<table>
<thead>
<tr>
<th>System Categories</th>
<th>Emission Source Categories</th>
<th>Emission Factor Sources</th>
<th>Description</th>
<th>Explanatory Notes/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Pipeline</td>
<td>Transmission Pipeline Leaks</td>
<td>Engineering Estimate</td>
<td>Emissions estimated from size of breach / pressure / duration calculation</td>
<td>For 2017, the INGAA Greenhouse Gas Emission Estimation Guidelines for Natural Gas Transmission and Storage - Volume 1 GHG Emission Estimation Methodologies and Procedures (September 28, 2005 - Revision 2) - Table 4-4 study provides the best available estimate of emissions for Transmission Pipeline, which includes emissions from Flanges and Valves. The emissions for the component leaks reported in &quot;Component leaks&quot; worksheet are accounted for by this mileage-based INGAA Emission Factor.</td>
</tr>
<tr>
<td>All damages (as defined by PHMSA)</td>
<td>All damages (as defined by PHMSA)</td>
<td>Engineering Estimate</td>
<td>Emissions estimated either from modelling or size of breach / pressure / duration</td>
<td>For the Transmission Odor Intensity Test; Annual Emission = Number of Tests * Volume per Test</td>
</tr>
<tr>
<td>Transmission Pipeline Blowdowns</td>
<td>Transmission Pipeline Blowdowns</td>
<td>Engineering Estimate</td>
<td>Unique equipment volume (corrected for pressure and temperature)</td>
<td>The following equations adhere to manufacturing specifications: For Transmission (BTU) Gas Chromatographs (GCs); Annual Emission = (Number of GCs * Sample Flow + Number of GC Streams * Bypass Flow) * Unit conversion factor. For Transmission (Gas Quality) Gas Chromatographs (GCs); Annual Emission = (Number of GCs * Sample Flow + Number of GCs + Number of Additional Streams) * Flow * Volume per Test Unit conversion factor. For Odorizer; Annual Emission = Number of strokes * Emission per stroke, where Number of strokes = (Gas Volume * Injection Rate) * (Odorant Density * Pump Stroke Volume) * Unit conversion factor.</td>
</tr>
</tbody>
</table>
| Pneumatic Devices - Pneumatic/Hydraulic Valve Operators, and Turbine Valve Operators | Pneumatic Devices - Pneumatic/Hydraulic Valve Operators, and Turbine Valve Operators | MRR                       | Low Continuous Bleed = 0.0336 Mscf/day/dev  
Intermittent Bleed = 0.0676 Mscf/day/dev  
High Continuous Bleed = 0.4457 Mscf/day/dev  
Hydraulic Valve Operator = TBD  
Turbine Valve Operator = TBD                  | 1.27 Mscf/yr/odorizer (if manufacturing specs are available, use the manufacturing specs instead of the default emission factor)                                                                                     |
| Pressure Relief Valves             | Pressure Relief Valves     | MRR                      | Pressure relief valve = 0.8713 Mscf/day/dev                                 |                                                                                                                                                                                                                          |
| Odorizer (Odorizer and Gas Sampling Vents) | Odorizer (Odorizer and Gas Sampling Vents) | TCR                      | 1.27 Mscf/yr/odorizer                                                      | The vented emissions for pneumatic devices reported in the "Component Vented Emissions" worksheet for Transmission M&R Stations are accounted for as part of the station’s emission factor, which is 1,554.8 Mscf/yr/station. The fugitive emissions for the component leaks reported in "Component leaks" worksheet for Transmission M&R Stations are accounted for as part of the station’s emission factor, which is 1,554.8 Mscf/yr/station. |
| M&R Stations - Farm Taps & Direct Industrial Sales | M&R Stations - Farm Taps & Direct Industrial Sales | MRR                      | # of leaks > 10,000 ppm x Subpart W EF  
Farmland Tap / Direct Sale = 12.2 Mscf/day/station  
Non-compressor components  
Valve = 0.1572 Mscf/day/dev  
Connector = 0.1399 Mscf/day/dev  
Open-ended line = 0.276 Mscf/day/dev  
Pressure relief valve = 0.0492 Mscf/day/dev  
Meter = 0.0728 Mscf/day/dev | The vented emissions for pneumatic devices reported in the "Component Vented Emissions" worksheet for Transmission M&R Stations are accounted for as part of the station’s emission factor, which is 1,554.8 Mscf/yr/station. The fugitive emissions for the component leaks reported in "Component leaks" worksheet for Transmission M&R Stations are accounted for as part of the station’s emission factor, which is 1,554.8 Mscf/yr/station. |
Ref: Table W-3 of Subpart W of Part 98  
Trans-to-trans = 1,554.8 Mscf/day/station  
Non-compressor components  
Valve = 0.1572 Mscf/day/dev  
Connector = 0.1399 Mscf/day/dev  
Open-ended line = 0.276 Mscf/day/dev  
Pressure relief valve = 0.0492 Mscf/day/dev  
Meter = 0.0728 Mscf/day/dev | The vented emissions for pneumatic devices reported in the "Component Vented Emissions" worksheet for Transmission M&R Stations are accounted for as part of the station’s emission factor, which is 1,554.8 Mscf/yr/station. The fugitive emissions for the component leaks reported in "Component leaks" worksheet for Transmission M&R Stations are accounted for as part of the station’s emission factor, which is 1,554.8 Mscf/yr/station. |
