# 2022 SHOW GUIDE

MALAYSIA | KUALA LUMPUR CONVENTION CENTRE | 23-26 MAY

AIPS

FOURTH BIENNIAL

ASIA TURBOMACHINERY & PUMP SYMPOSIUM

TEES TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

TEXAS A&M UNIVERSITY

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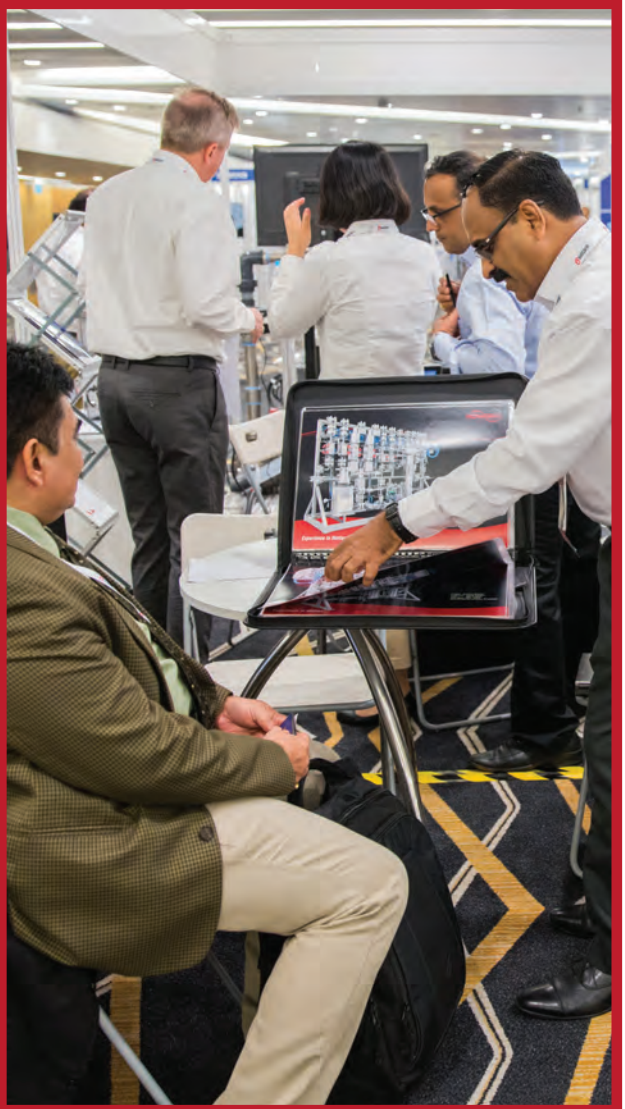
# INTRODUCTION

# WELCOME

## THE TURBOMACHINERY LABORATORY AT TEXAS A&M UNIVERSITY WELCOMES

you to the fourth biennial Asia Turbomachinery and Pump Symposium (ATPS) held at the Kuala Lumpur Conference Center (KLCC) on 23-26 May 2022. We are excited to be back face-to-face in Malaysia with our colleagues. Unfortunately, our 2020 event became a 2021 Virtual event – yet it was very well attended – so thank you for your continued support and participation in this premier technical event which strengthens our workforce and industry to sustain Asia Pacific's energy needs and challenges.

ATPS delivers in Asia the approach established 51 years ago by the successful, world-class Turbomachinery and Pump Symposia (TPS) event, held annually in Houston. TPS and ATPS's technical program promotes novel developments and efficient practices in the rotating equipment life cycle. Our delegates remark that attending these symposia has provided management insights and increased engineering proficiency, achieving hard business benefits. Together we are making a difference in a different way.

The ATPS program is curated by a Technical Advisory Committee comprised of prominent, field-experienced design, sales, consulting, and R&D engineers and academia in the Asia region and worldwide. Our avocation is to deliver a unique, timely program to support the workforce and industry in meeting ever-increasing challenges. The program provides continuing education to rotating equipment practitioners through committee-reviewed, one-day short courses, lectures, tutorials, case studies, technical briefs, and discussion groups.

Topics include practical and state-of-the-art knowledge in drivers, transmissions, components, and driven equipment. It also focuses on technology transfer and peer-networking, where consultants, manufacturers, technicians, and engineers discuss regional problems and global solutions. This proven, singular, collaborative event encourages the exchange of expert knowledge to colleagues to enhance their businesses starting tomorrow.

To drive change in critical areas, we have developed two exciting sessions featuring notable panelists discussing key challenges with Net Zero Emissions and Industry and Career Relations.

Another large part of ATPS is the world-class exhibition. The exhibition floor at KLCC showcases products and support technologies from the largest and leading rotating machinery OEMs. You can influence manufacturers and service providers by discussing your company's needs. Collaboration with exhibitors will foster partnerships to promote, use, and improve their products.

We are grateful to PETRONAS, our Platinum Sponsor and to Mitsubishi Compressor Corporation along with Mitsubishi Power Systems, our Gold Sponsor. These Sponsors are investing in the industry and workforce. Notably, ATPS is supported by the Malaysia Convention and Exhibition Bureau (MyCEB) and the Meet in Malaysia campaign. Many universities in Malaysia and Singapore are also valuable supporting partners who participate in the symposium. We are pleased to welcome a number of other supporting partners that include: The Institution of Engineers Malaysia, The Korea Rotating Machinery Engineers Association (KRMEA), The Institution of Mechanical Engineers, the Malaysia Investment Development Authority, the Malaysian Oil & Gas Services Council and the Malaysian Petroleum Resources Corporation.

We are delighted to welcome all our partners and supporting industries, friends, and colleagues in the oil and gas, petrochemical, power, and other related industries. Let us all make ATPS 2022 a resounding success that is impactful to our delegates and their businesses!

**Dag O. Calafell, II**
Chairman, ATPS Technical Advisory Committee

Texas A&M University
College Station, Texas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# EVENT PARTNERS

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| COMPANY | |
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| LNG INDUSTRY | |
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| COMPANY | |
|---|---|
| MODERN PUMPING TODAY | MPT Modern Pumping Today |
| PETROLEUM PRODUCTS & SOLUTIONS | PPS Petroleum Products & Solutions |
| TURBOMACHINERY INTERNATIONAL | Turbomachinery International |
| VIBRATION INSTITUTE | Vibration Institute |
| WORLD OILS | World Oils |

# HAVE YOU RESERVED YOUR BOOTH FOR TPS 2022?

COME TO THE REGISTRATION COUNTER ON LEVEL 4 TO TALK TO MARTHA BARTON, OUR EXHIBITOR SERVICES DIRECTOR ABOUT EXHIBITING AT OUR LARGER HOUSTON SYMPOSIUM, TPS.

**TPS 2022:** SEPTEMBER 13-15, 2022
SEPTEMBER 12: SHORT COURSES

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We seek energy potential across the globe, optimising value through our integrated business model. Our portfolio includes cleaner conventional and renewable resources and a ready range of advanced products and adaptive solutions.

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WIFI for KLCC: ConventionCtrFreeWIFI

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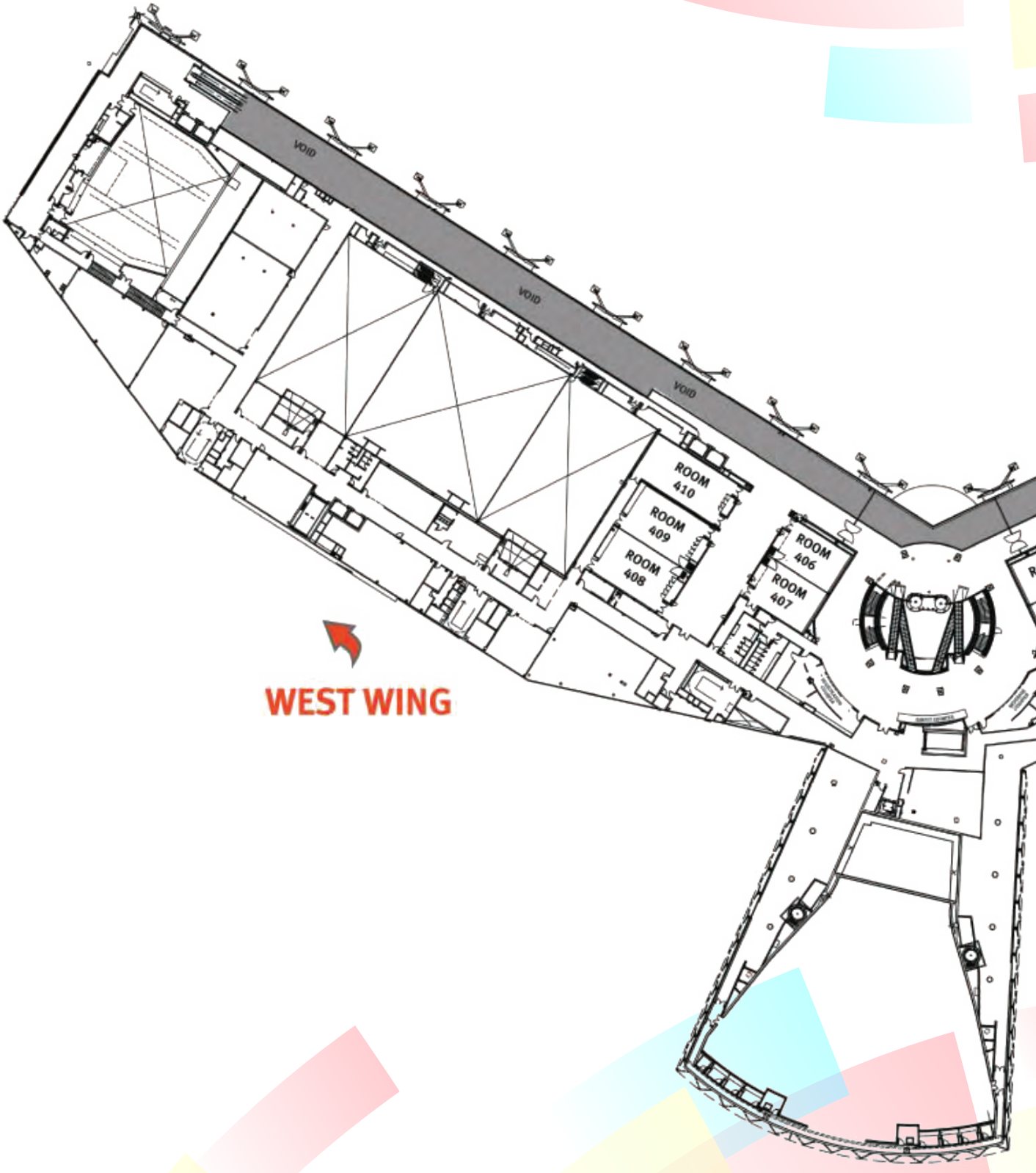
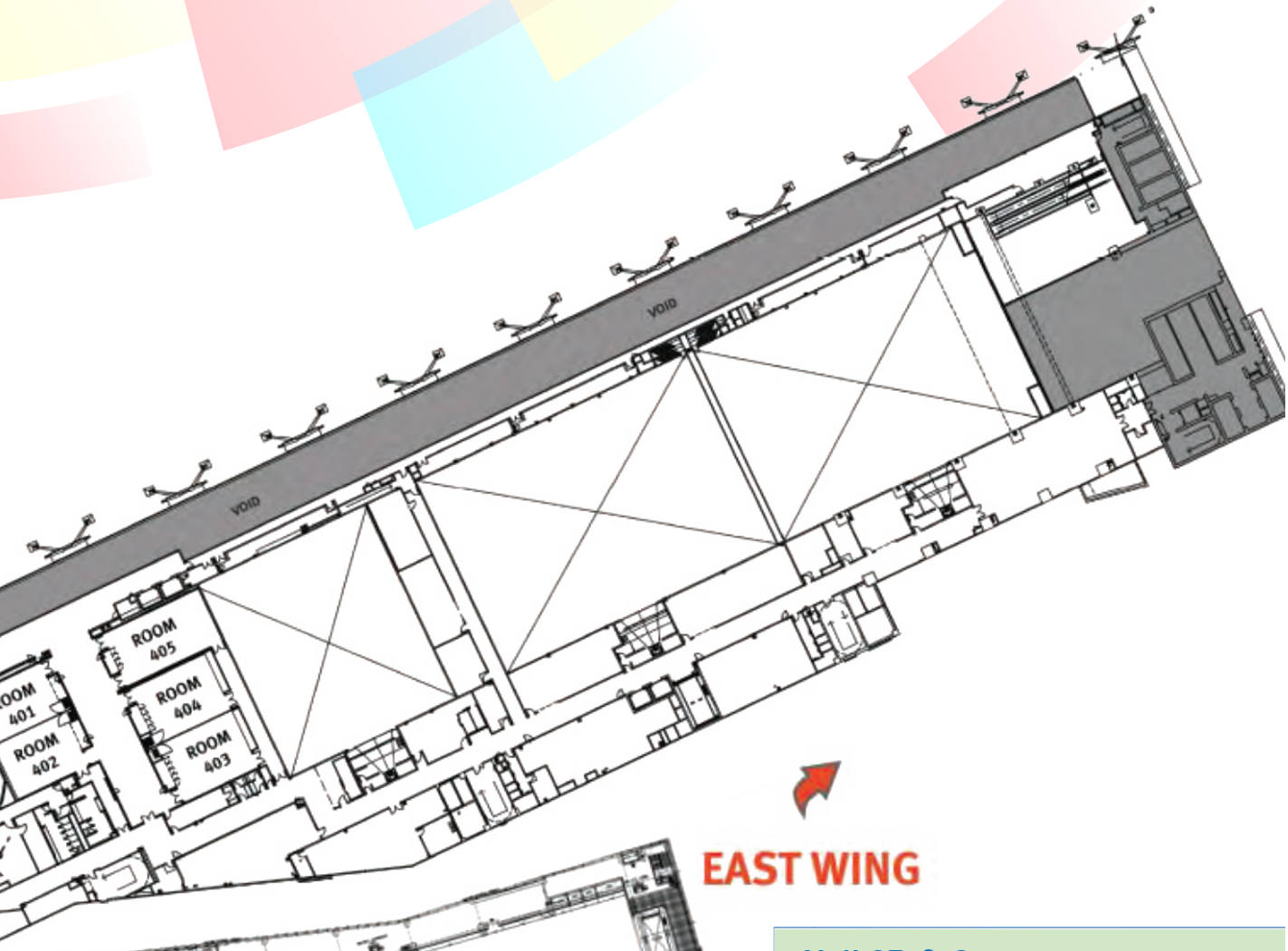
KUALA LUMPUR CONVENTION CENTRE FLOOR PLAN

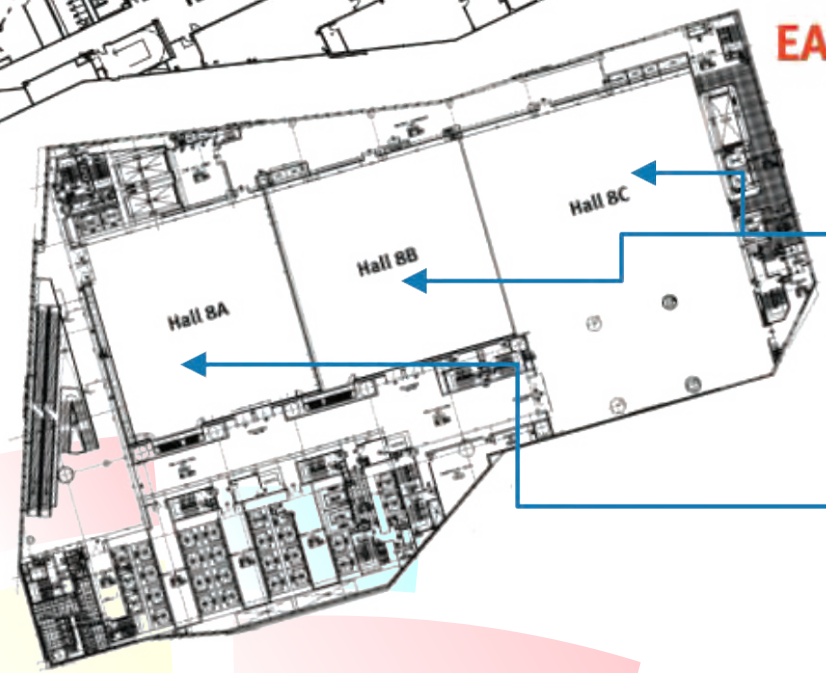
# SUNDAY, 22 MAY 2022

## LEVEL 4






EAST WING



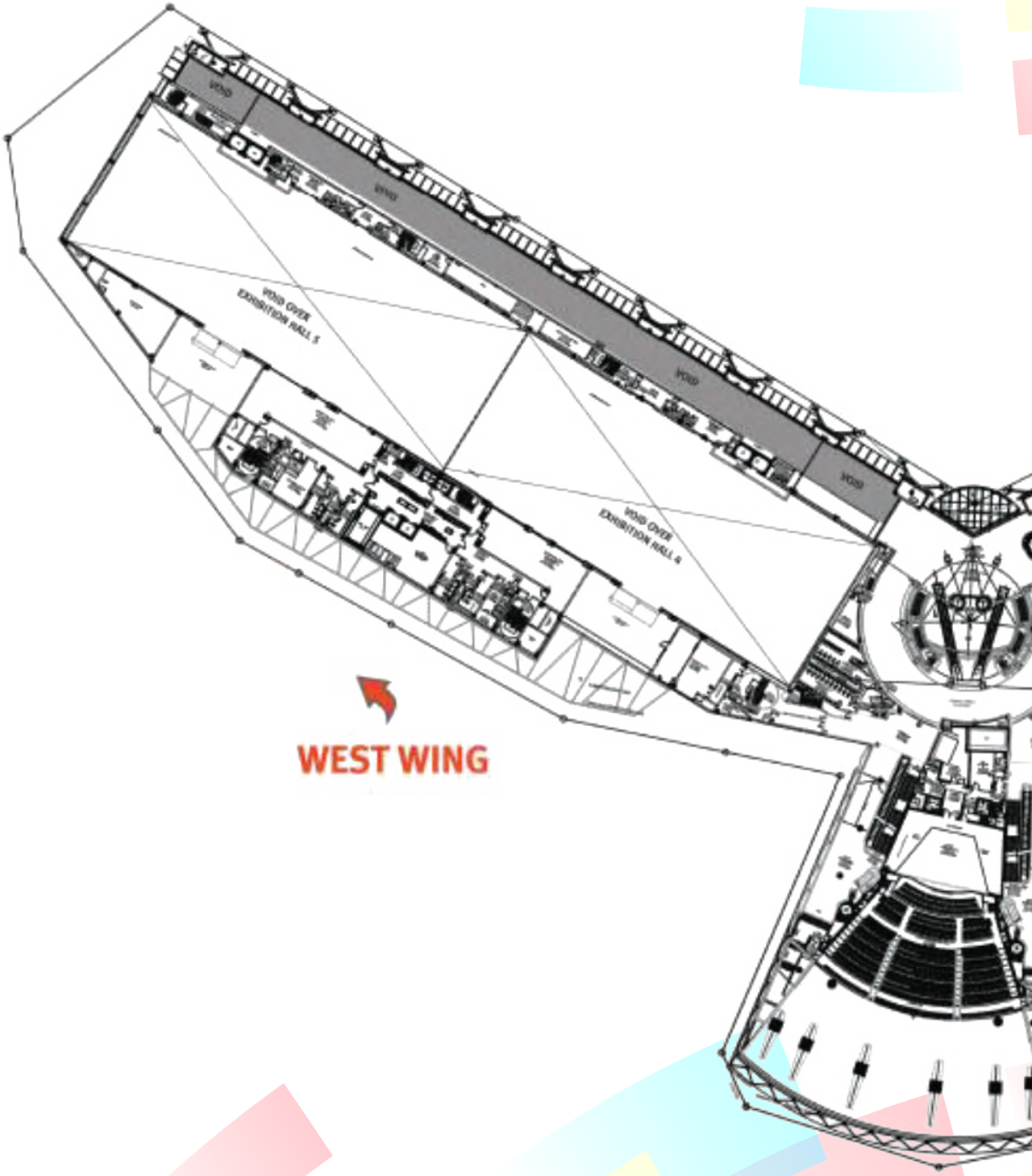

**Hall 8B & C**
**Exhibition**
Move In : 22 May 2022

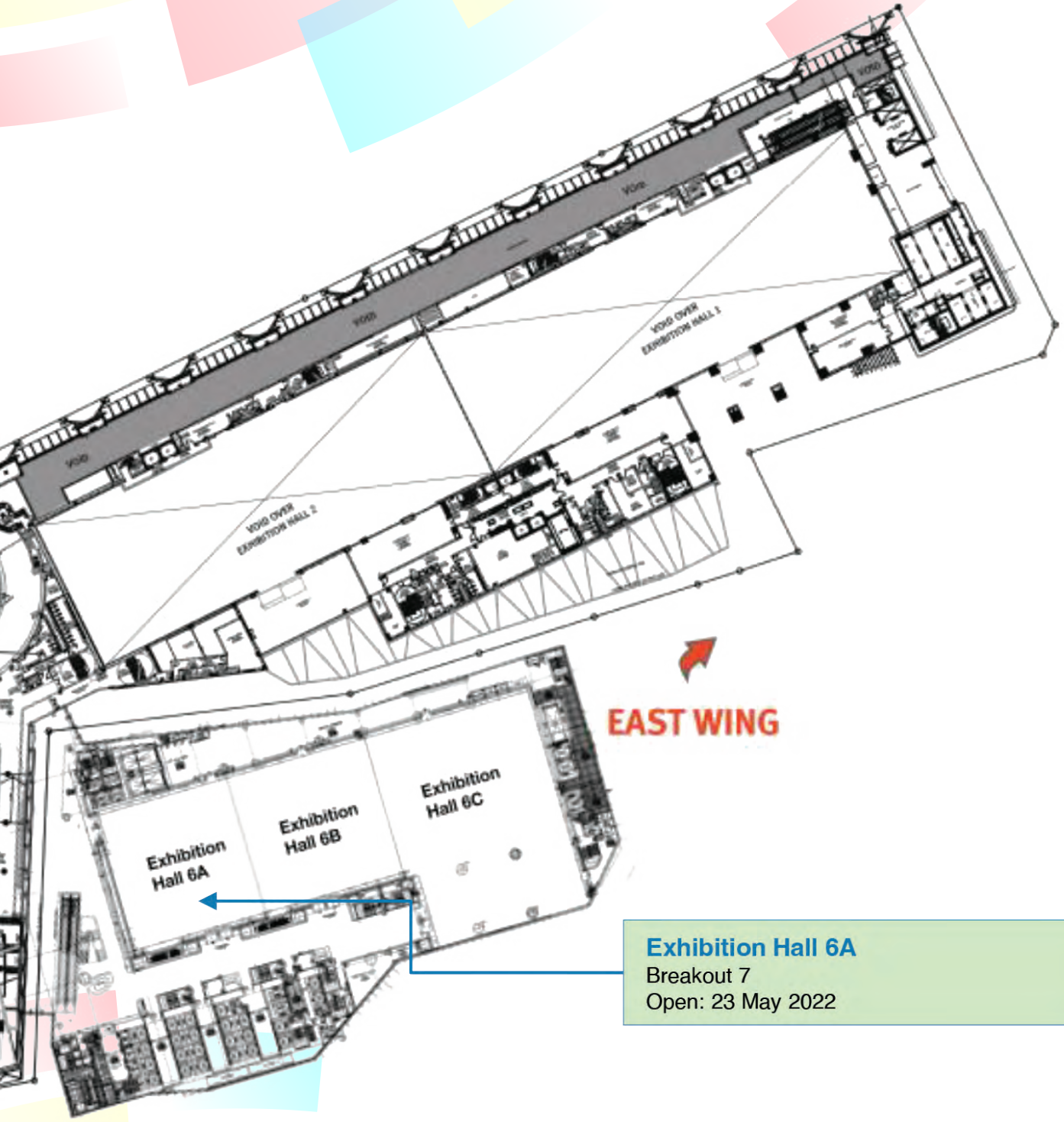
**Hall 8A**
**Registration & Secretariat Room**
Open: 22 May 2022

