

# **Predictive Maintenance Using Diagnostic System for Work Vessel Equipment**

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- Characteristics of Work Vessels
- Predictive Maintenance Technique
- Introduction of Predictive Maintenance Technique to ASIA MARU No.3
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# ■ Background of Development

## Issue of Work vessel

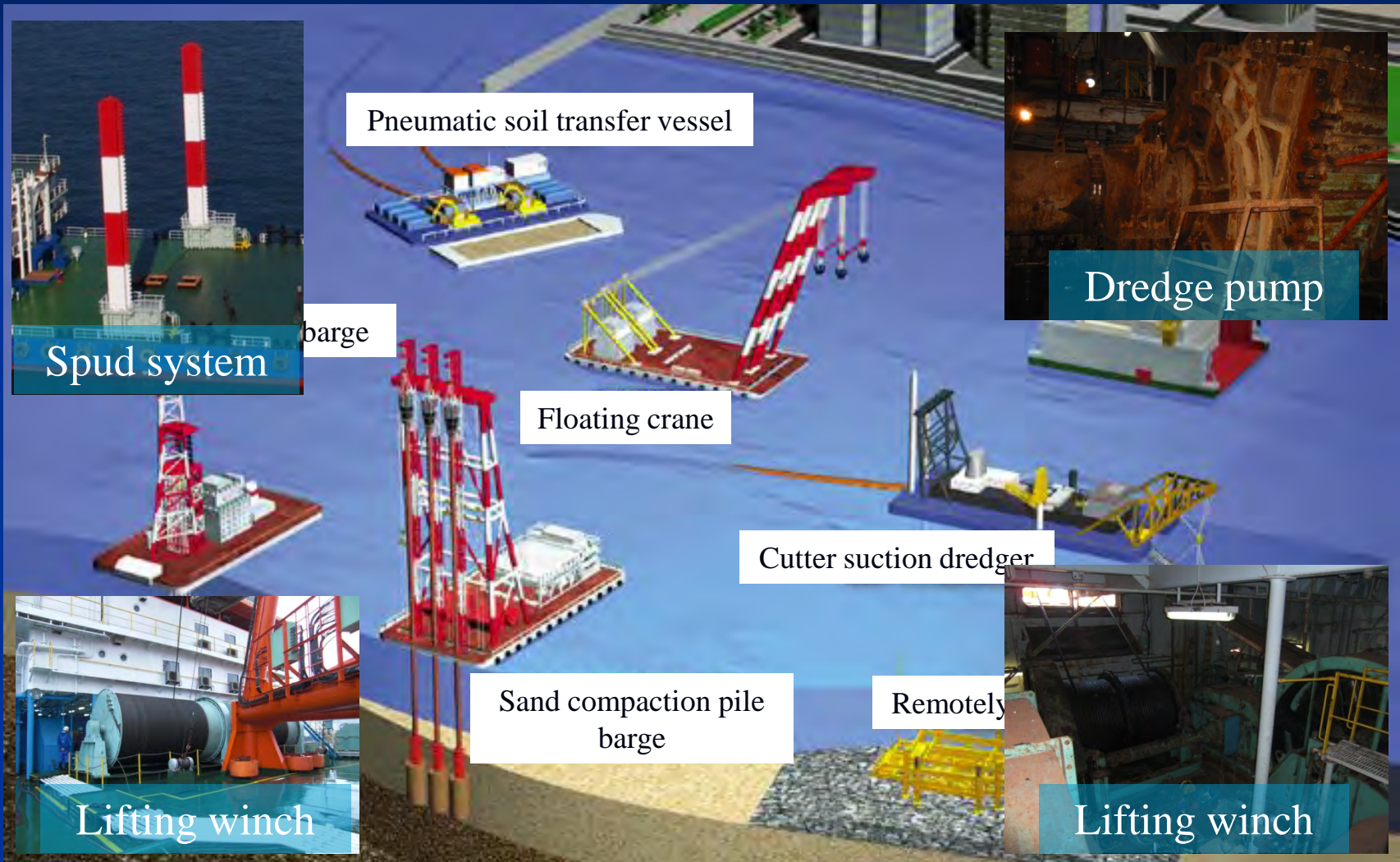
- Aging work vessel ( decrepit work vessel )
- Increase maintenance costs
- Increased risk of serious trouble

