618-01
GEMS 1081099

Mechanical Integrity Program Evaluation for Motiva Enterprises, LLC in Delaware City, Delaware

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Draft Report Submitted: September 2002
Final Draft Report Submitted: October 2002
Final Report Submitted: March 2003

This work was performed by ABSG Consulting Inc. for Motiva Enterprises, LLC under Proposal No. PROP-618-01.

NOTICE

EXECUTIVE SUMMARY

The Motiva Delaware City Refinery (DCR) is in the midst of many changes, including changes in the organizational structure and the implementation of new and improved work processes for many process equipment mechanical integrity (MI)-related activities. These changes are in response to many factors, including (1) the need to take positive steps to prevent future safety and environmental incidents, (2) a change in the corporate ownership arrangement, and (3) the need to achieve consistent profitability and competitiveness. Many of the changes were in various stages of planning, development, or implementation prior to the events of July 2001. Many initiatives are part of the growing influence of Shell Oil Products-United States (SOPUS). As will be discussed further, this influence and access to SOPUS's technical services and expertise establish a positive basis for long-term improvement in many aspects of the refinery's operation. In most instances, the issues discussed in this report can and should be resolved over the next several years with the continuing support and access to the resources and active guidance of SOPUS (or of another organization with similar resources and operating discipline).

To perform the evaluation, Motiva Enterprises, LLC (Motiva), on behalf of the Department of National Resources and Environmental Control (DNREC), contracted ABSG Consulting Inc. (ABS Consulting), an engineering consulting firm that specializes in safety and reliability analysis. The evaluation began with requested documents being provided by Motiva to ABS Consulting on May 7, 2002, and continued through a series of visits to the refinery between May 20, 2002, and August 16, 2002.

While progress has been made – and there are a number of success stories that will be discussed in this report – the conclusion must be drawn that, compared to refineries of similar size, complexity, age, and previous corporate ownership, the degree of progress, sophistication, and rate of implementation for a number of MI initiatives are currently below the industry norm.[1] ABS Consulting has identified a number of significant gaps in the DCR's MI program and practices and in related management system elements. This report contains 40 recommendations and 38 observations intended to address these gaps and improve the DCR's MI program.

[1]ABS Consulting's perspective on what constitutes the industry "norm" is based, in part, upon our perspective of the evolving standard of care commonly applied at the many facilities that we have audited in the 10 years since the implementation of OSHA's process safety management (PSM) standard 29 CFR 1910.119. The practices and programs that we cite in this evaluation predominately are direct or implied requirements of the PSM standard and should previously have been in place and functioning.

Significant gaps in the MI program, where they exist and for as long as they exist, increase the potential for safety and environmental events and elevate the risk of operations. The DCR, using a broad range of internal and external resources, has identified the most significant gaps and is working to close them. These efforts must continue.

Continuous improvement of the MI program should be, and seems to be, an imperative at the DCR. It is clear from the team's observations that considerable effort has been devoted to improving the MI program at the refinery, with significant resources devoted over the last 18 to 24 months to make needed enhancements. The DCR staff notes, however, that the recent rates of expenditures cannot continue indefinitely if the refinery is to survive financially. Thus, the current emphasis is to improve work processes to significantly increase the efficiency with which resources are used in order to achieve more with less.

Interviews indicated a generally positive attitude among the operators, craftsmen, and staff toward the actual changes noted over the last several years and other planned improvements. However, many interviewees expressed concerns regarding the sustainability of the effort. These concerns may abate if progress continues to be realized.

The improvement of the MI program is truly a "work in progress." As noted, advances are being made. However, the number of changes that are simultaneously being made – some only in their formative stages – makes it difficult, and perhaps imprudent, to predict a future rate of progress. For that reason, careful monitoring will be required to track the course and progress of the improvements in the MI program.

Environmental and safety incidents are not caused solely by equipment failures. A comprehensive and effective hazard management system is required to prevent incidents from occurring. We cannot overstate the importance of everyone's attention to (1) the details of implementing the MI initiatives and the other changes within the refinery, (2) the continuous monitoring and coordination of the results of the MI program activities, and (3) the technical excellence in evaluating the results. Successful and timely implementation of the many new MI initiatives, along with diligent adherence to the requirements of OSHA's PSM standard 29 CFR 1910.119, should provide the environment for significantly reducing the likelihood of undesired incidents within the DCR.

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1. INTRODUCTION

ABSG Consulting Inc. (ABS Consulting) was contracted, on behalf of the state of Delaware Department of National Resources and Environmental Control (DNREC), by the Motiva Delaware City Refinery (DCR) to provide mechanical integrity (MI) and process safety management (PSM) consulting services. Specifically, the scope of this project was to perform a comprehensive review and evaluation of the DCR's MI program and practices, to be followed by a period of ongoing monitoring of program implementation. To perform the evaluation Motiva Enterprises, LLC (Motiva) contracted ABS Consulting, an engineering consulting firm that specializes in safety and reliability analysis. The evaluation began with requested documents being provided by Motiva to ABS Consulting on May 7, 2002, and continued through a series of visits to the refinery between May 20, 2002, and August 16, 2002.

The purpose of this evaluation is to ensure that the inspection, monitoring, maintenance, repair, and replacement of equipment at the DCR meet recognized and generally accepted good engineering practices and are adequate to help ensure public health and safety and protect the environment.

This work is in response to an agreement in principle between Delaware Governor Ruth Ann Minner and the DCR. While ABS Consulting has contracted its services to the DCR, this work is being conducted under the oversight of DNREC. The DCR and DNREC anticipate negotiating a settlement agreement that will commit the DCR to a comprehensive plan for MI assurance. It is anticipated that this report will serve as one source of input to these deliberations. ABS Consulting project staff are available to answer any questions that either the DCR or DNREC may have on this report's contents.

This report documents the observations and recommendations resulting from ABS Consulting's review and evaluation of the DCR's current MI program. The review began with the first working visit to the refinery by the project team on May 20, 2002. References to incidents, inspections, repair activities, or work processes prior to that date are intended only to provide (1) a context for the evaluation of the technical content and thoroughness of the existing programs and activities and (2) a perspective on the challenges confronting the DCR. This report does not evaluate or speculate on the basis for past MI programs or practices that led to the existing status of the MI-related activities at the DCR.

2. BACKGROUND OBSERVATIONS

2.1 NEW INITIATIVES

The DCR is in the process of implementing nine new process safety initiatives (PSIs). These initiatives, listed in Table 2.1, are a compilation of Motiva/Shell Oil Products-United States (SOPUS) best hazard management practices and closely parallel a number of the OSHA PSM elements. The initiatives provide a framework for implementation standardization within the Motiva/SOPUS refinery system. The DCR will have to create new work processes and adapt existing refinery management systems to meet the many new requirements established by the PSIs.

Table 2.1 Motiva/SOPUS Process Safety Initiatives

• Shared Stewardship of Assets	• Management of Change
• Reliability-Centered Maintenance	• Incident Investigation
• Ensure Safe Production	• Audits and Assessments
• Protective Instrument Systems	• Goals and Measurement
• Training and Procedures	

Many of the PSIs have a direct bearing on equipment MI issues through (1) managing pressure equipment inspection results, (2) ensuring understanding of equipment operating limits, (3) developing reliability-centered maintenance activities, (4) managing change of process and equipment, (5) developing key operating variables for all aspects of the operations, and (6) managing protective instrument systems. Other PSIs, such as operating procedure development, operator training, incident investigation, and auditing and performance measurement, support the goals of the MI program as well.

2.2 COMPREHENSIVE PLAN FOR MI ACTIVITIES

ABS Consulting was tasked to evaluate the DCR Comprehensive Plan for its MI program. One of our challenges was to determine what constituted the "Comprehensive Plan." In our opinion, the DCR's Comprehensive Plan for equipment integrity should incorporate, but not be limited to, implementation of the PSI; meeting the additional requirements of PSM; and adherence to Motiva/SOPUS's best operating, maintenance, and engineering practices. Since there are so many activities, there is no single Comprehensive

Plan document to describe the MI activities for process equipment. The Comprehensive Plan described above applies to all types of process equipment.

2.3 RECOMMENDATION TRACKING

Many of the new and existing hazard management systems and the new work processes generate recommendations for future inspection, equipment repair or replacement, or additional technical analysis. The DCR is using a software tool it developed, called Findings, Evaluations, Recommendations, Resolution Tracking (FERRET), to manage the status and disposition of the recommendations from the many diverse sources. The software provides a means to electronically distribute the recommendations to those responsible for their completion and have their status responses electronically returned to the database. The goals of FERRET are to (1) provide management information for oversight of outstanding issues and (2) maintain the awareness of individual responsibility for recommendations in order to foster planning and completion of the work in accordance with the specified due dates.

2.4 DECISION-MAKING PROCESSES

These PSIs and related work processes should prompt improvements in the equipment integrity decision-making process at the DCR. For example, equipment repair and integrity decisions should:

- Become more “fact-based” as a result of factual, current equipment information developed and made available to decision makers by these initiatives

- Be made with risk-based decision-making techniques, using standardized risk evaluation tools and documentation protocols

- In most cases, be made by collaborative teams of technical, maintenance, and operations personnel

Access to SOPUS’s technical resources should also add to the technical content of the information and the factual basis for decisions.

2.5 CULTURAL AND ORGANIZATIONAL INFLUENCES

SOPUS Influence. SOPUS operates a refining system with ownership interests in many refineries. It has a strong desire to standardize the work processes within each refinery based upon the best-practice technical and hazard management work processes identified throughout its operations.

The DCR management is currently expending considerable effort to implement a viable and comprehensive hazard management system and has made significant progress. However, much work remains to be done over several years to achieve the desired result. In order to complete the implementation, many new activities are simultaneously being planned and implemented. Implementation schedules are being developed and tracked, and effort is being made to develop relevant performance metrics for measuring progress. The operating discipline imposed by SOPUS and the reporting of implementation progress to the corporate leadership should provide a strong impetus for continuous improvement in the operation of the refinery.

The Current Context. The changes currently in progress within the DCR will take several years to complete. There are many new or modified work activities simultaneously being implemented and, as with any new activity, there is a learning curve to achieve full effectiveness. Hazard management systems have closely aligned elements that must be coordinated for effective implementation.

Many of the new programs are documentation-intensive, require close attention to technical and implementation details, and require experienced personnel who have knowledge of the overall scope of the hazard management system. Early in 2001, there was a reorganization of the DCR structure and resources, which has provided opportunities for new roles as managers, developers, and implementers of the new work processes. Our observation is that the DCR personnel are talented and are working diligently to implement these new systems; however, the learning curve for the personnel to achieve fully effective coordination of the activities will be steep for several years. During this period a concern for the effectiveness of these activities to prevent equipment-related incidents will persist; however, the potential for realization of an incident that would set back progress should diminish as the new work processes are more fully implemented.

Communication between the various work groups appears to be effective. We cite, as an example, the new Operations, Engineering, Maintenance, and Inspection (OEMI) teams that were formed to enhance the maintenance coordination function (these teams will be discussed later in this report). However, many of the new initiatives introduce new information, which requires new information flow paths and the need for new coordination efforts between groups. The DCR will need to be vigilant in ensuring that these communications and coordinations are established and maintained (see, for example, the discussion of communication of layer of protection analysis learnings in Section A-3 of Appendix A).

The Magnitude of the Task. The changes currently in progress within the DCR are occurring within an environment filled with many challenges concerning the overall appearance and condition of the process equipment and related infrastructure. The total amount of work required to address these challenges is large and is growing. Nowhere is this more evident than in the maintenance function (for example, as equipment inspection programs are broadened, more conditions requiring correction are identified). Sources of work, in addition to the ongoing routine repair of process equipment, include (1) meeting mandated environmental compliance requirements, (2) addressing inspection code requirements, (3) implementing preventive and predictive maintenance tasks, (4) complying with new requirements of the Motiva/SOPUS PSI, and (5) addressing other traditional safety requirements.

Managing the Work. All MI-related maintenance tasks are in competition for resources with many other types of work. The large magnitude of outstanding work poses a prioritization challenge. This raises the concern that a task, less immediate initially, may be overlooked or implemented later than intended, increasing over time the likelihood of an incident related to the uncompleted task. This potential should diminish as experience is gained in the new work planning processes described in Section A-4 of Appendix A. The new work planning processes provide tools for identifying the scope of work, realistically characterizing when it is required to be completed, and scheduling its completion in balance with the competing requirements.

3. SUMMARY OF CONCERNS AND RECOMMENDATIONS

Detailed discussions of the specific findings of this evaluation are provided in Appendix A, along with corresponding recommendations. This section provides a summary of some key observations and the recommendations from these detailed discussions. The summaries presented here are not intended to touch on all of the issues addressed in Appendix A, and the recommendations are abbreviated. The reader should refer to Appendix A for a comprehensive treatment of all concerns and recommendations identified during the evaluation.

ABS Consulting has provided a suggested priority ranking for the recommendations, shown in brackets at the end of each recommendation (e.g., [Priority 1]). The bases for the priority rankings are defined as:

> Priority 1: Recommendations that have the greatest potential for increasing the effectiveness of the Mechanical Integrity program and reducing the risk of potentially serious safety or environmental incidents.
>
> Priority 2: Recommendations that would further improve the effectiveness of the Mechanical Integrity program and reduce the risk of less serious safety or environmental incidents (compared to Priority 1 items).
>
> Priority 3: Recommendations addressing gaps in the Mechanical Integrity program that should be addressed but have lowest risk of safety or environmental consequences.

Pressure Equipment Inspection. The concerns associated with equipment inspection include (1) inconsistencies in the technical rigor applied to the preparation and the review of inspection reports and (2) issues associated with the method of scheduling and publishing vessel inspections due dates, which leaves some equipment with no scheduled inspection dates. In addition, some inspection recommendations have not been appropriately resolved since they either (1) have been entered into the FERRET database without a due date or (2) are contained in inspection reports that predate the FERRET database. For example, an incident investigation concerning a pre-FERRET piping inspection illustrates that there are unresolved inspection recommendations.