KUALA LUMPUR CONVENTION CENTRE FLOOR PLAN

# MONDAY, 23 MAY 2022

## LEVEL 1



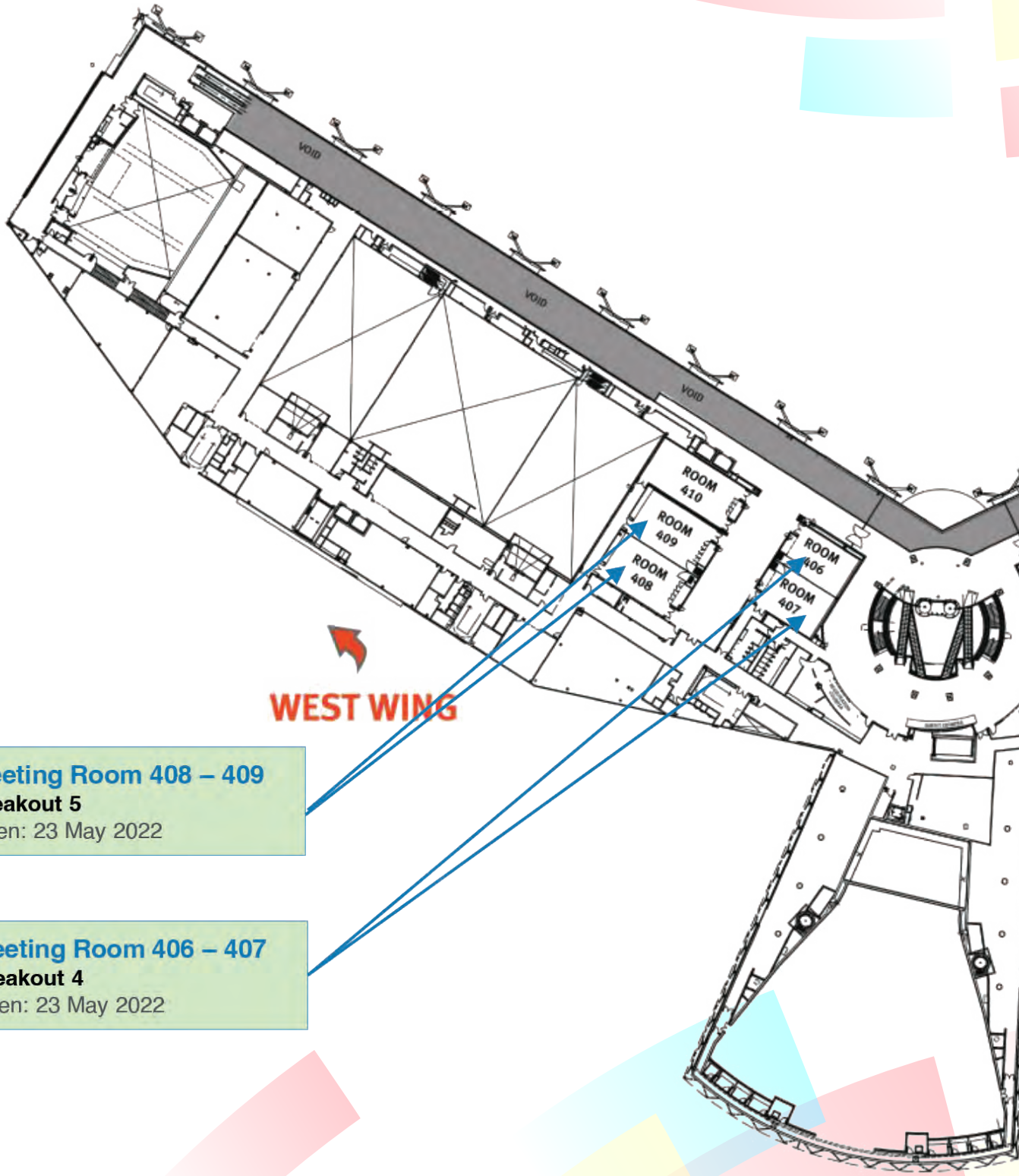



**Exhibition Hall 6A**
Breakout 7
Open: 23 May 2022

KUALA LUMPUR CONVENTION CENTRE FLOOR PLAN

# MONDAY, 23 MAY 2022

## LEVEL 4

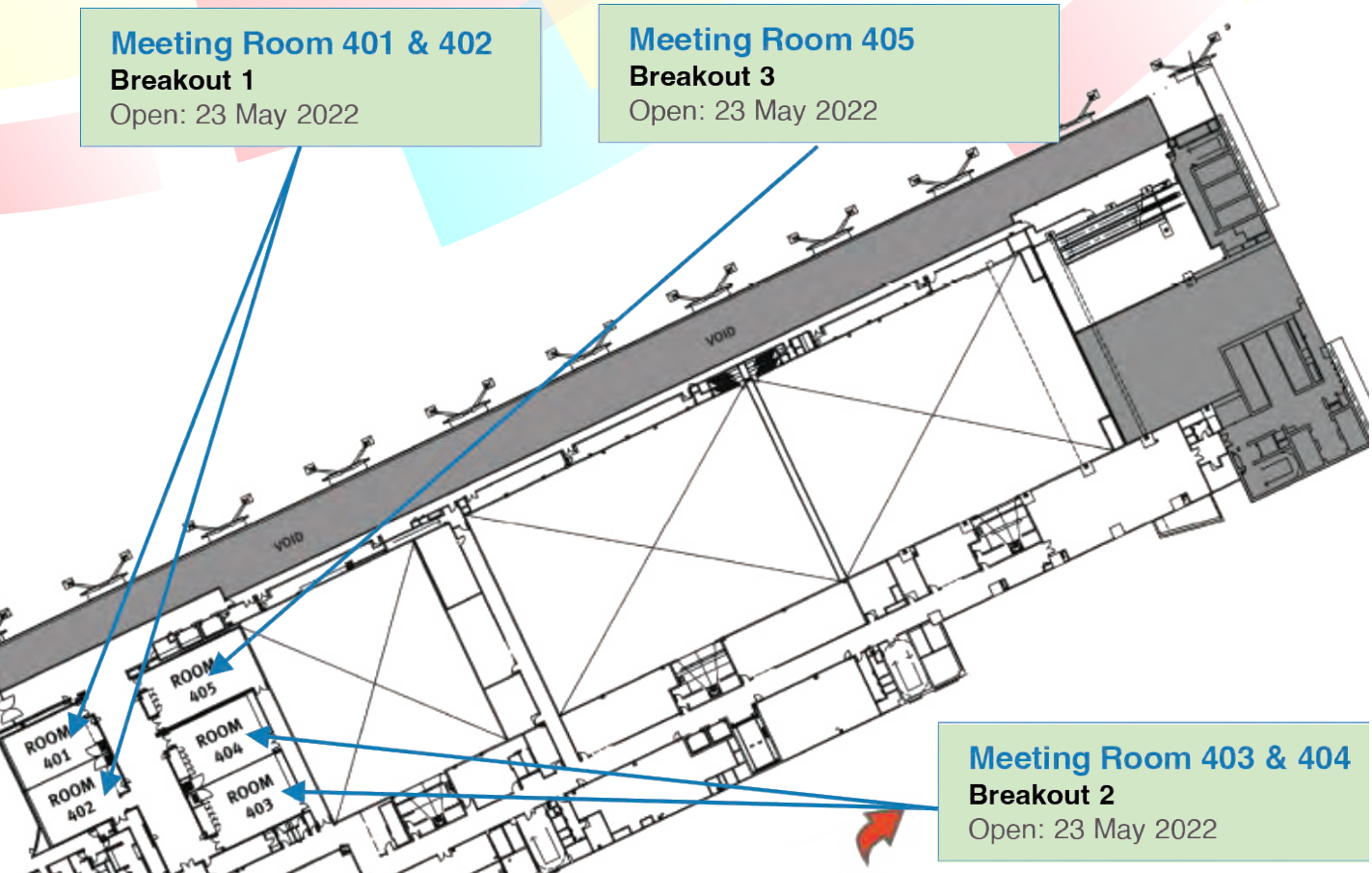



**Meeting Room 408 – 409**
**Breakout 5**
Open: 23 May 2022

**Meeting Room 406 – 407**
**Breakout 4**
Open: 23 May 2022

**Meeting Room 401 & 402**
**Breakout 1**
Open: 23 May 2022

**Meeting Room 405**
**Breakout 3**
Open: 23 May 2022




**Meeting Room 403 & 404**
**Breakout 2**
Open: 23 May 2022

## EAST WING

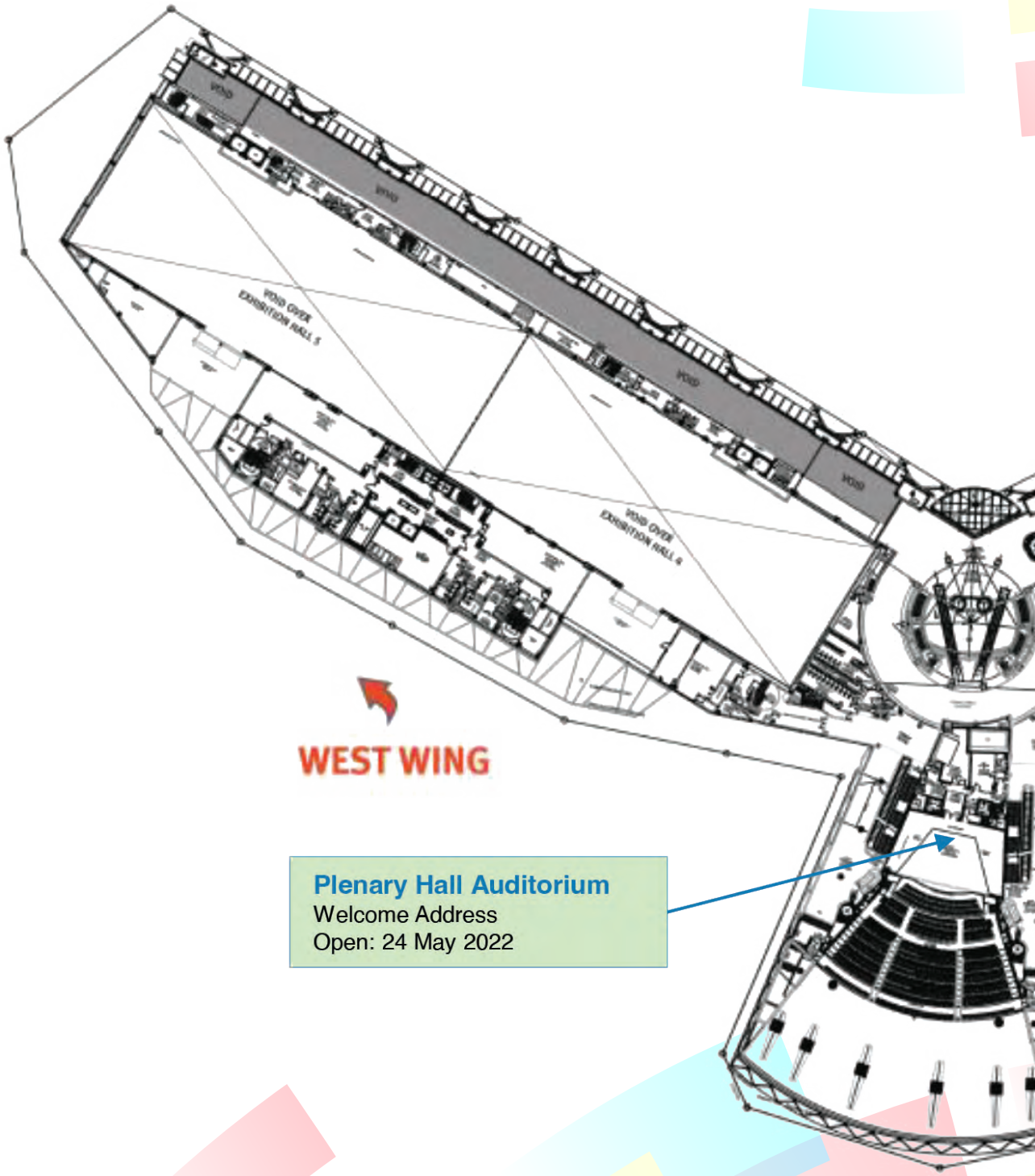

**Hall 8B & C**
**Exhibition**
Move In : 23 May 2022

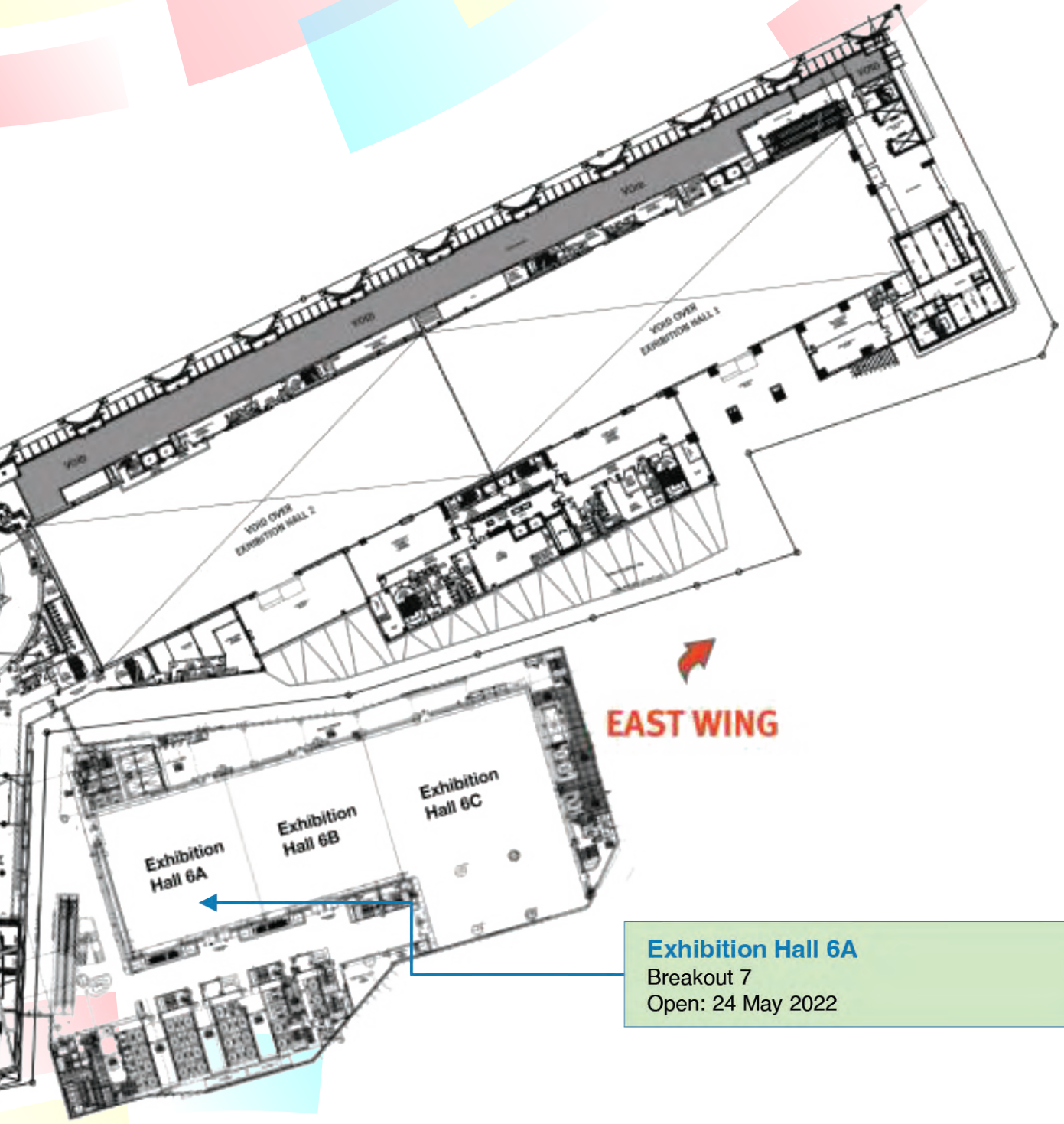
**Hall 8A**
**Registration**
Open: 23 May 2022

KUALA LUMPUR CONVENTION CENTRE FLOOR PLAN

# TUESDAY, 24 MAY 2022

## LEVEL 1



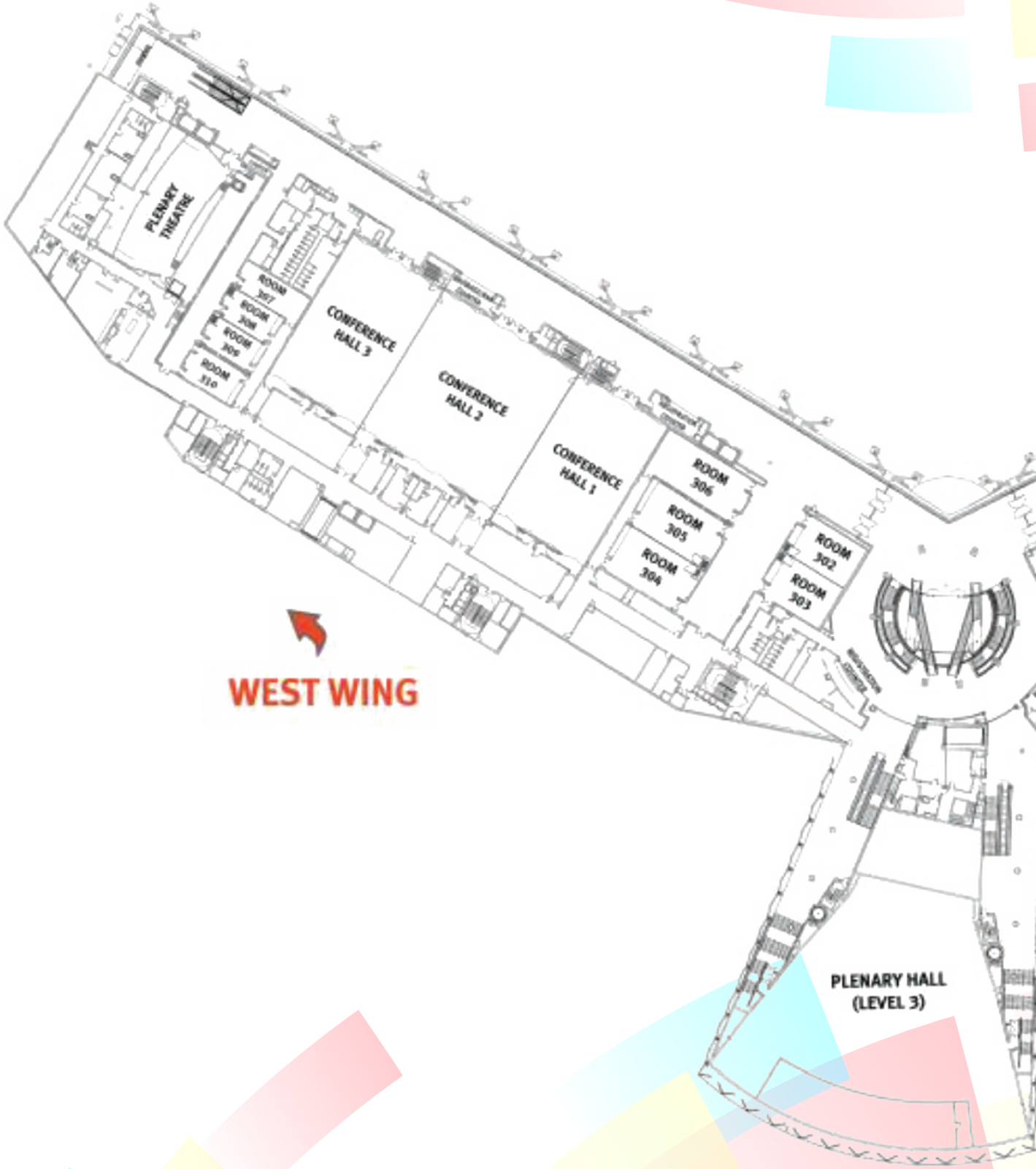



**Exhibition Hall 6A**
Breakout 7
Open: 24 May 2022

KUALA LUMPUR CONVENTION CENTRE FLOOR PLAN

# TUESDAY, 24 MAY 2022

## LEVEL 3




## EAST WING

### Hall 7C
**Meeting (U-Shape)**
Open: 24 May 2022

### Hall 7B
**Meeting (U-Shape)**
Open: 24 May 2022

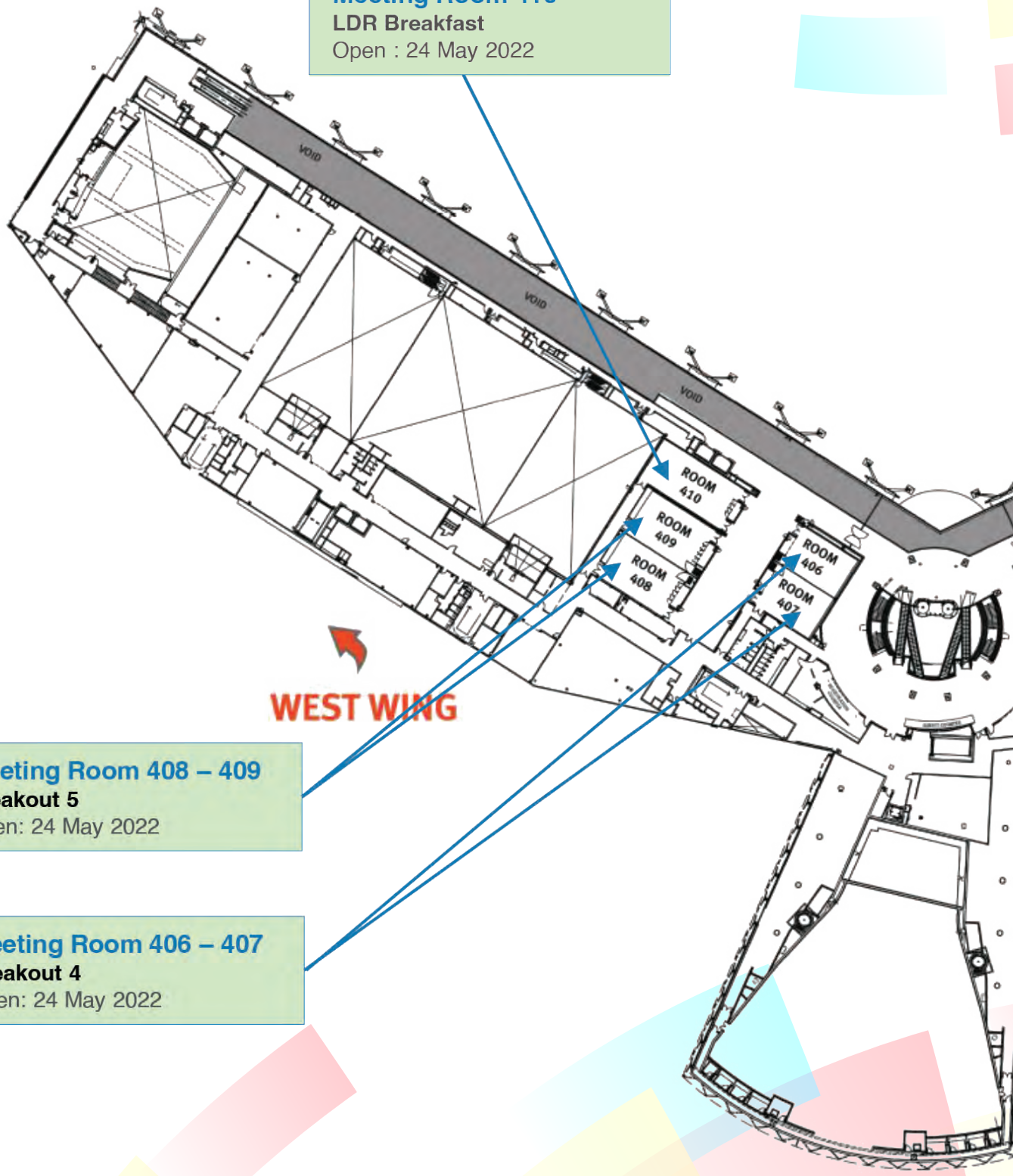
### Hall 7A
**Panel Session** Open: 24 May 2022

