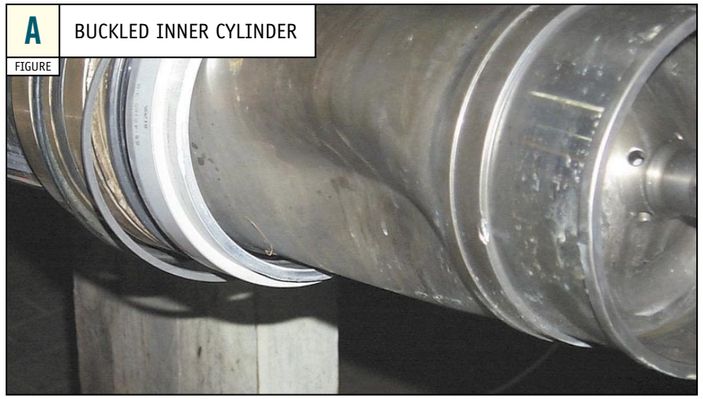
NON-NORMAL LANDING SERVICE EXPERIENCE

The following examples of unusual landing conditions provide noteworthy maintenance observations for operators. In all instances, the airplane structure performed as expected, and when necessary the structural fuse pins, or weak links, preserved the integrity of the fuel tank. No passenger injury occurred. What is often noted in these events is the need to recognize the potential for structural damage, followed by simple and directed inspections, and corrective maintenance and repair.

A BUCKLED INNER CYLINDER

FIGURE



UNREPORTED HARD LANDING

A 737 had what later was determined to be a hard landing. During a subsequent walk-around inspection, damage was found to the left engine cowling. Repairs were made. During the next three flights, there was persistent leakage of the left main landing gear shock strut, which led to the discovery that the inner cylinder had buckled (fig. A). The shock strut apparently was functioning and serviceable, but the persistent leakage led to further maintenance and removal of the buckled inner cylinder from service. Investigation concluded that the buckling of the inner cylinder became more pronounced with the continued service. Subsequent examination of the quick access recorder data showed a 3.8-g vertical acceleration landing. The landing was on the left gear with subsequent drag of the left engine on the runway. The pitch and roll attitude of the airplane indicated neither the nose gear nor the right main gear contacted at the high vertical acceleration; when the contacted, the accelerations were below 1.6 g.

Noteworthy observations:

- Any shock-strut leakage after hard landings may indicate damage to the internal components of the gear.
- Review flight data recorder (FDR) data as soon as possible after a landing has resulted in structure damage.

REMOTE STATION WITH LIMITED MAINTENANCE CAPABILITY

A Boeing airplane-on-ground (AOG) survey was requested when an operator could not service the 737 main gear shock struts after a hard landing. Loud noises were heard when retracting and extending during gear functional checking. The main gear shock struts were leaking fluid and jammed within the outer cylinders. The Boeing AOG survey verified that both main gears needed replacement. The operator also had found a skin buckle at the bottom of the fuselage just aft of the wing center section. During the AOG repair, fasteners common to the keel-beam joint were found sheared just above the fuselage skin buckle (fig. B). No other damage was found.

Noteworthy observations:

- Servicing shock struts that may be damaged should be done with caution. Limit the nitrogen added under pressure, and stop adding nitrogen if the inner cylinder does not move after an increase of 200 psi.
- Fuselage skin wrinkling above structural repair manual guidelines is usually accompanied by damage to the internal structure.
- Remote stations may need maintenance assistance to determine whether hard landing inspections are needed and, if so, to perform the inspections.

HIGH DRAG LOAD RESULTING FROM THE SHREDDING OF BOTH TIRES ON ONE GEAR

A 737 experienced tire-burst during takeoff on a rough runway. The airplane came to a full stop and both left main gear tires were flat and severely damaged. Secondary damage to the gear, flight control surfaces, and pylon was evident. All systems, such as anti-skid and autobrake, were found to be functionally satisfactory. FDR charts showed no anomaly. Drag loads were not recorded, and no excessive vertical loads were evident.

The likely scenario is that, after both tires shredded, combinations of vertical and high drag (drag impact) loads, which were caused by runway roughness and a locked brake, produced sufficient loads to fracture the main landing gear forward trunnion fuse bolt (fig. 4 on p. 17). The forward trunnion fuse bolt that fractured is not visible unless the trunnion link is removed.

When the forward trunnion fuse bolt fractured because of the high drag loads, the loads were transferred to two links that attach the main landing gear beam to the wing rear spar (fig. 2 on p. 16). Because these links are not designed to react to drag loads, the pins that attach the links to the rear spar fractured at the shear planes (fig. 3 on p. 17).

Boeing is revising the conditional inspections in the 737 AMM, section 05-51, to include inspection of these two pins during a phase I inspection as an indication of whether or not the forward trunnion fuse pin has been damaged. This permits an effective phase I indication that the forward trunnion fuse bolt is intact without removal of the trunnion link.

Noteworthy observations:

- High drag-load conditions, including off-runway excursions, may result in damage to landing gear structure and control surfaces.
- FDR data may not provide indications of high drag loads.
- All gear fuse pins need to be closely inspected after such conditions.
- A forward trunnion fuse pin fracture preserves the integrity of the fuel tank.

INTERPRETATION OF FDR DATA

An operator reported a hard landing in which one main gear inner cylinder was buckled, and latches were broken in the passenger service units. The FDR data showed a 5.12-g vertical acceleration spike. The operator asked Boeing whether a flareless landing could have caused the damage. Boeing advised the operator that the landing was considered very severe. It was equivalent to a landing in excess of 18 ft/s, which substantially exceeded airplane design parameters. The operator could expect to find additional structural damage. Both main gears were removed for inspection and possible salvage (see “Salvaging Gear Components” on p. 22).

Noteworthy observations:

- Observed damage can be the most meaningful indication that a hard landing has occurred and AMM conditional inspections should be completed.
- Operators should not hesitate to obtain technical reviews from Boeing through their Field Service representatives.
- Vertical acceleration guidelines to initiate conditional inspections are helpful when used in conjunction with flight crew observations.

B LOWER FUSELAGE SKIN BUCKLE AT KEEL-BEAM JOINT

FIGURE