Supplementary Information

Health Monitoring of Pressure Regulating Stations in a Gas Distribution Network using Digital Twins

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Table S1: Vendor data (inlet and outlet pressures, and flow) for all pressure regulators. The capacities shown in the tables are given in terms of natural gas specific gravity (SG = 0.6). For all other gases, multiply flow by the correction factor (= 0.6/SG of gas)$^{0.5}$.

| P_{in}, mbarg	P_{out}, mbarg	Q, m³/h			P_{in}, mbarg	P_{out}, mbarg	Q, m³/h
		4"	3"	2"			2"-S
750	15	5900	3100	1654	1000	17	500
500	15	4600	2450	1221	700	17	340
250	15	3000	1250	831	350	17	225
200	15	2875	980	703	140	17	140
150	15	2125	805	550	70	17	90
100	15	1400	605	462			
75	15	1250	550	300			
50	15	1160	485	220			
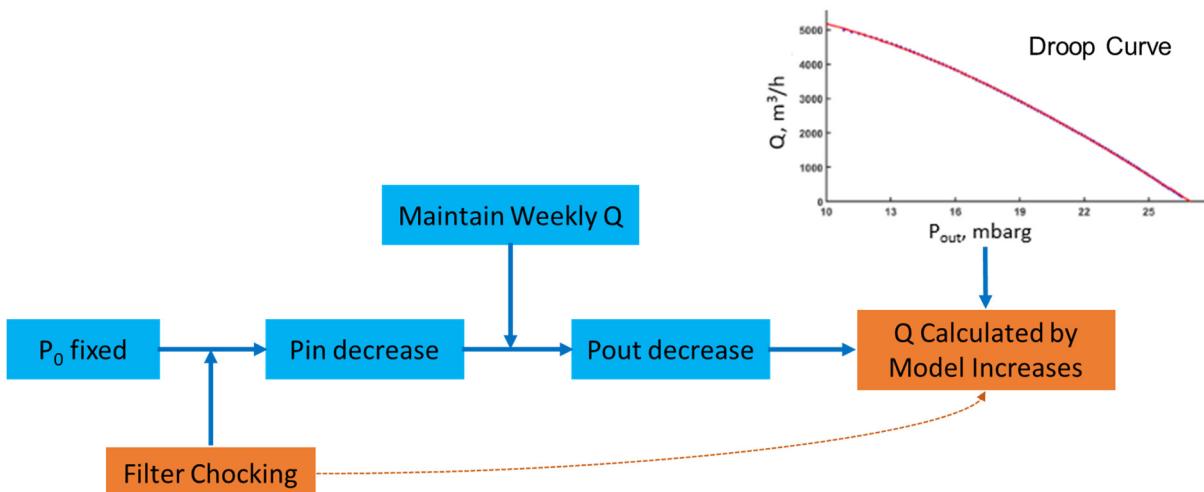
Figure S1: Impact of filter choking on the flow calculated by the mathematical model.

