GM WORLDWIDE ENGINEERING STANDARDS	**Test Procedure**	**GMW18242**

Pressure Pulsation Testing, Engine Air Delivery Systems

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. The purpose of this test procedure is to characterize the durability and longevity of a component part when subjected to internal air pressure pulsation over time at defined temperature.

1.2 Applicability. This specification applies to combustion engine pressurized air communication system components and assemblies, typically attached to intake side of cylinder head (e.g., naturally aspirated applications) or plumbed into the air delivery system between a turbocharger or supercharger and the engine cylinder head. Typical example parts are, but not limited to: intake manifold assembly, charge air cooler, resonator, adapter housings, and hose or duct plumbing.

This specification is typically applicable to composite material constructed components, for which pressure pulsation fatigue over time is a potential failure mode. Typical failures may be experienced at weld joint interfaces or outer shell/walls. This testing may not be required for metallic constructions (e.g., castings and sheet metal fabrications), pending structural analysis feedback.

- The applicable test sample quantities and the pressure and temperature exposure will vary by application and shall be specified in the applicable Bill of Design (BOD) Level 1 Statement of Requirements (SOR)/Component Technical Specification (CTS) Appendix C and C.1 for requirement definition. Otherwise, this specification will illustrate the generalized test guidelines and requirements.

This test is applicable to both Design Validation (DV)/Process Validation (PV) part durability validation testing and engineering development lab testing.

The defined test types (see 4.2) are applicable as follows:

- Type A: Throttled components, realizing negative pressure in use.
- Type B: Non-throttled part applications, not realizing negative pressure (or very little) in use.
- Type C: Engineering development/laboratory purposes.

  Note: Negative pressure, or vacuum, refers to pressure that is below Atmospheric Pressure (ATM). Otherwise known as the pressure difference between ATM and absolute pressure below ATM.

  Example: Type A is most applicable to intake manifold (i.e., throttled) applications, while Type B may be applicable to a turbo outlet resonator.

CG6079 is considered the standard or typical temperature cycles, temperature profiles, and pressure pulsation inputs, the applicable project DRE may indicate different test input values through the SOR Appendix C1 or by continued project learnings.

1.3 Remarks. Air communication system composite material constructions, which may most often be injection or blow molded and consist of welded or glued joints, are typically prone to pressure pulsation fatigue failures and are not infinitely resistant to these failure modes. For composite welded constructions, primarily failure at weld joints are anticipated.

Pressure pulsation fatigue testing is utilized to gage the longevity, or resistance to failure, of pressurized air systems components or assemblies. This procedure specifies the testing routine, which may be utilized to either validate (i.e., pass/fail to a specified exposure period) or test to failure (i.e., deliberately cause part breakage) to gage a component or assembly durability sensitivity.

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This procedure covers typical applications; however, the test parameters may need to be adjusted based on actual applications specifications and part exposure. Any test parameter revision shall be recorded in the project test report.

For a part to be throttled (typically by a throttle body component), suggests there is a restriction within the system (e.g., most often just upstream of an intake manifold), which causes a below ATM pressure differential between the throttling component and the engine cylinder pumping action.

Prior to testing or even more-so the tooling of new design parts, Finite Element Analysis (FEA) structural analysis shall have been performed outside of this test procedure, to illustrate part capability durability confidence.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW3149 GMW18241

2.3 Additional References.

- CG6079 Air Delivery Subsystem - Pressure Pulsation and Temperature Profiles
- Component Technical Specification (CTS), Appendix C of the Statement of Requirements (SOR)
- Reference example pressure control valve information can be found at https://www.parker.com/: (see Appendix A, Figure A6):

a. Parker 7000 Series, 3-way normally closed, 3/4" National Pipe Taper (NPT) general purpose solenoid valve.

Part Number: 73312BN52NJ0N0C111C2.

Specifications: 24 V (DC)/10 watt Direct Current (DC), Normally Closed, Maximum Pressure: 12.4 Bar, Maximum Fluid Temperature: 82 °C. Flow Factor 7.3 Cv.

b. Parker Gold Ring Series, 2-way normally closed, 3/4" NPT general purpose solenoid valve

Part Number: 12F24C2148A3F4C80.

