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Implementing Intelligent P&IDs at Rayong Olefins and Lyondell Chemical Company

By Monica Schnitger

Piping and instrumentation diagrams are one of the most crucial types of IP created during the design of a process plant.

Of the many types of intellectual property created during the design of a process plant, one of the most crucial is the piping and instrumentation diagrams or "P&ID." Each P&ID, and there may be hundreds for a process plant, contains vital information describing how a pipeline is connected to pumps or other assets, giving material and other information about the pipe itself and, in essence, describing the entire plant configuration. P&IDs are created during the design process and once approved, are released to the contractor building the process plant. Finally, once construction is complete, the operating plant is commissioned and a complete set of P&IDs is packaged as part of the legal document set.

P&IDs provide a systems view of a physical layout that can be a football field in length.

P&IDs, however, truly become useful once a plant is operational because they describe how the plant is connected: If a certain pump is shut off for maintenance, what production lines will be affected? If a geographic zone in a plant must be cordoned off for safety reasons, what systems might be affected? P&IDs provide a systems view of a physical layout that can be a football field in length.

Ongoing maintenance activities often require changes to existing assets, such as replacing a faulty valve. These changes can create discrepancies between the P&ID of the plant as originally handed over and the configuration currently in the field. As a result, plant operators must employ drafters or engineers to continually update the P&IDs — otherwise, inaccurate information can result in lost time, productivity and money.

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Reducing the overall lifecycle cost of an asset is very much a recurring theme in the process and power industry.

Management of Intellectual Property is Critical for Success in a Fragmented Industry

A recurring theme in the process and power industry is the need to reduce the overall lifecycle cost of an asset — be it a power plant, oil refinery, pharmaceutical manufacturing facility or chemical processing plant. A typical plant can take five years to design and build, include hundreds or thousands of systems, tens of thousands of feet of pipe — at a cost of over $1 billion. The plant may be in operation for 40 years — and return a daily profit of a million dollars. One week of unplanned downtime can radically change the economics of the plant.

Design firms, construction companies, equipment suppliers, subcontractors are all involved in creating and operating a plant...

The chain of participants that creates and operates each plant is very complex, involving design firms, construction companies, equipment suppliers and subcontractors. Each stakeholder may take part in only a portion of the project and is likely to have different incentives for completing its portion of the project. For example, a "front-end" engineering firm may design the chemical process the plant will use to produce a certain polymer. Constraints here could include using the most readily available ingredients, least amount of heat energy, producing as few pollutants as possible — all keys to reducing the overall cost of operating the plant during its lifecycle.

An engineering/procurement/construction firm (or "EPC") may take over the detail design of the physical plant, laying out each pipe, piece of equipment, structural support member and electrical system. The EPC is supposed to build the plant as quickly and inexpensively as possible — after all, no profit can be realized until the plant is actually operational. Once the plant construction is completed, the EPC proves to the owner that the plant performs as specified in the contracts during the commissioning of the plant. Once all parties are satisfied, the EPC "hands over" all material relating to the plant and the owner assumes control.

...and each of these stakeholders is likely to have different incentives for completing its portion of the project.

The owner of the plant is interested in meeting market goals: the right product to buyers at the opportune time. This involves operating the plant as economically as possible, balancing cost of inputs against the resultant price for the outputs — after all, the goal of the plant is to generate profit while minimizing environmental and safety risk to the owner.

Even in this simplified example, each of the three participants has a different goal and therefore different incentives. The chemical process designer is to create the most effective chemical reactions to get the desired output — often without regard to the design of the actual plant, since that is often not known when the process design takes place. The EPC's job is to build as quickly as possible, as inexpensively as possible — often without the luxury of assessing how to build the plant that a particular owner can operate most effectively. The owner must operate the plant as smoothly as possible — which could be in conflict with the EPC's goal of building as quickly as possible.

How can each participant in the plant creation process contribute to the reduction of overall cost?

How can each participant in the plant creation process contribute to the reduction of overall cost? How is this cost defined? As design cost? Construction cost? Operations cost? Or as a combination of all three? How is one participant compensated for a cost reduction that might happen at a point in time far removed from actual involvement in the project? In other words, how does the EPC contribute to and recognize benefit from reducing the operational cost of a plant 20 years after construction? How does an owner structure a contract to appropriately incentivize each participant?

