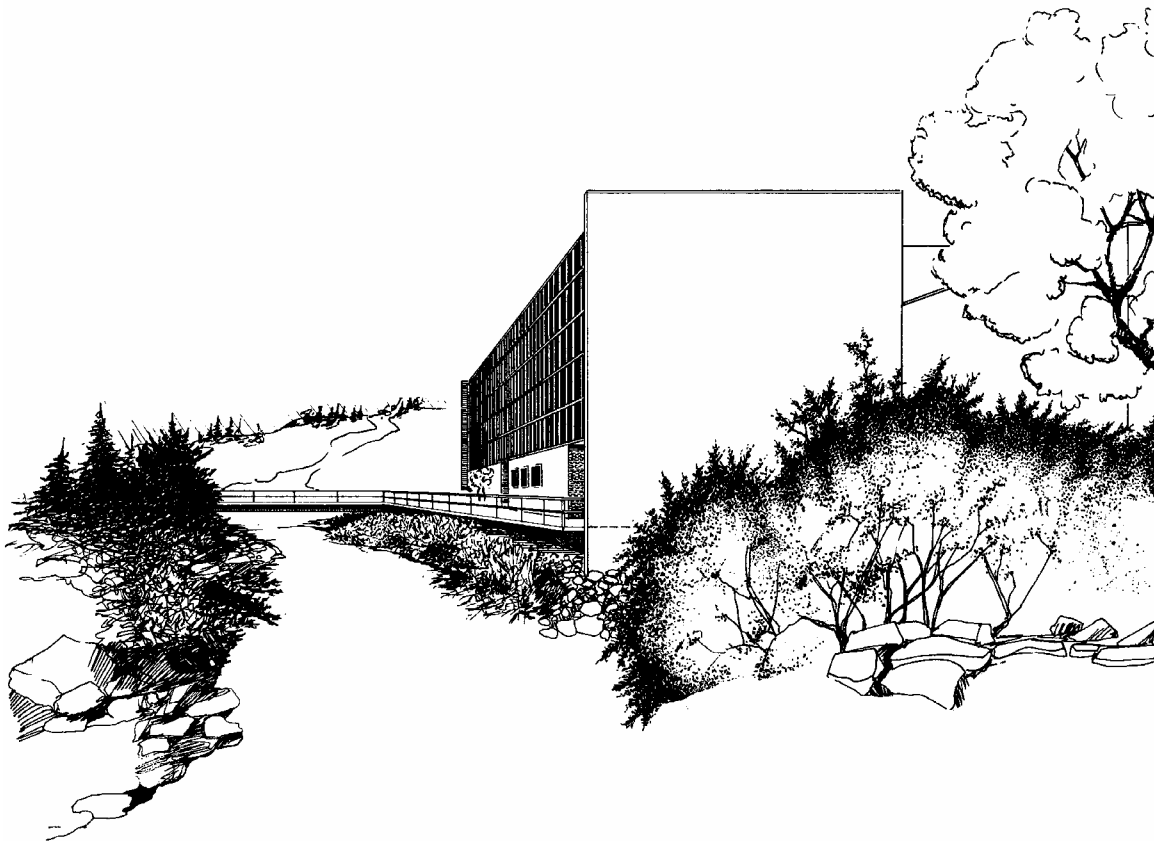


3/4-Inch MMPD Flow Meter Accuracy and Endurance Testing

Prepared for

Master Meter

September 2006



UTAH WATER RESEARCH LABORATORY

**Utah State University
Logan, Utah**

Report No. 1707

3/4-inch MMPD Flow Meter Accuracy and Endurance Testing

Submitted to:

Master Meter
101 Regency Parkway
Mansfield, TX 76063

By:

Michael C. Johnson Ph.D., P.E.
Nathan Q. Smith

Utah Water Research Laboratory
8200 Old Main Hill
Logan, UT 84322-8200

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Hydraulics Report No. 1707

INTRODUCTION

Utah State University was contracted by Master Meter to perform flow calibrations at the Utah Water Research Laboratory (UWRL) in Logan, Utah on five 3/4-inch MMPD (Master Meter Positive Displacement) flow meters. The testing required that the new meters be base line tested in cold water (water less than 80 degrees Fahrenheit) and then operated at a set flow rate of 15 gallons per minute until incremental volumes of 1,000,000 gallons, 2,000,000 gallons, and 3,000,000 gallons had passed through each meter. Upon reaching the volumes indicated, the meters were then accuracy tested to identify any shifts in performance associated with throughput. This test report summarizes the testing completed to date. As future data are collected, this test report will be updated.

