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PATUXENT RIVER, MARYLAND

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C2A1 AND LOW PROFILE AIR FILTER PACK FLOW CHARACTERISTICS WITH NAVY COMBAT EDGE

by

Kevin McOmber
Dennis Gordge

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14. ABSTRACT

One of the objectives of the Joint Services Aircrew Mask program was to add chemical, biological protection to an aircrew's breathing system such as the Navy Combat Edge (NCE). The purpose of this test was to compare and evaluate the compatibility of the C2A1 and Low Profile Air Filter Pack (LPAFP) canister with the NCE system. Areas of specific concern were the pressure drops associated with the canisters. The canister test was split into four phases including an endurance test, a steady flow test, a dynamic flow performance test, and a system lag time test. The endurance test was designed to monitor the canisters for charcoal degradation and system variation over an 8-hr period with an average breathing rate. The steady flow test gives a close look at the performance of the system at peak flow rates. The data also provided baseline figures for the dynamic flow performance test. The dynamic flow performance test recorded the system's performance with realistic breathing profiles simulating conditions of high demand with G's. The system lag time test was performed to analyze the response time of NCE with the added restriction of the canisters. In conclusion, no charcoal degradation was observed for either the C2A1 or LPAFP canister in the endurance test. Both canisters showed similar performance in the steady and dynamic tests with slightly lower pressure drops across the LPAFP canister. Negative mask pressures were observed with both canisters during the dynamic testing at the 1G condition but both remained above the Air Standardization Coordinating Committee (ASCC) minimum mask pressure requirements. In a chemical/biological system, negative mask pressures may be considered as a severe deficiency. The C2A1 displayed mask pressure swings slightly beyond the ASCC standard at peak flows between 0-115 liters per minute (LPM) but within the ASCC standard at flows above the 115 LPM. The LPAFP showed a slightly better performance with mask pressure swings being within the ASCC standard at all flows in the 1G condition. In all the cases tested for both the C2A1 and the LPAFP canister, no system lag times were observed.

15. SUBJECT TERMS

C2A1; Low Profile Air Filter Pack (LPAFP); Navy Combat Edge (NCE)

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SUMMARY

One of the objectives of the Joint Services Aircrew Mask program was to add chemical, biological protection to an aircrew's breathing system such as the Navy Combat Edge (NCE). The purpose of this test was to compare and evaluate the compatibility of the C2A1 and Low Profile Air Filter Pack (LPAFP) canister with the NCE system. Areas of specific concern were the pressure drops associated with the canisters. The canister test was split into four phases including an endurance test, a steady flow test, a dynamic flow performance test, and a system lag time test.

The endurance test was designed to monitor the canisters for charcoal degradation and system variation over an 8-hr period with an average breathing rate. The steady flow test gives a close look at the performance of the system at peak flow rates. The data also provided baseline figures for the dynamic flow performance test. The dynamic flow performance test recorded the system's performance with realistic breathing profiles simulating conditions of high demand with G's. The system lag time test was performed to analyze the response time of NCE with the added restriction of the canisters.

In conclusion, no charcoal degradation was observed for either the C2A1 or LPAFP canister in the endurance test. Both canisters showed similar performance in the steady and dynamic tests with slightly lower pressure drops across the LPAFP canister. Negative mask pressures were observed with both canisters during the dynamic testing at the 1G condition but both remained above the Air Standardization Coordinating Committee (ASCC) minimum mask pressure requirements. In a chemical/biological system, negative mask pressures may be considered as a severe deficiency. The C2A1 displayed mask pressure swings slightly beyond the ASCC standard at peak flows between 0-115 liters per minute (LPM) but within the ASCC standard at flows above the 115 LPM. The LPAFP showed a slightly better performance with mask pressure swings being within the ASCC standard at all flows in the 1G condition. In all the cases tested for both the C2A1 and the LPAFP canister, no system lag times were observed.

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INTRODUCTION

1. One of the objectives of the Joint Services Aircrew Mask program was to add chemical, biological protection to an aircrew's breathing system such as the Navy Combat Edge (NCE). The purpose of this test was to compare and evaluate the compatibility of the C2A1 and the Low Profile Air Filter Pack (LPAFP) canister with the NCE system. Areas of specific concern were the pressure drops associated with the canisters. The canister test was split into four phases including an endurance test, a steady flow test, a dynamic flow performance test, and a system lag time test.

2. The endurance test was designed to monitor the canisters for charcoal degradation and system variation over an 8-hr period with an average breathing rate of liters per minute (LPM)/25 breaths per minute (BPM). The steady flow test gives a close look at the performance of the system at peak flow rates. The data also provided baseline figures for the dynamic flow performance testing. The dynamic flow performance test recorded the systems performance with realistic breathing profiles simulating conditions of high demand with G's. The system lag time test was performed to analyze the response time of NCE with the added restriction of the canisters.

DESCRIPTION OF EQUIPMENT

3. The C2A1 is a filter canister designed to remove chemical/biological contaminants from aircrew breathing gases. It is currently in use by the Navy. The inlet and outlet ports are located on the top and bottom of the cylinder. Air flow is through the path of least resistance through the charcoal filter. The LPAFP is also a chemical/biological filter canister. It has a larger circumference and the inlet and outlet ports extrude perpendicularly from the sides of the canister. The ports have screw fittings that allow a tight hose connection. The air flow is circulated around the inside perimeter of the canister increasing the surface area of the charcoal canister.

METHOD

4. Each test phase was setup as depicted in appendix A. Tests were performed with bottled nitrogen in an NCE system representative of that worn by Naval aviators. This included a CSU-17/P counter pressure vest, a CRU-103/P regulator, and an MBU-20 mask. The C2A1 and LPAFP canisters were added between the regulator and the mask. The C2A1 canister was hooked up using the standard J-connector and rubber boot with a cable tie. A simulated g-signal was applied to the regulator by supplying the regulator's anti-g reference pressure inlet with the appropriate pressure. It should be noted that when g-signals above 5 G's were applied to the regulator, the C2A1 rubber boot would leak and even pop off at 9 G's. Therefore, the cable tie was replaced with a hose clamp. The LPAFP was also attached using hose clamps at the inlet and outlet of the canister because the standard connectors were unavailable. Pressure sensors were placed to measure the pressure drops across each component of the system. With the exception of the steady flows, all data points for each test condition were electronically monitored and recorded. A computerized data acquisition system was used to control the time period and the

data sample rate for each test. The basic input parameters and their ranges were as follows: regulator inlet pressures of 10-60 PSIG, peak flow rates of 50-240 LPM, g-signal applied to the regulator simulating 1-9 G's, and flow restrictors simulating different mask resistances by reducing the cross-sectional hose area by 40% and 70%. The flow restrictors were used to simulate various mask resistances in case an alternate mask with a different resistance than the MBU-20 was used in the final configuration. The pressure drops associated with each mask of the restrictors are displayed in appendix B. All test conditions were performed within the specifications of the CRU-103/P regulator. In cases where it was deemed safe and repeatable, the flows were set to exceed the standard specifications.

TEST DATA AND DISCUSSION

ENDURANCE TEST

5. The endurance test was performed for a period of 8 hr at an average flow rate of 25 LPM/20 BPM. Every hour, a clean cloth wipe test was performed on the mask and the canisters were weighted to monitor any possible charcoal decomposition. System pressures were recorded every half hour to monitor any performance changes within either of the canisters. Data were recorded for a period of 30 sec at a sample rate of 10 samples/sec. System pressures at the point of maximum demand or peak inhalation were averaged and graphed versus time. The C2A1 canister weight decreased by 0.3 grams and the LPAFP weight decreased by 0.4 grams over the 8-hr period (figures C-3 and C-4). There was no evidence of charcoal dust in the mask and no change in canister resistance (figures C-1 and C-2).

STEADY FLOW TEST

6. Each test condition in table 1 was performed using the setup as shown in appendix A. Data were recorded for a period of 15 sec at a rate of 5 samples/sec.

Table 1: Steady Flow Matrix

Condition	Average Flow (LPM)	Simulated G
Baseline (no canister)	28, 70, 112, 156, 198, 226	1, 5, 9
Canister No Flow Restrictor	28, 70, 112, 156, 198, 226	1, 5, 9
40% Flow Restrictor	28, 70, 112, 156, 198, 226	1, 5, 9
70% Flow Restrictor	28, 70, 112, 156, 198, 226	1, 5, 9

7. Steady flow test data is presented in appendix D. Flows were drawn with a vacuum pump and recorded with a variable area flow meter. Flows were corrected for pressure and density to standard atmospheric conditions (14.7 PSIG). The results of the tests were graphed as pressure versus system component. In the baseline chart, figure D-1, the pressure drops from the outlet of the regulator to the mask were no more than 3.0 in. H_2O with the minimum mask pressure being 0.0 in H_2O. The small spread of data points in the mask location shows a small pressure drop that

increased with increases in demand. The small spread of data points at the outlet of the regulator shows the function of the regulator to increase positive pressure with increases in demand. At every baseline condition, a positive pressure was maintained in the mask. With the addition of the C2A1 canister, the total pressure drop from the outlet of the regulator to the mask increased. The C2A1 added a 0.5 in H_2O pressure drop at flows of 28 LPM to 6.0 in H_2O pressure drop at 226 LPM (figure B-1). As the flows were increased, the pressure drop across the canister increased causing negative mask pressures at high flows in the 1Gz condition, figure D-2. The effect of the LPAFP canister was similar to that of the C2A1. Pressure drops increased with increases in flow also causing negative mask pressures at high flows in the 1G condition. As shown in figure D-3, the absolute pressure drop of the LPAFP was slightly less than the C2A1with the maximum negative mask pressure caused by the LPAFP being –4.5 in comparison to –6.0 in H_2O caused by the C2A1. LPAFP pressure drops ranged from 0.4 in H_2O at 28 LPM to 4.5 in H_2O at 226 LPM. As the g-signal to the regulator increased the pressure drops across the canisters remains consistent with the 1G values. Negative mask pressures were no longer present at the 5G and 9G conditions because of the CRU-103/P's function of increasing positive pressure with G's. The only affect of adding flow restrictors to the mask was a larger pressure drop across the mask. The resulting negative mask pressures due to the canisters and no flow restrictors were within the Air Standardization Coordinating Committee (ASCC) minimum mask pressure standard with the LPAFP exhibiting a slightly better performance in comparison to the C2A1.

DYNAMIC FLOW PERFORMANCE TEST

8. The test was performed with the breathing machine at every test condition in table 2. The time period of each test was adjusted to record a minimum of 8 breaths with a recording rate of 10 samples/sec.

Table 2: Dynamic Flow Performance Test Matrix

Condition	Minimum Regulator Inlet Pressure (PSIG)	Peak Flow (LPM/BPM)	Simulated G
Baseline (no canister)	10, 20, 40, 60	50/12, 100/19, 150/26, 200/33, 240/40	1, 5, 9
Canister No Flow Restrictor	10, 20, 40, 60	50/12, 100/19, 150/26, 200/33, 240/40	1, 5, 9
40% Flow Restrictor	10, 20, 40, 60	50/12, 100/19, 150/26, 200/33, 240/40	1, 5, 9
70% Flow Restrictor	10, 20, 40, 60	50/12, 100/19, 150/26, 200/33, 240/40	1, 5, 9

NOTE: At 10 PSIG, flow rates above 100 LPM were not required.

9. Data gathered during dynamic flow performance testing is presented in appendix E. The system pressures at the point of peak demand were averaged per test condition and graphed as

pressure vice system component. The result is a display of the absolute system pressures starting at the regulator outlet and ending at the mask. The system pressures of the baseline test showed the performance of the system without the canister. The pressure drops across the system were within the expected values established in the steady flow test with the largest pressure drop being 4.0 in H_2O at the high flow rates of 240 LPM. The baseline NCE system showed uniform performance across the 5G and 9G condition and across the regulator inlet pressure range of 10-60 PSIG (figures E-3 to E-6). Typical mask pressures at 1G ranged between 0.0 - 0.7 in H_2O. The maximum negative pressure drawn in the mask was -0.7 in H_2O at the 240 LPM flow and 1G condition.

10. Mask pressures were also compared to the ASCC standards. The area of specific interest is the total mask pressure swing from inhalation to exhalation and the absolute mask pressures during inhalation. Since the canisters provide additional resistance only during inhalation, exhalation mask pressures will not be discussed except when referenced in the total mask pressure swing. It should also be noted that the ASCC standards were last updated in 1988 before the existence of the positive pressure at G conditions. While all test conditions are graphed vice the ASCC standard, the 5G and 9G test data are for reference purposes and only the data at the 1G condition will be analyzed. The mask pressure swing in the baseline was within the ASCC standards at each flow and regulator inlet condition. The minimum mask pressures were also within the ASCC specification (figures E-1 and E-2).

11. While the effect of adding the C2A1 canister caused negative pressures in the mask at every flow rate in the 1G condition, every mask pressure was within the ASCC minimum mask pressure standard. The increased pressure drops due to the canister caused the mask pressure swings to increase outside of the ASCC spec at the 50-115 LPM flows. Beyond the 115 LPM flow, the mask pressure swings remained within the standard, table 3 and figure E-7. The canisters performance was consistent at the 5G and 9G condition for each regulator inlet pressure. Again, the only effect of adding flow restrictors to the mask was increased pressure drop across the mask, figures E-20 to E-42. The performance of the NCE system with the addition of the LPAFP canister was similar to that of the C2A1 canister. The LPAFP canister caused negative mask pressures at each flow rate except at 50 LPM where 0.0 in H_2O was maintained. Again, the mask pressures were within the ASCC minimum mask pressure standard, figure E-13. The mask pressure swings were within the ASCC standard with a difference of .10 in H_2O existing between the standard and LPAFP mask pressure swing at the 50-100 LPM flow, figure E-14. The performance of the C2A1 and LPAFP canisters were very similar with the LPAFP exhibiting slightly lower pressure drops and remaining within the ASCC specifications. The C2A1's performance was slightly below the ASCC standard at flow rates up to 115 LPM but within the standard for the remaining flow rates.

Table 3: ASCC and Canister Compliance

Flow (LPM)	Maximum Mask Pressure Swing within ASCC Specification	
	C2A1	LPAFP
50	No	Yes
75	No	Yes
100	No	Yes
125	Yes	Yes
150	Yes	Yes
175	Yes	Yes
200	Yes	Yes

SYSTEM LAG TIME TEST

12. The test was performed by applying a g-signal to the regulator and measuring the response time of each component in the system. The g-signal was applied at a rate of 6 G's/sec until the targeted value was reached. The system was then allowed to stabilize for a period of 3 sec and then the g-signal was instantaneously released. Before the test was run, the flow of 115 LPM was set with the g-signal present. The g-signal was then released and the test was run and recorded with the profile described earlier. All data were graphed as pressure vice time and analyzed for lag time within the periods of g-signal transition. Data were recorded for a period of 7 sec with a sample rate of 20 samples/sec. Each test condition was performed according as shown in table 4.

Table 4: System Lag Time Matrix

Condition	Regulator Inlet Pressure (PSIG)	Average Flow (LPM)	G Transition
Baseline (no canister)	40, 60	115	1-5, 1-9
Canister No Flow Restrictor	40, 60	115	1-5, 1-9
40% Flow Restrictor	40, 60	115	1-5, 1-9
70% Flow Restrictor	40, 60	115	1-5, 1-9

13. Data gathered during the system lag time testing is presented in appendix F. Lag time was analyzed by drawing a vertical line at the time at which the g-signal reached its targeted value. Next, a horizontal line was drawn across the chart at the targeted pressure value for each component. Then the point in time at which each component reached its targeted value was compared to the time at which the g-signal reached its targeted value. In the baseline case, the regulator outlet pressure and the mask pressure reached their targeted value 1/10 of a second before the g-signal, figure F-1. For future reference, when the component pressures reach their targeted values before or exactly at the same time as the g-signal target value, the system will be considered as having zero lag time. The baseline tests showed no lag time at each configuration. The performance of the C2A1 and LPAFP setup were similar to the baseline configuration with

component pressures reaching their targeted value before or equal to the time of the g-signal target value. There were no system lag times observed with the addition of either the C2A1 or LPAFP canister. Also, there were no system lag times observed with the addition of the flow restrictors to the mask, figures F-5 to F-28.

CONCLUSION

14. No charcoal degradation was observed for either the C2A1 or LPAFP canister in the endurance test. Both canisters showed similar performance in the static and dynamic tests with slightly lower pressure drops across the LPAFP canister. Negative mask pressures were observed in both canisters during the dynamic testing at the 1G condition but both remained above the ASCC minimum mask pressure requirement. In a chemical/biological system, negative mask pressures may be considered as a severe deficiency. The C2A1 displayed mask pressure swings slightly beyond the ASCC standard with flows between 0-115 LPM and within the ASCC standard at flows above the 115 LPM. The LPAFP showed a slightly better performance with mask pressure swings at all flows in the 1G condition being within the ASCC standard. In all the cases tested for both the C2A1 and the LPAFP canister, no system lag times were observed. It should be noted that when g-signals above 5 G's were applied to the regulator, the C2A1 rubber boot would leak and even pop off at 9 G's. The cable tie was replaced with a hose clamp.

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APPENDIX A
LAB SETUP DIAGRAMS AND PICTURES

Figure No.	Title	Page No.

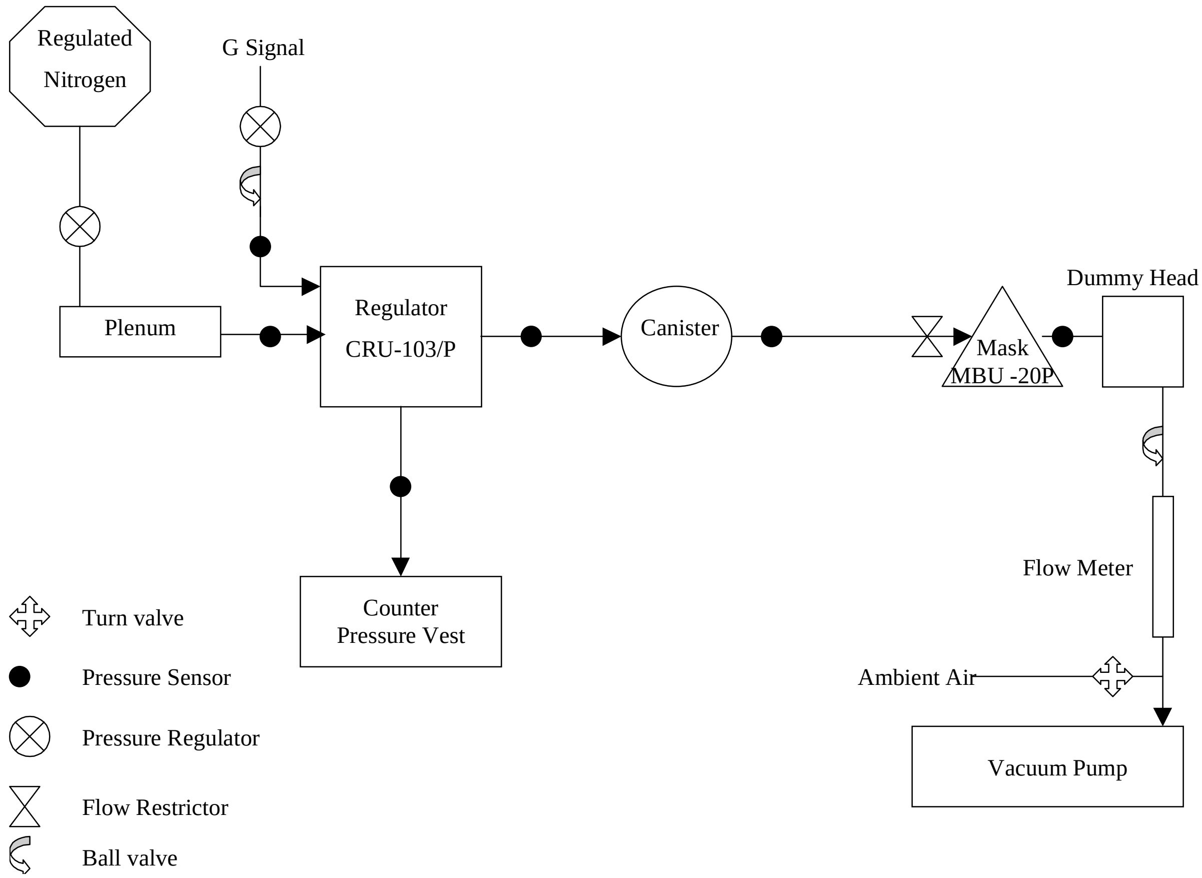

Figure A-1: Lab Setup for Static Flow Test and System Lag Time Test

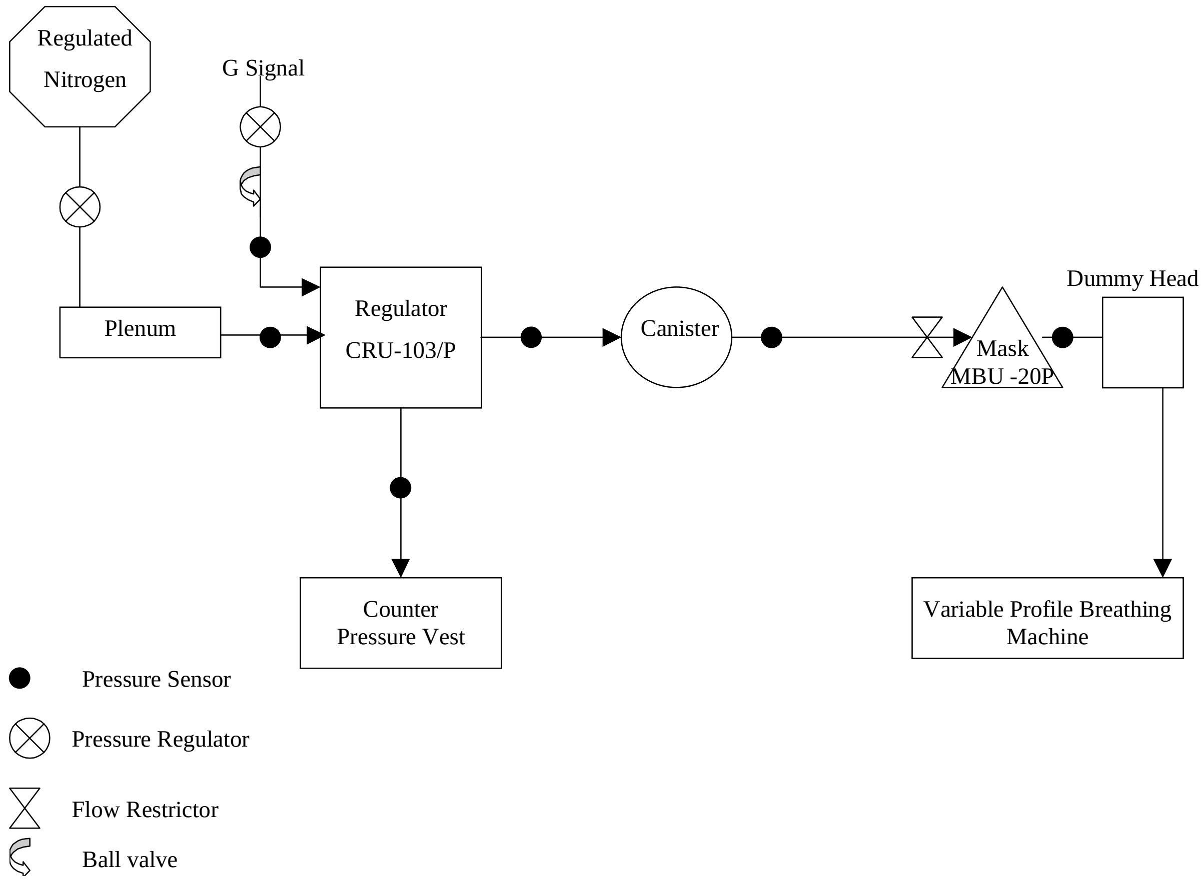

Figure A-2: Lab Setup for Endurance Test and Dynamic Flow Performance Test

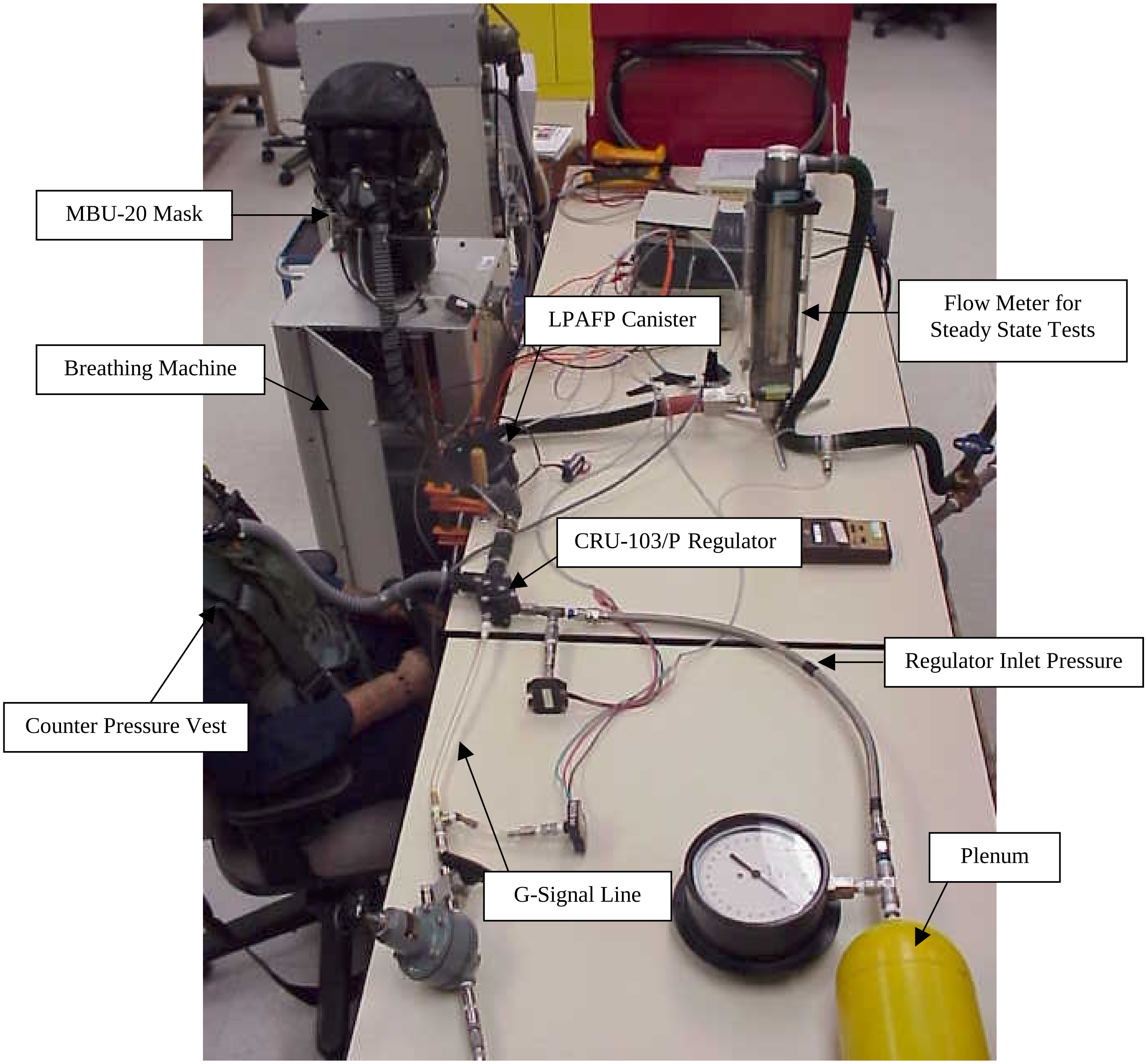

Figure A-3: Lab Setup with LPAFP Canister

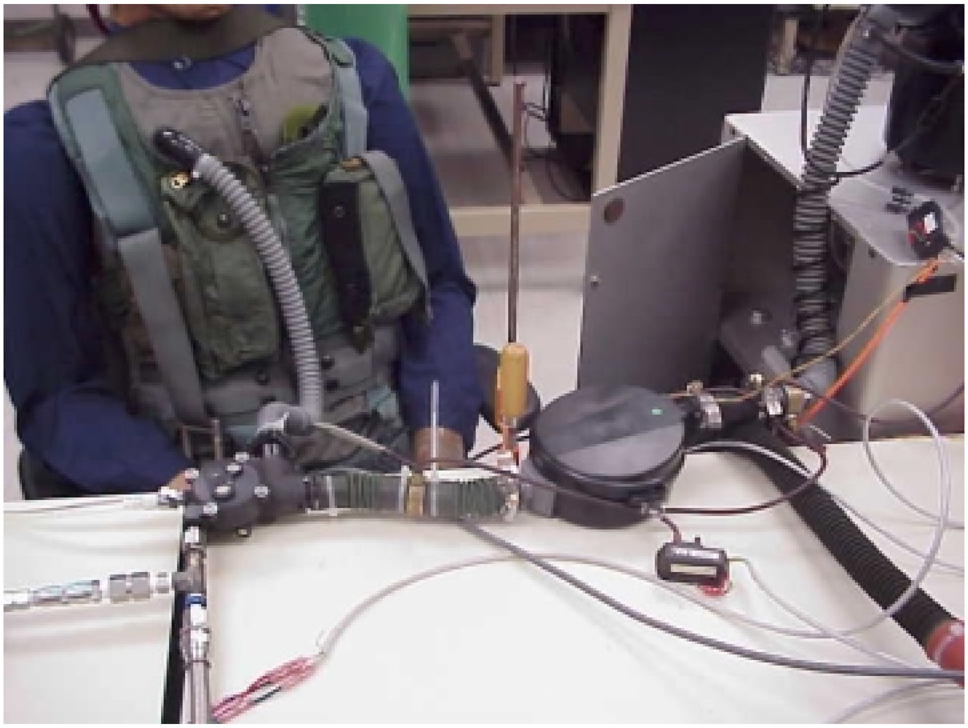

Figure A-4: LPAFP Closeup

Figure A-5: C2A1 Closeup

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APPENDIX B
SUPPORTING DATA

Table B-1: ASCC 61/112/2B Standard Matrix

Peak Inhalation and Exhalation Flows	Mask Cavity Pressure ($in H_2O$)		
LPM (ATPD)[(1)]	Minimum	Maximum	Maximum Swing
30	-1.9	+3.5	2.0
90	-3.6	+3.8	3.4
150	-6.6	+5.0	7.0
198	-10.0	+7.0	12.0

NOTE: (1) Atmospheric Temperature and Pressure Dry

Table B-2: Flow Restrictor Values

Open Cross Sectional Area ($in.^2$)		
No Flow Restrictor	40% Flow Restrictor	70% Flow Restrictor
0.486	0.289	0.136

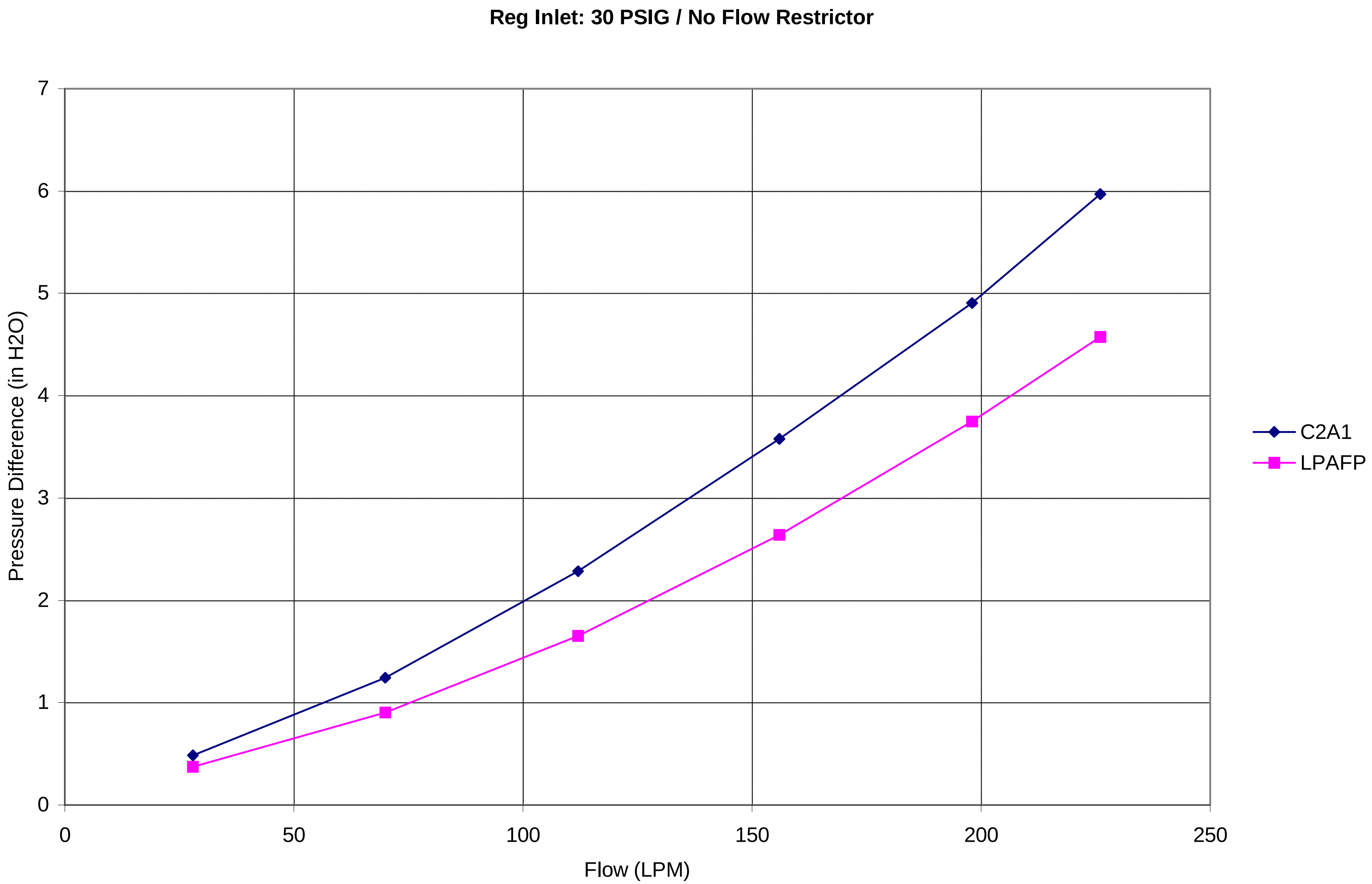

Figure B-1: Pressure Drop across the Charcoal Canisters

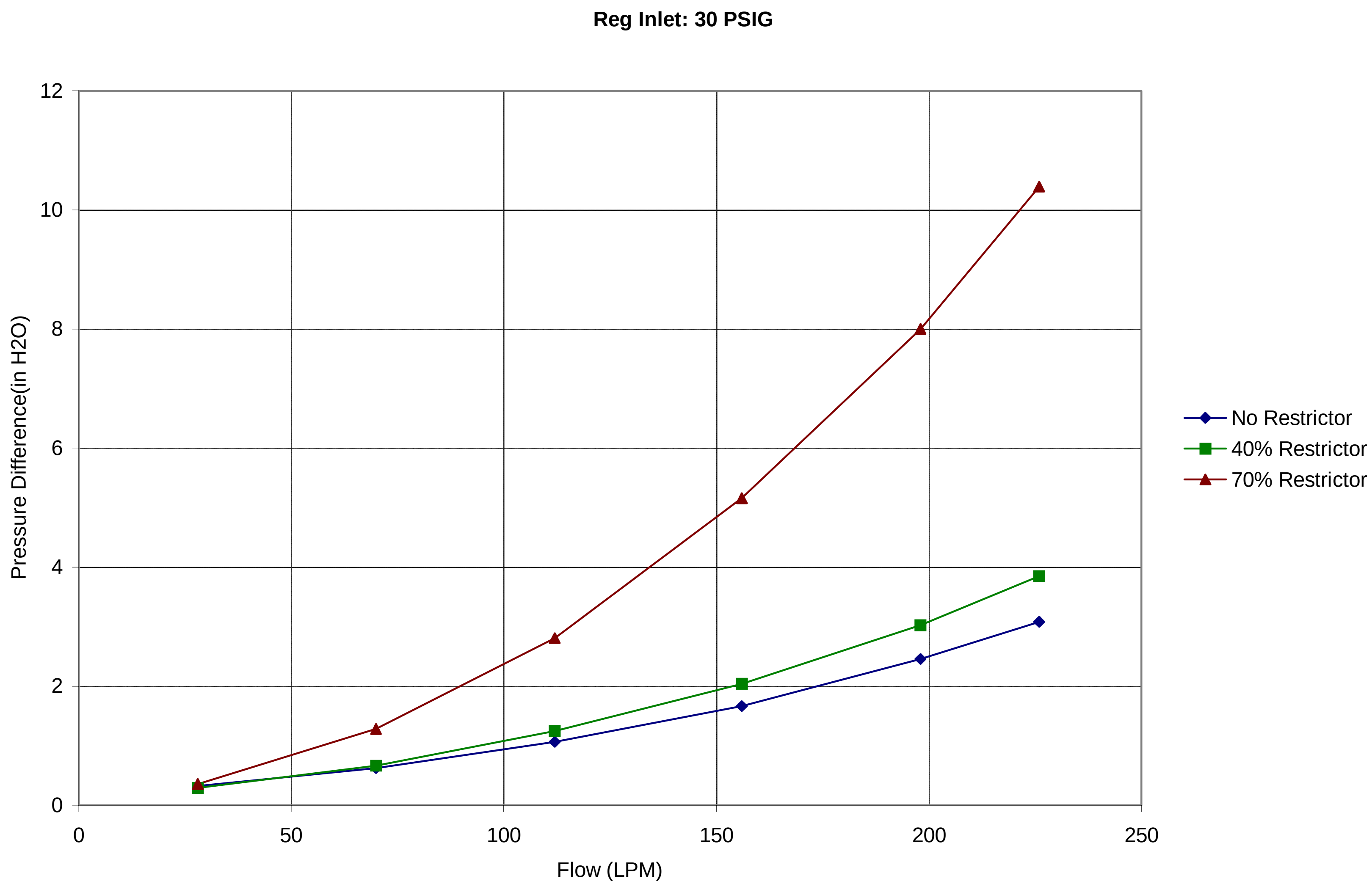

Figure B-2: Pressure Drop across the Mask Valve with and without Flow Restrictors

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APPENDIX C
ENDURANCE TEST FIGURES

