N86-11451

SEEDING SUBSONIC, TRANSONIC AND SUPERSONIC FLOWS WITH 0.5 MICRON POLYSTYRENE SPHERES

H. Lee Seegmiller
NASA Ames Research Center
Moffett Field, California

C-3

FACILITIES AND SEEDING MATERIAL

Polystyrene latex particles have been successfully used as laser velocimetry seed material for flows in the Ames High Reynolds Channels (HR) I and II, the pilot channel, and the one-foot low speed tunnel (ref. 1-4). These facilities provide test flows with Mach numbers from 0.1 to 3.0 and test section sizes from 4"x6" to 18"x24". Tunnel mass flow in the HR-II channel can approach 1000 lb/sec. The latex particles have the following favorable characteristics:

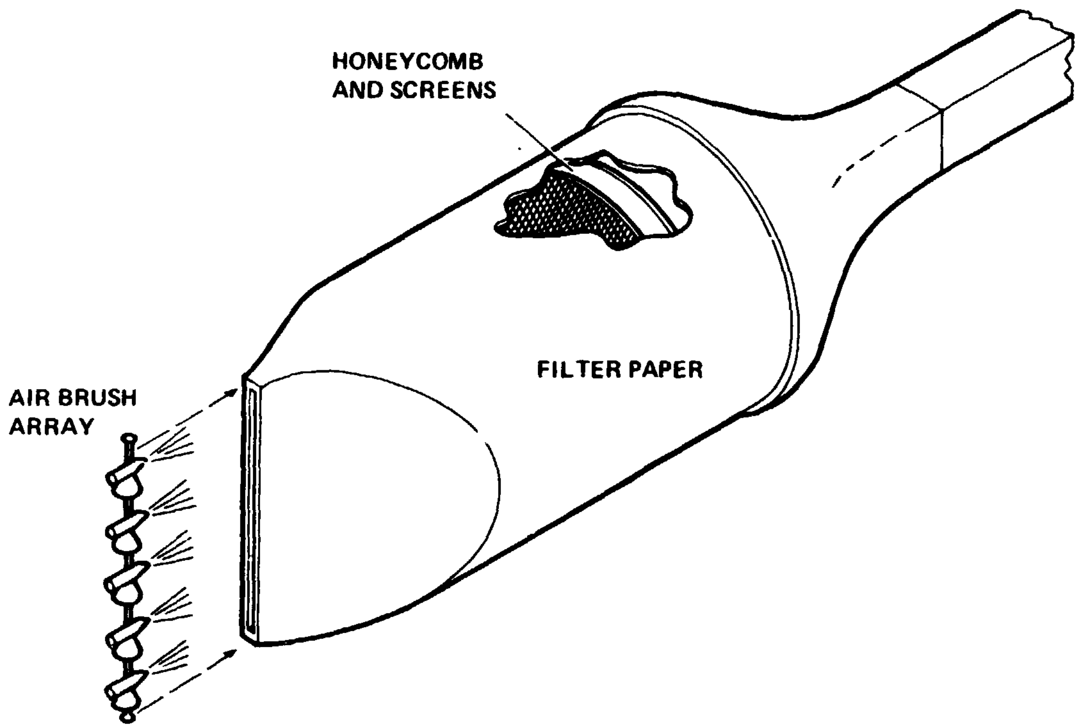
size:	0.35 to 0.55 μm dia.
shape:	spherical
specific gravity:	1.05
flow trackability:	excellent (ref. 5)
toxicity:	low
cost:	low

They have the disadvantage of being packaged as an aqueous suspension which must be diluted and introduced into the test flow as an atomized mist. This must occur sufficiently far upstream of the test section to minimize flow disturbances and permit the liquid mist to evaporate before reaching the model. Several techniques which have been developed to accomplish satisfactory seeding will be described.

