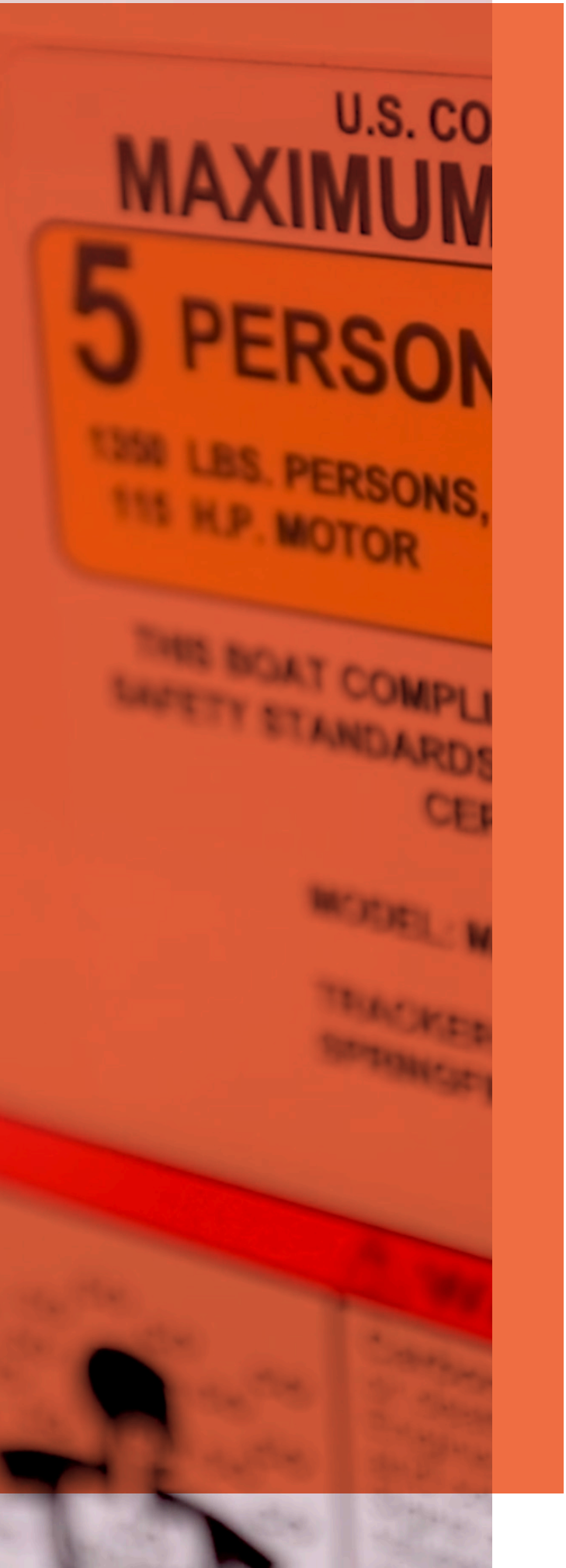


BOAT BUILDER'S HANDBOOK

2021 Edition

VENTILATION

33 CFR 183 SUBPART K

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INTRODUCTION

The federal regulation for ventilation of boats with gasoline-powered engines is the third of a series of interrelated regulations designed to reduce accidents involving fires and explosions on boats. The other two regulations are Title 33 CFR Subpart I — Electrical Systems and Title 33 CFR Subpart J — Fuel Systems. The purpose of ventilation is to remove potentially flammable and explosive vapors that may occur during the normal operation of a boat – and while the boat is sitting idle. Ventilation cannot be relied upon to maintain a safe atmosphere if the boat has a fuel leak.

In consideration of the stated limitations, the regulation has selected critical areas pertaining to ventilation systems from the standpoint of safety and stipulates requirements to assure that good practice is adhered to in these areas.

> **TAKE HEED:** Boatbuilder compliance means fully meeting all applicable regulations. The Boatbuilder's Handbook provides a basic introduction and summary of the regulations. Builders need to refer to the actual regulations for the complete text of the regulation to ensure full compliance. It is the boat manufacturer's responsibility to review, understand, and comply with all applicable regulations.

FORMAT

This guideline provides a plain language summary statement of the various parts of the 33 CFR Subpart K – Ventilation regulations and then provides discussion items to further explain the boatbuilder's responsibilities and options to meet those regulations. Diagrams and tables are added to illustrate and explain the requirements. Example ventilation system design calculations are given.

The two primary types of ventilation - powered ventilation & natural ventilation – are covered in detail.

1.0 APPLICABILITY

Per 183.601 – the ventilation regulations apply to all boats that have gasoline engines for electrical generation, mechanical power, or propulsion.

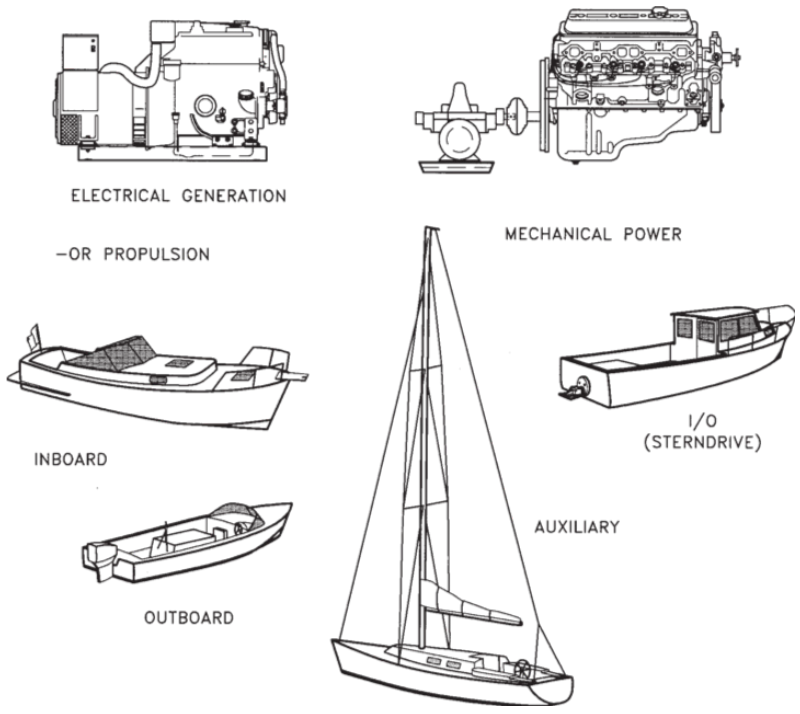
Figure 1 shows examples of the types of boats and installations that must meet the ventilation requirements.

An inboard/sterndrive boat (including an auxiliary sailboat) with an installed gasoline engine must meet the powered and natural ventilation requirements.

An outboard powered boat with an installed fuel tank may need to meet certain ventilation requirements. [The fuel system and electrical system subparts specifically state that those regulations do not apply to outboard powered boats – but there is no such blanket exemption with respect to ventilation.]

An outboard powered boat with an installed gasoline generator will need to meet ventilation regulations.

FIGURE 1 Applicability — All Recreational Boats with Gasoline Engines



2. DEFINITIONS

Per 183.605: gives important definitions with respect to the ventilation regulations:

Fuel means gasoline.

Open to the atmosphere means a compartment that has as least 15 square inches of open area directly exposed to the atmosphere for each cubic foot of net compartment volume.

Diesel fuel and compressed gaseous fuels (LPG, CNG, etc.) are not included.

A compartment is any space in a boat that has length, width and height. It may be completely enclosed, partially enclosed or have one of its surfaces completely open. An example would be a compartment under a bow deck or a motor well where there is not an enclosing bulkhead. A canvas cover is considered the same as an enclosing bulkhead when in place. A number of openings may be added together in order to obtain the required total.

NET COMPARTMENT VOLUME
Net compartment volume is the result of subtracting the volume of installed items of equipment and accessories from the total compartment volume.

Examples of items that may be subtracted include:

- Engines
- Tanks: Fuel, Water, etc.
- Auxiliary Generators
- Batteries
- Accessory equipment such as refrigeration machinery, pressure fresh water systems, etc.
- For outboard boats -one portable 6 gallon fuel tank, provided there is a defined storage location; i.e. straps or perimeters.

Examples of items that are not subtracted include:

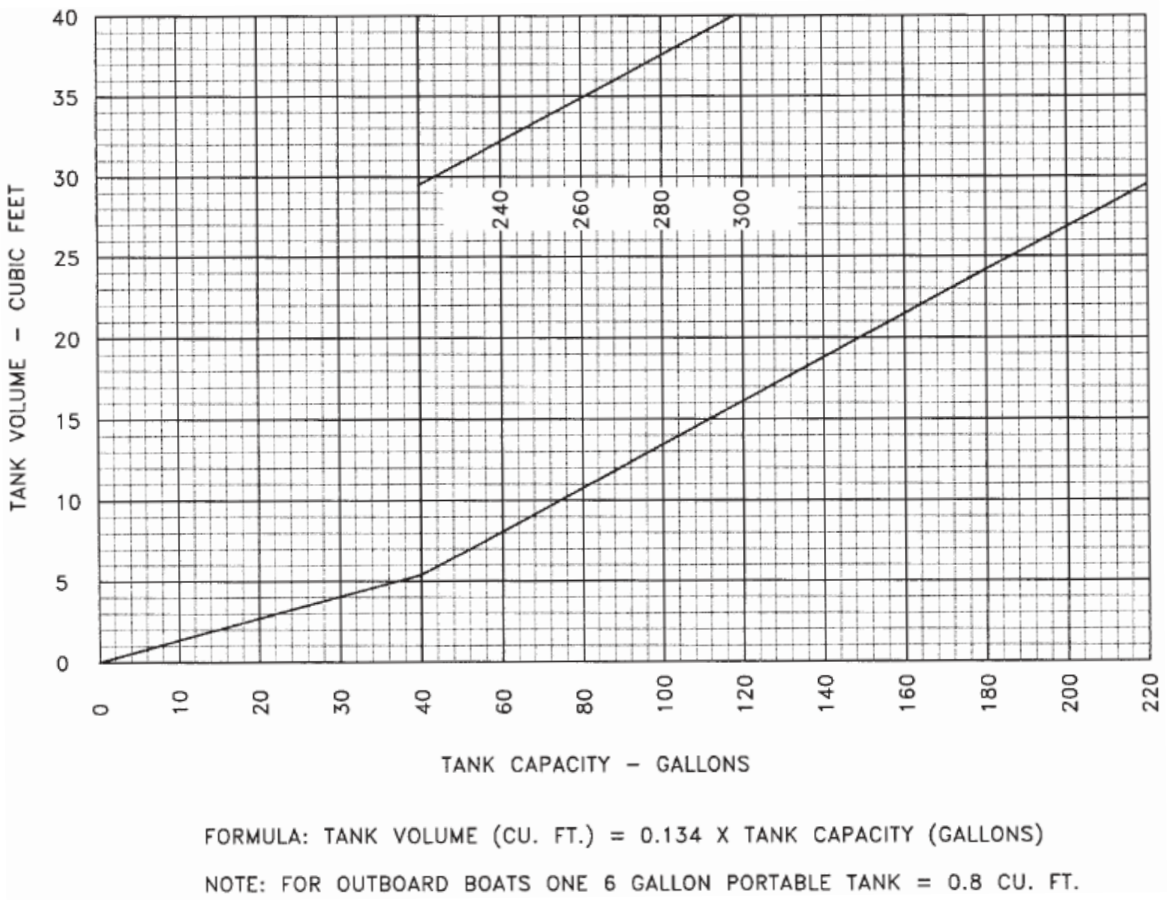
- Stowed Fenders
- Stowed Anchors and Line
- Stowed Chairs
- Picnic Coolers
- Other items that may or may not be in a compartment at any given time.