KUALA LUMPUR CONVENTION CENTRE FLOOR PLAN

# TUESDAY, 24 MAY 2022

## LEVEL 4

**Meeting Room 410**
**LDR Breakfast**
Open : 24 May 2022

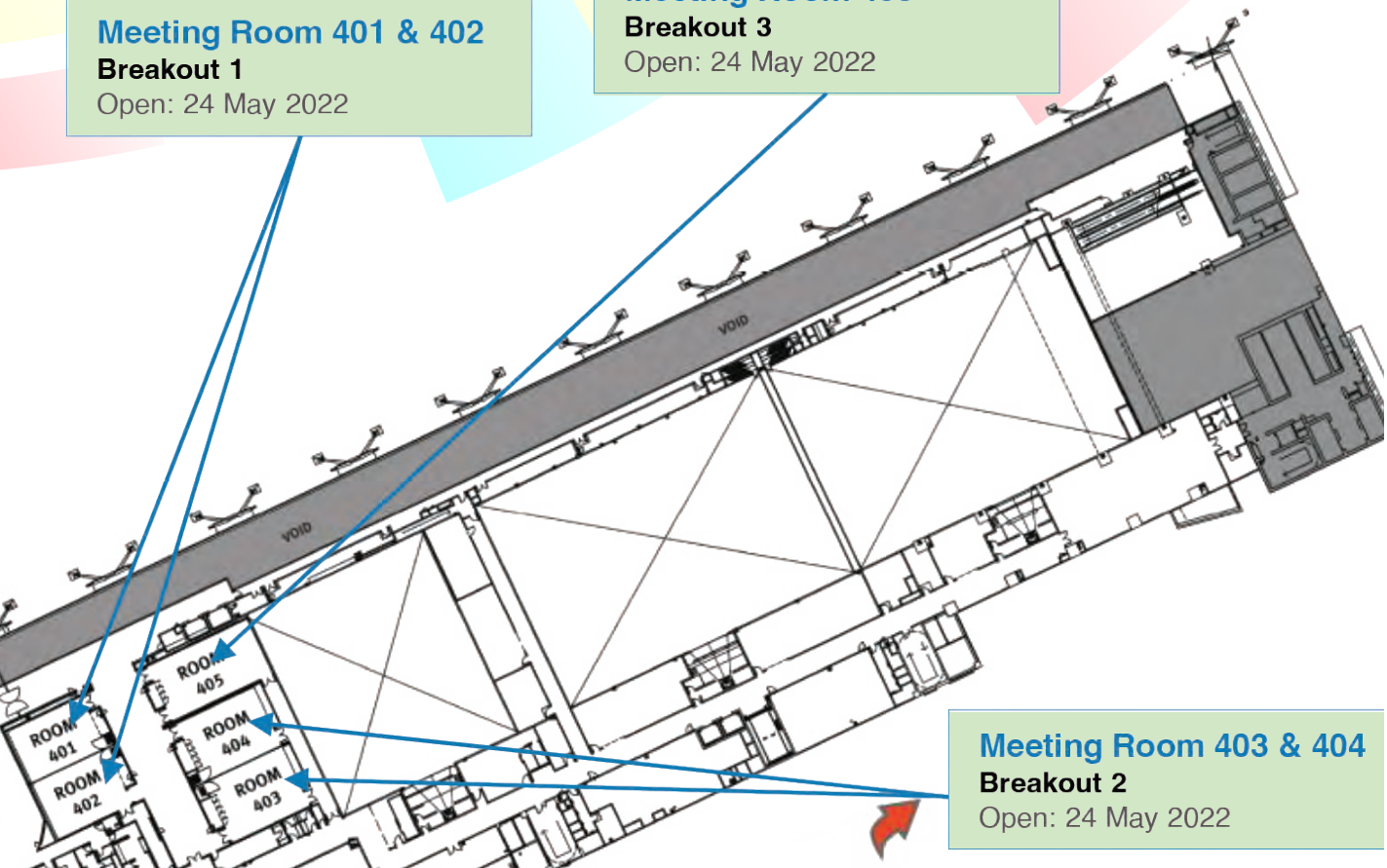



**Meeting Room 408 – 409**
**Breakout 5**
Open: 24 May 2022

**Meeting Room 406 – 407**
**Breakout 4**
Open: 24 May 2022

**Meeting Room 401 & 402**
**Breakout 1**
Open: 24 May 2022

**Meeting Room 405**
**Breakout 3**
Open: 24 May 2022




**Meeting Room 403 & 404**
**Breakout 2**
Open: 24 May 2022

## EAST WING

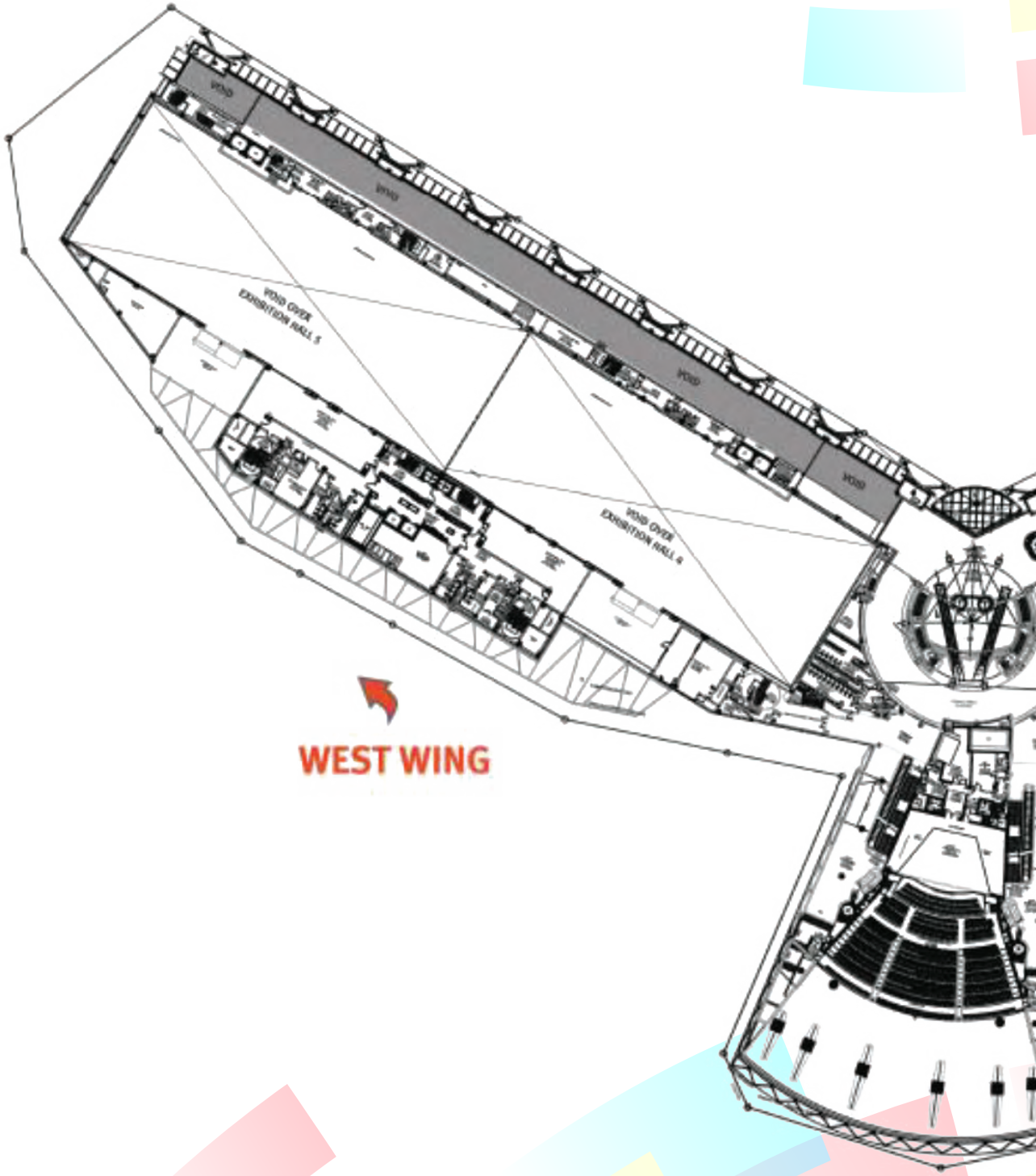

**Hall 8B & C**
**Exhibition**
Open: 24 May 2022

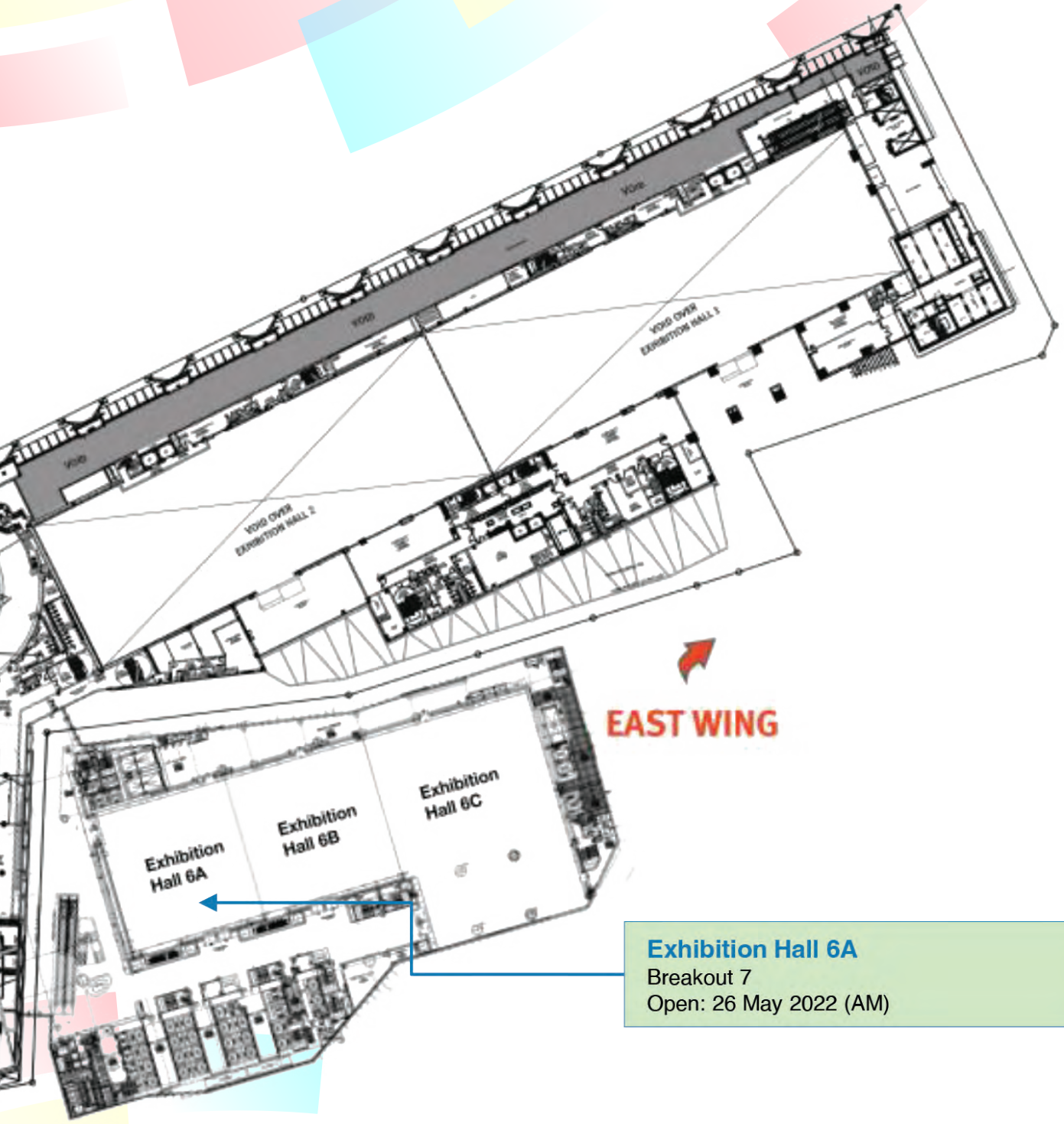
**Hall 8A**
**Registration**
Open: 24 May 2022

KUALA LUMPUR CONVENTION CENTRE FLOOR PLAN

# THURSDAY, 25 MAY 2022

## LEVEL 3





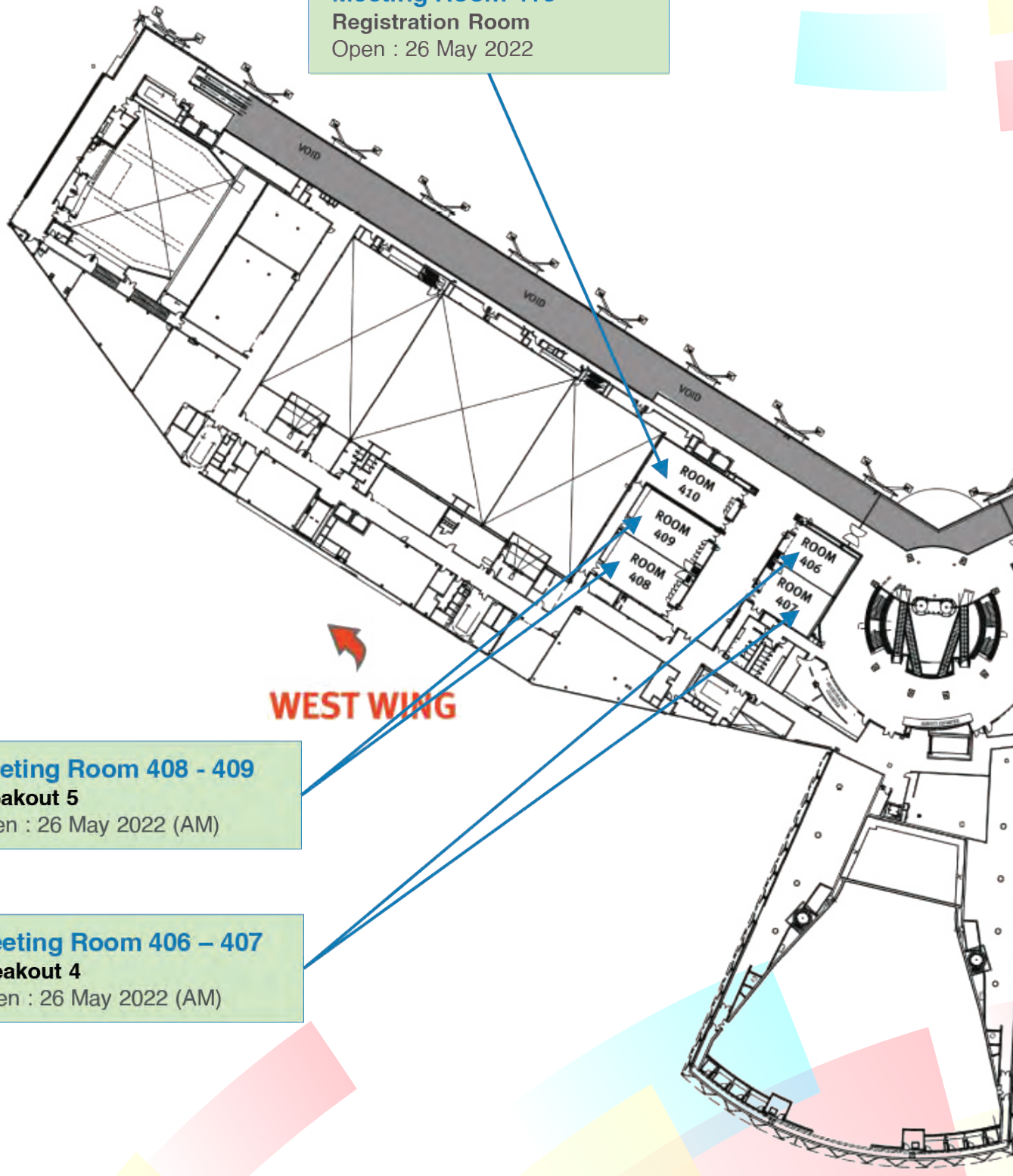

**Exhibition Hall 6A**
Breakout 7
Open: 26 May 2022 (AM)

KUALA LUMPUR CONVENTION CENTRE FLOOR PLAN

# THURSDAY, 25 MAY 2022

## LEVEL 4

**Meeting Room 410**
**Registration Room**
Open : 26 May 2022

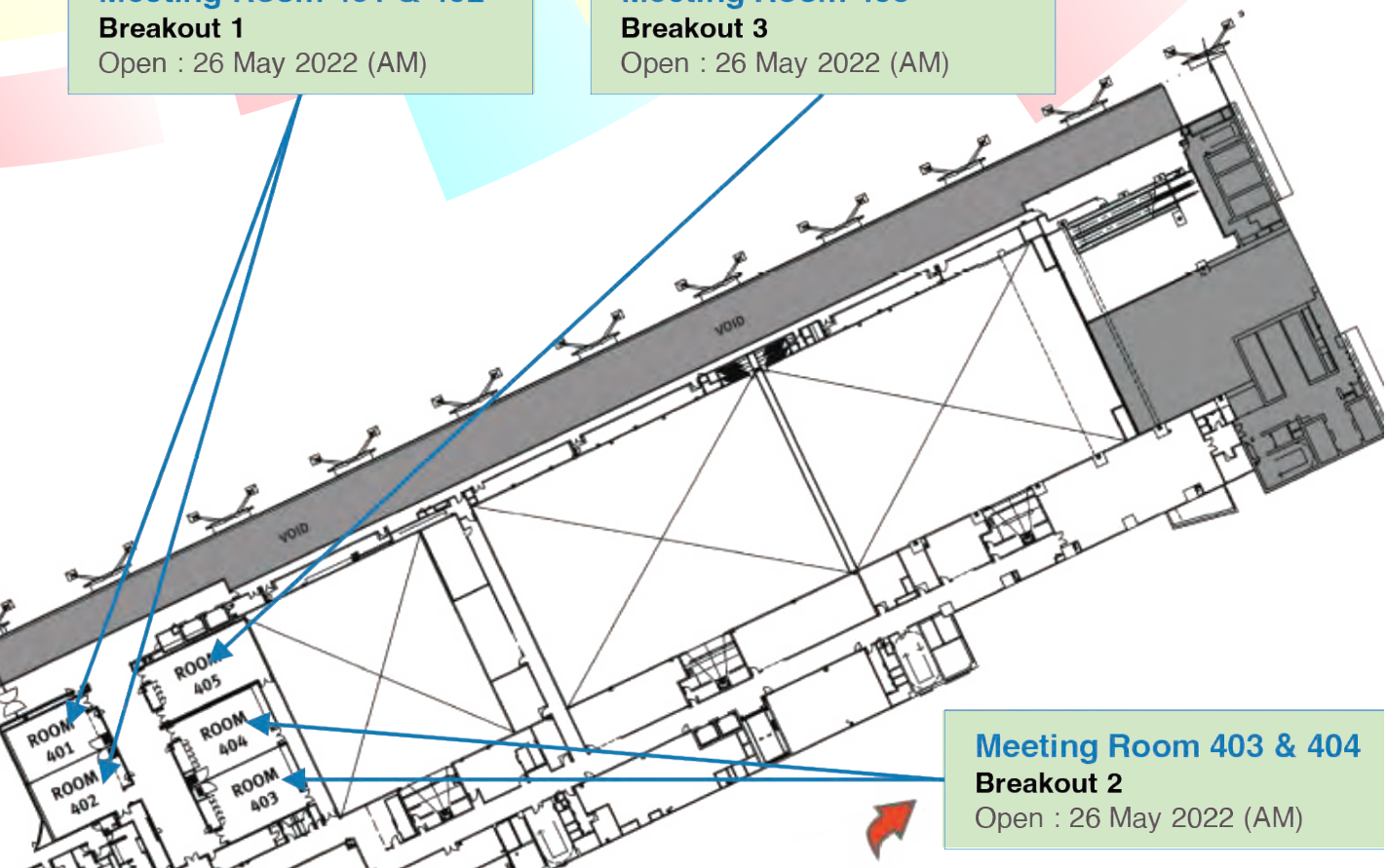



**Meeting Room 408 - 409**
**Breakout 5**
Open : 26 May 2022 (AM)

**Meeting Room 406 – 407**
**Breakout 4**
Open : 26 May 2022 (AM)

**Meeting Room 401 & 402**
**Breakout 1**
Open : 26 May 2022 (AM)

**Meeting Room 405**
**Breakout 3**
Open : 26 May 2022 (AM)




**Meeting Room 403 & 404**
**Breakout 2**
Open : 26 May 2022 (AM)

## EAST WING


**Hall 8B & C**
**Exhibition**
Open: 26 May 2022
Move Out : 26 May 2022

**Hall 8A**
**Registration**
Open : 26 May 2022

# MALAYSIA

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# SCHEDULE


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The world turns to Elliott.
KOBELCO

# SCHEDULE AT A GLANCE

| TIME | FUNCTION | LOCATION |
|---|---|---|
| **SUNDAY, 22 MAY 2022** | | |
| 1630 – 1800 | REGISTRATION | LEVEL 4, HALL 8A |
| **MONDAY, 23 MAY 2022** | | |
| 0800 – 1230 | REGISTRATION | LEVEL 4, HALL 8A |
| 0900 – 1730 | SHORT COURSES | LEVEL 4, MEETING ROOMS |
| 1030 – 1100 | REFRESHMENT BREAK | LEVEL 1, HALL 6B |
| 1200 – 1330 | SHORT COURSE LUNCHEON | LEVEL 1, HALL 6B |
| 1330 – 1700 | REGISTRATION | LEVEL 4, HALL 8A |
| 1430 - 1500 | REFRESHMENT BREAK | LEVEL 1, HALL 6B |
| 1745 – 1800 | ADVISORY COMMITTEE MEETING | LEVEL 1, HALL 6B |
| **TUESDAY, 24 MAY 2022** | | |
| 0830 – 0845 | LEADER ORIENTATION | LEVEL 4, MEETING ROOM 410 |
| 0800 – 1800 | REGISTRATION | LEVEL 4, HALL 8A |
| 0900 – 0935 | WELCOME ADDRESS | LEVEL 1, PLENARY HALL AUDITORIUM |
| 0945 – 1030 | SYMPOSIUM TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| 1000 – 1800 | EXHIBIT HALL OPEN | LEVEL 4, HALLS 8A-C |
| 1030 – 1100 | REFRESHMENT BREAK | LEVEL 4, HALLS 8A-C |


| TIME | FUNCTION | LOCATION |
|---|---|---|
| **TUESDAY, 24 MAY 2022** *(CONTINUED)* | | |
| 1100 – 1230 | SYMPOSIUM TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| | DISCUSSION GROUPS | LEVEL 3, HALL 7B AND 7C |
| 1230 – 1400 | LUNCH FOR EXHIBITORS & PAID DELEGATES | LEVEL 4, HALLS 8A-C |
| 1400 – 1530 | SYMPOSIUM TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| | DISCUSSION GROUPS | LEVEL 3, HALL 7B AND 7C |
| 1530 – 1600 | REFRESHMENT BREAK | LEVEL 4, HALL 8A-8C |
| 1600 – 1730 | NET ZERO EMISSIONS PANEL | LEVEL 3, HALL 7A |
| **WEDNESDAY, 25 MAY 2022** | | |
| 0830 – 0845 | LEADER ORIENTATION | LEVEL 4, MEETING ROOM 410 |
| 0800 – 1800 | REGISTRATION | LEVEL 4, HALL 8A |
| 0900 – 1030 | SYMPOSIUM TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| | DISCUSSION GROUPS | LEVEL 3, HALL 7B-7C |
| 1000 – 1800 | EXHIBIT HALL OPEN | LEVEL 4, HALL 8B-8C |
| 1030 – 1100 | REFRESHMENT BREAK | LEVEL 4, HALL 8B-8C |
| 1100 – 1230 | SYMPOSIUM TECHNICAL SESSIONS | LEVEL 4, HALL 8B-8C |
| | DISCUSSION GROUPS | LEVEL 3, HALL 7B AND 7C |

# SCHEDULE AT A GLANCE

| TIME | FUNCTION | LOCATION |
|---|---|---|
| **WEDNESDAY, 25 MAY 2022** *(CONTINUED)* | | |
| 1230 – 1400 | LUNCH FOR EXHIBITORS & PAID DELEGATES | LEVEL 4, HALL 8B-8C |
| 1400 – 1530 | SYMPOSIUM TECHNICAL SESSIONS | LEVEL 4, HALL 8B-8C |
| | DISCUSSION GROUPS | LEVEL 3, HALL 7B-7C |
| 1530 – 1600 | REFRESHMENT BREAK | LEVEL 4, HALL 8B-8C |
| 1600 – 1730 | CAREER AND INDUSTRY PANEL | LEVEL 3, HALL 7A |
| 1930 – 2100 | GALA DINNER | GRAND HYATT HOTEL, GRAND SALON, LEVEL 1 |
| **THURSDAY, 26 MAY 2022** | | |
| 0830 – 0845 | LEADER ORIENTATION | LEVEL 4, MEETING ROOM 410 |
| 0800 – 1300 | REGISTRATION | LEVEL 4, HALL 8A |
| 0900 – 1030 | SYMPOSIUM TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| 0900 – 1300 | EXHIBIT HALL OPEN | LEVEL 4, HALLS 8B-8C |
| 1030 – 1100 | REFRESHMENT BREAK | LEVEL 4, HALLS 8B-8C |
| 1100 – 1230 | SYMPOSIUM TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |

# Download the Mobile App for quick access to the technical program schedule, exhibition schedule, and map.

## SCAN TO DOWNLOAD MOBILE APP VIA APP STORE

# TECHNICAL PROGRAM SCHEDULE

| SUNDAY, 22 MAY 2022 | |
|---|---|
| 1630 PM – 1800 PM \| REGISTRATION | |
| EXHIBITOR REGISTRATION | LEVEL 4, HALL 8A |
| ATTENDEE REGISTRATION | LEVEL 4, HALL 8A |
| LEADER REGISTRATION | LEVEL 4, HALL 8A |

## PROCEEDINGS FROM ALL PREVIOUS SYMPOSIA ARE AVAILABLE FREE ONLINE

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| MONDAY, 23 MAY 2022 | |
|---|---|
| 0800 – 1230 \| REGISTRATION | LEVEL 4, HALL 8A |
| ALL REGISTRATION | LEVEL 4, HALL 8A |
| 0900 – 1730 \| SHORT COURSES | LEVEL 4, MEETING ROOMS |
| SHORT COURSE 1 (SC1) - TRANSMISSION TECHNOLOGY | LEVEL 4, MEETING ROOM 406 |
| SHORT COURSE 3 (SC3) - BEST PRACTICES IN TURBOMACHINERY MAINTENANCE AND RELIABILITY | LEVEL 4, MEETING ROOM 407 |
| SHORT COURSE 4 (SC4) - INDUSTRIAL GAS TURBINES | LEVEL 4, MEETING ROOM 405 |
| SHORT COURSE 5 (SC5) - LATERAL & TORSIONAL ROTORDYNAMICS OF MACHINERY | LEVEL 4, MEETING ROOM 403 |
| SHORT COURSE 6 (SC6) - INTRODUCTION TO RECIPROCATING COMPRESSORS, COMPONENTS, AND TROUBLESHOOTING | LEVEL 4, MEETING ROOM 408 |
| SHORT COURSE 7 (SC7) - PUMP FUNDAMENTALS | LEVEL 4, MEETING ROOM 401 |
| 1030 – 1100 \| REFRESHMENT BREAK | LEVEL 1, HALL 6B |
| 1200 – 1330 \| SHORT COURSE LUNCHEON | LEVEL 1, HALL 6B |
| 1330 – 1700 \| REGISTRATION | LEVEL 4, HALL 8A |
| 1430 – 1500 \| REFRESHMENT BREAK | LEVEL 1, HALL 6B |
| 1745 – 1800 \| ADVISORY COMMITTEE MEETING | LEVEL 1, HALL 6B |

# TECHNICAL PROGRAM SCHEDULE

| TUESDAY 24, MAY 2022 | |
|---|---|
| 0830 - 0845 \| LEADER ORIENTATION | LEVEL 4, MEETING ROOM 410 |
| 0800 – 1800 \| REGISTRATION | LEVEL 4, HALL 8A |
| 0900 – 0935 \| WELCOME ADDRESS | LEVEL 1, PLENARY HALL AUDITORIUM |
| 0945 – 1030 \| TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| LECTURE 7 - DESIGN AND TESTING OF A CENTRIFUGAL COMPRESSOR FOR SUPERCRITICAL CO2 APPLICATION | LEVEL 4, MEETING ROOM 406 |
| CASE STUDY 33 - IMPLEMENTATION OF VOTED FLAME DETECTORS TO PREVENT SPURIOUS FIRE DETECTION IN GAS TURBINES ENCLOSURES | LEVEL 4, MEETING ROOM 403 |
| LECTURE 9 - LEAKAGE AND DYNAMIC FORCE COEFFICIENTS FOR A STEPPED LABYRINTH SEAL AND A STEPPED POCKET DAMPER SEAL SUPPLIED WITH WET GAS | LEVEL 4, MEETING ROOM 408 |
| 1000 – 1800 \| EXHIBIT HALL OPEN | LEVEL 4, HALL 8B-8C |
| 1030 – 1100 \| REFRESHMENT BREAK | LEVEL 4, HALL 8B - 8C |
| 1100 – 1230 \| TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| TUTORIAL 1 - PNEUMATICALLY ACTUATED CONTROL VALVES IN OIL SYSTEMS: HARDWARE RECOMMENDATIONS AND TUNING CONSIDERATIONS | LEVEL 4, MEETING ROOM 403 |
| TUTORIAL 2 - LASER WELDING FOR TURBOMACHINERY ROTOR RESTORATION | LEVEL 4, MEETING ROOM 405 |