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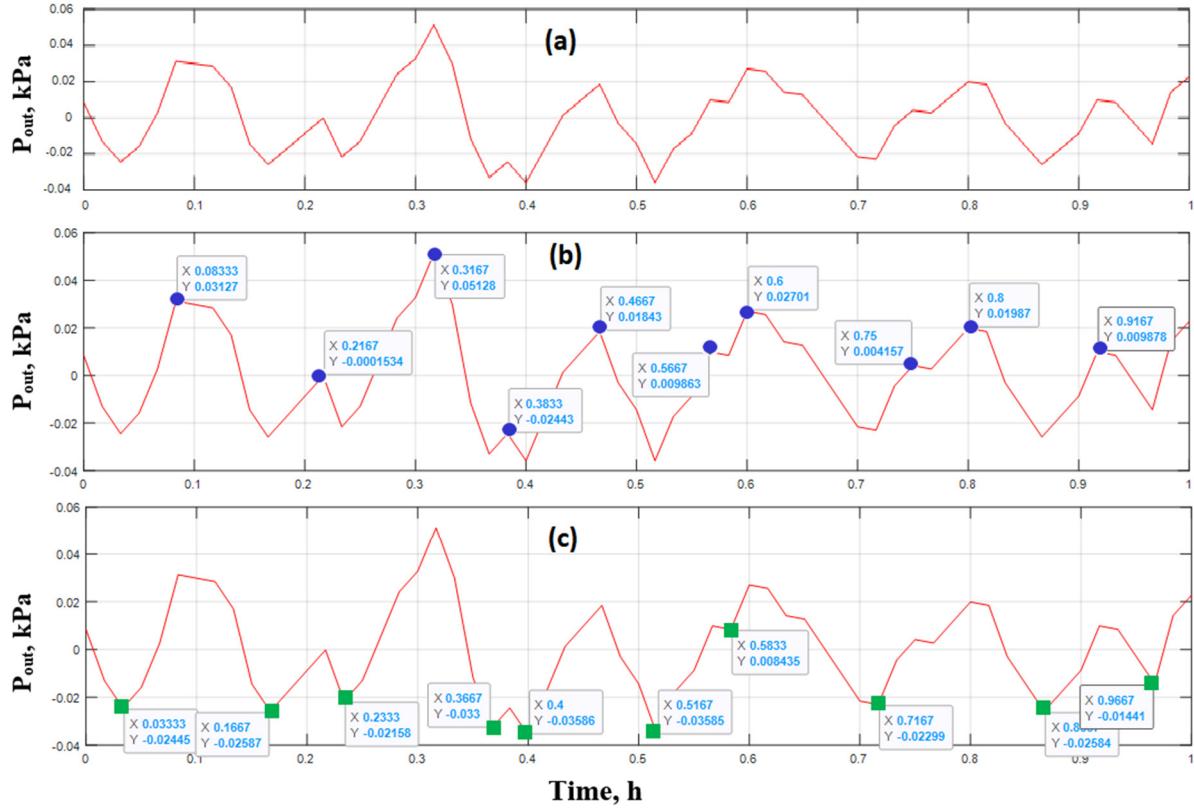
Figure S2: (a) detrend P_{out}, (b) local maximum ●, (c) local minimum ■