These are thorny issues, complicated by the fragmented and often adversarial nature of the process plant creation industry. But one thing is clear: the appropriate creation,

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management and use of the information asset that is created as the plant is designed is essential to reducing overall lifecycle cost, whether this process originates during new construction (or "greenfield") or during a "brownfield" refit.

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The Case for Intelligent P&IDs

If a plant operator is maintaining P&IDs as a routine part of the operation, why not maintain what are called "intelligent P&IDs"? P&IDs have traditionally been drawings — two-dimensional, stylized representations of piping systems, with annotations to identify components, specify pipe sizes, tag numbers, etc. This is a small part of the total information needed to describe the system; to really describe it, equipment manufacturer, pressure ratings, maintenance information and the like should be attached to components in addition to a naming tag. The combination of a traditional drawing of a P&ID with a data repository is called an "intelligent P&ID."

Intelligent P&IDs are drawing a lot of interest because of the many benefits seen in the organizations that implement the tools and work processes involved. During the design process, the existence of the underlying database drives design consistency, flags inconsistent elements for design review and ensures adherence to design rules.

Intelligent P&IDs and their underlying database promote better access and use of information...

Once the P&ID's component database is created, the potential is limitless. This data can be used to find all equipment of a similar type to simplify maintenance, or to improve responsiveness in case of an emergency situation in the plant, for example. Since this data is in a digital form, it can be made available and organized, queried, used to generate reports and imported/exported between applications. It can even be used to reduce design time for the next system, since all data pertaining to a working system is easily available.

The arguments for maintaining accurate, intelligent P&IDs are compelling. How are some of the most forward-thinking plant owner-operators using P&IDs? How have they capitalized on the increasing intelligence of P&IDs, and how have they examined the return on the investment of converting existing static or "dumb" P&IDs into intelligent P&IDs? This Study examines the thought processes and business decisions made by Lyondell Chemical Company and Rayong Olefins, two very different companies faced with optimizing plant operations.

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Rayong Olefins

One of the early adopters of Intergraph's intelligent P&ID solution, SmartPlant P&ID, is Rayong Olefins Co. Ltd., a subsidiary of the Siam Cement Group, one of Thailand's largest industrial concerns. The Group was founded in 1913 to produce cement for the growing Thai economy and has evolved over the last ninety years to produce goods as diverse as paper and packaging, petrochemicals, cement, building products and ceramics. The Group reported revenues of 149 billion Baht (roughly US$3.8 billion) in 2003.

The Group entered the petrochemical business in 1990 as a producer of high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE) and polypropylene resins. These products require olefins as inputs, which were expensive to import. To reduce its costs and reliance on outside suppliers, the Siam Cement Group in 1999 opened the Rayong Olefins plant to produce these inputs for sister companies within the Group and for export. At the time, the plant cost US$620 million to design and build.

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Demand for Rayong Olefin's products grew rapidly, leading the Siam Cement Group to retrofit the plant to increase capacity. A retrofit in 2001 raised production capabili-

Rayong Olefins realized that intelligent use of engineering data would save money and time and be crucial for efficient operation of its HDPE and LLDPE production plant...

ty to 800,000 tons of ethylene and 400,000 tons of propylene annually, or 33% more than planned just less than a few years earlier.

Production of HDPE and LLDPE is intensely competitive and financially risky. It relies on petroleum products as input — with very volatile prices. Demand for output fluctuates with the world economy. In general, the price for inputs rises ahead of declines in demand for outputs — a very difficult situation that requires very nimble plant operation. Like other chemical plants, the Rayong Olefins plant must be run for peak efficiency, leaving little room for unplanned maintenance or other downtime.

The company leadership understood that accurate plant lifecycle information is crucial to meeting Rayong Olefins' business objectives. In particular, the company realized that intelligent use of this engineering data would save money and time and be crucial for efficient operation. However, when the plant was designed and built, intelligent applications were not yet fully realized and the 3D design work was done using Intergraph's PDS product while the P&IDs were created using AutoCAD from Autodesk.

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But, as Surachate Chalothorn, the Technical Department Manager at Rayong Olefins, said, "An operating plant must occasionally be changed and this means changing the P&IDs. P&IDs all need to be kept up-to-date; we also needed to reduce the risk of using the wrong version of a P&ID. When we looked at this in 2002, we also realized that we had a lack of collaboration" — data was not being accessed by all applications that could take advantage of an intelligent format.

