TANKAGE | VENTING

RELIEF CAPACITY CURVES

SERIES 4000 MARSH HAWK TRV
SERIES 200 & 300 TVTH
SERIES 6000 PVRV
SERIES 5000 EPRV

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A relief capacity curve provides the flow relieving capacity of a particular venting device by plotting the flow rate through the device on the horizontal, or x-axis against the tank pressure specifically at the inlet of the vent, on the vertical or y-axis. These curves can be used to size a venting device for a given application.

**REQUIRED INFORMATION**

The type and configuration of the required device must be known in order to size a vent. This information is often integral to the purpose of the vent. For example, if the vent is for emergency pressure relief, an EPRV will likely be selected, if the relieved vapors must be collected or processed then a Pipe-Away PVRV will be selected. Refer to corresponding brochures and technical bulletin TB-1217-TV for assistance in vent selection.

A minimum of three quantities based on the design of the tank, process or application are required to size a relief device:

- required relieving flow capacity for pressure and/or vacuum;
- maximum relieving pressure/vacuum; and,
- set pressure/vacuum.

Pressure relief and vacuum relief are sized separately.

**HOW TO USE RELIEF CAPACITY CURVES**

1. Use the device and size estimation charts in conjunction with the table of contents to find the type and configuration of the device required.

2. Begin sizing by turning to the pressure flow curve (if applicable) of the smallest available size for the selected device.

3. Flow curves for multiple set pressures/vacuums are displayed on each graph. Identify the flow curve that corresponds to the required set pressure/vacuum.

4. On the vertical axis (Tank Pressure) find the maximum relieving pressure and draw a horizontal line at this pressure until it crosses the previously identified flow curve.

5. At the point where the flow curve and horizontal line cross, draw a vertical line down to the horizontal axis (Flow Rate through Device). The number on this axis represents the flow rate through the device at the maximum relieving pressure.

6. If the flow rate through the device is lower than the required relieving capacity, repeat steps 3-5 for the next larger vent size until the flow relieving capacity of the vent exceeds the required relieving capacity.

**Notes:**

i. If the required relieving capacity cannot be satisfied by the largest available size in the selected venting class, a larger venting class, such as an EPRV, or multiple vents can be added to meet the required relieving capacity.

ii. If the minimum required vent size differs as a result of pressure sizing and vacuum sizing, the larger vent of the two must be chosen.

iii. The gas type and conditions must be the same between units. Follow appropriate conversion method to convert between gas types and conditions.

iv. All pressure readings are provided in gauge pressure (zero-referenced to ambient pressure).

**UNIT CONVERSIONS - PRESSURE**

The pressures reported on the capacity charts published by Hawkeye Industries are in ounces per square inch (ozsi). To convert from other pressure units to ozsi, select the appropriate conversion factor from this chart:

<table>
<thead>
<tr>
<th>Conversion Factors</th>
<th>Pressure to Ounces per Square Inch (ozsi) (5 SIG FIG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To Convert From:</td>
<td>Multiply by:</td>
</tr>
<tr>
<td>psi</td>
<td>0.0625</td>
</tr>
<tr>
<td>atm</td>
<td>233.14</td>
</tr>
<tr>
<td>mbar</td>
<td>0.23206</td>
</tr>
<tr>
<td>bar</td>
<td>232.06</td>
</tr>
<tr>
<td>Pa</td>
<td>0.0023206</td>
</tr>
<tr>
<td>kPa</td>
<td>2.3206</td>
</tr>
<tr>
<td>MPa</td>
<td>2320.6</td>
</tr>
<tr>
<td>kgf/m²</td>
<td>0.022757</td>
</tr>
<tr>
<td>kgf/cm²</td>
<td>227.57</td>
</tr>
<tr>
<td>mmHg</td>
<td>0.30939</td>
</tr>
<tr>
<td>inHg</td>
<td>7.8363</td>
</tr>
<tr>
<td>inH₂O</td>
<td>0.57802</td>
</tr>
<tr>
<td>Torr</td>
<td>0.30939</td>
</tr>
</tbody>
</table>

**UNIT CONVERSIONS - VOLUMETRIC FLOW**

The flow rates reported on the capacity charts published by Hawkeye Industries are equivalent volumetric flows, in cubic feet per hour, of air at standard conditions, and noted as “SCFH (air).” Unlike liquid or solid quantities, measuring and reporting gaseous properties is complicated by properties that change as temperature and pressure change. As such, gaseous properties are reported in terms of reference conditions. These are conditions specified by API 2000 7th Edition, Annex D, and may not correspond to other internationally recognized conditions (IUPAC, ISO, etc.).

