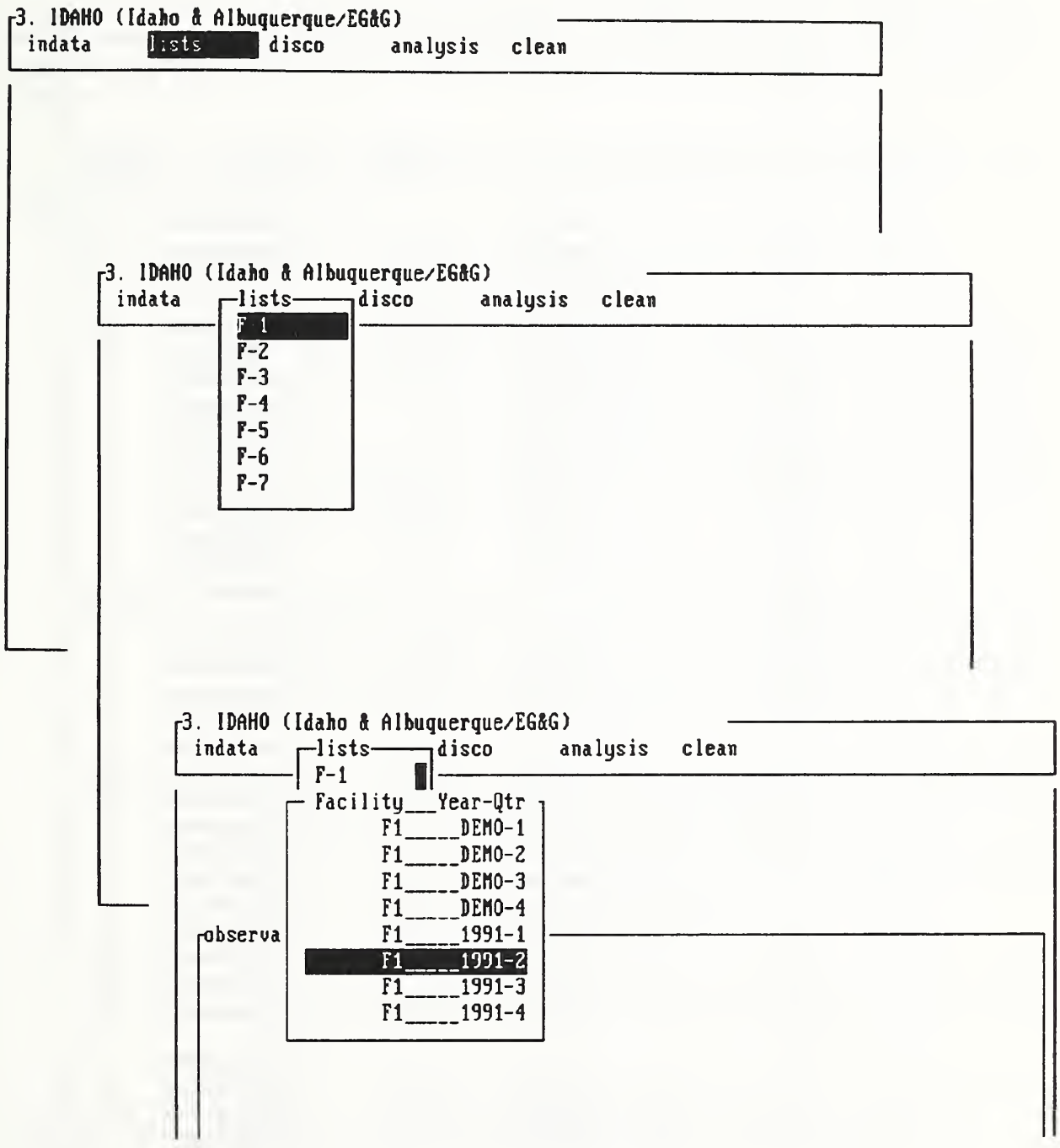
indata | lists | disco | analysis | clean

- F-1
- F-2
- F-3
- F-4

obs-label

Facil__Year/Qtr	DOE_ME_PI_Data___ID	PI_Number	PI_Value	n-data
observations				
F1____1991-1	1 91 1 ID EG&G AMCF	1100	0.0000000000	1
F1____1991-1	1 91 1 ID EG&G AMCF	1200	0.0000000000	2
F1____1991-1	1 91 1 ID EG&G AMCF	1300	0.0000000000	3
F1____1991-1	1 91 1 ID EG&G AMCF	1400	0.0000000000	4
F1____1991-1	1 91 1 ID EG&G AMCF	1520	0.0000000000	5
F1____1991-1	1 91 1 ID EG&G AMCF	1530	1820.0000000000	6
F1____1991-1	1 91 1 ID EG&G AMCF	1620	0.0000000000	7
F1____1991-1	1 91 1 ID EG&G AMCF	2100	0.0000000000	8
F1____1991-1	1 91 1 ID EG&G AMCF	2200	0.0000000000	9
F1____1991-1	1 91 1 ID EG&G AMCF	2300	1.0000000000	10
F1____1991-1	1 91 1 ID EG&G AMCF	2400	38.0000000000	11
F1____1991-1	1 91 1 ID EG&G AMCF	2500	0.0000000000	12
F1____1991-1	1 91 1 ID EG&G AMCF	2600	1.0000000000	13
F1____1991-1	1 91 1 ID EG&G AMCF	3110	0.0000000000	14
F1____1991-1	1 91 1 ID EG&G AMCF	3120	0.0000000000	15
observations				
F1____1991-1	1 91 1 ID EG&G AMCF	3210	0.0000000000	16
F1____1991-1	1 91 1 ID EG&G AMCF	3220	0.0000000000	17
F1____1991-1	1 91 1 ID EG&G AMCF	4100	0.0000000000	18
F1____1991-1	1 91 1 ID EG&G AMCF	4200	0.0000000000	19
F1____1991-1	1 91 1 ID EG&G AMCF	4300	4.0000000000	20
F1____1991-1	1 91 1 ID EG&G AMCF	4420	10.0000000000	21
F1____1991-1	1 91 1 ID EG&G AMCF	4430	14.0000000000	22
F1____1991-1	1 91 1 ID EG&G AMCF	4520	1.0000000000	23
F1____1991-1	1 91 1 ID EG&G AMCF	4530	1.0000000000	24
F1____1991-1	1 91 1 ID EG&G AMCF	4600	0.0000000000	25
F1____1991-1	1 91 1 ID EG&G AMCF	4711	68.0000000000	26
F1____1991-1	1 91 1 ID EG&G AMCF	4712	0.0000000000	27
F1____1991-1	1 91 1 ID EG&G AMCF	4713	68.0000000000	28
F1____1991-1	1 91 1 ID EG&G AMCF	4721	0.0000000000	29
F1____1991-1	1 91 1 ID EG&G AMCF	4722	0.0000000000	30
observations				
F1____1991-1	1 91 1 ID EG&G AMCF	4723	0.0000000000	31
F1____1991-1	1 91 1 ID EG&G AMCF	4731	0.0000000000	32
F1____1991-1	1 91 1 ID EG&G AMCF	4732	0.0000000000	33
F1____1991-1	1 91 1 ID EG&G AMCF	4733	0.0000000000	34

PDA Menu for *option lists* - *Continuation Sheet*



PDA Menu for *option lists* - *Continuation Sheet*

3. IDAHO (Idaho & Albuquerque/EG&G)

indata | lists | disco | analysis | clean

lists: F-1 F-2 F-3 F-4

obs-label

Facil	Year/Qtr	DOE_NE_PI_Data___ID	PI_Number	PI_Value	n-data
observations					
F1	1991-2	1 91 2 ID EG&G AMCF	1100	0.0000000000	1
F1	1991-2	1 91 2 ID EG&G AMCF	1200	0.0000000000	2
F1	1991-2	1 91 2 ID EG&G AMCF	1300	0.0000000000	3
F1	1991-2	1 91 2 ID EG&G AMCF	1400	0.0000000000	4
F1	1991-2	1 91 2 ID EG&G AMCF	1520	0.0000000000	5
F1	1991-2	1 91 2 ID EG&G AMCF	1530	3891.0000000000	6
F1	1991-2	1 91 2 ID EG&G AMCF	1620	0.0000000000	7
F1	1991-2	1 91 2 ID EG&G AMCF	2100	0.0000000000	8
F1	1991-2	1 91 2 ID EG&G AMCF	2200	0.0000000000	9
F1	1991-2	1 91 2 ID EG&G AMCF	2300	0.0000000000	10
F1	1991-2	1 91 2 ID EG&G AMCF	2400	3.0000000000	11
F1	1991-2	1 91 2 ID EG&G AMCF	2500	0.0000000000	12
F1	1991-2	1 91 2 ID EG&G AMCF	2600	0.0000000000	13
F1	1991-2	1 91 2 ID EG&G AMCF	3110	0.0000000000	14
F1	1991-2	1 91 2 ID EG&G AMCF	3120	0.0000000000	15
observations					
F1	1991-2	1 91 2 ID EG&G AMCF	3210	0.0000000000	16
F1	1991-2	1 91 2 ID EG&G AMCF	3220	0.0000000000	17
F1	1991-2	1 91 2 ID EG&G AMCF	4100	1.0000000000	18
F1	1991-2	1 91 2 ID EG&G AMCF	4200	0.0000000000	19
F1	1991-2	1 91 2 ID EG&G AMCF	4300	3.0000000000	20
F1	1991-2	1 91 2 ID EG&G AMCF	4420	11.0000000000	21
F1	1991-2	1 91 2 ID EG&G AMCF	4430	18.0000000000	22
F1	1991-2	1 91 2 ID EG&G AMCF	4520	0.0000000000	23
F1	1991-2	1 91 2 ID EG&G AMCF	4530	0.0000000000	24
F1	1991-2	1 91 2 ID EG&G AMCF	4600	0.0000000000	25
F1	1991-2	1 91 2 ID EG&G AMCF	4711	0.0000000000	26
F1	1991-2	1 91 2 ID EG&G AMCF	4712	0.0000000000	27
F1	1991-2	1 91 2 ID EG&G AMCF	4713	0.0000000000	28
F1	1991-2	1 91 2 ID EG&G AMCF	4721	0.0000000000	29
F1	1991-2	1 91 2 ID EG&G AMCF	4722	0.0000000000	30
observations					
F1	1991-2	1 91 2 ID EG&G AMCF	4723	0.0000000000	31
F1	1991-2	1 91 2 ID EG&G AMCF	4731	0.0000000000	32
F1	1991-2	1 91 2 ID EG&G AMCF	4732	0.0000000000	33
F1	1991-2	1 91 2 ID EG&G AMCF	4733	0.0000000000	34

Section 5.11 - *Save Data as DOS File* using *option disco*

In Sections 5.5 through 5.9, we learned how to create and review the content of a database using the option "indata". In Section 5.10, we learned how to list the content of a database using the option "lists". In the next three sections, we shall learn how to save the content of a database either as a DOS file or a DATAPLOT file using the option "disco".

To save the content of a database as a DOS file, we follow a sequence of steps as shown on pp. 80-82 and described below:

Step 1 — Position cursor at the option "disco" and hit carriage-return.

Step 2 — For the submenu under "disco" with five options, the first one, "op_sys", is for a temporary access to DOS as explained in Section 5.3, and the second, "splitfl_x", is for the partitioning of a DOE file as explained in Section 5.4. The remaining three, "sav_dosfl", "sav_dpdat", and "r_dpdat_y", are the subjects of this section, Section 5.12, and Section 5.13, respectively. So for this step, we shall position the cursor at the option "sav_dosfl" and hit carriage-return. A window menu of 7 facility labels is displayed.

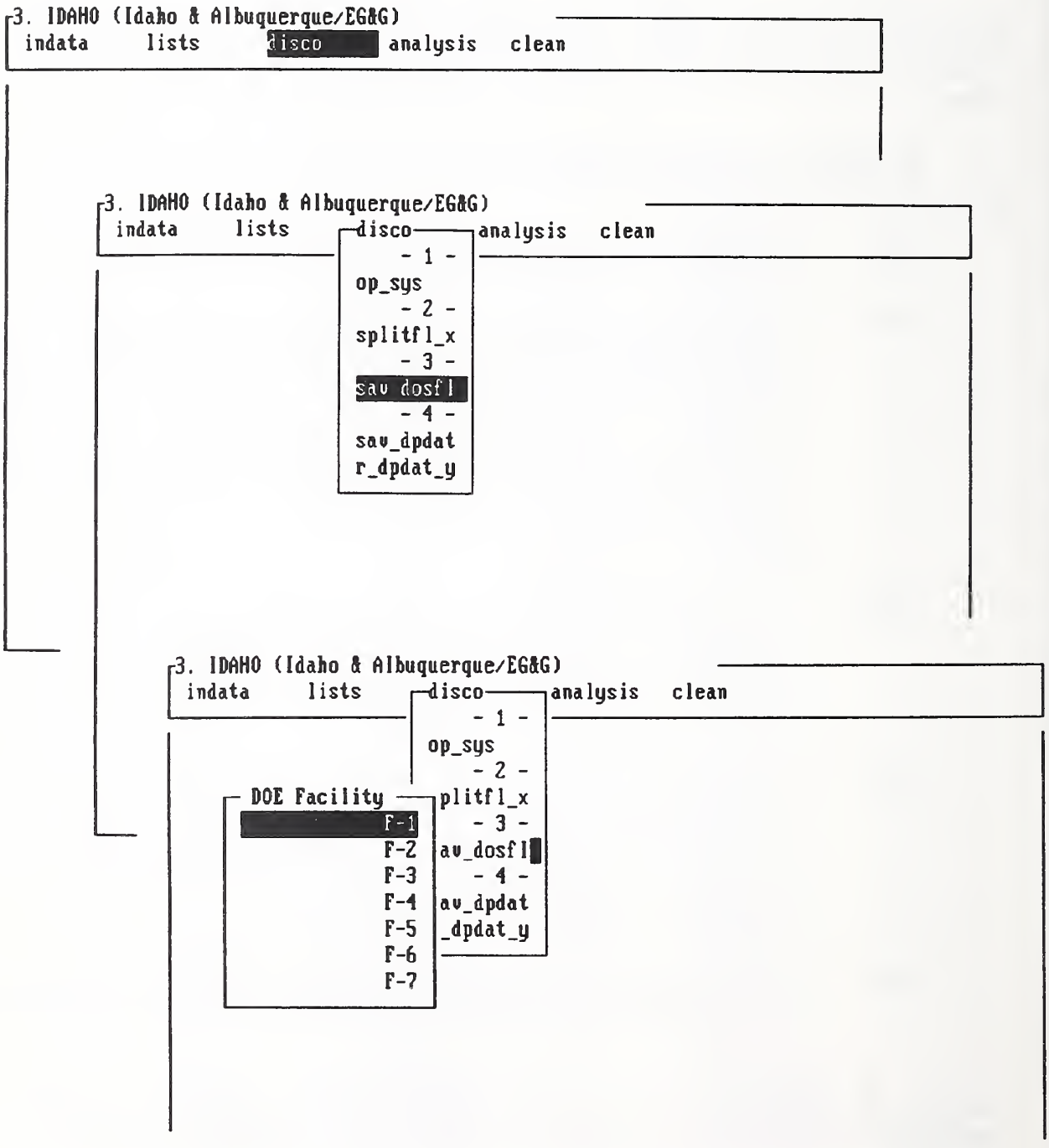
Step 3 — Use space-bar to select one of seven facility labels, F-1 through F-7. As explained in Section 5.10, for application 3. IDAHO, those labels correspond to facilities F31 through F37 as defined on page viii of this report. After a facility label is selected, hit carriage-return to display a second window-menu consisting of a label for facility, year, and quarter.

Step 4 — Use space-bar to select a facility-year-quarter label and hit carriage-return. A chart asking a user to enter the name of a DOS file to receive all information in the pre-selected database is displayed on page 81 (bottom figure). Read the instruction on the filename specificiation, type in a filename as directed, and hit carriage return.

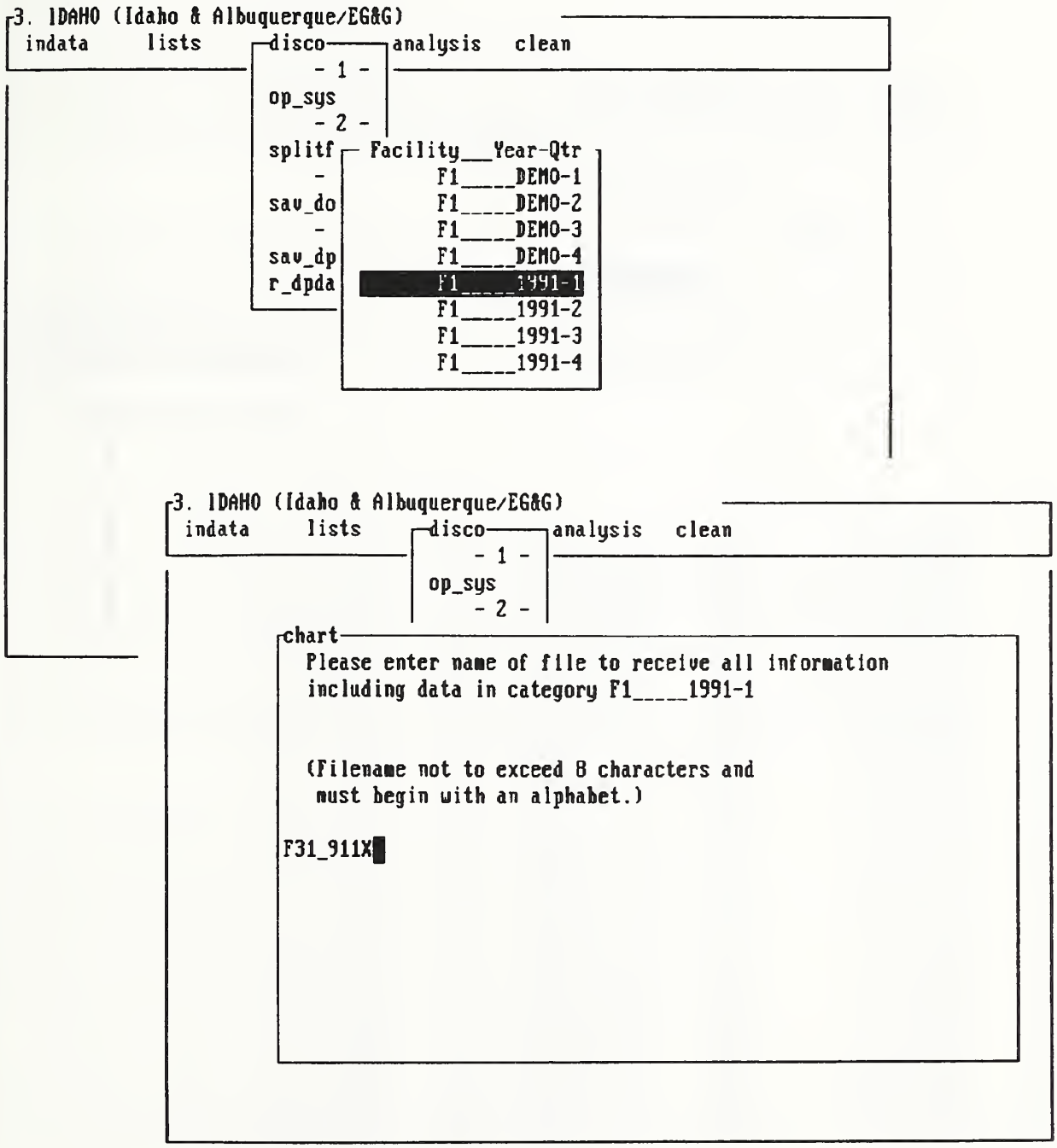
Step 5 — After the content of a database is saved on a DOS file, a message appears (see page 82) confirming that data have been recorded on a file previously named.

To check whether the content of the database is actually saved as a DOS file, use space-bar to position cursor on the option "op_sys" and hit carriage return. A temporary exit to DOS allows a user to use the TYPE command to see the newly-created file (see page 83).

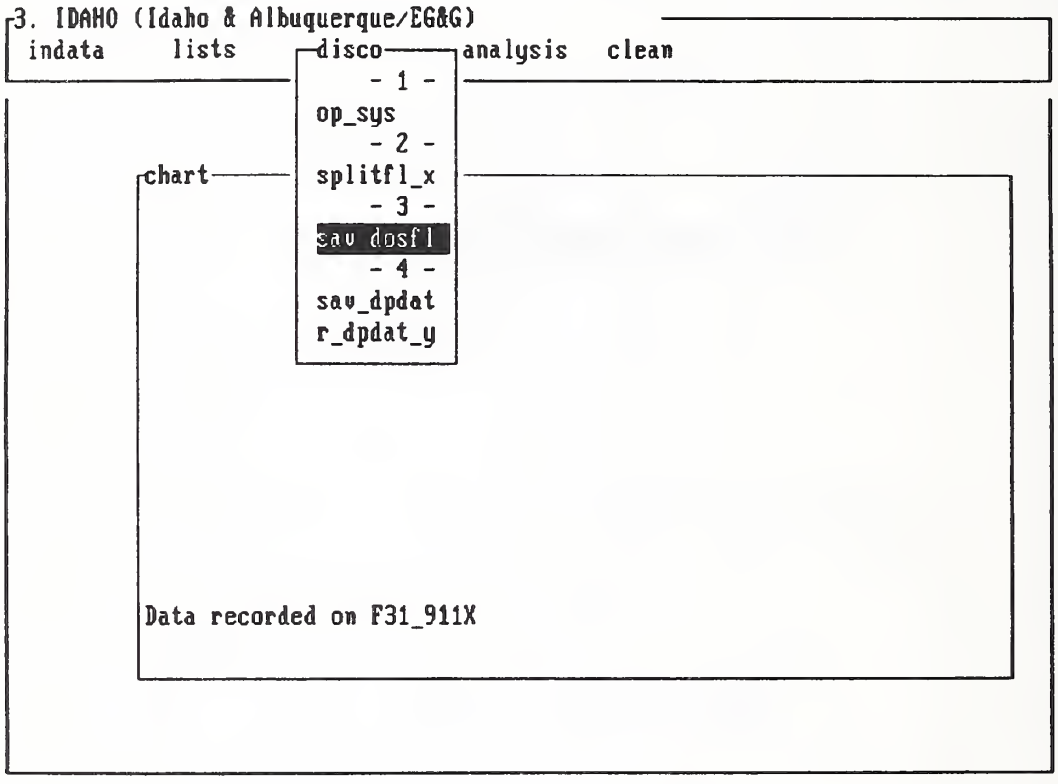
PDA Menu for *option disco*



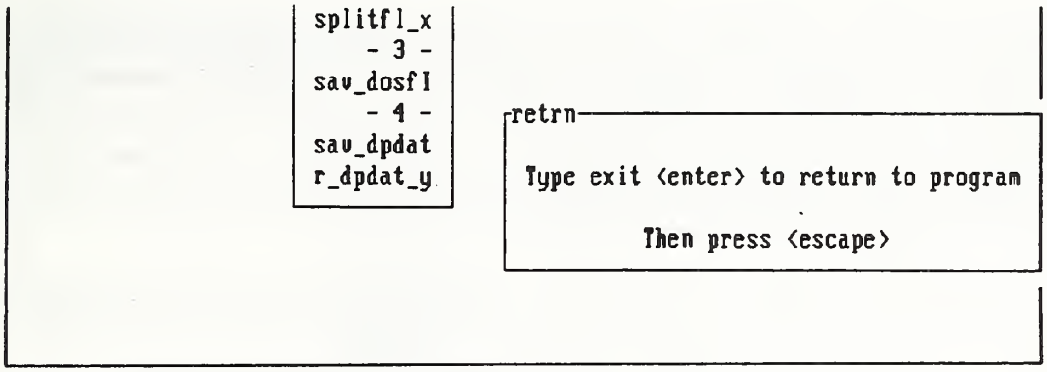
PDA Menu for *option disco* - *Continuation Sheet*



PDA Menu for *option disco* - *Continuation Sheet*



PDA Menu for *option disco* - *Continuation Sheet*




```
DR DOS Release 5.0
Copyright (c) 1976,1982,1988,1990 Digital Research Inc. All rights reserved.
Arima Computer Corporation

A:\>   TYPE F31_911X |MORE

.

     F1____1991-1   1 91 1 ID EG&G AMCF     1100          0.0000000000     1
     F1____1991-1   1 91 1 ID EG&G AMCF     1200          0.0000000000     2
     F1____1991-1   1 91 1 ID EG&G AMCF     1300          0.0000000000     3
     F1____1991-1   1 91 1 ID EG&G AMCF     1400          0.0000000000     4
     F1____1991-1   1 91 1 ID EG&G AMCF     1520          0.0000000000     5
     F1____1991-1   1 91 1 ID EG&G AMCF     1530       1820.0000000000     6
     F1____1991-1   1 91 1 ID EG&G AMCF     1620          0.0000000000     7
     F1____1991-1   1 91 1 ID EG&G AMCF     2100          0.0000000000     8
     F1____1991-1   1 91 1 ID EG&G AMCF     2200          0.0000000000     9
     F1____1991-1   1 91 1 ID EG&G AMCF     2300          1.0000000000    10
     F1____1991-1   1 91 1 ID EG&G AMCF     2400         38.0000000000    11
     F1____1991-1   1 91 1 ID EG&G AMCF     2500          0.0000000000    12
     F1____1991-1   1 91 1 ID EG&G AMCF     2600          1.0000000000    13
     F1____1991-1   1 91 1 ID EG&G AMCF     3110          0.0000000000    14
     F1____1991-1   1 91 1 ID EG&G AMCF     3120          0.0000000000    15
     F1____1991-1   1 91 1 ID EG&G AMCF     3210          0.0000000000    16
     F1____1991-1   1 91 1 ID EG&G AMCF     3220          0.0000000000    17
     F1____1991-1   1 91 1 ID EG&G AMCF     4100          0.0000000000    18
     F1____1991-1   1 91 1 ID EG&G AMCF     4200          0.0000000000    19
     F1____1991-1   1 91 1 ID EG&G AMCF     4300          4.0000000000    20
     F1____1991-1   1 91 1 ID EG&G AMCF     4420         10.0000000000    21
     F1____1991-1   1 91 1 ID EG&G AMCF     4430         14.0000000000    22
     F1____1991-1   1 91 1 ID EG&G AMCF     4520          1.0000000000    23
Strike a key when ready . . .
```

Section 5.12 - *Save Data as DATAPLOT File* using *option disco*

The file-saving exercise of the last section converts a 3-column-formatted file into a 5-column DOS file in drive "a", where the extra two columns are the database identifier and the data point indentifier as illustrated on page 83. For analysis and graphics purposes using a public-domain software package named DATAPLOT, we need to save the 3-column data in a variety of formats in drive "c" under the subdirectory c:\DATAPLOT. In particular, we have designed this feature to allow a user of a DATAPLOT macro to save input data on a file with generic names such as DOE_1COL.DAT, DOE_3COL.DAT, etc.

To accomplish this, we follow a sequence of steps as shown below and on pp. 85-91:

Step 1 — Position cursor at the option "disco" and hit carriage-return.

Step 2 — Position cursor at the option "sav_dpdat" and hit carriage-return.

Step 3 — Use space-bar to select a facility label from the window menu named "facility" (see page 85, bottom), and hit carriage-return.

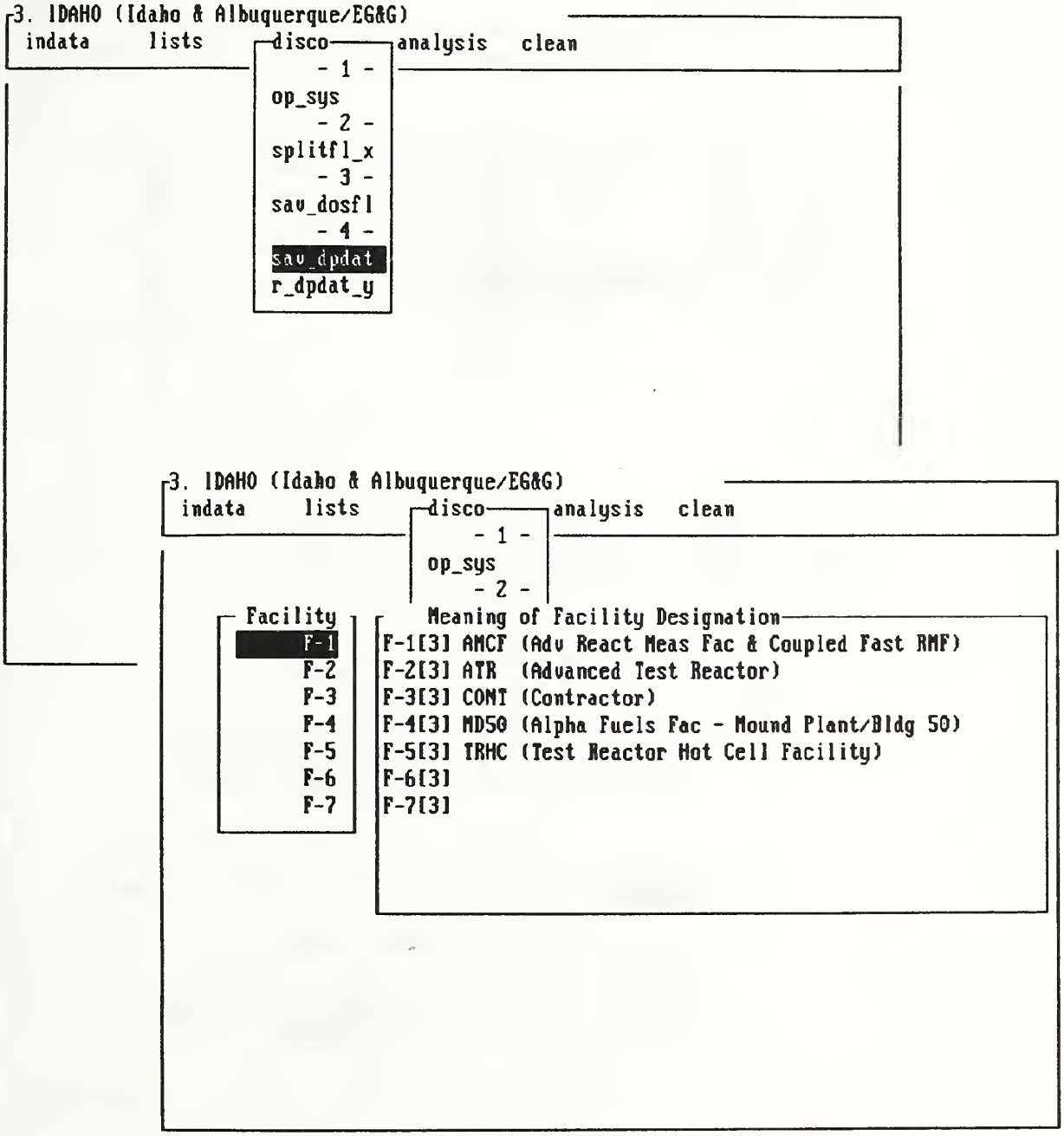
Step 4 — Use space-bar to select a facility-year-quarter label from the next window menu (see page 86, top), and hit carriage-return. At this point, a menu is displayed requesting a user to choose the name of a file from five options, namely, DAT_FILE, DOE_1COL, DOE_2CLA, DOE_2CLB, and DOE_3COL.

Step 5 — Follow the instructions (see page 86, bottom) and hit carriage-return after a particular option is selected.

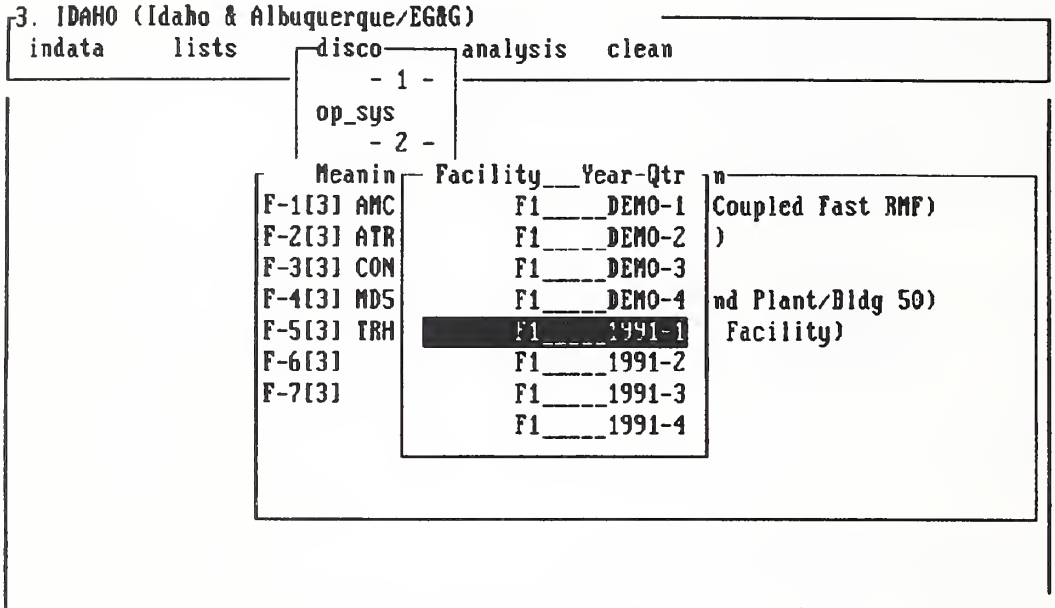
Step 6 — If the option "DAT_FILE" is selected, a user-specified filename must be entered (see page 87, top). If a file by the same filename already exists in the subdirectory c:\DATAPLOT, a warning sign is posted as shown on page 87 (bottom figure). If the warning sign is ignored, a message will appear (see page 88) indicating that data have been saved on a file by the user-specified name plus the three-character extension DAT. This facilitates a direct link with a DATAPLOT macro because DATAPLOT requires the name of a file to be read to have the .DAT extension.

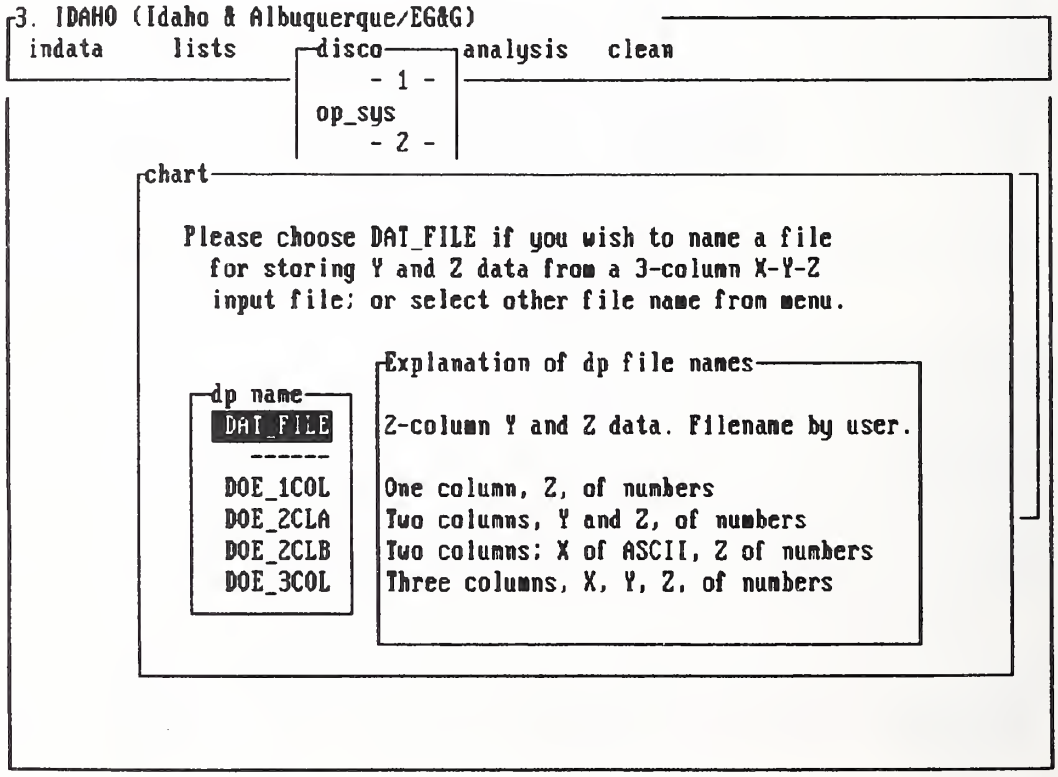
To verify that the DATAPLOT file is correctly generated, use the temporary access to DOS (Section 5.3) to check (see page 89). An example of selecting a pre-assigned filename, say, DOE_2CLB.DAT is given in pp. 90-91.

PDA Menu for *option disco*

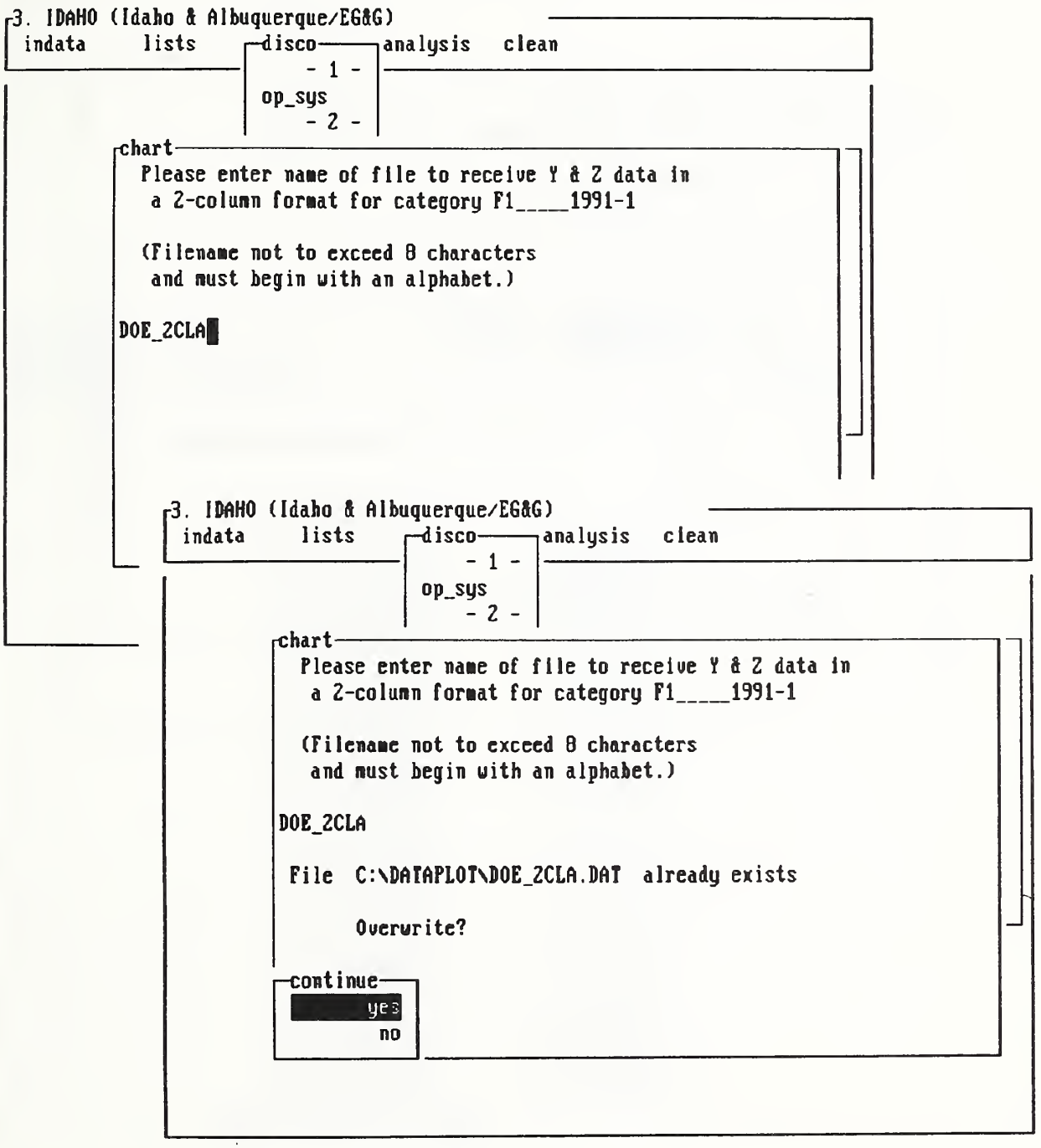


PDA Menu for *option disco* - *Continuation Sheet*

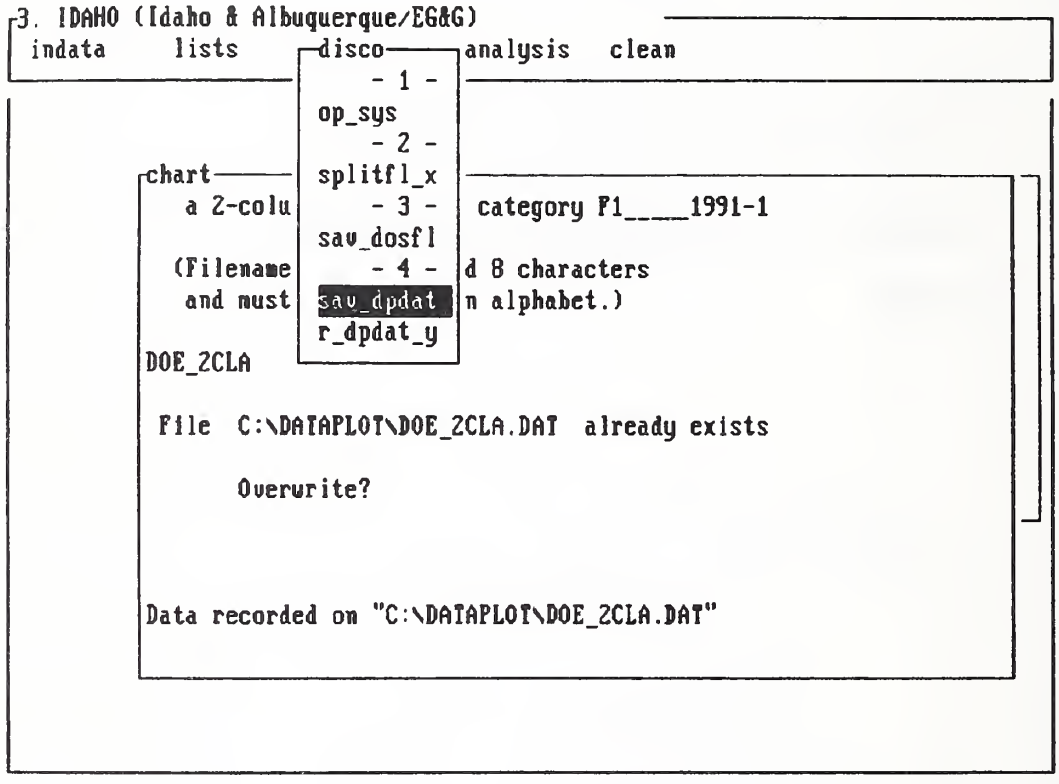




PDA Menu for *option disco* - *Continuation Sheet*



PDA Menu for *option disco* - *Continuation Sheet*



PDA Menu for *option disco* - *Continuation Sheet*

```
splitfl_x
    - 3 -
sav_dosfl
    - 4 -
sav_dpdat
r_dpdat_y

retrn
 Type exit <enter> to return to program
          Then press <escape>
```

```
DR DOS Release 5.0
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Arima Computer Corporation

A:\>   TYPE C:\DATAPLOT\DOE_ZCLA.DAT

          1100.0000000000          0.0000000000
          1200.0000000000          0.0000000000
          1300.0000000000          0.0000000000
          1400.0000000000          0.0000000000
          1520.0000000000          0.0000000000
          1530.0000000000       1820.0000000000
          1620.0000000000          0.0000000000
          2100.0000000000          0.0000000000
          2200.0000000000          0.0000000000
          2300.0000000000          1.0000000000
          2400.0000000000         38.0000000000
          2500.0000000000          0.0000000000
          2600.0000000000          1.0000000000
          3110.0000000000          0.0000000000
          3120.0000000000          0.0000000000
          3210.0000000000          0.0000000000
          3220.0000000000          0.0000000000
          4100.0000000000          0.0000000000
          4200.0000000000          0.0000000000
          4300.0000000000          4.0000000000
          4420.0000000000         10.0000000000
          4430.0000000000         14.0000000000
          4520.0000000000          1.0000000000
Strike a key when ready . . .
```
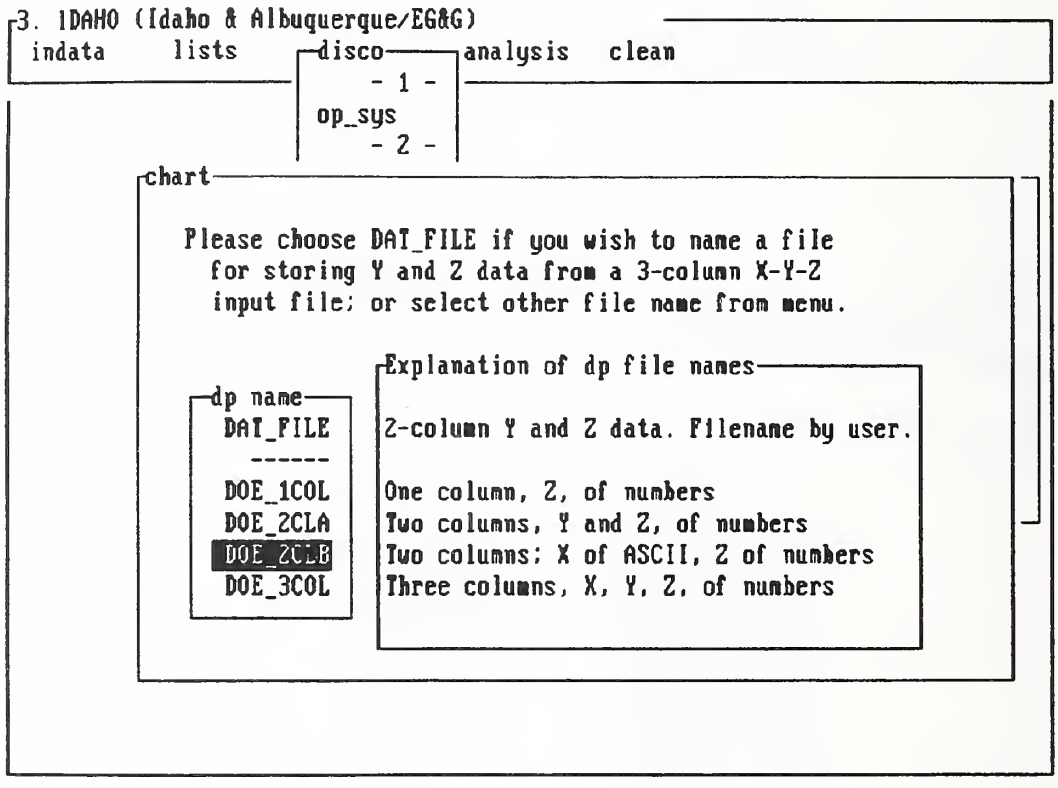

PDA Menu for *option disco* - *Continuation Sheet*



PDA Menu for *option disco* - *Continuation Sheet*

splitfl_x
- 3 -
sav_dosfl
- 4 -
sav_dpdat
r_dpdat_y

retrn

Type exit <enter> to return to program

Then press <escape>

```
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A:\>   TYPE C:\DATAPLOT\DOE_2CLB.DAT |MORE

          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF      1820.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         1.0000000000
          1 91 1 ID EG&G AMCF        38.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         1.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         0.0000000000
          1 91 1 ID EG&G AMCF         4.0000000000
          1 91 1 ID EG&G AMCF        10.0000000000
          1 91 1 ID EG&G AMCF        14.0000000000
          1 91 1 ID EG&G AMCF         1.0000000000
Strike a key when ready . . .
```

Section 5.13 - *Retrieve Data & Save as DATAPLOT File* using *option disco*

The file-saving exercise of the last section is designed to retrieve the content of a single database (facility-year-quarter) in a one-column (Z), two-column (X-Z or Y-Z), or three-column (X-Y-Z) format, where column Y lists all the Performance Indicator (P.I.) Nos. of interest to a DOE user.

Since one of the key objectives of the DOE Program is to analyze the P.I. data by keeping track of each individual P.I. over, say, ten to twelve quarters, it is desirable for a user to be able to retrieve all of the values of a single P.I. in a single or a group of facilities operated by a single contractor. For Phase-1 implementation of the expert system PDA, we included this retrieval capability for a single P.I., but we limit our design to a single facility as a test case against possible memory overflow. As we gain experience with the Phase-1 system using more data from DOE as test cases, we shall soon find out whether it is feasible to extend the retrieval capability to a group of facilities.

To learn how the P.I. data from more than one database (facility-year-quarter) are retrieved and saved in a DATAPLOT file, we follow a sequence of steps as described below and on pp. 93-94:

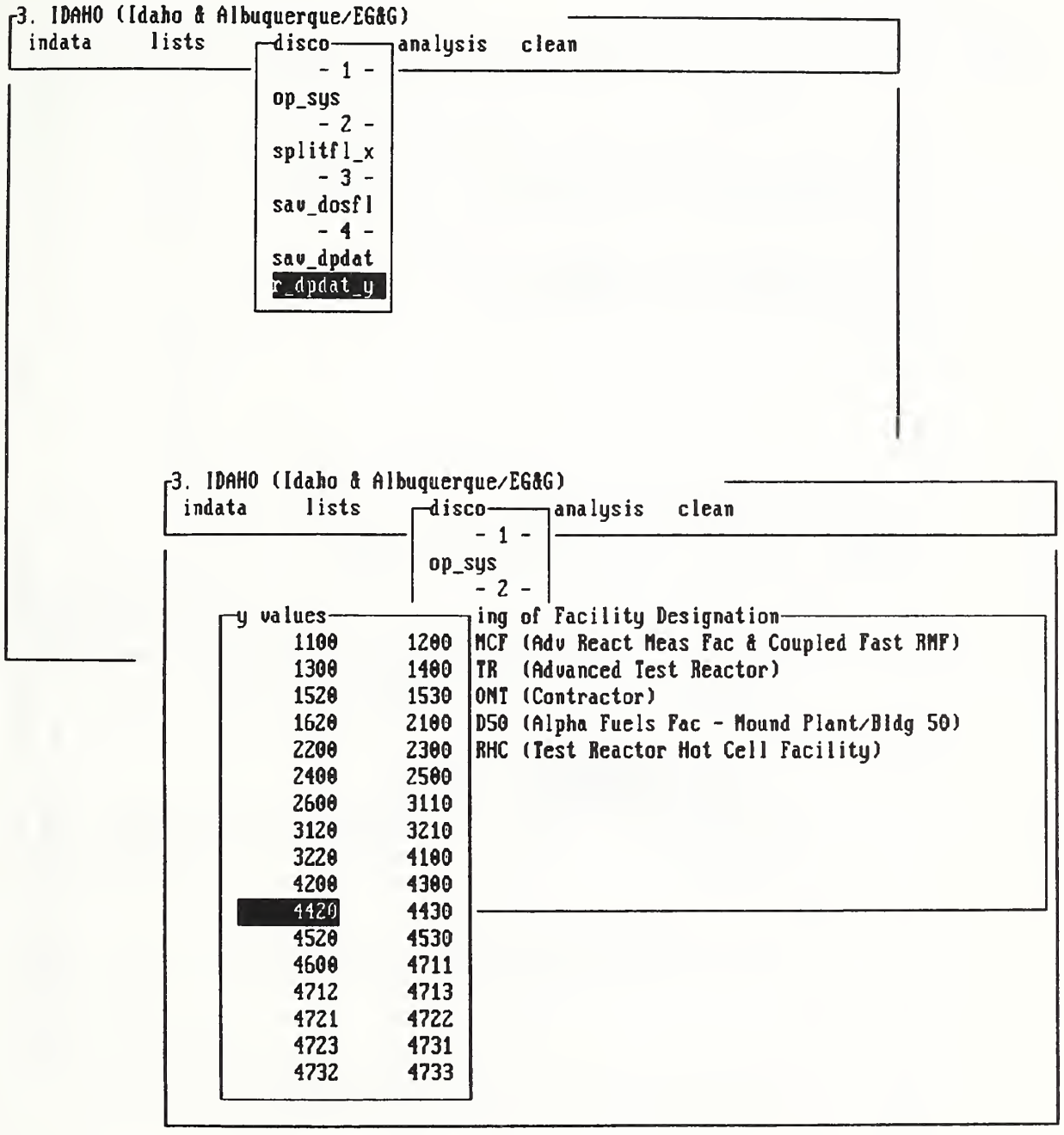
Step 1 — Position cursor at option "r_dpdat_y" in submenu named "disco".

