Benchmarking the Asian Energy Industry: Strengths and Opportunities in a Rapidly Developing Market

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FOREWORD

In 2013, Marsh issued its first benchmarking study gauging the comparative risk quality of the Middle Eastern oil, gas, and petrochemical facilities relative to more than 500 similar facilities worldwide, as present in Marsh's database. We are now delighted to extend this analysis to Asian onshore oil, gas, and petrochemical facilities. The results of which have been used in this report to contextualize risk quality in Asia and explore regional trends, thereby helping clients understand current trends and provide a comparative view of the risk quality of their assets and operations.

Marsh's risk ranking system provides an absolute measure of risk quality when compared against a defined set of criteria, while benchmarking determines a client's (or even a region's or industry's) position relative to its peers. These proprietary systems have been developed and enhanced over the past 25 years and are based on the views of both Marsh's risk engineers and those of the underwriting market. Marsh developed its benchmarking tool to provide a proactive risk-improvement approach based on current standards and best practice. For many of our clients, Marsh's benchmarking reports have proven to be a catalyst for change.

Overall benchmarking scores reveal the risk quality of Asia's onshore energy portfolio to be in the lower-middle quartile relative to its global peer group across a broad spectrum of risk-quality features. In terms of hardware, Asia lags behind its global peer group. This is partly due to the inherent natural catastrophe (NATCAT) exposures in the region and the limited suitable land available for energy production sites, which often require a very large "footprint."

Engineering standards vary across the region, primarily due to country-specific legislation and the influence of external third parties. Encouragingly, new projects in Asia typically achieve significantly higher risk benchmarking scores than existing assets, reflecting the adoption of the latest industry standards and best practices.

In general, Asia tends to lag slightly behind the global peer group in terms of software and emergency control. This can be, in part, attributed to the diversity of the region, which has no common overarching legislation.

The outlook, however, is a positive one. Insurance-related risk engineering surveys have identified huge potential for energy facilities to improve risk management through better training and the implementation of cost-effective improvements to on-site management systems. Improving risk quality will have advantages for both clients and underwriters, as higher-quality risks tend to produce fewer losses, generally resulting in better rates and capacity.

As with studies conducted in other regions, through highlighting strengths and opportunities, it is our hope that this study helps signpost the direction for further improvements and offers a positive contribution to ongoing loss prevention efforts.

Ian Henderson

Global Energy and Power Engineering Leader

ASIA: SUPPLYING A RAPIDLY DEVELOPING MARKET

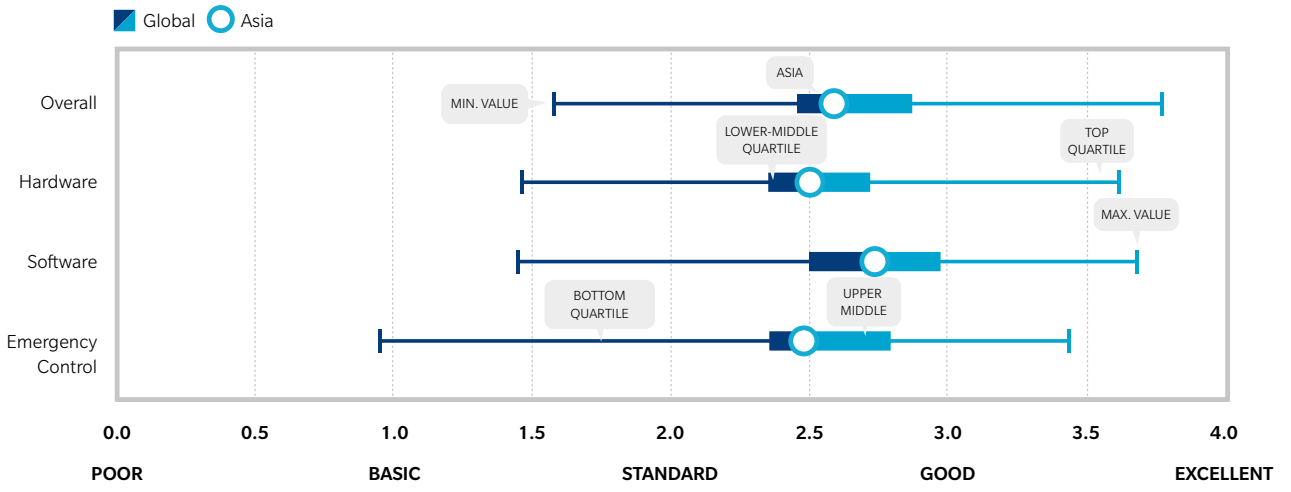
Asia is a geographically and culturally diverse region that has seen a significant increase in gross domestic product (GDP) growth and consumer demand in recent years. As a result, existing onshore energy facilities have been revamped and optimized in order to increase overall capacity in the region.

