MICHAEL KASTEN KASTEN MARINE DESIGN, Inc.

Phone 480-773-2756 michael@kastenmarine.com
Fax 604-648-9759 www.kastenmarine.com

The 96' ZEBULUN

Vessel Specification #11

I.	Overview	2
II.	General Concept	3
III.	Construction Materials	3
IV.	Interior Arrangement	4
V.	Proposed Interior Structure	6
VI.	Proposed Interior Joinery	6
VII.	Proposed Interior Finish	7
VIII.	Accommodation Space Ventilation	7
IX.	Mechanical Space Ventilation	8
X.	Engine Space Ventilation	8
XI.	Typical Engine Room Ventilation Targets	9
XII.	Engine Exhaust	10
XIII.	Engine Room Arrangement	10
XIV.	Power	11
XV.	Range	11
XVI.	Gears	11
XVII.	Propellers	11
XVIII.	Shafts	12
XIX.	Shaft & Tube Arrangement	12
XX.	Flexible Mounts and Shaft Couplings	12
XXI.	Cooling System	12
XXII.	Integral Tanks	13
XXIII.	Non-Integral Tanks	14
XXIV.	24 Volt DC Electrical	15
XXV.	Low Voltage Wiring	16
XXVI.	AC Electrical	17
XXVII.	AC and DC Wiring	18
XXVIII.	Lightning Attenuation System	18
XXIX.	Corrosion Protection System	18
XXX.	Through Hull Fittings	19
XXXI.	Ground Tackle	20
XXXII.	The Rudders	20

Phone 480-773-2756 michael@kastenmarine.com
Fax 604-648-9759 www.kastenmarine.com

XXXIII. Removable Rudder Heel Fitting 21
XXXIV. Steering System 21
XXXV. Hydraulic System 21
XXXVI. The Keels 22
XXXVII. The Rig 22
XXXVIII. Standing Rigging 23
XXXIX. Running Rigging & Deck Hardware 25
XL. Sails 25
XLI. Paint System 26
XLII. Thermal Insulation 27
XLIII. Engine Room Sound Attenuation 27
XLIV. Engine Room Fire Control 28
XLV. Ballast 28
XLVI. Equipment Summary 29
XLVII. Windows & Ports 31
XLVIII. Welding & Hull Construction Notes 33
XLIX. Scantlings – Updated 30 September 2003 34
L. Weld Size & Spacing 36
LI. NC Cutting 37
LII. Lofting Notes 38
LIII. The Building Plans 38
LIV. System Schematics 41
LV. General Terms 43

I.
II. Overview

This Vessel Specification is the central document from which the ***Zebulun 96*** will be built. Its purpose is to list the vessel's scantlings, specify the materials of construction, describe the intent of the design according to the owner's requirements, including the layout of the interior, the machinery, and the equipment that will be placed aboard.

It is the intent of this Vessel Specification to assure that the vessel's trim, stability, systems, structure, and the vessel's behavior, performance, and safety be as designed by Kasten Marine Design, Inc., and that the features of the yacht be as planned by the owner.

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III. General Concept

The intent of this design has been to create a highly capable long range, fast and safe offshore sailing vessel in aluminum, with the ability to do rescue work, mission work, and relief supply delivery for troubled areas. Long range under power has also been a primary requirement. ***Zebulun's*** lines are intended to provide a high performance easily driven hull for maximum speed and the fastest response time.

Particulars are: 96' LOA x 89.75' LWL x 23' Beam x 8' Draft. Having a design displacement of 209,800# ***Zebulun*** is of nearly "ultra light" displacement. Displacement will vary from around 203,000# when lightly loaded, to a maximum displacement of around 260,000# with tanks full, stores for twenty people, and the boat ready for a long passage, or with a cargo of supplies aboard.

The cabin structures provide a minimum standing headroom of 6' 8" on centerline throughout the main cabins. The exterior deck aft is raised to the height of the top of the main bulwark for the sake of headroom in the aft cabins. Where needed, headroom pockets have been made in the cockpit seating to allow full headroom in the master and guest cabins.

The deck is surrounded by substantial bulwarks for maximum safety, and the after deck is surrounded by a toe rail. Although not detailed as such on the drawings, the decks are additionally protected by a 36" high welded bow pulpit, stern pulpit and welded stanchions along both side decks. There will be welded aluminum hand rails along each house top.

There will be two hydraulic vertical axis windlasses on center forward, and one large substantial mooring bitt on either side of the foredeck. Additional mooring bitts will be placed on the side decks and on the after deck, three per side. Additional smaller bitts and cleats will be provided as needed.

IV. Construction Materials

The hull, deck and house structures will be built in **aluminum**, primarily for the purpose of extreme ruggedness, for ease of construction, and for a favorable strength to weight ratio, the goal being to permit adequate reserve capacity to carry cargo or passengers.

The hull structure for ***Zebulun*** has been designed to the ABS Offshore Racing Yacht Rule (to 90'), with applicable portions of the ABS Motor Pleasure Yacht Rule (79' to 200') and the ABS Rule for Building and Classing Aluminum Vessels (100' to 500'). Scantlings will be as given elsewhere in this Specification.

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All windows and portlights will be tempered and / or laminated glass, with thicknesses as given elsewhere in this Specification.

Interior materials have been chosen to be as light in weight as possible, while not being overly expensive to construct. Toward that end, wherever possible for larger panels in places where it will not increase the joinery labor to any appreciable degree, **Nida-Core** honeycomb panels will be used, as specified herein.

V. Interior Arrangement

For mission, charter, or rescue work, the accommodations aboard ***Zebulun*** have been designed to provide the maximum flexibility, including comfortable living for two to six crew aft, plus twelve or more passengers forward on extended passages.

Additionally, there is a large "Great Room" amidships for the purpose of comfortable lounging for passengers and crew, or for the purpose of carrying more passengers on shorter voyages, as well as for stowage of cargo or supplies being delivered.

As a description of the spaces, the following "walk-through" of the vessel is provided.

Forepeak: Beginning right forward, a spacious forepeak can be entered through a deck hatch and ladder. The forepeak is intended for sail and line storage, and also for the anchor rode, a combination of rope and chain.

Forward Heads: Aft of the forepeak are a pair of generous head compartments, pone to port and an identical one to starb'd. Each head has a shower, a vanity cabinet with a sink, a toilet and a small dressing area.

Guest Cabins: Aft of the forward head compartments are six separate guest cabins, each able to house two passengers. The forward pair will have two berths each, the central and after pair of these forward cabins will have a double berth and a deployable overhead bunk possibly for children. Each guest cabin will have a vanity cabinet, a sink, a separate bureau/nightstand for personal effects, plus generous storage in drawers below the berths.

Saloon: Amidships in the vessel is the "Great Room" which is alternately referred to as the "Saloon" per yacht terminology. The Great Room is intended to have the flavor of a library or reading room. The intent is that the entire Great Room be perceived as one single space with no substantial visual barriers. To either side of the central corridor, there will be a long settee with tables placed as shown in the drawings. Outboard, there will be long settees on both port and starb'd sides, having storage cabinets and bookshelves outboard.

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The "Great Room" will serve multiple purposes, as described, including the ability to accommodate various cargoes. Storage will be provided below the Great Room sole, in the space remaining available inboard of the tanks and aft of the house battery bank.

Office & Laundry: Aft of the Great Room and down a small stairway to port and starboard will be two small low-headroom spaces. An office will be to starboard, and a laundry room will be to port. The Office and Laundry rooms flank the engine room, which is accessed from aft. A watertight door will be placed in the bulkhead at Station

Pilot House: Aft of the Great Room and up a stairway will be the Pilot House, containing the Pilot's Seat; Helm; Navigation Area to starb'd forward; the Galley to port aft; and three separate Dining Areas arranged as shown on the drawings. The central portion of the pilot house sole is lowered in order to provide headroom to the walkway leading forward to the Great Room. The wheel house sole will have thorough sound insulation to attenuate engine noise from the engine room below, as is further detailed in this specification.

The "dashboard" area forward of the wheel will hold navigation instruments. Immediately forward of the helm will be a cabinet housing the helm controls and the engine controls. A magnetic compass will be mounted prominently forward of the wheel. A radar and sonar screen will be located within easy view from the helm. A VHF radio will be mounted near the helm. Other navigation instruments may be mounted overhead as needed. The helm seat will swivel to allow use as a chart table seat.

Aft of the Pilot House, on deck, is located the cockpit and exterior helm.

Aft Cabins: Aft of the Pilot House and down a stairway is a hallway, from which one may access the after cabins below the cockpit area, the engine room, and a centrally located Head. This aft head is intended to serve the aft cabins as well as being a "day head" for the crew. The head will contain a vanity cabinet with sink, a toilet, and a large shower.

The after cabins are arranged as follows:

A crew cabin is located to port forward and will contain a double berth outboard with a deployable berth for a child above. This forward-most after cabin will necessarily require that the galley cabinet above be dedicated to providing headroom for the cabin below. The cabin will contain a bureau / nightstand, as well as a vanity cabinet with a sink.

A second crew / guest cabin will be located to port and aft, and will contain a double berth toward the center of the vessel and aft against the transom. A long counter will be located outboard, and will have a sink at the forward end, and a hanging locker at the aft end. A "Dutch door" will lead aft through the transom to the swim platform.

