PDMT Panel Meeting

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GREEN VESSEL DESIGN

Guiding Principles for Sustainable Ship Design

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Introduction

- Environmental issues increasingly at forefront of public awareness
- Short and long-term implications of pollution, global warming, ozone depletion, and other environmental issues are major influences in public policy and regulation
- Relevant to marine community, 70% of the earth's surface is covered with water
- In 2030, about 70% of the world's population will live within approx. 60 miles of coast
- Marine industry in position to help shape policy and public opinion and has opportunity to demonstrate commitment to responsible stewardship

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Why Green Marine?

- Shipment by water is inherently "green" - most energy efficient mode of transportation of goods in significant quantities
- Relative to buildings, even traditionally constructed ships are inherently green
- However, seagoing requirements also result in some environmentally unfriendly practices

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Guiding Principles

- Minimize air emissions
- Minimize use of hazardous materials and environmental contaminates
- Maximize use of recycled and recyclable material
- Minimize waste and scrap
- Maximize use of rapidly renewable and regional materials
- Minimize energy use
- Minimize discharges to water

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Guiding Principles

- Naval architects/marine engineers have opportunity to improve upon design practices which will benefit the environment
- Guiding Principles are interdependent and not mutually exclusive to economic performance
- In many cases, they are natural progression of regulations refined through use and enforcement in the field

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Guiding Principles

- **The environmental impact of a ship occurs in three distinct stages of its life:**
  - Construction
  - Operation
  - Disposal
- **Green considerations during design translate to improvements in construction and operation throughout vessel lifecycle and provide for greener and more cost effective recycling at end of ship's life span**

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Background Info

- **Global Warming Potential (GWP)**

  Ratio of the warming caused by a substance to the warming caused by a similar mass of carbon dioxide

- **Ozone-Depleting Potential (ODP)**

  Number that refers to the amount of ozone depletion caused by a substance

- **Ozone-Depleting Substance (ODS)**

  Compound that contributes to stratospheric ozone depletion

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Background Info

- ***Montreal Protocol on Substances that Deplete the Ozone Layer*** **- all CFCs and HCFCs (common refrigerates) to be phased out by 2030.**

- **Clean Air Act of 1990 has significant restrictions on storage and handling of refrigerants and other ODS, as well as strict requirements for maintenance of equipment containing ODS in order to limit the amount of leakage**

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Minimize Emissions

- Greatest day-to-day impact on the marine environment is associated with its prime movers
- Diesel engines that power majority of the world's fleet are responsible for carbon dioxide, sulfuric and nitrous oxides, smoke and particulate emissions, noise, as well as sensible heat going out the stack
- Minimizing air emissions is area where positive change can make substantial environmental improvement
- Areas for emission-minimizing opportunities include hull form optimization, speed considerations, diesel choices and use of alternate fuels.
- But, its not all about emissions….

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Minimize Hazardous Materials/Contaminants

- **Green Passport (IMO program)**
  - Requires vessel owner to maintain accurate records of potentially hazardous materials aboard vessel
  - Passport follows the ship through its life span and should accurately include any relevant modifications
  - Voluntary program is expected to become mandatory by 2010.
  - IMO also addresses issues associated with ship and equipment recycling where it suggests using less hazardous alternatives

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Minimize Hazardous Materials/Contaminants

- **Significant New Alternatives Policy (SNAP)**
  - EPA's program to evaluate and regulate substitutes for ozone-depleting chemicals being phased out under the Clean Air Act
  - Includes substitutes for refrigeration and air conditioning, cleaning solvents, fire suppression and explosion protection, adhesives, and coatings

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Minimize Hazardous Materials/Contaminants

- **HVAC equipment offers excellent area for improving environmental performance**
  - Newer systems offer low refrigerant charge per ton of cooling capacity, as well as both low ODP and GWP
  - While some class society "clean" certifications permit an annual leakage rate of 10%, newer refrigeration systems can be as little as 2%, with a maximum of 10% released during final disposal and recycling of the refrigerate

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Minimize Hazardous Materials/Contaminants

- **Minimize Volatile Organic Compounds (VOCs)**
  - VOCs emitted as gases from certain solids or liquids and include variety of chemicals, some of which may have short- and long-term adverse health effects: *adhesives and sealants, coatings, cleaning liquids*
  - During ship construction and throughout a ship's life, use of low VOC products improve air quality and the health of the crew
  - There are a number of low VOC products on the market, such as paint and coatings, with many more in our future.