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|---|---|
| LECTURE 1 - ADVANCES IN AMMONIA COMBUSTION CHEMISTRY AND NH3 SENSING USING LASER DIAGNOSTICS<br><br>LECTURE 2 - HYDROGEN-COMBUSTION AND COMPRESSION | LEVEL 4, MEETING ROOM 406<br>*SESSIONS RUN CONSECUTIVELY* |
| LECTURE 4 - IGNITION CHARACTERISTICS OF GAS TURBINE LUBRICATION OILS | LEVEL 4, MEETING ROOM 408 |
| DISCUSSION GROUP 2 - TURBOMACHINERY AND PUMP VIBRATIONS | LEVEL 3, HALL 7C |
| DISCUSSION GROUP 4 - CENTRIFUGAL PUMPS: OPERATION, MAINTENANCE AND RELIABILITY, VERTICAL PUMP PROBLEMS AND SOLUTIONS | LEVEL 3, HALL 7B |
| 1230 – 1400 \| LUNCH FOR EXHIBITORS AND PAID DELEGATES | LEVEL 4, HALL 8B-8C |
| 1400 – 1530 \| TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| TUTORIAL 3 - COMPARISON OF CONTACTING WET AND DRY GAS SEALS (DGS) FOR MAIN PIPELINE PUMPS IN NGL SERVICES | LEVEL 4, MEETING ROOM 403 |
| TUTORIAL 4 - KEY DIFFERENCES BETWEEN STEAM TURBINES AND ELECTRIC MOTORS AS MAIN COMPRESSOR | LEVEL 4, MEETING ROOM 405 |
| TUTORIAL 11 – TURBOMACHINERY FOR REFINERY APPLICATIONS | LEVEL 4, MEETING ROOM 407 |

# TECHNICAL PROGRAM SCHEDULE

| TUESDAY 24, MAY 2022 *(CONTINUED)* | |
|---|---|
| LECTURE 5 - REALISTIC EXPECTATIONS FROM A UNIQUE PLAN 66A BUSHING DESIGN<br><br>TECHNICAL BRIEF 1 - CENTRIFUGAL COMPRESSOR PROLONGED LOW FLOW OPERATION CONSIDERATION FOR OPERATORS<br><br>TECHNICAL BRIEF 2 - COMPRESSOR ROTOR CRACK CASE | LEVEL 4, MEETING ROOM 406<br>*SESSIONS RUN CONSECUTIVELY* |
| LECTURE 6 - EVALUATION OF VARIOUS METHODS FOR MANUFACTURING ONE PIECE, SMALL TIP OPENING IMPELLERS<br><br>TECHNICAL BRIEF 3 - MECHANICAL DAMAGE TO IMPELLERS FROM LOW FLOW OPERATION<br><br>TECHNICAL BRIEF 5 - TURBOEXPANDERS IN PETROCHEMICAL INDUSTRIES ADVANCE TECHNOLOGY FOR GREEN HYDROGEN LIQUEFACTION | LEVEL 4, MEETING ROOM 408<br>*SESSIONS RUN CONSECUTIVELY* |
| DISCUSSION GROUP 8 - MAGNETIC BEARINGS | LEVEL 3, HALL 7C |
| DISCUSSION GROUP 9 - STEAM TURBINES: OPERATION & MAINTENANCE | LEVEL 3, HALL 7B |
| 1530 – 1600 \| REFRESHMENT BREAK | LEVEL 4, HALL 8B-8C |
| 1600 – 1730 \| PANEL SESSION | LEVEL 3, HALL 7A |
| PANEL SESSION 1 - NET ZERO EMISSIONS | LEVEL 3, HALL 7A |


| WEDNESDAY, 25 MAY 2022 | |
|---|---|
| 0830 - 0845 \| LEADER ORIENTATION | LEVEL 4, MEETING ROOM 410 |
| 0800 – 1800 \| REGISTRATION | LEVEL 4, HALL 8A |
| 0900 – 1030 \| TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| TUTORIAL 5 - MODERN LUBRICATING OIL SYSTEMS | LEVEL 4, MEETING ROOM 403 |
| TUTORIAL 6 - ANNULAR CLEARANCE GAS SEALS: MODELS AND MEASUREMENTS FOR LEAKAGE, FORCE COEFFICIENTS AND THEIR EFFECT ON ROTOR STABILITY | LEVEL 4, MEETING ROOM 405 |
| LECTURE 3 - COKING OF GAS TURBINE LUBRICATION OILS AT ELEVATED TEMPERATURES | LEVEL 4, MEETING ROOM 406 *SESSIONS RUN CONSECUTIVELY* |
| TECHNICAL BRIEF 6 - ADAPTATION OF REMOTE AUTONOMOUS OPERATION (RAO) FOR ROTATING EQUIPMENT OF PETRONAS FACILITIES | |
| LECTURE 8 - CRUDE OIL NON-PUSHER SECONDARY SEAL | LEVEL 4, MEETING ROOM 408 *SESSIONS RUN CONSECUTIVELY* |
| TECHNICAL BRIEF 4 - CENTRIFUGAL COMPRESSOR IN HIGH FLOW AND LOW HEAD APPLICATIONS: AN IMPELLER DESIGN CONCEPT FOR COPING WITH THE INCREASING VOLUME FLOW IN POLYOLEFIN PROCESSES | |
| DISCUSSION GROUP 5 - MECHANICAL (LIQUID) SEALS: GENERAL (INSTALLATION, OPERATION, TROUBLESHOOTING, AND RETROFITTING) | LEVEL 3, HALL 7B |
| DISCUSSION GROUP 6 - TURBOMACHINERY OPERATION AND MAINTENANCE IN A DIGITAL WORLD | LEVEL 3, HALL 7C |

# TECHNICAL PROGRAM SCHEDULE

| WEDNESDAY, 25 MAY 2022 *(CONTINUED)* | |
|---|---|
| 1000 – 1800 \| EXHIBIT HALL OPEN | LEVEL 4, HALL 8A |
| 1030 – 1100 \| REFRESHMENT BREAK | LEVEL 4, HALL 8B-8C |
| 1100 – 1230 \| TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| TUTORIAL 7 - MECHANICAL SEALING TECHNOLOGY USED IN MULTIPHASE PUMP APPLICATIONS | LEVEL 4, MEETING ROOM 403 |
| TUTORIAL 8 - MITIGATION OF AXIAL VIBRATION AND THRUST BEARING FAILURES IN ROTATING MACHINERY | LEVEL 4, MEETING ROOM 405 |
| LECTURE 10 - EXPERIENCES FROM DEVELOPING MATERIAL QUALIFICATION PLANS FOR ADDITIVELY MANUFACTURED STAINLESS-STEEL PARTS AS REPLACEMENTS TO EQUIVALENT CASTING GRADES<br><br>TECHNICAL BRIEF 7 - LASER ADDITIVE MANUFACTURING IN GENERAL PURPOSE EQUIPMENT REPAIR | LEVEL 4, MEETING ROOM 406<br>*SESSIONS RUN CONSECUTIVELY* |
| LECTURE 11 - DESIGN, TESTING, COMMISSIONING AND OPERATING EXPERIENCE OF A 2000HP HYDRAULIC TURBOCHARGER FOR REDUCING CARBON FOOTPRINT OF ACID GAS RECOVERY PROCESS<br><br>LECTURE 12 - ON THE INFLUENCE OF LUBRICANT FEEDHOLE SIZE AND END PLATE SEALS' CLEARANCE ON THE DYNAMIC PERFORMANCE OF INTEGRAL SQUEEZE FILM DAMPERS | LEVEL 4, MEETING ROOM 408<br>*SESSIONS RUN CONSECUTIVELY* |
| DISCUSSION GROUP 1 - CAVITATION/NPSH (FIELD PROBLEMS) | LEVEL 3, HALL 7B |
| DISCUSSION GROUP 3 - CENTRIFUGAL COMPRESSORS: OPERATION AND MAINTENANCE, ADVANCED DESIGN, WET AND SOUR GAS OPERATION | LEVEL 3, HALL 7C |


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| **TUTORIAL 12 - A COMPARISON OF OPERATING DEFLECTION SHAPE AND MOTION AMPLIFICATION VIDEO TECHNIQUES FOR VIBRATION ANALYSIS** | **LEVEL 4, MEETING ROOM 407** |
| **1230 – 1400 \| LUNCH FOR EXHIBITORS AND PAID DELEGATES** | **LEVEL 4, HALL 8A-8C** |
| **1400 – 1530 \| TECHNICAL SESSIONS** | **LEVEL 4, MEETING ROOMS** |
| **TUTORIAL 9 - STEAM TURBINE FUNDAMENTAL & LATEST TECHNOLOGY** | **LEVEL 4, MEETING ROOM 403** |
| **TUTORIAL 10 - AN OVERVIEW OF MACHINERY IN ENERGY STORAGE AND HYDROGEN APPLICATIONS** | **LEVEL 4, MEETING ROOM 405** |
| **LECTURE 13 - NUMERICAL AND EXPERIMENTAL ANALYSIS OF STARVATION IN A TILTING PAD JOURNAL BEARING**<br><br>**LECTURE 14 - CAVITATION PERFORMANCE IMPROVEMENT OF AN INDUSTRIAL CRYOGENIC CENTRIFUGAL PUMP BY IMPLEMENTING VARIABLE PITCH INDUCER** | **LEVEL 4, MEETING ROOM 406**<br>***SESSIONS RUN CONSECUTIVELY*** |
| **LECTURE 15 - THE USE OF ACOUSTIC COMB FILTERS TO AVOID CENTRIFUGAL COMPRESSOR DISCHARGE BLADE-PASS PULSATION INDUCED PIPING VIBRATIONS**<br><br>**LECTURE 16 - HIGH FREQUENCY ACOUSTIC EXCITATION IN CENTRIFUGAL COMPRESSOR AND ADJACENT PIPING VIBRATION** | **LEVEL 4, MEETING ROOM 408**<br>***SESSIONS RUN CONSECUTIVELY*** |
| **DISCUSSION GROUP 7 - DRY GAS SEALS: GENERAL (INSTALLATION, OPERATION, TROUBLESHOOTING, AND RETROFITTING), CONTROLS** | **LEVEL 3, HALL 7B** |
| **1530 – 1600 \| REFRESHMENT BREAK** | **LEVEL 4, HALL 8B-8C** |
| **1600 – 1730 \| PANEL SESSION** | **LEVEL 3, HALL 7A** |
| **PANEL SESSION 2 - CAREER AND INDUSTRY PANEL** | **LEVEL 3, HALL 7A** |

# TECHNICAL PROGRAM SCHEDULE

| THURSDAY, 26 MAY 2022 | |
|---|---|
| 0830 - 0845 \| LEADER ORIENTATION | LEVEL 4, MEETING ROOM 410 |
| 0800 – 1300 \| REGISTRATION | LEVEL 4, HALL 8A |
| 0900 – 1030 \| TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |
| CASE STUDY 1 - CENTRIFUGAL COMPRESSOR FAILURE DUE TO DIFFUSER STALL AND BALANCING LINE RESONANCE VIBRATION ANALYSIS<br>CASE STUDY 2 - CENTRIFUGAL COMPRESSOR HIGH SUB-SYNCHRONOUS VIBRATION DURING HIGHER LOAD AND SPEED<br>CASE STUDY 3 - UNEXPECTED VIBRATION ON A CENTRIFUGAL COMPRESSOR CAUSED BY VIBRATION PROBE SUPPORT | LEVEL 4, MEETING ROOM 406<br>*SESSIONS RUN CONSECUTIVELY* |
| CASE STUDY 4 - VIBRATION DIAGNOSTIC OF STEAM TURBINE INTERMITTENT RUBBING<br>CASE STUDY 5 - STEAM TURBINE HIGH AXIAL DISPLACEMENT DUE TO GOVERNOR ACTUATOR FILTER CLOG<br>CASE STUDY 6 - INTRODUCTION OF SCC LIFE TIME ESTIMATION FOR FIR TREE DESIGN ON STEAM TURBINE ROTOR | LEVEL 4, MEETING ROOM 408<br>*SESSIONS RUN CONSECUTIVELY* |
| CASE STUDY 7 - SILO EXHAUST FAN, STRUCTURAL VIBRATION ODS AND MOTION AMPLIFICATION<br>CASE STUDY 8 - TURBOMACHINERY FOR HIGH CO2 APPLICATION: CHALLENGES, OBSTACLES AND LESSON LEARNT<br>CASE STUDY 10 - HIGH SPEED COUPLING FAILURE RELATED TO TORSIONAL VIBRATION | LEVEL 4, MEETING ROOM 403<br>*SESSIONS RUN CONSECUTIVELY* |


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| **CASE STUDY 11 - BOILER FEED PUMP ELEVATED SLEEVE BEARING TEMPERATURE AND VIBRATION PROBLEMS RESOLVED**<br><br>**CASE STUDY 12 - CASE STUDY ON INVESTIGATION AND RESOLUTION OF HIGH LUBE OIL TEMPERATURE IN PUMP BEARING HOUSING FOR OFF SPEC. CONDENSATE RECYCLE PUMPS**<br><br>**CASE STUDY 30 - APPLICATION OF POLYCRYSTALLINE DIAMOND BEARING FOR LOOP REACTOR PUMP**<br><br>**CASE STUDY 13- BEARING LOAD ANALYSIS OF RECIPROCATING PISTON COMPRESSORS** | **LEVEL 4, MEETING ROOM 405**<br>***SESSIONS RUN CONSECUTIVELY*** |
| **CASE STUDY 14 - HIGH VIBRATION IN MOTORS DUE TO SHAFT STRAY CURRENT : ANALYSIS AND RESOLUTION**<br><br>**CASE STUDY 15 - TURNING GEAR MOTOR FAILURES, CONFIRMED BY MODEL BASED VOLTAGE & CURRENT METHOD OFF SPEC. CONDENSATE RECYCLE PUMPS**<br><br>**CASE STUDY 16 - RESOLUTION OF NON-REPEATABLE SYNCHRONOUS ROTOR RESPONSE OF A POWER GENERATOR** | **LEVEL 4, MEETING ROOM 401**<br>***SESSIONS RUN CONSECUTIVELY*** |
| 0900 – 1300 \| EXHIBIT HALL OPEN | LEVEL 4, HALL 8B-8C |
| 1030 – 1100 \| REFRESHMENT BREAK | LEVEL 4, HALL 8B-8C |
| 1100 – 1230 \| TECHNICAL SESSIONS | LEVEL 4, MEETING ROOMS |

# TECHNICAL PROGRAM SCHEDULE

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|---|---|
| CASE STUDY 17 - SOLVING MECHANICAL SEAL WITH SMALL VAPOR PRESSURE MARGIN ISSUE<br><br>CASE STUDY 18 - CATASTROPHIC MECHANICAL SEAL FAILURE LEADING TO LOSS OF PRIMARY CONTAINMENT (LOPC)<br><br>CASE STUDY 19 - HIGH SPEED PUMP MECHANICAL SEAL BAD ACTOR RESOLUTION | LEVEL 4, MEETING ROOM 408<br>*SESSIONS RUN CONSECUTIVELY* |

## THURSDAY, 26 MAY 2022 *(CONTINUED)*

| | |
|---|---|
| CASE STUDY 20 - DETECTION OF BROKEN BLADE ON COMPRESSOR<br><br>CASE STUDY 21 - VIBRATION ISSUE ON COMPRESSOR IN A NITRIC ACID PLANT (PART 2)<br><br>CASE STUDY 22 - TROUBLESHOOTING OF AIR COMPRESSOR HIGH VIBRATION DURING COMMISSIONING STAGE | LEVEL 4, MEETING ROOM 406<br>*SESSIONS RUN CONSECUTIVELY* |
| CASE STUDY 23 - PITTING CORROSION LED TO CATASTROPHIC GAS TURBINE COMPRESSOR BLADE LIBERATION<br><br>CASE STUDY 24 - GAS TURBINE LOAD LIMITED DUE TO HIGH EXHAUST TEMPERATURE DEVIATION<br><br>CASE STUDY 25 - GAS TURBINE COMPRESSOR INLET AIR FILTERS PERFORMANCE COMPARISON<br><br>CASE STUDY 9 - ELECTROSTATIC DISCHARGE-STG COMPRESSOR | LEVEL 4, MEETING ROOM 403<br>*SESSIONS RUN CONSECUTIVELY* |
| CASE STUDY 26 - CHRONIC HIGH VIBRATION ISSUE OF A CONDENSATE PUMP<br><br>CASE STUDY 27 - RELATION BETWEEN WEAR RING CLEARANCES AND NON-SYNCHRONOUS VIBRATIONS IN BFW CENTRIFUGAL PUMP<br><br>CASE STUDY 28 - PUMP VIBRATION DUE TO RECIPROCATING ENGINE BALANCE GEAR ISSUE | LEVEL 4, MEETING ROOM 401<br>*SESSIONS RUN CONSECUTIVELY* |

TEXAS A&M UNIVERSITY

# TPS

## 51ST TURBOMACHINERY & 38TH PUMP SYMPOSIA

TEES TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

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# PROGRAM



# SHORT COURSE DESCRIPTIONS

## Short Course 1 -
## Transmission Technology

**Monday, 23 May 2022**
**Level 4, Room 406** **0900 - 1730**

**Instructors: : Gwenael Perney (Lufkin Gears France), Joseph Watson (Allen Gears), Gaspare Maragioglio (Baker Hughes)**

In May 2021 the International Energy Agency (IEA) released its net-zero by 2050 report, a roadmap on how it believes industry, governments, investors, and citizens can advance the energy transition, in order to decarbonize fossil fuels and push for a greener, more diverse energy mix. Most of the global reductions in CO2 emissions between now and 2030 in the IEA net-zero pathway come from existing technologies. In 2050, almost half the reductions come from technologies that are currently only at the demonstration or prototype phase and this calls for major innovation progress this decade. According to the IEA pathway, the biggest innovation opportunities concern advanced batteries, hydrogen electrolyzes, and direct air capture and storage, but the turbomachinery industry is also called to provide its contribution, through advanced compression and combustion turbine technology for hydrogen use/distribution, carbon capture and geothermal. In the mentioned environment the turbomachinery OEM's are all exploring new frontiers in terms of products, this to support the applications for New Energy Solutions. Having said that, in a contest where power and rotating speed are going up, and where it is required to go beyond the experienced boundaries, the transmission technology became a key element. We see more and more unconventional combination of referenced drivers with referenced driven equipment, but never integrated in a single power train so far, like for instance the medium/ large Gas Turbines driving Reciprocating Compressors for H2 industry, multi shafts integral gear compressors, or hybrid trains with GT's, Electric Machines and Compressors, to mention but a few. This course on Transmission Technology is aimed to provide the audience with basic and advanced information on load gearboxes, used in the turbomachinery and pump applications, for the users to know better capabilities and limits of a product which is called to a core transformation.

## Short Course 3 -
## Best Practices in Turbomachinery Maintenance and Reliability

**Monday, 23 May 2022**
**Level 4, Room 407** **0900 - 1730**

**Instructors: Arun Kumar (HPCL- Mittal Energy Limited (HMEL), INDIA)**

Turbo machinery in process industry is business critical equipment and in number of cases it is a single line equipment (without any stand by). Undesired stoppage of turbomachinery in between maintenance intervals can cause a severe limitation such as throughput reduction or complete stoppage of unit/ complex. This calls for a strong and focused approach towards maintenance strategizes. The maintenance work is to be completed in limited time , should be well planned , of high quality , with no rework so as to achieve high reliability & uninterrupted operation of machine afterwards with sustained efficiency for prolonged time. For single line supercritical turbomachines the only opportunity available for maintenance and servicing is a planned turnaround. Normally, turnaround in refineries are scheduled at an interval of 4-5 years of operation. It has financial impact due to both 'loss of production' and

'shutdown expenses'. At the same time, it results in increase in asset reliability, continued production, inspection and reduction in the risk of unscheduled outages or catastrophic failures. Hence the turbomachinery has to perform well, as required, minimum till next turnaround cycle. Method are being thought of to increase the span between two turnarounds which places a challenge to ensure reliability of turbomachinery for a prolonged / extended period. This can be achieved by adopting best practices in machines maintenance and reliability. The future calls for predictive analytics and early detection of faults in turbomachinery so that action can be planned and executed instead of surprise. This call for digital transformation in area of turbomachinery maintenance and reliability. The subject short course compiles the practical aspect of maintenance and reliability practices out of experience, learnings and facts so as to achieve the high expectation in asset safety, integrity & reliability. The content of short course is systematically placed taking care of the attendees' requirement and easy grasping of the practices step by steps, supported by success stories and highlights of take away at the conclusion of the short course.

## Short Course 4 -
## Introduction to Industrial Gas Turbines

**Monday, 23 May 2022**
**Level 4, Room 405** **0900 - 1730**

**Instructors: Rainer Kurz (Solar Turbines), Klaus Brun (Elliott Group)**

The Short Course on Industrial Gas Turbines covers the gas turbine design principles by outlining all the major components of gas turbines, such as axial flow compressors, axial flow turbines, and dry low NOx combustors. This course will review the principal design aspects of its thermodynamics cycles, package requirements for the gas turbine, operation and maintenance practices as well as their effect on plant operation, plant availability, and reliability. It also addresses specific applications in the Oil and Gas Industry.

## Short Course 5 -
## Lateral & Torsional Rotordynamics of Machinery

**Monday, 23 May 2022**
**Level 4, Room 403** **0900 - 1730**

**Instructors: Brian Pettinato (Elliott Group), Jason Wilkes (Southwest Research Institute)**

One of the foremost concerns facing rotating equipment users today is that of torsional vibration. In contrast to lateral vibration, torsional vibration is rarely monitored. As a result, torsional failures can be especially heinous since the first symptom of a problem is often a broken shaft, gear tooth, or coupling. In the past, torsional vibration problems were considered to be rare; however the number of torsional field problems has markedly increased recently with the advent of higher power, higher complexity variable frequency drives (VFD's). The increased risk plus the difficulty of detecting incipient failures in the field makes the performance of a thorough torsional vibration analysis an essential component of the turbomachinery design process. There are three primary objectives to this Short Course: basic understanding of steadystate torsional vibrations, their potential for generating problems, and methodologies

that are commonly used to analyze and avoid these problems; provide users with some understanding of the more complex issues related to transient torsional vibration and acceptance based on stress analysis; & educate users on how VFD's work, and why they are a concern from a torsional standpoint.

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## Short Course 6 -
## Introduction to Reciprocating Compressors, Components, and Troubleshooting

**Monday, 23 May 2022**
**Level 4, Room 408** **0900 - 1730**

**Instructors: Andreas Brandl, Bernhard Fritz, Ahmad Faiz Kamarudin (Hoerbiger)**

Course Agenda

- Introduction to Reciprocating Compressors
- Break
- Introduction to Rings and Packing
- Introduction to Valves
- Lunch
- Theory of Compression and Capacity Control
- Introduction to Compressor Maintenance
- Break
- Compressor Diagnostics and Component Troubleshooting

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## Short Course 7 -
## Pump Fundamentals

**Monday, 23 May 2022**
**Level 4, Room 401** **0900 - 1730**

**Instructors: Nick Ahrens (Sulzer)**

The Sulzer Academy for pumps and systemsbrings its highly acclaimed Pump Fundamentals course to ATPS. An ideal introduction or refresher course for engineers and technicians with responsibilities involving pump systems. This one-day training class covers pump hydraulic fundamentals, operating principals, system design and cavitation prevention. The course helps system designers and operators understand centrifugal pumps and associated auxiliary equipment and hence improve the efficiency and reliability of their pumping equipment. The course will be conducted by Sulzer's senior technical trainer- Nick Ahrens, a chartered mechanical engineer with more than 30 years of in-depth experience designing and managing pumps and systems.

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# LECTURE DESCRIPTIONS

## Lecture 1 -
## Advances In Ammonia Combustion Chemistry And NH3 Sensing Using Laser Diagnostics

**Tuesday, 24 May 2022**
**Level 4, Room 406** **1100 - 1145**

**Instructors: Eric Petersen, (TEES Turbomachinery Laboratory), Sulaiman Alturaifi, (Texas A&M Univeristy), Olivier Mathieu, (Texas A&M University)**

Ammonia (NH3) is a promising alternative carbon-free fuel. For this reason and others, significant research is directed towards studying NH3 especially pertaining to its chemical kinetics. A brief review of the literature on ammonia combustion chemistry is provided in this paper, with emphasis on the studies related to fundamental reaction kinetics at elevated temperatures. Until recently, NH3 was never measured using laser absorption spectroscopy to study its chemical kinetics. This recent NH3 measurement was conducted by the authors? group using a newly developed laser absorption diagnostic that probes the v2 fundamental band of NH3 in the mid-infrared near 10.4 ?m. The present study utilized this recently developed NH3 diagnostic to highlight its capabilities and potential future use for studying ammonia combustion chemistry and also as an ammonia sensor for practical applications. The laser was operated using two methods: a scanned-wavelength method to measure the absorption spectra of NH3-containing mixtures, and a fixed-wavelength method to measure NH3 time histories behind reflected shock waves. The scanned-wavelength method was used to determine the NH3 mole fraction in multi-component gas mixtures; such a method presents future promise when the accurate determination of NH3 in a sampled gas is needed. The fixed-wavelength method, coupled with a shock tube, was used to follow NH3 time histories during the oxidation of NH3/O2 in Ar; such a method shows promise for studying the chemical kinetics of ammonia.

