Design and Implementation of Comprehensive Tank Overfill Protection Program

M.E. Erickson, SPE, Antea Group

Summary
Protecting human health and protecting the environment are essential requirements in today's exploration and production (E&P), refining, and petroleum marketing workplaces (pipelines and terminal facilities). Preventing tank overfills at above-ground, atmospheric storage tanks is essential, for "overfills" and the attendant consequences (e.g., potential volitization and groundwater/soil contamination) pose significant risk to the safety of workers, surrounding communities, and the environment itself. Overfill incidents demonstrate the need, and urgency, for tank-overfill-protection (TOP) measures to be evaluated and, as determined, undertaken.

The design and implementation of a TOP program offers potential benefits for E&P in the environmental, human-health, community-welfare, and safety performance areas. E&P operations do not necessarily involve the numbers of atmospheric tanks that are involved in, say for example, midstream (pipeline) operations; nonetheless, safety and environmental contamination are issues of concern. There are common attributes of a comprehensive overfill protection that can be applied to E&P settings.

A TOP program for a large pipeline organization—consisting of more than 800 above-ground, atmospheric storage tanks (Class 1 through 3 liquids), at more than 90 facilities—was recently developed and implemented, and is currently undergoing its first year of compliance and assurance (C&A) evaluation. This program was comprehensive in nature, containing its own unique objectives and distinctives.

The comprehensive approach and method undertaken provided major benefits to the organization and successful and long-term implementation. Such benefits apply to large-scale programs and projects alike and include the following:

- Defined management philosophy/vision
- Organizational commitment
- Strengthened accountability
- Identification of systemic gaps
- Consistency in policies, standards, and operations
- Long-term C&A

The results yield enhanced operations, risk reduction, and improved safety, all of which were evidenced in the TOP program.

There are two aspects to an overfill-protection program. The first is the "programmatic" aspect, which addresses the various program features [i.e., policy development, standards and procedures, roles and responsibilities, program management (PM) functions] and various content features of the overfill policy to be implemented. The second aspect deals specifically with overfill equipment, to include equipment identification and related engineering, procurement, and construction (installation) activities, as well as any necessary electrical and instrumentation upgrades at a facility. The programmatic aspect, in a proactive and preventive sense, is deemed the most protective regarding tank-overfill events.

This paper addresses a "conceptual model" for an overfill-protection program, based on this recent industry example. Key portions of the programmatic and overfill-equipment aspects will be addressed.

Introduction
An effective TOP program should be proactive and reflect management's vision, philosophy, and long-term commitment to achieve uniform protection standards and practices. The program should be reasonably comprehensive in scope, requiring development of key program parameters to ensure successful development and implementation. Such parameters necessarily include objectives to be accomplished; specific content features to be developed; new or revised definitions and terminology to be fully understood; operating requirements and practices to be defined and followed; appropriate organizational training required; engineering, procurement, and installation requirements (for identified overfill-protection equipment) to be established; and long-term commitment to C&A evaluations.

In sum, a conceptual model for a TOP program should seek to address or incorporate the following:

- Development of a tank-overfill philosophy, to include vision and objectives
- PM structure and protocols to achieve integration across the various stakeholders and full program implementation
- Survey of existing facilities to establish database of overfill input parameters (e.g., level settings or alarms)
- Program content features:
  - Standardized procedures and protocols
  - Standardized definitions and requirements, with a particular emphasis on alarm-set-point method and minimum response time (RT) for critical levels
  - Employee roles and responsibilities to be followed at the business-manager, engineering-staff, and operations levels
  - Conformance standards and measurement parameters
  - Integration requirements with engineering, inspection, and maintenance
  - Training to be accomplished, at all levels
  - Implementation of program policy requirements (the preceding) using management-of-change (MOC) procedures, and other means
  - C&A to evaluate conformance vs. nonconformances regarding policy implementation, with the goal of achieving continuous improvement and integrating shared learnings
  - Overfill-equipment (i.e., engineering, procurement) and installation evaluations

Program Philosophy, Vision, and Objectives
An overfill program should have a clear focus, purpose, and an end state to be achieved. A conceptualized vision statement and set of objectives might include the following.

Vision Concept. Committed to providing the highest-quality inventory-management practices resulting in TOP and safe operations, the goal is to be the recognized steward of products and overfill protection. We will continually review and improve overfill-protection effectiveness.