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The master's cabin will be located to starb'd aft. A double berth will be located inboard and aft, and will have a settee outboard with a small sideboard / end table at each end. The forward end of the cabin will have a hanging locker inboard, and a doorway to the master's head outboard. The head will have a vanity with sink, a toilet and a shower stall with a seat.

Engine Room: From the Pilot House, access to the Engine Room is via the stairway leading aft down to the aft hallway, then via another few steps down forward through the door to the engine room.

Workshop & Pantry: Within the engine room, access is provided to a tool room / workroom to starb'd, and a pantry / storage room to port (located below the galley).

VI. Proposed Interior Structure

- Cabin Soles: One face of 1/8" GRP laminate each side of a 1" Nida Core panel (1.25" total).
- Wood Bulkheads: (head, hallway, etc) One face of 1/4" marine grade hardwood plywood each side of a 1" Nida Core panel (1.5" total).
- Joinery Partitions; Berth Surfaces: One face of 1/8" marine grade hardwood plywood each side of a 1/2" thick Nida Core panel (3/4" total).

VII. Proposed Interior Joinery

Interior hardwood face frames, doors and trim to be cherry or other medium colored hardwood. Dark woods such as teak or walnut and bright woods such as ash or white oak will be avoided. Interior Joinery Surfaces are specified as follows:

- Overhead: Light colored neutral toned Formica on 1/4" marine grade hardwood plywood.
- Overhead Trim: Hardwood battens spaced at half the local structural deck beam spacing. Formica seams located so they are covered by a batten.
- Hull Ceiling: One face of 1/8" marine grade hardwood plywood each side of a 1/2" thick Nida Core panel (3/4" total).
- Wood Bulkhead Surfaces: Wainscot of 1/4" T&G to waist height, with wood veneer or Formica above a trim rail, to cover bulkhead plywood.

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- Minor Joinery Surfaces (shelves, etc): One face of 1/16" formica laminate each side of a 1/2" thick Nida Core panel (approx. 5/8" total).
- Table Surfaces: 1" Cherry or other medium toned hardwood.
- Trim Throughout: 3/4" to 1" Cherry or other medium toned hardwood.
- Joinery Face Frames: 3/4" cherry or other medium toned hardwood.
- Galley Counter Top: 5/4" Maple Chopping Block, beeswax finished.
- Galley Face Frame: 3/4" Cherry or other medium toned hardwood.
- Cabinet Doors Throughout: 1/2" Cherry or other medium toned hardwood frames with 1/4" plywood center panels having matching veneered wood surfaces.
- Pilot House Window Mullion Covers: 3/16" veneer surfaced plywood with trimmed edges. Alternately, a dark (possibly black) padded vinyl upholstery or leather.
- Stateroom / Head Doors: 5/8" or 3/4" Cherry or other medium toned hardwood frame with 1/4" plywood matching veneer center panels.
- Head / Vanity Countertops: 5/8" marine grade hardwood plywood, Formica surfaced.
- Cabin Soles: 1/4" medium toned hardwood over Nida Core sub sole.
- Steps and Companionway Ladders: 3/4" cherry or other medium toned hardwood.

VIII. Proposed Interior Finish

All joinery fasteners will be countersunk, bunged and sanded flush. There will be no exposed fasteners throughout the interior joinery.

Formica surfaces are to be light gray or creamy near-white.

Interior hardwoods and veneered panels are to be either oiled using Cetol, or varnished using a marine grade satin finish UV protected spar varnish.

Sole areas, steps and ladders will be treated so as to be non-skid.

IX. Accommodation Space Ventilation

Ventilation will be provided to the living spaces by dorades and by "electronics" type fans (for low amp-draw accommodation space ventilation). Approximate fan capacity will be 20 CFM. Each fan set will be individually controlled within the accommodation space which it serves.

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There will be one passive intake dorade and one exit fan / dorade combination located as follows: One pair in each sleeping cabin, one pair in each head, four pair in the Pilot House, four pair in the Great Room.

X. Mechanical Space Ventilation

Ventilation of the mechanical and storage spaces adjacent to the engine room will be via exit air fans capable of delivering a total minimum of 300 CFM. The ventilation of these mechanical / storage spaces will be integrated with the ventilation of the engine room.

XI. Engine Space Ventilation

The drawings will show the arrangement of the ventilation path for the Engine space intake and exit vents. The engine space ventilation plenums will be protected from water intrusion via dorade style intake and exit louvers located within the seat back coamings of the cockpit, port and starb'd. Per traditional yachting etiquette, the exit air plenum will be to port, and the intake will be to starboard.

A pathway between the engine space to the seat back coamings will be provided through the mechanical and pantry spaces to port and starb'd of the engine space as follows:

Intake Air Ducting: The intake air will enter via the seat-back louvers to starb'd. Intake air will pass through the space below the "shelf" outboard of the stairway to starb'd, then into and through the shop space to starb'd of the engine room, then to the engine room.

Approximately 300 CFM of this intake air will be diverted to the shop, and 300 CFM will be diverted to the Pantry space. These spaces will have flaps that permit regulation of the air exchange, in order to allow preference to be given to air conditioning in those spaces, rather than active ventilation.

Exit Air Ducting: The exit air ducting will pass out of the engine space, and through the Pantry to port. Exit air ducting will pass through the space below the Galley counter outboard of the stove, then will pass into the seat back coaming and exit via the louvers to port.

Approximately 300 CFM of exit air will be pulled from the shop, and 300 CFM will be pulled from the Pantry space. These spaces will have flaps that permit regulation of the air exchange, in order to allow preference to be given to air conditioning in those spaces, rather than active ventilation.

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Vent Fans: Engine room ventilation fans will be of the squirrel cage type for silent running. Fans will be placed on both the **entry air** and the **exit air** side in order to allow a smaller ducting cross section.

There will be an equal fan capacity on both intake and exit side, in order to protect the accommodation spaces from engine room air intrusion while the engines and or generator are operating (net negative engine room air pressure).

There will be two entry air fans and two exit air fans, in order to allow two modes of operation.

Each fan is assumed to operate against a 0.5" (water) static pressure.

XII. Typical Engine Room Ventilation Targets

Temperate

Item	Max HP	Combustion Air CFM	Total CFM **North**	Passive Duct Square Inches	Fan Driven Duct Square Inches	Louver Area Square Inches
Main #1	250	1000	2000	288	96	436
Main #2	250	1000	2000	288	96	436
Gen #1	45	180	360	52	17	79
Totals	**545**	**2,180**	**4,360**	**628**	**209**	**951**

Tropics

Total CFM **Tropics**	Passive Duct Square Inches	Fan Driven Duct Square Inches	Louver Area Square Inches
3000	432	144	655

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3000	432	144	655
540	78	26	118
0	0	0	0
6,540	**942**	**314**	**1,427**

XIII. Engine Exhaust

The engines and generators will have wet exhaust lines. Exhaust sound attenuation will be given the highest priority.

The exhaust lines will have flexible laminated billows couplings as close to the engines as possible. Exhaust will pass through a lagged dry "high loop" prior to having sea water injected. Exhaust lines will then become hose, and will pass into low back-pressure water-lift mufflers, from which they will exit the hull to port and starb'd of the engine space.

Exhaust lines will be sized according to engine manufacturer's specifications.

The generator will be provided with a Northern Lights "water drop" exhaust scrubber for use in a marina setting where emissions may be restricted.

Exhaust line materials will be chosen for maximum corrosion prevention in all exhaust line components. Preference will be given to Inconel or 70-30 CuNi for all metal exhaust components. Stainless will not be considered.

Pyrometers will be provided in each exhaust exit elbow on the engines and generator.

XIV. Engine Room Arrangement

The engine space is located below the Pilot House. The engine room will be thoroughly sound proofed, and will have a forced air ventilation system as described above.

Low levels of noise and vibration will be provided via adequate sound insulation and vibration damping. There will be flexible engine mounts and a flexible coupling on the shaft. Sound attenuation will be as described elsewhere in this specification.

Space around the engines will be adequate to get to all parts of the engines and gears.

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Phone 480-773-2756 michael@kastenmarine.com
Fax 604-648-9759 www.kastenmarine.com

XV. Power

There will be two fresh water cooled Cummins 6CTA 8.3-M (JWAC) marine diesel propulsion engines. Using a continuous duty Marine rating, the engines will provide 255 hp each at 1,800 rpm. At that rating, in the full load condition, 13 knots should be possible.

XVI. Range

Using 19.02 hp/gal/hr as the published specific fuel consumption for the engines, allowing for a 15% fuel reserve, a fuel tank capacity of ±4,422 gallons, range will be approximately as follows:

Long range cruising speed for this vessel will be between 10 and 11 knots. Per the typical Beebe method of calculating average range in ocean conditions, range should be approximately as follows: At 10 knots, range will be around 4,600 NM. At 11 knots range will be around 3,100 NM. At 12 knots, range will be around 2,300 NM.

Displacement hull speed per the traditionally applied limits will be around 13 knots. Maximum achievable speed for ***Zebulun***, due to the relatively light hull form, will be around 17 knots while motor sailing, or under sail alone, given the right conditions.

XVII. Gears

ZF-305 gears will be used, having a reduction ratio of 2.25:1.

Shaft rotations will be opposite, with the starb'd side propeller rotating counter clockwise, and the port side prop rotating clockwise, when viewed from aft.