The following summarizes the ABS Consulting recommendations addressing pressure equipment inspection:

- Improve the system for reviewing the inspection reports to ensure accuracy and appropriate content. [Priority 1]

- Ensure that equipment inspection schedules accurately reflect the current equipment condition, as well as any recommendations of the inspectors; that each piece of overdue equipment has an appropriate inspection plan and a documented technical basis for continued service-pending inspection; and that inspection report results are considered in the timing of the next scheduled inspection. [Priority 1]

- Implement a process to ensure that pre-FERRET PEI recommendations have been or will be appropriately resolved. [Priority 1]

- Provide required completion dates for currently unscheduled FERRET pressure equipment inspection (PEI) recommendations. [Priority 2]

- Revise the turnaround planning guidelines to include a process for conducting and documenting a turnaround deferral decision. [Priority 3]

Piping Inspections. One of the key concerns about the piping inspection program is the fact that it has not been fully implemented across the refinery. Resources are being applied to complete the piping inspection database; however, due to the lack of data, integrity issues will continue to surface through reactive inspections. Where schedules have been established, past-due inspections are noted in the records, some with thickness values below the suggested retirement thickness. External corrosion problems result from delays in making needed utility service leak repairs, painting piping, and replacing insulation.

The following summarizes the ABS Consulting recommendations addressing piping inspections:

- Continue the implementation of the SOPUS-based piping inspection program, and include appropriate pipe rack piping in the program. [Priority 1]

- In order to arrest the external corrosion of piping, improve the work process for (1) repairing utility service leaks, (2) removing temporary insulation, (3) making insulation repairs, and (4) painting. [Priority 1]

- Ensure that inspectors comply with the inspection schedule generated by the inspection database software. [Priority 1]

- Ensure that inspectors record data from the results of all piping inspections and use the piping database to capture inspection dates, either set by the inspector or based upon corrosion-rate calculations. [Priority 2]

MI Procedures and Training. Currently, the number of written MI procedures addressing process equipment, as well as the breadth of the topics addressed, is below the industry norm. A sustainable MI program, with trained personnel understanding their roles and responsibilities, will require appropriate procedures. The need for written procedures and training is emphasized by the DCR incident investigation recommendations; however, these recommendations have not been completed in a timely manner. Currently, a number of procedures that were recommended in response to incidents several years ago are not complete.

The following summarizes the ABS Consulting recommendations addressing MI procedures and training:

- Develop a schedule to identify and complete DCR-specific written MI procedures for equipment, including but not limited to, protective instrument systems (PIS) testing, equipment inspection, equipment reliability, maintenance craft skill, and equipment repair activities. [Priority 1 for PIS testing procedures. Priority 2 for all others]

- Train affected craftsmen and related personnel in the craft skill and PIS procedures prior to implementation. [Priority 1 for PIS testing procedures. Priority 2 for all others]

- Maintain existing vibration analysis monitoring activities in each unit until the reliability-centered maintenance (RCM) program is implemented. [Priority 2]

- Implement the means to ensure that what is learned from layer of protection analysis (LOPA) is properly reflected in the RCM tasks and the PIS procedures. [Priority 2]

- Ensure that machinery repairs are documented as specified in the existing and future repair procedures. [Priority 3]

- Complete the reconciliation and validation of the common instrument index data and the creation of the common machinery equipment files. [Priority 1 for the instrument index. Priority 3 for the machinery files]

Maintenance Prioritization and Backlog. The amount of maintenance work that must be accomplished is a significant MI challenge. While the DCR has implemented a new maintenance prioritization and scheduling system, additional experience and monitoring will be required to determine its effectiveness. Interviews with field personnel revealed some continued frustration with what they perceive as delays in getting requested repairs accomplished.

The following summarizes the ABS Consulting recommendations addressing maintenance prioritization and backlog:

- Complete the current effort to review, risk rank, and prioritize the existing maintenance backlog. [Priority 2]
- Complete the implementation of the metrics and means to (1) track the maintenance backlog and (2) monitor the effectiveness of the work prioritization process. [Priority 2]
- Provide a general orientation of refinery personnel on the Reliability and Maintenance Process (RAMP) system and related maintenance effectiveness initiatives. [Priority 3]

Management of Change and Pre-startup Safety Reviews. Observations have revealed a number of changes that were not reviewed under the management of change (MOC) procedure. This points to a need for a broader understanding and awareness about what constitutes a change that should be addressed under the MOC/pre-startup safety review (PSSR) system. The DCR personnel concede that there are recurrent difficulties in getting needed authorizations and confirmations of required activities completed in a timely manner.

The following summarizes the ABS Consulting recommendations addressing MOC and PSSRs:

- Expedite the approval and implementation of standing instruction 5.1.4, Temporary Repairs to Pressure Equipment. [Priority 1]
- Complete the implementation of the MOC PSI requirements and the training of affected personnel on the electronic MOC system. [Priority 2]
- Continue the quarterly audits of work orders to determine compliance with the MOC requirements, with statistics reported to and reviewed by management on a periodic basis. [Priority 3]
- Use the Joint Health and Safety Committee monthly unit audits to identify any facility modifications that may not have received MOC review. [Priority 3]

- Complete the development and implement tracking of MOC/PSSR performance metrics required by the PSI. [Priority 3]

Process Hazard Analysis. The backlog of open process hazard analysis (PHA) recommendations (approximately 2,300 currently, with some up to 11 years old) represents a potential liability. While not all of these recommendations are safety-related, there are a significant number of MI-related recommendations remaining open. While there are current efforts to close out these recommendations, there does not appear to be a system for prioritizing the remaining recommendations according to importance.

The following summarizes the ABS Consulting recommendations addressing PHA:

- Continue with the current process for the resolution of open PHA recommendations. [Priority 2]

- Implement an internal review of recommendations proposed for rejection to ensure that full technical and management consideration is given to the merits of the recommendation, and ensure that recommendation resolution is reviewed as part of the next PHA revalidation. [Priority 3]

- Establish a protocol for determining the priority for addressing the outstanding PHA recommendations. [Priority 3]

- Evaluate the DCR criteria for future PHA team makeup, and ensure that an appropriate mix of expertise is included on the PHA team. [Priority 3]

Incident Investigation. Approximately one-third of the DCR incident investigations have an MI link. A significant number of recommendations are not resolved on a timely basis, due to factors such as delays in issuing reports or the pace of subsequent follow-up.

The following summarizes the ABS Consulting recommendations addressing incident investigation:

- Implement policies or procedures to expedite the resolution of the existing follow-up actions (recommendations) on a timely basis. [Priority 1]

- Implement policies or procedures for the timely completion and review of incident investigation reports in order to identify, communicate, and resolve follow-up actions (recommendations) on a timely basis. [Priority 2]

- Evaluate, or provide, criteria for establishing target dates for implementation of incident investigation recommendations. [Priority 2]

- Ensure that incident investigations identify the true root causes of incidents and that recommendations appropriately address these root causes. [Priority 2]

- Establish linkages between the incident investigation program and the equipment inspection program to ensure that, where appropriate, process causes of MI problems are identified and resolved. [Priority 3]

Compliance Audits. The 1999 PSM compliance audit did not go into sufficient depth, especially with respect to the MI program. Very few findings addressed the programmatic gaps identified by the current MI program evaluation. Approximately 50% of the 70 recommendations from the 1999 audit report remain open, with only 3 recommendations closed within the last 12 months.

The following summarizes the ABS Consulting recommendations addressing compliance audits:

- The DCR should include participants from other Motiva/SOPUS locations, or from outside the company, on the 2002 PSM compliance audit team. [Priority 3]

- The DCR should consider more frequent, focused audits as it proceeds with the implementation of the MI initiatives that are addressed in this review. [Priority 3]

- Complete resolution of the remaining recommendations from the 1999 PSM compliance audit. [Priority 3]

FERRET Backlog Issues. While FERRET is proving to be an effective tool for tracking the status of recommendations, concerns remain about the number of backlogged tasks tracked by the database. Most departments have made a commitment for CY 2002 reductions but, for some, significant backlogs will carry forward. Firm, longer-term commitments have not been made to fully eliminate the backlogs.

The following summarizes the ABS Consulting recommendations addressing FERRET backlog issues:

- Implement specific goals, by department, that will establish a timely elimination of the FERRET overdue items. [Priority 2]

- Provide a mechanism(s) for prioritizing the efforts to reduce the FERRET overdue items so that more critical tasks are addressed first. [Priority 2]

- If risk-based decision making is used in prioritizing the execution of the FERRET overdue items, ensure that the individuals or teams making the decisions are properly trained in the methodology. Provide sufficient oversight to ensure that comparable risks prompt comparable decisions. [Priority 2]

Process Safety Initiatives. The DCR records show that the implementation of some initiatives, or some of their component tasks, is lagging behind the established schedule.

ABS Consulting's single recommendation for PSIs is:

- Reevaluate and revise, as appropriate, the implementation schedule for the PSIs, and then ensure compliance with the new schedule. [Priority 2]

Safe Work Practices. In reviewing the DCR incident investigations, ABS Consulting noted the prevalence of events involving failure of, or lack of compliance with, safe work practices such as lockout/tagout or hot work permits. In spite of the incident investigation findings, some interviewees believed that there were no serious problems with the application of safe work practices at the DCR. Industry experience has shown that failure to comply with these safe work practices has led to many serious incidents.

ABS Consulting's single recommendation for safe work practices is:

- Evaluate the recent incidents involving safe work practices, identify any common root causes, and develop appropriate responses to ensure safe work practice compliance. [Priority 1]

Budgeting. ABS Consulting previously recommended the need for implementing metrics and means to track the maintenance backlog in order to monitor the effectiveness of the work prioritization process. ABS Consulting believes that tracking this backlog and classifying it by risk level (an output reflecting the effectiveness of the maintenance management system) would be more effective than tracking maintenance operating cost expenditures (an input that does not necessarily correlate with the desired output of maintaining a low backlog of high risk work). There are no recommendations at this time related to budgeting issues.

4. NOTEWORTHY PROGRAMS AND PRACTICES

During the course of the evaluation, ABS Consulting identified a number of programs and practices that we believe are noteworthy.

Fact-based Decision-making Process. This is not a specific initiative, but it is the outcome of applying many of the new activities within the new organization. It facilitates making technically correct decisions in a timely manner. Equipment integrity, inspection, and repair timing decisions are made cooperatively within the work teams and are documented.

Current Relief Valve Inspection and Testing Status. According to the records sampled and the published testing schedules, all pressure relief valves for pressure vessels are current. In ABS Consulting's auditing experience, this status is uncommon in the process industries. The DCR should be commended for its efforts to achieve this outcome and the stated management expectation to maintain this status.

Establishing FERRET. FERRET is a computer database developed by the DCR personnel to inventory and track the status of recommendations associated with compliance-related activities. Each Monday morning, FERRET issues an e-mail to those individuals identified within the database as having responsibility for one or more recommendations. Responses updating the status of the recommendation can be e-mailed back for inclusion in the database. FERRET is discussed further in Section A-9 of Appendix A.

Use of LOPA in PIS Evaluations. The DCR's use of LOPA for identifying instrument systems required to be treated as PIS and for determining the required safety integrity level (SIL) for the PIS represents a state-of-the-art approach to this task.

Technical Evaluation and Analysis of Turnaround Work Scope. This is an example of the fact-based decision-making process that was first applied to the upcoming Hydrocracker Unit turnaround. It applies technical and operations expertise, current equipment knowledge, and risk analysis tools to make work-scope decisions that meet the business plan and address technical and inspection requirements for the equipment. This analysis is a formal, structured, and documented activity that occurs very early in the turnaround planning process. Post-turnaround critiques to gather lessons learned from both planning and unit-specific perspectives are a valuable exercise.

Reliability-centered Maintenance Plans. The scope, thoroughness, and practices to implement these plans are state of the art for the process industries. The Hydrocracker Unit is the first unit to execute the RCM planning, and the experience gained is being applied to the planning of the subsequent process units.

Formation of Operations Maintenance Teams. These teams, incorporating unit supervisors, maintenance team leaders, and operations maintenance coordinators, have clearly defined roles and provide the communication, focus, and leadership for appropriately managing all of the technical, environmental, and business plan requirements imposed on the operation of a process unit.

Welding Quality Control. The excellent practices and procedures of Washington Group International (WGI) and its interaction with the DCR inspectors provide a very effective system to manage welding activities within the refinery.

Creation of the Machinery Specialist and the Operations Machinery Specialist Roles. These functions, with clearly defined roles, should have a positive outcome for machinery reliability within the DCR. The inclusion of the operations machinery specialist as a stand-alone role is uncommon in the process industries. This role – to assist operator training in the operation of new, modified, and existing machinery – should provide reliability benefits, as well as reduce the likelihood of undesirable outcomes from machinery operation.

5. CONDUCT OF THE EVALUATION

5.1 SCOPE OF THE EVALUATION

This evaluation addressed the DCR's MI program and practices involving all process operations, including all equipment, storage tanks, pressure vessels, and piping.[2] The intent was to develop conclusions regarding the adequacy and timing of the inspection plans, practices, and procedures to protect the public health and safety and the environment.

The ABS Consulting project team also evaluated the underlying management systems and organizational issues that structure and support MI decision making throughout the refinery, including cultural, communication, and resources issues.

Finally, ABS Consulting was requested to analyze the DCR's MI operating expense and capital expenditure plans for the years CY 2002 through CY 2006 to ensure that sufficient resources are available to carry out necessary MI activities and equipment repairs/replacements.

This evaluation included a review of other management system elements that support the MI program (e.g., PHA, MOC, and incident investigation). The evaluation, however, was not intended to be a comprehensive audit of the DCR's PSM program. While the evaluation was rigorous, and the results of the evaluation should be indicative of the status of the DCR MI program and its implementation at the facility, this report cannot be interpreted to represent a comprehensive listing of all MI or PSM deficiencies.

This evaluation and the subsequent ongoing monitoring program are not intended to duplicate the efforts of other DNREC programs, such as the Delaware Accidental Release Prevention Program.

5.2 PROJECT STAFF

The staff for this effort consisted of senior members of the ABS Consulting Risk Consulting Division. These members have many years of experience in PSM, MI, and auditing of safety management systems.

