REVIEW OF VAPOR CONTROL SYSTEMS & MULTI-BREASTED TANDEM LOADING

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Purpose

This Plan Review Guideline (PRG) is used to provide guidance and information regarding the submission of vapor control system (VCS) piping plans and pressure drop calculations, including guidance on multi-breasted tandem loadings. This document identifies industry guidelines for determining the maximum liquid transfer rate for a tank vessels seeking compliance with 46 CFR 39 to transfer flammable, combustible, or hazardous cargo using a vapor control system.

Contact Information

If you have any questions or comments concerning this document, please contact the Marine Safety Center (MSC) by e-mail or phone. Please refer to Procedure Number C1-46.

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1. Applicability

This Plan Review Guideline (PRG) is applicable to tank vessels that carry oil or hazardous cargoes in bulk which are United States (US) flagged or operate on US waters that desire to transfer cargo using a vapor control system.

2. Background

This Plan Review Guide is broken down into two major approval requests: Vapor Control System and Multi-breasted Tandem Loading. Submissions may be emailed or mailed to the Marine Safety Center using the following contact information:

Commanding Officer (MSC-3)
U.S. Coast Guard Marine Safety Center
2703 Martin Luther King Jr. Ave SE
Washington, DC 20593-7430
Or
E-mail to: msc@uscg.mil

Vapor Control System Approval

VCS regulations took effect on July 23, 1990. The Environmental Protection Agency (EPA) mandated that states had the authority to individually regulate the volatile organic compound emission requirements in the Clean Air Act. In response to the EPA's mandates, many states required tank vessel owners to cease releasing certain volatile organic compound vapors, such as gasoline, into the air. The Coast Guard does not require the vessel owner to use a vapor control system. However, if a vapor control system is installed, the Coast Guard does regulate how the system is designed and operated via reference (a) to protect vessel personnel and the environment from the ramifications of explosion and/or over-pressurization. Title 46 CFR Part 39 limits the maximum liquid transfer rate for a tank vessel transferring a cargo using a VCS by the following factors:

1. The operating pressures of the VCS during cargo transfer operations (46 CFR 39.3001(d))
2. The operating limitations for the pressure/vacuum (P/V) relief valves (46 CFR 39.2011)
3. The operating criteria of the liquid overfill protection, including spill valve and rupture disk specifications and overfill alarm requirements (46 CFR 39.2007 or 39.2009)

In determining the maximum liquid transfer rate for a vessel's VCS, each of these factors must be addressed. If the cargo tank is inerted, the calculations must use a density estimate for the cargo vapor and inert gas mixture, based on a partial pressure method for the mixture and assuming ideal gas law conditions in accordance with 46 CFR 39.3001(c)(2).

Multi-Breasted Tandem Loading Approval

With an approved VCS onboard, submitters are authorized to conduct operations under 46 CFR 39.5000 by requesting approval for multi-breasted tandem loading, also known as dual loading. As described in 46 CFR Part 39.5000, multi-breasted tandem loading of vessels will be reviewed for compliance by the MSC and require calculations to justify compliance. Vessels desiring multi-breasted tandem loading shall be owned or operated by the same entity and must have an approved VCS system onboard in accordance with 46 CFR 39.5000. Additional restrictions on multi-breasted tandem loading operations may be put in place by the local OCMI in accordance with Marine Safety Information Bulletin 11-14.

Vapor Balancing, Vapor Processing Units (VPU), and Unique VCS Arrangements

Vessels with vapor control systems of unique design or incorporating components such as VPU's, will need to meet additional regulations as required by 46 CFR Chapter I, subchapters F, I, and J, as well as 33 CFR part 154, subpart P. Additional certification or review may be needed from the Coast Guard Office of Design & Engineering Standards (CG-ENG). Vessels using vapor balancing while conducting a vessel-to-vessel transfer operation must meet the requirements of 46 CFR Part 39, subparts 39.1000, 39.2000, 39.3000, and 39.4000.

3. References

a. 46 CFR Subchapter D, Part 39
b. 46 CFR Subchapter F, Part 56
c. ASTM F1155 – 10, Standard Practice for Selection and Application of Piping System Materials
d. Marine Safety Information Bulletin 11-14 dated July 18, 2014
e. Navigation and Vessel Inspection Circular 10-92, CH-2, "Coast Guard Recognition of Registered Professional Engineer Certification of Compliance with Coast Guard Requirements"
f. Navigation and Vessel Inspection Circular 10-82, CH-2, "Acceptance of Plan Review and Inspection Tasks Performed by the American Bureau of Shipping for New Construction or Major Modifications of U.S. Flag Vessels"

4. Definitions

a. General Definitions:
Refer to 46 CFR 39.1003

b. Multi-Breasted Tandem Loading:
Synonymous with the term "dual loading", "multi-breasted tandem loading" can be roughly defined as loading an inboard and an outboard barge at the same time, which simultaneously collects the cargo vapors from both barges. The term "dual loading" may also imply loading an outboard barge across an inboard barge while simultaneously collecting cargo vapors.

c. Maximum allowable working pressure (MAWP):
MAWP is the maximum pressure allowed to be exerted on any single cargo tank. The maximum allowable working pressure of a cargo tank is determined through separate plan review processes.

d. Vessel Vapor Processing Unit (VPU):
A VPU is a type of scrubber or other device installed aboard a tank vessel to process cargo vapors before their release to the atmosphere.