To assist in determining the amount of cubic feet to subtract, refer to Table I for suggested volumes of engines and batteries, and to Figure 2 for a graph of tank capacity vs. tank volume, in cubic feet.

TABLE 1 Typical Volumes of Engines and Batteries

ENGINES	
4 cylinder, in-line	2.5 cu. ft.
each 6 cylinder, in-line	3.5 cu. ft.
each 6 cylinder, V-6	4.0 cu. ft. each
Small V-8	4.5 cu. ft.
Large V-8	5.5 cu. ft.
(these numbers may be adjusted up for new engines with catalytic converter exhausts)	
Batteries	0.5 cu. ft. each

FIGURE 2 Tank Volume



The total compartment volume is determined by the average cross section of the compartment in square feet and multiplied by the length of the compartment in feet. This computation will give the compartment volume in cubic feet. For an irregular compartment, the volumes of portions of the compartment may be computed separately and then the volumes combined to get the total compartment volume.

The net volume of adjoining compartments may have to be added to the engine compartment volume. The following rule applies:

> ADD — If the area of openings between compartments is more than 2% of the area of the separation structure; i.e. bulkheads, stringers, frames, etc.

The regulation is not specific about compartments that adjoin a compartment that qualifies as open to the atmosphere. The following discussion presents acceptable ways of handling this problem but they are not necessarily the only ways.

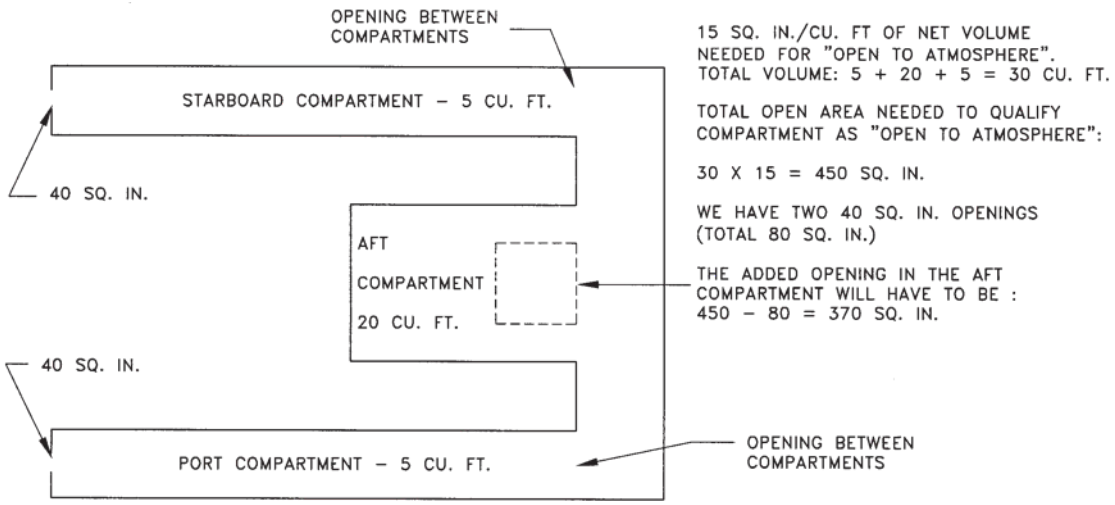
A compartment adjacent and connected to a compartment that is open to the atmosphere may be considered open to the atmosphere if:

The total of all open areas directly exposed to the atmosphere from both compartments is at least 15 square inches for each cubic foot of the combined net compartment volumes.

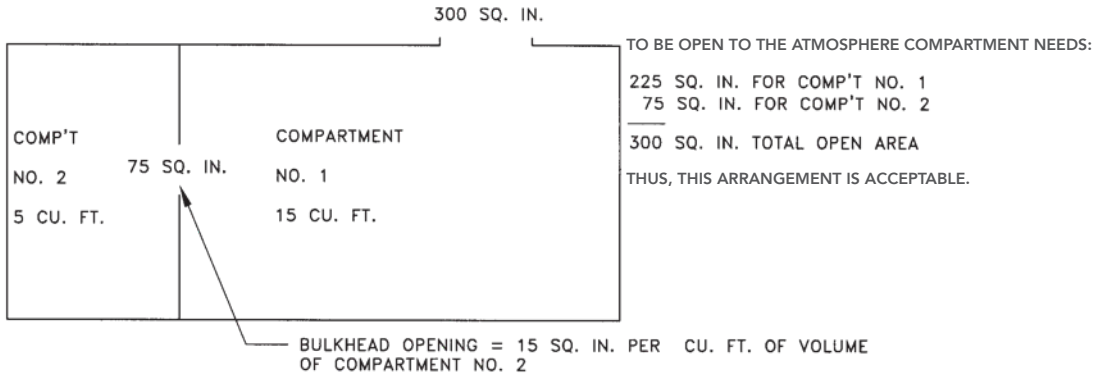
Long narrow compartments should have openings at each end or along the sides if they are to be considered open to the atmosphere.

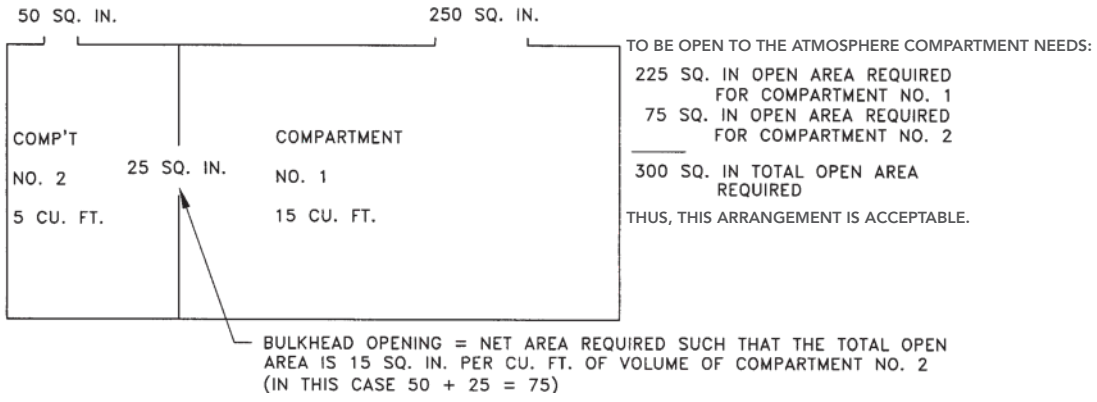
See Figure 3 for diagrams of connecting compartments.

FIGURE 3 Connecting Compartments Qualifying as "Open to the Atmosphere"



For both examples below, the area of openings between the compartments is more than 2% of the area of separation.





3.0 POWERED VENTILATION

Powered ventilation means the use of electric powered blowers with ducting to move air from the compartment to atmosphere.

> Per 183.610 (a) Boat compartments with a permanently installed gasoline engine must either be open to the atmosphere or be ventilated by an exhaust blower system.

Permanently installed with regard to an engine means that it is securely fastened to the boat's structure and the necessary wiring, piping and controls are connected and secured to the boat in accordance with the applicable USCG regulations. Inboard and sterndrive engines are permanently installed; outboard engines are not permanently installed.

3.1 POWERED VENTILATION SYSTEM DESIGN

> Per 183.610 (b) & (c) The compartment exhaust blower(s) must be rated at an air flow of not less than that computed by the formulas in Column 2 of the following table. The exhaust blower system must exhaust air from the boat at the rate given in Column 3 of the following table.

TABLE 2 183.610

COLUMN 1	COLUMN 2	COLUMN 3
Net Compartment Volume (V) of Engine Compartment and Compartments Open Thereto in Cubic Feet (ft.3)	Rated Blower Capacity (Fr) in Cubic Feet Per Minute (cfm)	Blower System Output (Fo) in Cubic Feet Per Minute (cfm)
Below 34 34 to 100 Over 100	Fr = 50 Fr = 1.5V Fr = V/2 + 100	Fo = 20 Fo = 0.6V Fo = 0.2V + 40

Note that in each range of compartment volume (V), the blower system output (Fo) must be at least 40% of the rated blower capacity (Fr).

Boatbuilders purchase the blowers from suppliers. Those suppliers need to provide documentation that the blower rating is in accordance with established industry standards. The regulation states that the blower rating must be determined according to AMCA Standard 210-74 or UL Standard 1128.

The powered exhaust openings or ducts need to be of adequate size to provide the necessary airflow. But – unlike natural ventilation (to be discussed below) there is no required size given in the regulations.

3.1.1 REMOVABLE ENCLOSURES

Fabric weather enclosures are not airtight and must be opened in order to enter the boat. Upon entering, any gasoline vapors present should be detectable by means of their odor. The boat's ventilation openings should remain outside of the weather enclosure. Snap-in bulkheads, such as motor well curtains, are not weather enclosures and may require the enclosed compartment to be ventilated.

3.1.2 SCREENS AND LOUVERS

If openings to a compartment are screened or louvered, the area of the opening is the aggregate net open area of the screen or louver. The powered ventilation regulations do not specify opening size, but the natural ventilation system regulations do require specific supply and exhaust opening size depending on the compartment volume. Thus, the discussion of the reduction of cumulative opening size due to covers / grates / screens is covered in detail in the natural ventilation system discussion in section 4.0 – with an example calculation included.

3.1.3 BLOWER SIZE SELECTION

The total rated capacity of the required blower or blowers (Fr) is based on the net compartment volume (V) as specified in Table 183.610. One or more blowers may be used to provide the required capacity. Figure 4 is a graph of rated blower capacity versus net compartment volume.

Example 1:

The net compartment volume of an engine compartment in a boat is 20 cubic feet.

The volume is below 34 cu ft – reading from Table 183.610 the required rated blower capacity is 50 cubic feet per minute.

Normally one blower will satisfy the requirement for this compartment.

Example 2:

The net compartment volume of an engine compartment is 100 cubic feet.

The volume is in the 34 to 100 cu ft range – calculating using the Table 183.610 equation - the required rated blower capacity is 150 cubic feet per minute. (1.5 x 100 = 150)

Two blowers may be needed to satisfy this requirement — one rated at 100 cubic feet per minute and one rated at 50 cubic feet per minute. One 150 cubic feet per minute blower would satisfy the requirement that Fr = 1.5 V.

