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Impact of various variables that influence the flow measurement through Orifice Metering System

Flow Equation as per API MPMS Chapter 14.3



Flow measurement through a Square Edged Concentric Orifice Plate can be made by using equation –

$$q_m = C_d \cdot \frac{1}{\sqrt{1 - \beta^4}} \cdot \varepsilon \cdot \frac{\pi d^2}{4} \cdot \sqrt{2 \rho_{t,p} \Delta P}$$

Parameters required for calculating flow*



Meter Tube Bore at Ref. Temp.	:	14.9536 Inch
Orifice Plate Bore at Ref. Temp.	:	9.9356 Inch
Temp. at Flowing Conditions	:	100.00 Deg. F
Press. at Flowing Conditions	:	200.00 psig
Differential Pressure	:	100.00 INWC
Dynamic Viscosity	:	7.13390 cP
API Value	:	30.0
<u>Calculation Results</u> -		
Mass Flow Rate	:	17,71,378.19 lbm/hr
Gross Volume Flow Rate	:	1,40,946.26 Bbl/day
Standard Volume Flow Rate	:	1,38,569.91 SBbl/day

** Crude Oil measurement through Orifice using API MPMS Chapter 14.3 and API 11.1*

Measurement Influencing Parameter - Pipe Diameter

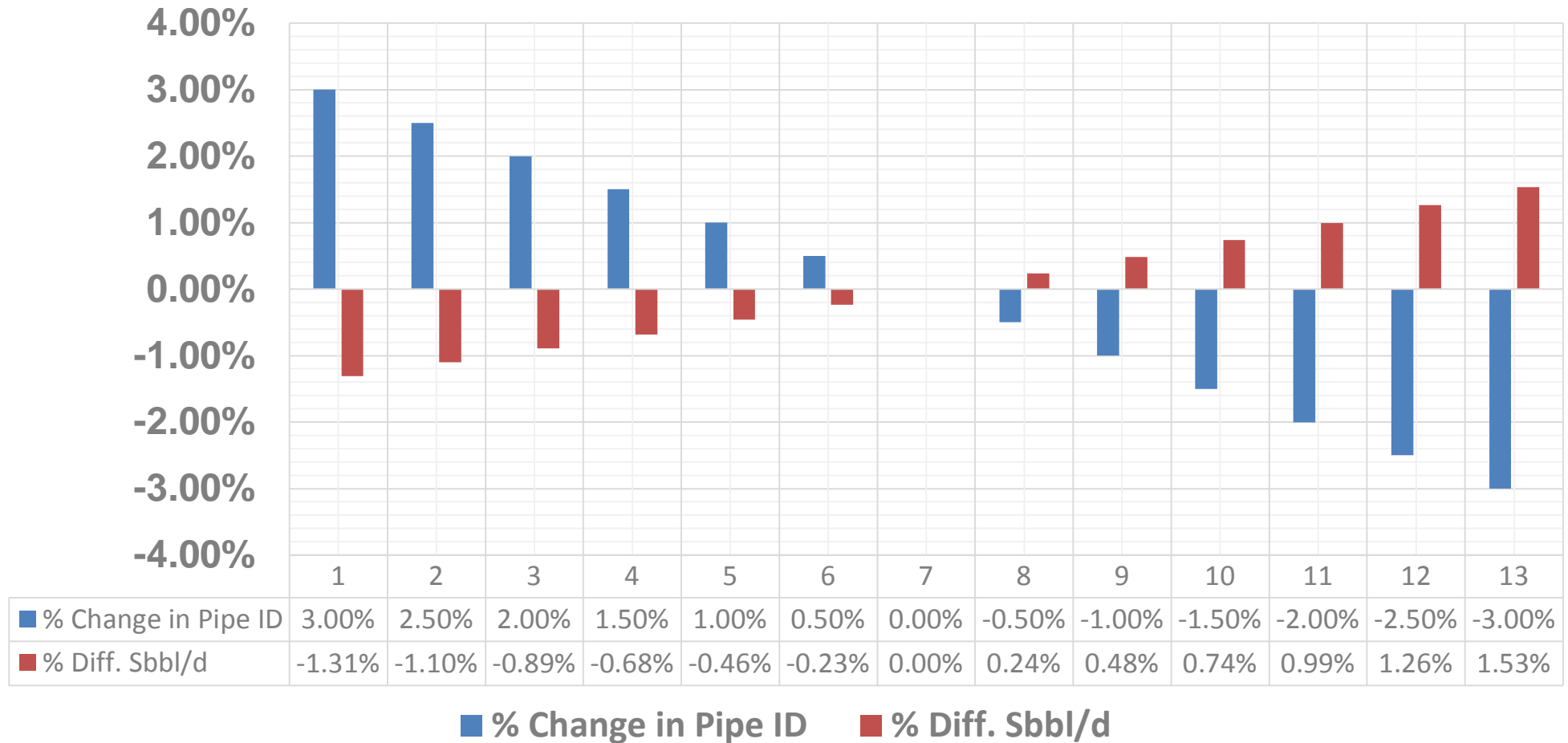


Impact due to Pipe Diameter					
Original Pipe ID Inch	% Change in Pipe ID	Value	Impact		
			SBbl/d	Diff. Sbbbl/d	% Diff. Sbbbl/d
14.9536	3.00%	15.4022	1,36,758	-1,812	-1.31%
	2.50%	15.3274	1,37,041	-1,529	-1.10%
	2.00%	15.2527	1,37,331	-1,239	-0.89%
	1.50%	15.1779	1,37,629	-941	-0.68%
	1.00%	15.1031	1,37,934	-636	-0.46%
	0.50%	15.0284	1,38,248	-322	-0.23%
	0.00%	14.9536	1,38,570	0	0.00%
	-0.50%	14.8788	1,38,901	331	0.24%
	-1.00%	14.8041	1,39,240	671	0.48%
	-1.50%	14.7293	1,39,590	1,020	0.74%
	-2.00%	14.6545	1,39,948	1,378	0.99%
	-2.50%	14.5798	1,40,317	1,747	1.26%
	-3.00%	14.5050	1,40,697	2,127	1.53%

