

USER'S GUIDE TO

FLEX

FLEXIBLE MEMBRANE LINER ADVISORY
EXPERT SYSTEM

VERSION 3.0

Prepared by:

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1

USER EVALUATION FORM

Mail to:

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We hope that you've enjoyed using FLEX and would appreciate if you would take a few minutes to fill out and return this evaluation form. Your specific responses will help us refine and improve the system.

1. What kind of problems did you have, if any, in installing the system?

2. Did you experience difficulties in using the system? If so, what were they and under what circumstances did they occur?

3. Were the onscreen directions clear and accurate? If not, where specifically could they be improved?

4. Were you able to print out your work without difficulty? If not, what kinds of problems did you experience?

5. Please write any additional comments:

Name

Organization

Street

City

 State

 Zip

Phone

 Date

DISCLAIMER

The system described herein was developed under contract for the United States Environmental Protection Agency. A review of this system by the Agency has yet to be completed. Information obtained through the use of this system should not be presumed to represent U.S. EPA policy and no official endorsement should be inferred. This system is not a substitute for review of EPA Method 9090 data or RCRA Part B applications by authorized regulatory personnel.

TECHNICAL SUPPORT

If you encounter a problem in using FLEX, version 3.0, we suggest that you first review the relevant part of this user's guide. If after doing so, you continue to have difficulty, please contact Expert System Software Support:

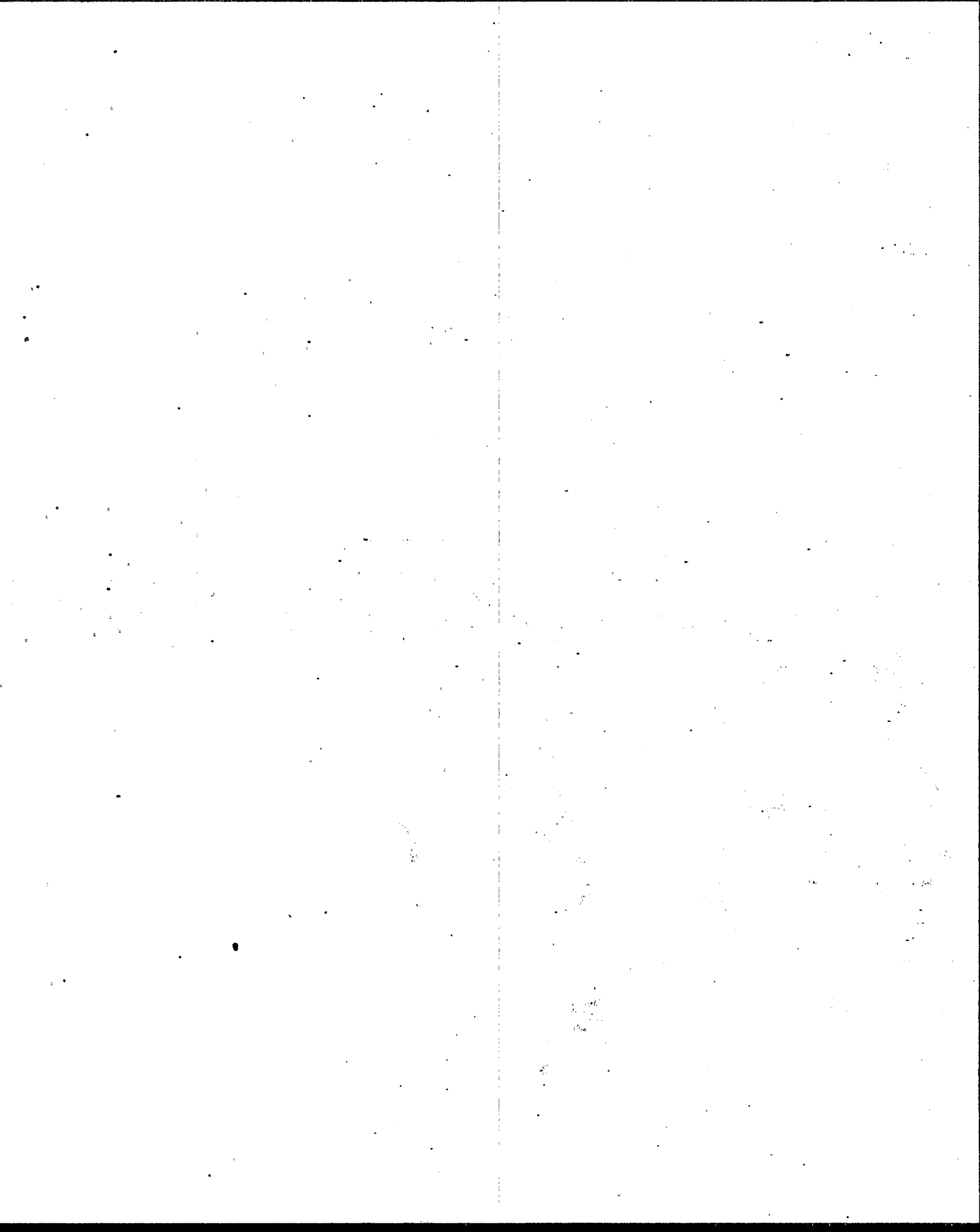
Daniel Greathouse
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26 W Martin Luther King Dr.
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(513) 569-7885 or FTS 684-7885

When you call, be prepared to describe the specific system operation and the history of responses to the system during the run which led to the problem experienced.

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1.0 INTRODUCTION

1.1 EPA Method 9090 and FLEX

FLEX, short for Flexible Liner Evaluation eXpert, is a computer program that assists in the interpretation of data from EPA Method 9090 tests. The U.S. Environmental Protection Agency uses Method 9090 as the standard test for determining the chemical compatibility of flexible membrane liners used in solid waste containment applications. In testing Method 9090, a portion of the liner is immersed in actual or synthesized leachate for 120 days. The leachate's composition is representative of the chemical composition which the liner is expected to encounter in the containment application. Various physical properties are measured prior to immersion and at 30 day intervals throughout the 120 day immersion period. Changes and trends in the data are then analyzed to determine whether the leachate has interacted with the liner in any way that could compromise the liner's integrity as a containment barrier. For example, if the analysis identifies an increase in the weight of a sample after immersion, this could indicate that leachate has been absorbed by the liner, rendering the liner unfit for the proposed installation.

The FLEX system (see Figure 1-1 for FLEX flowchart) uses artificial intelligence techniques to analyze selected EPA Method 9090 test results. The program's design enables the system to quickly run the 9090 test data through a large number of rules representing conventional liner standards. It then generates a report detailing data omissions, inconsistencies, and any indications that the liner may be unsuitable for containment of the test leachate or a chemically similar substance. This system can analyze data for three common flexible membrane liner materials:

- * High Density Polyethylene (HDPE)
- * Polyvinyl Chloride (PVC)
- * Reinforced Chlorosulfonated Polyethylene (CSPE-R)

The FLEX system is designed to run on an IBM PC AT or compatible computer. "Option menus" and on-screen instructions are displayed at turning points throughout the program, guiding the user every step of the way (please refer to 6.0 Sample Flex Session for screen representations). These "Option menus" present sets of available procedures that can be selected directly from the menu screen. Each menu screen provides instructions detailing the available options and the keystrokes required to execute them. Only a basic familiarity with the computer keyboard is needed to run the program. The operator should, however, have an understanding of EPA Method 9090 test procedures.

The FLEX system is a useful tool for reviewing EPA Method 9090 test results. It should be noted that the program is designed to provide assistance to those responsible for evaluating Method 9090 test results. Under no circumstances should the recommendations of FLEX be considered absolute; especially in the case that the system finds no problems with the test results. FLEX is not a substitute for a review of the test results by a human professional. Rather, FLEX is a screening tool geared for use by those familiar with flexible membrane liner testing and EPA Method 9090. The system can rapidly scan data sets and pinpoint inconsistencies in the test data and test results which suggest that the liner is

FLEX FLOW CHART

with LINER PARAMETERS

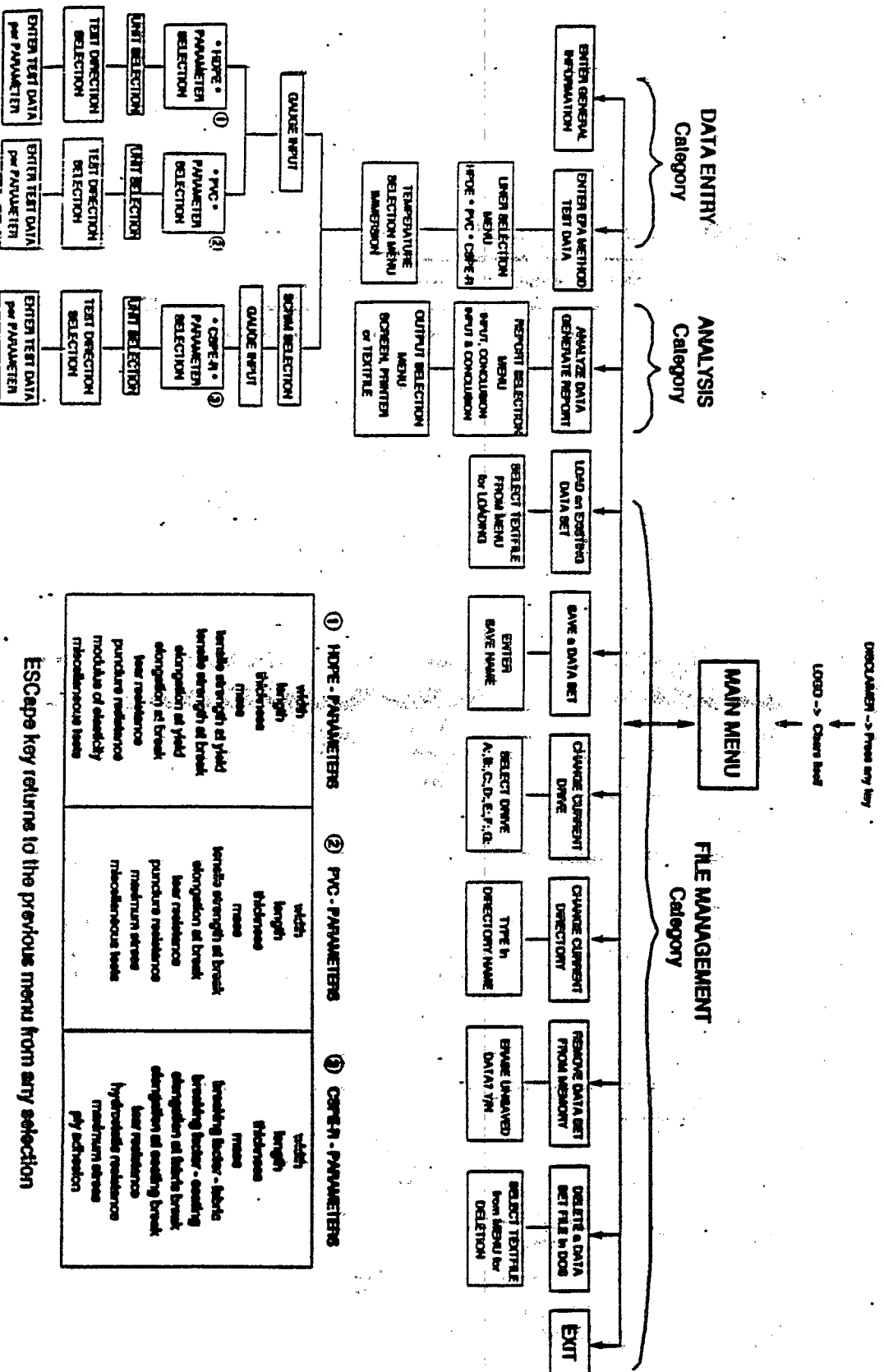


Figure 1-1

substandard or incompatible with the expected waste composition. In addition, the conclusion report can be used as a supporting document in the decision process when the reviewer concurs with the rational proposed by the system. In these capacities, FLEX can save time, reduce oversights, and enhance the consistency of Method 9090 test reviews.

1.2 Hardware Requirements

In order for the FLEX system to run on your computer, your machine must contain certain components and be configured properly. The following components are necessary in order to run FLEX:

- An IBM Personal Computer AT or compatible
- A minimum of 640K bytes of RAM memory
- only 1.2m disk drive
- DOS version 3.0 or higher
- A fixed disk drive with at least 1.5 megabytes of free space
- Optionally, a printer configured as system device PRN

NOTE: Although your computer may have 640K bytes of memory, memory resident programs in the CONFIG.SYS or the AUTOEXEC.BAT files may use some of this memory. The FLEX installation program alerts you if insufficient free memory is present to start the system.

1.3 Contents of the FLEX System

In addition to this manual, the FLEX system includes one double sided, high density 5 1/4" diskette. This FLEX System Disk should contain the files:

- INSTALL.EXE
- FLEX.EXE
- SAMPLEH.FLX
- SAMPLEP.FLX
- SAMPLEC.FLX

The three .FLX files are sample files which are representative of the three liner types which are analyzed by the FLEX system - HDPE, PVC, and CSPE-R. Section 6.0 SAMPLE FLEX SESSION in this manual examines the "SAMPLEH.FLX" data set.

1.4 Installing the System

Before FLEX can be installed on a personal computer system, the system must have the necessary configuration to support the program. See section 1.2 Hardware Requirements, for a list of the necessary system components. If all of the listed components are present, you are ready to install FLEX. Simply place the FLEX System Disk in the A: diskette drive. At the DOS prompt type **A:INSTALL** then press the **Enter** key. At this point the installation routine will ask for a disk drive on which to install the system. The user should specify the identifying letter of the disk where FLEX is to reside. The default (C:) is specified simply by pressing **Enter**. The installation program will now create a subdirectory to store the FLEX program code. The default subdirectory is **\FLEX**. The default can be accepted simply by pressing **Enter** or the user may type an alternative. If you already have a version of FLEX installed on the machine, you may receive the message **Unable to create directory**. This is not a problem but signifies that the copy of the program on the fixed disk is being replaced by the version on the installation floppy. When the installation program terminates, you are ready to run FLEX. Type **FLEX** then press **Enter** to run the system.

1.5 Starting the Program

To start a FLEX session, the subdirectory that contains the FLEX files must be the current directory. The current directory is set by the DOS **CD** command. The FLEX installation routine places a batch file, **FLEX.BAT**, in the root directory of fixed disk C: which makes the FLEX directory current and initiates the program. Thus, if **C:** is in the search path, FLEX can be run from any directory simply by typing **FLEX** at the DOS prompt. This method of starting the system should work on most computers. If it does not, use the following sequence of commands to start the program:

C:	(press Enter) -- Selects the hard disk, C:
CD \FLEX	(press Enter) -- Selects the FLEX directory
FLEX	(press Enter) -- Starts running FLEX

This sequence of commands assumes that the defaults were accepted when the FLEX was installed. If the program was installed on a disk other than C: or in a directory other than **\FLEX**, substitute these parameters for the ones shown in command line one and two above. For more information on directories, the search path, and entering DOS commands, see the MS-DOS user's manual that came with your computer.

