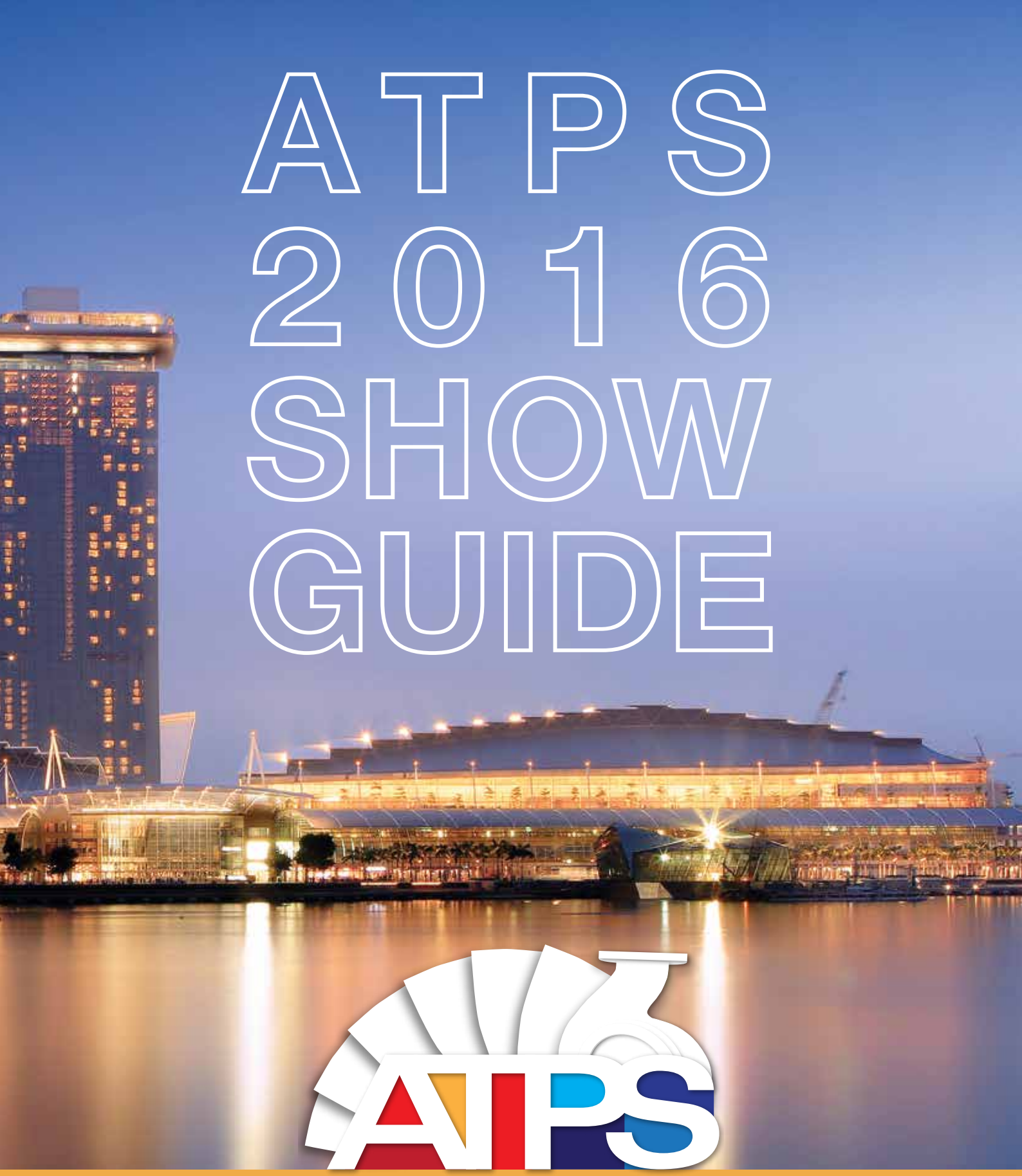
ATPS 2016 SHOW GUIDE



ASIA TURBOMACHINERY & PUMP SYMPOSIUM

SINGAPORE | 22 – 25 FEBRUARY 2016

MARINA BAY SANDS

MITSUBISHI HEAVY INDUSTRIES COMPRESSOR CORPORATION

TPS

TEES TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

CONTENTS

INTRODUCTION

ACKNOWLEDGMENTS

The inaugural 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 and National University of Singapore. Both institutions have provided valuable logistical support in organizing this symposium. Students from both universities are not only participating as delegates to the conference, but are assisting as ushers and greeters throughout the program. Faculty members from NTU and NUS serve on the ATPS advisory committee as well.

We also are grateful for the support from the Singapore Workforce Development Agency and the Singapore Tourism Board. Both organizations have provided ATPS with financial and logistical support in an effort to make ATPS a perennial success.

Thanks are extended to our major event sponsor Mitsubishi Heavy Industries.

The Turbomachinery Laboratory serves as a part of the Texas A&M Engineering Experiment Station (TEES) and The Texas A&M University System. 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 TEES in this undertaking and extend to them our gratitude.

The ATPS Technical Advisory Committee is comprised of highly respected engineers from various user and manufacturing turbomachinery 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.

WELCOME

The Turbomachinery Laboratory at Texas A&M University welcomes your attendance to the Asia Turbomachinery and Pump Symposium (ATPS) in Singapore (Feb 22-25, 2016). Your participation in this premier technical event gives relevance to a vibrant industry with sustained growth in Asia during the 21st century.

ATPS follows the format of our successful Turbomachinery and Pump Symposium (TPS) offered annually in Houston — a world-class technical conference and a strong international exhibition. Both events, in their 45th and 32nd year respectively, have educated thousands of practicing engineers while promoting novel developments in rotating machinery equipment and efficient practices in their design, construction, maintenance, and operation.

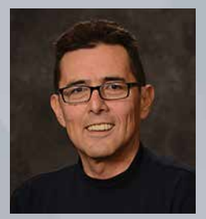
At ATPS, a Technical Advisory Committee comprised of the most prominent field experience and R&D engineers, who represent the region and the rest of the world, has worked tirelessly to bring you a unique technical program on par with that of our Houston show. ATPS establishes the ground for the continued education of rotating machinery professional engineers in Asia and beyond, as well as a venue to deliver state of the art knowledge in compressors, pumps, gas turbines and steam turbines, and service equipment such as controls, bearings, seals, etc. You have a unique opportunity to enjoy learning from 10 one-day short courses, 22 tutorials and 16 lectures, as well as 24 case studies, 6 technical briefs, and 12 discussion groups.

The Marina Bay Sands Hotel and Convention Center, a jewel of modern architecture, hosts ATPS. The exhibition floor showcases products from the largest rotating machinery OEMS and support technologies. You will meet with equipment manufacturers and service industries to discuss your company's needs as well as to foster partnerships with OEMS to promote, use, and improve products. While at ATPS, attending the short courses and various types of technical presentations will improve your professional development and continuing education in energy production and transformation industries, as well as the aerospace industry. The discussion groups and tutorials will promote technology transfer and peer networking, settings where practicing engineers and industrial R&D in Asia will discuss problems and solutions unique to the region.

Mitsubishi Heavy Industries Ltd and the Elliott Group are great financial sponsors of ATPS. Singapore, a bastion of education and research, has welcomed ATPS with open arms. We count on the National University of Singapore and Nanyang Technological University as educational partners. The Singapore Workforce Development Agency and the Singapore Exhibition and Convention Bureau also endorse the event. The Korea Rotating Machinery Engineers Association (KRMEA) and The Gas Turbine Users Forum are also partners promoting the event internationally.

We are pleased to welcome all our partners and supporting industries, friends, and colleagues in the oil and gas, petrochemical, power, and other related industries to fully participate in the event. We hope to have an ATPS every other year.

Join us in making this event successful!



Luis San Andrés
Advisory Committee Chairman
Associate Director of TEES Turbomachinery Laboratory
at Texas A&M University

EVENT PARTNERS

MHI	BRONZE SPONSOR	MITSUBISHI HEAVY INDUSTRIES COMPRESSOR CORPORATION
ELLIOTT GROUP	LANYARDS	ELLIOTT GROUP EBARA CORPORATION
STB	SUPPORTED BY	SINGAPORE EXHIBITION & CONVENTION BUREAU
NUS	ACADEMIC PARTNER	NUS National University of Singapore | Engineering
NTU	ACADEMIC PARTNER	NANYANG TECHNOLOGICAL UNIVERSITY
KRMEA	SUPPORTED BY	Korea Rotating Machinery Engineers Association KRMEA 2005
WDA	SUPPORTED BY	WDA singapore workforce development agency
GTUF	SUPPORTED BY	GTUF GAS TURBINE USERS FORUM

THANK YOU TO ALL OF OUR EVENT PARTNERS

ADVISORY COMMITTEE

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WI•FI CONNECTION

1. With a Wi-Fi enabled device, connect to the wireless network named Marina Bay Sands.
2. Enter the password: room number + first 3 letters of your last name, e.g. 1234tua.

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MEDIA PARTNERS

HYDROCARBON ENGINEERING

Turbomachinery INTERNATIONAL
The Global Journal of Energy Equipment

LNG INDUSTRY

MPT
Modern Pumping Today
Providing Solutions for the Worldwide Pump Industry

WORLD PIPELINES

orbit magazine

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.

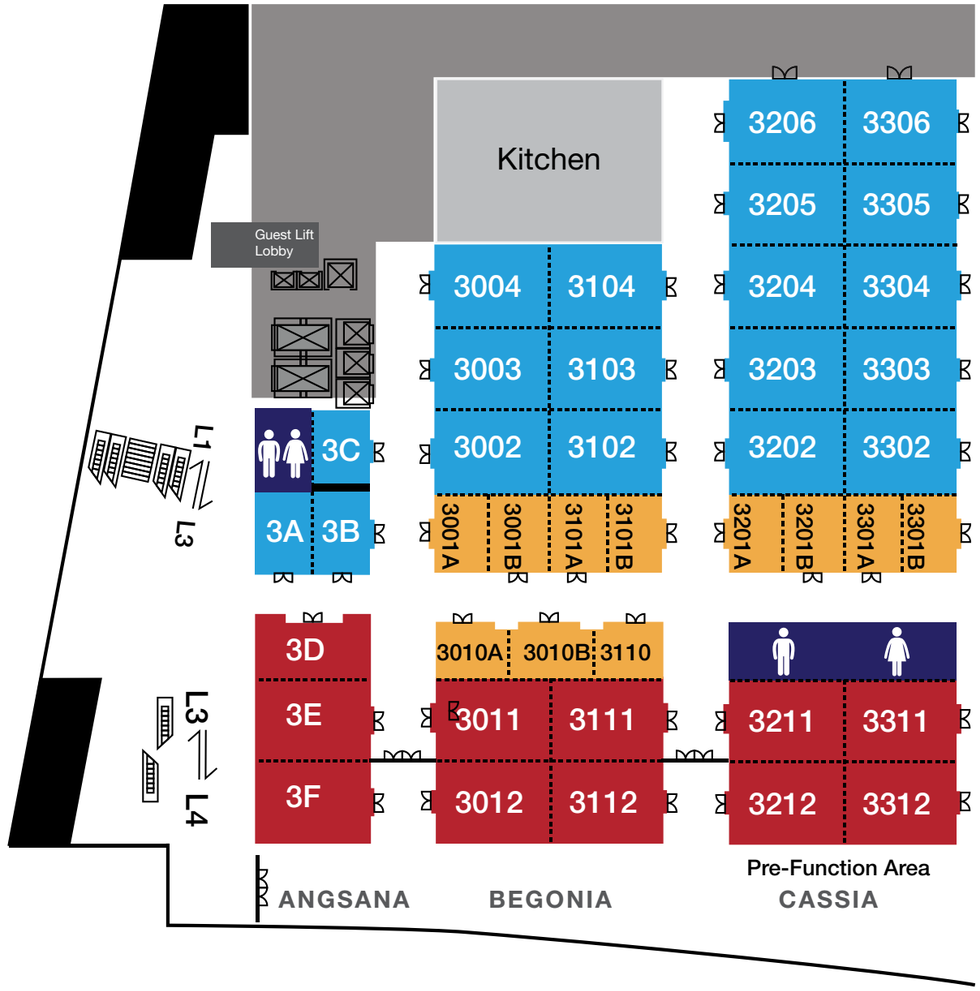
Singapore River - Cruise down the Singapore River with Singapore River Cruise and admire waterfront attractions like the Merlion.

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.

SANDS EXPO AND CONVENTION CENTER FLOOR PLAN

(LEVEL 3)



Escalator | Guest Elevator | Ballroom

Restroom | Stairs | Junior Ballroom

Freight Elevator | Service Elevator | Room

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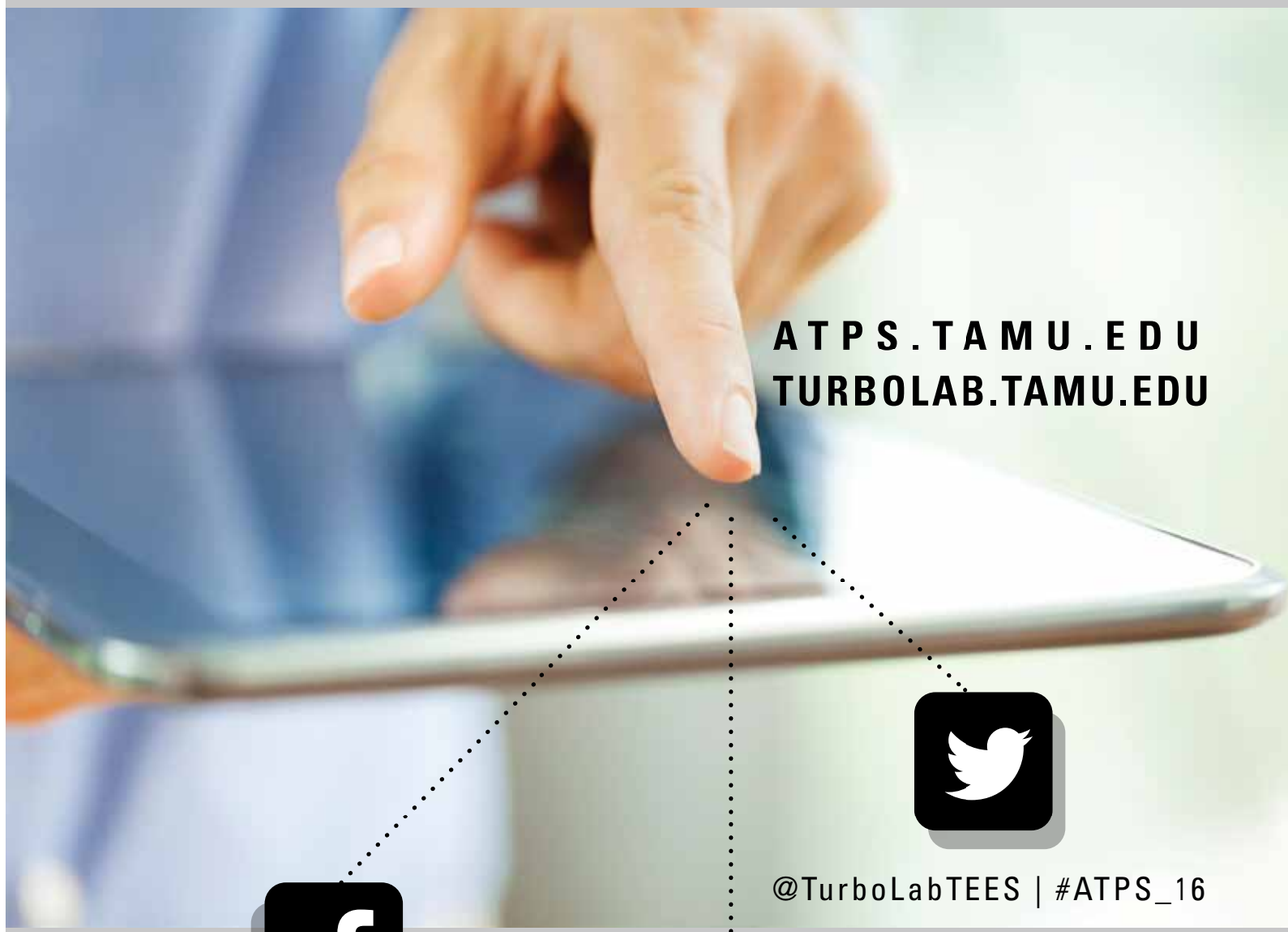
STAY CONNECTED

Stay connected with the **Turbo Lab** while at **ATPS 2016** and after you go home.