Measurement Influencing Parameter - Pipe Diameter



Impact due to Pipe Diameter



Measurement Influencing Parameter - Orifice Bore Diameter

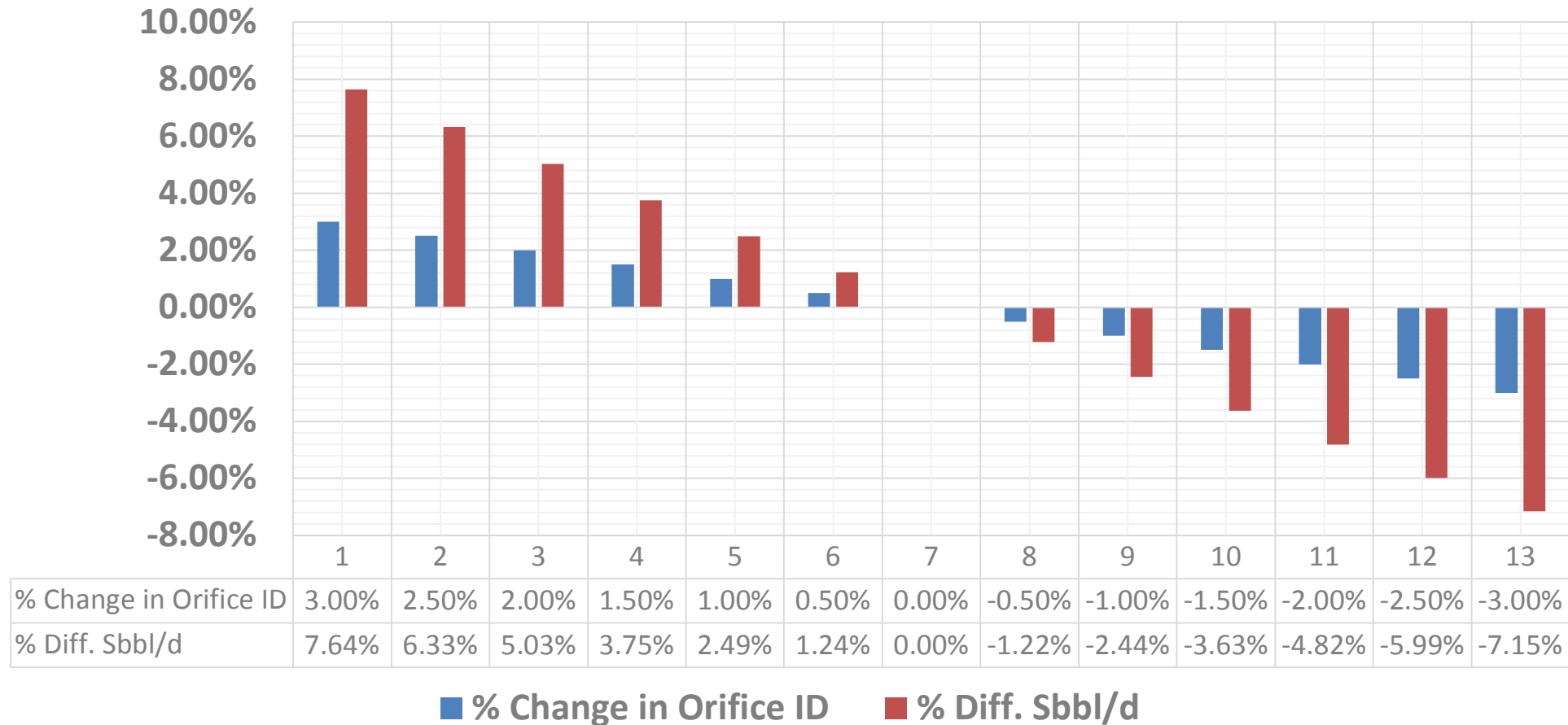


Impact due to Orifice Bore Diameter					
Original Orifice Bore Dia. Inch	% Change in Orifice Bore Dia.	Value	Impact		
			SBbl/d	Diff. Sbbbl/d	% Diff. Sbbbl/d
9.9356	3.00%	10.2337	1,49,152	10,582	7.64%
	2.50%	10.1840	1,47,339	8,769	6.33%
	2.00%	10.1343	1,45,546	6,976	5.03%
	1.50%	10.0846	1,43,773	5,203	3.75%
	1.00%	10.0350	1,42,020	3,450	2.49%
	0.50%	9.9853	1,40,285	1,715	1.24%
	0.00%	9.9356	1,38,570	0	0.00%
	-0.50%	9.8859	1,36,873	-1,697	-1.22%
	-1.00%	9.8362	1,35,194	-3,375	-2.44%
	-1.50%	9.7866	1,33,534	-5,036	-3.63%
	-2.00%	9.7369	1,31,891	-6,679	-4.82%
	-2.50%	9.6872	1,30,266	-8,304	-5.99%
	-3.00%	9.6375	1,28,657	-9,912	-7.15%