1.6 Introductory Screens

Once FLEX is started, the program immediately presents its first screen. A brief disclaimer appears. Pressing any key clears the disclaimer and produces a FLEX logo screen. This logo screen is automatically replaced after approximately three seconds or you can continue immediately to the first menu screen by pressing any key.

2.0 RUNNING THE SYSTEM

2.1 The Menuing System

Most of the information that the system needs from the user is input through the use of menus and data sheets. A menu is a list of choices, any one of which may be highlighted and selected, to perform a specific system function. When the first menu appears on the screen (the MAIN MENU), the first option listed is displayed in reverse video (dark letters on a white background). In order to select or highlight a different item, the arrow keys must be used. The right and down arrow keys move the "selector box" to the next lower item in the list. The left and up arrow keys move the "selector box" to the previous item in the list. When the desired item is selected or highlighted, press the Enter key to execute that option. As a general rule, the **ENTER** key enables you **ADVANCE** in the program and the **ESCAPE** key enables you to **RETURN** to the previous FLEX screen.

NOTE: On many keyboards, the arrow keys are shared with numbers on a special keypad. If no response is generated when the arrow keys are pressed, it may be that the NUM LOCK is on. NUM LOCK works like CAPS LOCK - it selects between two different interpretations of the same key. If NUM LOCK is on, the arrow keys are being interpreted as numeric digits rather than cursor direction keys. Simply press the NUM LOCK key to turn off this function and the selector block should now operate properly.

2.2 The MAIN MENU

The FLEX flow chart, Figure 1-1, illustrates the central role of the MAIN MENU in the program's organization. The MAIN MENU and all of the program's screens include on-screen information. The top of the MAIN MENU screen (see Figure 2-1), for instance, displays the version number of this installation and the Laboratory (RREL) and location (Cincinnati) where FLEX was developed. The bottom of the screen displays the easy-to-follow **INSTRUCTIONS** box (what to do at any given screen - CENTER), the **current directory**: that FLEX is using (please refer to 5.4 The Change current drive Option and 5.5 The Change current directory Option - LEFT) and **current data set**: information (the file you are using - RIGHT). Once a session or data set has been saved and reloaded, the MAIN MENU will display the liner type and thickness, the liners immersion temperature, and the name of the current data set or saved name.

The MAIN MENU is the program's central module from which all major commands are accessed in any order. This first functional screen presents eight commands which can be organized into three categories: **DATA ENTRY**, **ANALYSIS**, and **FILE MANAGEMENT**. Each of these categories within the MAIN MENU will be discussed in depth in forthcoming chapters in this user's guide.

The **DATA ENTRY** category includes the **Enter general information** and **Enter EPA Method 9090 test data** options. The first option, **Enter general**

information allows you to enter general information into FLEX (i.e. name, date, sitename, etc.) which will appear in the Summary Report. The second option, **Enter EPA 9090 test data**, allows you to select a liner material type, immersion test temperature, liner thickness, and then presents a **PARAMETER MENU** which contains a listing of all the characteristics of the flexible membrane liner that FLEX is programmed to analyze. After selecting a parameter and unit measurement, FLEX displays a data sheet in which the test data can be entered. For a detailed explanation of this command category refer to 3.0 **DATA ENTRY**.

FML ADVISOR, Version 3.0

RREL, USEPA

Cincinnati, Ohio

MAIN MENU	
Enter general information	
Enter EPA Method 9090 test data	
Analyze data & generate report	
Load an existing data set	
Save a data set	
Change current drive	
Change current directory	
Remove a data set from memory	
Delete a data set file from disk	
EXIT	

INSTRUCTIONS	
Use the arrow keys to highlight the desired function.	
Press Enter to execute the function.	
Select EXIT to return to DOS.	
Current directory: C:\FLEX	Current data set: none

Figure 2-1

The **ANALYSIS** category contains the **Analyze data & generate report** option, which when selected, will instruct FLEX to test the input data and generate a summary report. After selecting this command, the user has the option to select the type of information they would like to generate (input information, conclusion information, or both) and the type of output they would prefer (screen, printer, or textfile). Please refer to 4.0 **ANALYSIS** for further information.

The **FILE MANAGEMENT** category includes the remaining commands from the **MAIN MENU**: **Load an existing data set**, **Save or Create a data set**, **change current drive**, **Change current directory**, **Remove a data set from memory**, **Delete a data set file in DOS**, and **Exit**. These commands give you the flexibility to manage files or data sets more efficiently, especially when these files begin to multiply. For further information on these commands or options, please refer to 5.0 **FILE MANAGEMENT**.

3.0 DATA ENTRY

3.1 Enter General Information

While the main intent of this system is to generate a comprehensive analysis of the three FML liner's provided by FLEX, the **Enter general information** option is a valuable way to store all the additional information needed to produce a well-rounded analysis report with FLEX. It is strongly suggested that the **Enter general information** option be used as the first option when beginning a session with FLEX, unless you intend to specify a drive and directory for your FLEX data set storage (please refer to 5.4 The Change current drive Option and 5.5 The Change current directory Option), in which case you would immediately follow-up with this option. After selecting this option, a screen will appear with the following information to respond to:

- * Enter your name in the space provided:
- * Enter today's date in the space provided:
- * Enter the sitename in the space provided:
- * Enter a project I.D. in the space provided:

A blinking black cursor in a white box ("text box") will appear behind the first inquiry. You are now ready to type information into this box. Any type of text from the keyboard may be used (i.e. symbols, upper or lower-case, numbers, etc.). Each "text box" or cell on page (screen) 1 and 2 has a maximum space of 29 characters provided. When you complete typing your name into the first "text box", press the Enter key or the down-arrow key to advance to the second "text box" and so-forth. If you do not desire to enter information for a given inquiry simply skip over the "text box" by pressing the Enter key or the down-arrow key. If you want to edit a response to a "text box", use the backspace key or press the F1 key to delete it and re-type the new response. An INSTRUCTION box appears on the bottom of this screen which covers all these steps. When the Enter key is pressed in the last "text box" of a screen, a new screen will appear with more general information to respond to. The remaining screens within the **Enter general information** option are listed below:

- * Enter the name of the test laboratory:
 - * Enter the date Method 9090 test began:
 - * Enter the date Method 9090 test ended:
 - * Enter liner volatiles content (percent):
 - * Enter liner extractables content (percent):
 - * Enter liner specific gravity (ratio):
-
- * Describe liner material in detail:
 - * Describe the type of exposure tank material:
 - * Describe leachate in detail:
 - * Describe the frequency of leachate change:

- * Describe 9090 Method options that were not followed:
- * Describe incorrectly performed lab procedures:
- * Describe flaws in lab specimens:
- * Describe qualitative lab observances:

The screen format is the same on all four pages with corresponding "text boxes" for each inquiry and an INSTRUCTION box on the bottom of the screen. The same rules for entering text, skipping a "text box", editing and deleting text, and moving among "textboxes" apply, with one exception, pages 3 & 4 will now handle up to 77 characters. When all the desired information has been entered for each inquiry and the Enter key is pressed at the last "text box" of the last page, FLEX will return to the MAIN MENU.

3.2 Enter EPA Method 9090 test data

As you can see from the FLEX flowchart, Figure 1-1, the Enter EPA Method 9090 test data option is the second of the two DATA ENTRY options. This is where all pertinent liner type information is collected (via MENUS) and test results are entered.

After selecting this option, you will be asked to select from three common flexible membrane liner materials from the LINER SELECTION MENU, they are:

- * High Density Polyethylene (HDPE)
- * Polyvinyl Chloride (PVC)
- * Reinforced Chlorosulfonated Polyethylene (CSPE-R)

Note: CSPE-R is also referred to as Reinforced Hypalon.

Only one flexible membrane liner material may be selected with each FLEX session. After selecting the liner material, you will be prompted by the Temperature Selection Menu to select either Degrees Fahrenheit or Degrees Celsius for liner immersion test input. Once a temperature unit is entered, FLEX will prompt you for the immersion test temperature in the "text box" provided. A similar prompt will appear asking you to input the nominal immersion test gauge thickness (in mils) and will also provide a "text box" for this information. After this is entered, the PARAMETER SELECTION MENU (see Figure 3-1) appears and the information you have just entered i.e., liner type / scrim type (CSPE-R only) / thickness and temperature w/ degrees Fahrenheit or Celsius, appears on the left and right upper portions of the screen.

3.2.1 The Parameter Selection Menu and Data Sheets

The PARAMETER SELECTION MENU contains a list of all the characteristics of the flexible membrane liner that FLEX is programmed to analyze. The Flex flowchart, Figure 1-1, contains the parameter listings for each flexible membrane liner: HDPE, PVC, and CSPE-R. Once one of the parameters from the PARAMETER SELECTION MENU is selected a UNIT SELECTION MENU, which contains unit measurements options and/or a TEST

DIRECTION MENU containing machine & transverse options appears (please refer to Appendix A for specific parameter characteristics) and prompts you for a response. When this information is collected a data sheet is displayed for the parameter which was selected.

FML ADVISOR, Version 3.0 RREL, USEPA Cincinnati, Ohio
 Liner: HDPE (80 MILS) Temperature: 23 DEGREES CELSIUS

PARAMETER SELECTION MENU	
	width
	length
	thickness
	mass
	tensile strength at yield
	tensile strength at break
	elongation at yield
	elongation at break
	tear resistance
	puncture resistance
	modulus of elasticity
	miscellaneous tests

INSTRUCTIONS	
Use the arrow keys to highlight a parameter.	
Press Enter to select units and enter test data for that parameter.	
Press Esc to return to the main menu.	

Current directory: C:\FLEX Current data set: none

Figure 3-1

Data sheets are special screens designed for easy input of Method 9090 test results. You may enter data for the first time, or add and modify data in a partially filled data sheet. Data sets are made up of a collection of data sheets which may be loaded from the FLEX system files. Data sheets, like menus, interpret the keyboard arrow keys as instructions to move and highlight a desired cell. In data sheets, the white box or "text box" highlights the location or cell in which the test results will be entered. You select the appropriate cell on the test result data sheet with the arrow keys and type the value to be entered. The value is echoed on the top line of the screen, labeled **INPUT**. When either the Enter key or an arrow key is pressed, the entry is terminated and the number is displayed in the cell. If the entry does not represent a positive number, the cell is not filled and the **INPUT** line is replaced by the error message **ILLEGAL ENTRY! PRESS F1 TO CONTINUE**. You must press the F1 key to return to data entry mode. Once this is done you can continue to enter test data.

To change a figure existing in a data sheet, select the cell into which you want to insert the new value. The **INPUT** line will appear blank, ready to accept a new value. Type the new number and press Enter or an arrow key to fill the cell with the new value. If you want to

erase the contents of a cell without inserting a new value, select that cell and then press the F1 key. When all values have been entered for a particular data sheet (the data sheet need not be completely filled), press the **ESCAPE** key to return to the **PARAMETER SELECTION MENU**. If no more parameters are desired, press **ESCAPE** again to return to the **MAIN MENU**.

Space is provided on the sheet for five test replicas for each time period. If, however, less than five replications are reported or data for a certain time period is missing, the system will perform the analyses to the best of its ability. NSF recommends five replicates, while EPA recommends three replicates. If data for a particular parameter is insufficient to run one or more of the analyses, a message to this effect will be printed in the output report. There is no way to include more data than can be contained on a single input sheet for any parameter.

There are two different formats for data sheets, Non-Destructive and Destructive:

```

FML ADVISOR, Version 3.0      RREL, USEPA      Cincinnati, Ohio
Liner: HDPE (80 MILS)        Temperature: 23 DEGREES CELSIUS
Parameter: WIDTH              Unit: CENTIMETERS

```

INPUT: _

	CONTROL	DAY 30	CONTROL	DAY 60	CONTROL	DAY 90	CONTROL	DAY 120
1)	---	---	---	---	---	---	---	---
2)	---	---	---	---	---	---	---	---
3)	---	---	---	---	---	---	---	---
4)	---	---	---	---	---	---	---	---
5)	---	---	---	---	---	---	---	---

Type a number and press Enter to fill the highlighted cell.
 Use the arrow keys to move between cells. Press F1 to delete a cell.
 Press F10 to graph data. Press Esc to return to the parameter selection menu.
 Current directory: C:\FLEX Current data set: none

Figure 3-2

Non-Destructive is used for the parameters width, length, thickness, and mass of a liner sample (see Figure 3-2). This format has a control column (observed reference sample values) and a test column (values from sample exposed to leachate) for each of the four months of immersion. This assumes that a separate sample is used for

each time period and that the dimensions are recorded both before and after immersion. At this point, pressing the **F10** key will produce a graphic representation of the percent change between the control sample and the test sample for each column in the data sheet.

```

FML ADVISOR, Version 3.0          RREL, USEPA          Cincinnati, Ohio
Liner: HDPE (80 MILS)           Temperature: 23 DEGREES CELSIUS
Parameter: TENSILE STRENGTH AT YIELD  Unit: POUNDS/INCH OF WIDTH
  
```

INPUT: _

MACHINE DIRECTION	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	---	---	---	---	---
2)	---	---	---	---	---
3)	---	---	---	---	---
4)	---	---	---	---	---
5)	---	---	---	---	---

Type a number and press Enter to fill the highlighted cell.
 Use the arrow keys to move between cells. Press F1 to delete a cell.
 Press F10 to graph data. Press Esc to return to the test direction menu.
 Current directory: C:\FLEX Current data set: none

Figure 3-3

Destructive is used with physical property tests i.e., strengths, elongations, tear, puncture, hydrostatic resistances, elasticities, and adhesions (see Figure 3-3). This format has a single control column and a test column for each of the four months of immersion. The difference in formats is necessary because physical property tests are destructive and a sample can be measured only once. Changes in physical properties must be referenced to the average of control samples. Like the non-destructive format above, the same capability to produce graphs is provided by pressing the **F10** key. These graphs will be calculated by the actual values in the test data for each of the parameter types listed above.

4.0 ANALYSIS

4.1 Data Analysis and Report Generation

The **Analyze Data and Generate Report** option of the **MAIN MENU** is used to perform an analysis of Method 9090 test results previously entered into parameter data sheets (see section 3.3 for information on FLEX data sheets). The analysis subsystem consists of two menus, a "rule base", and a data browser. When this option is activated from the **MAIN MENU**, the system first checks for data in the data sheets. If no results have been entered into any of the data sheets, no analysis can be performed. The system displays a message to this effect, and control is returned to the **MAIN MENU**. If, however, this option is selected and data has been entered, the **REPORT SELECTION MENU** and the **OUTPUT SELECTION MENU** appear respectively. The operation of these menus is described in two subsequent sections of this chapter. After the **REPORT SELECTION** option is made, FLEX begins to assemble the output report. General information is listed in the output whenever it has been entered (please refer to 3.1 Enter General Information for description of fields). Input data, conclusion text, or both are listed as options in the output report according to the choice made at the **REPORT SELECTION MENU**. Likewise, the destination of the output report is determined by the choice made at the **OUTPUT SELECTION MENU**. As can be seen, the output report generated by the system can take a variety of forms depending upon user preferences specified via these two menus.

