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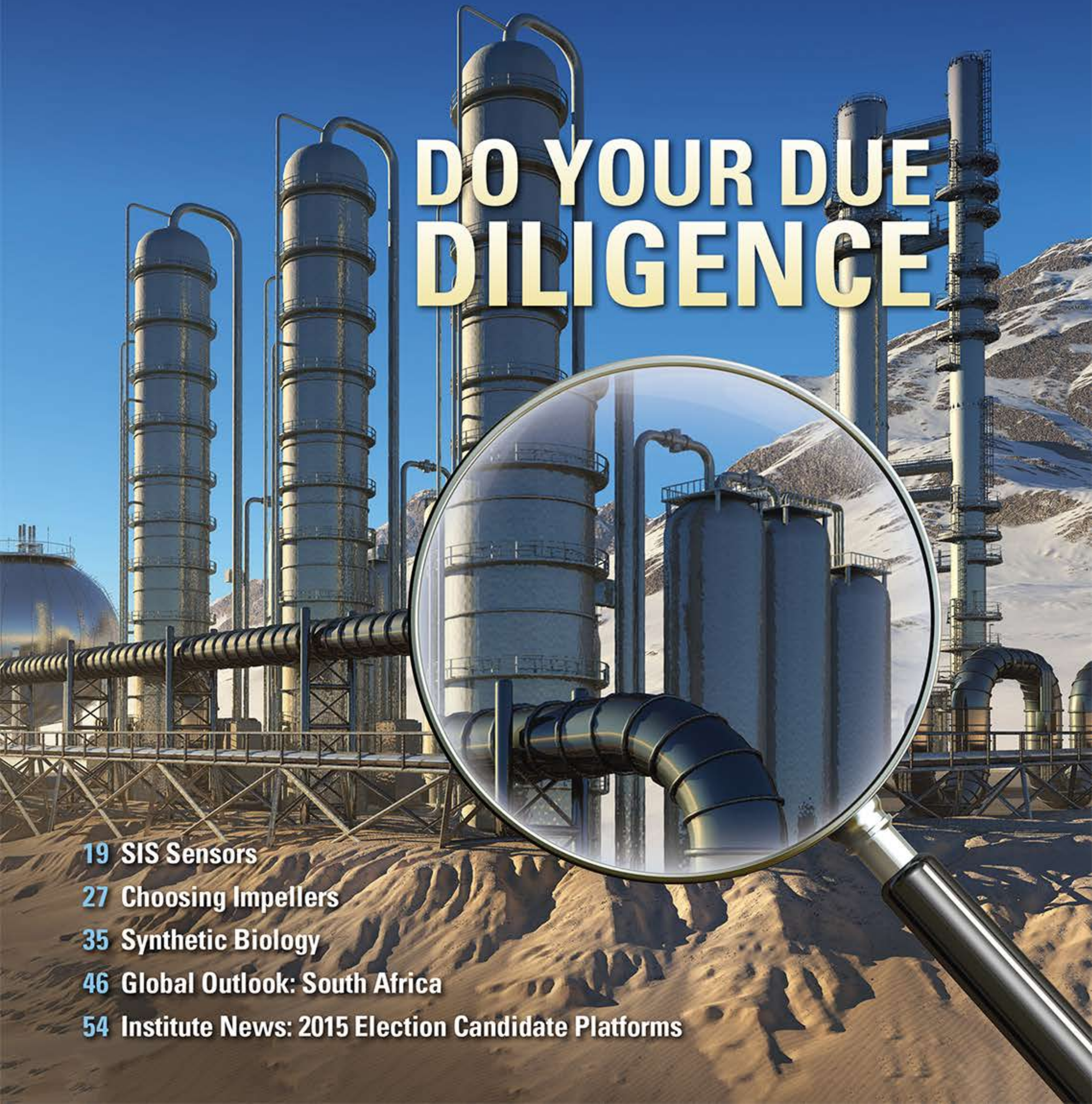

