A PUBLICATION OF THE DRESSER-RAND COMPANY

insights

SECOND QUARTER 1998

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Welcome to the first issue of *insights*, a publication of the Dresser-Rand Company. If you have been a reader of “TurboVisions” from Dresser-Rand Turbo Products, you’re already familiar with the concept of this publication. We have now expanded that theme and mission for this new periodical to represent the entire Dresser-Rand Company.

insights will provide features and news from the oil, gas and process industries that are of particular interest to our customers. In this first issue, we present stories ranging from reports from field services regarding DATUM centrifugal compressors, to a unique problem-solving situation with Mobil, to the introduction of Dresser-Rand’s new syn-gas steam turbine. Through real-life case studies and application stories we hope to demonstrate our commitment to providing reliable, highly engineered products, and our expertise in making them perform for you. Technical articles such as “Engineer’s Notebook,” provide useful information to “raise the bar” of advanced technology for the industry in general.

This premier issue of *insights* also includes the first in a series of new trade advertisements for Dresser-Rand. The theme, “Our reliability knows no bounds,” represents our commitment to providing the products, people and support you expect every day, in all parts of the world. These advertisements will be appearing in a number of the industry’s leading trade magazines in the months ahead.

As a publication that now includes customers from all of Dresser-Rand, there may be some duplication in our mailing data base. If you receive two issues of the magazine, we apologize for the error, and ask for your patience as we complete the merging of our lists. For your convenience, we’ve also included in this issue a postage-paid return card to help us accurately bring our mailing list up to date and add any new individuals who you think would be interested in receiving *insights.*

We look forward to your comments on this premier issue of *insights*, and welcome your suggestions on articles for future issues. Please feel free to contact us: Donald K. Kintner, Jr., *Insights* Magazine, Dresser-Rand, P.O. Box 560, Olean, NY 14760 USA, Phone: (716) 375-3000; Fax: (716) 375-3178

candid visions

Editor's Note:

In this issue of "insights" the "candid visions" column is an interview with Dave Norton, President and CEO of Dresser-Rand Company. Norton responds to questions from editors of "insights" regarding the changing global market and the direction of the company.

"One Face To The Customer"

insights: *This is the first issue of insights. How does it reflect your view of presenting one face to the customer?*

Norton: This new magazine is a microcosm of the changes that have been occurring at Dresser-Rand, as we continue to make it easier for our customers to do business with us. As a company, we must take advantage of our ability to leverage our various products and services to the benefit of our customers. Through greater internal integration we can offer our customers better, more thorough solutions to their problems than if we managed our business units as separate entities. Our decision to establish a single sales operation has helped move us closer to that goal. Instead of having multiple Dresser-Rand representatives contact a single customer, we've tried to simplify the process by having customers go to a single contact.

We like to look at this philosophy of "One face to the customer" as more than just the evolution of our company. It is a refinement of the way we deliver products and services to the benefit of customers.

Insights will certainly reflect this one face vision, as each issue will focus on how Dresser-Rand is solving its customers' problems regardless of the specific products or services that were involved.

insights: *Dresser-Rand truly is an international company with a major presence on every continent except Antarctica. What is the sales breakdown between international and domestic U.S.? How do you picture those ratios three to five years down the road?*

Norton: Approximately 70 percent of our equipment is shipped for installations outside the United States. The U.S. market is a very mature market and growth opportunities are limited, however, there are tremendous opportunities in the Asia-Pacific region of the world. To help take advantage of those opportunities, we established a joint venture with Shanghai Compressor Co. in China last year. Other key areas of opportunity for Dresser-Rand will be in Latin and South America, and the North Sea.

We foresee the sales ratios to be very similar to current sales for our business over the next three to five years.

insights: *Petroleum and energy related industries are the dominant forces Dresser-Rand serves. What do you forecast for those industries?*

Norton: Historically, this has been a very cyclical industry. The petroleum/energy industry is currently in the midst of a strong growth period.

Prior to the start of this growth period, which began a few years ago, we had several years of slow growth. We do expect the current growth period to last two or perhaps three years before the industry retrenches.

insights: *Dresser-Rand's various businesses are all fairly closely tied together in the marketplace. What is your outlook on the markets that your various business operations participate in?*

Norton: Our primary markets are strong and we do expect that to continue for the next several years. There will, of course, be unexpected changes as we saw with Asia last year. The upstream markets are expected to hold, but we have seen delays in the Asian downstream business. The South American and European markets remain active. With a recent drop in oil prices, many countries that depend on the sale of oil for the majority of their revenue have announced cut-backs in spending, but it is presently unclear what effect, if any, this will have on D-R.

insights: *Dresser-Rand's steam turbine business participates in a variety of markets that are not common to the other businesses. How do you perceive those markets and the D-R fit?*

Norton: The palm oil industry is usually a very steady customer for steam turbine products. The recent economic problems in Asia, however, have had a somewhat negative effect on this area of our business.

The sugar market remains steady, however, while the power generation market tends to be very cyclical and very competitive.

Our Energy Systems operation also sells to the pump, fan, and mill, as well as to other compressor manufacturers. The diversity of this business base helps to level out the fluctuations that occur in any one specific segment.

insights: *The Dresser-Rand partnership is just over 10 years old. Can you recap the impact Dresser-Rand has had on the marketplace, your employees, and your customers?*

Norton: Certainly Dresser-Rand has had a big impact on the marketplace. If Dresser Industries and Ingersoll-Rand had not decided to come together, there is no guarantee that either of the businesses would be around today. Because they did, thousands of people all over the world have benefited directly through employment. The company also has maintained the leadership achieved by its predecessor companies over the last 100+ years. Dresser-Rand is even raising the standard higher with products like our DATUM compressor line, a true Dresser-Rand product.

Our customers have also benefited in several ways. First, we have given them another quality supplier option in the marketplace. Also, we've maintained and improved upon the technology developed by our predecessors which were all industry leaders. It would have been a true setback for the industry if Dresser and Ingersoll-Rand had allowed those businesses to deteriorate.

insights: Dresser-Rand has sold more than 100 DATUM compressors. How has that accomplishment helped your customers?

Norton: We are very pleased with the enthusiastic market acceptance DATUM has achieved. When we started the DATUM project several years ago, we asked our customers what they wanted in a compressor, and they told us.

By acting on our customers' input, we have let them know that we value them and their ideas. With more than 100 units in production we have been able to expedite the learning curves of the various techniques utilized in designing and manufacturing these machines. Our customers benefit when we are able to share with them process improvements that have a favorable impact on the production of their machines. Those improvements are achieved as we continue to manufacture more DATUM compressors.

insights: Dresser-Rand initiated a number of changes in 1997. Can you summarize their impact on your customers?

Norton: In order to take advantage of the natural synergies that existed between our Engine Process Compressor Division and our Compression Services Division, we merged the two and formed the Reciprocating Products operation. In the same way, we brought together our Steam Turbine and Electric Machinery divisions to form the Energy Systems operation.

By creating common reporting structures in the two new organizations, we are better able to address our customers' needs and implement plans across the organization to satisfy those needs quickly. We also created a global supply chain management function which will allow us to leverage our considerable buying power with our various suppliers and pass those savings along to our customers.

insights: One of your parent companies, Dresser Industries, recently announced its intention to merge its business with another oil field services leader, Halliburton Company. How do you think this will impact Dresser-Rand?

Norton: We see no immediate impact on our business. This is an exciting time for our company. Dresser's and Halliburton's businesses complement each other very well, and the merger of these two companies will result in a clearly defined industry leader with many opportunities for Dresser-Rand. We are optimistic about the future and believe the impact will be positive not only for our business, but for our customers as well. Dresser-Rand is maintaining a "business as usual" approach in its day-to-day routine worldwide. ■

New Steam Turbine From Dresser-Rand Designed For Demanding Syn-Gas Applications

The new Dresser-Rand Syn-Gas Steam Turbine combines reliability and efficiency with high speed and power to address demanding syn-gas requirements.

Dresser-Rand Energy Systems has introduced a new steam turbine for the ammonia and methanol synthesis gas (syn-gas) markets. The turbine operates at high speeds and high powers, while providing the extraction steam at the range of pressures characteristic of these processes.

The production of ammonia and methanol require centrifugal compressors to raise the syn-gas to relatively high pressures at which the reactions to produce the end product are carried out. The compressors require large amounts of energy and the reliability of both the compressors and the driver is critical to the continued productivity of the plant. Because of this, most ammonia and methanol plants utilize steam turbines as the compressor drivers due to their inherent reliability, efficiency, and ability to combine high speeds and high powers in a compact space.

The Dresser-Rand Syn-Gas Steam Turbine is uniquely designed for the demanding performance requirements of syn-gas processes. It is a single-case, controlled extraction turbine, with high pressure and temperature inlet, condensing exhaust, and double extended shaft ends to drive one or more compressors from each end. The overall unit is approximately 11 feet long, 10 feet wide, and 12 feet high, and weighs approximately 100,000 pounds (45,500 kg.) It has a nominal bearing span of 96 inches (2438.4 mm), and has inlet pressure at temperature ratings up to 2000 psig at 1000F. The flowpath consists of a two-stage high pressure section and a five-stage condensing section. The Dresser-Rand Syn-Gas Steam Turbine underwent extensive performance testing at the Wellsville facility which verifies the turbine meets or exceeds the performance guarantees.

"This steam turbine design takes advantage of the most modern design and manufacturing technologies," said George Lucas, Manager, Project Engineering, "We sought to address the challenging combination of high inlet pressure and temperature, along with the high speed and power requirements that are essential for syn-gas processes–while still achieving high efficiency. We are extremely proud of the results."

Dresser-Rand is supplying the complete compression train which includes DATUM compressors for a methanol plant with Qatar Fuel Additives Limited, Mesaieed Industrial Area, Qatar. The unit is expected to ship April 1998, and commence operation mid 1999. The facility will be producing 610,000 tonnes of methanol annually.

