



AEROSPACE INFORMATION REPORT

AIR5024™

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Landing Gear Switch Selection Criteria

RATIONALE

AIR5024 has been reaffirmed to comply with the SAE five-year review policy.

FOREWORD

This document is intended to provide the landing gear designer with position sensing device guidance on appropriate technologies and means to achieve enhanced landing gear position sensing performance.

1. SCOPE:

The scope of this document is to discuss the differences between electromechanical and proximity position sensing devices when used on landing gears. It also contains information, which may be helpful, when applying either type of technology after the selection has been made. The purpose is to help the designer make better choices when selecting a position-sensing device. Once that choice has been made, this document includes information to improve the reliability of new or current designs. It is not intended to replace recommendations from sensor manufacturers or actual experience, but to provide a set of general guidelines.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications:

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

AIR1810A Design, Development and Test Criteria - Solid State Proximity Switches/Systems for Landing Gear Applications

AIR4077 Mechanical Switch Usage for Landing Gear Applications

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3. TECHNICAL DATA:

3.1 Environmental Factors:

a. Shock/Vibration

Electromechanical switches are affected by shock and/or vibration. Typically the switch is most susceptible in the plane parallel to contact motion. In this plane, the switch contacts will tend to be separated causing the signal to be lost momentarily. Generally switch contact separation longer than 10 μ s is considered a failure. Once the shock and/or vibration has been lowered or removed, the contact will generally stabilize. The typical design values for sealed switches used on landing gears are 100 to 200 g's sawtooth shock or 10 to 20 g's vibration.

Contact separation, especially repeated separations during high levels of vibration, will tend to prematurely wear out the contacts. Permanent damage to the electromechanical switch usually does not occur until shock and/or vibration levels are reached that are higher than required to separate the contacts. For each operation, the switch actually sees the contacts make and break the circuit on each separation caused by the shock and/or vibration. These separations can also cause false signals to be registered by electronic data processors without proper buffering or "de-bouncing".

Proximity devices by design are less susceptible to the effects of shock and vibration since they have no moving parts. However, the reliability of the device can be reduced due to shock and vibration. This is especially true of one-piece proximity devices where the active electronics are subjected to this environment. Typical design values are 500 g's shock and 30 g's vibration for one-piece proximity sensors and 2000 g's shock and 50 g's vibration for two piece sensors. Reliability and mean time between failure calculations should reflect the environment.

It should also be noted that the target and mounting of the proximity sensor and the actuator and mounting of the electromechanical switch should be rigid enough to withstand the dynamic loads caused by the shock and/or vibration. Resonant frequencies of the sensor and bracketry must be designed such that sensor assembly functions are not impaired. Vibration mode shapes should be considered when selecting sensor mounting locations either on structural components or on the landing gear itself.

3.1 (Continued):

b. Radio Frequency Interference/Electromagnetic Interference (RFI/EMI)

1. Susceptibility

Electromechanical switches are usually not considered susceptible to RFI/EMI. However, the wires connecting these switches to associated circuitry may require RFI/EMI shielding. One-piece proximity switches that include active electronics are susceptible to RFI/EMI especially in severe environments, such as near high power radar or near or during lightning strikes. The RFI/EMI environment must be carefully considered when designing the proximity sensor and its installation. Typically there are specific RFI/EMI performance specifications that the proximity sensor is required to meet. Twisting leadwires, metal overbraids, leadwire routing, as well as the device design, will minimize susceptibility.

2. Generation

Electromechanical switches can generate noise depending on the load. Non-arcing loads below approximately 0.5 amp are not considered to generate noise. Arcing currents, especially those controlling highly inductive loads, such as large solenoids or relays, can generate noise. Twisting leadwire, metal overbraids, and leadwire routing can reduce or eliminate generation problems when dealing with arcing loads. Transient protection networks are usually provided on inductive devices. Proximity devices generate a weak electromagnetic field to sense the target. This can be an interference problem if the proximity devices are mounted closer than 3/4 in to each other.

c. Temperature

Typically, electromechanical switches can withstand wide temperature ranges and rapid gradient shifts without damage or operating point shifts. Most aerospace switches operate at temperatures between -55 to 85 °C with designs available from -185 to 260 °C, or more. Higher temperatures require more exotic materials that increase cost and can limit life. It should be noted that O-ring seals and elastomer boot seals tend to stiffen in extreme cold that can increase operating forces and reduce release forces or delay switch release.

Aircraft proximity sensors are currently designed for a performance operating range of -65 to 150 °C for two piece devices, and between -65 to 125 °C for one-piece designs. Proximity switch operating and release points may shift during temperature excursions, shifts of up to 5% are common. If shifts up to 5% can be tolerated, the operating temperature can be extended.

3.1 (Continued):

Reliability of the one-piece proximity sensor will typically be highest at room temperature due to the active electronics. Reductions in reliability and mean time between failures (MTBF) estimates should be made for devices which must see high temperatures or high thermal gradients, especially one-piece proximity devices with active electronics which will see this environment. Reliability and MTBF calculations for two piece proximity sensors are largely unaffected by temperature extremes since their active electronics are located in the interior electronics bay of the aircraft. Current two piece sensor designs are all metal sealed units, intended to last the life of a 40,000 cycle aircraft.

d. Sealing

Electromechanical switches range in sealing from completely open to true hermetic sealing. Hermetic sealing is defined as metal to metal or glass to metal seals with leak rate of less than 1×10^{-8} cc/atm/sec. Resilient sealing is the most common seal in the aerospace industry. These switches have O-ring seals at the plunger with glass to metal seal around the basic switch and have leak rates less than 1×10^{-8} cc/atm/sec. The factors to determine seal level in an electromechanical switch are as follows:

1. Use a sealed switch when the switch will be exposed to a dirty environment in storage, assembly, or operations.
2. Use a higher level of sealing when the contacts will not have an arcing load. Switches that have arcing loads tend to self-clean the contacts. Low energy loads tend to be more susceptible to contamination.
3. Use a higher level of sealing when it is an extremely important function or the switch may not be used for long periods.

The seals, including the O-ring material, as well as any potting material, should be compatible with fluids in the intended environment.

Current proximity switch and sensor designs have an all-metal case with an elastomer compression lead wire seal, or a hermetic connector. Sealing baseline is at 1×10^{-5} cc/atm/sec, with 1×10^{-8} cc/atm/sec available if using a connector. Proximity sensors are considered explosion proof by design. Potting materials are not currently used. Older proximity sensor designs with plastic faces meet the 1×10^{-5} cc/atm/sec criteria unless damaged by hard physical contact.