The Way to Eco-Vessel: Reducing VOC from Hull Structural Aspects

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- VOC regulation
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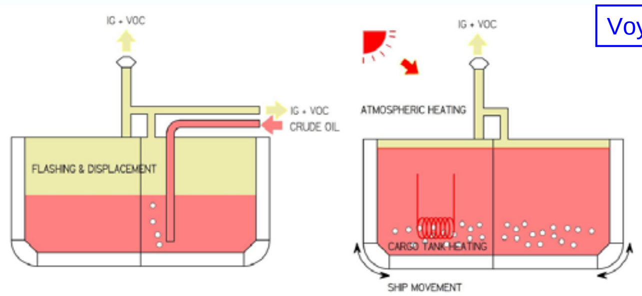
What is VOC?

- VOC(Volatile Organic Compounds)
  - A mixture of light end components (Methane to octane)
  - NMVOC: Non Methane VOC (Ethane to octane)
  - NMVOC + NOX → Ground level ozone
    - Detrimental effect on human health (eyes and lungs) and vegetation
- Source of VOC in Crude Oil Tankers

Loading

Voyage



VOC regulation

- MARPOL Annex VI Chapter III Reg. 16
  - Vapor emission control system is required.
  - Res. MEPC. 176(58): VOC management plan is required since July 1, 2010
    - To provide written procedure for minimizing VOC emission
    - To give consideration to the additional VOC generated by crude oil washing
  - Res. MEPC. 185(59): Guideline for VOC management plan
- North sea
  - Recovery efficiency at least 78% is required by Norwegian regulation. (Minimum requirement)

How to control VOC?

- VOC prevention method: reducing the generation of VOC

	KVOC	VOCON	Increased Tank Pressure
Supplier	Knutsen OAS Shipping	Samsung Heavy Industries	Yard
Operation	Loading	Voyage	Voyage

- VOC recovery method: re-collecting the occurred VOC

	Re-liquefaction	Re-absorbtion		
Supplier	Hamworthy	APL	GBA Marine	Venturie
Operation	Loading, Voyage	Loading, Voyage	Voyage	Voyage

Overview

- Introducing a shuttle tanker of Samsung Heavy Industries
  - Size: Aframax (109K)
  - Operation area: North sea
  - VOC control method
    - KVOC application
    - Higher tank pressure application
- Structural design of
  - KVOC and hull integration
  - Cargo tank boundaries and their supporting members with higher tank pressure

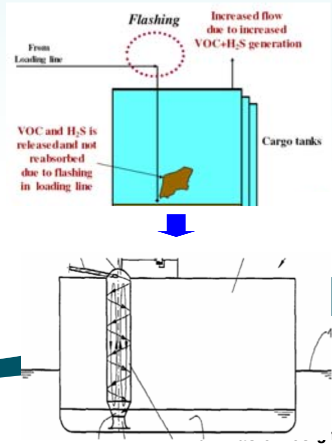
Structural design of KVOC and hull integration

- KVOC
- Structural arrangements
- Fatigue calculation
- Reinforcement

KVOC

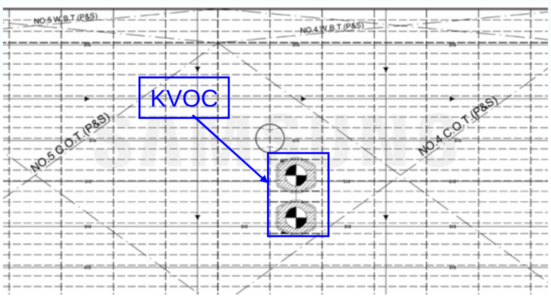
- General
  - System developed by Knutsen OAS Shipping proven by extensive onboard test
  - Significant reduction of VOC during loading up to 80%

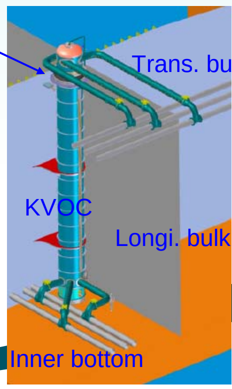
- Principle
  - Most of VOC is emitted during loading by flashing of dissolved gas due to vacuum in the drop line
  - To prevent vacuum in the drop line, the line diameter is increased by about 2 times
  - Also the crude oil loaded smoothly following the pipe wall in order to prevent flash avoiding impact on the flow



