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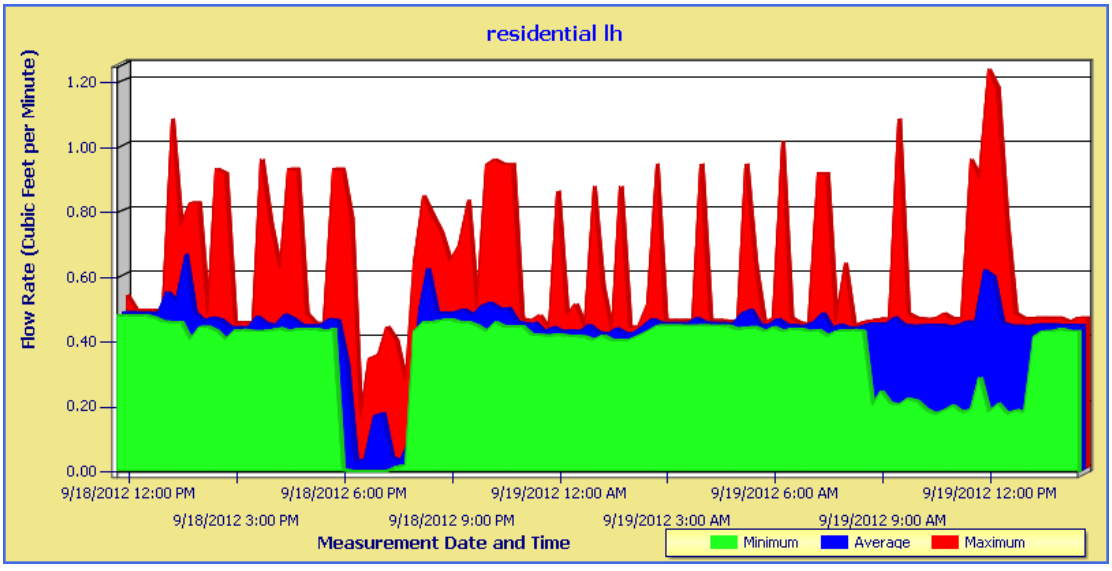
Analyzing Residential & Small Commercial Usage Patterns

with a focus on the impact of distribution system pressure oscillations

This document is intended to assist with the understanding of residential and small commercial water usage patterns generated using the Meter-Master Model 100 series flow recorders.

The graph and report options in the Model 100 Program software offer substantial resolution and presentation flexibility. Selecting the optimal graph & report options enable the user to present the data in the most accurate and revealing ways. Typically, the Meter-Master has been deployed because there is a problem requiring an explanation, such as a high bill. It is important to understand the Meter-Master graph & report selection options and output formats so that the data generated provides the best chance to address the problem. It is recommended that anyone responsible for analyzing the data & communicating the data results back to the water user have access to the software program in order to change the display parameters as needed to better define the 'story' being told by the data. We encourage users to experiment with the presentation options in order to better understand the software's capabilities. The default graphs & reports generated initially, without any user modification of the presentation options, are designed to provide an accurate overview of the data and will in many cases be sufficient to address the problem.

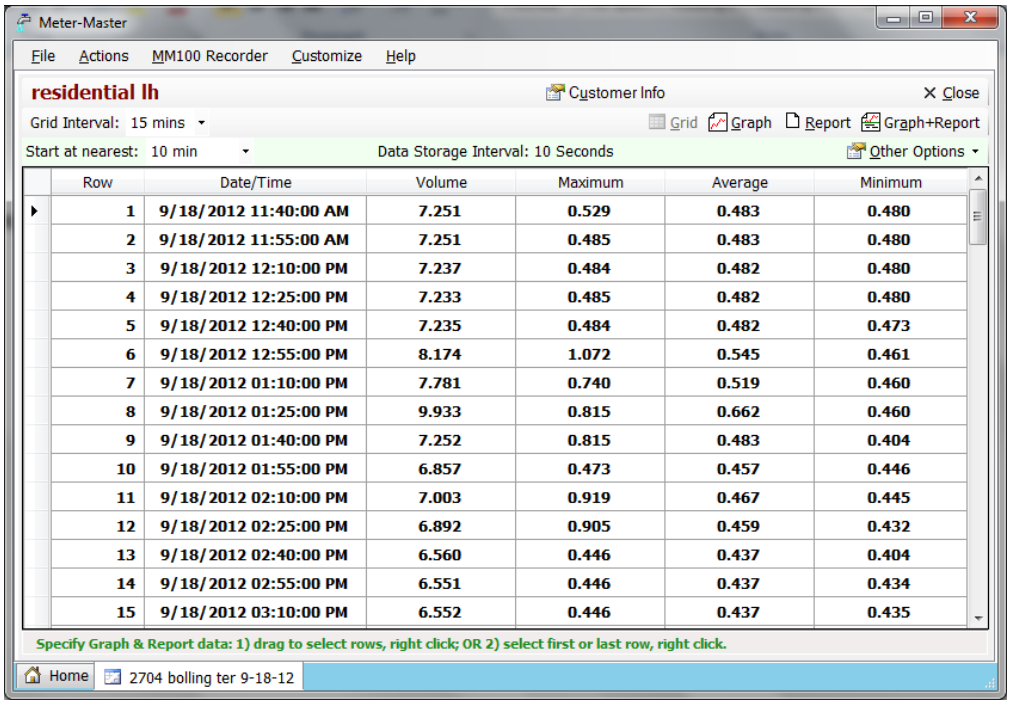
Below are some sample residential & small commercial water use graphs with explanations.



