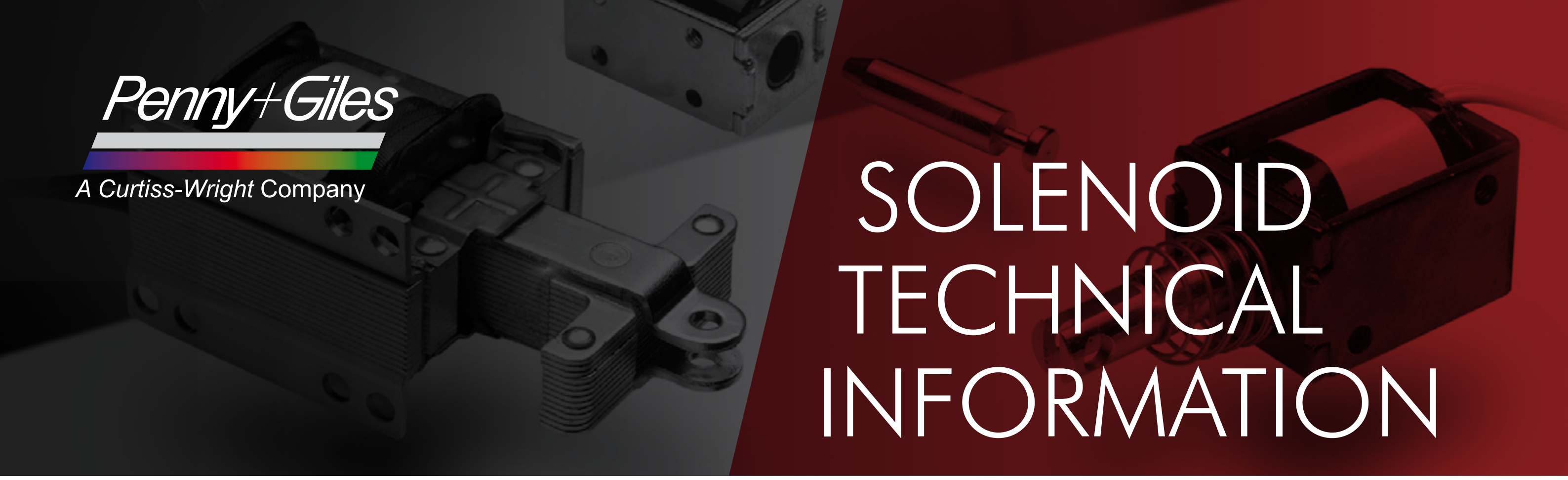


Penny+Giles
A Curtiss-Wright Company

SOLENOID TECHNICAL INFORMATION

1. INTRODUCTION

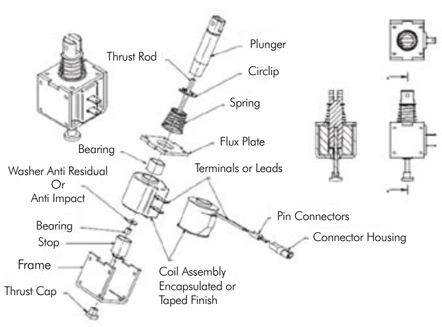
A large number of application possibilities, simple design and long service life make Penny+Giles solenoids cost-effective solutions for the most selected problems.

Applications range from general machine construction through plant engineering, vehicle construction, robotics, precision mechanics, household appliances and medical technology to hydraulic and pneumatic controls.

High reliability, long service life and high efficiency are all requirements that are met by Penny+Giles solenoids through precision manufacture, tight tolerances and suitable surface treatment. Customer-related solutions are developed in conjunction with the customer.

2. OPERATION

Solenoids transform electrical energy into mechanical movement.



3. DIRECT CURRENT (DC) SOLENOIDS

Contrary to an alternating current (AC) solenoid, the power consumption of a direct current (DC) solenoid is independent of the position of the plunger. DC solenoids are also characterised by soft and hard operation.

Inherently longer cycling times can be reduced by special circuitry. It is also possible to modify the stroke-force characteristics. High switching frequencies do not cause dangerously high thermal loads in DC solenoids; the maximum switching frequency is only limited by the pull-in and drop-out times.

