A knowledge-based assistant for valve maintenance planning

by

Michael John Winter

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I. INTRODUCTION

A. Statement of the Problem

Electric utilities in the U.S. are looking for ways to improve the safety, performance, and economics of their operating nuclear plants. A new computer programming technique, called knowledge-based or expert systems, may be one method for bringing about these improvements. Expert system programming is one subset of the artificial intelligence research field. Other parts of this field include robotics, machine vision, and natural language understanding.

By developing useful expert system applications for operating plants, the nuclear industry would again be moving toward the forefront of high technology. During the early years, nuclear power rivalled space exploration and the military as an innovator of new technologies. The industry has not moved much since then, because of overcautious management and overconservative regulations. A successful initiative into a revolutionary area such as artificial intelligence may help reestablish the nuclear industry in the forefront of technology, by offering new ideas for operating, maintaining, and controlling nuclear power plants.

This paper describes a project which could be part of such an initiative. The project is a knowledge-based demonstration program to assist maintenance engineers in maintenance planning for motor-operated valves. Small applications of this type are promising because they

minimize requirements for valuable expert consultation time and can be rapidly developed. Also, a maintenance application addresses the needs of today's aging plants. To aid in understanding the programming techniques used in this project, some of the fundamental expert system concepts and terms are explained in the following section.

B. Background on Expert Systems

The source of this background material is Harmon and King (1). Throughout this paper, the terms "expert system," "knowledge system," and "knowledge-based system," are used interchangeably. The term "expert system," as used here, is not restricted to systems which perform at the level of a human expert, as it is in some contexts.

Dr. Edward Feigenbaum of Stanford University, a pioneer in expert systems research, defined an expert system as:

> ". . . an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution. Knowledge necessary to perform at such a level, plus the inference procedures used, can be thought of as a model of the expertise of the best practitioners in the field."

Although this definition implies that expert systems can only be applied to expert problems, the crucial function of an expert system is stated explicitly: an expert system "uses knowledge and inference procedures to solve problems."

In contrast, conventional programs utilize complex, but well-defined and predictable, algorithms to process large amounts of low-

level data. In this context, expert systems can be thought of as processing high-level information, using ill-defined, inexact procedures, which are modeled after human problem-solving procedures. This comparative definition may be more useful to conventional programmers in comprehending the problem-solving role of expert systems.

A generic expert system architecture is shown in Figure 1. The subsystems and interfaces depicted below will now be described briefly.

The knowledge of a human expert is stored in a knowledge base. This knowledge can be implemented in different forms, with the predominant form being IF-THEN rules (productions). A multitude of data types have been developed for storing the information in a knowledge base, including frames and slots, object-attribute-value triplets, nodes and links, and others. Expert, rule-of-thumb knowledge typically consists of conditional relations between these data types, as shown in the following example.

```
IF    Condition A
AND   Condition B
OR    Condition C
THEN  Conclusion D
ELSE  Conclusion E
```

In this example, A, B, etc represent facts or relations which are interdependent. Facts A, B, and C are called antecedents, while D and E are referred to as conclusions of the rule. Structuring knowledge in this form allows a computer program to mimic human reasoning by inferring new facts from existing ones.

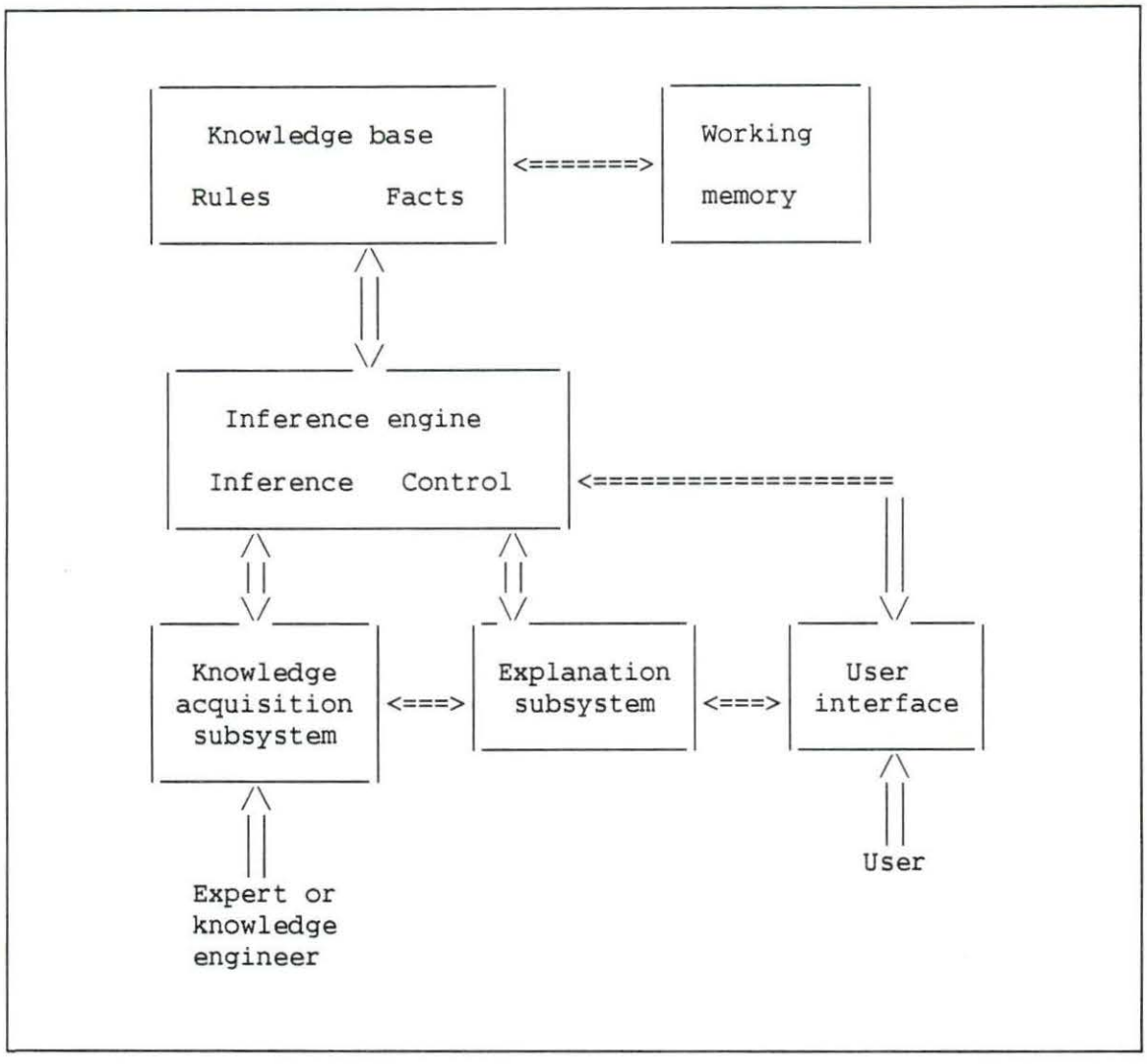

FIGURE 1. The architecture of a generic knowledge-based expert system (1)

All of the facts which are known at a certain point in a consultation session are stored in what is called a working memory. The working memory is continually updated as new facts become known, possibly through rule inferences or from direct user input. This information is cleared whenever a new consultation is begun.

The inference engine controls execution and inferencing in a knowledge-based program. With a production system, two different methods of inferencing are possible: forward chaining and backward chaining. In a forward chaining (also called data driven) system, an initial set of facts, or data, is used to infer new facts by executing appropriate rules. For example, if A, B, and C in the above example rule are known, then either conclusion D or E can be inferred. This technique is useful for problems which have many ill-defined solutions, because many different solutions can be pursued simultaneously. In contrast, backward chaining (or goal driven) systems begin by assuming a final or root goal, and then attempt to verify this goal by determining the truth value of antecedents in rules which conclude the goal. If these antecedents are also conclusions in other rules, then they become sub-goals in the process. The program asks the user a question when a required fact is not concluded in any rule. This information is then propagated down the constructed rule chain to determine if the root goal is actually supported by the evidence. If not, the next goal is selected and the process is begun again. Backward chaining works well for problems which have a limited number of known, well-defined solutions, since the search space can be rapidly reduced.

Another knowledge system component shown in Figure 1 is a knowledge acquisition subsystem. The sophistication of this component covers a broad range: from simple editors for entering new rules and relations into a knowledge base, to induction algorithms for building rules from

examples of decisions made by experts, to well-developed graphics tool kits for building models of physical systems interactively on the screen. Regardless of the method employed, the knowledge acquisition subsystem enables the knowledge engineer to transform an expert's knowledge into a useable form for the inference engine.

An integral part, and one of the defining features, of any knowledge system is an explanation facility. Transparency, traceability, and explainability are vital attributes of an expert system, because the user will only trust a proposed solution if the reasoning steps can be examined, much as asking a human expert for explanation. Again, the explanation capabilities of present programs cover a wide range.

The final component depicted in Figure 1 is the user interface. This component is one of the most important, since it heavily influences whether or not a system will actually be used. A user interface is simply a communication link between the person requiring advice and the expert's knowledge residing in the computer. The key attributes for a user interface are ease of use and transparency to the consultation session being developed by the inference engine.

This general background on knowledge systems should provide a basic understanding of the concepts and terminology used in he remainder of this paper, which is outlined in the following section.

C. Scope

Chapter II contains a literature review of previous work done within the scope of the topics covered in this thesis. First, the history and importance of valve maintenance in nuclear power plants is reported. Then, a review of efforts in expert system developments is presented, with a focus on systems most similar to the present study.

Valve maintenance planning is explored in Chapter III. The topics covered include: the valve maintenance planning process, a description of the items which must be evaluated for a typical maintenance planning case, and a discussion of the potential benefits of computerizing maintenance planning.

In Chapter IV, the steps in development of the valve maintenance planning assistant are outlined, including: criteria used for selecting the application problem and the development tool, the methods used for eliciting knowledge from maintenance planners, and the techniques used to structure this knowledge within INSIGHT2+ (the expert system development tool used in this work).

The results of this study are summarized in Chapter V. First, the organization of the program is presented, with reference to implemented functions. Then, a walk-through of an example consultation session is provided, including the actual screens a user would see. Also presented are plans for evaluating and validating the program, which include the capability to run a series of test cases in batch mode.

Conclusions and suggestions are given in Chapter VI. Finally, the valve maintenance planning program source and all supporting Pascal programs are listed in Appendices A and B.

II. LITERATURE REVIEW

Two distinct topics form integral parts of this investigation: maintenance of motor-operated valves (MOVs) in nuclear power plants, and expert or knowledge system applications. A review of past work in both of these topics is helpful in understanding the project described in this paper, the project being a knowledge-based MOV maintenance planning assistant.

A. Review of Valve Maintenance Literature

The first part of this review covers valve maintenance; the reader is referred to Chapter III for a more complete discussion of valve maintenance technical terms which pertain to this study.

Valve maintenance comprises a substantial portion (30%) of the U.S. nuclear industry's annual maintenance budget (2). In addition, valve problems cost an estimated $100 million per year in loss of plant availability (3). These numbers indicate that valve maintenance is a potential area for major reductions in nuclear power plant operating costs.

A Nuclear Regulatory Commission (NRC) investigation (4) of valve operator events (compiled from Licensee Event Reports, LERs) identified motor operators as the greatest single type (43%) of operator in the study sample. The predominance of motor operators among valve operator events is probably due to the complexity of a MOV system, which includes a control circuitry with limit switches, torque switches and associated sensors.

More than a dozen studies have been conducted in the past ten years on MOV problems (5). The subjects of these studies include torque switch failure, clutch component wear, limit switch gear lubricant, improper operator sizing, and improper switch settings. The results of these studies pointed out the need for more effective and consistent valve maintenance practices in the nuclear power industry.

In response to these investigations into MOV problems, a special session titled, "The Impact of Valves on Plant Operations and Plant Availabilities: Problems and Solutions," was sponsored by the American Nuclear Society's (ANS) Reactor Operations Division at the June 1985 ANS annual meeting. One of the papers at the session (3) described several projects being sponsored by the Electric Power Research Institute (EPRI) with the following objectives:

1. to develop equipment designs that will achieve performance requirements and be less prone to failure than existing designs
2. to extend the period between required maintenance
3. to improve maintainability so that a normally qualified work force can effectively perform the needed task

Brown (6), of the NRC, reported on his investigations of MOV events. He offered the following suggestions for addressing valve operability problems:

1. Develop improved methods and procedures for the setting of torque switches, and evaluate them relative to valve operability and functional qualification under accident conditions.
2. Develop signature tracing techniques to obtain limit switch/torque switch actuation set points, with the objectives of using these techniques as an indicator of

changes in operability characteristics and a predictor of the remaining margin to failure.

Charbonneau (7) described his company's MOVATS-2000 signature testing diagnostic system. During a valve cycle, this portable testing device measures and records the relative or actual valve stem thrust, the time and actuation of all control switches, and the dynamic motor current. This valve cycle signature trace can then be analyzed to determine mechanical and electrical degradations of the MOV. Initial testing of 132 MOVs (primarily with no failure history) identified sixteen degradation categories with 0.7% to 36% of the tested valves listed in each category.

Paul and VanScooter (2) discussed their work in addressing inadequate maintenance practices, which they claim is probably the greatest contributor to the overall valve problem in the industry. They have developed a one week curriculum for valve maintenance training, which consists of both class room and lab instruction. Industry feedback from field tests of this curriculum indicates that effective valve maintenance training can contribute significantly to reducing valve problems, maintenance costs, and plant leak rates.

More recently, the Electric Power Research Institute (EPRI) has established a Nuclear Maintenance Assistance Center (NMAC), with one of the first projects being MOV maintenance, "an issue of great interest to the nuclear utilities" (8).

B. Review of Expert System Literature

The second part of this review presents past work on the second major topic comprising this research project: expert system applications. Chapter I contains a background discussion of expert systems and associated terminology.

One of the first true expert systems developed was DENDRAL and its successors at Stanford University (9,10). The project was begun in 1968 and continues today. DENDRAL determines possible molecular structures of known constituent atoms by analyzing mass spectrographs of a sample. DENDRAL has been shown to equal the performance of human experts in its specialized domain.

Another Stanford project, MYCIN, is probably the most famous expert system developed to date (9,11). This program uses patient symptom data and lab analyses to diagnose infectious organisms and prescribe drug therapy. MYCIN's medical knowledge is stored in production (IF-THEN) rules, and its inference strategy is simple backward chaining. MYCIN's success helped to bring an awareness of expert system technology to many people outside of the Artificial Intelligence (AI) community.

Expert system applications in nuclear engineering were discussed at a recent ANS topical meeting. One of the papers described a Reactor Safety Assessment System (RSAS), being developed for the NRC (12). The purpose of the RSAS is to assess the status of a nuclear plant experiencing an alert or more serious incident. Another paper discussed a prototype fuel shuffling assistant developed by EPRI (13), which uses

heuristic fuel shuffling rules to find an optimum reloading pattern in a nuclear reactor core.

Many other AI applications to nuclear power plant operations were also presented at this topical meeting. Kiguchi et al. (14) reported on their system for diagnosing suspected faults in nuclear power plants, using both event-oriented and function-oriented knowledge.

A maintenance-related paper was presented by Frank et al. (15). Their system consists of two software packages (Reactor Trip Simulation Environment, RTSE, and Key Component Generation Environment, KCGE), developed by the Management Analysis Company. These packages are designed to improve plant availability by reducing the risk of inadvertent reactor trips. The RTSE is used to predict whether a proposed action or procedure could lead to a reactor trip. The KCGE identifies groups of "key components," whose simultaneous change of state could cause a trip, thus measuring the remaining margin to trip. These packages have been tested in actual plant environments.

Other expert system applications presented at this topical meeting include: reactor operations support (16), event tree analysis (17), and real-time diagnostics and control (18).

In a research project more closely related to maintenance engineering, Grant (19) surveyed potential applications of AI techniques to aircraft maintenance management for the Engineering Branch of the Royal Air Force. The six application classes he identified were:

- intelligent front ends
- consultative aids to technical manuals

- maintenance regulations and "good practices"
- diagnostic aids for novel and familiar faults
- an equipment assignment aid, and
- a maintenance work scheduling aid

In another maintenance application, Pau (20) performed a survey of expert systems for fault detection, test generation, and maintenance. He identified five major improvement areas with a potential for application of knowledge engineering techniques:

1. self-improving diagnostics: functional test sequences can be cost-effectively improved, and automated learning through metarules is a promising area
2. more effective fault detection and isolation, through built-in-test knowledge-based systems
3. discrimination between false alarms and intermittent faults, or multiple faults
4. reduction of skills required for test and maintenance
5. integrated diagnostics

Most of the expert system applications mentioned above were developed on mainframe computers, using a general-purpose language such as LISP. But with the evolution of cheaper, more powerful microcomputers, a new market has appeared for inexpensive, micro-based expert system development tools, thus making the technology available to small groups and individuals (21,22,23).

III. VALVE MAINTENANCE PLANNING

A. Introduction

In this chapter, the relevant concepts and procedures of valve maintenance planning, as performed at the Duane Arnold Energy Center (DAEC), are introduced. A discussion of valve maintenance planning is useful for several reasons. First, a familiarity with valve maintenance planning concepts is necessary to understand the knowledge transfer from the experts to the computer, in the form of the valve maintenance planning assistant. Also, a familiarity with valve maintenance planning terminology is required when evaluating what the valve maintenance planning assistant actually does. Finally, the motivation for developing innovative computer applications in this area can be seen more clearly once the maintenance planning process is explained.

The topics covered in this chapter include: an overview of the valve maintenance process, a more detailed description of maintenance planning tasks and parameters, and a discussion of the advantages of computerizing maintenance planning knowledge.

B. The Process of Valve Maintenance Planning

Valve maintenance planning is a very time-consuming task at nuclear power plants because of the large number of valves involved and the high level of quality assurance required. The steps comprising this process typically include diagnosis of the problem, prescription of maintenance

activities, and the determination of a number of factors which affect the maintenance task.

Diagnosis of a valve problem can range from being a trivial task to a lengthy process requiring complete disassembly of the valve. An example of a trivial diagnosis is when the sealtite between the motor and operator needs replacing. Sealtite is a protective sheath which covers wiring from one point to another. A broken section of sealtite can be detected during a visual inspection, without any disassembly of the valve system. A more complex diagnosis, such as a worn seating seal, would require an extensive disassembly of the valve body. If the problem is not completely known before maintenance work is begun on a valve, then the maintenance planning process cannot be completed in one step, since the required maintenance actions cannot be prescribed. In this case, several iterations of maintenance planning may be required, due to the change in scope of the repair. The result is a longer repair period, requiring more engineering time and maintenance labor.

Maintenance prescription is a step in the maintenance planning process which sometimes cannot be distinguished from problem diagnosis. For example, in the broken sealtite case mentioned above, the necessary repair is obviously to replace the broken section of sealtite. But in addition to simply stating the necessary repair, the maintenance planner might also need to outline the steps to follow in the repair procedure, if the maintenance activity does not already have a written procedure. In the case of the worn seating seal, the maintenance engineer may need

to write special instructions for disassembling the valve, depending on the valve type.

Other items relevant to the valve maintenance action also need to be evaluated by the maintenance planner. Included among these items are: post-maintenance testing, valve quality level, whether the valve is safety-related, the applicability of cleanliness control procedures, tag out requirements, primary containment considerations, radiation work permit requirements, heavy load, fire protection, parts, and lifted lead evaluation. The items in this list which have been incorporated into this project are described in the following section.

C. Description of Maintenance Planning Items

The current version of the valve maintenance planning assistant evaluates the following items: ASME (safety-related), tag out, primary containment, heavy load, and post-maintenance testing. Since post-maintenance testing was the first item included in this project, and has received the most attention, it will be described first.

The requirements for post-maintenance testing of valves are spelled out in the ASME Boiler & Pressure Vessel Code (24), which states

> "When a valve or its control system has been replaced or repaired or has undergone maintenance[1] that could affect its performance, and prior to the time it is returned to service, it shall be tested to demonstrate that the performance parameters which could be affected by the replacement, repair,

---

[1]Examples of maintenance that could affect valve performance parameters include adjustment of stem packing, removal of the bonnet, stem assembly, or actuator, and disconnection of hydraulic or electrical lines (24).

or maintenance are within acceptable limits."

This requirement means that the maintenance actions performed on a valve must be evaluated to determine if the valve performance may have been affected. If so, then adequate post-maintenance testing must be carried out to assure that the valve will perform its function if called upon. The types of tests that may be used to assure valve performance include stroke open and close tests (BTO,BTC), position indication test (PIT), local leak rate test (AT1,AT5), and hydrostatic system pressure test (SYSPR). Determining which (if any) of these tests must be performed after a given maintenance activity is one of the steps of valve maintenance planning.

The ASME, or safety-related item, also has its basis in the ASME Boiler & Pressure Vessel Code. The purpose of this item is to note whether or not the valve in question is within the scope of the ASME requirements, which is entirely dependent on the type and function of the valve. The scope section in the ASME code reads (24)

> "This Subsection provides the rules and requirements for inservice testing to assess operational readiness of certain Class 1, 2, and 3 valves (and their actuating and position indicating systems) in light-water cooled nuclear power plants, which are required to perform a specific function in shutting down a reactor to the cold shutdown condition or in mitigating the consequences of an accident."

This item is therefore independent of the maintenance actions performed on a valve.

Tag out refers to placing a notice on the valve control switch while maintenance is being performed. Tag out is required when the

maintenance action will incapacitate the valve, and either attempted actuation is dangerous, or it is necessary for the operators to be aware of the valve's condition. This determination is primarily dependent on the maintenance actions performed on the valve.

Primary containment indicates whether or not a valve forms part of the reactor containment system's primary containment boundary. This item is considered independent of maintenance actions.

Heavy load is the last item currently being considered in this project. Heavy load refers to the weight and size of the valve operator, and indicates whether special considerations must be made due to the operator size. This item depends on two factors: the size of the operator, and whether or not the operator needs to be removed during the maintenance. Heavy load is therefore dependent on both the valve and the maintenance actions performed.

All of the items mentioned above, with the exception of post-maintenance testing, require only a yes or no indication on the Corrective Maintenance Action Request (CMAR) form used at the DAEC. Next, several possible advantages of incorporating maintenance planning abilities in an expert system will be presented.

D. Advantages of Computerizing Maintenance Planning Knowledge

As mentioned previously, valve maintenance is a time-consuming task at nuclear power plants for both maintenance engineers and technicians. One of the problems facing the maintenance engineer is the number of

sources of information that must be consulted. These sources include the people who reported the problem, a data base which contains specific information about the valve, procedures and guides for determining the maintenance requirements, parts inventory lists, other engineers who may have expertise in this particular problem, and others. The planner must also coordinate the maintenance with previously scheduled maintenance plans, periodic testing requirements, and plant operation schedules.

By unifying a segment of this diverse information, a savings of time and effort involved in valve maintenance planning could potentially be realized. A demonstration of this unification is a major goal of this project. Also, if maintenance planning knowledge can be effectively implemented in a knowledge system, then the skills of the most competent valve maintenance planning expert could be made available to anyone in the plant who needs it.

This completes the background discussion of valve maintenance planning, with its concepts and procedures. Details of the development of the knowledge-based valve maintenance planning assistant are presented in the following chapter.

IV. DEVELOPMENT OF THE VALVE MAINTENANCE PLANNING ASSISTANT

The major steps in building the valve maintenance planning assistant are described in this chapter. First, the processes of problem selection and development tool selection for this project are discussed, including the criteria considered. Then, a description is given of how the knowledge contained in the system was acquired. Finally, the knowledge implementation scheme for the valve maintenance planning system is outlined, with reference to the various programs and their structure.

A. Selection of Problem and Development Tool

In this section, an explanation is given of two important steps in the project development: selection of the application problem for the project, and selection of the development tool used to construct the valve maintenance planning knowledge base. The intent of this explanation is to list the criteria considered during the selections, and to outline the reasoning which led to the specific selections.

1. Problem Selection

Selection of an appropriate problem application for a knowledge system is possibly the most crucial step in the development process (1). Seven months were allocated in the project proposal (25) to define selection criteria, to evaluate a number of possible applications using these criteria, and to make a final problem selection.

The selection criteria were defined to choose a problem for which a solution could be demonstrated successfully within the project time period (1-2 years). The following criteria were considered during the problem selection process:

1. The problem should be important enough to motivate a knowledge system application.

2. The problem should be simple enough to be solvable by a first time knowledge system developer.

3. The application area should have one or several identifiable persons to serve as experts for consultation.

4. The problem should be of a suitable type for the expert system tools (PC based) under consideration; generally, the problem should be of the diagnosis/prescription type.

5. The problem should be related to nuclear engineering (the developers' background).

Through discussions with plant personnel, three possible problem applications were identified: control rod pattern changes (BWR), component classification (safety-related, non safety-related, etc), and post-maintenance testing requirements for motor-operated valves (MOVs).

Control rod pattern development was passed over because some of the required information comes from a reactor model not accessible by the PC tools, and the problem only arises several times per year. The part classification problem was very interesting and will likely become an expert system application in the future. But the scope of the problem seemed too large to serve as a first project. The utility's objective is to reclassify every component in the plant, from the system level down to the individual part level.

MOV post-maintenance testing, on the other hand, fit the specified criteria quite well. First, the importance of valve maintenance has already been stressed. Second, with the original scope (post-maintenance testing determination for safety-related MOVs), the problem appeared appropriate as a first project. Third, several people were identified as domain experts. Fourth, the type of reasoning underlying the solution process fit the diagnosis/prescription mold. Finally, the problem domain fell under the broad umbrella of nuclear engineering subject matter. Thus, post-maintenance testing determination for safety-related MOVs was selected as the initial application for study.

Since selection of an appropriate application ultimately determines whether an expert system is successful, the initial work of specifying selection criteria and evaluating candidate problems cannot be overemphasized. Another significant decision to be made up front when developing an expert system is selection of a development tool, which will be discussed next.

2. Development Tool Selection

Selection of the expert system tool to be used for this initial project was simplified by several constraints, which helped define selection criteria. The criteria considered for tool selection are listed below.

1. Cost of the tool should be minimal (less than $1000) due to financial limitations.
2. The tool must be available for use on an IBM PC-XT or equivalent computer.

3. The tool should be simple enough so that a novice could learn how to use it quickly through self-training.

4. The tool must be able to interface with external programs written in standard languages.

INSIGHT2+, from Level Five Research, was selected as the development environment for this project. This program matched the specified selection criteria closely. Retail price of the package is approximately $500; it was designed to run on an IBM PC/XT/AT; knowledge bases are very easy to write, and consist of simple English IF-THEN production rules; and external programs can be called from within a knowledge base with simple programming steps.

Overall, INSIGHT2+ provided an easy-to-use tool which minimized the amount of time required for user training. This allowed more time for eliciting the crucial knowledge from the actual experts, which will be discussed next.

B. Knowledge Acquisition

Knowledge acquisition is probably the most important and yet most difficult step in expert system development. The performance of a knowledge system is directly related to the quality and quantity of the expertise comprising the knowledge base.

The methods used to gather information for this project will now be described. The sources of information included a valve data base, maintenance engineers, case histories of valve maintenance actions, and troubleshooting manuals.

The valve data base used consists of a listing of safety-related motor-operated valves in the plant's testing program. The following items were extracted for each valve: testing class, ASME category, physical characteristics (size, type, normal position), applicable post-maintenance tests, and test parameters (maximum stroke time, maximum leakage rates). This information was incorporated into a Turbo Pascal data base file, and is accessed by the knowledge base.

Maintenance engineers were the primary sources of maintenance planning knowledge. Several different methods were used to gather information from the engineers. The most effective method was face-to-face discussion and note-taking on the maintenance planning items, and the information required to make decisions about these items. A key realization made during these discussions was that the types of maintenance actions performed on a valve were fundamental in determining required post-maintenance testing and tag out requirements. General information about valve testing requirements was gained by attending and tape recording a lecture by an ASME expert. Finally, corrections and refinements to the knowledge base were made by running test cases with the maintenance engineer present to detect faults. These human experts provided the most valuable knowledge, and the most efficient means of obtaining this knowledge. An estimated forty hours of consultation time were spent with the experts to build this demonstration knowledge base.

Another important knowledge source was a set of maintenance records for the valves included in the data base. Examples of different types

and combinations of maintenance actions were extracted from these records to increase the scope of the knowledge base. Also, some special cases were incorporated by examining these case histories.

