DESIGN OF ICEBREAKING VESSELS

RINA (WA) 2018

Ken Goh - GM, Knud E. Hansen Australia
KNUD E. HANSEN

- Ship design, engineering, HVAC & ShipSpace
- Concept design of highly specialised vessels
- Vessels types include Cruise, Ferries, Ro-Pax, Ro-Ro, Ro-Con, Offshore, Yachts & Icebreakers
- Consecutive annual ShipPax & Significant Ships awards
- 80 staff, offices in Denmark, USA, UK, Greece & Australia
DESIGN OF ICEBREAKING VESSELS

ICEBREAKERS TYPES

▸ Escort
  ▸ Ice Management
  ▸ Break out beset vessels
  ▸ Towing

▸ Cargo
  ▸ Container, bulkers, tankers, general
  ▸ Maximise cargo volume
  ▸ Double acting, podded propulsion

▸ Research & Supply
  ▸ Very low underwater noise
  ▸ Dynamic positioning
  ▸ Moon pool, drop-keels, winches, lots of toys
ICE TYPES

▸ First Year Ice
  ▸ Seawater, low strength (~500 kPa)
  ▸ Level ice for icebreakers
  ▸ Many different formations

▸ Multi-Year Ice
  ▸ Much harder & thicker
  ▸ Inclusions in FYI

▸ Glacial Ice
  ▸ Fresh Water
  ▸ Very high strength (2-3 times FYI)
  ▸ Hard to see in open water
HULL FORMS

- **Polar Star** (1975)
  - L 122m x B 25.4m x D 9.4m
  - Block = 0.58
  - Traditional bowl, smooth
  - No parallel mid-body
  - 56 MW shaft power
  - 2.0m ice @ 3 kns
HULL FORMS

- **Oden** (1989)
- L 108m x B 25m x D 8.5m
- Block = 0.61
- Spoon bow
- Reamers & heeling
- 18 MW shaft power
- 1.8m ice @ 3 kns
DESIGN OF ICEBREAKING VESSELS

HULL FORMS

- Thyssen-Waas
- Oblique
- Trimaran
- Hovercraft
REGULATIONS

- **IMO - Polar Code**
  - North & South of 60 degrees
  - Safety & Environment
  - Design & Operations

- **IACS - Polar Class**
  - PC1 - PC7
  - Hull icebelt materials & strength
  - Propulsion capacity & strength

- **Flag State**
  - Addition Regulations
  - Environmental
  - Labour
**Cargo Vessel Comparison**

**Conventional Container Ship**
- Capacity - 1,000 TEU
- Deadweight - 10,000 DWT
- Lightweight - 7,000 T
- Length - 144 m
- Beam - 22.6 m
- Draft - 8.0 m
- Block - 0.70
- Speed - 20 kns
- Power - 10 MW

**Icebreaking Container Ship**
- Capacity - 1,000 TEU
- Deadweight - 10,000 DWT
- Lightweight - 8,500 T
- Length - 145 m
- Beam - 23 m
- Draft - 8.5 m
- Block - 0.71
- Speed - 16 kns
- Power - 17 MW
DESIGN OF ICEBREAKING VESSELS

STRUCTURE

**Hull Area** | **Area** | **Polar Class** | **Polar Class** | **Crushing Failure Class Factor (CF_C)** | **Flexural Failure Class Factor (CF_F)** | **Load Patch Dimensions Class Factor (CF_B)** | **Displacement Class Factor (CF_D)** | **Longitudinal Strength Class Factor (CF_L)**
---|---|---|---|---|---|---|---|---
**Bow (B)** | All | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 | PC7
Bow Intermediate | Icebelt Lower Bottom | BI | 0.90 | 0.85 | 0.85 | 0.80 | 0.80 | 1.00* | 1.00*
Midbody (M) | Icebelt Lower Bottom | MI | 0.70 | 0.65 | 0.65 | 0.60 | 0.55 | 0.55 | 0.50
Stern (S) | Icebelt Lower Bottom | SB | 0.75 | 0.70 | 0.66 | 0.60 | 0.50 | 0.40 | 0.36

**Polar Class**
- PC1
- PC2
- PC3
- PC4
- PC5
- PC6
- PC7

**Notes:**
- Welding details and procedures to Surveyor's satisfaction.
- Transverse sections are shown looking forward, and are symmetric unless noted otherwise.