SEEDING LOW-SPEED TUNNELS

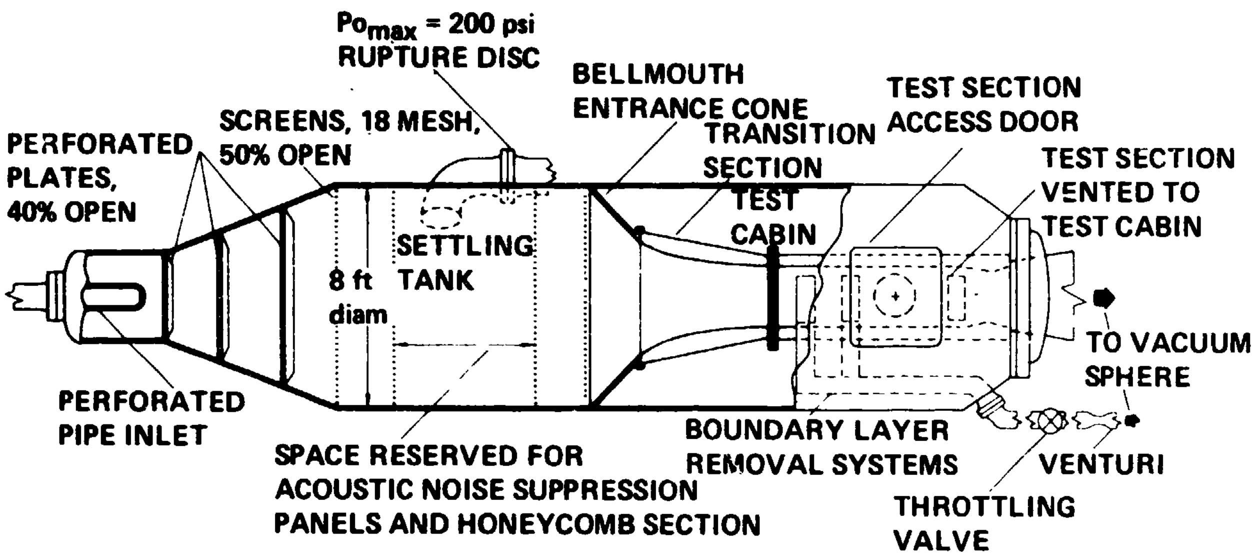
Both the pilot channel and the one-foot low speed tunnel are open circuit designs using atmospheric inlets. These subsonic tunnels are seeded with an array of commercial air brushes mounted upstream of the inlet. To prevent migration of the seed material into the room, screened cages were mounted at the tunnel inlets and covered with several thickness of filter paper. The air brush array was mounted in an opening at the front of the cage and sprayed the liquid-seed aerosol into the enclosure at the front of the tunnel inlet. Tests were made to insure that evaporation of the liquid (alcohol) occurred before reaching the inlet.

Care must be taken to provide a uniform distribution of seed into all of the flow influenced by the test model to minimize spatial seeding bias. This is easily done for tunnel wall measurements because of the mixing in the turbulent tunnel boundary layer. Seeding in the core flow, however, is more difficult and requires experimentation in the positioning of the air brushes.



HIGH REYNOLDS NUMBER CHANNELS I & II

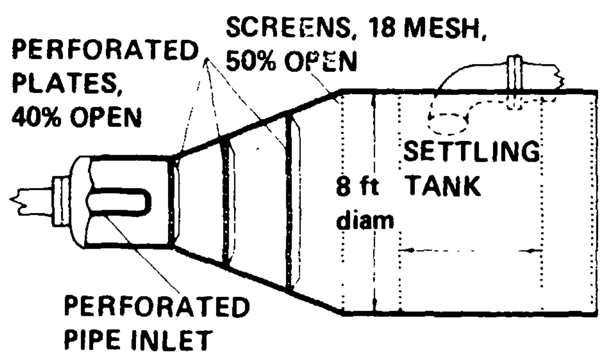
The High Reynolds Number Channels, I and II, are large transonic blowdown facilities with two-dimensional test sections adapted for airfoil testing. Additionally, HRC I can be used with fixed block supersonic nozzles for testing at M=2 and 3. The test section sidewalls of HRC II are fitted with porous metal suction panels which are used to thin the sidewall boundary layer and reduce airfoil interference effects. These porous panels, however, complicate LDV seeding because of the vulnerability to plugging with seed particles. The high pressure inlet piping and stagnation chamber arrangement of HRC II is shown below (ref. 6). HRC I is similar, but smaller in size. The high pressure air is first admitted to the tunnel through the perforated inlet pipe. Turbulence reduction occurs with flow through the three 40% open perforated plates and the 4 screens in the settling tank.



