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# NASA TECH BRIEF

## *Marshall Space Flight Center*



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### Wind Tunnel Investigations at Transonic Mach Numbers

The flow field induced in a wind tunnel by three-dimensional protuberances at transonic Mach numbers was investigated. The perturbed flow environments of both the protuberances and the surrounding structure were analyzed using static- and fluctuating-pressure measurements and oil-flow visualization techniques. Test results for the generalized configurations, which consisted of three different sized diameter cylindrical protuberances (of the ratio  $d$ ,  $d^2$ , and  $d^3$ , where  $d$  = diameter of smallest protuberance) were derived for a range of test variables consisting of protuberance heights from zero to twice the protuberance diameter, free-stream Mach numbers from 0.60 to 1.60, and Reynolds numbers from 1.5 to 4.5 million per 0.30 m of cylinder length.

The static pressure results are presented in coefficient form to show the axial pressure distributions associated with the protuberance induced flow field, as well as the distribution of surface pressures over the wall of the protuberances. Fluctuating pressure measurements are presented in the form of overall rms fluctuating pressure coefficients, power spectra, cross-power spectra, and narrow band convection velocities.

From the static- and fluctuating-pressure measurements and the oil-flow patterns, the structure of the perturbed flow field is defined. One of the most significant findings is that the upstream separated

flow field induced by three-dimensional protuberances consists of a complex, multiple vortex system which generates fluctuating pressures that are an order of magnitude greater than those observed in two-dimensional separated flows. The extreme fluctuating pressures encountered within the three-dimensional separated flow field are attributed to the shear interaction of two major vortices within the separated region.

#### Notes:

1. The experimental data can be used by aircraft designers for estimating the structural loading in a full-scale vehicle.
2. No additional documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer  
Code A&TS-TU  
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#### Patent status:

No patent action is contemplated by NASA.

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