TEST SETUP

Each 3/4-inch meter was installed in series with approximately 7 inches of straight pipe between each meter. Potable water from the City of Logan was used for the testing with it being continually refreshed to maintain temperatures less than 80 degrees. Upstream from the meters was a filter (500 micron) to prevent any debris from getting into the meters. The water was pumped using a 2 horsepower pump connected to a small reservoir and the flow rate was regulated using a throttling valve downstream from the meters. Figure 1 shows the meters installed in the endurance test loop.



Figure 1. Meter installation.

ACCURACY TESTING

Upon receipt of the flow meters from Master Meter, the meters were baseline tested. Table 1 shows the conditions under which each of the meter sizes were tested. The typical draft size for each meter at each flow rate is shown in Table 2.

Table 1. Flow conditions tested.

Meter Size	Min Flow (gpm)	Low Flow (gpm)	Intermediate Flow (gpm)	High Flow (gpm)
3/4-inch	0.5	2	15	23

Table 2. Draft sizes collected at the indicated flow rate.

Meter Size	Min Flow (gallons)	Low Flow (gallons)	Intermediate Flow (gallons)	High Flow (gallons)
3/4-inch	20	20	80	120

Rather than make adjustments to each meter at the baseline to represent the best possible accuracy over the range, it was determined by personnel from Master Meter and the Utah Water Research laboratory to simply let the as new condition represent the baseline. This was done because the endurance test is to identify changes in accuracy resulting from extended use. Therefore, changes in accuracy will be reported relative to the conditions established prior to endurance testing the meters.

The meters were tested using a gravimetric bench that was certified using NIST traceable weights. The weight of water of each draft and the water temperature were measured for each run.

RESULTS

Tables 3 through 7 show the results of the testing. Note that the lower portion of the tables (titled “Average Shift in Registry from Initial”) shows the shift from the initial testing in percent. The data collected for this study show that the meters perform well within the accuracy specified by AWWA Manual M6 “Water Meters – Selection, Installation, Testing and Maintenance.”

Table 3. Results from testing for meter 1.

Meter Serial Number 1							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.45%	99.61%	99.29%	99.25%			
23	99.43%	99.50%	99.31%	99.23%			
15	99.34%	99.79%	99.40%	99.47%			
15	99.49%	99.67%	99.28%	99.32%			
2	100.38%	101.32%	99.67%	100.68%			
2	100.21%	101.30%	99.99%	100.76%			
0.5	98.38%	99.37%	98.91%	98.72%			
0.5	98.56%	99.31%	99.24%	98.76%			

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Avg 23	99.44%	99.56%	99.30%	99.24%			
Std 23	0.013%	0.076%	0.013%	0.015%			
Avg 15	99.42%	99.73%	99.34%	99.40%			
Std 15	0.106%	0.086%	0.085%	0.101%			
Avg 2	100.29%	101.31%	99.83%	100.72%			
Std 2	0.121%	0.010%	0.223%	0.058%			
Avg 0.5	98.47%	99.34%	99.08%	98.74%			
Std 0.5	0.127%	0.037%	0.230%	0.030%			

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
23	-	0.11%	-0.14%	-0.21%			
15	-	0.31%	-0.07%	-0.02%			
2	-	1.01%	-0.46%	0.42%			
0.5	-	0.87%	0.60%	0.26%			

Table 4. Results from testing for meter 2.

