SAMPLE ID	CUMULATIVE NUMBER % LESS THAN INDICATED SIZE			NUMBER WEIGHTED MEAN (µm)
	D[n,0.10] (µm)	D[n,0.50] (µm)	D[n,0.90] (µm)	
11194	0.52	0.55	0.68	0.62
38C	0.52	0.60	0.92	0.69
38D	0.52	0.57	0.98	0.74
39A1	0.54	0.67	1.67	1.09
39A2	0.52	0.59	0.86	0.68

SAMPLE ID	CUMULATIVE VOLUME % LESS THAN INDICATED SIZE			VOLUME WEIGHTED MEAN (µm)
	D[v,0.10] (µm)	D[v,0.50] (µm)	D[v,0.90] (µm)	
11194	0.59	7.79	30.01	10.37
38C	0.71	8.44	26.58	10.71
38D	9.53	122.09	128.86	77.74
39A1	7.18	25.53	95.76	34.87
39A2	17.50	125.43	132.38	87.79

FIG. 1A

SAMPLE ID	STOCK CONCENTRATION NUMBER OF PARTICLES/mL ≥ 0.50 µm
11194	4.70×10^6
38C	5.96×10^6
38D	7.73×10^5
39A1	1.91×10^5
39A2	5.94×10^6

FIG. 1B

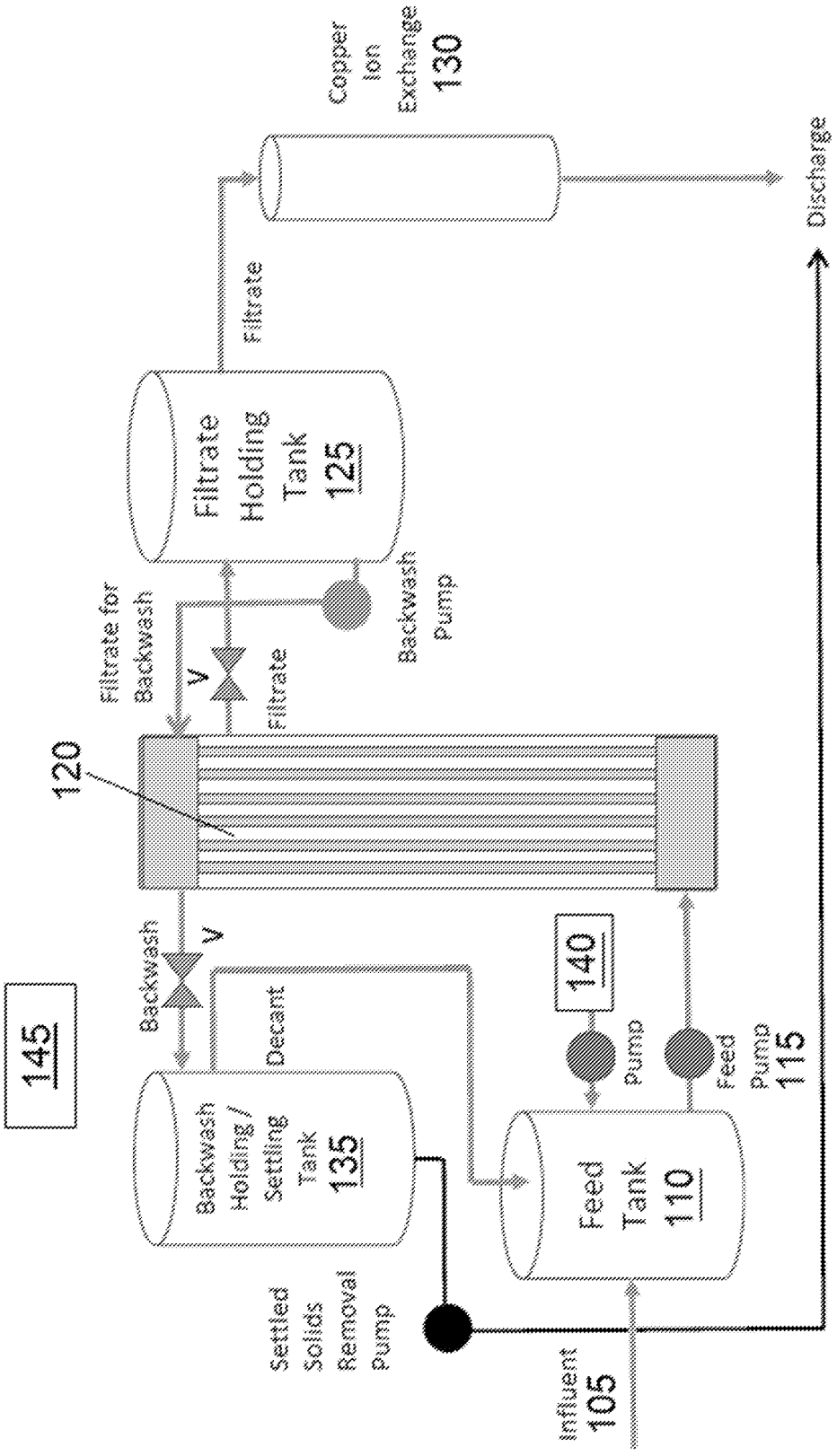

Copper Ion Exchange 130
Discharge
Filtrate
Filtrate Holding Tank 125
Backwash Pump
Filtrate for Backwash
V
Filtrate
120
Backwash
V
Decant
145
140
Pump
Feed Pump 115
Backwash Holding / Settling Tank 135
Feed Tank 110
Settled Solids Removal Pump
Influent 105