Several troubleshooting manuals for valves and valve operators were consulted for problem diagnosis strategies. These manuals provided a set of basic valve and operator problems, and their associated symptoms. Only these basic problems were incorporated into the knowledge base, since problem diagnosis was not a major part of the project.

Knowledge acquisition required the majority of project time, due to remoteness and limited availability of the human experts. The implementation of this knowledge in an INSIGHT2+ knowledge base is discussed in the following section.

C. Knowledge Implementation in the INSIGHT2+ Environment

This section contains descriptions of the rule structure in the INSIGHT2+ knowledge base, and the supporting Pascal programs. A more complete overview of the system structure is given in the following chapter.

The maintenance planning portion of the knowledge base contains rules for determining requirements for post-maintenance testing, tag out, heavy load, and primary containment (see Chapter III for a description of these items). As mentioned previously, maintenance actions performed on the valve are the primary data used by maintenance planners.

Two example rules from the post-maintenance testing section of the knowledge base are shown below.

```
RULE  For determining BTC requirements
IF    BTC applicable
AND   Maintenance affects stroke close time
THEN  BTC test is required
ELSE  BTC test is not required
```

```
RULE  For analyzing packing adjusted condition for BTC test
IF    valve body maintenance IS packing adjusted
THEN  Valve body maintenance requires BTC test
AND   FILE Packing adjusted requires BTC test
```

BTC refers to a stroke close test. These rules exhibit the simple, English rule syntax used in INSIGHT2+. The first rule screens for applicability of the test (IF clause), and calls other rules for determining if BTC is required (AND clause). The second example is a low level rule for analyzing one maintenance action. Writing small, modular rules in this fashion allows for easy additions and corrections to rule sections, without affecting other parts of the knowledge base. The structure for the tag out rules is similiar in form to the post-maintenance testing rules.

One of the rules for determining heavy load is shown below.

```
RULE  For checking conditions for heavy load notice
IF    The operator must be removed during the maintenance
AND   The operator size is large
THEN  Heavy load is indicated
AND   HLOD := Y
AND   FILE heavy load indicated
ELSE  Heavy load is not indicated
AND   HLOD := N
AND   FILE heavy load not indicated
```

The clause for operator removal is determined by several lower level rules, while the operator size clause generates a question for the user. Primary containment is determined by simply searching a list of primary containment valves.

The two rules listed below are from the problem diagnosis knowledge base.

```
RULE  For determining definite valve body problems
IF    Stem needs lubrication analyzed
AND   Worn body to bonnet gasket analyzed
AND   Worn packing analyzed
THEN  Definite valve body problems are known
```

```
RULE  For diagnosing stem lub from excessive handwheel effort body
IF    Affected system for diagnosis IS valve body
AND   valve body symptom IS Excessive handwheel effort
THEN  Definite evidence for stem lub
AND   valve body problem IS stem needs lubrication
AND   Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS motor control center
AND   valve body maintenance IS valve stem maintenance
AND   NOT valve body maintenance IS valve replaced
AND   NOT valve body maintenance IS valve disassembled
AND   NOT valve body maintenance IS packing adjusted
AND   NOT valve body maintenance IS repacking performed
AND   NOT valve body maintenance IS replaced body to bonnet gasket
AND   NOT valve body maintenance IS maintained seating surface
AND   DISPLAY valve diagnosis display
AND   DISPLAY stem lub from excessive handwheel effort body
AND   FILE stem lub from excessive handwheel effort body
```

The first rule drives the analysis of several possible valve body problems. The second rule is the low level rule which generates questions about valve symptoms for the user. This rule also illustrates how maintenance actions are prescribed for a specific valve problem. In

this case, the prescribed maintenance action is valve stem maintenance, derived from the symptom of excessive handwheel effort. After the maintenance actions have been prescribed, they are passed to the maintenance planning knowledge base as input. This eliminates manual input which the user would otherwise have to supply.

The control, diagnosis, maintenance planning, and batch testing knowledge bases contain a total of 252 rules. A listing of all the INSIGHT2+ knowledge base files has been included in Appendix A.

The valve data base information has been implemented in a PC using Turbo Pascal. Two Pascal programs have been written to manipulate the data base. The first program has editing and listing capabilities, and the second is used by the knowledge base to access information for a specific valve. A listing of all supporting Pascal programs is available in Appendix B.

This concludes the discussion on system development, including selection of the application problem and development tool, knowledge acquisition, and knowledge implementation. The following chapter contains a more complete description of the system structure and functions, and also demonstrates an example consultation session with the system.

V. RESULTS AND DISCUSSION

Unlike conventional computer-oriented research, the results of a knowledge-based programming project are inherent in the program itself, and in the running of the program. As a result, describing the results of such a project in a written report is difficult, and necessarily incomplete without an actual demonstration. The approach taken here is to describe the system's structure and functions, with all the program source included (Appendices A and B). Then, two example consultation sessions are provided, including actual screens the user would see while running the system. Finally, the work and planning done for evaluating and validating the system are described.

A. Structure and Functions of the Valve Maintenance System

Some examples of the internal rule structure used in the knowledge bases were given in the previous chapter. In this section, the emphasis is on the overall system structure. The actual knowledge base listings have been included in Appendix A for reference.

The valve maintenance planning system structure is shown graphically in Figure 2. The control knowledge base executes when the system is started, and accesses the valve data base. One possible flow path is to diagnose a valve problem and prescribe appropriate maintenance actions, based on user input symptoms. The control knowledge base calls the diagnosis program, and passes it the valve information. If the user has requested a maintenance planning

consultation with the diagnosis, the diagnosis program calls the maintenance planning knowledge base, and passes any prescribed maintenance actions it has found.

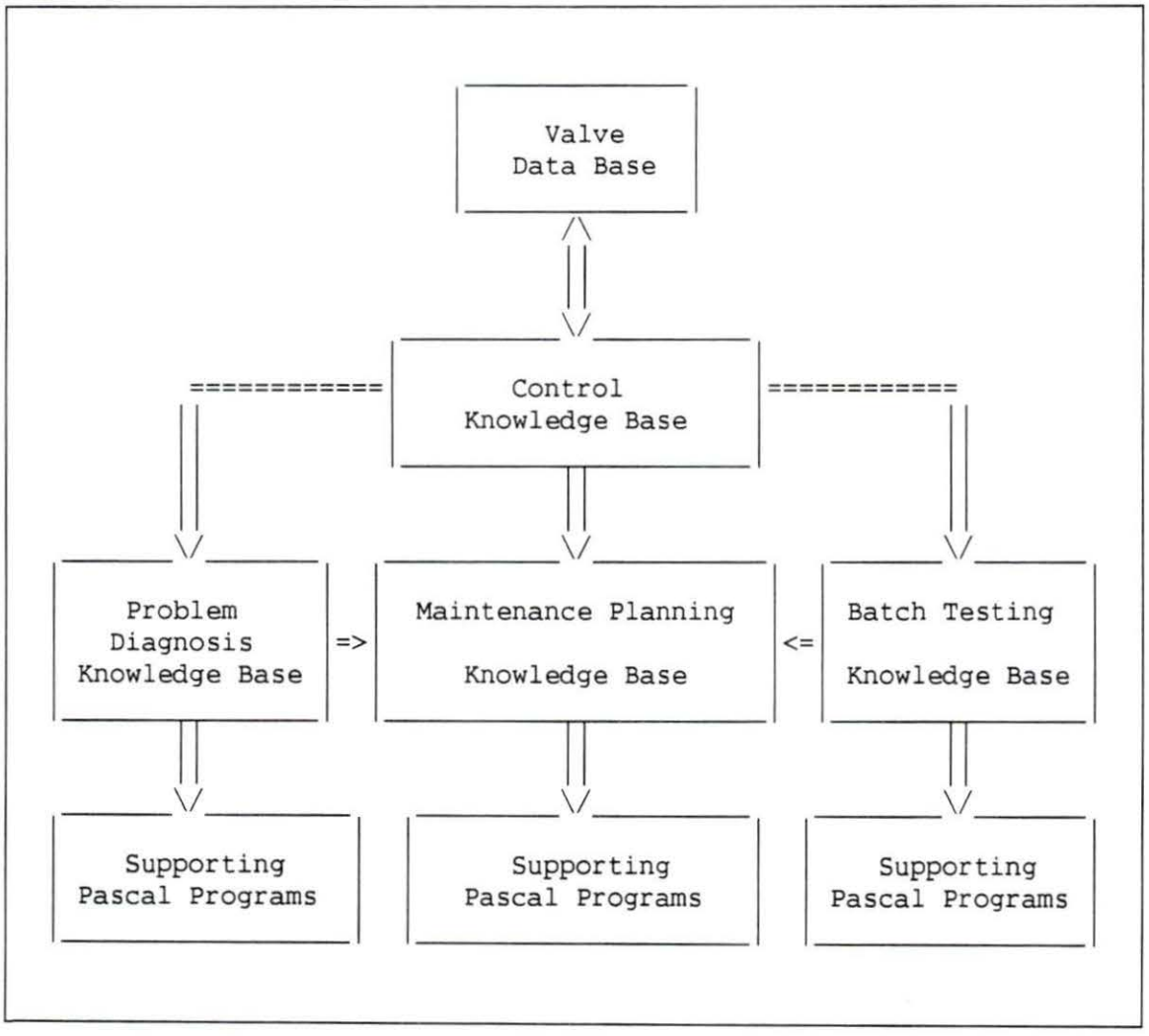

FIGURE 2. Structure of the valve maintenance planning system

The user also has the option of calling the maintenance planning program directly, if the problem and required maintenance are already known. Maintenance actions are then input manually, along with any required case-specific information. The maintenance planning items are then determined, and output in the same format as the plant's Maintenance Action Request form.

Another option available from the initial main menu is to run the batch testing knowledge base. Batch testing consists of analyzing a series of standard test cases by repeatedly calling the planning knowledge base, and storing the results in a data file. This file can then be displayed or compared to another set of results. Thus, this option can be used to check the effects of changes to the knowledge base.

Some examples of actual screens a user would see when running a session can be found in the following section.

B. Example Consultations With the Maintenance System

Two sample consultation sessions are illustrated in this section. The first begins with problem diagnosis, and continues automatically to maintenance planning. The second session begins directly with maintenance planning, so that these input screens can also be seen.

The main menu screen is shown in Figure 3, and the indicated option was selected for session one. The next screen to appear is shown in Figure 4, where the valve ID is entered to allow valve data base access.

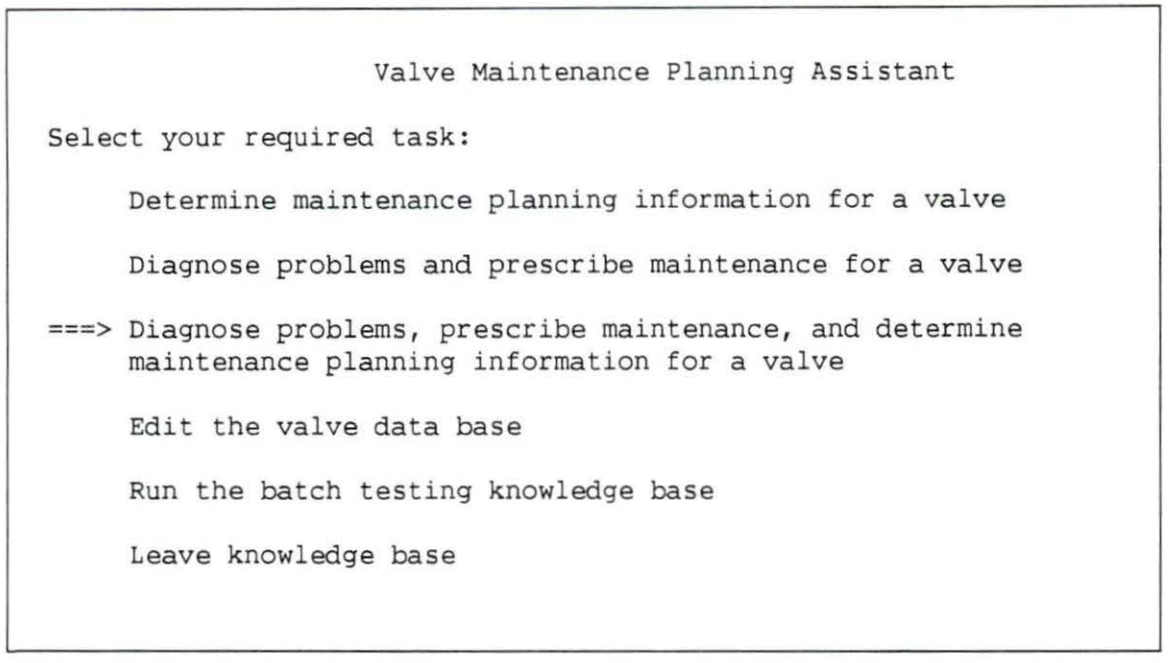

FIGURE 3. Main menu screen from control knowledge base

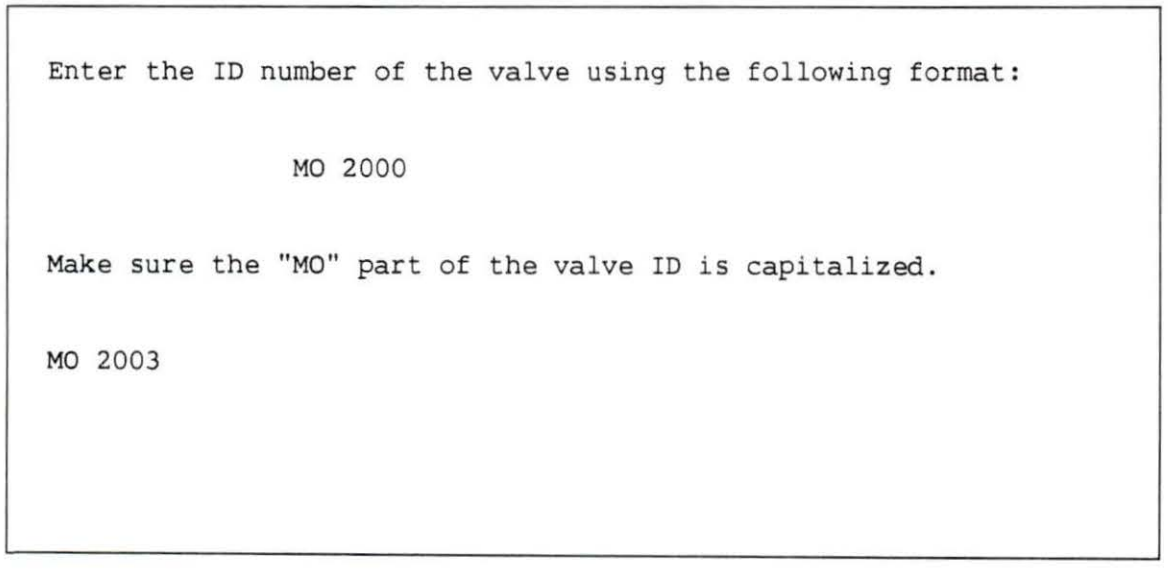

FIGURE 4. Valve ID input screen

Figure 5 shows the first diagnosis knowledge base screen. The valve body was selected as the problem area, which brings up a list of possible valve body problem symptoms, as shown in Figure 6. For this case, the symptom of "Leakage between valve body and bonnet area" was sufficient to diagnose the problem, and the results depicted in Figure 7 are displayed. The identified problem was a worn body to bonnet gasket, and the prescribed maintenance was to replace the gasket. This corresponds to the action of "valve disassembled" in the maintenance planning knowledge base.

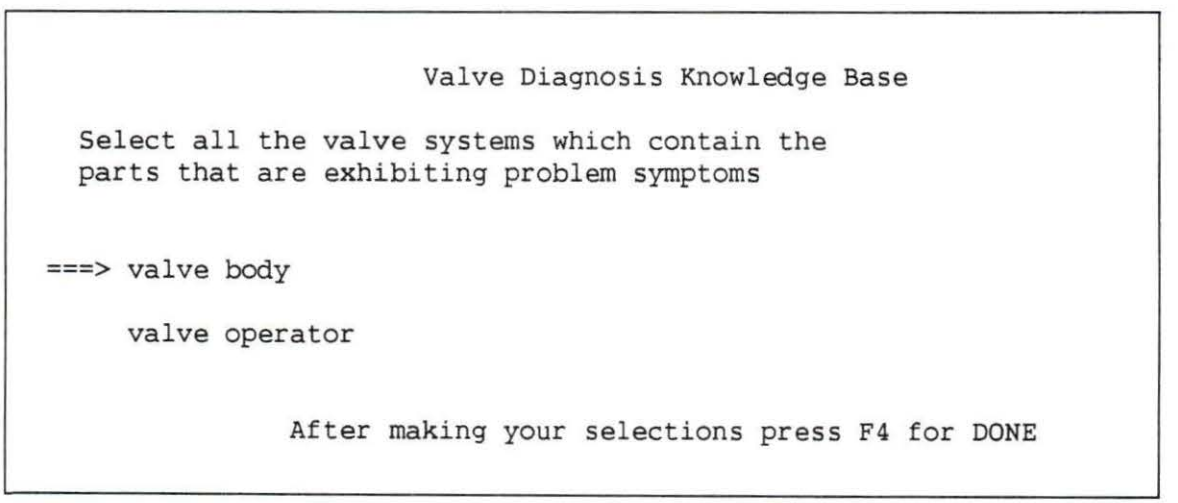

FIGURE 5. Diagnosis system selection screen

Since all necessary information was supplied to the maintenance planning program, it ran transparently, and produced the results screen shown in Figure 8.

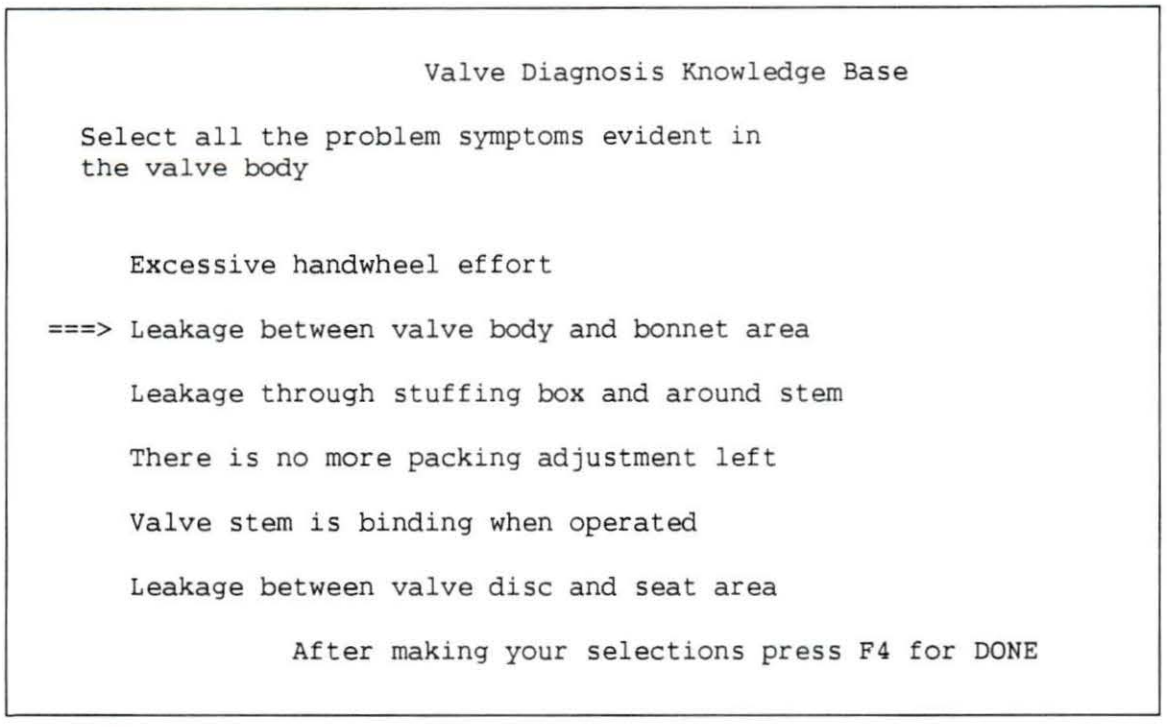

FIGURE 6. Diagnosis valve body symptom selection screen

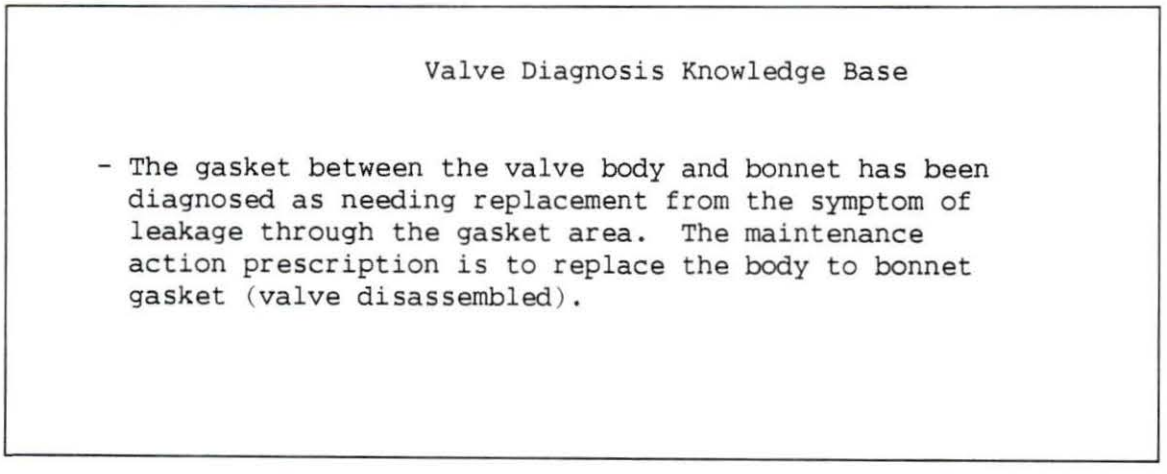

FIGURE 7. Diagnosis results screen

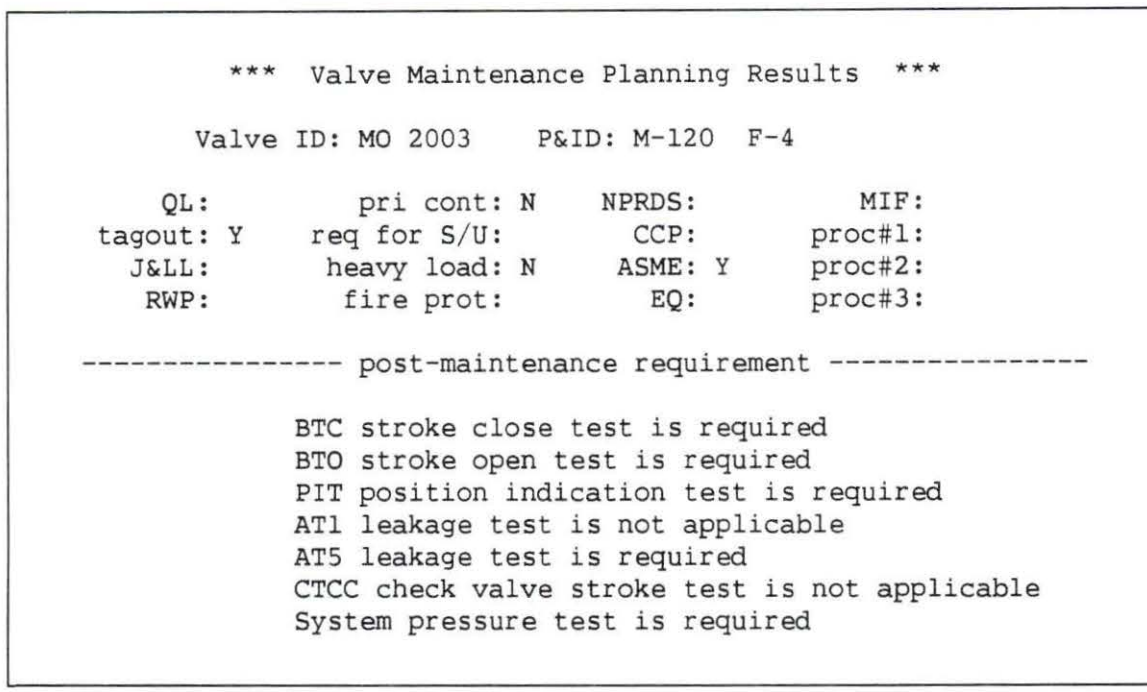

FIGURE 8. Maintenance planning results for first session

Next, another session is illustrated where the planning knowledge base was called directly. This time the valve operator was selected as the affected system, as shown in Figure 9. Possible valve operator maintenance actions are displayed in Figure 10, from which "Valve operator was lubricated" was selected. For this case, more specific information about the maintenance actions was required, and the queries depicted in Figures 11 and 12 were generated. Both questions were answered TRUE. The results for this session are shown in Figure 13.

