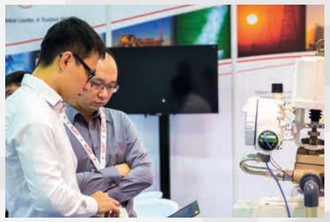
ATPS 2018 SHOW GUIDE

ASIA TURBOMACHINERY & PUMP SYMPOSIUM
SINGAPORE | 12-15 MARCH
SUNTEC SINGAPORE CONVENTION & EXHIBITION CENTRE



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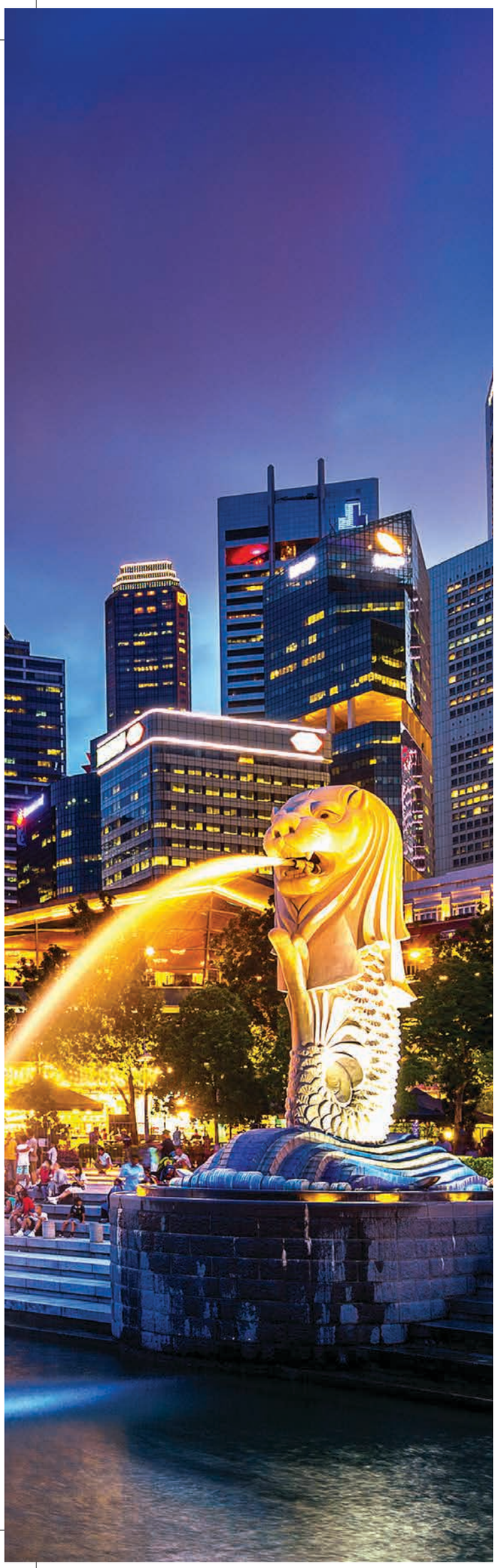

CONTENTS

INTRODUCTION


ELLIOTT
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ACKNOWLEDGMENTS

The second biennial Asia Turbomachinery and Pump Symposium would not be possible without the support of many people and organizations.

Thanks are extended to our Academic Partners; Nanyang Technological University of Singapore, National University of Singapore and Universiti Teknologi Malaysia. These institutions have provided valuable logistical support in organizing this symposium. Students from NUS and NTU are not only participating as delegates to the conference, but are assisting as ushers and greeters throughout the program. Faculty members from NTU, NUS and UTM serve on the ATPS advisory committee as well.

We also thank our association partners, the Korea Rotating Machinery Engineers Association, The Institution of Engineers, Singapore and the Institution of Engineers, Malaysia. These associations have continued to be invaluable partners for ATPS 2018, bringing awareness and delegates to the symposium.

We also are grateful for the Singapore Tourism Board for providing us with support in an effort to make ATPS a continued success.

Thanks are extended to our Silver sponsor, Mitsubishi Heavy Industries. MHI was also a major event sponsor for our inaugural 2016 ATPS. Support from MHI has ensured that we can continue planting roots for this symposium in Asia. We also thank Elliott Group for sponsoring our badge lanyards.

The ATPS Technical Advisory Committee has volunteered their time to oversee the success of the technical program. The committee is comprised of highly-respected engineers from various user and manufacturing companies all over the world. Likewise, the presenters of short courses, lectures, tutorials, case studies, technical briefs and discussion groups are also noted engineering leaders from the commercial turbomachinery community. The ATPS Technical Advisory Committee is greatly indebted to each of these individuals for their many outstanding contributions and active participation.

The Turbomachinery Laboratory, part of Texas A&M Engineering Experiment Station (TEES) and The Texas A&M University System is the organizer of ATPS. The Turbo Lab works year-round to organize the program and ensure the overall success of the Symposium. We would like to acknowledge the ongoing dedication and encouragement of the Turbo Lab, TEES and Texas A&M University in this undertaking, and extend to them our gratitude.


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WELCOME

The Turbomachinery Laboratory at Texas A&M University welcomes you to the second, biennial Asia Turbomachinery Pump Symposium (ATPS) at the Pan Pacific Hotel and the Suntec Conference Center in Singapore (12-15 March 2018). Your participation in this premier technical event strengthens the vibrant workforce and industry to sustain Southeast Asia's growing energy needs.

ATPS follows key elements from our successful Turbomachinery and Pump Symposia (TPS), a world-class technical conference and international exhibition, held annually in Houston. The events, in their 47th and 34th year respectively, have promoted novel developments in rotating machinery equipment and efficient practices in their design, construction, maintenance, and operation. They have also increased substantially the proficiency of thousands of practicing engineers resulting in sizeable business benefits. That legacy also continues with ATPS since 2016.

The program is curated by an Advisory Committee comprised of the most prominent field-experienced and R&D engineers representing the region as well as the rest of the world. They have worked tirelessly to bring you a unique technical program building on our success in 2016 and on-par with both the ATPS and TPS legacies.

ATPS provides continuing education of machinery professional engineers in Asia and beyond, and a venue to deliver state-of-the-art knowledge in compressors, pumps, motors, gas turbines and steam turbines, and systems such as controls, bearings, seals, etc. This is a unique opportunity to learn from leading experts and colleagues as well as see current and emerging hardware in the exhibition. Our program encompasses seven one-day short courses, 17 tutorials and 25 lectures, as well as 39 case studies, 11 technical briefs, and 12 discussion groups. We selected two panel sessions, on digitalization and on industry and career; both current, exciting challenges to explore and leverage for opportunities.

The exhibition floor at Suntec showcases products and support technologies from the largest and leading rotating machinery OEMs. You will meet with manufacturers and service industries to discuss your company's needs and to foster partnerships to promote, use, and improve products. Attending the short courses and technical presentations will improve your professional development and continuing education in energy, power, and aerospace industries. The discussion groups and tutorials will promote technology transfer and peer-networking, in settings where practicing engineers and industrial R&D in Asia will discuss problems and solutions focused on the region.

We are grateful to Mitsubishi Heavy Industries Ltd. as the major financial sponsor of ATPS. Singapore, a bastion of education and research, has welcomed ATPS. We count on the National University of Singapore and Nanyang Technological University and the Universiti Teknologi Malaysia as educational partners. The Institute of Engineers, Malaysia and the Institute of Engineers, Singapore are welcome supporters, while the Singapore Tourism Board endorses our event. Internationally, The Korea Rotating Machinery Engineers Association (KRMEA) is a promoting partner. We are proud of their support and engagement.

We are delighted to welcome all our partners and supporting industries, friends, and colleagues in the oil and gas, petrochemical, power, and other related industries. Help make ATPS 2018 a resounding success!

Dag O. Calafell, II
Chairman, ATPS Technical Advisory Committee
Texas A&M University
College Station, Texas

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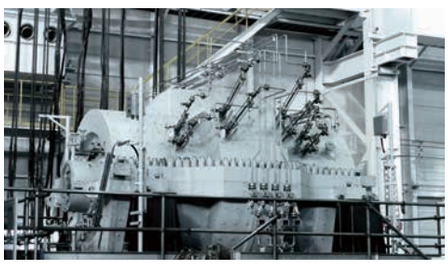

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is complimentary for all delegates
of the Asia Turbomachinery & Pump Symposium.

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Vibration Institute	Vibration Institute
Western Power Summit	4th Annual Western Power Summit

Explore Singapore

While you're here . . . explore Singapore!

Here in Singapore for business? It doesn't have to be all work and no play, especially when after-hours set in and the cityscape transforms into a vibrant feast for the senses.

HERE ARE BUT A FEW THINGS YOU CAN ENJOY:

GARDENS BY THE BAY
Ascend the SuperTrees - vertical gardens of up to 50 meters tall at Gardens by the Bay

SINGAPORE FLYER
Enjoy the sunset, go for a ride on the iconic Singapore Flyer, a giant observation wheel that offers a panoramic view of the city.

CHILLI CRAB
Finger-lickin' good chilli crab from Jumbo Seafood or Red House Seafood.

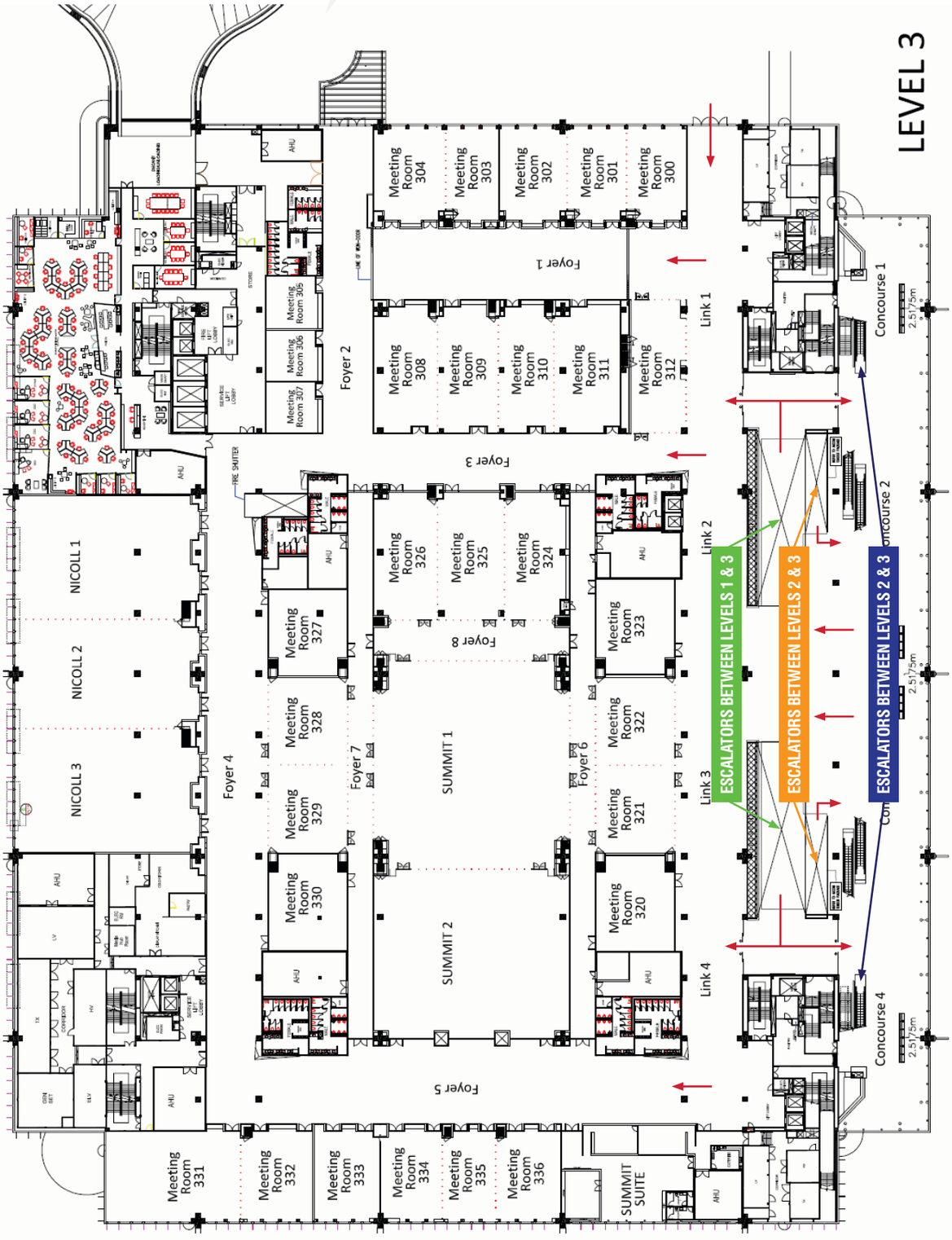
SENTOSA ISLAND
Visit the resort island of Sentosa, where you will find an array of exciting attractions all in one location.

SINGAPORE RIVER
Cruise down the Singapore River with Singapore River Cruise and admire waterfront attractions like the Merlion.

THE SINGAPORE ZOO
Enjoy an extra wild kind of night life on the zoo's Night Safari or enjoy a River Safari.

ORCHARD ROAD
Visit this one-way boulevard flanked by distinctive and iconic shopping malls, restaurants, and hotels.

SUNTEC SINGAPORE CONVENTION & EXHIBITION CENTRE FLOOR PLAN



Download the ATPS Mobile App

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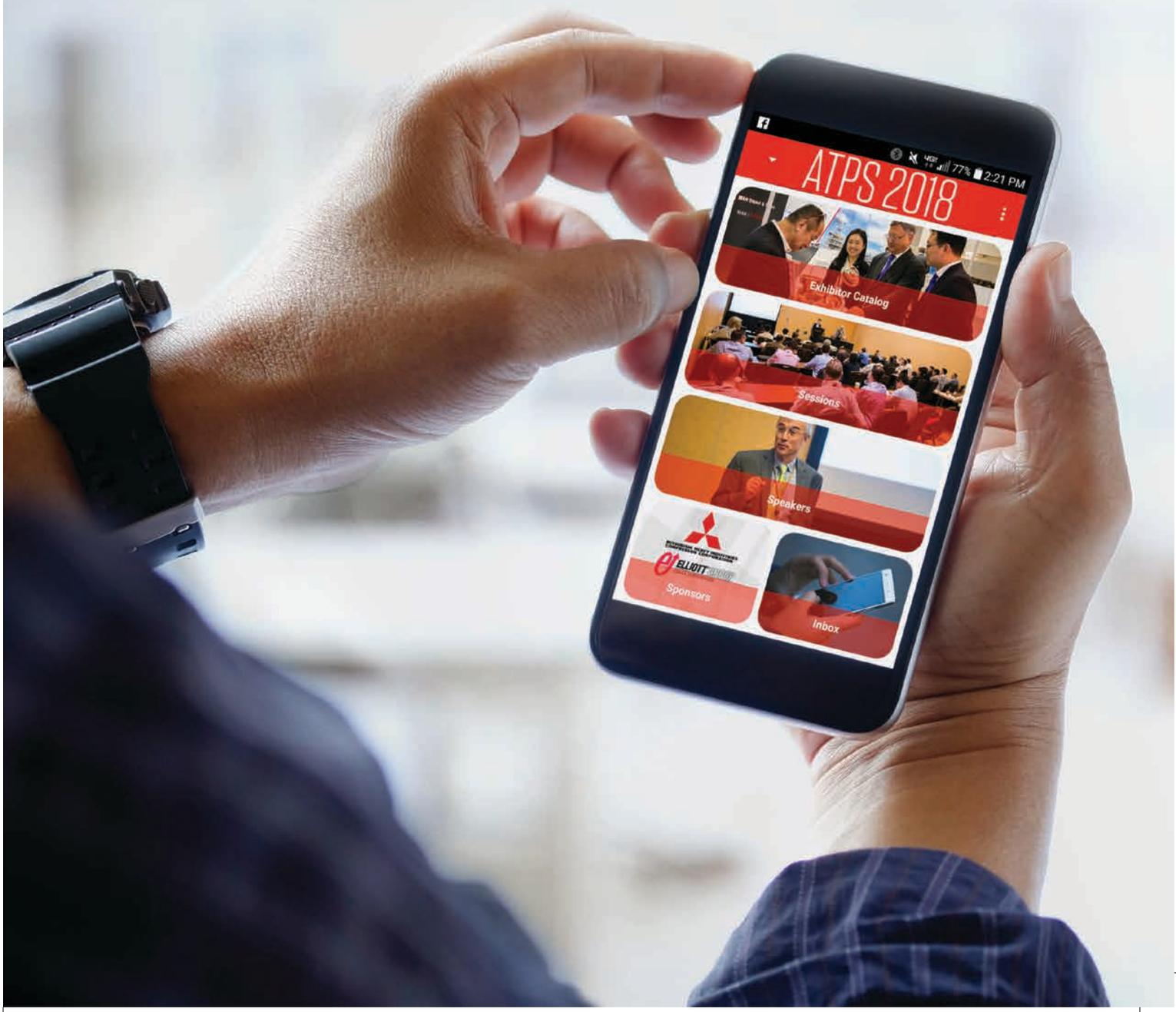
- Visit the appropriate app store – Apple or Android. Search for and download the “Loopd Events” app.
- Once in the app, you will be prompted to enter an access code. The access **code for ATPS is 013905.**



TRC
TURBOMACHINERY RESEARCH CONSORTIUM 1981 EST.

Join TRC today

The Turbomachinery Research Consortium (TRC) is an exclusive organization of major turbomachinery developers and users who have united with the Turbo Lab to find answers to important questions about turbomachinery performance and reliability through cutting-edge research.

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turbolab.tamu.edu/trc

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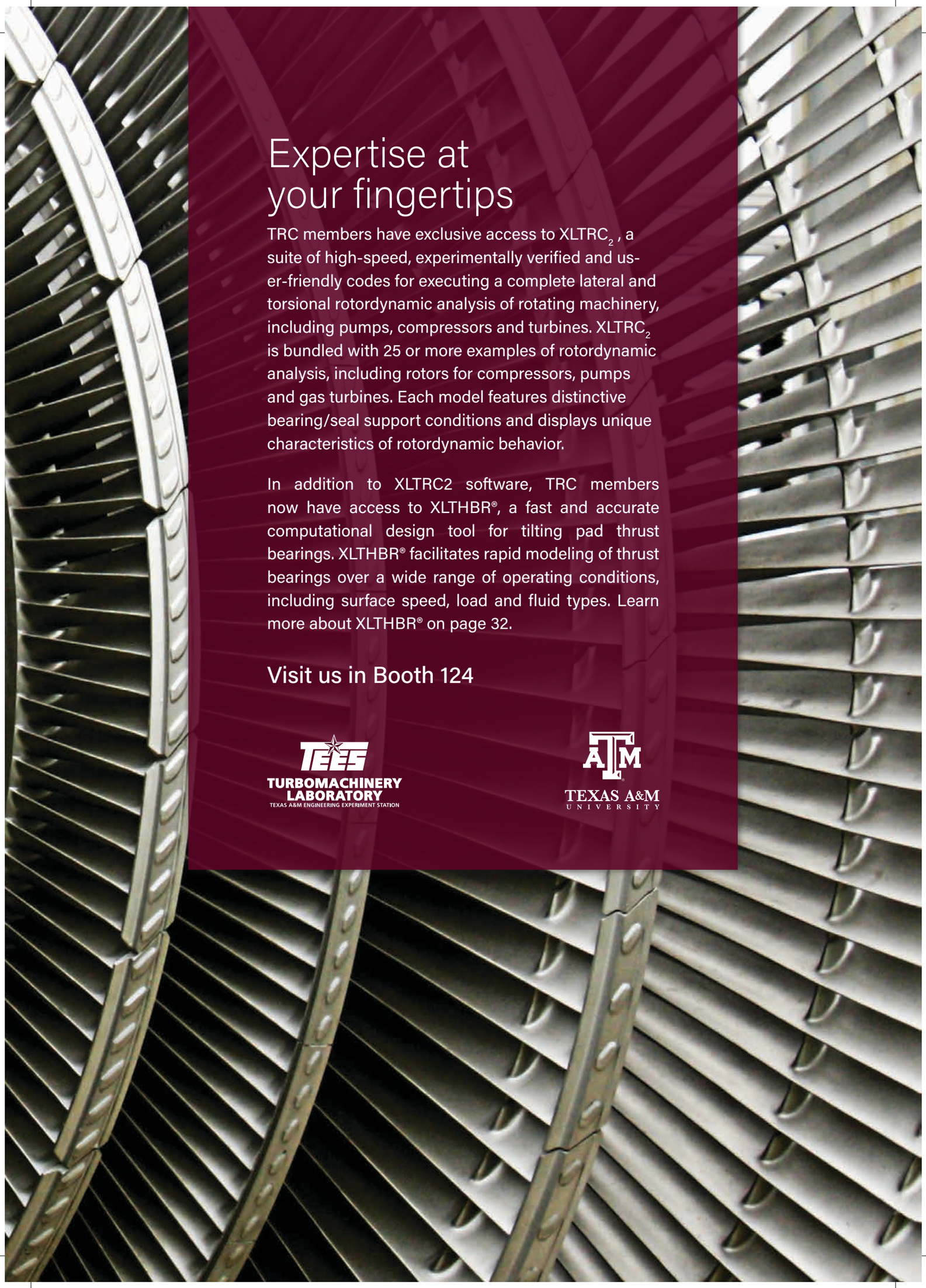

Expertise at your fingertips

TRC members have exclusive access to XLTRC$_2$, a suite of high-speed, experimentally verified and user-friendly codes for executing a complete lateral and torsional rotordynamic analysis of rotating machinery, including pumps, compressors and turbines. XLTRC$_2$ is bundled with 25 or more examples of rotordynamic analysis, including rotors for compressors, pumps and gas turbines. Each model features distinctive bearing/seal support conditions and displays unique characteristics of rotordynamic behavior.