Example 3:

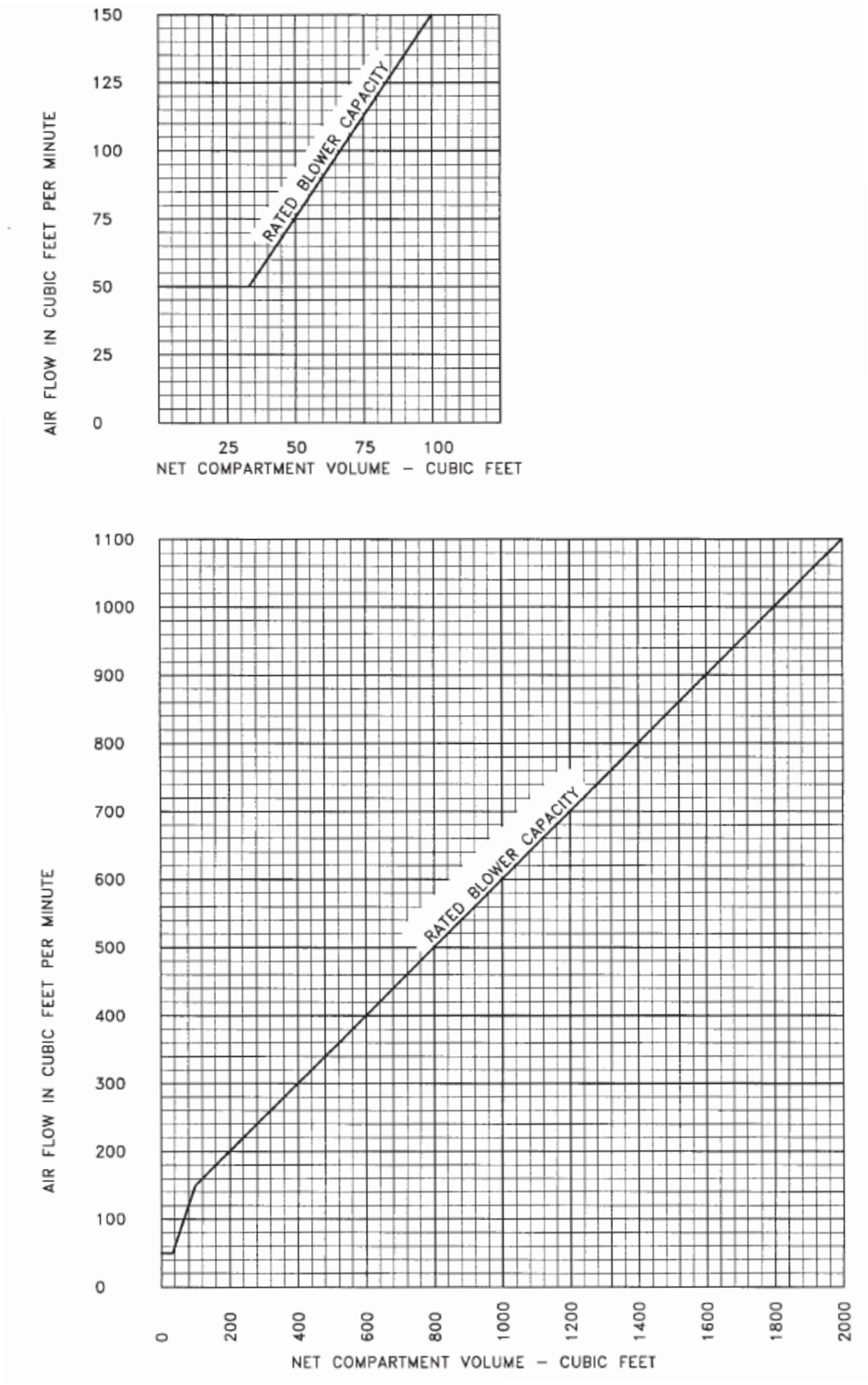
The net compartment volume of an engine compartment is 800 cubic feet.

The volume is in the over 100 cu ft range – calculating using the Table 183.610 equations – the required blower rating capacity required is 500 cubic feet per minute (800/2 + 100 = 500).

One, two or more blowers may be used to satisfy this requirement.

In all cases blowers with higher capacity ratings than the minimum may be used.

FIGURE 4 Rated Blower Capacity



A blower system includes the items and devices used to convey ventilation airflow into and out of a boat. Examples of such items and devices, but not excluding others, are as follows (Note: other items and devices may be part of a blower system):

- Blower(s)
- Ducting
- Terminal fittings
- Cowls, scoops, funnels

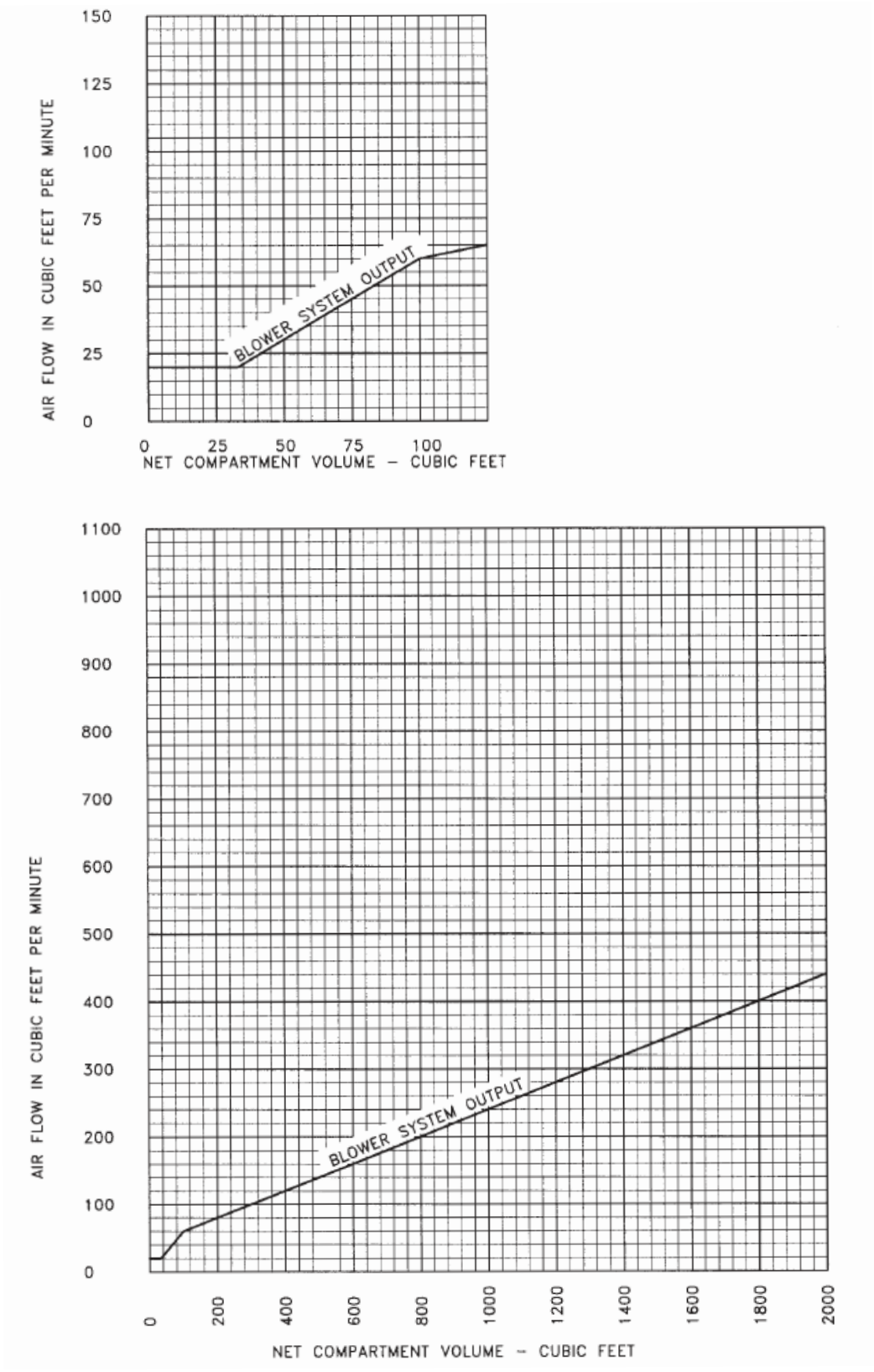
The airflow required (Fo) for the exhaust blower system, like the rated blower capacity, is based on the net compartment volume, V, shown in Column 1 of Table 183.610. The blower system output is stated in Column 3 of Table 183.610. These blower system output requirements establish the minimum efficiency permitted (40%) for an exhaust blower system design. Each item or device used in a blower system offers resistance to the airflow available at the blower. Consider the following when designing a blower system:

- Duct resistance
- Duct bend resistance: the tighter the bend, the higher the resistance
- Terminal fittings: end brackets, Y fittings, adapters, etc.
- The distance of the duct opening away from a surface that could obstruct airflow.
- Cowl, scoop or funnel resistance
- Screen resistance

The above list is not intended to exclude any item or device in the blower system that might offer resistance to airflow.

If more than one blower is used, the blower system output is the total quantity of air from all blowers, in cubic feet per minute, exhausted from the boat. Figure 5 is a graph of the minimum blower system output required versus net compartment volume.

FIGURE 5 Minimum Blower System Output



3.1.4 MEASURING POWERED VENTILATION SYSTEM OUTPUT

Measuring the actual airflow from an exhaust system is possible, but test results are hard to duplicate and are usually suspect. It is recommended that ventilation systems be designed to ensure that the efficiency of the system is at least 40% - to meet the output flow requirement. No sense building a multi-component/multi-turn system only to find a much diminished system outflow. A system close to the 40% efficiency standard will need to have the actual airflow measured.

The following table gives the estimated efficiency losses for the various types of ventilation system components.

TABLE 3 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%

Example: A contemplated blower system has a 5 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.

Because the performance of axial flow, in-line blowers are highly dependent upon the fan blade (also known as impeller or propeller) design and other factors selected by the blower manufacturer, the estimated effects of the airflow resistances in Table III will be unpredictable. If an axial flow blower is installed in the output system, an airflow meter, pitot tube or other system recommended by the blower manufacturer may be used to check the actual output of the ventilation system as installed in the boat.

3.1.5 EXHAUST DUCT LOCATION

> Per 183.610 each intake duct for an exhaust blower must originate in the lower one-third of the compartment (and be above the normal level of accumulated bilge water).

The purpose of exhausting air is to remove potentially explosive or flammable vapors that accumulate in the engine compartment during normal operation of the boat. Those vapors are heavier than air will accumulate in the lower part of the compartment. It is intended that the ventilation required by this regulation be sufficient to maintain safe operating conditions under normal circumstances. Ventilation cannot be relied upon to remove liquid fuel or all of the vapors that may be present if there is a leak in the fuel system.

It is important to evaluate each engine compartment design and locate the intake opening of the exhaust blower duct so it will be in the best position to remove any collected vapors.

The vapors that occur during operation will accumulate at idle speed and after the engine is turned off. These vapors will flow to and collect in the lowest part of the compartment. The duct connected to the intake side of the blower is used to select the point in a compartment where the compartment air will be exhausted. The regulation requires that the exhaust blower duct opening be located in the lower one-third of the compartment. Refer to 183.630(b). Usual locations include:

- under an engine
- between engine stringers
- at a sump, possibly provided as a bilge water collecting point.

Consideration must be given to the possibility of normal bilge water accumulations covering the intake opening. Normal accumulations of bilge water occur from propeller shaft stuffing box seepage, spray while operating the boat, and rainwater. Water remaining in the boat after a bilge pump completes its normal pumping cycle would be considered normal. The opening of the exhaust blower intake duct must be above this normal level of accumulated bilge water.