SCHEDULE

SCHEDULE AT A GLANCE

TIME	FUNCTION	LOCATION
SUNDAY, 21 February 2016		
1630 – 1800	**Attendee and Exhibitor Registration**	Level 1, Foyer of Hall A
1630 – 1800	**All Leader Registration**	Level 3, Room 3010A
MONDAY, 22 February 2016		
0700 – 1200	**Attendee and Exhibitor Registration**	Level 1, Foyer of Hall A
0700 – 1200	**All Leader Registration**	Level 3, Room 3010A
0830 – 1700	**Short Courses**	Level 3
1200 – 1315	**Short Course Luncheon**	Level 3, Cassia Main Ballroom A
1330 – 1700	**Attendee and Exhibitor Registration**	Level 1, Foyer of Hall A
1330 – 1700	**All Leader Registration**	Level 3, Room 3010A
1715 – 1745	**Advisory Committee Meeting**	Level 3, Angsana Ballroom 3B
TUESDAY, 23 February 2016		
0715 – 0745	**Leader Orientation**	Level 3, Angsana Ballroom 3B
0700 – 1800	**Attendee and Exhibitor Registration**	Level 1, Foyer of Hall A
0730 – 1700	**All Leader Registration**	Level 3, Room 3010A
0745 – 0800	**Welcome Address**	Level 3, Angsana Junior Ballroom 3D
0800 – 0830	**Plenary Lecture**	Level 3, Angsana Junior Ballroom 3D
0845 – 1015	**Symposium Technical Sessions**	Level 3
1000 – 1800	**Exhibit Hall Open**	Level 1, Hall A
1015 – 1030	**Refreshment Break**	Level 3 – Technical Sessions
1030 – 1200	**Symposium Technical Sessions**	Level 3
1200 – 1330	**Lunch for Exhibitors & Paid Attendees**	Level 1, Exhibit Hall A (Badge required, not open to free pass)
1330 – 1500	**Symposium Technical Sessions**	Level 3
1530 – 1600	**Refreshment Break**	Level 1, Exhibit Hall A
WEDNESDAY, 24 February 2016		
0745 – 0815	**Leader Orientation**	Level 3, Angsana Ballroom 3B
0800 – 1800	**Attendee and Exhibitor Registration**	Level 1, Foyer of Hall A
0800 – 1700	**All Leader Registration**	Level 3, Room 3010A
0830 – 1000	**Symposium Technical Sessions**	Level 3
1000 – 1800	**Exhibit Hall Open**	Level 1, Exhibit Hall A
1000 – 1030	**Refreshment Break**	Level 3 – Technical Sessions
1030 – 1200	**Symposium Technical Sessions**	Level 3
1200 – 1330	**Lunch for Exhibitors & Paid Attendees**	Level 1, Exhibit Hall A (Badge required, not open to free pass)
1330 – 1500	**Symposium Technical Sessions**	Level 3
1530 – 1600	**Refreshment Break**	Level 1, Exhibit Hall A
1930 – 2100	**Gala Dinner**	Level 4, Roselle Jr. Ballroom (Badge required, not open to free pass)
THURSDAY, 25 February 2016		
0745 – 0815	**Leader Orientation**	Level 3, Angsana Ballroom 3B
0800 – 1300	**Attendee and Exhibitor Registration**	Level 1, Foyer of Hall A
0800 – 1300	**All Leader Registration**	Level 3, Room 3010A
0830 – 1030	**Symposium Technical Sessions – Case Studies**	Level 3
0900 – 1300	**Exhibit Hall Open**	Level 1, Exhibit Hall A
1030 – 1100	**Refreshment Break**	Level 3 – Technical Sessions
1100 – 1230	**Symposium Technical Sessions – Case Studies**	Level 3
1300 – 1430	**Advisory Committee Luncheon**	Begonia Junior Ballroom, 3002

DAILY SCHEDULE

Sunday, February 21, 2016

1630 – 1800 | REGISTRATION

Attendee and Exhibitor Registration	Level 1, Foyer of Hall A
All Leader Registration (Lecture, Tutorial, Case Study Speakers, Discussion Leaders, Advisory Committee Members)	Level 3, Room 3010A

Monday, February 22, 2016

0700 – 1200 | REGISTRATION

Attendee and Exhibitor Registration	Level 1, Foyer of Hall A
All Leader Registration (Lecture, Tutorial, Case Study Speakers, Discussion Leaders, Advisory Committee Members)	Level 3, Room 3010A

0830 – 1700 | SHORT COURSES

Short Course 1 Pump Cavitation - Physics, Prediction, Control, Troubleshooting	Angsana Junior Ballroom, 3F
Short Course 2 Reciprocating Compressor 101 - Construction, Operating Principles and Maintenance Guidelines	Angsana Junior Ballroom, 3E
Short Course 3 Vibration Problems and Solutions in Pumps and Turbomachinery	Angsana Junior Ballroom, 3D
Short Course 4 Centrifugal Compressors 101	Angsana Ballroom, 3AB
Short Course 5 Magnetic Bearings in Turbomachinery	Begonia Ballroom, 3001AB
Short Course 6 Basic Knowledge of Steam Turbine Short Course, ST-101/201 Combined	Begonia Ballroom, 3002
Short Course 7 Introduction to Industrial Gas Turbines	Begonia Ballroom, 3004
Short Course 8 Babbitted Bearing Operation and Diagnosis	Begonia Ballroom, 3101AB
Short Course 9 Lateral Rotordynamics of Petrochemical Equipment - Review, Examples, and Problems	Begonia Ballroom, 3102
Short Course 10 Materials in Centrifugal Compressor and Steam Turbines: Selection, Processing, and Repair	Begonia Ballroom, 3104

1000 – 1030 | BREAK

Refreshment Break	Level 3, Technical Sessions

1200 – 1315 | LUNCH

Short Course Luncheon	Cassia Main Ballroom A

1330 – 1700 | REGISTRATION

Attendee and Exhibitor Registration	Level 1, Foyer of Hall A
All Leader Registration (Lecture, Tutorial, Case Study Speakers, Discussion Leaders, Advisory Committee Members)	Level 3, Room 3010A

1500 – 1530 | BREAK

Refreshment Break	Level 3, Technical Sessions

1715 – 1745 | ADVISORY COMMITTEE MEETING

Advisory Committee Meeting	Angsana Ballroom 3B

Tuesday, February 23, 2016

0730 – 1800 | ATTENDEE AND EXHIBITOR REGISTRATION

Level 1, Foyer of Hall A

0730 – 1700 | ALL LEADER REGISTRATION

(Lecture, Tutorial, Case Study Speakers, Discussion Leaders, Advisory Committee Members)

Level 3, Room 3010A

0715 – 0745 | LEADER ORIENTATION

Leader Orientation	**Angsana Ballroom 3B**

0745 – 0800 | WELCOME ADDRESS

Angsana Junior Ballroom 3D

0800 – 0830 | PLENARY LECTURE

Angsana Junior Ballroom 3D

TECHNICAL SESSIONS

0845 – 0930

Lecture 1 Development of High-Pressure Ratio and Wide-Operating Range 700bar Compressor	**Begonia Ballroom, 3002**
Lecture 2 Centrifugal Compressor Surge Control Systems - Fundamentals of a Good Design	**Begonia Ballroom, 3003**

0930 – 1015

Lecture 3 Solutions to Requirements on Electrical Drives in O&G Applications	**Begonia Ballroom, 3002**
Lecture 4 Definition of a Screening Criterion for Centrifugal Compressor Vibrations Induced by Inlet Gas Flow	**Begonia Ballroom, 3003**

0845 – 1015

Tutorial 1 Gas Turbine Performance	**Begonia Junior Ballroom, 3011**
Tutorial 2 Stability Considerations - A Simplified Approach	**Begonia Junior Ballroom, 3012**
Tutorial 3 An End-User's Guide to Centrifugal Pump Rotordynamics	**Begonia Junior Ballroom, 3111**
Tutorial 4 Regional Machinery Best Practices	**Begonia Junior Ballroom, 3112**
Discussion Group 1 Transmission Elements: Couplings and Alignment, Gears	**Begonia Ballroom, 3102**
Discussion Group 2 Dry Gas Seals: General (Installation, Operation, Troubleshooting, and Retrofitting), Controls	**Begonia Ballroom, 3103**

1000 – 1800 | EXHIBIT HALL OPEN

Exhibits Open Free to Public	**Level 1, Hall A**

1015 – 1030 | BREAK

Refreshment Break	**Level 3, Begonia, Pre-Function Area and Exhibit Hall**

1030 – 1115

Lecture 5 Design Validation of High Speed Ratio Epicyclic Gear Technology in Compression Systems	**Begonia Ballroom, 3002**
Lecture 6 Meeting Compression Train Base Package Design Requirements for Service on Floating Production Storage and Offloading Vessels	**Begonia Ballroom, 3003**

1115 – 1200

Lecture 7 Experimental Evaluation of the Effectiveness of Online Water-Washing in Gas Turbine Compressors	**Begonia Ballroom, 3002**
Lecture 8 Turbo Expander Technology Contribution in Development of Ethylene Plant Process	**Begonia Ballroom, 3003**

1030 – 1200

Tutorial 5 Combustion, Fuels, and Emissions for Industrial Gas Turbines	**Begonia Junior Ballroom, 3011**
Tutorial 6 Simplified Modal Analysis for the Plant Machinery Engineer	**Begonia Junior Ballroom, 3012**
Tutorial 7 Application and Design of Integrally Geared Compressors	**Begonia Junior Ballroom, 3111**
Tutorial 8 Carbon Foot Print Reduction Techniques with Rotating Machinery	**Begonia Junior Ballroom, 3112**
Discussion Group 3 Steam Turbines: Operation & Maintenance	**Begonia Ballroom, 3102**
Discussion Group 4 Centrifugal Pumps: Operation, Maintenance, and Reliability, Vertical Pump Problems and Solutions	**Begonia Ballroom, 3103**

1200 – 1330 | LUNCH FOR EXHIBITORS & PAID ATTENDEES

Lunch for Exhibitors & Paid Attendees	**Level 1, Exhibit Hall A (Badge required, not open to free pass)**

1330 – 1400

Technical Brief 1 Dry Gas Seal Contamination During Operation and Pressurized Hold – Background and Potential Solutions	**Begonia Ballroom, 3002**

1400 – 1430

Technical Brief 2 Mechanical Seals with DiamondFace Technology Used in Different Pipeline Services	**Begonia Ballroom, 3002**

1430 – 1500

Technical Brief 3 Using Non-Standard Materials for Couplings on Special Turbomachinery Applications	**Begonia Ballroom, 3002**

1330 – 1500

Tutorial 9 Technical Challenges for Compressors and Steam Turbines for Efficient and Sustainable Operation in Mega Ethylene Plants	**Begonia Junior Ballroom, 3011**
Tutorial 10a - Combo - Control Systems - Transient Modeling and Analysis of Centrifugal Compressors	**Begonia Junior Ballroom, 3012**
Tutorial 10b - Combo - Control Systems - Molecular Weight Compensation Consideration in Compressor Surge Control	**Begonia Junior Ballroom, 3012**
Tutorial 10c - Combo - Control Systems - Surge Control and Dynamic Behavior for Centrifugal Gas Compressors	**Begonia Junior Ballroom, 3012**
Tutorial 11 Piping and Machinery Integrity on Structurally Resonant Platforms and FPSOs	**Begonia Junior Ballroom, 3111**
Tutorial 12 The Development of API 682 4th Edition	**Begonia Junior Ballroom, 3112**
Discussion Group 5 Turbomachinery and Pump Vibrations	**Begonia Ballroom, 3102**
Discussion Group 6 Centrifugal Compressors: Operation and Maintenance, Advanced Design, Wet and Sour Gas Operation	**Begonia Ballroom, 3103**

1530 – 1600 | BREAK

Refreshment Break	**Level 1, Exhibit Hall A**

Wednesday, February 24, 2016

0800 – 1800 | ATTENDEE AND EXHIBITOR REGISTRATION

Level 1, Foyer of Hall A

0800 – 1700 | ALL LEADER REGISTRATION

(Lecture, Tutorial, Case Study Speakers, Discussion Leaders, Advisory Committee Members)

Level 3, Room 3010A

0745 – 0815 | LEADER ORIENTATION

Leader Orientation	**Angsana Ballroom 3B**

0830 – 0915

Lecture 9 Structural Dynamic Behavior of Frame 9E GTG Module for LNG Plant	**Begonia Ballroom, 3002**
Lecture 10 Effect of Inlet Cooling on the Performances of Isotherm Main Air Compressor Used for ASU Applications	**Begonia Ballroom, 3003**

0915 – 1000

Lecture 11 The Challenge for the Accurate Determination of the Axial Rotor Thrust in Centrifugal Compressors	**Begonia Ballroom, 3002**
Lecture 12 Evaluation of Various Methods for Manufacturing One Piece, Small Tip Opening Centrifugal Compressor Impellers	**Begonia Ballroom, 3003**

0830 – 1000

Tutorial 13 Gas Turbine Packaging Options and Features	**Begonia Junior Ballroom, 3011**
Tutorial 14 Fundamentals of Fluid Film Journal Bearing Operation and Modeling	**Begonia Junior Ballroom, 3012**
Tutorial 15 Couplings - Balancing Tutorial & “New Developments in Gas Turbine Couplings”	**Begonia Junior Ballroom, 3111**
Discussion Group 7 Other Compressors: Reciprocating, Screw (Wet and Dry), Integrally Geared, and Turbo-Expanders	**Begonia Ballroom, 3102**
Discussion Group 8 Gas Turbines: Operation & Maintenance	**Begonia Ballroom, 3103**

1000 – 1800 | EXHIBIT HALL OPEN

Exhibits Open Free to Public	**Level 1, Hall A**

1000 – 1030 | BREAK

Refreshment Break	**Level 3, Begonia, Pre-Function Area and Exhibit Hall**

1030 – 1115

Lecture 13 Coupled Torsional and Lateral Analysis for the Determination of the Damping of the First Torsional Mode of Synchronous Motor Driven Compressor Trains	**Begonia Ballroom, 3002**
Lecture 14 Operation of Centrifugal Compressors in Choke Conditions	**Begonia Ballroom, 3003**

1115 – 1200

Lecture 15 Squeeze Film Dampers: An Experimental Appraisal of Their Dynamic Performance	**Begonia Ballroom, 3002**
Lecture 16 Four Quadrant Centrifugal Compressor Performance	**Begonia Ballroom, 3003**

1030 – 1200

Discussion Group 9 Lubrication - Fluid Film Bearings: Operation, Maintenance, Troubleshooting	**Begonia Ballroom, 3102**
Discussion Group 10 Mechanical (Liquid) Seals: General (Installation, Operation, Troubleshooting, and Retrofitting)	**Begonia Ballroom, 3103**
Tutorial 16 Remaining Life Assessment of Steam Turbine and Hot Gas Expander Components	**Begonia Junior Ballroom, 3011**
Tutorial 17 Considerations in the Design of VFD Motor-Driven Compressors	**Begonia Junior Ballroom, 3012**
Tutorial 18 Shop Rotordynamic Testing - Options, Objectives, Benefits & Practices	**Begonia Junior Ballroom, 3111**

1200 – 1300 | LUNCH FOR EXHIBITORS & PAID ATTENDEES

Lunch for Exhibitors & Paid Attendees	**Level 1, Exhibit Hall A (Badge required, not open to free pass)**

1330 – 1400

Technical Brief 4 Dynamic Analysis of a Multi-Stage Compressor Train	**Begonia Ballroom, 3002**

1400 – 1430

Technical Brief 5 Field Evaluation of an Offshore Pumping System	**Begonia Ballroom, 3002**

1430 – 1500

Technical Brief 6 Frequency Dependence of Piles' Dynamic Stiffness	**Begonia Ballroom, 3002**

1330 – 1500

Tutorial 19a - Combo - Dry Gas Seals - Centrifugal Compressor Shaft End Seals	**Begonia Junior Ballroom, 3011**
Tutorial 19b - Combo - Dry Gas Seals - Application of Double vs. Tandem Dry Gas Seal Advantages	**Begonia Junior Ballroom, 3011**
Tutorial 19c - Combo - Dry Gas Seals - Wet Seal to Dry Gas Seal Conversion - Considering the Benefits of Retrofitting Your Compressor	**Begonia Junior Ballroom, 3011**
Tutorial 19d - Combo - Dry Gas Seals - Monitoring a Tandem Dry Gas Seal's Secondary Seal	**Begonia Junior Ballroom, 3011**
Tutorial 20 Hydrodynamic Torque Converters for Oil & Gas Compression and Pumping Applications: Basic Principles, Performance Characteristics, and Applications	**Begonia Junior Ballroom, 3012**
Tutorial 21 Integrating Dynamic Machinery Performance with Component Condition to Optimize Reliability	**Begonia Junior Ballroom, 3111**
Tutorial 22 Panel Session - Subsea Compression Applications	**Begonia Ballroom, 3003**
Discussion Group 11 Magnetic Bearings	**Begonia Ballroom, 3102**
Discussion Group 12 Protective Systems: Controls & Overspeed Trip	**Begonia Ballroom, 3103**

1530 – 1600 | BREAK

Refreshment Break	**Level 1, Exhibit Hall A**

1930 – 2100 | GALA DINNER

Gala Dinner	**Level 4, Roselle Jr. Ballroom (Badge required, not open to free pass)**

Thursday, February 25, 2016

0800 – 1300 | ATTENDEE AND EXHIBITOR REGISTRATION

Level 1, Foyer of Hall A

0800 – 1300 | ALL LEADER REGISTRATION

(Lecture, Tutorial, Case Study Speakers, Discussion Leaders, Advisory Committee Members)

Level 3, Room 3010A

0745 – 0815 | LEADER ORIENTATION

Leader Orientation	**Angsana Ballroom, 3B**

0830 – 0900

Case Study 1 Stress Corrosion Failure of a Low Pressure Disk from a 800MW Steam Turbine	**Angsana Ballroom, 3AB**
Case Study 2 2 Case Studies on Unique Machinery Repair Techniques: Brush Plating Repair of Eroded Compressor Diaphragm - Combining 2 Failed Gearboxes into 1 Functional and Reliable Gearbox	**Angsana Junior Ballroom, 3D**

0900 – 0930

Case Study 3 Steam Turbine Vibration Resonance of Pedestal, Vibration Investigation with Countermeasures in Singapore	**Angsana Ballroom, 3AB**
Case Study 4 High Vibration Problem Resolution in Centrifugal Pump through Design Change	**Angsana Junior Ballroom, 3E**
Case Study 6 Emergency Damage Restoration Experiences of 25MW Heavy-Duty Gas Turbine: Bearing Retrofit Design and Test Run	**Angsana Junior Ballroom, 3F**

0930 – 1000

Case Study 7 Case Study on Remote Diagnostics in Resolving Random Vibration on a Steam Turbine	**Angsana Ballroom, 3AB**
Case Study 9 Adapting Compression Equipment to Accommodate Declining Well Pressures and Ensure Overall Efficiency in Mid/Late Field Life	**Angsana Junior Ballroom, 3D**
Case Study 10 Repair of Severely Damaged Rotor as an Emergency Spare	**Angsana Junior Ballroom, 3F**

1000 – 1030

Case Study 11 Revamp of Steam Turbine for Synthesis Gas Compressor at NFL Nangal	**Angsana Ballroom, 3AB**
Case Study 12 Bad Actor Elimination in Pumps	**Angsana Junior Ballroom, 3E**
Case Study 13 Investigation of Process Gas Compressor Shaft Vibration Phenomena	**Angsana Junior Ballroom, 3D**
Case Study 14 Dry Gas Seal Failure and Trouble Shooting	**Angsana Junior Ballroom, 3F**

0900 – 1300 | EXHIBIT HALL OPEN

Exhibits Open Free to Public	**Level 1, Hall A**

1030 – 1100 | BREAK

Refreshment Break	**Level 3, Begonia, Pref-Function Area and Exhibit Hall**

1100 – 1130

Case Study 15 Abrupt Stoppage of Turbine Rotor, Running on Barring after Major Overhauling	**Angsana Ballroom, 3AB**
Case Study 16 Enhancement of Pump/Plant Performance by Correct Evaluation of Process Fluid Viscosity Variations and Pump Geometry	**Angsana Junior Ballroom, 3E**
Case Study 17 Effects of Shaft Geometric Unconformities on the Rotor-Dynamic Behavior in Hard Coupled Equipment	**Angsana Junior Ballroom, 3D**
Case Study 18 The Importance of Structural Modal Analysis in 2 Poles Induction Motors for LNG Application	**Angsana Junior Ballroom, 3F**