XVIII. Propellers

Two automatically feathering propellers will be used, each having a 900mm diameter, per **Autoprop** calculations.

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XIX. Shafts

Solid shafts, per ABS specification, will be 3" diameter for the specified engines and reduction ratio. Maximum bearing spacing with a 3" shaft is 11.6 feet. Minimum bearing spacing will be 5 feet.

Shafts will be Aquamet 22 (or Aqualloy 22), having a minimum tensile strength of 94,000 psi.

XX. Shaft & Tube Arrangement

The shaft and bearing assembly will be provided by **Evolution**, sized to fit a 3" diameter shaft, and able to fit within the integral shaft tubes of 5" Schedule 80 aluminum pipe.

The shafts will be grease or oil lubricated, using solid bearings forward and aft. Engine Flex Couplings and Flex Mounts will be chosen for compatibility with the solid stuffing gland bearing arrangement.

XXI. Flexible Mounts and Shaft Couplings

A flexible engine mounting system will be specified and provided by a single supplier or manufacturer. The optimum choice for this application will be provided by **Lo-Rez** of Vancouver, BC. A second choice supplier will be **Evolution**.

XXII. Cooling System

Engine and generator cooling will be arranged as though intended for keel cooling, and will make use of a double hull skin as the keel cooler, welded integrally with the hull.

Area provided will be 1/5 square foot of hull cooling surface area per horsepower, per typical Caterpillar recommendations, for a total of around 51 sq ft for each main engine, and approximately 9 sq ft for the generator.

The generator cooler area will be segregated from that of the main engines, having 4.5 sq ft to port, and 4.5 sq ft to starb'd

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The space occupied by these skin coolers will extend from the inboard engine girder / tank face, to the longitudinal located approximately 5' – 9" outboard. Skin coolers will be a minimum of 2" depth.

The inside of the skin coolers will not be painted. Coolant provided will be Texaco "Dex-Cool" Lifetime coolant, installed per Texaco specifications.

Per Cummins published data for these engines, flow rate to the keel coolers will be a maximum of 60 GPM.

The coolant line from engine to tank will be a minimum of 2.5" inside diameter, and will enter the coolant tank as low and as far aft as possible. Limbers for coolant will be provided at the bottom of each of the frames amounting to a minimum of 5 sq inches area per frame. Limbers for overflow and air will be provided at the top of each of the frames, amounting to 5 sq inch area. A return coolant line from tank to engine will exit the tank as far forward and as low as possible and will be a minimum of 2.5" inside diameter.

There will be a single expansion / header tank to serve the three separate keel cooling areas. The expansion tank will have enough capacity to hold 8 US gallons of coolant when cold, and will have a 16 gallon additional expansion capacity. There will be a 1" vent line from the highest point of the keel coolant tank aft, which will be led in a continuous rise to the top of an expansion / header tank. There will be a 1" inside diameter coolant line from the bottom of the expansion / header tank to the keel coolant tank. The cooling system is to be vented to operate at atmospheric pressure.

The generator cooling loop will make use of 1.5" exit and return lines, and a minimum of 2 sq inches of limber and air vent area. A 3/4" inside diameter expansion tank line will be used.

Consideration will be given to making use of an in-line fine screen coolant filter. Ready access will be provided to the filters for cleaning and replacement.

XXIII. Integral Tanks

All fuel and water tanks are to be integral with the hull. Each tank will have large cover plates to allow full access to all compartments during building, during blasting and painting, and for future maintenance. Water tanks will additionally have smaller easily removed inspection and cleanout plates.

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Fuel Bulk Tanks: Diesel fuel capacity will be ±4,420 US Gallons total. Bulk fuel will be stored in six integral tanks located outboard to port and starb'd below the Lounge sole. Each pair of outboard bulk tanks will hold ±1,775 US gallons for a total outboard capacity of ±3,550 USG. Bulk fuel will also be stored in two integral tanks located on center port and starb'd in the bilge area below the Lounge. Each of the bilge bulk tanks will hold ±275 US gallons for a total bilge tank capacity of ±550 USG. There will be a separate fill, vent and suction line for each of the bulk fuel tanks. Fuel suction lines will emerge from the lowest point on each fuel tank, on the aft side.

Fuel Clean Tank: Another integral bilge fuel tank will act as the clean day tank only. The clean diesel day tank will be located below the engine room sole, and will hold ± 320 US gallons. The "clean tank" will not be able to be filled from on deck. The clean day tank will have a fill (from the manifold only) a suction, a return (from the engine), and a vent **separate** from the other tanks.

Fuel Manifold: There will be a diesel fuel manifold arranged to allow "polished" fuel only into the clean day tank. Fuel will be transferred by electric pump and by manual backup pump.

Water Tanks: Water tank capacity will be approximately 870 US Gallons. There will be two water tanks built integrally with the hull, located to port and starb'd below the forward cabin sole. The water tanks will be able to be filled from on deck. Each water tank will have a fill, suction, vent and a clean-out plate. If fresh water flushing for the marine heads is planned, then it will be most suitable to provide a separate polyethylene "flush water" tank near each of the head compartments to prevent any cross contamination to the drinking water supply.

XXIV. Non-Integral Tanks

Black Water Tanks: There will be two holding tanks, one forward, and one aft, each of which will have a capacity of 60 gallons. The holding tanks will be heavy wall polyethylene, built to fit the compartment where located.

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Grey Water Tanks: There will be two sump tanks, one forward and one aft, each of which will have a capacity of 60 gallons. The grey water tanks will be heavy wall polyethylene, built to fit the compartment where located.

All polyethylene tanks will have removable lids for occasional access / maintenance. Poly tanks will have a minimum wall thickness of 1/2" up to 70 gallons. Poly tanks will have baffles located no farther apart than 18" in any direction.

XXV. 24 Volt DC Electrical

The ship's primary electrical systems will be both 110 / 220 volts AC, and 24 volts DC.

To serve the engine room 24v DC systems, there will be 4 storage batteries having an 8-D form factor, located in the engine room. The engine room battery bank will serve as start batteries for each of the engines and the generator.

To serve the house 24v DC systems, there will be two "house" banks of batteries located between Stations 10 and 12, below the Great Room, forward.

Battery mounting foundations will be provided forward, integrally welded to the floors in those bilge areas, located as low as possible in order to provide a level mounting surface on which to secure the batteries. The total combined weight of the house battery banks will be no greater than 4,000 lb.

The specifics of the engine room battery bank, the two house banks, and the charging system will be according to the supplier of the charging equipment (Balmar or Ample Power).

A battery monitoring system will be specified and installed by the supplier of the charging equipment. Attenuation of any possible Radio Frequency Interference will be given a high priority in the design of the battery charging system.

Several DC receptacles will be provided for small 12v DC loads, such as a laptop computer, shaver, cell phone and so-forth: One in each head; two in the galley; one in each cabin forward; two in each cabin aft; two in the pilot house; two in the office amidships; two in each storage room or work room. All 12v DC receptacles will be arranged for convenient use. Additional locations may be specified by the owner as required.

Isolation: The DC system and alternators are to be an "isolated ground" type of system, and will be fully isolated from the engine, the hull, and all metal hull fittings.

The propulsion engine will additionally be electrically isolated from the hull via flexible mounts and flexible couplings.

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There will be no bonding system aboard this vessel attached to the DC system.

For long term storage of the vessel, whether afloat or ashore, a conveniently located two pole switch will be provided in order to easily disconnect and completely isolate the batteries (both positive and negative legs) from all of the vessel's DC electrics while being charged via shore power.

Bilge pumps may possibly be considered for being directly wired to the batteries (to be decided). If so, the bilge pumps will be provided with their own separate in-line fuses.

Panels: The main DC distribution panel will be located within the Engine Room (specific location to be determined). The main DC panel will be provided with Voltage and Amperage meters. A DC sub-panel will be located within the Pilot House to serve individual communications and navigation electronics.

Lighting: There will be DC low-demand safety lighting in each compartment and in the Lazarette and Forepeak areas.

XXVI. Low Voltage Wiring

Phone: The vessel will be wired for phone connections. Except for head and storage areas, phone jacks will be conveniently located in each compartment.

Ethernet: The vessel will be wired with ethernet cable to each compartment for computer networking. Gigabit rated CAT 5 ethernet cable will be used. Except for head and storage areas, ethernet jacks will be conveniently located in each compartment. The ethernet wiring will be passive, and will be arranged to radiate from the Pilot House, where a non-integral ethernet router will be located.

Video: The vessel will be wired with coaxial cable Except for head and storage areas, coaxial cable jacks will be conveniently located in each compartment. Consideration may be given to wiring the coaxial cable system with paired wires, one for incoming signal, and one for outgoing signal in order to allow flexibility of source and display.

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XXVII. AC Electrical

The AC wiring system will be limited to specific AC loads. The AC panel and shore power inlets will be designed to be sufficient for the loads imposed by washers & dryers, air conditioning, power tools, for charging the batteries while dockside, and for other appliances (to be determined) which may require AC power.

Means will be provided for bringing aboard AC power through approved shore power cords, entering the vessel via electrically isolated marine rated AC shore power receptacles in the cockpit.

There will be an Isolation Transformer provided, complying with the most recent ABYC regulations. There will be **no** interface between the AC power and the DC system. The green grounding wire will be connected (or not) according to the instructions accompanying the isolation transformer, per ABYC regulations. It will be preferred that the green grounding wire not be extended to contact any portion of the hull, whether via the neutral bus, or even via the transformer case itself.

