

# MSC Guidelines for Carbon Dioxide Fire Suppression Systems

Procedure Number: E1-06

Revision Date: 08/07/2017

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## References

- a. Title 46 CFR 34.15 (Subchapter D)
- b. Title 46 CFR 76.15 (Subchapter H)
- c. Title 46 CFR 95.15 (Subchapter I)
- d. Title 46 CFR 108.431 (Subchapter I-A)
- e. Title 46 CFR 118.410 (Subchapter K)
- f. Title 46 CFR 132.310 (Subchapter L)
- g. Title 46 CFR 181.410 (Subchapter T)
- h. Navigation and Vessel Inspection Circular (NVIC) 6-72, "[Guide to Fixed Fire Fighting Equipment aboard Merchant Vessels](#)"
- i. National Fire Protection Association (NFPA) 12, 1996 Edition, "Carbon Dioxide Type Extinguishing Systems"
- j. COMDINST M16714.3, "Equipment List", Equipment Class 162.038
- k. Marine Safety Center Technical Note (MTN) 01-04, "Automatic Carbon Dioxide Extinguishing Systems for Small Unoccupied Spaces and Machinery Enclosures"
- l. International Convention for the Safety of Life at Sea (SOLAS)
- m. [Maritime Safety Committee Circular \(MSC\) 847](#) dated June 12, 1998 and [corrections](#) dated August 16, 1999
- n. International Code of Safety for High Speed Craft, 2000 (2008 Edition)

## Contact Information

If you have any questions or comments concerning this document, please contact the Marine Safety Center by e-mail or phone. Please refer to Procedure Number: **E1-06**.

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## Responsibilities

The submitter shall provide sufficient documentation and plans to indicate compliance with the applicable requirements. This includes protected space volume, design calculations, a component list from a USCG type-approved manual, piping materials specifications and arrangement plans. The submission shall be made in triplicate.

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## General Guidance:

### General

CO<sub>2</sub> system requirements outlined in 46 CFR Subchapters I, D, and H are similar in wording; further, Subchapters K and T requirements are similar in wording. Despite any dissimilarity in CO<sub>2</sub> fire suppression systems regulations, the installations must be in accordance with the appropriate USCG Type Approved manual. Acceptable arrangements are provided in the manuals.

- ❑ All CO<sub>2</sub> systems must be “USCG Type Approved.” Lists of USCG Type Approved systems are accessible in the Coast Guard Marine Information Exchange (CGMIX) system at: <http://cgmix.uscg.mil/> by searching the following Equipment Classes:
    - 1) Class 162.029: Pre-engineered systems (for small spaces; no modifications allowed)
    - 2) Class 162.038: Engineered systems (for large spaces; complete system design is required) Equipment Class 162.038
  - ❑ Calculations, as outlined in the approved manuals, must be submitted to justify system design.
  - ❑ When CO<sub>2</sub> systems are installed in enclosed ventilation systems for rotating electrical propulsion equipment, additional rules apply. Refer to the appropriate subchapter for guidance.
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### Pipe and Fittings:

- ❑ Acceptable material specifications, standards and pressure classes are listed in the approved manuals. Fittings must have a burst pressure of not less than 6,000 psi.
  - ❑ Pipe and fittings made of ferrous materials must be protected against corrosion (galvanized).
  - ❑ Piping equal to or less than ¾ inch (nps) shall be at least schedule 40; piping larger than ¾ inch (nps) shall be at least schedule 80.
  - ❑ Stainless steel pipe having the required flow area is acceptable in lieu of galvanized steel pipe. Materials shall be acceptable as per 46 CFR 56.60 and reference (i).
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## General Guidance (continued):

### Component Requirements and Arrangements

- ❑ System components must be listed and labeled by an independent laboratory. A component from a different system, even from the same manufacturer, must not be used unless included in the approval of the installed system.
- ❑ A pressure switch or other device must be provided to automatically shut down power ventilation serving the protected space and engines that draw air from the protected space prior to the discharge of the agent into the space. Pressure switches shall be located outside of the protected space.
- ❑ Engine shutdowns may be omitted for CO<sub>2</sub> systems on Subchapter T vessels. Alternative arrangements for Subchapter T vessels may be accepted by the cognizant OCMI. If this option is exercised, the submitter must demonstrate that the amount of CO<sub>2</sub> consumed by the engine(s) does not significantly impact the amount of agent available for suppressing the fire. For further details, please see the Office of Design & Engineering Standards, Life Saving & Fire Safety Division (CG-5214) policy for details on this subject:

[http://www.uscg.mil/hq/cg5/cg5214/fixedfireext\\_spv.asp](http://www.uscg.mil/hq/cg5/cg5214/fixedfireext_spv.asp)

- ❑ Spaces larger than 6,000 ft<sup>3</sup> (300 lbs or more of agent required) require two distinct actions to activate the system. One action shall open the valve in the piping which conveys the gas to the protected space and a second control shall discharge the gas from its storage cylinders.
- ❑ **FOR SOLAS VESSELS:** Two distinct actions are required to activate systems protecting cargo pump room or category A machinery spaces, regardless of the space volume, and other system protecting spaces larger than 6,000 ft<sup>3</sup>. (This is based on an interpretation of MSC resolution MSC.256(84) provided by the Office of Vessel Activities, Domestic Vessel Compliance Division (CG-5431) Marine Inspection Notice 02-10).
- ❑ **FOR SOLAS VESSELS:** Positive means shall be provided to ensure the valve in the distribution piping is opened prior to the gas being released from the storage cylinders (FSS Code Ch 5/2.2.2). Interlocks on the actuation controls must be provided to meet this requirement. Posted procedures are NOT acceptable for meeting this requirement.

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## General Guidance (continued):

- ❑ Remote controls for releasing the extinguishing agent must be located immediately outside the primary exit. Remote controls must be located in a break-glass enclosure or other enclosure listed in the type approved manual.
- ❑ Pull cables used to activate the system must be protected or enclosed in steel pipe or conduit.
- ❑ Systems protecting more than one space must have a manifold with a normally closed stop valve for each space protected.
- ❑ Pressure relief valves or safety outlets must be installed in CO<sub>2</sub> distribution manifolds that contain stop valves. The relief valve or safety outlet shall be set to relieve between 2,400 and 2,800 psi.
  - 1) **FOR SOLAS VESSELS:** Pressure relief valve discharge shall be piped to the open deck (FSS Code Chapter 5/2.1.2.4)
- ❑ Time delays and alarms are required for the following spaces and must meet the following requirements : {(95.15-10(f), 118.140(b)(9), 181.410(b)(9), 108.445(a) & Approved Manuals)}
  - 1) A system which protects a space having a volume of 6,000 ft<sup>3</sup> or larger (the system contains at least 300 lbs of agent) in which personnel normally work or access while the vessel is underway must be fitted with a time delay and alarm.
  - 2) A system which protects a space having a volume less than 6,000 ft<sup>3</sup> (the system contains less than 300 lbs of agent) AND the space does not have a horizontal escape must be fitted with a time delay and alarm.
  - 3) Small unoccupied spaces and machinery enclosures commonly used in offshore service have several allowable deviations from the regulations for arrangements, controls and alarms. Refer to [MSC Technical Note \(MTN\) 01-04](#) for details.
  - 4) The alarm must be powered by the CO<sub>2</sub> or other N<sub>2</sub>; electrically operated alarms are not acceptable.
  - 5) Alarms must sound for a minimum of 20 seconds or the time necessary to escape the space, whichever is greater, before the agent is released into the space

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## General Guidance (continued):

- 6) The gas supply connection for the alarm shall be connected upstream of the time delay such that the alarm will sound during the activation delay period.
- ❑ A gas activated valve or device, including time delays and stop valves, must be capable of override at the valve or device. The devices shall be located outside of the protected space.
- ❑ A manually operated lockout valve is required for a system protecting a space having a volume over 6,000 cubic feet. The lockout valve must be located in the discharge manifold prior to the distribution stop valve. (46 CFR 108.444, 118.410.(f)(7), 181.410(f)(7))
- ❑ An odorizer must be provided in the CO<sub>2</sub> systems distribution manifold, other than for small spaces meeting the following requirements: (46 CFR 95.15-60, 108.446, 118.410(h), 181.410(f)(8) and CG-Eng Policy letter 02-14):
  - 1) For gas turbine enclosures located on open decks of OCS facilities, system must contain no more than 300 lbs of CO<sub>2</sub>. For all other installations, the system contains no more than 100 lbs of CO<sub>2</sub>
  - 2) The protected space is not normally entered while is underway,
  - 3) Escaping CO<sub>2</sub> would not enter an adjacent enclosed space.
- ❑ Piping passing through accommodation spaces must not be fitted with drains or other openings within such places.
- ❑ **FOR HIGH SPEED CRAFT** :: Activation of the fixed fire fighting system shall be provided in the pilothouse (Reference (n), 7.7.3.1))
- ❑ Small unoccupied spaces and machinery enclosures commonly used in offshore service have several allowable deviations from the regulations for arrangements, controls and alarms. See reference (k) for details.