DO YOUR DUE DILIGENCE

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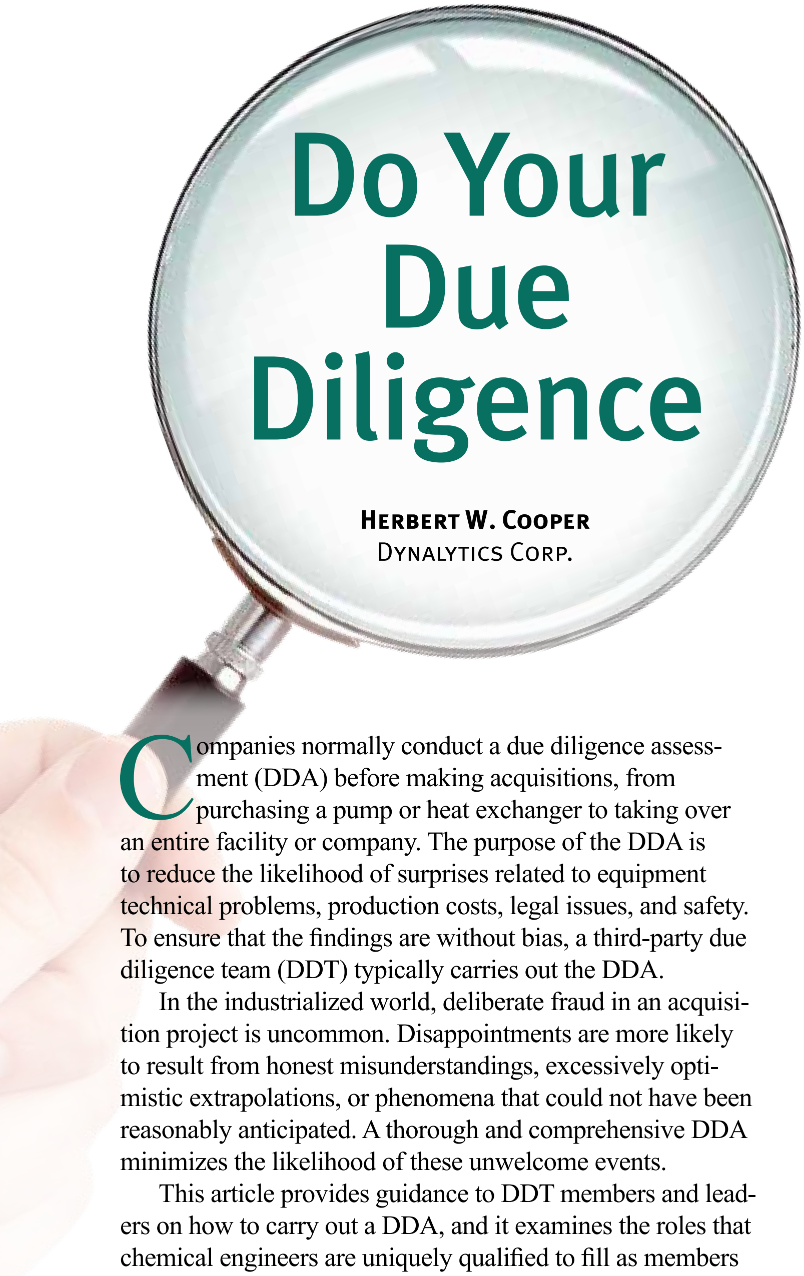

Do Your Due Diligence

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Use this guidance to conduct comprehensive due diligence assessments and help ensure your acquisitions — of equipment, technologies, facilities, or companies — are operationally and technologically successful.

Companies normally conduct a due diligence assessment (DDA) before making acquisitions, from purchasing a pump or heat exchanger to taking over an entire facility or company. The purpose of the DDA is to reduce the likelihood of surprises related to equipment technical problems, production costs, legal issues, and safety. To ensure that the findings are without bias, a third-party due diligence team (DDT) typically carries out the DDA.

In the industrialized world, deliberate fraud in an acquisition project is uncommon. Disappointments are more likely to result from honest misunderstandings, excessively optimistic extrapolations, or phenomena that could not have been reasonably anticipated. A thorough and comprehensive DDA minimizes the likelihood of these unwelcome events.

This article provides guidance to DDT members and leaders on how to carry out a DDA, and it examines the roles that chemical engineers are uniquely qualified to fill as members of a DDT for chemical process industries (CPI) projects. By nature, DDAs are unique to the facility or project; therefore, this article focuses on typical design and operation matters that are based on actual DDAs. Although important, issues related to pricing, marketing, contracts, and accounting are outside the scope of this article.

