

## **Sizing Tank Blanketing Regulators Using the Latest API 2000 7<sup>th</sup> Edition Guidelines**

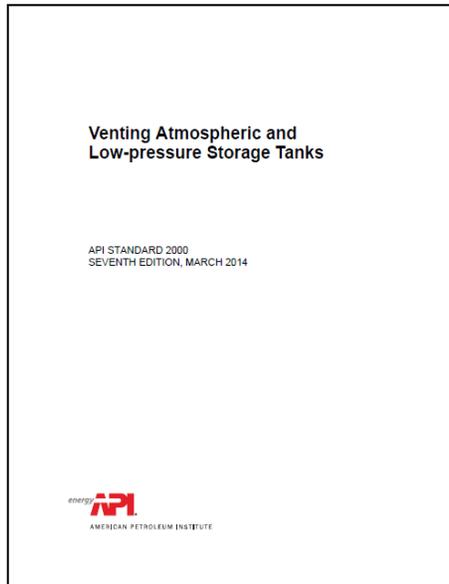
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## Introduction

In March of 2014, API Standard 2000 (Venting Atmospheric and Low-Pressure Storage Tanks) was revised. This Seventh Edition thus becomes the latest update. The subject of this article is how the latest changes affect the sizing of tank blanketing regulators, including backpressure ones used for vapor recovery systems.

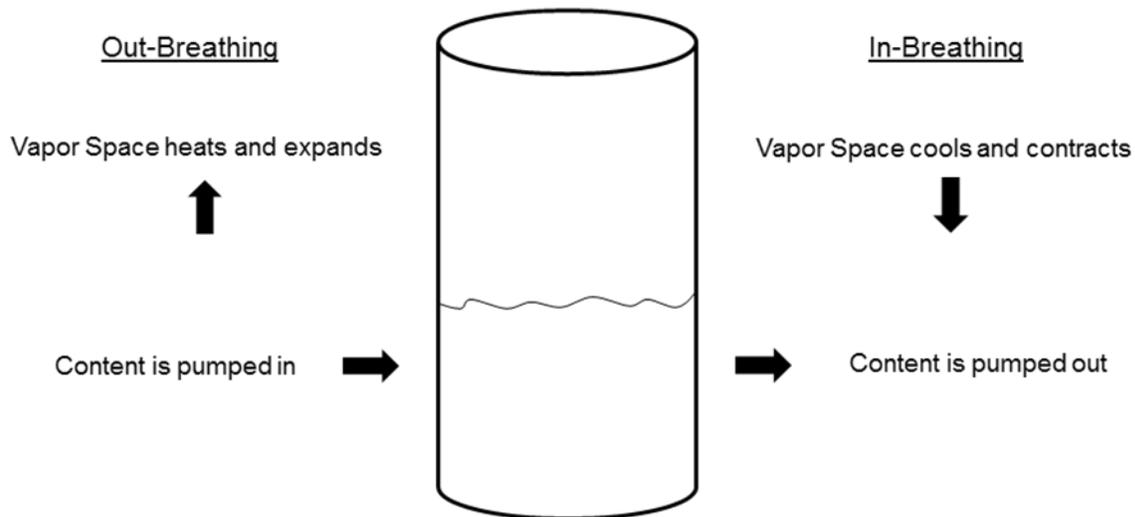


**Figure 1: The Latest Standard**

### The Fundamentals Remain Unchanged: Liquid Flow and Thermal Change

The first thing to understand is what has not changed. Namely, the fundamentals that impact tank pressure remain intact. This means that liquid flow (or pump-in and pump-out) and changes to temperature still form the fundamentals to the sizing calculations. Please see Figure 2.

- In-Breathing → Vapor space cooling down/contracting and pump-out
- Out-Breathing → Vapor space heating up/expanding and pump-in



**Figure 2: Liquid Flow and Thermal Change**

Let's take a closer look at the API Standard 2000 5<sup>th</sup>, 6<sup>th</sup>, and 7<sup>th</sup> Editions.

The API Standard 2000 5<sup>th</sup> Edition takes into account Tank Volume, Liquid Flow, and Temperature Change. It was written as a basis for the pressure control of hydrocarbons, and considered industrial tanks as well. It is this 5<sup>th</sup> Edition that is probably in widest use today.

In 2009, this was updated to the API Standard 2000 6<sup>th</sup> Edition. Note that the 5<sup>th</sup> Edition remained in the form of Appendix A, so it was not made obsolete per se. The additional factors of Average Storage Temperature, Vapor Pressure, and Latitude were added in the 6<sup>th</sup> Edition, as an additional focus was placed on alcohols which have higher vapor pressures and can significantly increase the inflow requirements.