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[2] The Repowering Project (a cogeneration project that is a joint venture with Conectiv) was not included in the scope of this evaluation.

Mr. Walt Frank, P.E., a senior consultant providing PSM services in ABS Consulting's Wilmington, Delaware, office, was team leader for this project. He has more than 29 years of experience in the chemical process industries, with the last 15 of those years as a risk, reliability, and safety consultant. Prior to joining ABS Consulting, he spent 24 years with DuPont in a variety of plant technical support, operations management, and research and development roles, concluding with 10 years in the DuPont Engineering Process Safety and Fire Protection consulting group. Mr. Frank has broad experience in conducting PSM and other regulatory compliance audits, including numerous audits of petroleum industry facilities.

Mr. Frank has an intimate knowledge of the OSHA PSM standard and the federal EPA risk management program (RMP) rule 40 CFR 68, as well as the Delaware *Regulation for the Management of Extremely Hazardous Substances*, having assisted DNREC in the development of its original regulation. He helped develop a continuing education course addressing compliance with the RMP rule for the American Institute of Chemical Engineers (AIChE) and served as an instructor for that course, as well as the AIChE course addressing PSM program development. His PSM program development experience includes an ongoing project assisting a major Canadian petroleum producer in its effort to integrate a new PSM program into its existing loss prevention program. Mr. Frank is the current chairman of the AIChE Safety and Health Division, and is a registered Professional Engineer in the state of Delaware.

Mr. Doug Hobbs, a senior consultant from ABS Consulting's Clear Lake, Texas, office, was the second member of the project team. Mr. Hobbs has over 28 years of engineering, facility operations management, and process safety consulting experience in the refining, chemical, and petrochemical industries. His technical industry experience includes working as a metallurgical, project, and process engineer at chemical and refining locations, and his management experience includes working as a unit operations manager and inspection supervisor. While working as an inspection supervisor, he was responsible for interpreting equipment inspection data, approving repair plans, establishing inspection frequencies, specifying inspection methods, and preparing turnaround work scopes based on equipment inspection data. Mr. Hobbs is a certified API 510 pressure vessel inspector. He has led or participated in over 25 PSM audits of refineries and chemical plants, primarily auditing MI programs.

In addition to these team members, Mr. Steve Arendt of the ABS Consulting Knoxville, Tennessee, office provided project technical support.

5.3 TECHNICAL APPROACH

The project team made three visits to the DCR, totaling 23 person-days on site. During these visits, team activities included:

- Reviewing the MI program and procedures
- Examining facility documentation resulting from these programs
- Interviewing management, operations, inspection, and maintenance personnel
- Observing MI-related activities, work practices, and equipment in the facility
- Conducting periodic debriefing meetings to keep the DCR and DNREC personnel apprised of review activities and results

Documentation reviews are an essential component of any program evaluation. Considering the overwhelming amount of documentation associated with an MI program, it was necessary that the team examine a representative sample of documents (e.g., inspection plans and procedures, inspection and testing records, training records, equipment files, drawings, MOC forms) sufficient to establish accurate conclusions about the implementation of the DCR MI program. Our consultants used their experience and knowledge of MI and PSM programs and recognized refining industry practices to establish an appropriate level of review. During the course of the review, nearly 3,500 pages of documents were received from the DCR for review.

MI program activities were assessed against recognized and generally accepted good engineering practices (RAGAGEP) established within the petroleum industry. These practices are documented in a number of industry consensus guidelines, recommended practices, and standards. The list of such documents would include, but not be limited to:

- API-510 - *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration*
- API RP-520 - *Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries, Part I - Sizing and Selection & Part II - Installation*
- API RP-521 - *Guide for Pressure-Relieving and Depressuring Systems*
- API-570 - *Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-Service Piping Systems*
- API RP-572 - *Inspection of Pressure Vessels*
- API RP-579 - *Fitness-for-Service*
- API-653 - *Tank Inspection, Repair, Alteration, and Reconstruction*

- ANSI/ISA Standard S84.01 - *Application of Safety Instrumented Systems for the Process Industries*
- American Society of Mechanical Engineers (ASME) Pressure Vessel Code

During the evaluation, the team interviewed approximately 50 refinery personnel, including both Motiva employees and contractors. Table 5.1 illustrates the distribution of interviewees by job function.

Table 5.1 Personnel Interviewed During the MI Evaluation

Functional Role	Number of Interviews	Functional Role	Number of Interviews
Plant Senior Staff	6	Machinery Specialist and Operations Machinery Specialist	2
Engineering Discipline and PEI Leaders	5	Shift Supervisors	4
Engineering and Technical Support Staff	10	Operators	5
Mechanics	3	Operations Maintenance Coordinators	4
Maintenance Team Leaders	2	Craft Supervisors/Planners	1
		Inspectors	6

5.4 ROLE AND RESPONSE OF MOTIVA PERSONNEL

This evaluation would not have been possible without the active support of a large cross-section of the DCR personnel. ABS Consulting acknowledges and commends the consistently constructive attitudes of the personnel who assisted our team in its evaluation. The cooperation and candor evidenced by the DCR personnel contributed significantly to the success of this evaluation. The evaluation would not have been as comprehensive and as thorough without this assistance.

6. GLOSSARY

TERM	ACRONYM	EXPLANATION (as required)
American Institute of Chemical Engineers	AIChE	—
American Petroleum Institute	API	—
American Society of Mechanical Engineers	ASME	—
Compliance Audits	—	The OSHA PSM standard and the EPA RMP rule require that audits be conducted every 3 years to confirm compliance with the requirements of the regulations.
Compliance Work Orders	—	Maintenance work orders generated to comply with specific, typically regulatory, requirements (e.g., to implement in incident investigation or PHA recommendation, or to repair an environmental monitoring device).
Delaware Accidental Release Prevention Program.	—	Delaware's state regulation requiring chemical accident prevention programs at certain industrial facilities.
Delaware City Refinery	DCR	The Motiva refinery.
Department of Natural Resources and Environmental Control	DNREC	—
Environmental Protection Agency	EPA	—
Findings, Evaluations, Recommendations, Resolution Tracking	FERRET	A database program developed by DCR personnel for use in tracking recommendations generated by compliance-based programs.
Hot Tapping	—	A procedure whereby a new connection is made to an in-service pipeline. Typically involves welding new piping onto a pressurized system.
Joint Health and Safety Committee	—	A DCR committee, consisting of management and worker representatives, that addresses safety issues.

6. GLOSSARY (cont'd)

TERM	ACRONYM	EXPLANATION (as required)
Layer of Protection Analysis	LOPA	LOPA is an industry-recognized analytical technique for evaluating the protections provided to prevent an undesired event and for determining the degree of additional protection required as a function of the risk posed by the event.
Maintenance Team Leader	MTL	Member of the Motiva maintenance group who is responsible for coordinating the activities of the various craft groups, including contractors.
Management of Change	MOC	A PSM program element that requires that changes to equipment and procedures be evaluated for their potential impact on safety and health, in order to identify considerations required to safely implement the change.
Mechanical Integrity	MI	The condition of process equipment that makes it suitable for continued operation at known process conditions for a specified period of time. An MI program encompasses the activities that serve to establish, maintain, and confirm this condition of continued suitability for service.
Minimum Thickness Calculation	—	A calculation to determine the thickness of a pipe or pressure vessel required to withstand the internal pressure load without failure.
Near Miss	—	A near miss is an unplanned sequence of events that did not result in undesirable consequences but could have if the circumstances had been slightly different. A near miss differs from an actual incident in that the actual consequences are usually not serious.
Occupation Safety and Health Administration	OSHA	—

6. *GLOSSARY (cont'd)*

TERM	ACRONYM	EXPLANATION (as required)
On-stream	—	In operation. As used in this report, "on-stream" refers to external vessel inspections that are made while the vessel is in operation.
Operations, Engineering, Maintenance, and Inspection Teams	OEMI	A newly formed team, representing the four named disciplines, developed to ensure that resources are used more effectively and that appropriate prioritization of maintenance effort is occurring.
Operations Maintenance Coordinator	OMC	The Operations Maintenance Coordinator is a member of the Operations department who is responsible for safety and environmental performance, overall unit production, and cost. The OMC's primary focus is the overall effectiveness of the maintenance process and the interface between Operations and Maintenance.
Predictive Maintenance	—	Similar to preventive maintenance but differs in that some form of equipment condition monitoring (such as a vibration check on a pump) is used to project the approaching need for maintenance.
Pressure Equipment	—	Process equipment designed to retain internal and/or external pressure from process conditions or hydrostatic loads (liquid levels in storage tanks)
Pressure Equipment Inspection	PEI	Inspection of pressure equipment and pressure relief devices according to appropriate inspection codes. Also, the name of the DCR department group responsible for conducting and/or scheduling such inspections.
Pressure Relief Protection Device	—	Mechanical devices that prevent process equipment from exceeding its design internal pressure or vacuum rating.
Pressure Safety Valve	PSV	A pressure relief protection device used primarily on pressure vessels and piping.

6. GLOSSARY (cont'd)

TERM	ACRONYM	EXPLANATION (as required)
Pre-startup Safety Review	PSSR	A PSM program element, often completed in conjunction with MOC. PSSR requires changes to be implemented as designed and requires confirmation that the required safety considerations have been addressed before the modified process or equipment is started up.
Preventive Maintenance	—	Routine maintenance activities, such as lubrication, intended to maintain equipment in an operable condition.
Proactive Work Orders	—	Work orders issued to accomplish predictive, preventive, or RCM maintenance tasks.
Process and Instrumentation Diagram	P&ID	An engineering drawing (blueprint) showing major pieces of equipment, interconnecting piping, and instrumentation systems.
Process Hazard Analysis	PHA	A formalized review of the process design, equipment, and procedures intended to identify the potential causes of process upsets, evaluate their significance, and propose additional protective features, where warranted.
Process Safety Initiative	PSI	PISs are programs, jointly developed by SOPUS and Motiva, to enhance the implementation of certain safety-critical tasks.
Process Safety Management	PSM	The application of management principles, methods, and practices for the prevention and control of hazardous chemicals or energy. OSHA's PSM standard requires the implementation of 14 management system elements addressing topics such as MI, MOC, PSSR, operating procedures, training, etc.
Process Safety Management Standard	—	OSHA's chemical accident prevention regulation, 29 CFR 1910.119. Primarily focused on worker protection.

6. GLOSSARY (cont'd)

TERM	ACRONYM	EXPLANATION (as required)
Protective Instrument System	PIS	PISs are instrument systems that prevent damage by automatically correcting deviations from process conditions known to be a threat to the protection of people, the environment, or the assets.
Reactive Work Orders	—	Work orders written on an as-needed basis to address the failure of a piece of equipment, or other deficient condition.
Recognized and Generally Accepted Good Engineering Practices	RAGAGEP	Commonly recognized practices for the design and maintenance of facilities and equipment, often documented via industry codes, standards, and recommended practice documents.
Reliability and Maintenance Process System	RAMP	DCR's new program for risk-based prioritization and scheduling of maintenance activities.
Reliability-centered Maintenance	RCM	A maintenance initiative that goes beyond just repairing what it broken. RCM addresses the basic causes of equipment failure in an effort to reduce the frequencies of failure and, consequently, improve the reliability of the equipment.
Relief Valve	RV	See Pressure Safety Valve
Retirement Thickness	—	The thickness of the pipe used to identify concerns for integrity considering both pressure and external loads. The retirement thickness is a conservative value that provides time for further evaluation of the extent of the concern and planning for mitigation.
Risk Management Program Rule	RMP Rule	EPA's chemical accident prevention rule, 40 CFR Part 68. The RMP rule overlaps the requirements of the OSHA PSM standard, but extends the focus to include protection of the public and the environment.

6. GLOSSARY (cont'd)

TERM	ACRONYM	EXPLANATION (as required)
Root Cause	—	A basic cause of a process incident for which other, more basic causes cannot be identified. Root causes are often failures of management system elements.
Safe Work Practices	SWP	Various procedures intended to safely control the implementation of a number of potentially hazardous work tasks. SWPs address topics such as: "hot work" (the use of flame or spark-producing tools in areas where flammable atmospheres may exist), "confined space entry" (access by personnel to areas where hazardous conditions may exist and from which escape may be difficult), and "lockout/tagout" (isolation of equipment from sources of hazardous chemicals or energy in preparation for maintenance activities).
Safety Integrity Level	SIL	A classification of the integrity (i.e., reliability) of a PIS. ISA Standard S84.01 describes three discrete safety integrity levels that are defined in terms of the probability that the PIS will fail to provide its protective function when called upon to act.
Shell Oil Products-United States	SOPUS	—
System, Application, and Products	SAP	A software program that DCR will use to monitor maintenance activities and records.
Triangle of Prevention	TOP	A formalized incident investigation protocol developed by the Paper, Allied-Industrial, Chemical and Energy Workers International Union. TOP includes a methodology for the identification of root causes.
Turnaround	—	An extended, typically scheduled, process unit shutdown, during which maintenance and inspection tasks are accomplished.

6. GLOSSARY (cont'd)

TERM	ACRONYM	EXPLANATION (as required)
Vacuum Relief Protection Device	—	A pressure relief protection device that protects pressure equipment from vacuum conditions. These devices are primarily used on storage tanks.
Washington Group International	WGI	The primary maintenance contractor at DCR.

Appendix A: Specific Observations, Concerns, and Recommendations

This section provides topical descriptions of ABS Consulting's observations from the evaluation. Where there were concerns, these are described along with recommended means for addressing the concerns. The recommendations are only suggested means for addressing the concerns, and other effective means of resolving the concerns may be identified later.

ABS Consulting has provided a suggested priority ranking for the recommendations, shown in brackets at the end of each recommendation (e.g., [Priority 1]). The bases for the priority rankings are defined as:

Priority 1: Recommendations that have the greatest potential for increasing the effectiveness of the Mechanical Integrity program and reducing the risk of potentially serious safety or environmental incidents.

Priority 2: Recommendations that would further improve the effectiveness of the Mechanical Integrity program and reduce the risk of less serious safety or environmental incidents (compared to Priority 1 items).

Priority 3: Recommendations addressing gaps in the Mechanical Integrity program that should be addressed but have lowest risk of safety or environmental consequences.