This boom in production has led to a significant spread in the ages and risk quality of assets in the region, which now face particular challenges regarding facility spacing (which is often driven by smaller plot sizes or expansion of older facilities) and in dealing with a disparate set of local engineering standards. Recent investment has brought about key improvements in certain areas; however, there is still some way to go before Asian facilities are able to achieve risk-quality positions akin to their peers in other regions.

This study benchmarks more than 50 sites located in East Asia (China, Japan, Taiwan, and Korea) and Southeast Asia (Indonesia, Malaysia, Thailand, Philippines, Singapore, Brunei, and Vietnam) in order to assess the region's risk quality compared to that of its global peers.

The overall benchmarking scores reveal that the Asian onshore energy portfolio has attained a risk-quality position in the lower-middle quartile relative to its global peer group across a broad spectrum of risk-quality features (see Figure 1). Asian benchmarking scores are either slightly higher or on a par with other such as India, Africa, and Latin America. However, Asian sites lag behind those in Western Europe and North America, which have more mature management organizations and systems, and in the Middle East and Australia where there has been a significant amount of new capacity added in recent years, particularly in the liquid natural gas (LNG) sector. It should be noted that many opportunities for improving the risk quality of the Asian sites have been identified during insurance-related risk engineering surveys, and are further evaluated in the course of this benchmarking study.