Because of the thermodynamic and aerodynamic challenges of accommodating both high pressure and low pressure performance, Dresser-Rand utilized a combination of blades or "buckets" in the flowpath design to produce power.

In the high pressure stages, where most of the power is achieved, buckets are mounted in the disk using axial fir tree roots. The buckets are made from Grade 422 stainless steel for higher strength and temperature tolerance than standard Grade 403 stainless steel. Integrally shrouded blades are used and a trapezoidal damping wire is inserted in a groove machined in the bucket shroud to strengthen the structure. In the final low-pressure section, however, the design needed to accommodate both high operating rotational speeds as well as higher flow during start-up. The solution was the use of long blade lengths made from high-strength titanium. The solid-forged rotor and integral coupling flanges reduce the overall length and weight of the rotor, thereby improving rotor dynamics and serviceability.

For more than 30 years Dresser-Rand has been the world's leading supplier of compression equipment for ammonia plants. "This extensive experience in compressor systems for syn-gas processes gave us a wealth of information to draw upon in drafting the requirements for the design of a high-efficiency steam turbine driver," Lucas said.

Ammonia is the source for most of the world's nitrogen fertilizer. In 1991, the total world capacity of ammonia plants was about 113 million metric tons of nitrogen. By 1996, capacity had increased to about 117. Estimates are that by 2005, global ammonia capacity will be over 126 million metric tons. Methanol is a primary liquid petrochemical that, when distilled to a chemical grade, is a primary building block used in the production of additives for gasoline to reduce emissions, as well as formaldehyde, MTBE, and a wide range of other chemical products. Both methanol and ammonia plants use natural gas as a feedstock.

Dresser-Rand has been manufacturing energy equipment since 1906 with over 80,000 steam turbines sold to customers around the world. ■

Dresser-Rand Contract Compression: Geared for Growth

What began in the early 1970s as just another customer contract option has become a major business segment for Dresser-Rand. For more than 20 years, the company's contract compression projects, in which Dresser-Rand designs, builds, owns and operates a compression facility, has been handled by its Compression Services operation in Broken Arrow, Oklahoma. Now with a presence on four continents and several large offshore stations, Dresser-Rand is moving to aggressively expand its contract compression business even further.

"Dresser-Rand has enlarged the umbrella of resources dedicated to contract compression in order to take advantage of all the opportunities out there," said Tom Gamble, president of Dresser-Rand Reciprocating Products, which includes the Compression Services Operation as well as the newly formed Extended Services Operation in Houston. "We have been doing this type of work for years and years, and we finally formalized our organization to include Contract Compression as a primary business segment-to give it the attention it deserves."

Contract Compression was a relatively small project-related business segment until 1987, when Dresser-Rand won contracts for several large portable compression stations on Venezuela's Lake Maracaibo. These Lake Maracaibo "Porta" projects included six jackup rigs which Dresser-Rand converted to compression stations housing reciprocating and turbo compression equipment.

The last two Porta rigs utilized gas turbine-driven centrifugal compressors and are, still to this day, the world's only jackup rig-mounted turbo compression installations.

"Contract Compression really began to grow with the Lake Maracaibo porta-compressor projects back in 1987," explained Von Thompson, senior vice president of the Extended Services Operation. "The initial Porta project began as an 18-month contract for Maraven, a member of PDVSA (Venezuela's state-owned oil company), with Maraven paying only for the gas delivered. With the success of that operation, Maraven renewed the contract rather than opting to buy the equipment and operate the station itself."

Since then, Dresser-Rand's success with contract compression has increased exponentially. Typical contract compression project terms are for five years and call for compression equipment availability guarantees of 95 percent or more.

"We now have over 100 compressor units operating in Latin America alone, with total horsepower nearing 400,000 on that continent," said Don Freeman, Manager of Compression Services International Operations. "With more contracts in the works, we can expect to double the amount of horsepower in service worldwide by the year 2000." This is in addition to traditional contracts in which the customer rents or buys the compressors and hires Dresser-Rand to operate and maintain the equipment and/or run the stations.

The latest units to come on line are for Petrolera Argentina San Jorge in the high desert area of west central Argentina. The project consists of two 1,215 horsepower reciprocating compression units with a discharge pressure rating of 2,959 psi.

The station has been operating since May of 1997 at 98.6 percent of gas availability, with average gas compression over 7 million standard cubic feet per day.

Currently in Argentina, Dresser-Rand is operating nine contract compression sites with 65 units. The largest station is at Loma La Lata, which went on line in October of 1996. Adolfo Lopez-Videla, Compression Services Marketing Manager for Latin America, describes the project, "Dresser-Rand performed the complete station installation, piping, buildings and controls for this four-station project. We manufactured 16 new compressor packages and rebuilt three used packages. The new packages included ten P9390GSI and six L7042GSI engines. The rebuilt units are two AT25GLs and one RDS." Total horsepower is 34,980, with a high pressure discharge rating of 3,600 psi. The equipment is powered by Waukesha natural gas four-stroke engines. Total gas reinjection is 15 million standard cubic feet per day for each of the four stations.

To date, Dresser-Rand's largest contract compression project is for Corpoven, another operating unit of PDVSA, in eastern Venezuela near the town of Anaco. The project involves six turbo compression trains installed in four stations with a total reinjection average of 450 million standard cubic feet per day. The Anaco field is a 30 year old field in which Corpoven wants to maintain production levels of 100,000 barrels per day.

"Nowadays the oil companies want to outsource," Thompson continued, "The customer wants to take a hands-off approach-they don't want to have to invest in the people needed to run the compression stations. Plus, Dresser-Rand has proven to customers that they can make more money letting us run the equipment than they can by doing it themselves. We're the specialists."

Indeed, the savings start the day the contract is signed. The customer doesn't have to foot the bill for the equipment. As a result, no loans are carried on their books. They pay only for the gas on delivery, and fiscally that is borne as a cost of business. Station operating costs, service and repair are Dresser-Rand's responsibility. "The elimination of large up-front expenses and operating headaches are the primary allure of contract compression." Thompson adds.

What got its start in the domestic gas fields has migrated to Latin America, Africa, Asia and Europe, and it is still growing. As Von Thompson commented, "The market for contract compression is really good now, and we don't see it slowing down." ■

Dresser-Rand's Persistence And Advanced Testing Receive Praise From Mobil

In the past five years, four impeller breakdowns unique to a Mobil oil platform off the west coast of Africa lead to a new and improved aeromechanical design, that resulted in special praise from a Dresser-Rand customer.

Special test techniques were developed at the Dresser-Rand Olean facility to resolve the problems incurred at the Mobil OSO oil production field offshore Nigeria.

"We know how important it is to recognize people when they do a good job," stated Pete Rasmussen, senior machinery engineer for Mobil's upstream business. "It's especially important when you're part of a larger team that includes not only your fellow employees, but also people from other companies. We certainly feel that the Dresser-Rand workforce deserves recognition for their efforts. It was a total team effort."

Turbocompressors have been designed, built, tested, and used in the United States for over 80 years. Like any other highly engineered product, the successes and failures have opened up new doors for technological improvements and increased performance. The result is advanced testing processes and a better product for the customer.

Often these advances come as a result of problems in the field. And the Mobil OSO experience backed this up.

One platform at Mobil OSO experienced a failure with a high pressure gas reinjection compressor manufactured by Dresser-Rand. This failure was the harbinger of problems to come.

The facility consists of two low pressure trains, and two high pressure trains. Each train is driven by a power turbine site rated at 26,400 bhp at 5500 rpm. At operating conditions with both trains running, the actual pressure needed at the compressor common injection header is slightly less than design at approximately 5200 psi.

The low pressure trains consist of two compressor bodies with three sections of compression. The high pressure trains also contain two compressor bodies but include a speed increasing gear to run at 10,750 rpm.

Within a few hours after bringing the compressor on line at full load, one of the trains shut down due to excessively high vibrations in the high pressure compressor. Close inspection revealed a major impeller failure in the third stage. The failure appeared to be the result of a severe axial force, and there were some uncertainties in the setup of the antisurge systems.

Dresser-Rand and Mobil engineers agreed that the key to preventing future failures was to obtain better control of the process. Therefore, a replacement rotor was installed, and the unit was returned to operation. After the unit had been in production for a short time, an identical failure occurred in the second train. Surge excursions on the second unit were not suspected to be the cause, as the control system for this train had been established correctly.

This sequence of identical failures resulted in an elaborate series of investigations and testing to determine the cause.

The investigation first focused on possible resonance conditions from interferences with stationary vanes upstream or downstream of the third stage impeller. These intereferences were eliminated, only to have another third stage failure after operating less than 20 hours at full load.

After this failure, it was determined that the next step in investigating the problem was to have a field team visit the site to determine if the problem was at the field itself. The field team, which consisted of representatives from Mobil, Dresser-Rand,

and for an independent analysis, representatives from Southwest Research Inc. (SRI), concluded that the problem could not be determined in the field.

Having experienced three nearly identical impeller failures in the same physical environment, it was evident that the existing impeller design was incapable of withstanding the forces acting upon it. This prompted Dresser-Rand engineers to develop a new, more robust impeller, which was later shown analytically to have both a significant increase in natural frequencies and a significant decrease in stress in the critical location.

Once the compressor was equipped with the new impeller, the unit was placed in operation. After nearly two years and 17,000 hours of operation, the unit experienced a fourth failure. This failure also closely resembled the previous failures experienced by the unit.

When traditional methods of identifying the source of the problem proved to be inconclusive, an extensive test program was initiated in an attempt to identify the forces causing the failures. "The objective of the shop test program was to identify and eliminate the mechanisms causing the compressor to fail," said Cy Borer, senior development engineer at Dresser-Rand.

The comprehensive in-shop testing program was designed to duplicate the site operating conditions for direct correlation of shop test results to the site.