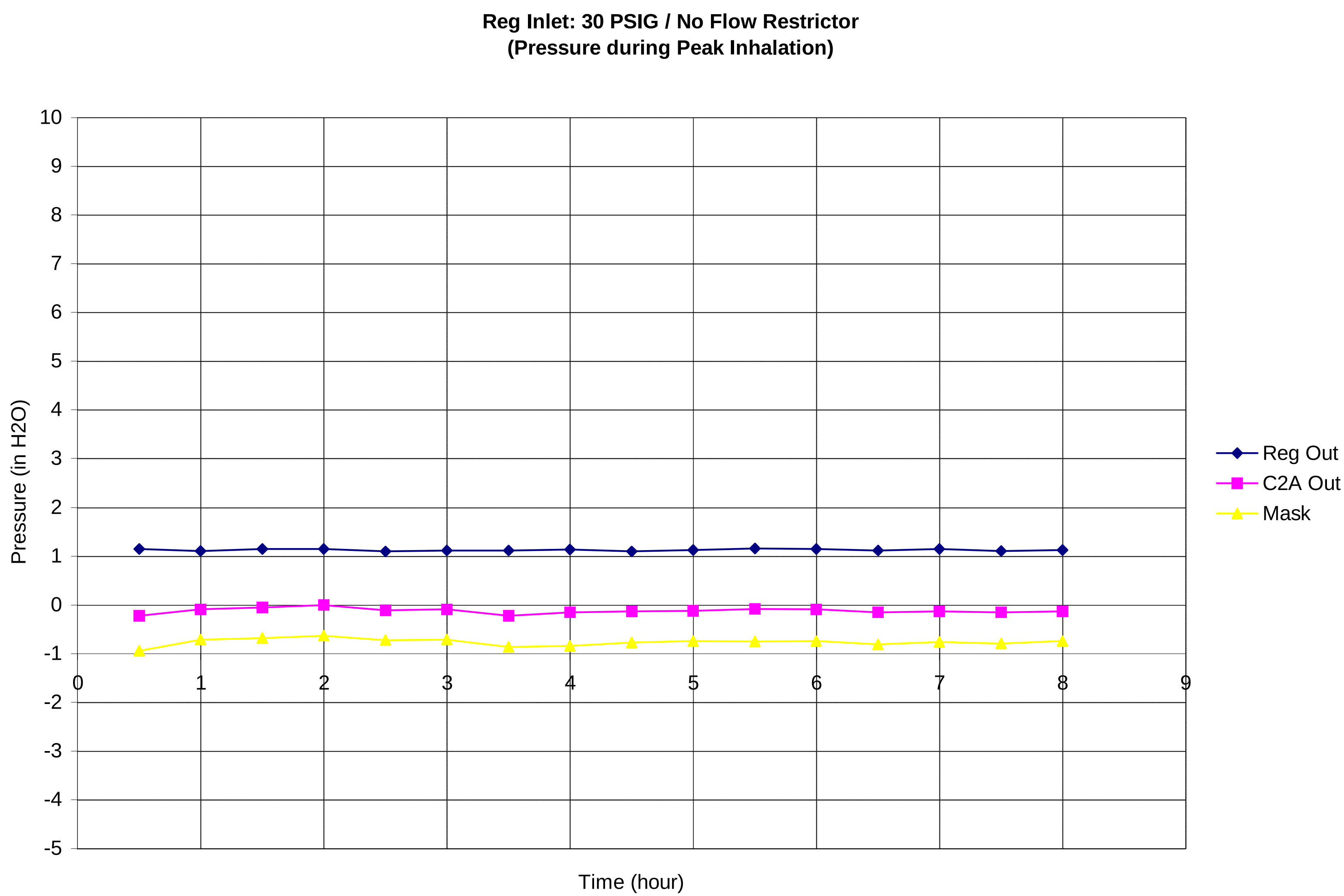

Figure C-1: System Pressures during C2A1 Endurance Test

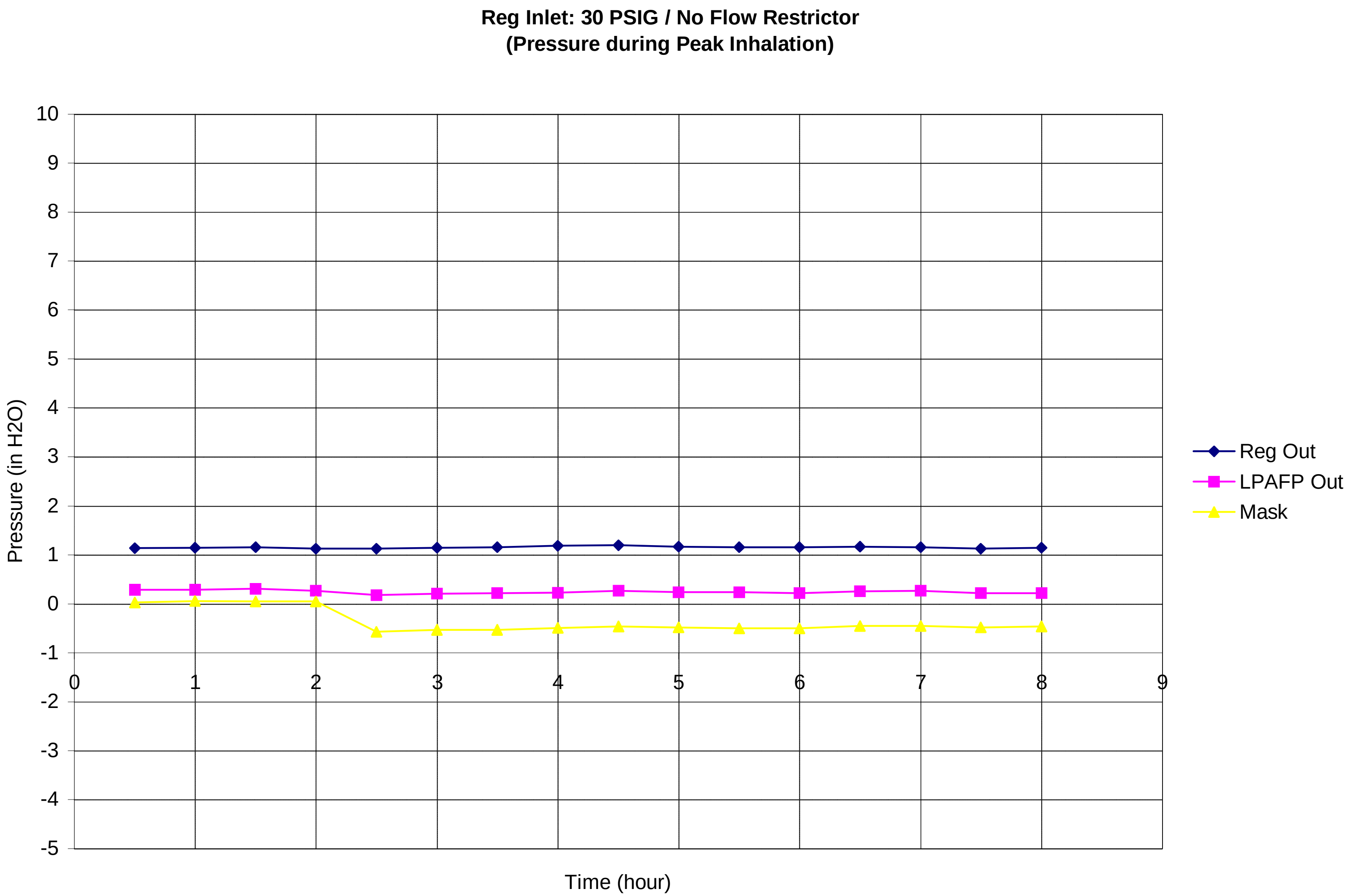

Figure C-2: System Pressures during LPAFP Endurance Test

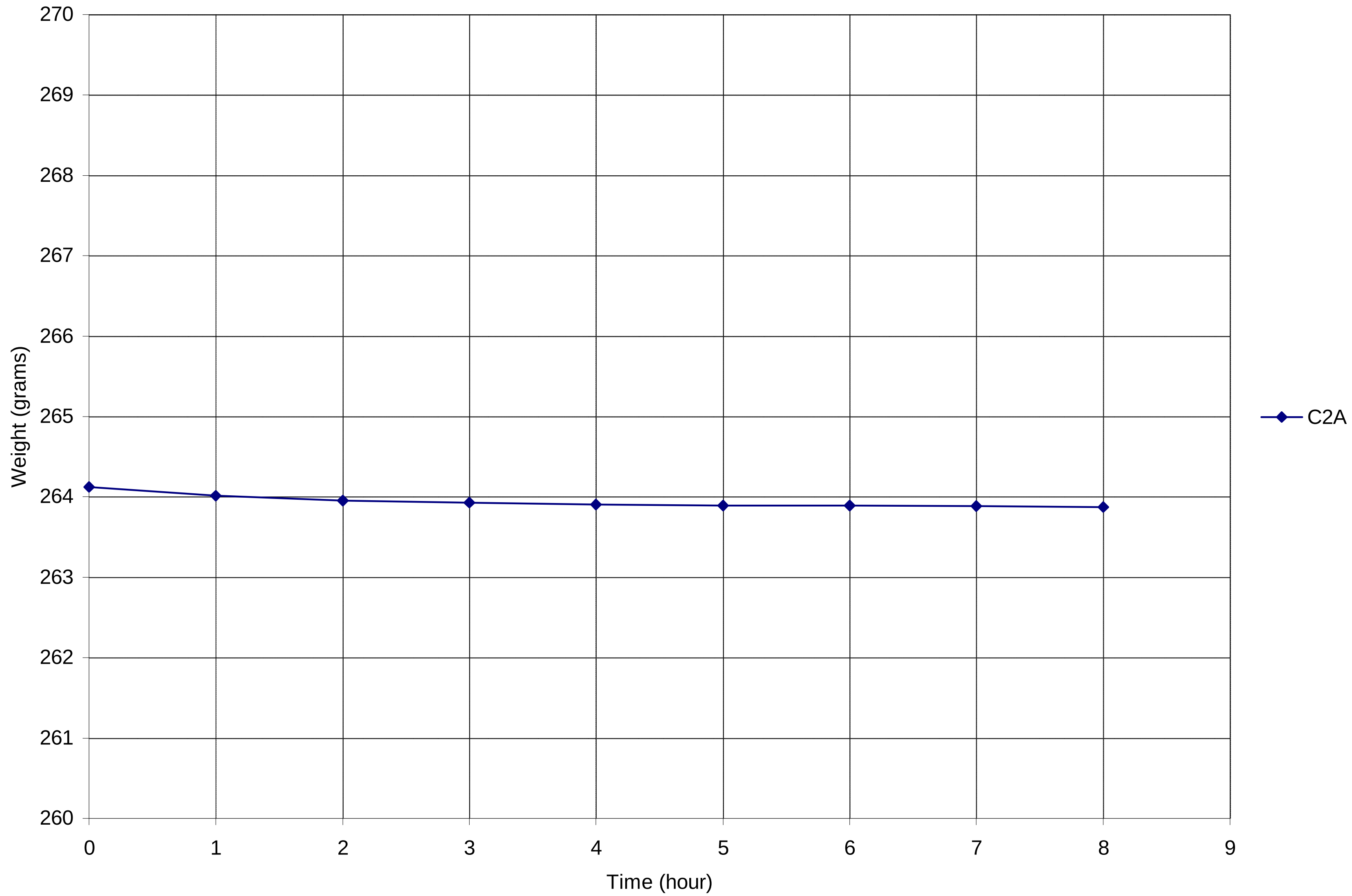

Figure C-3: C2A1 Canister Weight during Endurance Test

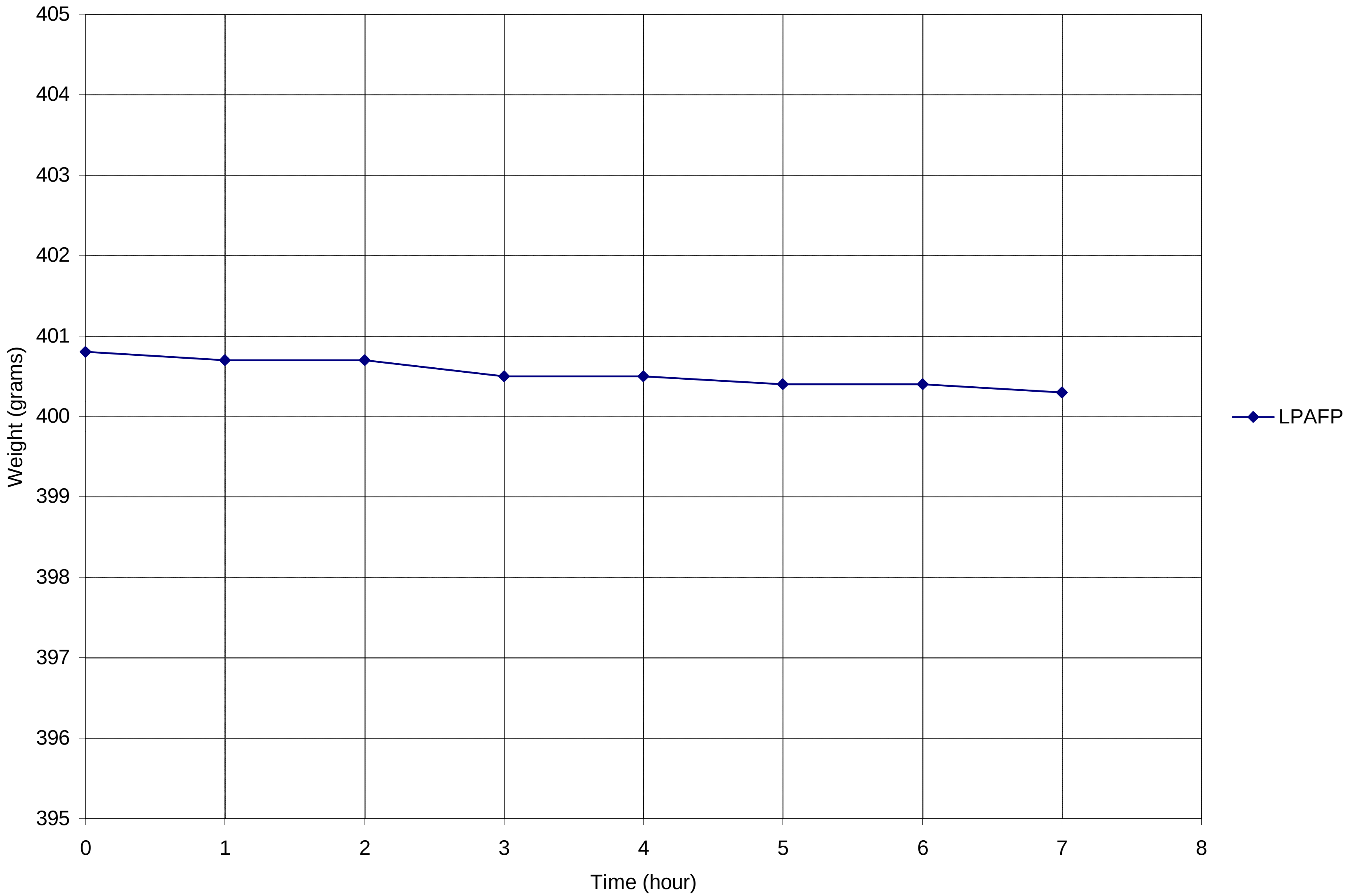

Figure C-4: LPAFP Canister Weight during Endurance Test

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APPENDIX D
STATIC FLOW TEST FIGURES

Figure D-1: Steady Flow Pressures at Baseline (no canister)

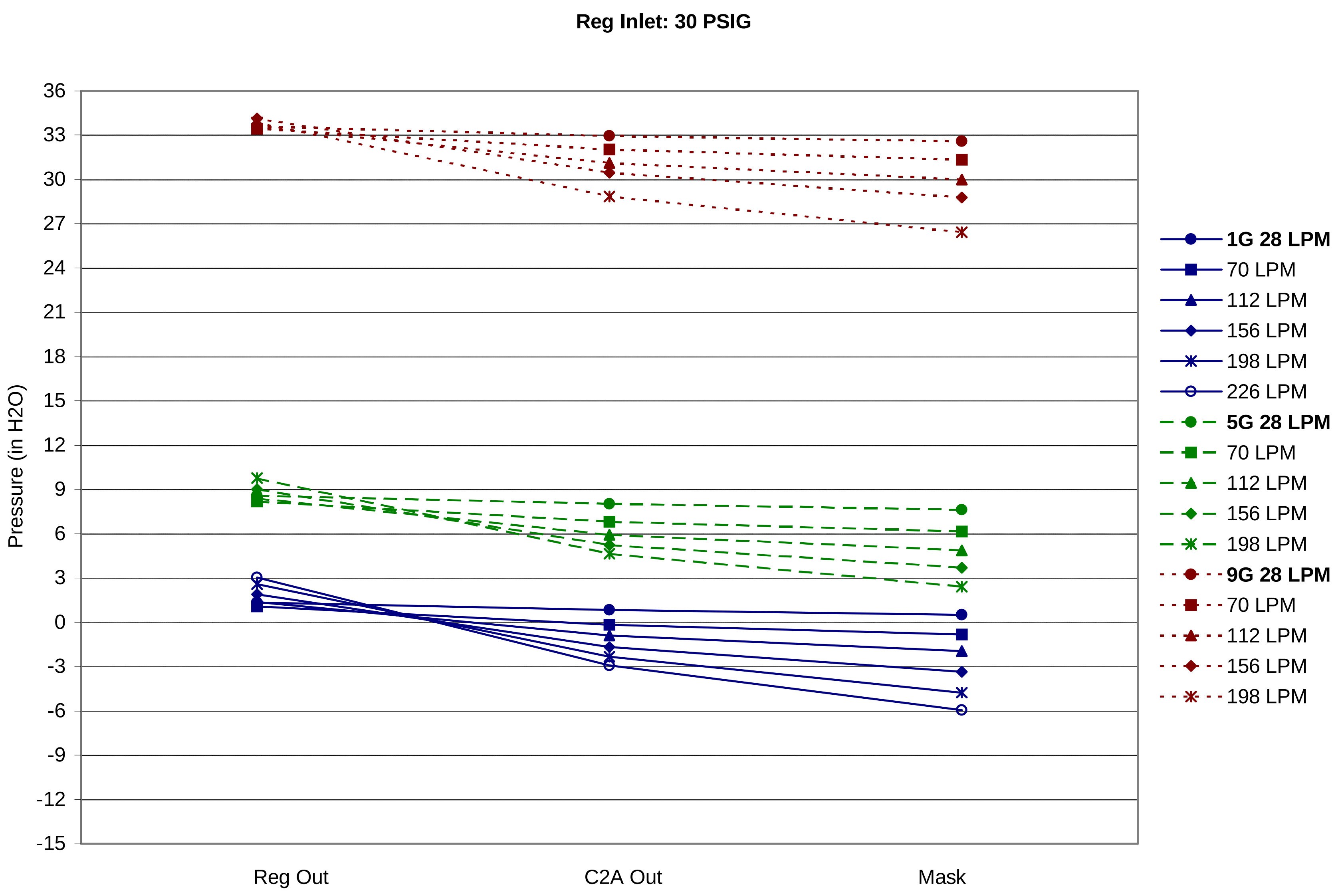

Figure D-2: Steady Flow Pressures with C2A1

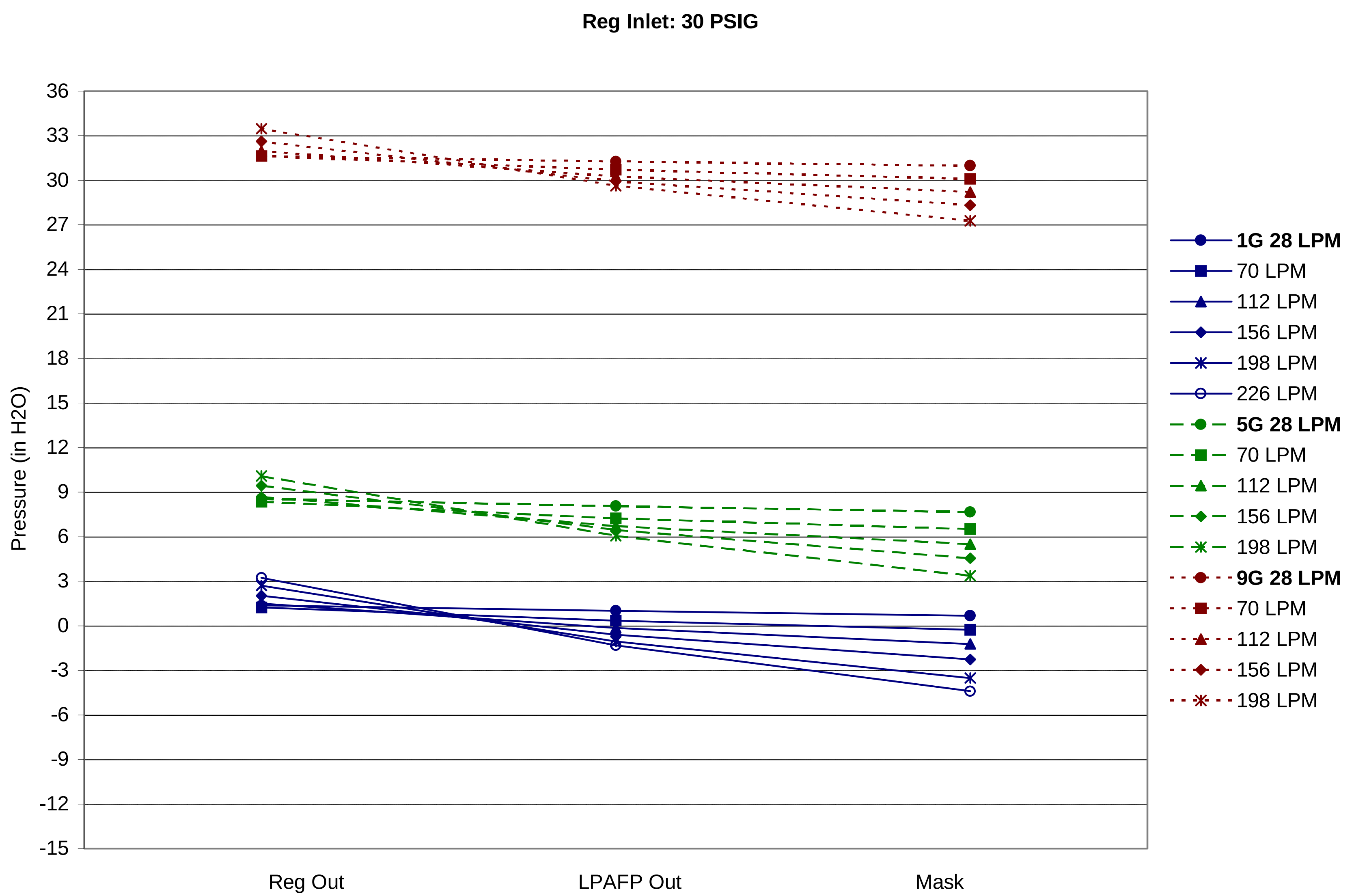

Figure D-3: Steady Flow Pressures with LPAFP

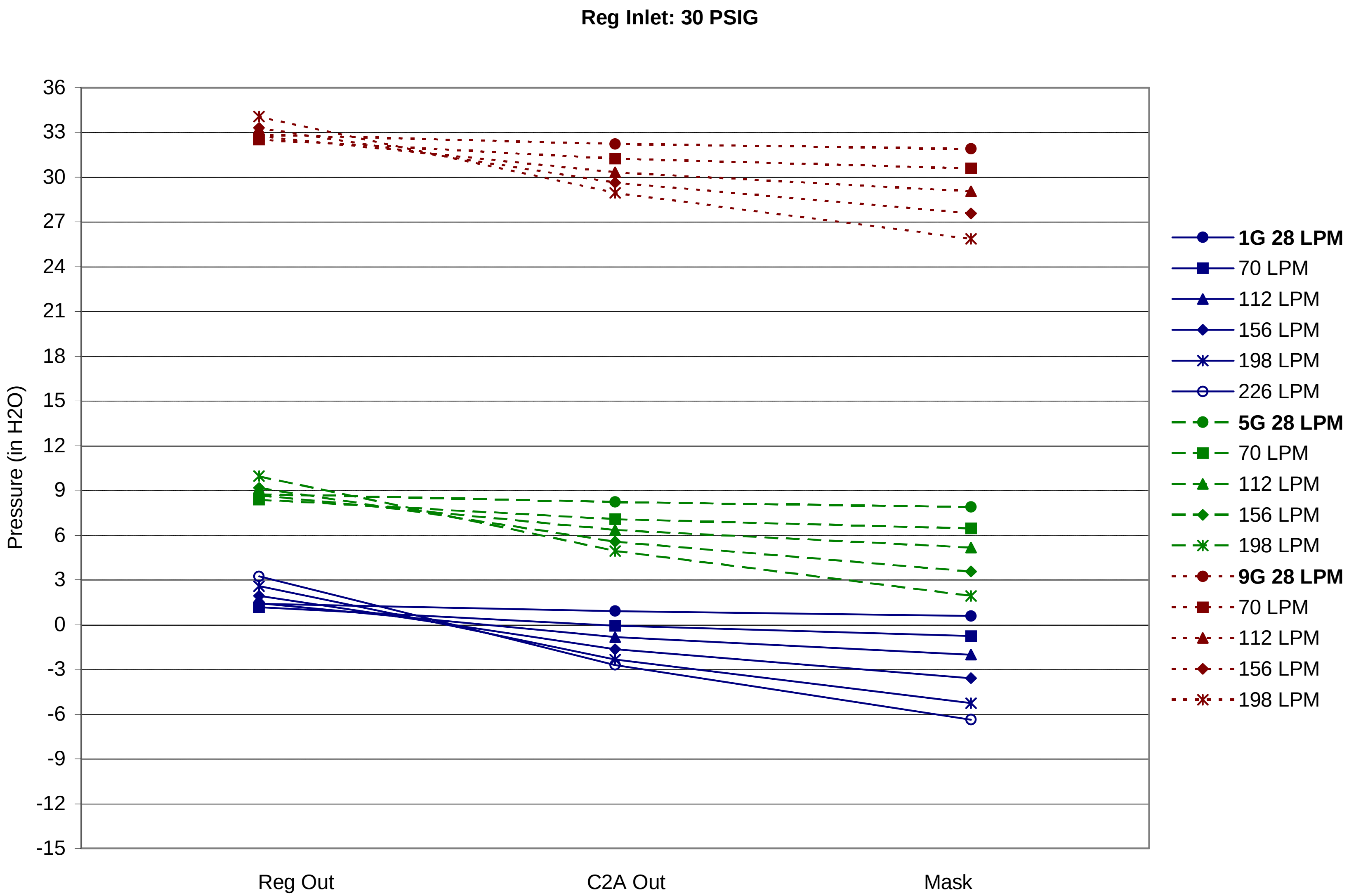

Figure D-4: Steady Flow Pressures with C2A1 and 40% Flow Restrictor

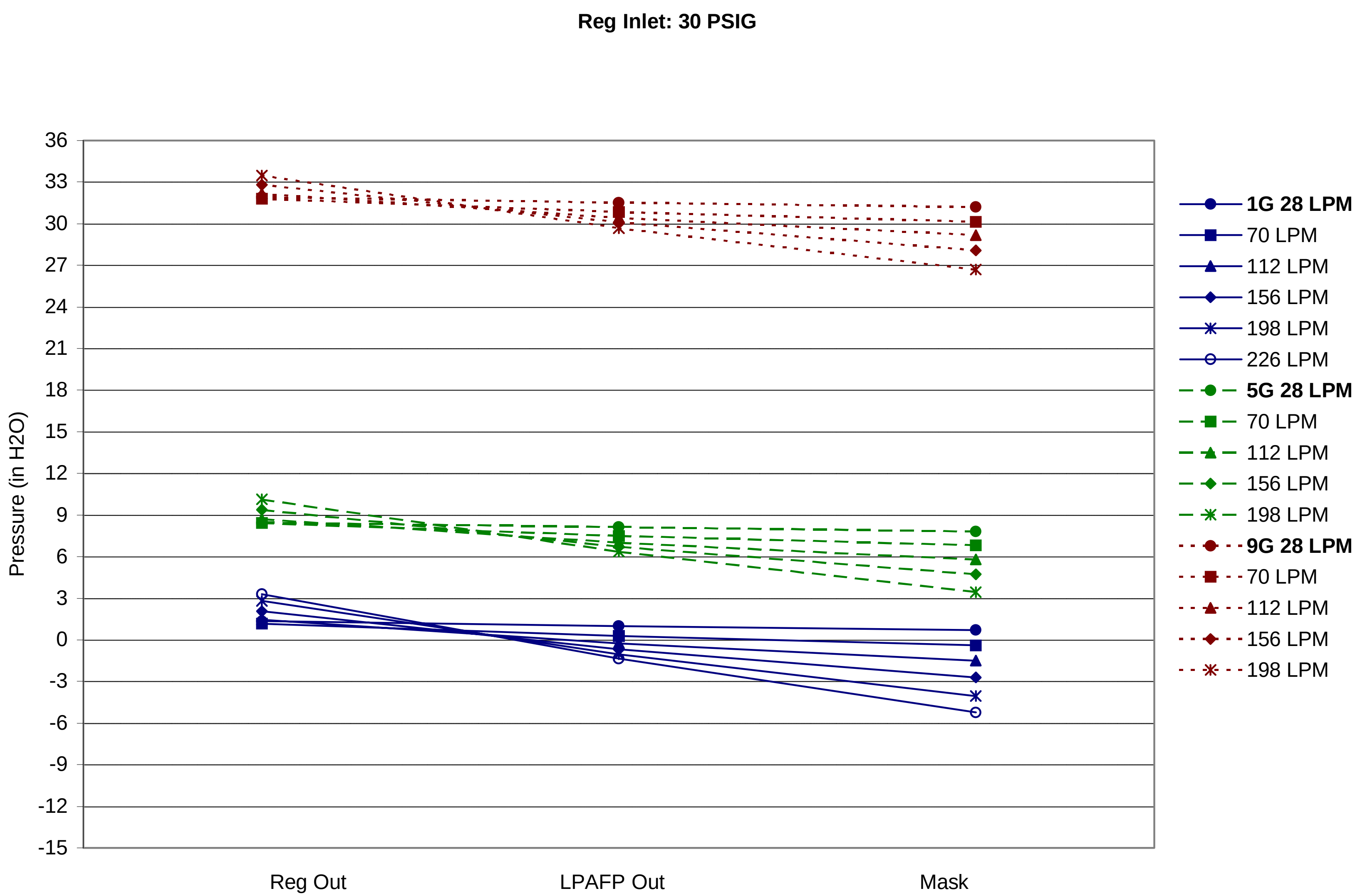

Figure D-5: Steady Flow Pressures with LPAFP and 40% Flow Restrictor

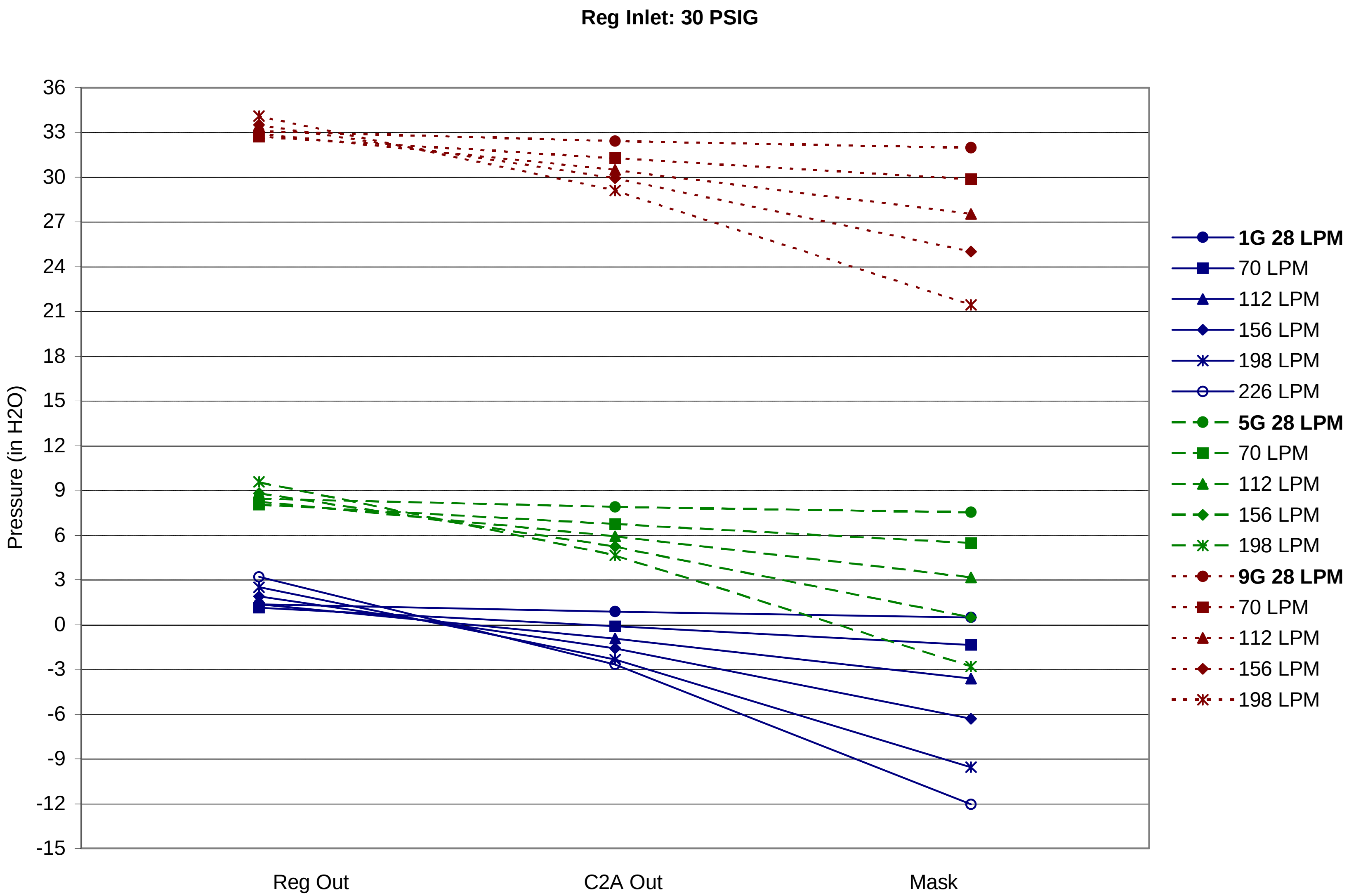

Figure D-6: Steady Flow Pressures with C2A1 and 70% Flow Restrictor

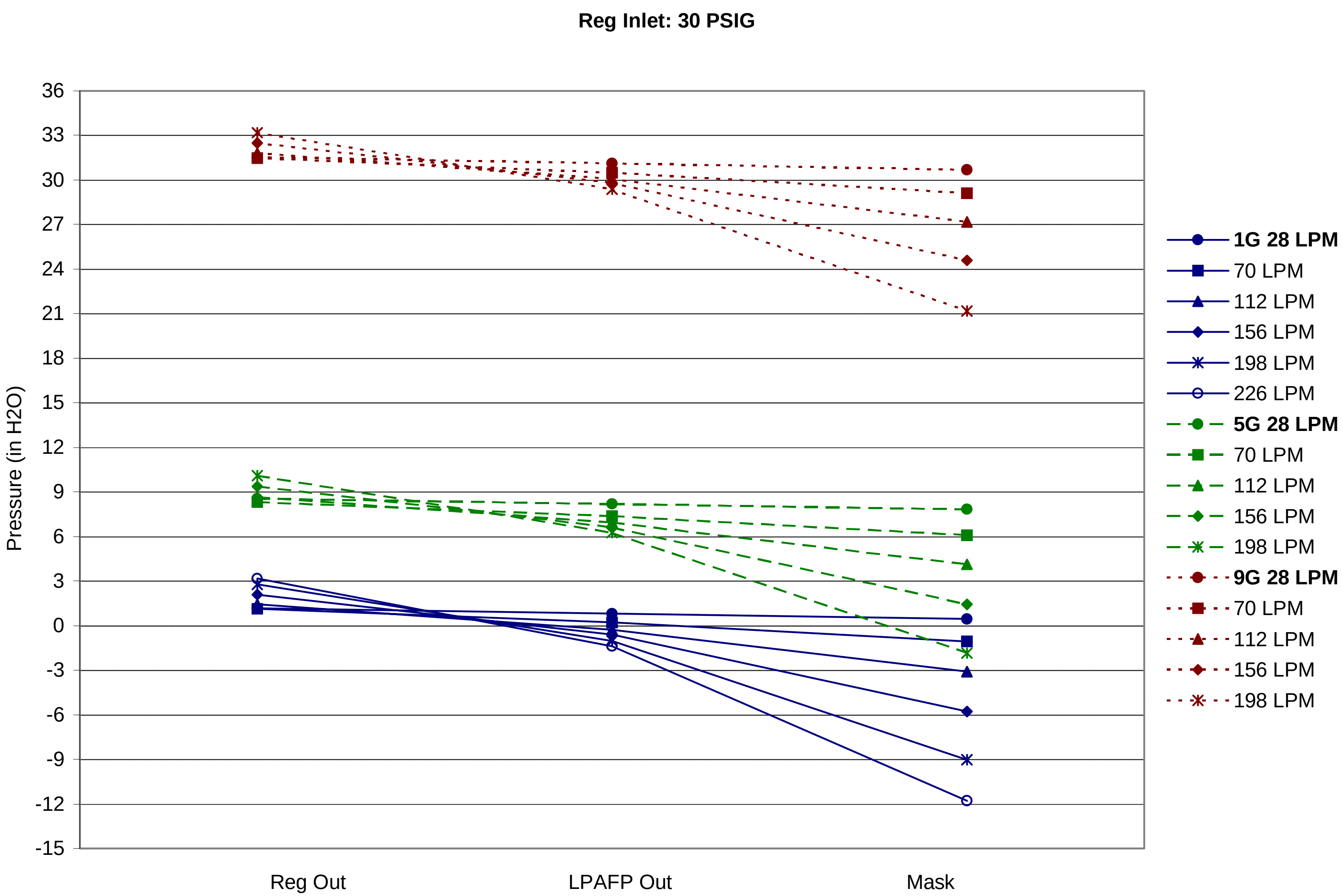

Figure D-7: Steady Flow Pressures with LPAFP and 70% Flow Restrictor

APPENDIX E
DYNAMIC FLOW PERFORMANCE FIGURES

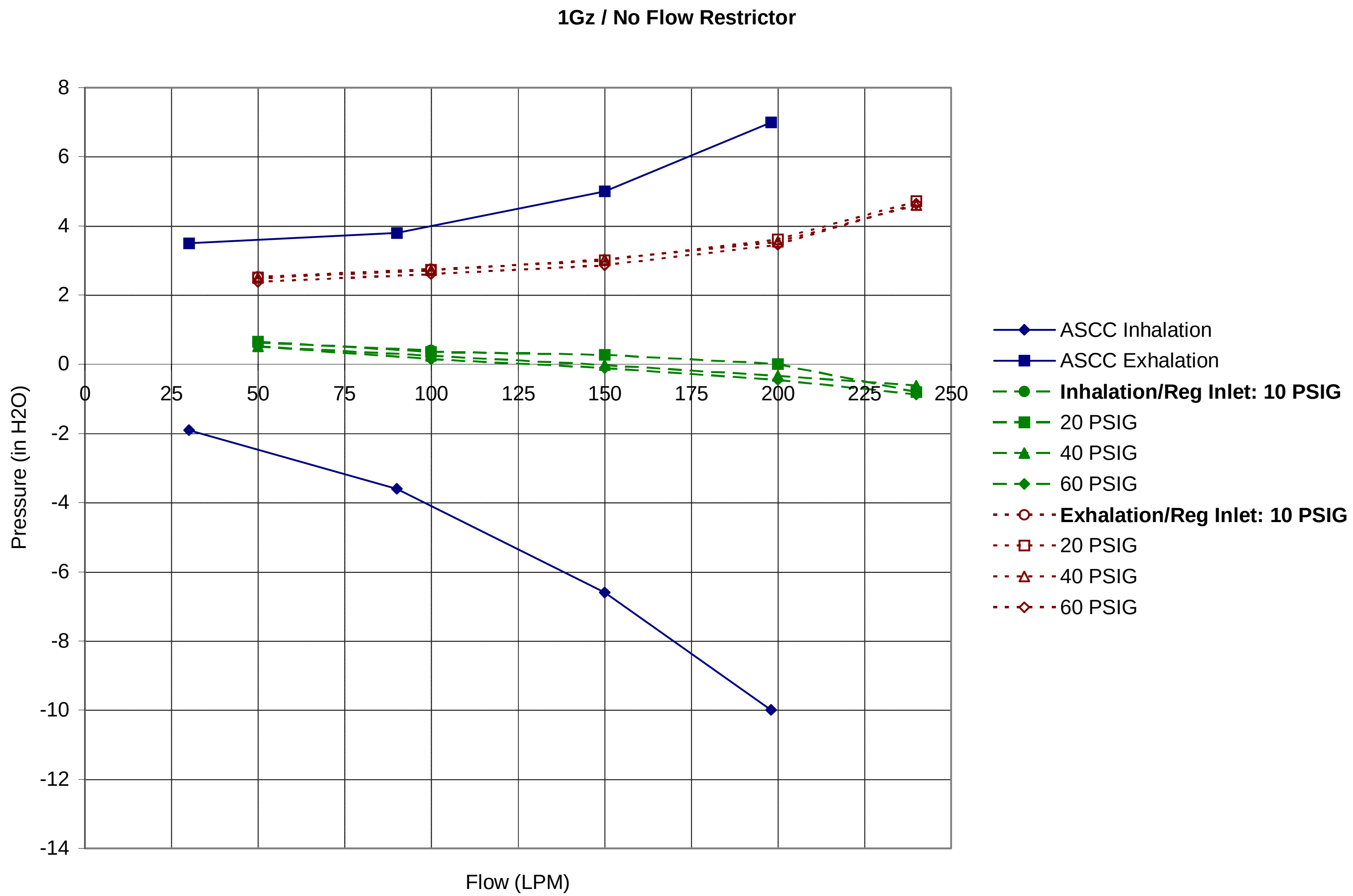

Figure E-1: ASCC Minimum/Maximum Allowable Mask Pressure Comparison at Baseline (no canister)

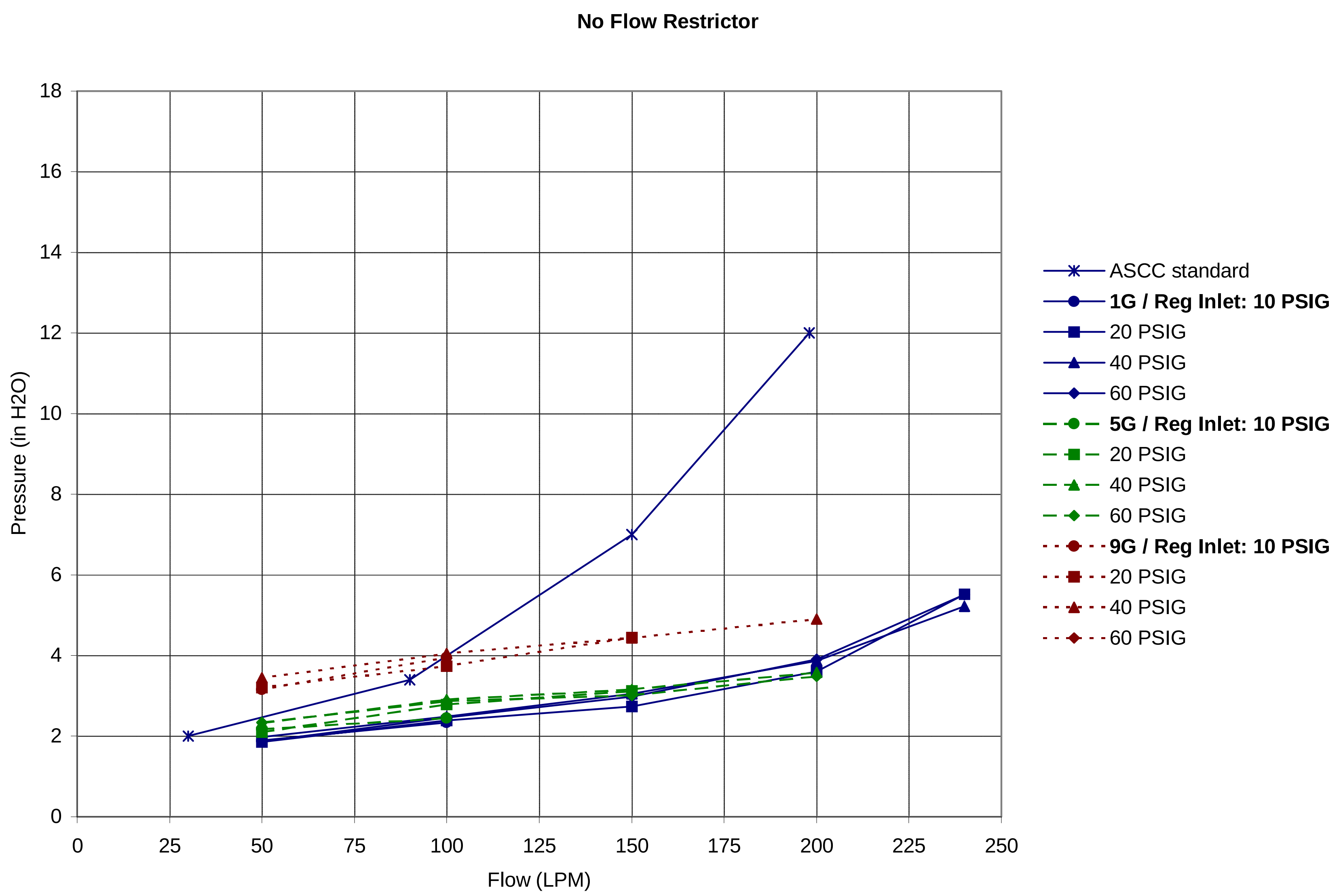

Figure E-2: ASCC Mask Pressure Swing Comparison at Baseline (no canister)

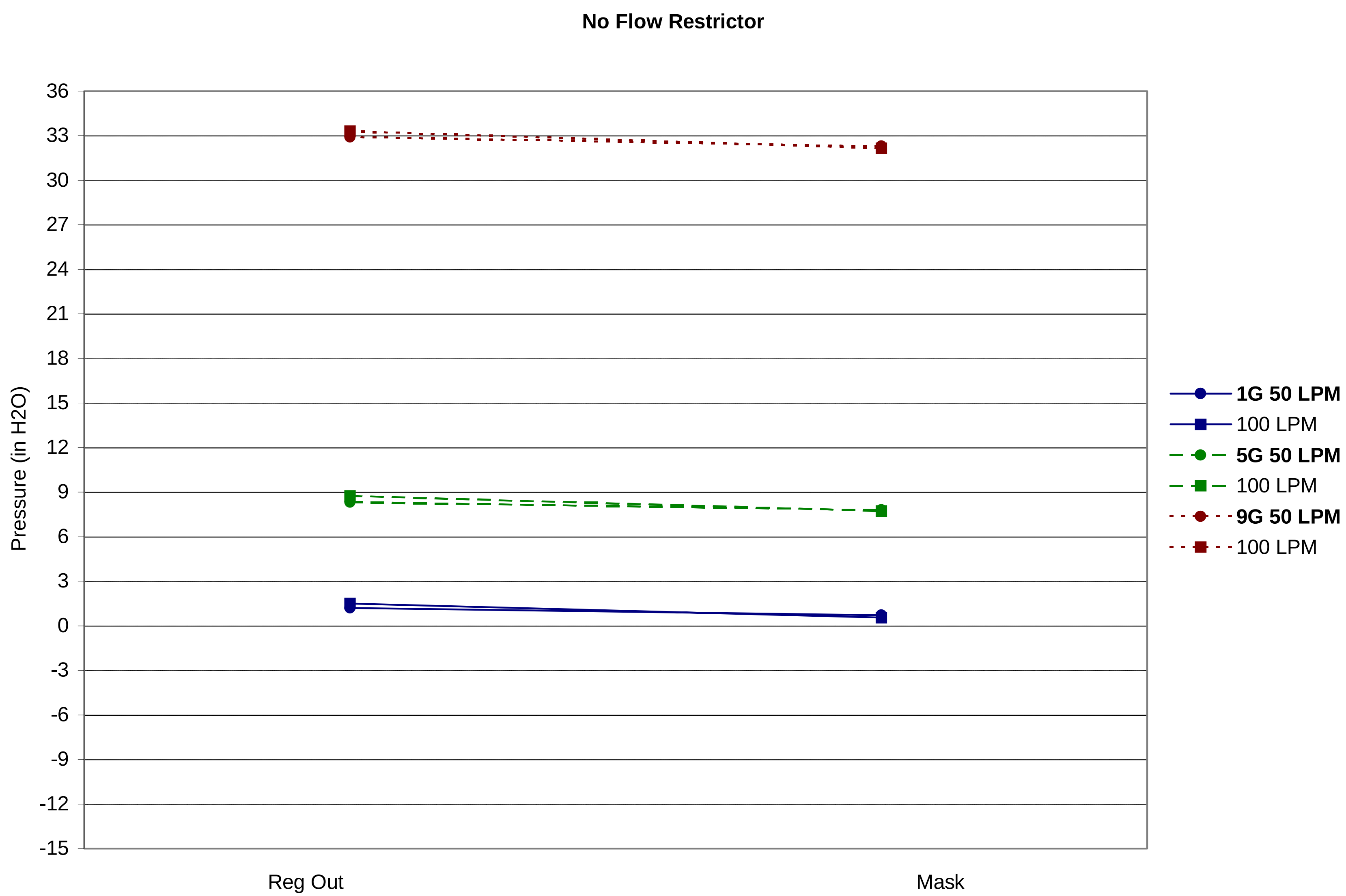

Figure E-3: Dynamic Flow System Pressures at Baseline (no canister) and 10 PSIG Regulator Inlet