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Maximize Recycled/Recyclable Materials

- Steel and aluminum are readily recyclable materials, but improvement in recycling is necessary in many other materials
- Design and installation of systems that *avoids contamination of recyclable material with non-recyclable and/or hazardous material*
- Insulating materials, interior bulkhead systems and flooring systems are prime examples

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Maximize Recycled/Recyclable Materials

- **Design for Disassembly (DfD)**
  - Design of structures to facilitate future change and eventual dismantlement (in part or whole) for recovery of systems, components and materials.
  - Design process includes developing assemblies, components, materials, construction techniques, and information and management systems to accomplish this goal.
  - Recovery of materials intended to maximize economic value and minimize environmental impacts through subsequent reuse, repair, remanufacture and recycling.

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Maximize Recycled/Recyclable Materials

- **DfD Principles**
  - Document materials and methods for deconstruction
  - Select materials using the precautionary principle*
  - Design connections that are accessible
  - Minimize or eliminate chemical connections
  - Use bolted, screwed and nailed connections
  - Separate mechanical, electrical and plumbing (MEP) systems
  - Design to the worker and labor of separation (DFP)
  - Simplicity of structure and form
  - Interchangeability
  - Safe deconstruction

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Maximize Recycled/Recyclable Materials

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Minimize Waste & Scrap

- Much of waste generated during construction can be reduced with careful production planning and weight control and greater reliance upon detailed design and computer lofting of structure and piping systems

- Design development involves optimization of structure, systems and hull form for reduced energy use and production

- At pre-production and production stages of design, computer lofting is extensively used in almost all structure of the ship and increasingly in piping and wireways.

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Minimize Waste & Scrap

- When comprehensively applied, weight and waste will be minimized with the added benefit of ***reduced production labor***

- Reduction of waste generated during construction is a one-time event, <u>but</u>

  waste built into the ship is detrimental throughout its operational life with a cumulative effect of decreased fuel efficiency and increased emissions

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Maximize Renewable/Regional Materials

- Rapidly renewable materials defined as having a *natural replacement cycle of less than 10 years*
- Rapidly renewable products such as bamboo, linoleum, cork, poplar and wool are less of a burden on our environment
- Rapidly renewable wood products can directly replace hardwoods in almost every application with minimal or no cost increases
- Wool carpeting is already standard for marine applications due to inherent low-smoke characteristics

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Maximize Renewable/Regional Materials

- Utilizing regional materials significantly reduces energy required for transportation

- This should include locally recycled material, regardless of original production location

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Minimize Energy Use

- **Overlooked aspects of design include location and placement of appendages**
  - Rudder, bilge keels, keel coolers, etc.
  - If not aligned to water flow over the hull, they can increase the drag

- **Installed generation capacity can be reduced on smaller ships by utilizing paralleling switchgear on systems not traditionally designed for parallel operation**

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Minimize Energy Use

- **Hybrid power and propulsion systems can reduce auxiliary engine and/or generator sizing by "peak shaving" short duration loads**

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Minimize Energy Use

- **HVAC requirements typically the single largest electrical load on ships and primary driver for sizing the service generators**
- **Increased hull and compartment insulation can significantly reduce HVAC energy use. With current costs of fuel, payback for better insulation can be measured in months, not years**
  - Smaller generators
  - Increased fuel efficiency
  - Reduced Emissions