This means that to convert a unit in normal conditions to a different unit in standard conditions, it is a two step process.

1. Convert conditions
2. Convert units

The first reference conditions, called “Standard Conditions,” reports the volume of a gas at a pressure of 101.325 kPa absolute [14.696 psia], and at a temperature of 15.56°C [60°F]. Units reported in Standard conditions are prefixed with an ‘S’ (eg. SCFM instead of CFM)

The other common condition, usually associated with metric units, is “Normal Conditions.” These report volume of a gas at pressure of 101.325 kPa absolute [14.696 psia] and at 0°C [32°F]. Units reported in Normal conditions are prefixed with an ‘N’ (eg. Nm3/hr instead of m3/hr)

To convert between normal and standard conditions, multiply the normal condition property by 1.0281.

Note the units remain the same in these conversions, only the conditions change.

To complete the conversion to another unit, i.e. CFH, the appro-
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conversion factors maintain the same condition of the starting unit.

CONVERSION FACTORS

VOLUMETRIC FLOW TO CUBIC FEET PER HOUR (CFH) (5 SIG-FIG)

To Convert From: Multiply by:
CFM cubic feet per minute 60
CFs cubic feet per second 3600
m³/hr cubic metres per hour 35.315
m³/min cubic metres per minute 2118.9
m³/s cubic metres per second 127130
L/hr litres per hour 0.035315
L/min litre per minute 2.1189
L/s litres per second 127.13
US gph US gallons per hour 0.13368
US gpm US gallons per minute 8.0208
US gasp US gallons per second 481.25
Imperial gph Imp/UK gallons per hour 0.16054
Imperial gpm Imp/UK gallons per minute 9.6326
Imperial gasp Imp/UK gallons per second 577.96
US bpd US Barrels per day 0.23394

UNIT CONVERSIONS - GAS FLOW TO AIR

AT STANDARD CONDITIONS

The rated flow capacities of venting devices are reported as the flow of air at either standard or normal conditions. This standard practice allows for the direct comparison of performance between venting devices and provides relieving capacity values in units that are similar to most practical venting situations.

In some applications, however, the relieving fluid may be substantially different than air at standard or normal conditions. In this case the following equation can be used to estimate the equivalent flow:

\[ q_{air} = q_i \frac{M_{fl}}{M_{air}} \]  \hspace{1cm} eq. 2

Where,

- \( q_{air} \) is the equivalent volumetric flow of air at standard conditions in SCFH;
- \( q_i \) is the actual volumetric flow rate of the relieving fluid in SCFH;
- \( M_{fl} \) is the molecular mass of the fluid;
- \( M_{air} \) is the molecular mass of air;


EXAMPLE CONVERSIONS:

Example: Convert 5 kPa to ozsi.

From the chart above, the conversion factor is 2.3206. We’ll multiply 5 kPa by this number to get the pressure in ozsi.

\[ 5 \text{ kPa} \times 2.3206 = 11.603 \text{ ozsi} \Rightarrow 11.6 \text{ ozsi} \]

Example: Convert 1000 Nm³/hr to Sm³/hr

We see that the provided volume is in Normal conditions, by the ‘N’ preceding the volume unit. To convert to an equivalent volume in standard conditions, we multiply by 1.0281

\[ 1000 \text{ Nm}^3/\text{hr} \times 1.0281 = 1028.1 \text{ Sm}^3/\text{hr} \]

Example: Convert 500 Nm³/hr to SCFH

We see that the provided volume is in Normal conditions, by the ‘N’ preceding the volume unit, and we are looking for an answer in Standard conditions.

1.) Convert to standard conditions

\[ 500 \text{ Nm}^3/\text{hr} \times 1.0281 = 514.05 \text{ Sm}^3/\text{hr} \]

2.) Convert units

From the chart, the conversion factor from m³/hr to CFH is
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Example: Convert 1,000 US gph to SCFH
There is no reference condition on the starting unit, so we can skip the reference condition conversion. Technically then, our answer will be in CFH, not SCFH.