Specifications: 24 V (DC)/11.5 watt (DC), Normally Closed, Maximum Pressure: 8.6 Bar, Maximum Fluid Temperature: 65.5 °C. Flow Factor 6.5 Cv.

- Test Script (Product Usage Measurements and Applications (PUMA), AVL Suite): C_CST_ENG_PressTestUniversal. (ID)

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3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment. The test equipment and test stand shall support specified testing utilizing pulsating pressurized (including negative pressure as required) air at specified temperature or temperature cycle.

The test cell, stand, or equipment shall have ability for air pressure decay leak rate measuring, typically at 50 cc/minute range and at either 50 kPa (for naturally aspirated applications) or maximum boost +50 kPa pressure (for boosted applications). For part leak check routine not performed within the pressure pulsation chamber, parts shall be checked with air pressure under water or with air pressure within a part burst resistant chamber.

Typical test stand equipment may consist of, but not limited to (see example test stand, Appendix A, Figure A4 and Figure A5):

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- Thermal chamber with environmental and part temperature profile capability control. Chamber should be resistant to part burst.
- Positive pressurized air source.
- Negative pressurized (i.e., vacuum) air source.
- Valve device(s) (see 2.3 and Appendix A, Figure A1 through Figure A3), for alternating/cycling pressure.
- Pressure and temperature sensors (see Appendix A, Figure A2 through Figure A3).
- Test controller and data recording device(s).

Note: Controller shall have capability to control both the pressure and temperature routines, typically by a defined script method. Data controller shall have capability to record cycle count, pressure traces or data, and temperature traces or data, throughout the duration of the entire test.

3.2.1 Equipment Capability. The test stand shall be fully enclosed for both safety (i.e., potential component burst) and environment temperature control. See CG6079 Temperature and Pressure Pulsation tabs for example pressure pulsation and temperature cycling graphs.

- Pressure pulsation range: -80 kPa (gage) to 300 kPa (gage) and control to ± 10 kPa, with lower limit (i.e., leak) monitoring control.

Note: GM Internal software script driven leak check shall have ability to set lower pressure limits to 40 kPa less than high pressure setting, and dwell high pressure for 30 s every 1000 cycles, for system and component part leak check. The supplier may choose to run similar scripted routine, manual routine, or run continuous leak check monitoring (i.e., pressurization limit controls) throughout the test per applicable DRE agreement.

- Temperature Range: -40 °C to 230 °C and control to ± 5 °C.
- Humidity: Not specified (utilize available ambient environment air).

3.3 Test Vehicle/Test Piece. The test sample components or assemblies shall represent the project applicable build phase (i.e., representative of DV or PV parts) part design intent and construction.

The test samples will typically require sealing and other opening block-off plates or plugs, which shall be significantly rigid to resist pressure pulsation and potential for leakage. The block-off plates or plugs shall sufficiently support the air pressure line connection, most typically with a threaded fitting (e.g., ⅛ in to ½ in NPT).

3.4 Test Time. Total test time may vary greatly, being dependent on the part(s) volume size and plumbing size, which will affect the pressure ramp and relief rates. This following is a general guideline based upon an example of 1 s dwell an ATM, 1 s pressure ramp, 3 s dwell at high pressure, and 1 s pressure relief time for 300 000 cycles:

Calendar time:	30 d ± 10 d
Test time:	500 h ± 100 h
Coordination time:	72 h

3.5 Test Required Information. The test type shall be specified per the applicable SOR or GM lab test request, as defined in 4.2.

The test operator shall be provided with the proper test matrix input parameters in advance of testing, to ensure that the proper test exposure conditions are included within the applied test range.

Any applicable facility and test related safety information shall be provided and communicated to the test engineer, prior to any testing.

3.6 Personnel/Skills. Test personnel shall be technically competent with operating the representative test equipment, have in-depth knowledge of pressure pulsation testing and the applicable part type and usage, and this test procedure. The test personnel shall also be trained in the facility and test equipment related safety procedures and protocols. The test personnel shall wear the appropriate Personal Protection Equipment (PPE) for part handling, and pressurized air or hot air.

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4 Procedure

4.1 Preparation. Per the SOR validation testing requirements, parts shall be exposed pre-test to heat aging and humidity conditioning accordingly.

