YOKOGAWA

Co-innovating tomorrow™

Success Story Collection

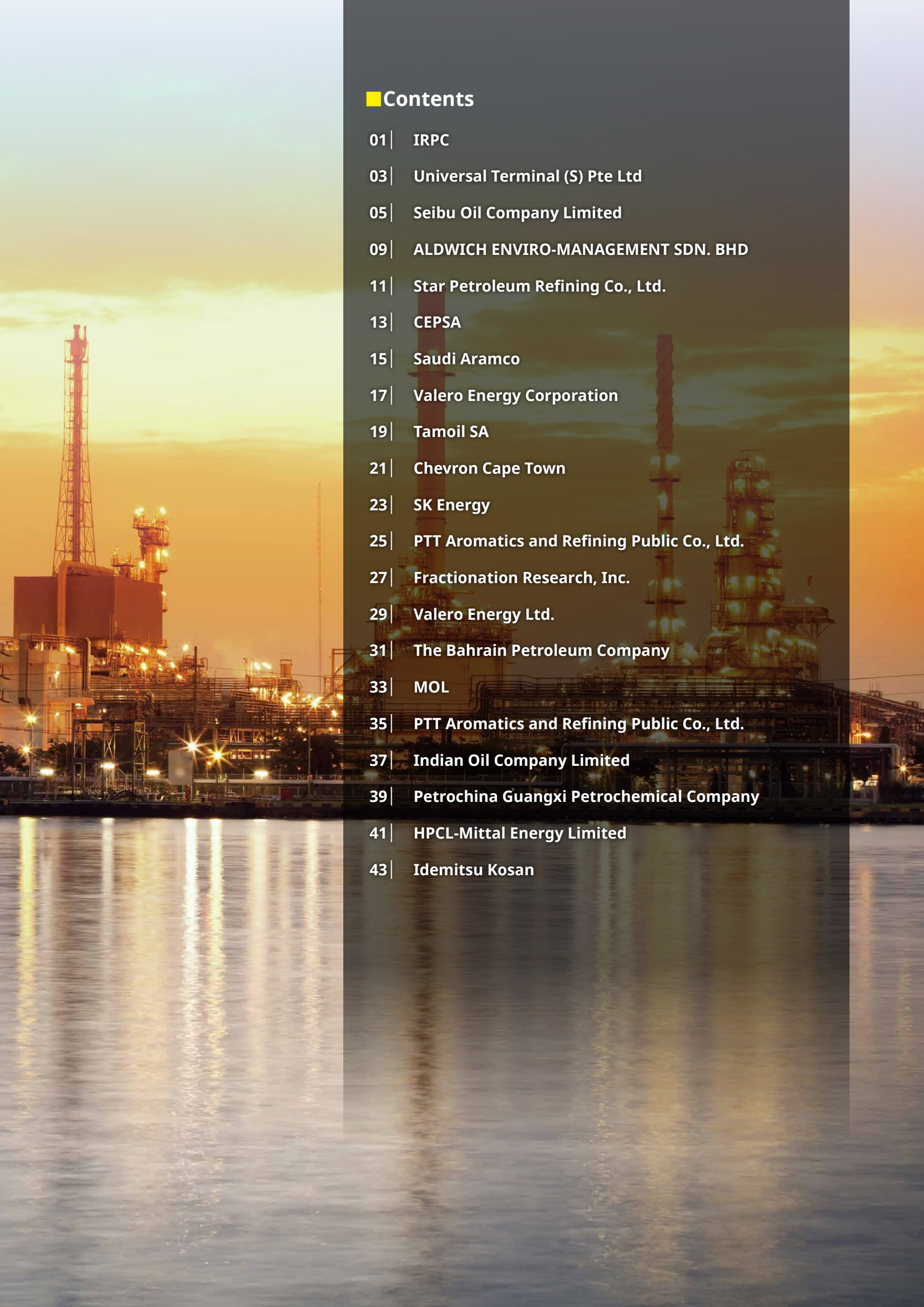
Oil & Gas Downstream

Bulletin 00A01A56-01EN

Success Story Collection

Oil & Gas Downstream

This is a showcase of success stories from our customers worldwide.
Many leading companies are using
Yokogawa products to manage their plants and processes.



Contents

Oil and Gas Downstream

Plant Information

- Location: Rayong, Thailand
- Order date: April 2008
- Completion: February 2009

IRPC

Integrated CENTUM VP and ProSafe-RS Systems Ensure Nonstop Operation of ADU/DKU Processes

Executive Summary

Integrated Refinery & Petrochemical Complex Public Co., Ltd. (IRPC) is an integrated producer of petrochemical products. Its complex consists of an upstream oil refinery and a downstream petrochemical plant. The oil refinery has a total capacity of 215,000 barrels per day, accounting for 21% of the country's total refining capacity.

Without the products from the refinery's atmospheric distillation unit (ADU) and diesel kerosene unit (DKU), operations at IRPC's downstream petrochemical plant would come to a halt. It is therefore absolutely essential for these units to operate nonstop, 24/7/365, with no unscheduled shutdowns.

The ADU and DKU each had a legacy production control system (PCS), with the former relying on a system from ABB and the latter using a Rosemount RS3 PCS. Both of these control systems could be operated from the same control room. The safety system was an A&B PLC.

Due to part supply difficulties and the discontinuance of vendor support, IRPC decided to replace these legacy systems with the latest systems technology. For this revamping project, Yokogawa Thailand successfully integrated the CENTUM VP PCS with the ProSafe-RS safety instrumented system (SIS), Plant Resource Manager (PRM) asset management package, and Exaplog event analysis package. In the control room, two large screens now display the status of processes throughout the plants and key process control trend data. The central control room is quiet and well managed.

The Challenges and the Solutions

Application of new technology to improve efficiency

There were two different production control systems side by side in one control room. Procedures for operating them were different, they did not use the same reporting format, and the engineering was also different. With CENTUM VP's new ergonomically designed human machine interface (HMI), information access became quicker and more intuitive, with operators being able to see lots of different process information at a glance and handle any situation seamlessly. By improving operator efficiency, it became possible to reduce the number of control room personnel.

Nonstop and safe operation

The nonstop supply of products from the ADU and DKU processes to the downstream plant was essential, so unscheduled shutdowns needed to be eliminated. As the CENTUM VP and ProSafe-RS systems each have processor cards with dual redundant CPUs, they achieve high availability and are highly reliable. Since the installation of these integrated control systems, operations have been able to continue nonstop with no major failures to the present day.

The integration of ProSafe-RS with CENTUM VP makes it possible to monitor all instrument blocks from the CENTUM VP HMI. The operation procedures for ADU and DKU are all the same now, eliminating operator confusion and bringing a higher level of safety.

If a problem occurs with the ProSafe-RS system, a sequence of event recorder (SOER) function that captures and stores time-stamped event data makes it possible to analyze what happened and make improvements to the plant operations.

Customer Satisfaction

Mr. Somnuk said, “We are happy using Yokogawa's systems because we have not had any major problems with them. The plant is easier to operate with the new CENTUM VP HMI.” He continued by saying, “This is a real VigilantPlant! We will continue to improve our production efficiency”.

Somnuk Boonprasert, IRPC's instrument supervisor, in the central control room

CENTUM field control station (FCS)

ProSafe-RS safety controller

Rack room: clean and neat

Oil and Gas Downstream

Plant Information

- Location: Jurong Island, Singapore
- Order date: April 2006
- Completion: October 2007

Universal Terminal (S) Pte Ltd

Universal Terminal Uses CS 3000 with Terminal Automation System

Executive Summary

Universal Terminal (S) Pte Ltd, one of the largest independent petroleum products storage terminals in the Asia Pacific, has been built on Singapore's Jurong Island at a cost of S$750 million.

Universal Terminal (S) Pte Ltd offers 2.3 million m^3 of storage capacity and modern berthing facilities. The terminal has 73 storage tanks with capacities ranging from 2,000 m^3 to 100,000 m^3 and provides a total of 12 berths, including two that can accommodate very large crude carriers (VLCCs).

Yokogawa Engineering Asia provided a complete terminal automation system (TAS) and a CCTV system for the terminal. The state-of-the-art TAS addressed key customer considerations regarding operational efficiency and system reliability.

The Challenges and the Solutions

The design work for this project started in 2004 and the terminal control system and the associated equipment were all decided in April 2006. The project was completed in the third quarter of 2007 and the terminal became operational in October 2007. One key consideration for selecting the automation vendor was engineering capability and the ability to deliver a system within the limited timeframe. The project team had to be flexible, reliable and cooperative to ensure smooth project implementation and completion of the project. Yokogawa Engineering Asia came through with its commitments and provided full engineering support, successfully delivering the TAS on schedule.

All the 12 berths are in constant use for the unloading of various oil products into the 73 storage tanks. The products are mixed at a pumping station before being moved to the other tanks. Universal Terminal operates continuously 24 hours/day, 7days/week throughout the year. Product specifications vary depending on the clients, so a large number of path selection and blending operations have to be accurately executed in this terminal. Yokogawa's CENTUM CS 3000 and TAS package are designed to handle such complex and demanding terminal operations.

Report data creation is a very important issue in the oil terminal business due to local government requirements for the monthly auditing of oil IN/OUT amounts. The TAS is designed to automatically create daily, weekly and monthly report.

Asset maintenance is very important in ensuring the efficiency of terminal operations. Yokogawa supplied a computer maintenance management system (CMMS) and fully integrated it with the CS 3000. This realizes predictive maintenance and reduces the total cost of ownership.

Central control room

Customer Satisfaction

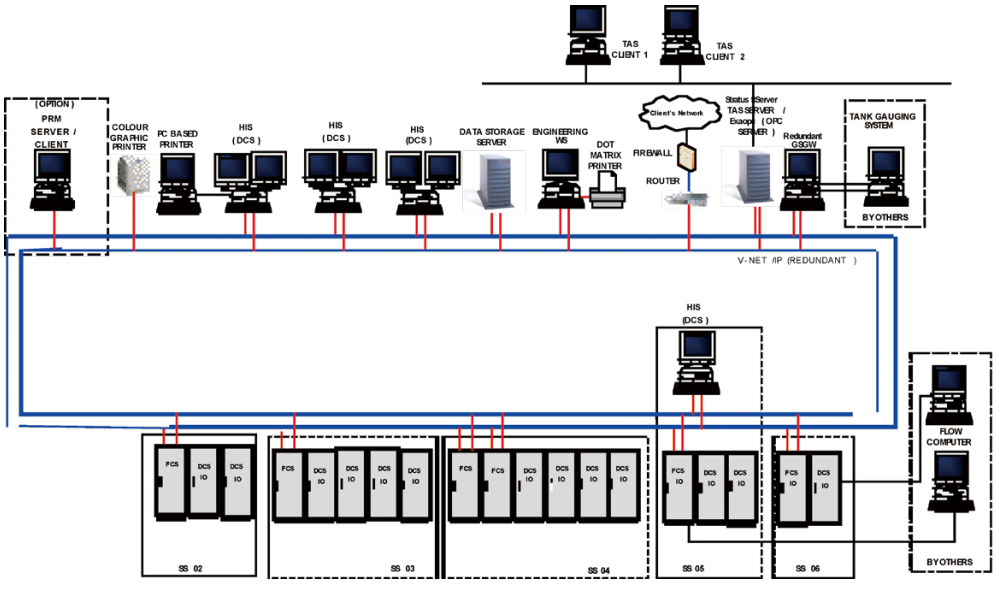
"We are pleased with the support team that Yokogawa has provided us with. They have been most helpful." said. Chandra Sekaran, Head of Logistics.

About TAS (Terminal Automation System)

The TAS handles the loading and unloading of oil products, LPG, petrochemicals and asphalt. Its functionality comprises all necessary monitoring and control functions for terminal operations. The TAS executes the movement control function with ease and efficiency, and monitors the quantities transferred to ensure accurate control, annunciating alarms as necessary in response to inadvertent operation or equipment malfunction. Control platforms can be variably selected to meet the user's needs. CENTUM,STARDOM and FA-M3 will be used.

System Details

Control system:	CENTUM CS 3000
Number of I/O points:	3,185(Di),1,718(Do),378(Ai)
Software Package:	TAS (Terminal Automation System), PRM
Additional supply :	CCTV



Terminal Automation System

Oil and Gas Downstream

Plant Information

- Location: Sanyo Onoda, Yamaguchi, Japan
- Order date: June 2013
- Completion: October 2014
- Industry: Refining

Seibu Oil Company Limited

Migration of Refinery Off-site System with Rapid 48 Hour Switchover Minimizes Downtime and Improves Reliability and Product Quality

Executive Summary

Seibu Oil Company Limited, a subsidiary of Showa Shell Sekiyu K.K., operates a 120,000 barrel per day oil refinery in Sanyo Onoda that supplies a wide range of environmentally friendly petroleum products to Showa Shell Sekiyu and other companies in the region. The refinery has secondary processing facilities that include vacuum distillation, diesel hydro desulfurization, continuous fluid catalytic cracking, and naphtha hydrotreating units, etc.

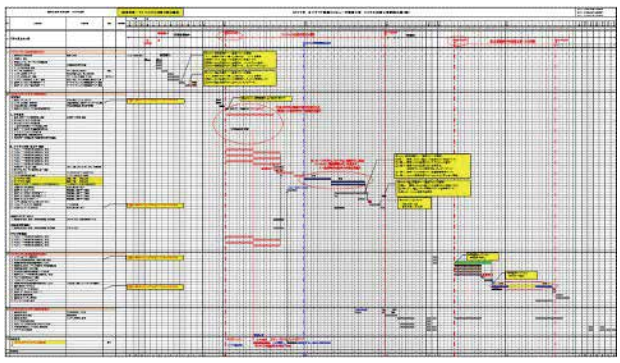
To improve the efficiency of this refinery's offsite operations, Seibu Oil decided to replace its Yokogawa CENTUM-XL distributed control system and other legacy computer systems with Yokogawa CENTUM VP production control and oil movement system (OMS). To minimize the impact on refinery operations, Yokogawa was given just 48 hours to complete the switchover to the new systems and get them operational again. Working closely with engineers from Shinkawa Electric, a Yokogawa distributor, as well as engineers from Seibu Oil who were familiar with the workings of the existing systems, Yokogawa prepared a detailed plan and successfully carried out the upgrade of these systems.

The Challenges and the Solutions

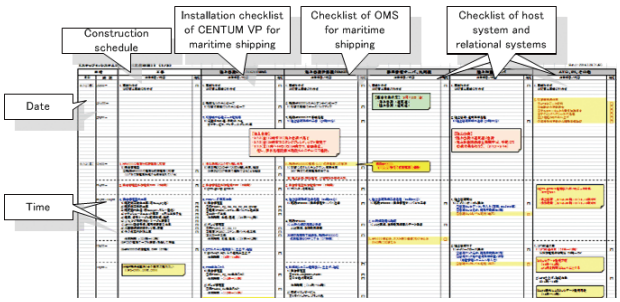
The refinery's off-site systems had been in use for 25 years, and needed to be replaced to improve efficiency. An added concern was that the refinery's most experienced operators were up for retirement within the next few years and needed to pass on their knowledge to their younger colleagues, yet their heavy workloads often made this difficult.