Step 2 — Hit carriage-return to display a menu of y-values (P.I. Nos.). Use space-bar to select the P.I. No., and hit carriage-return to display a chart requesting the user to furnish a filename to store the retrieved information.

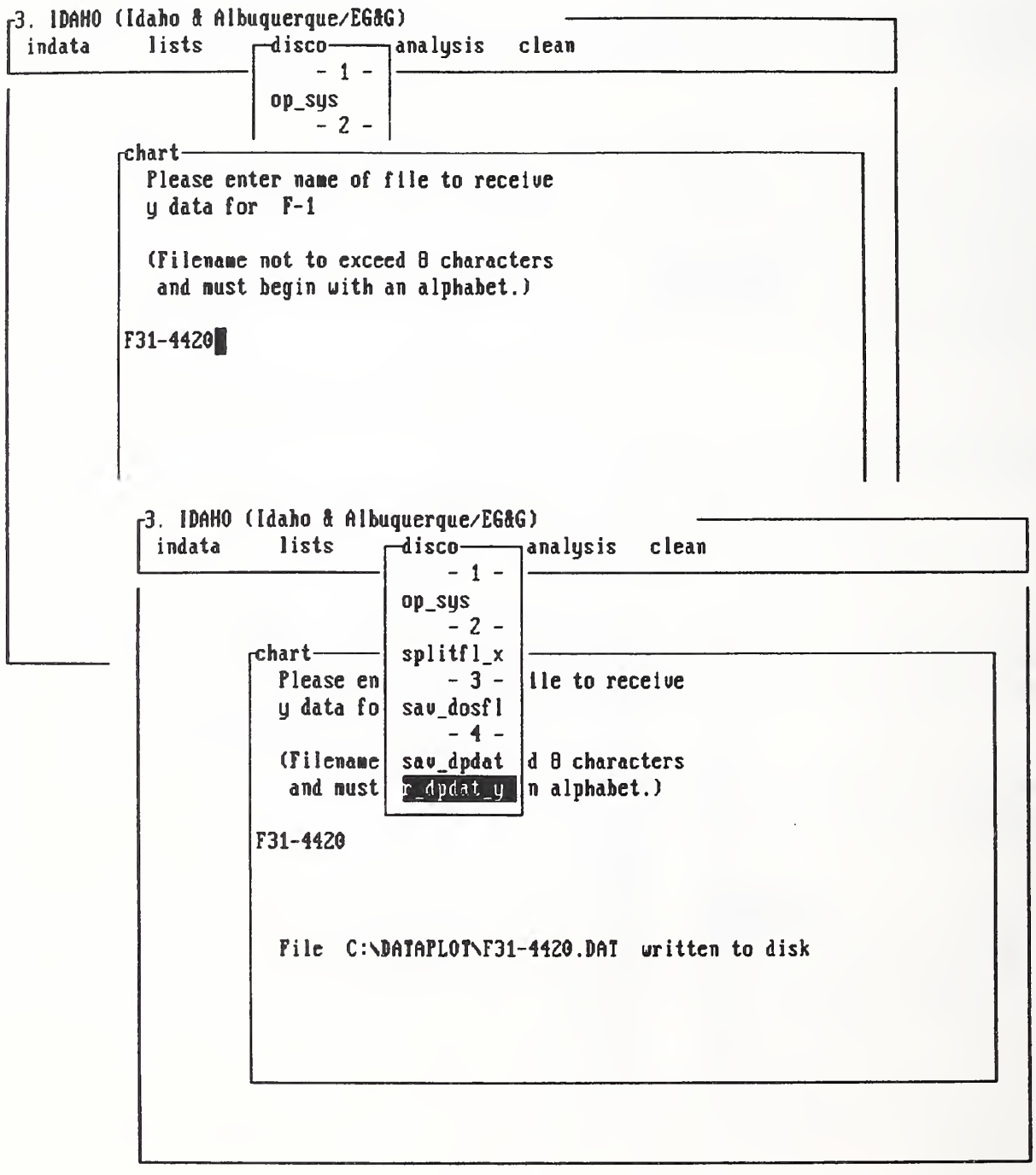
Step 3 — Follow the instructions on the menu (page 94, top), type in a file name, followed by a carriage-return. If there is no conflict with existing filenames, a message will appear indicating that the retrieved information has been stored as a DATAPLOT file in the subdirectory c:\DATAPLOT.

To verify that the DATAPLOT file indeed contains all of the data pertaining to a single P.I., use the temporary access to DOS (Section 5.3) to check. The example shown on page 95 indicates that the values of the P.I. No. 4420 for the first and second quarters of 1991 can be retrieved for trending analysis using DATAPLOT or other statistical analysis packages.

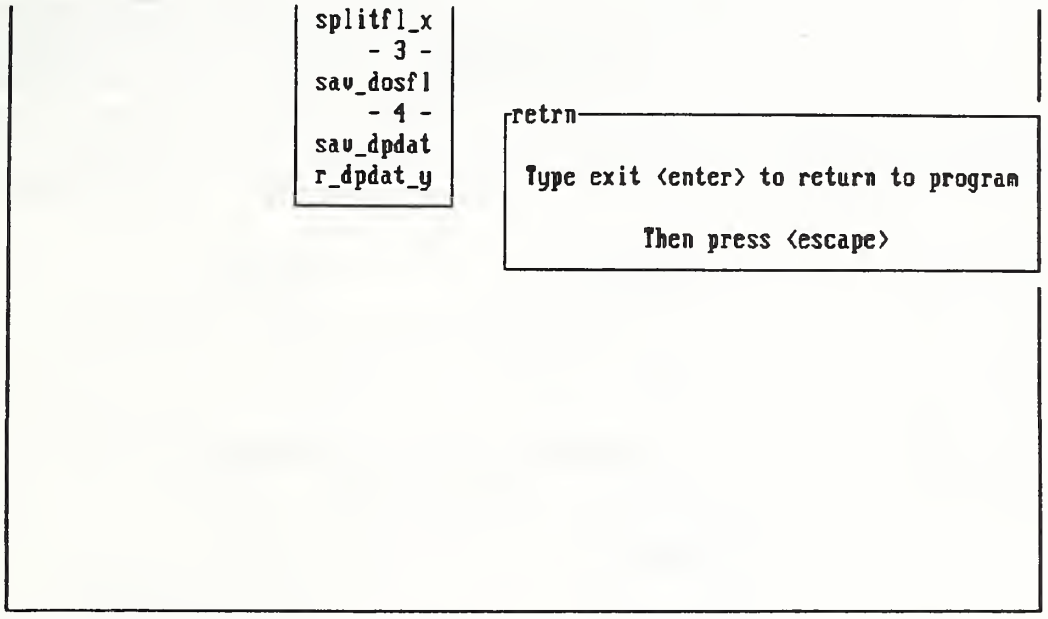
PDA Menu for *option disco*



PDA Menu for *option disco* - *Continuation Sheet*



PDA Menu for *option disco* - *Continuation Sheet*




```
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A:\>   TYPE C:\DATAPLOT\F31-4420.DAT


  F1____1991-1   1 91 1 ID EG&G AMCF     4420        10.0000000000    21
  F1____1991-2   1 91 2 ID EG&G AMCF     4420        11.0000000000    21


A:\>
```
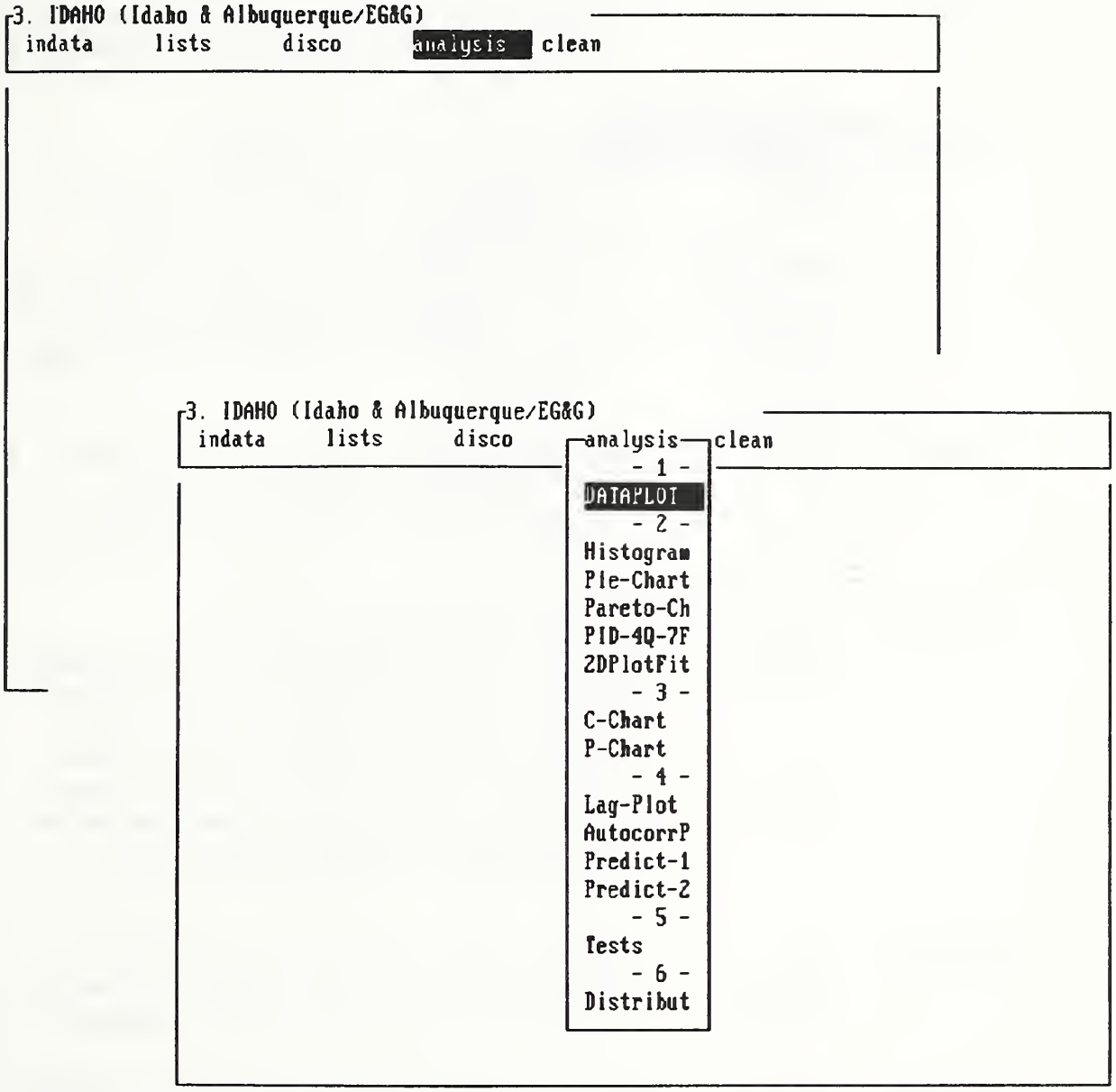

Section 5.14 - *Analysis of Data* using *option analysis*

At this point, we have completed all the necessary tutorials for data input and file management such that we can begin the access to the powerful analysis package named DATAPLOT. Let us review what we have accomplished so far in getting ready for DATAPLOT. In Section 5.4, we learned how to partition a DOE data file into smaller pieces where the first of a 3-column data file is identical. In Section 5.11, we learned how to save a 3-column data file as a 5-column DOS file where two extra columns were added to provide system-generated identification for each row of data. In Section 5.12, we learned how to selectively save from a 3-column, X-Y-Z data file into one of following five DATAPLOT files:

Original File	Saved File	Filename
3-column data, X, Y, Z.	1-column data, Z.	DOE_1COL.DAT
3-column data, X, Y, Z.	2-column data, Y, Z.	DOE_2CLA.DAT or, < Any 8-character filename > plus extension .DAT
3-column data, X (ascii), Y, Z.	2-column data, X (ascii), Z.	DOE_2CLB.DAT
3-column data, X, Y, Z.	3-column data, X, Y, Z.	DOE_3COL.DAT

In Section 5.13, we learned how to retrieve data from files belonging to different quarters (identified by X-value) but having the same PI number (identified by Y-value) such that we can track the variation of the PI values (identified by Z-value) over all quarters where data exist. Finally, it is important to emphasize that all files saved in this manner are stored in the subdirectory C:\DATAPLOT for processing after we activate the option "analysis" in the 5-option window named "3. IDAHO (Idaho & Albuquerque/EG&G)".

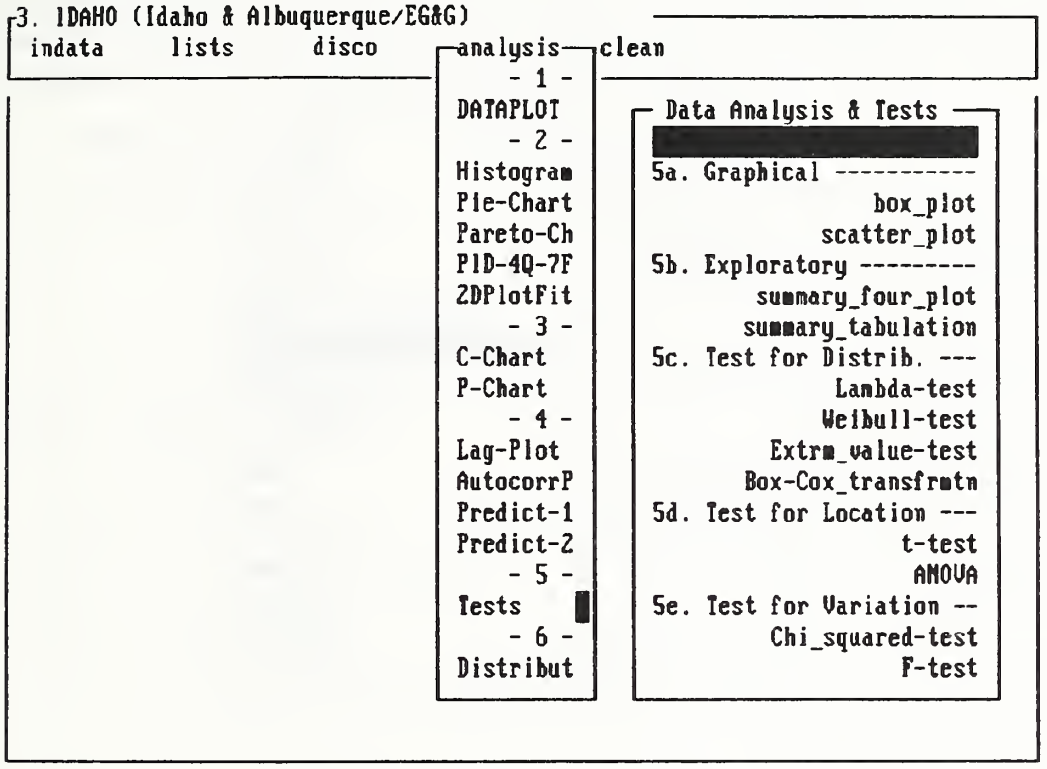
PDA Menu for *option analysis*



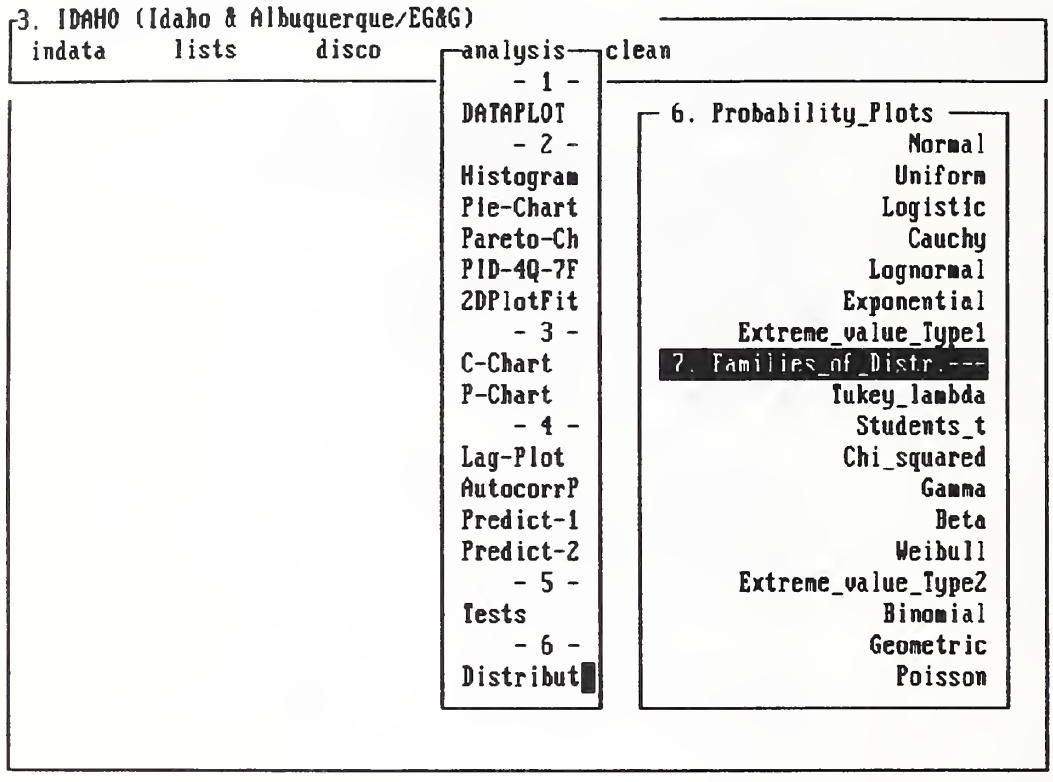
As shown on page 97, when we move the cursor to the option "analysis and hit the Carriage-Return, we activate a window with six subgroups of options as shown below:

	Option	Remarks
Subgroup 1	DATAPLOT	This option activates an interactive data analysis code named DATAPLOT. The user may type in any DATAPLOT commands as described in Appendix C and execute in the interactive mode.
Subgroup 2	Histogram	See Section 6.1 for a tutorial on this option.
	Pie-Chart	See Section 6.2 for a tutorial on this option.
	Pareto-Ch	This option fulfills one of 3 DOE chart requirements as specified in [2]. See Section 6.3 for a tutorial.
	PID-4Q-7F	This option was designed for a set of sample PI data given by DOE [16] for tutorial purposes. See Sect. 6.4.
	2DPlotFit	This Y-vs.-X plot and linear fit option is motivated by a round robin fatigue crack growth rate test program [8]. See Section 6.5.
Subgroup 3	C-Chart	This option fulfills one of 3 DOE chart requirements as specified in [2]. See Section 6.6 for a tutorial.
	P-Chart	This option fulfills one of 3 DOE chart requirements as specified in [2]. See Section 6.7 for a tutorial.
Subgroup 4	Lag-Plot	See Section 6.8 for a tutorial on this option.
	AutocorrP	See Section 6.9 for a tutorial on this option.
	Predict-1	This option was motivated by the option on P-Chart where a simple model (type 1) was used to predict a future data using results of a lag plot and autocorr. plot of past information. See Section 6.10 for a tutorial.
	Predict-2	This option was similarly motivated as Predict-1 except that a different model (type 2) was used when the lag plot and autocorr. plot results exceed a certain threshold value. See Section 6.11 for a tutorial.
Subgroup 5	Tests (more on page 99)	This option is further divided into five sub-classes of options (total 12) as shown on page 99. See Sections 6.12 and 6.13 for tutorials on 7 of the 12 options.
Subgroup 6	Distribut (more on page 100)	This option is also divided into two sub-classes of options (total 17) as shown on page 100. See Section 6.14 for a tutorial on 2 of the 17 options.

PDA Menu for *option analysis / Tests*



PDA Menu for *option analysis / Distribut*



Chapter 6 - Sample Applications using *option analysis*

In this chapter, we shall learn to perform a variety of exploratory data analysis tasks by a *single-stroke* execution of DATAPLOT macros written for users who know nothing about the English-like commands of DATAPLOT but are interested in learning about them. Of the 14 tutorials in this chapter, 10 are based on fictitious data that are motivated by DOE PI data analysis requirements as specified in the Guidance Document [2]. The ten tutorials are:

Section	Option	Datafile Name	Remark
6.1	Histogram	DOE_1COL.DAT	12 Monthly Data for PI 1.2 (Skin Contamination) for a particular year reported. Same data to be used for generating a C-Chart.
6.2	Pie-Chart	DOE_2CLB.DAT	Alternative to a Pareto Distribution Chart as required by DOE Guidance Document [2]. Same 2-column data with X(ascii) and Y(no. of events) to be used for generating a Pareto Chart.
6.3	Pareto-Ch	DOE_2CLB.DAT	One of 3 charts required by DOE. The fictitious data used here follow an example used in [2], p. A3-11.
6.4	PID-4Q-7F	DOE_3COL.DAT	This is not one of the required charts, but is introduced to represent a set of sample data furnished by DOE [16].
6.6	C-Chart	DOE_2CLA.DAT	1 of 3 required charts. Data on PI 1.2.
6.7	P-Chart	DOE_3COL.DAT	1 of 3 required charts. Data on PI 4.4.
6.8	Lag-Plot	DOE_1COL.DAT	Data of PI 4.4 in percentages are used.
6.9	AutocorrP	DOE_1COL.DAT	Data of PI 4.4 in percentages are used.
6.10	Predict-1	DOE_3COL.DAT	Same data of PI 4.4 for P-Chart are used to predict using model type 1.
6.11	Predict-2	DOE_3COL.DAT	Fictitious data used for model type 2.

To introduce the subject of exploratory data analysis, we added four more tutorials, Sections 6.5, 6.12, 6.13, and 6.14, using fatigue crack growth test data reported by six laboratories in a 1974 round robin program sponsored by the Society of Automotive Engineers [8].

Sect. 6.1 - *Histogram (Data File: **DOE_1COL.DAT**)*

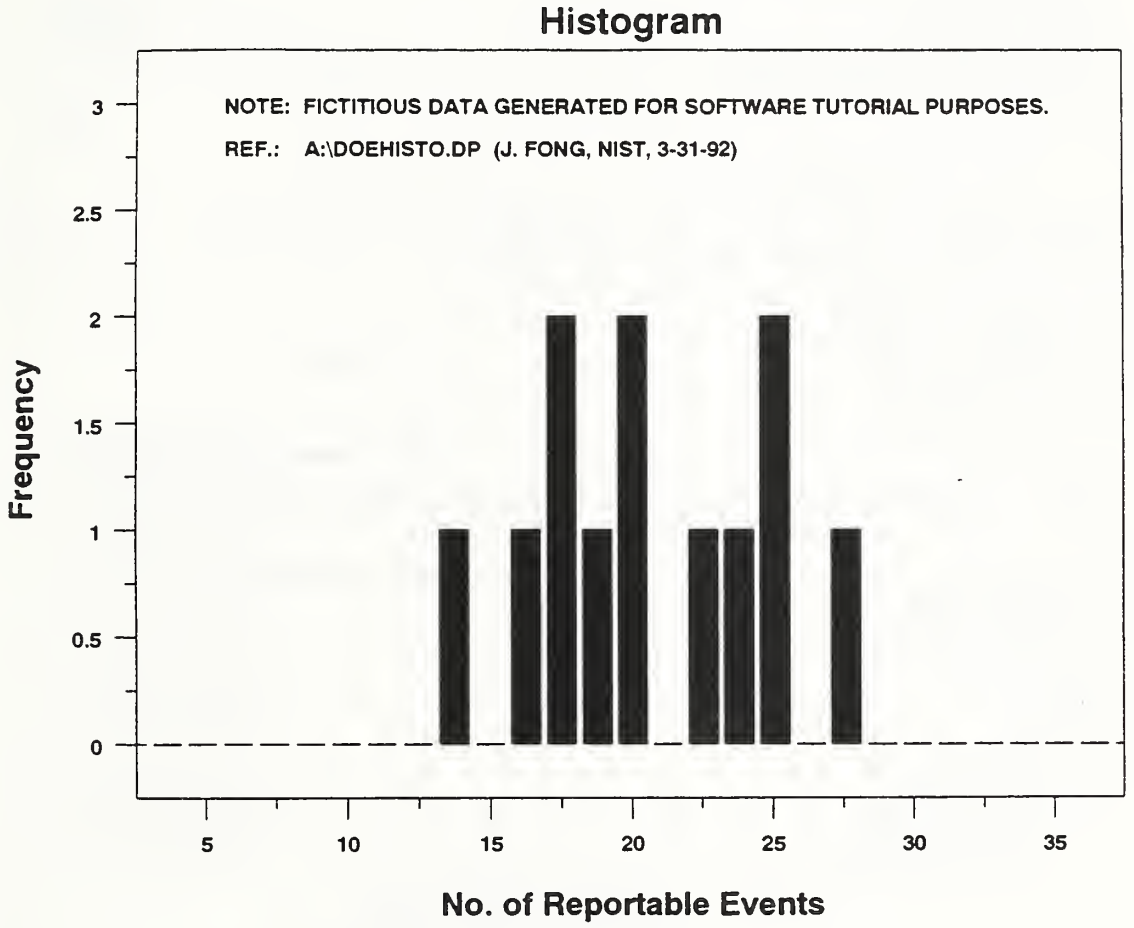
The purpose of this tutorial is to learn the meanings of all the English-like commands introduced by a DATAPLOT macro named "DOEHISTO.DP". To facilitate ease of references, we shall list all of the new commands used in the macro DOEHISTO.DP according to the 15 categories used in Appendix C to define all of the DATAPLOT commands. For the first of a series of DATAPLOT tutorials, 24 commands were used as listed below and on page 252:

Category	Pages	Command
Graphics	223-226	...HISTOGRAM (default to count vs. value)
Word Chart/Schematics	227-228	
Analysis	229	LET
Plot Control	230-232	BAR CHARACTER ...LABEL LEGEND ...LIMITS TIC TITLE WINDOW
Graphics Output Device	232	DEVICE
Input/Output	233	READ
Support	234-236	CLASS DEFINE DIMENSION EXIT FEEDBACK PAUSE "."
Reserved Words	236-237	
LET Subcommands	238-241	MEAN NUMBER STANDARD DEVIATION
SET Subcommands	241	
Library Functions	242-243	
Characters & Symbols	244-246	LC( ) UC( )
CHARACTER, LINES, or FONT Arguments	247-248	

The philosophy here is to introduce gradually the English-like commands of DATAPLOT to no more than, say, 90 commands through 20 example-driven macros in 14 tutorials. We also organize these tutorials in a logical sequence beginning with presentation graphics and moving to exploratory, exhaustive, and finally to confirmatory data analysis as envisioned by Tukey [20]. Readers are encouraged to write their own macros using ours as classroom examples.

Histogram *(Data File: DOE_1COL.DAT)*

Subroutine Name: ***DOEHISTO.DP*** *Ref.:* *pda-dp.2a*



DATAPLOT Code - *Continuation Sheet*

```
.
.       ----- DOEHISTO.DP (version 92-03-31, Fong & Filliben, Revision 3) -----
.
.                                                   ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                   ----- 2. INPUT DATA -----
READ DOE_1COL.DAT Y
.
.       READ A:DOE_HIST.DAT Y
.                                                   ----- 3. COMPUTATION -----
LET N = NUMBER Y
LET YBAR = MEAN Y
LET SD = STANDARD DEVIATION Y
.
LET BUPPER = YBAR + 6*SD
LET BLOWER = YBAR - 6*SD
.                                                   ----- 4. TITLE COMMANDS -----
TITLE HLC()ISTOGRAM
TITLE SIZE 3.5
TITLE DISPLACEMENT 1.5
.                                                   ----- 5. LEGEND COMMANDS -----
.
LEGEND 1    NOTE:  FICTITIOUS DATA GENERATED FOR SOFTWARE TUTORIAL PURPOSES.
LEGEND 2    REF.:    A:\DOEHISTO.DP  (J. FONG, NIST, 3-31-92)
.
.                                                   ----- 6. GRAPHICS COMMANDS -----
CLASS LOWER BLOWER
CLASS UPPER BUPPER
CLASS WIDTH 0.3*SD
.
BAR ON
BAR WIDTH 1
BAR FILL ON
.       BAR FILL OFF
BAR PATTERN SOLID
.       BAR PATTERN DU
.       BAR PATTERN DD
.       BAR PATTERN DUDD
.                          ----- Note 1:  DU denotes diagonal up;
.                                        DD denotes diagonal down;
.                                        DUDD denotes cross-hatched pattern.
.
.                                                   ----- 7. LABEL COMMANDS -----
Y1LABEL FLC()REQUENCY
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 5
.
LET FMAX = 3
Y1LIMITS 0 FMAX
.                          ----- Note 2:  For this exercise, maximum frequency FMAX is set at 3.
```

DATAPLOT Code - *Continuation Sheet*

```
LET YMIN = 5
LET YMAX = 35
XLIMITS YMIN YMAX
.                        ----- Note 3:  For this exercise, XLIMITS are given by YMIN and
.                                       YMAX.  For this plot, YMIN = 5, and YMAX = 35.
.
XLABEL NLC()O. OF UC()RLC()EPORTABLE UC()ELC()VENTS
XLABEL SIZE 3
.                                              ----- 8. PLOT COMMANDS -----
HISTOGRAM Y
LEGEND 1
LEGEND 2
.                                              ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                              ----- END OF DOEHISTO.DP -----
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file DOE_1COL.DAT, which is also stored
.                               as a backup named DOE_HIST.DAT:
```

20.0000000000
19.0000000000
28.0000000000
18.0000000000
25.0000000000
25.0000000000
14.0000000000
20.0000000000
16.0000000000
22.0000000000
24.0000000000
17.0000000000

Sect. 6.2 - *Pie Chart (Data File: **DOE_2CLB.DAT**)*

At the last tutorial, we learned how to code a DATAPLOT macro using 24 different commands to plot a one-column file of numbers as a frequency-vs.-value histogram where the maximum frequency was set through a parameter named FMAX, and the x-axis limits were set through YMIN and YMAX. This nomenclature is a little confusing, partly because it is customary in plotting histograms to refer to a column of numbers as Y rather than X.

Clearly, when the one-column data file DOE_1COL.DAT changes, so should the values of FMAX, YMIN, and YMAX. To accomplish this, readers need to use an editor to change the macro file named DOEHISTO.DP by editing a few lines including those beginning with the commands TITLE, LEGEND, Y1LABEL, and XLABEL.

We now wish to introduce the second tutorial macro named DOEPIECH.DP. We need 20 more new commands to code this macro where we can plot a pie chart from a 2-column data file with the first column contains ASCII characters and the second, numbers as shown on page 110. Again by category, we list the 20 new commands below and on page 252:

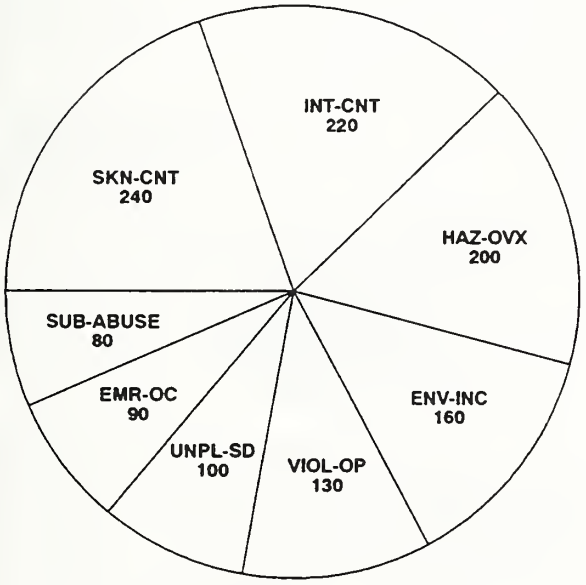
Category	Pages	Command
Graphics	223-226	PIE CHART
Word Chart/Schematics	227-228	HW JUSTIFICATION MARGIN MOVE TEXT VERTICAL SPACING
Analysis	229	
Plot Control	230-232	PRE-ERASE
Graphics Output Device	232	
Input/Output	233	COLUMN LIMITS ROW LIMITS SKIP
Support	234-236	DEGREES END OF LOOP IF LOOP
Reserved Words	236-237	FOR XPLOT YPLOT
LET Subcommands	238-241	SEQUENCE
SET Subcommands	241	
Library Functions	242-243	
Characters & Symbols	244-246	
CHARACTER, LINES, FONT Arguments	247-248	

To keep track of how we increase our DATAPLOT vocabulary, let us define SVI to be the size of our vocabulary after tutorial number I. For I = 1 and 2, SV1 = 24, and SV2 = 44, resp.

Pie-Chart (Data File: DOE_2CLB.DAT)

Subroutine Name: ***DOEPIECH.DP*** *Ref.:* *pda-dp.2b*

Root Cause of Unsafe Occurrences



Legend:

EMR-OC = Emergency & Unusual Occurrences.

ENV-INC = Environmental Incidents.

HAZ-OVX = Radioactive/Hazadous Material Overexposures.

INT-CNT = Internal Contaminations.

SKIN-CNT = Skin Contaminations.

SUB-ABUSE = Substance Abuse Incidents.

UNPL-SD = Unplanned Shutdowns.

VIOL-OP = Violations of Operating Procedures.

Note: The above pie chart is based on fictitious data generated for tutorial purposes.

Ref.: A:DOEPIECH.DP (J. FONG, NIST, 3-31-92)

DATAPLOT Code - *Continuation Sheet*

```
.
.       ----- DOEPIECH.DP (version 92-03-31, Fong & Filliben, Revision 2) -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 89 85
.                                                  ----- 2. INPUT DATA -----
COLUMN LIMITS 16 132
READ DOE_2CLB.DAT Y
.
.       READ A:DOE_PIE.DAT Y
.
COLUMN LIMITS 1 15
LET RN = NUMBER Y
SKIP 0
LOOP FOR K = 1 1 RN
ROW LIMITS K K
READ STRING DOE_2CLB.DAT S^K
END OF LOOP
.                                                  ----- 3. COMPUTATION -----
.                                                  ----- 4. TITLE COMMANDS -----
.                                                  ----- 5. LEGEND COMMANDS -----
.                                                  ----- 6. GRAPHICS COMMANDS -----
.                                                  ----- 7. LABEL COMMANDS -----
.                                                  ----- 8. PLOT COMMANDS -----
LET X = SEQUENCE 1 1 RN
PIE CHART Y X
.                                                  ----- 9. TEXT COMMANDS -----
LET XPCENT=41.8
LET XPMAX=68.6
LET YPCENT=55
LET YPMAX=90
DEGREES
LET THETANEW=180
LET XCUR=-1
LET YCUR=0
JUSTIFICATION CENTER
. LET R = 1.25
LET R = .55
HW 2 1
.
LOOP FOR K = 1 1 RN
LET K2 = 2*K
LET XOLD=XCUR
LET YOLD=YCUR
LET XCUR=XPLOT(K2)
LET YCUR=YPLOT(K2)
LET XMID=(XOLD+XCUR)/2
LET YMID=(YOLD+YCUR)/2
```

DATAPLOT Code - *Continuation Sheet*

```
.
LET THETAMID=ARCTAN(XMID/YMID) IF YMID >= 0
LET THETAMID=ARCTAN(XMID/ABS(YMID)) IF YMID < 0
LET THETAMID=90-THETAMID IF YMID >= 0
LET THETAMID=270+THETAMID IF YMID < 0
LET XT=R*COS(THETAMID)
LET YT=R*SIN(THETAMID)
LET XPT=XPCENT+(XPMAX-XPCENT)*XT
LET YPT=YPCENT+(YPMAX-YPCENT)*YT
LET YK=Y(K)
MOVE XPT YPT
TEXT ^S^K
LET YPT2 = YPT - 2
MOVE XPT YPT2
TEXT VALU()YK
END LOOP
.
PRE-ERASE OFF
WINDOW COORDINATES 0 0 95 95
JUSTIFICATION CENTER
MOVE 60 84
HW 5 3.5
TEXT RLC()OOT UC()CLC()AUSE OF UC()ULC()NSAFE UC()OLC()CCURRENCES
.
JUSTIFICATION LEFT
MOVE 64 70
HW 3.5 2.5
TEXT LLC()EGEND:
.
MARGIN 64
VERTICAL SPACING 3.25
MOVE 64 64
HW 2.2 1.5
TEXT EMR-OC = ELC()MERGENCY & UC()ULC()NUSUAL UC()OLC()CCURRENCES.
TEXT ENV-INC  =  ELC()NVIRONMENTAL UC()ILC()NCIDENTS.
TEXT HAZ-OVX  =  RLC()ADIOACTIVE/UC()HLC()AZADOUS UC()MLC()ATERIAL
MOVE 76 51
TEXT UC()OLC()VEREXPOSURES.
TEXT INT-CNT  =  ILC()NTERNAL UC()CLC()ONTAMINATIONS.
TEXT SKIN-CNT  =  SLC()KIN UC()CLC()ONTAMINATIONS.
TEXT SUB-ABUSE  =  SLC()UBSTANCE UC()ALC()BUSE UC()ILC()NCIDENTS.
TEXT UNPL-SD  =  ULC()NPLANNED UC()SLC()HUTDOWNS.
TEXT VIOL-OP = VLC()IOLATIONS OF UC()OLC()PERATING UC()PLC()ROCEDURES.
.
JUSTIFICATION CENTER
MOVE 60 13
TEXT NLC()OTE:  UC()TLC()HE ABOVE PIE CHART IS BASED ON FICTITIOUS DATA GENERATED FOR TUTORIAL PURPOSES.
MOVE 60 8
TEXT RLC()EF.:  UC()A:DOEPIECH.DP    (J. FONG, NIST, 3-31-92)
.
```

DATAPLOT Code - *Continuation Sheet*

```
.                                          ---- 10. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                          ----- END OF DOEPIECH.DP -----
.
.       -----  Note to Reader:  The following is a listing of th data
.                               file DOE_2CLB.DAT, which is also stored
.                               as a backup named DOE_PIE.DAT:
```

```
SKN-CNT        240
INT-CNT        220
HAZ-OVX        200
ENV-INC        160
VIOL-OP        130
UNPL-SD        100
EMR-OC          90
SUB-ABUSE       80
```

Sect. 6.3 - *Pareto Chart (Data File: DOE_2CLB.DAT)*

In the previous two sections, we learned 44 DATAPLOT commands to write two macros: one for plotting a histogram from a one-column data file, and the other, a pie chart from two columns of data, one of which consists of characters to be printed alongside the numbers.

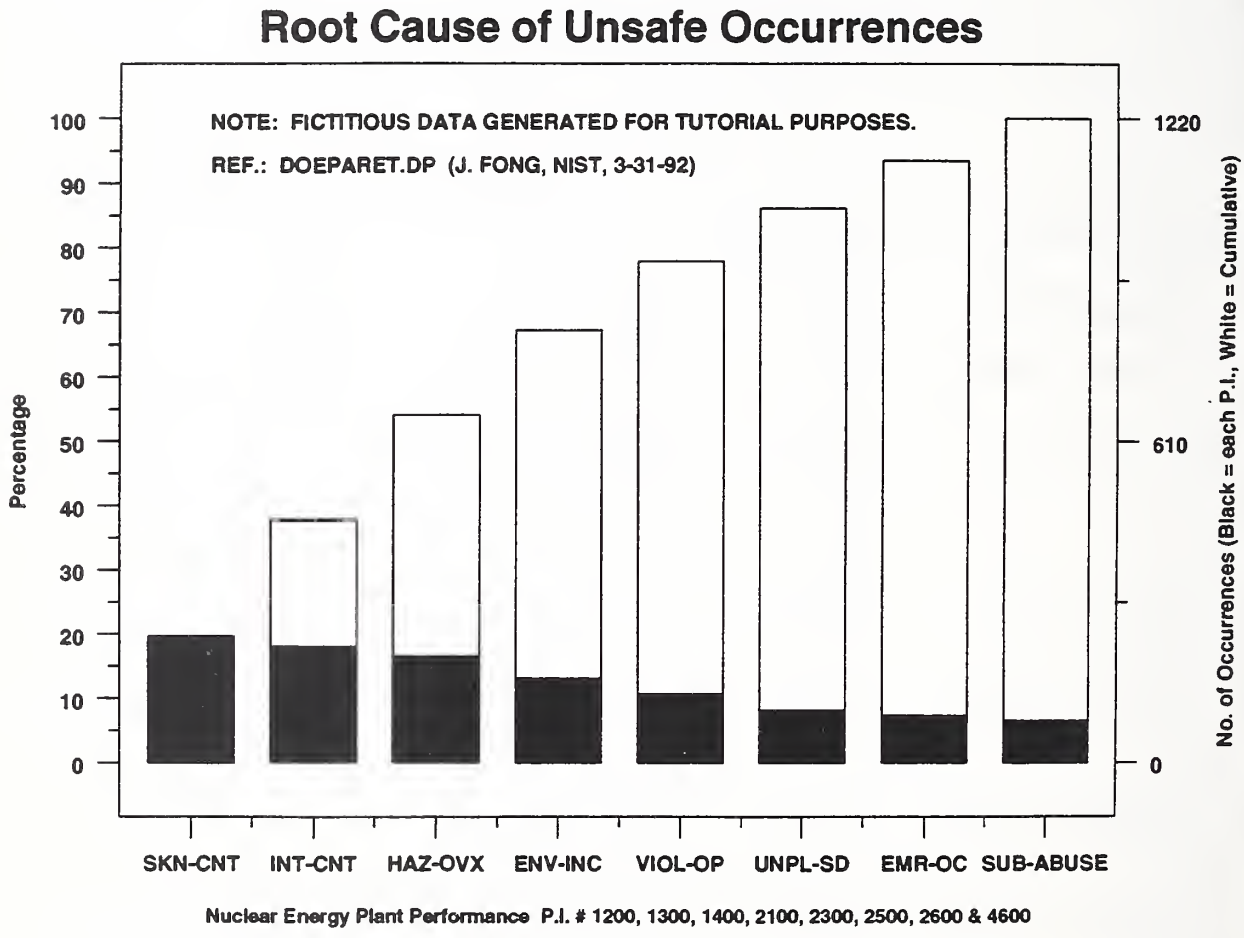
We are now ready to work on a chart known as the Pareto Distribution Chart, which is one of the three required for all DOE reports on the Performance Indicator (PI) data. A typical Pareto Chart using some fictitious data for tutorial purposes is given on the next page. To code the macro, "DOEPARET.DP", as listed on pp. 113-114, we need to learn 9 new commands, i.e,, "...", BLANK, CUMULATIVE SUM, LINES, MAJOR ...TIC NUMBER, MINOR ...TIC NUMBER, PLOT, SORTC and SUM. Note that SV3, the vocabulary size, has grown to 53.

To learn the essential features of the macro "DOEPARET.DP", and means of adapting it for other purposes, we examine the first seven of the 9 segments of the code as follows:

Segment of Macro	Comment ID	Comment on A Specific Feature of DOEPARET.DP
1. System Commands.	C-603-1-1	Window corner coordinates set at (0,0) and (95,95).
2. Input Data.	C-603-2-1	Input data file name set as "DOE_2CLB.DAT".
	C-603-2-2	Input data file consists of two columns, with the width of the first column set at 15 spaces.
	C-603-2-3	First column of data set as ASCII characters.
3. Computation.	C-603-3-1	Input file sorted by second column in decreasing order.
	C-603-3-2	Delete line containing SORTC if sorting is not required.
4. Title Commands.	C-603-4-1	Title of plot set as "Root Cause ..."
	C-603-4-2	UC( )CLC( )AUSE denotes upper case C, lower case AUSE.
	C-603-4-3	Character size of title set at 4 units.
5. Legend Commands.	C-603-5-1	Legend 1 set as "Note: ..."
	C-603-5-2	Legned 2 set as "Ref.: ..."
6. Graphics Commands.	C-603-6-1	Bar width set at 0.7 data units for Y2 (percentage) plot.
	C-603-6-2	Bar width set at 0.7 data units for Y3 (cumulative Y2) plot.
7. Label Commands.	C-603-7-1	Left Y-axis label set as "Percentage".
	C-603-7-2	Right Y-axis label set as "No. of ...".
	C-603-7-3	X-axis label set as "Nuclear Energy, etc.".
	C-603-7-4	X-axis label includes a continuation command "...".
	C-603-7-5	X-tic label given by first column ascii data of input file.

Pareto Chart (Data File: DOE_2CLB.DAT)

Subroutine Name: ***DOEPARET.DP*** *Ref.:* *pda-dp.2c*



DATAPLOT Code - *Continuation Sheet*

```
.       ----- DOEPARET.DP (version 92-03-31, Fong & Filliben, Revision 3) -----
.
.                                                   ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                   ----- 2. INPUT DATA -----
COLUMN LIMITS 16 132
READ DOE_2CLB.DAT Y
.
.       READ A:DOE_PARE.DAT Y
.
COLUMN LIMITS 1 15
.
LET RN = NUMBER Y
SKIP 0
LOOP FOR K = 1 1 RN
ROW LIMITS K K
READ STRING DOE_2CLB.DAT S^K
END OF LOOP
.                                                   ----- 3. COMPUTATION -----
LET X = SEQUENCE 1 1 RN
LET INDEX = SEQUENCE 1 1 RN
LET Y = -Y
LET Y = SORTC Y INDEX
LET Y = -Y
LET N = SUM Y
LET Y2 = 100*Y/N
LET Y3 = CUMULATIVE SUM Y2
.                                                   ----- 4. TITLE COMMANDS -----
.
TITLE RLC()OOT UC()CLC()AUSE OF UC()ULC()NSAFE UC()OLC()CCURRENCES
TITLE SIZE 4
TITLE DISPLACEMENT 2
.                                                   ----- 5. LEGEND COMMANDS -----
.
LEGEND 1    NOTE:  FICTITIOUS DATA GENERATED FOR TUTORIAL PURPOSES.
LEGEND 2    REF.:  DOEPARET.DP  (J. FONG, NIST, 3-31-92)
.
.                                                   ----- 6. GRAPHICS COMMANDS -----
LINES BLANK ALL
BAR ON ON
BAR FILL ON OFF
BAR WIDTH .7 .7
.                                                   ----- 7. LABEL COMMANDS -----
Y1LABEL PLC()ERCENTAGE
Y1LABEL SIZE 2
Y1LABEL DISPLACEMENT 5
YLIMITS 0 100
.
Y2LABEL NLC()O. OF UC()OLC()CCURRENCES (UC()BLC()LACK = EACH UC()P.I., WLC()HITE = UC()CLC()UMULATIVE)
Y2LABEL SIZE 2
Y2LABEL DISPLACEMENT 9
```

DATAPLOT Code - *Continuation Sheet*

```
.
XLABEL NLC()UCLEAR UC()ELC()NERGY UC()PLC()LANT UC()PLC()ERFORMANCE  UC()P.I. # 1200, ...
1300, 1400, 2100, 2300, 2500, 2600 & 4600
.
XLABEL SIZE 1.8
XLIMITS 1 RN
.
MAJOR X1TIC NUMBER RN
MINOR X1TIC NUMBER 0
.
X1TIC LABEL FORMAT ALPHA
.
LET I1 = INDEX(1)
LET STRING DUMMY = ^S^I1
.
LOOP FOR K = 2 1 RN
LET I^K = INDEX(K)
LET STRING DUMMY = ^DUMMY ^S^I^K
END LOOP
.
X1TIC LABEL CONTENTS ^DUMMY
X1TIC LABEL SIZE 2.0
.
Y2TICS ON
Y2TIC LABELS ON
Y2LIMITS 0 N
Y2TIC LABEL NUMBER 3
.                                              ----- 8. PLOT COMMANDS -----
PLOT Y2 Y3 VS X
LEGEND 1
LEGEND 2
.                                              ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.
.                                              ----- END OF DOEPARET.DP -----
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file DOE_2CLB.DAT, which is also stored
.                               as a backup named DOE_PARE.DAT:
```

SKN-CNT	240
INT-CNT	220
HAZ-OVX	200
ENV-INC	160
VIOL-OP	130
UNPL-SD	100
EMR-OC	90
SUB-ABUSE	80

Sect. 6.4 - *Summary Plot for P.I. 4.4 (Data File: **DOE_3COL.DAT**)*

In the last three sections, we used a total of 53 DATAPLOT commands to produce a histogram, a pie chart, and a Pareto distribution chart.

Our goal in this section is to see whether those 53 commands are sufficient for us to write a new macro to generate a report-quality plot of a specific set of performance indicator data furnished by DOE for tutorial purposes only.

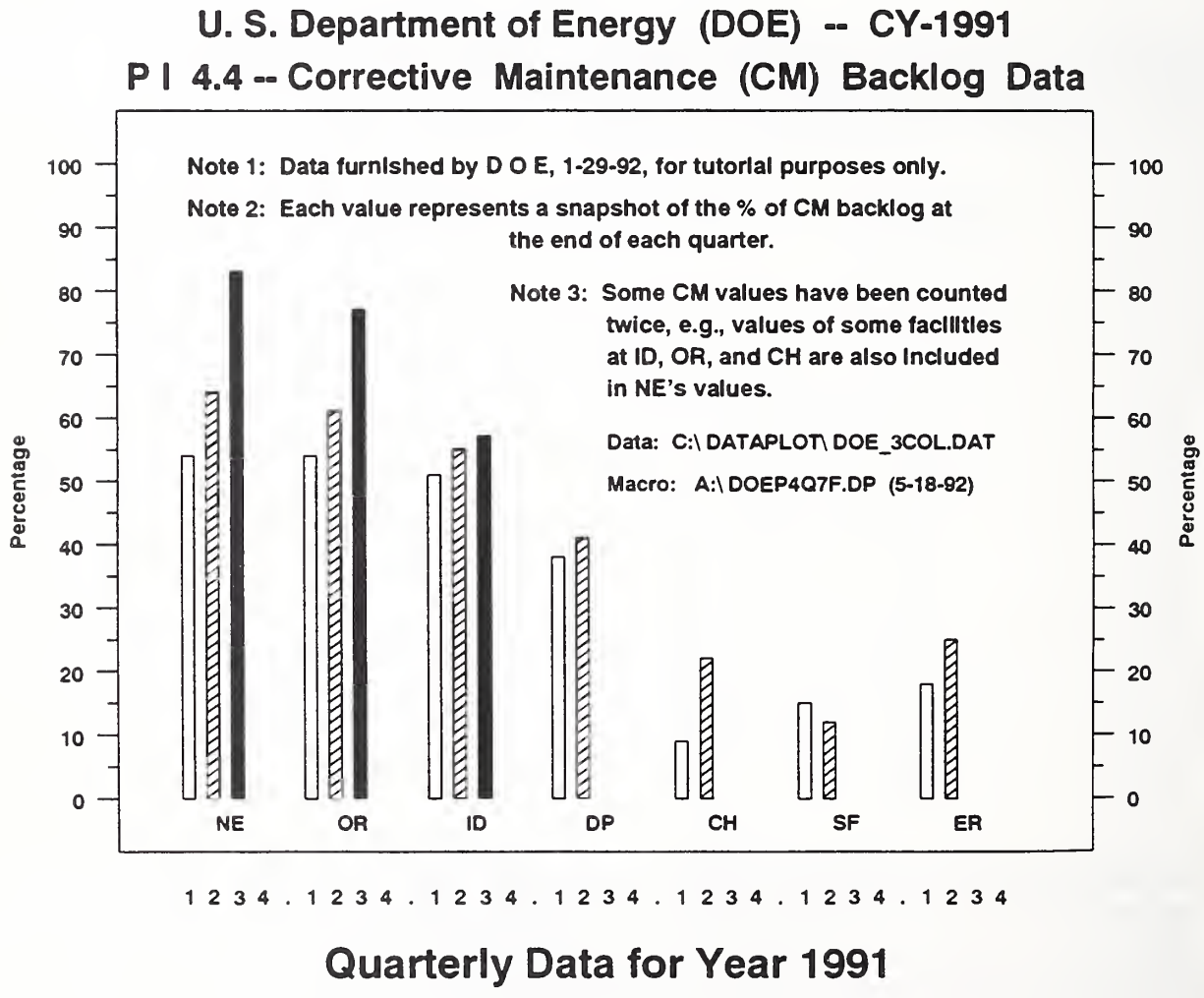
On Jan. 29, 1992, we received from DOE a set of quarterly data of Performance Indicator 4.4 (Corrective Maintenance Backlog) from 7 DOE organizations during CY-1991 [16]. We used the input feature of the expert system PDA to generate the following table of data as stored in a file named DOE_3COL.DAT:

Column 1 to 25 Organization	Column 27 to 46 Quarter	Column 48 to 67 Percentage (%)
NE	1	54.0
NE	2	64.0
NE	3	83.0
OR	1	54.0
OR	2	61.0
OR	3	77.0
ID	1	51.0
ID	2	55.0
ID	3	57.0
DP	1	38.0
DP	2	41.0
CH	1	9.0
CH	2	22.0
SF	1	15.0
SF	2	12.0
ER	1	18.0
ER	2	25.0

To complete the macro DOEP4Q7F.DP which produces the plot on the next page, we need to introduce three more DATAPLOT commands, namely, DELETE, MAXIMUM and SUBSET. This is encouraging news to the first-time user of DATAPLOT. With the increase of the size of command vocabulary apparently slowing down (SV1 = 24, SV2 = 44, SV3 = 53, and SV4 = 56), we observe that the tutorial goal of acquiring no more than 80 commands to reach a certain level of proficiency in DATAPLOT coding is, perhaps, achievable. A listing of the DATAPLOT macro, DOEP4Q7F.DP, appears on pp. 117-118.