5. Vapor Control System

The following items should be submitted to the Marine Safety Center to begin a formal review for VCS approval:

- ❑ VCS Piping Plans
- ❑ VCS Pressure Drop Calculations
- ❑ Overfill Alarm Calculations
- ❑ VCS Form (NOTE: VCS Categories defined in Enclosure (1))

- ❑ Manufacturer High Velocity Pressure-Vacuum Valve Flow Diagrams
- ❑ Verification of MAWP (Either by MSC or ACS approval letter or by submission of plans and calculations)

Submissions which would like review under NVIC 10-92 or NVIC 10-82 shall be properly submitted in accordance with NVIC 10-92 or NVIC 10-82 for expedited review timelines.

5a. VCS Piping Plan Review

The plans and/or calculations should provide evidence that the VCS meets the requirements outlined in 46 CFR 39, notably the following:

- ❑ Fixed piping and manifold location: 46 CFR 39.2001(a)
- ❑ Isolation of incompatible vapors, if applicable: 46 CFR 39.2001(b)
- ❑ Electrical continuity: 46 CFR 39.2001(c)
- ❑ Condensate elimination: 46 CFR 39.2001(d)
- ❑ Isolation valve: 46 CFR 39.2001(g)
- ❑ Markings: 46 CFR 39.2001(h)(1) and (2)
- ❑ Cargo gauging: 46 CFR 39.2003
- ❑ Hoses: 46 CFR 39.2001(i)
- ❑ Connection flange: 46 CFR 39.2001(j)
- ❑ Operating requirements: 46 CFR 39.3001
- ❑ Tankships with an Inert Gas System must have a means to isolate the inert gas supply from the VCS, as required by 46 CFR 39.2001(e) and SOLAS 74 II-2/62.10.8.
- ❑ Cargoes carried under 46 CFR, Part 151 or Part 153, may use flexible hoses no longer than three meters (9.84 ft) for interconnection between fixed piping to preserve cargo segregation. These flexible hoses must meet the requirements of 46 CFR 39.2001(a)(2) and the hose requirements of 46 CFR 39.2001(i).
- ❑ Overpressure and vacuum protection: 46 CFR 39.2011
    - P/V valves must be CG approved, per 46 CFR 162.017, and have a valid approval certificate for use in Vapor Control Systems.
    - A vessel that intends to carry toxic cargoes cannot have spill valves as the primary means of overfill protection, per 46 CFR 39.2011(m).
    - A liquid pressure-vacuum breaker may be used for vapor overpressure and vacuum protection, but the owner must seek approval from Commandant (CG-ENG-5) for this arrangement, in accordance with 46 CFR 39.2011(c).
    - The VCS system must not interfere with the cargo tank venting system, per 46 CFR 30.2001(f). When isolation valves are installed, each tank must have a means to bypass the isolation valves, as required by 46 CFR 32.55-25(b). If the vessel has a VCS and additional pressure-vacuum (P/V) relief valves are installed on individual tanks, they must be set at a higher relieving pressure than the high velocity P/V valve, unless it is able to relieve the full flow of vapors at the loading rate.
    - Tankships and barges must have a pressure sensing-device and associated alarms meeting the requirements of 46 CFR 39.2013 and 39.2015.
- ❑ Each VCS Plan must have a Bill of Materials
    - A list of materials that includes the components used to construct the VCS piping system, such as piping, flanges, valves, and other miscellaneous fittings. Piping components are required to satisfy the material and design specifications in 46 CFR Table 56.60-1(a) & (b).
- ❑ Liquid overfill protection system: The vessel must meet 46 CFR 39.2007 for a tankship, or 39.2009 for a tank barge. The plans for the overfill alarms must be submitted to the MSC

Electrical Branch for review and approval. Tankship high level and tank overfill alarms must be intrinsically safe per 46 CFR 39.2007(a). Spill valves and rupture discs are optional for tankships but must meet the requirements if installed. A tank barge is required to have a liquid overfill protection system that satisfies the conditions of 46 CFR 39.2009.

5b. Vapor Control System Calculations

Condition of the Vapor Space Inside the Cargo Tank

A temperature of 115 ºF and a pressure equal to the pressure setting of the cargo tank P/V valve is used in our calculations to determine the factor that limits the transfer rate. A temperature of 115 ºF was chosen, because it is the reference temperature for the design pressure of cargo tanks as specified in 46 CFR 151.15-3 and the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC 15.14). If the cargo tank P/V valves are adequately sized, the maximum pressure inside the cargo space should be only slightly higher than the pressure setting of the P/V valves. The temperature and pressure used is important because the vapor-air mixture weight density and vapor growth rate are affected by the temperature and pressure of the vapor space in the cargo tank.