Note that all maximum, average, and minimum flow rates in any graph or report are rates per minute, e.g., gpm or cfpm, regardless of the unit of measure and time intervals selected. The above graph is a standard, default Max/Avg/Min graph, displaying the max, avg, and min flow rates within 15 minute 'Grid Intervals'. The 'Max-Min Interval', in this case, is 10 seconds. The

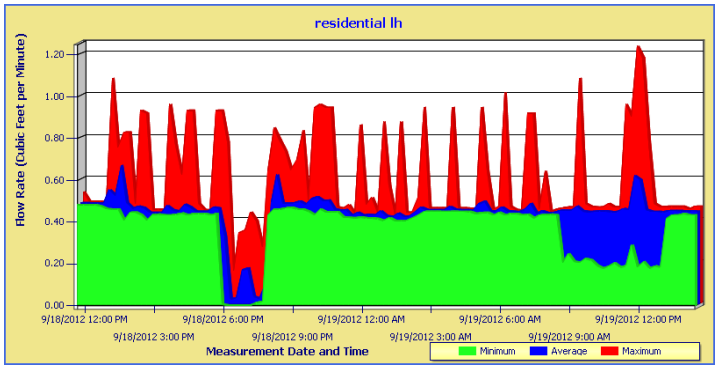
Max-Min Interval always defaults to equal the 'Data Storage Interval' selected when the unit was programmed to record in the field. Changing the Max-Min Interval is not recommended unless the user understands the implications. The Data Storage Interval is the smallest Max-Min Interval option available and will provide the most accurate, instantaneous max and min flow rates.

On the graph, **Green** is the minimum flow rate experienced within each Grid Interval. In this case, the Grid Interval is 15 minutes, the Max-Min Interval is 10 seconds (based on the 10 second storage interval in the field), and the units are cubic feet. **Green** shows the minimum cubic feet per minute (cfpm) flow rate experienced within any 10 second interval within each 15 minutes. In this case, there is a lot of green which means that there is a lot of continuous flow. **Blue** is the average flow rate within each 15 minutes in cfpm, and **Red** is the maximum cfpm flow rate experienced within any 10 second interval within each 15 minutes. Here is the same initial graph data shown in the software's Grid format. The first 15 minute Grid Interval ended at 11:40 AM and had a total volume of 7.251 cubic feet. The average flow rate was 0.483 cfpm, and the 10 second max and min flow rates were 0.529 and 0.480 cfpm, respectively.