These examples demonstrate only two of the possible combinations of user interactions with the system, but they serve to represent typical

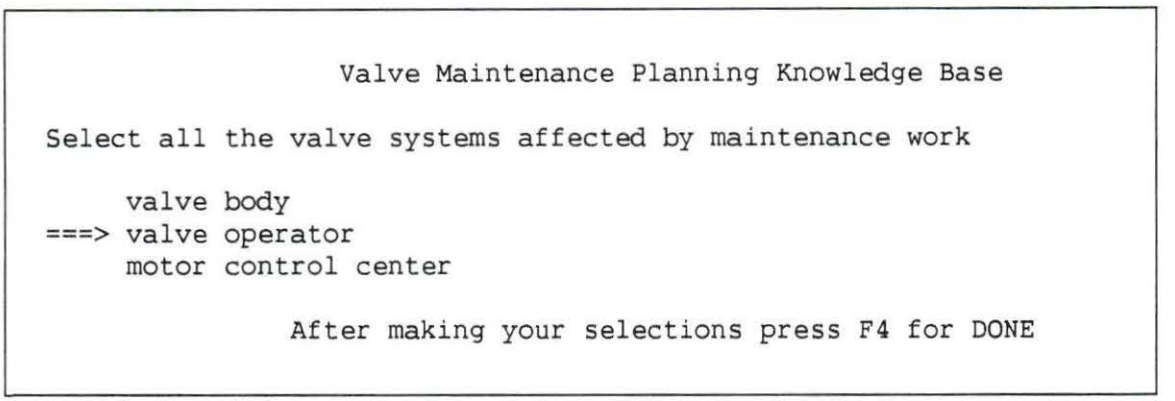

FIGURE 9. Maintenance planning system selection screen

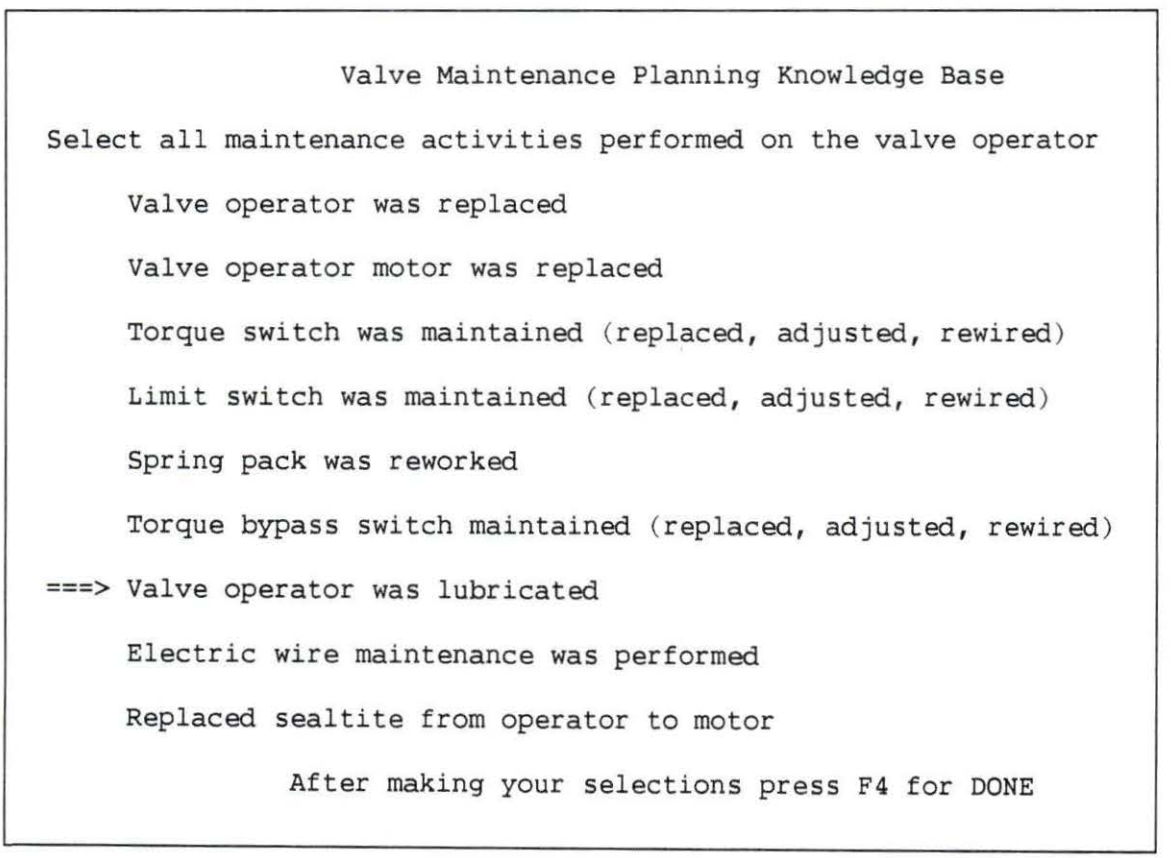

FIGURE 10. Valve operator maintenance action selection screen

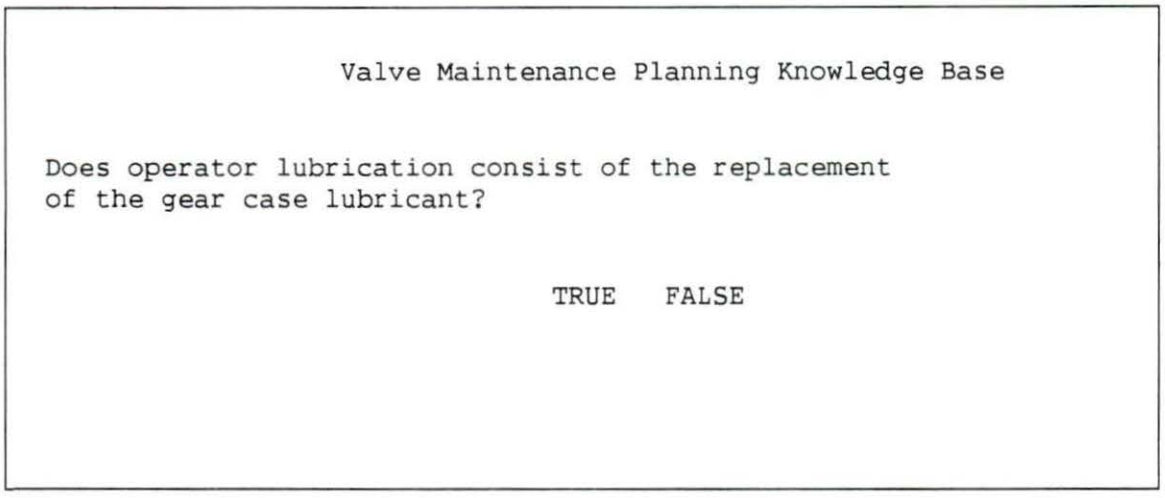

FIGURE 11. Operator lubrication query screen

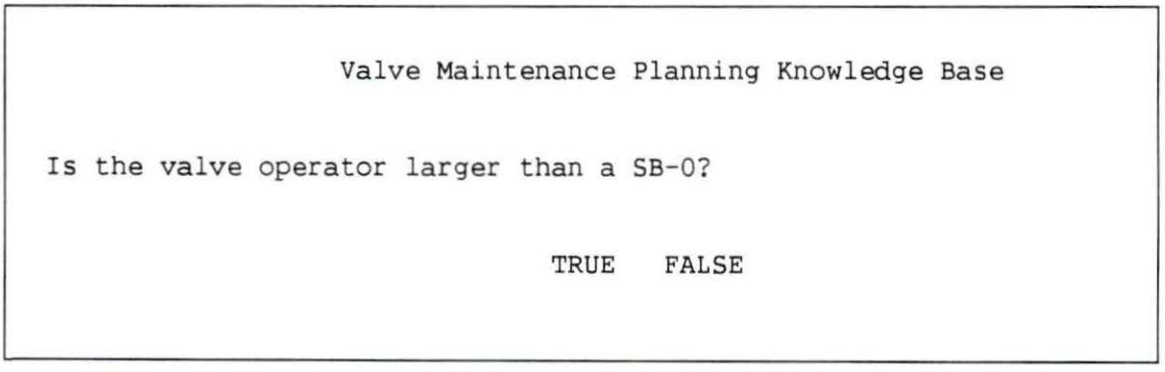

FIGURE 12. Operator size query screen

consultation sessions. Next, some of the steps for evaluating and validating this system are discussed.

```
        ***  Valve Maintenance Planning Results  ***

      Valve ID: MO 2003    P&ID: M-120  F-4

    QL:          pri cont: N    NPRDS:          MIF:
tagout: Y    req for S/U:         CCP:       proc#1:
  J&LL:       heavy load: Y     ASME: Y     proc#2:
   RWP:        fire prot:          EQ:       proc#3:

--------------- post-maintenance requirement ---------------

            BTC stroke close test is required
            BTO stroke open test is required
            PIT position indication test is required
            AT1 leakage test is not applicable
            AT5 leakage test is required
            CTCC check valve stroke test is not applicable
            System pressure test is not required
```

FIGURE 13. Maintenance planning results for second session

C. Evaluation and Validation Techniques

Since this project has only reached the demonstration stage, detailed procedures for evaluation and validation have not yet been developed. But some preliminary work and experience has been achieved.

The most effective method for evaluating the accuracy of this type of program appears to be direct testing by the domain expert who contributed to the knowledge base. This testing was done several times during the project, and resulted in useful corrections in a short amount of time. The problem with direct testing, as with consultation time for knowledge acquisition, is likely to be availability of the expert.

A more formal technique for evaluation and validation would be to use the batch testing mode of the knowledge base. This benchmarking technique is standard practice as a final step in validation of conventional programs, but is also applicable to knowledge systems.

Batch testing capability has already been built into this system. Next, a set of benchmark test cases should be developed, in conjunction with the aid of the domain expert. Then, after one or more maintenance engineers analyze the cases, a set of benchmark results can be determined, against which the program can be compared. One situation to avoid is a small test set which has been implemented as special cases in the program, so that it can't fail.

These are only a few ideas for testing this knowledge-based system. A more thorough review of the literature is necessary before developing a final set of evaluation and validation procedures.

VI. CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

A demonstration valve maintenance planning knowledge-based assistant has been developed. Since this system is a demonstration, and no actual field testing has been done, these conclusions should be viewed as preliminary.

First, a knowledge-based programming solution to a real problem can be demonstrated using an inexpensive, PC-based tool. The knowledge base of the system described in this paper is structured to be easily expandable to a full scale production program. Based on experience with the demonstration system, a production system could be implemented on a PC class computer, and run in a reasonable amount of time.

Second, with the appropriate application problem and development tool, a first-time developer can produce a successful demonstration without extensive training. The tool selected for this project was easy enough to use so that a fairly large knowledge base (over 250 rules) could be developed in a short amount of time, by a novice knowledge system programmer.

Third, it is important for the system developer to be thoroughly familiar with the problem domain before consulting with the expert. Contact time with the expert will generally be limited, so this time must be used efficiently. This consideration can be met either by choosing a problem with which the developer is already familiar, or by researching the problem domain prior to meeting with the expert.

Finally, the use and access of existing data bases must be considered when analyzing an application problem, and choosing a development tool. The interface barrier between mainframe data bases and PC-based knowledge systems is still quite prohibitive.

The primary suggestion for future work on this project is to further develop the valve maintenance assistant by increasing the depth of the knowledge base. The current structure of the knowledge base, both diagnosis and maintenance planning, can accommodate an increase in knowledge depth and coverage without major revisions. The recommended method for further developing this program is to have maintenance engineers at the plant test and evaluate the system during their normal activities.

Another item to consider when further developing this system is eventual access to the plant's mainframe component data base. The ideal method would be to directly access this already existing data base from the knowledge base, and thereby avoid duplicating information in a separate data base file. This consideration may have to wait until the final deployment of the program, so that the appropriate linkage software with the existing data base can be identified.

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IX. APPENDIX A - KNOWLEDGE BASE SOURCE LISTINGS

IEVALVE.PRL

```
TITLE   Valve Maintenance Planning Assistant
!
!
!*********************************************************************
!
!     Shared Parameters
!
!*********************************************************************
!
!
$ IESHARED.PRL
!
!
!*********************************************************************
!
!     Data Type Declarations
!
!*********************************************************************
!
!
$ IEDECLAR.PRL
!
!
!*********************************************************************
!
!     Parameter Initialization Statements
!
!*********************************************************************
!
!
INIT   Five = 5
AND    Initial screen file = "IESCREEN.PCX"
AND    Diagnosis documentation file := "IEDIAG.DOC"
AND    Planning documentation file := "IEPLAN.DOC"
AND    Knowledge base is being started up
REINIT Five = 5
AND    Initial screen file = "IESCREEN.PCX"
AND    Diagnosis documentation file := "IEDIAG.DOC"
AND    Planning documentation file := "IEPLAN.DOC"
AND    Knowledge base is being started up CF 0
FORGET ALL
!
!
```

```
!*********************************************************************
!
!     Control Element Selectors
!
!*********************************************************************
!
!
GOALSELECT OFF
$ IEMULTI.PRL
SUPPRESS ALL
!
!
!*********************************************************************
!
!     Goal Outline
!
!*********************************************************************
!
!
1. Show initial screen if startup
   1.1. Determine maintenance planning information for a valve
   1.2. Diagnose problems and prescribe maintenance for a valve
   1.3. Diagnose problems and determine MP information
   1.4. Edit the valve data base
   1.5. Perform batch testing functions
   1.6. Quit knowledge base execution
!
!
!*********************************************************************
!
!     Knowledge Base Rules
!
!*********************************************************************
!
!
!     Goal Processing Rules
!
!
RULE  For displaying initial screen
IF    Knowledge base is being started up
AND   ACTIVATE IESCREEN.COM
SEND  Five
SEND  Initial screen file
THEN  Show initial screen if startup
ELSE  Show initial screen if startup
!
!
!     Rules for determining major task
!
!
```

```
RULE  To ask if valve maintenance planning is required
IF    Major task IS valve maintenance planning
AND   This valve can be analyzed
AND   ACTIVATE IENFILE.COM
DISK  IEPARAM.DAT
SEND  Planning documentation file
THEN  Determine maintenance planning information for a valve
AND   Run mode IS normal
AND   CHAIN IEVALVE2
!
RULE  To ask if valve diagnosis is required
IF    Major task IS valve diagnosis
AND   This valve can be analyzed
AND   ACTIVATE IENFILE.COM
DISK  IEPARAM.DAT
SEND  Diagnosis documentation file
THEN  Diagnose problems and prescribe maintenance for a valve
AND   Run mode IS normal
AND   CHAIN IEVALVE1
!
RULE  To ask if both diagnosis and maint planning is required
IF    Major task IS diagnosis and planning
AND   This valve can be analyzed
AND   ACTIVATE IENFILE.COM
DISK  IEPARAM.DAT
SEND  Diagnosis documentation file
AND   ACTIVATE IENFILE.COM
DISK  IEPARAM.DAT
SEND  Planning documentation file
THEN  Diagnose problems and determine MP information
AND   Run mode IS normal
AND   CHAIN IEVALVE1
!
RULE  To ask if valve data base editing is required
IF    Major task IS valve data base editing
AND   ACTIVATE IEEDITDB.COM
AND   CYCLE
THEN  Edit the valve data base
!
RULE  To ask if batch testing functions are required
IF    Major task IS batch testing
THEN  Perform batch testing functions
AND   Run mode IS batch test
AND   Test case number := 0
AND   CHAIN IEBATCH
!
RULE  To ask if the user wants to quit
IF    Major task IS Leave knowledge base
THEN  Quit knowledge base execution
AND   STOP
```

```
!
RULE  For retrieving valve data
ASK   Valve ID
ACTIVATE IEACCDB1.COM
DISK  IEPARAM.DAT
SEND  Valve ID
RETURN Valve found in data base
RETURN Valve P&ID
RETURN P&ID coord
RETURN Valve IST class
RETURN Valve category
RETURN Valve size
RETURN Valve type
RETURN Valve actuator type
RETURN Normal position of valve
RETURN PIT applicable
RETURN BTC applicable
RETURN BTO applicable
RETURN AT5 applicable
RETURN AT1 applicable
RETURN CTCC applicable
RETURN PIT frequency
RETURN BTC frequency
RETURN BTO frequency
RETURN AT5 frequency
RETURN AT1 frequency
RETURN CTCC frequency
RETURN Maximum BTO stroke open time
RETURN Maximum BTC stroke close time
RETURN Maximum AT5 leakage
RETURN Maximum AT1 leakage
RETURN AT1 relief request
RETURN CTCC relief request
IF    Valve found in data base
THEN  This valve can be analyzed
ELSE  This valve cannot be analyzed
AND   DISPLAY valve id not available
!
!
!*********************************************************************
!
!     Information Displays
!
!*********************************************************************
!
!
!     TEXT References
!
!
TEXT  Major task
```

```
Select your required task:

!
TEXT  valve maintenance planning
Determine maintenance planning information for a valve
!
TEXT  valve diagnosis
Diagnose problems and prescribe maintenance for a valve
!
TEXT  diagnosis and planning
Diagnose problems, prescribe maintenance, and determine
maintenance planning information for a valve
!
TEXT  valve data base editing
Edit the valve data base
!
TEXT  batch testing
Run the batch testing knowledge base
!
TEXT  Valve ID


Enter the ID number of the valve using the following format:


               MO 2000


Make sure the "MO" part of the valve ID is capitalized.


!
!
!     DISPLAY References
!
!
DISPLAY valve id not available

   The valve ID you entered was [Valve ID].

   This valve is not currently available for use
   with this knowledge base.  Make sure you entered
   the "MO" part of the valve ID in capital letters.


!
!
!*************************************************************************
!
```

```
!     End of Knowledge Base
!
!*************************************************************************
!
!
END
```

IEVALVE1.PRL

```
TITLE    Valve Diagnosis Knowledge Base
!
!
!*********************************************************************
!
!     Shared Parameters
!
!*********************************************************************
!
!
$ IESHARED.PRL
!
!
!*********************************************************************
!
!     Data Type Declarations
!
!*********************************************************************
!
!
$ IEDECLAR.PRL
!
!
!*********************************************************************
!
!     Parameter Initialization Statements
!
!*********************************************************************
!
!
INIT   Motor control center diagnosis is complete
AND    Possible valve operator problems are known
REINIT Motor control center diagnosis is complete
AND    Possible valve operator problems are known
!
!
!*********************************************************************
!
!     Control Element Selectors
!
!*********************************************************************
!
!
GOALSELECT OFF
$ IEMULTI.PRL
SUPPRESS ALL
```

```
FILE IEDIAG.DOC
!
!
!*********************************************************************
!
!     Goal Outline
!
!*********************************************************************
!
!
1. Diagnose and prescribe maintenance for a valve
2. Diagnose prescribe and plan maintenance for a valve
!
!
!*********************************************************************
!
!     Knowledge Base Rules
!
!*********************************************************************
!
!
!     Goal Processing Rules
!
!
RULE  For starting diagnosis and prescription
IF    Major task IS valve diagnosis
AND   Diagnosis of valve problems complete
THEN  Diagnose and prescribe maintenance for a valve
AND   DISPLAY documentation file notice
AND   FORGET Run mode
AND   FORGET Major task
AND   FORGET Affected system for maintenance
AND   FORGET valve body maintenance
AND   FORGET valve operator maintenance
AND   FORGET motor control center maintenance
AND   FORGET Print item
AND   FORGET Batch test task
AND   CHAIN IEVALVE
!
RULE  For starting diagnosis prescription and planning
IF    Major task IS diagnosis and planning
AND   Diagnosis of valve problems complete
THEN  Diagnose prescribe and plan maintenance for a valve
AND   DISPLAY documentation file notice
AND   CHAIN IEVALVE2
!
!
!     Rules for driving valve problem diagnosis
!
!
```

```
RULE  For driving diagnosis part of knowledge base
FILE  valve diagnosis header
IF    Valve body diagnosis is complete
AND   Valve operator diagnosis is complete
AND   Motor control center diagnosis is complete
THEN  Diagnosis of valve problems complete
!
RULE  For driving valve body diagnosis
IF    Definite valve body problems are known
AND   Possible valve body problems are known
THEN  Valve body diagnosis is complete
!
RULE  For driving valve operator diagnosis
IF    Definite valve operator problems are known
AND   Possible valve operator problems are known
THEN  Valve operator diagnosis is complete
!
RULE  For driving motor control center diagnosis
IF    Definite motor control center problems are known
AND   Possible motor control center problems are known
THEN  Motor control center diagnosis is complete
!
!
!     Valve body diagnosis rules
!
!
RULE  For determining definite valve body problems
IF    Stem needs lubrication analyzed
AND   Worn body to bonnet gasket analyzed
AND   Worn packing analyzed
THEN  Definite valve body problems are known
!
RULE  For determining possible valve body problems
IF    Gland flange too tight analyzed
AND   Gland nuts tightened unevenly analyzed
AND   Foreign matter on seat surface analyzed
AND   Scarred or damaged seat analyzed
THEN  Possible valve body problems are known
!
RULE  For analyzing stem needs lubrication
IF    Stem needs lubrication is indicated
OR    Stem needs lubrication is not indicated
THEN  Stem needs lubrication analyzed
!
RULE  For driving stem lub
IF    Definite evidence for stem lub
THEN  Stem needs lubrication is indicated
ELSE  Stem needs lubrication is not indicated
!
RULE  For diagnosing stem lub from excessive handwheel effort body
```

```
IF    Affected system for diagnosis IS valve body
AND   valve body symptom IS Excessive handwheel effort
THEN  Definite evidence for stem lub
AND   valve body problem IS stem needs lubrication
AND   Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS motor control center
AND   valve body maintenance IS valve stem maintenance
AND   NOT valve body maintenance IS valve replaced
AND   NOT valve body maintenance IS valve disassembled
AND   NOT valve body maintenance IS packing adjusted
AND   NOT valve body maintenance IS repacking performed
AND   NOT valve body maintenance IS replaced body to bonnet gasket
AND   NOT valve body maintenance IS maintained seating surface
AND   DISPLAY valve diagnosis display
AND   DISPLAY stem lub from excessive handwheel effort body
AND   FILE stem lub from excessive handwheel effort body
!
RULE  For diagnosing stem lub from excessive handwheel effort oper
IF    Affected system for diagnosis IS valve operator
AND   valve operator symptom IS Excessive handwheel effort
THEN  Definite evidence for stem lub
AND   valve body problem IS stem needs lubrication
AND   Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS motor control center
AND   valve body maintenance IS valve stem maintenance
AND   NOT valve body maintenance IS valve replaced
AND   NOT valve body maintenance IS valve disassembled
AND   NOT valve body maintenance IS packing adjusted
AND   NOT valve body maintenance IS repacking performed
AND   NOT valve body maintenance IS replaced body to bonnet gasket
AND   NOT valve body maintenance IS maintained seating surface
AND   DISPLAY valve diagnosis display
AND   FILE stem lub from excessive handwheel effort operator
!
RULE  For analyzing worn body to bonnet gasket
IF    Worn body to bonnet gasket is indicated
OR    Worn body to bonnet gasket is not indicated
THEN  Worn body to bonnet gasket analyzed
!
RULE  For driving worn body to bonnet gasket
IF    Definite evidence for worn body to bonnet gasket
THEN  Worn body to bonnet gasket is indicated
ELSE  Worn body to bonnet gasket is not indicated
!
RULE  For diagnosing worn gasket from leakage in area
IF    Affected system for diagnosis IS valve body
AND   valve body symptom IS Leakage between valve body and bonnet area
THEN  Definite evidence for worn body to bonnet gasket
```

```
AND   valve body problem IS worn body to bonnet gasket
AND   Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS motor control center
AND   valve body maintenance IS valve disassembled
AND   valve body maintenance IS replaced body to bonnet gasket
AND   NOT valve body maintenance IS valve replaced
AND   NOT valve body maintenance IS packing adjusted
AND   NOT valve body maintenance IS repacking performed
AND   NOT valve body maintenance IS valve stem maintenance
AND   NOT valve body maintenance IS maintained seating surface
AND   DISPLAY valve diagnosis display
AND   DISPLAY worn gasket from leakage in area
AND   FILE worn gasket from leakage in area
!
RULE  For analyzing worn packing
IF    Worn packing is indicated
OR    Worn packing is not indicated
THEN  Worn packing analyzed
!
RULE  For driving worn packing
IF    Definite evidence for worn packing
THEN  Worn packing is indicated
ELSE  Worn packing is not indicated
!
RULE  For diagnosing worn packing from leakage around stem
IF    Affected system for diagnosis IS valve body
AND   valve body symptom IS stem leakage
THEN  Definite evidence for worn packing
AND   valve body problem IS worn packing
AND   Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS motor control center
AND   valve body maintenance IS repacking performed
AND   NOT valve body maintenance IS valve replaced
AND   NOT valve body maintenance IS valve disassembled
AND   NOT valve body maintenance IS packing adjusted
AND   NOT valve body maintenance IS replaced body to bonnet gasket
AND   NOT valve body maintenance IS valve stem maintenance
AND   NOT valve body maintenance IS maintained seating surface
AND   DISPLAY valve diagnosis display
AND   DISPLAY worn packing from leakage around stem
AND   FILE worn packing from leakage around stem
!
RULE  For diagnosing worn packing from no packing adjustment
IF    Affected system for diagnosis IS valve body
AND   valve body symptom IS no packing adjustment
THEN  Definite evidence for worn packing
AND   valve body problem IS worn packing
AND   Affected system for maintenance IS valve body
```

```
AND   NOT Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS motor control center
AND   valve body maintenance IS repacking performed
AND   NOT valve body maintenance IS valve replaced
AND   NOT valve body maintenance IS valve disassembled
AND   NOT valve body maintenance IS packing adjusted
AND   NOT valve body maintenance IS replaced body to bonnet gasket
AND   NOT valve body maintenance IS valve stem maintenance
AND   NOT valve body maintenance IS maintained seating surface
AND   DISPLAY valve diagnosis display
AND   DISPLAY worn packing from no packing adjustment
AND   FILE worn packing from no packing adjustment
!
RULE  For analyzing gland flange too tight
IF    Gland flange too tight is indicated possibly
OR    Gland flange too tight is not indicated possibly
THEN  Gland flange too tight analyzed
!
RULE  For driving gland flange too tight
IF    Possible evidence for gland flange too tight
THEN  Gland flange too tight is indicated possibly
ELSE  Gland flange too tight is not indicated possibly
!
RULE  For analyzing gland nuts tightened unevenly
IF    Gland nuts tightened unevenly is indicated possibly
OR    Gland nuts tightened unevenly is not indicated possibly
THEN  Gland nuts tightened unevenly analyzed
!
RULE  For driving gland nuts tightened unevenly
IF    Possible evidence for gland nuts tightened unevenly
THEN  Gland nuts tightened unevenly is indicated possibly
ELSE  Gland nuts tightened unevenly is not indicated possibly
!
RULE  For diagnosing possible gland problems from stem binding
IF    Affected system for diagnosis IS valve body
AND   valve body symptom IS Valve stem is binding when operated
THEN  Possible evidence for gland flange too tight
AND   Possible evidence for gland nuts tightened unevenly
AND   Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS motor control center
AND   valve body maintenance IS packing adjusted
AND   NOT valve body maintenance IS valve replaced
AND   NOT valve body maintenance IS valve disassembled
AND   NOT valve body maintenance IS repacking performed
AND   NOT valve body maintenance IS replaced body to bonnet gasket
AND   NOT valve body maintenance IS maintained seating surface
AND   NOT valve body maintenance IS valve stem maintenance
AND   DISPLAY valve diagnosis display
AND   DISPLAY gland problems from stem binding
```

```
AND   FILE gland problems from stem binding
!
RULE  For analyzing foreign matter on seat surface
IF    Foreign matter on seat surface is indicated possibly
OR    Foreign matter on seat surface is not indicated possibly
THEN  Foreign matter on seat surface analyzed
!
RULE  For driving foreign matter on seat surface
IF    Possible evidence for foreign matter on seat surface
THEN  Foreign matter on seat surface is indicated possibly
ELSE  Foreign matter on seat surface is not indicated possibly
!
RULE  For analyzing scarred or damaged seat
IF    Scarred or damaged seat is indicated possibly
OR    Scarred or damaged seat is not indicated possibly
THEN  Scarred or damaged seat analyzed
!
RULE  For driving scarred or damaged seat
IF    Possible evidence for scarred or damaged seat
THEN  Scarred or damaged seat is indicated possibly
ELSE  Scarred or damaged seat is not indicated possibly
!
RULE  For diagnosing possible seat problems from seat leakage
IF    Affected system for diagnosis IS valve body
AND   valve body symptom IS Leakage between valve disc and seat area
THEN  Possible evidence for foreign matter on seat surface
AND   Possible evidence for scarred or damaged seat
AND   Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS motor control center
AND   valve body maintenance IS maintained seating surface
AND   NOT valve body maintenance IS valve replaced
AND   NOT valve body maintenance IS valve disassembled
AND   NOT valve body maintenance IS packing adjusted
AND   NOT valve body maintenance IS repacking performed
AND   NOT valve body maintenance IS replaced body to bonnet gasket
AND   NOT valve body maintenance IS valve stem maintenance
AND   DISPLAY valve diagnosis display
!
!
!     Valve operator diagnosis rules
!
!
RULE  For determining definite valve operator problems
IF    Disc between motor power & control circuits analyzed
AND   Holding coil open circuited analyzed
AND   Motor trouble or improper overload heater sizing analyzed
AND   Damaged or worn mechanical parts analyzed
AND   Operator to motor sealtite needs replacing analyzed
THEN  Definite valve operator problems are known
```

```
!
RULE  For analyzing discont between motor power & control circuits
IF    Disc between motor power & control circuits is indicated
OR    Disc between motor power & control circuits not indicated
THEN  Disc between motor power & control circuits analyzed
!
RULE  For driving discont between motor power & control circuits
IF    Definite evidence for disc between power & control circuits
THEN  Disc between motor power & control circuits is indicated
ELSE  Disc between motor power & control circuits not indicated
!
RULE  For diagnosing disc between circuits from stalled motor
IF    Affected system for diagnosis IS valve operator
AND   valve operator symptom IS Stalled motor
THEN  Definite evidence for disc between power & control circuits
AND   valve operator problem IS discontinuity between circuits
AND   Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS motor control center
AND   valve operator maintenance IS electrical wire maintenance
AND   NOT valve operator maintenance IS operator replaced
AND   NOT valve operator maintenance IS motor replaced
AND   NOT valve operator maintenance IS torque switch maintained
AND   NOT valve operator maintenance IS limit switch maintained
AND   NOT valve operator maintenance IS spring pack reworked
AND   NOT valve operator maintenance IS torque bypass switch maintained
AND   NOT valve operator maintenance IS operator lubricated
AND   NOT valve operator maintenance IS handwheel maintenance
AND   DISPLAY valve diagnosis display
AND   DISPLAY disc between circuits from stalled motor
AND   FILE disc between circuits from stalled motor

!
RULE  For analyzing holding coil open circuited
IF    Holding coil open circuited is indicated
OR    Holding coil open circuited is not indicated
THEN  Holding coil open circuited analyzed
!
RULE  For driving holding coil open circuited
IF    Definite evidence for holding coil open circuited
THEN  Holding coil open circuited is indicated
ELSE  Holding coil open circuited is not indicated
!
RULE  For diagnosing holding coil open circuited from failed contacts
IF    Affected system for diagnosis IS valve operator
AND   valve operator symptom IS failed contacts
THEN  Definite evidence for holding coil open circuited
AND   valve operator problem IS holding coil open circuited
AND   Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS valve body
```

```
AND   NOT Affected system for maintenance IS motor control center
AND   valve operator maintenance IS electrical wire maintenance
AND   NOT valve operator maintenance IS operator replaced
AND   NOT valve operator maintenance IS motor replaced
AND   NOT valve operator maintenance IS torque switch maintained
AND   NOT valve operator maintenance IS limit switch maintained
AND   NOT valve operator maintenance IS spring pack reworked
AND   NOT valve operator maintenance IS torque bypass switch maintained
AND   NOT valve operator maintenance IS operator lubricated
AND   NOT valve operator maintenance IS handwheel maintenance
AND   DISPLAY valve diagnosis display
AND   DISPLAY holding coil open circuited from failed contacts
AND   FILE holding coil open circuited from failed contacts
!
RULE  For analyzing motor or overload heater sizing trouble
IF    Motor or overload heater sizing trouble is indicated
OR    Motor or overload heater sizing trouble is not indicated
THEN  Motor trouble or improper overload heater sizing analyzed
!
RULE  For driving motor or overload heater sizing trouble
IF    Definite evidence for motor or overload heater trouble
THEN  Motor or overload heater sizing trouble is indicated
ELSE  Motor or overload heater sizing trouble is not indicated
!
RULE  For diagnosing motor trouble from overload relay tripping
IF    Affected system for diagnosis IS valve operator
AND   valve operator symptom IS overload relay tripping
THEN  Definite evidence for motor or overload heater trouble
AND   valve operator problem IS motor trouble
!
RULE  For analyzing damaged or worn mechanical parts
IF    Damaged or worn mechanical parts is indicated
OR    Damaged or worn mechanical parts is not indicated
THEN  Damaged or worn mechanical parts analyzed
!
RULE  For driving damaged or worn mechanical parts
IF    Definite evidence for damaged or worn mechanical parts
THEN  Damaged or worn mechanical parts is indicated
ELSE  Damaged or worn mechanical parts is not indicated
!
RULE  For diagnosing damaged or worn mechanical parts from rev starter
IF    Affected system for diagnosis IS valve operator
AND   valve operator symptom IS reversing starter movement
THEN  Definite evidence for damaged or worn mechanical parts
AND   valve operator problem IS damaged or worn mechanical parts
AND   DISPLAY valve diagnosis display
AND   DISPLAY damaged or worn mechanical parts from rev starter
AND   FILE damaged or worn mechanical parts from rev starter
!
RULE  For analyzing operator to motor sealtite needs replacing
```

```
IF    Sealtite needs replacing is indicated
OR    Sealtite needs replacing is not indicated
THEN  Operator to motor sealtite needs replacing analyzed
!
RULE  For driving operator to motor sealtite needs replacing
IF    Definite evidence for sealtite needs replacing
THEN  Sealtite needs replacing is indicated
ELSE  Sealtite needs replacing is not indicated
!
RULE  For diagnosing sealtite replacement from broken sealtite
IF    Affected system for diagnosis IS valve operator
AND   valve operator symptom IS broken sealtite
THEN  Definite evidence for sealtite needs replacing
AND   valve operator problem IS sealtite needs replacing
AND   Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS motor control center
AND   valve operator maintenance IS replaced sealtite
AND   NOT valve operator maintenance IS operator replaced
AND   NOT valve operator maintenance IS motor replaced
AND   NOT valve operator maintenance IS torque switch maintained
AND   NOT valve operator maintenance IS limit switch maintained
AND   NOT valve operator maintenance IS spring pack reworked
AND   NOT valve operator maintenance IS torque bypass switch maintained
AND   NOT valve operator maintenance IS operator lubricated
AND   NOT valve operator maintenance IS electrical wire maintenance
AND   NOT valve operator maintenance IS handwheel maintenance
AND   DISPLAY valve diagnosis display
AND   DISPLAY sealtite replacement from broken sealtite
AND   FILE sealtite replacement from broken sealtite
!
!
!**********************************************************************
!
!     Information Displays
!
!**********************************************************************
!
!
!     TEXT References
!
!
TEXT  Affected system for diagnosis

  Select all the valve systems which contain the
  parts that are exhibiting problem symptoms

!
TEXT  valve body symptom
```

```
  Select all the problem symptoms evident in
  the valve body

!
TEXT  valve operator symptom

  Select all the problem symptoms evident in
  the valve operator

!
TEXT  motor control center symptom

  Select all the problem symptoms evident in
  the motor control center

!
TEXT  stem leakage
Leakage through stuffing box and around stem
!
TEXT  no packing adjustment
There is no more packing adjustment left
!
TEXT  failed contacts
Reversing starter contacts fail to open
!
TEXT  overload relay tripping
Continued tripping of overload relay
!
TEXT  motor trouble
Trouble with motor or improper sizing of the overload heater
!
TEXT  reversing starter movement
Restriction in the movement of the reversing starter
!
TEXT  broken sealtite
The sealtite between the operator and motor is broken
!
!
!     DISPLAY References
!
!
DISPLAY  documentation file notice


    A hard copy documentation of this session may be obtained
    by printing out the file "IEDIAG.DOC" using the DOS command

       "PRINT IEDIAG.DOC".

!
```

```
DISPLAY  valve diagnosis header

**********************************

Documentation file for problem diagnosis for
MO valve [Valve ID].  The P & ID for this valve
is [Valve P&ID]  [P&ID coord].

**********************************

!
DISPLAY  valve diagnosis display

**********************************

Documentation display for problem diagnosis for
MO valve [Valve ID].  The P & ID for this valve
is [Valve P&ID]  [P&ID coord].

Press ENTER or F2 to continue.

**********************************

!
DISPLAY  stem lub from excessive handwheel effort body

   - The stem has been diagnosed as needing lubrication
     since the handwheel exhibited excessive effort.

!
DISPLAY  stem lub from excessive handwheel effort operator

   - The stem has been diagnosed as needing lubrication
     since the handwheel exhibited excessive effort.

!
DISPLAY  worn gasket from leakage in area

   - The gasket between the valve body and bonnet has been
     diagnosed as needing replacement from the symptom of
     leakage through the gasket area.  The maintenance
     action prescription is to replace the body to bonnet
     gasket (valve disassembled).

!
DISPLAY  gland problems from stem binding

   - The gland nuts have been diagnosed as being either too
     tight or unevenly tightened from the symptom of
     valve stem binding.  The maintenance action prescription
```

```
     is to adjust the gland nuts (packing adjusted).

!
DISPLAY  worn packing from leakage around stem

   - Worn packing has been diagnosed from the symptom of
     leakage around the valve stem.  The maintenance action
     prescription is to replace the packing (repacking performed).

!
DISPLAY  worn packing from no packing adjustment

   - Worn packing has been diagnosed from there being no
     packing adjustment left.  The maintenance action
     prescription is to replace the packing (repacking performed).

!
DISPLAY  disc between circuits from stalled motor

   - A discontinuity between the motor power and control circuits
     has been diagnosed from the symptom of a stalled motor.  The
     maintenance action prescription is electrical wire maintenance.

!
DISPLAY  holding coil open circuited from failed contacts

   - The holding coil has been diagnosed as being open-circuited
     from the symptom of failed contacts.  The maintenance action
     prescription is electrical wire maintenance.

!
DISPLAY  sealtite replacement from broken sealtite

   - The sealtite from the operator to the motor has been diagnosed
     as needing replacement since it is broken.  The maintenance
     action is replaced sealtite.

!
DISPLAY  damaged or worn mechanical parts from rev starter

   - Damaged or worn mechanical parts has been diagnosed from
     the symptom of restriced movement of the reversing
     starter.

!
!
!**********************************************************************
!
!     End of Knowledge Base
!
```

```
!**************************************************************************
!
!
END
```