The lower end of the ducts should be securely fastened to ensure the system's continued operation as intended. Normal operation of the boat or routine maintenance on the engine may result in the duct being removed from its intended pickup point.

3.2 BLOWER WARNING LABEL

Per 183.610 (f) When a boat requires a powered exhaust blower the boatbuilder must post a warning label close to each remote ignition switch in plain view of the operator with the information as per the following example warning label.

WARNING

GASOLINE VAPORS CAN EXPLODE. BEFORE STARTING ENGINE OPERATE BLOWER FOR 4 MINUTES AND CHECK ENGINE COMPARTMENT BILGE FOR GASOLINE VAPORS.

The warning label must be posted at each starting station.

- For an ignition switch at the remote operator station the label should be on the top visible surface of the console.
- A boat with a second starting station on a flying bridge must have a warning label at both the main deck station and on the flying bridge.
- A boat with a gasoline-powered generator must have a label at the starting station.

The label must contain the information specified in the regulation. It does not have to be stated in the exact words used but it must deliver the same message.

An acceptable label consists of the following four elements:

1. The signal word: WARNING
2. The hazard: GASOLINE VAPORS
3. Consequences of the hazard: CAN EXPLODE
4. Action required: BEFORE STARTING ENGINE OPERATE BLOWER 4 MINUTES

4.0 NATURAL VENTILATION

Natural ventilation is a term applied to the provisions of air flow in and out of a compartment that is induced by non-powered means; i.e. ducts, louvers, clamshells, etc. That is, there are openings to allow for airflow. A powered blower itself is not a part of a natural ventilation system, but the powered exhaust ducting can be a part of the natural ventilation system. A natural ventilation system is not designed for air supply to an operating engine; the system is designed to exhaust accumulated vapors with the boat idle.

4.1 WHEN NATURAL VENTILATION IS REQUIRED

Per 183.620 – There are five situations specified where a boat compartment (that is not open to the atmosphere) must have a natural ventilation system. In each case the supply opening must be located on the exterior surface of the boat.

4.1.1 WHEN A BOAT COMPARTMENT CONTAINS A PERMANENTLY INSTALLED ENGINE

Permanently installed with regard to an engine, means that it is securely fastened to the boat's structure and the necessary wiring, piping and controls are connected and secured to the boat. Inboards and sterndrive boats have permanently installed engines. Installed generators are permanently installed engines; strapped down generators on the fantail are not permanently installed engines. Outboards are not permanently installed engines.

Open to the Atmosphere. Compartments that are open to the atmosphere do not require additional ventilation. Long narrow spaces formed by side panels or accommodation floors should have openings at each end or along the sides if they are to be considered open to the atmosphere.

4.1.2 COMPARTMENT THAT HAS OPENINGS BETWEEN IT AND A COMPARTMENT THAT REQUIRES VENTILATION WHERE THE AGGREGATE AREA OF THOSE OPENINGS EXCEEDS 2% OF THE AREA BETWEEN THE COMPARTMENTS

EXCEPTION: Compartments used for accommodations do not require ventilation if:

- the accommodation is above the compartment requiring ventilation; and
- the accommodation compartment is separated from the compartment requiring ventilation by a deck or other structure.

Accommodation compartments are designed for storage spaces and for living spaces for persons aboard the boat. Examples of specific uses of accommodation compartments include: staterooms, heads (bathrooms), galley, pilothouse, navigation, work area and other similar people oriented uses. The uses contrast with engine and fuel tank compartments.

4.1.3 CONTAINS A PERMANENTLY INSTALLED FUEL TANK AND AN ELECTRICAL COMPONENT THAT IS NOT IGNITION PROTECTED (AS DISCUSSED IN THE ELECTRICAL SYSTEMS GUIDELINE)

A compartment containing a fuel tank that is permanently installed, as opposed to a portable tank or container, does not require natural ventilation unless the compartment contains an electrical component that is not ignition protected.

Ignition protection is defined in Title 33 CFR Subpart I — Electrical Systems, 183.410(a) as follows: "(a) Each electrical component must not ignite a propane gas and air mixture that is 4.25 to 5.25 percent propane gas by volume surrounding the electrical component when it is operated at each of its manufacturer rated voltages and current loadings, unless it is isolated from gasoline fuel sources, such as engines, valves, connections, or other fittings in vent lines, fill lines, distribution lines or on fuel tanks, in accordance with paragraph (b) of this section."

Another definition is:

"The design and construction of a device such that under design operating conditions:

- it will not ignite a flammable hydrocarbon mixture surrounding the device when an ignition source causes an internal explosion, or
- it is incapable of releasing sufficient electrical or thermal energy to ignite a hydrocarbon mixture, or
- the source of ignition is hermetically sealed."

"Ignition protected" devices are not necessarily "explosion proof" or "intrinsically safe" as those terms are defined by the National Electrical Code and Title 46 CFR Part 111, sections 105-9 and 105-11. If, however, a device does meet the definition of either "explosion proof" or "intrinsically safe", as referenced above, then it is also "ignition protected" as defined in Title 33 CFR Subpart I — Electrical Systems.

Test standards to determine ignition protection may be found in SAE J1171, External Ignition Protection of Marine Electrical Devices, and in UL 1500, Ignition Protection Test for Marine Products.

Usually fuel level senders and the associated wiring are not sources of ignition and therefore would not normally require natural ventilation.

4.1.4 CONTAINS A FUEL TANK THAT VENTS INTO THAT COMPARTMENT

Permanently Installed Fuel Tanks

A permanently installed fuel tank must have a vent system in accordance with Title 33 CFR Subpart J — Fuel Systems, 183.520. This section on fuel tank vents requires that vents have a flame arrester and not allow a fuel overflow at the rate of up to two gallons per minute to enter the boat. This requires a fuel tank vent opening that is outside of the boat and will not vent into the compartment.

Portable Fuel Tanks

Compartments used to store vented portable fuel tanks or containers are required to be equipped with natural ventilation.

Cockpit seat lockers in auxiliary sailboats are often used as fuel tank compartments for portable outboard motor fuel tanks. If this fuel tank vents into the locker, then natural ventilation of this locker is required.

Since fuel vapors seek the lowest point of any compartment, gasoline vapors should be considered when designing and constructing a compartment that will contain a fuel tank or container that vents into a compartment. Any openings in or near the bottom of the compartment could permit explosive vapors to flow into the bilge of the boat where an ignition source might ignite the vapors.

4.1.5 CONTAINS A NON-METALLIC FUEL TANK WITH AN AGGREGATE PERMEABILITY RATE EXCEEDING 1.2 GRAMS OF FUEL LOSS IN 24 HOURS PER CUBIC FOOT OF NET COMPARTMENT VOLUME (OR EXCEEDING 1.2 GRAMS IF THE VOLUME IS LESS THAN ONE CUBIC FOOT)

All plastics and fiberglass will permit gasoline and its vapors to pass through them. This capability of the material is termed permeability. The permeability rate is the quantity of gasoline that passes through the material in a specific length of time or per unit of net compartment volume. See 183.605 of this guideline for a discussion of how to determine net compartment volume.

The permeability rate of a material is affected by the thickness and density of the material. The temperature at which the test is conducted may also have an effect on the permeability rate. The conditions and standard procedures of the test must be controlled when conducting the test.

Boatbuilders do not typically test the permeability of plastic tanks, but rather rely on the tank supplier to have the necessary information. This information may come in the form of a total tank permeability figure – or a permeability per square foot of tank area – or a statement as to minimum net compartment volume for tank installation. See example below:

Permeable, non-metallic materials may be used for fuel tanks in boats; however, depending on the permeability rate of the material and the net volume of the fuel tank compartment, natural ventilation may be required for the fuel tank compartment.

The regulation evaluates the need for natural ventilation of the fuel tank compartment based on whether its net volume is less than one cubic foot or one or more cubic feet.

Boat inspections had routinely required builder checks on the permeability of plastic tanks. With the advent of the EPA rules requiring a significant reduction in plastic fuel tank permeability, tanks are now routinely found to be in compliance with the USCG 33 CFR 183 Subpart K requirements.

Example:

> Total fuel loss for a non-metallic tank is found to be 10 grams in 24 hours. The net compartment volume for this example is 12 cu. ft.
>
> The permeability rate is 10 ÷ 12 or .833 grams of fuel loss in 24 hours per cubic foot of net compartment volume.
>
> Thus, the fuel tank compartment in the example does not need natural ventilation to meet the requirements of the regulation.
>
> Tank manufacturers may state the compartment volume acceptable for a specific tank. Taking this example one step further, what is the minimum net compartment volume before natural ventilation is required in the above example?
>
> Per the example, the fuel tank loss was stated to be 10 grams in 24 hours. The permitted fuel loss may not exceed 1.2 grams per cubic foot in 24 hours.
>
> Therefore the net compartment volume must be at least 8.33 cubic feet in order that no ventilation be required. A compartment of less than 8.33 cubic feet of net compartment volume requires natural ventilation to be provided.

4.2 NATURAL VENTILATION SYSTEM DESIGN

Per 183.630: A natural ventilation system will consist of both a supply and an exhaust opening (or duct). The exhaust opening (or duct) must originate in the lower third of the compartment and be above the normal accumulation of bilge water. Supply and exhaust opening size requirements are specified.

4.2.1 SUPPLY

The supply opening or duct may take air in from any of the following:

The Atmosphere — An opening on the outside surface of the boat. It may be fitted with a cowl, louver, clamshell or other suitable ventilation terminal fitting.

Ventilated Compartment — A supply opening or duct may be installed to take in air from a compartment that is required to be ventilated, provided the supply for that ventilated compartment is on the exterior surface of the boat. See requirements for determining which compartments need to be ventilated in 183.610(a) and 183.620(a).

Compartments Open to the Atmosphere — A supply opening or duct may be installed to take air in from a compartment that qualifies as open to the atmosphere as described in 183.605.

4.2.2 EXHAUST

The exhaust opening or duct may expel air into any of the following:

The Atmosphere — If the exhaust discharge point is directly into the atmosphere, there must be a duct from the air and/or vapors intake point to the exhaust discharge point, which is usually at the deck or hull side near the deck.

Ventilated Compartment — An exhaust opening may be located in a bulkhead or other structure that separates a ventilated compartment from the compartment in which the natural ventilated system is being considered.