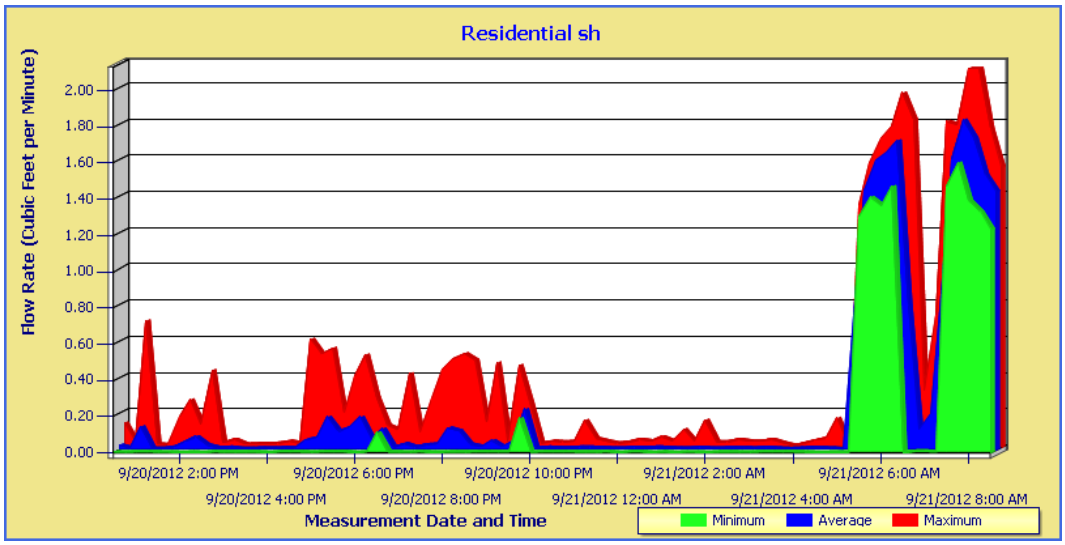
Row	Date/Time	Volume	Maximum	Average	Minimum
1	9/18/2012 11:40:00 AM	7.251	0.529	0.483	0.480
2	9/18/2012 11:55:00 AM	7.251	0.485	0.483	0.480
3	9/18/2012 12:10:00 PM	7.237	0.484	0.482	0.480
4	9/18/2012 12:25:00 PM	7.233	0.485	0.482	0.480
5	9/18/2012 12:40:00 PM	7.235	0.484	0.482	0.473
6	9/18/2012 12:55:00 PM	8.174	1.072	0.545	0.461
7	9/18/2012 01:10:00 PM	7.781	0.740	0.519	0.460
8	9/18/2012 01:25:00 PM	9.933	0.815	0.662	0.460
9	9/18/2012 01:40:00 PM	7.252	0.815	0.483	0.404
10	9/18/2012 01:55:00 PM	6.857	0.473	0.457	0.446
11	9/18/2012 02:10:00 PM	7.003	0.919	0.467	0.445
12	9/18/2012 02:25:00 PM	6.892	0.905	0.459	0.432
13	9/18/2012 02:40:00 PM	6.560	0.446	0.437	0.404
14	9/18/2012 02:55:00 PM	6.551	0.446	0.437	0.434
15	9/18/2012 03:10:00 PM	6.552	0.446	0.437	0.435

Returning to the graph, the presence of green is always indicative of continuous flow since it means that the flow rate never dropped to zero even for just 10 seconds during a 15 minute



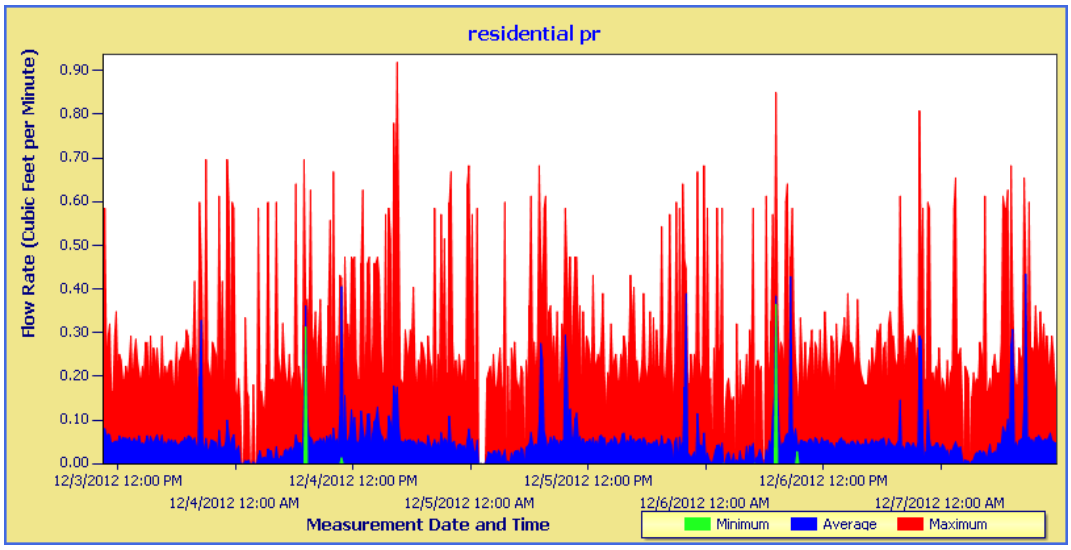
period. A steady rate of green as shown here (at about 0.5 cfpm) means that there is either leakage or a runny fixture. In this case, it would appear that the culprit is a runny fixture because there is a period of approximately 2 hours on Sept 18 when the minimum stayed at zero (no leakage), probably because the leaky fixture was tampered with to stop the leaky condition. On the 19th, there is a period of about 4.5 hours when the minimum dropped about 50% to about 0.25 cfpm. This could have been due to either an alteration of the runny fixture (e.g., toilet flapper was almost seated properly) or there was a drop in pressure at this location for 4.5 hours.