A-1. PRESSURE EQUIPMENT INSPECTION

BACKGROUND

Staffing. The DCR has an active and growing Pressure Equipment Inspection (PEI) Department. The PEI Department is responsible for conducting the inspections and maintaining the inspection records for pressure vessels (including heat exchangers and drums), process piping, relief devices, storage tanks, and storage spheres. During the last few years the number of written inspection reports has grown steadily; for example, the number of reports written to date this year exceeds the total number written during all of 2001. This increase is caused, in part, by an enhanced emphasis on the inspection of tanks, external inspections of pressure vessels, and piping inspections.

The number of DCR inspectors has increased over the last several years in recognition of the need to meet all inspection code requirements for the frequency of equipment inspections. Each process area now has a dedicated unit inspector responsible for all of the inspection activities in that unit. The unit inspectors have the appropriate American Petroleum Institute (API) and state of Delaware inspector certifications, and new inspectors are in various stages of training to receive their certifications. Appropriately qualified personnel are assigned to conduct equipment inspections. In addition, Motiva/SOPUS provides experienced inspectors from its other refineries for periods of high inspection activity. SOPUS also has extensive training classes that prepare inspectors for the API certification examinations and in other relevant technical material.

A metallurgist with extensive refinery experience is part of the PEI Department, and two mechanical engineers are working with the piping inspection program. These personnel provide technical support for the inspection activities. ASME pressure vessel code calculations for inclusion into pressure vessel design, alteration, or repair documentation are provided by a technical services organization within WGI. While WGI personnel handle the day-to-day technical management of the welding activities, the DCR PEI Department is ultimately responsible for all welding occurring in the refinery. These activities are extremely well executed, and the WGI personnel are exceptionally qualified to manage the quality control of the welding.

Inspections for all types of equipment are documented via written inspection reports that are given a unique identification number (a two-digit year code combined with a sequential number). Separate numbering and filing systems are maintained for routine inspection reports and the inspection reports generated during scheduled maintenance turnarounds. Each inspection report is intended to be independently reviewed and approved by the inspection supervisor, or designate, certified for the type of equipment inspected. Following approval, each report is filed sequentially in hard copy within the PEI Department for easy reference. Reports are also scanned into an electronic document management system that allows search and retrieval of the reports associated with a piece of equipment. Inspection reports previous to the electronic document management system are available through both a hard copy and a microfiche system.

Pressure Vessels. A senior inspector reviews each pressure vessel's inspection report, and relevant information is entered into a spreadsheet containing a written summary of the vessel's condition, the thickness readings, and any recommendations for long-term or turnaround inspections or repairs. This information provides the technical basis for conducting the pre-turnaround planning risk analysis to determine whether the equipment is to be inspected or repaired during a maintenance turnaround, or deferred until a later date. Based on review of the inspection report and in consideration of the inspector's recommendations, the senior inspector should establish inspection intervals, which are maintained in a spreadsheet documenting the scheduled dates for internal and external inspections, for each pressure vessel. The inspection schedules are established according to the guidance in the appropriate API inspection codes. ABS Consulting noted that, with few exceptions, all vessels are scheduled at the maximum interval permitted in the codes.

The DCR is attempting to complete external visual inspections for all pressure vessels by the end of 2002 in accordance with API-510, *Pressure Vessel Inspection Code*. These inspections have not traditionally been conducted in accordance with the API-510 schedule requirements. Consequently, around 30% (September 2002) of the vessels are shown to be past due for external inspection because there is no previous inspection history.

Currently, the DCR does not separately schedule on-stream thickness measurements based on corrosion rate calculations – even though, if the need for thickness measurements is suggested by corrosion concerns, common industry practice would require that these measurements be reflected in the internal inspection interval. API-510 allows on-stream thickness measurements in lieu of internal inspection under certain conditions, if the inspections are appropriate to determine that the essential elements of the vessel are suitable for continued service. This was the case for several vessels noted on the inspection schedule.

An inspection report for vessel 32-D-3 (June 2000) noted that, because of measured corrosion, a follow-up thickness monitoring inspection was recommended for the next turnaround (5 years later) in order to calculate a corrosion rate. Without previous thickness data, no corrosion rate could be calculated at the time that the inspection report was prepared. Yet, in spite of this lack of information, the vessel was given a 10-year internal inspection interval. This inspection report is an example of the inconsistent technical review of inspection reports observed at the DCR. The lowest thickness readings in one particular location on the vessel were slightly above the nominal required thickness (supplied thickness minus the corrosion allowance), yet no calculations were done to confirm the true minimum thickness requirements for the vessel. The inspector, with the available information, could not have known whether the corrosion was a short-term or long-term phenomenon. This calls into question the validity of the suggested 5-year interval, and it makes the 10-year interval technically unsupportable.

In addition, significant corrosion issues in this process unit occurred in late 2001, continuing through the spring of 2002, with several leak failures in a section of large diameter piping. The problems became severe enough to prompt a unit shutdown for repairs to this line. During this time, an analysis of the corrosion problem identified several areas for inspection – noting one of the reasons to be the "aggressive corrosion in 32-D-3" found during the last turnaround (June 2000). However, no thickness inspection of 32-D-3 was performed to confirm the corrosion rate or integrity of the vessel, even when piping from the vessel was inspected and corrosion was found.

The scheduling issues noted previously, and the issues associated with 32-D-3, reinforce concerns about the efficacy of the process for inspection report review, the coordination of the piping and vessel inspection activities, the use of inspection history for inspection planning, and the usefulness of the existing inspection schedules. Good inspection practice would likely have recommended a thickness monitoring inspection for 32-D-3 (as a follow-up to the June 2000 inspection) in about 6 to 18 months to determine whether the problem was a continuing short-term high corrosion rate phenomenon or an episodic situation. An inspector familiar with the equipment and its history should have specified that thickness measurements be taken during the unscheduled shutdown, with or without an inspection schedule.

The suction and discharge pulsation bottles on many of the hydrogen compressors within the refinery have only recently been actively included in the vessel inspection program (this is not a unique situation in the refining industry – many refineries have only come to realize the significance of these vessels within the last 5 years). As a consequence, these vessels – as well as a number of vessels primarily in low-risk utility or lube oil service – do not have extensive inspection histories. There are about 20 vessels in hydrocarbon service (out of ~1,200) that are either past due for internal inspection or have no prior internal inspection due date. The majority of these vessels, including several in service since 1956, have no documented inspection history or recorded inspection date subsequent to their construction. Nonetheless, all have a 10-year maximum interval listed as their inspection interval. Turnaround records indicate multiple opportunities to complete these inspections. Several vessels are in Unit 25, which was started up with a planned 5-year run even though it contained vessels having no inspection history. One vessel was scheduled for internal inspection 2 years into the planned run length and is now past due.

The DCR conducts special emphasis, or refining industry-recognized, inspections, such as those for wet hydrogen sulfide cracking using SOPUS's inspection guidelines. The technical planning and scheduling of these inspections are part of the senior inspector's responsibilities.

Atmospheric Storage Tanks. Another inspector is assigned responsibility for storage tank inspections. He maintains a spreadsheet for tank inspection information and inspection schedules for internal, external, thickness monitoring, and civil (tank foundation) inspections. It is this inspector's responsibility to establish dates for the required inspections in accordance with API-653, *Tank Inspection, Repair, Alteration and Reconstruction.* Completed inspection reports for tanks are intended to be independently reviewed and approved by the inspection supervisor, or designate, certified for the type of equipment inspected.

A recent initiative of the tank inspector is a program to identify and provide a unique equipment number for the vacuum and pressure relief protection devices on atmospheric storage tanks. In addition, the condition of these devices is now being documented as part of the tank's external inspection. The documentation is a checklist devised by the DCR personnel and is currently filed in the tank inspector's files.

Tank repairs are managed through the tank program coordinator position in the Turnaround Maintenance Organization. Discussions with the tank inspector and a review of the tank inspection data indicate that the DCR has a reasonable technical basis for its plan to complete mandated tank inspection obligations and to meet the ongoing requirements of the recommended schedules published in API-653, *Tank Inspection, Repair, Alteration, and Reconstruction*.

Relief (or Pressure Safety) Valves. An inspector is responsible for managing the relief valve inspection information. He maintains a spreadsheet with schedule information, as well as a file for each valve that contains copies of the previous relief valve inspection and test reports. The relief valve records indicate that the DCR is currently up to date with its inspection and test schedules. Two DCR standing orders address the scheduling, inspection, and testing of pressure relief devices, but these orders specifically exclude vacuum and pressure relief devices typically found on storage tanks (however, it was noted that relief devices for several atmospheric storage tanks were listed on the relief valve spreadsheet).

The DCR is in the process of installing dual relief valves, with isolation capabilities, on some vessels for which scheduling shutdowns is particularly difficult. This is intended to aid in making relief valves available for testing and inspection and should help ensure future schedule compliance.

Recommendation Tracking and Resolution. While many of the issues currently being identified by the equipment inspection activities have long-term integrity implications and many may have low consequences if not completed, all involve adherence to good engineering practice. In addition, equipment integrity concerns requiring immediate resolution also continue to be identified by both planned and reactive inspection activities. For these reasons, tracking recommendations to a timely resolution is an important adjunct to the pressure equipment inspection function.

Recommendations from inspection reports have been tracked using the FERRET software database since about the third quarter of 2001. The recommendations from each inspection report are entered into the database by the FERRET coordinator, and lists of open recommendations are then distributed weekly by e-mail to predesignated individuals on the operations-maintenance work teams responsible for planning and execution. The use of FERRET for disseminating PEI recommendations to appropriate individuals, and for tracking follow-up, has made improvements in the accountability and assurance of timely completion of PEI recommendations. Prior to FERRET, approved inspection reports with recommendations were sent to the appropriate operation department's unit supervisor for disposition.

A distinction must be made between those inspection recommendations for which firm completion due dates are established in FERRET, and those recommendations that are left open-ended. As discussed elsewhere in this report, recommendations without firm due dates will be less likely to be worked under the new RAMP maintenance prioritization system. There are a large number of open recommendations currently outstanding. Although many address issues such as equipment painting and insulation repair, there are also a significant number of recommendations for more time-critical tasks, such as piping replacement. This raises the concern that a task with no specified due date may be overlooked, or implemented later than required, increasing over time the likelihood of an incident related to the uncompleted task. Management emphasis has very recently been heightened to require that appropriate dates for completion are specified for each inspection report recommendation.

A related issue occurs where recommendations are made to perform an inspection or make a repair "at the next turn-around." Implicit in the recommendation is an assertion that the inspection or repair can be deferred to the date of the turnaround, as scheduled at the time the recommendation is made. However, scheduled turnarounds are occasionally delayed (common in the refining industry). The Motiva/SOPUS turnaround planning guideline does not contain a specific section describing how to conduct a turnaround deferral analysis. The current practice at the DCR is to hold a meeting with appropriate representatives and review the work scope to determine that the decision to change the schedule is technically sound. A defined, documented process for conducting and documenting a turnaround deferral decision should be included in the turnaround planning guidelines in order to be consistent with the fact-based decision-making climate being instilled at the DCR.

SOPUS Influence on the Inspection Program. The PEI technical discipline at the DCR is another area where SOPUS's influence has had, and should continue to have, positive outcomes for the DCR. SOPUS conducts periodic reviews of PEI activities within its refining system to ensure compliance with corporate and inspection code requirements. The DCR received such a review in July 2001, with a follow-up review in December 2001. The DCR indicates that it is working to resolve the action items from these reviews.

ABS Consulting sought an opportunity to review the findings of the July 2001 and December 2001 reviews; however, at the request of the DCR, ABS Consulting agreed not to pursue the review at this time in order to ensure the objectivity of our evaluation. The DCR did, however, share the identities and qualifications of the SOPUS team members. Based upon past personnel experience with key members of the SOPUS team and with the review process, ABS Consulting has confidence in the anticipated content and thoroughness of the July 2001 and December 2001 reviews.

SOPUS has extensive technical guidelines for managing and conducting equipment inspections, and these are available to the DCR for use. For example, the SOPUS *In-service Piping Inspection Guideline* is being used to conduct the DCR piping inspection effort. However, this guidance has not been codified into a site-specific piping inspection procedure. Furthermore, the DCR standing instructions do not include site-specific equipment inspection procedures for pressure vessels or atmospheric storage tanks. Site-specific inspection procedures would standardize the practices at the DCR, as well as serve as references and training guides for new inspectors. Currently, as a recent awareness initiative, the PEI Department is requiring each inspector to periodically read a different SOPUS inspection guideline.

The SOPUS inspection database software will be introduced at the DCR during the last quarter of 2002. This software will provide the capability to perform corrosion rate scheduling for pressure vessels.

CONCERNS BASED ON OBSERVATIONS

1. Recent inspection data for the compressor bottles have indicated a problem with internal and external corrosion, requiring the replacement of several of these bottles. This inspection activity has provided the PEI inspectors opportunities to make wall thickness calculations and corrosion rate calculations as part of their inspection reports. Our review of selected inspection reports for these compressor bottles (and other inspection reports) prompts our conclusion of inconsistent technical rigor in the preparation and the review of the inspection reports. The questionable technical issues noted represent deviations from good engineering and inspection practices. The issues noted in some of the reports examined for equipment 37-D-16 A, B and C; 29-D-98, 29-D-93 and 94; and pipe spool 23-16-O-57A are:

    - An inspection report showing inspection corrosion data from a similar vessel's report that were not relevant to the current report

    - An inspection report with the wrong vessel design pressure rating data

- Inspection reports with erroneous minimum thickness calculations or reporting erroneous results

- An inspection report with an unrealistically low required thickness value listed that resulted from a "minimum thickness calculation" made using operating conditions without a reference to the thickness requirements for the design conditions

- An inspection report that did not list the lowest thickness value determined during the inspection (the correct value was subsequently learned during an interview)

- A series of sequential inspection reports for a vessel that were not peer reviewed

- Three heat exchanger shells noted with "severe external corrosion" without characterization of the depth or extent of the corrosion, or a conclusion as to whether the corrosion represented an immediate concern (report contained a recommendation to prepare the shells for further inspection, but no due date was established)

- A July 2001 inspection of 37-D-1B did not reveal the extensive external corrosion that existed around the entire top head weld seam. While the July 2001 inspection was an internal inspection, the thickness measurements taken should have detected the extensive external wall loss and prompted an external inspection. The vessel, at that time, did not have documentation of any previous external inspection. A subsequent inspection (2 months later) of the companion vessel 37-D-1A did locate significant external corrosion in this same area, requiring extensive weld repairs to the vessel. As a follow-up to the findings on vessel 37-D-1A, an external inspection was scheduled for 37-D-1B, to be completed within 90 days after the repairs to 37-D-1A allowed it to be returned to service. However, the recommended external inspection of 37-D-1B was not started until 9 months following the repairs to 37-D-1A. In spite of its questionable status, 37-D-1B had been given a 10-year internal inspection interval based upon the July 2001 inspection

These questionable situations did not lead to legacy equipment integrity issues because, in each case, the equipment will be replaced in the near future, or the questionable practice led to a very conservative conclusion about the status of the equipment. The concern is that, with the current inspection report review system, it is possible that these types of practices could also lead to nonconservative assumptions and decisions about the suitability of a pressure vessel or piping component for continued extended service.

