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Session 3

Operator Training

Induction Course

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DYNAMIC POSITIONING: INDUCTION COURSE

COURSE DESCRIPTION -The Induction Course on Dynamic Positioning (DP) will provide an in-depth understanding of the positioning system as it is used to compensate for vessel movement. It will cover vessels' DP referencing systems, sensors, power plants, thrusters and feedback systems. While the course reviews material that was covered in the familiarization course, it goes into much more detail. The course should cover theories of redundancy, communication with the bridge, drill floor, and other vessel operations. Failure scenarios and simulator exercises should be covered on the final day.

WHO SHOULD ATTEND- Attending the DP Familiarization Course is not a prerequisite. A candidate should have a certain level of practical experience with electronic equipment, and knowledge and experience with marine operations. Upon completion of this course, an operator should be able to complete 60 - 90 days of supervised DP operation, therefore familiarization with a vessel's operation would be necessary. There will be some discussion of the various Societies that set standards for DP systems and different applications for DP systems.

I. INTRODUCTION -The student should be familiar with most of the material in this section. Rather than reviewing material as general knowledge, the student should consider how subjects apply to his particular situation.

A. Objective of the Induction Training

B. Definition of Dynamic Positioning Systems
1. Terminology

C. Objective of a Dynamic Positioning System

D. Required Training and Experience of Personnel to IMCA Standards

E. Classification Society Rules
1. Intent of the Rules
2. Consequence Classes
3. Vessel Operational Capabilities

F. DP Applications
1. Dive Support
2. Drilling
3. ROV Support
4. Cable
5. Pipe Lay
6. Military
7. OSV – Offshore Supply Vessel
8. Mooring Assist
9. AHTS – Anchor Handling/Tug Assist
10. Trenching

II. BASIC CONCEPTS -The student should have a working knowledge of these basic concepts as they apply to; DP control systems, sensor systems, thruster systems and power systems.

A. Triangulation

B. Oceanography/Meteorology
1. Waves
2. Ocean Currents
3. Weather Systems
4. Wave Drift

III. CONTROL THEORY - In the Induction Course, the following topics would be defined and their applicability to DP operations discussed. The student should have a solid understanding of why these theories (and systems) work, as they will be the basis for further work in this course and Simulation Course.

A. Basic Theory of Operation
   1. Definitions
   2. Types
   3. Classifications
   4. Block Diagrams

B. Closed Loop (Feedback) Control Systems
   1. The Model
   2. Terminology
   3. Application to DP
   4. Feed Forward Applications

C. PID Controllers
   1. Proportional Force
   2. Damping Force
   3. Integral Force

D. State Estimator (Kalman Filter)
   1. Behavior Characteristics
   2. Implementation
   3. Block Diagrams

E. Basic Time Response Characteristics
   1. Effects of Gain Change
   2. Effects of Damping
   3. Effects of Integral Term

F. Stability Characteristics
   1. Stable Conditions
   2. Unstable Conditions
   3. Characteristics and Causes and Effects
   4. Gain and Stability Margins Test

III. CONTROL THEORY(cont'd)

G. Thrusters
   1. Hardware Description
   2. Fundamental of Pitch and Azimuth Control
      a. Thruster Control Loops External to DP System
      b. DP System Interface
   3. Thruster Efficiencies
      a. Thrust-Power Characteristics
      b. Inflow Characteristics
      c. Cross-Coupling Effect
   4. Thruster Drive Systems
   5. Thruster Response Characteristics
   6. Thruster Allocation Logic

IV. ENVIRONMENTAL AND THRUSTER FORCES - Students should have a good working knowledge of these environmental forces and how they act upon the vessel. Likewise the vessel's holding capabilities used to counteract environmental forces should be thoroughly explained. Toward the end of this material, vessel control using a simulator should be reviewed.

