

# AEROSPACE RECOMMENDED PRACTICE

**SAE** ARP4386

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(R)

## Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies

### FOREWORD

This Aerospace Recommended Practice will serve as a guide for standard usage of terms and data by industry and government agencies engaged in aerospace technical activities within the United States. This revised and updated version has been reorganized in straight alphabetical sequence of terminology and reflects the accepted and approved usage of terms and definitions of the pertinent branches of technology. The current domestic user standard will be recommended for use as the International Standard to the International Organization for Standardization (ISO).

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## SAE ARP4386 Revision B

### 1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) comprises the technical terms and nomenclature, together with their definitions and abbreviations that are used in aerospace Fluid Power Actuation and Control Systems.

NOTE: When a term is applicable to more than one branch or segment of the technology it may have different meanings and definitions in each. Where this occurs the multiple listings with appropriate designations will be shown under the same primary term.

#### 1.1 Field of Application:

The data contained herein applies to all types of aerospace vehicles and their fluid power and control subsystems and components.

#### 1.2 Purpose:

The purpose of ARP4386 is to facilitate communications and standardize application of Fluid Power and Control System related terms in a consistent manner throughout the Society of Automotive Engineers publications and throughout the producer and user sectors of the aerospace Industry.

#### 1.3 Selection of Terms:

This revision B of ARP4386 carries all terms listed in previous revisions and such terminology as was received prior to January 1, 2001 from authors of SAE Aerospace Fluid Power documents and standards. Some of the definitions have been edited to reflect best current English grammar and syntax.

#### 1.4 Sequential Listing of Terms:

Where previous editions of ARP4386 have been segmented into numerous technical subdivisions, this revision lists all terms in alphabetical sequence and denotes, where necessary, special meanings ascribed to any terms by different technical branches of the technology.

**2. APPLICABLE DOCUMENTS:**

**2.1 SAE Publications:**

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

Format Guidelines for the Electronic Capture of SAE Documents, November 21, 1989

SAE Guide for Preparation of Aerospace Documents, AS, ARP, AIR, MA, and MAP, January 1, 1987

AS1290A Graphic Symbols for Aircraft Hydraulic and Pneumatic Systems

**2.2 Other Publications:**

ANSI/AIAA R-004-1992 Recommended Practice for Atmospheric and Space Flight Vehicle  
Coordinate Systems

ISO 6771 Pressure and Temperature Classifications - Fluid Systems and  
Components - Aerospace

ISO/TC20/SC10B/WB10 Terminology DP 8625 - Aerospace Fluid Power and Control/Actuation  
System Glossary

### 3. TERMINOLOGY, DEFINITIONS AND ABBREVIATIONS:

#### A

**ABLATING MATERIALS:** Special materials on the surface of a spacecraft that can be sacrificed (carried away, vaporized) during re-entry into the earth's atmosphere. Kinetic energy is dissipated and excessive heating of the main structure of the spacecraft is prevented.

**ABORT:** Failure to accomplish a mission or portion of a mission for any reason. It may occur at any point from initiation of operation to destination.

**ABSOLUTE (filter) RATING:** A theoretical size designation which is an estimation of the diameter of the largest hard spherical particle that can pass through a filter under specified test conditions. This is an indication of the largest opening in the filter. Absolute ratings can be determined by a maximum particle passed test such as in MIL-F-8815.

~ **PRESSURE:** Pressure value, using a reference of a hard vacuum (absolute zero) from which pressure changes are measured.

~ **TEMPERATURE:** Temperature value, using a reference of -273 °C or -459.7 °F, i.e. "absolute" zero.

~ **VISCOSITY:** See Viscosity.

**ACCESSIBILITY:** A measure of the relative ease of admission to the various areas of an item for the purpose of operation or maintenance.

**ACCUMULATOR, HYDROPNEUMATIC:** An accumulator in which the stored operating medium is hydraulic fluid, pressurized by means of compressed gas.

**ACE:** Acron. Actuator Control Electronics.

**ACT:** Abbr. Active control technology.

**ACTIVE:** An adjective which describes a system or portion of a system which is in control in contrast to being in standby; also, the operational status of a servocontrol device after a failure if the device is activated or remains in control.

**ACTIVE:** An adjective which describes a system or portion of a system which is in control in contrast to being in standby; also, the operational status of a servocontrol device after a failure if the device is activated or remains in control.

## 3. ACTIVE (Continued):

~ CONTROL TECHNOLOGY: An airplane design concept in which vehicle performance, weight, and economic characteristics are optimized through a reliance on automatic subsystems within the flight control system to augment the airplane's stability, to reduce the design loads through load reduction or redistribution and structural mode damping, and to manage the airplane's configuration for aerodynamic efficiency. Active control functions include:

- a. Pitch stability augmentation
- b. Lateral and/or directional stability augmentation
- c. Angle-of-attack limiting
- d. Wing-load alleviation
- e. Maneuver-load control
- f. Gust-load alleviation
- g. Flutter-mode control
- h. Ride smoothing

~ DEVICE: (Fluidics) The general class of device which respond to a signal or signals separate from the fluid stream which powers the output.

ACTUATION SYSTEM: An actuation system is comprised of a control system which receives input power from a power generation and distribution system to control an output load. Actuation systems include a controller, power modulator, actuator, and feedback elements (if needed). Figure 1 illustrates a typical actuation system.

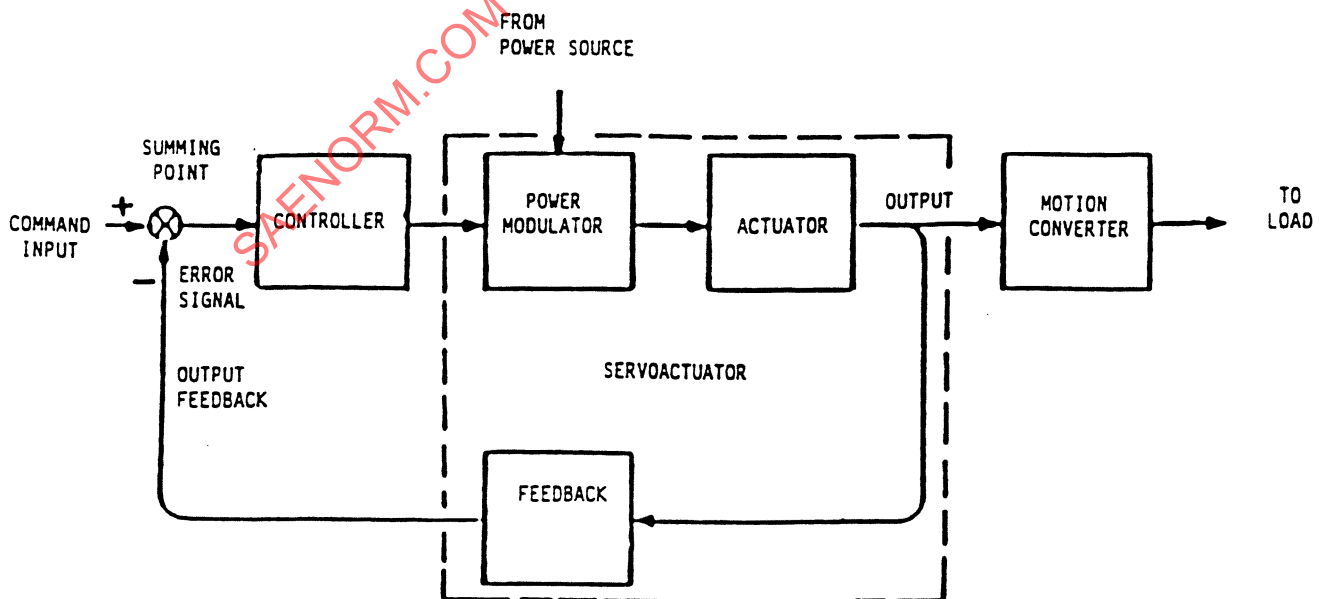


FIGURE 1 - Essential Actuation System

3. ACTUATION SYSTEM (Continued):

~, POWER-BY-WIRE: An integrated servoactuator which incorporates an electric motor to receive power from the aircraft main electric power system in lieu of an actuator connected directly to the aircraft main hydraulic system. Power conversion from electrical to mechanical may include mechanical devices such as ballscrews, gears, chains, cables, etc., or through a motor/pump and hydraulics. See Integrated Actuator Package.

ACTUATOR: The component of the actuation system that does work or dissipates energy to control a load. Actuator output is achieved by conversion of energy from the power system or load into mechanical work, torque, or force.

~, CONTINUOUS MOTION: A rotary actuator ( compare also Rotary Actuator) capable of infinite rotation in either direction. Continuous motion fluid actuators can be of the following types:

~, ~, AXIAL PISTON MOTOR: A motor utilizing multiple pistons which are pressurized in sequence as the output shaft rotates. Usually one half the pistons are pressurized to provide output torque. The linear motion of the pistons is converted to rotary motion by a swashplate, which is set at an angle with respect to the motor housing. Output speed control can be obtained by either controlling input flow or controlling swashplate angle.

~, ~, GEAR MOTOR: A motor utilizing two or more counter rotating gears which provide a fixed volumetric displacement per revolution of the output shaft. Since the displacement is fixed, output shaft speed can be controlled only by controlling input flow.

~, ~, RADIAL PISTON MOTOR: A motor utilizing multiple pistons arranged radially around a shaft with an eccentric cam. The pistons are pressurized in sequence and the linear to rotary motion conversion is accomplished by the eccentric cam action. Output speed control can be obtained by either varying input flow or controlling cam eccentricity.

~, ~, VANE MOTOR: A motor having a number of vanes attached to a shaft or an outer housing which are eccentric with respect to each other. The eccentricity provides differential volumes in the vane cavities so that sequential pressurization of the cavities causes output rotation. Output speed control can be obtained by either controlling input flow or shaft eccentricity.

~, ELECTROMECHANICAL: These definitions apply to electric motors used as torque generators in an electromechanical actuator. See Figure 2. Other electric motor definitions are covered in the pertinent sections.

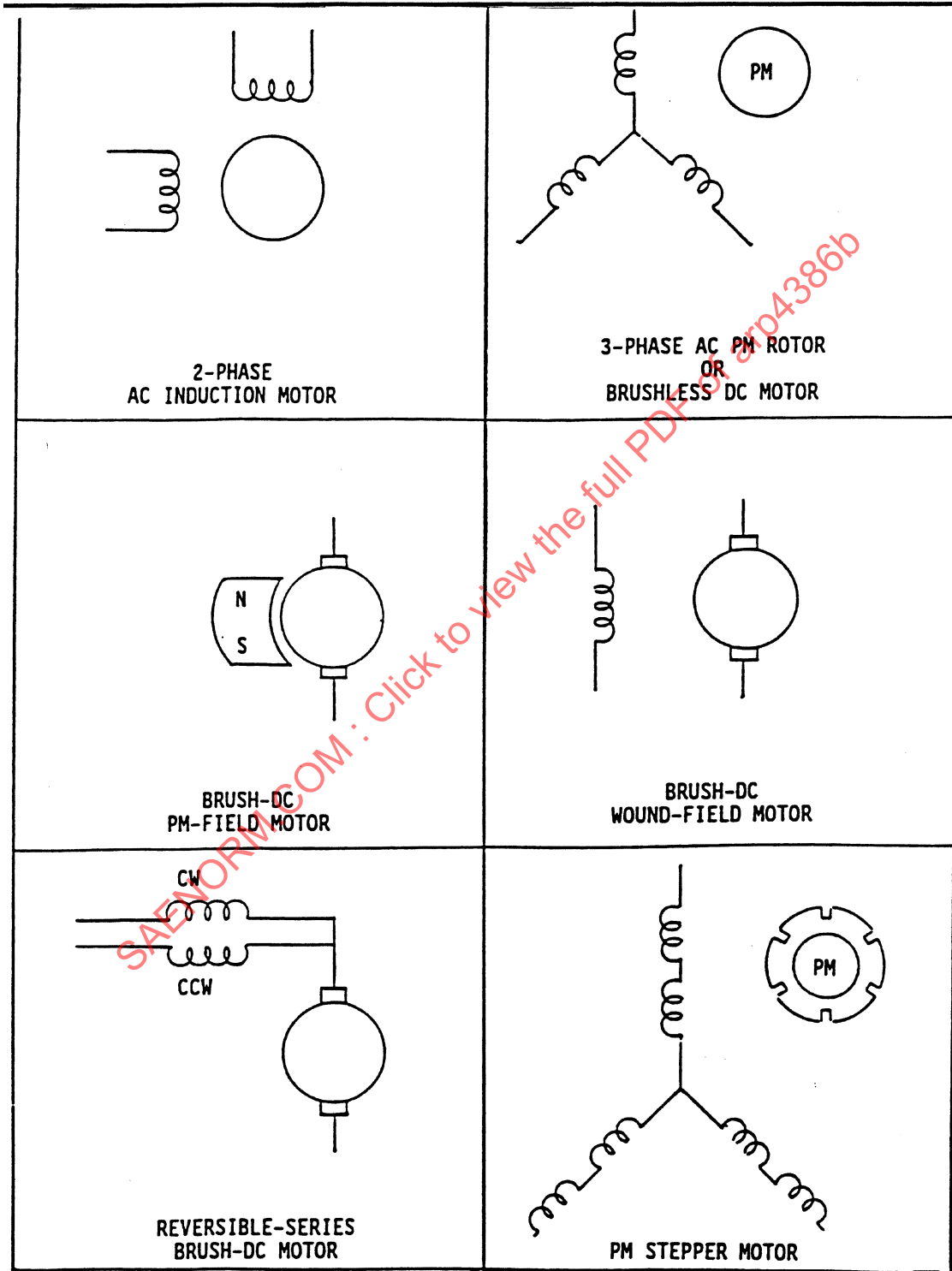


FIGURE 2 - Electromechanical Actuators/Motors

3. ACTUATOR, ELECTROMECHANICAL, (Continued):

~, ~, AC MOTORS: Electric torque generators which are powered by polyphase alternating current. The following types can be considered for electromechanical actuation.

~, ~, INDUCTION MOTOR: An AC motor in which alternating current supplied to the stator produces a rotating magnetic field. Alternating current is induced in the rotor by transformer action and the interaction between the induced rotor currents and the stator field produces torque.

~, ~, SQUIRREL CAGE MOTOR: An induction motor in which the rotor consists of inserted or cast parallel conductors, electrically shorted at each end.

~, ~, DC MOTORS: Electric torque generators which are powered by direct current. The following types can be considered for electromechanical actuation:

~, ~, BRUSH PERMANENT MAGNET MOTOR: A DC motor in which direct current supplied to the conductors in the rotor reacts with a magnetic field developed by permanent magnets located in the stator, resulting in motor torque. A commutator and brushes ensure that direct current is supplied to the rotor conductors such that unidirectional torque is produced with one polarity of current.

~, ~, BRUSH WOUND FIELD MOTOR: A DC motor similar to a brush PM motor, except that a wound coil supplied with continuous and unidirectional direct current is used in place of a PM field in the stator.

~, ~, BRUSHLESS PERMANENT MAGNET MOTOR: A DC motor in which DC current supplied to conductors in the stator reacts with the PM field developed by permanent magnets located in the rotor, resulting in motor torque. Electrically switched direct current is supplied to three or more sets of stator conductors in a sequence such that unidirectional torque can be developed. A rotor position transducer is used to sequence stator currents.

~, ~, COMPOUND WOUND MOTOR: A wound-field DC motor which incorporates both shunt and series windings in the stator.

~, ~, LINEAR DC MOTOR: A linear DC motor in which direct current supplied to the armature winding reacts with the stator field to produce a rectilinear force. Commutation is not required if the armature is always located within the magnetic field of the stator throughout its design stroke.

~, ~, SERIES WOUND MOTOR: A wound-field DC motor in which the rotor conductors and stator field coil are connected in series. A reversible series motor has two field coils oppositely connected and energized one at a time. This permits rapid switching of motor direction.

~, ~, SHUNT WOUND MOTOR: A brush wound-field DC motor in which the rotor conductors and the stator field coil are connected in parallel to the DC power source.

3. ACTUATOR, ELECTROMECHANICAL, (Continued):

~, ~, STEPPER MOTOR: A motor whose rotor moves in discrete angular steps determined by the number of poles of stator and rotor located around the circumference of the motor air gap. Sequential pulsing of multiphase windings causes the rotor to move one step for each pulse. Variable reluctance stepper motors require continuous energization to develop torque to hold rotor position. PM stepper motors hold the last energized position. Stepper motors are often used for open loop control.

~, FLUID: A component, which converts controlled fluid energy (hydraulic or pneumatic) into an equivalent mechanical output.

~, FLUIDIC: A component, which converts fluid energy derived from a fluidic control source into an equivalent mechanical output.

~, IRREVERSIBLE DRIVE: A drive which, without input torque (or force), cannot be back-driven from the output by a torque (or force) less than the maximum design load at the output.

~, LINEAR : An actuator which develops rectilinear motion and force as outputs.

~, ~, BEARING MOUNTED: An actuator mounted between the support structure and load with spherical bearings at each end. This type of actuator can articulate in two axes.

~, ~, DOUBLE ENDED: An actuator with a single cylinder and a piston that has two rods extending to atmosphere.

~,~, EQUAL AREA: An actuator having equal effective piston areas and equal force output for both directions of motion.

~, ~, FIXED BODY: An actuator with mounting provisions wherein the body is rigidly attached to the load bearing support. The output necessarily lies along one axis with no articulation possible.

~, ~, FOUR-WAY SERVO: A servoactuator having two control ports connecting to a four-way servovalve. A four-way linear servoactuator is usually, but not necessarily, a double ended actuator.

~, ~, MOVING BODY : An actuator with the body attached to the moving load and the piston rod attached to the support structure.

~, ~, PARALLEL: Two or more actuators arranged in parallel to drive a single output or load. Usually, parallel actuators are physically separated, each with its own output connection, and are tied together by the load in a force or torque-summing fashion. Sometimes referred to as side-by-side actuators.

~, ~, SIDE-BY-SIDE ACTUATOR: An actuator having two or more separate actuation elements in parallel which provide a single output motion.

~, ~, SINGLE ENDED: An actuator with a single cylinder and a piston which has only one rod extending to atmosphere.

3. ACTUATOR, LINEAR, (Continued):

~, ~, TANDEM: Two or more coaxial actuators that are mechanically constrained to move together. A tandem actuator usually has two pistons on the same rod, carried in a single actuator cylinder housing. Separate cylinders (with a common piston rod) can be used to give partial rip stop protection. Dual tandem actuators are commonly used where two hydraulic sources are utilized.

~, ~, THREE-WAY SERVO: A servoactuator having a single control port connecting to a three-way servovalve. The control port is connected to the large actuator area and system pressure is usually applied to the small area. A three-way linear servoactuator is usually, but not necessarily, a single-ended actuator.

~, ~, TRIPLE TANDEM: A tandem actuator having three separate actuation sections.

~, ~, TRUNNION MOUNTED: An actuator having the body mounted through a trunnion to the actuator support. The output rod can articulate in one axis only.

~, ~, UNEQUAL AREA: An actuator having different effective piston area for each direction of motion. An unequal area actuator may be either single-ended or double-ended. Since an unequal area actuator will have a higher force output in one direction, it is usually used where a significant bias load is anticipated. An actuator having an area ratio of 2:1 used with a three-way control valve is equivalent to an equal area actuator since the force output and actuation power consumption will be equal in both directions. Unequal area actuators are sometimes referred to as unbalanced actuators.

~, ~, MULTICHANNEL: An actuator, which contains more than one torque- or force-generating device.

~, ~, POSITION SUMMING: A multichannel arrangement, which sums the position outputs of multiple actuators into a single output.

~, ~, REVERSIBLE DRIVE: A drive which, without input torque (or force), can be back-driven from the output by a torque (or force) less than the maximum design load at the output.

~, ~, ROTARY: An actuator which develops rotary motion and torque as outputs. The term "rotary actuator" implies that the actuator is capable of limited output rotation. If the device is capable of continuous rotation, it is usually referred to as a motor.

~, ~, PUSH-PUSH: An actuator wherein two linear pistons act on the opposite ends of a crank arm attached to a rotary output shaft.

~, ~, RACK-AND-PINION: An actuator wherein the rotary motion is achieved by piston-driven linear racks engaging a rotary output gear.

~, ~, VANE: An actuator wherein fluid pressure is applied to either side of a vane or vanes which are integral with or geared to a rotary output shaft. Vane cavities are separated by center dams which limit rotation.

3. ACTUATOR, (Continued):

~, SERVO- or SERVOCONTROL-: A servoactuator consists of the power modulator, the actuator, and the feedback element, typically packaged together as a single component.

~, SINGLE CHANNEL: An actuator which contains a single torque- or force-generating device.

~, SMART: An electrohydraulic servoactuator containing the feedback loop closure and some or all of the redundancy management electronics in a line replacement unit.

~ STIFFNESS: The resistance of the actuator to externally applied loads; see also system and drive Stiffness. (See Figure 3)

~, TURBOMECHANICAL: Typically, these actuators utilize high speed turbines powered by warm gas generators. The turbine output speed is converted to mechanical motion by a combination of mechanical gearing and clutches.

~, ~, CLUTCH COUPLED: A turbomechanical actuator wherein a constant speed turbine is coupled to the load through a double-acting servocontrolled clutch. The clutch controls both the speed and direction of the load. A large gear reduction between the high speed turbine and the load is included in the actuator.

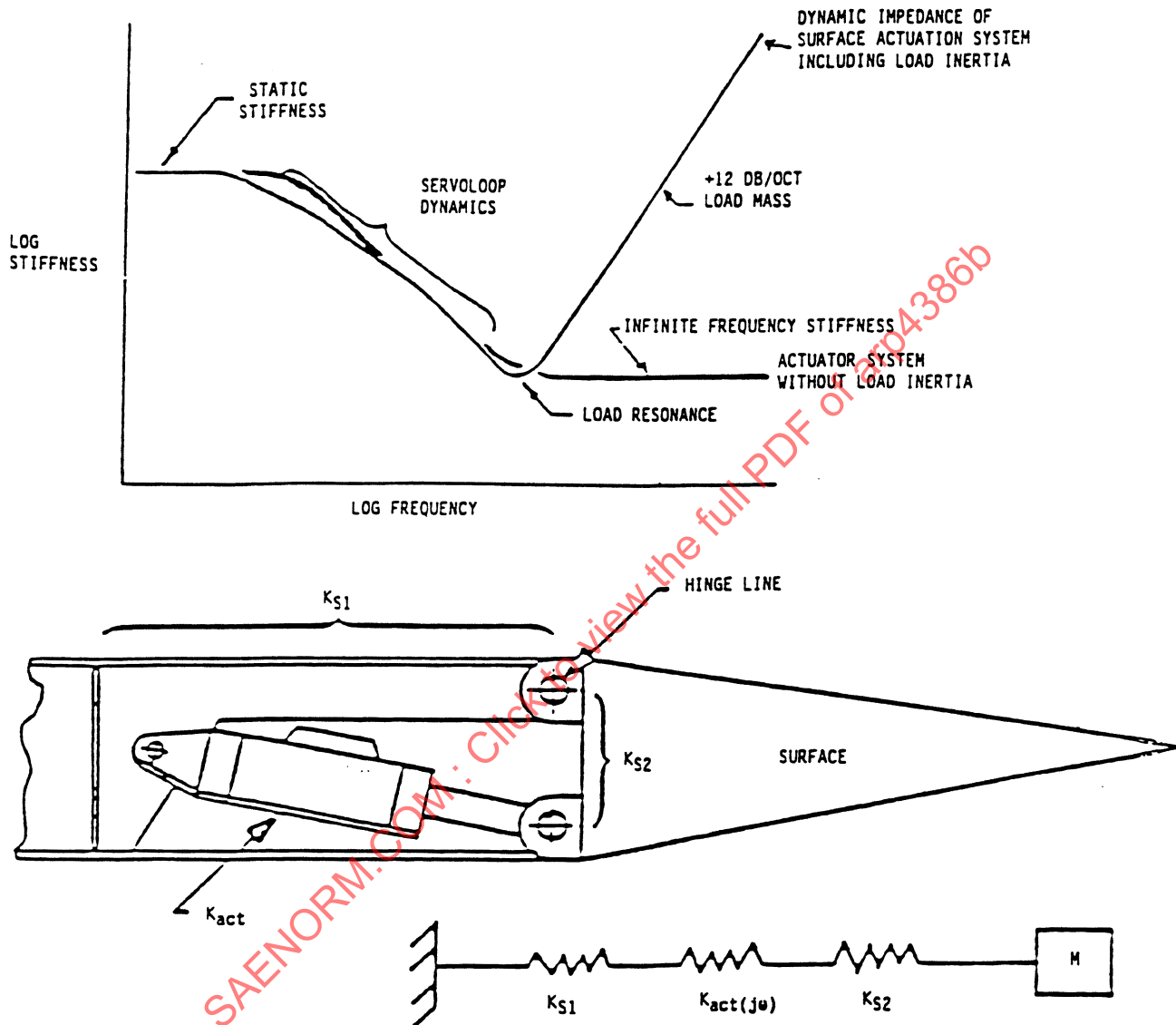
~, ~, DOUBLE TURBINE: A turbomechanical actuator utilizing two turbines of opposite directional sense mechanically coupled together. A control valve is used to proportionally control gas flow to either of the two turbines, thus providing control of load speed and direction. Speed reduction between the turbine and load is usually included.