Sample test parts shall be 100% leaked check, with same test block-off plates and plugs, prior to testing per GMW3149 or supplier equivalent per Design Release Engineer (DRE) agreement. For both leak checking and containing pressure during testing, sealing surface openings shall be blocked with test plates or plugs significantly rigid to resist leakage throughout the duration of the test. Block-off plates and plugs shall not be removed or loosen from initial leak check throughout duration of testing without applicable project DRE approval, until test completion and detected leaks, and any related failure mode issues are appropriately root caused.

For part leak check routine not performed within the pressure pulsation chamber, parts shall be checked with air pressure under water or with air pressure within a part burst resistant chamber.

A sample component test part per each pressure pulsation plumbed circuit shall be instrumented with a thermal couple to monitor surface temperature most near the center or otherwise concerning region of the part. For multiple sample number test and testing parts in parallel with each other, the most centrally located (in chamber) part shall be the instrumented part.

4.2 Conditions. The test conditions shall be per the following test types and shall be further defined by CG6079 and applicable SOR Appendix C (or C1)/CTS or specific GM lab test request:

- Type A: -80 kPa (gage) to maximum boost +50 kPa (gage) at temperature cycle profile.

Note: Maximum boost and temperature cycle profile as indicated by project specific SOR Appendix C1 or GM internal test request.

- Type B: ATM to maximum boost +50 kPa (gage) at temperature cycle profile.

Note: Maximum boost and temperature cycle profile as indicated by project specific SOR Appendix C1 or GM internal test request.

- Type C (for GM internal lab): ATM to 200 kPa (gage), or maximum boost +50 kPa (gage) if applicable, at defined constant temperature.

Note: Maximum boost and temperature cycle profile are as indicated by project specific SOR Appendix C1 or GM internal test request.

Note: Type C is typically reserved for test cells without variable temperature cycle, and for engineering development activities only.

Pressure dwell (i.e., hold) times shall be as follows:

- Type A and Type B: Per CG6079.
- Type C: Per CG6079, with 10 s high pressure optional for further development purposes. For further engineering development purposes, controlling the pressure rise and relief rates/times (possibly requiring variable flow control valves) per cycle, may be further defined by test requestor.

Both the pressure rise and relief times Per CG6079 are typically only limited to flow restrictions due to the overall volume of air (including part(s)), plumbing, and valve(s) sizing.

4.2.1 Environmental Conditions. Test chamber humidity level shall not be conditionally high (i.e., < 50%) and can typically simply be from test lab room air.

Chamber temperature limit(s) (i.e., high and low) control shall be ± 5 °C.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 Test Part Temperature. Component temperature shall be driven by the chamber environmental temperature but measured and monitored in response on each pressure loop sample part. Component testing shall not start pressure pulsation test until part temperature per each pressure circuit loop is at specified initial temperature. For test Type A and Type B this will be Room Temperature (RT) (i.e., 20 ± 5 °C), while test Type C will be the specified continuous temperature. Part monitored surface high and low temperature shall dwell for times as specified (see CG6079 Temperature and Pressure Pulsation tabs) by application type.

4.2.3 Part Conditions. Parts may require preconditioning (i.e., humidity and/or temperature exposure), verify per project SOR and per DRE agreement. Composite welded constructions will typically be representative of

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nominal weld conditions, previously confirm by static burst evaluation (reference GMW18241), however concerning design parts may need minimal weld conditions tested per DRE direction.

4.3 Instructions.

4.3.1 Start of Test. Test technician or operator shall ensure test stand and all related equipment is in valid working condition, prior to start of test.

Test technician or operator shall ensure all test parts are appropriately marked by sample number or recorded serialization.

All test parts shall be pre-test leak checked per GMW3149 or equivalent, and any within allowed leak rates shall be recorded by part sample. Parts above allowed leak rate shall not be tested, unless agreed to by applicable DRE. Air under water leak check (prior to component part fill with water) for champagne or larger bubbles is acceptable, pending DRE agreement. Test stand plumbing set-up, with parts plumbed to test stand, shall be pre-test leak checked for 30 s minimum.

Test chamber and therefore monitor part surface temperature shall be stabilized to specified beginning cycle temperature or constant temperature as specified by test type.

4.3.2 Test Routine. The pressure pulsation and temperature cycling (or Type C constant temperature) shall start in unison and continue together throughout the duration of the test.