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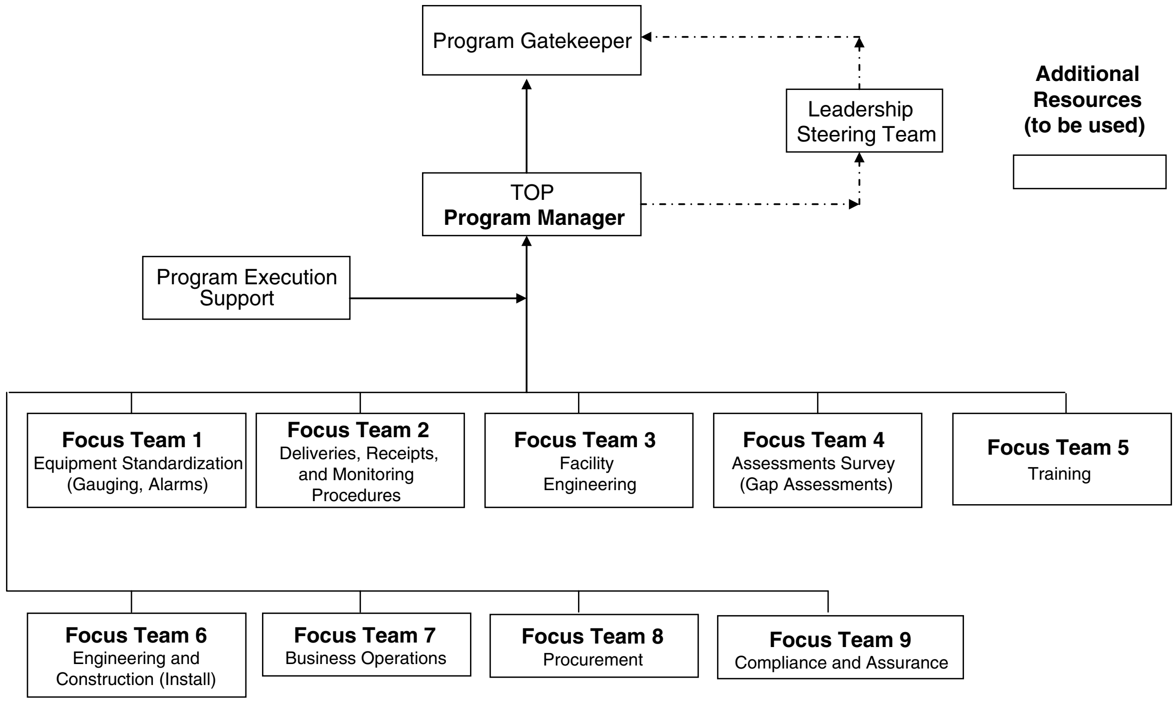

Fig. 1—TOP program management organizational chart.

Objectives. ***Consistency.*** Demonstrate recognized and measurable consistency in tank-inventory-management practices and TOP, which can be measured by establishing measurable standards of conformance. Identify nonconformances and corrective actions to be undertaken, and implement continuous improvement, shared learnings, and best practices.

Efficiency. Achieve optimal product delivery and receipts that ensure no tank overfills. The efficiency is measured by demonstrated clarity on available tank capacities and equipment status, demonstrated planning before product movements, and demonstrated knowledge and responses during inventory and product movements.

Safety. Improve and enhance safety performance and operational culture by implementing an overfill policy. Safety success will be measured by demonstrated leadership and commitment to safety, reduction in Occupational Safety and Health Administration (OSHA) recordables and meeting our safety expectations, and improvement in safety performance evaluations (e.g., field audits).

Environmental. Reduce or prevent environmental spills by eliminating tank overfills. Environmental commitment will be demonstrated through a demonstrated record of no tank overfills, establishment of a culture in which employees understand that they are individually accountable for adhering to and enhancing our quality program, and ensuring compliance with all applicable regulatory requirements.

Assurance. Develop a systemized approach for ensuring the delivery of conforming work products and outcomes. Assurance will be evidenced by establishing measurable objectives and ensuring compliance with all applicable regulatory requirements.

PM Structure

The PM structure must be designed to ensure alignment in objectives and achievement of key milestones and deliverables. The various teams must be properly identified to optimize alignment and accountability. Decision making must be efficient, and issues must be identified early on, with resolution occurring in a timely fashion.

The PM structure for a TOP program consists of key leadership assignments and accountabilities. Within the structure, there are “focus teams” that have a specific program area to accomplish and a scope of work to execute. Focus-team leaders make recommendations to the program manager and seek input from other team leaders. A “program execution support” serves to facilitate and coordinate the many activities and helps resolve the key issues that arise. An example structure is shown in **Fig. 1.** The focus teams must be integrated in communications and decision making, as shown in **Fig. 2.** The PM function must deal effectively with the organizational stakeholders. **Fig. 3** depicts such a reporting and decision-making relationship.