In addition to XLTRC2 software, TRC members now have access to XLTHBR®, a fast and accurate computational design tool for tilting pad thrust bearings. XLTHBR® facilitates rapid modeling of thrust bearings over a wide range of operating conditions, including surface speed, load and fluid types. Learn more about XLTHBR® on page 32.

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SCHEDULE


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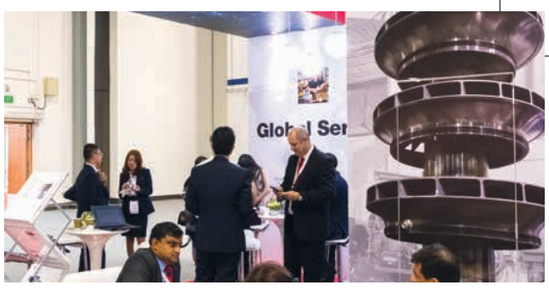
SCHEDULE AT A GLANCE

TIME	FUNCTION	LOCATION
SUNDAY, 11 MARCH 2018		
1630 – 1800	Registration	Level 3, Summit 1 & 2
MONDAY, 12 MARCH 2018		
0800 – 1230	Registration	Level 3, Foyer of Summit 1 & 2
0900 – 1730	Short Courses	Level 3, Meeting Rooms
1200 – 1330	Short Course Luncheon	Level 3, Nicoll 1
1330 – 1700	Registration	Level 3, Foyer of Summit 1 & 2
1745 – 1800	Advisory Committee Meeting	Level 3, Meeting Room 303
TUESDAY, 13 MARCH 2018		
0800 – 1900	Registration	Level 3, Foyer of Summit 1 & 2
0830 – 0845	Leader Orientation	Level 3, Meeting Room 333
0830 - 1730	Speaker Preparation	Level 3, Meeting Room 303
0900 – 0935	Welcome Address	Level 3, Meeting Rooms 334-336
0945 – 1030	Symposium Technical Sessions	Level 3, Meeting Rooms
1000 – 1900	Exhibit Hall Open	Level 3, Summit 1 & 2
1030 – 1100	Refreshment Break	Level 3, Summit 1 & 2
1100 – 1230	Symposium Technical Sessions	Level 3, Summit 1 & 2
1230 – 1400	Lunch for Exhibitors & Paid Delegates	Level 3, Summit 1 & 2 (Badge required, not open to free pass)
1400 – 1530	Symposium Technical Sessions	Level 3, Meeting Rooms
1530 – 1600	Refreshment Break	Level 3, Summit 1 & 2
1600 – 1730	Career & Industry Panel	Level 3, Meeting Room 311 (see p. 26 for more information)
1700 – 1900	Hospitality Event	Level 3, Summit 1 & 2



TIME	FUNCTION	LOCATION
WEDNESDAY, 14 MARCH 2018		
0800 – 1900	Registration	Level 3, Summit 1 & 2
0830 – 0845	Leader Orientation	Level 3, Meeting Room 333
0830 - 1730	Speaker Preparation	Level 3, Meeting Room 303
0900 – 1030	Symposium Technical Sessions	Level 3, Meeting Rooms
1000 – 1900	Exhibit Hall Open	Level 3, Summit 1 & 2
1030 – 1100	Refreshment Break	Level 3, Summit 1 & 2
1100 – 1230	Symposium Technical Sessions	Level 3, Meeting Rooms
1230 – 1330	Lunch for Exhibitors & Paid Delegates	Level 3, Summit 1 & 2 (Badge required, not open to free pass)
1400 – 1530	Symposium Technical Sessions	Level 3, Meeting Rooms
1530 – 1600	Refreshment Break	Level 3, Summit 1 & 2
1600 – 1730	Digitalization Panel	Level 3, Meeting Room 311 (see p. 26 for more information)
1930 – 2100	Gala Dinner	Pan Pacific Hotel, Pacific 3 Ballroom
THURSDAY, 15 MARCH 2018		
0800 – 1300	Registration	Level 3, Summit 1 & 2
0830 – 0845	Leader Orientation	Level 3, Meeting Room 333
0900 – 1030	Symposium Technical Sessions – Case Studies	Level 3, Meeting Rooms
0900 – 1300	Exhibit Hall Open	Level 3, Summit 1 & 2
1030 – 1100	Refreshment Break	Level 3, Summit 1 & 2
1100 – 1230	Symposium Technical Sessions – Case Studies	Level 3, Meeting Rooms
1300 - 1400	Advisory Committee Luncheon	Level 3, Meeting Room 333

TECHNICAL PROGRAM SCHEDULE

TUESDAY MARCH 13TH, 2018

0945 - 1030

Speaker Prep			303
Lecture 1			300
Lecture 2			301
Lecture 3			302
Lecture 4			308
Lecture 5			304

1100 - 1230

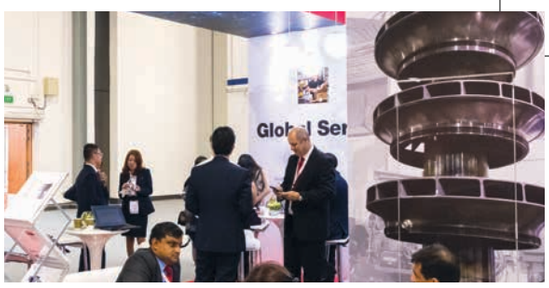
Lecture 6	Technical Brief 1	Technical Brief 2	300
Lecture 7	Technical Brief 3	Technical Brief 4	301
Lecture 8	Technical Brief 5	Technical Brief 6	302
Tutorial 1			310
Tutorial 2			304
Tutorial 3			308
Discussion Group 1			Nicoll 1
Speaker Prep			303
Discussion Group 2			329
Discussion Group 3			331

1400-1530

Lecture 9	Lecture 10	300
Lecture 11	Lecture 12	301
Tutorial 5		309
Tutorial 6		310
Tutorial 7		304
Tutorial 8		308
Discussion Group 4		Nicoll 1
Speaker Prep		303
Discussion Group 5		329
Discussion Group 6		331

1600 - 1700

Career & Industry Panel: See page 26	311



WEDNESDAY 14TH, 2018

0900 - 1030

Speaker Prep		303
Lecture 13	Lecture 14	300
Lecture 15	Lecture 16	301
Lecture 17	Lecture 18	302
Tutorial 9		304
Tutorial 10		308
Tutorial 11		327
Discussion Group 7		329
Discussion Group 8		331

1100 - 1230

Lecture 19	Technical Brief 7	Technical Brief 8	300
Lecture 20	Technical Brief 9	Technical Brief 10	301
Technical Brief 11 (Time modified 1100-1122)			302
Tutorial 12			327
Tutorial 13			304
Tutorial 14			308
Speaker Prep			303
Discussion Group 9			329
Discussion Group 10			331

1400-1530

Lecture 21	Lecture 22	300
Lecture 23		301
Tutorial 15		327
Tutorial 16		308
Tutorial 17		304
Case Studies 1-4		309
Case Studies 5-8		310
Speaker Prep		303
Discussion Group 11		329
Discussion Group 12		331

1600 - 1700

Digitalization Panel: See page 26	311

THURSDAY 15TH, 2018

0900 - 1030

1100 - 1230

Industry & Career Panel and Networking Session

TUESDAY, 13 MARCH 2018
1600 –1730 **ROOM 311**

This panel and networking session is intended for delegates enrolled in university, and early-career professionals. The keynote, by Deloitte Consulting, will cover trends in the oil & gas industry and its role in society and economics. Panelists will give an overview of their industry experience including benefits and challenges of working in the O&G sector.

A question-and-answer session will follow, with a networking reception closing out the event in the student poster session area of the exhibit hall. Refreshments and drinks provided.

SPEAKERS:

Rajeev Singh, Deloitte Consulting
Teo Woon Lip, ExxonMobil Chemical – Engineering Services
Armando Guerrero, Petron Asia Energy
Dr. Srithar Rajoo, Universiti Teknologi Malaysia
Dag Calafell, Technical Opus Solutions, ATPS Chair

Successful Applications of Digitalization in Oil & Gas

WEDNESDAY, 14 MARCH 2018
1600- 1730 **ROOM 311**

Digitalization is expected to transform the industrial segment, both oil & gas and power. The latest technological innovations in the industry are not fully understood, due to hype versus reality. This session seeks to widen technological perspective for ATPS attendees and remove silos in industry
for a multidisciplinary approach.

The latest trends and anticipated changes will be addressed. The discussion will feature first-hand accounts of successful applications, latest available developments in digitalization, as well as pain points and potential approaches. The panel will address how OEMs are able to help customers with successful application of digitalization. A question-and-answer session will follow the panel discussion.

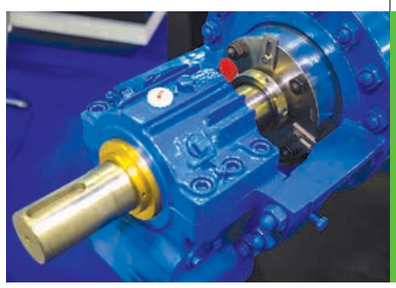
SPEAKERS:

Arun Kumar, HMEL
Hiroyasu Ishigaki, Mitsubishi Heavy Industries
Chirag Sehgal, Siemens
Jonas Berge, Emerson

PROGRAM


NY SEAL

SHORT COURSE DESCRIPTIONS



Short Course 1:

Pump Cavitation Physics, Prediction, Control, Troubleshooting

Monday, 12 March 2018

0830 - 1700 hours Room 300

Instructors: Bruno Schiavello, Frank C. Visser (Flowserve)

This short course gives insight into roto-dynamic pump cavitation and provides deeper understanding of particulars like cavitation inception, three-percent head drop, 40,000 hours life criterion, cavitation damage potential, NPSHR scaling laws, the effect dissolved gas, and thermodynamic effect for hot water and hydrocarbons. Furthermore, empirical correlations for predicting various types of NPSHR and the use of CFD will be discussed. Moreover, suction specific speed and suction energy will be critically reviewed along with criteria for NPSHA margin. Also the effect of fluid transients and viscosity will be addressed. The cavitation damage potential will be fully explained by the Cavitation Modes Map, which reflects fundamental insight gained since the 1940s; here in particular the striking departure in shape from the NPSH3 curve for part flows is highlighted, being a key reason of many cavitation pump problems. Attention is further devoted to Impeller Life Expectancy and Cavitation Control with modern designs tools. In conclusion, four field case studies will demonstrate the use of cavitation failure analysis and solution strategy.

Short Course 2:

High Performance Couplings and Rotating Machines

Monday, 12 March 2018

0830 - 1700 hours Room 301

Instructors: Steve Pennington (John Crane)

This course covers the design and application of high performance couplings and rotating machines. Initially the Turbomachinery driver and driven machines are analyzed together with their characteristics and how they affect the coupling. The various types of coupling in the market are covered next, including metal membranes and diaphragms and how these characteristics are utilized. Selection is reviewed next and how this affects the coupling design, including shaft end, balancing and materials. The oil and gas requirement to API671 are investigated and which coupling attributes are important. The course concludes with Installation and failure analysis and reviews the main factors affecting failures from misalignment through to torsional vibrations.

Short Course 3:

Process Safety

Monday, 12 March 2018

0830 - 1700 hours Room 302

Instructors: Cherng En Lee (Siemens)

Role of Process Safety Management:

Mechanical Integrity in Design, Installation, and Operation of Machinery Targeted at machinery professionals that manage integrity programs. The course covers Process Safety Management Elements and the interdependence of other reliability, operation, and maintenance programs. It also covers Recognized and Generally Accepted Good Engineering Practice, Inspection, Testing, and Preventive Maintenance, Loss of Primary Containment, and Risk Evaluation. There is substantial explanation and examples to understand the new API-691 Risk-Based Machinery Management Recommended Practice from June 2017. Actual PSM Incidents are presented to illustrate the analysis and prevention process.

Short Course 4:

Centrifugal Compressors 101

Monday, 12 March 2018

0830 - 1700 hours Room 310

Instructors: Mark J. Kuzdzal, Jay M. Koch (Dresser-Rand, Siemens Power and Gas Division)

This course is aimed at engineers and technical professionals who need a broad-based introduction to centrifugal compressor design and analysis. This course starts with the basics and builds to provide a full understanding of a centrifugal compressor. The course will include

the following topics: reciprocating, axial and centrifugal compressor similarities/differences; centrifugal compressor configurations; design consideration; and balancing aerodynamic, rotordynamic, and mechanical consideration. The course will answer the question “How do they work? factory testing, and future challenges. At the completion of the course, the attendees will hold a strong understanding of basic concepts. This knowledge will act as a springboard to further growth understanding of more complex centrifugal compressor concepts. An emphasis is placed on providing practical information with minimal theory. This is NOT a centrifugal compressor operations and maintenance class.

Short Course 5:

Materials in Centrifugal Compressor and Steam Turbines: Selection, Processing, and Repair

Monday, 12 March 2018

0830 - 1700 hours Room 304

Instructors: Scot Laney, David Dowson (Elliott Group)

Materials selection is significant with respect to performance, reliability, and longevity of turbomachinery, particularly given the increasing severity of the process environments. The trends are that the selection is becoming a cooperative effort between the OEMs and the customers and it is vital that all parties understand the implications of the materials selection and necessary manufacturing processes. This course reviews the material selection for major components for centrifugal compressors and steam turbines coving topics such as materials of construction, heat treatments, properties, fabrication and manufacturing methods, inspection methods, and compliance with industry specifications such as API and NACE along with other special requirements. Going beyond new equipment, the course will touch on the identification of damage mechanisms through root cause analysis and then delve into the procedures and documentation required to restore the components to operating condition. The course will end with a discussion of various coatings and surface treatments that can also be used to enhance the performance and/or longevity of the equipment.

Short Course 6:

Steam Turbine 101/201: Basic Knowledge of Steam Turbine

Monday, 12 March 2018

0830 - 1700 hours Room 308

Instructors: Kazuaki Sugimoto, Tomoaki Nogami, Matt Walton (Mitsubishi Heavy Industries Compressor International Corporation)

It is shown as the outline in this short course that the role of steam turbine, history, classification, basic structure, components and their function, manufacturing and design process and control system. And also, the basic thermal cycle, flow dynamics, strength analysis are explained as the academic knowledge. Finally, the trend of development and the state-of-the-art technology as the latest technical information and the typical root cause analysis as the example of troubleshooting are provided. Target audience; This short course is aimed at engineers, operations and maintenance personnel who need a broad-based introduction to mechanical drive steam turbine design, have a firm foundation in the basics associated with turbomachinery and mechanical engineering. This short course will provide the basic minimum knowledge of steam turbines from the design to the operation in half and more detail technical information, which will be useful design audit, trouble shooting, enhance participants, their own machines, how to approach in other half.

Short Course 7:

Introduction to Gas Turbines

Monday, 12 March 2018

0830 - 1700 hours Room 309

Instructors: Rainer Kurz (Solar Turbines Incorporated), Klaus Brun (SwRI)

Overview

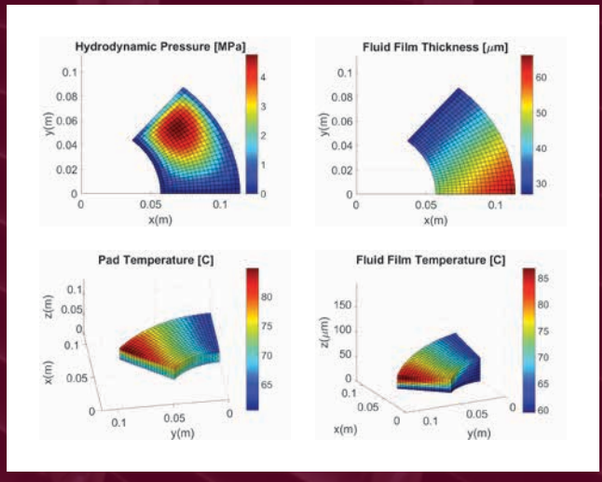
- Introduction
- Thermodynamics/Brayton Cycle etc.
- Gas Turbine Components and Performance
- Gas Turbine Package Systems
- Applications for Industrial Gas Turbines: Upstream/Midsteam Power Gen, LNG, etc
- Maintaining Performance
- Inlet Air /Fouling
- Water Washing
- Fuel (Gas, Liquid)
- Testing
- Questions

XLTHBR® now available to Turbomachinery Research Consortium members

XLTHBR® is a fast and accurate computational design tool for tilting pad thrust bearings. XLTHBR® closes a gap for members of the Turbo Lab's Turbomachinery Research Consortium (TRC), an exclusive organization of major turbomachinery developers and end-users who join with the Lab to answer important questions about performance and reliability of rotating machinery through research.

Version 1 of XLTHBR® is specific to laminar flow thrust bearings and includes the following features:

- Analysis for tilting pad (1D and 2D tilting) and fixed geometry (taper land) TBs
- 2D hydrodynamic pressure affected by cross film viscosity variations.
- 3D temperature in the fluid film (thermal energy transport equation), including a thermal oil mixing model in feed grooves.
- 3D heat conduction in a pad with specified sides' temperatures
- Various types of pivot stiffness models, linear and nonlinear
- Frequency reduced force coefficients (stiffness and damping) for thrust collar axial displacements



A sample of predictions generated by XLTHBR®

Visit turbolab.tamu.edu/trc to learn more about XLTHBR® and the Turbomachinery Research Consortium (TRC).

TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

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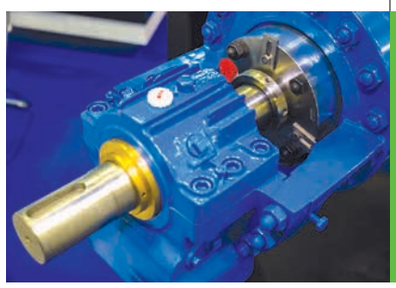
LECTURE DESCRIPTIONS



Lecture 1:

Dynamic Simulation and Testing to Assess Rundown Speed of a Compressor

Tuesday, 13 March 2018

0945 - 1030 hours Room 300

Instructors: Rainer Kurz (Solar Turbines Incorporated), Klaus Brun, Sarah Simons, Adrian Alvarado (Southwest Research Institute), Rienk Zwerver (Gasunie)

Dynamic simulations are frequently conducted to verify the behavior of compressor stations during transient events. The most difficult situation to analyze is the event of an emergency shutdown, due to the very fast transients. Unfortunately, there is very little documented data that compares simulation results and the actual behavior of the station. We will evaluate available data sets for 3 different studies. The studies include a shutdown of a compressor against a closed recycle valve, a very well documented and published study on the emergency shutdown of a compressor in a test facility, and new data from a compressor station where a major station modification led to a dynamic simulation and subsequent verification. The latter will be described in some detail.

The key finding is, that a difficulty, and a major source of inaccuracy lies in the correct prediction of the speed decay for the compressor.