4.1.1 Report Selection Menu

This menu allows the user to specify the type of output desired:

- * Output the input data
- * Output the conclusion
- * Output input data & conclusion

"Input data" refers to the values within each parameter data sheet. These values are included in the output report, if and only the first or third option is chosen at the **REPORT SELECTION MENU**. The "conclusion" refers to the collection of text that results from applying the input data to the "rule base" (please refer to Section 4.2 Conclusion Generation and the Rule Base, for an explanation of the function and operation of the FLEX system rule bases). The conclusion text is included in the output, if and only the second or third option is chosen at the **REPORT SELECTION MENU**.

Pressing **Esc** at the **REPORT SELECTION MENU** returns control to the **MAIN MENU**.

4.1.2 Output Selection Menu

This menu allows the user to specify the destination of the output report. Available options are:

- * Display the output report on the screen
- * Print the output report on system printer
- * Save the output report as a text file

The **Display the output report on the screen** option presents the output report to the user on the computer video display. General information and input data, if present, are displayed in the output window. The user is prompted to press a key in order to move from one screen to the next. The output report is displayed in the data browser. The data browser is a window which allows the user to scroll backward and forward through the output report using the up and down arrow keys or the PgUp (page up) and PgDn (page down) keys. PgUp and PgDn scroll the text a full page in the specified direction. Pressing **Esc** while in the browser will return you to the **OUTPUT SELECTION MENU**.

The **Print the output report on system printer** option sends the conclusion text to the system printer (DOS device PRN). If for some reason, the printer is not ready to accept information (not turned on, out of paper, etc.), the FLEX system will display an error message and give the user a chance to correct the problem. Alternatively, the user may press **Esc** to cancel the print command and return to the **OUTPUT SELECTION MENU**.

The **Save the output report as a text file** option allows the user to save the output report to a disk file in ASCII format. ASCII is the code used by DOS to store text. Also, most word processors have the ability to read ASCII files. Thus by saving the output report to disk, it can be edited and/or inserted into other documents (for example, a response to the applicant). This option provides a method to save the text of an analysis. Note that this saves only the text of the output report and not the structure of the data sheets that were input to generate the conclusion. Section 5.2 describes how to save a Method 9090 data set so that it can be reloaded at a later time for modification or further analyses. When the user selects this option, FLEX prompts for a file name. The name entered must be a legal DOS file specification. Legal file names are described in the MS-DOS user's guide. If the file name specified already exists, the system will prompt the user to verify that the file is to be overwritten or optionally allow the user to change the specified file name. The extension **.OUT** will automatically be concatenated to the file name you create but should not be specified when saving the output report as a text file.

Pressing **Esc** at the **OUTPUT SELECTION MENU** will return the system to the **REPORT SELECTION MENU**.

4.2 Conclusion Generation and the Rule Base

Although FLEX can be used simply as a record keeping system for Method 9090 test results, the primary benefit of using the system is to allow the computer to perform a rapid screening of the test results in order to reduce oversights and increase review consistency. To accomplish this FLEX contains a number of rules which specify what may be unacceptable changes in liner properties in the context of Method 9090 testing. When a

conclusion is requested via the **REPORT SELECTION MENU**, one of three sets of rules is selected based upon the liner material type specified in the **LINER SELECTION MENU**. The test results are first checked for compliance with applicable National Sanitation Foundation standards (please refer to **APPENDIX C - LINER NSF STANDARDS**). Next, rules are applied to see if changes in the reported test values exceed reasonable limits as determined through interviews with liner manufacturing and testing experts. If changes in the test values for a specific parameter are found to be within these limits of variation, then values produced by a quadratic regression of the data are checked against another set of limits to determine if there is a trend toward an excessive change in a parameter. In addition, data is checked for both completeness and consistency. The rules which incorporate these data checks (per liner type) are shown in the form of a flowchart in Appendix E.

The results of these quantitative analyses are subsequently expanded into English descriptions. These descriptions are then concatenated into a report which details any failure of the data to meet the listed criterion. In addition, justifications are provided to explain how this interpretation of the given data was reached and why this condition may or may not indicate a potential for failure of the liner system. This conclusion is optionally combined with General Information and Input Data and reported according to the option selected in the **OUTPUT SELECTION MENU**.

5.0 FILE MANAGEMENT

5.1 Organizing and Managing Your Data Sets with FLEX

The remaining seven choices provided by the **MAIN MENU** are the; **Load an existing data set**, **Save a data set**, **Change current drive**, **Change current directory**, **Remove a data set from memory**, **Delete a data set file from DOS**, and **EXIT** options. These functions enable the user to effectively manage sets of Method 9090 test results. Thus, the information entered in a FLEX session can be stored on and reloaded from a selected disk drive and directory of your choosing. In this way, results of a test need not be completely entered at one sitting. In addition, the reviewer can backup test results for future reference.

5.2 The Load existing data set Option

When **Load an existing data set** is executed, a menu of the available data files is presented. This menu differs from the other menus described in this manual in that it displays up to six columns of choices as opposed to a single column. However, the process of using the arrow keys and the Enter key to move the selection block and choose the desired option is the same i.e., use the arrow keys to move the highlight block to the desired data set name and press Enter to load the data. FLEX data sets are distinguished from other files in the directory by their **.FLX** extension. Normally, only files created by the FLEX **Save a data set** option should have this extension. After data is loaded, control is returned to the **MAIN MENU** and the user has the option of performing any operation exactly as if the data had been entered from the keyboard.

5.3 The Save data set Option

The **Save a data set** option creates a disk file which contains a copy of the Method 9090 data currently in use. Note that this function saves only the input data and not the text of the conclusion. The analysis must be re-run in order to obtain the conclusion from a saved data set. When this option is executed, the system will prompt for the name of the data set. This name should consist of up to eight characters each of which is either an alphabetic letter or a numeric digit. If more than eight characters are entered, only the first eight are used. Specifically, this creates a file in the current directory of the current disk with this name and a **.FLX** extension (this extension should not be specified when saving the current data set). In this way, the current data set can be referenced in the future without re-entering the test results. If a data set with the specified name already exists, FLEX will ask you to verify that this file should be overwritten. If you respond **YES**, the data in memory will be transferred to this file and the previous contents of the file will be lost. If you respond **NO**, FLEX gives the user another opportunity to enter the data set name. A complete explanation of file names and extensions is provided in the MS-DOS user's guide.

5.4 The Change current drive Option

The **Change current drive** option allows you to communicate directly with DOS from within FLEX and is an excellent way for you to organize your data set files. Selecting this option at the beginning of a FLEX session, and then selecting a drive from the **Drive Selection Menu**, will allow you to save your data sets to and load your data sets from either floppy disk (A: or B:) or a hard drive (C:, D:, E:, F: G:) supported by your computer. Because your data sets will only be saved to the current directory of these drives, you may follow-up this option with the **Change current directory** option (please refer to 5.5) to further refine and personnalize the "location" of your saved data sets via a directory.

5.5 The Change current directory Option

The **Change current directory** option should be used in conjunction with the **Change current drive** option (except for the default C: drive where this option can be selected directly from the **MAIN MENU**) to direct your data set to a directory of your choice. In order for this option to function, the directory you are saving your data set to or loading it from must already have been created in DOS. When you begin a session with FLEX and select your drive via the **Change current drive** option, select the **Change current directory** option to enter a new directory other than the FLEX directory. FLEX will then be directly linked to the selected directory throughout the session. If you type in a directory while one is already in use or one that has not been created a 'That directory does not exist. Press Esc to cancel or any other key to retry' message will appear.

5.6 The Remove a data set from memory Option

The **Remove a data set from memory** option deletes all the FLEX data currently residing in memory. This option can be used after running an analysis to clear all the test data prior to entering another data set. This option also removes from memory all information concerning the liner type and the data set name. **USE THIS OPTION WITH CARE!** If this option is executed and the parameter data has not previously been saved, this information cannot be retrieved.

5.7 The Delete data set Option

The **Delete a data set file in DOS** option allows the removal of FLEX data sets from a disk. It may happen that a data set which was saved to disk is no longer required. Deleting unwanted data sets will increase the amount of free space on the disk so that more information may be stored there. To delete unwanted data sets, choose this option from the **MAIN MENU**. Use the arrow keys to move the highlight block to the unwanted data set name and press Enter to delete. **USE CAUTION WITH THIS PROCEDURE.**

DELETED DATA SETS CANNOT BE REPLACED. This function performs exactly the same function as the DOS **del** and **erase** commands. However this function is preferable because it is menu driven and therefore easier to use.

5.8 The EXIT Option

The **EXIT** option should be selected when you want to leave FLEX. Be sure you have saved your data set before selecting this option (please refer to 5.3). Once you have entered any input into the FLEX system and select the **EXIT** option from the **MAIN MENU**, a **Data has been edited but not saved. The current data can be stored using the save feature in the main menu. Are you sure you want to EXIT without saving changes? (y/n)** message will appear. If you have already saved your data set, type "y" and press the Enter key to Exit. **USE CAUTION WITH THIS PROCEDURE.** If you have **not** saved your data set, a "y" and Enter key response to this message will **EXIT** the FLEX system without saving your session. A "n" and Enter key response to this message will return you to the **MAIN MENU** to select the **Save data set option.**

6.0 SAMPLE FLEX SESSION

6.1 Sample and Practice Consultation

The following is a general description of how the FLEX system works. This section contains a complete FLEX sample run, including input and analysis, and allows you the user to get "hands on" experience with FLEX. Before you begin this session, it is strongly suggested that you REVIEW THE MANUAL. While you are working through this session, please follow along with the FLEX flow chart (Fig. 1-1) in chapter 1. If you want to QUIT this session at any time, continue to press the ESCape key until the MAIN MENU appears, highlight EXIT, and press the Enter key.

In the sample session, you will begin by retrieving a partially completed data set called "SAMPLEH". You will be instructed to select a liner type, enter its immersion temperature, gauge, input test data on the width of the liner, correct improperly entered data, examine parameter data, and save the revised data set.

During this sample session:

REGULAR text indicate comments about FLEX

ITALIC text indicate the instructions for the user to type

NOTE: Remember that pressing the ESCape (Esc) key at any point in the FLEX system returns you to the previous screen. Executing ESCape no more than three times will return you to the MAIN MENU.

Now Begin Sample Session:

1. - Starting the system (Be sure FLEX is installed, refer to 1.4 Installing the System)

At the C: prompt (or whatever disk drive you specified FLEX to reside on)

type 'CD\FLEX'

At the FLEX: prompt

type 'FLEX'

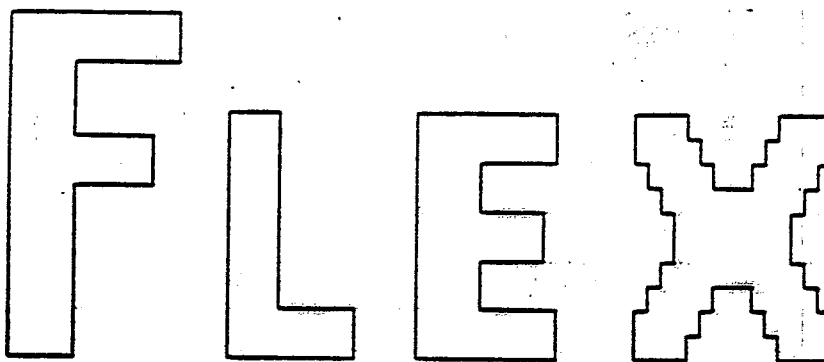
2. - The Disclaimer Screen appears

This is a demonstration copy of a program under development at the U.S. Environmental Protection Agency Research Center in Cincinnati, Ohio. This program has not yet undergone Agency review and no official endorsement of this system should be inferred.

PRESS A KEY TO BEGIN THE DEMONSTRATION

press the 'Enter' key

3. - The FLEX logo screen appears



Flexible Membrane Liner Advis

press the 'Enter' key

4. - The MAIN MENU appears

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```

----- MAIN MENU -----
Enter general information
Enter EPA Method 9090 test data
Analyze data & generate report
Load an existing data set
Save a data set
Change current drive
Change current directory
Remove a data set from memory
Delete a data set file from disk
EXIT
  
```