Pressure cycling shall maintain the low and high-pressure dwell time as specified per CG6079. Pressure rise and relief rate shall be hardware dependent and the time is undefined.

Temperature cycling shall maintain the low- and high-temperature dwell times as specified (see CG6079 Temperature and Pressure Pulsation tabs) and as monitored at the sample part surface temperature.

In test leak check shall be performed every 1000 cycles (or DRE agreed supplier routine per 3.2.1). Any suspect leaks shall be investigated per leak check routine, prior to further sample testing.

Testing shall complete pressure cycling as specified by applicable project SOR and CG6079 or specific GM test lab request.

4.3.3 In Test Leak Check. Whether manual or software Test Script (C_CST_ENG_PressTestUniversal) driven, the test routine shall run leak check every 1000 cycles (or DRE agreed supplier routine per 3.2.1). Leak check shall be 30 s dwell at high pressure setting. Software script monitoring shall have 40 kPa lower limit less than high pressure for test shut down. Suspect parts shall be further investigated to meet leak rate of 50 cc/minute maximum rate at either 50 kPa (non-boosted systems) or maximum boost +50 kPa pressure. To further root cause potential leaks, liquid leak detector solution shall be utilized.

For multi-component test (i.e., multiple parts on test in parallel), any components with detected leak shall be removed from test, and that plumbing pressure feed may be plugged or turned off (e.g., if valve control), in effort to continue other non-leak sample testing. All leak samples shall be fully reviewed with applicable project DRE or test requestor. Based upon leak part failure evaluation, it may be determined (e.g., safety concerns, or part build quality concerns, etc.,) that the test should be discontinued until further engineering design resolution is established.

4.3.4 End of Test. All test sample parts not already removed due to prior leaks, shall be further leak checked per GMW3149 or equivalent while remaining on test set-up, and leaks rates recorded respectively.

Parts shall be further visually inspected for any signs of fatigue stress, crack initiation, discoloration, or other typically known failure modes for part or material type. Any potential failure modes shall be recorded by images or illustrations, through the final test report.

Post-test parts shall be made available for applicable project DRE physical review.

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5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Suspect leak or gross failure mode parts shall be reviewed in detail with the applicable DRE, and supplier failure mode root cause engineering support shall be provided.

5.3 Test Documentation. The test report shall include pressure pulsation graph illustrating operating pressure range, ramp time, and dwell time, and shall be provided to the applicable DRE or test requestor.

All test documentation and test report shall be in International System of Units (SI metric) units.

Appropriate part images and failure images shall be included within the test reports.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary. Not applicable.

7.2 Acronyms, Abbreviations, and Symbols.

ATM	Atmospheric Pressure (e.g., Detroit, MI, USA example average approximately 101.6k Pa)
BOD	Bill of Design
Cc	Cubic Centimeter = 1 Milliliter
CTS	Component Technical Specification
DC	Direct Current
DRE	Design Release Engineer
DV	Design Validation
FEA	Finite Element Analysis
NPT	National Pipe Taper (thread)
PPE	Personal Protection Equipment
PUMA	Product Usage Measurements and Applications
PV	Process Validation
RT	Room Temperature, typically 20 °C ± 3 °C
SI	International System of Units (i.e., Metric)
SOR	Statement of Requirements

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW18242

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9 Release and Revisions

This standard was originated in November 2019. It was first approved by Powertrain - Global Engine Hardware Engineering in January 2020. It was first published in January 2020.

Issue	Publication Date	Description (Organization)
1	JAN 2020	Initial publication.
2	MAY 2020	Update to add CG6079. (Powertrain - Global Engine Hardware Engineering)

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Appendix A: Testing Illustrations