## Calculations of Agent Required

- ❑ The boundaries of the protected space should be gas-tight such that the amount of escaping gas is minimized. Opening such as watertight doors, side ports and ventilation openings should be capable of being closed from outside the protected space. The gas tight boundaries are the basis for determining the protected space gross volume.

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General Guidance  
(continued):

- ❑ **FOR SOLAS VESSELS:** Doors fitted in boundary bulkheads of Category A machinery spaces shall be reasonably gastight and SELF\_CLOSING to be considered as a boundary for the protected spaced. For OSVs having an “extended machinery space” , as defined in Marine Technical Note 02-00, which includes the space adjacent to the engine room, the entire “extended space” must be considered in determining the protected space gross volume.
- ❑ A fixed gas fire fighting system may protect more than one space. The quantity of the agent must be calculated for the largest of the spaces protected. If compartments are not entirely separate, the combined volume shall be used to determine the amount of CO2 required.
- ❑ For a vessel sailing domestic and internationally, the agent required shall be calculated in accordance with domestic and SOLAS requirements; the larger of the two masses shall indicate the amount of agent required.
- ❑ **FOR DOMESTIC ONLY VESSELS:** The mass of agent for each space is equal to the gross volume of the space divided by the appropriate flooding factor noted in Table 1(below). Cargo spaces use a flooding factor of 30 regardless of the protected space volume.

❑  $\text{mass of agent (lbs)} = \text{gross volume (ft}^3\text{)} / \text{flooding factor (ft}^3\text{/lb)}$

See attached sheet (Attachment 1) for assistance if calculations incorporate engine room casings (46 CFR 95.15-5(d)(2)).

Gross volume of compartment, cubic feet		Factor
Over	Not Over	
.....	500	15
500	1,600	16
1,600	4,500	18
4,500	50,000	20
50,000	.....	22
Cargo Spaces	.....	30

Note: See CFR 95.15-5(d)(3) for exceptions. Also see CFR 95.15-5(d)(2) for engine room casing exceptions.

**Table 1: Flooding Factor Based on Compartment Gross Volume**

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## General Guidance (continued):

- ❑ **FOR SOLAS VESSELS**
- ❑ Air receiver volume, converted to free air volume, shall be added to the machinery space gross volume unless the air receiver safety valves are vented outside of the protected space. (FSS Code 5/2.1.1.2)
  - ❑ Air receiver free air volume (ft<sup>3</sup>) = {air receiver pressure (psi) \* air receiver volume (ft<sup>3</sup>)} / 14.7 (psi)
  - ❑
  - ❑ **For cargo spaces**, the amount of agent required is based on 30% of space gross volume divided by the flooding factor. (FSS Code 5/2.2.1)
    - ❑ mass of agent (lbs) = {.30 \* gross volume (ft<sup>3</sup>)} / 8.97 (ft<sup>3</sup>/lb)
    - ❑ mass of agent (kg) = {.30 \* gross volume (ft<sup>3</sup>)} / .56 (m<sup>3</sup>/kg)
  - ❑ **For machinery spaces**, the amount of agent required is based on 40% of space gross volume, excluding casing, divided by the flooding factor. (FSS Code 5/2.2.1.2)
    - ❑ mass of agent (lbs) = {.40 \* gross volume (ft<sup>3</sup>)} / 8.97 (ft<sup>3</sup>/lb)
    - ❑ mass of agent (kg) = {.40 \* gross volume (ft<sup>3</sup>)} / .56 (m<sup>3</sup>/kg)
  - OR
  - ❑ 35% of space gross volume, including casing, divided by the flooding factor.
    - ❑ mass of agent (lbs) = {.35\* gross volume (ft<sup>3</sup>)} / 8.97 (ft<sup>3</sup>/lb)
    - ❑ mass of agent (kg) = {.35\* gross volume (ft<sup>3</sup>)} / .56 (m<sup>3</sup>/kg)
- ❑ For a cargo ship less than 2,000 gross tons, factors may be reduced to 35% and 30%, respectively, where two or more machinery spaces are not entirely separate and are considered a single space. (FSS Code 5/2.2.1.5)
- ❑ **FOR HIGH SPEED CRAFT** : Sufficient extinguishing agent shall be provided to provide two independent discharges. The second discharge must be initiated from outside of the protected space. A second discharge is not required if a local application fire suppression system is installed. (Reference (n), Regulation 7.7.3.3)