The various steering-committee groups represent key stakeholders across the larger organization, which have a potential impact on specific decisions regarding tank-overfill implementation [e.g., new standards issued throughout the organization, tank-capacity impacts (losses or gains) because of new minimum RTs to be met, budgetary implications, risk-management considerations].

Program Execution (Programmatic Aspects)

As noted, there are two aspects to an overfill-protection program (i.e., the programmatic portion and the portion concerned with field installation of new overfill equipment). Broad application and successful implementation of the programmatic features ultimately realize the greatest benefit to an organization in achieving overfill protection. The following programmatic activities are highlighted.

Governing Policy Document on TOP. An overarching document should be developed to establish the basic policy regarding TOP, and it should include key objectives, standards, and specific conformance requirements.

Of significance was management’s stated policy commitment to ensuring overfill protection. The policy’s provisions applied to all employees of the organization who were directly involved with, have an impact on, or influence storage-tank operations, including tank filling, monitoring and measuring, maintenance, and reporting. Further, the policy applied to all atmospheric storage tanks that receive pipeline, truck, rail, and marine deliveries (crude or petroleum) controlled or monitored by the organization’s personnel, and this even includes the organization’s owned tanks receiving deliveries by other nonorganizational operations. Finally, where pos-

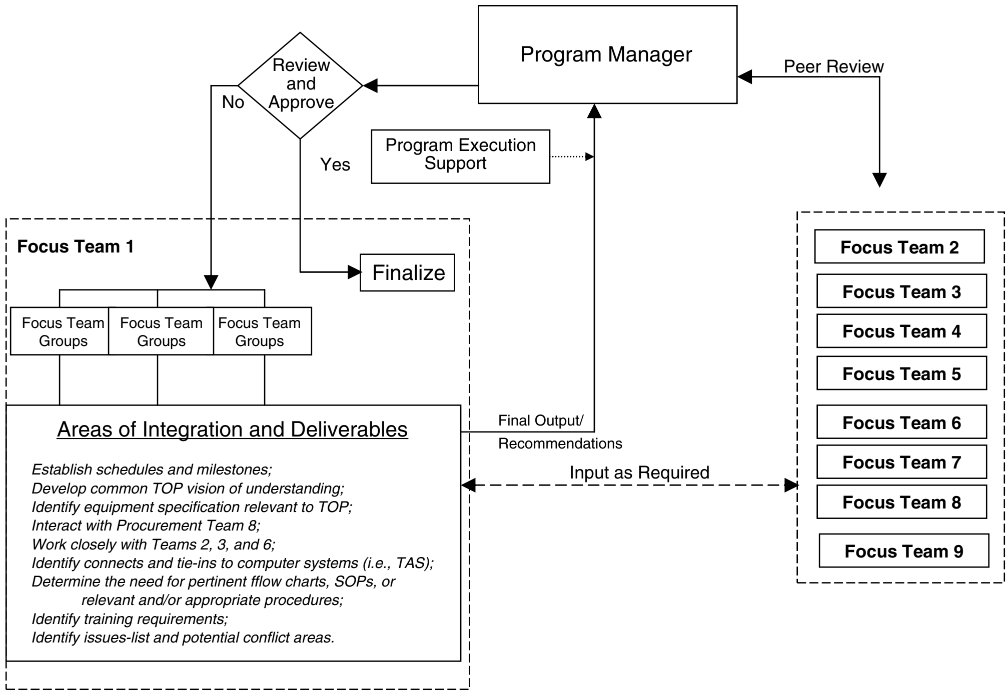

Fig. 2—Communications and review process.

sible to implement, the requirements applied to facilities owned by the organization but operated by others and even those facilities operated by the organization but owned by others.

The following is a structure for such a policy document:

- General
  - Purpose
  - Goals
  - Scope (required practices, applicability (personnel, new vs. existing equipment), standards, training
- Overfill-protection highlights (executive summary of policy)
- Alarm-set-point method
  - Critical alarm levels
  - Minimum RTs
- Tank-level monitoring (requirements and preventive actions to be taken)
- Installation, inspection, maintenance, testing, and commissioning of overfill-protection equipment
- MOC requirements (for modifications that could affect overfill limits)
- C&A requirements
- Key definitions
- References
- Administration
- Appendices
  - Work sheets and forms (preplanning forms for determining available capacities; expected vs. actual calculations for monitoring tank levels during receipts)
  - Training requirements
  - Planning and monitoring of product-movements procedures
  - Waivers (conditions authorizing exceptions in minimum RTs)