Due diligence goals

A DDT's goal is to evaluate the specific situation and attempt to answer questions such as: Will the process/plant work? Is it safe? Is it scalable to higher capacities? Does it have the permits it needs?

The purpose of a DDA is not to develop a better process, which distracts from the overall goal and introduces biases. If process improvement is desired, that should be handled as a separate effort.

An effective DDA identifies significant risks and assesses the likelihood of those risks materializing. Management can use this information to decide if the acquisition should proceed without any major changes. If it concludes that changes are required, it can use the assessment data to determine what aspects of the acquisition should be improved.

A DDT must include members with diverse backgrounds and subject matter expertise. Experience in process and equipment design and plant operations is vital. Depending on the nature of the assignment, experts may be required to assess materials of construction; environmental, health, and safety systems; environmental permitting; statistical analyses; electrical power generation and distribution; instrumentation and control systems; and intellectual property issues. Additionally, members must be proficient listeners and writers, capable of producing a DDA report that has clear conclusions and recommendations.

Information issues

To help the acquirer come to fact-based conclusions, the DDT reviews confidential information from both the acquirer and the supplier. The acquirer and supplier each typically executes a nondisclosure agreement (NDA) with the DDT before providing confidential information.

A potentially serious problem with NDAs is that parties frequently ask that all documents be returned to the provider, either on demand or at the end of the assignment. If the DDT were to be implicated in a legal battle, this might leave them without the documents necessary for a successful defense.

Thus, do not accept an NDA that demands documents be returned. Instead, come to reasonable compromises with the acquirer and supplier that ensure the team is not exposed in the event of a legal battle.

Access to information and valid data is critical. Regardless of how complete the documents you are supplied appear to be, there are almost always items that are not shown or that need to be clarified. To overcome these deficiencies, the DDT needs to be able to have honest and candid discussions with staff from both the supplier and acquirer throughout the DDA. If access to employees and information is restricted, the DDA report will likely contain qualifications that diminish its usefulness. At the beginning of the process, discuss this concern with the appropriate managers to ensure access to staff.

Assessment of physical properties

A threshold issue for a DDT is whether or not the facility in question can safely and consistently produce the quantities and quality of product the customer expects. Therefore, the assessment should start with a review of the product and feedstock requirements, including purities and production rates. Pay particular attention to physical and thermodynamic properties, the analytical methods used to measure them, and techniques used to extrapolate them to other conditions.

Many processes use raw materials with properties (*e.g.*, moisture content, impurity content, or distribution of isomers) that vary considerably. Because some properties can change during storage, the facility may need to conduct tests upon receipt of the materials and prior to using them.

To verify material quality, evaluate the test methods used to assess the raw materials, including in-house inspection procedures, assignments of responsibility, and documentation requirements. Additionally, review the technical aspects of the contract for the supply of raw materials. Does the contract contain appropriate bounds for impurities? How are samples analyzed? How are unacceptable raw materials disposed of?

Because variations in properties and compositions occur often, purchasers typically analyze small samples and then determine the probability that the concentration of an impurity would be unacceptably high in a larger batch. A normal (*i.e.,* Gaussian) distribution is typically assumed to evaluate probabilities, because it is well-known, mathematically simple, and easy to understand.

The normal distribution's application, however, is limited, because it depicts probabilities that are symmetrical around a mean value, and it indicates positive probabilities that a sample point (*e.g.*, composition) will extend from negative-infinity to infinity. For instance, consider establishing the ambient air conditions for the design of an air-cooled heat exchanger. A normal distribution of temperature data would indicate that there is a finite probability that extreme minimum and maximum air temperatures may be encountered, for example, –500°F and 500°F, respectively. Although these probabilities would likely be extremely small, they would not be zero. Since these ambient air temperatures could never occur, a different, more-appropriate probability distribution must be used. Similarly, a different probability distribution would be necessary for wind directions at a given location, which vary throughout the day and from season to season. The wind has a prevailing direction, but the distribution of wind directions is not symmetrical around a mean.

The sidebar on p. 43 provides examples of other distribution options.

Three major concerns related to statistical methods should be considered:

- Was the most appropriate statistical distribution used?
- Were all of the test data considered? Cherry-picking and subconscious biases that eliminate unfavorable, but valid, data can mislead results.
- Were situation-specific limits the basis for determining whether or not a data point is or is not statistically significant?