Measurement Influencing Parameter - Orifice Bore Diameter



Impact due to Orifice Bore Diameter



Measurement Influencing Parameter – Differential Pressure

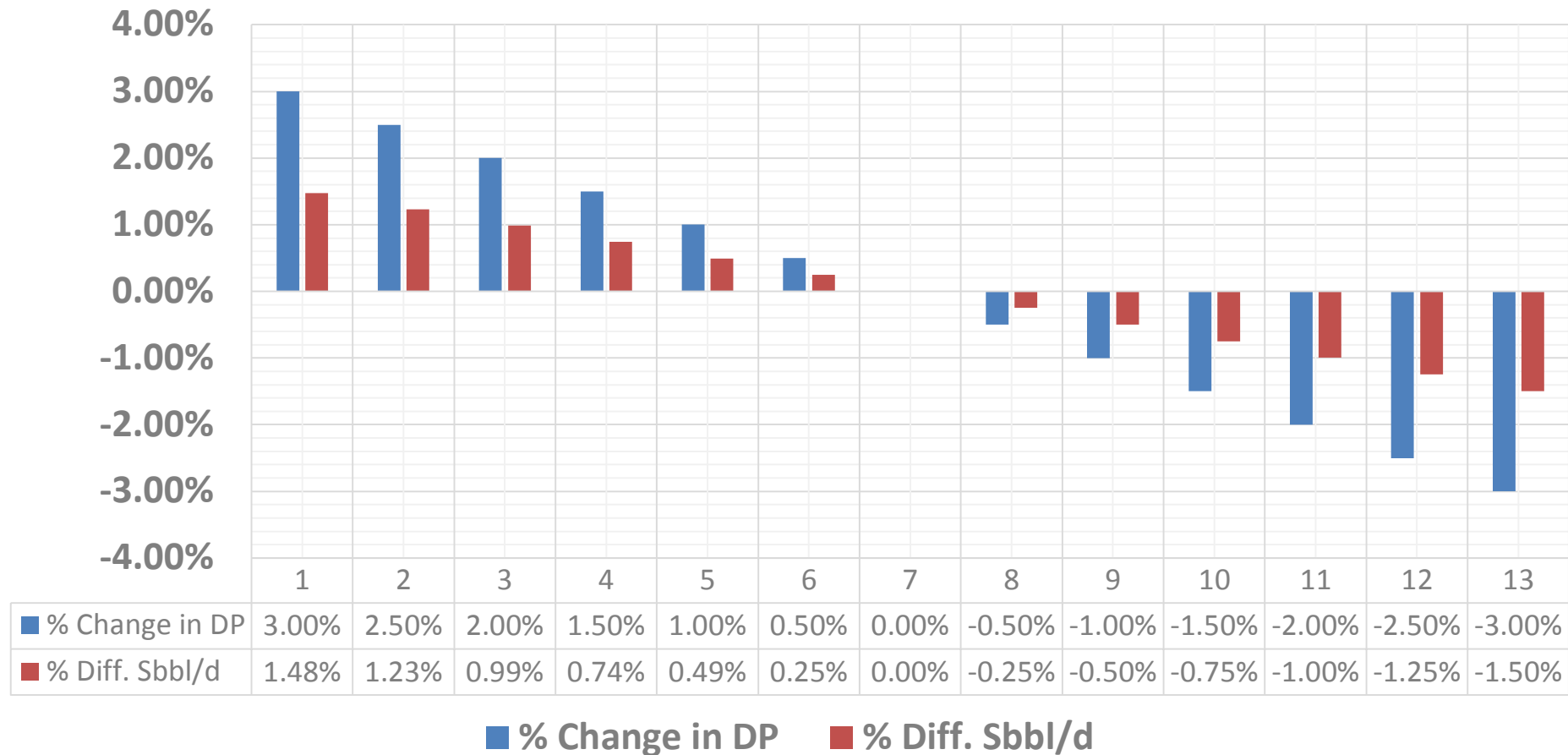


Impact due to Differential Pressure					
Original DP INWC	% Change in DP	Value	Impact		
			SBbl/d	Diff. Sbbl/d	% Diff. Sbbl/d
100	3.00%	103.000	1,40,617	2,047	1.48%
	2.50%	102.500	1,40,278	1,708	1.23%
	2.00%	102.000	1,39,938	1,368	0.99%
	1.50%	101.500	1,39,597	1,027	0.74%
	1.00%	101.000	1,39,256	686	0.49%
	0.50%	100.500	1,38,913	343	0.25%
	0.00%	100.000	1,38,570	0	0.00%
	-0.50%	99.500	1,38,226	-344	-0.25%
	-1.00%	99.000	1,37,881	-689	-0.50%
	-1.50%	98.500	1,37,535	-1,035	-0.75%
	-2.00%	98.000	1,37,188	-1,382	-1.00%
	-2.50%	97.500	1,36,841	-1,729	-1.25%
-3.00%	97.000	1,36,492	-2,078	-1.50%	