FIGURE 1 Overall Benchmarking Scores - Asia versus Global



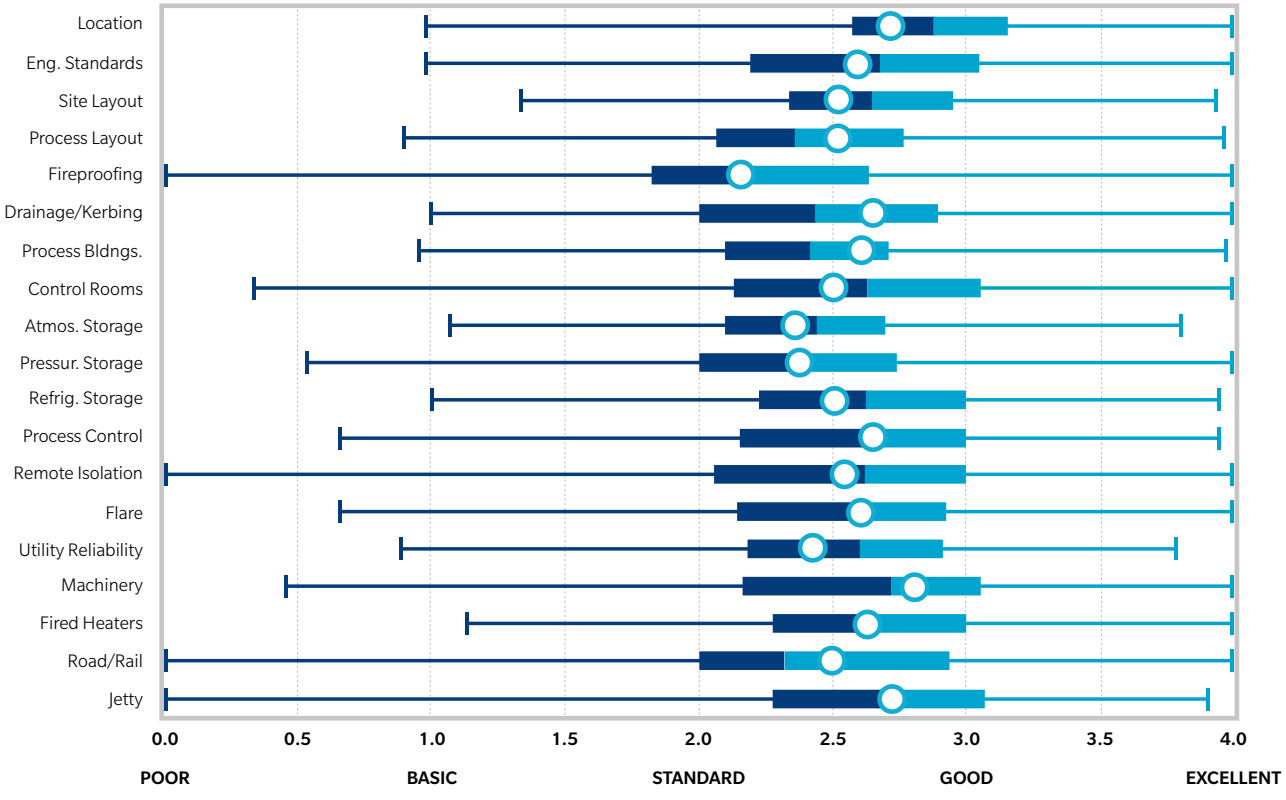
HARDWARE: MANAGING INHERENT EXPOSURES

Analysis of hardware-related topics and features has revealed that Asia lags behind its global peer group, partly due to the inherent natural catastrophe exposures in the region and the limited amount of suitable land available for industrial sites, which often require a very large "footprint."

Although geographically diverse, the NATCAT exposures in Asia present a significant risk exposure. Think of, for example, the numerous sites in Japan that experienced earthquake and tsunami damage as a result of the March 2011 Great Tohoku Earthquake. Other regions subject to earthquake and tsunami exposures include West Java, Sulawesi, and West Papua in Indonesia, Taiwan, and the Philippines. Where higher levels of NATCAT exposures exist, it is often necessary to install additional design features such as bracing on process structures and buildings for earthquake protection or tsunami flood defenses.

A common feature of Asian sites is that, due to the limited amount of suitable land for development, they are often constrained in size and located in highly populated areas. Site layout risk benchmarking scores for Asian sites are significantly lower than those of their global peers (see Figure 2).

FIGURE 2 Hardware Benchmarking - Asia versus Global



Government policy in several countries in the region, for example, Thailand, Taiwan, China, Korea, and Singapore, has focused the siting of oil, gas, and petrochemical companies in industrial zones or "chemical parks," leading to the potential aggregation of risk following a major incident. Ongoing development on constrained sites, rather than incurring the higher development costs associated with using reclaimed land in coastal areas or site preparation in areas of hilly terrain, has often led to less-than-ideal unit-to-unit separation distances. In addition, the physical location of utilities, storage import/export facilities or administration areas are often closer than desirable to process units. Existing and new projects typically have relatively small process footprints in relation to the production capacity, further increasing the site congestion and blast damage potential from a confined vapor-cloud explosion on the process unit. All these factors may result in an escalation of damages following an on-site incident. For example, in the May 2012 incident at a petrochemical facility in Thailand, a release of flammable hydrocarbons ignited, leading to a vapor-cloud explosion and significant damage not only to the affected process unit, but also to adjacent ones. In contrast, sites in the Middle East are often located in areas with much more generous plot sizes, resulting in inherently safer designs in terms of unit-to-unit separation distances.

Engineering standards vary depending on the age of the site, local legislation (which varies significantly from country to country), and the influence of external third parties. This is not unique to Asia; however, it poses specific issues in countries such as Japan and Korea where the refining and chemical industries have been heavily developed post World War II, making them much older than those found in many other countries in the region. The significant number of aging assets or sites, that have continued to develop over a period of 50 years, have resulted in varied risk quality. Although engineering standards have continued to evolve and incorporate best practices in the industry, retrofitting these facilities may be prohibitive in terms of cost or impractical due to lack of space.

Encouragingly, new projects in Asia typically achieve significantly higher risk benchmarking scores for hardware features than existing assets, reflecting the adoption of the latest industry standards and best practices.