The 95% confidence level is commonly used to assess significance. However, it is often not appropriate, and may be either too restrictive or not restrictive enough. For example, a 75% confidence level might be more appropriate for calculating the amount of a low-cost acid necessary to neutralize a waste stream with a pH that can be measured and adjusted prior to discharge. On the other hand, a 99% to 99.9% confidence level would be more suitable for establishing health- and safety-related requirements, such as the quantity of toxic or flammable materials formed as byproducts in a reactor, or the sizing of a relief valve and venting system.

Although often not considered a raw material, water is vital to the operation of most plants. However, droughts and competition from agricultural users are making it increasingly more difficult to ensure reliable supplies. In assessing water availability, evaluate economic, political, and historical availability records. If water resources threaten plant reliability, identify a workaround, such as using an air-cooled heat exchanger and accepting the lower efficiency as the cost of increased plant reliability.

Assessment of documentation

Examine process flow diagrams (PFDs) to understand the chemical and physical processes used for production, packaging, separations and purifications, disposal of solid and liquid wastes, and control of emissions. Due diligence concerns include:

- the presence of recycle streams in the process that may cause unintentional buildup of impurities or dangerously reactive compounds
- large pressure changes that may lead to substantial temperature reductions that in turn could cause phase changes, plug equipment, or compromise piping and vessel materials
- use of complex heat-recovery networks that reduce process flexibility and complicate startup and shutdown
- the methods and equipment employed to remove thermal energy from exothermic reactions.

Process designers typically use commercially available software to establish flowrates, compositions, temperatures, and pressures. Additionally, many companies, associations, and institutes have developed standard specification sheets (sometimes referred to as data sheets) that include all of the critical technical information necessary for the design of equipment such as heat exchangers, pumps and compressors, mixers, storage tanks, etc.

Assuming the software has been used by experienced engineers for the specific process under consideration and its limitations are understood, focus on the input and output documents and the options selected in the software. Examine the PFDs and any equipment specification sheets for consistency with all potential operating scenarios. Review information such as:

- catalyst specifications and operating conditions
- maximum working temperatures and pressures
- materials of construction and corrosion allowances
- major dimensions and critical tolerances
- provisions for taking process data measurements
- safety devices
- design codes, standards, and recommended practices used for the mechanical design of equipment
- fabrication and inspection techniques.

During a DDA, equipment often needs to be tested to determine compliance with performance requirements. Some professional institutes and associations have developed testing and data reduction procedures that are useful for this. For example, AIChE publishes procedures for testing centrifugal compressors and pumps, mixing equipment, particle-size classifiers, spray driers, and distillation columns.

For the purpose of due diligence, focus on the design information provided in the equipment data sheets and the results of tests that follow appropriate protocols. It is generally not necessary to verify every calculation.

Pay close attention to documentation and results related to emerging or quickly advancing technologies, such as high-density batteries, carbon capture and storage systems, and nanomaterials. Laboratory and pilot-plant investigations often show promising results. But because these technologies are new, there is limited experience for assessing their long-term stability and reliability. The DDT must be able to understand and evaluate the test methods and correlations used for extrapolations to plant operating conditions and over extended periods. It is also important to assess follow-up and monitoring protocols that may require revisions to initial estimates.

Assessing an existing plant

A DDT evaluating an existing facility must consider additional factors related to the physical plant and its operation, including the likelihood of critical equipment failures that may lead to fatalities or injuries, major damage, and/or reduced production.

P&ID review. Characterize the likelihood of failure for each piece of equipment — including equipment and instrumentation used for normal operation, as well as for startup and shutdown — by reviewing the plant's piping and instrumentation diagrams (P&IDs). The probability and consequences of a failure can be quantified or qualified as high, medium, or low. For example, the mechanical failure of a storage tank or pressure vessel for poisonous or flammable materials is likely to be designated as a low-probability but high-consequence event.

Regardless of the probability of failure, consequences are situation-specific. In most cases, it is advisable to focus first on high-consequence events, but another option is to first

LOOK BEYOND THE NORMAL DISTRIBUTION

- ***A Poisson distribution*** accounts for the number of events within a fixed time or space.

  Example: Based on historical utility-company availability data, what is the probability that an emergency generator will need to operate 25 times in a year?
- ***A binomial distribution*** counts the number of successes (or failures) in a fixed number of trials.

