AIRCRAFT CONTROLS & CABLES

For most of us little airplane folks, the cables which attach the cockpit stick, wheel, and pedals to the flight controls are vital to the operation. Despite the importance of this necessary group of components, many owners and pilots think very little about the mechanical condition of Controls and cables, and how they age or degrade over time.

A very close friend of mine, we will call him Bradley because that is his name, owns a 1961 Ce**na with fresh paint, a new interior, and a nicely restored panel. Bradley is a meticulous owner/mechanic, unafraid to ask questions and willing to properly maintain his airplane. Despite many years of loving restoration of his prized bird, Bradley never paid much attention to his control cables- until recently.
(FWIW, Bradley flew a Luscombe 8E until his family outgrew that steed)

During a post-flight (engine-off), conversation with another friend Bradley rested his arm on the controls. This moved the aileron cable, which with the engine silent, revealed a "scratching noise" similar to fingernails on a chalkboard. That noise was bothersome and annoying.

With his friend actuating the ailerons slowly, Bradley listened intently for noises in the wing until the source was located at the right hand wing root. Just inside the wing cavity Bradley found a cable which was fatigued and broken through four of seven strands.[1]

One month prior to this event, during his annual inspection, no cable damage was apparent hen he inspected this area. The aileron cables were removed, and further inspection found that two other strands in the same cable had broken wires, and were well into their failure mode. It then became clear that a loss of aileron control was merely a few flight hours from occurring, had not this fortuitous engine-off conversation taken place.

Bradley decided to remove and check ALL of the aircraft control cables in the airplane, after reviewing the aircraft logs and learning that none of the cables had been replaced over the past 45 years. <u>Only two</u> cable units were damage free. Most of the cables were corroded internally, or inside the stainless swaged fittings. Several cables had frayed strands, and some were wearing on pulleys that had seized, and were no longer affected by lubricants sprayed at them.

SADLY this kind of maintenance problem is NOT an irregular event. The Luscombe has cable ADs that require removing and inspecting cables ANNUALLY- Sadly few IA's will do the job as it is required[2]; Each year we see dozens of airplanes with rusty cables and rusty cable hardware flying in and out of the airport shows. (NOTE- aileron

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[1] Aircraft cable is constructed by 7 strands of wound wires, with 19 wires per strand to give it flexibility.

[2] Please refer to FAA AC43.13-2A Chapter 7, Section 8, Para 7-149 & 7-150 for explicit details on cable inspection and maintenance.

forks at the top of each wing are a very common corrosion point. Classic Aero Stocks stainless forks for these turnbuckles, to replace your rusty ugly old forks)

CABLE CONSTRUCTION

MIL –DTL-83420 Aircraft Cable (QPL) (galvanized steel), is considered to be 'super flexible'. 1/8" construction meets a 2000# pull test. PMA Cables must pull test to 60% of this load (1200#) for certification (there is no test on home-made or field-made cables). MIL Cable is impregnated with corrosion inhibitors and lubricants to resist water and corrosion. This lubricant and corrosion protection is "used up" after about 12 years in normal outside exposure. Corrosion and fatigue then accelerates quickly. Cable replacement should occur about each 15-20 years.

Cables can be constructed from either galvanized wire or stainless wire. Galvanized wire is more flexible, more supple, and provides very little resistance in the pulley runs for much of its life. Galvanized steel cables offer good corrosion resistance under normal operations EXCEPT where the aircraft will experience salt water spray.

CABLE CORROSION

If you see a little bit of rust outside the cable, that indicates that the corrosion between the wires and strands is far more serious. Spray the cable with WD-40 or light oil, or MIL-C-16173, then work it by bending 70 degrees side to side - you will find rust particles escape and stain your hand or rags used to hold the cable near the bend. Rust and other oxidation inside the cable strands acts as a minute abrasive upon the wires, this in turn increases the galling and fatigue of the individual wires, then the strands, and ultimately this results in the failure of the cable itself. <u>Thorough inspection is the key.</u>

Where there is paint on a cable you should be aware that this traps rain and other water in the cable strands which promotes corrosion.