There will be an AC distribution panel located in the galley, facing diagonally aft and toward the galley.

Power Alarms: Shore power input meters will be provided in order to indicate input voltage and frequency. Optionally, there will be an alarm capable of being set for different input voltages, sounding in the Engine Room and in the Pilot House. Consideration may be given to using a pre-set alarm threshold of 108v AC. A polarity indicator will be provided on the AC panel, and will be equipped with an alarm, sounding in the Engine Room and in the Pilot House.

Source Switching: A dedicated switching panel, or a region within the AC distribution panel will be provided for convenient switching between shore power, generator power, and inverter power sources. Amperage meters will be provided in the Source Switching panel in order to monitor AC power use. The AC supply system amperage meters will be arranged to function whether on shore power, generator power, or inverter power.

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Fax 604-648-9759 www.kastenmarine.com

XXVIII. AC and DC Wiring

AC and DC wiring will be installed according to ABYC recommended practices. AC wiring and DC wiring will be run in separate bundles, and not mingled.

AC / DC wiring distribution chase will be located to Port & Starb'd, just below the Main Deck edge. There will be no electrical wiring conducted through the bilge (reserved entirely for plumbing). Any wiring required to serve the bilge pumps will be led from the wire chase above rather than through the bilge.

DC battery charging circuit, and main DC trunk line from storage batteries to DC distribution panel will be led just below the Lounge Sole, in order to traverse the least distance possible.

Wiring which passes through bulkheads will be protected from chafe and sealed. A large diameter pipe will pass through and be fully welded to each watertight bulkhead, as needed for the requirements of the wiring distribution chase, and as needed to accommodate the main DC trunk line(s).

All wiring will be adequately supported (at least every 18 inches) and protected from vibration. All wiring will be tinned multiple strand (minimum 16 strands) marine quality copper wire (Ancor brand or equal).

XXIX. Lightning Attenuation System

Consideration will be given to the installation of a lightning protection system (to be determined).

XXX. Corrosion Protection System

There will be no **active** corrosion protection system provided on this vessel. There will be no bonding system provided on this vessel. **Passive** corrosion monitors will be provided, and will be located forward, amidships, and aft.

All dissimilar metal fittings will be completely and thoroughly isolated from the hull via a combination of paint, micarta (phenolic resin laminate) wafers, liners, and adhesive caulking. Each separate underwater fitting, where practical, will be supplied with its own separate zinc anode or anodes. The hull will be provided with zinc anodes as follows:

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- There will be one zinc on each side of each stainless rudder (four total)
- There will be one zinc on each side of each aluminum skeg (four total)
- There will be one zinc on each side of each of the shaft fins aft (four total).
- There will be one zinc on each side of each keel, toward the trailing edge at mid-height (four total).
- There will be one zinc on each side of the hull aft, and one on each side of the hull forward (four total).

The anodes will be approximately 8" diameter standard "rudder cheek" zincs (flat, round, lens shaped) having one bolting hole in the center. Type 316 stainless studs will be provided for attachment of these anodes. Studs will be 1/2" national coarse by 2" long, or a metric equivalent, and will the threaded into doubler plates, per details on the construction drawings.

XXXI. Through Hull Fittings

All discharges will be to port, all intakes will be to starboard.

Through hull valves located above the waterline may be RC Marine "Marlon" Nylon fiberglass reinforced plastic valves attached to Schedule 80 aluminum pipes welded to the hull above the **load** waterline.

Through hull valves located **below** the waterline will be flanged Type 316 Stainless tapered valves or ball valves bolted onto flanged Schedule 80 aluminum pipe through hull fittings welded to the hull and bracketed. All stainless through hull valves will be isolated thoroughly from the through hull mounting surfaces.

Metal through hull fittings such as transducers will be located as necessary, and will be mounted into heavy insert plates welded into the hull. All such dissimilar metal fittings will be thoroughly isolated from the hull. There will be no electrical continuity between any through hull fittings and the hull. All dissimilar metal fittings will be thoroughly isolated from the hull surfaces using the vessel's intact paint system, isolation sleeves, Micarta wafers and marine grade caulking, in combination.

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XXXII. Ground Tackle

There will be two primary working anchors: one **Bruce** and one **Plow** of approximately 110 lb. each. Primary anchor rodes will each be 300 feet of 1" Braided Nylon line and 60' of 5/8" HT galvanized chain. There will be two spare anchor rodes, each having 30 feet of 5/8" HT galvanized chain and 200 feet of 7/8" Braided Nylon line, each with one 60 lb. Danforth anchor.

Two 150 lb. storm anchors will be stowed below (type to be decided) each having a rode of 300 feet of 1" Braided Nylon line and 60' of 5/8" HT galvanized chain.

The stern anchor will be a 55 lb. Danforth. Stern anchor rode will be 15 feet of 1/2" HT galvanized chain and 200 feet of 5/8" Braided Nylon line. There will be 400 feet of 1" Braided Nylon line made into mooring lines.

There will be six large fenders of the spherical fisherman type.

Two hydraulic vertical capstan style anchor windlasses will be provided on the foredeck.

There will be eight aluminum hawse holes welded into the bulwark, four per side. There will be two larger aluminum hawse hole athwart the windlasses forward. There will be two heavy duty bitt welded onto the after deck, one per side right aft. There will be two heavy duty mooring bitts forward, one on either side of the fore deck. There will be four mooring bitts elsewhere, two per side.

There will be two anchor rode roller sheaves built into the bulwark on either side of the centerline forward.

XXXIII. The Rudders

There are twin rudders, each having approximately an 18% counterbalance. The rudder profile, the rudder stock sizes, and the bearing arrangements are shown on the Construction Drawings. The rudder heel fittings will be removable, allowing the rudders to be dropped.

Foil Shape: The rudders will be a symmetric NACA 0010 type foil in order to achieve the most lift with the least drag and the least tendency to stall. The rudder foil shapes will be established by horizontal "lifts" located at 24" intervals. A plot will be provided showing the shapes of each lift.

The rudder stocks will be 4.5" diameter type 316-L or Aquamet 22 stainless rod, welded integrally into the type 316-L rudder foil.

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The rudder stocks will be carried in a heavy wall aluminum rudder tube and cutless bearings, per the drawings.

XXXIV. Removable Rudder Heel Fitting

Each rudder heel fitting will be bolted with six Type 316-L Stainless bolts having a 1" minimum diameter. Bolt holes will be sufficiently oversize to permit the epoxy paint system to remain intact inside the bolt holes.

Each bolt will be thoroughly bedded in marine caulking. Each bolt will be provided with a "cap-nut" type of zinc (available from out-drive suppliers).

All faying surfaces of the rudder shoe piece and the rudder heel fitting will be painted with the vessel's paint system, and will be bedded in marine caulking (Sikaflex or 3M-5200).

The stainless rudder heel fitting bolts will be inspected annually by withdrawing one bolt on each successive year in rotation.

XXXV. Steering System

Manufacturer of all primary steering components will be **Wagner**. The hydraulic Helm-pump steering system will be controlled by a wheel located at the Helm within the Cockpit and within the Pilot House.

The autopilot system is by **ComNav** or **AutoNav**, per owner preference. Jog steering will be provided via the autopilot interface in the Pilot House only.

XXXVI. Hydraulic System

The hydraulic system will be designed by the hydraulic system installer. The hydraulic system will be designed to be capable of serving the requirements of the anchor windlass, deck winches, the steering system (if required), and halyard winches, if so desired.

The gears will each have a hydraulic pump driven by a PTO that will serve these requirements. Hydraulic pump, reservoir, filters, and cooling will be as specified by the supplier / installer of the hydraulic system.

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XXXVII. The Keels

The asymmetric keel foils are within the NACA 0010 series foil family, rather than the "laminar flow" foil family. The laminar flow foil shapes will stall much more readily than the 0010 family foils, especially when thinned down and wherever heavily loaded.

The specific parent foil section is an asymmetric NACA 2410. This foil type was selected on the basis of having the greatest resistance to stalling, and therefore the greatest resistance to unexpected changes in behavior and or steering anomalies while sailing, as well as while rolling under power.

The 24xx foil asymmetry was selected on the basis of being less radical than the next best candidate, a standard 44xx asymmetric foil. The first two digits refer to the percentage of asymmetry. The standard 44xx foils are nearly flat on one side. Per the published lift characteristics, the 44xx types exhibit a more abrupt change in lift at certain angles of attack, and therefore are less "docile" in terms of unexpected steering effects.

As modeled, the keel foil "fatness" is around 10.32% at the root, and 7.68% at the tip, where stalling is most likely due to the "sweep back" creating relatively heavier loading there.

The keel bulbs will function as an effective "end plate" for the keels, in order to help reduce "induced drag" due to excess tip vortices. The bulb foil shapes, due to the desirability of placing the maximum volume as far forward as possible, are within the 0010 NACA foil family.

Tank testing and the various published empirical results show that a toe-in of 0 degrees to 1.25 degrees to the vessel centerline produces the least overall drag. There is some evidence to suggest that a slight toe in may provide slightly greater lift to windward. However there is also evidence to suggest that toe in is not desirable in terms of steering behavior under power. Therefore, the keel foils are aligned **parallel** to the centerline.