Measurement Influencing Parameter – Differential Pressure



Impact due to Differential Pressure



Measurement Influencing Parameter – Pressure

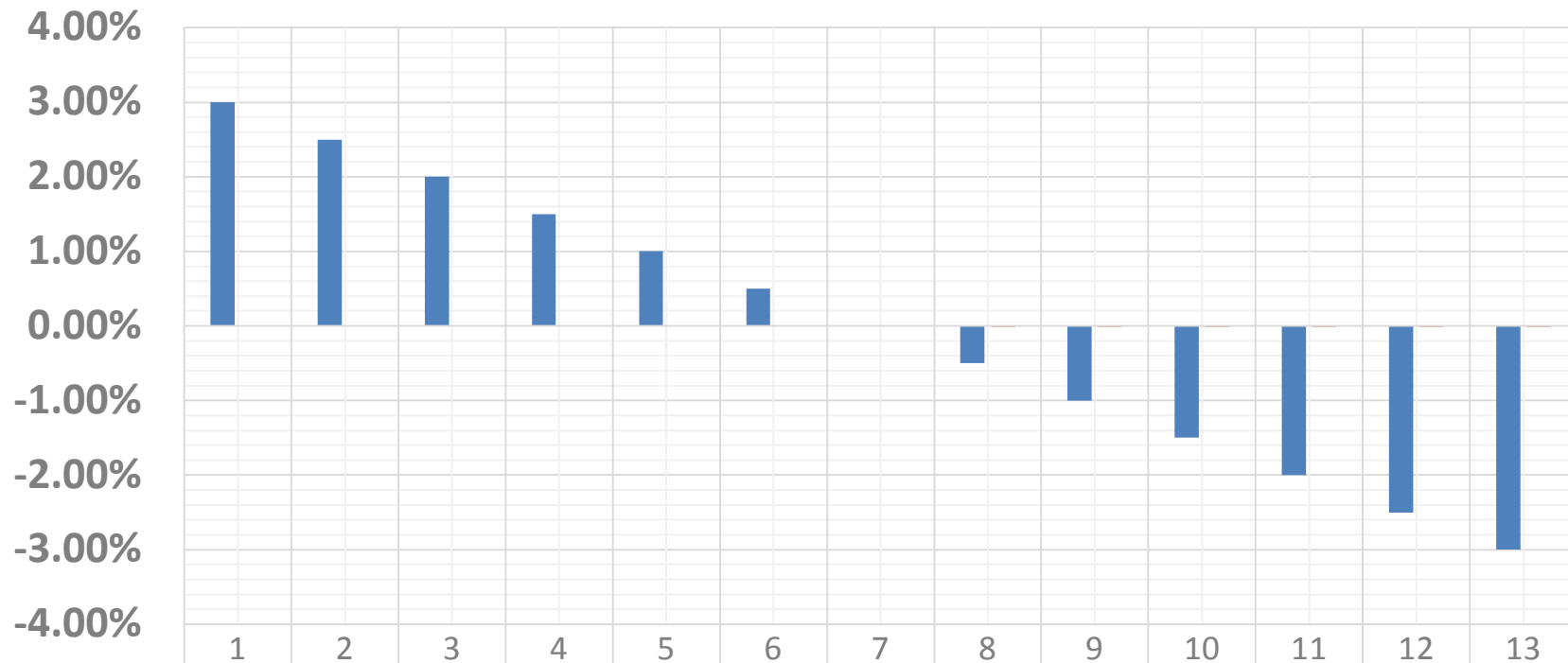


Impact due to Pressure					
Original Pressure PSIG	% Change in Pressure	Value	Impact		
			SBbl/d	Diff. Sbbl/d	% Diff. Sbbl/d
200	3.00%	206.000	1,38,572	2.13	0.002%
	2.50%	205.000	1,38,571	1.42	0.001%
	2.00%	204.000	1,38,571	1.42	0.001%
	1.50%	203.000	1,38,571	0.71	0.001%
	1.00%	202.000	1,38,571	0.71	0.001%
	0.50%	201.000	1,38,570	0.00	0.000%
	0.00%	200.000	1,38,570	0.00	0.000%
	-0.50%	199.000	1,38,569	-0.71	-0.001%
	-1.00%	198.000	1,38,568	-1.42	-0.001%
	-1.50%	197.000	1,38,568	-1.42	-0.001%
	-2.00%	196.000	1,38,568	-2.13	-0.002%
	-2.50%	195.000	1,38,568	-2.13	-0.002%
-3.00%	194.000	1,38,567	-2.84	-0.002%	

Measurement Influencing Parameter – Pressure



Impact due to Pressure



■ % Change in Pressure	3.00%	2.50%	2.00%	1.50%	1.00%	0.50%	0.00%	-0.50%	-1.00%	-1.50%	-2.00%	-2.50%	-3.00%
■ % Diff. Sbbl/d	0.002%	0.001%	0.001%	0.001%	0.001%	0.000%	0.000%	-0.001	-0.001	-0.001	-0.002	-0.002	-0.002