Careful planning for a 48 hour system switchover

Seibu Oil's management was very concerned about the impact that any long interruption in the deliveries of their petroleum products would have on their customers, and gave Yokogawa just a 48 hour shutdown period to complete the switchover to the new systems. One year in advance, Yokogawa began discussing this with Seibu Oil and Shinkawa Electric's engineers. Taking a team approach, they discussed the feasibility of carrying out all the installation work, communication testing, and loop testing in advance of the system switchover while reduce risking and ensuring that quality work was performed, and successfully created a concrete plan for this difficult project.



A very detailed schedule



Step-by-step work checklist

New CENTUM VP human interface stations (HIS) with large displays were installed to the side of the existing operator consoles in the control room. Field control stations (FCS) and OMS servers were installed next to the existing systems in the computer room.

While the existing systems continued to control operations, engineers carried out system start-up tests and tested communications between the new systems and the host computer. All of this work was finished before the switchover.

On the appointed day, the existing systems were shut down and all signal cables were disconnected from the old FCS cabinet and reconnected to the new CENTUM VP FCS. Working around the clock, engineers started up the new system, conducted comprehensive tests of approximately 1,000 control loops, and performed a final test of all systems, including the host system. The switchover was successfully completed on schedule, within the 48 hour shutdown period, and the new off-site systems operated smoothly, with no complications. With the subsequent removal of the old systems hardware, the project was completed.

Improved oil movement management

Seibu Oil chose to replace its legacy oil movement system with a Yokogawa OMS because Yokogawa is a proven supplier of comprehensive oil movement solutions, with over 30 years' experience in this field.

There are approximately 3,500 oil movement paths at this refinery that connect loading and unloading facilities and the tank complex, and with the legacy system all the information on these paths was managed using paper documents. Tapping the knowledge of the refinery's veteran operators, Yokogawa began preparations for configuring the OMS by digitizing the complicated path information to make a path list. A path list is an essential item for the construction of an oil management system that contains information on valves, pumps, and all other equipment at the off-site location.

Control room during the construction phase

Loop testing and commissioning

Oil and Gas Downstream

Seibu Oil Company Limited

Through improved visualization of path information and expert know-how, the new OMS made it possible for even relatively inexperienced personnel to control the operation of equipment, thus helping to prevent errors that result in problems such as product contamination and giveaway. In addition to improving product quality, the use of the path list improved the efficiency of the path change procedure and enabled improvements in device maintenance.

Control room design for HSE and smooth communication

The off-site control room was redesigned by Yokogawa's industrial design team, with Yokogawa designers visiting the refinery to consult with the customer and make a plan that satisfied their requirements. The new control room was designed with health, safety and environment (HSE) requirements in mind. The number of fluorescent tubes was reduced 35 percent without a decrease in luminance, and the lights were positioned to illuminate the walls, thus reducing operator eyestrain. And the vents for the air conditioning system were positioned so that operators would not have to sit directly under them.

The designers divided the control room into operation and communication zones, with the communication zone being a place where veteran and younger operators can sit down together before a large HIS display to exchange information about current processes and give/receive advice on how to correctly carry out specific operations.

Communication zone with large display

Control room created by the industrial design team
(Cool, calm colors in the operation zone, warm colors in the communication zone)

Pre-revamp control room with CENTUM-XL

New control room with CENTUM VP

Customer Satisfaction

Comments by Hidemichi Kasai, project leader:
"Securely and reliably replacing these systems was a top priority for us. In order to fulfill our responsibilities as a refiner, we must prevent shipment delays and emergency shutdowns. It is absolutely essential to prevent accidents. We wanted to be sure that we could complete the switchover within a 48 hour period. We selected Yokogawa because they are familiar with both our business and our systems.

The time was right for this upgrade, with highly skilled veteran operators due to retire over the next 1 to 2 years. To work on this upgrade project, we assigned teams from each section that were made up of a veteran operator and a younger operator. The veterans had all worked on our last upgrade project and had advanced know-how. Thanks to the fusion of this expertise with Yokogawa's rich experience in upgrading off-site systems, we were able to bring this difficult project to a successful conclusion, and our younger personnel were able to gain significant new knowledge and experience.

We accepted Yokogawa's proposal for the control room redesign and are pleased that there is sufficient storage space so that we can keep everything in a set location. Everything, including manuals, is stowed away in convenient locations for immediate access, and this helps us keep this refinery operating safely and efficiently. At the start of each workday and at shift handovers, operators gather in the communication zone and use the large display to exchange information on the tasks that lie ahead. The large screen is also utilized for operator training. Operators are really satisfied with this clean new control room."

Hideo Yamamoto, Yokogawa's project manager:
"One of the factors for the success was the close communication with Seibu Oil and Shinkawa Electric. We had meetings again and again to carefully plan everything. Thanks to that we were able to synchronize all of our project activities. I'm also glad that this project could help our customer develop their younger personnel. Our customer's assistance in creating and verifying the path list, carrying out all migration tasks, and coordinating all these activities within their organization also contributed to this project's success. Thanks to our customer, we were able to complete this upgrade without any incidents."

Celebrating completion of the project

Oil and Gas Downstream

Plant Information

- Location: Kemaman, Terengganu, Malaysia
- Order date: January 2004
- Completion: June 2005

ALDWICH ENVIRO-MANAGEMENT SDN. BHD

CENTUM CS 3000 Plays Key Role in Malaysian Waste Oil to Diesel Project

Aldwich's Waste Oil to Diesel Plant

Aldwich Enviro-Management Sdn Bhd provides integrated, environmentally safe, and cost effective waste oil management services to petrochemical plants in Kemaman, Terengganu, Malaysia. In 2004, Aldwich began construction of a waste oil to diesel plant (WODIP). Completed in mid 2005, the WODIP is composed principally of a tank farm area and a process area.

The Plant

Tanker trucks deliver waste oil from different sources to the WODIP, where they are blended, stored, and processed to produce a variety of high-quality, value-added products, primarily diesel, naptha, and fuel oil. A Yokogawa CENTUM CS 3000 R3 process control system (PCS) controls these batch processes as well as the plant's emergency shutdown (ESD) system and tank loading/unloading processes.

The specific waste oil recovery processes controlled by the Yokogawa PCS are as follows:

- Mixing of different grades of waste oil to achieve a favorable blend, which is then transferred to a main waste oil tank
- Conversion of the blended oils to the final products by means of continuous screening/filtration, dehydration, cracking/ separation, distillation, purification, and treatment

The diesel, naphtha, and fuel oil are then stored in designated storage tanks and shipped to end customers in tanker trucks.

The Challenges and the Solutions

Yokogawa proposed to provide its systems and services as the main instrument vendor for the Aldwich WODIP project, and our overall offer to supply the PCS and the field instruments for the process plant and tank farm as well as to calibrate products and conduct loop checks throughout this plant proved very persuasive to this customer. The Yokogawa project team worked together with the project consultant, main contractor, process licensor, and end users to conduct a piping and instrumentation diagram (P&ID) review and a hazard and operability (hazop) study. In so doing, Yokogawa demonstrated its excellent adaptability in providing services during the engineering phase. The support of Yokogawa's management and the company's efforts to develop a close relationship with this customer underscored our commitment to ensuring the success of this project.

The tank farm

Customer Satisfaction

According to S.Y.Fong, Maintenance manager, "The CENTUM CS 3000 PCS has proven to be highly stable and has experienced no major failures to the present day. We take great pride in the role that we are playing to recycle industrial waste, and appreciate Yokogawa's contribution to this effort."

Central control room

Waste oil recycling process

System Configuration

PCS – CENTUM CS 3000

- 3 FFCS, system panel, power distribution, and marshalling panels
- 2 dual screen HIS and YAX tables
- 1 EWS, event printer, report printer, and color printer
- 900 I/Os
- 3 serial links – furnace control (FA-M3) communication package

Field instruments

- Pressure & differential pressure transmitters
- Temperature transmitters and temperature sensors
- Pressure relief valves
- Orifice plates, orifice flanges
- Control valves
- Coriolis mass flowmeters

Instrument installation

- Calibration
- Installation
  Loop checking

PIMS

– Exaquantum

Oil and Gas Downstream

Plant Information

- Location: Rayong, Thailand
- Order date: June 2008
- Completion: February 2009

Star Petroleum Refining Co., Ltd.

Exapilot Contributes to Safety, Reduces Costs, and Retains Operational Know-how for SPRC's Product Transfer

Executive Summary

Star Petroleum Refining Co., Ltd.(SPRC),found in 1992, SPRC is a joint venture refinery between Chevron and PTT Public Company Limited that has land-marked itself as one of the most modern complex refinery in Asian Region. With 150,000 bpd production capacity, SPRC produces a wide range of quality and environment-friendly petroleum products. SPRC transfers oil products from its Map Ta Phut refinery to a station in Sriracha province and from there to customers all over the country via a pipeline network (annual capacity 26 billion liters) operated by the Thai Petroleum Pipeline Company (Thappline).

SPRC maintains storage facilities for four main types of products, and these include 12 diesel storage tanks, 11 jet fuel tanks, and 8 gasoline product tanks. To improve overall safety and reduce operational costs, it was essential to fully automate all transfer operations. Yokogawa (Thailand) Ltd. successfully accomplished this challenging and complex task by implementing the Exapilot package and integrating it with an existing CENTUM CS production control system.

Exapilot manages product transfer between the Map Ta Phut and Sriracha stations.

The Challenges and the Solutions

The first challenge was improving the efficiency of product transfer from SPRC to its downstream customers. From 60% to 70% of the existing operations had already been automated and the customer could operate the plant efficiently, and the challenge was to raise the level of automation to 100%. All operations such as sequences for starting/stopping motors, opening/closing valves, flow measurement, calculation of totals, and flushing sequences were configured in Exapilot. When a product transfer is requested, all operations are now safely, smoothly, and automatically executed. All procedures were written up by SPRC and configured in Exapilot by Yokogawa. Pretest was carefully performed within a very limited period to ensure safe operation.

The second challenge was minimizing shutdowns and keeping facilities operating 24 hours a day, 365 days a year. Following the introduction of the Exapilot software package, the overall operation became much more smooth as operators could monitor the status of the entire plant on a user-friendly graphic display, and always know what was going on at any point during the product transfer stage. The high reliability of this software and Yokogawa's control system ensured minimum downtime and continuous operation.

The third challenge was retaining operation know-how. SPRC realizes that operational knowledge is important to their business. When there is operator turnover or operators differ in skill level, they want to make sure that the valuable expertise of their most experienced operators is readily available and always visible for configuration. Exapilot perfectly answers this requirement: all operational procedures can be configured in a simple flowchart, with icon drag & drop functionality. The important conditions for each step are simply filled in using the definition window.

Exapilot performs the following two functions at the SPRC facilities
Flying mode: Manages the changeover to a targeted product
Switching mode: Manages the changeover from the prior product's tank

The introduction of these two modes has reduced downtime.

Our customer has found that Exapilot not only makes it possible to retain valuable expertise and enhances safety, it also improves operational efficiency.

Customer Satisfaction

Jamorn Arpapesuch,ISO-Coordinator of SPRC said “We are very happy to be using Exapilot in our product transfer because it has been operating safely for many days now. With the elimination of downtime our operation costs have been reduced. All operations are fully automatic - no manpower is required for changing valves, line selection, pump operation and flushing/purging operation.” He added that he and other members of the SPRC staff appreciate very much the support given by Yokogawa (Thailand) Ltd.

Oil and Gas Downstream

Plant Information

- Location: Algeciras, Spain
- Order date: 2001
- Completion: 2006

CEPSA

Yokogawa Installs Complete OMS System at CEPSA's Biggest Refinery in Spain

Executive Summary

Yokogawa has completed installation of an oil movement and storage (OMS) system for CEPSA's largest refinery, located in Algeciras, southern Spain. This has considerably improved the safety, quality, and efficiency of off-site operations. The refinery's OMS now operates in a much more structured and effective way, with a tailor-made system based on Yokogawa's OMC 3000 and BPC3000 resource and movement planner.

Customer Satisfaction

"Experience in installing similar systems in other refineries was an essential factor in supplier selection. Yokogawa was the clear choice for installation of the OMS. In addition to having extensive experience and a successful track record in this field, they were the only candidate with their own distributed control system (DCS) and a complete OMS application," said Ramon Segura, CEPSA's Planning Manager.

The Challenges and Solutions

"With more than one hundred jobs carried out simultaneously in the movement area at Algeciras at any given time, CEPSA required a comprehensive and reliable system which could cope easily with such heavy demands," explained Andrés Marín García, General Head of Yokogawa Iberia, S.A.

The OMS, which has taken more than five years to fully implement, will provide the following:

- Improved security: off-site area operation security is guided and supervised by the system.
- Enhanced quality: system supervision minimizes possible operational errors that can cause product contamination.
- Improved environmental performance: movement control by the OMS resolves environmental problems caused by tank overflow and other factors.
- Increased efficiency: the number of operations carried out by each person is minimized through valve motorization and the ability to search the existing isolation for lined-up jobs.
- Extended area knowledge: complete area knowledge is available to all operators and is kept continuously updated in the system database, which defines every path for the jobs.

Key Concepts

The OMS is based on a path database. A path is the combination of resources required (off-site equipment such as tanks, lines, valves, pumps, analyzers, process units, berths, pipelines) between a source and a destination. It is unique, and has a direction (from source to destination). The OMS path database includes all possible paths. When the application is running, the operator simply selects paths from those in the database.
In order to generate the paths for the database, all information related to lines, valves, tanks, flowmeters, etc. needs to be loaded into the database. Path generation for all existing source destination combinations and its later downloading into the database is done

in a path server through Yokogawa's PATH3000 package.
A job is the combination of a path and the corresponding resources needed to carry out an operation in off-site areas. All possible job sources and destinations require definition in the database. In the OMS there are two main job types: transfer job, a movement defined between a source and one or two destinations and blending job, a movement defined between several sources (up to 11) and one or two destinations.

With the OMS system, means CEPSA can find out:
- How many and what are the existing jobs in off-sites areas.
- What resources are used in existing jobs.
- Which products are moved in the jobs.
- Which resources are used for a certain job.
- Which resources are available.

This is always available in real-time.

As resources are frequently from third parties, Yokogawa's DCS is compatible with even the most complex instrumentation and offers efficient solutions for communicating with any other systems.

Customized Improvements

The installation required several customized changes were made for Yokogawa's standard packages. Because of the complexity of the paths, the maximum number of lines and valves included in a job was increased. Path information to the operator was improved and selection made easier. Graphic facilities were introduced to make job path selection by the operator more user-friendly. The system was developed to enable a clear view of the real isolation of the path when job-line up is completed. This minimizes valve operations and prevents line blocking. Options were included in the system to allow reporting on jobs done, for later study or investigation.

Ease of Operation

One key feature of the OMS increased ease-of-use for the operator. The operator is guided by the system through excellent graphics facilities.
Once the path for a job to be done is selected, the system provides a guide to line-up the circuit where the valves (manual and motorized), requiring a change of status appear. The job cannot be initialized until all the valves are in the desired status. During job execution, the system controls path line-up. Jobs are finished according to criteria previously defined by the operator.

Organizational Changes

Implementing the OMS has lead to some changes in the organization. The control room operator becomes responsible for selecting job paths and controlling them. As this results in a higher workload for the individual, an additional control room operator has been added to the refinery's staff; however, the role of the main field operator can now be effectively performed by the personnel at the CENTUM CS 3000 operator stations.