Meter Serial Number 2							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.35%	99.61%	99.22%	99.25%			
23	99.47%	99.54%	99.29%	99.18%			
15	99.50%	99.75%	99.35%	99.36%			
15	99.56%	99.79%	99.27%	99.22%			
2	100.81%	101.06%	100.03%	100.53%			
2	100.44%	101.30%	100.29%	100.76%			
0.5	98.43%	99.37%	98.01%	98.82%			
0.5	98.33%	99.57%	98.67%	98.86%			

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Avg 23	99.41%	99.57%	99.25%	99.21%			
Std 23	0.083%	0.053%	0.047%	0.050%			
Avg 15	99.53%	99.77%	99.31%	99.29%			
Std 15	0.043%	0.031%	0.059%	0.097%			
Avg 2	100.63%	101.18%	100.16%	100.64%			
Std 2	0.259%	0.169%	0.188%	0.164%			
Avg 0.5	98.38%	99.47%	98.34%	98.84%			
Std 0.5	0.071%	0.144%	0.472%	0.029%			

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
23	-	0.17%	-0.15%	-0.19%			
15	-	0.24%	-0.22%	-0.24%			
2	-	0.55%	-0.47%	0.01%			
0.5	-	1.09%	-0.04%	0.46%			

Table 5. Results from testing for meter 3.

Meter Serial Number 3							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.44%	99.69%	99.23%	99.50%			
23	99.54%	99.59%	99.34%	99.54%			
15	99.56%	99.72%	99.48%	99.66%			
15	99.45%	99.73%	99.40%	99.64%			
2	100.38%	100.56%	100.69%	100.93%			
2	100.92%	100.79%	100.60%	100.76%			
0.5	97.10%	99.63%	99.30%	99.54%			
0.5	97.39%	99.57%	99.34%	99.42%			

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Avg 23	99.49%	99.64%	99.28%	99.52%			
Std 23	0.070%	0.076%	0.076%	0.024%			
Avg 15	99.51%	99.73%	99.44%	99.65%			
Std 15	0.078%	0.004%	0.059%	0.013%			
Avg 2	100.65%	100.67%	100.64%	100.84%			
Std 2	0.382%	0.166%	0.062%	0.119%			
Avg 0.5	97.25%	99.60%	99.32%	99.48%			
Std 0.5	0.210%	0.039%	0.033%	0.087%			

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
23	-	0.15%	-0.20%	0.03%			
15	-	0.22%	-0.07%	0.14%			
2	-	0.03%	0.00%	0.19%			
0.5	-	2.35%	2.07%	2.24%			

Table 6. Results from testing for meter 4.

Meter Serial Number 4							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.37%	99.86%	99.54%	99.52%			
23	99.75%	99.79%	99.55%	99.46%			
15	99.81%	99.93%	99.54%	99.78%			
15	99.93%	99.92%	99.58%	99.64%			
2	100.67%	101.06%	100.69%	100.93%			
2	100.68%	101.25%	100.85%	100.76%			
0.5	98.75%	99.37%	98.68%	99.39%			
0.5	98.42%	99.31%	99.24%	99.57%			

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Avg 23	99.56%	99.82%	99.55%	99.49%			
Std 23	0.270%	0.048%	0.003%	0.039%			
Avg 15	99.87%	99.92%	99.56%	99.71%			
Std 15	0.079%	0.005%	0.030%	0.098%			
Avg 2	100.67%	101.16%	100.77%	100.84%			
Std 2	0.010%	0.133%	0.118%	0.119%			
Avg 0.5	98.59%	99.34%	98.96%	99.48%			
Std 0.5	0.232%	0.037%	0.399%	0.131%			

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
23	-	0.26%	-0.02%	-0.07%			
15	-	0.05%	-0.31%	-0.16%			
2	-	0.48%	0.10%	0.17%			
0.5	-	0.75%	0.37%	0.89%			

Table 7. Results from testing for meter 6.

Meter Serial Number 6							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.05%	99.76%	99.00%	99.03%			
23	99.05%	99.22%	99.02%	98.98%			
15	99.08%	99.41%	99.06%	99.24%			
15	99.19%	99.41%	99.21%	99.07%			
2	100.14%	100.81%	100.49%	100.43%			
2	99.97%	100.84%	100.35%	100.76%			
0.5	96.55%	98.59%	98.39%	98.30%			
0.5	96.93%	98.54%	98.78%	98.35%			