IEVALVE2.PRL

```
TITLE   Valve Maintenance Planning Knowledge Base
!
!
!*********************************************************************
!
!     Shared Parameters
!
!*********************************************************************
!
!
$ IESHARED.PRL
!
!
!*********************************************************************
!
!     Data Type Declarations
!
!*********************************************************************
!
!
$ IEDECLAR.PRL
!
!
!*********************************************************************
!
!     Parameter Initialization Statements
!
!*********************************************************************
!
!
INIT   ASME_code  CF 100
REINIT ASME_code  CF 100
FORGET ALL
!
!
!*********************************************************************
!
!     Control Element Selectors
!
!*********************************************************************
!
!
GOALSELECT OFF
$ IEMULTI.PRL
SUPPRESS ALL
FILE IEPLAN.DOC
```

```
!
!
!*************************************************************************
!
!     Goal Outline
!
!*************************************************************************
!
!
1. Maintenance planning finished
!
!
!*************************************************************************
!
!     Knowledge Base Rules
!
!*************************************************************************
!
!
!     Valve Maintenance Planning Rules
!
!
RULE  For concluding maintenance planning goal
IF    Run mode IS normal
AND   Maintenance planning information determined
AND   Desired output sent to printer
THEN  Maintenance planning finished
AND   FORGET Run mode
AND   FORGET Major task
AND   FORGET Affected system for maintenance
AND   FORGET valve body maintenance
AND   FORGET valve operator maintenance
AND   FORGET motor control center maintenance
AND   FORGET Print item
AND   FORGET Batch test task
AND   FORGET BTC applicable
AND   FORGET BTO applicable
AND   FORGET PIT applicable
AND   FORGET AT1 applicable
AND   FORGET AT5 applicable
AND   FORGET CTCC applicable
AND   FORGET SYSPR applicable
AND   FORGET BTC test is required
AND   FORGET BTO test is required
AND   FORGET PIT test is required
AND   FORGET AT1 test is required
AND   FORGET AT5 test is required
AND   FORGET CTCC test is required
AND   FORGET SYSPR test is required
AND   FORGET Tag out is required
```

```
AND   FORGET Heavy load is indicated
AND   FORGET Primary containment is indicated
AND   CHAIN IEVALVE
!
RULE  For driving maintenance planning tasks
IF    Run mode IS normal
AND   FILE maintenance planning header
AND   Post maintenance testing requirements determined
AND   Tag out determined
AND   Heavy load determined
AND   Primary containment determined
AND   ASME determined
AND   Printing options given
THEN  Maintenance planning information determined
AND   DISPLAY screen results
AND   FILE screen results
AND   DISPLAY documentation file for planning
!
!
!     Next two rules used only for batch testing
!
!
RULE  For concluding goal for batch testing
IF    Run mode IS batch test
AND   Maintenance planning information determined
AND   Desired output sent to printer
THEN  Maintenance planning finished
AND   CHAIN IEBATCH
!
RULE  For driving maintenance planning tasks for batch testing
IF    Run mode IS batch test
AND   FILE maintenance planning header
AND   Post maintenance testing requirements determined
AND   Tag out determined
AND   Heavy load determined
AND   Primary containment determined
AND   ASME determined
AND   Printing options given
THEN  Maintenance planning information determined
!
!
!     Rules for controlling printer output
!
!
RULE  For offering printing options
IF    Print item IS Nothing
OR    Print item IS Valve maintenance planning results
OR    Print item IS Line of reasoning report
THEN  Printing options given
!
```

```
RULE  For controlling printer output
IF    Line of reasoning sent to printer if desired
AND   Screen results sent to printer if desired
THEN  Desired output sent to printer
!
RULE  For sending nothing to printer
IF    Print item IS Nothing
THEN  Line of reasoning sent to printer if desired
AND   Screen results sent to printer if desired
!
RULE  For sending line of reasoning to printer
IF    Print item IS Line of reasoning report
THEN  Line of reasoning sent to printer if desired
AND   PRINT LORR
ELSE  Line of reasoning sent to printer if desired
!
RULE  For sending screen results to printer
IF    Print item IS Valve maintenance planning results
THEN  Screen results sent to printer if desired
AND   PRINT screen results
ELSE  Screen results sent to printer if desired
!
!
!     Valve Post-Maintenance Test Determination Rules
!
!
RULE  For driving post maintenance test determination
FILE  post maintenance testing header
IF    Post maintenance tests analyzed
AND   Test assignments have been made
THEN  Post maintenance testing requirements determined
!
RULE  For determining required post maintenance valve tests
IF    BTC test analyzed
AND   BTO test analyzed
AND   PIT test analyzed
AND   AT1 test analyzed
AND   AT5 test analyzed
AND   CTCC test analyzed
AND   SYSPR test analyzed
THEN  Post maintenance tests analyzed
!
!
!     The Following Rules Determine Which Post-Maintenance
!     Tests are Required
!
!
!     Rules For All Tests
!
!
```

```
RULE  For NO required testing  condition #1
IF    Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS valve body
AND   NOT Affected system for maintenance IS motor control center
AND   valve operator maintenance IS handwheel maintenance
AND   NOT valve operator maintenance IS operator replaced
AND   NOT valve operator maintenance IS motor replaced
AND   NOT valve operator maintenance IS torque switch maintained
AND   NOT valve operator maintenance IS limit switch maintained
AND   NOT valve operator maintenance IS spring pack reworked
AND   NOT valve operator maintenance IS torque bypass switch maintained
AND   NOT valve operator maintenance IS operator lubricated
AND   NOT valve operator maintenance IS electrical wire maintenance
THEN  BTC test is not required
AND   BTO test is not required
AND   PIT test is not required
AND   AT1 test is not required
AND   AT5 test is not required
AND   CTCC test is not required
AND   SYSPR test is not required
AND   FILE No required test number 1
!
!
!     Rules For BTC Test
!
!
RULE  For analyzing BTC test
IF    BTC test is required
OR    BTC test is not required
THEN  BTC test analyzed
!
RULE  For determining BTC requirements
IF    BTC applicable
AND   Maintenance affects stroke close time
THEN  BTC test is required
ELSE  BTC test is not required
!
RULE  For driving BTC valve body maintenance conditions
IF    Affected system for maintenance IS valve body
AND   Valve body maintenance requires BTC test
THEN  Maintenance affects stroke close time
!
RULE  For driving BTC valve operator maintenance conditions
IF    Affected system for maintenance IS valve operator
AND   Valve operator maintenance requires BTC test
THEN  Maintenance affects stroke close time
!
RULE  For driving BTC motor control center maintenance conditions
IF    Affected system for maintenance IS motor control center
AND   Motor control center maintenance requires BTC test
```

```
THEN  Maintenance affects stroke close time
!
!
!     Valve body maintenance rules for BTC
!
!
RULE  For analyzing valve replaced condition for BTC test
IF    valve body maintenance IS valve replaced
THEN  Valve body maintenance requires BTC test
AND   FILE Valve replaced requires BTC test
!
RULE  For analyzing valve disassembled condition for BTC test
IF    valve body maintenance IS valve disassembled
THEN  Valve body maintenance requires BTC test
AND   FILE Valve disassembled requires BTC test
!
RULE  For analyzing packing adjusted condition for BTC test
IF    valve body maintenance IS packing adjusted
THEN  Valve body maintenance requires BTC test
AND   FILE Packing adjusted requires BTC test
!
RULE  For analyzing repacking performed condition for BTC test
IF    valve body maintenance IS repacking performed
THEN  Valve body maintenance requires BTC test
AND   FILE Repacking requires BTC test
!
RULE  For analyzing replaced body bonnet gasket for BTC test
IF    valve body maintenance IS replaced body to bonnet gasket
THEN  Valve body maintenance requires BTC test
AND   FILE Replaced body to bonnet gasket requires BTC test
!
RULE  For analyzing seat maintenance condition for BTC test
IF    valve body maintenance IS maintained seating surface
THEN  Valve body maintenance requires BTC test
AND   FILE Seat maintenance requires BTC test
!
RULE  For analyzing stem maintenance condition for BTC test
IF    valve body maintenance IS valve stem maintenance
THEN  Valve body maintenance requires BTC test
AND   FILE Stem maintenance requires BTC test
!
!
!     Valve operator maintenance rules for BTC
!
!
RULE  For analyzing operator replaced condition for BTC test
IF    valve operator maintenance IS operator replaced
THEN  Valve operator maintenance requires BTC test
AND   FILE Operator replaced requires BTC test
!
```

```
RULE  For analyzing motor replaced condition for BTC test
IF    valve operator maintenance IS motor replaced
THEN  Valve operator maintenance requires BTC test
AND   FILE Motor replaced requires BTC test
!
RULE  For analyzing torque switch maint condition for BTC test
IF    valve operator maintenance IS torque switch maintained
THEN  Valve operator maintenance requires BTC test
AND   FILE Torque switch maint requires BTC test
!
RULE  For analyzing limit switch maint condition for BTC test
IF    valve operator maintenance IS limit switch maintained
THEN  Valve operator maintenance requires BTC test
AND   FILE Limit switch maint requires BTC test
!
RULE  For analyzing spring pack work condition for BTC test
IF    valve operator maintenance IS spring pack reworked
THEN  Valve operator maintenance requires BTC test
AND   FILE Spring pack rework requires BTC test
!
RULE  For analyzing torque bypass switch condition for BTC test
IF    valve operator maintenance IS torque bypass switch maintained
THEN  Valve operator maintenance requires BTC test
AND   FILE Torque bypass switch maint requires BTC test
!
RULE  For analyzing operator lubricated condition for BTC test
IF    valve operator maintenance IS operator lubricated
THEN  Valve operator maintenance requires BTC test
AND   FILE Operator lubricated requires BTC test
!
RULE  For analyzing electrical wire maint condition for BTC test
IF    valve operator maintenance IS electrical wire maintenance
THEN  Valve operator maintenance requires BTC test
AND   FILE Electrical wire maint requires BTC test
!
RULE  For analyzing sealtite replacement condition for BTC test
IF    valve operator maintenance IS replaced sealtite
THEN  Valve operator maintenance requires BTC test
AND   FILE Sealtite replacement requires BTC test
!
!
!     Motor control center maintenance rules for BTC
!
!
RULE  For analyzing breaker maintenance condition for BTC test
IF    motor control center maintenance IS breaker maintained
THEN  Motor control center maintenance requires BTC test
AND   FILE Breaker maintenance requires BTC test
!
RULE  For analyzing handswitch replaced condition for BTC test
```

```
IF    motor control center maintenance IS handswitch replaced
THEN  Motor control center maintenance requires BTC test
AND   FILE Handswitch replaced requires BTC test
!
RULE  For analyzing power cable replaced condition for BTC test
IF    motor control center maintenance IS power cable replaced
THEN  Motor control center maintenance requires BTC test
AND   FILE Power cable replaced requires BTC test
!
!
!     Rules for BTO test
!
!
RULE  For analyzing BTO test
IF    BTO test is required
OR    BTO test is not required
THEN  BTO test analyzed
!
RULE  For determining BTO requirements
IF    BTO applicable
AND   Maintenance affects stroke open time
THEN  BTO test is required
ELSE  BTO test is not required
!
RULE  For driving BTO valve body maintenance conditions
IF    Affected system for maintenance IS valve body
AND   Valve body maintenance requires BTO test
THEN  Maintenance affects stroke open time
!
RULE  For driving BTO valve operator maintenance conditions
IF    Affected system for maintenance IS valve operator
AND   Valve operator maintenance requires BTO test
THEN  Maintenance affects stroke open time
!
RULE  For driving BTO motor control center maintenance conditions
IF    Affected system for maintenance IS motor control center
AND   Motor control center maintenance requires BTO test
THEN  Maintenance affects stroke open time
!
!
!     Valve body maintenance rules for BTO
!
!
RULE  For analyzing valve replaced condition for BTO test
IF    valve body maintenance IS valve replaced
THEN  Valve body maintenance requires BTO test
AND   FILE Valve replaced requires BTO test
!
RULE  For analyzing valve disassembled condition for BTO test
IF    valve body maintenance IS valve disassembled
```

```
THEN  Valve body maintenance requires BTO test
AND   FILE Valve disassembled requires BTO test
!
RULE  For analyzing packing adjusted condition for BTO test
IF    valve body maintenance IS packing adjusted
THEN  Valve body maintenance requires BTO test
AND   FILE Packing adjusted requires BTO test
!
RULE  For analyzing repacking performed condition for BTO test
IF    valve body maintenance IS repacking performed
THEN  Valve body maintenance requires BTO test
AND   FILE Repacking requires BTO test
!
RULE  For analyzing replaced body bonnet gasket for BTO test
IF    valve body maintenance IS replaced body to bonnet gasket
THEN  Valve body maintenance requires BTO test
AND   FILE Replaced body to bonnet gasket requires BTO test
!
RULE  For analyzing seat maintenance condition for BTO test
IF    valve body maintenance IS maintained seating surface
THEN  Valve body maintenance requires BTO test
AND   FILE Seat maintenance requires BTO test
!
RULE  For analyzing stem maintenance condition for BTO test
IF    valve body maintenance IS valve stem maintenance
THEN  Valve body maintenance requires BTO test
AND   FILE Stem maintenance requires BTO test
!
!
!     Valve operator maintenance rules for BTO
!
!
RULE  For analyzing operator replaced condition for BTO test
IF    valve operator maintenance IS operator replaced
THEN  Valve operator maintenance requires BTO test
AND   FILE Operator replaced requires BTO test
!
RULE  For analyzing motor replaced condition for BTO test
IF    valve operator maintenance IS motor replaced
THEN  Valve operator maintenance requires BTO test
AND   FILE Motor replaced requires BTO test
!
RULE  For analyzing torque switch maint condition for BTO test
IF    valve operator maintenance IS torque switch maintained
THEN  Valve operator maintenance requires BTO test
AND   FILE Torque switch maint requires BTO test
!
RULE  For analyzing limit switch maint condition for BTO test
IF    valve operator maintenance IS limit switch maintained
THEN  Valve operator maintenance requires BTO test
```

```
AND   FILE Limit switch maint requires BTO test
!
RULE  For analyzing spring pack work condition for BTO test
IF    valve operator maintenance IS spring pack reworked
THEN  Valve operator maintenance requires BTO test
AND   FILE Spring pack rework requires BTO test
!
RULE  For analyzing torque bypass switch condition for BTO test
IF    valve operator maintenance IS torque bypass switch maintained
THEN  Valve operator maintenance requires BTO test
AND   FILE Torque bypass switch maint requires BTO test
!
RULE  For analyzing operator lubricated condition for BTO test
IF    valve operator maintenance IS operator lubricated
THEN  Valve operator maintenance requires BTO test
AND   FILE Operator lubricated requires BTO test
!
RULE  For analyzing electrical wire maint condition for BTO test
IF    valve operator maintenance IS electrical wire maintenance
THEN  Valve operator maintenance requires BTO test
AND   FILE Electrical wire maint requires BTO test
!
RULE  For analyzing sealtite replacement condition for BTO test
IF    valve operator maintenance IS replaced sealtite
THEN  Valve operator maintenance requires BTO test
AND   FILE Sealtite replacement requires BTO test
!
!
!     Motor control center maintenance rules for BTO
!
!
RULE  For analyzing breaker maintenance condition for BTO test
IF    motor control center maintenance IS breaker maintained
THEN  Motor control center maintenance requires BTO test
AND   FILE Breaker maintenance requires BTO test
!
RULE  For analyzing handswitch replaced condition for BTO test
IF    motor control center maintenance IS handswitch replaced
THEN  Motor control center maintenance requires BTO test
AND   FILE Handswitch replaced requires BTO test
!
RULE  For analyzing power cable replaced condition for BTO test
IF    motor control center maintenance IS power cable replaced
THEN  Motor control center maintenance requires BTO test
AND   FILE Power cable replaced requires BTO test
!
!
!     Rules for PIT test
!
!
```

```
RULE  For analyzing PIT test
IF    PIT test is required
OR    PIT test is not required
THEN  PIT test analyzed
!
RULE  For determining PIT requirements
IF    PIT applicable
AND   Maintenance affects position indication
THEN  PIT test is required
ELSE  PIT test is not required
!
RULE  For driving PIT valve body maintenance conditions
IF    Affected system for maintenance IS valve body
AND   Valve body maintenance requires PIT test
THEN  Maintenance affects position indication
!
RULE  For driving PIT valve operator maintenance conditions
IF    Affected system for maintenance IS valve operator
AND   Valve operator maintenance requires PIT test
THEN  Maintenance affects position indication
!
RULE  For driving PIT motor control center maintenance conditions
IF    Affected system for maintenance IS motor control center
AND   Motor control center maintenance requires PIT test
THEN  Maintenance affects position indication
!
!
!     Valve body maintenance rules for PIT
!
!
RULE  For analyzing valve replaced condition for PIT test
IF    valve body maintenance IS valve replaced
THEN  Valve body maintenance requires PIT test
AND   FILE Valve replaced requires PIT test
!
RULE  For analyzing valve disassembled condition for PIT test
IF    valve body maintenance IS valve disassembled
THEN  Valve body maintenance requires PIT test
AND   FILE Valve disassembled requires PIT test
!
!
!     Valve operator maintenance rules for PIT
!
!
RULE  For analyzing operator replaced condition for PIT test
IF    valve operator maintenance IS operator replaced
THEN  Valve operator maintenance requires PIT test
AND   FILE Operator replaced requires PIT test
!
RULE  For analyzing limit switch maint condition for PIT test
```

```
IF    valve operator maintenance IS limit switch maintained
THEN  Valve operator maintenance requires PIT test
AND   FILE Limit switch maint requires PIT test
!
RULE  For determining PIT for operator removal
IF    The operator must be removed during the maintenance
THEN  Maintenance affects position indication
AND   FILE Operator removal requires PIT test
!
!
!     Motor control center maintenance rules for PIT
!
!
RULE  For analyzing breaker maintenance condition for PIT test
IF    motor control center maintenance IS breaker maintained
THEN  Motor control center maintenance requires PIT test
AND   FILE Breaker maintenance requires PIT test
!
RULE  For analyzing power cable replaced condition for PIT test
IF    motor control center maintenance IS power cable replaced
THEN  Motor control center maintenance requires PIT test
AND   FILE Power cable replaced requires PIT test
!
!
!     Rules for AT-1 test
!
!
RULE  For analyzing AT1 test
IF    AT1 test is required
OR    AT1 test is not required
THEN  AT1 test analyzed
!
RULE  For determining AT1 requirements
IF    AT1 applicable
AND   Maintenance affects valve leakage  AT1
THEN  AT1 test is required
ELSE  AT1 test is not required
!
RULE  For driving AT1 valve body maintenance conditions
IF    Affected system for maintenance IS valve body
AND   Valve body maintenance requires AT1 test
THEN  Maintenance affects valve leakage  AT1
!
RULE  For driving AT1 valve operator maintenance conditions
IF    Affected system for maintenance IS valve operator
AND   Valve operator maintenance requires AT1 test
THEN  Maintenance affects valve leakage  AT1
!
RULE  For driving AT1 motor control center maintenance conditions
IF    Affected system for maintenance IS motor control center
```

```
AND   Motor control center maintenance requires AT1 test
THEN  Maintenance affects valve leakage  AT1
!
!
!     Valve body maintenance rules for AT1
!
!
RULE  For analyzing valve replaced condition for AT1 test
IF    valve body maintenance IS valve replaced
THEN  Valve body maintenance requires AT1 test
AND   FILE Valve replaced requires AT1 test
!
RULE  For analyzing valve disassembled condition for AT1 test
IF    valve body maintenance IS valve disassembled
THEN  Valve body maintenance requires AT1 test
AND   FILE Valve disassembled requires AT1 test
!
RULE  For analyzing packing adjusted condition for AT1 test
IF    valve body maintenance IS packing adjusted
THEN  Valve body maintenance requires AT1 test
AND   FILE Packing adjusted requires AT1 test
!
RULE  For analyzing repacking performed condition for AT1 test
IF    valve body maintenance IS repacking performed
THEN  Valve body maintenance requires AT1 test
AND   FILE Repacking requires AT1 test
!
RULE  For analyzing seat maintenance condition for AT1 test
IF    valve body maintenance IS maintained seating surface
THEN  Valve body maintenance requires AT1 test
AND   FILE Seat maintenance requires AT1 test
!
RULE  For analyzing stem maintenance condition for AT1 test
IF    valve body maintenance IS valve stem maintenance
THEN  Valve body maintenance requires AT1 test
AND   FILE Stem maintenance requires AT1 test
!
!
!     Valve operator maintenance rules for AT1
!
!
RULE  For analyzing operator replaced condition for AT1 test
IF    valve operator maintenance IS operator replaced
THEN  Valve operator maintenance requires AT1 test
AND   FILE Operator replaced requires AT1 test
!
RULE  For analyzing motor replaced condition for AT1 test
IF    valve operator maintenance IS motor replaced
THEN  Valve operator maintenance requires AT1 test
AND   FILE Motor replaced requires AT1 test
```

```
!
RULE  For analyzing torque switch maint condition for AT1 test
IF    valve operator maintenance IS torque switch maintained
THEN  Valve operator maintenance requires AT1 test
AND   FILE Torque switch maint requires AT1 test
!
RULE  For analyzing limit switch maint condition for AT1 test
IF    valve operator maintenance IS limit switch maintained
THEN  Valve operator maintenance requires AT1 test
AND   FILE Limit switch maint requires AT1 test
!
RULE  For analyzing spring pack work condition for AT1 test
IF    valve operator maintenance IS spring pack reworked
THEN  Valve operator maintenance requires AT1 test
AND   FILE Spring pack rework requires AT1 test
!
RULE  For analyzing torque bypass switch condition for AT1 test
IF    valve operator maintenance IS torque bypass switch maintained
THEN  Valve operator maintenance requires AT1 test
AND   FILE Torque bypass switch maint requires AT1 test
!
RULE  For analyzing operator lubricated condition for AT1 test
IF    valve operator maintenance IS operator lubricated
THEN  Valve operator maintenance requires AT1 test
AND   FILE Operator lubricated requires AT1 test
!
RULE  For analyzing electrical wire maint condition for AT1 test
IF    valve operator maintenance IS electrical wire maintenance
THEN  Valve operator maintenance requires AT1 test
AND   FILE Electrical wire maint requires AT1 test
!
!
!     Motor control center maintenance rules for AT1
!
!
RULE  For analyzing breaker maintenance condition for AT1 test
IF    motor control center maintenance IS breaker maintained
THEN  Motor control center maintenance requires AT1 test
AND   FILE Breaker maintenance requires AT1 test
!
RULE  For analyzing handswitch replaced condition for AT1 test
IF    motor control center maintenance IS handswitch replaced
THEN  Motor control center maintenance requires AT1 test
AND   FILE Handswitch replaced requires AT1 test
!
RULE  For analyzing power cable replaced condition for AT1 test
IF    motor control center maintenance IS power cable replaced
THEN  Motor control center maintenance requires AT1 test
AND   FILE Power cable replaced requires AT1 test
!
```

```
!
!     Rules for AT-5 test
!
!
RULE  For analyzing AT5 test
IF    AT5 test is required
OR    AT5 test is not required
THEN  AT5 test analyzed
!
RULE  For determining AT5 requirements
IF    AT5 applicable
AND   Maintenance affects valve leakage  AT5
THEN  AT5 test is required
ELSE  AT5 test is not required
!
RULE  For driving AT5 valve body maintenance conditions
IF    Affected system for maintenance IS valve body
AND   Valve body maintenance requires AT5 test
THEN  Maintenance affects valve leakage  AT5
!
RULE  For driving AT5 valve operator maintenance conditions
IF    Affected system for maintenance IS valve operator
AND   Valve operator maintenance requires AT5 test
THEN  Maintenance affects valve leakage  AT5
!
RULE  For driving AT5 motor control center maintenance conditions
IF    Affected system for maintenance IS motor control center
AND   Motor control center maintenance requires AT5 test
THEN  Maintenance affects valve leakage  AT5
!
!
!     Valve body maintenance rules for AT5
!
!
RULE  For analyzing valve replaced condition for AT5 test
IF    valve body maintenance IS valve replaced
THEN  Valve body maintenance requires AT5 test
AND   FILE Valve replaced requires AT5 test
!
RULE  For analyzing valve disassembled condition for AT5 test
IF    valve body maintenance IS valve disassembled
THEN  Valve body maintenance requires AT5 test
AND   FILE Valve disassembled requires AT5 test
!
RULE  For analyzing packing adjusted condition for AT5 test
IF    valve body maintenance IS packing adjusted
THEN  Valve body maintenance requires AT5 test
AND   FILE Packing adjusted requires AT5 test
!
RULE  For analyzing repacking performed condition for AT5 test
```

```
IF    valve body maintenance IS repacking performed
THEN  Valve body maintenance requires AT5 test
AND   FILE Repacking requires AT5 test
!
RULE  For analyzing seat maintenance condition for AT5 test
IF    valve body maintenance IS maintained seating surface
THEN  Valve body maintenance requires AT5 test
AND   FILE Seat maintenance requires AT5 test
!
RULE  For analyzing stem maintenance condition for AT5 test
IF    valve body maintenance IS valve stem maintenance
THEN  Valve body maintenance requires AT5 test
AND   FILE Stem maintenance requires AT5 test
!
!
!     Valve operator maintenance rules for AT5
!
!
RULE  For analyzing operator replaced condition for AT5 test
IF    valve operator maintenance IS operator replaced
THEN  Valve operator maintenance requires AT5 test
AND   FILE Operator replaced requires AT5 test
!
RULE  For analyzing motor replaced condition for AT5 test
IF    valve operator maintenance IS motor replaced
THEN  Valve operator maintenance requires AT5 test
AND   FILE Motor replaced requires AT5 test
!
RULE  For analyzing torque switch maint condition for AT5 test
IF    valve operator maintenance IS torque switch maintained
THEN  Valve operator maintenance requires AT5 test
AND   FILE Torque switch maint requires AT5 test
!
RULE  For analyzing limit switch maint condition for AT5 test
IF    valve operator maintenance IS limit switch maintained
THEN  Valve operator maintenance requires AT5 test
AND   FILE Limit switch maint requires AT5 test
!
RULE  For analyzing spring pack work condition for AT5 test
IF    valve operator maintenance IS spring pack reworked
THEN  Valve operator maintenance requires AT5 test
AND   FILE Spring pack rework requires AT5 test
!
RULE  For analyzing torque bypass switch condition for AT5 test
IF    valve operator maintenance IS torque bypass switch maintained
THEN  Valve operator maintenance requires AT5 test
AND   FILE Torque bypass switch maint requires AT5 test
!
RULE  For analyzing operator lubricated condition for AT5 test
IF    valve operator maintenance IS operator lubricated
```

```
THEN  Valve operator maintenance requires AT5 test
AND   FILE Operator lubricated requires AT5 test
!
RULE  For analyzing electrical wire maint condition for AT5 test
IF    valve operator maintenance IS electrical wire maintenance
THEN  Valve operator maintenance requires AT5 test
AND   FILE Electrical wire maint requires AT5 test
!
!
!     Motor control center maintenance rules for AT5
!
!
RULE  For analyzing breaker maintenance condition for AT5 test
IF    motor control center maintenance IS breaker maintained
THEN  Motor control center maintenance requires AT5 test
AND   FILE Breaker maintenance requires AT5 test
!
RULE  For analyzing handswitch replaced condition for AT5 test
IF    motor control center maintenance IS handswitch replaced
THEN  Motor control center maintenance requires AT5 test
AND   FILE Handswitch replaced requires AT5 test
!
RULE  For analyzing power cable replaced condition for AT5 test
IF    motor control center maintenance IS power cable replaced
THEN  Motor control center maintenance requires AT5 test
AND   FILE Power cable replaced requires AT5 test
!
!
!     Rules for CT-CC test
!
!
RULE  For analyzing CTCC test
IF    CTCC test is required
OR    CTCC test is not required
THEN  CTCC test analyzed
!
RULE  For determining CTCC requirements
IF    CTCC applicable
AND   Maintenance affects check valve stroke close time
THEN  CTCC test is required
ELSE  CTCC test is not required
!
RULE  For driving CTCC valve body maintenance conditions
IF    Affected system for maintenance IS valve body
AND   Valve body maintenance requires CTCC test
THEN  Maintenance affects check valve stroke close time
!
RULE  For driving CTCC valve operator maintenance conditions
IF    Affected system for maintenance IS valve operator
AND   Valve operator maintenance requires CTCC test
```

```
THEN  Maintenance affects check valve stroke close time
!
!
!     Valve body maintenance rules for CTCC
!
!
RULE  For analyzing valve replaced condition for CTCC test
IF    valve body maintenance IS valve replaced
THEN  Valve body maintenance requires CTCC test
AND   FILE Valve replaced requires CTCC test
!
RULE  For analyzing valve disassembled condition for CTCC test
IF    valve body maintenance IS valve disassembled
THEN  Valve body maintenance requires CTCC test
AND   FILE Valve disassembled requires CTCC test
!
RULE  For analyzing packing adjusted condition for CTCC test
IF    valve body maintenance IS packing adjusted
THEN  Valve body maintenance requires CTCC test
AND   FILE Packing adjusted requires CTCC test
!
RULE  For analyzing repacking performed condition for CTCC test
IF    valve body maintenance IS repacking performed
THEN  Valve body maintenance requires CTCC test
AND   FILE Repacking requires CTCC test
!
RULE  For analyzing seat maintenance condition for CTCC test
IF    valve body maintenance IS maintained seating surface
THEN  Valve body maintenance requires CTCC test
AND   FILE Seat maintenance requires CTCC test
!
RULE  For analyzing stem maintenance condition for CTCC test
IF    valve body maintenance IS valve stem maintenance
THEN  Valve body maintenance requires CTCC test
AND   FILE Stem maintenance requires CTCC test
!
!
!     Valve operator maintenance rules for CTCC
!
!
RULE  For analyzing operator replaced condition for CTCC test
IF    valve operator maintenance IS operator replaced
THEN  Valve operator maintenance requires CTCC test
AND   FILE Operator replaced requires CTCC test
!
RULE  For analyzing electrical wire maint condition for CTCC test
IF    valve operator maintenance IS electrical wire maintenance
THEN  Valve operator maintenance requires CTCC test
AND   FILE Electrical wire maint requires CTCC test
!
```

```
!
!     Rules for system pressure test
!
!
RULE  For analyzing SYSPR test
IF    SYSPR test is required
OR    SYSPR test is not required
THEN  SYSPR test analyzed
!
RULE  For determining SYSPR requirements
IF    SYSPR applicable
AND   Maintenance affects system pressure boundary
THEN  SYSPR test is required
ELSE  SYSPR test is not required
!
RULE  For determining applicability of SYSPR test
IF    Valve size > 1.
THEN  SYSPR applicable
ELSE  NOT SYSPR applicable
!
RULE  For driving SYSPR valve body maintenance conditions
IF    Affected system for maintenance IS valve body
AND   Valve body maintenance requires SYSPR test
THEN  Maintenance affects system pressure boundary
!
!
!     Valve body maintenance rules for SYSPR
!
!
RULE  For analyzing valve replaced condition for SYSPR test
IF    valve body maintenance IS valve replaced
THEN  Valve body maintenance requires SYSPR test
AND   FILE Valve replaced requires SYSPR test
!
RULE  For analyzing valve disassembled condition for SYSPR test
IF    valve body maintenance IS valve disassembled
THEN  Valve body maintenance requires SYSPR test
AND   FILE Valve disassembled requires SYSPR test
!
RULE  For analyzing seat maintenance condition for SYSPR test
IF    valve body maintenance IS maintained seating surface
THEN  Valve body maintenance requires SYSPR test
AND   FILE Seat maintenance requires SYSPR test
!
!
!     Rules For Tag Out Determination
!
!
RULE  For driving tag out determination
FILE  tag out header
```

```
IF    Tag out is required
OR    Tag out is not required
THEN  Tag out determined
!
RULE  For calling tag out rules
IF    Maintenance warrants control panel notice
THEN  Tag out is required
AND   TAGO := Y
ELSE  Tag out is not required
AND   TAGO := N
!
RULE  For driving tag out valve body maintenance conditions
IF    Affected system for maintenance IS valve body
AND   Valve body maintenance requires tag out
THEN  Maintenance warrants control panel notice
!
RULE  For driving tag out valve operator maintenance conditions
IF    Affected system for maintenance IS valve operator
AND   Valve operator maintenance requires tag out
THEN  Maintenance warrants control panel notice
!
RULE  For driving tag out motor control center maintenance conditions
IF    Affected system for maintenance IS motor control center
AND   Motor control center maintenance requires tag out
THEN  Maintenance warrants control panel notice
!
!
!     Valve body maintenance rules for tag out
!
!
RULE  For analyzing valve replaced condition for tag out
IF    valve body maintenance IS valve replaced
THEN  Valve body maintenance requires tag out
AND   FILE Valve replaced requires tag out
!
RULE  For analyzing valve disassembled condition for tag out
IF    valve body maintenance IS valve disassembled
THEN  Valve body maintenance requires tag out
AND   FILE Valve disassembled requires tag out
!
RULE  For analyzing repacking performed condition for tag out
IF    valve body maintenance IS repacking performed
THEN  Valve body maintenance requires tag out
AND   FILE Repacking requires tag out
!
RULE  For analyzing replaced body bonnet gasket for tag out
IF    valve body maintenance IS replaced body to bonnet gasket
THEN  Valve body maintenance requires tag out
AND   FILE Replaced body to bonnet gasket requires tag out
!
```

```
RULE  For analyzing seat maintenance condition for tag out
IF    valve body maintenance IS maintained seating surface
THEN  Valve body maintenance requires tag out
AND   FILE Seat maintenance requires tag out
!
RULE  For analyzing stem maintenance condition for tag out
IF    valve body maintenance IS valve stem maintenance
THEN  Valve body maintenance requires tag out
AND   FILE Stem maintenance requires tag out
!
!
!     Valve operator maintenance rules for tag out
!
!
RULE  For analyzing operator replaced condition for tag out
IF    valve operator maintenance IS operator replaced
THEN  Valve operator maintenance requires tag out
AND   FILE Operator replaced requires tag out
!
RULE  For analyzing motor replaced condition for tag out
IF    valve operator maintenance IS motor replaced
THEN  Valve operator maintenance requires tag out
AND   FILE Motor replaced requires tag out
!
RULE  For analyzing torque switch maint condition for tag out
IF    valve operator maintenance IS torque switch maintained
THEN  Valve operator maintenance requires tag out
AND   FILE Torque switch maint requires tag out
!
RULE  For analyzing limit switch maint condition for tag out
IF    valve operator maintenance IS limit switch maintained
THEN  Valve operator maintenance requires tag out
AND   FILE Limit switch maint requires tag out
!
RULE  For analyzing spring pack work condition for tag out
IF    valve operator maintenance IS spring pack reworked
THEN  Valve operator maintenance requires tag out
AND   FILE Spring pack rework requires tag out
!
RULE  For analyzing torque bypass switch condition for tag out
IF    valve operator maintenance IS torque bypass switch maintained
THEN  Valve operator maintenance requires tag out
AND   FILE Torque bypass switch maint requires tag out
!
RULE  For analyzing handwheel maintenance condition for tag out
IF    valve operator maintenance IS handwheel maintenance
THEN  Valve operator maintenance requires tag out
AND   FILE Handwheel maintenance requires tag out
!
RULE  For analyzing electrical wire maint condition for tag out
```

```
IF    valve operator maintenance IS electrical wire maintenance
THEN  Valve operator maintenance requires tag out
AND   FILE Electrical wire maint requires tag out
!
RULE  For analyzing sealtite replacement condition for tag out
IF    valve operator maintenance IS replaced sealtite
THEN  Valve operator maintenance requires tag out
AND   FILE Sealtite replacement requires tag out
!
RULE  For determining tag out for operator removal
IF    The operator must be opened during the maintenance
THEN  Maintenance warrants control panel notice
AND   FILE Operator removal requires tag out
!
!
!     Motor control center maintenance rules for tag out
!
!
RULE  For analyzing power cable replaced condition for tag out
IF    motor control center maintenance IS power cable replaced
THEN  Motor control center maintenance requires tag out
AND   FILE Power cable replaced requires tag out
!
!
!     Rules For Determining Heavy Load
!
!
RULE  For determining heavy load requirements
FILE  heavy load header
IF    Heavy load is indicated
OR    Heavy load is not indicated
THEN  Heavy load determined
!
RULE  For checking conditions for heavy load notice
IF    The operator must be removed during the maintenance
AND   The operator size is large
THEN  Heavy load is indicated
AND   HLOD := Y
AND   FILE heavy load indicated
ELSE  Heavy load is not indicated
AND   HLOD := N
AND   FILE heavy load not indicated
!
!
!     Rules For Determining Primary Containment Application
!
!
RULE  For determining primary containment
FILE  primary containment header
IF    Primary containment is indicated
```

```
OR    Primary containment is not indicated
THEN  Primary containment determined
!
RULE  For checking conditions for primary containment notice
IF    The valve is in the list of primary containment valves
THEN  Primary containment is indicated
AND   PCON := Y
AND   FILE primary containment indicated
ELSE  Primary containment is not indicated
AND   PCON := N
AND   FILE primary containment not indicated
!
RULE  For examining the list of primary containment valves
IF    Valve ID ="MO 4423"
OR    Valve ID ="MO 4424"
OR    Valve ID ="MO 4441"
OR    Valve ID ="MO 2312"
OR    Valve ID ="MO 2740"
OR    Valve ID ="MO 4442"
OR    Valve ID ="MO 4424"
OR    Valve ID ="MO 4424"
OR    Valve ID ="MO 4424"
OR    Valve ID ="MO 4424"
OR    Valve ID ="MO 2512"
OR    Valve ID ="MO 2400"
OR    Valve ID ="MO 2401"
OR    Valve ID ="MO 2238"
OR    Valve ID ="MO 2239"
OR    Valve ID ="MO 2700"
OR    Valve ID ="MO 2701"
OR    Valve ID ="MO 2115"
OR    Valve ID ="MO 2117"
OR    Valve ID ="MO 2135"
OR    Valve ID ="MO 2137"
OR    Valve ID ="MO 4841A"
OR    Valve ID ="MO 4841B"
OR    Valve ID ="MO 2290A"
OR    Valve ID ="MO 2290B"
THEN  The valve is in the list of primary containment valves
!
!
!     Rule for determining ASME application
!
!
RULE  For calculating ASME information
IF    ASME_code
THEN  ASME determined
AND   ASME := Y
ELSE  ASME determined
AND   ASME := N
```

```
!
!
!     Rules for determining miscellaneous maintenance actions
!
!
RULE  For determining if operator must be removed
IF    Affected system for maintenance IS valve operator
AND   valve operator maintenance IS operator lubricated
AND   gear case lubricant is replaced
THEN  The operator must be removed during the maintenance
AND   The operator must be opened during the maintenance
!
RULE  For determining if operator needn't be removed lub oprtr
IF    Affected system for maintenance IS valve operator
AND   valve operator maintenance IS operator lubricated
AND   operator lubricant needs to be added
THEN  NOT The operator must be removed during the maintenance
AND   NOT The operator must be opened during the maintenance
!
RULE  For determining if operator needn't be removed lub ls
IF    Affected system for maintenance IS valve operator
AND   valve operator maintenance IS operator lubricated
AND   limit switch compartment needs lube replaced
THEN  NOT The operator must be removed during the maintenance
AND   NOT The operator must be opened during the maintenance
!
!
!     Rules for displaying test determination results
!
!
RULE  For assigning tests for display
IF    BTC assigned
AND   BTO assigned
AND   PIT assigned
AND   AT1 assigned
AND   AT5 assigned
AND   CTCC assigned
AND   SYSPR assigned
THEN  Test assignments have been made
!
RULE  For assigning BTC for display #1
IF    NOT BTC applicable
THEN  BTC assigned
AND   BTC display := BTC stroke close test is not applicable
!
RULE  For assigning BTC for display #2
IF    BTC test is required
THEN  BTC assigned
AND   BTC display := BTC stroke close test is required
!
```

```
RULE  For assigning BTC for display #3
IF    BTC test is not required
THEN  BTC assigned
AND   BTC display := BTC stroke close test is not required
!
RULE  For assigning BTO for display #1
IF    NOT BTO applicable
THEN  BTO assigned
AND   BTO display := BTO stroke open test is not applicable
!
RULE  For assigning BTO for display #2
IF    BTO test is required
THEN  BTO assigned
AND   BTO display := BTO stroke open test is required
!
RULE  For assigning BTO for display #3
IF    BTO test is not required
THEN  BTO assigned
AND   BTO display := BTO stroke open test is not required
!
RULE  For assigning PIT for display #1
IF    NOT PIT applicable
THEN  PIT assigned
AND   PIT display := PIT position indication test is not applicable
!
RULE  For assigning PIT for display #2
IF    PIT test is required
THEN  PIT assigned
AND   PIT display := PIT position indication test is required
!
RULE  For assigning PIT for display #3
IF    PIT test is not required
THEN  PIT assigned
AND   PIT display := PIT position indication test is not required
!
RULE  For assigning AT1 for display #1
IF    NOT AT1 applicable
THEN  AT1 assigned
AND   AT1 display := AT1 leakage test is not applicable
!
RULE  For assigning AT1 for display #2
IF    AT1 test is required
THEN  AT1 assigned
AND   AT1 display := AT1 leakage test is required
!
RULE  For assigning AT1 for display #3
IF    AT1 test is not required
THEN  AT1 assigned
AND   AT1 display := AT1 leakage test is not required
!
```

```
RULE  For assigning AT5 for display #1
IF    NOT AT5 applicable
THEN  AT5 assigned
AND   AT5 display := AT5 leakage test is not applicable
!
RULE  For assigning AT5 for display #2
IF    AT5 test is required
THEN  AT5 assigned
AND   AT5 display := AT5 leakage test is required
!
RULE  For assigning AT5 for display #3
IF    AT5 test is not required
THEN  AT5 assigned
AND   AT5 display := AT5 leakage test is not required
!
RULE  For assigning CTCC for display #1
IF    NOT CTCC applicable
THEN  CTCC assigned
AND   CTCC display := CTCC check valve stroke test is not applicable
!
RULE  For assigning CTCC for display #2
IF    CTCC test is required
THEN  CTCC assigned
AND   CTCC display := CTCC check valve stroke test is required
!
RULE  For assigning CTCC for display #3
IF    CTCC test is not required
THEN  CTCC assigned
AND   CTCC display := CTCC check valve stroke test is not required
!
RULE  For assigning SYSPR for display #1
IF    NOT SYSPR applicable
THEN  SYSPR assigned
AND   SYSPR display := System pressure test is not applicable
!
RULE  For assigning SYSPR for display #2
IF    SYSPR test is required
THEN  SYSPR assigned
AND   SYSPR display := System pressure test is required
!
RULE  For assigning SYSPR for display #3
IF    SYSPR test is not required
THEN  SYSPR assigned
AND   SYSPR display := System pressure test is not required
!
!
!*************************************************************************
!
!     Information Displays
!
```

```
!*********************************************************************
!
!
!     TEXT References
!
!
TEXT  Print item

Select all the items you would like printed

!
TEXT  Affected system for maintenance

Select all the valve systems affected by maintenance work

!
TEXT  valve body maintenance

Select all the maintenance activities performed on the valve body

!
TEXT  valve replaced
Valve body was completely replaced
!
TEXT  valve disassembled
Valve was disassembled so that the pressure seal was
broken (bonnet removed)
!
TEXT  packing adjusted
Valve packing was adjusted
!
TEXT  repacking performed
Repacking was performed on the valve
!
TEXT  replaced body to bonnet gasket
The body to bonnet gasket was replaced
!
TEXT  maintained seating surface
The valve seating surface was maintained
!
TEXT  valve stem maintenance
The valve stem was maintained
!
TEXT  valve operator maintenance

Select all the maintenance activities performed on the valve operator

!
TEXT  operator replaced
Valve operator was replaced
```

```
!
TEXT  motor replaced
Valve operator motor was replaced
!
TEXT  torque switch maintained
Torque switch was maintained (replaced, adjusted, rewired)
!
TEXT  limit switch maintained
Limit switch was maintained (replaced, adjusted, rewired)
!
TEXT  spring pack reworked
Spring pack was reworked
!
TEXT  torque bypass switch maintained
Torque bypass switch was maintained (replaced, adjusted, rewired)
!
TEXT  operator lubricated
Valve operator was lubricated
!
TEXT  electrical wire maintenance
Electrical wire maintenance was performed
!
TEXT  replaced sealtite
Replaced sealtite from operator to motor
!
TEXT  handwheel maintenance
Handwheel maintenance was performed
!
TEXT  motor control center maintenance

Select all the maintenance activities performed on the
motor control center

!
TEXT  breaker maintained
Breaker was replaced or rewired
!
TEXT  handswitch replaced
Handswitch was replaced
!
TEXT  power cable replaced
Power cable was replaced
!
TEXT  The operator size is large

Is the valve operator larger than a SB-0?

!
TEXT  gear case lubricant is replaced
```

```
Does operator lubrication consist of the replacement
of the gear case lubricant?

!
TEXT  operator lubricant needs to be added

Does operator lubrication consist of adding
lubrication to the valve operator?

!
TEXT  limit switch compartment needs lube replaced

Does operator lubrication consist of replacing
lubrication in the limit switch compartment?

!
!
!     DISPLAY References
!
!
DISPLAY  maintenance planning header

**********************************

Documentation file for maintenance planning for
MO valve [Valve ID].  The P & ID for this valve
is [Valve P&ID]  [P&ID coord].

**********************************

!
DISPLAY  post maintenance testing header


POST MAINTENANCE TESTING Documentation
--------------------------------------


!
DISPLAY  No required test number 1

   - No test is required due to NO TEST condition 1

!
DISPLAY  Valve replaced requires BTC test

   - A BTC test is required since the valve body was replaced

!
DISPLAY  Valve disassembled requires BTC test
```

```
   - A BTC test is required since the valve was disassembled

!
DISPLAY  Packing adjusted requires BTC test

   - A BTC test is required since the packing was adjusted

!
DISPLAY  Repacking requires BTC test

   - A BTC test is required since the valve was repacked

!
DISPLAY  Replaced body to bonnet gasket requires BTC test

   - A BTC test is required since the body to bonnet
     gasket was replaced

!
DISPLAY  Seat maintenance requires BTC test

   - A BTC test is required since the valve seat surface
     was maintained

!
DISPLAY  Stem maintenance requires BTC test

   - A BTC test is required since the valve stem was maintained

!
DISPLAY  Operator replaced requires BTC test

   - A BTC test is required since the valve operator was replaced

!
DISPLAY  Motor replaced requires BTC test

   - A BTC test is required since the operator motor was replaced

!
DISPLAY  Torque switch maint requires BTC test

   - A BTC test is required since the torque switch
     was maintained

!
DISPLAY  Limit switch maint requires BTC test

   - A BTC test is required since the limit switch
```

```
     was maintained

!
DISPLAY  Spring pack rework requires BTC test

   - A BTC test is required since the spring pack
     was reworked

!
DISPLAY  Torque bypass switch maint requires BTC test

   - A BTC test is required since the torque bypass switch
     was maintained

!
DISPLAY  Operator lubricated requires BTC test

   - A BTC test is required since the operator was lubricated

!
DISPLAY  Electrical wire maint requires BTC test

   - A BTC test is required since operator electrical
     wires were maintained

!
DISPLAY  Sealtite replacement requires BTC test

   - A BTC test is required since the sealtite from the
     operator to the motor was replaced

!
DISPLAY  Breaker maintenance requires BTC test

   - A BTC test is required since the breaker
     was maintained

!
DISPLAY  Handswitch replaced requires BTC test

   - A BTC test is required since the handswitch
     was replaced

!
DISPLAY  Power cable replaced requires BTC test

   - A BTC test is required since power cables
     were replaced

!
```

```
DISPLAY  Valve replaced requires BTO test

   - A BTO test is required since the valve body was replaced

!
DISPLAY  Valve disassembled requires BTO test

   - A BTO test is required since the valve was disassembled

!
DISPLAY  Packing adjusted requires BTO test

   - A BTO test is required since the packing was adjusted

!
DISPLAY  Repacking requires BTO test

   - A BTO test is required since the valve was repacked

!
DISPLAY  Replaced body to bonnet gasket requires BTO test

   - A BTO test is required since the body to bonnet
     gasket was replaced

!
DISPLAY  Seat maintenance requires BTO test

   - A BTO test is required since the valve seat surface
     was maintained

!
DISPLAY  Stem maintenance requires BTO test

   - A BTO test is required since the valve stem was maintained

!
DISPLAY  Operator replaced requires BTO test

   - A BTO test is required since the valve operator was replaced

!
DISPLAY  Motor replaced requires BTO test

   - A BTO test is required since the operator motor was replaced

!
DISPLAY  Torque switch maint requires BTO test

   - A BTO test is required since the torque switch
```

```
     was maintained

!
DISPLAY  Limit switch maint requires BTO test

   - A BTO test is required since the limit switch
     was maintained

!
DISPLAY  Spring pack rework requires BTO test

   - A BTO test is required since the spring pack
     was reworked

!
DISPLAY  Torque bypass switch maint requires BTO test

   - A BTO test is required since the torque bypass switch
     was maintained

!
DISPLAY  Operator lubricated requires BTO test

   - A BTO test is required since the operator was lubricated

!
DISPLAY  Electrical wire maint requires BTO test

   - A BTO test is required since operator electrical
     wires were maintained

!
DISPLAY  Sealtite replacement requires BTO test

   - A BTO test is required since the sealtite from the
     operator to the motor was replaced

!
DISPLAY  Breaker maintenance requires BTO test

   - A BTO test is required since the breaker
     was maintained

!
DISPLAY  Handswitch replaced requires BTO test

   - A BTO test is required since the handswitch
     was replaced

!
```

```
DISPLAY  Power cable replaced requires BTO test

   - A BTO test is required since power cables
     were replaced

!
DISPLAY  Valve replaced requires PIT test

   - A PIT test is required since the valve body was replaced

!
DISPLAY  Valve disassembled requires PIT test

   - A PIT test is required since the valve was disassembled

!
DISPLAY  Operator replaced requires PIT test

   - A PIT test is required since the valve operator was replaced

!
DISPLAY  Limit switch maint requires PIT test

   - A PIT test is required since the limit switch
     was maintained

!
DISPLAY  Operator removal requires PIT test

   - A PIT test is required since the operator was
     removed during the maintenance

!
DISPLAY  Breaker maintenance requires PIT test

   - A PIT test is required since the breaker
     was maintained

!
DISPLAY  Power cable replaced requires PIT test

   - A PIT test is required since power cables
     were replaced

!
DISPLAY  Valve replaced requires AT1 test

   - A AT1 test is required since the valve body was replaced

!
```

```
DISPLAY  Valve disassembled requires AT1 test

   - A AT1 test is required since the valve was disassembled

!
DISPLAY  Packing adjusted requires AT1 test

   - A AT1 test is required since the packing was adjusted

!
DISPLAY  Repacking requires AT1 test

   - A AT1 test is required since the valve was repacked

!
DISPLAY  Seat maintenance requires AT1 test

   - A AT1 test is required since the valve seat surface
     was maintained

!
DISPLAY  Stem maintenance requires AT1 test

   - A AT1 test is required since the valve stem was maintained

!
DISPLAY  Operator replaced requires AT1 test

   - A AT1 test is required since the valve operator was replaced

!
DISPLAY  Motor replaced requires AT1 test

   - A AT1 test is required since the operator motor was replaced

!
DISPLAY  Torque switch maint requires AT1 test

   - A AT1 test is required since the torque switch
     was maintained

!
DISPLAY  Limit switch maint requires AT1 test

   - A AT1 test is required since the limit switch
     was maintained

!
DISPLAY  Spring pack rework requires AT1 test
```

```
   - A AT1 test is required since the spring pack
     was reworked

!
DISPLAY  Torque bypass switch maint requires AT1 test

   - A AT1 test is required since the torque bypass switch
     was maintained

!
DISPLAY  Operator lubricated requires AT1 test

   - A AT1 test is required since the operator was lubricated

!
DISPLAY  Electrical wire maint requires AT1 test

   - A AT1 test is required since operator electrical
     wires were maintained

!
DISPLAY  Breaker maintenance requires AT1 test

   - A AT1 test is required since the breaker
     was maintained

!
DISPLAY  Handswitch replaced requires AT1 test

   - A AT1 test is required since the handswitch
     was replaced

!
DISPLAY  Power cable replaced requires AT1 test

   - A AT1 test is required since power cables
     were replaced

!
DISPLAY  Valve replaced requires AT5 test

   - A AT5 test is required since the valve body was replaced

!
DISPLAY  Valve disassembled requires AT5 test

   - A AT5 test is required since the valve was disassembled

!
DISPLAY  Packing adjusted requires AT5 test
```

```
   - A AT5 test is required since the packing was adjusted

!
DISPLAY  Repacking requires AT5 test

   - A AT5 test is required since the valve was repacked

!
DISPLAY  Seat maintenance requires AT5 test

   - A AT5 test is required since the valve seat surface
     was maintained

!
DISPLAY  Stem maintenance requires AT5 test

   - A AT5 test is required since the valve stem was maintained

!
DISPLAY  Operator replaced requires AT5 test

   - A AT5 test is required since the valve operator was replaced

!
DISPLAY  Motor replaced requires AT5 test

   - A AT5 test is required since the operator motor was replaced

!
DISPLAY  Torque switch maint requires AT5 test

   - A AT5 test is required since the torque switch
     was maintained

!
DISPLAY  Limit switch maint requires AT5 test

   - A AT5 test is required since the limit switch
     was maintained

!
DISPLAY  Spring pack rework requires AT5 test

   - A AT5 test is required since the spring pack
     was reworked

!
DISPLAY  Torque bypass switch maint requires AT5 test
```

```
   - A AT5 test is required since the torque bypass switch
     was maintained

!
DISPLAY  Operator lubricated requires AT5 test

   - A AT5 test is required since the operator was lubricated

!
DISPLAY  Electrical wire maint requires AT5 test

   - A AT5 test is required since operator electrical
     wires were maintained

!
DISPLAY  Breaker maintenance requires AT5 test

   - A AT5 test is required since the breaker
     was maintained

!
DISPLAY  Handswitch replaced requires AT5 test

   - A AT5 test is required since the handswitch
     was replaced

!
DISPLAY  Power cable replaced requires AT5 test

   - A AT5 test is required since power cables
     were replaced

!
DISPLAY  Valve replaced requires CTCC test

   - A CTCC test is required since the valve body was replaced

!
DISPLAY  Valve disassembled requires CTCC test

   - A CTCC test is required since the valve was disassembled

!
DISPLAY  Packing adjusted requires CTCC test

   - A CTCC test is required since the packing was adjusted

!
DISPLAY  Repacking requires CTCC test
```

```
   - A CTCC test is required since the valve was repacked

!
DISPLAY  Seat maintenance requires CTCC test

   - A CTCC test is required since the valve seat surface
     was maintained

!
DISPLAY  Stem maintenance requires CTCC test

   - A CTCC test is required since the valve stem was maintained

!
DISPLAY  Operator replaced requires CTCC test

   - A CTCC test is required since the valve operator was replaced

!
DISPLAY  Electrical wire maint requires CTCC test

   - A CTCC test is required since operator electrical
     wires were maintained

!
DISPLAY  Valve replaced requires SYSPR test

   - A SYSPR test is required since the valve body was replaced

!
DISPLAY  Valve disassembled requires SYSPR test

   - A SYSPR test is required since the valve was disassembled

!
DISPLAY  Seat maintenance requires SYSPR test

   - A SYSPR test is required since the valve seat surface
     was maintained

!
DISPLAY  tag out header


TAG OUT Documentation
---------------------


!
DISPLAY  Valve replaced requires tag out
```

```
   - Tag out is required since the valve body was replaced

!
DISPLAY  Valve disassembled requires tag out

   - Tag out is required since the valve was disassembled

!
DISPLAY  Repacking requires tag out

   - Tag out is required since the valve was repacked

!
DISPLAY  Replaced body to bonnet gasket requires tag out

   - Tag out is required since the body to bonnet
     gasket was replaced

!
DISPLAY  Seat maintenance requires tag out

   - Tag out is required since the valve seat surface
     was maintained

!
DISPLAY  Stem maintenance requires tag out

   - Tag out is required since the valve stem was maintained

!
DISPLAY  Operator replaced requires tag out

   - Tag out is required since the valve operator was replaced

!
DISPLAY  Motor replaced requires tag out

   - Tag out is required since the operator motor was replaced

!
DISPLAY  Torque switch maint requires BTO test

   - Tag out is required since the torque switch
     was maintained

!
DISPLAY  Limit switch maint requires tag out

   - Tag out is required since the limit switch
```

```
     was maintained

!
DISPLAY  Spring pack rework requires tag out

   - Tag out is required since the spring pack
     was reworked

!
DISPLAY  Torque bypass switch maint requires tag out

   - Tag out is required since the torque bypass switch
     was maintained

!
DISPLAY  Handwheel maintenance requires tag out

   - Tag out is required since the operator
     handwheel was maintained

!
DISPLAY  Electrical wire maint requires tag out

   - Tag out is required since operator electrical
     wires were maintained

!
DISPLAY  Sealtite replacement requires tag out

   - Tag out is required since the sealtite from the
     operator to the motor was replaced

!
DISPLAY  Operator removal requires tag out

   - Tag out is required since operator was removed
     during the maintenance

!
DISPLAY  Power cable replaced requires tag out

   - Tag out is required since power cables
     were replaced

!
DISPLAY  heavy load header


HEAVY LOAD Documentation
------------------------
```

```
!
DISPLAY  heavy load indicated

   - Heavy load is indicated since the operator must be
     removed during the maintenance and the operator size is large

!
DISPLAY  heavy load not indicated

   - Heavy load is not indicated since either the operator need
     not be removed during the maintenance or the operator
     size is not too large

!
DISPLAY  primary containment header


PRIMARY CONTAINMENT Documentation
---------------------------------


!
DISPLAY  primary containment indicated

   -  Primary containment is indicated since the valve is
      in the list of primary containment valves

!
DISPLAY  primary containment not indicated

   -  Primary containment is not indicated since the valve is
      not in the list of primary containment valves

!
DISPLAY screen results


          ***  Valve Maintenance Planning Results  ***

        Valve ID: [Valve ID]    P&ID: [Valve P&ID]  [P&ID coord]

      QL:          pri cont: [PCON]    NPRDS:          MIF:
  tagout: [TAGO]     req for S/U:        CCP:        proc#1:
    J&LL:        heavy load: [HLOD]     ASME: [ASME]     proc#2:
     RWP:         fire prot:          EQ:        proc#3:


 ---------------- post-maintenance requirement ----------------
```

```
                [BTC display]
                [BTO display]
                [PIT display]
                [AT1 display]
                [AT5 display]
                [CTCC display]
                [SYSPR display]

!
DISPLAY  documentation file for planning


    A supplementary documentation of this session can be
    obtained be printing out the file "IEPLAN.DOC" using
    the DOS command

       "PRINT IEPLAN.DOC".


!
!
!*********************************************************************
!
!   End of Knowledge Base
!
!*********************************************************************
!
!
END
```