Implementation

It has taken over five years to implement the OMS system. A dedicated team consisting of experts from Yokogawa Iberia and CEPSA has completed the implementation in six phases.

About CEPSA

CEPSA is the second largest petroleum company in Spain. It explores for and produces oil and also refines, transports, and sells oil products. CEPSA is a powerful player in the petrochemical industry, and its petrochemical and refining operations are highly integrated, including the management of raw materials, products, and energy. CEPSA has production facilities in Spain, Algeria, Canada, and Brazil, and it operates the Algeciras, Huelva, and Tenerife refineries in Spain. Together, these have a total crude oil throughput exceeding 20,000,000 tons/year.

About Algeciras Refinery

The Algeciras refinery is the CEPSA Group's largest. It produces all types of combustible products (propane, butane, gasoline, jet fuel, gas-oil and fuel-oil) and a great quantity of basic products for the petrochemical industry (benzene, toluene, p-xylene, o-xylene, etc.). The refinery has an extension area of 1,500,000 m^2 and a crude distillation of 12,000,000 tons/year. Refinery storage capacity reaches 2,200,000m^3, with 900,000 m^3 used for crude and the rest for products. This capacity is distributed in approximately 150 tanks.
The off-site piping network has a total length of 220 km. Refinery crude supply is done through a submarine line connected to a single mooring buoy that is situated one mile offshore and accommodates tankers up to 350,000 DWT in size. The refinery has its own port terminal with nine berths available for the loading and unloading of products and crude oil.
The refinery is connected to the national pipeline network and inputs 3,500,000 tons of gasoline, jet fuel, and gas oil into it each year.

System Details

The main components of the installation include:
- OMS server: UNIX-based HP computer running ORACLE on-line path database
- Path server: Windows PC for generating off-line path database
- OMC 3000 and BPC3000 resource and movement planner
- Field control station (FCS): directly connected to the process and to the TIM3000, TRANS3000, BLEND3000, and BPC3000 execution control modules as well as standard DCS instruments and sequential charts requested for job execution
- Human interface station (HIS): operator consoles for movement control and general off-site area management
- Software components: for database, movement control, tank inventory management, transfer job sequential control, blending job sequential control, blending property control, and path database generation

Oil and Gas Downstream

Plant Information

- Location: Rabigh, Kingdom of Saudi Arabia
- Order date: October 2003
- Completion: May 2006

Saudi Aramco

Saudi Aramco Rabigh Refinery Control System Replacement (Hot Cutover)

About Saudi Aramco and the Rabigh Refinery

Saudi Aramco's operations span the globe and the energy industry. The world leader in crude oil production, Saudi Aramco also owns and operates an extensive network of refining and distribution facilities, and is responsible for gas processing and transportation installations that fuel Saudi Arabia's industrial sector. An array of international subsidiaries and joint ventures deliver crude oil and refined products to customers worldwide.

World-class refineries located across the country, from the Arabian Gulf to the Red Sea, reliably supply more than a million barrels of products each day to meet the needs of the Saudi Arabian and international markets. The Rabigh Refinery, located 160 kilometers north of Jeddah on the Rea Sea coast, is one such refinery operated by Saudi Aramco.

The Rabigh refinery has a 400,000 BPD crude topping facility. Crude is delivered by tankers through the Saudi Aramco Rabigh port. The main products are fuel oil, naphtha, and jet fuel. LPG and oil are used as fuel for the refinery while recovered sulphur is bagged and shipped.

Background of This Project

As part of an upgrade project to reap the benefits of the latest technology, Saudi Aramco Rabigh Refinery awarded Yokogawa this project to replace the existing control system with a state-of-the-art distributed control system (DCS). The entire complex was previously controlled by single loop controllers and a Foxboro IA system.

The decision to introduce the new system was motivated by the need to reduce the high maintenance costs of the single loop controllers and to obtain improved functionality. The selection criteria emphasized system reliability and the ability to replace the system while the plant was operational (hot cutover).

With SNC Lavalin Inc. as the design contractor and Carlo Gavazzi as the construction contractor, Yokogawa delivered the control system with the engineering assistance of its Middle East office in Bahrain.

In addition to the DCS, the project scope included the implementation of an oil blending system (OBS), multi-variable control (MVC), and heater pass balance control by Yokogawa Middle East. The OBS implementation is in progress while the MVC implementation was successfully completed in March 2007. Twenty existing and ten newly installed subsystem interfaces increased the complexity of the hot cutover and function test.

Team Effort Always Pays

According to the Saudi Aramco Project Management Team Lead Engineer, "One of the key factors leading to the smooth hot cutover was the team effort. Every activity was meticulously planned to ensure a safe change over. This was possible because everyone adhered to the procedures stipulated before the hot cutover was started by all the groups involved."

The major challenge was the integration of the subsystem interfaces. "We never felt the complexity of the integration work", said the Control System Engineer, "and this was possible since the integrated site acceptance test (ISAT) was so comprehensive."

Hot Cutover Challenges

The major challenges were winning the operators' acceptance of the new system, scheduling and coordinating the ISAT with all the subvendors, and quickly troubleshooting the problems encountered during the hot cutover.

Pre and post hot cutover planning was done in several meetings between Saudi Aramco, SNC Lavalin, Carlo Gavazzi, and Yokogawa Middle East. Various check sheets and procedures were in place for the tuning of loops and the final handover.

What This Project Achieved

- A smooth and safe switchover to the new system
- An easy-to-use, easy-to-engineer system, plus various post-installation enhancements
- Tuned controllers for smooth plant operation and better traceability of process upsets
- Various other improvements thanks to advanced process control and MVC implementation

What's Next?

Having successfully completed the control system replacement project, Yokogawa was awarded the Saudi Aramco - Sumitomo Joint Venture, PETRORabigh project to engineer and install the CS 3000 DCS for a huge petrochemical complex that is being built next to the refinery.

System Details

Control system:	CENTUM CS 3000 R3
Number of I/O points:	5,000
System configuration:	
• No. of domains:	6
• Engineering stations (ENG):	2
• Human Interface Stations (HIS):	14
• Field Control Stations (FCS):	12
• EXAOPC:	1
• Plant Resource Manager (PRM):	1

Oil and Gas Downstream

Plant Information

- Location: Ardmore, Oklahoma, USA
- Order date: February 2004
- Completion: April 2005

Valero Energy Corporation

Valero Selects Yokogawa System for Operational Improvements

About Valero Energy Corporation

Valero Energy Corporation is a Fortune 500 company based in San Antonio, with approximately 22,000 employees and expected annual revenue of more than $90 billion. The company owns and operates 18 refineries throughout the United States, Canada and the Caribbean with a combined throughput capacity of approximately 3.3 million barrels per day, making it the largest refiner in North America. Valero is also one of the nation's largest retail operators with approximately 5,800 retail and branded wholesale outlets in the United States, Canada and the Caribbean under various brand names including Valero, Diamond Shamrock, Shamrock, Ultramar, and Beacon. Please visit www.valero.com for more information.

About Valero Ardmore

Valero's refinery in Ardmore, Oklahoma, processes medium, sour crude oil from both domestic and foreign sources. It produces more than 90,000 BPD with major products including conventional and low-sulfur gasoline, conventional and low-sulfur - and recently, ultra-low sulfur - diesel, asphalt and refinery-grade propylene. In addition to production and processing, the refinery also has more than 2.4 million barrels of refined-product storage capacity.

Background of this Project

To take advantage of modern process control technology, the Valero Refinery in Ardmore, Oklahoma, recently replaced an existing legacy control system with a state of the art distributed control system (DCS) from Yokogawa. Valero Ardmore decided to replace the system because "(it) represented several different generations of equipment and it became apparent to us that a clean sweep approach would be more advantageous," said Ken Ferris, Refinery Engineering Manager. "A complete modern system could offer us the important opportunities for significant improvements via advanced process control (APC) and similar enhancements after initial system installation."

As maintenance costs increased for legacy system components and functionality of newer systems can achieve production improvements, the decision to change was made. The selection criterion was based on reliability, features, critical functionality, and cost.

"Our decision to replace the existing legacy DCS - plus expanding control for several units in the refinery - came about as we considered possibilities for interfacing schemes to extend capabilities of our existing system," explains Ken Ferris, Refinery Engineering Manager.

A team composed of representatives from all refinery departments began screening available choices and soon narrowed the choices to two automation suppliers. At that point, intensive evaluation of relative strengths and weaknesses for each of the two vendors included systems functionality, project execution, and support capability.

System reliability was a primary consideration because safety is the single most important element emphasized by Valero management. Before any significant operational improvement can be extracted through advanced process control, the plant must have safe and reliable operation. Another key systems functionality evaluated was system response speed. For example, the system ultimately selected had the capability to scan all I/O points for the entire refinery and graphically display results in only one second. Operators could essentially operate in real time, fast enough to apply remedial action before a potential process anomaly or equipment failure occurred.

The evaluation process concluded with Valero selecting the CENTUM CS 3000 R3 system from Yokogawa due to its reputation for reliability, integration capabilities, rich set of refinery applications and functions, and life-cycle cost.

Existing I/O Devices Used

Most of the plant's existing instruments and controls were used, with new I/O devices replacing antiquated legacy equipment where needed. A unit formerly operated manually with pneumatic equipment was also included in the scope for the new system. Each control/data loop was examined and "fine tuned" when appropriate.
Installation was achieved through a series of planned hot cutovers for more than 6,000 points. The sequence of these changeovers was determined by considering the urgency of a unit to meet operational needs plus the physical requirements involved with replacement logistics for large equipment in the rack room. The most complex cutover involved the hydrogen purification unit and the platformer unit, where complicated batch sequence programs had to be switched over to the new system.

A Vital Ingredient Initially Established Pays Off Early

"One of the key elements leading to the 'smooth' installation," says Mike Wallace, Valero Instrumentation Manager, "was an initial meeting with our people and the vendor team. We all were very open and honest in discussing what was going to be needed and what to expect. Opinions expressed ranged from personal to technically complex, and responses came 'with no holds barred.' Out of that meeting emerged what has become a very professional and valuable vendor/user team based on mutual trust and respect."

Just how well this group could actually function was sorely tested as installation neared completion. There was an incident of a hardware failure. To find the cause as rapidly as possible, Valero and Yokogawa complemented each other in ferreting out the problem's root cause. With a hot-cutover schedule pressing down, the culprit was finally isolated - corrosion from ambient hydrogen sulfide shorting out closely spaced connections on communication hardware. A modified hardware design solved the problem, and the refinery made changes to clean the atmosphere in the rack room where the hardware was located.

Customer Satisfaction

More than 6,100 I/O points were connected to the system with only one minor recordable safety incident occurring during installation. This was especially important to the refinery since it had been accepted into the OSHA Voluntary Protection Program as a "Star Site," one of the safest refineries in the nation.

Hot cutovers started in August 2004 and were completed in April 2005.

"One other factor helping our installation process, " said Ferris, "was a team we established to translate the legacy system into Yokogawa as we went along. We thus eliminated one potential source of delay and were ready to move ahead in completing the cutover schedule."

Growing Positive Operator Response

"In almost all cases, operators are now progressively praising and liking the new system as they use and become familiar with it," comments Stan Kersch, instrumentation consultant for the refinery.

"Some unit operators initially resisted various facets of display and control," he explains, "largely because 'things and actions didn't feel like' what they were used to with the legacy system. Now they are finding that it's really nice to not have to worry about units under their supervision; the system takes care of things without the constant operator attention formerly required."

What the CENTUM CS 3000 R3 Solution Contributed

- It helped to provide a smooth project execution with no schedule and/minimal safety incidents.
- It provided an easy to use, easy to reconfigure interface that has resulted in numerous post-installation enhancements.
- It has minimized day-to-day plant operation problems including reducing the alarming factor. Thus, the refinery can concentrate more on problems like maintenance of mechanical equipment.
- The vital basic availability necessary for Valero now allows Valero to consider various other improvements through APC and other advanced capabilities.
- It reduced variability throughout the refinery, allowing for increased throughput and higher product quality.

System Details

System:	CENTUM CS 3000 R3
Number of Operator Stations:	16 HIS
Number of Controllers:	11 FCS
Number of Engineering Workstations:	3 EWS
Total I/O:	6,100
Solution-based Packages:	3 Exaopc (OPC - DA, AE and HDA) Servers

Oil and Gas Downstream

Plant Information

- Location: Tamoil SA, Raffinerie de Colombey, Switzerland
- Order date: 2007
- Completion: 2007

Tamoil SA

Fast Online Gas Chromatograph Analysis for LPG Distillation

Executive Summary

The Tamoil SA refinery in Collombey has been producing a wide range of finished products since the 1960s, including various types of fuels and heating oils as well as liquefied petroleum gas (LPG), the latter of which is used as an alternative fuel for vehicles and as a raw material for the petrochemical industry. LPG, which consists of C3 and C4 hydrocarbons, constitutes only about three percent of the refinery's production. Nevertheless, it is highly significant because it is sold for use in LPG-powered vehicles, and – most importantly during wintertime – is used as a blending ingredient in liquid fuels.

The Challenges and the Solutions

In total, more than 250 m^3 of LPG are produced each day in Collombey. It is separated in three distillation columns (Fig. 1), i.e. during naphtha stabilization, reforming stabilization, and after hydro-treatment of light gas oil. The heavy fraction of the latter separation is fed back into the atmospheric distillation. By reducing the amount that must be recirculated, this extensive separation of LPG has the direct benefit of reducing energy costs. Furthermore, the higher purity of the LPG fractions produces economic benefits arising from the better fit to specifications. The composition of the LPG fraction is thus critical to the refinery's efficiency.

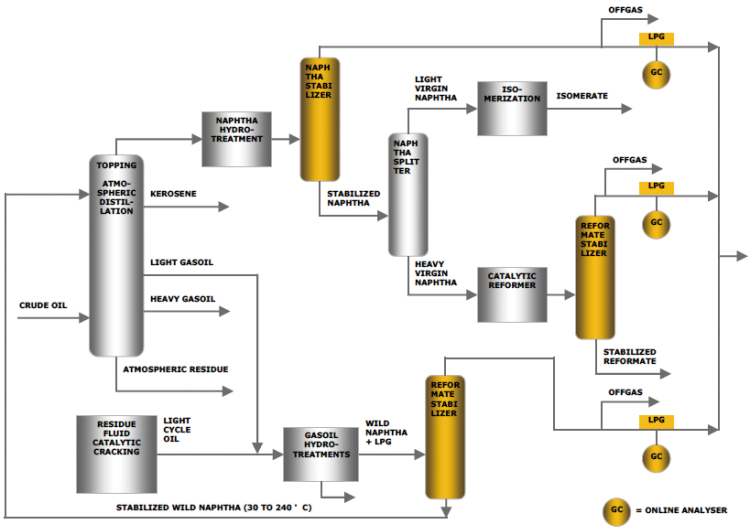


Fig. 1

The demand for a more efficient operating mode for the columns requires more precise information about LPG composition, which conventionally has been conducted by means of manual sampling laboratory analysis. Most important is the information about the C5+ content, i.e. the concentration in the LPG fraction of components having a higher boiling point, which is required at a higher frequency than is possible with conventional techniques.