A. Stationkeeping Capability
   1. Thruster and Power System Reliability
   2. Quasi-Static and Dynamic Loading
      a. Mean and Maximum Offset.
      b. Reserved Margin for Dynamic Loading
      c. Other Forces
   3. Thruster Characteristics
   4. Collinear and Non-Collinear Environments
   5. Holding Capability Study
   6. Survival Criteria
   7. Operation Criteria
   8. Damage Criteria

B. Environmental Forces
   1. Wave Forces
      a. First Order Forces
      b. Second Order Forces
      c. Model Testing
   2. Wind and Current Forces
      a. Square Law
      b. Drag Tables
      c. Model Testing

V. POWER PLANT SYSTEMS - Power systems can vary greatly from vessel to vessel. In this section, students should be provided a basic explanation of power systems. An important part of every DP Operator's job is to be able to quickly determine if the operator is not maintaining position and why. If the operator is having a power problem, the operator should be able to determine that and minimize any damage it might cause. Most importantly, a DP operator should know who to turn to on the vessel, should they be experiencing power problems.

A. Basic Power System

1. Requirements
2. Types of Loads
3. High Voltage Switch Gear
4. Low Voltage Switch Gear
5. Emergency Switch Boards
6. Redundancy Configurations
7. Basic Engine Control
8. Breaker Coordination

B. Basic Power Distribution Control System

C. Basic Power Management Theory
1. Skid Auto-Start and Advise Logic
2. Power Calculation and Monitoring
3. Load Shed Logic
4. Loss of an Engine
5. Basic Power Management Programs
6. Operator Interface
7. Operating Examples

VI. THRUSTERS AND DRIVE SYSTEMS -The basis of thruster and drive systems were covered in Section III Control Theory subsection G. This section will build on those fundamentals, followed by an analysis of possible failure scenarios. Having completed this section, the student should be able to recognize if his thrusters are working as designed and if not, what thruster problems he might be experiencing and why.

A. Thrust Required and Holding Capability
1. Survival in Maximum Environmental Conditions,
2. Sudden Squalls with Rapid Changes in Direction (available weather data),
3. Beam Thrust for Ship Shape Vessels
   a. the need for rapid turns
4. Vessel Drag Factors for Wind and Current
   a. calculated values,
   b. wind tunnel and
   c. tank tests

B. Control of Thrust
   1. Fixed Pitch vs Controllable Pitch
   2. Fixed vs Azimuthing

C. Thruster Drive Systems
1. Fixed Speed Drives
2. Variable Speed Drives
    a. DC Variable Voltage
    b. AC Variable Frequency

D. Thrust Efficiency and Losses

E. Propeller/Hull Interaction

F. Thrust Degradation, Hull Drag, Current Effects, Inflow, Cross Forces and Compensation

G. Access for Repair

H. Reliability, Failure Modes, Thruster Down Time for Service/Repair.

VII. DP SYSTEMS - DP systems are designed to have high reliability and a certain amount of built-in redundancy. Component failures are probable, therefore components are backed up. System design, reliability and redundancy requirements should be thoroughly explained in this section.

A. Redundancy Concepts and Reliability
1. Single Point Failure Analysis
    a. Failure Mode Effect Analysis (FMEA)
    b. Mean Time Between Failure
    c. Mean Time To Repair
2. Automatic Switching
3. System Modifications

B. Basic System Hardware Layout and 3-Axis Diagram
1. DP System Hardware
    a. Position Sensors
        1. Acoustic Position
        2. DGPS
        3. ARA - Acoustic Riser Angle
        4. ERA - Electric Riser Angle
        5. Taut Wire
        6. Land Based Radio Positioning System
        7. Laser Radar
    b. Attitude Sensors
    c. Environmental Sensors
        1. Current
        2. Wind
    d. Controller
    e. Operator Interface and Controls
    f. System Power
    g. UPS

h. Fiber Optics

C. Position Reference Systems
1. Acoustics
a. Hardware Description
b. Baselines
1. Ultra-Short
2. Short
3. Long
4. Combined Techniques