XXXVIII. The Rig

Zebulun has been provided with a three mast schooner rig in order to make use of relatively high aspect individual sails, while keeping the rig to a conservative height overall. Sails will be fully battened to enable the use of a large roach and an elliptical plan form, while still allowing maximum draft control. The three sails attached to the masts are as near identical in size and construction as possible.

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Per sailmaker choice, the sails may be cut differently in terms of draft in order to take maximum advantage of their relative positions in the rig. There will be one large roller furling jib on an inner forestay, and there will be two other light weather stays'ls which will be set from the respective mastheads.

XXXIX. Standing Rigging

The masts will each be identical in terms of their layout, with the exception of the amount of bury belowdecks, and the heights of the gooseneck fittings. Joints will be made in each mast, according to the spar drawing, located at the spreaders, and at the deck.

The masts will be constructed of 6061 T-6 aluminum pipe. Spreaders will be split pipe, with a plate insert in order to achieve the taper. The booms will be fabricated out of bent plate, having two breaks to create a deep inverted "U" shape, and will be plated over on the bottom. All spars will be welded shut and will be air and water tight.

Mast loading and section modulus calcs from German Lloyd's; Bureau Veritas; Miller & Miller; yield the following sizes:

- Masts: 12" Sch. 40 Pipe
- Foremast Lower Section: 12" Sch. 80 Pipe
- Spreaders: Fabricated of 1/4" Plate, as drawn in the Building Plans
- Booms: Fabricated of 1/4" Plate, as drawn in the Building Plans

The rig will be supported by 25 degree swept back spreaders, using a single lower shroud and a single upper shroud per mast per side. Running backstays are not required for this rig. If desired however, running backstays will be located and installed as drawn on the building plans.

Mast plates, rigging pin sizes, bushing sizes and weld specs will be according to the attached rigging schedule, and according to the rigging plan.

Wire will be 1 x 19 type 2205 Duplex stainless throughout (if available) or will be type 316 stainless throughout. Running backstays, if used, will be 7 x 19 type 316 stainless. Wire terminals will be **manganese bronze** poured sockets throughout.

Using typical rig loadings from German Lloyd's; Bureau Veritas; Miller & Miller rig analysis using a conservative 4:1 safety factor indicates the following sizes.

- Lower Shrouds & Headstay: 1.125" (28mm) Wire
- Upper Shrouds: 0.875" (22mm) Wire

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- Spring Stays: 0.625" (16mm) Wire
- Jib & Stays'l Luff Wires: 0.625" (16mm) Wire
- Running Backstays (if used): 0.625" (16mm) Wire

Turnbuckles will be type 2205 Duplex stainless (if available) or will be type 316 stainless. Turnbuckles will be fitted with toggles, and will be sized as follows:

- Lower Shrouds & Headstay: 1.75"
- Upper Shrouds: 1.25"
- Spring Stays: 1.125"
- Jib Stay: 1.125"

Chainplate pins will be type 2205 Duplex stainless (if available) or will be type 316 stainless. Pin diameters will be as follows:

- Shrouds: 2.125"
- Headstay: 1.625"
- Running Backstay (if used): 1.125"

Chainplates will be type 5086 H116 and will be integral with the hull. Chainplates will have type 316 stainless bushings, per the drawings, and per the attached rigging schedule. Chainplates have been calculated using a conservative 6:1 safety factor, and will be sized as follows:

- Upper & Lower Shrouds: 2" t. x 10.25" w. x 6" depth to pin
- Stem Fitting: 1" t. x 10.25" w. x 6.75" depth to pin
- Running Backstay (if used): 1" t. x 6.5" w. x 4" depth to pin

Misc. Rigging Notes: All Chainplates, hull insert plate reinforcements, mast tanks and fittings, booms, masthead fittings, goosenecks, etc. are detailed for NC cutting as part of the NC cutting package. Mast upper sections may optionally be tapered, if available in sufficiently long sections (typically available via street light pole suppliers).

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XL. Running Rigging & Deck Hardware

All running rigging lines will be pre stretched braided Dacron line. There will not be internal halyards. Blocks will be by Harken or equal. Halyards will terminate at the base of each mast. Sheets will be led to the cockpit area. Winches will be by Harken, Maxwell, Muir or equal.

Halyards: There will be two halyard winches per mast, one on each side at a convenient height.

Sheets: There will be three sheet winches per side to handle the jib and stays'ls. Jib sheet winches will be located on the side of the cockpit area. Each boom will have Harken or equal roller bearing travelers sized to the available width. Boom sheets will be located within the outer 20 percent of the booms. Boom sheets will lead aft to the cockpit area, as drawn.

Reefing: Reefing gear will be provided in order to allow two reefs in each of the three sails attached to the masts. Cleats and other line handling hardware will be by manufacturer of choice, and will be arranged according to the spar drawing.

Sail Track: Mast hardware will be by Antal (or equal) and will include luff track and batten cars.

Roller Furling: Roller furling gear will be provided for the jib.

XLI. Sails

The Foresail, Mainsail, and Mizzen will be fully battened. They will have a large roach and will be loose footed. A headboard will be machined of 1" thickness 6061 T-6 aluminum plate, per the shape given on the spar drawing. Heavy webbing straps will attach the headboard to the sail.

Sail cloth will be stabilized Dacron or better. Consideration will be given to use of a combination of Kevlar tape / Mylar / Cloth Overlay type of sail material for the sake of weight savings and therefore ease of sail handling. Sail weights and other sail specifications will be per sailmaker recommendation.

Battens will be Glass or Carbon Fiber laminate extrusions per sailmaker recommendation, and will be sized to suit the loads. Battens will be attached at the forward end to Harken or Antal (or equal) cars designed for the batten loads. The Fore, Main and Mizzen will each have two reefs.

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The jib will be roller furling. A smaller storm jib and a larger genoa or cruising spinnaker may be provided (to be decided).

For lighter weather, two stays'ls will be flown from the Main and Mizzen mastheads, set flying, and attached to the weather side near the base of the next-forward mast. The tack of each stays'l will be moved to the weather side of the next-forward-boom on each tack. In order to accommodate differing wind conditions (differing desired slot effect), there are two tack locations on each side of the Fore and the Main masts for the tack of the stays'ls, as drawn.

XLII. Paint System

For a detailed description of the paint system, please refer to the separate paint specification, attached to this general Vessel Specification. An abbreviated summary of the paint system is as follows.

With the exception of the anti-fouling paint, the protective paint coating system is specified as being Ameron's **Devoe** System.

In preparation for paint coatings, sand blasting will be done according to temperature and relative humidity recommendations of the paint system being used. Primers will be applied each day to cover that day's sandblasting, and prior to any significant temperature drop or rise in relative humidity at the end of the day.

Aluminum Hull Interior: After fabrication, the interior of the aluminum hull and decks will be brush-blasted in order to clean all welding and cutting areas. The interior aluminum surfaces will be primed with Devoe 201 primer or Devoe 236 epoxy.

Where blown in polyurethane or cut sheet foam insulation will be applied, the interior paint system will have a minimum thickness of 6 Mils DFT. Uninsulated areas may remain unpainted.

Tanks: After thorough blasting to remove **all** traces of contamination, all integral water tanks and fuel tanks will be coated with a minimum of three coats of Devoe 236, using colors approved for potable water. Minimum coating thickness will be 16 mils DFT.

Aluminum Hull Exterior: After fabrication, the exterior of the aluminum hull and decks will be sandblasted to a "commercial blast" standard.

All blasted areas will be primed with Devoe 201 or Devoe 236. All exterior surfaces will then receive a minimum of three coats of Devoe 236 high build epoxy paint. The exterior paint system will have a minimum thickness of 16 Mils DFT prior to application of color coatings or antifouling paint.

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All exterior hull and deck areas above the boot stripe will receive a minimum of two layers of Devoe 229 acrylic epoxy color coating applied over the high build coatings. Non-skid will be placed on all deck surfaces. Devoe 229 Acrylic Epoxy coatings have been chosen for their extreme ruggedness, ease of application, ease of re-coating, and for compatibility with the Devoe epoxy barrier coating system. Consideration may also be given to use of Devoe 239 LP color coatings in place of Devoe 229.

Anti-fouling Paint: Four coats of E-Paint's No-Foul ZDF (the solvent based type) will be applied to all under water areas, and brought up to the top of the boot stripe line.

Please refer to the separate **Paint Specification** for further detail.

XLIII. Thermal Insulation

Insulation throughout will be either blown in polyurethane foam, or will be cut-sheet foam (to be decided).

If blown-in polyurethane insulation is used on the hull, a fire retardant formulation will be chosen. There will be a **fire retardant sealant** type of paint coating applied to cover all blown in foam insulation.

Insulation will be applied to the deck and the hull sides down to the level of the lower cabin soles. There will be no thermal insulation in the bilge areas or in the forepeak.

Thermal insulation shall provide an R value of at least 8 when in a new state (equivalent to 2" of sprayed, two pound per cubic foot density polyurethane foam).

If cut sheet foam insulation is chosen, Ensolite or Neoprene foam will be the preferred choice, being flexible, closed cell, mildew resistant, and fire retardant.