```

----- INSTRUCTIONS -----
Use the arrow keys to highlight the desired function.
Press Enter to execute the function.
Select EXIT to return to DOS.
Current directory: C:\FLEX ----- Current data set: none
  
```

Note that the Current data set: is listed as "NONE".

press the down arrow key 3 times to highlight 'Load an existing data set' then press 'Enter' to select it.

5. -

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Use arrow keys to load the desired data set. Press Esc to cancel.

SAMPLEP

SAMPLEC

SAMPLEH

Current directory: C:\FLEX

Current data set: none

Notice that three data sets currently exist in FLEX - "SAMPLEP", "SAMPLEC", and "SAMPLEH". These are sample files which represent each of the three liner types which are analyzed by the FLEX system. In this sample session you will examine the HDPE liner "SAMPLEH" data set.

Each time you do a session with FLEX and save it, the data set name you have specified will appear on this screen when you select the Load existing data set option from the MAIN MENU. You will find that this is an important feature when your data sets with FLEX begin to multiply and you would like to go back to complete a partially completed saved data set or go back and edit a completed saved data set.

press 'right' arrow key 2 times, press 'Enter' to select "SAMPLEH"

6.

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Liner: HIGH DENSITY POLYETHYLENE (HDPE) Temperature: none

MAIN MENU

Enter general information
 Enter EPA Method 9090 test data /
 Analyze data & generate report
 Load an existing data set
 Save a data set
 Change current drive
 Change current directory
 Remove a data set from memory
 Delete a data set file from disk
 EXIT

INSTRUCTIONS

Use the arrow keys to highlight the desired function.
 Press Enter to execute the function.
 Select EXIT to return to DOS.

Current directory: C:\FLEX Current data set: SAMPLEH

NOTE that the Current data set: listed now is "SAMPLEH" - Remember it was pre-inputed for use of this sample session. When you begin your own session with FLEX the Current data set: will appear as "NONE" until you save it and assign it a data set name of your own choosing.

Now select the Enter general information option

press up arrow key 3 times, press 'Enter' to select 'Enter general information'

7. - It is strongly suggested that you use this option first when entering FLEX to enter all the pertinent information for the session.

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GENERAL INFORMATION

Enter your name in the space provided:

Enter today's date in the space provided:

Enter the sitename in the space provided:

Enter a project I.D. in the space provided:

INSTRUCTIONS

Type responses to the following questions within the highlighted cells.
Use the arrow keys to move between cells. Press F1 to delete a cell.
Press Enter to select a response. Press F2 to move to the next screen.
Press Esc to return to the previous screen and/or the main menu.

Current directory: C:\FLEX Current data set: SAMPLEH

Notice the Instruction box at the bottom of the screen, it contains all the information you need to easily "get around" to enter and edit your site-specific information.

- Enter your name in space provided:
type 'John Doe' - press 'Enter'
- Enter today's date in space provided:
type 'December 15, 1989' - press 'Enter'
- Enter the sitename in space provided:
type 'Anywhere, USA' - press 'Enter'
- Enter a project ID in space provided:
type '218-792' - press 'Enter'

Notice you are now on the 2nd page of General information

- Enter the name of test laboratory:
type 'USEPA' - press 'Enter'
- Enter the date Method 9090 test began:
type 'August 14, 1989' - press 'Enter'
- Enter the date Method 9090 test ended:
type 'December 12, 1989' - press 'Enter'
- Enter liner volatiles content (percent):
press 'Enter' to skip
- Enter liner extractables content (percent):
press 'Enter' to skip

- Enter the liner specific gravity (ratio):
type '0.94' - press 'Enter'

Notice you are now on the 3rd page of General information

- Describe liner material in detail:
type 'Any American Liner Inc., Non-reinforced High Density Polyethylene' - press 'Enter'
- Describe the type of exposure tank material:
type 'Stainless steel tank' - press 'Enter'
- Describe leachate in detail:
type 'Leachate taken from previously filled cell #4' in Anywhere USA - press 'Enter'
- Enter frequency of leachate change:
type 'Two times per month' - press 'Enter'

Notice you are now on the 4th and final page of General information

- Describe 9090 Method options that were not followed:
type 'All 9090 Method options were followed' - press 'Enter'
- Describe incorrectly performed lab procedures:
type 'All tests were performed correctly' - press 'Enter'
- Describe flaws in lab specimens:
type 'All specimens had scratches' - press 'Enter'
- Describe qualitative lab observances:
type 'All tests followed QA/QC procedures' - press 'Enter'

8. - After pressing Enter at the last General information item notice that the MAIN MENU screen reappears.

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Liner: HIGH DENSITY POLYETHYLENE (HDPE) Temperature: none

MAIN MENU

```

Enter general information      ✓
Enter EPA Method 9090 test data ✓
Analyze data & generate report
Load an existing data set
Save a data set
Change current drive
Change current directory
Remove a data set from memory
Delete a data set file from disk
EXIT
  
```

INSTRUCTIONS

Use the arrow keys to highlight the desired function.
Press Enter to execute the function.
Select EXIT to return to DOS.

Current directory: C:\FLEX

Current data set: SAMPLEH

Notice the checkmarks to the right of the Enter general information option. This indicates that data has been entered into this option or category (the sample data you have just entered). You will notice also that the Enter EPA Method 9090 test data option has a checkmark to it's right. This indicates that data has been inputted into this option of the "SAMPLEH" data set previously, for use of this sample session.

Select it to examine this data,
press 'down' key once, press 'Enter'

9.

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Liner: HIGH DENSITY POLYETHYLENE (HDPE) Temperature: none

LINER SELECTION MENU

High Density Polyethylene (HDPE)
Polyvinyl Chloride (PVC)
Fabric-reinforced Chlorosulfonated Polyethylene (CSPE-R).

NOTE: CSPE-R is also referred to as Reinforced Hypalon.

INSTRUCTIONS

Use the arrow keys to highlight a liner type.
Press Enter to select the type of liner tested.
Press Esc to return to the main menu.

Current directory: C:\FLEX

Current data set: SAMPLEH

Notice the liner type High Density Polyethylene (HDPE) has previously been selected, as indicated in the upper left-hand corner of the screen. A liner type must be selected from the LINER SELECTION MENU to advance in the program. Before proceeding, take note of the other screen format characteristics; the INSTRUCTIONS box, the Current directory: "C: \FLEX" information (please refer to 5.4 The Change current drive Option and 5.5 The Change current directory Option) and Current data set: "SAMPLEH" information appearing in the lower part of the screen, as they will throughout the program, to help inform and assist you through every step. Notice also the LINER SELECTION MENU format. Most of the screens in FLEX will be in MENU type format (except data sheets which will be explained shortly) for easy selection of the information that FLEX is programmed to analyze.

press 'Enter' to select 'High Density Polyethylene (HDPE)'

10. - The TEMPERATURE SELECTION MENU appears.

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Liner: HIGH DENSITY POLYETHYLENE (HDPE) Temperature: none

TEMPERATURE SELECTION MENU
Degrees Fahrenheit Degrees Celsius

INSTRUCTIONS
Use the arrow keys to highlight an immersion test temperature unit. Press Enter to select the temperature unit. Press Esc to return to the liner selection menu.
Current directory: C:\FLEX Current data set: SAMPLEH

press 'Enter' to select 'Degrees Celsius'

11. - Enter the IMMERSION TEST TEMPERATURE in the window provided.

type '23' press 'Enter'

12. -

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Liner: HDPE (80 MILS)

Temperature: 23 DEGREES CELSIUS

TEMPERATURE SELECTION MENU
Degrees Fahrenheit Degrees Celsius
Enter the immersion test temperature in the space provided: 23

GAUGE INPUT
Enter the nominal immersion test gauge thickness (in mils): 80

INSTRUCTIONS
Type an immersion test thickness in the highlighted space. Use the arrow keys to move within this cell. Press F1 to delete this cell. Press Enter to select a thickness. Press Esc to exit to the liner menu.
Current directory: C:\FLEX Current data set: SAMPLEH

Enter the GAUGE INPUT (in mils) in the window provided.

type '80' press 'Enter'

13. -

Liner: HDPE (80 MILS)

Temperature: 23 DEGREES CELSIUS

PARAMETER SELECTION MENU	
width	
length	/
thickness	/
mass	/
tensile strength at yield	/
tensile strength at break	/
elongation at yield	/
elongation at break	/
tear resistance	/
puncture resistance	/
modulus of elasticity	/
miscellaneous tests	/

INSTRUCTIONS	
Use the arrow keys to highlight a parameter.	
Press Enter to select units and enter test data for that parameter.	
Press Esc to return to the main menu.	
Current directory: C:\FLEX	Current data set: SAMPLEH

Once the immersion test gauge information has been entered, the PARAMETER SELECTION MENU for HDPE appears (see Figure 1-1 for PVC and CSPE-R liner type parameter menu's). This is a listing of all the HDPE parameter's that FLEX is programmed to analyze. Notice that the Width parameter requires data (as indicated by the absence of a checkmark) and the remainder of the parameters already contain sample data for this session. The Width parameter was intentionally left partially incomplete to give you 'hands on' experience with FLEX.

press 'Enter' to select 'Width'

14. - The UNIT SELECTION MENU appears

press 'Enter' to select 'Centimeters'

15. -

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Liner: HDPE (80 MILS)

Temperature: 23 DEGREES CELSIUS

Parameter: WIDTH

Unit: CENTIMETERS

INPUT: _

	CONTRL1 DAY 30	CONTRL2 DAY 60	CONTRL3 DAY 90	CONTRL4 DAY 120
1)	---	---	---	---
2)	---	---	---	---
3)	---	---	---	---
4)	---	---	---	---
5)	---	---	---	---

Type a number and press Enter to fill the highlighted cell.
 Use the arrow keys to move between calls. Press F1 to delete a call.
 Press F10 to graph data. Press Esc to return to the parameter selection menu.
 Current directory: C:\FLEX Current data set: SAMPLEH

Notice a data sheet appears. These are special screens designed for easy input of Method 9090 test results. You may enter all the data in one session, or add or modify data at a later time as test results come in (once your session is saved of course). This particular data sheet is in a 'Non-Destructive' format and is used for the parameters Width, Length, Thickness, and Mass for a liner type. This format has a control column (observed reference sample values) and a test column (values from sample exposed to leachate) for each of the four months of immersion. This assumes that a separate sample is used for each time period and the dimensions are recorded both before (control column) and after (test column) immersion.

Width is measured on the right edge, center, and left edges of the test sample. Data is entered as follows:

When a test method spreadsheet is invoked, the highlighted or "text" box appears below CONTRL1. To enter data for the Width at the left edge of the test sample, type the value 26.15 in the INPUT: box and press Enter. The value 26.15 will be placed below CONTRL1 and the highlighted box will move below DAY 30. Continue entering data for Width on line one as follows:

DAY 30	CONTRL2	DAY 60	CONTRL3	DAY 90	CONTRL4	DAY 120
26.15	26.05	26.1	26.05	26.1	25.95	26

After entering data for DAY 120 and pressing Enter, the highlighted box moves below CONTRL1 on line two. To enter data for the Width at the center of the test sample, type the value 26.15 in the INPUT: box and press Enter. The value 26.15 will be placed below CONTRL1 on line two and the highlighted box will move below DAY 30. Continue entering data for Width on line two as follows:

DAY 30	CONTRL2	DAY 60	CONTRL3	DAY 90	CONTRL4	DAY 120
26.05	26.1	26.1	26.05	26.15	25.9	26.20

After entering data for DAY 120 and pressing Enter, the highlighted box moves below CONTRL1 on line three. To enter data for the Width at the left edge of the test sample, type the value 25.95 in the INPUT: box and press Enter. The value 25.95 will be placed below CONTRL1 on line three and the highlighted box will move below DAY 30. Continue entering data for the Width on line three as follows:

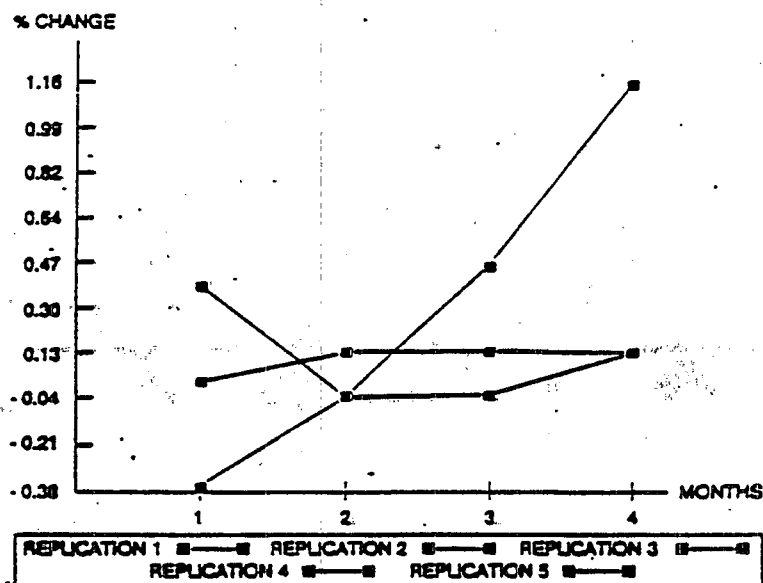
DAY 30	CONTRL2	DAY 60	CONTRL3	DAY 90	CONTRL4	DAY 120
26.05	26.05	26.05	26.1	26.1	25.8	26.20

The Control 4 cell has 25.8 cm instead of the intended 26.15 cm. To edit it, use the arrow keys to get back to this slot.

- press 'left' arrow key twice
- press 'F1' key to delete the cell
- type '26.15' then press 'Enter'

NOTE: the EPA requires a minimum of 3 replicates of completed lines covering all 4 months of immersion testing..

- press the 'F10' key



A graphic representation of the percent change between the control sample and the test sample for each column in the data sheet appears. Each replication is represented by its own line color. To get a hardcopy, press the shift key and PrtSc key at the same time or just press the PrtSc key - depending on the configuration of your keyboard.

- press 'Esc' key to return to data sheet

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Liner: HDPE (80 MILS)

Temperature: 23 DEGREES CELSIUS

Parameter: WIDTH

Unit: CENTIMETERS

INPUT: 26.1500_

	CONTRL1	DAY 30	CONTRL2	DAY 60	CONTRL3	DAY 90	CONTRL4	DAY 120
1)	26.1500	26.1500	26.0500	26.1000	26.0500	26.1000	25.9500	26.0000
2)	26.1500	26.0500	26.1000	26.1000	26.0500	26.1500	25.9000	26.2000
3)	25.9500	26.0500	26.0500	26.0500	26.1000	26.1000	26.1500	26.2000
4)	—	—	—	—	—	—	—	—
5)	—	—	—	—	—	—	—	—

Use Backspace to edit and Enter to select the current input value.

Use the arrow keys to move between cells. Press F1 to delete a cell.

Press F10 to graph data. Press Esc to return to the parameter selection menu.

Current directory: C:\FLEX

Current data set: SAMPLEH

Notice the format of the Non-destructive data sheet screen. It, like all the previous screens contain the INSTRUCTIONS box, the Current directory: information, and the Current data set: information (BOTTOM) - and the steps or information that you have selected (via MENU's) that gets you where you are (TOP).

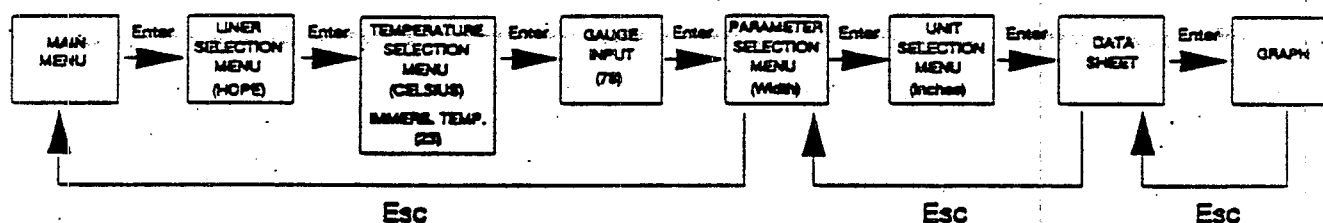


Fig. 6-1

Fig. 6-1 illustrate these steps and show how to backup by using the Esc key.

Since we've come to the end of the line for the parameter Width go back to the PARAMETER SELECTION MENU to select another HDPE parameter.

- press 'Esc' key

16. -

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Liner: HDPE (80 MILS)

Temperature: 23 DEGREES CELSIUS

PARAMETER SELECTION MENU	
width	/
length	/
thickness	/
mass	/
tensile strength at yield	/
tensile strength at break	/
elongation at yield	/
elongation at break	/
tear resistance	/
puncture resistance	/
modulus of elasticity	/
miscellaneous tests	/

INSTRUCTIONS	
Use the arrow keys to highlight a parameter.	
Press Enter to select units and enter test data for that parameter.	
Press Esc to return to the main menu.	
Current directory: C:\FLEX	Current data set: SAMPLEH

Notice that the Width parameter now has a checkmark to it's right indicating that it now contains data (the data that you've just inputed). Remember, when you begin your first session with FLEX the program will be completely empty of data - with NO checkmarks appearing - awaiting your input.

17. -

Now review the other HDPE parameters Length, Thickness, and Mass which also contain Non-destructive data sheets and contain pre-inputed data for this sample session.

Highlight the parameter 'Length' (with arrow key), then press 'Enter'

At the UNIT SELECTION MENU,

press 'Enter' to accept unit highlighted 'centimeters'

View the Non-destructive data sheet and previously entered data. Length data has already been entered in the SAMPLEH.FLX data set and is measured on the TOP edge, the CENTER, and the BOTTOM edge of the test sample. Feel free to examine the data sheet graph by pressing the F10 key.

Go back to the PARAMETER SELECTION MENU by

pressing the 'Esc' key

18. -

Continue these steps (step 16) to view the HDPE parameters Thickness and Mass which also contain pre-inputed data for this sample session as indicated by checkmarks.

19. -

Now you're ready to examine the HDPE parameter Tensile strength at yield.

highlight it, press 'Enter'

20. - FML ADVISOR, Version 3.0 RREL, USEPA Cincinnati, Ohio
 Liner: HDPE (80 MILS) Temperature: 23 DEGREES CELSIUS
 Parameter: TENSILE STRENGTH AT YIELD Unit: POUNDS/SQUARE INCH

UNIT SELECTION MENU
<p> <input type="radio"/> pounds/inch of width <input type="radio"/> pounds/square inch </p>

INSTRUCTIONS
<p> Use the arrow keys to highlight a unit. Press Enter to select the unit and enter test data. Press Esc to return to the parameter selection menu. </p>

Current directory: C:\FLEX Current data set: SAMPLEH

At the UNIT SELECTION WINDOW,
 press 'Enter' to select 'pounds/square inch'

21. - FML ADVISOR, Version 3.0 RREL, USEPA Cincinnati, Ohio
 Liner: HDPE (80 MILS) Temperature: 23 DEGREES CELSIUS
 Parameter: TENSILE STRENGTH AT YIELD Unit: POUNDS/SQUARE INCH

TEST DIRECTION MENU
<p> <input checked="" type="radio"/> machine direction <input type="radio"/> transverse direction </p>

INSTRUCTIONS
<p> Use the arrow keys to highlight a test direction. Press Enter to select the test direction and enter test data. Press Esc to return to the parameter selection menu. </p>

Current directory: C:\FLEX Current data set: SAMPLEH

At the TEST DIRECTION MENU,
 press 'Enter' to select 'Machine direction'

22. -

FML ADVISOR, Version 3.0 FREL, USEPA Cincinnati, Ohio
 Liner: HDPE (80 MILS) Temperature: 23 DEGREES CELSIUS
 Parameter: TENSILE STRENGTH AT YIELD Unit: POUNDS/SQUARE INCH

INPUT: 3020.00_

MACHINE DIRECTION	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	3020.00	3050.00	3090.00	3110.00	3200.00
2)	3020.00	3090.00	3110.00	3180.00	3210.00
3)	3030.00	3100.00	3110.00	3150.00	3210.00
4)	—	—	—	—	—
5)	—	—	—	—	—

Use Backspace to edit and Enter to select the current input value.
 Use the arrow keys to move between cells. Press F1 to delete a cell.
 Press F10 to graph data. Press Esc to return to the test direction menu.
 Current directory: C:\FLEX Current data set: SAMPLEH

Another data sheet appears and contains the information that gets you where you are (TOP) - and the INSTRUCTIONS box, the Current directory: information, and Current data set: information (BOTTOM). The data sheet format itself, however, is different than the prior ones you have examined. It is a 'Destructive' format and is used with physical property testing to analyze parameter classifications of Strengths, Elongations, Tear and Puncture resistances, Elasticities, and Adhesions (depending on the liner type you are using - see Fig.3-2 for liner parameter listings and APPENDIX A). This data sheet has a single control column and a test column for each of the four months of immersion. The difference in formats is necessary because physical property tests are destructive and a sample can be measured only once. Changes in physical properties must be referenced to the average of the control sample.

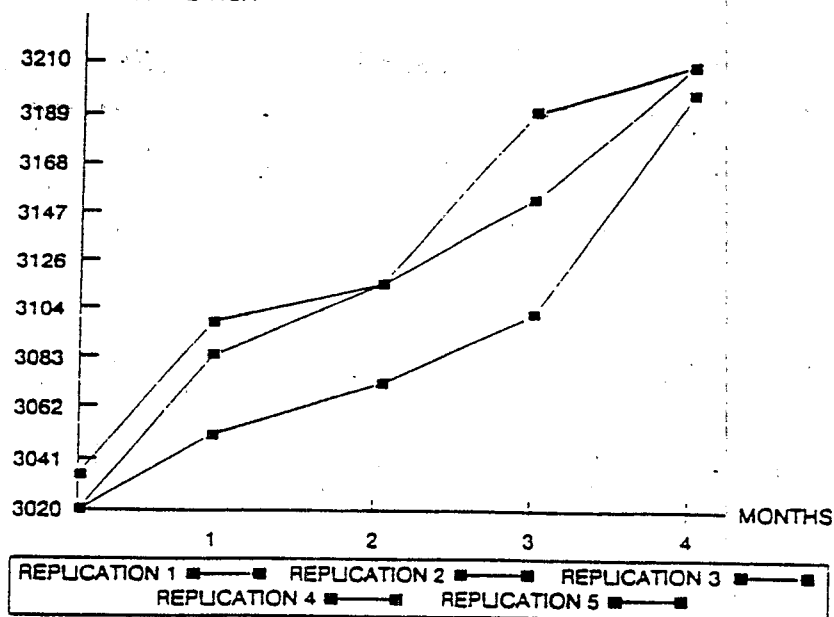
Notice that all the cells of the data sheet already contain previously entered data for this sample session. The same procedures in Step 15 for entering and editing data within data sheets apply here for input your own data sheet test results.

press the 'F10' key

23. -

32

POUNDS/SQUARE INCH



Like the Non-destructive data sheet, the Destructive data sheet has graphics capabilities. Destructive data sheets, however, will be calculated by the actual values in the test data for each of the parameter types listed in Step 20. To get a hardcopy, press the shift key and PrtSc key at the same time or just press the PrtSc key - depending on the configuration of your keyboard.

press 'Esc' to return to data sheet

press 'Esc' to return to the 'TEST DIRECTION MENU'

24. -

FME ADVISOR, Version 3.0

FREL, USEPA

Cincinnati, Ohio

Liner: HDPE (80 MILS)

Temperature: 23 DEGREES CELSIUS

Parameter: TENSILE STRENGTH AT YIELD

Unit: POUNDS/SQUARE INCH

TEST DIRECTION MENU	
machine direction	/
transverse direction	/

MACHINE DIRECTION	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	3020.00	3050.00	3090.00	3110.00	3200.00
2)	3020.00	3090.00	3110.00	3180.00	3210.00
3)	3030.00	3100.00	3110.00	3150.00	3210.00
4)	—	—	—	—	—
5)	—	—	—	—	—

INSTRUCTIONS	
Use the arrow keys to highlight a test direction.	
Press Enter to select the test direction and enter test data.	
Press Esc to return to the parameter selection menu.	
Current directory: C:\FLEX	Current data set: SAMPLEH

At the TEST DIRECTION MENU,

press 'down' arrow key, then press 'Enter' to select the other test direction option of 'Transverse direction'

Note, only one measurement unit (in this case pounds/square inch) can be used for both the Machine and Transverse test direction options.

25. - FML ADVISOR, Version 3.0 RREL, USEPA Cincinnati, Ohio
 Liner: HDPE (80 MILS) Temperature: 23 DEGREES CELSIUS
 Parameter: TENSILE STRENGTH AT YIELD Unit: POUNDS/SQUARE INCH

INPUT: 2990.00_

TRANSVERSE DIRECTION	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	2990.00	3090.00	3110.00	3220.00	3280.00
2)	2990.00	3040.00	3070.00	3190.00	3280.00
3)	2990.00	3070.00	3090.00	3100.00	3190.00
4)	—	—	—	—	—
5)	—	—	—	—	—

Use Backspace to edit and Enter to select the current input value.
 Use the arrow keys to move between cells. Press F1 to delete a cell.
 Press F10 to graph data. Press Esc to return to the test direction menu.
 Current directory: C:\FLEX Current data set: SAMPLEH

Another Destructive format data sheet appears with previously entered data for this sample session. Notice here that 'Transverse direction' appears below the input: box along with the other screen attributes which tell you exactly where you are in the program.

press the 'F10' key to examine the Transverse direction graphic

press 'Esc' key 3 times to return to the 'PARAMETER SELECTION MENU'

26. - FML ADVISOR, Version 3.0 RREL, USEPA Cincinnati, Ohio
 Liner: HDPE (80 MILS) Temperature: 23 DEGREES CELSIUS

PARAMETER SELECTION MENU	
width	/
length	/
thickness	/
mass	/
tensile strength at yield	/
tensile strength at break	/
elongation at yield	/
elongation at break	/
tear resistance	/
puncture resistance	/
modulus of elasticity	/
miscellaneous tests	/

INSTRUCTIONS	
Use the arrow keys to highlight a parameter.	
Press Enter to select units and enter test data for that parameter.	
Press Esc to return to the main menu.	
Current directory: C:\FLEX	Current data set: SAMPLEH

At this point feel free to examine the remaining parameters. They also contain previously entered data for this sample session and contain the Destructive data sheet formats. Remember,

press 'Enter' to ADVANCE - press 'Esc' to BACKUP

If you should inadvertently backup to the MAIN MENU, just continue to press the Enter key at the Enter EPA Method 9090 test data option, the LINER SELECTION MENU, the TEMPERATURE SELECTION MENU, the IMMERSION TEST TEMPERATURE prompt, and the GAUGE INPUT prompt until you advance to the PARAMETER SELECTION MENU (following the same steps you have previously taken - refer to Figure 6-1).

27. - When you are finished examining the remaining parameter listing of HDPE, you will notice the final option in the PARAMETER SELECTION MENU as being miscellaneous tests

highlight it and press Enter

Currently the ASTM 2552 is the environmental stress crack test of choice, however, old data may exist from ASTM D1693 and can be entered within the HDPE test menu. A Carbon Black Test is recommended by Method 9090 for HDPE liner types.

press Enter and Esc keys to examine the contents of each option

28. - Now you're ready to compile a report of the SAMPLEH data set.

from the 'PARAMETER SELECTION MENU' press the 'Esc' key

29. -

FML ADVISOR, Version 3.0

RREL, USEPA

Cincinnati, Ohio

Liner: HDPE (80 MILS)

Temperature: 23 DEGREES CELSIUS

MAIN MENU

