Smart O&M for infrastructures

Case studies in China and on the Belt & Road

siveco China

Sustainable infrastructures lie at the heart of the China Dream

Over the past decades, China has built up its infrastructures to an unprecedented scale and with unprecedented speed. Maintenance was never ignored, contrary to popular belief, in fact it was tackled through standardization and quality improvements, yet it was certainly not at the top of the agenda.

Recent years have seen growing awareness of the importance of good technical management practices, in relation to safety, environmental compliance and sustainability. Cost containment has also become a priority. The last "Maintenance in China" survey (scan the QR code below to download the report) put numbers on this evolution:

- 85% of respondents have a maintenance strategy
- 94% pay more attention to maintenance than before
- 95% see maintenance as "industrial risk management" (not just fixing what's broken)

As part of what is known today as the Belt and Road Initiative, this unique Chinese experience and capability is put to work to help industrialize other developing nations for mutual benefits. Most projects involve know-how, technologies and people from the country in which it is built, from China and from other parts of the world.

Siveco has been a fellow-traveler of Chinese utilities and infrastructures for over two decades. Some of our team members, me included, have been working with Chinese infrastructures since the mid-1990s. The company itself was founded in 2004 to provide "smart" or "4.0" technologies for O&M. We have taken part in numerous greenfield projects all over China to help develop systematic maintenance management from day one, using our expertise and technologies. We have deployed the same approach on existing infrastructures, often large multi-site companies operating both old (aging) and new equipment. We started working with Chinese EPCs on export markets long before the Belt & Road term was coined. Our asset management consulting team is active on projects as far as Africa. The innovative Maintenance 4.0 technologies we have developed in our Shanghai R&D center have won numerous awards and are widely used by customers.

This book is about customers. As we have always done, we believe that simply sharing our experience, sharing our customer stories, will continue to help raise awareness of how smart O&M positively contributes to society in the New Era.

Bruno Lhopiteau
Managing Director
Siveco China

Do not hesitate to add me on LinkedIn at
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Table of Content

The implementation of ISO 55000 and Maintenance 4.0 at Capital Water

The author Wang Guanghui is General Manager of the Operation Department at Capital Water Group.

Beijing Capital Co., Ltd. was established in 1999 and listed on the Shanghai Stock Exchange in April 2000 (SH60008). As a professional water service provider, the company has made significant achievements over the years:

- The world's 5th largest water operator
- The 1st state-owned listed enterprise in the environmental protection area
- The 1st listed company to invest in commercial water supply and the first state-owned company to introduce Public-Private Partnerships (PPP) in the water industry
- The most experienced water company in China with the highest water supply capacity
- The largest and most experienced enterprise in the field of rural sewage treatment
- Top 10 influential enterprises in China's water industry for 15 consecutive years
- The 5th most influential enterprise in China's solid waste industry for 2 years in a row

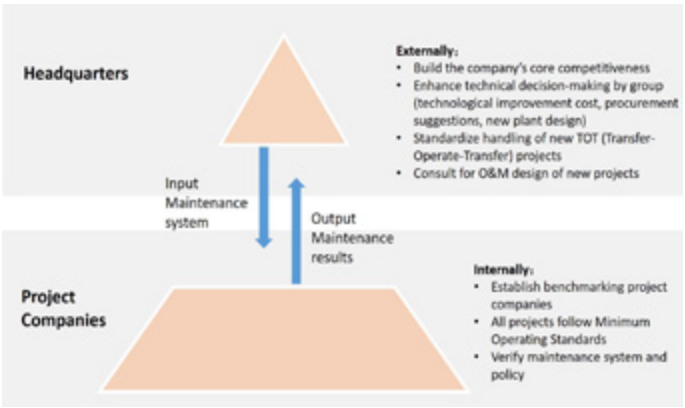
Introduction

In October 2016, after in-depth exchanges between the two companies, we found that Capital Water and Siveco China, the pioneer of "Maintenance 4.0", shared common goals and expectations in terms of maintenance improvement. Therefore, we launched our company's Asset Management system, based on the advanced management concepts provided by Siveco and the *ISO 55000* international standard, applied to the company's specific situation, in order to further enhance Capital Group's reliable service to municipalities across China.

Through this cooperation with Siveco, we aim to set a new benchmark for maintenance management in the Chinese water industry, ensuring public safety, sustainability and optimizing life-cycle cost by developing a systematic approach to asset management and enforce it across all our companies.

As a result of the project, a Group Core Model was created by the joint project team of Capital Water and Siveco China in compliance with *ISO 55000* and its Chinese equivalent *GB/T 33172*, while also taking into account our company's and our Chinese market characteristics.

The Group Core Model provides a strong framework for all stakeholders for at group level and site level. Furthermore, it contains practical guidelines for defining maintenance work processes, management and analysis reports, key performance metrics, etc.



One maintenance policy, nine objectives, five steps

A maintenance policy was defined, with nine objectives for its implementation, fully in line with our company's strategic objectives. To attain these objectives, a five-step plan was then established. This five-step plan can be summarized as follows:

> In order to successfully deploy and achieve the goal of asset management in practice, the 5 steps of asset management need to be driven in parallel.

Step 1: Know the assets, establish a reliable asset register (asset code, name, classification, document, structure and asset's critical rating); identifying each asset is the backbone for reliability improvement of Capital Water.

Step 2: Prepare and plan, define the asset maintenance plan and translate it into maintenance guidelines to implement the best practices and to achieve asset performance.

Step 3: Execute and report, ensure feedback using Work Orders for continuous improvement in asset management.

Step 4: Analyze and improve, rigorously review and analyze results to help the senior leadership of the company to formulate reasonable maintenance decisions to achieve the goals of asset management improvement.

Finally, in **step 5: Challenge and progress**, obtain sustainable improvement based on objectives; develop new benchmarks and strategies under the leadership of senior management..

Deploying the program into practice

In order to successfully deploy and achieve the goal of asset management in practice, the 5 steps of asset management need to be driven in parallel.

These drivers include roles and responsibilities of employees, communication and training, periodic meetings and audits, information system and documentation. The use of maintenance technology and maintenance management solutions in particular is critical to effectively support all the steps and to manage such large amounts of information, in fact "Big Data".

The first deployment took place at pilot company Yuyao Water in just three months and went live in December 2017, using Siveco's Maintenance 4.0 solutions (central database Coswin 8i and bluebee® mobile for operation and maintenance inspections).

Picture of the joint team at Yuyao Capital Water

bluebee®cloud

bluebee® mobile and tablet

Coswin

Find more about Siveco's software solutions at www.sivecochina.com/en/products

Municipal water company shares the results of its successful Maintenance 4.0 roll-out

On December 7th, 2017, Yuyao Water (Zhejiang province) shared the results of their Maintenance 4.0 project with representatives from group company Capital Water and some of its other subsidiaries.

Yuyao Capital Water was founded in 2004. The company's business includes the production and sales of tap water and other activities related to water treatment and water supply. Yuyao Capital Water operates 4 waterworks: Qilipu, Chengdong, Zhushan and Mazhu water plants. The water supply capacity is 400,000 tons/day. All four water plants use water from reservoirs and adopt a conventional water treatment process. The quality of the water is in line with the national standard for drinking water (*GB5749-2006*).

Yuyao Water was the pilot project selected by Capital Water to first deploy a Maintenance 4.0 solution based on the ISO 55,000-compliant Core Model established with Siveco. The solution, based on Coswin 8i and bluebee®, was implemented in less than 3 months.

Xie Chao, head of the Safety & Technology Department at Yuyao Water, explained that, thanks to a “Core Model” grounded in reality, the Coswin 8i and bluebee® platform provides a 360-degree view throughout the plant lifecycle, thus facilitating management decisions.

On behalf of Siveco, Vice General Manager Paul Wang thanked Capital Water for the smooth cooperation and the gratifying results obtained by this first attempt to introduce Maintenance 4.0 in a domestic water company.

The very successful workshop culminated with an onsite demonstration of the system in its daily usage by front-line staff of Yuyao Water.

Scan the QR code to read the detailed summary of the workshop written by Yuyao Water on the company’s official WeChat account.

Continuous improvement at leading industrial water treatment JV

Shanghai Chemical Industry Park Sino French Water Development Company Limited

The Sino French Water Development Company Limited ("Sino French Water") is a successful partnership between Suez Environment of France and NWS Holdings Limited of Hongkong. Sino French Water has been active in the Chinese water industry since 1992. Its core businesses can be classified into five areas: water production, water distribution, municipal sewage treatment, industrial water treatment services as well as investment holding company. Sino French Water currently operates 22 joint ventures in 16 Chinese municipalities, serving a population exceeding 14 million inhabitants and employs over 5,000 employees in China.

With an area of 29.4 km^2, Shanghai Chemical Industry Park (SCIP) is one of the most heavily invested in industrial projects in China's 10th Five-Year Plan. In 2002, Sino French Water partnered with SCIP Development Company Limited and SCIP Investment Company Limited to form Shanghai Chemical Industry Park Sino French Water Development Company Limited. With a concession period of 50-year, this joint venture (JV) is exclusively dedicated to providing water and wastewater treatment services to the industrial park.

Water Supply Capacity:

- Industrial water: 200,000 m^3/day
- Domestic water: 7,000 m^3/day
- Demineralized water: 150 m^3/hour

Wastewater Treatment Capacity: 50,000 m^3/day, CODcr load 30 tons/day

Wastewater Treatment Plant: Each inlet is equipped with online toxicity meters, for real time monitoring of the biological toxicity of the wastewater. Furthermore, the plant has a 15,000 m^3 emergency storage capacity for off-spec wastewater. This is used in the event of an accident during production. The storage facility also eliminates pollution load fluctuation from the treatment process. The plant's treated wastewater meets national emission standards and its discharge point is connected to Shanghai's Environmental Protection Bureau's online monitoring system.

Demineralized Water Plant: The plant has a production capacity of 150 m^3/hour. It can reuse treated wastewater as raw water for the production of demineralized water. This results in decreased WWTP discharge volume and better circular economy.

Laboratory: In 2006, the laboratory started to use a Laboratory Information Management System (LIMS). In 2007, it ranked as a "Reference Laboratory" in Suez Environment's Inter-laboratory Tests. In 2009, it achieved CNAS accreditation and achieved the *ISO 17025* certificate. The laboratory is capable of analyzing around 100 parameters and conducting more than 400 analyses a day.

SCIP Water Research Center (SWRc): It is China's first R&D organization dedicated to the research of industrial water and wastewater treatment. In 2008, SWRc acquired one patent. Another creation patent is under consideration in 2009. To promote circular economy, SWRc is working on two projects: one focused on using wetland to treat wastewater; the other on ways to reuse water.

Health and Safety Management: The JV achieved the Lloyd's Register Quality Assurance (LQRA) approved *ISO 9001* certificate in 2006, as well as the *ISO 14001* and *OHSAS 18001* certificates, accredited by the same body, in 2008.

The project

In 2006, SCIP Sino French Water initiated a selection process for a CMMS, to replace earlier purchased software that was never put into actual use. Coswin, with its flexible graphical user interface, compared very favorably with complex IT tools used elsewhere in the group. Moreover Siveco already had a successful reference in Shanghai Chemical Industry Park.

SCIP Sino French Water had from the outset a very clear plan: the implementation of the CMMS would allow the team to grow and improve at their own pace. The company's management team clearly stated that the project was about

> **Siveco has continuously helped us improve our maintenance management.**

learning from their own experience in order to improve, rather than about IT, in line with Siveco's approach. Consequently, the project was executed in several phases.

Building the foundation

The initial focus of the project with Siveco was on building the company's equipment structure from data already available and to support the work management process. Highly user-friendly diagrams were designed to allow operators to report failures and work requests directly in the system. By involving operation teams in the process and ensuring all corrective work orders were prepared and reported in Coswin, the Sino French Water maintenance team was able to raise its service quality.

Example of Coswin screen used by operators at SCIP Sino French Water

Supporting technical decisions

After one year of utilization, Sino French Water realized the need to optimize the existing equipments structures and failure codes, in order to better support the decision process and future maintenance improvements. The initial data structure was revamped with the help of Siveco engineers, thus ensuring it could better support future development (plant extension, changes in equipment, improvement in maintenance practice). The management of preventive maintenance was introduced (definition of job guidelines and inspection rounds). New management indicators and reports were designed to support regular meetings and management reporting.

