



AEROSPACE RECOMMENDED PRACTICE

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TURBINE NOZZLE AREA MEASUREMENT BY

WATER FLOW METHOD

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1. PURPOSE

To provide a recommended practice to establish the system concept, interface adapter flange standard and procedure for determining turbine nozzle effective area by the water flow method.

2. SCOPE

2.1 This recommended practice covers the essential features of the water flow test stand concept, adaptation flange details, nozzle mounting fixtures and adapters, reference orifice plates, and procedure for determining nozzle effective area by the water flow method.

2.2 The water flow system measures the time (T_e) required for a given turbine nozzle to pass a known volume of water through its nozzle area. The measured time is compared to the time (T_s) required for the same volume of water to pass through a calibrated orifice of known area (A_s). The calculation of the effective area is determined by converting the flow time data into effective nozzle area (A_e) after applying test stand correlation factor (K).

$$\text{Example: } A_e = K \frac{A_s T_s}{T_e}$$

3. LIMITATIONS

3.1 The water flow method is essentially intended for measuring turbine nozzle areas up to approximately 200 sq in. (1290 cm²). Experience indicates that it may not be practicable for measuring larger areas. Larger nozzle areas require larger water flows, and consequently larger storage tanks. In large tanks it is difficult to still the water. Swirls resulting from filling the tank may take hours to settle out - even with elaborate baffling. If stilling is not complete, repeatability of readings is impossible. Furthermore, large tanks can take a substantial amount of time to fill. Delays due to filling and stilling time can be the determining factor in the overall usefulness of the water flow systems. Because of these, and related problems, other techniques are being used to measure large nozzle areas, such as mechanical gaging.

3.2 Presently the largest nozzles which are known to be accurately measured by the water flow method are 94 sq in. (606 cm²). The storage capacity of the tanks used to measure these nozzles is 1700 gallons (6435 l).

4. GENERAL REQUIREMENTS

4.1 Applicable Specifications and Standards: The following specifications and standards of the issue in effect on date of invitation for bids form a part of this recommended practice to the extent specified herein.

4.1.1 AMS 2469: Process and Performance requirements for hard coating treatment of aluminum alloys.

4.2 Materials and Workmanship:

SAE Technical Board rules provide that: "All technical reports, including themselves approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

- 4.2.1 **Material:** Material used in the fabrication of a water flow stand should be of the best commercial quality suitable for the purpose. All surfaces that are in contact with the water should be corrosion resistant. The adapters, because of their size, may be aluminum, but should be hard anodized per AMS 2469 or equivalent to prevent corrosion and general handling damage. Any burrs or evidence of corrosion should be removed as soon as noticed to enhance the concept of providing a smooth and continuous surface for water to flow over and prevent turbulence.
- 4.2.2 **Cleanliness:** Turbine nozzles should be cleaned before water flow testing. Water cleanliness should be maintained by periodic draining of all the water and cleaning residue from the tanks. Recommend that water be changed and tank wiped down every 2 to 4 weeks. Longer periods will permit scum to form and cause level sensing devices (float switches) to become sluggish and erratic. When new water is added, chemical additives may be added to inhibit algae growth and to increase the operating periods between cleaning. Sodium nitrite may also be added to reduce staining and corrosion.

5. SYSTEM REQUIREMENTS

5.1 Water Flow Stand Concept (See Fig. 1 for Schematic):

- 5.1.1 The stand shall be sized so that the minimum running time is at least ten seconds for any given turbine nozzle.
- 5.1.2 Height to diameter ratio approaches point of diminishing returns. Volume of water should be capable of flowing through the nozzle for at least 10 seconds so that accuracy of time readings below the ± 0.1 second level would not lead to measurement problems.
- 5.1.3 The repeatability of the system shall be $\pm 0.15\%$ for any nozzle tested and should be determined by a minimum of three tests per nozzle. The correlation between stands shall not exceed $\pm 0.30\%$.
- 5.1.4 Provision should be made for suitable adapters and fixtures to permit testing a wide size range of nozzles on the same tank. See paragraph 5.2 for Standard Tank Flange Design.
- 5.1.5 The cleanliness of the water should be maintained by continuous filtering and by periodic flushing and draining of the entire system. See paragraph 4.2.2 for additional cleanliness requirements.
- 5.1.6 Baffles should be provided in the lower portion of the tank to prevent the formation of a vortex.
- 5.1.7 Provision for a "dwell" period should be made after water is pumped into the tank to eliminate "frothing" and still the water. The initial water level above the top level switch should repeatedly be the same and high enough to permit full opening of the bottom doors before the timer starts the count.
- 5.1.8 Provisions to control water temperature between 68° F and 80° F (20° C and 27° C) in order to insure requirements specified in 5.1.3.