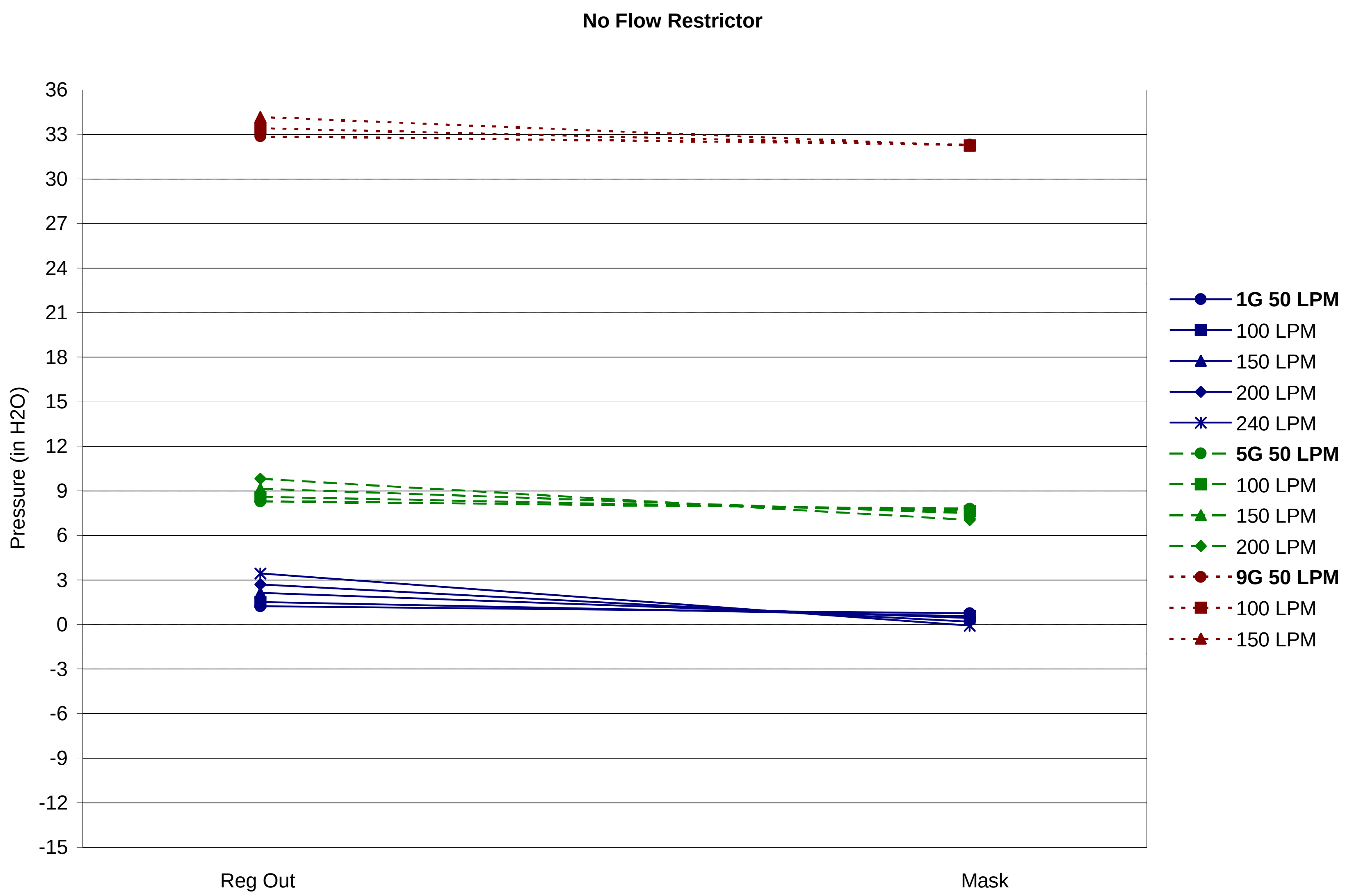

Figure E-4: Dynamic Flow System Pressures at Baseline (no canister) and 20 PSIG Regulator Inlet

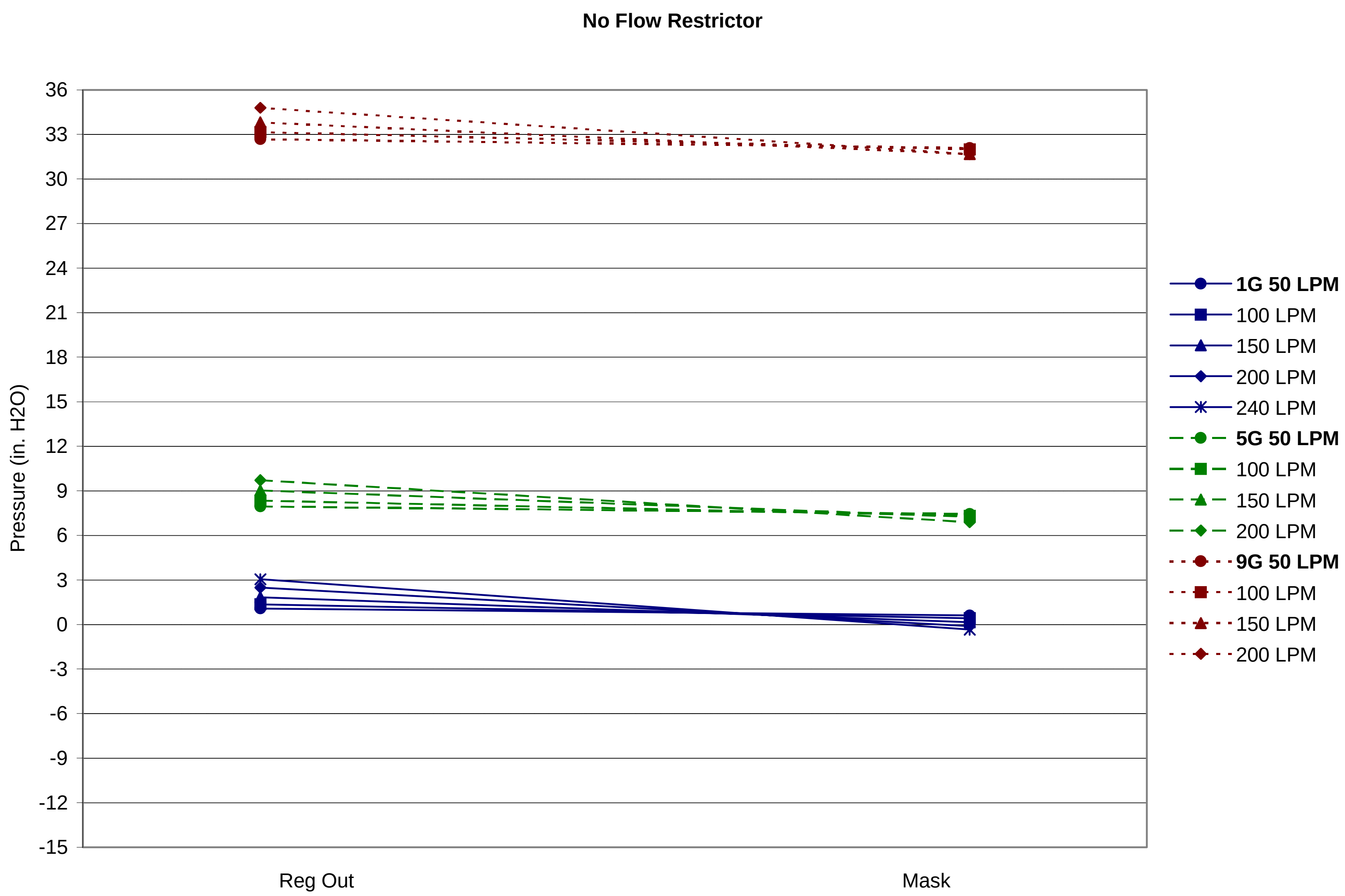

Figure E-5: Dynamic Flow System Pressures at Baseline (no canister) and 40 PSIG Regulator Inlet

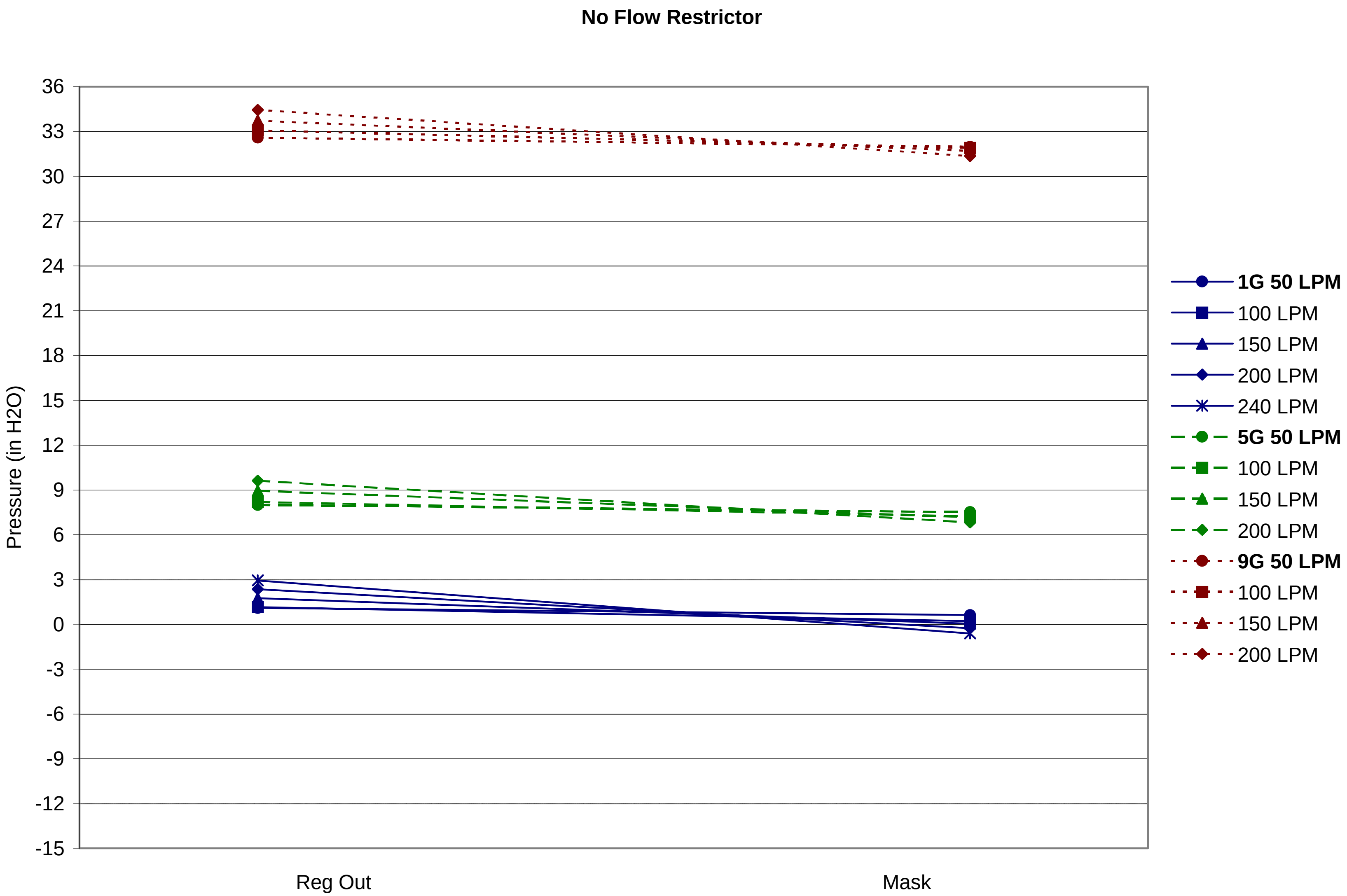

Figure E-6: Dynamic Flow System Pressures at Baseline (no canister) and 60 PSIG Regulator Inlet

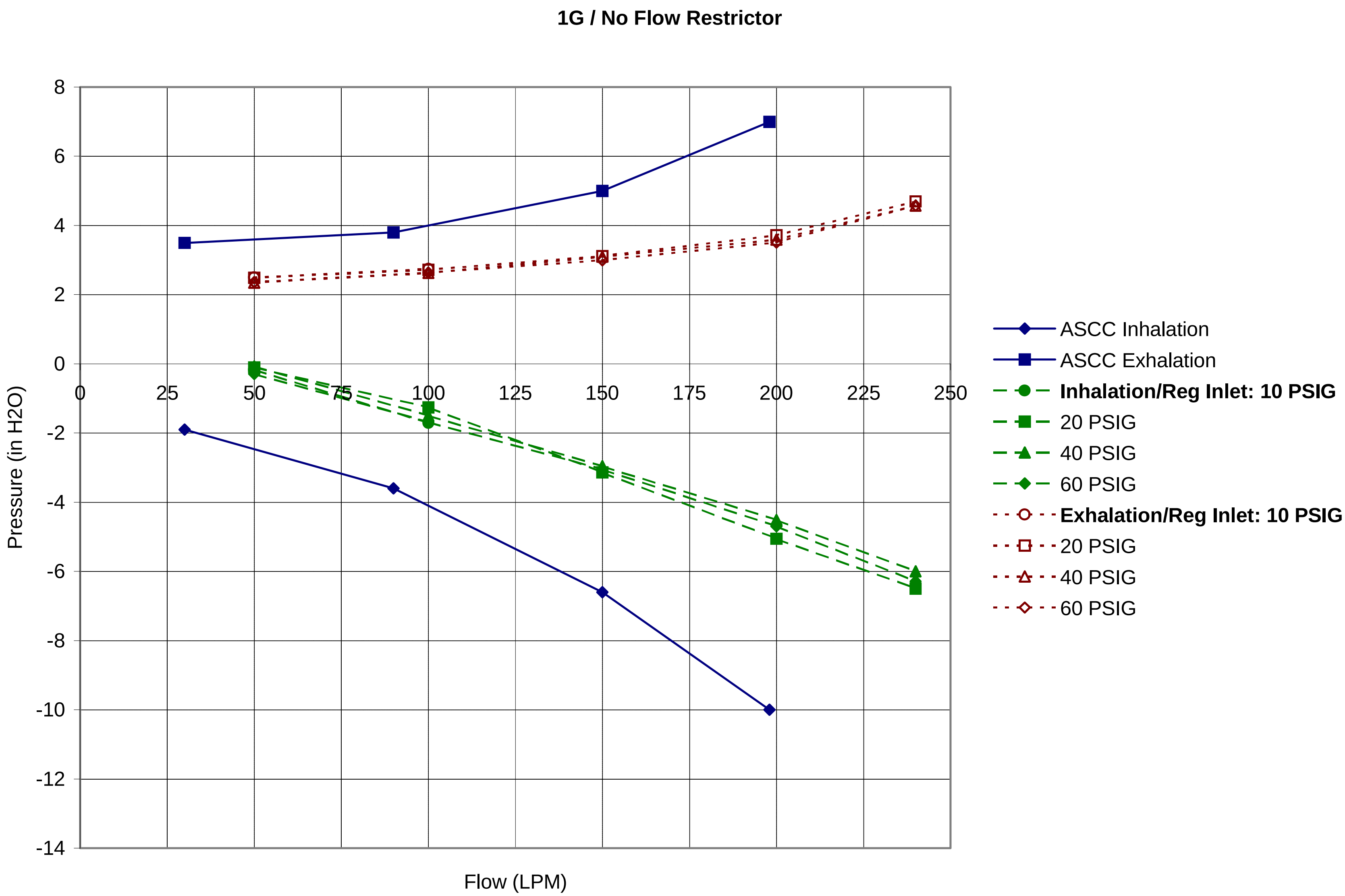

Figure E-7: ASCC Minimum/Maximum Allowable Mask Pressure Comparison with C2A1

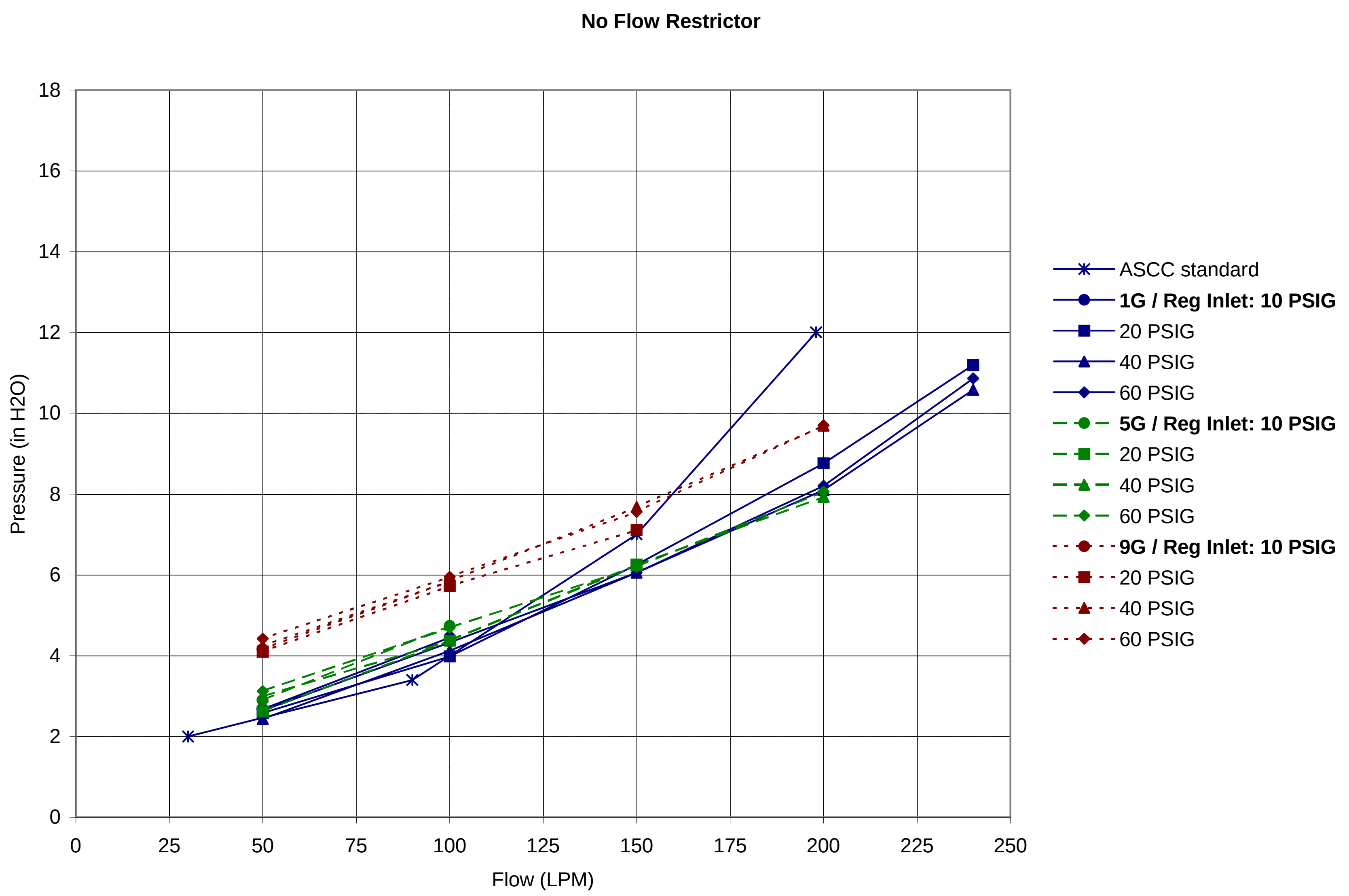

Figure E-8: ASCC Mask Pressure Swing Comparison with C2A1

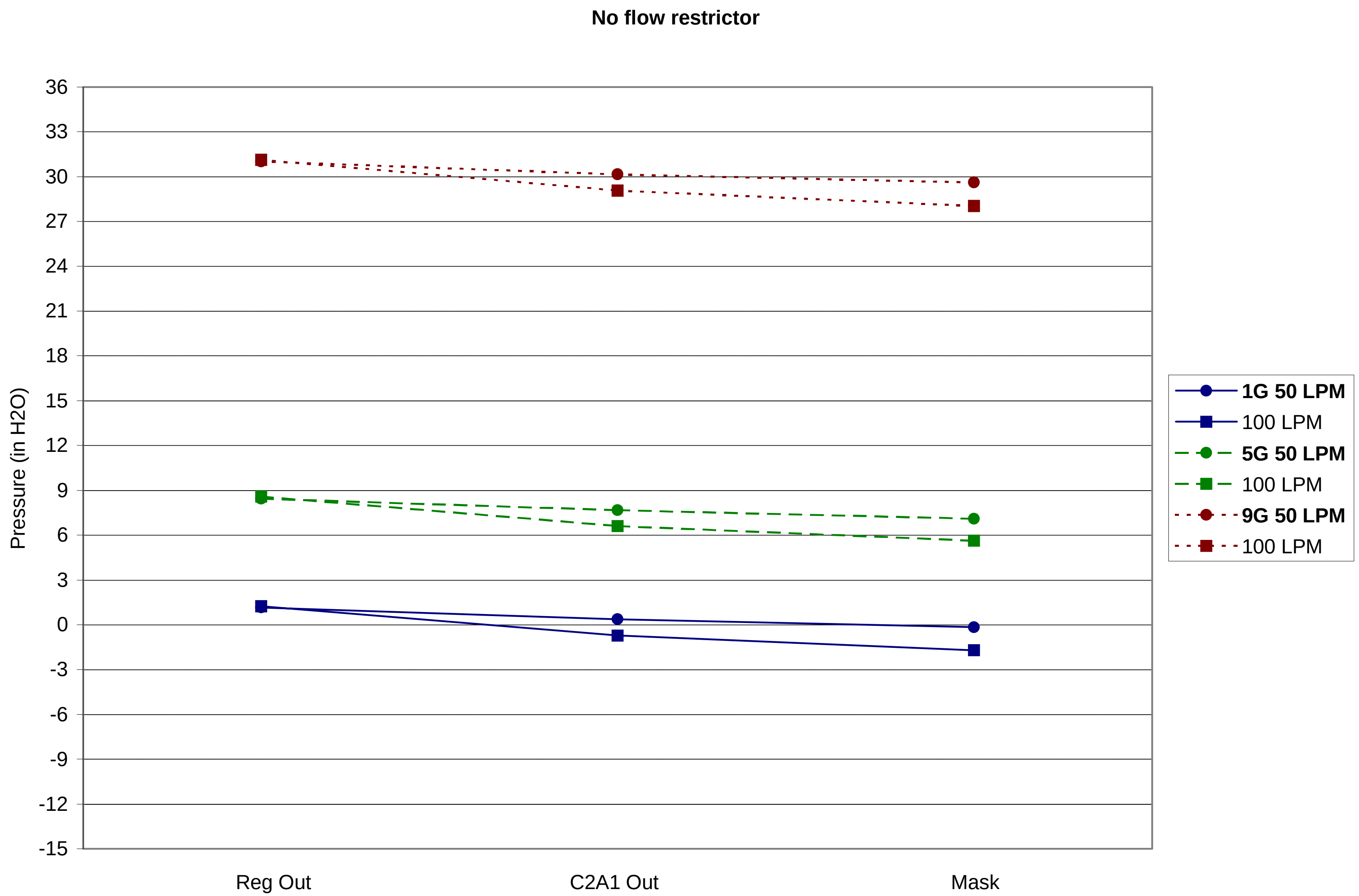

Figure E-9: Dynamic Flow System Pressures with C2A1 and 10 PSIG Regulator Inlet

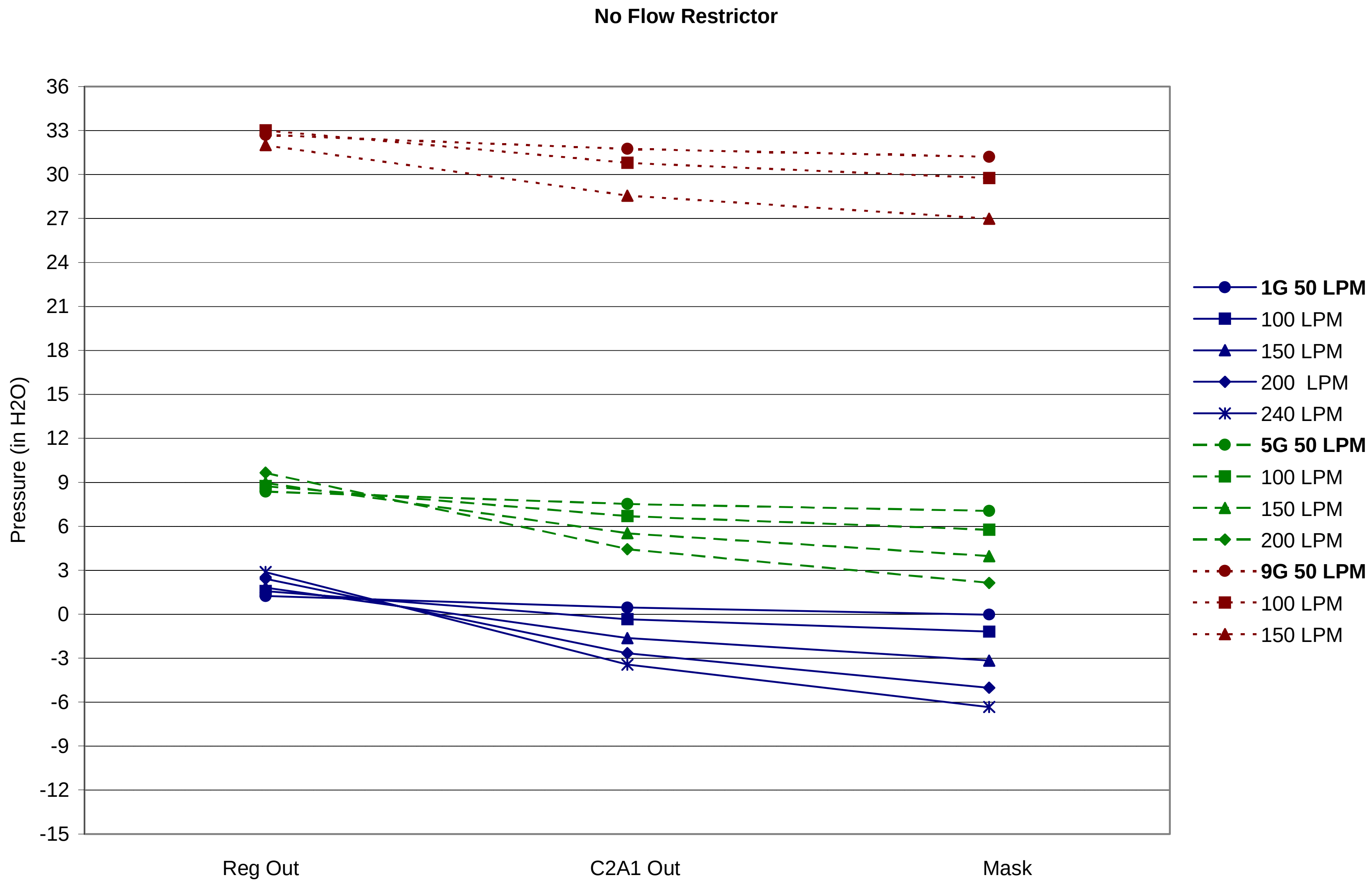

Figure E-10: Dynamic Flow System Pressures with C2A1 and 20 PSIG Regulator Inlet

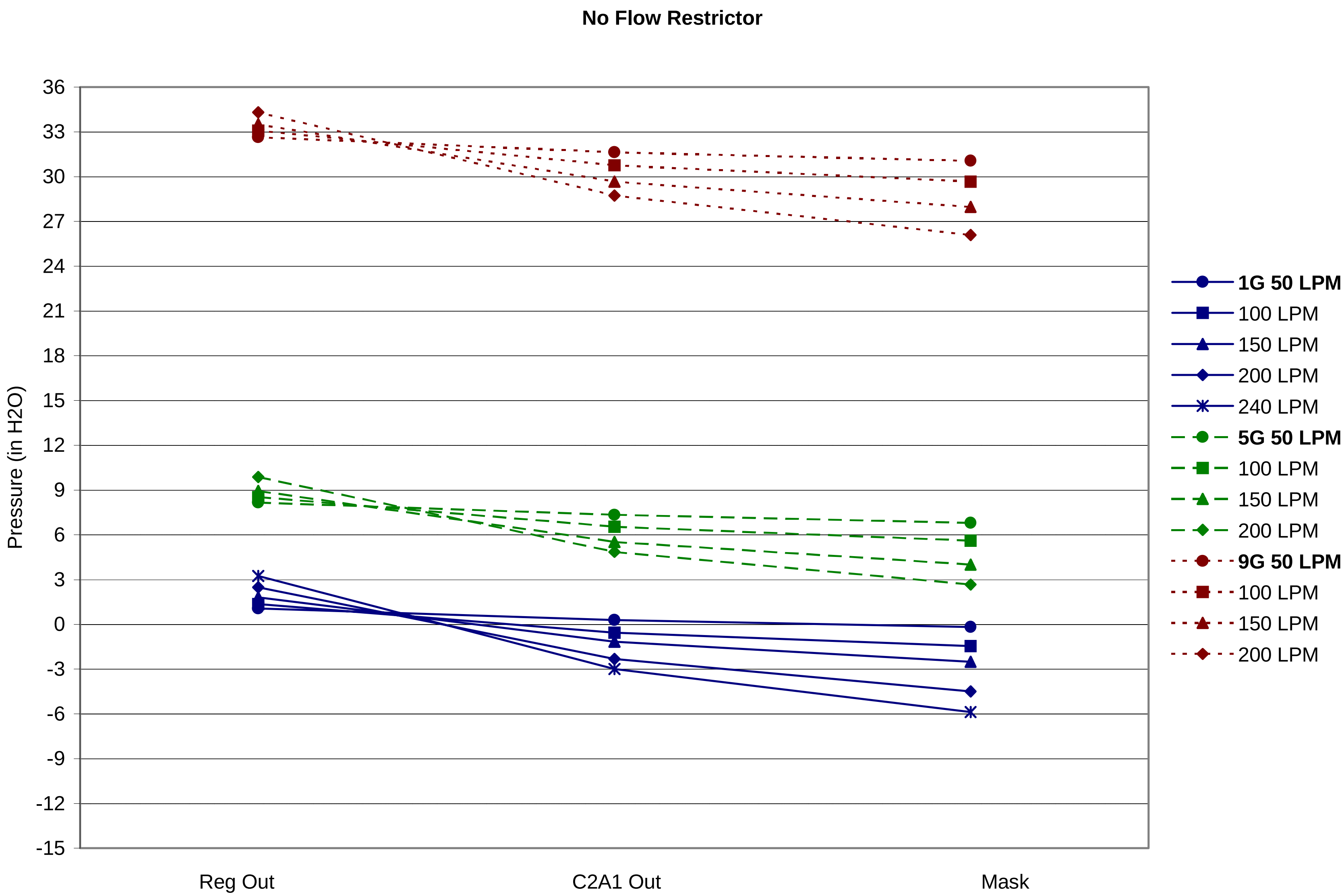

Figure E-11: Dynamic Flow System Pressures with C2A1 and 40 PSIG Regulator Inlet

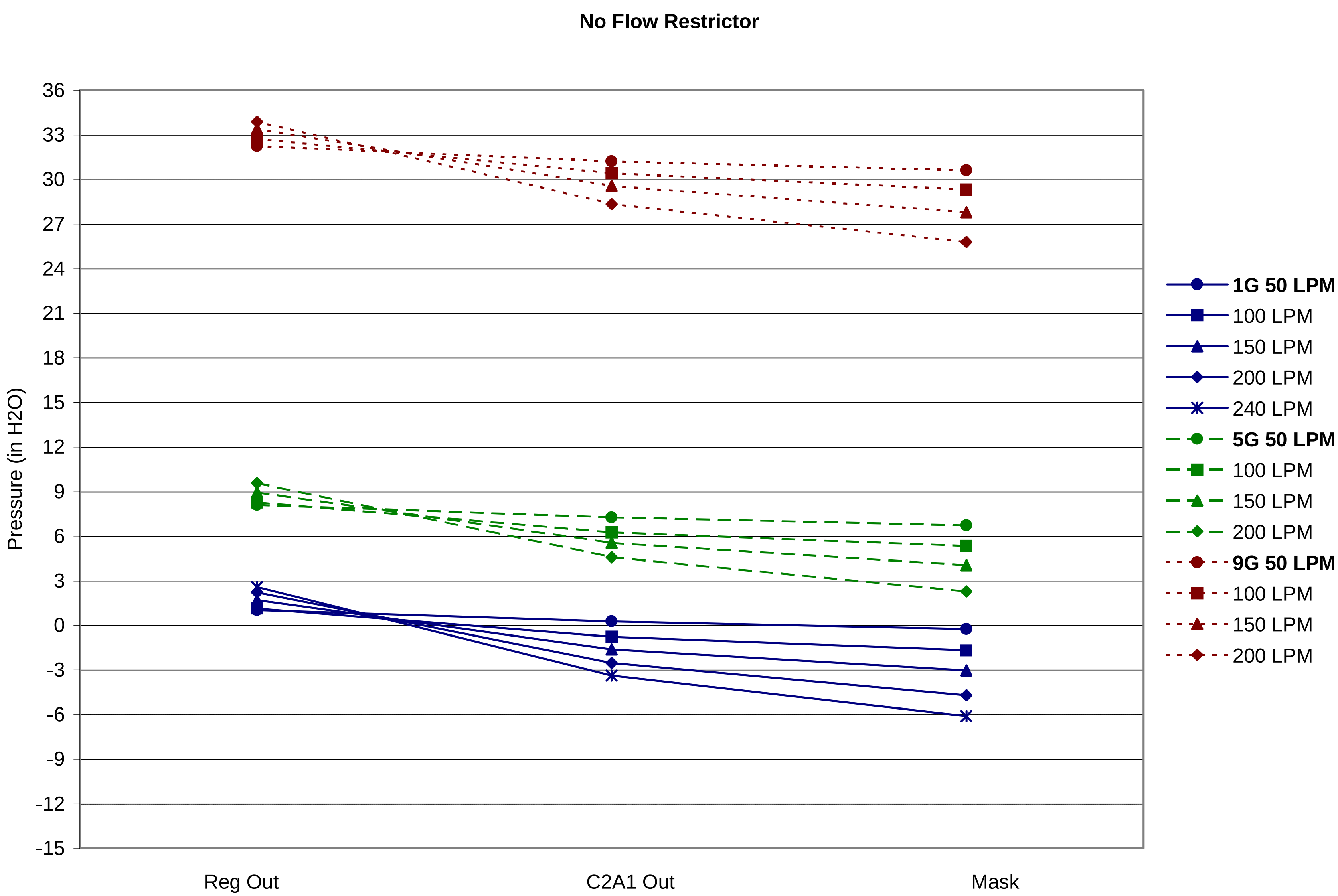

Figure E-12: Dynamic Flow System Pressures with C2A1 and 60 PSIG Regulator Inlet

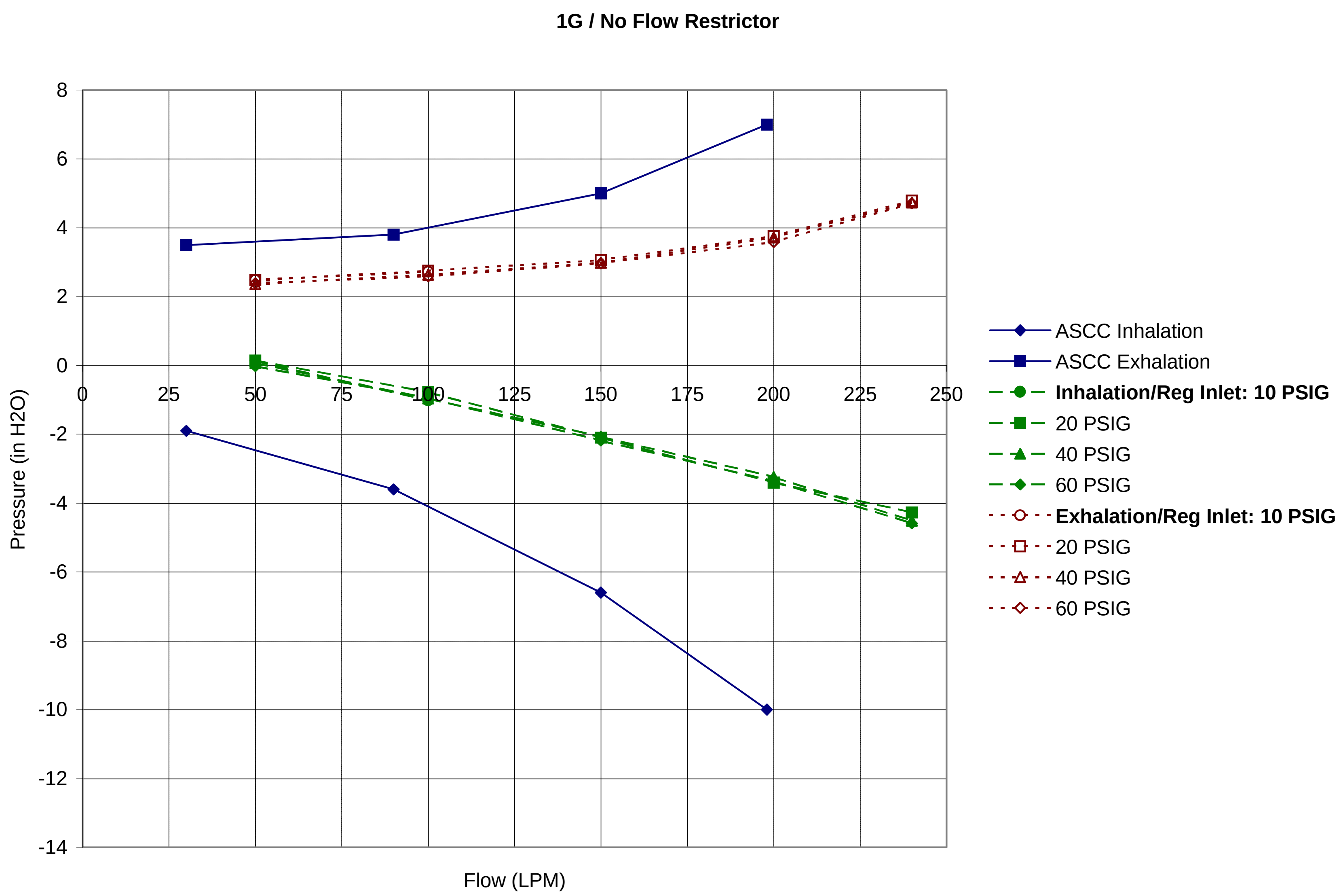

Figure E-13: ASCC Minimum/Maximum Allowable Mask Pressure Comparison with LPAFP

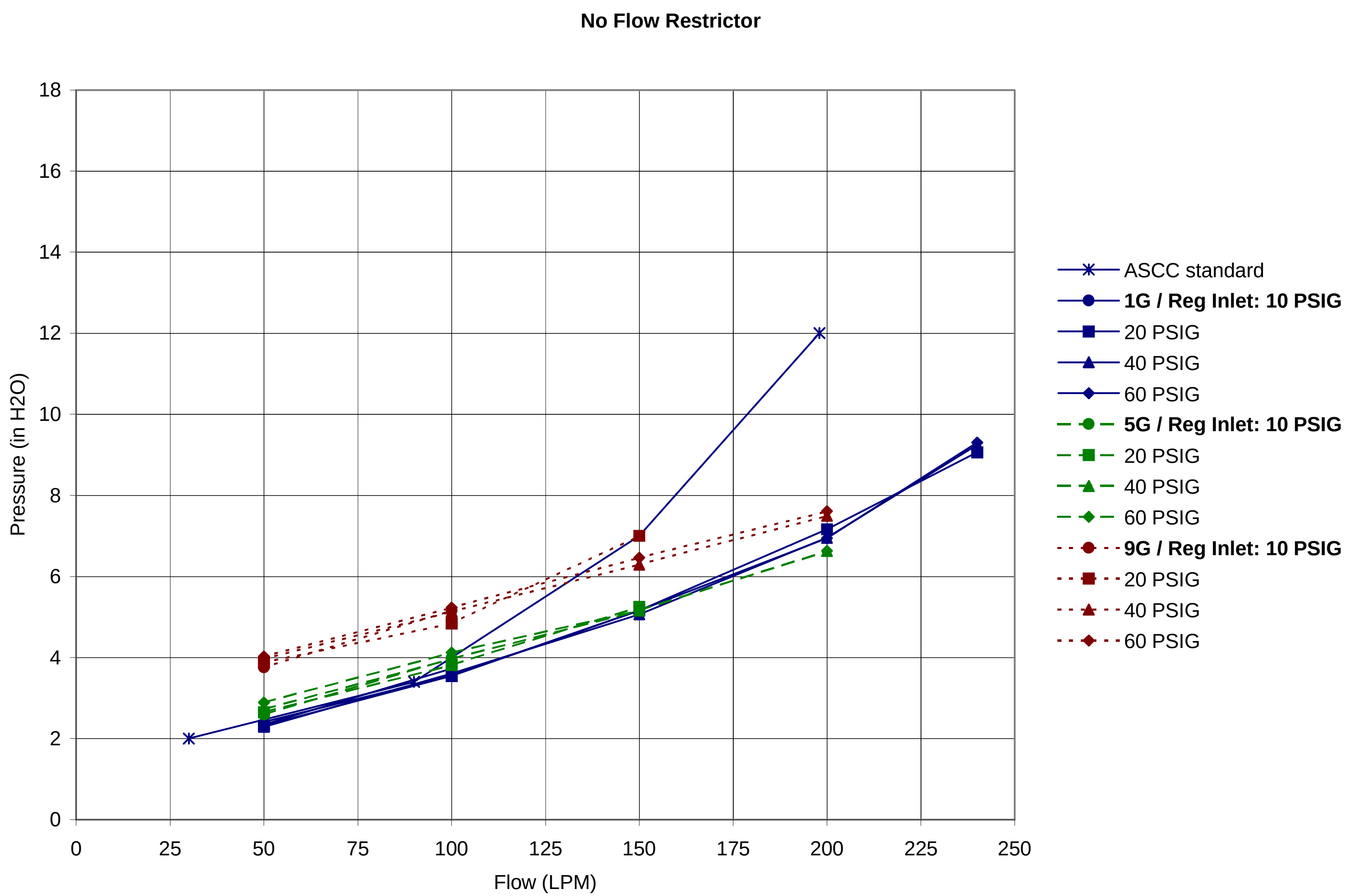

Figure E-14: ASCC Mask Pressure Swing Comparison with LPAFP

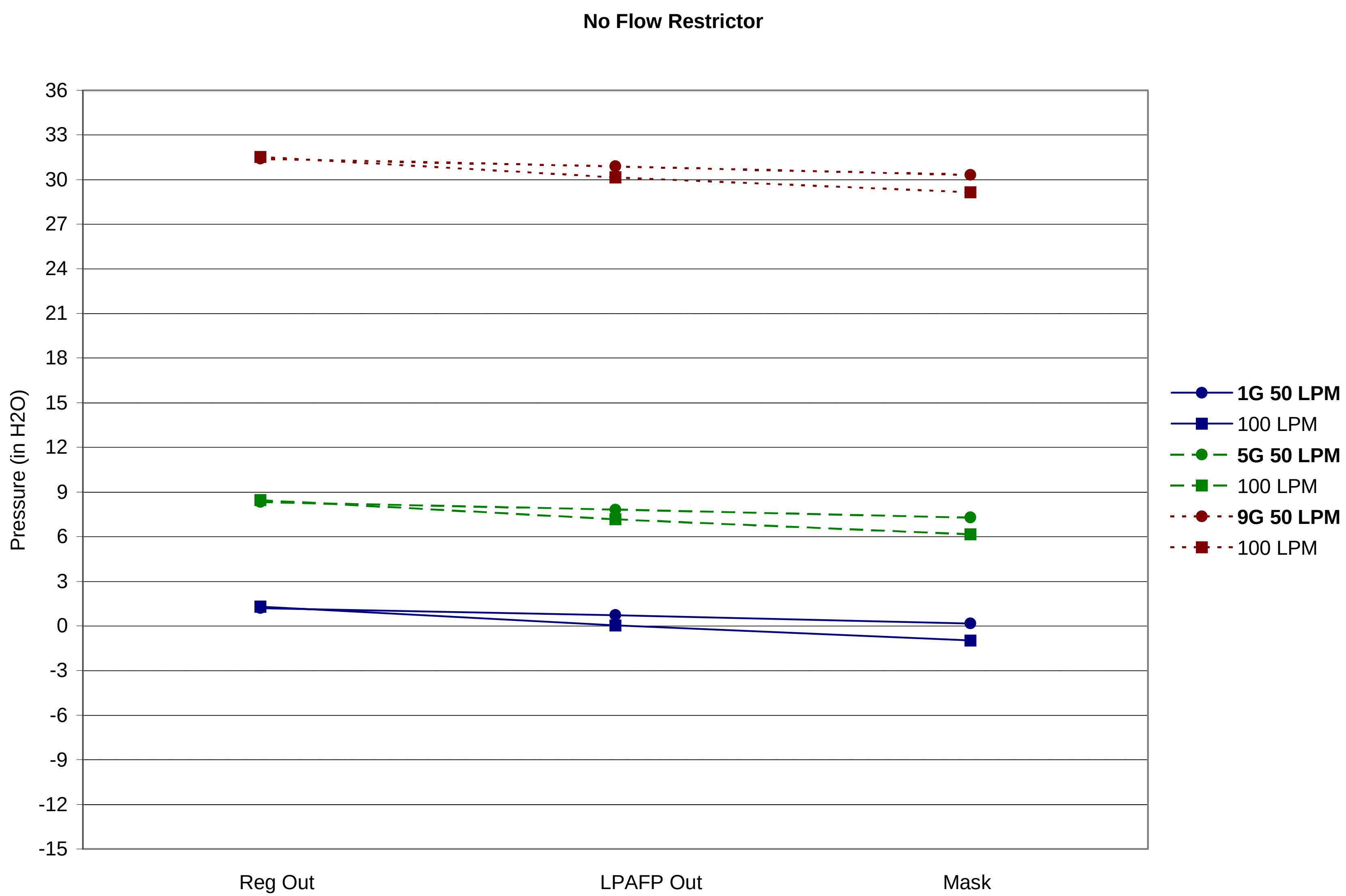

Figure E-15: Dynamic Flow System Pressures with LPAFP and 10 PSIG Regulator Inlet