■ % Change in Pressure ■ % Diff. Sbbl/d

Measurement Influencing Parameter – Temperature

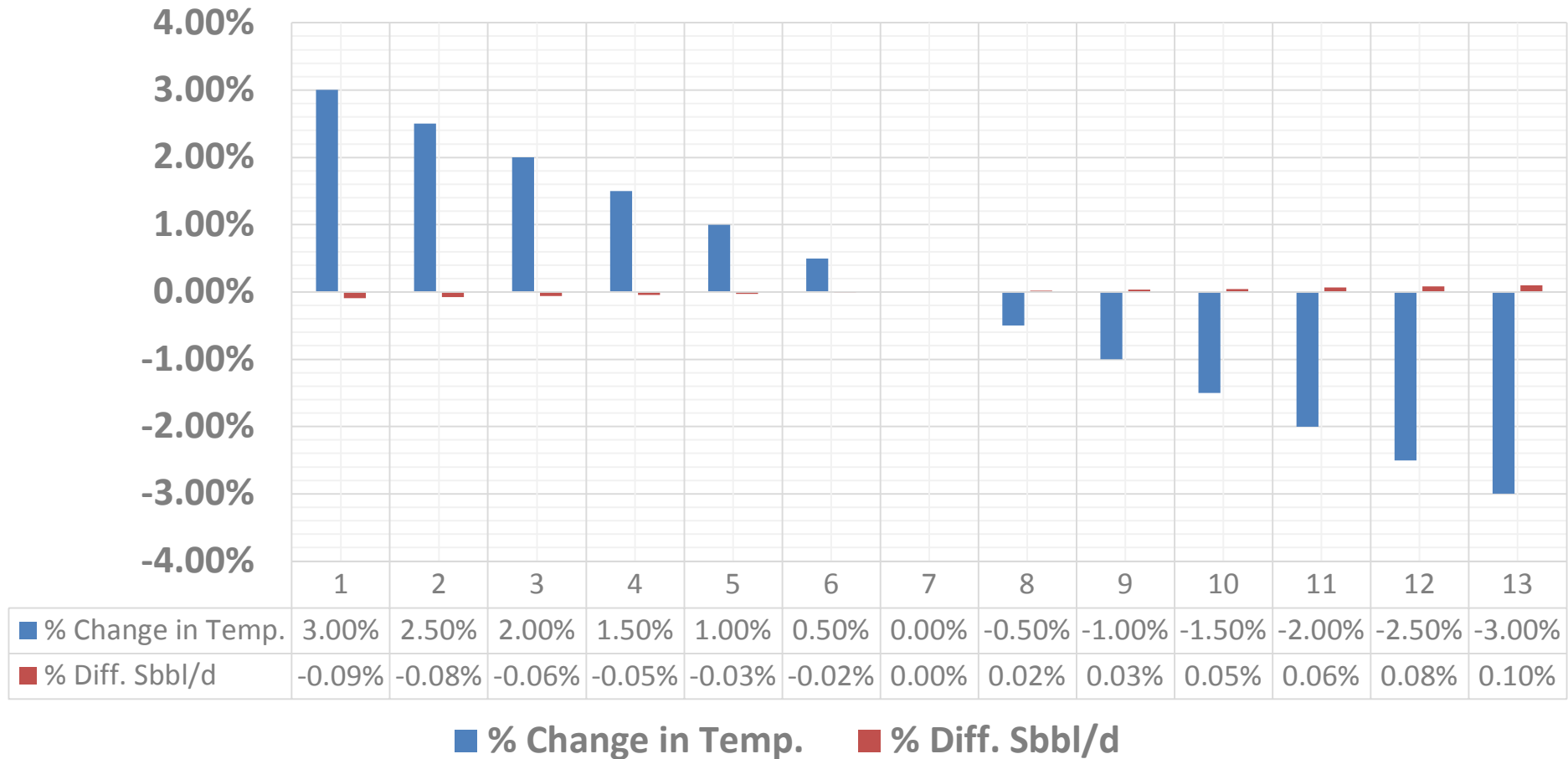


Impact due to Temperature					
Original Temp. °F	% Change in Temp.	Value	Impact		
			SBbl/d	Diff. Sbbbl/d	% Diff. Sbbbl/d
100	3.00%	103.000	1,38,439	-131	-0.09%
	2.50%	102.500	1,38,461	-109	-0.08%
	2.00%	102.000	1,38,482	-88	-0.06%
	1.50%	101.500	1,38,504	-66	-0.05%
	1.00%	101.000	1,38,526	-44	-0.03%
	0.50%	100.500	1,38,548	-22	-0.02%
	0.00%	100.000	1,38,570	0	0.00%
	-0.50%	99.500	1,38,592	22	0.02%
	-1.00%	99.000	1,38,613	43	0.03%
	-1.50%	98.500	1,38,635	65	0.05%
	-2.00%	98.000	1,38,658	88	0.06%
	-2.50%	97.500	1,38,680	110	0.08%
	-3.00%	97.000	1,38,702	132	0.10%

Measurement Influencing Parameter – Temperature



Impact due to Temperature



Measurement Influencing Parameter – API (Density)

