

# REVERSE FLOW EFFECTS ON TSI<sup>®</sup> GENERAL PURPOSE FLOWMETERS

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APPLICATION NOTE FLOW-003

December 2002

This applications note applies to the Following TSI Flowmeters: 4020, 4021, 4022, 4023, 4024, 4040, 4043, 4045, 4120, 4121, 4122, 4140, and 4143.

TSI<sup>®</sup> Flowmeters are designed and calibrated for flow in the direction indicated by the arrow on the flowmeter. Because the flowbodies are not symmetric and due to the location of the temperature compensation sensor, the flow in reverse direction will show a bias. For applications that require measurements in the reverse flow direction a simple correction equation can be applied.

The following pages show correction equations and graphs for the 4000 and 4100 series flowmeters. For reverse flow measurements, an additional uncertainty must be added to the 2% of reading standard uncertainty.

If reverse flow will be going through the meter, then a particle filter must be used on both ends of the meter to prevent contamination of the sensor.



## Series 4000 Flowmeters (4020, 4021, 4022, 4023, 4024, 4040, 4043, and 4045)

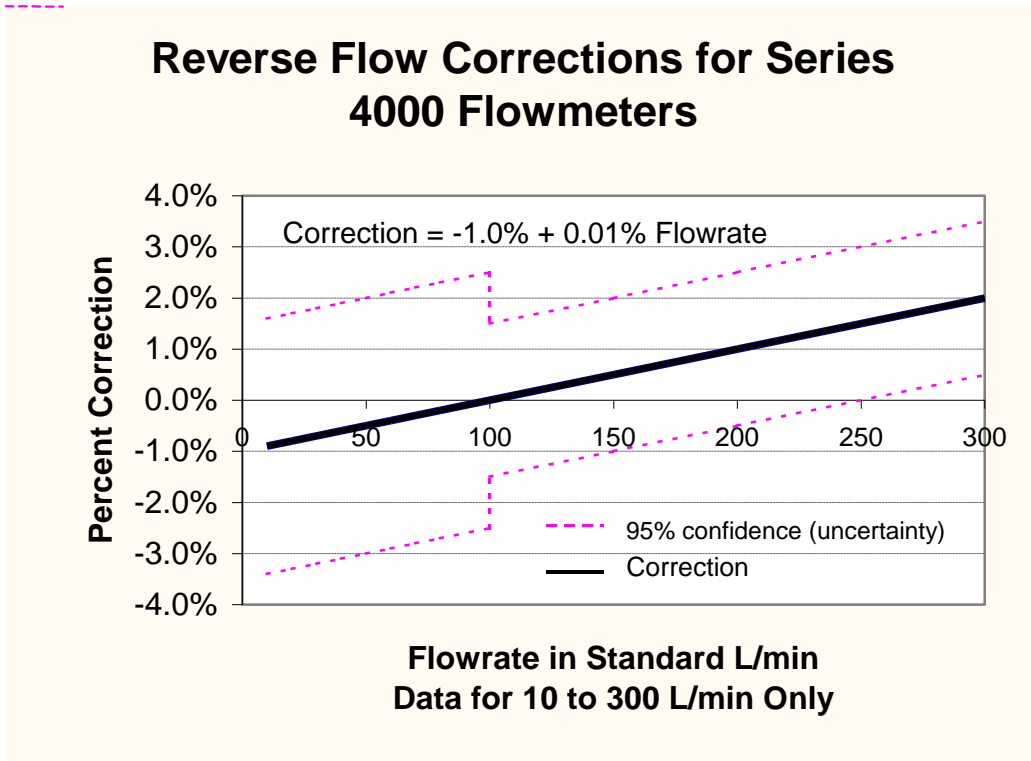
For flow rates above 10 standard L/min the below correction equation can be used for reverse flows. TSI does not recommend using reverse flow measurements below 10 standard L/min for this series of flowmeters, because the correction is large, has greater uncertainty, and depends on orientation of the meter.