FIG. 2

Forward Flow Rate:	120	mL/min	
On	32	min	
Off	2	min	
Backwash Flow Rate:	240	mL/min	
On	0.6	min	
Off	1.4	min	
Settled volume:	8	% in 1 hour	
one complete cycle every:	34	min	$32\ \text{min} + 2\ \text{min} = 34\ min$
Cycles / 24 hour day	42.35	cycles/day	$1440\frac{min}{day}$ x 1 cycle/34 min = 42.35 cycles/day
Quantities/Day			
Forward flow:	162,635	ml/day	$42.35\frac{cycles}{day}x\ 32\frac{min}{cycle}x\ 120\frac{ml}{min} = 162{,}624$ ml/day
Backwash flow:	6,099	ml/day	$42.35\frac{cycles}{day}x\ 0.6\frac{min}{cycle}x\ 240\frac{ml}{min} = 6{,}099$ ml/day
Backwash after Thick:	488	ml/day	$6{,}099\frac{mL}{day}x\frac{8}{100} = 488\ mL/day$
Copper in IX Eff	0.1	mg/L	
Copper in Backwash after thickener:	15	mg/L	
Copper in final combined effluent: (IX effluent + solids)	0.145	mg/L	$\left(15\frac{mg}{L}x488\frac{mL}{day}\right) + \left(\frac{0.1mg}{L}x\ 162{,}635\frac{mL}{day}\right) \div (488\frac{mL}{day} + 162{,}635\frac{mL}{day})$

FIG. 3

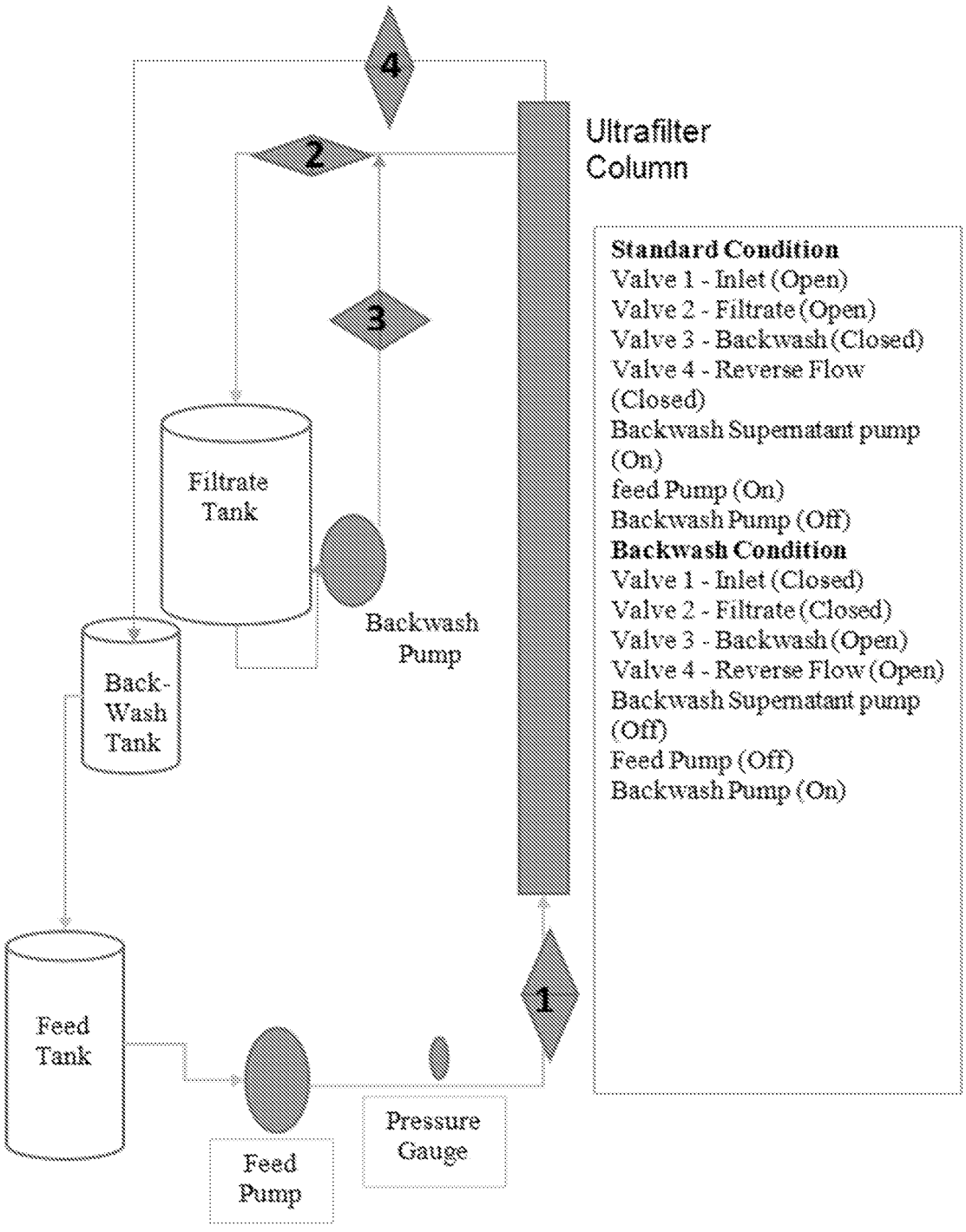

4
2
3
1
Ultrafilter Column
Filtrate Tank
Backwash Pump
Back-Wash Tank
Feed Tank
Feed Pump
Pressure Gauge
Standard Condition
Valve 1 - Inlet (Open)
Valve 2 - Filtrate (Open)
Valve 3 - Backwash (Closed)
Valve 4 - Reverse Flow (Closed)
Backwash Supernatant pump (On)
feed Pump (On)
Backwash Pump (Off)
Backwash Condition
Valve 1 - Inlet (Closed)
Valve 2 - Filtrate (Closed)
Valve 3 - Backwash (Open)
Valve 4 - Reverse Flow (Open)
Backwash Supernatant pump (Off)
Feed Pump (Off)
Backwash Pump (On)