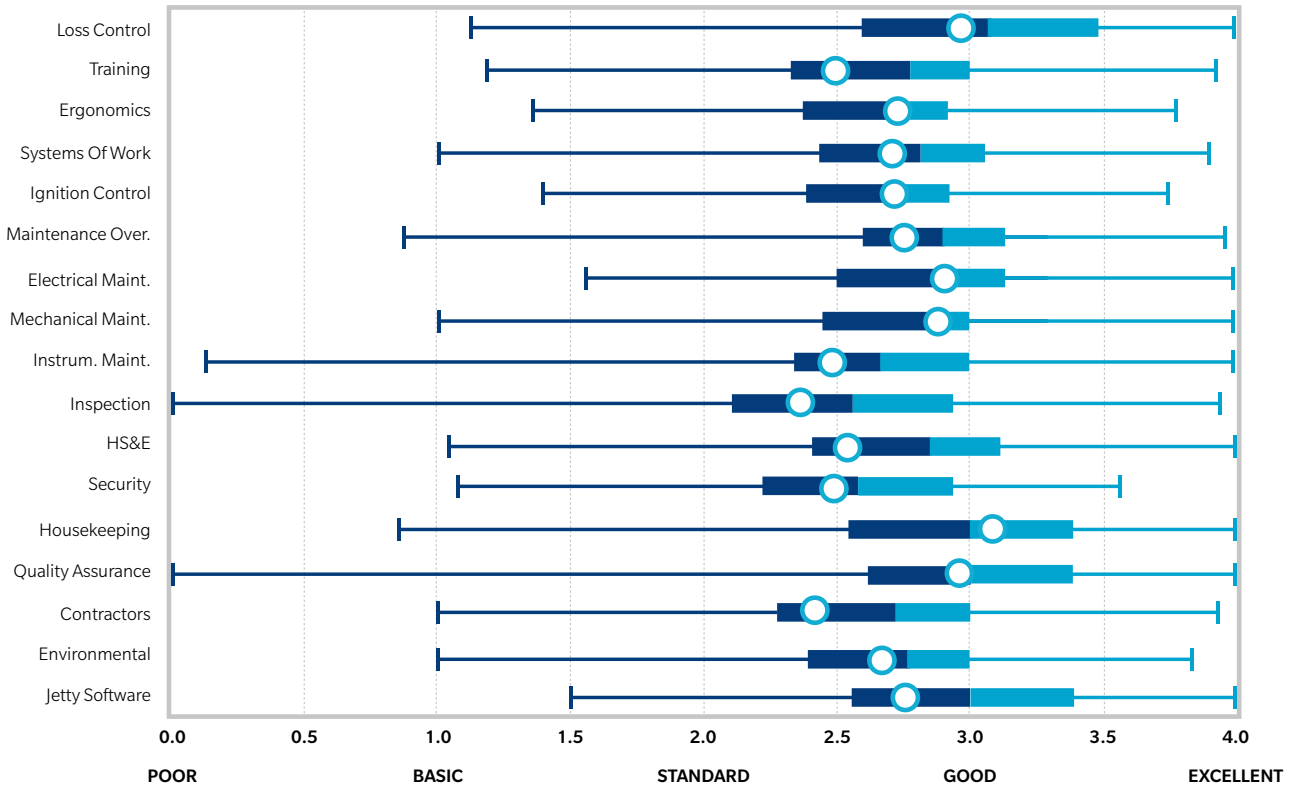
Positive features observed during site visits include well-designed process layouts with fired heaters located at the edge of process units, and process buildings with open-deck construction, providing good ventilation and extensive drainage systems, in response to the relatively high annual or seasonal rainfall experienced in many parts of Southeast Asia and East Asia.

While the data is not trended, there are encouraging signs that the significant growth in refining and petrochemicals in recent years have been supported by investment in best-in-class hardware features, particularly modern process control systems, machinery safeguarding systems such as on-line vibration monitoring systems for major compressors, and combustion safeguarding systems such as double block and bleed isolation on fuel lines to fired equipment.

SOFTWARE: OPPORTUNITIES ABOUND

In general, Asia tends to lag slightly behind the global peer group in terms of software topics (see Figure 3). This could be attributed to the diversity of the region, which has no common overarching legislation such as the OHSA PSM regulations in the US, SEVESO II legislation in the European Community, or Major Hazard Facilities legislation in Australia. Operators are typically focused on one geographical area, with a limited number of multinational companies in the region. Companies usually follow the legislation requirements in the country they operate in, rather than to rely on global best practices. In some cases, operators have the opportunity to benefit from the experience of joint-venture partners such as the International Oil Companies (IOCs), and this is reflected in the higher quality of management systems in use at those respective sites.