<table>
<thead>
<tr>
<th>System Categories</th>
<th>Emission Source Categories</th>
<th>Emission Factor Sources</th>
<th>Description</th>
<th>Explanatory Notes/Comments</th>
</tr>
</thead>
</table>
| **Transmission Compressor Stations** | Transmission M&R Leaks | MRR | # of leaks > 10,000 ppm x Subpart W EF (ref: Table W-3 of Subpart W of Part 98)  
Non-compressor components  
Valve = 0.1572 Mscf/day/dev  
Connector = 0.1399 Mscf/day/dev  
Open-ended line = 0.276 Mscf/day/dev  
Pressure relief valve = 0.0492 Mscf/day/dev  
Meter = 0.0728 Mscf/day/dev | See Appendix 2 Explanatory Notes / Comments |
| | Transmission M&R blowdown | Engineering Estimate | Unique equipment volume (corrected for pressure and temperature) | # of leaks > 10,000 ppm x Subpart W EF (ref: Table W-3 of Subpart W of Part 98)  
Compressor components  
Valve = 0.35616 Mscf/day/dev  
Connector = 0.13416 Mscf/day/dev  
Open-ended line = 0.41448 Mscf/day/dev  
Pressure relief valve = 0.95184 Mscf/day/dev  
Meter = 0.46392 Mscf/day/dev | |
| | Compressor Station - Transmission storage tanks | MRR | Direct measurement of tank vapor vent stack + operating hours (pg 218-219 of Regulation for MRR) | Annual Emissions for Tank Pressure Release Due to Temperature Fluctuation: The initial volume of gas released is calculated based on starting and ending pressures assuming a constant -260°F in the tank. This volume is then adjusted to standard conditions (sulf). Note: Pressure normally fluctuates slightly in the main tank due to instrument measurement accuracy, but any drop in pressure 1 psi or greater is typically due to a fill or maintenance procedure (including the vapor releases to maintain a safe operating pressure). An hourly pressure read from the LNG SCADA data is downloaded and all pressure drops meeting the above criteria are captured. |
| | Compressors (Centrifugal) - Transmission – data collection will require time spent in modes (active, pressurized idle, de-pressurized idle), compressor venting | MRR | Direct measurement x operating hours (operating mode) | |
| | Compressors (Reciprocating) - Transmission – data collection will require time spent in modes (active, pressurized idle, de-pressurized idle), compressor rod packing venting | MRR | Direct measurement x operating hours (operating mode) | |
| | Compressor station - Equipment and pipeline blowdowns | MRR | Eq. W - 144  
# of blowdowns * piping volume | LNG Tank annual emissions for Total Gas Lost Due to Filling Operations: The volume of gas delivered is recorded as gallons. This volume is then converted to standard conditions (sulf). |
| | Compressor Station - Natural gas pneumatic device venting | MRR | Low Continuous Bleed = 0.0336 Mscf/day/dev  
Intermittent Bleed = 0.0676 Mscf/day/dev  
High Continuous Bleed = 0.4457 Mscf/day/dev | |
| | Distribution Mains (Below-Ground Leaks) | GRI (1996) | Unprotected Steel Main = 0.1548 Mscf/day/leak  
Protected Steel Main = 0.0612 Mscf/day/leak  
Plastic Main = 0.2988 Mscf/day/leak | |
| | Distribution Mains (Above Ground Leaks) - Not MSA | GRI (1996) | Unprotected Steel Main = 0.1548 Mscf/day/leak  
Protected Steel Main = 0.0612 Mscf/day/leak  
Plastic Main = 0.2988 Mscf/day/leak | |
| | Distribution Service (Below-Ground Leaks) | GRI (1996) | Copper = 0.0226 Mscf/day/leak  
Unprotected Steel Service = 0.0600 Mscf/day/leak  
Protected Steel Service = 0.0276 Mscf/day/leak  
Plastic Service = 0.0089 Mscf/day/leak | |
| | Distribution Service (Above-Ground Leaks) - Not MSA | GRI (1996) | Copper = 0.0226 Mscf/day/leak  
Unprotected Steel Service = 0.0600 Mscf/day/leak  
Protected Steel Service = 0.0276 Mscf/day/leak  
Plastic Service = 0.0089 Mscf/day/leak | |
<p>| | Distribution Main, Pressure Relief Valves | MRR | Pressure relief valve = 0.0009 Mscf/day/dev | |</p>
<table>
<thead>
<tr>
<th>System Categories</th>
<th>Emission Source Categories</th>
<th>Emission Factor Sources</th>
<th>Description</th>
<th>Explanatory Notes/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution Mains and Services Pipelines</td>
<td>Distribution Mains and Services blowdown</td>
<td>MRR</td>
<td>Equation W-14A , Eq. W-35 , Eq. W-36</td>
<td>( \text{Annual Emission} = \pi \times \left( \frac{\text{Pipe Diameter}}{2} \right)^2 \times \text{Blowdown Footage} \times \text{Pressure conversion factor/Natural Gas Compressibility Factor} ). Note that for shut-in pressures less than 100 psig, the Natural Gas Compressibility Factor is 1.</td>
</tr>
<tr>
<td>All damages (as defined by PHMSA)</td>
<td>MRR</td>
<td>Equation W-14A , Eq. W-35 , Eq. W-36</td>
<td>( \text{Annual Emission} = \frac{\text{Pipe Diameter}^2}{4} \times \text{Blowdown Footage} \times \text{Pressure conversion factor/Natural Gas Compressibility Factor} ). Note that for shut-in pressures less than 100 psig, the Natural Gas Compressibility Factor is 1.</td>
<td></td>
</tr>
</tbody>
</table>