By using Mobil spares, engineers were able to assemble and outfit the compressor with unique instrumentation for the tests. "The dynamic strain gauges and vibration sensors were used to monitor mechanical response," said James Sorokes, supervisor of aerodynamics at Dresser-Rand. "By using these test instruments, we were able to gain tremendous insight into the sensitivity of the rotor to the aerodynamic phenomena." The compressor was installed in a closed loop system on the hydrocarbon test bed at the Dresser-Rand test facility in Olean, New York.

This was the first time Dresser-Rand had ever conducted such an extensive test under full load, full pressure conditions. "We needed to be creative working with various vendors on special seals and other components to come up with new combinations of equipment in order to go inside and measure stress and pressure," Borer said.

After several months of running tests on the compressor, the test program identified the complex problem faced by Mobil and Dresser-Rand. The test program indicated that the problem was related to a pressure field distortion coming from a volute tongue.

The solution to limit the effect of pressure field distortion on the impeller was to assemble a new vane diffuser design. In the fall of 1997, the solution was tested and proved to be effective.

"A tremendous amount of knowledge was learned from this test program regarding the aeromechanical forces acting upon the impellers in a high pressure, gas reinjection compressor operating at near field conditions," said Sorokes. "The information will be used to develop more reliable and accurate analytical methods in efforts to preclude recurrence of these problems in future machines operating under similar conditions."

After four failures on a single platform and extensive testing and analytical investigations, Dresser-Rand came up with a better product suited specifically to the needs of one customer on one application. As a result, Mobil Corporation gave its official thanks to the employees of Dresser-Rand Turbo Products. At several meetings, Mobil representatives thanked Dresser-Rand employees for the time and dedication they committed to the project. Mobil also ordered additional compressors for this installation at the Mobil OSO facility. ■

Ingersoll-Rand Continues To Change

It's difficult to change perceptions formed over 127 years, but that's what Ingersoll-Rand is doing. Most people who have heard of Ingersoll-Rand typically think of the company as a construction and mining machinery maker. That's understandable because, beginning with predecessor companies, Ingersoll-Rand has participated in the world's construction and mining industries since 1871. Today, however, that primary identification of Ingersoll-Rand overlooks the company's tremendous diversification. In fact, the infrastructure end market (involving construction projects such as roads, bridges, airports and dams), represents only 12 percent of the company's overall sales, while the mining market represents four percent of total sales.

Many Dresser-Rand people may remember another side of Ingersoll-Rand, when it was a major supplier to energy-related industries. In fact, as recently as the early 1980s, Ingersoll-Rand derived approximately 60 percent of its sales from the energy sector. Today, the company derives about 10 percent of its sales from energy-related industries (this, of course, does not include Dresser-Rand sales).

Ingersoll-Dresser Pump Company's expertise in the water resources industry is applied at the Hemphill Pumping Station in Atlanta, where eight vertical turbine pumps help meet the city's water supply needs.

For many reasons, Ingersoll-Rand today proclaims itself as fundamentally different from its past. In fact, the company has actively pursued changes over the recent years to become a different company An excerpt from the company's 1997 annual report relates the effect of these changes:

"Through an aggressive, unyielding pursuit of changes over the past four years, today: we are more diversified, less cyclical; we possess a larger portfolio of powerful industrial and commercial brands; we work smarter, more efficiently; we respond to customers faster, with better quality products and services; we are bigger, but more agile in pursuit of growth opportunities; we are more capable of achieving predictable and improving financial performance for years to come."

The most dramatic example of Ingersoll-Rand's change involves the company's restructured business portfolio. Since the beginning of 1994, Ingersoll-Rand:

- made its first hostile acquisition (Clark Equipment, for $1.5 billion);
- acquired Thermo King Corporation (from Westinghouse, for $2.56 billion);
- acquired Newman Tonks, an England-based architectural hardware maker (for $370 million); and
- divested businesses comprising approximately $550 million in sales.

Today's Ingersoll-Rand features a portfolio of worldwide businesses comprising an enviable roster of leading industrial and commercial brands, such as Schlage (locks), Torrington (bearings), Bobcat (light construction equipment), Club Car (golf cars) and Thermo King (transport temperature-control equipment). These, and many other Ingersoll-Rand brands, are positioned as number one or two in their markets.

While acquisitions and divestitures are a key part of Ingersoll-Rand's long-term strategy, other important changes have taken place. For instance, the company formed business development centers in Europe, Asia Pacific and Latin America. These regional business centers have simplified and integrated administrative functions while strengthening Ingersoll-Rand's overall market presence in these important world regions. Also, the company has implemented a worldwide strategic sourcing initiative designed to improve the overall quality of its purchased materials while achieving significant savings.

Another key change involves the manufacturing process. In particular, Ingersoll-Rand has moved aggressively to implement flow manufacturing. This approach to manufacturing shortens the time between the receipt of an order and the shipment of a product to the customer. As a result, the company's plants build products according to actual demand, rather than imprecise forecasts.

The compressed production cycle afforded by flow manufacturing means that orders can be filled more quickly than before, sometimes in hours versus days. Just as this reduces the need to carry excess inventory, the amount of inventory Ingersoll-Rand's distributors and dealers need to hold is reduced, which makes front-line partners financially stronger and more competitive. Also, suppliers are better equipped to schedule production in concert with a plant's activities, which allows them to pass along efficiency-related savings.

Driving all of these changes are two primary goals: to be the customer's supplier and partner of choice and to become more diversified in order to achieve more consistent and improving earnings performance. If six consecutive years of record sales are an accurate reflection, then Ingersoll-Rand's customers are responding favorably to the company's changes. In fact, the company has virtually doubled its sales from the 1993 level.

With respect to the second goal, the company's earnings continue to accelerate, having more than doubled since 1993 while establishing a company record for net earnings of $380.5 million in 1997. In large measure, this earnings performance reflects a diversified business portfolio that allows benefiting from growth opportunities in a variety of markets, and which shields the company from downturns in a few of its markets.

Other key measures of financial success, such as operating income, operating margins, free cash flow generation and working capital, have improved sharply. The company expects to continue this positive momentum, having set a target to achieve 12 to 15 percent average compound growth in annual earnings through the year 2000. Dresser-Rand has been a key part of this strong earnings performance over the years. In fact, Dresser-Rand's success contributed greatly to the decision to create Ingersoll-Dresser Pump Company, Ingersoll-Rand's other joint venture with Dresser Industries.

In many ways, Ingersoll-Rand and Dresser-Rand benefit from their affiliation. Foremost, the combination of Dresser-Rand and Ingersoll-Rand creates a strong presence in energy-related markets, where the two companies support each other in nurturing key customer relationships. In addition, Dresser-Rand's participation in Ingersoll-Rand's strategic sourcing initiative substantially increases the ability to achieve cost savings in purchased materials. Also, the two companies are able to share best business practices making each more efficient.

Ultimately, Dresser-Rand is a strong asset in Ingersoll-Rand's efforts to be a global, diversified manufacturer of industrial equipment and components, and a major contributor to Ingersoll-Rand's ongoing success. ■

A portable air compressor–one of I-R's more commonly seen products throughout the world–receives finishing touches at a Mocksville, North Carolina plant.

Working on a tight deadline, three Ingersoll-Rand compactors and two I-R Blaw-Knox asphalt pavers resurfaced one of the busiest runways at one of the busiest airports in the United States: Newark (New Jersey) International Airport. The units worked virtually nonstop for 15 days and nights, with nighttime illumination provided by 31 I-R portable light towers, to complete the job on time.

DATUM Centrifugal Compressors Receive High Grades For Service

When Dresser-Rand Company introduced its DATUM line of centrifugal compressors in late 1995, the goal was to provide customers with a centrifugal compressor that would excel in reliability, performance, and ease of maintenance. The compressor has out performed expectations, according to reports from the field.

DATUM users are now reporting remarkable short start-up times, reduced maintenance time and improved performance.

Since its introduction, more than 100 units have been ordered worldwide, and there are now more than ten units in operation. Until now, however, Dresser-Rand has not had proven field-service documentation of DATUM advantages.

The response to the DATUM centrifugal compressors has been positive. Most impressive is the reaction centering around the ease of assembly and maintenance due to the modular bundle, the taper bearings, and the polygon fit thrust disc.

One example of how the DATUM compressors are working once in production is illustrated by the feedback from Westlake Petrochemicals Corporation, in Sulphur, Louisiana.

In October of 1997, the first DATUM compressor was shipped to Westlake Petrochemicals. Westlake contracted with Dresser-Rand to supply three DATUM units for its ethylene plant. Dresser-Rand supplied the ethylene plant with three horizontally split DATUM centrifugal compressors. The units were to be used as part of a single process catalytic cracking gas unit.

The response from Westlake to DATUM is impressive. Westlake reported that the past two assembly times, from the beginning of the lift to completion ranged from 10-12 hours. This did not include shop time.

“The unique advantage that the DATUM has over other compressors is that if a customer has a complete spare module, the unit could be overhauled from shut down to start up in less than two days,” said Gerald Whiting, senior field service representative for Dresser-

Rand. "The previous turnaround for a train like this would be at least 14 days, if not longer."

The new taper bearings being used in the DATUM centrifugal compressors are also being well received. Customers report that the new taper bearings are a significant improvement to the standard bearing. The taper bearings are unique in that the crush is controlled by the engineer who is designing the bearing application. This allows the engineer to change the bearing clearance to fit the condition without a mechanical change. Additionally, the taper bearings are easy to remove and install, allowing them to be serviced without removing the entire module assembly.

The polygon fit thrust disc has also received high grades for serviceability. The thrust disc for the DATUM compressor was designed by installing a polygon shaped bore with matching polygon machined integral with the shaft. The polygon shaped bore fits squarely against a precision ground shoulder in the shaft, and is held in place by a locknut.

Due to the radial location being held in place by the polygon shape of the thrust disc, the use of hydraulic tooling is eliminated, and there is no need to use open flame heat in a volatile area.

This principle is currently being applied to the gas seals which will result in shortening the seal installation time by as much as five times.