4. ALTERNATING CURRENT (AC) SOLENOIDS

Unlike DC solenoids, AC solenoids provide relatively high operating/cycling frequencies and low cycling times; this results in hard operation which influences service life. Power consumption depends on the position of the plunger.

High cycling frequencies can cause dangerously high thermal loading in AC solenoids and the maximum permissible temperature is therefore the limiting factor for cycling frequency.

5. FORCE

Usually, the correct solenoid for a given application is the smallest one that has adequate magnetic force.

5.1. Magnetic force

The magnetic force in Newtons is the usable portion (i.e. that portion which is reduced by friction) of the mechanical force that is produced by the solenoid. It is measured at 90% of the rated voltage at normal operating temperature.

5.2. Holding force

The holding force of a solenoid is the force that is effective at the end of the stroke.

5.3. Residual force

The residual force, generated by any remaining (residual) magnetism, is the holding force that still applies after the electrical power is stopped. This force can be influenced by design features.

5.4. Return force

The return force is the force required to return the plunger from the end of stroke to the start of stroke.

5.5. Magnetic force / stroke characteristic

Traditional curves indicate the plunger movement toward the final (energised) position.

6. STROKE

The stroke is the usable distance travelled by the plunger from its initial position to the end of travel. As the stroke is increased the force is reduced and vice versa.

6.1. Start of Stroke

This is the position of the plunger before it starts its travel. It is also the position when it returns upon conclusion of the complete cycle.

6.2. End of Stroke

This is the designed final position of the plunger upon conclusion of the work portion of the complete cycle.

6.3. Stroke work

For the linear solenoid, the stroke work (in Newtons) is the magnetic force over the magnetic stroke.

A solenoid is the correct size if the magnetic force exceeds the opposing force at all times with only a slight amount of excess force to ensure long service life.

A solenoid is too small if the magnetic force is less than the opposing force over a certain range.

7. TIME TERMS

The use of solenoids necessitates a certain chronological sequence best clarified with the following terms:

7.1. Power-off pause

The power-off pause (in seconds) is the time between switching off the current and switching it on again.

7.2. ON period

This is the period (in seconds) between switching the current on and off again.

7.3. Cycle period

This is the sum of the ON period and the Power-off pause.

7.4. Duty cycle

The ratio between the ON and the cycle period is the relative ON period in %.

7.5. Cycling sequence

The cycling sequence (in seconds) is the single or periodically repeated joining of cycle period values of very different durations.

7.6. Response time

The response delay (in seconds) is the time between application of the current and initial movement of the plunger.

7.7. Stroke time

This time (in seconds) starts when the plunger begins to move from its initial position and ends when it reaches its limit of travel.

7.8. Pull-in time

The sum of Response time and Stroke time is the time required by the plunger to perform its work. Special measures in the circuit can shorten the pull-in time.

7.9. Drop-out delay

Drop-out delay (in seconds) is the time from current cut-out until the plunger starts to return to its initial position.

7.10. Return time

The return time (in seconds) is the time from the beginning of plunger return motion until it has reached its initial position.

7.11. Drop-out time

The sum of Drop-out delay and Return time is the drop-out time (in seconds).

8. TEMPERATURE TERMS AND CLASSES OF INSULATING MATERIAL

When selecting a suitable solenoid, temperature must be considered.

8.1. Ambient temperature
The ambient temperature is the temperature (°C) surrounding the solenoid when it is operating. If the range is outside +40°C to -50°C design changes may be required.

8.2. Permanent operating temperature
The permanent operating temperature (in °C) is equilibrium reached between the heat generated by the solenoid and that escapes. Equilibrium has been reached when the temperature changes by no more than 1°C in an operation period of 60 minutes. It is determined on a thermally non-conductive support in still air at the rated voltage.

8.3. Reference temperature
This temperature (in °C) is the constant temperature of the solenoid. This temperature may differ from the ambient temperature if, for example, the solenoid is mounted on a hydraulic valve which has warm hydraulic oil flowing through it.

8.4. Differential temperature
This is the number of degrees (°C) between the temperature of the solenoid and that of the cooling medium designated for the solenoid.

8.5. Limiting temperature
The upper limiting temperature (in °C) is the highest temperature permitted for the solenoid or any part thereof. The lower limiting temperature (in °C) is the lowest temperature permitted for the solenoid or any part thereof.