Stainless Steel will offer more resistance to corrosion, but has other flaws that make it a distant second choice for most owners

CABLE FATIGUE

Galvanized cable will resist fatigue better than Stainless steel because it is more flexible, and because it develops less memory during service. Galvanized cable may develop some memory by the time is replaced at 12-15 years. However, the alloy compounds in Stainless steel and stainless wire alloys cause that material to develop memory much more quickly.

In fact, Stainless wire and Stainless cable is considerably stiffer than galvanized wire and galvanized cable at the time of initial manufacture. Over its service life Stainless cable will become more stiff and resist the bends around pulley runs in the aircraft as it work hardens. Galvanized cable does work harden and fatigue, but it will do so at a much slower rate so it tends to stiffen more from internal corrosion, which then provides discoloration and warning signs during inspections.

CONTROL FEEL
I personally do not install stainless cables in light aircraft unless it is a seaplane that will be operated in/near salt water. Stiff Stainless cables affect the "feel" in systems like the Luscombe ailerons which already heavy, AND, I prefer the warnings from corroded cables over a longer period to the unknowns of stainless cables.

In addition to the 'control feel' issue and heavy ailerons on the Luscombe which would be exacerbated by stainless aileron cables, there is a fatigue problem with the rudder cables where they pass under the gearbox. This fatigue issue is even greater in the T8F rudder system due to additional rigging and bends. Because the stainless cable is so much stiffer, and because it is much more prone to hardening/ fatigue, the stainless cables are, IMHO, a lesser choice for use in most light aircraft where the pilot seeks to have a "light" stick force and feel.

CORRUGATED SKINS
All primary control cables on a Luscombe end at surfaces covered with corrugated skins made to Luscombe standards. A huge variation in the corrugations delivered by Luscombe was possible due to the large tolerance standards allowed. If you are considering re-skinning, the Endowment can now provide custom skins to exactly match your spars and opposing skins with a perfect diamond pattern at the trailing edge. No other supplier will do this and guarantee the outcome. The Luscombe Endowment supplies detailed re-skinning instructions with any purchase of corrugated skins.

LUSCOMBE CABLE INSPECTION & CABLE APPLICATIONS
RUDDER- Inspect and replace Luscombe rudder cables OFTEN (each 5 years). The high wear area is at pulleys under the gearbox area, where they must be disconnected at the rear, and pulled forward for a good inspection.
ELEVATOR- Inspect elevator cables annually- the rear pulleys tend to seize, but otherwise if tension is maintained this system is trouble-free.
AILERON- These cables must be virtually without tension and should 'slap' in the wing upon a sudden reversal of direction. Corrosion is an issue at the aileron end, and the nico-press fittings at the control stick are always a good inspection area.
TRIM- there are three trim cable assemblies (with shrouds) the two rear units collect water in the sheath, and the sheath is often damaged at the spar and rib pass-throughs. Use grommets and soak the cable inside the sheath with an anti-static lubricant such as MP. Do not attempt to reuse old sheaths, and replace the complete assemblies when service is required.
BRAKE- Originally these cables were 1/16". This was upgraded to 3/32" cable where the heavier cable provided a more secure brake actuation. The use of metal pulleys in brake applications is suggested to prevent the pilot from splitting the phenolic pulley shive and locking a brake unintentionally.

7-149. CABLE SYSTEM INSPECTION. Aircraft cable systems are subject to a variety of environmental conditions and deterioration. Wire or strand breakage is easy to visually recognize. Other kinds of deterioration such as wear, corrosion, and/or distortion are not easily seen; therefore, control cables should be removed periodically for a more detailed inspection.

a. At each annual or 100 hour inspection, all control cables must be inspected for broken wires strands. Any cable assembly that has one broken wire strand located in a critical fatigue area must be replaced.

b. A critical fatigue area is defined as the working length of a cable where the cable runs over, under, or around a pulley, sleeve, or through a fair-lead; or any section where the cable is flexed, rubbed, or worked in any manner; or any point within 1 foot of a swaged-on fitting.

