SUBPART K

VENTILATION

Revised November, 2003

Title 33 CFR, Sections 183.601–183.630

WARNING:
This guide only addresses provisions of the Federal Regulations.
It is NOT a complete engineering manual for the design of boat systems.
It is the manufacturer's responsibility to ensure Federal Regulations
cited in this guide have not been updated or revised.

Table of Contents

Figures and Tables

Introduction

The federal regulation for ventilation of boats with gasoline powered engines (Title 33 CFR Subpart K) 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. Ventilation cannot be relied upon to maintain a safe atmosphere in the presence of leaking and/or liquid fuel.

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. There may be more than one solution to the problem of providing sufficient ventilation for a particular boat. The regulation offers alternatives and states the requirements in terms of performance. The provision of these alternatives and the possible interpretations of the requirements may be confusing to the readers using these regulations.

Regulations are written in concise terms. The words and arrangement have been chosen to be enforceable and in some cases, to be interpreted legally. This format prohibits explanations, recommendations and easily detected alternative solutions. The regulation provides an outline about which a great deal of further information, interpretation, explanation, clarification and helpful hints are needed if compliance is to be achieved.

The Ventilation System Compliance Guideline attempts to fulfill the needs of the boatbuilder in achieving compliance with the ventilation regulations. It explains, interprets, clarifies and discusses alternatives. The guideline diagrams, tabulates, makes recommendations and in general complements the regulation to improve the reader's understanding.

CAUTION:

This guideline only addresses provisions of the Federal Regulations. It is not a complete engineering manual for the design of ventilation systems for boats. There are other manuals and standards available for that purpose.

It is recommended that the standards developed by the American Boat & Yacht Council, Inc. (ABYC) be consulted when designing, constructing, installing and maintaining ventilation systems on boats. These documents may be obtained from:

The American Boat & Yacht Council, Inc.
3069 Solomon's Island Road
Edgewater, MD 21037
(410) 956-1050 www.abycinc.org

FORMAT

The format of this guideline follows the sequence of requirements in the federal regulation regarding ventilation.

Each portion of the regulation is recorded first, preceded by the title, FEDERAL LAW, followed by a discussion which is designed to improve the reader's understanding of the intent of the regulatory requirement. Diagrams and tables are included to provide the reader with adequate illustrations of the subject(s) under discussion.

The discussion, diagrams and tables are followed by a checklist for regulatory compliance titled TO COMPLY WITH THE LAW. All the items in this section must be answered in the affirmative (YES) if compliance is to be achieved.

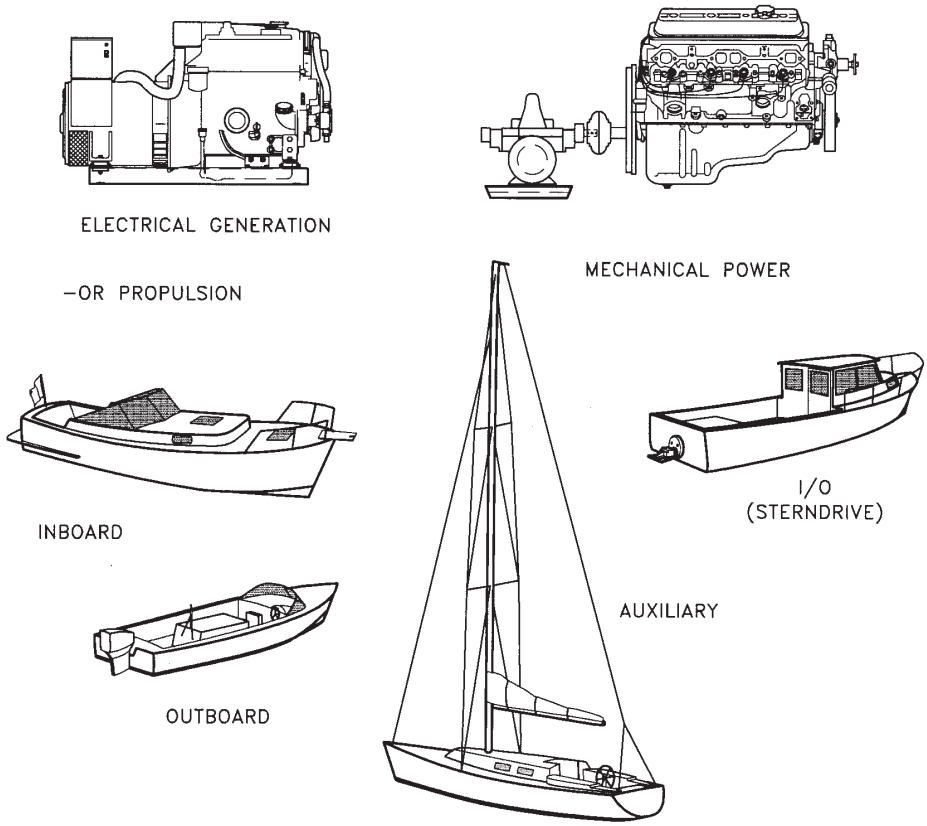
General

FEDERAL LAW:

183.601 Applicability.

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

FIGURE 1 Applicability — All Recreational Boats with Gasoline Engines



TO COMPLY WITH THE LAW

To determine if this regulation is applicable:

- *Is there a gasoline engine on the boat?*

FEDERAL LAW:

183.605 Definitions.
As used in this subpart:

"Fuel" means gasoline.

Alcohol extended gasoline (gasohol) and other such gasoline based fuels are included in the defined term fuel.

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

FEDERAL LAW:

183.605 Definitions.
As used in this subpart:

"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.

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.

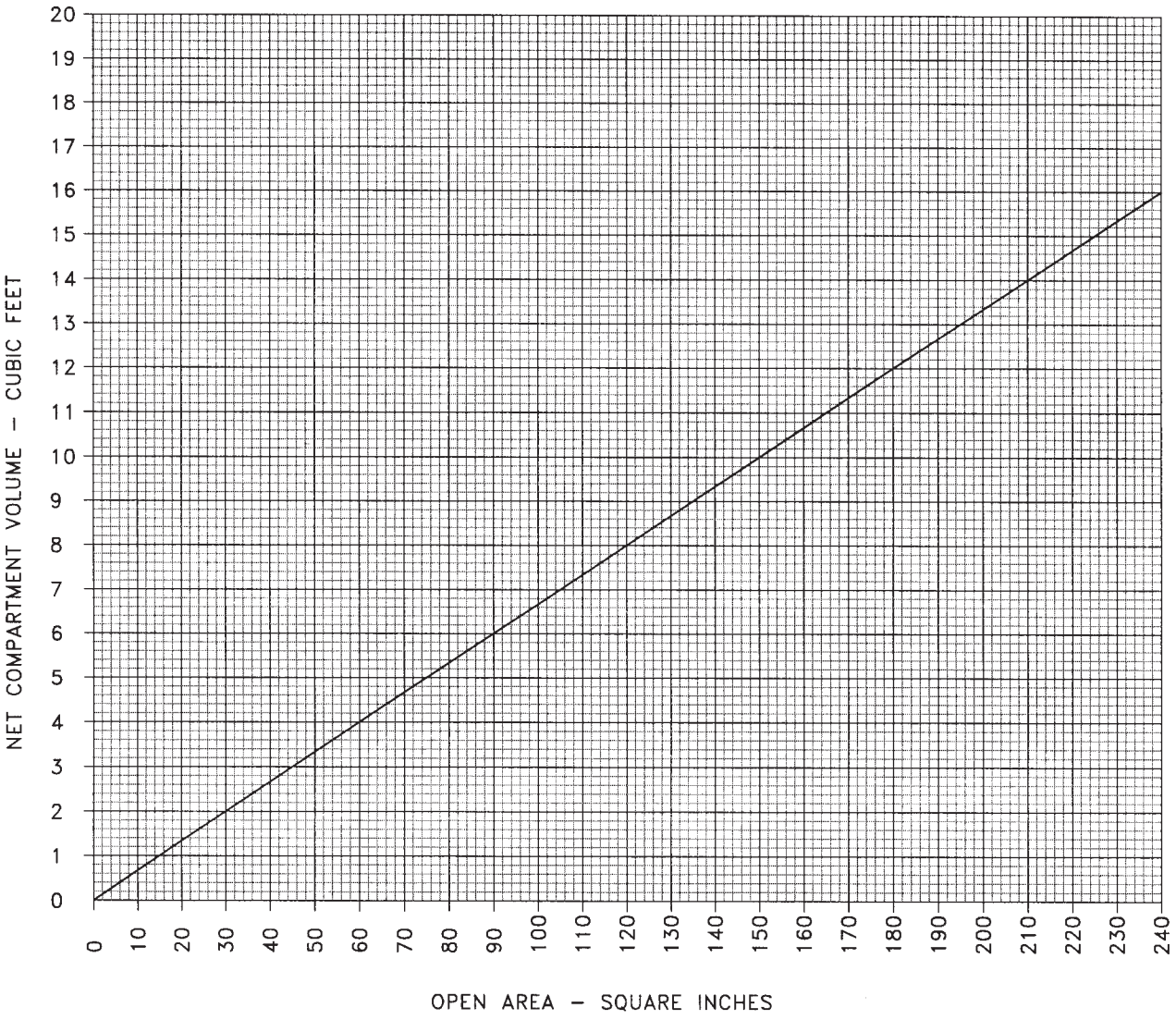
Open areas are openings that are not specified. Open areas may be at the bottom, side or top of a compartment as long as:

- the open area equals 15 square inches for each cubic foot of net compartment volume (See Figure 2), and
- the opening is directly exposed to the atmosphere.