According to Jean-Pierre Arcangeli, General Manager of SCIP Sino French Water Development:

> "Coswin has proven to be an excellent tool for our company and Siveco has continuously helped us improve our maintenance management. Four years down the line, good maintenance management habits have been acquired and, as our activity in Shanghai Chemical Industry Park grows, we continue to work with Siveco on the expansion of Coswin."

After using Coswin successfully for many years, Sino French Water and Siveco have signed of a corporate agreement covering all the company's operation in China (more than 30 joint ventures). The CMMS solution has subsequently been deployed to many of the group's joint ventures (full water service, water production, industrial waste water services, sewage water treatment and sludge treatment). Meanwhile, in Q3 2013, SCIP Sino French selected the bluebee® inspection solution, running on Android mobile phones, to add on to the current Coswin CMMS. This project went live in early 2014.

Maintenance 4.0 in practice: optimizing water supply assets with field inspections on mobiles

This project was nominated for the 2015 SFW Innovation Trophies.

Chongqing Sino French Water Supply Company Limited

Chongqing Sino French Water Supply Company is a joint-venture of Chongqing Water Group and Sino French Water, supplying drinking water to 1.2 million people. Chongqing is China's youngest municipality under the jurisdiction of the central government and the gateway to Western China. This JV was the first concession project following the opening up of China's distribution networks to foreign involvement and also Sino French Water's first large full services venture in China. In operation since November 2002, the JV remains the sole drinking water supplier and network manager for Jiangbei, Yubei and the new developed zone in the Northern part of Chongqing. This area is developing quickly and, over the past years, the demand for water has grown at an average rate of 14% per annum. In 2009, the JV also secured a new drinking water distribution contract for Yuelai District, with a daily capacity of 600,000 m³, representing a total investment of 1.5 billion RMB.

The project

To meet its maintenance improvement objectives, Chongqing Sino French Water has implemented the Coswin computerized maintenance management system since the beginning of 2013, covering the operation of 4 subsidiary plants. By getting rid of its old-time Excel-based management model, the project helped Chongqing Sino French Water build up a complete technical database and to streamline its previous preventive maintenance plans and fault reporting system, while optimizing decision-making through reports and KPIs generated by the system.

After one-year operating with the system and the results obtained, new requirements were raised by the management team: based on the CMMS, how to fill in the gap between onsite inspection and back-office engineering? How to replace the current paperwork by state-of-art technology? How to implement the best maintenance practices in the field? How to analysis the performance of inspection? How to motivate the junior technicians?

Inspired by the concept of "Maintenance 4.0", Chongqing Sino French Water was determined to use advanced mobility tool to improve the inspection work.

The goals

Based on initial studies, the project aimed at achieving the following objectives:

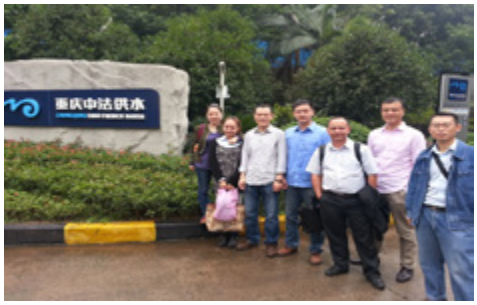
- Link the existing Work Orders (WO), preventive maintenance plan and fault codes (SDCA Symptom, Defect, Cause, Action) from the CMMS to onsite users and data, in order to bridge the gap
- Streamline the inspection SOP based on *ISO 55000 Asset management* and set up a comprehensive inspection technical database to prevent mistakes in the field
- Use technology to guide end-users to follow the best practices while improving work safety
- Analysis inspection results to provide technical-financial decision support
- Motivate the staff by fancy technologies, becoming the benchmark among all the Sino French JVs

The solution

Chongqing Sino French Water decided to work with Siveco to implement bluebee® solution to meet its inspection needs. bluebee® is an off-the-shelf, well-proven Maintenance 4.0 software package, unlike most self-developed applications found in the market. The coverage of the project included the 4 subsidiary plants and 30 pumping stations in the water supply network. The project required 46 mobiles phones (20 for plant maintenance, 24 for inspection and the rest for pump stations) and 1,200 QR-coded tags corresponding to 1,200 inspection areas. The total number of people using bluebee® is 88. The project started in January 2015.

> **The bluebee® project improves our inspection process, while ensuring the safety of our operations.**

To reach World Class Maintenance, the new inspection process was defined based on *ISO 55000 Asset management*, involving inspection strategy and policy, organization, equipment coding, job coding, job description, job type, job frequency, actions, action types, scan QR codes etc. Measurements were standardized as well in terms of temperature, vibration, pressure and normal values were defined. This was documented in the "Core Model".



The joint project team

Beyond traditional inspection tools, the bluebee® app allows users to create Work Orders and Job Requests once a problem is detected onsite. The technical know-how database is made available to field users for diagnosis and decision support. Through 4G network, the mobile phones can automatically synchronize data with the Coswin back-office system.

The Core Model established above has been adopted and configured by Siveco into the app. Considering the complex working environment and existing working habits, the user interface also ran several tests to ensure the smooth hand-over. The project officially went live in August 2015.

The benefits

In short term, Chongqing Sino French has defined certain reports and KPIs to measure the results and progress compared to the previous management model:

- Measurements over safe value
- Meters trends
- Abnormal failures analysis
- Comprehensive inspection analysis
- Unfinished job analysis

The bluebee® project improves the field inspection through SOP and systematic analysis. One stone, two birds: it also optimizes the usage of the existing CMMS system, ensuring greater ROI. The project also contributes to higher safety, always the top priority for Sino French Water.

According to Wang Zhibing, Chongqing Sino French Water's Production Leader:

> "We got rid of pen and paper and it is fun to be equipped with bluebee® while working."

Luo Feng, the company's Operation Manager, added:

> "The bluebee® project improves our inspection process, while ensuring the safety of our operations."

The introduction of "Maintenance 4.0" and more generally "Industry 4.0", corresponds to the "New Normal" phase of China's development. It requires the combination between new Internet technologies and industrial know-how. As a pioneer, Chongqing Sino French Water took the first steps to adopt this concept into day-to-day practice. The project not only motivated workers but also demonstrated the value of their work and their capacity for innovation.

Based on the complete inspection Core Model established in Chonqging, bluebee® is planned to be duplicated to the other Sino French Water JVs in 2016.

Tianjin water JV benefits from group best practices through Coswin

Tianjin Tanggu Sino French Water Supply

Tianjin Tanggu Sino French Water Supply ("TGSF") was formed in 2004 in response to the rapid economic growth of the Tianjin Binhai New Area.

A joint-venture between Tianjin Water Works Group and Sino French Water Investment Company, TGSF provides full water services (water production, sales, construction, distribution network management and related customer services) to one of the largest harbors and the second largest development zone in China. This company has a daily production capacity of 320,000 cubic meters, serving a population of 600,000.

The project: Deploying best maintenance practices through the CMMS

Based on the good results obtained by several other joint-ventures of Sino French Water with municipal water groups elsewhere in China, TGSF selected Siveco to deploy a computerized maintenance management system (CMMS) in order to improve its maintenance practice.

The kick-off meeting was held in October 2014. Two Siveco consultants involved in the project, with support from Siveco's back-office team, working with Zhao Hongwei, manager in charge of TGSF's Water Supply department.

A "Group Core Model" had already been established with Sino French Water, inorporating water industry maintenance management best practices, within a management framework in line with the *ISO 55000 Asset management* - Overview, principles and terminology and Sino French group reporting standards.

The first phase of the project consisted in training TGSF team in the Group Core Model and, after a thorough study of the local joint-venture's maintenance needs, adapting it into a local Core Model and planning its deployment through the Coswin 7i CMMS. In particular, TGSF outsources all its maintenance execution to contractors, both for corrective and preventive maintenance, working under the supervision of TGSF staff.

In TGSF, the coverage of the CMMS includes the management of all the company's equipment, work management, preventive maintenance, resources management, spare parts and tools management.

The system went live in March 2015.

Benefits obtained

The first benefit obtained from this project has been a smooth implementation of the group Core Model guidelines, using each step of the CMMS project and Coswin itself as a practical training tool. A full *ISO 55000* compliant management system is now in place at TGSF.

TGSF has established standard preventive maintenance activities, based on the know-how of its team, combined with the experience accumulated in Coswin at the other Sino French Water joint-ventures. The CMMS is setup to automatically generate the preventive work plan on a regular basis for its contractors.

Failures are systematically reported in Coswin in a structured manner: end-users can quickly find the related equipment in the system, using the plant layout, the equipment structure or through a search. A failure report can then be created, with Symptom, Defect, Cause and Action ("SDCA").

By using the system, TGSF is now able to continuous improve its maintenance strategy, to meet its management goals of reducing maintenance cost and enhance production efficiency.

According to Zhao Hongwei, Water Supply Department Manager at TGSF:

> "The Siveco project has helped us to further enhance our maintenance practice, to learn from the other joint-ventures, but also to contribute our own knowhow and experience to other sister companies in the group. This benchmarking process will allow us to continuously improve ourselves."

Water treatment specialist leverages its design, construction and operation know-how with IT tools

Degrémont, the world water treatment specialist

A subsidiary of the SUEZ ENVIRONNEMENT group, Degrémont has been the world water treatment specialist for more than 70 years. Operating in more than 70 countries with over 5,000 employees, Degrémont generated revenues of €1,110 million in 2013.

The Operation & Maintenance (O&M) Support Division represents one third of Degrémont's employee, namely 1,800 people, specialists in large high-tech facilities, present in 20 countries. 19 million people are serviced by a drinking water production plant operated by Degrémont and 21 million people-equivalent are serviced by a wastewater treatment plant operated by the company.

The main challenges faced by water treatment facility operators are: guaranteeing continued water production or water treatment, controlling operating costs and preserving assets. On a daily basis, these challenges translate into rigorous planning and a multitude of interventions to manage the facility.

In order to better serve its industrial clients in China with maintenance services, Degrémont has decided to team up with Siveco China, the country's largest maintenance consultancy. Siveco brings over 10 years of experience in the Chinese market, with a customer base of over 800 sites in China, a team of maintenance specialists and the award-winning bluebee® solution for multisite maintenance management.

Maintenance improvement services for industrial water plants

The service proposition prepared by Degrémont provides a broad range of solutions to allow operators to choose adapted and cost-efficient solutions. Siveco's maintenance specialists work as part of the Degrémont team, while Siveco also provides the central maintenance management platform bluebee® cloud that Degrémont uses to manage O&M contracts. The joint approach usually consists of three main phases:

1. Initial maintenance assessment

A joint Degrémont and Siveco team goes on site for an assessment of current facilities condition and maintenance status: inventory of key equipment and its condition, review of existing maintenance plans, records and documentation, interview with key personnel. This third-party assessment, based on European maintenance standards, provides clients with practical recommendations in the form of prioritized action list. Collected data and findings are uploaded into central bluebee® database, accessible by all parties.

2. Review and update of maintenance plans

Degrémont and Siveco recommends immediate corrective and improvement actions, based on onsite condition, as well as a professionally-reviewed inspection and preventive maintenance plans, based on equipment suppliers recommendations, industrial best practices and maintenance history at site. Plans include spare parts and consumable requirements. All actions are available in the easy-to-use bluebee® cloud database (export to Excel and pdf available) and immediately usable to obtain quotes from service suppliers. QR-coded tags for equipment and inspection points can also be printed directly from the system.

3. Implementation and follows-up

With a focus on ensuring that planned actions are actually being implemented, Degrémont and Siveco train the maintenance team (in-house or contractor) in new maintenance plan and usage bluebee® mobile (Android app), a foolproof mobile recording system based on scanning QR codes on equipment and inspection points. Monthly remote reviews are performed based on system reports, as well as additional onsite coaching every 3 months, and a yearly performance assessment. The combination of coaching and recording system ensures that

> **Thanks to our advanced IT tools, we leverage both expertise and ensure monitoring of the activity, to guarantee the quality and reliability of your installation.**

recommendations are actually implemented.

bluebee®, the supporting tool

The bluebee® suite supports the entire process: Degrémont and Siveco engineers are equipped with the bluebee® surveyor app for the initial audit. All data is then uploaded into bluebee® cloud, accessible with secure login by all authorized parties. Maintenance supervisor (customer's in-house team or appointed contractor) use the bluebee® technician app for daily recordings.