## **Diagnostic System For Work Vessel Equipment ( System to monitor the bearing and the gear )**

**Predict the exact repair timing !!**  
**Reduction of maintenance cost !!**  
**Prevention of equipment accident !!**  
**Predict the replacement timing !!**

# Characteristics of Work Vessels

## Main equipment of work vessel



# ■ Characteristics of Work Vessels

## Trouble case - 1

### ▣ Abnormal wear of gear



Type : Cutter Suction Dredger

Equipment : Ladder Lifting Winch

Damaged parts : The Sun gear of the  
planetary reduction gears

Material : SCM21

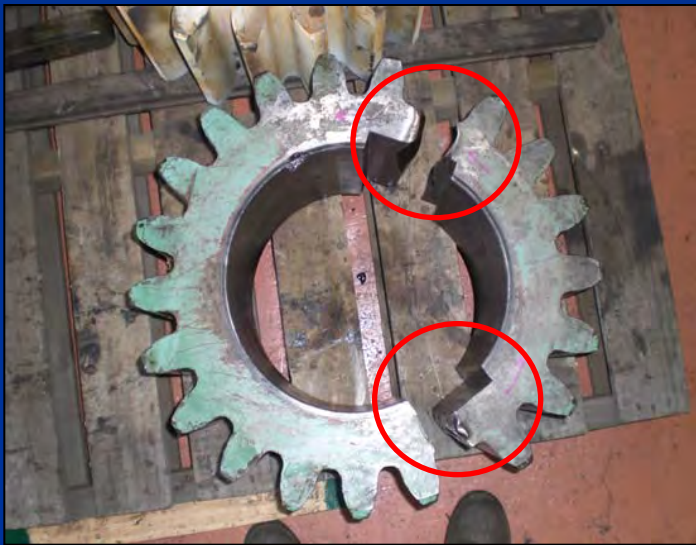
( Chromium molybdenum steel)



# ■ Characteristics of Work Vessels

## Trouble case - 2

### □ Broken gear



Type : Cement deep  
mixing barge

Equipment : Lifting Winch

Damaged parts : Pinion gear of winch  
drive shaft

Material : S45C ( Carbon steel )

# ■ Predictive Maintenance Technique

## Predictive Maintenance of Rotary Machines by Vibration Measurement

### □ General measurement item

➤ **Vibration** , noise , temperature , distortion

Table. Vibration measurement modes

| Mode                | Unit  | Frequency band | Feature of abnormality  |
|---------------------|-------|----------------|---|
| Displacement (DISP) | $\mu$ | 0~10Hz         | Mild vibration of structure   |
| Velocity (VEL)      | cm/s  | 10Hz~1kHz      | Imbalance, misalignment,<br>faulty foundation, backlash,<br>loosening of foundation bolt,<br>heavy damage to antifriction bearing |
| Acceleration (ACC)  | G     | Above 1kHz     | Damage to antifriction bearing,<br>faulty lubrication, damage to gear   |