Lecture 2:

Surge Exploration Tests and Second Quadrant Characteristic Dynamic Modeling on High Pressure Ratio Compressor (HPRC) Prototype

Tuesday, 13 March 2018

0945 - 1030 hours Room 301

Instructors: Mirco Calosi, Marco Pelella, Fabio Baldanzini (Baker Hughes, a GE company)

In the final step of development and validation of the High Pressure Ratio Compressor (HPRC) technology, a surge exploration test campaign has been carried out to evaluate the transient behavior and mechanical robustness of the compressor during a critical event such as Surge. The result of this work is a breakthrough for the tuning of a second quadrant centrifugal compressor model to be used for dynamic simulations and prediction of compressor dynamics during Surge events in a more reliable and robust way.

Surge exploration tests results analysis, in terms of vibrations,axial displacements and thrust loads, together with development of a compressor enhanced dynamic model, allowed a change from a Surge acceptance criterion,based on the time spent on the left of the Surge Limit Line,to a more physics related criterion, based on the acceptable number of Surge cycles, thus optimizing the selection of additional protections, such as hot/cold gas bypass valves.

Lecture 3:

Conventional Servo System to Direct Drive Actuators

Tuesday, 13 March 2018

0945 - 1030 hours Room 302

Instructors: Mayank Jain, Kenichi Nishiyama, Kyoichi Ikeno (Mitsubishi Heavy Industries Compressor Corporation)

This paper discusses the development of Actuators for turbine valve operation over a period of time. With the increasing demand for higher control of steam valves and depleting support for conventional servo system, there has been a gradual shift to Direct drive Actuator.

The conventional system consists of an E/H Actuator along with pilot valve, power cylinder and a complex system of linkages. The introduction of direct-drive actuators enables OEMs to eliminate pilot valve and power cylinder and to redesign the system for less space, better reliability, and low maintenance.

The major issue with conventional system is a large number of parts which can cause multiple failures over time. This paper presents the above failures and how the direct-drive actuators solve the issue. While the users experience many benefits, it is also important to understand the issues associated with direct Actuators. The paper also lists these disadvantages and remedial measures.

Lecture 4:

Development of a Single Mechanical Seal Equipped with a High-Pressure Containment Seal for Multiple Fluid Pipeline Pumps

Tuesday, 13 March 2018

0945 - 1030 hours Room 308

Instructors: Andreas Pehl, Peter Dröscher (EagleBurgmann Germany)

This paper descript a single wet lubricated mechanical seal in combination with a high-pressure containment seal. The seal has been designed to operate in a product range from the flashing hydrocarbons ethane, propane, butane up to non-flashing hydrocarbons, basically media with a specific gravity range of 0,35 up to 0,65 and designed up to 100bar, respecting the Pipeline Pressure. To achieve this an extensive performance calculation and optimization with FEM was done. The proposed mechanical seal design provides a reliable pump sealing solution for these critical applications with a “single mechanical seal” in combination with a “high-pressure containment seal”.

Lecture 5:

Static And Rotordynamic Analysis of a Plain Annular (Liquid) Seal in the Laminar Regime with a Swirl Brake for Three Clearances

Tuesday, 13 March 2018

0945 - 1030 hours Room 304

Instructors: Dara Childs (Turbomachinery Laboratory), Ovais Najeeb (Texas A&M University)

Annular seals are non-contacting mechanical elements designed to reduce leakage between two areas of differing pressures such as between two impeller stages in a pump. Circumferential fluid rotation inside the annular liquid seals is the leading cause of rotordynamic instabilities in a pump. Swirl brakes have been shown to be effective in reducing fluid rotation at the inlet of the seal; thus reducing cross coupling in the seal. The effect of swirl brakes at tight radius to clearance ratios and laminar fluid flow conditions is absent from literature.

Lecture 6:

Torsional Modal Damping of a LCI Driven Geared Moto-Compressor Train: Evaluation, Optimization Criteria and Active Control

Tuesday, 13 March 2018

1100 - 1230 hours Room 300

Instructors: Paolo Calore, Lorenzo Failla, Daniele Sgrò, Gaspare Maragioglio (Baker Hughes, a GE Company), Pierluigi Tenca (Electrical Technologies GE Global Research Center)

A comprehensive analysis of the key systems and parameters affecting the torsional modal response of a Load Commutated Inverter (LCI) driven motor-compressor is provided, and practical guidelines for system design optimization are given. Besides, when the equipment inherent damping properties are not sufficient to achieve demanding vibration performances, an active control could be required:

The real implementation of an active damping control system acting on the VSDS is therefore presented, showing its effectiveness on a real string by means of experimental results.

Simulations and field test results are shown, emphasizing the importance of torsional modal response optimization, considering mechanical aspects and analyzing electrical and control influence introduced using a VSDS. It is worth to highlight that the type of VSDS covered is the LCI, but the presented system design approach is in principle applicable to any VSDS topology, with specific electrical and control aspects to be considered for each drive.

This session runs consecutively with Technical Briefs 1 & 2

Lecture 7:

Impeller Stall Induced by Reverse Propagation of Non-Uniform Flow

Tuesday, 13 March 2018

1100 - 1230 hours Room 301

Instructors: Shinji Iwamoto, Keizo Yoneda, Akihiro Nakaniwa, Yoshiaki Shoji (Mitsubishi Heavy Industries Compressor Corporation), Bryan Barrington (LyondellBasell Global Engineering Services)

In the case of centrifugal compressors, minor non-uniform flow upstream of the impeller is induced by an asymmetrical configuration in the circumferential direction at the compressor suction casing. This non-uniform flow is transmitted to the impeller discharge, but this minor non-uniform flow does not usually cause an adverse effect on the impeller stage performance. However, we found this is amplified at the return channel due to flow separation at reduced flows (depending on return channel geometry), and the amplified non-uniform flow did induce impeller stall by reverse propagation from the return channel to the impeller.

This session runs consecutively with Technical Briefs 3 & 4

Lecture 8:

Rotordynamics, Design Aspects, Field and Operational Experiences of a Novel, Large Compressor String Supported by Active Magnetic Bearings

Tuesday, 13 March 2018

1100 - 1230 hours Room 302

Instructors: Frank Heidtmann, Rainer Gausmann (Siemens Power & Gas Division, Compressor Product Development)

The novel compression string consists of a 23-MW synchronous high speed high voltage (HSHV) motor in double end drive configuration, driving two directly attached 7- and 8-stage compressors. The approximate 16 m long string with about 14 mm axial thermal elongation is supported by six radial active magnetic bearings (AMBs) and two axial AMBs at the train outboards. This contribution deals with the axial, radial, and torsional rotordynamics of the AMB supported string focusing on the two compressors, as well as with string design aspects and latest field / operational experiences. This includes an experimental torsional string analysis and run-out effects in combination with the closed loop AMB controller design. Therefrom derived and presented improvements have led to an in-detail optimized compressor design and AMB control.

This session runs consecutively with Technical Briefs 5 & 6

Lecture 9:

Design And Testing of a High-Pressure-Ratio Centrifugal Stage – Probing the Aerodynamic and Mechanical Limits

Tuesday, 13 March 2018

1400 - 1530 hours Room 300

Instructors: Mark Kuzdzal, James M. Sorokes, Kirk Lupkes, Ravi Srinivasan, Dave J. Peer, Silvano Saretto (Dresser-Rand, a Siemens Business)

The paper provides an overview of the test compressor, instrumentation, test loop and the data acquisition system, and addresses the “shake-down” testing performed with a baseline configuration to establish feasibility, ground the analytical predictions, and identify potential oversights in the design. Test results from an enhanced design developed via aerodynamic optimization are also discussed. The paper closes with a review of the lessons learned and a summary of how the supersonic design extended the limits of what can be achieved with a centrifugal stage. Some thoughts regarding future work to enhance the performance of high pressure-ratio stages and on the use of advanced optimization methodologies are also offered.

Lecture 10:

A New Methodology for Verifying Pressurized Start-Up of Centrifugal Compressors Driven by Direct-On-Line Electric Motor by Leveraging String Test Results and Dynamic Simulation Analysis

Tuesday, 13 March 2018

1400 - 1530 hours Room 300

Instructors: Mirco Calosi, Marco Pelella, Riccardo Lorenzini, Riccardo Ranieri (Baker Hughes, a GE company), Ibrahim Ahmed Kobbia (ADMA-OPCO), Luca Magnante (TechnipFMC)

Fixed Speed Electric Motors driving Centrifugal Compressors are designed considering the pressurized start-up as the most critical condition in terms of the torque requirement. Their capability is checked during the design phase by means of dynamic simulation, which unfortunately suffers from uncertainties, especially in the low speed range.

String Test (Complete Unit Test as defined by API 617) is a powerful mean to validate and refine the dynamic simulation so to predict more accurately the behavior of the compressor train at site conditions and ensure the capability of the driver to start-up the compressor from Settled-Out condition.

The present paper describes a new methodology to leverage Direct-On-Line Centrifugal Compressor String Test results to improve predictability of on-site pressurized start-up thanks to an enhanced dynamic simulation model.

A case study is also presented showing how the methodology has been successfully applied to a reinjection compressor string.

Lecture 11:

Superimposing Planetary Gears as Variable Speed Drives for Rotating Equipment

Tuesday, 13 March 2018

1400 - 1530 hours Room 301

Instructors: Martin Tilscher, Bernd Lauter, Jochen Lindenmaier (Voith Turbo)

There are many high-power pumps installed in power plants, oil & gas applications and petrochemical industry consuming a considerable amount of energy. Significant interest exists within operators to improve efficiency in order to save energy and operating cost. There is a new method to improve efficiency of variable speed drives by power splitting. An epicyclic gear is designed as revolving planetary gear where all three shafts can turn. This principle allows using only a small percentage of rated power as control power to be generated by servo motors. A 7500 horse power prototype of an electrically controlled superimposing planetary gear was built and tested extensively. Its efficiency is up to 2.5 percent higher than conventional variable speed systems.

Lecture 12:

Subsynchronous Vibrations on a Vertical Electrical Motor During Factory Testing - Observed Phenomenon, Interpretation and Resolution

Tuesday, 13 March 2018

1400 - 1530 hours Room 301

Instructors: Minhui He, C. Hunter Cloud (BRG Machinery Consulting, LLC), Bernard Quoix, Alain Gelin (TOTAL)

During the factory tests of a vertical de-ballasting motor-pump, high vibrations were observed on the pump casing. Supported by fluid film bearings, this motor is cooled and lubricated by a low viscosity fluid in which the entire rotor assembly is submerged. A spectrum analysis revealed that the dominant vibration was subsynchronous at half of the rotating frequency. A modal analysis confirmed that this frequency matches the casing's reed mode, indicating a resonance situation. However, after installing proximity probes, it was observed that the shaft was whirling at very high displacement (90% of bearing clearance) with its frequency tracking half of the rotating speed. Therefore, the original high casing vibrations were caused by a rather unusual "perfect storm", i.e., a self-excited oil whirl instability causing a resonance situation at running speed. This conclusion and the solution of bearing modification were validated by detailed rotordynamics analysis, successful re-testing and field operation.

Lecture 13:

Influence Of Inter-Coolers Technologies on the Performance of Isotherm Centrifugal Compressors

Wednesday, 14 March 2018

0900 - 1030 hours Room 300

Instructors: Luca Porreca (MAN Diesel & Turbo Schweiz AG)

It is well known that gas compressor work can be greatly reduced by inter-stage cooling. Since decades, isotherm compressors are commonly used where very large volume of gases is needed and low power consumption is necessary.The main optimization goals in compressors technology are focused either on rotating components (mainly stage aerodynamics) as well as on intercooling (or heat exchange) process. In particular, current development is aiming either on improvement of cooling efficiency or (keeping the same efficiency) on size reduction, which is directly related also to overall cost reduction. Such improvements can derive from the use of different materials, coolers type/methods, geometries, manufacturing technologies, fouling modelisation and prevention etc. In this paper, a comprehensive and quantitative analysis of the influence of different intercoolers aspects is carried out with the aim to isolate the most critical factors to achieve an optimal combination between capital and operative costs of isothermal compressors.

Lecture 14:

Modification of Oil Brake on Cryogenic Expander For Improved Efficiency Under Varying Load Conditions

Wednesday, 14 March 2018

0900 - 1030 hours Room 300

Instructors: Trevor Mayne (Qenos Pty Ltd), Chris Bowly (Process Consultants Pty Ltd)

Investigation into the operation of a 200kW brake oil expander in a 1970's vintage ethane cracker revealed that maximum gas throughput was significantly below design and that the gas throughput varied significantly in normal operation. Expander refrigeration duty was thus below design, and substantial production losses accrued due to the inability to achieve the low cryogenic refrigeration temperatures at the original design point and as plant throughput varied. The oil brake control redesign has resulted in a robust and reliable oil brake control that has increased turbine efficiency to be better than 85% of the original BEP at all times. Analysis of the impact of the resultant increased refrigeration duty indicates that this project will have a payback time of less than 1 year.

Lecture 15:

Using Digital Models for Condition Based Maintenance of High Pressure Pumps in SWRO Desalination Plants

Wednesday, 14 March 2018

0900 - 1030 hours Room 301

Instructors: Mohamed Lotfy, Amr Abdel Fatah (British University in Egypt), Mohammed Hassan (Fayoum University), Antoine Dimitri (Cairo University)

Condition based maintenance (CBM) is a very useful technique built around the concept of monitoring the operation of assets. Incorporating simulation data collected from digital replica of the system with sensors' data can lead to more optimization for operation and maintenance. Two digital models have been developed for the high pressure pump experiencing cavitation condition. The first digital model is a 3-D fully turbulent Computational Fluid Dynamic (CFD) model which is used to model the pressure pulsations acting on the rotor. The second digital model is a pump rotor dynamic model which is used to predict the rotor vibration response to exciting forces. Results obtained from the digital models are validated using an experimental test rig of a small centrifugal pump. Using this concept, a pump faulty operation can be simulated to provide complete understanding of the root cause of the fault and propose an adequate corrective action.

Lecture 16:

A Study on the Operation of Pitot Tube Pumps

Wednesday, 14 March 2018

0900 - 1030 hours Room 301

Instructors: Bryce Neilson (Weir Specialty Pumps)

While pitot tube pumps have been commercially available since 1970 little is known and less is published about their internal operation and design principles especially when operating off design. This paper is a culmination of research conducted over the past several years aimed at understanding the internal operation of pitot tube pumps in their different configurations. This research includes computational fluid dynamic (CFD) studies, and laboratory testing. While pitot tube pumps are classified as centrifugal pumps since they add energy to the fluid by increasing the fluid angular momentum and such follow many of the same laws. However, due to their unique construction they operate differently that typical “impeller” pumps. Understanding these differences is imperative in their successful application.

Lecture 17:

Industrial IoT Technology Brings New Opportunities and Benefits for Rotating Equipment Suppliers and Plant Operators

Wednesday, 14 March 2018

0900 - 1030 hours Room 302

Instructors: Bob Gill, Tim Shea (ARC Advisory Group)

The evolution of the Industrial Internet of Things (Industrial IoT) including technologies such as sensors, gateways, networks, platforms, and analytics, brings with it new opportunities for industrial operators to connect once isolated plant equipment and obtain real-time information. The benefits include improved operating performance, higher availability and less unplanned downtime.

ROI-friendly technology investment for plant operators through Industrial IoT enables rotating equipment suppliers to stay connected to their assets and, consequently, develop new and lucrative business models where service becomes a more significant component of the supplier. Benefits include improved customer relationships and increasingly enhanced analytics technology through machine-learning based solutions.

Lecture 18:

Development, Testing and Qualification of Innovative Low Viscosity Oil in Turbomachinery Applications

Wednesday, 14 March 2018

0900 - 1030 hours Room 302

Instructors: Lorenzo Naldi, Massimo Camatti (Baker Hughes, a GE company), Manuela Toscanini, Marco Lattuada (Eni SpA- Research & Technological Innovation Department)

The continued market demand to have more efficient machines has motivated manufacturers to look for improvements even in area that have never been explored and evaluated till now. The authors focus the research, development and validation of a high-performance and high efficiency lubricant oil for Turbomachinery applications. The paper reports the entire qualification process of the oil, starting from laboratory tests to certify its chemical properties, then go through dynamic bearing test rig for the identification of stiffness and damping characteristics to finally present the results of tests on actual machinery under real operating conditions.

Lecture 19:

On The Leakage and Rotordynamic Force Coefficients of Pump Annular Seals Operating with Air/Oil Mixtures: Measurements and Predictions

Wednesday, 14 March 2018

1100 - 1230 hours Room 300

Instructors: Luis San Andres (Turbomachinery Laboratory), Xueliang Lu, Zhu Jie (Hunan SUND Industrial & Technological Co., Ltd.)

In the subsea oil and gas industry, multiphase pumps and wet gas compressors enable long distance tie back system that eliminates topside facilities such as an oil and gas separation station. Seals must be able to operate without affecting the system efficiency and dynamic stability. The lecture presents measurements of leakage and force coefficients for six annular seals (L = 46 mm, D = 127 mm) operating with an air in oil mixture ranging from pure liquid to just air. Each seal has a distinct clearance configuration: one is a plain seal with a small clearance (c=0.203 mm), and another has a larger (worn) clearance (c=0.274 mm); a third seal introduces a wavy clearance (cm= 0.191 mm) that produces a significant centering stiffness; a fourth seal has a shallow groove pattern (cr=0.211 mm); and the fifth and sixth seals have a stepped clearance (narrow to wide and wide to narrow).

This session runs consecutively with Technical Briefs 7 & 8

Lecture 20:

Subsynchronous Shaft Vibration in an Integrally Geared Expander-Compressor Due To Vortex Flow in an Expander

Wednesday, 14 March 2018

1100 - 1230 hours Room 301

Instructors: Daisuke Hirata, Naoyuki Nagai, Yoshiaki Shoji (Mitsubishi Heavy Industries Compressor Corporation), Hirotaka Higashimori (MHI Solution Technologies CO., Ltd.)

Subsynchronous shaft vibration was observed in an integrally geared expander-compressor when the machine was operated with a partial load in the course of plant start up. The root cause of the synchronous shaft vibration was identified as the vortex flow which was generated in the downstream piping of the gas expander wheel, by means of CFD analysis. OEM installed an object, called vortex breaker, in the piping in order to eliminate the excitation force of the vortex flow, and as the result, the subsynchronous shaft vibration disappeared. This paper provides the detailed shaft vibration data, root cause analysis, countermeasure and the result from the countermeasure.

This session runs consecutively with Technical Briefs 9 & 10

Lecture 21:

Application of Dynamic Pressure-Balanced Seals in a Multi-Stage Centrifugal Compressor

Wednesday, 14 March 2018

1400 - 1530 hours Room 300

Instructors: Harry Miller, Mark Kuzdzal, Charles Rohrs (Dresser-Rand, a Siemens Business), John Justak (ATGI), David Stiles (Hess Oil Co.), Mark Sandberg (Sandberg Turbomachinery Consulting, LLC)

Test results for an ASME Power Test Code 10 (PTC) Type 1 test of a 4,500 psia (310 Bara) discharge pressure gas lift centrifugal compressor outfitted with dynamic pressure-balanced seals at the impeller eyes; shaft interstage and division wall locations are presented and compared to the same testing with conventional labyrinth seals. Both aerodynamic performance and rotor dynamic stability, obtained via operational modal analysis (OMA), are presented. A client's motivation, along with the design and testing of dynamic pressure-balanced (DPB) seals for turbomachinery are also presented in this paper.

Lecture 22:

On the Performance of Tilting Pad Bearings: A Novel Model for Lubricant Mixing at Oil Feed Ports with Improved Estimation of Pads' Inlet Temperature and its Validation Against Experimental Data

Wednesday, 14 March 2018

1400 - 1530 hours Room 300

Instructors: Luis San Andres (Turbomachinery Laboratory), Behzad Abdollahi (LobePro Rotary Pumps)

The lecture details an analysis of tilting pad bearings and introduces a novel model for the mixing of flow and thermal energy at a lubricant feed port, which sets the temperature of the lubricant entering a pad leading edge. Precise estimation of this temperature (and inlet oil viscosity) and the flow rate entering a pad largely determine the temperature rise along the pad lubricated surface as well as the shear drag power loss, and ultimately the bearing load capacity. Examples of analysis predictions compared to test data validate the model and recommendations for a feed port efficiency parameter for various types of oil supply configurations follow. This parameter does not change with the bearing operation conditions. Thus, designers have a new tool that allows the early specification of flow rate as an input parameter, not a consequence of analysis nor a constraint during actual operation.