Figure S3: Input data table to analyze a group (e.g., regulator group 2) of pressure regulators.
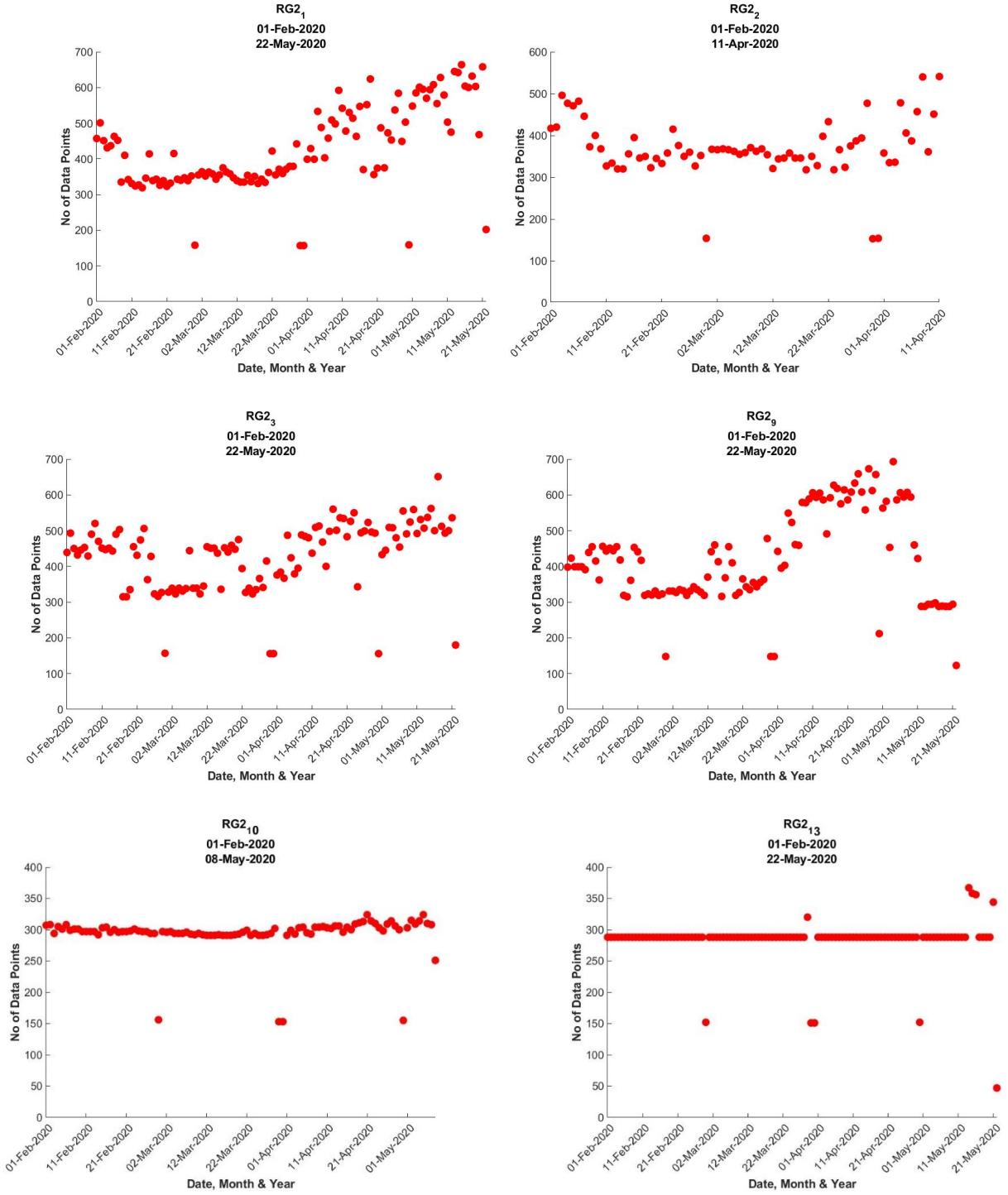
Figure S4: Daily number of data samples for RG2_1, RG2_2, RG2_3, RG2_9, RG2_10 and RG2_13 pressure regulators.
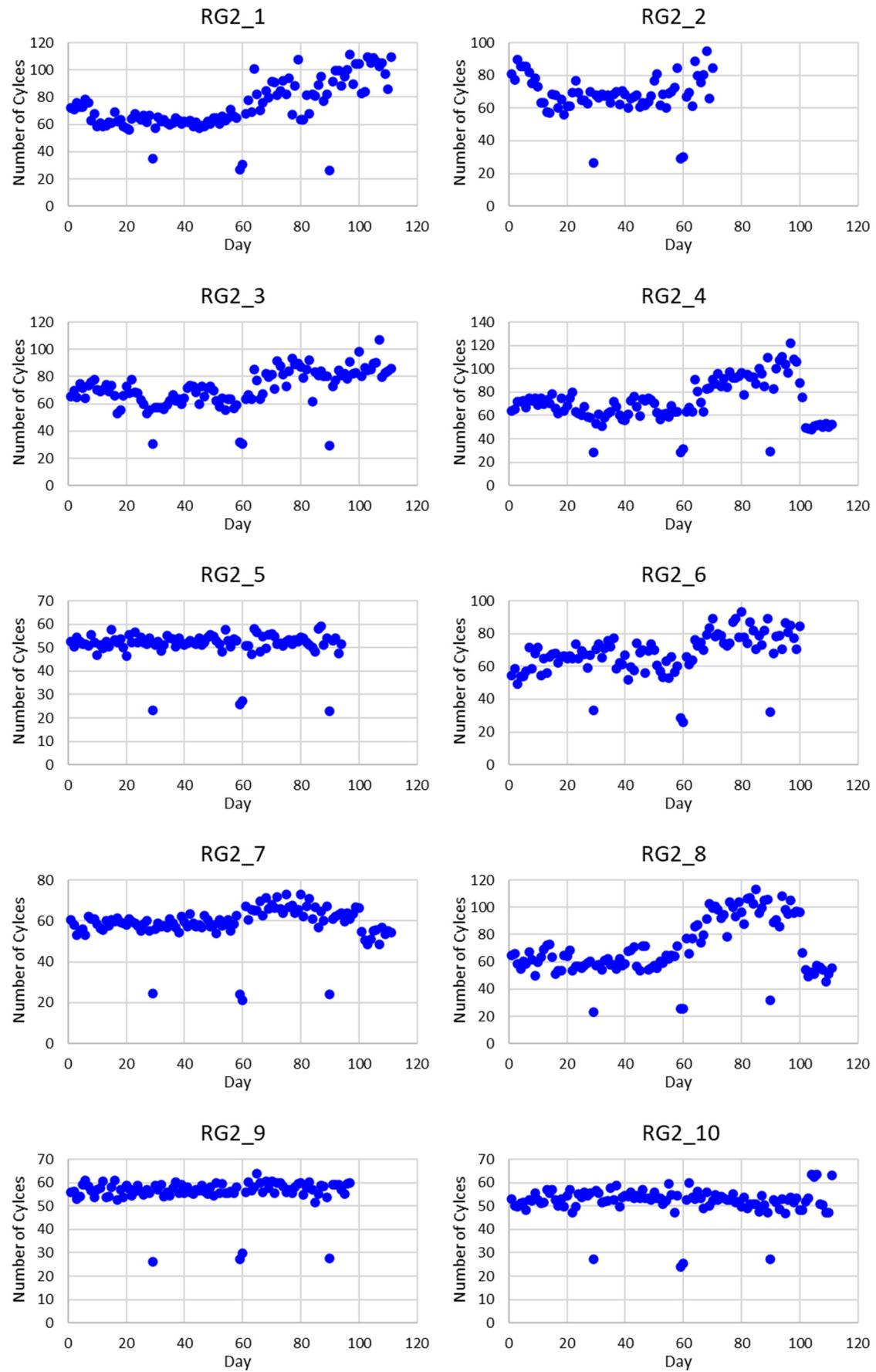
Figure S5: Daily number of diaphragm cycles for different pressure regulators.