~, MECHANICAL: A mechanical device used to amplify force, primarily through the use of reduction gearing or threaded screw jacks. Output may be linear or rotary. Input is generally rotary, using electric, hydraulic or pneumatic motor.

~, ~, ACME SCREW: A mechanical actuator consisting of an ACME threaded shaft and an ACME threaded nut and arranged so that a rotary input motion is converted to a linear output. The output force is also amplified by this action.

~, ~, BALL SCREW: A linear mechanical actuator consisting of a ball race, threaded shaft, and a ball race threaded nut, coupled together through spherical balls. (Sometimes called a ball-bearing screw.) The device normally converts rotational input motion to linear output motion but, in some cases, is used in the reverse manner to provide rotary output motion from a linear input motion (normally considered to be significantly more efficient than an acme screw).

~, ~, GEARED ROTARY: A mechanical device utilized for amplifying force through a series of gears converting high speed, low torque input into high torque, low speed output. Sometimes referred to as a power hinge.



$\omega$  is the oscillation frequency, in radians per second, and  $j$  is the square root of minus one.

FIGURE 3 - Actuator Stiffness

### 3. ACTUATOR, MECHANICAL, (Continued):

~,~, RACK-AND-PINION: A mechanical actuator generally consisting of reduction input gearing, outputting to a rotary pinion gear that connects with a rack to provide linear output actuation force. May also be used with linear motion rack, coupling to a pinion to provide rotary output torque.

~ TYPES: Actuators are frequently classified into linear and rotary output devices.

ADAPTIVE CONTROL: A control system which maintains optimum system performance by automatically changing system parameters.

~ FLIGHT CONTROL SYSTEM: A flight control system having the capability to vary its performance parameters in flight and thus adapt to the changing flight conditions so that the vehicle's structural integrity and stability limitations are not exceeded during critical phases of flight.

ADIABATIC, adj.: Without the exchange of heat between the medium and its surroundings, such as a thermodynamic process taking place.

~, HEAD: The head of gas available to do work expressed by Equation 1:

$$H_{ad} / 1/ = \left( \frac{\gamma}{\gamma - 1} \right) \frac{R'}{M} T \left[ 1 - \left( \frac{P_2}{P_1} \right)^{\frac{(\gamma - 1)}{\gamma}} \right] \quad (\text{Eq. 1})$$

where:

$H_{ad}$  = Adiabatic head, ft (m)

$\gamma$  = Gas ratio of specific heats, dimensionless

$R'$  = Universal gas constant (1544 ft-lb/mole°R) /1/

$M$  = Molecular weight of gas, lb/mole (kg/mole)

$T$  = Gas temperature, °R (°K)

$\frac{P_2}{P_1}$  = Exhaust-to-inlet pressure ratio, dimensionless

/1/ In SI metric units,  $R'$  is replaced by  $(R'/g)$ , where:

$R' = 8.31 \text{ kJ/mole } (^\circ\text{K})$

$g = 9.81 \text{ m/s}^2$

~ PROCESS (in a gas): An expansion or compression in which no heat transfer takes place. This is the standard for determining energy extraction or absorption in gases and represents the theoretical (100% efficient) reversible process. For air  $n = 1.4 = k/(k-1)$  where  $k = 3.5$  such that  $P/P_0 = (T/T_0)^{k/(k-1)}$ .

ADIRU: Abbr. Air data/inertial reference unit.

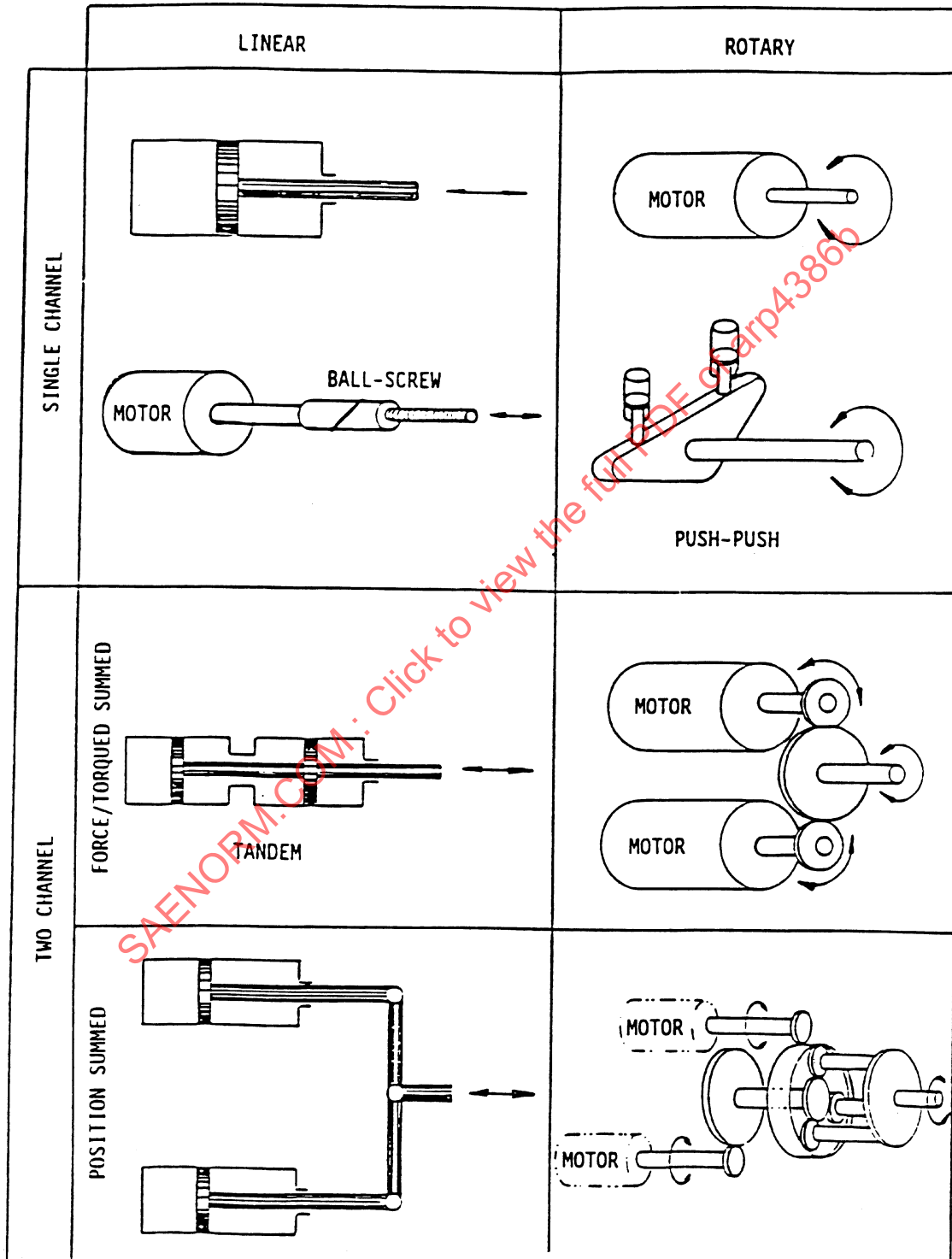


FIGURE 4 - Actuator Types

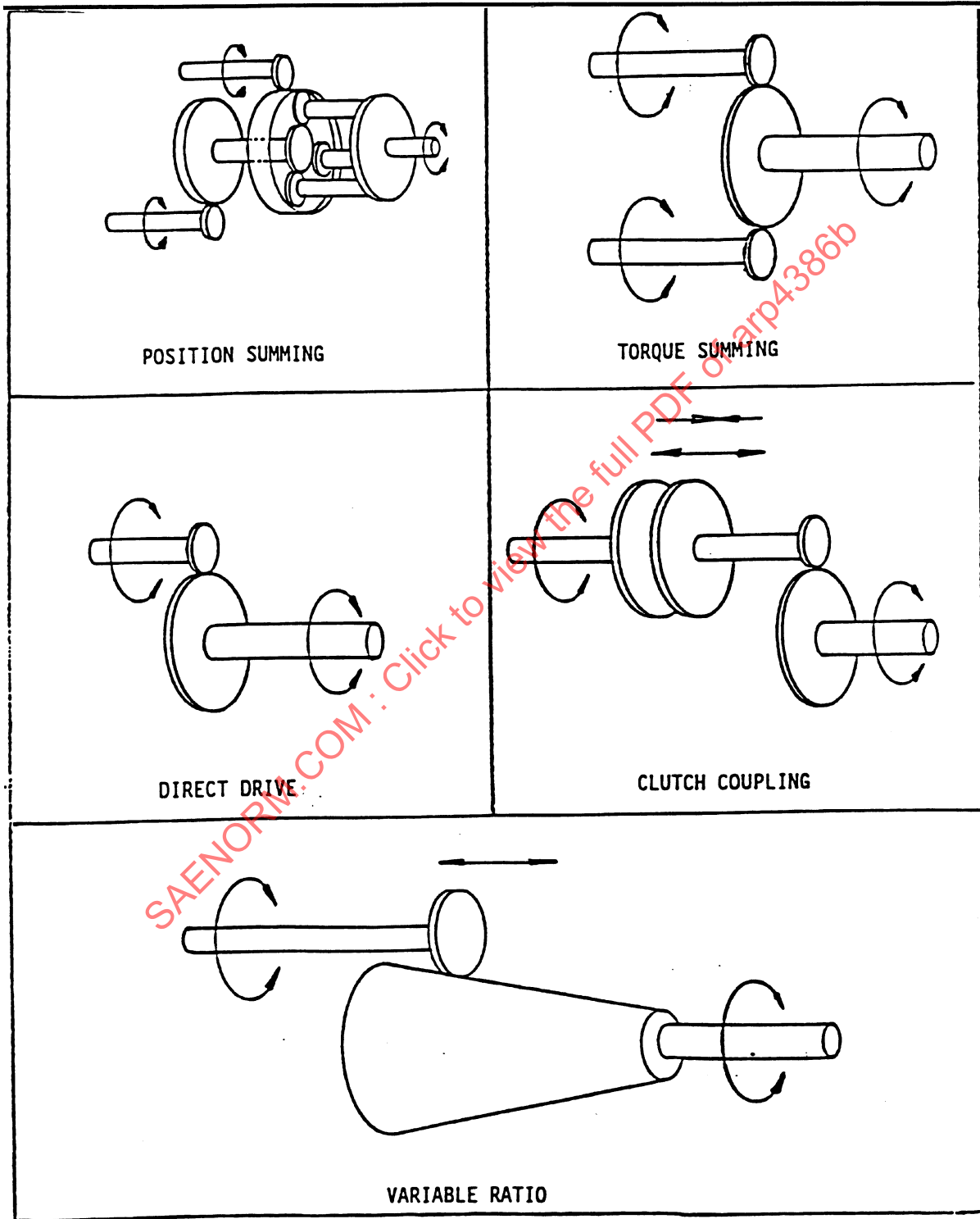


FIGURE 5 - Rotary Drive Classification

3. (Continued):

ADJUSTABLE RESTRICTOR VALVE: A restrictor valve having provisions for external adjustment.

ADM: Abbr. Air data module.

ADVERSE YAW: A negative yawing moment caused by a positive rolling surface deflection.

AERODYNAMIC HEATING: The rise in skin temperature of an aircraft due to friction of air at high speed.

AERODYNAMIC MISSILE: A missile which uses aerodynamic forces to maintain its flight path, generally employing propulsion guidance and a winged configuration.

AERODYNAMICS: That field of dynamics which treats the motion of bodies relative to the air they pass through, and the forces that act upon them, especially as they relate to flight.

AEROSPACE: An operationally indivisible medium consisting of the total expanse beyond the earth's surface.

~ VEHICLE: A vehicle which functions both in the sensible atmosphere and in the space equivalent or space environment.

A/F: Abbr. Airframe

AFCS: Abbr. Automatic flight control system.

AIDING LOAD: An aiding load is a force or torque on the actuator provided by load restoration or inertia, or both, which acts in the same direction as the desired direction of load motion. A force or torque, which acts in the opposite direction resisting motion, is called an opposing load.

AILERON: A control surface set into or near the trailing edge of an airplane wing to produce roll moments about the longitudinal axis. Ailerons usually work in pairs; when the aileron on one wing is deflected upward, the aileron on the other wing is simultaneously deflected downward. See also Control Surface.

~ ANGLE: The angular displacement of the aileron surface relating to the wing surface.

~ CONTROL: A control for producing a rolling moment on the airplane through the use of ailerons; a mechanism for moving the ailerons.

~ YAW: Yawing moment caused by aileron deflection. Depending upon the aircraft configuration, aileron yaw may be either proverse or adverse. For positive aileron deflection, proverse yaw produces a positive yawing moment; adverse yaw produces a negative moment.

3. (Continued):

AIR, n.: The gaseous fluid surrounding the Earth; average volumetric composition to 90 km altitude 78.084% N<sub>2</sub>, 20.948% O<sub>2</sub>, 0.934% Ar, 0.0314% CO<sub>2</sub>, 0.00182% Ne, 0.00052% He., 0.000114% Kr, 0.0002% CH<sub>4</sub>. Moisture content is not specified but is listed as % relative humidity or mass of H<sub>2</sub>O (vapor) per unit mass of dry air.

~ COOLED, adj.: To denote that the heat energy released by the subject is transferred to the surrounding air atmosphere; see also Motor.

~ DRAG: The drag exerted by air molecules upon a moving object, as upon an aircraft or rocket moving through the air, or upon an earth satellite that comes within the earth's atmosphere during orbit.

~ BREATHING MISSILE: A missile with an engine requiring the intake of air for combustion of its fuel, as in a ramjet or turbojet. To be contrasted with the rocket missile, which carries its own oxidizer and can operate beyond the atmosphere.

AIRBORNE: (1) Applied to personnel, equipment, etc. transported by air; e.g., airborne infantry. (2) Applied to material being or designed to be transported by aircraft, as distinguished from weapons and equipment installed in and remaining a part of the aircraft. (3) Applied to an aircraft from the instant it becomes entirely sustained by air until it ceases to be so sustained. A lighter-than-air aircraft is not considered to be airborne when it is attached to the ground, except that moored balloons are airborne whenever sent aloft.

AIRCRAFT, n.: A vehicle capable of transporting personnel or equipment through the atmosphere, without the use of ground supports, such as legs, wheels, or tracks.

AIRCRAFT VECTORING: (1) The act of directing control of inflight aircraft through control commands of azimuth headings. (2) The act of changing direction of the aircraft in pitch and yaw. See also Body Axes.

AIRCRAFT GROUND EQUIPMENT: Equipment required on the ground to support the operation and maintenance of an aircraft and its airborne equipment.

AIRCRAFT ON GROUND: Cannot fly until replacement parts are received to complete the maintenance action.

AIRFOIL, n: A surface or body, as a wing, propeller blade, rudder, or the like, especially designed to obtain a reaction, as lift or thrust, from the air through which it moves. For related nomenclature see Figure 6.

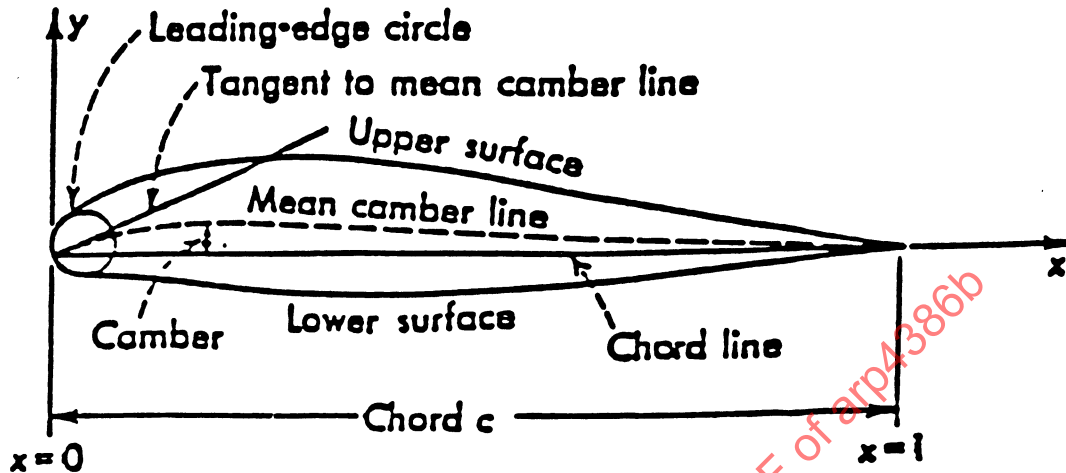


FIGURE 6 - Airfoil Section

## 3. (Continued):

**AIRFRAME**, n.: (1) The structural components of an airplane, including the framework and skin of various parts, such as the fuselage, empennage, wings, landing gear (minus tires), and engine mounts. (2) The framework, envelope, and cabin of an airship. (C) The assembled principal structural components, less propulsion system, control, electronic equipment, and payload.

**AIRSPEED**, n.: The speed of an aircraft relative to its surrounding air mass. The unqualified term "air speed" can mean any one of the following:

- a. **Indicated Airspeed**: The airspeed shown by an airspeed indicator
- b. **Calibrated Airspeed**: Indicated Airspeed corrected for instrument installation error
- c. **Equivalent Airspeed**: Calibrated Airspeed corrected for compressibility error

**True Airspeed**: Equivalent Airspeed corrected for error due to air density (altitude and temperature); the true speed of the vehicle through the air

**ALIGNMENT**, n.: Performing the adjustments that are necessary to return an item to specified operation.

**AMBIENT**, adj.: Pertaining to, of the surroundings; as in ambient temperature, ambient pressure.

**AMPLIFIER**, n.: An active component, which provides a variation in output power greater than the impressed control signal variation. The signal medium as well as the output may be electric, hydraulic, pneumatic, or optical energy. The polarity of the output may be either positive or negative relative to the control signal. The level (pressure, voltage, current or flow) of the control signal may be greater or less than the respective output levels.

3. AMPLIFIER, (Continued):

~, AXISYMMETRIC FOCUSSED-JET: An amplifier, which utilizes control of the attachment of an annular fluid jet to an axisymmetric flow separator (that is, control of the focus of the jet) to modulate the output. Usually employed as a digital amplifier.

~, CURRENT: An electronic amplifier designed to drive with its output devices that respond to changes in current rather than voltage, i.e.: torque motors.

~, ELECTRONIC: A solid state or vacuum tube device used to amplify electric signals.

~, FLOW: A component designed specifically for amplifying flow signals, usually with low impedance output.

~, IMPACT MODULATOR: An amplifier, which utilizes auxiliary flow at a nozzle throat for a control signal to modulate the output flow. Pressure level of the control signal may either be above or below local throat pressure to result in a positive or negative (suction) quiescent control flow.

~, JET INTERACTION: An amplifier, which utilizes control jets to deflect a power jet and modulate the output, usually employed as an analog amplifier.

~, LAMINAR FLOW: In this jet amplifier the nozzle Reynolds number is maintained at such a level that laminar flow conditions exist in the device.

~, OPTICAL: An opto-electronic device, frequently employed to isolate electronic circuits of differing ground potentials so as to prevent mutual interference.

~, POWER: A component designed specifically for increasing signal power.

~, PRESSURE: A component designed specifically for amplifying pressure signals, usually with high impedance output.

~, TURBULENCE: A fluid amplifier, which utilizes control of the laminar-to-turbulent transition of a power jet to modulate the output.

~, VORTEX: An amplifier, which utilizes the pressure drop across a controlled vortex for modulating the output.

~, WALL ATTACHMENT: An amplifier which utilizes control of the attachment of a free jet to a wall (Coanda effect) to modulate the output, usually employed as a digital amplifier.

~ VENTS: Auxiliary ports used to establish a reference pressure in a particular region of the amplifier; analogous to an electrical ground potential.

3. (Continued):

**AMPLITUDE RATIO:** The ratio of the sinusoidal flow amplitude to the sinusoidal current amplitude at a particular frequency, divided by the same ratio at zero frequency or some specified low frequency (usually 5 Hz). Amplitude ratio (AR) may be given in decibels (db) where  $db = 20 \log_{10} AR$ .

**ANALOG, adj.:** The general class of devices or circuits whose output is a continuous function of its input; for example, a proportional fluidic amplifier.

**ANALYTICAL REDUNDANCY:** A concept wherein an estimate of a physical parameter (e.g., aircraft attitude, acceleration, etc.) is computed by combining and filtering information from other sensed data, which have a known physical relationship to the signal of interest. In this way a signal may be synthesized from other sensor signals rather than be obtained from direct measurement. In control systems, the synthesized signal can be used to add a level of redundancy.

**ANGLE OF ATTACK:** (1) The acute angle between the chord of an airfoil and a line representing the undisturbed relative airflow. See Figure 7 and 8. See also Body Axes. (2) The acute angle in the x-z plane between the longitudinal axis of an aircraft and the projection of the aircraft velocity vector on the x-z plane.

**ANODE:** An electrode at which an oxidation reaction (loss of electrons) occurs. In secondary cells either electrode may become the anode depending upon direction of current flow.

**ANTISKID BRAKE:** A wheel brake system that avoids skidding by automatic reduction of the hydraulic system braking pressure when sensing initial skidding, or generally applied to braking torque adjustment to prevent skidding.

**AOA:** Abbr. Angle of attack.

**AOG:** Abbr. Aircraft on ground.

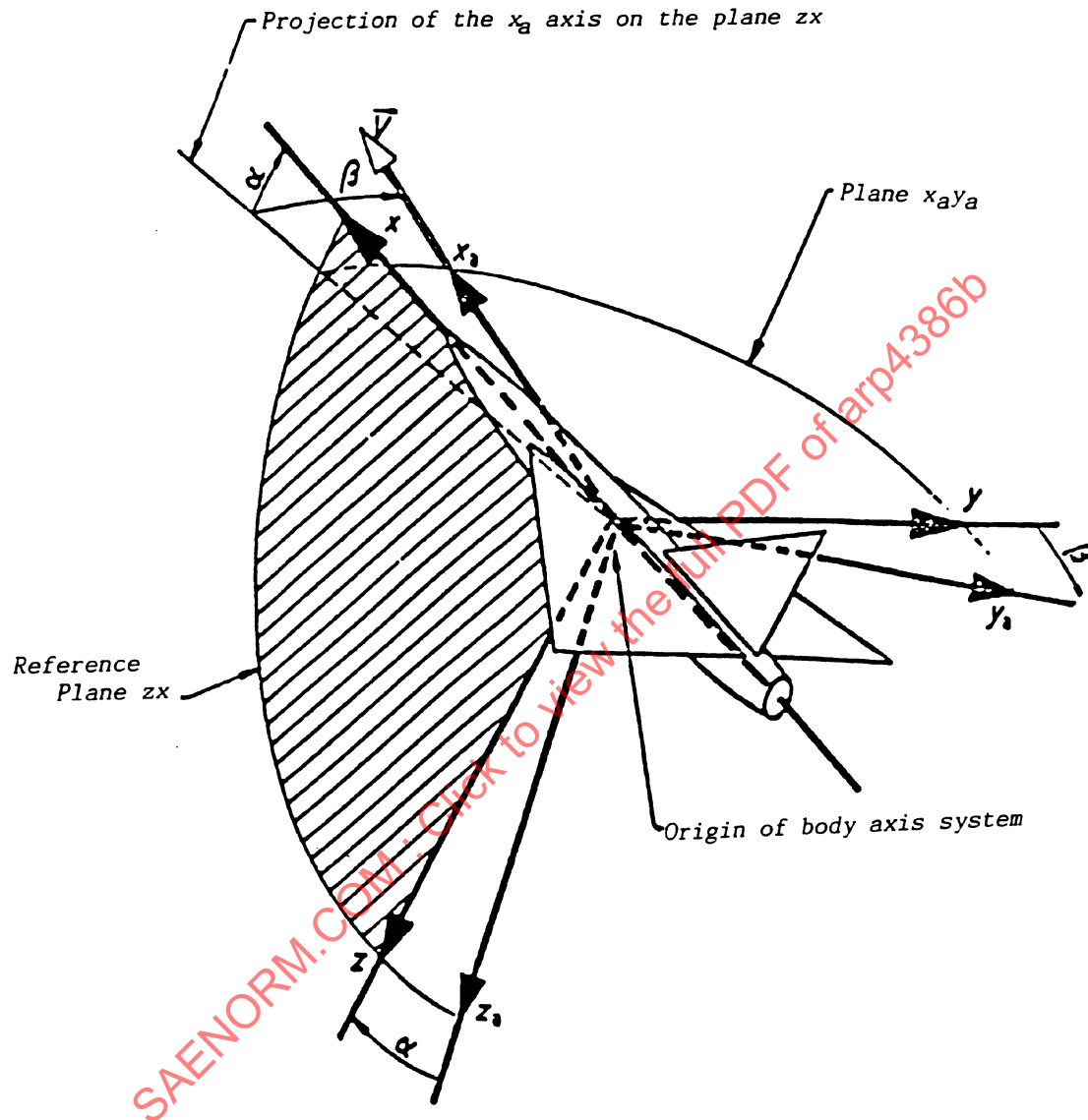
**A/P:** Abbr. Airplane.

**APOGEE:** The point at which a missile trajectory or a satellite orbit is farthest from the center of the gravitational field of the controlling body or bodies.

**ARINC:** Abbr. Aeronautical Radio Incorporated.

**ARTIFICIAL INTELLIGENCE:** A characteristic of a knowledge-based concept or process that involves decision making and reasoning based on stored knowledge. A system possessing such a characteristic is sometimes referred to as an "expert system"; i.e., it uses knowledge and inference procedures to solve problems or diagnose conditions by their symptoms.