IEBATCH.PRL

```
TITLE   Valve Maintenance Planning Batch Testing Knowledge Base
!
!
!*********************************************************************
!
!     Shared Parameters
!
!*********************************************************************
!
!
$ IESHARED.PRL
!
!
!*********************************************************************
!
!     Data Type Declarations
!
!*********************************************************************
!
!
$ IEDECLAR.PRL
!
!
!*********************************************************************
!
!     Parameter Initialization Statements
!
!*********************************************************************
!
!
INIT   Number of cases := 3
AND    Run mode IS batch test
AND    Print item IS Nothing
AND    Print item IS Valve maintenance planning results CF 0
AND    Print item IS Line of reasoning report CF 0
AND    Planning documentation file := "IEPLAN.DOC"
AND    One := 1
AND    Fail CF 0
AND    Test case number := 0
REINIT Number of cases := 3
AND    Run mode IS batch test
AND    Print item IS Nothing
AND    Print item IS Valve maintenance planning results CF 0
AND    Print item IS Line of reasoning report CF 0
AND    Planning documentation file := "IEPLAN.DOC"
AND    One := 1
```

```
AND    Fail CF 0
!
!
!*********************************************************************
!
!     Control Element Selectors
!
!*********************************************************************
!
!
GOALSELECT OFF
$ IEMULTI.PRL
SUPPRESS ALL
!
!
!*********************************************************************
!
!     Goal Outline
!
!*********************************************************************
!
!
1. Run the batch test cases
   1.1. Drive batch testing
        1.1.1. Store test case results
        1.1.2. Test case processed
        1.1.3. Test case processing complete
2. Compare two batch test results
3. Display batch test case results
4. Quit batch test knowledge base execution
!
!
!*********************************************************************
!
!     Knowledge Base Rules
!
!*********************************************************************
!
!
!     Goal Processing Rules
!
!
RULE  To ask if batch test case running is required
IF    Batch test task IS run batch test cases
THEN  Run the batch test cases
!
RULE  To drive batch testing
IF    Test case number = 0
AND   ASK Batch test case file
AND   ACTIVATE IENFILE.COM
```

```
DISK  IEPARAM.DAT
SEND  Planning documentation file
THEN  Drive batch testing
ELSE  Drive batch testing
!
RULE  To ask if batch test result comparison is required
IF    Batch test task IS batch test result comparison
AND   ASK First test case file
AND   ASK Second test case file
AND   ACTIVATE IECOMPAR.COM
DISK  IEPARAM.DAT
SEND  First test case file
SEND  Second test case file
THEN  Compare two batch test results
AND   FORGET Batch test task
AND   FORGET Run the batch test cases
AND   FORGET Drive batch testing
AND   FORGET Store test case results
AND   FORGET Test case processed
AND   FORGET Test case processing complete
AND   FORGET Compare two batch test results
AND   FORGET Display batch test case results
AND   CYCLE
!
RULE  To ask if batch test result display is required
IF    Batch test task IS display batch test results
AND   ASK Display test case file
AND   ACTIVATE IEDISPLA.COM
DISK  IEPARAM.DAT
SEND  Display test case file
THEN  Display batch test case results
AND   FORGET Batch test task
AND   FORGET Run the batch test cases
AND   FORGET Drive batch testing
AND   FORGET Store test case results
AND   FORGET Test case processed
AND   FORGET Test case processing complete
AND   FORGET Compare two batch test results
AND   FORGET Display batch test case results
AND   CYCLE
!
RULE  To ask if user wants to quit the knowledge base
IF    Batch test task IS Leave batch testing knowledge base
THEN  Quit batch test knowledge base execution
AND   FORGET Run mode
AND   FORGET Major task
AND   FORGET Affected system for maintenance
AND   FORGET valve body maintenance
AND   FORGET valve operator maintenance
AND   FORGET motor control center maintenance
```

```
AND   FORGET Print item
AND   FORGET Batch test task
AND   CHAIN IEVALVE
!
!
!     Rules for running batch test cases
!
!
RULE  For storing test case results
IF    Test case number > 0
AND   ACTIVATE IESTORE.COM
DISK  IEPARAM.DAT
SEND  Batch test case file
SEND  Test case number
SEND  Valve ID
SEND  BTC test is required
SEND  BTO test is required
SEND  PIT test is required
SEND  AT1 test is required
SEND  AT5 test is required
SEND  CTCC test is required
SEND  SYSPR test is required
SEND  Tag out is required
SEND  Heavy load is indicated
SEND  Primary containment is indicated
AND   Fail
THEN  Store test case results
!
!
!     Driving rule for batch test case processing
!
!
RULE  For driving batch testing
FORGET Valve ID
FORGET Affected system for maintenance
FORGET valve body maintenance
FORGET valve operator maintenance
FORGET motor control center maintenance
FORGET BTC test is required
FORGET BTO test is required
FORGET PIT test is required
FORGET AT1 test is required
FORGET AT5 test is required
FORGET CTCC test is required
FORGET SYSPR test is required
FORGET Tag out is required
FORGET Heavy load is indicated
FORGET Primary containment is indicated
READ  IECASE.SAV
DATA  Test case number
```

```
IF    Test case number <= Number of cases
AND   Test case information initialized
AND   Valve information retrieved
THEN  Test case processed
AND   Next case number := Test case number + 1
AND   WRITE IECASE.SAV
DATA  Next case number
AND   CHAIN IEVALVE2
ELSE  Test case processing complete
AND   WRITE IECASE.SAV
DATA  One
AND   DISPLAY batch processing complete
AND   FORGET Batch test task
AND   FORGET Run the batch test cases
AND   FORGET Drive batch testing
AND   FORGET Store test case results
AND   FORGET Test case processed
AND   FORGET Test case processing complete
AND   FORGET Compare two batch test results
AND   FORGET Display batch test case results
AND   CYCLE
!
RULE  For retrieving valve data
ACTIVATE IEACCDB1.COM
DISK  IEPARAM.DAT
SEND  Valve ID
RETURN Valve found in data base
RETURN Valve P&ID
RETURN P&ID coord
RETURN Valve IST class
RETURN Valve category
RETURN Valve size
RETURN Valve type
RETURN Valve actuator type
RETURN Normal position of valve
RETURN PIT applicable
RETURN BTC applicable
RETURN BTO applicable
RETURN AT5 applicable
RETURN AT1 applicable
RETURN CTCC applicable
RETURN PIT frequency
RETURN BTC frequency
RETURN BTO frequency
RETURN AT5 frequency
RETURN AT1 frequency
RETURN CTCC frequency
RETURN Maximum BTO stroke open time
RETURN Maximum BTC stroke close time
RETURN Maximum AT5 leakage
```

```
RETURN Maximum AT1 leakage
RETURN AT1 relief request
RETURN CTCC relief request
IF     Valve found in data base
THEN   Valve information retrieved
ELSE   This valve cannot be analyzed
AND    DISPLAY valve id not available
!
!
!      Rules for initializing maintenance planning test case data
!
!
RULE   For storing data for test case 1
IF     Test case number = 1
THEN   Test case information initialized
AND    Valve ID := "MO 2000"
AND    Affected system for maintenance IS valve body
AND    NOT Affected system for maintenance IS valve operator
AND    NOT Affected system for maintenance IS motor control center
AND    valve body maintenance IS packing adjusted
AND    NOT valve body maintenance IS valve replaced
AND    NOT valve body maintenance IS valve disassembled
AND    NOT valve body maintenance IS repacking performed
AND    NOT valve body maintenance IS replaced body to bonnet gasket
AND    NOT valve body maintenance IS maintained seating surface
AND    NOT valve body maintenance IS valve stem maintenance
!
RULE   For storing data for test case 2
IF     Test case number = 2
THEN   Test case information initialized
AND    Valve ID := "MO 2137"
AND    Affected system for maintenance IS valve operator
AND    NOT Affected system for maintenance IS valve body
AND    NOT Affected system for maintenance IS motor control center
AND    valve operator maintenance IS limit switch maintained
AND    NOT valve operator maintenance IS operator replaced
AND    NOT valve operator maintenance IS motor replaced
AND    NOT valve operator maintenance IS torque switch maintained
AND    NOT valve operator maintenance IS spring pack reworked
AND    NOT valve operator maintenance IS torque bypass switch maintained
AND    NOT valve operator maintenance IS operator lubricated
AND    NOT valve operator maintenance IS electrical wire maintenance
AND    NOT valve operator maintenance IS replaced sealtite
AND    NOT valve operator maintenance IS handwheel maintenance
!
RULE   For storing data for test case 3
IF     Test case number = 3
THEN   Test case information initialized
AND    Valve ID := "MO 1943A"
AND    Affected system for maintenance IS valve body
```

```
AND   NOT Affected system for maintenance IS valve operator
AND   NOT Affected system for maintenance IS motor control center
AND   valve body maintenance IS replaced body to bonnet gasket
AND   NOT valve body maintenance IS valve replaced
AND   NOT valve body maintenance IS valve disassembled
AND   NOT valve body maintenance IS packing adjusted
AND   NOT valve body maintenance IS repacking performed
AND   NOT valve body maintenance IS maintained seating surface
AND   NOT valve body maintenance IS valve stem maintenance
!
!
!*********************************************************************
!
!     Information Displays
!
!*********************************************************************
!
!
!     TEXT References
!
!
TEXT  Batch test task

 Select your required batch testing function

!
TEXT  run batch test cases
Run the batch of test cases and store the results
!
TEXT  display batch test results
Display the results of a batch test run
!
TEXT  batch test result comparison
Compare two batch test case results
!
TEXT  Batch test case file

Enter the file name for storing the batch test results

Note: If the file already exists, it will be rewritten

!
TEXT  First test case file

Enter the file name of the first batch test result file for comparison

!
TEXT  Second test case file

Enter the file name of the second batch test result file for comparison
```

```
!
TEXT  Display test case file

Enter the file name of the batch test result file to be displayed

!
!
!     DISPLAY References
!
!
DISPLAY batch processing complete

   All the test cases have been processed.

   Press ENTER or F2 to continue.

!
DISPLAY valve id not available

   The valve ID you entered was [Valve ID].

   This valve is not currently available for use
   with this knowledge base.  Check to make sure
   that you entered the "MO" in the valve ID in
   capital letters.


!
!
!*********************************************************************
!
!     End of Knowledge Base
!
!*********************************************************************
!
!
END
```