1130 – 1200

Case Study 19 Investigation of Steam Turbine Blade Failure	**Angsana Ballroom, 3AB**
Case Study 20 Vibration Field Problem Resolved with Analytical Diagnostic Approach and Innovative Impeller Design	**Angsana Junior Ballroom, 3E**
Case Study 21 Measurements and Analysis of High Machine Vibration — A Case Study of Screw Compressor Rub	**Angsana Junior Ballroom, 3D**
Case Study 22 A Solution to Years of High Vibration Problems in Three Reinjection Compressor Trains Running at 33 MPA Discharge Pressure	**Angsana Junior Ballroom, 3F**

1200 – 1230

Case Study 23 Hydraulic Power Recovery Turbine Operational Failure and Design Enhancement	**Angsana Ballroom, 3AB**
Case Study 24 Do You Have a Mechanical Seal Refurbishing Shop in Your Complex?	**Angsana Junior Ballroom, 3E**

1300 – 1400 | ADVISORY COMMITTEE LUNCHEON

Advisory Committee Luncheon	**Begonia Junior Ballroom, 3002**

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PROGRAM

SHORT COURSE DESCRIPTIONS

Short Course 1: Pump Cavitation - Physics, Prediction, Control, Troubleshooting

Monday, February 22, 2016

0830 - 1700 Angsana Junior Ballroom 3F

Instructors: Frank Visser, Bruno Schiavello (Flowserve)

This short course deals with cavitation in general and rotodynamic pump cavitation in particular. It gives an introduction to the subject matter and provides insights in particulars like cavitation inception, 3% head drop, and 40,000 hours impeller life, as well as NPSH scaling laws. It further devotes attention to the effect of dissolved gases, and thermal suppression (i.e. thermodynamic effect) when pumping hot water or hydrocarbons. For (hydrocarbon) mixtures it will also be outlined that cavitation intensity can be expected to be far less than with pure fluids. With regard to numerical prediction capabilities the use of Computational Fluid Dynamics (CFD) shall be discussed, and empirical correlations will be presented. Furthermore, some guidance for cavitation damage diagnosis shall be given, including prediction of cavitation erosion rate, and assessment of impeller life expectancy. Also addressed are suction specific speed, and how this dimensionless group tends to cause bias and give rise to misunderstanding and misinterpretation. In this context also the corrected suction specific speed will be presented, and the concept of suction energy will be discussed. Furthermore, NPSHR criteria and establishing NPSHA margins will be outlined. As special modes of operation, the effect of fluid transients will be highlighted, demonstrating that such may yield excessive cavitation. Furthermore, a qualitative “Cavitation Modes Map” will be presented, which reflects five decades of fundamental cavitation observations and experimental facts (laboratory research and field data) published in the years 1941 – 1991. In particular, the typical shape of the erosion curve versus flow – seemingly peculiar, but fully supported by cavitation physics for all types of rotodynamic pumps – is discussed by highlighting an absolutely striking departure from the shape of conventional NPSHR3% curve (universally used for decades) at part flows. This deviation, which has been fully ignored in the past and is today still often neglected at various stages (pump specifications and selection, pump design, and field root cause analysis) is a primary reason of the majority of cavitation pump problems, as will be explained in this short course. The course further includes four Field Case Studies demonstrating the practical application of “Cavitation Failure Analysis – Methodology (Diagnosis and Solution Strategy)“, covering low and high energy, single- and multistage, pumps.

Short Course 2: Reciprocating Compressor 101 - Construction, Operating Principles and Maintenance Guidelines

Monday, February 22, 2016

0830 - 1700 Angsana Junior Ballroom 3E

Instructors: Andre Eijk (TNO), Thomas Emminger (HOERBIGER)

This course is aimed at engineers and other technical professionals who need a broad-based introduction to reciprocating compressors. Though recips have been around for a long time, they remain state of the art common in refineries, petrochemical plants and natural gas applications. Installed and operated correctly, they are rugged, versatile, and energy-efficient. The emphasis here is on practical information, with some theoretical background where it is helpful. Starting with the basic layout of the compressor and its components, you will learn about fundamental working principles, installation, operation and maintenance. There is an overview of standards – API 618 and NACE – plus basic thermodynamics, and the fundamentals of how to minimize pulsation and vibration. After attending this course you will no longer find recips mysterious. You will have a strong understanding of how they work, their components, and best practices in installation, operation and maintenance. The course is taught by three reciprocating compressor experts representing a compressor manufacturer, an applied research institution, and a leading supplier of components and services.

Short Course 3: Vibration Problems and Solutions in Pumps and Turbomachinery

Monday, February 22, 2016

0830 - 1700 Angsana Junior Ballroom 3D

Instructors: Bill Marscher, Eric J. Olson (Mechanical Solutions, Inc.)

This course presents analysis and testing methods for pumps and turbomachinery. Focus is on centrifugal pumps of all types, centrifugal compressors, axial compressors, fans, steam turbines and gas turbines. Rotordynamics and bladed disk vibration are included as modules as well as discussion of fluid-induced vibration (e.g. rotating stall and blade pass frequencies), acoustics, and mechanically induced vibration (imbalance misalignment, rubs, looseness). Troubleshooting methods and fixes are discussed with many detailed case histories.

Short Course 4: Centrifugal Compressors 101

Monday, February 22, 2016

0830 - 1700 Angsana Ballroom 3AB

Instructors: Mark Kuzdzal, Jay Koch (Dresser-Rand)

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: Magnetic Bearings in Turbomachinery

Monday, February 22, 2016

0830 - 1700 Begonia Ballroom 3001AB

Instructors: Joseph Tecza, Rasish Khatri (Dresser-Rand), Richard Shultz (Waukesha Magnetic Bearings), Stan Uptigrove (ExxonMobil)

This course is aimed at engineers, operations, and maintenance personnel who need a broad-based introduction to magnetic bearing design, specification, and operation. This course aims to provide a balanced presentation of both the benefits and challenges associated with applying magnetic bearings to industrial turbomachinery and with operating/maintaining those machines. An emphasis is placed on providing practical information with minimal theory. At the completion of the course the attendees should have a firm foundation in the basics associated with specifying, purchasing, operating, and maintaining turbomachinery supported on magnetic bearings.

Short Course 6: Basic Knowledge of Steam Turbine Short Course, ST-101/201 Combined

Monday, February 22, 2016

0830 - 1700 Begonia Ballroom 3002

Instructors: Kyochi Ikeno, Makoto Katagake, Satoshi Hata, Takuro Koda (Mitsubishi Heavy Industries Compressor Corporation)

The wide basic knowledge and latest technical information of steam turbine is explained in this short course. 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 Industrial Gas Turbines

Monday, February 22, 2016

0830 - 1700 Begonia Ballroom 3004

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

Industrial gas turbines are used in many applications in the oil and gas industry, as well as in power generation. 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 components their working principles of a industrial gas turbine package are described and explained. This course will also address the basic characteristics of each of the components, and define the rules under which they interact, as well as typical control limits and control concepts. Important non-dimensional characteristics such as Mach number and Reynolds number will be introduced. The concept of component matching is explained. Based on this, the performance characteristics of a gas turbine under different design and off design conditions, and as a function of ambient conditions are explained. Also, a brief overview of typical gas turbine applications is given. Because proper maintenance and operating practices can significantly affect the level of performance degradation and thus time between repairs or overhauls of a gas turbine, considerations regarding inlet air, fuel and lube oil quality are discussed. The course provides a discussion on how degradation develops and affects the performance of the gas turbine. Recommendations are provided on how the operator can limit this degradation and any deterioration of the gas turbines through proper maintenance practices. The effects of waterwashing together with best washing practices are discussed. Emphasis is on monitoring of gas turbines performance parameters to establish condition based maintenance practices. The summary also includes recommendations and best practices, with special emphasis for the applications in the region.

Short Course 8: Babbitted Bearing Operation and Diagnosis

Monday, February 22, 2016

0830 - 1700 Begonia Ballroom 3101AB

Instructors: John Whalen (John Crane), Lim Lee Seng (ExxonMobil Asia Pacific Pte Ltd), C. Hunter Cloud (BRG Machinery Consulting LLC)

This short course is intended for plant personnel responsible for determining the health of operating critical rotating equipment running on babbitted journal and thrust bearings. A brief summary of bearing operation will be followed by condition monitoring considerations including oil analysis. The course will conclude with a presentation of the more common bearing failure mechanisms and design options available to increase bearing robustness.

1. Hydrodynamic lubrication background
2. Introduction to vibration analysis
3. Fundamentals of an oil analysis program
4. Bearing failures, design to avoid failure and case studies

Short Course 9: Lateral Rotordynamics of Petrochemical Equipment — Review, Examples and Problems

Monday, February 22, 2016

0830 - 1700 Begonia Ballroom 3102

Instructors: John Kocur (ExxonMobil Research & Engineering)

Reliability and operability of rotating equipment is strongly tied to its dynamic behavior. High vibrations resulting from poorly designed machinery can lead to bearing damage, efficiency loss due to internal rubbing, cyclic failure of rotating components and protracted unplanned shutdowns. Knowledge of the rotordynamic behavior and the impact of components on that behavior is critical in determining the success of new equipment, rerates of existing equipment or retrofitting components in the field. This short course will present the basics of rotordynamics and its application to turbomachinery. Shaft stiffness considerations, tilting pad journal bearing influence on stiffness and damping coefficients, influence of support stiffness and labyrinth and honeycomb seal impact on stability are some of the concepts covered. Basic rotordynamic analyses; undamped critical speeds, response to unbalance and rotor stability will be presented and their use in understanding the rotor behavior explained. Case studies showing problem solving using rotordynamic analysis are also included. The student should come away from the course with an appreciation for rotordynamic behavior, an ability to interpret rotordynamic predictions and an awareness of when this tool should be applied to ensure operability and reliability of equipment.

Short Course 10: Materials in Centrifugal Compressor and Steam Turbines: Selection, Processing, and Repair

Monday, February 22, 2016

0830 - 1700 Begonia Ballroom 3104

Instructors: Scot Laney, Derrick Bauer, 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 OEM's 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.

The ATPS advisory committee is happy to announce the ATPS 2016

PLENARY LECTURE

The Turbomachinery Laboratory, Pump and Turbomachinery Symposia; Looking Backward ... Looking Forward

23 FEBRUARY 2016 • 0800 hours

Dr. Dara Childs, Director of the Texas A&M Turbomachinery Laboratory

The first Turbomachinery Symposium was held in 1972 in College Station, Texas on the Texas A&M University Campus. It was the "brain child" of engineers working with turbomachinery notably including, in the oil and gas sector, Ed Nelson, AMOCO, A&M Class of 51 and petrochemical industry, Charlie Jackson, Monsanto, A&M Class of 51. It was initially sponsored by Dr. Cliff Simmang (then head of Mechanical Engineering) and was led by Dr. Mehrewan P. Boyce, then an Associate Professor of Mechanical Engineering at Texas A&M. The 1st Turbo Symposia had 21 exhibitors and an estimated attendance of 200 hundred.

The 1st International Pump Users Symposia was held in 1984 with 41 exhibitors and an estimated attendance of 300.

The 2015 (combined) Turbo and International Pump Symposia had an attendance of 5542 from 46 countries with 350 exhibiting companies.

We are presently attending the inaugural Asian Turbomachinery and Pump Symposia with a strong attendance and robust exhibit hall.

In 1972, many conferences competed for the attention of engineers wanting to learn more about the design, operation, and maintenance of turbomachinery. Today, most of them have disappeared, while the "TURBO" symposia continue to prosper. This talk looks back at the start of the Turbo symposia to explain why they have continued to grow and prosper while other programs have disappeared.

LECTURE DESCRIPTIONS

Lecture 1: Development of High-Pressure Ratio and Wide-Operating Range 700bar Compressor

Tuesday, February 23, 2016

0845 - 0930 Begonia Ballroom 3002

Instructors: Diogo Yoshikazu Ujihara (PETROBRAS), Akihiro Nakaniwa, Shinichiro Tokuyama, Satoshi Saburi (Mitsubishi Heavy Industries, Ltd.)

Pre-Salt development projects continue to expand offshore Brazil into ever deeper waters year after year. Consequently, the required Discharge Pressures for Re-Injection Compressors aboard FPSO's are likely to exceed current 550 bar levels, and requirements for design of higher pressure compressors becomes more severe. This paper presents development of super high pressure compressor and the results of verification tests. Super high pressure compressor can be used as re-injection compressor or injection compressor such as in the CCS plant and FPSO.

Lecture 2: Centrifugal Compressor Surge Control Systems - Fundamentals of a Good Design

Tuesday, February 23, 2016

0845 - 0930 Begonia Ballroom 3003

Instructors: Jordan Grose (BETA Machinery Analysis), Kamal Botros (NOVA Chemicals), Steven Hill (Williams Gas Pipeline)

Many facilities employ two or more centrifugal compressors, operated in either series or parallel configurations. An accurately designed surge control system that includes multiple compressors with the associated piping systems is a vital element of a facility's design and ongoing operational integrity. The design must ensure compressors are not subjected to damaging fast dynamic events leading to large capital costs and significant downtime for operators. Typical studies are not accurate enough to capture the complex interactions leading to catastrophic events, especially for complicated system arrangements. A new approach to centrifugal compressor surge control design that uses full governing partial differential equations (PDEs) is presented in this lecture.

Lecture 3: Solutions To Requirements On Electrical Drives In O&G Applications

Tuesday, February 23, 2016

0930 - 1015 Begonia Ballroom 3002

Instructors: Vijay Ganesan, Stephan Busse, Sven Demmig (Siemens AG)

Variable Frequency Drives (VFDs) are increasingly employed in Oil and Gas (O&G) processes due to better efficiency, reliability and process controllability compared to conventional drivers. The requirements on the VSDs keep rising with increasing demands, stricter regulations and the drive for efficient production. This paper discusses the key challenges faced by the VFDs in the O&G industry and presents solutions to overcome them.

Lecture 4: Definition of a Screening Criterion for Centrifugal Compressor Vibrations Induced by Inlet Gas Flow

Tuesday, February 23, 2016

0930 - 1015 Begonia Ballroom 3003

Instructors: Michele Fontana, Andrea Bernocchi, Alessandro Carnevali, Leonardo Baldassarre (GE Oil & Gas)

The process gas flowing into a centrifugal compressor induces pulsating radial forces on the rotor. Such forces represent a potential source of radial vibrations, particularly in case of high gas density and high inlet flowrate. A physical model, validated by comparison wah string test data, was developed to simulate the phenomenon and to predict its effects. It provided the basis for a screening diagram for compressor sensitivity to flow-induoed vibrations, to be used during the design phase and for diagnostics on running machines.

Lecture 5: Design Validation of High Speed Ratio Epicyclic Gear Technology in Compression Systems

Tuesday, February 23, 2016

1030 - 1115 Begonia Ballroom 3002

Instructors: Gaspare Maragioglio, Giuseppe Vannini (GE Oil & Gas), Paul Bradley, Shawn Buckley (Allen Gears)

Epicyclic gear technology is a key factor to support the compression growth strategy in electrified applications, due to the ever increasing transmission ratio required to meet the high compressor speeds. The paper collects the experience of the authors in developing a unique product through its conceptual design, as well as its mechanical and rotordynamic assessment, up to its complete validation with a full speed full load test in a complete unit arrangement. The power transmission was jointly developed by the gear and compressor manufacturers. The methods used to evaluate the gearbox configuration options are detailed in this paper, along with the gearbox specific technology design challenges faced. The paper will close with details of transmission performance testing from the gearbox manufactures test bed to the full load string test in a complete compressor unit arrangement, at different operating conditions.

Lecture 6: Meeting Compression Train Base Package Design Requirements for Service on Floating Production Storage and Offloading Vessels

Tuesday, February 23, 2016

1030 - 1115 Begonia Ballroom 3003

Instructors: Harry Miller, Ed Abraham (Dresser-Rand Company)

Typical floating production, storage and offloading (FPSO) compression applications are presented, including drivers and auxiliary equipment, and typical compressor operating conditions. Base packages consisting of centrifugal compressor(s), gear, motor or gas turbine driver, lube oil tank, and auxiliary equipment require extensive analyses to validate design requirements for service on FPSO vessels. Finite element analyses (FEA) are performed to insure that stress and displacement criteria are met. This paper discusses loading conditions that are evaluated including package lifting, transportation loads, short circuit torque, and upset loads. Operating load cases are also analyzed, which include dead weight, FPSO motion, rotor unbalance, torque, nozzle, and wind loads. Modal analyses are performed to ensure that predominant package modes do not lie in the run speed range. Rotor unbalance forced response analyses can be performed to ensure that amplitudes at key locations remain within allowable vibration criteria. Typical FEA models and analytical procedures are presented. The use of the analytical results to assist in selecting design modifications is discussed. The paper emphasizes the importance of gathering information early in the design cycle. This includes ship structural stiffness at the anti-vibration mount (AVM) locations, AVM stiffness, and load specifications including wind, wave, upset, and transport loading, and coupling capability. Finally, the paper presents a design change that allows for significant footprint reduction of the overall package.

Lecture 7: Experimental Evaluation of the Effectiveness of Online Water-Washing in Gas Turbine Compressors

Tuesday, February 23, 2016

1115 - 1200 Begonia Ballroom 3002

Instructors: Klaus Brun, Terrence Grimley (Southwest Research Institute), William Foils (BP Exploration & Production), Rainer Kurz (Solar Turbines, Inc.)

Gas turbine axial compressor blades foul due to the deposit of dirt particles during operation. This fouling significantly affects the gas compressor's aerodynamic performance and efficiency, thus forcing the operator to regularly shut down the unit for offline water washing of the compressor. Alternatively, online washing technologies have been developed to clean the compressor during operation to minimize gas turbine shutdowns and optimize availability. To gain an improved understanding of the effectiveness of online cleaning technologies, specifically the dirt removal and redeposit processes, a number of tests of fouled blades mounted in a high-speed wind-tunnel were performed. These tests quantified both the washing effectiveness using various washing fluids as well as the redeposit of foulant dirt in downstream stages. Test results indicate that spraying cleaning fluid into a flowing air stream is viable means of cleaning a compressor blade. Each of the fluids was able to clean the test blade at both low and high air velocities and at different blade incident angles. However, for all tested cleaning cases, there was always an area of the blade where some fouling deposits

remained. Dirt removed from the blades will redeposit in downstream stages as the cleaning fluid is evaporated. Redeposit occurred in flow recirculation zones during the cleaning tests, and heated flow tests demonstrated dirt deposit in the presence of a cleaning fluid. The type of fluid used for cleaning has no effect on the redeposit characteristics of the dirt. The above findings as well as the test setup and procedures are discussed in detail in the paper. Online washing effectiveness and redeposit data for all test cases is provided.