XLIV. Engine Room Sound Attenuation

Sound attenuation will be given a top priority. There will be no **thermal** insulation in the engine space. Instead, sound deadening materials will be used against the painted hull surfaces. Sound attenuation will be addressed on four fronts:

Structure Borne Sound Isolation: Soft Mounts, Flexible Coupling, Flexible Stuffing Box will be required for the propulsion engines. Generators and auxiliary mechanical equipment will also have flexible isolation type of mounts to prevent structure borne noise. Equipment requiring structure borne noise attenuation via isolation mounts includes: Propulsion Engines; Drive Lines; Watermaker Pump; Refrigeration Unit; Ventilation Fans; Water Pressure Pumps.

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Structure Borne Noise Absorption / Dampening: Areas such as Engine Girders; Hull Surfaces adjacent to the Engine Girders and directly above the Propeller will have weighted sound absorption / dampening materials applied. Materials will be specified from readily available sound attenuation products.

Air Borne Noise Isolation: All avenues for air borne noise between Engine Room and Accommodation Spaces will be sealed tight, including mechanical and electrical chase ways after installation of plumbing, cables, and wiring.

Air Borne Noise Absorption: All surfaces between engine room and living quarters shall be insulated with sound absorbing foam on the Engine Room side. Sound barrier foam to consist of 2" total, including White or Silver Mylar surface coating, foam absorption layer, weighted vinyl damping layer, and foam de-coupling layer. Installation to be done in such a way that the insulation is mechanically captured. All edges and joints to be sealed with Silver or White Mylar surfaced tape. All engine room air ventilation ducting will be treated with the same materials to a thickness of 1.5" total.

The Sound-Down Corporation or other sound attenuation specialists should be consulted for their complete sound attenuation regime.

XLV. Engine Room Fire Control

A **Fireboy** or similar brand of fire control system will be installed in the engine room. Automatic engine shut down switches will be connected to the propulsion engines and generators. Consideration will be given to providing "fire flaps" on the engine room ventilation ducts.

A manual trigger for the fire fighting system is to be fitted on the PH dashboard.

XLVI. Ballast

There is an allowance for approximately **54,600 lbs** of lead as ballast, to be located in the keel bulbs and in the keel cavity above the bulbs, as drawn. Ballast is to be poured in place, sealed by welded aluminum plates, and pressure tested for leaks. Further detail on this procedure is available on request.

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XLVII. Equipment Summary

A separate **Equipment List** is provided, and will be considered to be part of this Vessel Specification. The following is a brief summary of **major** equipment items only.

Steering: Steering will be via **Wagner** Helm-Pump hydraulic steering system, as drawn.

Windlass: Two vertical capstan hydraulic windlasses. Muir, Maxwell, or equal, as drawn.

Navigation: A Ritchie or Silva 8" spherical magnetic fluid filled compass will be fitted in the pilot house in front of the wheel. A repeater compass will be provided at the binnacle in the cockpit.

A radar with a closed array antenna will be fitted. The radar antenna will be mounted on the arch aft of the cockpit. The radar will interface to the GPS and autopilot.

Speed and depth information will be provided by a depth sounder (brand to be specified).

There will be an autopilot interfaced to the steering system (brand to be specified). There will be a GPS (brand to be specified).

A sextant will be provided, along with flares, a manual horn, a whistle, and a manual searchlight.

Communications: There will be two VHF radios. There will be a USCG approved bell and horn.

Galley: There will be a 24v DC refrigeration system. A propane range and separate propane oven will be provided (brands to be specified).

Plumbing: A Lavac or other marine toilet will be provided, and will have a manual and electric pump. Skandvik (or equal) marine sinks and faucets will be provided for head, shower, and galley. All water supply plumbing will be via PEX type plumbing system. All water drain plumbing will be via ABS schedule 80 pipe except where hose will be necessary. All black water hose will be 1.5" marine grade sanitation hose.

Water Distribution: Four 24v DC pumps will be provided with integral accumulator tanks. Cold water filtration will be provided for drinking water at the galley and in each head.

Bilge pumps: Six large capacity Jabsco electric bilge pumps will be provided, one for each sump compartment. Each will have its own exit through-hull above the waterline (port side). There will be three large capacity manual pumps (brand to be decided).

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There will be two large capacity emergency pumps, one belted to each of the propulsion engines. Emergency bilge pump intake and discharge diameters, and bilge line I.D. are to be no less than 2.5" per ABS requirements.

Engine Controls: A Morse or Kobelt (or equal) engine speed / gear control will be provided, and will have heavy duty cables. Alternately, a Kobelt or equal manual-hydraulic system may be specified (to be decided).

Filtration: A dual Racor filter unit (or equal) will supply each propulsion engine and generator directly from the clean day tank (filter sizes to be determined). Filters will be plumbed in parallel to permit switching filters while under way. Provision will be made for bleeding each while under way. A separate Racor filter pair will be used for all fuel transferred to the day tank from the bulk tanks. A squeeze bulb will be provided in the engine supply line for bleeding the system. Fuel system schematic.. (to be determined).

Search Light: There will be a 24v DC searchlight, electronically controlled from within the pilot house.

Navigation Lights: 24v DC Aqua Signal (or equal) navigation lights will be mounted to meet Colregs requirements for vessels of this size. An anchor light will be provided. A masthead strobe will be provided. A masthead tri-color will be provided.

Exterior Lighting: Mast mounted 24v DC deck lighting will be provided from each set of spreaders.

Interior Lighting: Interior 24v DC lighting will be provided throughout (type of lighting and locations to be specified).

Ventilation: There will be several small 24v DC vent fans for the accommodation spaces as specified . There will be 24v DC engine room squirrel-cage blowers as specified.

Heat: There will be a heating system consisting of a diesel fired **Hurricane** brand heater located in the Engine Room. A eutectic fluid circulation system will make use of insulated piping. The heating system will provide constant flow for on-demand use within each accommodation space.

Fire: There will be a Fireboy (or equal) engine room fire protection system, as described elsewhere in this Specification. In addition to that, there will be a fire extinguisher located in each accommodation space and in each head.

Safety: Two 12 person life rafts will be provided, which will be stowed on the Fore Deck. Type III life vests will be provided for 30 people. A float-free 406 MHz EPIRB will be provided on the Cockpit Deck. An offshore approved signal kit will be provided.

Shore Boats: Two 14' RIB type shore boats will be provided, per the preferences of the owners, to be stowed on the Fore Deck, as drawn.

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Fax 604-648-9759 www.kastenmarine.com

XLVIII. Windows & Ports

All windows shall be glazed with Tempered Glass, or with Tempered and Laminated glass.

Opening portlights will have either aluminum or stainless aluminum frames.

In order to eliminate the use of separate metal frames, both for strength and for cosmetic reasons, all other window glass will be adhesively bonded directly to the vessel's structure using high-strength bonding adhesives. All such windows will be bonded directly into integrally fabricated window frames as detailed on the plans.

Installation: With all structural bonding, the choice of a good adhesive system and good surface preparation are critical to achieving a strong and long-lasting bond. For direct-bonding of mineral glass, we recommend a polyurethane adhesive system.

The following description provides information about glass that is to be bonded into the structure. The following methods do not apply to glass installed within opening ports or manufactured doors and opening windows.

Tempered Glass: Whether bonded directly to the vessel's structure, or installed into opening ports or doors or opening windows, all glass will be tempered, or will be tempered and laminated. Glass thicknesses throughout will be as specified elsewhere in this specification.

Structural polyurethane will degrade in UV light. All glass that will be adhesively bonded to the structure will be delivered from the glass plant with a blacked-out perimeter sometimes called a "frit." The purpose of the frit is to provide a surface finish with enough "tooth" to assure a good bond with the mounting adhesive, as well as to protect the structural bonding adhesives from UV damage by exposure to sunlight.

The frit will be part of the glass. During manufacture, the frit will be baked into the inside of the tempered glass. If laminated glass is used, the frit may be applied between the layers of glass.

Sikaflex 296 Polyurethane: Bonds the glass directly to the structure. Original surface prep is extremely important. When bonding with polyurethanes, first remove all sealants from the bonding surface. For example, even a trace amount of silicone will prevent the polyurethane from adhering properly.

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Abrade the bond area on the boat's structure (if it is GRP), or thoroughly sandblast and paint the bond area (metal structure). Clean the bond area with the specific solvent recommended by the adhesive manufacturer. Apply primers appropriate to the bonding system being used.

The adhesive should be applied in a V-shaped bead. (A round bead can produce air pockets that may lead to a bond failure).

Sikaflex 295-UV Polyurethane: A UV resistant formulation. Once the structural Sikaflex 296 Polyurethane sets up, the Sikaflex 295-UV sealant can be injected into the gap around the window in order to form an expansion seal. Sikaflex 295-UV can also be "tooled" around the perimeter of the glass to create a "fillet" and to completely enclosed the glass edges.

Other Adhesives: If there is no frit or UV block on the glass, a structural silicone which is UV stable may be acceptable in certain limited situations. While structural silicones may work for windows that are set at an angle, silicone doesn't have sufficient shear strength for large pieces of glass set vertically.

