IMPLEMENTATION OF A COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM

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Summary

A primer Computerized Maintenance Management System (CMMS) has been established for NASA Ames pressure component certification program. The CMMS takes full advantage of the latest computer technology and SQL relational database to perform periodic services for vital pressure components. The Ames certification program is briefly described and the aspects of the CMMS implementation are discussed as they are related to the certification objectives.

Introduction

The Computerized Maintenance Management System (CMMS) is a response to calls for high performance and quality in areas of asset management and employee productivity. At NASA Ames Research Center (ARC), there is an urgent need for monitoring a large number of special equipment which is part of the high-pressure gas or liquid lines throughout the Ames property. Due to the nature of the working fluids and operating conditions, high pressure systems create a potential hazard to the surrounding environment. The safety of the personnel and facilities on-site would be jeopardized if this equipment fails to perform designated functions. Motivated by this need and the demand for more prompt services on this equipment, a computerized maintenance management system was implemented for the monitoring process. Documented here is the first phase of the pressure system monitoring project.

Pressurized Systems and Safety Inspection

There are more than a hundred research and development facilities used at ARC for various scientific experiments and studies. Approximately 80% of these facilities use pressurized vessels and systems (PV/S). Many of Ames' PV/S were built without being certified for conformance to applicable codes and standards. To ensure both the structural integrity of ARC's unique research facilities and the on-site personnel's safety, these PV/S must comply with current applicable safety codes and standards. To accomplish this, ARC established a certification/recertification program in the early 80's to determine the system's status (i.e., certification, repair, or replacement). After initial certification, recertification is periodically conducted using a schedule of inspection and tests to verify that a previously certified pressure system continues to be safe to operate. Ames certification and recertification may be accomplished on a whole system basis or on an all-individual component basis.

The process starts with collecting information by field visual inspection, size measurements of the pressure components, retrieving manufacturers's nameplate data, and historic records. Each component of every system is assigned a unique three-digit number called the component number, and is shown on a piping isometric drawing. The field data is then processed by a FORTRAN computer program on a VAX 11/785 in building N-213. The computer program produces comprehensive status sheets (SS) for the PV/S. The SS include field measurements, physical properties, the maximum allowable working pressure and temperature, certification status, future inspection intervals, and recommendations for recertifying, derating, repairing, or replacing each component. The SS, however, do not provide an easy way of tracing the changes and modifications made to the system after recertification. They also lack the capability to monitor the components continuously.

Objective of the Monitoring Project

Past recertification documents show that a large number of special components in ARC's pressure systems, such as pressure gauges and relief valves, are overdue for servicing. These special components need to be more closely monitored to safeguard the entire system. It is therefore necessary to establish an automatic tracking system in order to keep a timely record of each component and generate servicing notices. The Pressure System Safety Committee of ARC recognized this necessity, and consequently, a pressure system monitoring project for the recertification group was proposed in March 1992. The first phase of the project includes monitoring five types of components, namely pressure gauges, relief valves, hoses, rupture disks, and temperature gauges. These five special components were chosen because of their importance to the safety of the PV/S, and because the code requirements for them are more restrictive than other pressure components.

Pressure Gauges

A pressure gauge should give accurate readings for the pressure in a piping system. To ensure its function, Ames Health and Safety Manual (AHB 1700-1) requires that all pressure gauges be calibrated every two years and be of safety type. "Safety type" means that, in case of failure, the broken pieces of the gauge will blow out the back of the gauge, to prevent injuries to the gauge reader. Several manufacturers have established trademarks that represent the safe case. Typical gauges used in ARC facilities are made by US Gage and Ashcroft, trademarked by "SOLFRUNT," "MAXISAFE," or "DURAGAGE," respectively. The dial range of a gauge is recommended to be twice the intended operating pressure, and not less than 1-1/3 of the maximum operating pressure.

Recertification documents show that many gauges used in ARC have expired calibration dates, and that unsafe gauges are used occasionally. Some gauges do not have the recommended dial range. Some even have broken dial cover glass.

Relief Valves

These valves control the fluctuation of pressure in PV/S and protect the system from being suddenly over-pressurized by fire, among other causes. Generally, relief valves are required to open at 10% over the maximum allowable operating pressure and to be spring-loaded. NASA standards specify that the valves must be reset every two years while in more corrosive PV/S, such as water and liquid carbon dioxide, the valves must be reset annually.