2. Examination of inspection recommendations in the FERRET database revealed numerous examples of external inspections that were not completed because additional maintenance was required to gain access to the vessel's surface (e.g., building scaffolding and removing insulation). The inspection schedule, without qualifying comment, establishes the next periodic inspection date without consideration of the final results of the complete current inspection. In addition, one vessel was noted with an external inspection completion date listed on the schedule as having been performed in the month after the schedule was printed. These issues suggest (a) insufficient technical rigor and a perfunctory process for establishing inspection intervals and (b) that the inspection schedule for some vessels may not adequately reflect the condition of the vessels.

3. As stated previously, a review of the pressure vessel inspection schedule indicates process vessels that are past due for internal inspections or have no inspection history. This prompts doubts about the efficacy of a management system that has allowed these vessels to be listed with a 10-year inspection interval for extended time periods, with no inspection history or actual scheduled inspection date.

4. It was observed in the FERRET database that many routine inspection recommendations have no required dates for completion. While recent management emphasis has improved this situation, examples still exist, including numerous recommendations for piping spool replacement and recommendations for painting, cleaning, insulation repair, and preparing for external inspection. It was observed that, out of 20 piping replacement recommendations without a due date selected from the FERRET list printed in May, only 4 were shown as having been completed on a FERRET list printed in July. In addition, there was no change in the recommendation status for the other 16, such as a notation of importance or risk assessment to guide maintenance planning.

5. The large and growing number of inspection recommendations raises a concern about whether recommendations without a required completion date will be appropriately addressed within the routine work planning process. For example, during the team's first site visit, numerous references were made to organized painting plans to address the myriad of painting recommendations, but none have currently been completed.

6. During a review of recent equipment inspection reports, it was observed that there are references made to open recommendations from inspection reports that predate the implementation of the FERRET database. It was also noted in an incident investigation (May 2000) concerning a propane release that an inspection recommendation from 3 years previously (May 1997) was not followed, and no follow-up inspections were conducted in

the interim. This illustrates that there are unresolved pre-FERRET inspection recommendations that can have long-term equipment integrity consequences.

RECOMMENDATIONS

1. Improve the PEI management system for reviewing the inspection reports to ensure complete and appropriate content of the reports, accuracy and appropriateness of all referenced calculations, and assignment of recommendation completion dates. [Priority 1]

2. Improve the PEI management system to ensure that equipment inspection schedules accurately reflect the current equipment condition, as well as any recommendations of the inspectors. Ensure that each piece of overdue equipment has an appropriate inspection plan and a documented technical basis for continued service-pending inspection. In addition, ensure that each inspection report makes appropriate references as to whether the results of the current inspection affect the timing of the next scheduled internal, external, or thickness monitoring inspection. [Priority 1]

3. Implement a process to ensure that pre-FERRET PEI recommendations have been or will be appropriately resolved. [Priority 1]

4. Provide required completion dates for currently unscheduled FERRET PEI recommendations, including painting recommendations, based on equipment condition criteria or other appropriate factors, such as a risk evaluation. [Priority 2]

5. Revise the turnaround planning guidelines to include a process for conducting and documenting a turnaround deferral decision. [Priority 3]

A-2. PIPING INSPECTIONS

BACKGROUND

Piping inspections have been performed periodically since the refinery was constructed, but not on an organized, scheduled basis. Currently, *ad hoc* piping inspections are conducted by the unit inspectors in reactive response to problems or based upon the individual inspector's judgment. The DCR is currently implementing an extensive piping inspection program using SOPUS's piping inspection guidelines. The technical content of the piping inspection program is comprehensive, and progress is being made toward its implementation. Once in place, the program should ensure a regular proactive approach to piping inspection, with a greater percentage of the inspections performed in accordance with corrosion rate or time-based schedules projected based upon prior inspection data, rather than in reactive response to problems.

Currently, the DCR uses a commercial inspection database management software package, which is widely used throughout the process industries, to record the results of the inspections and to schedule the next inspection. The DCR intends to replace this with SOPUS's software during the last quarter of 2002.

The DCR is implementing the piping program within each process unit ahead of the turnaround planning process for that unit. In this way, replacement or inspection issues can be addressed during the turnaround. This implementation schedule suggests a multiyear time frame to complete all of the refinery's process units. The implementation plan does not specifically address unit interconnecting piping located in the refinery's pipe racks.

Due to the extensive activities and large amount of preparatory work required in establishing a piping inspection program, the initial piping inspection activities associated with the new program are being handled outside the unit inspectors' day-to-day activities by contract inspectors with oversight by a Motiva engineer. When the inspections are completed and properly documented, the information is passed to the unit inspector who then assumes the responsibility for conducting routine, ongoing external visual and thickness monitoring inspections according to the schedule.

There is a separate dedicated effort being made to complete an injection point inspection program by the end of 2002. This is an industry-recognized special emphasis piping inspection activity discussed in API-570, *Piping Inspection Code*. Progress is being made toward an on-schedule completion of this work. Other concerns that have been identified and are being addressed in a reactive fashion include corrosion of the bottom side of the rack piping where it contacts pipe supports and dummy support legs and corrosion under insulation.

CONCERNS BASED ON OBSERVATIONS

7. The piping inspection program for the DCR refinery should already have been fully implemented, and the refinery should have accumulated an extensive piping inspection history, including that for interconnecting piperacks. In our opinion, the lack of completeness of the piping inspection program, coupled with the apparent condition of the piping noted by the numerous external corrosion problems, represents one of the most significant issues with respect to the prevention of a loss of containment event.

8. While there are areas of the DCR with internal corrosion problems, in many cases reactive inspections are required due to external corrosion caused by wet and damaged insulation (corrosion under insulation), installation of temporary insulation blankets that remain in place for extended periods of time (likely without an MOC to ensure subsequent removal), or water and steam leaks that keep the piping and insulation wet. Delays in making needed utility service leak repairs, painting piping, and repairing or replacing insulation exacerbate this problem.

9. Where established inspection schedules have been generated from existing data in the inspection database, they are not being consistently accessed by the inspectors. Past-due inspections are noted in the records; some with thickness values below the suggested retirement thickness. In some cases, apparent corrosion trends may result from anomalous data (e.g., measure thickness less than the actual thickness of the pipe) and may not represent actual integrity concerns. Nonetheless, such issues should be resolved by the published inspection due date.

10. The piping thickness measurements taken by inspectors during the *ad hoc* or reactive inspections are not being consistently entered in the inspection database for data retention and corrosion rate and scheduling calculations. In one recent case involving large-diameter low-pressure piping, a corrosion pattern was noted over several years that resulted in numerous leaks, application of repair clamps, line replacements, weld repair, and multiple inspections. The thickness data were not entered into the inspection database even though piping inspection drawings and thickness monitoring locations had been previously identified.

RECOMMENDATIONS

6. Continue the implementation of the SOPUS-based piping inspection program. Explore ways to accelerate the rate of implementation of the program. Include appropriate pipe rack piping in the inspection program. [Priority 1]

7. Improve the work process for (a) repairing utility service leaks that are noted on inspection reports that create external corrosion environments, (b) accelerating the removal of temporary insulation, (c) making repairs to insulation, and (d) painting, in order to mitigate the existing corrosion environment and to arrest the external corrosion. [Priority 1]

8. Ensure that inspectors comply with the inspection schedule generated by the inspection database software. [Priority 1]

9. Ensure inspectors record in the inspection database appropriate thickness data for the results of all piping inspections (both scheduled and reactive) and that they use the database to capture inspection dates either set by the inspector or based upon corrosion rate calculations. [Priority 2]

A-3. MI PROCEDURES AND TRAINING

BACKGROUND

The majority of routine maintenance personnel within the DCR are Motiva and WGI craftsmen. Motiva has machinery repair, instrument, and electrical personnel, while WGI provides welders, metal trades (boilermakers and pipefitters), insulators, scaffold builders, and carpenters. WGI uses journeymen and apprentice craftsmen provided through the local labor unions. WGI (or previous corporate entities) has worked within the refinery since the refinery was built in 1956. Many WGI employees have long tenure working at the refinery, and some are included as key supervisors on the DCR's newly formed operations-maintenance teams. A long-term relationship, such as WGI's at the DCR, is not uncommon within the process industries, and it usually results in a knowledgeable and experienced workforce within the facility.

Written procedures and training affected personnel in the content of the procedures, coupled with an emphasis to follow the procedures in practice, are essential elements of a hazard management system. Requirements for written procedures to maintain the ongoing integrity of process equipment are included in OSHA's PSM standard. A review of the DCR's standing instructions and interviews with maintenance management, maintenance supervision, craftsmen, and engineering personnel from the technical disciplines indicate that there are few standing MI procedures approved for use within the DCR, and the existing standing instructions do not cover all aspects of equipment inspection and maintenance repair activities for all types of equipment. The standing instructions do cover the repair of the most common pumps fairly extensively, including having diagrammatical repair data sheets. Interviews with the DCR personnel revealed numerous references to the DCR practices, industry and SOPUS best practices documents, and procedures currently in draft form (several resulting from incident investigation recommendations), but few of these are site-specific procedures codified for use at the DCR. The response to complete written procedures recommended in incident reports has not been timely.

The DCR standing instructions require, consistent with industry practice, that data sheets be completed to document the results of machinery repairs. Some interviewees indicated concern with respect to inconsistent completion of the data sheets returned for archiving.

The DCR has recently hired experienced machinery repair craftsmen and instrument technicians. Initially, these personnel are assigned to work with experienced Motiva personnel for a familiarization period before being allowed to work independently within the refinery. Training for Motiva personnel typically consists of attending schools for specific process equipment repairs (such as a type of compressor or instrument) and training by vendors on specific diagnostic devices or tools needed to conduct their work (such as laser alignment and vibration analysis).

A recent change to improve the reliability of the rotating equipment (pumps, gas compressors and blowers), which constitutes a large portion of the backlog and current maintenance expense, has been the creation of two new roles associated with the operation and maintenance of rotating equipment. These are the machinery specialist and the operations machinery specialist. The machinery specialist's role is to (1) provide expertise in response to problems identified either by the RCM process or during repairs and (2) perform specialized diagnostic tests. The operations machinery specialist works with an operating department to (1) improve operating skills associated with starting up and shutting down equipment and (2) communicate special concerns to the operators about the machinery based upon its condition. Three teams, each with one machinery specialist and one operations machinery specialist, have been formed and have been assigned to specific process units. In our experience, these are unique positions in the industry and should help focus resources to improve machinery reliability and reduce maintenance costs.

The recently introduced PSIs have elements that require the implementation of a proactive RCM system and a technical management system for protective instrument systems (PISs). The PIS and RCM initiatives are both in the very early stages of implementation. The overall intent and scope of these initiatives being planned for the DCR are well-above average for the refining industry.

An RCM system is a comprehensive approach to asset management that uses the results from detailed analyses of potential equipment reliability problems to develop specific proactive and preventive tasks to improve the reliability of the equipment and to prevent failures. The RCM process defines equipment-specific reliability (preventive maintenance) tasks for operators, machinery specialists, and craftsmen. This entails creating the repetitive predictive/preventive maintenance work orders in the maintenance management computer system and creating the operator tasks, which are scheduled and monitored in a separate computer system. Identification of the RCM tasks has been completed for several process units, and the defined tasks are beginning to be conducted.

PISs are instrument systems that prevent damage by automatically correcting deviations from process conditions known to be a threat to the protection of people, the environment, or the assets. The PIS initiative requires the development of written procedures to manage the overall program and loop-specific procedures for testing the PIS. The system management procedure is in final draft form, and draft loop-specific procedures have been developed for one process unit. These procedures should have been completed previously. Interviews and a review of the documentation of PIS testing from the recent SRU-1 and SRU-2 turnarounds reinforce the need for the structure and discipline imposed by these procedures. The current testing practices likely completed all of the work as it is known but, as evidenced by these results, the results were not adequately documented. According to best practices, as reflected in the draft of the PIS procedure, the results of the PIS function tests for the SRU units should have indicated the as-found and as-left condition of the PIS.

Motiva/SOPUS has developed a methodology for using LOPA for identifying instrument systems required to be treated as PIS and for determining the required SIL for the PIS in accordance with the requirements of ISA Standard S84.01.[3] This methodology is being implemented at the DCR. In some cases, what is learned from LOPA will identify additional RCM tasks to be performed or will require changes in the PIS procedures to ensure the validity of the LOPA.

CONCERNS BASED ON OBSERVATIONS

11. The written MI procedures for the DCR should have been completed, covering equipment inspection, equipment reliability, and maintenance craft skill and equipment repair activities. Craft skill procedures are those required to ensure consistent performance to the DCR requirements for specific activities that are used repeatedly in many repair or testing activities. Examples of these include: gasket installation, bolt torquing for high-pressure applications, machinery alignment, machinery balancing, valve repair, and instrument calibration. Such procedures are especially important for craft training purposes.

