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Linear Solenoids Technical Notes

1. Definitions according to VDE 0580*

1.1 Linear solenoids

A **single acting solenoid** is a unit in which the linear stroke motion from a start position to an end position results from electro-magnetic forces. The return action is effected by some other external force mechanism.

Double acting solenoid (with neutral position). The stroke is made by energization of the solenoid in one of two opposite directions from the neutral position. Return action to the neutral position is provided by some other force mechanism. The neutral position is therefore the start position for both stroke directions.

Reversing linear solenoid (without neutral position). The stroke is made from one end position to the other when energization occurs. The end position in one direction is therefore the start position for the other opposite direction.

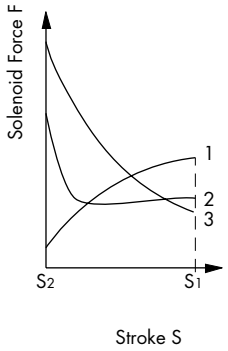
1.2 Mechanical data

Solenoid force (F) is the useful force developed in the direction of the stroke after allowing for the frictional loss.

Stroke force is the solenoid force available for operating on coupled components in the direction of the stroke.

a Horizontal stroke
Stroke force = Solenoid Force

b Armature weight acting in stroke direction (vertical mounting).
Stroke force = Solenoid Force + Armature weight



c Armature weight acting opposite to stroke direction (vertical mounting).
Stroke force = Solenoid Force - Armature weight

Solenoid Stroke is the distance moved by the armature from the start to end position.

Start position (s 1) is the position of the armature before commencing the stroke, or else after completion of the return.

End position (s 2) is the position reached after completion of the stroke.

.3 Solenoid stroke force characteristic

Three particular characteristics can be identified for solenoid operation.

1. Decreasing characteristic
2. Horizontal characteristic
3. Increasing characteristic

2. Mounting instructions

Threaded holes are indicated on drawings for fixing purposes. Screw length should be selected such that the coil cannot be damaged.

Side loads on the armature should be avoided, since increased frictional forces reduce operational life and function is impaired.

When the cooling process is improved by an additional cooling surface, the permissible relative duty cycle can be increased.

Blind holes are treated with an oily anticorrosive agent. This might be important to know when screws with safety varnish are used.

* Based on VDE 0580. The abstracts are reproduced with the approval of VDE-Verlag-GmbH, Berlin, Germany.

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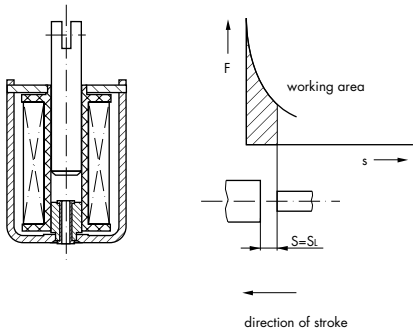
3. Armature systems and directional force diagrams

3.1 Flat face armature and flat core face



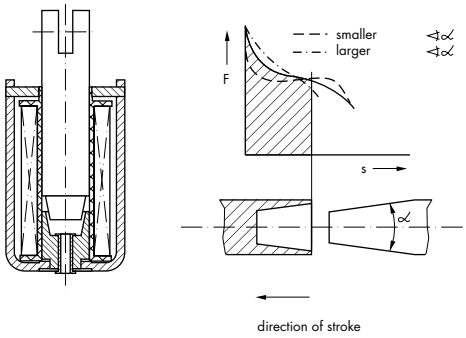
In this system, the magnetic air gap corresponds to the stroke of the solenoid armature. As induction in the air gap effects a quadratic response in force F,

$$F = \frac{B_L^2 \cdot A}{2 \cdot \mu_o} \quad \text{with} \quad B_L = \frac{\mu_o \cdot N \cdot I}{s_L}$$

B_L = induction in the air gap
A = pole surface of armature
μ_o = air permeability
μ = effective permeability
N = number of windings of coil
I = current
S_L = air gap between core and armature

a sharply rising stroke vs force curve results at the end of the stroke. Main applications are where a high end force at small strokes is required.