"We took a long-term perspective and saw we would need to update all of our P&IDs eventually," said Surachate. "It made sense to make them intelligent." Rayong Olefins selected Intergraph's SmartPlant P&ID as its P&ID solution.

Rayong Olefins decided to convert P&IDs for 300 of the plant's main systems into SmartPlant P&ID.

Rayong Olefins decided to convert P&IDs for 300 of the plant's main systems into SmartPlant P&ID. The company had carried out a similar conversion project (implementing Intergraph's INtools product for instrument data sheets and loop diagrams) using an engineering services company, but decided to do this conversion project with its own resources. As Surachate explained,

- the educational level of the engineering staff was very high, with some of the staff coming right out of technical school
- SmartPlant P&ID was designed to be very user-friendly which minimizes training time
- the company wanted its young engineers to gain familiarity with the plant through this project, and
- labor costs in Thailand are relatively low, meaning that outsourcing would not lead to significant savings.

"We took a long-term perspective and saw we would need to update all of our P&IDs eventually," said Surachate Chalothorn. "It made sense to make them intelligent."

A team of six drafters and one engineer began the project in August 2002. The staff received about one month of training and then began the conversion process. As Surachate recalled. "We started with our hardest P&ID, the most complicated. We had problems the first couple of months but, with Intergraph's help, we got through it." Upon reflection, Surachate suggests that others not begin a project this way, but rather start with easiest P&IDs and work up in order to build experience.

The team did its conversions on a "geometric" basis rather than system by system, working its way through the plant.

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"We had six full-time drafters and one engineer on the project," Surachate said. "The engineer was doing the quality checking [but no actual P&ID creation]. There was no real involvement by the IT department except to provide the hardware, backup capabilities, etc. Engineering did all of the work. Our effective start was in September or October [of 2002], and we completed the conversions in March (2003)." The team completed the final quality checks of the 300 P&IDs by early summer 2003.

Once the quality checks were completed, the P&IDs were turned over to the plant's operations and maintenance (O&M) team. It is now the responsibility of the O&M team to keep the P&IDs current; given the lessons learned during the P&ID conversion process, Rayong Olefins has determined that it will need one drafter to maintain the P&IDs, with engineering oversight.

The company declined to estimate the total cost of the conversion project, but Surachate points out one very salient fact: "Only one failure [attributable to using an out-of-date P&ID] would cost more than the conversion" to SmartPlant P&ID.

The company sees great benefit in easy access to consistent, current data and estimates that it will more than recoup the cost of software, training and conversion within one year. It cites the specific example of hazard and operability ("HAZOP") analyses. According to Surachate, HAZOP needs data such as the temperature, pressure, and process conditions — all data that could be stored with the P&ID. As part of the conversion process, the staff augmented the original "static" P&IDs by adding this data into the SmartPlant P&ID database. The staff collected some of the data, such as power requirements, while Toyo, the EPC firm that built the plant in 1999, supplied other pieces.

Now that this information is all in one database and is kept current, Rayong Olefins can analyze this data with a great deal of confidence. For example, Rayong Olefins can quickly search for critical systems or components for maintenance and inspection and enter the inspection results back into SmartPlant P&ID for access during the next maintenance cycle.

The Siam Cement Group prides itself on being "a major force in the introduction of new technology and new skills to Thailand." Clearly, the Rayong Olefins team exemplifies this goal as early, successful adopters of intelligent P&IDs. In fact, the team has recommended implementation of SmartPlant P&IDs to its sister companies within the Group. Rayong Olefins also plans to implement Intergraph's SmartPlant Foundation, which will allow it to integrate INtools, SmartPlant P&ID and other applications, so that Rayong Olefins can manage changes affecting electrical systems, pipes, equipment and other assets.

Lyondell Chemical Co.

Lyondell Chemical Company faced a different problem. While Rayong Olefins worked to justify converting "static" data to intelligent data in a brownfields project, Lyondell had the opportunity to start with a strategy that embraced intelligent data from the beginning of the project.

Lyondell is a leading producer of chemical products, with a portfolio of companies addressing different sectors of the process industry. Lyondell itself was spun-off from Atlantic Richfield Company in 1989 and began, in the mid-1990s, to focus on a series of initiatives that have grown the company into a global enterprise with more than $12 billion in assets under management. The company operates under three umbrella businesses:

- Lyondell Chemical Company is, according to the company's data,

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the leading producer of propylene oxide (PO) in North America, and number two provider in the world.