The critical overfill parameters to be followed are depicted in Fig. 4 (i.e., levels of concern and alarm set points). **Fig. 4** illustrates and summarizes levels of concern and RT parameters. The RT in minutes is the time for operators-responders to be contacted and stop-divert flow to prevent activation of the next critical alarm level. Three RT levels have been established, shown as ZZ, YY, and XX minimum RTs in Fig. 4. Selected concepts are as follows:

- A “primary RT” is the amount of time at maximum flow rate (MFR) between a high-level (HL) alarm and a high-high-level (HHL) alarm. This time shall be used to calculate the HL alarm set point. The YY-minute primary RT is the minimum standard to be used.
- A “secondary RT” is the amount of time at MFR between an HHL alarm and the overfill-level (OFL) of the tank. This time shall be used to calculate the HHL alarm set point. The XX-minute secondary RT is the minimum standard to be used.
- Alarm set points shall be established that are based on the amount of a tank’s available space required to support the RTs determined in the preceding and at maximum possible flow rates. The calculations shall be completed for each tank at a facility, and resulting documentation shall be archived and made available to all facility personnel. (Note that the overfill policy requires a minimum RT between the “low working level” and “low alarm level,” as indicated on the diagram in Fig. 4.)

Survey of Existing Facilities (Establishment of a Database). The front-end loading (FEL) of key overfill information is essential in developing an effective protection program. A survey should be conducted of all applicable tanks to gather key information. Key information is necessary to understand existing overfill conditions. Examples of information are provided below (by location/facility):

- Tank number, status (active or inactive), current service
- Roof type, overfill slots, and strapping chart—is the strapping chart up to date and reliable?
- Nominal tank diameter (ft) and nominal tank height (ft)
- OFL height (ft)
- Gross shell capacity (bbl)
- Safe or normal working level [safe fill working level (SFWL)] (ft)
- HL alarm (ft)
- HHL alarm (ft)
- MFR (definition per policy, in bbl/hr)
- Tank gauge type, manufacturer, model
- HL alarm (type, manufacturer, model, tag number, connection point)

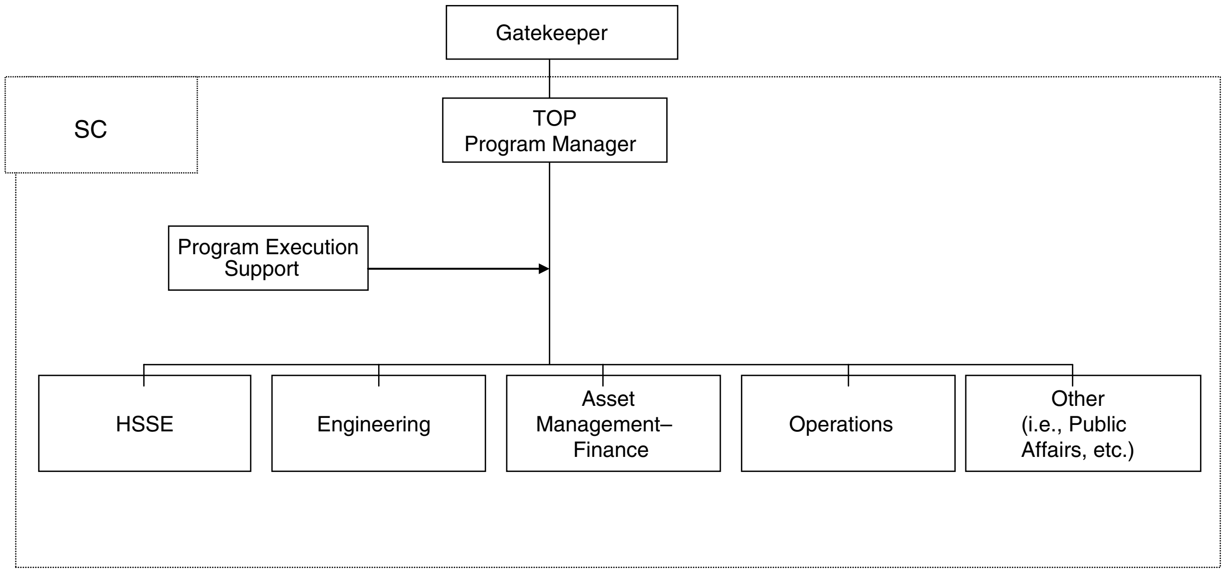

Fig. 3—Steering committee (SC).

- HHL alarm (independent, type, manufacturer, model, tag number, connection point)
- Tank capacity (bbl/ft)
- OFL-HHL (ft)
- Calculated RTs: OFL-HHL (minutes)
- HHL level-HL level (ft)
- Calculated RT: HHL-HL (minutes)
- HL-SFWL (ft)
- Calculated RT: HL-SFWL (minutes)
- Total time (minutes) (total calculated RTs from OFL-SFWL)

From this database, determinations could be rendered as to the potential number of tanks and alarm settings not in compliance with the company's minimum RTs, and additional stakeholder considerations could be made transparent.