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
Avg 23	99.05%	99.49%	99.01%	99.00%			
Std 23	0.001%	0.381%	0.012%	0.038%			
Avg 15	99.13%	99.41%	99.13%	99.16%			
Std 15	0.078%	0.004%	0.102%	0.119%			
Avg 2	100.05%	100.83%	100.42%	100.59%			
Std 2	0.119%	0.023%	0.099%	0.235%			
Avg 0.5	96.74%	98.57%	98.58%	98.33%			
Std 0.5	0.269%	0.031%	0.275%	0.035%			

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	-	-	-
23	-	0.44%	-0.04%	-0.05%			
15	-	0.28%	0.00%	0.02%			
2	-	0.77%	0.36%	0.54%			
0.5	-	1.83%	1.85%	1.59%			

Meter Serial Number 1							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.45%	99.61%	99.29%	99.25%	99.20%		
23	99.43%	99.50%	99.31%	99.23%	99.14%		
15	99.34%	99.79%	99.40%	99.47%	99.35%		
15	99.49%	99.67%	99.28%	99.32%	99.25%		
2	100.38%	101.32%	99.67%	100.68%	100.55%		
2	100.21%	101.30%	99.99%	100.76%	100.64%		
0.5	98.38%	99.37%	98.91%	98.72%	98.58%		
0.5	98.56%	99.31%	99.24%	98.76%	98.77%		

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Avg 23	99.44%	99.56%	99.30%	99.24%	99.17%		
Std 23	0.013%	0.076%	0.013%	0.015%	0.038%		
Avg 15	99.42%	99.73%	99.34%	99.40%	99.30%		
Std 15	0.106%	0.086%	0.085%	0.101%	0.073%		
Avg 2	100.29%	101.31%	99.83%	100.72%	100.59%		
Std 2	0.121%	0.010%	0.223%	0.058%	0.063%		
Avg 0.5	98.47%	99.34%	99.08%	98.74%	98.67%		
Std 0.5	0.127%	0.037%	0.230%	0.030%	0.136%		

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
23	-	0.11%	-0.14%	-0.21%	-0.28%		
15	-	0.31%	-0.07%	-0.02%	-0.12%		
2	-	1.01%	-0.46%	0.42%	0.30%		
0.5	-	0.87%	0.60%	0.26%	0.20%		

Meter Serial Number 2							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.35%	99.61%	99.22%	99.25%	99.20%		
23	99.47%	99.54%	99.29%	99.18%	99.17%		
15	99.50%	99.75%	99.35%	99.36%	99.22%		
15	99.56%	99.79%	99.27%	99.22%	99.18%		
2	100.81%	101.06%	100.03%	100.53%	100.30%		
2	100.44%	101.30%	100.29%	100.76%	100.64%		
0.5	98.43%	99.37%	98.01%	98.82%	99.09%		
0.5	98.33%	99.57%	98.67%	98.86%	98.82%		

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Avg 23	99.41%	99.57%	99.25%	99.21%	99.18%		
Std 23	0.083%	0.053%	0.047%	0.050%	0.021%		
Avg 15	99.53%	99.77%	99.31%	99.29%	99.20%		
Std 15	0.043%	0.031%	0.059%	0.097%	0.029%		
Avg 2	100.63%	101.18%	100.16%	100.64%	100.47%		
Std 2	0.259%	0.169%	0.188%	0.164%	0.240%		
Avg 0.5	98.38%	99.47%	98.34%	98.84%	98.96%		
Std 0.5	0.071%	0.144%	0.472%	0.029%	0.192%		

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
23	-	0.17%	-0.15%	-0.19%	-0.23%		
15	-	0.24%	-0.22%	-0.24%	-0.33%		
2	-	0.55%	-0.47%	0.01%	-0.16%		
0.5	-	1.09%	-0.04%	0.46%	0.58%		

Meter Serial Number 3							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.44%	99.69%	99.23%	99.50%	99.59%		
23	99.54%	99.59%	99.34%	99.54%	99.51%		
15	99.56%	99.72%	99.48%	99.66%	99.49%		
15	99.45%	99.73%	99.40%	99.64%	99.55%		
2	100.38%	100.56%	100.69%	100.93%	101.00%		
2	100.92%	100.79%	100.60%	100.76%	100.69%		
0.5	97.10%	99.63%	99.30%	99.54%	99.87%		
0.5	97.39%	99.57%	99.34%	99.42%	99.60%		