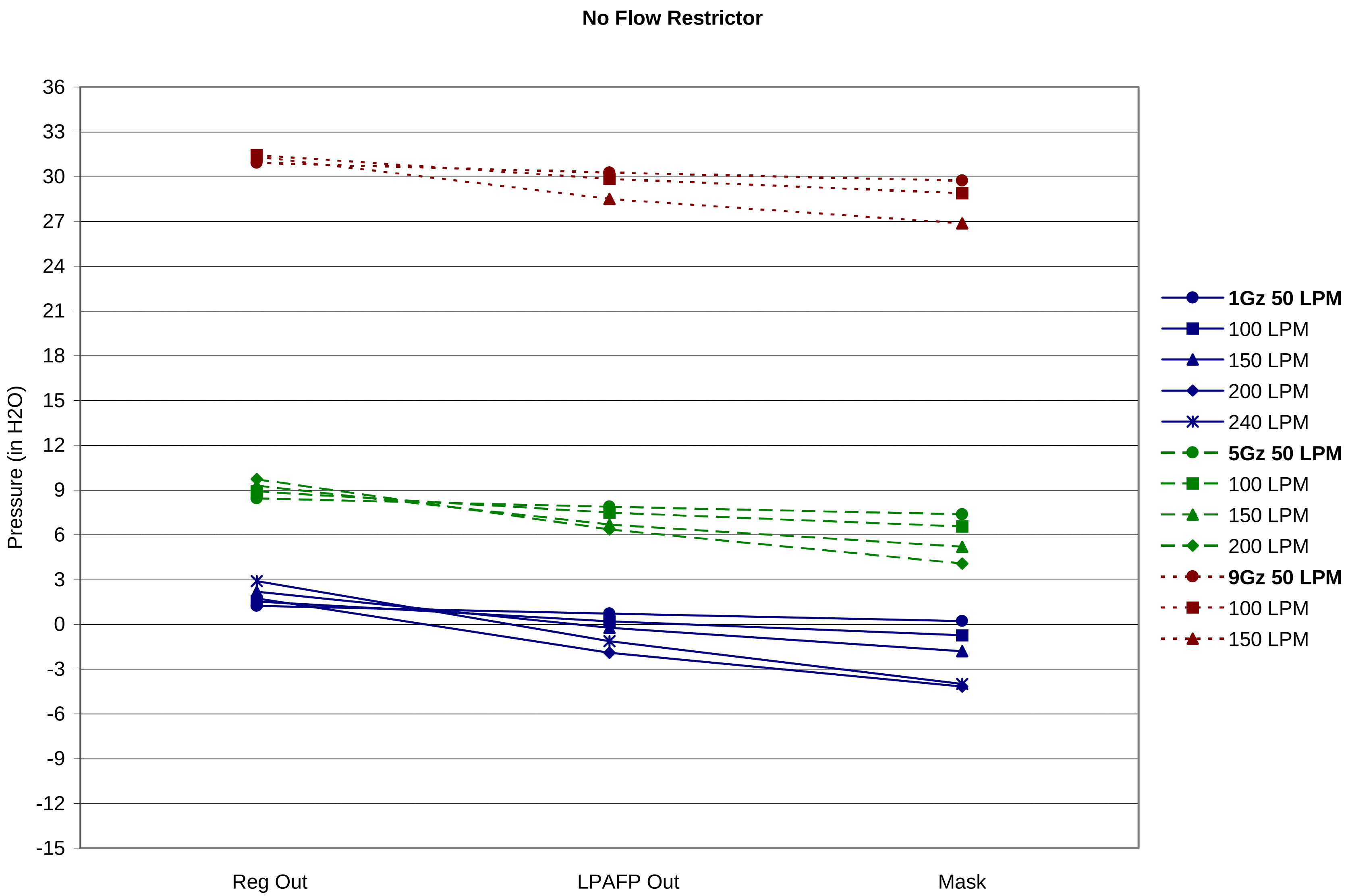

Figure E-16: Dynamic Flow System Pressures with LPAFP and 20 PSIG Regulator Inlet

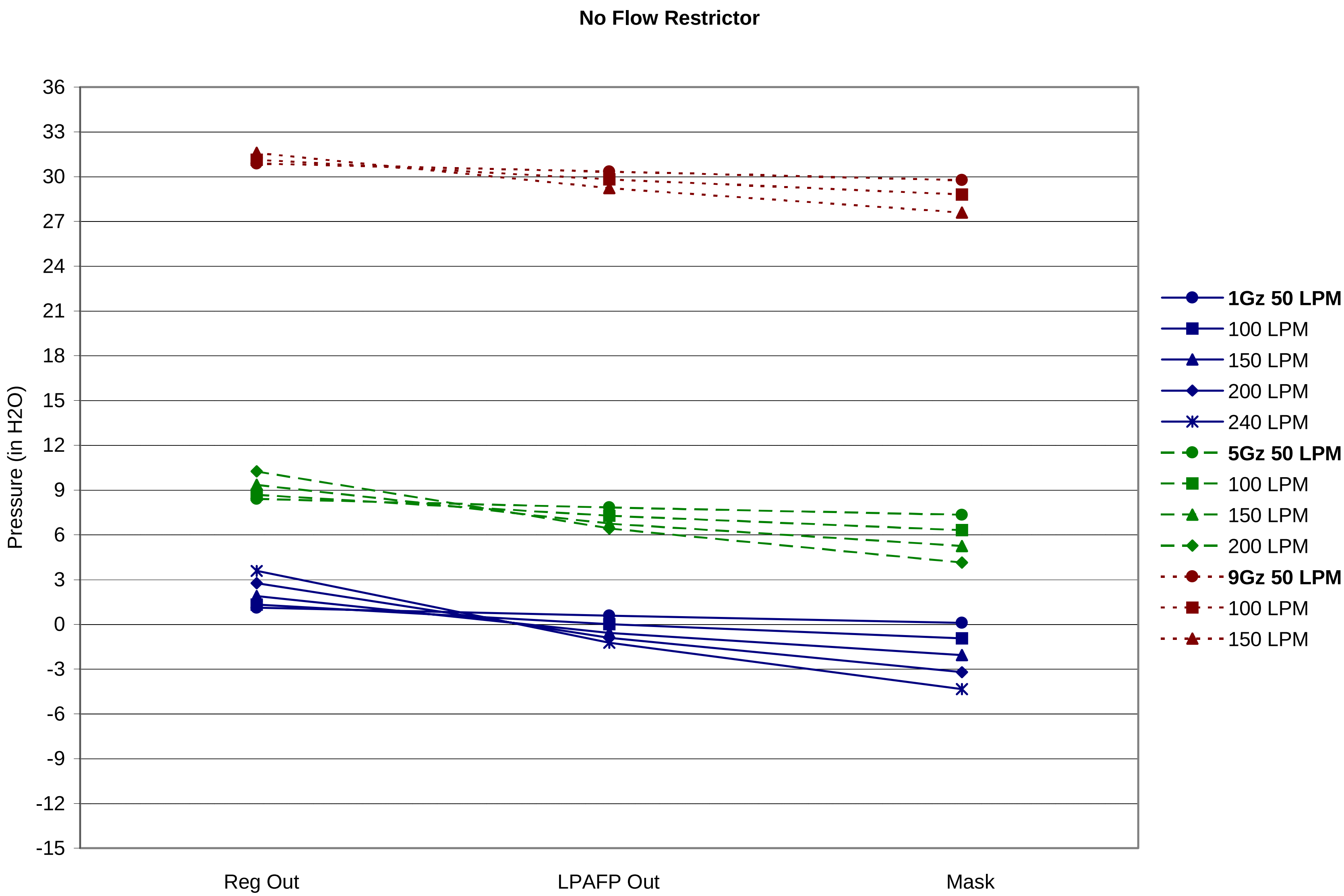

Figure E-17: Dynamic Flow System Pressures with LPAFP and 40 PSIG Regulator Inlet

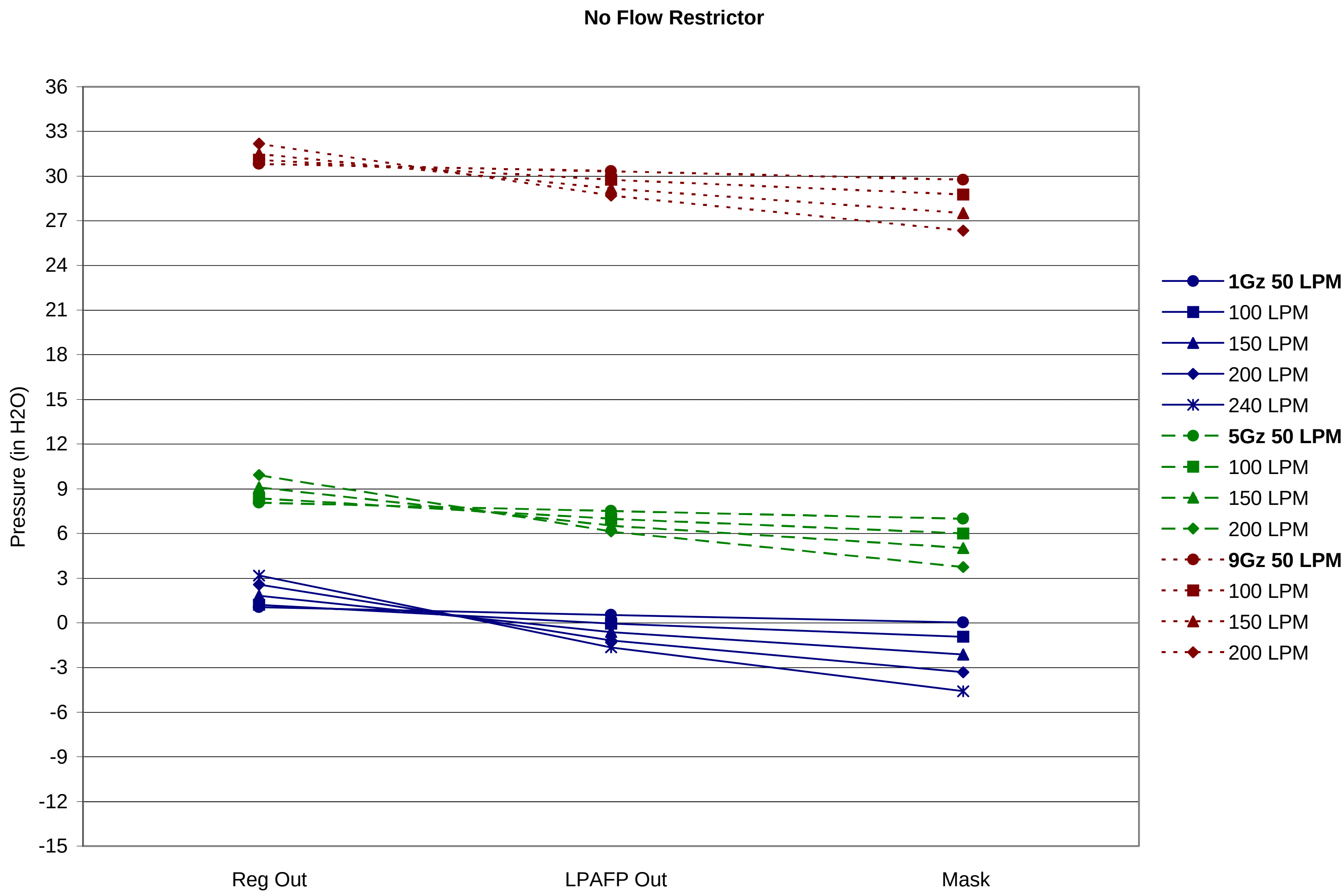

Figure E-18: Dynamic Flow System Pressures with LPAFP and 60 PSIG Regulator Inlet

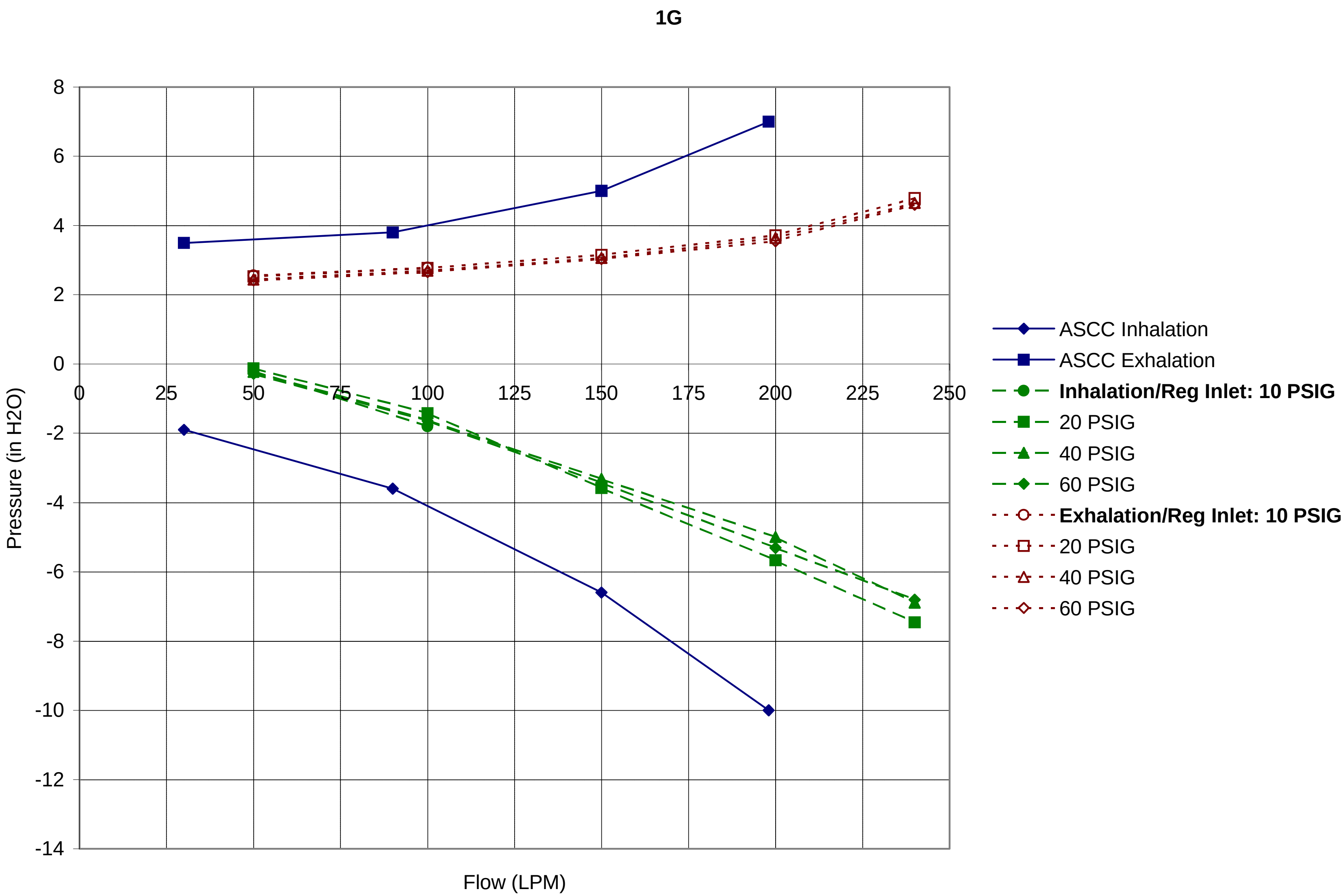

Figure E-19: ASCC Minimum/Maximum Allowable Mask Pressure Comparison with C2A1 and 40% Flow Restrictor

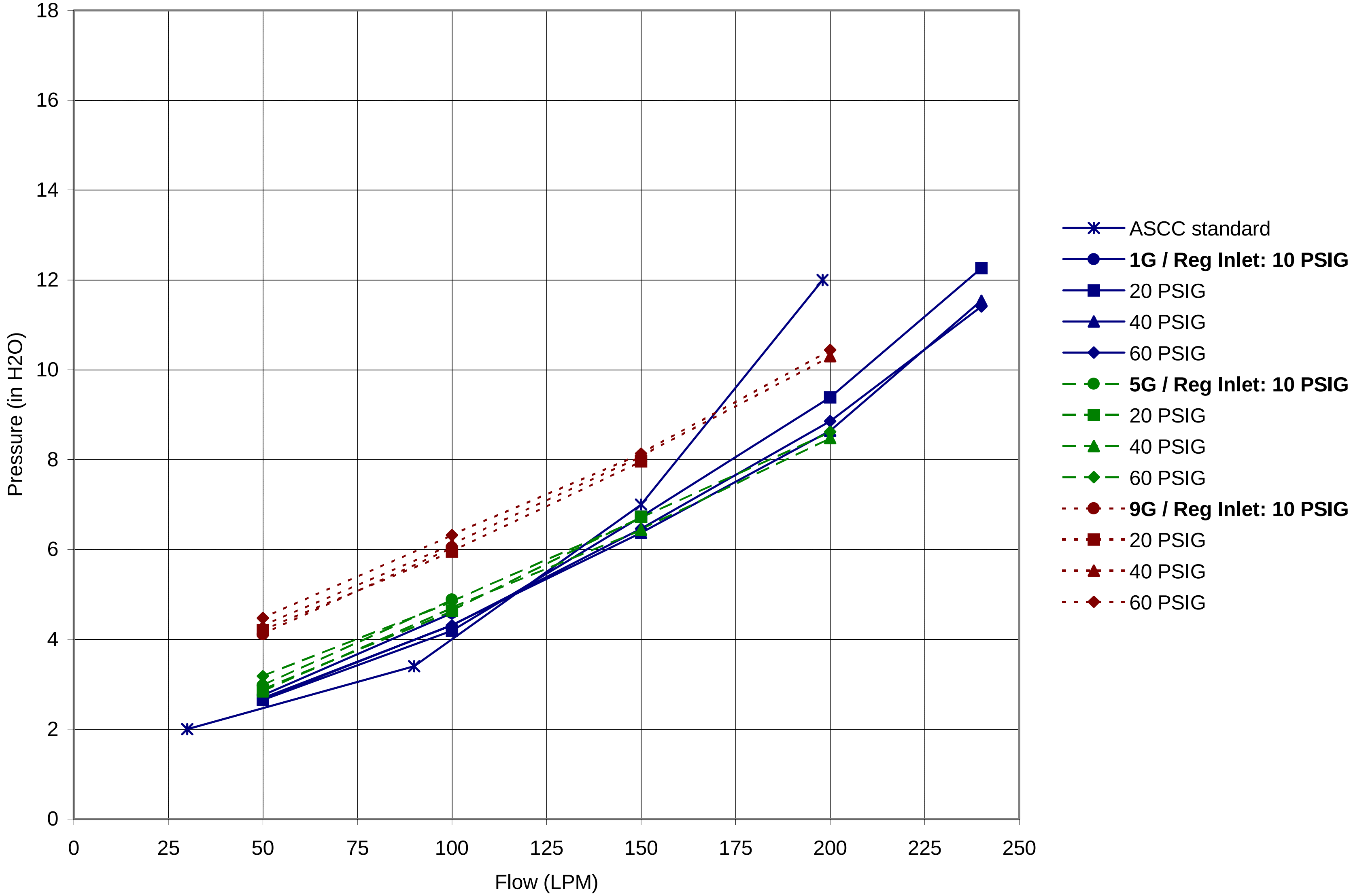

Figure E-20: ASCC Mask Pressure Swing Comparison with C2A1and 40% Flow Restrictor

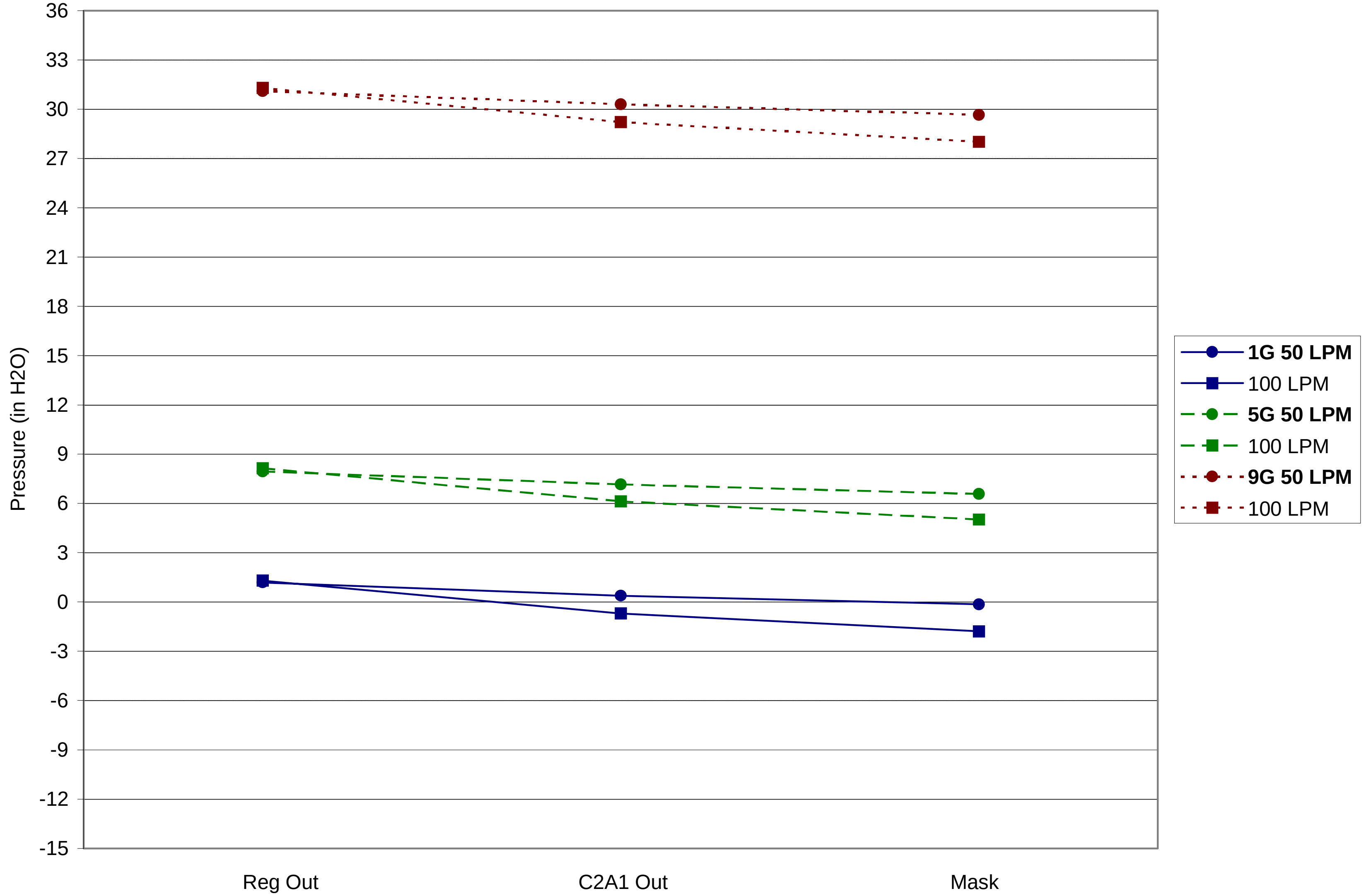

Figure E-21: Dynamic Flow System Pressures with C2A1 and 10 PSIG Regulator Inlet/40% Flow Restrictor

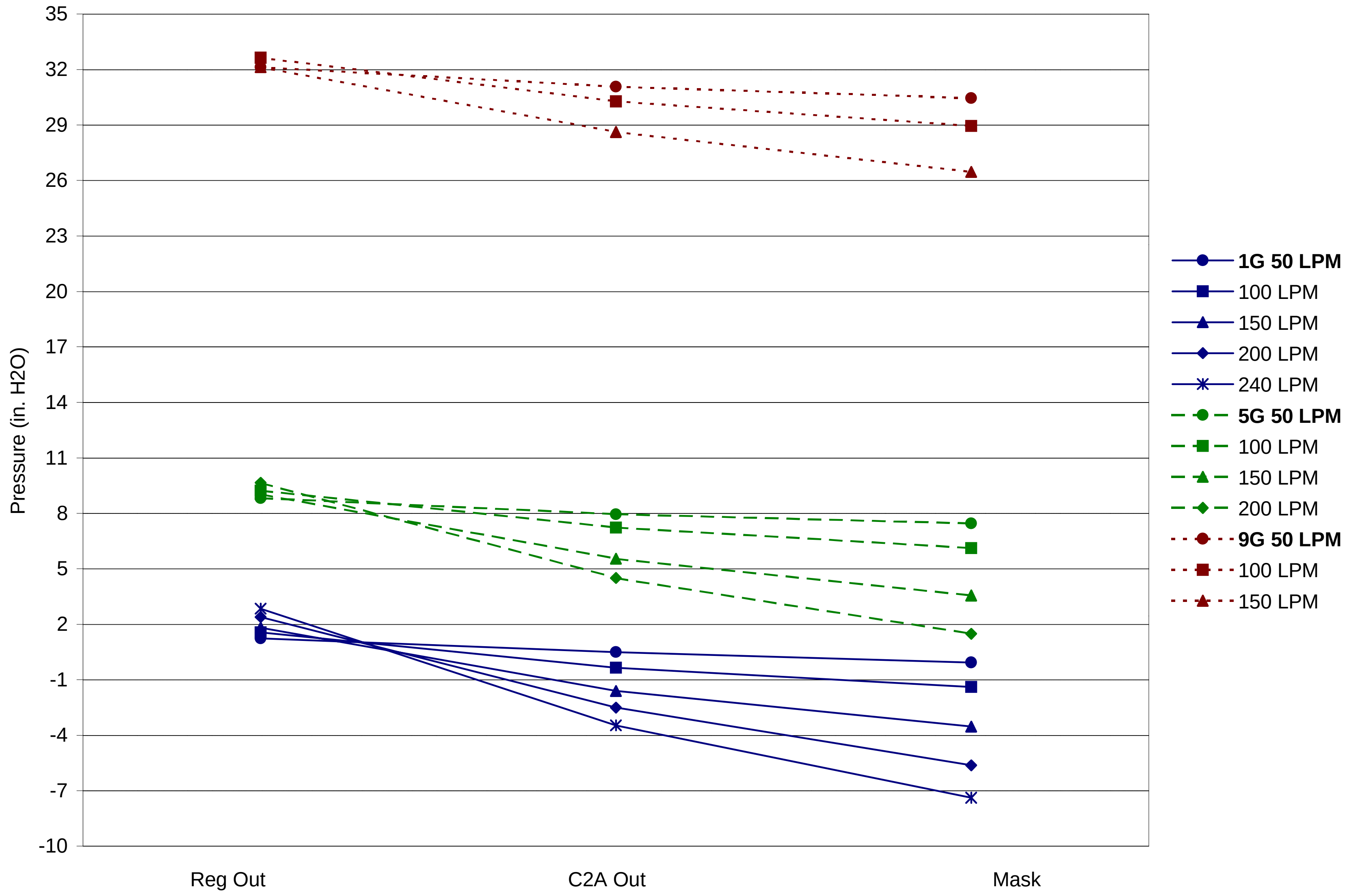

Figure E-22: Dynamic Flow System Pressures with C2A1 and 20 PSIG Regulator Inlet/40% Flow Restrictor

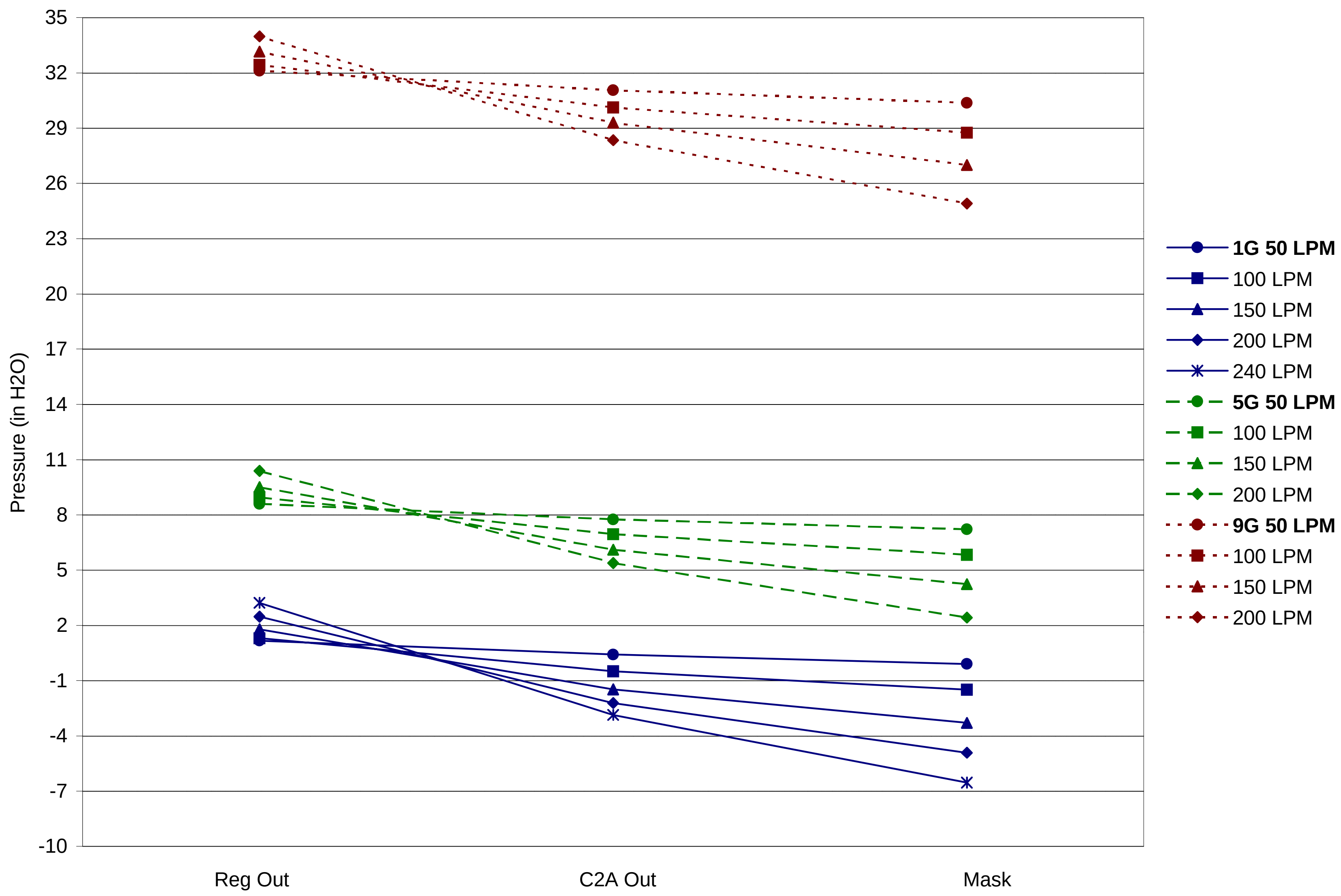

Figure E-23: Dynamic Flow System Pressures with C2A1 and 40 PSIG Regulator Inlet/40% Flow Restrictor

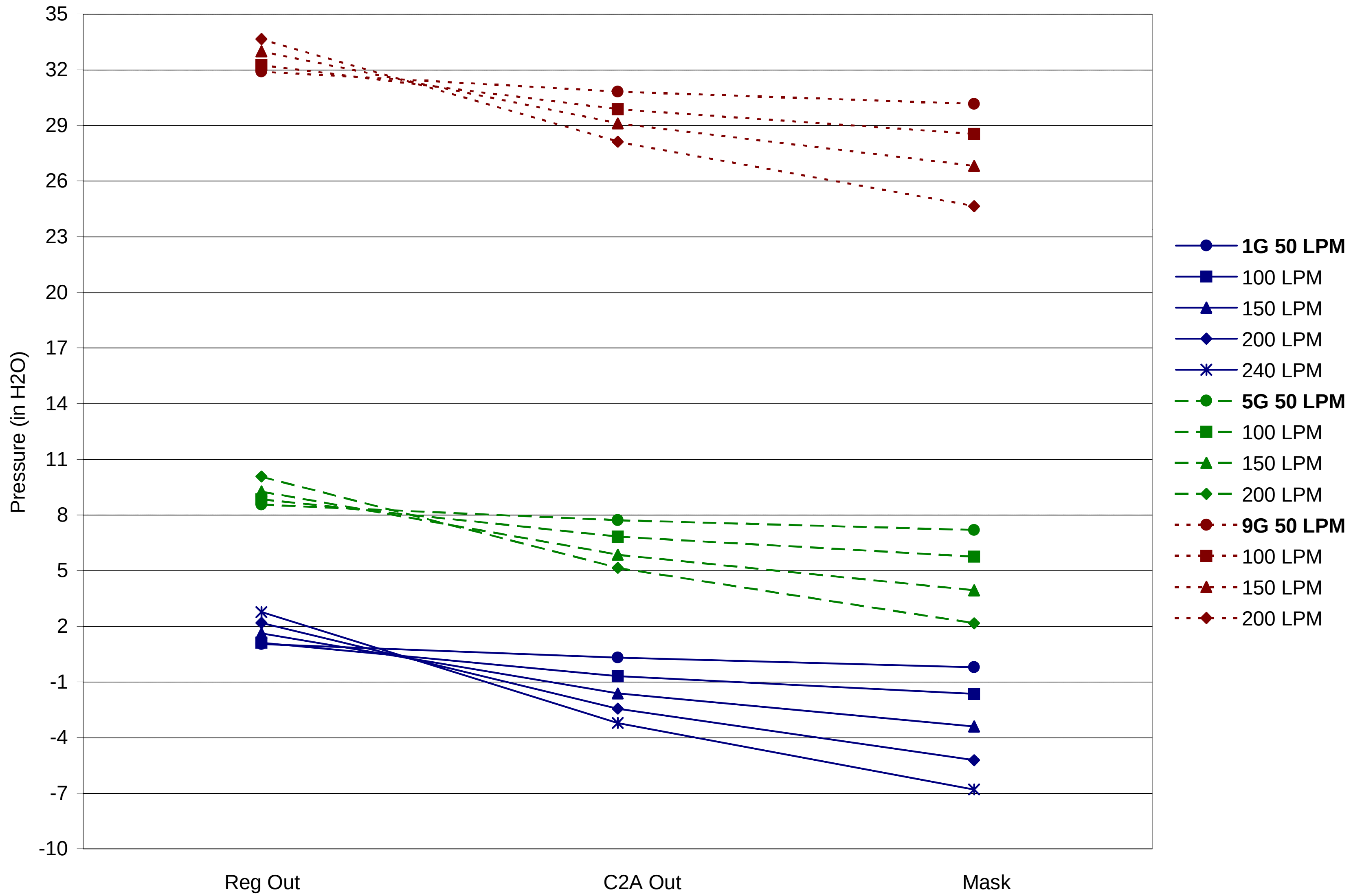

Figure E-24: Dynamic Flow System Pressures with C2A1 and 60 PSIG Regulator Inlet/40% Flow Restrictor

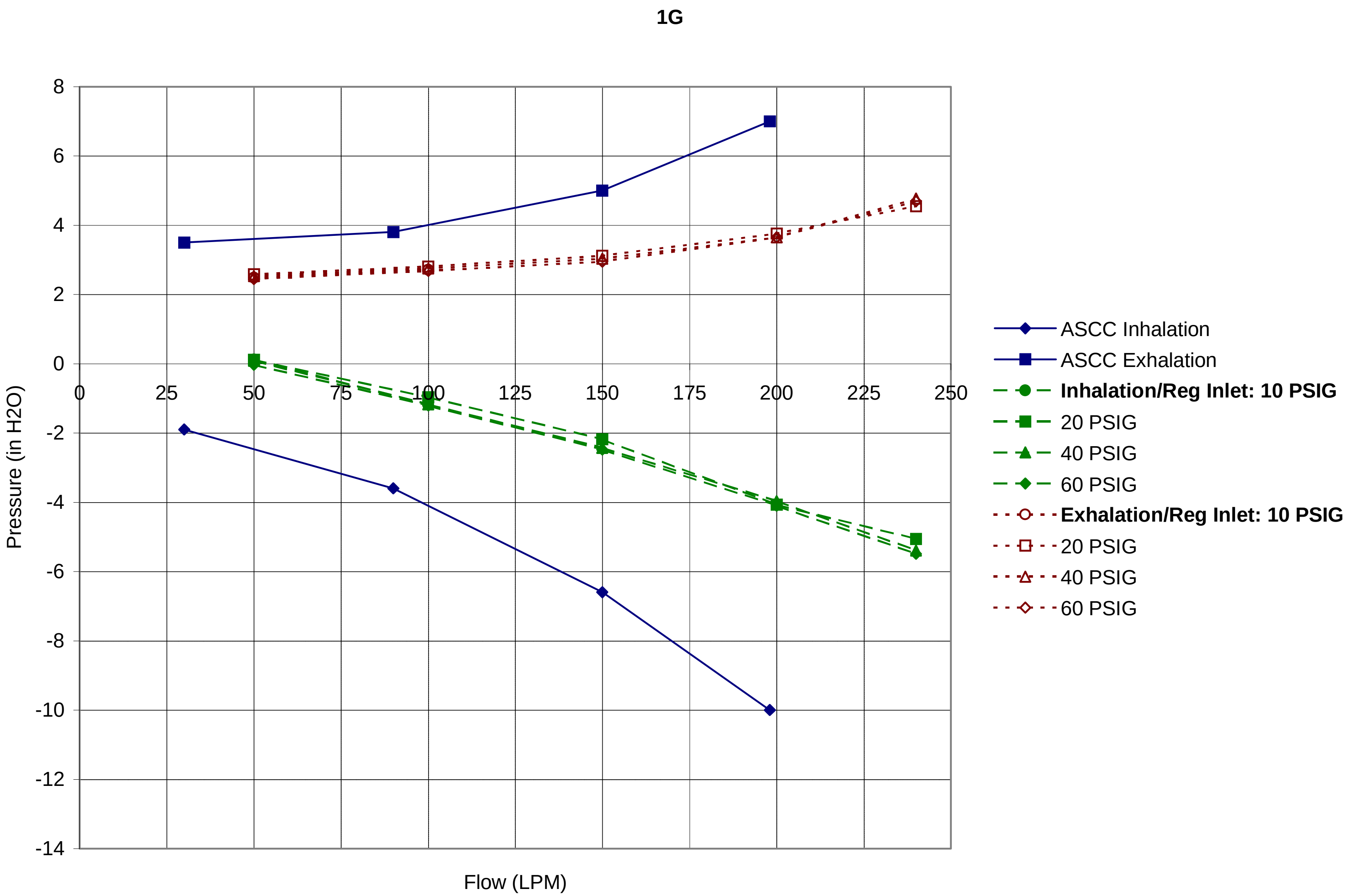

Figure E-25: ASCC Minimum/Maximum Allowable Mask Pressure Comparison with LPAFP and 40% Flow Restrictor