Simple diagnosis



Abnormal sign



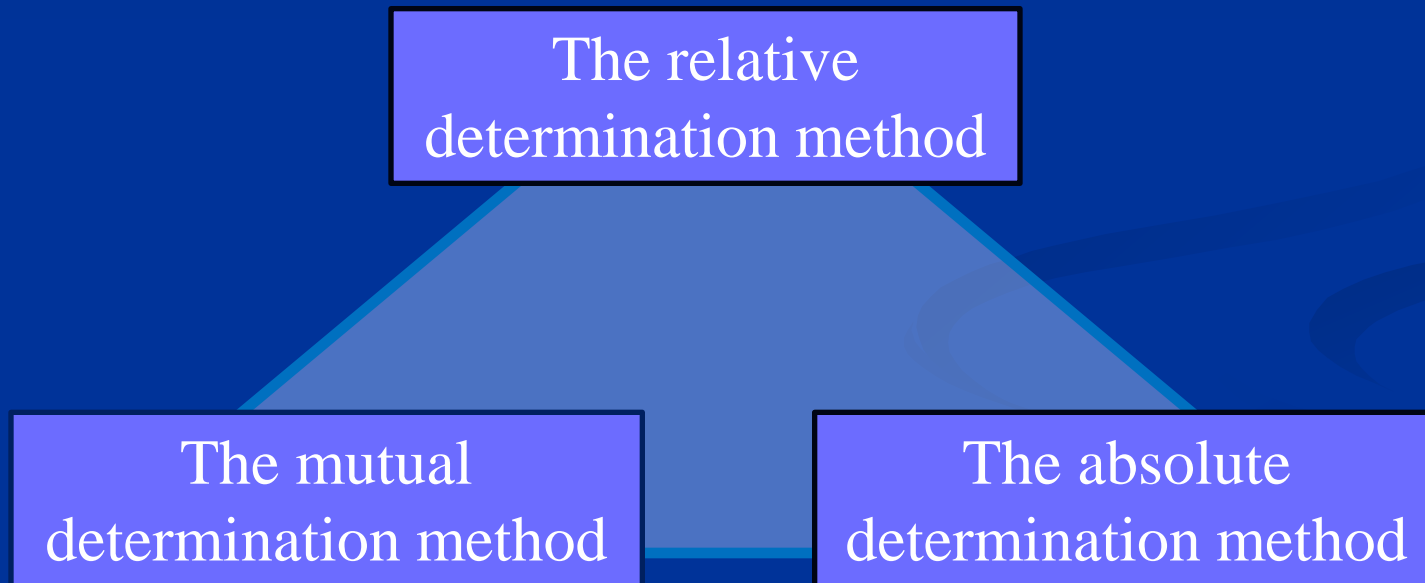
Precise diagnosis

# ■ Predictive Maintenance Technique

## Predictive Maintenance of Rotary Machines by Vibration Measurement

### □ Simplified diagnosis

- Compared with the reference value of the vibration level



**Using determination method two or more**

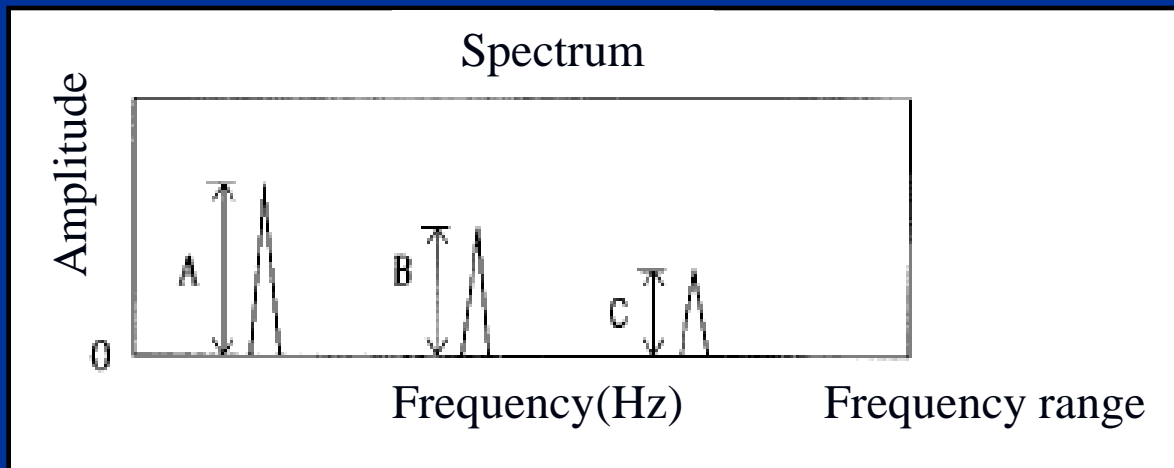


# ■ Predictive Maintenance Technique

## Predictive Maintenance of Rotary Machines by Vibration Measurement

### □ Precise diagnosis

- Analyze the periodicity in the vibration
- The estimated cause and location of damage



- Analyzed using the FFT
- To evaluate the spectrum

# ■ Predictive Maintenance Technique

## Introduction to the work vessel

### ▣ Points to be noted

➤ Large winch of work vessel



: Low-speed ( 10rpm below )