NOTE:

A number of openings may be added together in order to obtain the required total. Openings into an open cockpit are acceptable.

FIGURE 2 Open Area



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:

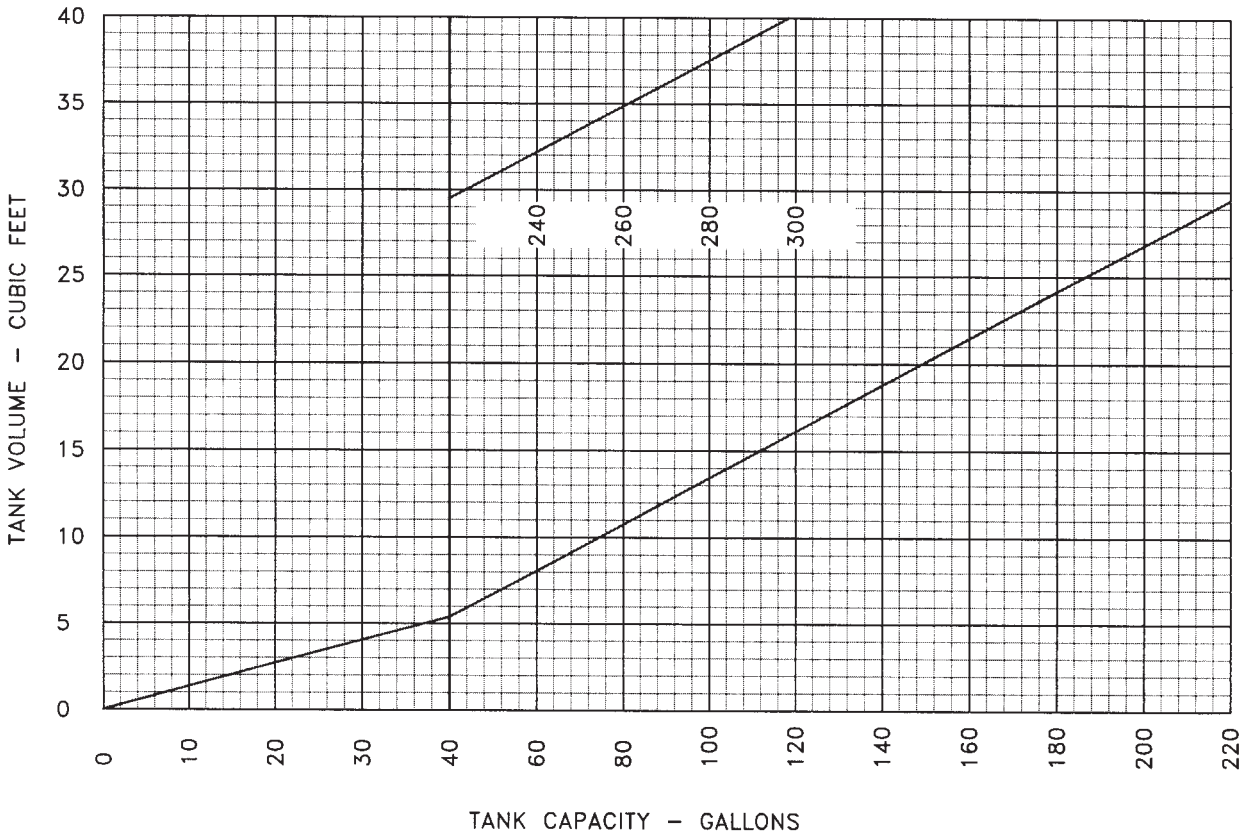
- Stowed Fenders
- Stowed Anchors and Line
- Stowed Chairs
- Picnic Coolers
- Other items that may or may not be in a compartment at any given time.

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 3 for a graph of tank capacity vs. tank volume, in cubic feet.

TABLE I 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. each
Large V-8	5.5 cu. ft. each
Batteries	0.5 cu. ft. each

FIGURE 3 Tank Volume



FORMULA: TANK VOLUME (CU. FT.) = 0.134 X TANK CAPACITY (GALLONS)

NOTE: FOR OUTBOARD BOATS ONE 6 GALLON PORTABLE TANK = 0.8 CU. FT.

FEDERAL LAW:

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, 2100 Second Street, SW, Washington, DC 20593-0001 and at the Office of the Federal Register Library, 800 North Capitol Street, NW, Suite 700, Washington, DC 20408.

(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 incorporation in paragraphs (a)(1) and (3) on March 24, 1978.

Powered Ventilation

FEDERAL LAW:

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.

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. See Title 33 CFR Part 183, Subpart I, Electrical Systems and Title 33 CFR Part 183, Subpart J, Fuel Systems. The use of the term "permanently installed" is to highlight that the engine is not portable or easily removed from the boat and to differentiate it from "portable equipment".

The term **gasoline engine with a cranking motor** is used to indicate that the gasoline engine can be started from a location that is remote from the compartment where it is permanently installed. An engine without a cranking motor (starter) requires the presence of a person at the engine location in order to start the engine. Presumably, any dangerous conditions such as liquid fuel or vapors being present at the engine location would be detected by odor and/or sight and remedied before the engine is started.

This section of the regulation addresses boats that have a permanently installed engine with a cranking motor in a compartment. To comply with the regulation one of the following alternatives must be satisfied:

1. The compartment must be open to the atmosphere, as defined in 183.605.

2. There must be an exhaust blower system installed to ventilate the compartment in which the engine is installed. An exhaust blower system consists of one or more blowers with ductwork and terminal fittings attached to the ducts.

TO COMPLY WITH THE LAW

- ***Is there a gasoline engine permanently installed in the compartment?***
- ***Does the gasoline engine have a cranking motor (starter)?***

If you have answered NO to either of the above, see 182.620, Natural Ventilation.

If you have answered YES to both of the above, then you must answer YES to one of the following:

- ***Is the compartment open to the atmosphere? See 183.605 for requirement.***
- ***Is there an exhaust blower system? See 183.610, (b) through (f), for requirements.***

FEDERAL LAW:

183.610 Powered ventilation 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 II 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

Net compartment volume is the result of subtracting the volume of permanently installed items such as the engine(s), fuel tanks, equipment and accessories from the total compartment volume of the compartment. A discussion of the items that may or may not be included, and suggestions for accounting for engines and fuel tanks appears as part of the discussion under 183.605 of this guideline.

The regulation is not specific about compartments that adjoin a compartment which 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.

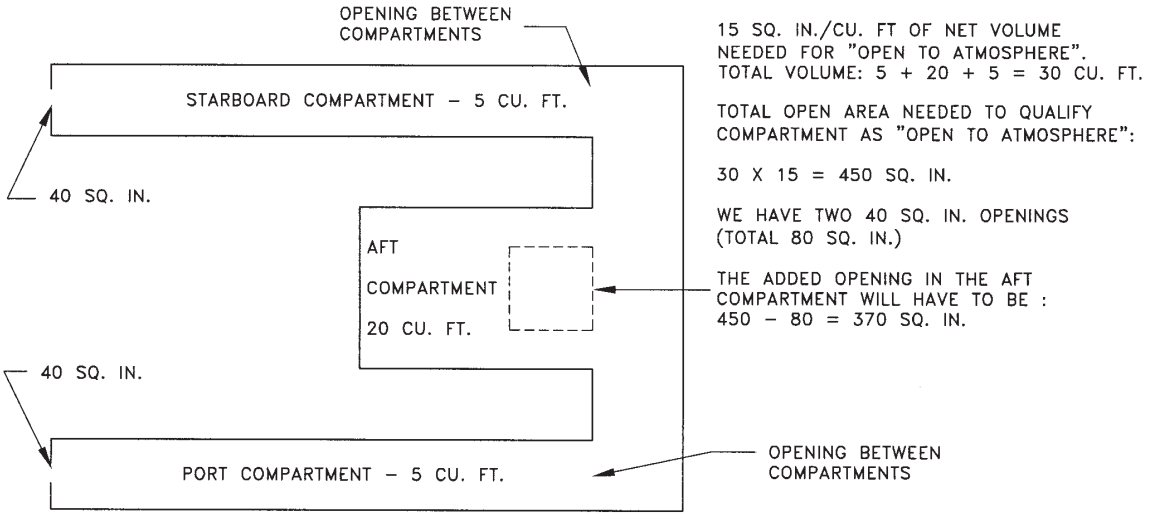
Long narrow compartments should have openings at each end or along the sides if they are to be considered open to the atmosphere.

See Figure 4 for diagrams of connecting compartments.