Glass Thicknesses: Per ABS requirements, **minimum** glass thicknesses are as follows (the next larger **standard** inch thickness will be used in each case):

	Inches	**mm**	**lb./sq. ft.**
Fwd Glass, Fwd Half Main Deck	0.592	15.0	7.40
Fwd Glass, Aft Half Main Deck	0.478	12.1	5.98
Fwd Glass, Fwd Half Second Deck	0.558	14.2	6.97
Fwd Glass, Aft Half Second Deck	0.438	11.1	5.48
Side Glass, Fwd Half	0.444	11.3	5.55
Side Glass, Aft Half	0.375	9.5	4.69
Aft Glass, Aft Half	0.564	14.3	7.05

Dodger **center forward** windows will be glass. All other dodger windows will be Lexan.

All dodger **forward** windows will hinge outward and upward, awning style, using a hinge arm, dogs, and squishy gaskets per drawing details.

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All dodger **side** windows will be Lexan and will be removable, using dogs and squishy gaskets per drawing details.

Hull side ports and cabin side windows will be fixed glass, bonded in place, with thicknesses per the above table. Hull side ports will have a minimum thickness of 3/8" tempered glass, or tempered and laminated safety glass throughout.

XLIX. Welding & Hull Construction Notes

Per the requirements of the ABS Rule, all transverse and longitudinal framing will be shaped so as to fit fully in contact with the hull plating, and will be skip-welded to the plating per a separate welding specification.

Transverse frames will be NC cut from 5086 H-116 aluminum plate. If higher as-welded strength is desired, 5083 H-116 may be used instead of 5086 H-116.

All frames, floors, and deck beams will have a 6061 T-6 aluminum FB "rider bar" all around the inside edge, arranged as an "L" or a "T" as illustrated in the Building Plans, and as needed to suit the requirements of mounting the bulkheads.

Longitudinals will be **continuous** rather than intercostal per ABS requirements. Long'ls will penetrate and be fully welded to all transverse framing members. Where they end, longitudinal framing members are to terminate on transverse framing members, not on the hull plating.

Plating butts will be kept fair via the use of "sister" longitudinals across the plating butts. Internal sister long'l are intended to be permanent (layout as shown on the Construction Drawings). Temporary longitudinals may be placed on the **exterior** of the plating butt joints during weld-up. Plating butt locations will be as illustrated on the Building Plans (to be decided, based on plate size and availability).

Longitudinal stringers that support the exterior plating will be 6061 aluminum FB throughout, spaced as given. On the bottom and sides of the hull, the long's are arranged to converge as fair curves. Where long's are closer than half the specified spacing, they will terminate on the nearest frame so that no region of plating has a long'l spacing greater than specified. Long's on deck are arranged parallel to the centerline.

Care shall be taken in all weldments to avoid tri-axial weld intersections, per the requirements of the ABS rule, and per good ship building practice established by the American Welding Society, as given in the AWS publication, **"Aluminum Hull Welding."**

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Butt and seam welds will be ground smooth on all exterior surfaces. It will **not** be required to grind smooth any fillet welds on hull or house except to remove any unsightly weld stop-starts.

Weld inspections may be requested by owner. If requested, weld inspection approvals will be kept on hand by the builder for inspection by the owner. A series of magna flux tests, X rays or Ultra sound tests may be requested to check weld integrity of the following areas: keel plating; keel floors; sample areas of hull seam welding; engine girders; tanks.

Welding will be in accordance with ABS rules and good AWS practice. A separate Welding Specification in accordance with the ABS rule will be supplied by Kasten Marine Design, Inc. and will be made part of this Vessel Specification.

Certification as to the alloys supplied will be obtained from suppliers and will be kept on hand for inspection by the owner or the owner's representative. All aluminum materials are to be marked at the factory with alloy number and batch number.

L. Scantlings – Updated 30 September 2003

Aluminum for hull construction will be 5086 H-116 for NC cut plate and 6061 T-6 for extrusions. If higher as-welded strength is desired, 5083 H-116 may be used instead of 5086 H-116. Note that 5083 is less corrosion resistant, and has less ductility (possibly an issue for forming.

Aluminum Hull Plate

- Hull Plating, Bulwarks, Transom, Swim Stop, Collision Bulkhead: 3/8" Plate
- Deck, Tank Faces, WT Bulkheads, Sole Edges: 1/4" Plate
- Cabin Sides, Cabin Tops: 3/16" Plate
- Keel Sides: 1/2" Plate
- Rudder Skeg Sides, Bulb Top, Bulb Sides: 3/4" Plate
- Bulb Bottom: 1" Plate

Aluminum Hull Framing

- Hull & Deck Frames & Floors Forward and Aft of Lounge: 1/2" x 7" Plate, with 1/2" x 2" FB Flange @ 44" o.c. Max

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- Hull & Deck Frames & Floors Station 11 to 17: 1/2" x 7" Plate, with 1/2" x 2" FB Flange @ 29" o.c. Max
- House & Cabin Top Frames: 5" FB, thickness and spacing same as bottom frames, with 1/2" x 2" FB Flanges on all Frames.
- Deck Longitudinals: 1/2" x 2" FB @ 12" o.c.
- Hull Side Longitudinals: 1/2" x 2.5" FB @ 12" o.c.
- Hull Bottom and Radius Longitudinals: 1/2" x 3" FB @ 12" o.c.
- House Top & Side Long's: 3/8" x 1.5" FB @ 12" o.c.
- Engine Girders: 3/4" Plate
- Engine Girder Cap Flange: 3/4" x 5" FB
- Stem, Keelson, Anchor Roller Cheeks: 1" Plate
- Hull Insert Plates at Keels and Rudders: 3/4" Plate
- Deck Insert Plates: 1/2" Plate
- Keelson Flange: 3/4" Plate
- WT Bulkhead Stiffeners: 1/2" x 2" FB @ 12" o.c. Maximum Span 55"

Misc Shapes – 6061 T-6

- Forward Bitts: 4" Sch 80 Pipe
- Bitt Tops: 3/4" Plate
- Aft Cleats: 2" Sch 80 Pipe
- Midships Cleats: 2" Sch 80 Pipe
- Sheer Rub Rail: 3" Sch 80 Pipe
- Bulwark Top: 1.5" Sch 80 Pipe
- Stem & Stern Pulpit Top: 1.25" Sch 80 Pipe
- Stanchions; Hand Rails: 1.25" Sch 80 Pipe
- Stanchion Tops; Cleat Ends: 1.25" Sch 80 Pipe Weld Caps
- Prop Shaft Tube: 5" Sch 80 Pipe
- Rudder Stock Bearing Tube: See Drawings
- Cockpit Seat Trim: 1" Sch. 80
- Rudder Leading Edge: 1.5" Solid Round Rod
- Keel Leading Edge: 4" Solid Round Rod

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Stainless Shafting

- Propeller Shaft: 3" Aquamet 22 Round Shafting
- Rudder Stocks: 4.5" Aquamet 22 Round Rod

LI. Weld Size & Spacing

ABS Motor Pleasure Yachts - ALUMINUM STRUCTURE

Intermittent Staggered Fillet Weld		Lesser Plate Thickness **Inches**	Minimum Weld Length **Inches**	Maximum Weld Intervals **Inches o. c.**	Minimum Width Of Weld Face **Inches**
Fwd 1/4 of Bottom Frames to Shell	0.375	3.0	8.0	0.343	0.375
Engine Space Frames to Shell	0.375	3.0	8.0	0.371	0.375
All Other Frames to Shell (Bottom)	0.375	3.0	10.0	0.336	0.375
All Other Frames to Shell (Sides)	0.375	3.0	9.0	0.311	0.375
All Other Frames to Shell (Deck)	0.250	2.5	9.0	0.266	0.250
Beams; Long's; Girders to Shell	0.375	2.5	8.0	0.360	0.375
Tank Stiffs to Tank Shell	0.250	2.5	7.0	0.266	0.250

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www.kastenmarine.com

Framing Double Continuous Fillet Weld			Weld Length		Weld Face
Frame; Long'l; Girder ENDS	5086 H-116	0.500	6.00	Continuous	0.44
Girders to Intermediate Floors	5086 H-116	0.500	6.00	Continuous	0.30

Plating Double Continuous Fillet Weld			Weld Length		Weld Face
Engine Foundations to Shell	5086 H-116	0.3750	4.50	Continuous	0.35
Framing Above Prop to Shell	5086 H-116	0.3750	4.50	Continuous	0.22
Tank & WT Bhd Plating to Shell	5086 H-116	0.2500	3.00	Continuous	0.23
Deck Plating at Edge	5086 H-116	0.2500	3.00	Continuous	0.22

LII. NC Cutting

Hull and superstructure surfaces have been computer modeled and faired, and the structure is detailed for NC cutting.

Frames, bulkheads girders, keelson, stem, engine beds, tank faces and tops, and all exterior hull plating are included in the NC cutting files. All fames have limbers and long'l cutouts.

All components are nested onto plate sizes as required by the cutter. Kasten Marine Design, Inc. will interface with the cutters directly to assure quality of production.

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LIII. Lofting Notes

Offsets: Since the vessel is being NC cut, **offsets** are deemed irrelevant.

Lofting will consist only of any full size output deemed desired during construction. For accurate assembly of the frames and bulkheads, an accurate 24" grid will be scribed horizontally and vertically directly on the fabrication floor.

All frames and bulkheads have the same 24" grid marked on the cut pieces. Once the grid on the pieces is accurately aligned with the grid on the floor, those components (frames, etc.) can be welded together. There is a similar grid marked on the NC cut stem and keelson, for ease of set-up. All hull plate also has index marks for frame locations, etc.