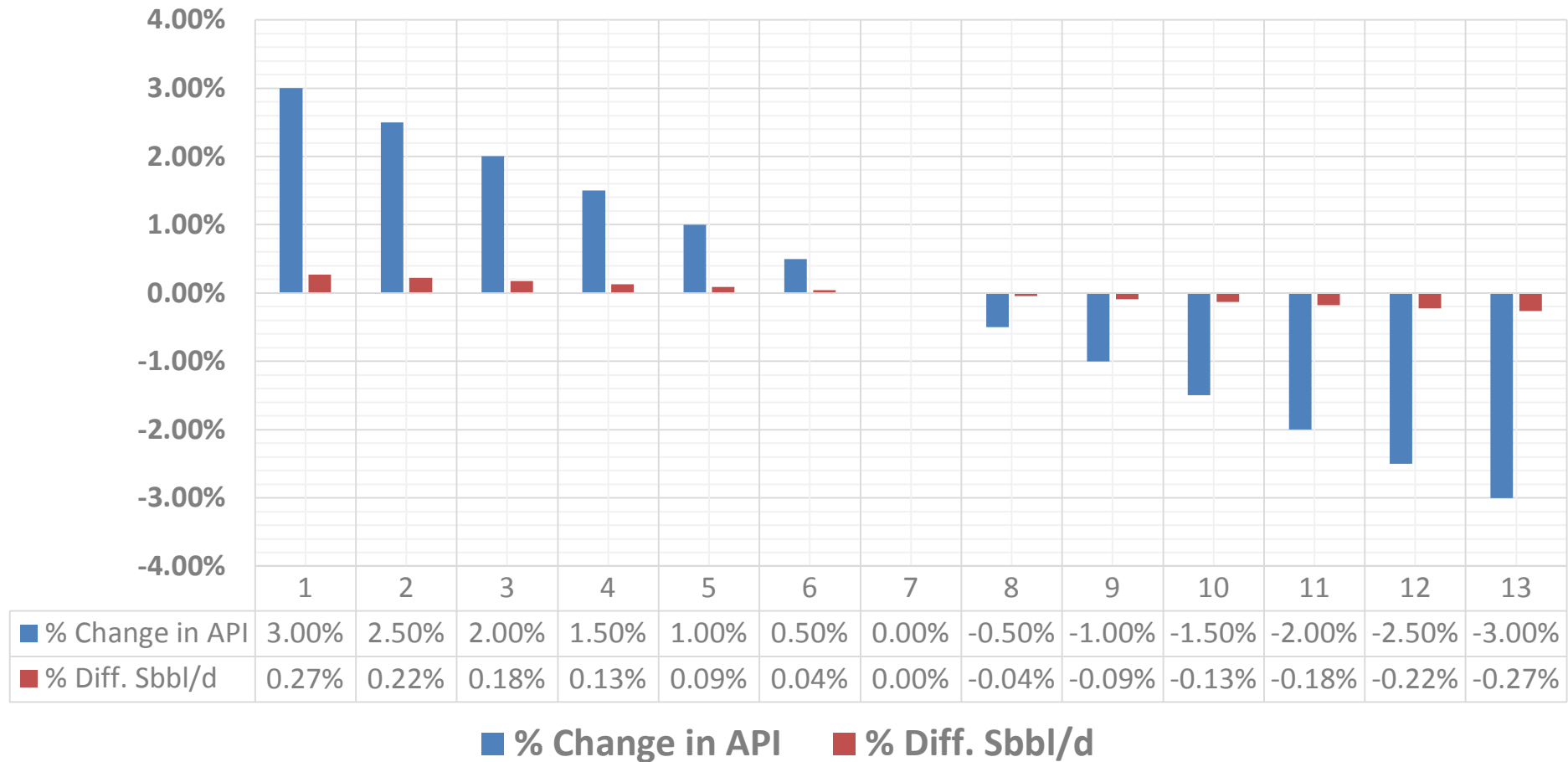


Impact due to API					
Original API	% Change in API	Value	Impact		
			SBbl/d	Diff. Sbbl/d	% Diff. Sbbl/d
30	3.00%	30.900	1,38,943	373	0.27%
	2.50%	30.750	1,38,874	304	0.22%
	2.00%	30.600	1,38,813	243	0.18%
	1.50%	30.450	1,38,752	182	0.13%
	1.00%	30.300	1,38,691	122	0.09%
	0.50%	30.150	1,38,631	61	0.04%
	0.00%	30.000	1,38,570	0	0.00%
	-0.50%	29.850	1,38,509	-61	-0.04%
	-1.00%	29.700	1,38,448	-122	-0.09%
	-1.50%	29.550	1,38,388	-182	-0.13%
	-2.00%	29.400	1,38,319	-251	-0.18%
	-2.50%	29.250	1,38,260	-310	-0.22%
-3.00%	29.100	1,38,199	-370	-0.27%	

Measurement Influencing Parameter – API (Density)