  Example: What is the probability that the emergency generator will successfully operate 10 times out of 25 attempts?
- ***A geometric distribution*** counts the number of events within a fixed time or space until a success or failure occurs.

  Example: What is the probability that the emergency generator will successfully operate 20 times before it fails?
- ***A Gumbel distribution*** is appropriate for extreme-value extrapolations from sample data. It focuses on the highest or lowest values encountered in periodic trials.

  Example: Based on historical weather data, what is the maximum ambient air temperature likely to be encounterd each week at a given site, within a 95% confidence level?
- ***A Weibull distribution*** is similar to the geometric distribution, but broader. It is widely used in reliability analysis because it can model various failures, including those caused by increased aging.

  Example: What is the probability that a specific pump assembly will last for at least 50,000 hr of operation?

evaluate high-probability events. Both approaches are justifiable as long as the design, construction, and operation of the entire plant is evaluated.

Time-to-failure review. The time to failure of any component depends on its precise composition, fabrication, inspection methods and history, and environment. Physical failures, such as the rupture of a tank, and operational failures, such as an engine not starting when required, are both time-to-failure concerns. Failure times cannot be predicted with high accuracy, but realistic data on the probability that a type of equipment will fail within a specified time are available from various sources, including the International Atomic Energy Agency (IAEA), National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), American Petroleum Institute (API), American Society of Mechanical Engineers (ASME), Electric Power Research Institute (EPRI), and AIChE.

CHECK FOR THESE MECHANICAL INTEGRITY THREATS

- ***Corrosion under insulation (CUI)*** is a common and potentially dangerous phenomenon that can be difficult to detect. Conventional radiography, pulsed eddy current, and ultrasonic methods are used to detect CUI, but they are not very effective. Another option is to completely remove insulation, but this is also an imperfect solution that is difficult, expensive, and, in the case of asbestos-containing insulation, hazardous.
- ***Abrasion or corrosion*** of piping and critical components can be detected by measuring wall thicknesses and comparing the measurements to the original design specifications or to more-recent measurements (if any are available). If there is significant wall-thickness reduction, the cause needs to be determined and addressed. That could be complicated and expensive.
- ***Surface defects*** may arise from long-term stresses, changes in material structure, or friction from abrasive particles in moving components. Defects can be detected by various nondestructive examination (NDE) techniques, such as liquid penetrants and eddy-current arrays.
- ***Subsurface defects***, such as voids and cracks within equipment walls and internals, that are subject to cyclic temperature and pressure changes and gradients grow over time. It is costly to locate and assess subsurface defects, but it is a vital task, because such defects can cause catastrophic failures.

Publicly available data are typically suitable for use in a DDA. In-house experience should not be ignored, but there is rarely a sufficient amount of detailed information within a single company. Process licensors and equipment vendors can provide guidance, but are often reluctant to share data.

Maintenance review. Devote considerable effort to the assessment of maintenance practices, because they are an indication of management's long-term view. For example, a lowest-first-cost philosophy may indicate short-sightedness that often incurs future high-cost maintenance and replacements.

High-quality maintenance practices reduce the frequency and impact of equipment failures. Therefore, check for the presence of written maintenance procedures and schedule manuals for each piece of equipment, accurate inspection and maintenance records, and the use of predictive maintenance techniques (particularly for rotating equipment and equipment subject to vibrations).

Pay particular attention to the presence of corrosion under insulation (CUI), abrasion and corrosion of piping and critical components, surface defects, and subsurface defects. The sidebar provides additional information on these mechanical integrity threats.

You can draw conclusions about the condition of equipment by examining the results of mechanical integrity tests performed for or by the company. If adequate testing has not been done, maintenance and operating records can provide insight into whether tests need to be performed. Mechanical integrity tests deserve special attention because they are required by the U.S. Environmental Protection Agency's (EPA's) Spill Prevention, Control, and Countermeasure (SPCC) regulation and the U.S. Occupational Safety and Health Administration's (OSHA's) Process Safety Management of Highly Hazardous Chemicals regulation.

Since equipment failures can lead to loss of production and dangerous conditions, determine whether process streams can be effectively rerouted to alternative equipment. Is there adequate redundancy and capacity of installed spare equipment? Is an inventory of spare parts needed for routine maintenance, such as filters and fan belts, readily accessible? The extent and capacity of spare parts should be based on anticipated time-to-failure, time-to-repair, and economic impacts of plant downtime. Equipment vendors normally provide recommendations regarding spare parts.

