

Thermco Technical Advantage

Subject: Infinite Turndown Ratio: Practical and Economic Importance

The term “turndown ratio” is often applied to flow measurement devices such as rotameters (variable area) and mass flowmeters. Rotameters are often specified to maintain a flow accuracy of $\pm 2\%$ of full scale over a flow measurement range of 100% to 10%: a turndown ratio of 10:1. Mass flowmeters are often specified to maintain a flow accuracy of $\pm 1\%$ of full scale with a flow measurement range of 100% to 1%: a turndown ratio of 100:1.

For this technical article, the definition of turndown ratio for gas mixers is:

The ratio of the maximum design mixed gas flowrate to minimum design mixed gas flowrate, where the mixed gas percentage produced will be maintained within the specified accuracy.

Thermco Technical Advantage:

Thermco gas mixers are designed for infinite (∞) turndown ratios which means that the gas mixers will operate from the maximum design mixed gas flowrate flows such as 750 SCFH (standard cubic feet per hour), 2000 SCFH, etc., down to zero (no flow) and the mixed gas percentage will not vary outside the specified mixed gas percentage accuracy during any low flow and no flow condition.

Discussion:

Some gas mixers manufactured by other companies are not designed for infinite turndown ratio. Such gas mixers may only be designed to maintain their gas mixing percentage accuracy over a limited flow capacity range such as a flow capacity of 100% to 15% of rated capacity (a turndown ratio of about 7:1) or 700 SCFH to 20 SCFH: a turndown ratio of 35:1. With a turndown ratio of 35:1, it appears that this gas mixer is suitable for the normal operation of 1 to 20 manual weld stations based upon a mixed shield gas usage of 35 SCFH per station or a food packaging machine operating at 700 SCFH to 20 SCFH.

We have tested other manufacturer's gas mixers which are not designed for infinite turndown ratio capability and the creation of out-of-specification gas mixtures at low mixed gas flowrates has been analytically verified.

| Competitor's Gas Mixer Set to Produce a Mixture of 25% CO ₂ in Ar (Gas mixer not designed for infinite turndown ratio.) | | | | | | | | |
|---|------|------|------|------|------|------|------|------|
| Mixed Gas Flowrate, SCFH | 300 | 200 | 100 | 80 | 60 | 40 | 20 | 1 |
| Mixed Gas CO ₂ % | 24.8 | 25.7 | 26.6 | 27.5 | 28.8 | 30.7 | 40.9 | 90.8 |

For mixed gas flowrates of 100 SCFH or less, with the gas mixer set to produce a mixed gas of 25% CO₂, this gas mixer produced mixed gas outside the normal expected $\pm 1.5\%$ CO₂ tolerance: 23.5 to 26.5% CO₂.

Infinite Turndown Ratio: Practical and Economic Importance (Continued)

If the actual mixed gas flowrate is less than the gas mixer's minimum designed flowrate, then the gas mixer may create an out-of-specification gas mixture which may eventually fill the entire mixed gas distribution system. If the out-of-specification gas mixture is not purged from the mixed gas header, poor welds may be created due to the out-of-specification shield gas (which will result in the need for rework), or out-of-specification modified atmosphere packaging (MAP) gas mixtures can fill food packages (which can cause reduced shelf life or spoilage).

Question: What operating conditions might cause the actual mixed gas flowrate to be much lower than the normal production mixed gas usage?

Although mixed gas piping systems are intended to be leak-free, over time such piping distribution systems with screwed piping or some shutoff valve packing or quick-disconnect fittings may begin to slowly leak. The leakage rate may be only a few SCFH which might be less than the minimum design flowrate of the gas mixer.

Also, some customers require continuous mixed gas analysis verification, so if a gas analyzer is attached to the mixed gas header system, the continuous gas analyzer sample flowrates are typically 0.5 to 2 SCFH.