### Correction in percent of reading = $-1\% + (0.01\% \times \text{Indicated Flow Rate})$

Example if the meter indicates 200 standard L/min the corrected reading would be  
 $200 \text{ std L/min} + 200 \text{ std L/min} \times (-1\% + 0.01\% \times 200)$   
 $= 200 \text{ std L/min} + 200 \text{ std L/min} \times (-1\% + 2\%)$   
 $= 200 \text{ std L/min} + 2 \text{ std L/min} = 202 \text{ std L/min}$

### Additional uncertainty of the readings for reverse correction equation (in addition to the 2% of reading base uncertainty)

Above 100 standard L/min: 1.5% of reading  
 From 10 to 100 standard L/min: 2.5% of reading  
 Below 10 standard L/min: Do not use in this range to measure in reverse direction.



Graph 1

## Series 4100 Flowmeters (4120, 4121, 4122, 4140, 4143)

For flow rates above 3 standard L/min the below correction equation can be used for reverse flows. TSI does not recommend using reverse flow measurements below 3 standard L/min for this series of flowmeters, because the correction is large, has greater uncertainty, and depends on orientation of the meter.

### Correction in percent of reading = $-6.67\% + 0.167\% \times \text{Indicated Flow Rate}$

Example if the meter indicates 12 standard L/min the corrected reading would be

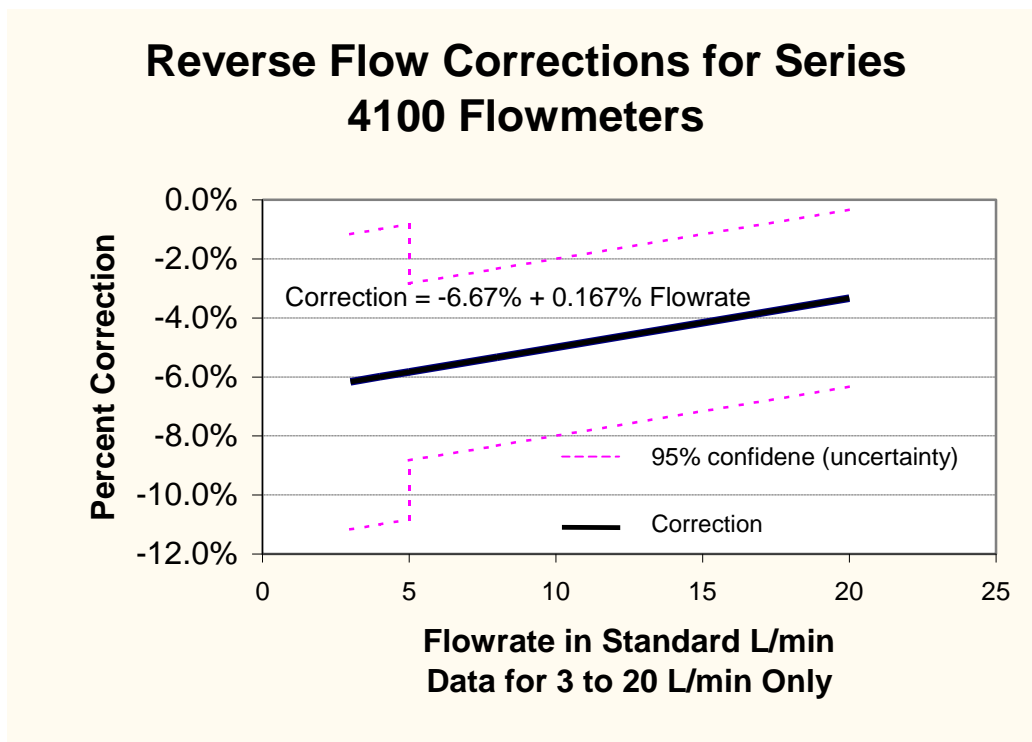
$$\begin{aligned} & 10.0 \text{ std L/min} + 10.0 \text{ std L/min} \times (-6.67\% - 0.167\% \times 10.0) \\ & = 10.0 \text{ std L/min} + 10.0 \text{ std L/min} \times (-6.67\% + 1.67\%) \\ & = 10.0 \text{ std L/min} + 0.5 \text{ std L/min} = 9.5 \text{ std L/min} \end{aligned}$$

### Additional uncertainty of the readings for reverse correction equation (in addition to the 2% of reading base uncertainty)

Above 5 standard L/min: 3% of reading

From 3 to 5 standard L/min: 5% of reading

Below 3 standard L/min: Do not use in this range to measure in reverse direction.



Graph 2



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