Summary Plot for P.I. 4.4 (Data File: DOE_3COL.DAT)

Subroutine Name: ***DOEP4Q7F.DP*** *Ref.:* *pda-dp.2d*



DATAPLOT Code - *Continuation Sheet*

```
.
.       -----   DOEP4Q7F.DP (version 92-05-18, Fong & Filliben, Revision 2) -----
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES                                                    NE      1       54.0
DEFINE ER ESC FF                                                           NE      2       64.0
TIC OFFSET UNITS SCREEN                                                    NE      3       83.0
TIC OFFSET 5 5                                                             OR      1       54.0
CHARACTER COLOR BLACK ALL                                                  OR      2       61.0
BAR COLOR BLACK ALL                                                        OR      3       77.0
DEVICE 2 POSTSCRIPT                                                        ID      1       51.0
WINDOW CORNER COORDINATES 0 0 95 95                                        ID      2       55.0
.                                                  ----- 2. INPUT DATA     ID      3       57.0
COLUMN LIMITS 27 132                                                       DP      1       38.0
READ DOE_3COL.DAT QUARTER Y                                                DP      2       41.0
.       READ A:DOE_PI44.DAT QUARTER Y                                      CH      1        9.0
COLUMN LIMITS 1 25                                                         CH      2       22.0
LET RN = NUMBER Y                                                          SF      1       15.0
SKIP 0                                                                     SF      2       12.0
LOOP FOR K = 1 1 RN                                                        ER      1       18.0
ROW LIMITS K K                                                             ER      2       25.0
READ STRING DOE_3COL.DAT S^K
END OF LOOP
.                                                  ----- 3. COMPUTATION -----
LET X = SEQUENCE 1 1 RN
LET INDEX = SEQUENCE 1 1 RN
LET INDEX2 = INDEX
DELETE INDEX2 SUBSET QUARTER 2 3 4
LET N = SUM Y
LET Y2 = 100*Y/N
LET NUMSITE = NUMBER INDEX2
LOOP FOR K = 1 1 NUMSITE
LET I1 = INDEX2(K)
LET SITE = K FOR I = I1 1 RN
END OF LOOP
LET X2 = (SITE - 1)*5 + QUARTER
.                                                  ----- 4. TITLE COMMANDS -----
.
TITLE P I  4.4 -- CLC()ORRECTIVE  UC()MLC()AINTENANCE  UC()(CM)  BLC()ACKLOG  UC()DLC()ATA
TITLE SIZE 3.5
TITLE DISPLACEMENT 2
.                                                  ----- 5. LEGEND COMMANDS -----
.                                                  ----- 6. GRAPHICS COMMANDS -----
.                                                  ----- 7. LABEL COMMANDS -----
.
Y1LABEL PLC()ERCENTAGE
Y1LABEL SIZE 2
Y1LABEL DISPLACEMENT 5
Y1LIMITS 0 100
Y2TICS ON
Y2TIC LABELS ON
Y2LABEL PLC()ERCENTAGE
Y2LABEL SIZE 2
Y2LABEL DISPLACEMENT 8
Y2LIMITS 0 100
LET NUMTICS = 5*NUMSITE
XLIMITS 1 NUMTICS
MAJOR X1TIC NUMBER NUMTICS
MINOR X1TIC NUMBER 0
X1TICS OFF
```

DATAPLOT Code - *Continuation Sheet*

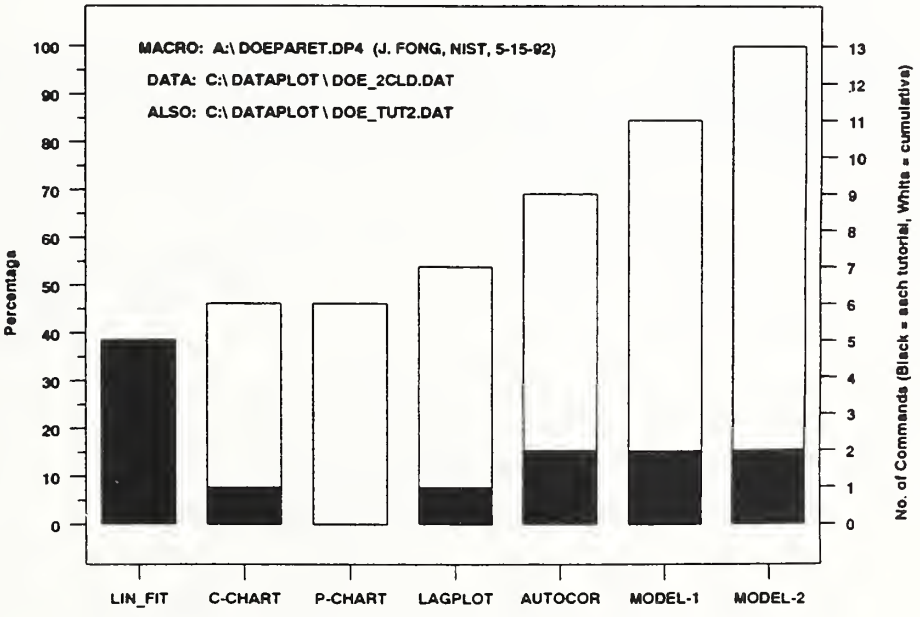
```
X1TIC LABEL FORMAT ALPHA
LET STRING SJUNK = BL 1 2 3 4
LET STRING SJ = 1 2 3 4 .
X1TIC LABEL CONTENTS ^SJ ^SJ ^SJ ^SJ ^SJ ^SJ 1 2 3 4
X2LABEL QLC()UARTERLY UC()DLC()ATA FOR UC()YLC()EAR 1991
X2LABEL SIZE 4
X2LABEL DISPLACEMENT 8
CHAR OFF ALL
LINES BLANK ALL
BAR ON ON ON ON
BAR FILL ON ON ON ON
BAR WIDTH .5 .5 .5 .5
BAR PATTERN NONE DU SOLID DUDD
.                                                  ----- 8. PLOT COMMANDS -----
PLOT Y X2 QUARTER
JUSTIFICATION CENTER
LET LEFTFRA = 15
LET OFFSET = 5
LET RIGHTFRA = 85
LET START = LEFTFRA+OFFSET
LET WIDTH = (RIGHTFRA-OFFSET)-(LEFTFRA+OFFSET)
LET FUDGE1 = 1.5
LET FUDGE2 = 1.03
LET Y0 = 22
LOOP FOR K = 1 1 NUMSITE
LET I^K = INDEX2(K)
LET STRING DUMMY = ^S^I^K
LET P = (K-0.5)/NUMSITE
LET X0 = (START-FUDGE1)+P*WIDTH*FUDGE2
MOVE X0 Y0
TEXT ^DUMMY
END LOOP
.
JUSTIFICATION LEFT
MOVE 20 84
HW 2.2 1.5
TEXT NLC()OTE 1:  UC()DLC()ATA FURNISHED BY UC()D O E, 1-29-92, LC()FOR TUTORIAL PURPOSES ONLY.
MOVE 20 80
TEXT NLC()OTE 2:  UC()ELC()ACH VALUE REPRESENTS A SNAPSHOT OF THE % OF UC()CM LC()BACKLOG AT
MOVE 43 77
TEXT LC()THE END OF EACH QUARTER.
MOVE 43 72
TEXT NLC()OTE 3:  UC()SLC()OME UC()CM LC()VALUES HAVE BEEN COUNTED
MOVE 50 69
TEXT LC()TWICE, E.G., VALUES OF SOME FACILITIES
MOVE 50 66
TEXT LC()AT UC()ID, OR, LC()AND UC()CH LC()ARE ALSO INCLUDED
MOVE 50 63
TEXT LC()IN UC()NELC()'S VALUES.
MOVE 50 58
HW 2 1.3
TEXT DLC()ATA:  UC()C:\ DATAPLOT\ DOE_3COL.DAT
MOVE 50 54
TEXT MLC()ACRO:   UC()A:\ DOEP4Q7F.DP  (5-18-92)
JUSTIFICATION CENTER
MOVE 50 97
HW 3.5 2.4
TEXT U. S. UC()DLC()EPARTMENT OF UC()ELC()NERGY  UC()(DOE)  --  CY-1991
.                                                  ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                  ----- END OF DOEP4Q7F.DP -----
```

Sect. 6.5 - *2D Plot with Linear Fit (Data File: **ASTM_2CL.DAT**)*

So far, we have introduced 56 DATAPLOT commands for presentation graphics. The second group of 13 commands, to be introduced in Sections 6.5 through 6.11, will enable us to do some simple analysis and modeling. The 13 commands, spread among 7 macros, are:

Anal. Option	Name of Macro	Datafile	Name of Commands
2DPlotFit	DOEPLOTF.DP	ASTM_2CL.DAT	... FIT; LINEAR FIT; PRED; RESSD; TPPF.
C-Chart	DOECCC.DP	DOE_2CLA.DAT	SPIKE.
P-Chart	DOEPCC.DP	DOE_3COL.DAT	
Lag-Plot	DOELAG.DP	DOE_1COL.DAT	... LAG PLOT.
AutocorrP	DOEAUTO.DP	DOE_1COL.DAT	AUTOCORRELATION; AUTOCORRELATION PLOT.
Predict-1	DOEPRED1.DP	DOE_3COL.DAT	STANDARD DEVIATION OF MEAN; DATA.
Predict-2	DOEPRED2.DP	DOE_3COL.DAT	WEIGHTED MEAN; CIRCLE.

Group 2 - 13 New Commands in 7 Macros

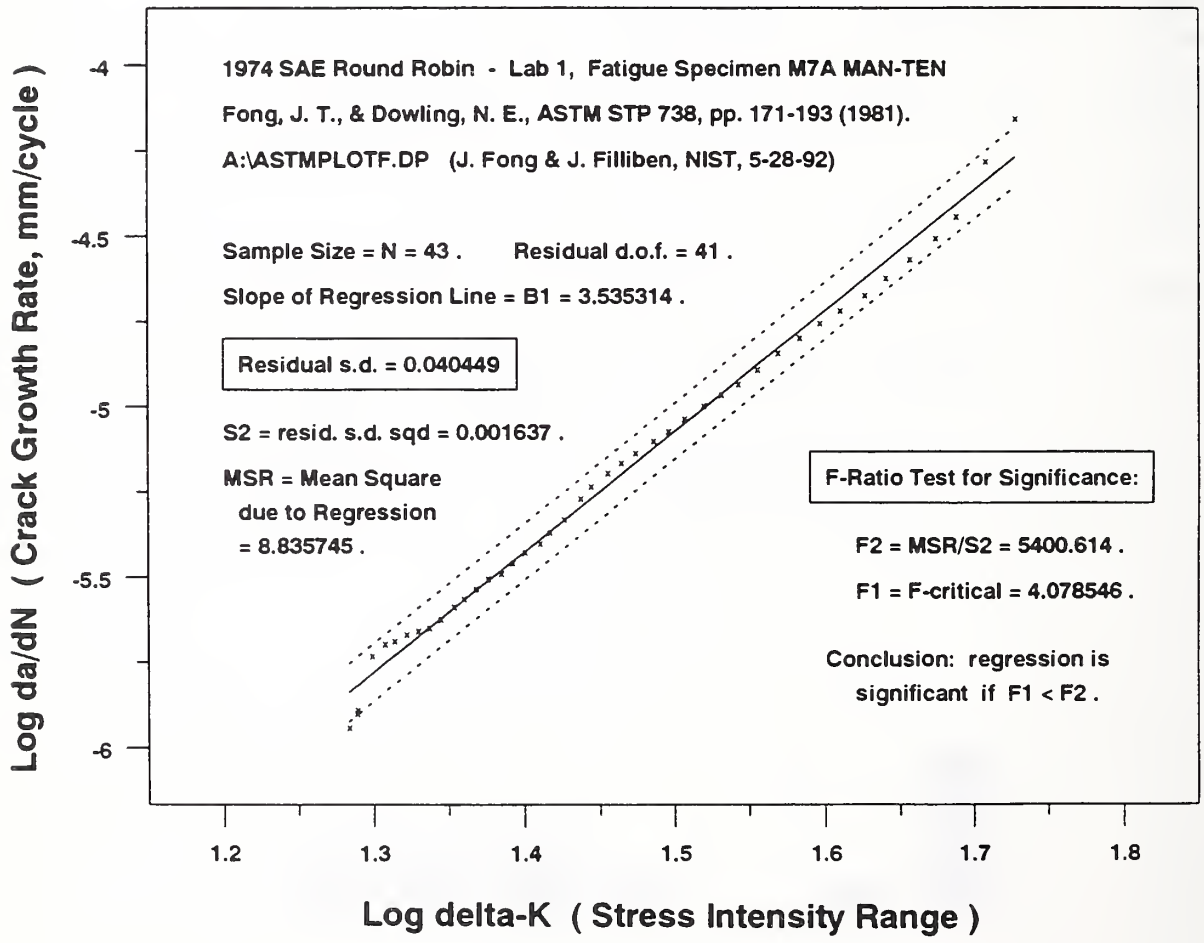


7 DATAPLOT Macros for Analysis of DOE P. I. Data

DATAPLOT Code for *analysis option:* *2DPlotFit*

Subroutine Name: ***DOEPLOTF.DP*** *Ref.:* *pda-dp.2e*

Typical Y vs. X Plot with Linear Fit and 95% Confidence Band



DATAPLOT Code - *Continuation Sheet*

```
.       -----   DOEPLOTF.DP (version 92-05-28, Fong & Filliben, Revision 1) -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
READ ASTM_2CL.DAT X1 Y1
.       READ A:ASTM_ANK.DAT X1 Y1               -
LET X = LOG10(X1)
LET Y = LOG10(Y1)
LINEAR FIT Y X
LET N = NUMBER X
LET TERM1 = 1/N
LET XBAR = MEAN X
LET DEL = X-XBAR
LET DEL2 = DEL*DEL
LET SSQ2 = SUM DEL2
LET TERM2 = DEL2/SSQ2
LET SDPRED = RESSD*SQRT(1 + TERM1 + TERM2)
LET NM2 = N-2
LET UPPER = PRED+TPPF(.975,NM2)*SDPRED
LET LOWER = PRED-TPPF(.975,NM2)*SDPRED
LET Y1 = MEAN Y
LET DY = Y - Y1
LET DY2 = DY*DY
LET D1 = SUM DY2
.               --- SLOPE (A1) & Y-INTERCEPT (A0) ARE COMPUTED FROM LINEAR FIT ---
LET B1 = A1
LET EX = B1*DEL
LET EX2 = EX*EX
LET E1 = SUM EX2
LET S2 = (D1 - E1)/(N - 2)
LET F2 = E1/S2
LET F1C = FPPF(0.95,1,NM2)
TITLE TLC()YPICAL UC()Y LC()VS. UC()X PLC()LOT WITH UC()LLC()INEAR UC()FLC()IT AND 95% UC()CLC()ONFIDENCE UC()BLC()AND
TITLE SIZE 3.5
LEGEND 1 1974 SAE RLC()OUND UC()RLC()OBIN  -  UC()LLC()AB 1,  UC()FLC()ATIGUE UC()SLC()PECIMEN UC()M7A MAN-TEN
LEGEND 2 UC()FLC()ONG, UC()J. T., & DLC()OWLING, UC()N. E., ASTM STP 738, LC()PP. 171-193 (1981).
LEGEND 3 A:\ASTMPLOTF.DP    (J. FLC()ONG & UC()J. FLC()ILLIBEN, UC()NIST, 5-28-92)
Y1LABEL LLC()OG DA/DUC()N  ( CLC()RACK UC()GLC()ROWTH UC()RLC()ATE, MM/CYCLE )
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 5
XLABEL LLC()OG DELTA-UC()K  ( SLC()TRESS UC()ILC()NTENSITY UC()RLC()ANGE )
XLABEL SIZE 3
CHAR X BLANK BLANK BLANK
CHAR SIZE 0.75
LINES BLANK SOLID DOT DOT
PLOT Y PRED UPPER LOWER VS X
JUSTIFICATION LEFT
MOVE 20 68
HW 2 1.33
TEXT SLC()AMPLE UC()SLC()IZE = UC()N = ^N .        RLC()ESIDUAL D.O.F. = ^NM2 .
MOVE 20 64
TEXT SLC()LOPE OF UC()RLC()EGRESSION UC()LLC()INE = UC()B1 = ^B1 .
MOVE 21 58
TEXT RLC()ESIDUAL S.D. = ^RESSD
MOVE 20 52
TEXT S2 = LC()RESID. S.D. SQD UC()= ^S2 .
MOVE 20 48
TEXT MSR = MLC()EAN UC()SLC()QUARE
MOVE 21 45
TEXT LC()DUE TO UC()RLC()EGRESSION
MOVE 21 42
TEXT = ^E1 .
```

DATAPLOT Code - *Continuation Sheet*

```
MOVE 60 48
TEXT F-RLC()ATIO UC()TLC()EST FOR UC()SLC()IGNIFICANCE:
MOVE 62 42
TEXT F2 = UC()MSR/S2 = ^F2 .
MOVE 62 38
TEXT F1 = F-LC()CRITICAL = ^F1C .
MOVE 60 32
TEXT CLC()ONCLUSION:  RLC()EGRESSION IS
MOVE 62 29
TEXT LC()SIGNIFICANT  IF  UC()F1 < F2 .
BOX 59 46.5 82 51
BOX 20 56.5 39.5 61
PAUSE
ER
EXIT
.                                              ----- END OF DOEPLOTF.DP -----
.       -----  Note to Reader:  The following is a listing of the data
.                               file ASTM_2CL.DAT, which is also stored
.                               as a backup named ASTM_ANK.DAT:
                                  19.20          0.000001144
                                  19.44          0.000001259
                                  19.45          0.000001287
                                  19.89          0.000001851
                                  20.30          0.000002010
                                  20.59          0.000002055
                                  20.96          0.000002145
                                  21.34          0.000002193
                                  21.71          0.000002243
                                  22.10          0.000002377
                                  22.54          0.000002586
                                  22.90          0.000002728
                                  23.31          0.000002925
                                  23.75          0.000003123
                                  24.23          0.000003233
                                  24.64          0.000003469
                                  25.11          0.000003731
                                  25.70          0.000003962
                                  26.09          0.000004276
                                  26.65          0.000004670
                                  27.34          0.000005363
                                  27.78          0.000005811
                                  28.51          0.000006376
                                  29.07          0.000006836
                                  29.76          0.000007306
                                  30.59          0.000007938
                                  31.30          0.000008442
                                  32.07          0.000009207
                                  33.00          0.000010050
                                  33.93          0.000010840
                                  34.85          0.000011650
                                  35.90          0.000012820
                                  37.03          0.000014380
                                  38.27          0.000015880
                                  39.45          0.000017540
                                  40.67          0.000019120
                                  42.29          0.000021190
                                  43.68          0.000023790
                                  45.35          0.000026950
                                  47.18          0.000031140
                                  48.71          0.000036010
                                  50.96          0.000052080
                                  53.34          0.000069480
```

Sect. 6.6 - *Count Chart or C-Chart (Data File: DOE_2CLA.DAT)*

According to the DOE Guidance Document on the Performance Indicator (P.I.) Program [2], DOE and DOE contractor line management are required to assess and quantify the information for each PI using a Pareto distribution chart and two control charts commonly known as the C-Chart and the P-Chart. In Section 6.4, we discussed the plotting of a Pareto chart using a DATAPLOT macro named DOEPARET.DP. In this section, we introduce a macro named DOECCC.DP and some fictitious quarterly data for P.I. No. 1.2 (Skin Contaminations) to produce a C-Chart on the next page. As shown on page A4-3 of Reference [2], the control chart formulas employed in developing C-Charts are:

Central Line = $\bar{c}$ [average of data. Data from all previous periods up to the last 3 years or 12 calendar quarters should be used in calculating the average of data.]

Upper Control Limit (UCL) = $\bar{c} + 3\sqrt{\bar{c}}$

Lower Control Limit (LCL) = $\bar{c} - 3\sqrt{\bar{c}}$

In the same reference, it is also stated that for P.I. Nos. 1.5 (Lost Work Days), 1.6.1 (Recordable Injuries/Illness), 4.4 (Corrective Maintenance Backlog), and 4.5 (Preventive Maintenance Overdue), the use of C-Charts is not appropriate. For a complete documentation of the DOE P.I. numbering convention, see pages ix-x of this report.

To recap our DATAPLOT tutorial, we recall that on page 119, we introduced the macro DOEPLOTF.DP to do a linear fit of two columns of numbers and added five new commands to bring the size of the command vocabulary, SV5, to 61. For this exercise, only one new command, SPIKE, is needed (see pp. 125-126). The new vocabulary size, SV6, is now 62.

Again, it is useful to repeat what is stated in [2] that in evaluating control charts, managers should look for the following indications:

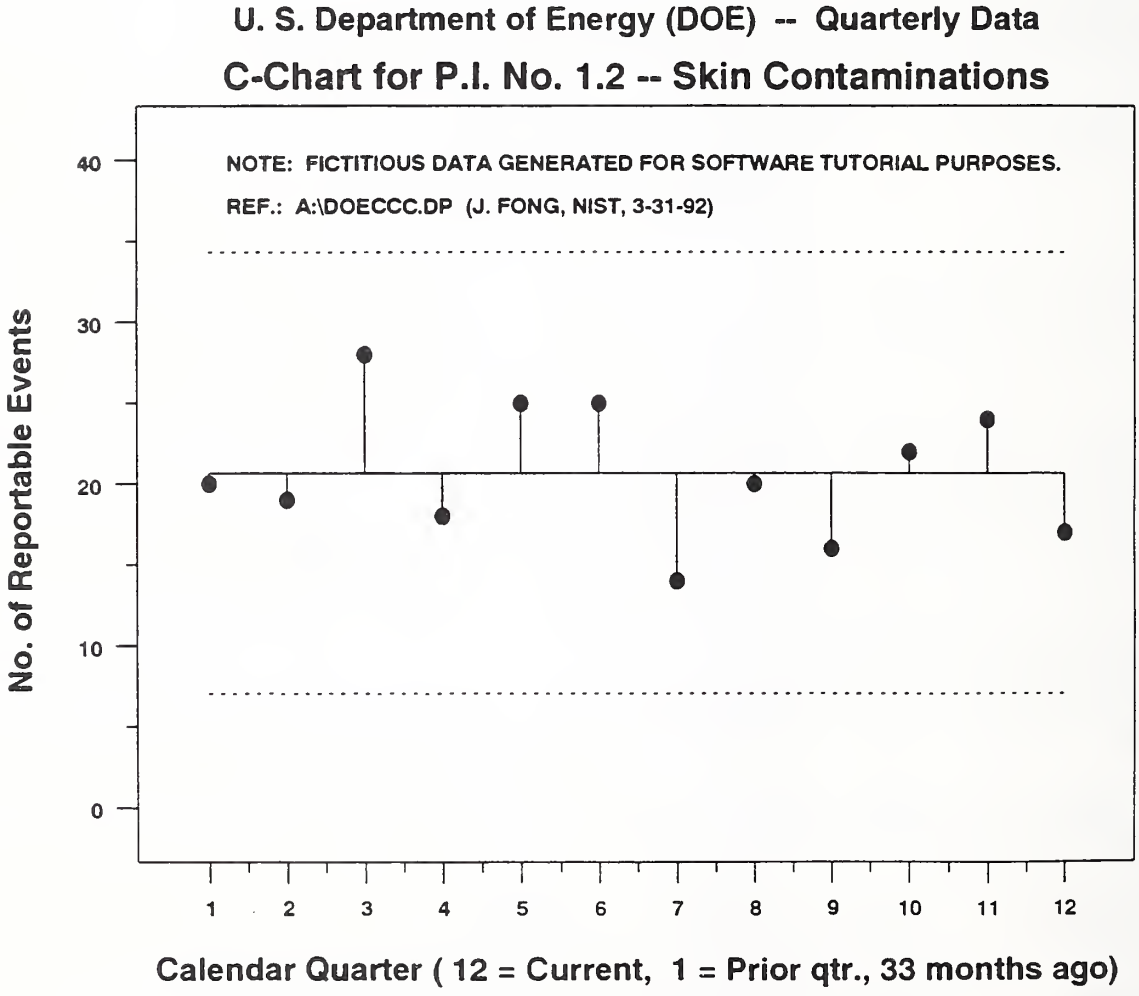
Outliers - Data that falls outside the control lines.

Runs - Series of data points over or below the central line. A "run" of 7 consecutive points or 10 out of 11 points indicates an abnormality.

Trends - Continual rise or fall of data points. If 7 data points rise or fall continuously, an abnormality is considered to exist.

Count Chart or C-Chart (Data File: DOE_2CLA.DAT)

Subroutine Name: ***DOECCC.DP*** *Ref.:* *pda-dp.3a*



DATAPLOT Code - *Continuation Sheet*

```
.
.       -----   DOECCC.DP (version 92-03-31, Fong & Filliben, Revision 4) -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                  ----- 2. INPUT DATA -----
READ DOE_2CLA.DAT X Y
.
.       READ A:DOE_CCC.DAT X Y
.                                                  ----- 3. COMPUTATION -----
LET N = NUMBER  Y
LET YBAR = MEAN  Y
.
LET SDYBAR = SQRT(YBAR)
LET UPPER = YBAR+3*SDYBAR
LET LOWER = YBAR-3*SDYBAR
.                                                  ----- 4. TITLE COMMANDS -----
.
TITLE CLC()-UC()CLC()HART FOR UC()P.I. NLC()O. 1.2 -- UC()SLC()KIN UC()CLC()ONTAMINATIONS
TITLE SIZE 3.5
TITLE DISPLACEMENT 1.5
.                                                  ----- 5. LEGEND COMMANDS -----
.
LEGEND 1    NOTE:  FICTITIOUS DATA GENERATED FOR SOFTWARE TUTORIAL PURPOSES.
LEGEND 2    REF.:  A:\DOECCC.DP  (J. FONG, NIST, 3-31-92)
.
.                                                  ----- 6. LABEL COMMANDS -----
.
Y1LABEL NLC()O. OF UC()RLC()EPORTABLE UC()ELC()VENTS
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 5
.
XLIMITS 1 N
.
XLABEL CLC()ALENDAR UC()QLC()UARTER ( 12 = UC()CLC()URRENT,  1 = UC()PLC()RIOR QTR., 33 MONTHS AGO)
XLABEL SIZE 3
.                                                  ----- 7. GRAPHICS COMMANDS -----
CHAR CIRCLE BL BL BL
CHAR FILL ON
CHAR HW 1.5 1
LINES BLANK SOLID DOT DOT
SPIKE ON OFF OFF OFF
SPIKE BASE YBAR
```

DATAPLOT Code - *Continuation Sheet*

```
.                                              ----- 8. PLOT COMMANDS -----
PLOT Y X AND
PLOT YBAR FOR X = 1 1 N AND
PLOT UPPER FOR X = 1 1 N AND
PLOT LOWER FOR X = 1 1 N
.
JUSTIFICATION CENTER
MOVE 50 97
HW 3 2
TEXT U. S. DLC()EPARTMENT OF UC()ELC()NERGY UC()(DOE)  --  UC()QLC()UARTERLY UC()DLC()ATA
.
.                                              ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                              ----- END OF DOECCC.DP -----
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file DOE_2CLA.DAT, which is also stored
.                               as a backup named DOE_CCC.DAT:
```

1	20.0000000000
2	19.0000000000
3	28.0000000000
4	18.0000000000
5	25.0000000000
6	25.0000000000
7	14.0000000000
8	20.0000000000
9	16.0000000000
10	22.0000000000
11	24.0000000000
12	17.0000000000

Sect. 6.7 - *Proportion Chart or P-Chart (Data File: **DOE_3COL.DAT**)*

The DOE Guidance Document for the Performance Indicator (P.I.) Program [2] states on page A4-4 that "for the performance indicators Lost Work Days (P.I. #1.5), Recordable Injuries/Illnesses (P.I. #1.6.1), Corrective Maintenance Backlog (P.I. #4.4), and Preventive Maintenance Overdue (P.I. #4.5)," the control chart to be used is not the C-Chart, but the P-Chart (otherwise referred to as "proportion" chart).

P-Charts are used to show the fraction defective of a non-standard sample size over a constant time frame of reporting, e.g., a calendar month or quarter. For example, the sample size for the corrective maintenance backlog is the total number of maintenance items scheduled for the period of interest. If we denote the reporting period number by i ($i = 1, 2, \ldots, N$), the sample size by n, and the number of maintenance requests unfilled for, say, 3 months, by m, then the data to be computed and plotted for developing a P-Chart are as follows:

Fraction defective at i-th period $= y(i) = m(i) / n(i)$.

Central Line $= \overline{p} =$ Average of $y(i)$, $i = 1, 2, \ldots, N$.

Upper Control Limit (UCL) $= U(i) = \overline{p} + 3\sqrt{\overline{p}(1 - \overline{p})/n(i)}$

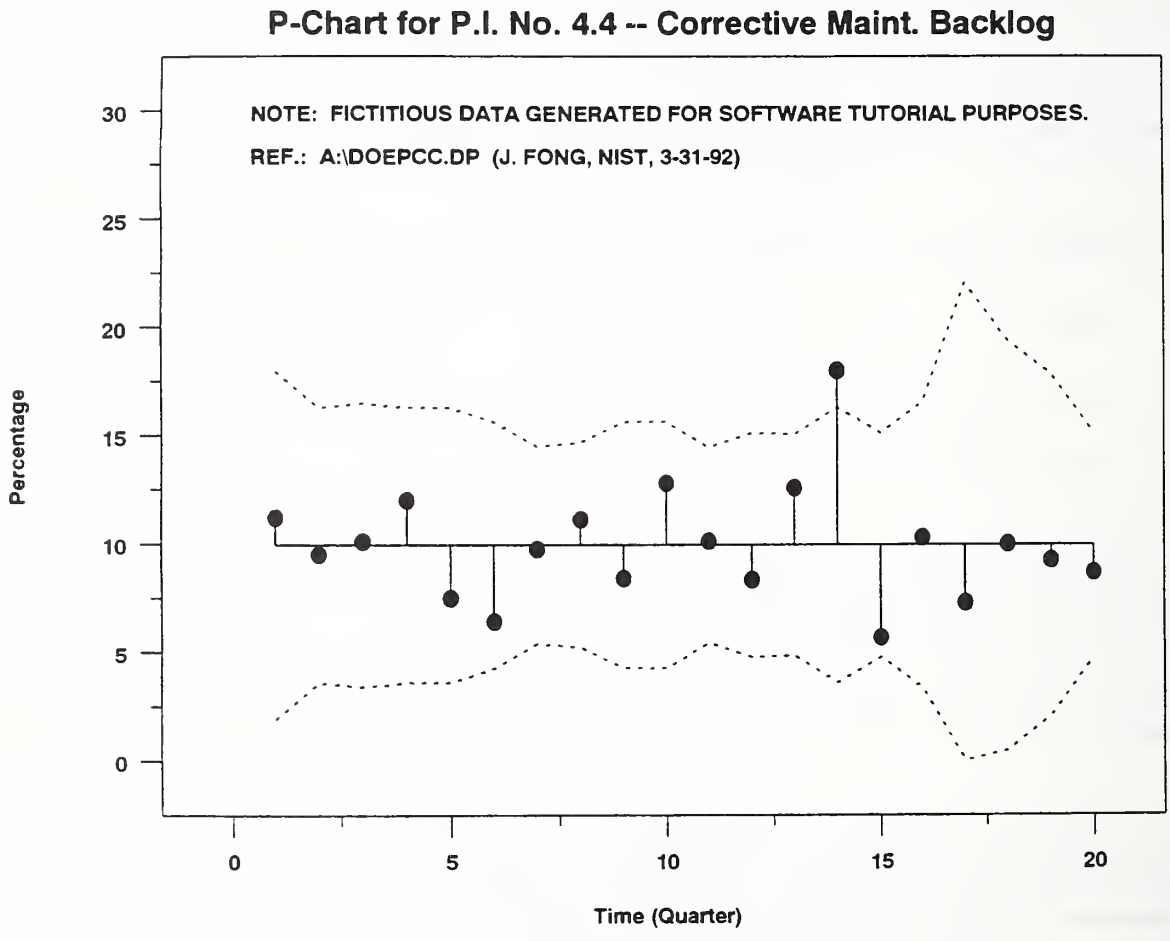
Lower Control Limit (LCL) $= L(i) = \overline{p} - 3\sqrt{\overline{p}(1 - \overline{p})/n(i)}$

Since the sample size n normally varies over each time period, the control limits UCL and LCL also vary and need to be computed for $i = 1, 2, \ldots, N$. Using some fictitious data for the P.I. #4.4 (Corrective Maintenance Backlog), we introduce a macro named DOEPCC.DP to plot a P-Chart on the next page for a 3-column (i, m, n) datafile named DOE_3COL.DAT (see p. 130). No new command is needed to code the macro DOEPCC.DP. Thus the size of the command vocabulary, SV7, is the same as SV6, i.e., 62.

At this point, we have completed the 3-chart requirement of the analysis described in the DOE guidance document [2]. But with access to DATAPLOT, much more analysis could be done to make trend predictions, to determine the cause of variations in operations and to select appropriate managerial actions to effect improvements. In the next two sections, we introduce two plots, a lag plot and an autocorrelation plot, with which one could select a specific model to predict a future data point. Using the same set of 20 data points for P.I. #4.4 in this section, we show in Section 6.10 that a model of type 1 can be constructed to estimate the 20th point from an analysis of the previous 19 points. In Section 6.11, we introduce a 50-point data set to show that a different type of model is called for when the lag plot and autocorrelation plot give indications that model type 1 is not appropriate.

Proportion Chart or P-Chart (Data File: DOE_3COL.DAT)

Subroutine Name: ***DOEPCC.DP*** *Ref.:* *pda-dp.3b*



DATAPLOT Code - *Continuation Sheet*

```
.
.       ----- DOEPCC.DP (version 92-03-31, Fong & Filliben, Revision 4) -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                  ----- 2. INPUT DATA -----
READ DOE_3COL.DAT XI CI NI
.
.       READ A:DOE_PCC.DAT XI CI NI
.                                                  ----- 3. COMPUTATION -----
LET Y = 100*(CI/NI)
.
LET N = NUMBER Y
LET YBAR = MEAN Y
LET SDYBAR = SQRT(YBAR*(100-YBAR)/NI)
LET UPPER = YBAR+3*SDYBAR
LET LOWER = YBAR-3*SDYBAR
LET LOWER = 0 SUBSET LOWER < 0
.                                                  ----- 4. TITLE COMMANDS -----
.
TITLE P-CLC()HART FOR UC()P.I. NLC()O. 4.4 -- UC()CLC()ORRECTIVE UC()MLC()AINT. UC()BLC()ACKLOG
TITLE SIZE 3
TITLE DISPLACEMENT 2
.                                                  ----- 5. LABEL COMMANDS -----
Y1LABEL PLC()ERCENTAGE
Y1LIMITS 0 30
.
XLABEL TLC()IME (UC()QLC()UARTER)
.                                                  ----- 6. GRAPHICS COMMANDS -----
CHAR CIRCLE BL BL BL
CHAR FILL ON
CHAR HW 1.5 1
LINES BLANK SOLID DOT DOT
SPIKE ON OFF OFF OFF
SPIKE BASE YBAR
.                                                  ----- 7. LEGEND COMMANDS -----
.
LEGEND 1    NOTE:  FICTITIOUS DATA GENERATED FOR SOFTWARE TUTORIAL PURPOSES.
LEGEND 2    REF.:  A:\DOEPCC.DP  (J. FONG, NIST, 3-31-92)
.
.                                                  ----- 8. PLOT COMMANDS -----
PLOT Y XI AND
PLOT YBAR FOR X = 1 1 N AND
PLOT UPPER XI AND
PLOT LOWER XI
LEGEND 1
LEGEND 2
```

DATAPLOT Code - *Continuation Sheet*

```
.                                              ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                              ----- END OF DOEPCC.DP -----
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file DOE_3COL.DAT, which is also stored
.                               as a backup named DOE_PCC.DAT:
```

1	14	125
2	19	200
3	19	188
4	24	200
5	15	200
6	16	250
7	38	390
8	40	360
9	21	250
10	32	250
11	40	395
12	25	300
13	39	310
14	36	200
15	17	300
16	19	185
17	4	55
18	9	90
19	12	130
20	26	300

Sect. 6.8 - *Lag Plot (Data File: **DOE_1COL.DAT**)*

In the last seven sections, we used a 62-command vocabulary and sample data sets to produce customized and report-quality charts such as histogram, pie chart, Pareto chart, C-Chart, and P-Chart. Beginning with this section, we shall introduce a series of techniques to answer four basic questions in data analysis, i.e.,

Q-6.8.1 What is the "randomness" of the data ?

Q-6.8.2 What is the "best-fit" distribution ?

Q-6.8.3 What is the estimated location parameter for a fixed distribution ?

Q-6.8.4 What is the estimated variation parameter for a fixed distribution ?

To answer the first question, we introduce two plots that will yield a measure of "randomness" both graphically and quantitatively. The first plot is known as a lag plot, and by learning one new command, "LAG PLOT", a macro named DOELAG.DP can be coded to produce the plot on the next page. A listing of that macro is given on pp. 133-134. The size of the DATAPLOT command vocabulary after 8 tutorials, SV8, is now 63.

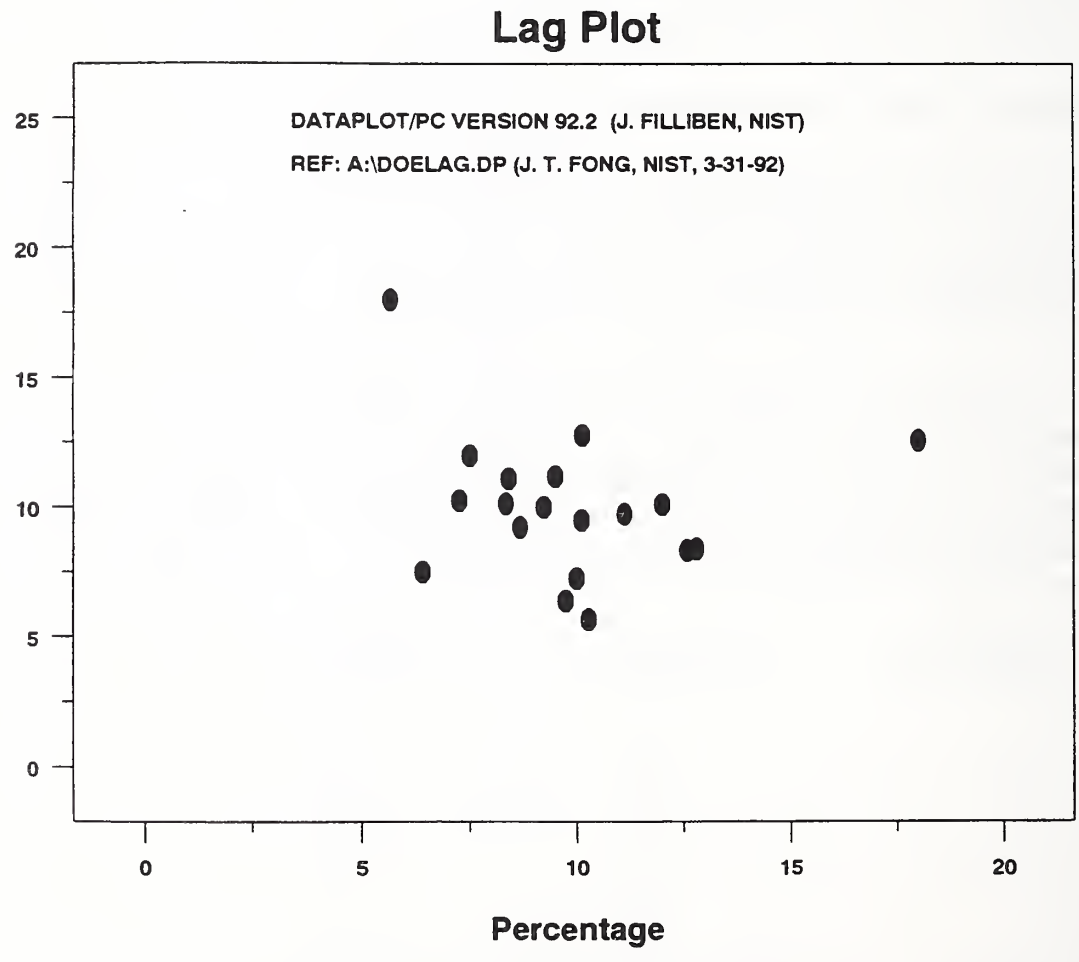
To interpret the meaning of the lag plot, we remark that for data taken in sequence such as those reported in the DOE Performance Indicator (P.I.) Program, a tendency known as "serial dependence" often exists for observations made close together in time to be more alike than those taken farther apart. Such tendencies of non-randomness can be demonstrated by plotting each observation against the immediately preceding one. For example, consider the following data set as listed on p. 130 for P.I. #4.4 (Corrective Maintenance Backlog) with computed y_i :

Time (Quarter)	Unfilled Requests	Total Requests	%-Backlog
i	m_i	n_i	$y_i = m_i / n_i$
1	14	125	11.20
2	19	200	9.50
3	19	188	10.11
...	...	...	...
19	12	130	9.23
20	26	300	8.67

For i = 20, 19, ..., 2, we plot on the next page the %-backlog y_i , observed at quarter i , against the previous %-backlog y_{i-1} , made at quarter i-1 . Similar plots can be made for data two units apart (y_i versus y_{i-2}), three units apart, and so on. The distance between the observations that are so correlated is called the lag. The plot given on the next page is a lag 1 plot. Graphically, a shot gun pattern implies a qualitative measure of "randomness."

Lag Plot (Data File: DOE_1COL.DAT)

Subroutine Name: ***DOELAG.DP*** *Ref.:* *pda-dp.4a*



DATAPLOT Code - *Continuation Sheet*

```
.
.       -----   DOELAG.DP (version 92-03-31, Fong & Filliben, Revision 2 -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                  ----- 2. INPUT DATA -----
READ DOE_1COL.DAT Y
.
.       READ A:DOE_LAG.DAT Y
.
.               READ A:DOE_LAG2.DAT CI NI
.               LET Y = 100*(CI/NI)
.
.                       READ A:DOE_LAG3 XI CI NI
.                       LET Y = 100*(CI/NI)
.                                                  ----- 3. COMPUTATION -----
.                                                  ----- 4. TITLE COMMANDS -----
TITLE LLC()AG UC()PLC()LOT
TITLE SIZE 4
TITLE DISPLACEMENT 2
.                                                  ----- 5. LABEL COMMANDS -----
XLABEL PLC()ERCENTAGE
XLABEL SIZE 3
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 5
Y1LIMITS 0 25
.                                                  ----- 6. GRAPHICS COMMANDS -----
SPIKE OFF
CHAR CIRCLE ALL
CHAR FILL ON ALL
LINES BLANK ALL
.                                                  ----- 7. LEGEND COMMANDS -----
.
LEGEND 1                          DATAPLOT/PC VERSION 92.2  (J. FILLIBEN, NIST)
LEGEND 2                          REF: A:\DOELAG.DP (J. T. FONG, NIST, 3-31-92)
.
.                                                  ----- 8. PLOT COMMANDS -----
LAG PLOT Y
LEGEND 1
LEGEND 2
.                                                  ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                  ----- END OF DOELAG.DP -----
```

DATAPLOT Code - *Continuation Sheet*

. ----- Note to Reader: The following is a listing of the data
. file DOE_1COL.DAT, which is also stored
. as a backup named DOELAG.DAT:

```
11.20
 9.50
10.11
12.00
 7.50
 6.40
 9.74
11.11
 8.40
12.80
10.13
 8.33
12.58
18.00
 5.67
10.27
 7.27
10.00
 9.23
 8.67
```

Sect. 6.9 - *Autocorrelation Plot (Data File: DOE_1COL.DAT)*

The lag plot introduced in the last section for a set of data y_i , i = 1, 2, ... , N, can be given a quantitative interpretation through a family of parameters known as the *lag k sample autocorrelation coefficient* r_k . For k = 1, 2, ..., N-1, the coefficients r_k are defined by

$$r_k = \frac{\sum_{i=1}^{N-k} (y_i - \bar{y}) (y_{i+k} - \bar{y})}{\sum_{i=1}^{N} (y_i - \bar{y})^2} , \qquad (1)$$

where $\bar{y}$ = average of y . We observe that for k = 0, the autocorrelation coefficient is always unity, i.e., $r_o = 1$. For k = 1, 2, 3, ... , the coefficients r_k vary between -1 and 1 , and can be meaningfully computed for any given set of data, y_1 , y_2 , ... , y_N , provided N is not too small[10]. The data set is considered to be randomly distributed without serial dependence if all of the r_k , k = 1, 2, 3, ... , are zero or very close to zero.

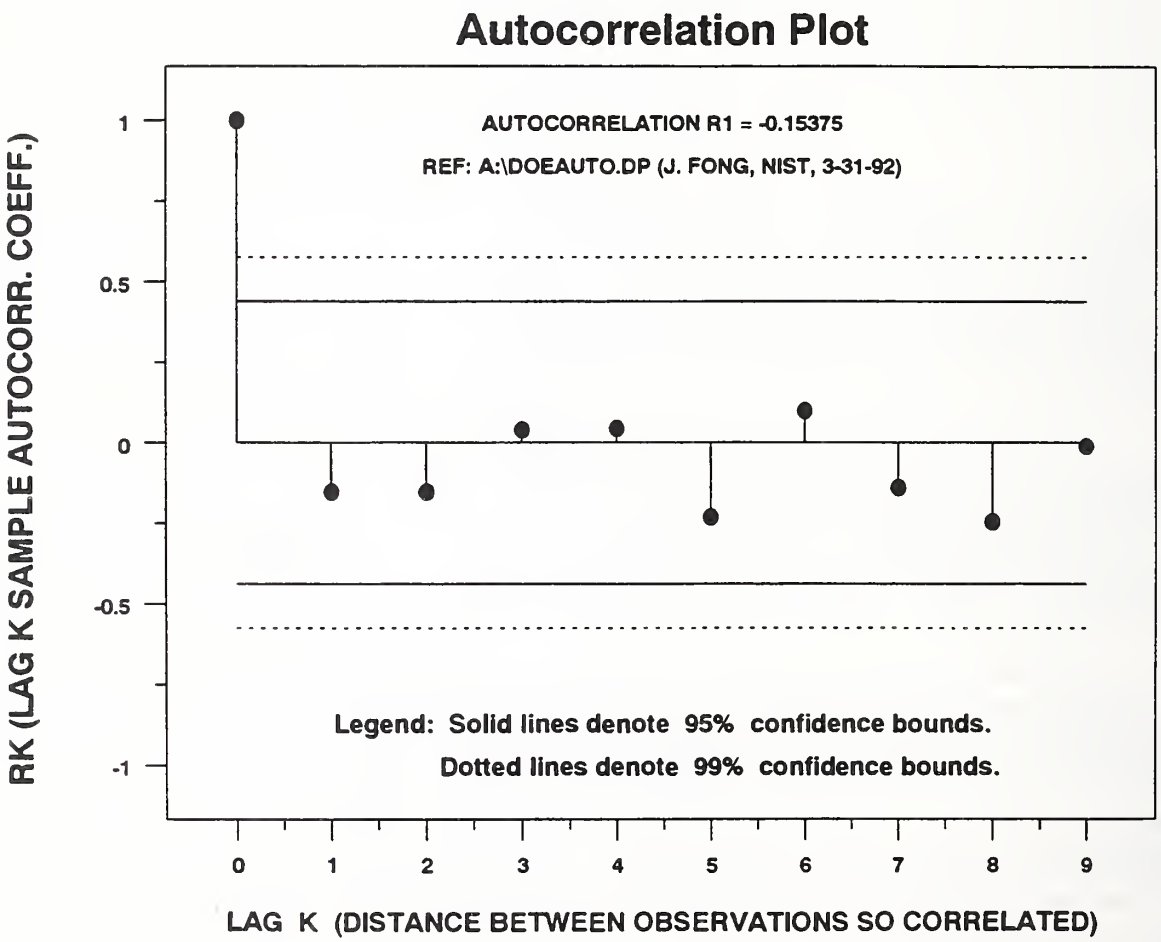
To illustrate the power of the analysis technique based on r_k , we compute them for the 20-point data set used in the last section (see page 134) for k up to 9 , and plot r_k versus k on the next page using a DATAPLOT macro named DOEAUTO.DP. Two new commands, AUTOCORRELATION and AUTOCORRELATION PLOT, are needed to code the DATAPLOT macro. The size of the command vocabulary, SV9, now becomes 65.

With the lag 1 plot on page 132 and the autocorrelation plot on page 136, we can make a statement on the "randomness" of the 20-point data set. First of all, we note from the autocorrelation plot that the lag 1 sample autocorrelation coefficient r_1 equals -0.15375, and is not far from zero, the ideal for complete randomness. We then note that all of the r_k plotted for k = 1, 2, ... , 9 fall within the 95% confidence band (solid lines) computed by the DATAPLOT macro using an approximation explained in Kendall & Stuart [41, pp. 292-293]. We conclude that there is no evidence that this 20-point data set is not randomly distributed.

[10]The lag k sample autocorrelation coefficient is a special case of the well-known sample correlation coefficient $r(y_1, y_2)$, which measures the degree of association between two random variables Y_1 and Y_2 (see, e.g., Box, Hunter & Hunter [23, p. 61]). As shown by Kendall & Stuart [41, pp. 292-293], the distribution of r , through a transformation of variable z = arc tanh r , is very close to normal with the variance of z approximately equal to 1/(N-3) for sample size N > 50. However, for small sample sizes (e.g., N = 10), Box, Hunter & Hunter [23, p. 63] warned that calculated auto-correlation coefficients are unreliable and could seriously invalidate standard tests that assume independence.

