

Applying Limit Switches with Success

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Many modern machines incorporate numerous functions that are controlled electronically. For safety and reliability, these systems require sensors and limit switches acting in a monitoring role. The correct selection of switch can be crucial to effective operation

Control Products provides a number of unique switching solutions to a variety of industries ranging from commercial applications such as personal watercraft, through industrial vehicular applications, including lift trucks and various construction equipment, to sophisticated thermal sensing in aerospace applications. Most products have been derived from customer applications, where off-the-shelf solutions would not do the job. This history of customer derived applications has translated into the customer focus that drives the activities of the company.

By applying some powerful operational principles, CPI® has created a viable formula for long-term relationships with its OEM customers. The two aspects that have greatly enhanced CPI's value to the OEM are project management and absolute customer focus. The first necessarily supports the second.

APPLICATIONS

Applications for CPI limit switches are often safety-related or critical to the performance of a machine, where failure of the component would be catastrophic. Add requirements such as five million electromechanical cycles, large overtravel, precise actuation point and a hostile environment, and a home can be found for a CPI limit switch.

The aim of this article is to expand on the concept of understanding the application to optimize the specification of limit switches. Listed below are scenarios with some common pitfalls, and the solutions to these tricky applications. In instances where the application solution has yet to be found, it is to be hoped that

the information provides some helpful guidance to component specification.

APPLICATION PARAMETERS

Electrical endurance

Along with the current, voltage and type of electrical load (motor, resistive, inductive), the duty cycle should be

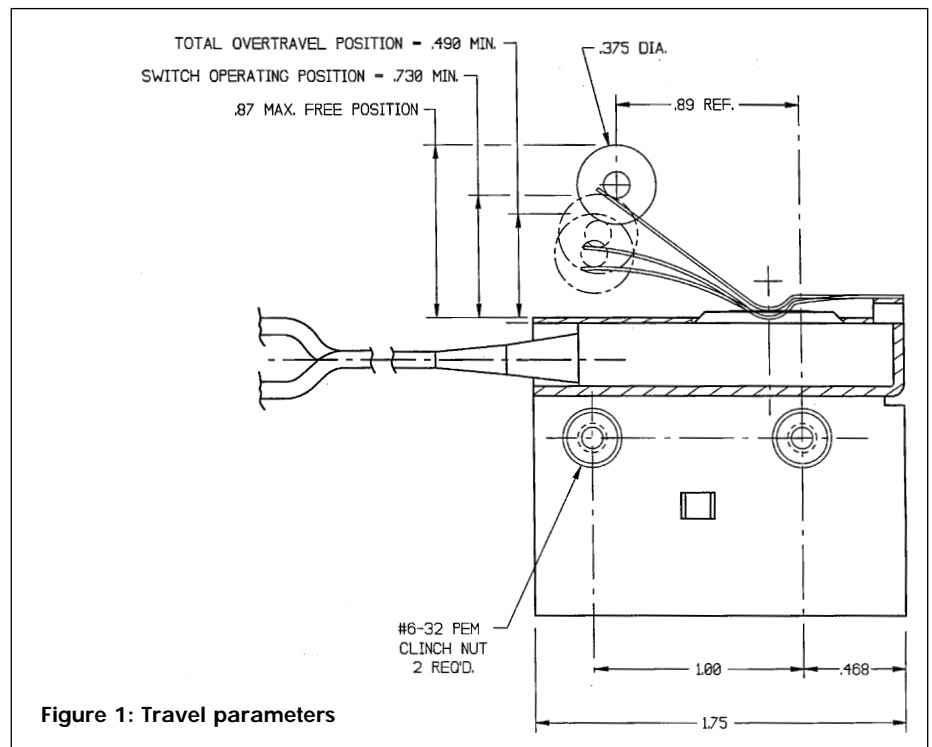


Figure 1: Travel parameters

considered. If, for example, a lamp load is specified where the filament does not completely cool between cycles, the application may not be too harsh. Conversely, the cool down period on the filament also allows heat to transfer from the switch contacts. In summary, if the golden rule 'performance test is best' is applied, surprises are avoided.

Circuit type

The type of circuit that is to be used – normally open, normally closed, single pole double throw – should be considered. Consideration to circuit type must be given in system FMEA (in other words, design for 'fail safe').

Mechanical endurance

How many times will this component be actuated to full travel? How will this component be actuated? Interface with the limit switch actuator, and how forces are applied to the switch will affect endurance.

Actuator style

The actuator that is to be used should also be taken into account – plunger, lever, roller-lever, ball. Again, interface with the limit switch actuator, desired motion, and how forces are applied must be considered.

Travel parameters

Parameters such as pretravel, actuation point, overtravel, differential should be considered. A thorough understanding of the system where the switch is installed is necessary before specifying what the switch must do. For example, Control Products has seen tolerances stack up in a system to the point that a switch would not work at all in a significant percentage of those systems.

Mounting and packaging

It is not only the performance specifications such as environmental considerations that should be taken into account, but also production assembly and servicing concerns.

SCENARIOS

Problem 1

Travel parameters: small pretravel, large overtravel, precise operating point, one million electromechanical cycles. The pitfall here is that these parameters are conflicting. Large overtravel on an actuator in this case meant significant stresses, which worked against the one million cycle objective.

