Solenoids

Basics

From operating engine run/stop levers, throttles, chokes, valves and clutches to protecting expensive diesel engines from overspeed, low lube pressure and high temperature, you can rely on Synchro-Start solenoids to meet the ever changing technical demands of modern industry.

The Basic Single Coil Solenoid

A solenoid is a device that converts electrical energy into mechanical work. Solenoids are made up of a free moving steel plunger that sits within a wound coil of copper wire. When electric current is introduced, a magnetic field forms which draws the plunger in.

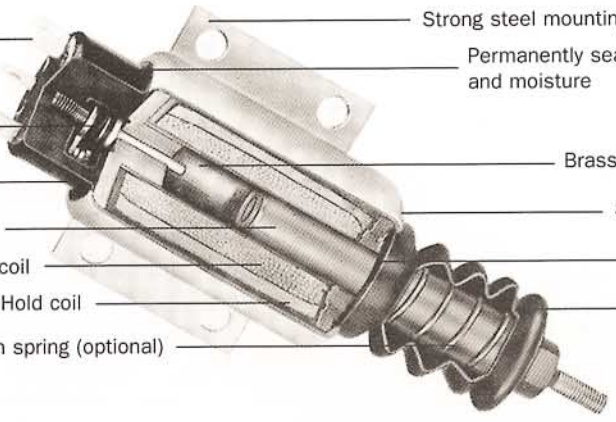
The exposed end of the plunger can be attached to equipment, and when the solenoid is activated, the plunger will move to open, close, turn on or turn off that equipment.

The Synchro-Start Dual Coil Solenoid

To allow a solenoid to be held energized for long periods of time without overheating, Synchro-Start uses two separate coil windings instead of one.

The first wound coil operates at a high current level to provide maximum pull or push. The second wound coil simply holds the plunger in place after it has completed its stroke and "bottomed out"

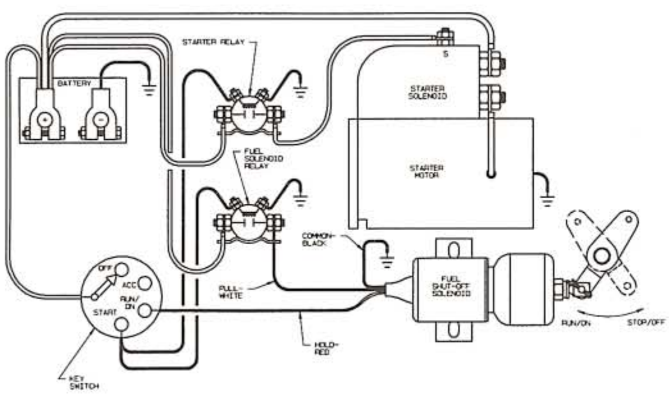
Since the current required to hold the plunger in place is low, Dual Coil Solenoids can be energized continuously without overheating. This unique design concept results in a highly efficient compact solenoid approximately 1/2 the size of a comparable single coil unit.



Basics

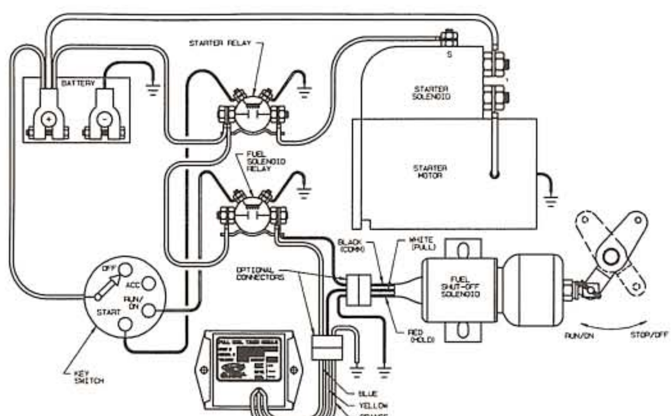
Three methods for turning off the pull coil

After energizing and pulling in the plunger, the pull coil in a dual coil solenoid must be turned off as soon as possible to prevent overheating (see Synchro-Start wiring instructions for specifications for energizing time for pull coil). There are three basic methods for switching off the pull coil as discussed below.



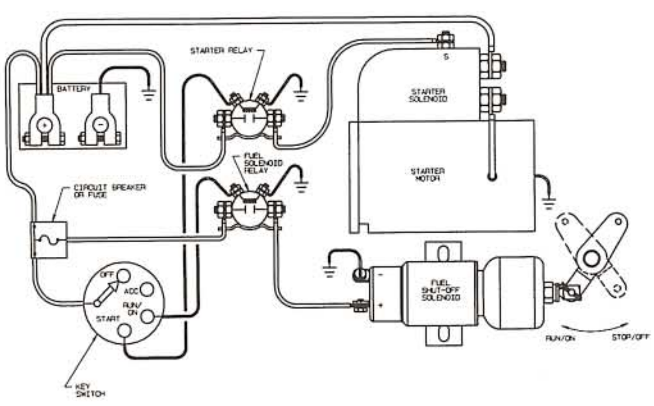
1. External Switching

The externally switched (3-wire) solenoid is used in applications where an operator/ driver manually turns a key switch that temporarily energizes the pull coil to pull in the plunger. The most popular application is for start-stop control of engines in trucks, and mobile equipment where moisture, dirt, dust, and high vibration are present. The sealed 3-wire solenoid is well suited for these harsh conditions.



