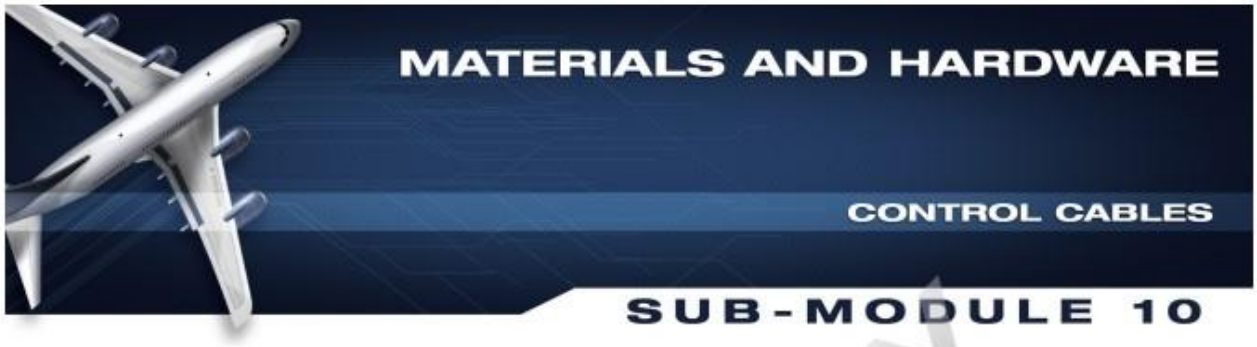

PART-66 SYLLABUS LEVELS

CERTIFICATION CATEGORY → B1

Sub-Module 10

CONTROL CABLES

Knowledge Requirements

6.10 - Control Cables	
Types of cables;	2
End fittings, turnbuckles and compensation devices;	
Pulleys and cable system components;	
Bowden cables;	
Aircraft flexible control systems.	

6.10 - CONTROL CABLES

CABLE CONTROL SYSTEMS

Flexible control cables are common, especially in smaller aircraft to actuate flight and engine controls from the cockpit. Very little play is present in controls and no lost motion exists between the actuator and unit. Consequently, cable controlled units respond quickly and accurately to cockpit control movement.

Cable linkage has several advantages. It's strong and light weight, and its flexibility makes it easy to route through the aircraft. An aircraft cable has high mechanical efficiency and can be set up without backlash, which is very important for precise control. A disadvantage is that cable tension must be adjusted frequently due to stretching and temperature changes. Turnbuckles and other means are often used to adjust tension.

Cables will not sever easily under sudden strains. They are stronger than rods or tubing of the same size. They flex without becoming deformed and can be led easily around obstacles by using pulleys. Cables can be installed over long distances without a great degree of sagging. Vibration will not cause them to harden, crystallize, or break, as may be the case with push-pull control rods. Because of the number of wires used in cables, cable failure is never abrupt, but is progressive during extended use.

CABLE CONSTRUCTION

The basic element of a cable is strand. Numbers of strands are braided together to form a wire and number of wires are braided together to form a cable.

The direction of the twist of strands and wires could be either in the same or opposite directions. When opposite, the tendency of the wires and strands to uncoil is reduced when the cable is twisted in one direction. This opposite direction twist which is most common is called a regular lay. Cables may have a right or left regular lay. If the strands are twisted around the center core, the lay is called a Lang lay. Most aircraft cables have a right regular lay.

When aircraft cables are manufactured, each strand is first formed to the spiral shape to fit the position it is to occupy in the finished cable. This process is called preforming. It is adopted to ensure flexibility in the finished cable and to relieve twisting stresses as strands they are woven into the cable. It also keeps the strands from spreading when the cable is cut. All aircraft cables are internally lubricated during construction.

TYPES OF CONTROL CABLES

Cables are designated according to the number of wires in a cable and the number of strands in each wire. The most common aircraft cables are 7 × 7 and 7 × 19. A 7 × 7 cable consists of 7 strands of 7 wires each. Six of these strands lay around a center strand. This is a medium flexibility cable and is used for trim tab, indicator, and engine controls. The 7 × 19 cable is made of 7 strands of 19 cables. This cable is extra flexible and is used in places where operation over pulleys is frequent. Aircraft control cables vary in diameter from 1/16 to 3/8 inch. (***Figure 10-1***)

Non-flexible Cables

In areas which do not pass over pulleys, non-flexible cable can be used. Non-flexible cable is available in both galvanized carbon steel and stainless steel.