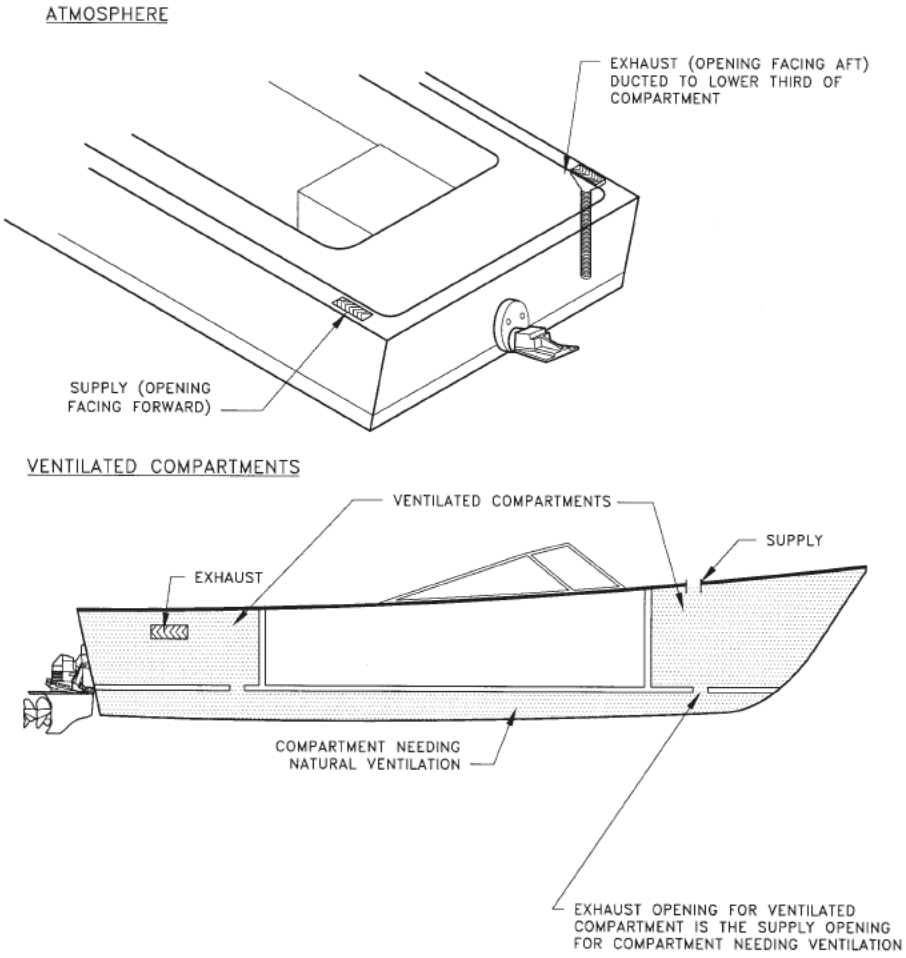
The ventilated compartment into which the exhaust opening discharges may not be the same ventilated compartment that contains a supply opening or duct for the compartment being considered.

Air intake openings inside a compartment should be separated from the exhaust duct openings inside the compartment by 24 inches, compartment dimensions permitting.

A powered ventilation system exhaust duct may double as a natural ventilation exhaust – even with the blower vanes in line.

The powered ventilation system duct doubles as a part of the natural ventilation system – and boat builders routinely attach a blower duct to the lower third of the compartment. It is very common that a single blower will meet the powered ventilation flow requirement, but the area of the single exhaust duct attached to the blower is not sufficient to meet the natural ventilation exhaust opening size requirement. The additional natural ventilation exhaust duct thus required to meet the size requirement, must also originate in the lower third of the compartment.

FIGURE 6 Natural Ventilation and Exhaust Options

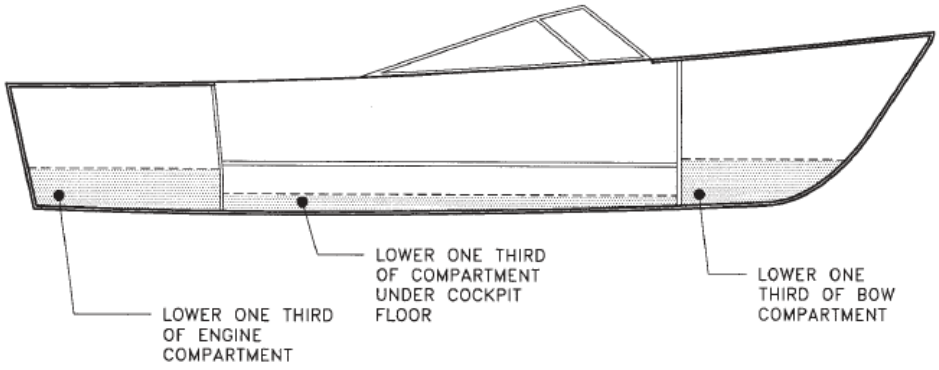


The location of an exhaust opening or an exhaust duct intake opening is required to be in the lower third of the compartment. The intent is for the exhaust opening to be in a position to remove any flammable or explosive vapors as air from the supply circulates through the compartment and discharges through the exhaust.

If there is uncertainty as to the upper limit of the lower third, perhaps due to a complexly shaped compartment, keep in mind that the lower the exhaust opening or duct intake is located in a compartment, the more effective it is. Normal bilge water level must also be considered as stated in 183.630(c).

Ideally, the exhaust opening or duct intake should be positioned in the lowest part of the compartment where vapors are likely to accumulate. It would then be reasonable to measure the height of the compartment at the position of the exhaust opening or duct intake to determine the lower third level. See Figure 12.

FIGURE 7 Lower Third Levels



Consideration must be given to the possibility of normal bilge water accumulations covering the intake opening. Normal accumulations of bilge water occur from propeller shaft stuffing box seepage, spray while operating the boat and from rain. The water remaining in the boat after a bilge pump has completed its normal running cycle would be considered normal. The openings and duct intakes of both supply and exhaust must be above this normal level of accumulated bilge water.

It is important to evaluate compartment design and to locate the openings and ducts in the best positions for the effective removal of any accumulated vapors.

4.2.3 NATURAL VENTILATION SYSTEM SUPPLY AND EXHAUST OPENING SIZE

Natural ventilation system supply and exhaust openings (ducts) must each have minimum aggregate cross-sectional area calculated by:

$$A = 5 \ln (V/5)$$

The formula stated in words is:

> "the cross-sectional area of both the supply openings / ducts and the exhaust openings / ducts must (at least) equal five times the natural logarithm of one fifth the net compartment volume."
>
> [With area (A) in square inches and net compartment volume (V) in cubic feet.]

This calculation can be completed in two ways:

Mathematical calculation with the natural log (ln) in the formula can be done with a scientific calculator – or by use of the natural log table given in the 'Ventilation' Design Guideline.

Read a number for 'Area of Openings' from the graph of Net Compartment Volume (cu ft) vs. Area of Openings (sq in) in the 'Ventilation' Guideline.

Decorative grills and covers reduce the aggregate cross-sectional area of openings.

The minimum internal cross-sectional area of each supply opening or duct and exhaust opening or duct must exceed 3.0 square inches. A 2" diameter hole has the cross-sectional area of 3.14 sq in.

The minimum internal cross-sectional area of the terminal fittings for flexible ventilation ducts must not be less than 80 percent of the required internal cross-sectional area of the flexible ventilation duct.

Most terminal vent fixtures are designed with couplings that fit inside flexible exhaust ducts. The couplings therefore reduce the effective cross-sectional area of the duct to the inside area of the coupling. This internal coupling area must not be less than 80% of the cross-sectional area for the flexible ducts under consideration.

This 80% area reduction is only permitted with respect to the terminal fitting. This does not apply to the reduction of area due to decorative grills and covers.

The cross-sectional area of the terminal fitting does not have to be at least 80% of the installed duct cross-sectional area - but is required to be at least 80% of the required area for the duct. For example, if a 12 sq in duct is installed where only 10 sq in is required, a fitting with a cross-sectional area down to 8 sq in is acceptable.

To use the formula:

Determine the net compartment volume (V) in cubic feet. The net volume of connecting compartments must be included if the openings in the separation structure are more than 2% of the area of the separation structure between the compartments. The exception stated in 183.620(c) for accommodation compartments above a compartment requiring ventilation and separated by a deck or other structure, may be applied.

Divide the net compartment volume (V) by 5.

Determine the natural logarithm (Ln) of V / 5. Natural logarithms are tabulated in books of mathematical tables, engineering handbooks, trigonometry textbooks, etc. Figure 8 is a Table of Natural Logarithms.

Multiply the natural logarithm by 5.

The result is the minimum required area (A) in square inches.

Figure 9 is a graph of the formula. Entering the graph with the net compartment volume in cubic feet you can read the area of openings and ducts directly along the vertical scale on the left of the graph.

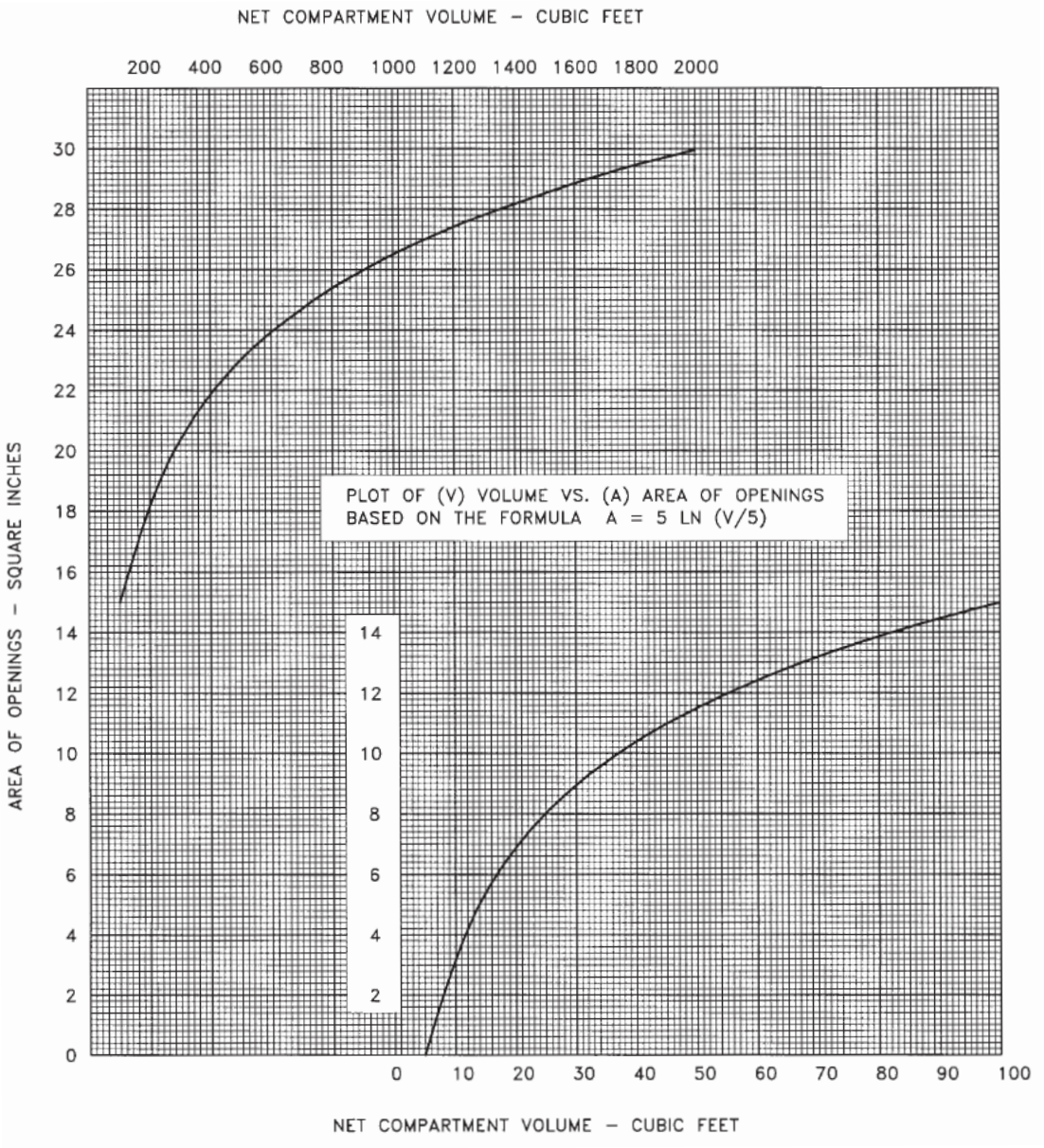
The graph is approximate. The formula provides the accurate area.

