

Technical explanation: Push and pull electromagnets

Every product made by NAFSA fulfills the European Directive 2006/95/CEE about the electrical appliances and certain voltage limits.

Made according to the following norms: DIN VDE0580, UNE-EN 60204-1, NFC79300.

BASIC CONCEPTS

FORCE

Magnetic Force (F_m):

It is the force developed by the solenoid measured in the stroke direction.

Effective Force (F_h):

It is the magnetic force (F_m) after adding or subtracting the plunger and the spring weight.

Final magnetic Force:

It is the magnetic force obtained in the solenoid after finishing the stroke using standard power.

Remanent Force:

It is the force remaining after switching off the current.

Returning Force:

It is the force needed to make plunger back to its initial position, after turning off the power.

STROKE

Magnetic Stroke (s):

It is the distance the plunger has to do from its initial position to the final one.

Initial Position (s_1):

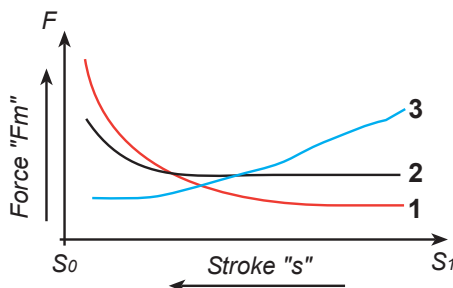
It is the position in which the plunger starts the stroke and where it comes back after return movement.

Final Position (s_0):

It is the position the plunger reaches after finishing the stroke, being the stroke at 0mm.

Characteristic curve- Magnetic Force- Stroke:

It is the graphic about the magnetic force according to the plunger stroke. You can distinguish three characteristic curves in final position (s_0) direction.



- 1- Rising curve: suitable to work against spring
- 2- Horizontal curve: suitable to work against constant forces
- 3- Decreasing curve: manufactured under demand.

VOLTAGE, CURRENT AND POWER

Standard Voltage (U_n):

This is the value supposed for the solenoid correct performance. A variation between +5% and -10% is admitted.

Standard Current (I_n):

It is the electrical current going through the coil at the standard voltage, being the coil temperature 20°C. The current in amperes is calculated dividing the Power (W) shown in the catalogs by the standard voltage (U_n).

Standard Absorbed power (P_n):

It is the power absorbed by the coil being fed at the standard voltage and 20°C (coil temperature). It is calculated multiplying standard voltage (U_n) and standard current (I_n).

Resistance:

Manufacturing tolerance will be $\pm 10\%$.

Maximum performance room temperature: 55°C.

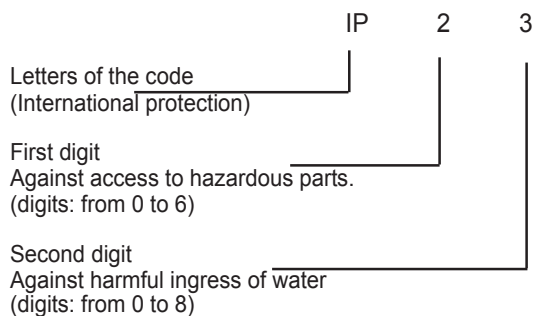
Protection types:

All material surfaces are protected against corrosion by using galvanotecnical treatments, following the UNE-EN 12329 norm.

Protection against ingress of solid objects, such as dust, accidental contact or water-CEI-IEC 60529 (IP code) norms.

DESIGNATIONS:

IP code disposition according to EN 60529 norm.
Protection rates provided by steam casing.

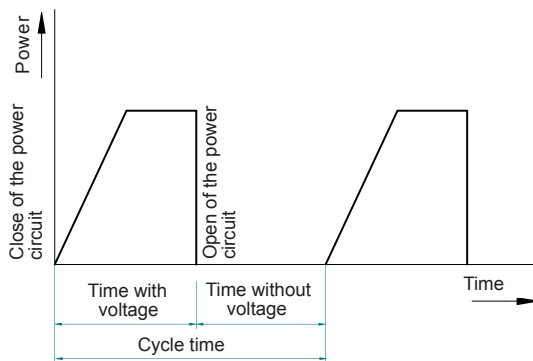


NOTE: The higher the value of the digits is, the higher the protection will be.

Under demand: we can adapt our products to different rates of protections specified in the data sheets.

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PERFORMANCE CYCLES



Time with voltage:

Time passed between connection and breaking.

Time without voltage:

Time passed between breaking and connection.

Cycle time:

Time passed adding the time with voltage to the time without.

A programme time:

One or some cycles that happen repetitively.

Working cycle:

The movement the plunger makes from initial (S1) to final position (S0), and from final to initial position.

Number of cycles:

The number of performance cycles.