Impact due to API

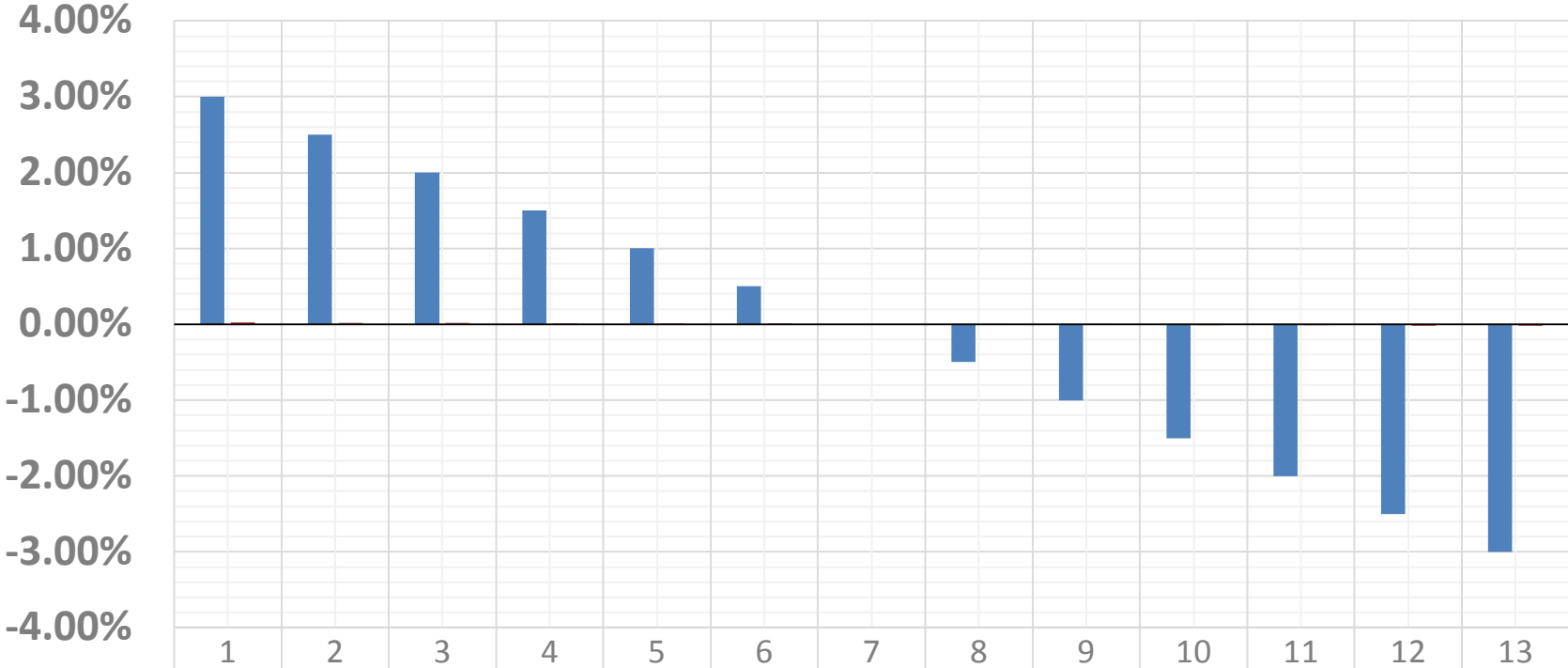


Measurement Influencing Parameter – Dynamic Viscosity

Impact due to Dynamic Viscosity					
Original Dy. Visc. cP	% Change in Dy. Visc. cP	Value	Impact		
			SBbl/d	Diff. Sbbl/d	% Diff. Sbbl/d
7.1339	3.00%	7.3479	1,38,603	33	0.02%
	2.50%	7.3122	1,38,597	27	0.02%
	2.00%	7.2766	1,38,592	22	0.02%
	1.50%	7.2409	1,38,586	16	0.01%
	1.00%	7.2052	1,38,581	11	0.01%
	0.50%	7.1696	1,38,575	5	0.00%
	0.00%	7.1339	1,38,570	0	0.00%
	-0.50%	7.0982	1,38,564	-5	0.00%
	-1.00%	7.0626	1,38,559	-11	-0.01%
	-1.50%	7.0269	1,38,553	-17	-0.01%
	-2.00%	6.9912	1,38,548	-22	-0.02%
	-2.50%	6.9555	1,38,542	-28	-0.02%
-3.00%	6.9199	1,38,537	-33	-0.02%	

Measurement Influencing Parameter – Dynamic Viscosity

Impact due to Dynamic Viscosity



■ % Change in Viscosity	3.00%	2.50%	2.00%	1.50%	1.00%	0.50%	0.00%	-0.50%	-1.00%	-1.50%	-2.00%	-2.50%	-3.00%
■ % Diff. Sbb/d	0.02%	0.02%	0.02%	0.01%	0.01%	0.00%	0.00%	0.00%	-0.01%	-0.01%	-0.02%	-0.02%	-0.02%

■ % Change in Viscosity ■ % Diff. Sbb/d

Overall Impact Analysis



Original Parameters	% Change in Original Parameters	Impact due to Various Parameters (% Diff. Sbbl/d)						
		Pipe ID	Orifice Bore	DP	Press.	Temp.	API	Dynamic Viscosity
	3.00%	-1.31%	7.64%	1.48%	0.002%	-0.09%	0.27%	0.02%
	2.50%	-1.10%	6.33%	1.23%	0.001%	-0.08%	0.22%	0.02%