Flexible Cables

Flexible steel cable made up of seven strands of seven wires each is called 7 × 7 or flexible cable and is available in 1/16 and 3/32 inch sizes in both galvanized carbon steel and stainless steel. Both types are preformed.

Extra Flexible Cable

The most widely used cable is 7 × 19 available in sizes from 1/8 inch and up. These cables are available in galvanized or stainless steel. Galvanized cable is more resistant to fatigue than stainless steel, but in applications where corrosion is a factor, stainless steel is used.

CABLE FITTINGS AND COMPENSATION DEVICES

Cables may be equipped with several types of fittings, such as terminals, thimbles, bushings, and shackles.

CABLE END FITTINGS

Cable ends may be equipped with several different types of fittings such as terminals, thimbles, bushings, and shackles. Terminal fittings are generally of the swaged type. Terminal fittings are available with threaded ends, fork ends, eye ends, and single-shank and double-shank ball ends. Threaded-end, fork-end, and eye-end terminals

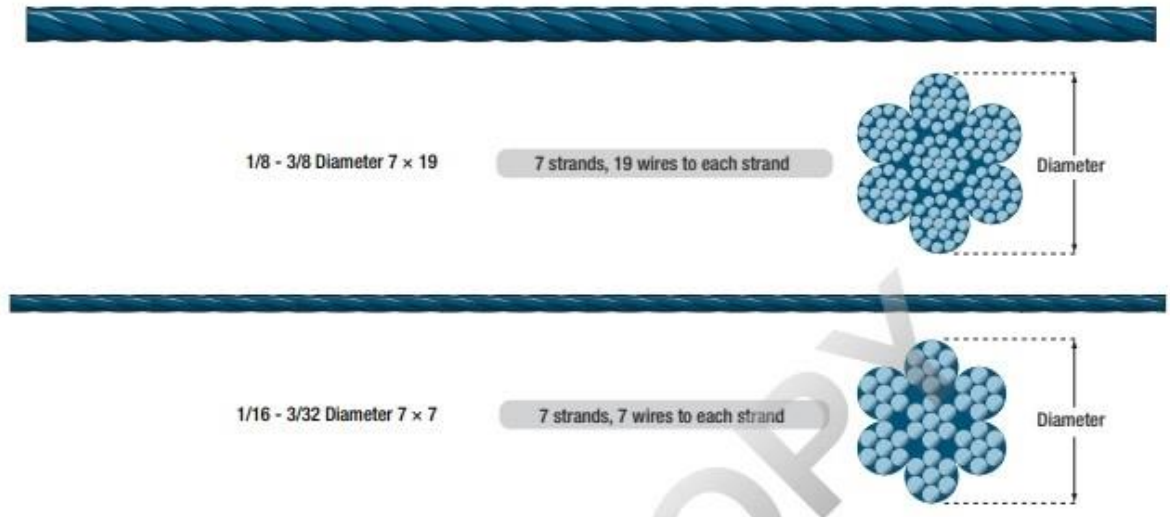

Figure 10-1. Cable cross sections.

are used to connect the cable to turnbuckles, bell cranks, and other linkage in the system. The ball terminals are used for attaching cable to quadrants and special connections where space is limited. The single-shank ball end is usually used on the ends of cables, and the double-shank ball end may be used at either the ends or in the center of a cable run. Thimble and bushing fittings may be used in place of some types of terminal fittings when facilities and supplies are limited and immediate replacement of the cable is necessary. (***Figure 10-2***).

