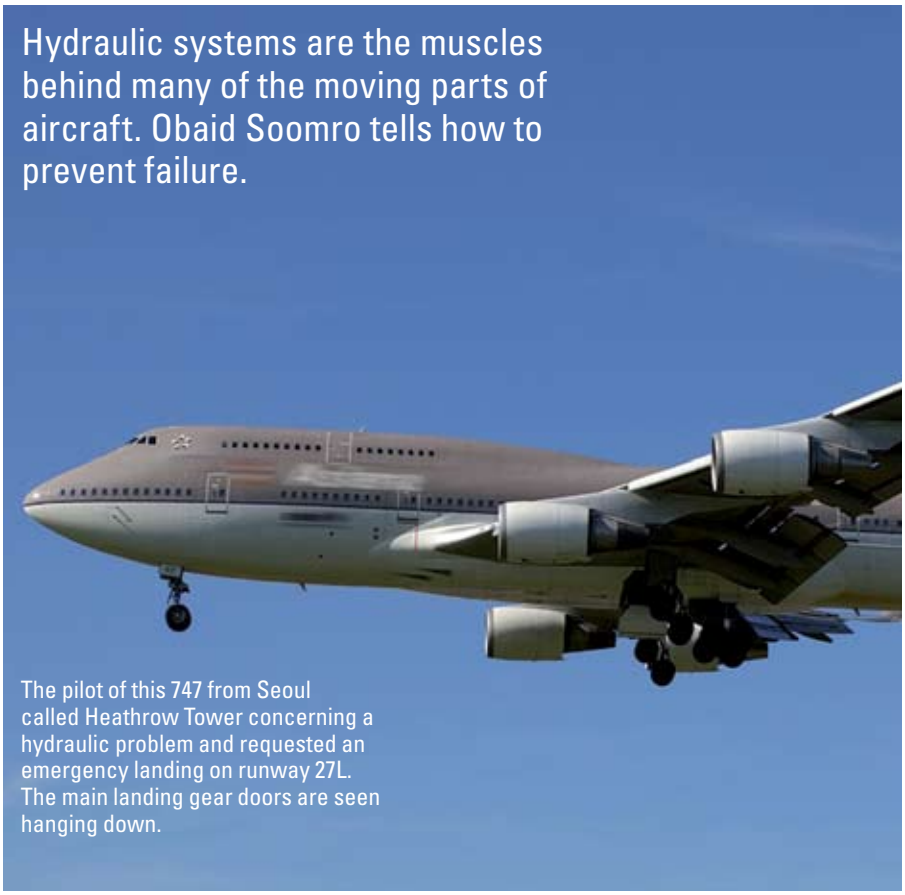
HYDRAULICS: A PRIMER

Hydraulic systems are the muscles behind many of the moving parts of aircraft. Obaid Soomro tells how to prevent failure.



The pilot of this 747 from Seoul called Heathrow Tower concerning a hydraulic problem and requested an emergency landing on runway 27L. The main landing gear doors are seen hanging down.

From precision servo controls to the actuators moving heavy wing surfaces against tremendous aerodynamic forces, it's all hydraulic power in action.

Aircraft hydraulic systems comprise hydraulic fluid, reservoirs, actuators, pumps, motors, valves, transducers, gauges and plumbing, including lines, pipes, hoses, unions and seals.

Proper scheduled maintenance, detailed inspection, timely snag rectification and gradual replacement or modification of high-life and worn-out parts before they fail extend hydraulic system longevity.

Failure of one part of the hydraulic system can put the whole system out of action. The warning signs are usually material deterioration and leaks. If you don't pay attention at that point, you are heading for a system breakdown.

There are many ways a hydraulic system can fail.

One is fluid contamination: the build-up of solid particle contaminants can result in abrasion wear, and controls can lock if enough solids accumulate in tight spaces. Prevention of fluid contamination is easy:

- Use clean tools and keep the system clear of outside contaminants.
- Cap all component or line openings.
- If a component is new, remove any preservative fluid.
- Do not mix different types of fluids unless permitted by the aircraft manufacturer.
- If indicators pop, change filters immediately.
- Investigate all instances of contamination. Material liberated during cavitation or other internal damage might act as a contaminant.

Other causes of hydraulic failure are leaks, sludge and cavitation: if you see an internal or external fluid leak, fix it quickly because it is the precursor of a system failure.

Internal leaks usually result from worn or damaged seals and malfunction of the hydraulic system. Seals can swell or shrink if the seal and fluid materials are incompatible.

