PARAMETRIC STUDY OF THE EFFECTS OF FLAMEHOLDER BLOCKAGE ON THE EMISSIONS AND PERFORMANCE OF LEAN PREMIXED-PREVAPORIZED COMBUSTORS

by

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The report presents test results from a parametric study of the effects of flameholder blockage on the emissions and performance of lean premixed-prevaporized combustors. Tests were conducted at inlet air pressures of 3×10^5 and 5×10^5 pascals, inlet air temperatures of 600K, 700K and 800K, reference velocities from 20 to 35 meters per second, and equivalence ratios from the lean stability limit to 0.7 using Jet A Fuel.

The tests reported herein were conducted in a closed duct test facility as shown in figure 1. Inlet air to the test section was preheated to temperatures from 600K to 800K using a nonvitiating preheater. A contraction section lowered the flow area by a factor of four. To insure good atomization, fuel was injected in the upstream direction through the fuel injector shown in figure 2. The fuel-air mixture passed through a mixer-vaporizer tube which ended in a diffuser section to return to the original flow area. The conical flameholder used in these tests was mounted in the diffuser cone at one of two axial positions to give a flameholder blockage area ration of either 56% or 80%. Figure 3 shows the 5.0 cm diameter cone mounted at the 80% blockage position. The fuel-air mixture burned in a water-cooled combustion section. Gas sampling of the combustion products was accomplished by two sets of four multipoints probes, one of which is shown in figure 4.

Results form the tests support the theory that flameholder blockage is one of the major determinants of the size and shape of the recirculation zone as shown schematically in figure 5. The test data in figure 6 show that higher blockage with its larger recirculation zone provides more residence time which leads to more NO_X formation. These data were taken with the gas sampling probes that were 30 cm. downstream of the flameholder station; thus, the plug flow residence time is the same for both sets of blockage data.

The total residence time of combustion gases is the sum of the recirculation zone residence time and a plug flow residence time. A comparison of test data in which the plug flow residence time of the 56% flameholder blockage data is approximately twice that of the 80% blockage data is shown in figure 7. Since the NO_X levels are relatively close, especially at high flame temperatures, this implies that the total residence times are approximately equal. Thus, the recirculation zone size for the 80% blockage flameholder is approximately twice that of the 56% blockage flameholder. A well stirred reactor computed model prediction is also shown in figure 7 to indicate the approximate true residence time of the gases in the combustor.