The relief valves used in ARC's facilities often do not meet the above safety standards. A large number of valves were tested and reset in intervals greater than the required two years.

Hoses

When used in high pressure systems, hoses must pass hydrostatic pressure test every two years to ensure there are no leaks or other damages done to the hoses. Many hoses used in the field do not comply with the requirement.

Rupture Disks

These are commonly used in parallel with relief valves. The disks are made to burst at certain pressure levels therefore to protect the system from being over pressurized. To avoid premature rupture, they should be replaced per manufacturer's specification. Many rupture disks used in the high pressure systems at ARC are not properly tagged to show the installation date.

Temperature Gauges

The temperate gauges installed on PV/S have the same requirements as for pressure gauges. There are not many pressurized temperature gauges used in ARC's facilities, however, some of them are found to be outdated.

All these five types of pressure components have to be recertified every ten years in addition to the above-mentioned regular maintenance. Any problems, such as the ones mentioned above, should be brought to the user's attention, along with suggestions for appropriate action.

Implementation of CMMS

To prepare the database of the monitoring project, all the special components inventoried in the previous status sheets were assembled. The data collected in the status sheets were updated by field-checking. Errors were corrected and missed information was added. Original drawings showing the location of each component were retrieved and attached to the complied SS for five types of special components. When substantial modifications had been made since the last recertification, new drawings were sketched and new set of numbers were assigned to the components. There are approximately 700 special components in 60 facilities or systems that were selected for the first phase of monitoring project. Each facility and/or system was assigned a three-digit number. The previous component number used in the drawings was prefixed with its facility/system number, making a unique identification for the component. Examples of the new component number are 100-038, 230-199, etc.

Research was conducted to find a suitable database to accomplish monitoring goals. Several sources were accessed including the one used by NASA Ames Maintenance Management Office. They surveyed about 20 different CMMS products for their routine maintenance work and decided on MAXIMO Maintenance System by Project Software & Development, Inc. (PSDI). The software was installed on a file server (PC) and has been used since 1990. Our main concerns were cost-effectiveness, customization, training, graphics and multi-task capability and other aspects of the prospective

CMMS. It was concluded that MAXIMO was best suited too. The heart of MAXIMO is its work-order system, which tracks maintenance activities through a standardized database that automatically generates a work order using user-defined criteria. However, due to the limitations of the version (Version 2.6) used by EM, some requirements of the monitoring project, such as data entry validation, are not satisfied. During the period of July to August of 1992, a new version of Windows-based MAXIMO (Series 3, Version 1.1c) was installed for the Pressure System Recertification Group. Series 3 has an on-screen menu with a wide range for customization in areas such as screen layout, extra tables, etc. The most useful feature for the monitoring project is the capability to attach a user-defined value list to any data field that requires operator entry. This feature validates all the crucial data entered by accepting only those values as defined in the value list. The pull-down menu of the value list provides additional convenience for the operator and reduces the possibility of human error. Another advantage of Series 3 is the accessibility of the information stored in the database. Since MAXIMO utilizes the SQL relational database and is Windows compatible, queries about the data can be made right from the data screen, including the use of wild cards and operators. The need for extracting information easily from the database was recognized before but was not achieved until the implementation of MAXIMO series 3. The third feature that is rather attractive to the monitoring project is the ability to add new screens or modules within MAXIMO. The added screens are not necessarily related to the maintenance activities but are required by the pressure system inspection and recertification. This flexibility enables MAXIMO to be "made" exactly for the monitoring project.

Because MAXIMO was designed for maintenance function not specifically for pressure safety inspection, however, substantial modifications are necessary to match the needs of monitoring a pressure system. Four modules or applications of the MAXIMO have been modified. The Equipment module, which contains all the information for a piece of equipment to be maintained, has been changed to match the SS. It includes information that is common to all types of pressure components. The Preventive Maintenance Master (PM) module, which sets up the maintenance schedule for periodic services, and the Work Order Tracking module, which processes the work orders, have been altered also to meet monitoring requirements. The Job Plan module, which details the work procedures, has been changed into a code reference library with an identification (ID) number assigned to each applicable reference.