: Collision energy of damage is small

: High noise

**Vibration measurement is not suitable**

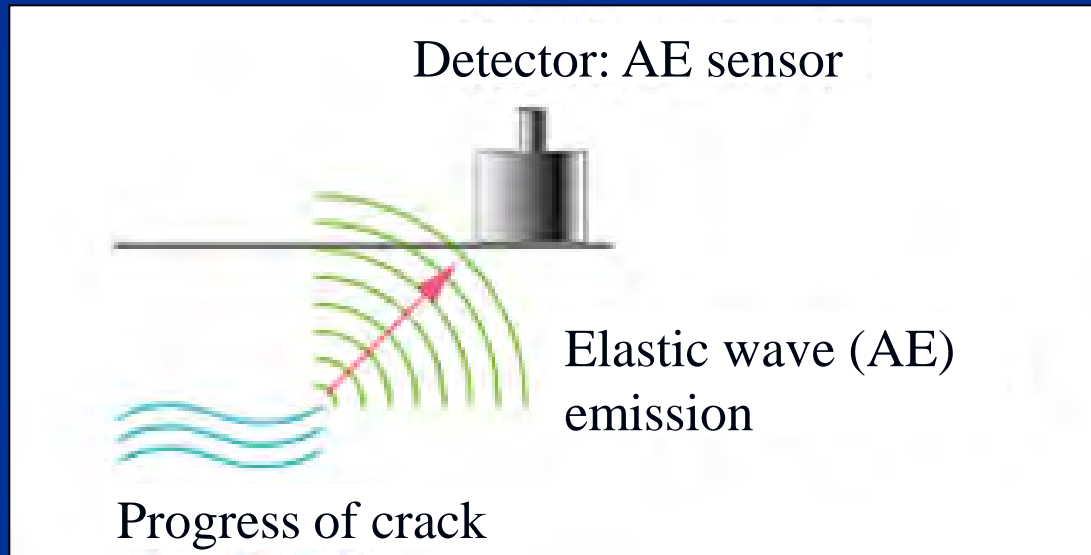


- **Introduction of AE ( Acoustic Emission ) measurement**
- **Can measure the bearing of 150rpm or less**