Determining the Vapor-Air Mixture Weight Density

Ideal gas laws may be used to estimate the density of the vapor-air mixture in the vapor space of the cargo tank. Equations (1) through (6) are derived from the ideal gas law. Equation (1) defines the relationship between partial pressures and partial volumes and equation (2) defines the maximum total pressure of the vapor space inside the cargo tank. Equation (3) may be used to calculate the vapor-air mixture weight density.

$$V_{v,115} = \frac{P_{v,115}}{P_{t,115}} \qquad V_{a,115} = \frac{P_{t,115} - P_{v,115}}{P_{t,115}} \qquad \text{Eq. (1)}$$

$$P_{t,115} = P_{p/v} \qquad \text{Eq. (2)}$$

$$\rho_{v-a,115} = [(S.G._v)(V_{v,115}) + V_{a,115}]\rho_{a,115} \qquad \text{Eq. (3)}$$

$$\rho_{a,115} = 0.0047 P_{p/v} \qquad \text{Eq. (4)}$$

$\rho_{v-a,115}$ - vapor-air weight density (lbm/ft^3) at 115 ºF and the pressure setting of the cargo tank P/V valves

$S.G._v$ - specific gravity of cargo vapor

$V_{v,115}$ - partial volume of vapor at 115 ºF

$V_{a,115}$ - partial volume of air at 115 ºF

$\rho_{a,115}$ - air weight density (lbm/ft^3) at 115 ºF and the pressure setting of the cargo tank of the cargo tank P/V valves in lbm/ft^3

$P_{v,115}$ - saturated vapor pressure at 115 ºF in psia

$P_{p/v}$ - cargo tank P/V valve setting in psia

$P_{t,115}$ - total vapor-air pressure at 115 ºF in psia

Cargoes with a Saturated Vapor Pressure of 14.7 psia or less at 115°F (VCS Categories 1 through 4)

If the cargo tank is not inerted, the air weight density in equation (3) may be substituted with equation (4), leading to equation (5).

$$\rho_{v-a,115} = \left[(S.G._v)\left(V_{v,115}\right) + V_{a,115}\right]0.0047(P_{p/v}) \qquad \text{Eq. (5)}$$

Saturated vapor pressures at 115 ºF ($P_{v,115}$) and cargo vapor specific gravities ($S.G._v$) may be obtained from various sources including Safety Data Sheets and *CHRIS Hazardous Chemical Data Manual (COMDTINST M16465.12B).*

CHRIS Manual

Cargoes with a Saturated Vapor Pressure Greater Than 14.7 psia at 115°F (VCS Categories 5 through 7)

Saturated vapor weight density at 115ºF from the Safety Data Sheet or estimates as determined by equation (6) may be used:

$$\rho_{v-a,115} = \frac{(S.G._v)(P_{v,115})}{14.7}\,(0.0047P_{p/v}) \qquad \text{Eq. (6)}$$

Determining the Vapor Growth Rate

During cargo loading, some of the cargo will evaporate until the pressure in the cargo tank vapor space reaches the saturation pressure of the cargo. If vapors are being removed from the cargo tank through a VCS, the saturation pressure is never reached and the evaporation of the cargo continues throughout the loading operation. As a result, the volume of the vapors emitted from the cargo tank (Q_{v-a}) is equal to the volume that is displaced by the incoming cargo (q_{disp}) plus the volume of the cargo vapors that have evaporated (q_{vg}).

$$Q_{v-a} = q_{disp} + q_{vg} \qquad \text{Eq. (7)}$$

Q_{v-a} - volume of vapors (vapor-air mixture) emitted from cargo tank
q_{disp} - vapor flow due to cargo displacement
q_{vg} - vapor flow from cargo evaporation (vapor growth)

The rate of evaporation is cargo dependent and is called the cargo's vapor growth rate. To simplify calculations, a vapor growth rate factor (VGR) is used to quickly obtain the vapor-air flow rate from the liquid transfer rate.

$$Q_{v-a} = (Q_l)(VGR) \qquad \text{Eq. (8)}$$

Q_{v-a} - vapor-air mixture volumetric flow rate (bbl/hr)
Q_l - liquid transfer rate (bbl/hr)
VGR – vapor growth rate factor for vapor-air mixture

The vapor growth rate factor is the ratio of volumetric liquid transfer rate (Q_l) to the volumetric vapor-air flow rate (Q_{v-a}).

$$VGR = 1 + (\frac{q_{vg}}{Q_l}) \qquad \text{Eq. (9)}$$

The regulations in 46 CFR Part 39 require the venting system to be able to discharge cargo vapor at the maximum transfer rate plus the vapor growth for the cargo such that the pressure in the vapor space of each tank connected to the VCS does not exceed (a) the maximum design working pressure for the tank or (b) if a spill valve or rupture disk is fitted, the pressure at which the device operates.

Calculation of Vapor Growth Rate

Using gasoline as a baseline cargo with an assumed vapor growth rate of 25% of the cargo transfer rate, equation (11) may be used to estimate the vapor growth rate factors of other cargoes.

$$VGR = 1 + 0.25\ (\frac{P_{v,115}}{12.5(vapor\ pressure\ of\ Gasoline)}) \qquad \text{Eq. (10)}$$

Capacity of the Cargo Tank Pressure-Vacuum Relief Valve

The capacity of the venting system is best measured by determining the pressure drop through the venting system. This includes the venting piping and the P/V valve. The pressure drop between the cargo tank and the point of vapor discharge cannot exceed the cargo tank maximum design working pressure. Darcy's Equation, equation (11), is an acceptable method to estimate the pressure drop of the vapor-air mixture through the vent piping.

$$\Delta P = \frac{\rho f L v^2}{144 D 2 g} \qquad \text{Eq. (11)}$$

ΔP - Pressure Drop (psig)
ρ - Weight Density of Fluid (lbm/ft3)
f - Darcy Friction Factor
L - Equivalent Length of Pipe (ft)
v - Mean Velocity of Flow (ft/s)
D - Internal Diameter of Pipe (ft)
g - Acceleration Constant (32.2 ft.lbm/s^2.lbf)