Electricity review. Plant operation and safety depend on the availability of electricity. Assess the reliability of the electricity supply to the plant, including whether the uninterruptable power supplies are adequate, particularly for critical safety and shutdown instrumentation.

Additionally, the site may need to have a backup generator to meet key electricity demands (not related to safety), such as those for office and critical plant equipment. The capacity of the backup generator can be established by analyzing the electricity needs of each piece of equipment. It is usually not necessary for a backup generator (and its fuel supply) to be able to handle the plant's full production capacity.

It is worth noting that the probability of successfully starting and then operating diesel generators has historically not been high (*e.g.*, during the Fukashima Daiichi nuclear power plant disaster in Japan). If they must be relied on, establish that the generators are started and checked at least once per month and have an adequate fuel supply onsite. Fuel storage tanks should be at an elevation substantially above anticipated storm surge and flooding levels, and their enclosures should adequately protect them from flying debris during severe storms. Fuel systems should include automatic filtration mechanisms to remove water or sludge that can arise during storage. Furthermore, check that the starting batteries are functional, because they are susceptible to internal electrode and automatic recharging system failures.

Safety review. Failure, absence, or disregard of a safety system or protocol impacts the plant, people, and community in ways that dwarf considerations of financial liability. The DDT's major concern is that the plant is not, will not, and cannot be operated at conditions that exceed the limits of its equipment, piping, and safety systems. Compare the requirements shown on the as-designed and installed equipment data sheets with information from operating and production logs that show how the plant was actually operated.

Review the plant layout to ascertain compliance with codes that specify minimum allowable spacing between plant equipment and between the plant equipment and property lines, as well as locations of firewater and fire extinguishers.

Safety evaluations must also extend to the transportation networks and providers used by the facility. Many companies limit their transportation providers to a small group of carefully vetted suppliers.

The danger of not examining the safety records and practices of a transportation provider is illustrated by the derailment in 2013 of a runaway freight train that was carrying light crude oil. The accident killed 47 people and destroyed much of the city of Lac Mégantic, Quebec, Canada. The Transportation Safety Board of Canada concluded that the accident was caused by defective locomotive equipment, poor maintenance, driver error, flawed operating procedures, lack of safety redundancy, and weak regulatory oversight. Some, if not all, of the deficiencies could have been identified if the shipper had performed a DDA that included an evaluation of the transportation provider.

Also consider the risks associated with the type of transportation and the material being transported (*e.g.*, shipping crude oil by rail). Evaluate alternative shipping options.

Beyond physical systems, consider the safety culture of the plant and company. Interview plant staff and assess their in-house training. Verify the availability of standard safety data sheets for each chemical handled in the plant, and ensure operating and maintenance staff understand them. Examine emergency response instruction documents, such as those related to evacuation and notification of fire departments, police, hospitals, and environmental and other regulatory agencies. Determine whether periodic fire and evacuation drills that enhance employees' behavioral reliability under stressful conditions are conducted.

The effectiveness of a company's safety-related performance may be inferred by studying the firm's insurance claims and reports submitted to OSHA.

Permit review. Permits are required for any facility that discharges quantities of air, water, and solid pollutants that exceed specified thresholds. For example, a plant in the U.S. might require a Title V operating permit (colloquially referred to as an air permit) that forbids certain activities, establishes emissions limits, and requires periodic testing and reporting. Not having required permits, or having permits with unduly restrictive conditions, can be a huge problem.

Additional permits and federal requirements may include a water allocation permit, a water discharge permit, a process safety management plan, a SPCC plan, and hazard and operability (HAZOP) studies and results. Other permits from local fire or health departments may be required for the storage of certain chemicals.

While details may differ, all industrialized countries have similar requirements. The possession of all required permits and an evaluation of the conditions that they impose must be verified and evaluated. Moreover, ensure that the plant can realistically operate within the terms of each permit.

Closing thoughts

Both parties should agree on a scope of work for the due diligence assessment to ensure the due diligence team is properly staffed and has access to all necessary parties and information. It is equally important that aspects that are not to be addressed are made clear to all parties involved. Finally, in order to be effective, the DDT must be able to operate independently and be able to present its conclusions completely and without bias. CEP

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