**~ GRAVITY:** A simulated gravity set up within an aerospace vehicle, as by rotating a cabin about the longitudinal axis of a spacecraft, the centrifugal force generated being similar to the force of gravity.



Body axis system  $(x, y, z)$

Air-path axis system  $(x_a, y_a, z_a)$

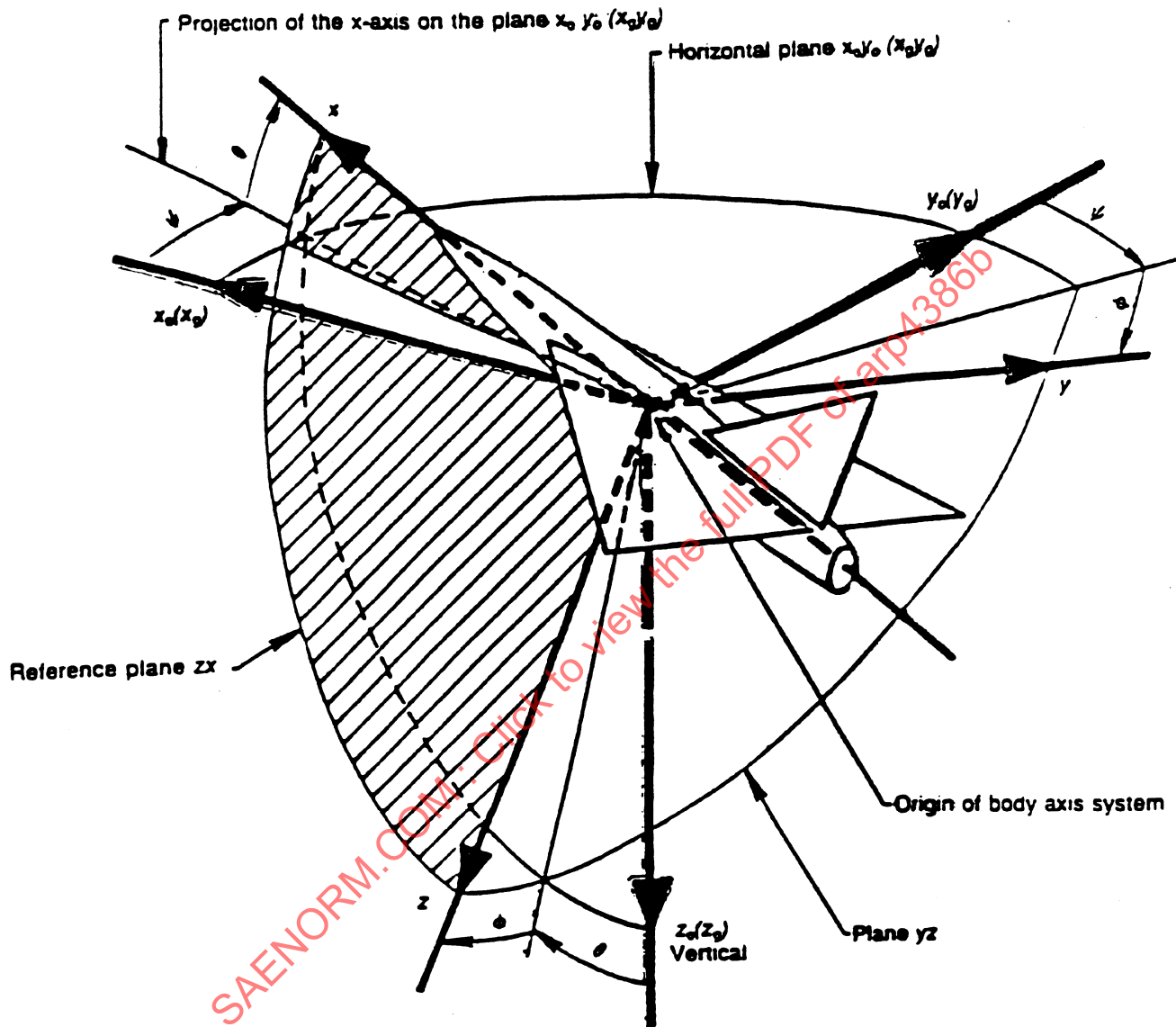
$\bar{V}$  - Vehicle Velocity

$\alpha$  - Angle of Attack, alpha

$\beta$  - Sideslip Angle, beta

NOTE: The angles shown are positive. When the origin of the systems is not in the reference plane, the  $z$ - $x$  plane is parallel to it and the angles are unchanged.

FIGURE 7 - Orientation of the Vehicle Velocity With Respect to the Body Axis System



Vehicle-carried normal Earth-axis system ( $x_0, y_0, z_0$ )

Body axis system ( $x, y, z$ )

NOTE - The angles shown are positive. When the origin of the systems is not in the reference plane, the  $z$ - $x$  plane is parallel to it and the angles are unchanged.

FIGURE 8 - Orientation of the Body Axis System to the Vehicle-Carried Normal Earth Axis System

3. (Continued):

**ASPECT RATIO:** (1) The relationship of the wing span to the surface area of the wing, generally expressed as the ratio of the square of the wing span over the surface area. See Figures 10 and 11 for diagrams.

$$AR = \frac{b^2}{S} \quad (\text{Eq. 2})$$

It may also be expressed in terms of the tip chord and root chord.

where:

$$AR = \frac{2b}{C_r \left(1 + \frac{C_t}{C_r}\right)}$$

AR = Aspect Ratio

b = Wing span

S = Wing area

C<sub>t</sub> = Tip chord

C<sub>r</sub> = Root chord

(2) In particle/filter technology, Aspect Ratio refers to the ratio between the length of a particle and its width as measured at a right angle to the axis of the length.

**ASTRIONICS**, n. pl.: The science of adapting electronics to aerospace flight.

**ASTRONAUTICS**, n.: The art or science, of designing, building, or operating space vehicles.

**ATE:** Abbr. Automatic test equipment.

**ATMOSPHERE**, n.: The gaseous fluid surrounding celestial bodies, specifically the air surrounding the Earth, and used as a measure of pressure; i.e., 1 Atm. = 1.013 bar (abs.) = 0.1013 mPa = 14.69 psia.

~, **STANDARD:** Refers to the accepted/agreed upon standardized pressure, temperature and other physical constants of the earth atmosphere at sea level, Z = 0 m T = 288.15°K, p = 1.01325 bar abs., ρ = 1.225 Kg/m<sup>3</sup>, g = 9.80665 m/s<sup>2</sup>, M = 28.964, c<sub>s</sub> = 340.29 m/s. The standard atmosphere has been defined for altitudes to 10<sup>6</sup> m.

**ATMOSPHERIC BRAKING:** The action of atmospheric drag in decelerating a body that is approaching a planet; can be deliberately used, where sufficient atmosphere exists, to lose much of the vehicle velocity before landing.

**ATTITUDE:** Position of a body as determined by the inclination of the axes to some frame of reference. If not otherwise specified, this frame of reference is fixed to the earth such that the vertical axis coincides with the gravitational vector and the horizontal plane is tangential to the earth surface. See Figures 7 and 8, pp. 22 and 23; see Figure 14, p. 49.

3. ATTITUDE (Continued):

~ CONTROL: A control mode of the flight control system, which directs and maintains the desired attitude of the vehicle.

~ HOLD: An automatic flight control mode, which maintains a desired attitude for the vehicle.

AUTOMATIC FLIGHT CONTROL SYSTEM (AFCS): An Automatic Flight Control System consists of electrical, mechanical, and hydraulic components which generate and transmit automatic control commands which provide pilot assistance or relief through automatic or semiautomatic flight path control or which automatically control airframe response to disturbances. This classification includes automatic pilots, stick or wheel steering, autothrottles, structural mode control, and similar control mechanizations.

a. AFCS functions include:

- (1) Airspeed hold
- (2) All-weather landing
- (3) Altitude hold
- (4) Altitude select
- (5) Attitude hold (pitch and roll)
- (6) Automatic carrier landing
- (7) Automatic instrument low approach
- (8) Automatic navigation
- (9) Automatic terrain following
- (10) Automatic vectoring/traffic control
- (11) Heading hold
- (12) Heading select
- (13) Mach hold

~ FCS PRE-ENGAGE SYNCHRONIZATION: The process of biasing a new input signal to correspond with the AFCS output position prior to switching to the new input signal. The bias is ramped out after switching.

~ TEST EQUIPMENT: Equipment that automatically carries out a program of testing for possible malfunction, with minimum reliance upon human intervention. This equipment should be self-checking to ensure that the automatic test equipment itself does not lead to additional difficulty.

~ VALVE: A valve in which operation is controlled entirely by action of fluid, which passes through it.

AUTOPILOT: A portion of the aircraft's flight control system, which automatically initiates flight corrections by sensing deviations from a fixed reference, performs the necessary functions including computations and actuation in order to maintain the aircraft on a steady preset course and attitude without assistance from the pilot. The term autopilot is short for automatic pilot.

3. (Continued):

**AVAILABILITY:** A measure of the degree to which an item is in an operable and committable state at the start of a mission when the mission is called for at an unknown (random) time.

**AVIONICS:** The application of electronics to aviation and astronautics.

**AVERAGING SYSTEM:** The type of fault-tolerant system using two or more active channels wherein the individual channel outputs are summed to provide an average output. All channels are normally operative so performance degradation may occur after a failure. An example of an averaging system is the use of multiple control surfaces on an airplane, each individually actuated.

**AXIAL, adj.:** Located or arranged in parallel with the axis (e.g., of rotation of a motor). See also hydraulic motors, axial piston motor.

**B**

**BACK PRESSURE:** The pressure caused by resistance to flow in the return line, precharged reservoirs, or both.

**BACKLASH:** The uncontrolled load motion due to clearance in actuation elements, including the load attach point, usually expressed in terms of absolute load motion.

**BACKUP STIFFNESS:** The mechanical stiffness of the actuator attach point(s) through which load reaction forces are transmitted.

**BACKUP SYSTEM:** A mode of control which is engaged upon failure of the primary operational system. Usually used to refer to a system which is as independent as possible from the primary system. Sometimes used as protection against multiple generic failures.

**BALL SCREW ACTUATOR:** A linear mechanical actuator consisting of a ball race, threaded shaft, and a ball race threaded nut, coupled together through spherical balls. (Sometimes called a ball-bearing screw.) The device normally converts rotational input motion to linear output motion but, in some cases, is used in the reverse manner to provide rotary output motion from a linear input motion (normally considered to be significantly more efficient than an acme screw).

**BALLISTIC MISSILE:** Any missile, which does not rely upon aerodynamic surfaces to produce lift. Consequently follows a ballistic trajectory when thrust is terminated.

**BALLISTIC TRAJECTORY:** The trajectory traced after the propulsive force is terminated and the body is acted upon only by gravity and aerodynamic drag.

**BANDWIDTH:** The frequency range over which the actuation system has acceptable dynamic response. This spectrum extends from DC up to a specified frequency, which is usually the frequency where the open loop amplitude ratio has unity gain (0 dB). For a first-order system, this is the frequency where the closed loop response is down 3 dB with 45° phase lag.

3. (Continued):

**BATTERY:** A collection of chemical cells, normally connected in series, for the production or storage of electrical energy. (Van Nostrands Scientific Encyclopedia, fourth edition, [1969].)

~, **FAST CHARGE:** A battery which can be charged at a fast charging rate and which gives a signal that can be used to terminate the fast charge without damage to the battery.

~, **QUICK CHARGE:** A nickel-cadmium battery that can be charged fully in 3 to 5 h by a constant-current charger and is also capable of continuous overcharge at this quick charge rate.

**BEARING, n.:** (1) (Aircraft): A horizontal angle of a given direction measured clockwise from a reference azimuth datum. (2) A stationary mechanical support for a rotating or moving member such as a motor shaft or engine drive shaft, rudder, etc.

**BEARING MOUNTED ACTUATOR:** An actuator mounted between the support structure and load with spherical bearings at each end. This type of actuator can articulate in two axes.

**BELT DRIVE:** Power transmitted by a continuous loop belt and pulleys.

**BENCH CHECK:** A functional check of an item in the shop to determine whether the item may be returned to service, or whether it requires adjustment, repair, overhaul, or replacement.

**BIAS OR PRELOAD:** A steady-state load that is unidirectional and constant over full load travel.

**BINDER:** A composition that holds together a charge of finely divided particles and increases the mechanical strength of the resulting propellant grain when it is consolidated under pressure. Binders are usually resins, plastics, or asphaltics used dry or in solution.

**BIPROPELLANT:** A propellant consisting of two unmixed or uncombined chemicals (a fuel and an oxidizer) fed to the gas generator (combustion chamber) separately. Bipropellants are usually liquids.

**BISTABLE AND TRISTABLE CONTROL:** A control system in which the power to control the load is fully on in either polarity (bistable), or fully on in one polarity, off, or fully on in the other polarity (tristable). These systems are sometimes called on-off systems or bang-bang systems. When the time duration of the application of power is modulated by the input, the system is called pulse width modulated (PWM).

**BIT:** Acron. Built-In Test.

**BLEED LINE:** A line, selectively open to overboard, which serves only for removing foreign substances from a system or unit, as for removal of entrapped air from a hydraulic circuit.

3. (Continued):

**BLEED (PORT):** A port for removal of air, water, etc., in servicing. Applicable where local removal of accumulation is required in servicing, as in brakes, actuators, and pneumatic reservoirs.

**BLOCK, TIME:** Block time is the time an aircraft is underway. It covers the time from pulling the chocks at the parked position until parked at the destination. Block time is entered on the aircraft log sheets and is used in computing airline or user statistical information. It includes taxi time, waiting on taxiways and at the end of runways, takeoff run, flight time, landing roll, and taxi-in. It excludes running of engines or systems, or both, while aircraft are parked or for strictly maintenance check/test purposes.

**BLOW BY:** A condition where fluid leaks at a high rate across a sealing surface permitting high pressure fluid to pass (blow by) from one cavity to one of much lower pressure and usually occurs during rapid pressure reversals.

**BLOW DOWN ACCUMULATOR:** Similar to a direct blow down system except that the stored cold gas is applied to a vessel containing hydraulic fluid with provision for fluid separation. The incompressible fluid then powers the actuation components. This system is primarily used for short duty cycles where the higher stiffness resulting from the use of hydraulic fluid is desired. The hydraulic fluid is usually dumped overboard after providing actuation power.

**BLOWOFF VALVE:** A valve which releases fluid to overboard when its setting is exceeded.

**BODE PLOT (FREQUENCY RESPONSE):** The complex ratio of the actuation system output to the command input, while the input is cycled sinusoidally and the frequency is varied. Frequency response is usually presented as a combined plot of normalized amplitude ratio in dB, and of the input to output phase angle, in degrees, versus the logarithm of frequency.

**BODY AXES:** The body axes system is a set of orthogonal axes rigidly fixed in the airplane with the origin located at the center of gravity and extending forward, downward, and to the right. See Figure 10 and Table 1. See also Angle of Attack.

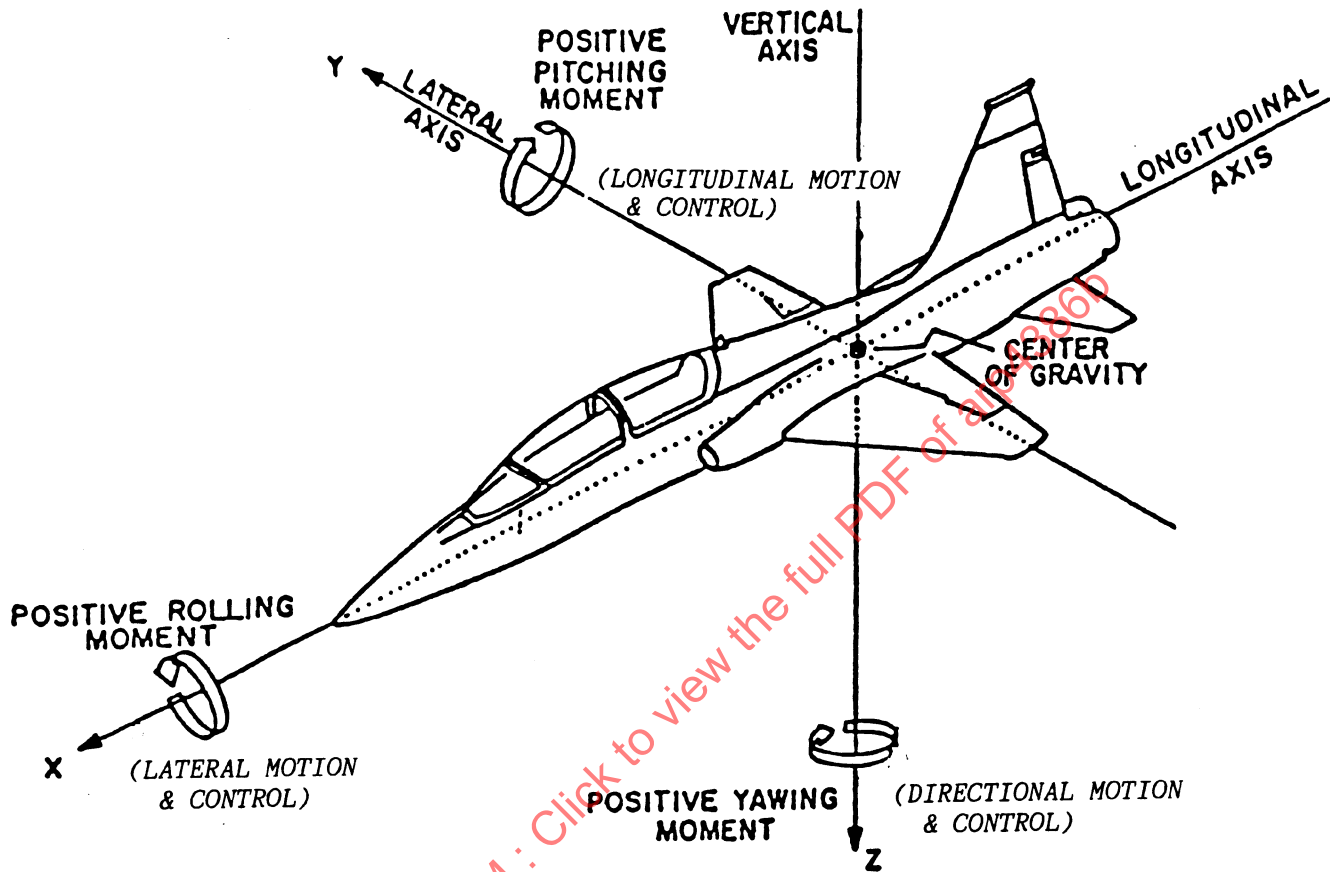


FIGURE 9 - Aircraft Body Axes

TABLE 1 - Notation for Body Axes

| Axis Designation     | Longitudinal                       | Lateral                         | Vertical                           |
|----------------------|------------------------------------|---------------------------------|------------------------------------|
| Symbol               | X                                  | Y                               | Z                                  |
| Sign Convention      | Forward +                          | To right +                      | Down +                             |
| Motion About Axis    | Rolling Motion                     | Pitching Motion                 | Yawing Motion                      |
| Sign Convention      | Right Roll + ( $Y \rightarrow Z$ ) | Nose Up + ( $Z \rightarrow X$ ) | Nose Right + ( $X \rightarrow Y$ ) |
| Angular Displacement | $\phi$ Roll Angle                  | $\theta$ Pitch Angle            | $\psi$ Yaw Angle                   |
| Sign Convention      | Right Roll +                       | Nose Up +                       | Nose Right +                       |

3. (Continued):

**BOOSTER CHARGE:** The ignition component, ignited by the primer charge, which either pressurizes the generator to operating pressure or generates a higher energy shock pulse.

**BOOST-GLIDE VEHICLE:** A rocket-boosted winged vehicle capable of leaving the atmosphere and re-entering under aerodynamic control in an unpowered or gliding condition.

**BOOTSTRAP RESERVOIR:** An airless reservoir with two pistons of unequal area; a large area piston connected to the pump inlet and a small area piston connected to the pump outlet. At start-up the pump outlet pressure acts on the small piston area, hence the name, as it literally "pulls itself up by the bootstraps".

**BRAKE:** A fluid, magnetic or mechanical device that absorbs energy and thereby resists motion.

~, **ANTISKID:** A wheel brake system that avoids skidding by automatic reduction of the hydraulic system pressure when sensing initial skidding.

~, **PARKING:** A static brake that, when actuated, continuously holds a load or prevents motion.

~, **TORQUE LIMITING:** A mechanical device that permits free flow of torque below a predetermined level. Once that level is exceeded, the excess torque is routed to ground through a brake or the torque is disrupted in slippage as in a slip clutch. There are two basic types of torque limiters: load weighing and capstan coil.

~ **PORT:** An outlet port carrying modulated brake actuating pressure. Applicable to brake valves and pressure-generating cylinders.

~ **VALVE:** A valve for control of wheel brake actuating pressure. A brake valve is usually a mechanical or pressure operated variable pressure reducing valve with provision for opening brake pressure outlet port to "Return" when outlet pressure exceeds the pressure setting at the moment.

**BREAKOUT LOAD:** The minimum load under which the system starts moving while the controller is gradually moved towards saturation.

**BREAKOUT PRESSURE:** The pressure required to overcome static friction in a component.

**BREECH:** A reloadable pressure vessel used to contain a propellant cartridge.

**BRUSH PERMANENT MAGNET MOTOR:** A DC motor in which direct current supplied to the conductors in the rotor reacts with a magnetic field developed by permanent magnets located in the stator, resulting in motor torque. A commutator and brushes ensure that direct current is supplied to the rotor conductors such that unidirectional torque is produced with one polarity of current.

3. (Continued):

**BRUSH WOUND FIELD MOTOR:** A DC motor similar to a brush PM motor, except that a wound coil supplied with continuous and unidirectional direct current is used in place of a PM field in the stator.

**BRUSHLESS PERMANENT MAGNET MOTOR:** A DC motor in which DC current supplied to conductors in the stator reacts with the PM field developed by permanent magnets located in the rotor, resulting in motor torque. Electrically switched direct current is supplied to three or more sets of stator conductors in a sequence such that unidirectional torque can be developed. A rotor position transducer is used to sequence stator currents.

**BTU:** Abbr. British thermal unit, English unit of thermal energy = 1055 Joules.

**BUBBLE POINT:** The value of pressure at which a constant stream of bubbles first appears from a filter mesh that is immersed a given depth below the surface of a given liquid with known temperature, density, and surface tension.

**BUFCS:** Abbr. Backup flight control system.

**BUFFETING:** A forced vibration of aircraft structural components caused by unsteady aerodynamic forces due to wake effects, mach effect, or pre-stall conditions.

**BULK MODULUS:** The bulk modulus of a trapped fluid volume is:

$$\frac{\text{incremental pressure}}{(\text{incremental volume/total volume})} \quad (\text{Eq. 3})$$

The Units of Bulk Modulus are Pa or psi. Depending on the conditions under which the measurement of bulk modulus B is performed, one must distinguish between isentropic (adiabatic)  $B_s$  and isothermal  $B_t$ . The relationship  $B_s/B_t = k$ , the ratio of  $c_p$  the specific heat at constant pressure and  $c_v$  the specific heat at constant volume, which for most hydraulic fluids is approximately 1.2.

**BUILT-IN-TEST:** An operational status checkout or test system which is integrated into a control system or function. Usually used to verify operational status of as many aspects of a control function as possible within the limits of integrated test capability. May be initiated automatically or on command.

**BURN-IN:** The operation of an item under stress to stabilize its characteristics.

**BURNING:** Rapid release of energy through chemical reaction between fuel and an oxidizing agent (see Combustion). Burning rate is the propagation rate of a pyrotechnic or propellant mixture. Burning time is the elapsed time between initiation and completion of the reaction of the pyrotechnic or propellant mixture. Burning time depends on many factors such as length of column, degree of consolidation, temperature, pressure, percentage of ingredients, and their particle size.

3. BURNING (Continued):

~, NEUTRAL: The burning of a propellant grain in which the reacting surface area remains approximately constant during combustion.

~, PROGRESSIVE: The burning of a propellant grain in which the reacting surface area or burning rate increases during combustion. The mass flow rate produced increases as the web increases.

~, REGRESSIVE: A condition in which the mass flow produced by the propellant grain decreases as the web is consumed due to decreasing area, decreasing burn rate, or both.

BURNOUT, n.: The point in time when the fuel of a rocketpropelled vehicle is used up.

~ VELOCITY: The velocity attained by a missile at the point of burnout.

~ WEIGHT: Weight of a missile at the time of burnout, but including any unusable fuel.

BURST PRESSURE: The maximum test pressure a hydraulic or pneumatic component must withstand without rupture.

BURST PRESSURE, ACTUAL: The pressure at which a component bursts, exhibits massive leakage due to permanent or nonpermanent structural failure, or due to structural deflection.

BURST PRESSURE, MINIMUM: The pressure during burst pressure testing up to which no externally visible bursting and no significant external leakage occurs. Deformation and permanent set are permitted. Function may be impaired.

BUSAS: Acron. Backup Stability Augmentation System.

BUZZ: Undesirable vibration of a flight control surface induced and maintained by aerodynamic forces.

C

C\*: Abbr. C-Star.

CALIBRATED FLOW: In a unit which controls or limits rate or quantity of flow, that rate or quantity of flow for which the unit is calibrated or adjusted. When calibration is related to specific conditions, the condition of calibration must be stated. Example, a restrictor may be calibrated to pass 1 gpm (4 L/min) at 1500 psi (10 500 kPa) pressure differential.