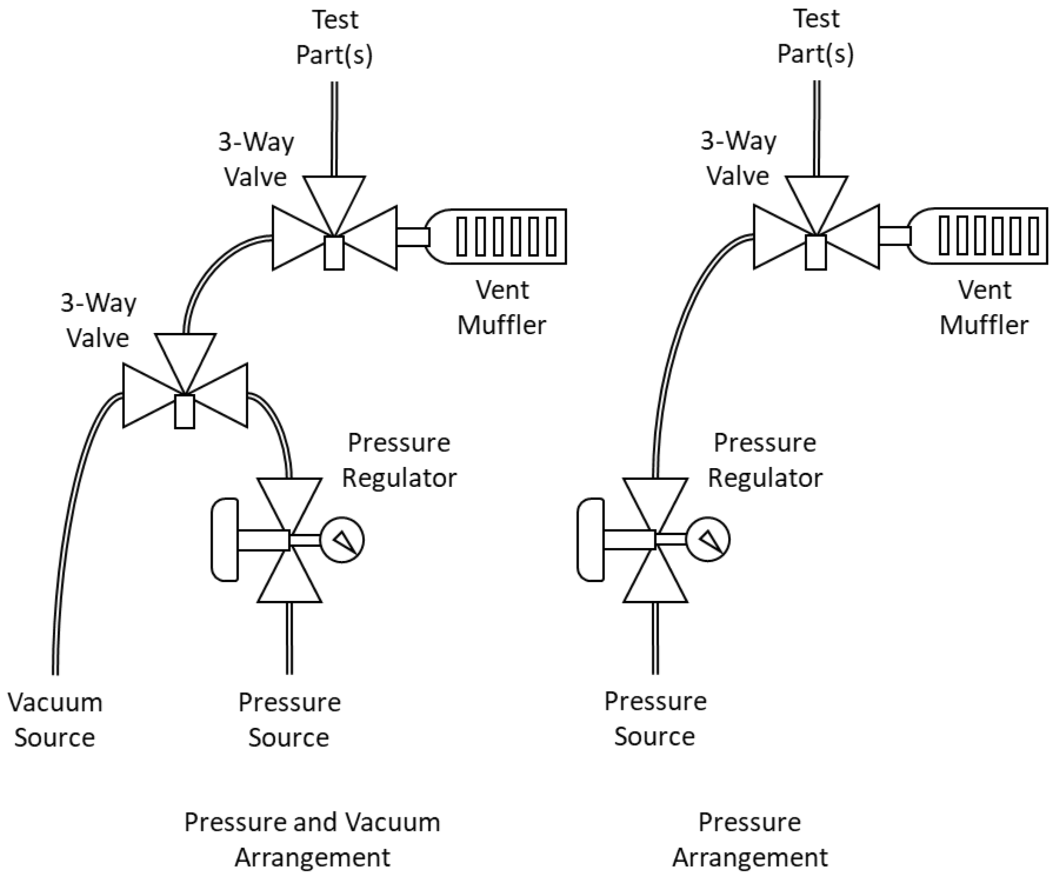

Figure A1: Example Simplified Pressure and Vacuum Pulsation Test Schematic

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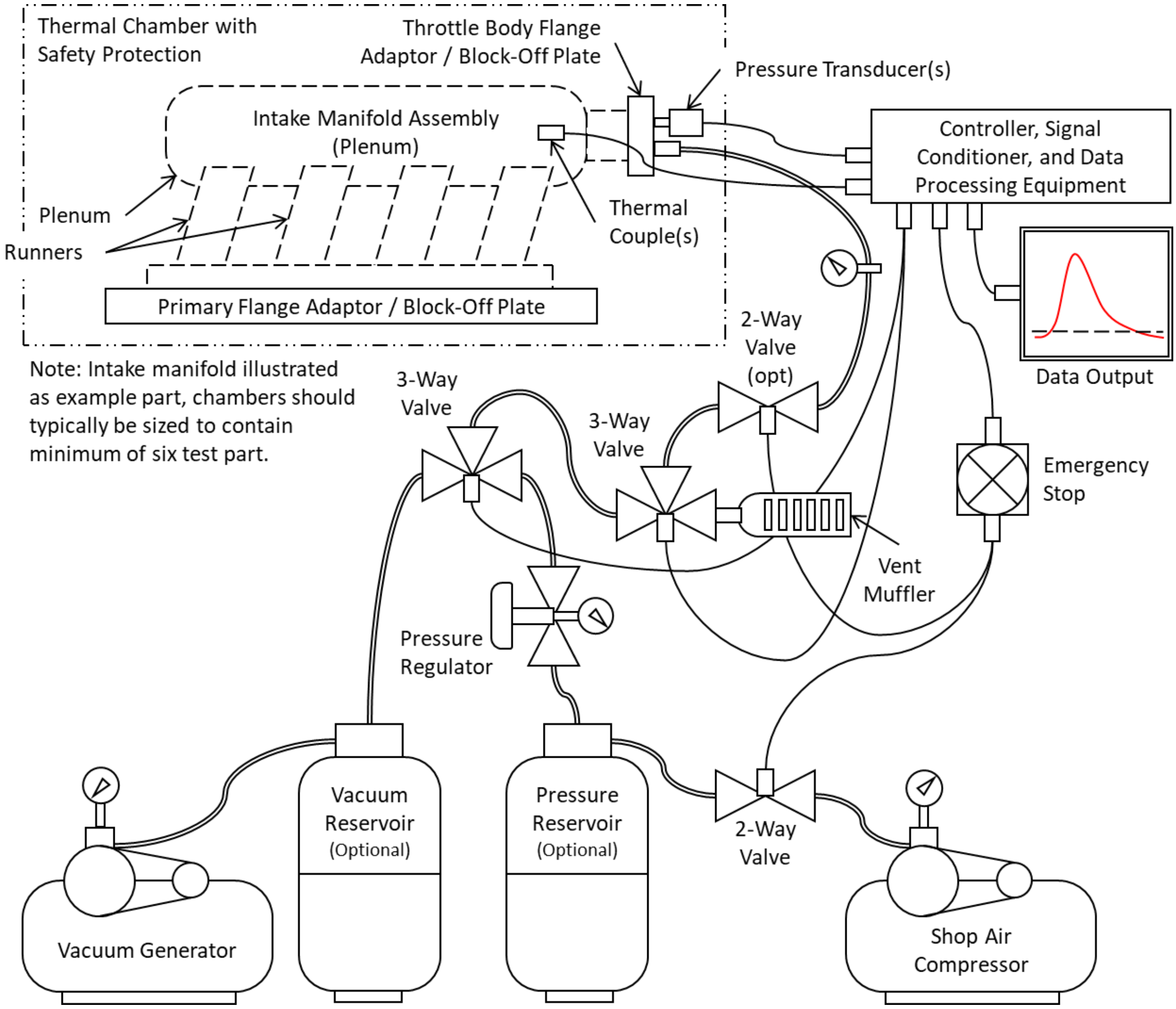

Figure A2: Example Pressure and Vacuum Pulsation with Thermal Chamber Test Schematic (not to scale)

