

AEROSPACE RECOMMENDED PRACTICE

ARP4024™

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Aircraft/Engine Fuel Pump
Net Positive Suction Pressure Performance Test and Evaluation

RATIONALE

ARP4024 has been reaffirmed to comply with the SAE five-year review policy.

FOREWORD

Net positive suction pressure (NPSP) is the minimum total pressure minus the fuel true vapor pressure (TVP) at the test fuel temperature, at which the pump under evaluation will operate and meet the specification requirements for the system in which it is to be used. This condition implies that the vapor/liquid (V/L) ratio is zero at the flow rate through the specified inlet line, i.e., no valves or artificial restrictions are introduced to create a pressure drop or decrease in test tank ambient pressure, causing vapor formation. Performance is judged based on the pump degradation compared to operation at maximum specified inlet pressure and the ability to meet the specification requirements.

1. SCOPE:

This procedure applies to engine or airframe-mounted fuel pumps. The procedure recommends single-pass operation to minimize changes in fuel properties affecting NPSP capability. An optional method using a recirculation system is also included and may be specified at the discretion of the equipment specification.

This procedure defines the recommended test setup, test procedure, data acquisition, and data presentation.

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1.1 Purpose:

- 1.1.1 This SAE Aerospace Recommended Practice (ARP) defines standard procedures to conduct tests and evaluations of aircraft and engine fuel pumps for the purpose of determining NPSP performance capability.

$$NPSP = Total\ pressure - TVP \quad (Eq.1)$$

$$NPSP = (P\ static + P\ Dynamic) - TVP \quad (Eq.2)$$

- 1.1.2 The procedure recommended herein is intended to produce useful, reproducible results at steady state conditions.
- 1.1.3 This test is not intended to establish altitude, climb rate, starting, or other transient performance of the article being tested for a specific aircraft installation. This test does address interstage or discharge heat input from the engine in addition to heat generated by the pump itself. This is common to modern engine fuel systems and can significantly influence NPSP capability. This is especially true at high turn down conditions as described in 3.1.1.

NOTE: At high flow conditions where metal conduction is negligible when compared to flow capability to remove heat, interstage or discharge heat may not be required since inlet pump elements are unaffected. Prior testing with temperature measured directly at the pump inlet may be required to determine the influence of this heat addition.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other documents shall be the issue in effect on the date of the purchase order.

- 2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP492 Aircraft Engine Fuel Pump Cavitation Endurance Test
AIR1326 Aircraft Fuel System Vapor Liquid Ratio Calculations

2.1.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM D 270 Sampling Petroleum and Petroleum Products
ASTM D 323 Vapor Pressure of Petroleum Product (Reid Method)
ASTM D 1298 Density, Specific Gravity or API Gravity of Crude Petroleum and Liquid Petroleum Products by the Hydrometer Method
ASTM D 3827 Solubility of Gases in Petroleum and Other Organic Liquids, Estimation of
ASTM D 4057 Manual Sampling of Petroleum and Petroleum Products, Method for

2.1.3 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-G-5572 Gasoline, Aviation, Grades 80/87, 100/130, 115/145
MIL-T-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-T-83133 Turbine Fuel, Aviation, Kerosene Type, Grade JP-8

3. TECHNICAL REQUIREMENTS:

The following paragraphs discuss the variables/recommendations with respect to test Figures 1, 2, and 3.

3.1 Recommended Fuel:

MIL-T-5624, Grade JP-4 with a reid vapor pressure (RVP) of $2.8 \text{ psi} \pm 0.2 \text{ psi}$ during the NPSP Capability Test of 6.1 and 6.2.

Tests to this practice may also be conducted using other fuels such as aviation gasoline per MIL-G-5572, JP-5 per MIL-T-5624, or JP-8 per MIL-T-83133 with their associated RVP having a tolerance of $\pm 0.2 \text{ psi}$ during the NPSP Test of 6.1 and 6.2.

CAUTION: Measurements of the RVP, inlet fuel temperature and pressure are critical in defining a pump's NPSP performance.

3.1.1 Fuel Temperature:

- T_1 in supply tank: $\pm 2^\circ\text{F}$ of T_2 at the pump inlet.
- T_2 at pump inlet: In accordance with applicable specification.
- T_3 at pump interstage or boost stage discharge (if applicable): As measured.

NOTE: Pump heat "soak back" and pump "spit back" at high turndown ratios may obscure the intent of this requirement which is to limit the heating or cooling of the fluid between the tank and the pump. Therefore T_2 should be measured upstream of the inlet a distance equivalent to 15 to 20 pipe diameters to negate soak back effect. A mid-stream or center line temperature measured 10 diameters upstream is also acceptable.