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## General Guidance (continued):

- The total area of all discharge outlets shall not exceed 85% nor be less than 35% of the nominal cylinder outlet area or the supply pipe area, whichever is smaller. This can be completed by following the instructions below:
  1. Refer to the manufacturer's tech pub to determine the single nozzle orifice area for the nozzle listed on the bill of materials. Multiply the single nozzle orifice area by the number of nozzles used to obtain the total nozzle area.
  2. Determine the main distribution pipe internal area; see Table 2 below.
  3. Calculate the nominal cylinder outlet area by multiplying the CO<sub>2</sub> required by 0.0022.
  4. Divide the total nozzle area by either the nominal cylinder outlet area or the supply pipe area, whichever is smaller. The resulting ratio must be between 35% and 85%. Ratios outside of these parameters require modification in the number and/or size of nozzles provided for the design.

### Main and Branch Distribution Piping:

- Determine proper pipe size for the main distribution piping based on the mass of agent, as listed in Table 2.

Maximum Quantity of Carbon Dioxide required (lbs).	Minimum Pipe Size (in)	Internal Area (in <sup>2</sup> )
100	1/2	0.304
225	3/4	0.533
300	1	0.719
600	1 1/4	1.283
1,000	1 1/2	1.767
2,450	2	2.953
2,500	2 1/2	4.238
4,450	3	6.605
7,100	3 1/2	8.888
10,450	4	11.5
15,000	4 1/2	

**Table 2: Minimum Acceptable Pipe Size Based on Volume of Agent**



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## General Guidance (continued):

- 1) Branch lines to cargo holds and 'tween decks must be 3/4-inch minimum (46 CFR 95.15-5(c)(3)).
- 2) In some cases, the manifolds may be sized no larger than 1 1/2 inches (nps) regardless of the amount of agent in the pipe. See approved manuals for details.
- 3) Branch piping must be capable of handling all CO<sub>2</sub> delivered to the nozzles on that branch. Minimum branch pipe size is per Table 2.

## General Guidance (continued):

### Example Calculations:

Given:	Total Agent:	469 lbs of CO <sub>2</sub>
	Branch Lines:	2
	Total Nozzles:	7 (3 on one branch line, 4 on the other)

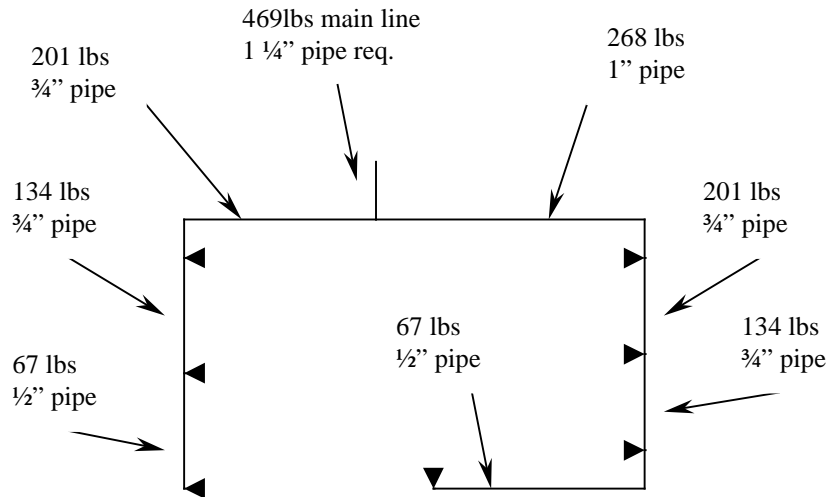
Assumptions: (1) All nozzles are of equal size  
(2) CO<sub>2</sub> is equally distributed from each nozzle

- 1) Divide the agent required by the number of nozzles (7) to obtain the mass of agent per nozzle (67 lbs).
- 2) Determine the mass of agent required in each branch line by multiplying the mass of agent per nozzle by the number of nozzles in each branch (3 x 67 lbs. and 4 x 67 lbs). This yields 201 lbs and 268 lbs of CO<sub>2</sub>, respectively.
- 3) Determine the mass of agent in each pipe segment. Begin at the intersection of the main distribution line and the branch lines, and subtract the mass of agent per nozzle (67 lbs) after each nozzle. (See below).