## Lecture 2 -
## Hydrogen-Combustion and Compression

**Tuesday, 24 May 2022**
**Level 4, Room 406** **1145 - 1230**

**Instructors: Rainer Kurz (Solar Turbines)**

Recently, the use of hydrogen-natural gas mixtures as a fuel, but also as a means of storing and transporting hydrogen from surplus electricity as a result of renewable energy production has drawn significant attention. One of the approaches to manage the intermittent nature of wind and solar generated electricity is to create, store and transport hydrogen in natural gas pipeline networks. Blending hydrogen into the existing natural gas pipeline network appears to be a strategy for storing and delivering renewable energy to markets. Adding Hydrogen to the natural gas requires considerations regarding combustion systems, as well as the impact on compressors and pipeline hydraulics.

This paper addresses combustion issues with various levels of hydrogen in natural gas, the transport of these mixtures in pipelines, and the compression of these mixtures. Thus, the transport efficiency of the pipeline, the impact

on pipeline capacity, and the capability of existing and new infrastructure to use natural gas – hydrogen mixtures as fuel are discussed.

Used as a fuel, hydrogen-natural gas mixtures increase the reactivity, with increased flame velocity, reduced auto-ignition delay times, and a wider range of flammability. The handling of failed starts, where unburned fuel can be present in the exhaust system and may cause an explosion hazard, has to be addressed. Increasing hydrogen content also increases flame temperature which can lead to higher NOx emissions and mitigation strategies are discussed. Results from analysis and rig testing of the combustion components with hydrogen and natural gas mixtures are presented.

## Lecture 3 -
## Coking of Gas Turbine Lubrication Oils at Elevated Temperatures

**Wednesday, 25 May 2022**
**Level 4, Room 406** **0900 - 0945**

**Instructors: : Eric Petersen (TEES Turbomachinery Laboratory), Raquel Juarez (Texas A&M University)**

Over the last several decades, turbine efficiency has improved significantly, resulting in higher turbine operating temperatures that negatively affect the lubricating oil circulating through the system. Exposure to high temperatures results in oil degradation and the eventual formation of solid deposits in the oil which greatly limit the oil's ability to reduce wear and cool the turbine components. An experimental apparatus was designed and built to allow for the studying and better understanding of this phenomenon. The apparatus consists of a flow loop with a heated test section through which the oil is pumped. The oil that comes into contact with the hot surfaces degrades and forms solid deposits. As time passes, the deposit buildup decreases the heat transfer that occurs at the test section. Deposit induction time and buildup rate are measured, and the deposits can also be analyzed. Air or an inert gas may be used to pressurize the system up to 69 bar, while test section surface temperatures may be as high as 650°C. Data from an initial test performed with the apparatus using a gas turbine lube oil are included in this paper. The test resulted in the clear formation of solid deposits on the heated surfaces and in the data that show the decrease in the bulk oil temperature over time due to their formation. Assembly and testing of the apparatus have been completed, and it is now fully operational and ready for future studies on lubricating oil thermal degradation and oxidation.

## Lecture 4 -
## Ignition Characteristics of Gas Turbine Lubrication Oils

**Tuesday, 24 May 2022**
**Level 4, Room 408** **1145 - 1230**

**Instructors: Eric Petersen (TEES Turbomachinery Laboratory) , Alfaia Ba Sallom, Sean Cooper, David Teitge, James Thomas, Chad Mashuga, Olivier Mathieu (Texas A&M University)**

Ignition of lubricating oil is a highly undesirable event that is a major safety hazard that could also be incredibly costly. The possibility for lubricant ignition is present in numerous mechanical systems and applications. To better understand this possibility, an extensive review of the literature reveals the applications affected by this hazard and methods that have

been applied to understand the underlying causes. While some work has been completed in this area, the fundamental chemical kinetics of lubricant ignition remains widely unknown. A shock-tube experiment was hence developed and implemented to collect fundamental ignition delay time (tign) measurements of lubricants at high temperatures. The shock tube is used to generate high-temperature air, and an automotive injector is used to spray lubricant into the high-temperature air. Combustion of the lubricant is then observed using pressure and chemiluminescence diagnostics. Several key features are observed in the resulting τign curve from the experiments, and these observations are briefly described and discussed. A second experiment, designed to characterize the propensity of an oil to ignite when touching a hot surface was also developed, called the hot-surface ignition experiment. Initial results from this experiment demonstrate the ability to determine a minimum ignition temperature for an off-the-shelf gas turbine lubrication oil.

## Lecture 5 -
## Realistic Expectations from a Unique Plan 66A Bushing Design

**Tuesday, 24 May 2022**
**Level 4, Room 406** **1400 - 1445**

**Instructors: Jim Wasser, John Morton (John Crane)**

The Plan 66A is an API piping plan for leakage containment primarily intended for use on crude oil (pipeline) duties. Crude liquid hydrocarbon pipelines represent 1/3rd of total liquid hydrocarbon mileage. The arrangement is generally used on single seal installations – marginalizing this as a North American solution where single seals on crude pipeline applications are still common. Whilst it is intended for wide spread use there are only a few primary operators that have adopted this type of containment technology. Many operators still deploy plan 65 arrangements, whilst others have moved from Plan 65's or similar to a full API Type 2 arrangements employing a full back up mechanical seal.

## Lecture 6 -
## Evaluation Of Various Methods For Manufacturing One Piece, Small Tip Opening Impellers

**Tuesday, 24 May 2022**
**Level 4, Room 408** **1400 - 1445**

**Instructors: Scot Laney, Derrick Bauer (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 7 -
## Design and testing of a centrifugal compressor for supercritical CO2 application

**Tuesday, 24 May 2022**
**Level 4, Room 406** **0945 - 1030**

**Instructors: Alberto Milani, Ernani Fulvio Belobuono, Giuseppe Vannini, Manuele Bigi, Matteo Dozzini, Silvia Evangelisti, Valentina Bisio (Baker Hughes)**

sCO2Flex (H2020 grant agreement #764690) is a project that addresses the necessities to upgrade existing fossil fuel plants to integrate

renewable energy sources increasing the overall efficiency in power generation plus avoiding the use of water. Deliverable of the project is the development and validation of all main components of a sCO2 Brayton cycle capable to provide 25MWe at 100% load ensuring a wide plant flexibility (from 100% to 20% of the electrical load). Moreover, it includes testing of a centrifugal compressor prototype.

The present work will describe several new challenges faced by OEM during the design of turbomachinery for this application. The first is linked to the operating conditions of the main compressor, which achieves the highest cycle efficiency in a region close to the CO2 critical point. In these conditions, possible co-existence of different phases may occur with sudden change of speed of sound causing uncertainties in performance predictability. To minimize these uncertainties and at the same time fulfil loop flexibility needs, specific design for compressor internals was adopted and will be discussed in this article.

The present work will conclude with highlights on the full size 5 MW prototype compressor that was manufactured and tested in OEM test facility in Q2 2021. The test replicated exactly the nominal operating conditions, specifically vicinity of the compressor suction to CO2 critical point. This has enabled a direct validation of compressor performance predictability and at the same time allowed to verify the compressor rotordynamic, mechanics and aerodynamic behavior.

## Lecture 8 -
## Crude Oil Non-Pusher Secondary Seal

**Wednesday, 25 May 2022**

**Level 4, Room 408** **0900 - 0945**

**Instructors: Jim Wasser, John Morton (John Crane)**

Crude oil pipeline pumps traditionally suffer from seal leakage due to the fretting or wearing of the dynamic O-ring. A new concept secondary seal has been developed to eliminate this fretting occurrence. All major seal suppliers have products designed specifically for the operational challenges of crude oil pipeline services, some more than others recognize the application difficulties and have design characteristics that belie these. However none are designs based on non-pusher secondary seal concepts. A "non-pusher" style represents a targeted response to customer dissatisfaction and root cause of failure where crude oil is sealed. A more robust non-dynamic secondary seal cannot hang up and a non-dynamic secondary seal does not wear the stub sleeve. Site surveys and equipment Root Cause Analysis, have shown that solids & debris contained in the pumped product result in secondary seal damage and ultimately seal failure. Degradation of this secondary seal subsequently wears the stub sleeve making refurbishment more costly.

Providing a more reliable secondary seal, especially as pumping stations that serve transmission and gathering pipe lines can be very remote and often unmanned, increases both pump and pipeline reliability. Reduced sleeve fretting maintains seal integrity, delivering improved spill prevention, and is valuable to operators in terms of assets protected as well as critical asset expansion. This paper will look at the design theory of a non-collapsible flexible sealing membrane, the subsequent successful development and testing of a non-pusher elastomer seal, and field deployment.

## Lecture 9 -

### Leakage And Dynamic Force Coefficients For A Stepped Labyrinth Seal And A Stepped Pocket Damper Seal Supplied With Wet Gas

**Tuesday, 24 May 2022**
**Level 4, Room 408** **0945 - 1030**

**Instructors: Luis San Andres (Texas A&M University), Jing Yang (TAMU-Turbomachinery Laboratory), Jose Torres (Texas A&M University)**

The lecture presents experimental results for the leakage and dynamic force coefficients for a stepped shaft PDS and a stepped shaft LS. Both seals feature the same journal diameter D (127 mm), seal length L = 0.38D, and four blades (eight 45º pockets), and slightly different clearances. The operating conditions are similar: shaft speed up to 5,250 rpm (surface speed = 35 m/s), pressure ratios (inlet/exit) = 2.5 to 4.2, and a wet gas composition with up to 10% in liquid volume fraction. For an inlet LVF ranging from 0 to 10%, the LS leaks more, as its step clearance is 15% larger than that of the stepped PDS. For operation with just gas (LVF=0), the LS effective clearance (Ce) is ~ 60% larger than that for the PDS. Under wet gas conditions (maximum inlet LVF = 6%), Ce for the PDS decreases as LVF increases, whereas Ce for the LS increases. The LS produces negligible direct stiffness (K) and effective damping (Ceff) compared to the force coefficients of the PDS. The excitation frequency more so than journal speed affects the K and Ceff of the PDS. The PDS direct damping decreases steadily with frequency while slightly increasing as the inlet LVF increases from 0 to 0.7%. For whirl frequencies below 60 Hz, the PDS direct (centering) stiffness is negative, its magnitude increasing with the liquid content. The stepped PDS exhibited subsynchronous vibrations (SSVs) for operation with a wet gas, and which became broadband with more liquid added.

## Lecture 10 -

### Experiences From Developing Material Qualification Plans For Additively Manufactured Stainless-Steel Parts As Replacements To Equivalent Casting Grades

**Wednesday, 25 May 2022**
**Level 4, Room 406** **1100 - 1145**

**Instructors: Timothy Nitz, Kaushik Asokan, Guo Shanwei (Flowserve)**

Metal Additive Manufacturing (AM) has emerged as a state-of-the-art technology with the potential to revolutionize the global parts manufacturing landscape and drastically reducing manufacturing lead times. The technology enables the production on-demand pump components particularly suited to the aftermarket sector where parts are of high mix and low volume. This paper presents a comprehensive study to qualify 3D-printable materials for use in the construction of pump impellers. Analyses on chemical compositions and mechanical properties of additively manufactured austenitic and martensitic stainless steels are addressed and benchmarked against equivalent standard cast grades, typically used in pump impeller construction. Further investigations were done to correlate the impact of different heat treatment cycles and their effects on mechanical and corrosion properties. Discussions on intergranular corrosion (IGC), corrosion rates from standardized corrosion tests, as well as material selection guidance of these AM-equivalents are also presented in this paper.

## Lecture 11 -

### Design, Testing, Commissioning And Operating Experience Of A 2000hp Hydraulic Turbocharger For Reducing Carbon Footprint Of Acid Gas Recovery Process

**Wednesday, 25 May 2022**
**Level 4, Room 408** **1100 - 1145**

**Instructors: Chinmay Deshpande, Matthew Pattom, Dung Tran (Energy Recovery), Rehan Farooqi, Mohammad Buali, Abdullalh A. Al-Ghamdi (Saudi Aramco)**

Four sets of hydraulic turbocharger based energy recovery systems (2000 hp each) were successfully designed, manufactured, tested and commissioned for Acid Gas Recovery plants (AGR) in Saudi Arabia. The hydraulic turbocharger consists of a liquid phase turbine runner and a pump impeller mounted in a back-to-back configuration on a common rigid shaft, in a single seal-less casing. The shaft is supported by process lubricated hydrodynamic radial and axial (dual-acting) bearings of non-metallic construction. The turbine side extracts wasted pressure energy from the rich amine and along with a series of throttle, auxiliary and bypass valves, controls the level in the absorber. The pump side boosts the lean amine solvent to the absorber. Such a design provides major advantages compared to a conventional configuration of a reverse running pump-as-turbine coupled to a pump. These advantages include a compact single stage hydraulic design (as opposed to a multi-stage design for a reverse running pump), smaller footprint, higher efficiency, absence of mechanical seals & associated support system, absence of lubrication oil system as well as simpler control.

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## Lecture 12 -

## On The Influence Of Lubricant Feedhole Size And End Plate Seals' Clearance On The Dynamic Performance Of Integral Squeeze Film Dampers

**Wednesday, 25 May 2022**

**Level 4, Room 408** **1145 - 1230**

**Instructors: Luis San Andres (Texas A&M University), Jing Yang (TAMU-Turbomachinery Laboratory), Jose Torres (Texas A&M University)**

In rotating machinery, squeeze film dampers (SFDs) reduce rotor synchronous response amplitude motions, provide structural isolation and enhance rotordynamic stability. Compared to conventional squirrel cage supported SFDs, integral squeeze film dampers (ISFDs) are more compact and require a shorter axial span. This paper presents predictions of pressure profile, lubricant flow rate, and dynamic force coefficients of a four-arc pads ISFD having a diameter D= 141 mm, length L= 0.4 D, and clearance c =0.004 D; and configured with distinct inlet orifices (d0=1.98 mm to 3 d0) and ends' seal gaps b1 =0.191 mm = 1/3 c to 3b1. The analysis quantifies the effect of the lubricant feedholes' size and the end seals' gap on the required flow and force coefficients of an ISFD for a typical compressor. An increase in feed orifice diameter, from d0 to 2d0, rises significantly the fluid film pressure, delaying the onset whirl speed of oil cavitation although demanding of more flow rate. Incidentally, for a nominal gap b1 in the end plate seals, the ISFD damping and inertia coefficients reduce by almost 1/3 as the oil feed orifice diameter increases from d0 to 2d0. The ISFD damping and inertia coefficients are more sensitive to the end seal clearance than to the diameter of the oil feed orifice. In addition, predictions for the ISFD operating with an air in oil mixture shows that the damping and added inertia coefficients drop almost linearly as the inlet gas volume fraction (GVF) increases from 0.0 (all liquid) to 0.2.

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## Lecture 13 -

## Numerical And Experimental Analysis Of Starvation In A Tilting Pad Journal Bearing

**Wednesday, 25 May 2022**

**Level 4, Room 406** **1400 - 1445**

**Instructors: Cori Watson-Kassa, Houston Wood, Roger Fittro (University of Virginia - ROMAC), Bruce Fabijonas, Scan DeCamillo, (Kingsbury Inc), Minhui He (BRG Machinery Consulting)**

A series of journal bearing tests were conducted to acquire more detailed information on the behavior of individual pads in a tilting pad journal bearing and how the individual behavior may affect the performance and dynamic characteristics of the bearing. Load cells, proximity probes, and an array of

capacitance and temperature probes were installed to measure pad motion, oil films, and hydrodynamic film forces of the individual pads. Unique information regarding the oil films and hydrodynamic forces were acquired during the course of the tests. Two results are particularly interesting. First, the oil films tend to aerate at the axial edges in the case of insufficient flow rather than starve the leading edge. (Leading edge starvation is a typical assumption in direct lube bearing code development). Second is a tendency for an increase in temperature towards the axial edge rather than the trailing edge centerline of the pad surface in the case of insufficient flow. The side aeration and increased edge pad temperature were difficult to envision as simultaneous until a recently published computational fluid dynamics (CFD) analysis of a slider bearing predicted similar behavior. The authors decided to collaborate on applying the CFD analysis to the tilt pad experimental configuration, the results of which are presented in this paper.

## Lecture 14 -
## Cavitation Performance Improvement Of An Industrial Cryogenic Centrifugal Pump By Implementing Variable Pitch Inducer

**Wednesday, 25 May 2022**
**Level 4, Room 406** **1445 - 1530**

**Instructors: Klaus Brun, Brian Pettinato (Elliott Group), Rainer Kurz (Solar Turbines), Eugene Broerman (SwRI)**

Cavitation performance improvement of an industrial cryogenic pump is studied in this paper. A variable pitch helical inducer is designed and implemented to the existing pump assembly to enhance the cavitation performance in terms of Net Suction Positive Head (NPSH). Initially, Computational Fluid Dynamics (CFD) simulations of the pump assembly are conducted for the original configuration and the pump with new proposed inducer to determine the cavitating (two-phase) and non-cavitating (single-phase) performance. The Rayleigh-Plesset cavitation along with homogeneous fluid model is used to study the bubble dynamics under the assumptions of single fluid undergoing no thermal energy transfer between each phase. Experimental tests are conducted on the existing configuration of the pump and also with the new variable pitch inducer to determine the true performance in cavitating and non-cavitating operating conditions. Experimental results are compared to the simulations to validate the accuracy of the proposed numerical modelling and assumptions. NPSH with 3% (NPSH3) differential head drop is employed as a criterion to identify the true cavitation performance of each inducer configuration. It is found that, NPSH3 performance can be improved by 25% by replacing the existing inducers with the proposed new variable pitch inducer. In addition, with the new inducer there is minimal impact to the existing single-phase pump performance.

## Lecture 15 -
## The Use Of Acoustic Comb Filters To Avoid Centrifugal Compressor Discharge Blade-Pass Pulsation Induced Piping Vibrations

**Wednesday, 25 May 2022**
**Level 4, Room 408** **1400 - 1445**

**Instructors: Klaus Brun, Brian Pettinato (Elliott Group), Rainer Kurz (Solar Turbines), Eugene Broerman (SwRI), Marybeth Mcbain (Kinder Morgan)**

Centrifugal compressor blade-pass interaction periodic pulsation can cause acoustic resonance conditions and pipe vibrations in the suction and discharge lines of the compressor. A series of two or more progressively placed quarter wave resonators, called a quarter wave comb filter, can be designed to attenuate these pulsations and eliminate the risk of acoustically induced pipe vibrations. Comb filters have been used and demonstrated for over 50 years for a wide range of acoustic attenuation applications and their physics is well understood. This paper discusses the practical design of such a comb filter, its installation in the downstream piping near the discharge of the compressor, basic comb filter design rules, a step-by-step design process for comb filters, and provides a basic

case study which quantifies its attenuation effectiveness. A number of parametric studies for key design variables, such as the number of circumferentially located comb filters, stub diameters, and number of filter stages versus pulsation attenuation effectiveness, are also presented. Results showed that two to three-stage comb filters can be effectively used to eliminate centrifugal compressor blade-pass excitation induced pipe radial resonances and associated vibrations.

## Lecture 16 -

## High Frequency Acoustic Excitation in Centrifugal Compressor and Adjacent Piping Vibration

**Wednesday, 25 May 2022**

**Level 4, Room 408** **1445 - 1530**

**Instructors: Daisuke Hirata, (Mitsubishi Heavy Industries Compressor Corporation), Akihiro Nakaniwa, Yoshitsugu Nekomoto, (Mitsubishi Heavy Industries, Ltd.), Pieter Beek, (TNO), Fady Ibrahim, (Yara AB), Luca Frediani, (Casale SA)**

In a centrifugal compressor, interactions between impeller blades and stationary parts such as diffuser vanes will generate high frequency pressure pulsations. The frequencies of these pulsations, so called "blade passing frequency" (hereafter BPF), depend on the rotating speed and number of impeller blades. The BPF of a centrifugal compressor is typically beyond 1 kHz, and the resulting pressure pulsations can excite high frequency vibrations in the compressor itself and in the adjacent process piping. In the piping system, generally, there are many natural frequencies around the BPF, and the accompanying vibration modes can be complex shell wall type. In some cases, excessive piping vibration and noise radiation can be observed due to excessive BPF pulsation amplitudes. In the worst-case scenario, cracks in the pipe and eventual failure can occur. Any pipe failure is a serious safety concern and can further cause downtime for the plant operation. It is, therefore, very important to control the piping vibration in the engineering phase of the design.

# TUTORIAL DESCRIPTIONS

## Tutorial 1 -
### Pneumatically Actuated Control Valves in Oil Systems: Hardware Recommendations and Tuning Considerations

**Tuesday, 24 May 2022**
**Level 4, Room 403** **1100 - 1230**

**Instructors: Alex Schaefer, Brian Pettinato (Elliott Group)**

Well designed and properly commissioned auxiliary systems are crucial to the reliability of rotating equipment. This paper addresses the upfront hardware selection and commissioning of pneumatically actuated control valves when applied in oil systems. Either improper selection and tuning of these valves or improper system design can cause poor reliability of the oil system resulting in spurious trips that can adversely impact turbomachinery and plant operation. Common problems are addressed.

## Tutorial 2 -
### Laser Welding for Turbomachinery Rotor Restoration

**Tuesday, 24 May 2022**
**Level 4, Room 405** **1100 - 1230**

**Instructors: Michael Kuper, Michael Metzmaier (Elliott Group)**

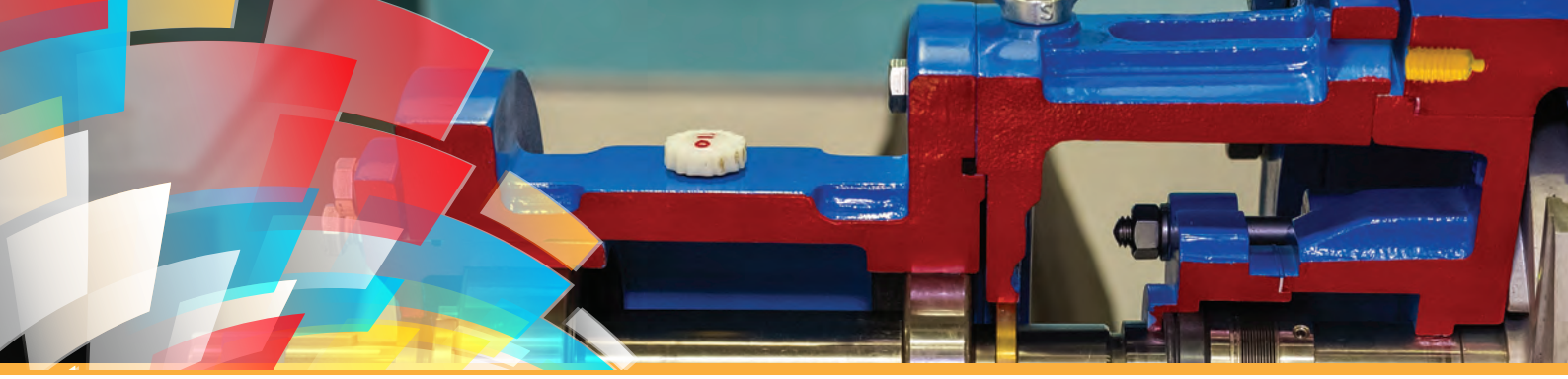
Laser cladding is gaining acceptance for turbomachinery rotor restoration, which has resulted in increased customer demand for laser cladding options. This has increased the number of laser welding suppliers. Therefore, it is important to understand the basic capabilities, limitations, and potential pitfalls of the laser cladding process. It is still unclear how the process should be qualified to ensure that laser weld repairs meet the requirements for turbomachinery applications. Filler material alloy selection, form, and delivery methods can have a significant impact on the quality and suitability of the weldment. Also, it is commonly claimed that a post weld heat treatment is not required with laser welding due to the low heat input of the process, which greatly reduces the size of the heat affected zone. Little academic research has been done to prove this claim, so further testing must be completed to ensure that the repaired component will be suitable for the application. This is especially important for quenched and tempered steels, which form fresh martensite during welding. This paper discusses the most commonly repaired shaft areas, the risks associated with laser welding in these locations, and the types of tests that should be required to qualify a procedure.

## Tutorial 3 -
### Comparison Of Contacting Wet And Dry Gas Seals (DGS) For Main Pipeline Pumps In NGL Services

**Tuesday, 24 May 2022**
**Level 4, Room 403** **1400 - 1530**

**Instructors: Emery Johnson (EagleBurgmann), Jim O'Hare, Bernhard Gilch, Andreas Pehl, Nikolaus Necker (EagleBurgmann Germany GmbH & Co. KG)**

This paper discusses the general design aspects for two different sealing technologies applied in NGL pipeline services, in particular the leakage and friction behavior. The two designs being, contacting wet lubricated mechanical seals



(2CW-CS / Arrangement 2 Contacting Wet – Containment Seal) and non-contacting Dry Gas Seals (2NC-CS / Arrangement 2 Non-Contacting – Containment Seal). The impact of critical operating parameters like vapor pressure and temperature margin, flush flow rates, solids handling, axial shaft shuttling is assessed. In addition to safety, leakage containment and monitoring related aspects are described and compared with the mechanical seal selection.