```

Enter general information      /
Enter EPA Method 9090 test data /
Analyze data & generate report
Load an existing data set
Save a data set
Change current drive
Change current directory
Remove a data set from memory
Delete a data set file from disk
EXIT
  
```

INSTRUCTIONS

Use the arrow keys to highlight the desired function.
Press Enter to execute the function.
Select EXIT to return to DOS.

Current directory: C:\FLEX Current data set: SAMPLEH

From the MAIN MENU,

highlight 'Analyze and generate report option' to select it, press Enter

30. -

FML ADVISOR, Version 3.0

RREL, USEPA

Cincinnati, Ohio

REPORT SELECTION MENU
Output the input data
Output the conclusion
Output input data & conclusion

INSTRUCTIONS
Use the arrow keys to highlight a report type.
Press Enter to select the type of report for output.
Press Esc to return to the main menu.
Current directory: C:\FLEX
Current data set: SAMPLEH

The REPORT SELECTION MENU appears with three options available to you;

- 1 - Output the input data - produces a report reviewing the general information and data sheet information you have entered.
- 2 - Output the conclusion - analyzes all input in the data set and produces a report which accounts for - suspected deficiencies with liner type and missing information, and then provides justifications for the conclusions..
- 3 - Output input data & conclusion - produces a report containing the contents of 1 & 2.

press 'down' arrow key 2 times to highlight 'Output input data & conclusion', then press Enter

31. - When the Generating Report message disappears,

FML ADVISOR, Version 3.0

FREL, USEPA

Cincinnati, Ohio

Report: OUTPUT INPUT DATA & CONCLUSION

OUTPUT SELECTION MENU

Display the output report on the screen
Print the output report on system printer
Save the output report as a text file

INSTRUCTIONS

Use the arrow keys to highlight a output mode.

Press Enter to select the mode of output.

Press Esc to return to the report selection menu.

Current directory: C:\FLEX Current data set: SAMPLEH

The OUTPUT SELECTION MENU appears with three options available to you:

- 1 - Display the output report on the screen - this option enables you to view your REPORT SELECTION MENU selection on your computer monitor.
- 2 - Print the output report on system printer - this option enables you to obtain a 'hardcopy' of your REPORT SELECTION MENU selection from your system printer.
- 3 - Save the output report as a text file - this option is an excellent way to produce a 'readable' file which can be saved or transferred via floppy disk and then, if desired, viewed through a word processor (Note: because the report is saved as a DOS file when this option is selected, you will have to import it into the word processing software. Most of the major packages have this capability). The report you obtain when selecting this option will depend on your REPORT SELECTION MENU selection.

press 'Enter' to select 'Display the output report on the screen'

32. - Now examine the sample FLEX summary report for this sample session. Refer to 6.2 Sample FLEX Summary Report which has a 'hardcopy' and further explanation of the same report you are viewing on your monitor screen. It is a sample of the kind of Summary Report you would produce had you selected Print the output report on system printer in Step 31.

- examine the 'GENERAL INFORMATION' section of the Summary report, press the 'PgDn' key or the 'down' arrow key to scroll.
- Press the 'PgDn' key or the 'down' arrow key to scroll through the parameter data sheets to examine the 'Analysis of HDPE Liner Data' section of the Summary Report

When you get to the end,

- press 'Esc' 3 times to backup to 'MAIN MENU'

33. - At MAIN MENU,

press 'down' key 2 times to highlight 'Save a data set', then press 'Enter'

34. -

FML ADVISOR, Version 3.0

RREL, USEPA

Cincinnati, Ohio

Please enter a save name for this data set.

Limit this name to eight characters. Press Esc to cancel.

Save name: SAMPLEH

Current directory: C:\FLEX

Current data set: SAMPLEH

Although the **Save a data set** option can be utilized at any time, it is better to save a data set at it's conclusion. This option stores the data set currently in use to a new file. When the file is created, the program will ask for a file name of less than 8 characters. Names must be composed of only letters or numbers. After saving a data set, the **MAIN MENU** appears.

In order to allow multiple users to work their way through a test session, do NOT save the sample data set under the name "SAMPLEH". Saving the data set under a different name, i.e. "MYTEST", retains "SAMPLEH" in its original form.

press the 'backspace' key 7 times to erase "SAMPLEH"

type 'MYTEST', then press Enter

If this had been the Sample Session name used before, the following screen will appear,