c. A swaged-on fitting can be an eye, fork, ball, ball and shank, ball and double shank, threaded stud, threaded stud and turnbuckle, compression sleeve, or any hardware used as a termination or end fitting on the cable. These fittings may be attached by various swaging methods such as rotary swaging, roll swaging, hydraulic pressing, and hand swaging tools. (See MIL-T-781.) The pressures exerted on the fittings during the swaging process sometimes pinch the small wires in the cable. This can cause premature failure of the pinched wires, resulting in broken wires.

d. Close inspection in these critical fatigue areas, must be made by passing a cloth over the area to snag on broken wires. This will clean the cable for a visual inspection, and detect broken wires if the cloth snags on the cable. Also, a very careful visual inspection must be made since a broken wire will not always protrude or stick out, but may lie in the strand and remain in the position of the helix as it was manufactured. Broken wires of this type may show up as a hairline crack in the wire. If a broken wire of this type is suspected, further inspection with a magnifying glass of 7 power or greater, is recommended. Figure 7-16 shows a cable with broken wires that was not detected by wiping, but was found during a visual inspection. The damage became readily apparent when the cable was removed and bent as shown in figure 7-16.

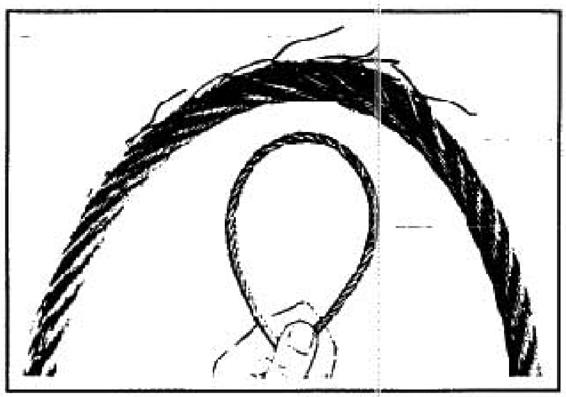

FIGURE 7-16. Cable inspection technique.

e. Kinking of wire cable can be avoided if properly handled and installed. Kinking is caused by the cable taking a spiral shape as the result of unnatural twist. One of the most common causes for this twist is improper unreeling and uncoiling. In a kinked cable, strands and wires are out of position, which creates unequal tension and brings excessive wear at this part of the cable. Even though the kink may be straightened so that the damage appears to be slight, the relative adjustment between the strands has been disturbed so that the cable cannot give maximum service and should be replaced. Inspect cables for a popped core or loose strands. Replace any cable that has a popped core or loose strands regardless of wear or broken wires.

f. Nylon-jacketed cable with any cracks or necking down in the diameter of the jacket shall be replaced. Usable cable life is over when these conditions begin to appear in the nylon jacket.

g. External wear patterns will extend along the cable equal to the distance the cable moves at that location and may occur on one side of the cable or on its entire circumference. Replace flexible and nonflexible cables when the individual wires in each strand appear to blend together (outer wires worn 40 to 50 percent) as depicted in figure 7-17. Actual instances of cable wear beyond the recommended replacement point are shown in figure 7-18.

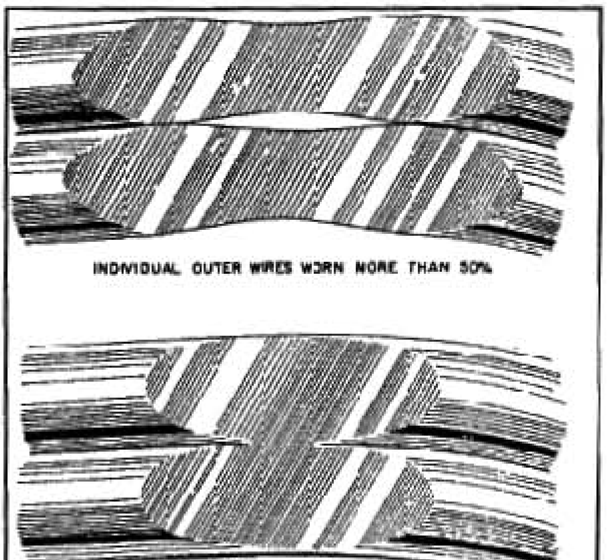

FIGURE 7-17. Cable wear patterns.

h. As wear is taking place on the exterior surface of a cable, the same condition is taking place internally, particularly in the sections of the cable which pass over pulleys and quadrants. This condition (shown in figure 7-19) is not easily detected unless the strands of the cable are separated. This type of wear is a result of the relative motion between inner wire surfaces. Under certain conditions, the rate of this type of wear can be greater than that occurring on the surface.