VII. DP SYSTEMS (cont'd)

c. Fundamentals of Acoustic Systems
   1. Theory of Operation
   2. Environmental Considerations
      a. Ambient Sea Noise
      b. Signal to Noise Ratio
      c. Water Temperature
      d. Other Acoustic Noise Sources
   3. System Accuracy
      a. Vertical Reference Sensor
      b. Alignments (Offsets, azimuth and tilts)
      c. Incident Angle (Offset and range)
   4. Display and Performance Monitoring
      a. Display and Control
      b. Alarm Monitoring
      c. Status Monitoring
   5. Modes of Operation
   6. Operating Practices and Procedures
      a. Normal Positioning
      b. Re-Entry
   7. Operating Practices and Procedures
      a. Parameter Setup
      b. Alarm Monitoring
      c. Status Monitoring
   8. System Limitation and Field Experience

2. Taut Wire
   a. Hardware
   b. Principals of Operation
   c. Operational Practices
      1. Initial System Setup
      2. Normal Operation
      3. Position Limitations
      4. Dragging of Anchor
      5. Potential Operational Problems
   d. System Limitation and Field Experience

VII. DP SYSTEMS (cont'd)

3. Electric Riser Angle
   a. Hardware
   b. Theory of Operation
   c. Static and Dynamic Operational Characteristics
      1. Sensor and Riser Sections
      2. Riser Dynamics/Response
      3. Vessel Motion
   d. Operating Practices and Modes
      1. Sensor Selection
      2. Sensor Zero Calibration
      3. BOP Stack Tilt
      4. BOP Stack Rotation and Azimuth
   e. System Limitation and Field Experience

4. Differential Global Positioning System
   a. Hardware
   b. Theory of Operation
   c. Operational Characteristics
   d. Vessel Motions
   e. Operational Practices
      1. Sensor Selection
      2. Glonass
   f. System Limitation and Field Experience
      1. Acoustic Noise
      2. Taut Wire
      3. Electric Riser Angle
      4. DGPS and Selective Availability
      5. Sensor Selection

D. Position Data Processing
1. First Order Wave Filters
2. Position Error Detection and Rejection Logic
   a. Triple Voting
   b. Multiple Sensor Variations
3. Position Sensor Data Blending Logic
   a. Sensor Switch Selection
   b. Automatic Transfer Logic
   c. Bumpless Transfer Logic
   d. Noise Rejection Logic
   e. Kalman Filters
4. Dead Reckoning Mode

VII. DP SYSTEMS (cont'd)

E. Thruster Allocation Logic
1. Optimal Thruster Allocation
2. Control and Power Biasing
3. Power Limiting
   a. Modes of Operation
   b. Power Plant Interface
4. Selection of On-Line Thrusters

F. Operator Interface
1. Setup Pages
2. Vessel Position and Heading Commands
   a. Control Panel and Display Pages
   b. Setpoint Changes
3. DP System Performance Monitoring
   a. Position
   b. Heading
   c. Attitude
   d. Environmental
4. Thrust Control
5. Consequence Analysis

G. Data Logging
1. On-Line Capability
2. Post Event Analysis
3. Troubleshooting

H DP Operator
1. Training and Experience
2. Organization and Procedures
   a. Chain of Command
   b. Normal Operating Procedures
   c. Emergency Operating Procedures
   d. DP Operator Logbook
3. Communications Systems

I. Simulation
1. Onshore Training
2. Offshore On-station Training

VIII. DP SYSTEM OPERATIONAL CHARACTERISTICS -This section should take into consideration external forces that effect DP performance. These may differ according to operations.