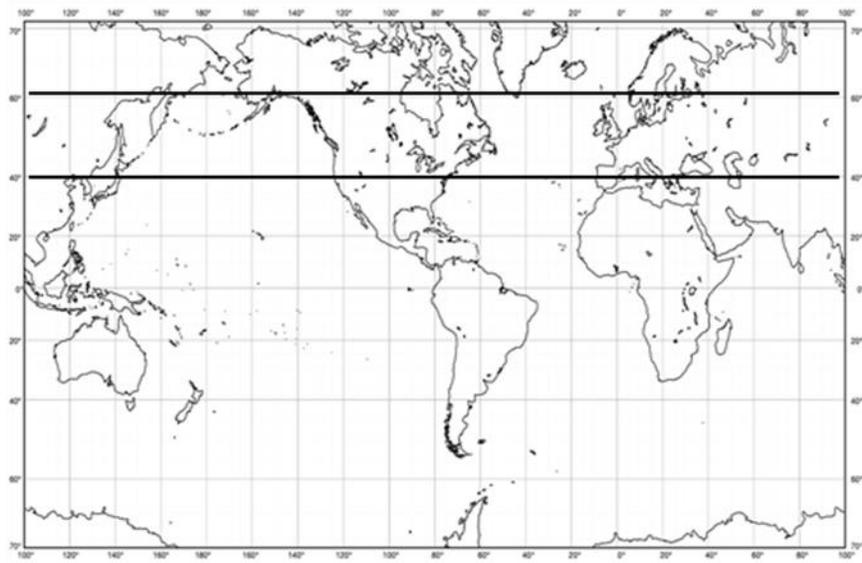
This year, minor changes were implemented and the latest guideline is now the 7<sup>th</sup> Edition. One of the changes has to do with a simplified calculation for volatile liquids. Figure 3 summarizes the similarities and differences between the three latest editions of the standard.

<u>API 2000 – 5<sup>th</sup> Edition</u>	<u>API 2000 – 6<sup>th</sup> Edition</u> (Appendix A = API 5 <sup>th</sup> Edition)	<u>API 2000 – 7<sup>th</sup> Edition</u> (Appendix A = API 5 <sup>th</sup> Edition)
<ul style="list-style-type: none"> <li>• Tank Volume</li> <li>• Liquid Flow (Pump-In/-Out)</li> <li>• Temperature Change</li> </ul> <p>➤ Directed at pressure control for hydrocarbons in low pressure tanks</p> <p>➤ Industrial tanks as well</p>	<ul style="list-style-type: none"> <li>• Tank Volume</li> <li>• Liquid Flow (Pump-In/-Out)</li> <li>• Pump Out</li> <li>• Temperature Change</li> <li>• Avg Storage Temperature</li> <li>• Vapor Pressure</li> <li>• Latitude</li> </ul> <p>➤ Additional focus on alcohols</p> <p>➤ Higher vapor pressures</p> <p>➤ Can double the inflow (big change in thermal vacuum)</p>	<ul style="list-style-type: none"> <li>➤ Minor calculation changes</li> <li>➤ For volatile liquids, the outbreathing calculation is simply doubled               <ul style="list-style-type: none"> <li>○ No need to perform an evaporation rate calculation</li> </ul> </li> </ul>

**Figure 3: A Comparison of Recent Standard Updates**

**New Variables: C-Factor & Y-Factor**

Both the API Standard 2000 6<sup>th</sup> and 7<sup>th</sup> Editions include new variables in the calculations which depend on latitude. The key latitude categories are “Below 42 Degrees”, “Between 42 and 58 Degrees” and “Above 58 Degrees.” These latitude lines are where weather will patterns shift enough to cause meaningful differences in tank pressure.



**Figure 4: The Latitude Variable**

As you can see in the Figure 5 tables, the C-Factor depends not only on latitude, but also on vapor pressure and average storage temperature. This C-Factor is used when making in-breathing flow calculations, which are required to size a tank blanketing regulator. The Y-Factor, on the other hand, is only dependent on latitude and is used when making out-breathing calculations, which are required to size a vapor recovery regulator.