2. External Switching with timer module

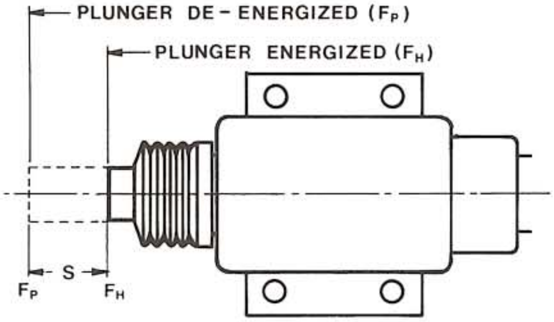
With the addition of a Synchro-Start Pull Coil Timer Module, the externally switched (3-wire) solenoid can be used not only in operator/ driver controlled vehicles, but also in unattended equipment, throttle, and choke controls. The timer ensures that the pull coil is turned off within 1/2 second after energizing, which prevents overheating of the coil in situations such as abusive overcranking of an engine.



3. Internal Switching

The internally switched solenoid utilizes a mechanical, double contact switch, mounted on the rear of the solenoid to turn off the pull coil. Best suited for applications such as standby generator sets or other applications where vibration, dirt, moisture, and excessive cycling are not present.

Solenoid Selection Factors



1. The pull or push force (Fp) required to move the plunger and load from a de-energized or non-voltage position to an energized or voltage induced position.

2. The force required to hold (Fh) the plunger and load in its energized or voltage induced position.

3. The total distance or stroke (S) the plunger travels when the solenoid is energized.

4. All solenoids are affected by temperature. The hotter the solenoid, the less work it can do because the copper coil wire resistance changes.

5. Low voltage also reduces the solenoid's work output.

To evaluate (4) and (5), use the “pull vs stroke” "voltage correction" and "temperature correction" graphs on this page and follow this example:

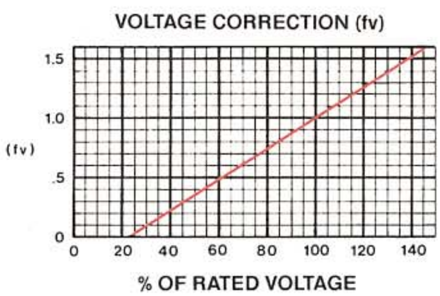
Let's assume your application requires a maximum pull force of 7 pounds at a 1 inch stroke. After looking at the "pull vs stroke" graph, the solenoid you're considering (Model 1502) has a 9 pound pull force at 1 inch stroke. We'll represent this pull force with the letters (Fo). You know the solenoid is operating at 100% of rated voltage. A quick look at the voltage correction graph, which corrects for any extreme voltages, provides a 1.0 factor. We'll represent the voltage correction factor with the letters (fv). Your solenoid is located near the engine; therefore, the ambient temperature of 122°F exceeds the normal 77°F ambient. The temperature correction graph indicates a correction factor of .83 be used. We'll indicate the temperature correction factor with the letters (ft).

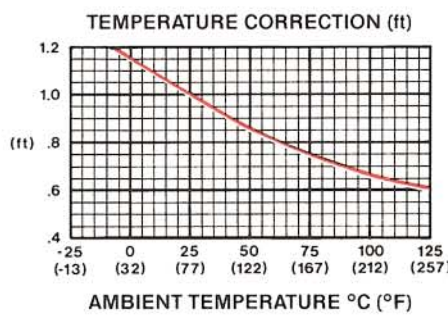
Using the formula: F=Fo x fv x ft or F=9 x 1.0 x.83=7.471bs.

Since the available solenoid force of 7.47 lbs. is greater than your required pull force of 7 lbs., the solenoid is suitable for this particular application.

Measurements for above factors must be taken in operating conditions. For example: you must start the engine and measure the force to move the lever to the stop position. The engine governor often exerts force on the stop lever, which is not apparent on a stationary engine.

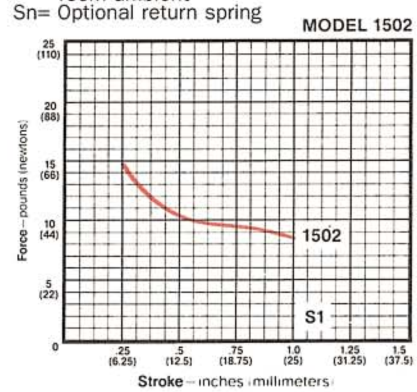
Solenoid Deration Graphs





Pull Force vs. Stroke

Fo= Force at rated voltage, room ambient
Sn= Optional return spring



Return spring deration

In some cases, an optional spring (see solenoid diagram above) is attached to ensure that the solenoid's de-energized plunger returns to its original position. For these applications, when using the "F = Fo x fv x ft" formula to determine the right solenoid, remember: As the "pull vs. stroke" graph illustrates, the addition of a return spring changes the force (Fo) characteristics. When determining (Fo) for a solenoid with a return spring, refer to the appropriate line on the graph illustrating the return spring value.