Lecture 23:

Atypical Results from Improperly Sized and Charged Pulsation Dampeners

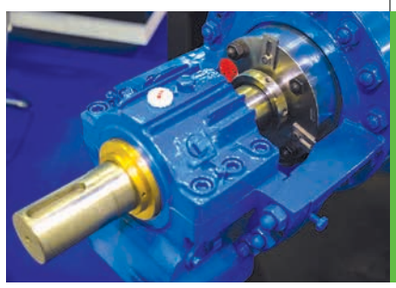
Wednesday, 14 March 2018

1400 - 1530 hours Room 301

Instructors: Nathan Poerner, Eugene Broerman, Trenton Cook (Southwest Research Institute), Tappan Souther (Liberty Resources, LLC)

At a facility with four quintuplex pumps, pulsation dampeners were being used to control pulsations in the discharge line. However, the initial dampeners were both undersized and undercharged for the application. As a result, in addition to some typically expected results, including high pulsations and frequent failures of the internal bladders, the effective volumes of the dampeners and lengths of piping in the system set up an acoustic natural frequency that caused significant safety concern and limited system operability. This natural frequency was in a range that could be excited by the pumps such that the presence of the dampeners in the system was actually causing even higher pulsation levels. This paper will look at the troubleshooting efforts including field testing and acoustic simulations. Results from the modified system will also be discussed.

TUTORIAL DESCRIPTIONS



Tutorial 1:

Examination of Methods of Dry Gas Seal Supply, Regulation, and Monitoring

Tuesday, 13 March 2018

1100 - 1230 hours Room 310

Instructors: Richard Hosanna, Kevin Dwyer (John Crane), Vladimir Bakalchuk, Sreenivasulu Chinnaswamy (Flowserve), Robert Eisenmann (BP), Jim McCraw (VAM Consulting)

Compressor dry gas seal failure is a common issue that affects turbomachinery train availability. Most turbomachinery trains are un-spared critical assets, and unscheduled shutdowns have a major impact on the operating facility. As operators look to extend equipment run time, the quality and delivery of the primary seal gas supplied to the dry gas seal in addition to the primary vent monitoring are vital to the long term operation of equipment. This tutorial examines the two main philosophies for delivering seal gas, before describing a recommend primary vent monitoring setup and the associated instrumentation. The tutorial concludes with several examples based off real world failures to further illustrate the monitoring and diagnostic abilities of the dry gas seal system.

Tutorial 2:

A Fresh Look at Containment Seals and Equipment

Tuesday, 13 March 2018

1100 - 1230 hours Room 304

Instructors: Chris Carmody, Richard J. Smith (AESSeal PLC)

This tutorial looks at how containment seals have been applied historically and the issues that have surrounded the technology thereby questioning proper application and usage. The philosophy of dry containment seals is explained where both contacting and non-contacting containment seal options are discussed along with the associated sealing system requirements for each preference. It explains the need for introducing in-situ periodic test procedures such that containment seal functionality is not impaired during service. Finally some guidance is offered so that containment seals can be assessed and selected such that optimum performance can be assured.

Tutorial 3:

Gas Turbine Performance and Maintenance

Tuesday, 13 March 2018

1100 - 1230 hours Room 308

Instructors: Rainer Kurz (Solar Turbines Incorporated), Klaus Brun (Southwest Research Institute)

In this tutorial, we will address the basic characteristics of each of the components in a gas turbine (compressor, combustor, gas generator turbine, power turbine) and the impact of typical control limits and control concepts. The power and efficiency characteristics of a gas turbine are the result of a complex interaction of different turbo machines and a combustion system The goal is to provide explanations for the operational characteristics of typical industrial gas turbines, emphasizing the interaction between the gas turbine components. Methods are introduced that allow the use of data for trending and comparison purposes, and component degradation is discussed, together with strategies to reduce the impact of degradation. Fuel types, fuel issues as well as the importance of appropriate gas turbine inlet air filtration are addressed.

The concepts developed will be used to derive basic principles for successful condition monitoring and performance testing of gas turbines.

Tutorial 5:

Metallurgical Failure Analysis of Steam Turbine, Compressor, and Hot Gas Expander Components

Tuesday, 13 March 2018

1400 - 1530 hours Room 309

Instructors: David Dowson (Elliott)

Components fail due to a number of reasons such as but not limited to improper design, poor material selection, off design and poor service conditions. In order to determine why a component fails one needs to perform a root cause failure analysis (RCFA). A metallurgical analysis is one of the key components of a comprehensive RCFA. This Tutorial will outline the stages involved when conducting a metallurgical failure analysis. Details on the techniques used and the various damage mechanisms observed on failed components will also be presented. Finally, several case studies involving failure of turbomachinery components will be shown. Subjects will include high temperature corrosion on hot gas expander blades and stress corrosion cracking of steam turbine disks and compressor impellers.

Tutorial 6:

HF Acid Alkylation Processes: Pump and Mechanical Seal Application and Design Considerations for Increased Reliability

Tuesday, 13 March 2018

1400 - 1530 hours Room 310

Instructors: Brian Kalfrin (John Crane), Jonathan O'Brien (Monroe Energy LLC)

Hydrofluoric (HF) acid is an extremely corrosive solution commonly found in many oil refineries where it is used as a catalyst in the production of gasoline blending stock. HF acid is almost synonymous with the alkylation unit where the processing takes place within the refinery process flow. This tutorial will focus on HF alkylation and the challenges associated with handling this solution and the process streams. The HF alkylation process uses HF acid which is dangerous and requires special treatment, particularly in the area of shaft sealing along with pump design. This tutorial will attempt to address several topics centered on reliable operation of pumps in an HF alky unit, including pump and mechanical seal design and construction, along with mechanical seal support system considerations.

Tutorial 7:

Save Your Centrifugal Machinery During Commissioning

Tuesday, 13 March 2018

1400 - 1530 hours Room 304

Instructors: Arun Kumar, Mohit Sabharwal (HPCL-Mittal Energy Limited)

During the commissioning of centrifugal machines (Compressors, steam turbines, pumps, fans etc.), lack of flushing, inspection and ignorance of critical areas & procedures can lead to major problems, damage, and serious safety issues.

These serious issues and damages lead to a delay in startup of the refinery, resulting in large monetary loss & further delay as major spares required to carry repairs may not be available in initial stage. It is possible to prevent such damage by following the procedures and inspections which are discussed in detail in this paper.

The Tutorial illustrates what can go wrong with centrifugal machinery during commissioning and startup and actual case studies of damage are provided along with the corrective and preventive measures suggested for successful commissioning. A Checklist of Do's and Don'ts to be followed before and during commissioning is also provided.

Tutorial 8:

Medium Voltage Variable Speed Drive Systems in Oil & Gas Applications

Tuesday, 13 March 2018

1400 - 1530 hours Room 308

Instructors: Umesh Mandlekar (Siemens)

Various Topics to be covered:

- Various VFD topologies and their applications and advantages and limitations.
- Effects of VFD on continuous duty Motor applications
- Various starting methods for Motors and their benefits & limitations
- Line side Harmonics, effects of VFD on power quality and various harmonics mitigation techniques
- High availability VFDs for critical applications.

Tutorial 9:

Drivetrain Protection Through Coupling Design

Wednesday, 14 March 2018

0900 - 1030 hours Room 304

Instructors: Oliver Doidge (Altra Couplings)

This paper is designed to explain types of coupling advanced features and modifications used in turbomachinery, where drivetrain protection is desired. The subject includes a review of flexible coupling types, their characteristics, a detailed outline of their failure modes and application examples.

Tutorial 10:

Conversion from Centrifugal to Rotary Positive Displacement Pumps

Wednesday, 14 March 2018

0900 - 1030 hours Room 308

Instructors: Morg Bruck (Hydraulic, Measurement, and Inspection Consulting, LLC)

A major U.S. pipeline company was experiencing multiple problems at a crude pipeline intermediate pump station. The application seemed ideal for a rotary positive displacement (PD) pump. Working with a vendor and seeing a working pipeline system in Canada, the pipeline company then used computer simulations to model the hydraulic responses of the pump, controls and pipeline system. The computer simulations convinced management that rotary PD pumps would indeed function properly and safely in series with reciprocating PD pumps that were located at the originating pipeline station (upstream in the system).

The tutorial will show examples of:

1. Operating data showing system flow before and after station re-design
2. Rotating equipment installation improvements using before and after photos
3. Operating data showing pressure management improvements
4. Station operating costs before and after and cost per barrel improvements
5. Pump testing and inspection to ensure minimal start-up issues.

Tutorial 11:

Turbomachinery Control Valves Sizing and Selection

Wednesday, 14 March 2018

0900 – 1030 hours Room 327

Instructors: Medhat Zaghloul (Compressor Controls Corporation)

Turbomachinery Controls dedicated to centrifugal and axial compressors use several types of control valves, such as:

- Antisurge (recycle) valve
- Suction throttle valve
- Hot-gas bypass valve
- Quench control valve

As the final control element in its control loop, these control valves are vital to implementing good turbomachinery controls. This tutorial will examine the control objective of each type of valve, its ideal location relative to the turbocompressor and the optimum performance characteristics for the valve. Valve selection criteria and sizing methodologies with examples will be addressed. Recommendations for valve noise abatement will be provided, as well as valve noise-abatement pitfalls that should be avoided will be identified.

The possible negative or positive impact of annular seal on rotordynamics of compressors and steam turbines is discussed. The nature of destabilizing forces that can be developed by Asee-through@ and interlocking labyrinths is discussed.

Tutorial 12:

Rotor-Bearing Dynamics of Integrally Geared Turbomachinery

Wednesday, 14 March 2018

1100 - 1230 hours Room 327

Instructors: Karl Wygant, Chad Robertson, Fang Li (Hanwha Power Systems)

This tutorial focuses on the rotordynamic characteristics of integrally geared turbomachinery. The topics covered include understanding the influence of gear forces, thrust collars (hydrodynamic elements that transmit load from pinion shaft to bull gear shaft), and thrust bearings on the reaction loads of the pinion and bull gear bearings. The various aspects that couple the pinion and bull gear dynamics such as: 1) gear contact stiffness and 2) thrust collar moment stiffness are examined to show the influence of coupled pinion-bull gear rotordynamics. Torsional, lateral, and axial rotordynamic behavior of geared systems is discussed relative to different design standards: API617, API672, etc. Various case studies are presented that show the vibration characteristics for common field and shop problems. The case studies used to illustrate the topics presented show the origin of “step increases in vibration,” “sub-synchronous vibration originating from aerodynamic excitation and bull gear harmonics on the pinion shafting.”

Tutorial 13:

Advancements in Mechanical Sealing - API 682 Fourth Edition

Wednesday, 14 March 2018

1100 - 1230 hours Room 304

Instructors: Michael Huebner, R Sathya Srinivasan (Flowserve)

API 682 is the leading document for mechanical seals in petrochemical, chemical, and pipeline services worldwide. It has combined the aspects of seal design, testing, standardization, and applications to provide the users and OEMs alike with a common source of information for mechanical seals. As seal technology has advanced, the standard has expanded to incorporate new seal designs, materials, seal selection guidance, and piping plans. The current edition, the Fourth Edition, was published in May of 2014 and is now available for purchase. This tutorial will cover the major changes introduced in the Fourth Edition.

Tutorial 14:

Fundamentals of Fluid Film Thrust Bearing Operation and Modeling

Wednesday, 14 March 2018

1100 - 1230 hours Room 308

Instructors: Minhui He, James Byrne (BRG Machinery Consulting, LLC)

Widely used in turbomachinery, the fluid film thrust bearing is critical to the overall reliability of a machine. Their design complexity and application severity continue to increase, making it challenging for the plant engineer to evaluate their reliability. This tutorial provides practical knowledge on their basic physics, including hydrodynamic pressure generation, temperature rise due to internal viscous shearing and elastic deformation, as well as how those aspects interact with each other during operation. Examples are given to demonstrate how common design and operational parameters affect a bearing’s key performance parameters, such as the minimum film thickness and pad temperature. Then, this tutorial reviews the analytical models used to simulate the various physical aspects. The state of the art techniques for modeling important aspects are presented, along with discussions on their capabilities and limitations. Also covered are subjects including housing design, direct lubrication, as well as dynamics.

Tutorial 15:

Investigating and Improving the Drooping Curve of a Two-Stage Feed Pump

Wednesday, 14 March 2018

1400 - 1530 hours Room 327

Instructors: Tzuu Bin Ng (Flowserve)

A two-stage between-bearing pump of the upgraded material was supplied to replace the existing machine. The pump utilized a higher number of impeller blades to obtain higher efficiency at its design point, but exhibited a drooping head-flow characteristic during its shop test. Impeller reworks were done to improve the drooping curve. CFD study was carried out to examine the pump flow behavior. A more stringent test procedure using the high sampling frequency was implemented. Judging from the parameter fluctuations and uncertainties, the pump curve was deemed statistically stable. A key lesson learnt from this particular case is not to overly push the efficiency of the pump at a single best efficiency point, but to have a more balanced design between achieving good pump efficiency and attaining a stable curve.

Tutorial 16:

The Selection and Design of Dual Pressurized Liquid Sealing Systems

Wednesday, 14 March 2018

1400 - 1530 hours Room 308

Instructors: Michael Huebner, Kent Appleman (Flowserve)

Dual mechanical seals represent one of the most common approaches to improving seal reliability and reducing process emissions. While the presence of the pressurized barrier fluid provides significant benefits, the challenge for the end user is to select the most appropriate method of creating this pressurized environment. Fortunately there are several defined options for piping plans which describe the general characteristics of a dual pressurized sealing system. This however is just the starting point. The user must consider the impact of the seal design, the operating environment of the pump, and the considerations and risk assessment for upset conditions in their system evaluation. Other factors include maintenance requirements and seal monitoring strategies. Finally the selection of individual components for the systems will be dictated by operational requirements, local codes, and customer preferences. All of these considerations will require that the end user use a complete, systematic evaluation of their application in specifying the most appropriate system.

Tutorial 17:

Overview of Turbomachinery for Super-Critical Co_2 Applications

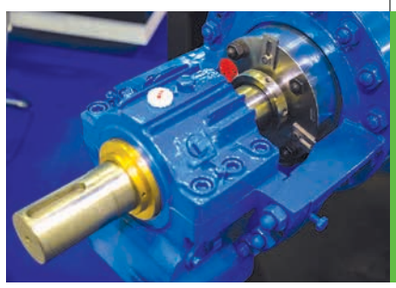
Wednesday, 14 March 2018

1400 - 1530 hours Room 304

Instructors: Tim Allison (Southwest Research Institute), Karl Wygant, Robert Pelton (Hanwha Power Systems)

Cycles involving super critical carbon dioxide (sCO_2) have the potential to increase system efficiencies well beyond current industry norms. Research on advanced direct and indirect cycles is ongoing in national labs and major companies. sCO_2 machinery tends to have small foot print sizes making for excellent applications in marine, or space limited, environments. As $scCO_2$ turbomachinery gains acceptance in various industries the need to understand the applications, potential, and limits is paramount. Discussed in this tutorial are 1) various direct and indirect cycles 2) various applications, and 3) specific impact to turbomachinery design. Specific applications are described in detail including waste heat recovery, power generation, concentrated solar power, and marine applications. Discussed are transient, thermal-mechanical, material, rotordynamic and many other factors affecting the turbomachinery.

DISCUSSION GROUP DESCRIPTIONS



Discussion Group 1:

Digitalization in Oil & Gas

Tuesday, 13 March 2018

1100 - 1230 hours Room Nicoll 1

Instructors: Manoj Gupta, Amit Saxena (Siemens)

Suggested Topics:

- Attendees Topics of Interests
- IoT
- Cyber Security
- Data Connectivity
- Cloud Solutions
- Integrated Engineering Design Tools
- Predictive Analytics
- Autonomous Operations
- Asset Performance Management
- Digital Twin
- Augment Reality / Virtual Reality

Discussion Group 2:

Lubrication: Fluid Film Bearings: Operation, Maintenance, Troubleshooting

Tuesday, 13 March 2018

1100 - 1230 hours Room 329

Instructors: James Byrne, Minhui He (BRG Machinery Consulting, LLC), Norbert Holscher (RENK), Brian Pettinato (Elliott Group)

- Turbomachinery bearings
  - Sleeve and tilting pad journal bearings
  - Thrust bearings
  - Babbitt bearing failures
  - Bearing upgrades
- Clearances, preload, offset
- Installation
  - Oil
- Specific questions
  - Journal bearing fit – loose? Line on line? Or some crush?
  - Discuss API temperature sensor placement:
    - Journal – how many per bearing? Axial locations?
    - Thrust – how many?
  - TPJ No. of pads & orientation – LOP or LBP?
  - TPJ Pivot design
    - Experience with pivot wear?
    - Experience with Ball & Socket pivots?
      - Locking issues?
- Alarm and shut down values
  - Bearing temperature
  - Rotor movement
- Varnish experiences?
  - Solutions?
- Oil types – who is using synthetics and why?

Discussion Group 3:

Centrifugal Pumps: Operation, Maintenance and Reliability, Vertical Pump Problems and Solutions

Tuesday, 13 March 2018

1100 - 1230 hours Room 331

Instructors: Bruno Schiavello (Flowserve), Jihoon Yoon (Donyang Chemical Pump)

Suggested Topics:

- Seal plan which was not expected – wrong for the application
- Preventive/predictive technologies
- Off design operation
- Mean time between failure – how do we measure, and how do we use the metrics
- How to create pump reliability in an unreliable plant
- Seal-less versus sealed pump reliability, canned motor pumps versus mag drive pump reliability
- Mechanical Integrity Inspections of VS 6 pumps in hydrocarbon service



- Seals in light hydrocarbon service – operations, risk, leak response, maintenance
- Pump predictive/preventive maintenance program elements 3.
- Measures of effectiveness of preventive and predictive programs for pumps
- Roles of operations and maintenance/ reliability in improvements and data collection
- Reliability experience with liquid versus non contacting gas seals applications
- Maintenance philosophy for pumps
- Spare parts – OEM versus non-OEM
- Repairs – OEM versus non-OEM service facilities
- Pump foundation, alignment and pipe strain influence of reliability
- Impact of corporate purchasing alliances on pump reliability
  - Repair facilities alliances
  - New equipment purchasing alliances
- Repair techniques and material improvements
- Portable and on-line monitoring – impact on reliability
- Wireless monitoring – impact on reliability and risk of failure
- Optimization of thrust bearings configuration
- Lubrication system impact on reliability – oil mist versus flood, oil selection
- Mechanical Seals

Discussion Group 4:

Transmission Elements: Couplings and Alignment, Gears

Tuesday, 13 March 2018

1400 - 1530 hours Room Nicoll 1

Instructors: Gaspare Maragioglio (Baker Hughes, a GE Company), Chris Wolford (Altra Engineering)

Suggested Topics:

- Coupling guard design
- Shaft alignment and tolerances
- Balancing methods
- Coupling selection and specifications
- Shaft alignment methods
- Thermal growth considerations
- Application of optical alignment
- Hub/shaft fits and keys
- Coupling types and applications
- Startup problems
- 8th Edition recommendations
- Allowable nozzle loads
- Warmup piping procedures
- Case deflection, temperature, and pressure
- Piping alignment
- Pipe strain

Discussion Group 5:

Dry Gas Seals: General (Installation, Operation, Troubleshooting, and Retrofitting), Controls

Tuesday, 13 March 2018

1400 - 1530 hours Room 329

Instructors: S.P. Asokan (Flowserve), Vasanth Bhat (Singapore Refining Company), Daniel Goebel (Eagle-Burgmann), Leonardo Baldassarre (Baker Hughes, a GE Company), Athal Doorenbos (Siemens), Michael Weegenhausen (John Crane), R Sathya Srinivasan (Flowserve Asia Pacific – Singapore), Chris Carmody (AESSEAL PLC), Teo Woon Lip (ExxonMobil Chemical), Michael Sean Forsthoffer, William Eugene Forsthoffer (Forsthoffer Associates, Inc.)