3.2 Conical face armature and conical core face

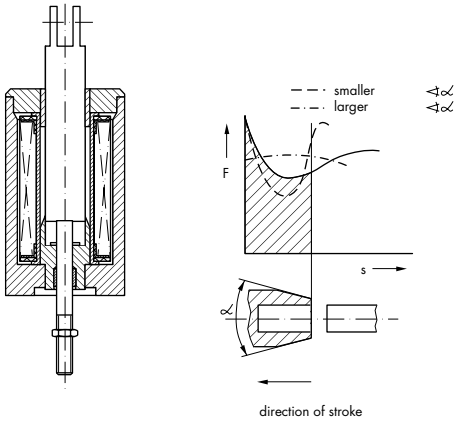


With armature and core faces of conical shape, the directional force curve is determined by three values:

a) Change in surface area of the air gap
b) decrease of the air gap
c) the axial force component of the air gap, given by the angle for the core conus.

It is thus apparent, that this system offers more possibilities for application than 3.1. Depending on the angle of the conus the stroke vs. force curve can be fixed from nearly horizontal (small angle) to steeply increasing (large angle).

3.3 Flat face armature inside a hollow cylinder with external conical shape



In this system, a flat face core enters a hollow cylinder. The air gap between cylinder and armature remains constant throughout the stroke. The length of the cylinder equals the stroke. A force in the direction of the axis is effected by the increase of the magnetic field, corresponding to the air gap area. The conical design on the outside of the cylinders influences the stroke vs. force curve from a horizontal direction (small angle) to steeply decreasing (large angle). The flat face of the armature aids towards an increased end force at the end of the stroke.