Cycle frequency:

The duty-cycle per hour.

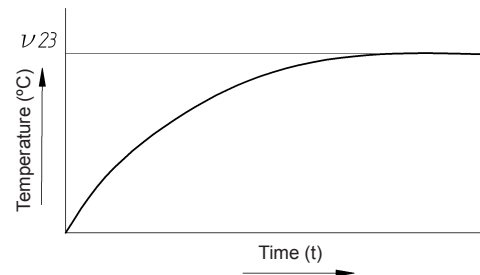
Duty-cycle(ED%):

It is the result of dividing time connected between the total cycle expressed as a percentage.

PERFORMANCE CONDITIONS

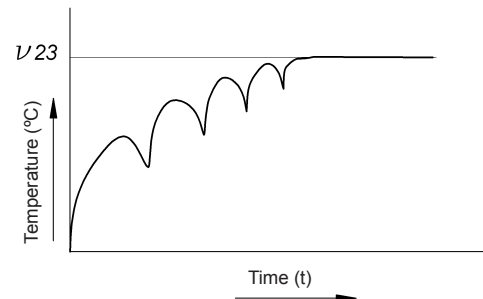
Continuous operation:

The duration of the solenoid on is so long that the performance temperature is achieved. For this kind of performance, solenoids with 100% duty-cycle (ED) must be selected.



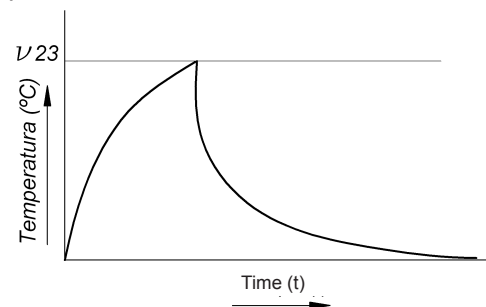
Intermittent Operation:

In this type of operation mode, the time on and off alternate, following a regular or irregular pattern. The time off is so short, that the solenoid cannot get cooled to the room temperature.



Short time operation:

The time on is so short that the solenoid cannot get the working temperature. The time off is long enough for the solenoid to get cold and achieve the room temperature.



How to obtain the duty-cycle (ED%):

$$ED\% = \frac{\text{Time with voltage}}{\text{Time with voltage} + \text{Time without voltage}} \times 100 = \frac{\text{Time with voltage}}{\text{A cycle time}} \times 100$$

Example: Time under voltage: 1 second ; Time without voltage: 4 seconds

$$ED\% = \frac{1}{1 + 4} \times 100 = 20\%$$

It is desirable choosing higher duty-cycle than the one obtained in the formula to avoid overheating. Depending on the force needed different duty cycles can be chosen such as ED% 25%, 40% or 100%.

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TEMPERATURE AND INSULATION

Insulation class:

It is the working temperature limit of the materials used in the solenoid manufacture. Normally, insulation class B is used (130°C). These temperature limit may admit a variation of 5K (K=5°C). Under demand, we can manufacture our products in class F (155°C) even class H (180°C)

Insulation class chart:

Insulation class	Temperature limit(C°) V ₂₁	Heating limit (K) (Room temperature 35 C°)
Y	90	50
A	105	65
E	120	80
B	130	90
F	155	115
H	180	140
C	200	>200

Reference temperature V₁₁ (°C):

It is the constant temperature of the solenoid without voltage.
Sometimes it can be different from V₁₃.

Minimum room temperature V₁₂ (°C):

The lowest temperature admitted to the correct working of solenoid.

Room temperature V₁₃ (°C):

The temperature of the place where the solenoid is going to work.

Maximum room temperature V₁₄ (°C):

The highest admitted room temperature for the correct solenoid performance.

Room temperature range ΔV_{15} (°C):

It is the difference between maximum and minimum admitted room temperature.

Initial temperature at the beggining of the test V₁₆ (°C):

Room temperature at the beginning of the test.

Temperature limit V₂₁ (°C):

The maximum admitted temperature for each solenoid.

Temperature limit range ΔV_{22} (°C):

Difference between V₂₁ and V₁₂.

Working temperature V₂₃ (°C):

Temperature reached by the solenoid when it is under constant nominal voltage. $V_{23}=V_{13}+\Delta V_{31}$

Temperature rise ΔV_{31} (°C):

It is the temperature difference between initial room temperature and the working temperature

Final temperature rise ΔV_{32} (°C):

It is the temperature rise on the solenoid above room temperature due to constant voltage on the coil.