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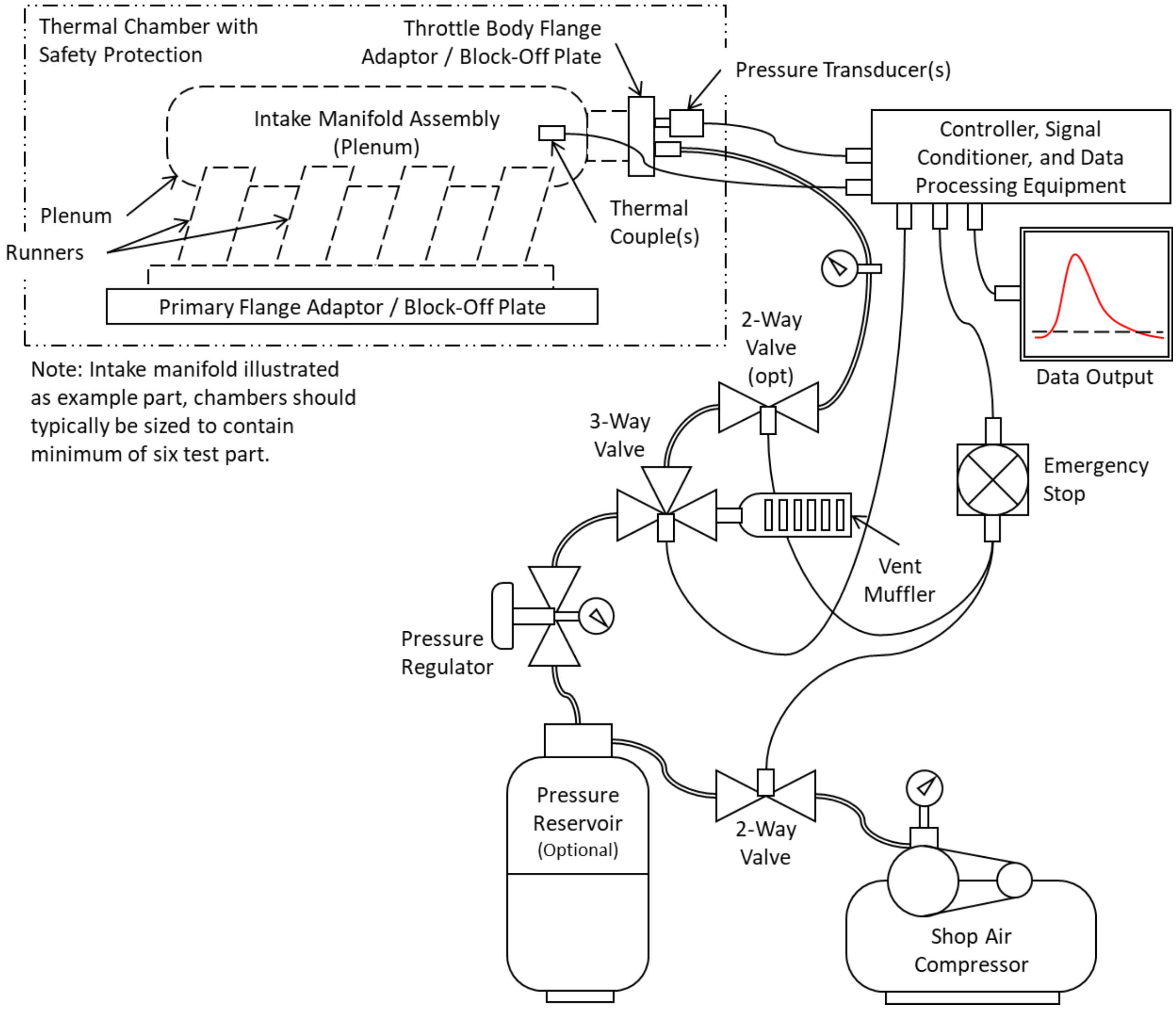

Figure A3: Example Pressure Pulsation with