Technical consideration for onboard Wind-Assisted Propulsion Systems (WAPS)

Sail-assisted tanker “SHIN AITOKU MARU”(1980)

Hard sail system “Wind Challenger”
ClassNK’s AiP granted in 2019

Introduction – Rigid sail, Rotor sail

Rigid Sail

- **Principle:**
- ✓ A sail with an airfoil cross section that catches the wind to generate lifting force.
- **Features:**
- ✓ Sail angle, shrunk/expanding are controllable according to wind speed and direction.
- ✓ No deformation of the sail surface due to wind, so the optimum airfoil shape can be maintained all times.

Source: MOL

Rotor sail

- **Principle:**
- ✓ A cylinder shape device rotating at high speed obtains lifting force by the “Magnus effect”.
- **Features:**
- ✓ Only the rotation speed is controlled according to wind speed and direction
- ✓ Higher lift coefficient can be achieved by the rotation mechanism.
- ✓ Simple structure, also available for a laying down type. (in port, etc.)

Source: Norsepower

Introduction – Towing Kite, Turbo Sail

Towing Kite

- **Principle:**
  - ✓ A kite catches the wind in forward direction and tows the vessel for propulsion.
- **Features:**
  - ✓ Automatic control of the kite flight.
  - ✓ Automatic launch and stowage of the kite.
  - ✓ Strong winds at higher altitudes can be utilized. (abt. 200m high)

Source: Airseas

Turbo Sail (Suction Wing)

- **Principle:**
  - ✓ Lifting force is obtained by controlling the boundary layer around the device using movable flaps and an air intake mechanism.
- **Features:**
  - ✓ Air intake mechanism and flaps are controlled according to wind speed and direction.
  - ✓ Higher lift coefficient can be achieved by the air intake mechanism.
  - ✓ Simple structure, also available for a laying down type.

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Class approach for WAPS implementation

Safety of WAPS

- Design Loads / Structural Strength
- Driving System
- Control System
- Emergency Operation

Safety for Base Ship

Assessment of the impact of WAPS on the base ship

- Hull girder strength
- Stability
- Navigation bridge visibility
- Navigation lights
- Rader equipment
- Power capacity

GHG reduction

- EEDI/EEXI (CO_2 emission reduction）
- Improvement of fuel efficiency
- Optimal route for wind-assisted ships
- Simulation technology

Approval procedure for WAPS and Ship with them

WAPS

Design

Drawing Review

Survey

Product Certification

Base Ship

Design

Drawing Review

Installation

Survey

Class Notation

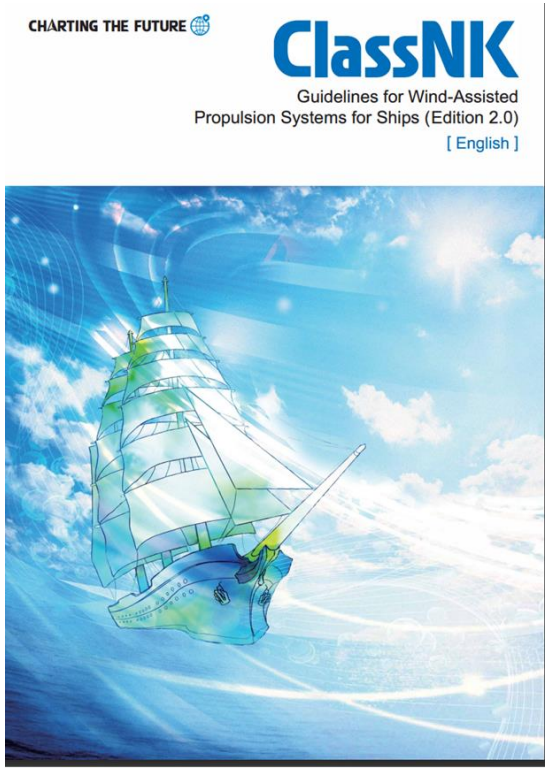
Periodical Surveys

AiP, as necessary

Rigid / soft sail type systems *EQ WAPS-S*
Rotor sail type systems: *EQ WAPS-R*
Turbo sail type systems: *EQ WAPS-T*
Towing kite type systems: *EQ WAPS-K*

ClassNK Guidelines for WAPS

Guidelines for Wind Assisted Propulsion Systems for Ships



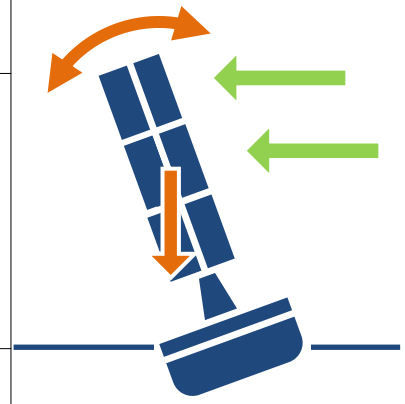
2019 Edition 1.0: has provided design requirements under the special attention on interference with ships

2023 Edition 2.0 updated based on recent expertise, improving clarity, comprehensiveness, and level of detail

1. General
Part A Requirements for WAPS
2. Risk Assessment
3. Loads
4. Structural Design
5. Materials and Joints
6. Driving and Control Systems
7. Operation and Maintenance
Part B Requirements for Base Ships
8. Effect on Hull Construction
9. Effect on Ship Motion
10. Blind Sectors due to WAPS
11. Other Effects
Part C Requirements for Surveys
12. Surveys