The award-winning bluebee® system is designed to be easy-of-use, facilitating daily work. It automatically produces maintenance reports based on European standards.

Benefits: Leveraging process and maintenance expertise with IT tools

According to Herve Lienhardt, Asia Services & Equipment Solutions Director at Degrémont:

> "Our partnership with Siveco ensures for our customer one single interface for a dual expertise: process & maintenance. Thanks to our advanced IT tools, we leverage both expertise and ensure monitoring of the activity, to guarantee the quality and reliability of your installation."

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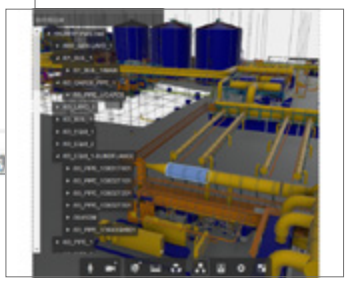
BIM for Asset Management
at cutting-edge organic waste treatment facility

The Oscar Bioenergy Joint Venture selected Siveco to provide the Computerized Maintenance Management System (CMMS) and related data preparation services for Hong Kong's first organic waste treatment facility, under construction on North Lantau Island. This cutting-edge facility will start operation in 2018 to treat 200 tons of food waste daily and will turn it into biogas and compost. As a result around 14 million KWh of surplus electricity will be injected into the electrical grid as green energy. This project provides a good showcase of integrating 3D BIM models in the CMMS for Operations & Maintenance. This short article gives an overview of the solution.

From the start, the development of the BIM model is coordinated with O&M data preparation. The integrated solution allows viewing all data from the 3D model.



All the related asset data are easily accessible incl. spares, contracts, documentation, preventive maintenance instructions, etc.

For work preparation, technicians can direct view equipment to be maintained in the 3D model.

During commissioning, the system also ensures strict safety management onsite (lockout/ tagout - LOTO - process with QR code scanning).

The platform also provides mobile access for plant technicians (bluebee®) and is designed to integrate with various other systems including SCADA and ERP.

Siveco provides key support to Suez NWS's growing waste-to-energy business

The author Benjamin CHAN PIU is Deputy Business Line Director at Suez Recycling & Recovery Asia (Suez NWS).

SUEZ NWS Limited ("SUEZ NWS") is a joint venture between SUEZ and NWS Holdings Limited that encompasses four essential business segments – Water Management, Recycling and Waste Recovery, Water Infrastructure Construction and Consultancy in the Greater China region. With 8,000 employees and over 60 joint ventures with local partners, SUEZ NWS is helping authorities and industries develop innovative solutions to address climate change and sustainable resource management. It has built over 240 water and wastewater treatment plants in Greater China, supplying drinking water to 20 million people. It is a leading operator of waste management in Hong Kong and delivers its expertise in the management of environmental services to 11 industrial parks in Mainland China.

Siveco has been working with us at the Recycling & Recovering division of Suez for over a decade now, starting with the construction of our first waste treatment plant in mainland China, one of the world's largest hazardous waste-to-energy plants, which started operations in Shanghai Chemical Industry Park in 2006. Siveco helped establish the maintenance management system for the plant and has supported us ever since as we developed our China business.

Picture of the joint team at Nantong SITA

In Plant maintenance is at the core of our business to support the sustainable development of the Chinese economy, especially since we deal with dangerous waste material. Achieving European standards in terms of air emissions requires not only technology and advanced process control, but also a strong maintenance management system. As our company expanded, the relationship with Siveco grew very deep.

Minimum Operating Standards (MOS) were established for maintenance, with a "Core Model" applicable to all our sites, in line with the principles of the *ISO 55000* Asset Management standard. Siveco defined a comprehensive rollout program, as part of every new plant construction project, with support from their Maintenance 4.0 tools, namely Coswin as the main database structuring our best practices and the bluebee® mobile app, used by operators and maintenance technicians for inspections. All our sites are under so-called "Enhanced" support by Siveco, with involves regular coaching, onsite audits and a multisite benchmarking service. In addition, Siveco is conducting our corporate Maintenance Management training program, which all key personnel must attend.

Today Suez hazardous waste-to-energy facilities include the SCIP plant (recently expanded with a third incineration line), another energy recovery plant serving the Nantong Economic Technology and Development Area (NETDA), both under operational support by Siveco. Three other plants are scheduled to start in 2018, following the same approach to setup advanced maintenance standards well before start-up. This extended footprint allows Suez to bring solutions to more and more industrial companies for the safe management & disposal of their hazardous waste, in more and more regions of China.

The graphical CMMS navigation for Nantong SITA

> **World-class maintenance practices are taken into account throughout the life-cycle of our projects.**

For a new plant, the construction period is always full of challenges. During commissioning and start-up in particular, it is tempting to put maintenance preparation aside. Thanks to the comprehensive approach we have developed with Siveco, we ensure world-class maintenance practices are taken into account throughout the life-cycle of our projects, guaranteeing the availability and quality of our services to industrial clients, in compliance with the strictest environmental standards.

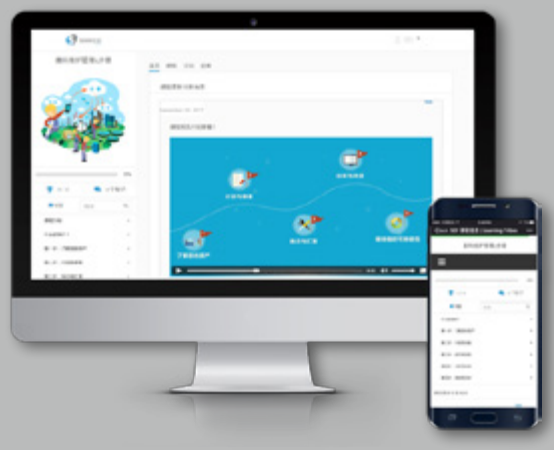
Siveco has been working with Suez NWS in China since 2005, providing Maintenance 4.0 technologies and consulting services to the group's many joint-ventures in the Water and Waste & Recycling segments.

The company also won an Innovation Trophy in 2016 for its Maintenance Inception Training program, aimed at providing a strong common guideline for all Suez maintenance teams, in order to promote, enforce and sustain good maintenance management practices.

China's first online course on Asset Management

Siveco, China's largest maintenance consultancy, has decided to open its bluehoney online training platform, used in-house since 2012, to all maintenance professional in China. The first course covers the "5 Steps to Maintenance", with one introductory module and 5 lessons aligned with the *ISO 55000* Asset Management standard.

Talk to us at 4006-300-213 or info@sivecochina.com.



"Maintenance is the key to our business" at leading-edge hazardous waste incinerator

Background

Shanghai Chemical Industry Park (SCIP) lies at the north coast of Hangzhou Bay with the total planning area of 29.4 km^2. SCIP is one of the industrial projects with the highest investment in China during the 10th Five-year Plan period. It is the first industrial zone specialized in the development of petrochemical and fine chemistry businesses, and is also one of the four industrial production bases in Shanghai.

Established in 2003, SCIP SITA Waste Services Company Ltd. (SCIP SITA Waste Services) was jointly built by SCIP DC, SITA WASTE SERVICES (the waste management branch of French group SUEZ ENVIRONNEMENT) and NWS Holdings Limited (HK) with a total investment of 575 million RMB.

SCIP SITA Waste Services operates the largest and most sophisticated chemical waste incinerator in mainland China, with an annual treatment capacity of 60,000 tons per year. The incinerator, in operation since June 2006, is a critical element in the supply chain of giant chemical producers located in the park, which rely on the SCIP SITA to burn hazardous by-products according to European standards.

Project objectives

Based on SCIP SITA and Siveco's experience of greenfield utility projects, the main goals of the projects were to:

- Build a strong foundation for future operations by accurately documenting the plant before start-up, allowing smooth knowledge transfer from engineering to maintenance.
- Ensure the systematic use of work orders (what, when, who, impact on operation and safety) for follow-up actions and analysis.
- Help the operation team focus on preventive maintenance.

Project implementation

The plant was fully documented in the Coswin CMMS before start-up. The 4 months project allowed SCIP SITA to build its management system and train the maintenance team based on industry's best practices and European standards.

Starting from the commissioning stage, 100% of the work was managed with work orders, ensuring full traceability of all actions. When problems did occur, corrective action requests were immediately documented for follow-up.

Once this basic discipline, necessary for SCIP SITA to ensure strict regulatory compliance, was in place, the team moved its focus to improving the maintenance strategy, namely by promoting a preventive maintenance approach.

> **Maintenance is under full control, regardless of the inevitable personnel changes.**

The entire process is, since 2006, managed in Coswin, all the way from work management, planning, inventory management and procurement.

Comments by SCIP SITA General Manager Philippe Allouche

"From day one, we recognized maintenance as a key success factor for our project. The Coswin Computerized Maintenance Management System (CMMS) was implemented before startup."

"The system allowed us to manage safety right from the commissioning stage, by enforcing a strict work process. The CMMS is used to educate and organize our team and to support management decisions."

"Reliability is the key to our business, serving chemical plants in the area, whose own operation could be affected by a prolonged downtime of our facility. Four years down the line, we have succeeded in creating a true culture of maintenance in our Chinese operation: maintenance is under full control, regardless of the inevitable personnel changes."

Today

In October 2009, SCIP SITA Waste Services and Siveco China were jointly nominated by the Global Supply Chain Council, Asia's largest supply chain organization for the Green Supply Chain Award for the CMMS project. Each year, the awards recognize the importance of supply chain, procurement and logistics excellence, by identifying and rewarding outstanding performance among leading manufacturers, retailers, service providers and key individuals working in Asia.

Hazardous waste incineration plant optimizes plant inspections with bluebee® mobile solution

The case study was nominated for the 2015 Suez Innovation Trophies.

SCIP SITA Waste Services, a subsidiary of SITA Waste Services, operates a Hazardous Waste Incineration Plant ("HWIP") in Shanghai Chemical Industrial Park ("SCIP") since 2006. It has a successful record of treating a wide range of hazardous waste, in full compliance with applicable Chinese regulation. The current facility consists of two incinerators with a total capacity of 60,000 tons per year. The plant is becoming one of the largest HWIP in the world with the extension of a third line.

Ensuring and optimizing the high availability of equipment is critical for the continuing success of the plant and its coming extension. The main way to ensure it is through an excellent preventive maintenance by checking and measuring frequently the critical equipment and also doing appropriate replacement on some parts, based on scientific and on-site knowledge.

Since start-up, the Maintenance department uses a Computerized Maintenance Management System (CMMS) to record and create all maintenance work, including preventive maintenance and overhauls. Inspections however were set by each engineer using a paper-based process which didn't allow analysis or consistent tracking of findings and measurements. Inspection quality was impossible to measure or review.

The bluebee® project

The bluebee® project aim was to improve the quality of maintenance by standardizing the inspection content (such as routine and daily inspection) and increasing the reliability of data coming from the field. The use of bluebee® was to eliminate the traditional paper work orders from the CMMS system and help establishing a real inspection database for diagnosis and performance analysis.

The pilot project started in March 2013 and went through several optimization phases. Due to the plant hazardous working environment, explosion-proof ATEX Zone 2 mobiles were selected, supplied by Bartec, a Siveco Value Added Partner.

bluebee® PDA, with a QR code tag

The inspection process

The plant operation condition is constantly monitored online by the plant supervision and control system. Another level of monitoring is performed through onsite inspections by the operation and maintenance team. Many rely on the five human senses: vision, hearing, touch, smell… only taste is limited to the company canteen and is not used to detect problems. Other inspections rely on using specific tools or instruments, including more complex vibration measurement, X-ray test or material analysis. This sometimes inconsistent and hard to optimize paper process was replaced by bluebee® mobile, integrated with the existing CMMS.

A total of 102 inspection were defined initially. The frequency of inspections vary, from daily or weekly routine, to less frequent schedules, according to the criticality of the equipment and the probability of degradation or failure.

Each equipment is labelled with a unique QR code, with its name and code: as part of the project, a total 1,116 QR codes have been installed in the plant (159 for mechanical, 145 for electrical and 812 for instruments).