Suggested Topics for Dry Gas Seals Discussion group:

- DGS operating characteristics
- Unidirectional versus bidirectional
- Seals faces and seats, O rings materials
- Explosive decompression
- Primary seal gas supply control system Primary seal failure detection
- Primary seal gas vent to flare control system
- Secondary seal failure detection
- Tertiary seal types, carbon rings versus labyrinth
- Buffer gas and associated control
- Separation gas, air or nitrogen and associated controls
- Tandem versus double seals application
- Field problems and experiences
- Challenges in Dry Gas Seal retrofits
- Operation and spares maintenance, shelf life and requalification.
- Dry Gas seals reliability and availability
- Dew point monitoring and control
- Seal Gas Conditioning systems
- Seal Gas Boosters and Heaters
- API 614 – 5th Edition, current and advancements in Dry Gas seals & Systems

Discussion Group 6:

Magnetic Bearings

Tuesday, 13 March 2018

1400 - 1530 hours Room 331

Instructors: Sreenivas Raghavendr (Shell), Manoj Gupta (Siemens), Armando Guerrero (Petronasia Energy), Rasish Khatri, Jay Koch (Dresser-Rand, A Siemens Business)

Suggested Topics:

- Magnetic bearing operating characteristics
- Field problems and experiences
- Shutdown problems
- Control recommendations
- Auxillary bearings
- Rotordynamics
- Operation, maintenance and troubleshooting
- Specifying magnetic bearings
- Fault tolerance

Discussion Group 7:

Turbomachinery and Pump Vibrations

Wednesday, 14 March 2018

0900 - 1030 hours Room 329

Instructors: Gaspare Maragioglio, Lorenzo Naldi (Baker Hughes a GE Company), Jim Byrne, Minhui He (BRG Machinery Consulting, LLC), Hussain Al-Baloshi (Qatar Petroleum)

This group will discuss plant machinery vibration detection, monitoring, and diagnosis, from a Plant O&M point-of-view. All attendees will be encouraged (but not required) to participate in discussions, and contribute topics worthy of discussion. Likely topics presently suggested, which will be affirmed or rejected by attendee vote, include the following:

- Condition monitoring vibration sensors and methods
- Effectiveness of vibration condition monitoring on rotating equipment for detecting problems
- “Diagnostics” versus “prognostics”
- Value of, and ROI of, condition-based monitoring of vibration
- Vertical pump monitoring, including below ground monitoring

- Vibration standards for various pumps and turbomachinery types, sizes, and applications
- Vibration test method options, and their proper selection and use
- Standard locations for vibration measurement on machinery
- Wireless devices: radio noise, effectiveness, experiences, security
- Troubleshooting methods for typical vibration problems, and fix options
- Operating Deflection Shapes and integration with condition-based monitoring
- Finite element analysis application in support of machinery selection and troubleshooting
- Rotordynamics analysis use in machinery selection and troubleshooting
- Hydraulically-induced vibration: structural, system, rotor, acoustic
- Measurement of presence, location, and severity of pump cavitation
- Effect of high GVF (gas volume fraction) in centrifugal pumps
- Mechanical installation (e.g. piping, foundation, alignment) issues affecting vibration
- Seal and bearing effects on vibration, and vibration effects on bearings and seals

Discussion Group 8:

Centrifugal Compressors: Operation and Maintenance, Advanced Design, Wet and Gas Operation

Wednesday, 14 March 2018

0900 - 1030 hours Room 331

Instructors: Urs Baumann (MAN Diesel & Turbo), Shin Konomi (Elliott Group), Arun Kumar (HMEL), Leonardo Baldassarre (GE O&G), Manoj Gupta (Siemens), Takeshi Hataya (MHI)

Topics Outline:

- Meeting current rotordynamics stability standards
- High flow coefficient/mach number impellers
- Low flow coefficiens/high pressure impellers; Reynolds correction
- Complicated high pressure gas properties. E.g., CO_2, acid gas, H_2S
- Testing of the equipment
- Modern manufacturing/forming methodologies
- Simulation and dynamic process modeling
- Handling of Chlorides in sour/acid gas applications, including piping; end-user strategies
- Hermetically-sealed compression

Discussion Group 9:

Gas Turbines: Operation and Maintenance

Wednesday, 14 March 2018

1100 - 1230 hours Room 329

Instructors: Klaus Brun (SwRI), Rainer Kurz (Solar Turbines), Hussain Al-Baloshi (Qater Pet), Manoj Gupta (Siemens)

Suggested Topics:

- Preventive/predictive maintenance
- Condition monitoring
- Air filtration onshore and offshore
- Fogging/evaporative cooling/inlet chilling
- Liquid fuel handling and storage
- Gas fuel issues
- Lean premix combustion and emissions issues
- Repair techniques
- Matching of driver and driven equipment
- Auxiliary systems reliability
- Noise
- Maintenance and spare parts philosophies, including LTSAs, OEM versus non-OEM, engine exchange
- Component failures

Discussion Group 10:

Mechanical (Liquid) Seals: General (Installation, Operation, Troubleshooting, and Retrofitting)

Wednesday, 14 March 2018

1100 - 1230 hours Room 331

Instructors: S.P. Asokan (Flowserve), Shifeng Wu (A.W. Chesterton Co), Nikoluas Necker (EagleBurgmann), John Morton (John Crane), Vasanth Bhat (Singapore Refining Company), Michael Sean Forsthoffer, William Eugene Forsthoffer (Forsthoffer Associates, Inc.), Seetharam Lalithkumar, Sathya Srinivasan (Flowserve Asia Pacific – Singapore), Chris Carmody (AESSEAL PLC)

Mechanical seals are the most common method of sealing industrial centrifugal pumps and other rotary equipment. Although the basic concepts of a seals are simple, successfully using seals requires an understanding of the selection and operational requirements which can be unique for a specific application. In this discussion group, we will cover many of these considerations along with other application experiences from end users and seal OEMs. The discussion group will actively solicit topics from the attendees so the discussions will address real-world problems and challenges faced by the group.

Suggested Topics for Mechanical Seals (Liquid) - Discussion group:

- Advancements in mechanical sealing – API 682 4th Edition
- Air testing of seals in pumps prior to installation
- Challenges with low temperatures sealing
- Effective leakage containment of single seals
- The Selection and Design of Dual Pressurized Liquid Sealing Systems
- Strengths and weaknesses in Plan 53A, 53B, and 53C piping plans
- Considerations when sealing abrasive slurries
- How to apply dual pressurized gas seals
- Mechanical seals for multiphase applications
- Advances in seal face materials
- Process for handling problem pump and seal applications
- Definition of mean time between failure and industry best practices • How and when to use split seals
- Seal & System for rotating equipment other than pumps
- Polymer and Elastomers sealing elements – reliability in Mechanical Seals

Discussion Group 11:

Steam Turbines Operation and Maintenance

Wednesday, 14 March 2018

1400 - 1530 hours Room 329

Instructors: Ronald Josefczyk (Elliot Group), Arun Kumar (HPCL-Mittal Energy Limited, India)

Suggested Topics:

- Overhaul intervals
- Maintenance practices
- Solid particle erosion
- Contract versus in-house maintenance
- Mechanical driver turbine issues - design et al
- Steam path repairs
- Turbine casing and alignment issues
- Steam turbine performance, degradation, etc.
- Reliability/availability

Discussion Group 12:

Other Compressors: Reciprocating, Screw (Wet and Dry), Integrally Geared, AND Turbo-Expanders

Wednesday, 14 March 2018

1400 - 1530 hours Room 331

Instructors: Armando Guerrero (Petronasia Energy), Sreenivas Raghavendr (Shell), Ulrich Schmitz (Atlas Copco)

Suggested Topics:

- Offshore and marine applications

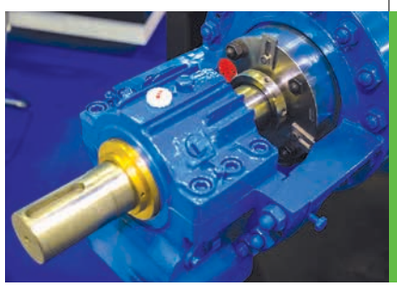
Cryogenic considerations

- Industry standards – API 617, 618, API 688, API 670, etc.
- Bearings, seals, and couplings

Capacity Control – speed, IGV, DGV, recycle, unloaders (all types)

- Modern wear components – design, reliability and failures
- Maintenance strategy / Best Practices
- Process gas quality and conditioning
- Pulsation, vibration and torsional issues
- Packaging / Size and Weight Considerations / Installation Type
- Field Testing and commissioning
- Advanced Condition monitoring

CASE STUDY DESCRIPTIONS



Case Study 1:

Molten Urea Transfer
Pump Seal Failures Case Study

Wednesday, 14 March 2018

1400 - 1422 hours Room 309

Instructors: Danish Moin (Engro Fertilizers Ltd.)

The Case Study "Molten Urea Transfer Pump Seal Failures – Case Study" details the study of mechanical seal failures on molten urea service. A FMEA approach discusses the most relevant causes and the solutions implemented so far in improving the reliability of the pump.

Case Study 2:

NPSHR (NPSH3) Improvement
of a Low Pressure Safety Injection Pump

Wednesday, 14 March 2018

1422 - 1444 hours Room 309

Instructors: Frank Visser, Mark Ketelaar (Flowserve)

This case study discusses the rerate of a set of vertically-mounted single-stage end-suction centrifugal pumps used for low pressure safety injection (LPSI) in a nuclear power plant. The original LPSI pumps were supplied early 1970's and for safety purposes it was decided to overhaul these pumps to improve NPSHR (i.e. NPSH3).

The rerate consisted of replacing the existing impeller with a new design yielding close to identical head performance characteristic, yet better NPSHR. Aim was to improve NPSHR by (minimally) 0.5 m (1.64 ft) at rated capacity of 682 m3/h (3003 USGPM) and 1470 r/min running speed, and demonstrate by test the actual improvement in NPSHR.

Case Study 3:

Applying Upstream Pumping Sealing Technology for High Corrosive Fluid – Improve Reliability and Operating Cost

Wednesday, 14 March 2018

1444 - 1506 hours Room 309

Instructors: Yanhui Xu, Gibbon FitzGibbon (John Crane)

This is a mechanical seal upgrade case study about applying advanced upstream pumping technology instead of a conventional tandem seal arrangement with external flushing in high corrosive fluid pump seal applications in order to improve equipment reliability and minimizing the operating cost.

Case Study 4:

Base Plate Corrosion and
Premature Failure in RO Pump

Wednesday, 14 March 2018

1506 - 1528 hours Room 309

Instructors: Moorthy Subramanian (KSB Singapore (Asia Pacific) Pte. Ltd.)

On 19th Aug 2017, abnormal noise noticed from RO (Reverse osmosis) Membrane Feed pump coupling area. Checked the vibration for pump & motor and found very high vibration at Pump Drive end. The vibration level at Pump DE Vertical recorded as 4.5 mm/sec (Allowable: 3 mm/sec Max.)

Pump was stopped to identify the reason for the high vibration and abnormal noise. Checked the alignment and found the vertical offset at motor end coupling is 0.8 mm higher than the pump end.

Customer has tried to perform the alignment with their own maintenance team and found there is no shim at motor foot to do the necessary correction.

Customer has approached OEM Service team.

Case Study 5:

Zero Leakage Compressor Seals

Wednesday, 14 March 2018

1400 - 1422 hours Room 310

Instructors: Takuya Watanabe (Mitsubishi Heavy Industries Compressor Corporation)

Dry gas seal is applied to refrigeration compressor. Some of configurations for dry gas seal system are shown in API 617 and 614, however those systems are designed with condition that leak gas from dry gas seal is released to atmosphere or flare system.

In order to minimize emissions and refrigerant make up, this paper introduces the development of new concept of leakage recovery system by distillation column (process patented), and provides verification test results.

Case Study 6:

Mechanical Seal Failure in Oil Flooded Screw Compressor

Wednesday, 14 March 2018

1422 - 1444 hours Room 310

Instructors: Minho Kim, Mugeon Kim (SK INCHEONPETROCHEM), Younggon Kim (Korea Flowserve)

We consistently experienced mechanical seal failure of the oil-flooded screw compressor in refrigeration system. This seal failure was repeated 4 times every 3 months. All the seal failures were caused by oil carbonization. These phenomena happened on the outboard only.

We did the the root cause analysis and it was determined that the carbonization was caused by high lube oil viscosity, low flushing flow rate, contact with air, and high differential pressure on the seal face. We tried to apply some methods and finally solved this problem. While our solution is not commonly used, it is easy to apply and it can be a viable approach in case of oil carbonization and urgent situations

Case Study 7:

Dry Gas Seal Separation Seal Failure - A Case Study

Wednesday, 14 March 2018

1444 - 1506 hours Room 310

Instructors: Teo Woon Lip, Ajay Mathew (ExxonMobil), Raj Mane (John Crane), Takayuki Ogata (Mitsubishi Heavy Industries Compressor Corporation)

This case study presents the failures experienced on segmented contact type carbon ring bushing separation seals installed on several compressors in ethylene plant. The failures resulted in oil migration to the dry gas seals. Failure analysis was performed and root cause identified. Various solutions were studied and some preliminary design changes were implemented in the seals. However these changes did not improve the oil migration issue. Further site evaluation combined with OEM support resulted in implementation of two design changes which have effectively mitigated the oil migration. This case study will present problems encountered, root cause analyzed, solutions implemented, learnings and results after 4 years of operation.

Case Study 8:

Steam Whip Phenomenon in Steam Turbine

Wednesday, 14 March 2018

1506 - 1528 hours Room 310

Instructors: Nicolas Peton, Sergey Drygin (Baker Hughes a GE Company)

This case study is designed to outline how the high vibration issue was successfully diagnosed, the root cause for the high vibration found and correction actions recommended. The source of mentioned high vibration - sub synchronous excitation is steam induced instability – steam whip, detected in HP/LP turbine seals, closer to Drive End bearing.

This turbine was initially equipped by Anti-swirl packages. It was confirmed that this system is installed or operated not properly, non-original spare parts were installed during last overhaul.

Case Study 9:

Investigation and Resolution of Propane Compressor High Axial Position

Thursday, 15 March 2018

0900 - 0930 hours Room 308

Instructors: Sridhar Kuppa Padmanabha, Peck Lui Ng (ExxonMobil)

A case study of centrifugal compressor surge controller effect on improving mechanical performance of the compressor.

Case Study 10:

Conversion of A Horizontal Split Centrifugal Compressor with a Closed Impellor to an Open Face Impellor with a One Piece Diaphragm

Thursday, 15 March 2018

0930 - 1000 hours Room 308

Instructors: Trevor Mayne (Qenos Pty Ltd)

“A 1970 vintage polyethylene plant faced a market driven requirement to improve its polyethylene grade. The improved, new grade required a new highly reactive catalyst and needed to be ready for customer’s product trial in less than 12 months. The catalyst licensee recommended that a new replacement compressor would be required for the new grade however this would require a high capital outlay, a three week outage for installation and 18 months lead time.

A review of the original horizontally split compressor and its suitability to be converted to an open face nonfouling design was made. This included the potential to use a one piece inlet diaphragm. This approach resulted in an upgrade that was 60% the cost of a new compressor, a fast tracked delivery in 9 months and a conversion that was completed in a 1 week outage.”

Case Study 11:

Investigation of High Bearing Temperature in Centrifugal Compressor

Thursday, 15 March 2018

1000 - 1030 hours Room 308

Instructors: Takashi Oda, Daisuke Hirata, Akinori Tasaki, Goenka Mohit (Mitsubishi Heavy Industries, Compressor Corporation), Ajay Mathew (ExxonMobil Manufacturing Engineering Singapore)

Suction side Journal bearing temperature increased to around 130 degC from 60 degC instantaneously. Further the temperature was decreased to 80 degC accompanied by increase in rotor vibration.(from 5 to 15 μm p-p) Bearing was inspected and damage to bearing pads was found.

Horizontal side bearing clearance was decreased because of shrink the casing at low suction temperature.(roughly -100 degC)

As countermeasure, bearing clearance was increased. After that, bearing temperature became stable.

Case Study 12:

Steam Turbine Steam Control Valve Failure

Thursday, 15 March 2018

0900 - 0922 hours Room 309

Instructors: Vasanth Bhat, Thangavel Suthan (Singapore Refining Company Pte Ltd)

The Wet Gas compressor is one of the most critical assets in a FCCU/RCCU of a oil refinery.

The back pressure steam turbine driver of this compressor faced two failures in the main valve stem of the steam inlet valve. Detailed study jointly between the End user and the OEM resulted in identification of the right issues causing the failure and applying relevant solutions.

Case Study 13:

Glycol-Based Lube Oil Behavior and its Effects in Fuel Gas Compression System

Thursday, 15 March 2018

0922 - 0944 hours Room 309

Instructors: Yupiter Kristiyanto, Douglas Funk, Aditya Kris Harjanto, (ExxonMobil)

Oil-flooded screw compressor delivers fuel gas from Acid Gas Recovery Unit (AGRU) to Gas Turbine Generator. The compressor experienced repetitive downtime due to lube oil (gear) pump failures resulting in costly diesel fuel consumption. The pump failures were due to poor lubrication as lube oil viscosity drops resulted from water contamination. Polyalkylene glycol lube oil used in this application is hygroscopic which tends to absorb free water from fuel gas stream that comes from AGRU to compressor inlet at saturated conditions. The fuel gas condenses water along uninsulated suction piping. It is therefore crucial to identify the cause and come up with Fit to Purpose solutions to eliminate the dependency on expensive diesel fuel especially in the current cost sensitive environment.

Case Study 14:

Investigation and Resolution of Governing Valve Linkage Failure

Thursday, 15 March 2018

0944 - 1006 hours Room 309

Instructors: Kenichi Nishiyama, Mayank Jain (Mitsubishi Heavy Industries Compressor Corporation), Elumalai Subramani (ExxonMobil Chemical)

Fatigue failure of Governing Valve Linkage Rod end bearing and wear marks on several parts was observed on an extraction steam turbine (driving a centrifugal compressor) after it was in service for more than 9 year. The top surface of rod-end bearing was completely worn out. A detailed motion analysis was carried out to estimate the vibratory force and slip velocity of the Bearing ball and body. This paper presents the details of observations, inspections carried out and root cause analysis of the valve linkage failure along with the future recommendations.

Case Study 15:

Investigation of Unexpected Trips in Steam Turbine

Thursday, 15 March 2018

1006 - 1028 hours Room 309

Instructors: Shunsuke Fuchiwaki, Kenichi Nishiyama, Mayank Jain (Mitsubishi Heavy Industries Compressor Corporation), Teo Woon Lip (ExxonMobil Chemical)

A 56 MW steam turbine tripped several times over a short period of time although the trip signal was not sent. A thorough examination of the turbine at site ruled out any problems with the trip system. The pressure data for control oil line indicated a sudden drop in oil pressure forcing the trip button in trip relay system to move to the trip position. Dynamic simulation of the trip system was carried out to find the effect of various factors including the abnormal behavior of different components. This presentation shows the detailed analysis results, possible causes of failure of the trip system and solution employed to solve these problems.

Case Study 16:

Case Study on Resolving Structural Vibration Issues on a Multi Stage Pump

Thursday, 15 March 2018

0900 - 0922 hours Room 310

Instructors: Nicolas Peton, Sankar Ganesh (Baker Hughes a GE Company)

This case study is designed to outline how the high vibration issue on a newly commissioned multistage pump was successfully diagnosed, the root cause for the high vibration and finally how it was mitigated using some of the structural analysis techniques (modal analysis, Operating Deflection Shape etc). Lessons learned are also discussed on the discovery methodology using expert system available at site, project point of view as well as from design point of view, which will be very much useful for the audience.

Case Study 17:

Resolving High Vibration on A Vertical Pump

Thursday, 15 March 2018

0922 - 0944 hours Room 310

Instructors: Mustafa Shalabi, Sanker Ganesh (Baker Hughes, a GE company), Sami Al-Mubarak, Ahmad F Bn Nawawi (Saudi International Petrochemical Company)

There is a single stage vertical pump installed in Acetic Acid area in a petrochemical plant. The unit is vertical high pressure (HP) reactor feed pump driven by induction motor through a flexible shim pack coupling. High vibration levels were observed on the motor, pump and structure for more than 2 years with 1X dominant vibration (1X motor dominant frequency).The timely right decision by the experts to carry out an onsite balancing on the motor, which was intended to remove the excitation force, yielded good results which exposed a mistake in the balancing activities carried out by a local vendor at work shop. This case study is designed to outline how the high vibration issue was successfully diagnosed using various tests at site including the Operating Deflecting Shape analysis, the root cause for the high vibration and finally how it was addressed.

Case Study 18:

Plunger Pump Station — Vibration-Induced Cracks in Piping

Thursday, 15 March 2018

0944 - 1006 hours Room 310

Instructors: Kelly Eberle, Mena Ghattas, Paul Crowther (Wood)

Objective:

Demonstrate the risks and costs of excluding a pulsation analysis from a pump installation as well as ways to mitigate the pulsation and cavitation risks.

Analysis approach:

Field-measured pulsations and numerical simulations (1-D pulsation model).