Dresser-Rand DATUM centrifugal compressors have demonstrated considerably greater ease of maintenance at Westlake Petrochemicals Corporation's ethylene plant in Sulphur, Louisiana

The DATUM line of centrifugal compressors will continue to gain world wide acceptance as more compressors are placed into production. The DATUM compressor began as a concept, and has become the future of centrifugal compressor technology. ■

Turn-Key Controls Retrofit Of Pemex Transmission Stations Makes Pipeline More Efficient

Turn-Key Controls Retrofit Of Pemex Transmission Stations Makes Pipeline More Efficient

by Luis Echegaray, Senior Controls Sales Engineer

In an effort to improve the efficiency of two of its key gas pipeline stations in the state of Tabasco Mexico, Pemex recently contracted Dresser-Rand Control Systems, based in Houston Texas, to retrofit the station controls and 14 Unit Control Panels driving Dresser-Clark compressors.

Key components of the retrofit project included improving the reliability of the gas turbine fuel control systems, improving the compressor surge control systems and adding instrumentation to the stations and the units which allows for more precise monitoring of key station and machinery parameters. In addition to new controls and instrumentation, Pemex wanted one-point accountability for the project. Dresser-Rand responded by providing turn-key services, supplying all the engineering, materials and labor to install and commission the control systems, and a variety of field devices.

The two pipeline booster stations–Jujo and Paredon–are equipped with Dresser-Clark (now Dresser-Rand) compressors driven by Ruston (now European Gas Turbines, Ltd.) TB5000 gas turbines. The units were installed with Ruston control systems in the late 1970s.

Station Control

Both Paredon and Jujo stations were retrofitted with new Station Control Consoles (SCC) which included dual operator interface screens. GE Fanuc Programmable Logic Controller (PLC) based systems provide supervisory control and data acquisition of the units and the stations.

D-R installed Genius Input/Output (I/O) blocks (a distributed I/O system with enhanced diagnostics) in the field as well as in the console panels. "In order to minimize the downtime as well as the installation cost, we agreed that the use of Genius I/O blocks at the equipment was best," said Ted Cossins, Dresser-Rand Project Engineer. "A single set of twisted-pair wires feeds information back (from the Genius blocks) to the PLCs in the station consoles. Approximately 80 percent of the I/O is mounted outside the SCC cabinets, allowing us to monitor the field devices remotely."

Another facet of the SCC design included the use of Ethernet fiber optic communications links to each Unit Control Panel (UCP). Use of fiber optics eliminated the possibility of creating ground loops which can be introduced when physical wire type connections are used.

The units at each of the stations are arranged in a parallel configuration. Load sharing control is provided in the station and unit PLCs to provide maximum equipment operating efficiencies.

Both stations are to be connected to Pemex's district maintenance office through dedicated phone lines with 64K baud digital modems allowing maintenance personnel to monitor the units on a remote basis.

Unit Control

Eight Unit Control Panels were designed for the Paredon booster station, and another six UCPs for Jujo. All are GE Fanuc PLC-based systems for primary control, protection and monitoring of the units. All control and monitoring functions, including fuel and surge control, vibration and temperature monitoring and load sharing are integrated into the PLC.

"The existing unit controls were particularly outdated," said Cossins. "Plus, because of high levels of hydrogen sulfide gases at the sites, the equipment was nearly eaten away. We took extra precautions to protect the new control systems by installing them in specially-designed enclosures which are suitable for corrosive atmospheres."

A parametric flame detection system was designed to replace the existing U/V (Ultra/Violet) flame detection systems which were unreliable due to aging. This system uses all 16 thermocouples to detect flame in the four combustors using an algorithm which identifies discrete temperature increases during the start-up sequence.

Where the original control system used eight of these thermocouples for protection and the other eight for control, the retrofitted system integrates all 16 thermocouples into the PLC and uses all of them for more precise control and protection of the turbine.

The original pneumatic surge control systems were retrofitted with electronic systems using a PLC based algorithm which utilizes a Universal Performance Curve. Dresser-Rand developed and patented this method which offers several benefits when compared to traditional surge control methods. Extremely accurate surge control is provided by defining the surge point over a wide range of gas mole weights and other process conditions.

Several unit field switches used for pressure, temperature and flow were removed and replaced with transmitters. New vibration transmitters and additional thermocouples were also added. This additional instrumentation allows the operator to control and monitor the equipment more effectively which results in more efficient control of the units and the stations.

The unit and station operator interface systems are standard Windows NT, Pentium processor-based systems with color monitors and high-resolution graphics. The graphical interface software was developed by Dresser-Rand engineers specifically for rotating equipment and related applications.

"This system provides a window into the machinery to display text and graphic information to control and protect the machinery," added Cossins. "It's a result of years of experience working not only with Dresser-Rand equipment, but other OEM machinery in a variety of applications."

Approximately 50 percent of the unit Input/Output structure is provided using Genius blocks mounted on or near the machinery skid. This configuration saved considerable installation time and expense because one twisted pair of wires can communicate signals that would normally need to be wired back to the PLC using hundreds of separate wires.

Fuel Control System

In an effort to satisfy the requirements of increasing the reliability of the fuel delivery system, Dresser-Rand developed a new and improved Fuel Control Valve Actuator Electronic Assembly.

The original electronics assembly consisted of five circuit boards placed, inside an explosion-proof box on the skid. The new assembly mounts directly into the existing box which minimizes installation costs and maximizes the use of existing hardware.

The assembly connects to existing terminals and receives a 4 - 20 milliamp signal from the Unit Control Panel to operate the fuel gas throttle valve. "The new Actuator Electronic Assembly allowed us to provide improved reliability, protection and performance without having to replace the fuel valve actuator," Cossins said. "While this design was specific to the Ruston TB5000, it could be easily adapted, with little modification, to the Ruston "Tornado" and some "Typhoon" model gas turbines.

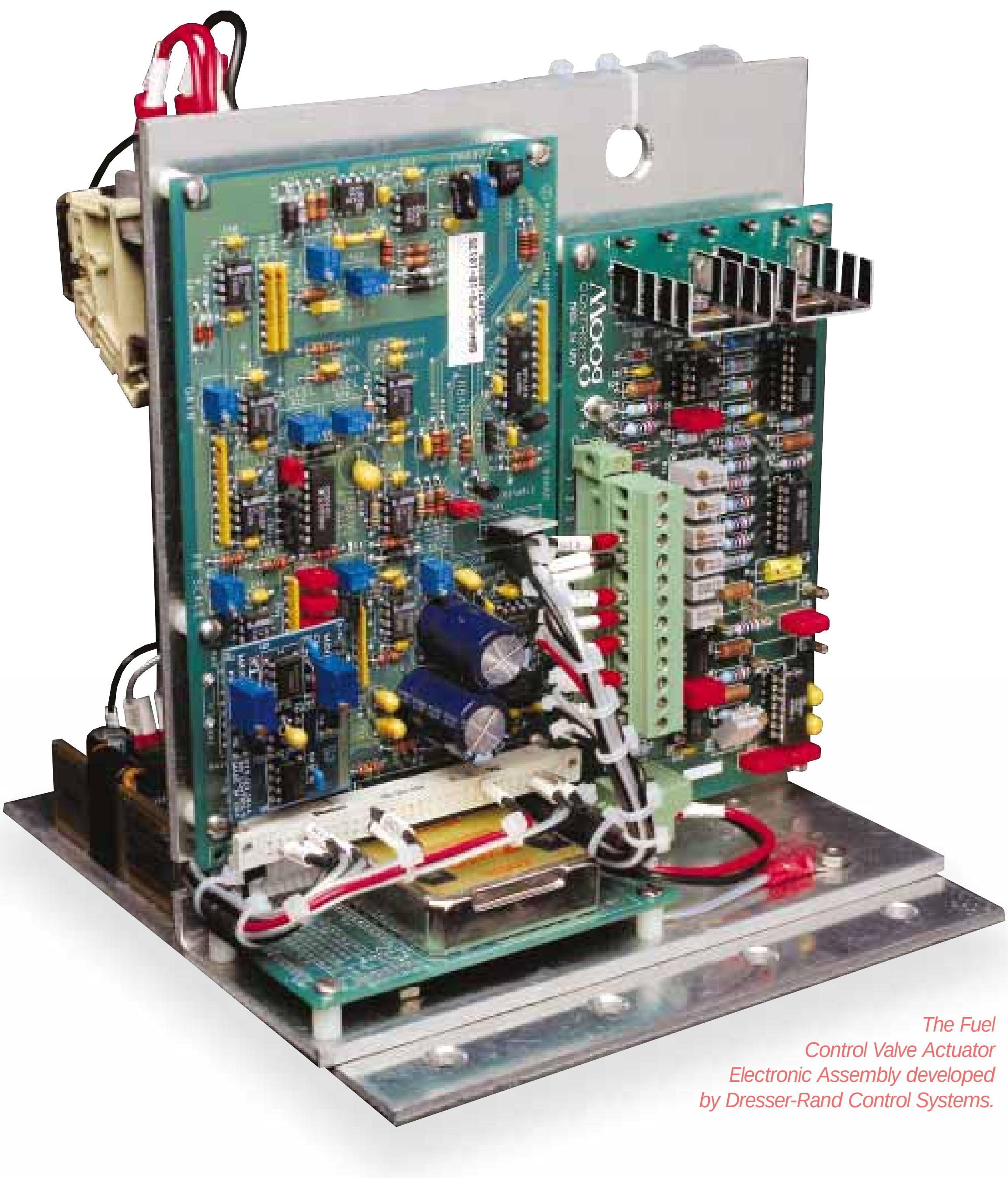
Dresser-Rand provided a modern, size-34 stepper motor, and re-configured the motor phase windings to increase the torque provided by the valve, which will significantly reduce the incidence of seizing due to contaminants in the fuel.

Conclusion

This retrofit project is the latest in a long line of on-shore and off-shore projects that Dresser-Rand and Pemex have collaborated on during the last several decades. "Dresser-Rand's experience with retrofit applications was a key to this project," Cossins added.
"It comes down to problem-solving for a unique set of requirements, and having the technical expertise to address them effectively."