Lecture 8: Turbo Expander Technology Contribution in Development of Ethylene Plant Process

Tuesday, February 23, 2016

1115 - 1200 Begonia Ballroom 3003

Instructors: Reza Agahi, Behrooz Ershaghi (Atlas Copco Gas and Process), Saleh Al Halaki (QAPCO), Trevor Mayne (Qenos Altona Olefins)

Ethylene plant process and turbo expander technology developments have been interrelated and dependent on each other's. Design improvements and technology innovations associated with inflow radial turbine, turbo expander, have been the main motivation for the improved and more productive ethylene plant processes. The early process design that was based on Jule Thompson expansion valve was replaced by the process designs that utilize several stages of expander -compressor or expander- generators. The latest technology innovation that was embraced by the ethylene plant engineering companies and the owners was expander-compressor with active magnetic bearings. The early applications of expander-compressor with magnetic bearings began in the 1980's. The present product improvement activities by turbo expander suppliers are to reduced number of expansion stages. High head and low flow coefficient expander wheel as well as high peripheral speed wheels are being developed to achieve the latter objective. The next innovative technology that is knocking at the door of ethylene plants is expander - high speed permanent magnet generator with magnetic bearings.
In this paper the authors present a brief history of ethylene plant process, expander technology developments and show their reliance. The authors will also present their suggestions about the next innovation of the expander with high speed generator.

Lecture 9: Structural Dynamic Behavior of Frame 9E GTG Module for LNG Plant

Wednesday, February 24, 2016

0830 - 0915 Begonia Ballroom 3002

Instructors: Marco Giancotti, Stefano Fattori, Roberto Biondi, Alessio Margiotta (GE Oil & Gas)

The traditional onshore installation of heavy duty gas turbine generator trains, especially for power >80MW, is stick built on heavy and rigid concrete block foundation. The challenge of modularization is that vibrations have to be transferred to concrete through structural steel, nevertheless implementing vibrations' acceptance criteria that were developed for direct concrete foundations. This novel concept of modularization needs a deeper dynamic analysis at system level to ensure that flexible structure modes are not excited at any operating condition; with respect to this subject, the Appendix A to this lecture is a dynamic analysis tutorial for turbomachinery modules, having the aim to describe the process and the tools to be used for purpose, based on author's experiences and lessons learnt also during the experiment described herein. The results of the dynamic analysis made on a complete system including module, foundation and sub foundation in "Full Speed No Load Test (FSNL) configuration have been for the 1st time compared with field measurements.

Lecture 10: Effect of Inlet Cooling on the Performances of Isotherm Main Air Compressor Used for ASU Applications

Wednesday, February 24, 2016

0830 - 0915 Begonia Ballroom 3003

Instructors: Luca Porreca (MAN Diesel & Turbo AG Schweiz), Wentao Zhu (Bosch Mahle Turbosystems Austria GmbH)

In this paper, a study is presented where different types of cooling technologies are applied in inline isotherm (intercooled) air centrifugal compressors. In particular, a "passive, and "active, cooling method is described and investigated and a thermo-economic case study is discussed. Audience for this lecture should be designers and manufacturers of industrial centrifugal compressors, in particular for ASU applications. Also designers and engineers interested on the effect of inJet cooling technology used for gas turbine and axial compressors can benefit from this lecture.

Lecture 11: The Challenge for the Accurate Determination of the Axial Rotor Thrust in Centrifugal Compressors

Wednesday, February 24, 2016

0915 - 1000 Begonia Ballroom 3002

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

This paper describes the calculation procedure for the accurate evaluation of the thrust in centrifugal compressors. The paramount factors which influence the thrust are considered such as the operating conditions, variable labyrinth seal clearances or different roughness of rotor and stator. Different arrangements of the compressor like in-line and back-to-back configurations are analysed and compared.
To validate the calculations extensive measurements of the thrust forces acting on the axial thrust bearing were performed during the full-load, full-pressure factory testing of different high pressure centrifugal compressors. The results of the tests demonstrate the accuracy of the prediction and the high sensitivity of the thrust to the boundary conditions. These measurements emphasize the importance of performing such thrust measurements during a full-load, full-pressure or ASME PTC10 Type 1 test. Finally the requirements of some specifications are discussed and their consequences on the design of the compressor are evaluated with respect to their feasibility.

Lecture 12: Evaluation of Various Methods for Manufacturing One Piece, Small Tip Opening Centrifugal Compressor Impellers

Wednesday, February 24, 2016

0915 - 1000 Begonia Ballroom 3003

Instructors: Scot Laney, Derrick Bauer, Akiyoshi Ando (Elliott Group)

Closed centrifugal compressor impellers have been manufactured using several methods through the years. Due to limitations of the materials and machining processes, most of these impellers have been manufactured in what is considered two piece or three piece methods. Despite the vast amount of experience with traditional construction methods, there is a drive to move towards one piece construction, where there are no joints and, in theory, lower probability of preexisting defects. Typically, the impellers that are being offered as one piece are those with relatively large openings where 5-axis milling machines can be utilized. This paper investigates several alternative methods to manufacturing small tip opening impellers as a single piece. The methods discussed include Electrical Discharge Machining (EDM), investment casting, Hot Isostatic Pressed Powder Metal (HIP'd PM), and Direct Metal Laser Sintering (DMLS).

Lecture 13: Coupled Torsional and Lateral Analysis for the Determination of the Damping of the First Torsional Mode of Synchronous Motor Driven Compressor Trains

Wednesday, February 24, 2016

1030 - 1115 Begonia Ballroom 3002

Instructors: Jean-Claude Pradetto, Urs Baumann (MAN Diesel & Turbo Schweiz AG)

At the start-up of synchronous motor driven compressor units the oscillating torque of the motor inevitably becomes resonant with the 1st torsional mode of the shaft train. In resonance the shafts are highly loaded and the number of the allowed starts is normally limited. The magnitude of the load and thus the lifetime of the shafts are strongly dependent on the damping ratio of the mode. This paper presents torque measurements which were recently done at two air compressor trains of different size. For both machines the measured torques were much lower than predicted and it was recognized that the system's damping is considerably higher than the commonly used standard for geared trains. The identification of the damping, as well as its determination with an eigenvalue analysis of the torsionally and laterally coupled shaft train system is described. The influence of the train components' stiffness and inertia is also studied for a variety of compressor trains and finally, a criterion for a rough estimation of the damping in terms of a first screening of a shaft train is discussed.

Lecture 14: Operation of Centrifugal Compressors in Choke Conditions

Wednesday, February 24, 2016

1030 - 1115 Begonia Ballroom 3003

Instructors: Rainer Kurz, Russell K. Marechale, Edward J. Fowler, Min Ji, Michael J. Cave (Solar Turbines Incorporated)

Centrifugal compressors are at times required to operate in or near the choke region. Various limits of the degree of allowable operation in choke have been established. Based on test data and numerical data, the behavior of centrifugal compressors in the choke region is studied. Changes in aerodynamic performance, thrust load, volute behavior and radial loading are considered. The issue of excitation of impeller vanes is addressed. Particular consideration is given to multistage machines, as well as dual compartment machines, in particular regarding the effects of impeller mismatch during operating conditions at flows significantly higher than the design flow. Limitations in the overload operating range of a compressor not only impact the operational flexibility , but also can require more complicated control systems. The paper addresses aerodynamic, structural as well as rotordynamic issues related to the operation in choke.

Lecture 15: Squeeze Film Dampers: An Experimental Appraisal of Their Dynamic Performance

Wednesday, February 24, 2016

1115 - 1200 Begonia Ballroom 3002

Instructors: Luis San Andrés, Sung-hwa Jeung, Sean Den (Texas A&M University), Gregory Savela (Pratt & Whitney Engines, UTC)

Squeeze Film Dampers (SFDs) are effective means to ameliorate rotor vibration amplitudes and to suppress instabilities in rotor-bearing systems. The lecture first reviews how SFDs work, then answers common questions among practitioners: why don't dampers have a centering stiffness; why is there fluid inertia or added mass in a damper; how does damping and added mass change when the length or clearance is changed; how much does damping increase with end seals; is using feedholes as effective as using feed groove; what happens if a feedhole is plugged; does amplitude and shape of whirl affect performance; does its performance become non-linear if it is largely off-centered; how do prevailing theoretical predictions correlate with experiment measurements?

Lecture 16: Four Quadrant Centrifugal Compressor Performance

Wednesday, February 24, 2016

1115 - 1200 Begonia Ballroom 3003

Instructors: Elisabetta Belardini, Dante Tommaso Rubino, Libero Tapinassi, Marco Pelella (GE Oil & Gas)

The characterization of the compressor behavior in all quadrants of performance map has acquired, in the last years, growing attention. Two dedicated experimental campaigns have been performed to characterize fourth quadrant and second quadrant operation in terms of performance, pressure fluctuations and mechanical vibrations. Experimental campaigns allowed the acquisition of performance curves of a centrifugal compressor in deep choke up to reverse pressure and indicated a large region of safe operating conditions at low peripheral Mach number. In stable reverse flow, the trends of work coefficient and pressure ratio were acquired for a large range of flow rates together with the evolution of vibration and pressure fluctuation along the speed lines. Pressure ratio and absorbed power for the different modes of operation can be very important to simulate dynamic scenarios far from the steady state operation and size accordingly compressor protection equipment and predict accurately compressor startup torque from pressurized condition (Fourth Quadrant Operations). The main frequency content and amplitude of pressure variations within the flow field or the radial/axial vibrations at the bearings are important to estimate blade loading and possible presence of excitation frequencies in the system. In the reported experience the operating points characterized by stable reverse flow rates close to the nominal one in direct flow did not show features much 2 more critical than in standard conditions (Second quadrant operation) . This result may be hopefully used to reduce BOP in early design phase of system layout.

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TUTORIAL DESCRIPTIONS

Tutorial 1: Gas Turbine Performance

Tuesday, February 23, 2016

0845 - 1015 Begonia Junior Ballroom 3011

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

The power and efficiency characteristics of a gas turbine are the result of a complex interaction of different turbo machines and a combustion system. In this tutorial, we will address the basic characteristics of each of the components in a gas turbine (compressor, gas generator turbine, power turbine) and the impact of typical control limits and control concepts. The goal is to provide explanations for the operational characteristics of typical industrial gas turbines, emphasizing the interaction between the gas turbine components. The concept of component matching is explained. Additionally, methods are introduced that allow the use of data for trending and comparison purposes. The impact of component degradation on individual component performance, as well as overall engine performance is discussed, together with strategies to reduce the impact of degradation.

Tutorial 2: Stability Considerations — A Simplified Approach

Tuesday, February 23, 2016

0845 - 1015 Begonia Junior Ballroom 3012

Instructors: Urs Baumann (Man Diesel & Turbo Schweiz AG)

This tutorial proposes a simplified stability check for turbocompressor rotors based on the gas swirl in the labyrinth seals. With this approach only a minimum of operational and design data is required to gain a picture of the stability behavior of an investigated machine. The proposed method is compared to analytical and measurement data and very good correlation can be shown.

Tutorial 3: An End-User's Guide to Centrifugal Pump Rotordynamics

Tuesday, February 23, 2016

0845 - 1015 Begonia Junior Ballroom 3111

Instructors: Bill Marscher (Mechanical Solutions, Inc.)

This tutorial discusses concepts and methods involved in performing and evaluating centrifugal pump rotordynamic analysis. The presentation includes Lomakin Effect, Gyroscopic Effect, Cross-Coupling, Rotordynamic Stability, Critical Speeds and their Mode Shapes, Forced Response, common Excitation Forces (both hydraulic and mechanical), and typical plant rotordynamic problems and solutions. Case Histories are included to provide examples of successful use of rotordynamic analysis.

Tutorial 4: Regional Machinery Best Practices

Tuesday, February 23, 2016

0845 - 1015 Begonia Junior Ballroom 3112

Instructors: William Eugene Forsthoffer, Michael Sean Forsthoffer (Forsthoffer Associates, Inc.)

This tutorial will focus on different types of machinery and typical issues we have seen in our many years of experience working in the region. Each Best Practice describes how to best resolve the problems we have faced.

Tutorial 5: Combustion, Fuels, and Emissions for Industrial Gas Turbines

Tuesday, February 23, 2016

1030 - 1200 Begonia Junior Ballroom 3011

Instructors: Michael Welch, Brian M. Igoe, David Wilson (Siemens Industrial Turbomachinery Ltd.)

It is important that gas turbines used in Oil & Gas applications can burn a wide variety of fuels with the minimum impact on the environment or economics. Many types of gaseous and liquid fuels that can be used in Gas Turbines are discussed, as will be the two basic types of combustion system employed – 'conventional' and 'Dry Low Emissions' – along with the flexibility of these systems to accept different types of fuel. Some of the common contaminants found in fuels are discussed along with the impact these have on the operability and maintenance of industrial and aero-derivative gas turbines.

Topics include:

- Types of gas turbines
- Types of exhaust emissions regulated
- Conventional combustion systems
- Dry Low (Pre-mixed) emissions combustion systems
- Fuel quality requirements
- 'Pipeline' quality Natural Gas fuels
- Premium liquid fuels (diesel, kerosene)
- Wellhead Gases as a Gas Turbine Fuel
- Liquefied Natural Gas (LNG)
- Biogas fuels - Refinery and process
- Syngas
- Natural Gas Liquids and LPG fuels
- Crude Oil
- Operational impact of contaminants , including sulphur
- Water in fuel
- Storing fuels correctly

Tutorial 6: Simplified Modal Analysis for the Plant Machinery Engineer

Tuesday, February 23, 2016

1030 - 1200 Begonia Junior Ballroom 3012

Instructors: Jose A. Vazquez, C. Hunter Cloud (BRG Machinery Consulting LLC), Robert J. Eizember (DuPont Company)

Experimental modal analysis and operating deflection shapes (ODS) are powerful tools in vibration analysis and machinery troubleshooting. However, the machinery plant engineer often doesn't believe such techniques are available given a lack of advanced measurement equipment. This tutorial presents best practices with simplified experimental modal analysis and ODS techniques that can be used by a plant machinery engineer with the limited vibration analysis equipment usually available at a plant site. Minimum requirements and analyzer settings are discussed for a variety of commonly available measurement equipment. For different machinery problems, common measurement pitfalls and limitations are reviewed and, where appropriate, alternative methods are presented. During the presentation, demonstrations of modal testing measurements will be conducted using a portable generic data acquisition system.

Tutorial 7: Application and Design of Integrally Geared Compressors

Tuesday, February 23, 2016

1030 - 1200 Begonia Junior Ballroom 3111

Instructors: Karl Wygant, Jonathan Bygrave, Werner Bosen, Rob Pelton (Hanwha Techwin)

An integrally geared compressor (IGC) has a series of pinions typically driven by a single bull gear. Each pinion may have an impeller mounted on one or both ends of the pinion. Integrally geared compressors are common in plant/instrument air service as well as air separation applications, and continue to gain acceptance over a wide range of other applications. An IGC can achieve high efficiencies but is subject to complicated mechanical interactions. As a result of the mechanical complexity: design engineers, application engineers, and even end users of IGCs benefit from a diverse and in-depth knowledge of all of the engineering principles applied to arrive at an efficient machine with robust operating characteristics. This paper emphasizes the practical aspects of sizing and selection criteria for an integrally geared compressor for a range of various applications and promotes a thorough understanding of practical limits of this type of compressor. Underlying aerodynamic principles are reinforced and limiting design aspects such as: gear tooth loading, lateral rotordynamics, bearing surface speed and loads, low and highcycle fatigue of impeller blades are all iterated to find compromises to meet the demands of each application. Understanding the application and applying appropriate design limits is essential to meeting ever more challenging installation requirements.

Tutorial 8: Carbon Foot Print Reduction Techniques with Rotating Machinery

Tuesday, February 23, 2016

1030 - 1200 Begonia Junior Ballroom 3112

Instructors: Vasanth Bhat, Quek Ser King Aaron (Singapore Regining Company - A Chevron JV)

Global Environment concerns and need for more optimized production costs is driving all industries including Oil & Gas to look at more ways to reduce energy consumption without compromising on plant throughputs. This is specially challenging for older units to carry out modifications on existing assets and justify these

with good paybacks for the capital investment needed. The article looks at the possible solutions available in this regard relating to rotating equipment and are illustrated with case studies to back these recommendations in most cases.

Tutorial 9: Technical Challenges for Compressors and Steam Turbines for Efficient and Sustainable Operation in Mega Ethylene Plants

Tuesday, February 23, 2016

1330 - 1500 Begonia Junior Ballroom 3011

Instructors: Satoshi Hata, Kyoichi Ikeno, Akinori Tasaki, Matt Walton, Abhay Jain (Mitsubishi Heavy Industries Compressor Corporation)

Turbomachinery equipment manufacturers have been moving forward to apply state of the art technologies for critical components in order to provide more efficient and reliable machines corresponding to the high power requirements for ethylene services. The authors introduce the technology development history map in the past and future for typical designs, verification tests, and application results in terms of transient fluid dynamics, thermodynamics, rotor dynamics, and blade vibration strength evaluation. In addition, after commissioning turbomachinery performance and reliability tends to deteriorate during longterm operation. The typical damage and deterioration map for machinery is introduced, and the authors explain practical technologies that are applied, such as flow path surface treatment, effective on-line washing, combination of anti-corrosion, erosion prevention and stage performance enhancement by partial component replacement, NDE techniques for both compressors and steam turbines, including a unique casing replacement technique on the same footprint for increasing capacity.

Tutorial - Combo — Control Systems 10a: Transient Modeling and Analysis of Centrifugal Compressors

Tuesday, February 23, 2016

1330 - 1500 Begonia Junior Ballroom 3012

Instructors: Augusto Garcia-Hernandez, Jeffrey A. Bennett (Southwest Research Institute)

Centrifugal compressors are subject to transient events, such as emergency shutdowns, which can cause energetic surge events during rapid shutdown transients. Many modeling tools and methodologies are used to predict the behavior of compressor systems during fast transient events. However, modeling of centrifugal compressor transient events requires a detailed evaluation of many system variables to obtain accurate results. Therefore, this tutorial presents a generic methodology to improve modeling predictions and main considerations that are part of the analysis. In addition, a comparison of the modeling results and experimental data are presented and complemented with parametric studies of different variables. In general, this work should provide guidelines for advancing the modeling of centrifugal compressor transients as well as showing the application of a valuable tool for designing surge control systems for centrifugal compressors.