Autocorrelation Plot (Data File: DOE_1COL.DAT)

Subroutine Name: ***DOEAUTO.DP*** *Ref.:* *pda-dp.4b*



DATAPLOT Code - *Continuation Sheet*

```
.       -----   DOEAUTO.DP (version 92-03-31, Fong & Filliben, Revision 2) -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                  ----- 2. INPUT DATA -----
READ DOE_1COL.DAT Y
.       READ A:DOE_AUTO.DAT Y
.               READ A:DOE_AUT2.DAT CI NI
.               LET Y = 100*(CI/NI)
.
.                       READ A:DOE_AUT3.DAT XI CI NI
.                       LET Y = 100*(CI/NI)
.                                                  ----- 3. COMPUTATION -----
LET R = AUTOCORRELATION Y
.                                                  ----- 4. GRAPHICS COMMANDS -----
CHAR CIRCLE BL BL BL BL BL
CHAR FILL ON OFF OFF OFF OFF OFF
CHAR HW 1.5 1 ALL
LINES BLANK SOLID SOLID SOLID DOTTED DOTTED
SPIKE ON OFF OFF OFF OFF OFF
SPIKE BASE 0
.                                                  ----- 5. LEGEND COMMANDS -----
.
LEGEND 1                                             AUTOCORRELATION R1 = ^R
LEGEND 2                                  REF: A:\DOEAUTO.DP (J. FONG, NIST, 3-31-92)
.
.                                                  ----- 6. TITLE COMMANDS -----
TITLE ALC()UTOCORRELATION UC()PLC()LOT
TITLE SIZE 4
TITLE DISPLACEMENT 2
.                                                  ----- 7. LABEL COMMANDS -----
Y1LIMITS -1 1
Y1LABEL RK (LAG K SAMPLE AUTOCORR. COEFF.)
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 7
.
XLABEL LAG  K  (DISTANCE BETWEEN OBSERVATIONS SO CORRELATED)
XLABEL SIZE 2.5
.                                                  ----- 8. PLOT COMMANDS -----
AUTOCORRELATION PLOT Y
.
JUSTIFICATION CENTER
MOVE 50 28
HW 2.4 1.6
TEXT LLC()EGEND:  UC()SLC()OLID LINES DENOTE  95%  CONFIDENCE BOUNDS.
MOVE 54 24
TEXT DLC()OTTED LINES DENOTE  99%  CONFIDENCE BOUNDS.
.
.                                                  ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                  ----- END OF DOEAUTO.DP -----
```

DATAPLOT Code - *Continuation Sheet*

. ----- Note to Reader: The following is a listing of the data
. file DOE_1COL.DAT, which is also stored
. as a backup named DOE_AUTO.DAT:

```
11.20
 9.50
10.11
12.00
 7.50
 6.40
 9.74
11.11
 8.40
12.80
10.13
 8.33
12.58
18.00
 5.67
10.27
 7.27
10.00
 9.23
 8.67
```

Sect. 6.10 - *P-Chart with Modeling-1 (Data File: **DOE_3COL.DAT**)*

In Section 6.9, we learned from an exploratory data analysis using a lag plot and an autocorrelation plot for a 20-point data set that the assumption of randomness is valid. This implies that all four questions posed in Section 6.8 can be answered, i.e.,

Answer to Question Q-6.8.1 (Randomness): Yes.

Answer to Question Q-6.8.2 (Distribution): Normal.

Answer to Question Q-6.8.3 (Location): Sample Mean.

Answer to Question Q-6.8.4 (Variation): Sample Variance.

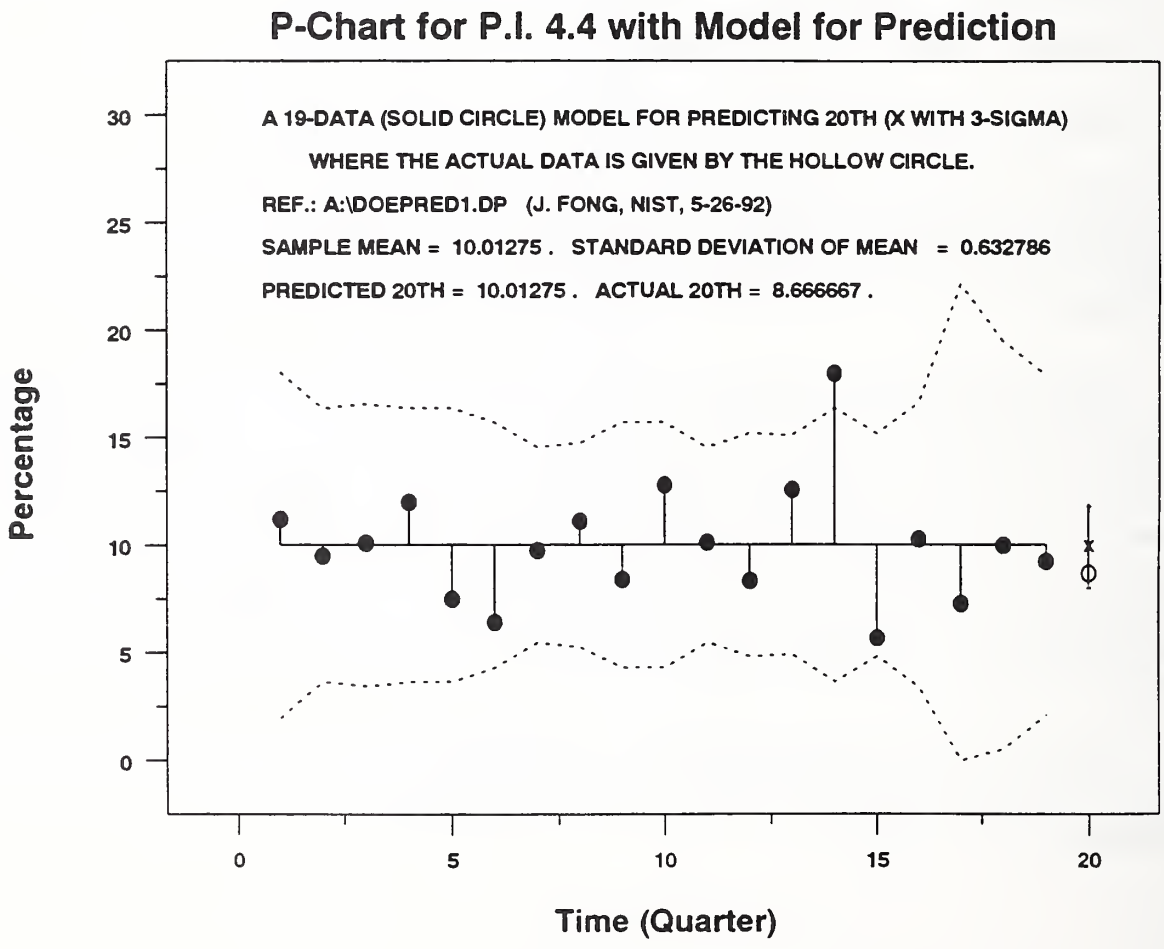
In this section, we shall go one step further by using the results of the analysis on a N-point data set to propose a model for predicting the value of the (N+1)th data point with a 3-sigma band of confidence and to plot the prediction on a P-Chart for comparison with the value of an actual observation.

Using a macro named DOEPRED1.DP as listed on pp. 141-142, we first obtain a lag plot and an autocorrelation plot for the first 19 points of the same data set we used for the exercise in Section 6.7 (P-Chart). The resulting plots are not much different from those given on pages 132 and 136, and are not reproduced here for brevity. After we are assured that the truncated data set is randomly distributed, we adopt the normal distribution as a model (type 1) to predict the 20th point using the mean as the predicted value and 3 sigmas as the 99% confidence band. The results of this predictive model and a comparison with the actual value are given on the next page in the form of a modified P-chart. We observe that the actual value falls reasonably well within the confidence band of the predicted model.

In coding the macro DOEPRED1.DP, we introduced two more DATAPLOT commands, namely, STANDARD DEVIATION OF THE MEAN, and DATA. The size of our command vocabulary, SV10, is now 67.

P-Chart with Modeling-1 *(Data File: DOE_3COL.DAT)*

Subroutine Name: ***DOEPRED1.DP*** *Ref.:* *pda-dp.4c*



DATAPLOT Code - *Continuation Sheet*

```
.
.       -----   DOEPRED1.DP (version 92-05-26, Fong & Filliben, Revision 3) -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                  ----- 2. INPUT DATA -----
READ DOE_3COL.DAT XI CI NI
.
.       READ A:DOE_MB20.DAT XI CI NI
.                                                  ----- 3. COMPUTATION -----
LET Y = 100*(CI/NI)
LET N = NUMBER Y
.
LET Y2(1)=Y(N)
LET YACT = Y(N)
LET X2(1)=XI(N)
DELETE Y XI CI NI FOR I = N 1 N
LET N = N-1
LET YPRED=MEAN  Y
LET SDM = STANDARD DEVIATION OF THE MEAN Y
LET Y2(2)=YPRED
LET Y2(3)=YPRED+3*SDM
LET Y2(4)=YPRED-3*SDM
LET X2 = N+1 FOR I = 1 1 4
LET TAG2 = DATA 2 3 4 4
.
LET N = NUMBER Y
LET YBAR = MEAN Y
LET SDYBAR = SQRT(YBAR*(100-YBAR)/NI)
LET UPPER = YBAR+3*SDYBAR
LET LOWER = YBAR-3*SDYBAR
LET LOWER = 0 SUBSET LOWER < 0
.                                  ----- 3A. LAG PLOT & AUTOCOR. PLOT FOR MODELING ---
TITLE LAG 1 PLOT
CHAR CIRCLE ALL
CHAR FILL ON ALL
LINES BLANK ALL
LET R = AUTOCORRELATION Y
LEGEND 1           AUTOCORRELATION  R1 = ^R
LAG PLOT Y
PAUSE
.
CHAR CIRCLE BL BL BL BL BL
CHAR FILL ON OFF OFF OFF OFF
CHAR HW 1.5 1 ALL
LINES BLANK SOLID SOLID SOLID DOTTED DOTTED
SPIKE ON OFF OFF OFF OFF OFF
SPIKE BASE 0
.
TITLE AUTOCORRELATION PLOT
AUTOCORRELATION PLOT Y
PAUSE
```

DATAPLOT Code - *Continuation Sheet*

```
.                                                    ----- 4. TITLE COMMANDS -----
.
TITLE P-CLC()HART FOR UC()P.I. 4.4 LC()WITH UC()MLC()ODEL FOR UC()PLC()REDICTION
TITLE SIZE 3.5
TITLE DISPLACEMENT 2
.                                                    ----- 5. LABEL COMMANDS -----
Y1LABEL PLC()ERCENTAGE
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 7
Y1LIMITS 0 30
.
XLABEL TLC()IME (UC()QLC()UARTER)
XLABEL SIZE 3
.                                                    ----- 6. GRAPHICS COMMANDS -----
CHAR CIRCLE BL BL BL CIRCLE X -
CHAR FILL ON OFF OFF OFF OFF OFF OFF
CHAR HW 1.5 1 ALL
LINES BLANK SOLID DOT DOT BLANK BLANK SOLID
SPIKE ON OFF OFF OFF OFF OFF OFF
SPIKE BASE YBAR
.                                                    ----- 7. LEGEND COMMANDS -----
.
LEGEND 1     A 19-DATA (solid circle) MODEL FOR PREDICTING 20th (x with 3-sigma)
LEGEND 2           where the actual data is given by the hollow circle.
LEGEND 3     Ref.: A:\DOEPRED1.DP   (J. FONG, NIST, 5-26-92)
LEGEND 4     SAMPLE MEAN =  ^YBAR .   STANDARD DEVIATION OF MEAN   =  ^SDM
LEGEND 5     PREDICTED 20TH =  ^YPRED .   ACTUAL 20TH =  ^YACT .
.
.                                                    ----- 8. PLOT COMMANDS -----
PLOT Y XI AND
PLOT YBAR FOR X = 1 1 N AND
PLOT UPPER XI AND
PLOT LOWER XI AND
PLOT Y2 X2 TAG2
.                                                    ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.       -----  Note to Reader:  The following is a listing of the data
.                                file DOE_3COL.DAT, which is also stored
.                                as a backup named DOE_MB20.DAT:
                                 1          14         125
                                 2          19         200
                                 3          19         188
                                 4          24         200
                                 5          15         200
                                 6          16         250
                                 7          38         390
                                 8          40         360
                                 9          21         250
                                10          32         250
                                11          40         395
                                12          25         300
                                13          39         310
                                14          36         200
                                15          17         300
                                16          19         185
                                17           4          55
                                18           9          90
                                19          12         130
                                20          26         300
```

Sect. 6.11 - *P-Chart with Modeling-2 (Data File: DOE_3COL.DAT)*

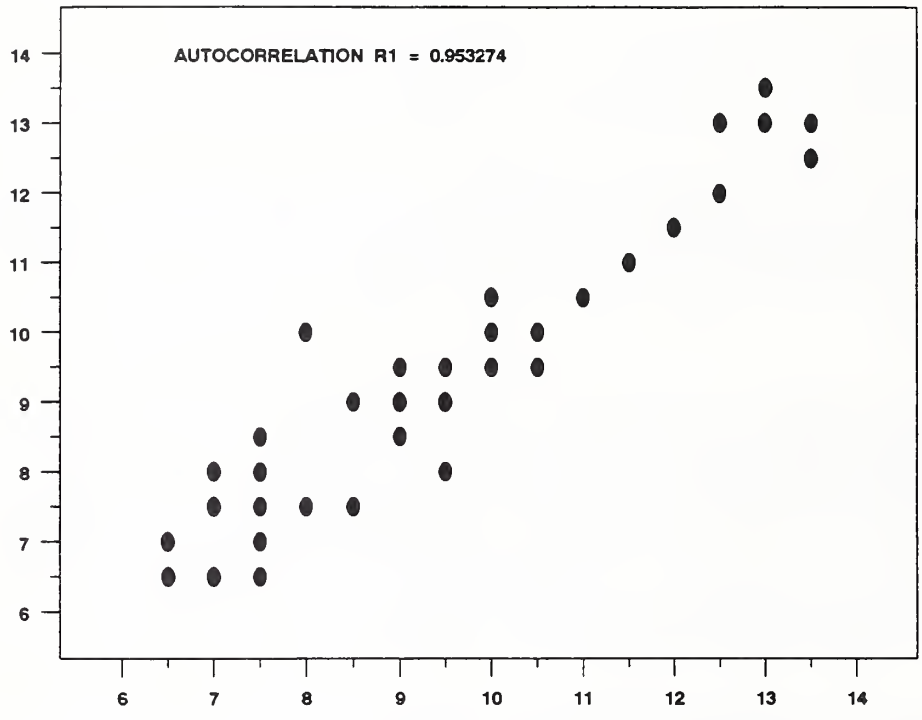
In Section 10, we introduced a normal distribution model to predict a future data point when an autocorrelation plot showed that the assumption of randomness in a given data set is valid. In this section, we shall show that a different model needs to be introduced if the autocorrelation plot reveals that the data set shows serial dependence, i.e., the assumption of randomness is not valid.

To illustrate this exercise, we choose to work with a 50-point data set that we know is not randomly distributed. The data set is listed on page 148. On pp. 146-147, we list a new macro named DOEPRED2.DP which is designed to first produce a lag plot and an autocorrelation plot (see page 144) for interpretation. In this case, we observe that the lag plot is far from a shot-gun pattern and the lag 1 autocorrelation coefficient, R_1, is too far from being zero, the ideal for randomness of the data. The autocorrelation plot also shows that most of the R_k, k=1,2,3,..., are outside the 99% confidence band such that we can safely conclude the data set is not random.

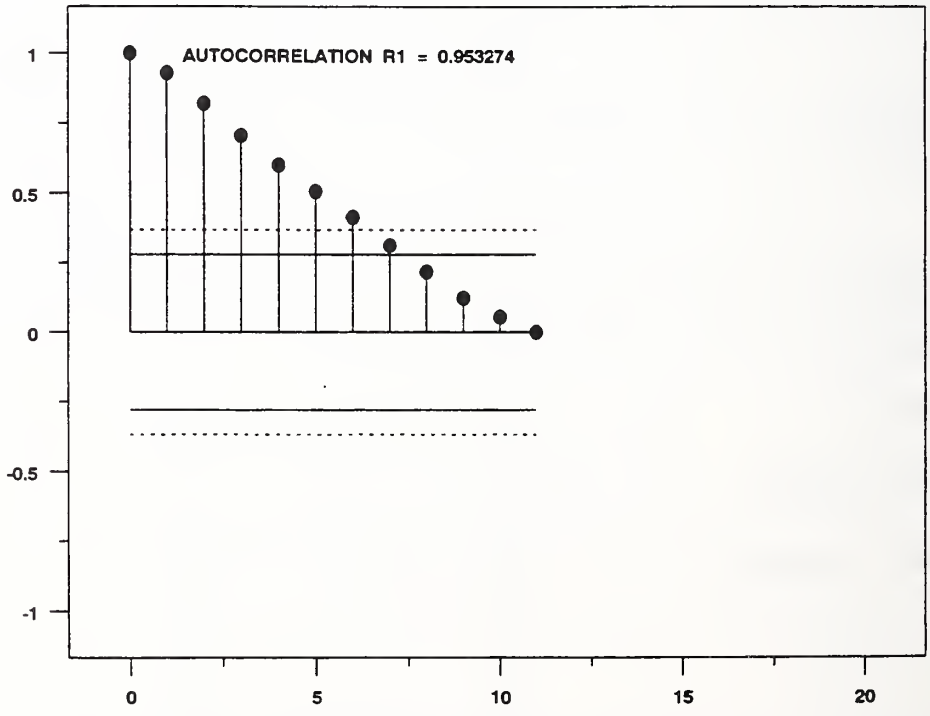
With the question of randomness answered in the negative, we need to look for a new model to predict the (N+1)th point from a N-point data set. Experience shows that a good model would give more weight to those data points of the most recent past, so a simple example would be to adopt a weighted-mean, truncated-series model to predict the 50th point based on a 49-point data set. The truncation is accomplished through the use of a window parameter where in this case only 10 of the data points nearest to the 50th are used. A one to ten scale of weights are assigned with ten being assigned to the 49th point, nine to the 48th, etc. The predicted value of the 50th point is plotted on page 145 to show that the actual value of the 50th point does fall reasonably well within the 3-sigma band of 99% confidence.

In coding the macro DOEPRED2.DP, we introduced two additional commands, namely, CIRCLE and WEIGHTED MEAN. The command vocabulary, SV12, is now 69. A summary of the size increase of the DATAPLOT command vocabulary as we step through the first 11 sections of this tutorial chapter is given below:

Section	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	6.10	6.11
New Commands	24	20	9	3	5	1	0	1	2	2	2
Size of Vocabulary	24	44	53	56	61	62	62	63	65	67	69

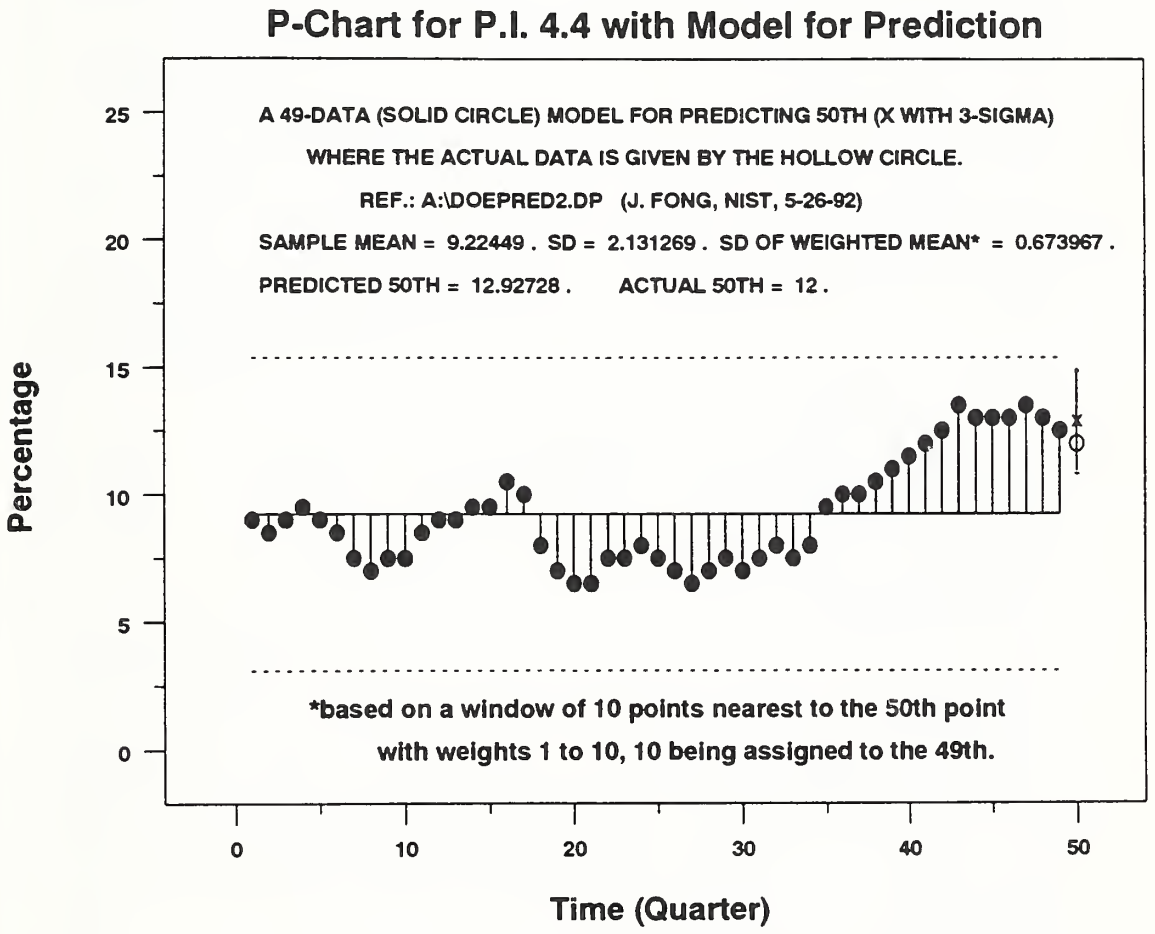


AUTOCORRELATION PLOT



P-Chart with Modeling-2 *(Data File: DOE_3COL.DAT)*

Subroutine Name: ***DOEPRED2.DP*** *Ref.:* *pda-dp.4d*



DATAPLOT Code - *Continuation Sheet*

```
.
.       ----- DOEPRED2.DP (version 92-05-26, Fong & Filliben, Revision 3) -----
.
.                                                    ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHAR COLOR BLACK ALL
BAR COLOR BLACK ALL
.                                                    ----- 2. INPUT DATA -----
READ DOE_3COL.DAT XI CI NI
.
.       READ A:DOE_MB50.DAT XI CI NI
.                                                    ----- 3. COMPUTATION -----
LET Y = 100*(CI/NI)
LET N = NUMBER Y
.
LET Y2(1) = Y(N)
LET YACT = Y(N)
LET X2(1) = XI(N)
DELETE Y XI CI NI FOR I = N 1 N
.
LET N = N-1
.
LET WINDOW = 10
LET NSTART = N-(WINDOW-1)
LET W = 0 FOR I = 1 1 N
LET W = SEQUENCE 1 1 WINDOW FOR I = NSTART 1 N
LET YPRED=WEIGHTED MEAN  Y W
LET SDY = STANDARD DEVIATION Y
LET SDM = SDY/SQRT(WINDOW)
LET Y2(2)=YPRED
LET Y2(3)=YPRED+3*SDM
LET Y2(4)=YPRED-3*SDM
LET X2 = N+1 FOR I = 1 1 4
LET TAG2 = DATA 2 3 4 4
.
LET N = NUMBER Y
LET YBAR = MEAN Y
LET SDYBAR = SQRT(YBAR*(100-YBAR)/NI)
LET UPPER = YBAR+3*SDYBAR
LET LOWER = YBAR-3*SDYBAR
LET LOWER = 0 SUBSET LOWER < 0
.                                  ----- 3A. LAG PLOT & AUTOCOR. PLOT FOR MODELING -----
TITLE LAG 1 PLOT
CHAR CIRCLE ALL
CHAR FILL ON ALL
LINES BLANK ALL
LET R = AUTOCORRELATION Y
LEGEND 1           AUTOCORRELATION  R1  =  ^R
LAG PLOT Y
PAUSE
.
CHAR CIRCLE BL BL BL BL BL
CHAR FILL ON OFF OFF OFF OFF OFF
CHAR HW 1.5 1 ALL
```

DATAPLOT Code - *Continuation Sheet*

```
LINES BLANK SOLID SOLID SOLID DOTTED DOTTED
SPIKE ON OFF OFF OFF OFF OFF
SPIKE BASE 0
.
TITLE AUTOCORRELATION PLOT
AUTOCORRELATION PLOT Y
PAUSE
.                                                  ----- 4. TITLE COMMANDS -----
.
TITLE P-CLC()HART FOR UC()P.I. 4.4 LC()WITH UC()MLC()ODEL FOR UC()PLC()REDICTION
TITLE SIZE 3.5
TITLE DISPLACEMENT 2
.                                                  ----- 5. LABEL COMMANDS -----
Y1LABEL PLC()ERCENTAGE
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 7
Y1LIMITS 0 25
.
XLABEL TLC()IME (UC()QLC()UARTER)
XLABEL SIZE 3
.                                                  ----- 6. GRAPHICS COMMANDS -----
CHAR CIRCLE BL BL BL CIRCLE X -
CHAR FILL ON OFF OFF OFF OFF OFF OFF
CHAR HW 1.5 1 ALL
LINES BLANK SOLID DOT DOT BLANK BLANK SOLID
SPIKE ON OFF OFF OFF OFF OFF OFF
SPIKE BASE YBAR
.                                                  ----- 7. LEGEND COMMANDS -----
.
LEGEND 1     A 49-data (solid circle) model for predicting 50th (x with 3-sigma)
LEGEND 2           where the actual data is given by the hollow circle.
LEGEND 3                    Ref.: A:\DOEPRED2.DP   (J. FONG, NIST, 5-26-92)
LEGEND 4     Sample Mean =  ^YBAR .  SD =  ^SDY .  SD of Weighted Mean*  =  ^SDM .
LEGEND 5     Predicted 50th =  ^YPRED .        Actual 50th =  ^YACT .
.
.                                                  ----- 8. PLOT COMMANDS -----
PLOT Y XI AND
PLOT YBAR FOR X = 1 1 N AND
PLOT UPPER XI AND
PLOT LOWER XI AND
PLOT Y2 X2 TAG2
.
JUSTIFICATION CENTER
MOVE 50 28
HW 2.4 1.6
TEXT *LC()BASED ON A WINDOW OF 10 POINTS NEAREST TO THE 50TH POINT
MOVE 52 24
TEXT LC()WITH WEIGHTS 1 TO 10, 10 BEING ASSIGNED TO THE 49TH.
.                                                  ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                  ----- END OF DOEPRED2.DP -----
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file DOE_3COL.DAT, which is also stored
.                               as a backup named DOE_MB50.DAT:
```

DATAPLOT Code - *Continuation Sheet*

```
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file DOE_3COL.DAT, which is also stored
.                               as a backup named DOE_MB50.DAT:
```

1	18.00	200
2	17.00	200
3	18.00	200
4	19.00	200
5	18.00	200
6	17.00	200
7	15.00	200
8	14.00	200
9	15.00	200
10	15.00	200
11	17.00	200
12	18.00	200
13	18.00	200
14	19.00	200
15	19.00	200
16	21.00	200
17	20.00	200
18	16.00	200
19	14.00	200
20	13.00	200
21	13.00	200
22	15.00	200
23	15.00	200
24	16.00	200
25	15.00	200
26	14.00	200
27	13.00	200
28	14.00	200
29	15.00	200
30	14.00	200
31	15.00	200
32	16.00	200
33	15.00	200
34	16.00	200
35	19.00	200
36	20.00	200
37	20.00	200
38	21.00	200
39	22.00	200
40	23.00	200
41	24.00	200
42	25.00	200
43	27.00	200
44	26.00	200
45	26.00	200
46	26.00	200
47	27.00	200
48	26.00	200
49	25.00	200
50	24.00	200

Sect. 6.12 - *Exploratory Analysis-1 (Data File: **ASTM_1CL.DAT**)*

The tutorials of the last eleven sections (6.1 through 6.11) were designed primarily for DOE-specific data sets except for Section 6.5 on linear fit which was intended for a general audience. With 69 DATAPLOT commands and 11 macros, we learned to produce report-quality graphics such as histograms, pie-chart, Pareto-chart, C-chart, and P-chart. We also learned to interpret the results of a lag plot and an autocorrelation plot to justify the use of two predictive models for sample data sets with or without the likelihood of serial dependence.

In the next three sections, we intend to introduce 9 more DATAPLOT macros using 16 new commands to address more thoroughly the same four questions posed earlier in Sect. 6.8:

- What is the "randomness" of the data ?
- What is the "best-fit" distribution for a given set of data ?
- What is the estimated location parameter for a fixed distribution ?
- What is the estimated variation parameter for a fixed distribution ?

To illustrate the additional analysis techniques, we use the following sample data set which came from a paper by Fong and Dowling [8] based on the test data generated by 6 laboratories in a 1974 round robin program sponsored by the Society of Automotive Engineers (SAE):

Lab. No.	Specimen No.	Crack Growth Rate Exponent[11]
1	1	3.535
1	2[12]	3.038[12]
2	1	3.038
2	2[12]	3.218[12]
3	1	3.218
3	2[12]	3.263[12]
4	1	3.263
4	2[12]	3.014[12]
5	1	3.014
5	2[12]	3.535[12]
6	1	3.760
6	2	4.221

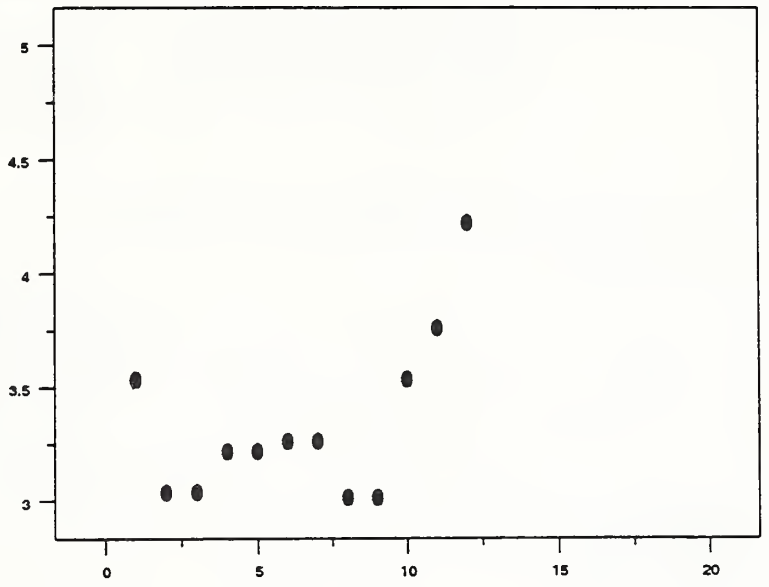
[11]Each exponent is the slope of a regression line based on a linear fit of 43 or more test data as shown in Sect. 6.5.
[12]Fictitious data introduced to illustrate interlaboratory data analysis techniques [8] when we discovered Labs 1-5 had data only on one specimen. All 12 data are used in Sect. 6.12 and 6.14 to illustrate univariate data analysis.

Summary 4-Plot (Data File: ASTM_1CL.DAT)

Subroutine Name: ***STATSUM4.DP*** *Ref.:* *pda-dp.5b1*

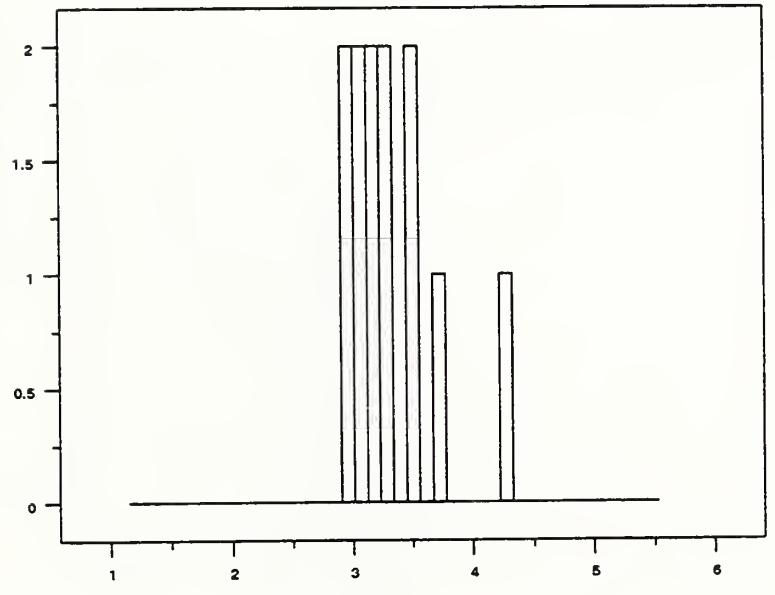
```
.
.       -----   STATSUM4.DP (version 92-04-10, Fong & Filliben, Revision 1) -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                  ----- 2. INPUT DATA -----
READ ASTM_1CL.DAT Y
.
.       READ A:ASTM_FCG.DAT Y
.                                                  ----- 3. COMPUTATION -----
.                                                  ----- 4. TITLE COMMANDS -----
TITLE SLC()UMMARY 4-UC()PLC()LOT  (UC()RLC()EF.: A:\UC()STATSUM4.DP)
TITLE SIZE 4
TITLE DISPLACEMENT 2
.                                                  ----- 5. LABEL COMMANDS -----
X3LABEL AUTOMATIC
.                                                  ----- 6. GRAPHICS COMMANDS -----
SPIKE OFF
CHAR CIRCLE ALL
CHAR FILL ON ALL
LINES BLANK ALL
.                                                  ----- 7. LEGEND COMMANDS -----
.                                                  ----- 8. PLOT COMMANDS -----
4-PLOT Y
.                                                  ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                  ----- END OF STATSUM4.DP -----
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file ASTM_1CL.DAT, which is also stored
.                               as a backup named ASTM_FCG.DAT:

                                 3.535
                                 3.038
                                 3.038
                                 3.218
                                 3.218
                                 3.263
                                 3.263
                                 3.014
                                 3.014
                                 3.535
                                 3.760
                                 4.221
```

DATAPLOT Code - *Continuation Sheet*



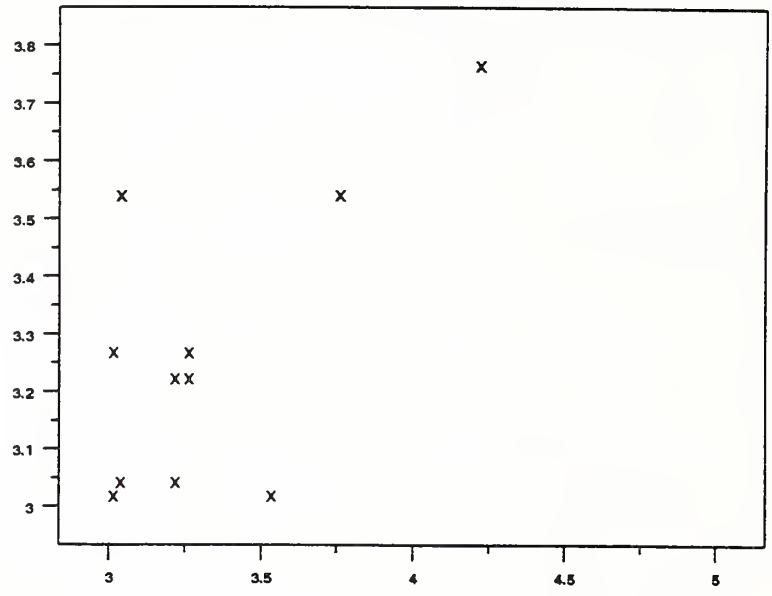
RUN SEQUENCE PLOT Y

Summary 4-Plot (Ref.: a:\STATSUM4.DP)



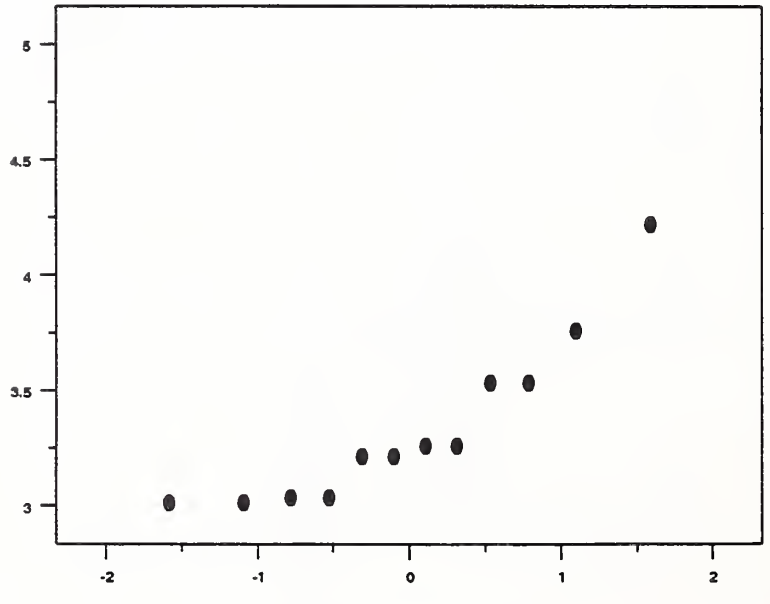
HISTOGRAM Y

DATAPLOT Code - *Continuation Sheet*



LAG PLOT Y

Summary 4-Plot (Ref.: a:\STATSUM4.DP)



NORMAL PROBABABILITY PLOTY

Summary Tabulation (Data File: ASTM_1CL.DAT)

Subroutine Name: ***STATSUMT.DP*** *Ref.:* *pda-dp.5b2*

```
.
.       -----   STATSUMT.DP (version 92-04-02, Fong & Filliben, Revision 0) -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
DEVICE 2 POSTSCRIPT
CAPTURE A:ASTM_FCG.OUT
.                                                  ----- 2. INPUT DATA -----
READ ASTM_1CL.DAT Y
.
.       READ A:ASTM_FCG.DAT Y
.                                                  ----- 3. COMPUTATION -----
.                                                  ----- 4. TITLE COMMANDS -----
.                                                  ----- 5. LABEL COMMANDS -----
.                                                  ----- 6. GRAPHICS COMMANDS -----
.                                                  ----- 7. LEGEND COMMANDS -----
.                                                  ----- 8. PLOT COMMANDS -----
SUMMARY Y
.                                                  ----- 9. CLOSURE COMMANDS -----
END OF CAPTURE
PAUSE
ER
EXIT
.                                                  ----- END OF STATSUMT.DP -----
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file ASTM_1CL.DAT, which is also stored
.                               in two backups named ASTM_FCG.DAT:
```

3.535
3.038
3.038
3.218
3.218
3.263
3.263
3.014
3.014
3.535
3.760
4.221

DATAPLOT Code - *Continuation Sheet*

SUMMARY

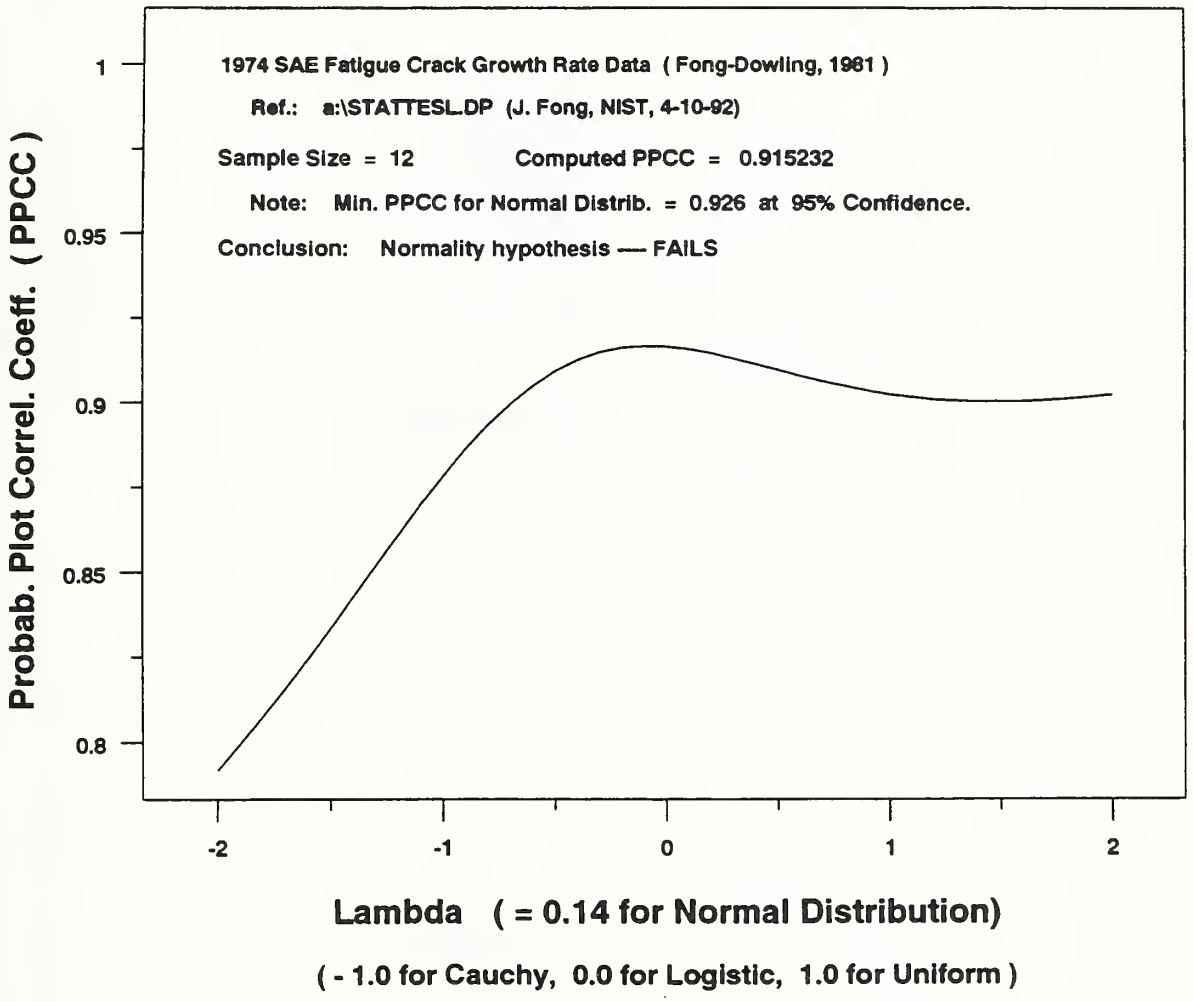
NUMBER OF OBSERVATIONS = 12

LOCATION MEASURES			DISPERSION MEASURES		
MIDRANGE	=	0.3617500E+01	RANGE	=	0.1207000E+01
MEAN	=	0.3343083E+01	STAND. DEV.	=	0.3649512E+00
MIDMEAN	=	0.3165000E+01	AV. AB. DEV.	=	0.2530833E+00
MEDIAN	=	0.3240500E+01	MINIMUM	=	0.3014000E+01
	=		LOWER QUART.	=	0.3038000E+01
	=		LOWER HINGE	=	0.3038000E+01
	=		UPPER HINGE	=	0.3535000E+01
	=		UPPER QUART.	=	0.3535000E+01
	=		MAXIMUM	=	0.4221000E+01
RANDOMNESS MEASURES			**DISTRIBUTIONAL MEASURES**		
AUTOCO COEF	=	0.6435551E+00	ST. 3RD MOM.	=	0.1178715E+01
	=	0.0000000E+00	ST. 4TH MOM.	=	0.3424925E+01
	=	0.0000000E+00	ST. WILK-SHA	=	-0.2921102E+01
	=		UNIFORM PPCC	=	0.9026427E+00
	=		NORMAL PPCC	=	0.9154305E+00
	=		TUK -.5 PPCC	=	0.9094493E+00
	=		CAUCHY PPCC	=	0.8857194E+00

Lambda Test (Data File: ASTM_1CL.DAT)

Subroutine Name: ***STATTESL.DP*** *Ref.:* *pda-dp.5c1*

Tukey Lambda Test for Symmetric Distributions



DATAPLOT Code - *Continuation Sheet*

```
.
.       ----- STATTESL.DP (version 92-04-10, Fong & Filliben, Revision 0) -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                  ----- 2. INPUT DATA -----
READ ASTM_1CL.DAT Y
.
.       READ A:ASTM_FCG.DAT Y
.                                                  ----- 3. COMPUTATION -----
LET N = NUMBER Y
.                                                  ----- 4. TITLE COMMANDS -----
TITLE TLC()UKEY UC()LLC()AMBDA UC()TLC()EST FOR UC()SLC()YMMETRIC UC()DLC()ISTRIBUTIONS
TITLE SIZE 3.5
.                                                  ----- 5. LEGEND COMMANDS -----
.
LEGEND 1 1974 SAE FLC()ATIGUE UC()CLC()RACK UC()GLC()ROWTH UC()RLC()ATE UC()DLC()ATA  ( UC()FLC()ONG-UC()DLC()OWLING, 1981 )
LEGEND 2      RLC()EF.:    A:\UC()STATTESL.DP  (J. FLC()ONG, UC()NIST, 4-10-92)
LEGEND 3 SLC()AMPLE UC()SLC()IZE  =  ^N               UC()CLC()OMPUTED UC()PPCC  =
LEGEND 4      NLC()OTE:    UC()MLC()IN. UC()PPCC LC()FOR UC()NLC()ORMAL UC()DLC()ISTRIB.  =  0.926  AT  95% UC()CLC()ONFIDENCE.
LEGEND 5 CLC()ONCLUSION:     UC()NLC()ORMALITY HYPOTHESIS ---- UC()FAILS
.
.
.                                                  ----- 6. GRAPHICS COMMANDS -----
.                                                  ----- 7. LABEL COMMANDS -----
Y1LABEL PLC()ROBAB. UC()PLC()LOT UC()CLC()ORREL. UC()CLC()OEFF.  ( UC()PPCC )
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 5
.
Y1LIMITS 0.8 1.0
.
XLIMITS -2 2
.
X1LABEL LLC()AMBDA   ( = 0.14 FOR UC()NLC()ORMAL UC()DLC()ISTRIBUTION)
X3LABEL ( - 1.0 LC()FOR UC()CLC()AUCHY,  0.0 FOR UC()LLC()OGISTIC,  1.0 FOR UC()ULC()NIFORM )
X1LABEL SIZE 3
X3LABEL SIZE 2.5
.                                                  ----- 8. PLOT COMMANDS -----
PPCC PLOT Y
LET A1 = YPLOT(22)
LET A2 = YPLOT(23)
LET A3 = 0.4*A1 + 0.6*A2
JUSTIFICATION LEFT
MOVE 55 76
TEXT ^A3
.                                                  ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                  ----- END OF STATTESL.DP -----
```

DATAPLOT Code - *Continuation Sheet*

----- Note to Reader: The following is a listing of the data file ASTM_1CL.DAT, which is also stored as a backup named ASTM_FCG.DAT:

```
3.535
3.038
3.038
3.218
3.218
3.263
3.263
3.014
3.014
3.535
3.760
4.221
```

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The Probability Plot Correlation Coefficient Test for Normality

James J. Filliben

National Bureau of Standards
Statistical Engineering Laboratory
U.S. Department of Commerce
Washington, D.C. 20234

This paper introduces the normal probability plot correlation coefficient as a test statistic in complete samples for the composite hypothesis of normality. The proposed test statistic is conceptually simple, is computationally convenient, and is readily extendible to testing non-normal distributional hypotheses. An empirical power study shows that the normal probability plot correlation coefficient compares favorably with 7 other normal test statistics. Percent points are tabulated for $n = 3(1)50(5)100$.