SEEDING THE HIGH REYNOLDS NUMBER CHANNELS

Several seeding arrangements have been used in these large blow-down facilities. The objective is to introduce a finely atomized aerosol of the polystyrene particles and the liquid diluent into the flow. This must be done at a location sufficiently far upstream to permit the liquid to evaporate, and to allow injection disturbances to be damped. Existing tunnel access port location and size were further limitations. Two locations have been tested: in the high pressure feed pipe upstream of the tunnel, and in the entrance chamber just downstream of the perforated pipe inlet.

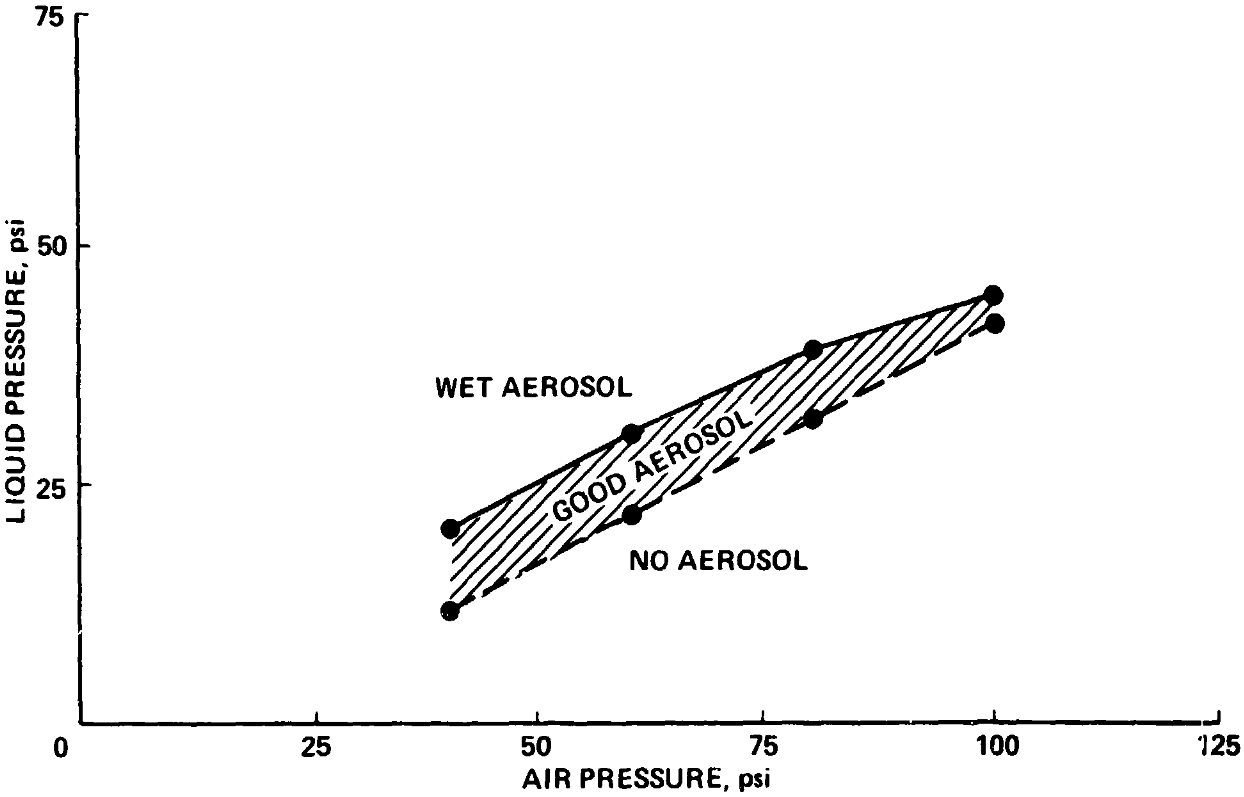
Excellent mixing and distribution were obtained with the first location. Seed deposits on the test section walls and windows, however, indicated that this location could cause the porous boundary layer removal panels to become plugged with seed material. Despite the turbulence at the tunnel inlet caused by the perforated inlet pipe, tests indicated that injection here could be done without filling the tunnel sidewall boundary layer.



COMMERCIAL SEEDING INJECTORS

Several commercial atomizing nozzles were tested with generally poor results. The "airless" types produced a coarse, wet spray for a variety of pressures and orifice sizes and had an unsatisfactory geometric pattern. The air-liquid types that were tested were found to have a very limited range of usable pressures. The performance of one of the better types is graphed below.