Case Study 19:

Unsteady Vibration Due to Cavitation in Mixed Flow Pumps

Thursday, 15 March 2018

1006 - 1028 hours Room 310

Instructors: Hideaki Maeda, Takuya Nakano (Torishima Pump Mfg. Co., Ltd.)

In regarding to the large vertical mixed flow pump for seawater supply pump, the authors experienced the strange excessive vibration:

the vibration level intermittently changed and the peak frequency was the blade passing frequency as like the vibration due to the submerged vortex in sump.

In order to investigate the real cause, the model test was performed and it was found that the cause was due to the strong tip vortex cavitation on the blade surface of the impeller.

As the countermeasure, the forward swept impeller was designed to suppress the strong tip vortex cavitation. After that, the model test had been performed to estimate the effect of the forward swept impeller on the cavitation condition. As the result, it was confirmed that the cavitation condition was drastically improved. Finally, the strange excessive vibration was disappeared in the actual pump by applying the improved impeller.

Case Study 20:

Large Vibrations on Centrifugal Compressor Caused by Inappropriate Operation During Mechanical Running Test

Thursday, 15 March 2018

0900 - 0922 hours Room 311

Instructors: Yves Bidaut (MAN Diesel & Turbo Schweiz AG)

During the mechanical test of a centrifugal compressor, the rotor experienced a sudden increase of the radial vibrations. After re-start, the compressor showed unacceptably high vibrations.

The RCA revealed:

The vibrations increased while running at trip speed close to surge. The shrink of the impeller, which had moved on the shaft, was too low to withstand these conditions.

The impeller was removed and the shrink increased. After reassembly no high vibration appeared at trip speed anymore. Generally, the

operation time at trip speed shall be reduced to its minimum and shall not be considered as “normal” continuous operation.

Case Study 21:

Flow Induced Vibration Problem During Full Load Testing of a Multi-Stage Centrifugal Compressor

Thursday, 15 March 2018

0922 - 0944 hours Room 311

Instructors: Yutaka Kurashiki, Takahiro Hirao, Hidenori Yoshida (Kawasaki Heavy Industries, Ltd)

During FAT of a centrifugal compressor, non-synchronous vibrations were observed. The dominant frequencies are different from both a) the rotor system natural frequency, and b) typical rotating stall frequency in parallel wall diffuser.

Investigation is conducted and found that the downstream flow control valve generates pressure pulsation and it caused rotor vibration.

As a practical solution, the flow control valve location is modified and this result in the lower pressure fluctuation and vibration amplitude.

CFD analysis illustrates the actual phenomena qualitatively.

Case Study 22:

Blade Failures on An Axial Compressor by Unexpected Gas Compositions

Thursday, 15 March 2018

0944 - 1006 hours Room 311

Instructors: Marco Schwarz (MAN Diesel & Turbo SE)

A fifteen stage axial compressor including a bleed extraction was subject to a major overhaul after nearly 20 years of trouble free operation. Shortly after recommissioning and resumption of the production the compressor faced three major failures within two weeks. A root cause failure analysis was conducted and revealed that the process plant start-up procedures caused gas compositions which deviated strongly from the design conditions. The valve designs as well as the available control parameters were not able to protect the compressor from off-design operating conditions. For future compressor failure prevention, the process start-up procedures were adapted and the existing control parameters/logic was upgraded. The new control logic reacts to the transient process behavior during start-up by continuous harmonization of the safety valves.

Case Study 23:

Vibration Analysis of Gas Turbines Transportation Carrigage and Warranty Issues

Thursday, 15 March 2018

1006 - 1028 hours Room 311

Instructors: Danilo Matos, Wiriton Silva de Matos (Tecvib Engenharia)

This paper describes the investigation of whether the vibration shock limits were exceeded on the transportation of 2 gas turbines from one port to the installation site. This investigation was requested due to an improper suspension type of the carriage used in the transport and the OEM consideration if vibration limits were exceeded during the route. It ultimately lead to a contractual impasse where the OEM required full bearing inspection prior to commissioning as a prerequisite to maintain the warranty on the equipment which the client did not agree to follow without further investigation.

Case Study 24:

Case Study on Resolving High Vibration Issue of a Centrifugal Compressor at an Offshore Platform

Thursday, 15 March 2018

1100 - 1122 hours Room 308

Instructors: Amit Sharma, Sanker Ganesh (Baker Hughes, a GE company)

This case study describes a vibration problem on a Gas Injection Compressor at an offshore platform. The gradual increase of vibration on the compressor non drive end bearing along with the load became a concern. The vibration level sometimes were reaching up to the alarm set point. This case study is designed to outline how the gradual vibration increase was successfully diagnosed, the root cause for the high vibration, and finally how it was resolved. Lessons learned are also discussed on the discovery methodology using expert system available at site.

Case Study 25:

Rotor Magnetization in Turboexpander and its Effect on Vibration Readings

Thursday, 15 March 2018

1122 - 1144 hours Room 308

Instructors: Ajay Kumar (Petronas)

Undesired magnetism in Turbo machinery accounts for many unexpected issues including erroneous vibration readings in machinery fitted with proximity probes. Often, decisions based on erroneous vibration readings result unscheduled downtime with consequent production losses. This presentation highlights the importance of recognizing rotor magnetization as one of the potential issues in Turboexpander, its effect on vibration readings, and how to successfully mitigate the issues based on experiences of the industries. A case study has been discussed that focuses on source of magnetism, failure modes, problem identification and successful resolution of the issue. Lesson learnt from the incident is also being shared.

Case Study 26:

Emerging Failures in Gas Turbine Engines

Thursday, 15 March 2018

1144 - 1206 hours Room 308

Instructors: Kaartik Palaniappan, Stan Uptigrove (ExxonMobil Exploration & Production Malaysia Inc), Steve Broomfield, Camille Rizzetto (Siemens Industrial Turbine Company (UK))

Two (2) gas turbine engines operating offshore experienced Domestic Object Damage (DOD) failure with damaged blades in the HP compressor section.

The failures were caused by repeated use of a component undergoing wear accelerated by hot ambient environment (tropical climate) and operating in full load. A variety of different failure modes and how the root cause was determined is presented. The current solution to prevent failures is to replace the component during engine overhaul. The component is the shroud box which holds the 7th Stage Outlet Guide Vane (OGV) of the engine's IP compressor section.

Risk exposure for the remaining fleet was analyzed to prevent repeat failure and improvements were made on the online algorithm to provide earlier indication of a potential failure.

Case Study 27:

New Concept of On-Line Wash For Centrifugal Compressor

Thursday, 15 March 2018

1206 - 1228 hours Room 308

Instructors: Tokuyama Shinichiro, Goenka Mohit, Akihiro Nakaniwa (Mitsubishi Heavy Industries Compressor Corporation), Ajay Mathew, Elumalai Subramani (ExxonMobil)

This paper introduces the development of new concept of on-line wash oil injection system which includes the optimization of oil quantity, location of injection nozzles, hole size etc.

As common practice, wash oil injection nozzles are usually installed on the suction piping as well as return bend on each stage. However, performance reduction due to foulant material has been reported.

Therefore, User and OEM investigated the root cause of this phenomenon and constructed the new concept design of on-line wash oil injection system in consideration of wash area, oil quantity, erosion etc. To verify the effectiveness of this new concept design, component test, full scale test and actual machine verification test was conducted and successfully completed in OEM's factory. After completion of these tests, OEM delivered newly developed oil injection in user site, and User and OEM confirmed the effectiveness of new oil injection system at site operation.

Case Study 28:

Operating with a Broken Pinion Teeth

Thursday, 15 March 2018

1100 - 1130 hours Room 309

Instructors: Vasanth Bhat, Keith Loh (Singapore Refining Company Pte Ltd)

There was a failure in the gear box of the main feed pump of the hydrocracker unit. As no spare was available, there was no immediate fix to the failure. A quick evaluation of the damage to the gear was done and an interim measure was taken to use back the old damaged pinion shaft.

A successful risk based repair and restoration plan developed jointly with OEM support, until the new spare gear set was made available. The paper highlights on the ways the risks were managed during this interim period and share the observations during this interim operation.

Case Study 29:

Unexpected Vibrations in Gearbox Caused by System Integration Issues

Thursday, 15 March 2018

1130 - 1200 hours Room 309

Instructors: Gianluca Boccadamo, Gaspare Maragioglio (Baker Hughes, a GE company)

This case study deals with a 24MW turbo-compressor unit composed of a gas turbine, a speed reduction gearbox with a lube oil pump mounted on its low speed shaft and two compressors in series. The unit was subject to high radial vibrations at the gearbox low speed shaft during initial running phase. Technical investigation identified the root cause as lube oil pump working in aeration condition owing to a wrong pressure set point. Aeration, in turns, excited a torsional natural mode of the train. This case study highlights some of the implications of mechanical integration of machines and auxiliary systems, where the modification of operating parameters may lead to unwanted outcomes which may affect availability and integrity of the unit.

Case Study 30:

Gear Box Bull Gear High Vibration Due to Rotor Instability and Analytical Evaluation of New Bearing Design

Thursday, 15 March 2018

1200 - 1230 hours Room 309

Instructors: Bhagyesh Chavda, Saqib Ashraf, John Kocur (ExxonMobil), Heinrich Baer (MAN Diesel & Turbo SE)

A case study of gear box shaft high vibration detailed analysis and proposed bearing modification to overcome rotor instability.

Case Study 31:

Catastrophic Failure Diagnosis with Modal Analysis of Generator Endwindings

Thursday, 15 March 2018

1100 - 1122 hours Room 310

Instructors: Danilo Matos (Tecvib Engenharia)

In this paper, the catastrophic failure of a 2-pole 360MW unit will be presented. This failure lead a root cause analysis and a series of investigations that was taken place in a similar design unit deployed at a different site. This paper will describe the bump test and modal analysis procedures and results that were carried out on the end of all coils of the stator winding in the sister unit of the failed 360MW generator which lead to conclusions that were crucial for the determination it´s failure root cause.

Case Study 32:

Accurate Estimation of Start-Up Pulsating Torque of Direct on Line Synchronous Motors Driving Compressor Trains

Thursday, 15 March 2018

1122 - 1144 hours Room 310

Instructors: Francesco Meucci, David Donati, Stefano Del Puglia, Niccolò Spolveri (Baker Hughes a GE Company)

In a compressor train driven by fixed speed synchronous motor (>17MW) was discovered a potential torsional problem on the input shaft of the hydraulic variable speed gear during the start-up phase when only low speed shaft line is engaged. It was due to high motor excitation torque crossing the 1st torsional critical speed during startup causing a very limited numbers of train startups (1400) versus project requirements (5000). Supported by API 617 (8th edition), the motor excitation air-gap torque during startup has been analyzed considering electrical system characteristics that influence the effective voltage drop at motor terminals. A more realistic analysis of the excitation confirmed the correctness of the shaft line design avoiding any redesign and impacts in the projects execution.

Case Study 33:

Benefits of Installing Restrictive Orifice Plates on the Suction of Reciprocating Pumps: 1D Pulsation and CFD Studies

Thursday, 15 March 2018

1144 - 1206 hours Room 310

Instructors: Cajetan Ijeomah, Zixiang Chen, Paul Crowther, Jordan Grose (Wood)

To conserve NPSHA, pump designers rely on rules of thumb that resist the addition of pressure drop elements such as restrictive orifice plates, choke tubes and line-size reductions to inlet piping of pumps.

Can there be a balance between pulsation control benefits of pressure drop elements and the need to meet NPSHA?

This paper challenges industry resistance to pressure drop elements in the suction piping of reciprocating pumps by, first, outlining the virtues achieved in terms of pulsation and vibration control, and second, presenting results from numerical simulations. Recent field data from a quintuplex pump installation shows that well-designed orifice plates and other pressure drop elements are reducing pulsations and cavitation risks; and can be used efficiently in the suction piping of reciprocating pumps.

Case Study 34:

Reciprocating Pump on Unstable Condensate

Thursday, 15 March 2018

1206 - 1228 hours Room 310

Instructors: Jason Jakubiak (Peroni Pumps America), Luigi Mascherpa (Peroni Pompe)

Reciprocating plunger pumps only operate with single phase liquids. Unstable or two-phase process conditions create problems for reciprocating plunger pumps. Pumping hydrocarbon condensates is an application where the reciprocating plunger pump manufacturer must take extra caution to ensure proper performance even if the process is unstable. This case study explains that standard sealing and lubrication systems for packing is not effective approach for pumping hydrocarbon condensate. Special materials and auxiliary systems must be considered to mitigate this process instability.

Case Study 35:

Rotordynamics Analyses of A Modified Hydraulic Power Recovery Turbine

Thursday, 15 March 2018

1100 - 1122 hours Room 311

Instructors: Ng Tzuu Bin, Edmund Lek, Cheong Kai Chiat (Flowserve)

The rotordynamics analyses were performed to investigate the stability of the upgraded HPRT rotor for the new operating condition. A Holzer's torsional model was constructed for the entire train including the HPRT rotor, clutch, electric motor, speed reduction gearbox, couplings, and the process pump rotor. The study revealed the high likelihood of the presence of resonance for the upgraded design due to the very tight separation margin between the first critical torsional speed and the running speed. Several modification methods are examined to resolve the resonance problem. Changing the coupling design located at two ends of the clutch is finally adopted because of cost and lead time consideration. A key lesson to take away from this case is that the rotordynamics study should always be performed to verify the stability of the complex machine train before changing the machine operating condition or modifying any components within the machine train.

Case Study 36:

Failure, Repair and Overhaul of 5 Mw Right Angle Reduction Gearbox

Thursday, 15 March 2018

1122 - 1144 hours Room 311

Instructors: Haseeb Bukhari, Ahtsham Ahmad (Engro Fertilzers)

The case study deals with the effective troubleshooting of an obscure cause of Gear Tooth failure. The presentation shall cover the diagnostics, repair and the design changes that were needed to ensure reliable operation of the machine and arrest the Root Cause. The goal of the case study is to share experience on Gear Box diagnostics and especially on the Gearboxes with very limited Condition Monitoring system. Also it will be a great learning experience for those who may want to know about the sustained Gear Box operation with broken tooth. It shall also give an insight to the Customer to consider design changes.

Case Study 37:

Cooling Water Pump Gearbox Diagnostics, Failure and Remedial Actions

Thursday, 15 March 2018

1144 - 1206 hours Room 311

Instructors: Haider Ali, M. Asad Akram Awan, Mojiz Mansoor, Syed Haseeb Bukhari, Nooruddin Burrero (Engro Fertilizers)

Failure of an industrial scale bevel gear assemble in 2.5 years of its commissioning. The gear box drives a pumps rated at 16240m3/h at 47.5 meter of head. The unit developed an abnormal noise with slightly higher impacting (vibration waveform) on the gearbox. However upon inspection, increased back-lash (still in recommended limit) was observed on the unit and the machine was kept in operation.

During a startup in March 2014, high cyclic impacting was observed in vibration waveform which indicated gearbox wear/damage. Upon inspection, leading edge teeth of the bevel gearbox was found broken (in reverse direction). Further investigation revealed increased back-lash, change in contact area of the gears and loose gear on shaft.

The case study covers the complete RCA of GB failure and the remedial action taken on similar units installed on site.

Case Study 38:

Large Cooling Water Pump Upgrade For Increased Capacity and Reduced Impeller Cavitation

Thursday, 15 March 2018

1206 - 1228 hours Room 311

Instructors: Frank Visser (Flowserve)

This case study discusses the hydraulic upgrade of two sets of four (25 percent) large vertical cooling water pumps. To increase the electrical output of subject power station, the cooling water pumps of block 1 and 2 had to be upgraded in capacity minimally thirteen percent, thereby also attempting to minimize the occurrence of impeller cavitation.

The upgrade consisted of replacing the existing impeller and diffuser plus casing, and installing new electric motors. To corroborate anticipated hydraulic performance the replacement impeller and diffuser were model tested on a 1:4 scale. The model test further served to determine final sizing dimension of the upgrade.

TECHNICAL BRIEF DESCRIPTIONS

Technical Brief 1:

Design and Implementation of Swirl Brakes For Enhanced Rotordynamic Stability in an Off-Shore Centrifugal Compressor

Tuesday, 13 March 2018

1100 - 1230 hours Room 300

Instructors: Balaji Venkataraman, Chris Clarke (Solar Turbines Inc.), David Moulton, Michael Cave, Jason Wilkes, Jeffrey Moore (Southwest Research Institute), Thom Eldridge (Shell Americas)

Rotordynamic stability of gas compressors at high speeds and operating pressures is a significant technical challenge. Dynamic instability must be avoided for the sake of safe, reliable and continuous operation of turbomachinery. It must be mentioned that while the industry has successfully used swirl-brakes for a few decades, many of these applications were for a Teeth-on-Stator configuration. This paper presents the design, testing and successful implementation of swirl-brakes for a Teeth-on-Rotor configuration.

This session runs consecutively with Lecture 6 & Technical Brief 2

Technical Brief 2:

Natural Frequency Whirl Instability in an Industrial Gas Turbine

Tuesday, 13 March 2018

1100 - 1230 hours Room 300

Instructors: Chris White, Mark Brennan (Wood Group - Vibration, Dynamics and Noise)

Following failure and in-situ replacement of Bearing 1 on a two-shaft 70 MW industrial gas turbine, excessive vibration was observed on Bearing 2 a few months later. This brief describes the vibration symptoms and discusses possible causes of the sub-synchronous vibration observed at normal operating speed. A bistable vibration phenomenon at cranking speed was observed, and the means to alleviate symptoms and hence maintain production are also discussed.

This session runs consecutively with Lecture 6 & Technical Brief 1

Technical Brief 3:

Operator / OEM Collaboration on Trip and Alarm Rationalization

Tuesday, 13 March 2018

1100 - 1230 hours Room 301

Instructors: Azeem Meruani, Michael Matheidas, Niran Singh Khaira (ExxonMobil), Mohamad-Ali Mortada, David Wilson (Siemens)

Turbomachinery has increased in complexity and monitoring capabilities over the last several decades. This has resulted in an increased number of trips to protect various machinery systems. The prevailing OEM philosophy has been to protect the machine assuming that an immediate trip is safer and results in the lowest financial consequences. ExxonMobil and Siemens collaborated to redesign machinery protection and control systems with an “Operator’s mindset” – considering the integrated, full plant risk. The goal was to maximize safety and minimize integrated risk resulting in an increase in mean time between forced outage (MTBFO).

This session runs consecutively with Lecture 7 & Technical Brief 4

Technical Brief 4:

Novel Fiber Optic Technology Monitors In-Slot Vibration And Hot Spots in an Air-Cooled Gas Generator

Tuesday, 13 March 2018

1100 - 1230 hours Room 301

Instructors: Peter Kung, George Dailey, Robert Idsinga (QPS Photronics Inc), LuFan Zou (OZ optics), Craig Spencer (Calpine Corporation)

Gas-fired and air-cooled generators are subjected to continuous start-stop-load cycles related to thermal/mechanical stresses, and continuous vibration. The machines are designed to run at highly efficient material use and close to its design limit. One big concern relates to hot spots in the stator core where thousands of insulated carbon steel laminates are tightly pressed and clamped together. Damaged insulation can cause large Eddy currents to flow leading to core damage or machine shut down.

Another important problem is vibration sparking:

This paper will describe a new online distributed vibration monitoring technology and a field test involving these fiber optics sensors placed inside the stator slot and a Brillouin technology based distributed temperature sensor measuring hot spots simultaneously. The test is conducted with Calpine Corporation. These sensors were wideband, they can measure vibration frequency from 10 Hz to 1 kHz.

This session runs consecutively with Lecture 7 & Technical Brief 3

Technical Brief 5:

Operating Conditions of Floating Ring Annular Seals

Tuesday, 13 March 2018

1100 - 1230 hours Room 302

Instructors: Mihai Arghir (Institut PPrime), Antoine Mariot (Safran Aircraft Engines, France)

Floating ring annular seals are used when large radial rotor displacements must be accommodated. They belong to a larger family of sealing devices that includes face seals and segmented seals. They all use carbon rings and have small axial or radial clearances that make them more effective than labyrinth seals. Compared to faces seals, segmented and floating ring annular seals can accommodate much larger radial and/or axial dynamic displacements of the rotor. On the other hand, at large pressure differences they might lock. In this case, they behave as eccentred annular seals with a non-negligible cross-coupling stiffness and all the accompanying drawbacks (destabilizing effect due to the decrease of the effective stiffness). The present work is based on the author's experience in theoretical and experimental analysis of floating ring annular seals. Numerical and experimental results enlighten different operating regimes that may characterize the dynamic response of floating ring annular seals.