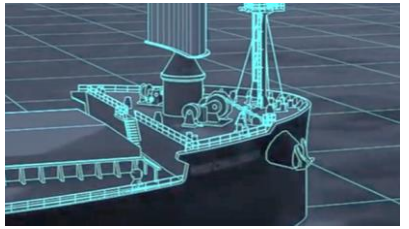
ClassNK Guidelines for WAPS

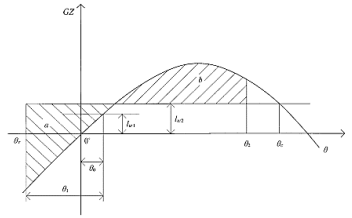
Part A Requirements for WAPS	
2. Risk Assessment	
3. Loads	-Load Cases(in-service, stand-by, abnormal) -Kind of Loads ・Aerodynamic Loads ・Loads due to Ship Motion ・Green Sea Loads
4. Structural Design	Allowable Stress for Combined Load Buckling Strength Fatigue Strength Strength members with special geometry
5. Materials and Joints	
6. Driving and Control Systems	Electric Systems Hydraulic Systems Control Systems
7. Operation and Maintenance	



ClassNK Guidelines for WAPS

Part B Requirements for Base Ships	
8. Effect on Hull Construction	Supporting structures Hull Girder Strength Loading Manual and Loading Computer Installation on Existing Ships
9. Effect on Ship Motion	Intact & Damage Stability Maneuverability Ship Speed
10. Blind Sectors due to WAPS	Navigation Bridge Visibility Navigation Lights Radio Equipment
11. Other Effects	Risk Assessment Equipment Number Electrical Systems Deck Equipment Gross Tonnage Fire Safety Operation
Part C Requirements for Surveys	
12. Surveys	WAPS Production / Installation / Periodical





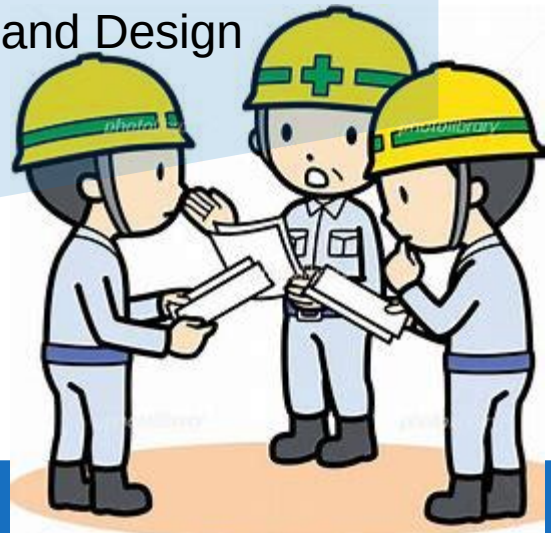
What should be considered for actual project

Arrangement - examples

- Navigation Bridge Visibility
- Navigation Lights, COLREG convention
- Interference with Cargo Handling Equipment or Helicopter Deck
- Stability

Risk Assessment

- Preliminary Investigation
- Preparation for Risk Assessment Meeting
- Risk Assessment Meeting
- Reporting
- Feedback to Manuals and Design

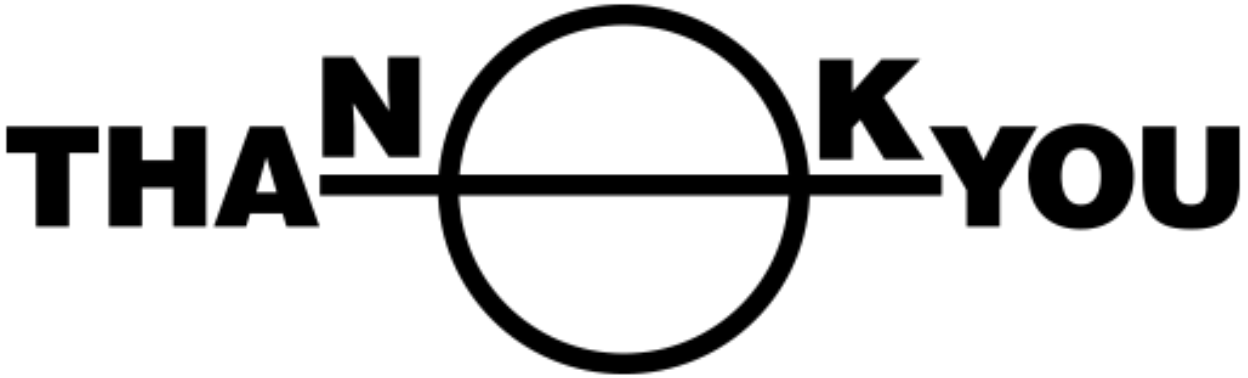


What should be considered for actual project

Keywords to identifying hazards (dangerous factors):
Collision, contact, structural damage, equipment and system failures, operational failures, sudden loads from the external environment, etc.

Examples of risk assessment

Object	Hazard	Cause	Expected impact	Implemented risk control measures	Priority	Additional safety measures
Base ship	Hull Damage	Load by WASP	Collapse of lower support	➢ Verification of structural strength by class rules ➢ Condition monitoring of the WASP	Medium	None
WASP	Overload	Gust	Damage to WASP	➢ Strength evaluation considering the impact of gust ➢ Introduction of an automatic control system to prevent overload	Medium	None



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