## Tutorial 4 -
## Key Differences between Steam Turbines and Electric Motors as Main Compressor

**Tuesday, 24 May 2022**
**Level 4, Room 405** **1400 - 1530**

**Instructors: Tomoaki Nogami, Ayush Singh, Rishav Jain, Yusuke Oishi, Yuta Miwada (Mitsubishi Heavy Industries Compressor Corporation)**

This study starts by presenting a typical ethylene plant which will act as the 'base plant' for this case study. Then, a 'low-emission' ethylene plant is introduced which employs a new cracker technology having the potential to reduce the requirement of fuel by nearly 30%. Next, this study explores the key differences present between two types of drivers (namely, Steam Turbines and Electric Motors) on the basis of Utility Requirement, Cost (both Capital expenditure and Operational Expenditure), Carbon Footprint(including manufacturing process), Maintenance requirements, operability, and train arrangement. As a result, it is shown that a mix of steam turbine and motor drivers are beneficial and leave less carbon footprint than traditional plants but with high financial cost. Additionally, recent technology developments are helping OEMs to decrease the utility requirement in case of steam turbine drivers. So, this study also talks about the elimination of two such utilities, i.e. Control oil for control valves (which are used to actuate the inlet steam of turbines) and LP steam for ejectors (which are used to suck air out of condensers in order to maintain the exhaust pressure of turbines). Automatic operation of the steam turbine for the better operability is also introduced. Furthermore, this study talks about generator steam turbines, which are installed in the ethylene plant, for private power generation. The difference of Cost (both Capital expenditure and Operational Expenditure), Carbon Footprint between the private electric power case and the public electric power case is also discussed in this study.

## Tutorial 5 -
## Modern Lubricating Oil Systems

**Wednesday, 25 May 2022**
**Level 4, Room 403** **0900 - 1030**

**Instructors: Neetin Ghaisas (Fluor), Charles (Chuck) Parker (G.J. Oliver, Inc.), Michael Long (The Hilliard Corporation)**

This tutorial discusses the selection and sizing considerations for components and elements that constitute the pressurized lubricating oil system for a modern turbomachinery string. The design principles explained in this text are commonly applied to oil systems that serve different types of driven and driving equipment. Hydraulic oil systems for gas turbines are not covered in this text.

Auxiliary components and accessories, such as oil accumulators, overhead rundown tanks (atmospheric and pressurized), oil mist eliminators and oil conditioners are elaborated

in the following sections. It also presents a sample Hazard and Operability Study (HAZOP) of API 614 oil system with typical causes, consequences, severity, and barriers.

## Tutorial 6 -
## Annular Clearance Gas Seals: Models And Measurements For Leakage, Force Coefficients And Their Effect On Rotor Stability

**Wednesday, 25 May 2022**
**Level 4, Room 405** **0900 - 1030**

**Instructors: Adolfo Delgado, Associate Professor (Texas A&M University - Turbomachinery Laboratory), Jing Yang (TAMU Turbomachinery Laboratory), Luis San Andres (Texas A&M University- Turbomachinery Laboratory)**

Turbomachinery seals are engineered to maintain efficiency and power delivery by minimizing leakage. Seals also appreciably affect the system rotordynamic behavior due to their relative position within a turbomachine. The tutorial reviews the experimental record on gas seals as published in the 21st century, and gives insight on the physical models predicting leakage and dynamic force coefficients. Unlike experiences in the past century, damper seals offer a remarkable opportunity to control the leakage and tailor the rotordynamic performance and stability of modern rotating machinery.

## Tutorial 7 -
## Mechanical Sealing Technology used in Multiphase Pump Applications

**Wednesday, 25 May 2022**
**Level 4, Room 403** **1100 - 1230**

**Instructors: Nikolaus Necker (EagleBurgmann Germany)**

Multiphase pumps have demonstrated their capability to operate successfully in pumping the product extremes, means 100% liquid up to 100% gas, and solids. This duty is difficult for a pump and thus even more difficult for its mechanical seals, which are a critical component of any pump.

The tutorial gives an overview about the most used multiphase pump technologies, from rotary screw pumps up to helico-axial pumps. It focuses on a comprehensive overview about the different concepts sealing multiphase with single or with dual seal arrangements. It also describes seal face materials, like Diamond Face Technology, which offers specific benefits in multiphase applications.

## Tutorial 8 -
## Mitigation Of Axial Vibration And Thrust Bearing Failures In Rotating Machinery

**Wednesday, 25 May 2022**
**Level 4, Room 405** **1100 - 1230**

**Instructors: Mantosh Bhattacharya (PETROFAC)**

The objectives of this tutorial are to familiarize rotating machinery engineers involved in detailed engineering and site operation on various aspects of axial vibration in rotating machinery. Among all rotating machines failure modes in various sectors of industries, issues of axial vibrations and thrust bearing failures are puzzling and difficult to solve. There are many factors involved with issue of high axial vibrations and thrust bearings failures which can be addressed right from design / selection (early engineering phase of a project). The prudent knowledge of various failure modes owing to high axial excursion of rotor / high axial loads at various operating points and proper selection of bearing and rotor setting can mitigate this type failures in great extent.

The proposed tutorial paper endeavors to provide readers various aspects and issues causing high axial thrust and mitigation actions in combination. This tutorial takes up few salient case studies as well. A sample thrust calculation included in this paper render a good understanding of predicted behavior

of machine in terms of axial vibration and subsequent failure modes. Correct methods of sensor mounting, methods of proper setting of thrust bearing end play and voting are discussed as a part of on-site work carried out during pre- commissioning activity of mission critical turbomachinery

## Tutorial 9 -
## Steam Turbine Fundamental & Latest Technology

**Wednesday, 25 May 2022**
**Level 4, Room 403** **1400 - 1530**

**Instructors: Tomoaki Nogami, Abhishek Sahoo, Akihiro Hara, Yusuke Oishi (Mitsubishi Heavy Industries Compressor Corporation)**

This tutorial will provide the basic knowledge of steam turbines from design to operation in half and more detail technical information, which will be useful for design audit, trouble shooting, enhance participants, their own machines, how to approach in other half. An emphasis is placed on providing practical and technical information T.

- Fundamental technology
  - Classification of steam turbine
  - Flow dynamics of steam turbine
  - Turbine control system
- Latest technology
  - Reliability improvement
  - Inspection, Technical support by remote
  - Typical RCA of steam turbine

## Tutorial 10 -
## An Overview of Machinery in Energy Storage and Hydrogen Applications

**Wednesday, 25 May 2022**
**Level 4, Room 405** **1400 - 1530**

**Instructors: Tim Allison (Southwest Research Institute), Klaus Brun (Elliott Group), Aaron Rimpel, Natalie Smith (Southwest Research Institute)**

Decarbonization of electric power infrastructure requires the development of cost-effective, sustainable, and reliable energy storage technologies that are capable of many Megawatts or Gigawatts of output and long storage durations potentially spanning days, weeks, and months. These technologies would absorb power from the grid during periods of excess renewable generation, and release the stored energy to generate power when renewable sources are unavailable. The first part of this tutorial introduces the history of energy storage technologies, general requirements for energy storage applications, and challenges with grid-scale electrochemical batteries that drive the development of machinery-based systems for energy storage.

In particular, the authors will discuss hydrogen machinery including an overview of hydrogen impacts on compression and combustion in machinery for pure hydrogen and blended hydrogen applications.

## Tutorial 11

### Turbomachinery For Refinery Applications

**Tuesday, 24 May 2022**

**Level 4, Room 407** **1400 - 1530**

**Instructors: Klaus Brun, Adam Neil, Brian Pettinato, Derrick Bauer, Stephen Ross (Elliott Group), Rainer Kurz (Solar Turbines)**

This tutorial covers the basics, applications, and operation of compressors, expanders, steam turbines, and gas turbines in refinery applications. Modern refineries utilize a wide range of turbomachinery that must flexibly operate under harsh fluid conditions with long life and minimal maintenance downtime. In refinery service the fluids pose unique aerodynamic, materials, and structural design challenges including wet gas service, high gas path temperatures, and corrosive, flammable, and sometimes toxic service. These requirements make the design, packaging, controls, application and operation of turbomachines in refineries highly complex and challenging. Operational and technical details of turbine and compression applications such as gas boost, refrigeration, hydrogen recycle, blow gas compression, coke gas compression, reformer recycle compression, steam turbine drivers, and gas turbine drivers will be discussed for refinery processes including alkylation, reforming, hydro-cracking, fluid cracking, power generation, and gas boost.

## Tutorial 12

### A comparison of Operating Deflection Shape and Motion Amplification Video Techniques for Vibration Analysis

**Wednesday, 25 May 2022**

**Level 4, Room 407** **1100 - 1230**

**Instructors: Stephen Price (Engineering Dynamics Incorporated)**

Operating Deflection Shape (ODS) testing that was derived from Experimental Modal Analysis in the 1980's has served well to assist users in quantifying vibration amplitudes, determining vibration mode shapes, mechanical integrity, the most effective locations and directions to add stiffness, and identifying cracks in beams and foundations. A recent technique that provides amplified motion from video (MAV) has become accepted that can do much the same with considerably less effort. However, each technique has its own difficulties and range of applicability. The paper provides some technical basis for the video technique and examples from the field using both ODS and MAV to help users evaluate their relative strengths and weaknesses

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# DISCUSSION GROUP DESCRIPTIONS

## Discussion Group 1:
### Cavitation/NPSH (Field Problems)

**Wednesday, 25 May 2022**
**Level 3, Hall 7B** **1100 - 1230**

**Instructors: Frank Visser (Flowserve), Francesco Annese (Baker Hughes), Bruno Schiavello (Independent), Paul Den Held (REVAS), Dan Baun (Sulzer)**

1. Unexpected cavitation erosion (despite NPSHA > NPSHR)
2. Key parameters to consider for Root Cause Analysis when experiencing cavitation damage
3. Cavitation erosion rate and impeller life assessment
4. High cavitation-resistant materials
5. NPSHR, NPSHA, NPSH margin
6. Impact of dissolved and/or entrained gas on NPSH
7. NPSH requirements when pumping hot water or hydrocarbons
8. NPSH requirements for (cold) water applications
9. Common types of (rotodynamic) pump cavitation, including: sheet cavitation, suction recirculation induced vortex cavitation, corner (vortex) cavitation, and tip vortex cavitation
10. Field cases (suggested by audience): Quick fix and ultimate solution

## Discussion Group 2:
### Turbomachinery and Pump Vibrations

**Tuesday, 24 May 2022**
**Level 3, Hall 7C** **1100 - 1230**

**Instructors: Gaspare Maragioglio, Lorenzo Naldi (Baker Hughes), Jim Byrne, Minhui He (BRG Machinery Consulting), John Yu (BHGE)**

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 3:

### Centrifugal Compressors: Operation and maintenance, advanced design, wet and sour gas operation

**Wednesday, May 25 2022**

**Level 3, Hall 7C** **1100 - 1230**

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

Topics Outline:

- Meeting current rotordynamics stability standards
- High flow coefficient/mach number impellers
- Low flow coefficiens/high pressure impellers; Reynolds correction
- Complicated high pressure gas properties. E.g., CO2, acid gas, H2S
- Testing of the equipment
- Modern manufacturing/forming methodologies
- Simulation and dynamic process modeling
- Handling of Chlorides in sour/acid gas applications, including piping; end-user strategies
- Hermetically-sealed compression

## Discussion Group 4:

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

**Tuesday, 24 May 2022**

**Level 3, Hall 7B** **1100 - 1230**

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

Suggested Topics:

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

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

## Discussion Group 5:
## Mechanical (Liquid) Seals: General (Installation, Operation, Troubleshooting, and Retrofitting)

**Wednesday, 25 May 2022**
**Level 3, Hall 7B** **0900 - 1030**

**Instructors: S.P. Asokan (Flowserve), Shifeng Wu (A.W. Chesterton Co), Nikoluas Necker (EagleBurgmann), John Morton (John Crane), Vasanth Bhat (Singapore Refining Company), Seetharam Lalithkumar, Sathya Srinivasan (Flowserve Asia Pacific – Singapore), C.J. Carmody (AES Seal plc UK)**

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

Suggested Topics for Mechanical Seals (Liquid):

- Advancements in mechanical sealing  API 682 4th Edition
- Air testing of seals in pumps prior to installation
- Challenges with low temperatures sealing
- Effective leakage containment of single seals
- The Selection and Design of Dual Pressurized Liquid Sealing Systems
- Strengths and weaknesses in Plan 53A, 53B, and 53C piping plans
- Considerations when sealing abrasive slurries
- How to apply dual pressurized gas seals
- Mechanical seals for multiphase applications
- Advances in seal face materials
- Process for handling problem pump and seal applications

- Definition of mean time between failure and industry best practices
- How and when to use split seals
- Seal & System for rotating equipment other than pumps
- Polymer and Elastomers sealing elements reliability in Mechanical Seals

## Discussion Group 6:

### Turbomachinery Operation and Maintenance in a Digital World

**Wednesday, 25 May 2022**

**Level 3, Hall 7C** **0900-1030**

**Instructors: Klaus Brun (Elliott Group), Rainer Kurz (Solar Turbines), Girish Kamal (PETRONAS)**

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 7:

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

**Wednesday, 25 May 20222**

**Level 3, Hall 7B** **1400 - 1530**

**Instructors: S.P. Asokan (Flowserve), Vasanth Bhat (Singapore Refining Company), Daniel Goebel (Eagle-Burgmann), Leonardo Baldassarre (GE OG), Athal Doorenbos (Siemens), Michel Weegenhausen (John Crane), Sathya Srinivasan (Flowserve Asia Pacific – Singapore), C.J. Carmody (AES Seal plc UK), Wei Sing (ExxonMobil Chemical), Girish Kamal (PETRONAS)**

Suggested Topics for Dry Gas Seals Discussion group:

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

## Discussion Group 8:
## Magnetic Bearings

**Tuesday, 24 May 2022**
**Level 3, Hall 7C** **1400-1530**

**Instructors: Armando Guerrero (Petronasia Energy), Urs Baumann (MAN Energy Solutions)**

Suggested Topics:

- Field problems and experiences
- Operation, maintenance, and troubleshooting
- Specifying magnetic bearings
- Auxiliary bearings
- New advancements and upgrades
- Subsea
- Control recommendations
- Rotordynamics
- Fault tolerance

## Discussion Group 9:
## Steam Turbines: Operation & Maintenance

**Tuesday, 24 May 2022**
**Level 3, Hall 7B** **1400-1530**

**Instructors: Arun Kumar (HMEL), Ronald Josefczyk (Elliott Group)**

Suggested Topics:

- Overhaul intervals. Maintenance- Rotor change out intervals overhaul
  - 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
- Steam quality related issues and control.
- Sub synchronous vibrations
- Varnishing of bearings/ rotors
- Turbine casing life span.
- M/c protection
- Oil contamination with condensate.
- Erosion in steam valves, nozzles and spindles due to exfoliated metal oxide layer from steam inlet piping.
- Water carry over from steam drum of Boiler along with steam, damages of thrust bearing.
- Centering disturbance problem.
- Low vacuum problems. Ways to predict source of air intake and solutions.
- Steam gland versus seals.
- Should we balance turbine rotor on actual speed (vacuum tunnel) or low speed .
- Tilting pad versus Mitchel bearing (Multi lobe) in steam turbine.
- Piping stresses from inlet and extraction piping.
- Parting plane leakages.

TEXAS A&M UNIVERSITY

# TPS

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ROUP DESCRIPTIONS

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# CASE STUDY DESCRIPTIONS

## Case Study 1 -
### Centrifugal Compressor Failure due to Diffuser Stall and Balancing Line Resonance Vibration Analysis

**Thursday, 26 May 2022**
**Level 4, Room 406** **0900 - 0930**

**Instructors: By: Ricky Stu Anding, Khairul Fata Ahmad Asnawi (PETRONAS Carigali Sdn. Bhd.)**

An offshore platform consists of a single train centrifugal compressor experienced compressor balance line cracked which believed caused by the vibration from fractured 3rd stage impeller. The failure of the impeller is caused by rare occurrence of diffuser stall which occurred due to the compressor operating point is moving away from its original duty i.e. depleting platform production. Through rotor Vibration Analysis, the impeller experienced diffuser stall shown from presence of sub-synchronous and vane pass frequency in spectrum.

## Case Study 2 -
### Centrifugal compressor high sub-synchronous vibration during higher load and speed

**Thursday, 26 May 2022**
**Level 4, Room 406** **0930 - 1000**

**Instructors: By: Mohd Faizal Mohamed, Mohd Hafiz Abdul Manan (PETRONAS Carigali Sdn Bhd)**

Process fluid changes such as present of contaminants, water and corrosive gas composition i.e., H2S can give significant impact on the degradation mechanisms of materials which require for design modification or revision in inspection, monitoring & maintenance. Besides that, it is crucial to have information on spare rotor assembly critical speed whenever any major maintenance done for the compressor. This is essential to ensure operating regime meet sufficient separation margin on system resonances. In this case study, present of moisture, contaminant & H2S in process gas was discussed that led to compressor component deteriorate and damage. In addition, having situation of idling the compressor close to its critical speed also accelerated further impact & resulted to SSV issue

## Case Study 3 -
### Unexpected Vibration on a Centrifugal Compressor Caused by Vibration Probe Support

**Thursday, 26 May 2022**
**Level 4, Room 406** **1000 - 1030**

**Instructors: Yves Bidaut (MAN Energy Solutions Schweiz AG)**

During the commissioning of a Main Air Compressor in an Air Separation Unit, the rotor showed increased radial vibrations at the Non-Drive End probe.

The RCA revealed: The vibration resulted from the excitation of a natural frequency of the vibration probe support, triggered by the pressure fluctuation at the suction of the 11 blades-impeller. The probe support was redesigned to increase its stiffness in order to shift the natural frequency. After replacement of the support, no particular vibration appeared anymore. Generally: The vibration probe

support requires careful attention, especially if the machine is standardized for a very large operation speed range.

## Case Study 4 -
## Vibration Diagnostic of Steam Turbine Intermittent Rubbing

**Thursday, 26 May 2022**
**Level 4, Room 408** **0900 - 0930**

**Instructors: Pin Jun Ker, Wei Sing Ng, (ExxonMobil Engineering Services)**

A special purpose steam turbine has started to experience intermittent radial vibration spikes. The turbine is used to drive a Hydrogen Recycle Gas Compressor in Aromatics unit. No abnormality observed on the compressor end. ADRE 408 external data acquisition and diagnostic system was used to collect vibration data during steady state operation. Detailed vibration diagnosis was performed to evaluate overall rotor dynamic behavior of the machine train, assess vibration levels against the OEM set-points and ISO 7919-3 standards, troubleshoot potential mechanical malfunctions that leads to intermittent vibration spike and provide recommendations for safe operation of the unit. From the analysis, the cause of high vibration was determined to be intermittent light rubbing of the steam turbine rotor with the bearing housing oil baffle (seal).

## Case Study 5 -
## Steam Turbine High Axial Displacement due to Governor Actuator Filter Clog

**Thursday, 26 May 2022**
**Level 4, Room 408** **0930 - 1000**

**Instructors: Pin Jun Ker, Imran M Kassim, Wei Sing Ng, (ExxonMobil Engineering Services)**

The governor actuator for a steam turbine was observed to be hunting and failed to maintain stable operating speed. The steam turbine is used to drive a centrifugal compressor for H2 service in a recycle loop. The extent of speed oscillating was exaggerating over time and caused excessive turbine axial movement. The unit was forced to shut down to prevent secondary damage due to turbine high axial movement. This case study presents the unusual phenomenon, troubleshooting tools, recovery process and key learnings which provide user operating with similar service a reference.

## Case Study 6 -
## Introduction of SCC life time estimation for fir tree design on steam turbine rotor

**Thursday, 26 May 2022**
**Level 4, Room 408** **1000 - 1030**

**Instructors: Tomotaka Ouchi (Mitsubishi Heavy Industries Compressor Corporation)**

The evaluation method for SCC of fir tree blade groove without FEA is to be introduced in this study. It would be helpful to decide the concrete action during the short term like turn around period since there is no requirement of FEA to estimate the lifetime. OEM can advise

the status of SCC phenomenon on a timely basis and related parties can start the next action like replacement of rotor from working to spare rotor, further investigation and so on.

## Case Study 7 -
## Silo Exhaust Fan, Structural Vibration ODS and Motion Amplification

**Thursday, 26 May 2022**
**Level 4, Room 403** **0900 - 0922**

**Instructors: Bopanna Ponnanna, Nicolas Peton, John Yu, Sergey Drygin, (BakerHughes Bently Nevada), Steven Schluter (Kogan Creek Power station, CS energy)**

Two different technologies were used to diagnose the root cause of the structural issue and corrective actions were carried out to improve the structural vibration.

## Case Study 8 -
## Turbomachinery For High Co2 Application: Challenges, Obstacles And Lesson Learnt

**Thursday, 26 May 2022**
**Level 4, Room 403** **0923 - 0945**

**Instructors: Ir Dr Harris Abd Rahman Sabri, (PETRONAS), Usaid Khaliq (PETRONAS)**

Turbomachinery is the heart of any platform, which generates power and compresses gas. However, the current practices of turbomachinery are entangled with various challenges and obstacles, which eventually affect the overall performance of the platform. Hence, this paper aims at appraising the challenges and obstacles in turbomachinery application for high CO2 application. This paper aims to achieve few objectives: (1) reviewing the oil and gas industry in terms of its operation and project execution; (2) determining the basic attributes of turbomachinery as well as the challenges and obstacles entangling its execution; and (3) proposing the solutions to these challenges and obstacles. It is found that stabilized process requirement and constant flow; subsurface uncertainties; production decline; selection process; specification and standard variations; contractual delivery; human factor; after sales support and services; and expenditure are listed as amongst the challenges and obstacles in executing turbomachinery project for oil and gas. The findings of this paper would technically contribute to the project management elements of turbomachinery project execution and assist the management team particularly on the client/consultant side in efficiently and effectively manage the turbomachinery project execution via the prediction of challenges and obstacles. This case study will present the issues encountered, solutions implemented, results mitigation, lessons learnt, and technical replication based on two high CO2 application projects.

## Case Study 9 -
## ELECTROSTATIC DISCHARGE- STG COMPRESSOR

**Thursday, 26 May 2022**
**Level 4, Room 403** **1200 - 1230**

**Instructors: Bopanna ponnanna, Nicolas PETON, John Yu (BakerHughes Bently Nevada)**

Electrostatic discharge (ESD) can cause catastrophic mechanical damage and lower the life span of an asset if not detected early and rectified. Continuous discharge of static electricity can cause micro pitting of bearing or shaft surface leading to material loss and eventual failure.

This presentation outlines a success story where an ESD malfunction was detected on turbine compressor and subsequent diagnosis lead to prevention of asset failures. Changes in shaft centerline plots/DC gap trends and raises in bearing metal temperature were some of typical symptoms of ESD along with spiking pattern in orbit plots. These malfunctions and subsequent diagnoses to prevent failures are discussed in this presentation.

## Case Study 10 -
### High Speed Coupling Failure related to Torsional Vibration

**Thursday, 26 May 2022**
**Level 4, Room 403** **1007 – 1030**

**Instructors: Chek Zin Tan, Chris K Morgan, Imran M Kassim, Jeremy M Bullock, Woon-Lip Teo (ExxonMobil)**

This case study presents compressor high speed coupling failure where torsional natural frequency is excited. The mature unit had operated successfully for more than 15 years with no changes that would affect fundamental natural frequencies within compressor train until a series of compromising events created gears degradation which triggered natural frequencies excitation. Results are presented herein of the evidence of the failure mode of the couplings which show fatigue fractures leading to catastrophic failure due to high alternating torsional stress.

## Case Study 11 -
### Boiler Feed Pump Elevated Sleeve Bearing Temperature and Vibration Problems Resolved

**Thursday, 26 May 2022**
**Level 4, Room 405** **0900 - 0930**

**Instructors: By: Chad Pasho, Maki Onari (Mechanical Solutions, Inc.)**

A boiler feed pump (BFP) at a power plant was driven by a unique drive train experiencing elevated sleeve motor bearing temperatures and vibration. Testing methods included: Motion Magnification Video (MMV) testing, Experimental Modal Analysis (EMA) testing, Operating Deflection Shape (ODS) testing, and a vibration survey. Specific solution recommendations, including Finite Element Analysis (FEA) results and descriptive CAD drawings were presented. Subsequent post-fix testing confirmed the problem was resolved.

## Case Study 12 -
### Case Study on Investigation and Resolution of High Lube Oil Temperature in Pump Bearing Housing for Off Spec. Condensate Recycle Pumps

**Thursday, 26 May 2022**
**Level 4, Room 405** **0930 - 1000**

**Instructors: Girish Kamal (PETRONAS CARIGALI SDN BHD)**

Off Spec Condensate Recycle Pumps on an onshore gas production facility exhibited high lube oil temperature in pump bearing housing that exceeded the alert limits since commissioning. High temperatures were not consistently noticed always. A Structured Root Cause Analysis was carried out to ascertain the cause of the high lube oil temperature that identified a large variation in pumping medium specific gravity as against the design data.

Higher specific gravity of the pumping medium resulted in disturbance in hydraulic balancing causing excessive pump bearing loading that also caused higher lube oil temperature in pump bearing housing. As a solution to the above issue, change in hydraulic balancing (i.e. varying the balance drum size) was sought from vendor to ensure that the pump bearing is not getting overloaded for the wider range of specific gravity of pumping medium. Also, validation of the efficacy of the solution was obtained by way of axial thrust & bearing load/ life estimations for the new balancing drum which proved to be effective.

This case study will cover review of the pump design, problem history, root cause analysis conducted, solution implemented, conclusion along with results and lessons learnt.