External leaks come from failure of hoses, pipes, unions, couplings or seals. You should:

- Watch out for abnormally high or low fluid levels and colour. Keep an eye on filters. Record hydraulic fluid consumption and investigate if it bucks the normal trend.
- Use only approved seals, elastomers and fluids.
- Carry out regular inspection of hydraulic lines for wear, chafing and deterioration.
- Inspect and maintain flexible hoses. Refer to Airworthiness Bulletin 02–06, available on the CASA website, if required.

Exposure of the fluid to system stresses and to moisture can lead to chemical changes and sludge formation. Check out any abnormal loading, like jammed control surfaces.

When hydraulic pressure falls below a certain level, air and vapour can form cavities that expand and collapse in the moving fluid. This is called cavitation.

Malfunction of hydraulic components such as pumps, valves and actuators can cause cavitation, which you can detect from the system's peculiar chatter, jerkiness and slow response.

Cavitation can cause physical damage. The cure is to ensure proper priming and

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absolute sealing of the system.

A third cause of hydraulic failure is stress and servicing: wear is accelerated by work-induced stress, overstressing, erosion, corrosion, abrasion, adhesion, surface fatigue and fretting.

Inappropriate tube bending when installing hydraulic lines, hoses and pipes can flatten the radii. Similarly, if the tube needs to be worked or bent to fit in tight places, the only defence against weakening it is to comply with standard engineering practices.

Guard against over-torquing of fittings, as this can cause cracked flares.

At times, hydraulic system failure is traceable to indirect sources. For example, unbalanced propellers can transmit high-frequency vibrations that can weaken hydraulic system components. Keep vibrations to the minimum, whatever the source.

And incorrect servicing of the accumulator and allowing excessive "slamming" can weaken components over time.

Do not neglect clamps. Watch out for chafing due to deterioration of cushion clamps, incorrect clamping, wrong installation and loose support blocks. Prevention of chafing requires enough clearance between components.

To ensure proper hydraulic system functioning, follow the manufacturer's instructions, and use original parts. If as a last resort you are going to fabricate a hydraulic line, follow the approved processes and data. Approved designs and modifications by a CAR 35 authorised person are also OK.

Opt for the manufacturer's modifications and service bulletin that are likely to enhance system or parts reliability. Plan gradual retirement of the marginal parts.

And review your maintenance program to ensure that the level and frequency of hydraulic system inspection meets the manufacturer's requirements.

– Obaid Soomro is a technical specialist in CASA's propulsion and mechanical systems section.

DRY DIPSTICKS

Good oil monitoring delivers safety and financial dividends. Obaid Soomro tells why some engines gulp oil.

John Lowing (Schofields Flying Club)

Å rather noticeable oil leak

Pre-flight: you open the hatch in the engine cowling, pull out the engine oil dipstick and stare at the gap between the oil line and the engraved "full" mark. Oil seems low. Wipe the dip stick and try again. Oil is low! Perhaps about now you get the feeling that oil consumption is out of sync with flight hours.

The recording and trending of oil consumption figures against flight hours is a good diagnostic tool and may forewarn you of engine failure.

Engines with new piston rings may have erratic or high oil consumption, but after the rings are seated consumption should stabilise below the maximum limits specified by the manufacturer. An abrupt increase warrants investigation and rectification.

CASA Airworthiness Directive (AD) AD/Eng/4 Appendix A mandates monitoring of oil consumption, requiring recording of oil uplift and the corresponding engine hours. Failure to record these data or unreliable records could violate AD/Eng/4 requirements.

If there is no evidence of unsafe condition, it is reasonable to top the oil up to the correct level and make an entry in the relevant document to establish the oil consumption rate by recording all oil added to maintain that mark over the next 20 flight hours.

If oil consumption looks high, you should find out why. It could be caused by one or more of the following:

- external oil leaks
- use of oil other than the one approved by the manufacturer (thinner oils can leak past the piston rings.)
- problems related to piston rings, including:
  - failure of the piston rings to seat properly after rings change
  - worn, stuck or broken piston rings
  - piston rings size not matching with the cylinder barrel size
  - plugged expander in the oil control ring
  - plugged injector nozzle – lack of fuel and combustion pressure may allow oil to bypass the piston rings
- combustion gas blow-by – it may pressurise the crankcase and force excessive oil out through breather
- glazed cylinder barrels
- worn valve guides
- loss of oil in-flight past oil tank filler cap.

In aviation, nothing is trivial but some factors are more important than others. Use of clean oil of the correct grade, and the monitoring of its condition and consumption, will help extend the engine lifespan. The replacement of oil and filters as recommended by the aircraft engine manufacturer will also help. And timely troubleshooting can save thousands of dollars in engine maintenance.