FIGURE 3 Software Benchmarking - Asia versus Global



Insurance-related risk engineering surveys are a mechanism for identifying potential gaps in site management systems. Training along these lines is an area for improvement in the region, with suggested examples identified, including;

- Formalized training and competency development of operators to develop skills within the shift teams.
- Refresher training at fixed intervals to maintain knowledge of emergency operating procedures, such as loss of power or cooling water.
- Use of distributed control systems (DCS) training simulators for start-up/shutdown training and handling plant upsets. As processes become more reliable and intervals between turnarounds become longer there is less opportunity to experience start-ups, shutdowns, and handling process upsets other than by the use of a bespoke simulator.

In some regions, there may be more intractable issues to deal with (for example, in India, where there is an attrition of workers to the Middle East; or other locations, where plants are geographically remote from major population centers, making recruitment of experienced workers a challenge).

While location and the labor force may be long-term challenges, in terms of making cost-effective but substantial improvements in management systems, there are common themes that can be easily adopted and which are frequently identified during risk engineering surveys:

- Management systems (such as work permits, lockout/tagout systems and emergency shutdown (ESD) bypass management procedures) are commonly used; however, they can be further strengthened by the adoption of risk assessments.
- The management of change and, in particular, the management of short-term or temporary changes is a topic where companies in Asia often demonstrate limited understanding of the potential hazards of uncontrolled changes. Several major industry losses, such as Flixborough in the UK and Longford in Australia have been attributed to the poor management of change. Reviews of instrument maintenance activities have shown there is limited use of safety integrity level (SIL) assessments to verify that appropriate ESD testing intervals are in place. There has been substantive improvement in this field across the Middle East, Europe, and the US.

Generally, we see that site-inspection departments are reasonably well established, with a moderate range of inspection techniques in use, and are following legislation-based inspection requirements or adopting risk-based inspection (RBI) philosophies. A topic for further improvement is the use of positive material identification (PMI) of incoming materials, as there have been instances of losses related to the supply of piping with incorrect metallurgy; some specific Asian manufacturing locations are seen as being potential sources of poor or incorrect material quality.

Health, Safety and Environmental (HSE) management systems are typically focused on personal safety, rather than process safety. Companies could also benefit from the development of a set of process safety management leading and lagging performance indicators based on API 754 guidelines. This is a key output from the *Baker Report* in Texas City and is a major area of focus for insurance underwriters.

Electrical maintenance, mechanical maintenance, and housekeeping are regularly identified as a strength in the region, with initiatives such as “Kaizen” (literally translated as “small incremental improvement”) philosophy or practices originally developed in Japan being adopted by companies across the region. This philosophy empowers operators to take ownership for maintaining the condition of individual pieces of equipment at the plant, resulting in impressive visible improvements in physical condition.

EMERGENCY CONTROL: WHEN DISASTER STRIKES

Risk managers should focus their attention on proactive measures, including those embedded in the hardware and software features, to ensure incidents do not occur and/or to minimize any potential impact of an incident. However, it is important to be prepared for what can go wrong, however unlikely that may be. The emergency control features, which include passive and active fire protection facilities, emergency response systems and resources, act as the final "barrier" to prevent or minimize consequences.

Emergency control is a combination of both hardware (see Figure 4) and software topics (see Figure 5). It is considered to be a separate unique category by Marsh due to its importance in mitigating an incident. The benchmarking of emergency control features in Asia against the global dataset revealed that the region tends to slightly lag its global peers in several topics such as gas detection, firefighting resources, emergency planning, and testing.

