Enabling the refinery of the future – Safety first

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Author: Dan Mulholland

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The recent downturn in oil prices has reduced feedstock purchasing costs for the hydrocarbon processing industry (HPI). As a result, refineries are running above and beyond their design parameters. This, in turn, has increased the pace of expansion, upgrades, modifications and the number of debottlenecking projects to accommodate increasing throughput.

Within this "new" economic environment, refinery automation systems must be capable of delivering new levels of productivity and scalability, while ensuring safety, managing globalizations and addressing changing workforce demographics. Is the current automation infrastructure ready for this, and are these issues being given the appropriate priority levels?

Today's infrastructure

The refinery of the future (ROF) is focused around the improved capture of data, retention and definition of knowledge and overall clarity. However, it does not refer solely to a new facility, but it also incorporates and embraces the desired functionality and operation of existing systems/sites.

Justification must exist for requirements to be introduced into these expedited brownfield projects, and the catalyst for real change needs to be centered more on the avoidance of unacceptable risk. Since the explosion and resulting fire on the Piper Alfa North Sea oil production platform in 1988, which killed 167 men and caused a loss of approximately $3.4B, the industry has moved towards safer working practices under IEC 61511, or equivalent, guidelines.

When process industry incidents are examined, the majority of causes are attributed to engineering design or maintenance procedure errors. There are multiple mediums and languages used in the communication of specification requirements, formats, design details and engineering outputs, as well as different parties involved – including end-users.; licensors; engineering, procurement and construction (EPC) companies, consultants; and contractors/integrators. It is not surprising that challenges arise at each stage.

Beyond the design, system maintainability is also a main cause of incidents. The 2005 explosion at the ISOM isomerization process unit at BP's Texas City refinery in Texas, which killed 15 workers and injured 170 other, and Piper Alfa are well publicized examples of traditional methodologies that have failed to protect the workforce, the asset and the environment. Despite such compelling justification, the implementation of functional safety management (FSM) practices preached by IEC 61511 remains slows. The FSM premise is the maintenance of a compliant safety life cycle (Fig. 1.), but, because the industry is mainly brownfield, it is difficult to gain a starting point or foothold on that lifecycle.

If the ROF is to be introduced in today's refinery environment, an entry point to implement this technology on every modification, upgrade and maintenance work package must be found.

FIG. 1. The maintenance of a compliant safety life cycle is pushing the modernization of HPI refinery automation systems.

Distributed complications

The one common obstacle is organizational inconsistency, ranging across differences in standardization levels, centralized engineering, fixed vendors lists, contractors vs. staff ratios, etc. Even single suppliers use different engineering centers to deliver the best margin for a single customer. The underpinning principal of all forward thinking strategies is standardization. With the number of people, companies and cultures involved in a project, it can be difficult to implement document-based guidelines.

The safety industry has identifies tools to support its safety life cycle, but management barriers have traditionally prevented their adoption. Although the desire to attain a maintainable life cycle (Fig.2.) is

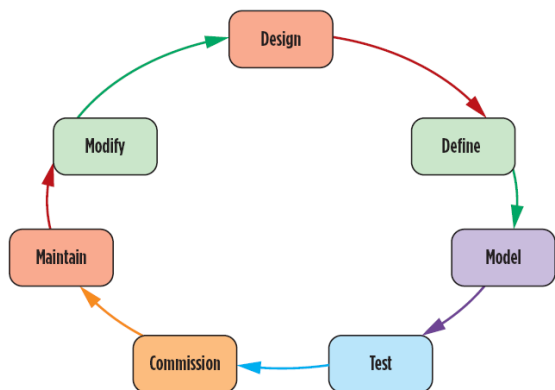common, transitioning from current systems can appear distant.

FIG. 2. An efficient, maintainable and compliant life cycle is attainable with modernized FSM practices.

Documenting knowledge

In older plants, it is understood that documents will be lost, changes will be undocumented and knowledgeable staff will leave. One of the biggest obstacles is that much of the expertise behind these systems is inside the heads of the engineers who built them, and it is not properly documented. This makes modifications difficult, potentially dangerous and certainly noncompliant. Gathering design intentions and the distilled knowledge that produces the downloaded operating code is imperative before improvements in data recording or plant expansion are possible.