IEDECLAR.PRL

```
!
SIMPLEFACT  Valve found in data base
AND         BTC applicable
AND         BTO applicable
AND         PIT applicable
AND         AT1 applicable
AND         AT5 applicable
AND         CTCC applicable
AND         SYSPR applicable
AND         BTC test is required
AND         BTO test is required
AND         PIT test is required
AND         AT1 test is required
AND         AT5 test is required
AND         CTCC test is required
AND         SYSPR test is required
AND         BTC test is not required
AND         BTO test is not required
AND         PIT test is not required
AND         AT1 test is not required
AND         AT5 test is not required
AND         CTCC test is not required
AND         SYSPR test is not required
AND         ASME_code
!
!
NUMERIC  Valve IST class
AND      Valve size
AND      Maximum BTO stroke open time
AND      Maximum BTC stroke close time
AND      Test case number
AND      Next case number
AND      One
AND      Five
!
!
STRING  Valve ID
AND     Valve P&ID
AND     P&ID coord
AND     Valve category
AND     Valve type
AND     Valve actuator type
AND     Normal position of valve
AND     PIT frequency
AND     BTC frequency
AND     BTO frequency
```

```
AND     AT5 frequency
AND     AT1 frequency
AND     CTCC frequency
AND     Maximum AT5 leakage
AND     Maximum AT1 leakage
AND     AT1 relief request
AND     CTCC relief request
AND     BTC display
AND     BTO display
AND     PIT display
AND     AT1 display
AND     AT5 display
AND     CTCC display
AND     SYSPR display
AND     ASME
AND     TAGO
AND     HLOD
AND     PCON
AND     First test case file
AND     Second test case file
AND     Initial screen file
AND     Batch test case file
AND     Display test case file
AND     Diagnosis documentation file
AND     Planning documentation file
!
!
OBJECT  Major task
AND     Affected system for diagnosis
AND     Affected system for maintenance
AND     valve body symptom
AND     valve operator symptom
AND     motor control center symptom
AND     valve body problem
AND     valve operator problem
AND     motor control center problem
AND     valve body maintenance
AND     valve operator maintenance
AND     motor control center maintenance
AND     Print item
AND     Run mode
AND     Batch test task
!
```

IEMULTI.PRL

```
!
MULTI   Affected system for diagnosis
AND     Affected system for maintenance
AND     valve body symptom
AND     valve operator symptom
AND     motor control center symptom
AND     valve body problem
AND     valve operator problem
AND     motor control center problem
AND     valve body maintenance
AND     valve operator maintenance
AND     motor control center maintenance
AND     Print item
!
```

IESHARED.PRL

```
!
SHARED SIMPLEFACT  BTC applicable
AND SIMPLEFACT     BTO applicable
AND SIMPLEFACT     PIT applicable
AND SIMPLEFACT     AT1 applicable
AND SIMPLEFACT     AT5 applicable
AND SIMPLEFACT     CTCC applicable
AND SIMPLEFACT     SYSPR applicable
AND SIMPLEFACT     BTC test is required
AND SIMPLEFACT     BTO test is required
AND SIMPLEFACT     PIT test is required
AND SIMPLEFACT     AT1 test is required
AND SIMPLEFACT     AT5 test is required
AND SIMPLEFACT     CTCC test is required
AND SIMPLEFACT     SYSPR test is required
AND SIMPLEFACT     Tag out is required
AND SIMPLEFACT     Heavy load is indicated
AND SIMPLEFACT     Primary containment is indicated
!
!
SHARED NUMERIC  Valve IST class
AND NUMERIC     Valve size
AND NUMERIC     Maximum BTO stroke open time
AND NUMERIC     Maximum BTC stroke close time
AND NUMERIC     Test case number
!
!
SHARED STRING  Valve ID
AND STRING     Valve P&ID
AND STRING     P&ID coord
AND STRING     Valve category
AND STRING     Valve type
AND STRING     Valve actuator type
AND STRING     Normal position of valve
AND STRING     PIT frequency
AND STRING     BTC frequency
AND STRING     BTO frequency
AND STRING     AT5 frequency
AND STRING     AT1 frequency
AND STRING     CTCC frequency
AND STRING     Maximum AT5 leakage
AND STRING     Maximum AT1 leakage
AND STRING     AT1 relief request
AND STRING     CTCC relief request
AND STRING     Batch test case file
!
```

```
!
SHARED OBJECT  Major task IS valve maintenance planning
AND OBJECT     Major task IS valve diagnosis
AND OBJECT     Major task IS diagnosis and planning
AND OBJECT     Major task IS valve data base editing
AND OBJECT     Major task IS batch testing
AND OBJECT     Major task IS Leave knowledge base
!
AND OBJECT     Affected system for maintenance IS valve body
AND OBJECT     Affected system for maintenance IS valve operator
AND OBJECT     Affected system for maintenance IS motor control center
!
AND OBJECT     valve body maintenance IS valve replaced
AND OBJECT     valve body maintenance IS valve disassembled
AND OBJECT     valve body maintenance IS packing adjusted
AND OBJECT     valve body maintenance IS repacking performed
AND OBJECT     valve body maintenance IS replaced body to bonnet gasket
AND OBJECT     valve body maintenance IS maintained seating surface
AND OBJECT     valve body maintenance IS valve stem maintenance
!
AND OBJECT     valve operator maintenance IS operator replaced
AND OBJECT     valve operator maintenance IS motor replaced
AND OBJECT     valve operator maintenance IS torque switch maintained
AND OBJECT     valve operator maintenance IS limit switch maintained
AND OBJECT     valve operator maintenance IS spring pack reworked
AND OBJECT     valve operator maintenance IS torque bypass switch maintained
AND OBJECT     valve operator maintenance IS operator lubricated
AND OBJECT     valve operator maintenance IS electrical wire maintenance
AND OBJECT     valve operator maintenance IS replaced sealtite
AND OBJECT     valve operator maintenance IS handwheel maintenance
!
AND OBJECT     motor control center maintenance IS breaker maintained
AND OBJECT     motor control center maintenance IS handswitch replaced
AND OBJECT     motor control center maintenance IS power cable replaced
!
AND OBJECT     Run mode IS normal
AND OBJECT     Run mode IS batch test
!
AND OBJECT     Print item IS Nothing
AND OBJECT     Print item IS Valve maintenance planning results
AND OBJECT     Print item IS Line of reasoning report
!
AND OBJECT     Batch test task IS run batch test cases
AND OBJECT     Batch test task IS batch test result comparison
AND OBJECT     Batch test task IS display batch test results
AND OBJECT     Batch test task IS Leave batch testing knowledge base
!
```

