H-2 VENTILATION OF BOATS USING GASOLINE

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Based on ABYC's assessment of the existing technology, and the problems associated with achieving the goals of this standard, ABYC recommends compliance with this standard for all boats, associated equipment, and systems manufactured and/or installed after July 31, 2001.

2.1 *PURPOSE*

These standards and recommended practices are guides for the design, construction, and installation of ventilation systems of engine and fuel tank compartments of boats using gasoline for mechanical power, propulsion, or auxiliary generators.

NOTES:

1. The United States Coast Guard has promulgated mandatory requirements for ventilation in 33 CFR, Subpart K, Sections 183.601 - 183.630. Refer to the CFR for complete, current federal requirements.

2. Ventilation Principle - Ventilation cannot be relied upon to remove all flammable vapors emanating from the presence of liquid fuel resulting from fuel system failures or fuel spillage. See ABYC H-24, Gasoline Fuel Systems. Boat ventilation cannot create a safe condition when liquid gasoline is exposed to the atmosphere in a boat because liquid gasoline will continue to create gasoline vapors as long as liquid gasoline is present.

3. Gasoline engine exhaust can form an atmosphere laden with carbon monoxide gas, both inside the engine space, and outside the engine space, in the cockpit, or outside the boat where it may enter the boat through ventilating openings required for ventilation. While total control of the diffusion of gasses in the atmosphere is not possible, some requirements are intended to minimize intrusion of toxic gas into accommodation compartments.

2.2 *SCOPE*

These standards and recommended practices apply to boats using gasoline for electrical generation, mechanical power or propulsion, including outboard boats.

NOTES:

1. Ventilation guidelines for boats using diesel fuel are contained in ABYC H-32, Ventilation of Boats Using Diesel Fuel.

2. Ventilation cannot be relied upon to remove all carbon monoxide vapors that may be produced from the operation of the vessel or its equipment. See ABYC TH-22, Educational Information About Carbon Monoxide, and ABYC TH-23, Design, Construction And Testing Of Boats In Consideration Of Carbon Monoxide, for further information.

3. Heat Dissipation - The ventilation system described in this standard is sufficient to provide for the requirements for ventilation of vapors from the engine space. However, the standard may not provide sufficient ventilation for heat dissipation.

2.3 *REFERENCED ORGANIZATIONS*

ABYC - American Boat & Yacht Council, Inc., 3069 Solomons Island Road, Edgewater, MD 21037-1416 (410) 956-1050 fax: (410) 956-2737. Visit the web site: www.abycinc.org

AMCA - Air Movement & Control Association, 30 West University Drive, Arlington Heights, IL 60004 (847) 394-0150. Visit the web site: www.amca.org

ASTM - American Society For Testing And Materials, 100 Barr Harbor Drive, W. Conshohocken, PA 19428 610-832-9585. Visit the web site: www.astm.org

CFR - Obtain the Code Of Federal Regulations and other government publications from the Superintendent Of Documents, United States Government Information, POB 371954, Pittsburgh, PA 15250-7954 (202) 512-1800, or fax (202) 512-2250. An excerpted edition of the 33 CFR is available from ABYC, Inc., 3069 Solomons Island Road, Edgewater, MD 21037-1416 (410) 956-1050, or fax (410) 956-2737

SAE - Society Of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096 (724) 776-4841. Visit the web site: www.sae.org

UL - Underwriters Laboratories Marine Department, POB 13995, 12 Laboratory Drive, Research Triangle Park, NC 27709. 919 549 1400. Obtain standards from Global Engineering Documents, Inc., 15 Inverness Way East, Englewood , CO 80112, (800) 854-7179 (US and Canada), (303) 397-7956 (outside US and Canada), fax: (303) 397-2740.

2.4 *DEFINITIONS – For the purposes of this standard, the following definitions apply.*

Accommodation compartment - spaces designed for living purposes for persons aboard a boat; Examples of specific uses of accommodation compartments include: staterooms, heads (bathrooms), galley, pilothouse, navigation, workshop, and other similar people oriented spaces. These uses contrast with engine and fuel tank compartments.