Here is a graph that shows morning irrigation from 5:30 to 6:30 AM and from 7:30 to 8:30 AM at about 1.4 cfpm (about 10 gpm). Since the Grid Interval here is also 15 minutes, a steady rate of



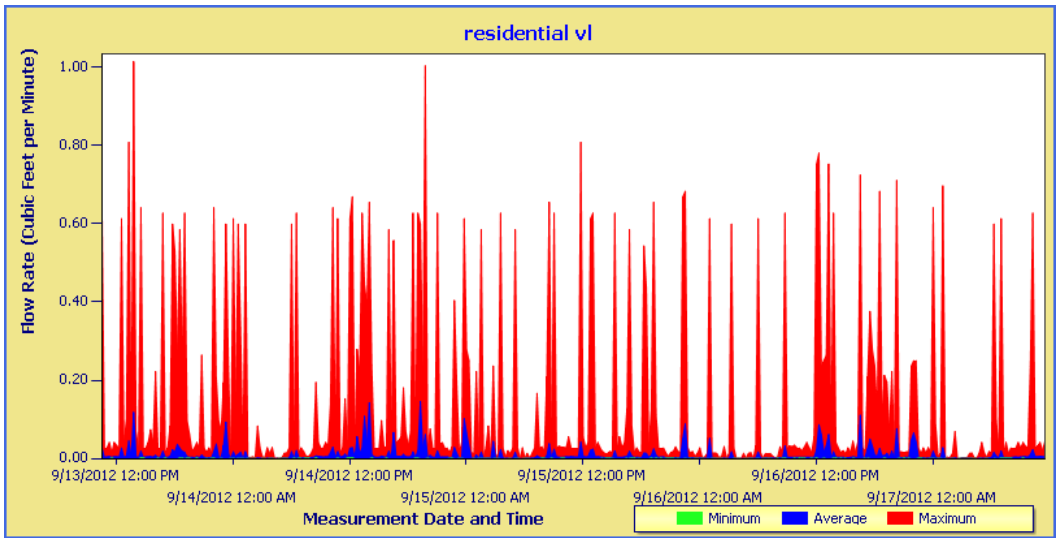
Green can only appear if there is continuous flow for an entire 15 minute interval. If a shower lasts 10 minutes, and there are no other uses during that 15 minutes, there will not be any Green shown since there would have been at least 10 seconds with zero flow. The only evidence of the shower or a toilet flush would be a red spike indicating a unique, short term event. If there is a lot of **Blue** during a 15 minute interval or sequence of 15 minute intervals, that would be an indication that there is a lot of intermittent flow, such as from dish washing or clothes washers. Typically, there is a lot of **Blue** during active periods (mornings & evenings). This graph also shows the presence of 'pressure oscillations' which will be discussed in more detail below.

The Meter-Master detects the rotation of a water meter's internal drive magnets by detecting the flux change in the magnetic field generated by the rotating magnets. The Meter-Master will detect and log this activity regardless of whether the water is moving forwards or backwards thru the meter. With a standard residential water meter, the Meter-Master detects between 50 & 125 pulses per gallon. Accordingly, if there are pressure oscillations in a water distribution system which cause the water to shift back & forth even very slightly, thereby causing the water meter magnet to shift back and forth, the Meter-Master will log pulses which are not representative of actual use. This results in the excessive appearance of **Red** in the graphs (normally denoting short term events), even during low use periods such as at night. The first indication of the possible presence of pressure oscillations is when the Meter-Master volume shown during the download routine significantly exceeds the register volume (difference between beginning & ending meter reads entered during the download routine). This indicates that the Meter-Master recorded more pulses than it should have. Below is an extreme case of pressure oscillations.