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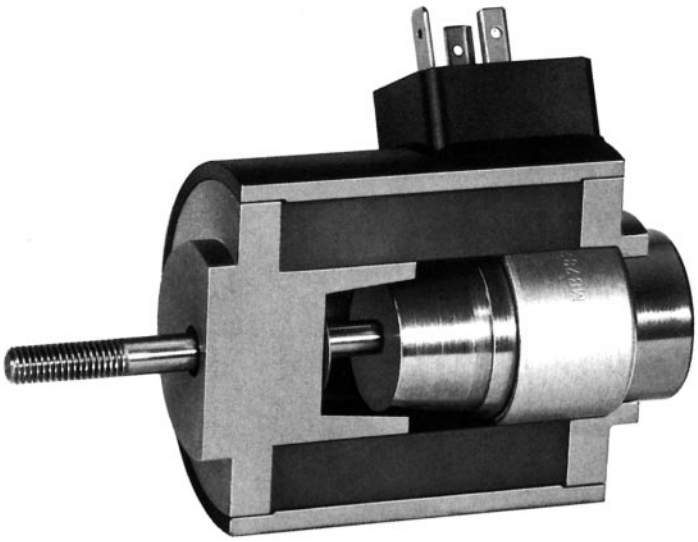
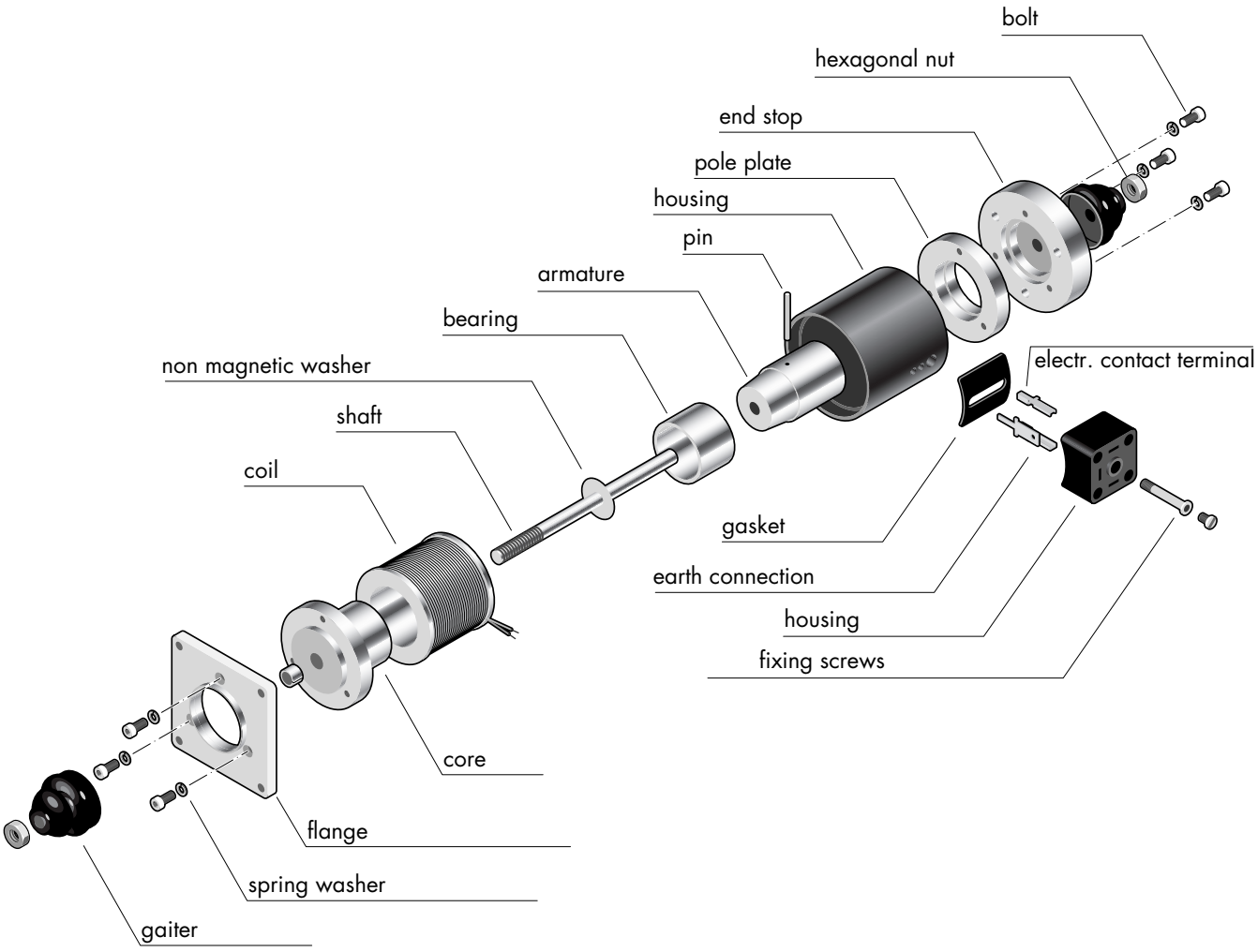
4. Detailed diagram of a heavy duty linear solenoid, series RM



Sectional view RM



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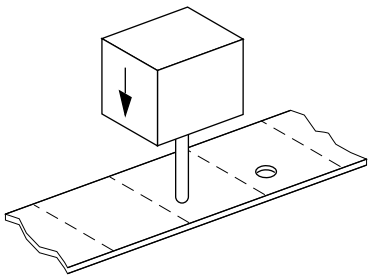
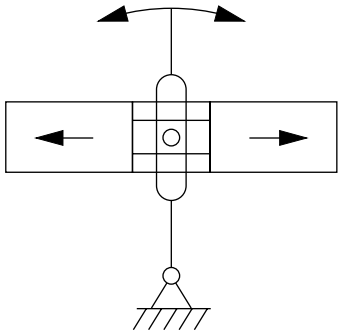
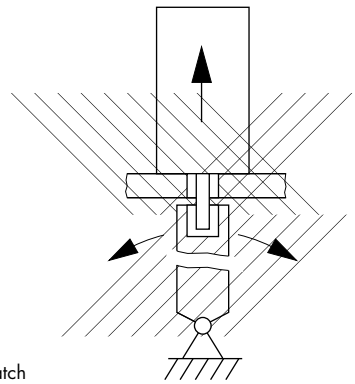
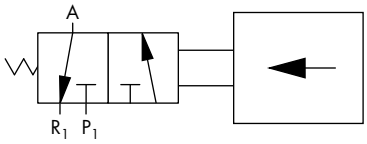
5. Examples of application