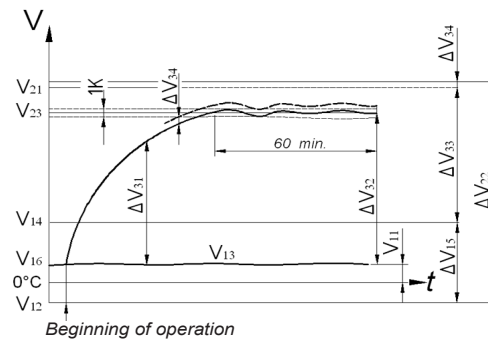
Limit temperature rise ΔV_{33} (°C):

The maximum admitted temperature over the room and coil temperature working at nominal voltage.

Difference between hotspots ΔV_{34} (°C):
It's the difference between the average and maximum temperatures on the coil.

Temperature graphic:

The temperature are shown in C° and the temperature differences in K (5°C)



REMARKS: We consider the temperature balance is reached when the temperature variation in 60 minutes is less than 1K.

WORKING ROOM CONDITIONS

Room temperature:

Room temperature must be equal or less than 40°C and its average during 24h cannot be higher than 35°C. Furthermore, the temperature cannot be lower than -5°C.

Altitude:

The altitude where the solenoid is installed cannot be higher than 1000m above sea level.

Enviroment conditions:

NAFSA solenoids must be protected from enviroments containing a huge quantity of dust, dirt, corrosive gases, steam, sea air, etc...

Relative humidity:

The humidity in the enviroment must be under 50% at 40°C. At lower temperature higher relative humidity can be admitted, for example at 20°C- 90% humidity. Occasional condensation in the enviroment must be avoided.

Treatment against corrosion:

The coatings used by NAFSA can range from 25 hours to 400 hours in salt spray chamber. Zined solenoids (resistance up to 200 hours salt spray chamber) such as ER, ERC, ECM, ERD, ERB, ECI series and Holding electromagnet. Solenoids with Cataphoresis or Geomet (resistance up to 400 hours in salt spray chamber) such as ECH CU, ECR series.

Under demand we can apply other coatings according to the requirements of each application.

Special working conditions:

If normal working conditions cannot be assured, special solutions will be adapted, such as stronger insulation, special coating or protection... The temperature limit admitted will depend on the limit of the insulation materials used in the coil.

Technical explanation: Holding electromagnets

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Holding electromagnets TYPES

Electropermanent holding electromagnets with incorporated magnet:

The attraction and holding of the ferromagnetic material is made by permanent magnets incorporated in the product. It has not got any plunger, its magnetic circuit is opened. Apart from the permanent magnets there is a coil mounted in, when this is fed, cancels part of the magnet field of the magnets allowing to loose the piece. When the coil feeding stops, the product recovers its initial force.

Electromagnetic holding electromagnets:

The attraction and holding of the ferromagnetic material is made when the coil is turned on. It has not got any plunger, its magnetic circuit is open. When the coil is turned off, the piece drops.

BASIC CONCEPTS

Ferromagnetism:

It is the magnetic property of the materials with $\mu_r \gg 1$ permeability.

Magnetic poles: (North =N) (South =S).

Attraction faces: where the ferromagnetic materials are held, and the points where the magnetic flux (Φ) goes in and out.

Holding force (Fm):

The force perpendicular to the attraction faces needed to hold the attracted piece.

It is shown in the specification sheets and it refers to the whole contact face.

Side force (FL):

It is the parallel force needed to loose the attracted piece.

Depending on the finish of the attracted piece, the force (FL) may vary between 20% and 35% of the holding force (Fm).

Air gap (δ_L):

It is the medium distance between the attraction face of the holding electromagnets and the ferromagnetic piece surface.

The shape and the roughness of these two surfaces and the non-magnetic materials between them, such as galvanic protection, dust, etc... determine its value.

Standard Voltage(Un):

It is the value for which the holding electromagnet coil has been made.

Duty-cycle (ED%):

It is the value obtained dividing the connection time and the total cycle duration expressed in %. Standard holding electromagnets are prepared for a ED100% duty-cycle.

Remanence (Br):

It is the force the electromagnet uses to hold the ferromagnetic piece after cancelling the magnetic field. Its approximate value is 5% of Fm depending on the piece (size, roughness, material, etc..)

Polarity inversion:

To cancel the remanent magnetism of the attraction face in electromagnetic holding electromagnets after cutting voltage feeding, a reversal of polarity with limited duration and intensity is needed.

Standard power demand(Pn):

It is what each holding electromagnets demands.

Hot rate:

Holding electromagnet temperature rising over determined room temperature due to power absorption under voltage. If nothing against is indicated, temperature for reference will be 35°C.

Material insulation class:

Correspondence between coil insulation and a temperature limitation of the material used for coils manufactured. Normally, B thermal class insulation (130°C) is used.