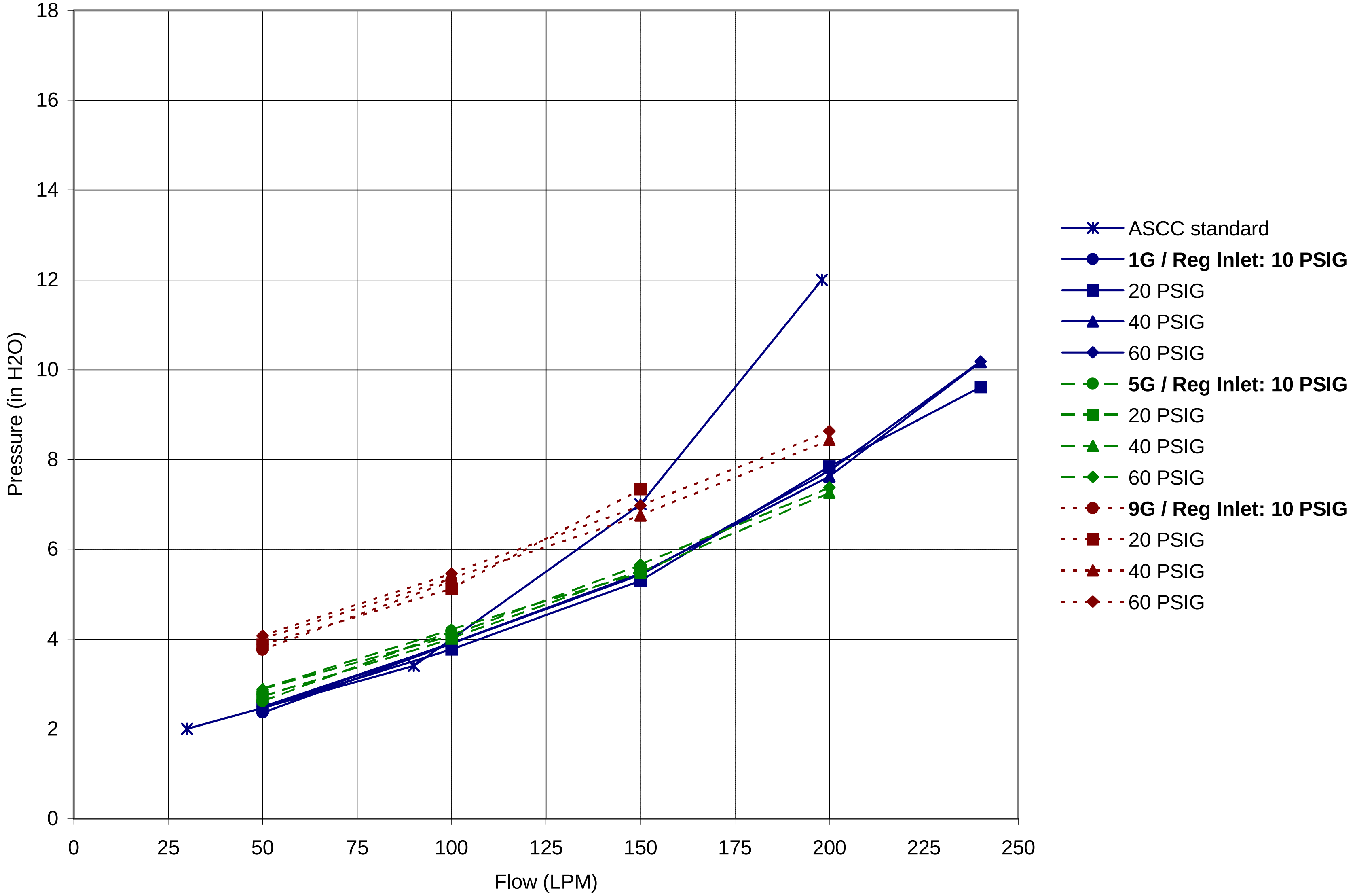

Figure E-26: ASCC Mask Pressure Swing Comparison with LPAFP and 40% Flow Restrictor

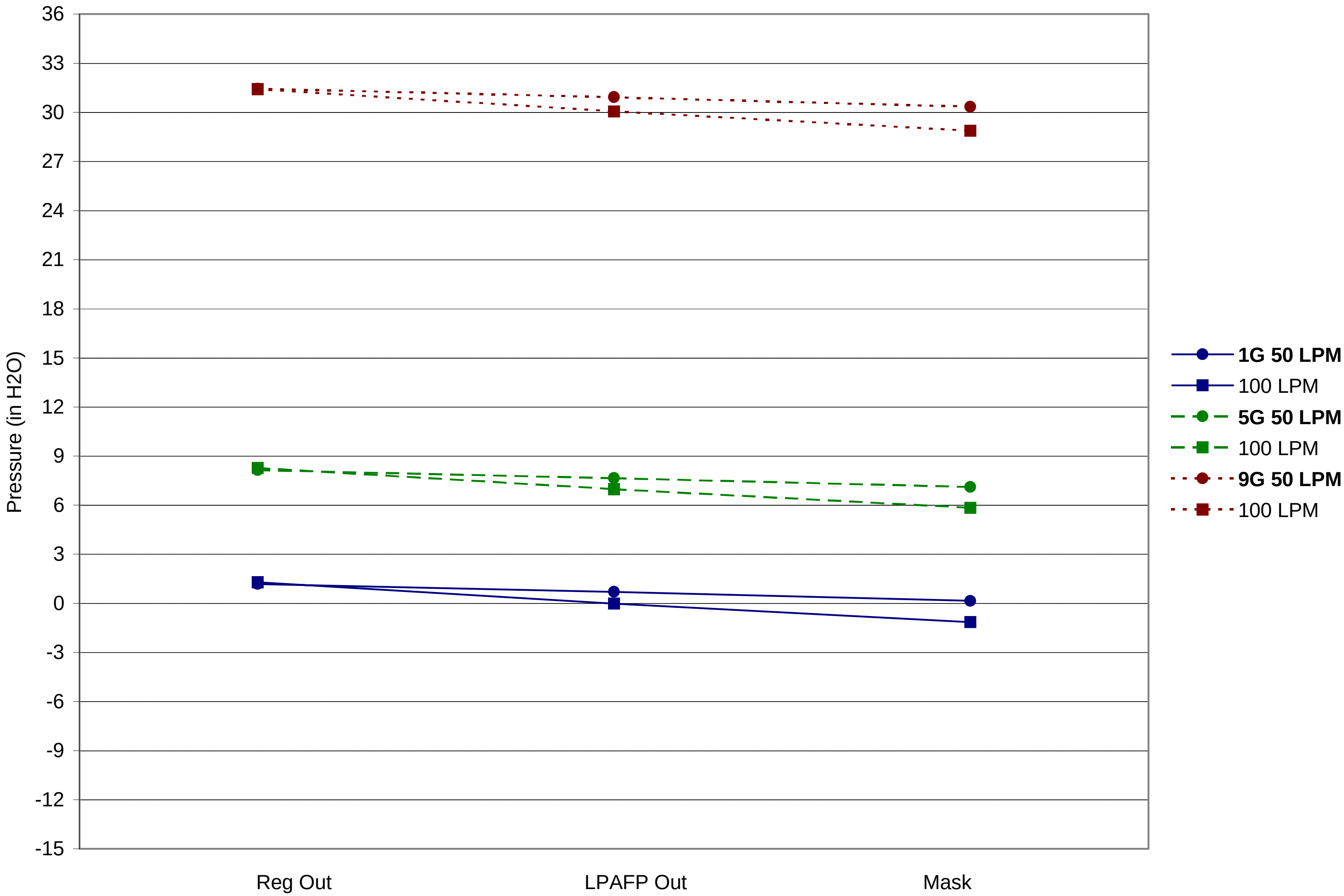

Figure E-27: Dynamic Flow System Pressures with LPAFP and 10 PSIG Regulator Inlet/40% Flow Restrictor

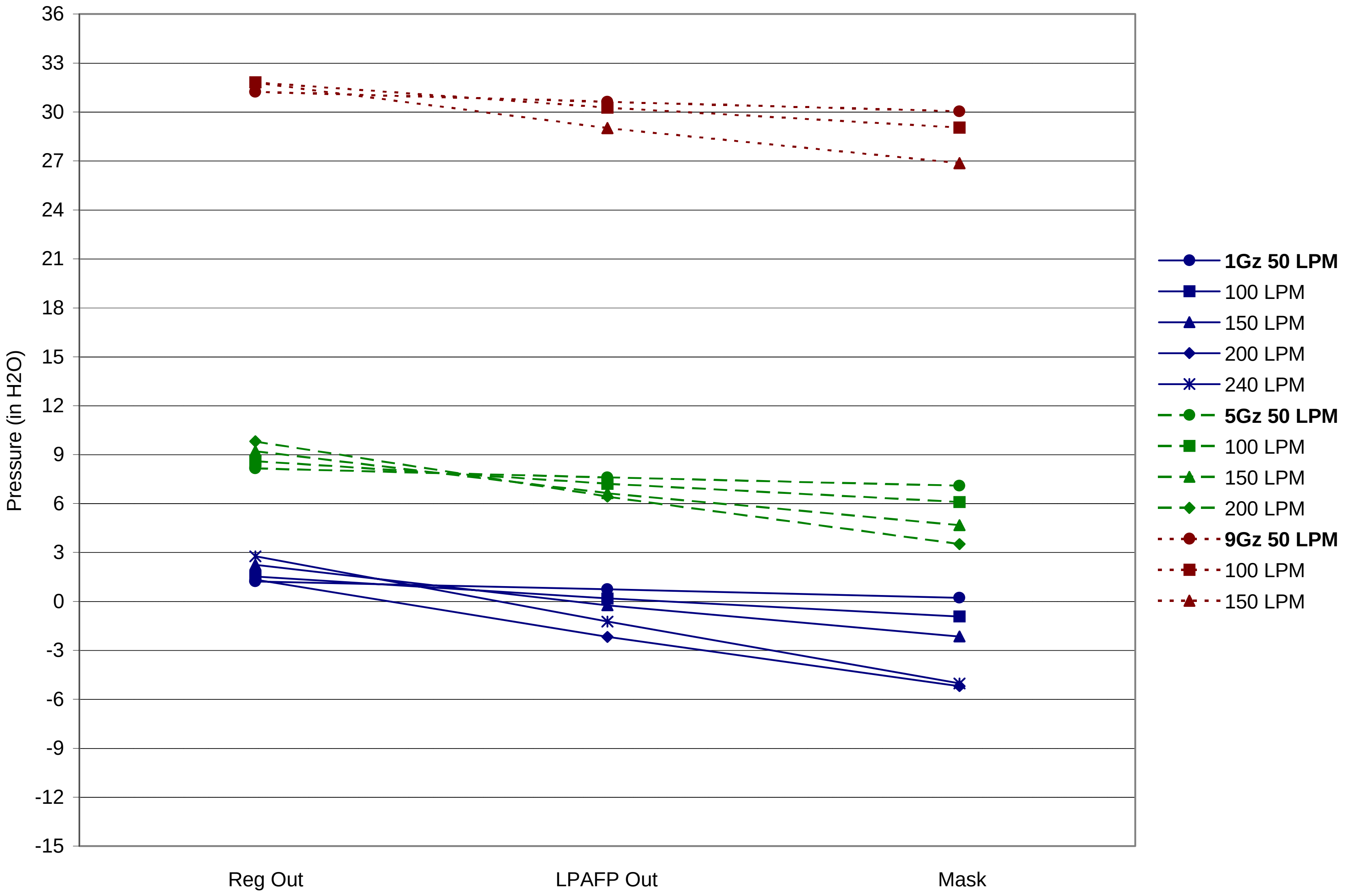

Figure E-28: Dynamic Flow System Pressures with LPAFP and 20 PSIG Regulator Inlet/40% Flow Restrictor

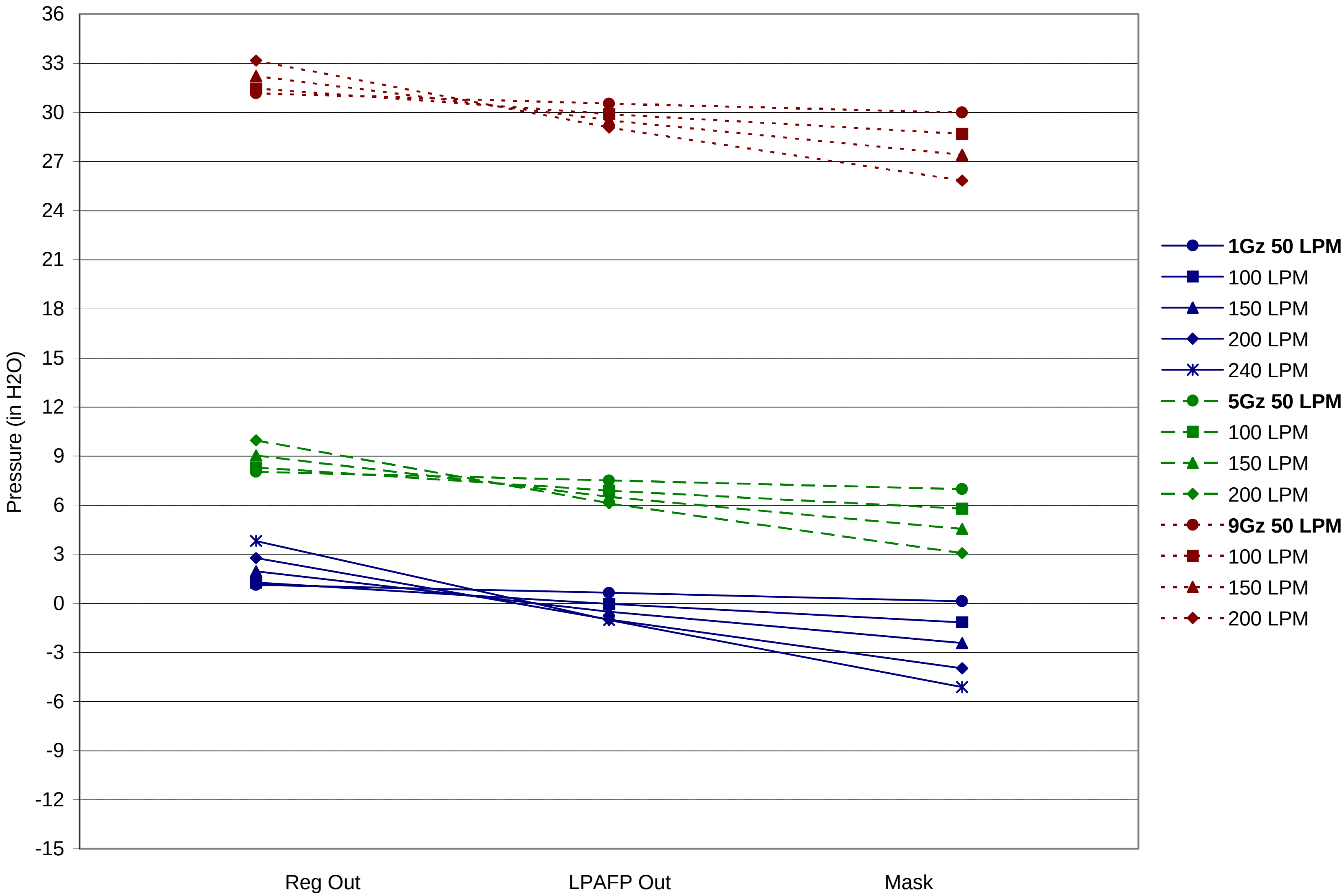

Figure E-29: Dynamic Flow System Pressures with LPAFP and 40 PSIG Regulator Inlet/40% Flow Restrictor

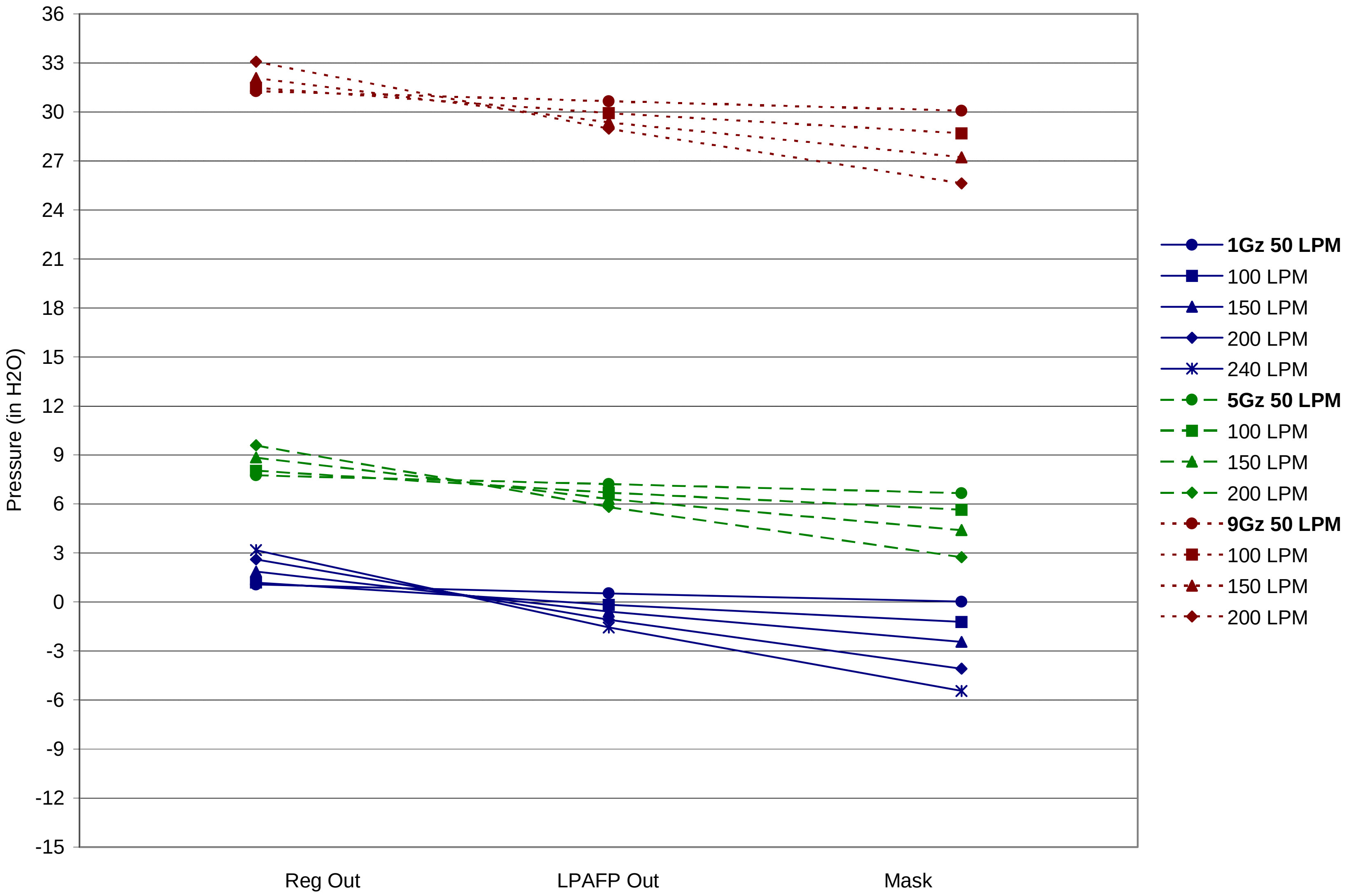

Figure E-30: Dynamic Flow System Pressures with LPAFP and 60 PSIG Regulator Inlet/40% Flow Restrictor

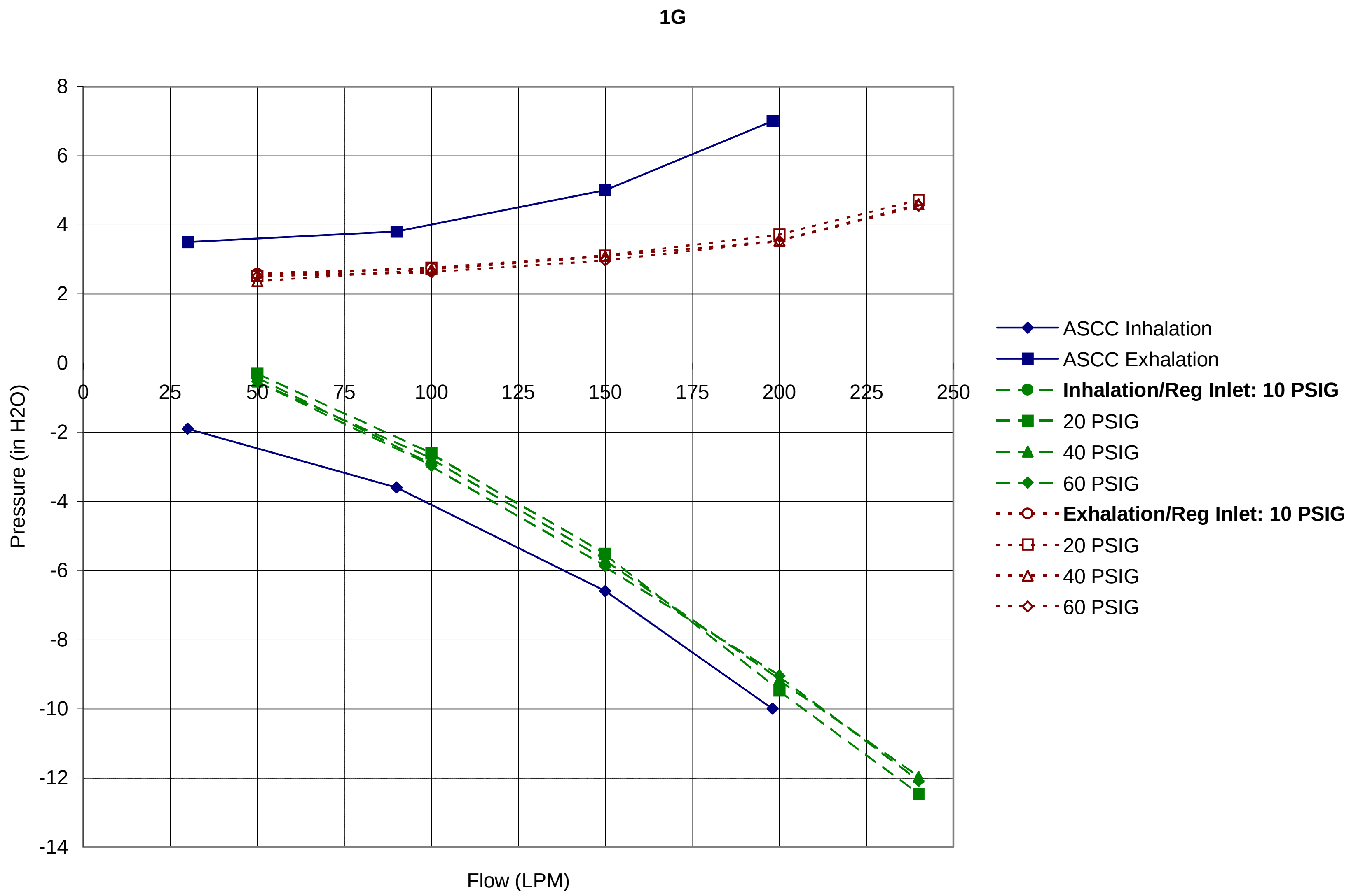

Figure E-31: ASCC Minimum/Maximum Allowable Mask Pressure Comparison with C2A1 and 70% Flow Restrictor

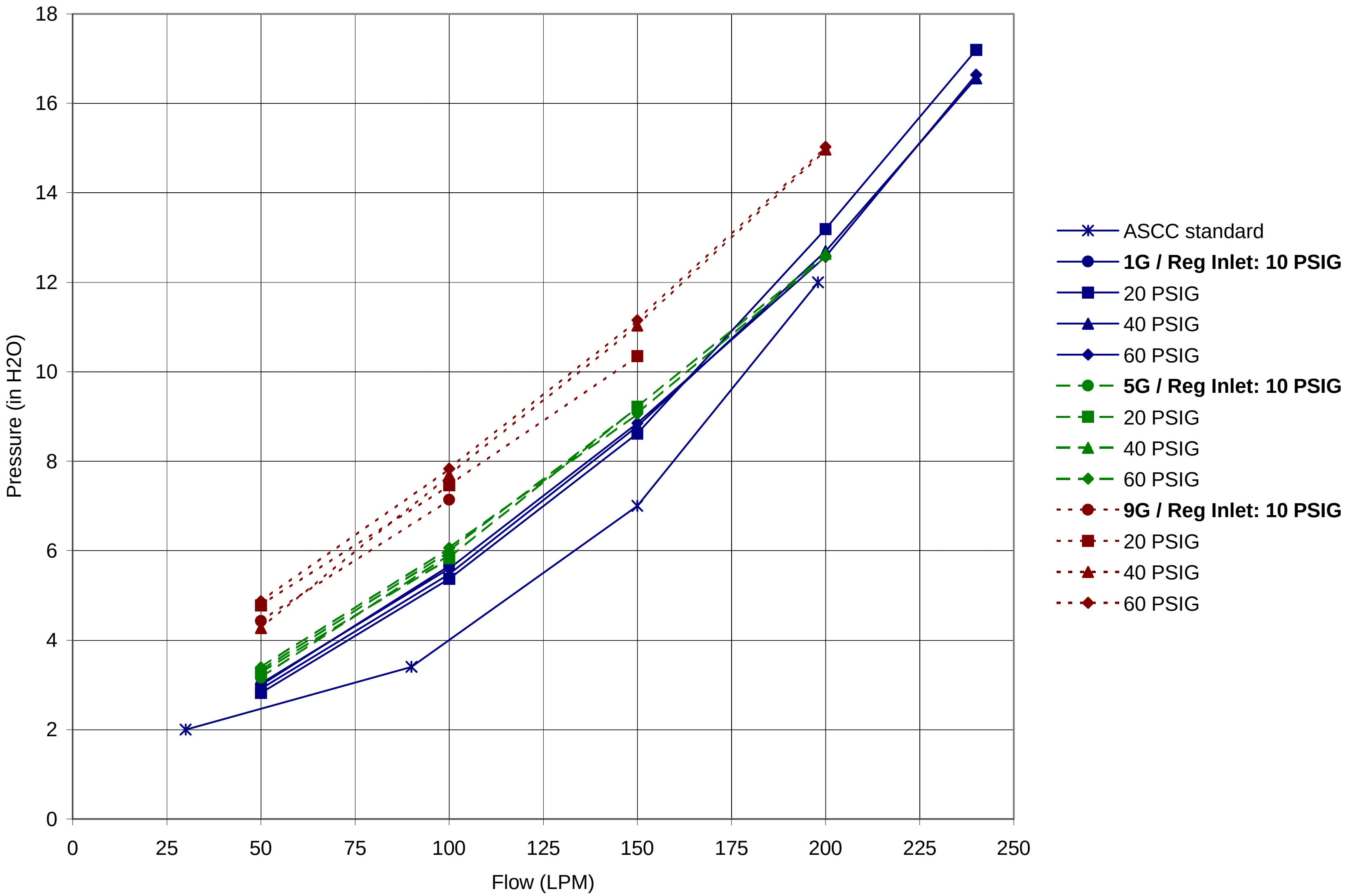

Figure E-32: ASCC Mask Pressure Swing Comparison with C2A1and 70% Flow Restrictor

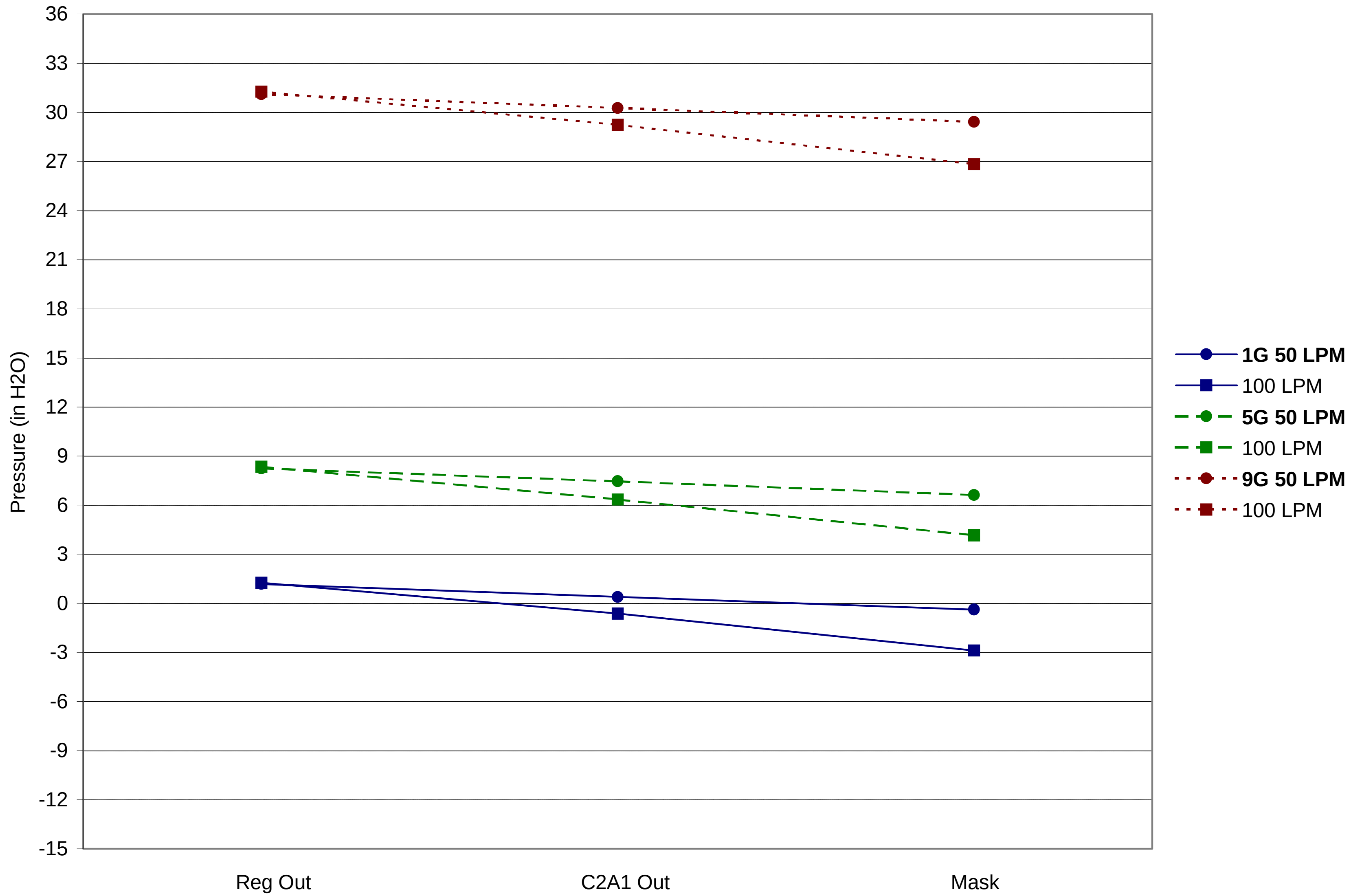

Figure E-33: Dynamic Flow System Pressures with C2A1 and 10 PSIG Regulator Inlet/70% Flow Restrictor

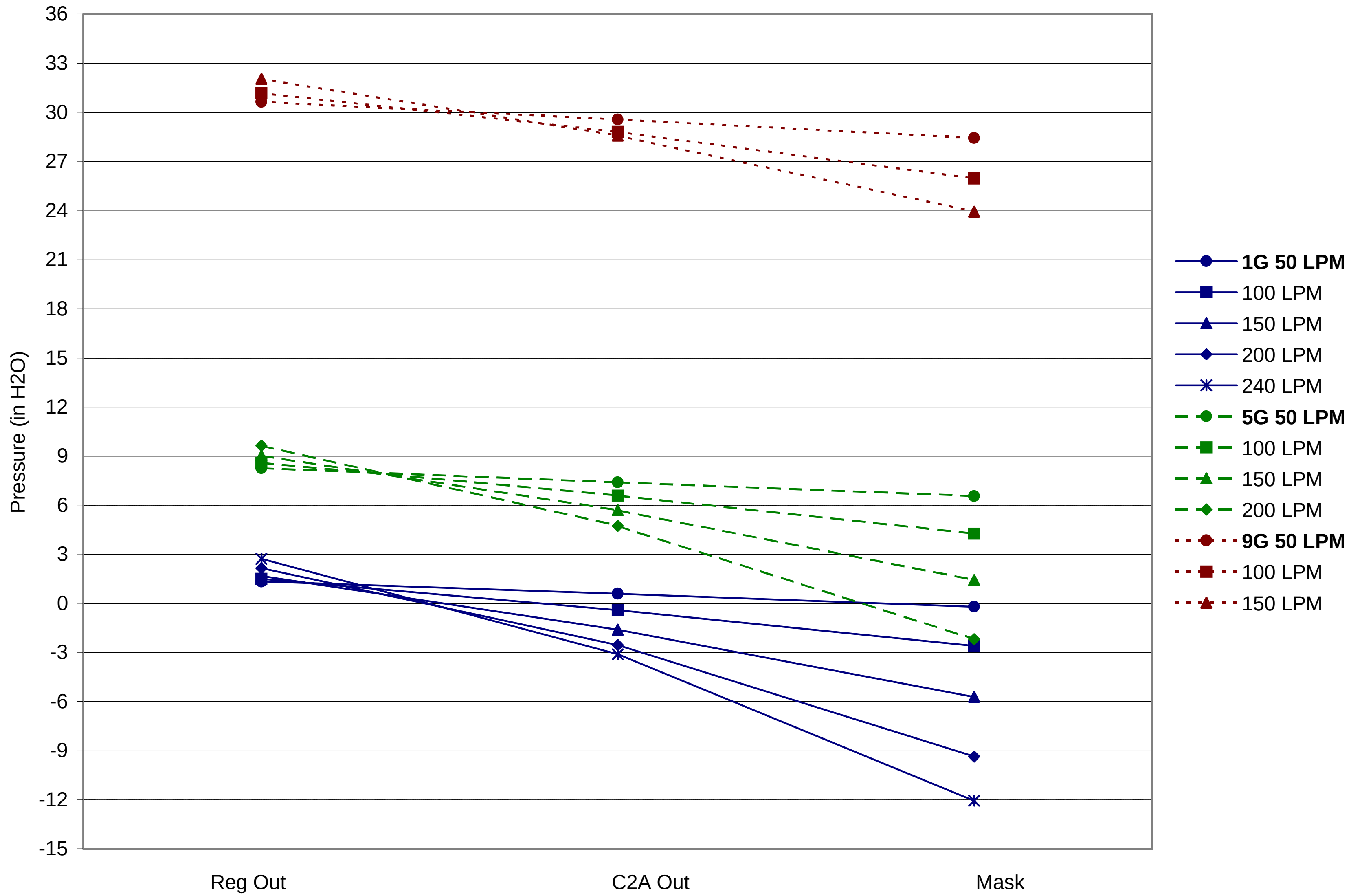

Figure E-34: Dynamic Flow System Pressures with C2A1 and 20 PSIG Regulator Inlet/70% Flow Restrictor

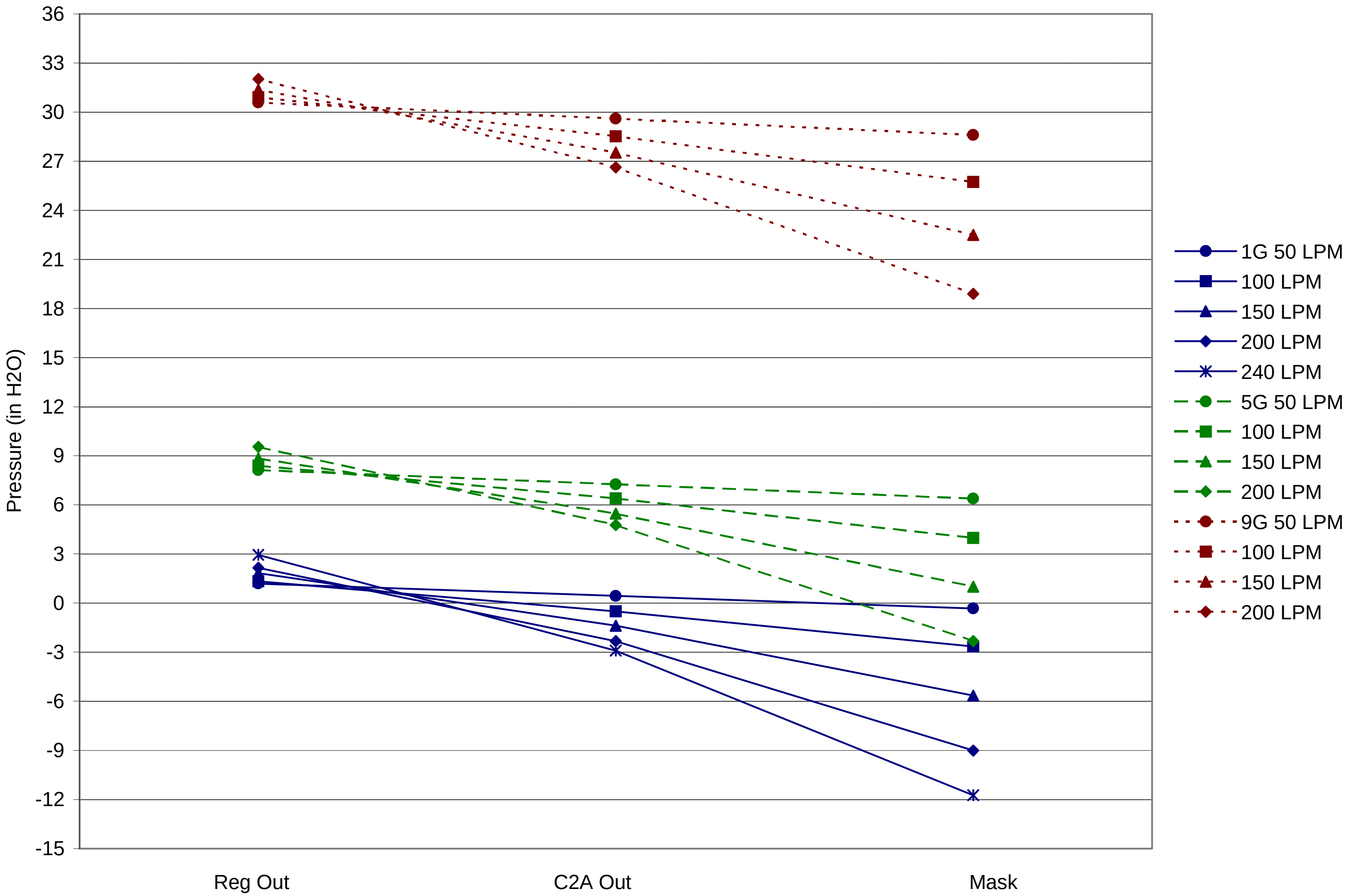

Figure E-35: Dynamic Flow System Pressures with C2A1 and 40 PSIG Regulator Inlet/70% Flow Restrictor

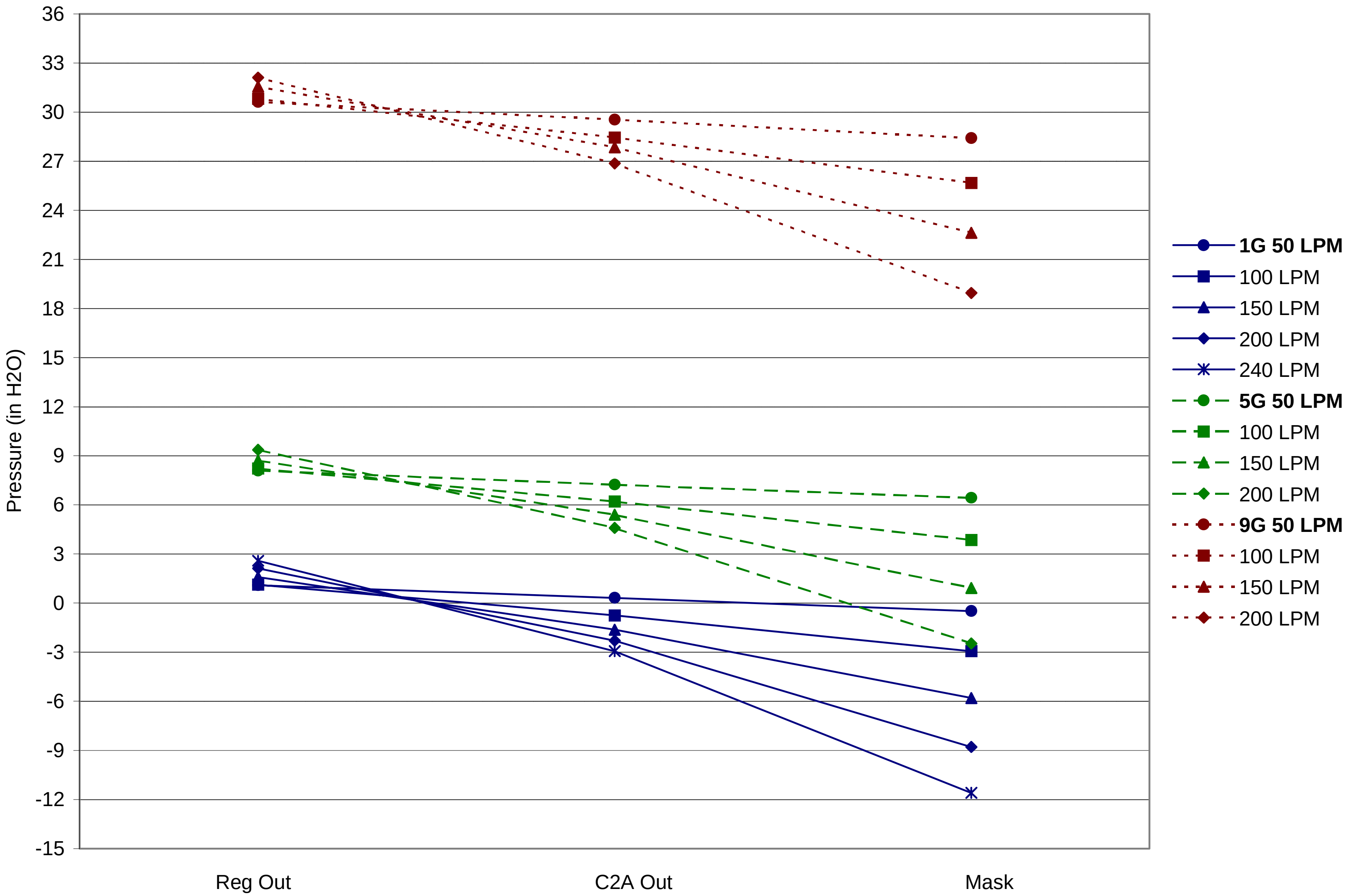

Figure E-36: Dynamic Flow System Pressures with C2A1 and 60 PSIG Regulator Inlet/70% Flow Restrictor