It should also be noted that in addition to this database, risk-evaluation considerations were undertaken, particularly with respect to establishing equipment prioritization. Such considerations included aged equipment and locations in proximity to sensitive receptors.

Additional Content Features

In addition to the specific requirements reflected in the policy (see document structure in Governing Policy Document on TOP subsection), there were some special features, which, when completed, added strength to the program. These features merit consideration in any overfill-protection program.

Special Procedures and Protocols. Given the diversity of equipment, facilities, and varying monitoring and delivery methods used throughout the organization (e.g., manned vs. unmanned; automated vs. manual), the policy mandated three additional standard operating procedures (SOPs) to be established:

- Focus Team 1 prepared an equipment SOP for the standardization of tank gauging and alarms;
- Focus Team 7 prepared a special SOP for the planning and monitoring of deliveries and receipts
- Each facility was required to develop its own SOP on planning and monitoring of deliveries and receipts, consistent with the product from Focus Team 7. This facility SOP is to be tailored to its unique operations.

There were standardized calculation forms to be used in the preplanning phase to determine available tank capacities in advance of a planned receipt, as well as during periodic intervals of a receipt to monitor expected vs. actual levels.

Waivers. All tanks must meet minimum RTs, based on alarm level settings, at MFRs (i.e., the ZZ, YY, and XX minimum RTs in the diagram in Fig. 4). If these RTs were not achieved, then the alarms must be adjusted to bring overfill requirements into conformance. However, a formal "waiver" process was established to grant exceptions.

The waiver process is, in effect, a petitioning process, whereby the tank owner seeks permission to operate at RTs less than the minimums. However, respective managers must justify the waiver petition, on the basis of analyses of relevant business and technical/engineering drivers. Additionally, accompanying each waiver request is a risk management and mitigation plan, in which the following criteria must be demonstrated:

- Increased operational safeguards have been established (e.g., increased manning)
- Technical/engineering safeguards have been engineered and installed
- Operational safeguards and enhancements have been undertaken (e.g., additional communication linkage with suppliers).

Standardized Definitions. An effective policy should identify a common set of terms and concepts to be clearly understood and embraced by personnel. Among the many definitions to be understood and accepted, three deserve emphasis:

OFL. Liquid level when the tank is filled to its maximum capacity, and the lowest level at which any of the following occur:

- Additional product will overfill and spill out of the tank (through foam nozzle, overfill slot, overfill nozzle, or top of tank)
- Floating roof component comes into contact with fixed roof component (e.g., seal touches fixed roof structural, floating roof leg touches fixed roof).
- Maximum allowable stress level is reached in tank shell.
- Secondary seal reaches the top of tank shell on external floating roof tank (EFRT) with primary and secondary seals.
- Top of primary seal reaches top of shell on EFRT with primary seal only.

Independent (Alarm). A type of alarm that is free from any control or influence by any other gauge or alarm on the tank. The HHL alarm shall be independent.

MFR. The highest possible flow rate to a tank, but not including a potential initial spike associated with the very beginning of the receipt.

Definition. The MFR (in bbl/hour) is the flow rate used in calculating the minimum RTs for crude/product deliveries into an atmo-

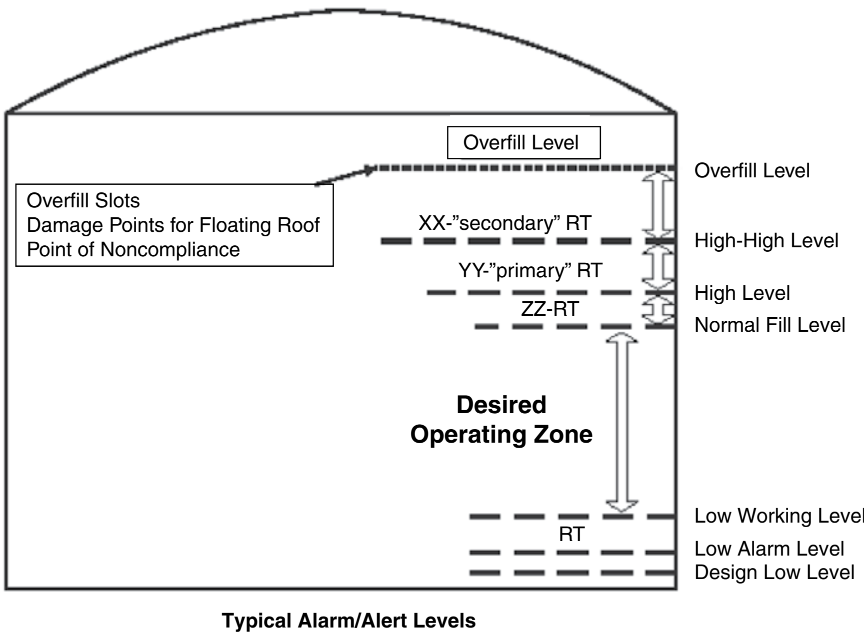

Fig. 4—RT minutes (minimums).