- Equistar Chemicals, a joint venture with Millennium, is a leading North American producer of ethylene, propylene and polyethylene.
- LYONDELL-CITGO Refining, a joint venture with CITGO, is a major refiner of heavy crude oil.

This diversified strategy has paid off as Lyondell currently employs over 7,700 people and generates over $12 billion in sales from its ventures. Lyondell credits its success, in part, to the belief that successful competitors in the chemical industry must focus on lowering total production cost and creating sustainable competitive advantages by shifting production to lower cost, more efficient sites, increasing operation efficiency and simplifying production scheduling.

In building a new PO/SM plant, Lyondell's goal was to make is so efficient that it created a competitive barrier to entry that could sustain Lyondell for years to come.

The company believes that operating excellence and technology leadership are key to building this competitive advantage. To that end, Lyondell built a new propylene oxide/styrene monomer (or "PO/SM") plant on the Rotterdam Maasvlakte, the Netherlands, known as PO-11, through a joint venture with Bayer. PO-11 has an annual capacity of 625 million pounds of PO and 1.4 billion pounds of SM using Lyondell's proprietary PO/SM manufacturing technology. Bayer and Lyondell each own 50% of the plant, and will independently off-take its 50% share of the PO and styrene products. Lyondell operates the facility, which went operational on October 14, 2003.

Lyondell's goal, from the outset, was to design a PO-11 plant that is so efficient as to create a competitive cost advantage — one that will be difficult for others to meet — thereby setting up a barrier to entry that could sustain Lyondell for years to come.

The company considers its use of technology to be another strategic differentiator, including managing engineering design and equipment performance data over the life cycle of a plant to reduce capital, operational and maintenance costs. One element of this strategy is the creation and use of a totally electronic project documentation database, including intelligent P&IDs.

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David Chapman, Director of Business Solutions explains that intelligent P&IDs fit right into the corporation's overall IT strategy: "We want to enable our employees and partners to make better business decisions at the right time, at the right place and with the right information. Enabling technologies are necessary to generate that decision information."

Chapman continued, "Within the plant, you must understand the equipment from the very beginning of the lifecycle when a plant or unit is designed through its installation, operation and decommissioning. The better you understand the equipment and its performance, the better you can predict any potential failure to perform. You can also correct that in a planned way before it becomes a reliability issue, and at a much lower cost than dealing with it reactively."

"We want to enable our employees and partners to make better business decisions at the right time, at the right place and with the right information," said David Chapman of Lyondell.

Lyondell decided to create fully digital plant data very early in the design process. Says Chapman, "Greenfield sites don't happen very often. We asked ourselves, 'Since we're building the plant, how can we set up the processes and technology to our best advantage for this new facility?' Part of that is using an intelligent P&ID application [such as Intergraph's SmartPlant P&ID] to electronically capture and maintain that data. The speed of accessing information is the primary goal."

Chapman also points out an added benefit of intelligent, digital data: "Another issue

we face is the changing operations work force. An increasing percentage of the operators in the chemical industry are nearing retirement age. With intelligent P&IDs, operators who may have less history with a facility can electronically mine data quickly. We won't have to rely on what is in an employee's head. [Without intelligent data], it's only in one person's head. If it's digital and visible, it can be in the head of any person who needs that information quickly to make the right decisions.

"With intelligent P&IDs, operators who may have less history with a facility can electronically mine data quickly..."

Finally, Chapman said that the use of intelligent P&IDs facilitates keeping current, up-to-date plant data: "Updating the P&IDs is greatly simplified since you can maintain one data point and then represent it in multiple locations."

Lyondell also sees great utility for intelligent P&IDs in brownfield situations. As Chapman explained, "One reason for implementing intelligent P&IDs [on the PO-11 project] is that we didn't have some of the barriers to entry that we would have at existing plants, such as data conversion. We plan to implement intelligent P&IDs [in revamps] during an expansion, de-bottlenecking or some other enhancement to the site that requires cleanup of the data. The new construction or work can be captured intelligently as if it were a greenfield activity. Since engineering for a revamp will be done electronically, why throw away that work? This would lower the cost of [introducing the use of intelligent P&IDs] to that particular facility, and it becomes an opportunity to prove value. We're replacing costs, not adding them."