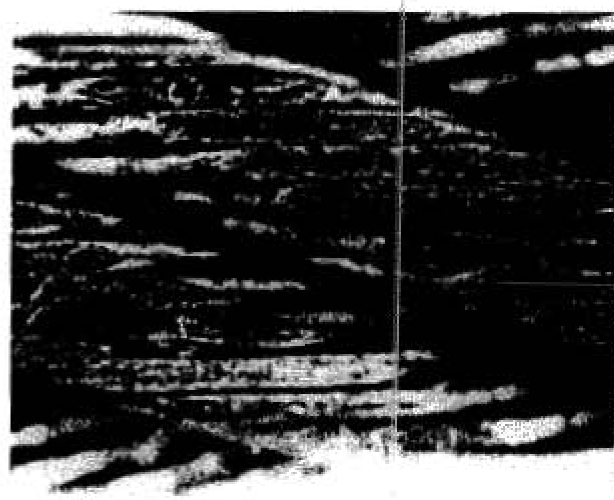

FIGURE 7-18. Worn cable (replacement necessary).

i. Areas especially conducive to cable corrosion are battery compartments, lavatories, wheel wells, etc.; where a concentration of corrosive fumes, vapors, and liquids can accumulate. Carefully examine any cable for corrosion, when it has a broken wire in a section that is not in contact with a wear-producing airframe component, such as a pulley, fair-lead, etc. If the surface of the cable is corroded, relieve cable tension and carefully force the cable open by reverse twisting and visually inspect the interior. Corrosion on the interior strands of the cable constitutes failure, and the cable must be replaced. If no internal corrosion is detected, remove loose external rust and corrosion with a clean, dry, coarse-weave rag, or fiber brush. Do not use metallic

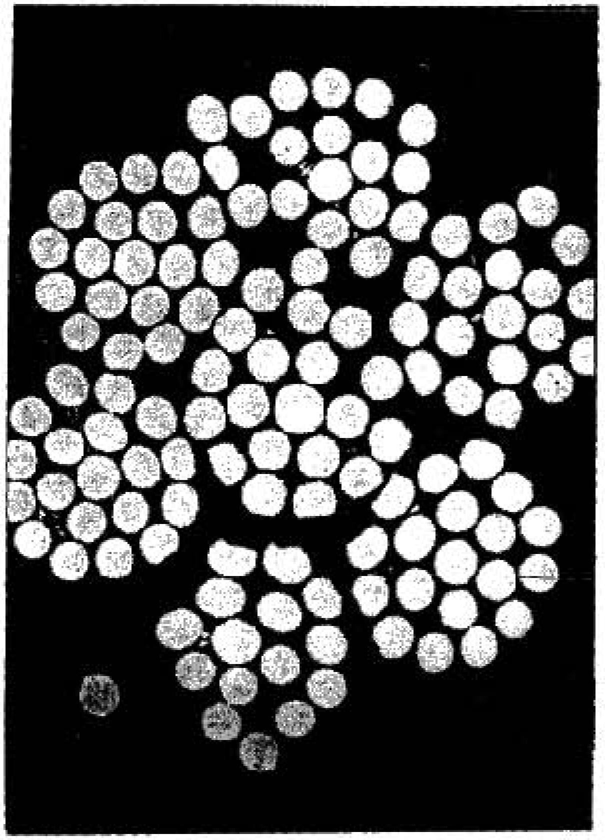

FIGURE 7-19. Internal cable wear.

wool or solvents to clean installed cables. Use of metallic wool will embed dissimilar metal particles in the cables and create further corrosion problems. Solvents will remove internal cable lubricant allowing cable strands to abrade and further corrode. After thorough cleaning, sparingly apply specification MIL-C-16173, grade 4, corrosion-preventive compound to cable. Do not apply the material so thick that it will interfere with the operation of cables at fair-leads, pulleys, or grooved bellcrank areas.

j. Examine cable runs for incorrect routing, fraying, twisting, or wear at fair-leads, pulleys, antiabrasion strips, and guards. Look for interference with adjacent structure, equipment, wiring, plumbing, and other controls. Inspect cable systems for binding, full travel, and security of attaching hardware. Check for slack in the cable system by attempting to move the control column and/or pedals while the gust locks are installed on the control surfaces. With the gust locks removed, actuate the controls and check for friction or hard movement. These are indications that excessive cable tension exists.