```

FML ADVISOR, Version 3.0          RREL, USEPA          Cincinnati, Ohio
Please enter a save name for this data set.
Limit this name to eight characters. Press Esc to cancel.
Save name: MYTEST
          That data set already exists.
          Would you like to overwrite it? (y/n)

```

Current directory: C:\FLEX

Current data set: MYTEST

Now Flex informs you that the data set name already exists and would you like to overwrite it?

type 'y', then press 'Enter' to save your inputs under 'MYTEST'

35. - At the **MAIN MENU** notice that the **Current data set: name** is now "MYTEST" (When you begin a new session with FLEX and select the **Load an existing data set** option the data set "MYTEST" will appear in the listing along with the

other three original data set files; "SAMPLEH", "SAMPLEC", and "SAMPLEP" .

press 'down' key 3 times to highlight 'EXIT', type 'y', then press 'Enter'

Congratulations! You have just completed a 'comprehensive' session with FLEX. When you begin your own sample session with FLEX, remember to follow the on-line instructions appearing on every screen throughout the program. Feel free to load and examine the data of the other liner sample data sets "SAMPLEC" and "SAMPLEP".

NOTE: All but four of the MAIN MENU options were mentioned in this sample session; Change current drive, Change current directory, Remove a data set from memory and Delete a data set file in DOS. They are fairly self-explanatory and more can be learned about them in 5.0 FILE MANAGEMENT of this manual.

6.2 Sample FLEX Summary Report

The following is an example of a FLEX Summary Report which contains the input data and conclusion information of the data set "SAMPLEH" (please refer to 6.1 Sample and Practice Consultation) which analyzes HDPE liner characteristics. It was produced by selecting the **Analyze data & generate report** option from the **MAIN MENU** and then selecting the **Output input data & conclusion** and **Print the output report on system printer** options (please refer to 4.1.1 Report Selection Menu and 4.1.2 Output Selection Menu). The "Input data" section of the Summary Report contains the **GENERAL INFORMATION** which was entered at the beginning of the FLEX session and displays the values within each of the parameter data sheets. The "Conclusion" or Analysis of HDPE Liner Data section of the Summary Report displays the collection of text that results from applying the input data to the "rule base" (please refer to 4.2 Conclusion Generation and the Rule Base). The "Rule base" for HDPE liner criteria, for example, will analyze for over 65 conditions. These "rules" or conditions for the HDPE liner and the other two liners which FLEX analyzes (PVC and CSPE-R) are listed in APPENDIX E. As you can see from this sample Summary Report, the HDPE liner EPA Method 9090 test results are adequate in this case.

Data Set Name: SAMPLEH.FLX Date: 01/25/90 Time: 07:57:15

FLEX SYSTEM / VERSION 3.0
RISK REDUCTION ENGINEERING LABORATORY
US EPA / CINCINNATI, OHIO

GENERAL INFORMATION

Name: John Doe
Date: December 15, 1989
Sitename: Anywhere, USA
Project I.D.: 218-792

The Name of the Test Laboratory: US EPA
The Date Method 9090 Test Began: August 14, 1989
The Date Method 9090 Test Ended: December 12, 1989
No Reported Liner Volatiles Content!
No Reported Liner Extractables Content!
The Liner Specific Gravity (Ratio): 0.94

A Description of the Liner Material:

Any American Liner Company, Non-Reinforced High Density Polyethylene

A Description of the Type of Exposure Tank Material:

Stainless Steel Tank

A Description of the Leachate:

Leachate Taken From Previously Filled Landfill Cell #4 in Anywhere,
USA

A Description of the Frequency of Leachate Change:

Two Times per Month

A Description of 9090 Method Options that were not followed:

All 9090 Method Options Were Followed.

A Description of Incorrectly Performed Lab Procedures:

All Tests Were Performed Correctly.

A Description of Flaws in Lab Specimens:

All Specimens Had Scratches.

A Description of Qualitative Lab Observances:

All Tests Followed QA/QC Procedures.

Liner: HDPE (80 MILS)
Temperature: 23 DEGREES CELSIUS
Parameter: WIDTH
Unit: CENTIMETERS

[illegible]

Liner: HDPE (80 MILS)
Temperature: 23 DEGREES CELSIUS
Parameter: LENGTH
Unit: CENTIMETERS

[illegible]

Liner: HDPE (80 MILS)
Temperature: 23 DEGREES CELSIUS
Parameter: THICKNESS
Unit: MILLIMETERS

	CNTRL1	DAY 30	CNTRL2	DAY 60	CNTRL3	DAY 90	CNTRL4	DAY 120
1)	2.09000	2.03000	2.09000	1.97000	2.09000	1.95000	2.09000	1.93000
2)	2.20000	2.12000	2.20000	1.97000	2.20000	1.97000	2.20000	1.95000
3)	2.35000	2.10000	2.35000	2.05000	2.35000	2.03000	2.35000	2.00000
4)	---	---	---	---	---	---	---	---
5)	---	---	---	---	---	---	---	---

Liner: HDPE (80 MILS)
Temperature: 23 DEGREES CELSIUS
Parameter: MASS
Unit: GRAMS

	CNTRL1	DAY 30	CNTRL2	DAY 60	CNTRL3	DAY 90	CNTRL4	DAY 120
1)	11.1100	11.1010	11.0980	10.9970	10.8810	10.7890	10.5600	10.5320
2)	10.9900	10.9570	10.8920	10.8860	10.7800	10.7330	10.5620	10.5490
3)	10.9500	10.9300	10.8760	10.8210	10.7750	10.7680	10.7450	10.7340
4)	---	---	---	---	---	---	---	---
5)	---	---	---	---	---	---	---	---

Liner: HDPE (80 MILS)
Temperature: 23 DEGREES CELSIUS
Parameter: TENSILE STRENGTH AT YIELD
Unit: POUNDS/SQUARE INCH

MACHINE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	3020.00	3050.00	3090.00	3110.00	3200.00
2)	3020.00	3090.00	3110.00	3180.00	3210.00
3)	3030.00	3100.00	3110.00	3150.00	3210.00
4)	---	---	---	---	---
5)	---	---	---	---	---

TRANSVERSE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	2990.00	3090.00	3110.00	3220.00	3280.00
2)	2990.00	3040.00	3070.00	3190.00	3280.00
3)	2990.00	3070.00	3090.00	3100.00	3190.00
4)	---	---	---	---	---
5)	---	---	---	---	---

Liner: HDPE (80 MILS)
Temperature: 23 DEGREES CELSIUS
Parameter: TENSILE STRENGTH AT BREAK
Unit: POUNDS/SQUARE INCH

MACHINE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	3070.00	3150.00	3240.00	3440.00	3750.00
2)	3060.00	3090.00	3120.00	3460.00	3720.00
3)	3010.00	3100.00	3370.00	3570.00	3790.00
4)	---	---	---	---	---
5)	---	---	---	---	---

TRANSVERSE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	3800.00	3900.00	4010.00	4100.00	4200.00
2)	3800.00	3920.00	4050.00	4090.00	4130.00
3)	3800.00	3880.00	3990.00	4010.00	4180.00
4)	---	---	---	---	---
5)	---	---	---	---	---

Liner: HDPE (80 MILS)
 Temperature: 23 DEGREES CELSIUS
 Parameter: ELONGATION AT YIELD
 Unit: PERCENT

MACHINE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	18.2600	19.0000	19.3800	19.5800	20.1000
2)	18.9700	19.0500	19.2300	19.4700	19.7500
3)	17.5500	18.1000	18.9000	19.1300	19.6700
4)	---	---	---	---	---
5)	---	---	---	---	---

TRANSVERSE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	17.4000	18.7000	18.9000	19.4000	19.5000
2)	17.9800	18.3000	18.6000	19.2100	19.4400
3)	17.6500	18.5000	18.6400	18.8500	19.1000
4)	---	---	---	---	---
5)	---	---	---	---	---

Liner: HDPE (80 MILS)
 Temperature: 23 DEGREES CELSIUS
 Parameter: ELONGATION AT BREAK
 Unit: PERCENT

MACHINE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	605.000	612.000	615.000	618.000	620.000
2)	620.000	659.000	664.000	688.000	690.000
3)	620.000	654.000	655.000	663.000	670.000
4)	---	---	---	---	---
5)	---	---	---	---	---

TRANSVERSE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	620.000	652.000	670.000	674.000	698.000
2)	570.000	583.000	590.000	629.000	640.000
3)	620.000	635.000	640.000	664.000	680.000
4)	---	---	---	---	---
5)	---	---	---	---	---

Liner: HDPE (80 MILS)
 Temperature: 23 DEGREES CELSIUS
 Parameter: TEAR RESISTANCE
 Unit: POUNDS

MACHINE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	76.4000	76.0000	77.0000	77.8000	78.0000
2)	74.5000	76.0000	76.3000	78.4000	80.0000
3)	74.5000	77.0000	78.1000	79.4000	82.0000
4)	---	---	---	---	---
5)	---	---	---	---	---

TRANSVERSE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	76.8000	77.9000	79.0000	78.3000	71.4000
2)	73.4000	75.0000	75.8000	76.8000	70.2000
3)	73.4000	76.0000	86.3000	79.6000	69.2000
4)	---	---	---	---	---
5)	---	---	---	---	---

Liner: HDPE (80 MILS)
 Temperature: 23 DEGREES CELSIUS
 Parameter: PUNCTURE RESISTANCE
 Unit: POUNDS

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	85.0000	87.0000	89.0000	92.0000	96.0000
2)	85.0000	86.0000	91.0000	92.0000	100.000
3)	85.0000	86.0000	89.0000	93.0000	95.0000
4)	---	---	---	---	---
5)	---	---	---	---	---

Liner: HDPE (80 MILS)
 Temperature: 23 DEGREES CELSIUS
 Parameter: MODULUS OF ELASTICITY
 Unit: POUNDS/SQUARE INCH

MACHINE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	82600.0	84000.0	87500.0	86400.0	87800.0
2)	84100.0	85600.0	86200.0	88800.0	90100.0
3)	83000.0	83400.0	87500.0	88000.0	89900.0
4)	---	---	---	---	---
5)	---	---	---	---	---

TRANSVERSE DIRECTION

	CONTROL	DAY 30	DAY 60	DAY 90	DAY 120
1)	84900.0	87000.0	89000.0	90300.0	91900.0
2)	85200.0	84900.0	85500.0	87700.0	90200.0
3)	85000.0	85500.0	86000.0	86400.0	88000.0
4)	---	---	---	---	---
5)	---	---	---	---	---

HDPE MISCELLANEOUS TESTS

ASTM Test Performed: Environmental Stress Rupture ASTM D2552

The thickness of ASTM D2552 test samples: 80 mils

The percentage of ASTM D2552 test samples that failed: 8 percent

Test Performed: Carbon Black Test

The percentage of carbon black in the liner tested: 4 percent

Analysis of HDPE Liner Data

The chemical resistance of the liner material to the leachate/waste said to be that of or representative of the waste site was judged according to criteria generally considered practical and reasonable by liner industry and liner material specialists. There may be exceptions to these generalizations. In its present stage of development, this analysis system provides guidance that must be considered along with a variety of site-specific and application-specific factors. The analysis involved an assessment of the changes and trends in changes of certain physical properties and attributes upon exposure to the waste/leachate under the conditions of EPA Method 9090 (Sept. 1986) or similar procedures. In addition, information specific to the liner material selected concerning the test conditions and planned installation conditions of the liner were reviewed. The information was also assessed for its completeness and reasonableness.

