Technical Explinations for - D.C. Solenoids

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Product group

G XX

Contents

Contents

1. Designs, Components and Types

1.1 Designs

-D.C. Solenoids are manufactured and delivered according to the relevant regulations and standards, especially to the 'Regulations for Electromagnetic Equipment DIN VDE 0580'. The product range practically comprises solenoids for each technical application case and for nearly all technical requirements, so that it will be possible for the user mainly to select list solenoids with the basis „as good as economically useful".

The D.C. Solenoids contained in the pamphlets are exclusively plunger solenoids at which the working air gap lies between core and armature within the coil winding. Thus, the armature plunges into the coil winding.

A special design of the armature and core near the working air gap makes it possible to use the magnetic energy mainly for the generation of the work. Working air gaps and the air gaps of the magnetic field of the magnetic body to the armature – on which the mechanical force is removed – are designed rotationally symmetrical to avoid stray and eddy fields.

Basically, **always 2 designs** are distinguished:

a) The coil winding is enclosed wholly by the magnetic body. (Figure 1.1.1)

Fig. 1.1.1

b) The coil winding is only enclosed partly by the magnetic body. (Figure 1.1.2)

Fig. 1.1.2

While the design mentioned in a) is always applied where there are highest technical requirements in work, protection class and service life, the design mentioned in point b) satisfies application cases at which the technical requirements can be reduced because of a requested low price.

According to the type of the stroke movement it is distinguished between single-acting, double-acting and reverse solenoids:

Single-Acting Solenoids are solenoids with which the stroke movement happens from the start of stroke to the end of stroke by an electromagnetic force effect and by the reset by external forces. (Figure 1.1.3)

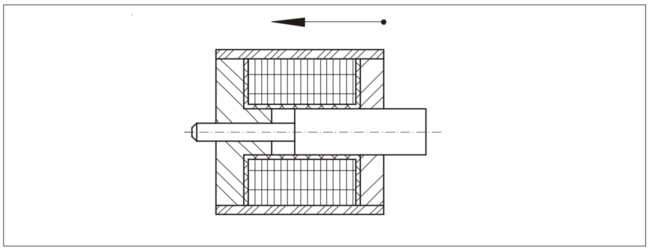

Fig. 1.1.3

Double-acting solenoids (with neutral position) are solenoids with which the stroke movement – depending on the excitation of the two coils – happens starting from the neutral position into one of the two opposite directions. The reset into the neutral position happens after the switching-off by external return forces. Thus, the neutral position is the start of stroke for both directions. (Figure 1.1.4)

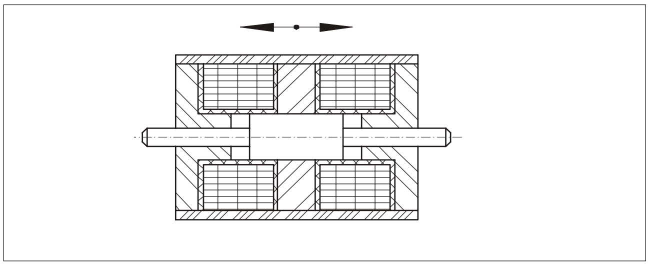

Fig. 1.1.4

Reverse solenoids (without neutral position) are solenoids with which the stroke movement – depending on the excitation of the two coils – happens from one end of stroke to the other or in reverse order. At the same time the start of stroke is in the opposite direction. (Figure 1.1.5)

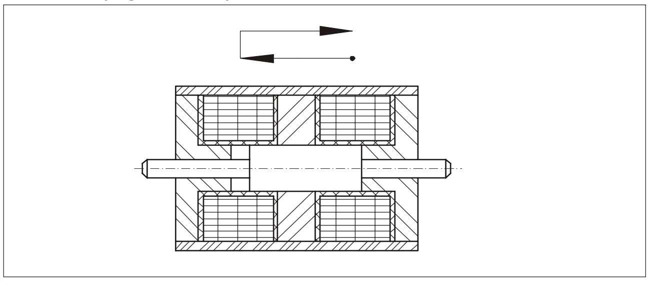

Fig. 1.1.5

1.2 Components and Types

-D.C. Solenoids consist of the following main components (figure 1.2.1):

a) magnetic body
b) coil winding
c) armature
d) operational components

1.2.1 The **magnetic body** is the magnetic part which contains the coil winding. It consists of the magnetic flow-leading parts, yoke ring and core cover with core and coat, these are developed optimally – both in material and in their geometry – for the conduction of the effective flow generating the magnetic force. (Figure 1.2.1 a)