**Web frame spacing:** 104"  
**Frame spacing:** 26"
DESIGN OF ICEBREAKING VESSELS

PROPULSION SYSTEMS

▶ Conventional
  ▶ Enclosed shafts
  ▶ Propeller type, nozzles
  ▶ Rudder, large spade, protection

▶ Pods & Thrusters
  ▶ Very good manoeuvrability
  ▶ Ice milling & flushing
  ▶ Little experience with MYI

▶ Power Plant
  ▶ Diesel electric
  ▶ Diesel mechanical
  ▶ Hybrid
PROPULSION SYSTEMS

Diesel Electric

Mechanical

DE/Mech Hybrid
DE over-torque
DE constant-torque
DE additional-power
DE constant-power
Bollard Pd
Open-water Pd

Torque %

Shaft RPM

Power

100%

70%
ICEBREAKER SYSTEMS

- **Auxiliary Icebreaking**
  - Bow wash, bubbler
  - Fast powerful heeling
  - Hull coatings, SS cladding

- **Winterisation**
  - Temperature rated (design/operation)
  - Tank, deck & equipment heating
  - De-icing steam
  - Besetment (safe haven)

- **Machinery**
  - Ice box, sea-bays
  - Ban on residual fuels
  - Engine low-temp limit
  - Emissions control
AUSTRALIAN ANTARCTIC TERRITORY

- Australia claims 42% of the Antarctic Continent
- Australian Antarctic Division (AAD) operates 4 permanent stations
- Resupply is primarily by ship during 6-7mth ‘summer season’
- Typically 5-6 voyages per season
- Southern Ocean has highest average waves (SS5-SS9)
- Sea ice is increasing in Antarctic waters (significant multi-year ice)
PROJECT HISTORY

- Existing RSV Aurora Australia in operation since 1989
- **Request For Proposal** released in January 2013 for Design, Build, Operate & Maintain contract
- DMS Team
  - DMS (Prime contractor & Operator)
  - Damen (Shipbuilder)
  - Knud E Hansen A/S (Designer)
- **Request For Tender** released July 2014 for short-listed teams
- DMS preferred tenderer October 2015
- Keel laying June 2017
- RSV Nuyina naming October 2017
- operational 2019/2020 season
MISSION PROFILE – SUPPLY

- Dry Cargo: 1,200 tons or 100 TEU
- Wet Cargo: 1,900 m³ Fuel Oil + 200 m³ Fresh Water
- Over-ice resupply using tracked & wheel vehicles
- Over-water resupply using landing barges
- Amphibious resupply using LARCs & helicopters
- Fuel oil transfer using hose reels & booster pumps
MISSION PROFILE – RESEARCH

- 500m² science laboratories & offices
- 20 modular science containers
- CTD side & bottom deployment system
- 8 meter stern A-frame
- Twin Drop Keels: 2 x 1 meter sensor
- Moon Pool: 4 x 4 meter aperture
- Seabed long corer: Up to 24m cores
- Weather doppler radar
- 9m RHIB science tender
CONCEPT DESIGN - ANTARCTIC SUPPLY & RESEARCH VESSEL

PRIMARY REQUIREMENTS

- IACS PC3 Icebreaker, -40C (Polar Code - Cat. A)
- IMO Polar Code - New damage stability requirements
- Safety Regime - IMO Special Purpose Ship code
- Environment - **Clean design ‘Green Passport’**
- Icebreaking Criteria
  - 1.65 m 700kPa ice + 300 mm snow loading @ 3 kns
- Icebreaking Endurance
  - 30 days @ 60% MCR + 9,000 nm @ 12 kns SS5
- **Redundant Propulsion System**
- Dynamic Positioning
  - DP2 in SS4, Beaufort Force 8, current 1kn
- Acoustic Performance - **DNV Silent R**
- Mission Endurance
  - 90 days with 180 day survival capability
- **Good Seakeeping**
DESIGN OF ICEBREAKING VESSELS

RSV NUYINA

Dimensions
- Length OA = 160m
- Beam moulded = 25.6m
- Depth to main deck = 19.2m
- Draft max. = 9.5m
- Air draft max. = 41m
- Displacement full load = 25,000T

Performance
- Speed max. = 18+ kns
- Speed eco. = 12-14 kns
- Speed silent = up to 8 kns
- Icebreaking = 1.65+ meters @ 3kn
- Range = 16,000+ nm
- Endurance = 90+ days
DESIGN OF ICEBREAKING VESSELS

Barge Operations

Helicopter & LARC Operations

Refuelling Operations

Over-ice Operations
DESIGN OF ICEBREAKING VESSELS

KNUD E. HANSEN
SHIP DESIGN SINCE 1937