FIG. 4

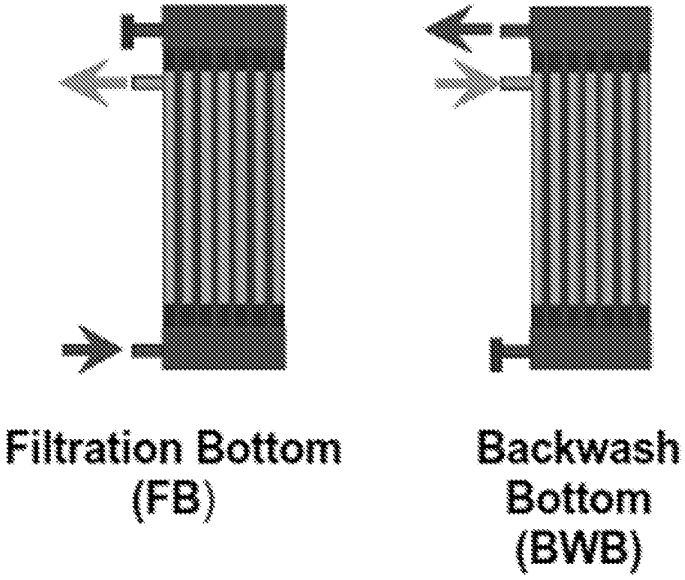


FIG. 5

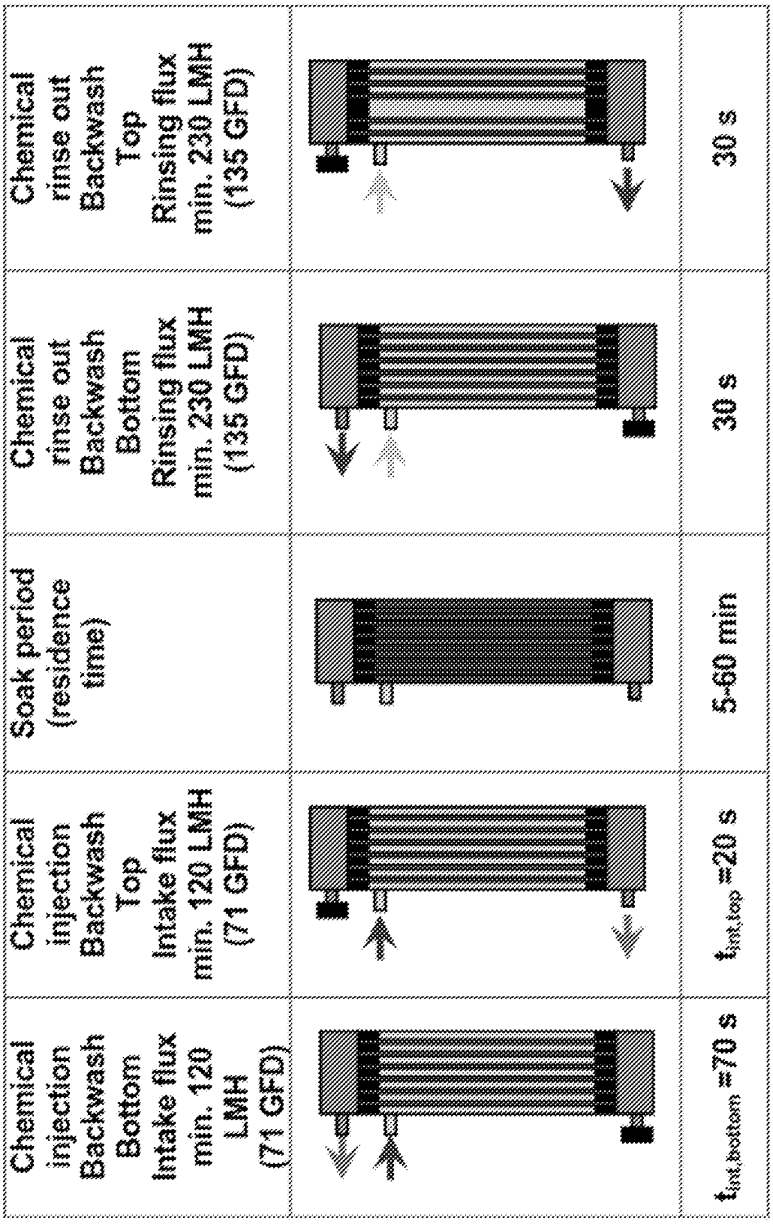

Chemical injection Backwash Bottom Intake flux min. 120 LMH (71 GFD)
Chemical injection Backwash Top Intake flux min. 120 LMH (71 GFD)
Soak period (residence time)
Chemical rinse out Backwash Bottom Rinsing flux min. 230 LMH (135 GFD)
Chemical rinse out Backwash Top Rinsing flux min. 230 LMH (135 GFD)
$t_{int,bottom}$ =70 s
$t_{int,top}$ =20 s
5-60 min
30 s
30 s

FIG. 6


Condition 3: Time vs Inlet Pressure
Inlet Pressure (PSI)
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
9
Time (hours)