5.2 Standard Tank Adapter Flange Design:

- 5.2.1 The conical section of the head tank should be equipped with two standard mounting flanges. The upper mounting flange (See Fig. 3) should permit adaptation of nozzles up to 200 sq in. (1290 cm²) in area with an outside diameter up to 35 in. (889 mm). A transition conical section should mate with the upper mounting flange and reduce down to the lower mounting flange (See Fig. 2).

The lower mounting flange should permit adaptation of nozzles up to 120 sq in. (774 cm²) in area with an outside diameter up to 20 in. (508 mm).

- 5.2.2 Figures 2 and 3 provide dimensional details of the standard mounting flange configuration.

5.3 Nozzle Adapter and Fixture Design Considerations:

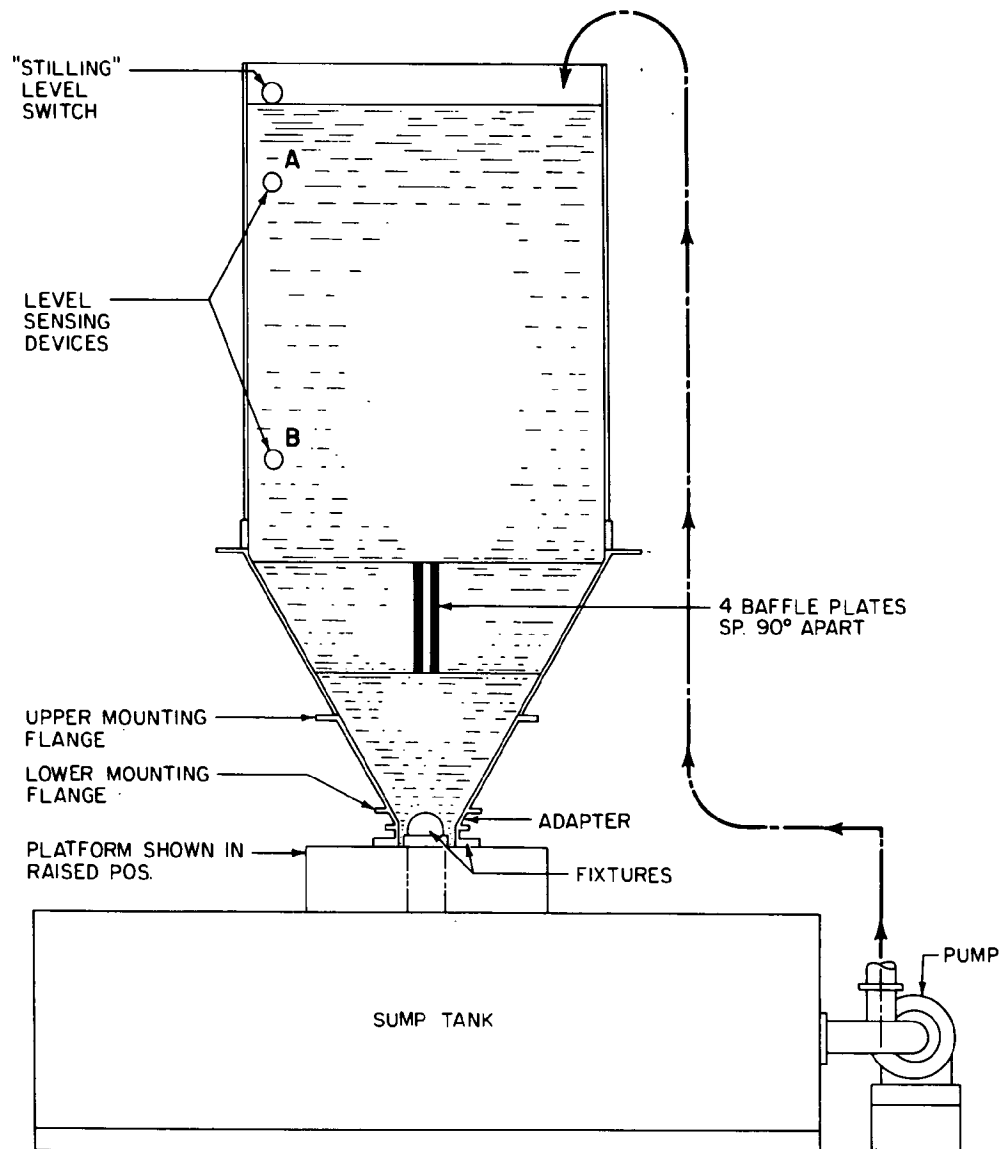


FIGURE 1 - WATER FLOW STAND CONCEPT

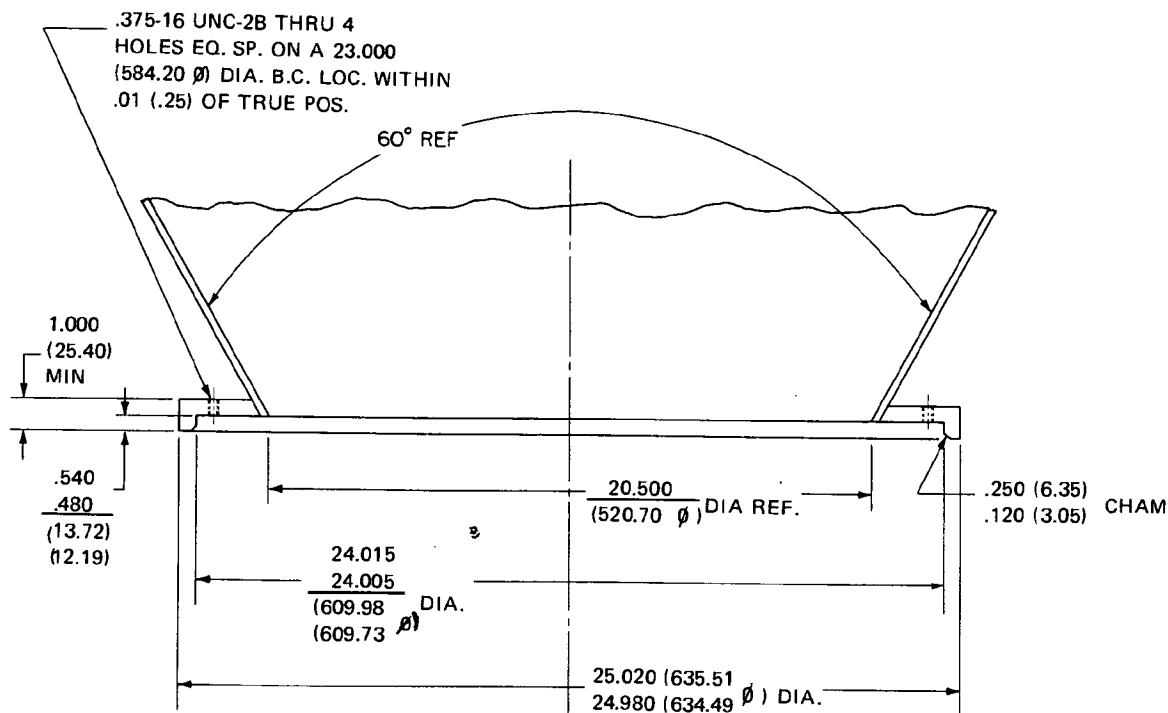


FIGURE 2 - LOWER MOUNTING FLANGE

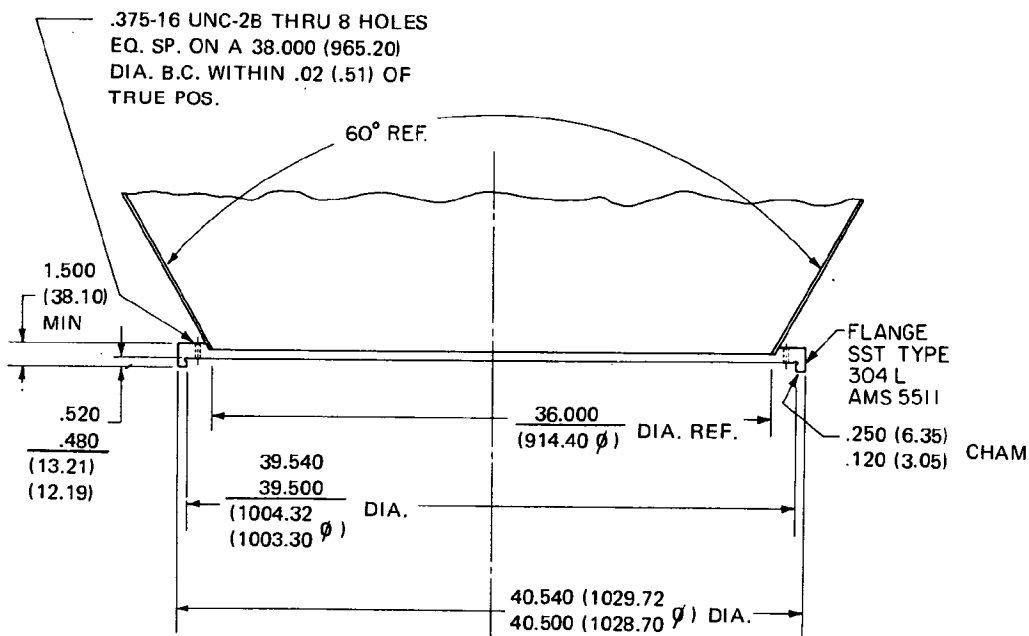


FIGURE 3 - UPPER MOUNTING FLANGE

NOTE: Dimensions shown in inches (millimetres).