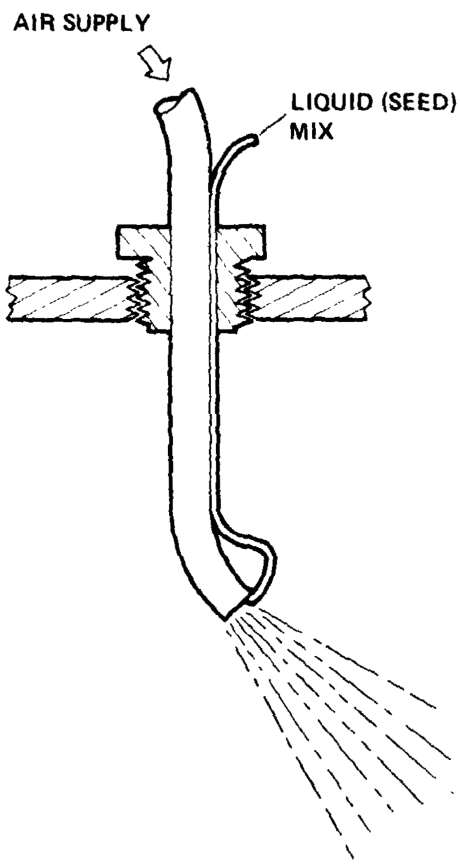
Observations were made of the mist droplet size captured on a lucite sheet 3 feet from the nozzle during bench tests and from the quality of the Doppler signal observed during a tunnel run.



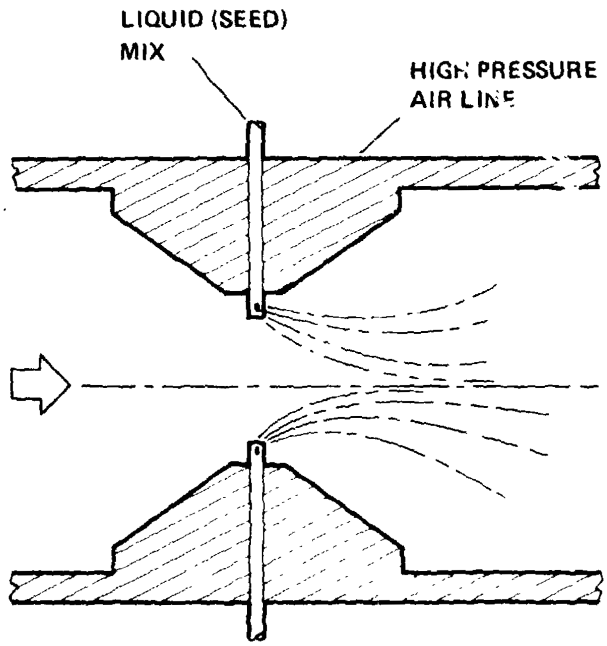
AMES DESIGNED INJECTORS

Three types of seeding injectors using air-liquid mixing have been successfully used in the High Reynolds facilities. Good atomization was obtained with all three designs for a wide range of pressures.

Type A was used in HRC I for several tests which did not require seeding of the entire flow. Wake surveys planned for HRC II, however, required more extensive seeding distributions. Multiple liquid nozzles at a throttling orifice in the high pressure air supply were used as shown at B. This arrangement provided a finely atomized spray with excellent distribution and uniformity. Previously mentioned concerns abut plugging of the porous boundary-layer removal panels in the test section side walls, however, eliminated this approach.