spheric storage tank, for the purposes of setting the normal (safe) working alert level, HL alarms, and HHL alarms.

Determination Basis. The MFR represents the MFR conditions under all intended and purposeful operating plans for that tank. The MFR is not the average or typical flow rate, but a flow rate based on recognized and approved operational scenarios. The determination shall include the maximum flow in a particular pipeline and any additional contributions (flow rates) from other pipeline sources, as well as contributions from overfill/relief systems. A new MFR should be determined when the tank-service and/or delivery-service conditions change.

Employee Roles and Responsibilities. It is important that an effective policy be clear and unconfused regarding roles, responsibilities, and accountabilities. An organization would do well to consider clarity on "shall" vs. "should" statements. The organization must provide a clear and consistent tank-operating philosophy, requirements, and expectations for operators and tank maintenance and inspection personnel.

All personnel must be fully trained and possess a clear understanding of the key terminology and concepts, to include the minimum RTs (i.e., ZZ, YY, and XX minimum times) and corresponding alarm-set-point bases; MFRs used to determine any approved waivers; preplanning calculation bases used to determine available capacities as well as calculations for estimated vs. actual tank levels during receipts; and any specific duties, responsibilities, and procedures required to achieve overfill-protection conformance.

Integration of Engineering, Inspection, and Maintenance Activities. Successful overfill-protection programs must integrate engineering, inspection, and maintenance activities with overfill practices and operational conditions. There should be periodic inspections (e.g., monthly, quarterly, semiannual, and annual events) for designated equipment. Preventive maintenance and walk-around inspections should occur frequently and constitute hallmarks of a proactive program. Maintenance and inspection records should be documented and be readily available to operators.

Training. All individuals from (managers to operators) should be trained on the basic "programmatic" aspects and concepts of an overfill program. This level of training would normally include the philosophy, vision, objectives, and all key definitions and content items. As previously noted, personnel must be trained and possess a clear understanding of terminology and concepts, especially to include minimum RTs (i.e., ZZ, YY, and XX minimum times), MFRs, and preplanning calculation bases used to determine available capacities as well as calculations for estimated vs. actual tank levels during receipts.

Training may be structured according to need and various levels to fit roles and responsibilities. For example, whereas all personnel should take basic programmatic training, specific equipment operators should undergo training on radar automatic tank gauges (ATGs).

Implementation of Program Policy Using MOC Procedures. Implementation of the programmatic aspects of an overfill policy should be performed in a way that ensures successful implementation and strengthens accountability throughout an organization. An MOC process will normally be administered as set forth by the organization. However, experience shows that additional and/or concurrent steps are useful and may even prove more effective in achieving implementation. Such measures include coaching sessions, town-hall meetings, dial-in conference calls with question-and-answer sessions, and road-show presentations. All the tools in the implementation toolbox are needed.

Conformance Standards and Measurement Parameters. Tracking performance metrics regarding overfills is essential. The following metrics will provide sufficient evidence that adherence to the overfill policy is occurring appropriately:

- An absence of HL, HHL, and low-level alarm activations will demonstrate that overfill planning as established by the policy requirements is taking place.
- Appropriate level (local/regional) management should require periodic confirmation (e.g., quarterly), that the sum of all tank alarm activations for the reporting period does not exceed 1 event. Evidence that any HHL alarm activation has occurred shall be investigated.
- All unintended HHL alarm activations shall be considered a serious "near miss" and require a root-cause investigation (RCI) along with timely implementation of RCI recommendations.
- Independent confirmation is required that timely and effective corrective action has been implemented regarding C&A findings on overfill nonconformances.