NOTE: If the control movement is stiff after maintenance is performed on control surfaces, check for parallel cables twisted around each other, or cables connected in reverse.

k. Check swaged terminal reference marks for an indication of cable slippage within the fitting. Inspect the fitting assembly for distortion and/or broken strands at the terminal. Ensure that all bearings and swivel fittings (bolted or pinned) pivot freely to prevent binding and subsequent failure. Check turnbuckles for proper thread exposure and broken or missing safety wires/clips.

l. Inspect pulleys for roughness, sharp edges, and presence of foreign material embedded in the grooves. Examine pulley bearings to ensure proper lubrication, smooth rotation; and freedom from flat spots, dirt, and paint spray. During the inspection, rotate the pulleys, which only turn through a small arc, to provide a new bearing surface for the cable. Maintain pulley alignment to prevent the cable from riding on the flanges and chafing against guards, covers, or adjacent structure. Check all pulley brackets and guards for damage, alignment, and security.

m. Various cable system malfunctions may be detected by analyzing pulley conditions. These include such discrepancies as too much tension, misalignment, pulley bearing problems, and size mismatches between cables and pulleys. Examples of these condition are shown in figure 7-20.

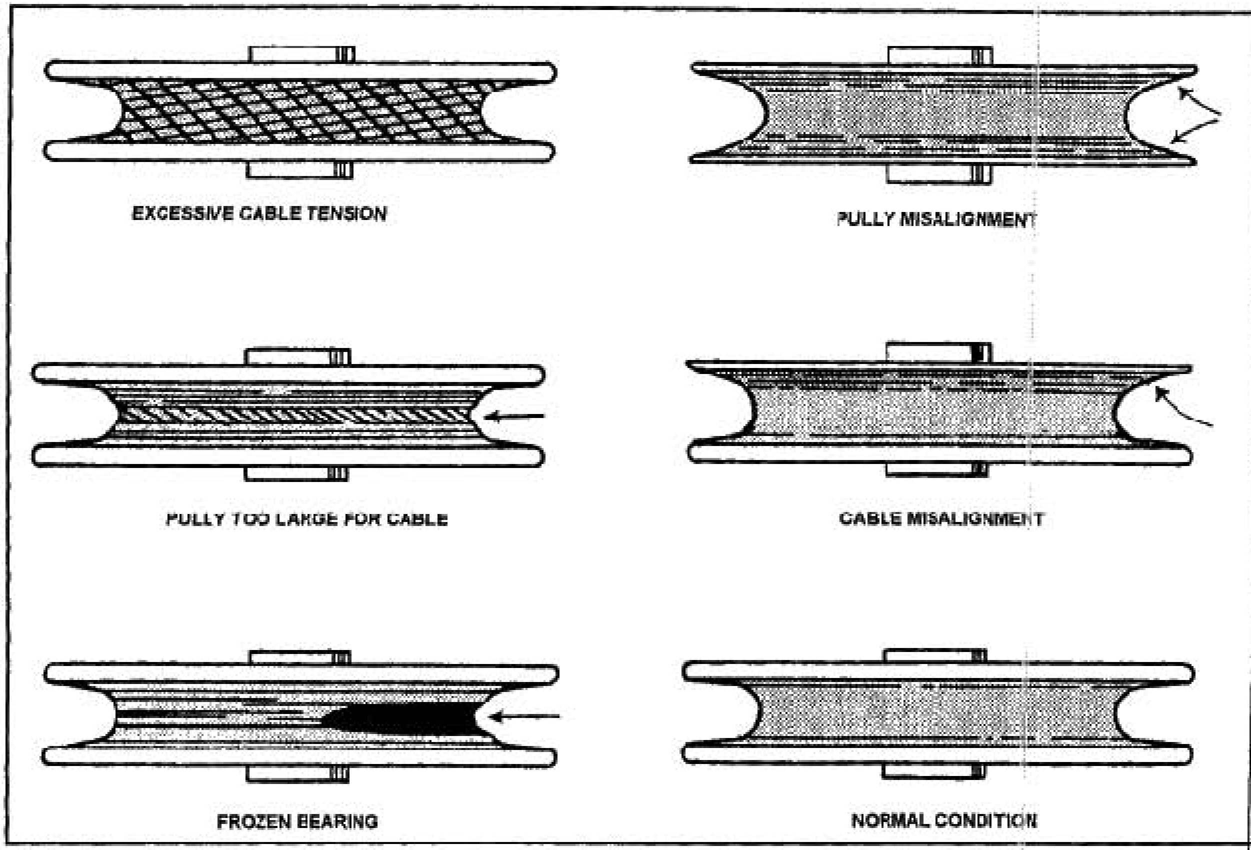

FIGURE 7-20. Pulley wear patterns.

n. Inspect fair-leads for wear, breakage, alignment, cleanliness, and security. Examine cable routing at fair-leads to ensure that defection angles are no greater than 3° maximum. Determine that all guides and anti-abrasion strips are secure and in good condition.

o. Examine pressure seals for wear and/or material deterioration. Seal guards should be positioned to prevent jamming of a pulley in case pressure seal fails and pieces slide along the cable.

7-150. CORROSION AND RUST PREVENTION. To ensure a satisfactory service life for aircraft control cables, use a cable lubricant to reduce internal friction and prevent corrosion.

a. If the cable is made from tinned steel, coat the cable with rust-preventive oil, and wipe off any excess. It should be noted that corrosion-resistant steel cable does not require this treatment for rust prevention.