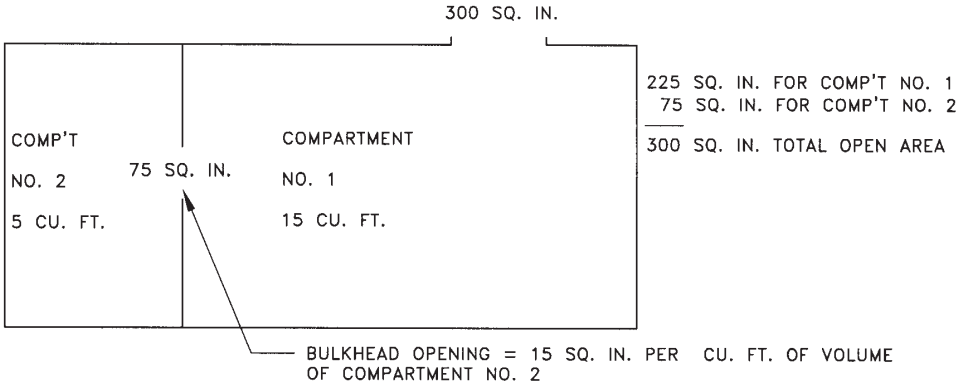
REMOVABLE ENCLOSURES

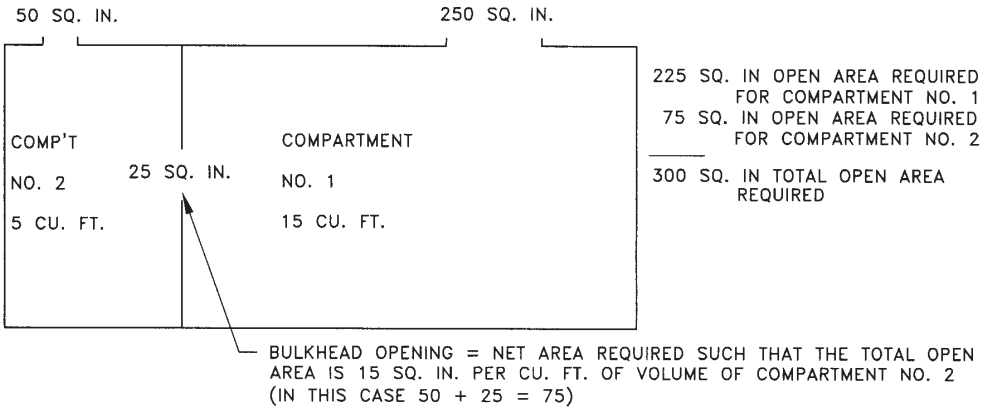
Fabric weather enclosures are not airtight and must be opened in order to enter the boat. Upon entering, any gasoline vapors present should be detectable by means of their odor. If an open compartment is covered by removable fabric weather enclosures, the enclosure may be ignored. The actual ventilation 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.

FIGURE 4 Connecting Compartments Qualifying as "Open to the Atmosphere"



NOTE: THE PRINCIPLE DEPICTED ABOVE MAY BE APPLIED TO I/O (STERNDRIVE) BOATS WITH SKI RACKS ALONG THE SIDES, OR TO BOATS WITH BOTTOM COMPARTMENTS BETWEEN THE STRINGERS.





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 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. To get the net compartment volume, subtract the volume of the installed items as referred to in 183.605.

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

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.

DO NOT ADD — If the area of openings between compartments is equal to or less than 2% of the area of the separation structure; i.e. bulkheads, stringers, frames, etc.

The total net volume of the engine compartment and all other connecting compartment volumes are required to be ADDED. See Column 1 of Table 183.610. These volumes are used to determine the required rated blower capacity and the blower system output. See Columns 2 and 3 of Table 183.610.

RATED BLOWER CAPACITY — TABLE 183.610 COLUMN 2

The air flow capacity rating (Fr) of blowers is determined by one of the following procedures:

1. AMCA Standard 210-74, Figure 12 or UL Standard 1128. The UL Standard is specifically for testing marine blowers. See the appendix for the reference.

2. This information may be found in the information supplied by the blower manufacturer.

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 5 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 (Below 34; See 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 (34 to 100 cu. ft.; See Table 183.610).

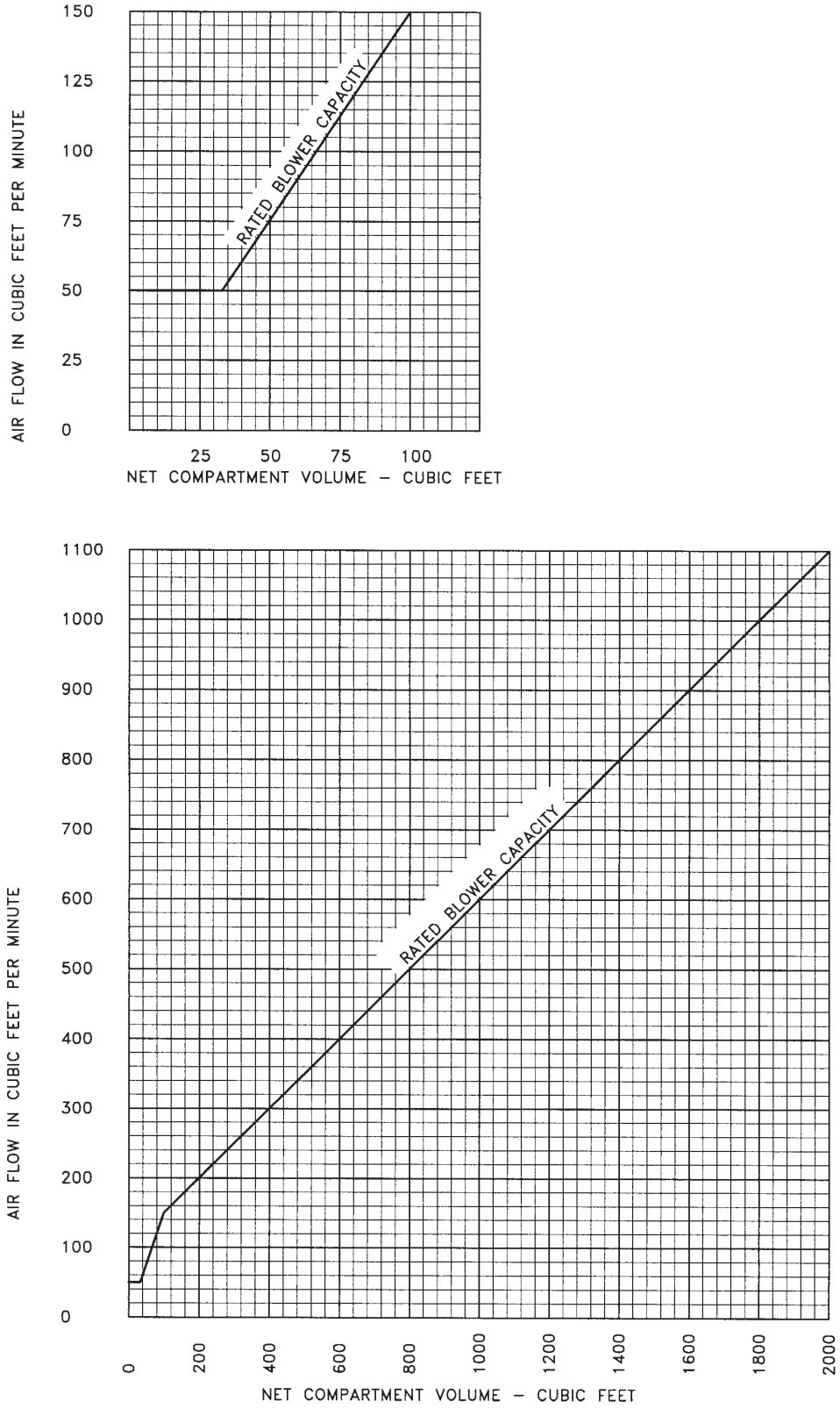
The required rated blower capacity is 150 cubic feet per minute. (1.5 x 100 = 150)

Two blowers could be used 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. Blowers with higher capacity ratings than the minimum may be used.

Example 3 — The net compartment volume of an engine compartment is 800 cubic feet (over 100 cu. ft.; See Table 183.610). The rated blower capacity required in this installation is 500 cubic feet per minute (800/2 + 100 = 500).

One, two or more blowers may be used to satisfy this requirement. Using readily available marine blowers, two 200 cubic feet per minute blowers and one 100 cubic feet per minute blower might be selected. Blowers with higher capacity ratings than the minimum may be used.

FIGURE 5 Rated Blower Capacity



TO COMPLY WITH THE LAW

Answer YES to one of the following:

- *Is the blower rated in accordance with AMCA Standard 210-74, or*
- *Is the blower rated in accordance with UL Standard 1128 as evidenced by the display of the UL Marine label?*

If the answer is NO in both cases, then the boatbuilder must rate the blower in accordance with one of the above referenced standards. See Appendix.

- *Having determined the net compartment volume in Column 1, is the rated blower capacity of the blower or blowers selected at least that required in Column 2, Table 183.610?*

FEDERAL LAW:

183.610 Powered ventilation system.

(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.

TABLE III 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

Columns 1 and 2 were discussed under 183.610(b).

COLUMN 3 — Blower System Output

A blower system includes the items and devices used to convey ventilation air flow 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

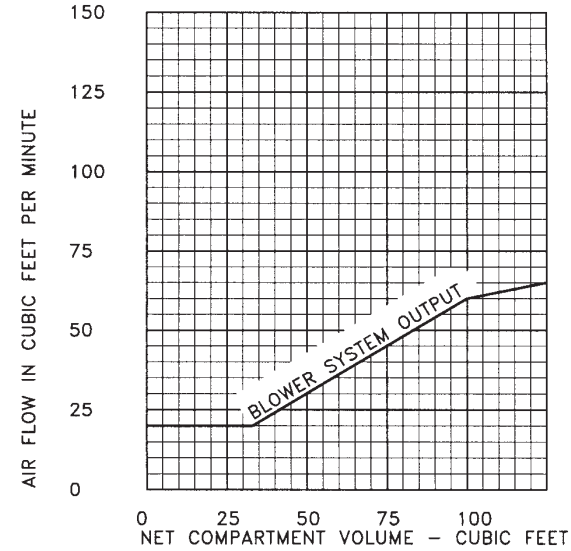
The air flow required (Fo) for the exhaust blower system, like the rated blower capacity, is based on the net compartment volume, V, shown in Column 1 of Table 183.610. The blower system output is stated in Column 3 of Table 183.610. These blower system output requirements establish the minimum efficiency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