Darcy's Equation provides a reasonable approximation of the pressure drop for compressible fluids, provided the calculated pressure drop is no more than 10% of the initial absolute pressure. Since the Reynolds numbers (Re) for the maximum liquid transfer rates are generally in the complete turbulent region (i.e., 10^4-10^7), the friction factor (f) may be determined from a technical reference such as Crane's *Flow of Fluids Through Valves, Fittings, and Pipe (Technical Paper No. 410)*. The equivalent length of the system (L) may be obtained by summing the length of straight pipe and the equivalent lengths of various fittings in the system. Again, *Crane's* may also be used for this determination. The mean velocity of the vapor-air mixture (v) can be determined using the following equation:

$$v = \frac{(Q_l)(VGR)(5.61\frac{ft^3}{bbl})}{(3600\frac{sec}{hr})(\frac{D}{2})^2\pi} \quad \text{Eq. (12)}$$

P/V valves can have an important effect on the overall pressure drop in the venting system. They must be adequately sized to keep the pressure in the vapor space of the cargo tank below the cargo tank's maximum design working pressure. The pressure relieving capacity and the vacuum relieving capacity may be different for a P/V valve; therefore, they must be evaluated separately.

For the pressure relieving capacity, the required vapor-air mixture volumetric flow rate through a P/V valve is equal to the liquid loading rate multiplied by the vapor-air mixture growth rate (Eq. (13)). If the data supplied by the manufacturer on the P/V valve's venting capacity is for air, a vapor density correction must be made (equation (14)). Once the required air equivalent volumetric flow rate is known, the pressure drop across the P/V valve can be determined from data supplied by the manufacturer. Please note that the manufacturer’s pressure drop versus flow rate data for each part of the valve must be submitted to the MSC.

$$Q_a = Q_{v-a}\left(\sqrt{\frac{\rho_{v-a,115}}{\rho_{a,115}}}\right) \quad \text{Eq. (13)}$$

Qv-a - vapor-air mixture volumetric flow rate (bbl/hr)
Qa - required air equivalent volumetric flow rate (bbl/hr)
$\rho_{v-a,\,115}$ - vapor –air weight density (lbm/ft^3) at 1150°F and the pressure setting of the cargo tank P/V valves
$\rho_{a,\,115}$ - air weight density (lbm/ft^3) at 115°F and the pressure setting of the cargo tank P/V valves

For the vacuum relieving capacity, **no vapor growth rate or vapor density correction is necessary**. The P/V valve vacuum relieving capacity must be equal to or greater than the maximum liquid discharge rate, in accordance with 46 CFR 39.001(d)(2). When a maximum discharge rate is not specified in your submittal, the MSC will use the maximum cargo transfer rate to determine if the VCS satisfies this requirement. Again, once the required vacuum relieving capacity of the P/V valve is known, the pressure drop across the P/V can be determined from the data supplied by the manufacturer.

Capacity of the Cargo Tank Spill Valve or Rupture Disk

Paragraph 46 CFR 39.2009(a)(3) requires that the maximum pressure at the cargo tank top during liquid overfill at the maximum loading rate for the tank not exceed the tank maximum design working pressure. Where spill valves or rupture disks are used to limit the tank pressure in a liquid overfill scenario, their liquid relieving capacity (Q_l) must be corrected for density if the data supplied by the manufacturer is for water. Equation (14) may be used for this correction.

$$Q_l = \frac{Q_w}{\sqrt{S.G.}} \quad \text{Eq. (14)}$$

Q_w – relieving capacity of spill valve based on the density of water
S.G. – specific gravity of the liquid cargo
Q_l – relieving capacity of spill valve based on liquid cargo

When making the density correction to determine the pressure drop across the spill valve, use the maximum density cargo authorized for carriage in the cargo tanks.

NOTE: For subchapter O/D barges, the maximum density is listed on the COI or on the first page of the barge's 46 CFR Part 151 Cargo List, which is created by the Marine Safety Center.

Maximum Liquid Transfer Rate Imposed by the Set Point of the Overfill Alarm

Title 46 CFR 39.2007 and 39.2009 require the maximum liquid transfer rate to be such that, after the sounding of the overfill alarm, there is sufficient time to stop the transfer operation before the tank overflows. The maximum liquid transfer rate will be reduced if the operator fails to demonstrate to the cognizant Officer in Charge, Marine Inspection (OCMI) that the system meets this requirement. The calculations submitted to the MSC for barges installing an intrinsically safe overfill control system must demonstrate the overfill control system shutdowns cargo transfer operation at least 60 seconds prior to tank becoming 100% full at the maximum requested transfer rate.

The Maximum Liquid Transfer Rate as Imposed by Cargo Transfer during Operations

Title 46 CFR 39.3001(d)(3) requires the sum of the pressure drop in the VCS piping and the pressure at the facility vapor connection not to exceed 80 percent of the setting of any pressure relief valve in the cargo tank venting system.