Tutorial - Combo — Control Systems 10b: Molecular Weight Compensation Consideration in Compressor Surge Control

Tuesday, February 23, 2016

1330 - 1500 Begonia Junior Ballroom 3012

Instructors: Amit Saxena (Dresser-Rand)

The effects of gas molecular weight variation on a centrifugal compressor's surge line and computation of the operating margin from surge for the purposes of antisurge control is discussed using different methods. This paper will review the accuracy of most commonly used coordinate system (reduced polytropic head vs reduced flow) for molecular weight compensation used by some OEMs and third party surge control vendors using test results from a FPSO application employing Main gas, Injection gas and Export gas compressors, and present an alternative highly accurate molecular weight compensation method that can be used by surge controllers to account for shifts in the surge point under varying molecular weight conditions. This alternate method has been field tested on several compressor control applications in FPSOs, refineries, LNG and petrochemical plants.

Tutorial - Combo — Control Systems 10c: Surge Control and Dynamic Behavior for Centrifugal Gas Compressors

Tuesday, February 23, 2016

1330 - 1500 Begonia Junior Ballroom 3012

Instructors: Rainer Kurz, Robert C. White, Bernhard Winkelmann (Solar Turbines), Klaus Brun (Southwest Research Institute)

This tutorial discusses the design and function of surge control systems, or more precisely, surge avoidance systems on the basis of the behavior of centrifugal compressors when they interact with compression systems. Therefore, the control system, as well as the phenomenon of surge and stall is discussed. The paper emphasizes the interrelation between the process system and the compressor. Regarding the compressor, different methods of controlling the compressor are discussed, together with different operating regions like stall and choke. The differences between stall and surge are explained. Additionally, the impact of the process and how the process dynamics interact with the compressor is analyzed, categorized, and explained. Based on the above, process control and in particular, surge control systems are discussed. Critical features of surge control systems are explained, and options for different arrangements are given.

Tutorial 11: Piping and Machinery Integrity on Structurally Resonant Platforms and FPSOs

Tuesday, February 23, 2016

1330 - 1500 Begonia Junior Ballroom 3111

Instructors: Michael Cyca, Kelly Eberle, Guy Gendron (BETA Machinery Analysis)

Operators face significant integrity risks on offshore production facilities due to vibration of machinery and piping systems. These applications are more challenging than land based systems becallse compressors, pumps, and other rotating machines are mounted on steel modules that can become structurally resonant and cause excessive vibration. Vibration problems cause fatigue failure in the piping system, machinery component failure, and operator safety issues. This tutorial identifies best design practices to find and resolve structural vibration problems. The recommendations are based on input and guidance from various offshore operators. The tutorial will highlight the results from recent field investigations into structural vibration and will evaluate engineering methods used to address structural dynamic issues during the design phase.

Tutorial 12: The Development of API 682 4th Edition

Tuesday, February 23, 2016

1330 - 1500 Begonia Junior Ballroom 3112

Instructors: Peter Bowden (Independent Consultant)

API 682 was first published in 1994 and it became established as the industry leading document for mechanical seals. It promoted proven, high reliability seal solutions across refining markets. As new sealing technologies were developed, the standard was developed further and opened out to chemical, petrochemical and other industries. Published in 2014 the 4th Edition of API 682 continues to promote proven sealing solutions but has been updated to be less prescriptive. This tutorial will discuss changes to the standard for 4th Edition and will provide an insight into the decision making process used by the Task Force.

Tutorial 13: Gas Turbine Packaging Options and Features

Wednesday, February 24, 2016

0830 - 1000 Begonia Junior Ballroom 3011

Instructors: Klaus Brun (Southwest Research Institute), Rainer Kurz, Bernhard Winkelman (Solar Turbines, Inc.)

Industrial and aeroderivative gas turbines are commonly employed in applications where high power to weight ratio, low emissions, and high availability requirements prohibit the use of other mechanical drivers. For example, in the oil and gas industry, small industrial gas turbines are used for pipeline compression, oil pumping, water injection, gas lift, and offshore platform power generation. Also, in the large electric power plant market, gas turbine combined cycle plants are preferred because of their low air emissions and part load performance. In upstream and midstream service, industrial gas turbines are frequently used as This tutorial will describe standard ancillary/ auxiliary equipment options for gas turbine driven compressor systems and their relative advantages and disadvantages in oil & gas applications. Some discussion on API standards and how they relate to packaging options is also provided.

Tutorial 14: Fundamentals of Fluid Film Journal Bearing Operation and Modeling

Wednesday, February 24, 2016

0830 - 1000 Begonia Junior Ballroom 3012

Instructors: Minhui He, C. Hunter Cloud, James M. Byrne, Jose A. Vazquez (BRG Machinery Consulting, LLC)

Widely used in turbomachinery, the fluid film journal bearing is critical to a machine's overall reliability level. Their design complexity and application severity continue to increase making it challenging for the plant machinery engineer to evaluate their reliability. This tutorial provides practical knowledge on their basic operation and what physical effects should be included in modeling a bearing to help ensure its reliable operation in the field. All the important theoretical aspects of journal bearing modeling, such as film pressure, film and pad temperatures, thermal and mechanical deformations and turbulent flow are reviewed. Through some examples, the tutorial explores how different effects influence key performance characteristics like minimum film thickness, Babbitt temperature as well as stiffness and damping coefficients. Due to their increasing popularity, the operation and analysis of advanced designs using directed lubrication principles, such as inlet grooves and associated starvation issues, are also examined with several examples including comparisons to manufacturers' test data.

Tutorial 15: Couplings — Balancing Tutorial & "New Developments in Gas Turbine Couplings"

Wednesday, February 24, 2016

0830 - 1000 Begonia Junior Ballroom 3111

Instructors: Joe Corcoran (KopFlex), Christian Wolford (Altra Couplings)

This tutorial compares the characteristics of various types of flexible gas turbine couplings: diaphragm and disc primarily, with some coverage of the declining gear coupling installed base. Rigid or quill shaft couplings are not covered. Analysis of these different coupling types will show that they do not react in the same way while performing their function of transmitting torque and accommodating machinery misalignment. Proper selection and sizing, service and safety factors, rotor dynamic influences and environmental conditions address the importance of the flexible coupling in the turbomachinery train. Balance methods, the reactive forces that each type can produce on the equipment, advances in manufacturing, materials and design tools are reviewed. Special features such as torquemeter systems, fail safe back-ups, and overload protection devices will also be covered. A review of failure modes is also included.

Tutorial 16: Remaining Life Assessment of Steam Turbine and Hot Gas Expander Components

Wednesday, February 24, 2016

1030 - 1200 Begonia Junior Ballroom 3011

Instructors: David Dowson, Derrick Bauer (Elliott Group)

In today's market place, a large percentage of oil refinery, petrochemical, and power generation plants throughout the world have been trying to reduce their operation cost by extending the service life of their critical machines, such as steam turbines and hot gas expanders, beyond the design life criteria. The key ingredient in plant life extension is Remaining Life Assessment Technology. This tutorial will outline the Remaining Life Assessment procedures, and review the various damage mechanisms such as creep, fatigue, creep-fatigue and various embrittlement mechanisms that can occur in these machines. Also highlighted will be the various testing methods for determining remaining life or life extension of components such as high precision SRT (Stress Relaxation Test), which determines creep strength, and CDR (Constant Displacement Rate) Test, which evaluates fracture resistance. Other tests such as replication/microstructure analysis and toughness tests will be reviewed for assessment of the remaining life or life extension of the components. Use of computer software will be highlighted showing how creep-life, fatigue-life and creep/fatigue-life calculations can be performed. Actual examples of remaining life assessment testing performed on steam turbines and hot gas expander components will be provided.

Tutorial 17: Considerations in the Design of VFD Motor-Driven Compressors

Wednesday, February 24, 2016

1030 - 1200 Begonia Junior Ballroom 3012

Instructors: Masayuki Kita (Mitsubishi Heavy Industries Compressor Corporation)

The various drivers for process compressor trains are designed in accordance with the pertinent process requirements. In the case of variable speed applications for process compressors, Steam turbines or Gas turbines are typically applied as a standard practice. However, improvements in inverter technology have made Variable Frequency Drive (VFD) motors a viable solution for variable speed applications. Motor drivers are well suited for constant speed applications, but VFD motor drive systems represent a relatively new technology for process compressor applications, so the technical differences and associated risks need to be well understood by Users, EPC contractors and Turbomachinery OEM's. Any misunderstanding or miscommunication among any of these parties could lead to a worst case scenario of machine damage and unexpected plant shutdowns. This paper addresses the basics of VFD technology from a practical as well as technical point of view with the overall aim of helping to pre-empt worst case scenarios.

Tutorial 18: Shop Rotordynamic Testing — Options, Objectives, Benefits & Practices

Wednesday, February 24, 2016

1030 - 1200 Begonia Junior Ballroom 3111

Instructors: C. Hunter Cloud (BRG Machinery Consultants LLC), John Kocur (ExxonMobil Research & Engineering)

This tutorial provides an in-depth examination of the various shop testing options for mitigation of field lateral vibration problems. Two categories of testing are discussed: vibration demonstration tests which include mechanical run, string and full load, full pressure testing, and design verification tests for unbalance response and stability.

Tutorial - Combo — Dry Gas Seals 19a: Centrifugal Compressor Shaft End Seals

Wednesday, February 24, 2016

1330 - 1500 Begonia Junior Ballroom 3011

Instructors: Vasanth Bhat (Singapore Regining Company - A Chevron JV)

An analysis of un-planned trips and events of single line critical compressors in a typical refinery indicates above 20% of incidents are due to seal leaks. Some of these events could have quick recovery but majority may involve outages in the duration of 7 to 15 days resulting in significant losses. The presentation explains some of these events and share their behavior and lessons learnt from these incidents.

Tutorial - Combo — Dry Gas Seals 19b: Application of Double vs. Tandem Dry Gas Seal Advantages

Wednesday, February 24, 2016

1330 - 1500 Begonia Junior Ballroom 3011

Instructors: John Sears, Detlev Steinmann, Vladimir Bakalchuk, S.P. Asokan (Flowserve Corporation)

Traditionally double seals have been used for low pressure applications when nitrogen gas at pressure higher than process was available for sealing. Double seals were not applied to low pressure processes where process contamination by nitrogen was not permitted. In these cases application of the process gas for sealing in a double seal was considered "unsafe" and the preference was given to a tandem seal. In recent years this approach has been re-evaluated and additional steps to insure safety in case of a secondary seal failure undertaken. Since both tandem and double seals can be used for applications with sealing pressure below approximately 40 bar, what benefits are to be gained by double seal application? Double seal arrangement, among other things, allows for system simplification and more reliable operation, significant reduction of sealing gas volumes, prevention of seal reverse pressurization and shorter in-between the bearings shaft span. A possibility of secondary seal failure and prevention of uncontrolled process gas emission can be addressed in a variety of ways - from incorporation of flow restriction to utilization of separation seal as safety seal.

Tutorial - Combo — Dry Gas Seals 19c: Wet Seal to Dry Gas Seal Conversion - Considering the Benefits of Retrofitting Your Compressor

Wednesday, February 24, 2016

1330 - 1500 Begonia Junior Ballroom 3011

Instructors: Athal Doorenbos (Dresser-Rand S.A., A Siemens Business)

Dry gas seals are specified in most of the new centrifugal compressors; yet many installed units are still equipped with conventional oil sealing systems. The benefits of dry gas seals conversions from traditional oil seals to dry gas seals are usually advantageous to compressor operators. However, end users should ask themselves several questions before deciding to retrofit their compressors with dry gas seals. The decision to retrofit a compressor with these upgraded seals may be dictated by economic factors, HSE constraints or technical considerations. Users should consider all of these factors when deciding whether or not to upgrade a compressor with dry gas seals. In addition, the following precautions should be taken during project execution to ensure successful conversion: perform a detailed physical integration analysis of the dry gas seal in the existing compressor; conduct a detailed rotor dynamic analysis; select the proper gas seal system design for the compressor; and plan for operator training.

Tutorial - Combo — Dry Gas Seals 19d: Monitoring a Tandem Dry Gas Seal's Secondary Seal

Wednesday, February 24, 2016

1330 - 1500 Begonia Junior Ballroom 3011

Instructors: Rich Hosana (John Crane), Glenn Schmidt (DGS Glenn), Vladimir Bakalchuk (Flowserve Corporation), Jim McCraw (BP America Inc.)

Rotating equipment and instrument engineers working with dry gas seals should attend this tutorial to increase their knowledge of methods for monitoring secondary seals. Over the last several years a number of compressor manufactures have issued safety notices concerning the industries inability to properly detect secondary seal failures in a tandem dry gas seal arrangement. When a secondary seal failure is undetected, the potential for an uncontrolled process gas release increases, leading to risks indicated in the safety notices issued. This tutorial will examine the methods of monitoring the secondary seal in a tandem dry gas seal arrangement and the means to detect a secondary seal failure.

The information and diagrams in this tutorial do not provide detail design requirements for the total seal monitoring system but only methods currently being used for monitoring the secondary seal.

Tutorial 20: Hydrodynamic Torque Converters for Oil & Gas Compression and Pumping Applications: Basic Principles, Performance Characteristics and Applications

Wednesday, February 24, 2016

1330 - 1500 Begonia Junior Ballroom 3012

Instructors: Klaus Brun (Southwest Research Institute), Christoph Meyenberg (Voith Turbo), Joseph Thorp (Aramco Services)

The hydrodynamic torque converter was invented in 1905 by Herrmann Fottinger as an alternative to a regular speed changing gear for shipboard propulsion. At the time no mechanical reduction gears were available for such high power applications. The core idea of hydrodynamic torque converters and fluid couplings is to provide wear free power transmission. In the following decades hydrodynamic torque converters experienced significant improvements driven by the automotive industry and their use spread out into various applications. Today, torque converters are commonly used in cars, busses, locomotives, construction equipment, and gas compression as a means of (i) smooth power transmission, (ii) to provide torque amplification during startup conditions, and (iii) to act as a damper for driver and driven equipment torsional disturbances and shock loads. In the oil and gas industry torque converters are often used as integrated components in drive transmissions for electric motor driven compressors or pumps trains. The goals of this short course are to provide a basic understanding of the function of hydrodynamic couplings and torque converters, the physics of the hydrodynamic circuits, the influence on the performance characteristic of the three active main components (pump, turbine, and stator), and the application of the torque converter for startup assist and speed control. The function and basic fluid mechanics of hydrodynamic torque transmission will be discussed. Design options, sizing, and function will be explained using simplified examples. Finally, a number of application case studies of torque converters in the upstream and midstream oil & gas compression industry will be presented.

Tutorial 21: Integrating Dynamic Machinery Performance with Component Condition to Optimize Reliability

Wednesday, February 24, 2016

1330 - 1500 Begonia Junior Ballroom 3111

Instructors: William Eugene Forsthoffer, Michael Sean Forsthoffer (Forsthoffer Associates, Inc.)

The focus of this tutorial is to define what FAI means by component condition monitoring and how, if done correctly, you can maximize on stream time and make accurate decisions on when maintenance is or is not required.

Tutorial - Panel Session 22: Subsea Compression Applications — Panel Session

Wednesday, February 24, 2016

1330 - 1500 Begonia Ballroom 3003

Instructors: Jose Gilarranz, William Maier (Dresser-Rand), Urs Baumann (MAN Diesel & Turbo), Richard Barratt (Siemens Energy), Manuele Bigi (GE Oil &Gas)

The use of Subsea gas compression technology for subsea re-injection and/or gas transport boosting represents a new and exciting application for rotating equipment, which will allow new gas/condensate field production opportunities, enhanced recovery of existing gas/condensate fields and cost effective production from marginal gas fields. This panel session includes short presentations on the benefits of subsea compression, an overview of currently ongoing projects, and recent advances and technologies that are available and/or under development for subsea gas compression.

DISCUSSION GROUP DESCRIPTIONS

Discussion Group 1:

Transmission elements: Couplings and Alignment, Gears

Tuesday, February 23, 2016

0845 - 1015 Begonia Ballroom 3102

Instructors: Chris Wolford (Altra Couplings), Joe Corcoran (Kop-Flex), Gaspare Maragioglio (GE Oil & Gas)

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 2:

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

Tuesday, February 23, 2016

0845 - 1015 Begonia Ballroom 3103

Instructors: S.P. Asokan (Flowserve), Daniel Goebel (Eagle-Burgmann), Leonardo Baldassarre (GE Oil & Gas), Athal Doorenbos (Dresser-Rand), Teo Woon Lip (ExxonMobil Chemical), Vasanth Bhat (Singapore Refining Company), Michael Sean Forsthoffer, William Eugene Forsthoffer (Forsthoffer Associates, Inc.)