FIG. 7A

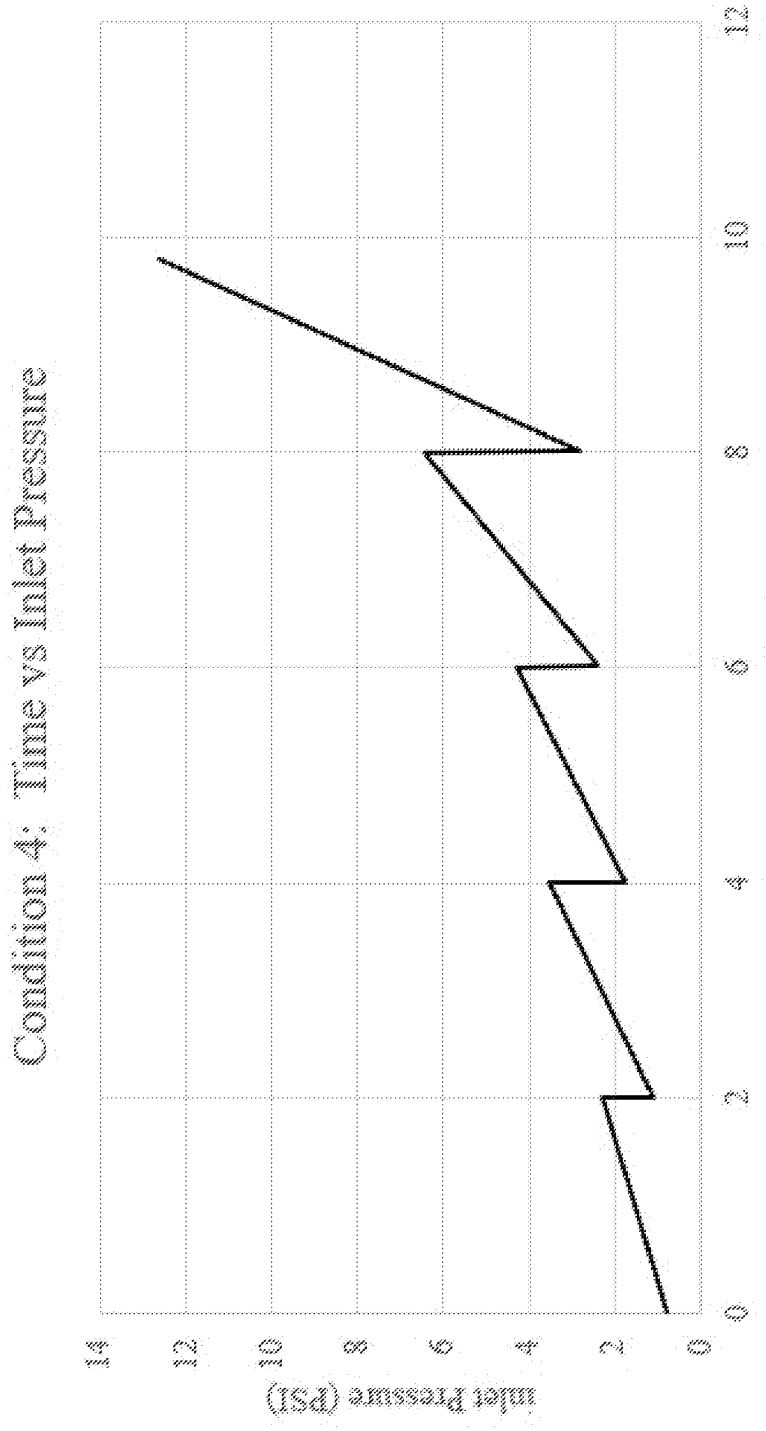

Condition 4: Time vs Inlet Pressure
Inlet Pressure (PSI)
0
2
4
6
8
10
12
14
Time (hours)
0
2
4
6
8
10
12