**Pneumatic Devices - Pneumatic/Hydraulic Valve Operators, and Turbine Valve Operators**

<table>
<thead>
<tr>
<th>System Categories</th>
<th>Emission Source Categories</th>
<th>Emission Factor Sources</th>
<th>Description</th>
<th>Explanatory Notes/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution M&amp;R Stations</td>
<td>Distribution Above grade M&amp;R Station Leaks ( &gt; 300 psi)</td>
<td>GRI (1996)</td>
<td>1,684.5 Mscf/yr/station</td>
<td>The fugitive emissions for the component leaks reported in the “Component Leaks” worksheet for Distribution M&amp;R Stations are accounted for as part of the station’s emission factor.</td>
</tr>
<tr>
<td>Distribution M&amp;R Stations</td>
<td>Distribution Above grade M&amp;R Station Leaks (100 - 300 psi)</td>
<td>GRI (1996)</td>
<td>896.5 Mscf/yr/station</td>
<td>The fugitive emissions for the component leaks reported in the “Component Leaks” worksheet for Distribution M&amp;R Stations are accounted for as part of the station’s emission factor.</td>
</tr>
<tr>
<td>Distribution M&amp;R Stations</td>
<td>Distribution Above grade M&amp;R Station Leaks ( &lt; 100 psi)</td>
<td>GRI (1996)</td>
<td>40.6 Mscf/yr/station</td>
<td>The fugitive emissions for the component leaks reported in the “Component Leaks” worksheet for Distribution M&amp;R Stations are accounted for as part of the station’s emission factor.</td>
</tr>
<tr>
<td>Distribution M&amp;R Stations</td>
<td>Distribution Below grade M&amp;R Station Leaks ( &gt; 300 psi)</td>
<td>GRI (1996)</td>
<td>12.176 Mscf/yr/station</td>
<td>The fugitive emissions for the component leaks reported in the “Component Leaks” worksheet for Distribution M&amp;R Stations are accounted for as part of the station’s emission factor.</td>
</tr>
<tr>
<td>Distribution M&amp;R Stations</td>
<td>Distribution Below grade M&amp;R Station Leaks (100 - 300 psi)</td>
<td>GRI (1996)</td>
<td>1,840 Mscf/yr/station</td>
<td>The fugitive emissions for the component leaks reported in the “Component Leaks” worksheet for Distribution M&amp;R Stations are accounted for as part of the station’s emission factor.</td>
</tr>
<tr>
<td>Distribution M&amp;R Stations</td>
<td>Distribution Below grade M&amp;R Station Leaks ( &lt; 100 psi)</td>
<td>GRI (1996)</td>
<td>0.964 Mscf/yr/station</td>
<td>The fugitive emissions for the component leaks reported in the “Component Leaks” worksheet for Distribution M&amp;R Stations are accounted for as part of the station’s emission factor.</td>
</tr>
</tbody>
</table>