The unit and station control systems are projected to be fully retrofitted at Jujo and Paredon by May of 1998. Remote connections from the stations to the Pemex district maintenance office are expected to be completed by the summer of 1998.

Installation of the new control systems and instrumentation has helped to ensure that these stations, with their 20-year-old equipment trains, will continue to operate reliably and efficiently for years to come. ■



The Fuel Control Valve Actuator Electronic Assembly developed by Dresser-Rand Control Systems.

profile: Tony Fullen

Tony Fullen Embraces Anytime, Anywhere Concept Everyday

Tony Fullen

Dresser-Rand Field Service Representative

Singapore

When Dresser-Rand Services wanted to capture the essence of its commitment to do whatever it takes to satisfy its customers, it adopted the phrase "Anytime, Anywhere." This focus has been embraced by Dresser-Rand employees worldwide, and one of the best examples of this attitude in action is found in D-R field service representative Tony Fullen.

Living up to this commitment everyday is not easy. It takes special people to fill the role of a 24-hour-a-day, on-call field specialist at Dresser-Rand. Tony is just one of those special people.

When a customer experienced a compressor failure which resulted in the shutdown of their entire refinery, it didn't take Tony long to realize this problem required immediate personal attention. Soon after, Tony was on a plane from his home in Singapore and headed to Taiwan.

In June of 1996, the Chinese Petroleum Company (CPC) refinery located in Kaohsiung, Taiwan, experienced a problem with a Dresser-Rand axial flow air compressor. The compressor, which provides air to a reactor, overheated, and it was severely damaged. This forced the entire refinery to shut down.

A local D-R competitor contacted the customer first and offered to assist in the repair of the unit. The competitor told CPC that their solution would require remachining the compressor case, and replacing the damaged rotor and stators with the customer's spare parts at a cost of more than $150,000 U.S. dollars. But worse, this repair would require the refinery to be off-line for at least three months.

This unscheduled downtime would certainly result in a major loss of income for CPC.

Jack Lee, a Dresser-Rand agent based in Taipei, Taiwan, was informed of the problem and immediately contacted Dresser-Rand offices in Singapore and Olean, New York. He met with Tony upon his arrival in Taiwan and they went directly to the job site where they met with CPC representatives.

"The customer explained that just prior to the compressor shut down, the case was glowing red," Fullen said. "After inspection later, it was obvious that the intake air filter housing was completely destroyed." At that time, Fullen was not 100 percent certain what caused the damage to the compressor, but the customer believed that the problem may have been with the check valve in the compressor discharge line. "If the check valve was the problem, it could have allowed hot gas to flow back into the compressor."

Over the course of three days, Tony had evaluated the damage to the compressor, which was severe. He believed he could make the compressor run again with a change-out of the compressor rotor and stator assemblies, which the customer had in their inventory.

Tony's real challenge now was how to establish acceptable running clearances on the axial compressor, whose case was warped due to the overheating that occurred during the failure.

Over the next three weeks, with the help of CPC engineers and mechanics, the compressor overhaul was completed, and they were able to confirm that they had acceptable running clearances for both hot and cold conditions.

"Solving a problem like this one requires teamwork. Good support from everyone involved–the customer, Dresser-Rand engineers and Jack Lee–made the challenge of correcting the problem in a short time period possible," Fullen said. "The customer didn't have three months to wait for the problem to be solved. In fact, we had the compressor running efficiently at the end of the three weeks, and to date, it is still running efficiently."

CPC was so impressed with the quick response and quality of Dresser-Rand's service and support, that they decided to order a new spare rotor and new stator assemblies for the compressor.

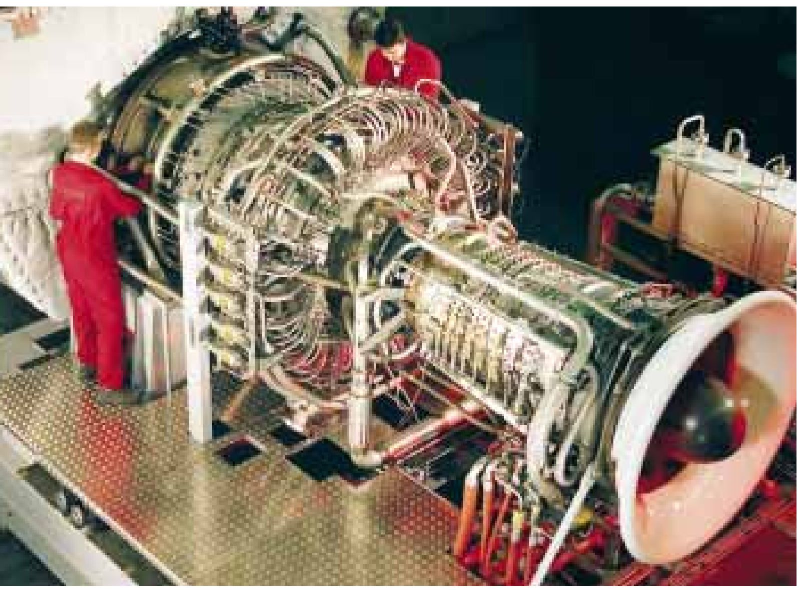
Achieving this level of customer satisfaction didn't go unnoticed internally either. The D-R Services Quality Team was equally impressed, and demonstrated their appreciation by selecting Tony as a winner for a 4th Quarter D-R Services Turbo Recognition Award. "We selected Tony for this award because he demonstrated the 'Anytime, Anywhere' spirit exemplified by the Services Division," said Mike Bunce, Director, Turbo Product Services.

Tony and his wife live in Singapore. He has worked for the company for 18 years. ■

VECTRA-40 Power Turbine Passes Development Test Program

When Dresser-Rand Company introduced its VECTRA-40 line of power turbines to the industry in 1996, the goal was to provide customers with a power turbine that would excel in ease of assembly, disassembly, and minimize downtime.

Engineers ran two engines on the VECTRA test stand, which is located at the Dresser-Rand facility in Olean, New York. This test stand is dedicated to the VECTRA power turbine line and all of the required testing for the power turbines is conducted at this facility.



At Dresser-Rand's Kongsberg, Norway plant, this VECTRA-40 power turbine and GE LM2500+ were prepared for packaging and shipment to Transco. The unit is one of five purchased by Transco for installation at three gas pipeline sites in the United Kingdom.

A new series of sophisticated, expanded testing clearly demonstrates that the goals have been achieved. As part of the test program, Dresser-Rand engineers installed 734 items of test development instrumentation. This was in addition to the standard instrumentation in the turbine package and on the test stand equipment.

The test cell is unique because of the new data collection system that allows engineers to monitor over 1,100 pieces of instrumentation simultaneously and record data in five second intervals. All of the information is stored in a database that is immediately accessible for analysis.

The first engine tested, was a production configuration, and it ran for 42 hours and 37 starts. The second engine was a highly instrumented unit that ran for 76 hours and 59 starts.

"The units were successfully run at all types of operating conditions at varying speed and power," said Bruce deBeer, Manager, Gas Turbine Engineering for Dresser-Rand Turbo Products. "The results from the strain gauge blades were positive. Stress levels were very low and no blade resonance frequency problems were encountered."

After conducting the tests, a few design modifications were made to the power turbine. The diameter of the balance piston was increased to reduce the thrust bearing load. In addition, the flow area of the first stage vanes was reduced slightly to better match the GE LM2500+ gas generator, with which the VECTRA was designed to operate.

Five VECTRA-40 power turbines and corresponding 70 PDI pipeline compressors have been manufactured and sold to Transco Bg plc for installation at three gas pipeline sites in the United Kingdom.

"The first unit for Transco has been tested with all the design modifications and the performance of the unit has met expectations and equals predicted values," deBeer said. The second unit for Transco has been manufactured and is in the test cell at the Olean facility. The third and fourth units are being assembled. All five of the units are expected to be shipped to Transco by the end of April 1998.

The VECTRA-40 power turbine has a maximum continuous operating speed of 6,500 RPM, and an ISO rating of 40,200 horsepower (30 megawatts) at maturity with a GE LM2500+ gas generator. It is the highest speed power turbine available for use with the LM2500+.

The advanced modular design of the VECTRA-40 power turbine makes it a lighter weight than earlier designs of power turbines. The VECTRA-40 was designed to be installed and removed as a unit, either separate from, or with the gas generator. This makes service and shipping, particularly for offshore and remote applications, easier for the customer.

Another unique design feature of the VECTRA is that unlike most industrial turbines, VECTRA power turbines use rolling element bearings, which are common in aeroderivative turbines, instead of fluid film bearings.

The rolling element bearings reduce frictional losses and heat injection while requiring lowering oil flows. In addition, the VECTRA does not require post-lubrication, or a battery powered pump back-up system for use in the event of a power outage. To simplify installation the power turbine and gas generator use the same oil system.

"While the oil and lube system in the VECTRA power turbine simplifies installation, it also makes operation and maintenance easier for the customer," said deBeer. "The VECTRA only requires six gallons of oil per minute, whereas other power turbines may require approximately 100 gallons of oil per minute to operate. This provides operational benefits as well as environmental ones." ■

engineer's notebook

Subtracting Residual Unbalance For Improved Test Stand Vibration Correlation

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SYNOPSIS

The following is the final installment of a two-part article describing a method of subtracting residual unbalance for improved test stand vibration correlation during unbalance verification testing. The first installment, which addressed steam turbines, appeared in the First Quarter 1998 edition of TurboVisions. In this segment, several examples relating to centrifugal compressors are presented.