## Case Study 13 -
### Bearing Load Analysis Of Reciprocating Piston Compressors

**Thursday, 26 May 2022**
**Level 4, Room 405** **1000 - 1030**

**Instructors: Andreas Brandl, Bernhard Fritz (Hoerbiger)**

Many problems in today's industrial environment require smart modeling assumptions in order to make them numerically accessible with an acceptable amount of effort. This case study shows how a field problem (main bearing failures) is turned into a numerical model: we present a bearing force analysis of a 5-throw reciprocating compressor with severe problems on its third main bearing. Inertial and gas-dependent forces are calculated. The crankshaft is modeled as a uniform beam; its load-dependent deformation and the resulting bearing loads are estimated based on Clapeyron's three-moment equation with the assumption of zero bearing clearances. The resulting calculation time is < 1s for a 360-degree load cycle, allowing detailed studies that yield conclusive results: polar load diagrams clearly confirm that the problematic bearing is exposed to the highest loads in operation. The short calculation time allows for parametric studies investigating the effect of lower reciprocating masses, partial load conditions, counterweights, different crankshaft designs, or combinations of the above.

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## Case Study 14 -
## High Vibration in Motors Due to Shaft Stray Current : Analysis and Resolution

**Thursday, 26 May 2022**
**Level 4, Room 401** **0900 - 0930**

**Instructors: Arun Kumar, Anurag Chopra, Gautam Bora, (Hpcl- Mittal Energy Limited, India)**

To share with users of Turbo machinery/ Pumps, a very typical and practical learning about repeated problems of high vibrations in newly commissioned electrical motors of two different pumps in Crude distillation unit and Bitumen unit of Refinery. The vibration spectrum indicated the domination of bearing fault frequencies. Motor bearings (antifriction bearings) were found defective and hence replaced, but the phenomena got repeated just after 2 months of replacement with similar defect frequencies as before. After analysis of failed bearing it was revealed that the root cause behind high vibration was generation of shaft voltage - leading to stray (leakage) current, which is unusual for HT motors of these frame sizes.

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## Case Study 15 -
## Turning Gear Motor Failures, Confirmed By Model Based Voltage & Current Method

**Thursday, 26 May 2022**
**Level 4, Room 401** **0930 - 1000**

**Instructors: Peter Popaleny, Andrew Bibby, Nicolas Peton (BakerHughes / Bently Nevada)**

The paper discusses several fatal failures on the Turning Gear Motor (TGM) over the short time period of one-month, resulting in two motor replacements. The Turning Gear Motor was monitored by an online monitoring system using improved Motor Current Signature Analysis (MCSA), aka. Model-Based Voltage and Current (MBVI). TGM mechanical and electrical malfunctions are reflected in the dynamic current spectrum using improved MCSA. Utilizing this methodology, prompt and precise diagnostics was carried out and subsequent decision could take place regarding the electrical and mechanical integrity of this motor installed on this critical Centreline Machine Train. The paper further shows the real case data analysis and findings on this Electric Motor.

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## Case Study 16 -
## Resolution of Non-Repeatable Synchronous Rotor Response of a Power Generator

**Thursday, 26 May 2022**
**Level 4, Room 401** **1000 - 1030**

**Instructors: Mohammed Ashour, Mustafa Shalabi (Baker Hughes)**

A complete case study with root cause identified and lesson learnt during a balancing job of power generator. It also underlines the importance of confirming the linearity and repeatability of the balance response and influence vector calculations to achieve a successful balance job.

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## Case Study 17 - Solving Mechanical Seal with Small Vapor Pressure Margin Issue

**Thursday, 26 May 2022**
**Level 4, Room 408** **1100 - 1130**

**Mohamad Saaim Mohamed Amin (PETRONAS Penapisan [Terengganu] Sdn Bhd), Khairul Fata Ahmad Asnawi ( PETRONAS Carigali Sdn. Bhd)**

This paper discussed about the challenge in operating light naphtha pumps with small vapor pressure to seal chamber pressure margin which had resulted to multiple mechanical seal failures.

After thorough investigation, manipulating the pumps' seal flushing plan and reinstating the pumps' throat bush were the key success factors which successfully improved the mechanical seals' reliability. Lesson learnt from this incident is valuable to prevent similar failures to take place, especially to pumps with small vapor pressure margin.

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## Case Study 18 - Catastrophic Mechanical Seal Failure Leading to Loss of Primary Containment (LOPC)

**Thursday, 26 May 2022**
**Level 4, Room 408** **1130 - 1200**

**Instructors: Mohd Faizal Mohamed, Khairil Ikhwan A Rahman, (PETRONAS Carigali Sdn Bhd)**

The purpose of this case study is to present 2 failure mechanisms which have contributed to catastrophic mechanical seal failures leading to loss of primary containment (LOPC) at condensate transfer pumps (CTP). The impact of LOPC is more severe if the product itself is hazardous to people, asset environment. Mechanical seal failure may be contributed by many factors such as poor installation, misalignment of seal face cascaded from pump vibration, dry running, over compression, thermal shock or expansion, poor barrier fluid quality, etc. For case# 1 catastrophic seal failure occurred due to presence of free water and sludge in seal barrier fluid which has caused the water vaporization due to high heat generation and low boiling point The thin barrier fluid film between seal faces cannot be sustained leading to face to face contact As a result, chipping of seal face was formed. Meanwhile for case# 2 another failure mechanism was due to poor preservation of spare mechanical seal which has caused the moisture from atmosphere to accumulate at the seal face, creating a slip stick condition and initiate a hairline crack on seal face pin slot due to the high torque from the pump, the hairline crack propagate thru the pin slot at the outboard rotating seal face. The outboard seal cracked, leading to the hammering on anti rotating pin dislodged and subsequently hammered the inboard seal face

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## Case Study 19 - High Speed pump Mechanical Seal Bad Actor Resolution

**Thursday, 26 May 2022**
**Level 4, Room 408** **1200 - 1230**

**Instructors: Ahmad Faiz A Aziz, Imran M Kassim (ExxonMobil Engineering Services)**

Case study includes a vertical pump in sour water service running at high speed of 17200 rpm. Pump originally equipped with single

seal & Plan21 configuration since day one. In 2018, as part of a reliability upgrade, seal was converted to a double seal design (Plan53A). Pump MTBF reduced from 24months to 6months. While utilizing existing Plan53A, a practical & cost effective approach is to have external cooling supply to seal chamber. Plan32 then is introduced; together with seal scallop design upgrade and reducing amount of elbows on current seal piping system. With new upgrade changes, the pump seal has been operating satisfactory since commissioning, exceeding its previous operating life.

## Case Study 20 -
## Detection of Broken Blade on Compressor

**Thursday, 26 May 2022**
**Level 4, Room 406** **1100 - 1130**

**Instructors: John Yu (Baker Hughes)**

A sudden step change in vibration was observed on a 7400-rpm compressor with direct amplitude from 43 um pp to over 62 um pp (trip level) at NDE, thus tripping the unit. Vibration reached over 120 um pp at 4000 rpm, compared to normally 20 um pp during coast-down. Vibration excursion was dominantly due to the 1X component. It was noticed that thrust probe gap readings started to fluctuate 6 months prior to the vibration trip. A sudden change in unbalance was diagnosed, followed by an inspection. It appeared that a balance pipe started to leak earlier, causing the axial thrust force to fluctuate, as indicated by fluctuating thrust gap. It was possible that a piece of damaged fragments entered the gas flow and hit the 3rd stage blade, thus breaking the blade to lead to a sudden change in unbalance.

## Case Study 21 -
## Vibration issue on Compressor in a Nitric Acid Plant (Part 2)

**Thursday, 26 May 2022**
**Level 4, Room 406** **1130 - 1200**

**Instructors: Gary Wright, Sergey Drygin, Nicolas PETON (BakerHughes / Bently Nevada)**

The NAP2 PAC consist of a 50 Hz 4-pole sleeved bearing 2.6 MW electric motor driving from one end a step-up gearbox which is coupled to a hot gas expander, fitted with tilting pad bearings, via a gear type coupling. The remaining end of the motor drives a three-stage integral gear compressor (12,553, 17,934 & 25,174 rpm) via a gear flex coupling.

The NAP2 PAC was completely overhauled in March/April 2019 during a scheduled turn-around period, conducted every 5 years, inclusive of a motor rotor replacement, step-up gearbox overhaul, a new air end compressor installation as well as hot gas expander thrust bearing and thrust collar replacements/repairs. Additionally, the expander seals were replaced with like-for-like but tighter clearance carbon seals, the entire drive train was re-aligned and a new anti-surge valve was installed.

## Case Study 22 -
## Troubleshooting Of Air Compressor High Vibration During Commissioning Stage

**Thursday, 26 May 2022**
**Level 4, Room 406** **1130 - 1230**

**Instructors: Azmi Md Lasin (PETRONAS)**

An air compressor encountered high vibration issue during its commissioning stage, leading to impeller and casing rub.

Inspection performed found dislodged shrink fitted thrust collar, resulting in excessive axial movement of the pinion and eventually rubbing.

This case study will include the investigation finding, root cause identification, rectification work and lesson learnt.

## Case Study 23 -
## Pitting corrosion led to catastrophic gas turbine compressor blade liberation

**Thursday, 26 May 2022**
**Level 4, Room 403** **1100 - 1130**

**Instructors: Mohd Faizal Mohamed, Fadlil Hafeez Zainol Alam (PETRONAS Carigali Sdn Bhd)**

A gas turbine's intake system usually has 3-4 stages of filtration. After the primary and secondary filter, the final marine vane separator (MVS) was used. These filters are designed to keep rainwater , debris, and salt from entering gas turbine intake systems. The chemical reaction between salt and MVS can cause flying debris. A MVS made of aluminum will experience galvanic corrosion caused by sub-micron salt particles. Debris in the air intake system causes erosion, exposing the compressor blade's base material. This process is known as pitting corrosion. A specific examination techniques were used to investigate the traces of debris material at compressor blade in order to relate back to the system weakness. Hence, the main root caused could be determine and appropriate counter measure can be applied.

## Case Study 24 -
## Gas Turbine Load Limited due to High Exhaust Temperature Deviation

**Thursday, 26 May 2022**
**Level 4, Room 403** **1130 - 1200**

**Instructors: Ahmad Faiz A Aziz, Wei Sing Ng, Ashutosh Vengurlekar, Sutanto Augustino Pernama (ExxonMobil Engineering Services)**

This case study presents an incident of sudden exhaust temperature spread increase of a medium power range Gas Turbine Generator (GTG) during normal operation. The analysis of exhaust temperature spread, field troubleshooting and recommended solution are presented to share the key learnings.

## Case Study 25 -
## Gas Turbine Compressor Inlet Air Filters Performance Comparison

**Thursday, 26 May 2022**
**Level 4, Room 403** **1200 - 1230**

**Instructors: Sutanto Augustino Pernama, Ashutosh Vengurlekar, Wei Sing Ng (ExxonMobil Engineering Services)**

Gas Turbine compressor efficiency and long term operability are highly affected by the air quality entering the compressor through its intake air filtration system. This case study presented the experience of an industrial Gas Turbine application in Singapore that has had a retrofitting project to improve the filtration system performance. The retrofitting scope comprised mainly of an upgrade to filter efficiency class and the intake system design to minimize fouling agent and rainwater ingression into the compressor. The two-pronged approach resulted in slower deterioration of compressor efficiency as well as reduction of offline water wash frequency. While the results benefited the compressor performance, the filters run length was found to be too short than expected.

## Case Study 26 -
## Chronic high vibration issue of a Condensate Pump

**Thursday, 26 May 2022**
**Level 4, Room 401** **1100 - 1200**

**Instructors: Muneeb Sheikh, Syed Muhammad Haseeb Bukhari (Engro Fertilizers)**

Chronic high vibration issue was being observed on a critical condensate pump. Although this motor driven pump is a standby

unit, however, in case the running pump has a breakdown and this motor pump is unavailable, the Ammonia Plant will trip. This is a horizontal, overhung, centerline mounted, single stage pump. The pump was relocated to current site in 1992 and the problem of high vibration was observed after ~10 years of operation. The issue was observed around the timeframe when locally manufactured spares were used since OEM had discontinued offering its spares. The pump was overhauled 03 times in past 10 years, but the high vibration issue remained as such.

## Case Study 27 -
## Relation between wear ring clearances and non-synchronous vibrations in BFW centrifugal pump

**Thursday, 26 May 2022**
**Level 4, Room 401** **1130 - 1200**

**Instructors: Waqar Ahmad (Engro Fertilizer Company Limited)**

A de-superheating boiler feed water pump was facing high vibration issue for last 19 years.

Pump had been overhauled multiple times in past, but the issue was not resolved. Dominant frequency appearing in vibration spectrum was 1.58 X order, which was not matching with any of the pump component frequency. Furthermore, maintenance history of the pump prior to year 2005 & complete machine manual was not available.

Detailed study was conducted to resolve the high vibration issue of the pump, major cause of the problem was identified to be the increased wear ring clearance.

## Case Study 28 -
## Pump Vibration due to Reciprocating Engine Balance Gear Issue

**Thursday, 26 May 2022**
**Level 4, Room 401** **1200 - 1230**

**Instructors: Sebastian anak Sidi, Khairul Fata bin Ahmad Asnawi (PETRONAS CARIGALI SDN BHD)**

This paper presents the effect of balance gear on a reciprocating engine which drive the crude oil transfer pump that had experienced vibration at one of the offshore platform in Malaysia.

Based on this case, it is imperative to understand more on the reciprocating engine vibration behavior especially those related to the balance gear positioning. The balance gear is a critical component that must be fitted right at the first installation. Due to the rarity of requirement for balance gear adjustments, there are gaps in term of experience and exposure of the operators with regards to the maintenance of this component. Hence, this paper addresses the gap.

## Case Study 29 -
## Case Study on Additive Manufacturing Metallic and Non-Metallic Pump Impellers for Corrosive Application.

**Thursday, 26 May 2022**
**Level 4, Room 405** **1100 - 1122**

**Instructors: Kaushik Asokan, Chew Grace (Flowserve Corporation)**

Frequent replacement of the Hastelloy C casted pump impeller used in corrosive service with Sodium Hypochlorite application. The existing impeller was always noticed with severe pitting corrosion damage and often required a quick turnaround to replace the parts back to service.

With Additive Manufacturing (AM) Metallic Ti6Al4V Impeller solution, it helped to improve the part life together with a quick turnaround time. 3D printed Ti-6AL4V was found to have better corrosion properties and has superior mechanical properties over existing casted parts. The summary of test results of the 3D-printed part with standard corrosion test in the pumping media and test plan verification of mechanical properties are detailed in this presentation.

3D printing special Metallic materials are not always economical. The alternate solution to Additive manufacturing (AM) [Non-Metallic] materials such as PEKK CF (23%) were also explored to replace special metallic materials like Titanium and Hastelloy for low-duty corrosive applications. Lessons learned from the material test and corrosion test are also discussed in this presentation.

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## Case Study 30 -
## Application of Polycrystalline Diamond Bearing for loop reactor pump

**Thursday, 26 May 2022**
**Level 4, Room 405** **1000 - 1030**

**Instructors: Praveen Lakshmanan, Ashutosh Vengurlekar, Ryan Poon (ExxonMobil)**

The axial flow loop reactor pump installed in a polymer unit facilitates slurry circulation in the reactor. The seal cartridge contains a radial bearing for shaft support to ensure stability on the cantilevered pump design. There have been multiple failures in the past with low seal MTBF. The failure analyses conducted indicate similar failure mechanism- seal support bearing failure leading to primary seal leak and subsequent shutdown. To address these vulnerabilities, a Polycrystalline Diamond (PCD) bearing is installed to replace existing spherical roller bearing for the rotor support system inside the mechanical seal cartridge.

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## Case Study 31 -
## Offline Chemical Wash for Internal Fouled Multistage Pump

**Thursday, 26 May 2022**
**Level 4, Room 405** **1146 - 1208**

**Instructors: Tinagaran Puvanasan, Wei Sing Ng (ExxonMobil Engineering Services)**

High pressure lean amine pump performance dropped within a span of about 1 month due to internal fouling. Fouling was caused by accumulation of iron sulphide. To address the fouling, pump would have been to taken out of service for a full overhaul, resulting in extended downtime and high cost of repair. Offline chemical wash with 1% EDTA solution pursued as an alternative to the pump overhaul. Prior to commencing with the chemical wash, material compatibility of pumps/mechanical seals wetted parts, and process fluid flow path were considered as part of the technical evaluation. During chemical wash, samples were regularly collected at the circulation outlet to check for appearance in order to determine progress of the chemical wash in removing the foulants. Pump performance recovered upon completion of the chemical wash.

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## Case Study 32 -
## Wet Refrigeration Screw Compressor Failure due to Liquid Slugging

**Thursday, 26 May 2022**
**Level 4, Room 405** **1123 - 1145**

**Instructors: Sridhar Kuppa Padmanabha, Imran M Kassim, Ke Yuan Dalton Ong (ExxonMobil)**

A wet screw refrigeration compressor had three failures and all failures were related to male rotor HH axial displacement. The failure was concluded to be due to liquid propane formation at compressor suction, resulting in abrupt excessive thrust load. The liquid formation was due to suction temperature dropped below propane condensing point.

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## Case Study 33 -

# Implementation of Voted Flame Detectors to Prevent Spurious Fire Detection in Gas Turbines Enclosures

**Tuesday, 24 May 2022**

**Level 4, Room 403** **0945 - 1030**

**Instructors: Surendran Kandasamy, Nuban Muthukumar (PETRONAS)**

Fire detection inside Gas Turbine enclosures is a safety critical component to prevent unwanted consequences should a fire occur within the enclosure.

The standard design and implementation strategy remains by and large placing multiple detectors in a 1oo1 configuration which ensures sufficient coverage and focuses on specific areas within the Gas Turbine enclosure.

1oo1 configuration despite being safe comes at the expense of higher risks of unwanted spurious trips resulting in unwanted downtime.

This case study explores the course of action taken by end user to vote between flame detectors inside the gas turbine enclosure. This solution is supported by demonstrating sufficient area coverage of the flame detectors using 3D modelling software in order to arrive at a compromised balance between safety and availability.

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# TECHNICAL BRIEF DESCRIPTIONS

## Technical Brief 1 -
## CENTRIFUGAL COMPRESSOR PROLONGED LOW FLOW OPERATION CONSIDERATION FOR OPERATORS

**Tuesday, 24 May 2022**
**Level 4, Room 406** **1400 - 1530**

**Instructors: Dayang Nurhan Binti Awang Mahmood, Khairul Fata Bin Ahmad Asnawi (Petronas Carigali Sdn Bhd - Sarawak Gas)**

Centrifugal compressor is the heart of upstream and downstream oil and gas operation as its ability to move large volume of fluid to its end destination. Centrifugal compressors are designed at certain range of operation. One of the biggest concerns is operating the machine at low flow, where the surge is expected to happen. Many research and references addressed the surge phenomenon and how it contributes to enormous damage to centrifugal compressor in seconds. However, to the authors' experiences, there are other situations, where comprehensive attention shall be given by the machine operators. When centrifugal compressor operates near to the predicted surge line for a long time, there are concerns to the centrifugal compressor and its driver, which are further addressed and elaborated in this paper. In summary, prolonged operation at low flow region can contribute to failure to anti-surge valve, increase in suction and discharge temperature, waste of energy, failure of driver and initiation of a diffuser stall. If these potential failures went unnoticed, it may fail the centrifugal compressor promptly without any warning.

## Technical Brief 2 -
## Compressor Rotor Crack Case

**Tuesday, 24 May 2022**
**Level 4, Room 406** **1400 - 1530**

**Instructors: Peter Popaleny, Nicolas PETON, Joe Blackwell (BakerHughes Bently Nevada)**

The case study describes rotor crack detection using vibration measurements, documented on real case of Induction Motor driven Compressor Unit. The study highlights the complexity of rotor crack diagnostics as the primary problem as it can be often masked by other existing machine malfunctions.

In this case indication of the possible rotor crack, led to the Compressor bundle removal and rotor inspection. The rotor problem was confirmed, but not due to rotor crack but luckily only due to rotor thrust collar fit found to be worn and locating pin to be bent. Thrust collar had become eccentric (radial run out measured) causing a mass unbalance on the rotor in one direction, with similar symptoms as rotor crack.

## Technical Brief 3 -
## Mechanical Damage to Impellers From Low Flow Operation

**Tuesday, 24 May 2022**
**Level 4, Room 408** **1400 - 1530**

**Instructors: Dayang Nurhan Binti Awang Mahmood, Khairul Fata Bin Ahmad Asnawi (Petronas Carigali Sdn Bhd - Sarawak Gas)**

High-cycle fatigue damage imparted on a BB5 pump impeller operating at low flow operation points was analyzed via numerical methods, utilizing a 1-way Fluid-Structure interaction

approach. The study's results showed a significant increase in fluctuating stress ranges as the flow decreased, and gave strong support to the root cause analysis's conclusion that cracks were a result of operation at low flow.

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## Technical Brief 4 -
## Centrifugal Compressor in High Flow and Low Head Applications: An Impeller Design Concept for Coping with the Increasing Volume Flow in Polyolefin Processes

**Wednesday, 25 May 2022**
**Level 4, Room 408** **0945 - 1007**

**Instructors: Andreas Hardt, Jurgen Bohn, Oskar Schnabel (Atlas Copco Gas & Process)**

The paper discusses the development of a novel impeller design concept that addresses changing requirements for radial centrifugal compressors applied in the polymer/ downstream petrochemical industry. The impeller design concept developed balances the need for low heads, while at the same time achieving higher flow volumes for the compressor. The approach is described in form of a case study.

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## Technical Brief 5 -
## Turboexpanders in Petrochemical Industries Advance Technology for Green Hydrogen Liquefaction

**Tuesday, 24 May 2022**
**Level 4, Room 408** **1507 - 1530**

**Instructors: Louis Mann, Behrooz Ershaghi (Atlas Copco Gas & Process), Trevor Mayne (Qenos), Jabob Thomas (JTurbo Engineery & Technology, LLC)**

In efforts to reduce greenhouse gas emissions and meet net zero commitments by 2050, global demands for green hydrogen are on the rise. Hydrogen liquefiers are needed to transport green hydrogen from its source to consumers. As a result, the demand for turbomachines to carry out cryogenic hydrogen services is growing. Turboexpanders have been used in hydrogen-rich petrochemical applications since the early 1960s. This technical brief discusses turboexpander design for hydrogen service, including challenges associated with high enthalpy drop, high impeller tip speed, loading configuration and material selection for deep cryogenic hydrogen.

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## Technical Brief 6 -
## Adaptation Of Remote Autonomous Operation (Rao) For Rotating Equipment Of Petronas Facilities

**Wednesday, 25 May 2022**
**Level 4, Room 406** **0900 - 1030**

**Instructors: Ir Dr Harris Abd Rahman Sabri, M Helmi A Malek, Usaid Khaliq (PETRONAS)**

The Oil and Gas industry is increasingly facing with more complex and hazardous operations. This is resultant from integration with a more complex feed and product properties as well as requirement for operation in harsher environment. At the same time, a much stronger Environmental regulation is currently enforced which demands strict adherence and compliance by all Operating Assets/Facilities.

More industries have started to embrace automation as a safety and productivity enabler and as a critical factor in running business and operation. The center of attention to this shift is automation of Rotating Equipment covering broad range from Turbomachinery down until a Potable Water Pump.

Network communication enhancement via 5G technology has allowed remote operations and control technology able to be safely deployed. The new norm of Remote Autonomous Operation (RAO) via Artificial Intelligence, Machine Learning, Digitalization effort as well as Digital Twins are also increasingly being adopted to allow for better performance monitoring, remote trouble shooting, predictive and prescriptive ability for Rotating Equipment.

PETRONAS have also successfully embarked on remote autonomous operation journey for its Rotating Equipment fleet which will add clear value: it can improve safety, increase production efficiency, and lower maintenance costs. Although, implementing autonomous systems may also expose and presents new challenges such as cyber security and safety risks, the obvious advantage supersedes the risk which needs to be managed accordingly. This paper explains the challenges, the lesson learnt and PETRONAS approach in adapting RAO for Rotating Equipment.

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## Technical Brief 7 -
## Laser Additive Manufacturing In General Purpose Equipment Repair

**Wednesday, 25 May 2022**

**Level 4, Room 406** **1100 - 1230**

**Instructors: Sutanto Augustino Pernama, Tinagaran Puvanasan, Ashutosh Vengurlekar, Ser-Hor Chong, Wei Sing Ng (ExxonMobil Engineering Services)**

Deploying new technology that can benefit equipment component repair lead time, while sustaining its integrity, is becoming more crucial in this age of nimbleness. Many repairs have traditionally occupied conventional methods (coating, machining, casting), which have been proven to work well. However, the lead time and quality do not always meet users' expectation. Additive Manufacturing (AM) in the form of Laser Printing and Cladding are viewed as alternatives to repair methods, which can close the gap in lead time and quality.