Application solution

From the start it was most important to select an LPG analysis solution that was state-of-the-art and robust, yet attractive in terms of total cost of ownership. After discussions with Yokogawa the decision was made to go with a gas chromatograph (GC) solution. A key requirement was the ability to conduct an analysis in near real time. For a GC solution, this is achieved most economically by positioning the analyzers close to the columns (Fig. 2).

A minimal fast loop sampling concept, developed together with Yokogawa, presented further advantages: near real-time access to precise process information, coupled with simple and therefore robust installation. Yokogawa's analyzer, the GC1000 Mark II, also has the advantage of not requiring air conditioning in decentralized applications. To determine the C5+ contents in the shortest possible time, this analyzer utilizes the backflush technique.

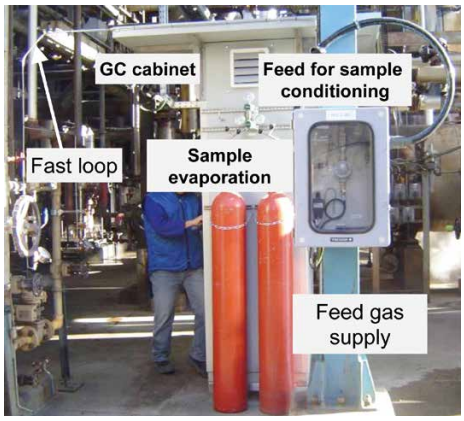


Fig. 2

GC units were installed on all three LPG columns. The exact positioning and arrangement of the sample supply were done in consultation with Yokogawa and its authorized local installation partner. The equipment was installed as part of a planned plant shutdown in the summer of 2007. Afterwards, the measuring points were gradually put into operation in August/September 2007. Although the analyzers are several hundred meters apart on the plant premises, they can be controlled and supervised from a central server. In addition to online status information, detailed status reports and chromatograms can be called up, and calibration procedures can be initiated and monitored. Only the replacement of empty carrier gas bottles and calibration medium still has to be done at the analyzer cabinets.

Results

The key objective was to achieve a clear increase in efficiency, and this has already been realized. Around the clock, a measured value for the C5+ concentration is now available every 150 seconds, at each measuring point. The ability to obtain these precise and reliable values has led to substantially improved distillation quality. The quick and timely adjustment of distillation parameters is now possible, bringing the total response time down to as little as 15 minutes.

The new analysis equipment has proven to be particularly successful in the columns downstream of the hydrotreaters. The increased separation efficiency yielded approximately 1.5-2 m^3/h more LPG than before. The resulting increase in the amount of LPG available for sale and the energy savings from the reduced feedback to the atmospheric distillation column contributed significantly to the bottom line.

Customer Satisfaction

Ciro Pendino, Process Control Engineer and Group Leader at Tamoil SA, said: "The analytical upgrade project with Yokogawa's process GCs was a complete success. All systems have worked very reliably from the start. Clear responsibilities and short response times led to the fact that barely a year separated the first tender and commissioning. The choice of an experienced system supplier, who was responsible for the entire project from solution design through planning, engineering, installation and start-up up to the training of the workers, has proven to be optimum for us. This was all the more applicable because the project required a high level of process understanding and was therefore in good hands with a competent project manager. In this way, additional workload for the refinery personnel could be avoided. Tamoil has received a convincing solution, last but not least due to an efficient and competent system partner, with whom we co-operated on this occasion for the first time, but certainly not for the last."

Oil and Gas Downstream

Plant Information

- Location: Cape Town, South Africa
- Order date: August 2008
- Completion: February 2011

Chevron Cape Town

Yokogawa Successfully Completes DCS Controller Replacement Project (hot cutover)

Executive Summary

Chevron entered the South African market in 1911 and now markets its products there under the Caltex brand, which was created in 1936 by a joint venture between Standard Oil of California (the present Chevron) and The Texas Company (Texaco). Chevron operates a 100,000 barrel-per-day refinery in Cape Town that produces gasoline, diesel, jet fuel, LPG, and asphalt.

Chevron South Africa initiated a project to replace the existing Yokogawa CENTUM-XL process control system at the Cape Town refinery with CENTUM CS 3000 hardware and upgrade the control network to Vnet/IP.

Project Background

This project had the overall aim of ensuring the high reliability and availability of the refinery's distributed control system (DCS). The existing CENTUM-XL control system had been in use for over 15 years, leading to concerns about the rising risk of unplanned plant shutdowns and production losses as well as increased maintenance costs.

The intent was to replace the existing CENTUM-XL control stations with the latest Yokogawa CS 3000 hardware and upgrade the control network to the faster and more efficient Vnet/IP.
In June 2008, Yokogawa South Africa was appointed principal contractor and given overall responsibility for the project.

Project Overview

The plan was to minimize plant downtime by doing a hot cutover from the old to the new control system, and to then immediately test all instruments and controls.
Structured and formal project and engineering procedures were developed to make sure that every process requirement would be fulfilled and all risks mitigated. The execution procedure culminated with a thorough risk assessment process that involved all key stakeholders.

To meet all of Chevron's requirements, personnel responsible for reliability and maintenance, advanced control, construction, and operations were assigned to the project.

Prior to the hot cutover of each control station, the existing system was re-configured for the CS 3000. A formal process was followed to ensure all the control logic and functionality was retained and that this complied with the software configuration standard developed for the project.

After the approval of the design, the Yokogawa CS 3000 hardware was installed in the DCS panels and the panels were acceptance tested.

The hot cutover process was carried out on an individual I/O point basis. Field wiring was transferred point by point from the old DCS to the new DCS and at the same time the existing configuration (program) was disabled and the new configuration activated. Control valves were bypassed until the controller was successfully cut over.

Success Factors

The cutover of this 100,000 barrel-per-day Cape Town refinery was performed live without disruption to production operations, and Yokogawa achieved this on time and within budget.

The following key factors contributed to this success:

- The experience of the team members
- Excellent teamwork between the Yokogawa and Chevron personnel assigned to the project
- Good communication between team members during the cutover process
- The planning and implementation of a structured and methodical approach
- The completion of a thorough risk assessment process to mitigate all risks
- Continual evaluation and improvement of processes based on lessons learned

Customer Satisfaction

Comment from Phillip Venter – Project Manager

"There are several factors that I believe were major contributors to the success of this project. From the RFQ stage of the project there was excellent teamwork between Yokogawa and Chevron. We all shared the vision of successfully completing the project within schedule and budget, with no production loss and zero incidents.

Phillip Venter Chevron

Having the entire Yokogawa team in one location on site has drastically improved the efficiency of the team, coupled with each team member's personal commitment to the project. It sure has been a pleasure and an honor to work with the Yokogawa project team.

In any project, strength lies in the ability to adapt to the ever changing circumstances and the collective effort of continuous improvement."

Project Statistics

Control system upgraded to CENTUM CS 3000 Vnet/IP

Hardwired I/O cut over:	7,132
FCS's cut over:	24
I/O modules:	611
Nodes:	123
System cables:	805
Terminal boards:	499
Domains upgraded to Vnet/IP:	3
Engineering stations (EWS):	3
Human interface stations (HIS):	30
Incident free man-hours on site to date:	50,584
Number of loss incidents:	0

Oil and Gas Downstream

Plant Information

- Location: Ulsan, South Korea
- Order date: August 2006
- Completion: June 2008

SK Energy

Yokogawa Provides CENTUM CS 3000 and Field Instruments for New FCC Facility

Executive Summary

SK Energy is the energy and chemical affiliate of South Korea's SK Group. Korea's largest oil refiner (1.1 million barrels of daily refining capacity), SK Energy controls about 35% of Korea's fuel retailing market and operates 4,270 service stations. The firm is involved in oil exploration and production in 15 countries and has proven reserves of 500 million barrels of oil equivalent. SK Energy imports coal and liquid petroleum gas (LPG), and claims a 44% share of the Korean LPG market. The company supplies natural gas to Seoul and other cities in Korea, and also makes lubricants, low-pollutant gasoline, and petrochemicals.

SK Energy decided to construct a new fluid catalytic cracking (FCC) facility at its Ulsan refinery to convert bunker C oil into high quality, low sulfur, and high value-added refined liquid products such as gasoline and diesel. This decision was made for the following reasons:

- Respond to growing demand for cleaner burning distillate fuels and falling demand for residual fuels such as bunker C fuel oil due to stricter environmental regulations
- Increase gasoline output to meet growing demand through 2010
- Enhance the company's price competitiveness in the global fuel market
- Increase the complexity ratio of the Ulsan refinery, which is lower than that of the company's other refineries in South Korea

For this new FCC facility, SK Energy awarded Yokogawa Korea a contract to install a state-of-the art CENTUM CS 3000 distributed control system (DCS) and field instrumentation. Working on a very tight project schedule, Yokogawa Korea successfully completed all control system and instrumentation engineering and the new facility was able to launch production of commercial-grade products on schedule.

The new central control room

The Challenges and the Solutions

The overall project goals were identified during the feasibility study and project planning phases, and emphasized schedule, quality, cost, and safety.
A major challenge was the tight project schedule as SK Energy needed to complete construction of this new FCC plant in just 15 months and begin a pilot program of operational testing no later than mid 2008. Normally such plants take at least two years to complete and commission, and require another three months before they can be operating at full capacity.
After receiving this order in August 2006, Yokogawa Korea's project team worked closely with personnel from three different EPC companies, holding biweekly technical meetings to discuss and decide on hardware and software specifications.

For this new FCC project, more than 40 sub-system interface cards and a Modbus interface were utilized to integrate systems from 14 partner companies with the CENTUM CS 3000 DCS. This enabled status information and other types of data from compressors, blowers, filter systems, dryers, and a wide variety of other types of equipment to be transferred to the DCS and viewed by operators on various graphic displays at the human interface stations (HIS). By keeping constantly up to date on the status of all processes, the operators are able to easily analyze and understand the process situation and take action immediately. In addition, all production data gathered at the DCS can be transferred to higher level computer systems via an OPC interface. That data can be stored for the tracking of overall production efficiency and used for asset management analysis and other types of plant equipment studies. In these ways, integration contributes to visualization of all plant data, significantly reduces labor costs, and ensures safe plant operation.

Customer Satisfaction

In appreciation for its key contribution with the control system and instrumentation engineering, Yokogawa Korea was awarded a plaque by SK Energy. Following the successful completion of this project, other refiners (GS Caltex, Hyundai Oil Bank) have selected Yokogawa Korea as their technology partner.

J.W Park, Lead I&C Engineer of SK Energy, said, "Yokogawa worked collaboratively with our team through the many challenges of the FEED phase and subsequent design, build & test phases, delivering the system on time and completing preparations for the successful start-up and commissioning of this plant. Lessons have been learned which will benefit the management and planning of future projects. We commend Yokogawa for their open and honest acceptance of responsibility, support, and dedication, especially during the challenging installation, start-up, and commissioning of the plant."
Mr. Park went on to say, "SK Energy is always looking to make further improvements in its operations, and we are now considering how to improve the sustainability of our manufacturing operations. We have heating furnaces and boilers at our site and are looking for ways to save energy and reduce CO_2 emissions by reducing flue gas oxygen concentrations. And for complex plant operations, we also are looking at operation support systems like Exapilot that will retain the expertise of our most expert operators and eliminate lost production. We see a great need for this function and believe it can lead to increased productivity. For these reasons, we would like to keep working together with Yokogawa Korea."

J.W Park of SK Energy

System Details

DCS:	CENTUM CS 3000
I/O points:	21,500
Domains:	3
Engineering stations (EWS):	4
HIS:	43 (2 dual screens)
Field control stations (FCS):	20
Sub-system interface cards:	46
Field instruments:	1,500 EJA, 400 YTA, 800 PK200

Oil and Gas Downstream

Plant Information

- Location: Rayong, Thailand
- Order date: 2010
- Completion: March 2011

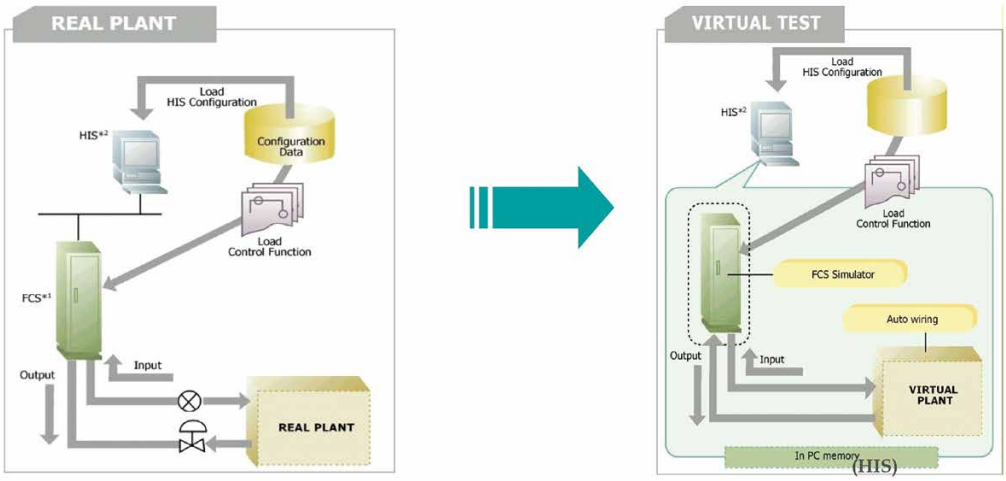
PTT Aromatics and Refining Public Co., Ltd.

Flawless Refinery Start-up Assured by Operator Training Simulator

Executive Summary

PTT Aromatics and Refining Public Company Limited (PTTAR, Current PTT Global Chemical Public Company Limited) has three large-scale plants at the Map Ta Phut Industrial Estate in Rayong, Thailand. AR1 is a refinery and AR2&3 are aromatics plants. This PTTAR refinery and aromatics plant complex has a refining capacity of 280,000 barrels per day and an aromatics capacity of 2.26 million tons per year. AR1 had a legacy distributed control system (DCS) that had been in use for more than 10 years. With the aim of upgrading to the latest technologies, PTTAR decided to replace this system with Yokogawa's CENTUM CS 3000.

The major challenges in this system migration were to minimize the replacement period while ensuring that the refinery's operators could soon make the transition to the new man machine interface and operate the system safely. To facilitate this transition, PTTAR decided to purchase a Yokogawa OmegaLand operator training simulator (OTS). Yokogawa Thailand successfully installed both the new CENTUM CS 3000 DCS and the OmegaLand OTS, and used the OTS's simulation function to confirm the functionality of the new DCS. In so doing the AR1 project team was able to achieve a flawless start-up, with no losses or downtimes. The operators particularly appreciated this OTS's virtual test functions.



Virtual Test Function

The Challenges and the Solutions

Familiarizing operators with the new DCS system

Through the use of a realistic plant-like operational environment, operators can be trained to perform a variety of plant operations. Training operators with an OTS is an effective means of helping them learn how to deal with unsteady state conditions and improve their operation skills.