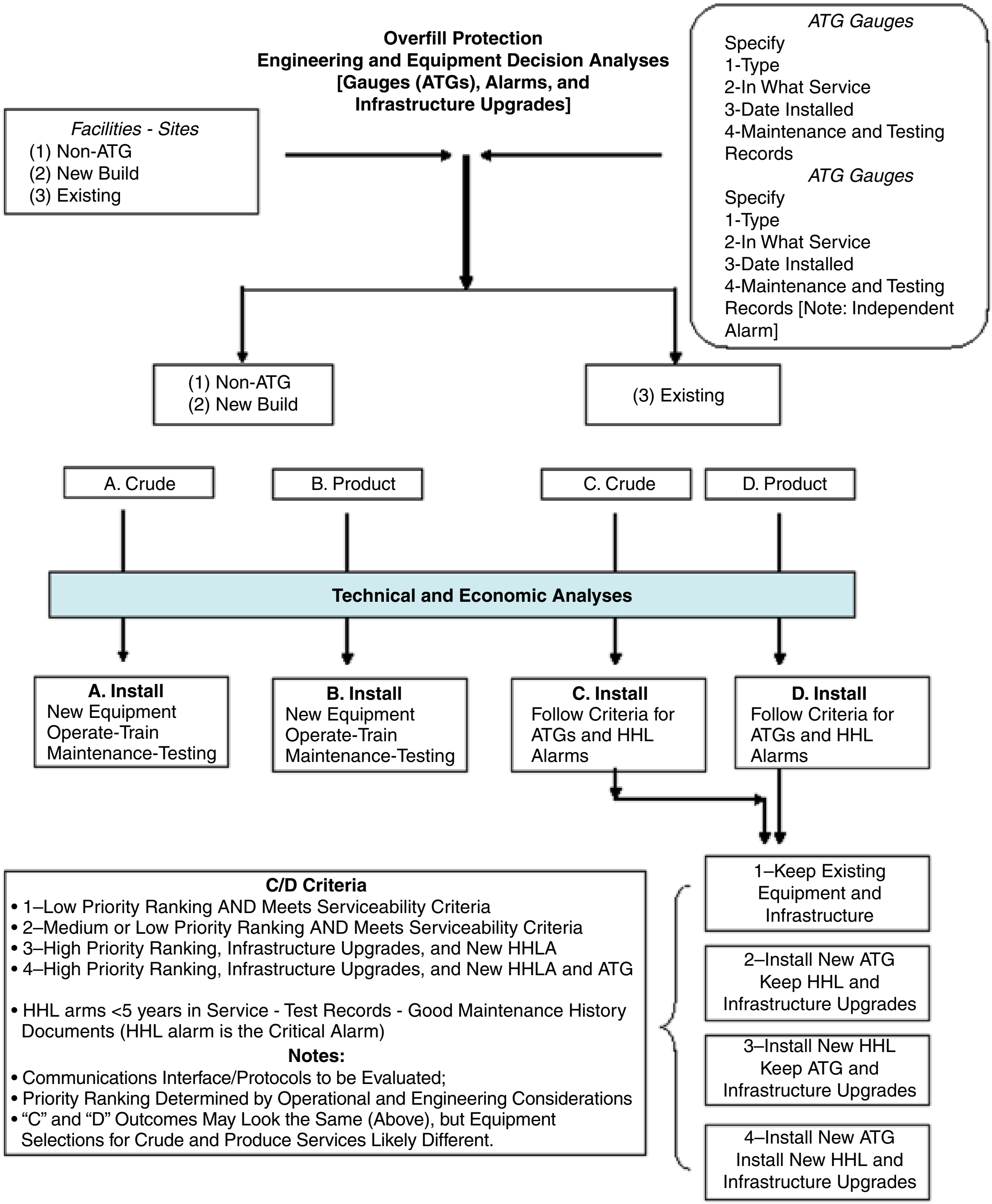

Fig. 5—Engineering and equipment decision analyses.

C&A and Achieving Continuous Improvement and Shared Learnings. The policy must be dynamic and living—not a one-time event to be placed on a shelf or embedded on a library server. An effective overfill-protection policy should provide, proactively, a mandated provision for C&A. A C&A program should be established to provide for identification of shared learnings and continuous improvement opportunities, through internal and/or independent means.

Periodic internal auditing will be conducted at local facilities, with nonconformances noted, and shared learnings and continuous improvement opportunities will be reported throughout the organization.

Integration must be widespread, designed to encompass the key elements of policy, data, training, equipment, and C&A.

Program Execution (Equipment and Infrastructure Aspects)

As noted, there is an equipment aspect to the overfill program. This portion largely focuses on new ATGs and alarms, but may also include necessary instrumentation and electrical upgrades.

A comprehensive program does not necessitate encompassing purchases of new equipment. In fact, use of existing equipment is deemed appropriate, when properly demonstrated to reside within acceptance criteria.

Engineering, Procurement, and Installation Evaluations.