# ■ Predictive Maintenance Technique

## Predictive Maintenance of Rotary Machine by AE Measurement

### □ Principle of Acoustic Emission ( AE )

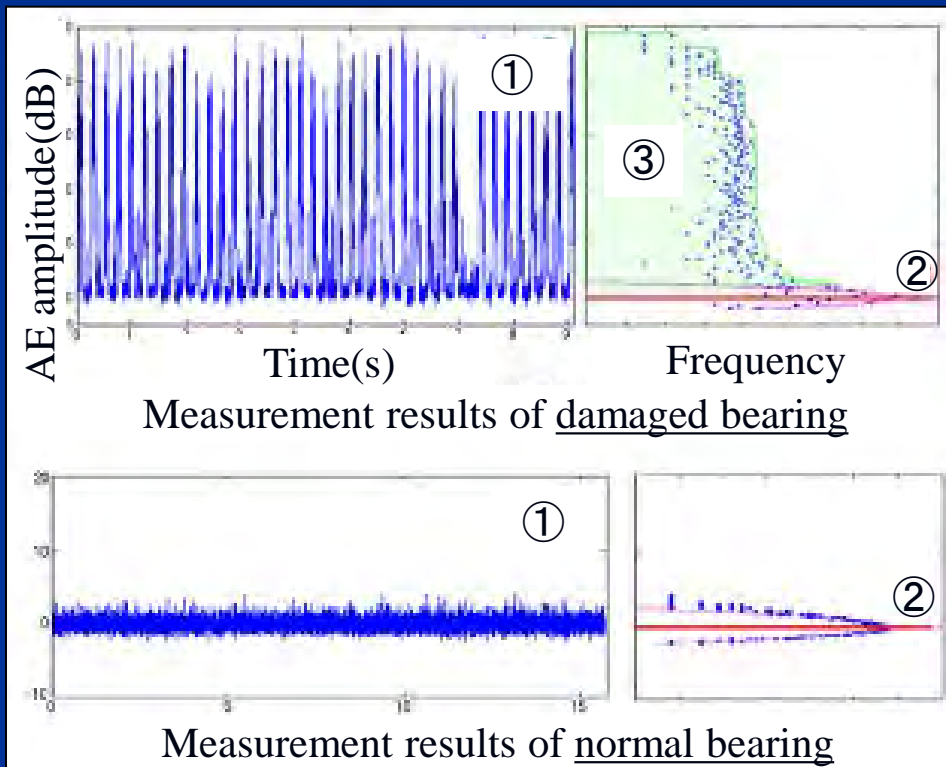


- **Detecting of elastic wave by AE sensor**
- **Evaluating the fracture process of the material**

# Predictive Maintenance Technique

## Predictive Maintenance of Rotary Machine by AE Measurement

□ Typical diagnostic parameter : E\_area



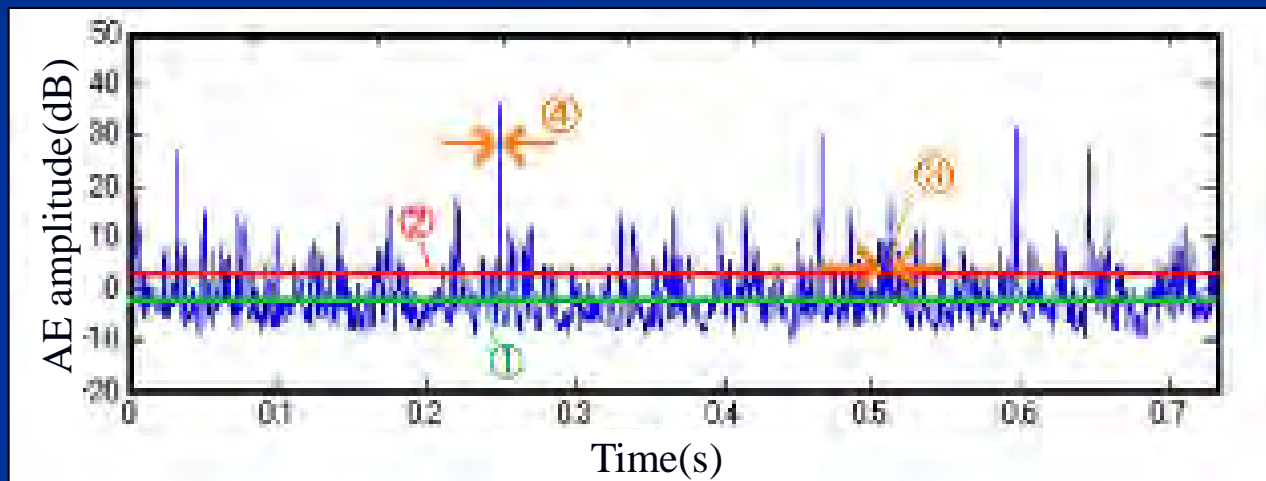
- ① Amplitude of AE signal
- ② Most frequency amplitude
- ③ Asymmetric Frequency distribution of amplitude (E\_area)

- To quantify asymmetric distribution
- Comparing the normal value and E\_area

# ■ Predictive Maintenance Technique

## Predictive Maintenance of Rotary Machine by AE Measurement

□ Typical diagnostic parameter : E\_ratio



- ① Average Amplitude
- ② Setting The Detection Level
- ③ AE Amplitude more than the set detection level (④ Noise)

▪ **Ratio of AE amplitude more than the set detection level**

# ■ Predictive Maintenance Technique

## AE Measurement

### □ Diagnostic parameter

- ①E\_area : To quantify the asymmetric frequency distribution of amplitude.
- ②E\_ratio : Ratio per revolution of AE amplitude of more than a setting the detection level
- ③E\_peak : Maximum AE amplitude per revolution
- ④E\_ave : Average amplitude per revolution
- ⑤Peak : Maximum amplitude per revolution
- ⑥Ave : Average of AE amplitude that omitted the part deviates from the normal waveform.



