Computerized plant condition management systems outperform manual methods in the enhancement of safety and the reliability of equipment and piping. Accurate treatment of inspection data can cut inspection monitoring costs.

Regulatory requirements and industry codes and practices, combined with an international drive for more cost-effective preventive maintenance, are leading many plants toward computerized information management systems to help organize and prioritize maintenance activity.

This shift coincides with a movement toward a risk-based approach to plant condition management that ranks units or individual equipment according to criticality or risk, allowing inspection efforts to be focused where they can have the greatest effect in risk reduction. There are a number of points to bear in mind when planning to implement a plant condition management system.

Data analysis software systems are now used in many refineries, chemical plants, and production facilities for the management of inspection information on piping, pressure vessels, and other equipment. These systems provide the economic tools to budget and plan long-term maintenance strategies, and they increase the ability to identify a problem before failure actually occurs. Inspections then lead to cost reductions.

Linking risk assessment to an information management system focuses inspection and preventive maintenance resources on high-risk areas where problems are most likely to occur. Equipment such as ultrasonic dataloggers cut costs by reducing the required inspection labor, reducing the required data entry, and eliminating the need for manual calculation of corrosion rates and remaining life predictions.

Plant piping and vessel condition management programs help answer a number of key questions:

- How can the safety of operating personnel, the general public, and property be assured?
- What engineering and metallurgical concerns need to be addressed?
- What equipment, piping, and appurtenances require maintenance attention, replacement, or monitoring?
- How should we prioritize this maintenance?
- What is the remaining useful life of each piece of equipment?
- How much inspection is required for each type of process or service?

- What are the most efficient and cost-effective methods to achieve these goals?
- What is the repair, alteration, and inspection history of piping and equipment?
- How can records be updated to reflect the rapid changes in design and layout?

The issues that must be addressed when implementing any piping and pressure vessel condition management process were identified at a recent PCMS Users Conference. A number of those observations are outlined in the following sections.

Understand the objectives and software
Setting objectives was identified as the first implementation step. This step calls for the development of a comprehensive understanding of the compliance requirements for the applicable codes. Each plant must develop a specific mission statement for its program, wherein the expected improvements in plant reliability are clearly stated and then evaluated to meet the constraints of existing resources. Such resources include manpower availability and overall budget allowances. This step clarifies for the entire management team that project completion is a long-term goal that must be continually revisited and re-evaluated.

INSPECTION METHODS FOR INSULATED PIPING SYSTEMS
Uninsulated piping can be inspected by straight beam or L-wave ultrasonic techniques to gauge pipe thickness. Instruments with datalogging capabilities can be used to collect and store data for electronic download directly into the information management system. The detection of corrosion under insulation presents a challenge.

Insulation removal
The most effective method for inspecting insulated piping for corrosion is to remove the insulation, check the surface condition of the pipe, and replace the insulation. This approach will detect corrosion-induced stress corrosion cracking (CISCC) on stainless steels and may require eddy current, field metalography, or liquid penetrant inspection. This method is the most expensive method in terms of cost and time lost. The logistics of insulation removal will probably involve asbestos and its attendant complications. Process-related problems may occur if the insulation is removed while the piping is in service.

Ultrasonic thickness

Ultrasonic thickness measurement taken through inspection holes cut in the insulation is an effective inspection method but it is limited to a small area. It is expensive to cut the inspection holes and cover them with caps or covers. It is not practical to cut enough holes to get a reliable result. Inspection holes cut in the insulation may compromise the integrity of the insulation and add to the corrosion-under-insulation problem if they are not re-covered carefully. This technique will not detect CISCC on stainless steels.

Profile radiography
Profile radiography provides an x-ray type photograph of a small section of the pipe wall. The exposure source is usually iridium 19, or cobalt 60 for heavier wall pipe. A comparator block is included in the picture to determine the blowout factor for the exposure in order to calculate the remaining wall thickness of the pipe. Profile radiography is an effective evaluation method, but it becomes technically challenging in piping systems over 10 in. in diameter and offers the luxury of verifying only relatively small areas. This technique will not detect CISCC on stainless steels. In addition, radiation safety is a concern. Plant personnel cannot work within the area while the inspection is under way, which can result in downtime and manpower scheduling conflicts.

Real-time radiography
Real-time radiography (RTR) or fluoroscopy provides a clear view of the pipe's outside diameter through the insulation, producing a silhouette of the pipe's outside diameter on a television-type monitor that is viewed during the inspection. No film is used or developed. The real-time device has a source and image intensifier and detector connected to a C-arm. There are two major categories of RTR devices: one using an x-ray source and one using a radioactive source. Each has advantages and limitations; however, the x-ray systems deliver far better resolution than the isotope type equipment.