There are products that enable translation of the downloaded legacy code into a future system. One such product translates the code of legacy systems into intermediate mathematical formulae, which can then be reviewed. The old flat-logic, object-oriented patterns are refined to new corporate requirements and exported to a new system or specification. Scenarios can easily be tested and refined, including negative testing to mimic potentially thousands of possibilities that explore what the system can achieve or withstand. The true value lies in documenting the increasingly complex code to demystify and fully understand its functionality.

Joining components in plant packages

An estimated 44% of incidents can be traced back to poor specification requirements (Fig.3), and

remedying this can be a complex and time consuming task that requires expertise across multiple disciplines. Communicating control requirements across those disciplines requires a universally understandable platform or language.

Collaboration in the design process and on simulation models is a practical, inexpensive and invaluable first step to defining functionality and removing ambiguity. Specifications can be created and implemented in a soft environment quickly and without risk, and compliance is checked throughout the process. A database-driven lifecycle engineering environment can deliver this functionality as the components are referenced in the database.

In the ROF, system structures, form and content must be aligned and maintained by more global support infrastructures. However, attempts at standardization across different geographic regions, languages, cultures and working practices have created problems in the past.
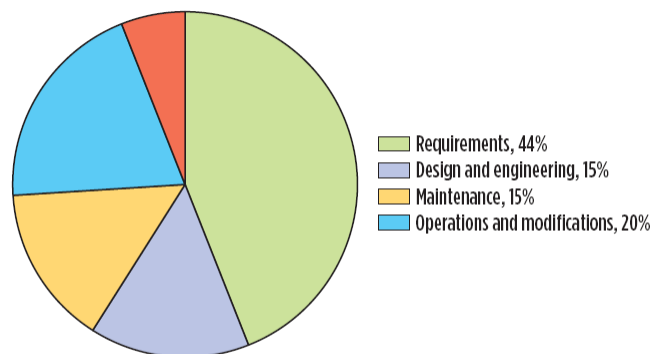

Requirements, 44%
Design and engineering, 15%
Maintenance, 15%
Operations and modifications, 20%

FIG. 3. Remedying the causes of incidents requires expertise across multiple disciplines.

Moving away from pre-canned technologies

While the concept of entering domains with pre-canned technologies is easy to grasp, the execution is less simplistic. It is very rare for two "common" packages to remain the same. Tag changes are necessary, physical environments may demand different setups, company standards request various instrument suppliers, etc.

Rather than developing packages that are static, the specifications, simulations, testing regimes and FSM

can now be linked to the packaged plant. If an instrument type change is entered in one location, the automated tools ensure that the documents are updated, safety integrity level (SIL) calculations are rerun, maintenance regimes are updated, loop drawings are redrafted and system functionality is updated.

Modular package –based systems are now specified based on functionality and not components, leading to original equipment manufacturer (OEM) packages aligning with corporate requirements without upsetting package suppliers' sensitivities.

Key performance indicator (KPI) tools exist across the industry. There are open interfaces to capture available data and present information on process performance or maintenance requirements, but sometimes that data is not the appropriate information. Instead of attaching tools to interpret that data, standardizing and refining the basic building blocks of the functionality, including metrics and indicators, should be considered.

Regulatory compliance

Last year, $41B of losses were reported in the HPI due to bypassed safety practices, plant closures, lost jobs and tragic loss of life.
The latest release of IEC 61511 highlights the need to reread the supporting documentation each year. If a regulatory requirements changes, the tools should accommodate and inform, where appropriate. A new era of electronic standard operating procedures (eSOPs) are available and FSM is paving the way to demonstrate the benefits.

The standardization of global processes, the monitoring of stage progressions and bottlenecks, and the updating and more efficient distribution of corporate procedures are key factors in maintaining compliance.

Decision support

Recently adopted safety- related management systems and captured data are reducing cost of poor quality (COPQ), or "regret", cost, and are being linear documentation driven to database-centric, changes and their potential impact can be better understood.