TABLE 1—*Percent points of the normal probability plot correlation coefficient r*

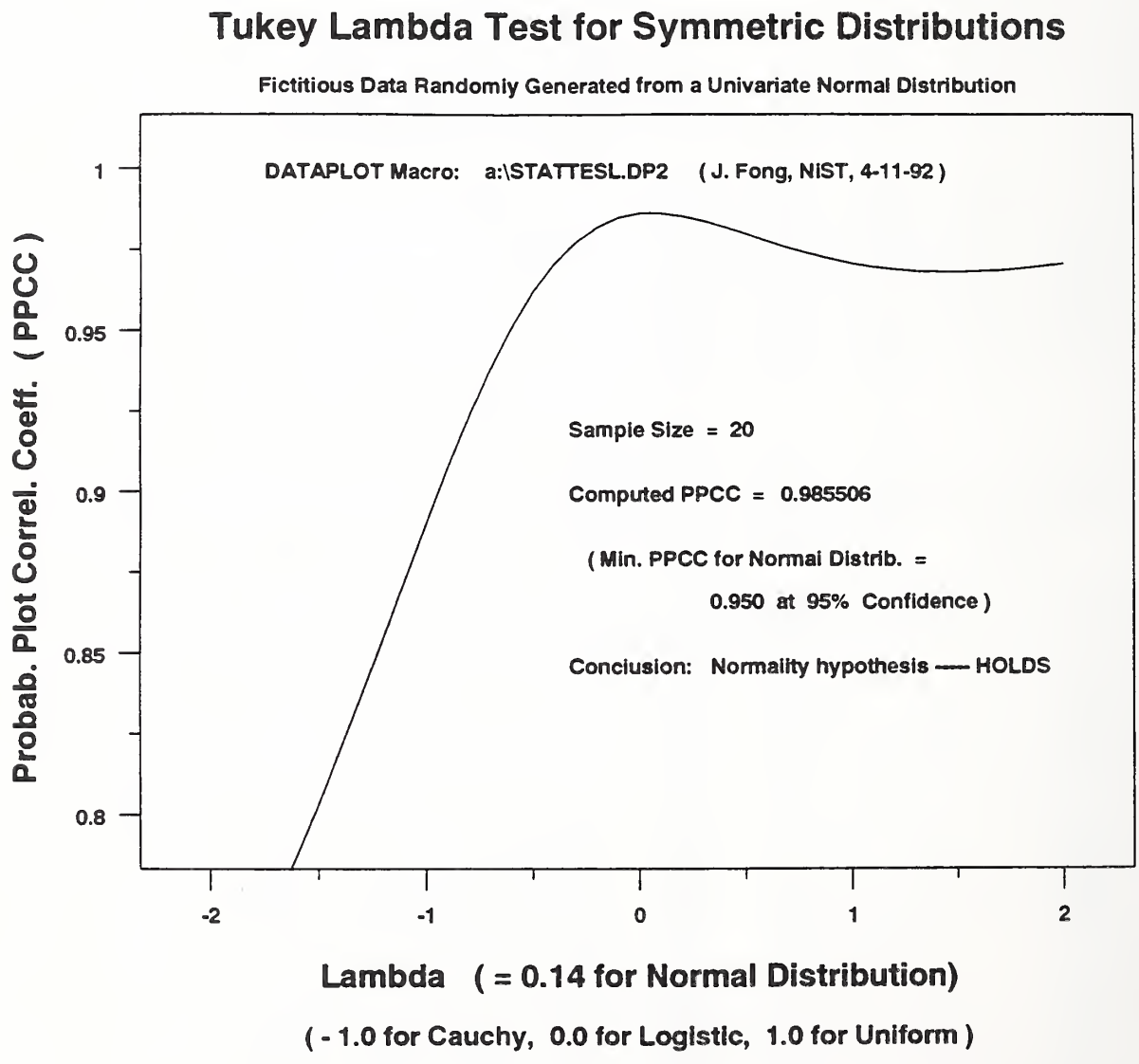
	Level							
n	.000	.005	.01	.025	.05	.10	.25	.50
3	.366	.867	.869	.872	.879	.891	.924	.966
4	.784	.813	.822	.845	.868	.894	.931	.958
5	.726	.803	.822	.855	.879	.902	.935	.960
6	.683	.818	.835	.868	.890	.911	.940	.962
7	.648	.828	.847	.876	.899	.916	.944	.965
8	.619	.841	.859	.886	.905	.924	.948	.967
9	.595	.851	.868	.893	.912	.929	.951	.968
10	.574	.860	.876	.900	.917	.934	.954	.970
11	.556	.868	.883	.906	.922	.938	.957	.972
12	.539	.875	.889	.912	.926	.941	.959	.973
13	.525	.882	.895	.917	.931	.944	.962	.975
14	.512	.888	.901	.921	.934	.947	.964	.976
15	.500	.894	.907	.925	.937	.950	.965	.977

TABLE 1—*Percent points of the normal probability plot correlation coefficient r*

	Level							
n	.000	.005	.01	.025	.05	.10	.25	.50
16	.489	.899	.912	.928	.940	.952	.967	.978
17	.478	.903	.916	.931	.942	.954	.968	.979
18	.469	.907	.919	.934	.945	.956	.969	.979
19	.460	.909	.923	.937	.947	.958	.971	.980
20	.452	.912	.925	.939	.950	.960	.972	.981
21	.445	.914	.928	.942	.952	.961	.973	.981
22	.437	.918	.930	.944	.954	.962	.974	.982
23	.431	.922	.933	.947	.955	.964	.975	.983
24	.424	.926	.936	.949	.957	.965	.975	.983
25	.418	.928	.937	.950	.958	.966	.976	.984
26	.412	.930	.939	.952	.959	.967	.977	.984
27	.407	.932	.941	.953	.960	.968	.977	.984
28	.402	.934	.943	.955	.962	.969	.978	.985
29	.397	.937	.945	.956	.962	.969	.979	.985
30	.392	.938	.947	.957	.964	.970	.979	.986
31	.388	.939	.948	.958	.965	.971	.980	.986
32	.383	.939	.949	.959	.966	.972	.980	.986
33	.379	.940	.950	.960	.967	.973	.981	.987
34	.375	.941	.951	.960	.967	.973	.981	.987
35	.371	.943	.952	.961	.968	.974	.982	.987
36	.367	.945	.953	.962	.968	.974	.982	.987
37	.364	.947	.955	.962	.969	.975	.982	.988
38	.360	.948	.956	.964	.970	.975	.983	.988
39	.357	.949	.957	.965	.971	.976	.983	.988
40	.354	.949	.958	.966	.972	.977	.983	.988
41	.351	.950	.958	.967	.972	.977	.984	.989
42	.348	.951	.959	.967	.973	.978	.984	.989
43	.345	.953	.959	.967	.973	.978	.984	.989
44	.342	.954	.960	.968	.973	.978	.984	.989
45	.339	.955	.961	.969	.974	.978	.985	.989
46	.336	.956	.962	.969	.974	.979	.985	.990
47	.334	.956	.963	.970	.974	.979	.985	.990
48	.331	.957	.963	.970	.975	.980	.985	.990
49	.329	.957	.964	.971	.975	.980	.986	.990
50	.326	.959	.965	.972	.977	.981	.986	.990
55	.315	.962	.967	.974	.978	.982	.987	.991
60	.305	.965	.970	.976	.980	.983	.988	.991
65	.296	.967	.972	.977	.981	.984	.989	.992
70	.288	.969	.974	.978	.982	.985	.989	.993
75	.281	.971	.975	.979	.983	.986	.990	.993
80	.274	.973	.976	.980	.984	.987	.991	.993
85	.268	.974	.977	.981	.985	.987	.991	.994
90	.263	.976	.978	.982	.985	.988	.991	.994
95	.257	.977	.979	.983	.986	.989	.992	.994
100	.252	.979	.981	.984	.987	.989	.992	.994

Lambda Test-2 (Data File: ASTM_1CL.DAT)

Subroutine Name: ***STATTESL.DP2*** *Ref.:* *pda-dp2.5c1*



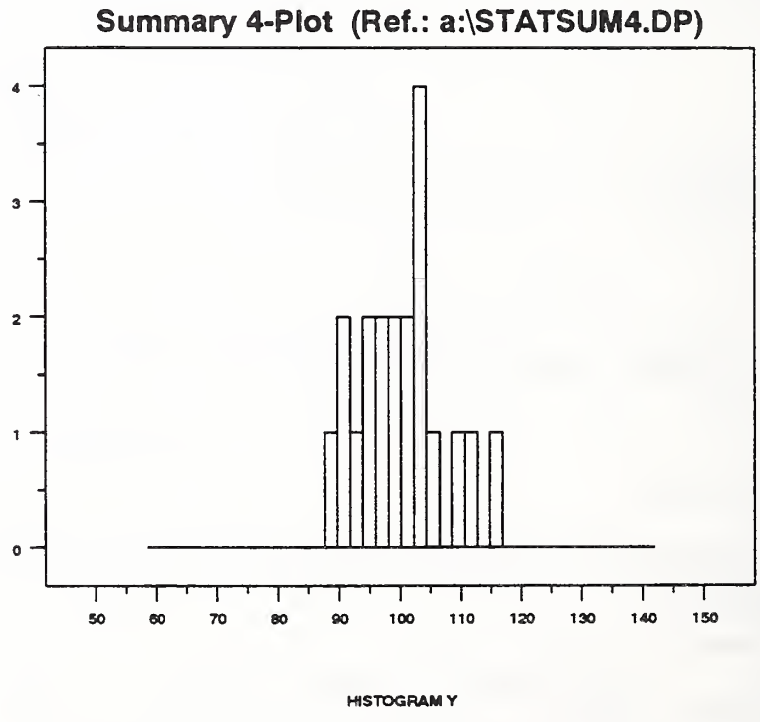
DATAPLOT Code - *Continuation Sheet*

```
.
.       ----- STATTESL.DP2 (version 92-04-11, Fong & Filliben, Revision 0) -----
.
.                                                 ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                 ----- 2. INPUT DATA -----
READ ASTM_1CL.DAT Y
.
.       READ A:ASTM_RND.DAT Y
.                                                 ----- 3. COMPUTATION -----
LET N = NUMBER Y
.                                                 ----- 4. TITLE COMMANDS -----
TITLE TLC()UKEY UC()LLC()AMBDA UC()TLC()EST FOR UC()SLC()YMMETRIC UC()DLC()ISTRIBUTIONS
TITLE SIZE 3.5
.                                                 ----- 5. LEGEND COMMANDS -----
.
LEGEND 1          DATAPLOT MLC()ACRO:    A:\UC()STATTESL.DP2     ( J. FLC()ONG, UC()NIST, 4-11-92 )
.
.                                                 ----- 6. GRAPHICS COMMANDS -----
.                                                 ----- 7. LABEL COMMANDS -----
Y1LABEL PLC()ROBAB. UC()PLC()LOT UC()CLC()ORREL. UC()CLC()OEFF.  ( UC()PPCC )
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 5
.
Y1LIMITS 0.8 1.0
.
XLIMITS -2 2
.
X1LABEL LLC()AMBDA   ( = 0.14 FOR UC()NLC()ORMAL UC()DLC()ISTRIBUTION)
X3LABEL ( - 1.0 LC()FOR UC()CLC()AUCHY,  0.0 FOR UC()LLC()OGISTIC,  1.0 FOR UC()ULC()NIFORM )
X1LABEL SIZE 3
X3LABEL SIZE 2.5
.                                                 ----- 8. PLOT COMMANDS -----
PPCC PLOT Y
JUSTIFICATION CENTER
MOVE 50 92
TEXT FLC()ICTITIOUS UC()DLC()ATA UC()RLC()ANDOMLY UC()GLC()ENERATED FROM A UC()ULC()NIVARIATE UC()NLC()ORMAL UC()DLC()ISTRIBUTION
JUSTIFICATION LEFT
MOVE 45 60
TEXT SLC()AMPLE UC()SLC()IZE  =  ^N
.
MOVE 45 54
TEXT CLC()OMPUTED UC()PPCC  =
.
LET A1 = YPLOT(22)
LET A2 = YPLOT(23)
LET A3 = 0.4*A1 + 0.6*A2
MOVE 60 54
TEXT ^A3
```

DATAPLOT Code - *Continuation Sheet*

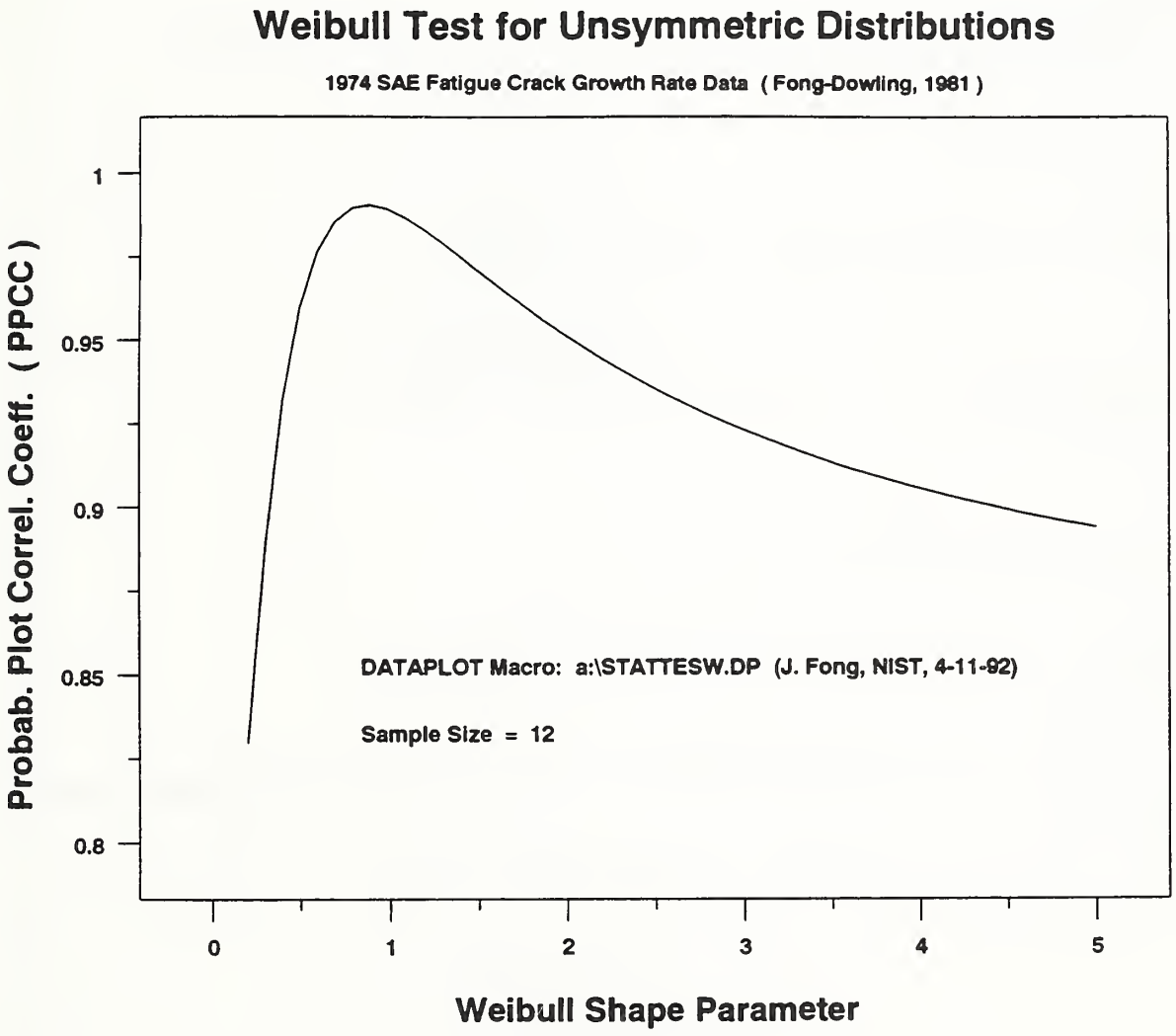
```
.
MOVE 45 48
TEXT    ( MLC()IN. UC()PPCC LC()FLC()OR UC()NLC()ORMAL UC()DLC()ISTRIB.  =
.
MOVE 55 44
TEXT 0.950  LC()AT  95%  UC()CLC()ONFIDENCE )
.
MOVE 45 38
TEXT CLC()ONCLUSION:   UC()NLC()ORMALITY HYPOTHESIS ----- UC()HOLDS
.
.                                                  ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                  ----- END OF STATTESL.DP2 -----
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file ASTM_1CL.DAT, which is also stored
.                               as a backup named ASTM_RND.DAT:
```

```
 89.27
105.73
 91.27
102.34
 95.45
 94.75
 92.94
100.32
111.91
102.70
 98.51
 98.03
 97.57
 91.59
 98.96
104.19
102.64
108.98
100.34
115.88
```



Weibull Test (Data File: ASTM_1CL.DAT)

Subroutine Name: ***STATTESW.DP*** *Ref.:* *pda-dp.5c2*

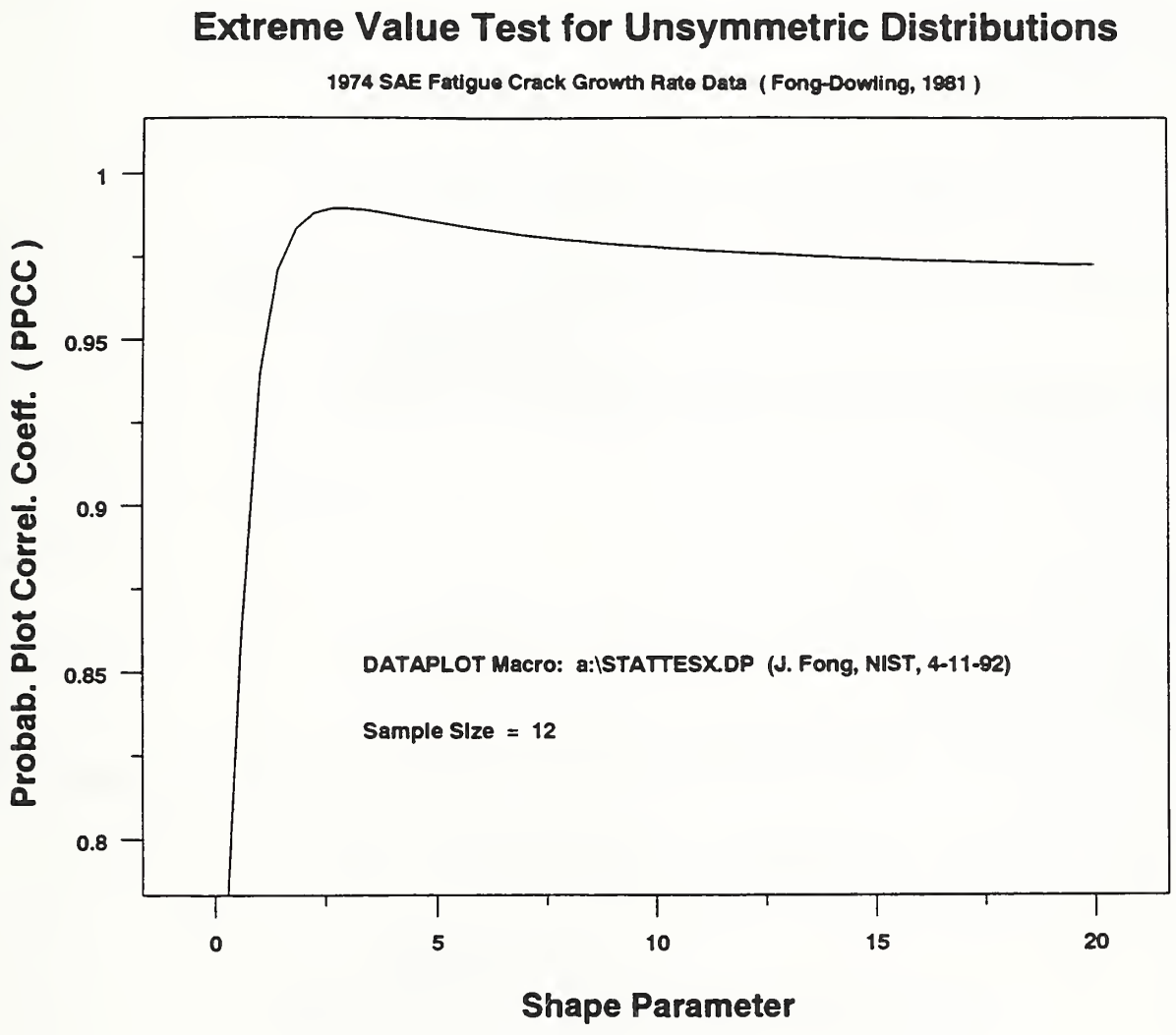


DATAPLOT Code - *Continuation Sheet*

```
.
.       ----- STATTESW.DP (version 92-04-11, Fong & Filliben, Revision 0) -----
.
.                                                   ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                   ----- 2. INPUT DATA -----
READ ASTM_1CL.DAT Y
.
.       READ A:ASTM_FCG.DAT Y
.                                                   ----- 3. COMPUTATION -----
LET N = NUMBER Y
.                                                   ----- 4. TITLE COMMANDS -----
TITLE WLC()EIBULL UC()TLC()EST FOR UC()ULC()NSYMMETRIC UC()DLC()ISTRIBUTIONS
TITLE SIZE 3.5
.                                                   ----- 5. LEGEND COMMANDS -----
.                                                   ----- 6. GRAPHICS COMMANDS -----
.                                                   ----- 7. LABEL COMMANDS -----
Y1LABEL PLC()ROBAB. UC()PLC()LOT UC()CLC()ORREL. UC()CLC()OEFF.  ( UC()PPCC )
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 5
.
Y1LIMITS 0.8 1.0
.
XLIMITS 0 5
.
X1LABEL WLC()EIBULL UC()SLC()HAPE UC()PLC()ARAMETER
X1LABEL SIZE 3
.                                                   ----- 8. PLOT COMMANDS -----
LET GAMMA1 = 0.2
LET GAMMA2 = 5.0
WEIBULL PPCC PLOT Y
JUSTIFICATION CENTER
MOVE 50 92
TEXT 1974 SAE FLC()ATIGUE UC()CLC()RACK UC()GLC()ROWTH UC()RLC()ATE UC()DLC()ATA  ( UC()FLC()ONG-UC()DLC()OWLING, 1981 )
.
JUSTIFICATION LEFT
MOVE 30 40
TEXT DATAPLOT MLC()ACRO:  A:\UC()STATTESW.DP  (J. FLC()ONG, UC()NIST, 4-11-92)
.
MOVE 30 34
TEXT SLC()AMPLE UC()SLC()IZE  =  ^N
.                                                   ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                   ----- END OF STATTESW.DP -----
```

Extreme Value Test *(Data File: ASTM_1CL.DAT)*

Subroutine Name: ***STATTESX.DP*** *Ref.:* *pda-dp.5c3*

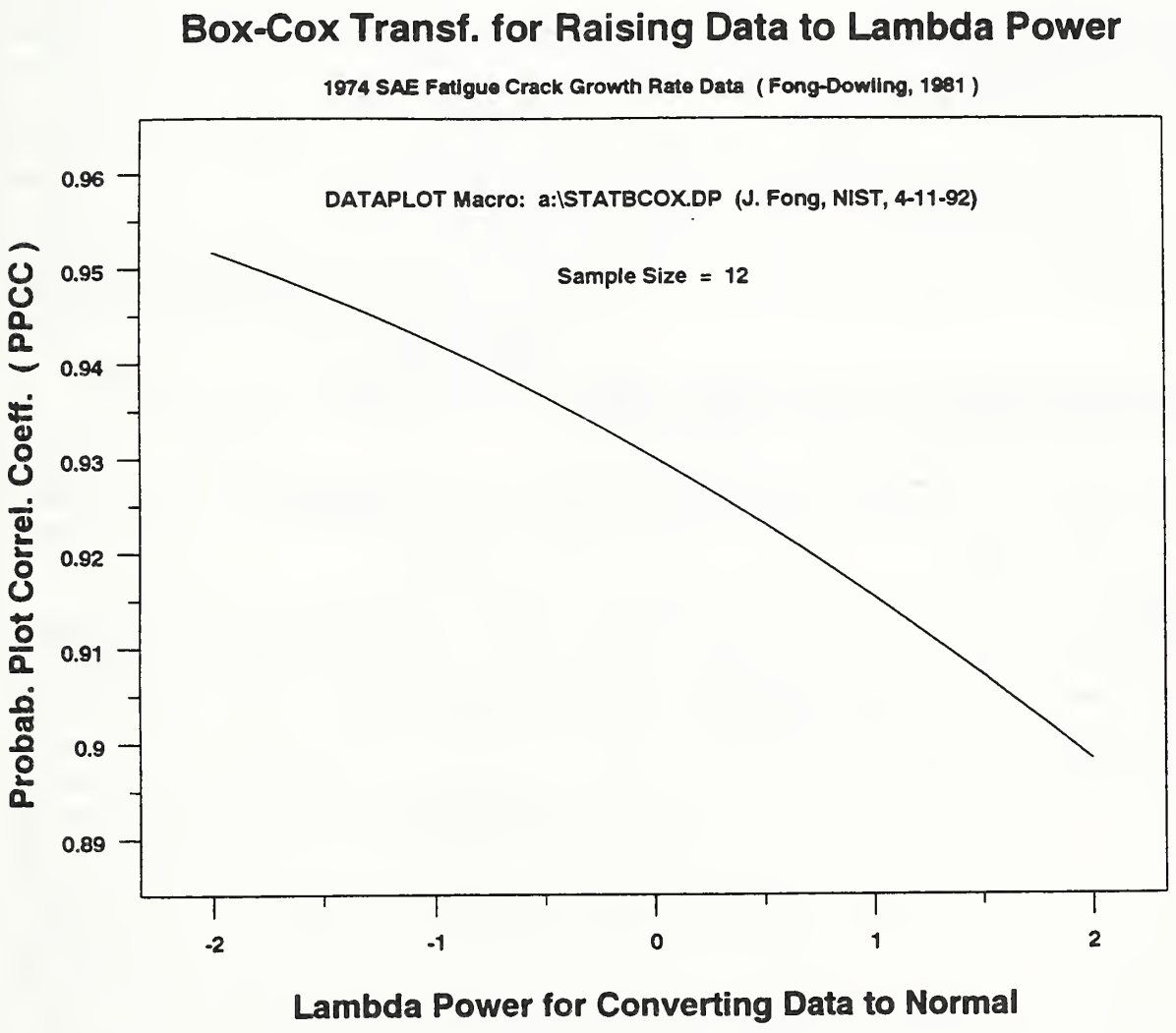


DATAPLOT Code - *Continuation Sheet*

```
.
.       ----- STATTESX.DP (version 92-04-11, Fong & Filliben, Revision 0) -----
.
.                                                ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                ----- 2. INPUT DATA -----
READ ASTM_1CL.DAT Y
.
.       READ A:ASTM_FCG.DAT Y
.                                                ----- 3. COMPUTATION -----
LET N = NUMBER Y
.
TITLE ELC()XTREME UC()VLC()ALUE UC()TLC()EST FOR UC()ULC()NSYMMETRIC UC()DLC()ISTRIBUTIONS
TITLE SIZE 3.5
.                                                ----- 5. LEGEND COMMANDS -----
.                                                ----- 6. GRAPHICS COMMANDS -----
.                                                ----- 7. LABEL COMMANDS -----
Y1LABEL PLC()ROBAB. UC()PLC()LOT UC()CLC()ORREL. UC()CLC()OEFF.  ( UC()PPCC )
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 5
.
Y1LIMITS 0.8 1.0
.
XLIMITS 0 20
.
X1LABEL SLC()HAPE UC()PLC()ARAMETER
X1LABEL SIZE 3
.                                                ----- 8. PLOT COMMANDS -----
LET GAMMA1 = 0.2
LET GAMMA2 = 20
EXTR VALUE TYPE 2 PPCC PLOT Y
JUSTIFICATION CENTER
MOVE 50 92
TEXT 1974 SAE FLC()ATIGUE UC()CLC()RACK UC()GLC()ROWTH UC()RLC()ATE UC()DLC()ATA  ( UC()FLC()ONG-UC()DLC()OWLING, 1981 )
.
JUSTIFICATION LEFT
MOVE 30 40
TEXT DATAPLOT MLC()ACRO:  A:\UC()STATTESX.DP  (J. FLC()ONG, UC()NIST, 4-11-92)
.
MOVE 30 34
TEXT SLC()AMPLE UC()SLC()IZE  =  ^N
.                                                ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                ----- END OF STATTESX.DP -----
```

Box-Cox Transformation *(Data File: ASTM_1CL.DAT)*

Subroutine Name: ***STATBCOX.DP*** *Ref.:* *pda-dp.5c4*



DATAPLOT Code - *Continuation Sheet*

```
.
.       ----- STATBCOX.DP (version 92-04-11, Fong & Filliben, Revision 0) -----
.
.                                                  ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
TIC OFFSET UNITS SCREEN
TIC OFFSET 5 5
CHARACTER COLOR BLACK ALL
BAR COLOR BLACK ALL
DEVICE 2 POSTSCRIPT
WINDOW CORNER COORDINATES 0 0 95 95
.                                                  ----- 2. INPUT DATA -----
READ ASTM_1CL.DAT Y
.
.       READ A:ASTM_FCG.DAT Y
.                                                  ----- 3. COMPUTATION -----
LET N = NUMBER Y
.
TITLE BLC()OX-UC()CLC()OX UC()TLC()RANSF. FOR UC()RLC()AISING UC()DLC()ATA TO UC()LLC()AMBDA UC()PLC()OWER
TITLE SIZE 3.5
.                                                  ----- 5. LEGEND COMMANDS -----
.                                                  ----- 6. GRAPHICS COMMANDS -----
.                                                  ----- 7. LABEL COMMANDS -----
.
Y1LABEL PLC()ROBAB. UC()PLC()LOT UC()CLC()ORREL. UC()CLC()OEFF.  ( UC()PPCC )
Y1LABEL SIZE 3
Y1LABEL DISPLACEMENT 5
.
X1LABEL LLC()AMBDA UC()PLC()OWER FOR UC()CLC()ONVERTING UC()DLC()ATA TO UC()NLC()ORMAL
X1LABEL SIZE 3
.                                                  ----- 8. PLOT COMMANDS -----
BOX-COX NORMALITY PLOT Y
JUSTIFICATION CENTER
MOVE 50 92
TEXT 1974 SAE FLC()ATIGUE UC()CLC()RACK UC()GLC()ROWTH UC()RLC()ATE UC()DLC()ATA  ( UC()FLC()ONG-UC()DLC()OWLING, 1981 )
.
MOVE 50 82
TEXT DATAPLOT MLC()ACRO:  A:\UC()STATBCOX.DP  (J. FLC()ONG, UC()NIST, 4-11-92)
.
MOVE 50 75
TEXT SLC()AMPLE UC()SLC()IZE  =  ^N
.                                                  ----- 9. CLOSURE COMMANDS -----
PAUSE
ER
EXIT
.                                                  ----- END OF STATBCOX.DP -----
```

Sect. 6.13 - *Analysis of Variance-1 (Data File: **ASTM_3CL.DAT**)*

In Sect. 6.12, we introduced 6 macros, STATSUM4.DP, STATSUMT.DP, STATTESL.DP, STATTESW.DP, STATTESX.DP, and STATBCOX.DP to analyze a 12-point data set given by 6 laboratories as listed on p. 149. The first macro, STATSUM4.DP, yielded four plots which convinced us that the data is unlikely to be normally distributed. The tabulated results of the second macro, STATSUMT.DP, gave us on p. 154 the quantitative evidence through the autocorrelation coefficient r_1 , which, at 0.64, is too far away from zero, the ideal measure of randomness. Using a macro named STATTESL.DP, we subjected the 12-point data set to further scrutiny via the so-called Tukey Lambda test [20, 25], where we observe on p. 155 that normality hypothesis fails when the computed probability plot correlation coefficient (PPCC=0.915) is below the minimum (0.926) tabulated for a sample of 12 at 95% confidence (see p. 158)[13]. We then began a search for the "best-fit" distribution by plotting once again the PPCC versus the shape parameters of two well-known families of distributions, namely, the Weibull (STATTESW.DP) and the Extreme-Value Type 2 (STATTESX.WP). We see on pages 163 and 165 that both would admit valid shape parameters if the values of PPCC are above a certain threshold value equal to, say, 0.926.

Section 6.12 concludes with a macro named STATBCOX.DP and a plot associated with that macro where the values of PPCC are plotted against an exponent named lambda. The purpose of that plot is to select a value for lambda at the highest PPCC such that a transformation of the data set by raising each data to the power of lambda converts a non-normal set to a normal one. This technique is therefore useful in modeling non-normal data sets.

In this section, we introduce a very brief macro named STATANOV.DP to perform an interlaboratory data analysis using a technique known as ANOVA. The goal of this analysis is to evaluate the between-laboratory variance which is a measure of the "reproducibility" of a specific measurement. A complete description of this exercise is given in a paper by Fong and Dowling [8]. On page 170, we show the listing for the macro and two data files named ASTM_LAB.DAT and ASTM_LB5.DAT. The first one is the 6-laboratory, 2-specimen data file we used for Section 6.12 and reproduced on page 149. The second data file is the same as the first except that the last two data points from the 6th laboratory are removed. The output for the analysis of variance of the first and the second data files are given on pages 171 and 172, respectively. Even though the replication standard deviations computed for the two data files are about the same (0.26256 vs. 0.24796), the F-test statistics (3.049 vs. 0.184) and the corresponding F CDF values (89.642% vs. 6.341%) are different. The main conclusion is that there is indeed a qualitative difference between the first five laboratories and the sixth with acceptable degree of reproducibility among all laboratories if the 6th laboratory is left out.

[13]For completeness, we added a macro named STATTESL.DP2 (pp. 160-162) to analyze a 20-point data set randomly generated from a univariate normal distribution. As expected, the computed PPCC (0.985) exceeds the minimum (0.950) shown on page 159, and the normality hypothesis holds.

ANOVA (Data File: ASTM_3CL.DAT)

Subroutine Name: ***STATANOV.DP*** *Ref.:* *pda-dp.5d2*

```
.       -----   STATANOV.DP (version 92-04-11, Fong & Filliben, Revision 0) -----
.
.                                               ----- 1. SYSTEM COMMANDS -----
FEEDBACK OFF
DIMENSION 100 VARIABLES
DEFINE ER ESC FF
DEVICE 2 POSTSCRIPT
CAPTURE A:ASTM_LAB.OUT
.                                               ----- 2. INPUT DATA -----
READ ASTM_3CL.DAT X1 X2 Y
.
.       READ A:ASTM_LAB.DAT X1 X2 Y
.                                               ----- 3. COMPUTATION -----
.                                               ----- 4. TITLE COMMANDS -----
.                                               ----- 5. LABEL COMMANDS -----
.                                               ----- 6. GRAPHICS COMMANDS -----
.                                               ----- 7. LEGEND COMMANDS -----
.                                               ----- 8. PLOT COMMANDS -----
ANOVA Y X1
.                                               ----- 9. CLOSURE COMMANDS -----
END OF CAPTURE
PAUSE
ER
EXIT
.                                               ----- END OF STATANOV.DP -----
.
.       -----  Note to Reader:  The following is a listing of the data
.                               file ASTM_3CL.DAT, which is also stored
.                               in two backups, one named ASTM_LAB.DAT for
.                               a 6-lab data set, and the other named ASTM_LB5.DAT
.                               for a 5-lab data set after the data for 6th lab were removed:
.
.       ASTM_LAB.DAT                            ASTM_LB5.DAT

        1       1       3.535           1       1       3.535
        1       2       3.038           1       2       3.038
        2       1       3.038           2       1       3.038
        2       2       3.218           2       2       3.218
        3       1       3.218           3       1       3.218
        3       2       3.263           3       2       3.263
        4       1       3.263           4       1       3.263
        4       2       3.014           4       2       3.014
        5       1       3.014           5       1       3.014
        5       2       3.535           5       2       3.535
        6       1       3.760
        6       2       4.221
```

DATAPLOT Code - *Continuation Sheet*

```
                  **********************************
                  **********************************
                  **  1-WAY ANALYSIS OF VARIANCE  **
                  **********************************
                  **********************************

      NUMBER OF OBSERVATIONS                =        12
      NUMBER OF FACTORS                     =         1
      NUMBER OF LEVELS FOR FACTOR 1         =         6
      RESIDUAL    STANDARD DEVIATION        =    0.26258280873E+00
      RESIDUAL    DEGREES OF FREEDOM        =         6
      REPLICATION CASE
      REPLICATION STANDARD DEVIATION        =    0.26258280873E+00
      REPLICATION DEGREES OF FREEDOM        =         6
      NUMBER OF DISTINCT CELLS              =         6

                         *****************
                         *  ESTIMATION   *
                         *****************

      GRAND MEAN                            =    0.33430833817E+01
      GRAND STANDARD DEVIATION              =    0.36495119333E+00

                LEVEL-ID      NI      MEAN      EFFECT     SD(EFFECT)
   ------------------------------------------------------------------------
   FACTOR  1--    1.00000      2.    3.28650    -0.05658    0.16950
           --    2.00000      2.    3.12800    -0.21508    0.16950
           --    3.00000      2.    3.24050    -0.10258    0.16950
           --    4.00000      2.    3.13850    -0.20458    0.16950
           --    5.00000      2.    3.27450    -0.06858    0.16950
           --    6.00000      2.    3.99050     0.64742    0.16950


          MODEL                 RESIDUAL STANDARD DEVIATION
   ------------------------------------------------------------
   CONSTANT              ONLY--          0.3649511933
   CONSTANT & FACTOR  1 ONLY--           0.2625828087

                            *************
                            *  TESTING  *
                            *************

                NUM. LEVELS     F STAT.        F CDF
   ------------------------------------------------------
   FACTOR  1--        6       3.04971241951  89.642%

         RESIDUAL    STANDARD DEVIATION =          0.26258280873
         RESIDUAL    DEGREES OF FREEDOM =               6
         REPLICATION STANDARD DEVIATION =          0.26258280873
         REPLICATION DEGREES OF FREEDOM =               6
```

DATAPLOT Code - *Continuation Sheet*

```
                  ************************************
                  ************************************
                  **  1-WAY ANALYSIS OF VARIANCE    **
                  ************************************
                  ************************************

      NUMBER OF OBSERVATIONS                =        10
      NUMBER OF FACTORS                     =         1
      NUMBER OF LEVELS FOR FACTOR 1         =         5
      RESIDUAL    STANDARD DEVIATION        =    0.24796687067E+00
      RESIDUAL    DEGREES OF FREEDOM        =         5
      REPLICATION CASE
      REPLICATION STANDARD DEVIATION        =    0.24796687067E+00
      REPLICATION DEGREES OF FREEDOM        =         5
      NUMBER OF DISTINCT CELLS              =         5

                         ****************
                         *  ESTIMATION  *
                         ****************

      GRAND MEAN                            =    0.32136001587E+01
      GRAND STANDARD DEVIATION              =    0.19800846279E+00

              LEVEL-ID      NI      MEAN      EFFECT     SD(EFFECT)
-------------------------------------------------------------------------
FACTOR  1--    1.00000      2.    3.28650     0.07290     0.15683
        --    2.00000      2.    3.12800    -0.08560     0.15683
        --    3.00000      2.    3.24050     0.02690     0.15683
        --    4.00000      2.    3.13850    -0.07510     0.15683
        --    5.00000      2.    3.27450     0.06090     0.15683


       MODEL                RESIDUAL STANDARD DEVIATION
-----------------------------------------------------------
CONSTANT             ONLY--         0.1980084628
CONSTANT & FACTOR  1 ONLY--         0.2479668707

                            *************
                            *  TESTING  *
                            *************

              NUM. LEVELS    F STAT.       F CDF
-----------------------------------------------------
FACTOR  1--        5       0.18470549583   6.341%

      RESIDUAL    STANDARD DEVIATION =         0.24796687067
      RESIDUAL    DEGREES OF FREEDOM =              5
      REPLICATION STANDARD DEVIATION =         0.24796687067
      REPLICATION DEGREES OF FREEDOM =              5
```

Sect. 6.14 - *Statistical Distribution-1 (Data File: ASTM_1CL.DAT)*

Before we discuss the last tutorial of this chapter, let us summarize Sect. 6.1-6.13:

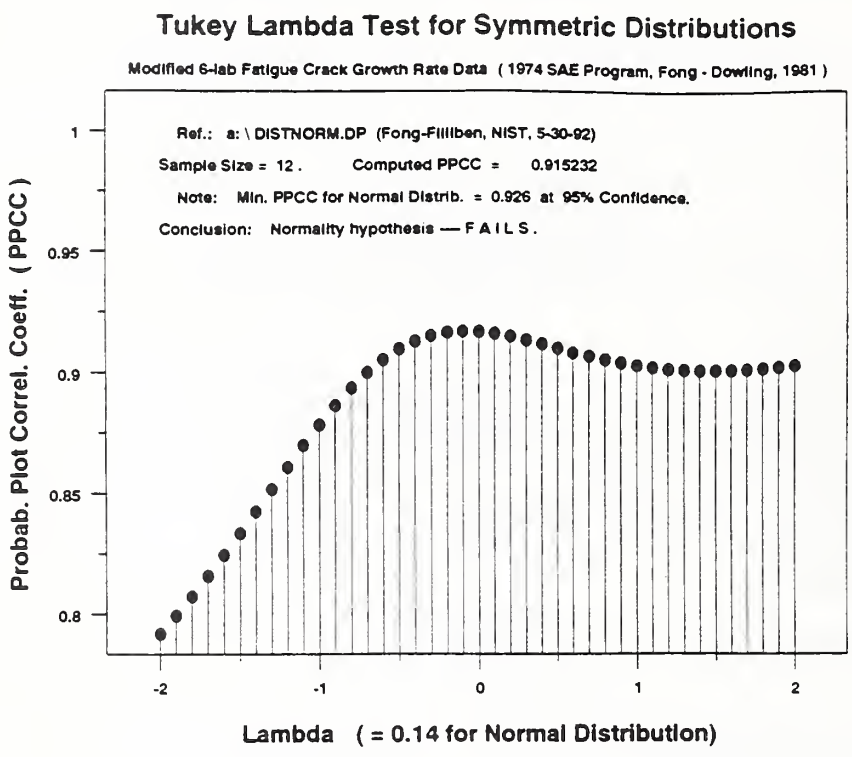
Section	Name of Macro	Name of DATAPLOT Command	No.	Subtotal
6.1	DOEHISTO.DP	(See p. 102.)	24	24
6.2	DOEPIECH.DP	(See p. 106.)	20	44
6.3	DOEPARET.DP	(See p. 111.)	9	53
6.4	DOEP4Q7F.DP	(See p. 115.)	3	56
6.5	DOEPLOTF.DP	(See p. 119.)	5	61
6.6	DOECCC.DP	SPIKE	1	62
6.7	DOEPCC.DP		0	62
6.8	DOELAG.DP	... LAG PLOT	1	63
6.9	DOEAUTO.DP	(See p. 119.)	2	65
6.10	DOEPRED1.DP	(See p. 119.)	2	67
6.11	DOEPRED2.DP	(See p. 119.)	2	69
6.12	STATSUM4.DP (p. 150)	4-PLOT AUTOMATIC	2	71
	STATSUMT.DP (p. 153)	CAPTURE END OF CAPTURE SUMMARY	3	74
	STATTESL.DP (p. 156)	... PPCC PLOT	1	75
	STATTESL.DP2 (p. 161)			
	STATTESW.DP (p. 164)			
	STATTESX.DP (p. 166)			
	STATBCOX.DP (p. 168)	BOX-COX NORMALITY PLOT	1	76
6.13	STATANOV.DP (p. 170)	ANOVA	1	77

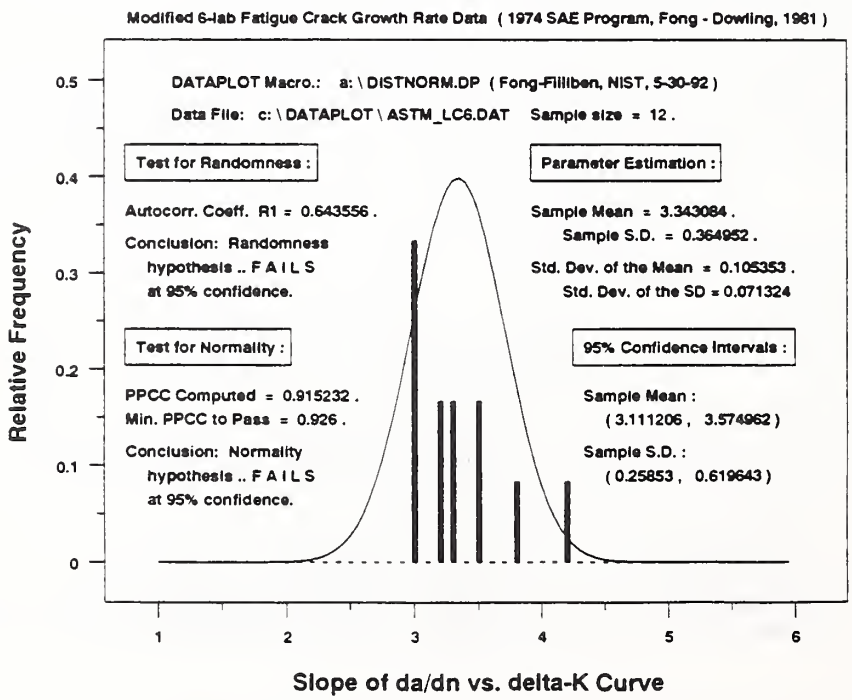
In this section, we introduce five more macros and 8 more commands to bring to a conclusion an exploratory data analysis of a 12-point data set first introduced in Section 6.12 with the filenames of ASTM_1CL.DAT or ASTM_FCG.DAT (see page 150) and renamed ASTM_LC6.DAT for the two new macros listed below and the output on pp. 174-177:

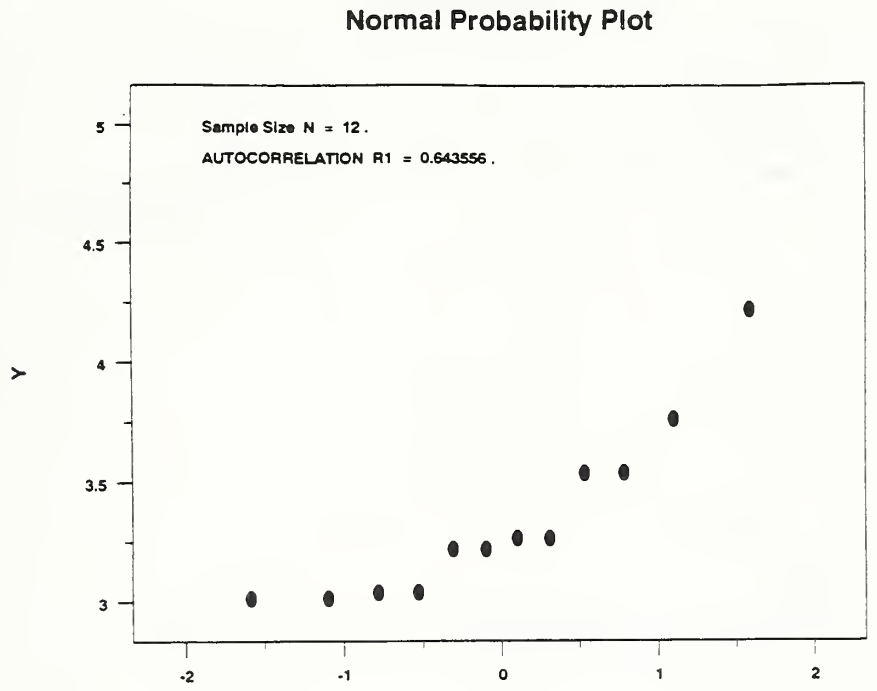
Sect. 6.14	DISTNORM.DP (test fails)	CHSPPF(P,NU) NORPDF(x)	2	79
	DISTNORM.DP5 (test passes)		0	79
	DISTWEIB.DP	CORRELATION ... PROBABILITY PLOT		
	DISTWEIB.G09 (Gamma=0.9)	SORT UNIFORM ORDER STAT MEDIAN		
	DISTWEIB.G13 (Gamma=1.3)	WEIPDF(X, GAMMA) WEIPPF(P, GAMMA)	6	85

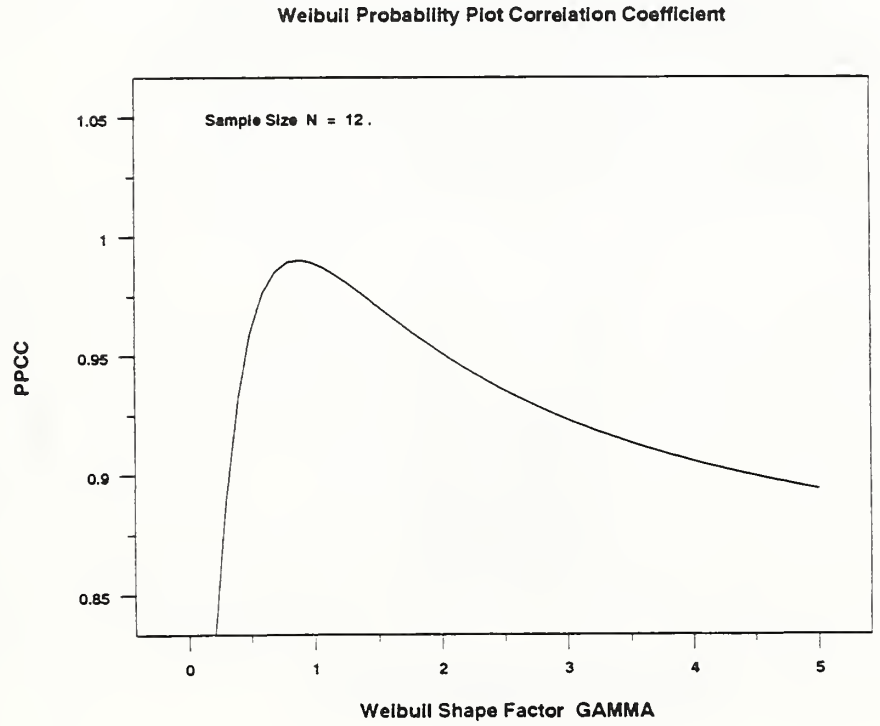
Two of the 85 commands deserve special mention. They are "... PPCC PLOT", which can handle 9, and "... PROBABILITY PLOT", which can handle 24 distributions as listed below:

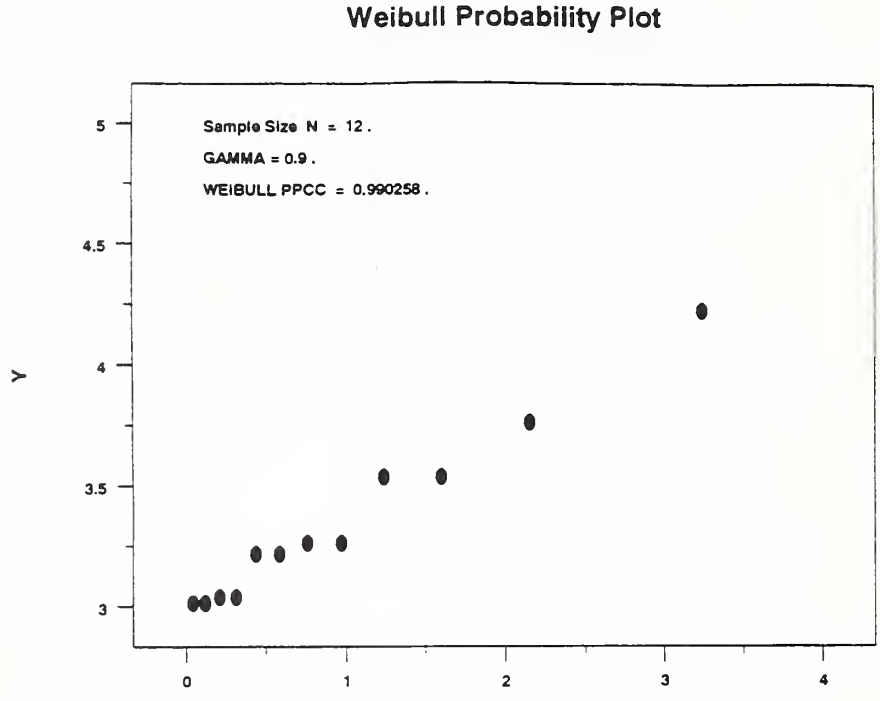
"... PPCC PLOT"	Chi-Squared; Extr Value Type 2; Gamma; Geometric; Pareto; Poisson; T; Tukey Lambda (default); Weibull.
"... PROBABILITY PLOT"	Beta; Binomial; Cauchy; Chi-Squared; Double-Exponential; Exponential; Extr Value Type 1; Extr Value Type 2; F; Gamma; Geometric; Half Normal; Logistic; Lognormal; Negative Binomial; Normal; Pareto; Poisson; Semicircular; T; Triangular; Tukey Lambda; Uniform; Weibull.