CAMBER: Camber is the maximum rise of the mean line from the chord line.

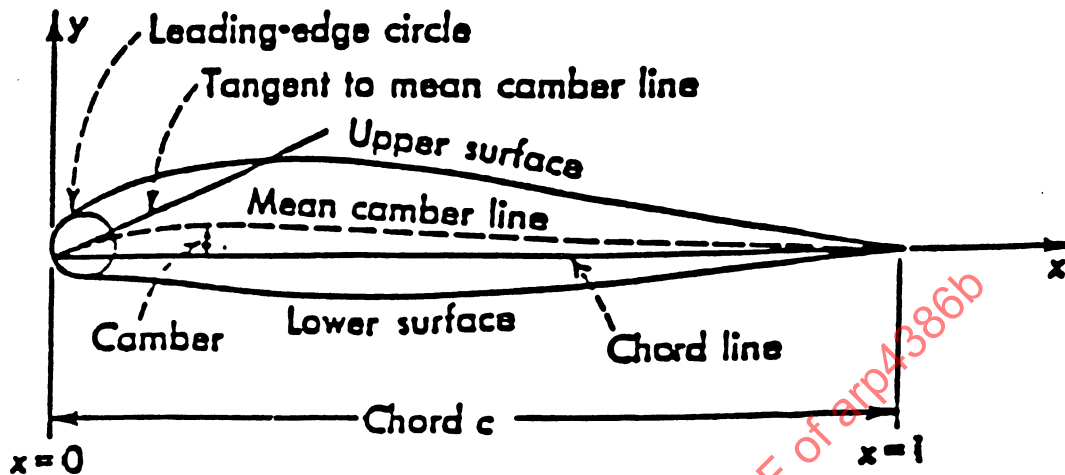


FIGURE 10 - Airfoil Section

## 3. (Continued):

**CANADIAN TRANSPORT COMMISSION (CTC) REGULATIONS:** Regulations of the CTC (previously called the Board of Transport Commissioners or BTC) are contained in the document "Regulations for the Transportation of Dangerous Commodities by Rail".

**CANARD:** An airfoil surface located forward of the wing.

**CAPACITOR:** A passive fluidic element which, because of its own compliance or fluid compressibility, produces a pressure in the device which lags net flow into it by essentially  $90^\circ$ . Note that fluidic capacitor cannot block steady flow in the way its electrical counterpart blocks DC.

**CAPACITY:** The product of current multiplied by the time current is flowing. Capacity of a cell or battery is usually expressed in ampere hours.

**CAPSTAN CLUTCH:** A coaxial spring and shaft with a preloaded fit wherein power can be transmitted through the shaft spring interface.

**CAPSTAN COIL (WRAP SPRING) NO BACK:** A capstan coil is essentially a coil spring placed in a housing with a slight interference fit. Motion in either direction (to unwind the spring), initiated at the output end, will prevent back-driving motion. Motion in either direction (to wind the spring) initiated at the input end will result in coupling and drive.

**CAPSTAN COIL:** The capstan coil operates on the principle that a mechanical coil, under a torque in an unwind direction, radially expands and engages the housing, thus grounding the input torque above a predetermined level. In this case, the load weighing and braking are both accomplished by the capstan coil.

3. (Continued):

**CARTRIDGE:** A replaceable unit used in a pressure vessel which is capable of producing pressurized gas when ignited. An example is the solid propellant cartridge used with an aircraft engine starter.

**CAS:** Abbr. Control augmentation system.

**CASE:** A pressure vessel designed to contain a propellant charge before and during burning.

**CASE DRAIN FLOW:** Cooling flow and internal leakage of a hydraulic pump or motor to the housing and out of the case drain port, not provided in all models.

**CATALYST:** A substance, which by its mere presence, changes the rate of a reaction (decomposition) and may be recovered unaltered in nature or amount at the end of the reaction.

**CATASTROPHIC FAILURE:** A sudden change in the operating characteristics of material resulting in a complete lack of useful performance.

**CATHODE:** An electrode at which a reduction reaction (gain of electrons) occurs. In secondary cells either electrode may become the cathode depending upon direction of current flow.

**CAVITATION:** Formation and their collapse at higher pressures of cavities, either gaseous or vapor, within a liquid stream, which occurs where the pressure is locally reduced to vapor pressure of the liquid. It may include gas coming out of solution in the liquid as pressure is reduced (soft cavitation).

**CBL:** Abbr. Control by light

**CBW:** Abbr. Control by wire

**CCV:** Abbr. Control configured vehicle

**CELESTIAL NAVIGATION:** A form of navigation using the celestial bodies for reference. In missile terminology, a system wherein a guided missile, suitably instrumented and containing all necessary guidance equipment, may follow a predetermined course with reference primarily to the relative positions of the missile and certain preselected celestial bodies.

**CELESTIAL SPHERE:** An imaginary sphere of infinite radius concentric with the earth, on which all celestial bodies except the earth are imagined to be projected.

**CELL:** An electrochemical device composed of positive and negative plates, a separator, and an electrolyte, which is capable of storing electrical energy. When encased in a container and fitted with terminals, a cell is the basic "building block" of a battery.

3. CELL, (Continued):

~ REVERSAL: The reversal of polarity of the terminals of a cell in a multicell battery due to over-discharge.

CENTER OF LIFT: The mean of all the centers of pressure on an airfoil.

CENTER OF MASS: The point at which all the given mass of a body or bodies may be regarded as being concentrated as far as motion is concerned. Commonly called center of gravity.

CENTER OF PRESSURE: The point on the chord of an airfoil section which is at the Intersection of the chord (prolonged if necessary) and the line of action of the combined air forces (resultant air force).

CENTRIFUGAL PUMP: A pump which creates high fluid velocity through centrifugal action. Fluid momentum is recovered as a pressure head at the pump outlet. A centrifugal pump is not a positive displacement device and output pressure remains essentially constant at constant speed for varying output flows up to pump cavitation.

CERTIFICATION PRESSURE: The authorized pressure for formal acceptance tests.

CHAIN DRIVE: A series of links used to transmit power from one rotating member to another. In many applications the links are so joined as to form a continuous loop between the driving shaft (input) and a driven shaft (output). Chain drive systems may be used to transmit power through the chain, either in a forward driving condition or as a holding, controlling, back-driven system.

CHAMBER PRESSURE: The pressure within the case during combustion.

CHAMBER TEMPERATURE: The temperature of combustion products in the combustion chamber, generally considered to be the adiabatic isobaric flame temperature.

CHANNEL: One signal or control path of a redundant set. A channel is an entity within itself and contains elements individual to that channel. A model may be used as a reference channel in a detection-correction system.

~ BUFFERING: A technique used in fault-tolerant systems that minimizes the possibility of a failure in one channel to induce a failure in another channel.

~ PRIORITY: The order of authority of the various channels in a redundant system where the channels are not equivalent. Examples of channel prioritizing are:

- a. Primary/secondary
- b. Active/standby
- c. Normal/alternate

3. CHANNEL (Continued):

~ SUMMING: The combining of multiple channels to provide a control function. Examples of channel summing techniques are:

- a. Flow summing
- b. Flux summing
- c. Force summing
- d. Position summing
- e. Torque summing
- f. Velocity summing

CHARGE: ([3] The amount of material introduced periodically into a process. (Van Nostrands Scientific Encyclopedia, Fourth edition, [1968])

~, FLOATING: The use condition of a storage battery wherein charge is maintained by a continuous, long-term constant-potential charge.

~, PRIMER: A secondary component in an ignition train, which is ignited by an initiator, starts pressurization of a generator, and ignites the ignition booster charge.

~, QUICK: A charging rate that ranges from 0.2 to 0.5 C rate.

~ RETENTION: The tendency of a charged cell to resist self-discharge.

~, SLOW: An "overnight" return of energy to a battery at 0.05 to 0.1 C rates.

~, STANDBY: A low overcharge current rate, on the order of 0.01 to 0.03 C, applied continuously to a vented-cell battery to maintain its capacity in a ready-to-discharge state. Often called "trickle" charging. Sealed cells used for emergency standby power are usually given a continuous "slow" charge (0.05 to 0.1 C) rather than the lower current "standby" charge.

~, SUSTAINER: A component (optional) of an ignition train that maintains the operating pressure until thermal equilibrium is obtained.

CHARGING: The process of supplying electrical energy for conversion to stored chemical energy.

~ FAST: The rapid return of energy to a battery at the C Rate or greater. See C Rate definition under Battery Performance.

CHECK VALVE: A valve which allows free flow of fluid in one direction only and prevents flow in the opposite direction.

3. CHECK VALVE, (Continued):

~, CONTROLLABLE: A two position manually operated valve which functions as a conventional valve in one position, but permits free flow in either direction when actuated to the other operating position.

CHECK, BENCH: A functional check of an item in the shop to determine whether the item may be returned to service, or whether it requires adjustment, repair, overhaul, or replacement.

CHECK, C: A heavy maintenance check; also see Letter Check.

CHOKED FLOW: Flow of a compressible fluid (gas), limited by the speed of sound in the fluid at the throat of a control section.

CHORD: The longest straight line between the leading and trailing edges of an airfoil section. See also Airfoil. See Figure 6.

CIRCULAR VELOCITY: Critical velocity at which a satellite will move in a circular orbit around its primary. Circular velocity is a special case of orbital velocity and one which is not likely to be obtained in practice due to accuracy of control needed.

CISLUNAR SPACE: Space between the earth and the orbit of the moon.

CLEAN AIRCRAFT: (1) An aircraft in flight configuration versus landing configuration (i.e., landing gear and flaps retracted, etc.); (2) An aircraft whose external stores are removed (i.e., not attached).

CLEANLINESS LEVEL: The amount of particles by size range and number in a given volume of fluid as determined by a particle count to a requirements document such as MIL-STD-1246, NAS1638, or AS4059.

CLOSED CENTER VALVE: No position allows flow from "Pressure" to "Return" port; "Pressure" port blocked in "Off" position.

CLOSED CENTER SYSTEM: In a hydraulic system, when no service is actuated, the system is closed to flow, as distinguished from an open center system. A closed center system may utilize a continuous pressure supply, as with a variable displacement pump or an intermittent pressure supply by means of an unloading valve, motor driven pump, or by bypassing provisions.

CLOSED LOOP CONTROL SYSTEM: A control system in which the command is compared with a measurement of system output and the resulting error signal is used to drive the load towards the desired output. Figure 8 illustrates a closed loop control system. See Figure 11.

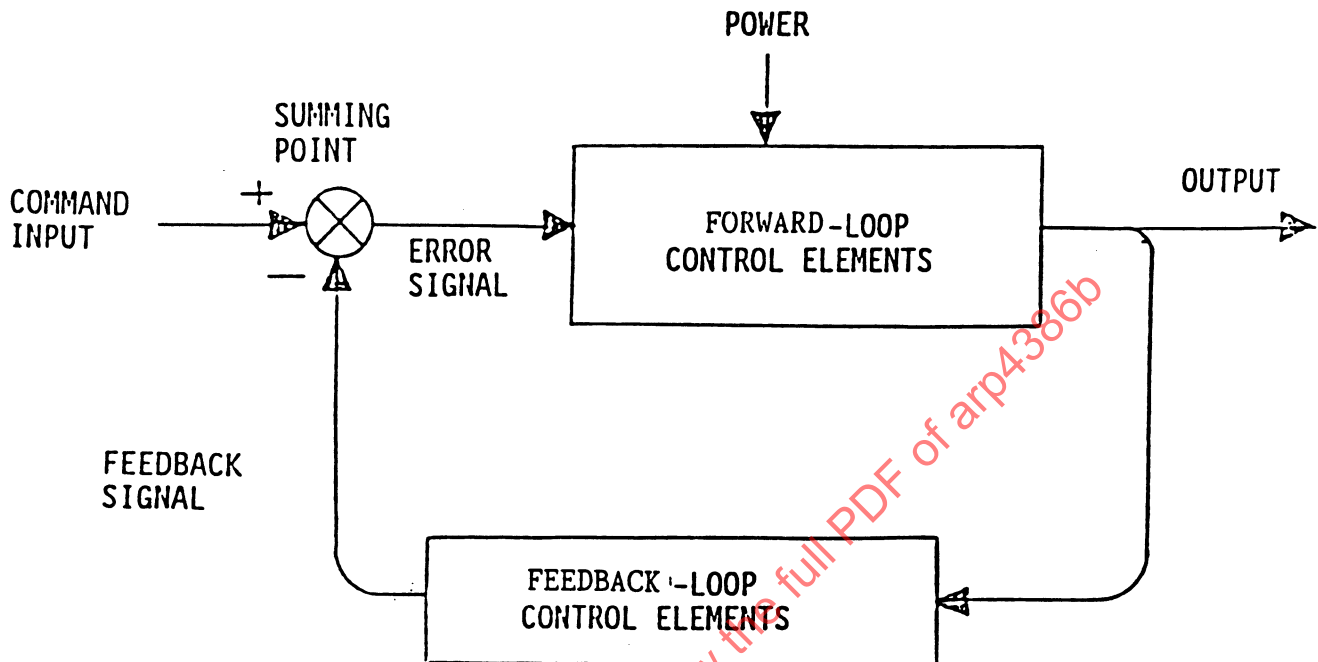


FIGURE 11 - Closed Loop Control System

3. (Continued):

**CLOSED LOOP FREQUENCY RESPONSE:** The frequency response between command input and control system output with the feedback signal summed with command. Actuation system response for a closed loop system is usually specified as a closed loop frequency response. See Figure 3.

**CLOSED NEUTRAL VALVE:** In a directional control valve, "Cylinder" or "Load" ports are blocked in "Neutral" or "Off" position.

**CLUTCH:** A mechanical device that transfers or interrupts mechanical power from an input shaft to an output shaft. See Figure 12 for various types.

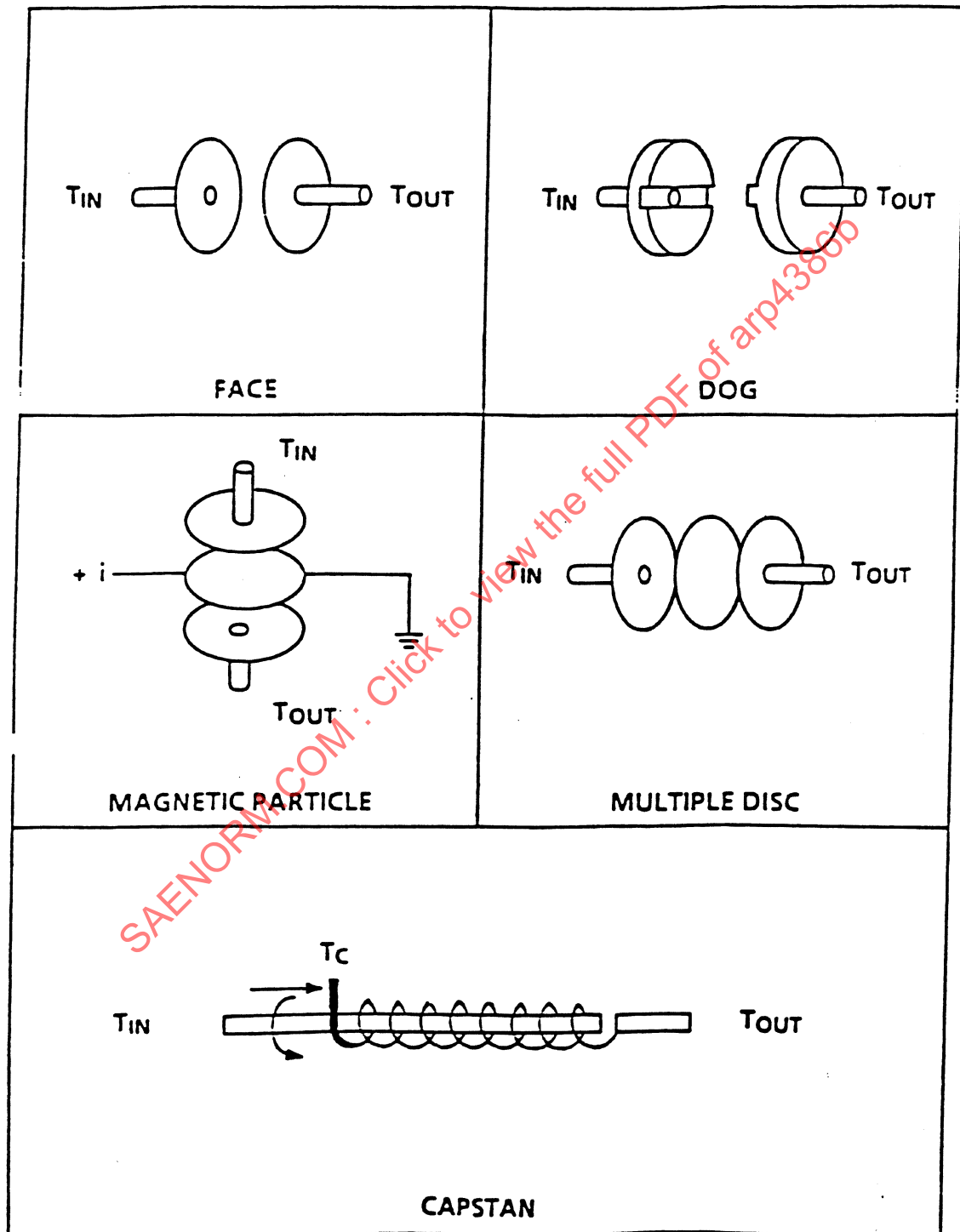


FIGURE 12 - Clutches

3. CLUTCH (Continued):

~ DOG: Two interfacing elements which transmit mechanical power when in contact by means of pins, teeth, dowels, or other load carrying elements.

~ FACE: Two interfacing, rotating elements which transmit mechanical power when in contact by means of friction surfaces.

CLUTCH COUPLED TURBOMECHANICAL ACTUATOR: A turbomechanical actuator wherein a constant speed turbine is coupled to the load through a double-acting servo-controlled clutch. The clutch controls both the speed and direction of the load. A large gear reduction between the high speed turbine and the load is included in the actuator.

CLUTCH COUPLING DRIVE: A motion transmission, which allows interruption of the load path for control purposes.

CM: Abbr. Conditions monitored or conditions monitoring.

COASTING FLIGHT: The flight of a rocket missile or other vehicle between burnout or thrust cutoff of one stage and ignition of another, or between burnout and summit altitude or maximum range.

COIL IMPEDANCE: The complex ratio of coil voltage to coil current. It is important to note that the coil impedance of an electromechanical device may vary with signal frequency, signal amplitude, and other operating conditions due to back emf generated by the moving armature.

COIL RESISTANCE: The DC resistance of the coil of an electromechanical or electrohydraulic device, expressed in ohms.

COLD GAS: Gas at essentially room (ambient) temperature, or at a temperature that is generally available from a pressure source without burning, decomposition, or external heating. Examples are gas drawn from a storage vessel, or that extracted from an operating compressor. Cold gas is used typically for pressurization, inflation or expulsion purposes, or both. However, it is also used as the potential energy source and the fluid medium in some servoactuator control systems.

COLD START TEMPERATURE: The temperature at which the hydraulic system will start to operate, but need not necessarily meet full performance.

COMBUSTION: A continuous, rapid chemical process accompanied by the evolution of energy which is commonly the union of a fuel and an oxidizing agent.

COMMAND: An input which represents the desired output of the control system.

COMPANION BODY: A nose cone, last stage rocket, or other body that orbits along with an earth satellite.

3. (Continued):

**COMPOSITE SOLID PROPELLANTS:** Composite solid propellants are commonly defined as those propellants in which a granular inorganic oxidizer is suspended in an organic fuel binder, neither of which would burn without the presence of the other. Typical oxidizers are ammonium nitrate and ammonium perchlorate; fuel binders are usually either rubber or plastic.

**COMPOUND WOUND MOTOR:** A wound-field DC motor which incorporates both shunt and series windings in the stator.

**COMPRESSED GAS:**

~ **IN SOLUTION:** A nonliquefied gas (such as Acetylene), which is dissolved in a solvent.

~ **LIQUEFIED:** A gas which, under the charging pressure, is partially liquid at a temperature of 70 °F (21 °C). A flammable compressed gas which is normally nonliquefied at 70 °F (21 °C), but which is partially liquid under the charging pressure and temperature, shall follow the requirements for liquefied compressed gases.

~ **NONLIQUEFIED:** A gas not in solution which, under the charging pressure, is entirely gaseous at a temperature of 70 °F (21 °C).

~ **PRESSURIZED LIQUID:** A compressed gas not in solution, which cannot be liquefied at a temperature of 70 °F (21 °C), and which is maintained in the liquid state at a pressure not less than 40 lb/in<sup>2</sup> (abs) (2.07 m Hg abs) by maintaining the gas at a temperature less than 70 °F (21 °C).

**COMPRESSIBLE FLOW:** Flow of a fluid wherein the conditions of pressure, density, and temperature may vary between cross sections of the stream in the direction of flow.

**CONDITION MONITORING:** a. Process: Condition monitoring is a data gathering, not a preventive maintenance, process. It allows failures to occur and relies on analysis of operating experience information to indicate the need for appropriate action. If the removal rate is deemed to be excessive, the component may temporarily be assigned a hard-time removal limit until corrective action can restore its removal performance to an acceptable level.

~ **ITEM:** A Condition Monitoring item has neither hard-time removal nor scheduled test to determine its continued serviceability. All removals are for unscheduled cause. All units removed must, upon arrival in the shop, be given a check in accordance with the procedures in the appropriate shop manual. If the unit "passes", it is returned to service. Failure to pass the check requires the unit to be repaired to a state that it will pass and be serviceable.

**CONDITIONING:** A maintenance procedure consisting of deep discharge, short, and constant-current charge used to correct cell imbalance which may have been acquired during battery use.

3. (Continued):

**CONFIDENCE FACTOR:** The percentage figure that expresses confidence level.

**~ LEVEL:** The probability that a given statement is correct, usually associated with statistical predictions.

**~ TEST:** A test primarily performed to increase the confidence that the unit under test is operating acceptably.

**CONFINED DETONATOR FUSE:** A mild detonating fuse completely contained within a shock absorbing sheath to prevent damage to the surroundings when the fuse is detonated.

**CONTAMINANT:** Any material, usually a solid, that is suspended or dissolved in a fluid system and is not there by design.

**CONTINUOUS POWER:** The maximum power which can be delivered by the actuation system for an indefinite period without sustaining damage or reducing life. With an electric actuator, continuous power is generally much less than rated power due to material limitations, which are time and temperature-related.

**CONTRAORBIT MISSILE:** Missile sent backward along the calculated orbit of an approaching spacecraft, satellite, or aerospace weapon for the purpose of destroying it in a head-on collision with an explosive warhead or by missile. Contraorbit attacks are considered much easier to accomplish than orbital attacks.

**CONTROL:** [1] A system or device which exerts a restraining, governing, or directive influence. (Van Nostrands Scientific Encyclopedia, Fourth edition, [1968])

**~, DIRECTIONAL:** Control of the directional motion of an aircraft. Directional control is primarily achieved through control of yaw and sideslip.

**~ AUGMENTATION SYSTEM:** A function of the flight control system, including command shaping, sensors, actuators, etc., that perform in such a manner so as to augment the static and dynamic stability, and maneuver response of the aircraft. When considered as an entity it is essentially a closed loop tracking control system, responding to pilot commands.

**~ AUTHORITY:** The amount of control surface or thrust vector deflection that can be produced by AFCS signals relative to the total available control deflection. This phrase is often preceded by the word electrical, or abbreviations such as CAS or SAS, in order to be more explicit.

**~ BY-LIGHT SYSTEM:** A flight control system wherein vehicle control information is transmitted by light through a fiber-optic cable.

**~ BY-WIRE SYSTEM:** A flight control system wherein vehicle control information is transmitted completely by electrical means.

3. CONTROL (Continued):

~ COLUMN: A control lever for the pilot having a wheel (or the equivalent) mounted at the upper end; turning of the wheel provides control about the longitudinal axis while forward and back motion provides control about the lateral axis.

~ CONFIGURED VEHICLE: A vehicle so designed (configured) as to produce performance benefits by exploiting the capabilities of the aircraft's flight control system to augment the inherent aerodynamic design characteristics of the basic aircraft.

~ (PORT): A port for connection of pilot line for operation or control of the unit. Applicable to remote control units, such as valves and pumps.

~ PRESSURE: The pressure required to control or influence any motion or change in motion.

~ REVERSAL: The change in the direction of the lift increment from that normally produced by a movable control surface. It results from the elastic torsional deflection of the fixed surface caused by the aerodynamic moments applied when the movable control surface is deflected.

~ ROCKET: A vernier rocket, retro-rocket, or other such rocket used to guide, accelerate, or decelerate a ballistic missile, spacecraft, or the like.

~ STICK: A cockpit control lever of a particular type used to produce longitudinal and lateral control inputs to the aircraft.

~ SURFACE: (1) Aeronautics: The movable segment or segments of an airfoil that are used to control the flight path or attitude of a vehicle (e.g., flaps, ailerons, elevators, rudder, trim tabs, spoilers). See Figure 13. (2) Fluid Mechanics: An arbitrary boundary of a fluid system used in defining the mass flow into and out of the enclosed control volume and the forces acting upon the fluid system.