8.6. Maximum temperature above normal
This is the maximum permissible number of degrees (°C) of Differential temperature.

8.7. Thermal insulation classes
Thermal insulating materials are divided into the following classes based on their thermal resistance.

Thermal Insulation Class	Maximum Temperature (°C)	Maximum Temperature Rise
Y	90	50
A	105	65
E	120	80
B	130	90
F	155	115
H	180	140

9. ELECTRICAL TERMS

If solenoids are to operate reliably, they must be provided with suitable power; the following are a few terms to aid in understanding:

9.1. Nominal voltage
The nominal voltage is that with which a solenoid is normally operated, the tolerance is +5% to -9%.

9.2. Nominal current
The nominal current given in the data sheets is always referenced to the rated voltage and a winding temperature of 20 °C.

9.3. Nominal power
The nominal power (in W) is calculated from the rated voltage and current (at a winding temperature of 20 °C) given in the data sheets.

9.4. Test voltage
Solenoids are tested for electrical insulation and dielectric strength at a certain test voltage that lies above the rated voltage. The test voltage is applied between the exciter winding and the metal parts of the unit that can be touched.

10. PROTECTION CLASSES

Protection can be divided into three classes:

- Class I – voltage-carrying parts have only an operating insulation and a connection for the neutral line
- Class II – operating and protective insulation provided but no connection for the neutral line
- Class III – operates at less than 42 Volts and has no circuit designed for any higher voltage

10.1. Types of protection
The following types of protection are standardised in IEC 60529. They concern protection against touching, foreign bodies and humidity.

IP 65 is a common example where IP is the code for the standardised type of protection, the first digit relates to touching or the entry of foreign bodies and the second digit concerns protection against the penetration of water.

First Digit	Protection against touching and foreign bodies
0	no protection
1	protected against large foreign bodies
2	protected against medium-sized foreign bodies
3	protected against small foreign bodies
4	protected against grain-sized foreign bodies
5	protected against dust deposits
6	protected against dust entry

Second Digit	Protection against water
0	no protection
1	protected against vertically falling water
2	protected against water falling at an angle
3	protected against sprayed water
4	protected against splashing
5	protected against water jets
6	protected in case of flooding
7	protected in case of immersion
8	protected in case of submersion

11. SAMPLE CIRCUITS

Suitable circuitry will influence the operating times and service life of the solenoid.

In an AC circuit the over-voltage at cut-off is fully damped, however this severely delays the drop-out time.

In a DC circuit the over-voltage at cut-off is not damped. This circuit usually uses magnetic units of low electrical power in order to shorten the drop-out time. There are ways of reducing the contact wear of DC solenoids.

12. DAMPING

There are three ways of damping solenoids:

12.1. Damping by Ohmic resistance
A parallel resistor can be used to limit the voltage surge that occurs when the power to the solenoid is cut-off. As a result, however, the drop-out time increases as does the power requirement. Both are reduced as the parallel resistance is reduced.

12.2. Damping by Varistor (voltage-dependent resistor)
A Varistor may be used to damp the voltage surge at cut-off. This causes only a slight rise in power requirement.

12.3. Damping by diode
Diodes will completely damp the cut-off surge voltage, however the drop-out time will be greater.

13. VARIABLE CURRENT (E.G. USING A RESISTOR)

Varying the current applied makes it possible to use a smaller solenoid. To prevent the winding from overheating the current is limited by a resistor after the plunger reaches the end of the stroke. This circuit cannot be used with high operating frequencies. The size of the dropping resistor depends on the resistance of the winding.

14. INSTALLATION GUIDELINES

- DC solenoids may be installed in any position.
- AC solenoids are prone to buzzing if they are not installed squarely in the application.
- The plunger should only be used in the axial direction.
- In order to achieve maximum service life solenoids should be loaded with at least 70% of the magnetic force.
- It is imperative that voltage, ON period, temperature and protection be checked before a solenoid is operated.
- If a neutral lead is required, it should be provided and fitted by the customer in compliance with VDE 0100.

15. SOLENOID SPECIFICATION

To help us identify the correct solenoid for your application, please provide us with as much of the following information as possible:

- Model Number
- Voltage
- ON period
- Stroke (in mm)
- Magnetic force / stroke characteristics
- Ambient temperature
- Stroke force (in Newtons)

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