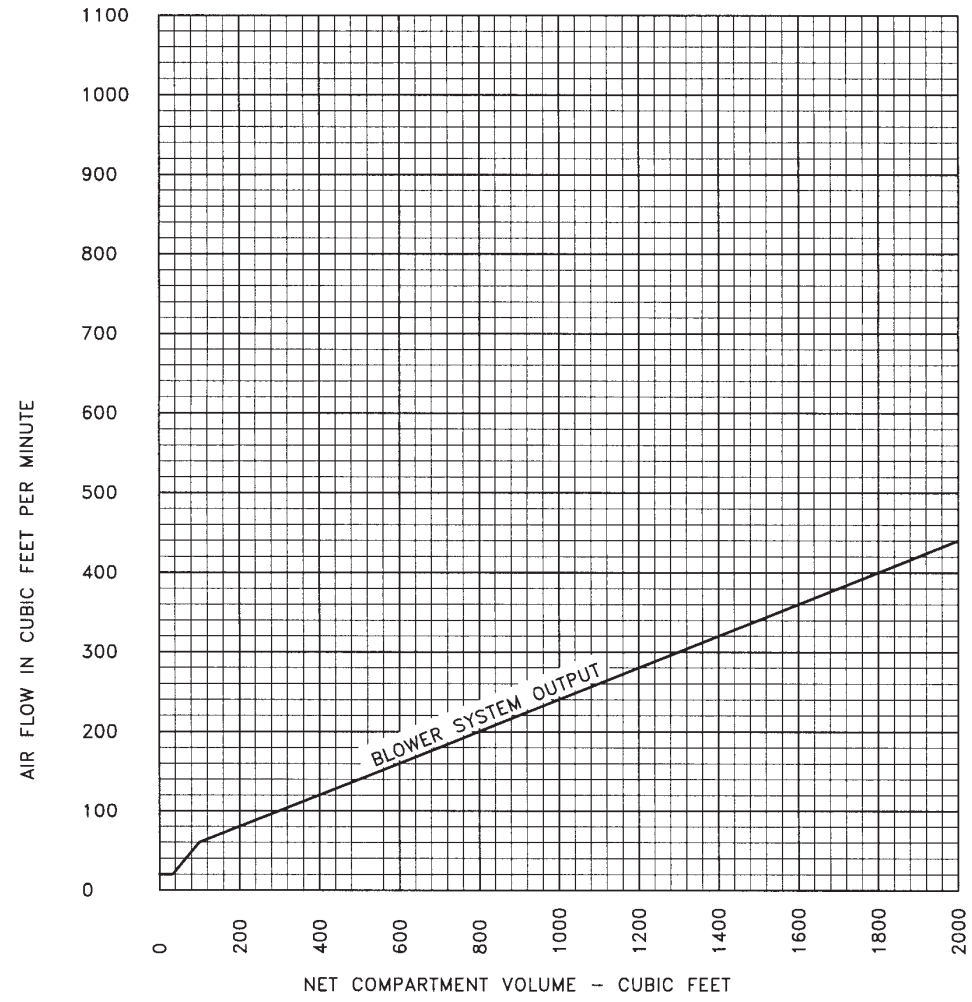
- Duct resistance
- Duct bend resistance: the tighter the bend, the higher the resistance
- Terminal fittings: end brackets, Y fittings, adapters, etc.
- The distance of the duct opening away from a surface that could obstruct air flow.
- Cowl, scoop or funnel resistance
- Screen resistance
- Dorade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

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

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 6 is a graph of the minimum blower system output required versus net compartment volume.

FIGURE 6 Minimum Blower System Output





EXHAUST BLOWER SYSTEM AIR FLOW DETERMINATION

During the process of rating a blower, curves of blower performance are usually developed and are required to be tested in accordance with the UL 1128 Marine Blower standard. The curves show air flow for various static pressures and record the current and RPM of the blower at these air flows. See Figure 7 for typical blower curves.

VENTILATION SYSTEM DESIGN

In designing a powered ventilation system, it is helpful to have an 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. The data is not to be used to determine compliance with the regulation but only to estimate the blower system output. See Table II below.

TABLE IV 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%

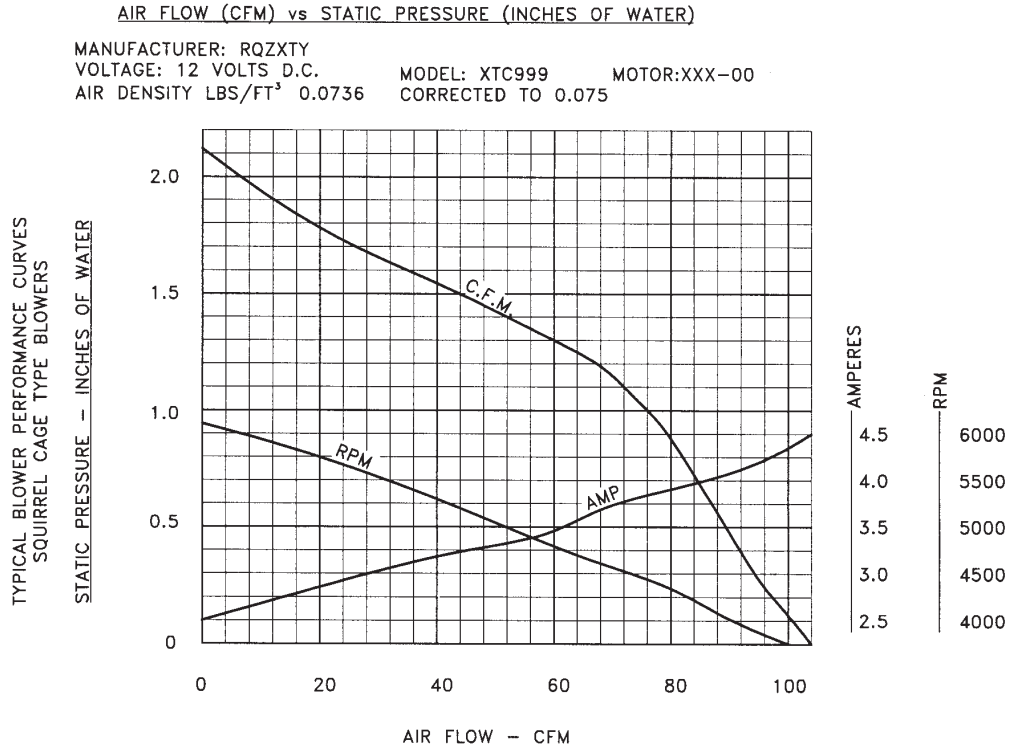
NOTE:

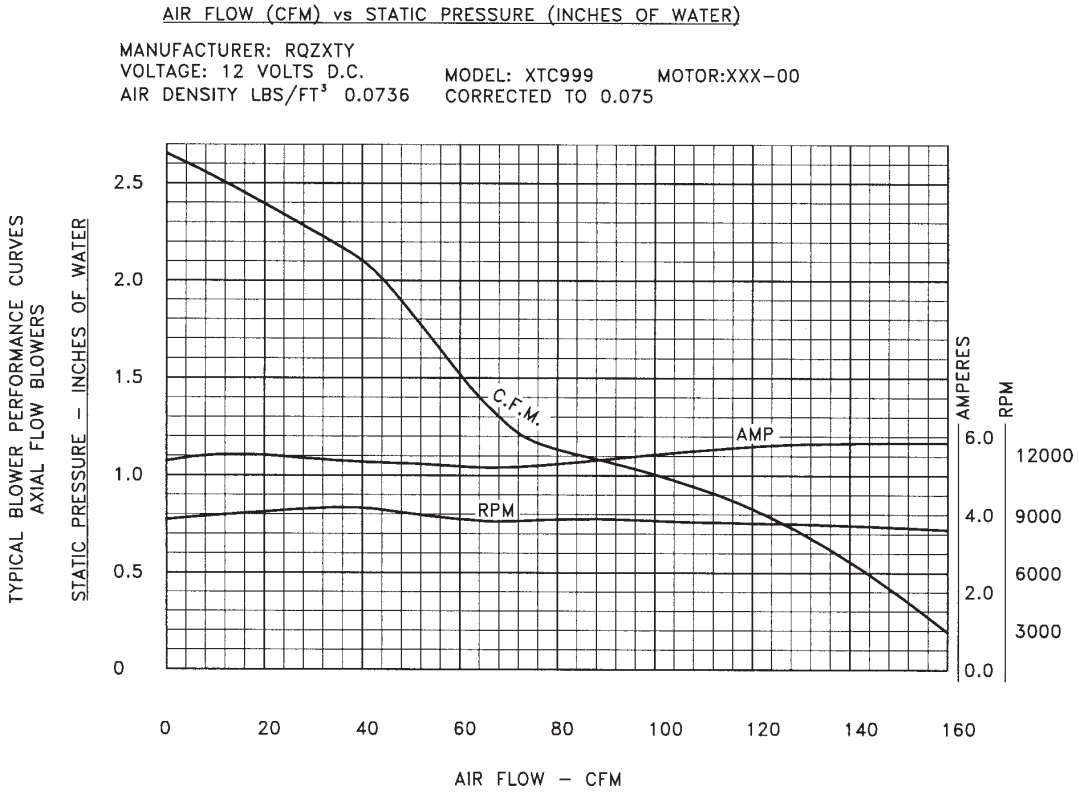
Lower resistance items may be selected resulting in an improved system efficiency

Example: A contemplated blower system has a 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 propeller design and other factors selected by the blower manufacturer, the estimated effects of the airflow resistances in Table II 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 must be used to check the actual output of the ventilation system as installed in the boat.

FIGURE 7 Typical Blower Performance Curves





Obtaining the air flow of an exhaust blower system, using the blower performance curves, is an easy task. The following outlines three methods which may be used on an installed system:

METHOD 1 — Current Measurement.

See Figure 8.

Step 1. Connect an ammeter into the wiring going to the blower.