Latitude	C-Factor			
	Vapor pressure similar to Hexane		Vapor pressure higher than Hexane or unknown	
	Average Storage Temperature			
	< 77 F	> 77 F	< 77 F	> 77 F
Below 42 Deg	4	6.5	6.5	6.5
Between 42 and 58 Degrees	3	5	5	5
Above 58 Degrees	2.5	4	4	4

Latitude	Y-Factor
Below 42 Deg	0.32
Between 42 & 58 Deg	0.25
Above 58 Deg	0.20

**Figure 5: C-Factor and Y-Factor**

**Sizing Calculation for a Tank Blanketing Regulator**

Let's now turn to the sizing calculations themselves, starting with In-Breathing, which will determine the flow requirement for a tank blanketing regulator. The general steps are:

- (1) determine the volumetric flow rate required to replace the liquid being pumped out;
- (2) determine the volumetric flow rate required due to temperature drop;
- (3) add the results of (1) and (2) together.

$$\begin{aligned} \text{Tank blanketing regulator flow} &= \text{maximum pump out rate} + \text{temperature drop} \\ &= [8.02 \times \text{maximum pump out rate}] + [3.08 \times \text{C-Factor} \times (\text{Tank Volume})^{0.7} \times \text{insulation factor}] \end{aligned}$$

(Note that the constants 8.02 and 3.08 are to convert the result from metric to English units.)

To illustrate how this calculation, let's consider the following example:

Latitude → Below 42 Degrees  
 Vapor Pressure → Unknown  
 Average Storage Temp → 80 Degrees F  
 Tank Volume → 50,000 Barrels  
 Insulation → None  
 Max Pump In/Out → 100 Gallons/Min  
 Liquid Type → Volatile

Latitude	C-Factor			
	Vapor pressure similar to Hexane		Vapor pressure higher than Hexane or unknown	
	Average Storage Temperature			
	< 77 F	> 77 F	< 77 F	> 77 F
Below 42 Deg	4	6.5	6.5	6.5
Between 42 and 58 Degrees	3	5	5	5
Above 58 Degrees	2.5	4	4	4

Tank blanketing regulator flow = maximum pump out rate + temperature drop

$$\begin{aligned}
 &= [8.02 \times \text{maximum pump out rate}] + [3.08 \times \text{C-Factor} \times (\text{Tank Volume})^{0.7} \times \text{insulation factor}] \\
 &= [8.02 \times 100] + [3.08 \times (6.5) \times (50,000 \times 5.618)^{0.7} \times 1] \\
 &= 131,254 \text{ SCFH}
 \end{aligned}$$

Note that the insulation factor is 1 because there is no insulation. Also, the 5.618 constant converts barrels to cubic feet so that as result in SCFH can be obtained.

## Implications of the New Guideline: In-Breathing

The latest API Standard 2000 7<sup>th</sup> Edition (and 6<sup>th</sup> Edition for that matter) result in greater In-Breathing requirements, and they may be much greater depending on the C-Factor which takes into account vapor pressure, average storage pressure, and latitude.

This is illustrated in Figure 6 which shows in-breathing requirements vs. tank size. The curve at the bottom of the graph depicts results using API Standard 2000 5<sup>th</sup> Edition, also known as Appendix A. Note that this curve ends at 180,000 barrels. This is because the scope of this edition was limited to this tank size. All of the other curves depict the 7<sup>th</sup> Edition, under different C-Factors. It can be seen that the relationship between in-breathing and tank size is not a linear one. The reason is that for smaller tanks, the tank surface to volume ratio is greater - and for larger tanks, the surface to volume ratio is smaller. This is why the curves start out linear and then tend to flatten out.