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Gasoline - includes all gasoline based fuels; The Federal Hazardous Substance Act classifies gasoline as "extremely flammable," having a flash point at, or below, 20°F (-7°C).

Net compartment volume:

For inboard boats - the result of subtracting the volume of the permanently installed items of equipment and accessories from the total, or gross, compartment volume.

For outboard boats - the result of subtracting the volume of permanently installed items of equipment and accessories from the total , or gross, compartment volume, plus one portable six (6) gallon fuel tank, provided there is a defined storage location, such as labeling, straps, recesses, perimeters, or other means for indicating a tank placement.

NOTE: Examples of items that may be subtracted from the total, or gross, compartment volume include engines, fuel and water tanks, auxiliary generators, batteries, and accessory equipment such as refrigeration machinery, pressure fresh water systems, etc. Examples of items that may not be subtracted include stowed fenders, anchors, and line, chairs, picnic coolers, and other items that may or may not be in a compartment at any given time.

Nominal voltages - those commonly used voltages such as 6, 12, 24 and 32 volts DC.

Open to the atmosphere - a space or compartment that has at least 15 square inches of net open area directly exposed to the atmosphere for each cubic foot (.34 m^2 per m^3) of net compartment volume.

Permanently installed - securely fastened so that tools, such as wrenches and screwdrivers, must be used for removal.

Ventilation - the changing of air within a compartment by natural or mechanical means. Ventilation may be effected by dilution of contaminated air, by local exhaust of contaminated air, or by introduction of fresh air.

2.5 ***REQUIREMENTS IN GENERAL***

2.5.1 Fixed Fire Extinguishing Systems - If a fixed fire extinguishing system is installed, refer to ABYC A-4, Fire Fighting Equipment, for provisions that may affect the ventilation system.

2.5.2 Storage Batteries - For battery ventilation requirements refer to ABYC E-10, Storage Batteries.

2.5.3 Natural Ventilation - Each compartment not open to the atmosphere must be provided with a natural ventilation system if:

2.5.3.1 it contains a permanently installed gasoline engine, or

2.5.3.2 it contains a portable fuel tank that vents into the compartment, or

2.5.3.3 it contains a non-metallic fuel tank

2.5.3.3.1 with an aggregate permeability rate exceeding 1.2 grams of fuel loss in 24 hours per cu. ft. (42 g / m^3) of net compartment volume;

2.5.3.3.2 if the net compartment volume is less than one cubic foot (0.028m^3), having a permeability rate exceeding 1.2 grams of fuel loss in 24 hours. Reference fuel "C" at 104°F +/- 3°F (40°C +/- 2°C) from ASTM D-471-1979 is to be used in determining the permeability rate.

2.5.3.4 If the space under an outboard motor well is large enough to accommodate a six gallon portable fuel tank, but is not intended for such usage, the space shall have a warning label that complies with H-2.5.5.

NOTE: An example of such a label follows:

⚠ WARNING

No ventilation is provided.
Fuel vapors are a fire and explosion hazard.
To avoid injury or death, do not store fuel or flammable liquids here.

NOTE: ABYC E-8, Alternating Current (AC) Electrical Systems On Boats, and ABYC E-9, Direct Current (DC) Electrical Systems On Boats, require ignition protected electrical components in compartments containing permanently installed fuel tanks and gasoline engines.

2.5.4 Powered Ventilation - In addition to natural ventilation, each compartment not open to the atmosphere that has a permanently installed gasoline engine with a cranking motor must be ventilated by an exhaust blower system.

2.5.4.1 There shall be at least one powered blower for each gasoline engine used for propulsion.

EXCEPTION: Jet boats covered by ABYC H-37, Mini Jet Boats, that may use only one blower if the system complies with ABYC H-2.6.3.2.