Inspection workload is automatically balanced by the system, optimizing the daily schedules of all technicians. Each morning, each technician downloads his work orders of the day and prepares for his inspection route accordingly. There is no need to bring any paper on site. After scanning the equipment QR code with his mobile, the user inputs related data. The action of scanning a QR code makes the process more reliable in many aspects: no loss of information as with paper notes, true information collected at the source, easy to check the regularity and content of work, etc. When the technician comes back to his

> **The project makes inspection and preventive maintenance more efficient, reliable and easier.**

office, he only needs to launch the synchronization process (using the office Wifi or USB cable to computer) and can focus on something else. Everyone has direct access to the data, there is no need any more for data input, sending emails, etc. The automatic input make analysis easier, thanks to the back-office reporting system (part of the CMMS).

The results obtained

According to Baptiste Garro, Planning Engineer:

"The project makes inspection and preventive maintenance more efficient, reliable and easier. Data from the field (reports, measurements) is now available in the same central database, allowing in-depth analysis and better support on decisions. The technicians benefit from higher motivation in their work, thanks to this technology.

Although there are direct efficiency improvements (less time spend reporting on paper, compiling data or looking for missing data), the main benefit will be indirect: less problems, improved thinking on risks and losses, and scientifically taken decisions.

Finally, it directly helps the detection of minor and major malfunctions that can lead to a breakdown. Each day when a breakdown is avoided is a day without safety or environmental issues. It also will save huge direct and indirect costs from avoided breakdown."

the bluebee® Team, from left to right: Thomas Tao, Baptiste Garro, Sun Junwei and Xu Yong

Scan QR code to watch the movie!

Welcome to Maintenance 4.0: bluebee® in action at SCIP SITA Waste Services

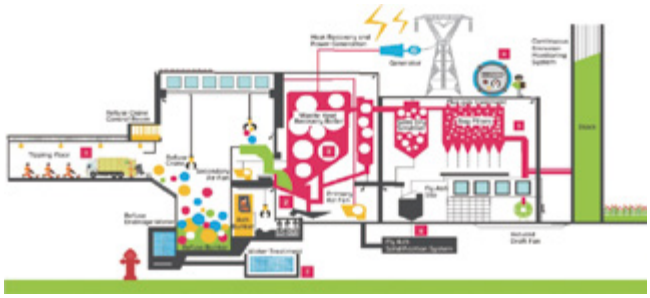
In January 2017, our team visited a long-time member of the Siveco family, our customer Suez Waste & Recycling waste incinerator in Shanghai Chemical Industry Park, to shoot a short movie about their daily operation process using bluebee®. The film demonstrates a highly condensed version of a working day featuring our customer's best practices.

Taiwanese waste-to-energy plant optimizes its entire operation with Coswin

SITA Waste Services Limited, Taiwan Branch, Renwu Plant

SITA Waste Services Limited is a subsidiary of SUEZ ENVIRONNEMENT, a world leader exclusively dedicated to water and waste management services.

SITA was awarded a contract in Taiwan by Kaohsiung government for the operation and maintenance of Renwu Incineration Plant under a 20 years contract. Commencing from December, 1st 2000, the facility is managed by high calibre crew trained by SITA for the purpose of maximizing energy efficiency, and meeting the most stringent environmental protection standards in the world.



Main equipment at SITA Renwu Waste Incinerator

The facility is designed to incinerate 1,350 tonnes each day of blended non-hazardous combustible solid waste with a weighted-average heating value of 2,300 kcal/kg. The energy generated is converted to a total of 33 MW of electricity.

The CMMS project

In December 2012, SITA Waste Services selected Siveco China to implement a Computerized Maintenance Management System for the Renwu waste incinerator. The choice of Siveco was based on the company' successful experience at another SITA facility located in mainland China.

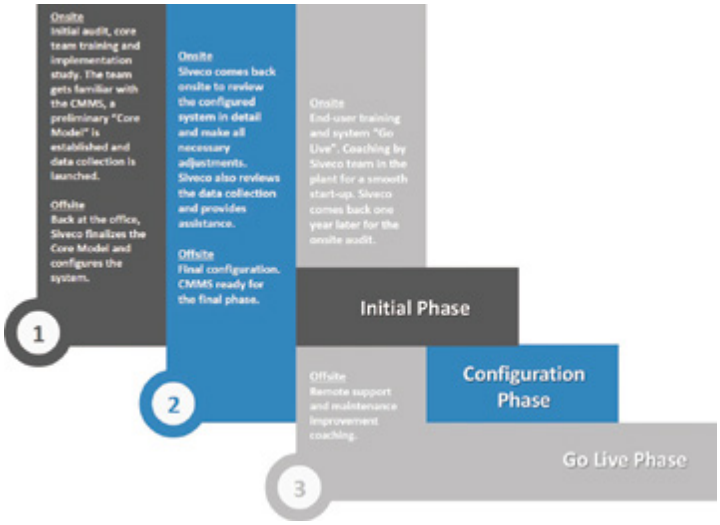
The project covered the implementation of the Coswin CMMS, with a step-by-step approach aimed at promoting maintenance improvement at the plant, through a progressive structuring of the maintenance activity towards systematic analysis and preventive maintenance.

The project was entirely managed by the Siveco China team, traveling onsite to Kaohsiung, with support from the Siveco back-office in Shanghai, following the company's well-established "export" implementation model for CMMS.

The Siveco implementation methodology builds on over 20 years of implementing maintenance solutions in utility plants all over the world, either for existing plants or as part of new construction projects, and specific experience accumulated in recent years by the China team. Siveco has developed a cost-effective and proven model whereby Siveco engineers set up the main system in China before delivering it onsite.

Siveco engineers will come to site at the initial, middle and final stages of the project, ensuring a smooth CMMS implementation. This approach, used for the SITA Renwu project, is summarized below:

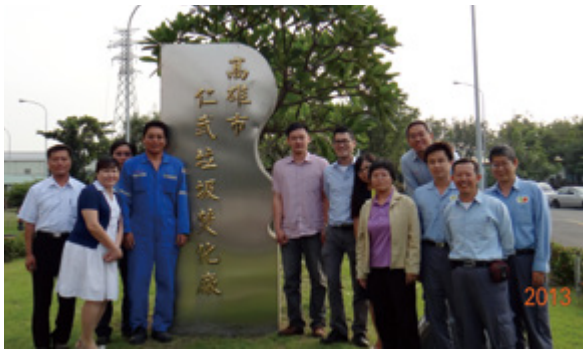
The CMMS project started in January 2013. The new management system was in place eight months later, in September 2013, after which the project entered its Enhanced Maintenance Support phase, during which Siveco monitors system usage on a monthly basis and comes back onsite once a year.



> The solution implemented has helped us in the analysis of maintenance data and in the orientation of the maintenance strategy.

A user-friendly system to support a comprehensive management model

All departments of SITA Renwu have taken part in the project and are now using the system, which covers a comprehensive functional scope: equipment management, work management (corrective maintenance, preventive maintenance



and overhaul management), spare parts stock management, purchasing management, reports and analysis. The entire management team was involved under the plant manager, with additional support from China-level management. Several exchange meetings were also organized with other SITA plants using Coswin. As a result, the entire management of the Renwu plant was streamlined and the system will continue to support improvement for years to come.

Another key aspect of the CMMS is the use of Coswin Diagrams to easily navigate the system and graphical

management and analysis reports. The reports offer support for management meetings at departmental and plant levels.

As part of the Enhanced Maintenance Support (EMS) contract, Siveco will also analyse the results obtained, the utilization of the system and resulting operational improvement, in order to suggest improvements. The last EMS visit took place in September 2014, during which improvement actions for the coming year were clearly identified by the joint SITA-Siveco team.

"Siveco team had demonstrated their expertise in CMMS development and implementation that bring Renwu CMMS project a success. We had raised quite a few special requests during the development phase that may not be common to other industries. Siveco team managed to find solutions to adjust the CMMS to best fit our needs. I am expecting Siveco to be our long term partner that brings our maintenance management to a higher level." said Mr. Franco Wong, General Manager of SITA Waste Services Limited Taiwan Branch.

"The selection of Siveco as CMMS supplier and as the solution implementer for Renwu WTE plant is part of our long term maintenance strategy in the region. Siveco is able to deliver a friendly and efficient tool and is guiding the local team during implementation. After implementation, Siveco is supporting the local team by a succession of Audits to improve the usage of the system. Siveco is a professional Company offering maintenance solution for the industry. They differentiate themselves with their local team who can speak the maintenance language. The solution implemented has helped us in the analysis of maintenance data and in the orientation of the maintenance strategy." Francois Jenny, Business Unit Director.

A long term relationship

Based on the results obtained in the SITA Renwu and other projects with Siveco, SITA has strengthened its partnership with Siveco: the CMMS Coswin and its mobile solution for plant technician, known as bluebee®, will be deployed to all future SITA sites in Asia. Siveco also assists SITA to develop its in-house maintenance management training program.

Suez Nantong waste-to-energy plant optimizes maintenance and overhaul with Coswin 8i

In March 2014, Suez Environnement subsidiary SITA Waste Services established a joint venture with Shanghai Chemical Industry Park Investment Corporate (SCIP) and Nantong Economic Technology and Development Area Company (NETDA) for the construction and operation of a new hazardous waste plant in the Nantong Economic Technology and Development Area. The contract will approximately generate a revenue of 4.9 billion RMB in the coming 30 years.

The energy recovery and treatment plant (referred to as "SITA Nantong") has a design capacity of 30,000 tons/year for the treatment of locally-generated hazardous waste and 3,300 tons/year for medical waste. This state-of-the-art incinerator strictly meets both Chinese and European emission standards and is managed according to the best international safety and environmental standards.

Why the project?

Siveco was selected to implement the Coswin 8i computerized maintenance management system (CMMS) for the plant, when it was still under construction, in order to:

- Define the plant maintenance strategy in compliance with group best practices and international practices and standards
- Ensure smooth handover from construction to operation
- Record failures from the commissioning stage
- Enforce good maintenance practices from day one

Implementing a CMMS during plant construction

China's largest maintenance consultancy, Siveco is known to have pioneered the concept of implementing maintenance systems during the construction. Siveco started working with Suez Environment companies in China in 2005 and has since delivered dozens of projects for the company's water supply, waste treatment and energy projects all over Asia.

During the third quarter of 2015, the project officially started. Two Siveco consultants teamed up with the client staff to form the joint project committee. The kick-off meeting was held in February, 2015 when plant was still under construction. One year later, the system went live, before plant start-up.

Results obtained

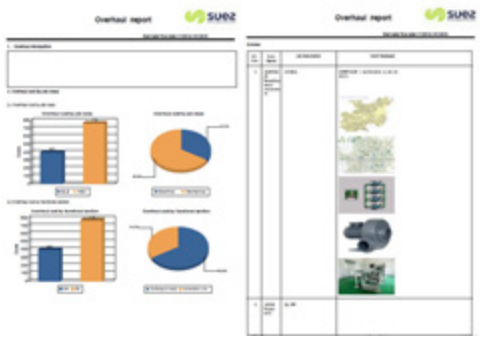
By working with the EPC and equipment suppliers, Siveco assisted SITA Nantong to build up its "as-built" plant database, which was immediately used to support commissioning.

Siveco delivered a comprehensive CMMS scope, thanks to a step-by-step implementation approach aimed at promoting maintenance improvement at the plant, through a progressive structuring of the maintenance activity towards systematic analysis and preventive maintenance.

The graphical CMMS navigation for the plant

Siveco also defined specific report templates for plant overhauls. The same report will later be deployed to the sister SITA sites in Shanghai and Taiwan, allowing benchmarking of overhaul activities between sites.

Meanwhile, the plant is using an ERP system to manage its purchasing and stocks. An interface has been set up between the two systems to simplify maintenance cost accounting.



Overhaul activities report

> **With Coswin now in the place, our equipment data is available in a structured way .**

Words from the client

Mr. Kaixiang Jie, Planning Engineer of SITA Nantong said

"I am very satisfied with the entire project implementation! Siveco's engineers assisted us to improve our work process, define management reports, system diagrams and the accounting interface.

With Coswin now in the place, our equipment data is available in a structured way and we have gained good habits to keep updating the technical database and consistently optimize our maintenance plan."