Operation training can be divided into planned event and unplanned event categories. Furthermore, training procedures can be provided for normal operations and exceptional operations. It is possible to perform all of these types of training by combining the functional modules of the OmegaLand OTS.
In the time leading up to refinery start-up, operators can fully familiarize themselves with the new CENTUM CS 3000 DCS by undergoing a lot of training of different types under a variety of conditions, as follows:

- Training for normal conditions
- Training for abnormal conditions
- Training for transient conditions
- Training for emergencies

Project schedule

With the expectation that DCS-OTS integration would take at least three months and that the system would have to be ready at least six months before the actual start of the plant revamping, PTTAR considered the overall schedule when taking bids for the AR1 project. It proved to be a great advantage that the OmegaLand OTS could be made available one year before the start-up, giving operators all the time they needed to familiarize themselves with the new DCS.

Fidelity for process simulation

The virtual test function of the OmegaLand simulator created the same environments as the new DCS.

- Simulation of all DCS functions
- 100% engineering and operation functionality
- Wireless debugging to simulate inputs and outputs
- Snapshots for evaluation purposes

Validation of control logic and control strategy

AR1 used the OTS to validate its control logic and control strategy. With this tool, it could carry out dynamic analyses and examine processes and control systems while taking plant operations into account. The following items could be examined on a virtual plant prior to actual operation:

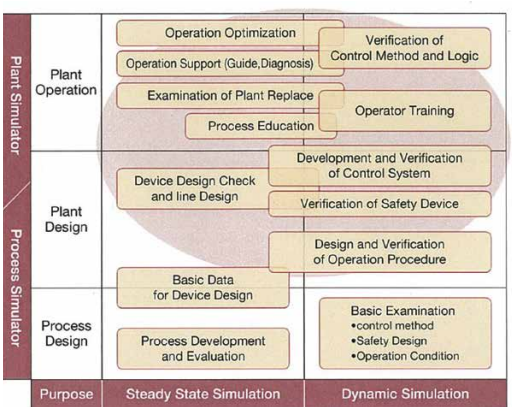
- Verification of operating procedures for start-up and shutdown of the new plant
- Prior to remodeling lines and equipment, limitations and capacity could be changed
- Advance feasibility studies could be performed when operating conditions including feed composition, operation load, and equipment had to be changed
- Changes in control systems could be examined, and control systems could be tuned

Customer Satisfaction

Suppalerk Suppawatin, Process & Performance & Control Division Manager, said, “We were very happy that we could use Yokogawa’s CENTUM CS 3000 system and the OmegaLand OTS software for our replacement project. We selected the right solution from Yokogawa and we executed the right project schedule. We minimized the total cost and achieved a successful replacement. We assigned the right engineers and operators, who worked closely with Yokogawa members as an excellent project team.”

Operator training simulator

Yokogawa’s simulator offers a highly accurate operator training system with a realistic feel, an environment for examining and verifying control methods, functions for plant optimization, energy saving designs, and online operation support through the use of modeling and simulation technologies. OmegaLand is an integrated environment for dynamic simulation that enables the creation of a virtual plant. OmegaLand consists of independent modules with specific functions and offers an environment for the achievement of all sorts of objectives.



Fields of Application of Plant Simulators

Oil and Gas Downstream

Plant Information

- Location: Stillwater, Oklahoma, USA
- Completion: 2009

Fractionation Research, Inc.

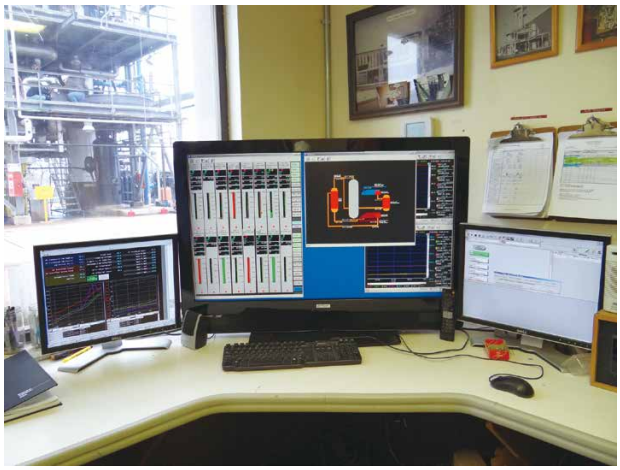
Exapilot Smoothly Starts Up and Shuts Down the World's Biggest Experimental Distillation Unit

Executive Summary

Fractionation Research, Inc. (FRI) is a non-profit research consortium supported by over 70 organizations, including many of the world's largest petroleum, chemical, and engineering companies. The experimental unit is located on the Oklahoma State University campus in Stillwater, Oklahoma.

At the heart of the FRI experimental facility are two commercial-scale low and high pressure distillation columns along with the equipment needed to support their operation. The auxiliary equipment includes low and high pressure kettle reboilers, low and high pressure condensers, as well as a dedicated boiler and cooling water tower. The low pressure column has the capability to operate from a deep vacuum, while the high pressure column can operate at up to 500 psia. Each column has a 4 foot (internal diameter) by 28 foot section, but the low pressure column also has a section that is 8 feet in diameter and 12 feet high. Each column is equipped with a permanent, automated gamma ray scanner that measures liquid holdup density during the experimental runs. Strategically positioned windows on the columns allow technicians to look inside and even take video. The FRI facility also has viewing windows on one of its kettle reboilers, a feature not available anywhere else in the world. In addition, cross connections between the two columns allow the sharing of some auxiliary equipment and the parallel operation of both reboilers and condensers while the low pressure column is operating. From 2007 to 2009, the experimental unit was refurbished and debottlenecked, and has since been demonstrated to be capable of testing the full range of hydraulic capacity of all known column internal contact devices.

At this FRI facility, process control and data capture were handled by a Yokogawa Micro-XL DCS, and this has recently been replaced with a CENTUM CS 3000 system, also from Yokogawa. At the same time, FRI introduced Yokogawa's Exapilot operator support package and Exaquantum historian. FRI conducts many experiments throughout the year, and Exapilot has enabled this facility to achieve faster and safer start-ups and shut-downs, and has also helped improve another key parameter: time to steady state. This has reduced steam consumption. By providing operators real-time process data at the right time, Exaquantum helps them make quick decisions at every stage of a process.



CENTUM CS 3000 integrated with Exapilot and Exaquantum

The Challenges and the Solutions

Smooth and safe start-up and shut-down

FRI normally has about 20 different test operations a year. Each test may last about two to three weeks. To minimize steam consumption, FRI needs to start up the unit quickly, smoothly, and safely. And when a test is completed, the operator has to shut down the unit smoothly and safely.

Exapilot is used to build and execute electronic, semi-automatic procedures using a modular procedural automation (MPA) methodology. Yokogawa and FRI engineers programmed Exapilot for start-ups, transitions, and shut-downs. The software is capable of providing control room technicians with all of the following:

- A step-by-step listing
- Prompts regarding next steps
- Warnings regarding next steps
- Initiation of the actual opening and closing of valves or changes at controller set-points, one at a time in sequence or more than one at the same time
- Performance of "watchdog" function for critical events
- A record of completed steps
- Status information on process changes

When the Yokogawa and FRI staff members first started working together, the learning curve was steep. The Yokogawa people needed to learn the two distillation columns, the three binary systems, and the steps associated with the starts, transitions, and stops. Fortunately, up-to-date and accurate PFDs and P&IDs were available, and these proved to be an essential asset. The FRI people needed to learn the software's capabilities and master electronic procedure building.

Several semi-automatic procedures were written. None were completely perfect when initially tested in the control room. It was very easy, however, to run a computer program in parallel with process changes, in offline mode, without handing over complete control to the computer program. FRI's best board operators were in the control room during these trial runs and had a hand in perfecting the program. With this program running under Exapilot, there is now uniformity in how starts, changes, and stops are executed.

Easy data management

FRI needs to collect a lot of data from a test operation and analyze it as quickly as possible.
Before Exaquantum was introduced, operators had to enter figures in a spreadsheet and then wait at least three hours to see the results of the distillation test. With Exaquantum, the process data is updated every second and displayed in a trend display along with a summary. At a glance, operators can verify the test situation and take immediate action. Data visualization is the key, giving operators a complete understanding of what is going on in the process, in real time.

In summary, the integrated use of the CENTUM CS 3000 DCS, Exaquantum, and Exapilot has reduced steam consumption and improved safety at the FRI test facility by facilitating the execution of non-routine operations.

Customer Satisfaction

According to Mike Resetarits, a technical director, "Manpower reduction is not one of the goals of semi-automatic procedures. In too many global control rooms, manpower reductions have already occurred. Additionally, many senior technicians have retired over the last 10 years. Semi-automatic procedures are intended to help, not eliminate, the present generation of technicians." He continues, "These days, in the FRI control room, the FRI technicians seem to enjoy using the semi-automatic procedure software. It collaborates, for them, their recollections, judgments, and decisions regarding next steps. They say, 'It's like having our best board "man" alongside us in the control room all of the time.'"

Mike Resetarits Technical Director

Unit operators are happy to use Exapilot and Exaquantum

Oil and Gas Downstream

Plant Information

- Location: Pembroke, Wales, UK
- Completion: 2010

Valero Energy Ltd.

Exapilot Contributes to Operational Consistency and Procedure Management in Large Refinery Plant

Executive Summary

Valero Energy Ltd's Pembroke Refinery is situated on the Pembrokeshire coast in Wales, UK. The oil refinery first came on stream in 1964, with the fluid catalytic cracking unit coming on stream in 1982. The refinery also has an HF Alkylation unit, catalytic reforming unit and three hydrotreating units. Pembroke refinery has the capability of refining acid crude oils such as Captain and Doba crudes. The refining capacity is 10.5 million tonnes per year and the product output is gasoline, diesel, kerosene & jet fuel, fuel oil and LPG petrochemical feedstocks.

The crude oil terminal is capable of handling tankers of 275,000 tonnes deadweight. Products are distributed mainly by sea (90%), road and pipeline which connects to the Midlands and Manchester. As the oil industry changes in the current economic climate with the need to make downstream more competitive, it becomes increasingly important to consider higher productivity and higher product quality. Of course safe operation is always the number one priority. Valero's Pembroke refinery carefully studied the functionality of Exapilot and implemented an application on the Butane Driers.

The Challenges and the Solutions

Stable regeneration of butane driers

There are two sets of driers, the first one for water content removal and the second for hydrogen removal. The driers are regenerated through an operator-activated regeneration sequence. More than 50 valves are located around the driers and an operator has to carefully follow a sequence to regenerate them. A lot of complicated procedures are needed based on the operational conditions. Regeneration of these driers is a very important process to purify the butane gas product.

The Exapilot program automatically controls the valve alignment throughout the entire regeneration cycle and places the driers in the correct positions after regeneration. The procedure includes a critical sequence of opening and closing valves. Failure to correctly isolate a regenerating drier may result in leaks or explosions caused by hydrogen pressure build-up.

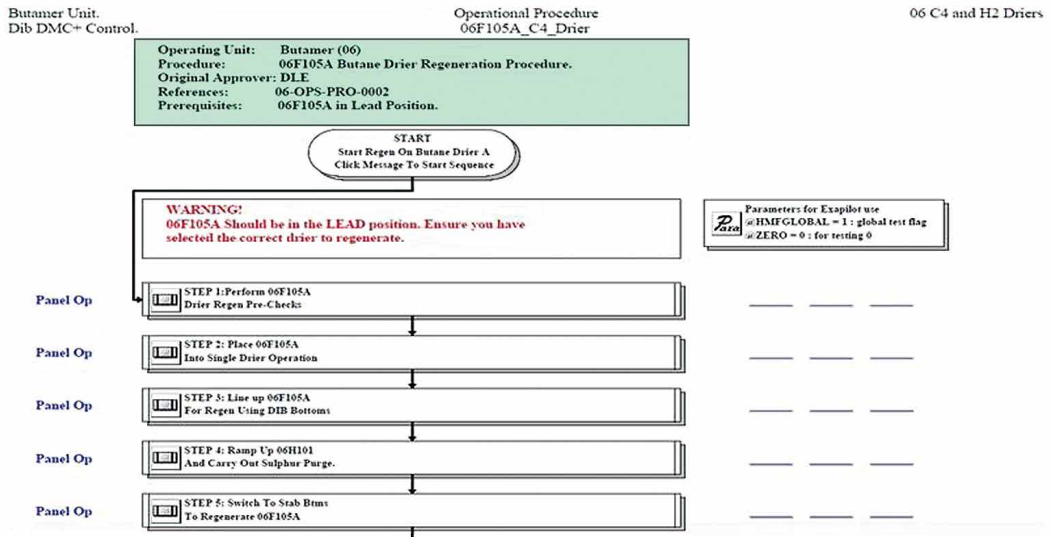
Exapilot aids procedure management at Valero's Pembroke refinery.

Effective start-up of Sulfur Recovery Plant

When the sulphur recovery plant is shut down by the emergency shutdown system (ESD), operators have to carefully start up the plant using a complex recovery procedure, which can be time consuming. Exapilot will help Valero successfully execute any start ups of the sulphur recovery plant in the event of an emergency shutdown.

The following benefits are brought to the operation.

- Maintains consistency of operation
- Maintains a safe operation
- Reduces steam consumption



Procedures in Exapilot

Exapilot

One of the major concerns in the plant operations is how to reduce its operation costs so that the profit is optimized. The industrial plant operations are fully automated with process control systems (PCS); however, startup, shutdown, load/grade changes, and other non-routine works are largely done by manual operations. The operation efficiencies can further be improved by automating these non-routine operations
as much as possible.

Exapilot operation efficiency improvement package is a tool to help operators create semi-automatic sequences to replace non-routine and manual operations in the plant.