FIG. 7B

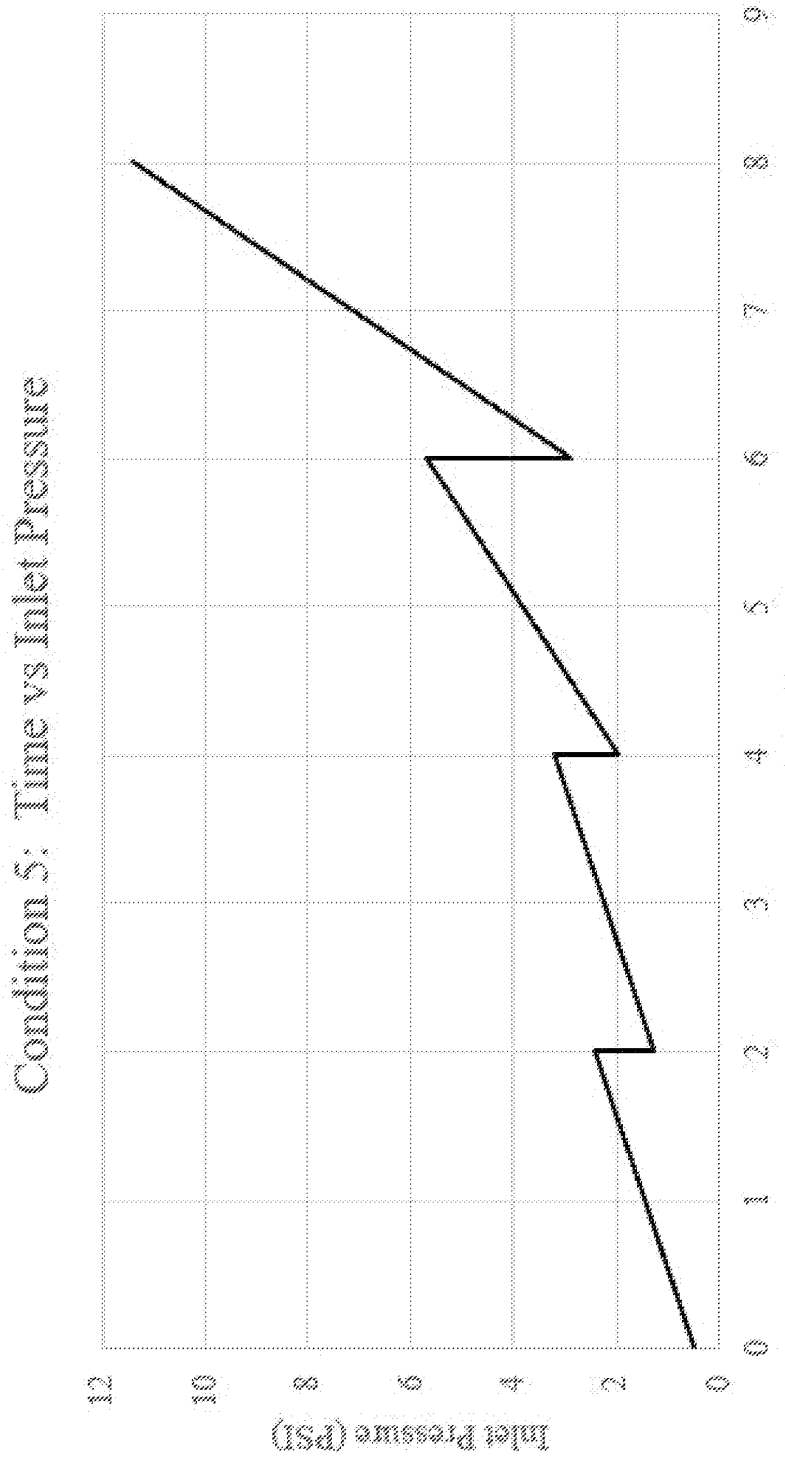

Condition 5: Time vs Inlet Pressure
Inlet Pressure (PSI)
0
2
4
6
8
10
12
Time (hours)
0
1
2
3
4
5
6
7
8
9

FIG. 7C

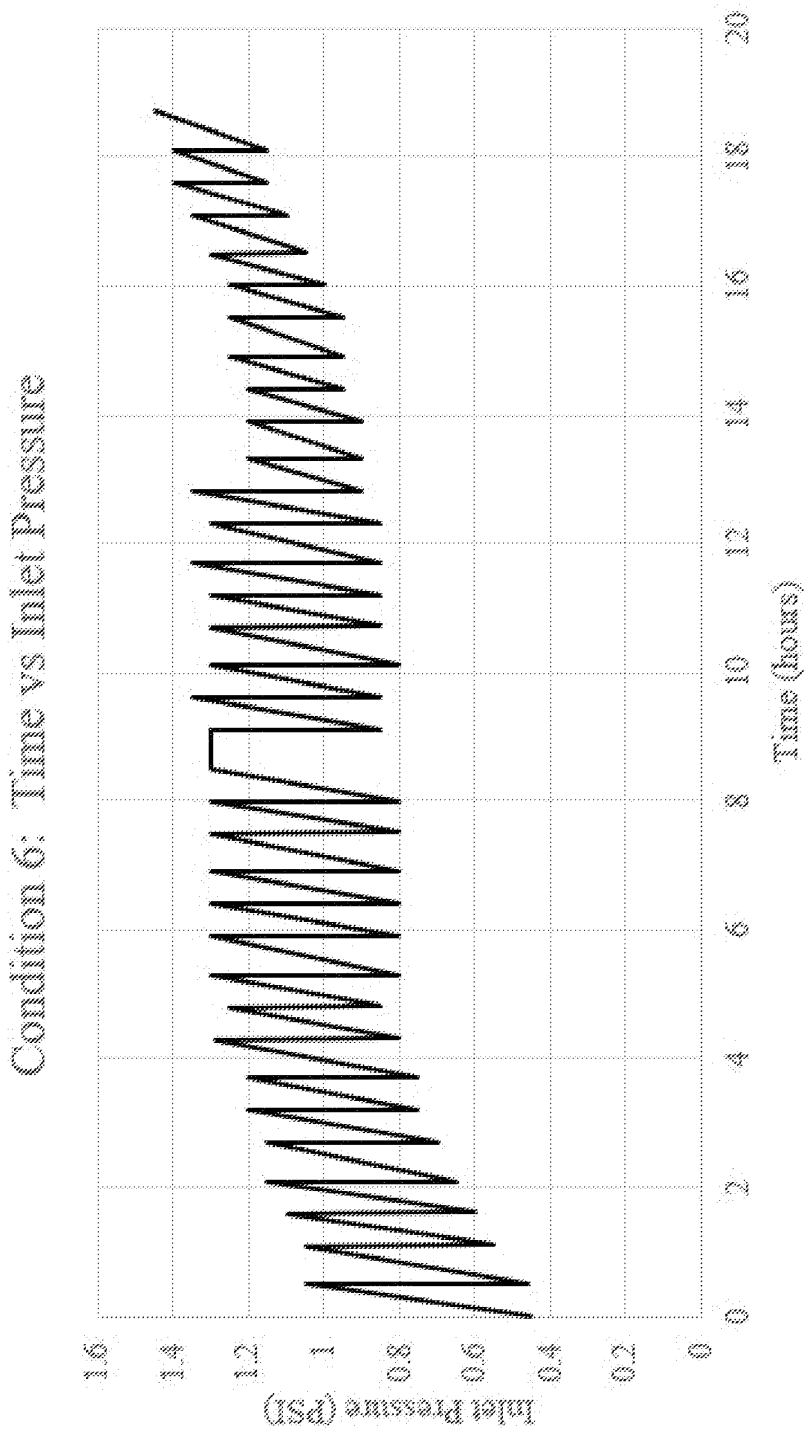

Condition 6: Time vs Inlet Pressure
Inlet Pressure (PSI)
Time (hours)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0
2
4
6
8
10
12
14
16
18
20