Structural arrangement

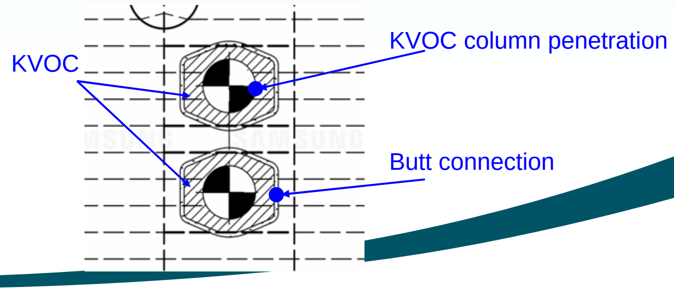
- KVOC installed on main deck of mid cargo hold area widely open to major hull girder loads





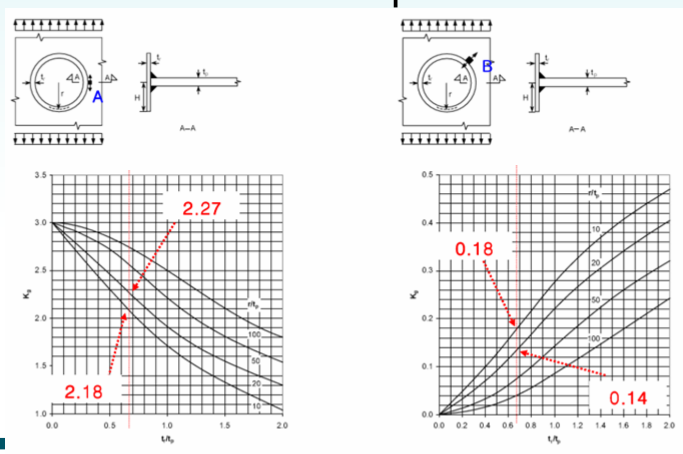
Fatigue calculation

- Simplified approach as per DNV CN30.7
- Check locations
  - KVOC column penetration to main deck
  - Butt connection of KVOC insert plate and main deck



Fatigue calculation

- SCF for KVOC column penetration



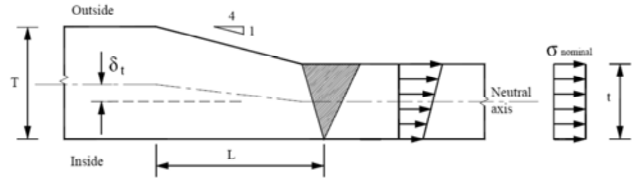
Fatigue calculation

◈ SCF for butt connection

$$SCF = 1 + \frac{6(\delta_m + \delta_t - \delta_0)}{t\left[1 + \frac{T^{1.5}}{t^{1.5}}\right]}$$

where

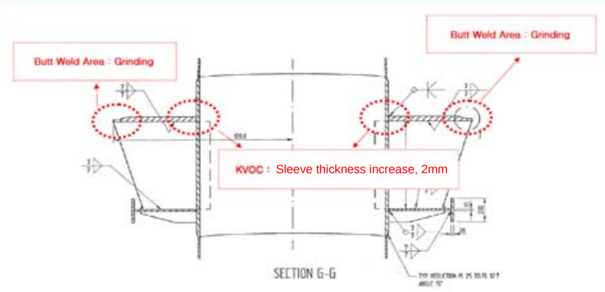
δ_m = maximum misalignment
δ_t = ½ (T − t) eccentricity due to change in thickness
δ_0 = 0.1 t is misalignment inherent in the S-N data for butt welds
T = thickness of thicker plate
t = thickness of thinner plate



TSCF 2010 - Tokyo

Fatigue calculation

◈ Results of fatigue calculation



Structural design for higher tank pressure application

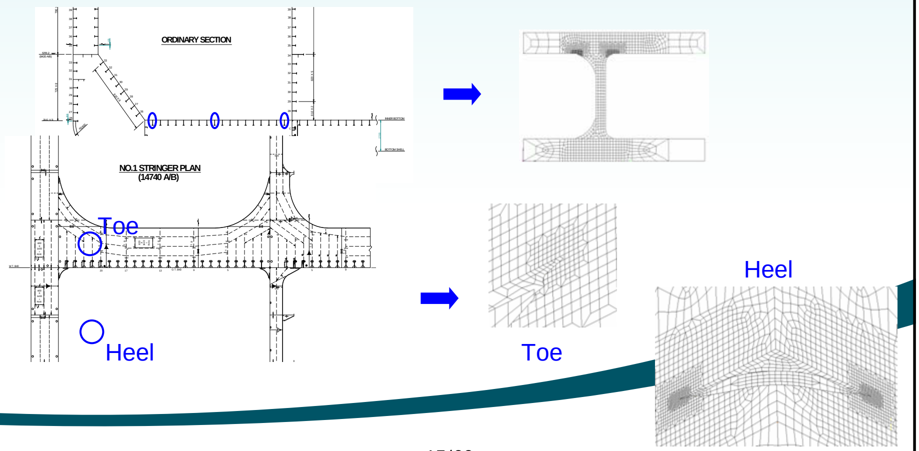
- Work scope
- Low cycle fatigue
- Reinforcement