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## General Guidance (continued):

The main line carries 469 lbs of CO<sub>2</sub> and requires a 1-1/4 inch pipe; the branch line carrying 201 lbs requires a 3/4 inch pipe and the branch line carrying 268 lbs of CO<sub>2</sub> requires a 1-inch pipe. As the piping passes each nozzle, the mass of CO<sub>2</sub> carried to the remaining nozzles is reduced by 67 lbs. The pipe size is dependent on the mass of CO<sub>2</sub> carried through that pipe segment.

### General Piping Requirements:

- ❑ Distribution lines must extend two inches beyond the last orifice and be closed with a cap or plug.
- ❑ Drains and dirt traps shall be fitted where necessary to prevent the accumulation of dirt and moisture.
- ❑ Piping must be used for no other purpose except that it may be incorporated with the fire detection system.

### Cylinders and Storage Space

- ❑ Agent storage cylinders must be located outside the space protected unless the space is a normally unoccupied space having a volume less than 6,000 cubic feet. (108.451(b), 181.410(c)).

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- ❑ Where cylinders are located inside the protected space, the system must be capable of automatic operation by heat actuated detectors. Detectors are to be spaced as outlined in approved manuals. (108.451(b), 181.410(c))
- ❑ **FOR SOLAS VESSELS:** The storage cylinders may be located within the protected space having a volume less than 6,000 cubic feet which is not a category A machinery space or a cargo pump room.
- ❑ **FOR SOLAS VESSELS:** When the agent storage cylinders are located outside the protected space, they shall be stored in a room which is used for no other purposes and is aft of the forward collision bulkhead. Access to the space shall preferably be from the open deck and independent of the protected space. If located below deck, the storage space shall be no more than one deck below the open deck and be directly accessible by stairs or ladder from the open deck. If not accessible from the open deck, exhaust ventilation which provides at least 6 air changes per hour must be provided. (SOLAS II-2, Reg 10/4.3)
- ❑ The storage space must be accessible in the event of a fire in the protected space.
- ❑ The cylinder control heads shall be selected in accordance with the approved manual. Cylinder control heads actuated by the manual controls may differ from those actuated by a heat detector or by manifold pressure.
- ❑ For a system actuated by heat actuated detectors, a single cylinder (primary) must be provided with a VENTED head. All other cylinders (slaves) must be provided with NON-VENTED (tandem) heads.
- ❑ Cylinder storage spaces must have doors that open outwards or be fitted with kick out panels in each door.
- ❑ **FOR SOLAS VESSELS:** A fitting must be installed to facilitate the use of compressed air to be used to test for free air flow to all pipes and nozzles (FSS Code Chapter 5/2.1.2.6)
- ❑ Not less than 2 pilot storage cylinders shall be used for systems consisting of more than 2 storage cylinders
- ❑ CO<sub>2</sub> cylinders may not be inclined more than 30 degrees from vertical, unless fitted with fixed or bent siphon tubes, in which case they may be inclined up to 80 degrees from vertical.

General Guidance  
(continued):

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- ❑ Storage cylinders must be securely fastened, supported and protected.
  - ❑ The system must have local manual controls located at the storage cylinders capable of releasing the extinguishing agent. (These controls are not required if the storage cylinders are located in the space).
  - ❑ Provisions for closing natural ventilation from outside the protected space are required. Relatively tight doors, shutters or dampers shall be provided in the lower portions of the space. Openings in the upper portion of the space can be closed off by either permanently installed means or by the use of canvas or other material which is normally carried on the vessel.
  - ❑ Spaces containing storage cylinders must be maintained at a temperature within the range of -20 degrees and 130 degrees F, based on the DOT approval of the cylinders.
- General Guidance  
(continued):
- ❑ Controls and storage cylinders can only be located in a locked space if the key to the space is in a break-glass box located conspicuously adjacent to the space.
  - ❑ Storage cylinders must be accessible and capable of easy removal for recharging and inspection. Provisions must be available for weighing the cylinders in place.
  - ❑ Where subject to moisture, a storage cylinder must be installed to provide a space of at least two inches between the deck and the bottom of the storage cylinder.
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## Disclaimer:

This guidance is not a substitute for applicable legal requirements, nor is it itself a rule. It is not intended to nor does it impose legally-binding requirements on any party. It represents the Coast Guard's current thinking on this topic and may assist industry, mariners, the general public, and the Coast Guard, as well as other federal and state regulators, in applying statutory and regulatory requirements. You can use an alternative approach for complying with these requirements if the approach satisfies the requirements of the applicable statutes and regulations. If you want to discuss an alternative, you may contact the Marine Safety Center (MSC), the unit responsible for implementing this guidance.