There are several ways the person in charge of cargo transfer can determine whether the pressure at the facility vapor connection would lower the vessel's designed maximum liquid transfer rate as described above. The MSC requires the VCS pressure drop calculations to contain either a table or graph vessel operators can use to determine the maximum allowable transfer rate as a function of the pressure at the facility vapor connection. Figure 1 on the following page is an example of an acceptable format for this graph. To obtain the graph, simply subtract the pressure drop through the vapor control system piping at each transfer rate from the fixed value, 80% of the P/V valve setting, and plot the result versus the cargo transfer rate. Use the graph required by paragraph 10 of The "Marine Safety Center Form for Tank Vessels Installing a Vapor Control System." for the pressure drop through the VCS piping as a function of flow rate.

Figure 1 shows the relationship between the pressure at the facility vapor connection and the maximum liquid transfer rate. With the pressure at the facility vapor connection known, the person in charge of cargo transfer can quickly use the graph to determine the maximum liquid transfer rate.

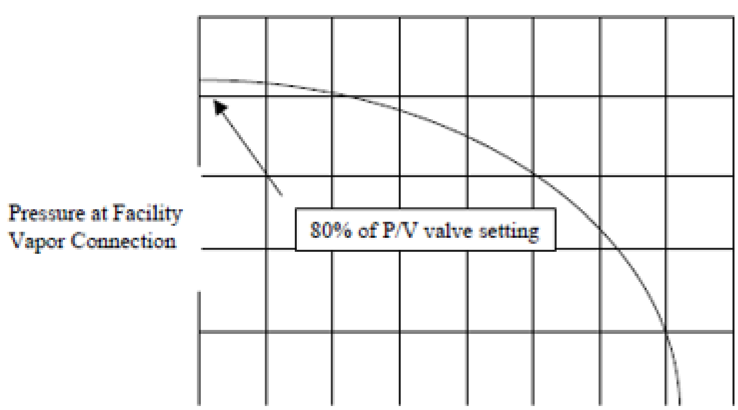


Figure 1: Maximum Cargo Transfer Rate

To accommodate a higher rate for a cargo with a vapor-air mixture weight density less than that of the maximum, information may be presented as in Figures 2. For extrapolation, the curves should be labeled with values of at least the heaviest, lowest and intermediate vapor-air mixture weight densities. For these graphs to be of any use, vapor density of the vapor being transferred must be available at the time of transfer.

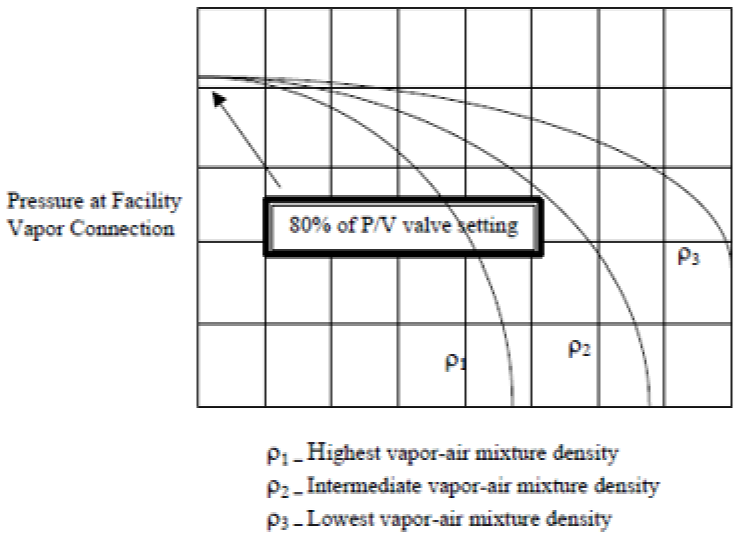


Figure 2: Maximum Transfer Rate

5c. VCS Overfill Calculations

For tank barges, the submission must include calculations for the set points of all tank gauges connected to the overfill protection system prescribed in 46 CFR 39.2009(a)(2). At the calculated set point, the overfill protection system must actuate an alarm and automatically shut down the system at the facility overfill control panel 60 seconds prior to the tank being 100 percent liquid-full. Alternatively, the submission for a tank barge may include calculations for the overfill protection system prescribed in 46 CFR 39.2007.

For tankships, the submission must include calculations for the set point of the high level and overfill alarms prescribed in 46 CFR 39.2007. The high level alarm set point must be set at 95 percent liquid-full, but must activate before the overfill alarm. The overfill alarm must activate with enough time to allow the person in charge of the cargo transfer operation to stop the operation before the tank overflows.

5d. Multi-Breasted Tandem Loading

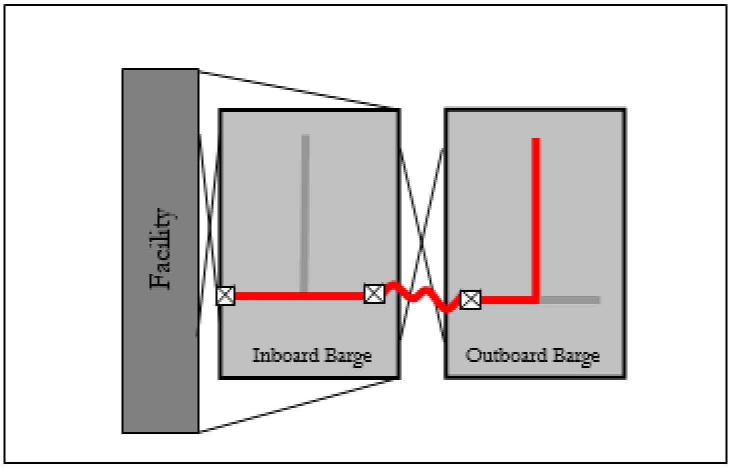


Figure 3: Multi-Breasted Tandem Loading Sample Setup

MSC will review the calculations required by 46 CFR 39.5001(e) to ensure the system complies with the material, overfill, and cargo tank over pressurization requirements of 46 CFR 39. In accordance with the procedural changes outlined in MSIB 11-14, tandem loading no longer requires final approval by Commandant (CG-ENG-5), but may require additional review by the local Officer in Charge of Marine Inspections to ensure it complies with all local requirements for tandem loading operations.