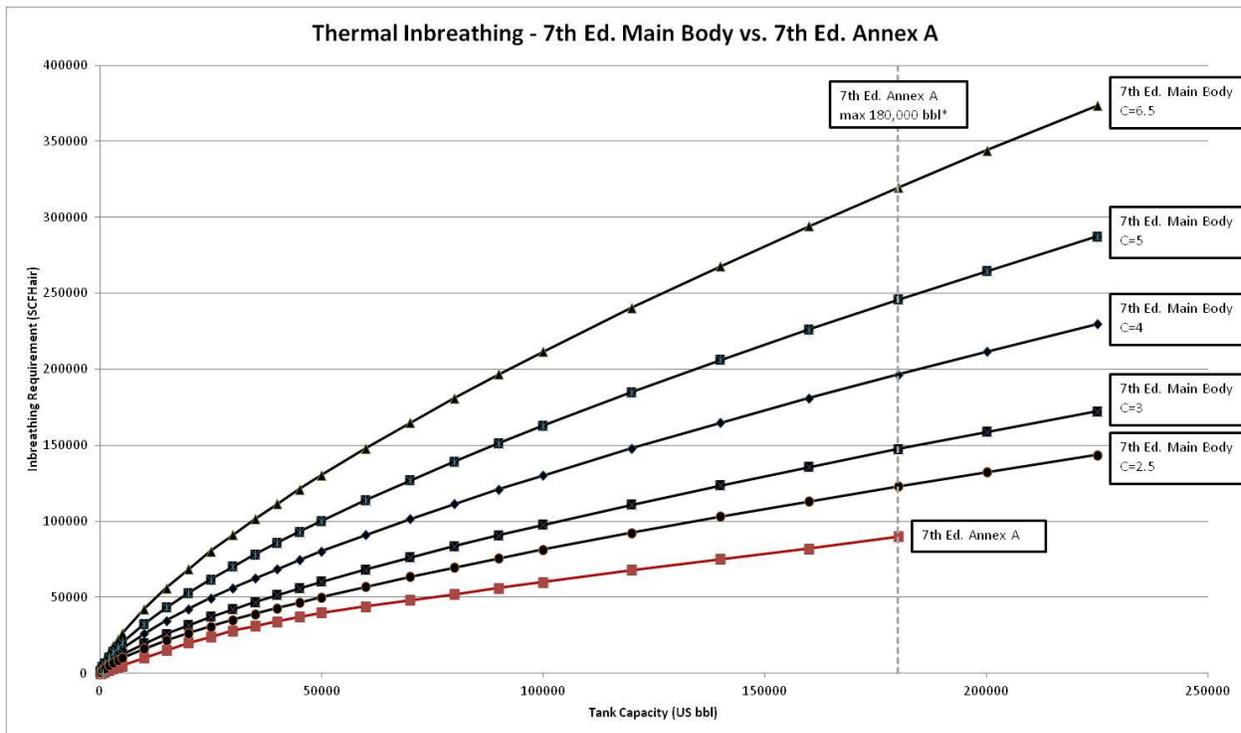


Figure 6: API Standard 2000 5<sup>th</sup> vs. 6<sup>th</sup>/7<sup>th</sup> Editions – In-Breathing

### Sizing Calculation for a Vapor Recovery Regulator

Let's now turn to the sizing calculations for out-breathing, which will determine the flow requirement for a vapor recovery regulator. The general steps in this case are:

- (1) determine the volumetric flow rate required to compensate for the liquid being pumped in;
- (2) determine the volumetric flow rate required due to temperature rise;
- (3) add the results of (1) and (2) together.

In the case of the out-breathing calculations, there are 2 sets of equations, one for non-volatile, and another for volatile liquids.

#### Non-volatile liquids

$$\begin{aligned} \text{Vapor recovery regulator flow} &= \text{maximum pump in rate} + \text{temperature rise} \\ &= [8.02 \times \text{maximum pump in rate}] + [1.51 \times \text{Y-Factor} \times (\text{Tank Volume} \times 5.618)^{0.9} \times \text{Insulation Factor}] \end{aligned}$$

(Note that the constants 8.02 and 1.51 are to convert the result from metric to English units.)

#### Volatile liquids

$$\begin{aligned} \text{Vapor recovery regulator flow} &= \text{maximum pump in rate} + \text{temperature rise} \\ &= [16.04 \times \text{maximum pump in rate}] + [1.51 \times \text{Y-Factor} \times (\text{Tank Volume} \times 5.618)^{0.9} \times \text{Insulation Factor}] \end{aligned}$$

Notice that the only difference between the equations for non-volatile and volatile liquids is that the 8.02 constant changes to 16.04 for volatile liquids. This is a key simplification mentioned earlier, that has been implemented with the 7<sup>th</sup> Edition of API Standard 2000. Volatile liquids will result in twice the out-breathing flow requirements as non-volatile ones.

To illustrate how this calculation works, let's consider the same example once again:

Latitude → Below 42 Degrees  
Vapor Pressure → Unknown  
Average Storage Temp → 80 Degrees F  
Tank Volume → 50,000 Barrels  
Insulation → None  
Max Pump In/Out → 100 Gallons/Min  
Liquid Type → Volatile

Latitude	Y-Factor
Below 42 Deg	0.32
Between 42 & 58 Deg	0.25
Above 58 Deg	0.20

$$\begin{aligned} \text{Vapor recovery regulator flow} &= \text{maximum pump in rate} + \text{temperature rise} \\ &= [16.04 \times \text{maximum pump in rate}] + [1.51 \times \text{Y-Factor} \times (\text{Tank Volume} \times 5.618)^{0.9} \times \text{Insulation Factor}] \\ &= [16.04 \times 100] + [1.51 \times 0.32 \times (50,000 \times 5.618)^{0.9} \times 1] \\ &= 40,314 \text{ SCFH} \end{aligned}$$

## Implications of the New Guideline: Out-Breathing

Figure 7 shows a comparison of out-breathing requirements vs. tank size. The two curves indicated as Appendix A represent the API Standard 2000 5<sup>th</sup> Edition. There are two curves shown to illustrate both non-volatile and volatile liquids. The remaining curves depict results obtained using the 7<sup>th</sup> Edition, under different Y-Factor figures. The use of the latest guideline can result in greater out-breathing requirements, but not always. And, in general, when increased flow requirements result, they do not represent as much of a difference as do the in-breathing requirements explained earlier.