2.5.5 Safety signs and labels shall comply with ABYC T-5, Safety Signs and Labels, and shall contain at least the following informational elements:

2.5.5.1 The signal word for the hazard intensity level; and

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2.5.5.2 the nature of the hazard; and

2.5.5.3 the consequences that can result if the instructions to avoid the hazard are not followed; and

2.5.5.4 instructions on how to avoid the hazard.

2.6 ***DESIGN AND CONSTRUCTION***

NOTE: Ambient temperature - For design purposes, the ambient temperature of machinery spaces is considered to be 122°F (50°C) and all other spaces is considered to be 86°F (30°C).

2.6.1 Spaces Open To The Atmosphere

2.6.1.1 Spaces that are open to the atmosphere do not require ventilation.

NOTE: These spaces may still be subject to accumulation of carbon monoxide.

2.6.1.2 Compartments or spaces connecting with engine or portable fuel tank spaces that are open to the atmosphere do not require ventilation if the connecting space has an open area of at least 15 square inches (9677 mm^2) per cubic foot of its net volume. The open area shall be open either to the atmosphere or into another open space, providing there is a total area open to the atmosphere for the combined net volume of the connecting spaces of at least 15 square inches (9677 mm^2) per cubic foot.

2.6.1.3 Long narrow spaces with a length to width ratio greater than 1:5, e.g., side panels or under accommodation compartment floors, shall have openings at both ends or along the sides if they are to be considered open to the atmosphere.

2.6.2 Connecting Compartments or Spaces

2.6.2.1 Compartments that have interconnecting openings to compartments which are open to the atmosphere shall be considered connecting compartments if the aggregate area of interconnecting openings is greater than 2% of the area between the compartments.

NOTE: Compartments that communicate with a machinery space may be subject to carbon monoxide accumulation.

2.6.2.2 The volume of compartments or spaces that are not open to the atmosphere, and that communicate with a compartment requiring ventilation by means of interconnecting openings, whose aggregate area is more than 2% of the area between the compartments, must be added to the volume of the compartment or space requiring ventilation when determining ventilation requirements, or must be ventilated separately.

2.6.2.3 Openings such as crevices, holes, joints, and penetrations for wiring, cable, and hose, etc., in bulkheads or decks between accommodation compartment(s) that are adjacent to, or above a compartment(s) that contains a gasoline engine shall be constructed to minimize the flow of gas or vapors from the machinery space by means such as, but not limited to, flexible compounds.

NOTE: Sealing bulkheads between machinery spaces and accommodation compartments will not preclude carbon monoxide intrusion via other routes.

2.6.2.4 Electrical components in compartments communicating with a gasoline fuel tank compartment via a limber hole shall be ignition protected. See ABYC E-8, Alternating Current (AC) Electrical Systems On Boats, and ABYC E-9, Direct Current (DC) Electrical Systems On Boats.

2.6.3 Powered Ventilation System

2.6.3.1 Blowers

2.6.3.1.1 Blowers shall be rated for continuous operation at 120% of nominal voltage.

2.6.3.1.2 As installed, no surface temperature shall exceed 302°F (150°C) when operating, or with a stalled rotor, at 120% of nominal voltage, in an ambient temperature of 140°F (60°C) for a period of seven hours.

2.6.3.1.3 The powered ventilation system shall not be activated by the vapor detector.

2.6.3.1.4 Blowers shall meet the external ignition protection requirements of UL 1128, Marine Blowers, UL 1500, Ignition Protection Test For Marine Products, or SAE J1171, External Ignition Protection Of Marine Electrical Devices.

2.6.3.1.5 Blowers shall be rated for air flow in cubic feet per minute, at nominal voltage in accordance with Figure 12 of Air Movement And Control Association (AMCA) standards 210-74, Test Code Of Air Moving Devices, or Underwriter's Laboratories, UL 1128, Marine Blowers.