Multi-breasted tandem loading requests should include calculations that account for the most conservative loading situation. Calculations should demonstrate that the total equivalent length for each vessel pair in the multi-breasted tandem loading fleet does not create a situation where the outboard barge will over-pressurize its cargo tanks, in accordance with 46 CFR 39.5001(e). At a minimum, tandem loading submissions are recommended to include the following data and calculations for each vessel in the fleet:

- ❑ A statement indicating that all vessels in the proposed fleet are owned or operated by the same entity, demonstrating compliance with 46 CFR 39.5001(a)
- ❑ Maximum allowable working pressure (MAWP)
- ❑ P/V valve settings
- ❑ Flow curves provided by the P/V valve manufacturers
- ❑ Vapor piping diameters for each VCS piping segment
- ❑ Equivalent length calculations for piping runs such as the following:
    - Furthest cargo tank to the outboard vessel's vapor connection
    - Across the inboard vessel's transverse vapor header or dummy header
- ❑ Date and serial number of VCS approval letter, demonstrating compliance with 46 CFR 39.5001(a)

As shown in Figure (3), the total equivalent length includes the longitudinal VCS header of the outboard barge, transverse VCS header of both barges, no more than 25 feet of hose between the barges (unless greater length is captured in computations), and all associated valves and fittings. The multi-breasted tandem loading calculations must account for the increased flow rate in the applicable portion of the inboard barge's transverse VCS header.

NOTE: If the inboard barge is fitted with a "dummy" vapor header, the inboard barge must meet the additional requirements of 46 CFR 39.5005.

6. 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 MSC, the unit responsible for implementing this guidance.

VCS Categories

Vapor Control System Categories

Category 1: (No additional VCS requirements above those for benzene, gasolines and crude oil) All requirements applying to the handling of oil and hazardous materials in Titles 33 and 46 Code of Federal Regulations (CFR) apply to these cargoes. Those specifically dealing with vapor control systems are in 33 CFR 155.750, 33 CFR 156.120, 33 CFR 156.170, 46 CFR 35.35 and 46 CFR 39. The cargo tank venting system calculations (46 CFR 39.20-11) and the pressure drop calculations (46 CFR 39.30-1(b)) must use appropriate friction factors, vapor densities and vapor growth rates.

Category 2: (Polymerizes) Polymerization and residue build-up of these cargoes can adversely affect the vessel by fouling safety componenets and restricting vapor flow which could lead to cargo tank overpressurization. The vessel's owner must develop a method of ensuring all VCS safety components are functional and polymer build-up is not causing an unsafe condition due to increased pressure in the vapor control piping and cargo tanks. The method shall be acceptable to the local Officer in Charge, Marine Inspection. This is in addition to the requirements of Category 1. Please note that a material not normally considered a monomer can be a problem in detonation arrester.

Category 3: (Highly toxic) VCSs for these toxic cargoes cannot use a spill valve or rupture disk as the primary means to meet the overfill protection requirement of 46 CFR 39.20-9. This requirement is in addition to the requirements of Category 1.

Category 4: (Polymerizes and highly toxic) Must comply with requirements of Categories 1, 2 and 3.

Category 5: (High vapor pressure) VCS pressure drop calculations for cargoes with a vapor pressure greater than 14.7 psia at 115 F must take into account increased vapor-air mixture densities and vapor growth rates as compared to Category 1cargoes. Consult the Marine Safety Center's VCS Guidelines for further information. This requirement is in addition to the requirements of Category 1.

Category 6: (High vapor pressure and highly toxic) Must comply with requirements of Categories 1, 3 and 5.

Category 7: (High vapor pressure and polymerizes) Must comply with requirements of Categories 1, 2 and 5.