FIG. 7D

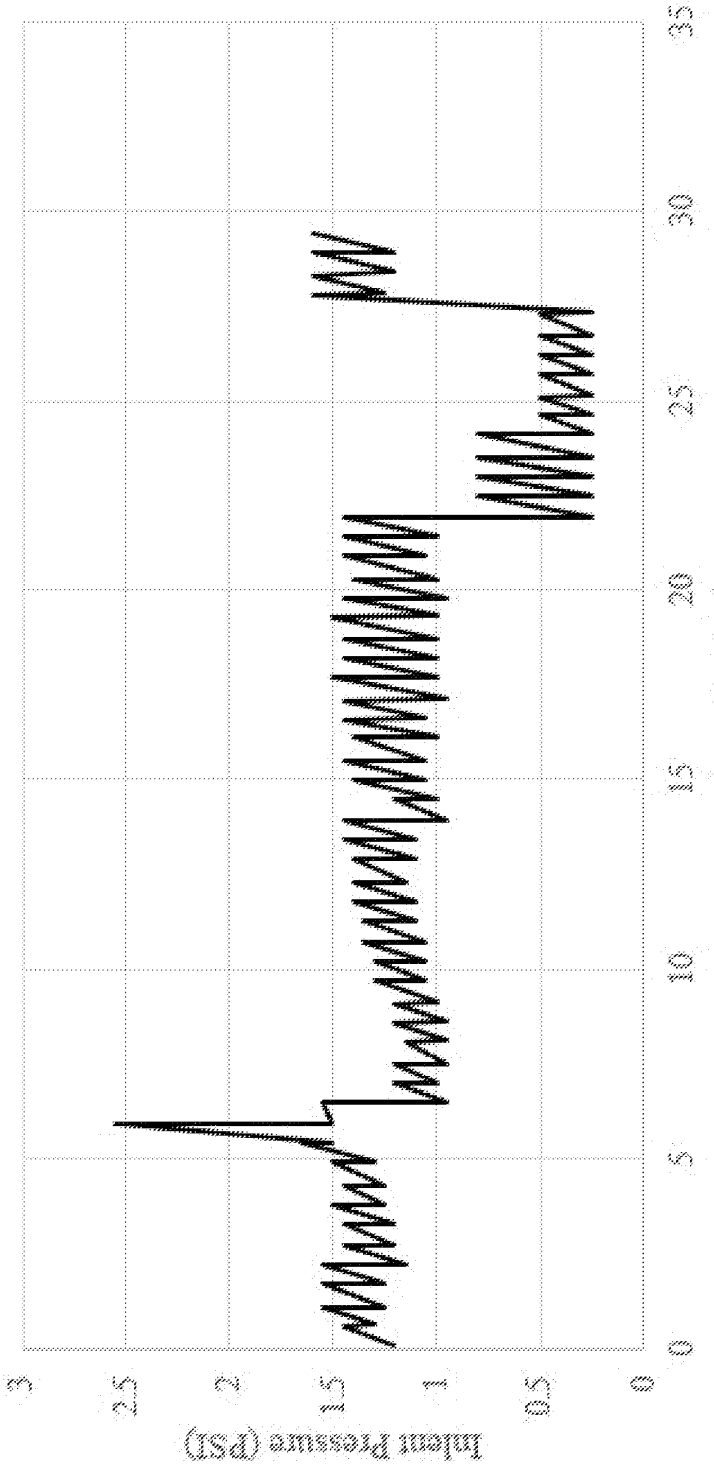

Condition 7: Time vs Inlet Pressure
Inlet Pressure (psi)
Time (hours)
0
0.5
1
1.5
2
2.5
3
0
5
10
15
20
25
30
35

FIG. 7E

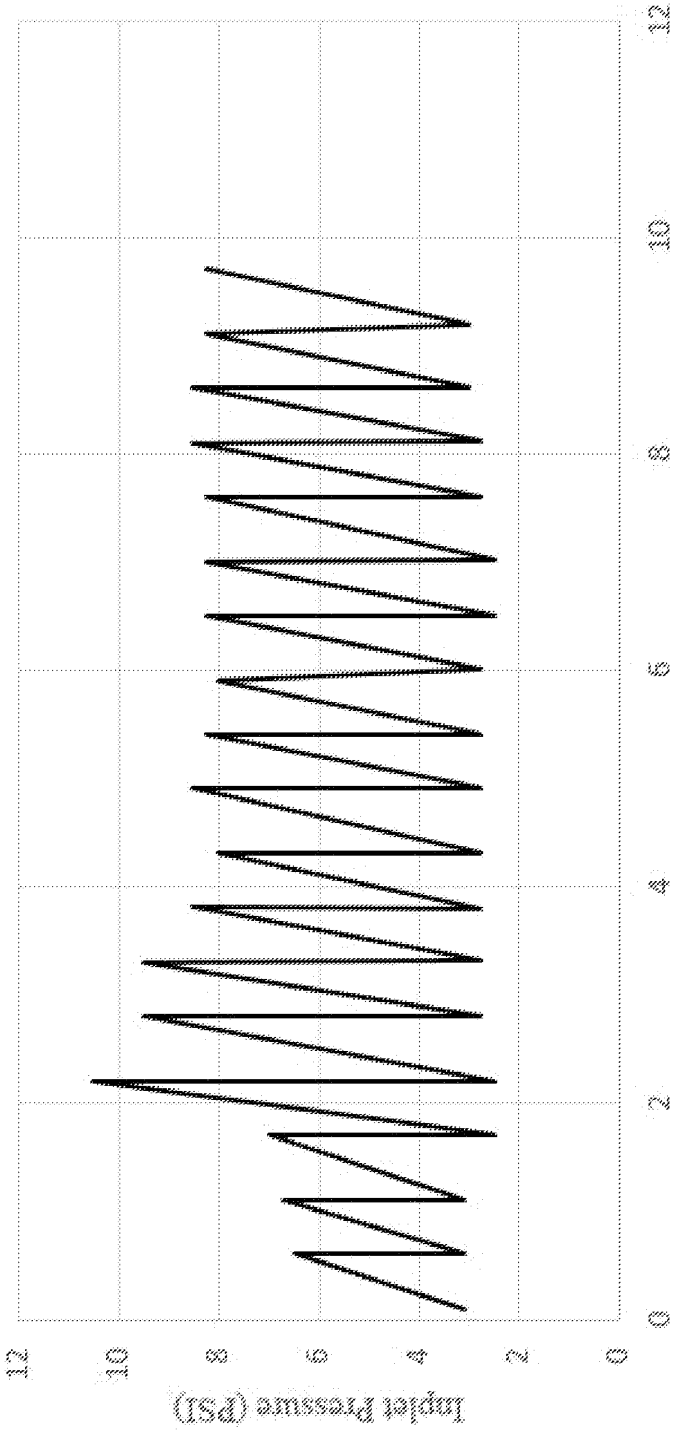

Condition 8: Time vs. Inlet Pressure
Inlet Pressure (psi)
Time (hours)
0
2
4
6
8
10
12