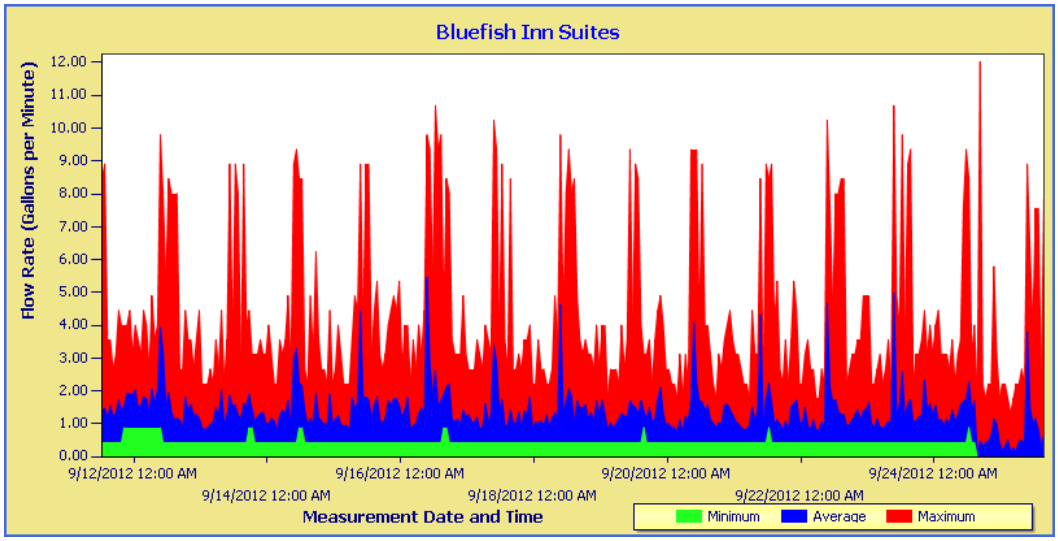


In this case, there appears to be constant water use 24 hours a day over the 4 day recording period. However, we know that this can't be true. There are also 2 notable instances of green at about 7:15 AM on both Dec 4th and 6th. The flow rate is a little over 0.3 cfpm or about 2.5 gpm which would indicate a shower. Since the Grid Interval in this graph is 10 minutes, this would indicate that the user took showers for at least 10 minutes on each of these mornings. Although the pressure oscillations distort the data by indicating a lot of 'false' usage throughout the report, the absence of green with the exception of the 2 showers, indicates that there is neither leakage nor other extended uses such as 1 hour irrigation cycles. Accordingly, the data is still of use for problem solving even though it has been distorted by pressure oscillations.

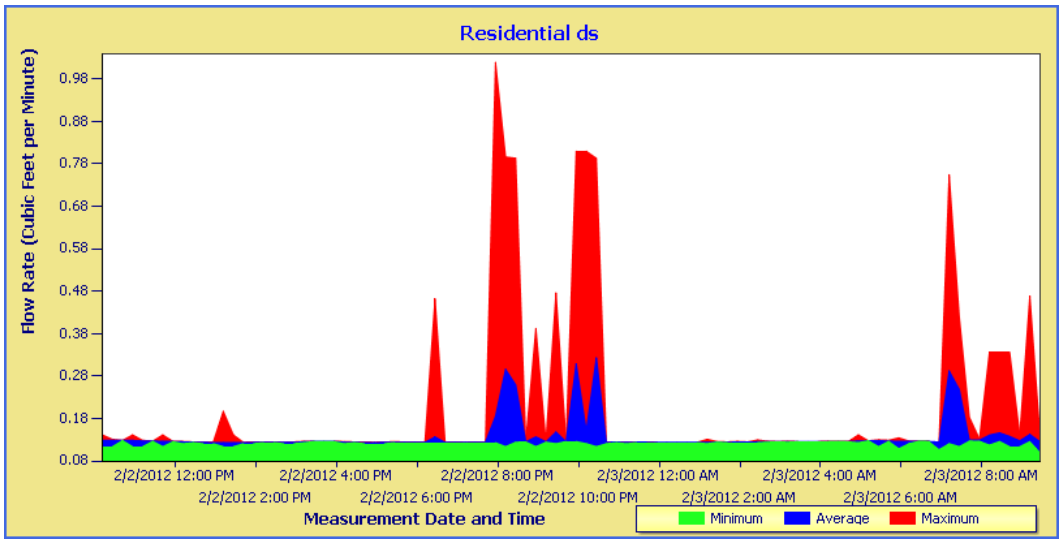
Pressure oscillations can't result in a steady rate of green (true steady flow) because the oscillations cause a variance in 'false' flow rates. In the case of the below graph, pressure oscillations are present due to the regular presence of **Red** and **Blue** 24 hours a day; however, the Meter-Master volume exceeded the register volume by just 15%; accordingly, the distortion is fairly minimal. As can be seen, the higher **Red** spikes mostly have a maximum flow rate of 0.6 cfpm which suggests that there is a fixture that works at this flow rate. The other graphs shown above have similar, consistent maximum flow rates which suggests that these are true flow rates. The pressure oscillations are, therefore, denoted by the excessive **Blue** and low flow rate **Red** areas.