Figure 4: VCS Categories Defined

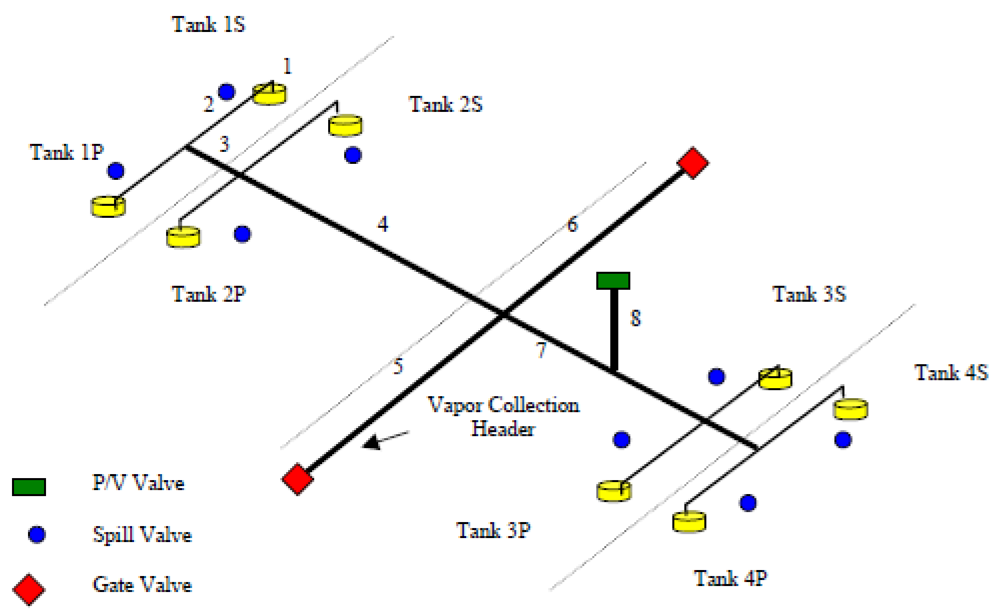
VCS Sample Problem

1. General Description of Vessel

A. **Vessel Particulars**: USCG Barge MSC, O.N. 000000, DOT Hull 01
B. **Dimension**: 297.5' x 54' x 12.5'
C. **Service**: Tank Barge (O/D)
D. **Max. Design Working Pressure**: 3.0 psig

2. Complete VCS Piping Plan and List of Materials. The piping plan must include all of the information required Section I. of the "Guidelines."

3. Vapor Control System Configuration



Pipe Diameter: 6 and 8 inches
Pipe Lengths:

1- 2.5'	2 – 15'	3 – 10'	4 – 60'
5- 25'	6- 27'	7 – 25'	8 – 10.5'

P/V Valve: MSC 8" High Velocity Type Bravo
(2) Set at 1.5 psig
(3) Vacuum Set at –0.5 psig below atmospheric pressure
Spill Valve: MSC 12" Type Delta, Set at 2.75 psig (Only means of tank overfill protection)

Requested Maximum Transfer Rate: 7500 bbl/hr

1. Cargo Authority: A barge must have carriage authority for a cargo prior to requesting the MSC add its VCS List of Cargoes. For instance, this barge's VCS can safely handle Benzene vapors, but it does not have carriage authority for cargo.

2. Vapor Control Categories: This submittal only includes calculations for 5 flammable and combustible cargoes. All of these cargoes are Category 1 cargoes, therefore, the MSC will not include any High Vapor Growth Rate Cargoes (VCS Categories 5 through 7) in the VCS List of Cargoes it creates. In addition, barges with spill valves or rupture disks as their primary means of tank overfill protection will not be able to use their VCS to capture VCS toxic cargoes (VCS Categories 3, 4 & 6). Click here for an explanation of VCS Categories.

<u>Requested Cargoes</u>
Dodecylbenzene
Methyl tert-Butyl Ether (MTBE)
Styrene
Gasoline
1,1 Dichoroethane

Verify your requested cargoes are approved by the Coast Guard for collection by a vapor control system. Coast Guard's Hazardous Materials and Standards Divisions (add link to website and phone number) reviews cargoes for use with vapor control systems and assigns it VCS Category. If there is any doubt whether the cargoes have been approved by the Coast Guard, contact the MSC's Cargo Authority branch at 202 366-6441.

Cargo	VCS Cat.	Liquid Specific Gravity	Vapor Specific Gravity	Vapor Pressure 115F (psia)	Vapor Growth Rate
Dodecylbenzene	1	0.86	8.4	4.7	1.09
MTBE	1	0.74	3.1	4.1	1.084
Styrene monomer	2	0.92	3.6	.4	1.01
Gasoline	1	0.75	3.4	12.5	1.25
1,1 Dichloroethane	1	1.18	3.41	9.9	1.2

The Maximum Liquid Transfer Rate as Imposed by the Capacity of the Cargo Tank Venting System

Calculate the equivalent length from the most remote cargo tank to the facility vapor connection and the P/V valve. In this case, 1 Starboard is the most remote cargo tank. Click Here to see an example of the equivalent length calculation. The equivalent length for the 6" pipe is approximately 84' for both routes. The equivalent length for the 8" pipe is 209' and 190' to the PV valve and the facility vapor connection, respectively.

Use Darcy's Equation, equation (8), and the friction factor obtained from Crane's Technical Pub. 410 to determine the pressure drop at the maximum requested transfer rate through the VCS piping from the most remote cargo tank to both the P/V valve and Facility Vapor Connection. Note that the ideal gas law was used to calculate Gasoline: Polymer's vapor density. This is acceptable because a more conservative value is derived than the 50/50 mixture required by 46 CFR 39.30-1(b)(2). Next, determine the required venting capacity for the pressure side of the P/V valve using equations (10) and (11). Then determine required spill valve relieving capacity using equation (12). With these values you can verify that cargo tank's maximum design working is not exceed when using the vapor control system or its relieving devices.

