

STABILIZER TRIM LIMIT REVISION

A GENERAL description of stabilizer trim system operation was published in the AIRLINER for May 1961. Although some details have changed on later 707/720 models and on 727's, the basic principle of operation as described in the above mentioned article is still valid for all Boeing commercial jet airplanes.

The horizontal stabilizer is designed to provide the necessary trim capability and leave the elevators for maneuvering. However, the wide range of stabilizer movement which provides the large trim capability also presents the potential threat of large out-of-trim conditions. In other words, the stabilizer is a very effective and powerful means of pitch control and certain precautions are necessary to prevent inadvertent or indiscriminate operation from introducing large out-of-trim conditions from which recovery might be difficult.

Approximately two years ago, the above reasoning resulted in a design change to the 707/720 airplanes. This change relocated the electrical limit switches to restrict electrical operation of the stabilizer to just the range necessary for normal airplane operation at the extremes of the flight envelope. Relocation of the electrical limit switches was offered for retrofit on delivered airplanes by recommended Service Bulletin 1635.

As a result of recent investigation of turbulent air penetration procedures, new attention has been focused on the electrical trim limits in the airplane nose-down direction. It was found that an undesirable situation could develop as a result of

improper use of stabilizer trim, and procedures now state that trim should be established before entering a turbulent area and then LEFT ALONE. (See AIRLINER article, "Flying In Severe Turbulence," in the November-December 1963 issue.)

To illustrate the point, suppose a series of large vertical drafts results in a nose-up attitude, with airspeed decreasing. The pilot may be tempted to disregard recommended procedures and apply nose-down stabilizer trim in addition to applying down elevators in order to recover quickly. Electrical operation of stabilizer trim by the "pickle" switch on the control column will move the stabilizer to the full nose-down limit within a few seconds. Once the nose does start down, airspeed would begin to increase rapidly. This condition could be intensified by a simultaneous shift in the direction of the vertical draft. The pilot's natural reaction would be to pull back on the control column using the elevators to bring the airplane nose up again. If large amounts of nose-down trim were used to pitch the airplane down, it would take more back pressure than usual to bring the nose up, because some additional elevator would be required to compensate for the excessive nose-down trim. In extreme cases where the airplane accelerated to a very high indicated airspeed (in excess of placard speed - V_{MO}), it would be difficult to retrim, because excessive back pressure on the column could stall the trim motor. The solution would be to relax control column back pressure to the point where the trim motor

will operate, then carefully trim nose-up in small increments to avoid excessive "g" loads during recovery. On 707/720 airplanes, the recovery may be aided by the use of the outboard speed brakes in accordance with emergency procedures for out-of-trim flight contained in the Flight Manual and Operations Manual. However, the need for such action could have been avoided by not mis-trimming the stabilizer in the first place.

The elevator does have the capability of counteracting large amounts of stabilizer mis-trim at low speeds, but as speed increases, stick forces also increase, and at very high speeds the elevator effectiveness decreases because of structural deflection. Thus, a given amount of mis-trim which is no problem at low speeds may become quite serious if speed is allowed to build up appreciably before correcting the mis-trim.

Additional Boeing investigation of the airplane nose-down trim requirements has resulted in further restriction of the electrical trim limit on some of the airplane models. Recommended Service Bulletin 27-13 and the production equivalent have been released to reduce the limit on the 727 airplane. This limit is established by the maximum trim requirement for the extreme conditions of high altitude, high airspeed, light airplane gross weight, and aft center of gravity. Recommended Service Bulletin 1990 has been released to further reduce the nose-down electrical trim limit on some 707 model airplanes, and additional investigation is being conducted to determine the feasibility of further reducing the nose-down electrical trim limit on other models.

The reduction of the stabilizer electrical trim limit to a minimum is added protection against the possible hazards caused by out-of-trim operation. The infrequent occurrence where stabilizer trim beyond the electrical limit is required (and must be accomplished manually) is only a slight inconvenience for the extra protection obtained. The stabilizer can be returned electrically towards neutral from a position outside of the established range.