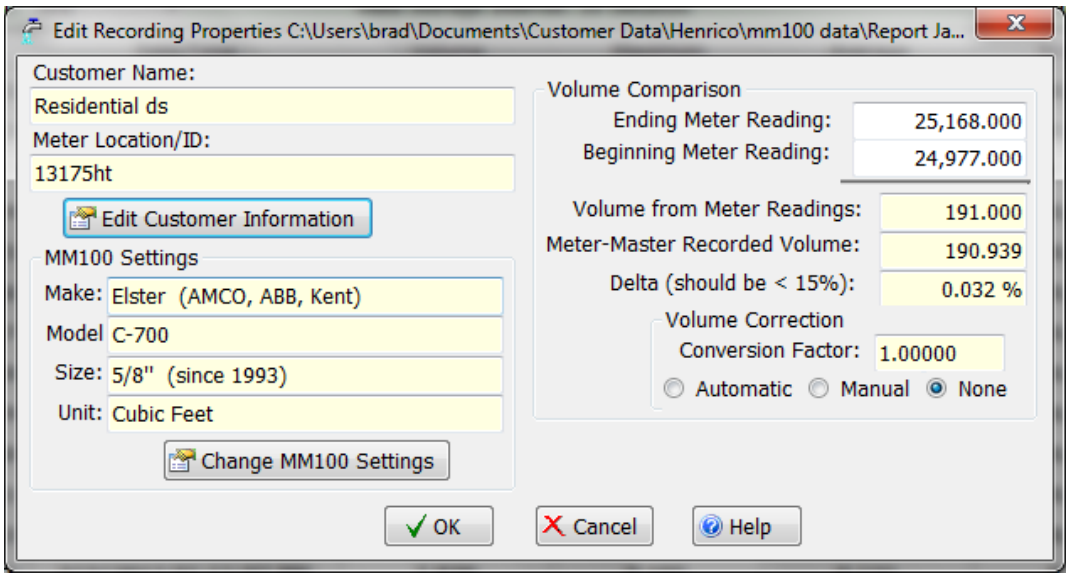
Below is a 2 week graph of a small hotel which shows a leak being fixed toward the end of the 2nd week. Hotels typically have very repetitive daily patterns. In this case, the maximum usage occurs each day from around 9 AM until mid-afternoon (likely that it's washing machines).



The below graph is a residential user with a continuous leak. Note that with both this data file and



the data file for the first graph shown above, the Meter-Master and register volumes correlated 100%. Even if there had been pressure oscillations present, this could not have adversely impacted the Meter-Master data since the water was essentially always flowing forward thru the meter to the user. Pressure oscillations only have an adverse impact when there is zero real flow. Below is the Customer Information Screen for this data file which shows the close correlation between the Meter-Master and register volumes (difference between the beginning and ending meter readings recorded by the technician at the field site at the beginning & end of the recording). In this case, the Meter-Master volume was 190.939 cubic feet (total pulse count multiplied by pulse factor for this meter model in the Meter-Master software database), and the register volume was 191.000 cubic feet.



Pressure oscillations are not present in all systems, and, where present, can differ a lot in various zones. The purpose of this document is to enable useful analysis from Meter-Master data files even when the data is compromised by 'false' pulsing due to pressure oscillations.

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