The road ahead

On February 26, 2016, the "Maintenance Inception Training" program conducted by Siveco China for Suez waste and water treatment plants in the Greater China region won the Gold Award at the Suez Asia Innovation Trophies. The Inception Training is part of an overall Maintenance Excellence program managed by Siveco, aimed at providing a strong common guideline for all Suez maintenance teams, in order to promote, enforce and sustain good maintenance management practices.

Siveco is proud to witness the business growth that Suez Asia has made in the past years over the country. The cooperation continues in 2016 with the first organic waste treatment facility in Hong Kong built by Suez and the partnership between SITA and Beijing Enterprises Environment Group Limited located in suburban Haidian District, Beijing.

Measure and improve performance with Standard Reports Library

Drive Best Maintenance Practice into the daily life of your organization, using touchscreens or mobile reports based on the standard *EN 15341 Maintenance Key Performance Indicators*, combined with 30 years of Siveco consulting experience. The Standard Report Library is sold as a software license for Coswin or bluebee® cloud, with annual support to benefit from future updates and improvements.

Talk to us at 4006-300-213 or info@sivecochina.com.

A collaborative approach to asset lifecycle management in gas turbine power plant project

The Ranhill Powertron II (RPII) 190MW Power Plant

Ranhill Berhad is one of Malaysia's leading engineering and construction company, with asset management and ownership in the environment, infrastructure, power, petroleum and chemical sectors. With more than five decades in the industry, Ranhill has a strong presence in Malaysia and growing overseas operations in China, India, Libya, Saudi Arabia, Sudan and Thailand.

In mid-2009, Ranhill started the construction of a new 190 MW combined-cycle gas turbine power plant (CCGT) in the state of Sabah in East Malaysia, known as Rugading Power Plant in addition to the existing 190 MW Teluk Salut CCGT power plant which is located next to it. The Rugading power plant was built by the Chinese EPC. China National Electric Engineering Company (CNEEC) at a total project cost of 1.74 billion RMB and commissioned in less than 22 months. It comprises two gas turbines of Frame 6FA (Model PG6111+e) units each with a nominal capacity of 65 MW. The first gas turbine unit achieved COD in March 2010 and the second unit COD was on July 2010. The overall Combined Cycle Plant Facility was on Commercial Operations in April 2011, making Ranhill the largest Independent Power Producer in the State of Sabah.

The CMMS implementation: a collaborative project led by Siveco

In 2009, CNEEC selected the partnership of ABB Bailey Beijing Engineering Company and Siveco China to supply DCS and CMMS for the power plant. Based on a long experience of greenfield infrastructure projects all over the world, the Siveco China team had developed a specific expertise to assist EPC companies and their equipment suppliers during the construction phase, ensuring smooth transfer of technical documentation to operation, supporting plant commissioning and start-up with an accurate technical database and enforcing good maintenance practice from day one.

Siveco launched the data collection phase in Beijing on December 2009, working alongside CNEEC, the Northwest Electric Power Design Institute (NWEPDI), equipment suppliers like GE for the turbines and ABB (DCS) to define the data structure, coding rules, based on international standards: *IEC61346*, *IEC PAS 62400* and *ISO/TS 16952-10 RDS-PP* (the "new KKS"). Data collection priorities were then defined.

In the beginning of 2010, Siveco China engineers set up and configured the CMMS "Coswin" at Siveco Shanghai office. Available data were uploaded into the CMMS by batch using the Clic-Clac tool, ensuring consistency and quality control. The system was shipped to customer site in Sabah, Malaysia towards the end of the year, for final data migration and system acceptance tests, after which Siveco is providing babysitting support onsite to ensure Coswin is effectively put into operation.

Training took place in several stages. An implementation study was conducted with the RPII team at the early stage of the project. Core Team training was performed on the preconfigured system at Siveco Shanghai mid-2010. A few months before "Go Live", Siveco organized end-users training on site in Sabah, after which the power plant's operation and maintenance team has started to use the CMMS to manage its daily maintenance job and spare parts inventory.

> Siveco's role in the project proved to be critical, considering the very different working practices between Chinese construction firms and overseas power plant operators like us.

Functional scope of the CMMS

The CMMS covers a complete life-cycle asset management scope, as follows:

- Graphical diagram navigation
- Asset management
- Corrective maintenance
- Safety and work permits
- Preventive maintenance
- Stock management
- Repairable spares handling
- Procurement

Results

According to Mr. Muhamad Kamal Ibrahim, Operations Manager at RPII O&M:

> "Siveco's role in the project proved to be critical, considering the very different working practices between Chinese construction firms and overseas power plant operators like us: Siveco's experience of both ensured that that our expectations were met despite the obvious challenges."

He added:

> "The approach consisting in preparing the CMMS from the early construction stage helped us ensure operation readiness in time, a major business goal for Ranhill being our commitment to reduce construction time and providing the much needed energy for Sabah."

Ranhill is now considering extending the usage of Coswin to its other units.

Ranhill Powertron II is the first major cooperative project of Siveco and Chinese engineering and construction companies in Asia. Siveco is actively promoting the same concept to Chinese EPC companies building infrastructures all over the world. The concept could also be successfully applied to Chinese power project, as operators' expectations evolve and get closer to those of international players.

Maintenance preparation support for Indonesia's Banjarsari power plant with CNEEC

Bukit Asam's Banjarsari power plant

PT Bukit Asam (PTBA) is an Indonesian state-owned coal mining company, partly listed on the Indonesian stock exchange. The second largest coal producer in Indonesia, with mineable reserves of approximately 7.3 billion tons (17% of the total coal reserves in Indonesia), PTBA strives to become a competitive energy company. This vision has been manifested by the establishment of PT Bukit Pembangkit Innovatif (BPI), a sister company of PTBA, to operate the Banjarsari mine-mouth coal-fired steam power plant.

The 2x135MW power plant, a total investment of 240M USD, is located in South Sumatra province. China National Electric Equipment Corporation (CNEEC) was selected as the EPC contractor for this project. Construction started in April 2012 and the plant was handed over to client at the end of 2015, after which the warranty period started.

The challenge: meeting the owner's expectations for plant documentation

Chinese engineering and construction companies traditionally emphasize cost control during construction, with progressive adjustments and modifications of the design as the project moves ahead. While the resulting speed and construction cost advantages have proven critical to support the development needs of many countries such as Indonesia, it often comes at the expense of maintenance preparation: Chinese EPCs face difficulties to provide complete as-built drawings or preventive maintenance instructions.

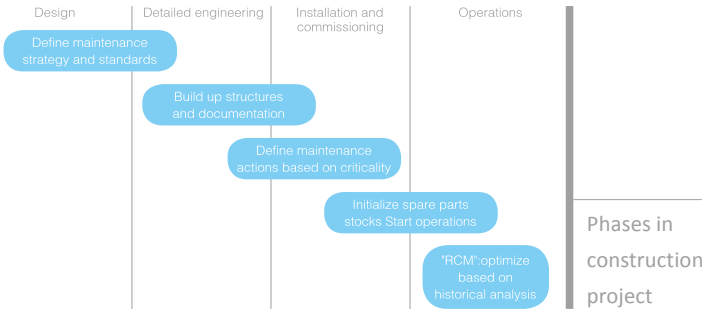
On the other hand, plant owners or operators in overseas markets have certain expectations in terms of the documentation to be handed over to the maintenance team, often as part of the Computerized Maintenance Management System (CMMS) delivery. For the Banjarsari power plant, PTBA required the plant technical database to be loaded in a Computerized Maintenance Management System (CMMS), to be delivered turn-key by the EPC.

CNEEC selected Siveco China, the country's largest maintenance consultancy, for this project. Based on a long experience of greenfield infrastructure projects all over the world, Siveco has developed a specific expertise working alongside EPC companies and their equipment suppliers during the construction phase, ensuring smooth transfer of technical documentation to the plant owner, supporting plant commissioning and strat-up with an accurate technical database and enforcing good maintenance practice from day one. Siveco was awarded the contract in March 2013.

The project: preparing maintenance during the construction stage

The main objective of the project was to build up the plant database in a CMMS for hand-over to operations before startup, in order for all the plant to be accurately documented in the system and for maintenance teams to use the system to support their daily work from day one.

The figure below summarizes the Siveco approach for maintenance preparation during a construction project based on the utilization of the CMMS:



The Banjarsari project was split into three main phases:

1. Data preparation
2. CMMS configuration and factory-testing
3. Onsite delivery

> The Core Model describes the overall maintenance strategy, the CMMS data structures, all the plant's maintenance management business processes.

The first two phases were mostly performed in China, working closely with CNEEC and subcontractors. Phase 3 was performed at the plant in Indonesia starting in the last quarter of 2015.

Siveco appointed a project manager for the entire project, a senior maintenance consultant with experience in similar power plant projects. Siveco China's main resource center in Shanghai provides personnel for phases 1 and 2. All Siveco engineers are bilingual Chinese-English and have experience working in an international environment.

Phase 1 - Building a detailed, accurate and easily accessible technical documentation

The plant's technical documentation consists of plant structures, equipment data, specifications, contracts, spare-parts, preventive maintenance instructions and inspection routines, technical documents etc. It can be entirely delivered in the CMMS and its associated Document Management System.

While this is ideally launched before contracts with the major equipment suppliers are signed, in order to ensure that the data collection requirements are incorporated into those suppliers contract with a clear delivery schedule, it is often not possible, as was the case for the Banjarsari project… Instead, Siveco held a kick-off meeting in April 2013 with CNEEC and key subcontractors to review the project schedule, explain the plant owner's requirements and define the data collection process, activities and milestones, as well as applicable standards (*IEC61346*, *IEC PAS 62400* and *ISO/TS 16952-10 RDS-PP* also known as the "new KKS").

Siveco engineers created the overall plant structure and are supervising the entire data collection project, checking the quality of data provided on a monthly basis, ensuring consistency and compliance with standards, proposing alternative solutions when data is not readily available. The data collection phase will continues until the end of the construction, at which point the final data will be delivered in the CMMS database. It runs parallel with phase 2 (CMMS configuration).

Phase 2 - Preparing the CMMS before onsite delivery

In July 2013, a week-long "Implementation Study" workshop was conducted by Siveco experts with Banjarsari power plant's top managers in Shanghai (at this stage of the project, it is normal that the maintenance team is not yet in place). The main purpose of the Implementation Study is to ensure that the CMMS supports the plant's maintenance strategy and deliver the expected functionality and benefits.

Implementation Study with Banjarsari Power Plant leaders and Siveco team

Drawing on Siveco's long experience with similar projects all over the world, the Implementation Study resulted in a "Core Model" document (sometimes known as "CMMS blueprint"), defining the way the CMMS will be used in the plant. The Core Model describes the overall maintenance strategy, the CMMS data structures, all the plant's maintenance management business processes (including spare parts management). The document also defines Key Performance Indicators (KPIs) and management reports, based on the *EN 15341 Maintenance Key Performance Indicators* standard.

The Banjarsari CMMS Core Model was finalized and approved in September 2013, after which the CMMS configuration activities started at Siveco office.

> Coswin 8i has become the main operation and maintenance management system for the plant.

On August 27, 2013, the power plant's number 1 boiler underwent successful water pressure test.

Based on the Core Model, the CMMS was configured at Siveco Shanghai office. Already prepared plant data were uploaded for Factory Acceptance Testing (FAT) in Q1 2014. Data collection continued until final delivery onsite.

Phase 3 - Onsite delivery

Onsite delivery started during Q4 2015. The Siveco project team conducted end-users training and babysitting activities in Indonesia for several weeks. At the end of 2015, BPI purchased a total of 10 Coswin 8i concurrent user licenses for the Banjarsari power plant. Coswin 8i has become the main operation and maintenance management system for the plant, covering the following main processes:

- Plant data management: keeping up-to-date of equipment structure and equipment-related information
- Preventive maintenance planning: standard work instructions and the entire planning process
- Work management: scheduling, execution and reporting all maintenance activities
- Stock management: maintain item register, stock receipt, stock issue, stock transfer, stock adjustment, stock count and repairable management process
- Purchasing management: purchase request, quotation, purchase order
- Management and analysis reports and KPIs

Additional coaching services are provided during 2016, as part of the warranty period.

Lifecycle support for Hanas New Energy LNG Plant

Hanas New Energy LNG Plant

China's Hanas New Energy is one of the world's diverse energy solutions providers. Hanas New Energy's core business is the provision of wind power, solar-thermal power and distributed energy. The Group also delivers production of LNG (Liquefied Natural Gas), CCHP (Combined Cooling, Heating and Power), urban gas operation, and centralized natural gas heating and cooling. Hanas New Energy is promoting China's energy transformation.