This session runs consecutively with Lecture 8 & Technical Brief 6

Technical Brief 6:

Effective Procedure for Turbomachinery Field Balance

Tuesday, 13 March 2018

1100 - 1230 hours Room 302

Instructors: Alessandro Pescioni, Gaspare Maragioglio (Baker Hughes, a GE company)

When unbalance induced vibrations exceed allowable limits, a more accurate system balance is required. If performed at site on assembled machines, it is commonly called field balance. Key point of the activity is the determination of the unbalance amount and position, to be added or removed, in order to minimize the trial and error attempts: it can be challenging due to the quality of available data and due to a lot of variable factors to be considered, both during analysis and activity execution. The present case study shows how a field balance, performed on a gas turbine compressor train, composed by five rotating equipment, can be effective and resolutive at first attempt.

This session runs consecutively with Lecture 8 & Technical Brief 5

Technical Brief 7:

Dry Gas Seal Contamination During Operation and Pressurized Hold Background and Potential Solutions

Wednesday, 14 March 2018

1100 - 1230 hours Room 300

Instructors: Daniel Goebel (EagleBurgmann Germany GmbH & Co. KG), Glenn Schmidt (EagleBurgmann)

This paper will discuss the challenges with contamination of gas seals. The reliability of gas seals is largely dependent on having a continuous supply of clean and dry seal gas. In dynamic mode, gas supply systems take product gas from a higher-pressure level in the compressor, filter it and use it to create the ideal environment for the gas seal. This typically ensures that the gas seal effectively protected against contaminated process gas.

This session runs consecutively with Lecture 19 & Technical Brief 8

Technical Brief 8:

Tandem Dry Gas Seals – Design and Maintenance Considerations for Enhanced Reliability and Performance

Wednesday, 14 March 2018

1100 - 1230 hours Room 300

Instructors: Girish Kamal (Petronas Carigali Sdn Bhd)

Dry Gas Seals have been in existence in the process centrifugal compressor industry for the last three decades and majority of the compressor units in operation today are installed with Dry Gas Seals. DGS sealing and the associated systems gained importance predominantly due to unreliability, high operating and maintenance costs and hazardous characteristics inherent with the conventional lubricated shaft sealing systems.

This Technical Brief shall cover the best practices to improve dry gas seals reliability and performance including:

- Design and Maintenance considerations
- Major factors affecting Dry Gas seals life and efficient operation
- Seal Gas supply and control requirements
- Primary Gas seal venting and health monitoring
- Secondary Gas seal venting and health monitoring
- Separation gas supply and control requirements
- Recommended Alarm and Shutdown conditions

This session runs consecutively with Lecture 19 & Technical Brief 7

Technical Brief 9:

Condition Monitoring of Turbomachinery with Internet-Of-Things (IOT)

Wednesday, 14 March 2018

1100 - 1230 hours Room 301

Instructors: C.W. Yap (Institute of Engineers, Malaysia)

Condition monitoring is one of the critical process in turbomachinery equipment. As a factory equipment, Turbormachinery mostly transfers data via controllers such as programmable-logic-controller (PLC). Parameters of the machine health is transferred and monitored via local-area-network or wireless network to the control center. The technology of Internet-of-Things (IoT) has become matured and offers another alternative to transfer data, and this can be useful for condition monitoring on turbomachinery equipment. This project studies the vibration sensors suited for the project, the communication networks, and demonstrated the built prototype. Data collected from the vibration sensors will be transmitted via LoRa network to the cloud. LoRa is the long range, low power wireless network for data transmission, usually seen as an enabler for Internet-of-Things (IOT). The transmitted data will be received and display on devices. This method offers an innovative solution for condition monitoring on turbomachinery.

This session runs consecutively with Lecture 20 & Technical Brief 10

Technical Brief 10:

Digitalisation in Medium Voltage Variable Speed Drive Systems to Increase Productivity in O&G Applications

Wednesday, 14 March 2018

1100 - 1230 hours Room 301

Instructors: Umesh Mandlekar, Alexander Unruh, Vijay Ganesan (Siemens AG)

In this paper we talk about influence of digitalization in process industries and how it can be adapted to Medium Voltage drive systems. Various aspects of digitalization like monitoring, preventive maintenance and using detailed simulations will be discussed in details. Detailed information about medium voltage drive train analytics will be provided. Simulation models can be used to analyze complex drive system topics such as Voltage dips or protective measures in case of short circuits which cannot be tested physically in the field. Also simulations can be used to reduce the risk during commissioning by performing pre commissioning studies. This helps to identify the project specific drive system parameters prior to commissioning.

This session runs consecutively with Lecture 20 & Technical Brief 9

Technical Brief 11:

Erosion Prediction of Gas Turbine Compressor Blades Subjected to Water Washing Process

Wednesday, 14 March 2018

1100 – 1122 hours Room 302

Instructors: Salvatore Costagliola, Serena Gabriele (Baker Hughes a GE Company), Paolo Venturini, Alessandro Chiariotti, Domenico Borello (Sapienza University of Rome)

Blade fouling is a relevant problem in turbo-machinery applications. It affects both compressors and turbines. In the first case, fouling can be generated by the presence of dust, ashes or brackish air. Blade fouling leads to a reduction of the performance due to an increase on profile losses. Here we focus on the fouling due to salt deposition on naval/off-shore applications. In such applications, it is common to introduce online washing devices aiming at removing fouling from the early stages of the compressors. The water is sprayed upstream of the first rotor, it impacts on the rotor blades and thus dissolving the deposited salt. However, this procedure possibly leads to blade erosion and/or corrosion. A clear comprehension of the erosion mechanism is the main objective of the present work. To this end, an integrated multi-phase CFD tool will be presented.

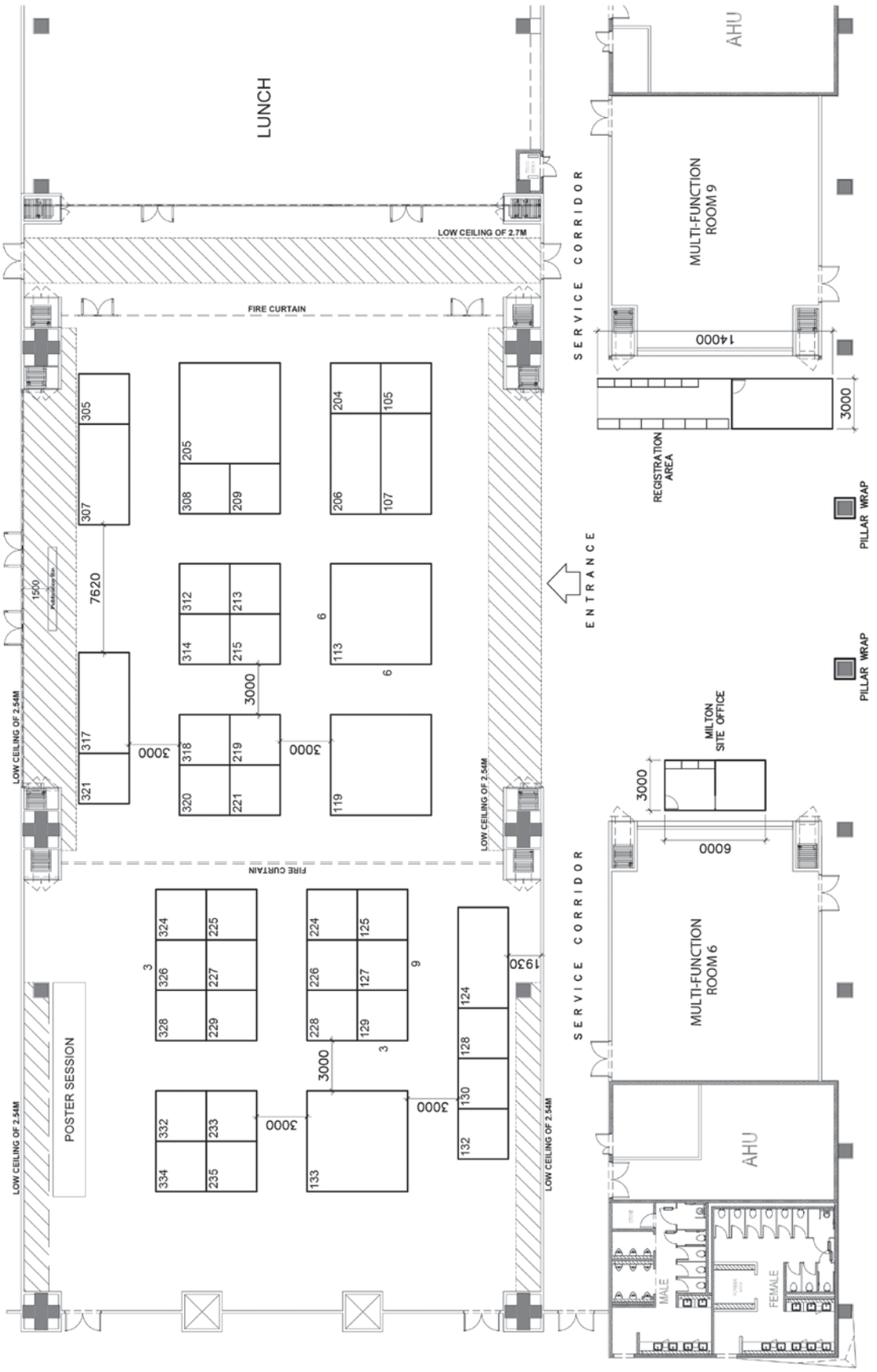
EXHIBITORS


RICHARD

EXHIBITOR FLOOR MAP

ASIA TURBOMACHINERY & PUMP SYMPOSIUM

SUNTEC SINGAPORE CONVENTION & EXHIBITION CENTRE



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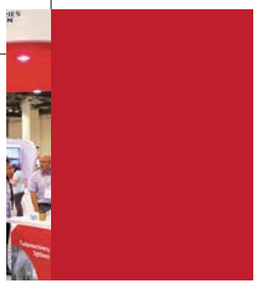

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COMPANY DESCRIPTIONS

AESSEAL Malaysia Sdn Bhd. 129

N0 9, Jalan MJ 13, Taman Industri Meranti Jaya Puchong
Selangor 47120 Malaysia
PH: (+)1 601-922-2526
www.aesseal.com

AESSEAL® is one of the world's leading specialists in the design and manufacture of mechanical seals, seal support systems and bearing protection. Our promise to customers is simple: we aim to give such exceptional service that they need never seek another source of supply. Established in 1983, it is our focus on customer service and quality that has seen us grow. Today, we have 230 locations worldwide, supplying customers in 104 countries, and employ a global network of sales engineers, technical support specialists and stocking distributors. By investing in pioneering technology, we respond quickly to customers'- whatever and wherever.

Altra Couplings 133

449 Gardner Street
South Beloit, Illinois 61080 USA
PH: (+)01 717-217-3879
www.altramotion.com

Since 1917, with the introduction of the resilient grid coupling, Bibby Turboflex has designed and manufactured highly-engineered industrial couplings. Beginning in 1928, Ameridrives created advanced coupling technologies that compensate or minimize the effects of unavoidable misalignment and end movement of coupled shafts. As global leaders in their industry, both brands will present in booth 133 at the 2018 Asia Turbomachinery and Pump Symposium, showcasing the LM2500 Coupling, Turboflex Plus, Torsiflex Pump Couplings, and Marine Couplings. With products to fit many markets including turbomachinery and mechanical, learn more about Ameridrives, Bibby Turboflex and all of the brands that make up Altra Industrial Motion, a global designer and manufacturer of quality power transmission and motion control products.

Atlas Copco Gas and Process Division 206

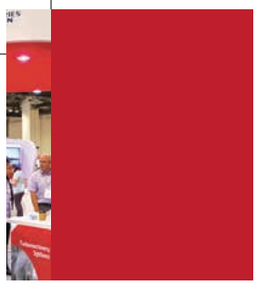
Schlehenweg 15
Cologne 50999 Germany
PH: (+)4922369650750
http://www.atlascopco-gap.com

Gas and Process is a division within the Atlas Copco Group's Compressor Technique business area. It designs, develops, manufactures and maintains turbocompressors, positive displacement compressors, and expansion turbines. In addition, Gas and Process offers a matching range of aftermarket products. The Division's solutions are used in oil and gas and chemical/petrochemical processes, power generation, renewables, and the industrial-gases sector. The divisional headquarters is located in Cologne, Germany, and the production centers are in the United States, China, and India.

Boulden International 219

1013 Conshohocken Rd., Ste. 308
Conshohocken, Pennsylvania 19428 USA
PH: (+)01 610-825-1515 | FX: (+)01 610-825-5544
www.bouldencompany.com

Boulden is the global supplier of DuPont™ Vespel® CR-6300, and Krytox® lubricants. Vespel® CR composite materials are used for pump wear rings, throttle bushings, and vertical pump shaft bushings. The materials are easy to machine and install, and readily available. Krytox® is a family of PFPE synthetic lubricants with unusual properties allowing users to solve the toughest lubrication problems.



Burnaby Solutions Pte Ltd **128**

7030 Ang Mo Kio Avenue 5, #08-24 Northstar @ AMK
Singapore 569880 Singapore
PH: (+)6568481345
FX: (+)6566848417
www.burnaby-solutions.com

Burnaby Solutions is an organisation that specialises in professional services with local knowledge and resources. Burnaby Solutions offers integrated Hospitality Services, Conference & Exhibition Management Services, and signature Lifestyle & Entertainment Events to support your strategic marketing management plan.

We meet client's goals and objectives covering the following:

- Manning of housing bureau for major trade shows or conferences in Singapore & the Region
- Organising of event activities (local venues, caterers, decor and other event services)
- Organising and coordinating tours and transportations
- Providing logistical support (logistical elements for major trade/conference/corporate events including safety concerns and financial cooperation).

Compressor Controls Corporation **320**

4725 121st Street
Des Moines, Iowa 50323-2316 USA
PH: (+)01 515-270-0857
https://www.cccglobal.com

CCC (Compressor Controls Corporation) is a leading provider of turbomachinery control solutions. We employ a knowedgeable and comprehensive team of turbomachinery experts. Our engineers utilize fast and reliable automation platforms and field-proven control applications to deliver tangible economic benefits to our customers. Owning the life-cycle of the entire control system - from hardware, software, to control applications - enables us to provide robust control solutions with global support like no other.

Concepts NREC **217**

217 Billings Farm Road
White River Junction, VT 05001
PH: (+)01 802-296-2321
www.conceptsnrec.com

For over 60 years, Concepts NREC has been partnering with leading OEMs to improve the performance and manufacturability of their turbomachines. We are the only company in the world whose in-house capabilities span the entire process - from conceptual design through CAE and CAM software, manufacturing, testing, and installation. This unique perspective creates powerful synergies that drive innovation across our entire offering. Our clients benefit from having a trusted partner who can see the big picture and provide valuable insights that save them time and money.

We push past what has been done to explore what can be done.

Elliott Group **119**

901 North Fourth Street
Jeannette, Pennsylvania 15644 USA
PH: (+)01 724-527-2811
http://www.elliott-turbo.com

Elliott Group designs, manufactures and services critical compressor trains, steam turbine drivers, and hot gas expanders for oil & gas applications, and Ebara cryogenic pumps and expanders for liquefied gases. Elliott's dual factories in Pennsylvania and Japan are similarly equipped with modern CNC machine tools and test floor capabilities, and they coordinate and balance project loads to ensure that critical project schedules are met. Elliott Group's integrated global service network also provides expert, single source service and support for overhaul projects throughout the world, regardless of the original equipment manufacturer.

Energy Control Technologies, Inc. 225

10664 Justin Drive
Urbandale, Iowa 50322 USA
PH: (+)01 515-223-1635 | FX: (+)01 515-223-1638
http://www.energycontroltechnologies.com

Energy Control Technologies (ECT) delivers control solutions for turbocompressors, steam turbines, gas turbines, turboexpanders, screw compressors, reciprocating compressors, and centrifuges. ECT provides solutions using both Rockwell Automation Allen-Bradley ControlLogix and CompactLogix and Siemens hardware platforms in the Oil & Gas, Industrial/ Manufacturing and Biofuels markets including full duplex and SIL 2 systems. ECT solutions increase energy efficiency and production while improving machine protection.

Solutions include surge control, performance control, loadsharing, steam turbine speed and extraction control, gas turbine fuel control and sequencing, turboexpander control, vibration protection, plant air network control, simulation services, and centrifuge control and protection systems.

Flowserve 326

03-16 to 19, Block B, Jackson Square 11, Lorong 3 Toa Payho
Singapore 319579 Singapore
PH: (+)6567273900
FX: (+)6563975953
www.burnaby-solutions.com

Flowserve [NYSE: FLS] is the world's premier provider of industrial flow management services. The world headquarter is located in Texas, U.S.A. The company produces engineered pumps, precision mechanical seals, automated and manual quarter-turn valves, control valves and actuators, and provides a range of related flow management services, primarily for the process industries. As the world's premier provider of flow management solutions and related aftermarket services, Flowserve has also been investing with customers to develop solutions for alternative and renewable sources of power generation like clean coal, solar, geothermal, and wind power.

FS-Elliott 224

5710 Mellon Road
Export, Pennsylvania 15632 USA
PH: (+)01 724-387-3200
http://www.fs-elliott.com

FS-Elliott is a global leader in the engineering and manufacturing of oil-free, centrifugal compressors with operations in over 90 countries. Building on a 50-year tradition of excellence, FS-Elliott combines an unwavering commitment to quality with the desire for advancing technology to bring value to our customers, allowing them to increase their productivity and lower system operating costs. For more information, please visit www.fs-elliott.com.

Graphite Metallizing Corp 229

1050 Nepperhan Ave.
Yonkers, New York 10703 USA
PH: (+)01 908-698-7953
http://www.graphalloy.com

Graphite Metallizing Corporation - Graphalloy®, graphite/metal alloy from Graphite Metallizing Corporation, is a uniform, solid, self-lubricating bushing and bearing material for pumps that permits dry starts, survives frequent loss of suction, reduces bivration and extends pump life for continuous service. Graphalloy's unique non-galling and self-lubricating properties enable a pump to handle fluids and survive upsets that would seize a metal fitted pump.

Graphalloy is normally supplied in finished form and can be installed without additional machining. Graphite Metallizing has over 100 yearss of experience solving the toughest bearing problems. Most of its products are custom designed to unique requirements of the specific application.

John Crane Singapore Pte Ltd. 307

15 Tuas View Place
Singapore 637432 Singapore
PH: (+)65181800 | FX: (+)65181858
http://www.johncrane.com

John Crane is a global leader in rotating equipment solutions, supplying engineered technologies and services to process industries. The company designs and manufactures a variety of products including mechanical seals and systems, couplings, bearings, filtration systems and predictive digital monitoring technologies. John Crane customer service is accessed through a global network of more than 200 sales and service facilities in over 50 countries. John Crane is part of Smiths Group, a global leader in applying advanced technologies for markets in threat and contraband detection, energy, medical devices, communications, and engineered components.

Kobe Steel, Ltd. 205

9-12, Kits-Shinagawa 5-Chome, Shinagawa-ku
Tokyo 141-8688 Japan
PH: (+)81357396771 | FX: (+)81357396991
www.kobelco.co.jp

Kobe Steel, Ltd. Began manufacturing compressors in 1915 and today is a global leader in compressor technology, engineering, and innovation. Kobelco designs, manufactures and packages Screw (API619), Reciprocating (API618), and Centrifugal (API617) compressors for virtually any process gas application. Each system is custom engineered for optimum performance and outstanding return on investment. Through innovative technology and quality manufacturing, Kobelco offers solutions to boost productivity, reduce operating costs, and safeguard the environment. Visit our booth to speak with our compressor experts and learn about our custom engineered compression solutions.

Korea Rotating Machinery Engineers Association **127**

1st floor, Bethel Bldg, 23 Dongsan-ro, Seocho-ku
Seoul 06779 South Korea
PH: (+)8225796271
http://www.krmea.or.kr

Korea Rotating Machinery Engineers Association [KRMEA] was established in 1998 as a non-profit organization with an object to develop reliability technologies of rotating machinery for Refinery, Petrochemical, Gas, Iron/Steel and Power industries.

It takes an important role in promoting the mutual benefits and seeking better cooperation not only among relevant corporations but also individual members throughout the world by sharing information and technologies.