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.

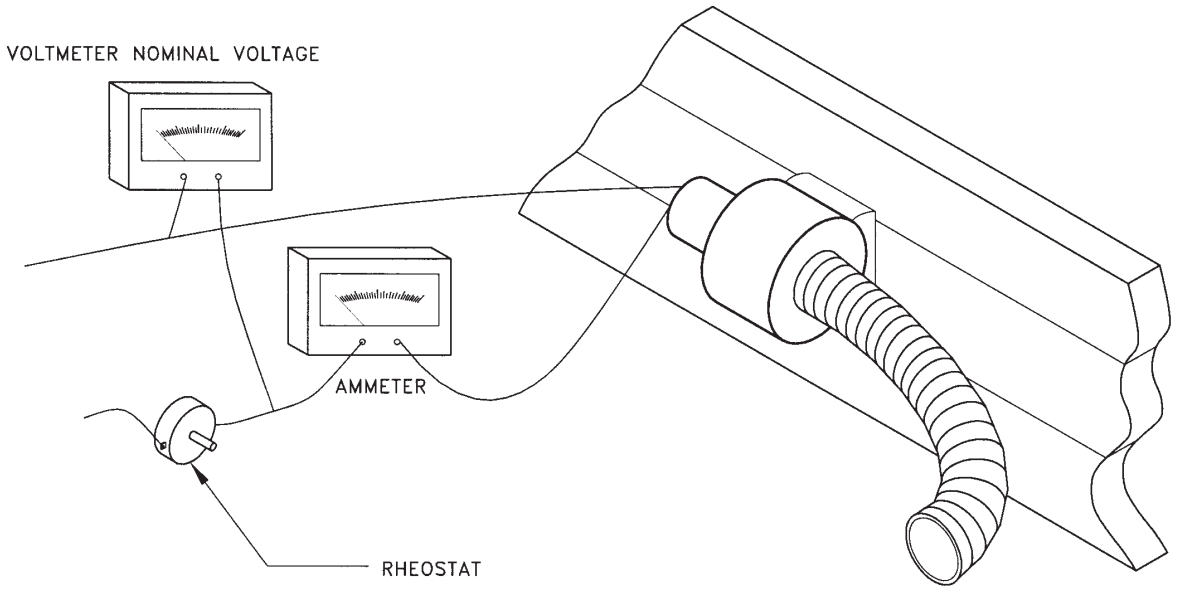
Step 3. Read the current draw in amperes. The engine should not be operating while taking the reading.

Step 4. Enter the performance curves at the determined amperage and read the air flow in cubic feet per minute (c.f.m.)

NOTE:

This current measurement method does not provide accurate results for in-line, axial flow blowers.

FIGURE 8 Method 1 — Current Measurement



METHOD 2 — RPM Measurement.

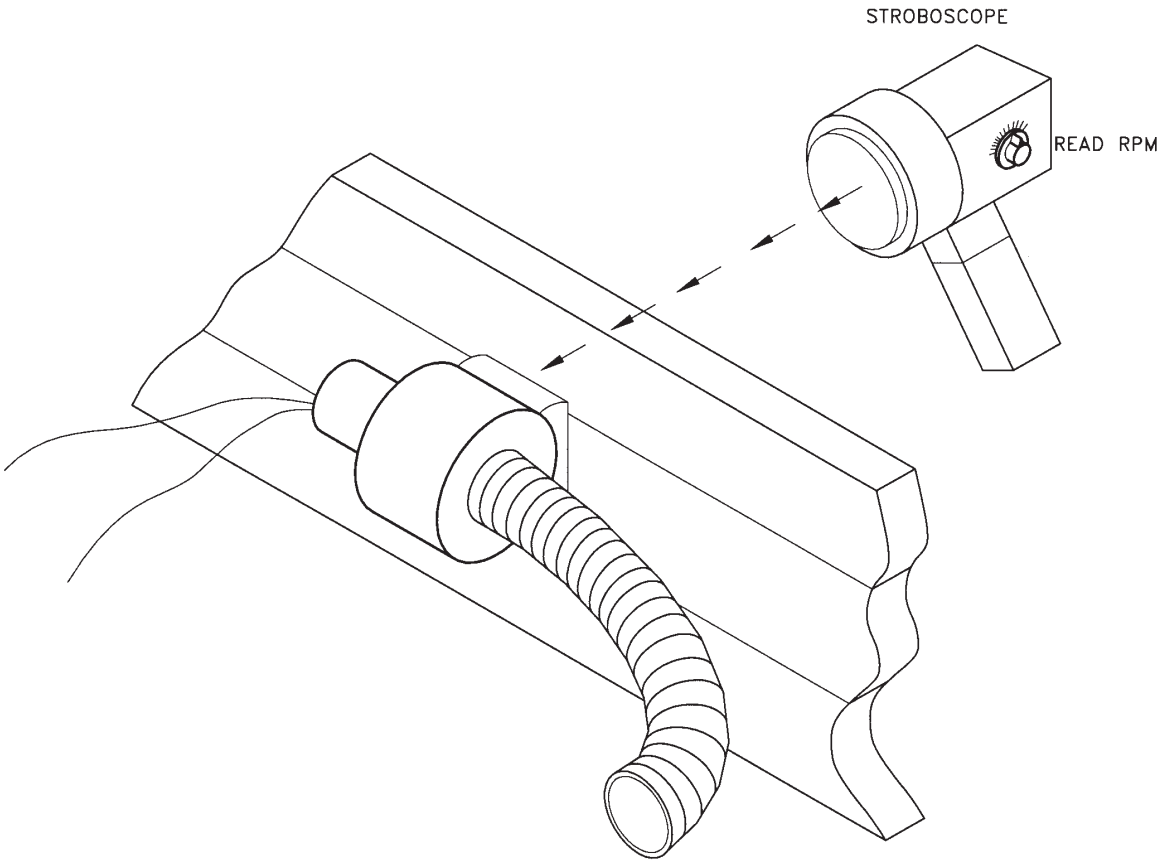
See Figure 9

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

Step 2. Determine the RPM of the blower. A stroboscope is one instrument that is used to read RPM of rotative machinery. The boat's engine should not be operating during the testing process. Carefully follow the test procedures supplied with the instrument to avoid a false reading.

Step 3. Enter the performance curves at the determined RPM and read the air flow in cubic feet per minute (c.f.m.)

FIGURE 9 Method 2 — RPM Measurement



The above methods are accurate for determining the effective air flow of an exhaust blower system with a squirrel cage (radial fan). There are many instruments that measure air velocity in feet per minute.

METHOD 3 — Air Velocity Measurement

To obtain air flow in cubic feet per minute:

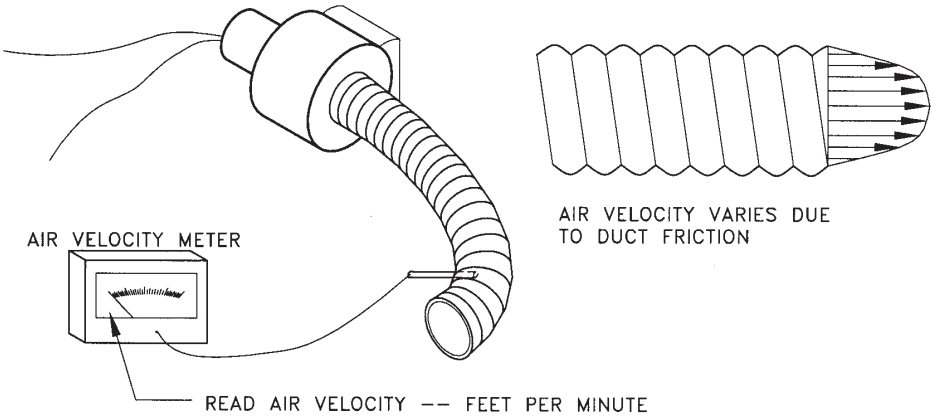
Step 1. Determine the cross section of the duct, at the measuring point, in square feet.

Step 2. Determine 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 10.

Step 3. Multiplication of the cross section in square feet by the average air velocity in feet per minute will provide the air flow in cubic feet per minute (c.f.m.).

This method depends on the ability to determine an accurate average air velocity. This is probably the only method that will work for axial flow type blowers. It is possible to develop a correlation between this method and Methods 1 or 2 in which case this method may prove satisfactory. If you are familiar with duct air flow theory and the associated formulas, all the above could be used.

FIGURE 10 Method 3 — Air Velocity Measurement



TO COMPLY WITH THE LAW

Having determined the net compartment volume, Column 1:

- ***Is the exhaust blower system output at least that required in Column 3 when the engine is not operating?***

FEDERAL LAW:

183.610 Powered ventilation system.

(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.

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. 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 normal operation are associated with carburetor boil-off 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.

TO COMPLY WITH THE LAW

Is the intake opening of the exhaust blower duct:

- ***Located in the lower one-third of the compartment?***
- ***Above the normal level of accumulated bilge water?***

FEDERAL LAW:

183.610 Powered ventilation system.

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

This section authorizes the use of more than one blower in a compartment in order to provide the required rated blower capacity and the required blower system output. Using two or more blowers in combination means they must be energized together. The use of one or more blowers is discussed in a previous section.

FEDERAL LAW:

183.610 Powered ventilation system.

(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.

If a blower is required on a boat, there must be a label affixed to the boat. The label must be located so that the following requirements are satisfied:

- It must be near the ignition switch(es), and
- It must be able to be seen by an operator who is in a normal position to operate the ignition switch(es)

Examples of Label Locations

1. If the ignition switch(es) is (are) on the side of a console then the label(s) should be on the top visible surface of the console above the switch(es)

2. If two ignition switches are located next to each other, then one label serves both switches.

3. If two or more ignition switches are provided for one engine as might be the case with a boat with two steering stations then a label must be affixed to each location. A boat with a flying bridge has two steering stations.