	n	n (2.3026)	n (0.0974-3)
	1	2.3026	0.6974-3
	2	4.6052	0.3948-5
This table gives the natural or Napierian logarithms (Ln) of numbers between 1 and 10, correct to four places. Movingthe decimal point n places to the right (or left) in the number is equivalent to addingn times 2.3026 (or n times 3.6974) to thelogarithm. Base e = 2.71828	3	6.9078	0.0922-7
	4	9.2103	0.7897-10
	5	11.5129	0.4871-12
	6	13.8155	0.1845-14
	7	16.1181	0.8819-17
	8	18.4207	0.5793-19
	9	20.7233	0.2767-21

Number	0	1	2	3	4	5	6	7	8	9	Mean diff
1.0	0.0000	0.0100	0.0198	0.0296	0.0392	0.0488	0.0583	0.0677	0.0770	0.0862	95
1.1	0.0953	0.1044	0.1133	0.1222	0.1310	0.1398	0.1484	0.1570	0.1655	0.1740	87
1.2	0.1823	0.1906	0.1989	0.2070	0.2151	0.2231	0.2311	0.2390	0.2469	0.2546	80
1.3	0.2624	0.2700	0.2776	0.2852	0.2927	0.3001	0.3075	0.3148	0.3221	0.3293	74
1.4	0.3365	0.3436	0.3507	0.3577	0.3646	0.3716	0.3784	0.3853	0.3920	0.3988	69
1.5	0.4055	0.4121	0.4187	0.4253	0.4318	0.4383	0.4447	0.4511	0.4574	0.4637	65
1.6	0.4700	0.4762	0.4824	0.4886	0.4947	0.5008	0.5068	0.5128	0.5188	0.5247	61
1.7	0.5306	0.5365	0.5423	0.5481	0.5539	0.5596	0.5653	0.5710	0.5766	0.5822	57
1.8	0.5878	0.5933	0.5988	0.6043	0.6098	0.6152	0.6206	0.6259	0.6313	0.6366	54
1.9	0.6419	0.6471	0.6523	0.6575	0.6627	0.6678	0.6729	0.6780	0.6831	0.6881	51
2.0	0.6931	0.6981	0.7031	0.7080	0.7129	0.7178	0.7227	0.7275	0.7324	0.7372	49
2.1	0.7419	0.7467	0.7514	0.7561	0.7608	0.7655	0.7701	0.7747	0.7793	0.7839	47
2.2	0.7885	0.7930	0.7975	0.8020	0.8065	0.8109	0.8154	0.8198	0.8242	0.8286	44
2.3	0.8329	0.8372	0.8416	0.8459	0.8502	0.8544	0.8587	0.8629	0.8671	0.8713	43
2.4	0.8755	0.8796	0.8838	0.8879	0.8920	0.8961	0.9002	0.9042	0.9083	0.9123	41
2.5	0.9163	0.9203	0.9243	0.9282	0.9322	0.9361	0.9400	0.9439	0.9478	0.9517	39
2.6	0.9555	0.9594	0.9632	0.9670	0.9708	0.9746	0.9783	0.9821	0.9858	0.9895	38
2.7	0.9933	0.9969	1.0006	1.0043	1.0080	1.0116	1.0152	1.0188	1.0225	1.0260	36
2.8	1.0296	1.0332	1.0367	1.0403	1.0438	1.0473	1.0508	1.0543	1.0578	1.0613	35
2.9	1.0647	1.0682	1.0716	1.0750	1.0784	1.0818	1.0852	1.0886	1.0919	1.0953	34
3.0	1.0986	1.1019	1.1053	1.1086	1.1119	1.1151	1.1184	1.1217	1.1249	1.1282	33
3.1	1.1314	1.1346	1.1378	1.1410	1.1442	1.1474	1.1506	1.1537	1.1569	1.1600	32
3.2	1.1632	1.1663	1.1694	1.1725	1.1756	1.1787	1.1817	1.1848	1.1878	1.1909	31
3.3	1.1939	1.1969	1.2000	1.2030	1.2060	1.2090	1.2119	1.2149	1.2179	1.2208	30
3.4	1.2238	1.2267	1.2296	1.2326	1.2355	1.2384	1.2413	1.2442	1.2470	1.2499	29
3.5	1.2528	1.2556	1.2585	1.2613	1.2641	1.2669	1.2698	1.2726	1.2754	1.2782	28
3.6	1.2809	1.2837	1.2865	1.2892	1.2920	1.2947	1.2975	1.3002	1.3029	1.3056	27
3.7	1.3083	1.3110	1.3137	1.3164	1.3191	1.3218	1.3244	1.3271	1.3297	1.3324	27
3.8	1.3350	1.3376	1.3403	1.3429	1.3455	1.3481	1.3507	1.3533	1.3558	1.3584	26
3.9	1.3610	1.3635	1.3661	1.3686	1.3712	1.3737	1.3762	1.3788	1.3813	1.3838	25
4.0	1.3863	1.3888	1.3913	1.3938	1.3962	1.3987	1.4012	1.4036	1.4061	1.4085	25
4.1	1.4110	1.4134	1.4159	1.4183	1.4207	1.4231	1.4255	1.4279	1.4303	1.4327	24
4.2	1.4351	1.4375	1.4398	1.4422	1.4446	1.4469	1.4493	1.4516	1.4540	1.4563	23
4.3	1.4586	1.4609	1.4633	1.4656	1.4679	1.4702	1.4725	1.4748	1.4770	1.4793	23
4.4	1.4816	1.4839	1.4861	1.4884	1.4907	1.4929	1.4951	1.4974	1.4996	1.5019	22
4.5	1.5041	1.5063	1.5085	1.5107	1.5129	1.5151	1.5173	1.5195	1.5217	1.5239	22
4.6	1.5261	1.5282	1.5304	1.5326	1.5347	1.5369	1.5390	1.5412	1.5433	1.5454	21
4.7	1.5476	1.5497	1.5518	1.5539	1.5560	1.5581	1.5602	1.5623	1.5644	1.5665	20
4.8	1.5686	1.5707	1.5728	1.5748	1.5769	1.5790	1.5810	1.5831	1.5851	1.5872	20
4.9	1.5892	1.5913	1.5933	1.5953	1.5974	1.5994	1.6014	1.6034	1.6054	1.6074	20
5.0	1.6094	1.6114	1.6134	1.6154	1.6174	1.6194	1.6214	1.6233	1.6253	1.6273	20
5.1	1.6292	1.6312	1.6332	1.6351	1.6371	1.6390	1.6409	1.6429	1.6448	1.6467	19
5.2	1.6487	1.6506	1.6525	1.6544	1.6563	1.6582	1.6601	1.6620	1.6639	1.6658	19
5.3	1.6677	1.6696	1.6715	1.6734	1.6752	1.6771	1.6790	1.6808	1.6827	1.6845	18
5.4	1.6864	1.6882	1.6901	1.6919	1.6938	1.6956	1.6974	1.6993	1.7011	1.7029	18

Number	0	1	2	3	4	5	6	7	8	9	Mean diff
5.5	1.7047	1.7066	1.7084	1.7102	1.7120	1.7138	1.7156	1.7174	1.7192	1.7210	18
5.6	1.7228	1.7246	1.7263	1.7281	1.7299	1.7317	1.7334	1.7352	1.7370	1.7387	18
5.7	1.7405	1.7422	1.7440	1.7457	1.7475	1.7492	1.7509	1.7527	1.7544	1.7561	17
5.8	1.7579	1.7596	1.7613	1.7630	1.7647	1.7664	1.7681	1.7699	1.7716	1.7733	17
5.9	1.7750	1.7766	1.7783	1.7800	1.7817	1.7834	1.7851	1.7867	1.7884	1.7901	17
6.0	1.7918	1.7934	1.7951	1.7967	1.7984	1.8001	1.8017	1.8034	1.8050	1.8066	16
6.1	1.8083	1.8099	1.8116	1.8132	1.8148	1.8165	1.8181	1.8197	1.8213	1.8229	16
6.2	1.8245	1.8262	1.8278	1.8294	1.8310	1.8326	1.8342	1.8358	1.8374	1.8390	16
6.3	1.8405	1.8421	1.8437	1.8453	1.8469	1.8485	1.8500	1.8516	1.8532	1.8547	16
6.4	1.8563	1.8579	1.8594	1.8610	1.8625	1.8641	1.8656	1.8672	1.8687	1.8703	15
6.5	1.8718	1.8733	1.8749	1.8764	1.8779	1.8795	1.8810	1.8825	1.8840	1.8856	15
6.6	1.8871	1.8886	1.8901	1.8916	1.8931	1.8946	1.8961	1.8976	1.8991	1.9006	15
6.7	1.9021	1.9036	1.9051	1.9066	1.9081	1.9095	1.9110	1.9125	1.9140	1.9155	15
6.8	1.9169	1.9184	1.9199	1.9213	1.9228	1.9242	1.9257	1.9272	1.9286	1.9301	14
6.9	1.9315	1.9330	1.9344	1.9359	1.9373	1.9387	1.9402	1.9416	1.9430	1.9445	14
7.0	1.9459	1.9473	1.9488	1.9502	1.9516	1.9530	1.9544	1.9559	1.9573	1.9587	14
7.1	1.9601	1.9615	1.9629	1.9643	1.9657	1.9671	1.9685	1.9699	1.9713	1.9727	14
7.2	1.9741	1.9755	1.9769	1.9782	1.9796	1.9810	1.9824	1.9838	1.9851	1.9865	14
7.3	1.9879	1.9892	1.9906	1.9920	1.9933	1.9947	1.9961	1.9974	1.9988	2.0001	13
7.4	2.0015	2.0028	2.0042	2.0055	2.0069	2.0082	2.0096	2.0109	2.0122	2.0136	13
7.5	2.0149	2.0162	2.0176	2.0189	2.0202	2.0215	2.0229	2.0242	2.0255	2.0268	13
7.6	2.0281	2.0295	2.0308	2.0321	2.0334	2.0347	2.0360	2.0373	2.0386	2.0399	13
7.7	2.0412	2.0425	2.0438	2.0451	2.0464	2.0477	2.0490	2.0503	2.0516	2.0528	13
7.8	2.0541	2.0554	2.0567	2.0580	2.0592	2.0605	2.0618	2.0631	2.0643	2.0656	12
7.9	2.0669	2.0681	2.0694	2.0707	2.0719	2.0732	2.0744	2.0757	2.0769	2.0782	12
8.0	2.0794	2.0807	2.0819	2.0832	2.0844	2.0857	2.0869	2.0882	2.0894	2.0906	12
8.1	2.0919	2.0931	2.0943	2.0956	2.0968	2.0980	2.0992	2.1005	2.1017	2.1029	12
8.2	2.1041	2.1054	2.1066	2.1078	2.1090	2.1102	2.1114	2.1126	2.1138	2.1150	12
8.3	2.1163	2.1175	2.1187	2.1199	2.1211	2.1223	2.1235	2.1247	2.1258	2.1270	12
8.4	2.1282	2.1294	2.1306	2.1318	2.1330	2.1342	2.1353	2.1365	2.1377	2.1389	12
8.5	2.1401	2.1412	2.1424	2.1436	2.1448	2.1459	2.1471	2.1483	2.1494	2.1506	12
8.6	2.1518	2.1529	2.1541	2.1552	2.1564	2.1576	2.1587	2.1599	2.1610	2.1622	12
8.7	2.1633	2.1645	2.1656	2.1668	2.1679	2.1691	2.1702	2.1713	2.1725	2.1736	11
8.8	2.1748	2.1759	2.1770	2.1782	2.1793	2.1804	2.1815	2.1827	2.1838	2.1849	11
8.9	2.1861	2.1872	2.1883	2.1894	2.1905	2.1917	2.1928	2.1939	2.1950	2.1961	11
9.0	2.1972	2.1983	2.1994	2.2006	2.2017	2.2028	2.2039	2.2050	2.2061	2.2072	11
9.1	2.2083	2.2094	2.2105	2.2116	2.2127	2.2138	2.2148	2.2159	2.2170	2.2181	11
9.2	2.2192	2.2203	2.2214	2.2225	2.2235	2.2246	2.2257	2.2268	2.2279	2.2289	11
9.3	2.2300	2.2311	2.2322	2.2332	2.2343	2.2354	2.2364	2.2375	2.2386	2.2396	11
9.4	2.2407	2.2418	2.2428	2.2439	2.2450	2.2460	2.2471	2.2481	2.2492	2.2502	11
9.5	2.2513	2.2523	2.2534	2.2544	2.2555	2.2565	2.2576	2.2586	2.2597	2.2607	10
9.6	2.2618	2.2628	2.2638	2.2649	2.2659	2.2670	2.2680	2.2690	2.2701	2.2711	10
9.7	2.2721	2.2732	2.2742	2.2752	2.2762	2.2773	2.2783	2.2793	2.2803	2.2814	10
9.8	2.2824	2.2834	2.2844	2.2854	2.2865	2.2875	2.2885	2.2895	2.2905	2.2915	10
9.9	2.2925	2.2935	2.2946	2.2956	2.2966	2.2976	2.2986	2.2996	2.3006	2.3016	10
10.0	2.3026										