Thermal Chamber Test Schematic (not to scale)

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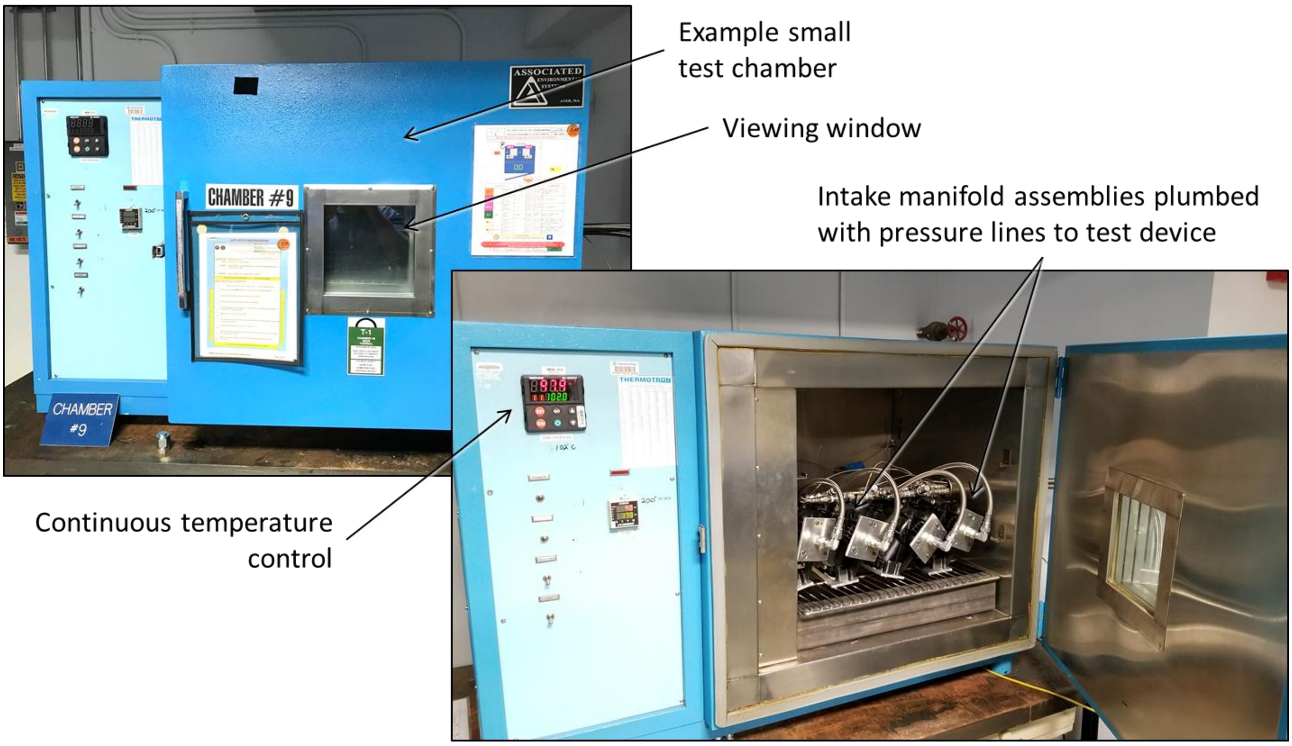