1.) Convert units
From the chart, the conversion factor from US gph to CFH is 0.13368.
1,000 US gph × 0.13368 = 133.7 CFH.

Example: Estimate 1,000 SCFH Methane flow in standard air-equivalent.
As this is asking only for an estimate, so we will use eq. 2.

1.) Determine Molecular Masses
The molecular mass is the sum of the masses of the constituent atoms. The molecular formula for methane is CH₄, and the atomic weights of carbon (C) and hydrogen (H) are 12.011 and 1.008 respectively.

\[ M_{\text{methane}} = M_C + 4 \times M_H = 12.011 + 4 \times 1.008 = 16.043 \text{ g/mol} \]

\[ M_{\text{air}} \text{ is empirically derived to be 28.966 g/mol} \]

2.) Convert flow

\[ q_{\text{fl}} = 1,000 \text{ SCFH} \]

\[ q_{\text{air}} = 1,000 \text{ SCFH} \times \left( \frac{16.043}{28.966} \right)^{1/2} \]

\[ q_{\text{air}} = 1,000 \times (0.55386)^{1/2} = 1,000 \times 0.74421 = 744.2 \text{ SCFH} \]

MORE COMPLICATED CONVERSIONS

Example: Convert 12 ozsi to Pa
The values on the pressure conversion chart are for converting to ozsi, not from. However, we can still use these factors and divide by them instead of multiplying.
From the chart, the conversion factor from Pa to ozsi is 0.0023206. To get bar from ozsi, we will divide by this number.

\[ 12 \text{ ozsi} \div 0.0023206 = 5,171.1 \text{ Pa} \]

Example: Convert 20,000 CFH to m³/hr
The values on the volumetric flow conversion chart are for converting to CFH, not from. However, we can still use these facts and divide by them instead of multiplying.
Note, there is no reference conditions on the units we are working with.
From the chart, the conversion factor from m³/hr to CFH is 35.315. To get m³/hr from CFH, we will divide by this number.

\[ 20,000 \text{ CFH} \div 35.315 = 566.3 \text{ m³/hr} \]

Example: Convert 5,000 SCFH to Nm³/hr
Note, there are reference conditions on the units we are working with, so we will need to take that into account.
The factor of 1.0281 we have is to go from Normal conditions to Standard conditions. We can convert from Standard conditions to normal by dividing by this same number.

1.) Convert to Normal Conditions

\[ 5000 \text{ SCFH} \div 1.0281 = 4863.34 \text{ NCFH} \]

2.) Convert units
From the chart, the conversion factor from m³/hr to CFH is 35.315. To get m³/hr from CFH, we will divide by this number.

\[ 4863.37 \text{ NCFH} \div 35.315 = 137.7 \text{ Nm³/hr} \]
1.) LOCATE FLOW RATE ON HORIZONTAL (X) AXIS.

2.) TRACE LINE UPWARDS TO DESIRED TANK PRESSURE FROM VERTICAL (Y) AXIS [NOTE: PRESSURE IS IN TERMS OF % OVER SET PRESSURE, WHERE 100% = 2 × SET PRESSURE]

3.) SELECT DEVICE SIZE WHOSE FLOW PROFILE CONTAINS THE INTERSECTION OF THESE TWO LINES.

4.) IF THE INTERSECTION POINT LIES WITHIN MULTIPLE DEVICE PROFILES, SELECT THE LEFT-MOST DEVICE FOR SMALLER SIZE.

5.) ONCE DEVICE SIZE IS SELECTED, CONSULT THE FLOW CURVE TO THAT SPECIFIC DEVICE, CONFIGURATION SIZE, VALVE TYPE AND CONFIRM SUITABILITY OF FLOW CAPACITY.
1.) Locate flow rate on horizontal (X) axis.
2.) Trace line upwards to desired tank pressure from vertical (Y) axis
   (Note: pressure is in terms of % over set pressure, where 100% = 2 × set pressure)
3.) Select device size whose flow profile contains the intersection of these two lines.
4.) If the intersection point lies within multiple device profiles, select the left-most device for smaller size.
5.) Once device size is selected, consult the flow curve to that specific device, configuration size, valve type and confirm suitability of flow capacity.
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### CONTACT YOUR HAWKEYE SALES REP FOR THE FLOW CURVE FOR YOUR DEVICE.