FIGURE 9 Area of Openings



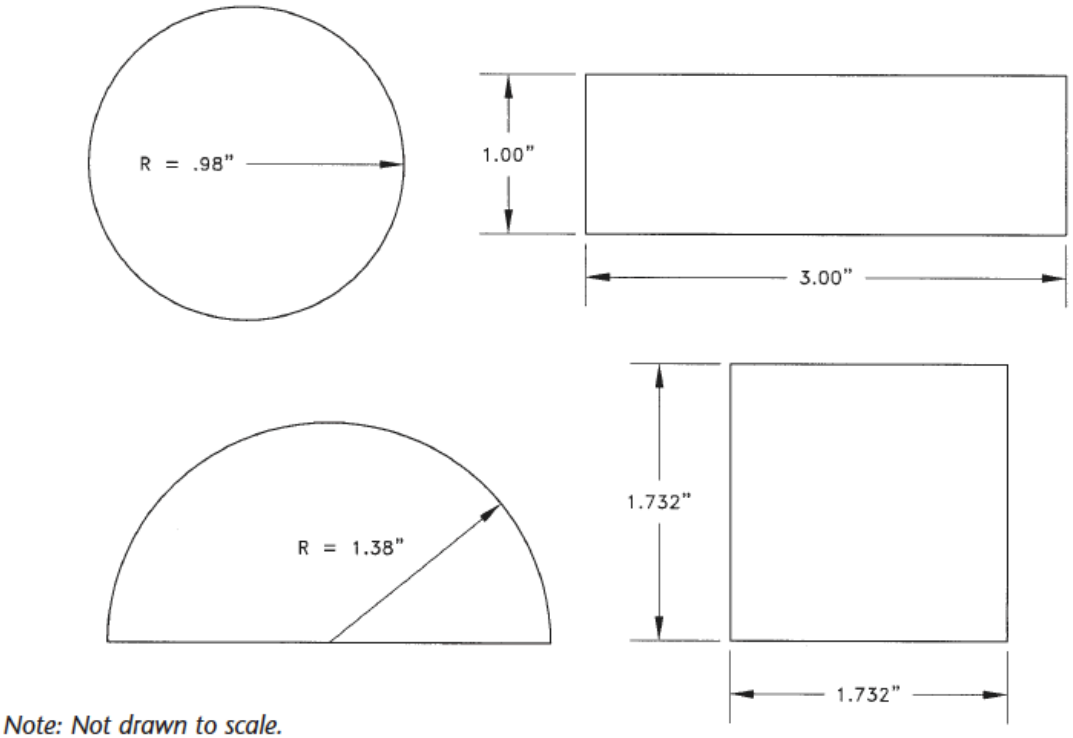
EXAMPLE:
The net volume of a compartment is 37 cu ft. per Figure 9, with a 37 cu ft net compartment volume (on the horizontal scale), the required minimum area of the natural ventilation openings (on the vertical scale) is 10.0 square inches.

The total cross-section of all supply openings and ducts into the compartment must be equal to or exceed 10.0 square inches. The aggregate area of exhaust openings and ducts must equal to or exceed 10.0 square inches.

The minimal internal cross-sectional area of each supply opening or duct must exceed 3.0 square inches. The minimum required open area is specified as an accumulated value – but builders may not use a bunch of 1 inch diameter holes to achieve the standard. Smaller holes tend to get covered or clogged. As seen in the following figure, a minimum hole diameter of 2 inches will meet the standard.

The shape of the opening is not specified, but to give an idea of what three square inches looks like, Figure 10 depicts a few common geometric shapes, each of which is three square inches.

FIGURE 10 Three Square Inches



Note: Not drawn to scale.

4.2.4 WHERE TO LOCATE POWERED AND NATURAL VENTILATION OPENINGS

The standards specify that the supply and exhaust openings need to be from the atmosphere or from a ventilated compartment – but the CFR does not state specific requirements regarding the location of the supply and exhaust in relation to each other and to other openings such as fuel tank vents.

Clearly the supply and exhaust openings must not share the same plenum. Allowing the exhaust air to be sent back to the space via a co-located supply duct eliminates the purpose of the openings. A good practice is to locate all exhaust ducting on one side of the boat, and the air supply openings and ducts on the other side.

The fuel system guideline also discusses the placement of ventilation openings and fuel fills and fuel tank vents. The placement must serve to keep fuel vapors and fuel spills from entering the boat. But again, the fuel regulations do not specify required separation distances. The ABYC Standard H-24 does give some recommended practices:

- "Separation between compartment ventilation openings and fuel fill openings shall be at least 15 inches."
- "Separation between compartment ventilation openings and fuel tank vent line termination shall be at least 15 inches."

While there is no USCG regulation to cite, it is recommended that ventilation supply and exhaust openings inside a compartment be separated by at least 24 inches, compartment dimensions permitting.

4.2.5 GRILLS AND DECORATIVE COVERS

The design and installation of natural and powered ventilation systems on boats is a critical safety element in the prevention of boat fires and explosions. The installation of gratings and decorative covers over ventilation system openings restricts airflow. Such gratings and decorative covers reduce the aggregate cross-sectional area for ventilation system openings and reduce the effectiveness of natural and powered ventilation systems.

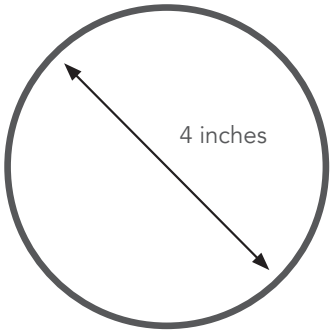
EXAMPLE:

That engine compartment with a net volume of 37 cubic feet would require a powered ventilation system with a blower capacity of 55.5 cubic feet per minute, a powered ventilation system output of 22.2 cubic feet per minute and a natural ventilation system with supply and exhaust openings of 10.0 square inches (each). A natural ventilation system consisting of one 4 inch diameter opening (area of 12.6 sq in) or two 3-inch diameter openings (area of 7.1 sq in x 2 = 14.2 sq in total) for both supply and exhaust would be acceptable. If decorative gratings/covers reduce the aggregate open area to less than10 square inches, the natural ventilation system would not be in compliance with the regulations. The output of the powered blower system would be unacceptable if the tested output dropped below 22.2 cfm due to the placement of restrictive gratings/covers.

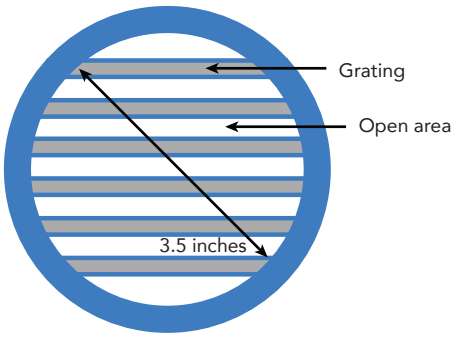
Over-sizing the ventilation system hull/deck openings to account for restrictive gratings/covers would be an acceptable means to meet the minimum natural ventilation system requirements.

Figure 11 illustrates the effect of a cover grating for this example. One totally clear 4 in diameter opening (12.6 sq in area) is adequate. The decorative grill drops the open area for the natural ventilation system opening to an unacceptable 6.4 sq in.

FIGURE 11 Reduction of Ventilation Net Open Area With Grating Installed



Ventilation Opening
Needed opening = 10 sq. in.
Diameter = 4"
Area = pi D^2 / 4 = 12.6 sq in



Note: Not drawn to scale.

'Mallory Motorboats' decides to add a grating:
Inside diameter of grating ring = 3.5"
Percentage of open area inside grating ring = 67%
Area inside grating ring = pi $(3.5)^2$ / 4 = 9.6 sq in
Open area = 0.67 (9.6) = 6.4 sq in.

Open area reduced from 12.6 sq. in. (adequate with a bit to spare) to 6.4 sq. in. (a ventilation system safety violation).