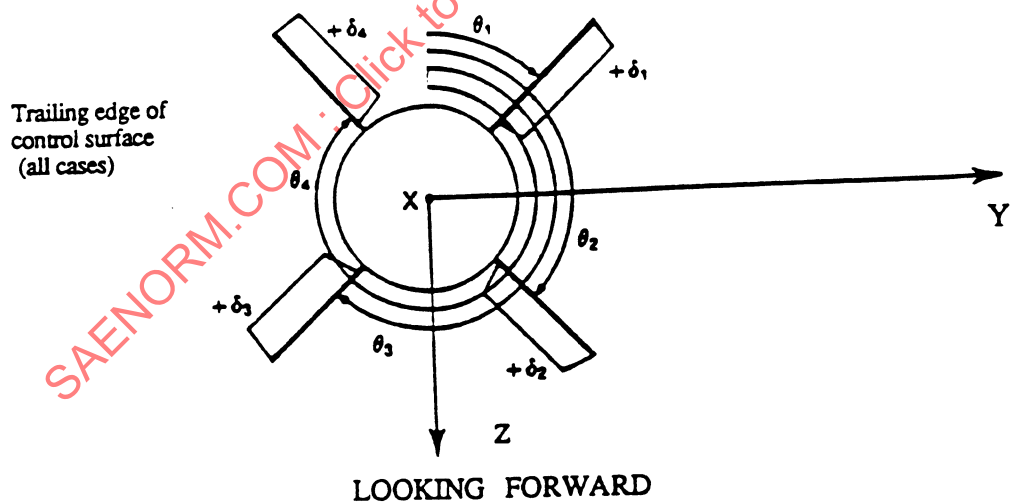
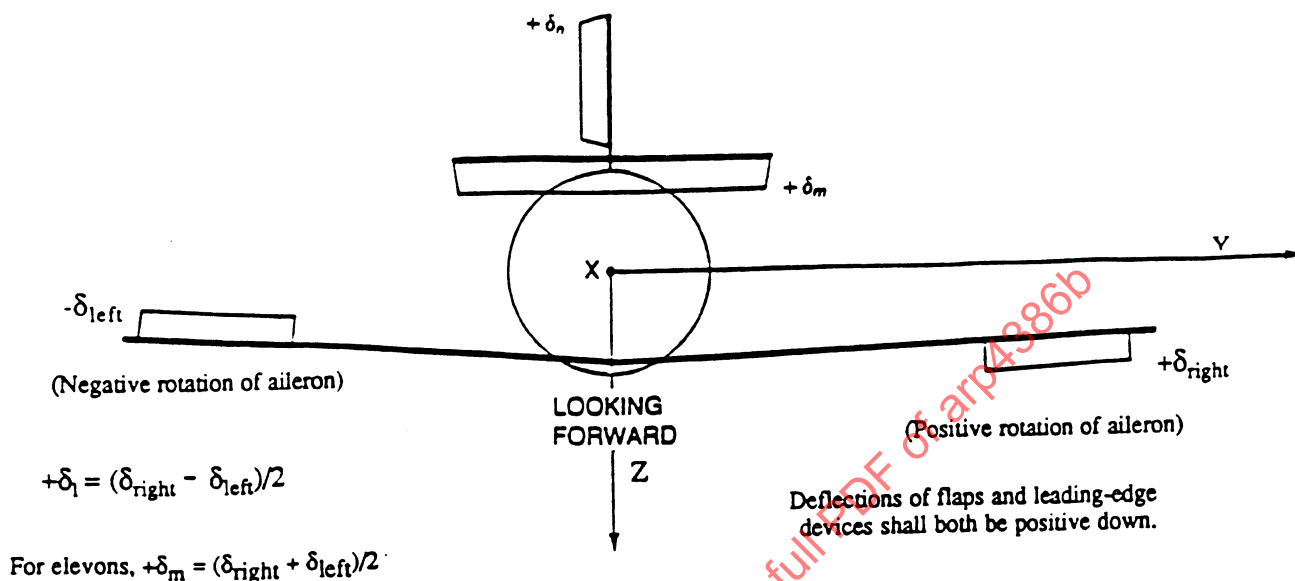
~ SYSTEM: A system in which deliberate guidance or manipulation is used to achieve a prescribed value of a variable. A control system has at least one input and one output.

CONTROL VALVE: A valve in which flow pattern or rate is controlled by external means.

~, DIRECTIONAL: A selector valve having four working ports: "Pressure", "Return", and two "Cylinder" or "Load" ports; and a reversible flow pattern.

CONTROLLER: The component of the actuation system that controls the power modulator as a function of the command or error signal. Many of the electronic controllers have dynamic compensation as well as significant gain, so they must be recognized as separate components in the actuator loop.

CONVERSION: The process of changing from one type of control or operational state to another; e.g., from an active to a standby control or from a primary to a secondary system.



$$\delta_l = \frac{1}{4} (\delta_1 + \delta_2 + \delta_3 + \delta_4)$$

$$\delta_m = \frac{1}{2} (\delta_1 \sin \theta_1 + \delta_2 \sin \theta_2 + \delta_3 \sin \theta_3 + \delta_4 \sin \theta_4)$$

$$\delta_n = -\frac{1}{2} (\delta_1 \cos \theta_1 + \delta_2 \cos \theta_2 + \delta_3 \cos \theta_3 + \delta_4 \cos \theta_4)$$

Positive direction of spoiler deflections shall be those that cause the same direction of rolling moments as  $+\delta_{\text{right}}$ .

FIGURE 13 - Sign Convention for Control Surface Deflection

3. (Continued):

**COROLIS EFFECT:** The deflection of a body in motion due to the earth's rotation, diverting horizontal motions to the right of the direction of rotation in the northern hemisphere and to the left in the southern hemisphere.

**COULOMB FRICTION LOAD:** A steady friction load that is present whenever the load is moving or about to move and opposes load motion.

**COUPLINGS:** A mechanical device utilized to join shafting that is used to transmit power and/or motion between operating members of a mechanism. Couplings may be rigid (sleeve type) or flexible.

**CRAB:** To turn the aircraft partly into the wind to compensate for drift.

**CRACKING PRESSURE:** The pressure at which a valve becomes unseated and begins to pass fluid.

**C-RATE:** The discharge or charge rate in amperes, which is numerically equal to the rated capacity of a cell in ampere-hours.

**CREEP:** The property of a material, which causes it to be permanently deformed when subjected to a prolonged constant stress. Creep is accelerated at elevated temperatures.

**CRITICAL ANGLE OF ATTACK:** The angle of attack of an airfoil at which the flow of air about the airfoil changes abruptly in such a manner that lift is sharply reduced and drag is sharply increased. Also called the "stalling angle of attack".

**CRITICAL ITEM:** An item or condition that:

- a. Has a limitation to warrant controlled surveillance under specified conditions
- b. Is known to require special handling, transportation, storage, or test precautions
- c. Does not have sufficient history of its own, or a similarity to other items that have the demonstrated high reliability to provide confidence in its reliability. (x.x.x)

**CRITICALITY:** (1) A relative measure of the consequences of a failure mode. (2) A nuclear reaction resulting from the interaction of fissionable material.

3. (Continued):

**CROSSOVER GAIN AND PHASE MARGIN FREQUENCY:** The point on the Bode Plot of the transfer function at which the magnitude crosses over unity:

$$\text{Log}_m G(j\omega) = 0 \text{ dB} \quad (\text{Eq. 4})$$

where:

$\omega$  = Oscillation frequency, in radians per second

$j$  = Square root of minus one

The frequency at gain crossover is called the phase margin frequency.

**CROSSTALK:** A term used in multiple channel units to describe the voltage produced in the secondary of one channel by the primary excitation of another channel.

**CRUISE CONTROL:** A control mode whereby the aircraft is controlled to obtain the greatest practical efficiency for a given flight or mission.

**~ MISSILE:** A guided missile, the major portion of whose flight path to its target is conducted at approximately constant velocity; it depends upon the dynamic reaction of air for lift, and upon propulsion forces to balance drag.

**CRUISING ALTITUDE:** An altitude, as shown by a constant altimeter indication in relation to a fixed and defined datum, maintained during the cruise portion of flight.

**CRYOGENIC LIQUID:** Liquefied gas at very low temperature, such as liquid oxygen, nitrogen, argon.

**CRYOGENICS:** The subject of physical phenomena in the temperature range below about -150 °C (-238 °F). More generally, cryogenics, or its synonym cryogeny, refers to methods of producing very low temperatures.

**C-STAR:** A longitudinal handling qualities criterion based on time response envelopes of a linear combination of normal acceleration, pitch rate, and pitch acceleration per unit stick force.

**CTC:** Abbr. Canadian Transport Commission

**CURRENT LIMITING CONTROL:** A motor control for restricting the maximum motor torque or force by limiting the current supplied to the motor.

**CURVE (PLAIN):** Analytically, a curve is defined by a function of two or more variables but the shape is most readily described by a graph of the function. Geometrically, a curve can be regarded as the locus of the equation, which describes the motion of the generation point. (Van Nostrands Scientific Encyclopedia. Fourth edition, [1968])

3. (Continued):

~ INPUT/OUTPUT: The graphical representation of actuation system output versus command input. This is usually a continuous plot throughout a complete cycle between plus or minus rated commands. The cycling must be sufficiently below the control bandpass so that velocity errors are not included in this measurement.

CUTOFF: The deliberate shutting off of a reaction engine.

~ VELOCITY: The velocity attained by a missile at the point of cutoff.

~ VOLTAGE: The voltage at which a discharge or charge is terminated.

CUTOUT PRESSURE: The pressure at which the sequence of reduced flow of a component or system begins.

CYCLE: [1] A series of changes executed in an orderly sequence, by which a mechanism, a working substance, or a system is caused periodically to the return to the same initial condition, constitutes a cycle. (Van Nostrands Scientific Encyclopedia, Fourth edition [1968])

~, DUTY: A description of the load position and the load conditions through total mission time with sufficient detail to determine load velocity requirements and dynamic load characteristics. A complete duty cycle description will define the (x.x.x.)

CYLINDER, ACTUATING (sometimes called "Jack", "Ram", or "Strut"): A linear motion device in which the thrust or force is proportional to the effective cross-sectional area and the pressure differential.

~ (CYL): A port selectively carrying operating pressure, to be numbered when more than one port is present. Applicable to selector valves, inlet ports of dump valves, etc.; see also Load.

~ FIXED END: A cylinder, which is held in a rigid position.

~ ROTATING END: A cylinder mounted to permit limited rotary movement about a fixed point.

~ SINGLE ACTING: A cylinder in which fluid pressure is introduced in one end so that fluid force is exerted in one direction only. Gravity, spring forces, or other means are used to accomplish the return stroke.

~ SWIVEL END: A cylinder with one or both ends provided with a joint which not only allows oscillation of the cylinder but which also incorporates stationary fluid connections.

~ TRANSFER: A device for transmitting fluid pressure from one circuit to another without intermixture of fluid between the circuits.

3. (Continued):

D

DASHPOT: A snubbing device within a fluid-operated unit which operates at the extremity of the stroke by displacing operating fluid through a restricted passage, as sometimes used in an actuating cylinder.

DATAAC: Acron. Digital Autonomous Terminal Access Communication

db: Abbr. Decibel

DDV: Abbr. Direct drive valve

DECIBEL: A unit of measure used to express amplitude ratio of control input and output.

$$\text{Decibels} = 20 \log_{10} (\text{Amplitude Out/Amplitude In}) \quad (\text{Eq. 5})$$

DEMODO: Acron. Demodulator

DEPTH FILTER: A filter that removes particles from a fluid system by the combined principles of direct interception and entrapment. The depth filter is usually a layer or material of randomly oriented fibers, creating numerous flow passages or pores to trap particles. A depth filter is normally considered a non-cleanable or disposable filter.

DETECTION-CORRECTION SYSTEM: The type of fault-tolerant system wherein a failure or out-of-operating tolerance condition is detected and corrective action is taken automatically. This may involve switching to a standby system; or, if two or more systems are normally operating, correction may involve switching-out the failed channel. Inherent in this type of system is the existence of a finite time for detection and correction. With detection-correction systems, it is possible to use a model of an active system as a reference in order to extend the failure correction capability of the total system.

DFO: Abbr. Dual fail operative

DIRECT LIFT CONTROL: Employment of lifting surfaces independent of the elevators or elevons, such as flaps, symmetrical ailerons, spoilers, canards, etc. to exert vertical flight path control by means of applied lift forces.

~ DRIVE VALVE: A servovalve where the power control valve is driven directly by the electric control signal.

DIRECTIONAL AXIS: The vertical (Z) axis of an aircraft about which the aircraft revolves in yawing. Positive is downward when looking forward. See Figure 14.

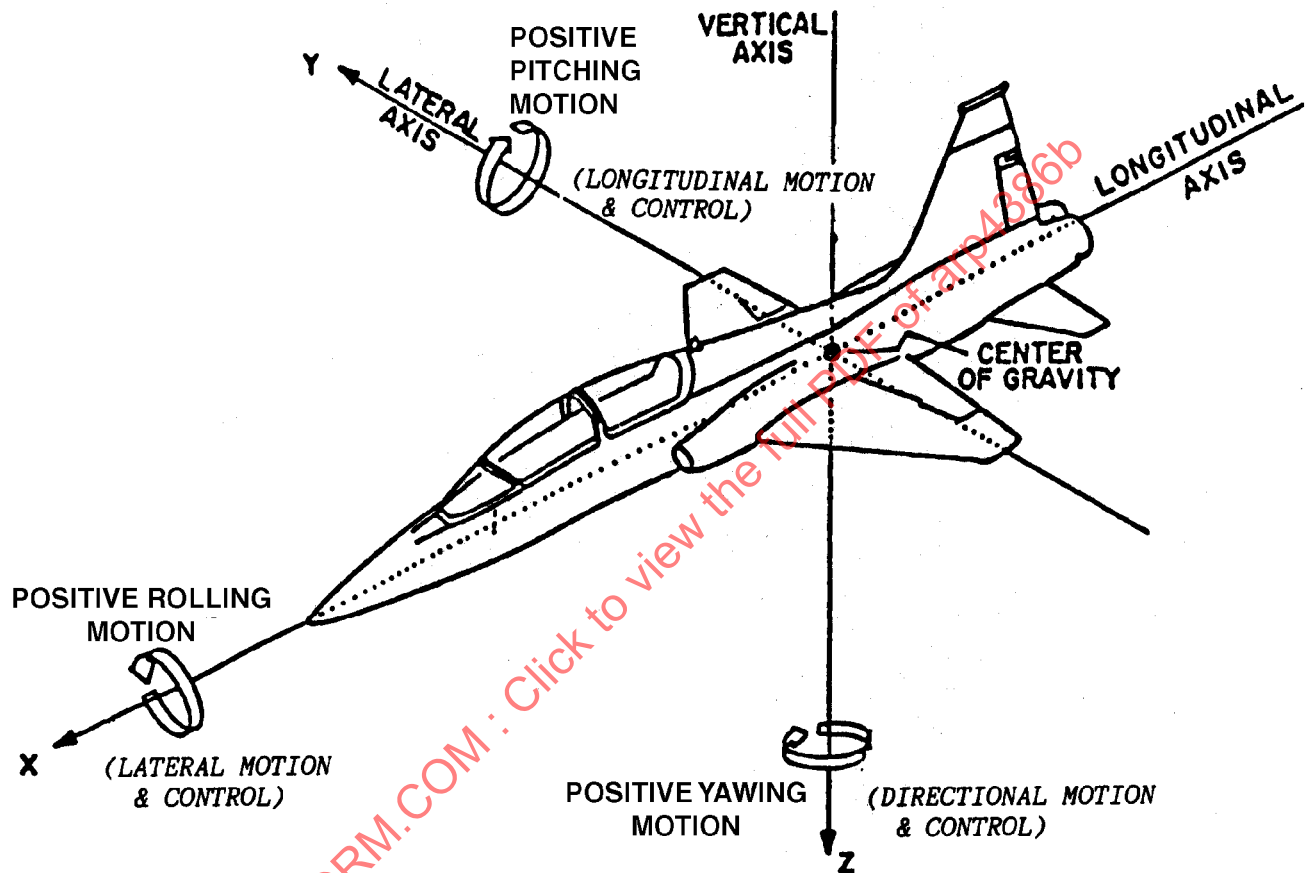


FIGURE 14 - Aircraft Body Axes

3. DIRECTIONAL (Continued):

~ CONTROL: (1) Control of the directional motion of an aircraft. Directional control is primarily achieved through control of yaw and sideslip. (2) In fluid power systems directional control refers to the motion control of the actuator by means such as reversible hydraulic or pneumatic flow control valves or overcenter strokable hydraulic pumps.

~ MOTION: Rotational motion of the vehicle about the vertical axis.

DITHER: (1) A low amplitude, relatively high frequency periodic electrical signal, sometimes superimposed on the servovalve input to reduce threshold. Dither is expressed by the dither frequency (Hz) and the peak-to-peak dither current amplitude. (2) A low amplitude, relatively high frequency signal superimposed on the input signal to provide motion to the servovalve spool and thus reduce static friction and dead zone. A commonly used dither frequency has been 400 Hz. (3) A low amplitude high frequency periodic signal used in a control system to reduce nonlinear effects or to identify changes in process dynamics for certain adaptive control techniques. The dither frequency is always selected to be beyond the system response frequency cutoff, so as not to interfere with the controlled motion.

DOT: Abbr. Department of Transportation

DOUBLE ENDED ACTUATOR: An actuator with a single cylinder and a piston that has two rods extending to atmosphere.

DOWNWASH: The downward deflection of air, relative to the direction of motion of an airfoil.

DRAG: (1) The aerodynamic force in a direction opposite to that of flight and due to the resistance to movement brought to bear on an aerospace vehicle by the atmosphere through which it passes. (2) The fluid force or torque experienced by translating or rotating fluid machinery in motion within its case or housing.

DRIFT: (1) A lateral divergence of an aircraft from the projected line of its heading, arising from movement due to wind. (2) The slow aberration of any controlled function from its design condition.

DRONE: An unmanned vehicle which is remotely or automatically controlled.

DUAL CONTROL: A double set of cockpit controls to permit: (1) pilot or copilot or (2) instructor or student, to fly the aircraft.

~ FAIL OPERATIVE: A condition or requirement wherein an active control device or system can sustain any two failures within the system and remain operative. It is implicit with a Dual Fail Operative system that it be able to accept identical but nonsimultaneous failures in two of its channels and continue to operate with no nominal loss of performance. Unless specifically stated, it is understood that no nominal loss of performance occurs after one or two failures.

3. DUAL (Continued):

~ LOAD PATH: A type of mechanical paralleling wherein two separate load-carrying paths exist from the control system input to the system output. Each load path is capable of carrying sufficient load such that failure of any one member will not jeopardize system performance.

~ TANDEM VALVE: A tandem valve having two separate control sections.

DUPLEX: An adjective meaning twofold, as a duplex valve, duplex actuator, etc.

DUTCH ROLL: A lateral mode consisting of a combined lateral-directional oscillation in which the rolling and yawing frequencies are the same but out of phase by approximately 90°. The motion, which causes little deviation from a linear flight path, is similar to the weave of a skater's body, hence the term Dutch Roll. Also called the Lateral Oscillation Mode.

E

EDV: Abbr. Electrical depressurization valve

E/E/bay: Abbr. Electronics equipment bay

EED: Abbr. Electroexplosives device

EFFECTIVENESS: The probability that the material will operate successfully when required.

EFSC: Abbr. Electronic flight control system

EHA: Abbr. Electrohydraulic actuator

EHV: Abbr. Electrohydraulic valve

ELECTRIC MOTOR CONTROLLERS:

ELECTRIC MOTOR: Electric motors are divided into two categories: direct current (DC) and alternating current (AC). Motors falling under this description are usually employed to drive hydraulic pumps or pneumatic compressors on a continuous or intermittent duty cycle. Motors are wound to operate on the specified voltage and frequency of the input current to provide the speed and torque conditions required by the pump. Basic motor design practice applies. Options to be considered include: Continuous or intermittent duty cycle, Cooling requirements, Electric power availability, Load speed/torque demand. See also Actuators, electromechanical.

ELECTRICAL CONTROL POWER: The power dissipation required for control of the servovalve. Control power is a maximum with full input signal, and is zero with zero-input signal. It is independent of the coil connection (series, parallel, or differential) for any conventional two-coil operation. For differential operation, the control power is the power consumed in excess of the electrical quiescent power. This power increase is a result of the differential current change.

3. (Continued):

**ELECTRICAL LOGIC:** Logic for mode switching or failure detection and correction performed with electronic or electrical components.

**ELECTRICAL QUIESCENT POWER:** The dissipation required for differential operation when the current through each coil is equal and opposite in polarity.

**ELECTRICAL STROKE:** The displacement range over which the output signal and all electrical parameters are achieved.

**ELECTRICAL STROKE:** The displacement range over which the output signal and all electrical parameters are achieved.

**ELECTRODES OR PLATES:** A conducting body containing active materials by which the electrochemical reaction occurs.

**ELECTROEXPLOSIVE DEVICE (EED):** Any detonator or initiator initiated by an electric current.

**ELECTROHYDRAULIC SERVOVALVE:** A servovalve wherein the input is electrical and the output is hydraulic fluid; the electric control signal is sometimes amplified hydraulically in the first stage to drive the second stage power control valve spool.

**ELECTROHYDROSTATIC ACTUATOR:** An actuator configuration, which uses a variable-speed-reversible electric motor to drive a hydraulic pump that is coupled to a piston or vane hydraulic motor.

**ELECTROMECHANICAL ACTUATORS:** These definitions apply to electric motors used as torque generators in an electromechanical actuator. See Figure 7. Other electric motor definitions are covered under 3.1.2.3.

**ELEVATOR:** A control surface usually attached to the horizontal stabilizer and located aft of the wing which controls pitching motion of the aircraft.

~ **ANGLE:** The acute angle between the chord of the aircraft elevator moved from its neutral position and its chord in neutral position. The angle is positive when the trailing edge of the elevator is below the neutral position.

~ **CONTROL:** Control of the pitch motion of an aircraft as effected by deflections of the ailerons, spoilers, and rudder.

**ELEVON:** A control surface combining the functions of an elevator and an aileron.

**EMA:** Acron. Electromechanical Actuator

**EMI:** Abbr. Electromagnetic interference

3. (Continued):

EMPENNAGE: The fuselage assembly located at the aft end of an aircraft comprised of the horizontal and vertical stabilizers (or equivalent) and their associated control surfaces.

ENDURANCE: (1) The time an aircraft can continue flying under given conditions without refueling.  
(2) The time a system continues to perform without deviating from the norm.

~ TESTING: The process of subjecting material to stress levels within design limits until failure occurs or until the desired life has been demonstrated. (An accelerated endurance test is accomplished by subjecting material to stress levels beyond design limits to induce failure.)

ENERGY: (1) The work output capacity of a device. In mechanical terms energy is defined by the force acting through a movement with the unit of measurement being lb-in, lb-ft, N-m etc. (2) In fluid systems energy is defined by the pressure-volume product. (3) In electrical systems, the output capability of a cell or battery expressed as capacity times voltage, or watt-hours (Wh).

~ DENSITY: A figure of merit for batteries, expressed by the stored energy per unit of battery weight or volume. Energy density is dependent upon the discharge rate.

ENGINE: An energy conversion device usually employed to convert chemical potential energy into heat and subsequently generate mechanical power.

~ START VALVE: A valve whose function is to initiate or terminate hydraulic starter operation by opening or closing the fluid inlet line in response to an external signal, and which usually provides automatic shutoff at the end of an engine starting cycle.

EQUALIZATION (CHANNEL BALANCING): The use of feedback to achieve close coincidence between the outputs of two or more elements or channels in a fault-tolerant control system. Equalization may be necessary to reduce the transient that could occur while shutting off a failed channel, or it may be necessary to minimize the adverse effects of normal tolerances.

EQUILIBRIUM GLIDE: A flight trajectory along which the total vertical acceleration of the vehicle is zero. That is, the gravitational force is balanced by the lift force and the centrifugal force.

ERFE: Abbr. Electromagnetic radio frequency emission

ERROR: A mistake in specification, design, production, maintenance, or operation that causes an undesired performance of a function.

~ INDEX: The total error incurred in a system over the present time ( $t$ ) and future time ( $T$ ) where the control system operates. Symbolic it is  $e(t)$ , where  $e$  is a function of  $t$ , and  $t \leq T$ .

~ SIGNAL: The output of the summing point which compares an input or command signal with one or more output or feedback signals.

3. (Continued):

ESCAPE ORBIT: One of the various paths that a body or particle escaping from a central force field must follow in order to escape. This orbit must have an eccentricity of not less than one, as on a parabolic curve or hyperbolic curve.

~ VELOCITY: The speed a body must attain to overcome a gravitational field, such as that of the earth, and thus theoretically travel on to infinity. The velocity of escape at the earth's surface is 36 700 ft/s.

EXCITATION VOLTAGE: The electrical potential used to excite the transformer. The frequency and waveform of this voltage must be stated along with magnitude.

EXERCISER: A machine that simulates the strains and vibrations to which a missile is subjected, and used to test the missile for structural integrity.

EXOTIC FUEL: Unusual fuel combinations for aircraft and rocket use with the purpose of attaining far greater thrust.

EXPERT SYSTEM: Same as Artificial Intelligence.

EXPLODING BRIDGEWIRE DETONATOR OR INITIATOR: A detonator or initiator that is initiated by capacitor discharge that explodes (rather than merely heats) the bridgewire. These devices cannot be initiated by any normal shock or electrical energy.

Explosion proofing  
Explosion proofing

EXPOSURE TIME: The period (in hours or cycles) during which a system, subsystem, unit, or part is exposed to failure, measured from when it was last verified as functioning to when its proper performance is or may be required.