1. INLET LINE LENGTH SHOULD BE MINIMIZED TO REDUCE EFFECTS CAUSING A V/L AT THE PUMP INLET WHEN FUEL IS HOT.
2. THE LINE SHOULD BE LEVEL OR SLOPE UPWARD TOWARD THE PUMP TO PREVENT VAPOR COLLECTION IN THE LINE UNDER V/L CONDITIONS. (REF: ARP 492)
3. THE PUMP SHOULD BE MOUNTED IN ITS NORMAL INSTALLED POSITION RELATIVE TO THE FORCE OF GRAVITY TO PRECLUDE AIR COLLECTION IN PUMP CAVITIES WHICH MAY INFLUENCE NPSP.
4. THE SUPPLY TANK IS USED TO MAINTAIN A CONSTANT FUEL LEVEL (HEAD) IN THE FUEL INLET TANK.
5. THE RECEIVING TANK IS USED TO COLLECT THE FUEL TO ENABLE A "ONE" PASS SYSTEM TEST AND TO PROVIDE A SYSTEM FOR PRE-SETTING PUMP TEST CONDITIONS.
6. THE CIRCULATION PUMP MUST HAVE SUFFICIENT CAPACITY TO MEET THE NEEDS OF THE TEST PUMP. THE CIRCULATION PUMP IS USED TO "CONDITION" THE FUEL PRIOR TO THE TEST RUN.

FIGURE 1 - Test Setup, Single Pass System

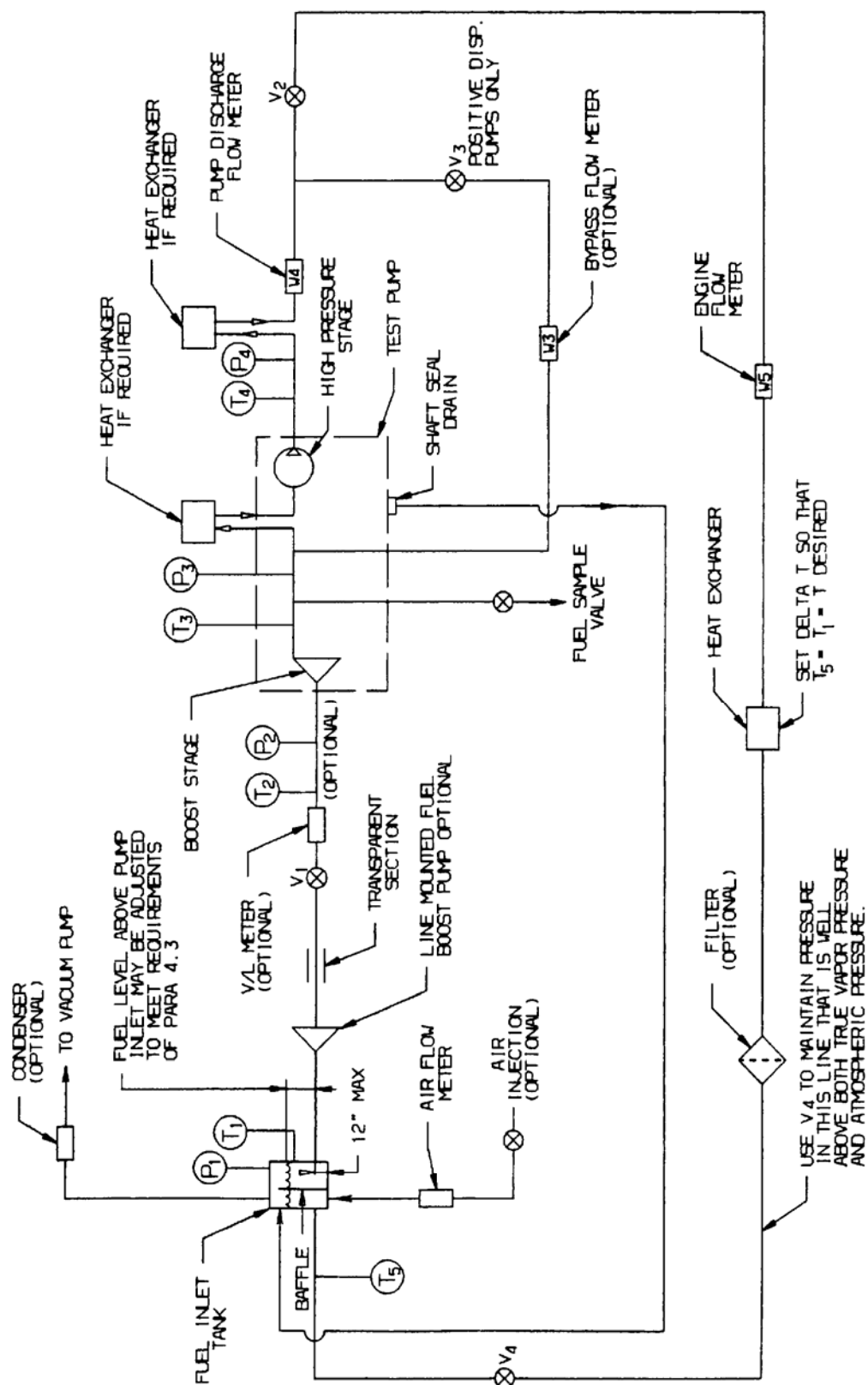


FIGURE 2 - Test Setup, Recirculation System

NOTES:

1. INLET LINE LENGTH SHOULD BE MINIMIZED TO REDUCE EFFECTS CAUSING A V/L AT THE PUMP INLET WHEN THE FUEL IS HOT.
2. THE LINE SHOULD BE LEVEL OR SLOPE UPWARD TOWARD THE PUMP TO PREVENT VAPOR COLLECTION IN THE LINE UNDER V/L CONDITIONS. (REF. ARP 492B)
3. THE PUMP SHOULD BE MOUNTED IN ITS NORMAL INSTALLED POSITION RELATIVE TO THE FORCE OF GRAVITY TO PRECLUDE AIR COLLECTION IN PUMP CAVITIES WHICH MAY INFLUENCE NPSP.

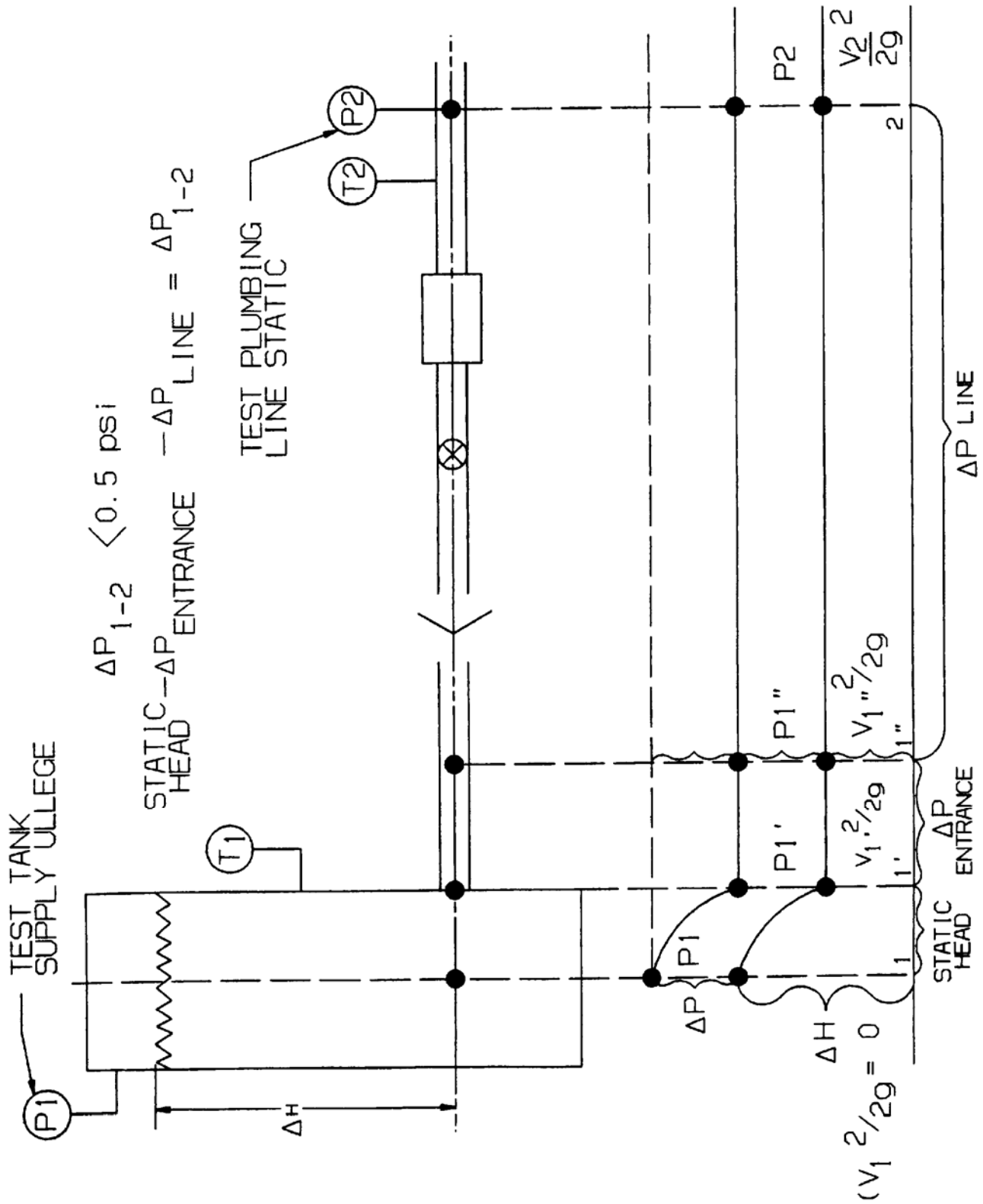


FIGURE 3 - Inlet Line Loss