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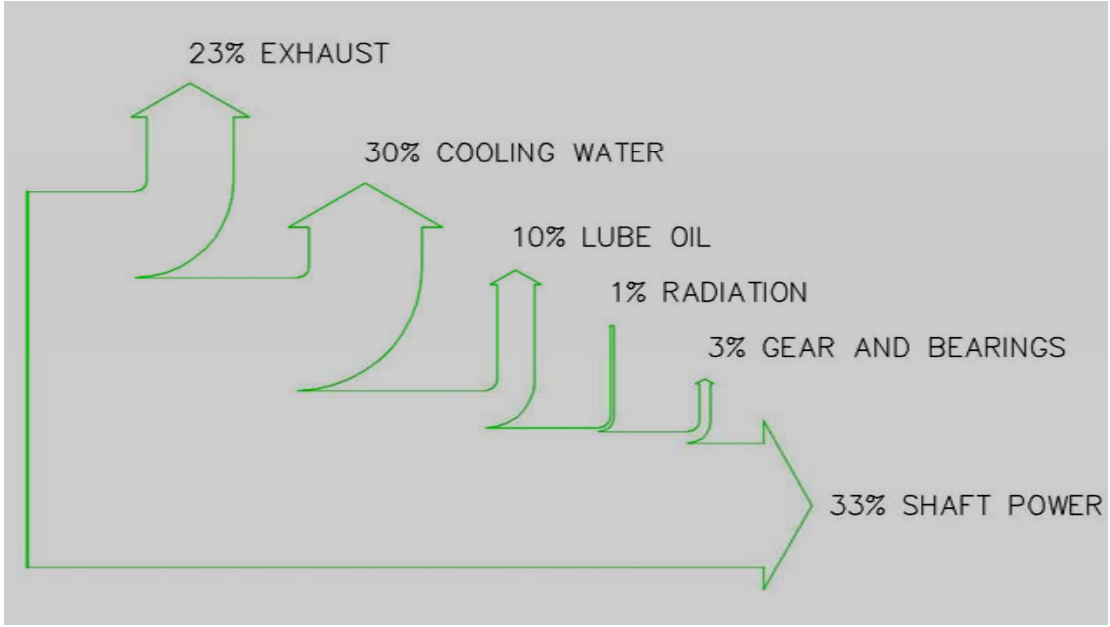
Minimize Energy Use

- **Heat recovery systems save energy from fuel lost through engine exhaust or engine cooling**
  - To maintain interior air quality, 20% or more of conditioned ventilation air is typically exchanged with fresh air from outside
  - This improves interior air quality, but represents lost energy used to heat or cool the air



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Minimize Discharges To Water

- Certain vessels have been subject to IMO MARPOL and OPA90 double-hull regulations for some time
- Smaller vessels have generally been exempted if they carry less than 500 cubic meters of fuel or have damaged outflow less than a given criteria
- Regardless of size of ship, placing oil tanks away from side and bottom shell greatly reduces probability of oil spill in event of grounding or collision

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Minimize Discharges To Water

- **Many operators have ambitious and laudable goals to approach zero overboard discharge of waste**
  - Requires complex number of shipboard procedures and installed systems to minimize the production of waste and then process it for onboard reuse, or reduction and compaction and storage for shore-side recycling
- **Recent challenges have successfully addressed the elimination of oily waste discharge**
- **Current challenge is processing and total onboard recycling of black and gray water or treatment such that overboard discharge is sterile water with no residual toxins**
- **Next challenge is treatment of ballast water to eliminate transference of invasive species, again with no residual toxins.**

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Wrap Up

- The greatest opportunity to achieve greenest (and most cost effective) ship is in early design phase
- Closely scrutinizing ship's requirements and designing with view to maximize efficiencies
- For ships already in operation, select design efficiencies and improvements can bring substantial benefit through greener technologies
- It is our goal to improve upon these practices, benefitting the environment and vessel owners and operators

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