EXTERNAL STORES: Mission-oriented items carried externally to the aircraft's normal configuration; e.g., fuel tanks, bombs, etc., attached to the underside of the wing.

Interfaces  
Interfaces  
Noise filter requirements  
Noise filter requirements

3. (Continued):

F

FBL: Abbr. Fly-by-light

FBW: Abbr. Fly-by-wire

FCS: Abbr. Flight control system

FIBER: Any particle of at least 100  $\mu\text{m}$  in length that has a length-to-width ratio of 10 or more.

FIRST AIR: A term in air monitoring of environmentally-controlled environments that refers to the quality of the air as it first enters the controlled environment.

FLAME SHIELD: The metal shield adjacent to the case insulation, which prevents erosion of the insulation and objectionable insulation pyrolysis products from entering the gas stream.

FLAP: A control surface used primarily to alter the lift or drag of an airfoil, usually by effectively changing the camber of the airfoil.

FLAPERON: An airfoil control surface combining the functions of a flap and an aileron.

FLARE: During landing approach the change in pitch angle required to reduce the aircraft rate of descent in a gradual manner prior to touchdown.

FLASH POINT: Temperature at which a liquid gives off sufficient vapor to cause it to ignite when a small flame is applied, under controlled conditions.

FLIGHT PATH: The line or way connecting the continuous positions occupied, or to be occupied, by an aircraft, missile, or spacecraft as it moves through space with reference to the vertical and horizontal planes.

~ ANGLE: The angle measured, in the vertical plane, between the horizontal and velocity vector of the aircraft.

~ CONTROL: The process of guiding or directing a vehicle so that its position vector describes a desired locus in space. Flight path control implies control of both course and altitude, whereas directional control implies control of course only. The attitude of the vehicle is not specified.

FLIGHT PROFILE: A graphic portrayal of the line of flight of a missile, aircraft, or space probe as seen from the side, indicating the various altitudes along the route.

3. (Continued):

**FLOW:** Rate of fluid movement; the quantity of fluid (volume or mass) crossing the transverse plane of a flow path per unit of time. The volume of fluid passing a designated location in a conduit per unit of time is measured in liters/min or gallons/min (gpm),  $\text{m}^3/\text{s}$  or  $\text{in}^3/\text{s}$  as the system parameters may dictate. Volume flow,  $Q$ , is related to mass flow  $m$ ,  $\text{Kg/s}$  or  $\text{lb-s/ft}$  by the fluid density  $\rho$  with units of  $\text{Kg/m}^3$  or  $\text{lb-s}^2/\text{ft}^4$  by  $m = \rho Q$  and to the weight flow  $w$  by the fluid weight density  $\gamma$  with units of  $\text{lb/ft}^3$  by  $w = \gamma Q$ . Gas volume flow may be expressed at standard condition of sea level atmospheric pressure and ambient temperature.

~, **CALIBRATED:** In a unit which controls or limits rate or quantity of flow, that rate or quantity of flow for which the unit is calibrated or adjusted. When calibration is related to specific conditions, the condition of calibration must be stated. Example, a restrictor may be calibrated to pass 1 gpm (4 L/min) at 1500 psi (10 500 kPa) pressure differential.

~, **CASE DRAIN:** Internal leakage of a hydraulic pump or motor to the housing and out of the case drain port, not provided in all models. This flow is frequently used as cooling flow.

~, **CHOKED:** Flow of a compressible fluid (gas), limited by the speed of sound in the fluid at the throat of a control section.

~, **COMPRESSIBLE:** Flow of a fluid wherein the conditions of pressure, density, and temperature may vary between cross sections of the stream in the direction of flow.

~, **CONTROL:** The flow through the valve control ports, expressed in cis or gpm. Control flow is referred to as No-Load Flow when there is zero load pressure drop. Control flow is referred to as Loaded Flow when there is a load pressure drop. Conventional test equipment normally measures no-load flow. (ARP4493)

~, **EXTERNAL LEAKAGE:** Leakage from the interior of a device to the exterior, other than out of the fluid port.

~, **INCOMPRESSIBLE:** Flow conditions where the fluid maintains a constant density.

~, **INTERNAL LEAKAGE:** Leakage between internal cavities of a device.

~, **LAMINAR:** Flow of a fluid dominated by viscous forces and characterized by the gliding of fluid layers (laminae) past one another in orderly fashion.

~, **LEAKAGE:** Flow through a passage that is in a nominally closed position or at a location which normally should permit no flow.

~, **NULL LEAKAGE:** Internal leakage of a valve when output flow is negligible.

3. FLOW, (Continued):

~, QUIESCENT: Total internal leakage of a complete hydraulic system or a branch of a hydraulic system at rest; e.g., the magnitude of fluid flow through all stages of a servo valve when the valve is closed or centered.

~, RATED: (1) Specified flow at steady-state conditions for a component or system; the nominal maximum operating flow, applicable where control of that flow rate is not basic: e.g., a one-way restrictor valve with a calibrated flow of 1 gpm (4 L/min) at 1500 psi (10 500 kPa) pressure differential may have a rated flow of 3.5 gpm (14 L/min) in the reverse or free flow direction. (2) The specified control flow (of a servo valve) corresponding to rated command at specified temperature, and pressure conditions, and specified load pressure drop. Rated Flow is normally specified as the no-load flow. (ARP4493)

~, SEEPAGE: Occurrence of extremely slight amount of fluid at the surface of a component or part of a hydraulic system, normally due to "breathing" of seals under cyclic pressure load. No drops are allowed over an extended period of observation.

~, STEADY: This occurs when conditions at any point in the fluid do not change with time.

~, TURBULENT: Flow of a fluid characterized by the random motion of fluid particles in directions transverse to the direction of the main flow.

~, UNSTEADY FLOW: A flow rate (in a system) which changes and is a function of time.

FLOW CONTROL: A control circuit or valve designed to adjust the flow rate according to some predetermined algorithm or externally commanded value.

~ CURVE: The graphical representation of control flow versus input current of command (of a servo valve). This is usually a continuous plot of a complete full flow valve cycle. (ARP4493)

~,~ NORMAL: The locus of the midpoints of the complete cycle flow curve (i.e., zero hysteresis Flow Curve). (ARP4493)

~ DIVIDER: A flow proportioner which operates to divide flow.

~ EQUALIZER: A flow proportioner in which the portions are equal.

~ GAIN: The slope of the control flow vs. input command curve in any specific operating region, expressed in cis/amp, gpm/am, cis/v, gpm/v etc. Three regions are usually significant with flow control servo valves: Null flow, normal flow, and saturation. (ARP4493). NORMAL FLOW GAIN: The slope of a straight line drawn from zero flow point of the normal flow curve, throughout the range of rated current of one polarity and so drawn as to minimize deviations of the curve from a straight line. (ARP4493). RATED FLOW GAIN: The ratio of rated flow to rated current or command, expressed in cis/amp, etc. (ARP4493)

3. FLOW (Continued):

~ LIMIT: The condition (in a servo valve) wherein control flow no longer increases with increasing input current. (ARP4493)

~ PROPORTIONER: A device which automatically maintains a relatively constant ratio between the portions of dividing or combining flow passing through it regardless of differences in pressure between the portions. A flow proportioner may operate only with combining flow, dividing flow, or with both.

~ SATURATION: The operating region where flow gain decreases with increasing command (in a servo valve). (ARP4493)

~ SURGE: Temporary rise and fall of flow.

FLUID: A substance whose molecules have such a low cohesive force that they move freely under the influence of an applied shear force and assume the shape or volume of the container. Two groups of substances meet this requirement: Group I, Liquids, which when placed in a container and acted on only by the force of gravity, will fill the lower section of the container and assume its shape; and Group II, Gases, which, when placed in a container, will occupy the entire volume inside the walls of the container.

~ ACTUATOR: A hydraulic or pneumatic power converter with either linear or rotary mechanical output motion. See also Actuator, Actuator Types, Actuator Stiffness etc.

~ POWER: That branch of technology that concerns itself with power conversion, generation, control, and utilization of fluids whose predominant energy levels are derived from high static pressures. It is distinguished thereby from Fluid Dynamics and Aerodynamics where energy exchange is primarily accomplished by manipulation of kinetic or velocity energy.

~ TEMPERATURE: Temperature of the fluid measured at a specified point in the system.

FLUTTER: A self-excited, usually divergent, oscillation of an airfoil and its associated structure in flight caused by a combination of the aerodynamic, inertial, and elastic characteristics of the components themselves, and not by any externally applied vibratory excitations.

FORCE: A vector quantity measuring the action of one body on another that will cause acceleration of the second body unless acted upon by an equal and opposite action counteracting the effect of the first body. (Marks' Standard Handbook for Mechanical Engineers, 10th ed. p3-2).

~, CHIP SHEAR: The valve force available at the metering element to shear a lodged chip or foreign particle. This is typically defined at the maximum valve stroke, the closing direction, and includes forces produced by the motor and by mechanical springs but does not include flow forces. (ARP4493)

3. FORCE (Continued):

~ SUMMING DRIVE: A multichannel summing arrangement, which sums the torque or force outputs of multiple actuators wherein individual actuators are constrained to have the same position.

FOWLER FLAP: An airfoil attached to the trailing edge of the wing. Its motion is such that in the fully extended position it appears as an extension to the wing. These flaps may be slotted or unslotted.

FREQUENCY

~, NATURAL: A frequency at which, in the absence of damping, a limited input tends to produce and unlimited output. It is a function of the valve mass elements and spring rates, which include flow forces where applicable. (ARP4493)

~ RESPONSE (of a servo valve): The complex ratio of flow-control flow to input command as the command is varied sinusoidally over a range of frequencies. F.R. is normally measured with constant input command amplitude and zero load pressure drop expressed as amplitude ratio and phase angle. (ARP4493)

FRISE AILERON: A type of aileron having its leading edge projection well ahead of the hinge axis. When the trailing edge of the Frise Aileron is deflected upward its leading edge protrudes below the wing's lower surface, thereby producing increased drag, which tends to add proverse yaw to counter the adverse yaw produced by the opposite wing aileron.

FS: Abbr. Fail safe

ft: Abbr. Foot, English system measure of length = 12 in = 0.3048 m

G

GAS CLASSIFICATION:

~, COMPRESSED IN SOLUTION: A nonliquefied gas (such as Acetylene) which is dissolved in a solvent. FREE AIR OR FREE GAS: Air or gas measured at sea level, Standard Day conditions, pressure of 14.7 lb/in<sup>2</sup> (absolute) (760 mm Hg abs) and a temperature of 59 °F (15 °C).

~, LIQUEFIED COMPRESSED: A gas which, under the charging pressure, is partially liquid at a temperature of 70 °F (21 °C). A flammable compressed gas which is normally nonliquefied at 70 °F (21 °C), but which is partially liquid under the charging pressure and temperature, shall follow the requirements for liquefied compressed gases.

~, NONLIQUEFIED COMPRESSED: A gas not in solution which, under the charging pressure, is entirely gaseous at a temperature of 70 °F (21 °C).

### 3. GAS (Continued):

~, PRESSURIZED LIQUID COMPRESSED: A compressed gas not in solution, which cannot be liquefied at a temperature of 70 °F (21 °C), and which is maintained in the liquid state at a pressure not less than 40 lb/in<sup>2</sup> (abs) (2.07 m Hg abs) by maintaining the gas at a temperature less than 70 °F (21 °C).

GAS GENERATOR: A device in which a liquid monopropellant is decomposed (also called a decomposition chamber), or in which liquid bipropellants or solid propellants are burned to produce a sustained flow of gas at a pressure (also called a combustor).

GAS POWER: The amount of energy in the gas theoretically available to do work, expressed by Equation 6:

$$GP / 1/ = W \frac{H_{ad}}{E} \quad (\text{Eq. 6})$$

where:

GP = Available gas power, hp (kW)

W = Gas flow rate lb/s (kg/s)

E = Energy equivalent (550 ft-lb/s/hp) (1000 Nm/s/kw)

H<sub>ad</sub> = Adiabatic head, ft (m)

/1/ In SI metric units, W is replaced by (Wg), where g = 9.81 m/s<sup>2</sup>

GAS PROCESSES: See the following:

ISOBARIC PROCESS:

ISOCHORIC PROCESS

ISOPYCNIC PROCESS:

ISOSTERIC PROCESS:

ISOTHERMAL EXPANSION:

POLYTROPIC EXPANSION:

REVERSIBLE ADIABATIC OR ISENTROPIC EXPANSION

GAS TO FLUID CONVERSION: The definitions listed in this section apply primarily to missile applications and although a gas is also a fluid, the term gas to fluid implies a gas source driving a component whose output is pressurized hydraulic fluid.

GAS RELEASE: The capability of pressurizing a specified downstream volume to a specified pressure level within a defined time.

3. (Continued):

**GAS TYPES:** **COLD GAS:** Gas at essentially room (ambient) temperature, or at a temperature that is generally available from a pressure source without burning, decomposition, or external heating. Examples are gas drawn from a storage vessel, or that extracted from an operating compressor. Cold gas is used typically for pressurization, inflation or expulsion purposes, or both. However, it is also used as the potential energy source and the fluid medium in some servoactuator control systems. **HOT GAS:** Gas at a temperature over 2500 °F (1400 °C) and typical of gases used in rocket motors for propulsion. Because materials that can operate at temperatures above 2500 °F (1400 °C) for a sustained period of time are relatively rare and expensive, hot gas is generally not used as the power source for aircraft actuator control systems. **WARM GAS:** Gas at 1000 °F (540 °C) to 2500 °F (1400 °C) and typically available from the decomposition of a liquid monopropellant (e.g., ammonium nitrate composite), or from burning liquid propellants at nonstoichiometric conditions (e.g., JP-fuel and oxygen). Typical warm gas applications for actuation systems are to drive turbines and displacement motors, to pressurize tanks, and to expel fluids.

**GAIN MARGIN:** A measure of system stability defined as the reciprocal of the magnitude of the open loop gain at 180° of phase lag crossover frequency, usually expressed in decibels.

**GALLING:** Developing a condition on a rubbing surface of one or both mating parts where excessive friction of high spots results in localized welding with subsequent spalling and further roughening of the surface.

**GAS TO FLUID CONVERSION:** The definitions listed in this section apply primarily to missile applications and although a gas is also a fluid, the term gas to fluid implies a gas source driving a component whose output is pressurized hydraulic fluid.

**GASKET:** The flexible sealing element in a stationary or static fluid seal.

**GAUSSIAN OR NORMAL DISTRIBUTION:** A density function of a population which is bell-shaped and symmetrical, and which is completely defined by two independent parameters, the mean and the standard deviation.

**GEARED ROTARY ACTUATOR:** A mechanical device utilized for amplifying force through a series of gears converting high speed, low torque input into high torque, low speed output. Sometimes referred to as a power hinge.

**GLAND:** The cavity or space provided for the accommodation and operation of an elastic packing or gasket for sealing of a fluid vessel or compartment

**GLASS BEAD RATING:** A size designation in micrometers that represents the largest pore in a porous media through which a glass sphere of a designated size can pass.

3. (Continued):

GLIDE PATH: (1) The line to be followed by an aircraft as it descends from horizontal flight to land on the surface. The glide path is predetermined under ILS procedures by a glide path radio beam. (2) An automatic flight control mode in which the glide path radio beam is used by the flight control system to continually maintain the aircraft on the glide path without pilot intervention.

GLIDE ROCKET: A rocket vehicle kept within or near the sensible atmosphere so as to assume a flat gliding altitude within the atmosphere after power shutoff.

GM: Abbr. Guided missile

Gpm: Abbr. Gallons(US) per minute also written GPM, gpm. = 3.7854 L/min = 0.00006309 m<sup>3</sup>/sec.

GRAIN: An elongated molding or extrusion of solid propellant, regardless of size.

GRAPHIC SYMBOLS: The utilization of graphics in the form of lines and geometric shapes to illustrate hydraulic or pneumatic components within a system and their relative location and function within that system. It becomes somewhat of a language in shorthand form to the understanding of the parts and components and their operation within a system. See Figure 15.

GROUND ROLL: When an aircraft lands, the distance between touchdown and final stop is the ground roll.

GROUND SUPPORT EQUIPMENT: Same as Aircraft Ground Equipment.

GUIDANCE, CELESTIAL: The guidance of a vehicle by reference to celestial bodies.

~, STELLAR: A system wherein a guided missile may follow a predetermined course with reference primarily to the relative position of the missile and certain bodies.

~, TERMINAL: (1) The guidance applied to a guided missile between midcourse guidance and arrival in the vicinity of the target. (2) Electronic, mechanical, visual, or other assistance given an aircraft pilot to facilitate arrival at, operation within or over, landing upon, or departure from an air landing or air drop facility.

GUIDED AIRCRAFT MISSILE: A type of self-propelled missile, normally carried by a parent aircraft, which, after launching, can be guided to surface targets.

GUIDED MISSILE: An unmanned vehicle moving above the surface of the earth, whose trajectory or flight path is capable of being altered by an external or internal mechanism.

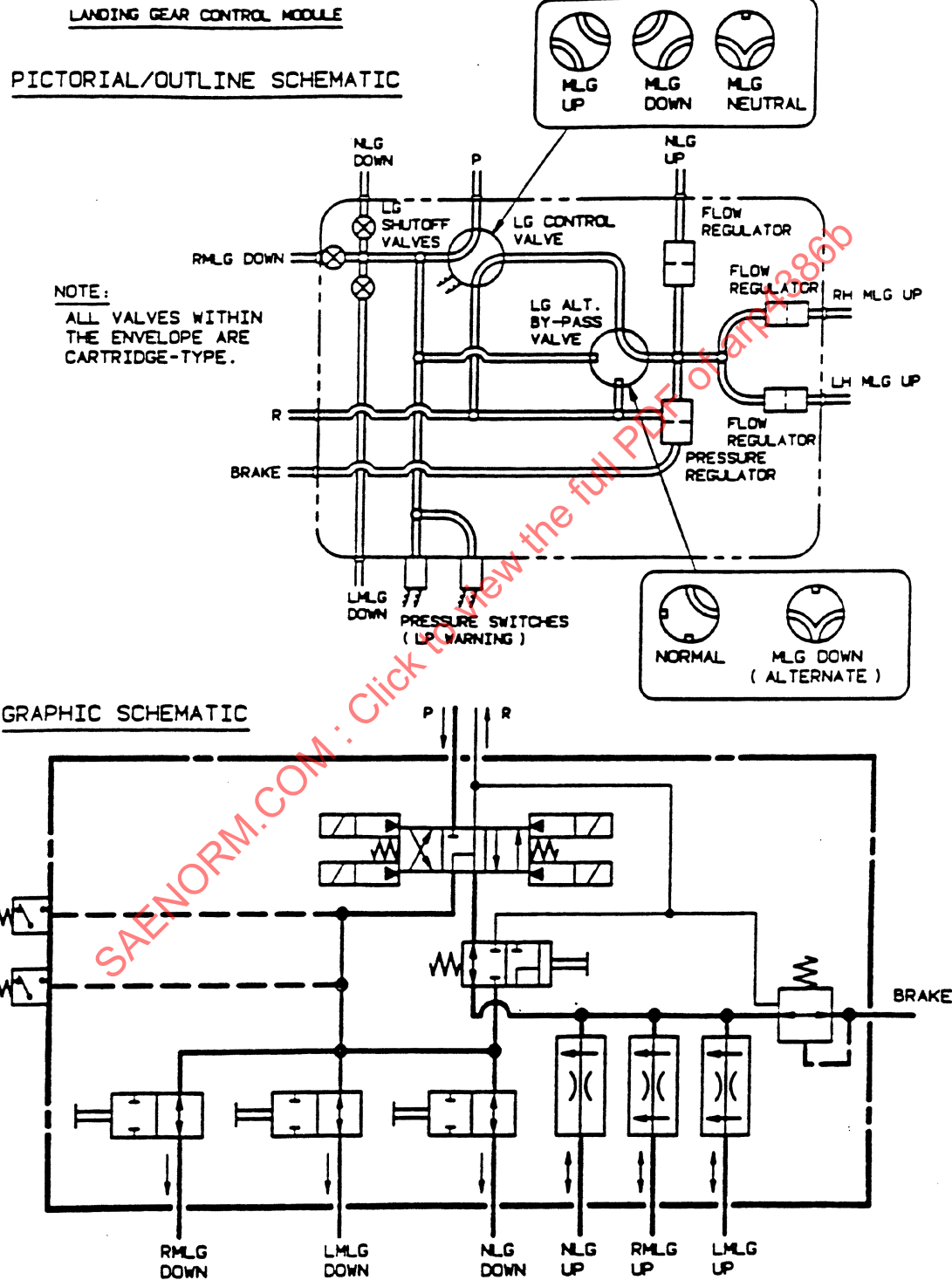


FIGURE 15 - Composite Symbols and Circuits

3. (Continued):

H

**HARDOVER:** The displacement of a control member from its normal or neutral position to maximum (extreme) travel either in direction or rotation; i.e., according to its mode of motion.

**HEADING:** The direction in which the longitudinal axis of an aircraft is pointed, usually expressed in degrees from North (true, magnetic, compass, or grid).

**HEADING HOLD:** An automatic flight control mode in which a desired aircraft heading is maintained continuously without pilot intervention.

**HINGE LINE:** A line corresponding to the axis about which a control surface is deflected.

**HINGE MOMENT:** The product of the aerodynamic force acting upon the center of pressure of a control surface and perpendicular distance from the center of pressure to the hinge line.

**HORIZONTAL FLIGHT:** A flight in which the aircraft maintains constant altitude above sea level.

**HSCT:** Abbr. High speed civil transport

**HT:** Abbr. Hart time

**HYDROMECHANICAL LOGIC:** Logic, as for failure detection or correction, performed with only mechanical elements where the information is in the form of hydraulic pressures or flows.

**HYDRAULIC AMPLIFIER:** A fluid valving device which acts as a power amplifier, such as a sliding spool, or a nozzle/flapper, or a jet pipe with receivers.

**HYDRAULIC STARTER:** A device for converting fluid energy into rotary mechanical energy intended to provide continuous torque for engine starting purposes, and usually incorporating a suitable mechanism to connect the starter to the engine during starting cycles only.

**HYDRAULIC STARTER, FIXED DISPLACEMENT:** A starter whose displacement remains constant under all operating conditions and which theoretically requires a constant volume of fluid-per-revolution.

**HYDRAULIC STARTER, VARIABLE DISPLACEMENT:** A starter whose displacement during the starting cycle is automatically controlled, usually to limit the flow rate to a predetermined maximum.

3. (Continued):

**HYDRAULIC STARTER/PUMP:** A rotary device capable of converting fluid energy into mechanical energy when operating as a starter, and capable of converting mechanical energy into fluid energy when operating as a pump. A starter/pump is usually equipped with suitable controls to automatically provide a smooth transition from operation as a fixed or variable displacement starter to operation as a pressure compensated pump.

**HYDRAULIC SYSTEM:**

~, TYPE: A classification standard for a military aircraft hydraulic system based on minimum and maximum allowable fluid temperatures is defined as follows:

Type I -54 to +71 °C (-65 to +160 °F)

Type II -54 to +135 °C (-65 to +275 °F)

Type III -54 to +199 °C (-65 to +390 °F)

~, CLOSED CENTER: In a hydraulic system, when no service is actuated, the system is closed to flow, as distinguished from an open center system. A closed center system may utilize a continuous pressure supply, as with a variable displacement pump or an intermittent pressure supply by means of unloader valve, motor driven pump, or pump bypassing provisions.

~, CLOSED (CONTROL) LOOP: A hydraulic feedback control system.

~, CLOSED (RESERVOIR): A hydraulic power system whose fluid reservoir has no atmospheric interface.

~, OPEN CENTER: In a hydraulic system, when no service is actuated, the system is open to flow, completing the circuit through the control units back to the reservoir. An open center system will normally employ a fixed displacement pump.

~, OPEN (CONTROL) LOOP: A hydraulic control system whose input-output relationship responds to a predetermined program without corrective feedback.

~, OPEN (RESERVOIR): A hydraulic system whose fluid reservoir is pressurized by the surrounding atmosphere.

**HYDRAULIC UTILITY SYSTEM:** An aircraft hydraulic system whose basic purpose is to provide hydraulic power for operation of equipment not part of primary subsystems used for flight control; e.g., it supplies power to landing gear, brakes, gun turrets, etc.

**HYPERGOLIC FUEL:** Fuel, which will spontaneously ignite with an oxidizer, such as aniline with fuming nitric acid. It is used as the propulsion agent in certain missile systems.

**HYPERSONIC:** Of or pertaining to speeds equal to or in excess of five times the speed of sound.

3. (Continued):

**HYSTERESIS:** The difference in command inputs required to produce the same actuation system output as the output is cycled through the full plus or minus range of travel. The cycling rate must be significantly below the control bandpass so that velocity error signals are not included in this parameter.

I

**IACS:** Abbr. Integrated avionics computer system

**IAP:** Abbr. Integrated actuator package

**IDLING PRESSURE:** The pressure required to maintain a system or component at the idling speed, or flow.

**IGNITION TRAIN:** The step-by-step arrangement of charges in a pyrotechnic or propellant mixture by which initial fire from a primer is transmitted and intensified until it reaches and sets off the main charge. Also called burning train or explosive train.

**IMPACT MODULATOR:** An amplifier which utilizes auxiliary flow at a nozzle throat for a control signal to modulate the output flow. Pressure level of the control signal may either be above or below local throat pressure to result in a positive or negative (suction) quiescent control flow.