1.2.2 The **coil winding** picks up the electric energy to generate the magnetic field. All insulation materials and materials correspond to the latest state of the art and have being each adjusted to the latest developments through constant contacts of our company to other manufactures of these materials and through own examinations. (Figure 1.2.1 b)

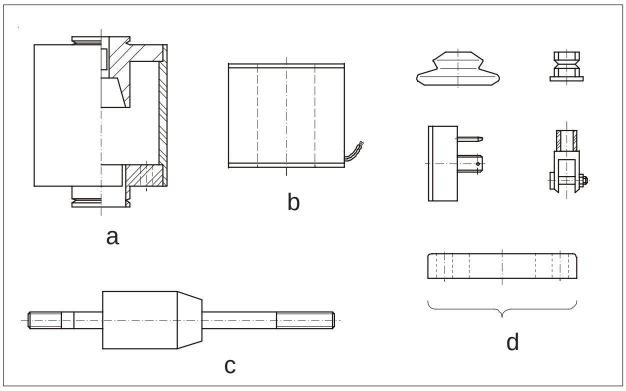

Fig. 1.2.1

1.2.3 The **armature** is the part which is generated by the magnetic field and plunges into the coil winding, or respectively, is held to it. Usually it is led in plastic-compound-bearings with little cycle, these need not to be maintained and are highly heat-resistant. Thus, high service lives are achieved which are barely used in practice. (Figure 1.2.1 c)

The armatures are only led in non-magnetizing tubes with good gliding features if the solenoids have low requirements regarding magnetic force / stroke characteristic and service life.

1.2.4 **Operational components** are such parts which are not directly essential to generate the magnetic force but, however, have to be a constructive part of the solenoid for the practical operation. This also encloses e.g. for the mechanical use of the magnetic force: stroke limits, push- and pull-rods, fork joints etc. and for the electrical connection of the coil winding: cable connections, terminals, plugs etc. (Figure 1.2.1 d)

1.2.5 The **finishes** of the iron parts are protected effectively by modern coating processes to avoid corrosion.

1.2.6 The **device's protection classes** according to DIN VDE 0470/ EN 60529 each are indicated in the pamphlets. Deviations from them can be delivered on request.

1.2.7 Solenoids to be applied in an extreme **humid atmosphere,** in a **tropic-proof design,** to be applied in **radioactive rooms** and in the **nuclear technology,** for **aggressive ambient conditions** etc. can be delivered on request.

2. Force, Stroke and Work

2.1 Force

2.1.1 The **magnetic force F_M** is the utilizable part which thus is reduced by the friction of the mechanical force produced in the solenoid in the stroke direction. (Figure 2.1.1.1)

It refers to the operating-warm condition of the coil winding and to 90% of the rated voltage. The **temperature rise** increased by the **reference temperature of mainly 35°C** represents the **temperature of the operating-warm condition.**

The **temperature rise** is determined – unless indicated in a different way in the pamphlets - on the basis of the **rated voltage, the cycle time of 300 sec. (corresponding to 12 S/h) mounted on a heat insulated base.**

If operated with rated voltage the list values increase by approx. 20%.

The determination of the operating-warm condition is based on the unfavourable conditions which appear in practical application.

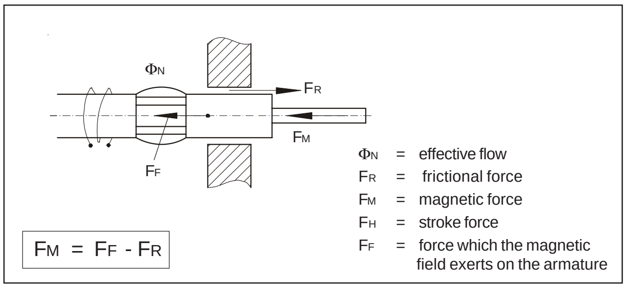

Fig. 2.1.1.1

(Heating when mounted on a heat insulated base without additional cooling.) If, in practice, the solenoids are mounted on a heat conductive base (e.g. engine bed, frame parts of iron, metal chassis etc.), so the magnetic force can be increased especially by an adjustment of the coil power to the relevant operating conditions.

An increase of the magnetic force is also possible if the ambient temperature is permanently lower than the reference temperature of +35°C. On the other hand, the electric coil power has to be decreased if the ambient temperature is permanently above +35°C which is connected with a decrease of the magnetic force. All of these measures mean special designs which are not possible to realize unless an discussion with us about the exact relevant operating conditions was made.