Pembroke Refinery

Oil and Gas Downstream

Plant Information

- Location: Manama, Bahrain
- Order date: March 2011
- Completion: September 2011

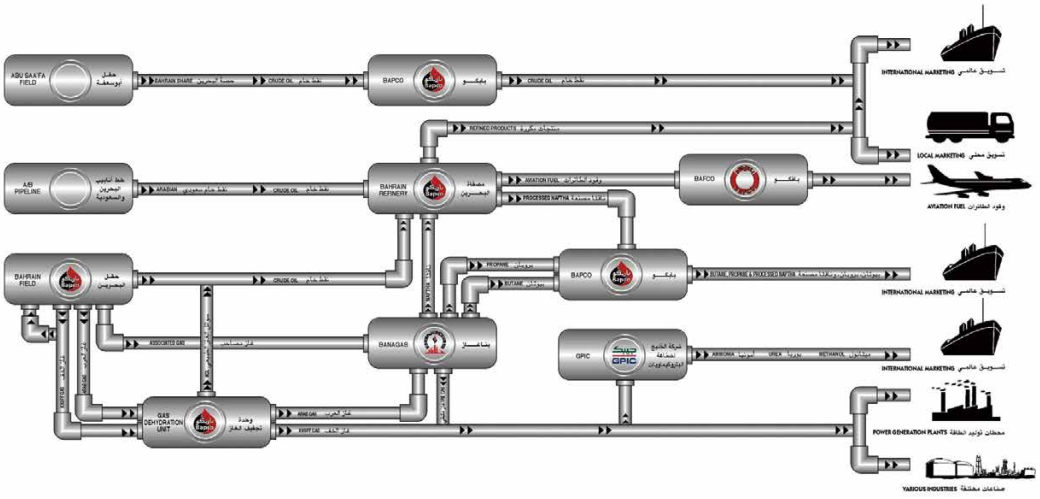
The Bahrain Petroleum Company

Successful Migration of In-line Blending Distributed Control and Oil Movement Systems

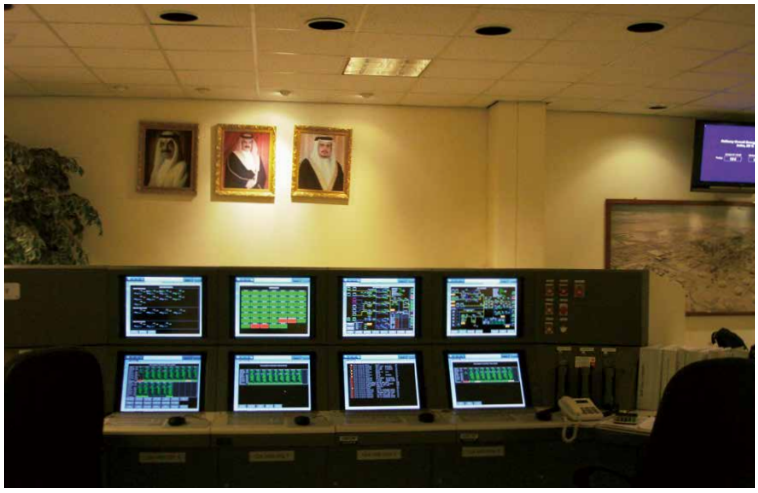
Executive Summary

Bahrain Petroleum Company (BAPCO), wholly owned by the Government of Bahrain, is engaged in oil exploration, drilling, production, and refining, and in the distribution, sale, and export of crude oil, refined products, and natural gas. The company owns a 250,000 barrel-a-day refinery, storage facilities for more than 14 million barrels, a marketing terminal, and a marine terminal for its petroleum products. BAPCO's prime customers for crude oil and refined products are based in the Middle East, India, the Far East, Southeast Asia, and Africa, and 95 percent of its refined products are exported.

BAPCO was using Yokogawa's Unix-based CENTUM CS process control system to control operations at its refinery tank farm. Due to the obsolescence of this Unix-based system, BAPCO decided to replace it with Yokogawa's latest CENTUM VP distributed control system (DCS). In addition to the upgrade of this key tank farm system, BAPCO also replaced its oil movement system (OMS) with a Yokogawa's OMS based on Windows Server - Enterprise Edition.



BAPCO's total operation



Central control room (CENTUM VP, 2011)

The Challenges and the Solutions

Proper planning and good teamwork achieves successful upgrade

Proper planning and good teamwork during the design phase along with a thorough factory acceptance test (FAT) ensured that the cutover to the new system could be carried out without having to shut down the fuel oil blender, which normally runs 24x7. It is worth mentioning that the project team was able to start up the new system six hours ahead of schedule due to excellent coordination between the various departments that were involved in this process.

The oil movement system package installed in the refinery tank farm control building is very specialized software that monitors and controls the blending of gasoline, diesel, and fuel oil, including complicated tank to tank, tank to unit, and unit to tank transfers. As called for in the refinery operations planning (ROP) specifications, the monitoring and control of oil movement between the refinery and the company's facilities on Sitra island and the blending of fuel oil, diesel, and gasoline is automated through the use of property and ratio control to minimize operator intervention and keep the product properties on specification. The success of this project was made possible by excellent and commendable teamwork between BAPCO's OS&E, Plant Engineering, ROP, Plant Maintenance, and PC&I departments.

Project scope

The project scope involved the installation of new CENTUM VP consoles in the control room and the replacement of redundant central processing units (CPU) and installation of new oil movement servers in the refinery tank farm control building and ROP office. Taking advantage of the advanced features of the CENTUM VP DCS, the process graphics and system parameters were also enhanced to provide the operators with up-to-date information for the smooth running of BAPCO's day-to-day operations.

Customer Satisfaction

The members of the BAPCO project team were very happy with the outcome of this project, commenting that they took pride in having been able to complete it on schedule and on budget. They believe that the upgrade of these systems gives them the following advantages:

- System maintenance will be easier to carry out.
- It will be possible to conduct test environment and modification preparations more quickly.
- Future modifications will cost less to implement.
- The long-term market availability of system hardware is assured.

From the left, Pradeep Gururaj-YME, M.Ouchi-YHQ, Mitsuya Hara-YHQ, Shuaib-BAPCO, N.Venkatesh- YME, Teruhiko Azami- YME

Oil and Gas Downstream

Plant Information

- Location: Százhalombatta, Hungary
- Order date: 2008
- Completion: 2009

MOL

Computerized Maintenance Management System by PRM and SAP Schedules Field Instrumentation Maintenance

Executive Summary

MOL-Group's Downstream Division operates 6 production units with a total capacity of 20.9 mtpa renfing and 2.1 mtpa petrochemicals with more than 1700 service stations under 8 brands in 11 Central European countries, all supported by a far-reaching logistics system and driven by Supply Chain Management. MOL's strategic aim is to further developing all its refineries, increasing the ratio of top quality motor fuel products and exploiting all the opportunities for organic growth on the basis of its excellent downstream knowledge. The company top priorities also include compliance with the latest environmental regulations and major projects aim at improving environmental cleanliness and product quality. MOL Group is the only refiner of petroleum products in Hungary, Slovakia and Croatia. All businesses are supported by cutting edge supply-chain optimization.
The Danube Refinery has been the only Hungarian MOL refinery to conduct crude distillation since 2001. The Refinery is located in Százhalombatta, close to Budapest. Its crude distillation capacity is 8.1 mtpa and complexity ratio is 10.6 (NCI). The Danube refinery is a complex refinery with deep conversion units, allowing the high yield of motor fuels and other valuable products from heavy and sour crudes.

This Danube Refinery set-out to improve their operation and decided to overhaul its maintenance systems with a new, united asset management system strategy. The on-line systems use FDT technology embedded in their device configuration and maintenance systems. PRM from Yokogawa enabling fast, simple and safe device configuration and diagnostics as an important part of their on-line maintenance system strategy.

By using PRM, it supports the field instrumentation maintenance activity providing information used to; identify the location of an asset problem, for device repair, and remotely accessing device information and changing the device configuration. Using the wealth of the available information, its goal was to improve maintenance processes, and human competencies and skills.

The Challenges and the Solutions

In Hungary the MOL production sites currently have about 30,000 smart devices the majority installed at the Danube location. Devices at the Danube refinery are connected to an on-line system using both HART and FOUNDATION™ Fieldbus field digital communication technology- many of these having DTMs (see Pic 1.) that provide simple and fast information access which is traceable-documenting device status and changes. In the 15 key production units, there are 3,855 instruments connected to the computerized maintenance management system (CMMS). The maintenance staff, including engineers and technicians benefit from having quick access to information that provides early warning of potential problems.

Using a combination of the device DTM (similar to a device driver that is included with a new printer) and the PRM device management tool (examples of a frame application), it is able to: diagnose problems with smart devices, perform loop checks, modify the configuration and get a visual overview (range, alarms, etc.) of the device. This information is available from a safe and secure location which reduces the number of trips into the production area and provides faster response to potential problems.

The frame applications and DTMs support the preventive maintenance strategy with self-diagnostic and condition monitoring. Examples: by reading the cell temperature of a pressure

Picture 1. Screen view of Yokogawa EJA DTM

transmitter, they check the impulse-line heaters. This is critical in order to avoid slow-downs or a shut-down of production. Also, reading the set-point and the current travel of control valves by accessing information in the valve positioners, they are able to know the status of the valve's condition.
Reading other parameters such as drive-signal (or drive current), supply pressure and cycle-count, they are able to have information that helps troubleshoot and prevent problems. This information is unique and essential to make on-time decisions in order to avoid slow-downs or shut-downs (see Pic 2).

"We gather information before a turnaround using device diagnostics, which in the case of control valves, saves us $20,000-$70,000 per turnaround-making us more predictive and proactive and less reactive. Using diagnostic tools we select the bad actors and remove just the poor performers " says Bereznai. "The DTM provides fast detailed device checks with a visualized faceplate and simple to understand device overview."
As shown in the chart Pic 3., there is a significant reduction in the number of control valves that have to be removed, repaired and replaced during a unit turnaround. Before and during each scheduled turnaround, each valve's diagnostic are checked to determine which control valve's actually need to be repaired during the turnaround; saving both time and money.

In the following example tells you where the usage of Field Instrumentation Maintenance System (FIMS) had became the part of the daily routine. In MOL Delayed Cooker Unit FIMS was connected to the SAP-PM here the corrective manually entered work orders were replaced by FIMS generated work notifications. These notifications are preventive actions comparing the unit operators entered mostly reactive type work notifications. Since 2010 the number of manually entered work orders are stagnating that gives us a positive feedbacks about the effective usage of the on-line control valve diagnostic system in this unit.

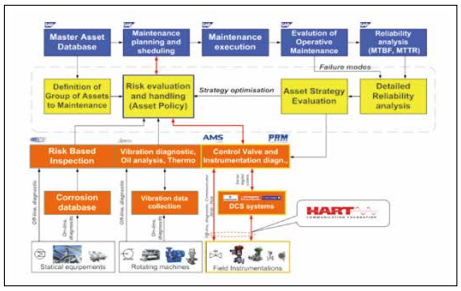
In today's economic situation of reduced maintenance budgets and manpower, it is reasonable to look for non-traditional ways to remain competitive. A change in maintenance strategy from reactive to predictive is not easy. A change to improved or proactive asset management is not easy. Using the intelligence in the installed measurement assets could provide big returns on the investment. The old saying, it takes a village to raise a child, also applies to automation- it takes the entire plant operation to improve plant reliability and performance. Integrating intelligent device information, providing the tools to access the information and training the human resources- maintenance technicians, engineers, unit operators and management- to more fully understand and use this valuable information is part of their future plans. The image above demonstrates the significant benefit in the reduction of control valve maintenance costs without and with the use of intelligent device diagnostics.

FDT technology provides the core element of effective asset management system. By being supplier, protocol and system independent, it provides a window into the intelligent measurement devices that have a direct influence on the profitability and availability of the operation. As in the case of MOL, plant performance can be significantly improved if users are willing to access and use the intelligent device information for more than just configuration.

Customer Satisfaction

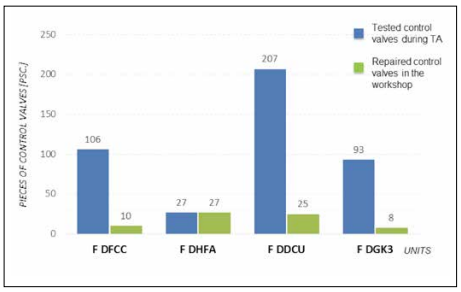
According to Gábor Bereznai, MOL instrumentation and electrical department head, " I would like to emphasize that the FDT technology is one portion of the total solution which includes several systems developments. I think many companies, including the big ones, often underestimate the need to improve both the process and the human side of the activity. That's why many times they are not able to fully utilize the benefits of available and installed technology." Gábor comments on the importance of provided people with the information they can use to maximize their performance.

Gábor Berenznai
Head of Instrumentation and Electrical Engineering

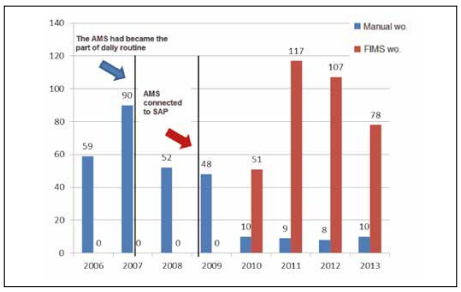


Picture 2. Maintenance structure from the equipment's level up to the CMMS

Picture 4. Unit operators in front of Yokogawa CS3000 HMI in CCR unit



Picture 3. Significant reduction in the number of control valves during the turnaround



Picture 5. Control valve related manual and automatic work orders in Delayed Cooker unit

Oil and Gas Downstream

Plant Information

- Location: Rayong, Thailand
- Order date: 2010
- Completion: 2011

PTT Aromatics and Refining Public Co., Ltd.

Achieving an Intelligent Oil Movement System

Executive Summary

PTT Aromatics and Refining Public Company Limited (PTTAR, Current PTT Global Chemical Public Company Limited) has a refinery (AR1) and two aromatics plants (AR2&3) at the Map Ta Phut Industrial Estate in Rayong, Thailand. These are very large-scale plants, capable of refining 280,000 barrels of oil per day and producing 2.26 million tones of aromatics per year.

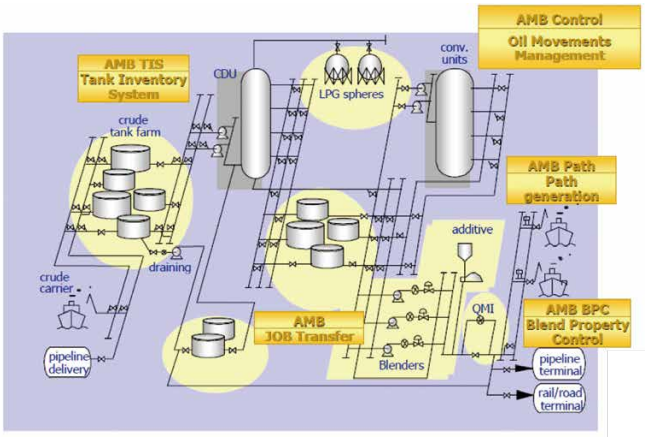
An oil movement system (OMS) manages all pipelines, crude oil storage tanks, and LPG storage spheres in the tank farm area and controls the movement of all intermediate components and finished products.
A storage and handling unit receives and handles products from the process units, imported crude oil, imported condensate for AR2&3, imported fuel oil, and export fuel oil, and also delivers products to the jetty, pipeline, road, and rail. Various grades of fuel oil are produced in the storage and handling unit by blending intermediate component products. The blending process has its own quality measurement instrument (QMI) validation system to control the quality of the product blends.
The AR1 refinery recently replaced its legacy DCS with Yokogawa's CENTUM CS 3000 and has been successfully using this to control the oil movement system as well all refinery plant facilities, with no major problems. AR1 is looking now to introduce Yokogawa's APC and Exapilot solutions to improve product quality and production efficiency.

The Challenges and the Solutions

Challenges

AR1 needed new technology for its refinery and decided to replace its legacy DCS with Yokogawa's CENTUM CS 3000. One key issue with this replacement was the need for there to be no change in the man-machine-interface's graphic displays. At the same time, the operators needed to stay on top of all movements of materials around the refinery. In addition, PTTAR1 needed to accomplish the following:

- Address quality complaints
- Reduce high demurrage costs
- Reduce quantity giveaway
- Reduce quality giveaway
- Eliminate human error
- Reduce inventory
- Improve maintenance
- Improve time management
- Improve safety



AMB=Advanced movement blending

Overview of PTTAR OMS

Results of OMS system

The use of Yokogawa's OMS (Oil Movement System) brought the following benefits to AR1:

- **Enhanced safety**

  OMS systems allow for a more intelligent alarming approach that goes beyond the simple detection of high and low levels. When meters are not available, flows can be estimated from inventory changes and used to ensure that maximum loading rates are not exceeded. Excessive tank drainage can be avoided, preventing product loss or contamination. Leak detection methods can be applied.