**IMPULSE:** (1) Total Impulse of a rocket engine: the product of the engine thrust in pounds and the burning time in seconds. (2) Specific Impulse: the thrust in pounds (newtons) of a specified fuel with its oxidizer in one second. (3) A pulsed signal or force whose duration is small compared to the response time of the dynamical system in which the impulse is applied.

**IMPULSE RESPONSE OPTIMIZATION:** The selection of the composite impulse response of both the dynamic process and the controller to minimize the error index.

**in:** Abbr. Inch, English measure of length = 0.025400 meters.

**IN:** Marking Fluid entrance port, not otherwise designated, where direction of flow is critical. Applicable to filters, flow dividers, motors, nonreversible shutoff valves, pumps, priority valves, shuttle valves, etc.

**in-lb:** Abbr. Inch pound; English measure of torque.

**INCOMPRESSIBLE FLOW:** Flow conditions where the fluid maintains a constant density.

**INDUCTION MOTOR:** An AC motor in which alternating current supplied to the stator produces a rotating magnetic field. Alternating current is induced in the rotor by transformer action and the interaction between the induced rotor currents and the stator field produces torque.

3. (Continued):

**INERTIA LOAD:** A load proportional to load acceleration or deceleration. The load is usually opposing for acceleration and aiding during deceleration.

**INERTIAL SPACE:** An assumed stationary frame of reference. A nonrotating set of coordinates in space, relative to which the trajectory of an aerospace vehicle is calculated.

**INITIAL APPROACH:** That portion of the flight of an aircraft immediately prior to arrival over the airport of destination or over the reporting point from which the final approach to the airport is commenced.

**INITIATION:** The functioning of the first element in the ignition train.

**INFINITE FREQUENCY STIFFNESS:** The stiffness associated with the output deflections of an active actuation system caused by externally applied loads where the frequency of the load disturbance is significantly above the bandpass of the actuation system. Since the system cannot actively react against high frequency load disturbances, this stiffness is identical to stiffness-to-ground at frequencies well beyond the system bandwidth. See Figure 4.

**INLET PRESSURE:** The pressure at the inlet of a component.

**INLET TEMPERATURE:** Fluid temperature at the plane of the inlet port.

**INPUT:** Any quantity which is presented to or imposed on a component or system.

**INPUT CURRENT:** The current to the valve, expressed in milliamperes, which commands control flow.

**~ IMPEDANCE:** The electrical load the primary coil presents to the excitation source.

**~/OUTPUT CURVE:** The graphical representation of actuation system output versus command input. This is usually a continuous plot throughout a complete cycle between plus or minus rated commands. The cycling must be sufficiently below the control bandpass so that velocity errors are not included in this measurement.

**~ POWER:** The real power in watts or the apparent power in volt-amperes used for excitation.

**~ VOLTAGE OF LVDT:** An alternating current voltage that is required for operation.

**INSPECTION, NONDESTRUCTIVE:** A family of methods for investigating the quality, integrity, properties, and dimensions of materials and components without damaging or impairing their serviceability through the use of dye penetrant, magnetic eddy current, ultrasonic, radiographic, infrared, and other devices. Nondestructive testing is widely used in aircraft structural inspection.

3. INSPECTION, (Continued):

~, PERIODIC: A thorough check of the overall aircraft. Each periodic inspection comprises all intermediate, preflight, thru-flight, and postflight inspections. Repeated at regular intervals of calendar time or hours of operation.

~, SAMPLE: The monitoring or withdrawal, or both, of random selected devices from assembly line or service to permit determination of their condition at predetermined progressive intervals.

INTEGRAL CONTROL (TYPE 1, 2): A control system which uses integration in the control loop elements to provide an output in response to the error signal. This is referred to as a Type N system where N is the order of the integrator.

INTEGRATED ACTUATOR PACKAGE (IAP): A self-contained hydraulic servoactuator designed as a packaged unit with an electric motor driving a hydraulic pump to pressurize the hydraulic system in the package which includes reservoir, filter, check valve, control valve, and other elements that are necessary to provide an output, which controls the position of a device, usually an airfoil. Power for the IAP is derived from the vehicle's electrical system.

INTENSIFIER: A device which converts an input pressure to a higher output pressure which is proportional to its input pressure.

INTERNAL LEAKAGE: Leakage between internal cavities of a device.

INTERNAL PRESSURE: The pressure inside a system or component.

INTERNAL SYSTEM LOAD: A load which is dynamically generated by the system and which may exceed the externally applied loads, e.g., dynamic jam loads.

INTERFLOW: Flow between ports of a valve at intermediate positions (between established positions) which is not in accordance with nominal or intended flow pattern.

ION ENGINE: A type of engine in which the thrust to propel the missile or spacecraft is obtained from a stream of ionized atomic particles, generated by atomic fusion, fission, or solar energy.

IRREVERSIBLE COMPONENT: Any component of the system (such as gearing or screw threads) which has a forward driven mechanical efficiency of less than 50% (under all operating conditions) is an irreversible component, and can fulfill the function of a no back.

IRREVERSIBLE DRIVE: A drive which, without input torque (or force), cannot be back-driven from the output by a torque (or force) less than the maximum design load at the output.

IRREVERSIBLE SURFACE: A control surface whereby the control mechanism prevents aerodynamic forces from moving the surface.

ISM: Abbr. Input signal management

3. (Continued):

ISOBARIC PROCESS: Of equal or constant pressure, with respect to either space or time. The coefficient of polytropy  $k$  (see Polytropic expansion and compression) = 0.

ISOCHORIC PROCESS: Of equal or constant volume, usually applied to a thermodynamic process during which the volume of the system remains unchanged.

ISOLATION: A technique used in fault tolerant systems that removes the effects of a failure or prevents a failure from propagating or affecting the continued operation of the system.

ISOPYCNIC PROCESS: Of equal or constant density with respect to either space or time; equivalent to isosteric.

ISOSTERIC PROCESS: Of equal or constant specific volume with respect to either space or time; equivalent to isopycnic. The coefficient of polytropy  $k$  (see Polytropic expansion and compression) = 1.

ISOTHERMAL EXPANSION: An expansion process in which the gas temperature remains constant.

ITEM: Term referring to any defined, separate entity, such as a component, a piece, an action.

~, COMPLETED: Items of equipment (including basic or end items, components, assemblies) that have been overhauled, modified, renovated, and completed in accordance with terms of contracts, project orders, or other work directives and authorizations, and are ready for their intended use after receiving final mechanical acceptance inspection.

~, CONDITION MONITORING: A Condition Monitoring item has neither hard-time removal nor scheduled test to determine its continued serviceability. All removals are for unscheduled cause. All units removed must, upon arrival in the shop, be given a check in accordance with the procedures in the appropriate shop manual. If the unit "passes", it is returned to service. Failure to pass the check requires the unit to be repaired to a state that it will pass and be serviceable.

~, CRITICAL: An item that:

- (1) Has a limitation to warrant controlled surveillance under specified conditions
- (2) Is known to require special handling, transportation, storage, or test precautions
- (3) Does not have sufficient history of its own, or a similarity to other items that have the demonstrated high reliability to provide confidence in its reliability

~, LEVELS: Item levels from the simplest to the more complex are as follows: Part, Subassembly, Assembly, Unit, Group, Set Subsystem, System.

~, LIFE LIMITED: An item that must be removed from service and discarded before a specified time is achieved. It is referred to as an XXX time life part or component.

3. ITEM (Continued):

~, MAINTENANCE SIGNIFICANT: Items identified by the manufacturer whose failure:

- (1) Could affect safety
- (2) Could be undetectable during operations
- (3) Could have significant operational economic impact
- (4) Could have significant nonoperational economic impact

~, SERVICEABLE: An item that can be returned to service with appropriate airworthiness documentation.

J

J: Abbr. Joule, metric unit of energy = 1 N-m (Newton-meter) = 0.7376 ft-lb = 0.0009478 BTU

JET PIPE SERVOVALVE: An electrohydraulic servovalve where the electric control signal moves a pipe discharging a high velocity jet of hydraulic fluid to modulate flow between two ports in the first stage of the valve.

JETAVATOR: A control surface that may be moved into or against an engine's jet stream, used to change the direction of the jet flow for thrust vector control.

JET INTERACTION AMPLIFIER: An amplifier which utilizes control jets to deflect a power jet and modulate the output, usually employed as an analog amplifier.

K

KRUGER FLAP: A movable flap running underneath the leading edge of the wing with the hinge line on the upstream side of the flap. Rotation of the flap into the airstream modifies the leading edge profile to increase the stalling angle of the wing.

L

lb: Abbr. Pound, English unit of force = 4.448 Newtons

LEADING EDGE: The part of an airfoil facing the airstream. See Airfoil. See also Figure 6.

LETTER CHECK: In the airline industry the alphabetic designations given to scheduled maintenance procedure packages. A maintenance package is a group of maintenance tasks scheduled for execution at a specified time.

LINEAR INDUCTION MOTOR: A linear motor in which polyphase alternating current supplied to the primary winding produces a translating magnetic field. Alternating current is induced in the secondary winding by transformer action and the interaction between the induced secondary current and the primary magnetic field produces force.

3. (Continued):

Lpm: Abbr. Liters per minute, also written LPM.

LRU: Abbr. Line replaceable unit

LVDT: Abbr. Linear variable differential transformer

M

m: Abbr. meter, metric unit of length. m as prefix denotes milli or 0.001 such as in mm, a millimeter = 0.001m

M: Abbr. Mach number

MACH NUMBER: The ratio of local velocity to that of sound in the surrounding medium.

MAJORITY VOTING SYSTEM: A fault tolerant system wherein the outputs of three or more signals are summed to provide a single signal representative of the majority of the individual signals, often providing detection logic for identifying a failed channel. Also see Voter.

MANUAL FLIGHT CONTROL SYSTEM: Manual flight control systems consist of electrical, mechanical, and hydraulic components that transmit pilot commands, or generate and convey commands that augment pilot control commands, and thereby accomplish flight control functions. This classification includes the longitudinal, lateral directional, lift, drag, and variable geometry control systems. In addition, their associated augmentation, performance limiting, and control devices are included. A manual flight control system does not include vehicle motion or flight path sensors.

MANUAL OVERRIDE: The capability of a flight control system to enable the pilot to override the Automatic Flight Control System (AFCS) through a cable and/or linkage system and exert control in excess of the AFCS authority or in opposition to the AFCS command.

MAW: Acron. Mission adaptive wing.

MEAN TIME BETWEEN FAILURES: A basic measure of reliability for repairable items. The mean number of life units during which all parts of the item perform within their specified limits during a particular measurement interval under stated conditions. Abbreviation MTBF.

MEAN LINE: The locus of points halfway between the upper and lower surfaces of the airfoil as measured perpendicular to the mean line itself. See Figure 12.

MECHANICAL REVERSION: The capability of reverting from fly-by-wire control to a state wherein the pilot's control is mechanically coupled to the actuator control valves.

MEDP: Abbr. Minimum equipment and dispatch procedures

3. (Continued):

MEL: Abbr. Minimum equipment list

MFCS: Abbr. Manual flight control system

MID-VALUE LOGIC SYSTEM: A fault-tolerant system having an odd number of active channels (usually three) where the system output is determined by the middle of the (three) input signals.

MIS: Abbr. Item, maintenance significant

MISSION ADAPTIVE WING: A variable geometry wing which uses an actuation system to vary wing camber, both prior to flight and in flight, in response to pilot commands which increases the wing efficiency for that portion of the flight mission.

MODEL: (1) A device used in a failure detection-correction system to simulate the performance of a component or a channel used for control. Typical models are electrically implemented. (2) An object, usually a scaled representation of prototype, built to give some idea of what a functioning prototype would be like. (3) A mathematical description, usually idealized, of the performance of a dynamical system.

MONITOR: A device used for sensing the operation of a component or channel such that failures may be detected. In-line and cross-channel are two forms of monitoring. In-line monitoring compares output performance to the command input or a model. Cross-channel monitoring compares equivalent performance features of two or more channels.

MOTOR, AIR COOLED: A motor incorporating a fan, which pulls cooling air axially around the stator (air over) or through internal passages and air gaps in the stator and rotor (air through).

~, AXIAL PISTON: A fluid motor utilizing multiple pistons located in parallel with the axis of rotation, which are pressurized in sequence as the output shaft rotates to produce torque proportional to fluid pressure and rotational speed proportional to fluid flow. Usually one half the pistons are pressurized to provide output torque. The linear motion of the pistons is converted to rotary motion by a swashplate, which is set at an angle with respect to the motor housing. Output speed control can be obtained by either controlling input flow or controlling swashplate angle.

~, AC: Electric torque generators, which are powered by polyphase alternating current. The following types can be considered for electromechanical actuation.

~, DC: Electric torque generators, which are powered by direct current. Both mechanical/brush commutation and solid state commutation are in use in current electrical systems.

3. MOTOR, (Continued):

~, GEAR: A fluid motor utilizing variations in fluid volume between the engaging and disengaging gear teeth of a meshing gear set to produce torque proportional to fluid pressure and rotational speed proportional to fluid flow. Both external (spur gear) and internal (Gerotor) gears are used for the implementation of gear motor functions. Gear motors are fixed displacement hydraulic torque generators.

~, INDUCTION: An AC motor in which alternating current supplied to the stator produces a rotating magnetic field. Alternating current is induced in the rotor by transformer action and the interaction between the induced rotor currents and the stator field produces torque.

~, OIL COOLED: An electric motor utilizing internal fluid flow from the hydraulic pump, or system, for cooling. Fluid passages may be positioned around the stator (oil over) or the flow may be forced through passages and gaps in the stator and rotor (oil through).

~, RADIAL PISTON: A continuous rotation fluid motor utilizing the radial motion of cylindrical or spherical pistons running against an eccentric peripheral cam ring or race to produce torque proportional to fluid pressure and rotational speed proportional to fluid flow.

~, VANE: (1) A continuous rotation fluid motor utilizing the variable volume between a set of radially movable vanes in a rotor and an eccentrically positioned cam ring to produce torque proportional to fluid pressure and rotational speed proportional to fluid flow. Single lobe and multiple lobe cams are used for this type of motor. In some designs the vanes are rollers while in others the vanes slide on the cam ring. Single lobe cam designs can be used for variable displacement torque generator applications. Vane pumps can be ported radially through the rotor bearing or peripherally at the cam ring. (2) A limited rotation fluid actuator employing a single vane or multiple vanes operating in a cylindrical fluid cavity with fixed dam(s) dividing the high and low pressure fluid.

MTBF: Abbr. Mean time between failures

MTBM: Abbr. Mean time between maintenance action

MTBJR: Abbr. Mean time between justified removals

MTBR: Abbr. Mean time between removals

N

N: Abbr. Newton, metric unit of force

NDI: Abbr. Inspection, nondestructive

N-m: Abbr. Newton-meter, metric unit of torque, also written Nm

3. (Continued):

**NONDETECTABLE FAILURE:** A failure that, upon occurrence, is not recognized by the failure detection scheme(s) of a fault tolerant flight control system. Unless stated otherwise, a flight control system must maintain its fail operative status after the occurrence of a nondetectable failure.

**NONSEPARABLE FILTER:** A filter that is permanently encased in its housing. This is usually done to reduce potential leak paths or to save weight, typically in servo valves.

**NORMAL FLOW CURVE:** The locus of the midpoints of the complete cycle flow curve, which is the zero hysteresis flow curve. Usually valve hysteresis is sufficiently low, such that one side of the flow curve can be used for the normal curve.

**NORMAL FLOW GAIN:** The slope of a straight line drawn from the zero flow point of the normal flow curve, throughout the range of rated current of one polarity, and drawn to minimize deviations of the normal flow curve from the straight line. Flow gain may vary with the polarity of the input, with the magnitude of load differential pressure and with changes in operating conditions.

**NULL:** (1) In Servo Valves: The condition where the valve supplies zero load flow at zero load pressure drop. (2) In general: The input condition at which any control device generates zero output.

~ **BIAS:** (1) The input current in milliamperes required to bring a servo valve to null under any particular specified conditions. (2) In general, the input signal to any control device, which results in a zero output under specified conditions of operation.

~ **PRESSURE:** The pressure existing at both control ports of a servo valve at null, expressed in psi (kPa).

~ **PRESSURE GAIN:** The change of load differential pressure in a servo valve at zero load flow with input current, measured at the null point (psi/ma).

~ **REGION:** The region about null in a servo valve where effects of lap in the output stage predominate.

~ **SHIFT:** (1) In a servovalve, a change in null bias, expressed as percent of rated current. Null shift may occur with changes in supply pressure, temperature, and other operating conditions. (2) In a LVDT, a change, or shift, in the null position, usually due to temperature, which causes linear expansion of the materials. (3) In any control device, it is the output variation for a constant input signal when operating parameters deviate from standard conditions.

3. (Continued):

O

OC: Abbr. On condition

OPTICAL SENSOR ARRAYS: A distributed network of multiple sensors, using laser beams, to provide real-time data for on-board processing.

OPTIMUM CONTROL SYSTEM: A control system that minimizes a given error index for a dynamic process subject to given design constraints.

OVERLAP: The lap condition in a spool valve, which results in a decreased slope of the normal flow curve in the null region.

OPEN LOOP CONTROL SYSTEM: A control system in which gain and power control elements are used to provide an output in direct response to a command without feedback comparison. Figure 16. illustrates a block diagram representation of an open loop control system.



FIGURE 16 - Open Loop Control System

P

Pa: Abbr. Pascal, metric (SI) unit of pressure =  $1 \text{ N/m}^2 = 0.00001 \text{ bar}$

PACKING: The flexible sealing element in a fluid seal which is subject to sliding motion.

PARALLEL SERVO: A servo located in a control system so that the servo output drives in parallel with the major input. This arrangement usually is used with actuators which perform an alternate function to that of the pilot. The parallel servo output will drive both the pilot controls and the flight control system.

PARAMETER OPTIMIZATION: The selection of parameters, such as gains and time constraints, to minimize the error index.

3. (Continued):

**PARTICLE:** A solid piece of material so small as to be unidentifiable by the unaided eye.

**~ COUNT METHOD:** A method by which particles in a fluid sample can be counted by number in size ranges. This can be done by membrane filtration and manual microscope counting (Reference ARP598) or by any of the automatic techniques (e.g., AIR4086).

**PASSIVE FAILURE:** The type of failure wherein the failed device or system has no effect on the operational performance of a fault tolerant system even when it is commanded to function. Usually associated with standby or inactive features of a fault-tolerant system.

**PASSIVE PARALLELING:** The simplest and most common type of redundancy, wherein two parallel functional devices are utilized such that if one fails the second is still available. This approach is limited to the more simple elements of the control system which can only fail passively, such as springs and linkages. When failure of one element occurs, there may be a change in performance or capability.

**PAYLOAD:** (1) The load (expressed in weight of cargo or equipment, volume of liquid, or number of passengers) the vehicle is designed to transport under specified conditions of operation, in addition to its unladen weight. (2) The warhead, its container, and activating devices in a military missile. (3) The satellite or research vehicle of a space probe or research missile.

**PCE:** Abbr. Pilot control electronics

**PCU:** Abbr. Pilot control unit

**PDM:** Abbr. Pulse duration modulation

**PEDAL:** A cockpit control device operated by the foot and used to produce directional rudder control, directional steering control, and brake control.

**PERIGEE:** The point at which a satellite orbit is the least distant from the center of the gravitational field of the controlling body or bodies.

**PFC:** Abbr. Primary flight computer

**PFCS:** Abbr. Primary flight control system

**PHASE:** The angular relationship between a time variant signal, current, or motion and an arbitrary reference (controls, electric motors, sound etc.).

**~ LAG:** The instantaneous time separation between the input current and the corresponding control-flow variation, measured at a specified frequency and expressed in degrees (time separation in seconds x frequency in Hz x 360° per cycle). (ARP4493)

3. PHASE (Continued):

~ DIFFERENCE: The maximum allowed difference in the phase shift of two secondary voltages when using a three wire or split secondary.

~ SHIFT: The difference in angular degrees between the primary excitation voltage and the secondary output voltage when the output is taken differentially.

PHASING: Phase of the differential output voltage with the primary voltage as the armature is displaced through the null position.(AC electric motors).

PHUGOID MODE: A longitudinal mode consisting of a long-period lightly damped oscillation in pitch and velocity with nearly constant angle of attack. An interchange between kinetic and potential energies produces a slow rising and falling of the aircraft accompanied by changes in speed. First described and named by Lanchester, from Greek root for flee; Lanchester actually wanted to fly.

PISTON: A cylinder part which slides in a cylinder or barrel and serves to transfer force to or from the enclosed fluid.

~ ROD: A coaxial column or rod, attached to or integral with a piston, which serves to transmit force between the piston and another mechanical member.

PITCH: Rotation about the lateral axis of a vehicle.

~ AXIS: The lateral or (Y) axis of an aircraft about which pitching occurs. See Figure 10.

PLATE: See Electrode

PM: Abbr. Permanent magnet

POLARITY: The relationship between the direction of control flow and the direction of input current. (ARP4493)

3. (Continued):

POLYTROPIC EXPANSION or COMPRESSION: An expansion or compression process in which changes of pressure (P) and density ( $\rho$ ) are related to Equation 3:

$$P\rho^{-n} = P_o\rho_o^{-n} \quad (\text{Eq. 7})$$

where:

n is a dimensionless constant and the subscript o denotes initial values of the variables. Therefore, pressure and temperature are similarly related:

$$P/P_o = (T/T_o)^k \quad (\text{Eq. 8})$$

where:

k is the coefficient of polytropy ( $k = n/(n-1)$ )

PORT: (1) An opening at a surface of a component incorporating provisions for attachment of a fluid carrying passage, line, fitting, or removable plug. (2) Fluid Connection to the (Direct Drive) Valve, e.g., supply port, return port, control port. (ARP4493)

POSITION: In actuation systems the spacial location of an output device, frequently the controlled variable of the system.

~ CONTROL

~ SENSOR

~ SUMMING: A multichannel arrangement which sums the position outputs of multiple actuators into a single composite output.

~ FEEDBACK: Electrical or Mechanical means for closing a position loop within a (Direct Drive) Valve. Closed loop systems typically enjoy improved performance characteristics and reduced sensitivity to construction variations at the cost of added complexity. Devices for electrical position feedback include LVDTs, RVDTs, radiomatic potentiometer and Hall effect sensors. Mechanical feedback can be accomplished by use of springs, linkages or gears. (ARP4493)

POUR POINT: Lowest temperature at which a liquid will flow under specified conditions.

3. (Continued):

POWER: The product of Force and Velocity or in hydraulic terms Pressure and Flow.

~, CONTINUOUS: The maximum power which can be delivered by the actuation system for an indefinite period without sustaining damage or reducing life. With an electric actuator, continuous power is generally much less than rated power due to material limitations, which are time and temperature-related.

~, ELECTRICAL CONTROL: The power dissipation required for control of the servovalve. Control power is a maximum with full input signal, and is zero with zero-input signal. It is independent of the coil connection (series, parallel, or differential) for any conventional two-coil operation. For differential operation, the control power is the power consumed in excess of the electrical quiescent power. This power increase is a result of the differential current change.

~, ELECTRICAL QUIESCENT: The dissipation required for differential operation when the current through each coil is equal and opposite in polarity.

~, CHIP SHEAR: The electrical power required to produce chip shear force specified at 68 °F and expressed in watts. (ARP4493)

~, CONTINUOUS: The electrical power level which may be sustained for a specified period of time with the (Direct Drive) Valve at specified fluid and ambient temperatures, with exceeding material limitations that may damage the assembly or degrade performance beyond acceptable limits. Normally this is specified at the maximum current level. (ARP4493)

~, GAS: The amount of energy in the gas theoretically available to do work, expressed by Equation 9:

$$GP /1/ = W \frac{H_{ad}}{E} \quad (\text{Eq. 9})$$

where:

GP = Available gas power, hp (kW)

W = Gas flow rate lb/s (kg/s)

E = Energy equivalent (550 ft-lb/s/hp) (1000 Nm/s/kw)

H<sub>ad</sub> = Adiabatic head, ft (m)

/1/ In SI metric units, W is replaced by (W/g), where g = 9.81 m/s

~, MAXIMUM: The maximum power level which corresponds with the maximum current level for the specified conditions of fluid temperature and ambient temperature. Maximum power is expressed in Watts. (ARP4493)

3. POWER, (Continued):

~, PEAK: The maximum power that the actuation system is capable of delivering. This may be higher than rated power determined by system actuation requirements.

~, RATED: (1) The product of rated load and rated velocity, also called the Power Point. This point usually determines the maximum power required from the actuation system. (2) The electrical power expressed in watts, required to produce rated current. The power is specified at 68 °F unless otherwise noted. (ARP4493)

~ AMPLIFIER: A component designed specifically for increasing signal power. See also amplifier.

~ CONVERTER: The component of the power system that transforms energy from the power source into a form compatible with the servoactuator requirements.

~ FACTOR: The ratio of the real power in watts to the apparent power in volt-amperes.

~ LANDING: The landing of a spacecraft on a body in space in which the thrust of its motors is used as a brake.

~ MODULATOR: The component of the actuation system that regulates the potential energy of the power source to the actuator as a function of controller output. In a simple hydraulic power boost system, which has no separate controller, the power modulator controls the power to the actuator directly as a function of the command or error signal.

~ SOURCE: The component of the power system which supplies energy for load actuation. This power, supplied by the vehicle, may be AC or DC electrical power, hydraulic power, or pneumatic power.