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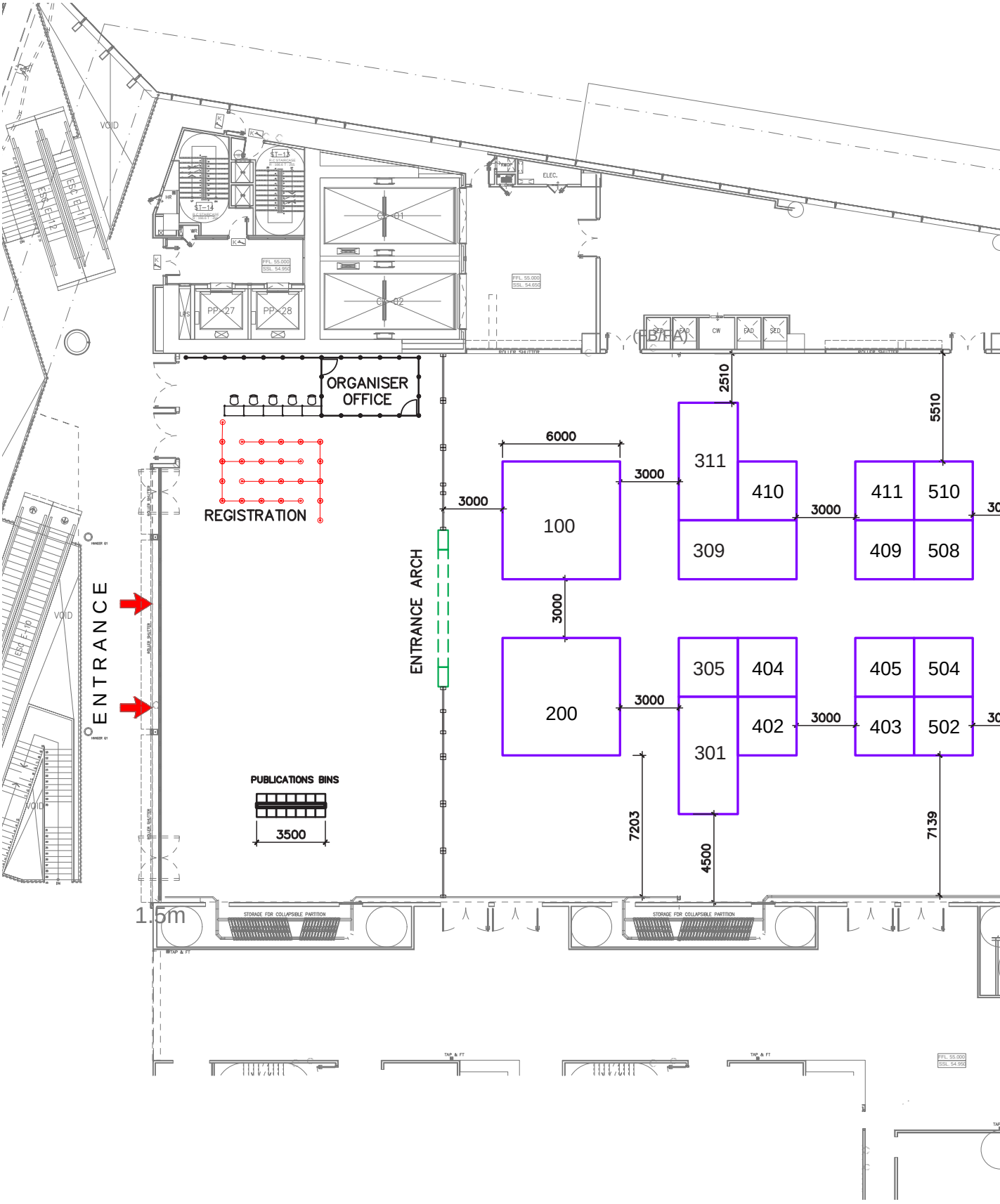

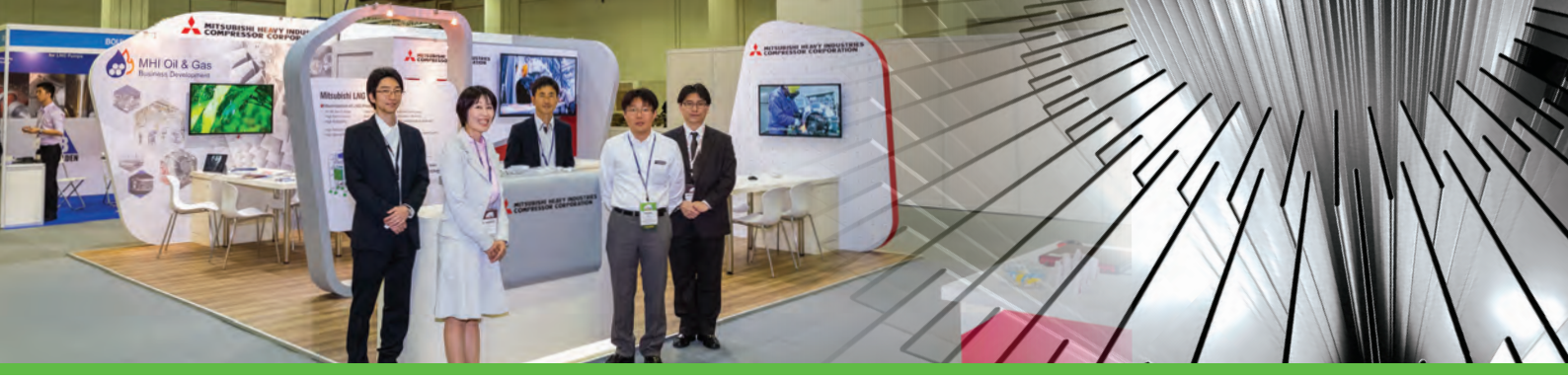
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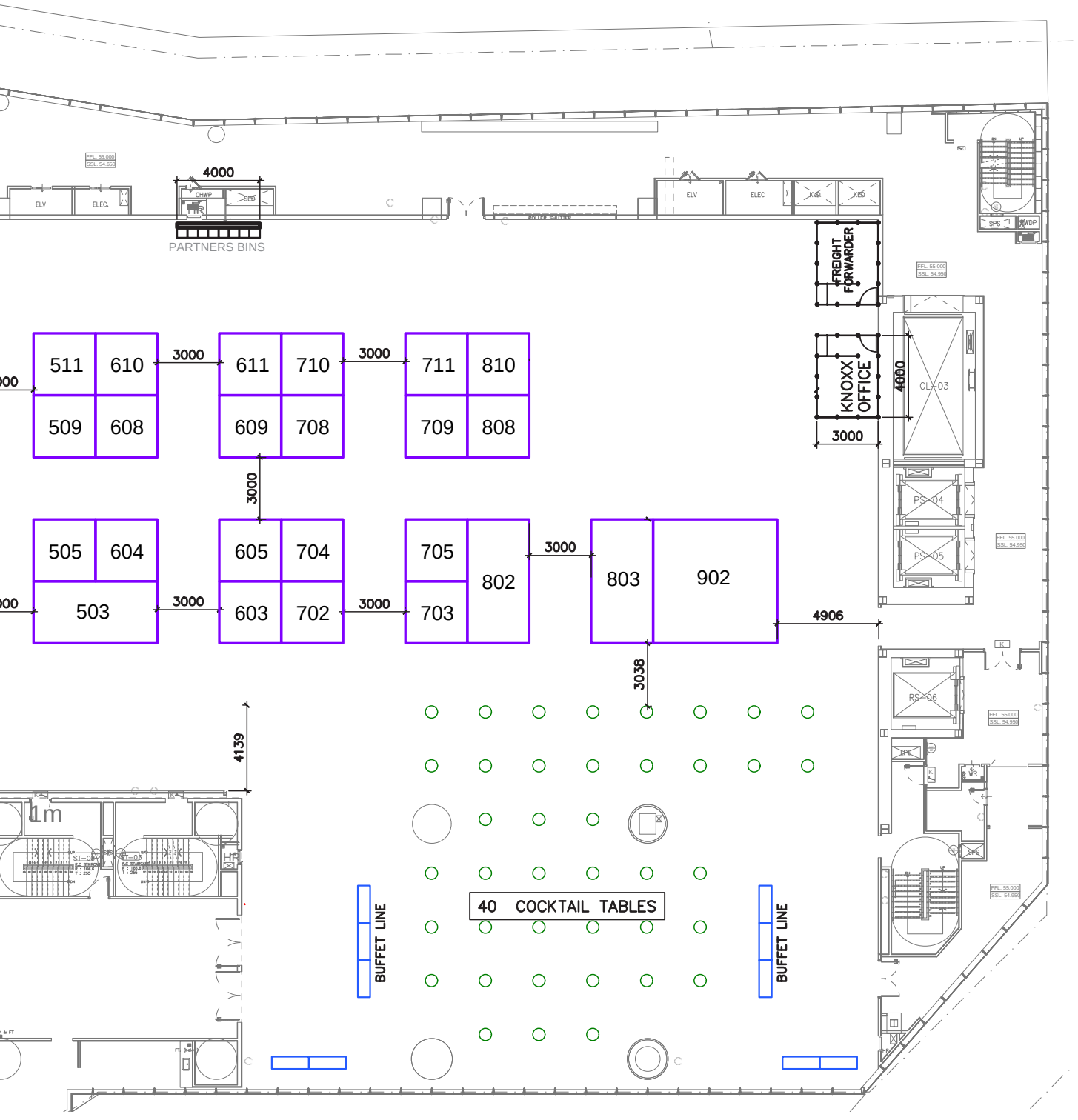
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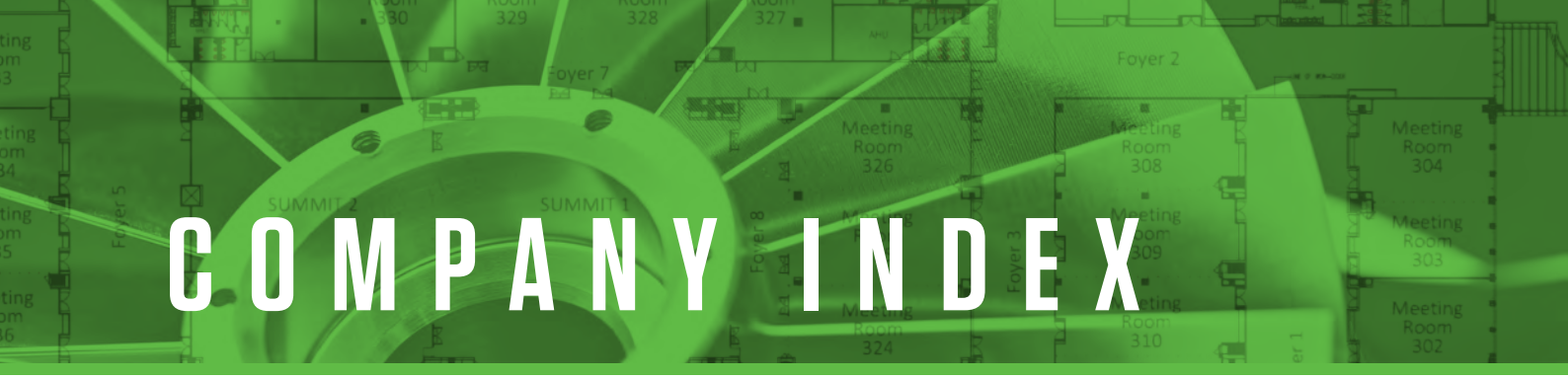


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# COMPANY DESCRIPTIONS

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## FLOWDY 708

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## GRAPHALLOY 609

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**http://www.isomag.com**

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**P: +65181800**
**http://www.johncrane.com**

John Crane is an American company, now a subsidiary of Smiths Group and provider of engineered

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## MITSUBISHI HEAVY INDUSTRIES COMPRESSOR CORPORATION 200

MITSUBISHI HEAVY INDUSTRIES
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MITSUBISHI POWER, LTD.

**6-22, Kan-on-shin-machi 4-Chome, Nishi-ku**
**Hiroshima Hiroshima 7338553 Japan**
**P: +81-82-291-2200**
**F: +81-82-294-0345**
**http://www.mhicompressor.com/en/**

Mitsubishi Heavy Industries Compressor Corporation (MCO) has been renowned as the most reliable compressor and steam turbine manufacture through its highest technological background and customer-oriented services. Backed by its wealth of experience, MCO has brought forth various improvements in compressor and steam turbine design, production, and applications. Thanks to these efforts, Mitsubishi Compressors and Steam turbines are now used worldwide. MCO has numerous revamp/replacement experiences and continuously improves its technology based on market and customer needs. MCO are ready to dispatch skilled technical advisors and to provide timely maintenance service to enable safe long-term operation.

## NEUMAN & ESSER SOUTH EAST ASIA LTD. 604

178/1 Moo 7, T. Phe, A. Muang
Rayong Rayong 21160 Thailand
P: +66 38 923 745
F: +66 38 923 761
https://www.neuman-esser.de/en/

NEUMAN & ESSER is a leading provider of reciprocating compressor solutions for the energy industry. More than 180 years of manufacturing heritage has positioned the company as one of the premier manufacturers, packagers and service providers of gas-separable, reciprocating compressors. As OEM, NEUMAN & ESSER is responsible for the manufacturing, packaging, service and spare parts inventory of every compressor it delivers, giving customers the most integrated and efficient compressor solutions available. This combination of quality, performance, integration and expertise results in improved reliability, reduced business risk and a lower total cost of ownership.

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**P: +01 713 956 2002**
**F: +01 713 956 2141**
**http://www.pumpworks.com**

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

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**P: +01 610 481 4991**
**http://www.rotoflow.com**

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**http://www.sohreturbo.com**

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

## SULZER PUMPS WASTEWATER MALAYSIA SDN BHD 702

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## TERAJU PETROLEUM SDN BHD 404

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Teraju Petroleum Sdn bhd is a fully Malaysian-owned oil and gas company. Teraju Petroleum is led by a team of oil and gas industry professionals with an excess of experienced, hands-on staff with top management experience in all phases of the upstream and downstream of oil and gas industry in petroleum, mechanical, power, and energy services backgrounds. Teraju Petroleum aims to be a force and significant player across the entire value chain of the oil & gas industry in Malaysia. We are a mechanical static and rotating equipment provider.
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**http://www.turbogemilang.com**

Turbo Gemilang Engineering Sdn Bhd specializes in diesel engine turbochargers service, repair & spare supply for all major types. Facility is fully operational 24/7 in Malaysia. Our experienced engineers attended several training programs organized by maker/builder and are knowledgeable in ABB, MET, MAN, NAPIER & KBB turbochargers service & troubleshooting. Turbo Gemilang is a 1000sqft building and workshop equipped with major machines such as the Schenck balancing machine, Ash blasting and Mitotoyo measurement tools. Facilities minimize repair hours and meet customer expectations within the given time. We are accredited with ISO:9001 and approved by Register Quality Assurance.

## TURBOMACHINERY LABORATORY 309

**3254 TAMU**
**College Station, TX 77843 USA**
**P: +01 979 845 7417**
**http://turbolab.tamu.edu/**

The Turbomachinery Laboratory, part of The Texas A&M System, conducts theoretical and applied research intro reliability and performance of turbomachinery. The Turbo Lab impacts the industry through three pathways: 1) Research: The Turbomachinery Research Consortium was formed in 1983 to find answers to important questions of reliability and performance of turbomachinery for industrial companies who supply annual research grants. 2) Education: The Turbo Lab produces engineers ready to work by offering undergraduate and graduate engineering education. 3) Professional Workforce Development: The Turbo Lab organizes the annual Turbomachinery & Pump Symposia in Houston and the biennial Asia Turbomachinery & Pump Symposium in Malaysia.

## VIBRO TECHNOLOGIES & ENGINEERING PTE LTD 705

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**Singapore 408569 Singapore Singapore**
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Established in 1997, Vibro Technologies is an authority in predictive maintenance product and services in Singapore. We strive to elevate our consumer's competitiveness regardless of what industries they may be in by enhancing the lifespan of their machineries, equipment & using the leverage of new technologies to position them to always be one step ahead of their competitors. A combination of comprehensive knowledge, relevant skills, innovation and a tinge of human touch in our services is what keeps Vibro Technologies so sought after in our area of expertise after all these years. No problems! Only solutions.


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### ACCUMULATORS (PULSATION DAMPENERS)



### ALIGNMENT TOOLS & EQUIPMENT



### BALANCING MACHINES



### BEARINGS - FLUID FILM



### BEARINGS – ISOLATORS

### PUMPS



## EDUCATION/RESEARCH/ TRAINING

### CONSULTING - MAINTENANCE & RELIABILITY



### CONTINUING EDUCATION CREDIT COURSES



### EDUCATIONAL COURSES



### PUMPS/FLUID HANDLING



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### INTERNATIONAL FREIGHT FORWARD



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# TRC

TURBOMACHINERY RESEARCH CONSORTIUM

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## Join TRC today

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

**Eric Petersen,** Director
**Debbie Maggs,** Program Manager

## Expertise at your fingertips

TRC members have exclusive access to XLTRC2 , a suite of high-speed, experimentally verified and user-friendly codes for executing a complete lateral and torsional rotordynamic analysis of rotating machinery, including pumps, compressors and turbines. XLTRC2 is bundled with 25 or more examples of rotordynamic analysis, including rotors for compressors, pumps and gas turbines. Each model features distinctive bearing/seal support conditions and displays unique characteristics of rotordynamic behavior.

FOR MORE INFORMATION
**turbolab.tamu.edu/trc**

**979-845-7417**
**trc@turbo-lab.tamu.edu**

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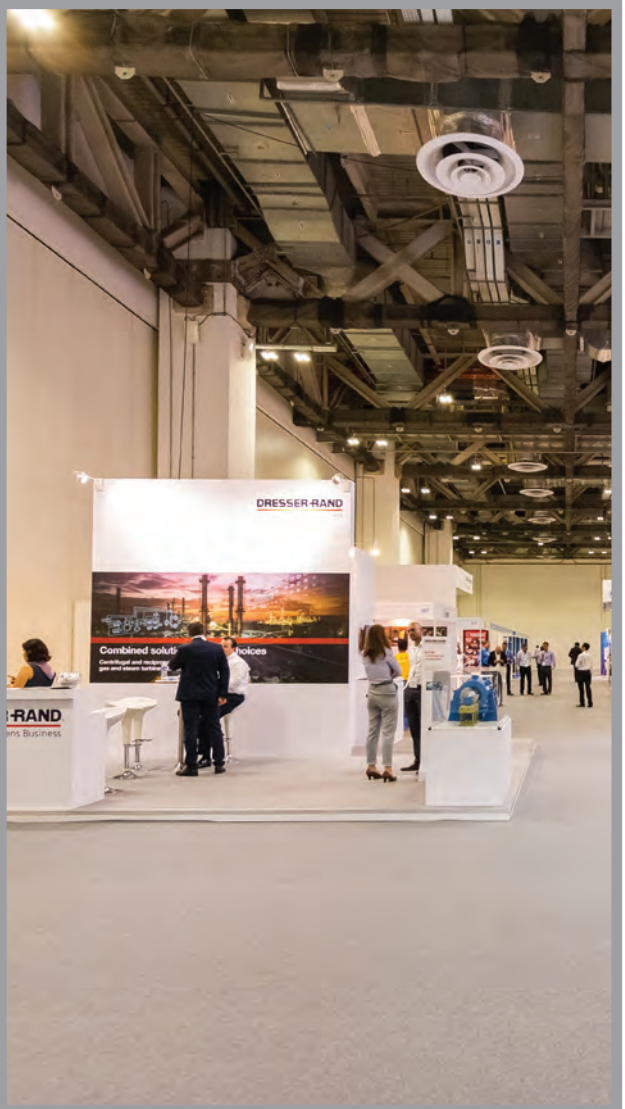


# GENERAL INFORMATION

## REGISTRATION/INFORMATION

On the first day of the conference, registration will be held on Level 4, in Hall 8A. Please come by to pick up your information bag, the conference schedule, and your registration badges.

## EXHIBITION

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

The exhibition for delegates is hosted on Level 4, Hall 8B and 8C at the Kuala Lumpur Convention Center. The hall will be open during the following times:

| | |
|---|---|
| TUESDAY, 24 MAY 2022 | 1000 – 1800 HOURS |
| WEDNESDAY, 25 MAY 2022 | 1000 – 1800 HOURS |
| THURSDAY, 26 MAY 2022 | 0900 – 1300 HOURS |

## WELCOME ADDRESS

***Badge required – not open to Free Pass***

The Welcome Address is scheduled for Tuesday, 24 May 2022 in the Plenary Hall Auditorium.

## LUNCHEONS

***Badge required – not open to Free Pass***

Lunch will be served on 24 and 25 May 2022, on Level 4, Hall 8B and 8C. Lunch is included in the full symposium registration fee. The one-day symposium registration fee includes a luncheon ticket for the respective day of purchase.

## GALA DINNER

***Badge or ticket required – not open to Free Pass***

The Gala Dinner is scheduled for Wednesday, 25 May 2022, 1930-2100, Grand Salon 1, Grand Hyatt Hotel. A Gala Dinner ticket is included in the full symposia registration fee and your badge is required for admission. Additional tickets are available for purchase at Registration (USD 100).

## ATPS SYMPOSIUM PROCEEDINGS

The Turbomachinery Laboratory is proud to present the full technical program for the Asia Turbomachinery and Pump Symposium. These Proceedings are included as part of the full and one-day symposium registration fee. To access the Proceedings documents, see the "Where are my Proceedings?" flyer in your information bag or at the registration counter.

*The Proceedings QR code will be available for 10 days following the symposium, after which time, the link will close. Proceedings will be available to the public 6 months post-conference via: turbolab.tamu.edu/proceedings.*

## CONTINUING EDUCATION UNITS (CEUs)/ PROFESSIONAL DEVELOPMENT HOURS (PDHs)

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

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

In order to receive a CEU/PDH certificate, you must complete and return the appropriate CEU/PDH request form to the registration counter during the symposia or after the symposia via email to the CEU Coordinator, debbie@turbo-lab.tamu.edu: 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 29 April 2022. There will be a $100.00 USD administrative and banking fee charge to cancel registration. Substitutions are encouraged. We do request that substitutions be made in advance, as substitutions made onsite at the symposium will result in registration delays.

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

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

# FACULTY DIRECTORY

## DR. ERIC PETERSEN

Turbomachinery Laboratory Director | Mechanical Engineering

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Mechanical Engineering

**DR. DARA CHILDS**
Emeritus Professor, Retired

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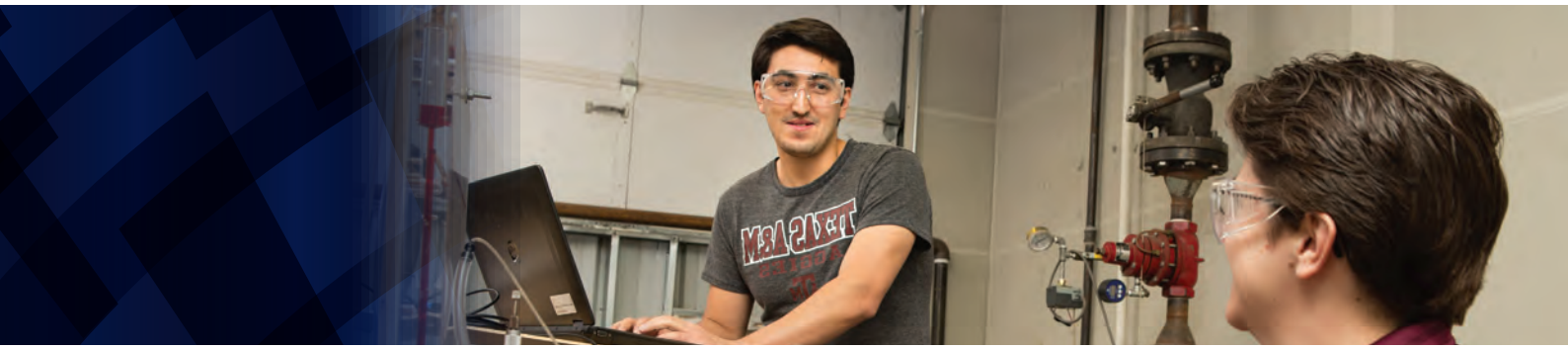
# ABOUT THE TURBOMACHINERY LABORATORY



## OUR MISSION

The Turbomachinery Laboratory, a center of the Texas A&M Engineering Experiment Station (TEES) and a member of The Texas A&M University System, proudly continues Texas A&M's land-grant charter and tradition of identifying research areas critical to the state's economic development, leadership, and quality of life. Priorities include Basic and Applied Research, Undergraduate and Graduate Education, and Continuing Education and Professional Development. In sum, the Turbomachinery Laboratory makes a vital impact on turbomachinery and related industries through three pathways:

### BASIC AND APPLIED RESEARCH

A variety of fundamental and applied research is performed by Turbomachinery Lab faculty, post docs, and students. This research is sponsored by a combination of government and industry sources through traditional grants and contracts and covers the entire range of specialties of the Turbo Lab research groups. These specialties include rotordynamics, turbine blade heat transfer, combustion, optical diagnostics, bearings, machine learning, uncertainty quantification, chemically reacting flows, computational fluid dynamics, and seals, among others. Unique test rigs and extreme environments are among the many reasons why the Turbomachinery Lab continues to be a leader in turbomachinery-, propulsion-, and energy- related research.

Another way Turbomachinery Lab faculty and students team up with industry partners is through the Turbomachinery Research Consortium. The TRC is a unique organization of major turbomachinery developers and users who have joined with the Turbo Lab to find answers to important questions through research.

### UNDERGRADUATE AND GRADUATE EDUCATION

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

### WORKFORCE DEVELOPMENT (SYMPOSIA & SHORT COURSES)

TL's acclaimed Turbomachinery and Pump Symposia (TPS) is held annually in Houston, Texas, and its sister event, the Asia Turbomachinery and Pump Symposia, biennially in Malaysia. TPS is recognized as being the principal meeting for users and manufacturers of industrial turbomachinery. Both symposia feature a technical program hand-selected by an advisory committee of industry experts combined with an international exhibition of more than 350 companies in a world-class exhibit hall. Additional continuing education opportunities are available through short courses offered throughout the year by the Turbomachinery Lab.

DIRECTOR:
Dr. Eric Petersen
epetersen@tamu.edu
979.845.1257
turbolab.tamu.edu
Visit turbolab.tamu.edu for more information.

# HAVE YOU RESERVED YOUR BOOTH FOR TPS 2022?

COME TO THE REGISTRATION COUNTER ON LEVEL 4 TO TALK TO MARTHA BARTON, OUR EXHIBITOR SERVICES DIRECTOR ABOUT EXHIBITING AT OUR LARGER HOUSTON SYMPOSIUM, TPS.

**TPS 2022:** SEPTEMBER 13-15, 2022
SEPTEMBER 12: SHORT COURSES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