# ■ Introduction of Predictive Maintenance Technique to AJIA MARU No.3

## Outline of ASIA MARU No.3

### □ Cutter suction dredger



| Principal particulars        |          |
|------------------------------|----------|
| Year of build                | 1979     |
| Length                       | 78.0m    |
| Breadth                      | 19.5m    |
| Depth                        | 5.5m     |
| Draft                        | 4.1m     |
| Fully equipped engine output | 10,830kW |
| Dredging pump output         | 5,880kW  |

# ■ Introduction of Predictive Maintenance Technique to ASIA MARU No.3

## Measurement points

▣ Total of 48 points



Equipment: Ladder lifting winch  
Ladder Swing winch  
Spud winch  
Stern winch

Bearing : Electric motor  
( gear ) Reducer  
Pinion  
Winch drum

Vibration : 15points

AE : 33points

# ■ Introduction of Predictive Maintenance Technique to ASIA MARU No.3

## Measurement points

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Spud winch

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Pinion

Winch drum

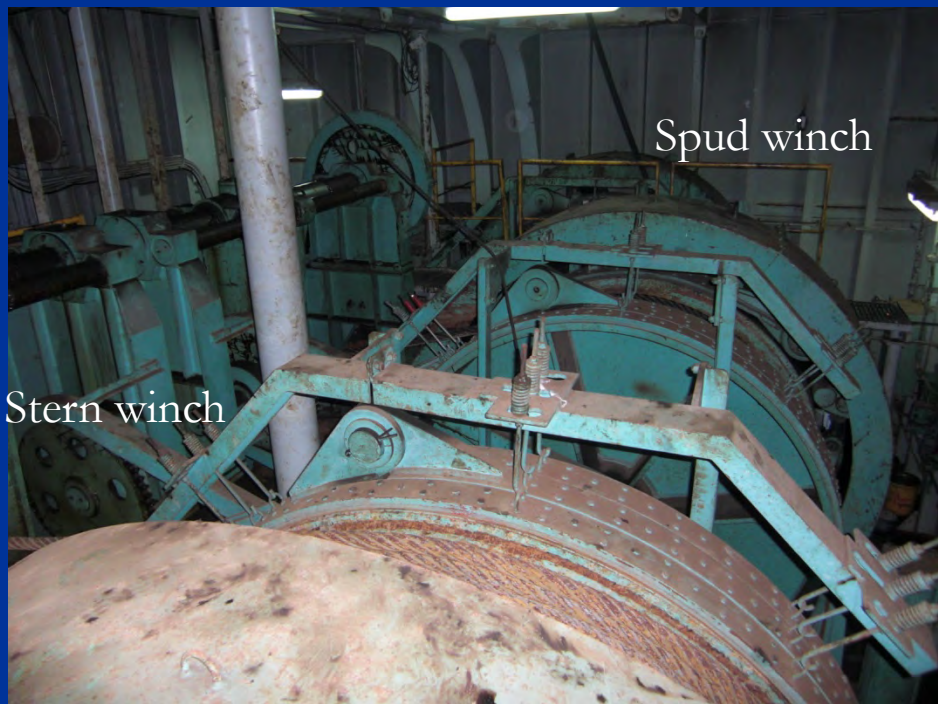
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# ■ Introduction of Predictive Maintenance Technique to ASIA MARU No.3

## Measurement points

▣ Total of 48 points



Equipment: Ladder winch

Swing winch

Spud winch

Stern winch

Bearing : Electric motor

( gear ) Reducer

Pinion

Winch drum

Vibration : 15points

AE : 33points



# ■ Introduction of Predictive Maintenance Technique to ASIA MARU No.3

## Measuring instruments

### □ Vibration meter

Manufacturer : JFE Advantech Co., Ltd.

Model : MK-210HE II

Characteristic: Trend management , Deterioration prediction , FFT



### □ AE meter ( Slow rotating bearing diagnosis instrument )

Manufacturer : JFE Advantech Co., Ltd.