Five additional screens (modules) were created to accommodate the data for pressure gauges, relief valves, hoses, rupture disks and temperature gauges. These screens contain the data pertaining only to each type of components. Value lists are attached to several data fields in these screens. Data fields "Inlet type" and "outlet type" describe how the component is engaged to the piping system. Typical types, such as male-pipe threaded (MPT), female-pipe threaded (FPT) or flanged (FLGD) are included in value list INTYPE. In the pressure gauge screen, value list CASETYPE is attached to the case type field which specifies the trade marks of the gauge (e.g., SOLFRUNT, MAXISAFE, DURAGAGE and other brands). Numerical fields (such as inlet size) are defined to accept only numbers. These five screens separate the special components from others and allow easy querying of one group of special components at a time. The value lists provide a certain degree of protection from data entry errors and reduce the chance of mixing different type of data with different components.

The implementation of the CMMS was finished in early September 1992, and the data entry started in the middle of the September. Information from updated SS and additional data from field inspection were input to the database via the Equipment screen and corresponding component screens. A maintenance scheduler (PM) for each component was established. Based on component type, a pertaining code reference ID number was assigned on the PM of a component. When corrective maintenance is required, a work order is generated separately. Service requests are based on the last completion date of the service, plus the frequency of service defined by the relevant code. The due dates printed on the work order reflect the actual date when the service should be completed plus 30 extra days allowance. It is expected that when all the components are brought up to schedule, a more restrictive due date will be imposed. The first set of work orders, renamed as "Periodic Maintenance Notice" (refer to fig. 1 for a sample output), were sent out on Oct. 6, 1992, to appropriate facility representatives. The response from the users who received the notice was prompt and supportive. On one occasion, the user finished the required service within 24 hours. All the notices have been responded to before the due date. Users have expressed their appreciation of the notice. As of January 1993, the modified CMMS is fully functional and the first phase of the monitoring project is progressing satisfactorily.

Summary

Safety is the paramount concern when dealing with pressure vessels and systems, and good maintenance is the only way to ensure it. A systematic approach and well-organized maintenance scheme is necessary for any facility or plant. The Computerized Maintenance

Management System (CMM) alone will not improve maintenance performance without proper implementation and a feasible plan. To produce positive results and justify their cost, CMMS's must be incorporated with careful maintenance planning and goal setting. The implementation of MAXIMO in the monitoring project is successful because these guidelines have been followed.

While improvement of the current version of the CMMS continues, the second phase of the monitoring project is expected to include all pressure components which require regular services. More advanced features of updated CMMS will be explored. Graphics packages will be attached to the database so that engineering drawings can be reviewed on the same data screen of the component. The physical appearance of the component and disassembly charts can also be scanned into the CMMS, making a complete database for a particular component or equipment. The prospect of future application to other aspects of maintaining PV/S, such as nondestructive examination, is promising as the project progresses.

References

1. NASA Ames Research Center: Health and Safety Manual, AHB 1700-1, Chapter 10.
2. Larson, Paul: Maintenance As a Strategic Asset, Maintenance Technology, vol 5, no. 5, p. 44, May 1992.

Biography

Yonghong Shen was born in China in 1958. In 1982 Shen completed her undergraduate education and continued graduate study at Stanford University. She obtained her Master's Degree in Mechanical Engineering in 1983. She then worked in various research institutes in Arizona and Illinois. She joined Bentley Engineering Company in February 1992.