2.6.3.2 Installation of Powered Ventilation

2.6.3.2.1 There shall be a visual indicator(s), other than the switch position, at each blower switch location to indicate that power (voltage) is applied to each blower circuit.

2.6.3.2.2 Blower capacity shall be selected in accordance with the rated blower capacity curve in Figure 1.

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NOTE: More than one blower may be used to achieve the required capacity.

2.6.3.2.3 Multiple blowers shall operate simultaneously, and each blower shall be provided with dedicated overcurrent protection. See ABYC E-9, Direct Current (DC) Electrical Systems On Boats.

2.6.3.2.4 As installed, the blower system(s) shall exhaust air from the boat at a rate in accordance with the blower system performance curve in Figure 1 when the engine is not operating and the blower is operating at the electrical system's nominal voltage. The blower manufacturer shall provide each unit with a system performance curve. This curve shall indicate the air flow versus the motor speed.

2.6.3.2.5 Blowers shall be mounted above the normal level of accumulated bilge water.

2.6.3.2.6 The intake and exhaust ducts shall not share the same plenum.

2.6.3.2.7 Blowers shall be installed with ducts whose intake openings are

2.6.3.2.7.1 permanently fixed, and

2.6.3.2.7.2 self-draining so that any water will drain from the ducting, and

2.6.3.2.7.3 located in the lower one-third of the compartment, and

2.6.3.2.7.4 above the normal level of accumulated bilge water, and

2.6.3.2.7.5 as nearly as practicable below the engine(s) that it serves.

2.6.3.2.8 Electrical wiring shall be installed in accordance with ABYC E-9, Direct Current (DC) Electrical Systems On Boats.

2.6.3.2.9 Each boat that has a powered ventilation system shall have a label that complies with H-2.5.5 and 33 CFR, Subpart K, Section 183.610 (f). This label shall be located in plain view of the operator and as close as practicable to each ignition switch, including the ignition switch(s) for auxiliary equipment (e.g., generator set).

NOTE: An example of such a label follows.

⚠ WARNING

Gasoline vapors can explode,
resulting in injury or death.
Before starting engine

• check engine compartment bilge
for gasoline or vapors, and
• operate blower for four minutes, and
• verify blower operation.

Run blower when boat is operating below
cruising speed.

2.6.4 Natural Ventilation

2.6.4.1 In each natural ventilation system, the intake and exhaust ducts shall not share the same plenum.

2.6.4.2 Each natural ventilation system shall be constructed with at least one intake opening.

2.6.4.3 Each intake opening shall be on the boat's exterior surface.

2.6.4.4 Each compartment requiring natural ventilation shall be equipped with exhaust duct(s) originating in the lower one-third of the compartment.

2.6.4.4.1 The duct opening shall be permanently secured above the normal accumulation of the bilge water, and

2.6.4.4.1.1 shall be self-draining so that water will drain from the ducting, and

2.6.4.4.1.2 if the compartment is an engine compartment, exhaust duct(s) shall be located as nearly as practicable below the engine(s).

NOTE: Exhaust(s) and intake(s) may not function as intended when wind direction varies.

2.6.4.5 Each exhaust opening shall terminate on the boat's exterior surface.

2.6.4.6 Air intake openings inside a compartment shall be separated from exhaust duct openings inside the compartment by at least 24 inches (0.6 m), compartment dimensions permitting.

2.6.4.7 The minimum aggregate internal cross-sectional area of intake ducts or openings shall be calculated as follows:

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$A = 5 \log_e (V/5)$ where

A = the minimum aggregate internal cross-sectional area of the openings or ducts in square inches.

V = The net compartment volume in cubic feet, including the net volume of other compartments sharing the same ventilation system.

$\text{Log}_e (V/5)$ = the natural logarithm of the quantity V/5. See Figure 2.

2.6.4.8 The minimum aggregate internal cross sectional area of exhaust ducts or openings shall be calculated in the same manner as for intakes.