FIGURE 4 Emergency Control Benchmarking - Asia versus Global

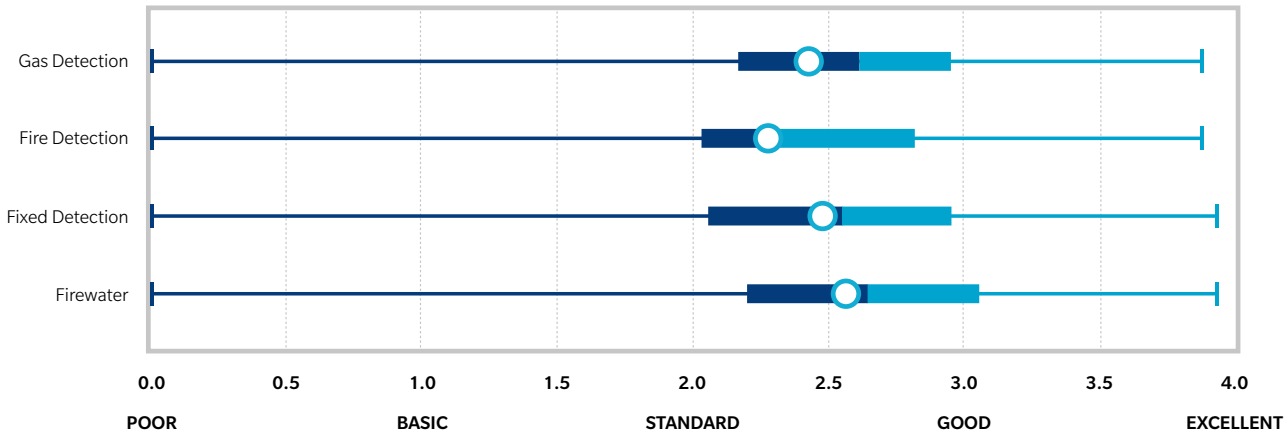
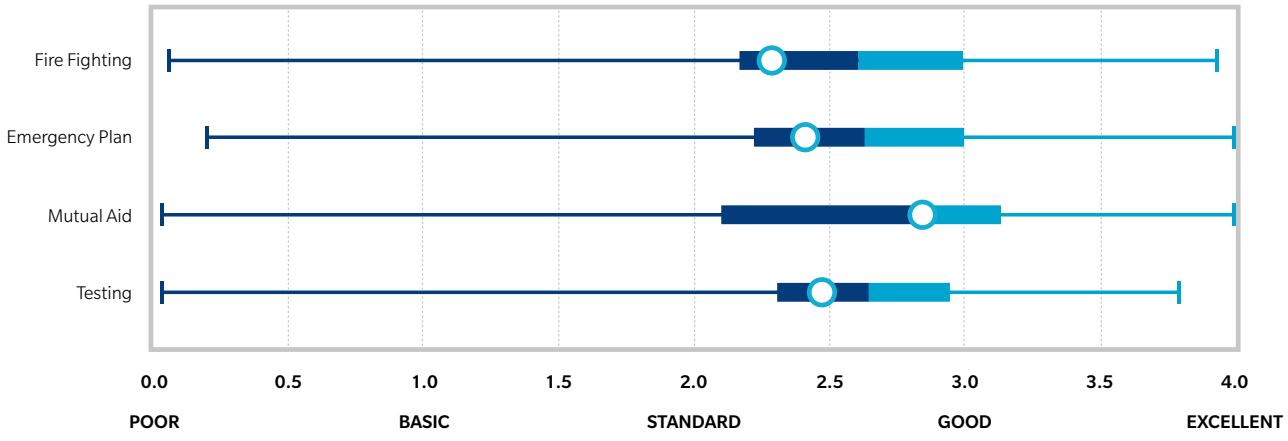


FIGURE 5 Emergency Control Benchmarking - Asia versus Global



For hardware topics, the reliance is often on meeting local legislation, rather than fully adopting international standards, such as American Petroleum Institute (API) guidance practices or National Fire Protection Association (NPFA) guidelines. For example, control-room fire detection is usually limited to a ceiling-mounted smoke detector rather than an underfloor-located, very early smoke detection (VESDA) alarm system. Also, the fire-fighting protection for a control room is most likely to consist of hand-held fire extinguishers rather than a gas suppression system in the DCS rack room and console area.

Fixed-fire protection on the process units is typically provided by fire hydrants and monitors at the edge of the unit, as opposed to having fixed-fire-water deluge systems mounted on vessels containing large inventories of highly flammable materials or pumps on liquid petroleum gas (LPG)-type service.

Other common concerns highlighted during risk engineering surveys include:

- Diesel fuel inventory on firewater pumps not being adequately managed, such as the isolation valve on the supply not being locked open, the diesel inventory in the tank not being checked regularly to ensure there is sufficient fuel supply, or simply the condition of the diesel fuel tank showing abnormal levels of deterioration.
- Car-seal philosophy typically associated with valve safety management not being applied to firewater valves.
- Inappropriate use of firewater for other purposes.
- Insufficient training available for fire fighters.
- Inadequate fire pre-planning and drills.
- Inadequate inspection, maintenance and testing of fire protection systems (including firewater pumps).