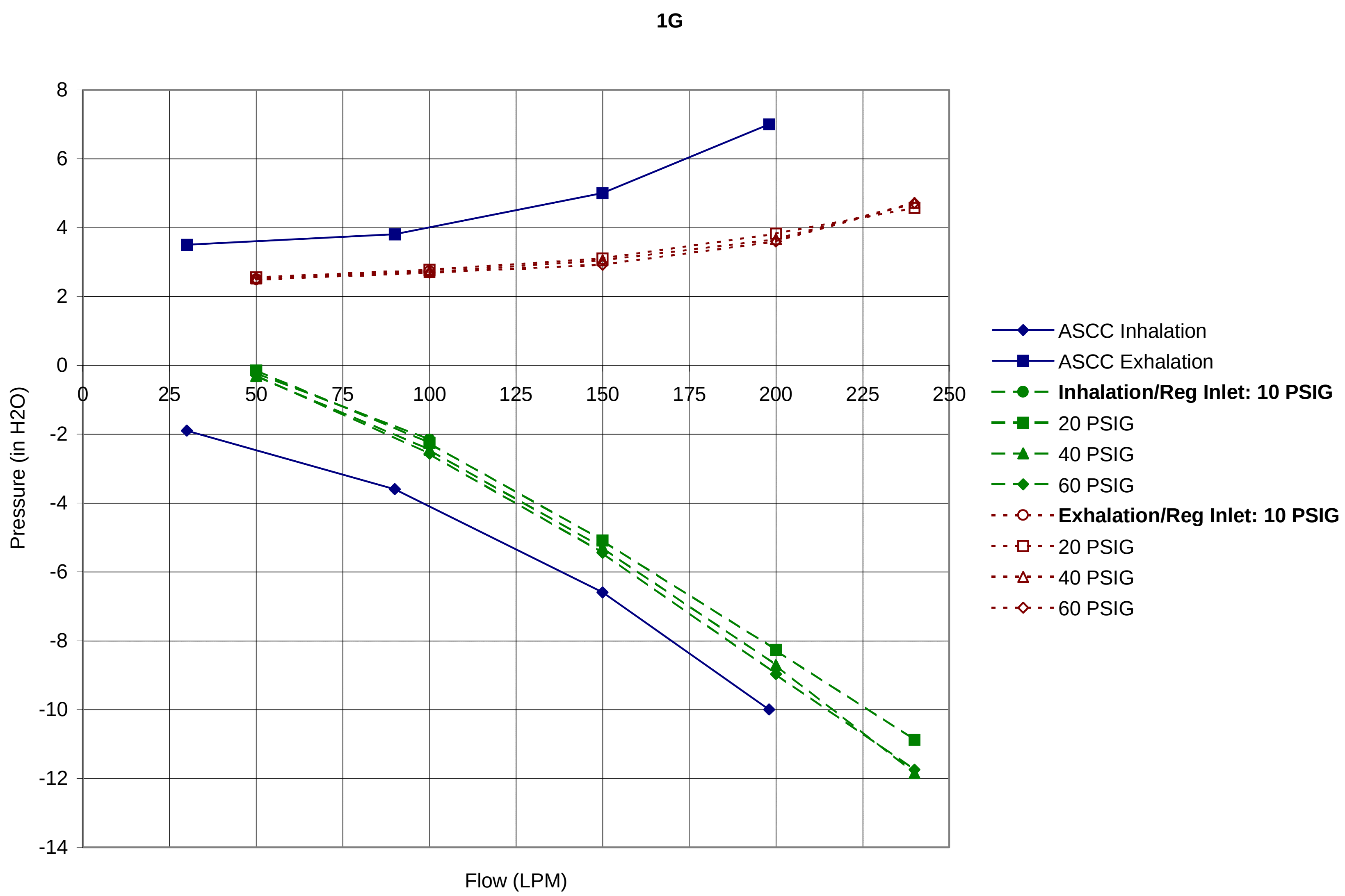

Figure E-37: ASCC Minimum/Maximum Allowable Mask Pressure Comparison with LPAFP and 70% Flow Restrictor

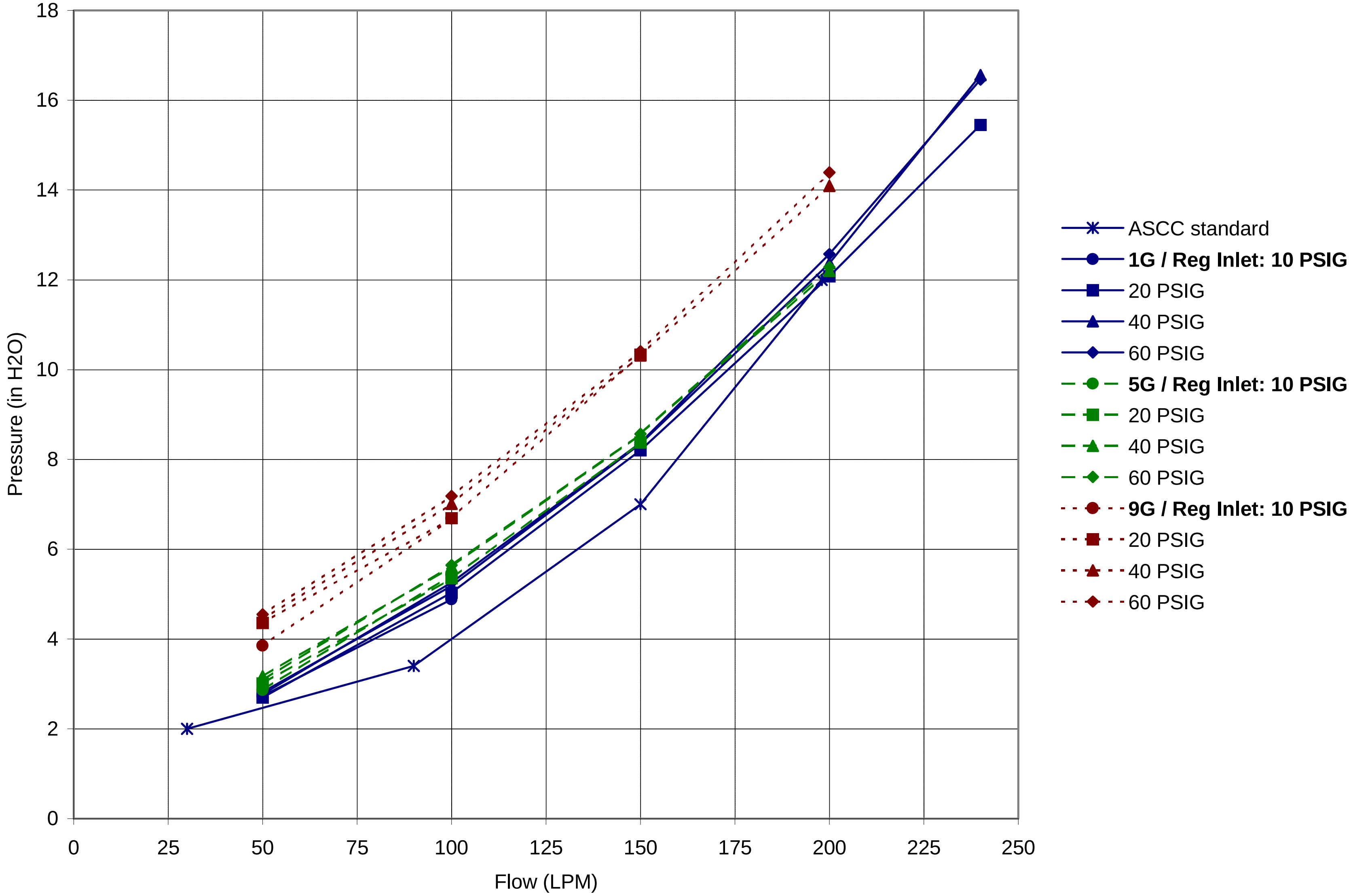

Figure E-38: ASCC Mask Pressure Swing Comparison with LPAFP and 70% Flow Restrictor

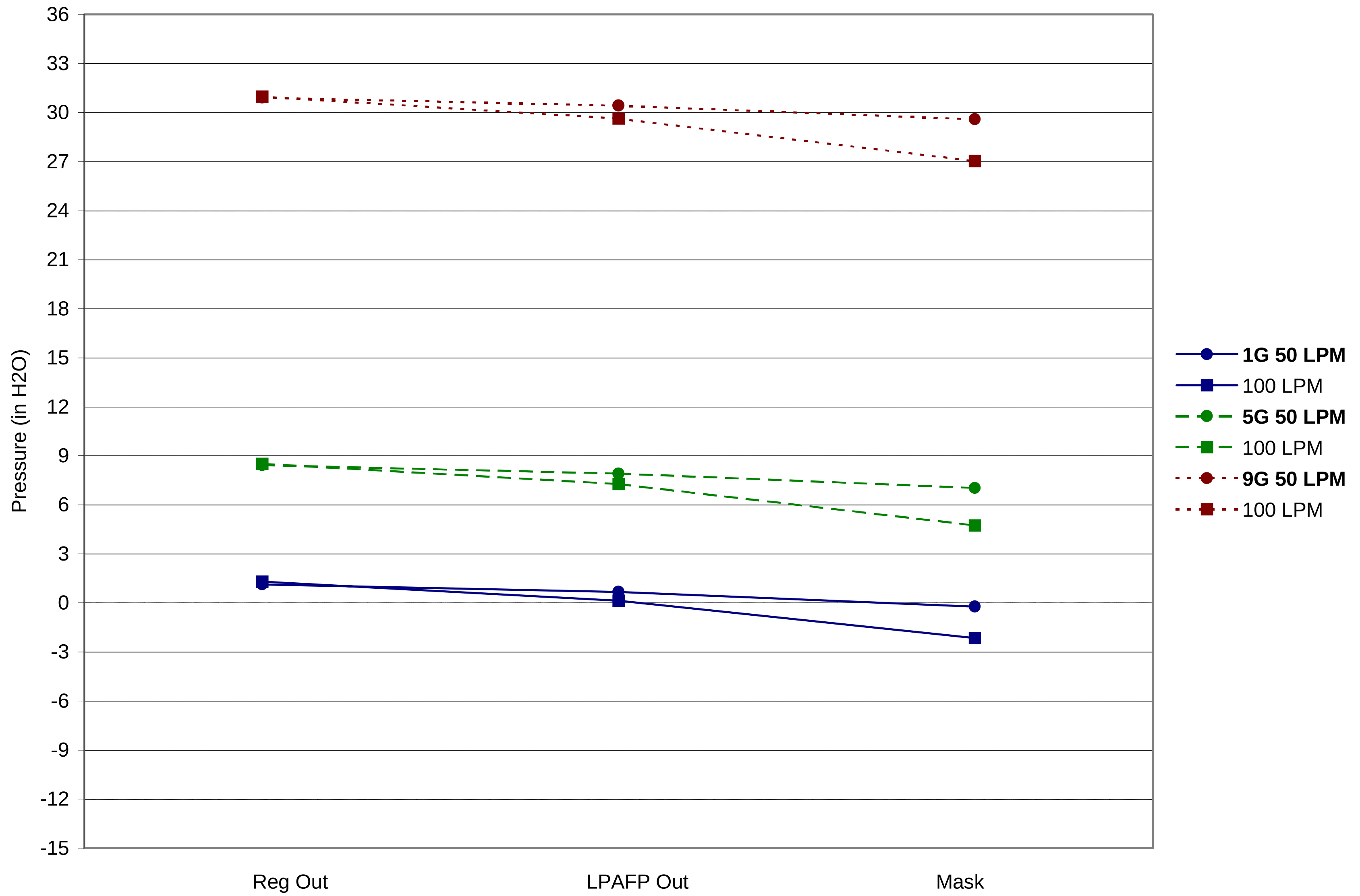

Figure E-39: Dynamic Flow System Pressures with LPAFP and 10 PSIG Regulator Inlet/70% Flow Restrictor

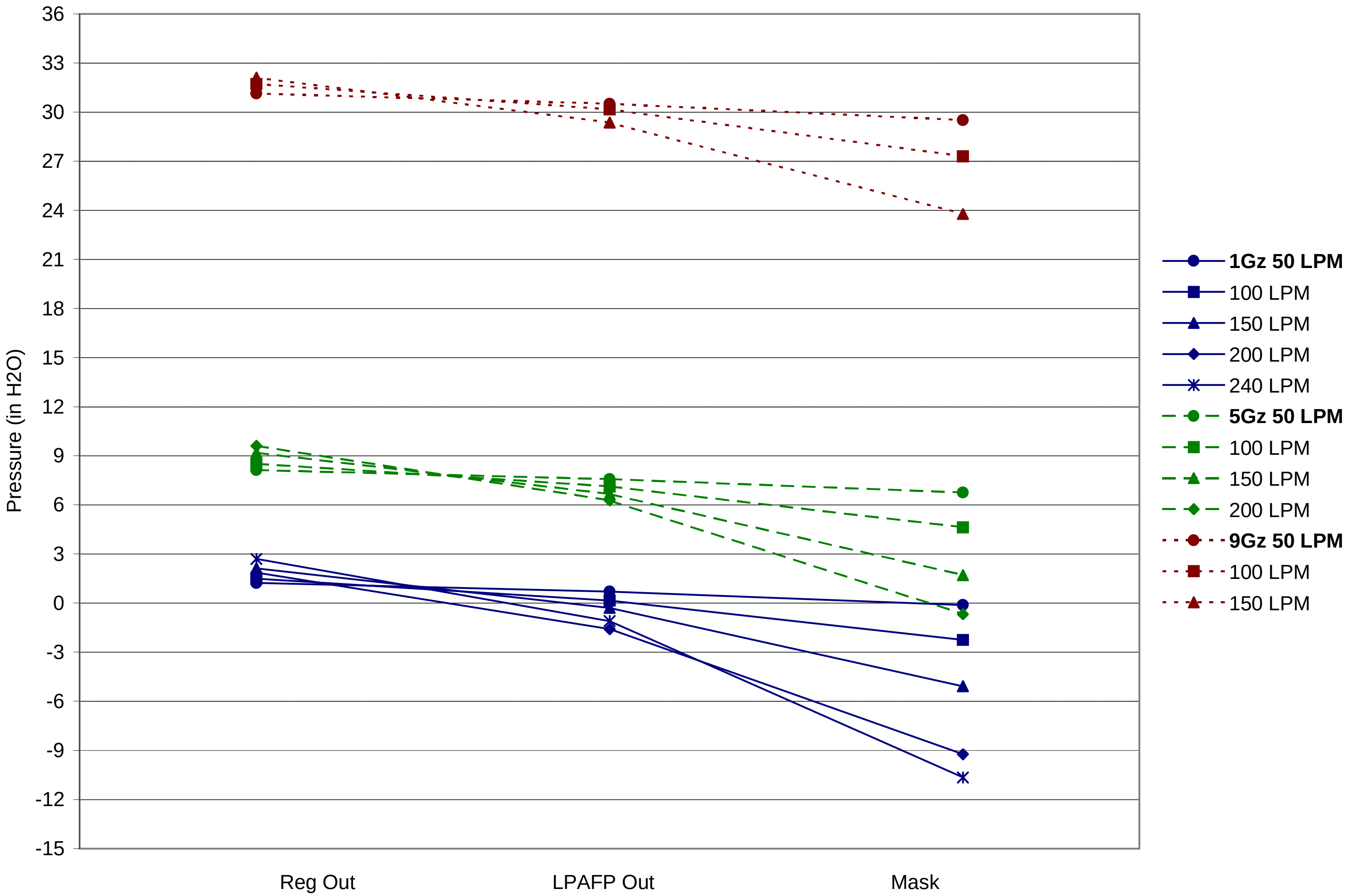

Figure E-40: Dynamic Flow System Pressures with LPAFP and 20 PSIG Regulator Inlet/70% Flow Restrictor

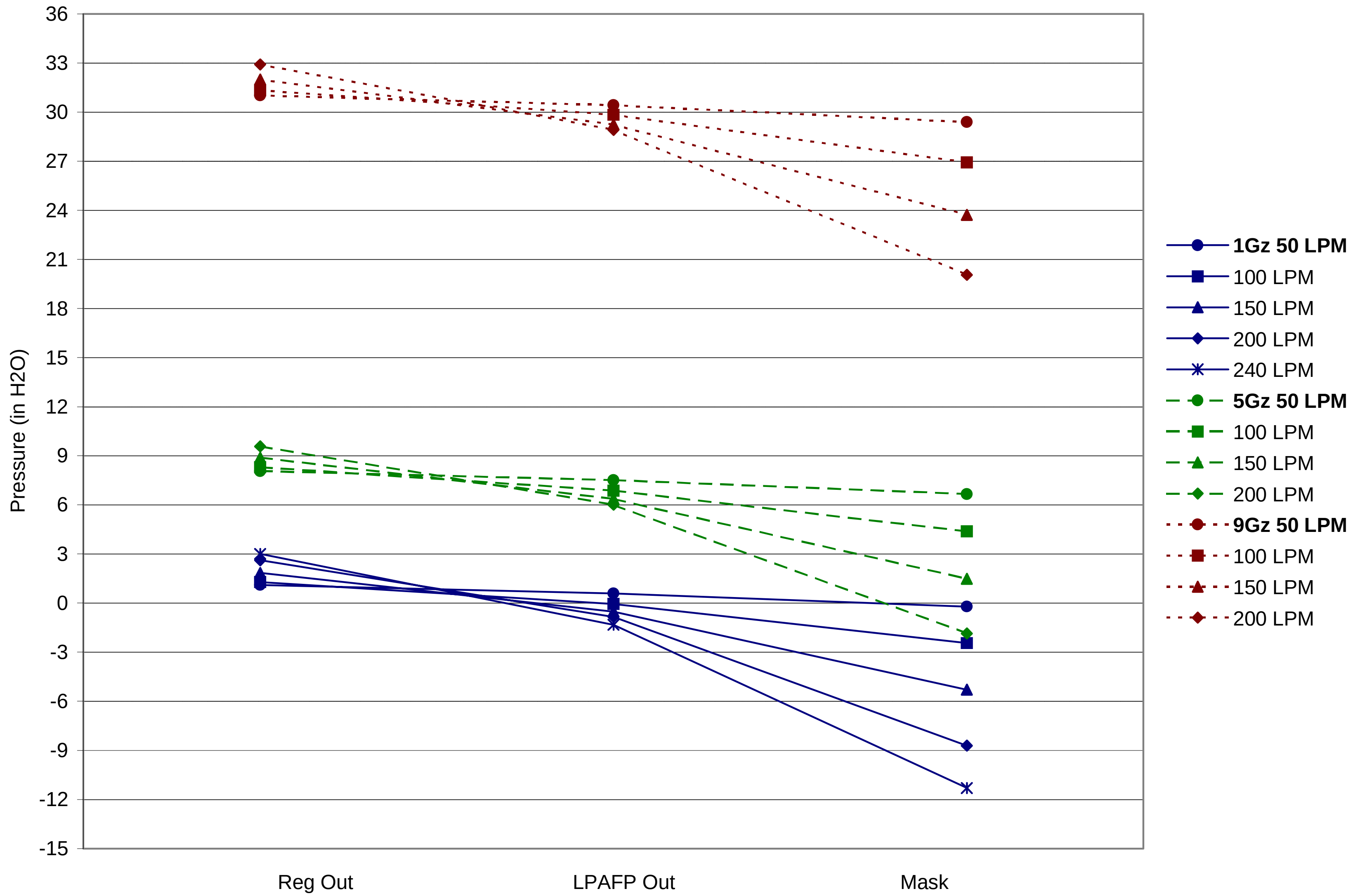

Figure E-41: Dynamic Flow System Pressures with LPAFP and 40 PSIG Regulator Inlet/70% Flow Restrictor

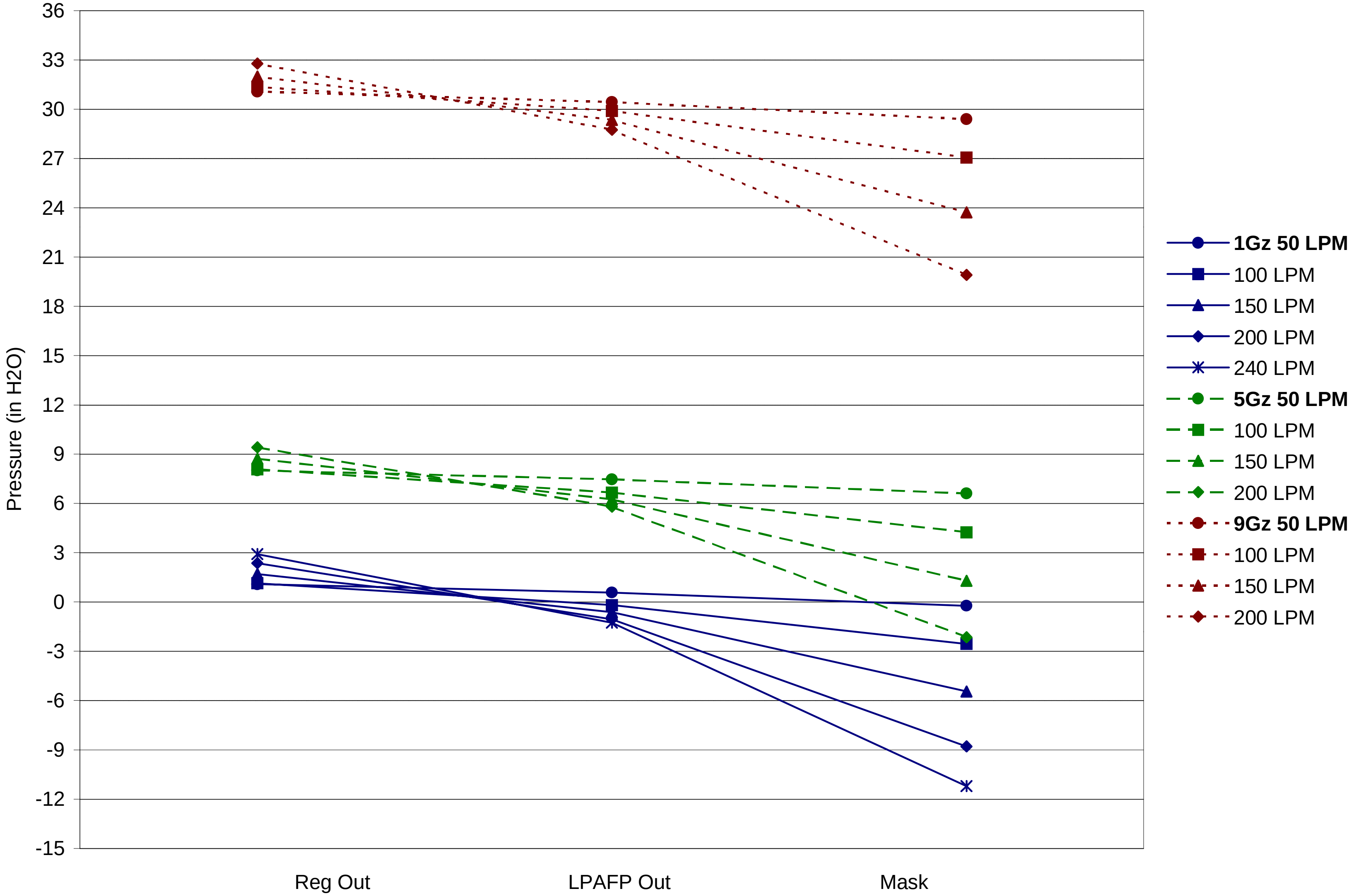

Figure E-42: Dynamic Flow System Pressures with LPAFP and 60 PSIG Regulator Inlet/70% Flow Restrictor

APPENDIX F
SYSTEM LAG TIME FIGURES

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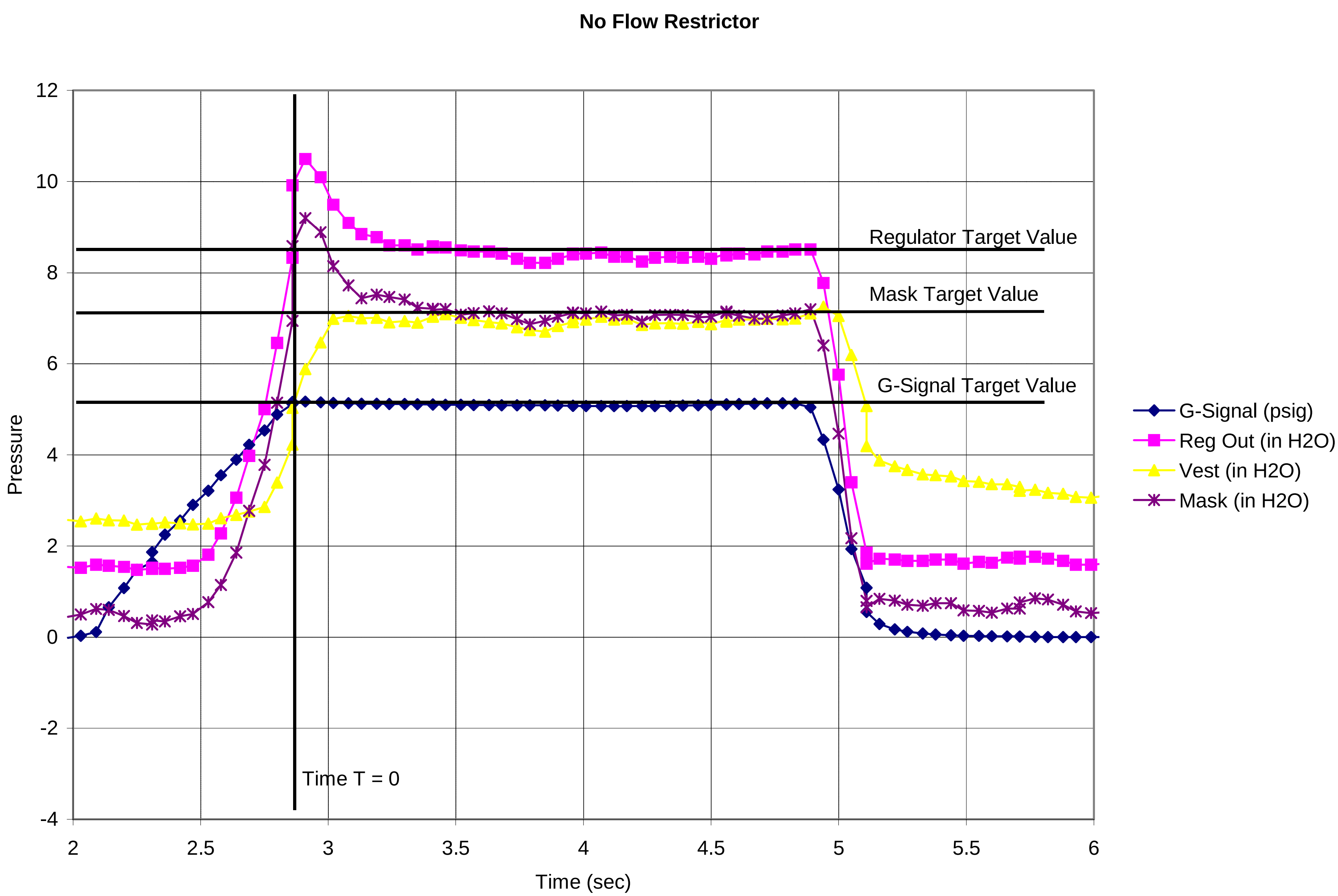


Figure F-1: System Lag Time at Baseline (no canister) and 40 PSIG Regulator Inlet/5G Transition

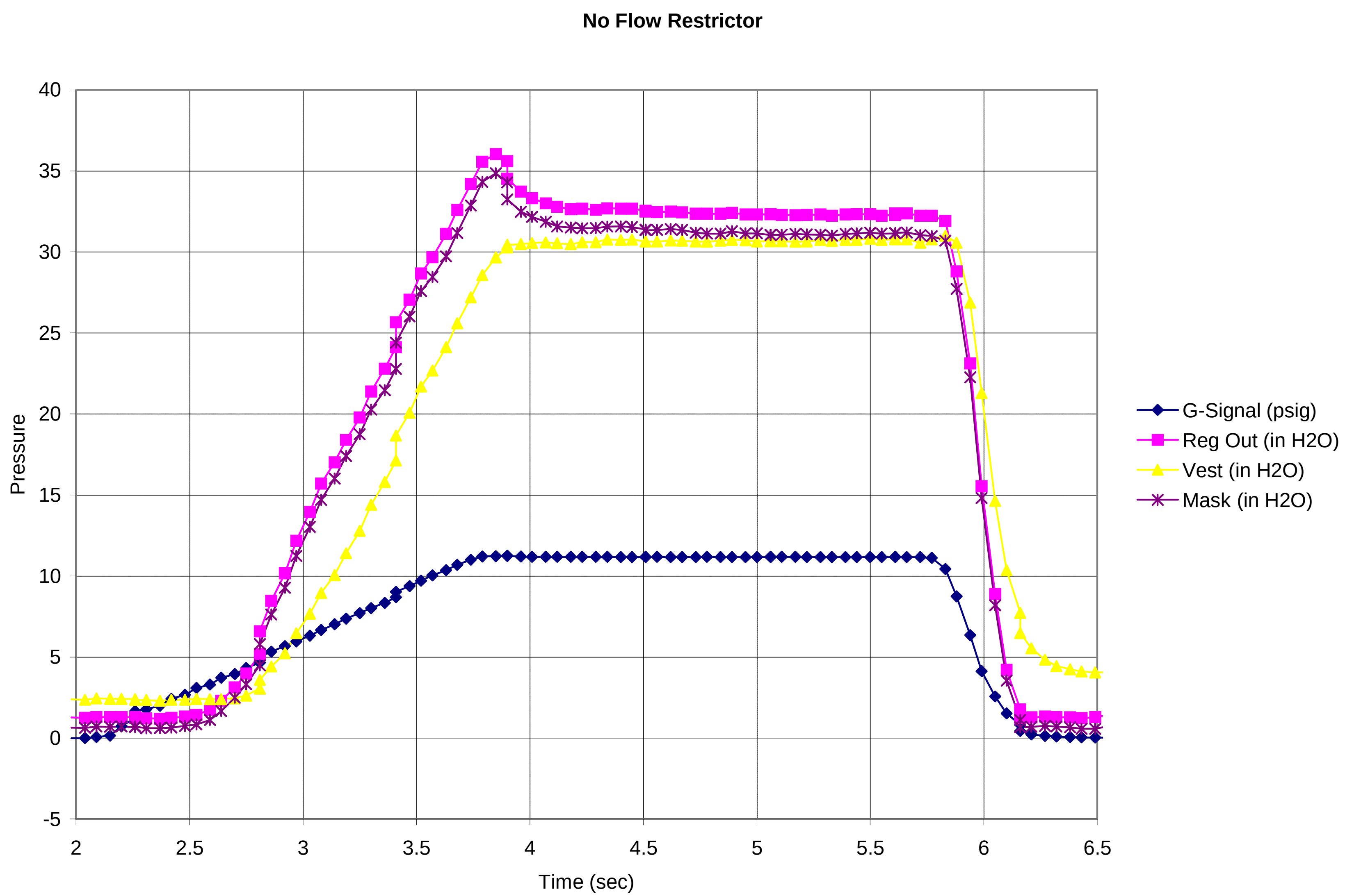


Figure F-2: System Lag Time at Baseline (no canister) and 40 PSIG Regulator Inlet/11G Transition

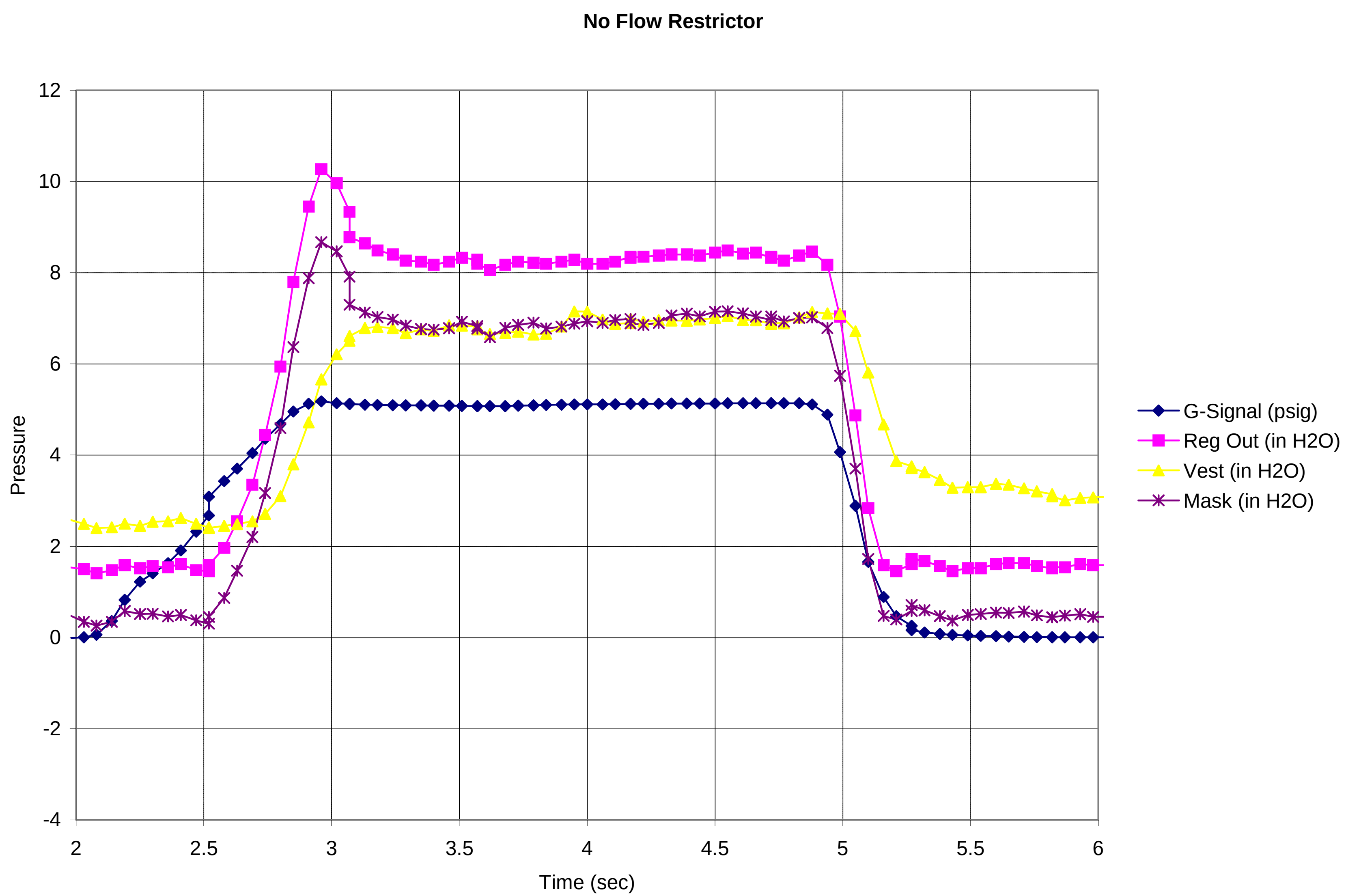
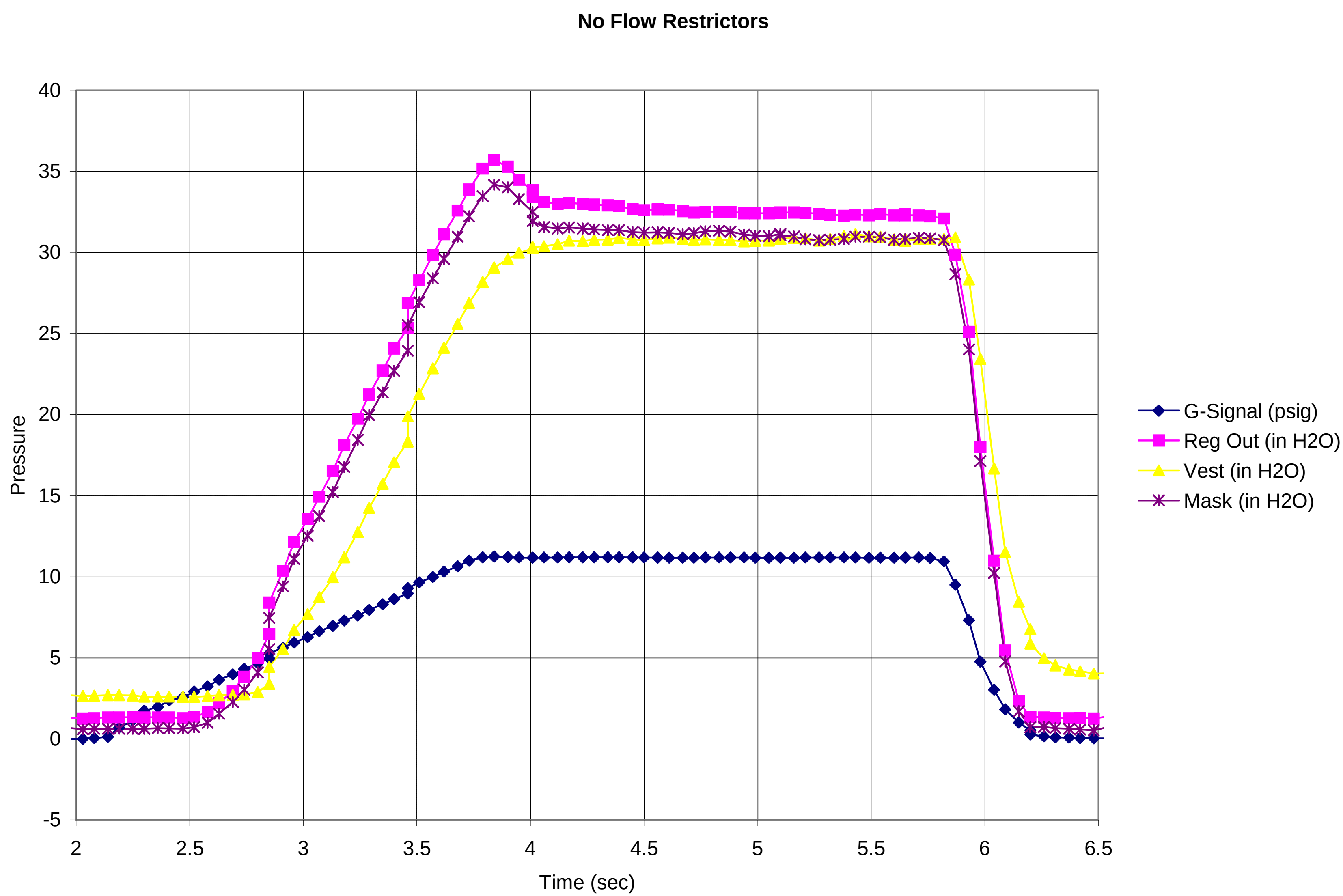


Figure F-3: System Lag Time at Baseline (no canister) and 60 PSIG Regulator Inlet/5G Transition



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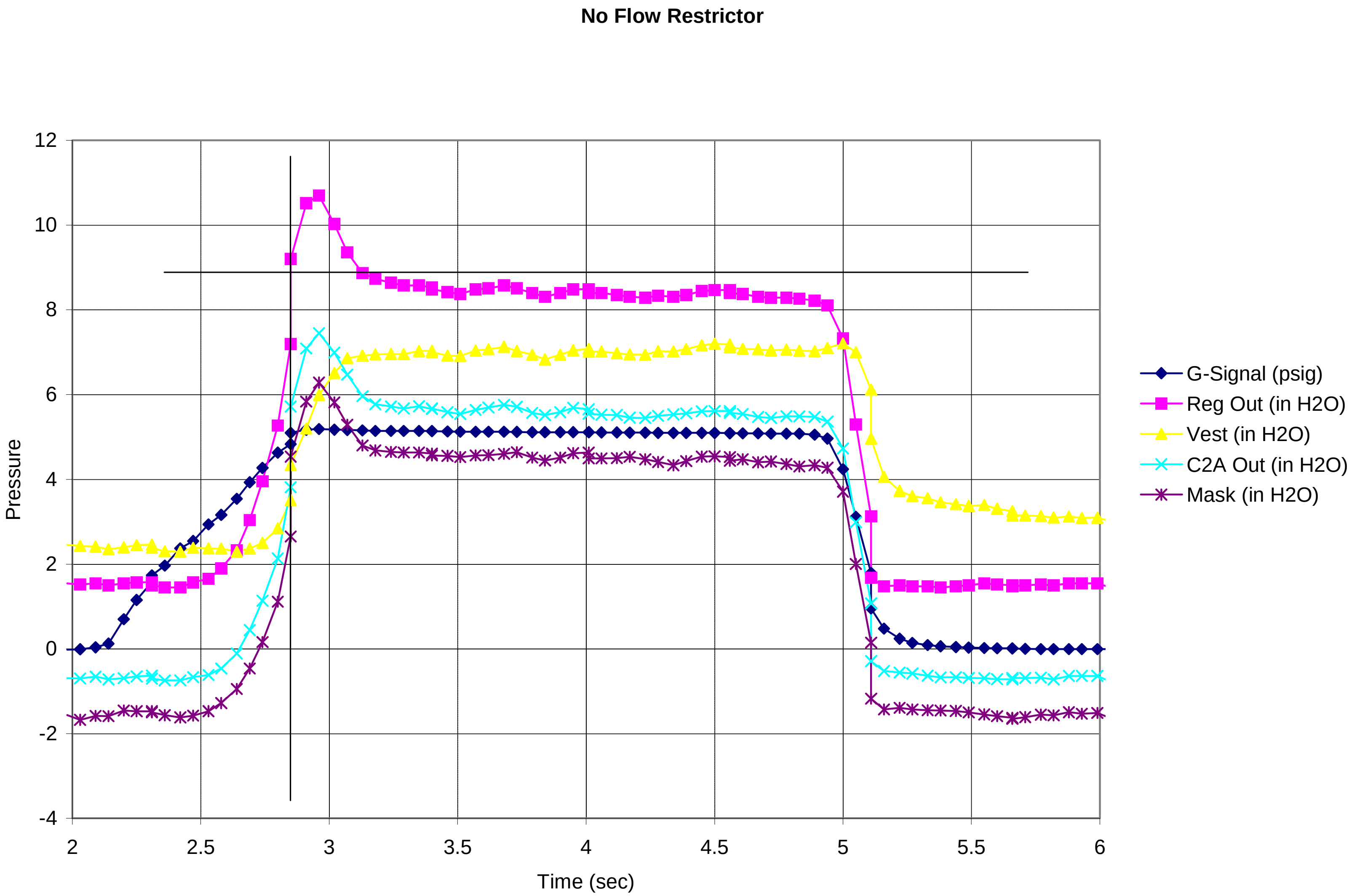
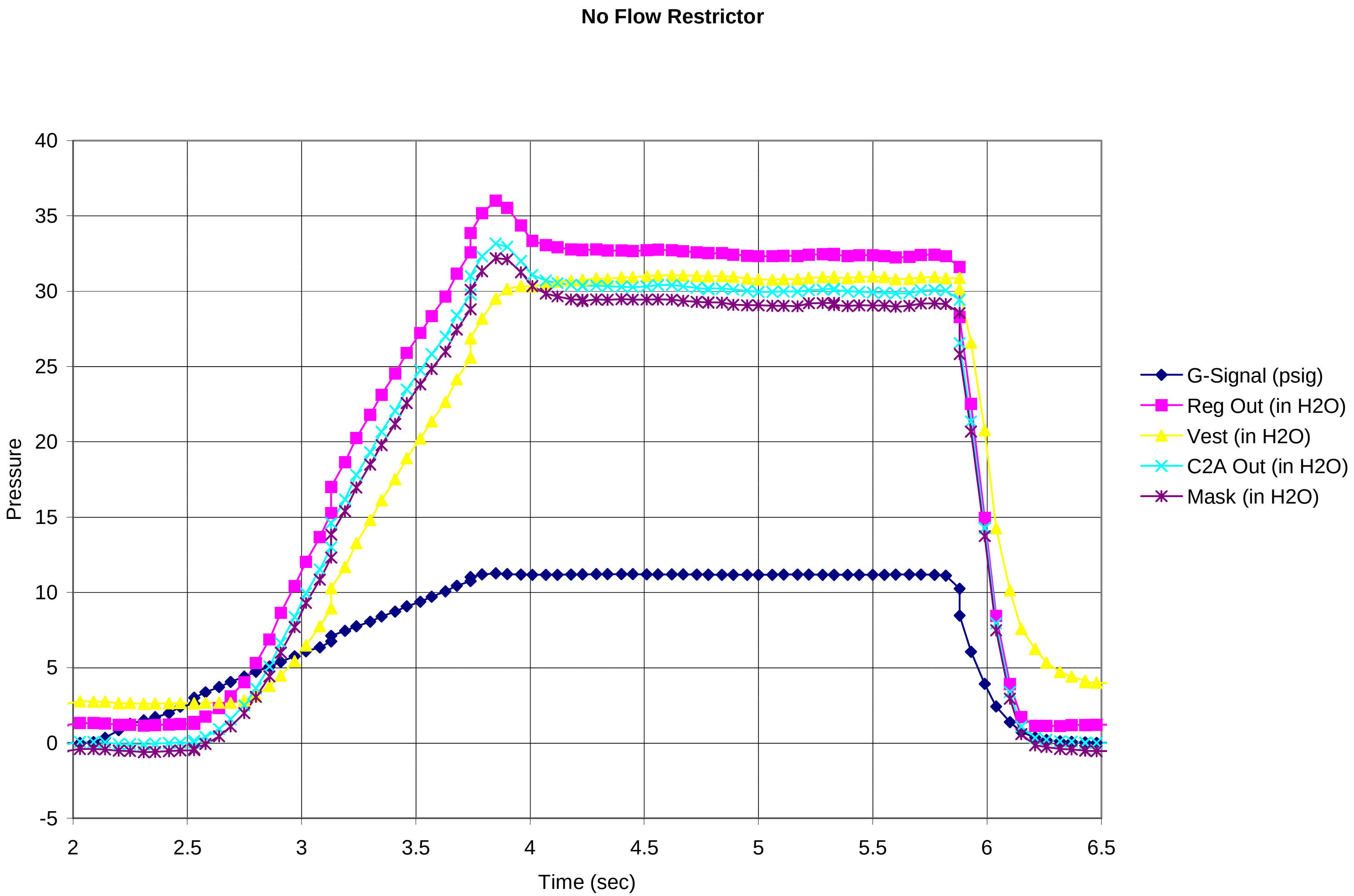