Based upon the EPA Method 9090 four month immersion test results that were entered, there is no indication that the liner is not chemically resistant to the waste/leachate used as the test medium.

7.0 TROUBLESHOOTING

7.1 Error messages

Many of the input values in FLEX have LIMIT and/or TYPE restrictions. LIMIT restrictions refer to the ranges (gains / losses) examined by the rule base. A listing of the LIMIT restrictions is available in APPENDIX D - FLEX SYSTEM LIMITS on INPUT DATA. TYPE restrictions apply to input data that must be exclusively numeric or exclusively character types. All error messages are inactivated by entering a correct data type within the required limits.

7.2 Software Support

FLEX was developed by the Risk Reduction Engineering Laboratory, U.S. Environmental Protection Agency. Version 3.0 of the Flexible Membrane Liner Evaluation Expert System is being distributed on a limited basis for the purpose of field testing and to obtain feedback concerning the system's performance and content. As stated in the disclaimer, this system has not undergone Agency review and no official endorsement by the U.S. EPA should be presumed. Comments on the system should be addressed to:

Daniel G. Greathouse
USEPA
Risk Reduction Engineering Laboratory
26 W. Martin Luther King Dr.
Cincinnati, Ohio 45268

If problems are encountered which cannot be solved using the information in this manual, telephone support is provided free of charge by the authors. To report problems and/or obtain assistance call:

Jay Clements
USEPA
684-7836
513-569-7836
(FTS)
(Commercial)

APPENDIX A

LINER PARAMETERS UNITS and TEST DIRECTIONS

HDPE PARAMETERS
(Test Direction)

UNITS

width
(machine)inches
centimeters
millimeterslength
(machine)inches
centimeters
millimetersthickness
(machine)mils
millimetersmass
(machine)grams
poundstensile strength at yield
(machine,transverse)pounds/inch of width
pounds/square inchtensile strength at break
(machine,transverse)pounds/inch of width
pounds/square inchelongation at yield
(machine,transverse)

percent

elongation at break
(machine,transverse)

percent

tear resistance
(machine,transverse)pounds
pounds/inch of thickness
pounds/mil of thicknesspuncture resistance
(machine)pounds
pounds/inch of thickness
pounds/mil of thicknessmodulus of elasticity
(machine,transverse)pounds/inch of width
pounds/square inchPVC PARAMETERS
(Test Direction)

UNITS

width
(machine)inches
centimeters
millimeterslength
(machine)inches
centimeters
millimeters

thickness
(machine)

mil
millimeters

mass
(machine)

grams
pounds

tensile strength at break
(machine,transverse)

pounds/inch of width
pounds/square inch

elongation at break
(machine,transverse)

percent

tear resistance
(machine,transverse)

pounds
pounds/inch of thickness
pounds/mil of thickness

puncture resistance
(machine)

pounds
pounds/inch of thickness
pounds/mil of thickness

maximum stress
(machine,transverse)

pounds/inch of width
pounds/square inch

CSPE-R PARAMETERS (Test Direction)

UNITS

width
(machine)

inches
centimeters
millimeters

length
(machine)

inches
centimeters
millimeters

thickness
(machine)

mil
millimeters

mass
(machine)

grams
pounds

breaking factor - fabric
(machine,transverse)

pounds
pounds/inch of width
pounds/square inch

breaking factor - coating
(machine,transverse)

pounds
pounds/inch of width
pounds/square inch

elongation at fabric break
(machine,transverse)

percent

elongation at coating break

percent

(machine,transverse)

tear resistance
(machine,transverse)

pounds
pounds/inch of thickness
pounds/mil of thickness

hydrostatic resistance
(machine)

pounds/square inch

maximum stress
(machine,transverse)

pounds/inch of width
pounds/square inch

ply adhesion
(machine,transverse)

pounds/inch of width

APPENDIX B

LINER TEST METHODS / DECEMBER 1989

HDPE Liners

Width
Length
Thickness

Mass
Tensile Strength at Yield
Tensile Strength at Break
Elongation at Yield
Elongation at Break
Tear Resistance
Puncture Resistance
Modulus of Elasticity
Environmental Stress Cracking
Carbon Black

ASTM Test Method

Left Edge, Center, Right Edge
Top Edge, Center, Bottom Edge
ASTM D374, D1593 Para.8.1.3,
D3767
ASTM D1910
Tensile Behavior
Tensile Behavior
Tensile Behavior
Tensile Behavior
Tear Behavior
Puncture Behavior
ASTM D882 Mtd. A
ASTM D1693, D2552
ASTM D1603

PVC Liners

Width
Length
Thickness
Mass
Tensile Strength at Break
Elongation at Break
Tear Resistance
Puncture Resistance
Maximum Stress

ASTM Test Method

Left Edge, Center, Right Edge
Top Edge, Center, Bottom Edge
D1593 Para. 8.1.3, D3767
ASTM D1910
Tensile Behavior
Tensile Behavior
Tear Behavior
Puncture Behavior
Tensile Behavior

CSPE-R Liners

Width
Length
Thickness
Mass
Breaking Factor - Fabric
Breaking Factor - Coating
Elongation at Fabric Break
Elongation at Coating Break
Tear Resistance
Hydrostatic Resistance
Maximum Stress
Ply Adhesion

ASTM Test Method

Left Edge, Center, Right Edge
Top Edge, Center, Bottom Edge
ASTM D751, D3767
ASTM D1910
Tensile Behavior
Tensile Behavior
Tensile Behavior
Tensile Behavior
Tear Behavior
ASTM D751 Mtd. A, Procedure 1
Tensile Behavior
ASTM D413 Section 12.2,
Machine Mtd., Type A, 180 deg.
peel

NOTE: Descriptions for Tensile Behavior, Tear Behavior, and Puncture Behavior appear on following page.

Tensile Behavior

1. Dumbbell Shape ASTM D412, D638, D882 Mtd. A or B, D751 Mtd. A
2. Uniform Width ASTM D4885 (Narrow or Wide Width Specimens)
3. Three-Dimensional GRI Standard GM-4

Tear Behavior

1. Miscellaneous Tests ASTM D751, D1424, D1938
2. Trapezoidal Tear Test ASTM D1004 Die C, D2263
3. Tongue Tear Test ASTM D2261 (Scrim Reinforcement)

Puncture Behavior

1. ASTM D2582, D3787
2. FTMS 101C Method 2031, 2065

All Liners (HDPE, PVC, CSPE-R) ASTM Test Method

Extractables

ASTM D3083, SW 870 App. III-E

Volatiles

ASTM D1203 Mtd. A, SW 870 App. III-D

Specific Gravity (<1.0)

ASTM D792 Mtd. A, (D1505)

APPENDIX C

LINER NSF STANDARDS

HDPE NSF STANDARDS

Tensile Strength at Yield

60 mil	80 mil	100 mil
2000.0 psi	1750.0 psi	1800.0 psi

Tensile Strength at Break: 3000.0 psi

Elongation at Yield: 10.0 %

Elongation at Break: 500.0 %

Tear Resistance

60 mil	80 mil	100 mil
30.0 lbs	40.0 lbs	50.0 lbs

Modulus of Elasticity: 80000.0 psi

PVC NSF STANDARDS

Tensile Strength at Break: 2400.0 psi

Elongation at Break: 300.0 %

Tear Resistance

30 mil	45 mil
8.0 lbs	11.0 lbs

Maximum Stress: 900.0 psi

CSPE-R NSF STANDARDS

Breaking Factor - Fabric: 6X6 YARNS/INCH

30 mil	36 mil	45 mil
60.0 lbs	60.0 lbs	90.0 lbs

Breaking Factor - Fabric: 8X8 YARNS/INCH

30 mil	36 mil	45 mil
120.0 lbs	120.0 lbs	125.0 lbs

Breaking Factor - Fabric: 10X10 YARNS/INCH

200.0 lbs

Breaking Factor - Coating

30 mil	36 mil	45 mil
185.0 lbs	145.0 lbs	120.0 lbs

Elongation at Coating Break: 20.0 %

Maximum Stress

30 mil	36 mil	45 mil
750.0 psi	640.0 psi	500.0 psi

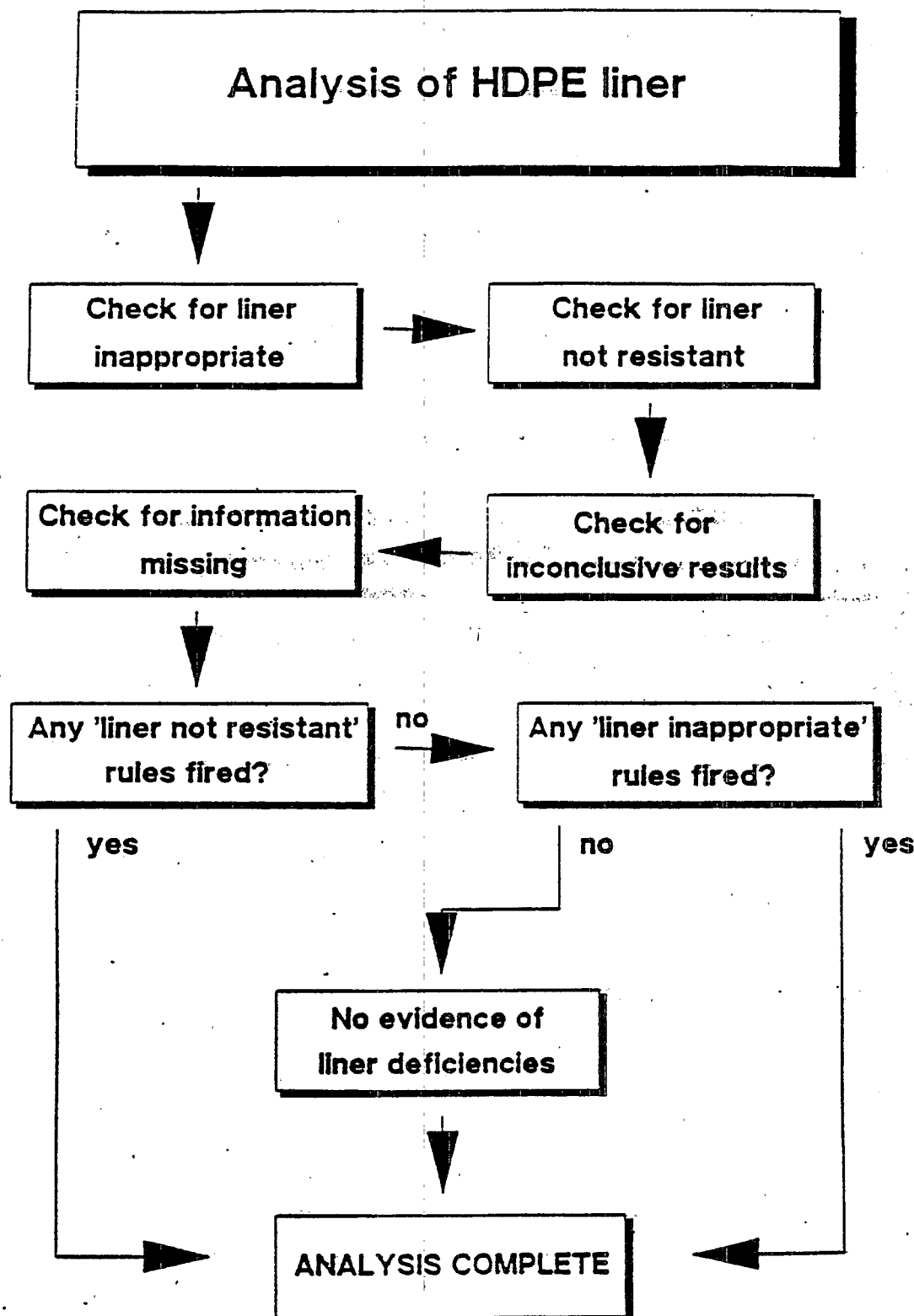
APPENDIX D

FLEX SYSTEM LIMITS on INPUT DATA

Test (units)	Limits (Lower,Upper)
Liner Volatiles Content (percent)	(-100,100)
Liner Extractables Content (percent)	(-100,100)
Liner Specific Gravity (ratio)	(0,3)
Liner Immersion Test Temperature (deg. F or C)	(0,250)
Liner Nominal Gauge Thickness (mils)	(0,250)
E.S.C. Thickness (mils)	(0,250)
E.S.C. # failed (percent)	(0,100)
Carbon Black (percent)	(0,100)
Service Life (years)	(0,100)
Max. Exposure Temperature (degrees F)	(0,250)

APPENDIX E

LINER "Rulebase" FLOWCHARTS



Liner is inappropriate IF:

gauge < 60 mils

liner fails
NSF standards

carbon black > 5%

80 < gauge < 100 mils
and
minimum tensile strength
at yield < 1750 psi

60 < gauge < 80 mils
and
minimum tensile strength
at yield < 2000 psi

gauge > 60 mils
and
minimum tensile strength
at break < 3000 psi

gauge > 100 mils
and
minimum tensile strength
at yield < 1800 psi

gauge > 60 mils
and
minimum elongation
at break < 500 %

gauge > 60 mils
and
minimum elongation
at yield < 10 %

gauge > 60 mils
and
minimum modulus
of elasticity < 80000 psi

60 < gauge < 80 mils
and
minimum tear strength
< 30 lbs

80 < gauge < 100 mils
and
minimum tear strength
< 40 lbs

gauge > 100 mils
and
minimum tear strength
< 50 lbs

Liner not resistant IF:

**environmental stress
crack test is run and
failures > 10 %**

**evidence of
chemical reaction**

**evidence of
excessive softening**

**evidence of liner
absorbing leachate**

evidence of chemical reaction IF:

loss in weight
at month 4 > 3 %
(excessive weight
decrease)

loss in weight
at month 4 < 3 %
and loss in weight
predicted by quadratic
fit at month 4 > 2%
(excessive weight
decrease trend)

tensile strength at break
at month 4 < tensile strength
at yield before immersion
and elongation at break
at month 4 < elongation
at yield before immersion
(brittle failure)

loss in weight at month
4 between 1-3 % and
loss in tensile strength
at yield at month 4
> 5 % and loss in tensile
strength at break at
month 4 > 10 %

loss in weight at month
4 between 1-3 % and
loss in tensile strength
at yield at month 4
> 5 % and loss in
elongation at break at
month 4 > 10 %

loss in weight at month
4 between 1-3 % and
loss in tensile strength
at break at month 4
> 10 % and loss in
elongation at break at
month 4 > 10 %

evidence of liner absorbing leachate IF:

gain in weight at
month 4 > 5 %
(excessive weight
increase)

gain in weight at
month 4 < 5 % and
gain in weight predicted
by quadratic fit at
month 4 > 3 %
(excessive weight
increase trend)

gain in length at
month 4 > 5 %
(swelling)

gain in length at
month 4 < 5 % and
gain in length predicted
by quadratic fit at
month 4 > 3 %
(swelling trend)

gain in width at
month 4 > 5 %
(swelling)

gain in width at
month 4 < 5 % and
gain in width predicted
by quadratic fit at
month 4 > 3 %
(swelling trend)

gain in weight at month
4 between 2-5 % and
loss in tensile strength
at yield at month 4
> 15 % and loss in tensile
strength at break at
month 4 > 18 %

gain in weight at month
4 between 2-5 % and
loss in tensile strength
at yield at month 4