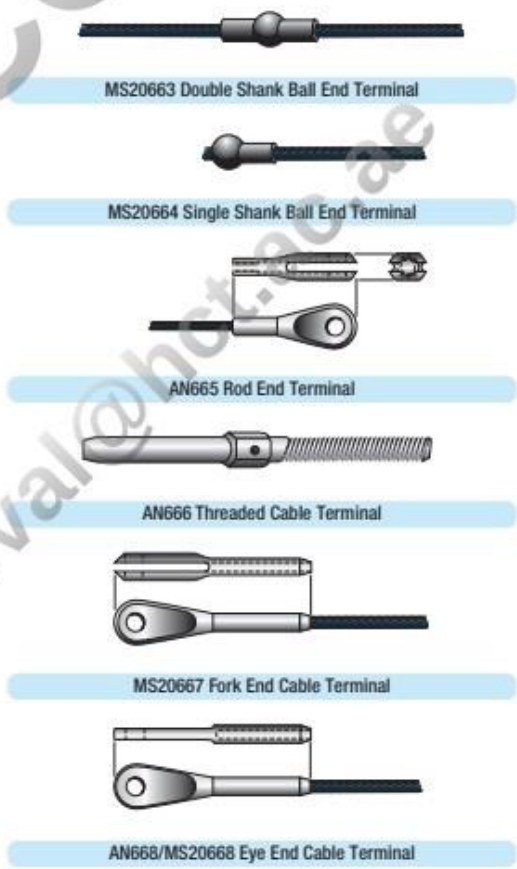

Figure 10-2. Types of terminal fittings.

CABLE TENSION

One disadvantage of a cable system relates to thermal contraction. As an aircraft climbs to a high altitude; its temperature drops and its structure contracts at a lower rate than the cable itself. As a result, cables lose their tension. Large aircraft have a rather complex automatic tensioning system to keep tension relatively constant as this occurs. Small aircraft without these automated systems must have their cable tension adjusted on the ground so they are not too tight when the airplane heats or cools.

Tensiometers

For the aircraft to operate as it was designed, the cable tension for the flight controls must be correct. To determine the amount of tension on a cable, a tensiometer is used. When properly maintained, a tensiometer is 98 percent accurate. Cable tension is determined by measuring the amount of force needed to make an offset in the cable between two hardened steel blocks called anvils. A riser or plunger is pressed against the cable to form the offset. Several manufacturers make a variety of tensiometers, each type designed for different kinds of cable, cable sizes, and cable tensions. (***Figure 10-3***)

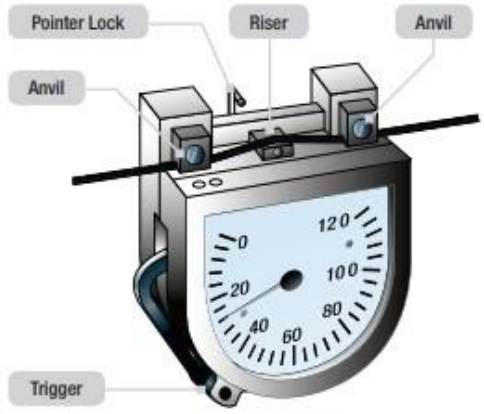

Figure 10-3. Tensiometer.

Tension Regulators

Cable tension regulators are used in some flight control systems because there is considerable difference temperature expansion of the aluminum aircraft structure and the steel control cables. Some large aircraft incorporate tension regulators in the control cable systems to maintain a given cable tension automatically. The unit consists of a compression spring and a locking mechanism that allows the spring to make correction in the system only when the cable system is in neutral.

TURNBUCKLES

A turnbuckle assembly is a mechanical screw device consisting of two threaded terminals and a threaded barrel. Turnbuckles are fitted in cable assembly for the purpose of making minor adjustments in cable length and for adjusting cable tension. One of the terminals has right-hand threads, and the other has left-hand threads. The barrel has matching right- and left-hand internal threads. The end of the barrel with the left-hand threads can usually be identified by a groove or knurl around that end of the barrel. (***Figure 10-4***)

When installing a turnbuckle in a control system, it is necessary to screw both of the terminals an equal number of turns into the barrel. It is also essential that all turnbuckle terminals be screwed into the barrel until not more than three threads are exposed on either side of the turnbuckle barrel. After a turnbuckle is properly adjusted, it must be safetied. There are a number of methods to safety a turnbuckle and/or other types of swaged cable ends that are satisfactory. A double-wrap safety wire method is preferred. Some turnbuckles are manufactured and designed to accommodate special locking devices. A typical unit is shown in ***Figure 10-5.***

Turnbuckles are commonly used in applications which require a great deal of tension; This can range in mass from about ten grams for thin cable used in light commercial applications to thousands of kilograms for structural elements in buildings and suspension bridges.