In Asia, there are many examples of well-developed mutual aid agreements between companies. These are a significant positive benefit, partly due to the location of sites in industrial zones, which facilitates the sharing of resources and aids quick response times. In addition, local authorities are often involved in coordinating the emergency response to major incidents. In September 2011, a major fire at a refinery in Singapore utilized the combined response of the refinery and the Civil Defense fire fighting teams to successfully contain the fire.

SUMMARY OBSERVATIONS

Further analysis of the Asia dataset has identified pockets of best practice within the population, with Southeast Asia sites typically achieving higher risk benchmarking scores than their peers in East Asia. This is likely due to the age of the sites in the Southeast Asia region being newer and also the greater influence of IOCs in these sites.

In Asia, the demand for energy and hydrocarbon-related products has continued to grow at a steady pace as economies develop and consumer incomes rise. The region is expected to see further capacity enhancements to meet this growth in demand, and the challenge is to achieve this in a safe and cost-effective manner. At the same time, there is significant pressure on profit margins due to the increasing presence of suppliers from other regions, such as the Middle East, with access to lower cost natural resources. This often requires companies to rationalize capacity by either upgrading existing plants or shutting down obsolete plants in order to maintain cost competitiveness. It is important that the industry recognizes and addresses the risks involved in meeting these challenges. Benchmarking can help to identify the strengths and opportunities to improve the risk quality for individual sites.

Marsh has seen many examples of companies that are reviewing their existing management systems and structure in order to enhance their organizations and strive towards safer and more reliable operations. It should be stressed that the implementation of improvements to management systems (such as management of change (MOC), ESD bypass control, corrosion under insulation (CUI) inspection programs) are a much more cost-effective option than carrying out upgrades to hardware systems (such as control-room blast resistance, fireproofing of supports and process structures etc).

APPENDIX MARSH'S RISK RANKING AND BENCHMARKING:

THE PARAMETERS

Marsh's risk ranking and benchmarking systems evaluate and compare the risk quality of topics grouped under three key categories: hardware (plant and equipment), software (management systems), and emergency control, in addition to providing an overall weighted score. The 44 defined risk-quality topics Marsh uses to evaluate and compare onshore downstream operations include:

1. Location.
2. Engineering standards.
3. Site layout.
4. Process layout.
5. Process buildings.
6. Drainage, kerbing, and effluent treatment.
7. Fireproofing.
8. Atmospheric storage.
9. Pressurized storage.
10. Refrigerated storage.
11. Control rooms.
12. Process control.
13. Pressure relief and flare.
14. Isolation, depressuring, and dumping.
15. Combustion safeguards.
16. Utility reliability.
17. Machinery features.
18. Road and rail operations.
19. Jetty operations.
20. Loss control.
21. Recruitment and training.
22. Contractors.
23. Housekeeping.
24. Ergonomics and operability.
25. Systems of work.
26. Jetty software.
27. Maintenance overview.
28. Maintenance electrical.
29. Maintenance mechanical.
30. Maintenance instruments.
31. Inspection.
32. HSE.
33. Environmental monitoring.
34. Quality management.
35. Security.
36. Control of ignition.
37. Mutual aid.
38. Fire detection and alarm.
39. Gas detection.
40. Maintenance and testing.
41. Fixed-fire protection.
42. Fire fighting.
43. Emergency planning.
44. Firewater system.

Topics and features have been carefully selected to reflect key areas of risk quality and the main concerns of the insurance market. Within the risk-quality topics, there are more than 400 individual features, each with a clearly defined assessment model. Features are also weighted and ranked on a scale of 0 to 4:

- **Excellent**
  The very best of current-day practice in the industry; an industry leader.
- **Good**
  Embodies some of the best practices in the industry.
- **Standard**
  Acceptable standards exhibited but with room for improvement.
- **Basic**
  Some areas below the standard of current-day practice, with considerable potential for improvement.
- **Poor**
  Embodies few or none of the standards expected of current-day practice.

Feature risk ranking scores are fed into the benchmarking database to determine the site's relative position compared with the defined population. The results from the peer group are statistically analyzed in order to group the results into quartiles, each representing 25% of the sample population.

Risk quality can be benchmarked against the key energy installations across the world, such as refineries, petrochemical and gas-processing plants present in Marsh's benchmarking database or against a variety of customized peer groups. Significant benefits and insight can also be gained from benchmarking group companies against each other.