Hanas New Energy owns and operates the largest LNG Plant in China with a production capacity of nearly 1 million tons per year. The plant liquefies natural gas from the CNPC West-East pipeline, using the APCI liquefaction process with a single mixed refrigerant (SMR) in two parallel liquefaction trains. LNG produced is stored in a 50,000 m3 tank and exported by trucks from the terminal.

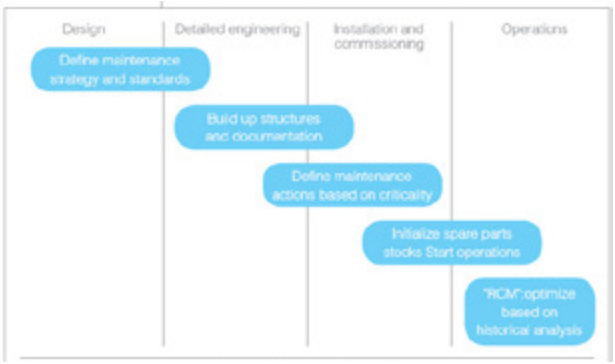
Implementing the CMMS before plant start-up

In line with international best practices, a Computerized Maintenance Management System (CMMS) was implemented during the construction of the plant (2009-2011). Siveco has over the years refined this practice to meet the demands of Chinese projects, where as-built documentation is difficult to obtain and operators lack experience of modern maintenance practices.

Hanas New Energy consequently selected Siveco and its "Coswin" CMMS.

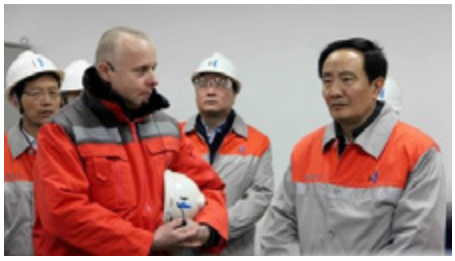
Siveco maintenance specialists worked alongside the EPC and Hanas New Energy engineering team until plant start-up in early 2012, thus ensuring smooth transfer of technical documentation from construction to operation, supporting plant start-up with an accurate technical database and enforcing good maintenance practice from day one.

Efficient work management



Once the LNG plant was put in operation, the CMMS served as the single repository for all maintenance, inspection and testing information. Work planning is done in Coswin, ensuring greater work efficiency and control over the most important aspects of the process.

> **The CMMS is crucial to our operation, aiming at zero harm to people and environment, surpassing regulatory requirements.**



Plant visit by the governor of Ningxia Hui Autonomous Region

According to Plant Manager Dietrich Roeben:

> "The CMMS ensures most efficient work turnaround for all preventive and corrective maintenance, inspection, testing and plant modifications. The CMMS also plays a role in effective risk management, which is crucial to our operation, aiming at zero harm to people and environment, surpassing regulatory requirements."

Five years later

Years later, the Siveco team continues to support Hanas New Energy LNG Plant with regular training and coaching, as well as support. Coswin stock management module was also put into use in March 2016.

In the word of the Plant Manager:

> "In spite of inevitable personnel changes since the plant started, the CMMS and support from Siveco has remained strong, ensuring true lifecycle support and continuous improvement for our plant."

On the Belt & Road: powering infrastructure development in Algeria

The government of Algeria has launched an unprecedented infrastructure development program to support the North African nation's urbanization and industrialization. During an inspection tour at the end of 2017, Energy Minister Mustapha Guitouni declared: "Since 2000, the State has invested USD 150 billion in the construction of power plants nationwide. The national production capacity has increased from 3,900MW to now 18,000MW." Algeria's current 10-year plan (2015-2025) calls for an additional 27,800MW capacity increase.

Recognizing the strategic importance of maintenance, Sonelgaz, the state-owned power company, has requested the CMMS to be included in all new projects: EPC companies have the responsibility to deliver all technical data in the CMMS and to ensure the system is used from day one. Siveco China, partner of choice for Asia-based EPCs, was selected to provide the CMMS for contracts awarded to Korean and Turkish construction groups.

Ain Arnat 1200MW Combined Cycle Power Plant
EPC: Hyundai Engineering & Construction (Korea)

Biskra 450MW Simple Cycle Power Plant
EPC: Hanwha Engineering & Construction (Korea)

Boufarik 750MW Simple Cycle Power Plant
EPC: GAMA Power Systems (Turkey)

Jijel 1300MW Combined Cycle Power Plant
EPC: Hyundai Engineering & Construction (Korea)

Oumache 1300MW Combined Cycle Power Plant
EPC: Hyundai Engineering & Construction (Korea)

Kais 1266MW Combined Cycle Power Plant
EPC: GS Engineering & Construction (Korea)

For all the projects, overall program management, project management, system configuration and data engineering services are performed by the Siveco Shanghai office, while a certified partner in Algeria provides training and long term support. Thanks to the successful track record, Siveco is already pre-selected as the CMMS supplier for all upcoming projects in the country.

Ensuring maintenance readiness at Fushun Mining Group's ATP project

Fushun Mining Group ("FMG") is a large state-owned mining company located in Fushun, Liaoning Province, China. The corporation consists of about 30 companies focused on coal mining and oil shale processing, with a total of around 28,000 employees. FMG is one of the world's largest oil shale producers: it owns 3.5 billion tons of geological reserve for high grade oil shale, of which the exploitable reserve is 560 million tons. The company operates the largest oil shale plant in the world consisting totaling 220 sets of Fushun-type retorts, with annual shale oil yields of 330,000 tons. In this process, finer particles of oil shale are discarded, resulting in waste and environmental pollution.

To make full use of resources, FMG invested 800M RMB to build the first Alberta Taciuk Processor (ATP), designed by a Canadian subsidiary of ThyssenKrupp Technologies to treat small-size oil shale that can't be processed in Fushun retort with a capacity of 6000 tons per day.

From construction to maintenance, specific challenges

ATP construction started in early 2006 and was completed in 2010. Commissioning took several years to complete until late 2012, reflecting the great complexity of the facility. FMG's management team, recognizing the maintenance challenge presented by the new plant and its imported technology, decided to tackle the problem and contacted Siveco. China's largest maintenance consultancy, Siveco is known to have pioneered the concept of implementing maintenance systems during the construction of a plant, thus supporting start-up and enforcing good maintenance practices from day one.

Typical plant documentation and maintenance preparation challenges, met in construction projects all over the world, tend to be exacerbated in China, where operators lack the long track record of their Western counterparts. In addition, greenfield projects in China often present specific challenges, as for the ATP plant its uniqueness, size and complexity.

FMG also realized that simply cutting and pasting a Western management model would not work in China. Foreign engineering companies involved in Chinese projects, especially those lacking local experience, often fail to recognize the specific needs, strengths and weaknesses of Chinese maintenance team, and get bogged down in misunderstandings. Siveco, with its in-depth knowledge of "maintenance with Chinese characteristics" was a good match for this project.

Building the maintenance system

FMG hired Siveco to implement the new plant's maintenance management system in time for startup. The contract was signed in June 2012 covering the maintenance system itself, as well as start-up assistance to ensure smooth handover from commissioning to operation.

Specific goals for the project included:

- Building a complete plant database, to avoid omissions or mistakes in the transfer of technical documentation from construction to maintenance.
- Ensuring work safety, through strict operating procedures and tracking of employees' qualifications and licenses.
- Enabling feedback from event and failures (symptoms, failure, actions, etc.), in order to create usable historical records for improvement purposes.
- Implementing the preventive maintenance strategy from the first day of the operation and developing good habits of regular analysis.

To achieve these objectives, Siveco implemented a maintenance management system (CMMS), integrated with a documentmanagement system (DMS) and a mobile solution for

> **This project provides critical support for the long-term operation of this technologically-complex plant by our local team.**

plant inspections. The Siveco project team provided maintenance engineering services onsite, working alongside the ATP maintenance team for a five-month period, until the system was put into use in December 2012.

ATP implemented Siveco's mobile solution bluebee® "for the worker of tomorrow" to support daily maintenance work

The maintenance system, ready for startup

By the end of the project, FMG's objectives were achieved:

- The plant was fully documented in the CMMS and DMS, including equipment structures and related documentation, technical specifications, spare-parts lists, contracts, standard work instructions, etc. The entire database was built on standard coding rules, allowing quick retrieval of information.
- The system provides full support and traceability of work procedures: maintenance work orders, work permits, inspections. The bluebee® mobile solution, used for plant inspections, enables strict supervision of field work through scanning of barcodes and onsite data capture, without having to rely on paperwork.
- The work order system ensures incidents and work done are reported in a structured manner, to form comprehensive and usable historical records. The planned maintenance system allows automatic generation of preventive maintenance schedules and an assessment of their execution.
- Finally, Key Performance Indicators (KPIs) and analysis reports were defined in the system, to support the maintenance team's regular review meetings. Reports comply with the international standard *EN 15341 Maintenance Key Performance Indicators*.

According to Director Sun Yongshu:

> "Our maintenance system covers both the front-end (technicians working onsite) and the back-end (technical management team). Already considered a milestone in the industry, this project provides critical support for the long-term operation of this technologically-complex plant by our local team."

Operational Excellence & Continuous Improvement: Baosteel Gases Excellence Maintenance Management system goes on-line

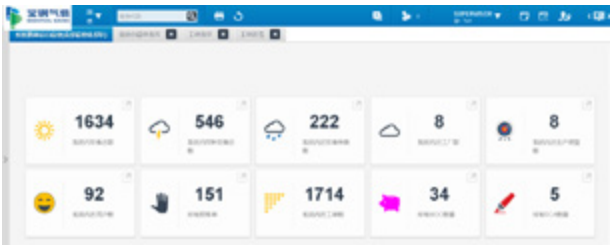
This article was first published in Baosteel Metal magazine "VISION" P7-10. Author: Chen Yi, Baosteel Gases.

In April 2016, Baosteel Gases selected Siveco's Coswin 8i for their Excellent Maintenance Management System (EMMS) project, aimed at strengthening the company's reliability and maintenance excellence program. Its first phase, to establish a maintenance "core model" with guidelines applicable to all sites, was completed in June. The system went live on the first pilot site in July .

At the end of July, after about a year of careful preparation, Baosteel Gases' Excellence Maintenance Management System (EMM) was officially put into use in the first pilot plant of Hefei Baoxin Gas. This event marked the transition of Baosteel Gases ASU (Air Separation Unit) business from a paper-based disparate management approach to a computerized and standardized management system.

Baosteel Gases initially established its "Operational Excellence & Continuous Improvement" concept to ensure high reliability and stability in plants operation. However, to more effectively achieve this goal, a management system or platform was needed to support and promote the concept. This is especially true for Baosteel Gase, with its "headquarters + subsidiaries plant" model: how to ensure its execution, implementation, feedback in the daily management and operation of the various subsidiaries? Based on this, Baosteel Gases began to deploy the EMM system.

Nowadays, advanced, large-scale companies at home and abroad, all have their own customized management system, SAP or CMMS systems. Its main purpose is to standardize and solidify the company's daily operation and maintenance process, rather than staying with paper-based management. Over time, large amounts of operational data accumulate, also known as "Big Data", enabling a PDCA feedback loop and long-term optimization, to ultimately achieve high reliability.



Baosteel Gases EMM system

Based on the PDCA feedback loop concept, Baosteel Gases EMM system is currently composed of 5 modules:

Standardized equipment database: standardized equipment hierarchy, equipment types and their main components, equipment, technical specifications and preventive maintenance work libraries.

Workflow and reporting: daily routine management processes and tracking, daily preventive maintenance work order processes, and various associated KPI data reports.

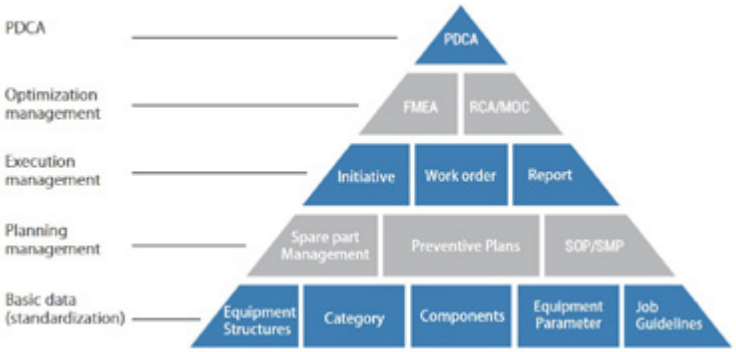
FMEA (Failure Mode and Effect Analysis): components failure mode analysis, management of equipment types and components, and the actual management of the fault analysis process.