~ SOURCE, FLUID: The fluid power source, whether on an aircraft or missile, is a hydraulic pump. On aircraft, the pump, in almost all cases, is driven by the main engine, whereas on a missile it may be driven by a turbine (gas driven) or an electric motor.

~ SYSTEM: The power system generates, conditions, and distributes power to the power utilization actuator systems. The power system is not a part of the actuation system.

POWERED FLIGHT: The flight of an aircraft, missile, or spacecraft during the period or periods in which it is propelled by a self-contained engine.

3. (Continued):

**PRESSURE:** Pressure is defined as fluid force per unit area. The pressure in a fluid at rest is equal at all points and in all directions (Pascal's Law). In many aerospace applications it is normally used as a modifier to designate a portion of a system or unit which operates at, or is exposed to, the system pressure. Except as specified otherwise, the term pressure is considered to mean gage pressure. The units of pressure are Pascal (Pa)  $1 \text{ Pa} = 1 \text{ N/m}^2$ ,  $100,000 \text{ Pa} = 1 \text{ Bar} = 14.5033 \text{ lb/in}^2$ .

The following terms are commonly used as qualifiers to the noun pressure.

**PRESSURE, ABSOLUTE:** The pressure value using absolute vacuum as a reference.

~, **AMBIENT:** The static pressure surrounding a component.

~, **ATMOSPHERIC:** The absolute pressure of the atmosphere at a given location and time.

~, **BACK:** The pressure caused by resistance to flow in the return line, precharged reservoirs, or both.

~, **BREAKOUT:** The pressure required to overcome static friction in a component.

~, **BURST:** The maximum test pressure a hydraulic or pneumatic component must withstand without rupture.

~, **BURST, ACTUAL:** The pressure at which a component bursts, exhibits massive leakage due to permanent or nonpermanent structural failure, or due to structural deflection.

~, **BURST, MINIMUM:** The pressure during burst pressure testing up to which no externally visible bursting and no significant external leakage occurs. Deformation and permanent set are permitted. Function may be impaired.

~, **CERTIFICATION:** The authorized pressure for formal acceptance tests.

~, **CHAMBER:** The pressure within the (rocket motor) case during combustion.

~, **CONTROL:** The pressure required to control or influence any motion or change in motion.

~, **CRACKING:** The pressure at which a valve becomes unseated and begins to pass fluid.

~, **CUTOUT:** The pressure at which the sequence of reduced flow of a component or system begins.

~, **DIFFERENTIAL:** The difference in value between two functionally related pressures occurring simultaneously at different points, such as at opposite sides of an actuator piston.

3. PRESSURE, (Continued):

~, DYNAMIC: (1) That portion of the local pressure in a fluid which is recovered when the fluid is brought to rest without loss. (2) The pressure of the air through which an aircraft is flying, determined by the aircraft's velocity and the density of air.

~, EXIT PLANE: The static pressure of the gas stream existing at the nozzle exit plane. (rocket motor)

~, FLUSHING: The pressure required to flush a system at defined conditions (for instance, at defined flow).

~, GAUGE: The absolute pressure minus atmospheric pressure.

~, IDLING: The pressure required to maintain a system or component at the idling speed, or flow.

~, INLET: The pressure at the inlet of a component.

~, INTERNAL: The pressure inside a system or component.

~, LOAD: The pressure reacting to a static or dynamic load. (Same as Pressure Under Load)

~, LOCKUP: The maximum permissible output pressure when the regulator flow demand is zero.

~, MAXIMUM PERMISSIBLE: The highest pressure that is permitted for safety reasons.

~, MAXIMUM: The highest transient pressure that can occur temporarily.

~, MINIMUM OPERATING: The lowest pressure at which a system or component must function; that pressure below which a mechanism may not operate (as in a pilot operated valve, which requires a certain minimum pressure for operation).

~, MINIMUM: The lowest transient pressure that can occur temporarily.

~, NO LOAD: Pressure required to maintain a system at a specified speed with no external load.

~, NOMINAL: The general pressure setting of the system.

~, OPERATING: The pressure available to a component or system.

~, OPPOSING LOAD: The pressure acting to oppose operating pressure.

3. PRESSURE, (Continued):

~, OUTLET: The pressure at the outlet of a component.

~, OUTPUT: In a pressure control device, such as a pressure reducer or power brake valve, the pressure which will be produced at the outlet port. In a pressure modulating unit, as in a brake valve, the output pressure should be specified as maximum or the range stated.

~, PEAK: The maximum pressure, usually of short duration.

~, PILOT: The pressure from the first stage or pilot stage of a valve which is directed to a subsequent (usually second) stage of the valve to change its position.

~, PROOF: Pressure above nominal system pressure of the component or system when the application at defined test conditions must not lead to external leakage, permanent deformation, or detrimental influence on function; the pressure which a component must withstand as a production inspection test without damage, normally related to rated pressure.

~, RATED: The nominal maximum input or operating pressure.

~, REFERENCE: The pressure against which another pressure can be compared or measured. This pressure is arbitrary but agreed to and stipulated by those involved with its intended use.

~, RESEAT: (1) The pressure at which a valve, such as a check valve or a relief valve, will close so that the flow reverts to zero or to a specified leakage rate. (2) The pressure at which the valve is reseated and flow is interrupted. (Also see Pressure Reseat)

~, RESPONSE: The pressure at which a function is initiated.

~, RETURN: Pressure caused by resistance to flow in the return line or by precharged reservoirs, or both. (Same as Back Pressure)

~, SET: The pressure, which a component is defined to provide for a defined operation.

~, STANDARD ATMOSPHERIC: Mean atmospheric pressure related to sea level (corresponding to the definition for the physical atmosphere 1013.25 mbar).

~, STATIC: The local pressure in a fluid that has no element due to velocity of the fluid.

~, SUCTION: The atmospheric pressure minus absolute pressure for values below atmospheric pressure.

~, SWITCHING: The pressure at which a system or component is activated, deactivated, or reversed.

### 3. PRESSURE, (Continued):

~ TOTAL: The sum of the static and dynamic pressures at a location.

~ ULTIMATE: Same as Burst Pressure, Minimum. In the following terms PRESSURE becomes the qualifier for another parameter.

~ AMPLIFIER: A component designed specifically for amplifying pressure signals, usually with high impedance output. See also Amplifier.

~ ALTITUDE: The height of an aircraft as measured from an atmospheric pressure level of 1013.23 mb or 29.92 in.Hg. Commonly used to indicate flight levels.

~ CURVE: The pressure variation, expressed graphically in relation to another variable; e.g., time. (See Figure 16) Note the magnitude of the various pressure terms.

~ DROOP: The change in pressure from a higher level to a lower level with flow of a pressure compensated pump or regulator.

~ DROP: The reduction in fluid pressure due to flow. When applied to a fluid control unit, pressure drop is measured between given ports of the unit at a given flow and does not include the loss in fittings, which are installed in ports (normally the value applicable to a complete flow pattern at rated flow unless otherwise stated). (2) Specifically LOAD PRESSURE DROP  $P_L$  in a servo valve is the differential pressure between the control ports, expressed in psi.  $P_L = P_S - P_R - P_O$  where  $P_S$  is the supply pressure,  $P_R$  is the return pressure, and  $P_O$  is the control orifice drop. (ARP4493). (3) Servo Valve Pressure Drop,  $P_O = P_S - P_R - P_L$ , is the sum of the differential pressures across the output stage. (ARP4493)

~ GAIN: The rate of change of load pressure drop with input current at zero control flow (control ports blocked), expressed in psi/ma (kPa/ma). Pressure gain is usually specified as the average slope of the curve of load pressure drop versus current between  $\pm 40\%$  of maximum load pressure drop. (ARP4493)

~ FLUCTUATION: The variation of pressure with time, usually occurring randomly.

~ GRADIENT: The change in pressure value with distance in a steady-state flow.

~ HEAD: The equivalent height of a column of liquid required to produce a given pressure.

~ IMPULSE: A rapid rise and fall of pressure, or vice versa, of extremely short duration.

~ LOSS: The pressure loss is the reduction in pressure caused by resistance to flow or by an extraction of energy that is not converted into useful work.

~ MISMATCH: The differential pressure in psi between the output pressures of the elements of a tandem valve when the valve assembly is at hydraulic null. (ARP4493)

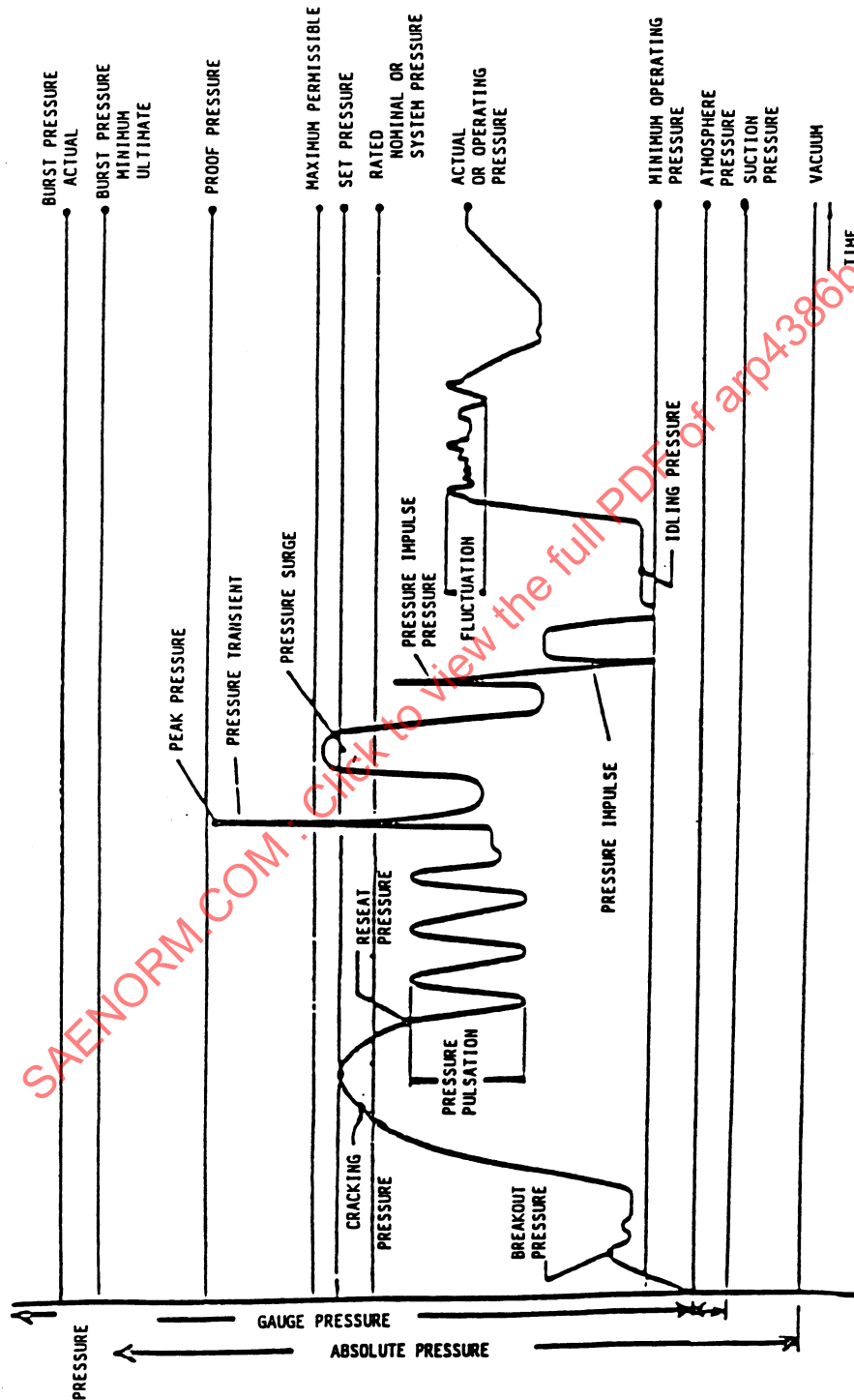


FIGURE 17 - Graphical Representation of Arbitrary Pressure Versus Time Curve

3. PRESSURE (Continued):

~ OPERATED: When a device is operated by application of pressure through a control port of ports such as in a pressure control valve.

~ PULSATION: Periodical variation of pressure in synchronism with the operating speed of rotating equipment.

~ RATIO: Numerical ratio of the value of two pressures.

~ RIPPLE: Periodical variation of pressure in synchronism with the operating speed of rotating equipment. (Same as Pressure Pulsation.)

~ RISE: Change in pressure from a lower level to a higher level (due to energy addition or kinetic energy recovery).

~ SURGE: Pressure rise and fall over a period of time; the maximum magnitude of a transient pressure rise.

~ TRANSIENT: Pressure rise or drop, or both, of extremely short duration with negligible energy.

~ UNDER LOAD: The pressure reacting to a static or dynamic load.

~ WAVE: A cyclic variation of pressure with relative low amplitude and long period.

PRIMARY FLIGHT CONTROL: The stability and/or maneuvering control of aircraft using force/moment generators; i.e., aerodynamic control surfaces and propulsive thrust vectoring.

PROPELLANT: Any agent used for consumption or combustion in a gas generator and from which the chamber generates its gas, such as a fuel, oxidizer, additive, catalyst, and any compound mixture of these. Specifically, a fuel, oxidant, or a combination or mixture of fuel and oxidant used in a gas generator.

~, LIQUID: A propellant in liquid form generally consisting of a single liquid (monopropellant) or two liquids (a bipropellant). Examples of liquid propellants include fuels such as alcohol, gasoline, Aerozine 50 and liquid hydrogen, and oxidants such as liquid oxygen, hydrogen peroxide, and nitric acid.

~, MONO-: A liquid propellant consisting of a single homogeneous chemical agent or substance capable of producing a heated gas without the addition of a second substance. Examples are hydrazine, ethylene oxide, hydrogen peroxide, and nitromethane. Monopropellants are stable at ordinary atmospheric conditions, but decompose in the presence of heat or a catalyst, or both, to yield decomposition gases and heat.

3. PROPELLANT, (Continued):

~, SOLID: A propellant in solid form usually containing both the fuel and oxidizer combined or mixed and formed into a monolithic (not powdered or granulated) grain. Solid propellants may be roughly divided into two principal types: composite propellants, and double base propellants. However, this division is not rigid and examples of propellants exist which actually fit both categories.

psi: Abbr. Pound per square inch, English system measure of pressure 1 psi = 6895 Pa (N/m<sup>2</sup>).

psia: Abbr. Pound per square inch, absolute, English unit of absolute pressure.

Pst: Abbr. Static pressure. Also written  $P_{st}$

PULSEJET: A jet-propulsion engine containing neither compressor nor turbine. Equipped with vanes in the front which open and shut, to create thrust it takes in air in rapid periodic bursts rather than continuously.

PUMP: HYDRAULIC

~, AXIAL PISTON: A pump utilizing multiple pistons arranged such that the pistons stroke in sequence as the pump drive shaft rotates. Normally, piston stroke is determined by the angle between a swash plate and the piston housing such that, at a given pump speed and swashplate angle, flow output will be essentially constant for any system pressure.

~, CENTRIFUGAL: A pump which creates high fluid velocity through centrifugal action. Fluid momentum is recovered as a pressure head at the pump outlet. A centrifugal pump is not a positive displacement device and output pressure remains essentially constant at constant speed for varying output flows up to pump cavitation.

~, FIXED DISPLACEMENT: A pumping unit in which the displaced volume is fixed by design; i.e., its output at a fixed revolutions-per-minute-and-output-pressure cannot be varied. Pump outlet flow is essentially constant for any given pump speed regardless of system pressure level.

~, FREE PISTON: A reciprocating piston device that converts pneumatic power to hydraulic power. The free piston pump usually acts as an intensifier with the pneumatic pressure increased to a higher hydraulic pressure. This allows the stored cold gas to be bled down to a lower pressure, thus increasing the energy extraction from the pneumatic power source. The term "free piston" implies the absence of a mechanical drive.

~, GEAR: A pump utilizing two or more counter rotating gears to provide a positive volume displacement. Gear pumps are usually fixed displacement; and at a given speed, output flow is essentially constant at any system pressure.

~, MECHANICAL VOLUME CONTROL: A variable delivery pump whose output per cycle is controlled by external mechanical means.

3. PUMP, (Continued):

~, PILOT CONTROL: A variable delivery pump whose output is controlled by the pressure at a control port.

~, PRESSURE VOLUME CONTROL: A variable delivery pump whose output is controlled by its discharge pressure.

~, SMART: A variable displacement, pressure-compensated hydraulic pump, where the displacement and the pressure and power setting may be controlled remotely, where transient cavitation protection, reduced starting torque, built-in test and health monitoring and other optional features may be provided.

~, VANE: A variable or fixed displacement pump having a number of cavities such that the rotation varies the volume of fluid entrapped between vanes which creates a pumping action through positive volume displacement.

~, VARIABLE DISPLACEMENT: A pumping unit in which the displaced volume is varied by a control mechanism. The output can be controlled independently of pump speed (revolutions per minute) by varying the output volume per cycle (one revolution of the pump). This mechanism is typically a pressure sensitive device, which reduces pump output flow when a preset pressure level is attained. The pump will deliver only that output flow necessary to meet system flow demands. Other variations include servo control pumps, constant torque and flow control hydraulic pumps, constant or programmable power ("smart") pumps.

Pt: Abbr. Total pressure. Also written  $P_t$

PWM: Abbr. Pulse width modulation

Q

QA: Abbr. Quality assurance

QD: Abbr. Quick disconnect

QUAD VOTER: A voter that selects one common output to represent the four input signals or values.

QUADRUPLEX: An adjective meaning fourfold, as used for a four channel system.

QUADRUPLEX SYSTEM: A control system containing four signal paths so as to provide multiple failure capability such as Single Fail Operative/Fail Safe, Dual Fail Operative/Fail Safe.

QUICK CHARGE: A charging rate that ranges from 0.2 to 0.5 C rate.

3. (Continued):

**QUICK CHARGE BATTERY:** A nickel-cadmium battery that can be charged fully in 3 to 5 h by a constant-current charger and is also capable of continuous overcharge at this quick charge rate.

**QUIESCENT CURRENT:** The zero signal input current per coil in milliamperes for valves with differential coil connections.

**QUIESCENT FLOW:** Total internal leakage of a complete hydraulic system or a branch of a hydraulic system at rest; e.g., the magnitude of fluid flow through all stages of a servo valve when the valve is closed or centered.

R

**RACK-AND-PINION FLUID ACTUATOR:** An actuator wherein the rotary motion is achieved by piston-driven linear racks engaging a rotary output gear.

**RACK-AND-PINION MECHANICAL ACTUATOR:** A mechanical actuator generally consisting of reduction input gearing, outputting to a rotary pinion gear that connects with a rack to provide linear output actuation force. May also be used with linear motion rack, coupling to a pinion to provide rotary output torque.

**RADIAL PISTON MOTOR:** A motor utilizing multiple pistons arranged radially around a shaft with an eccentric cam. The pistons are pressurized in sequence and the linear to rotary motion conversion is accomplished by the eccentric cam action. Output speed control can be obtained by either varying input flow or controlling cam eccentricity.

**RAMJET:** A jet-propulsion engine containing neither compressor nor turbine which depends for its operation on the air compression accomplished by the forward motion of the engine.

**RAT:** Acron. Ram air turbine

**RATE LIMIT:** The maximum velocity of the control system output. Usually, rate limit is defined under maximum aiding load conditions with saturation signals applied to the servoactuator.

**RATED CURRENT:** The specified current increment from null in milliamperes to produce rated flow. For three and four lead coils, rated current is the differential coil current.

**RATED FLOW:** Specified flow at steady-state conditions for a component or system; the nominal maximum operating flow, applicable where control of that flow rate is not basic.

**RATED FLOW GAIN:** The change in output flow per unit current input  $\frac{\text{in}^3/\text{s}}{\text{ma}}$  or  $\frac{\text{m}^3/\text{s}}{\text{ma}}$ . Incremental flow gain will vary with the magnitude of the signal input and other variables.

3. RATED (Continued):

~ LOAD: A specified steady-state load applied to the actuator for determining rated velocity. Usually, rated load is an opposing load.

~ POWER: The product of rated load and rated velocity, also called the Power Point. This point usually determines the maximum power required from the actuation system.

~ PRESSURE: The nominal maximum input or operating pressure.

~ VELOCITY: The required actuation system output velocity when the specified rated load is applied at the actuation motion attach point. Rated velocity can be determined at any load position.

READINESS: The probability that material will perform satisfactorily upon demand.

RECONFIGURABLE: That characteristic of a fault-tolerant device or system whereby continued functional operation, subsequent to a failure, is provided by rearranging or recombining the surviving control elements. Sometimes referred to as self-repairing.

REDUNDANCY: The existence of more than one independent means of accomplishing a given function.

REDUNDANCY MANAGEMENT: That portion of the system logic and control (hardware or software) which detects and isolates failures in a fault-tolerant system; and reconfigures the system after the failure is detected and isolated so as to maintain the same or a reduced level of operation.

REDUNDANCY, ACTIVE: That redundancy where all means for accomplishing a given function operate simultaneously and share the output load, rather than being activated when needed.

REDUNDANCY, STANDBY: That redundancy where the alternative means of performing a function is inoperative until needed, and is activated upon failure of the primary means of performing the function.

REDUNDANT: An adjective to denote the use of duplicate or alternate components for the purpose of improving mission safety or reliability.

REDUNDANT ACTUATOR: A multichannel actuator design wherein the channels are identical, each receiving the same input, connecting the individual outputs to form a common, or single, output.

REFERENCE PRESSURE: The pressure against which another pressure can be compared or measured. This pressure is arbitrary but agreed to and stipulated by those involved with its intended use.

3. (Continued):

**REGRESSIVE BURNING:** A condition in which the mass flow produced by the propellant grain decreases as the web is consumed due to decreasing area, decreasing burn rate, or both.

**RELAXED STATIC STABILITY:** (1) The use of automatic flight control augmentation design to relax the conventional configuration constraints of the basic aircraft's aerodynamic static stability. (2) A lessening of an aircraft's static stability to improve its maneuvering performance capability.

**RELIABILITY:** The probability that a system, subsystem, unit, or part will perform its intended function for a specified interval, under stated operational and environmental conditions.

**RELIABILITY ENGINEERING:** That applied science concerned with utilizing matter, the properties of matter, and the physical forces involved to achieve material having known reliability characteristics.

**RELIABILITY PREDICTION:** A method, or technique, used to predict the reliability of an item at a future time; for example, one derived method titled "the propagation of variance" measures the change in performance at given intervals of operation and, based on the operating parameter changes, predicts when the performance limits will be exceeded (thus a failure) and the numerical value of reliability.

**RELIABILITY TEST:** Testing a material sample under specified conditions for predetermined periods or until a predetermined number of failures occur.

**RELIABILITY, ASSESSED:** The reliability of an item determined within stated confidence limits, determined by tests, or using failure data and compared to nominally identical items.

**RELIABILITY, DISPATCH:** The probability that a scheduled or planned flight will depart without incurring a delay (technical) or cancellation (technical).

**RELIABILITY, ESTIMATED:** A reliability factor that is postulated for a system, a subsystem, or equipment under specified conditions of test or use.

**RELIABILITY, INHERENT:** The reliability potential in a given design configuration when used in accordance with the design specification.

**RELIABILITY, MISSION:** The probability that a system or an item will give specified performance for the duration of a mission when used in the manner and for the purpose intended, given that the item is functioning properly at the start of the mission.

**RELIEF VALVE:** A valve automatically releasing pressure higher than its setting; see Pressure Relief Valve and Thermal Relief Valve.

3. (Continued):

REMOVAL AND REPAIR:

- a. REMOVAL, CONFIRMED: A removal where a failure or defect is found that substantiates the reason for removal.
- b. REMOVAL, JUSTIFIED: The total removals of some unit may include items removed for maintenance convenience, as well as those for which no problems are found, and those for which a shop check reveals a defect. The last group is the only one for which removals are justified.
- c. REMOVAL, UNCONFIRMED: The removal of an item where no defect or failure is found, which substantiates the reason for removal, even though another defect or failure may be found.
- d. REMOVAL, SCHEDULED:
  - (1) Removal of an item when the hard time limit is reached
  - (2) Removal of an "On-Condition" item during a scheduled periodic inspection or test
- e. REMOVAL, UNSCHEDULED: The removal of an item brought about as a result of a known or suspect malfunction or defect or both at a time other than scheduled maintenance, inspection, or test. It includes:
  - (1) All conditions monitored items
  - (2) Only those on-condition items removed prior to their scheduled check
  - (3) Only those hard-time items removed prior to their schedule
- f. REPAIR: The restoration of an item to a serviceable condition. Repair includes airworthiness documentation.
- g. REPAIRABLE ITEM: An item that can be restored to perform all of its required functions by corrective maintenance.
- h. REPAIR CYCLE: The period that elapses from the time the item is removed in a repairable condition to the time it is returned to stock in a serviceable condition.
- i. REPAIR, ESSENTIAL: Only those repairs necessary to ensure that the end item will fulfill its mission efficiently and safely.
- j. REPAIR/OVERHAUL, MODULAR: Application of maintenance procedures and techniques that concentrate attention to a defective subassembly or module and its repair or overhaul, in lieu of treating the complete assembly as an entity for all maintenance actions.
- k. REPAIR PART, HIGH MORTALITY: A repair part with failures anticipated or actual, of 30 or more per 100 end items per year.