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Avg 23	99.49%	99.64%	99.28%	99.52%	99.55%		
Std 23	0.070%	0.076%	0.076%	0.024%	0.062%		
Avg 15	99.51%	99.73%	99.44%	99.65%	99.52%		
Std 15	0.078%	0.004%	0.059%	0.013%	0.043%		
Avg 2	100.65%	100.67%	100.64%	100.84%	100.84%		
Std 2	0.382%	0.166%	0.062%	0.119%	0.220%		
Avg 0.5	97.25%	99.60%	99.32%	99.48%	99.73%		
Std 0.5	0.210%	0.039%	0.033%	0.087%	0.191%		

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
23	-	0.15%	-0.20%	0.03%	0.06%		
15	-	0.22%	-0.07%	0.14%	0.01%		
2	-	0.03%	0.00%	0.19%	0.20%		
0.5	-	2.35%	2.07%	2.24%	2.49%		

Meter Serial Number 4							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.37%	99.86%	99.54%	99.52%	99.53%		
23	99.75%	99.79%	99.55%	99.46%	99.49%		
15	99.81%	99.93%	99.54%	99.78%	99.60%		
15	99.93%	99.92%	99.58%	99.64%	99.56%		
2	100.67%	101.06%	100.69%	100.93%	100.55%		
2	100.68%	101.25%	100.85%	100.76%	100.64%		
0.5	98.75%	99.37%	98.68%	99.39%	99.50%		
0.5	98.42%	99.31%	99.24%	99.57%	99.60%		

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Avg 23	99.56%	99.82%	99.55%	99.49%	99.51%		
Std 23	0.270%	0.048%	0.003%	0.039%	0.027%		
Avg 15	99.87%	99.92%	99.56%	99.71%	99.58%		
Std 15	0.079%	0.005%	0.030%	0.098%	0.028%		
Avg 2	100.67%	101.16%	100.77%	100.84%	100.59%		
Std 2	0.010%	0.133%	0.118%	0.119%	0.063%		
Avg 0.5	98.59%	99.34%	98.96%	99.48%	99.55%		
Std 0.5	0.232%	0.037%	0.399%	0.131%	0.064%		

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
23	-	0.26%	-0.02%	-0.07%	-0.05%		
15	-	0.05%	-0.31%	-0.16%	-0.29%		
2	-	0.48%	0.10%	0.17%	-0.08%		
0.5	-	0.75%	0.37%	0.89%	0.96%		

Meter Serial Number 6							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Flow (gpm)	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered	Percent Registered
23	99.05%	99.76%	99.00%	99.03%	98.94%		
23	99.05%	99.22%	99.02%	98.98%	99.13%		
15	99.08%	99.41%	99.06%	99.24%	99.10%		
15	99.19%	99.41%	99.21%	99.07%	98.93%		
2	100.14%	100.81%	100.49%	100.43%	100.45%		
2	99.97%	100.84%	100.35%	100.76%	100.23%		
0.5	96.55%	98.59%	98.39%	98.30%	98.32%		
0.5	96.93%	98.54%	98.78%	98.35%	98.82%		

Averages and Standard Deviations							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
Avg 23	99.05%	99.49%	99.01%	99.00%	99.04%		
Std 23	0.001%	0.381%	0.012%	0.038%	0.134%		
Avg 15	99.13%	99.41%	99.13%	99.16%	99.01%		
Std 15	0.078%	0.004%	0.102%	0.119%	0.119%		
Avg 2	100.05%	100.83%	100.42%	100.59%	100.34%		
Std 2	0.119%	0.023%	0.099%	0.235%	0.154%		
Avg 0.5	96.74%	98.57%	98.58%	98.33%	98.57%		
Std 0.5	0.269%	0.031%	0.275%	0.035%	0.355%		

Average Shift in Registry from Initial							
Test Cond.	INITIAL	1,000,000	2,000,000	3,000,000	4,000,000	-	-
23	-	0.44%	-0.04%	-0.05%	-0.01%		
15	-	0.28%	0.00%	0.02%	-0.12%		
2	-	0.77%	0.36%	0.54%	0.29%		
0.5	-	1.83%	1.85%	1.59%	1.83%		