Possible applications include the impact of delaying a proof test on a systems interoperability framework (SIF) or the impact of changing a trip point on a downstream valve on the upstream process. A UK-based refinery recently avoided collapsing a stripper unit by deploying a high resolution model attached to a live model of its safety system a scenario of a downstream SIF positively tripping. The result agreed with the hazard and operability (HAZOP)study, and the function tripped. Eight minutes later, the process backed up knocking out the compressors and causing a vacuum in the stripper beyond its design limits. This was not picked up by the HAZOP study. As processes become more complex and the number of experienced engineers dwindles, the lesson learned us that decision support systems need to be adopted.

The human factor

As the events of the past are studied, a key influencer in the prevention of incidents is personnel. For example, operators catch process issues, maintenance staff identify failure components or overrides, etc. Despite advance control technologies utilizing fuzzy logic and neutral networks, the HPI is not yet in a position to start automating some of the more safety-related or complex process decisions. These are left to trained operators. While operator training simulators (OTS) help to eliminate the risks, the functionality of the OTS commonly remains fixed at the original design parameters, while the actual process is constantly changing.

As the processes are integrated into a dynamic, maintainable lifecycle environment, capturing all changes as they happen, the OTC can be attached to that model.

When keeping a safety requirement specification (SRS) up to date, either because of evolving plant design or a pending site safety inspection, the relevant documentation and personnel are gathered to determine whether the SRS needs to be updated. This manual process is often driven solely by the need to create documents, most of which are ambiguous, short on detail and out of date.

As with all manual processes, there is considerable room for errors, which means additional time and expense to becoming IEC 61511-compliant.
It is not surprising that an estimated 44 % of errors are introduced during the specification stage, with 15 % occurring during documentation, 20% during engineering and implementation, 6% during testing and 15% at the operations stage, as illustrated in Fig.4. When SRS is produced, it is only valid at that time. As further system changes are made, it becomes necessary to manually reproduce another SRS to ensure its validity.
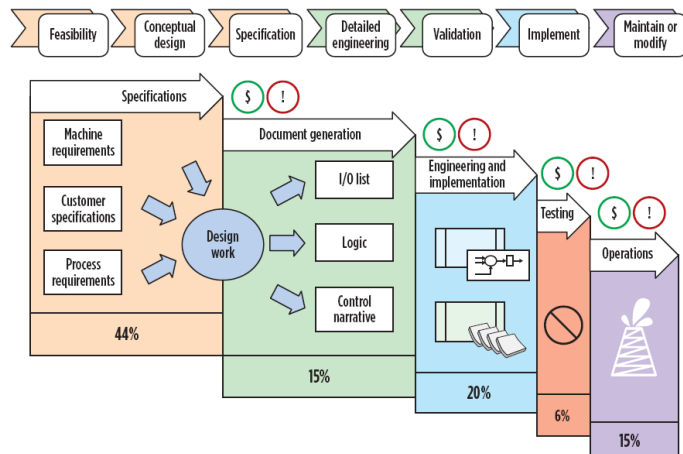
distributed control systems in hazardous and harsh environments while working with GE Intelligent Platforms and formerly, Measurement technology Ltd. Mr. Mulholland has lectured both BS and MS curriculum in mechatronics at Leeds University and is introducing lifecycle management solutions focused on automating Phase 4 activities with TIS.

FIG. 4. In manual engineering processes, there is considerable room for errors and wasted expenditures.

Knowledge as the key proponent

A single strategy based upon common platforms should be embraced wherever possible. The evolving ROF should solve current struggles over obsolescence through intelligence recovery and the re-engineering of systems. Coalescing different disciplines through graphical languages will remove ambiguity through high level knowledge-based systems. There are available tools that embrace these concepts, providing simpler collaborative engineering environments and enabling a maintainable lifecycle management for existing systems. This provides the base that encourages attainment of ROF benefits.

About the Author:

Dan Mulholland is a global sales director for Trinity Integrated Systems Ltd. (TIS), and he has worked through the introduction of a new concept of physically