PULLEYS AND CABLE SYSTEM COMPONENTS

PULLEYS

Pulleys are used to guide cables and also to change the direction of cable movement. Pulley bearings are sealed and need no lubrication other than the lubrication done at the factory. Brackets fastened to the structure of the aircraft support the pulleys. Cables passing over pulleys are kept in place by guards. The guards are close fitting to prevent jamming or to prevent the cables from slipping off when they slacken due to temperature variations. Pulleys should be examined to ensure proper lubrication; smooth rotation and freedom from abnormal cable wear patterns which can provide an indication of other problems in the cable system. (***Figure 10-6***)

FAIRLEADS

Fairleads may be made from a nonmetallic material, such as phenolic, or a metallic material, such as soft aluminum. The fairlead completely encircles the cable where it passes through holes in bulkheads or other metal parts. Fairleads are used to guide cables in a straight line through or between structural members of the aircraft. Fairleads should never deflect the alignment of a cable more than 3° from a straight line.

Figure 10-4. Typical turnbuckle assembly.

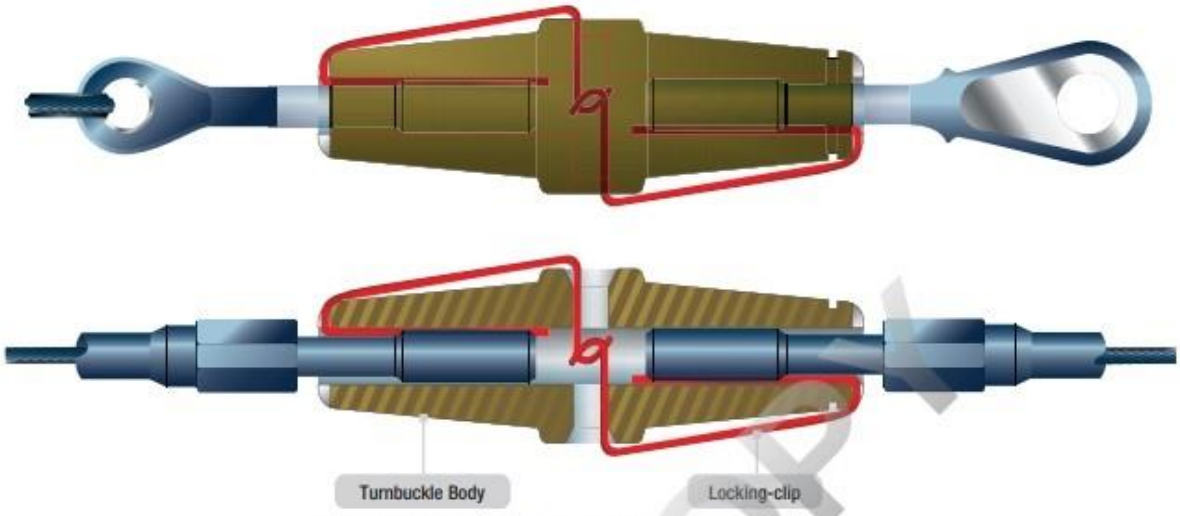

Figure 10-5. Typical turnbuckle assembly with locking mechanism.

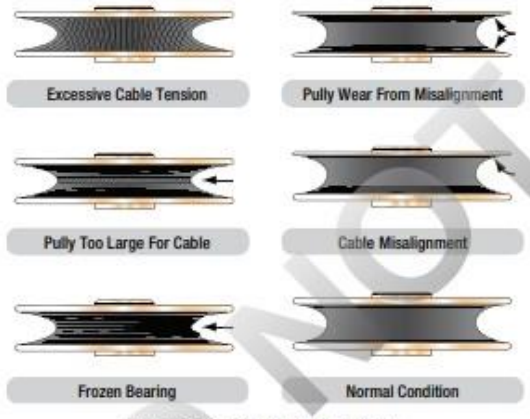

Figure 10-6. Pulley wear patterns.