FLAMEHOLDER TEST RIG

DIMENSIONS IN cm

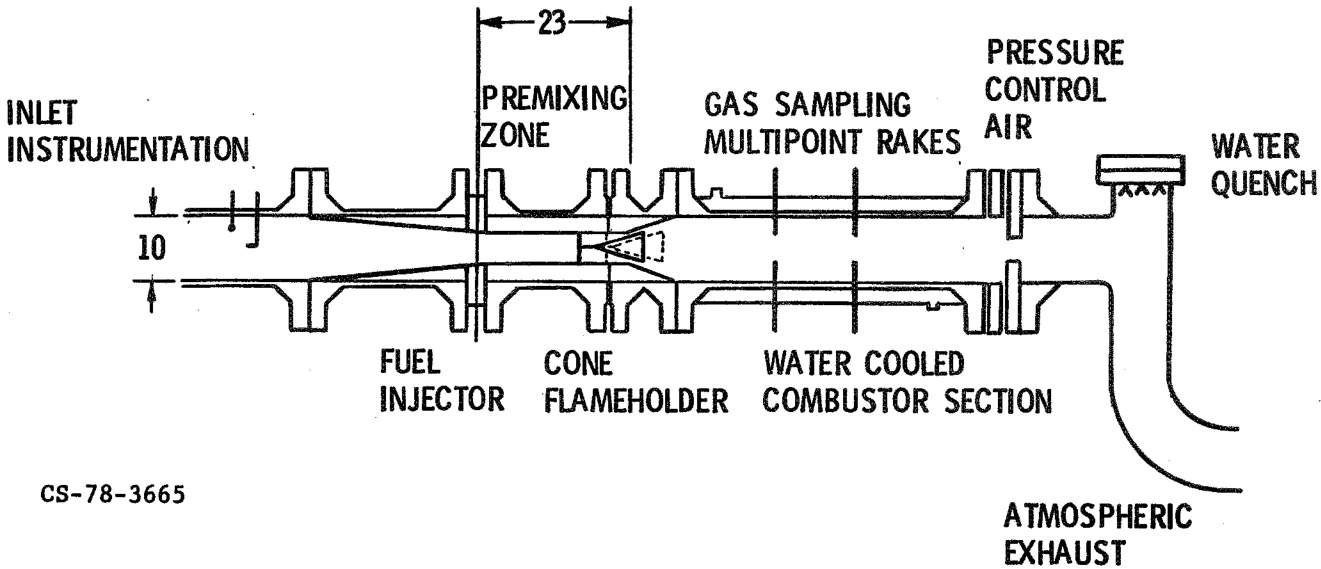

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FIGURE 1.

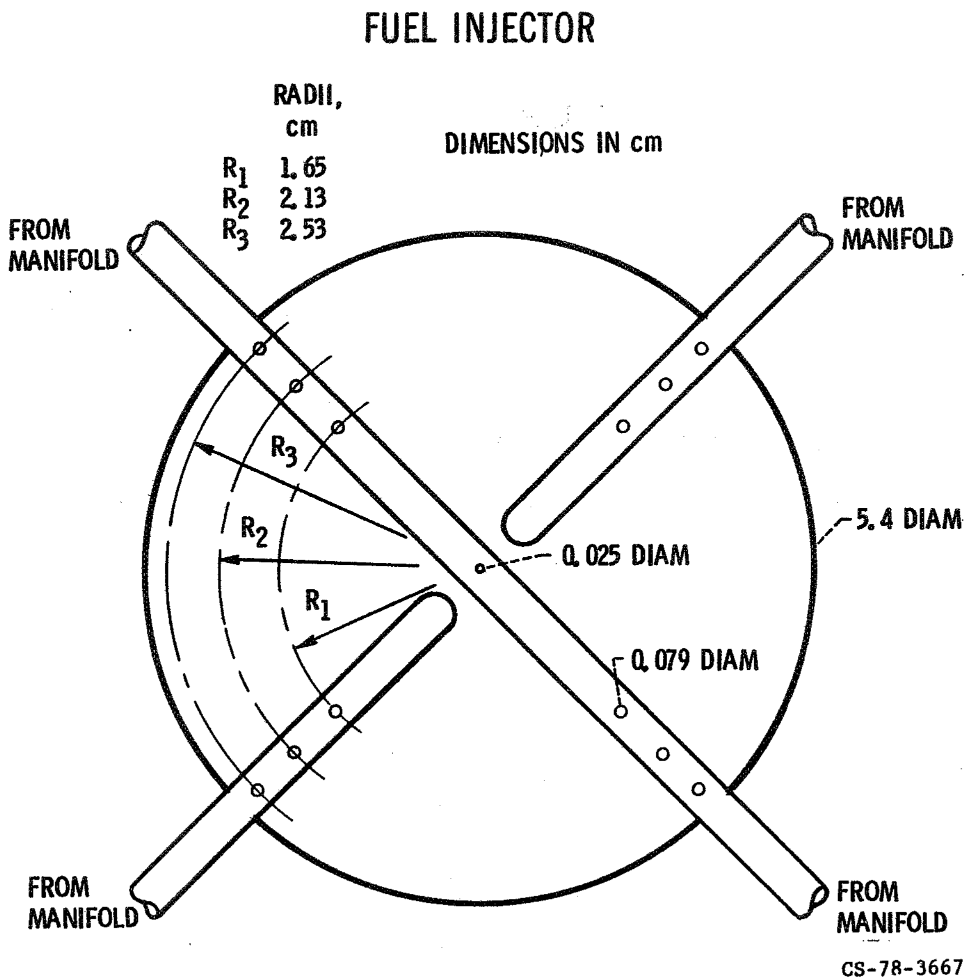
FUEL INJECTOR
RADII,
cm
R1 1.65
R2 2.13
R3 2.53
DIMENSIONS IN cm
FROM MANIFOLD
FROM MANIFOLD
FROM MANIFOLD
FROM MANIFOLD
R3
R2
R1
0.025 DIAM
5.4 DIAM
0.079 DIAM
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FIGURE 2.