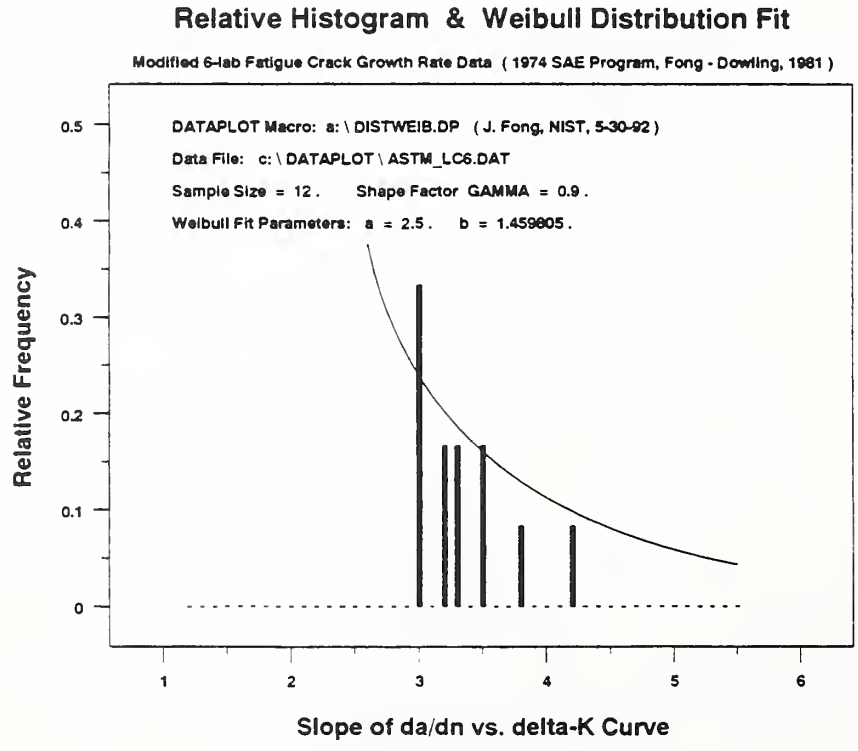

Tukey Lambda Test for Symmetric Distributions
Modified 6-lab Fatigue Crack Growth Rate Data (1974 SAE Program, Fong - Dowling, 1981)
Ref.: a: \ DISTNORM.DP (Fong-Filliben, NIST, 5-30-92)
Sample Size = 12 . Computed PPCC = 0.915232
Note: Min. PPCC for Normal Distrib. = 0.926 at 95% Confidence.
Conclusion: Normality hypothesis — F A I L S .
Probab. Plot Correl. Coeff. (PPCC)
1
0.95
0.9
0.85
0.8
-2
-1
0
1
2
Lambda (= 0.14 for Normal Distribution)


Relative Histogram & Normal Distribution Fit
Modified 6-lab Fatigue Crack Growth Rate Data (1974 SAE Program, Fong - Dowling, 1981)
DATAPLOT Macro.: a: \ DISTNORM.DP (Fong-Filliben, NIST, 5-30-92)
Data File: c: \ DATAPLOT \ ASTM_LC6.DAT Sample size = 12 .
Test for Randomness :
Autocorr. Coeff. R1 = 0.643556 .
Conclusion: Randomness hypothesis .. F A I L S at 95% confidence.
Test for Normality :
PPCC Computed = 0.915232 .
Min. PPCC to Pass = 0.926 .
Conclusion: Normality hypothesis .. F A I L S at 95% confidence.
Parameter Estimation :
Sample Mean = 3.343084 .
Sample S.D. = 0.364952 .
Std. Dev. of the Mean = 0.105353 .
Std. Dev. of the SD = 0.071324
95% Confidence Intervals :
Sample Mean :
(3.111206 , 3.574962)
Sample S.D. :
(0.25853 , 0.619643)
Relative Frequency
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
6
Slope of da/dn vs. delta-K Curve

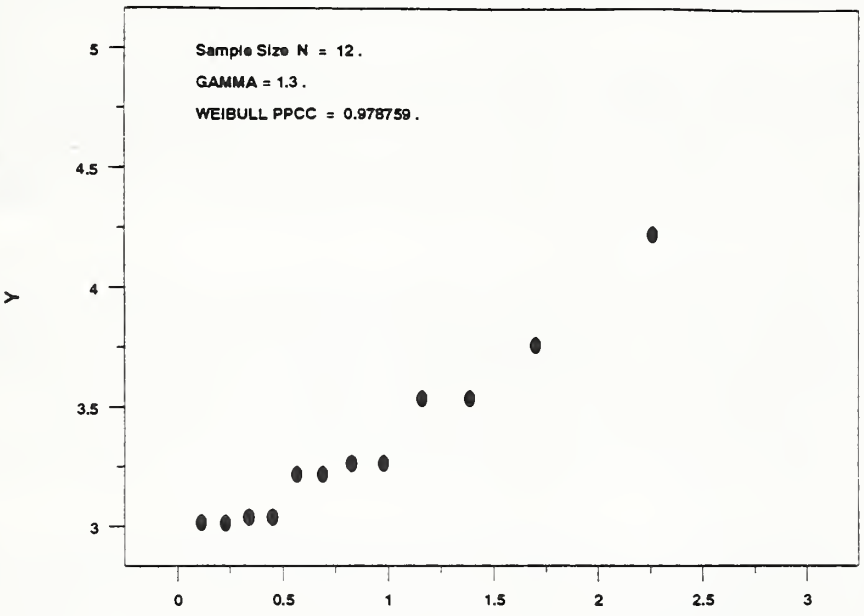

Normal Probability Plot
Sample Size N = 12.
AUTOCORRELATION R1 = 0.643556.
Y
5
4.5
4
3.5
3
-2
-1
0
1
2


Weibull Probability Plot Correlation Coefficient
Sample Size N = 12.
PPCC
1.05
1
0.95
0.9
0.85
0
1
2
3
4
5
Weibull Shape Factor GAMMA


Weibull Probability Plot
Sample Size N = 12 .
GAMMA = 0.9 .
WEIBULL PPCC = 0.990258 .
Y
5
4.5
4
3.5
3
0
1
2
3
4

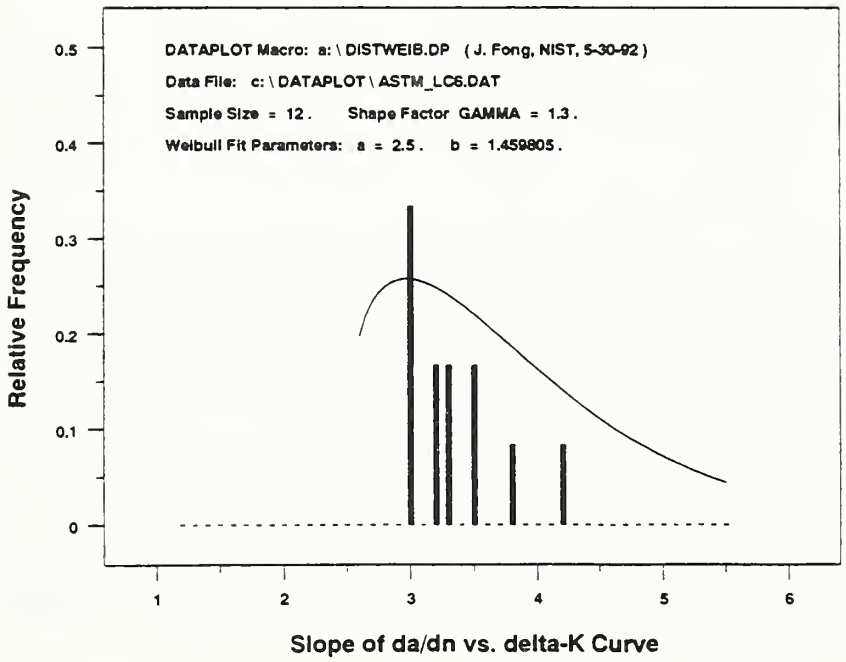

Relative Histogram & Weibull Distribution Fit
Modified 6-lab Fatigue Crack Growth Rate Data (1974 SAE Program, Fong - Dowling, 1981)
DATAPLOT Macro: a: \ DISTWEIB.DP (J. Fong, NIST, 5-30-92)
Data File: c: \ DATAPLOT \ ASTM_LC6.DAT
Sample Size = 12 . Shape Factor GAMMA = 0.9 .
Weibull Fit Parameters: a = 2.5 . b = 1.459805 .
Relative Frequency
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
6
Slope of da/dn vs. delta-K Curve

Weibull Probability Plot



Relative Histogram & Weibull Distribution Fit

Modified 6-lab Fatigue Crack Growth Rate Data (1974 SAE Program, Fong - Dowling, 1981)



Chapter 7 - Significance & Limitations of *PDA (v. 92.2)*

As originally agreed between NIST and the DOE Office of Nuclear Safety Self-Assessment in a procurement request dated Sep. 30, 1991, an expert system named PDA (v. 92.2) with a single-stroke access to a powerful data analysis package named DATAPLOT (v. 92.2) was developed by Feb. 1992 and delivered to DOE on a floppy diskette named 92330FONG-1 (see listing in Appendix A).

As part of the agreement, we also made several visits in March 1992 to the Germantown office of DOE to install and test a copy of DATAPLOT in the drive "C" of a desktop PC to make sure that the system PDA will properly run when inserted in the floppy drive "A". During April, 1992, several preliminary drafts of this report including 33 tutorial sections in Chapters 4, 5, and 6 were submitted to DOE for comments with the final draft being reviewed by both DOE and NIST for public release.

The purpose of this chapter is to discuss the significance and the limitations of the Phase-1 implementation of the expert system PDA. With a design philosophy to reduce as much as possible the initial get-acquainted time between a user and a command-driven analysis package such as DATAPLOT, we have developed PDA as a menu-driven front-end not only as a workhorse for analysis and graphics but also as a desktop "instructor" for either an entry-level or a refresher course on three distinct topics, namely,

Topic 1 Exploratory Data Analysis.

Topic 2 Applied Statistics.

Topic 3 Expert Systems.

Within hours, if not minutes, from inserting the floppy 92330FONG-1 into drive "A", a user could learn how to prepare datafiles, generate charts, and conduct exploratory data analysis (Topic 1) without knowing anything about DATAPLOT or micro-PROLOG. After the user becomes comfortable with the menu-driven system PDA, he or she is encouraged to learn Topic 2 by studying how to code in DATAPLOT using Appendix C for the command index and Chapter 6 for the listings of 20 macros. Finally, when the user is proficient in both PDA and DATAPLOT, he or she may be interested in developing or modifying an expert system such as PDA (Topic 3) by studying the Prolog source code in Appendix B with the help of a Prolog manual [38]. In short, the system PDA (v. 92.2) as implemented for Phase 1 is capable of assisting DOE staff or the general public far beyond what was originally intended in the goal statements of the DOE procurement request.

As stated in Chapter 3, the primary goal of the present version of PDA is to acquaint DOE staff with the analysis and graphics capability of DATAPLOT. A full implementation of the design with 20 programming features is beyond the time frame of the DOE procurement request. Consequently, the present version of PDA has four specific limitations that need to be addressed during the second and third phases of the implementation. The four shortcomings are:

Shortcoming 1	Obsolescence of micro-PROLOG Version 1.4.
Shortcoming 2	Flat, i.e., Non-Modular Structure of the micro-PROLOG Code.
Shortcoming 3	Incomplete Implementation of the Analysis Option, i.e., only 20 of the 40 DATAPLOT macros were implemented in PDA (v. 92.2).
Shortcoming 4	Lack of an Application-Specific Analysis Help Module.

The first shortcoming can be eliminated by a code conversion effort from micro-PROLOG (v. 1.4) to DOS Prolog (v. 3.0). The second is more basic, but is equally important because as the Prolog code becomes larger (say, more than 2,000 lines), it would be more cost-effective to maintain the code if it is modular. The third shortcoming needs to be taken care of as soon as possible if PDA is to graduate from a prototype to a fully-operational version. The elimination of all three has been recommended by the authors as the primary goal during the Phase 2 implementation of the expert system design.

Shortcoming 4 presents a different story. In principle, every data analysis expert system should include an application-specific help module to assist a user in interpreting the results of his or her exploratory, exhaustive, and confirmatory data analyses. However, the design and implementation of such a module is meaningful only if the requirements of the application are well understood. Since the DOE PI Program was only initiated in 1991 and is currently undergoing a learning period where some of its goals and requirements may change from the reporting experience of the DOE facilities and contractors, we recommend that the task of eliminating Shortcoming 4 be undertaken during the third and final phase of the implementation of PDA. To put it in another way, Shortcoming 4 is not a deficiency of PDA (v. 92.2), but a projected goal of a future version of PDA after the DOE PI Program settles down to a well-defined application.

Chapter 8 - Concluding Remarks

As we complete a short-term computational and analysis consulting assignment for the U. S. Department of Energy (DOE) with a by-product in the form of a software code that is useful to DOE as well as to a certain segment of the technical community, we are obliged to answer three additional questions that seem natural to the solution on hand:

Question 4 What's new in this software code, i.e., PDA (v. 92.2)?

Question 5 Did the development of this code depend significantly on some past and on-going research at NIST?

Question 6 How does the code benefit people beyond DOE?

To answer Question 4, we recall that in Chapter 3, pp. 8-9, the code PDA (v. 92.2) differs from two previous systems [11, 12] by incorporating seven new features, six of which are related to the application of DATAPLOT to the DOE PI Program. As a front end to a powerful 12-MB Fortran-77 executable file named DATAPLOT.EXE, the menu-driven PDA allows a user the luxury of a *single-stroke* execution of a large number of analysis macros written in DATAPLOT. Apart from this exciting and user-friendly feature in performing data analysis and generating report-quality graphics, the system PDA can also serve as a desktop "instructor" on data analysis and applied statistics through the use of the example-driven tutorials.

Question 5 is relatively easy to answer. As described in Chapters 1 and 2, the development of PDA depends significantly on the past and on-going research of two of us at NIST and the third at the Illinois Institute of Technology. Without the results of our past and present research reported during the last two decades, it would not be possible to develop the system PDA within the time frame specified in the DOE Sep. 30, 1991 procurement request.

Finally, we wish to answer Question 6 in the affirmative with three short remarks:

Remark 6-1 To another government agency having a performance-based management or quality-assurance program involving public safety and requiring exhaustive data analysis, PDA may serve as a reference model for a similar development.

Remark 6-2 To a practicing engineer or scientist, PDA and DATAPLOT offer a state-of-the-art tool for data analysis and a built-in tutorial on data analysis and statistics.

Remark 6-3 To students and faculty at engineering schools, PDA and DATAPLOT provide an instructional aid in data analysis, experimental design, and statistical process control.

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Appendix A

Listing of NIST Diskette

92330FONG-1

and

Note on Availability

The diskette 92330FONG-1 is available on a loan basis (see Loan Agreement on the next page) to any participant of an expert system tutorial conducted by Jeffrey T. Fong, P.E., of the U. S. National Institute of Standards & Technology, Gaithersburg, MD. The diskette contains an ascii file named PDA.LOG which is written in Micro-Prolog (v. 1.4) and is the source code for an expert system named PDA. The execution of the system PDA requires an access to six proprietary files copyrighted by Logical Programming Associates (LPA), Ltd., London, U.K. Pending written permission from LPA, the duplication of this diskette is not permitted by law. Please return the loan diskette by the date indicated on the Loan Agreement to: **Dr. Jeffrey T. Fong, P.E.,** Mail Code A238/101, NIST, Gaithersburg, MD 20899 U.S.A. (Tel. 301-975-2720; 975-2128 fax).

Loan Request Form

for a
Tutorial Diskette named **92330FONG-1**

Date: _____

Dr. Jeffrey T. Fong
National Inst. of Standards & Technology
Room A238, Bldg. 101
Gaithersburg, MD 20899

Dear Dr. Fong:

I attended an Expert System Tutorial entitled "An Introduction to Engineering Statistical Analysis using a PC-based Software named DATAPLOT" on _____, 19 ____, and I saw a demonstration of an expert system named PDA.

I understand that the tutorial diskette named 92330FONG-1 contains six proprietary software codes copyrighted by the Logical Programming Associates (LPA), Ltd., London, U.K., and that pending a written permission from LPA, the duplication of this diskette is not permitted by law.

I am, however, interested in receiving a loan copy of this diskette for learning purposes, and if my request is granted, I agree to abide by the copyright protection laws of the United States and to return the same by first class mail no later than _____, 19 ____.

With my signature below and a copy of this note, I acknowledge the receipt of a loan copy of the tutorial diskette and a copy of this form.

Sincerely,

_____ *(signature)*

_____ *(full name)*

_____ *(affiliation)*

_____ *(str. address)*

_____ *(city & zip)*

Please check below for size of floppy borrowed:

☐ **5-1/4" - 1.21 MB**

☐ **3-1/2" - 1.44 MB**

Appendix A - Listing of NIST Diskette *92330FONG-1*

```
     104 File(s)    735232 bytes free
 Directory of A:\
 Volume in drive A is 92330FONG-1
APP        MOD     39552   2-02-87  12:44p
ASTM_1CL   DAT        94   4-02-92  10:07a
ASTM_2CL   DAT       901   4-10-92   8:24a
ASTM_3CL   DAT       130   4-10-92   8:24a
ASTM_ANK   DAT       901   4-10-92   8:24a
ASTM_FCG   DAT        94   4-02-92  10:07a
ASTM_FCG   TAB      1813   4-02-92   1:04p
ASTM_LAB   DAT       130   4-10-92   8:24a
ASTM_LAB   TAB      2293   4-11-92   3:06p
ASTM_LB5   DAT       108   4-11-92   3:02p
ASTM_LB5   TAB      2227   4-11-92   3:03p
ASTM_LC6   DAT        82   6-01-92  11:56a
ASTM_RND   DAT       178   4-10-92  12:54p
ASTM_RND   TAB      1813   4-10-92   1:17p
CLEANFL    EXE     35246  12-20-91   2:28p
CLEANFL    FOR       301  12-20-91   2:27p
COMMAND    COM     32496   8-14-90   5:00a
CONVFL     EXE     35070  12-11-91   9:56a
DISTBETA   DP       2114   4-12-92  10:54a
DISTBINO   DP       2114   4-12-92  10:58a
DISTCAUC   DP       2114   4-12-92  10:59a
DISTCHSQ   DP       2114   4-12-92  11:01a
DISTEXPO   DP       2114   4-12-92  11:02a
DISTGAMA   DP       2114   4-12-92  11:03a
DISTGEOM   DP       2114   4-12-92  11:04a
DISTLMDA   DP       2114   4-12-92  11:05a
DISTLOGI   DP       2114   4-12-92  11:06a
DISTLOGN   DP       2114   4-12-92  11:07a
DISTNORM   DP       5964   6-02-92  10:58a
DISTNORM   DP5      5949   6-01-92   9:56a
DISTPOIS   DP       2114   4-12-92  11:09a
DISTSTUD   DP       2114   4-12-92  11:10a
DISTUNIF   DP       2114   4-12-92  11:11a
DISTWEIB   DP       3934   6-02-92  10:50a
DISTWEIB   G09      3934   6-02-92  11:07a
DISTWEIB   G13      3934   6-02-92  10:50a
DISTXVT1   DP       2114   4-12-92  11:12a
DISTXVT2   DP       2114   4-12-92  11:13a
DOEAUTO    DP       1799   5-21-92   3:33p
DOECCC     DP       1865   5-20-92  11:58a
DOEHISTO   DP       1996   3-31-92  10:45a
DOELAG     DP       1385   4-01-92   3:38p
DOEP4Q7F   DP       3327   5-20-92   9:12a
DOEPARET   DP       2756   5-14-92   3:18p
DOEPCC     DP       1649   4-01-92   2:22p
DOEPIECH   DP       2859   3-31-92  12:20p
DOEPLOTF   DP       2616   5-28-92   3:27p
DOEPRED1   DP       2740   5-26-92  10:52a
DOEPRED2   DP       3094   5-26-92   1:56p
DOE_1COL   DAT       327   3-10-92  10:55a
DOE_2CLA   DAT       383   4-01-92   1:34p
DOE_2CLB   DAT       160   3-13-92   4:41p
DOE_3COL   DAT      1174   5-19-92  10:21p
DOE_AUT2   DAT       320   4-01-92   3:25p
DOE_AUT3   DAT       620   4-01-92   2:16p
DOE_AUTO   DAT       138   4-01-92   3:42p
DOE_CCC    DAT       383   4-01-92   1:34p
DOE_HIST   DAT       327   3-10-92  10:55a
DOE_LAG    DAT       138   4-01-92   3:32p
DOE_LAG2   DAT       320   4-01-92   3:25p
DOE_LAG3   DAT       620   4-01-92   2:16p
DOE_MB20   DAT       620   3-12-92  10:33a
DOE_MB50   DAT      1700   3-12-92  10:34a
DOE_PARE   DAT       160   3-13-92   4:41p
DOE_PCC    DAT       620   4-01-92   2:16p
DOE_PI44   DAT      1174   5-19-92  10:21p
DOE_PIE    DAT       160   3-13-92   4:41p
DOE_PLOT   DAT       383   4-01-92   1:34p
DP         BAT        67   2-24-92   1:38p
DPDATA          <DIR>      5-14-92  10:13a
DPLOGF     TEX      3708  11-13-91  12:26p
DPSYSF     TEX       295  11-14-91   6:27a
EDCOMM     TEX       405   2-24-92   2:40p
F3-911PI            6392   3-11-92   1:33p
F3-911RC            6139   3-11-92   1:21p
F3-912PI            4794   3-30-92  11:47a
F31-91-1            1598   5-19-92   9:45p
F31-91-2            1598   3-30-92   2:06p
FIGURE     SYS      5089   1-22-87  12:52p
LINKER     SYS      4752  11-07-86   6:07p
LOADER     SYS      3428  11-12-86  12:14p
PDA        BAT        94  11-11-91   3:14p
PDA        LOG     50944   5-19-92  10:03p
PIQTR1_X            62631   3-11-92   1:03p
PIQTR2_X            80274  10-23-91   9:41a
POSTSCRI   TEX     110637   2-19-92   2:16p
PROLOG     EXE      46300   2-02-87  12:21p
PROLOG     SYS       7424  11-07-86   6:42p
SAVEPLUS            2560  12-20-91   4:39p
SCRATCH             1194   2-19-92   2:09p
STATANOV   DP        990   4-11-92   3:11p
STATANOV   DP2       827   4-11-92   2:57p
STATBCOX   DP       1544   5-27-92   3:20p
STATBOXP   DP       2114   4-12-92  11:14a
STATCHIS   DP       2114   4-12-92  11:16a
STATSCAT   DP       2114   4-12-92  11:17a
STATSUM4   DP       1079   4-10-92  10:17a
STATSUMT   DP        809   4-10-92   1:15p
STATTESF   DP       2114   4-12-92  11:18a
STATTESL   DP       1995   5-27-92   3:17p
STATTESL   DP2      2103   4-11-92   1:51p
STATTEST   DP       2114   4-12-92  11:19a
STATTESW   DP       1605   5-27-92   3:18p
STATTESX   DP       1578   5-27-92   3:19p
```

Appendix A - Listing of NIST Diskette *92330FONG-1*

Continuation Sheet

```
      30 File(s)    735232 bytes free
 Directory of A:\DPDATA
 Volume in drive A is 92330FONG-1
.            <DIR>      5-14-92  10:13a
..           <DIR>      5-14-92  10:13a
ASTM_1CL DAT       94   4-02-92  10:07a
ASTM_2CL DAT      901   4-10-92   8:24a
ASTM_3CL DAT      130   4-10-92   8:24a
ASTM_ANK DAT      901   4-10-92   8:24a
ASTM_FCG DAT       94   4-02-92  10:07a
ASTM_LAB DAT      130   4-10-92   8:24a
ASTM_LB5 DAT      108   4-11-92   3:02p
ASTM_LC6 DAT       82   6-01-92  11:56a
ASTM_RND DAT      178   4-10-92  12:54p
DOE_1COL DAT      327   3-10-92  10:55a
DOE_2CLA DAT      383   4-01-92   1:34p
DOE_2CLB DAT      160   3-18-92   2:39p
DOE_3COL DAT     1174   5-19-92  10:21p
DOE_AUT2 DAT      320   4-01-92   3:25p
DOE_AUT3 DAT      620   4-01-92   2:16p
DOE_AUTO DAT      138   4-01-92   3:42p
DOE_CCC  DAT      383   4-01-92   1:34p
DOE_HIST DAT      327   3-10-92  10:55a
DOE_LAG  DAT      138   4-01-92   3:32p
DOE_LAG2 DAT      320   4-01-92   3:25p
DOE_LAG3 DAT      620   4-01-92   2:16p
DOE_MB20 DAT      620   3-12-92  10:33a
DOE_MB50 DAT     1700   3-12-92  10:34a
DOE_PARE DAT      160   3-18-92   2:39p
DOE_PCC  DAT      620   4-01-92   2:16p
DOE_PI44 DAT     1174   5-19-92  10:21p
DOE_PIE  DAT      160   3-13-92   4:41p
DOE_PLOT DAT      383   4-01-92   1:34p
```

Appendix B

Listing of Prolog Code

PDA.LOG (v. 92.2)