2.6.4.9 Duct sizes shall be selected using cross-sectional areas based on their nominal diameters.

2.6.4.10 The nominal diameter of ventilation ducting shall be at least 2 ½ inches (64 mm). Openings shall be at least equivalent to cross-sectional area. See Table I for standard duct sizes.

TABLE I - STANDARD DUCT SIZES

DIAMETER		CROSS SECTIONAL AREA	
in.	mm	$in.^2$	mm^2
2 ½	64	4.9	3,161
3	76	7.1	4,580
3 ½	89	9.6	6,193
4	102	12.6	8,129
5	127	19.6	12,645

2.6.4.11 The minimum cross sectional area of terminal fittings for flexible ventilation ducts shall not be less than 80% of the required internal cross sectional area of the flexible ventilation duct.

2.6.5 Arrangements of Openings

2.6.5.1 On boats with accommodation compartments there shall be no engine ventilation system openings in aft facing surfaces at the stern.

EXCEPTION: Where testing in accordance with ABYC TH-23, Design, Construction, And Testing Of Boats In Consideration Of Carbon Monoxide, indicates that machinery or tank compartments connected to these openings do not have sustained accumulated levels of carbon monoxide (CO) in excess of 125 ppm.

2.6.5.2 External openings of intakes and exhausts shall be located and oriented to prevent entry of fuel vapors. In no instance shall the intakes and exhausts be closer than 15 inches (380mm) from the gasoline fill and tank vent fittings.

2.6.5.3 Ventilation openings shall remain outside of weather enclosures.

NOTE: Ventilation openings should be located with consideration of their potential contribution to water ingress. Ventilation openings below the shear may lower the effective freeboard.