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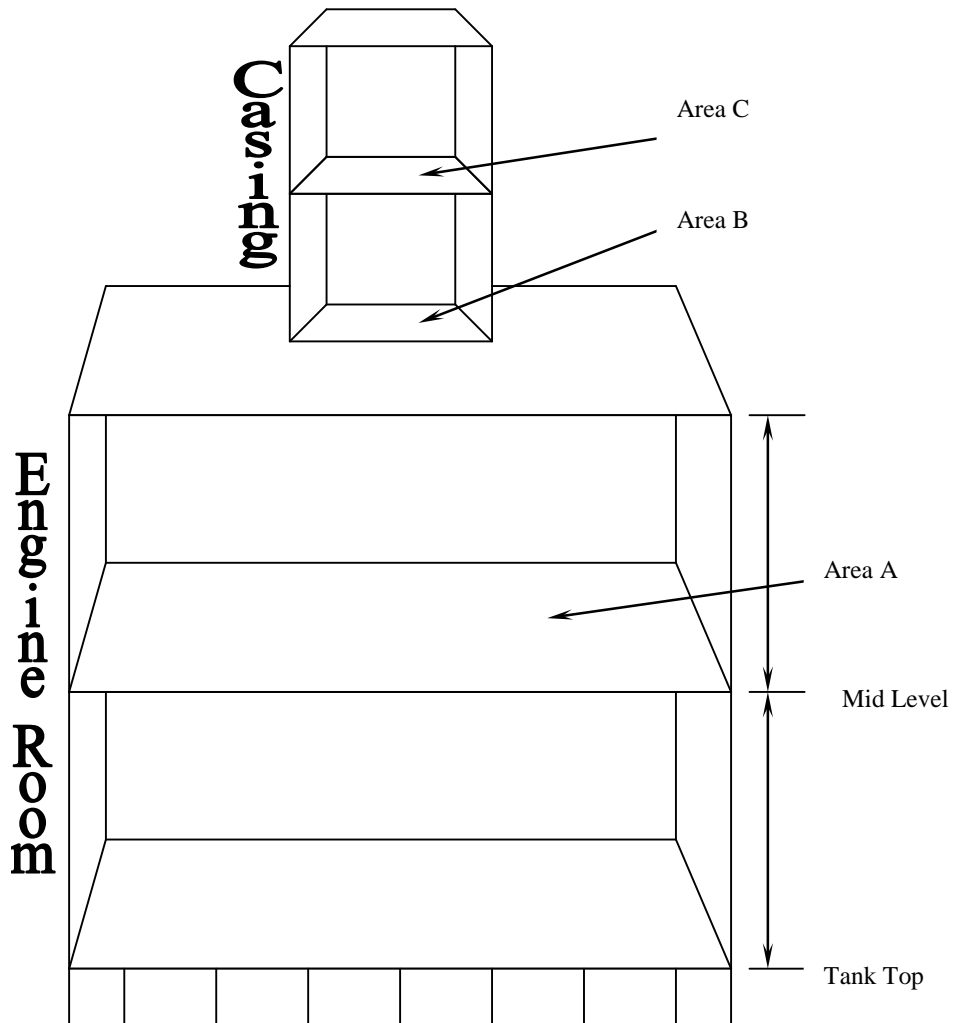
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Attachment:

Gross volume determination for engine rooms with casings:



For the casing to be considered separate from the gross volume of the machinery space, Area "B" must be 40% or less of Area "A".

If Area "B" is greater than 40% of Area "A", the volume of casing in Area "B" must be included. If Area "C" (a reduction in the volume of the casing) is more than 40% of Area "B", it must also be included in the gross volume of the space.

Any area of the casing containing boilers, internal combustion machinery, or oil-fired installations must be included in the gross volume of the engine room.