MOC (Management of Change): management of plant and equipment modifications, approval process for changes, and the associated equipment database.

RCA (Root Cause Analysis): handling and tracking of root cause analysis procedures for failures, and the associated technical database.

> Thanks to the preventive maintenance plan, most of the work to be done at the plant each year is defined.

Overall design of the EMM system



Baosteel Gases EMM innovation

Innovative integration of management tools: at present large domestic and multinational companies utilize CMMS, RCA, FMEA and MOC tools, but those are usually separate software packages. Baosteel Gases' EMM system, on the other hand, took all tools and functionalities into consideration from the design stage, realizing them in one single platform rather than separate systems, providing comprehensive data support for the group's overall management and optimization.

Standard FMEA for equipment categories and components: while most of plants in China perform FMEA at equipment level, Baosteel Gases does it more accurately at main component level. The theoretical FMEA is linked to the actual fault diagnostics (PDCA module) in work orders, thus the actual diagnostics can validate the FMEA definition and help improve it.

Innovative standardization: Baosteel Gases ASU division operation team carried out extensive work, reviewing and analyzing the current daily operation and maintenance practices, preparing a unified standard applicable to the various subsidiaries, standardizing data preparation requirements, such as equipment types, technical parameters, etc. Finally, maintenance processes were standardized in order to facilitate unified, advanced, practices for both old and new plants.

Group deployment: Baosteel Gases considered group deployment from the inception of the project, unlike traditional site-by-site deployment, taking advantage of Big Data analysis and standardized management to smoothly promote the project.

Benefits for Baosteel Gases operations

- Clarify work in the plant: we often wonder why some of the company's employees are very clear about what to do, how to do, why do it, with a strong sense of initiative. Through careful observation and analysis of the best companies, you can identify a basic management system driving behaviors and processes.

With Baosteel Gases EMM on line, the maintenance staff, daily, weekly, monthly, annual preventive maintenance work is immediately visible: "Who does, how to do, when to do." For operators, work orders, MOC and RCA guide the operation and management processes and their daily tasks.

For plant managers, since most of the work has been standardized and clarified, it is now possible to focus on the major aspects of the plant:

1. Plant annual maintenance budget and spare parts procurement plan: thanks to the preventive maintenance plan, most of the work to be done at the plant each year is defined, with corresponding costs and spare parts requirements, resulting in an accurate plant maintenance budget. The spare parts procurement plan will also be of great help.

2. Track and control incidents in a timely manner: thanks to the fault reporting and RCA process, the causes of each incident are systematically analyzed, ultimately ensuring safe, stable and efficient plant operation.

3. Management and control of plant technical changes: with the MOC approval process managed in the EMM system, there will be a comprehensive support from headquarters, taking safety and cost into consideration, as well as the early technical program review and late document compliance and drawings updated.

- Data and experience sharing: all Baosteel Gases plants use the EMM system and this data is open and shared, so that staff from any plant can view the other sites data and experience, so as to optimize plant operation and maintenance.

“All machines of the same type can be identified across all sites and all plants concerned be notified, thus preventing a safety risk.”

- Continuously improve operation and maintenance of both new and old plants: For older plants where the management system is imperfect based on existing habits, continuous

improvement is a complex task. The EMM system now in place to promote change is conducive to rapid improvement in management level. For new plants, this standardized, shared management platform helps setup the management system quickly and comprehensively to achieve a multiplier effect.

- Bid Data for operation and maintenance: the EMM system aggregates and analyses actual data from all Baosteel Gases subsidiaries, providing objective basis for decision-making and management at headquarters level.

For example, system data may show that a certain manufacturer’s equipment has high failure rate and poor reliability. Related data analysis can be sent to the procurement and engineering departments in order to optimize future projects, thus reducing operation and maintenance costs. In another example, a particular brand of equipment experiences safety problems in one of the plant: through the system, all machines of the same type can be identified across all sites and all plants concerned be notified, thus preventing a safety risk.

Building the Baosteel Gases’ EMM

For multi-site companies that want to launch a new maintenance management system, top-level design and planning need to be carefully considered: how to define the standard database, how to design workflows that match daily operations, how to build a preventive maintenance plan, how to set KPIs, how to extend the system in the future, how to strike the right balance between functional depth and ease-of-use, and how to manage headquarters standards and SOP / SMP files, etc. To achieve this, Baosteel Gases’ operation team at headquarters conducted an extensive implementation study and business process review.

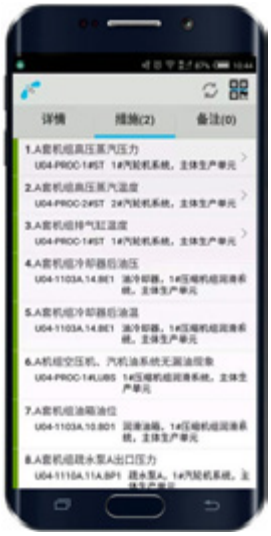
The purpose of project was to solidify all the management file and processes into the management platform. Information Technology is used to ensure that work execution is compliant with standard, with all feedback data stored in the system. The management team is now able to optimize processes and standards by analyzing the data. Thanks to this PDCA approach, efficiency, safety and reliability of plants operation is continuously improved.

Baosteel Gases and Siveco joint team

Digitalizing O&M management at Baosteel Gases plants with EMM and bluebee®

The EMM team of Baosteel Gases won the 2016 Prize for Outstanding Contribution by Baosteel Science and Technology Association for this project.

The author of this paper is Yan Wei, Operation Director at Baosteel Gases.



China's leading industrial gases company, Baosteel Gases is affiliated to Baosteel Metal, a wholly-owned subsidiary of Baosteel Group. The five strategic business areas of Baosteel Gases are air separation, packaged gas, hydrogen, syngas and clean energy. It also integrates supporting competences of R&D, sales, logistics, construction and operation.

Following the EMM system (see case study of the EMM – Coswin 8i implementation at Baosteel Gases on page 35), the bluebee® inspection system was successfully put into use on August 29, 2017. Both are used to manage the maintenance and reliability of the plants, providing strong support for lean operations and closed-loop management. This project opened a new chapter in the digitalization of the plants' maintenance management.

Baosteel Gases totally integrates Reliability and Maintenance in its management model and its daily work, in order to ensure the safe and stable operation of the plants and to provide high quality service to customers, through the EMM and bluebee® electronic patrol system. Based on an approval mechanism defined in the Core Model, the Preventive Maintenance and Inspection plans of each plant need to be reviewed by headquarters before being made available in the system. The EMM then automatically dispatches work orders to the operators' bluebee® mobiles, to guide their inspection patrols, to facilitate problems identification and to ensure timely recording of text, photos or other information directly on the scene. Meanwhile, supervisors will receive and approve work orders in the EMM. A real-time "kanban" screen is available at the operation and maintenance office, so that supervisors can understand the situation in a timely manner and arrange appropriate teams for troubleshooting.

Baosteel Gases has developed a series of specific maintenance modules with the help of Siveco. One of them is the MOC (Management of Change) module. This module facilitates the submission by the plant of complete safety and technical plans for technical modifications.

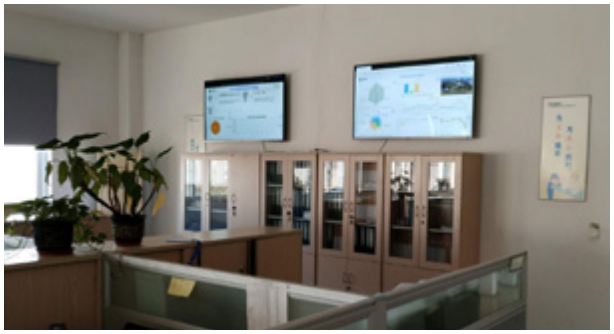
Baosteel Gases has developed a series of specific maintenance modules with the help of Siveco. One of them is the MOC (Management of Change) module. This module facilitates the submission by the plant of complete safety and technical plans for technical modifications. Resulting execution work orders are then followed by professional experts at headquarter, ensuring that new technical projects remain under control. Potential technical issues can be assessed and mitigation scenarios prepared.

In the FMEA module, when reporting repair work, the engineer will record fault diagnosis (symptom, cause and solution for this specific equipment). Based on this data, the plant's reliability engineer will be able to regularly compare his FMEA action plan with the actual equipment failures, thus improving the effectiveness of FMEA from practice. Through the continuous

> The EMM, combined with the electronic patrol system, has now completely replaced the old-style paper-based management.

accumulation of failure data in the EMM system, engineers can also more accurately determine the cause of failure and quickly define the best solution for repair.

After the EMM system went live, Baosteel Gases' reliability team continued to bring new requirements to the Siveco project team, based on system usage. Thanks to the flexible configuration tools provided by EMM, no software development was ever needed, saving both time and money. During the first year of usage, Baosteel Gases independently deployed the EMM to four plants, each with its own user interface and specific needs. The central team gathered suggestions from the plants and reasonable common demands were implemented, for example: repair orders may be directly assigned to a specific technician, but this information can be changed onsite if another person performs the work.



Apart from day-to-day maintenance management, another major highlight of the EMM system is the use of standard reports to analyze maintenance on a monthly basis, from different perspectives: equipment, work, time and others. The system displays visual Key Performance Indicators to help the plant management team gain an intuitive understanding of current equipment maintenance, for example: top ten equipment items in terms of cost, labor, average down time, etc. On the other hand, headquarters manager can obtain macro-level data for benchmarking, for example a comparison across all plants of work completion ratio, inspection completion ratio, preventive plan on-time execution ratio, etc.

The plants and headquarters can query reports at any time, but users also automatically receive reports from the system, on a regular basis, according to their role in the organization. For example plant shift leaders receive a report showing the previous day's exception records (measurements outside normal range, abnormal inspection results, safety issues…); headquarters' managers receive a summary report for all plants.

Staff reviewing reports on big screen

After a year of preliminary research, system implementation, commissioning and other preparatory work, Baosteel Gases electronic patrol system (bluebee®) was successfully put online at Shaanxi Baosteel Gases plant. The EMM, combined with the electronic patrol system, has now completely replaced the old-style paper-based management, low-quality and low-efficiency; information islands have been eliminated; the goal of digitalizing plant operation and maintenance has been realized.

Party for bluebee® going live at Baosteel Gases plant

How Baida Air unified its multisite operations with Coswin 8i

Beijing Baida Air Co., Ltd.

Beijing Baida Air , is a specialized company established in 2010 to supply oxygen to industrial clients using vacuum-pressure swing adsorption (VPSA) technology. This technology can be applied widely in the fields of fiberglass, glass, steel, nonferrous metals, recycled metals, coal gasification, sewage treatment and other industrial applications of oxygen.

Through its strategy of specialization, Baida Air is 100% dedicated to become the leader in VPSA oxygen supply. Focused on providing long-term value based on customers' needs, with a partnership approach to development, Baida Air has already, six years after its creation, invested, built and now operates oxygen plants in Sichuan, Jiangsu, Shandong, Fujian, Jiangxi and other provinces. With plant scale ranging from 1500Nm3/h to 12500Nm3/h (the largest domestic VPSA oxygen supply project), Baida Air has become one of the largest player in the field.

Competing with international gas suppliers, Baida Air has always operated its plants in line with international standards. To ensure high reliability, low energy consumption, smooth operations and other technical advantages, Baida Air has deployed multisite fault diagnosis solutions, supervision systems, maintenance management systems and set-up a reliability technology center, also relying on third-party technical support when needed. The company's reliability and safety in gas operations has passed the most stringent industry tests and been recognized by clients, setting new benchmarks for domestic pressure swing absorption oxygen in terms of management and technology.

Ensuring reliable and safe gas supply, while continuously reducing oxygen cost for customers, remain Baida Air's continuing mission!

The CMMS project

When the project was initiated, Baida Air already had three plants in operation and was developing aggressively in the market. As the company expanded, multisite technical management started to become critical. To fulfill its industrial objectives, Baida Air required an easy-to-expand maintenance management system (CMMS).