FIGURE 1 - MINIMUM BLOWER CAPACITY AND SYSTEM PERFORMANCE

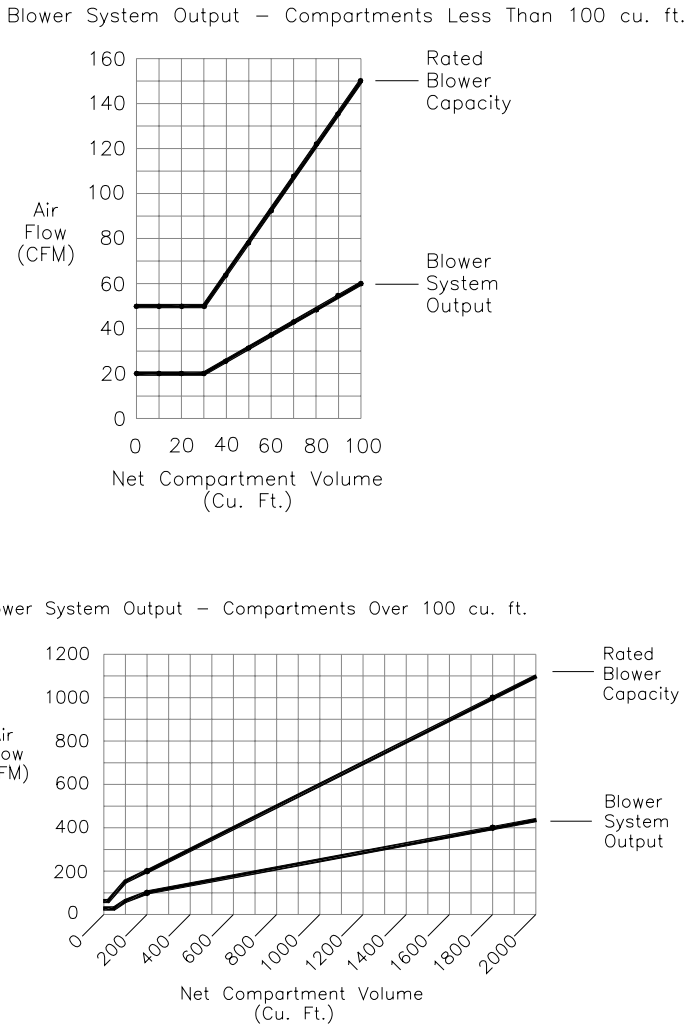

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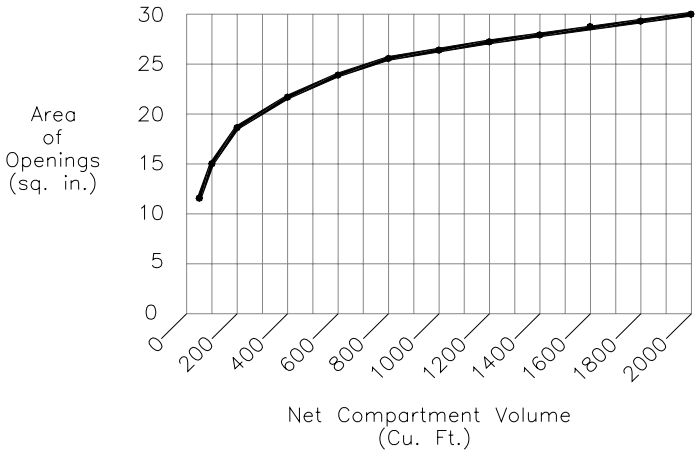
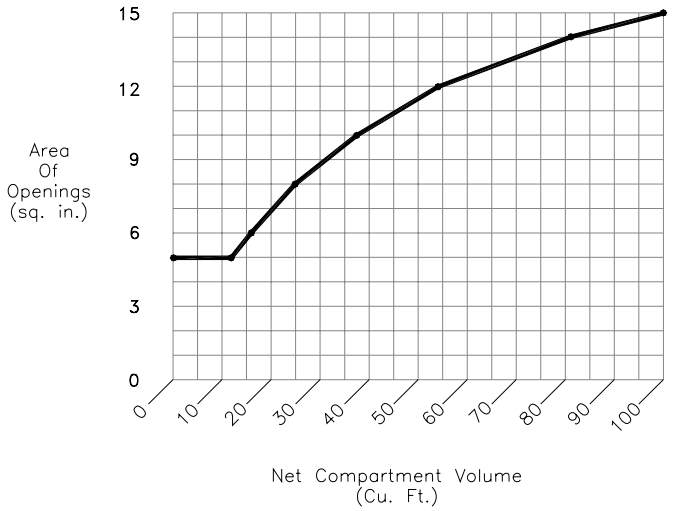
FIGURE 2 - AREA OF OPENINGS





H-2 APPENDIX

Ap.1 EXHAUST BLOWER SYSTEM AIR FLOW DETERMINATION

Ap.1.1 During the process of rating a blower, curves of blower performance are usually developed, and are required if tested in accordance with the UL 1128, Marine Blowers, standard. The curves show air flow for various static pressures and also record the current and RPM of the blower at these air flows. See FIGURE 6 for a typical set of blower curves.

Ap.2 VENTILATION SYSTEM DESIGN

Ap.2.1 In laying out a powered ventilation system, it would be helpful to have some idea of what the system output might be before the boat is built. The rules of thumb presented here are based on data accumulated from a number of isolated tests and are not to be used to determine compliance with the regulation. They may only be used to estimate the blower system output.

Ap.2, TABLE I - ESTIMATED EFFECT OF BLOWER SYSTEM COMPONENTS

ITEM	PERCENT LOSS OF BLOWER RATED CAPACITY
Ducting	2% per ft. of length
Ducting bends – 90°	10% each bend
Clamshell	20%
Louver	20%
Screen - 1/4" mesh	10%

NOTE: Lower resistance items may be selected resulting in an improved system efficiency.

EXAMPLE: A contemplated blower system has a five foot duct (10%), one 90° bend (10%), a clamshell (20%) and a screen (10%). Therefore, the estimated blower system output is 50% less than the blower rated capacity.