4. If a boat is equipped with auxiliary gasoline powered equipment such as a generator, then the ignition switch location for this equipment must have a label.

5. If the switch is located in a position which may not be readily visible from the helm; i.e. on the side of a console, two labels are needed. Locate one label near the switch and the other on the console in a location visible from the helm, near the throttle.

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

Additional information my be included on the label.

<u>The following is an example of a prepared label:</u>

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

TO COMPLY WITH THE LAW

- *Is a blower required?*
  If YES, then:

- *Is there a label installed?*
  If YES, then:

- *Is there a label near each engine and generator ignition switch, and is the label located so that the boat operator can read it?*

- *Does the label contain the information required by 183.610(f)(3)?*

Natural Ventilation

FEDERAL LAW:

183.620 Natural ventilation system.

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

(1) Contains a permanently installed gasoline engine;

Natural ventilation is a term applied to the provisions of air flow inside a compartment that is induced by non-powered means; i.e. ducts, louvers, clamshells, etc. The requirements for the natural ventilation system are described in detail in 183.630. Any compartment that has a permanently installed gasoline fueled engine must have natural ventilation. Engines for propulsion and auxiliary equipment are included.

EXCEPTION:

Compartments qualified as open to the atmosphere do not require additional ventilation. See 183.605 for the definition of open to the atmosphere.

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 Title 33 CFR Part 183, Subpart I, Electrical Systems, and Title 33 CFR Part 183, Subpart J Fuel Systems. The use of "permanently installed" is to highlight its difference from the use of "portable equipment".

TO COMPLY WITH THE LAW

- *Is there a gasoline fueled engine permanently installed in the compartment?*

  If YES, then one of the following must be answered YES.

- *Is the compartment open to the atmosphere as defined under 183.605? or*

- *Is there a natural ventilation system provided? See 183.630 for requirements.*

FEDERAL LAW:

183.620 Natural ventilation system.

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

(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;

(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.

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.

ADJOINING COMPARTMENTS — The 2% Rule

Natural ventilation for a compartment adjacent to a compartment requiring ventilation is needed if the total area of all openings between these compartments is more than 2% of the separating structure. If this area is equal to or less than 2%, natural ventilation is not needed for that adjacent compartment.

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, pilot house, navigation, work area and other similar people oriented uses. The uses contrast with engine and fuel tank compartments.

TO COMPLY WITH THE LAW

- *Is the adjoining compartment requiring ventilation separated by a bulkhead or other structure where the total area of all openings is more than 2% of the area of said bulkhead or other structure?*

  If YES, natural ventilation is required for said adjoining compartment except as indicated below.

- *Is the adjoining compartment vented to a compartment requiring ventilation?*

  If YES, then no additional ventilation is required.

- *Is the adjoining compartment:*
  - *an accommodation compartment?*
  - *above the compartment requiring ventilation?*
  - *separated by a deck or other structure?*

  If YES to all items, then natural ventilation is not required.

- *Is the adjoining compartment to a compartment requiring ventilation, separated by a bulkhead or other structure with the total area of openings equal to or less than 2% of the area of the bulkhead or other structure?*

  If YES, natural ventilation is not required.

FEDERAL LAW:

183.620 Natural ventilation system.

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

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

OPEN TO THE ATMOSPHERE

Compartments that are open to the atmosphere do not require additional ventilation.

FUEL TANK COMPARTMENTS

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.

TO COMPLY WITH THE LAW

- ***Does the compartment contain a permanently installed fuel tank and an electrical component that is not ignition protected?***

If YES, then one of the following must be answered YES.

- ***Is the compartment open to the atmosphere as defined in 183.605, or***
- ***Is natural ventilation provided? See 183.630 for requirement.***

FEDERAL LAW:

183.620 Natural ventilation system.

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

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

OPEN TO THE ATMOSPHERE

Compartments that are open to the atmosphere do not require additional ventilation.

FUEL TANK 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. For permanently installed fuel tanks, 183.620 (a)(3) and (5) of this guideline apply.

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.

TO COMPLY WITH THE LAW

- *Is there a fuel tank in the compartment that vents into the compartment?*

If YES, then one of the following must be answered YES:

- *Is the compartment open to the atmosphere, as defined under 183.605, or*
- *Is there a natural ventilation system which meets the requirements of 183.630?*

FEDERAL LAW:

183.620 Natural ventilation system.

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

(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 Sec.183.5) is to be used to determine the permeability rate.

OPEN TO THE ATMOSPHERE

Compartments that are open to the atmosphere do not require additional ventilation.

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.

THE TEST

There are two ways that tests may be conducted to obtain the permeability rate of non-metallic materials used for fuel tanks. The two ways are differentiated by how the test sample is prepared.

1. A test sample of an actual fuel tank may be subjected to the test procedure, or

2. A 6" x 6" test sample from a piece of fuel tank material mounted on a standardized container and then subjected to the test procedures with the results extrapolated mathematically to obtain the performance of a full sized tank.

Both of these methods have been used experimentally and appear to correlate. Permeability rate data should be obtained from the tank manufacturer.

The fuel used in the test, to represent gasoline, has been standardized as ASTM D 471 Reference Fuel C.

REQUIREMENTS FOR VENTILATION

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.

LESS THAN ONE CUBIC FOOT

If a fuel tank compartment's net volume is less than one cubic foot, it is required to have natural ventilation if the fuel tank's permeability rate is more than 1.2 grams total fuel loss in 24 hours.

ONE OR MORE CUBIC FEET

A fuel tank compartment with a net volume of one or more cubic feet is required to have natural ventilation if the fuel tank's permeability rate is more than 1.2 grams of fuel loss per each cubic foot of net compartment volume in a 24 hour period.

TEST PROCEDURE:

1. Obtain the permeability rate of the non-metallic fuel tank for a 24 hour period in terms of grams of fuel loss.
2. Determine the net compartment volume for the fuel tank compartment.
3. Calculate the grams of fuel loss per cubic foot of net compartment volume.

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.

Conclusion: The fuel tank compartment in the example does not need natural ventilation to meet the requirements of the regulation.

Question: What is the minimum net compartment volume before natural ventilation is required in the above example?

Answer: 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.

NOTE:

Some non-metallic materials in current use for gasoline fuel tanks have a permeability rate such that natural ventilation of the fuel tank compartment will be required in order to comply with this section of the regulation.

TO COMPLY WITH THE LAW

- *Is the fuel tank non-metallic?*

  If YES, then:

What is the total fuel loss of the fuel tank as determined by a PERMEABILITY TEST conducted for a period of 24 hours using Reference Fuel C at 40 ± 2 degrees Celsius as described in ASTM Standard D 471?

1. *Is the fuel tank compartment's net volume less than one cubic foot?*

   If NO, see 2. If YES, then:

   a. Is the permeability rate of the tank 1.2 grams or less in 24 hours?

   If NO, see b. If YES, then no natural ventilation required.

   b. Is the permeability rate of the tank more than 1.2 grams in 24 hours?

   If NO, see 2. If YES, then natural ventilation required.

2. *Is the fuel tank compartment's net volume one or more cubic feet?*

   If NO, see 1. If YES, then:

What is the permeability rate of the tank, per cubic foot of net compartment volume, in 24 hours?

   a. Is it 1.2 grams per cubic foot or less?

   If NO, see b. If YES, then no natural ventilation required.

   b. Is it more than 1.2 grams per cubic foot?

   If NO, see a. If YES, then natural ventilation required.

FEDERAL LAW:

183.620 Natural ventilation system.

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

FEDERAL LAW:

183.620 Natural ventilation system.

(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.

The discussion of this section is included in 183.620(a)(2).

FEDERAL LAW:

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.

NATURAL VENTILATION SYSTEM

A natural ventilation system must have two elements:

- a supply opening or a duct
- and an exhaust opening or duct.

NOTE:

An exhaust duct may serve for both the natural ventilation system and the powered ventilation system.

SUPPLY

The supply opening or duct may take air in from any of the following: See Figure 11.

1. **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.

2. **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).

3. **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.