> 15 % and loss in
elongation at break at
month 4 > 18 %

gain in weight at month 4 between 2-5 % and
loss in tensile strength at break at month 4 > 18 %
and loss in elongation at break at month 4 > 18 %

**evidence of
excessive softening IF:**

**brittle failure not evidenced
and tensile strength at break
at month 4 < tensile strength
at yield before immersion**

**loss in tensile strength
at yield at month 4 > 20 %**

**loss in elongation at
break at month 4 > 25 %**

**loss in elongation at break
at month 4 < 25 % and
loss in elongation at break
predicted by quadratic fit
at month 4 > 15 %**

**loss in modulus of elasticity
at month 4 > 25 %**

**loss in puncture strength
at month 4 > 25 %**

**loss in puncture strength
at month 4 < 25 % and
loss in puncture strength
predicted by quadratic fit
at month 4 > 15 %**

results are inconclusive IF:

**insufficient information
to run scatter test**

**excessive scatter
in parameter data**

**insufficient information
to run trend analysis**

trend analysis unsuccessful

**the change in weight
predicted by quadratic fit
at month 4 > 0 and
the change in tensile strength
at break predicted by
quadratic fit at month 4 > 0**

**environmental stress crack test
ASTM D1693
is run and gauge of stress crack
test samples < 0.9 times gauge of
immersion test samples**

**environmental stress crack test
ASTM D2552
is run and gauge of stress crack
test samples < 0.9 times gauge of
immersion test samples**

**insufficient information
to run scatter test IF
for any parameter:**

pure error sum of squares = 0

OR

data reported for only three time periods

OR

**number of time periods for which
data was reported =
total number of data points**

**insufficient information
to perform trend analysis IF
for any parameter:**

**excessive scatter not
present in parameter data**

AND EITHER

residual sum of squares = 0

OR

**three data points entered
for this parameter**

information is missing IF:

for any parameter

no data is entered for the parameter

OR

no month 4 data is
entered for the parameter

OR

no control data is
entered for the parameter

OR

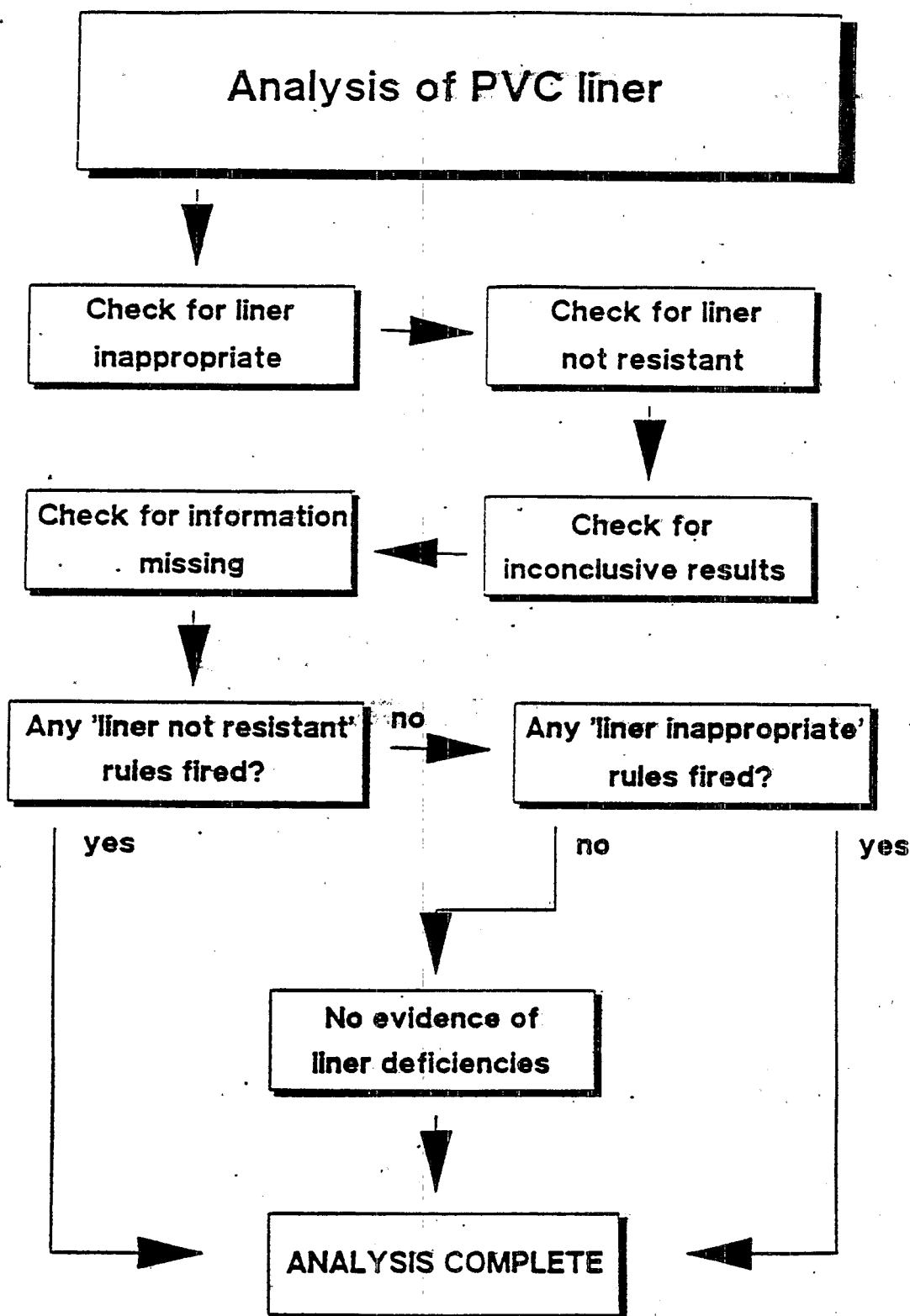
environmental stress crack test ASTM 1693
results are not reported

OR

environmental stress crack test ASTM 2552
results are not reported

OR

carbon black test results are not reported



Liner is inappropriate IF:

gauge < 30 mils

liner is exposed
to sunlight

liner fails
NSF standards

liner fails temperature/
service life criteria

gauge \geq 30 mils
and
minimum tensile strength
at break < 2300 psi

installation temp. > 170°F

gauge \geq 30 mils
and
minimum elongation
at break < 300 %

installation temp. > 150°F and
est. service life > 1 year

gauge \geq 30 mils
and
minimum / maximum
stress < 900 psi

installation temp. > 130°F and
est. service life > 2.5 years

installation temp. > 120°F and
est. service life > 3.5 years

30 mils \leq gauge < 40 mils
and
minimum tear resistance < 8 lbs

installation temp. > 110°F and
est. service life > 5 years

gauge \geq 45 mils
and
minimum tear resistance < 11 lbs

installation temp. > 90°F and
est. service life > 10 years

Liner not resistant IF:

**evidence of
chemical reaction**

**evidence of liner
absorbing leachate**

**evidence of
excessive softening**

**evidence of excessive
plasticizer loss**

evidence of
chemical reaction IF:

loss in tensile strength at break at month 4 $> 10\%$
AND
loss in elongation at break at month 4 $> 20\%$
AND
loss in maximum stress at month 4 is not $> 20\%$
AND
the absolute loss in maximum stress over the
four month period is not > 20000 psi

gain in tensile strength at break at month 4 $> 20\%$
AND
loss in elongation at break at month 4 $> 20\%$
AND
loss in maximum stress at month 4 is not $> 20\%$
AND
the absolute loss in maximum stress over the
four month period is not > 20000 psi
AND
gain in maximum stress at month 4 is not $> 20\%$
AND
the absolute loss in maximum stress over the
four month period is not > 20000 psi

**evidence of liner
absorbing leachate IF:**

gain in weight at month 4 $> 10\%$

loss in weight at month 4 $\geq 10\%$

AND

**gain in weight at month 4 predicted
by a quadratic fit of weight data $> 7\%$**

AND

the goodness of fit test for weight data succeeds

gain in width at 4 months $> 15\%$

gain in length at 4 months $> 15\%$

gain in thickness at 4 months $> 3\%$

evidence of excessive softening IF:

loss in tensile strength at
break at month 4 > 10%

gain in elongation at break
at month 4 > 20%

loss in maximum stress
at month 4 > 20%
or the absolute loss in maximum
stress over
over the 4 month period

gain in weight at month 4 > 9%
loss in tensile strength at break
at month 4 > 9%

gain in weight at month 4 > 9%
and gain in elongation at break
at month 4 > 18%

gain in weight at month 4 > 9%
and loss in maximum
stress at month 4 > 18%

loss in tensile strength at break
at month 4 > 9% and gain in
elongation at break
at month 4 > 18%

loss in tensile strength at break
at month 4 > 9% and loss in
maximum stress at
month 4 > 18%

loss in tensile strength at break
at month 4 > 9% and loss
in maximum stress
at month 4 > 18%

gain in elongation at break at
month 4 > 18% loss in maximum
stress at month 4 > 18%

gain in weight at month 4 > 7%
and loss in tensile strength at
break at month 4 > 7%

gain in weight at month 4 > 7%
and loss in tensile strength at
break at month 4 > 7%

gain in weight at month 4 > 7%
and gain in elongation at break
at month 4 > 14% and loss in
maximum stress month 4 > 14%

loss in tensile strength at
break at month 4 > 7% and gain
in the elongation at break at
month 4 > 14% and loss in
maximum stress at
month 4 > 14%

evidence of excessive plasticizer loss IF:

loss in weight at month 4 > 5%

loss in weight at month 4 > 5%
and loss in weight at month 4
predicted by a quadratic fit of
the weight data > 3% and fit
test for the weight data good

gain in tensile strength at break
at month 4 > 10%

loss in elongation at break at
month 4 > 20%

gain in maximum stress
at month 4 > 20%
or the absolute gain in
maximum stress over the
4 month period

loss in thickness at month 4 > 3%

loss in width at month 4 > 15%

loss in length at month 4 > 15%

loss in weight at month 4 > 4%
and gain in tensile strength at
break at month 4 > 9%

loss in weight at month 4 > 4%
and loss in elongation at break
at month 4 > 18%

loss in weight at month 4 > 4%
and gain in maximum
stress at month 4 > 18%

gain in tensile strength at break
at month 4 > 9% and loss in
elongation at break at month 4 > 18%

gain in tensile strength at break at
month 4 > 9% and gain in maximum
stress at month 4 > 18%

loss in elongation at break at month
4 > 18% and gain in maximum
stress at month 4 > 18%

loss in weight at month 4 > 3% and
gain in tensile strength at break
at month 4 > 7% and loss in elong-
ation at break at month 4 > 14%

loss in weight at month 4 > 3% and
gain in tensile strength at break
at month 4 > 7% and gain in
maximum stress at month 4 > 14%

loss in weight at month 4 > 3% and
loss in elongation at break at
month 4 > 14% and gain in maximum
stress at month 4 > 14%

gain in tensile strength at break
at month 4 > 7% and loss in elong-
ation at break at month 4 > 14%
and gain on maximum stress
at month 4 > 14%

results are inconclusive IF:

**insufficient information
to run scatter test**

**excessive scatter
in parameter data**

**insufficient information
to run trend analysis**

trend analysis unsuccessful

**gain in weight at month 4 > 10%
AND
loss in tensile strength at break at month 4 not > 10%**

**gain in weight at month 4 > 10%
AND
loss in maximum stress at month 4 is not > 20%
AND
absolute loss in maximum stress at month 4 is not > 20000 psi
AND
absolute gain in maximum stress over 4 month period is not > 20000 psi**

**gain in weight at month 4 > 10%
AND
gain in elongation at break at month 4 not > 20%**

information is missing IF:

for any parameter

no data is entered for the parameter

OR

no month 4 data is
entered for the parameter

OR

no control data is
entered for the parameter

OR

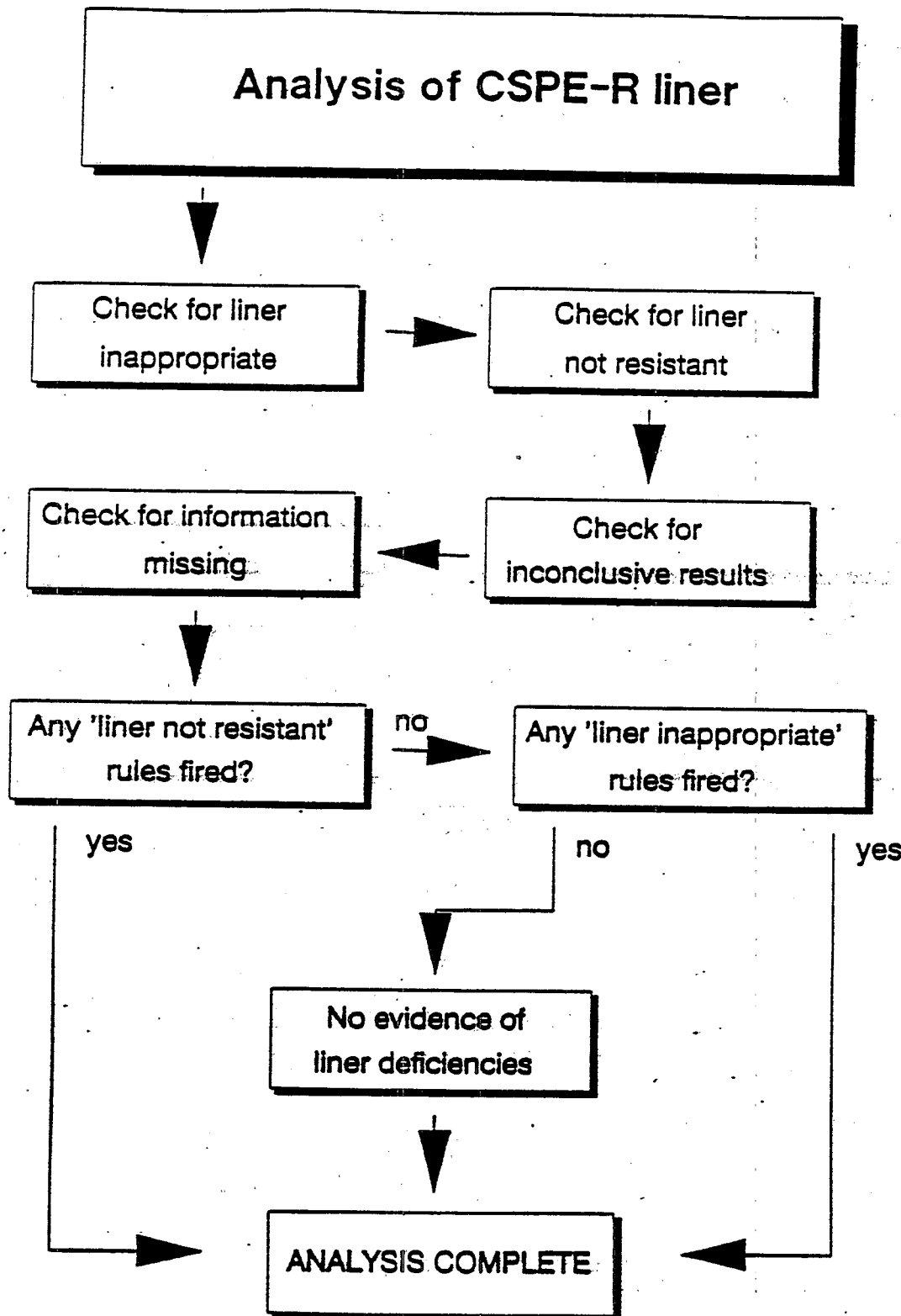
no service life data

OR

no exposure to sunlight data

OR

no maximum exposure temperature



Liner is inappropriate IF:

gauge < 30 mils

liner fails
NSF standards

gauge \geq 30 mils and gauge < 45 mils
and liner is supported (6x6 yarns/inch)
and minimum tensile strength
at break < 60 psi

gauge \geq 45 mils and liner is supported
(6x6 yarns / inch) and minimum
tensile strength at break < 90 psi

gauge \geq 30 mils and gauge < 45 mils
and liner is supported (8x8 yarns/inch)
and minimum tensile strength
at break < 120 psi

gauge \geq 45 mils and liner is supported
(8x8 yarns/inch) and minimum
tensile strength at break < 125 psi

gauge \geq 30 mils and liner is supported
(10x10 yarns/inch) and minimum
tensile strength at break < 200 psi

Liner not resistant IF:

**evidence of
chemical reaction**

**evidence of liner
absorbing leachate**

**evidence of
excessive softening**

**evidence of excessive
plasticizer loss**

evidence of
chemical reaction IF:

loss in weight at month 4 $>$ 5%

gain in weight at month 4 $>$ 5%
AND
loss in weight predicted by quadratic fit at month 4 $>$ 3%

**evidence of liner
absorbing leachate IF:**

gain in weight at month 4 > 10%

**gain in weight predicted by quadratic
fit at month 4 > 5% and quadratic fit
of weight data is good and loss in tear
resistance at month 4 > 20%**

**gain in weight predicted by quadratic
fit at month 4 > 10% and quadratic fit
of weight data is good and loss in tear
resistance at month 4 > 20%**

**evidence of
excessive softening IF:**

loss in puncture resistance at month 4 > 30%

**test temperature ≤ 35 degrees C
AND
loss in tensile strength at break at month 4 > 25%**

**liner supported
AND
loss in puncture resistance at month 4 > 20%
AND
loss in tear resistance at month 4 > 20%**

results are inconclusive IF:

**insufficient information
to run scatter test**

**excessive scatter
in parameter data**

**insufficient information
to run trend analysis**

trend analysis unsuccessful