Marsh's database is rapidly growing and currently contains risk-quality factors for more than 500 sites worldwide, including:

- More than 150 refineries.
- More than 240 petrochemical facilities.
- More than 70 gas plants.
- More than 20 integrated sites.

Clients include:

- Multinational integrated oil companies.
- National oil companies.
- Multinational petrochemical companies.
- Independent refiners.
- Independent petrochemical companies.

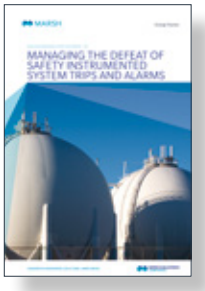
The database covers assets in North America, South America, Europe, the Middle East and Africa, Asia, and Australasia. Furthermore, Marsh's database is updated every month and consequently contains recent and dynamic data.

FURTHER READING
ENGINEERING POSITION PAPERS

Marsh's engineering position papers leverage our knowledge on best practice to establish standards that don't currently exist. These papers define the key attributes that we would define as being "very good."

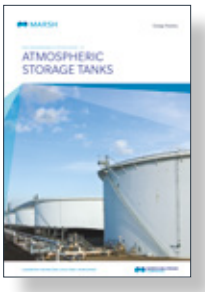
PRE-START UP SAFETY REVIEW

These recommendations can be used to support and define risk improvements and also provide detailed advice to clients seeking to improve their management systems.



MANAGING THE DEFEAT OF SAFETY INSTRUMENTED SYSTEM TRIPS AND ALARMS

Whenever a safety instrumented system (SIS) is defeated, the risk exposure is increased to an extent that depends on the nature of the hazard involved.



ATMOSPHERIC STORAGE TANKS

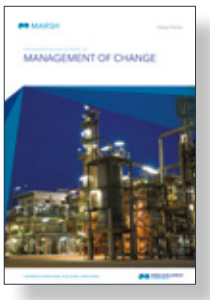
Following numerous incidents involving atmospheric storage tanks, data has been compiled indicating that overfilling of atmospheric storage tanks occurs once in every 3,300 filling operations.

PROCESS-SAFETY PERFORMANCE INDICATORS

The process industry has a long history of major incidents that are well-publicized. The underlying causes of major incidents are often related to failures in process-safety management.

FIRE PRE-PLANS

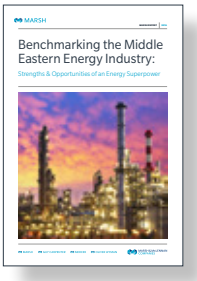
There have been numerous large damaging fires over the years, including tank fires. These involve massive product losses and process unit fires that cause major plant damage and process interruption.



MANAGEMENT OF CHANGE

During the lifetime of an operating process plant, many changes will occur, including to the physical hardware of the plant, control systems, business processes, and/or to the organization running the plant.

BENCHMARKING



ENERGY RISK QUALITY BENCHMARKING IN THE MIDDLE EAST

This paper contextualizes risk quality in the Middle East and explores regional trends to gauge the comparative risk quality of oil, gas, and petrochemical facilities relative to similar facilities worldwide.

DATA-DRIVEN INSIGHTS

THE 100 LARGEST LOSSES1974-2015. LARGE PROPERTY DAMAGE LOSSES IN THE HYDROCARBON INDUSTRY

The 24th edition of The 1*00 Largest Losses* reviews the 100 largest property damage losses that have occurred in the hydrocarbon processing industry since 1972. This review is based on Marsh's energy loss database, which compiles information gathered in the course of our interactions with the industry, as well as from the public domain.

About Marsh

Marsh is a global leader in insurance broking and risk management. Marsh helps clients succeed by defining, designing, and delivering innovative industry-specific solutions that help them effectively manage risk. Marsh's approximately 30,000 colleagues work together to serve clients in more than 130 countries. Marsh is a wholly owned subsidiary of Marsh & McLennan Companies (NYSE: MMC), a global professional services firm offering clients advice and solutions in the areas of risk, strategy, and people. With annual revenue of US$13 billion and approximately 60,000 colleagues worldwide, Marsh & McLennan Companies is also the parent company of uy Carpenter, a leader in providing risk and reinsurance intermediary services; Mercer, a leader in talent, health, retirement, and investment consulting; and Oliver Wyman, a leader in management consulting. Follow Marsh on Twitter, @MarshGlobal; LinkedIn; Facebook; and YouTube.

Notes

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