MAN Diesel & Turbo Singapore Pte. Ltd. **107**

29 Tuas Avenue 2
Singapore 639460 Singapore
PH: (+)6563491600
www.mandieselturbo.com

MAN Diesel & Turbo SE, based in Augsburg, Germany, is the world's leading provider of large-bore diesel engines and turbomachienry for marine and stationary applications. It designs two-stroke and four-stroke engines with power outputs from 47 kW to 97 NW. MAN Diesel & Turbo also designs and manufactures gas turbines of up to 150 MW, steam turbines amd compressors. The product range is rounded off by turbochargers, CP propellers, gas engines, engines for locomotives and chemical reactors. MAN Diesel & Turbo's range of goods includes marine propulsion systems and turbomachinery units. Customers receive worldwide after-sales services marketed under the MAN PrimeServ brand.

Mitsubishi Heavy Industries Compressor Corporation 113

6-22, Kan-on-shin-machi 4-Chome, Nishi-ku
Hiroshima 7338553 Japan
PH: (+)81822912200 | FX: (+)81822940345
http://www.mhicompressor.com/en

Mitsubishi Heavy Industries Compressor Corporation(MCO) has been renowned as the most reliable compressor and steam turbine manufacture through its highest technological background and customer-oriented services. Backed by its wealth of experience, MCO has brought forth various improvements in compressor and steam turbine design, production, and applications. Thanks to these efforts, Mitsubishi Compressors and Steam turbines are now used worldwide.

MCO has numerous revamp/replacement experiences and continuously improves its technology based on market and customer needs.

MCO are ready to dispatch skilled technical advisors and to provide timely maintenance service to enable safe long-term operation.

Notre Dame Turbomachinery Laboratory 215

Ignition Park, Catalyst II
1165 Franklin Street, Suite 200
South Bend, IN 46601
PH: (+) 01 574-631-7781
turbo.nd.edu

The Notre Dame Turbomachinery Laboratory (NDTL) is focused on research, testing and workforce development for a wide range of applications that involve turbomachinery technology. NDTL's new 28,000-square-foot, world-class facility in South Bend, Indiana, USA offers experimental and numerical capabilities for the development of rotating machinery that requires high power levels and related specialized support. These capabilities create a shorter development path for new gas turbine engine technologies within any industry. For more information, please visit turbo.nd.edu.

OELTECHNIK 204

Lessingstrasse 32
Waghaeusel 68753 Germany
PH: (+)4972549810
http://www.oeltechnik.com

Private owned German based engineering & manufacturing company for turbine and compressor auxiliaries. Intercoolers, after coolers, surface condensers, lube-, seal- and control oil systems, seal gas panels, fin fan coolers, TEMA type shell & tube heat exchangers, nitrogen steam heaters, miscellaneous pressure vessels, high fin tubing with copper foot brazed fins or aluminium extruded fins.

Certifications: ASME Code, PED 97/23/EC, Chinese Manufacturing License for A1+A2 pressure equipment.

Well re-known within all major international engineering companies and being familiar with their specification. Thermal design performed with in-house developed rating software. Results are checked against actual performance data.

OROS 312

23 chemin des Pres
Meylan 38240 France
PH: (+)33476906236
http://www.oros.com

OROS designs and manufactures noise and vibration testing systems (instruments and software) for more than 30 years, meeting the requirements and expectations of automotive, aerospace, marine energy & process, manufacturing and automation industries. French company with worldwide scope (80% of turnover with 2 subsidiaries, 6 offices, 8 maintenance centers and representatives in more than 35 countries), OROS is a dynamic company where innovation is at the heart of its strategy to offer a range of high-tech products and solutions.

PEC Ltd. 318

21 Shipyard Road
Singapore 628144 Singapore
PH: (+)62689788
http://www.peceng.com

PEC is an established plant and terminal engineering specialist providing Project Works, Maintenance Services and other related services to the oil and gas, petrochemical, oil and chemical terminals, and pharmaceutical industries in Asia and the Middle East.

PumpWorks 610 314

8885 Monroe Road
Houston, Texas 77061 USA
PH: (+)01 713-956-2002
http://www.pumpworks610.com

With extensive experience as a specialty manufacturer of API 610 and ANSI Process Industrial Pumps, PumpWorks has accumulated the expertise needed to manufacture products that meet even the most specific of client or industry requirements. We pride ourselves on our ability to manufacture any type of pump for any type of application.

Rochem Technical Services 209

5-6 Sun Valley Business Park, Winnall Close
Winchester, Hampshire SO23 LB United Kingdom
PH: (+)441962890089 | FX: (+)441962890090
http://www.rochem.co.uk

Rochem delivers cleaning system and chemicals designed to maximise the performance of gas turbines and process compressors used in the Oil & Gas, Power and Aviation sectors.

We provide bespoke design, full installation and commissioning services, as well as a dedicated after sales commitment.

Sichuan Sunny Seal Co, Ltd. 233

8#, Wuke West 4 Rd. Wuhou District
Chengdu, Sichuan 610045 China
PH: (+)8618980767975 | FX: (+)862885366222
www.sns-china.com

Sichuan Sunny Seal Co., Ltd. serves as the leading enterprise in fluid sealing industry of China. The products are widely used in fields such as petrochemical industry, coal chemical industry, natural gas industry, oil & gas transportation, electric power and metallurgy. The products are exported to Europe, Southeast Asia, etc.

Its main products include mechanical seal, dry gas seal, metal bellows seal, silicon carbide, auxiliary system, control panel, etc.

Siemens 317

The Siemens Center
60 MacPherson Road
Singapore 348615 Singapore
PH: (+)6564906000
FX: (+)6564906001
www.siemens.com

Siemens AG is a global technology powerhouse that has stood for engineering excellence, innovation, quality, reliability and internationality for more than 165 years. The company is active in more than 200 countries, focusing on the areas of electrification, automation and digitalization. One of the world's largest producers of energy-efficient, resource-saving technologies, Siemens is a leading supplier of efficient power generation and power transmission solutions and a pioneer in infrastructure solutions as well as automation, drive and software solutions for industry. In fiscal 2017, which ended on September 30, 2017, Siemens generated revenue of €83.0 billion and net income of €6.2 billion.

Sohre Turbomachinery Inc. 308

128 Main Street, P.O. Box 1099
Monson, Massachusetts 01057 USA
PH: (+)01 413-267-0590 | FX: (+)01 413-267-0592
http://www.sohreturbo.com

Sohre Turbomachinery makes shaft grounding brushes to control stray electrical currents in electrical and nonelectrical turbomachinery. Sohre brushes are useful for electrostatic, electromagnetic, or other electrically induced stray currents. The current rating of Sohre brushes ranges from 1 to 100 DC amperes per year of bristle life. Brushes utilize special alloy bristles and are run directly on shaft, either dry or in oil. Cleaning or maintenance generally is not necessary.

TEES - Turbomachinery Laboratory 124

3254 TAMU
College Station, Texas 77843 USA
PH: (+)01 979-845-7417 | FX: (+)01 979-845-1835
http://turbolab.tamu.edu

TEES TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

AIPS Event Organizer

The Turbomachinery Laboratory was established in 1971 to address the needs of the turbomachinery and pump industries. The Laboratory continues Texas A&M's land grant charter and tradition in continuing education and professional development; undergraduate and graduate education, and basic research. Toward this goal, the Turbomachinery Research Consortium was formed in 1983. Member companies pay a yearly membership fee to share in the sponsored research of the TRC. A research building was completed in 1993. This facility has 12 test cells and a high bay area. The Laboratory sponsors the International Pump Users Symposium and the Turbomachinery Symposium.

Torquemeters Limited 213

West Haddon Road
Ravensthorpe, Northamptonshire NN6 8ET United Kingdom
PH: (+)4401604770232 | FX: (+)4401604770778
http://www.torquemeters.com

Torquemeters LIMITED
high performance test & measurement systems

Measuring steady state torque and torsional vibration in a single product, our Torquetronic™ Continuous Duty Torque measurement system is the recognized industry standard for independent, accurate shaft horsepower measurement, including new SIL 2 level functionality. Used extensively on mechanically driven turbo machinery applications in the Oil, Gas and Petrochemical industries, such as ethylene plants, LNG export plants, pipeline compressor stations, and any large injection/compression application.

The company's 800 family of electronics provides a flexible platform for all Torquetronic™ torque measurement systems. Continuous Torque and Torsional vibration Analysis with integral FFT capability are available as standard.

Turbomachinery International Publications 221

535 Connecticut Avenue
Norwalk, Connecticut 06854 USA
PH: (+)01 203-523-7053
http://www.turbomachinerymag.com

Turbomachinery International (TMI) is industry's technology and business beacon worldwide. For 58 years, TMI's products and services have been unmatched in reporting on global energy news and technology. #1 in readership, we reach over 28,500 online and print subscribers to the magazine, newsletter, handbook , blog and pump supplements. TMI is the one-stop shop for industry news, engineering breakthroughs and expert opinion unavailable elsewhere.

Vibration Institute 125

2625 Butterfield Rd., Ste 128N
Oakbrook, Illinois 60523 USA
PH: (+)01 630-654-2254 | FX: (+)01 630-654-2271
http://www.vi-institute.org

The Vibration Institute is the premier provider of ISO 18436 vibration analysis certification and training. VI is dedicated to the dissemination of practical information on evaluating machinery behavior and condition without commercial interest and is the only vibration analysis certification provider accredited by the American National Standards Institute.

COMPANY CATEGORY LIST

AFTER MARKET SERVICES & PRODUCTS

Compressor parts, repair, overhaul

Coupling repairs

Expander parts, repair, overhaul

Field Service

Gas turbine parts, repair, overhaul

Gear box repairs

Pump parts and repair

Steam turbine parts, repair, overhaul

AUXILIARY EQUIPMENT

Compressors, air

Control & control systems

Coolers, after

Coolers, inter

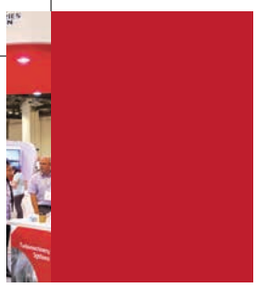
Diaphragms

Drivers - Steam Turbines

Efficiency Improvement for gas turbines

Gas turbine washing

Heat exchangers



Pressure vessels
Oeltechnik 204

Shaft-current control equipment
Sohre Turbomachinery Inc. 308

Torque Meters
Torquemeters Limited 213

Vibration measuring, monitoring, analysis
Torquemeters Limited 213

DISTRIBUTORS

Pump Related Equipment
PumpWorks 610 314

EDUCATION/RESEARCH/TRAINING

Consulting - Maintenance & Reliability
Compressor Controls Corporation 320

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Continuing Education Credit Courses
Korea Rotating Machinery Engineers Association 127

TEES - Turbomachinery Laboratory 124

Educational Courses
Korea Rotating Machinery Engineers Association 127

TEES - Turbomachinery Laboratory 124

Research - Pumps/Fluid Handling
TEES - Turbomachinery Laboratory 124

Research - Turbines/Rotating Equipment

Training

Training Materials

MACHINERY-ANALYSIS SOFTWARE

CFD

Design and analysis

Finite elements analysis

Rotordynamics analysis

MACHINERY SERVICES

Alignment

Balancing

Component Development & Testing

Control systems

Design

Efficiency Improvement for Gas Turbines

Gas Turbine Washing

In-Place Machining Equipment

Installation

Laboratory Testing Services

Lubrication Systems

Machinery Protection Systems

Predictive Maintenance

Pressure Testing

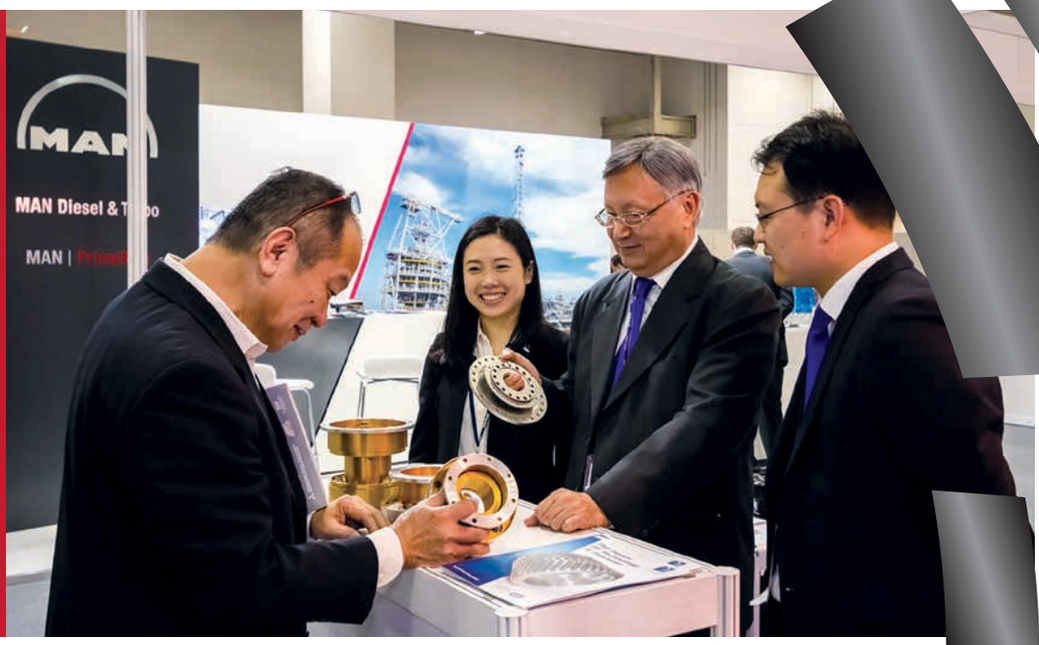
Vibration Analysis

MANUFACTURERS

Compressor – Axial

Compressor - Centrifugal

GENERAL


MAN
MAN Diesel &
MAN |

GENERAL INFORMATION

EXHIBITION

In addition to our technical sessions, we encourage you to join us for our product showcase in the exhibit hall. Our exhibition will provide you the opportunity to engage with expert technical personnel and view the latest in industry technology.

The exhibition for delegates is hosted on Level 3, Summit 1 & 2 at the Suntec Convention Center. The hall will be open during the following times:

Tuesday, 13 March 2018	1000 – 1900 hours
Wednesday, 14 March 2018	1000 – 1900 hours
Thursday, 15 March 2018	0900 – 1300 hours

WELCOME ADDRESS

Badge required – not open to Free Pass

The Welcome Address is scheduled for Tuesday, 13 March 2018, 0900-0935, Level 3, Meeting Rooms 334-336.

LUNCHEONS

Badge required – not open to Free Pass

Lunch will be served on 13 and 14 March 2018, on Level 3, Summit 1 & 2. Lunch is included in the full symposium registration fee. The one-day symposium registration fee includes a luncheon ticket for the respective day of purchase.

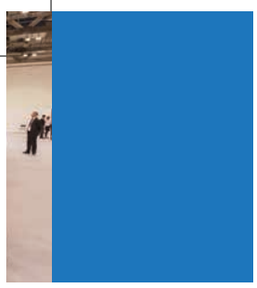
GALA DINNER

Badge or ticket required – not open to Free Pass

The Gala Dinner is scheduled for Wednesday, 14 March 2018, 1930-2100, Pacific 3 Ballroom, Pan Pacific Hotel. A Gala Dinner ticket is included in the full symposia registration fee and your badge is required for admission. Additional tickets are available for purchase at Registration (USD 100).

ATPS SYMPOSIUM PROCEEDINGS

The Turbomachinery Laboratory is proud to present the full technical program for the Asia Turbomachinery and Pump Symposium. These Proceedings are included as part of the full and one-day symposium registration fee. To access the Proceedings documents on the Proceedings USB drive, insert the drive into your CPU or other computing device. You'll see several files, click on clickme.html. Then browse through the Table of Contents on the main page and navigate to the full texts and/or author biographies of different technical sessions.



CONTINUING EDUCATION UNITS (CEUS)/ PROFESSIONAL DEVELOPMENT HOURS (PDHS)

The CEU/PDH is the nationally recognized unit designed to provide a record of an individual's continuing education achievements.

Symposium attendees can earn .04 CEU/4 PDHs per day or 1.2 CEUs/12 PDHs for full symposia participation. Short Course attendees can earn .06 CEU/4 PDHs. No CEU/PDH credits will be available to individuals who register to attend the Exhibit Hall only.

In order to receive a CEU/PDH certificate, you must complete and return the appropriate CEU/PDH request form to the registration counter during the symposia or after the symposia via email to the CEU Coordinator, debbie@turbo-lab.tamu.edu or via fax to 979-845-1835: A certificate will be prepared and forwarded to participants 4-6 weeks after the symposia.

NOTE: Registration is verified prior to issuing certificate.

COPYRIGHT INFORMATION

All technical sessions are protected by US copyright laws. Photography and video/audio recording of any kind are strictly prohibited in the sessions and throughout the exhibition area except for authorized press.

CANCELLATION POLICY

Should symposium and/or Short Course cancellation be necessary, written refund requests must be received in the Turbomachinery Laboratory office by 2 March 2018. There will be a $100.00 USD administrative and banking fee charge to cancel registration. Substitutions are encouraged. We do request that substitutions be made in advance, as substitutions made onsite at the symposium will result in registration delays

Late cancellations will be reviewed on a case-by-case basis for personal hardships, unprecedented weather phenomena, and national emergencies. After the cancellation date, the Turbomachinery Laboratory will not refund for business decisions by delegate's employer such as job reassignment, plant emergencies, etc. In the event of a "no-show" cancellation, Symposium Proceedings and Short Course USBs will be forwarded to the absent delegate. Registration fees cannot be applied toward future registrations.

The Turbomachinery Laboratory reserves the right to cancel any Short Course or Symposium in the event of insufficient registration or unforeseen circumstances. In the event of such circumstances, all registration fees will be refunded. The Turbomachinery Laboratory will not be responsible for any losses incurred by the registrants, including but not limited to airline cancellation charges or hotel deposits.

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CARL JOHNSON
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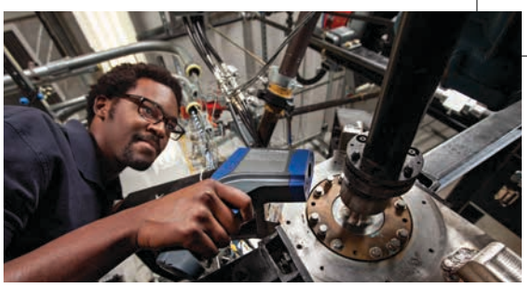
carljohnson@exchange.tamu.edu

ABOUT THE TURBOMACHINERY LABORATORY



The Turbomachinery Laboratory is a center of the Texas A&M Engineering Experiment Station (TEES) and part of The Texas A&M University System. The Turbo Lab conducts basic and applied research into important problems of reliability and performance of turbomachinery — rotating machinery that extracts or adds energy to fluids.

Located in College Station, Texas, the Turbo Lab draws from the research expertise of Texas A&M University's Dwight Look College of Engineering and TEES.

The Turbo Lab makes a vital impact on turbomachinery and related industries through three pathways:

RESEARCH

Turbo Lab faculty and students team up with industry partners to conduct research into important problems of reliability and performance of turbomachinery through the Turbomachinery Research Consortium (TRC). The TRC is a unique organization of major turbomachinery developers and users who have joined with the Turbo Lab to find answers to important questions through cutting-edge research.

In addition to TRC research, the Lab conducts industry and government-sponsored projects.

EDUCATION

The Turbo Lab produces engineers ready to work by offering undergraduate and graduate engineering education through Texas A&M's Department of Mechanical Engineering. The Turbomachinery Research Consortium blends the Turbo Lab's impact areas of education and research by teaming graduate students with industry to find solutions to real-world problems. Turbo lab students are highly sought after for industry positions upon graduation.

PROFESSIONAL WORKFORCE DEVELOPMENT

The Turbo Lab impacts turbomachinery and related industries by providing a platform for the continuous exchange of ideas among working professionals. These platforms include the annual Turbomachinery & Pump Symposia (TPS) in Houston, the biennial Asia Turbomachinery & Pump Symposium (ATPS) in Singapore, and various short courses held throughout the year.

Visit turbolab.tamu.edu for more information.

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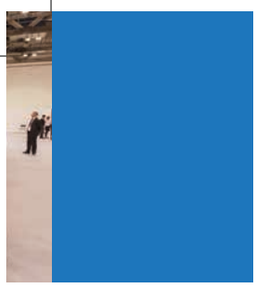

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