X. APPENDIX B - TURBO PASCAL SOURCE LISTINGS

IEACCDB1.PAS

```
Program IE_Acc_Db1;

type

  s255 = string[255];
  s40 = string[40];
  s20 = string[20];
  s10 = string[10];
  s5 = string[5];
  s4 = string[4];
  s3 = string[3];
  valv_dat = record
               valve_ID : s10;
               P_ID_coor : s4;
               IST_class : s3;
               valve_cat : s5;
               valve_size : s5;
               valve_type : s5;
               actuator_type : s5;
               normal_position : s5;
               PIT_required : boolean;
               BTC_required : boolean;
               BTO_required : boolean;
               AT5_required : boolean;
               AT1_required : boolean;
               CTCC_required : boolean;
               PIT_freq : s3;
               BTC_freq : s3;
               BTO_freq : s3;
               AT5_freq : s3;
               AT1_freq : s3;
               CTCC_freq : s3;
               max_BTO_time : s3;
               max_BTC_time : s3;
               max_AT5_leakage : s3;
               max_AT1_leakage : s3;
               AT1_relief : s5;
               CTCC_relief : s5;
             end;

  new_valv_dat = record
               valve_ID : s10;
               P_ID : s5;
```

```
    P_ID_coor : s4;
    IST_class : s3;
    valve_cat : s5;
    valve_size : s5;
    valve_type : s5;
    actuator_type : s5;
    normal_position : s5;
    PIT_required : boolean;
    BTC_required : boolean;
    BTO_required : boolean;
    AT5_required : boolean;
    AT1_required : boolean;
    CTCC_required : boolean;
    PIT_freq : s3;
    BTC_freq : s3;
    BTO_freq : s3;
    AT5_freq : s3;
    AT1_freq : s3;
    CTCC_freq : s3;
    max_BTO_time : s3;
    max_BTC_time : s3;
    max_AT5_leakage : s3;
    max_AT1_leakage : s3;
    AT1_relief : s5;
    CTCC_relief : s5;
    Valve_Mfg : s20;
    Valve_Model : s10;
    Valve_Serial : s10;
    Valve_Dwg_Mfg : s10;
    Valve_Dwg_Plant : s10;
    Valve_Packing_Size : s5;
    Valve_Gasket_Size : s5;
    Oper_Mfg : s20;
    Oper_Model : s10;
    Oper_Serial : s10;
    Oper_Dwg_Mfg : s10;
    Oper_Dwg_Plant : s10;
    Oper_Schem_Mfg : s10;
    Oper_Schem_Plant : s10;
    Torque_Switch_Setting : s5;
    Limit_Switch_Setting : s5;
    ISI : boolean;
    Eq : boolean;
    Heavy_Load : boolean;
    Rwp_Int : boolean;
    Rwp_Ext : boolean;
    Nprds : boolean;
  end;

var
```

```
  valv_data_file : file of new_valv_dat;
  valv_rec : new_valv_dat;
  b_PIT_required,b_BTC_required,b_BTO_required,b_AT5_required,
  b_AT1_required,b_CTCC_required,found : boolean;
  dum1 : char;
  retrieve_ID,s_P_ID : s255;
  s_P_ID_coor,s_valve_cat,s_valve_type,s_actuator_type,s_normal_position,
  s_PIT_freq,s_BTC_freq,s_BTO_freq,s_AT5_freq,s_AT1_freq,s_CTCC_freq,
  s_max_AT5_leakage,s_max_AT1_leakage,s_AT1_relief,s_CTCC_relief : s255;
  Param_File : s40;
  i_IST_class,i_valve_size,i_max_BTO_time,
  i_max_BTC_time,code : integer;

{$I ASCIIPRM.PAS}


procedure input;

begin { procedure input }

  Param_File := 'ieparam.dat';
  Open_Param_File (Param_File);
  Read_String (retrieve_ID);

end;  { procedure input }


procedure output;

begin { procedure output }

  Reset_Param_File (27);
  Write_Boolean (found);
  Write_String  (s_P_ID);
  Write_String  (s_P_ID_coor);
  Write_Integer (i_IST_class);
  Write_String  (s_valve_cat);
  Write_Integer (i_valve_size);
  Write_String  (s_valve_type);
  Write_String  (s_actuator_type);
  Write_String  (s_normal_position);
  Write_Boolean (b_PIT_required);
  Write_Boolean (b_BTC_required);
  Write_Boolean (b_BTO_required);
  Write_Boolean (b_AT5_required);
  Write_Boolean (b_AT1_required);
  Write_Boolean (b_CTCC_required);
  Write_String  (s_PIT_freq);
  Write_String  (s_BTC_freq);
```

```
  Write_String  (s_BTO_freq);
  Write_String  (s_AT5_freq);
  Write_String  (s_AT1_freq);
  Write_String  (s_CTCC_freq);
  Write_Integer (i_max_BTO_time);
  Write_Integer (i_max_BTC_time);
  Write_String  (s_max_AT5_leakage);
  Write_String  (s_max_AT1_leakage);
  Write_String  (s_AT1_relief);
  Write_String  (s_CTCC_relief);
  Close_Param_File;

end;  { procedure output }



begin { main program }

  Input;
  assign (valv_data_file,'ievalves.dbl');
  reset (valv_data_file);
  with valv_rec do
  begin { with valv_rec }

    found := false;
    while (not eof (valv_data_file)) and (not found) do
    begin { while not eof }

      read (valv_data_file,valv_rec);
      if retrieve_ID = valve_ID then found := true;

    end;  { while not eof }
    if not found then begin

      clrscr;
      writeln ('Valve ',retrieve_ID,' not found in data base');
      writeln;

    end
    else begin { if found }

      clrscr;
      writeln ('Record number of retrieved valve = ',
               filepos(valv_data_file));
      writeln;
      s_P_ID := P_ID;
      s_P_ID_coor := P_ID_coor;
      val(IST_class,i_IST_class,code);
      s_valve_cat := valve_cat;
      val(valve_size,i_valve_size,code);
```

```
        s_valve_type := valve_type;
        s_actuator_type := actuator_type;
        s_normal_position := normal_position;
        b_PIT_required := PIT_required;
        b_BTC_required := BTC_required;
        b_BTO_required := BTO_required;
        b_AT5_required := AT5_required;
        b_AT1_required := AT1_required;
        b_CTCC_required := CTCC_required;
        s_PIT_freq := PIT_freq;
        s_BTC_freq := BTC_freq;
        s_BTO_freq := BTO_freq;
        s_AT5_freq := AT5_freq;
        s_AT1_freq := AT1_freq;
        s_CTCC_freq := CTCC_freq;
        val(max_BTO_time,i_max_BTO_time,code);
        val(max_BTC_time,i_max_BTC_time,code);
        s_max_AT5_leakage := max_AT5_leakage;
        s_max_AT1_leakage := max_AT1_leakage;
        s_AT1_relief := AT1_relief;
        s_CTCC_relief := CTCC_relief;

      end;        { if found }

    end;  { with valve_rec }
    close (valv_data_file);
    Output;

end.  { main program }
```

IEEDITDB.PAS

```
Program Edit_DB1;

type

  s30 = string[30];
  s20 = string[20];
  s10 = string[10];
  s5 = string[5];
  s4 = string[4];
  s3 = string[3];
  valv_dat = record
               valve_ID : s10;
               P_ID_coor : s4;
               IST_class : s3;
               valve_cat : s5;
               valve_size : s5;
               valve_type : s5;
               actuator_type : s5;
               normal_position : s5;
               PIT_required : boolean;
               BTC_required : boolean;
               BTO_required : boolean;
               AT5_required : boolean;
               AT1_required : boolean;
               CTCC_required : boolean;
               PIT_freq : s3;
               BTC_freq : s3;
               BTO_freq : s3;
               AT5_freq : s3;
               AT1_freq : s3;
               CTCC_freq : s3;
               max_BTO_time : s3;
               max_BTC_time : s3;
               max_AT5_leakage : s3;
               max_AT1_leakage : s3;
               AT1_relief : s5;
               CTCC_relief : s5;
             end;

  new_valv_dat = record
               valve_ID : s10;
               P_ID : s5;
               P_ID_coor : s4;
               IST_class : s3;
               valve_cat : s5;
               valve_size : s5;
```

```
                valve_type : s5;
                actuator_type : s5;
                normal_position : s5;
                PIT_required : boolean;
                BTC_required : boolean;
                BTO_required : boolean;
                AT5_required : boolean;
                AT1_required : boolean;
                CTCC_required : boolean;
                PIT_freq : s3;
                BTC_freq : s3;
                BTO_freq : s3;
                AT5_freq : s3;
                AT1_freq : s3;
                CTCC_freq : s3;
                max_BTO_time : s3;
                max_BTC_time : s3;
                max_AT5_leakage : s3;
                max_AT1_leakage : s3;
                AT1_relief : s5;
                CTCC_relief : s5;
                Valve_Mfg : s20;
                Valve_Model : s10;
                Valve_Serial : s10;
                Valve_Dwg_Mfg : s10;
                Valve_Dwg_Plant : s10;
                Valve_Packing_Size : s5;
                Valve_Gasket_Size : s5;
                Oper_Mfg : s20;
                Oper_Model : s10;
                Oper_Serial : s10;
                Oper_Dwg_Mfg : s10;
                Oper_Dwg_Plant : s10;
                Oper_Schem_Mfg : s10;
                Oper_Schem_Plant : s10;
                Torque_Switch_Setting : s5;
                Limit_Switch_Setting : s5;
                ISI : boolean;
                Eq : boolean;
                Heavy_Load : boolean;
                Rwp_Int : boolean;
                Rwp_Ext : boolean;
                Nprds : boolean;
              end;

var

  main_option : integer;
```

```
label

  main_menu, Quit;


procedure add_rec;

var

  valv_rec : valv_dat;
  valv_data_file : file of valv_dat;
  add_another : boolean;
  add_flag,PIT_flag,BTC_flag,BTO_flag,AT5_flag,AT1_flag,CTCC_flag : char;
  file_name,default_file_name,temp_file_name : s30;

begin { procedure add_rec }

  clrscr;
  default_file_name := 'IEVALVES.DB1';
  write ('Enter data base file name (def - ',default_file_name,') : ');
  readln (temp_file_name);writeln;
  if temp_file_name = '' then file_name := default_file_name
  else file_name := temp_file_name;
  assign (valv_data_file,file_name);
  reset (valv_data_file);
  seek (valv_data_file, filesize (valv_data_file));
  clrscr;
  with valv_rec do
  begin { with valv_rec }

    add_another := true;
    while add_another do
    begin { while add_another }

      valve_ID := '';
      P_ID_coor := '';
      IST_class := '';
      valve_cat := '';
      valve_size := '';
      valve_type := '';
      actuator_type := '';
      normal_position := '';
      PIT_required := FALSE;
      BTC_required := FALSE;
      BTO_required := FALSE;
      AT5_required := FALSE;
      AT1_required := FALSE;
      CTCC_required := FALSE;
      PIT_freq := '';
      BTC_freq := '';
```

```
BTO_freq := '';
AT5_FREQ := '';
AT1_freq := '';
CTCC_freq := '';
max_BTO_time := '';
max_BTC_time := '';
max_AT5_leakage := '';
max_AT1_leakage := '';
AT1_relief := '';
CTCC_relief := '';
PIT_flag := ' ';
BTC_flag := ' ';
BTO_flag := ' ';
AT5_flag := ' ';
AT1_flag := ' ';
CTCC_flag := ' ';
write ('Enter ID # of valve to be added   : ');readln (valve_ID);
write ('Enter valve P & ID coordinates    : ');readln (P_ID_coor);
write ('Enter valve IST class             : ');readln (IST_class);
write ('Enter valve catagory              : ');readln (valve_cat);
write ('Enter valve size                  : ');readln (valve_size);
write ('Enter valve type                  : ');readln (valve_type);
write ('Enter valve actuator type         : ');readln (actuator_type);
write ('Enter normal position of valve    : ');readln (normal_position);

write ('Is a PIT test applicable (Y/N)?   : ');readln (PIT_flag);
if (PIT_flag = 'y') or (PIT_flag = 'Y') then PIT_required := true
else PIT_required := false;

write ('Is a BTC test applicable (Y/N)?   : ');readln (BTC_flag);
if (BTC_flag = 'y') or (BTC_flag = 'Y') then BTC_required := true
else BTC_required := false;

write ('Is a BTO test applicable (Y/N)?   : ');readln (BTO_flag);
if (BTO_flag = 'y') or (BTO_flag = 'Y') then BTO_required := true
else BTO_required := false;

write ('Is a AT-5 test applicable (Y/N)?  : ');readln (AT5_flag);
if (AT5_flag = 'y') or (AT5_flag = 'Y') then AT5_required := true
else AT5_required := false;

write ('Is a AT-1 test applicable (Y/N)?  : ');readln (AT1_flag);
if (AT1_flag = 'y') or (AT1_flag = 'Y') then AT1_required := true
else AT1_required := false;

write ('Is a CT-CC test applicable (Y/N)? : ');readln (CTCC_flag);
if (CTCC_flag = 'y') or (CTCC_flag = 'Y') then CTCC_required := true
else CTCC_required := false;

if PIT_required then begin
```

```
  write ('Enter PIT frequency                : ');readln (PIT_freq);
end;

if BTC_required then begin
  write ('Enter BTC frequency                : ');readln (BTC_freq);
end;

if BTO_required then begin
  write ('Enter BTO frequency                : ');readln (BTO_freq);
end;

if AT5_required then begin
  write ('Enter AT-5 frequency               : ');readln (AT5_freq);
end;

if AT1_required then begin
  write ('Enter AT-1 frequency               : ');readln (AT1_freq);
end;

if CTCC_required then begin
  write ('Enter CTCC frequency               : ');readln (CTCC_freq);
end;

if BTC_required then begin
  write ('Is there a maximum BTC stroke close time (Y/N)? : ');
  readln (BTC_flag);
  if (BTC_flag = 'y') or (BTC_flag = 'Y') then begin
    write ('Enter maximum BTC stroke close time (sec)       : ');
    readln (max_BTC_time);
  end;
end;

if BTO_required then begin
  write ('Is there a maximum BTO stroke open time (Y/N)? : ');
  readln (BTO_flag);
  if (BTO_flag = 'y') or (BTO_flag = 'Y') then begin
    write ('Enter maximum BTO stroke close time (sec)      : ');
    readln (max_BTO_time);
  end;
end;

if AT5_required then begin
  write ('Is there a maximum AT-5 leakage (Y/N)? : ');
  readln (AT5_flag);
  if (AT5_flag = 'y') or (AT5_flag = 'Y') then begin
    write ('Enter maximum AT-5 leakage             : ');
    readln (max_AT5_leakage);
  end;
end;
```

```
      if AT1_required then begin
        write ('Is there a maximum AT-1 leakage (Y/N)? : ');
        readln (AT1_flag);
        if (AT1_flag = 'y') or (AT1_flag = 'Y') then begin
          write ('Enter maximum AT-1 leakage            : ');
          readln (max_AT1_leakage);
        end;
      end;

      if AT1_required then begin
        write ('Is there an AT-1 relief request (Y/N)? : ');
        readln (AT1_flag);
        if (AT1_flag = 'y') or (AT1_flag = 'Y') then begin
          write ('Enter AT-1 relief request #           : ');
          readln (AT1_relief);
        end;
      end;

      if CTCC_required then begin
        write ('Is there a CT-CC relief request (Y/N)? : ');
        readln (CTCC_flag);
        if (CTCC_flag = 'y') or (CTCC_flag = 'Y') then begin
          write ('Enter CT_CC relief request #          : ');
          readln (CTCC_relief);
        end;
      end;

      write (valv_data_file,valv_rec);writeln;

      write ('Do you want to add another record to data base (Y/N)? : ');
      readln (add_flag);
      if (add_flag = 'N') or (add_flag = 'n') then add_another := false;
      if add_another then clrscr;

    end;  { while add_another }

  end;  { with valv_rec }
  close (valv_data_file);

end;  { procedure add_rec }


procedure list_db;

var

  valv_rec : new_valv_dat;
  valv_data_file : file of new_valv_dat;
  i,n,lines,page,current_rec,first_rec,last_rec,
  default_first_rec,default_last_rec,code : integer;
```

```
  dum1,FF,ESC,VT,NUL,SI,DC2 : char;
  hard_copy : boolean;
  temp_first_rec,temp_last_rec : s4;
  test,relief : array [1..6] of s5;
  freq,stroke,leakage : array [1..6] of s3;
  file_name,default_file_name,temp_file_name : s30;

label

  Quit;

procedure printer_heading;

var

  i : integer;


begin { procedure printer_heading }

  writeln (lst,'                                                    ',
               '                                    MAXIMUM');
  writeln (lst,'  RECORD    VALVE    P&ID   IST  VALVE VALVE  VALVE',
               '   ACTUATOR  NORMAL          TEST  STROKE ',
               '   MAXIMUM   RELIEF');
  writeln (lst,'  NUMBER    NUMBER   COOR  CLASS  CAT   SIZE   TYPE',
               '     TYPE   POSITION  TEST   FREQ   TIME  ',
               '   LEAKAGE   REQUEST   REMARKS');
  writeln (lst,'  ------  --------  ------ ----- ----- -----  -----',
               '   -------- -------- ------  ----  -------',
               '   -------   -------   -------');
  for i := 1 to 3 do writeln (lst);
  lines := lines+7;
end;  { procedure printer_heading }


begin { procedure list_db }

  clrscr;
  default_file_name := 'IEVALVES.DB1';
  write ('Enter data base file name (def - ',default_file_name,') : ');
  readln (temp_file_name);writeln;
  if temp_file_name = '' then file_name := default_file_name
  else file_name := temp_file_name;
  assign (valv_data_file,file_name);
  reset (valv_data_file);
  writeln ('FileSize = ',filesize(valv_data_file),' records');
  writeln;
  default_first_rec := 1;
  default_last_rec := filesize(valv_data_file);
```

```
repeat begin  { repeat }

  write ('Enter first record to list (default - Beg.) : ');
  readln (temp_first_rec);
  if temp_first_rec = '' then first_rec := default_first_rec
  else val(temp_first_rec,first_rec,code);
  write ('Enter last record to list (default - End)   : ');
  readln (temp_last_rec);writeln;
  if temp_last_rec = '' then last_rec := default_last_rec
  else val(temp_last_rec,last_rec,code);

end;          { repeat }
until (first_rec <= last_rec) and (first_rec > 0) and
(last_rec <= filesize(valv_data_file));

first_rec := first_rec-1;
last_rec := last_rec-1;
hard_copy := FALSE;
write ('Do you want a hard copy of the listing (Y/N)? ');
readln (dum1);
if (dum1='y') or (dum1='Y') then hard_copy := TRUE;
clrscr;
with valv_rec do
begin { with valv_rec }

  writeln ('         VALVE    P&ID   IST  VALVE VALVE  VALVE   ACTUATOR',
           '  NORMAL');
  writeln ('         NUMBER         CLASS  CAT   SIZE   TYPE     TYPE  ',
           ' POSITION');
  writeln ('       --------  ------ ----- ----- -----  -----   --------',
           ' --------');writeln;writeln;
  if hard_copy then begin
    FF := chr(12);
    ESC := chr(27);
    VT := chr(11);
    NUL := chr(0);
    SI := chr(15);
    DC2 := chr(18);
    lines := 0;
    page := 1;
    write (lst,SI);
    write (lst,ESC,'0');
    write (lst,ESC,'BJ',NUL);
    printer_heading;
  end;
  seek (valv_data_file,first_rec);
  current_rec := first_rec;
  while current_rec <= last_rec do
  begin { while current_rec }
```

```
read (valv_data_file,valv_rec);
current_rec := current_rec+1;
writeln (valve_ID:15,P_ID:8,IST_class:4,valve_cat:6,
         valve_size:7,valve_type:7,actuator_type:10,
         normal_position:9);
if hard_copy then
begin { if hard_copy }

  i := 0;

  if PIT_required then begin
    i := i+1;
    test[i] := 'PIT';
    freq[i] := PIT_freq;
    stroke[i] := '';
    leakage[i] := '';
    relief[i] := '';
  end;

  if BTC_required then begin
    i := i+1;
    test[i] := 'BTC';
    freq[i] := BTC_freq;
    stroke[i] := max_BTC_time;
    leakage[i] := '';
    relief[i] := '';
  end;

  if BTO_required then begin
    i := i+1;
    test[i] := 'BTO';
    freq[i] := BTO_freq;
    stroke[i] := max_BTO_time;
    leakage[i] := '';
    relief[i] := '';
  end;

  if AT5_required then begin
    i := i+1;
    test[i] := 'AT-5';
    freq[i] := AT5_freq;
    stroke[i] := '';
    leakage[i] := max_AT5_leakage;
    relief[i] := '';
  end;

  if AT1_required then begin
    i := i+1;
    test[i] := 'AT-1';
    freq[i] := AT1_freq;
```

```
      stroke[i] := '';
      leakage[i] := max_AT1_leakage;
      relief[i] := AT1_relief;
    end;

    if CTCC_required then begin
      i := i+1;
      test[i] := 'CT-CC';
      freq[i] := CTCC_freq;
      stroke[i] := '';
      leakage[i] := '';
      relief[i] := CTCC_relief;
    end;

    n := i;

    writeln (lst,current_rec:6,valve_ID:12,P_ID:8,IST_class:4,
                 valve_cat:6,valve_size:7,valve_type:7,actuator_type:10,
                 normal_position:9,test[1]:8,freq[1]:6,stroke[1]:8,
                 leakage[1]:10,relief[1]:11);
    for i := 2 to n do begin

      if i = 2 then
        writeln (lst,P_ID_coor:25,test[i]:52,freq[i]:6,stroke[i]:8,
                     leakage[i]:10,relief[i]:11)
      else
        writeln (lst,test[i]:77,freq[i]:6,stroke[i]:8,leakage[i]:10,
                     relief[i]:11);

    end;
    writeln (lst,'  ------------------------------------------',
                 '----------------------------------------',
                 '--------------------------------');

    lines := lines + n + 1;
    if lines >= 66 then begin
      write (lst,VT);
      writeln (lst,'     Valve Data Base Listing       Page ',page);
      write (lst,FF);
      lines := 0;
      printer_heading;
      page := page + 1;
    end;

  end;  { if hard_copy }
  writeln ('     ------------------------------------------------',
           '-------------');

end;  { while current_rec }
if hard_copy then begin
```

```
      write (lst,VT);
      writeln (lst,'     Valve Data Base Listing       Page ',page);
      write (lst,FF);
      write (lst,DC2);
      write (lst,ESC,'2');
    end;

  end;  { with valv_rec }
  close (valv_data_file);writeln;
  write ('Strike "ENTER" to return to Main Menu');readln (dum1);
  clrscr;

Quit:

end;  { procedure list_db }


procedure edit_rec;

label

  top;

var

  valv_rec : valv_dat;
  valv_data_file : file of valv_dat;
  edit_ID,temp : string[10];
  found : boolean;
  edit_another,PIT_flag,BTC_flag,BTO_flag,AT5_flag,AT1_flag,CTCC_flag : char;
  file_name,default_file_name,temp_file_name : s30;

begin { procedure edit_rec }

  clrscr;
  default_file_name := 'IEVALVES.DB1';
  write ('Enter data base file name (def - ',default_file_name,') : ');
  readln (temp_file_name);writeln;
  if temp_file_name = '' then file_name := default_file_name
  else file_name := temp_file_name;
  top:
  assign (valv_data_file,file_name);
  reset (valv_data_file);
  write ('Enter valve ID # of record to edit : ');readln (edit_ID);
  with valv_rec do
  begin { with valv_rec }

    found := false;
    while (not eof (valv_data_file)) and (not found) do
    begin { while not eof }
```

```
  read (valv_data_file,valv_rec);
  if edit_ID = valve_ID then found := true;

end;  { while not eof }
writeln;

if not found then writeln ('Valve ',edit_ID,' not found in data base')
else begin { if found }

  writeln ('Record number of record to edit = ',
           filepos (valv_data_file));
  writeln;
  writeln ('The default value for each field is shown in');
  writeln ('parenthesis.  To keep this value, just press "ENTER"');
  writeln;

  temp := '';
  write ('Enter ID # of valve (',valve_ID,') : ');
  readln (temp);
  if temp <> '' then valve_ID := temp;

  temp := '';
  write ('Enter valve P & ID coordinates (',P_ID_coor,') : ');
  readln (temp);
  if temp <> '' then P_ID_coor := temp;

  temp := '';
  write ('Enter valve IST class (',IST_class,') : ');
  readln (temp);
  if temp <> '' then IST_class := temp;

  temp := '';
  write ('Enter valve catagory (',valve_cat,') : ');
  readln (temp);
  if temp <> '' then valve_cat := temp;

  temp := '';
  write ('Enter valve size (',valve_size,') : ');
  readln (temp);
  if temp <> '' then valve_size := temp;

  temp := '';
  write ('Enter valve type (',valve_type,') : ');
  readln (temp);
  if temp <> '' then valve_type := temp;

  temp := '';
  write ('Enter valve actuator type (',actuator_type,') : ');
  readln (temp);
```

```
if temp <> '' then actuator_type := temp;

temp := '';
write ('Enter normal position of valve (',normal_position,') : ');
readln (temp);
if temp <> '' then normal_position := temp;

temp := '';
if PIT_required then PIT_flag := 'Y' else PIT_flag := 'N';
write ('Is a PIT test applicable (Y/N)? (',PIT_flag,') : ');
readln (temp);
if temp <> '' then PIT_flag := temp;
if (PIT_flag = 'y') or (PIT_flag = 'Y') then PIT_required := true
else PIT_required := false;

temp := '';
if BTC_required then BTC_flag := 'Y' else BTC_flag := 'N';
write ('Is a BTC test applicable (Y/N)? (',BTC_flag,') : ');
readln (temp);
if temp <> '' then BTC_flag := temp;
if (BTC_flag = 'y') or (BTC_flag = 'Y') then BTC_required := true
else BTC_required := false;

temp := '';
if BTO_required then BTO_flag := 'Y' else BTO_flag := 'N';
write ('Is a BTO test applicable (Y/N)? (',BTO_flag,') : ');
readln (temp);
if temp <> '' then BTO_flag := temp;
if (BTO_flag = 'y') or (BTO_flag = 'Y') then BTO_required := true
else BTO_required := false;

temp := '';
if AT5_required then AT5_flag := 'Y' else AT5_flag := 'N';
write ('Is a AT5 test applicable (Y/N)? (',AT5_flag,') : ');
readln (temp);
if temp <> '' then AT5_flag := temp;
if (AT5_flag = 'y') or (AT5_flag = 'Y') then AT5_required := true
else AT5_required := false;

temp := '';
if AT1_required then AT1_flag := 'Y' else AT1_flag := 'N';
write ('Is a AT1 test applicable (Y/N)? (',AT1_flag,') : ');
readln (temp);
if temp <> '' then AT1_flag := temp;
if (AT1_flag = 'y') or (AT1_flag = 'Y') then AT1_required := true
else AT1_required := false;

temp := '';
if CTCC_required then CTCC_flag := 'Y' else CTCC_flag := 'N';
write ('Is a CTCC test applicable (Y/N)? (',CTCC_flag,') : ');
```

```
readln (temp);
if temp <> '' then CTCC_flag := temp;
if (CTCC_flag = 'y') or (CTCC_flag = 'Y') then CTCC_required := true
else CTCC_required := false;

temp := '';
if PIT_required then begin
  write ('Enter PIT frequency (',PIT_freq,') : ');
  readln (temp);
  if temp <> '' then PIT_freq := temp;end
else PIT_freq := '';

temp := '';
if BTC_required then begin
  write ('Enter BTC frequency (',BTC_freq,') : ');
  readln (temp);
  if temp <> '' then BTC_freq := temp;end
else BTC_freq := '';

temp := '';
if BTO_required then begin
  write ('Enter BTO frequency (',BTO_freq,') : ');
  readln (temp);
  if temp <> '' then BTO_freq := temp;end
else BTO_freq := '';

temp := '';
if AT5_required then begin
  write ('Enter AT5 frequency (',AT5_freq,') : ');
  readln (temp);
  if temp <> '' then AT5_freq := temp;end
else AT5_freq := '';

temp := '';
if AT1_required then begin
  write ('Enter AT1 frequency (',AT1_freq,') : ');
  readln (temp);
  if temp <> '' then AT1_freq := temp;end
else AT1_freq := '';

temp := '';
if CTCC_required then begin
  write ('Enter CTCC frequency (',CTCC_freq,') : ');
  readln (temp);
  if temp <> '' then CTCC_freq := temp;end
else CTCC_freq := '';

temp := '';
if BTC_required then begin
  write ('Enter maximum BTC stroke close time (',max_BTC_time,') : ');
```

```
      readln (temp);
      if temp <> '' then max_BTC_time := temp;end
    else max_BTC_time := '';

    temp := '';
    if BTO_required then begin
      write ('Enter maximum BTO stroke open time (',max_BTO_time,') : ');
      readln (temp);
      if temp <> '' then max_BTO_time := temp;end
    else max_BTO_time := '';

    temp := '';
    if AT5_required then begin
      write ('Enter maximum AT-5 leakage (',max_AT5_leakage,') : ');
      readln (temp);
      if temp <> '' then max_AT5_leakage := temp;end
    else max_AT5_leakage := '';

    temp := '';
    if AT1_required then begin
      write ('Enter maximum AT-1 leakage (',max_AT1_leakage,') : ');
      readln (temp);
      if temp <> '' then max_AT1_leakage := temp;
      temp := '';
      write ('Enter AT-1 relief request # (',AT1_relief,') : ');
      readln (temp);
      if temp <> '' then AT1_relief := temp;end
    else begin max_AT1_leakage := '';AT1_relief := '';end;

    temp := '';
    if CTCC_required then begin
      write ('Enter CT-CC relief request # (',CTCC_relief,') : ');
      readln (temp);
      if temp <> '' then CTCC_relief := temp;end
    else CTCC_relief := '';

    seek (valv_data_file,filepos(valv_data_file)-1);
    write (valv_data_file,valv_rec);
    close (valv_data_file);writeln;

  end;  { if found }

end;  { with valv_rec }
write ('Do you want to edit another data base record (Y/N)? : ');
readln (edit_another);
if (edit_another = 'y') or (edit_another = 'Y') then begin
  clrscr;
  goto top;
end;
```

```
end;  { procedure edit_rec }


procedure open_fil;

var

  file_open : file of valv_dat;
  file_name : string[20];
  dum1 : char;


begin { procedure open_fil }

  clrscr;
  write ('Enter file name of file to open (may contain path) : ');
  readln (file_name);writeln;
  assign (file_open,file_name);
  rewrite (file_open);
  close (file_open);
  writeln ('File "',file_name,'" has been created');
  writeln ('and is ready for editing');writeln;
  write ('Strike "ENTER" to return to main menu');
  readln (dum1);
  clrscr;

end;


procedure sort_dbase;

var

  first_rec,last_rec,default_first_rec,default_last_rec,code : integer;
  valv_rec : valv_dat;
  valv_data_file : file of valv_dat;
  dum1 : char;
  temp_first_rec,temp_last_rec : s4;
  file_name,default_file_name,temp_file_name : s30;


procedure quicksrt (first_rec,last_rec : integer);


procedure quick (lb,ub : integer);

var

j : integer;
```

```
procedure rearrange (lb,ub : integer; var j : integer);

var

  up,down : integer;
  a,x_up,x_down : sl0;


function x (pos : integer) : sl0;

begin { function x }

  seek (valv_data_file,pos);
  read (valv_data_file,valv_rec);
  x := valv_rec.valve_ID;

end;  { function x }

procedure switch_records (pos1,pos2 : integer);

var

  temp_rec1,temp_rec2 : valv_dat;

begin { procedure switch_records }

  seek (valv_data_file,pos1);
  read (valv_data_file,temp_rec1);
  seek (valv_data_file,pos2);
  read (valv_data_file,temp_rec2);
  seek (valv_data_file,pos1);
  write (valv_data_file,temp_rec2);
  seek (valv_data_file,pos2);
  write (valv_data_file,temp_rec1);

end;  { procedure switch_records }


begin { procedure rearrange }

  a := x(lb);
  j := lb;
  up := ub;
  down := lb;
  repeat
    while (up > down) and (x(up) >= a)
      do up := up - 1;
    j := up;
    if up <> down then
```

```
    begin { if up }

      switch_records (down,up);
      while (down < up) and (x(down) <= a)
        do down := down + 1;
      j := down;
      if down <> up then
        switch_records (up,down);

    end;  { if up }
  until down = up;

end;  { procedure rearrange }


begin { procedure quick }

  if lb < ub then
  begin { if lb }

    rearrange (lb,ub,j);
    quick (lb,j-1);
    quick (j+1,ub);

  end;  { if lb }

end;  { procedure quick }

begin { procedure quicksrt }

  quick (first_rec,last_rec);

end;  { procedure quicksrt }

begin { procedure sort_dbase }

  clrscr;
  default_file_name := 'IEVALVES.DB1';
  write ('Enter data base file name (def - ',default_file_name,') : ');
  readln (temp_file_name);writeln;
  if temp_file_name = '' then file_name := default_file_name
  else file_name := temp_file_name;
  assign (valv_data_file,file_name);
  reset (valv_data_file);
  writeln ('FileSize = ',filesize(valv_data_file),' records');
  writeln;
  default_first_rec := 1;
  default_last_rec := filesize(valv_data_file);
  repeat begin  { repeat }
    write ('Enter first record to list (def - Beg.) : ');
```

```
    readln (temp_first_rec);
    if temp_first_rec = '' then first_rec := default_first_rec
    else val(temp_first_rec,first_rec,code);
    write ('Enter last record to list (def - End)   : ');
    readln (temp_last_rec);writeln;
    if temp_last_rec = '' then last_rec := default_last_rec
    else val(temp_last_rec,last_rec,code);
  end;          { repeat }
  until (first_rec <= last_rec) and (first_rec > 0) and
  (last_rec <= filesize(valv_data_file));
  first_rec := first_rec-1;
  last_rec := last_rec-1;
  writeln;
  write (file_name,' is being sorted on the valve ID # field ...');
  quicksrt (first_rec,last_rec);writeln;
  writeln ('Sort complete.');writeln;
  write ('Strike "ENTER" to return to main menu');
  readln (dum1);
  clrscr;
  close (valv_data_file);

end;  { procedure sort_dbase }


procedure rewrite_dbase;


var

  old_rec : valv_dat;
  new_rec : new_valv_dat;
  old_file : file of valv_dat;
  new_file : file of new_valv_dat;
  old_file_name,default_file_name,temp_file_name : s30;
  new_file_name : s20;
  rewrite_another : boolean;
  rewrite_option : char;

begin { procedure rewrite_dbase }

  clrscr;
  default_file_name := 'IEVALVES.DB1';
  write ('Enter old data base file name (def - ',default_file_name,') : ');
  readln (temp_file_name);writeln;
  if temp_file_name = '' then old_file_name := default_file_name
  else old_file_name := temp_file_name;
  write ('Enter new data base file name : ');
  readln (new_file_name);
  assign (old_file,old_file_name);
  reset (old_file);
```

```
assign (new_file,new_file_name);
rewrite (new_file);
clrscr;
with new_rec do
begin { with new_rec }

 rewrite_another := TRUE;
 while (not eof(old_file)) and (rewrite_another) do begin { while }

  read (old_file,old_rec);
  valve_ID := old_rec.valve_ID;
  write ('Enter P&ID for valve ',valve_ID,' : ');
  readln (P_ID);
  P_ID_coor := old_rec.P_ID_coor;
  IST_class := old_rec.IST_class;
  valve_cat := old_rec.valve_cat;
  valve_size := old_rec.valve_size;
  valve_type := old_rec.valve_type;
  actuator_type := old_rec.actuator_type;
  normal_position := old_rec.normal_position;
  PIT_required := old_rec.PIT_required;
  BTC_required := old_rec.BTC_required;
  BTO_required := old_rec.BTO_required;
  AT5_required := old_rec.AT5_required;
  AT1_required := old_rec.AT1_required;
  CTCC_required := old_rec.CTCC_required;
  PIT_freq := old_rec.PIT_freq;
  BTC_freq := old_rec.BTC_freq;
  BTO_freq := old_rec.BTO_freq;
  AT5_freq := old_rec.AT5_freq;
  AT1_freq := old_rec.AT1_freq;
  CTCC_freq := old_rec.CTCC_freq;
  max_BTO_time := old_rec.max_BTO_time;
  max_BTC_time := old_rec.max_BTC_time;
  max_AT5_leakage := old_rec.max_AT5_leakage;
  max_AT1_leakage := old_rec.max_AT1_leakage;
  AT1_relief := old_rec.AT1_relief;
  CTCC_relief := old_rec.CTCC_relief;
  Valve_Mfg := '';
  Valve_Model := '';
  Valve_Serial := '';
  Valve_Dwg_Mfg := '';
  Valve_Dwg_Plant := '';
  Valve_Packing_Size := '';
  Valve_Gasket_Size := '';
  Oper_Mfg := '';
  Oper_Model := '';
  Oper_Serial := '';
  Oper_Dwg_Mfg := '';
  Oper_Dwg_Plant := '';
```

```
    Oper_Schem_Mfg := '';
    Oper_Schem_Plant := '';
    Torque_Switch_Setting := '';
    Limit_Switch_Setting := '';
    ISI := FALSE;
    Eq := FALSE;
    Heavy_Load := FALSE;
    Rwp_Int := FALSE;
    Rwp_Ext := FALSE;
    Nprds := FALSE;
    write (new_file,new_rec);
    write ('Do you want to rewrite another record (Y/N)? ');
    readln (rewrite_option);
    if (rewrite_option <> 'Y') and (rewrite_option <> 'y') then
    rewrite_another := FALSE;

   end; { while }

  end;  { with new_rec }
  close (old_file);
  close (new_file);

end;  { procedure rewrite_dbase }


begin { main program }

  main_option := 0;
  clrscr;

  main_menu :

  writeln ('MAIN MENU FOR EDITING DATA BASE # 1');writeln;
  writeln ('1. List data base records');
  writeln ('2. Add records to data base');
  writeln ('3. Edit a data base record');
  writeln ('4. Open a new data base file');
  writeln ('5. Sort a data base file');
  writeln ('6. Write to new data base structure');
  writeln ('7. Quit');writeln;
  write   ('Choose an option by typing its number : ');
  readln (main_option);
  case main_option of { case main_option }

    1 : begin list_db; clrscr; goto main_menu; end;
    2 : begin add_rec; clrscr; goto main_menu; end;
    3 : begin edit_rec; clrscr; goto main_menu; end;
    4 : begin open_fil; clrscr; goto main_menu; end;
    5 : begin sort_dbase; clrscr; goto main_menu; end;
    6 : begin rewrite_dbase; clrscr; goto main_menu; end;
```

```
    7 : goto Quit;
    else
      begin
        clrscr;
        writeln ('Please enter an integer  1 - 7  from the menu');
        writeln;
        goto main_menu;
      end;

    end;                { case main_option }

  Quit :

end.  { main program }
```