12. The need for written procedures and attendant training is emphasized by the DCR incident investigation recommendations. Data from the DCR incident investigations in 2000 and 2001 indicate 24 recommendations (about 6% of the total) for maintenance procedures and 32 recommendations (7.5 % of the total) for the training of maintenance crews. Notable among these recommendations are (a) the identified need for written procedures to cover the craft skill of gasket installation and bolt tightening for high-pressure applications (assigned to WGI group for development), (b) the frequent activity of temporary leak repair, and (c) the essential incident prevention activity of protective instrument testing. In addition, a new written procedure, which as interviews indicated, codifies an acceptable existing practice for the hazardous activity of hot tapping, is in draft form. The specific procedures listed above, given the regulatory impetus from PSM, should already have been in place.

13. Current operating procedures require that, on a monthly basis, unit operators take machinery vibration readings for analysis by the reliability engineers. These activities have not been regularly performed as intended (e.g., for the first quarter of 2002 only about 45% of the process units had completed their vibration surveys). The nature of this activity will change to a regimen of less data-intensive, but more frequent, evaluation of the machinery as the RCM process is implemented throughout the refinery. In addition, the controls built

[3]LOPA is an industry-recognized analytical technique for evaluating the protections provided to prevent an undesired event and for determining the degree of additional protection required as a function of the risk posed by the event. ISA Standard S84.01 provides guidance for the design of protective systems to ensure their reliability is commensurate with the risk of the event against which protection is sought.

into the RCM data-gathering process should ensure that these activities will be completed and reviewed for follow-up action by the conclusion of each shift.

14. An implicit requirement in the implementation of a viable written repair or testing procedure is the need for accurate equipment data and repair histories that are accessible by the persons performing the work. The equipment information for instruments and machinery is located in various files and databases within the DCR. Some concern was expressed during interviews of the validity of the information located in the disparate databases, especially for the instrument data. While there are efforts underway to reconcile these sources of information into a single file location for the machinery and into a common and validated instrument index, the potential exists in the interim for incomplete or inaccurate information to be used in procedure development, maintenance, or inspection and testing decisions associated with these types of equipment.

15. Based upon interviews, it is not clear that a system has been established to ensure the coordination of the LOPA results with RCM planning and PIS procedure writing. This coordination is essential because each of these activities is occurring for different process units simultaneously.

RECOMMENDATIONS

10. Develop a schedule to identify and complete DCR-specific written MI procedures for equipment, including, but not limited to, PIS testing, equipment inspection, equipment reliability, maintenance craft skills, and equipment repair activities. Ensure that written maintenance procedures developed or used by WGI are consistent with the DCR engineering standards. [Priority 1 for PIS testing procedures. Priority 2 for all others]

11. Train affected craftsmen and related personnel in the craft skill and PIS procedures prior to implementation. [Priority 1 for PIS testing procedures., Priority 2 for all others]

12. Maintain existing vibration analysis monitoring activities in each unit until the RCM program is implemented. [Priority 2]

13. Implement the means to ensure that what is learned from LOPA is properly reflected in the RCM tasks and the PIS procedures. [Priority 2]

14. Ensure that machinery repairs are documented as specified in the existing and future repair procedures. [Priority 3]

15. Complete the reconciliation and validation of the common instrument index data and the creation of the common machinery equipment files. [Priority 1 for the instrument index. Priority 3 for the machinery files]

A-4. MAINTENANCE PRIORITIZATION AND BACKLOG

BACKGROUND

Backlog. Beginning early in 2001, the backlog of requested maintenance tasks, as reflected by the total person-hours estimated for completion, began to grow, doubling from about 100,000 hours to about 200,000 hours by year-end. ABS Consulting did not investigate the cause of this growth, and focused, instead, on evaluating the programs intended to reduce and control this backlog in the future. (ABS Consulting understands that one factor in the increase was the dedication of additional resources for planning work, which allowed assigning estimates of the person-hours required to complete work requests that were in the system but were not previously planned and estimated.)

Operations maintenance coordinators (described below) are in the process of reviewing the maintenance backlog and closing work orders for work that has been completed or that is no longer required. In addition, there are many duplicative work orders that must be eliminated from the system. Interviews with operators and first-line supervisors confirmed that writing multiple work orders over a period of time has been a common practice for emphasizing the importance of a particular requested task.

New initiatives, described below, have been implemented to increase the productivity of the maintenance function. At the same time, the amount of work to be done will likely increase, at least in the near term. For example, as equipment and piping inspection programs are broadened, new work will be identified. Legacy tasks, not currently in the backlog, will likely be added as remedial programs address matters such as working off the PHA recommendation and inspection report recommendation backlogs. In fact, in spite of the effort to reduce the backlog, the total number of open work orders for the refinery as a whole has trended down only slightly since the first of this year (it is recognized that some of these new work orders cover RCM tasks that are assigned to the new machinery specialists and, thus, do not represent an increase in backlog for the traditional craft groups). The percentage of work orders over 90 days old has remained essentially constant.

Organizational Changes. Earlier this year (2002), the DCR reorganized its maintenance coordination function around the concept of the OEMI team. In doing so, the DCR sought to stimulate better liaison and coordination among these four functions, to ensure that resources were used more effectively and that appropriate prioritization of effort was occurring. These cross-functional teams provide a forum for more informed dialogue around issue resolution.

Two new functions were created as part of this initiative: the operations maintenance coordinator (OMC) and the maintenance team leader (MTL). The OMC reports to the operations unit supervisor (US) and has the following role, as defined by the DCR:

> "The Operations Maintenance Coordinator is a member of the Operations department that is responsible for safety and environmental performance, overall unit production and cost. The OMC's primary focus is the overall effectiveness of the maintenance process and the interface between Operations and Maintenance. Emphasis is on efficiently maintaining the operating equipment with minimal impact to the operating plan. He/she also proactively seeks opportunities for continuously improving the maintenance process and elimination of chronic maintenance problems."

The MTL, who may be either a Motiva or WGI employee, reports to the Motiva area maintenance superintendent. A partial list of the responsibilities of the MTL, as excerpted from the DCR's job description for this role, include:

- Responsible for activities of WGI routine maintenance team crafts and secondary contractors working in the operating area. Coordinate jobs with craft foremen, operations and fire & safety
- Short-term interventions with other departments (as required) to eliminate barriers
- Review all W/O plans with the planner/scheduler, OMC, and craft foreman
- Communicate daily with the planner/scheduler and crafts on delays, absenteeism, job scope changes, interferences, and schedule interruptions. Analyze and review the daily delay reporting … to overcome obstacles that are causing delays and schedule deviations

There are currently six OMCs, six MTLs, and six USs to cover the refinery. Each OMC/MTL/US team has the responsibility for multiple process units.

Reliability and Maintenance Process. In concert with the reorganization of the maintenance functions, the DCR is implementing a new maintenance prioritization and scheduling system called RAMP. RAMP is a Motiva/SOPUS initiative that is intended to drive maintenance work to predominantly focus on predictive/preventive tasks in order to reduce reactive tasks. In parallel, RAMP assists in the scheduling of reactive maintenance work based upon the relative risks that would exist were the work not completed. A detailed protocol guides the user in the risk evaluation process, including steps for determining what might happen if the work is deferred, how severe the consequences would be, and how likely are these consequences to occur. Numerical rankings of relative risk allow classifying the work as:

- Emergency – work that must be started as immediately as resources are available

- Schedule Breaker – work that is urgent and warrants amending the planned schedule established for the next 5 work-days

- Routine – work to be factored into the routine schedule. Work will generally be prioritized based upon the numerical risk ranking, but can be worked out of priority on an opportunistic basis. A very low priority work order, as determined by the risk ranking, may be canceled

- Shutdown – work that requires a production outage, such as a turnaround, to accomplish

All new work orders are being risk ranked and prioritized according to RAMP.

RCM. At the same time, the DCR is implementing, as one of the Motiva/SOPUS-wide process safety initiatives, an RCM program. RCM is a proactive program that attempts to anticipate the causes of equipment failures and to select the most appropriate, cost-effective ways of preventing the failures. As a simple example, rather than just periodically replacing a failed pump seal, the RCM process analyzes the causes of seal failure and identifies the preventive actions to be taken to minimize or prevent seal failures.

RCM (described in greater detail in Section A-3) will create programmed tasks for operators and craftsmen. The latter tasks, while important, will add to the burden imposed on the maintenance management system.

Maintenance Prioritization. RAMP work order prioritization applies only to work orders written by field personnel for routine repairs and upgrades ("reactive" work orders). Other maintenance requirements come from sources of "proactive" or "compliance" tasks. "Proactive" tasks include, but are not limited to, predictive/preventive maintenance (RCM) work and repetitive work for instrument calibration. "Compliance" tasks include work required to implement PHA and incident report recommendations, to complete those Inspection Department recommendations with required completions dates, and to satisfy safety and environmental regulation requirements (e.g., to correct leaks identified under the Leak Detection and Repair program).

The completion of routine repair work must be accomplished within an environment of finite resources. RAMP, in recognition of this, evaluates the importance of each repair work order against environmental, safety, business interruption, and corporate reputation criteria. The repair work orders are then scheduled for execution on a risk basis within a planning regimen that is also intended to ensure that compliance-mandated work is also accomplished. The backlog of work may grow at times, but the intent of the risk analysis is to ensure that the most important work is being addressed first.

The DCR management has established an imperative that compliance work, especially those tasks with an established due date, will be completed on schedule. As such, this work takes precedence over the routine work orders coming out of the RAMP system and could turn into emergency or schedule-breaker work if not completed in a timely manner. Other (noncompliance) emergency or schedule-breaker work takes precedence over proactive work. Proactive work is desired to be completed ahead of other reactive work, but not at the risk of turning reactive work into schedule-breaking work. The work process is still too new to understand how all potential priority conflicts among reactive, proactive, and compliance work will be resolved.

Our discussions with personnel responsible for managing the day-to-day work confirmed that the intent of the planning system is to first ensure that compliance-mandated work is normally given highest priority. Planned monitoring of the system's performance, at least during its initial implementation, will be required to determine whether priorities are being balanced in such a way that the important repair work is being completed in a timely manner.

Interviews with craftsmen, operators, and first-line operations supervisors revealed they are unfamiliar with the details of the RAMP system, and that there is a frustration with the maintenance backlog issue. There is some understanding that certain maintenance tasks may take longer because more care is being devoted to the repairs (for example, investigation may determine that stress imposed by the piping configuration may be contributing to the periodic failure of a pump seal, and RCM considerations dictate that the piping must be revised before the pump is returned to service). Conversely, efforts to eliminate duplicate work orders, and other work perceived as no longer needed, will likely be viewed with suspicion by some.

Interviews also revealed a general appreciation that an increased level of emphasis had recently been devoted to working the backlog of needed tasks. At the same time, the anticipation that the current level of expenditures could not go on indefinitely left some apprehension of what would follow.

Interviews with the DCR staff indicated that some reduction of the current rate of maintenance expenditures will be required to allow the refinery to become cost-competitive. The intent is to reduce maintenance costs through more effective use of resources. RCM should extend the mean time between failures, reducing the expenditures for a particular piece of equipment. RAMP should aid in prioritizing work to ensure that resources are devoted only to addressing tasks that have a high value. Other initiatives, not detailed here, are addressing the productivity of the maintenance workforce.

CONCERNS BASED ON OBSERVATIONS

16. While some OMCs are attempting to meet the management goal of risk ranking the maintenance backlog according to the RAMP protocol by the end of 2002, it is not clear that all OMCs understand this to be a definitive requirement to integrating this backlog work into the current prioritization system.

17. There appears to be a lack of understanding of the RAMP system among operators and shift supervisors and, for some, a suspicion of the maintenance prioritization system. A broader understanding of the RAMP process, beyond the OMCs, MTLs, etc., may enhance buy-in and support of the overall maintenance effectiveness program.

18. The DCR has implemented a number of initiatives that are new and unproven, at least at the DCR. The DCR management intends to monitor this maintenance effectiveness program by tracking the backlog as a function of risk ranking. If the backlog of work with high risk rank increases in a particular area, resources will be diverted or additional resources provided to reduce the backlog. However, currently, the DCR does not have an effective means of tracking maintenance backlog by process area, craft, or risk rank and may not have such a system until the System, Applications, and Products (SAP) maintenance management system is implemented late in 2003.

RECOMMENDATIONS

16. Complete the current effort to review, risk rank, and prioritize the existing maintenance backlog. [Priority 2]

17. Complete the implementation of the metrics and means (a) to track the maintenance backlog and (b) to monitor the effectiveness of the work prioritization process (including, if necessary, establishing an interim system, pending implementation of the future SAP maintenance management system). [Priority 2]

18. Provide a general orientation of refinery personnel on the RAMP system and related maintenance effectiveness initiatives. [Priority 3]

A-5. MANAGEMENT OF CHANGE AND PRE-STARTUP SAFETY REVIEW

BACKGROUND

MOC and the related program, PSSR, are elements of OSHA's PSM standard and EPA's RMP rule (implemented in Delaware under the Extremely Hazardous Substances Risk Management Program regulation). While described as separate elements in the regulations, the DCR implements MOC and PSSR via a common procedure, as do many other refineries. These elements can have a direct bearing on MI for many changes related to the process and equipment.

MOC applies to process changes and equipment modifications that are not replacements in kind (a replacement in kind is defined as an installation that meets the original design specifications). MOC requires the evaluation of proposed changes for their potential impact on safety and health to identify considerations required to safely implement the change. PSSR requires changes to be implemented as designed and that the required safety considerations have been addressed before the modified process or equipment is started up. Commonly required safety considerations could include, but are not limited to, modification of operating and maintenance procedures, training of affected personnel, updating the emergency response plan, etc.

Process or equipment changes implemented under the MOC/PSSR programs can prompt other activities that must be completed, but are not necessary prior to startup. An example might be updating process and instrumentation diagrams (P&IDs). MOCs are tracked in the FERRET system until all the necessary approvals have been obtained, the modification has been started up, and all related documentation has been completed. Changes may be approved only for a specified temporary duration. MOCs for these temporary changes are not closed out until the modified facilities are returned to their normal state.