Suggested Topics:

- 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

Discussion Group 3: Steam Turbines: Operation & Maintenance

Tuesday, February 23, 2016

1030 - 1200 Begonia Ballroom 3102

Instructors: Takeshi Hataya (MHI), Ronald Josefczyk (Elliott Group), Elumalai Subramani (ExxonMobil Chemical), Arun Kumar (HMEL)

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 4: Centrifugal Pumps: Operation, Maintenance and reliability, Vertical Pump Problems and Solutions

Tuesday, February 23, 2016

1030 - 1200 Begonia Ballroom 3103

Instructors: Jihoon Yoon (Dongyang Chemical Pump), Bruno Schiavello (Flowserve), Kenneth Atkins (Engineering Dynamics, Inc)

Suggested Topics:

1. Seal plan which was not expected – wrong for the application
2. Preventive/predictive technologies
3. Off design operation
4. Mean time between failure – how do we measure, and how do we use the metrics
5. How to create pump reliability in an unreliable plant
6. Seal-less versus sealed pump reliability, canned motor pumps versus mag drive pump reliability
7. Mechanical Integrity Inspections of VS 6 pumps in hydrocarbon service
8. Seals in light hydrocarbon service – operations, risk, leak response, maintenance
9. Pump predictive/preventive maintenance program elements 3.
10. Measures of effectiveness of preventive and predictive programs for pumps
11. Roles of operations and maintenance/ reliability in improvements and data collection
12. Reliability experience with liquid versus non contacting gas seals applications
13. Maintenance philosophy for pumps
14. Spare parts – OEM versus non-OEM
15. Repairs – OEM versus non-OEM service facilities
16. Pump foundation, alignment and pipe strain influence of reliability
17. Impact of corporate purchasing alliances on pump reliability
    a. Repair facilities alliances
    b. New equipment purchasing alliances
18. Repair techniques and material improvements
19. Portable and on-line monitoring – impact on reliability
20. Wireless monitoring – impact on reliability and risk of failure
21. Optimization of thrust bearings configuration
22. Lubrication system impact on reliability – oil mist versus flood, oil selection
23. Mechanical Seals

Discussion Group 5:

Turbomachinery and Pump Vibrations

Tuesday, February 23, 2016

1330 - 1500 Begonia Ballroom 3102

Instructors: An Sung Lee (KIMM), Bill Marscher, Eric J. Olson (Mechancial Soutions), C. Hunter Cloud, Jim Byrne (BRG Machinery), Joe Tecza (Dresser-Rand), Marimuthu Gurusamy, Kenneth Atkins (Engineering Dynamics, Inc), Gaspare Maragioglio (GE Oil & Gas)

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

Tuesday, February 23, 2016

1330 - 1500 Begonia Ballroom 3103

Instructors: Urs Baumann (Man Turbo), Leonardo Baldassarre (GE Oil & Gas), Jay Koch, Jose Gilarranz (Dresser-Rand), Shin Konomi (Elliott Group), Ashutosh Vengurlekar (ExxonMobil), Arun Kumar (HMEL)

Suggested Topics:

- Meeting current rotordynamics stability standards
- High flow coefficient/Mach number impellers
- Complicated high pressure gas properties. E.g., CO2, acid gas, H2S
- Validity of CFD modeling
- Modern manufacturing/forming methodologies
- Simulation and dynamic process modeling
- Handling of Chlorides in sour/acid gas applications, including piping; end-user strategies
- Materials for compressors in extreme acid/sour gas applications with and without chlorides
- Hermetically-sealed compression

Discussion Group 7: Other Compressors: Reciprocating, Screw (Wet and Dry), Integrally Geared, and Turbo-Expanders

Wednesday, February 24, 2016

0830 - 1000 Begonia Ballroom 3102

Instructors: Armando Guerrero (International Oil & Gas Consultants), Kenneth Atkins (Engineering Dynamics, Inc), Manoj Gupta (Dresser-Rand), Klaus Brun (Southwest Research Institute) , Karl Wygant (Hanwha Techwin), Andre Eijk (TNO) and Thomas Emminger (HOERBIGER)

Suggested Topics:

- Advanced Condition monitoring
- Modern wear components – design, reliability and failures
- Maintenance strategy / Best Practices
- Industry standards – API 618, API 688, API 670 annex P, ISO 13631, etc.
- Capacity Control – speed, recycle, unloaders (all types)
- Process gas quality and conditioning
- Couplings
- Pulsation, vibration and torsional issues
- Valve design, reliability, and fouling
- Packaging / Size and Speed Considerations / Installation Type
- Field Testing

Synchronous motor starting issues

Discussion Group 8: Gas Turbines: Operation & Maintenance

Wednesday, February 24, 2016

0830 - 1000 Begonia Ballroom 3103

Instructors: Klaus Brun (Southwest Research Institute), Rainer Kurz (Solar Turbines), Hussain Al-Baloshi (Qater Pet), Peter Collins (Inpex), Manoj Gupta (Dresser-Rand)

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 9: Lubrication: Fluid Film Bearings: operation, maintenance, troubleshooting

Wednesday, February 24, 2016

1030 - 1200 Begonia Ballroom 3102

Instructors: John Whalen (John Crane), Minhui He, Jim Byrne (BRG Machinery), Brian Pettinato (Elliott Group), An Sung Lee (KIMM)

Suggested Topics:

Introduction
Plant Wide Maintenance and Problems

- Effective Maintenance Programs
- Best Practices
- Oil Varnish

Oil / Grease

- ype and Selection
- Testing and Maintenance Including Frequency
- Mixing and Compatibility

Lubrication Systems and Auxiliaries

- API 614 Systems
- Oil Mist Systems
- Grease Systems

Discussion Group 10: Mechanical (Liquid) Seals: General (Installation, Operation, Troubleshooting, and Retrofitting)

Wednesday, February 24, 2016

1030 - 1200 Begonia Ballroom 3103

Instructors: S.P. Asokan (Flowserve), Shifeng Wu (A.W. Chesterton Co), John Morton (John Crane), Nikolaus Necker (EagleBurgmann)

Mechanical seals are the most common method of sealing industrial centrifugal pumps and other rotary equipment. Although the basic concepts of a seal is 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. Typical topics covered in this discussion group include:

- Changes in upcoming API 682 4th edition
- Air testing of seals in pumps prior to installation
- Challenges with low temperatures sealing
- Effective leakage containment of single seals
- 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

Discussion Group 11: Magnetic Bearings

Wednesday, February 24, 2016

1330 - 1500 Begonia Ballroom 3102

Instructors: Armando Guerrero (International Oil & Gas Consultants), Sreenivas Raghavendr (Shell), Rasish Khatri, Jay Koch (Dresser-Rand)

Suggested Topics:

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

Discussion Group 12: Protective Systems: Controls & Overspeed Trip

Wednesday, February 24, 2016

1330 - 1500 Begonia Ballroom 3103

Instructors: Manoj Gupta, Amit Saxena (Dresser-Rand), Teo Woon Lip (ExxonMobil Chemical)

- Attendees Topics of Interests
- Reliability Limits of components and systems
- Considerations for new systems
- Interlocks Integrity
- Interlocks testing
- Surge system integrity and testing
- LOPA (Layer Of Protection Analysis)
- SIL (Safety Integrity Levels)
- Verifying reciprocating compressor protection systems
- Liquid level integrity
- Critical Pump protection systems

CASE STUDY DESCRIPTIONS

Case Study 1: Stress Corrosion Failure of a Low Pressure Disk from a 800MW Steam Turbine

Thursday, February 25, 2016

0830 - 0900 Angsana Ballroom 3AB

Instructors: Anthony Tipton (Thielsch Engineering, Inc.)

Stress corrosion cracking is known to be a function of stress, material and environment. However, a fourth variable that is often overlooked is operating time. Maintaining steam chemistry within OEM and industry guidelines is not sufficient to prevent stress corrosion cracking in high stress locations such as the blade attachments of older low pressure turbine disks. Resulting stress corrosion failures occur without warning and generally result in significant secondary damage and unit downtime. This case study discusses the root cause analysis of a recent stress corrosion failure of a low pressure disk from an 800 MW steam turbine. Turbine disk modifications to prevent future stress corrosion cracking are detailed.

Case Study 2: 2 Case Studies on Unique Machinery Repair Techniques: Brush Plating Repair of Eroded Compressor Diaphragm - Combining 2 Failed Gearboxes into 1 Functional and Reliable Gearbox

Thursday, February 25, 2016

0830 - 0900 Angsana Junior Ballroom 3D

Instructors: Stan Uptigrove (Exxon Mobil), Chin Tze-Hur, Karl Edward (ExxonMobil Exploration and Production Malaysia Inc.)

When machinery challenges arise in aging equipment within declining oil and gas facilities it requires innovative solutions taking into account life expectancy, production impact and declining production to establish fit for purpose solutions. With good engineering, unique repairs can help limit production impact, extend equipment life and provide a more robust solution for current operating conditions. Two cases studies of novel equipment repairs are presented to demonstrate these principles: 1) Brush plating repair of Eroded Compressor Diaphragm, 2) Combined Two Failed Gearboxes Into One Functional and Reliable Gearbox. Focus was on restoring safe and reliable operation.

Case Study 3: Steam Turbine Vibration Resonance of Pedestal, Vibration Investigation with Countermeasures in Singapore

Thursday, February 25, 2016

0900 - 0930 Angsana Ballroom 3AB

Instructors: Kyoichi Ikeno, Makoto Katagake, Satoshi Hata (Mitsubishi Heavy Industries Compressor Corporation)

Steam Turbine had been in operation for several years and this turbine experienced the wear damage of governor linkage. Then, measured the vibration velocity profile on Governor side pedestal to identify the excited vibration mode and frequency According to collected data, investigated the possible root causes and conducted 30 vibration response analysis to the existing and the improved pedestal. And, improved pedestal was supplied to the client and applied for actual machine during turnaround. And, finally, the advantage of new improved pedestal was confirmed. This case study introduces the typical phenomena, RCA investigation, detail vibration analysis, countermeasures and verification results as technical process.

Case Study 4: High Vibration Problem Resolution in Centrifugal Pump through Design Change

Thursday, February 25, 2016

0900 - 0930 Angsana Junior Ballroom 3E

Instructors: Mahesh Shet, Arun Kumar, Navneet Singh, (HMEL)

This case study highlights a balanced approach towards the site investigations, root cause analysis and corrective actions implementation fir troubleshooting high vibrations problem in a pump. It also provides hints to address thermal growths issues when equipment operates at very high temperature. The uneven expansion of pump casing during pump warm-up misaligns the DE side floating bearing within bearing housing and restrict its axial displacement. As a consequence, thermal growth of pump shaft gets restricted, rotates in deflected shape and rubs within throat bushes. Rubbing excites the natural frequency of pump rotor system, resulting in 1.3xRPM frequency vibrations.

Case Study 5: Polytrophic Efficiency Improvements and Sustenance on Centrifugal Compressor: Corrosion Erosion and Impact of Fouling

Thursday, February 25, 2016

0900 - 0930 Angsana Junior Ballroom 3D

Instructors: Tan Chek Zin, Ng Wei Sing, Arni R. Tharakaram (ExxonMobil), Koguichi Satoshi (Hitachi Japan)

This paper presents case study on rapid deterioration of compressor polytrophic efficiency relating to systemic fouling and corrosion issues. Due to fouling present and corrosion issue, compressor service life had reduced from 10 years (1997 to 2007) to 5 years (2007 to 2012) and subsequently 2 years (2012 to 2014) following the creep project. All compressor overhauls were driven by compressor polytrophic efficiency drop hovering between 10 to 22%. Elemental analysis of sample collected from compressor internal confirmed presence of contamination. The aluminum labyrinth were first suffering erosion / corrosion. Subsequently, contamination causing rubbing against trailing face of the impeller. Deep grooving damaged was evident for 1st, 2nd and 3rd inter-stage labyrinths that fully filled with black particles. Extensive improvement studies were conducted to manage system corrosion and liquid ingress in order to improve compressor reliability and polytrophic efficiency sustenance.

Case Study 6: Emergency Damage Restoration Experiences of 25MW Heavy-Duty Gas Turbine: Bearing Retrofit Design and Test Run

Thursday, February 25, 2016

0900 - 0930 Angsana Junior Ballroom 3F

Instructors: An Sung Lee, Byung Ok Kim, Kyung Ho Sun (KIMM), Byeong Kyu Park, Young-Soon Bae (LG Chem Ltd.)

A 25MW gas turbine had been damaged during operation. Particularly, its tilting pad journal bearings and shaft journals had suffered complete wiping-out and deep crack damages, respectively. For an emergency restoration, both cracked journals had been machined out as much as 2% per the specified design diameter, and a series of design, analysis and manufacturing of the retrofit journal bearings had been carried out to have practically identical overall design characteristics to the OEM bearings. To verify operational reliability, the restored GT rotor had been test-run at KIMM's high-speed balancing facility. Since the test results had been favorable, the rotor had been put into an onsite operation, immediately. The restored GT system has been continuously running a stable commercial operation for more than 41 months up until now. This presentation introduces design analysis of the retrofit bearings, test run result of the restored GT rotor-bearing system, and the lessons learned.

Case Study 7: Case Study on Remote Diagnostics in Resolving Random Vibration on a Steam Turbine

Thursday, February 25, 2016

0930 - 1000 Angsana Ballroom 3AB

Instructors: R. Sankar Ganesh, Muhammad Zeeshan Iqbal (GE)

This case study narrates the incident of how the random vibration spikes on a Steam turbine were analyzed successfully by a remote monitoring engineer. This case study covers the root cause analysis details and the lessons learned also.

Case Study 8: Investigation & Resolution on Oxination Feed Pump Pulsation Related Fatigue Failures

Thursday, February 25, 2016

0930 - 1000 Angsana Junior Ballroom 3E

Instructors: Arni Rajaram Tharakaram, Saqib Ashraf (ExxonMobil), Rudiger Bullert (LEWA GmbH), Harry Korst, Andre Eijk (TNO)

This case study presents details of investigation analysis and intensive study done on high pressure Triplex reciprocating pump.Issues observed during operation and subsequent detailed pulsation analysis to understand root cause of the piping and pump valve failures. A more detailed pulsation analysis of the cylinder nozzles of the discharge resonators showed that

standing wave type resonance with the same frequency as measured during actual operation were present, leading to large pulsation-induced forces. The problem was resolved by implementing recommendations of the study: installation of orifice plates at the inlets of the discharge dampeners. Piping designs and its structural J hanger supports were reviewed and modified to countermeasure the influence on hydraulic pulsation forces and mechanical vibrations, leading to acceptable cyclic stresses.

Case Study 9: Adapting Compression Equipment to Accommodate Declining Well Pressures and Ensure Overall Efficiency in Mid/Late Field Life

Thursday, February 25, 2016

0930 - 1000 Angsana Junior Ballroom 3D

Instructors: Ben Gunn, Rainer Kurz, Jonathan Bender (Solar Turbines), Joel Hayes, Yakin Hai, Aning Restu Utami (ConocoPhillips)

Compression systems are designed for the governing process conditions. In the Oil and Gas industry, these conditions are often dynamic and a function of reservoir or field characteristics which have varying head and flow rate requirements throughout the field life. The main application objective when designing a gas turbine driven centrifugal compression solution to suit these applications, is to maximize efficiency while minimizing the requirement for additional package modifications or major capital works in mid to late field life. This presentation shows how these objectives were achieved for a case example in South Sumatra, Indonesia where an onshore gas field, feeds a localized gas plant that requires front end compression.

Case Study 10: Repair of Severely Damaged Rotor as an Emergency Spare

Thursday, February 25, 2016

0930 - 1000 Angsana Junior Ballroom 3F

Instructors: Scot Laney, Doug Richards (Elliott Group), Nicholas White (RASGAS)

The subject rotor was unexpectedly found to have severe cracking on the first stage impeller and foreign object damage on the remaining three impellers. This presentation describes the steps taken to resolve the rotor to a usable condition while a new rotor was manufactured.

Case Study 11: Revamp of Steam Turbine for Synthesis Gas Compressor at NFL Nangal

Thursday, February 25, 2016

1000 - 1030 Angsana Ballroom 3AB

Instructors: Rakesh Markan (National Fertilizers Limited)

National Fertilizers Limited, Nangal Unit, India had undertaken the revamp of Steam Turbine of Synthesis Gas Compressor in January 2014. The plant startup, after machine revamp, was delayed by 40 days, because of various activities related to machine revamp which were not envisaged before commencement of the revamp. This paper throws light on those unforeseen jobs which lead to delay in startup and the lessons learnt to avoid such delays in future.

Case Study 12: Bad Actor Elimination in Pumps

Thursday, February 25, 2016

1000 - 1030 Angsana Ballroom 3E

Instructors: Vasanth Bhat, Thangavel Suthan (Singapore Regining Company - A Chevron JV)

Most industry end users reckon more than 90% of their assets perform to the required expectations and it is that balance 10% which brings down availability, results in high costs and possible safety related incidents. The Bad Actors are identified using Asset Management Systems or Computerized Maintenance Management Systems (CMMS) systems which can show where the organization is spending most of its efforts in terms of man hours or spending. As can be seen by adjoining plots in most organizations a few assets create the majority of the pains. A systematic cross discipline approach, involving identification of failure causes, carrying out Root Cause Analysis and recommending appropriate actions so that these root causes could be addressed will help to eliminate these expensive failures. The presentation explains 3 such cases which followed a process as mentioned above and had successful outcomes.

Case Study 13: Investigation of Process Gas Compressor Shaft Vibration Phenomena

Thursday, February 25, 2016

1000 - 1030 Angsana Junior Ballroom 3D

Instructors: Ashutosh Vengurlekar (Exxon-Mobil & MHI), Teo Woon Lip, Nathan Little (ExxonMobil Research and Engineering), Satoru Yoshida (Mitsubishi Heavy Industries Compressor Corporation)

This paper presents details of investigation results of issues observed during plant start-up on a centrifugal compressor. Compressor was operated with air/ nitrogen during start-up and high shaft vibration (approx. 75 um) were observed on DE side of compressor accompanied by high levels of coast down vibration levels (exceeding alarm levels). This paper presents subsequent detailed rotor dynamics analysis to understand root cause of the high vibrations.

Case Study 14: Dry Gas Seal Failure and Trouble Shooting

Thursday, February 25, 2016

1000 - 1030 Angsana Junior Ballroom 3F

Instructors: A. Manikandan(GE Oil &Gas Doha), Moorthy Subramaniyam (EagleBurgmann Middle East FZE, UAE)

The process gas centrifugal compressors used in Oil & Gas industries requires highly safe and reliable operating requirement. The dry gas seals are used to prevent gas leakages from the compressors and plays role as critical component. Hence the proper design and monitoring the performance of the dry gas seal are most important. This case study represents the frequent failure of dry gas seal in recycle gas compressor which tripped due to very high leakage in the primary vent and the trouble shooting experience.

Case Study 15: Abrupt Stoppage of Turbine Rotor, Running on Barring after Major Overhauling

Thursday, February 25, 2016

1100 - 1130 Angsana Ballroom 3AB

Instructors: Ranga Reddy, Ravi S. Reddy (BVL Power Systems Pvt Ltd.)

This case study is about a typical experience where a steam turbine, which was running at 100 RPM on barring (turning) after overhaul, stopped abruptly and the rotor was found to be seized. The case study is about this incident and the external factors influencing the turbine rotor seizure, from 100 RPM to zero RPM in less than 5 seconds, its root cause and the rectification activities.

Case Study 16: Enhancement of Pump/Plant Performance by Correct Evaluation of Process Fluid Viscosity Variations and Pump Geometry

Thursday, February 25, 2016

1100 - 1130 Angsana Junior Ballroom 3E

Instructors: Giancarlo Cicatelli, Bruno Schiavello (Flowserve)

In the modern pump industry, processed fluids are characterized by a wide spectrum of viscosity values. An unpredicted variation of actual process fluid properties, including viscosity, may lead to unexpected pump performance alteration. Also manufacturing deviations from expected internal pump geometry may cause pump performance deterioration Both causes may determine undesired limitations of the pump operating range and plant production loss. The present paper illustrates a real case story of incorrect evaluation of the process fluid viscosity and pump geometry deviations, both determining performance deteriorations, described through a detailed evaluation of the internal pump losses. From the presentation of a real case, this case study highlights the importance of both the correct evaluation of viscous effects and the internal pump geometry through the application of existing loss correlations.