Model : MK-560

Characteristic: E\_area , E\_ratio , E\_peak , E\_ave



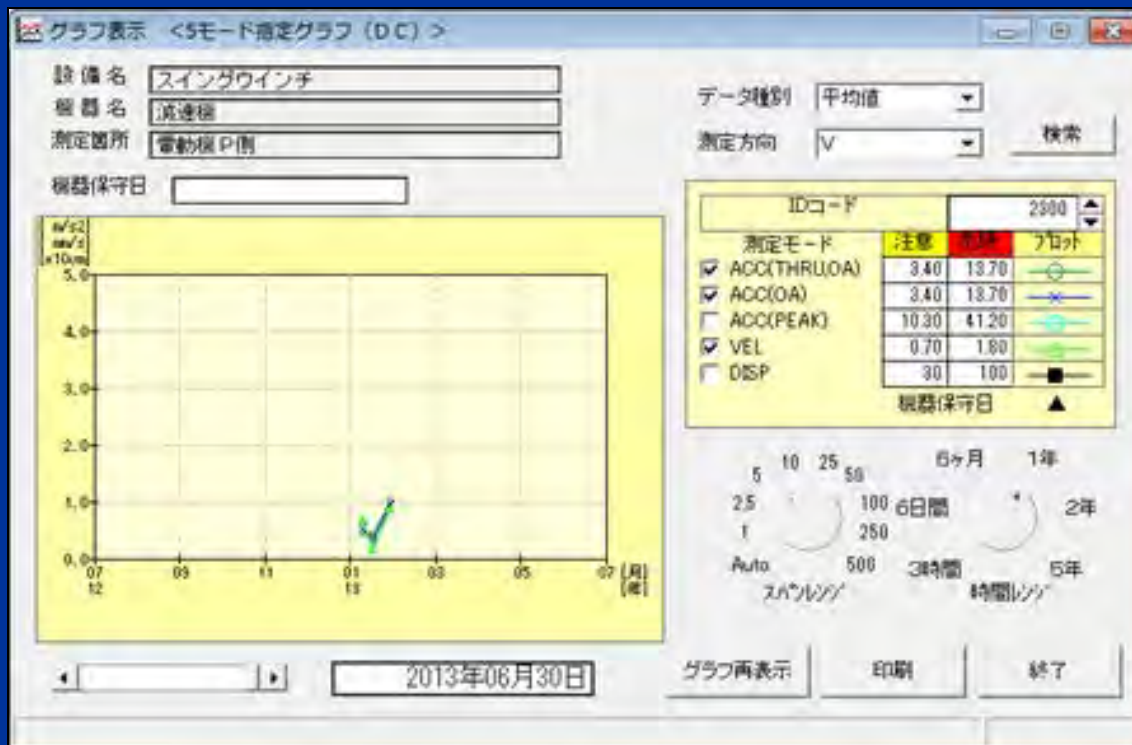
# Introduction of Predictive Maintenance Technique to ASIA MARU No.3

## Result of measurement

### Example of vibration measurement result

( Port swing winch reduction map )