2.1.2 The **rated magnetic force F_M** is the magnetic force which is mostly indicated in the pamphlets for different strokes and appears for a certain stroke and current on the devices' rating plates.

2.1.3 The **stroke force F_H** is the magnetic force which has an external effect – under consideration of the accompanying component of the armature weight. (Figure 2.1.3.1)

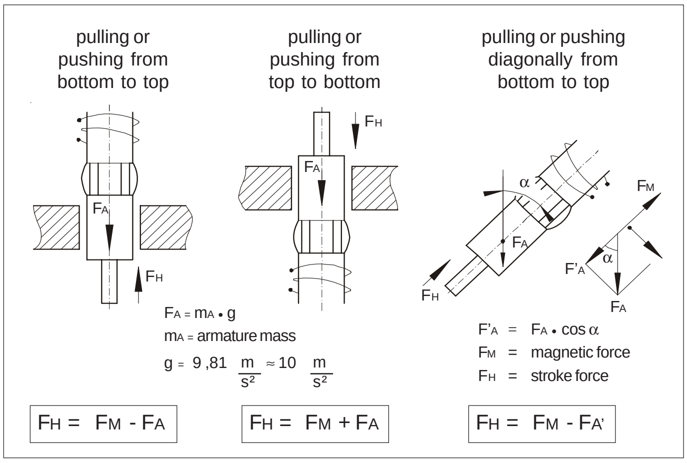

Fig. 2.1.3.1

2.1.4 The **holding force** is the magnetic force at the end of stroke – thus at stroke 0.

2.1.5 The **residual force** is the holding force which remains after switching-off.

2.1.6 The **resetting force** is the force which is required for the armature return to the start of stroke after switching-off.

2.2 Stroke

2.2.1 The **solenoid path s** is the way which the armature travels between the start of stroke and end of stroke.

2.2.2 The **start of stroke s1** is the starting position of the armature before the stroke movement starts or, respectively, after the return has been completed.

2.2.3 The **end of stroke s0** (also see abscissa zero in figure 2.3.1) is the constructive position of the armature in the device which the armature takes up as a result of the electromagnetic power's effect.

2.3 Magnetic Force / Stroke Characteristic

Basically, there are three different types of characteristics (Figure 2.3.1):

I. decreasing characteristic
II. horizontal characteristic
III. increasing characteristic

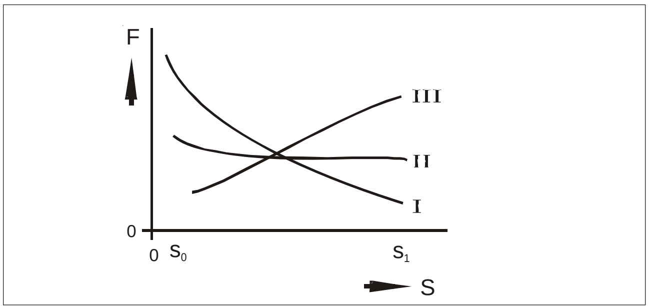

Fig. 2.3.1

The **magnetic force / stroke characteristics** of MSM D.C. Solenoids can be controlled by a corresponding design of the magnetic system.

The most common types are:

The **increasing characteristic** is especially suitable for a spring-counteracting-force and the **horizontal characteristic** is especially suitable for constant counteracting forces.

Normally the **decreasing characteristic** is only available in special designs.

2.4 Adjustment of Magnetic Force / Stroke Characteristic to certain Strokes

By a special adjustment of the active magnetic parts which control the magnetic force / stroke characteristic, the solenoid paths can be adjusted in relatively wide limits (reduced or extended) without essential changes of the work. This means an increase of the magnetic force if the work is reduced and a decrease of the magnetic force if the work is extended. (Examples see Figure 2.4.1)

