Flight Flutter Testing

By John W. Thorp

The flight flutter test is intended to demonstrate that the subject airplane is free from flutter behaviors within the specified operating limits of the airplane. This demonstration necessarily requires that the airplane be flown at high speed which in itself introduces certain hazards. These hazards may be minimized when the structural part of the flight test program, SPORT AVIATION, November, is conducted prior to the flight flutter test.

In order to demonstrate freedom from flutter, it is usual practice to dive the airplane to a speed V_D which is 10 percent greater than the maximum indicated air speed at which the airplane need ever be flown. This "never exceed" speed, V_{NE}, is the speed which is marked with a red line on the face of the airspeed indicator.

At V_D, an effort is made to excite flutter by shaking the controls. It is obvious that if flutter does develop under these conditions, the consequence will likely be the loss of the airplane.

Like in structural flight testing, the secret of longevity in flight flutter testing is to creep up on critical speeds cautiously, and to be equipped with a parachute that can be used if someone has guessed wrong.

There is no point in picking a V_{NE} for basis of the V_D test which is far above any speed that the airplane may logically use. In correllary, the speed should not be so low as to seriously limit the usefulness of the airplane. For most airplanes a V_{NE} of 15 percent to 20 percent above the maximum speed that the airplane will attain in level flight is adequate. Airplanes which are not aerodynamically clean and which are used for aerobatics may require a higher ratio of V_{NE} to maximum level flight speed. It doesn't seem likely that the ratio would ever need to be more than 1.33, however.

Flutter susceptibility is a function of true air speed. The red line is indicated air speed. Just because an airplane doesn't flutter at 110 percent of V_{NE} at sea level is no assurance that it will not flutter at altitude at this indicated air speed. Also, there is less aerodynamic damping at altitude. These facts plus consideration of "bail out" in the event of a flutter disintegration point up the desirability of running the flight flutter test at the **highest feasible altitude.**

In conducting the flight flutter test, it is desirable to only test one set of control surfaces at a time. Since the elevator, ailerons and rudder will each be tested up to V_D, a number of dives will be required.

To minimize the risk of flutter, it is well to attempt to execute flutter first at low air speeds. A good speed for the first attempt at producing flutter is probably in level flight at normal cruise power. When steady conditions exist and the airplane is trimmed hands-off, "slap" the stick a sharp blow in the **aft direction.** This so that if the elevator is going to flutter, the speed is in the process of being reduced, greatly reducing the danger of a divergent flutter condition. If the stick oscillations have been heavily damped, the test may be repeated at a 2 to 5 M/H higher indicated air speed. This is repeated again and again until a speed 10 percent over the red line (V_{NE}) has been attained without any evidence of flutter. It is desirable to make at least three attempts at excitation for each condition before proceeding.

The ailerons may be tested next. Again, it is well to start at cruising speed. With the airplane trimmed, pull back slightly on the stick, then "bat" the ailerons a sharp blow with the open hand. A large surface displacement is not required and can be structurally dangerous at higher speeds. Displacement of the surface should be at least three degrees, however. If the ailerons are well damped, a higher speed may be selected a few miles per hour faster than the last. In every case, back pressure is exerted on the stick before exciting the ailerons. A transitory air speed, particularly diminishing, minimizes the possibility of a divergent flutter condition developing. However, if an incipient flutter condition is encountered, a few undamped oscillations of the surface will be evidence that the "dragon's tail" has been "tickled" enough until corrective measures have been taken.

After 110 percent of V_{NE} has been attained and the ailerons have demonstrated no tendency to flutter a similar series of tests are conducted attempting to excite the rudder. In every case after a steady trim speed is attained, the stick is pulled back slightly before kicking the rudder so that the air speed will be decreasing as the rudder is excited.

All surfaces must be free from flutter up to V_D. To demonstrate freedom from flutter at V_D with a transient speed, it will be necessary to start the final check on each surface at a speed slightly above V_D.

All elastic structures have critical flutter speeds. Flutter can destroy a structure in a matter of seconds. Unless measures are taken to prevent flutter, all airplanes will experience flutter in one or more component at some speed, possibly very high.

If the operating speeds are low enough the flutter prevention measures may be pretty elementary. As speeds increase, a greater degree of sophistication will be required to insure against flutter. In any case the builder of an airplane has the obligation to demonstrate that his airplane will not flutter within the airspeed limits established for the particular airplane.

Since flutter is apt to be destructive, be cautious in all phases of the flight flutter testing—**you** are taking **your** life in **your** hands. Good luck!

Scaling On Steel Tubing?

If excessive scaling occurs on steel tubing and the base metal is pitted, too much heat is being used for welding. Even a small flame can burn base metal if held too long at one place. Undercutting severely weakens a weld. If edges of weld metal do not taper smoothly into base metal, the welding is too cold. Hacksaw your practice welds in half to see cross-sections of your bad work such as undercutting, burning and inadequate penetration.