FIG. 7F

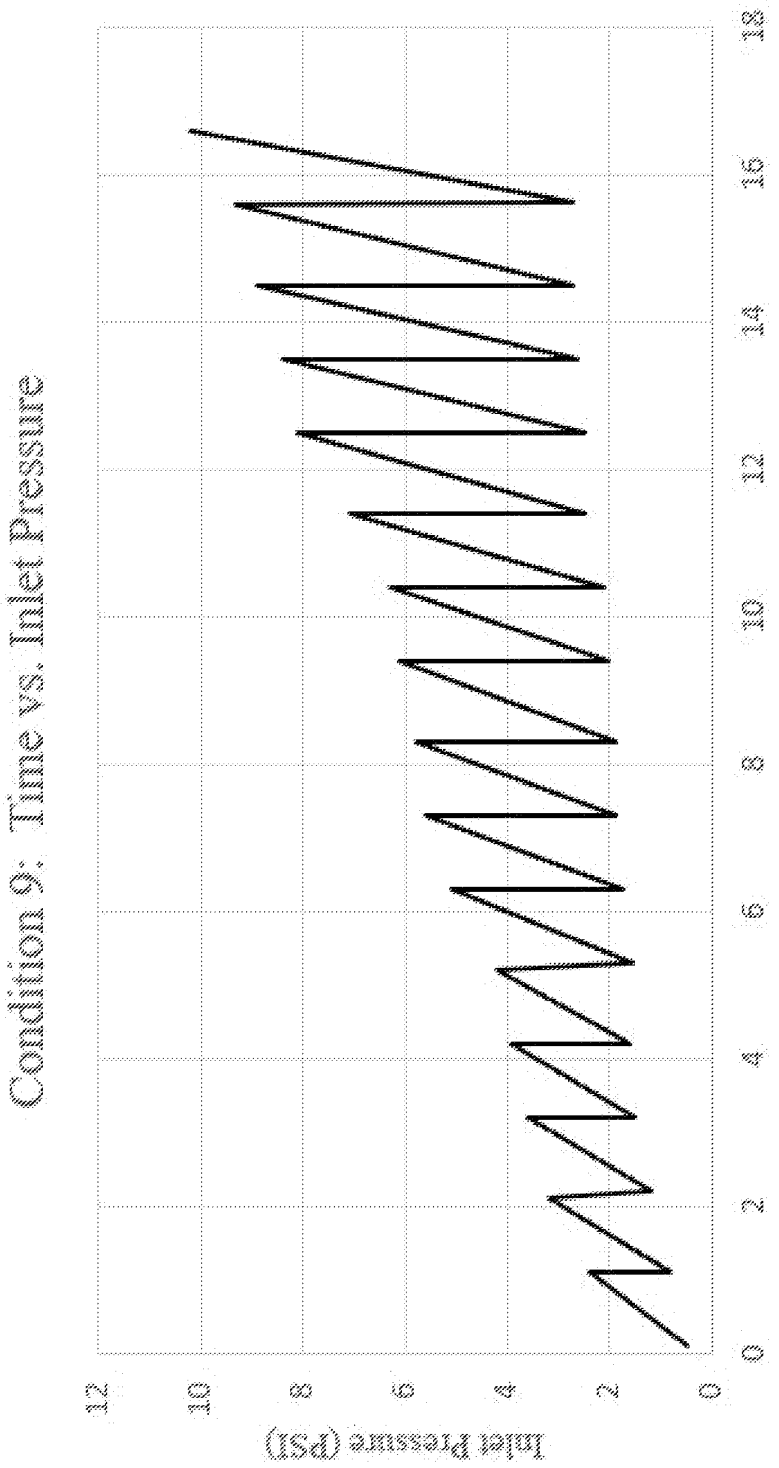

Condition 9: Time vs. Inlet Pressure
Inlet Pressure (PSI)
Time (hours)
0
2
4
6
8
10
12
14
16
18