Appendix B - Listing of Prolog Code *PDA.LOG (v. 92.2)*

```
((xmen2 20 _smlst _remlst _lst)
  (xmen _lst))
((xmen2 _nn _smlst () _lst)
  (CONCAT _smlst ("next page" exit) _ls))
((xmen1 _lst)
  (xmen2 0 () _lst _lst))
((isat _x _lx _y _plst _newlst)
  (ON "-@" _lx)
  (remvatgo _y _plst _newlst))
((isat _x _lx _y _plst _newlst)
  (remvatgo _y (_x|_plst) _newlst))
((frmlgoon _fnme _plst _lst _x)
  (ON _x _plst)
  (frmlgo _fnme _plst _lst))
((frmlgoon _fnme _plst _lst _x)
  (frmlgo _fnme (_x|_plst) _lst))
((a 11))
((b 12))
((wrf _ap _fk _fl _y)
  (CREATE _fl)
  (OPEN _fl)
  (FORALL ((_fk _cat) (oldav _ap _cat _x _y _z _la)) ((list3-1a _fl _cat _x _y _z _la) (WRITE _fl ())))
  (CLOSE _fl)
  (PP)
  (PP)
  (P "  File " _fl " written to disk"))
((shdir4 _ap _fk _fl _y no)
  (onlywelds x)
  (opn chart)
  (shdir _fk _y))
((shdir4 _ap _fk _fl _y yes)
  (wrf _ap _fk _fl _y))
((shdir3 _ap _fk _fl _y _lst)
  (ON _fl _lst)
  (PP)
  (P " File " _fl " already exists")
  (PP)
  (PP)
  (P "     Overwrite?")
  (SMENU _count (yes no) " continue" 15 30 1 1 10)
  (shdir4 _ap _fk _fl _y _count))
((shdir3 _ap _fk _fl _y _lst)
  (wrf _ap _fk _fl _y))
((shdir2 _ap _fk exit _y)
  (be nice))
((shdir2 _ap _fk _fl _y)
  (DIR "C:/DATAPLOT/*.*" _lst)
  (shdir3 _ap _fk _fl _y _lst))
((try empt)
  (OPEN junk)
  (FR junk ((S 0)) (_x))
  (PP _x)
  (READ junk ())
  (PP _w)
  (CLOSE junk))
```

```
((godeco _fdir () _a _drep)
  (REVERSE _a _drep))
((godeco _fdir (_a|_b) _c _drep)
  (CONCAT _fdir _q _a)
  (godeco _fdir _b (_q|_c) _drep))
((decorep _fdir _rep _drep)
  (godeco _fdir _rep () _drep))
((era _no)
  (aplnm _ap)
  (DELCL ((mtype _ap _no)))
  (FORALL ((oldav _ap _x _y _z _zz _no)) ((DELCL ((oldav _ap _x _y _z _zz _no))))))
((savit ndd)
  (SAVE ndd2weld))
((findpos1 -1 _x _po _t)
  (aplnm _ap)
  (= _qo (_po + 1))
  (findpos _x _qo _t))
((findpos1 _u _x _po _t)
  (aplnm _ap)
  (ADDCL ((mtype _ap _x)) _po))
((endpos _x)
  (aplnm _ap)
  (mtype _ap _t)
  (CMP -1 _po _t)
  (ADDCL ((mtype _ap _x)))
  (FORALL ((testP _z) (_z _u)) ((ADDCL ((oldav _ap _u 0 0 0 _x))))))
((endpos _x)
  (aplnm _ap)
  (mtype _ap _t)
  (NOT CMP -1 _t _po))
((reweld x)
  (CUWIND welds)
  (CLOSE old-data)
  (CLOSE new-data)
  (CLOSE chart)
  (rewind welds welds))
((closewind _x)
  (CUWIND &:)
  (CLOSE _x))
((alter -1 up))
((alter 0 unchanged))
((alter 1 down))
((compar _x _y _z)
  (= _w (_x * 10000))
  (= _u (_y * 10000))
  (= _xx (IP _w))
  (= _yy (IP _u))
  (CMP _crit _xx _yy)
  (alter _crit _z))
((abc _xx)
  (mtype _xx)
  (PP mtype exists))
((abc _xx)
  (PP new mtype))
((round _x _y _rd)
  (= _z (10 ^ _x))
  (= _w (_z * _y + 0.5))
  (= _yy (IP _w))
  (= _rd (_yy / _z)))
((up2 _tp _sl)
  (up3 _tp _sl))
((up2 _tp _sl)
  (onlywelds x))
```

```
((men-doe-fac2 _tp _cat)
  (ISALL _ea _y (_tp _y))
  (SMENU _cat _ea " Facility___Year-Qtr " 5 5 1 1 20))
((over2 _tp _sl "in same list")
  (onlywelds x)
  (up4 _tp _sl "enter data"))
((over2 _tp _sl "in another list")
  (old))
((over2 _tp _sl no)
  (onlywelds x))
((over1 _tp _sl)
  (onlywelds x)
  (rewind "Continue?")
  (PP)
  (P "             list " _sl)
  (PP)
  (PP)
  (P " ")
  (P "Do you wish to alter another point?")
  (SMENU _wh ("in same list" no "in another list") " go on " 12 28 1 1 16)
  (over2 _tp _sl _wh))
((go4a _tp _ft new)
  (another _tp _ft))
((go4a _tp _ft old)
  (over1 _tp _ft))
((go4 _tp -enter- _tm _ft _xp _yp _zp _nxp _nyp _nzp _olne)
  (aplnm _ap)
  (DELCL ((oldav _ap _ft _ux _uy _uz _tm)))
  (ADDCL ((oldav _ap _ft _nxp _nyp _nzp _tm)))
  (re-sort _ft)
  (onlywelds x)
  (go4a _tp _ft _olne))
((go4 _tp repeat _tm _ft _xp _yp _zp _nxp _nyp _nzp _olne)
  (onlywelds x)
  (go3 _tp _tm _ft _xp _yp _zp _olne))
((go3c _tp _titfk _tm _ft _xp _yp _zp _nxp _nyp exit _olne)
  (onlywelds x))
((go3c _tp _titfk _tm _ft _xp _yp _zp _nxp _nyp _nzp _olne)
  (rewind new-data)
  (P _titfk)
  (P "         new observation          n-data")
  (PP)
  (PP)
  (list3-1a new-data _ft _nxp _nyp _nzp _tm)
  (SMENU _chc (-enter- repeat) entry 15 15 1 1 9)
  (go4 _tp _chc _tm _ft _xp _yp _zp _nxp _nyp _nzp _olne))
((go3b _tp _titfk _tm _ft _xp _yp _zp _nxp exit _olne)
  (onlywelds x))
((go3b _tp _titfk _tm _ft _xp _yp _zp _nxp _nyp _olne)
  (PP)
  (P "Please enter new observed z-data ")
  (R _nzp)
  (go3c _tp _titfk _tm _ft _xp _yp _zp _nxp _nyp _nzp _olne))
((go3a _tp _titfk _tm _ft _xp _yp _zp exit _olne)
  (onlywelds x))
((go3a _tp _titfk _tm _ft _xp _yp _zp _nxp _olne)
  (PP)
  (P "Please enter new observed y-data ")
  (R _nyp)
  (go3b _tp _titfk _tm _ft _xp _yp _zp _nxp _nyp _olne))
((titl F-1 "DOE Facility No. 1"))
((titl F-2 "DOE Facility No. 2"))
((titl F-3 "DOE Facility No. 3"))
```

```
((up4c file _tp)
  (up4q _tp))
((up4c keybd _tp)
  (up4d _tp))
((up4c _ndat _tp _sl)
  (onlywelds x)
  (rewind n-data-)
  (P "   n-data " _sl)
  (CUWIND welds)
  (go2 _tp _ndat _sl old))
((up4d _tp)
  (opn obs-label)
  (PP Enter number for n-data)
  (R _ndat)
  (rewind obs-label)
  (up4e _tp _ndat))
((go3 _tp _tm _ft _xp _yp _zp _olne)
  (rewind old-data)
  (CLOSE chart)
  (titl _fk _titfk)
  (P _titfk)
  (P "             old observation          n-data")
  (PP)
  (PP)
  (list3-1a old-data _ft _xp _yp _zp _tm)
  (PP)
  (PP)
  (P "Please enter new observed x-data ")
  (R _nxp)
  (go3a _tp _titfk _tm _ft _xp _yp _zp _nxp _olne))
((up4e _tp exit)
  (onlywelds x))
((up4e _tp _ndat)
  (aplnm _ap)
  (mtype _ap _ndat)
  (go2 _ndat _tp))
((up4e _tp _ndat)
  (PP n-data _ndat does not exist))
((up4q1 _ap _tp _run exit)
  (PP)
  (P "   Thank you"))
((up4q1 _ap _tp _run _fname)
  (PP)
  (P "     ")
  (PP reading _fname)
  (OPEN _fname)
  (reading _fname _ap _run 0)
  (rewind "reading from disc")
  (PP)
  (P " Data from " _fname ", for " _run " have been entered")
  (PP)
  (PP)
  (P " in the database:  ")
  (P _ap)
  (re-sort _run))
```

```
((up4 _tp _sl "see all")
  (aplnm _ap)
  (onlywelds x)
  (opn observations)
  (liston _tp _sl _ap back))
((up4 _tp _sl "enter data")
  (onlywelds x)
  (rewind "Change old data")
  (PP)
  (P "        ")
  (P _sl)
  (PP)
  (PP)
  (P "   Select point to alter")
  (PP)
  (P "   from menu at left")
  (aplnm _ap)
  (ISALL _all _x (mtype _ap _sl _x))
  (SMENU _ndat _all "data pt" 5 5 1 1 9)
  (up4c _ndat _tp _sl))
((up3a _tp)
  (SMENU _nxt ("enter data" "see all") -next-step 5 5 1 1 9)
  (up4 _tp _nxt))
((another1 _tp _sl "to same list")
  (onlywelds x)
  (opn new-data)
  (key1 _tp _sl))
((another1 _tp _sl "to another list")
  (up1-1 keyboard))
((another1 _tp _sl _y)
  (onlywelds x))
((key1 _tp _sl)
  (rewind "Current List")
  (PP)
  (P "   ")
  (PP _sl)
  (rewind new-data)
  (PP)
  (P "  Please enter the name label (e.g., 1, 2, 3, A1, A2, etc.)")
  (PP)
  (PP)
  (P "     of the new data point (n-data) below:")
  (PP)
  (PP)
  (P "           (Six characters maximum)")
  (PP)
  (PP)
  (P "  ")
  (R _y)
  (up1a _tp _y _sl))
((up1a _tp exit _sl)
  (onlywelds x))
((up1a _tp _y _sl)
  (PP _sl)
  (PP Thank you)
  (CLOSE "First number of data points (n-data)")
  (ckdup _tp _y _sl))
```

```
((findpos _x _sl _po _tt)
  (aplnm _ap)
  (mtype _ap _sl _t)
  (CMP -1 _tt _t)
  (CMP _crit _t _x)
  (findpos1 _crit _sl _x _po _t))
((findpos _x _sl _po _tt)
  (aplnm _ap)
  (ADDCL ((mtype _ap _sl _x)) _po))
((findpos _x _sl _po _tt)
  (aplnm _ap)
  (FORALL ((testP _fl) (_fl _tp)) ((ADDCL ((oldav _ap _tp 0 0 0 _x)) _po))))
((another _tp _sl)
  (onlywelds x)
  (rewind "Continue?")
  (PP)
  (P "         list  " _sl)
  (PP)
  (PP)
  (P " ")
  (P "Do you wish to add another point?")
  (SMENU _wh ("to same list" no "to another list") "go on" 12 28 1 1 16)
  (another1 _tp _sl _wh))
((ckdup _tp _x _sl)
  (aplnm _ap)
  (mtype _ap _sl _t)
  (EQ _t _x)
  (PP n-data _x already exists)
  (PP)
  (P "Enter any letter to continue ")
  (R _oo)
  (another _tp _sl))
((ckdup _tp _x _sl)
  (aplnm _ap)
  (FORALL ((testP _fl) (_fl _r)) ((ckduq _ap _r _x)))
  (findpos _x _sl 1 0)
  (ck2 _tp _x _sl))
((ckduq _ap _tp _x)
  (oldav _ap _tp _a _b _z _x))
((ckduq _ap _tp _x)
  (ADDCL ((oldav _ap _tp 0 0 0 _x))))
((re-sort _sl)
  (aplnm _ap)
  (mtype _ap _sl _rr)
  (ISALL _all _x (mtype _ap _sl _x))
  (SORT _all _alls)
  (FORALL ((mtype _ap _sl _y)) ((DELCL ((mtype _ap _sl _y)))))
  (FORALL ((ON _z _alls)) ((ADDCL ((mtype _ap _sl _z))))))
((re-sort _sl))
((ck2 _tp _ndat _sl)
  (re-sort _sl)
  (onlywelds x)
  (go2 _tp _ndat _sl new))
((up3 _tp _sl)
  (SMENU _nxt ("enter data" "see all") next-step 5 5 1 1 9)
  (up4 _tp _sl _nxt))
((up3 _tp _sl _nxt))
```

```
((list4 _cr _sl listing))
((list4 _cr _sl back)
  (opn cont)
  (P "          Type any letter to continue ")
  (R _xx)
  (onlywelds x)
  (up3 _cr _sl))
((list4 _cr _sl back))
((list3a _cr _ap _tt _ll)
  (oldav _ap _tt _a _b _z _c)
  (FORALL ((mtype _ap _tt _ru) (oldav _ap _tt _xp _yp _zp _ru)) ((list3-1a observations _tt _xp _yp _zp _ru)))
  (list4 _cr _tt _ll))
((list3a _cr _ap _tt _ll)
  (PP)
  (PP)
  (PP)
  (PP)
  (PP)
  (P "             No data exist for run " _tt)
  (list4 _cr _tt _ll))
((up4q _tp)
  (onlywelds x)
  (aplnm _ap)
  (ISALL _all _x (_tp _x))
  (SMENU _run _all " Facility___Year-Qtr " 5 30 1 1 20)
  (rewind "reading from disc")
  (PP)
  (P "    Please name file to read")
  (PP)
  (P "    ")
  (R _fname)
  (conv _fname)
  (rewind "reading from disc")
  (up4q1 _ap _tp _run _fname))
((up1-1a file)
  (men-doe-fac _tp)
  (up4q _tp))

((interpr "3. IDAHO" ("F-1[3] AMCF (Adv React Meas Fac & Coupled Fast RMF)" "F-2
[3] ATR  (Advanced Test Reactor)" "F-3[3] CONT (Contractor)" "F-4[3] MD50 (Alpha
 Fuels Fac - Mound Plant/Bldg 50)" "F-5[3] TRHC (Test Reactor Hot Cell Facility)
" "F-6[3]     " "F-7[3]     ")))
((interpr "1. CH-AN" ("F-1[1] CONT (Contractor)" "F-2[1] EBR  (Experimental Bree
der Reactor -II)" "F-3[1] FMF  (Fuel Manufacturing Facility)" "F-4[1] HFEF (Hot
Fuel Examination Facility)" "F-5[1] HANU (Janus)" "F-6[1] NRAD (Neutron Radiogra
phy Facility)" "F-7[1] TREA (Transient Reactor Test)")))
((interpr "2. CH-BN" ("F-1[2] BMRR (Brookhaven Medical Research Reactor" "F-2[2]
 CONT (Contractor)" "F-3[2] HFBR (High Flux Beam Reactor" "F-4[2]  " "F-5[2]  "
"F-6[2]   " "F-7[2]   ")))
((interpr "4. OAKRI" ("F-1[4] CONT (Contractor)" "F-2[4] HFIR (High Flux Isotope
 Reactor)" "F-3[4] PADU (Paducah Gaseous Diffusion Plant)" "F-4[4] PORT (Portsmo
uth Gaseous Diffusion Plant)" "F-5[4] REDC (Radiochemical Engineering Dev. Ctr.)
" "F-6[4] TSR  (Tower Shielding Reactor)" "F-7[4]")))
((interpr "5. RL-WH" ("F-1[5] B308 (Building 308)" "F-2[5] CONT (Contractor)" "F
-3[5] FFTF (Fast Flux Test Facility)" "F-4[5] FMEF (Fuels & Materials Examinatio
n Facility)" "F-5[5] MASF (Maintenance & Storage Facility)" "F-6[5]" "F-7[5]")))

((interpr "6. SF-LL" ("F-1[6] AVLI (AVLIS)" "F-2[6] CONT (Contractor)" "F-3[6]"
"F-4[6]" "F-5[6]" "F-6[6]" "F-7[6]")))
((interpr "7. SF-RI" ("F-1[7] CONT (Contractor)" "F-2[7] ETEC (Energy Technology
 Engineering Center)" "F-3[7]" "F-4[7]" "F-5[7]" "F-6[7]" "F-7[7]")))
((interpr "8. TOTAL" ("F-1[8]" "F-2[8]" "F-3[8]" "F-4[8]" "F-5[8]" "F-6[8]" "F-7
[8]")))
((interpr "0.  DEMO" ("F-1[x]" "F-2[x]" "F-3[x]" "F-4[x]" "F-5[x]" "F-6[x]" "F-7
[x]")))
```

```
((windcont _tp)
  (aplnm _ap)
  (shortaplnm _ap _aps)
  (onlywelds x)
  (opn "    Meaning of Facility Designation")
  (FORALL ((interpr _aps _expl) (ON _ex _expl)) ((P _ex) (PP)))
  (ISALL _all _x (testP _x))
  (SMENU _tp _all " Facility " 5 5 1 1 9))
((insup _tp _sl)
  (PP)
  (PP)
  (P "  Please select from menus")
  (PP)
  (men-doe-fac _tp)
  (ISALL _ev _y (_tp _y))
  (SMENU _sl _ev " Facility__Year-Qtr " 5 30 1 1 20))
((goout save)
  (SAVE "a:\PDA.LOG")
  (EXIT 0))
((goout nosave)
  (EXIT 0))
((clean exit)
  (SMENU _x (save nosave) quit 5 20 1 1 9)
  (goout _x))
((clean save)
  (SAVE "a:\PDA.LOG"))
((clean clear)
  (closeall x)
  (barit x))
((clean restart)
  (closeall x)
  (aplic x))
((F-3 F3_____DEMO-1))
((F-3 F3_____DEMO-2))
((F-3 F3_____DEMO-3))
((F-3 F3_____DEMO-4))
((F-3 F3_____1991-1))
((F-3 F3_____1991-2))
((F-3 F3_____1991-3))
((F-3 F3_____1991-4))
((F-2 F2_____DEMO-1))
((F-2 F2_____DEMO-2))
((F-2 F2_____DEMO-3))
((F-2 F2_____DEMO-4))
((F-2 F2_____1991-1))
((F-2 F2_____1991-2))
((F-2 F2_____1991-3))
((F-2 F2_____1991-4))
((F-1 F1_____DEMO-1))
((F-1 F1_____DEMO-2))
((F-1 F1_____DEMO-3))
((F-1 F1_____DEMO-4))
((F-1 F1_____1991-1))
((F-1 F1_____1991-2))
((F-1 F1_____1991-3))
((F-1 F1_____1991-4))
((F-7 F7_____DEMO-1))
((F-7 F7_____DEMO-2))
((F-7 F7_____DEMO-3))
((F-7 F7_____DEMO-4))
((F-7 F7_____1991-1))
((F-7 F7_____1991-2))
((F-7 F7_____1991-3))
((F-7 F7_____1991-4))
```

```
((F-6 F6____DEMO-1))
((F-6 F6____DEMO-2))
((F-6 F6____DEMO-3))
((F-6 F6____DEMO-4))
((F-6 F6____1991-1))
((F-6 F6____1991-2))
((F-6 F6____1991-3))
((F-6 F6____1991-4))
((F-5 F5____DEMO-1))
((F-5 F5____DEMO-2))
((F-5 F5____DEMO-3))
((F-5 F5____DEMO-4))
((F-5 F5____1991-1))
((F-5 F5____1991-2))
((F-5 F5____1991-3))
((F-5 F5____1991-4))
((F-4 F4____DEMO-1))
((F-4 F4____DEMO-2))
((F-4 F4____DEMO-3))
((F-4 F4____DEMO-4))
((F-4 F4____1991-1))
((F-4 F4____1991-2))
((F-4 F4____1991-3))
((F-4 F4____1991-4))
((listless _x _lst _plst)
  (listless1 _x _lst () _plst))
((listless1 _x () _qlst _plst)
  (REVERSE _qlst _plst))
((listless1 _x (_x|_y) _qlst _plst)
  (listless1 _x _y _qlst _plst))
((listless1 _x (_a|_y) _qlst _plst)
  (listless1 _x _y (_a|_qlst) _plst))
((elim () _smlst _smlst))
((elim (_a|_b) _smlst _plst)
  (ON _a _plst)
  (elim _b _smlst _plst))
((elim (_a|_b) _smlst _plst)
  (elim _b _smlst (_a|_plst)))
((raising () _aurev _aurev))
((raising (_u|_v) _arev _aurev)
  (CHAROF _u _nu)
  (CMP -1 _nu 123)
  (CMP 1 _nu 96)
  (= _nnu (_nu - 32))
  (CHAROF _w _nnu)
  (raising _v (_w|_arev) _aurev))
((raising (_u|_v) _arev _aurev)
  (raising _v (_u|_arev) _aurev))
((scrlst _lst _smlst)
  (elim _lst _smlst ()))
((asmlst () _ally _ally))
((asmlst (_a|_b) _plst _ally)
  (aplnm _ap)
  (ISALL _pl _y (oldav _ap _a _x _y _z _la))
  (CONCAT _pl _plst _newlst)
  (asmlst _b _newlst _ally))
((raisecase _arev _aurev)
  (raising _arev () _aurev))
((sortout _fk _y _lst)
  (scrlst _lst _smlst)
  (SORT _smlst _srtlst)
  (SMENU _y _srtlst "y values" 5 5 1 1 9))
((mklst _every _ally)
  (asmlst _every () _ally))
```

```
((remvatgo () _newlst _newlst))
((remvatgo (_x|_y) _plst _newlst)
  (STRINGOF _lx _x)
  (isat _x _lx _y _plst _newlst))
((namefl2 _ap _ft EXIT _fnme)
  (be nice))
((namefl2 _ap _ft exit _fnme)
  (be nice))
((namefl2 _ap _ft _fnm _fnme)
  (CONCAT _fnm ".DAT" _fnm2)
  (CONCAT "C:\DATAPLOT\" _fnm2 _fnme))
((caseconv _a _b)
  (STRINGOF _alst _a)
  (REVERSE _alst _arev)
  (raisecase _arev _aurev)
  (STRINGOF _aurev _b))
((prmes _ft 1)
  (P "  Please enter name of file to receive Y & Z data in")
  (PP)
  (P "   a 2-column format for ")
  (P category _ft))
((prmes _ft 2)
  (P "  Please enter name of file to receive ")
  (PP)
  (P "  y data for " _ft))
((asmbl _fk _y _every)
  (aplnm _ap)
  (mklst _every _ally)
  (sortout _fk _y _ally))
((remvat _lst)
  (rmvatgo () _plst _lst))
((remvat _oldlst _newlst)
  (remvatgo _oldlst () _newlst))
((frmlgo _fnme _plst _lst)
  (EOF _fnme)
  (CLOSE _fnme)
  (EQ _plst _lst))
((frmlgo _fnme _plst _lst)
  (FR _fnme ((C 19)) (_x))
  (FR _fnme ((C 28)) (_w))
  (frmlgoon _fnme _plst _lst _x))
((conv _fname)
  (REN _fname OOOPPPPP)
  (EXEC "convfl.exe" () _ret)
  (REN OOOQQQ _fname)
  (DEL OOOPPPPP))
((xmen _lst _x _plst)
  (CONCAT _lst (exit) _elst)
  (MMENU (_x|_y) () _elst x-values 5 5 10 1 25)
  (listless _x _lst _plst))
((shdir _fk _y)
  (onlywelds x)
  (opn chart)
  (aplnm _ap)
  (namefl _ap _fk _fl 2)
  (shdir2 _ap _fk _fl _y))
((gofor datafl _fk _y)
  (onlywelds x)
  (men-doe-fac _fk)
  (ISALL _every _w (_fk _w))
  (asmbl _fk _y _every))
```

```
((wind welds))
((wind n-data-))
((wind old-data))
((wind new-data))
((wind chart))
((wind retrn))
((wind anita-out))
((wind "To print output"))
((wind esc))
((wind "Name Your Application"))
((wind " DOE NE Performance Indicator Data Analysis System "))
((wind "First number of data points (n-data)"))
((wind observations))
((wind obs-label))
((wind cont))
((wind "writing to disc"))
((wind "reading from disc"))
((wind "new image file"))
((wind "current data"))
((wind "re-format image file"))
((wind "input examples"))
((wind "process file"))
((wind "Deleting data points"))
((wind "Select Deletions"))
((wind "Change old data"))
((wind "Continue?"))
((wind "Current List"))
((wind instructions))
((wind "    Meaning of Facility Designation"))
((wind "Delete old Application"))
((wind "Explanation of dp file names"))
((list3-1a _wn _tt _xp _yp -1 _ru)
  (FW _wn ((U 15) "   " (U 19) "    " (U 5) "                    " (U 6)) (_tt _xp _yp _ru))
  (PP))
((list3-1a _wn _tt _xp _yp _zp _ru)
  (FW _wn ((U 15) "   " (U 19) "    " (U 5) "   " (F 18 10) (U 6)) (_tt _xp _yp _zp _ru))
  (PP))
((formxlist)
  (onlywelds x)
  (opn chart)
  (PP)
  (P "  Please enter name of file to read ")
  (PP)
  (PP)
  (P "  ")
  (R _fnme)
  (frmxlist _fnme _lst)
  (takex _fnme _lst))
((gofl2)
  (onlywelds x)
  (opn chart)
  (gofor datafl _fk _y)
  (shdir _fk _y))
((sp1)
  (onlywelds x)
  (aplnm _ap)
  (men-doe-fac _fk)
  (ISALL _every _y (_fk _y))
  (SMENU _ft _every " Facility___Year-Qtr " 5 30 1 1 20)
  (opn chart)
  (sp1-1 _ap _ft))
((dos x)
  (EXEC "c:\command.com" () _ret)
  (onlywelds x))
```

```
((justanita _x)
  (CUWIND welds)
  (FORALL ((wind _wnd) (NOT EQ _wnd welds) (NOT EQ _wnd anita-out) (NOT EQ _wnd "To print output")) ((CLOSE _wnd))))
((save1)
  (onlywelds x)
  (aplnm _ap)
  (ISALL _all _x (testP _x))
  (SMENU _fk _all " DOE Facility " 5 5 1 1 16)
  (ISALL _every _y (_fk _y))
  (SMENU _ft _every " Facility___Year-Qtr " 5 30 1 1 20)
  (opn chart)
  (P "  Please enter name of file to receive all information")
  (PP)
  (P "  including data in ")
  (PP category _ft)
  (PP)
  (PP)
  (P "  (Filename not to exceed 8 characters and")
  (PP)
  (P "   must begin with an alphabet.)")
  (PP)
  (PP)
  (R _fnme)
  (CREATE _fnme)
  (OPEN _fnme)
  (FORALL ((mtype _ap _ft _tm) (oldav _ap _ft _xp _yp _zp _tm)) ((list3-1a _fnme _ft _xp _yp _zp _tm) (WRITE _fnme ())))
  (CLOSE _fnme)
  (PP)
  (PP Data recorded on _fnme))
((disco sav_dosfl)
  (save1))
((disco op_sys)
  (justanita x)
  (rewind retrn)
  (PP)
  (P " Type exit <enter> to return to program")
  (PP)
  (PP)
  (P "          Then press <escape>")
  (dos x))
((disco sav_dpdat)
  (sp1))
((disco r_dpdat_y)
  (gofl2))
((disco splitfl_x)
  (formxlist))
((disco "    - 1 -")
  (disco op_sys))
((disco "    - 2 -")
  (disco op_sys))
((disco "    - 3 -")
  (disco op_sys))
((disco "    - 4 -")
  (disco op_sys))

((liston _tp _sl _ap _ll)
  (opn obs-label)
  (FW obs-label ((U 15) "   " (U 19) "   " (U 9) (U 18) " " (U 6)) ("Facil__Year
/Qtr" DOE_NE_PI_Data___ID PI_Number "PI_Value     " n-data))
  (CUWIND observations)
  (list3a _tp _ap _sl _ll))
```

```
((list3 _cr _ap _ll)
  (ISALL _all _x (_cr _x))
  (SMENU _tt _all " Facility___Year-Qtr " 3 10 1 1 20)
  (liston _cr _tt _ap _ll))
((list2 _cr _ap _chc)
  (onlywelds x)
  (opn observations)
  (list3 _cr _ap _chc))
((listit _cr _chc)
  (aplnm _ap)
  (list2 _cr _ap _chc))
((lists _x)
  (onlywelds x)
  (propwind chart _aa _ab _ba _bb)
  (CRWIND chart _aa _ab _ba _bb)
  (listit _x _listing))
((readbk1 _ap _rn _fl _p)
  (NOT EOF _fl)
  (READ _fl _a)
  (READ _fl _b)
  (ADDCL ((oldav _ap _rn _a _b _z _p)))
  (= _q (_p + 1))
  (ADDCL ((mtype _ap _rn _p)))
  (readbk1 _ap _rn _fl _q))
((readbk1 _ap _rn _fl _p)
  (EOF _fl)
  (CLOSE _fl))
((readback _ap _rn _fl)
  (readbk1 _ap _rn _fl 1))
((runit1a _to _run)
  (OPEN output)
  (FORALL ((mtype _to _run _ndat) (oldav _to _run _xu _yu _zu _ndat)) ((DELCL ((
mtype _to _run _ndat))) (DELCL ((oldav _to _run _xu _yu _zu _ndat)))))
  (readback _to _run output)
  (PP)
  (P "  " _to " results entered on " _run))

((forprog Relaxation Creep r-creep))
((forprog Creep Relaxation c-relax))
((runit1 _from _to)
  (onlywelds x)
  (ISALL _all _x (testP _x))
  (SMENU _tp _all "relax and creep" 4 10 1 1 15)
  (ISALL _every _y (_tp _y))
  (SMENU _run _every relax-creep 3 10 1 1 15)
  (CREATE input)
  (CREATE input-n)
  (OPEN input)
  (CREATE output)
  (OPEN output)
  (FORALL ((mtype _from _run _xx) (oldav _from _run _xa _ya _za _xx)) ((FW input ((F 6 0) (F 20 10)) (_ya _za))
     (WRITE input ())))
  (CLOSE input)
  (rewind "writing to disc")
  (forprog _from _to _prog)
  (EXEC "\command.com" ("/c" _prog) _ret)
  (CLOSE output)
  (runit1a _to _run))
```

```
((runit graph)
  (onlywelds x)
  (aplnm _ap)
  (ISALL _all _x (testP _x))
  (SMENU _fk _all testPs- 4 23 1 1 9)
  (ISALL _every _y (_fk _y))
  (SMENU _ft _every testP-typ 3 23 1 1 9)
  (CREATE input)
  (OPEN input)
  (CREATE output)
  (OPEN output)
  (FORALL ((mtype _ap _ft _tm) (oldav _ap _ft _xp _yp _zp _tm)) ((FW input ((F 6 0) (F 20 10)) (_yp _zp))
     (WRITE input ())))
  (CLOSE input)
  (rewind "writing to disc")
  (PP)
  (PP)
  (P "     The data have been recorded in a file named INPUT")
  (EXEC "\command.com" ("/c" vgraph-1) _ret)
  (CLOSE output))
((dp5d2)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:statanov.dp 0") _r))
((dp5e2)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:stattesf.dp 0") _r))
((dp5e1)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp statchis.dp 0") _r))
((dp5d1)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:stattest.dp 0") _r))
((dp5c4)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:statbcox.dp 0") _r))
((dp5c3)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c;\command.com" ("/c" "dp a:stattesx.dp 0") _r))
((dp5c2)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:stattesw.dp 0") _r))
((dp5c1)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:stattesl.dp 0") _r))
((dp5b2)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:statsumt.dp 0") _r))
((dp5b1)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:statsum4.dp 0") _r))
((dp5a2)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:statscat.dp 0") _r))
((dp5a1)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:statboxp.dp 0") _r))
((dp7j)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distpois.dp 0") _r))
((dp7i)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distgeom.dp 0") _r))
((dp7h)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distbino.dp 0") _r))
```

```
((dp7g)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distxvt2.dp 0") _r))
((dp7f)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distweib.dp 0") _r))
((dp7e)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distbeta.dp 0") _r))
((dp7d)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distgama.dp 0") _r))
((dp7c)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distchsq.dp 0") _r))
((dp7b)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:diststud.dp 0") _r))
((dp7a)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distlmda.dp 0") _r))
((dp6g)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distxvt1.dp 0") _r))
((dp6f)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distexpo.dp 0") _r))
((dp6e)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distlogn.dp 0") _r))
((dp6d)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distcauc.dp 0") _r))
((dp6c)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distlogi.dp 0") _r))
((dp6b)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distunif.dp 0") _r))
((dp6a)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:distnorm.dp 0") _r))
((dptest1 "   ")
  (dp1))
((dptest1 "5a. Graphical ----------")
  (dp1))
((dptest1 "5b. Exploratory ---------")
  (dp1))
((dptest1 "5c. Test for Distrib. ---")
  (dp1))
((dptest1 "5d. Test for Location ---")
  (dp1))
((dptest1 "5e. Test for Variation --")
  (dp1))
((dptest1 box_plot)
  (dp5a1))
((dptest1 scatter_plot)
  (dp5a2))
((dptest1 summary_four_plot)
  (dp5b1))
((dptest1 summary_tabulation)
  (dp5b2))
```

```
((dptest1 Lambda-test)
  (dp5c1))
((dptest1 Weibull-test)
  (dp5c2))
((dptest1 Extrm_value-test)
  (dp5c3))
((dptest1 Box-Cox_transfrmtn)
  (dp5c4))
((dptest1 t-test)
  (dp5d1))
((dptest1 Chi_squared-test)
  (dp5e1))
((dptest1 F-test)
  (dp5e2))
((dptest1 ANOVA)
  (dp5d2))
((dpdistr1 Normal)
  (dp6a))
((dpdistr1 Uniform)
  (dp6b))
((dpdistr1 Logistic)
  (dp6c))
((dpdistr1 Cauchy)
  (dp6d))
((dpdistr1 Lognormal)
  (dp6e))
((dpdistr1 Exponential)
  (dp6f))
((dpdistr1 Extreme_value_Type1)
  (dp6g))
((dpdistr1 " 7. Families_of_Distr.---")
  (dp1))
((dpdistr1 Tukey_lambda)
  (dp7a))
((dpdistr1 Students_t)
  (dp7b))
((dpdistr1 Chi_squared)
  (dp7c))
((dpdistr1 Gamma)
  (dp7d))
((dpdistr1 Beta)
  (dp7e))
((dpdistr1 Weibull)
  (dp7f))
((dpdistr1 Extreme_value_Type2)
  (dp7g))
((dpdistr1 Binomial)
  (dp7h))
((dpdistr1 Geometric)
  (dp7i))
((dpdistr1 Poisson)
  (dp7j))
((delit1 _ap)
  (mtype _ap _u _x)
  (DELCL ((mtype _ap _u _x)))
  (delit1 _ap))
((delit1 _ap))
((dp4c2)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doepred2.dp 0") _r))
((dp4c1)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doepred1.dp 0") _r))
```

```
((dp4b)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doeauto.dp 0") _r))
((dp4a)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doelag.dp 0") _r))
((dp3b)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doepcc.dp 0") _r))
((dp3a)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doeccc.dp 0") _r))
((dp2e)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doeplotf.dp 0") _r))
((dp2d)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doep4q7f.dp 0") _r))
((dp2c)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doeparet.dp 0") _r))
((dp2b)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doepiech.dp 0") _r))
((dp2a)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" "dp a:doehisto.dp 0") _r))


((dptest it)
  (SMENU _chc ("   " "5a. Graphical -----------" box_plot scatter_plot "5b. Expl
oratory ---------" summary_four_plot summary_tabulation "5c. Test for Distrib. -
--" Lambda-test Weibull-test Extrm_value-test Box-Cox_transfrmtn "5d. Test for L
ocation ---" t-test ANOVA "5e. Test for Variation --" Chi_squared-test F-test) "
 Data Analysis & Tests " 3 48 1 1 25)
  (dptest1 _chc))
((dpdistr it)
  (SMENU _chc (Normal Uniform Logistic Cauchy Lognormal Exponential Extreme_valu
e_Type1 " 7. Families_of_Distr.---" Tukey_lambda Students_t Chi_squared Gamma Be
ta Weibull Extreme_value_Type2 Binomial Geometric Poisson) " 6. Probability_Plot
s " 3 48 1 1 25)
  (dpdistr1 _chc))

((dp1)
  (EXEC "\command.com" ("/c" "c:") _ret)
  (EXEC "c:\command.com" ("/c" dp) _r))
((deconm (._|_b) _c _nm)
  (REVERSE _c _nm))
((deconm () _c _nm)
  (REVERSE _c _nm))
((deconm (_a|_b) _c _nm)
  (deconm _b (_a|_c) _nm))
((del5 _cat _cc)
  (aplnm _ap)
  (FORALL ((ON _u _cc) (oldav _ap _cat _x _y _z _u)) ((DELCL ((oldav _ap _cat _x _y _z _u)))))
  (FORALL ((ON _uu _cc) (mtype _ap _cat _uu)) ((DELCL ((mtype _ap _cat _uu)))))
  (onlywelds x)
  (rewind "Deleting data points")
  (PP)
  (PP)
  (PP)
  (P "                Deletions complete."))
```

```
((del4 _cat)
  (rewind "Select Deletions")
  (PP)
  (P "        Category " _cat)
  (PP)
  (PP)
  (P ----------------------------------------)
  (PP)
  (PP)
  (P "  To the left is a multiple choice menu")
  (PP)
  (PP)
  (P "  Space bar or backspace key will move arrow")
  (PP)
  (PP)
  (P "  When arrow is on a selection, Use")
  (PP)
  (P "     plus sign to highlight it")
  (PP)
  (P "     minus sign to remove highlight")
  (PP)
  (PP)
  (P "  <ctrl>J will highlight all items")
  (PP)
  (P "  <ctrl>L will remove all highlights")
  (PP)
  (PP)
  (P "  When highlighting is complete, press <ENTER> ")
  (PP)
  (P "  to delete highlighted data "))
((delit _ap)
  (oldav _ap _a _b _c _z _d)
  (DELCL ((oldav _ap _a _b _c _z _d)))
  (delit _ap))
((delit _ap)
  (delit1 _ap))
((carryout _chc _fl)
  (onlywelds x)
  (opn "process file")
  (PP)
  (P "         Program not yet ready for image")
  (PP)
  (PP)
  (P "        " _chc " of " _fl))
((carryout _chc _fl)
  (onlywelds x))
((analysis "    - 1 -")
  (dp1))
((analysis "    - 2 -")
  (dp1))
((analysis "    - 3 -")
  (dp1))
((analysis "    - 4 -")
  (dp1))
((analysis "    - 5 -")
  (dp1))
((analysis "    - 6 -")
  (dp1))
((analysis Distribut)
  (onlywelds x)
  (dpdistr it))
((analysis Tests)
  (onlywelds x)
  (dptest it))
```

```
((analysis DATAPLOT)
  (dp1))
((analysis Histogram)
  (dp2a))
((analysis Pie-Chart)
  (dp2b))
((analysis Pareto-Ch)
  (dp2c))
((analysis PID-4Q-7F)
  (dp2d))
((analysis "2DPlotFit")
  (dp2e))
((analysis C-Chart)
  (dp3a))
((analysis P-Chart)
  (dp3b))
((analysis Lag-Plot)
  (dp4a))
((analysis AutocorrP)
  (dp4b))
((analysis Predict-1)
  (dp4c1))
((analysis Predict-2)
  (dp4c2))
((findname _l _nam)
  (STRINGOF _lst _l)
  (deconm _lst () _nm)
  (STRINGOF _nm _nam))
((copypix _chc _ftr)
  (findname _ftr _y)
  (CONCAT _y ".pix" _z)
  (CONCAT "COPY " _chc _c1)
  (CONCAT _c1 " " _c2)
  (CONCAT _c2 _z _c3)
  (EXEC "c:\command.com" ("/c" _c3) _ret))
((give example)
  (CURSOR "input examples" 2 23)
  (P "Examples:")
  (PP)
  (PP)
  (FW "input examples" ((U 3) (Q 6) (Q 20) (Q 20)) (" " "A:" "\DOS\PROLOG\" "B:\TOOLS\"))
  (PP)
  (PP)
  (P "     "))
((del3 _cat)
  (onlywelds x)
  (del4 _cat)
  (aplnm _ap)
  (ISALL _all _x (mtype _ap _cat _x))
  (MMENU _sel () _all deletions 2 2 15 3 6)
  (del5 _cat _sel))
((men-doe-fac _tp)
  (windcont _tp))
((del1a-1 yes)
  (aplnm _ap)
  (delit _ap)
  (rewind "Deleting data points")
  (aplnm _ap)
  (PP)
  (P "   All data in application " _ap)
  (PP)
  (PP)
  (P "   have been deleted."))
```

```
((del1a-1 no)
  (rewind "Deleting data points")
  (PP)
  (PP)
  (P "    Deletions Cancelled"))
((askproc _fl)
  (opn "current data")
  (PP)
  (P "  " _fl)
  (SMENU _chc (display analysis transport) image 5 5 1 1 9)
  (CLOSE _fl)
  (carryout _chc _fl))
((entfile "enter new name")
  (opn "new image file")
  (PP)
  (P "   Please enter name of file ")
  (R _fn)
  (CONCAT _fn ".pix" _fdir)
  (CREATE _fdir)
  (OPEN _fdir)
  (rewind "new image file")
  (PP)
  (P "    File " _fn " has been re-formatted to the current")
  (PP)
  (PP)
  (P "    directory as a file (512 X 512) named " _fdir)
  (askproc _fdir))
((entfile "input file")
  (rewind "re-format image file")
  (CURSOR "re-format image file" 2 16)
  (P "In double quotes, and in")
  (CURSOR "re-format image file" 4 18)
  (P "CAPITAL LETTERS ONLY")
  (PP)
  (PP)
  (P "    enter name of directory containing the input file")
  (opn "input examples")
  (give example)
  (R _direc)
  (onlywelds x)
  (CONCAT _direc *.* _fdir)
  (DIR _fdir _rep)
  (SMENU _chc _rep _direc 5 5 1 1 16)
  (CONCAT _direc _ftr _chc)
  (copypix _chc _ftr)
  (findname _ftr _justfl)
  (CONCAT _justfl ".pix" _fpix)
  (onlywelds x)
  (rewind "new image file")
  (PP)
  (P "  File " _chc " has been re-formatted and")
  (PP)
  (PP)
  (P "  stored in the  current directory as " _fpix)
  (askproc _fpix))
```

```
((del1a All)
  (aplnm _ap)
  (rewind "Deleting data points")
  (PP)
  (P "      Are you sure that you wish to")
  (PP)
  (PP)
  (P "      delete all data in application")
  (PP)
  (PP)
  (P "            " _ap ?)
  (SMENU _chc (no yes) "last chance" 14 15 1 1 16)
  (del1a-1 _chc))
((del1a "Selected Data")
  (onlywelds x)
  (men-doe-fac _tp)
  (onlywelds x)
  (ISALL _ea _y (_tp _y))
  (SMENU _cat _ea " Facility___Year-Qtr " 5 5 1 1 20)
  (del3 _cat))
((up1-1 keyboard)
  (onlywelds x)
  (opn new-data)
  (insup _tp _sl)
  (key1 _tp _sl))
((up1-1 file)
  (onlywelds x)
  (up1-1a file))
((askimage "new image")
  (SMENU _chc ("enter new name" "input file") "which file?" 5 30 1 1 15)
  (entfile _chc))
((askimage _fl)
  (askproc _fl))
((del1 x)
  (aplnm _ap)
  (opn "Deleting data points")
  (PP)
  (P "    How do you wish to proceed with deletions")
  (PP)
  (PP)
  (P "       of selected data in database named:")
  (PP)
  (PP)
  (P "      " _ap)
  (SMENU _meth ("Selected Data" All) "deletion method" 14 15 1 1 16)
  (del1a _meth))


((resort _cat)
  (aplnm _ap)
  (mtype _ap _cat _ttt)
  (FORALL ((mtype _ap _cat _x) (oldav _ap _cat _b _c _cz _x)) ((DELCL ((oldav _a
p _cat _b _c _cz _x))) (ADDCL ((toa _ap _a _b _c _cz _x)))))
  (FORALL ((toa _ap _cat _bb _cc _ccz _xx)) ((ADDCL ((oldav _ap _cat _bb _cc _cc
z _xx))) (DELCL ((toa _ap _cat _bb _cc _ccz _xx))))))
((resort _sl))
```

```
((old)
  (aplnm _ap)
  (men-doe-fac _tp)
  (men-doe-fac2 _tp _sl)
  (mtype _ap _sl _x)
  (onlywelds xx)
  (up2 _tp _sl))
((old)
  (onlywelds xx)
  (opn "First number of data points (n-data)")
  (PP)
  (P "              No n-data exist.")
  (up1 addtype))
((up1 addtype)
  (opn new-data)
  (P " Do you wish to enter a new n-data value from the keyboard,")
  (PP)
  (PP)
  (P " or do you wish to read data from a file?")
  (SMENU _chc (keyboard file) "keybd or file" 12 25 1 1 15)
  (up1-1 _chc))
((gobin binary)
  (DIR "*.pix" _all)
  (onlywelds x)
  (EQ _alla ("new image"|_all))
  (SMENU _fl _alla "image file" 5 5 1 1 12)
  (askimage _fl))
((gobin binary)
  (onlywelds x))
((update add-ndata)
  (onlywelds x)
  (up1 addtype))
((update old-ndata)
  (old))
((update sort)
  (resort x))
((update del-ndata)
  (onlywelds x)
  (del1 x))
((indata text)
  (onlywelds x)
  (SMENU _chc (old-ndata add-ndata del-ndata) text 5 5 1 1 9)
  (update _chc))
((indata binary)
  (gobin binary))
((indata binary))
((testP F-1))
((testP F-2))
((testP F-3))
((testP F-4))
((testP F-5))
((testP F-6))
((testP F-7))
((oapos1 -1 _x _po _t)
  (= _qo (_po + 1))
  (oapos _x _qo _t))
((oapos1 _u _x _po _t)
  (apln _ap)
  (FORALL ((testP _fl) (_fl _tp)) ((ADDCL ((oldav _ap _tp 0 0 0 _x)) _po))))
((oapos _x _po _tt)
  (aplnm _ap)
  (oldav _uu _uv _uw _uh _uz _t)
  (CMP -1 _tt _t)
  (CMP _crit _t _x)
  (oapos1 _crit _x _po _t))
```

```
((onlywelds _x)
  (CUWIND welds)
  (FORALL ((wind _wnd) (NOT EQ _wnd welds)) ((CLOSE _wnd))))
((writ in)
  (onlywelds x)
  (rewind chart)
  (CUWIND welds)
  (PP Enter number of types)
  (P)
  (R _nocas)
  (FW chart ((U 4)) (_nocas))
  (nextwrit _nocas))
((nextwrit 0)
  (CUWIND chart))
((nextwrit _nocas)
  (CUWIND welds)
  (PP Enter title message enclosed in double quotation marks)
  (PP)
  (R _titmes)
  (P " Enter nclass 8, 15 or 17")
  (PP)
  (R _nclass)
  (lbl _nclass _lbl)
  (DATE _da _mo _yr)
  (PP)
  (PP)
  (P " Enter krange")
  (PP)
  (R _krange)
  (WRITE chart ())
  (WRITE chart (Class _lbl _titmes _da _mo _yr))
  (FW chart ((U 4) (U 4)) (_nclass _krange))
  (WRITE chart ())
  (tydeg _krange 0)
  (SUM _curcas 1 _nocas)
  (PP _curcas)
  (nextwrit _curcas))
((lbl 8 D2H))
((lbl 15 D4H))
((lbl 17 C3V))
((tydeg _krange _krange))
((tydeg _krange _nplac)
  (SUM _nplac 1 _newpl)
  (PP Enter type and degree for _newpl)
  (R _typ)
  (R _deg)
  (FW chart ((U 4) (U 4)) (_typ _deg))
  (tydeg _krange _newpl))
((readit1 xx)
  (NOT EOF tempo2)
  (READ tempo2 _a)
  (READ tempo2 _b)
  (ADDCL ((mtype _a _b)))
  (readit1 xx))
((readit1 xx)
  (EOF tempo2)
  (CLOSE tempo2)
  (DEL tempo2))
```

```
((readit xx)
  (NOT EOF tempo1)
  (READ tempo1 _a)
  (READ tempo1 _b)
  (READ tempo1 _c)
  (READ tempo1 _d)
  (READ tempo1 _z)
  (READ tempo1 _e)
  (ADDCL ((oldav _a _b _c _d _z _e)))
  (readit xx))
((readit xx)
  (EOF tempo1)
  (CLOSE tempo1)
  (DEL tempo1)
  (OPEN tempo2)
  (readit1 xx))
((reread all)
  (OPEN tempo1)
  (readit _x))
((dumpit all)
  (CREATE tempo1)
  (FORALL ((oldav _a _b _c _d _z _e)) ((WRITE tempo1 (_a _b _c _d _z _e))))
  (CLOSE tempo1)
  (CREATE tempo2)
  (FORALL ((mtype _aa _bb)) ((WRITE tempo2 (_aa _bb))))
  (CLOSE tempo2)
  (redo xx))
((redo _x)
  (KILL oldav)
  (KILL mtype)
  (ADDCL ((oldav)))
  (ADDCL ((mtype))))
((aplic x)
  (EXEC "c:\command.com" ("/c" "COPY \COMMAND.COM") _rtn)
  (rewind " DOE NE Performance Indicator Data Analysis System ")
  (oldap lst))
((explan apldel)
  (opn "Delete old Application")
  (P " Move arrow with space-bar or backspace key.")
  (PP)
  (P " Select by hitting plus sign (<shift> +)")
  (PP)
  (P " Deselect by hitting minus sign (-)")
  (PP)
  (P " After selections have been made, hit <enter>"))
((oldap lst)
  (opn instructions)
  (P "    ** Use Space-Bar to Select___Then Hit Return **")
  (CUWIND " DOE NE Performance Indicator Data Analysis System ")
  (ISALL _all _x (appl _x))
  (EQ _alla ("Delete Old Application"|_all))
  (EQ _allb ("Add New Application"|_alla))
  (SMENU _curap _allb " PDA (NIST/DOE Expert System, v. 92.2) " 2 10 1 1 55)
  (useapl _curap))

((barit x)
  (aplnm _nmap)
  (propwind welds _tw _lw _hw _ww)
  (CRWIND welds _tw _lw _hw _ww)
  (BAR _nmap ((indata (text binary)) (lists (F-1 F-2 F-3 F-4 F-5 F-6 F-7)) (disc
o ("    - 1 -" op_sys "    - 2 -" splitfl_x "    - 3 -" sav_dosfl "    - 4 -" sa
v_dpdat r_dpdat_y)) (analysis ("    - 1 -" DATAPLOT "    - 2 -" Histogram Pie-Ch
art Pareto-Ch PID-4Q-7F "2DPlotFit" "    - 3 -" C-Chart P-Chart "    - 4 -" Lag-
Plot AutocorrP Predict-1 Predict-2 "    - 5 -" Tests "    - 6 -" Distribut)) (cl
ean (clear save exit restart)))))
```

```
((closeall _x)
  (CUWIND &:)
  (FORALL ((wind _y)) ((CLOSE _y))))
((shortaplnm "3. IDAHO (Idaho & Albuquerque/EG&G)              " "3. IDAHO"))
((shortaplnm "1. CH-AN (Chicago/Argonne)                       " "1. CH-AN"))
((shortaplnm "2. CH-BN (Chicago/Brookhaven)                    " "2. CH-BN"))
((shortaplnm "4. OAKRI (Oak Ridge/Martin Marietta)             " "4. OAKRI"))
((shortaplnm "5. RL-WH (Richland/Westinghouse-Hanford)         " "5. RL-WH"))
((shortaplnm "6. SF-LL (San Francisco/Lawrence Livermore)      " "6. SF-LL"))
((shortaplnm "7. SF-RI (San Francisco/Rockwell International)  " "7. SF-RI"))
((shortaplnm "8. TOTAL (Group of Facilities with PI Data)      " "8. TOTAL"))
((shortaplnm "   DEMO (C-Chart/ P-Chart/ Distribution Chart/)  " "0.  DEMO"))
((appl))
((appl " "))
((appl "   DEMO (C-Chart/ P-Chart/ Distribution Chart/)  "))
((appl "           --------------------                  "))
((appl "1. CH-AN (Chicago/Argonne)                       "))
((appl "2. CH-BN (Chicago/Brookhaven)                    "))
((appl "3. IDAHO (Idaho & Albuquerque/EG&G)              "))
((appl "4. OAKRI (Oak Ridge/Martin Marietta)             "))
((appl "           --------------------                  "))
((appl "5. RL-WH (Richland/Westinghouse-Hanford)         "))
((appl "6. SF-LL (San Francisco/Lawrence Livermore)      "))
((appl "7. SF-RI (San Francisco/Rockwell International)  "))
((appl "8. TOTAL (Group of Facilities with PI Data)      "))
((appl "           --------------------                  "))
((propwind welds 0 0 23 78))
((propwind old-data 8 4 13 75))
((propwind new-data 8 2 15 75))
((propwind n-data- 20 60 2 18))
((propwind chart 5 10 15 65))
((propwind retrn 8 38 4 40))
((propwind anita-out 13 0 2 43))
((propwind "To print output" 18 0 4 43))
((propwind esc 8 25 2 30))
((propwind "Name Your Application" 5 10 10 60))
((propwind "First number of data points (n-data)" 4 10 7 50))
((propwind observations 8 2 15 75 0 0 4))
((propwind obs-label 6 2 2 75))
((propwind cont 2 10 3 65))
((propwind "writing to disc" 10 10 5 65))
((propwind "reading from disc" 10 10 5 65))
((propwind "new image file" 10 10 5 60))
((propwind "current data" 19 60 3 18))
((propwind "re-format image file" 5 11 6 56))
((propwind " DOE NE Performance Indicator Data Analysis System " 0 0 23 78))
((propwind "input examples" 13 11 7 56))
((propwind "process file" 10 20 5 55))
((propwind "Deleting data points" 4 9 7 65))
((propwind "Select Deletions" 2 31 20 47))
((propwind "Change old data" 4 48 7 28))
((propwind "Continue?" 5 20 5 38))
((propwind "Current List" 20 50 3 12))
((propwind instructions 22 10 1 57))
((propwind "    Meaning of Facility Designation" 5 19 10 58))
((propwind "Delete old Application" 19 10 4 47))
((propwind "Explanation of dp file names" 11 28 8 40))
```

```
((useapl "Add New Application")
  (CLOSE instructions)
  (propwind "Name Your Application" _tw _lw _hw _ww)
  (CRWIND "Name Your Application" _tw _lw _hw _ww)
  (CURSOR "Name Your Application" 3 10)
  (P Please Name Your Application)
  (CURSOR "Name Your Application" 5 10)
  (R _nmap)
  (KILL aplnm)
  (ADDCL ((aplnm _nmap)))
  (ADDCL ((appl _nmap)))
  (ADDCL ((shortaplnm _nmap _nmap)))
  (closeall x)
  (barit x))
((useapl "          --------------------                  ")
  (useapl " "))
((useapl " ")
  (CLOSE instructions)
  (oldap lst))
((useapl "Delete Old Application")
  (CLOSE instructions)
  (ISALL _all _x (appl _x))
  (explan apldel)
  (MMENU _de () _all "Applications to Delete" 5 5 10 1 55)
  (FORALL ((ON _y _de)) ((elim1 _y) (elim2 _y) (DELCL ((appl _y))) (DELCL ((shortaplnm _y _z)))))
  (closeall x)
  (aplic x))
((useapl _oldname)
  (KILL aplnm)
  (ADDCL ((aplnm _oldname)))
  (closeall x)
  (barit x))
((elim1 _y)
  (FORALL ((oldav _y _u _v _w _z)) ((DELCL ((oldav _y _u _v _w _z))))))
((elim2 _y)
  (FORALL ((mtype _y _h)) ((DELCL ((mtype _y _h))))))
((go2 _tp _ndat _sl _olne)
  (onlywelds x)
  (opn n-data-)
  (P "  " _ndat)
  (CUWIND welds)
  (aplnm _ap)
  (oldav _ap _sl _xp _yp _zp _ndat)
  (go3 _tp _ndat _sl _xp _yp _zp _olne))
((go1a _tm _fk)
  (SMENU _q (enter-data see-all) next-choice 16 10 1 1 10)
  (go2 _tm _fk _q))
((aplnm "3. IDAHO (Idaho & Albuquerque/EG&G)              "))
((go1 _tp)
  (aplnm _ap)
  (CLOSE old-data)
  (CLOSE new-data)
  (CLOSE chart)
  (ISALL _all _x (_tp _ap _x))
  (SMENU _fk _all testPs 5 5 1 1 9)
  (go1a _fk _tp))
((read1 _fname _ap _run _xp _yp _zp _q)
  (mtype _ap _run _q)
  (ADDCL ((oldav _ap _run _xp _yp _zp _q)))
  (reading _fname _ap _run _q))
((read1 _fname _ap _run _xp _yp _zp _q)
  (ADDCL ((mtype _ap _run _q)))
  (ADDCL ((oldav _ap _run _xp _yp _zp _q)))
  (reading _fname _ap _run _q))
```

```
((read1 _fname _ap _run _q)
  (mtype _ap _run _q)
  (DELCL ((mtype _ap _run _q)))
  (read2 _fname _ap _run _q))
((read1 _fname _ap _run _q)
  (read2 _fname _ap _run _q))
((read2 _fname _ap _run _q)
  (oldav _ap _run _a _b _z _q)
  (DELCL ((oldav _ap _run _a _b _z _q)))
  (read3 _fname _ap _run _q))
((read2 _fname _ap _run _q)
  (read3 _fname _ap _run _q))
((read3 _fname _ap _run _q)
  (NOT EOF _fname)
  (FR _fname ((S 19)) (_xpp))
  (READ _fname _yp)
  (FR _fname ((S 2)) (_w))
  (STRINGOF _xpp _xp)
  (ADDCL ((mtype _ap _run _q)))
  (read4 _fname _ap _run _xp _yp _w _q))
((reading _fname _ap _run _p)
  (= _q (_p + 1))
  (read1 _fname _ap _run _q))
((reading _fname _ap _run _p)
  (EOF _fname)
  (CLOSE _fname))
((read4 _fname _ap _run _xp _yp (" " " ") _q)
  (READ _fname _zp)
  (FR _fname ((S 2)) (_w))
  (ADDCL ((oldav _ap _run _xp _yp _zp _q)))
  (reading _fname _ap _run _q))
((read4 _fname _ap _run _xp _yp _w _q)
  (ADDCL ((oldav _ap _run _xp _yp -1 _q)))
  (reading _fname _ap _run _q))
((add-db _ap _rn _p)
  (mtype _ap _p)
  (add-db1 _ap _rn _p))
((add-db _ap _rn _p)
  (ADDCL ((mtype _ap _p)))
  (add-db1 _ap _rn _p))
((del2 All)
  (rewind "Deleting data points")
  (PP)
  (PP)
  (P "   Are you sure?")
  (SMENU _chc (yes no) "last chance" 14 10 1 1 11))
((opn _wnd)
  (propwind _wnd _tw _lw _hw _ww)
  (CRWIND _wnd _tw _lw _hw _ww))
((opn _wnd)
  (propwind _wnd _a _b _c _d _e _f _g)
  (CRWIND _wnd _a _b _c _d _e _f _g))
((explain files)
  (opn "Explanation of dp file names")
  (PP)
  (P "2-column Y and Z data. Filename by user.")
  (PP)
  (PP)
  (P "One column, Z, of numbers")
  (PP)
  (P "Two columns, Y and Z, of numbers")
  (PP)
  (P "Two columns; X of ASCII, Z of numbers")
  (PP)
  (P "Three columns, X, Y, Z, of numbers")
  (CUWIND chart))
```

```
((namefl _ap _ft _fnme _nn)
  (prmes _ft _nn)
  (PP)
  (PP)
  (P "  (Filename not to exceed 8 characters")
  (PP)
  (P "   and must begin with an alphabet.)")
  (PP)
  (PP)
  (R _fnn)
  (caseconv _fnn _fnm)
  (namefl2 _ap _ft _fnm _fnme))
((spla _ap _ft ------)
  (spla _ap _ft DAT_FILE))
((spla _ap _ft DAT_FILE)
  (namefl _ap _ft _fnme 1)
  (ckdr _ap _ft _fnme))
((spla _ap _ft _fnme)
  (CONCAT _fnme ".DAT" _fnme1)
  (CONCAT "C:\DATAPLOT\" _fnme1 _fnme2)
  (PP)
  (PP)
  (ckdr _ap _ft _fnme2))
((ckdr _ap _ft _fnme)
  (DIR _fnme _lst)
  (ON _fnme _lst)
  (PP)
  (P " File " _fnme " already exists")
  (PP)
  (PP)
  (P "       Overwrite? ")
  (SMENU _count (yes no) continue 18 10 1 1 10)
  (ckdr2 _ap _ft _fnme _count))
((ckdr _ap _ft _fnme)
  (splcon _ap _ft _fnme))
((spl-1 _ap _ft)
  (PP)
  (P "   Please choose DAT_FILE if you wish to name a file")
  (PP)
  (P "     for storing Y and Z data from a 3-column X-Y-Z")
  (PP)
  (P "     input file; or select other file name from menu.")
  (explain files)
  (SMENU _flnm (DAT_FILE ------ DOE_1COL DOE_2CLA DOE_2CLB DOE_3COL) "dp name" 12 14 1 1 9)
  (rewind chart)
  (spla _ap _ft _flnm))
((rewind _x)
  (closewind _x)
  (opn _x))
((rewind _wo _wn)
  (CUWIND &:)
  (CLOSE _wo)
  (propwind _wn _tp _lft _hgt _wdth)
  (CRWIND _wn _tp _lft _hgt _wdth))
((ckdr2 _ap _ft _fnme yes)
  (splcon _ap _ft _fnme))
((ckdr2 _ap _ft _fnme no)
  (rewind chart)
  (spl-1 _ap _ft))
((oldav))
((mtype))
```

```
((spicon _ap _ft "C:\DATAPLOT\DOE_1COL.DAT")
  (CREATE "C:\DATAPLOT\DOE_1COL.DAT")
  (OPEN "C:\DATAPLOT\DOE_1COL.DAT")
  (FORALL ((mtype _ap _ft _tm) (oldav _ap _ft _xp _yp _zp _tm)) ((list3-1z "C:\DATAPLOT\DOE_1COL.DAT" _zp)))
  (CLOSE "C:\DATAPLOT\DOE_1COL.DAT")
  (PP)
  (PP)
  (PP)
  (PP)
  (PP Data recorded on "C:\DATAPLOT\DOE_1COL.DAT"))
((spicon _ap _ft "C:\DATAPLOT\DOE_2CLA.DAT")
  (CREATE "C:\DATAPLOT\DOE_2CLA.DAT")
  (OPEN "C:\DATAPLOT\DOE_2CLA.DAT")
  (FORALL ((mtype _ap _ft _tm) (oldav _ap _ft _xp _yp _zp _tm)) ((list3-1y "C:\DATAPLOT\DOE_2CLA.DAT" _yp _zp)))
  (CLOSE "C:\DATAPLOT\DOE_2CLA.DAT")
  (PP)
  (PP)
  (PP)
  (PP)
  (PP Data recorded on "C:\DATAPLOT\DOE_2CLA.DAT"))
((spicon _ap _ft "C:\DATAPLOT\DOE_2CLB.DAT")
  (CREATE "C:\DATAPLOT\DOE_2CLB.DAT")
  (OPEN "C:\DATAPLOT\DOE_2CLB.DAT")
  (FORALL ((mtype _ap _ft _tm) (oldav _ap _ft _xp _yp _zp _tm)) ((list3-1xz "C:\DATAPLOT\DOE_2CLB.DAT" _xp _zp)))
  (CLOSE "C:\DATAPLOT\DOE_2CLB.DAT")
  (PP)
  (PP)
  (PP)
  (PP)
  (PP Data recorded on "C:\DATAPLOT\DOE_2CLB.DAT"))
((spicon _ap _ft "C:\DATAPLOT\DOE_3COL.DAT")
  (CREATE "C:\DATAPLOT\DOE_3COL.DAT")
  (OPEN "C:\DATAPLOT\DOE_3COL.DAT")
  (FORALL ((mtype _ap _ft _tm) (oldav _ap _ft _xp _yp _zp _tm)) ((list3-1x "C:\DATAPLOT\DOE_3COL.DAT" _xp _yp _zp)))
  (CLOSE "C:\DATAPLOT\DOE_3COL.DAT")
  (PP)
  (PP)
  (PP)
  (PP)
  (PP Data recorded on "C:\DATAPLOT\DOE_3COL.DAT"))
((spicon _ap _ft _fnme)
  (CREATE _fnme)
  (OPEN _fnme)
  (FORALL ((mtype _ap _ft _tm) (oldav _ap _ft _xp _yp _zp _tm)) ((list3-1c _fnme _yp _zp)))
  (CLOSE _fnme)
  (PP)
  (PP)
  (PP)
  (PP)
  (PP Data recorded on _fnme))
((list3-1z _fnme _zp)
  (FW _fnme ((F 20 10)) (_zp))
  (WRITE _fnme ()))
((list3-1y _fnme _yp _zp)
  (FW _fnme ((F 20 10) " " (F 20 10)) (_yp _zp))
  (WRITE _fnme ()))
((list3-1xz _fnme _xp _zp)
  (FW _fnme ((C 25) " " (F 20 10)) (_xp _zp))
  (WRITE _fnme ()))
((list3-1x _fnme _xp _yp _zp)
  (FW _fnme ((C 25) " " (F 20 10) " " (F 20 10)) (_xp _yp _zp))
  (WRITE _fnme ()))
```

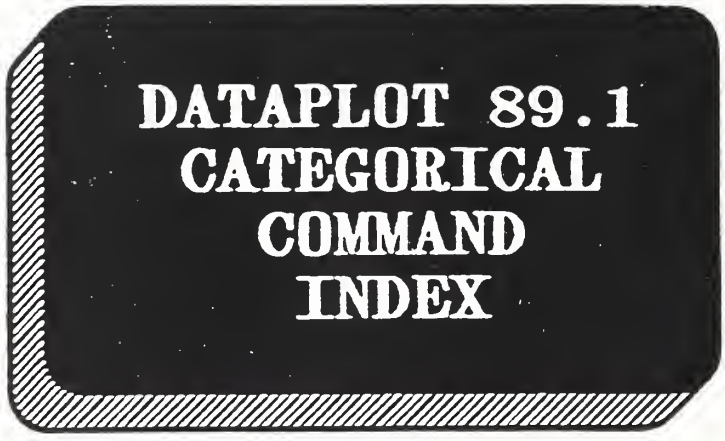
```
((list3-1c _fnme _yp -1)
  (FW _fnme ((U 5) "                          ") (_yp))
  (WRITE _fnme ()))
((list3-1c _fnme _yp _zp)
  (FW _fnme ((U 5) " " (F 20 10)) (_yp _zp))
  (WRITE _fnme ()))
((list3-1b _fnme _yp -1)
  (FW _fnme ((U 5) "                          ") (_yp))
  (PP))
((list3-1b _fnme _yp _zp)
  (FW _fnme ((U 5) (F 20 10)) (_yp _zp))
  (PP))
((jk () _u _u))
((jk))
((frmxlist _fnme _lst)
  (conv _fnme)
  (OPEN _fnme)
  (frmlgo _fnme () _olst)
  (remvat _olst _lst))
((runfrm _y)
  (frmxlist _y _lst)
  (PP _lst))
((takex _fnme ())
  (PP)
  (P "  Thank you."))
((takex _fnme _lst)
  (xmen _lst _x _plst)
  (takex2 _fnme _x _plst))
((takex2 _fnme exit _plst)
  (PP)
  (P " Thank You"))
((takex2 _fnme _x _plst)
  (pickx _fnme _x)
  (takex _fnme _plst))
((pickx _fnme _x)
  (PP)
  (P "  Please name output file")
  (PP)
  (P "  ")
  (R _gnme)
  (pickx2 _fnme _gnme _x)
  (cleanfile _gnme))
((be nice)
  (clean clear))
((pickx2 _fnme exit _x)
  (be nice))
((pickx2 _fnme _gnme _x)
  (CREATE _gnme)
  (OPEN _fnme)
  (OPEN _gnme)
  (pickxon _fnme _gnme _x))
((cleanfile _fname)
  (REN _fname ooojjj)
  (EXEC "cleanfl.exe" () _ret)
  (REN oookkk _fname)
  (DEL ooojjj))
((pickxon1-a _fnme _gnme _x _xx _xl)
  (ON "-@" _xl)
  (CLOSE _fnme)
  (CLOSE _gnme))
((pickxon1-a _fnme _gnme _x _xx _xl)
  (READ _fnme _y)
  (READ _fnme _z)
  (FR _fnme ((C 2)) (_h))
  (pickxon1 _fnme _gnme _x _xx _y _z))
```

```
((pickxon _fnme _gnme _x)
  (EOF _fnme)
  (CLOSE _fnme)
  (CLOSE _gnme))
((pickxon _fnme _gnme _x)
  (FR _fnme ((C 19)) (_xx))
  (STRINGOF _xl _xx)
  (pickxon1-a _fnme _gnme _x _xx _xl))
((pickxon1 _fnme _gnme _x _x _y _z)
  (FW _gnme ((U 19) (U 5) (F 21 10)) (_x _y _z))
  (WRITE _gnme ())
  (pickxon _fnme _gnme _x))
((pickxon1 _fnme _gnme _x _xx _y _z)
  (STRINGOF _xl _xx)
  (ON "~@" _xl)
  (pickon _fnme _gnme _x))
((pickxon1 _fnme _gnme _x _xx _y _z)
  (pickxon _fnme _gnme _x))
```

Appendix C

DATAPLOT (v. 89.1)

Categorical Command Index



James J. Filliben
National Institute of Standards and Technology
Washington, D. C.

January 1989

Graphics Commands

```
ALLAN STAN DEVIATION PLOT   GR-CO Generate an Allan stand. dev. plot
ALLAN VARIANCE PLOT         GR-CO Generate an Allan variance plot
AMPLITUDE SPECTRAL PLOT     GR-CO Generate amplitude spectral plot
ANOP PLOT                   GR-CO Generate ANOP plot
ARGAND SPECTRAL PLOT        GR-CO Generate argand spectral plot
AUTOCORRELATION PLOT        GR-CO Generate autocorrelation plot
AUTOCORRELATION STAT PLOT   GR-CO Generate autocorrelation (vs. subset) plot
AUTOSPECTRAL PLOT           GR-CO Generate autospectral plot

BETA PROBABILITY PLOT       GR-CO Generate beta probability plot
... BIHISTOGRAM             GR-CO Generate (counts & relative) bihistogram
BINOMIAL PROBABILITY PLOT   GR-CO Generate binomial probability plot
BOX COX LINEARITY PLOT      GR-CO Generate linearity plot (Box-Cox family)
BOX PLOT                    GR-CO Generate box plot
BOX-COX HOMOSCED PLOT       GR-CO Generate homosced. plot (Box-Cox family)
BOX-COX NORMALITY PLOT      GR-CO Generate normality plot (Box-Cox family)

C CHART                     GR-CO Generate C control chart
CAUCHY PROBABILITY PLOT     GR-CO Generate Cauchy probability plot
CHI-SQUARED PPCC PLOT       GR-CO Generate chi-squared prob plot corr cf plot
CHI-SQUARED PROB PLOT       GR-CO Generate chi-squared probability plot
CO-SPECTRAL PLOT            GR-CO Generate co-spectral plot
COHERENCY SPECTRAL PLOT     GR-CO Generate coherency spectral plot
COMPLEX DEMOD AMPL PLOT     GR-CO Generate complex demodulation amp. plot
COMPLEX DEMOD PHASE PLOT    GR-CO Generate complex demodulation phase plot
... CONTROL CHART           GR-CO Generate mean, sd, or range control chart
CONTOUR PLOT                GR-CO Generate contour plot
... CORRELATION PLOT        GR-CO Generate auto- or cross-correlation plot
COUNTS PLOT                 GR-CO Generate counts (vs. subset) plot
CROSS-CORRELATION PLOT      GR-CO Generate cross-correlation plot
CROSS-PERIODOGRAM           GR-CO Generate cross-periodogram
CROSS-SPECTRAL PLOT         GR-CO Generate cross-spectral plot

... DECILE PLOT             GR-CO Generate decile (vs. subset) plot
DOUBLE EXPO PROB PLOT       GR-CO Generate double exp. probability plot

ERROR BAR PLOT              GR-CO Generate error bar plot
EXPONENTIAL PROB PLOT       GR-CO Generate exponential probability plot
EXTR VALUE TYPE 1 PROB PLOT GR-CO Generate ext. val. type 1 probability plot
EXTR VALUE TYPE 2 PPCC PLOT GR-CO Generate ext. val. type 2 prob plot cc plot
EXTR VALUE TYPE 2 PROB PLOT GR-CO Generate ext. val. type 2 probability plot

F PROBABILITY PLOT          GR-CO Generate F probability plot
FRACTAL PLOT                GR-CO Generate fractal plot
... FREQUENCY PLOT          GR-CO Generate frequency plot--cum/rel/cum rel
```

```
GAIN SPECTRAL PLOT          GR-CO Generate gain spectral plot
GAMMA PPCC PLOT             GR-CO Generate gamma prob plot corr coef plot
GAMMA PROBABILITY PLOT      GR-CO Generate gamma probability plot
GEOMETRIC PPCC PLOT         GR-CO Generate geometric prob plot corr coef plot
GEOMETRIC PROB PLOT         GR-CO Generate geometric probability plot

HALFNORMAL PROB PLOT        GR-CO Generate halfnormal probability plot
... HINGE PLOT              GR-CO Generate lower/upper hinge (vs. subset) plot
... HISTOGRAM               GR-CO Generate histogram--cum/rel/cum rel
HOMOSCEDASTICITY PLOT       GR-CO Generate homoscedasticity plot.

I PLOT                      GR-CO Generate I plot

KURTOSIS PLOT               GR-CO Generate kurtosis (vs. subset) plot

... LAG PLOT                GR-CO Generate lag plot for a given lag number
LINEAR CORRELATION PLOT     GR-CO Generate linear corr (vs. subset) plot
LINEAR INTERCEPT PLOT       GR-CO Generate linear intercept (vs. subset) plot
LINEAR RESSD PLOT           GR-CO Generate linear res. sd. (vs. subset) plot
LINEAR SLOPE PLOT           GR-CO Generate linear slope (vs. subset) plot
LOGISTIC PROBABILITY PLOT   GR-CO Generate logistic probability plot
LOGNORMAL PROBABILITY PLOT  GR-CO Generate lognormal probability plot
LOWER HINGE PLOT            GR-CO Generate lower hinge (vs. subset) plot
LOWER QUARTILE PLOT         GR-CO Generate lower quartile (vs. subset) plot

MAXIMUM PLOT                GR-CO Generate maxima (vs. subset) plot
MEAN CONTROL CHART          GR-CO Generate mean control chart
MEAN PLOT                   GR-CO Generate mean (vs. subset) plot
MEDIAN PLOT                 GR-CO Generate median (vs. subset) plot
MIDMEAN PLOT                GR-CO Generate midmean (vs. subset) plot
MIDRANGE PLOT               GR-CO Generate midrange (vs. subset) plot
MINIMUM PLOT                GR-CO Generate minima (vs. subset) plot

NEGATIVE BINO PROB PLOT     GR-CO Generate neg. bin. probability plot
NORMAL PROBABILITY PLOT     GR-CO Generate normal probability plot
NP CHART                    GR-CO Generate Np control chart

P CHART                     GR-CO Generate P control chart
PARETO PLOT                 GR-CO Generate Pareto plot
PARETO PPCC PLOT            GR-CO Generate Pareto prob plot corr coef plot
PARETO PROBABILITY PLOT     GR-CO Generate Pareto probability plot
PERCENT POINT PLOT          GR-CO Generate percent point plot
... PERIODOGRAM             GR-CO Generate auto- or cross-periodogram
PERIODOGRAM                 GR-CO Generate auto-periodogram
PHASE SPECTRAL PLOT         GR-CO Generate phase spectral plot
PIE CHART                   GR-CO Generate pie chart
PLOT                        GR-CO Generate plot of var &/or func
POISSON PPCC PLOT           GR-CO Generate Poisson prob plot corr coef plot
POISSON PROBABILITY PLOT    GR-CO Generate Poisson probability plot
... PPCC PLOT               GR-CO Generate prob plot corr coef plot (9 fam)
PPCC PLOT                   GR-CO Generate (Tukey lambda) prob plot cc pl
... PROBABILITY PLOT        GR-CO Generate probability plot (24 dist)
```

PRODUCT PLOT	GR-CO Generate product (vs. subset) plot
PROFILE PLOT	GR-CO Generate profile plot (multivar anal)
PROPORTION PLOT	GR-CO Generate proportion (vs. subset) plot
QUADRATURE SPECTRAL PLOT	GR-CO Generate quadrature spectral plot
QUANTILE-QUANTILE PLOT	GR-CO Generate quantile-quantile plot
... QUARTILE PLOT	GR-CO Generate lower/upper quart (vs. subset) plot
R CHART	GR-CO Generate range control chart plot
RANGE CONTROL CHART	GR-CO Generate range control chart
RANGE PLOT	GR-CO Generate range (vs. subset) plot
RELATIVE SD PLOT	GR-CO Generate relative st. dev. (vs. subset) plot
ROOTOGRAM	GR-CO Generate rootogram
RUN SEQUENCE PLOT	GR-CO Generate run sequence plot
RUNS PLOT (FUTURE)	GR-CO Generate runs plot
S CHART	GR-CO Generate st. dev. control chart plot
SEMI-CIRULAR PROB PLOT	GR-CO Generate semi-circ. probability plot
SINE AMPLITUDE PLOT	GR-CO Generate sine amplitude (vs. subset) plot
SINE FREQUENCY PLOT	GR-CO Generate sine freq. (vs. subset) plot
SKEWNESS PLOT	GR-CO Generate skewness (vs. subset) plot
... SPECTRAL PLOT	GR-CO Generate auto-, cross-, etc spectral plot)
SPECTRAL PLOT	GR-CO Generate (auto-) spectral plot
STAN DEVI OF THE MEAN PLOT	GR-CO Generate sd of mean (vs. subset) plot
STAN DEVI CONTROL CHART	GR-CO Generate stan. dev. control chart
STANDARD DEVIATION PLOT	GR-CO Generate standard dev (vs. subset) plot
STAR PLOT	GR-CO Generate star plot (multivar anal)
STEM-AND-LEAF DIAGRAM	GR-CO Generate stem-and-leaf diagram
SUM PLOT	GR-CO Generate sum (vs. subset) plot
SYMMETRY PLOT	GR-CO Generate a symmetry plot
T PPCC PLOT	GR-CO Generate t prob plot corr coef plot
T PROBABILITY PLOT	GR-CO Generate t probability plot
TAGUCHI SN PLOT	GR-CO Gen Tag. (target) sig/noi (vs. subset) plot
TAGUCHI SNL PLOT	GR-CO Gen Tag. (large) sig/noi (vs. subset) plot
TAGUCHI SNS PLOT	GR-CO Gen Tag. (small) sig/noi (vs. subset) plot
TAGUCHI SN2 PLOT	GR-CO Gen Tag. (target2) sig/noi (vs. subset) plot
TRIANGULAR PROB PLOT	GR-CO Generate triangular probability plot
TRIMMED MEAN PLOT	GR-CO Generate trimmed mean (vs. subset) plot
TUKEY LAMBDA PPCC PLOT	GR-CO Generate Tukey lambda prob plot cc plot
TUKEY LAMBDA PROB PLOT	GR-CO Generate Tukey lambda probability plot
U CHART	GR-CO Generate U control chart
UNIFORM PROBABILITY PLOT	GR-CO Generate uniform probability plot
UPPER HINGE PLOT	GR-CO Generate upper hinge (vs. subset) plot
UPPER QUARTILE PLOT	GR-CO Generate upper quartile (vs. subset) plot
VARIANCE OF THE MEAN PLOT	GR-CO Generate var. of mean (vs. subset) plot
VARIANCE PLOT	GR-CO Generate variance (vs. subset) plot
WEIBULL PLOT	GR-CO Generate Weibull plot
WEIBULL PPCC PLOT	GR-CO Generate Weibull prob plot corr coef plot

```
WEIBULL PROBABILITY PLOT     GR-CO Generate Weibull probability plot
WINDSORIZED MEAN PLOT        GR-CO Generate Winsorized mean (vs. subset) plot

YOUDEN PLOT                  GR-CO Generate Youden plot

XBAR CHART                   GR-CO Generate xbar (= mean) control chart plot

3-D PLOT                     GR-CO Generate 3-dimensional plot of var &/or func
4-PLOT                       GR-CO Generate 4-plot univariate analysis plot
```

Word Chart/Schematics Commands

AMPLIFIER	WC-CO Draw an amplifier
AND	WC-CO Draw an and box
ANGLE	WC-CO Set angle for TEXT strings
ANGLE UNITS	WC-CO Define angle units for ANGLE command
ARC	WC-CO Draw an arc
ARROW	WC-CO Draw an arrow
BACKGROUND COLOR	WC-CO Set color of background after next ERASE
BOX	WC-CO Draw a box
CAPACITOR	WC-CO Draw a capacitor
CASE	WC-CO Set case of letters (UPPER, LOWER)
CH	WC-CO Activate and read cross-hair (0 to 100)
CIRCLE	WC-CO Draw a circle
COLOR	WC-CO Set color of TEXT letters (RED, BLUE, etc)
COPY	WC-CO Copy the current scr onto local hardcopier
CR	WC-CO Set automatic carriage return after TEXT
CRLF	WC-CO Set auto carr return/line feed after TEXT
CROSS-HAIR (or CH)	WC-CO Activate and read cross-hair (0 to 100)
CUBE	WC-CO Draw a cube
DIAMOND	WC-CO Draw a diamond
DRAW	WC-CO Draw a line
ELLIPSE	WC-CO Draw an ellipse
ERASE	WC-CO Erase the current screen
FILL	WC-CO Set fill switch (ON/OFF) for TEXT figure
FONT	WC-CO Set font for letters (TRIPLEX, COMPLEX, etc)
GROUND	WC-CO Darw a ground
HEIGHT	WC-CO Set height of letters (0 to 100)
HEXAGON	WC-CO Draw a hexagon
HORIZONTAL SPACING	WC-CO Set horiz. spacing between char (0 to 100)
HW	WC-CO Set height and width of letters
INDUCTOR	WC-CO Draw an inductor
JUSTIFICATION	WC-CO Set justif of text (LEFT, CENTER, RIGHT)
LATTICE	WC-CO Draw a lattice
LF	WC-CO Set automatic line feed after TEXT
LINE THICKNESS	WC-CO Set thickness of lines (0 to 100)