	2.00%	-0.89%	5.03%	0.99%	0.001%	-0.06%	0.18%	0.02%
Pipe Dia. = 14.9536	1.50%	-0.68%	3.75%	0.74%	0.001%	-0.05%	0.13%	0.01%
Orifice Dia. = 9.9356	1.00%	-0.46%	2.49%	0.49%	0.001%	-0.03%	0.09%	0.01%
DP = 100	0.50%	-0.23%	1.24%	0.25%	0.000%	-0.02%	0.04%	0.00%
Pressure = 200	0.00%	0.00%	0.00%	0.00%	0.000%	0.00%	0.00%	0.00%
Temperature = 100	-0.50%	0.24%	-1.22%	-0.25%	-0.001%	0.02%	-0.04%	0.00%
Dy. Viscosity = 7.1339	-1.00%	0.48%	-2.44%	-0.50%	-0.001%	0.03%	-0.09%	-0.01%
Density = 30	-1.50%	0.74%	-3.63%	-0.75%	-0.001%	0.05%	-0.13%	-0.01%
	-2.00%	0.99%	-4.82%	-1.00%	-0.002%	0.06%	-0.18%	-0.02%
	-2.50%	1.26%	-5.99%	-1.25%	-0.002%	0.08%	-0.22%	-0.02%
	-3.00%	1.53%	-7.15%	-1.50%	-0.002%	0.10%	-0.27%	-0.02%
Primary Measurement					Volume Correction		Fluid Properties	

Conclusion



1. The impact on Flow measured is maximum due to the change in the Orifice Diameter.
2. The other two elements viz. Pipe Diameter and Differential Pressure change also impact significantly on account of the fact that these are parameters used for the Primary measurement.
3. The combined impact due to change in the parameters that determine the Fluid properties viz. Viscosity and Density is comparatively less.
4. The combined impact due to change in the Volume Correction parameters is minimal even less than the combined impact due to parameters that determine Fluid properties.



THANK YOU