"...We won't have to rely on what is in an employee's head," said Chapman.

Chapman's concept of "replacing costs" as a measure of how useful an IT project may be is an interesting way to approach the problem. According to Chapman, "The biggest barrier to any successful IT implementation is the change management on the project: the alignment of the problem or opportunity statement, the expected benefits, the work it will take and the preparation it will take to achieve those benefits. Any ROI activity gives IT and our internal client community a clearer view of where benefits may be. When you're implementing a new, integrated [set of products], part of it is simply a belief. Then you have to monitor those beliefs. Our beliefs center on asset intimacy, and [these products] fill in a gap in our asset knowledge. As our new plant comes online, we will watch performance to assess our business case. The ROI case is built around tangible benefits, not immeasurable ones that lead many people to be skeptical."

Chapman is realistic about the benefits of any IT implementation, saying "The biggest potential savings will come from what we do with the information..."

But Lyondell is realistic about the benefits of any IT implementation. Says Chapman, "The biggest potential savings will come from what we do with the information. This is where change management comes in. If you can change the behavior of an organization, the benefits are going to dwarf anything that is in the ROI calculation. If our people can access information more timely and make different decisions as a result, $400,000 will be easily achievable. Potentially, it's a much bigger number than that. But it's a much more difficult number to achieve because you have to change behavior. I'm talking about more than implementing applications to address particular problems or needs. The entire organization that is affected must have a clear understanding of the business process in place or have a vision of the process that will be leveraged by the information. Unless those elements are there, information for information's sake is wasted."

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So, are Intelligent P&IDs Right for You?

As we've seen, forward-thinking companies have recognized the benefits of intelligent P&IDs as part of a comprehensive "digital plant" vision. How can you apply the lessons learned by Lyondell, Rayong Olefins and other owner/operators? How can you learn from this if you're an EPC?

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The experiences of Rayong Olefins and Lyondell teach many valuable lessons about intelligent P&ID implementations.

- Intelligent P&IDs add significant value during operations — but the design rules and consistency checking also make this an attractive proposition for the design and construction phases of a plant's lifecycle. How much productivity is currently lost during design because of inconsistencies and non-adherence to design rules?
- Audit your current processes to determine if they meet your organization's current needs. Often, processes grow over time but do not represent the best an organization can do today. For example, how does your maintenance organization gather its data? Are the employees skilled or relatively new? Is there are lot of data, as David Chapman of Lyondell said, "in people's heads"? Are the P&IDs accessed routinely or only rarely?
- Examine your current data management strategy. Can you be certain that any given P&ID represents the current, as-built plant? Can you benefit from the reporting capability that the database underlying the P&ID offers for inventory, maintenance, and commonality of components?

As Ratong Olefins learned, when embarking upon a conversion process, start with a relatively simple set of P&IDs to gain expertise and prove value.

- Whether on a greenfield or brownfield project, determine what an optimum process might be in two or five years keeping in mind:
  - Anticipated refit plans and their timeframes. Even if not designed with intelligent P&IDs, using this technology on a refit may produce advances and could be a means to convince the organization that this technology can yield a significant return.
  - The cost of converting legacy P&IDs continues to decline as tools become more automated. As Surachate said, the cost of a single mistake during maintenance could more than pay for the conversion.

If you embark upon a conversion process, start with a relatively simple set of P&IDs to gain expertise and prove value.

Lyondell's experience shows that intelligent P&IDs will yield the greatest ROI...

Intelligent P&IDs are likely to yield the greatest return on investment if the surrounding design and operations work processes are reconfigured to take advantage of the data now available.

Tie all process redesign to meeting business goals. Lyondell believes it cannot achieve its competitive goals without a solid IT infrastructure to present accurate information when it's needed, where it's needed — and, indeed, companies that cannot claim this will no longer be in business in a couple of years.

....if the surrounding design and operations work processes are reconfigured to take advantage of the data now available.

Finally, examine investments from a plant lifecycle perspective. Asset owners should consider writing the creation of intelligent plant data into their contracts. EPCs will benefit from the use of intelligent data to guide the plant design and construction and the O/O will receive an accurate as-built model at hand-over.

No one questions the need to have accurate, current information to operate process plants as efficiently as possible. Investing in intelligent P&IDs will allow you access to more accurate information and realize significant efficiencies in plant design and operations.

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