MOC/PSSR implementation over the last few years has been in a state of flux. The DCR had moved away from a paper-based system and had implemented an e-mail-based work flow program for creating and circulating for approval the forms necessary to implement MOC/PSSR. The manufacturer of the software subsequently stopped supporting the program, necessitating the DCR to move to a system where the MOC/PSSR forms were generated by computer, but subsequently printed and circulated in hard copy for approval. Completed and approved forms were then scanned back into the computer for storage. At the time of this evaluation, the DCR was implementing a new Motiva/SOPUS-standardized, computer-based work flow program for MOC/PSSR.

One of the most challenging aspects of auditing an MOC program is determining whether or not changes are being implemented that should have been assessed under the MOC system, but were not assessed. During our review, ABS Consulting reviewed work orders and incident investigations to identify any such changes (specific observations resulting from these reviews are discussed in the Concerns section, below). In addition, selected P&IDs were reviewed to determine if drawing revisions could be traced back to specific MOCs (this review did not identify any changes of concern). Due to schedule constraints, the team was not able to conduct detailed field surveys to search for potential modifications.

CONCERNS BASED ON OBSERVATIONS

19. Descriptions for over 1,300 authorized maintenance work orders were reviewed. Of these, about 97% were clearly related to routine maintenance, repair, and inspection. Approximately 35 work orders that appeared to request changes were reviewed in detail. Of these, 10 were indeed changes for which MOCs had been initiated and 5, in the opinion of the team, were changes that should have been processed through the MOC procedure, including 1 for the installation of a temporary leak repair. The team understands that the MOC coordinator audits approximately 1,000 work orders each quarter to determine compliance with the MOC requirements.

20. In Section A-2 of this report, we reference the use of temporary insulation blankets and the widespread corrosion problems caused by these nonweather-proof installations. The use of a temporary insulation blanket in place of the original insulation, or on a surface that was not originally specified to be insulated, is clearly not a replacement in kind. In addition, a May 2000 incident investigation report described a hydrocarbon release and subsequent unit evacuation caused by the failure of a temporary hose installed to route a purge stream from a leaking reboiler to the flare system. Many organizations would prepare a temporary MOC to authorize such a nonstandard transfer. Examples such as these suggest that there is insufficient awareness about what constitutes a change that should be addressed under the MOC system.

21. The DCR is preparing a procedure to cover the installation of temporary leak repairs. This procedure is intended to address MOC considerations relative to the

installation of temporary clamps, patches, etc. Incident investigation report #5004203 (42-D-29 Leak, unit evacuation), issued 6/12/2000, recommended the development of a standing instruction for the installation of temporary repairs. The procedure has not been approved and placed into service.

22. The DCR staff acknowledged that there are recurrent difficulties in getting all of the needed authorizations and confirmations of required activities completed prior to the modifications being placed in service. Review of the documentation, provided for a number of completed MOCs, confirmed this problem. This problem likely has been exacerbated by the frequent changes in MOC/PSSR system. The team understands that the DCR personnel involved with the MOC/PSSR system are to be retrained with the implementation of the new electronic MOC/PSSR work flow system.

23. The new Motiva/SOPUS PSI for MOC includes specific monitoring requirements with metrics addressing issues such as "percent of MOCs commissioned with completed and approved PSSRs" and "percentage of…work orders audited…that require an MOC and for which an MOC was initiated." As of the end of May, the implementation of this PSI at the DCR was behind schedule.

RECOMMENDATIONS

19. Expedite the approval and implementation of standing instruction 5.1.4, Temporary Repairs to Pressure Equipment. [Priority 1]

20. Complete implementing the MOC PSI requirements and training affected personnel on the electronic MOC system. [Priority 2]

21. Continue the quarterly audits of work orders to determine compliance with the MOC requirements. Statistics should be reported to, and reviewed by, management on a periodic basis, with noncompliances (i.e., work orders requiring, but not receiving, MOC review) expressed relative to the number of work orders implementing a change, rather than relative to the total number of work orders. (This recommendation is included on an interim basis, and will be superceded by recommendation 23, when the MOC PSI is fully implemented.) [Priority 3]

22. The DCR Joint Health and Safety Committee recently instituted a program of monthly unit audits addressing a number of regulatory compliance issues. The DCR should add to the scope of these audits the identification of facility

modifications that may not have received MOC review. Identifying, correcting, and publicizing these situations should enhance the awareness of MOC across the refinery. [Priority 3]

23. Complete the development and implement tracking of MOC/PSSR performance metrics required by the PSI. When they become available, these metrics should be reported to, and reviewed by, management on a periodic basis. [Priority 3]

A-6. PROCESS HAZARD ANALYSIS

BACKGROUND

PHAs are detailed reviews intended to:

- Identify the hazards associated with the process (e.g., the presence of flammable or toxic materials)
- Identify combinations of equipment failures and human errors that could lead to undesired events (e.g., toxic releases or explosions)
- Evaluate the adequacy of existing controls to prevent the events or mitigate their effects
- Qualitatively evaluate the risk of such events, as a function of consequence and likelihood
- Where the risk is perceived to be too great, propose additional safeguards

Processes covered by OSHA's PSM standard or EPA's RMP rule (implemented in Delaware under the Extremely Hazardous Substances Risk Management Program regulation) are required to have a documented PHA report that is to be updated at least every 5 years. The regulations require that recommendations developed from the PHA review be resolved in a timely manner.

ABS Consulting did not conduct a detailed review of the DCR's PHAs because these have previously been reviewed by DNREC. Our focus was limited to the follow-up on the PHA report recommendations, especially those having potential MI significance.

Recommendations from all PHA reports are now tracked via the FERRET system. Approximately 2,300 PHA recommendations remained unresolved as of the end of May 2002. Some of these recommendations were from PHAs that had been conducted 11 years ago. Not all of these recommendations are MI-related. The backlog also represents a combination of PSM-related recommendations, recommendations addressing personal safety issues, and process improvement recommendations.

Many PHA recommendations with potential MI significance have been assigned to the Engineering Group for resolution. At the beginning of 2002, the total number of PHA-related recommendations assigned to the Engineering Group was approximately 800. As of the end of July, this total had been reduced to approximately 470. In an interview, the engineer responsible for managing the resolution of these recommendations agreed that the effort to date largely focused on resolving those recommendations that could be closed out most expeditiously, and that the rate of progress would slow as more technically complex recommendations were addressed.

CONCERNS BASED ON OBSERVATIONS

24. Recommendations addressing process safety issues represent a judgment by the PHA team that the risk of a process deviation was great enough to warrant some form of additional mitigation. The backlog of PHA recommendations represents a potential safety liability. The DCR management has communicated an imperative that the backlog be expeditiously reduced. It is likely that some recommendations will be rejected because (a) they are infeasible, (b) they are no longer required, (c) they are perceived to not yield the desired safety improvements, or (d) their intent can be accomplished by some other means. While the PHA coordinator is reviewing the entries made into the FERRET system documenting the resolution of recommendations, there are no formalized management controls in place to ensure that all recommendations pending rejection receive appropriate technical consideration.

25. The concept of screening the backlog lists for easily resolved recommendations to quickly reduce the size of the lists (i.e., "picking the low-hanging fruit") is not without merit. However, there should also be consideration of the relative importance of the remaining recommendations when prioritizing efforts to resolve them.

26. It was observed by the DCR staff that many PHA recommendations did not address process hazards; rather, they addressed process efficiency or traditional safety issues (i.e., slips, trips, and falls). While these other types of concerns are often identified during a PHA, many companies will record these ancillary learnings apart from the PHA so that they are not confused with the recommendations intended to improve process safety.

27. The DCR staff observed that many of the backlogged recommendations proved to be relatively easy to resolve and suggested that the underlying questions might have been addressed, and the recommendation avoided, had broader expertise been included on the PHA team. ABS Consulting concurs, acknowledging the

importance of team selection, including team leader, in the conduct of an effective PHA.

RECOMMENDATIONS

24. Continue with the current process for the resolution of open PHA recommendations. Establish metrics, and ensure that progress is regularly reviewed by the DCR management. [Priority 2]

25. Implement a formalized mechanism for the internal review of recommendations proposed for rejection to ensure that full technical and management consideration is given to the merits of the recommendation. Ensure that the documented resolution of the recommendation is reviewed as part of the next revalidation of the affected PHA. [Priority 3]

26. Establish a protocol for determining the priority of the outstanding PHA recommendations, such as risk ranking, as an aid in prioritizing their resolution. When setting priorities, consider a means to discriminate between those recommendations that address process safety concerns and those that address ancillary issues. Also, implement the risk ranking of recommendations during the PHA deliberations for future PHAs. [Priority 3]

27. Evaluate the DCR criteria for future PHA team makeup, and ensure that an appropriate mix of expertise is included on the PHA team. [Priority 3]

A-7. INCIDENT INVESTIGATION

BACKGROUND

The review team elected to evaluate the incident investigation program since process equipment failures and material releases often occur as a consequence of MI problems. In fact, the DCR's own statistics indicate that approximately one-third of the incidents investigated in 2000 and 2001 had an MI-related cause or recommendation. Thus, it is important to ensure that incidents and near misses[4] that have an actual, or potential, relevance to MI matters are promptly and thoroughly investigated and that resulting recommendations are resolved in a timely manner.

A review of the incidents investigated since October 1999 indicates that the DCR is annually investigating on the order of 50 incidents and serious near misses having process-related significance (e.g., not counting motor vehicle accidents and incidents involving personnel injuries unrelated to processing operations). This number is consistent with the number of incident investigations typically encountered at comparably sized facilities. This observation is not intended to dissuade the DCR from more aggressive efforts to identify and investigate incidents and near misses.

In particular, the investigation of near misses can be a valuable, resource-effective means of identifying learnings that can be applied to prevent future incidents. It is the team's opinion that near misses are under-reported at the DCR. While this does not rise to the level of a "concern," as we are using the term in this report, it does provide an opportunity for improvement. The DCR personnel are aware of this and are actively trying to stimulate the reporting of near misses. A new near-miss reporting tool was implemented in May 2002, but additional time will be required to evaluate its effectiveness.

Incidents and near misses are investigated using the Triangle of Prevention (TOP) incident investigation procedure. This formalized protocol was developed by the Paper, Allied-Industrial, Chemical and Energy Workers International Union and includes a methodology for the identification of root causes. Facilitators trained in the TOP methodology lead the investigations, and all plant personnel have received awareness training on the TOP methodology.

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[4]A near miss is an unplanned sequence of events that did not result in undesirable consequences but could have if the circumstances had been slightly different. For example, a small fire might have caused considerable damage but did not, only because someone happened to be in the area and discovered the fire before it caused a problem.

CONCERNS BASED UPON OBSERVATIONS

28. The DCR procedures require that incident investigations be closed out within 30 days. A report documenting the status of 36 "Ongoing or In Review" incident investigation reports indicates that about 40% of the reports were not completed within the 30-day deadline. More significantly, a number of reports, shown completed within the required 30 days, appear to remain "In Review" some 6 to 11 months after the stated completion date. Some of these reports are marked "notice of action items sent," and the associated recommendations were found in a contemporaneous FERRET printout. However, recommendations for other "In Review" reports had not been entered into FERRET, in some cases as long as 8 months after the report had been "completed." These observations, coupled with the information from the FERRET report (discussed in item 30), leave concerns that some incident report recommendations, including recommendations having MI import, are not being resolved in a timely basis.

29. Deadlines established for implementation of some recommendations appear to be inconsistent with the importance of the recommendation. For example, two investigation reports addressing failures to comply with established safe work practices contained recommendations for alerting and retraining affected plant employees. The target dates established for the recommendations were from 11 to 14 months after the dates of the incidents.

30. The DCR personnel concede that less than 60% of incident investigation recommendations for 2000 and 2001 have been resolved. A FERRET printout of incident investigation recommendations beginning about October 1999 showed that at least 18 incident investigations had one or more MI-related recommendations that had not been resolved within 12 months after completion of the investigation. Some MI-related recommendations were from 25 to 29 months old. It is noted that a number of open recommendations specify the creation of MI-related procedures, such as standing instructions for gasket installation and bolt tightening for high-pressure service and temporary repair clamps.

31. A review of equipment inspection records revealed a number of situations where unusually high corrosion rates have been noted. One example is the recent corrosion experience in the Tetra Unit's 30-inch diameter piping between 32-E-1 and 32-C-4, for which short-term corrosion rates of up to 1/8-inch per year have been noted. There is no indication that a formal incident investigation has been conducted to identify (a) the source and route of the corrosion causing compounds

into the Tetra Unit, (b) other process units that could be affected by the phenomena, or (c) the means to prevent it from occurring again.

32. A review of the recommendations from a number of investigation reports leaves concerns regarding the identification of root causes and the formulation of recommendations in response. For example, several reports addressed incidents involving noncompliance with safety work practices such as lockout/tagout and hot work. Each report contained a recommendation to retrain affected personnel on the relevant work practice. Given the frequency of such events, there is concern whether episodic retraining, such as the training being applied, is really getting at the root of the problem. Consideration should be given to the content and frequency of the initial and refresher training given to employees and, conversely, as to whether this is solely a training-related problem. Another report described an incident where a wooden plug was used as a temporary means to stop a process leak. While the report noted that use of wooden plugs for process leaks was not a normal DCR practice, one recommendation in the report was to review, with affected personnel, the importance of properly securing wooden plugs. It is the team's opinion that a more appropriate recommendation would have been to reinforce the practice of not using wooden plugs with process leaks.

RECOMMENDATIONS

28. Implement policies or procedures to expedite the resolution of the existing follow-up actions (recommendations) on a timely basis. [Priority 1]

29. Implement policies or procedures for the timely completion and review of incident investigation reports in order to identify, communicate, and resolve follow-up actions (recommendations) on a timely basis. [Priority 2]

30. Evaluate, or provide, criteria for establishing target dates for implementation of incident investigation recommendations. [Priority 2]

31. Ensure that incident investigations identify the true root causes of incidents and that recommendations appropriately address these root causes. Special consideration should be given to situations where there appears to be a trend of related incidents that may indicate a systemic problem. [Priority 2]

32. Establish linkages between the incident investigation program and the equipment inspection program to ensure that, where appropriate, process causes of MI problems are identified and resolved. [Priority 3]

A-8. COMPLIANCE AUDITS

BACKGROUND

Facilities covered by OSHA's PSM standard and EPA's RMP rule are required to audit their compliance with the regulations at least every 3 years. The MI program and its implementation are among the regulatory requirements that must be covered by these audits. Consequently, the audits provide an opportunity to evaluate the MI program against the basic requirements of the regulations. Furthermore, since the regulations require that portions of the MI program comply with "recognized and generally accepted good engineering practices," a thorough compliance audit will evaluate the MI program against the guidance contained in relevant industry consensus standards and company-specific procedures and technical guidance.