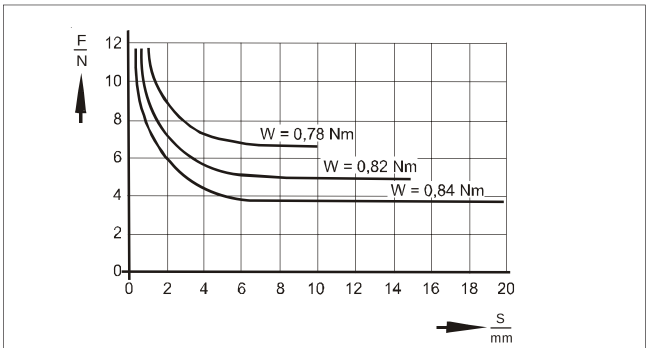

Fig. 2.4.1

2.5 Work

2.5.1 The **work W** is the integral of the magnetic force above the solenoid path. (Figure 2.5.1.1)

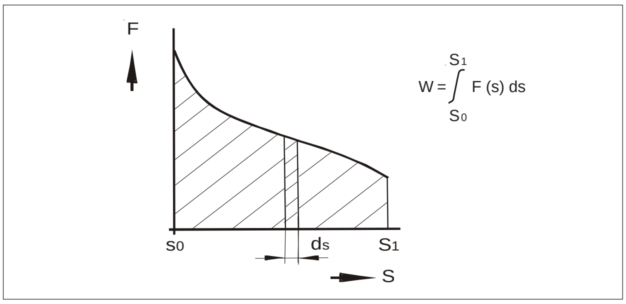

Fig. 2.5.1.1

2.5.2 The **work rating WN** – which is indicated in the pamphlets – is the product, unless otherwise specified, of the rated magnetic force at start of stroke and solenoid path. (Figure 2.5.2.1)

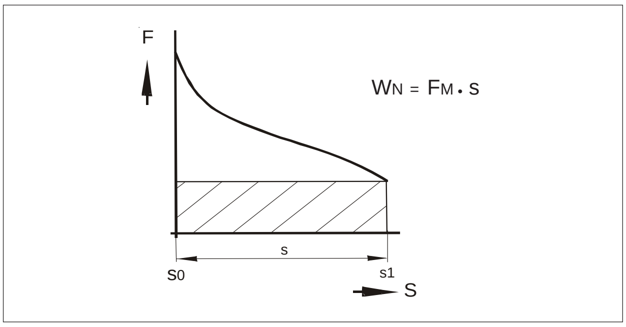

Fig. 2.5.2.1

3. Voltage, Current and Power

3.1 Voltage and Current

Unless otherwise specified, indications about voltage and current at direct current (D.C.) are arithmetic mean values.

3.1.1 The **rated voltage** of a solenoid is the voltage for which the solenoid is designed for. Unless otherwise specified, the values indicated in the pamphlets base on a rated voltage of 24 V. With other rated voltages there could be deviations from the indicated magnetic forces caused by the different insulation classes in the coil windings. These deviations may both happen upwards (mostly at >24 V) and downwards (mostly at <24 V).

3.1.2 The **voltage conducter-ground** is the voltage for which the insulation, the leakage path and the air gap are measured.

According to DIN VDE 0110/11.72§4 table 1, the following values for D.C. voltage are valid for the **rated insulation voltage (reference voltage):**

15 V, 36 V, 75 V, 150 V, 300 V, 450 V, 600 V.

Unless otherwise specified, MSM D.C. Solenoids are designed - regarding their voltage conductor-ground - in such a way that equal or smaller rated voltages are assigned to a certain voltage conductor-ground.

3.1.3 The **continuously permitted voltage variation** on D.C. Solenoids is +6% to -10% of the rated voltage.

3.1.4 The **rating current** is the current which adjusts itself at rated voltage and a temperature of the coil winding of +20°C. It can be established by dividing the rated capacity – indicated in the pamphlets – by the rated voltage.

3.1.5 The current to which the magnetic force values indicated in the values refer is called **test current**. This results in:

$$I_{Pr} = \frac{0{,}9\ U_N}{R_W}$$

in which U_N means the rated voltage and R_W the operating-warm resistance of the coil winding.

3.2 Power

The rated power P_N, which is indicated in the pamphlets, refers to the rated voltage and the rating current. Unless otherwise specified, this bases on a rated voltage of 24 V.

4. Duty Cycle Rating, Cycle Time, Cycle Sequence, Operating Mode, Working Cycle, Operating Frequency, Nominal Operating Modes