FIG. 7G

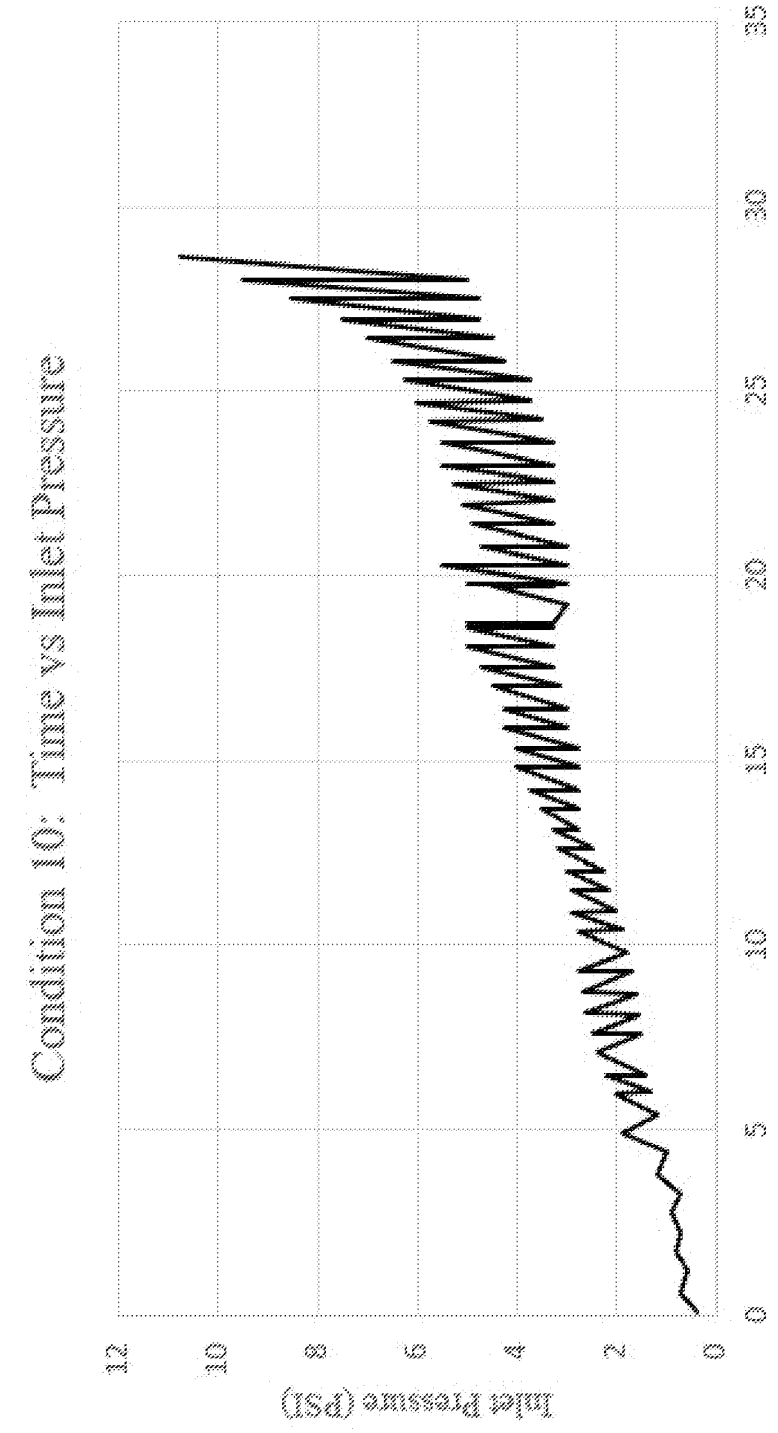

Condition 10: Time vs Inlet Pressure
Inlet Pressure (PSI)
0
2
4
6
8
10
12
Time (hours)
0
5
10
15
20
25
30
35

FIG. 7H

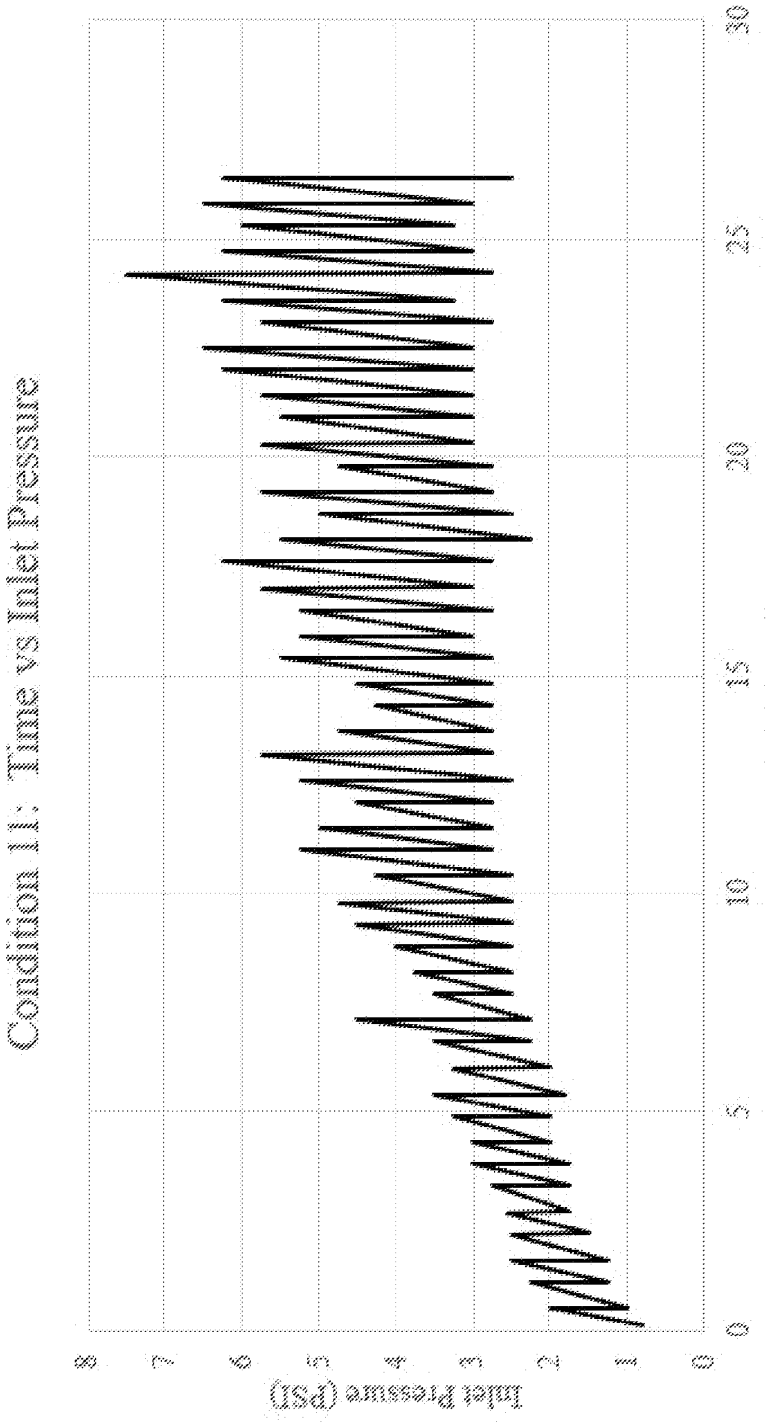

Condition 11: Time vs Inlet Pressure
Inlet Pressure (psi)
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
Time (hours)

FIG. 7I