A. Normal Operation

B. Environmental Effects on DP Performance
   1. Support Vessels Effect on DP Performance

IX. SYSTEM TESTING

A. System Testing
   1. Dockside Tests
   2. Sea Trials
   3. First Location Setup/Testing
   4. Between Operations
   5. Stability Gain Margin Checks
   6. Hydrophone Alignment
   7. Other Tests

X. DRILLING OPERATING REQUIREMENTS - Depending upon the operation that the students are involved in, emphasis should be placed on only one of the DP applications, covered in sections IX, X, and XI. Teaching of this section should not only take into consideration the general DP application, but should go as far as to take into consideration the vessel's characteristics.

A. Drilling Operating Procedures and Contingence Planning

B. Emergency Disconnect Procedures
   1. Limiting Criteria
   2. Drive-Off and Drift-Off Analysis

C. Operation Considerations of Dynamic Positioned Drilling
   1. Guidelineless Drilling from DP Vessels
      a. Pre-Planning for Efficient Operation
         1. Typical Drilling Program
         2. Planned Loading
         3. Pre-Operational Checks
         4. Location Staking
      b. Setting Up on Location
         1. Drill Pilot Hole
         2. Determine Mud Line Depth
         3. Conduct jet test
      c. Jet 30", GRA and Drill 26" Hole
         1. Space Out Bit at 30" Shoe
         2. Double 'J' Tool
      d. Drill 36" Hole (Alternative)
         1. Land TGB with 36" Drilling Assembly
         2. Re-enter with 30" Casing
      e. Run 18-3/4" Wellhead on 20" Casing
         1. Re-entry with Subsea TV and ROV
         2. Land and Cement Casing/Wellhead
      f. Run BOP Stack and Riser
         1. Re-entry with 'Bombshell' TV or ROV
         2. Install Slip Joint and Diverter
         3. Continue Drilling Program
         4. Verify BOP Stack/Riser Angle Axis Heading
         5. Riser Management
      g. Re-entry with LMRP

X. DRILLING OPERATING REQUIREMENTS (cont'd)

2. Severe Environment Procedures
   a. BOP Control System
      1. Subsea BOP Control System Evolution
      2. Multiplex System Operation
         a. Major Components
         b. How does Multiplex Control Work
         c. Acoustic back-up BOP controls
         d. Stack mounted TV

3. Re-Entry
   a. Deep Water Re-Entry Systems Evolution
      1. Sonar Re-Entry
      2. Stack TV Re-Entry
      3. Combination Sonar/TV Re-Entry
      4. Vibration Isolated TV (Drill Pipe & Casing Guide)
   b. Re-Entry Systems
      1. Guideline Telescoping TV
      2. Drill Pipe or Casing Guided TV
      3. Inside Riser TV (Bombshell TV)
      4. ROV Systems

4. ROV's
   1. Garaged or Top Hat
   2. Non-Garaged

5. Diving Operations

XI. MANNED DIVING OPERATING REQUIREMENTS - The amount of training and experience needed by personnel to perform their functions safely varies. However the following minimum standards are recommended, but some may need to be exceeded in some cases:

A. Minimum Standards for Operation
   1. Supervised Operations
   2. Minimal Practical experience
   3. Supervised Watchkeeping
   4. Training of Maintenance Personnel

XII. SUPPORT VESSEL OPERATING REQUIREMENTS

A. Preparations
   1. Approach
      a. Drilling Vessel
      b. Support Vessel
   2. Moored Condition

a. Drilling Vessel
b. Support Vessel

B. Communications

XIII. DYNAMIC POSITIONING INCIDENTS -

This final section should emphasize the importance of maintaining a reliable system and the consequences of system failure.

A. Events and/or Incidents
1. Design Faults
2. DP Operator and Other Personnel
3. Environmental
   a. Wind
   b. Current
4. Drift Off
5. Drive Off

B. Consequences and Cost
1. Drilling
2. Manned Diving
3. Pipelaying
4. Cable Laying
5. Coiled Tubing
6. Workovers

C. Lesson Learned
1. Report and Documentation