Table S2: Confidence intervals of estimated coefficients (intercept and slope) of linear regression model for filter (RUL). The confidence intervals were calculated for fitted line with positive slope.

PR name	Parameters of linear regression model for filter RUL						RUL & 95% confidence range, w
	Intercept	Intercept confidence interval: 95%		Slope	Slope confidence interval: 95%		
		Lower	Upper		Lower	Upper	
RG2_1	129579	128425	130733	341	221	460	70.2 & 45-122
RG2_3	442483	438992	445973	1344	983	1705	57 & 39-87
RG2_5	476043	472041	480045	1393	979	1807	59 & 40-95
RG2_7	133117	132441	133792	424	354	494	48.1 & 38-63
RG2_8	438118	434934	441303	1572	1243	1901	46.4 & 34-65
RG2_9	524466	520079	528853	1358	904	1811	70.2 & 46-118
RG2_10	94904	92781	97028	295	45	544	71.5 & 26-591
RG2_13	129783	129039	130527	402	325	479	54.1 & 41-73

Table S3: Confidence intervals of estimated coefficients (intercept and slope) of linear regression model for valve seat (RUL). The confidence intervals were calculated for fitted line with positive slope.

PR name	Parameters of linear regression model for valve seat RUL						RUL & 95% confidence range, d
	Intercept	Intercept confidence interval: 95%		Slope	Slope confidence interval: 95%		
		Lower	Upper		Lower	Upper	
RG2_7	1.88	1.87	1.89	0.000252	0.000164	0.000340	2344 & 1684-3731
RG2_8	2.05	2.04	2.06	0.000624	0.000451	0.000796	612 & 443-910
RG2_9	1.90	1.90	1.91	0.000129	0.000027	0.000230	4536 & 2455-22112
RG2_10	1.91	1.90	1.91	0.000068	-0.000020	0.000155	8638