CENTRIFUGAL COMPRESSORS

As sent to the test stand, centrifugal compressor residual unbalance will normally exist. For high speed flexible shaft designs, this will include an unbalance distribution that is often sacrificed to some extent at the first critical speed to achieve low vibration levels over the operating range. Thus, sufficient excitation usually exists to easily identify the peak response at the first critical as observed at the probe locations. However, unlike special purpose steam turbines, centrifugal compressors are not required to have externally accessible field balance planes. Most compressor unbalance tests, therefore, are conducted by placing the verification weight at the coupling. Consequently, for flexible rotors with an extended separation margin between the first and second critical speeds, the coupling weight will have little effect on vibration levels at the first critical speed.

Example 4: Three Stage Centrifugal Compressor

First consider the three stage centrifugal compressor illustrated in Figure 16. Pertinent rotor and bearing information are listed in Table 8. This compressor was designed with sufficient separation margins to meet current rotordynamic specifications and, thus, is insensitive to coupling unbalance. The predicted response to a coupling unbalance of 32W/N (where W is the rotor overhung weight) at the coupling end probe is shown in Figure 17. At the operating speed of 13,400 rpm, response levels below 0.1 mil pk-pk are predicted. At the predicted damped first critical speed of 9,000 rpm, the coupling unbalance is shown to have little effect on the response. Consequently, the location of the first critical speed cannot easily be identified in the plot.

Figure 18 presents the coupling end vibration of this compressor in the as balanced condition. Clearly, the first critical speed is easily identified. A well damped first peak response near 10,000 rpm is evident. With the placement of the 32W/N verification weight on the coupling, the Bode plot of Figure 19 was produced.

The first peak response speed remains clearly evident. However, any increase in the vibration level at the critical due to the unbalance weight is not perceivable.

Now, a direct comparison is made for the three stage compressor between the test stand results of Figure 19 and the analytical results of Figure 17. From Figure 17, the analysis predicts a valley in the response at 11,000 rpm. The test stand results from Figure 19 actually shows a valley near 13,000 rpm.

Clearly, it appears that the analysis (Figure 17) does not correspond to the test stand unbalance plots (Figure 19). This is largely due to the fact that the vibration plotted from the verification test is a result of the verification weight plus the rotor's residual unbalance. This residual unbalance is unknown and cannot be taken into account in the

	Example 4	Example 5
Rotor		
Weight (lbf)	285	1587
Bearing Span L_b (in)	36.0	76.81
Midshaft Diameter D_s (in)	5.25	7.25
L_b/D_s Ratio (dim)	6.9	10.6
Field Balance Planes	No	No
Bearings		
Type	Tilting Pad	Tilting Pad
Journal Diameter (in)	2.5	5.0
L/D Ratio (dim)	0.45	0.46
Projected Load (psi)	50.6	69.0
Bearing Clearance (mil)	4.0	8.0
Number Shoes	5	5
Pivot Offset	0.5	0.55
Load Orientation	Between Pad	Between Pad

Table 8 - Centrifugal Compressor Rotor and Bearing Information.

analysis. Furthermore, the results would be unchanged by the size of the coupling unbalance since the test weight used did not affect the vibration level at the first critical speed.

The effect of the verification weight can be isolated by subtracting the as balanced vibration (Figure 18) from the verification test vibration (Figure 19). Figure 20 presents the result of this residual unbalance subtraction for the three stage compressor. Notice that the peak at 10,000 rpm is replaced by a valley near 11,000 rpm, as predicted by the analytical results of Figure 17.

Example 5: Eight Stage Centrifugal Compressor

Finally consider the eight stage compressor illustrated in Figure 21. Rotor and bearing information are listed in Table 8. This compressor also was designed with sufficient separation margins to meet current rotordynamic specifications and, thus, also is insensitive to coupling unbalance. The predicted response to a coupling unbalance of 32W/N (where W is the rotor overhung weight) at the coupling end probe is shown in Figure 22. At the maximum continuous speed of 11,500 rpm, response levels of 0.15 mil pk-pk are predicted. Furthermore,

Continued on page 18

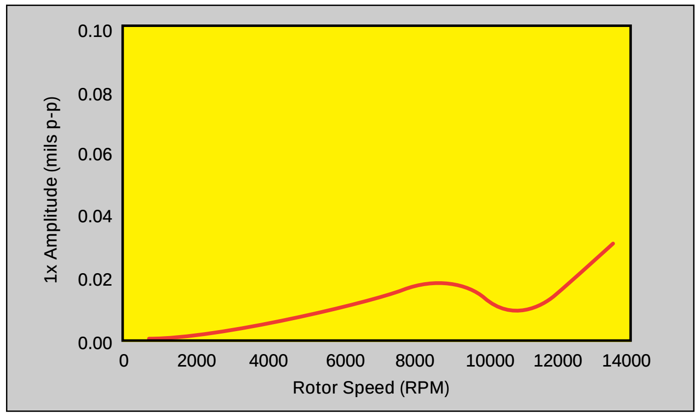


Figure 17 - Three Stage Compressor Analytically Predicted Response with 32 W/N Coupling Unbalance - Example 4.

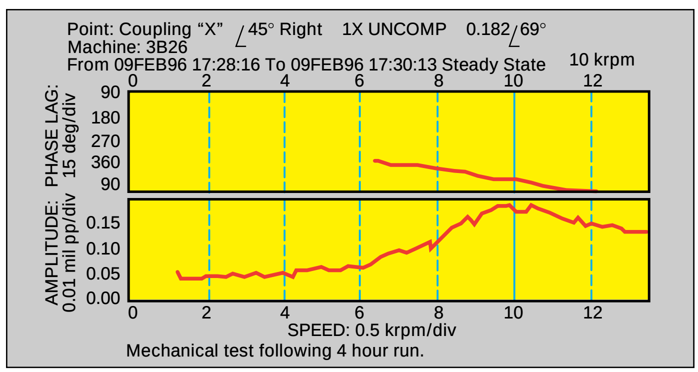


Figure 18 - Three Stage Compressor Actual Test Response with Residual Unbalance - Example 4.

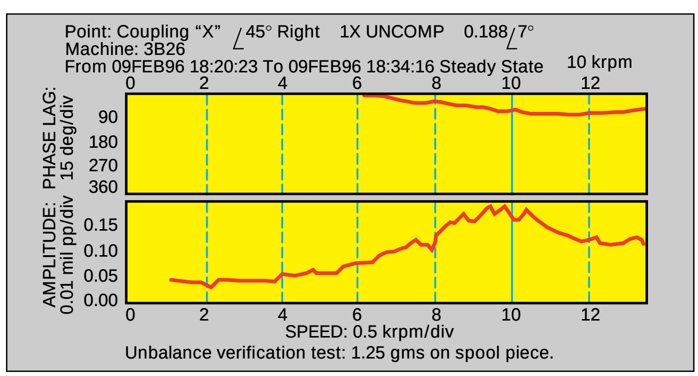


Figure 19 - Three Stage Compressor Actual Test Response with 32 W/N Coupling Unbalance without Residual Subtraction - Example 4.

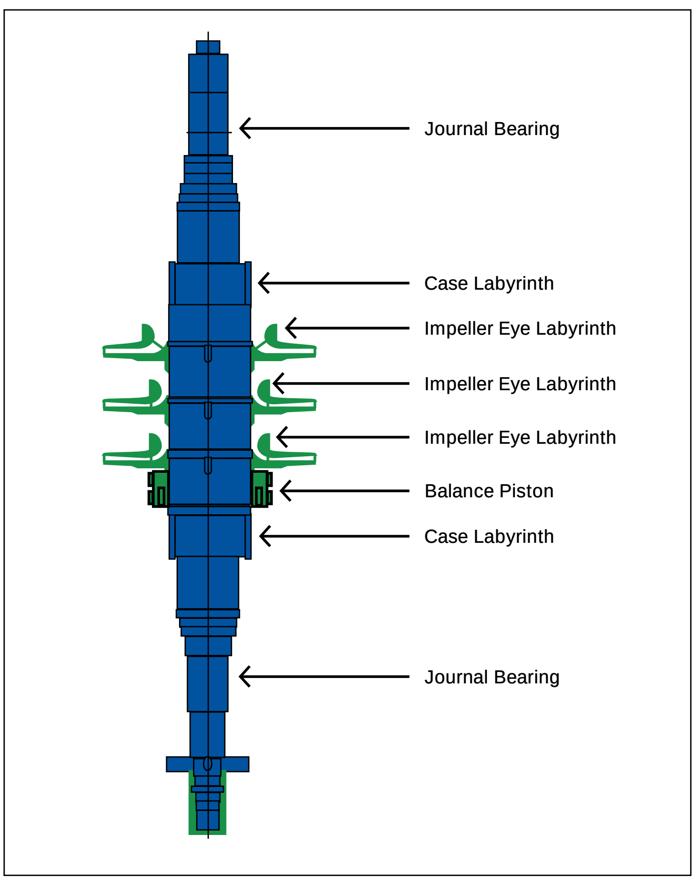


Figure 16 - Three Stage Compressor Schematic - Example 4.

Subtracting Residual Unbalance…cont'd

Continued from page 17

a nodal situation occurs at the first critical speed of this rotor, ie at 3,600 rpm.

The eight stage compressor in the as balanced condition produced the Bode plots shown in Figure 23. Figure 24 represents the compressor's Bode plots with a 32W/N verification weight at the coupling. The response of the first critical speed is easily identified in both plots at 3,700 rpm. However, as before, any increase in the vibration level at the critical due to the unbalance weight is not perceivable. The effect of the verification weight may again be isolated by subtracting the residual unbalance data (Figure 23) from the unbalanced data (Figure 24). Figure 25 shows the result of this subtraction for the eight stage compressor. The 3,700 rpm peak at the first critical that is evident in Figures 23 and 24 is hardly noticeable in Figure 25, as predicted by the analytical results from Figure 22.