PRESSURE SEALS

Pressure seals are installed where cables (or rods) move through pressure bulkheads. The seal grips tightly enough to prevent excess air pressure loss but not enough to hinder movement of the cable. Pressure seals should be inspected at regular intervals to determine that the retaining rings are in place. If a retaining ring comes off, it may slide along the cable and cause jamming of a pulley. (***Figure 10-7***)

CABLE CONNECTORS

In addition to turnbuckles, cable connectors are used in some systems. These connectors enable a cable length to be quickly connected or disconnected from a system. ***Figure 10-8*** illustrates one type of cable connector.

CONTROL SURFACE TRAVEL ADJUSTMENT

Control surfaces should move a certain distance in either direction from the neutral position. These movements must be synchronized with the movement of the flight deck controls. The flight control system must be adjusted (rigged) to obtain these requirements. The tools for measuring surface travel primarily include protractors, rigging fixtures, contour templates, and rulers. These tools are used when rigging flight control systems to assure that the desired travel has been obtained.

Generally speaking, the rigging consists of the following:

1. Positioning the flight control system in neutral and temporarily locking it there with rig pins or blocks.
2. Adjusting system cable tension and maintaining rudder, elevator, and ailerons in the neutral position.
3. Adjusting the control stops to the aircraft manufacturer's specifications.

RIGGING FIXTURES

Rigging fixtures and templates are special tools (gauges) designed by the manufacturer to measure control surface travel. Markings on the fixture or template indicate desired control surface travel.

SPRING-BACK

With a control cable properly rigged, the flight control should hit its stops at both extremes prior to the flight deck control. The spring-back is the small extra push that is needed for the flight deck control to hit its mechanical stop.

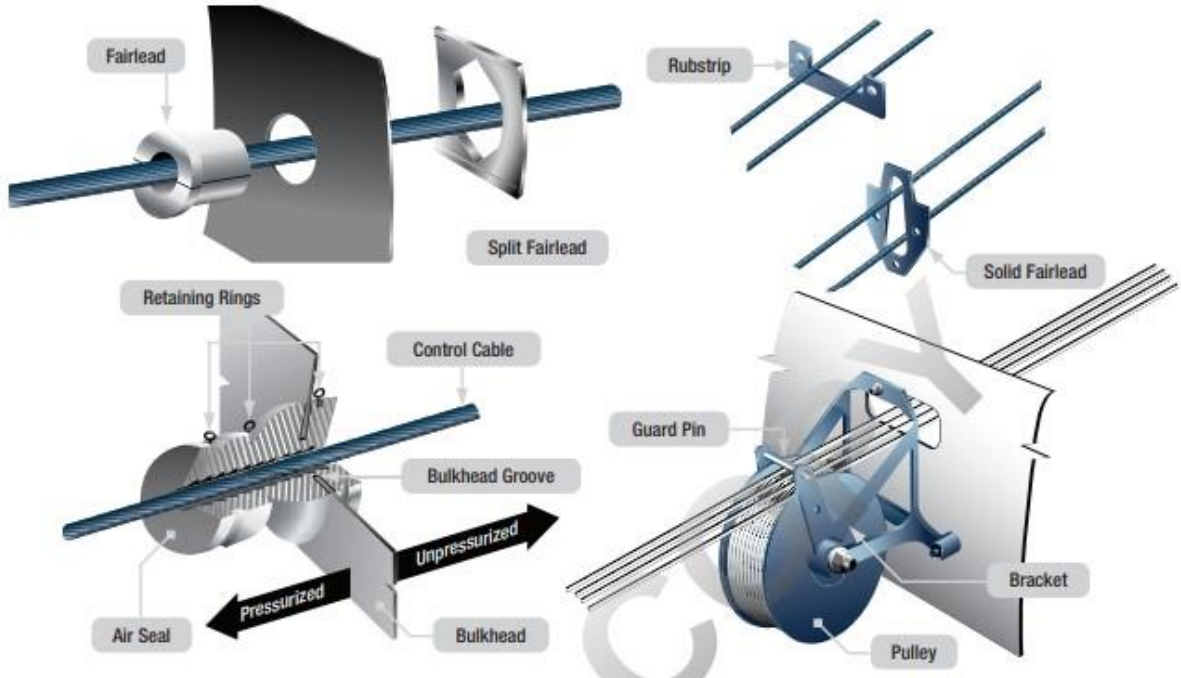

Figure 10-7. Cable guides.