**Residential Meters**

- **GRI (1996)**: 0.184 Mscf/yr/meter

**Commercial and Industrial Meters**

- **GRI (1996)**: 0.651 Mscf/yr/meter
<table>
<thead>
<tr>
<th>System Categories</th>
<th>Emission Source Categories</th>
<th>Emission Factor Sources</th>
<th>Description [in natural gas volume]</th>
<th>Explanatory Notes/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial, Industrial and Residential Meters</td>
<td>All damages (as defined by PHMSA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vented Emission from MSA</td>
<td>Engineering Estimate</td>
<td>Estimated volume release by MSA and activity type</td>
<td>See Appendix 6 Explanatory Notes / Comments</td>
<td></td>
</tr>
</tbody>
</table>

- Engineering Estimate: Estimated volume release by MSA and activity type
- One of the following three cases per dehydrator facility:
  1. Glycol dehydrator with VRU and thermal oxidizer = 0 Mscf
  2. Glycol dehydrator with no control device = Engineering Estimate
  3. Desiccant dehydrator = 2.23E-03 Mt CH4/MMscf
  (Alternative: Eq. 5 in MRR)

### Underground Storage

- Dehydrator Vents - Storage
  - GRI (1996)
  - One of the following three cases per dehydrator facility:
    1. Glycol dehydrator with VRU and thermal oxidizer = 0 Mscf
    2. Glycol dehydrator with no control device = Engineering Estimate
    3. Desiccant dehydrator = 2.23E-03 Mt CH4/MMscf
    (Alternative: Eq. 5 in MRR)

- Storage - piping leakage
  - MRR
  - Leaker EFS -- Storage Station, Gas Service
    (Survey was conducted, and only recorded leaking components use following EFS)
    - Valve = 129.998 Mscf/yr/dev
    - Connector = 49.573 Mscf/yr/dev
    - Open Ended Line = 151.285 Mscf/yr/dev
    - Pressure Relief Valve = 347.422 Mscf/yr/dev
    - Meter = 169.331 Mscf/yr/dev
  - Population EFS -- Storage Wellheads, Gas Service
    (Survey was not conducted, all components use following EFS)
    - Connector = 0.0876 Mscf/yr/dev
    - Valve = 0.876 Mscf/yr/dev
    - Pressure relief Valve = 1.489 Mscf/yr/dev
    - Open Ended Line = 0.2628 Mscf/yr/dev

- Storage - surface casing leakage
  - Engineering Estimate
  - TBD

- Storage - Wellhead leakage
  - Engineering Estimate
  - leak survey + extrapolation

- Storage - Compressor & blowdowns
  - Engineering Estimate
  - Eq. 13 of MRR (piping volume x # of blowdowns)

- Storage - Wellhead Rework blowdown and bring-in
  - Engineering Estimate
  - Eq. 9,10,11,12 of MRR

- Pressure Relief Valves
  - MRR
  - Pressure relief valve = 0.9713 Mscf/day/dev.

- Pneumatic Devices - Pneumatic/Hydraulic Valve Operators, and Turbine Valve Operators
  - MRR
  - Low Continuous Bleed = 0.0316 Mscf/day/dev
  - Intermittent Bleed = 0.0676 Mscf/day/dev
  - High Continuous Bleed = 0.4457 Mscf/day/dev
  - Hydraulic Valve Operator = TBD
  - Turbine Valve Operator = TBD