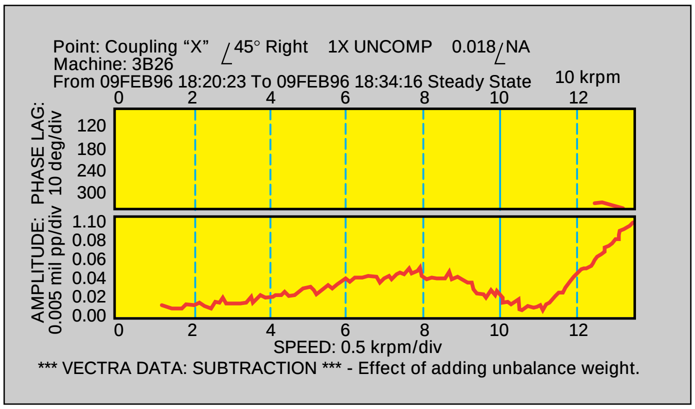


Figure 20 - Three Stage Compressor Actual Test Response with Residual Subtraction - Example 4.

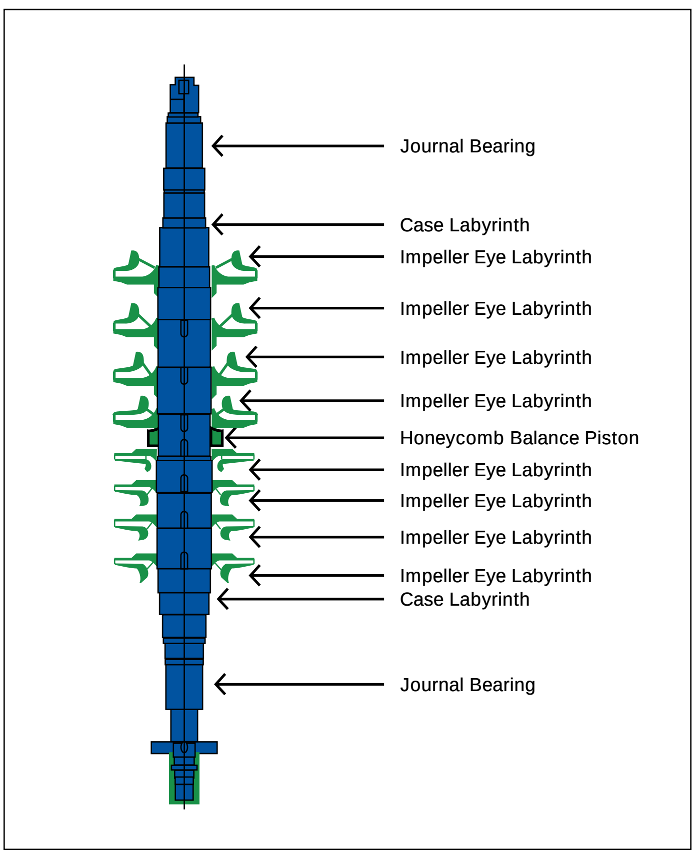


Figure 21 - Eight Stage Compressor Schematic - Example 5.

DISCUSSION

Influence of Residual Unbalance

However small, the residual unbalance inherent in a rotor can influence the correlation of test stand data with analytical prediction. In all of the examples presented, an overall improvement in the correlation of the test stand data with analytical prediction was observed by subtracting the vibration due to residual unbalance. In particular, in the centrifugal compressor examples, the vibration with the unbalance test weight was indistinguishable from the data with residual unbalance alone. This is because the modal influence of the test weight was insignificant when compared to effects of the residual unbalance. In these cases, performing the residual subtraction for meaningful test stand vibration correlation is a necessity.

Influence of Unbalance Location

The location used for placement of the unbalance test weight is a major factor influencing the quality of the test results. Results obtained from an unbalance condition that logically excites the mode in question will always yield superior data. Nevertheless, even in those cases where the modal effect of the unbalance weight is not readily evident, its influence can be isolated by subtracting the vibration due to residual unbalance.

Effect of Probe Location

Clearly, from the examples presented, there always will be some judgement required in the interpretation of the measured data. Even in the case of a relatively rigid rotor supported on soft bearings, there often will be some degree of correlation variation at all of the vibration probes. This not only will be in terms of the location of the peak response speed, but also in terms of the value of the amplification factor.

There are several reasons why this should be the case that, at the design stage, are impossible to include in the analytical model. The primary reason is the unknown distribution of unbalance in the rotor which is indeterminable. Another factor is the influence of the support which often is treated as a symmetric stiffness in the analytical model. In practice, support characteristics are asymmetric and frequency dependent, and can have a significant effect on critical speed. Secondary effects include values assumed for bearing and pad clearance at each journal bearing, and the influence of fluid forces (such as oil and labyrinth seals, and bearing preload resulting from coupling misalignment, aerodynamic and/or steam partial admission.)

CONCLUSIONS

A methodology is presented that can be used to isolate the modal influence of a verification weight(s) for improved test stand vibration correlation. The results presented demonstrate the importance of recognizing the limitations in conducting such tests when unbalance weights cannot be placed to logically excite modes under consideration. In such cases, the modal influence of an unbalance weight can be insignificant when compared to the residual unbalance inherent in a rotor. This effect must be accounted for in the evaluation of the test data to provide any meaningful correlation.

The primary conclusions of this investigation may be summarized as follows:

- There will often be some degree of variation in the location of critical speed and amplification factor as observed at the vibration probes.
- Residual unbalance can have a significant influence on the response of a rotor, particularly at speeds near to or above the first critical speed.
- The degree to which an unbalance test can be correlated with analytical prediction is, to some extent, highly dependent on the location used for the test weight.
- On insensitive designs that are to be verification tested by placing an unbalance weight at the coupling, a limit should be placed on the value of unbalance used to avoid excessive unbalance forces being applied to the rotor.
- At the design stage, it is impossible to include all factors that could influence the test stand response of a rotor. Consequently, it is reasonable to expect some degree of variation in the correlation of the verification test with analysis.

RECOMMENDATIONS

In correlation of the analytical model with the unbalance test, allowance must be made for the fact that critical speeds will vary with probe location, and amplification factors and vibration magnitudes will be influenced by residual unbalance. Without subtracting the vibration due to residual unbalance from the unbalance test, one must recognize that applying stringent acceptance criteria on critical speed, amplification factor, and vibration magnitude can be limited. If the test stand correlation is judged to be unacceptable, the vibration due to residual unbalance should be subtracted and the results compared with analytical prediction.

For a copy of the entire paper, please write, phone or FAX: Dresser-Rand Turbo Products, P.O. Box 560, Paul Clark Drive, Olean, New York 14760, Phone: (716) 375-3990, Fax: (716) 375-3178.

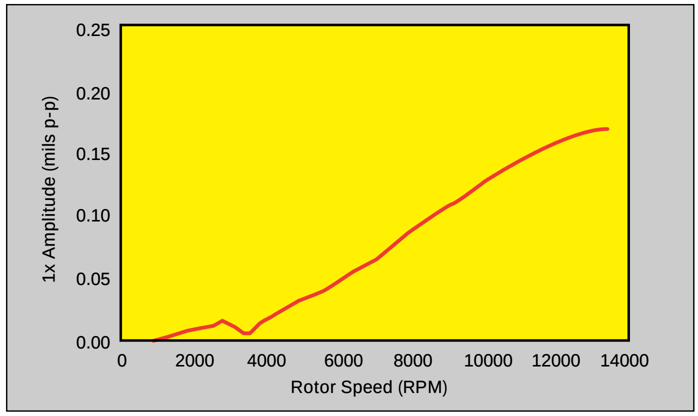


Figure 22 - Eight Stage Compressor Analytically Predicted Response with 32 W/N Coupling Unbalance - Example 5.

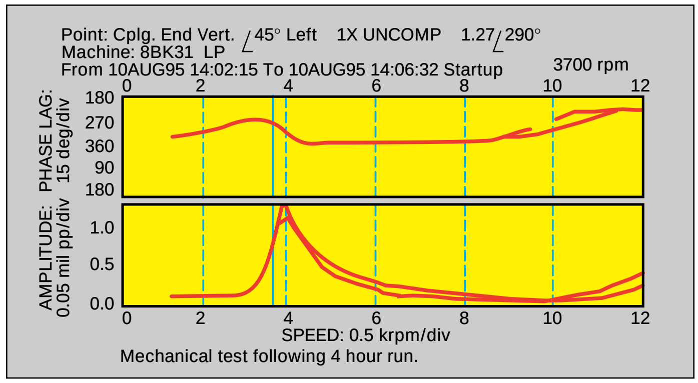


Figure 23 - Eight Stage Compressor Actual Test Response with Residual Unbalance - Example 5.

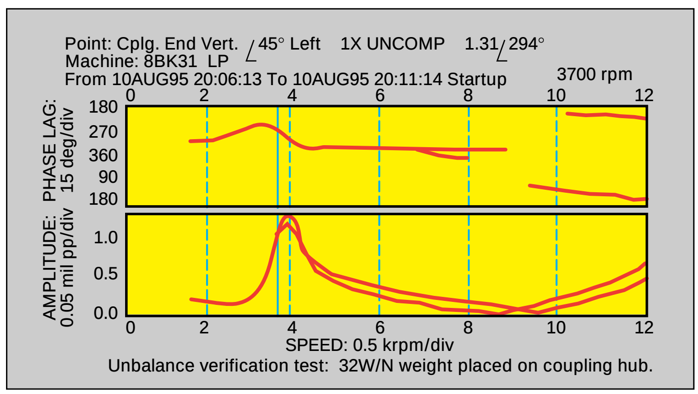


Figure 24 - Eight Stage Compressor Actual Test Response with 32 W/N Coupling Unbalance without Residual Subtraction - Example 5.