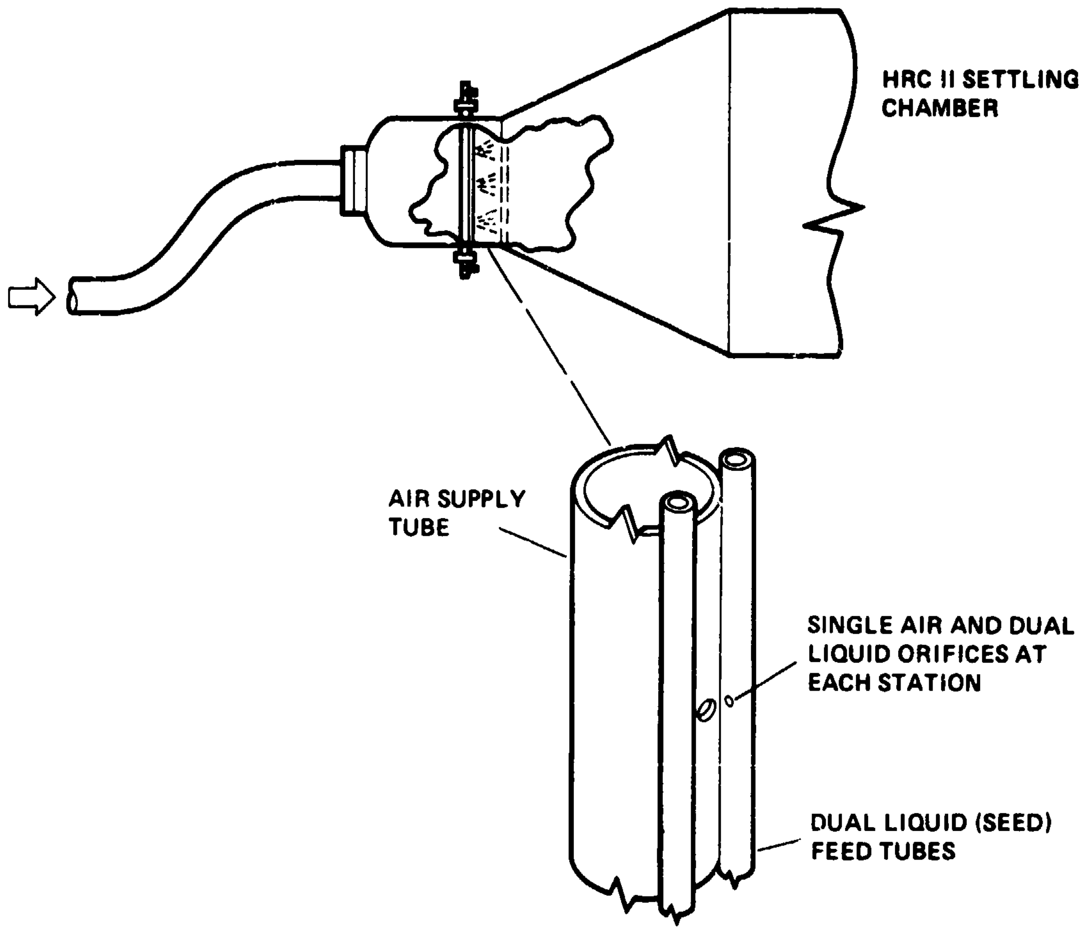
A



B

AMES TYPE C INJECTOR

The injector configuration shown at C was devised to provide a good distribution in the central "core" flow without filling the side boundary layers. This design has been used in both HRC I and II with excellent results. It is located in the tunnel entrance section on the plane of symmetry and spans the tunnel from top to bottom. It can be installed through the available 1-1/4"NPT threaded openings and can accommodate an arbitrary number and location of injection stations. Provision is made in the mounting for thermal strain relief and easy removal for cleaning. The opposing liquid jets are well atomized by the sonic air jet and the impingement of the air jet on the liquid supply tubes promotes a fan-shaped spray. Adjustment of the injection pressure and number of stations has provided the desired uniform distribution of seed material in the test section core without seeding the sidewall boundary layers.



C

REFERENCES

1. Seegmiller, H. L.; Marvin, J. G.; and Levy, L. L., Jr.: Steady and Unsteady Transonic Flow. AIAA J., vol. 16, no. 4, December 1978, pp. 1262-1270.

2. Seegmiller, H. Lee; Marvin, J. G.; Harrison, D. R.; and Kojima, G.: Application of Laser Velocimetry to an Unsteady Transonic Flow. ICIASF '79 Record, September 1979, pp. 284-293.

3. Driver, D. M.; and Seegmiller, H. L.: Features of a Reattaching Turbulent Shear Layer Subject to an Adverse Pressure Gradient. AIAA 82-1029, June 1982.

4. Robinson, S. K.; Seegmiller, H. L.; and Kussoy, M. I.: Hot-wire and Laser Doppler Anemometer Measurements in a Supersonic Boundary Layer. AIAA 83-1723, July 1983.

5. Maxwell, Barry R.; and Seasholtz, Richard G.: Velocity Lag of Solid Particles in Oscillating Gases and in Gases Passing through Normal Shock Waves. NASA TN D-7490, March 1974.

6. McDevitt, J. B.; Polek, T. E.; and Hand, L. A.: A New Facility and Technique for Two-Dimensional Aerodynamic Testing. AIAA Testing Conference, AIAA-82-0608-CP, 1982.