b. Lubrication and corrosion preventive treatment of carbon steel cables may be effected simultaneously by application of compound MIL-C-16173, grade 4, or MIL-C-11796, Class I. MIL-C-16173 compound should be brushed, sprayed, or wiped on the cable to the extent it penetrates into the strands and adequately covers the cable surfaces. It will dry "tack free" in 24 hours at 77 °F. MIL-C-11796 compound is applied by dipping the cable for 1/2 minute into a tank of compound heated to 77 ° ± 5 °C (170 ° ± 9 °F) for 1/2 minute then removing it and wiping off the excess oil. (An example of cable corrosion, attributable to battery acid, is shown in figure 7-21.)

FIGURE 7-21. Corrosion.

7-151. WIRE SPLICES. Standard manufacturing splices have been mistaken for defects in the cable because individual wire end splices were visible after assembly of a finished cable length. In some instances, the process of twisting outer strands around the core strand may also slightly flatten individual outer wires, particularly in the area of a wire splice. This flattening is the result of die-sizing the cable, and does not affect the strength of the cable. These conditions (as shown in figure 7-22) are normal, and are not a cause for cable rejection.

FIGURE 7-22. Manufacturer's wire splice.

7-152. CABLE MAINTENANCE. Frequent inspections and preservation measures such as rust-prevention treatments for bare carbon steel cable areas, will help to extend cable service life. Where cables pass through fair-leads, pressure seals, or over pulleys, remove accumulated heavy coatings of corrosion-prevention compound. Provide corrosion protection for these cable sections by lubricating with a light coat of grease or general-purpose, low-temperature oil.

7-153. CABLE TENSION ADJUSTMENT. Carefully adjust, control cable tension in accordance with the airframe manufacturer's recommendations. On large aircraft, take the temperature of the immediate area into consideration when using a tension meter. For long cable sections, use the average of two or three temperature readings to obtain accurate tension values. If necessary, compensate for extreme surface temperature variations that may be encountered if the aircraft is operated primarily in unusual geographic or climatic conditions such as arctic, arid, or tropic locations. Use rigging pins and gust locks, as necessary, to ensure satisfactory results. At the completion of rigging operations, check turnbuckle adjustment and safetying in accordance with section 10 of this chapter.

7-154.—7-164. [RESERVED.]