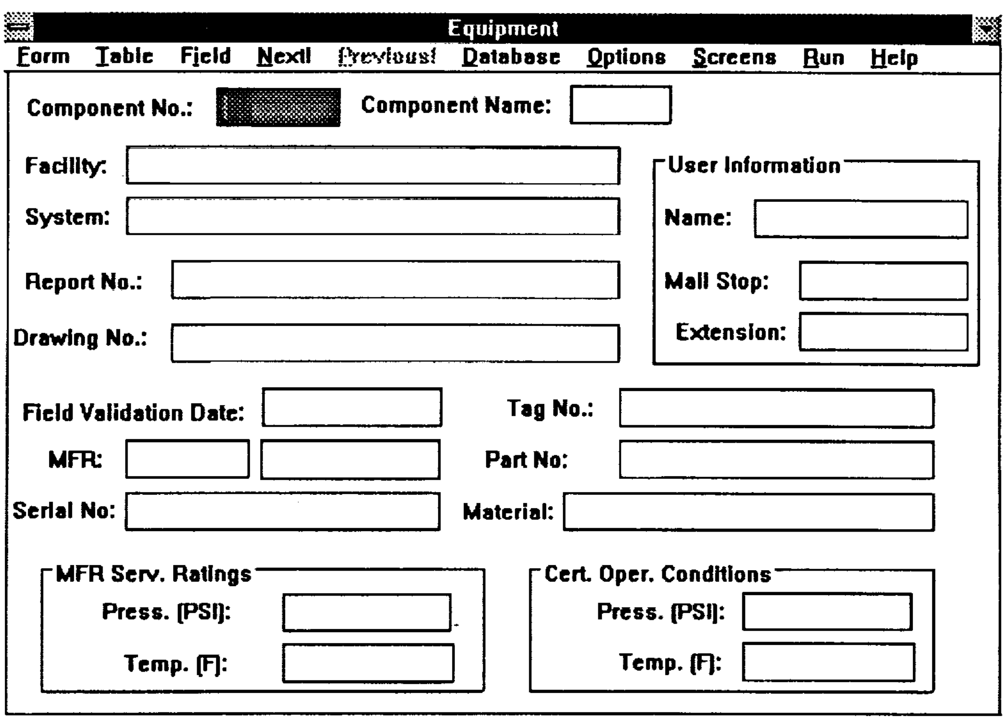

Figure 1. Equipment Screen

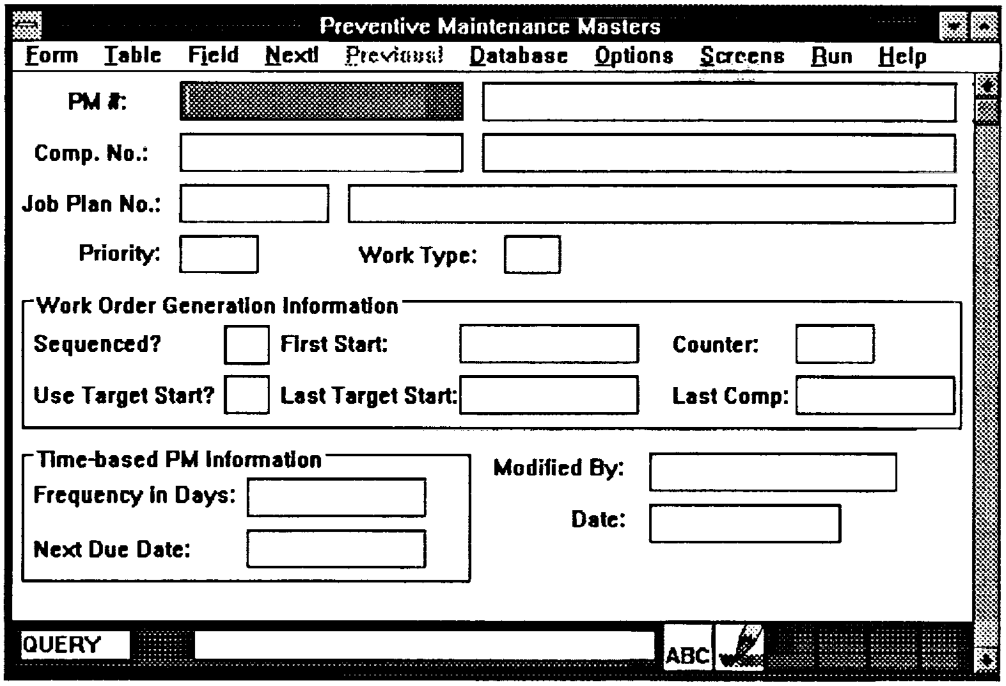

Figure 2. Preventative Maintenance Master Screen

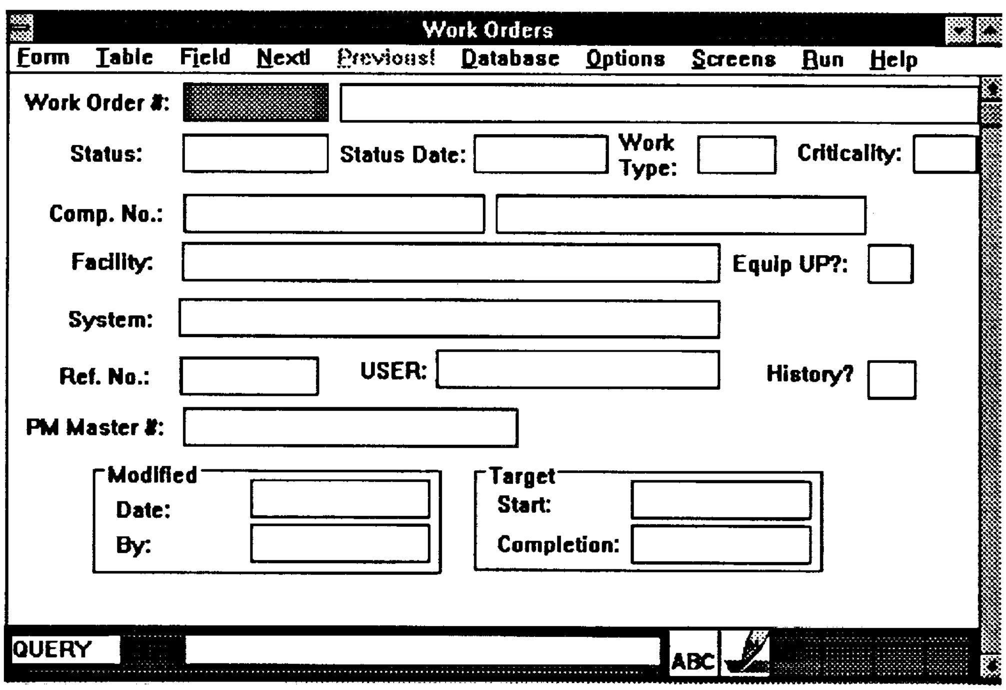

Figure 3. Work Order Tracking Screen

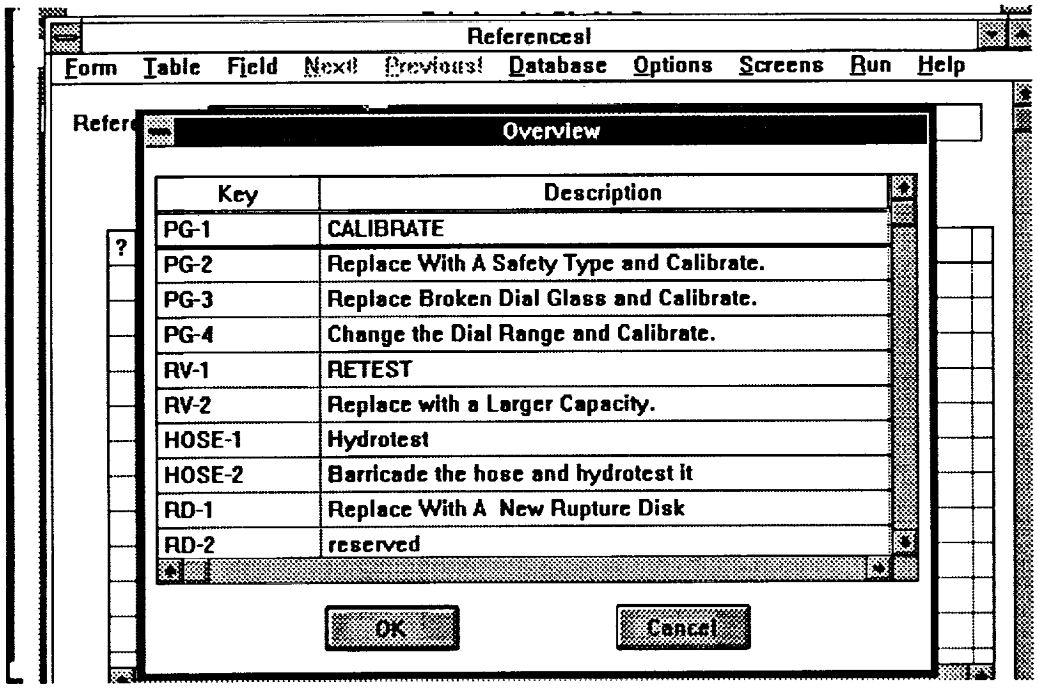

Figure 4. Reference (Job Plan) Screen

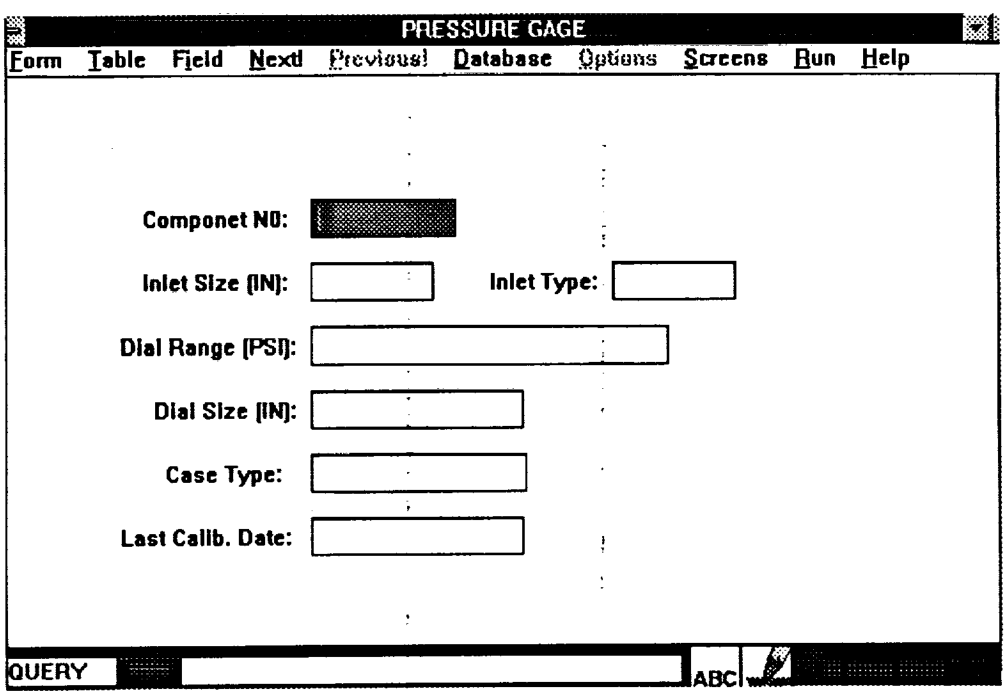

Figure 5. Pressure Gauge Screen

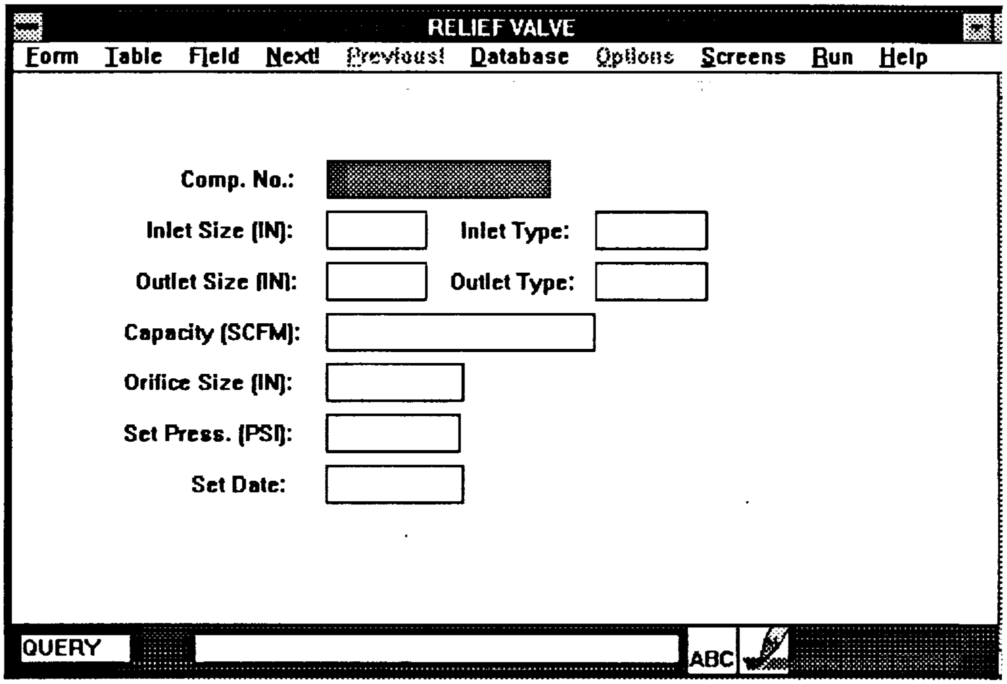