Figure 10-8. Spring type connector.

CABLE DRUMS

Cable drums are used primarily in trim tab systems. As the trim tab control wheel is moved clockwise or counterclockwise, the cable drum winds or unwinds to actuate the trim tab cables. (***Figure 10-9***)

FLEXIBLE CONTROL SYSTEMS

Normal aircraft cables are only capable of performing a pulling action, due to their lack of rigidity, so, where a two-directional movement (push/pull) is required it would be necessary either to employ the use of rods, with the attendant weight penalty, or to use flexible control systems. The two most common are:

1. Bowden cables.
2. Teleflex® control systems.

BOWDEN CABLES

A Bowden cable is an inner steel cable which is free to slide inside an outer housing. The housing is typically heavy gauge helical steel wire. The inner cable moves linearly to transmit force while the housing is typically fixed at both ends. (***Figure 10-10***)

Many light aircraft use a push/pull Bowden cables for the throttle or carburetor mixture control. Usually, provision is made for adjusting the cable tension using an inline hollow bolt (often called a "barrel adjuster"), which lengthens or shortens the cable housing relative to a fixed anchor point. Turning the barrel adjuster out tightens the cable; Turning it in loosens the cable.

Bowden cables can cease to function smoothly if water or contaminants get into the housing. In cold climates Bowden cables are prone to malfunction due to water freezing. Cables also wear through use over a long time, and can be damaged through kinking or raveling. Another common failure occurs at the point where the housing enters a barrel adjuster when loose housing ends tend to fray the housing, making adjustments uncertain.

There is some controversy regarding "cable stretch". Newly installed cables can seem to elongate, requiring readjustment. While inner wires stretch very little, if at all, housings and linings may compress slightly, and all