This value must be subtracted from the solenoid performance curve to assure adequate force is available under derated conditions. Using our original example, the solenoid pull force (Fo) for model 1502 at 1 inch is now 7 lbs., which is 9 lbs. minus the 2 lbs. required to begin compressing the optional return spring (S1) at 1 inch. (See 1502 chart above). Substituting 7 lbs. for (Fo) in the original example indicates: F=Fo xFv xFt or F=7x1x.83=5.81 lbs. Available solenoid force has dropped to 5.81 lbs., far below the required 7 lbs. for this application. Therefore, a solenoid model with a higher force rating such as the 1504 or 1753 would be required.

Solenoid Mounting

Location: Although the solenoid is designed to operate in harsh environments, locations with excessive heat build-up and constant exposure to liquid and particulate contaminants should be avoided.

Brackets: Must be sufficiently strong to handle solenoid pull forces, vibration and shock inherent in the application.

Alignment: The solenoid should be mounted to permit the plunger to be linked in a direct line to the load. Misalignment causes side loading and resulting friction reduces the solenoid's available force. Increasing the distance between the solenoid and the lever actuating mechanism will reduce the force lost due to side loading friction.

Solenoid position: The solenoid should be oriented with the plunger pointed vertically down or at some downward angle. If the plunger is pointed up, contaminants may collect in the plunger bore, affecting long term operation.

Solenoid Linkage

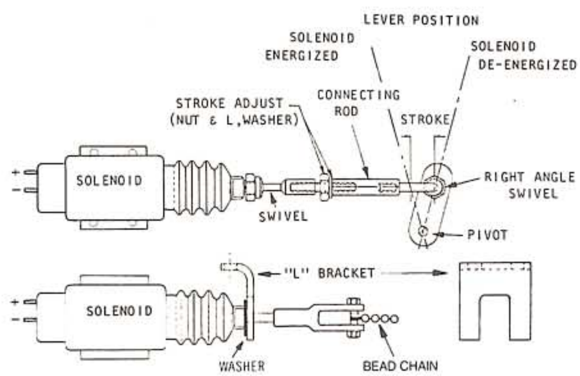
The connecting link between the solenoid and its intended application is known as the solenoid linkage. For the internal switch to automatically disconnect the high current pull coil, solenoid linkage systems must allow the plunger to move completely into the solenoid body and "bottom out" without binding. Failure to "bottom out" will cause an internally switched solenoid to burn out and an externally switched solenoid to "drop out". Solenoid linkage can take several forms: A rod threaded at both ends, a bead chain, a cable, etc.

Rod: When a connecting rod is employed, the stroke is adjusted by turning the rod on its threads and locking the rod in place with a lock washer and nut. The solenoid should be energized during adjustment.

A swivel joint should be incorporated with this type of linkage system to compensate for possible misalignment between the connecting rod and solenoid plunger.

Bead chain or cable: When linkage is in either of these forms, the solenoid should be energized and the bead chain or cable length adjusted to give the desired lever position.

Plunger travel: Plunger travel must be checked, especially when a bead chain or cable is used in a connecting device. The plunger travel must be limited to the solenoid's rated stroke when it is de-energized. An "L" bracket can be used to limit the plunger travel. (See solenoid linkage diagram below).



Solenoid Voltage

Solenoid Series	1502/1753/1757		1504/1751/ 2001/1756		2003/2370	
Volts	12	24	12	24	12	24
Wire Thickness						
16 gauge or $1.5mm^2$	-	-	-	21	-	-
14 gauge or $2.5mm^2$	12	40	9	34	5	9
12 gauge or $4.0mm^2$	19	64	14	54	9	14
10 gauge or $6.0mm^2$	20	102	23	86	14	23
	Wire length (ft.)					

To minimize voltage loss and resulting solenoid force deration, this chart should be used to select the proper wire thickness based upon the total wire length from the battery to the solenoid and back to the battery.

Solenoid Current

Solenoid Series	1502/1753/1757		1504/1751/ 2001/1756		2003/2370	
Volts	12	24	12	24	12	24
Slow Blow Fuse Type 3AG	8	6	12	7	20	10
Breaker Amps Max	8	6	12	7	20	10

To protect solenoids from permanent overload damage, a well designed system will include an overload protection device. This chart indicates proper fuse and circuit breaker ratings to incorporate into the wiring system.

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ENGINE MANAGEMENT SYSTEMS AND CONTROLS

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