- **Reduced losses**

  - **Slopping**

    Slopping can often occur inadvertently, without any changes in metered flows. This can occur after start-ups or large upsets, when valves may be left cracked open by one shift and remain unnoticed.

    Monitoring for changes in slop production rate in the tank area can draw attention to the problem and provide diagnostic aids to identify the source.

  - **Jump over**

    One advantage of OMS automation is that it brings the discipline to properly document routings, usually in the form of operator graphics. Most systems also have the necessary logic to identify all feasible routings and detect conflicts.

  - **Routing errors**

    The issuance of an alarm when there is a change in the tank level will cause an operator to check whether the product movement was unplanned or whether there is some other cause, such as someone simply forgetting to enter the movement plan. By continuously reconciling source and destination inventories with tank to tank transfers, it is possible to detect whether product is wrongly leaving or entering the transfer. Reconciling change in inventory against integrated process flow meters will detect if product rundowns have been misrouted.

  - **Oil losses**

    A major potential source of oil loss is the overestimation of imports and underestimation of exports. Within OMS systems, many measurements can be cross-validated. Loading meters are automatically checked against tank levels. Statistical methods can be applied to check and calibrate meters.

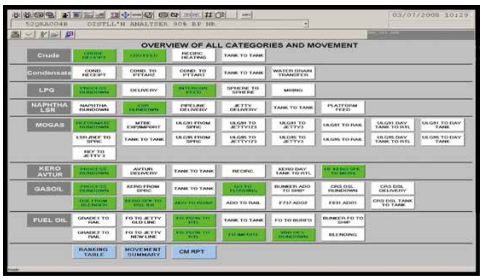
  - **Blending**

    Reduction of giveaway
    Minimization of re-blending
    Minimization of valuable component consumption
    Reduction in the use of intermediate tanks

New central control room (CCR)

- **Inventory utilization**

  Careful analysis has shown that when a tank farm is automated, it is possible to make optimal use of existing inventory and also to expand refinery operations without increasing the number of tanks.



Rundown and delivery operations
Operators can observe and monitor movements throughout the plant. Green indicates a safely running operation.

Safe operation

Customer Satisfaction

Chalongchai Banglap Refinery senior process engineer

Chalongchai Banglap, the Refinery Senior Process Control Engineer, said, "The system allows operators to clearly see the plant's status and know what is going on. With this OMS, our operators can take quick action whenever an action is needed. Our plant is now very safely operated without any losses of raw materials or products. We are very pleased with the performance of Yokogawa's CENTUM CS 3000 and the related package software. Yokogawa is one of our best partners."

Mr. Banglap went on to say "We appreciate the concept and the following features and benefits of Yokogawa's OMS:

- The modular approach towards a total solution
- Improved safety
- Improved profitability
- Improved information management
- The user friendly interface
- The open, state-of-the-art system architecture."

Oil and Gas Downstream

Plant Information

- Location: Uttar Pradesh, India
- Order date: March 12, 2013
- Completion: July 11, 2013

Indian Oil Company Limited

Yokogawa Meets Tight 20 Day Shutdown Schedule for Replacing Legacy DCS with Integrated Solution at Mathura Refinery in India

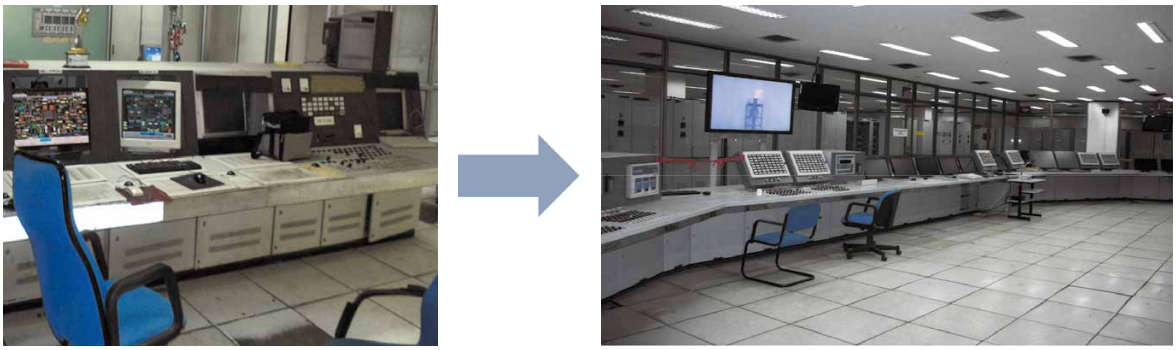
Executive Summary

The Mathura refinery is a strategically important facility that supplies diesel, gasoline, aviation turbine fuel, kerosene, liquefied petroleum gas, furnace oil, and bitumen to customers throughout northwestern India. The sixth refinery to be built by the Indian Oil Company Limited (IOCL), it had an initially capacity of 6.0 MMTPA at the time of its commissioning in 1982. Originally configured with facilities that included crude oil distillation (CDU), vacuum distillation (VDU), vis-breaker (VBU), and Merox process units, this refinery was revamped beginning in 1999 with the installation of a diesel hydro desulphurization unit (DHDS) licensed from the French firm Axens, for the production of high speed diesel (HSD) fuel with a low sulphur content of 0.25% (maximum).

A once-through hydrocracker (OHCU) and a hydrogen generation unit (HGU) were added on in 2000, increasing the plant's capacity to 8.0 MMTPA. As part of this plant revamp, a new distributed control system (DCS) and safety instrumented system (SIS) were installed to control both the originally configured and newly introduced units at this refinery.

In 2013, Yokogawa India was commissioned to carry out a revamping of the control and safety systems at the Mathura refinery.

This project involved the design, engineering, installation, and commissioning of a CENTUM VP distributed control system (DCS) and a ProSafe-RS safety instrumented system (SIS) to replace the refinery's legacy systems. The project scope included the removal of the legacy DCS and the design, engineering, installation, and commissioning of an integrated CENTUM VP DCS and ProSafe-RS SIS solution. All this work was done on a tight schedule, while the refinery was shut down for routine maintenance.



Before and after revamp photos of the central control room (CCR). The CCR layout was jointly designed by IOCL and Yokogawa India. The number of consoles was increased to improve efficiency.

The Challenges and the Solutions

A tight schedule for a demanding project

- The removal of the existing systems, including 180 cabinets and 28,300 terminations, modifications to accommodate the new CENTUM VP system, installation of new marshalling and system cabinets (201 cabinets), termination of signals (approximately 30,000), powering, loop checking, loop commissioning and system commissioning needed to be completed within a refinery shutdown period of just 20 days.
- For 400 signals, loop checking extended beyond the field junction boxes as the corresponding transmitters were to be replaced by Yokogawa HART transmitters.
- The "as built" I/O database was not available due to modifications that had been carried out over the past 10-15 years.
- No loop / logic write-up was available for the existing system.
- The DHDS AspenTech APC and connectivity to the plant LAN through a Honeywell PHD process information management system needed to be restored on the new system.
- The, suppliers had to be very tightly monitored as they had just eight weeks to deliver 200 cabinets (Rittal), 8,000 safety barriers (P&F), and workstations and servers (Dell).

Good teamwork

With the aim of having minimal re-engineering of control loops and ensuring the commissioning of the units on the first attempt, Yokogawa and IOCL's engineers worked closely together to expedite the following tasks:

- A task force was formed to directly retrieve data from field devices and the existing systems.
- Based upon the physically verified termination schedule, a new I/O database was created and compared with the existing system's database. To ensure the complete correctness of the new database, which had been designed based on existing documents, internal loop checking was conducted on the existing DCS after the plant was shut down. Any necessary modifications were then made to ensure the 100% mapping of field data needed for a smooth start up of the plant. This remained the key for making the system ready exactly as built at site, enabling a smooth re-commissioning of the plant.
- The IOCL engineering team physically validated all engineering inputs, which also served to double check the engineering database.
- Based on photos of the existing graphics, new graphics were created. Each and every type of graphic modifier (color change / blinking) in the existing DCS was checked and recorded and then configured in the Yokogawa DCS so as to retain operational integrity after the revamp.
- With IOCL's support, all 3rd party interfaces were engineered, validated, and commissioned on site.
- Staging and FAT for all six units was done in parallel at Yokogawa India, in close cooperation with IOCL.
- IOCL assisted by making building modifications to accommodate the removal of old cabinets and the installation of new cabinets.
- Given the tight schedule for the on-site work, a detailed hourly work plan was prepared for the period commencing with the receipt of the systems at the site. Necessary items were stored based on the order in which they would be used during the refinery shutdown period and consequent evacuation of space to make room for replaced system at stores to field loop checking up to field instrument.
- Commissioning of the hydrogen unit and parallel commissioning of all remaining units along with communications between the units were priority items during the shutdown.

All installation work was completed, units were powered on, loops were checked, commissioning was completed, and stable operation was achieved in a span of just 19 days – one day ahead of schedule.

Customer Satisfaction

The following key parameters were provided by IOCL as benchmarks for this project and each was met by Yokogawa India:

- Provide a best-in-class DCS/SIS solution on a robust, fast DCS network
- Integrate the DCS/ESD system network
- Ensure a robust HMI to be used as a direct node on the DCS network
- Provide a redundant ProSafe-RS SIS architecture for both ESD, from I/O level to CPU
- Include sequence of events (SOE) functionality with 1 msec event resolution for trip analysis and troubleshooting in the SIS — implemented as a built-in feature of ProSafe-RS
- Ensure stable control functions – implemented rigorously through offline checks during pre-commissioning
- Strictly adhere to supply and shutdown schedule

New system

System tags:	23,800
Field control stations (DCS controllers):	28
Safety control stations (ProSafe-RS):	11
Human machine interface stations:	23
DCS engineering stations:	4
SIS engineering stations:	4
Other stations:*	14

* Historical data stations, OPC interface stations for 3rd party systems, alarm information and management stations, documentation node (DON) stations, sequence of events (SOE) stations

Oil and Gas Downstream

Plant Information

- Location: Qinzhou city, Guangxi province, China
- Order date: September 2007
- Completion: September 2010

Petrochina Guangxi Petrochemical Company

Yokogawa Provides CENTUM, OMS, OTS, PRM Solutions for CNPC Guangxi Petrochemical Company's 10MT/Y Refinery

Executive Summary

CNPC Guangxi Petrochemical Company has completed construction of a combined refinery and petrochemical production complex in Qinzhou, a port city in China's Guangxi Autonomous Region. With a 10 million ton per year capacity, the refinery is one of China's largest, and is truly world class, using a highly advanced hydrogenation process, with the main process technologies coming from the USA and France. The refinery has over 10 main process units, including a 10 million ton/year atmospheric and vacuum distillation unit, a 3.5 million ton/year heavy oil catalytic cracking unit, a 2.2 million ton/year continuous catalytic reforming unit, and a 2.2 million ton/year wax oil hydrocracking unit, as well as auxiliary utilities, a tank farm, jetties, a truck terminal, and railway facilities. This refinery processes crude oil brought in from Sudan and the Middle East, and currently is capable of supplying 8.3 million tons of oil products to China's southwest region each year. The company's long-term goal is to increase annual production to 20 million tons. Owing to its modern central control technology and highly competent workforce, the entire complex can be operated with just over 900 personnel.

To manage construction of this plant, the CNPC Guangxi Petrochemical Company established an integrated project management team with European and Chinese contracting & engineering companies. A total of 10 engineering companies participated in the design work.

In September 2010, all of the devices throughout this refinery were started up successfully and all of the products produced complied with design standards. This plant was started up successfully on the first try, and it had the shortest startup time among all of CNPC's refinery projects.

CNPC aims to optimize the management of its operations at this refinery so as to maximize efficiency and ensure all devices run safely and in an environmentally friendly manner, with long-term stability. Toward this end, Yokogawa provided CNPC its CENTUM CS 3000 integrated production control system (PCS) for controlling all plant processes, the PRM device management system, the ExaOPC server package, an oil movement system (OMS), and an operator training system (OTS), and the company's engineers and project managers worked closely with CNPC Guangxi Petrochemical Company and associated design institutes and suppliers to ensure a smooth and on-time startup.

Tank farm at the Qinzhou refinery and petrochemical complex

The Challenges and the Solutions

The presence of inflammable and explosive gases and materials in continuous processes at such large refineries always presents a certain level of risk. To safely manage such processes, an advanced and highly reliable PCS is essential. The implementation of this system for this plant's proprietary technologies required a depth of engineering experience and a knowledge of the equipment used in such processes as steam production, hydrogen production (pressure swing adsorption), nitrogen generation (air separation), and wastewater treatment.

All of the plant's process equipment, utilities, and storage and transportation facilities (except oil loading and unloading facilities) are monitored and controlled from its central control room (CCR). A field cabinet room (FCR) was also set up to house the plant's I/O cards and controllers. Communications between the human interface stations (HIS) in the CCR and the controllers in the field cabinet room pass over high speed fiber optic cables. There is also a field control center near the refinery's wharf that houses cabinet and operation rooms with HISs. Data from each of these locations is transmitted wirelessly to a real-time database.

The CCR at the Guangxi refinery and petrochemical complex

Uploading of production process data in real time

Staying on top of what is happening throughout this massive refinery complex and having all the information at hand that is needed to respond quickly and appropriately is absolutely essential. This is made possible by Yokogawa's ExaOPC server, which seamlessly uploads all process data from the CENTUM CS 3000 PCS to the refinery's real-time database. A manufacturing execution system gives the refinery's managers complete access to all this data, allowing them to monitor all processes from the receipt of raw materials to the storage of refined products and make the right decisions at the right time needed to optimize the refinery's operations.

Eliminating risks posed by inexperienced personnel and ensuring a successful startup

Many of the operators at this plant are new hires and fresh out of university, without much plant operating experience. Even those who have some experience need to familiarize themselves with new devices and new technologies and processes, and tend not to have experience working at such a large-capacity facility. Therefore, it is very important for them to receive training in this refinery's processes using an OTS. In addition to being used in training, such a system can be used to test PCS logic and control loops to identify problems and eliminate potential risks. The OTS solution provided by Yokogawa has an interface that has been designed based on the object linking and embedding (OLE) for process control specification, or OPC, allowing a seamless connection between the OTS, the PCS, and third-party software such as an APC package. The interface is identical to that used on the PCS, and the database interface is identical to that for the plant's real-time database. The PCS configuration files can be directly downloaded to the OTS and configuration files that have been generated or modified by the OTS can also be directly uploaded to the PCS. A virtual control station running on the OTS can simulate up to four field control stations (FCS). The OTS can also be used to maintain, configure, and update the PCS interface and configuration logic. With the OTS, operators receive training that accurately and reliably simulates the experience of operating a real plant PCS.

Protection of DCS from lightning-induced power surges

The Qinzhou refinery is located in southwest China, which has a subtropical oceanic monsoon climate, and intense thunderstorms are a frequent occurrence during the summer. To protect the analog I/O modules in the CS 3000 FCS cabinets and ensure stable, uninterrupted operation, the modules are all equipped with surge arrestors.