IENFILE.PAS

```
Program IENFILE;

type

  s255 = string[255];
  s40 = string[40];
  s20 = string[20];
  s10 = string[10];
  s5 = string[5];
  s4 = string[4];
  s3 = string[3];

var

  tfile,tfile2 : text;
  Param_File,file_name,tname,part1,part2,part3 : s20;
  file_string : s255;
  OK : boolean;
  backupnum : integer;

{$I \pas\ASCIIPRM.PAS}

function Exist (filename : s20) : boolean;

var textfile : text;

begin { function Exist }

  assign (textfile,filename);
  {$I-} reset (textfile) {$I+};
  Exist := (IOresult = 0);

end;  { function Exist }


begin { main program }

  Param_File := 'IEPARAM.DAT';
  Open_Param_File (Param_File);
  Read_String (file_string);
  Close_Param_File;
  file_name := file_string;
  if Exist (file_name) then begin

    clrscr;
    writeln ('The documentation file ',file_name,' already exists',
```

```
            ' and will be renamed.');
    part1 := copy (file_name,1,6);
    part2 := '1';
    part3 := '.DOC';
    tname := part1 + part2 + part3;
    backupnum := 1;
    while ((Exist (tname)) and (backupnum <= 20)) do begin

      backupnum := backupnum + 1;
      str (backupnum,part2);
      tname := part1 + part2 + part3;

    end;  { while }
    if backupnum > 20 then begin

      tname := part1 + '1' + part3;

    end;  { if }
    assign (tfile,file_name);
    close (tfile);
    rename (tfile,tname);
    writeln;
    writeln;
    writeln ('The old ',file_name,' has been renamed : ',tname);
    delay (2000);
  end;  { if Exist }

end.  { main program }
```

IESTORE.PAS

```
Program IESTORE;

type

  s255 = string[255];
  s40 = string[40];
  s20 = string[20];
  s10 = string[10];
  s5 = string[5];
  s4 = string[4];
  s3 = string[3];
  case_dat = record
               case_number : integer;
               valve_ID : s10;
               BTC_required : boolean;
               BTO_required : boolean;
               PIT_required : boolean;
               AT1_required : boolean;
               AT5_required : boolean;
               CTCC_required : boolean;
               SYSPR_required : boolean;
               tagout_required : boolean;
               heavy_load_indicated : boolean;
               primary_containment_indicated : boolean;
             end;


var

  case_file : file of case_dat;
  case_rec : case_dat;
  Param_File,file_name : s20;
  s_valve_ID,file_string : s255;

{$I \pas\ASCIIPRM.PAS}

begin { main program }

  with case_rec do
  begin { with case_rec }

    Param_File := 'IEPARAM.DAT';
    Open_Param_File (Param_File);
    Read_String (file_string);
    Read_Integer (case_number);
```

```
    Read_String (s_valve_ID);
    Read_Boolean (BTC_required);
    Read_Boolean (BTO_required);
    Read_Boolean (PIT_required);
    Read_Boolean (AT1_required);
    Read_Boolean (AT5_required);
    Read_Boolean (CTCC_required);
    Read_Boolean (SYSPR_required);
    Read_Boolean (tagout_required);
    Read_Boolean (heavy_load_indicated);
    Read_Boolean (primary_containment_indicated);
    Close_Param_File;
    valve_ID := s_valve_ID;
    file_name := file_string;
    assign (case_file,file_name);
    if case_number = 1 then
      rewrite (case_file)
    else
      reset (case_file);
    seek (case_file,case_number-1);
    write (case_file,case_rec);
    close (case_file);

  end;  { with case_rec }

end.  { main program }
```

IECOMPAR.PAS

```
Program IECOMPAR;

type

  s255 = string[255];
  s40 = string[40];
  s20 = string[20];
  s10 = string[10];
  s5 = string[5];
  s4 = string[4];
  s3 = string[3];
  case_dat = record
               case_number : integer;
               valve_ID : s10;
               BTC_required : boolean;
               BTO_required : boolean;
               PIT_required : boolean;
               AT1_required : boolean;
               AT5_required : boolean;
               CTCC_required : boolean;
               SYSPR_required : boolean;
               tagout_required : boolean;
               heavy_load_indicated : boolean;
               primary_containment_indicated : boolean;
             end;

var

  first_case_file,second_case_file : file of case_dat;
  case_rec_1,case_rec_2 : case_dat;
  Param_File : s20;
  first_file_name,second_file_name : s255;
  dum1 : char;
  difference : boolean;

{$I \pas\ASCIIPRM.PAS}

procedure checkfile (Var filename : s255; filenumber : integer);

var  datfile : file of case_dat;
     OK : boolean;

begin { procedure openfile }

  repeat
```

```
    assign (datfile,filename);
    {$I-} reset (datfile) {$I+};
    OK := (IOresult = 0);
    if not OK then begin

      clrscr;
      writeln ('The file name (',filename,') entered for file',
               ' number ',filenumber,' does not exist.');
      writeln;
      write ('Enter the correct name for file number ',filenumber,
             ' : ');
      readln (filename);

    end;

  until OK;
  close (datfile);

end;  { procedure checkfile }


begin { main program }

  Param_File := 'IEPARAM.DAT';
  Open_Param_File (Param_File);
  Read_String (first_file_name);
  Read_String (second_file_name);
  Close_Param_File;
  checkfile (first_file_name,1);
  checkfile (second_file_name,2);
  assign (first_case_file,first_file_name);
  assign (second_case_file,second_file_name);
  reset (first_case_file);
  reset (second_case_file);
  difference := false;
  clrscr;
  while (not eof (first_case_file)) do
  begin { while not eof }

    read (first_case_file,case_rec_1);
    read (second_case_file,case_rec_2);
    writeln ('Test case number ',case_rec_1.case_number,
             '  Valve : ',case_rec_1.valve_ID);
    writeln;
    writeln;
    if case_rec_1.BTC_required <> case_rec_2.BTC_required then begin

      difference := true;
      writeln ('BTC test requirements differ.');
```

```
end;  { if }
if case_rec_1.BTO_required <> case_rec_2.BTO_required then begin

  difference := true;
  writeln ('BTO test requirements differ.');

end;  { if }
if case_rec_1.PIT_required <> case_rec_2.PIT_required then begin

  difference := true;
  writeln ('PIT test requirements differ.');

end;  { if }
if case_rec_1.AT1_required <> case_rec_2.AT1_required then begin

  difference := true;
  writeln ('AT1 test requirements differ.');

end;  { if }
if case_rec_1.AT5_required <> case_rec_2.AT5_required then begin

  difference := true;
  writeln ('AT5 test requirements differ.');

end;  { if }
if case_rec_1.CTCC_required <> case_rec_2.CTCC_required then begin

  difference := true;
  writeln ('CTCC test requirements differ.');

end;  { if }
if case_rec_1.SYSPR_required <> case_rec_2.SYSPR_required then begin

  difference := true;
  writeln ('SYSPR test requirements differ.');

end;  { if }
if case_rec_1.tagout_required <> case_rec_2.tagout_required then begin

  difference := true;
  writeln ('Tag out requirements differ.');

end;  { if }
if case_rec_1.heavy_load_indicated <> case_rec_2.heavy_load_indicated
then begin

  difference := true;
  writeln ('Heavy load requirements differ.');

end;  { if }
```

```
    if case_rec_1.primary_containment_indicated <>
    case_rec_2.primary_containment_indicated then begin

      difference := true;
      writeln ('Primary containment requirements differ.');

    end;  { if }
    if not difference then begin

      writeln;
      writeln;
      writeln ('No differences found in test case ',
      case_rec_1.case_number);

    end;  { if difference }

    difference := false;
    writeln;
    writeln;
    write ('Strike ENTER to continue . . . ');
    readln (dum1);
    clrscr;

  end;  { while not eof }
  close (first_case_file);
  close (second_case_file);

end.  { main program }
```

IEDISPLA.PAS

```
Program IEDISPLA;

type

  s255 = string[255];
  s40 = string[40];
  s20 = string[20];
  s10 = string[10];
  s5 = string[5];
  s4 = string[4];
  s3 = string[3];
  case_dat = record
               case_number : integer;
               valve_ID : s10;
               BTC_required : boolean;
               BTO_required : boolean;
               PIT_required : boolean;
               AT1_required : boolean;
               AT5_required : boolean;
               CTCC_required : boolean;
               SYSPR_required : boolean;
               tagout_required : boolean;
               heavy_load_indicated : boolean;
               primary_containment_indicated : boolean;
             end;


var

  case_file : file of case_dat;
  case_rec : case_dat;
  Param_File,file_name : s20;
  s_valve_ID,file_string : s255;
  dum1 : char;

{$I \pas\ASCIIPRM.PAS}

procedure checkfile (Var filename : s20);

var  datfile : file of case_dat;
     OK : boolean;

begin { procedure openfile }

  repeat
```

```
    assign (datfile,filename);
    {$I-} reset (datfile) {$I+};
    OK := (IOresult = 0);
    if not OK then begin

      clrscr;
      writeln ('The case file ',filename,' to display does not ',
               'exist');
      writeln;
      write ('Enter the correct name for this file : ');
      readln (filename);

    end;

  until OK;
  close (datfile);

end;  { procedure checkfile }


begin { main program }

  clrscr;
  with case_rec do
  begin { with case_rec }

    Param_File := 'IEPARAM.DAT';
    Open_Param_File (Param_File);
    Read_String (file_string);
    Close_Param_File;
    file_name := file_string;
    checkfile (file_name);
    assign (case_file,file_name);
    reset (case_file);
    clrscr;

    while not eof(case_file) do
    begin { while not eof }

      read (case_file,case_rec);
      writeln ('Test case number ',case_number,'  Valve : ',valve_ID);
      writeln;
      writeln;
      if BTC_required then begin

        writeln ('BTC test is required');

      end else begin
```

```
  writeln ('BTC test is not required');

end;  { if }
if BTO_required then begin

  writeln ('BTO test is required');

end else begin

  writeln ('BTO test is not required');

end;  { if }
if PIT_required then begin

  writeln ('PIT test is required');

end else begin

  writeln ('PIT test is not required');

end;  { if }
if AT1_required then begin

  writeln ('AT1 test is required');

end else begin

  writeln ('AT1 test is not required');

end;  { if }
if AT1_required then begin

  writeln ('AT1 test is required');

end else begin

  writeln ('AT1 test is not required');

end;  { if }
if AT5_required then begin

  writeln ('AT5 test is required');

end else begin

  writeln ('AT5 test is not required');

end;  { if }
if CTCC_required then begin
```

```
    writeln ('CTCC test is required');

  end else begin

    writeln ('CTCC test is not required');

  end;  { if }
  if SYSPR_required then begin

    writeln ('SYSPR test is required');

  end else begin

    writeln ('SYSPR test is not required');

  end;  { if }
  if tagout_required then begin

    writeln ('Tag out is required');

  end else begin

    writeln ('Tag out not required');

  end;  { if }
  if heavy_load_indicated then begin

    writeln ('Heavy load is indicated');

  end else begin

    writeln ('Heavy load is not indicated');

  end;  { if }
  if primary_containment_indicated then begin

    writeln ('Primary containment is indicated');

  end else begin

    writeln ('Primary containment is not indicated');

  end;  { if }
  writeln;
  writeln;
  write ('Strike ENTER to continue. . . ');
  readln (dum1);
  clrscr;

end;  { while not eof }
```

```
    close (case_file);
  end;  { with case_rec }
end.  { main program }
```

IESCREEN.PAS

```
program picture;

{$I \pas\ASCIIPRM.PAS } { INSIGHT 2+ PARAMETER PASSING INCLUDE FILE }

const
  pict_size = 16000;
type
  string80 = string[80];
var
  ch                : char;
  code, inp, option : integer;
  count             : integer;
  path              : string80;
  picture_file_name : string255;
  pict_file         : file;
  screen            : array [1..16384] of byte absolute    $B800:0000;
  screen1           : array [1..4096]  of integer absolute $B800:0000;
  screen2           : array [1..4096]  of integer absolute $BA00:0000;
  screen1b          : array [1..8192]  of byte absolute $B800:000;
  screen2b          : array [1..8192]  of byte absolute $BA00:000;
  blk               : array [1..32767] of byte;
  iblk              : array [1..16384] of integer absolute blk;

{
*************************************************************************
*   Name : message
*   Audit:
*************************************************************************
}
procedure message (mess_no : integer);
begin
  gotoxy (1, 24);
  textcolor (lightred);
  textbackground (black);
  case mess_no of
    1 : write ('Picture : You need a graphics card to run this program.');
    2 : write ('Picture : You need to specify a display mode between 0 ',
               'and 3.');
    3 : write ('Picture : Could not find the directory specified on the ',
               'picture name.');
    4 : write ('Picture : Could not open the picture file.');
    5 : write ('Picture : The picture specified was not in the proper ',
               'format.')
  end;
  delay (3000);
end;
```

```
{
*************************************************************************
*   Name : color_monitor
*   Audit:
*************************************************************************
}
function color_monitor : boolean;
type
  registers = record
    ax,bx,cx,dx,bp,si,di,ds,es,fg : integer;
  end;
var
  regs : registers;
begin
  Regs.AX := $0F00;
  Intr ($010, Regs);
  color_monitor  := (Regs.AX and $00FF) <> 7;
end;
{
*************************************************************************
*   Name : extract_filename
*   Audit:
*************************************************************************
}
procedure extract_filename (in_str : string80;
                            var filename : string255;
                            var path     : string80;
                            extension    : string80);
var
  edge : boolean;
  len, i : integer;
begin
  len := length (in_str);
  for i := 1 to len do
    if ord(in_str[i]) > $60 then in_str[i] := chr(ord(in_str[i]) - $20);
  edge := false;
  i := len;
  repeat
    if (in_str[i] = '\') or (in_str[i] = ':') then edge := true
      else i := i - 1;
  until edge or (i=0);
  if edge then begin
    if in_str[i] = '\' then
      path := copy (in_str, 1, i-1)
    else
      path := copy (in_str, 1, i);
    filename := copy (in_str, (i+1), (len-i));
  end else filename := in_str;
  if pos ('.', filename) = 0 then filename := filename + extension;
end;
```

```
{
*************************************************************************
*   Name : text_mode
*   Audit:
*************************************************************************
}
procedure text_mode;
begin
  textmode (C80);
  blockread (pict_file, screen, 1);
  if ioresult <> 0 then message (4);
end;
{
*************************************************************************
*   Name : graph_color_mode
*   Audit:
*************************************************************************
}
procedure graph_color_mode;
begin
  graphcolormode;
  blockread (pict_file, screen, 1);
  if ioresult <> 0 then message (4);
end;
{
*************************************************************************
*   Name : hires_mode
*   Audit:
*************************************************************************
}
procedure hires_mode;
begin
  hires;
  blockread (pict_file, screen, 1);
  if ioresult <> 0 then message (4);
end;
{
*************************************************************************
*   Name : Savegraf_mode
*   Audit:
*************************************************************************
}
procedure SaveGraf_mode;
var
  top : boolean;
  marker, n_bytes, x, i, repeats, in_index: integer;
begin
  blockread (pict_file, blk, 1);
  if ioresult = 0 then begin
    if (blk[1] <> 239) or (blk[2] <> 190) then begin
```

```
      message(5);
      exit;
      end;
    top := true;
    in_index := 10;
    x := 1;
    n_bytes := 0;
    marker := (blk[17]*256 + blk[16]);
    graphcolormode;
    palette((blk[18] and $00F0));
    repeat
      if iblk[in_index] = marker then begin
        in_index := in_index + 1;
        repeats := iblk[in_index];
        in_index := in_index + 1;
        for i := 1 to repeats do begin
          if top then
            screen1 [x] := iblk [in_index]
          else
            screen2 [x] := iblk [in_index];
          if ((x mod 40) = 0) then
            if top then begin
              x := x - 40;
              top := false;
            end else
              top := true;
          x := x + 1;
          if x > 4000 then exit;
        end;
        in_index := in_index + 1;
        n_bytes := n_bytes + repeats * 2 + 4;
      end else begin
        if top then
          screen1 [x] := iblk [in_index]
        else
          screen2 [x] := iblk [in_index];
        if ((x mod 40) = 0) then
          if top then begin
            x := x - 40;
            top := false;
          end else
            top := true;
        x := x + 1;
        in_index := in_index + 1;
        n_bytes := n_bytes + 2;
      end;
    until x > 8000;
  end else message (4);
end;
{
```

```
*************************************************************************
*   Name : drhalo_mode
*   Audit:
*************************************************************************
}
procedure drhalo_mode;
var
 loopc, screenc, recsread : integer;
 firstime : boolean;

  procedure cpdata;
   var
   i : integer;
  begin
    for i := 1 to (blk[loopc]-128) do begin
      if screenc < 16384 then begin
        screen[screenc] := blk[loopc + 1];
        screenc := screenc + 1;
      end;
    end;
    loopc := loopc + 2;
  end;          {cpdata}

  procedure uncpdata;
   var
   i : integer;
  begin
    for i := 1 to blk[loopc] do begin
      if screenc < 16384 then begin
        screen[screenc] := blk[loopc + i];
        screenc := screenc + 1;
      end;
     end;
    loopc := loopc + blk[loopc] + 1;
  end;          {uncpdata}

begin {drhalo_mode}
 screenc := 1;
 BlockRead(pict_file, blk, 1);
 if (blk[1] = 65) and (blk[2] = 72) then begin
  graphcolormode;
  palette(blk[15]);
  GraphBackground(blk[13]);
  loopc := 17;
  while (screenc < 16384) do begin
    if blk[loopc] = 128 then
     if ((loopc/2) = int(loopc/2)) then loopc := loopc + 1
     else loopc := loopc + 2
    else
      while blk[loopc] <> 128 do begin
```

```
        if blk[loopc] > 128 then cpdata
        else uncpdata
      end;
   end;
 end
else message(5);
end;
{
*************************************************************************
*   Name : mspaint_mode
*   Audit:
*************************************************************************
}
procedure mspaint_mode;
var
  top : boolean;
  marker, n_bytes, x, i, repeats, in_index: integer;
begin
  blockread (pict_file, blk, 1);
  if ioresult = 0 then begin
    if (blk[1] <> 10) then begin
      message(5);
      exit;
      end;
    top := true;
    in_index := 129;
    x := 1;
    n_bytes := 0;
    graphcolormode;
    palette(1);
    repeat
      if blk[in_index] >= 192 then begin
        repeats := blk[in_index]-192;
        in_index := in_index + 1;
        for i := 1 to repeats do begin
          if top then
            screen1b [x] := blk [in_index]
          else
            screen2b [x] := blk [in_index];
          if ((x mod 80) = 0) then
            if top then begin
              x := x - 80;
              top := false;
            end else
              top := true;
          x := x + 1;
          if x > 8192 then exit;
        end;
        in_index := in_index + 1;
        n_bytes := n_bytes + repeats * 2 + 4;
```

```
      end else begin
        if top then
          screen1b [x] := blk [in_index]
        else
          screen2b [x] := blk [in_index];
        if ((x mod 80) = 0) then
          if top then begin
            x := x - 80;
            top := false;
          end else
            top := true;
        x := x + 1;
        in_index := in_index + 1;
        n_bytes := n_bytes + 2;
      end;
    until x > 8192;
  end else message (4);
end;
{==================== begin Picture ============================}
begin
  if color_monitor then begin
    init_param_addr;
    read_integer (option);
    if (option in [0..5]) then begin
      getdir (0, path);
      read_string (picture_file_name);
      extract_filename (picture_file_name, picture_file_name, path, '.PIC');
      chdir (path);
      if ioresult = 0 then begin
        assign (pict_file, picture_file_name);
        if ioresult = 0 then begin
          reset (pict_file, pict_size);
          if ioresult = 0 then begin
            case option of
              0 : text_mode;
              1 : graph_color_mode;
              2 : hires_mode;
              3 : SaveGraf_mode;
              4 : drhalo_mode;
              5 : mspaint_mode;
            end;
            close (pict_file);
            if ioresult = 0 then begin

              count := 0;
              while (count <= 10) and (not keypressed) do begin

                count := count + 1;
                delay (350);
```

```
            end;  { while }
            if keypressed then read (kbd, ch);

          end;  { if ioresult }

        end else message (4);
      end else message (4);
    end else message (3);
  end else message (2);
end else message (1);
textmode (C80);
end.
```