Figure A4: Example Small Thermal Test Chamber

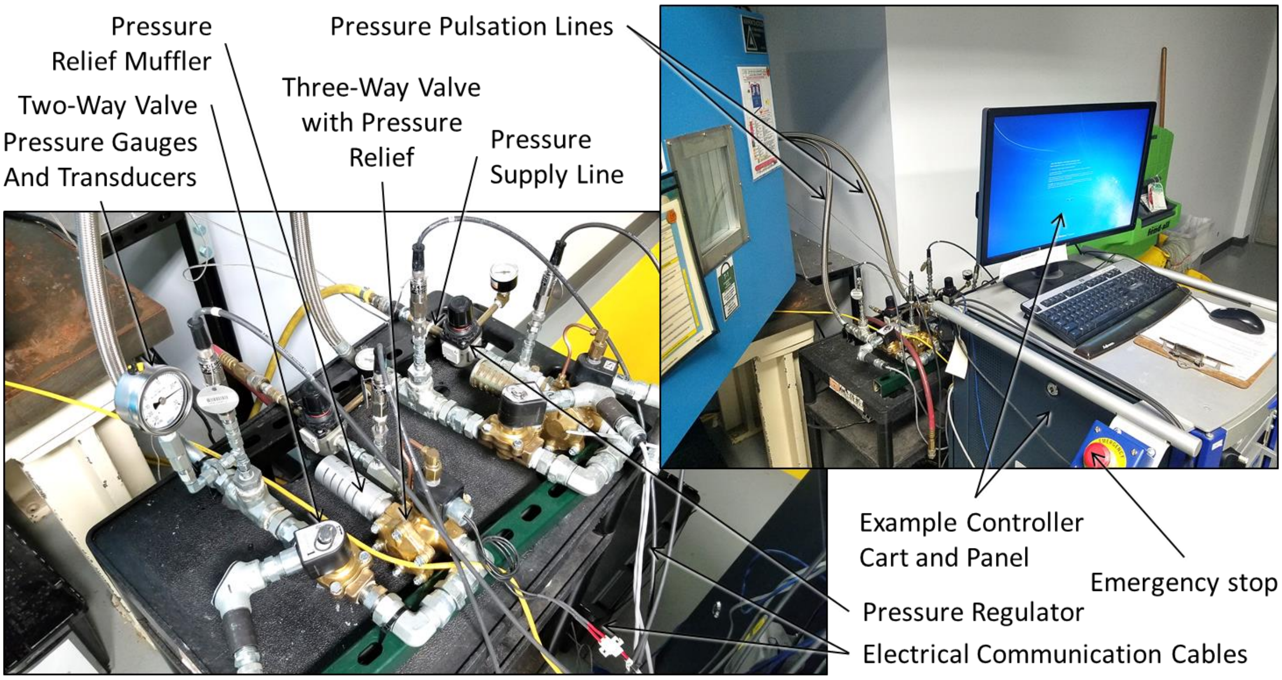

Figure A5: Example Pressure Pulsation Test Cart and Controller Cart

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Parker 3-Way Valve

Parker 2-Way Valve

Figure A6: Example Flow Control Valves

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