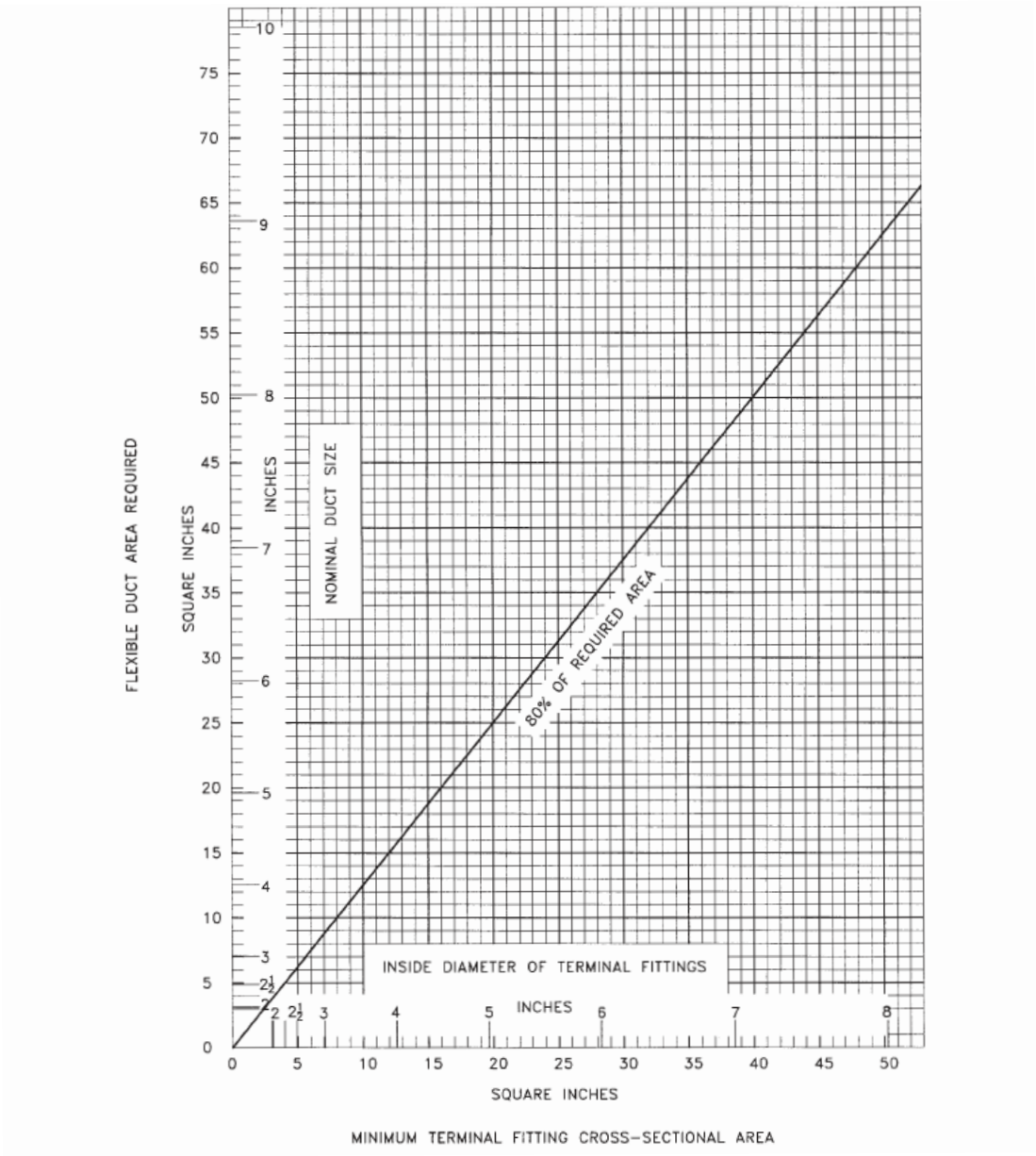
4.2.6 TERMINAL ENDS

Some of the flexible ventilation ducts that are available for marine use may be fitted with terminal fittings made to fit the duct. Some of these are designed to fit inside the flexible duct. For these fittings the reduced cross-section at the fitting is permitted to be not less than 80% of the cross- section required for the flexible duct under consideration. It is important to remember that this reduction in the cross-section is only permitted inside a terminal fitting. No reduction in cross- sectional area is permitted any place in the natural ventilation system. Also, note that the 80% figure applies to the required area of the duct. For example, if the required area is 5 sq. in., but the installed duct has a cross-sectional area of 8 sq. in., the 80% (minimum) figure applies to the 5 sq. in.

Figure 16 is a graph that is intended to aid in determining compliance. The minimum terminal fitting cross-sectional area must be at or above the 80% of required area line in order to comply with this section of the regulation. The diameters at the various areas are included on the graph to aid in evaluating terminal fittings by simply measuring the inside diameters.

The following discussion and graph has assumed that circular air ducts are used. If other shapes of flexible ducts are used, the same principles apply, but their measurements and area calculation must be appropriate for the shape under consideration.

FIGURE 12 Terminal Fitting Area



Per 183.607: The regulations list the AMCA, ASTM, and UL references that are incorporated by reference.

These references are listed in Appendix 1.

Appendix 1. Ventilation References & Resources

The following standards are referenced in the regulations:

AMCA 210-16	"Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating" - sections 183.607 and 183.610.
ASTM D 471	"Standard Test Method for Rubber Property Effect of Liquids" - sections 183.516 and 183.620.
UL 1128	"Standard for Marine Blowers" - sections 183.607 and 183.610.

The following standards are referenced in this compliance guideline:

NAFA 70	"National Electric Code" – section 183.20.
SAE J1171	"External Ignition Protection of Marine Electrical Devices" – section 183.620.
UL 1500	"Standard for Ignition – Protection Test for Marine Products" – section 183.620.

AMCA standards are available from the Air Movement and Control Association International, Inc., 30 West University Drive, Arlington Heights, IL 60004-1893, ph 847-394-1050, www.acma.org.

ASTM standards are available from the American Society for Testing and Materials, P.O. Box C700, West Conshohocken, PA 19428-2959, ph 610-832-9500.

NFPA standards are available from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471, ph 800-344-3555, www.nfpa.org

SAE standards are available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096, ph 724-776-4841, www.sae.org.

UL standards are available from Underwriters Laboratories, P.O. Box 13995, Research Triangle Park, NC 27009-3995, ph 919-549-1400, www.ul.com

Appendix 2. 33 CFR 183 Subpart K – Ventilation

§ 183.601 APPLICABILITY

This subpart applies to all boats that have gasoline engines for electrical generation, mechanical power, or propulsion.

§ 183.605 DEFINITIONS

As used in this subpart:

"Fuel" means gasoline.

"Open to the atmosphere" means a compartment that has at least 15 square inches of open area directly exposed to the atmosphere for each cubic foot of net compartment volume.

§ 183.607 INCORPORATION BY REFERENCE

(a) The following standards are incorporated by reference. Copies may be obtained from the sources indicated. They are also available for inspection at Coast Guard Headquarters. Contact Commandant (CG-BSX-23), Attn: Recreational Boating Product Assurance Branch, U.S. Coast Guard Stop 7501, 2703 Martin Luther King Jr. Avenue SE., Washington, DC 20593-7501. It is also available at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to: *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html*.

(1) AMCA Standard 210-74, Figure 12. Air Moving and Conditioning Association, 30 West University Drive, Arlington Heights, Illinois 60004.

(2) ASTM Standard D 471. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

(3) UL Standard 1128, Underwriters Laboratories, Incorporated, 12 Laboratory Drive, Research Triangle Park, NC 27709-3995.

(b) The Director of the Federal Register approved the incorporation by reference in paragraph (a)(2) on September 26, 1976 and the incorporations in paragraphs (a) (1) and (3) on March 24, 1978.

§ 183.610 POWERED VENTILATION SYSTEM

(a) Each compartment in a boat that has a permanently installed gasoline engine with a cranking motor must:

(1) Be open to the atmosphere, or

(2) Be ventilated by an exhaust blower system.

(b) Each exhaust blower or combination of blowers must be rated at an air flow capacity not less than that computed by the formulas given in Table 183.610, Column 2. Blower rating must be determined according to AMCA Standard 210-74, Figure 12, or UL Standard 1128.

TABLE 183.610

COLUMN 1[1]	COLUMN 2[2]	COLUMN 3[3]
Below 34	Fr = 50	Fo = 20
34 to 100	Fr = 1.5V	Fo = 0.6V
Over 100	Fr = V/2 + 100	Fo = 0.2V + 40
Louver	20%	
Screen — 1/4" mesh	10%	

1 Net compartment volume of engine compartment and compartments open thereto (V) cubic feet.
2 Rated blower capacity (Fr) cubic feet per minute.
3 Blower system output (Fo) cubic feet per minute.

(c) Each exhaust blower system required by paragraph (a)(2) of this section must exhaust air from the boat at a rate which meets the requirements of Table 183.610, Column 3 when the engine is not operating.

(d) Each intake duct for an exhaust blower must be in the lower one-third of the compartment and above the normal level of accumulated bilge water.

(e) More than one exhaust blower may be used in combination to meet the requirements of this section.

(f) Each boat that is required to have an exhaust blower must have a label that:

(1) Is located as close as practicable to each ignition switch;

(2) Is in plain view of the operator; and

(3) Has at least the following information:

WARNING

GASOLINE VAPORS CAN EXPLODE. BEFORE STARTING ENGINE OPERATE BLOWER FOR 4 MINUTES AND CHECK ENGINE COMPARTMENT BILGE FOR GASOLINE VAPORS.

§ 183.620 NATURAL VENTILATION SYSTEM

(a) Except for compartments open to the atmosphere, a natural ventilation system that meets the requirements of § 183.630 must be provided for each compartment in a boat that:

(1) Contains a permanently installed gasoline engine;

(2) Has openings between it and a compartment that requires ventilation, where the aggregate area of those openings exceeds 2 percent of the area between the compartments, except as provided in paragraph (c) of this section;

(3) Contains a permanently installed fuel tank and an electrical component that is not ignition protected in accordance with § 183.410(a);

(4) Contains a fuel tank that vents into that compartment; or

(5) Contains a non-metallic fuel tank:

(i) With an aggregate permeability rate exceeding 1.2 grams of fuel loss in 24 hours per cubic foot of net compartment volume, or

(ii) If the net compartment volume is less than one cubic foot, having a permeability rate exceeding 1.2 grams of fuel loss in 24 hours.

Note:
Reference fuel "C" at 40 degrees Celsius plus or minus 2 degrees Celsius from ASTM standard D 471 (incorporated by reference, see § 183.5) is to be used in determining the permeability rate.

(b) Each supply opening required in § 183.630 must be located on the exterior surface of the boat.

(c) An accommodation compartment above a compartment requiring ventilation that is separated from the compartment requiring ventilation by a deck or other structure is excepted from paragraph (a)(2) of this section.

§ 183.630 STANDARDS FOR NATURAL VENTILATION

(a) For the purpose of § 183.620, "natural ventilation" means an airflow in a compartment in a boat achieved by having:

(1) A supply opening or duct from the atmosphere or from a ventilated compartment or from a compartment that is open to the atmosphere; and

(2) An exhaust opening into another ventilated compartment or an exhaust duct to the atmosphere.

(b) Each exhaust opening or exhaust duct must originate in the lower third of the compartment.

(c) Each supply opening or supply duct and each exhaust opening or exhaust duct in a compartment must be above the normal accumulation of bilge water.

(d) Except as provided in paragraph (e) of this section, supply openings or supply ducts and exhaust openings or exhaust ducts must each have a minimum aggregate internal cross-sectional area calculated as follows:

$$A = 5 \ln (V/5);$$

where:

(1) A is the minimum aggregate internal cross-sectional area of the openings or ducts in square inches;

(2) V is the net compartment volume in cubic feet, including the net volume of other compartments connected by openings that exceed 2 percent of the area between the compartments; and

(3) ln (V/5) is the natural logarithm of the quantity (V/5).

(e) The minimum internal cross-sectional area of each supply opening or duct and exhaust opening or duct must exceed 3.0 square inches.

(f) The minimum internal cross-sectional area of terminal fittings for flexible ventilation ducts installed to meet the requirements of paragraph (d) of this section must not be less than 80 percent of the required internal cross-sectional area of the flexible ventilation duct.