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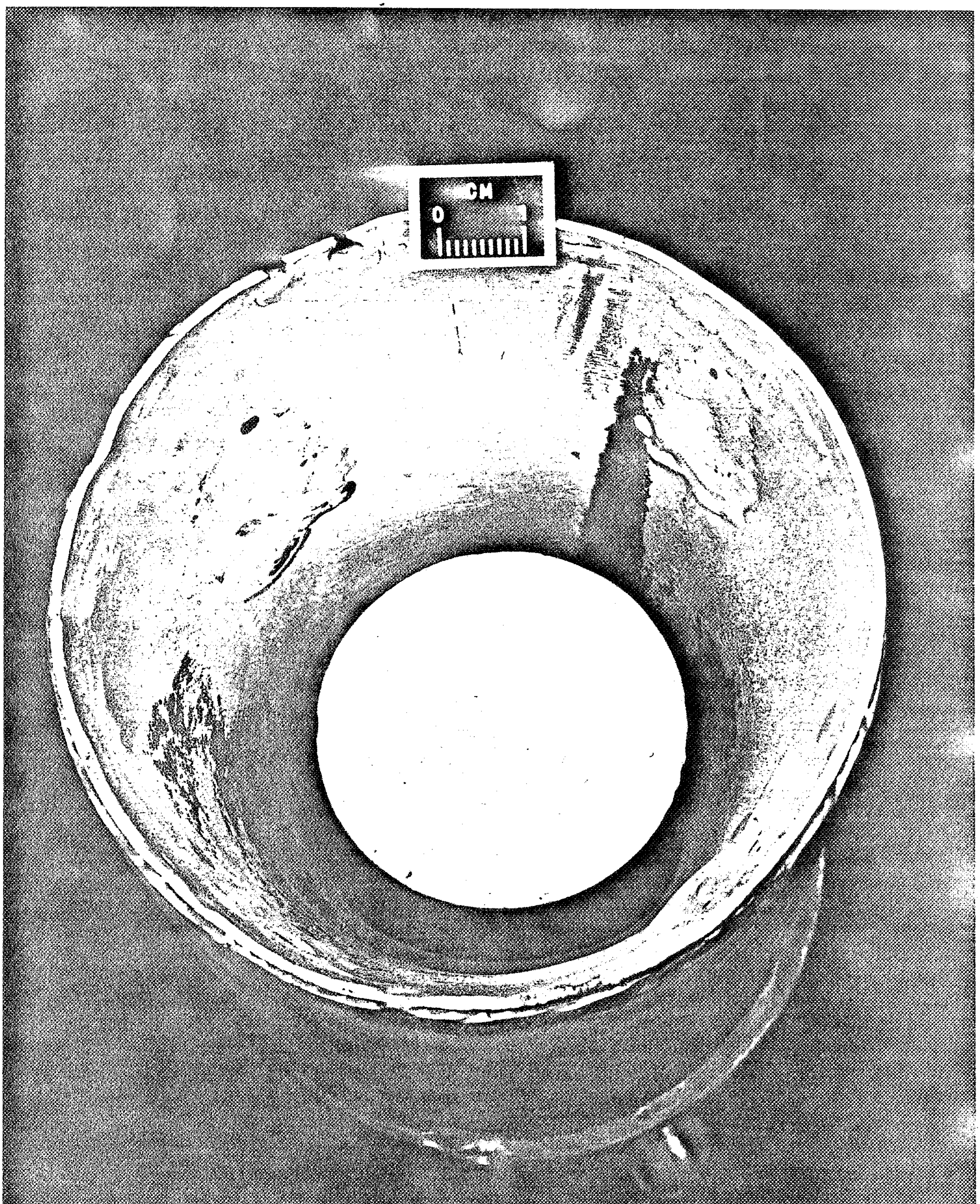
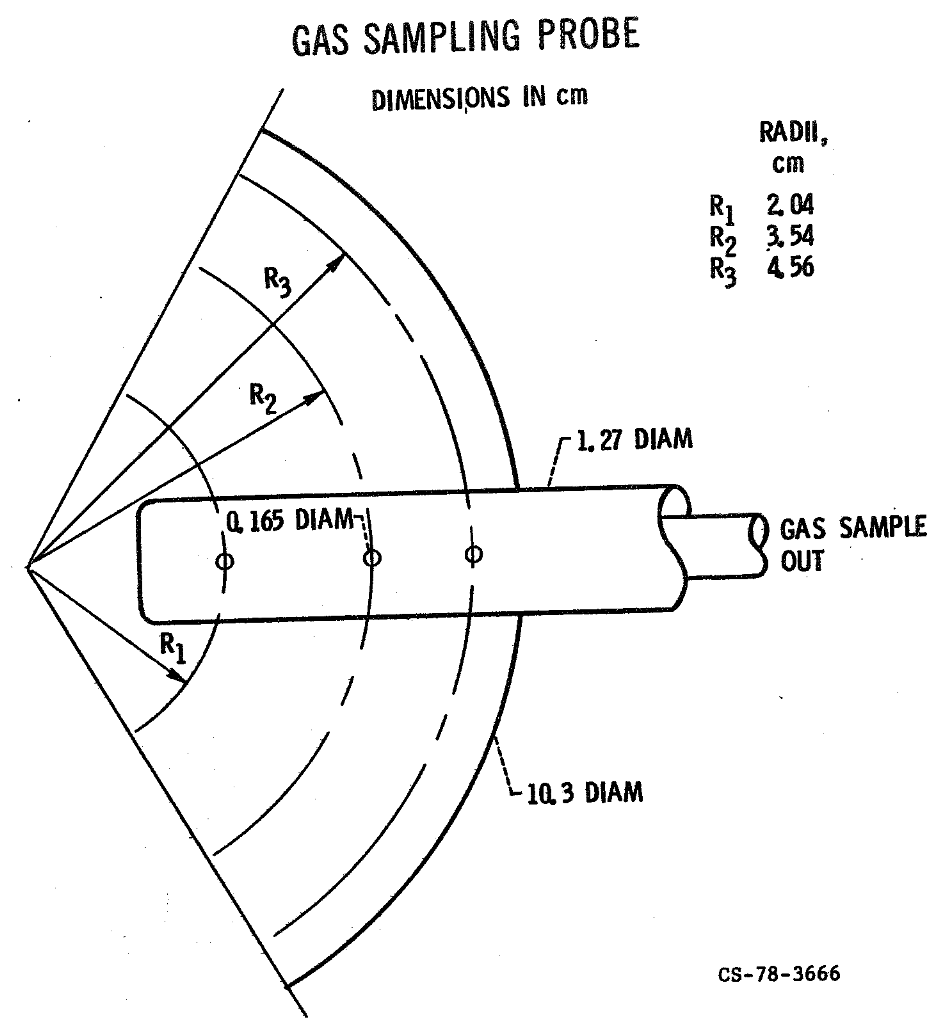


FIGURE 3. MOUNTED FLAMEHOLDER



GAS SAMPLING PROBE
DIMENSIONS IN cm
RADII, cm
R1 2.04
R2 3.54
R3 4.56
R3
R2
R1
1.27 DIAM
0.165 DIAM
GAS SAMPLE OUT
10.3 DIAM
CS-78-3666

FIGURE 4.