Maximum performance room temperature:

55°C.

Protection types:

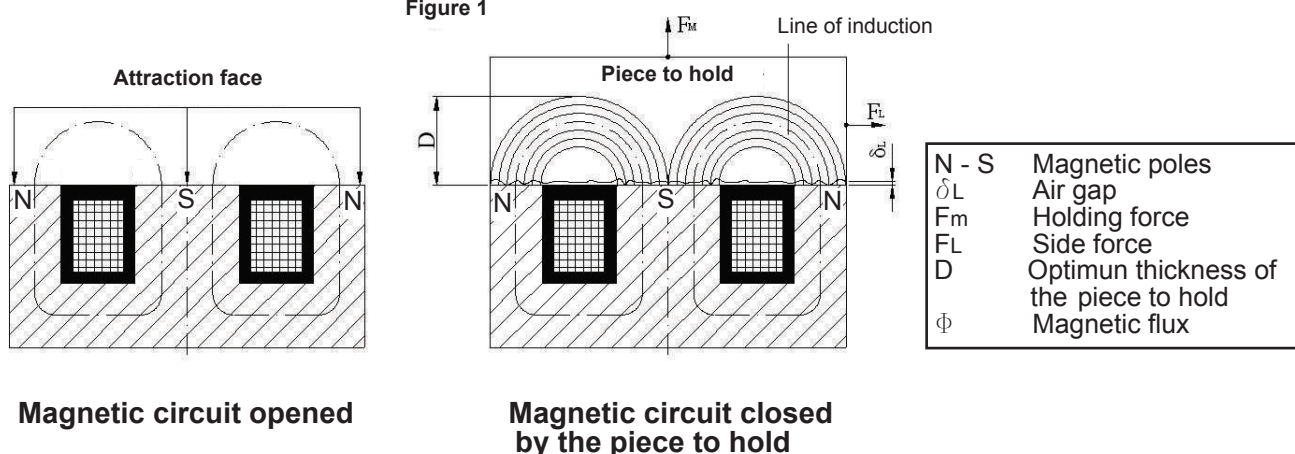
This products have protection against corrosion using galvanic treatments. UNE-EN 12329 Norm. Protection against intrusion of solid object dust, accidental contact and water.. CEI-IEC 60529 (IP code) Norm.

To obtain the duty-cycle (ED%):

$$ED\% = \frac{\text{Time on}}{\text{Time on} + \text{Time off}} \times 100 = \frac{\text{Time on}}{\text{A cycle duration}}$$

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Figure 1



Magnetic flux Φ :

These electromagnets generate on the surface of the piece to hold a magnetic field between North and South poles.

When bringing near the piece to hold to the magnetic circuit, it is closed by it, so the magnetic flux increases. The number of force lines per cm² that crosses perpendicular a surface, is the flux density also called magnetic induction B.

Piece to hold and surface of contact:

Surface of contact between the electromagnet and the piece to hold is the attraction face of the holding electromagnet, and the surface of the piece to be held will be the one in contact with holding electromagnet's attraction face.

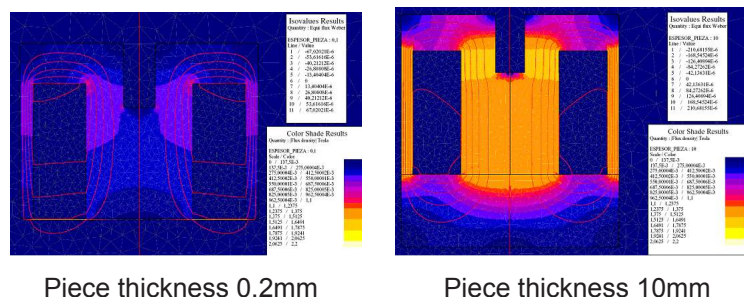
Holding force on the attraction surface is practically constant.

The piece to hold determines the maximum holding force value (F_m). It depends on the size and thickness of its contact surface.

For a field intensity H determined by a magnet or a coil, the induction that can be reached depends on the material type to handle. $B=f(H)$. See figure 2.

In the same electromagnet the holding forces may vary due to the magnetic properties of the material to hold. Among other things, saturation induction of the material determines the maximum holding force.

Magnetic field and field lines behaviour depending on the thickness of the piece to hold.



The material of the piece to hold:

Material used in electromagnets manufacturing where the magnetic field takes place, is made of soft iron, with high magnetic permeability.

Internal structure and composition vary depending on the different materials. Carbon impurities, chrome, nickel, manganese, molybdenum, copper, plumb, etc... reduce the magnetic conductivity. The tempered pieces present a further reduction of the holding force, the harder tempered is, the worse conductivity will be.

Imantation curve of several materials.

Figure 2