Figure 6. Relief Valve Screen

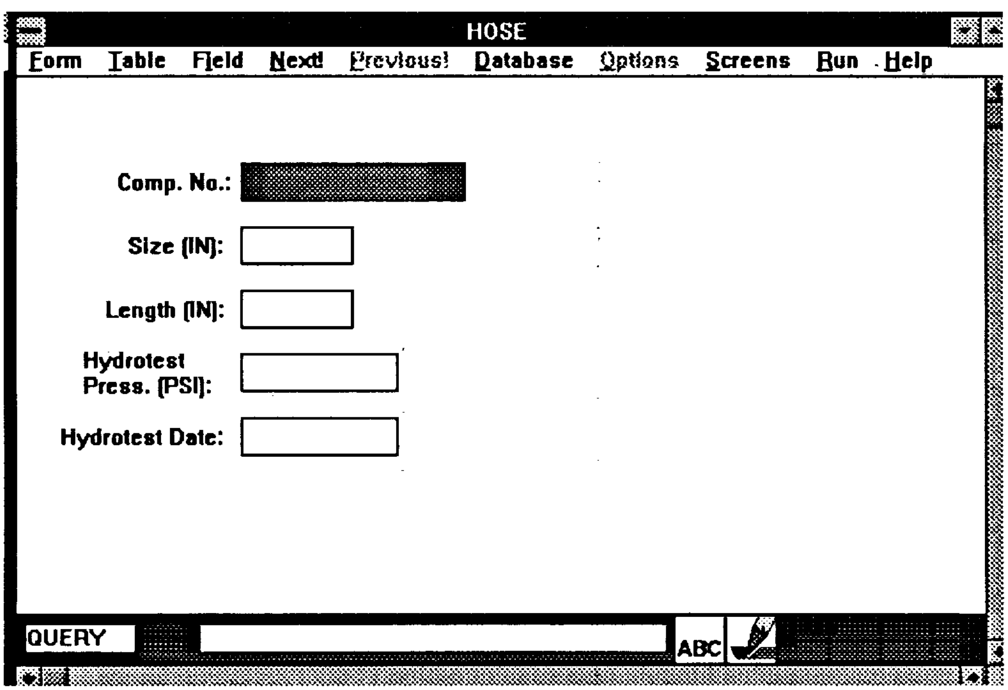

Figure 7. Hose Screen

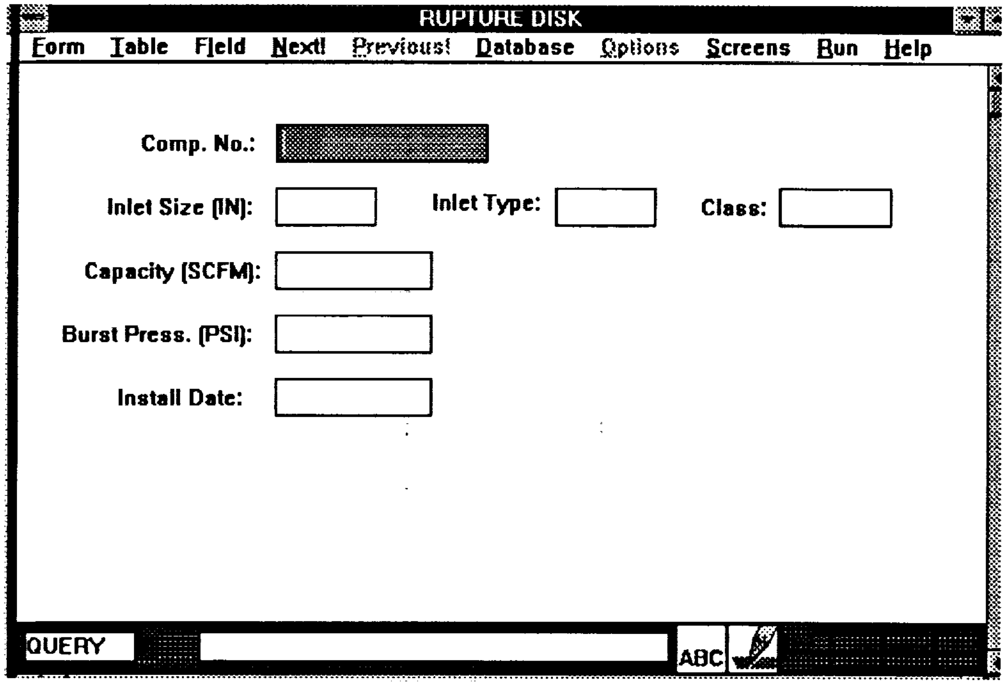

Figure 8. Rupture Disk Screen

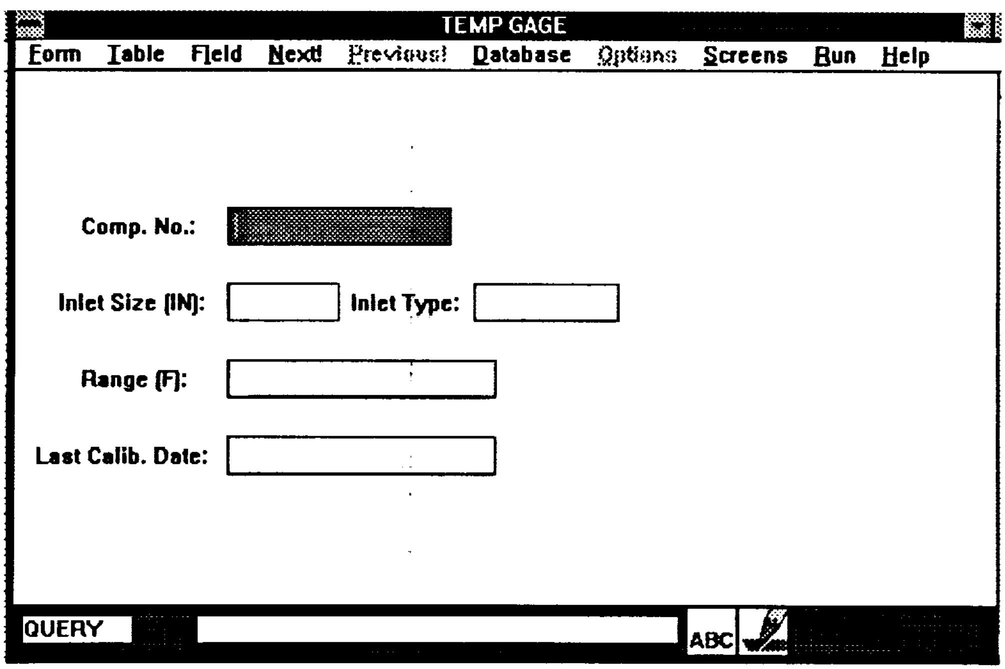

Figure 9. Temperature Gage Screen

PERIODIC MAINTENANCE NOTICE

User: Peter Arthur
User's M/S: N229-4
User's Ext.: 4-5403

PAGE: 1
Issue Date: 10/28/92
BEC WO#: 0000001212

Facility: 3000 PSI Distribution Network associated with Bldg. N229