These audits may be (1) first-party audits (conducted by facility personnel), (2) second-party audits (conducted by company representatives not assigned to the facility), (3) third-party audits (conducted by outside parties not associated with the company), or (4) staffed with personnel representing a mix of these perspectives.

A report, including any recommendations addressing the audit findings, is to be prepared at the conclusion of the audit. The facility must resolve the audit findings and document the resolution. Audit recommendations are entered into the FERRET database for tracking.

ABS Consulting reviewed the audit conducted in 1999. This audit was conducted by site personnel and was actually conducted as a series of audits, one per each major process area. The DCR is due to conduct the next audit later this year to meet the triennial requirement.

CONCERNS BASED UPON OBSERVATIONS

33. In the opinion of the review team, the 1999 audit did not go into sufficient depth, especially with respect to the MI program. Very few findings addressed the MI program, and the programmatic gaps identified by the current review were not noted. For example, the maintenance and inspection procedures that currently do not exist, as detailed in Section A-3 of this report, were not noted in the audit report. Similarly, the status of the piping inspection program, as described in Section A-2 of this report, was not addressed in the audit. ABS Consulting

believes that most, if not all, of the gaps identified likely existed in 1999 (e.g., procedures that do not exist today likely did not exist in 1999).

34. A July 22, 2002, printout from the FERRET database revealed that approximately 50% of the 70 recommendations from the 1999 audit report remained open, and that only 3 of the recommendations had been closed within the last 12 months. A number of the recommendations remaining open have peripheral MI implications (for example, a number of recommendations address the failure to conduct an MOC or PSSR for a specific piece of equipment).

RECOMMENDATIONS

33. The DCR should include second-party or third-party participants in the 2002 PSM compliance audit. Such participants bring a fresh viewpoint that aids in identifying problems and can provide valuable perspective on practices implemented elsewhere. [Priority 3]

34. The DCR should consider more frequent, focused audits as it proceeds with the implementation of the MI initiatives that are addressed in this review. Such "mini-audits" can be valuable for checking course and progress between the required triennial audits. [Priority 3]

35. Complete resolution of the remaining recommendations from the 1999 PSM compliance audit. [Priority 3]

A-9. FERRET BACKLOG ISSUES

BACKGROUND

One of the common themes that appears throughout the results of this evaluation is that of task backlogs, both from the standpoint of the number of tasks outstanding for a particular activity and, in some cases, the duration of the delinquency (i.e., how old some of the outstanding tasks are). We have commented elsewhere on the specific issues related to task backlogs for the following activities:

- Pressure vessel and piping inspection programs
- Inspection report recommendations (for reactive inspections)
- PHA recommendations
- PSM compliance audit recommendations
- Maintenance work orders
- MOC approvals
- Incident report recommendations

In contrast, we have also cited the pressure relief valve inspection and testing program as an example of a success story where a task backlog problem was aggressively addressed and resolved. This section of the report addresses other backlog matters not previously discussed and attempts to address some common issues.

An important task in managing backlogs is that of tracking the outstanding tasks. As noted elsewhere in this report, the DCR has developed the FERRET database to inventory and track the status of compliance-related tasks. Activities listed above for which FERRET is being used are reactive inspection reports, PHAs, PSM compliance audits, MOC approvals, and incident investigations. In total, there are approximately 20 different compliance activities for which recommendations and other activities are tracked within FERRET.

FERRET has provided a positive influence with respect to dealing with task backlogs. As explained by one DCR employee in an interview, a contributing factor to the accumulation of the task backlogs was the general lack of awareness of how much there was that was going undone. One key performance feature of FERRET is the mechanism to ensure such an awareness. Each week, an e-mail is sent to each individual identified within FERRET as having responsibility for one or more tasks (a single e-mail summarizes all tasks assigned to that individual). Furthermore, supervisors and managers, in addition to receiving their own to-do lists, can obtain information on the status of the to-do lists of personnel reporting to them.

To put the numbers into perspective, as of January 1, 2002, there were nearly 4,800 tasks entered into FERRET, of which about 4,100 were indicated to be overdue. As of August 1, 2002, the numbers were about 4,400 total and about 2,700 overdue. Thus, the overdue tasks had been reduced by about one-third. The total number of tasks did not drop as markedly, presumably because, as noted elsewhere, current initiatives such as the equipment inspection program continue to add new items to the FERRET database. It should be noted that not all of these tasks are MI-related (or, for that matter, PSM-related).

Several references have been made elsewhere in this report to risk-based decision-making processes for prioritizing work (e.g., with respect to work orders and PHA recommendations). There is a strong precedent in industry for such risk-based decision making applied to process safety-related matters. Good ideas come easily, but resources for implementation are usually more constrained, and making decisions based upon risk perspectives can provide a means for maximizing the benefit that can be achieved with a finite amount of resources. It is important, however, that those individuals or teams that are making the risk-based decisions have a proper understanding of, and training for, the decision-making process.

CONCERNS BASED ON OBSERVATIONS

35. The DCR departments were required to establish year-end goals for reduction of FERRET backlog items. Departments with relatively few overdue items generally committed to having no overdue tasks by December 31, 2002. Departments with more substantial backlogs generally committed to an absolute numerical or percentage reduction in overdue items. In some instances, achievement of these goals will still leave a significant number of overdue tasks carrying over into 2003, with no forecast of how much additional time will be required to fully eliminate the overdue backlog. It should be remembered that, embedded in these total numbers, are tasks such as 11-year-old PHA recommendations.

36. It is not apparent that the goals and implementation plans for FERRET backlog reduction include a mechanism for prioritizing the effort based upon the relative importance of the backlog tasks.

RECOMMENDATIONS

36. Implement specific goals, by department, that will establish a timely resolution of the FERRET overdue items. [Priority 2]

37. Provide a mechanism(s) for prioritizing the efforts to reduce the FERRET overdue items so that more critical tasks are addressed first. [Priority 2]

38. If risk-based decision making is used in prioritizing the execution of the FERRET overdue items, ensure that the individuals or teams making the decisions are properly trained in the methodology. Provide sufficient oversight to ensure that comparable risks prompt comparable decisions. [Priority 2]

A-10. PROCESS SAFETY INITIATIVES

BACKGROUND

The nine Motiva/SOPUS PSIs were discussed in Section 2.1 of this report. Other sections of the report cite the ways in which the successful implementation of these initiatives should enhance the MI program and describe the reliance that is being placed upon them. The PSIs will not be further described here.

CONCERN BASED ON OBSERVATIONS

37. The DCR tracking indicates that the implementation of some initiatives, or some of their component tasks, is lagging behind the established schedule. While it is acknowledged that the schedule initially established for PSI implementation may have been ambitious, the importance of these tasks requires timely implementation. Furthermore, missed deadlines for programs as visible as these potentially communicates the wrong message about their importance.

RECOMMENDATION

39. Reevaluate and revise, as appropriate, the implementation schedule for the PSIs, and then ensure compliance with the new schedule. [Priority 2]

A-11. SAFE WORK PRACTICES

BACKGROUND

Safe work practices (SWPs) involve a diverse set of practices and procedures related to preparing equipment for maintenance or inspection activities, accessing equipment for such activities, or performing such activities. SWPs include, but are not limited to, procedures for (1) lockout/tagout of electrical, mechanical, or process energy sources, (2) confined space entry, (3) first line break, (4) hot work, (5) excavation and shoring, and (6) hot tapping. Industry best practices and OSHA regulations provide guidance and requirements for most SWPs.

While some may question the relevance of this topic in an evaluation focused on mechanical equipment integrity programs, MI activities must unavoidably include opening of lines, confined space entries, and hot work such as cutting and welding. Failure to understand and comply with established SWPs leaves open the potential that a task intended to improve the safety of the facility could have quite the opposite result. MI programs should "First, do no harm."

In reviewing the DCR incident investigations, ABS Consulting noted the prevalence of events involving failure of, or lack of compliance with, SWPs such as lockout/tagout or hot work permits. As noted elsewhere in this report, the amount of maintenance work at the DCR will likely increase, at least in the near term. This could mean a corresponding increase in the use of these SWPs and an increased opportunity for incidents that could result from unsafe work practices.

CONCERN BASED ON OBSERVATIONS

38. A number of incident investigations in the last several years have dealt with failure of, or lack of compliance with, SWPs. Our concern is heightened by the observations of some interviewees who believed that there were no serious problems with the application of SWPs at the DCR.

RECOMMENDATION

40. Evaluate the circumstances surrounding recent incidents involving SWPs, identify any common root causes, and develop appropriate responses to ensure compliance with industry-established (and, in some cases, regulation-mandated) SWPs. [Priority 1]

A-12. BUDGETING

The DCR has separate capital spending, tank repair, and maintenance turnaround spending forecasts for the next 5 years. Capital spending forecasts incorporate identified needs over the time period for environmental projects, major tank repairs or replacements, consent decree requirements, profit improvement projects, equipment replacement, and refinery infrastructure and utility systems improvements. A review of the projects approved over the last 5 years indicates an appropriate mix of projects in these categories

Tank repairs and process unit turnarounds represent significant expenditures over short periods of time and are planned as separate detailed 5-year forecasts by tank and process unit. The turnaround and tank spending forecasts are based on known inspection requirements and are periodically updated as turnaround issues emerge from equipment inspection activities and process unit operating performance. The planning and coordinating of these activities are intense and usually begin more than a year in advance of the event. There is a separate organization dedicated to these planning efforts. The projected intervals between process unit turnarounds premised in the DCR's turnaround spending forecast are typical of the refining industry. The tank maintenance and turnaround spending forecasts are consistent with typical spending profiles in the refining industry.

The historical data provided by the DCR for capital approvals and expenditures for the last 5 years indicate through 2001 that expenditures on-balance have lagged approvals by about $9 million. This is not unexpected given the lead times for engineering and equipment delivery, and long-term projects with expenditures spread out over several years. The capital approval data for 2002 through September and the total 2002 expenditure forecast show slightly higher cumulative approvals than cumulative expenditures. In addition, the amount of capital approved through September 2002 is nearly equal to the annual average of the total approved capital over the last 5 years. Of the capital approved to date in 2002, half is targeted at specific equipment reliability concerns, and a third is planned as part of the long-term improvements to the refinery's relief and flare system. The capital expenditure forecast for 2002 is well above the average expenditure for the last 5 years, and the cumulative total through 2006 is about $35 million more than the previous 5 years. It is the review team's understanding that capital spending for major projects, such as a new process unit, requiring specific board of directors approval, is not included in these capital spending forecasts or expenditures and was not within the scope of this review.

The capital spending profile over the last several years, shown in Table A-12.1, appears inline with the refining industry trend to execute projects that ensure they maintain competitive position.

Table A-12.1 Historical and 2002 Forecast Spending, Percentage of Total Dollars

Year	General Infrastructure (GI)	Tank Repairs (TR)	Utility Systems (US)	Reliability Improvements (RI)	Profit Improvements (PI)
1997	10	17	37	31	5
1998	56	6	6	27	5
1999	41	5	24	22	8
2000	0	18	49	31	3
2001	5	6	29	60	0
2002	21	2	68	9	0
Average	29	7	29	31	4

Notes:
GI Consists of buildings, tools and equipment, piers, dredging spoils dike development, etc.
TR Consists of new floors, installation of heater/mixing systems, tank replacements, etc.
US Consists of boiler life extension work, electrical, steam, water, and fuel oil system upgrades, etc.
RI Consists of equipment material upgrades, pump upgrades, equipment replacement, etc.
PI Consists of projects performed basis pure financial consideration

Maintenance operating cost expenses are generally forecast based on historical trends. The maintenance manpower will fluctuate over time reflecting special needs or circumstances, but the overall trend is planned to be toward a more uniform but declining number of maintenance personnel. This anticipated trend assumes improvements in maintenance effectiveness through better job planning and priority setting and a reduction in work resulting from equipment reliability improvements. In this environment it can be expected that some work will not be done if it is low risk, or it may remain open for a long time and be completed in a focused "campaign" to complete allied work, such as the anticipated equipment painting plans.

The team held discussions with the DCR personnel about the refinery's competitiveness as measured by the Solomon Associates Survey. The Solomon Associates Survey is a proprietary service for members only that collects data from refineries worldwide and presents that data in a manner that allows benchmarking a refinery's performance in many areas to other refiners with similar refinery configurations. Measurement indexes include maintenance spending, energy efficiency, and capital spending. Though the specifics of the outcomes for the DCR could not be shared, it was clear from the discussions that the DCR is not competitive in many areas. These include higher-than-average expenditures for turnarounds, routine maintenance, and maintenance capital replacement; however, the overall amount of capital spending was considered average. The impetus for the substantive changes in the work processes at the DCR is unambiguous. The review team's impression of the DCR based on our experience agrees with the general tone of the Solomon Associates Survey data as presented by the DCR management.

CONCERNS BASED ON OBSERVATIONS

ABS Consulting has no concerns at this time relative to budgeting issues.

RECOMMENDATIONS

> Recommendation 17 addresses the need for implementing metrics and means to track the maintenance backlog in order to monitor the effectiveness of the work prioritization process. The intent of the recommendation is to provide a means to determine if work representing high risk is accumulating and persisting in the backlog so that appropriate resources can be directed in response to reduce the work backlog having the highest contribution to the overall risk of operations. ABS Consulting believes that tracking a risk-weighted backlog (an output reflecting the effectiveness of the maintenance management system) would be more effective than tracking maintenance operating cost expenditures (an input that does not necessarily correlate with the desired output of maintaining a low backlog of high risk work).