➤ Damage were not observed



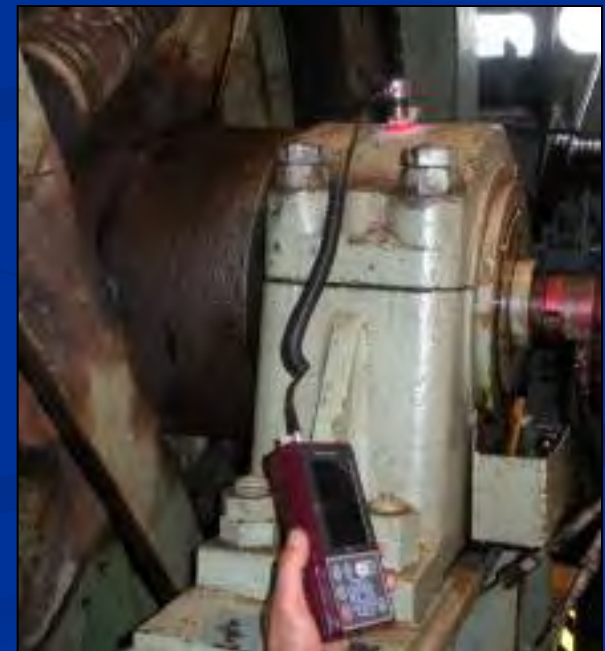
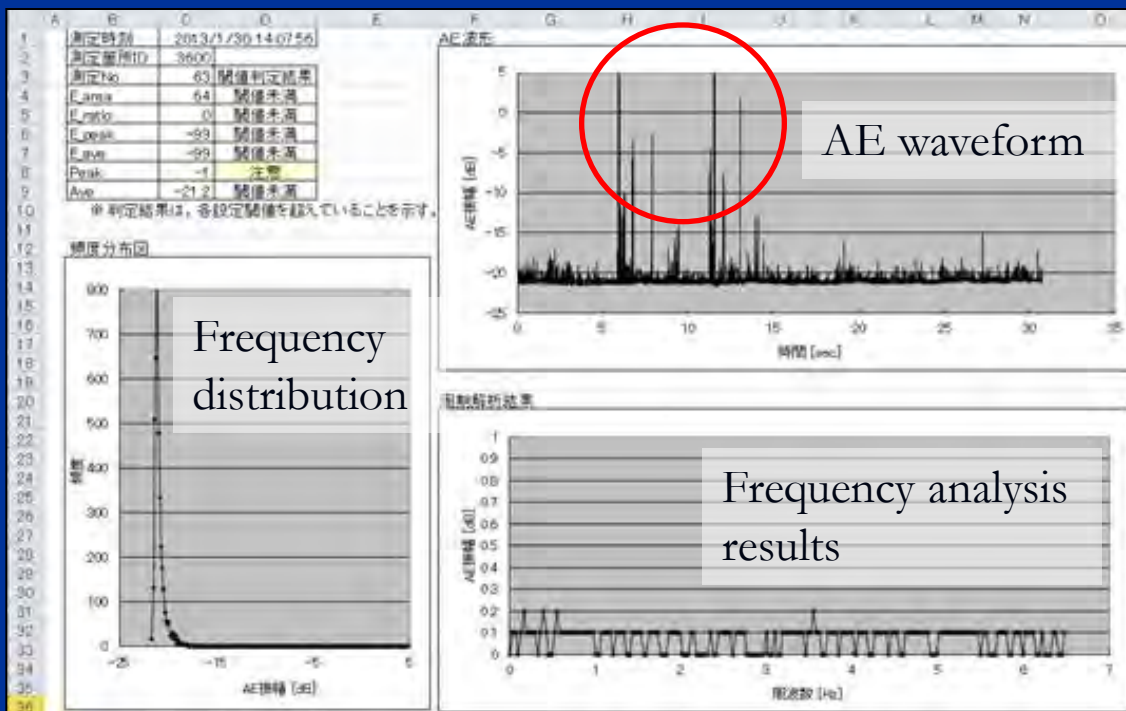


# Introduction of Predictive Maintenance Technique to ASIA MARU No.3

## Result of measurement

### Example of AE measurement result ( Port spud drum bearing )

- E\_area and E\_ratio were found normal
- Signal without periodicity was observed in the AE waveform
- It seems not due to damage.



## ■ Plans for future

- Continue the data acquisition
- Introduction of remote automatic measurement by the online system
- Introduction of fatigue degradation monitoring technology by distortion measurement

**To plan further improvement of  
the maintenance efficiency**

**Thank you for your attention.**



**TOA CORPORATION**



**JMU IMC Co., Ltd.**

# ■ Predictive Maintenance Technique

## Predictive Maintenance of Rotary Machines by Vibration Measurement

### □ Simplified diagnosis

➤ Compared with the reference value of the vibration level

### ● Determination method

➤ ① The relative determination method

⇒ Trend management

➤ ② The absolute determination method

⇒ Absolute value determination ( ISO or Maker's own )

➤ ③ The mutual determination method

⇒ Comparison between the same type machine

**Using determination method two or more**

# ■ Introduction of Predictive Maintenance Technique to ASIA MARU No.3

## Introduction costs

### □ Purchase cost of instrument

- Vibration measuring instrument ( including client software )
- AE measuring instrument

### □ Cost of system introduction

- Installation work for measurement pickup base
- Software production ( AE data analysis tool for PC )
- Work of data entry
- Guidance system introduced

# Introduction of Predictive Maintenance Technique to ASIA MARU No.3

## Result of measurement

### Example of AE measurement result ( Port spud drum bearing )

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