Linear solenoids are a contribution to automation. Below, please find some examples of how they can be used.

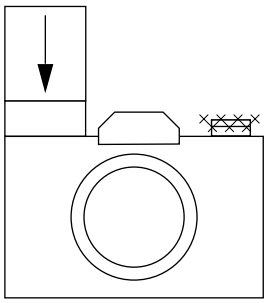

Ticket cancellation

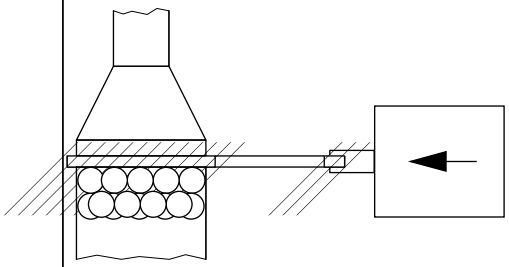

Diverter

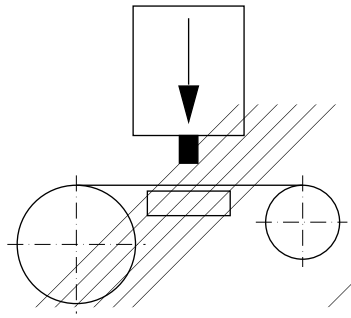

Latch

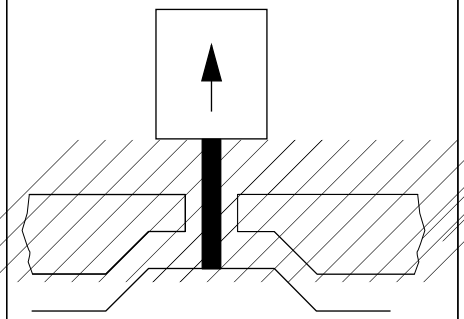


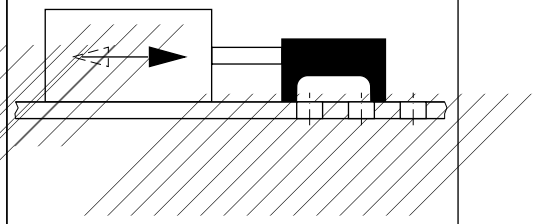
Valve actuator

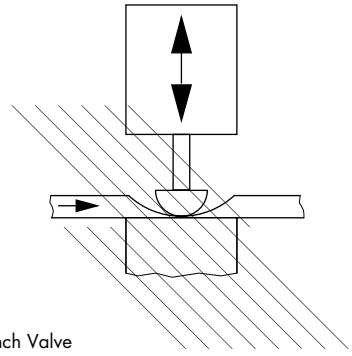

Initiator

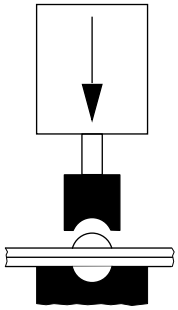

Measuring bulk

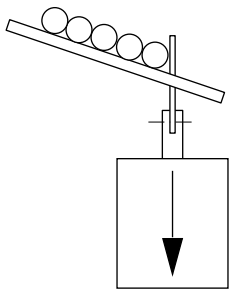

Print, Stamp, Mark


Ventilator


Mover


Pinch Valve


Rivet punch


Lock