Case Study 17: Effects of Shaft Geometric Unconformities on the Rotor-Dynamic Behavior in Hard Coupled Equipment

Thursday, February 25, 2016

1100 - 1130 Angsana Junior Ballroom 3D

Instructors: Gianluca Boccadamo, Paolo Agnoletti, Gaspare Maragioglio (GE Oil & Gas)

This case study deals with 25MW turb-generator train with a semi-rigid connection between generator and gearbox. For this application, machine alignment and connection is a key factor for a smooth rotor-dynamic system behavior: both high run-out and high radial vibration can be induced by poor quality of the assembly. The rotor-dynamics of the train in subject was negatively influenced by a geometrical out-of-tolerance on the generator flange, causing a distortion in the shaft line which introduces a pre-stress on the rotor system. The aim of this case study is to draw the attention on the importance of system integration

especially in presence of semi-rigid assembly, which requires specific design, manufacturing and integration requirements.

Case Study 18: The Importance of Structural Modal Analysis in 2 Poles Induction Motors for LNG Application

Thursday, February 25, 2016

1100 - 1130 Angsana Junior Ballroom 3F

Instructors: Francesco Meucci, Niccolo Spolveri, Francesco Capanni, Stefano Rossin (GE Oil & Gas)

High vibrations due to 2X electrical frequency excitation on bearing housings and frame occurred on a 20MW 2-Pole Induction Motors during acceptance tests in manufacturer workshop in stand alone configuration. Modal Analysis results in Factory Acceptance Tests (FAT) configuration were confirmed by Operating Deflection Shape (ODS) and Experimental Modal Analysis (EMA - Hammer test) leading to supports redesign. To mitigate the risk of high vibration in string test bench and customer site, validating also the present motor design, a further Modal Analysis were executed using the experimental data collected during the FAT to drive mode selection.

Case Study 19: Investigation of Steam Turbine Blade Failure

Thursday, February 25, 2016

1130 - 1200 Angsana Ballroom 3AB

Instructors: Ashutosh Vengurlekar, Robert D Fisher (ExxonMobil Research and Engineering), Yuki Nakamura, Yuichi Sasaki, Satoshi Hata, Kyoichi Ikeno (Mitsubishi Heavy Industries Compressor Corporation)

Blade failure was observed on a backpressure steam turbine (driving a centrifugal compressor) after it was in service for more than one year. This paper presents details of observations, inspections carried out and root cause analysis of the turbine blade failure.

Case Study 20: Vibration Field Problem Resolved with Analytical Diagnostic Approach and Innovative Impeller Design

Thursday, February 25, 2016

1130 - 1200 Angsana Junior Ballroom 3E

Instructors: Bruno Schiavello, Giancarlo Cicatelli (Flowserve)

Vibration Field Problem Resolved with Analytical Diagnostic Approach and Innovative Impeller Design Several pumps of same design exhibited field vibrations above API limits, dominated by Vane Passage Frequency (VPF). Root cause analysis included both experimental and theoretical paths. Experimental investigation , with shop vibration tests and modal analysis, showed natural frequency of bearing housings at VPF. The theoretical approach , based on mainly hydraulic analysis, pointed out to discharge recirculation as primary cause of hydraulic excitation for high VPF vibrations. The solution was identified with the design of an innovative impeller geometry (5+9 vanes). Shop tests confirmed both overall performance and drastic reduction of vibrations below API limits. Pumps with the innovative impeller were installed in the field confirming reduction of vibrations. Lesson learned: high number of vanes at impeller outlet is a key feature for controlling hydraulic excitation forces, changing both VPF and amplitude.

Case Study 21: Measurements and Analysis of High Machine Vibration - A Case Study of Screw Compressor Rub

Thursday, February 25, 2016

1130 - 1200 Angsana Junior Ballroom 3D

Instructors: Sherief Mekawey (GE Int Ops), Dum Muele Kuebari (GE M&C Bently Nevada)

This case study concerns a screw compressor operating in offshore process environment with unpredictable gas composition. The compressor was tripped on high vibration during startup after seals replacement. Analysis of the acquired transient vibration data indicated rub as secondary cause of the high vibration, and improper timing gears assembly as a root cause. Shop inspections confirmed rub between male and female rotors. Implemented recommendations ensured timely return of the compressor to service, and lessons learned prevented repeat occurrence on similar machines.

Case Study 22: A Solution to Years of High Vibration Problems in Three Reinjection Compressor Trains Running at 33 MPA Discharge Pressure

Thursday, February 25, 2016

1130 - 1200 Angsana Junior Ballroom 3F

Instructors: Barry J. Blair, Jong Kim (Waukesha Bearings Corporation), Marcio Felipe dos Santos (PETROBRAS)

Three gas reinjection compressor trains were retrofitted with optimized Flexure Pivot (FP) tilt pad journal (TPJ) bearings with Integral Squeeze Film Damper (ISFD) technology. The FP TPJ bearings with ISFD technology were installed to reduce the chances of machine trips and the yearly replacement of worn traditional tilt pad journal bearings and O-ring squeeze film dampers (SFDs). With the FP TPJ bearings with ISFD technology installed, the reinjection compressors have exhibited lower vibration levels that do not grow over time, have had ZERO trips, and have not required field balancing for continuous operation. Overall efficiency has increased by approximately 1%.

Case Study 23: Hydraulic Power Recovery Turbine Operational Failure and Design Enhancement

Thursday, February 25, 2016

1200 - 1230 Angsana Ballroom 3AB

Instructors: Kunarak Kunakulsawat (PTT Public Company Limited), Daniel Baun (Sulzer Pumps USA)

PTT operate a number of hydraulic power recovery turbines in their gas processing plants in Rayong Thailand. One of the newest plants incorporates some of the largest such turbines ever produced. The turbine design under discussion includes an inlet guide vane system and double suction design with opposing impellers to balance thrust forces. Within this class of equipment, special consideration must be given to metallurgical selections, robust bearing, as well as seal designs owing to the mixed phase discharge conditions. Within the first year of operation, several turbine issue were observed. This case study seeks to describe the nature of the issues, as well as the resulting evaluation and root cause analysis. Further the paper will describe the design improvements being implemented.

Case Study 24: Do You Have a Mechanical Seal Refurbishing Shop in Your Complex?

Thursday, February 25, 2016

1200 - 1230 Angsana Junior Ballroom 3E

Instructors: Mohit Sabharwal, Arun Kumar, Dilip Paliwal (HMEL)

Importance of having Mechanical Seal Refurbishment facility in a refinery complex, supported by interesting case studies on critical mechanical seal failures. Minimum set up required for Inhouse Mechanical Seal Refurbishment facility. The success story of having a Mechanical Seal Refurbishment facility at 9MMTPA Grass Root Refinery, which proved a major factor in timely project completion and vital during the safe and successful refinery commissioning and steady state operations. At what stage the Mechanical Seal Refurbishment facility should be functional in the project?

TECHNICAL BRIEF DESCRIPTIONS

Technical Brief 1: Dry Gas Seal Contamination During Operation and Pressurized Hold – Background and Potential Solutions

Tuesday, February 23, 2016

1330 - 1400 Begonia Ballroom 3002

Instructors: Daniel Goebel, 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 is provided with effective protection against contaminated process gas. Compressor gas seals are very robust sealing devices, but need to be operated in a dry and clean environment. The leading root cause of gas seal failures is contamination. One of the most common sources of contamination is during compressor start up, slow-roll, standstill, or shutdown modes or because the conditioning skid is not sufficient. In these modes there is a lack of seal gas flow, which suggests no means to produce seal gas flow is available, such as a high pressure gas source or booster for the seal gas supply. This is where it pays to have a reliable, clean gas supply. Without seal gas flow, sufficient seal gas cannot be provided to the gas seal and results in the gas seal being contaminated. This paper will describe contamination to the gas seal by process gas, during commissioning, by particle and by liquids, which are caused by inadequate seal gas supply. Then it will focus on different methods of providing seal gas flow during transient conditions. And finally, it will discuss solutions to ensure a reliable, clean gas flow to the seal at all relevant conditions together with additional possibilities to add robustness to gas seals.

Technical Brief 2: Mechanical Seals with DiamondFace Technology Used in Different Pipeline Services

Tuesday, February 23, 2016

1400 - 1430 Begonia Ballroom 3002

Instructors: Nicholas Necker (EagleBurgmann)

This paper describes two applications using a unique mechanical sealing solution for pumps, an engineered seal design and a specific sliding face Diamond material. In the first case, the end-user is using Multiphase Pumps to transfer a mixture of crude oil and gas in a single pipeline without separation. The pumped fluid does not provide the required stable liquid lubrication film for their mechanical seal faces. Another challenge is the presence of abrasive particles. To solve this problem, a slurry seal design with Diamond seal face material was installed. Seal faces with diamond surfaces offer outstanding abrasive resistance and provide considerably dry running capability. In the second case, the end-user is using High Pressure Pipeline Pumps for the transportation of the heavy crude oil. In case of high pressures, high speed and abrasive particles, which is typical in crude oil applications, their mechanical seals need special attention. In both installations, engineered mechanical seals with Diamond seal face material are used successfully since the start-up of the pumps. This new sealing technology offers significant benefits to the end-user.

Technical Brief 3: Using Non-Standard Materials for Couplings on Special Turbomachinery Applications

Tuesday, February 23, 2016

1430 - 1500 Begonia Ballroom 3002

Instructors: Jack Xu (Altra Industrial Motion)

Flexible couplings are a critical component in turbo-machinery train. It is a challenge and very important for coupling designers to select suitable materials for special turbo-machinery applications. The non-standard material addressed here is for the couplings operated in the environments such as:

1. Corrosion(Chloride, Stress Corrosion, hydrogenembrittlement etc.)
2. Spark Resistant/Explosive-proof
3. Low Temperature
4. Titanium spacer on sensitivecompressor for rotor-dynamicsolutions

By joint researchwith compressor OEM and coupling vendor, the technical briefs intends to find the best materials for the applications where working conditions or rotor dynamic concerns dictate their use.

Technical Brief 4: Dynamic Analysis of a Multi-Stage Compressor Train

Wednesday, February 24, 2016

1330 - 1400 Begonia Ballroom 3002

Instructors: Augusto Garcia-Hernandez, Jeffrey A. Bennett, Klaus Brun (Southwest Research Institute)

A multiple-stage compressor train which is part of an off-shore booster installation was facing process and mechanical related problems. Thus, a detailed dynamic simulation analysis of the subject compressor trains was performed in order to provide a series of recommendations that would improve the safe operation and increase the reliability of the compression systems. The dynamic model included compressor performance maps, gas compositions for each stage and train, piping yard, recycle, isolation, check and blowdown valves, scrubbers, separators, and coolers. Several simulation cases were conducted to evaluate the effect of the delay and travel times of the existing anti-surge valves, delay of the coast down action, failure of the non-return valves (NRVs), action of a blowdown valve on the emergency shutdown (ESD) sequences, recycle valve bypasses, check valve arrays, and process upset conditions. The results of this analysis provided recommendations in solving some of the existing issues and creating more understanding of the dynamics of the system. Feasible recommendations for practical implementation were presented for reducing the constant risk of mechanical failure and surge events.

Technical Brief 5: Field Evaluation of an Offshore Pumping System

Wednesday, February 24, 2016

1400 - 1430 Begonia Ballroom 3002

Instructors: Jeffrey A. Bennett, Augusto Garcia-Hernandez (Southwest Research Institute), Marco Antonio Muñoz Prior, Moisés León Dorantes (PEMEX)

An evaluation was performed for one of the largest offshore PEMEX Exploration and Production facilities because forecasts predict that future crude oil production will contain heavier oils. The primary function of the evaluation was to assist PEMEX in determining if the facilities pumps needed to be upgraded. In addition, several of the centrifugal pumps of the platform had been recently replaced with screw pumps. Therefore the evaluation was performed in three parts: first the remaining centrifugal pumps were evaluated in the field at available testing conditions, second a hydraulic analysis of the network was conducted to predict the system performance with heavier oils, and third an interactive pump simulator was developed to train operators on the new screw pump equipment. This presentation will focus on the first step, the field evaluation of the centrifugal pumps, and the remaining steps will be briefly discussed.

Technical Brief 6: Frequency Dependence of Piles' Dynamic Stiffness

Wednesday, February 24, 2016

1430 - 1500 Begonia Ballroom 3002

Instructors: Marco Giancotti, Alessio Margiotta (GE Oil & Gas), Maurizio Orlando, Paolo Spinelli (University of Florence)

The evaluation of the dynamic behavior of deep foundations for Turbomachinery Modules is not a simple task due to uncertainties in the evaluation of the soil shear modulus and the approximations introduced with published literature formulas for complex stiffness (impedance) functions of piles. The direct measurement of the dynamic response of full scale piles can be an efficient method to reduce considerably these uncertainties and to get a reliable evaluation of the dynamic response of deep foundations. The above should also positively impact both the risks and the engineering schedule in the execution phase of the projects, reducing the dynamic analysis cases. The authors present herein the results of full-scale dynamic tests on piles, which have been performed by applying sinusoidal forces to their top.

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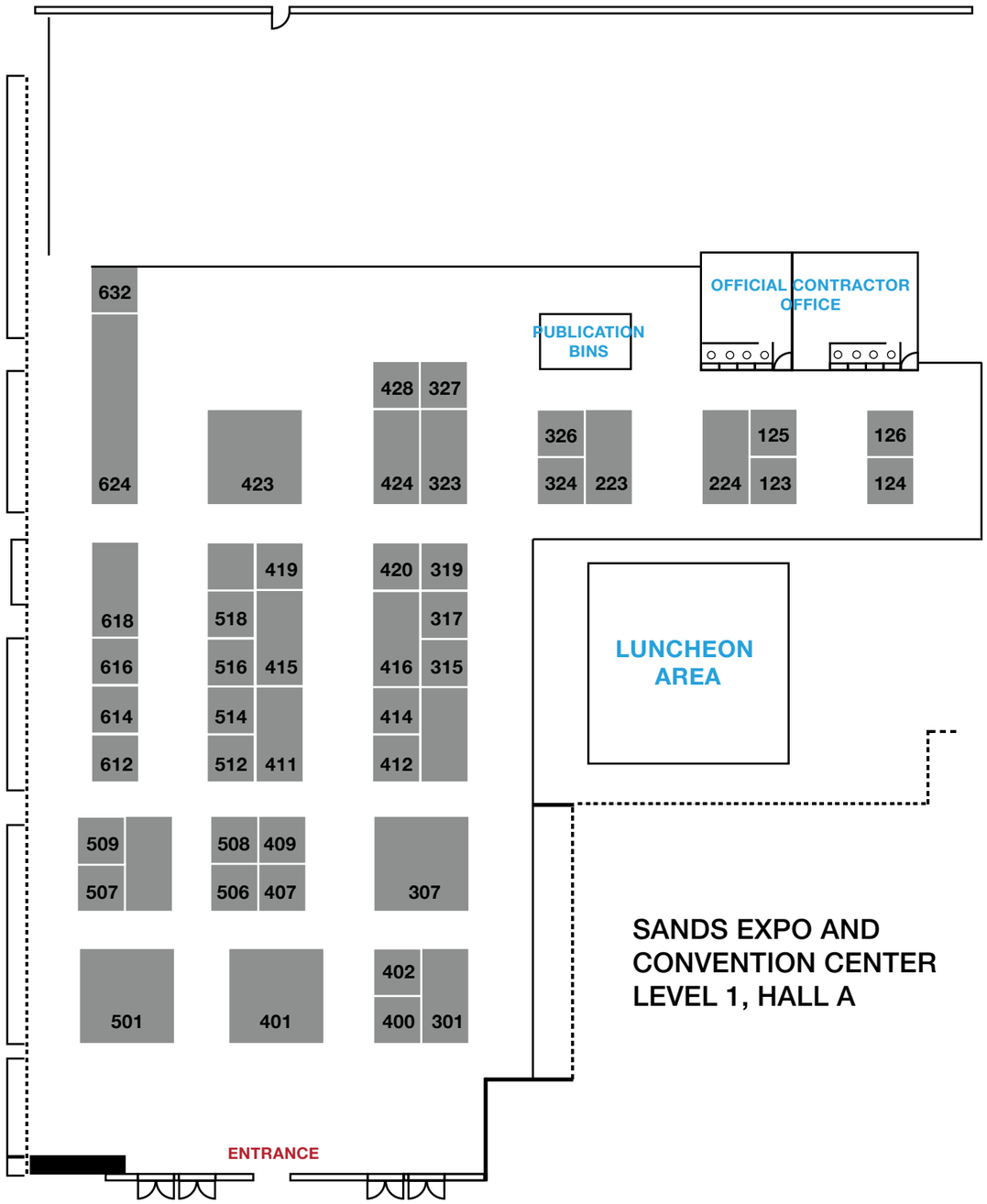
EXHIBITORS

EXHIBITOR FLOOR MAP

INAUGURAL ASIA TURBOMACHINERY AND PUMP SYMPOSIUM
FEBRUARY 23 – 25, 2016



COMPANY INDEX

COMPANY DESCRIPTIONS

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Atlas Copco Gas and Process 424

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Atlas Copco Gas and Process is a division within Atlas Copco that develops and manufactures turbocompressors, reciprocating compressors and expansion turbines for oil and gas and energy recovery applications. In addition, Gas and Process offers a matching range of aftermarket products. Atlas Copco Gas and Process 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, India and Switzerland.

BETA Machinery Analysis (Vibration, Dynamics & Noise - Wood Group) 319

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Beta Machinery Analysis specializes in advanced vibration analysis, a key element in integrity management and reliability engineering for production facilities.

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3. Structural dynamic analysis of support systems; foundations, offshore structures, skids, elevated systems.
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Boulden International 412

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Dongyang Chemical Pump Co. Ltd. 624

119, Donyu 2-ro
Munsaneup Paju-si, 413902 Gyeonggi-do South Korea
PH: (+)821043845337 | FX: (+)82319353930
www.dycp.co.kr

Dongyang Chemical Pump Co., Ltd is leading pump manufacturer in the market. The "TRUFLO" is brand for pumps produced by Dongyang Chemical Pump Co. Ltd. Dongyang manufactures centrifugal pumps according to API & ASME with advanced technology and facilities. Company offers wide range of pumps for the process industries such as Oil & Gas, Petrochemical and others. API 610 : TSP(OH2) / DSV(BB1) / TDP(BB2) / TDSP(BB2) / TSTP(BB2) / TSMP(BB3) / RSMP(BB4) / RSMP-B(BB5) / TVP(VS1,VS2) / TVSP(VS4) / TVCP (VS6)API 685 : TMP (Sealless Magnetic Drive Pump) ASME B73.1 : DAP ASME B73.3 : MAP (Seal-less Magnetic Drive Pump)* OH3 type pumps are available.

Dresser-Rand - A Siemens Business 501

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www.dresser-rand.com

The Dresser-Rand business is among the largest suppliers of rotating equipment solutions worldwide. D-R products, centrifugal and reciprocating gas compressors, gas and steam turbines, gas expanders, gas and diesel engines, and associated control panels, are used in oil and gas production, high-pressure field injection and oil recovery, gas liquefaction, gas transmission, refinery processes, natural gas processing, and petrochemical production.