Solution: this problem was actually solved in two ways in two different applications. In one case, the actuator was stress relieved through the use of FEA, satisfying all of the travel param-

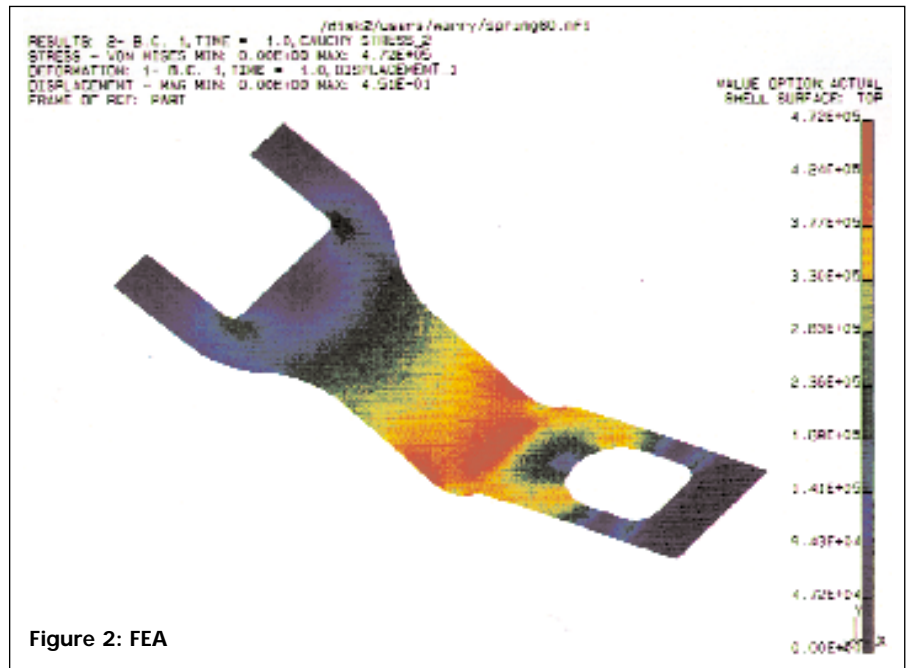


Figure 2: FEA

ters without exceeding the stress threshold of the actuator. In another application, a secondary spring was applied that eliminated excessive deflection on the actuator. In both cases, the designer questioned the traditional actuator lever design, applying minor modifications with significant results.

Problem 2

Cold temperature response time: switches, like people and molasses, move somewhat slower in cold weather. Control Products has found that its industrial grade contact mechanism had problems deactuating when left in the actuated position for extended periods of time in extreme cold, for example below -10°F . The Santoprene boot would take a set at the lower temperature, such that the return force of the moveable contact would not overcome the now harder thermoplastic cover. Please note the pitfall here is that this problem is only exhibited in performance tests where the switch is held actuated for several hours at cold temperature.



Figure 3: Cold test fixture

Solution: the solution was to be found in the company's military grade products, where the performance specification is -65°F . Rather than thermoplastic Santoprene, these units are encased in neoprene rubber. The problem with the neoprene seal is that it is a compression molding process which has a significantly longer cycle time than the injection molded Santoprene, hence a much higher cost. In addition, the neoprene process requires that the switches be sent out of the building for processing, hence less control and more cost. It was found that Control Products could combine the best of both worlds by creating a high-volume neoprene molding process and a new sealing method that eliminated the need for an outplant process.

Problem 3

Premature switch failure due to heavy electrical load: even after performing electrical endurance testing in the lab, field problems occurred. It was later learned that the tests were performed using a power supply, rather than a 12V battery, which significantly changed the load characteristics.

Solution: design modifications to contact mass and material contribute to many of the electrical load solutions. While this specific application remains unsolved, other harsh loads have been solved using diode suppression and also by observing polarity in the installation. Depending on the switch construction, performance can vary greatly when the polarity is reversed on the switch (in our case, making the stationary contact the anode improved switch performance).

Problem 4

Contact chatter due to a particular vibration: the symptoms of this problem can be misleading, as it may only occur under certain conditions. For example, a specific rpm range on diesel equipment may produce a resonant frequency causing unwanted contact closure. If the machine only passes through that rpm range for seldom-used operations, the problem is not readily traced to the switch.



Figure 4: Vibration test facility



Figure 5: Vacuum chamber

Solution: vibration characteristics of diesel-powered equipment provide many opportunities for this problem to occur. Advanced testing of the component, either on the machine or in the lab will usually identify possible problems. When specifying switches, snap action devices are generally configured to provide high-vibration resistance. Some manufacturers will offer a higher contact force calibration which improves vibration immunity.

Problem 5

Contact contamination due to environment: never underestimate what the real world will do to equipment. Where an engineer thought he was specifying components for a fairly benign environment, the end user found a new application for a pressure washer.

Solution: if the application is safety-related and there is a chance of bad weather, temperature extremes, condensation, salt air, dust, or any other contaminant, a totally sealed switch should be specified. Remember, too, the golden rule: run a qualification test.

Problem 6

High warranty cost due to improper mounting or field adjustment: providing adjustability in a limit switch design can be useful, as it helps to overcome tolerances in a system and provides flexibility

to allow use in multiple applications. The potential pitfall is that greater care must be taken during assembly. For while what happens on the assembly line can be controlled, service organizations may be less attentive to detailed assembly requirements. In some cases, Control Products has seen safety interlock features in the field disabled by the operator as adjustment problems became a nuisance.

Solution: While it would certainly be nice to purchase a single solution for all limit switch applications, it may not be the most economical route when all the costs are considered. It is generally best to minimize the adjustment required when installing components.

Control Products, Inc of East Hanover, New Jersey, manufactures a sturdy line of completely sealed, truly waterproof switches. Based on a military design, the product line has evolved into a truly versatile product for industrial applications where traditional splashproof or wash-down resistant switches do not survive. Other products manufactured by CPI include panel mount waterproof switches, and high-reliability thermal switches for products ranging from military vehicles and construction equipment, through to helicopters, regional and commercial aircraft.