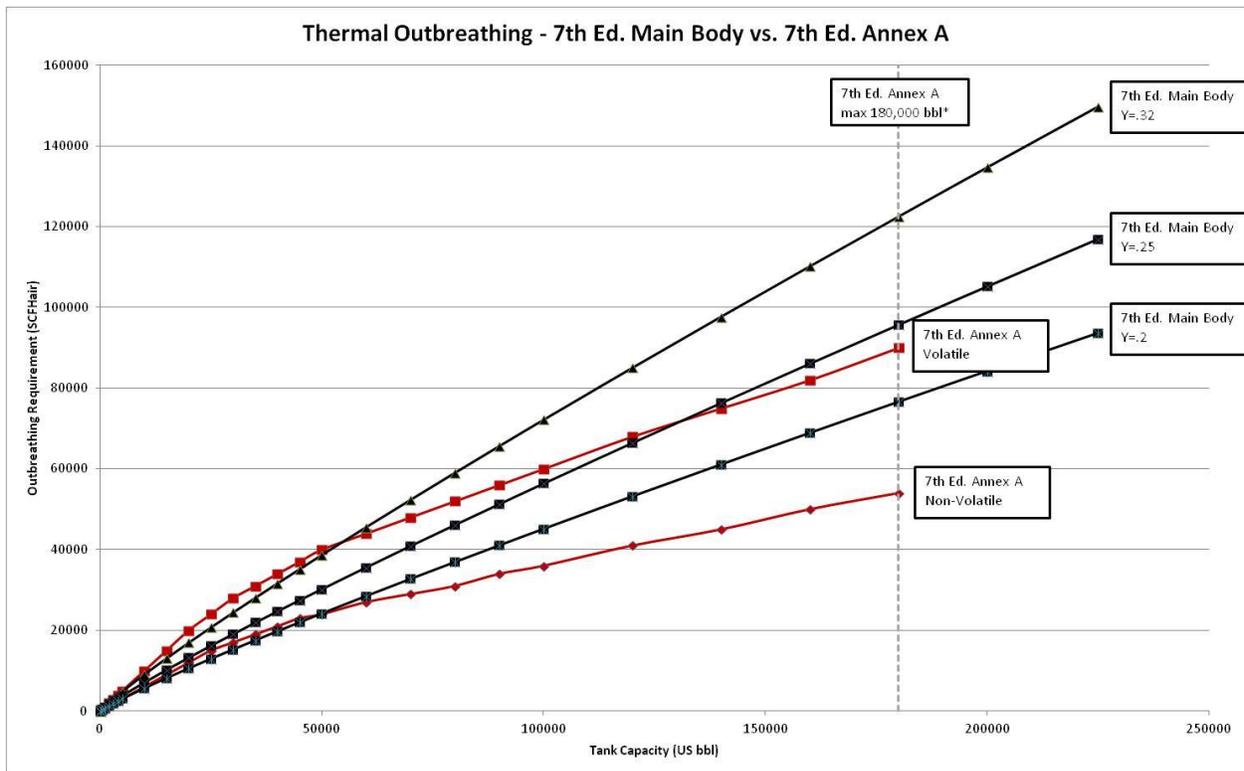


Figure 7: API Standard 2000 5<sup>th</sup> vs. 6<sup>th</sup>/7<sup>th</sup> Editions – Out-Breathing

## Conclusions

The latest API Standard 2000 7<sup>th</sup> Edition represents minor changes to the previous edition. However, it is important to recognize that the changes set forth by API Standard 2000 6<sup>th</sup> Edition remain intact. Although the 5<sup>th</sup> Edition continues to be widely used for sizing blanketing and vapor recovery regulators, it is expected that the newer editions will gain more acceptance and use in the years ahead.

These newer editions often result in greater flow requirements, especially for in-breathing. So it is important to recognize that the selection of the appropriate regulator may be impacted. Once the required flow is determined, other factors to consider would be the type of application, pipe size requirements, pressure, the desired set point, and the chemical compatibility of materials.