After several technical exchanges and visits to reference sites, followed by a formal bidding process, Siveco was identified as the most suitable supplier with its Coswin 8i CMMS. A pilot site was selected: Sichuan Baida Industrial Gas, located in Luojiang, Sichuan province.

Project objectives

The main objective of the project was to build an easy-to-use maintenance management platform for Baida Air multiple sites. The first step was to establish the technical equipment database and related maintenance procedures knowledge base. Then, through the CMMS, to implement and optimize the maintenance plan and to report the various types of work performed in plants. Finally, by tracking on-site equipment operations in real-time, detailed analysis would become possible for technical management and decision making.

All in all, the CMMS must provide technical and managerial support for the following:

- Plants technical database and document management system
- Build up and training of the maintenance team for new plants

> Coswin 8i helped Baida Air achieve its goal of unifying the management of all its plants.

- Maintenance historical knowledge base for technical analysis and diagnosis
- Headquarters' KPIs and reporting system, allowing benchmarking
- Setup and implementation of preventive maintenance

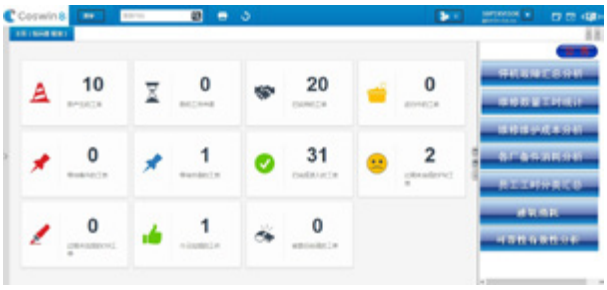
The Siveco project

The project was kick-off on June 18, 2014 by Baida Air technical director and the Siveco project team. On August 25, 2014 the CMMS went "live".

At the beginning of the project, the Siveco team conducted an in-depth implementation study, documented in a group-level "Core Model" for Baida Air. The document describes how the Coswin 8i maintenance management system will be implemented, providing a quick and easy guideline for future deployment and support.

The Coswin 8i platform was installed on a central cloud server, to which all Baida Air plants can access through a secured internet connection.

The project team then guided the data collection process for the pilot site in Sichuan. Data was imported into Coswin 8i, forming an asset technical database to support the daily work of engineers.



Through systematic records of failures and corrective maintenance actions, Coswin 8i gradually builds up a historical database of maintenance for technical analysis purposes.

For preventive maintenance, Baida Air uses Coswin 8i automatic planning functions. Based on predefined templates, the CMMS automatically generates preventive maintenance plans and issues work orders, ensuring rapid and accurate planning.

Coswin 8i system multi-site inventory functions allow a unified management of spare parts. Quantities available in the different plants are visible to all, ensuring optimized stock levels.

Different Baida Air users have different KPIs. Based on work reports from the plants, the CMMS automatically generates KPIs and standard reports on a monthly basis. Baida Air users can view different categories of reports as needed.

Upon completion of the pilot, Coswin 8i was immediately rolled out to all the other sites.

Project results

According to Lu Jun, General Manager of Baida Air:

> "Coswin 8i helped Baida Air achieve its goal of unifying the management of all its plants, providing immediate visibility into organization structures, assets database and spare parts stocks across sites."

Since Coswin 8i was implemented, each plant systematically records maintenance work and receives effective support for maintenance and operation improvement decisions.

During monthly meetings, by reviewing reports such as: reliability analysis, downtime reports, maintenance cost tracking and employee hours, Baida Air managers and engineers can assess the operating condition of each plant and the impact of maintenance actions in a timely and accurate manner.

All project objectives were met.

Future developments

Baida Gas continues to grow its business in Sichuan, Jiangsu, Shandong, Fujian, Jiangxi and other provinces, investing in, building and operating new oxygen plants. Each new plant deploys Coswin 8i to achieve compliance with the group's standardized operation and maintenance, thus ensuring reliable and efficient production.

Storage terminal takes risk & asset management to world-class level with bluebee® cloud

LBC Shanghai Shipping Terminal

LBC Shanghai Shipping Terminal is a joint-venture between LBC Tank Terminals (Belgium) and China COSCO Shipping Group. The company operates a 74,200 m³ bulk liquid chemicals and petroleum products storage terminal in Shanghai's Waigaoqiao area.

The terminal facilities include 62 tanks from 650 to 3,000 m³ capacity for the storage of chemicals, mineral and vegetable oils. Tanks are equipped with heating, cooling, blanketing and vapor recovery. Infrastructures include ten trucking loading bays, five drum filling stations, two 60MT weighbridges, 120MT per day waste water treatment unit, nitrogen system, steam, radar tank gauge, third-party laboratory etc.

In terms of safety, the terminal and tanks are all equipped with foam line and water sprinkler system, all fully automated. Two diesel fire pumps each almost 800 m³/hour taking in fresh water from the Changjiang River. Security is 24/7 with two technicians on duty at the central control room to monitor product temperature, alarm system etc.

Project background

In recent years, due to various accidents in storage terminals, local authorities have strengthened regulations and stepped up law enforcement. Accidents can often be traced to human management and operation problems. At the end of 2016, In order to improve the safety of operation as well as the standard management of facilities and equipment, the top management of LBC Shanghai Shipping Terminal decided to further enhance the terminal's risk management processes.

The company selected Siveco China and its bluebee® solution after an evaluation process including technical discussions, system demonstrations and customers visits. Siveco China, founded in 2004, is the country's largest maintenance consultancy and a pioneer in the development of Maintenance 4.0 technologies, with a focus on mobile solutions "for the worker of tomorrow". Based on long experience of "maintenance with Chinese characteristics", Siveco has developed a unique approach to combining maintenance consulting and software tools, particularly well-suited to the needs of LBC Shanghai Shipping.

Siveco had previous experience working for storage facilities in China, such as Tianjin Shell Petroleum Storage & Distribution, a 200,000 cubic meters oil storage facility located in the Nangang Industry Zone. Siveco clients also include Hanas New Energy (LNG), Baosteel Gases and Baida Air (industrial gas supply) and numerous utilities (waste, water and energy), an experience which LBC Shanghai Shipping Terminal considered highly relevant.

A Software-as-a-Service (SaaS) approach to risk prevention

The project was designed to take the company through all the steps of implementing a sustainable risk prevention management system, in compliance with the *ISO 55000* Asset Management and *ISO 31000* Risk Management standards, with support from Siveco's bluebee® solution.

The terminal's technical personnel would use the bluebee® mobile app on explosion-proof ATEX-certified Android phones,

> **Fault diagnosis information is now recorded systematically, allowing for scientific analysis and improvement.**

also provided by Siveco, and connect to the central management platform bluebee® cloud, operated by Siveco. The solution is provided on a SaaS (Software-as-a-Service) basis, letting the project team focus on critical business processes rather than IT.

As of January 2017, over 1,000 sites are using bluebee® cloud in China, mostly large multisite facility operators.

Staff is using an explosion-proof mobile with bluebee® Android app installed

Project phases

The kick-off meeting held on January 25, 2017. The system was officially "live" on April 26, 2017, meaning that it is used on a daily basis by the terminal staff. This initial project phase is followed by an ongoing continuous improvement phase.

Firstly, the needs of various stakeholders were analyzed, with a focus on HSE and technical management, in order to identify priorities and to establish a "Core Model" based on which bluebee® cloud was setup by the Siveco project team. The Core Model was designed in compliance with the *ISO 55000* Asset Management standard (and its Chinese equivalent *GB/T 33172*).

Followed a data preparation phase, during which the joint project team systematically identified critical equipment, inspections points and tasks, and preventive maintenance plans. QR-coded tags were affixed to equipment, to be scanned by technicians using the bluebee® app.

Finally the system was put into daily use, providing strong guidelines for day-to-day and allowing, thanks to systematic reporting from mobile users, to continuously improve technical risk management and demonstrate progress to the various stakeholders.

The terminal is currently under Enhanced Maintenance Support by Siveco, meaning that Siveco not only operates the bluebee® cloud platform, but also ensures regular visits by maintenance consultants to ensure ongoing improvement.

Overview of bluebee® usage at LBC Shanghai Shipping Terminal

All departments can create incident reports or work requests using explosion-proof mobile devices. Requests must be then be approved by department managers. The system reduces approval time delay and helps establish work priorities for the Engineering or Project departments.

Based on inspections and preventive action guidelines, pre-defined as per regulations, equipment suppliers' recommendations or the terminal's own risk analysis, the bluebee® cloud planning engine automatically creates working plans.

Both corrective and preventive work orders are assigned to relevant personnel and sent to their mobiles, thus highly improving technical staff working efficiency: no more paper forms. QR code scanning, voice records and detailed task reporting in bluebee® handheld devices provide strong evidences that the work is done.

Overall, bluebee® ensures efficient communication between operation, HSE, maintenance departments and top management. It assists in the implementation of daily work and work management.improvement phase.




Based on work feedback, accurately obtained in real-time from mobile users, bluebee® cloud automatically creates monthly management report and performance appraisals. LBC Shanghai Shipping Terminal teams can analyze reports and performance by equipment type, incident type and cause, and other classifications.

Results obtained

The terminal is now actively using bluebee® to optimize its assets management. All technical work is managed in the system, significantly improving the working efficiency of the technical team. Fault diagnosis information is now recorded systematically, allowing for scientific analysis and improvement. Getting rid of the old paper-and-Excel based system meant that the corresponding administrative time could be reallocated to preventive activities. Overall inter-departmental collaboration has been optimized with a beneficial impact on safety.

According to LBC Shanghai Shipping Terminal's General Manager Yuan Xiaolin:

> "bluebee® is helping managers to monitor the condition of facilities and equipment, to identify risks and to track improvement actions. Non-compliance and risk areas are instantaneously reported on mobiles. Data records allow us to demonstrate compliance with the strictest standards and to systematically analyze and improve."

Both Siveco and LBC Shanghai Shipping hope that this project, showing tangible improvement in terminal risk management, using technological tools and good management practices, will help promote further improvement in the industry as a whole. We welcome experience-sharing with other terminals.

bluebee® cloud itself is highly scalable, from one to many sites, allowing sharing and benchmarking between terminals within the same group or even between different companies, while ensuring data security and confidentiality. Some siveco clients already operate several hundreds of sites with bluebee® cloud.

"Achieving better risk prevention in Chinese terminals"

"Achieving better risk prevention in Chinese terminals" was published in the January 2018 issue of Tank Storage Magazine. This article details the experience of LBC Shanghai Shipping making tangible progress towards better risk prevention with the use of a specialised risk prevention management system.

Talk to us at 4006-300-213 or info@sivecochina.com

Other key projects

Siveco is assisting many other infrastructure projects, either state-owned or public-private partnerships (PPP), to implement world-class asset management practices using Siveco's Maintenance 4.0 technologies and specialist consulting services.

Zhongshan Public Utilities Water Company enhances Risk Prevention using bluebee® for patrols

Beijing Enterprises Environment Group started up its Beijing Haidian Waste-to-Energy Plant with Coswin 8i

Tianjin Shell Petroleum Storage & Distribution organized its maintenance around Coswin

Macao's waste management company: Companhia de Sistemas de Resíduos Lda (CSR) deploys Coswin 8i

Engie chose Siveco to support its Distributed Energy JV projects in Sichuan

The largest waste transfer station in Hong Kong: West Kowloon Transfer Station (WKTS) to optimize maintenance with Siveco

Everbright SITA Solid Waste Treatment (Changzhou) implemented Coswin 8i during construction

Hong Kong's largest landfill: West New Territories (WENT) selected Siveco for ISO 55000-compliant Asset Management System

Thanking our 850+ customer sites

Welcome to Maintenance 4.0

The world has known three industrial revolutions and the fourth one is well on its way. Dubbed Industry 4.0, it promotes increased computerization and integration of industrial systems. Maintenance lies at the core of this fourth industrial revolution. Siveco China, founded in 2004, is a pioneer in the development of Smart Technologies for the Operation & Maintenance of infrastructures and industrial plants, with a focus on mobile solutions "for the worker of tomorrow". Rather than replicating a western model, as previous Industrial IT initiatives have done, Siveco is designing new solutions to address the needs of maintenance "with Chinese characteristics".

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