- Equipment evaluations should consider
  - Technical evaluations (new vs. existing)

– Total cost of ownership
– Organizational and facility impacts
– Electrical and instrumentation upgrades
– Stakeholder needs
– Regulatory drivers
- Evaluations include
– Traditional engineering, procurement, and installation analyses
– Special studies

A strong overfill program must recognize the diversity that inherently exists. This extends to facilities (existing non-ATG sites, crude vs. product tankage, and new sites—tanks to be built), monitoring methods employed (fully automated vs. manual), manning and resource levels (manned or unmanned), and varying gauges and alarms (e.g., radar, magnetostrictive, servo, tape and float gauges, and varying alarm types, to include mechanical switches, and electronic-capacitance devices).

To meet this challenge, the various technologies and associated costs were examined for various configurations in existing and new equipment, as well as instrumentation and electrical upgrades required.

Fig. 5 identifies a conceptualized evaluation process (technology and life-cycle costs) and decision matrix for crude and product technology options.

Post-Program Implementation Evaluation

The TOP program accomplished its primary programmatic aspects and is in full program implementation. C&A is currently in progress by the business unit, with internal audits of facilities and C&A integration in all areas of the business unit. Equipment and installation activities are ongoing.

The results today indicate that the program has achieved the following:

- Defined management philosophy/vision
- Organizational commitment
- Strengthened accountability
- Identification of systemic gaps
- Consistency in policies, standards, and operations
- Long-term C&A.

The program results have been clearly attested to, and manifested, in the following areas: management's strong commitment to the program policy and emphasis placed on identification of best practices in overfill protection; employee awareness and dialogue in areas of overfill policy, procedures, and requirements; integration of shared learnings across various business regions; evaluation of metrics performance; identification and review of training enhancements; and long-term C&A plans integrated across the business. The net effect in the business unit today is enhanced operations, risk reduction, and improved safety. The program has received such support as to have been submitted by leadership for consideration of special award recognition at the corporate level.

With respect to costs, while the program is ongoing in its first-year compliance evaluation, programmatic development and implementation costs across all areas are approximated at USD 600,000. These costs are based on external-consultant support in all programmatic areas, over a 3-year period, and do not include internal costs borne by the organization. The comprehensive survey of existing facilities (to identify and record key tank and overfill data) was handled by outside-engineering-firm teams over a 3-month period at a cost of approximately USD 65,000. Installation costs regarding new alarms, automatic tank gauges, and facility upgrades (e.g., new conduit) will vary significantly, depending on the decision-matrix outcomes (as noted in Fig. 5).

Conclusion

Protecting human health and protecting the environment are essential requirements in today's workplace. The design and implementation of a TOP program offers potential benefits for E&P in the environmental, human-health, community-welfare, and safety performance areas. While E&P operations do not necessarily involve the numbers of atmospheric tanks that are involved in midstream (pipeline) operations, there are common attributes of a comprehensive overfill protection that can be applied to E&P settings.

The programmatic aspects of an overfull program are deemed the most protective regarding tank overfill, in that they are proactive in nature and represent prevention at numerous levels. For an overfill-protection program to be successful, there must be clarity and transparency in all of its programmatic features, to include a well-written and management-supported policy, uniform standards and procedures, roles and responsibilities, and an effective program management function. An overfill program cannot be a one-time event—it must be characterized by a C&A program and commitment to continuously improve and strive for excellence.

Management must have a passion for this long-term commitment.

In conclusion, the comprehensive approach is relevant and needed. In 2007, the Buncefield Standards Task Group (BSTG) rendered concluding thoughts in its final report [Safety and Environmental Standards for Fuel Storage Sites, (pages 65–67, http://www.hse.gov.uk/comah/buncefield/bstgfinalreport.pdf)], all of which are demonstrated in this case presentation. "Delivering high performance through culture and leadership. The sector ... needs leadership in operating and safety standards on a long-term basis...

- Clear goals and objectives are set ... made visible by leadership...
- Expectations are translated into procedures and practices at all levels ...
- Relevant metrics are set and performance is assessed at appropriate intervals ...
- Lessons from incidents/near misses are shared ...
- All hazards are considered ... personal, process safety, security, environmental ...
- There is open communication and consultation..."

Michael E. Erickson is a consultant for Antea Group with 35 years in program management of refinery, pipeline, and remediation projects; operational audits at US and international facilities; authoring policies and procedures; and developing strategic management initiatives. E-mail: Michael.Erickson@anteagroup.com. As a senior consultant for Antea Group since 2004, he led in the design and implementation of a client company's nationwide tank overfill protection program. Erickson holds a BS degree (1971) from the US Military Academy, West Point, New York, USA and an MS degree (1982) in mechanical engineering from the University of Illinois at Urbana-Champaign, Illinois, USA.