EXHAUST

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

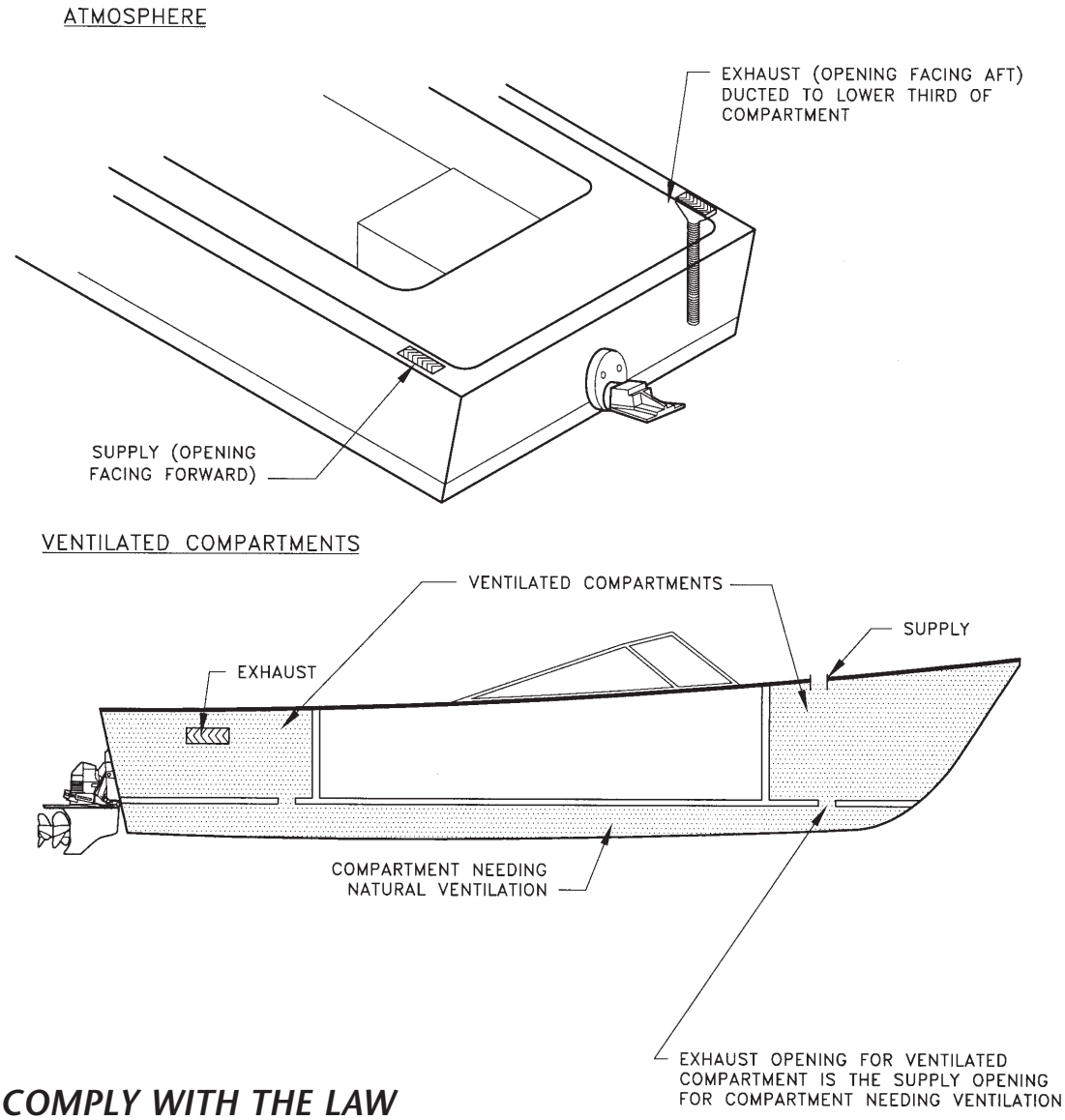
1. **The Atmosphere** — If the exhaust discharge point is directly into the atmosphere, there must be a duct from the air and/or vapors intake point to the exhaust discharge point, which is usually at the deck or hull side near the deck.

2. **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.

FIGURE 11 Natural Ventilation and Exhaust Options



TO COMPLY WITH THE LAW

One of the following must be answered YES:

- ***Is the supply opening or duct from the atmosphere, a ventilated compartment with intake on the exterior surface of the boat or a compartment that is open to the atmosphere?***

And, one of the following must be answered YES:

- ***Is there an exhaust opening into a ventilated compartment other than that in which the supply is located, or is there an exhaust duct to the atmosphere?***

FEDERAL LAW:

183.630 Standards for natural ventilation.

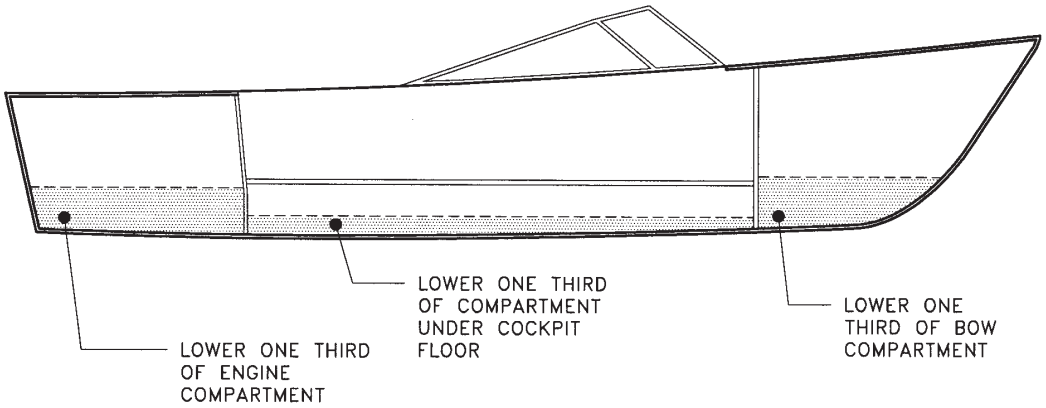
(b) Each exhaust opening or exhaust duct must originate in the lower third of the compartment.

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 12 Lower Third Levels



TO COMPLY WITH THE LAW

- ***Are exhaust openings and duct intake openings located in the lower third of the compartment?***

FEDERAL LAW:

183.630 Standards for natural ventilation.

(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.

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.

TO COMPLY WITH THE LAW

- ***Are both supply and exhaust openings and ducts located above the normal accumulation of bilge water?***

FEDERAL LAW:

183.630 Standards for natural ventilation.

(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 compartments; and

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

The minimum total cross-section of all supply openings and ducts in a compartment is determined by the use of the formula. The formula is also used to determine the minimum total cross-sectional area of all exhaust openings and ducts in a compartment.

THE FORMULA

$$A = 5 \text{ Ln } (V / 5)$$

The formula stated in words is:

"the cross-sectional area of either the supply openings and ducts or the exhaust openings and ducts (in square inches) equals five times the natural logarithm of one fifth the net compartment volume in cubic feet."

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 13 is a Table of Natural Logarithms.

Multiply the natural logarithm by 5.

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

	n	n (2.3026)	n (0.0974-3)
This table gives the natural or Naplerian 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 adding n times 2.3026 (or n times 3.6974) to thelogarithm. Base e = 2.71828	1	2.3026	0.6974-3
	2	4.6052	0.3948-5
	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

Avg Number	0	1	2	3	4	5	6	7	8	9	Avg 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	21
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

Avg Number	0	1	2	3	4	5	6	7	8	9	Avg 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	15
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	13
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 13 Natural Logarithms

Figure 14 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.

EXAMPLE

The net volume of a compartment is 80 ft.^{3}. Go to Figure 14 and enter the graph with 80 ft.^{3} and read the area of the openings and ducts from the vertical scale at 13.92 square inches.

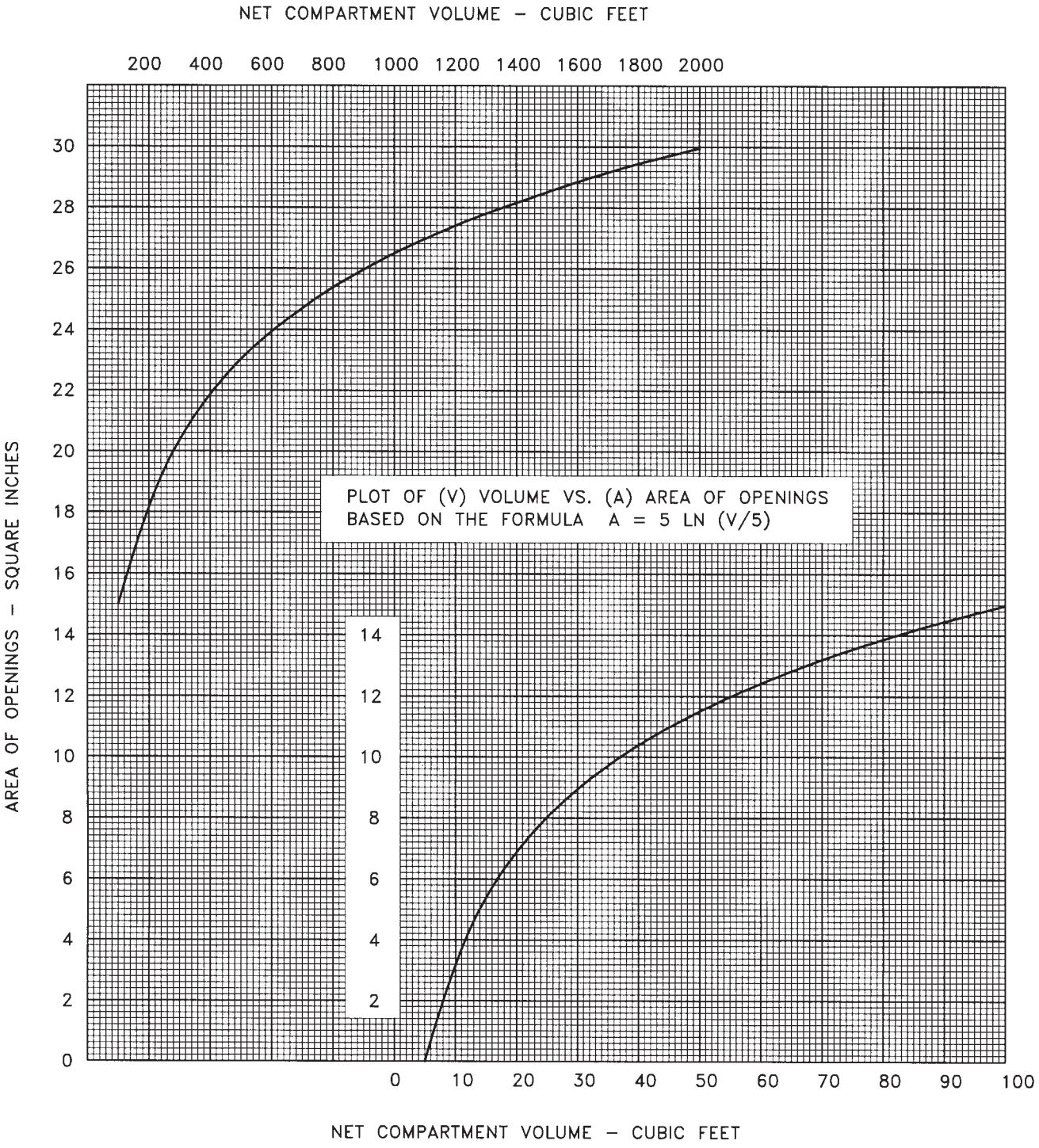
The total cross-section of all supply openings and ducts into the compartment must be equal to or exceed 13.9 in^2. with the minimum area of 3in^2 per opening.