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EBI Asia Pacific Pte Ltd. 411

1 International Business Park #03-01A
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PH: (+)6565656623 | FX: (+)6565659663
www.eagleburgmann.com

The EagleBurgmann Group: Sealing technology by EagleBurgmann is used worldwide in oil and gas industries, refineries and the petrochemical. Close to 6,000 employees provide their ideas, solutions and commitment so that customers can rely on our sealing technology. EBI's product portfolio includes everything from Dry Gas Seals and systems, mechanical seals and seal supply systems to magnetic couplings, carbon floating ring seals, as well as comprehensive services.

High-end sealing technology: EagleBurgmann gas seals are used in all types of compressors. Applications include oil and gas processes, pipelines, refinery equipment and the petrochemical industries. The EagleBurgmann solutions are technically safe and highly cost-effective.

Elliott Group 401

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www.elliott-turbo.com

Elliott Group designs, manufactures and services steam turbines, compressors, and power recovery expanders for oil & gas, LNG, refining, petrochemical, and other power and process applications. Elliott single-stage YR turbines are the market leader as mechanical drives for pumps, fans, generators, compressors, shredders and other industrial machinery. Elliott is recognized worldwide for its service network and expertise in the repair of rotating equipment from any manufacturer. Elliott employs 2,700 people in 40 locations around the world. Elliott Group is a subsidiary of Ebara Corporation, a major industrial conglomerate headquartered in Tokyo, Japan.

Energy Capital 518

48 Toh Guan Road East #03-98 Enterprise Hub
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www.energycapital.net

Energy Capital is an engineering company specializing in power generation and related engineering activities.

Energy Capital is the exclusive representative of Flender Graffenstaden and Turbine Services Ltd in Asia Pacific region. It supports clients in all aspects of managing their power plant, from consultancy and engineering through to maintenance.

Energy Capital is the perfect partner for the operation and maintenance of power plants.

Energy Control Technologies, Inc. 324

2751 99th St
Urbandale, IA 50322 USA
PH: (+)1-515-223-4572 | FX: (+)1-515-223-1638
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 Rockwell Automation Allen-Bradley ControlLogix and CompactLogix 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 Pte Ltd 618

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PH: (+)6567273900
www.flowserve.com

Flowserve is a leading manufacturer and aftermarket service provider of comprehensive flow management products and services. The company's solutions help move, control and protect the flow of materials in critical industries around the world. Flowserve is one of the world's leading providers of pumps and services for the global infrastructure and process industries. Flowserve designs, manufactures and distributes mechanical seals, sealing systems and parts to customers worldwide.

Fluid Science Dynamics 327

#09-05 One Commonwealth
Singapore, 149544 Singapore
PH: (+)6564792282/(+)6596680757 | FX: (+)6564792272
www.fluidscdynamics.com

Fluid Science Dynamics is an independent engineering consultancy which provides turbo machinery products and services to the oil and gas industry.

Fluid Science Dynamic has a growing team of dedicated process, mechanical, machinery, controls and software development engineers with a wealth of hands-on practical experience in turbo-machinery and mission critical components such as hydrodynamic bearings, gas seals and high-performance power transmission couplings.

FS-Elliott Co., LLC 507

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Export, PA 15632-8948 USA
PH: (+)1-724-387-3200 | FX: (+)1-724-387-3270
www.fs-elliott.com

FS-Elliott is a leading manufacturer of centrifugal air and gas compressors with sales, service and manufacturing locations around the world. First introduced to the market over 50 years ago; the company's energy-efficient machines incorporate the latest aerodynamic and control system technologies to ensure optimum performance.

Graphite Metallizing Corporation 614

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PH: (+)1-914-968-8400 X824
www.graphalloy.com

GRAPHITE METALLIZING CORPORATION - GRAPHALLOY®, a 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 vibration 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 years of experience solving the toughest bearing problems. Most of its products are custom designed to unique requirements of the specific application.

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Hydrocarbon Engineering is the leading monthly publication for the downstream oil and gas industry, offering unparalleled coverage of the global refining, gas processing and petrochemical industry. The independently audited publication is distributed internationally, providing regular regional reports, keynote pieces from major oil and gas companies, technical institutions and industry commentators, as well as case studies and detailed technical articles relating to all aspects of the hydrocarbon processing sector. Visit the website, www.hydrocarbonengineering.com, or join the Twitter following, @Energy_Global, for the latest international oil and gas news.

Kobe Steel, Ltd. 423

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Tokyo, 141-8688 Japan
PH: (+)81357396771 | FX: (+)81357396991
www.kobelco.co.jp/english/

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 Engineeers Assoc. (KRMEA) 632

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Seoul 06779 Korea
PH: (+)8225796271 | FX: (+)8225796273
www.krmea.or.kr

KRMEA (Korea Rotating Machinery Engineers Association), a non-profit organization was established in 1998 with main objective to develop reliability technologies of rotating machinery of Refinery, Petrochemical, Gas, Iron/Steel and Power industries.

This organization takes an important role in promoting the mutual benefit and seeks better cooperation by sharing information and technologies between not only relevant corporations but also individual members throughout the world.

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LNG Industry is the leading publication for the global LNG industry, focusing on the entire LNG value chain. The magazine provides a global perspective on the industry with regular regional overviews, expert analysis and case studies, as well as in depth technical features addressing all aspects of the LNG industry. Visit the website for the latest LNG news.

MAN Diesel & Turbo Schweiz AG (Oil and Gas) 224

Hardstrasse 319
Zurich 8005 Switzerland
PH: (+)41442782211 | FX: (+)41442782261
www.mandieselturbo.com

MAN Diesel & Turbo SE, based in Augsburg, Germany, is the world's leading provider of large-bore diesel engines and turbomachinery for marine and stationary applications. It designs two-stroke and four-stroke engines with power outputs from 47 kW to 97MW. MAN Diesel & Turbo also designs and manufactures gas turbines of up to 150 MW, steam turbines and 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.

Mechanical Solutions, Inc. 407

11 Apollo Drive
Whippany, NJ 7981 USA
PH: (+)1-973-326-9920 X125 | FX: (+)1-973-326-9919
www.mechsol.com/

MSI's reputation is founded on its ability to solve difficult rotating machinery problems using specialized vibration, strain, dynamic pressure, operating deflection shape (ODS), and surge/stall testing and analysis techniques. MSI also provides complete turn-key machinery and component development services, mechanical and fluid dynamic analysis services, and foil (air) bearing designs and products. In addition to specialized field and lab testing tools, computational tools regularly utilized by MSI include computational fluid dynamics (CFD), finite element analysis (FEA), and rotordynamics analysis packages. MSI's years of machinery experience have been leveraged to develop and support its physics-based Sentry™ condition based maintenance (CBM) system.

Mitsubishi Heavy Industries Compressor Corporation 307

6-22, Kan-on-shin-machi 4-Chome, Nishi-ku
Hiroshima 733-8553 Japan
PH: (+)81822912191 | FX: (+)81822940379
www.mhicompressor.com/en/

Mitsubishi Heavy Industries Compressor Corporation (MCO) has been renowned as the most reliable manufacture through its highest technological background and customer-oriented services.

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Modern Pumping Today — Pub Bin

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Modern Pumping Today is a new publication providing solutions for the worldwide pump industry. The company's editorial mixes technical white papers and application solutions for the wide range of business sectors that pump and rotary equipment manufacturers need to reach each month. Visit www.modernpumpingtoday.com to get all of your pump industry news as it actually comes across the wire, plus see video demos from a wide variety of pump and related manufacturers. Also, anyone in the USA or abroad can subscribe free of charge to the company's digital edition of Modern Pumping Today to stay connected to the pump industry.

Nanyang Technological University (NTU) — 616

50 Nanyang Avenue
Singapore, 639798 Singapore
PH: (+)6567911744 | FX: (+)6567911859
www.ntu.edu.sq

Young and research-intensive, Nanyang Technological University (NTU Singapore) is ranked 13th globally. It is also placed 1st amongst the world's best young universities.

The university has colleges of Engineering, Business, Science, Humanities, Arts, & Social Sciences, and an Interdisciplinary Graduate School. It also has a medical school, Lee Kong Chian School of Medicine, set up jointly with Imperial College London.

NTU provides a high-quality global education to about 33,000 undergraduate and postgraduate students. The student body includes top scholars and international olympiad medallists from the region and beyond.

National University of Singapore (NUS) — 317

21 Lower Kent Ridge Road
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PH: (+)6565166666
www.nus.edu.sg

Over a century ago, the National University of Singapore was born in a bustling metropolis at the crossroads of Asia.

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Oeltechnik — 400

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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. Certified for ASME Code, PED 91/23/EC, Chinese Manufacturing License for category A1 and A2 pressure equipment.

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OROS — 124

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OROS is a global manufacturer and solution provider of noise and vibration measurement systems: Instruments, Software and Services. Designing and manufacturing rugged and real-time noise and vibration analyzers with efficient software solutions, OROS is a leader in rotating analysis.

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PEC Ltd. — 123

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PM Control is a vertically-integrated provider of energy control solutions for engines,turbines, power management systems, and compressors. With more than 100 dedicated personnel in five strategic locations in Asia, PM serves organizations in the Energy, Transportation and Process sectors throughout East Asia and Australasia. PM has the experience and capabilities to address specific turbomachinery control needs, providing energy control and optimization solutions that encompass design, production, test, simulation, commissioning and services. Its solutions and expertise have been applied to 100's of turbomachinery upgrades and retrofits. PM Control Systems is an appointed Distributor and Recognized Turbine Retrofitter for Woodward Inc. (USA).

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Shin Nippon Machinery Co., Ltd. 415

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Sichuan Sunny Seal Co, Ltd. 409

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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.

Sohre Turbomachinery Inc. 419

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Shaft grounding brushes to control stray electrical currents for electrical and nonelectrical turbomachinery (compressors, gears, turbines, generators, motors, ship propeller shafts), for electrostatic, electromagnetic, or other electrically induced stray currents. Depending on model, the current rating of the models is 1 to 100 DC amperes per year of bristle life. Brushes utilize special alloy bristles and are run directly on shaft, dry, or in oil. Cleaning or maintenance is generally not necessary.

Solar Turbines Incorporated 509

P.O. Box 85376
San Diego, CA 92186-5376 USA
PH: (+)1-619-544-5337 | FX: (+)1-619-544-2444
www.solarturbines.com

Headquartered in San Diego, California, USA, Solar Turbines, a subsidiary of Caterpillar Inc., is one of the world's leading manufacturers of industrial gas turbines and compressors, with approximately 14,700 units with more than 2 billion operating hours in more than 100 countries.

Products from Solar play an important role in the development of oil, natural gas and power generation projects around the world. Solar's products include gas turbine engines, gas compressors, and gas turbine-powered compressor sets, mechanical-drive packages and generator sets.

SPC "Dynamics" 420

Rabinovicha st. 108
Omsk, 644007 Omskaya Oblast Russian Federation
PH: (+)73812254244 | FX: (+)738122254372
www.dynamicsru.com/

Scientific-and-Production Company Diagnostics

Torquemeters Limited 323

West Haddon Rd
Ravensthorpe, NN6 8ET Northamptonshire United Kingdom
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Tractors Singapore Limited 428

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www.tractors.com.sg

Tractors Singapore Limited (TSL) was established in 1966 and has been the authorized Cat® dealer covering Singapore, Christmas Island (Indian Ocean) and Maldives. TSL is also the dealer for Sullair air compressors for over two decades. Sullair compressors are widely used for both industrial and offshore applications. TSL is specialized in providing complete compressed air turnkey solutions.

Turbolink Co., Ltd. 508

103-30, Golden Root-ro
Juchon, Gimhae, 50969 South Korea
PH: (+)82553102808 | FX: (+)82553122851
www.turbolink.co.kr

Turbolink specializes in design and manufacturing of fluid film bearings, the key parts of high-speed, high-load rotating machinery. Since the foundation in 2001 and the establishment of a R&D center in 2003, Turbolink has been developing various products, such as bearings for 65,000 RPM super-speed turbo compressors and high-load turbines and generators with hundreds of tons of axial load, using its own technology. Turbolink is going all-out in R&D and quality improvement to become the No.1 bearing manufacturer in the world.

Turbomachinery International Publications 506

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PH: (+)1-203-663-7814
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Turbomachinery International covers industries engaged in all forms of energy, including power generation, electric utilities and cogeneration. It also covers oil & gas refining, gas processing, compression, drilling and exploration. The emphasis is on application where gas and steam turbines and related turbomachinery are used worldwide. Coverage includes maintenance, overhaul and repair of all turbines and rotating equipment, including pumps and compressors. Turbomachinery News/Blog is an interactive hub, featuring a daily newsletter loaded with the latest news, blogs, commentary from top experts around the world, engineering data and graphics, and cutting-edge stories that you won't find in print.

Turbomachinery Laboratory 301

509 Engineering/Physics Building
College Station, TX 77843 USA
PH: (+)1-979-845-7417 | FX: (+)1-979-845-1835
www.turbolab.tamu.edu

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.

Voith Turbo Pte Ltd 520

10 Jalan Lam Huat
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Waukesha Bearings Corporation is a global leader in the design and manufacture of engineered hydrodynamic bearings, magnetic bearing systems and bearing protection products for high-performing turbomachinery. Waukesha serves its global customer base through four businesses: Waukesha Bearings, Waukesha Magnetic Bearings, Inpro/Seal and Bearings Plus. Backed by robust product development and years of application experience, its high-performing bearings are designed for optimized performance and engineered to provide low power consumption, reduced operating temperatures, and increased reliability and efficiency. Waukesha Bearings is an operating company of Dover and has facilities in the United States, United Kingdom, Mexico, Russia, Brazil, China and India.

World Pipelines Pub Bin

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World Pipelines is the international publication for the oil and gas pipeline industry, covering all aspects of pipeline engineering, construction and maintenance, as well as the technical and business issues that pertain to the industry. World Pipelines is:

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Compressor - Screw

Expanders

Gears and Gearboxes

Mechanical Seal

Pump - Centrifugal

Pump - Sealless

Turbines - Gas

Turbines - Steam

MATERIALS

Carbon and carbon products

GENERAL

GENERAL INFORMATION

EXHIBITION

In addition to our technical sessions, we encourage you to join us for our outstanding product show and experience all it has to offer. Our exhibition will provide you the opportunity to engage with world-class technical personnel and view the latest in industry technology.

The exhibition for delegates will take place in Level 1, Exhibit Hall A at the Sands Expo and Convention Center. The hall will be open during the following times:

Tuesday, 23 February 2015	**1000 – 1800 hours**
Wednesday, 24 February 2015	**1000 – 1800 hours**
Thursday, 25 February 2015	**0900 – 1300 hours**

WELCOME ADDRESS AND PLENARY LECTURE

Badge required – not open to Free Pass
The Welcome Address and Plenary Lecture are scheduled for Tuesday, 23 February 2016, 0745-0830, Level 3, Angsana Ballroom 3D.

LUNCHEONS

Badge required – not open to Free Pass
Lunch will be served on 23 and 24 February 2016, in Exhibit Hall A, Level 1. Lunch is included in the full symposium registration fee. The one-day symposium registration fee includes a luncheon ticket for that day.

GALA DINNER

Badge or ticket required – not open to Free Pass
The Gala Dinner is scheduled for Wednesday, 24, February 2016, 1930-2100, Level 4, Roselle Jr. Ballroom. 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 inaugural 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 recognized in the United States as the unit designed to provide a record of an individual's continuing education achievements.

- Short Course attendees earn 0.6 CEUs/6 PDHs
- Symposium attendees earn 0.45 CEUs/4.5 PDHs for attending Tuesday or Wednesday and 0.3 CEUs/3 PDHs for attending Thursday or 1.2 CEUs/12 PDHs for full symposium participation
- No CEU credits will be awarded to those persons registered 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 symposium or after the symposium 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 5 February 2016. 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 USB's 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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WATCH & WIN!

Watch for the **ATPS 2016** Post-Event Online Survey…

GIVE US YOUR OPINION & ENTER TO WIN A

GOPRO HERO 4 SILVER 4K!

CONTINUING EDUCATION SHORT COURSES

The Turbo Lab offers multi-day short courses each spring in Houston, Texas. These classes qualify for continuing education units and are an excellent investment for your training budget. **Visit turbolab.tamu.edu for updated information.**

MARCH 2016

ROTORDYNAMICS
MARCH 22 – 25, 2016 | Double Tree by Hilton at Hobby Airport | Houston, TX
Instructor: Malcolm Leader (Applied Machinery Dynamics)

CENTRIFUGAL COMPRESSOR OPERATIONS FOR 21ST CENTURY USERS
MARCH 22 – 24, 2016 | Double Tree by Hilton at Hobby Airport | Houston, TX
Instructors: Jigger Jumonville (Jumonville Engineering), Jeff Moore (Southwest Research Institute), Pete Rasmussen (Rasmussen Machinery Consulting), Jim Sorokes (Dresser-Rand)

DRY GAS SEALING SYSTEMS
MARCH 22 – 24, 2016 | Double Tree by Hilton at Hobby Airport | Houston, TX
Instructors: Vladimir Bakalchuk (Flowserve Corp.), Rich Hosanna (John Crane Inc.), James “Jim” McCraw (BP)

TEES | TURBOMACHINERY LABORATORY
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ABOUT THE TURBOMACHINERY LABORATORY

The Turbomachinery Laboratory (TL) is a center of the Texas A&M Engineering Experiment Station (TEES) and The Texas A&M University System. The TL conducts basic and applied research into important problems of reliability and performance of turbomachinery — rotating machinery that extracts or adds energy to fluids. That's everything from classic Dutch windmills to the space shuttle's main engine turbopumps and compressors that move natural gas through the distribution system.

The TL annually sponsors several large industrial symposia to provide continuing education opportunities to users of industrial turbomachinery, and to generate profits to foster and support graduate and undergraduate education in turbomachinery. Events include the Turbomachinery and Pump Symposia held each Fall in Houston, Texas, and the Asia Turbomachinery and Pump Symposium (ATPS) held biennially in the Spring in Singapore (February 22-25, 2016). Additional continuing education opportunities include intensive short courses offered throughout the year — taught on varying topics relevant to today's professionals in the turbomachinery and pumping industries.

Located in College Station Texas, The TL draws from the world-renowned research expertise of Texas A&M University's Dwight Look College of Engineering and the Texas A&M Engineering Experiment Station.

FOR MORE INFORMATION, VISIT OUR WEBSITE AT:
TURBOLAB.TAMU.EDU

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