Automation of blending, pipeline transmission, and shipping

This petrochemical complex has 50 crude tanks, nearly 90 product tanks, and a total of 7 berths for ships ranging in size from 3000 deadweight tons (DWT) to 100,000 DWT. To control the receiving of crude oil, product blending, and product shipping, Yokogawa provided an OMS solution. This greatly improves the safety and efficiency of off-site operations for gasoline on-line pipeline blending and diesel oil on-line pipeline blending, and ensures high product quality. In the pipeline, all blending components including additives are blended automatically and in the desired proportions, at the same time. To facilitate the transmission of quality blended products via pipelines for storage in tanks or direct loading for shipment, advanced automatic control equipment such as computers and online quality monitoring instruments must be used in the blending process.

Pipeline blending has numerous advantages. For example, this reduces the need for component storage tanks, saves time by eliminating the need for intermediate analysis, saves time and energy by eliminating the need for pump operation and mixing, allows for airtight operation that reduces oil oxidation and evaporation, eases the changing of blending schemes, and ensures that personnel do not have to come into direct contact with toxic additives.

The use of the Yokogawa OMS minimizes the amount of time that is required to unload and load a vessel, which has the added benefit of reducing the berthing fee that a ship operator must pay for the time that a ship is in port. Accurate blending and efficient loading and unloading operations are thus very much appreciated by the CNPC Guangxi Petrochemical Company.

Extended lifespan and reduced maintenance costs

This combined refinery and petrochemical plant complex has a total of 24,000 HART field devices from Yokogawa and other suppliers. Inspecting and maintaining all these devices using conventional means takes a lot of time. To improve efficiency and cut costs, this complex employs Yokogawa's PRM solution to remotely configure, monitor, diagnose, and calibrate these devices, and with FDT/DTM technology. PRM also enables automatic record management for all these devices. With PRM, operators can quickly identify whether any of the field instruments in this complex have maintenance issues that need to be addressed. This enables a proactive maintenance approach that eliminates unplanned shutdowns, extends equipment life, and reduces maintenance costs.

Customer Satisfaction

A CNPC Guangxi Petrochemical Company manager who is responsible for instrumentation, said, "Yokogawa provided not only the PCS, but also the OTS and OMS for the refinery. Yokogawa's engineering department was responsible for engineering, and their work was all well done. We selected Yokogawa to supply the control system because we consider them to be a first-class company in the PCS industry, with powerful engineering capabilities. During project execution and startup, and in a subsequent expansion project, Yokogawa's project team members worked together very well with our people. Since it was put into operation, the large oil refinery has been running very smoothly, without any problems. Compared to other equivalent facilities in China, our refinery has fewer plant operators and a much smaller workforce overall. We fully utilize the all functions of the CENTUM system and have used it to automate process operations as much as possible. This has all been made possible by the long-term stability and high reliability of Yokogawa's systems and the close cooperation with Yokogawa's engineering and technical personnel. We really appreciate the team approach taken by the members of the Yokogawa project team."

Oil and Gas Downstream

Plant Information

- Location: Punjab, India
- Order date: June 2009
- Completion: March 2012

HPCL-Mittal Energy Limited

High Uptime and Maintainability Secured by Full-fledged Automation Platform at Indian Refinery

Executive Summary

HPCL-Mittal Energy Limited (HMEL) is a joint venture between Hindustan Petroleum Corporation Limited and Mittal Energy Investment Pte Ltd, a Lakshmi N Mittal company that is based in Singapore. HMEL has built and currently operates the Guru Gobind Singh refinery, which is located near Bathinda in India's Punjab region. This new refinery has a production capacity of 9 million tons per annum (the equivalent of 180,000 bpd) and complies with the Euro IV emission norms. This is a zero bottom plant, with a very high Nelson Complexity Index. The refinery facilities include a polypropylene unit (PPU) that utilizes the Novolen® gas-phase polypropylene (PP) process and is capable of producing 440,000 tons per year of homo-polymer PP.
HMEL produces an entire range of PP homo-polymers. The refinery's state-of-the art delayed coker unit (DCU) produces a high sulfur petroleum coke (pet coke) derivative. The sulfur recovery unit produces very high quality sulfur in powder and lump form. The other notable deliverable is a high yield of environmentally friendly liquid petroleum gas (LPG) for household and commercial customers in the northern region of the country.

For the monitoring and control of the entire Guru Gobind Singh refinery, HMEL selected an integrated solution from Yokogawa consisting of the CENTUM VP state-of-the-art distributed control system, the ProSafe-RS safety instrumented system, the Plant Resource Manager (PRM) asset management system, the Exasmoc, Exarqe, and fitOMS advanced process control (APC) packages, FOUNDATION™ Fieldbus instruments, and an operator training simulator (OTS). Yokogawa India oversaw and implemented their engineering, installation, and commissioning, and the refinery has performed flawlessly since coming online in early 2012.

The Challenges and the Solutions

Maintenance

This full scale refinery has a total of nearly 12,000 field instruments. To ensure the efficient utilization and maintenance of these assets, HMEL decided to use the FOUNDATION™ field bus technology in tandem with the PRM asset management package. With this solution, personnel in the central control room can monitor the performance of these field assets and diagnose their condition. PRM also has a control valve signature analysis function. With these capabilities, the HMEL maintenance team is able to adopt a proactive maintenance approach whereby problems are spotted before a field device or control valve fails and maintenance can be scheduled to be performed at an opportune time. In addition to improving plant uptime, this eliminates the need for many manual checks of devices in the field, reducing field operator workload.

Safety

Safety is always a paramount concern at an oil refinery. ProSafe-RS is SIL-3 certified by TUV for the management of the emergency shutdown (ESD) system and the fire & gas system (FGS), and is fully integrated with the DCS. In addition to the many benefits of an integrated human machine interface (HMI) for DCS and ESD, the integration of DCS and ESD also allows the seamless exchange of signals between the DCS interlocks and the ESD logic, especially in the PP units.

Efficiency and product quality

HMEL utilizes APC packages together with the DCS to improve efficiency and ensure the highest levels of product quality. The Exasmoc multivariable optimization controller and the Exarqe robust quality estimator are used to reduce the amount of steam consumed by the continuous distillation unit (CDU), DCU, and fluidized catalytic cracking unit (FCCU) and to help ensure the steady operation of the entire refinery.

The central control room

Blending is the last step in the process of producing finished products from crude oil. Quality control for the finished products is one of the most important steps in the refining process. At the HMEL refinery, Yokogawa's fitOMS (future integration technology for oil movement system) APC solution works in conjunction with near infrared analyzers (NIR) to optimize mid sulfur (MS) oil blending and high speed diesel (HSD) blending. This ensures that the finished products are kept within the targeted blend ranges and that this is done in the most cost-effective way.

The package includes an OTS for a total of 10 process units. Built by Omega Simulation Co., Ltd., this is a DCS direct connect type OTS used in operator training that also can function as a DCS-programmable logic controller (PLC) to check out control strategies. The early delivery of the OTS ensured that the operators could familiarize themselves with the systems before the plant commissioning. The specific process units covered by the OTS are:

- CDU, vacuum distillation unit (VDU)
- Naphtha hydrotreater (NHT)
- Isomerization (ISOM) unit
- Catalytic reformer
- Diesel hydrotreater (DHDT)
- Vacuum gas oil – hydrotreater) (VGO-HDT)
- Fluidized catalytic cracking – propylene recovery unit (FCC-PRU)
- Polypropylene
- Hydrogen generation unit (HGU)
- DCU & sulfur recovery unit (SRU)

Customer Satisfaction

P.S. Prasad, General Manager, Maintenance – Control & Instrumentation at HMEL, commented, "The CENTUM VP system supplied by Yokogawa forms a complete integrated network connecting all the process units and the central control room. Since its commissioning in 2012, the system has been very robust and has withstood all plant disturbances. PRM has proven to be an extremely effective maintenance tool as the majority of the closed loops are based on FOUNDATION™ Fieldbus. The ESD and FGS systems designed to work with ProSafe-RS have performed as specified. Yokogawa has been very forthcoming with its support and maintenance of the integrated automation system, ensuring high uptime."

P.S. Prasad, General Manager, Maintenance – Control & Instrumentation

Client satisfaction parameters:

- Robust best-in-class DCS/PLC solution
- Robust, fast Vnet/IP network
- Control of field instruments on FOUNDATION™ Fieldbus closed loops
- Integrated DCS/ESD PLC network
- Robust HMI used as direct node on DCS network
- Remote PLC I/O for hardwired console in CCR
- Able to perform PRM control valve signature analysis and partial stroke testing of shutdown valves from CCR
- Redundant ProSafe-RS architecture for both ESD and FGS, from I/O level to CPU
- ProSafe-RS sequence of events (SOE) functionality with 1-msec event resolution for trip analysis and troubleshooting

Project details:

Total system tags:	41,000
Total DCS closed loops (conventional) :	2,350
Total devices on FOUNDATION™ Fieldbus:	2,000
Total FOUNDATION™ Fieldbus segments:	2,240
Maximum number of devices per segment:	9
Total FOUNDATION™ Fieldbus closed loops:	1,210
Total HMIs:	82
Total ESD and FGS PLC I/Os (ProSafe-RS):	6,240
Video wall size in main control room:	48,854 mm (W) x 2,200 mm (H)(80 x 60" displays)

Oil and Gas Downstream

Plant Information

- Location: Chiba Prefecture, Japan
- Order date: October 2010

Idemitsu Kosan

Yokogawa's Exapilot Introduced to Maximize Operational Efficiency at an Experimental Refining Facility

Executive Summary

Idemitsu Kosan Co., Ltd. is a leading producer and distributor of oil, lubricants, and petrochemical products, and is also engaged in the research and development of functional and electronic materials as well as agricultural biochemicals. At the company's Technology & Engineering Center, technical experts are carrying out research in the refining and petrochemical fields, focusing on topics related to development, design, construction, operation, quality control, maintenance, and systems.

They provide technical support that ensures safe and stable operation and enhances the competitiveness of processes. They also assist in the development of new processes for manufacturing functional chemicals and in licensing for the export of process and catalyst technologies.

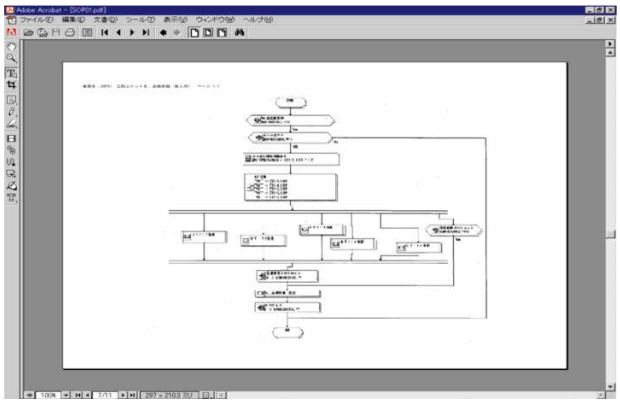
At this center's bench plant, Idemitsu is using Yokogawa's Exapilot operation efficiency improvement package in experiments involving catalysts that are used in refinery hydrogenation and catalytic decomposition units and which play an important role in determining the quality of the refined product. To optimize the catalytic reaction, catalysts are evaluated in the bench plant under various temperatures and pressure levels.

Idemitsu has been using the Yokogawa CENTUM distributed control system at this bench plant, and was also already familiar with the benefits of Exapilot, having used this package elsewhere in its organization. To improve operations and achieve the same benefits at this very complex bench plant facility, they decided to introduce Exapilot here as well.

The Challenges and the Solutions

This bench plant carries out more than 100 experiments each year. The operational settings differ for each test, determining how the plant's individual reactor units must be started up and shut down. The equipment used throughout the plant also varies depending on when it was installed. To prevent operator errors, it was essential to standardize operating procedures. To accomplish this, Exapilot was first introduced for use with the bench plant's main systems, then its use was broadened to other of this plant's functions. Specific advantages of the Exapilot system are as follows:

Bench plant



A standard operating procedure flowchart created by Exapilot

Kunio Furuuchi and Kazushige Chiba of
the Idemitsu Technology & Engineering Center

Dissemination of operator know-how

The bench plant startup and shutdown procedures for these experiments are complex, and they must be carried out repeatedly, placing great demands on the operators. The Exapilot system draws on the expertise of experienced personnel to provide cues that navigate operators step by step through each procedure.

Standardization of operations

Thanks to the use of Exapilot to set temperature gradients and alarm thresholds, the operation of the units throughout this plant is smoother and more uniform, resulting in improved safety.

Maintenance efficiency

Flowcharts created with Exapilot facilitate a greater understanding of the operation procedures. Idemitsu anticipates that this will allow its more junior personnel to operate this plant more effectively.

Labor-saving

Each experiment requires different parameter settings. Before the introduction of Exapilot, operators needed to manually enter data based on the information specified in a hard copy experiment plan submitted by the department that was requesting the experiment. Now operators receive an Excel document that can be used to automatically enter the data to the DCS in a single operation, and the operators only need to confirm the parameter settings. Excel reports can also be sent back to the requesting department, speeding up the overall process and ensuring greater accuracy.

Future Plan

Based on the results achieved so far, Idemitsu expects that it will be able to achieve a 2,000 hour reduction in work hours by introducing Exapilot throughout this experimental facility. And to make more effective use of assets such as process gas chromatographs that are shared by more than one unit, the plan is to import the test schedule to Exapilot and automatically reflect this in the operating plan.

Customer Satisfaction

Our feedback from Idemitsu indicates that they have found Exapilot to be an effective tool in improving work efficiency. They appreciate the ability to create a flowchart that guides them in streamlining and optimizing an operation. They would like to see Exapilot enter wide use so that their operators can accumulate know-how and solve operational issues on their own. While still evaluating the use of Exapilot at their experimental facility, they do recognize that it has had the desired effect, and would like to extend the scope of its application and obtain further benefits.

OpreX™ Through the comprehensive OpreX portfolio of products, services, and solutions, Yokogawa enables operational excellence across the enterprise.

YOKOGAWA ELECTRIC CORPORATION
World Headquarters
9-32, Nakacho 2-chome, Musashino-shi, Tokyo 180-8750, Japan
https://www.yokogawa.com/

YOKOGAWA CORPORATION OF AMERICA
12530 West Airport Blvd, Sugar Land, Texas 77478, USA
https://www.yokogawa.com/us/

YOKOGAWA EUROPE B.V.
Euroweg 2, 3825 HD Amersfoort, The Netherlands
https://www.yokogawa.com/eu/

YOKOGAWA ENGINEERING ASIA PTE. LTD.
5 Bedok South Road, Singapore 469270, Singapore
https://www.yokogawa.com/sg/

YOKOGAWA CHINA CO., LTD.
Room 1801, Tower B, THE PLACE,
No.100 Zunyi Road, Changning District, Shanghai, China
https://www.yokogawa.com/cn/

YOKOGAWA MIDDLE EAST & AFRICA B.S.C. (c)
P.O. Box 10070, Manama
Building 577, Road 2516, Busaiteen 225, Muharraq, Bahrain
https://www.yokogawa.com/bh/

Represented by:

Trademarks
All brand or product names of Yokogawa Electric Corporation in this bulletin are trademarks or registered trademarks of Yokogawa Electric Corporation.
All other company brand or product names in this bulletin are trademarks or registered trademarks of their respective holders.

Subject to change without notice
All Rights Reserved. Copyright © 2016, Yokogawa Electric Corporation

[Ed:03/d] Printed in Japan, 203(KP)

YOKOGAWA