It is important to understand the software features that assist with data analysis. To operate an effective program from a limited budget, it is vital to distinguish among information required to operate the system, supplementary information that maximizes the analytical ability of the system, and truly optional information. Optional information adds value, but it can be added later, after the first round of implementation.

Develop an implementation plan
The next step is developing an implementation plan. Because costs of data entry, record

organization, quality assurance checks on historical data, and program related inspections by far outweigh the costs of the software, a well planned implementation approach can deliver considerable savings. This step includes decisions on how much of the plant will be included in the initial implementation: the entire plant or perhaps only selected units or critical areas first.

Existing historical data from paper files, spreadsheets, process and instrumentation drawings, and isometric drawings should be carefully evaluated to decide what information is pertinent for transfer to the new software. Then the quality of this historical data must be evaluated. Obviously inaccurate thickness readings will distort the calculations for corrosion rates and remaining life. User experience shows that failure to check these data leads to problems following implementation, such as incorrect pipe sizes and schedules and thickness readings, which slow the program and increases costs.

Data entry methods must be considered. Although data always can be entered at the program screens, software that allows mass data entry from spreadsheets and dataloggers enhances the process. It may be necessary to gather data immediately to populate or enhance the database. The users group recommends the development and immediate documentation of guidelines for gathering thickness data. The guidelines should cover where to place thickness monitoring locations (TML), how to find TMLs in the field, and how the thickness readings should be taken. Over half of the users developed their own guidelines.

With the implementation plan in place it is possible to estimate the labor resources (internal, external, or both) needed to staff the project. Users report considerable success through a joint steering committee composed of plant personnel and representatives of the inspection company contracted to gather data. Used correctly, the steering committee keeps the relationship fresh, encourages change, and helps address problems in their infancy. Whether a steering committee or an individual, someone must be assigned responsibility to drive the project. Experience demonstrates that piecemeal planning will not work.

Field operations

The following information can help with planning, implementation, and operation of the plant condition management process.

- Check quality of historical data. This task is tedious and exasperating but it is a key part of the operation. Plant personnel often find ingenious uses and filing systems for key data such as UW 1 forms. The more remote the plant site is, the more extraordinary the hiding places. In addition, the adage "garbage in, garbage out" keenly applies. To avoid this concern, it is vital to check the quality of data before input.

- Systemize and circuitize according to like service and components. Systems should be broken down into circuits of similar corrosion rates and failure mechanisms. Visual inspectors should walk down every line and piece of equipment to verify that existing drawings are accurate. It is common to find that repairs and alterations affected over the years have not been updated in plant records or drawings. Visual inspectors make changes on the drawings or draft new isometric drawings if none exist and return the drawings for CAD drafting.

Thickness monitoring locations are then assigned for ultrasonic and radiographic thickness measurements at the locations most susceptible to corrosion. TMLs are assigned to offer a representative sampling of the piping or equipment, for example, 20 percent of fittings, elevation changes, and high and low vents and drains. The inspection work is then assigned to the plant's nondestructive testing (NDT) crew or a contractor. Data are entered into the system upon completion of the inspections.

Data and information management

An efficient plant condition management program manages data and converts it into information. Data can be numeric and text based. Numeric data include material thickness readings, corrosion coupon data, cathodic protection system data, and NDT results. Text-based data are usually reports on visual inspections performed. The use of both numeric and textual data is important in developing a cost-effective preventive maintenance program.

Although numeric thickness data provides a view of system condition, it is not complete without reports from radiography inspection and corrosion-under-insulation fluoroscopy inspection, together with other text-based data that cover external corrosion. Other failure mechanisms such as weld deterioration and wet H2S attack also are reported through textual data. The combination and compilation of these data for analysis and reporting lead to a better understanding of plant equipment and the mechanisms for potential failures.

The PCMS Users Group indicated that the keys to implementing an effective software-based plant condition management program are

1. Develop realistic achievable objectives and agree on comprehensive guidelines
2. Perform quality assurance checks on design data and on the historical records that will be used
3. Estimate the work and budget realistically.

There is a popular movement in the industry toward the risk-based inspection approach to plant condition management. This approach ranks equipment according to criticality or risk, allowing inspection efforts to be focused where they can have the greatest effect in risk reduction. The correct plant condition management system provides the platform for this fundamental shift in management strategy. **MT**

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