Figure F-5: System Lag Time with C2A1 and 40 PSIG Regulator Inlet/5G Transition



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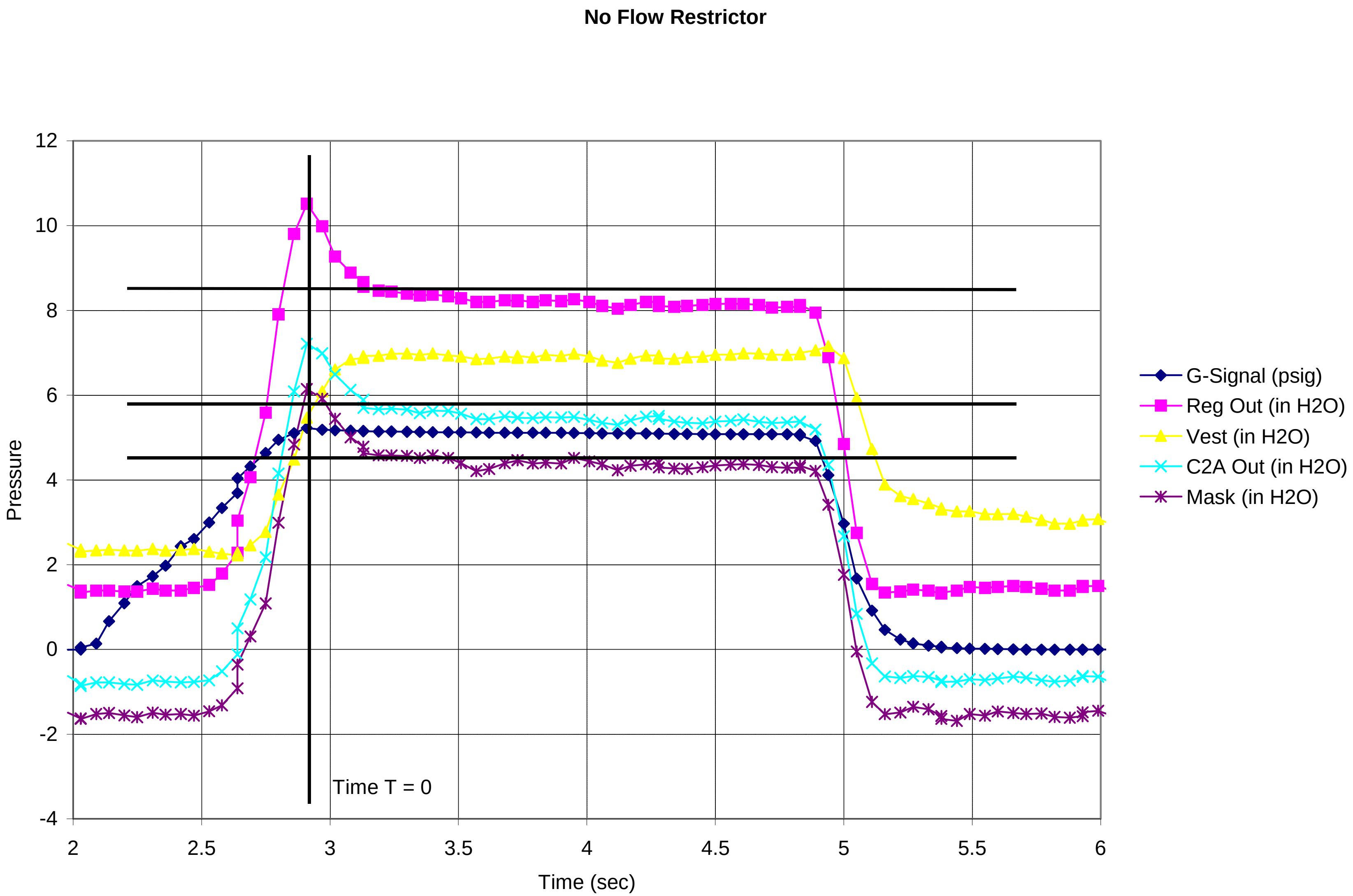


Figure F-7: System Lag Time with C2A1 and 60 PSIG Regulator Inlet/5G Transition

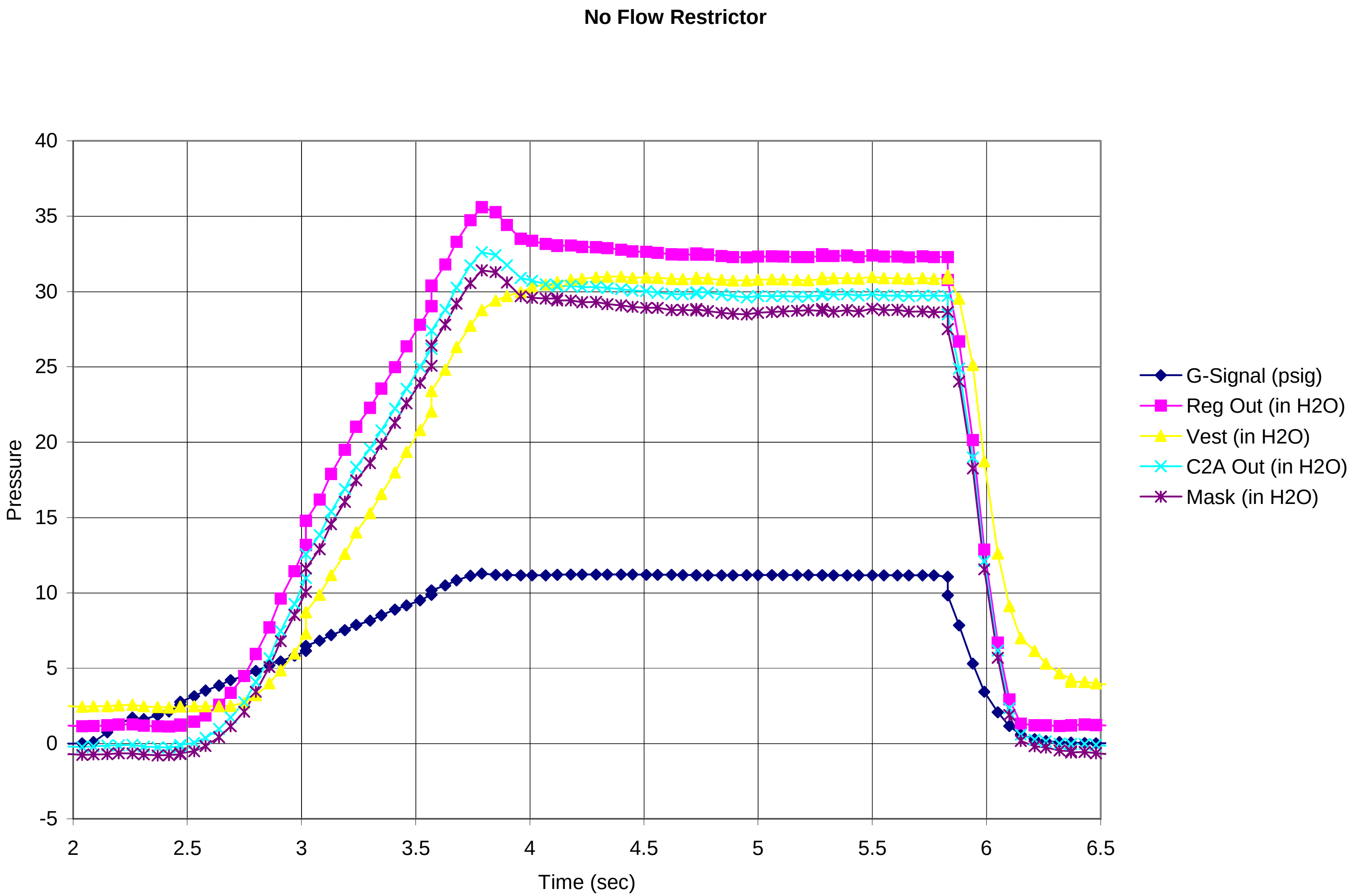


Figure F-8: System Lag Time with C2A1 and 60 PSIG Regulator Inlet/11G Transition

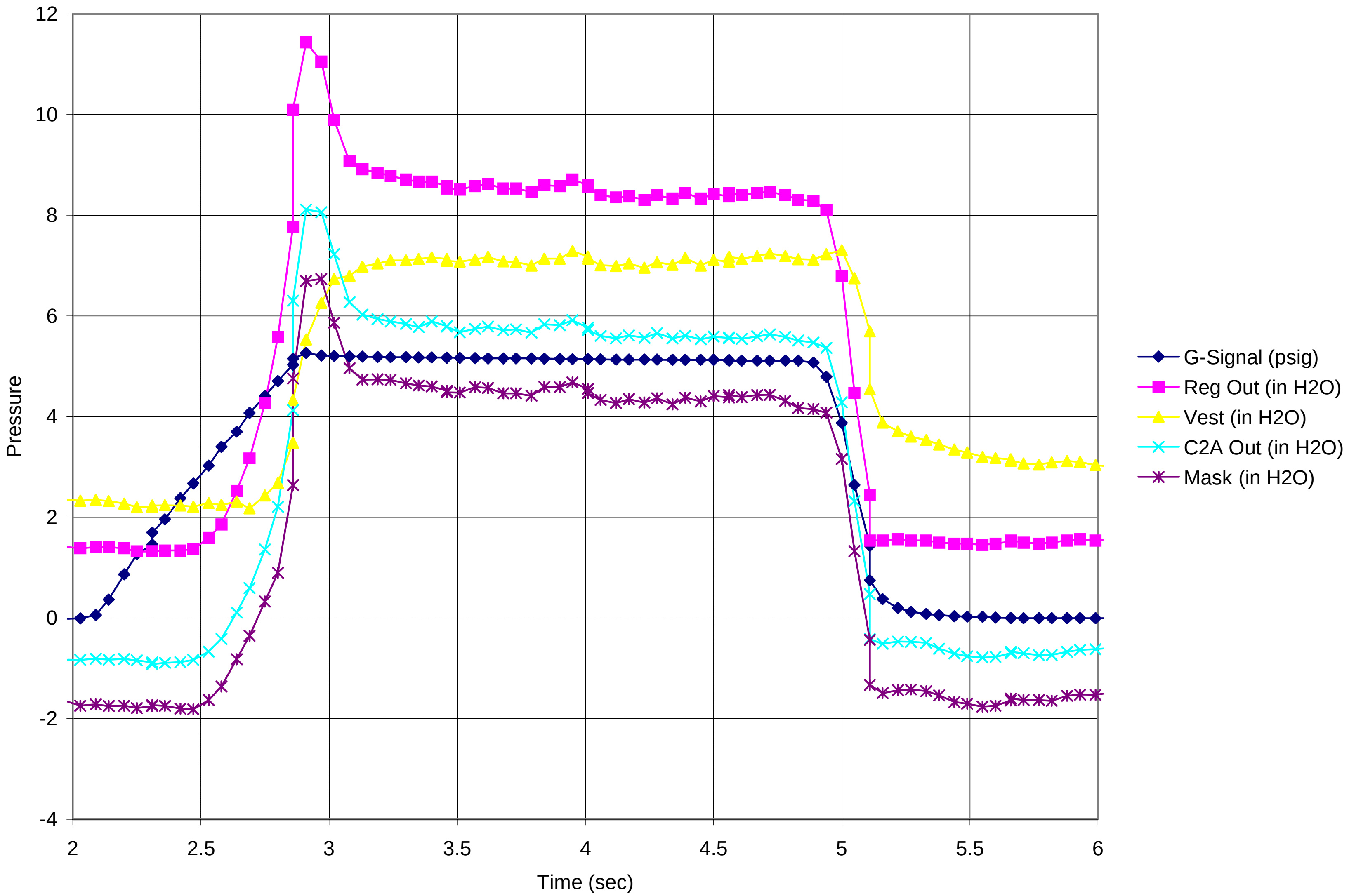


Figure F-9: System Lag Time with C2A1 and 40 PSIG Regulator Inlet/5G Transition/40% Flow Restrictor

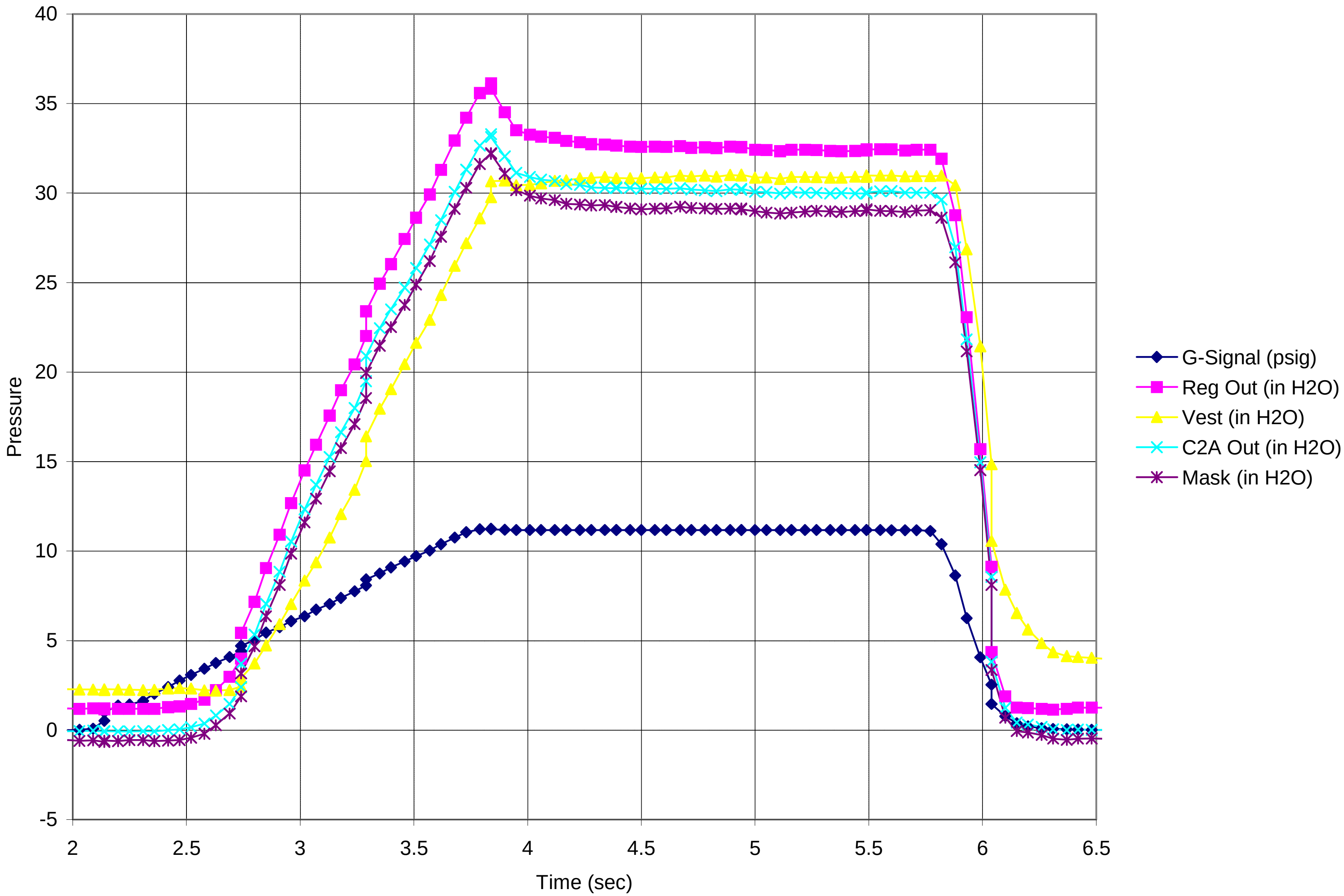


Figure F-10: System Lag Time with C2A1 and 40 PSIG Regulator Inlet/11G Transition/40% Flow Restrictor

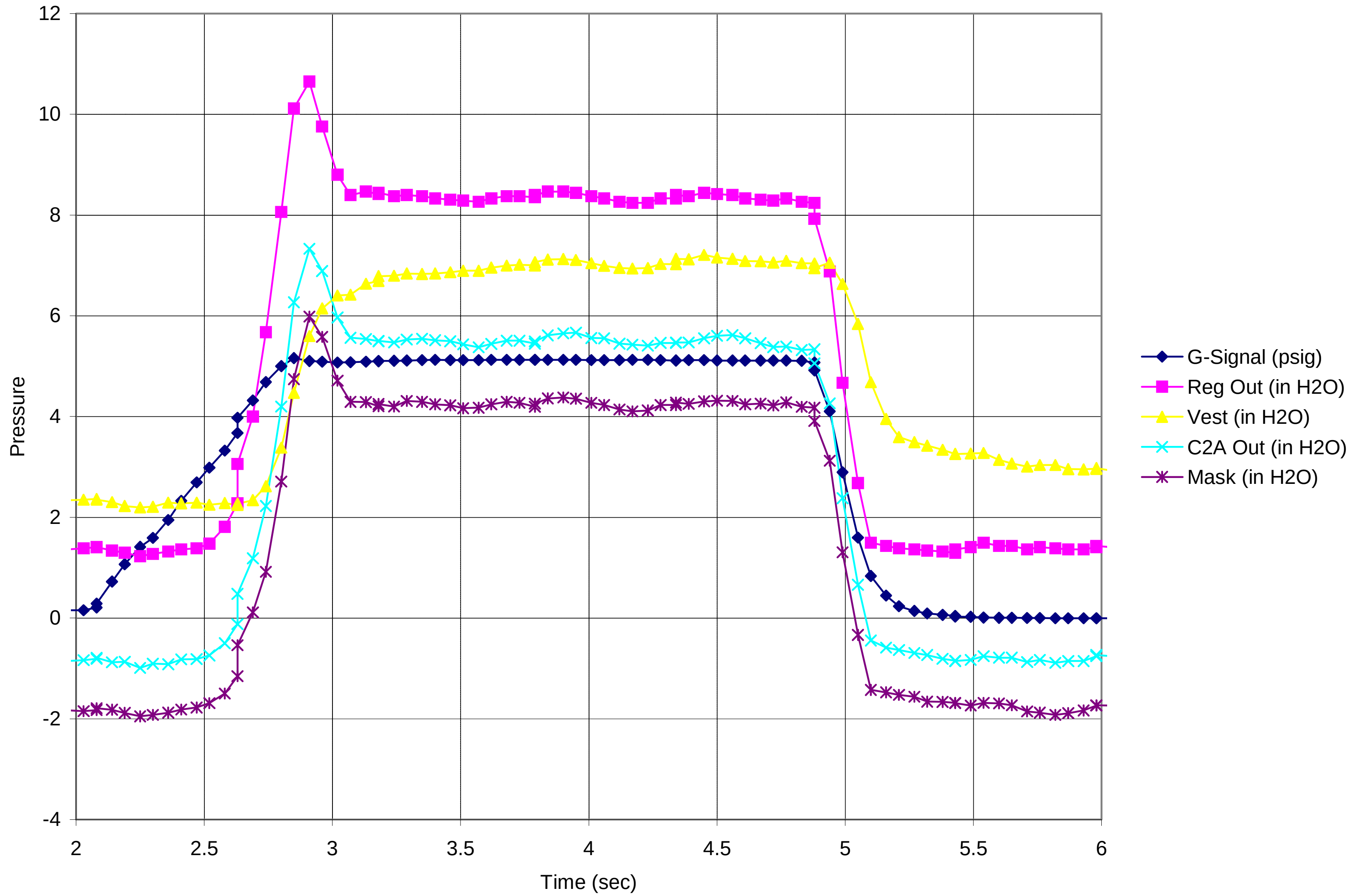
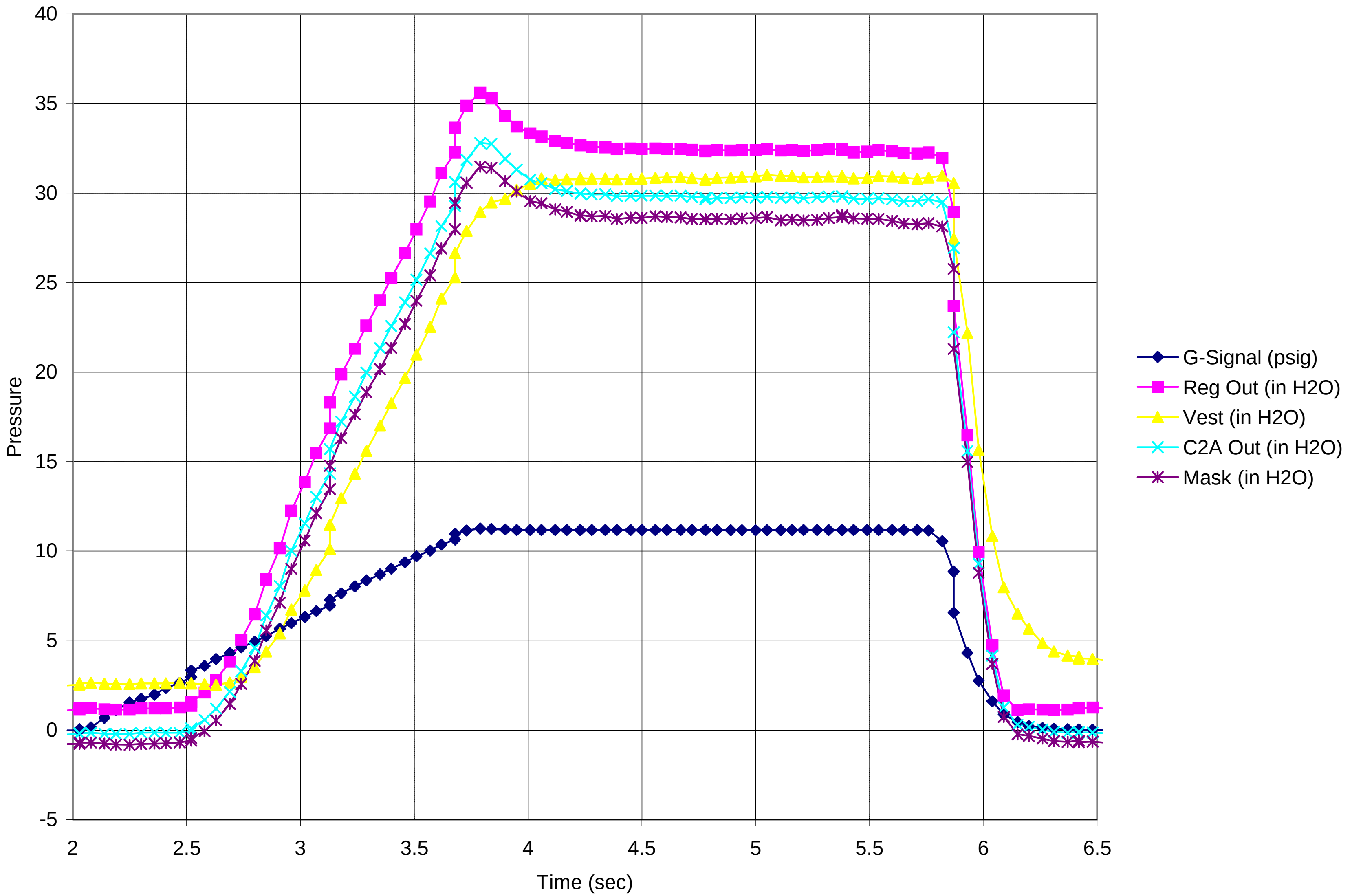


Figure F-11: System Lag Time with C2A1 and 60 PSI/G Regulator Inlet/5G Transition/40% Flow Restrictor



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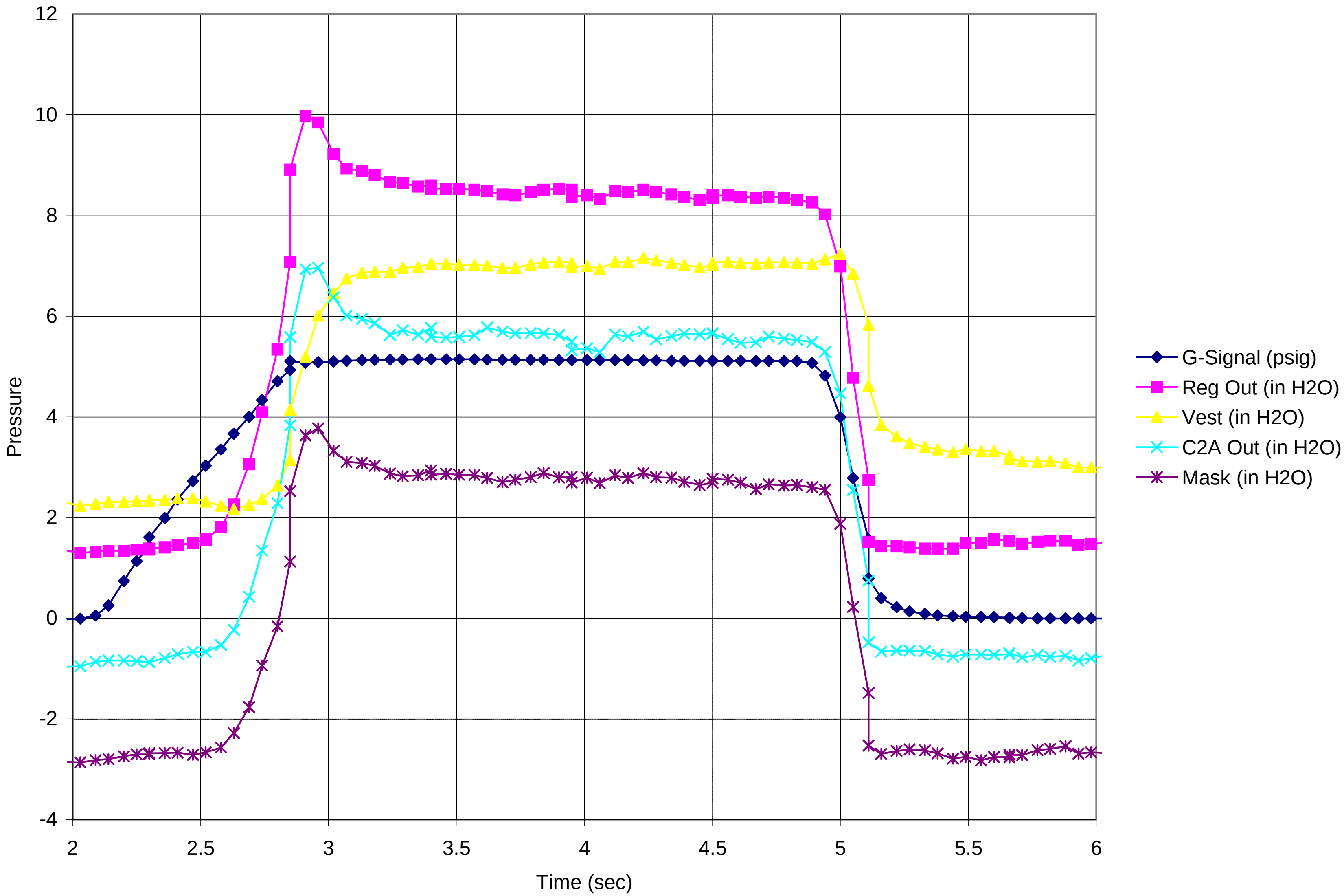

Figure F-13: System Lag Time with C2A1 and 40 PSIG Regulator Inlet/5G Transition/70% Flow Restrictor

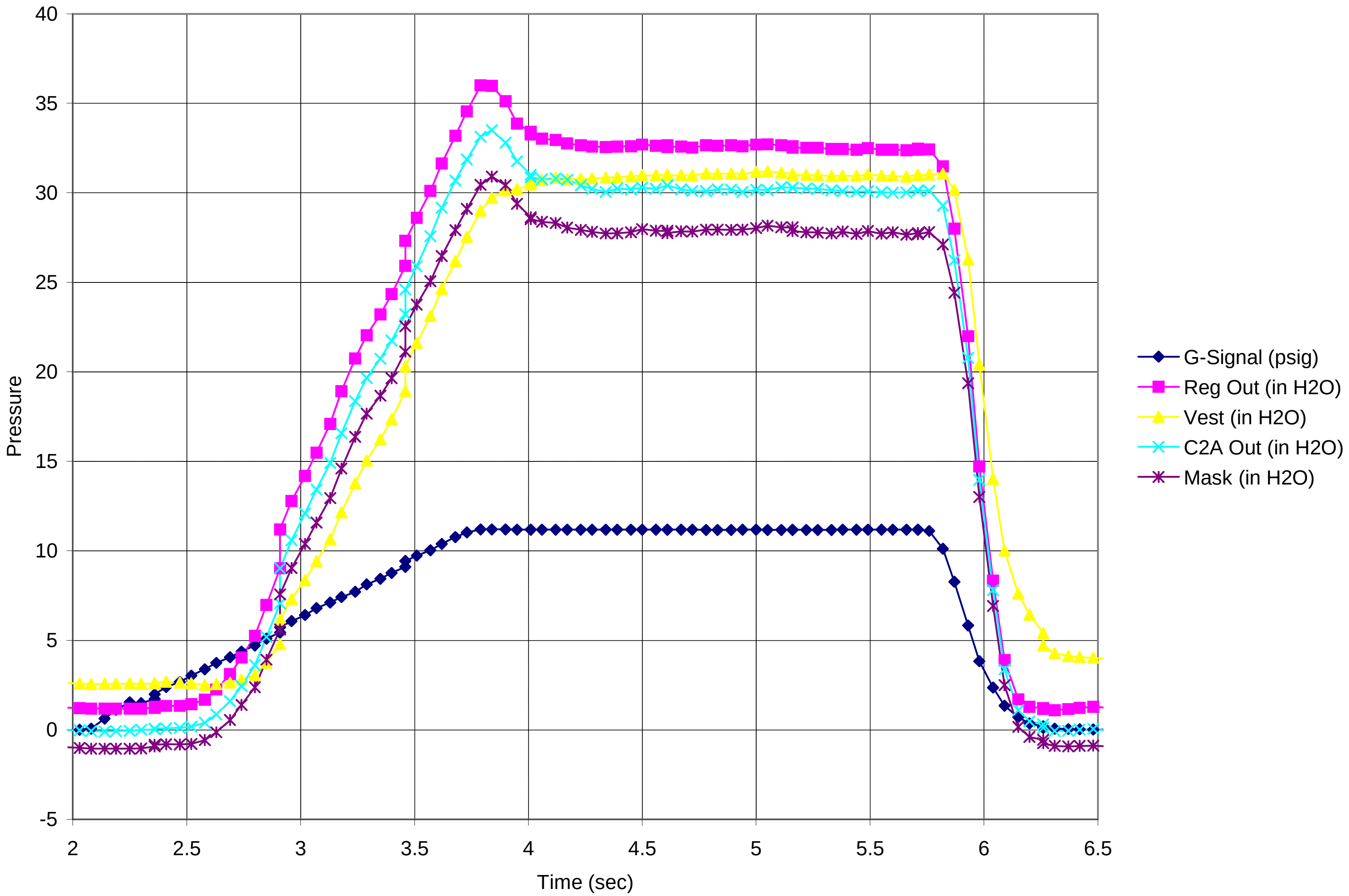

Figure F-14: System Lag Time with C2A1 and 40 PSIG Regulator Inlet/11G Transition/70% Flow Restrictor

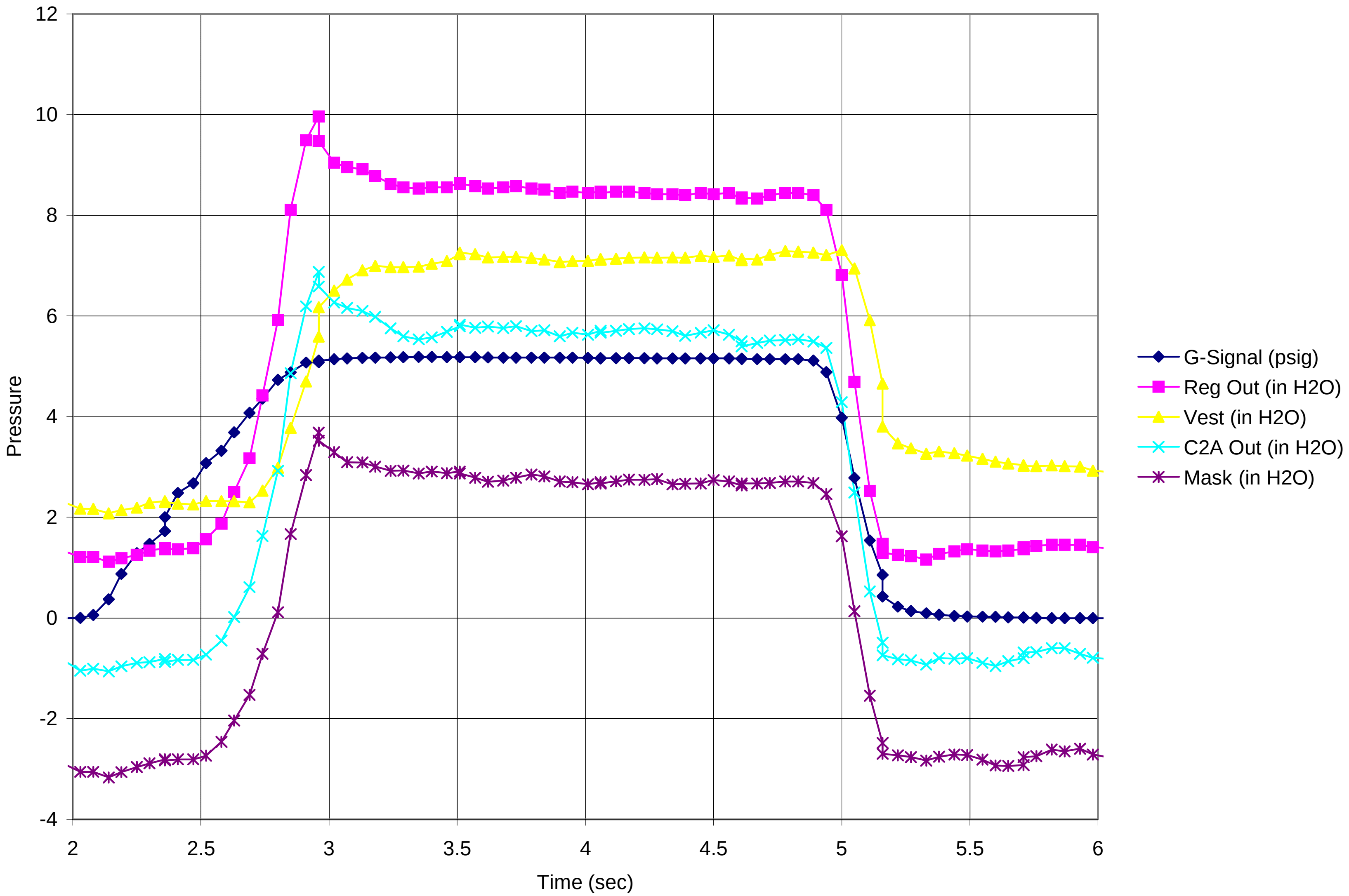

Figure F-15: System Lag Time with C2A1 and 60 PSIG Regulator Inlet/5G Transition/70% Flow Restrictor

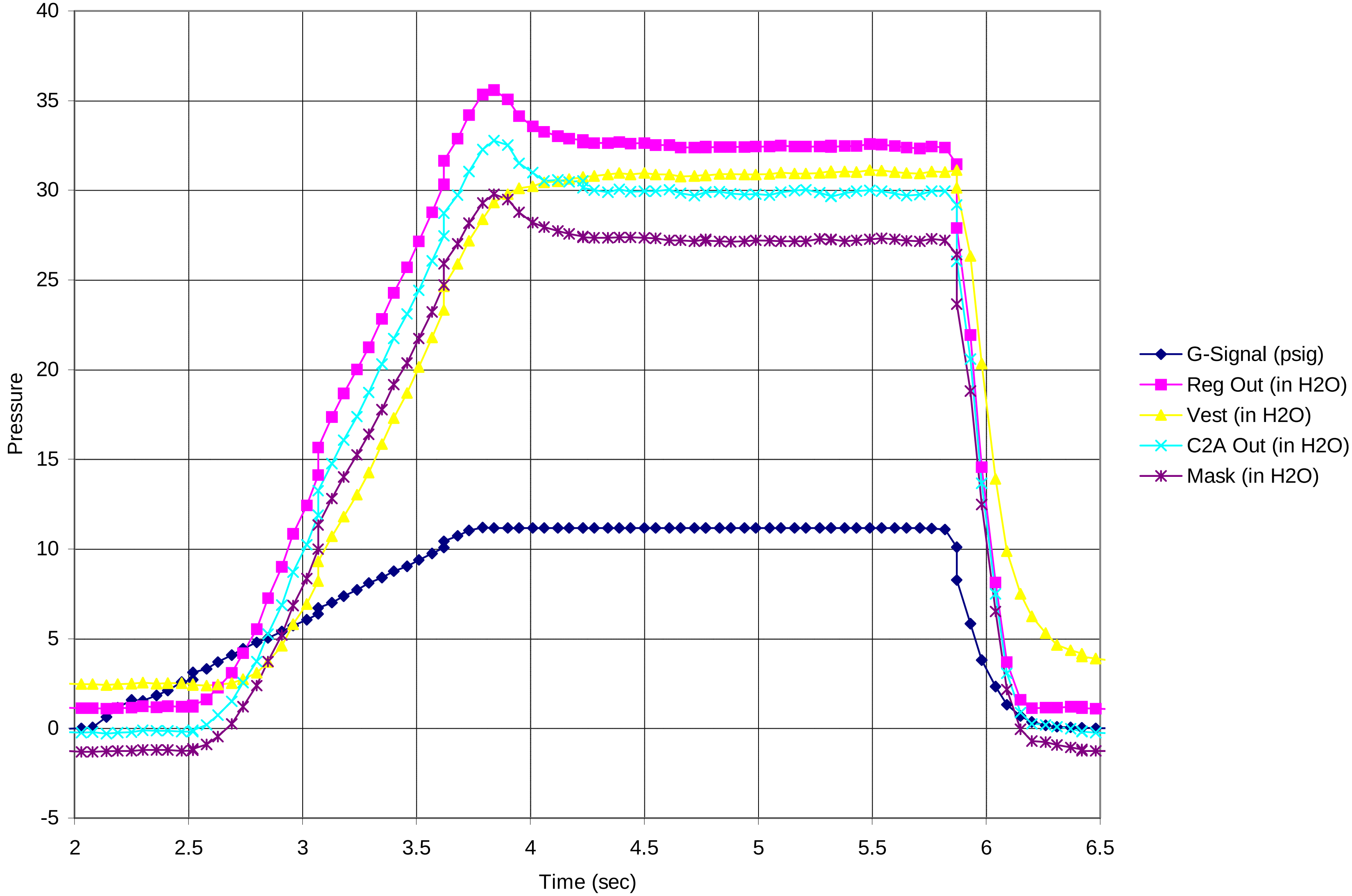

Figure F-16: System Lag Time with C2A1 and 60 PSIG Regulator Inlet/11G Transition/70% Flow Restrictor

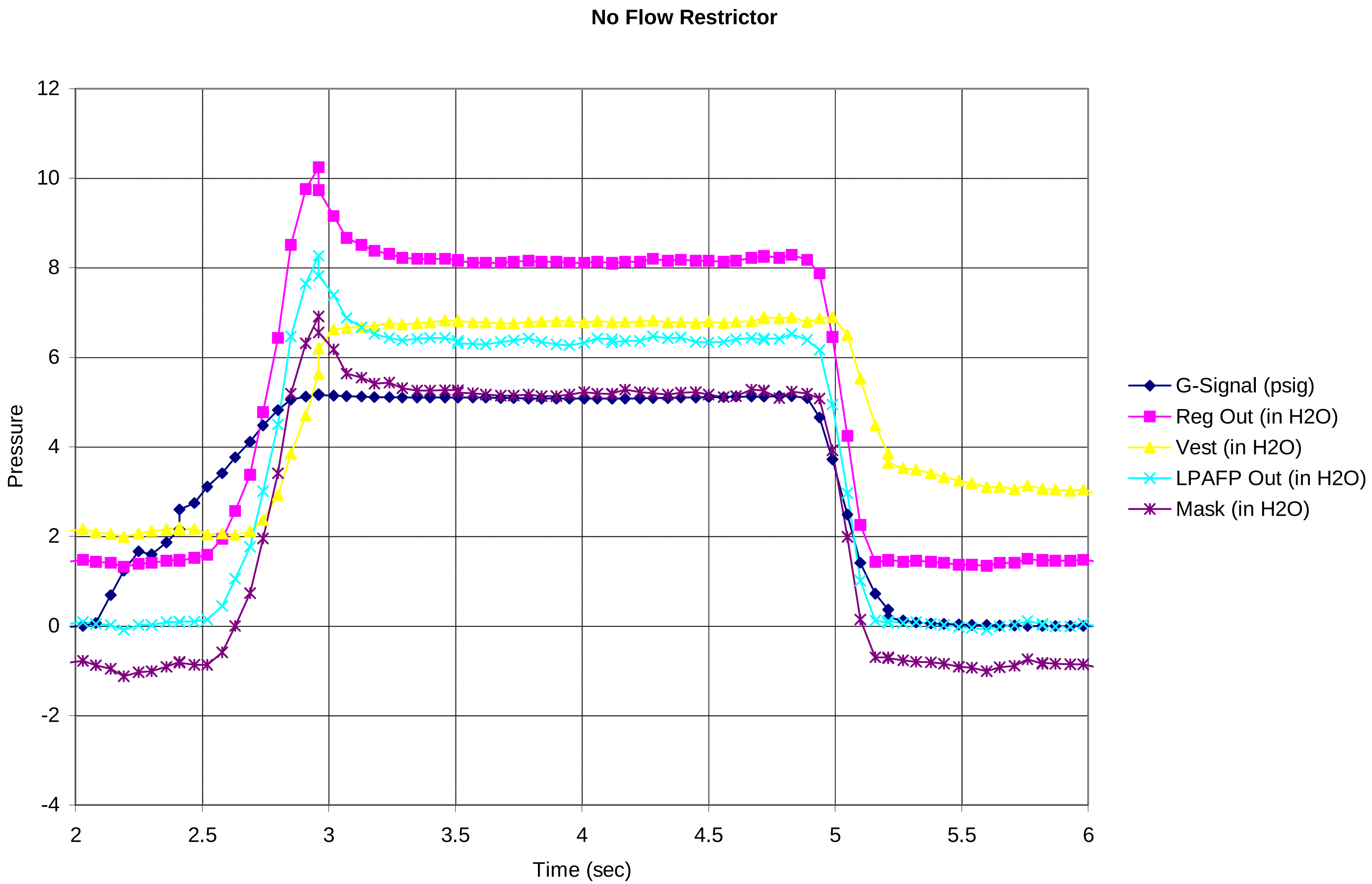

Figure F-17: System Lag Time with LPAFP and 40 PSIG Regulator Inlet/5G Transition