The aggregate area of exhaust openings and ducts must equal or exceed 13.9 in^2.

TO COMPLY WITH THE LAW

- ***Is the total area of exhaust openings and ducts for the compartment and the included connecting compartments at least 5 Ln (V/ 5) square inches?***

FIGURE 14 Area of Openings



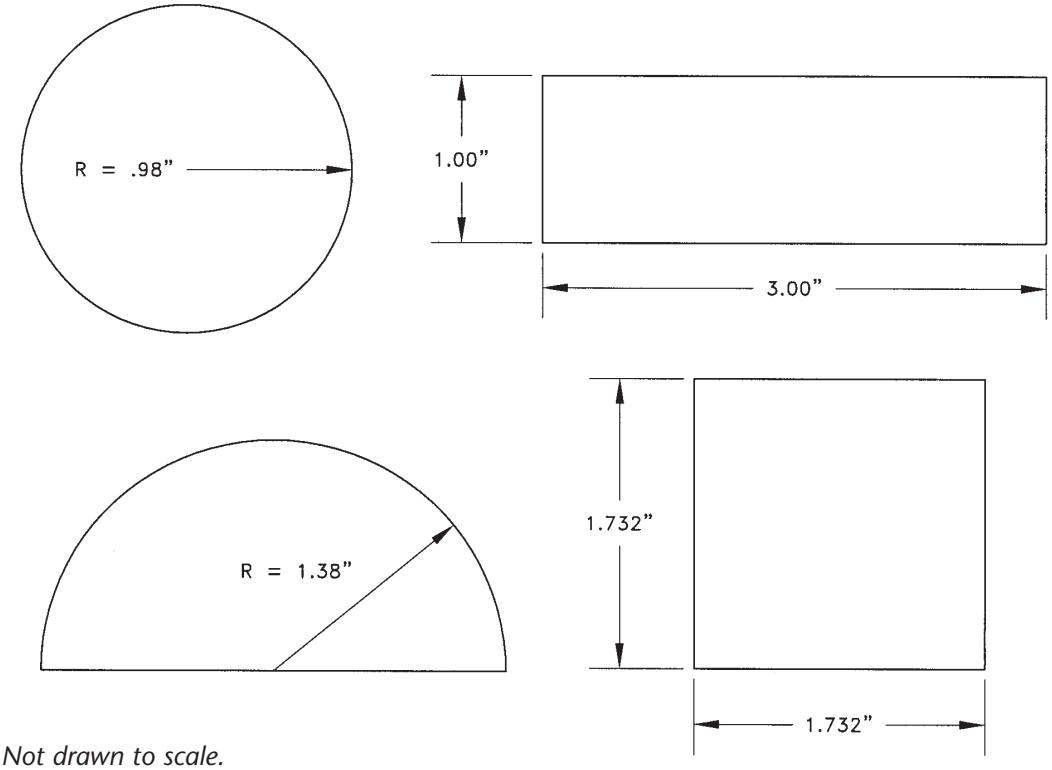
FEDERAL LAW:

183.630 Standards for natural ventilation.

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

The shape of the opening is not specified but to give an idea of what three square inches looks like, Figure 15 depicts a few common geometric shapes, each of which is three square inches.

FIGURE 15 Three Square Inches



Note: Not drawn to scale.

The regulation requires each opening and each duct, whether a supply or an exhaust, to have more than 3.0 square inches in cross-sectional area. Therefore, openings and ducts must be larger than those shown in Figure 15.

TO COMPLY WITH THE LAW

- ***Is each opening and each duct, regardless of whether it is a supply or an exhaust, more than 3.0 square inches in cross-sectional area?***

FEDERAL LAW:

183.630 Standards for natural ventilation.

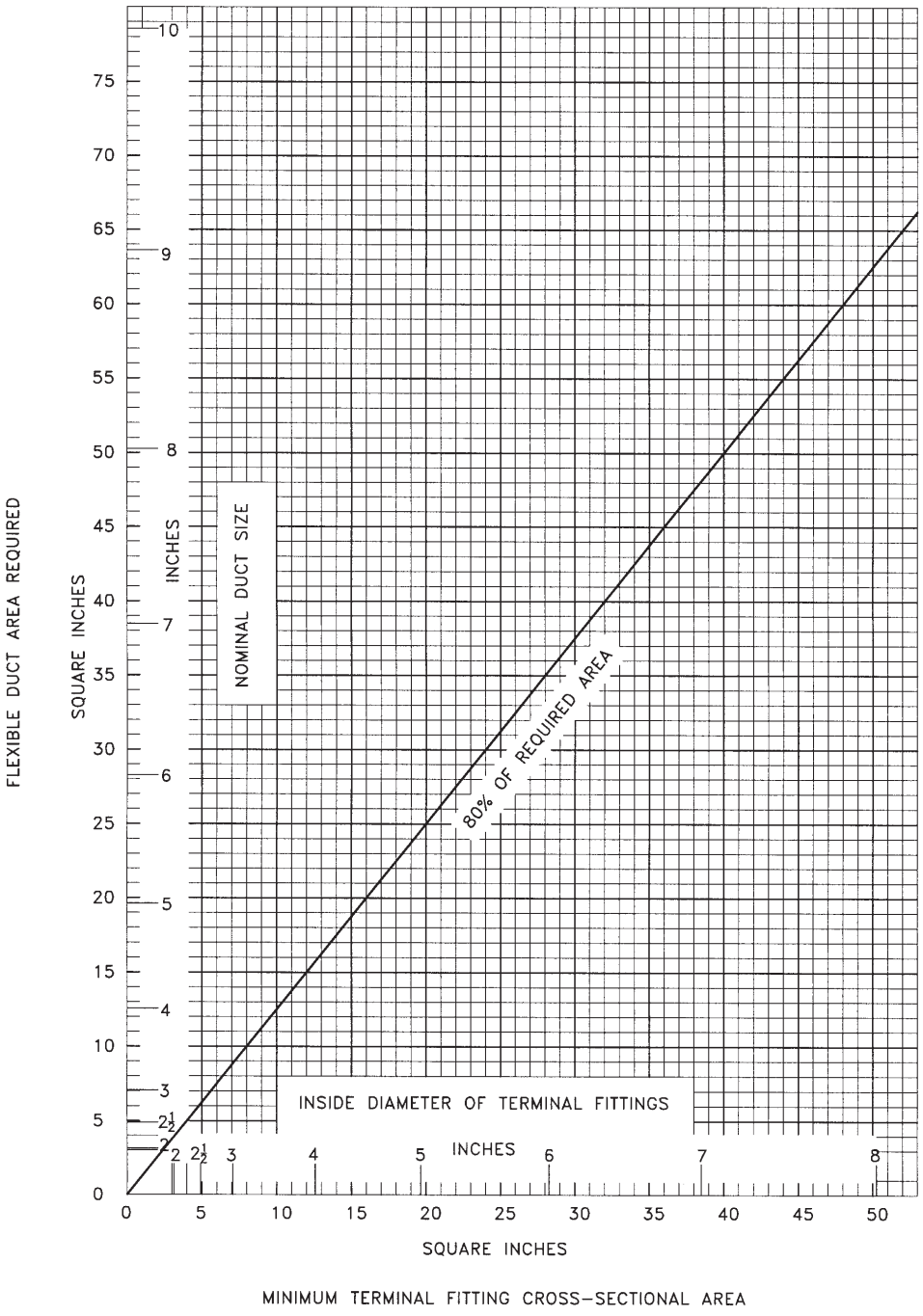
(f) The minimum internal cross-sectional area of the terminal fittings for flexible ventilation ducts installed to meet the requirements of paragraph (d) of this section must not be less than 80 percent of the required internal cross-sectional area of the flexible ventilation duct.

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 16 Terminal Fitting Area



TO COMPLY WITH THE LAW

- ***Is the cross-section of the terminal fitting for a flexible duct at least 80% of the cross-sectional area required for the duct?***

APPENDIX — References and Resources

The following standards are referenced in this regulation:

AMCA 210-74	"Laboratory Methods of Testing Fans for Aerodynamic Performance Rating". Applies to section 183.610 (b).
ASTM D 471	"Test Method for Rubber Property — Effect of Liquids". Applies to section 183.516.
UL 1128	"Marine Blowers". Applies to section 183.610 (b).

The following standards are referenced in this compliance guideline:

NEC	"National Electrical Code".
SAE J1171	"External Ignition Protection of Marine Electrical Devices".
UL 1500	"Ignition-Protection Test for Marine Products".

AMCA standards are available from the Air Movement and Control Association International, Inc., 30 West University Drive, Arlington Heights, IL 60004-1893, (847) 394-0404.

ASTM standards are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, (610) 832-9585.

NEC: NFPA standards are available from the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, (617) 770-3000.

SAE standards are available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096, (412) 776-4841.

UL standards: Contact Underwriter Laboraties for information on obtaining UL standards. Underwriter Laboratories, P.O. Box 13995, 12 Laboratory Drive, Research Park, NC 27709, (919) 549-1400.