Ap.2.2 To obtain the air flow of an exhaust blower system using the blower performance curves then becomes an easy task. The following outlines two methods that may be used on an installed system. Methods 1 and 2 are accurate means for determining the effective air flow of an exhaust blower system. Also, there are numerous instruments that measure air velocity in feet per minute (see method 3).

Ap.2.2.1 METHOD 1 - CURRENT MEASUREMENT

Ap.2.2.1.1 Step 1. Connect an ammeter to the blower motor circuit.

Ap.2.2.1.2 Step 2. Energize the blower at its nominal voltage, e.g. 12, 24, 32 volts, etc. A rheostat may be needed to control the voltage.

Ap.2.2.1.3 Step 3. Read the current draw in amperes. The boat's engine is not to be operating when taking this reading.

Ap.2.2.1.4 Step 4. Enter the performance curves at the determined amperage and read the air flow in cubic feet per minute (CFM).

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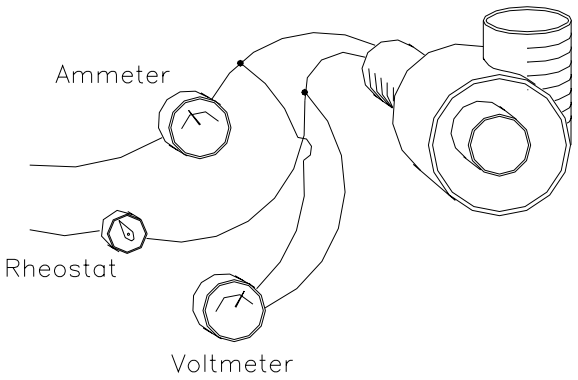
FIGURE 3 - METHOD 1 - CURRENT MEASUREMENT



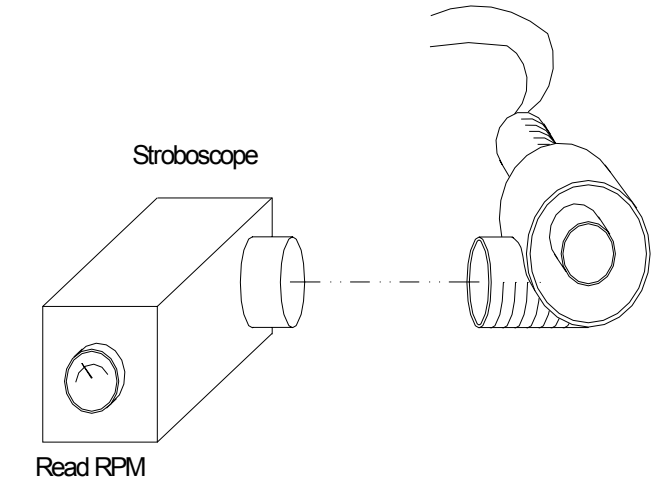
Ap.2.2.2 METHOD 2 - RPM MEASUREMENT

Ap.2.2.2.1 Step 1. Energize the blower at its nominal voltage; e.g. 12, 24, 32 volts, etc. A rheostat may be needed to control the voltage.

Ap.2.2.2.2 Step 2. Determine the RPM of the blower. A stroboscope is one instrument that may be used to read RPM of rotating machinery. The boat's engine is not to be operating during this reading.

Ap.2.2.2.3 Step 3. Enter the performance curves at the determined RPM and read the air flow in cubic feet per minute (CFM).

FIGURE 4 - METHOD 2 - RPM MEASUREMENT



Ap.2.2.3 METHOD 3 - AIR VELOCITY MEASUREMENT

Ap.2.2.3.1 To obtain air flow in cubic feet per minute requires the following:

Ap.2.2.3.1.1 Determination of the cross sectional area of the duct, at the measuring point, in square feet;

Ap.2.2.3.1.2 Determination of the average air velocity across the duct at the measuring point. The air velocity varies from the duct surface to the center of the duct. See Figure 5.

Ap.2.2.3.1.3 Multiplying the cross sectional area in square feet by the average air velocity in feet per minute will provide the air flow in cubic feet per minute (CFM).