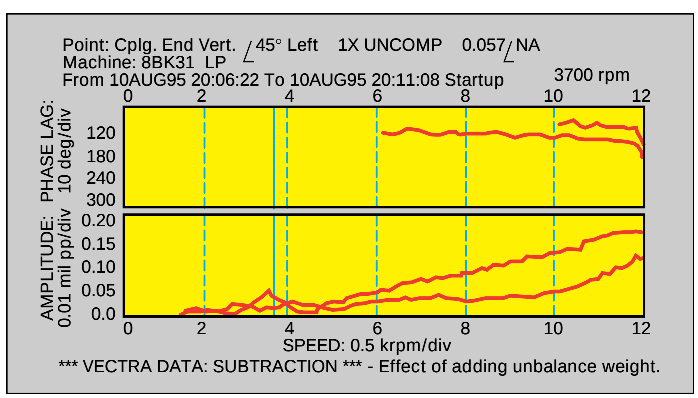


Figure 25 - Eight Stage Compressor Actual Test Response with Residual Subtraction - Example 5.

global visions

Methanex Expands World's Largest Methanol Plant, Picks Dresser-Rand Again For Compression Equipment

PUNTAS ARENAS, CHILE– With its second methanol plant on line for less than a year in Puntas Arenas, Chile, Methanex Corporation has begun construction of a third plant, again using Dresser-Rand Company for compression equipment. Dresser-Rand is supplying the turbo compressors and some of the steam turbine equipment.

The new plant, which will have a rated capacity of 2,800 tons a day, is projected to come on line in 1999. Methanex is based in Vancouver, British Columbia, Canada. The first plant in Puntas Arenas began operating in 1988 and has a rated capacity of 2,500 tons a day. The second plant, completed in December 1996, has a rate capacity of 2,700 tons a day.

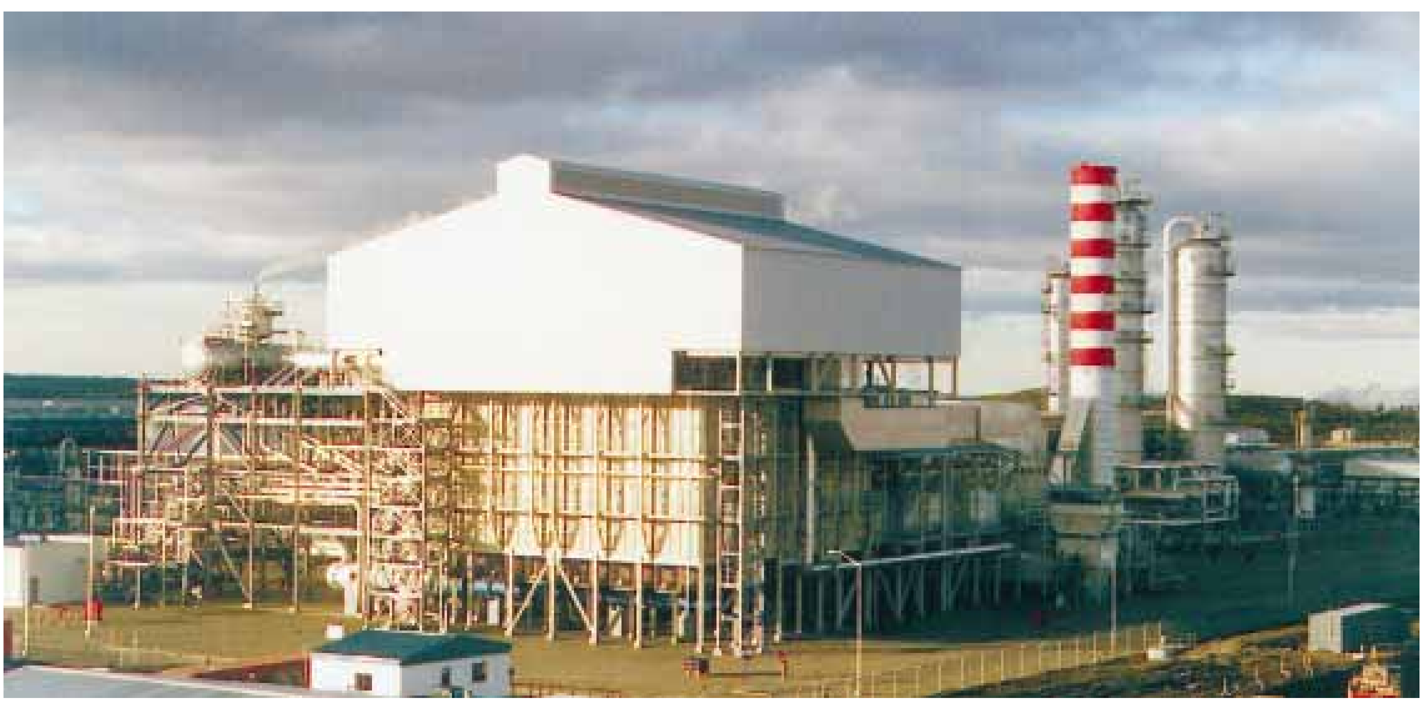
Total value of the Dresser-Rand contract approaches $10 million and includes two centrifugal compressors; a 50 PDI pipeline compressor with a Dresser-Rand steam turbine; and a 6.0 MW steam turbine generator set.

"Clearly, Methanex is pleased with our equipment used in the world's largest methanol production facility," says Larry Richards, of Dresser-Rand. Methanex in July announced that it would add two new ships to its fleet of methanol carriers including the world's largest, a 96,000 MT dwt vessel–to serve its operations in Puntas Arenas.

Processing of methanol has engineering similarities to ammonia production. For more than 30 years Dresser-Rand has been the world's leading supplier of compression equipment for ammonia plants. "Our vast experience in ammonia syn gas compression has helped us in our success in methanol production," Richards explains. "The compression and turbine applications for methanol and ammonia are not dissimilar. They both require high pressure ratios, low molecular weights, and low flow."

Methanol is a primary liquid petrochemical that is synthesized under pressure in a catalytic process, usually requiring natural gas as the feedstock. Methanol distilled to a chemical grade is a primary building block used in the production of additives for gasoline to reduce emissions, as well as formaldehyde, MTBE, and a wide range of other chemical products.

The methanol market may become even larger. Methanex secured the rights for emulsifier technology to blend methanol with diesel fuel for the reduction of particulate emissions. The company continues to promote methanol in the alternative fuels sector, both blended with gasoline and as a neat fuel. Methanex is also promoting methanol as the fuel of choice for fuel cells for power generation and transportation uses. ■



The Methanex facility in Puntas Arenas Chile is the largest methanol producing complex in the world.

EX-IM Bank Guarantees $96 Million For Pipeline In Turkmenistan

The Export-Import Bank of the United States (Ex-Im Bank), has approved a $96 million long-term guarantee to Turkmenistan for the sale of gas compression equipment and related engineering services by Edward L. Bateman, Inc. of Jersey City, New Jersey. Turkmenistan, which is located on the Caspian sea, is bordered by Iran to the south, Afghanistan to the east, and Kazakhstan and Uzbekistan to the north.

The Dresser-Rand Company, with headquarters in Corning, New York, and General Electric Company, of Schenectady, New York, have been selected by Bateman to provide compressors and power turbines for this natural gas pipeline systems upgrade. Bateman Engineering, Inc., of Denver, Colorado will supply engineering services.

"This is the first time Ex-Im Bank has financed an oil transaction in Turkmenistan," said James A. Harmon, chairman of Ex-Im Bank. "Turkmenistan's vast oil and gas sector represent a huge potential export market for U.S. goods and services. Ex-Im Bank believes this is the first of many more infrastructure projects in Turkmenistan that we will finance in the future."

The U.S. manufacturers won this contract over tough competition from Japan, Germany and Italy, according to Chris Schmitt, manager of the Gas Transmission Unit at Dresser-Rand Turbo Products in Olean, New York. "Our business relies heavily on exports and without Ex-Im Bank financing we just wouldn't be able to win these types of orders," said Schmitt.

The pipeline upgrade will allow Turkmenistan to transport and sell natural gas to external markets which will increase the country's gas export earnings and support the future development of the economy. Export credit agencies from Israel and the Czech Republic will also provide financing in addition to Ex-Im Bank's $96 million. The total cost of the project is $180 million.

Ex-Im Bank is an independent federal agency that supports U.S. jobs by financing the sales of U.S. goods and services to foreign markets. Approximately 70 percent of Dresser-Rand's products and services are sold for applications outside of the United States. ■

Energy Systems Division Of Dresser-Rand Names Richard H. Dittmar As Director Of Human Resources

Richard H. Dittmar has been named Director of Human Resources for Dresser-Rand Energy Systems, located in Wellsville, New York.

Dittmar has over 30 years of human resource management experience in manufacturing. For the past 18 years, Dittmar was employed by Kerr Group, Inc., a plastic packaging products company located in Lancaster, Pennsylvania, where he served as Vice President of Employee Relations. Prior to employment at Kerr, Dittmar held various human resource management positions with Indian Head and Ideal Industries, Inc., both of which are manufacturing companies involved in manufacturing glass and electrical products.

Dittmar is originally from Illinois, and is a graduate of Northern Illinois University where he received a bachelor's degree in education. Dittmar currently resides in Wellsville, New York with his wife Janis. ■

Dresser-Rand Names Brian Jordan Manager, Market Research

The Dresser-Rand Company, with headquarters in Corning, New York, has named Brian R. Jordan Manager of Market Research. Jordan will be responsible for assisting with the Company's efforts in the collection, analysis, and distribution of market intelligence in the areas of market and product assessment.

Jordan joined Dresser-Rand three years ago. He held a similar position at Dresser-Rand Turbo Products in Olean, New York.

Prior to Dresser-Rand, Jordan was employed by GE Aircraft Engines and Pratt & Whitney. Jordan graduated from the University of Rhode Island with a bachelor of science degree in mechanical engineering. Jordan also holds a masters degree in computer and electrical engineering from the University of Cincinnati, and is currently completing his masters degree in business administration at St. Bonaventure University.

Jordan is originally from Rhode Island. He now resides in Allegany, NY. ■

insights

Editorial Statement:

"insights" is a periodical publication of the Dresser-Rand Company. Its editorial mission is to inform our readership in the areas of energy industries, as well as business, and world affairs that have an impact upon our mutual concerns. Comments, inquiries and suggestions should be directed to:

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