Work scope

- Resultant valve pressure increased up to 0.7 bar
- Objective
  - Verification of tank boundaries and their supporting members with higher tank pressure
- Following calculation updated;
  - Local scantling for local and primary supporting members
  - 3D cargo hold analysis
  - Low cycle fatigue analysis

Low cycle fatigue

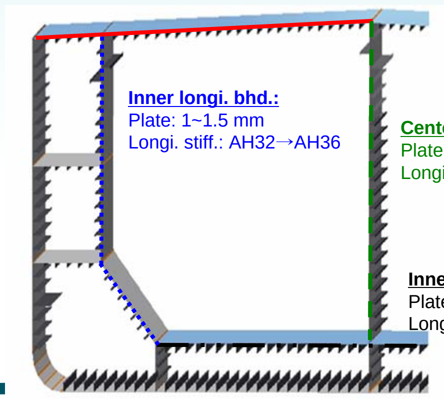
◈ Simplified approach as per DNV CN30.7



Reinforcement

◈ Ordinary section

Deck longi. stiffeners:
Changed to T-bar with size increase



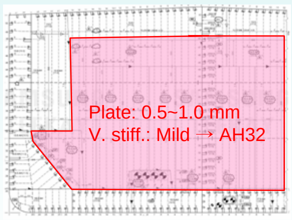
Inner longi. bhd.:
Plate: 1~1.5 mm
Longi. stiff.: AH32→AH36

Center longi. bhd.:
Plate: 1.5~2.0 mm
Longi. stiff.: Size increase and Mild → AH32

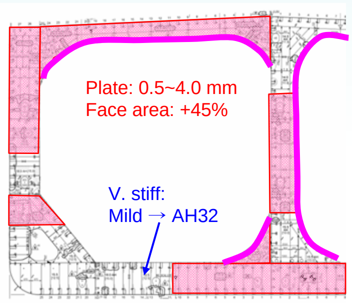
Inner botom:
Plate: 0.5~1.0 mm
Longi. stiff.: AH32 → AH36

Reinforcement

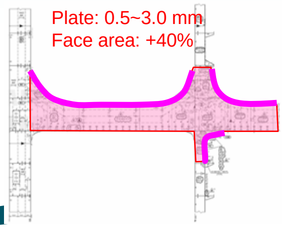
◈ Transverse members



O. T. Bulkhead



Transverse webs



Stringer

Installation and test

- Installation
- Test

Installation

Manufacturing

Moving

Lifting & Laying

Handling

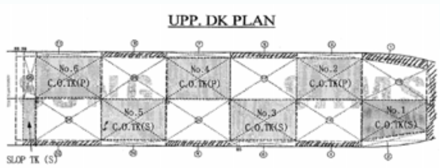
Setting

Fixing

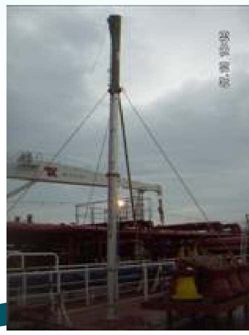
Welding

Test

- To verify the structural integrity with 0.7 bar hydro static pressure, 7m height pipe is applied on deck.



Tank test plan



Tank test

Conclusion remarks

- Summary
  - VOC reducing methods were successfully applied to Aframax shuttle tanker.
  - Structural arrangement and fatigue assessment were carried out for KVOC and hull integration.
  - Tank boundaries and their supporting structures were reinforced to withstand higher tank pressure.
    - Local scantling
    - 3D cargo hold analysis
    - Low cycle fatigue calculation
  - Tank test was performed to check the structural integrity of tank boundaries.
- Samsung Heavy Industries are expanding this successful experience to more crude oil tankers.
- This would be a good example of eco-friendly vessel to comply with the needs of eco-friendly operation worldwide.