Therefore, when there is no mixed gas production usage (break times, overnights, weekends), the mixed gas flow may be less than the minimum turndown ratio which could create an out-of-specification gas mixture. After a while, the out-of-specification gas mixture could fill the entire mixed gas distribution system.

As a consequence, after break times the complete mixed gas distribution system would have to be purged of the out-of-specification gas mixture. When purging the out-of-specification gas mixture from the mixed gas header, valuable production time will be lost and gas supplies will be wasted.

The cost to purge a mixed gas system will vary depending upon the personnel/machine cost, the time to purge the mixed gas system and the cost of the gas.

Infinite Turndown Ratio: Practical and Economic Importance (Continued)

Lost Productivity Cost Caused by Gas Mixers Not Designed for Infinite Turndown Ratio

If personnel time or machine downtime costs are considered to purge the header system for 1 minute at the start of daily operations and 1 minute after 3 breaks a day (4 purges total per day), the productivity loss could be as much as US\$3,000 or more depending upon the number of welders or packaging machines and the cost value of each worker or packaging machine. Refer to the examples below.

**Productivity Losses Due to Mixed Gas Header Purging, One Shift per Day -
Caused by Gas Mixers Not Designed for Infinite Turndown Ratio**

| Application | Number of Welders or Machines | Worker or Machine Value | Combined Value | Purge Time, Minutes | Number of Purges per day | Operating Days per Year | Lost Productivity Cost per Year |
|------------------------|-------------------------------|-------------------------|----------------|---------------------|--------------------------|-------------------------|---------------------------------|
| Manual Welding | 10 | \$20/hr | \$200/hr | 1 | 4 | 250 | \$3,333 |
| Food Packaging Machine | 2 | \$100/hr | \$200/hr | 1 | 4 | 250 | \$3,333 |

Lost Gas Cost Caused by Gas Mixers Not Designed for Infinite Turndown Ratio

If gas costs are considered to purge the header system for 1 minute at the start of daily operations and 1 minute after 3 breaks a day (4 purges total per day), the lost gas cost per year would be about US\$343 to US\$2,030 per year which is dependent upon the gases used and the price paid for each cubic foot of gas. The gas costs indicated in the table below are for the gas contents and do not consider the equipment costs such as cylinder rental, delivery, facility equipment fees or handling costs, etc., which would be additional costs.

**Gas Cost Losses Due to Mixed Gas Header Purging – One Shift per Day
Caused by Gas Mixers Not Designed for Infinite Turndown**

| Application | Purge Rate, SCFH | Purge Time, Minutes | Number of Purges per day | Gas User Size | Minor gas | | | Major gas | | | Operating Days per Year | Lost Gas Cost per Year |
|------------------------|------------------|---------------------|--------------------------|---------------|-----------------|-----------|-------|----------------|-----------|-------|-------------------------|------------------------|
| | | | | | Gas Type | Mixture % | \$/CF | Gas Type | Mixture % | \$/CF | | |
| Manual Welding | 700 | 1 | 4 | Small | CO ₂ | 20% | 0.030 | Ar | 80% | 0.210 | 250 | \$2,030 |
| | | | | Large | CO ₂ | 20% | 0.027 | Ar | 80% | 0.070 | 250 | \$716 |
| Food Packaging Machine | 700 | 1 | 4 | Small | CO ₂ | 20% | 0.030 | O ₂ | 80% | 0.080 | 250 | \$817 |
| | | | | Large | CO ₂ | 20% | 0.027 | O ₂ | 80% | 0.030 | 250 | \$343 |

Infinite Turndown Ratio: Practical and Economic Importance (Continued)

Conclusion and Recommendation:

Therefore, when selecting a gas mixer, insist that the gas mixer be designed for infinite turndown ratio and that the mixed gas percentage accuracy will be maintained for low mixed gas flowrates such as 0.5 SCFH or less. Thermco gas mixers are designed and manufactured to meet this infinite turndown ratio requirement.