System: 3000 PSI Air
Ref. DWG No.: 8---9230-P1
Ref. Rep.No.: A8---8231-XV1,A829-8232-XV5,A8---8431-XV13,A8---8631-XV18

COMPONENT NAME: **PRESS. GAGE** No.: 074 (Ref. above Dwg.)
ACTION REQUIRED: Replace With A Safety Type and Calibrate.
DUE DATE: 27-NOV-1992

Additional information for the PG :

Tag No.	Dial Range (PSI)	MFR/ Part No.	Case Type	Inlet size (IN) / Type	last Cal Date	MFR Pres. (PSI)	Cert. Pres. (PSI)	MFR Temp. (F)	Cert. Temp. (F)
NO ID TAG	5000	US GAGE 22961-1	NOT SAFE TYPE	.25 MPT	Unk	3750	3000	100	100

Reference:

1. Replace the press gage with a safety type that is either certified by its manufacturer not to cause shrapnel upon failure of its pressure element or features a full blowout back and equipped with an armored plate behind the dial. AHB 1700-1, Chapter 10, Paragraph 5g(1).

2. Calibrate and tag pressure gage every two years in accordance with AHB 1700-1, Chapter 10, Paragraph 9a&9b, and AHB 1710-3, Section 4, Paragraph 4.i(1).

User's Response:

The above services have been performed. YES _____ NO _____

COMMENTS:

Date:

Upon completion of the above action, please return the form to Pressure System Recertification at M/S N213-8 on or before the due date.

Figure 10. Sample Periodic Maintenance Notice with the associated drawing (next page).