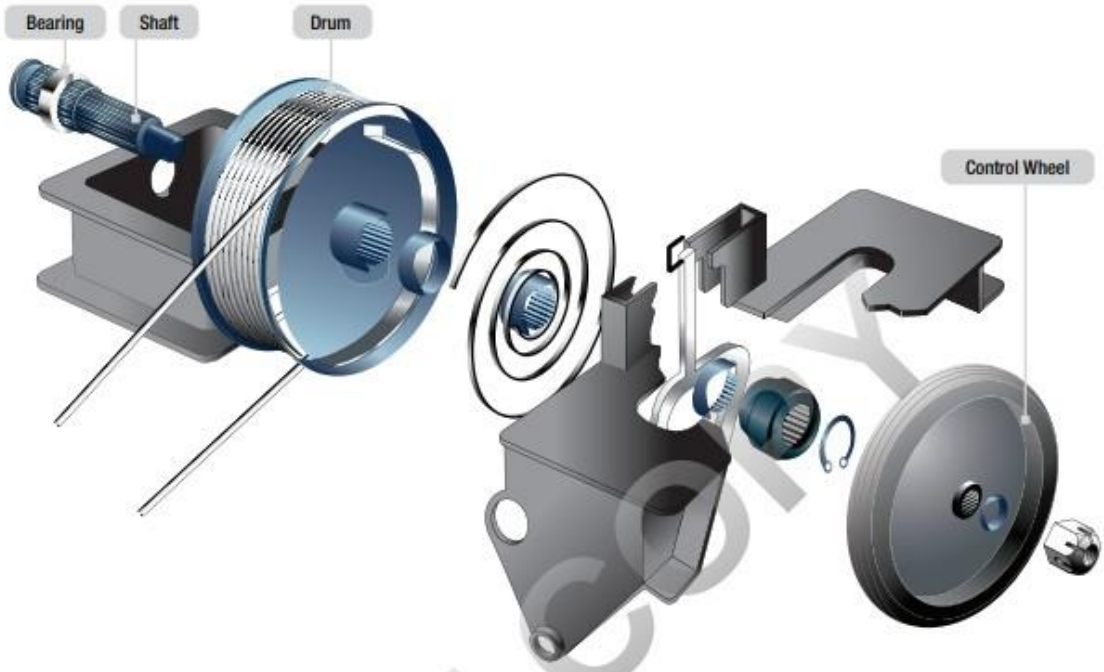

Figure 10-9. Trim tab cable drum.

Figure 10-10. Bowden cable with fittings configured for throttle control.

Figure 10-11. A Teleflex cable with a vernier fitting to allow both large and micro adjustments.

parts may generally "settle in". Lightweight assemblies such as those used on bicycles or ultralight aircraft are more susceptible to this.

TELEFLEX® CONTROLS

Teleflex® controls are installed in modern aircraft and used to operate components such as engine and propeller controls, trimming controls, and fuel valves. They are capable of transmitting both push and pull motion through a single cable. Like the Bowden system, the Teleflex® cable consists of a flexible transmitting cable operating inside a rigid or flexible metal conduit. Its advantages over the Bowden system are that it provides a more accurate and positive control throughout the range of movement and that the internal component can be temporarily locked in any desired position. (***Figure 10-11***)

The basic Teleflex® components are its cable, which is wound with a left or right hand helix wire, a protective conduit and a wide range of end fittings. Depending on the distances between the cockpit and the components to be operated, the control run may or may not be completely Teleflex®. In most instances a single length of Teleflex® cable is used, operating on the pull-push mode. In longer installations, rigid linkages may be used to bridge the gap between Teleflex® units at the extreme ends of the run.

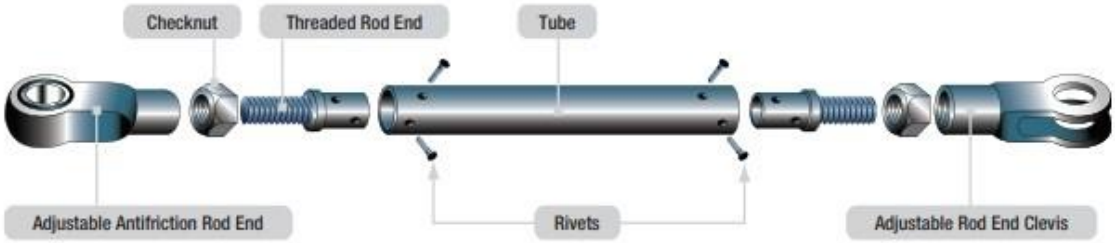

Figure 10-12. Push rod.

CONTROL RODS

PUSH-PULL RODS

Push rods are used as links in the flight control system to give push-pull motion. They may be adjusted at one or both ends. ***Figure 10-12*** shows the parts of a push rod.

Notice that it consists of a tube with threaded rod ends. An adjustable antifriction rod end, or rod end clevis, attaches at each end of the tube. The rod end, or clevis, permits attachment of the tube to flight control system parts. The checknut, when tightened, prevents the rod end or clevis from loosening. They may have adjustments at one or both ends. The rods should be perfectly straight, unless designed to be otherwise. When installed as part of a control system, the assembly should be checked for correct alignment and free movement.

It is possible for control rods fitted with bearings to become disconnected because of failure of the peening that retains the ball races in the rod end. This can be avoided by installing the control rods so that the flange of the rod end is interposed between the ball race and the anchored end of the attaching pin or bolt as shown in ***Figure 10-13***.

Another alternative is to place a washer, having a larger diameter than the hole in the flange, under the retaining nut on the end of the attaching pin or bolt. This retains the rod on the bolt in the event of a bearing failure.

Figure 10-13. Attached rod end.

Figure 10-14. Torque tube.

TORQUE TUBES

Where an angular or twisting motion is needed in a control system, a torque tube is installed. ***Figure 10-14*** shows how a torque tube is used to transmit motion in opposite directions.