Cargo	Vapor Density (lbm/ft^3)	ΔP to P/V Valve (psi)	ΔP to Facility Connect. (psi).	Required P/V Vent. Capacity (bbl/hr) air	Required Spill Valve Capacity (bbl/hr) Water
Dodecylbenzene	0.2396	0.5940	0.5705	14555	6955
MTBE	0.1166	0.2838	0.2726	10061	6452
Styrene monomer	0.0810	0.1705	0.1638	7799	7194
Gasoline: Polymer	0.2171	0.7027	0.6750	15832	6495
1,1 Dichloroethane	0.1883	0.5597	0.5376	14129	8147

The MSC 8" High Velocity Bravo P/V valve when set at 1.5 psig has pressure drop of .875 psi across the valve at 15832 bbl/hr of air. 15832 bbl/hr is the highest required venting capacity calculated for the 5 cargoes requested. The back pressure in the most remote cargo tank when venting through the P/V for Gasoline: Polymer at the maximum transfer rate requested is only 1.57 psig, which doe not exceed the cargo tank maximum design working pressure (3.0 psig).

The vacuum side of the valve must be adequately sized for the barge's maximum discharge rate. In many cases submitters opt not differentiate between the maximum transfer rate and the discharge rate. In these cases the MSC will size the vacuum valve according to the requested maximum transfer rate.

3. **The Maximum Liquid Transfer Rate as Imposed by the Relieving Capacity of the Cargo Tank Spill Valves.**

The MSC 12" Type Delta, set at 2.75 psig, has a pressure drop of 2.1 psi across the valve at 8147 bbl/hr (water). This value is less than the tank maximum design working pressure; therefore, the spill valve is adequately sized for the cargoes requested. Use the maximum density authorized for carriage on the barge to make the density correction for the spill valve. Without making the correction for the maximum density cargo authorize, the VCS List of Cargoes created by the MSC may not include a large number of cargoes that would otherwise appear on the list.

3. Create table of graph required by 46 CFR 39.30-1(b)(3)

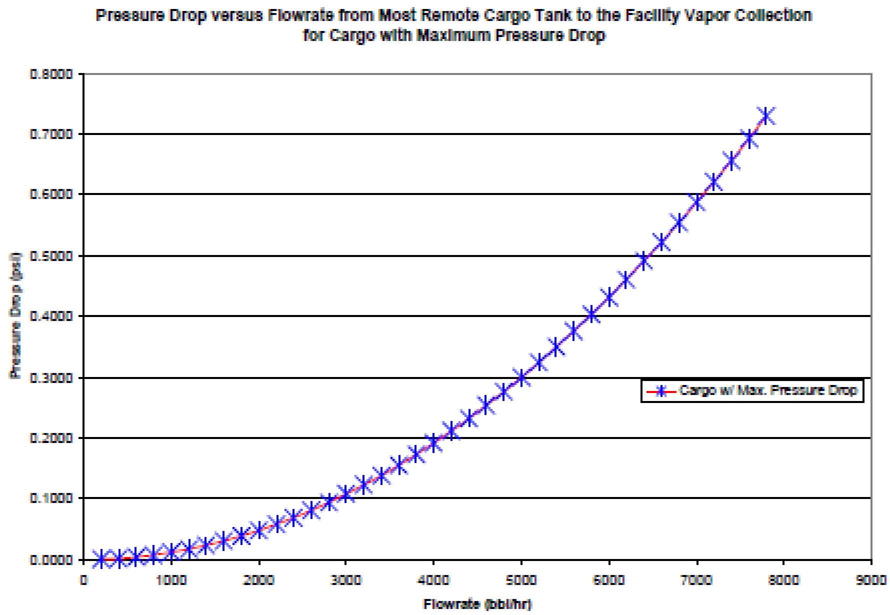
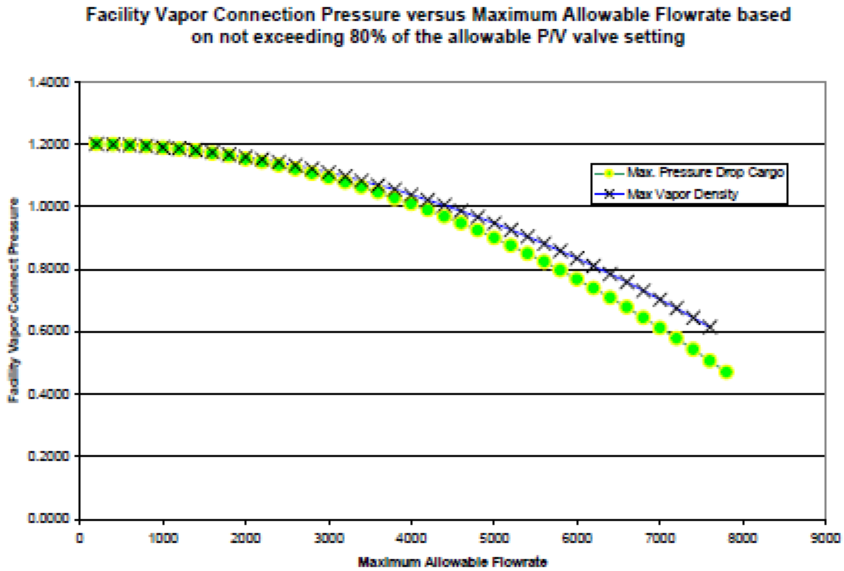


Table or Graph as Imposed by 46 CFR 39.30-1(d)(3):



The pressure at the facility vapor connection must be kept below 0.6 psig in order to achieve the maximum transfer rate of 7500 bbl/hr when loading Gasoline: Polymer.