LINES	WC-CO Set line type for figures (SOLID, DOT, etc)
MARGIN	WC-CO Set posit (0 to 100) for carr ret after TEXT
MOVE	WC-CO Move to a point
NAND	WC-CO Draw a nand box
NOR	WC-CO Draw a nor box
OR	WC-CO Draw an or box
OVAL	WC-CO Draw an oval
POINT	WC-CO Draw a point
PROMPT	WC-CO Set switch (ON/OFF) for prompt
PYRAMID	WC-CO Draw a pyramid
REGION FILL	WC-CO Set fill switch (ONXX/OFF) for reg (& 3d)
RESISTOR	WC-CO Draw a resistor
RING BELL	WC-CO Ring the bell
SEMI-CIRCLE	WC-CO Draw a semi-circle
SPACING	WC-CO Set spacing (equal/proportional) for TEXT
SPIKE COLOR	WC-CO Set color for spikes
SPIKE PATTERN	WC-CO Set line pattern for spikes
SPIKE THICKNESS	WC-CO Set thickness for spikes
TEXT	WC-CO Write out text
THICKNESS	WC-CO Set thickness of TEXT letters (0 to 100)
TRIANGLE	WC-CO Draw a triangle
VERTICAL SPACING	WC-CO Set vert. spacing between lines (0 to 100)
WIDTH	WC-CO Set width of letters (0 to 100)

Analysis Commands

ANOVA	AN-CO Perform analysis of variance
CONFIDENCE LIMITS MEAN	AN-CO Compute confidence limits for mean
EXACT ... RATIONAL FIT	AN-CO Perform exact rational function fit
... FIT	AN-CO Perform lst sq lin/poly/multilin/non-lin fit
LET	AN-CO Define var & param; calc stat; roots/dif etc
LET FUNCTION	AN-CO Define & operate on func; differentiate
LOWESS SMOOTH	AN-CO Perform locally-weighted scat. plot smoothin
MEDIAN POLISH	AN-CO Perform analysis of variance
ORTHOGONAL FIT [FUTURE]	AN-CO Carry out a least squares orthogonal fit
... PRE-FIT	AN-CO Perform pre-fit analysis for starting values
RUNS	AN-CO Carry out runs analysis
... SMOOTH	AN-CO Perform smoothing of equi-spaced data
... SPLINE FIT	AN-CO Perform spline fit
SUMMARY	AN-CO Compute summary statistics
T TEST	AN-CO Carry out 1- or 2-sample t test
TABULATE	AN-CO Tabulate counts of distinct values of a var
TABULATE COUNTS	AN-CO Tabulate counts of var 1 based on var 2
TABULATE MEANS	AN-CO Tabulate means of var 1 based on var 2
TABULATE RANGES	AN-CO Tabulate ranges of var 1 based on var 2
TABULATE SD	AN-CO Tabulate st. devs. of var 1 based on var 2
YATES ANALYSIS	AN-CO Carry out Yates analysis of 2**k design

Plot Control Commands

ARROW ... COLOR	PC-CO Set colors for arrows on plots
ARROW ... COORDINATES	PC-CO Set location of arrows on plots
BACKGROUND COLOR	PC-CO Set color of background (= inside frame)
BAR	PC-CO Set switch (ON/OFF) for bars on plots
BAR BASE	PC-CO Set base location for bars on plots
BAR BORDER COLOR	PC-CO Set color of border on bars
BAR BORDER LINE	PC-CO Set line type for border on bars
BAR BORDER THICKNESS	PC-CO Set thickness of border on bars
BAR DIMENSION	PC-CO Set bar dimension to 2d or 3d
BAR DIRECTION	PC-CO Set bar dirction (H/V)
BAR FILL	PC-CO Set switch (ONXX/OFF) for bar fill subregion
BAR FILL COLOR	PC-CO Set (background) color of bar fill
BAR PATTERN	PC-CO Set type of pattern for bar fill
BAR PATTERN COLOR	PC-CO Set line color in bar fill pattern
BAR PATTERN LINE	PC-CO Set pattern line type within bars
BAR PATTERN LINE TYPE	PC-CO Set line type in fill pattern
BAR PATTERN SPACING	PC-CO Set line spacing in bar fill pattern
BAR PATTERN THICKNESS	PC-CO Set line thickness in bar fill pattern
BAR WIDTH	PC-CO Set width for bars on plots
BELL	PC-CO Set automatic pre-plot bell (ON/OFF)
BOX ... COLOR	PC-CO Set colors for box frame on plots
BOX ... COORDINATES	PC-CO Set location of boxes on plots
CHARACTERS	PC-CO Set plot character types (X, SQUARE, etc)
CHARACTER ANGLE	PC-CO Set angle (in deg) for characters on plot
CHARACTER COLORS	PC-CO Set colors for characters on plots
CHARACTER FILL	PC-CO Set fill switch (ON/OFF) for char. on plot
CHARACTER HW	PC-CO Set height & width for characters on plot
CHARACTER JUSTIFICATION	PC-CO Set justification for characters on plot
CHARACTER OFFSET ...	PC-CO Set offset (displacement) for char on plot
CHARACTER SIZES	PC-CO Set size (height) for characters on plot
CHARACTER WIDTH	PC-CO Set width for characters on plots
EYE COORDINATES	PC-CO Set eye position for 3-dimensional plot
...FRAME	PC-CO Set switch (ON/OFF) for frames on plots
...FRAME COLOR	PC-CO Set colors for frame on plots
FRAME COORDINATES	PC-CO Set plot frame location and shape
GRID COLOR	PC-CO Set color for grid on plots
GRID PATTERN	PC-CO Set line type for grid on plots
...GRID	PC-CO Set swch. (ON/OFF) for (major) grid on plots
HARDCOPY	PC-CO Set auto copy of plots to loc hdcpy (ON/OFF)

...LABEL	PC-CO Set labels at sides & bottom of plot
...LABEL COLOR	PC-CO Set colors for labels on plots
...LABEL SIZE	PC-CO Set size (height) for labels on plots
LEGEND ...	PC-CO Set text for plot legends
LEGEND ... COLOR	PC-CO Set color for legends on plots
LEGEND ... COORDINATES	PC-CO Set plot legend positioning
LEGEND ... SIZE	PC-CO Set size (height) for legends on plots
LEGEND HW --	PC-CO Set legend height & width
...LIMITS	PC-CO Set limits (min and max) for plot frame
LINE COLORS	PC-CO Set colors for lines (plots & figures)
LINE THICKNESS	PC-CO Set thicknesses of lines (plots & figures)
LINES	PC-CO Set line types (SOLID, DOT, etc.) on plots
...LOG	PC-CO Set switch (ON/OFF) for log scale on plots
MAJOR ...TIC NUMBER	PC-CO Set number of major tics on plots
MARGIN COLOR	PC-CO Set color of margin (= outside frame)
...MAXIMUM	PC-CO Set maxima to appear on plot frame
...MINIMUM	PC-CO Set minima to appear on plot frame
MINOR ...TIC NUMBER	PC-CO Set number of minor tics on plots
MINOR GRID	PC-CO Set switch (ON/OFF) for minor grid on plots
MULTIPLOT	PC-CO Set number of rows & columns for multiplot
MULTIPLOT COORDINATES	PC-CO Change default global coor. for MULTIPLOT
ORIGIN COORDINATES	PC-CO Set reference origin for 3-dimensional plot
PEDESTAL HEIGHT	PC-CO Set height for 3-d pedestal
PRE-ERASE	PC-CO Set switch (ON/OFF) for auto-erase bef plots
PRE-SORT	PC-CO Set automatic pre-plot sort (ON/OFF)
PREPLOT	PC-CO Set graphics device for pre-plot strings
SEGMENT ... COLOR	PC-CO Set colors for line segments on plots
SEGMENT ... COORDINATES	PC-CO Set location of line segments on plots
SEQUENCE	PC-CO Set auto-seq-numbering for plots (ON/OFF)
SPIKE	PC-CO Set switch (ON/OFF) for spikes on plots
SPIKE BASE	PC-CO Set base location for spikes on plots
SPIKE DIRECTION	PC-CO Set spike direction (H/V)
SPIKE LINE	PC-CO Set line types for spikes on plots
...TIC	PC-CO Set existence (ON/OFF) for tic marks
...TIC COLOR	PC-CO Set color of tic marks on plots
...TIC LABEL	PC-CO Set switch (ON/OFF) for tic mark labels
...TIC LABEL COLOR	PC-CO Set color for tic mark labels
...TIC LABEL CONTENTS	PC-CO Specify (alphabetic) contents for tic labels
...TIC LABEL DECIMALS	PC-CO Set number of decimals for plot tic labe
...TIC LABEL FORMAT	PC-CO Set format (alpha, exp, etc) for tic labels
...TIC LABEL HW	PC-CO Set height/width of tic labels
...TIC LABEL SIZE	PC-CO Set tic mark label size (= height)
...TIC POSITION	PC-CO Set plot tic mark position (in/out/thru)
...TIC SIZE	PC-CO Set plot tic mark size
TIC LABEL DECIMALS	PC-CO Set number of decimals for tic labels
TIC LABEL HW	PC-CO Set tic label height & width

TITLE	PC-CO Set title at top of plot
TITLE COLOR	PC-CO Set color for title on plots
TITLE SIZE	PC-CO Set plot title size (height)
VISIBLE [future]	PC-CO Set 3-d bkgrd lines visibility (ON/OFF)
...WEIBULL SCALE	PC-CO Set scale for plots to be Weibull
WINDOW COORDINATES	PC-CO Set graphics region coor. (0 to 100)

Graphics Output Device Commands

BATCH	GD-CO Set dev 1 to 130-char alpha dev
DEVICE ...	GD-CO Set dev 1/2/3 manufacturer
DEVICE ... COLOR	GD-CO Set dev 1/2/3 color (ON/OFF)
DEVICE ... PICTURE POINTS	GD-CO Set dev 1/2/3 num of pic pts
DEVICE ... POWER	GD-CO Set dev 1/2/3 power (ON/OFF)
DEVICE ... TEKTRONIX 4010	GD-CO Set dev 1/2/3 to Tekt 4010 class
DEVICE ... TEKTRONIX 4014	GD-CO Set dev 1/2/3 to Tekt 4014 class
DEVICE ... TEKTRONIX 4105	GD-CO Set dev 1/2/3 to Tekt 4105 class
DEVICE ... TEKTRONIX 4662	GD-CO Set dev 1/2/3 to Tekt 4662
DEVICE ... REGIS	GD-CO Set dev 1/2/3 to DEC REGIS class
DEVICE ... HP-GL	GD-CO Set dev 1/2/3 to HP-GL class
DEVICE ... HP 2623	GD-CO Set dev 1/2/3 to HP 2623
DEVICE ... HP 7221	GD-CO Set dev 1/2/3 to HP 7221
DEVICE ... GENERAL	GD-CO Set dev 1/2/3 to dev-indep
DEVICE ... GENERAL CODED	GD-CO Set dev 1/2/3 to coded dev-indep
DISCRETE	GD-CO Set dev 1 to 70-char alpha dev
GENERAL	GD-CO Set dev 1 to device-indep
GENERAL (CODED)	GD-CO Set dev 1 to coded device-indep
HP-GL	GD-CO Set dev 1 to HP-GL class
HP 2623	GD-CO Set dev 1 to HP 2623
HP 7221	GD-CO Set dev 1 to HP 7221
PICTURE POINTS (or PP)	GD-CO Set dev 1 num of pict pts
REGIS	GD-CO Set dev 1 to DEC Regis class
TEKTRONIX 4010	GD-CO Set dev 1 to Tekt 4010 class
TEKTRONIX 4014	GD-CO Set dev 1 to Tekt 4014 class
TEKTRONIX 4105	GD-CO Set dev 1 to Tekt 4105 class
TEKTRONIX 4662	GD-CO Set dev 1 to Tekt 4662

Input/Output Commands

COLUMN LIMITS	IO-CO Set col limts for READ & SERIAL READ
END OF DATA	IO-CO Define end data for READ & SERIAL READ
PRINT	IO-CO Write (terminal/file) var, param, func
READ	IO-CO Read variables
READ FUNCTION	IO-CO Read 1 line of functions (= READ STRING)
READ MATRIX	IO-CO Read in a matrix
READ PARAMETER	IO-CO Read one line of parameters.
READ STRING	IO-CO Read one line of strings (= READ FUNCTION)
ROW LIMITS	IO-CO Set row limts for READ and SERIAL READ
SERIAL READ	IO-CO Read variables serially
SKIP	IO-CO Set num of header lines to skip for READ
WRITE	IO-CO Write (terminal/file) var, param, func
WRITE " "	IO-CO Write (terminal/file) a literal text string

Support Commands

ANOP LIMITS	SU-CO Set limits for region in ANOP Plot
APPEND	SU-CO Append one var to end of another var
BAUD RATE	SU-CO Set baud rate
BUGS	SU-CO List known bugs
BYE	SU-CO Exit from DATAPLOT (= EXIT, STOP, etc.)
CALL	SU-CO Execute a DATAPLOT subprgm from file
*CAPTURE	SU-CO Divert/Capture text output to a file.
CLASS ...LOWER	SU-CO Spec. first class lower lim for HISTOGRAM
CLASS ...UPPER	SU-CO Spec. last class upper lim for HISTOGRAM
CLASS ...WIDTH	SU-CO Set class width for HISTOGRAM
COMMENT	SU-CO Insert a comment line in code
CREATE	SU-CO Create a subprogram
CURSOR COORDINATES	SU-CO Set cursor coor loc after PLOT, ERASE, etc
CURSOR SIZE	SU-CO Set cursor size after a plot
DEFINE	SU-CO Define general ASCII string commands
DEFINE POSTHELP	SU-CO Define terminal string to succeed HELP
DEFINE PREHELP	SU-CO Define terminal string to precede HELP
DEGREES	SU-CO Set degrees for trig calculations (ON/OFF)
DELETE	SU-CO Delete var or elements of a var
DEMODULATION FREQUENCY	SU-CO Set frequency for COMP DEMOD ... PLOT
DIMENSION	SU-CO Set dimensions of internal data storage
ECHO	SU-CO Set auto echo of command lines (ON/OFF)
END	SU-CO Exit from DATAPLOT (= STOP, EXIT, etc.)
*END OF CAPTURE	SU-CO End CAPTURing of output to a file.
END OF CREATE	SU-CO End CREATion of a subprogram
END OF IF	SU-CO Define end of condit-executed commands
END OF LOOP	SU-CO Terminate a loop
ERASE DELAY	SU-CO Set delay factor for ERASE
EXIT	SU-CO Exit from DATAPLOT (= STOP, END, etc.)
EXPERT	SU-CO Invoke expert subsystem
EXTEND	SU-CO Extend one var by (attaching) another var
FEEDBACK	SU-CO Allow/suppress feedback printing (ON/OFF)
FENCE	SU-CO Set fence switch (ON/OFF) for BOX PLOT
FILTER WIDTH	SU-CO Set filter width for SMOOTH
FIT ITERATIONS	SU-CO Set upper bound on iterations for FIT
FIT POWER>>PRE-FIT	SU-CO Set fit criterion power for PRE-FIT
FIT STANDARD DEVIATION	SU-CO Set lower bound on res sd for FIT
GRADS	SU-CO Set grads for trig calculations (ON/OFF)
HALT	SU-CO Exit from DATAPLOT (= STOP, END, etc.)
HARDCOPY DELAY	SU-CO Set delay factor for hardcopy

*Added after Jan. 1989. Available in all versions higher than 89.1.

```
HELP                        SU-CO Print short documentation for a command
HOST                        SU-CO Set host computer

IF                          SU-CO Define start of condit-executed commands
IMPLEMENT                   SU-CO Activ local chg to DTPLT. implement. (obs)

KNOTS                       SU-CO Set knots variable for SPLINE

LIST                        SU-CO List last 20 (or more) commands entered
LIST ...                    SU-CO List contents of a file
LIST CONCLUSIONS            SU-CO List DATAPLOT's Conclusions file
LIST DEFINITIONS            SU-CO List current user-defined definit (DEFINE)
LIST DICTIONARY             SU-CO List DATAPLOT's Dictionary file
LIST DIRECTORY              SU-CO List DATAPLOT's Directory (= Master) file
LIST SAVE                   SU-CO List current Saved-Commands file (SAVE)
LOOP                        SU-CO Initiate a loop
LOWESS PROPORTION           SU-CO Set 0 to 100% width for lowess smooth
LOWESS WIDTH                SU-CO Set absolute width for lowess smooth

MAIL                        SU-CO Print message from DATAPLOT service org

NAME                        SU-CO Assign (equate) additional names to a var
NEGATE                      SU-CO Set switch (ON/OFF) to negate vert. plot
NEWS                        SU-CO Print general news from DATAPLOT service org


PAUSE                       SU-CO Stop execution (of a macro) until CR entered
POLYNOMIAL DEGREE           SU-CO Set degree of polynomial in smoothing; (obs)
PRINTING                    SU-CO Allow/suppress analysis printing (ON/OFF)
PROBE                       SU-CO Examine code settings (used by implementor)
PROPORTION LIMITS           SU-CO Set limits for region in Proportion Plot

QUERY                       SU-CO Send query line to DATAPLOT consultant file
QUIT                        SU-CO Exit from DATAPLOT (= STOP, END, etc.)

R                           SU-CO Re-execute one previous command
RADIANS                     SU-CO Set radians for trig calculations (ON/OFF)
RENAME                      SU-CO Assign a different name to a variable
REPEAT (or R)               SU-CO Re-execute one previous command
RESET                       SU-CO "Zero-out" all var, param, func, etc
RESTORE MEMORY              SU-CO Restore all saved var/param/func from file
RETAIN                      SU-CO Retain var or elements of a var
ROOT ACCURACY               SU-CO Set accuracy for ROOT subcommand under LET

SAVE                        SU-CO Save selected LISTed commands
SAVE MEMORY                 SU-CO Save all var/param/func to file
SEARCH                      SU-CO Search a file for all occurrances of string
SEARCH DICTIONARY           SU-CO Srch DATAPLOT Dict. file for all occ of str
SEARCH DIRECTORY            SU-CO Srch DATAPLOT Direc. file for all occ of str
SEARCH1                     SU-CO Search file for 1st occurrance of string
SEARCH1 DICTIONARY          SU-CO Srch DATAPLOT Dict. file for 1st occ of str
SEARCH1 DIRECTORY           SU-CO Srch DATAPLOT Direc. file for 1st occ of str
```

SEED	SU-CO	Set seed for random number generators
SET	SU-CO	Specify settings for certain commands
SHOW READ FORMAT	SU-CO	Show current format for (fast) READ
STATUS	SU-CO	Print status of lines, char, var, par
STOP	SU-CO	Exit from DATAPLOT (= EXIT, END, etc.)
TERMINATOR CHARACTER	SU-CO	Set character to terminate commands
TRANSLATE	SU-CO	Define auto-translation of any graphics
TRIGONOMETRIC UNITS	SU-CO	Set trigonometric units
WEIGHTS	SU-CO	Set weights variable for FIT, PRE-FIT, etc
.	SU-CO	Insert a comment line in code
/	SU-CO	Re-execute SAVEd commands.

Reserved Words

AND	RESW	Used with PLOT, etc for multi-trace plot
AUTOMATIC	RESW	Set a switch to "automatic" position
B...	RESW	Params with comput. WEIBULL PLOT percent pts
CONCLUSIONS	RESW	Symbolic name for DATAPLOT's Conclus. file
DEMODF	RESW	Param with updated demod freq. (COMP DEMOD)
DEFAULT	RESW	Set a switch to "default" position
DEMODF	RESW	Param with updated complex demodulation freq
DICTIONARY	RESW	Symb name for DATAPLOT's Dictionary file
DIRECTORY	RESW	Symb name for DP's Directory (= Master) file
EXCEPT	RESW	Qualifier denoting excepted subset
FOR	RESW	Qualifier denoting elts or var of interest
I	RESW	Var denoting dummy index; used in FOR
INFINITY	RESW	Parameter with value "infinity"
LOFCDF	RESW	Param with lack of fit cdf val from FIT, etc
MASTER	RESW	Symb name for DP's Directory (= Master) file

OFF	RESW	Set a switch to "off" position
ON	RESW	Set a switch to "on" position
PI	RESW	Parameter with value 3.1415926
PRED	RESW	Var with predicted values from FIT, etc
REPDF	RESW	Param with rep deg of freedom from FIT etc
REPSD	RESW	Param with replic. sd from FIT, ANOVA, etc
RES	RESW	Var with residuals from FIT, ANOVA, etc
RESDF	RESW	Param with res deg of freedom from FIT etc
RESSD	RESW	Param with res sd from FIT, ANOVA, etc
SAVE	RESW	Symbolic name for DTPLT SAVEd-command file
SUBSET	RESW	Qualifier denoting subset of interest
*TAGPLOT	RESW	Var with trace identifier for last multiple-trace plot
TO	RESW	Set interval of values within a variable
VERSUS	RESW	Used with PLOT, etc for multi-trace plot
VERTICALLY	RESW	Rotate contents (but not frame) of plot
WRT	RESW	"With respect to"; used in LET for roots etc
*XPLOT	RESW	Var with horizontal axis value from last plot
*X2PLOT	RESW	Var with 2nd horizontal axis value from last 3-D plot
*YPLOT	RESW	Var with vertical axis value from last plot
()	RESW	Set math/Greek char in TEXT, LABEL, etc.
;	RESW	Terminator character for a command
<	RESW	"Less than"
<=	RESW	"Less than or equal to"
<>	RESW	"Not equal to"
=	RESW	"Equal"; used in FIT, PRE-FIT, FOR, etc
>	RESW	"Greater than"
>=	RESW	"Greater than or equal to"
...	RESW	Continue command onto next line.

*Added after Jan. 1989. Available in all versions 89.1 and higher.

Subcommands Under LET Command

AUTOCORRELATION	SC-LE Compute sample autocorrelation
AUTOCOVARIANCE	SC-LE Compute sample autocovariance
BETA RANDOM NUMBERS	SC-LE Generate beta random num.
BINOMIAL RANDOM NUMBERS	SC-LE Generate binomial random num.
BIWEIGHT	SC-LE Compute biweight transform. for robust fitti
CAUCHY RANDOM NUMBERS	SC-LE Generate Cauchy random num.
CHI-SQUARED RANDOM NUMBERS	SC-LE Generate chi-squared random num.
CODE	SC-LE Code the elements in a variable
CODE...	SC-LE Carry out binary, quartile,... coding
CODE2	SC-LE Carry out binary coding
CODE4	SC-LE Carry out quartile coding
CODE8	SC-LE Carry out octile coding
COMPLEX ADDITION	SC-LE Carry out complex addition
COMPLEX CONJUGATE	SC-LE Carry out complex conjugate
COMPLEX DIVISION	SC-LE Carry out complex division
COMPLEX EXPONENTIATION	SC-LE Carry out complex exponentiation
COMPLEX MULTIPLICATION	SC-LE Carry out complex multiplication
COMPLEX ROOTS	SC-LE Compute complex roots
COMPLEX SQUARE ROOT	SC-LE Carry out complex square root
COMPLEX SUBTRACTION	SC-LE Carry out complex subtraction
CONVOLUTION	SC-LE Compute convolution of elts in 2 var
CORRELATION	SC-LE Compute sample correlation
COVARIANCE	SC-LE Compute sample covariance
CUMULATIVE INTEGRAL	SC-LE Compute cum. integrals of elts in a var
CUMULATIVE PRODUCT	SC-LE Compute cum. products of elts in a var
CUMULATIVE SUM	SC-LE Compute cum. sums of elts in a var
DATA	SC-LE Generate a set of data values
... DECILE	SC-LE Compute decile
DERIVATIVE	SC-LE Compute derivative of a function
DISTINCT	SC-LE Extract distinct elements from a var
DOUBLE EXPO RANDOM NUMBER	SC-LE Generate double exponential random num.
EXPONENTIAL RANDOM NUMBERS	SC-LE Generate exponential random num.
EXTR VALUE 1 RANDOM NUMBERS	SC-LE Generate extreme value type 1 ran num
EXTR VALUE 2 RANDOM NUMBERS	SC-LE Generate extreme value type 2 ran num
F RANDOM NUMBERS	SC-LE Generate F random num.
FFT	SC-LE Compute fast Fourier transform
FIBONNACCI NUMBERS	SC-LE Generate Fibonnacci numbers
FOURIER TRANSFORM	SC-LE Compute Fourier transform
FOURTH CENTR MOME	SC-LE Compute sample 4th central moment
FRACTAL (future)	SC-LE Compute values of fractal curve

FREQUENCY	SC-LE Compute frequencies of distinct values
GAMMA RANDOM NUMBERS	SC-LE Generate gamma random num.
GEOMETRIC RANDOM NUMBERS	SC-LE Generate geometric random num.
HALFNORMAL RANDOM NUMBERS	SC-LE Generate halfnormal random num.
INTEGRAL	SC-LE Compute definite integral of a function
INTEGRAL	SC-LE Compute integral of elements in a var
INTERPOLATION	SC-LE Compute (cubic spline) interpolated values
INVERSE FFT	SC-LE Compute inverse fast Fourier transform
INVERSE FOURIER TRANSFORM	SC-LE Compute inverse Fourier transform
KURTOSIS	SC-LE Compute sample kurt (stand 4th cent mom)
LOGICAL AND	SC-LE Carry out logical and
LOGICAL IFF	SC-LE Carry out logical iff
LOGICAL IFTHEN	SC-LE Carry out logical ifthen
LOGICAL NAND	SC-LE Carry out logical nand
LOGICAL NOR	SC-LE Carry out logical nor
LOGICAL NOT	SC-LE Carry out logical not
LOGICAL OR	SC-LE Carry out logical or
LOGICAL XOR	SC-LE Carry out logical xor
LOGISTIC RANDOM NUMBERS	SC-LE Generate logistic random num.
LOGNORMAL RANDOM NUMBERS	SC-LE Generate lognormal random num.
LOWER HINGE	SC-LE Compute sample lower hinge
LOWER QUARTILE	SC-LE Compute sample lower quartile
MATRIX ADDITION	SC-LE Carry out matrix addition
MATRIX COFACTOR	SC-LE Compute matrix cofactor
MATRIX DEFINITION	SC-LE Set matrix definition
MATRIX DETERMINANT	SC-LE Compute matrix determinant
MATRIX EIGENVALUES	SC-LE Compute matrix eigenvalues
MATRIX EIGENVECTORS	SC-LE Compute matrix eigenvectors
MATRIX EUCLIDEAN NORM	SC-LE Compute matrix Euclidean norm
MATRIX INVERSE	SC-LE Compute matrix inverse
MATRIX MINOR	SC-LE Compute matrix minor
MATRIX MULTIPLICATION	SC-LE Carry out matrix multiplication
MATRIX NUMBER OF COLUMNS	SC-LE Compute matrix number of columns
MATRIX NUMBER OF ROWS	SC-LE Compute matrix number of rows
MATRIX SIMPLEX SOLUTION	SC-LE Compute matrix simplex solution
MATRIX SOLUTION	SC-LE Compute matrix solution
MATRIX SPECTRAL NORM	SC-LE Compute matrix spectral norm
MATRIX SPECTRAL RADIUS	SC-LE Compute matrix spectral radius
MATRIX SUBMATRIX	SC-LE Define matrix submatrix
MATRIX SUBTRACTION	SC-LE Carry out matrix subtraction
MATRIX TRACE	SC-LE Compute matrix trace
MATRIX TRANSPOSE	SC-LE Compute matrix transpose
MAXIMUM	SC-LE Compute sample maximum
MEAN	SC-LE Compute sample mean
MEDIAN	SC-LE Compute sample median
MIDMEAN	SC-LE Compute sample midmean

MIDRANGE	SC-LE	Compute sample midrange
MINIMUM	SC-LE	Compute sample minimum
NEGATIVE BINO RANDOM NUMBERS	SC-LE	Generate negative binomial random num.
NORMAL ORDER STAT MEDIANS	SC-LE	Generate normal order statistic medians
NORMAL RANDOM NUMBERS	SC-LE	Generate normal N(0,1) random num.
*NUMBER	SC-LE	Compute number of observations in a var
PARETO RANDOM NUMBERS	SC-LE	Generate Pareto random num.
PATTERN	SC-LE	Generate a patterned seq within a var
POISSON RANDOM NUMBERS	SC-LE	Generate Poisson random num.
POLYNOMIAL ADDITION	SC-LE	Carry out polynomial addition
POLYNOMIAL DIVISION	SC-LE	Carry out polynomial division
POLYNOMIAL EVALUATION	SC-LE	Carry out polynomial evaluation
POLYNOMIAL MULTIPLICATION	SC-LE	Carry out polynomial multiplication
POLYNOMIAL SQUARE	SC-LE	Carry out polynomial square
POLYNOMIAL SUBTRACTION	SC-LE	Carry out polynomial subtraction
PRIME NUMBERS	SC-LE	Generate prime numbers
PRINCIPLE COMPONENTS	SC-LE	Gen matrix of prin. comp.
PRIN COMP EIGENVECTORS	SC-LE	Gen matrix of prin. comp. eigenvectors
PRIN COMP EIGENVALUES	SC-LE	Gen matrix of prin. comp. eigenvalues
... PRIN COMP	SC-LE	Gen a specific prin. comp.
... PRIN COMP EIGENVEC	SC-LE	Gen a specific prin. comp. eigenvector
... PRIN COMP EIGENVAL	SC-LE	Gen a specific prin. comp. eigenvalue
PRODUCT	SC-LE	Compute product of elements in a var
RANGE	SC-LE	Compute sample range
RANK	SC-LE	Rank the elements in a variable
RANK CORRELATION	SC-LE	Compute sample rank correlation
RANK COVARIANCE	SC-LE	Compute sample rank covariance
RELATIVE STANDARD DEVIATION	SC-LE	Compute sample relative stand dev
ROOTS	SC-LE	Compute roots of a function
RUNGE-KUTTA	SC-LE	Compute Runge-Kutta diff. eq. solution
SEMI-CIRC RANDOM NUMBERS	SC-LE	Generate semi-circular random num.
SEQUENCE	SC-LE	Generate a sequence within a var
SEQUENTIAL DIFFERENCE	SC-LE	Compute seq. differences of elts in a var
SET CARDINALITY	SC-LE	Compute set cardinality
SET CARTESIAN PRODUCT	SC-LE	Carry out set cartesian product
SET COMPLEMENT	SC-LE	Carry out set complement
SET DISTINCT	SC-LE	Extract distinct elements of a set
SET INTERSECTION	SC-LE	Carry out set intersection
SET UNION	SC-LE	Carry out set union
SIZE	SC-LE	Compute sample size (number of observ)
SKEWNESS	SC-LE	Compute sample skew (stand 3rd cent mom)
SORT	SC-LE	Sort the elements in a variable
SORTC	SC-LE	Sort elem in 1 var & carry another var
STANDARD DEVI OF THE MEAN	SC-LE	Compute standard deviation of the mean
STANDARD DEVIATION	SC-LE	Compute sample standard deviation
SUM	SC-LE	Compute sum of elements in a variable
T RANDOM NUMBERS	SC-LE	Generate t random num.
THIRD CENTRAL MOME	SC-LE	Compute sample third central moment

*Added after Jan. 1989. Available in all versions 89.1 and higher.

```
TRIANGULAR RANDOM NUMBERS   SC-LE Generate triangular random num.
TRICUBE                     SC-LE Compute tricube transform. for robust fittin
TRIWEIGHT                   SC-LE Compute tricube transform. for robust fittin
TUKEY LAMBDA RANDOM NUMBERS SC-LE Generate Tukey lambda random num.

UNIFORM ORDER STAT MEDIANS  SC-LE Generate uniform order statistic medians
UNIFORM RANDOM NUMBERS      SC-LE Generate uniform (0,1) random num.
UPPER HINGE                 SC-LE Compute sample upper hinge
UPPER QUARTILE              SC-LE Compute sample upper quartile

VARIANCE                    SC-LE Compute sample variance
VECTOR ADDITION             SC-LE Carry out vector addition
VECTOR ANGLE                SC-LE Compute vector angle
VECTOR DISTANCE             SC-LE Compute vector distance
VECTOR DOT PRODUCT          SC-LE Carry out vector dot product
VECTOR LENGTH               SC-LE Compute vector length
VECTOR SUBTRACTION          SC-LE Carry out vector subtraction

WEIBULL ADJUSTED RANKS      SC-LE Generate adj. ranks for Weibull analysis
WEIBULL RANDOM NUMBERS      SC-LE Generate Weibull random numbers
WEIGHTED MEAN               SC-LE Compute sample weighted mean
WEIGHTED RANGE              SC-LE Compute sample weighted range
WEIGHTED SD                 SC-LE Compute sample weighted st. dev.
```

Subcommands Under SET Command

```
FOURIER EXPONENT            SC-SE Set Fourier exponent

HELP LINES                  SC-SE Set number of lines/screen for HELP
IO                          SC-SE Set IO source for menu macros
IPR                         SC-SE Set log unit num for printed output
IRD                         SC-SE Set log unit num for input
LIST LINES                  SC-SE Change number of commands for LISTing
PREPLOT                     SC-SE Define gr dev for PREPLOT/POSTPLOT str
READ FORMAT                 SC-SE Set format for (fast) READ
SUBSTITUTION CHARACTER      SC-SE Define alternate substitution char (for \)
WRITE DECIMALS              SC-SE Set num. decimals for WRITE output
```

Library Functions

ABS(X)	FUNC	Compute absolute value
ARCCOS(X)	FUNC	Compute arccosine
ARCCOSH(X)	FUNC	Compute hyperbolic arccosine
ARCCOT(X)	FUNC	Compute arccotangent
ARCCOTH(X)	FUNC	Compute hyperbolic arccotangent
ARCCSC(X)	FUNC	Compute arccosecant
ARCCSCH(X)	FUNC	Compute hyperbolic arccosecant
ARCSEC(X)	FUNC	Compute arcsecant
ARCSECH(X)	FUNC	Compute hyperbolic arcsecant
ARCSIN(X)	FUNC	Compute arcsine
ARCSINH(X)	FUNC	Compute hyperbolic arcsine
ARCTAN(X)	FUNC	Compute arctangent
ARCTANH(X)	FUNC	Compute hyperbolic arctangent
BESS0(X)	FUNC	Compute Bessel func 1st kind & order 0
BESS1(X)	FUNC	Compute Bessel func 1st kind & order 1
CHEB0(X)	FUNC	Compute Chebychev poly 1st kind & ord 0
CHEB1(X)	FUNC	Compute Chebychev poly 1st kind & ord 1
CHEB2(X)	FUNC	Compute Chebychev poly 1st kind & ord 2
CHEB3(X)	FUNC	Compute Chebychev poly 1st kind & ord 3
CHEB4(X)	FUNC	Compute Chebychev poly 1st kind & ord 4
CHEB5(X)	FUNC	Compute Chebychev poly 1st kind & ord 5
CHEB6(X)	FUNC	Compute Chebychev poly 1st kind & ord 6
CHEB7(X)	FUNC	Compute Chebychev poly 1st kind & ord 7
CHEB8(X)	FUNC	Compute Chebychev poly 1st kind & ord 8
CHEB9(X)	FUNC	Compute Chebychev poly 1st kind & ord 9
CHEB10(X)	FUNC	Compute Chebychev poly 1st kind & ord 10
CHSCDF(X,NU)	FUNC	Compute chi-squared cumulative dist func
CHSPDF(X,NU)	FUNC	Compute chi-squared prob density func
CHSPPF(P,NU)	FUNC	Compute chi-squared percent point func
COS(X)	FUNC	Compute cosine
COSH(X)	FUNC	Compute hyperbolic cosine
COT(X)	FUNC	Compute cotangent
COTH(X)	FUNC	Compute hyperbolic cotangent
CSC(X)	FUNC	Compute cosecant
CSCH(X)	FUNC	Compute hyperbolic cosecant
DECOCT(X)	FUNC	Compute decimal to octal conversion
DIM(X,YU)	FUNC	Compute positive difference-- x-min(x,y)
ERF(X)	FUNC	Compute error function
ERFC(X)	FUNC	Compute complementary error function
EXP(X)	FUNC	Compute exponential func

```
FCDF(X,NU1,NU2)          FUNC  Compute F cumulative dist func
FPDF(X,NU1,NU2)          FUNC  Compute F probability density func
FPPF(P,NU1,NU2)          FUNC  Compute F percent point function
FRACT(X)                 FUNC  Compute fractional portion

GAMMA(X)                 FUNC  Compute gamma function

IND(X,TAG)               FUNC  Compute (0-1) indicator function
INT(X)                   FUNC  Compute integer portion

LN(X)                    FUNC  Compute logarithm (natural)
LOG(X)                   FUNC  Compute logarithm (natural)
LOG10(X)                 FUNC  Compute logarithm (base 10)
LOG2(X)                  FUNC  Compute logarithm (base 2)
LOGGAMMA(X)              FUNC  Compute log (to the base e) gamma func
LSD(X)                   FUNC  Compute least significant digit

MAX(X,Y)                 FUNC  Compute maximum
MIN(X,Y)                 FUNC  Compute minimum
MOD(X,Y)                 FUNC  Compute modulo

NORCDF(X)                FUNC  Compute normal N(0,1) cumulative dist func
NORPDF(X)                FUNC  Compute normal N(0,1) prob density func
NORPPF(P)                FUNC  Compute normal N(0,1) percent point func

OCTDEC(X)                FUNC  Compute octal to decimal conversion

ROUND(X,N)               FUNC  Compute rounded value (to N dec. places)

SEC(X)                   FUNC  Compute secant
SECH(X)                  FUNC  Compute hyperbolic secant
SIGN(X)                  FUNC  Compute sign
SIN(X)                   FUNC  Compute sine
SINH(X)                  FUNC  Compute hyperbolic sine
SQRT(X)                  FUNC  Compute square root

TAN(X)                   FUNC  Compute tangent
TANH(X)                  FUNC  Compute hyperbolic tangent
TCDF(X,NU)               FUNC  Compute t cumulative dist func
TPDF(X,NU)               FUNC  Compute t probability density func
TPPF(P,NU)               FUNC  Compute t percent point function

WEICDF(X,GAMMA)          FUNC  Compute Weibull cum distribution func
WEIPDF(X,GAMMA)          FUNC  Compute Weibull prob density func
WEIPPF(P,GAMMA)          FUNC  Compute Weibull percent point function
```

Characters & Symbols

ALPH()	CH/SY Write/draw Greek alpha
APPR()	CH/SY Write/draw approximatly equal to
ARRD()	CH/SY Write/draw arrow pointing down
ARRL()	CH/SY Write/draw arrow pointing left
ARRR()	CH/SY Write/draw arrow pointing right
ARRU()	CH/SY Write/draw arrow pointing up
BAR()	CH/SY Write/draw bar
BARH()	CH/SY Write/draw horizontal bar
BARV()	CH/SY Write/draw vertical bar
BASL()	CH/SY Write/draw backslash
BETA()	CH/SY Write/draw Greek beta
BRAD()	CH/SY Write/draw larger radical
BREV()	CH/SY Write/draw breve
BS() <make work>	CH/SY Move 1 backspace
CARA()	CH/SY Write/draw carot
CHI()	CH/SY Write/draw Greek chi
CINT()	CH/SY Write/draw circular integral
CIRC()	CH/SY Write/draw circle
CUBE()	CH/SY Write/draw cube
DAGG()	CH/SY Write/draw dagger
DARR()	CH/SY Write/draw down arrow
DDAG()	CH/SY Write/draw double dagger
DEL()	CH/SY Write/draw vector product
DELT()	CH/SY Write/draw Greek delta
DIAM()	CH/SY Write/draw diamond
DIVI()	CH/SY Write/draw division
DOTP()	CH/SY Write/draw dot product
DVBA()	CH/SY Write/draw double vertical bar
ELEM()	CH/SY Write/draw is an element of
EPSI()	CH/SY Write/draw Greek epsilon
EQUI()	CH/SY Write/draw equivalence
ETA()	CH/SY Write/draw Greek eta
GAMM()	CH/SY Write/draw Greek gamma
GT()	CH/SY Write/draw greater than
GTEQ()	CH/SY Write/draw greater than or equal to
HASP()	CH/SY Move a half-space
HAT()	CH&SY Write/draw hat (= high carat)
HBAR()	CH/SY Write/draw horizontal bar

```
IASP()          CH/SY Write/draw inverted nasp
INFI()          CH/SY Write/draw infinity
INTE()          CH/SY Write/draw integral
INTR()          CH/SY Write/draw intersection
IOTA()          CH/SY Write/draw Greek iota

KAPP()          CH/SY Write/draw Greek kappa

LACC()          CH/SY Write/draw left accent
LAMB()          CH/SY Write/draw Greek lambda
LAPO()          CH/SY Write/draw left apostrophe
LARR()          CH/SY Write/draw left arrow
LBRA()          CH/SY Write/draw left bracket
LC()            CH/SY Shift to lower case
LCBR()          CH/SY Write/draw left curly bracket
LELB()          CH/SY Write/draw left elbow
LHBA()          CH/SY Write/draw long horizontal bar
LQUO()          CH/SY Write/draw left quote
LRAD()          CH/SY Write/draw large radiacal
LT()            CH/SY Write/draw less than
LTEQ()          CH/SY Write/draw less than or equal to
LVBA()          CH/SY Write/draw long vertical bar

MU()            CH/SY Write/draw Greek mu

NASP()          CH/SY Write/draw nasp
NOT=()          CH/SY Write/draw not equal
NU()            CH/SY Write/draw Greek nu

OMEG()          CH/SY Write/draw Greek omega
OMIC()          CH/SY Write/draw Greek omicon

PARA()          CH/SY Write/draw paragraph
PART()          CH/SY Write/draw partial derivative
PHI()           CH/SY Write/draw Greek phi
PI()            CH/SY Write/draw Greek pi
PRIM()          CH/SY Write/draw prime
PROD()          CH/SY Write/draw product
PSI()           CH/SY Write/draw Greek psi
PYRA()          CH/SY Write/draw pyramid

RACC()          CH/SY Write/draw right accent
RADI()          CH/SY Write/draw radical
RAPO()          CH/SY Write/draw right apostrophe
RARR()          CH/SY Write/draw right arrow
RBRA()          CH/SY Write/draw right bracket
RCBR()          CH/SY Write/draw right curly bracket
RELB()          CH/SY Write/draw right elbow
RHO()           CH/SY Write/draw Greek rho
RQUO()          CH/SY Write/draw right quote

SIGM()          CH/SY Write/draw Greek sigma
```

```
SQUA()                  CH/SY Write/draw square
STAR()                  CH/SY Write/draw star
SUB()                   CH/SY Shift to subscript
SUBS()                  CH/SY Write/draw subset
SUMM()                  CH/SY Write/draw summation
SUP()                   CH/SY Shift to superscript
SUPE()                  CH/SY Write/draw superset

TAU()                   CH/SY Write/draw Greek tau
THET()                  CH/SY Write/draw Greek theta
THEX()                  CH/SY Write/draw there exists
THFO()                  CH/SY Write/draw therefore
TILD()                  CH/SY Write/draw tilda
TIME()                  CH/SY Write/draw times sign
TRIA()                  CH/SY Write/draw triangle
TRII()                  CH/SY Write/draw inverted triangle

UARR()                  CH/SY Write/draw up arrow
UC()                    CH/SY Shift to upper case
UNIO()                  CH/SY Write/draw union
UNSB()                  CH/SY Shift to un-subscript
UNSP()                  CH/SY Shift to un-superscript
UPSI()                  CH/SY Write/draw Greek upsilon

VALU()                  CH/SY Write actual value of succeeding param
VARI()                  CH/SY Write/draw varies
VBAR()                  CH/SY Write/draw vertical bar

XI()                    CH/SY Write/draw Greek xi

ZETA()                  CH/SY Write/draw Greek zeta

+-()                    CH/SY Write/draw + or -
-+()                    CH/SY Write/draw - or +
^                       CH/SY Write actual value of succeed. param or str
```

Arguments for CHARACTERS Comm.

ARROWD	AR-CH Set plot character to arrow down
ARROWU	AR-CH Set plot character to arrow up
BLANK	AR-CH Set plot character to blank
BOX PLOT	AR-CH Set all plot characters for BOX PLOT
BUILT-IN CHAR/SYMBOL (ANY)	AR-CH All b-i char/sym may be used for plot char
CIRCLE	AR-CH Set plot character to circle
CONTROL CHART	AR-CH Set all plot characters for CONTROL CHART
CUBE	AR-CH Set plot character to cube
DIAMOND	AR-CH Set plot character to diamond
I PLOT	AR-CH Set all plot characters for I PLOT
KEYBOARD CHARACTER (ANY)	AR-CH All keybd char may be used for plot char
PYRAMID	AR-CH Set plot character to pyramid
REVTRI	AR-CH Set plot character to reverse triangle
SQUARE	AR-CH Set plot character to square
STAR	AR-CH Set plot character to star
TRIANGLE	AR-CH Set plot character to triangle
TUFTE BOX PLOT	AR-CH Set all plot characters for TUFTE BOX PLOT
VB	AR-CH Set plot character to vertical bar

Arguments for LINES Command

BLANK	AR-LI Set line type to blank (= none)
BOX PLOT	AR-LI Set all plot lines for BOX PLOT
CONTROL CHART	AR-LI Set all plot lines for CONTROL CHART
DASH1	AR-LI Set line type to dashed type 1
DASH2	AR-LI Set line type to dashed type 2
DASH3	AR-LI Set line type to dashed type 3
DASH4	AR-LI Set line type to dashed type 4
DASHED	AR-LI Set line type to dashed
DOTTED	AR-LI Set line type to dotted
I PLOT	AR-LI Set all plot lines for I PLOT
SOLID	AR-LI Set line type to solid
TUFTE BOX PLOT	AR-LI Set all plot lines for TUFTE BOX PLOT

Arguments for FONT Command

COMPLEX	AR-FO Set font to complex
COMPLEX SCRIPT	AR-FO Set font to complex script
DUPLEX	AR-FO Set font to duplex
SIMPLEX	AR-FO Set font to simplex
SIMPLEX SCRIPT	AR-FO Set font to simplex script
TEKTRONIX	AR-FO Set font to Tektronix
TRIPLEX	AR-FO Set font to triplex
TRIPLEX ITALIC	AR-FO Set font to triplex italic

Appendix D

Prolog and *DATAPLOT*

Service Contacts

Appendix D Section 1 - *Prolog* Service Contacts

The expert system PDA (v. 92.2) described in this document was coded in LPA PROLOG Professional (version 1.4, Standard Lisp-like syntax), which is a copyrighted product of the Logical Programming Associates, London, U.K., and was marketed in the United States under the name of micro-PROLOG. A complete listing of the expert system PDA code is given in Appendix B. In the introductory chapter of the micro-Prolog version 1.4 Manual [Ref. 25], McCabe et al wrote

> *"LPA PROLOG Professional (i.e., micro-PROLOG) is both powerful and flexible, with an optimising compiler and matching interpreter. It supports programming in both its Standard, Lisp-like syntax and in the Edinburgh syntax used in many mainframe systems.*
>
> *"Standard syntax is ideal for writing programs that manipulate themselves or other programs as data because it treats programs and data alike as a single data type - the list. Furthermore, its meta-level power is unequalled because programs can be written with PROLOG variables in place of predicate names, argument lists, individual goals or even an entire clause body. Provided the variable has been instantiated by the time of the call, the program will run correctly.*
>
> *"Edinburgh syntax is far richer, but at the same time more restrictive, because terms and lists are of different types, and goals, argument lists and bodies cannot be represented in source code by PROLOG variables."*

Between March 1987 and June 1991, the version number of micro-PROLOG rose from 1.4 to 3.0. According to reliable information, a major change occurred at around version 2.0 when the language dropped its support for Standard syntax and went solely for the Edinburgh syntax. The U.S. distributor of the Prolog products was also changed and the current one is:

Qunitus Corporation	Tel. (415) 813-3800.
2100 Geng Road	(800) 542-1283.
Palo Alto, CA 94303	Fax: (415) 494-7608.
Sales Contact:	Carrie Biondi DuBois (415-813-3828).
Technical Support:	Ken Crawbuck (415-813-3811).

The Prolog products are available across PC DOS, Macintosh, UNIX, VAX/VMS, IBS/MVS, and IBM/VM platforms. The basic DOS Prolog Compiler (version 3.0) adheres to the Edinburgh syntax and lists for $595. The old version 1.4, which supports both the Standard and the Edinburgh syntax, is neither available for sale nor eligible for technical support.

Appendix D Section 2 - *DATAPLOT* Contact

DATAPLOT is a R&D statistical analysis software program prototype developed by the National Institute of Standards and Technology (NIST). The program is Fortran 77-based and is portable on all major mainframes, minis, workstations, and 386SX/386/486 personal computers (PCs).

To obtain additional information on DATAPLOT, write to

Statistical Engineering Division
National Institute of Standards & Technology
Room A337, Admin. Bldg.
Gaithersburg, MD 20899
Tel. 301-975-2839

Index of

85 DATAPLOT Commands used in Tutorials 6.1 to 6.14

Note: **Bold face** *denotes first occurrence.*

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NIST
Computing & Applied Mathematics Laboratory
Gaithersburg, MD 20899

U.S. Department of Energy
Office of Nuclear Energy
Office of Nuclear Energy Self-Assessment
Washington, DC 20585

10. SUPPLEMENTARY NOTES

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

A personal computer (PC)-based expert system is developed as a front end to commercially-available MS-DOS-based software and a public-domain statistical package named DATAPLOT (v92.2). Coded in micro-PROLOG (v.1.4), the expert system PDA is designed to (1) facilitate the analysis of the so-called performance indicator data by the technical staff of the Office of Nuclear Energy (NE), U.S. Department of Energy (DoE); (2) enhance the analysis and database management capability of an engineer or scientist through a series of tutorial exercises; and (3) encourage the modification of the Prolog code of PDA or the English-based codes of the DATAPLOT macros by users interested in customizing the system for new or proprietary applications. To achieve these objectives, the system includes three special features: (i) A temporary exit to access any MS-DOS-based packages such as LOTUS 1-2-3, etc. (ii) More than twenty built-in DATAPLOT macros for a user to obtain, at a single key stroke, simple plots such as histograms, pie charts, Pareto charts, C-charts (count charts), P-charts (proportion charts), lag plots, autocorrelation plots, box plots, scatter plots, etc., as well as statistical tests to identify data distributions such as normal, lognormal, uniform, logistic, exponential, Cauchy, Poisson, Gamma, Beta, Weibull, extreme value types I and II, and binomial. (iii) A direct access to DATAPLOT for users to write their own macros to conduct a full-range of tests, analysis, and experimental design. The minimum requirements of the PC computing environment for running PDA are: 80386SX-16 CPU, 8/16-MHz, 2MB-RAM, 40MB-Hard disk, math-coprocessor, 1.44-MB 3.5" or 1.2-MB 5.25" high density floppy drive, MS-DOS 3.3, and a properly installed version of DATAPLOT (v. 92.2).

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

artificial intelligence; computational mathematics; data analysis; DATAPLOT; engineering expert system; expert system; micro-PROLOG; nuclear energy; PC-computing; performance indicator; statistical engineering

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