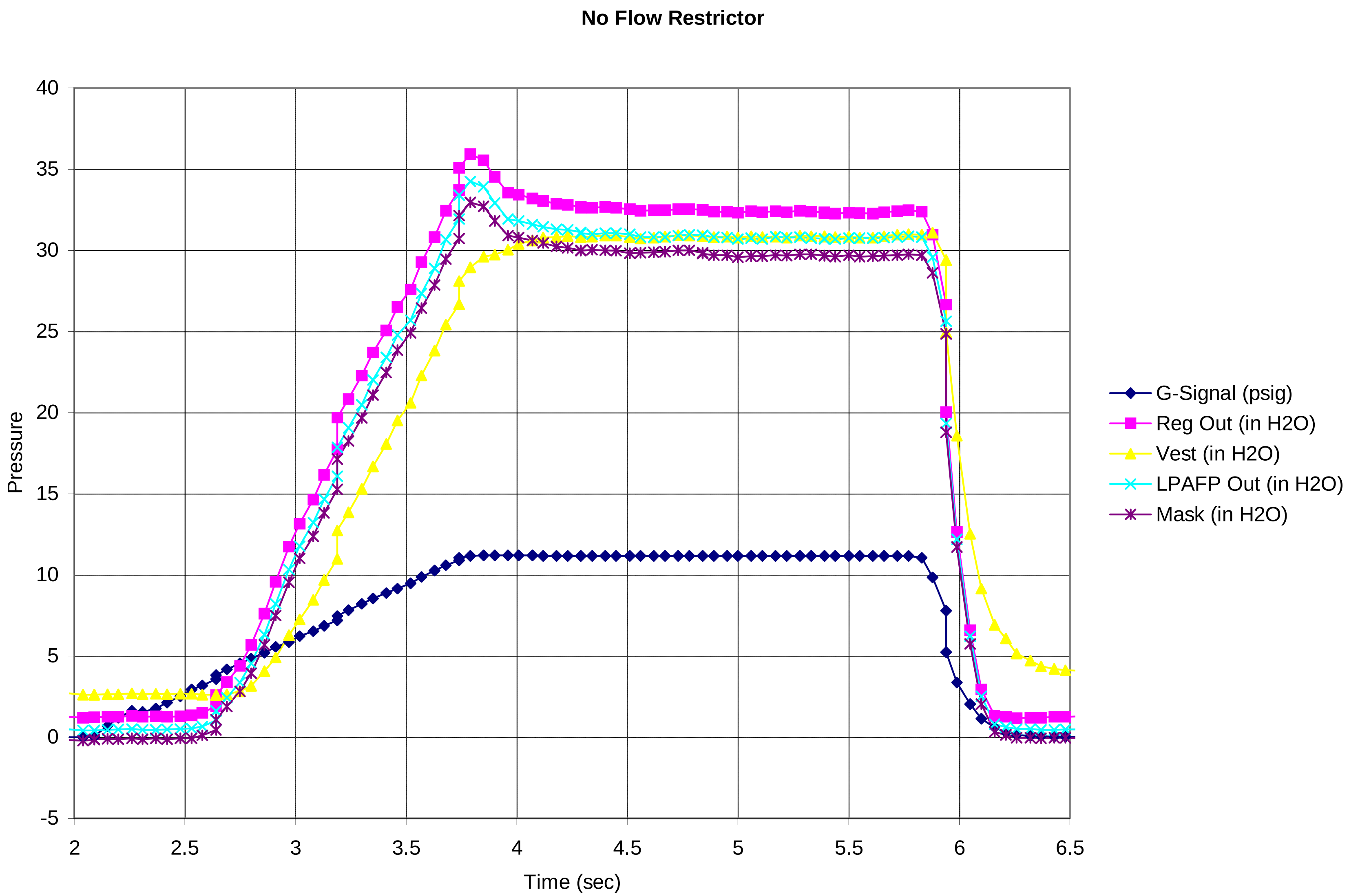

Figure F-18: System Lag Time with LPAFP and 40 PSIG Regulator Inlet/11G Transition

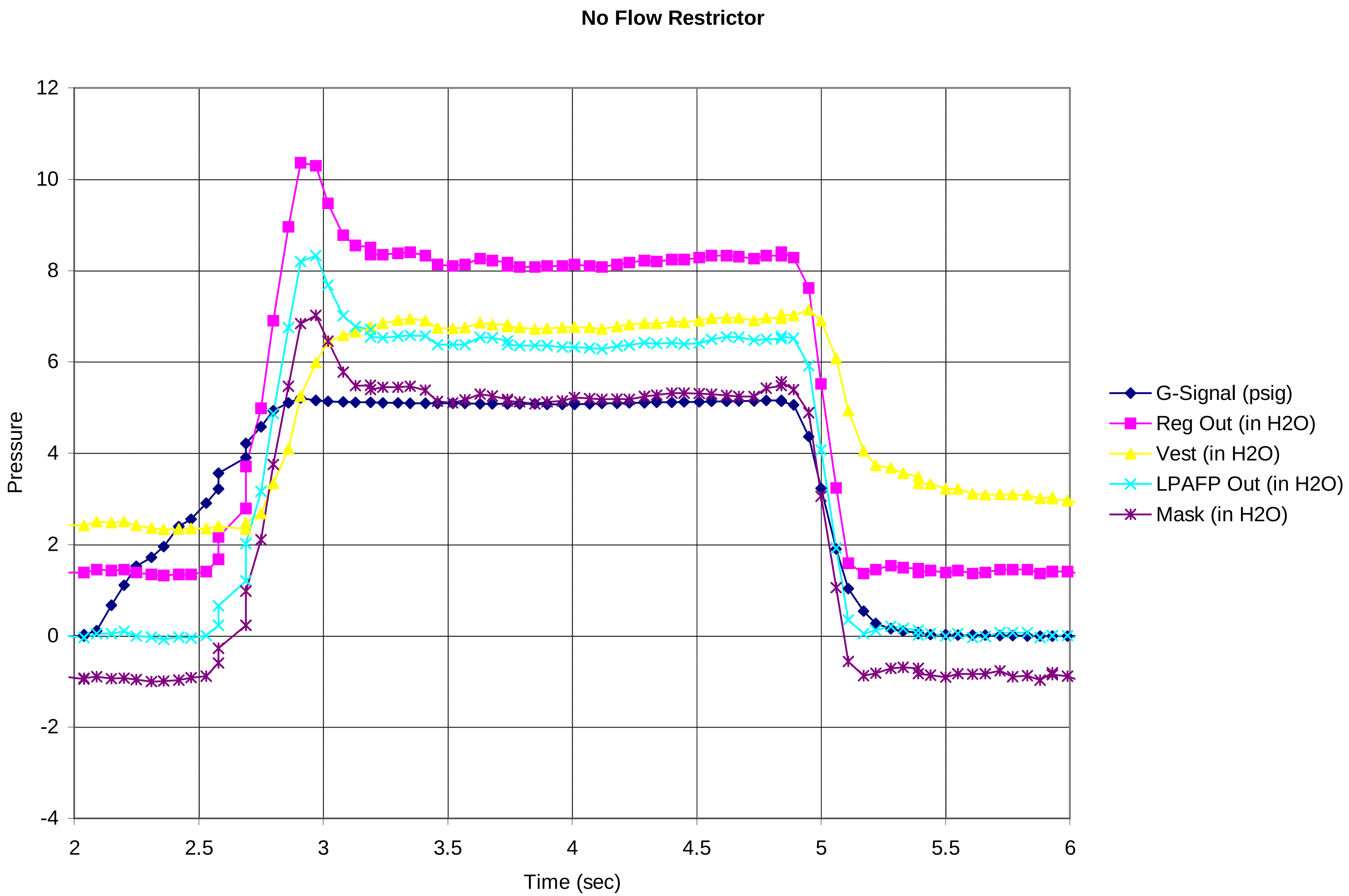

Figure F-19: System Lag Time with LPAFP and 60 PSIG Regulator Inlet/5G Transition

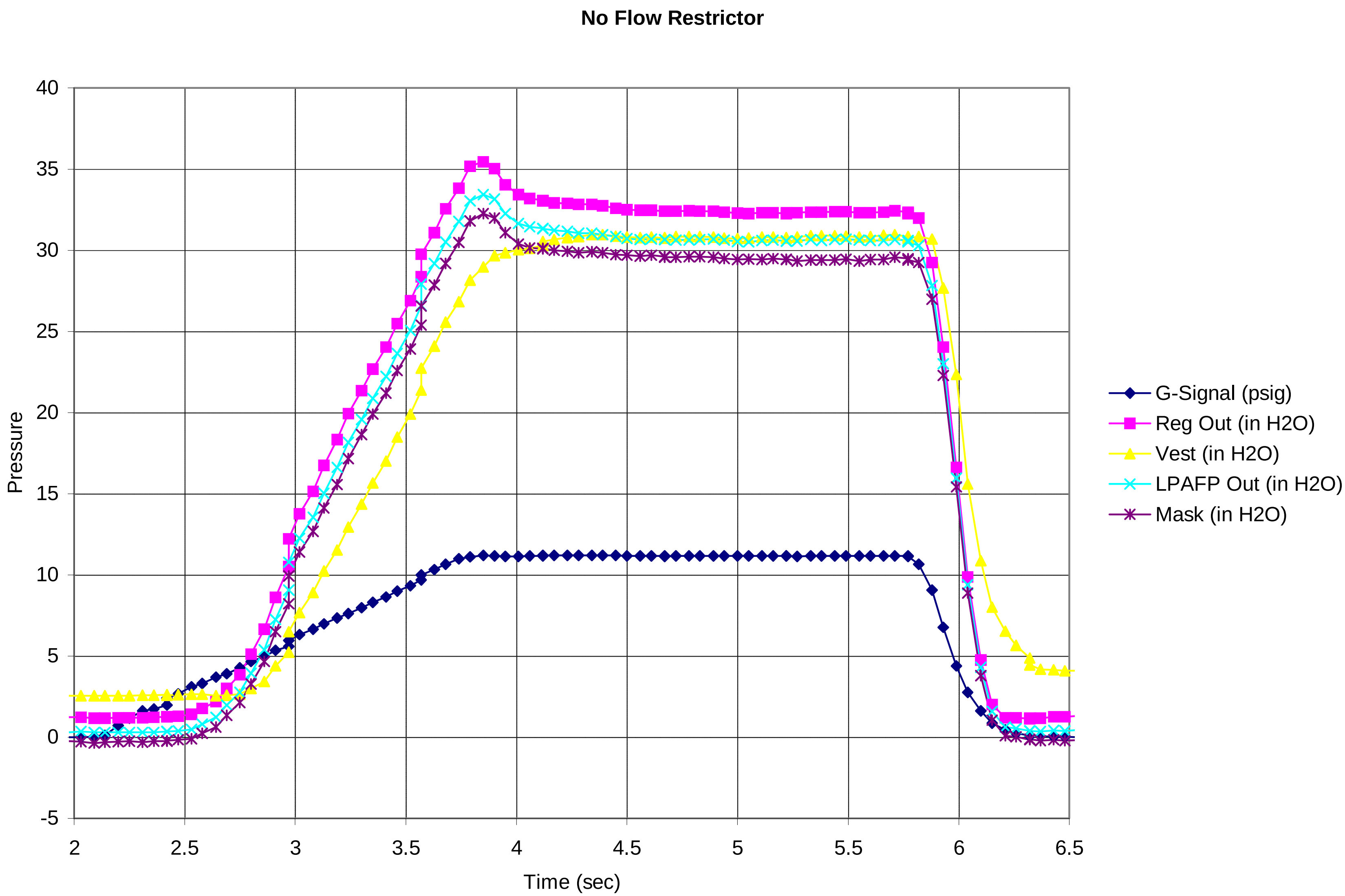

Figure F-20: System Lag Time with LPAFP and 60 PSIG Regulator Inlet/11G Transition

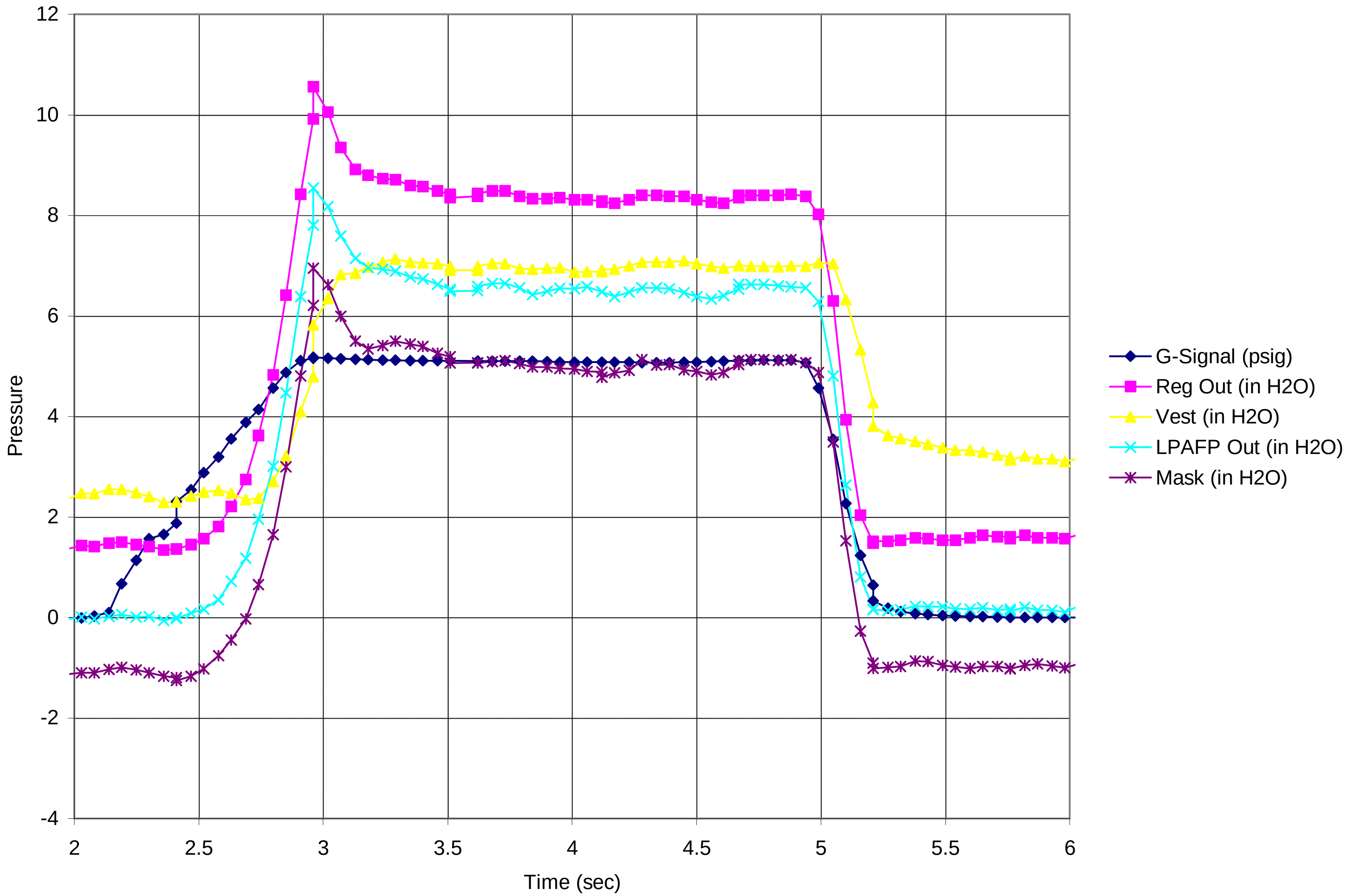

Figure F-21: System Lag Time with LPAFP and 40 PSIG Regulator Inlet/5G Transition/40% Flow Restrictor

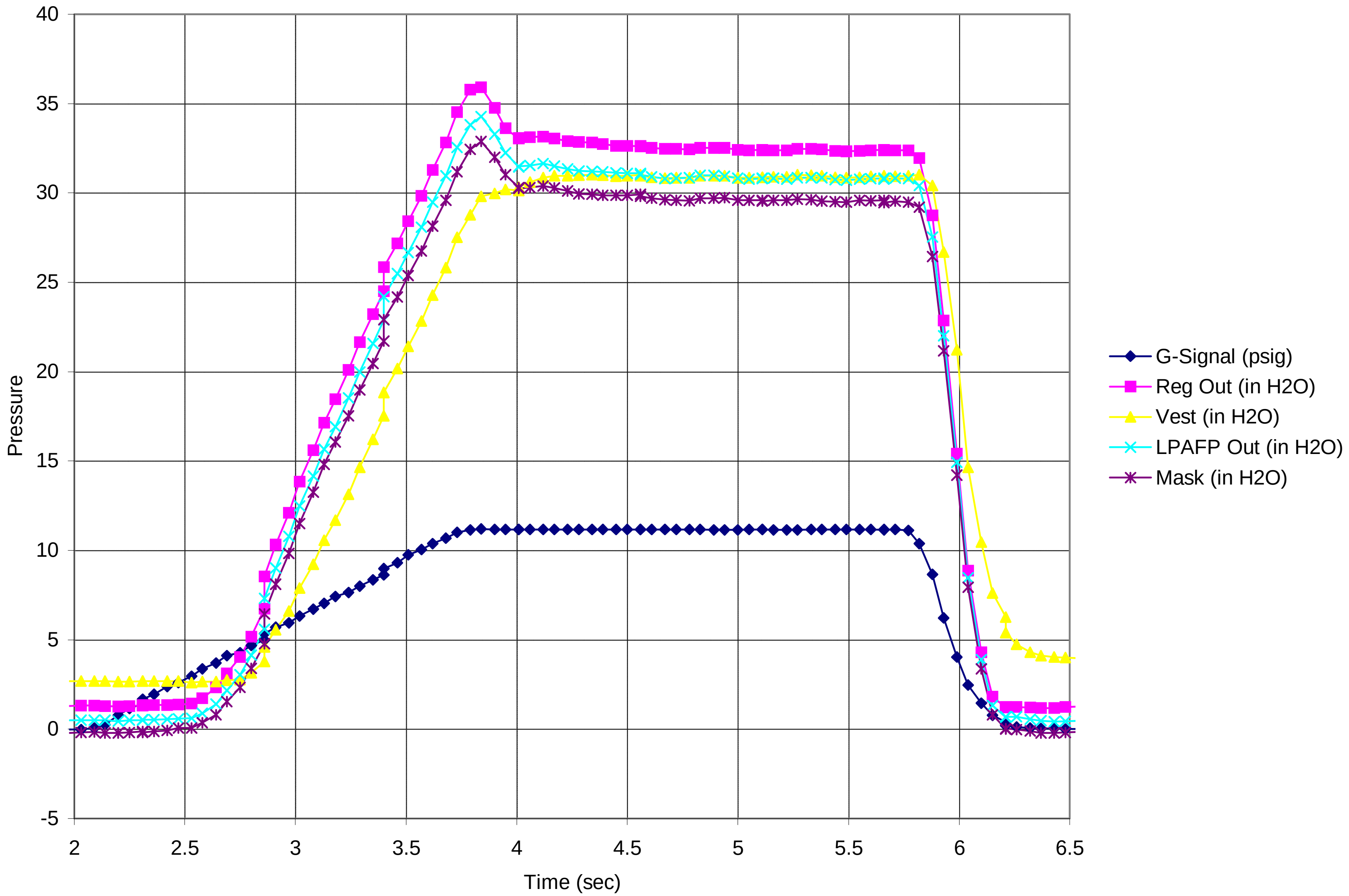

Figure F-22: System Lag Time with LPAFP and 40 PSIG Regulator Inlet/11G Transition/40% Flow Restrictor

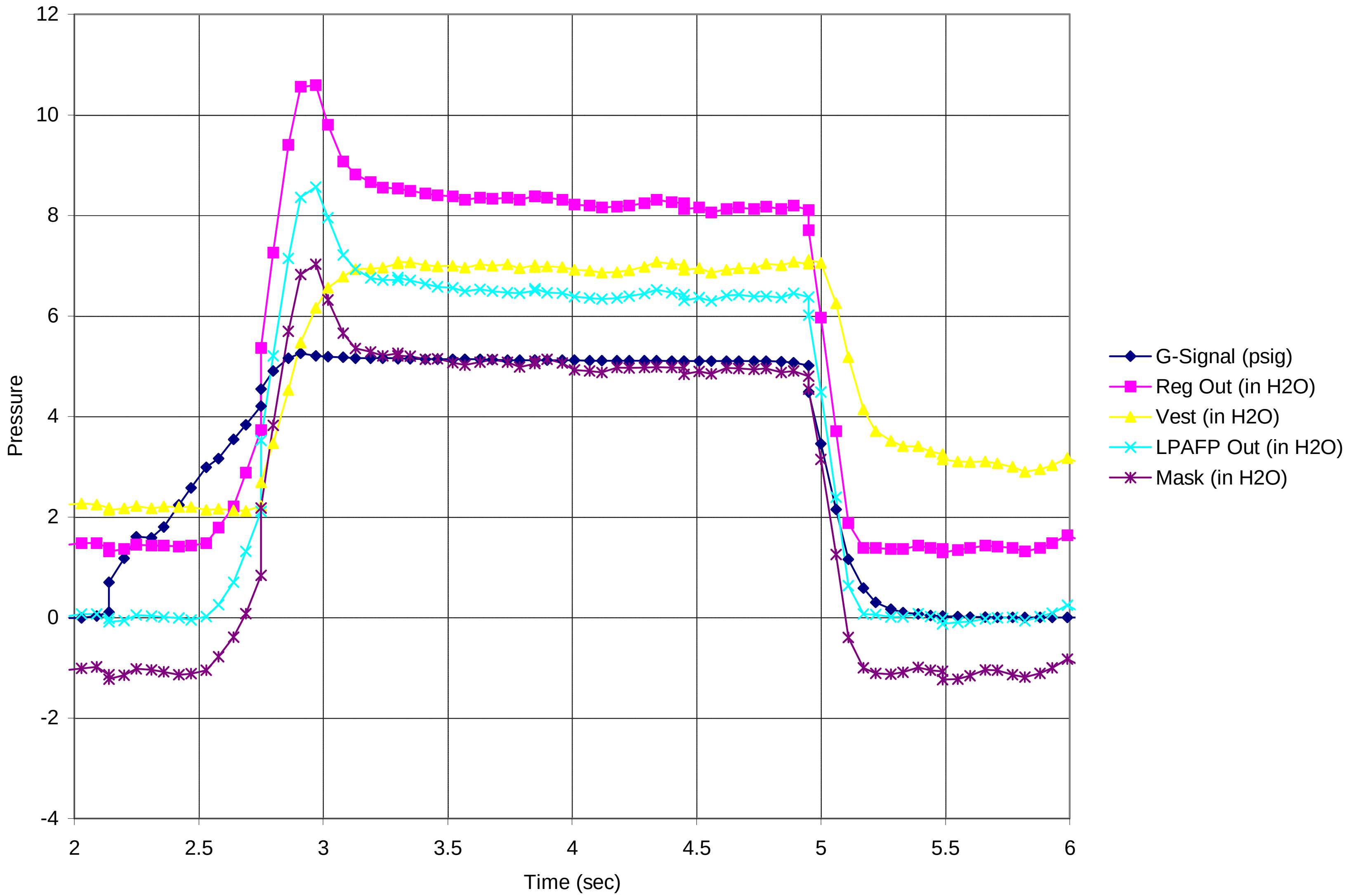

Figure F-23: System Lag Time with LPAFP and 60 PSIG Regulator Inlet/5G Transition/40% Flow Restrictor

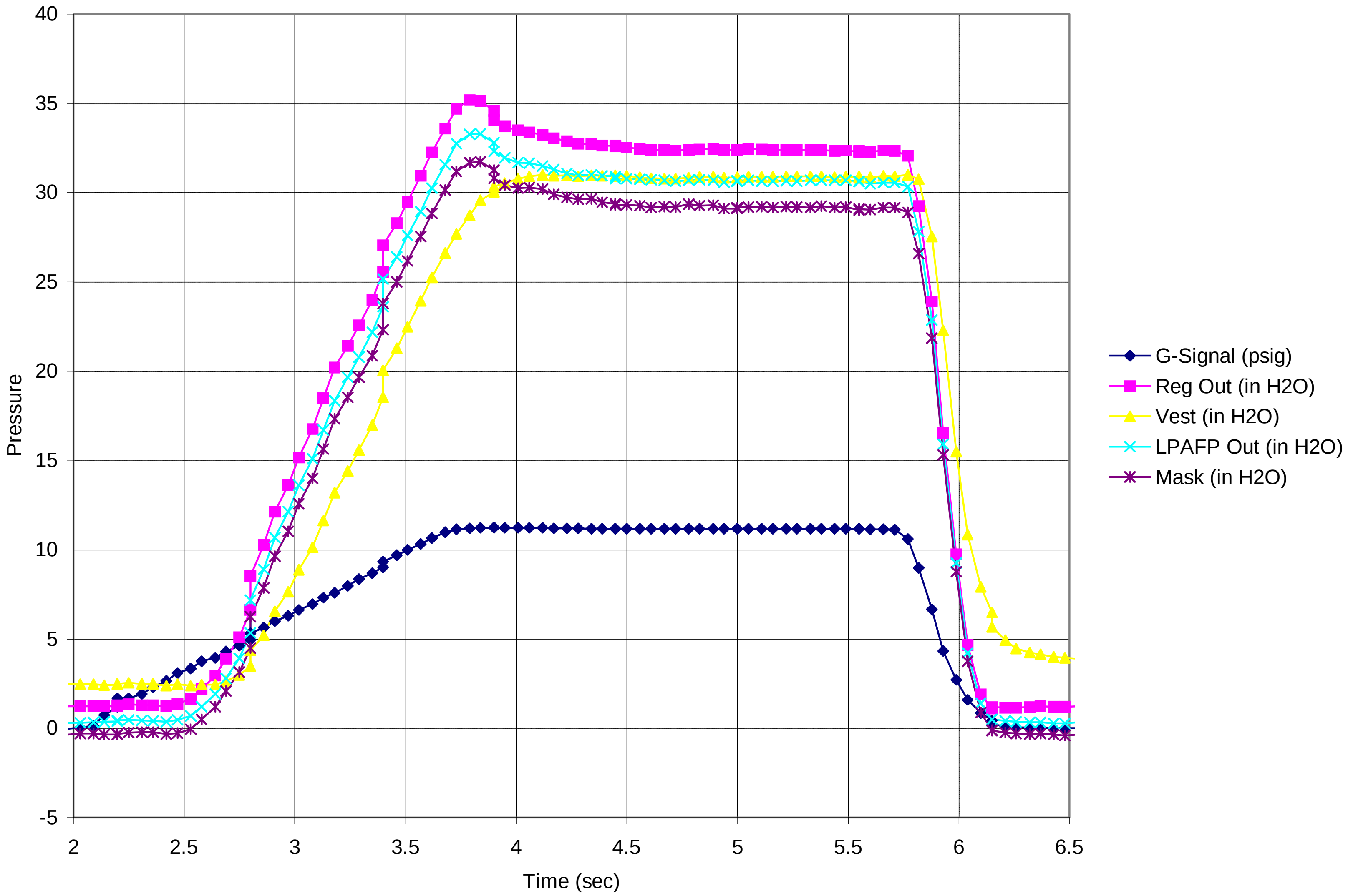

Figure F-24: System Lag Time with LPAFP and 60 PSIG Regulator Inlet/11G Transition/40% Flow Restrictor

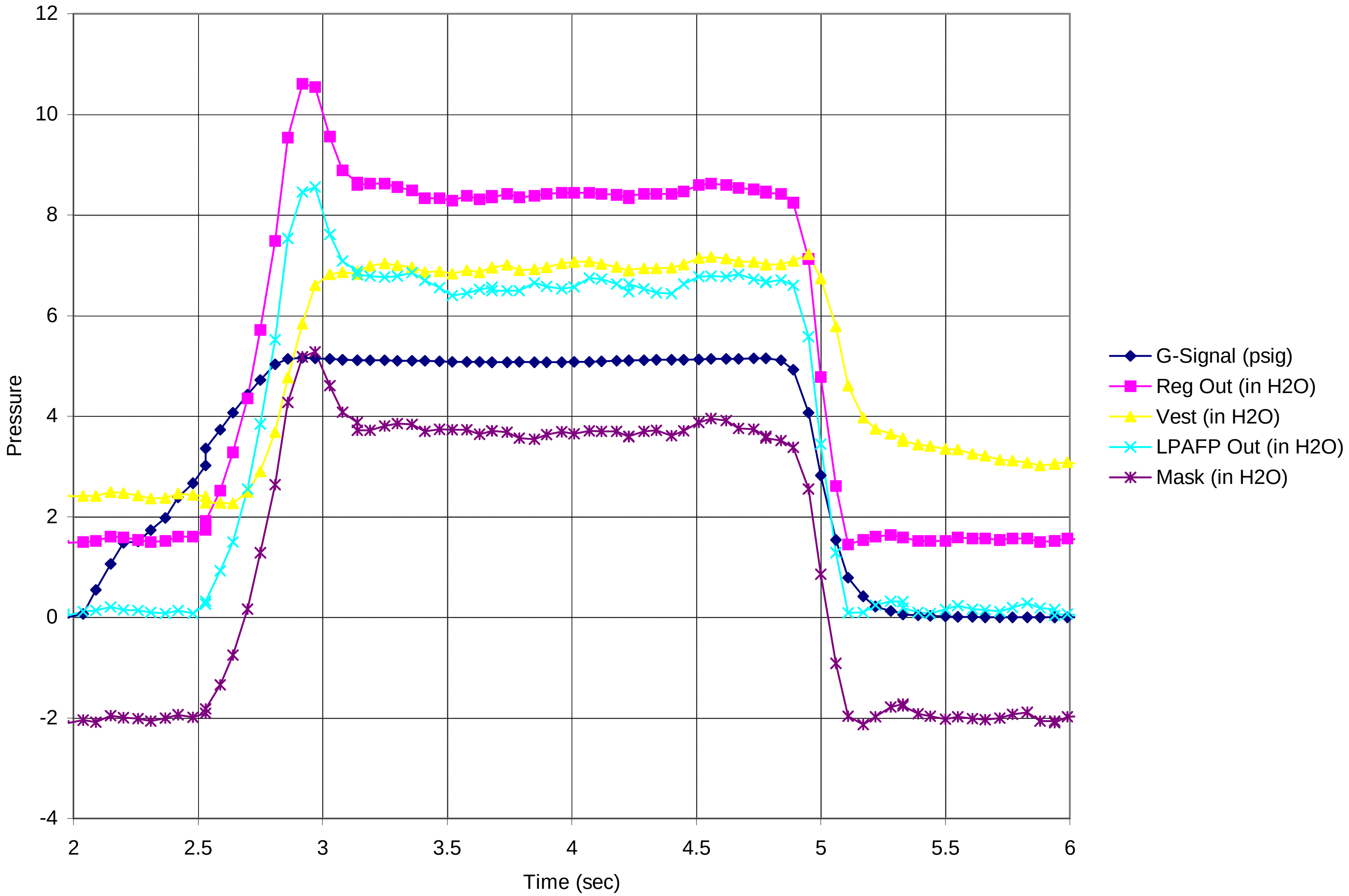

Figure F-25: System Lag Time with LPAFP and 40 PSIG Regulator Inlet/5G Transition/70% Flow Restrictor

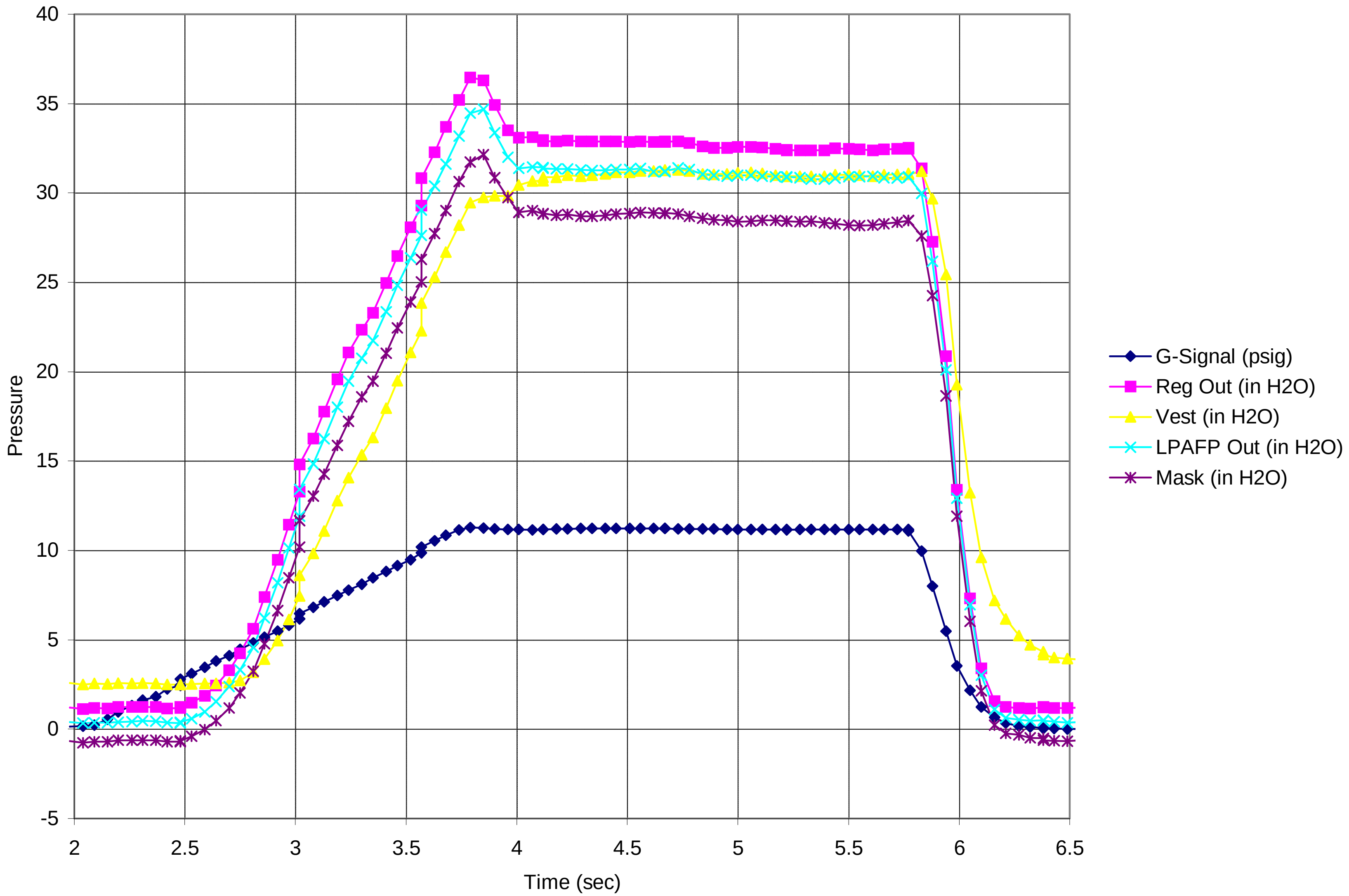

Figure F-26: System Lag Time with LPAFP and 40 PSIG Regulator Inlet/11G Transition/70% Flow Restrictor

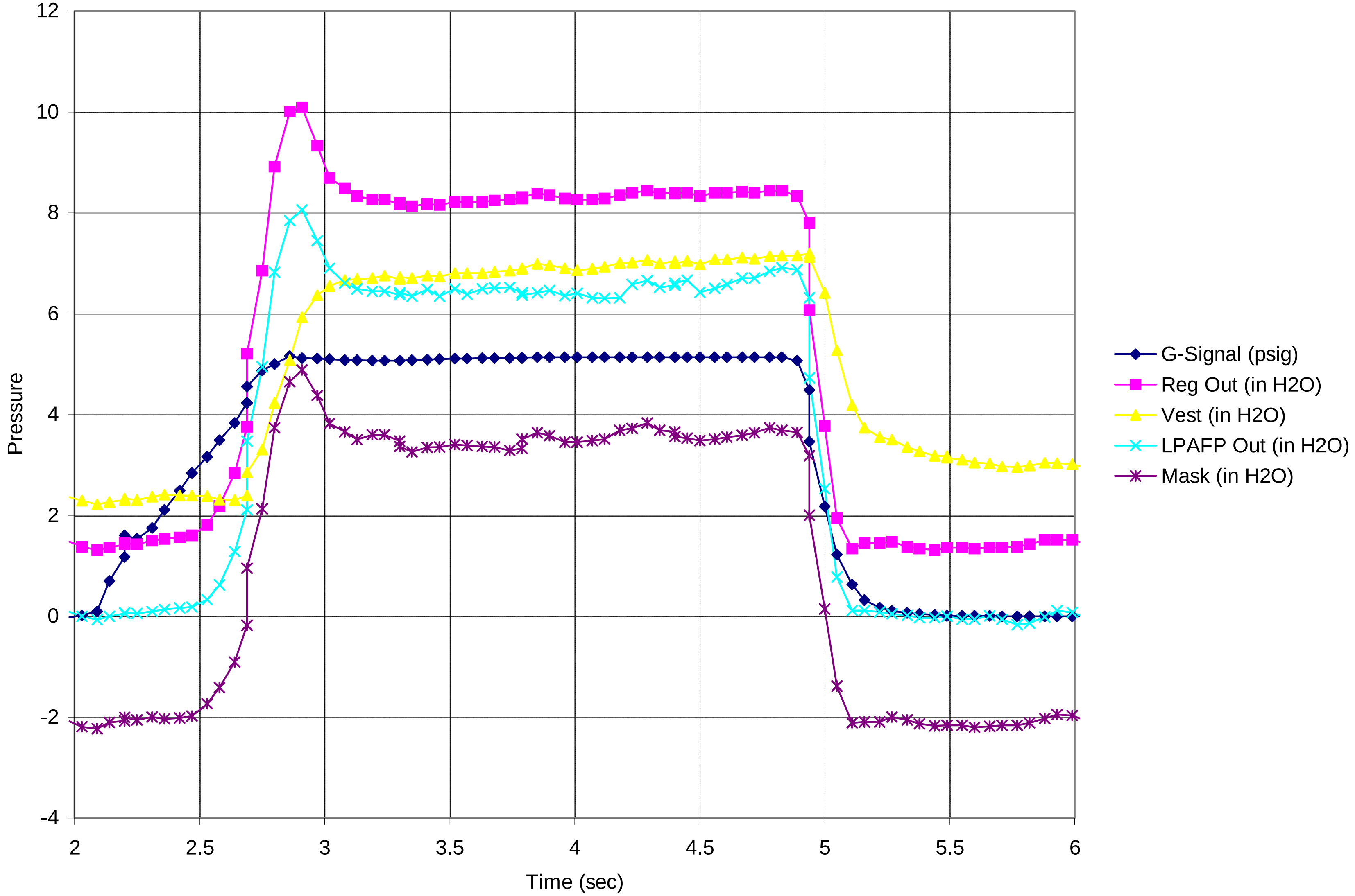

Figure F-27: System Lag Time with LPAFP and 60 PSIG Regulator Inlet/5G Transition/70% Flow Restrictor

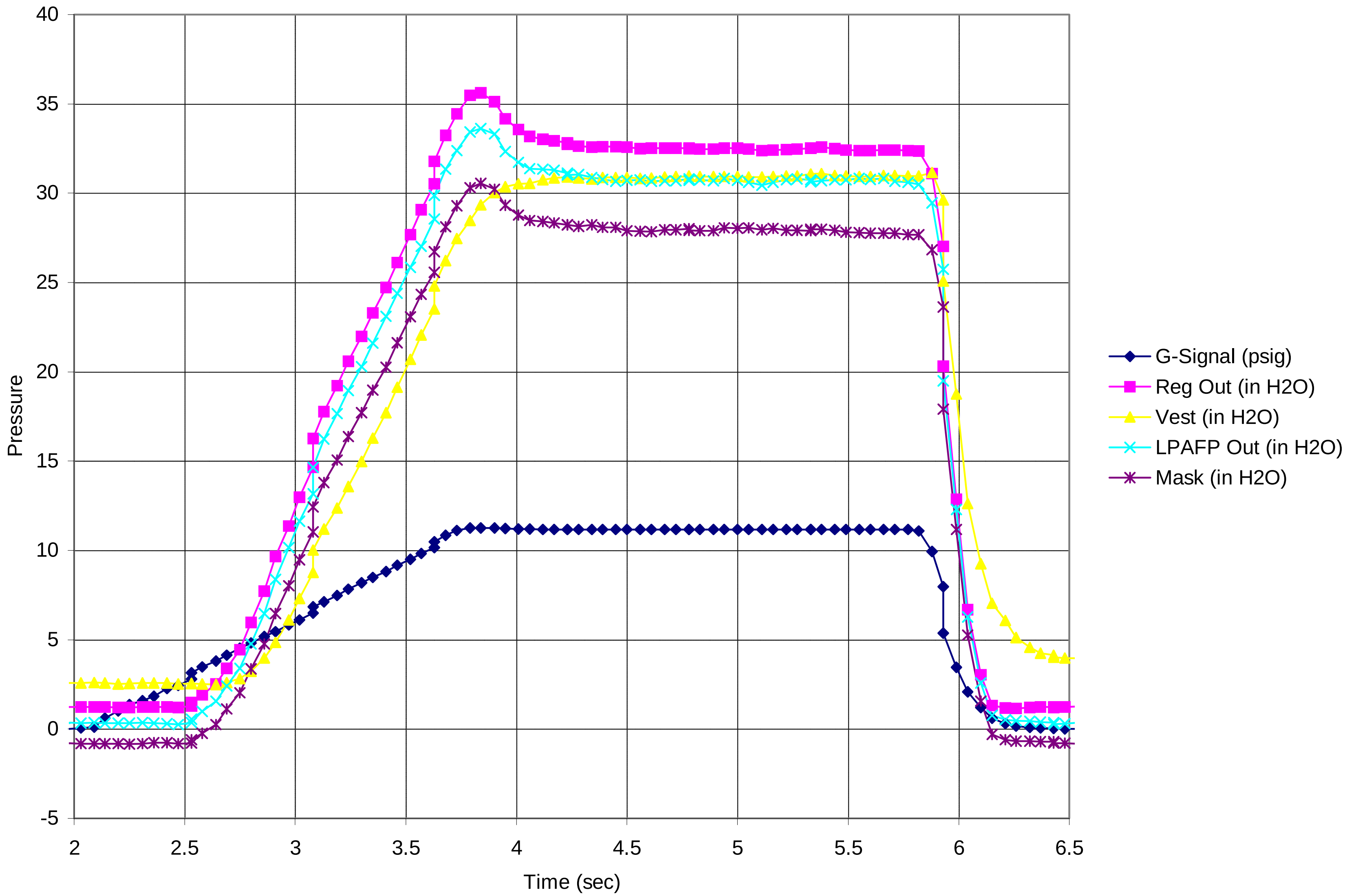

Figure F-28: System Lag Time with LPAFP and 60 PSIG Regulator Inlet/11G Transition/70% Flow Restrictor

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