Ap.2.2.3.2 This method may not be accurate as it depends on the ability to determine an accurate average air velocity. It may be possible to develop a correlation between this method and either method 1 or 2, in which case this method may prove satisfactory. Also, if duct air flow theory and the associated formulas are familiar, they could be used.

FIGURE 5 - METHOD 3 - AIR VELOCITY MEASUREMENT

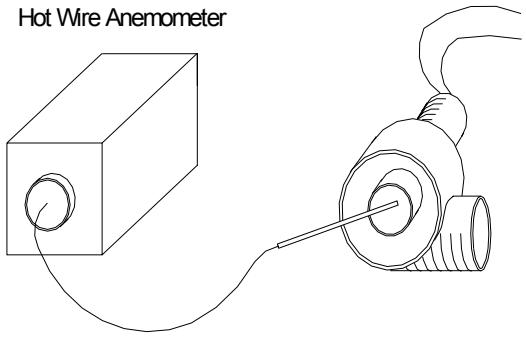


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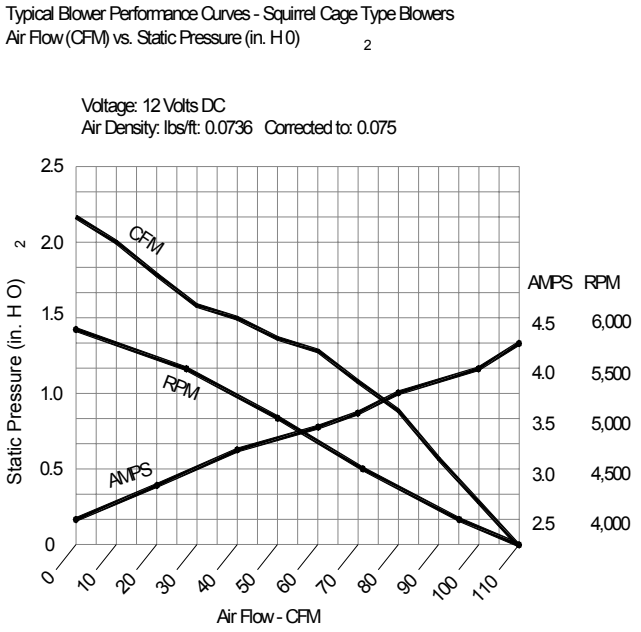
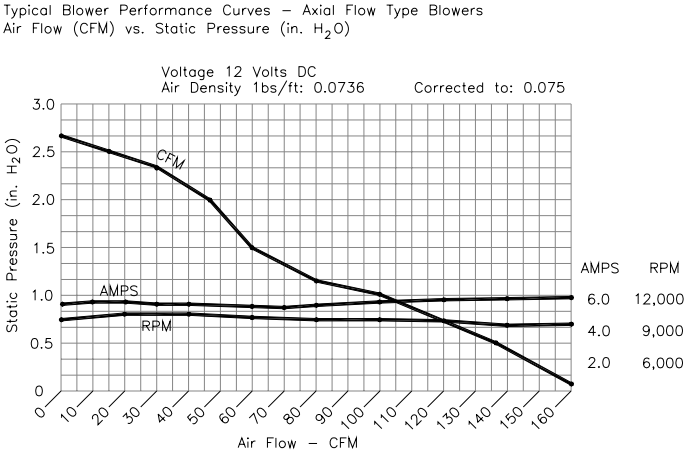
FIGURE 6 - TYPICAL BLOWER PERFORMANCE CURVES

Squirrel Cage Type Blowers



Axial Flow Blowers



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Origin and Development of ABYC H-2, Ventilation of Boats Using Gasoline

ABYC H-2 first appeared in 1957, was revised in 1958, and approved in 1959. It was then updated in 1965, 1970, 1972, 1981 and 1997. The 2000 update is the work of the Fuel and Ventilation Project Technical Committee.

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