Frame Spacing: The spacing for the **frames** as shown on the Construction Drawings is the same as the **station** spacing given on the Lines Drawing. The frames are placed to take maximum advantage of the given interior layout, to match the bulkhead placement.

LIV. The Building Plans

The Building Plans consist of the following **numbered drawings**:

1. Outboard Profile & Sail Plan
2. Interior Profile & Arrangement Plan
3. Pilot House & Deck Arrangement Plan, Misc. Joinery Sections
4. Hull Structural Profile & Arrangement Plan
5. Deck, Cabin Top, Pilot House Structural Arrangement Plan
6. Misc. Structural Sections Layout
7. Misc. Structural Section Layout
8. Engine Room Ventilation Plan
9. Engine Room Structural Layout (Large Scale)
10. Rudder & Strut General Structure
11. Rudder & Strut Misc. Details
12. Anchor Handling Scheme & Structural Details
13. Hatch & Port Light Details
14. Deck Fitting Details
15. Chain Plate Layout & Details
16. Mast & Spar Layout & Details
17. Dimensioned Shaft Layouts
18. Backstay Chainplates, Bulwark Supports, Misc. Details
19. Interior Bulkhead Attachments to Frames

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20. Ceiling & Overhead Attachment to Frames
21. Lofting Conventions, Data Points
22. Cockpit Hinge Detail
23. Lines Drawing – Profile and Plan Views
24. Lines Drawing – Body View
25. Frame Details Forward
26. Frame Details Amidships
27. Frame Details Aft of Amidships
28. Frame Details Aft, Transom, Stem, Keelson
29. Plate Layout – Cabins
30. Plate Layout – Decks
31. Plate Layout – Soles, Tank Tops
32. Plate Layout – Tank Faces, Window Frames
33. Plate Layout – Keels, Rudders, Girders
34. Plate Layout – Hull Plating
35. Nestings – 3/8" Plates
36. Nestings - 3/8" Plates
37. Nestings – 1/4" Plates
38. Nestings – 1/4" Plates
39. Nestings – 1" & 3/4" Plates
40. Nestings – 1/2" Plates
41. Nestings – 3/16" Plates
42. Scantling List
43. Rig Geometry Development
44. Mast Parts Development
45. Mast Parts Detail
46. Boom Parts Detail
47. Aluminum Mast Parts Layout
48. Stainless Rudder & Mast Parts Layout

Drawing A - Typical Nida Core Joinery Details

In addition to the above drawing sheets, there are the following **documents**:

A. This Vessel Specification
B. Paint Specification
C. Equipment List
D. Rigging Size Summary
E. ABS Structure Summary
F. Weight Study Summary

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G. Hydrostatic Summary
H. Stability Summary

Items not directly addressed in this Specification or detailed on the Building Plans will be specified and built according to owner and builder mutual choice, and will be according to good boat building practice, subject to owner or owner's representative approval.

Outside the scope of the Basic Building Plans itemized above, there may be additional drawings and / or schematics requested per the preference of the owner. Any additionally requested drawings, documents, schematics, or specifications provided by Kasten Marine Design, Inc. will be charged for on an hourly basis.

Examples of additional drawings recommended for construction / finishing / outfitting are as follows:

- Machinery Layout, showing larger items such as Generator, Steering Gear, Pumps, Heater, Ventilation Fans, Vent Chases; Battery Locations & Mounting System, Electrical & Mechanical Chases.
- Additional Detail Drawings as needed for Joinery or other items.
- Basic System Schematics and Layouts for Electrical, Fresh Water, Salt Water, Engine Cooling, Fuel Piping, etc.

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The Basic Building Plans provided by Kasten Marine Design, Inc. are intended to illustrate the general type of construction to be followed. The basic design, arrangement, strength and weight shall be in agreement with those plans.

Details and dimensions shown on the plans shall be followed insofar as practicable, however it will be the responsibility of the Builder to check such dimensions and details as needed to satisfy himself, by full size layout if necessary, so that interferences are eliminated and components are properly installed.

The Builder will notify the Owner and Kasten Marine Design, Inc. for mutual resolution of any dimensions and details that he cannot follow or that he recommends changing.

It will be the responsibility of the Builder and of his subcontractors and equipment suppliers to assure that all mechanical components are suited to the purpose for which they are intended.

LV. System Schematics

The following notes are intended to clarify the design and development of system schematics.

In general, the system installer, in cooperation with the owner, will be the best qualified to provide the schematics for, the engineering of, and the installation of the **Basic Systems** and of the **Integrated Systems** as listed below, in accordance with the general guidelines provided within this Vessel Specification, with applicable regulations, with good boat building practice.

System schematics will be per this specification and per the owner's specific requirements. All system schematics will be subject to the owner's approval, or the approval of the owner's agent.

Basic Systems

In addition to the scope of the Basic Building Plans and Design Documents listed above, Kasten Marine Design, Inc. will be available on an hourly basis per owner request during or before the vessel's construction to design or to review **Basic System** schematics for the following:

- Fuel fill / distribution schematic
- Fresh water system piping schematic
- Black water system piping schematic
- Grey water system piping schematic
- Bilge pump piping schematic

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- Engine room ventilation schematic
- Basic engine cooling water supply schematic

Integrated Systems

Aside from the **Basic System** Schematics listed above, the other various **Integrated Systems** and their schematics are complex and specialized to the point that the installer or supplier of the equipment will be required to engineer those systems according to their own expertise, following the general guidelines expressed within this Vessel Specification as closely as possible.

Systems will conform to GL norms, unless specifically otherwise stated in these specifications. Specifically, these **Integrated Systems** include but are not limited to the following:

- Hydraulics system
- AC electrical distribution system
- DC electrical distribution system
- AC electrical component interfaces to each other or to the electrical system
- DC electrical component interfaces to each other or to the electrical system
- Electronics interfaces to each other or to the electrical system
- Shore power system (isolation transformer, etc.)
- Charging system or its interface to the electrical system
- Steering system
- Autopilot system
- Firefighting system
- Heating system
- Watermaker system
- Air Conditioning system

In general, only the suppliers / installers of these various complex and highly specialized **Integrated Systems** will be considered to be qualified to design and review their schematics, or to determine whether the systems comply with the general guidelines within this Vessel Specification.

Kasten Marine Design, Inc. does not propose to review the **Integrated Systems** nor their schematics, nor to offer specific comment on them, except to address questions from the suppliers / installers for best compliance with the general intent of this Vessel Specification.

If it is desired to have a third party review of the systems as they are installed, the owner will make use of an independent surveyor for that task, hired by and paid for by the owner.

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LVI. General Terms

Correct displacement, trim, stability and hull strength are a tightly integrated whole. Arbitrary changes made may adversely affect the vessel's trim, and therefore the vessel's behavior, performance, and safety. In order to assure success with the building of this vessel, it is assumed that the plans and specifications will be followed as closely as possible.

There will be no changes from this specification or to the vessel's structure, materials, equipment, or layout without written approval from Kasten Marine Design, Inc. Changes made without written approval from Kasten Marine Design, Inc. will relieve Michael Kasten, and Kasten Marine Design, Inc. of responsibility for any possible effects of those changes.

The Builder and Owner will construct and equip this vessel complete in every respect and ready for service. Omission from the plans and / or this specification of any items which according to generally accepted practice are necessary for the proper operation of the vessel will not release the Builder and or Owner from supplying and installing same.

Materials and manufactured articles of construction and equipment are to be of the best quality for their respective purposes. References to trade names and catalog numbers are generally intended to be specific. Where substitutions are necessary, the owner and / or Kasten Marine Design, Inc. will approve them on the basis that there be no sacrifice in quality or ease of maintenance. Changes from items listed by brand and model will be made only with written approval.

The Builder will assure that the materials, workmanship, construction, machinery and safety equipment of this vessel are according to generally accepted good boat building practice, and that the vessel will be suitable for registry in Indonesia or Thailand as a passenger carrying vessel.

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It is recommended that the Builder follow the standards of the National Fire Protection Association Booklet No. 302 or local equivalent, and the standards and recommended practices of the German Lloyd's Rule as applicable to a vessel of this type.

This vessel design, the Study Plan drawings; the Building Plans; final Construction Drawings; this Specification; and all other documents listed above, including any drawings and specifications that may be additionally prepared by Kasten Marine Design, Inc. for the purpose of building this vessel will remain the copyrighted property of Kasten Marine Design, Inc.

Permission is granted to the owner and the builder of this vessel to make any necessary in-house copies of these documents as needed during the construction and the subsequent use of this vessel. Upon supply of the completed Building Plans to the Builder, permission is granted to the owner to build **one** vessel from these plans and documents.

Permission to use these documents for any other purpose; to build other vessels from them; to reproduce them for distribution to others; to publish them in print or on the web, etc. may be granted only by Kasten Marine Design, Inc. in writing on a case-by-case basis, at which time a royalty will be due and payable to Kasten Marine Design, Inc. by the builder and /or owner of that vessel. If subsequent vessels built to this design are of interest, please inquire.

Kasten Marine Design, Inc. retains the right to publish details of the construction or drawings or specifications of this vessel, or to promote this vessel or its builder by whatever means.

This Vessel Specification, along with these General Terms, the above listed Building Plans, the Equipment List, and the Vessel Painting Specification will be made part of any contract or agreement between owner and builder.