4.1 The **duty cycle rating t_5** is the time between the switching-on and switching-off of the current.

4.2 The **de-energized period t_6** is the time between switching-off and re-switching-on of the current.

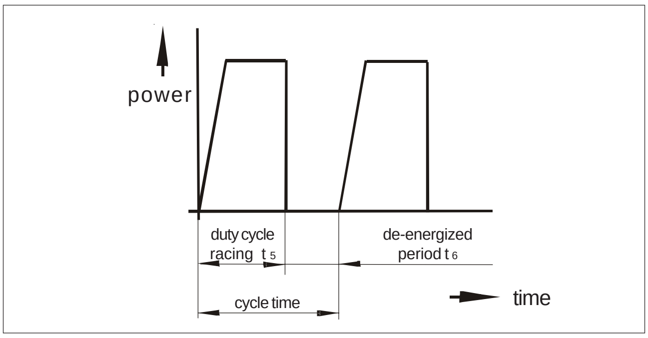

Fig. 4.1

4.3 The **cycle time** is the sum of the duty cycle rating and the de-energized period.

4.4 The **cycle sequence** is a single or periodically repeated summation of cycle times with different lengths.

4.5 The **operating mode** (%) is the percentage ratio duty cycle rating to cycle time.

$$\%\ \text{duty cycle rating} = \frac{\text{duty cycle rationg}}{\text{cycle time}} \cdot 100$$

4.6 One **working cycle** covers a full switching-on and switching-off process.

4.7 The **operating frequency** is the number of working cycles per hour.

4.8 **Nominal Operating Modes**

D.C. Solenoids can be designed for the following different operating modes:

4.8.1 **Continuous Operation (S 1)**

The duty cycle rating is so long that the steadystate temperature is practically reached. (Figure 4.8.1.1)

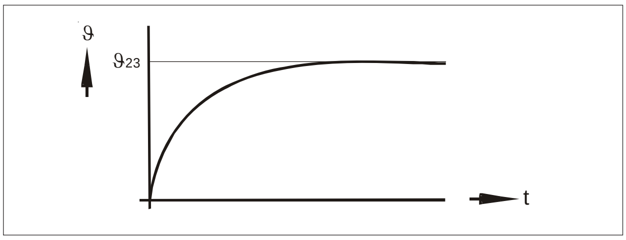

Fig. 4.8.1.1

4.8.2 **Intermittent Operation (S 3)**

Duty cycle rating and de-energized period interchange in regular or irregular sequence. Here, the de-energized periods are so short that the device does not cool down to its reference temperature. (Figure 4.8.2.1)

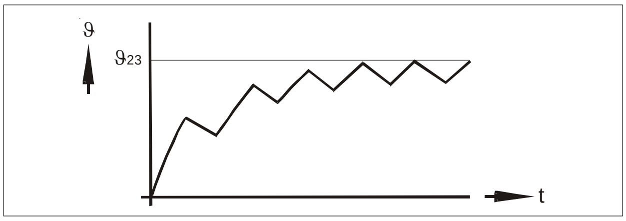

Fig. 4.8.2.1

4.8.3 **Short Operation (S 2)**

The duty cycle rating is so short that the steadystate temperature is not reached. The de-energized period is so long that the device practically cools down to the reference temperature. (Figure 4.8.3.1)

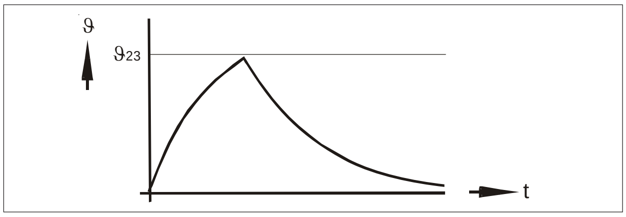

Fig. 4.8.3.1

5. Selection of the Solenoids for different Nominal Operating Modes

5.1 With **continuous operation (S 1)** only a solenoid, which coil winding is designed for duty cycle rating = 100%, can be selected. It is to be noticed that, with continuous operation, the solenoid is occasionally operated for a longer time to avoid a sticking of the operational components due to environmental effects (e.g. dirt, humidity …).

5.2 With **intermittent operation (S 3)** essentially stronger powers and thus magnetic forces can be installed than with continuous operation. The relative duty cycle rating, the cycle time and the thermal time constant of the solenoid are decisive for the admitted power to be installed. According to DIN VDE 0580, 2, 5, 10 and 30 minutes are the preferential values for the cycle time.

The preferential values for the relative duty cycle rating (%) are 5, 15, 25, 40 %.

The force, power, work and time values indicated in the pamphlets refer – without consideration – to a cycle time of 5 minutes (300 sec.). This cycle time results in the following admitted maximum values for the duty cycle rating:

relative duty cycle rating (%)	5	15	25	40
admitted maximum duty cycle rating (sec.)	15	45	75	120

If the admitted maximum duty cycle rating is exceeded, so the solenoid has to be chosen for the next higher relative duty cycle rating.

If the duty cycle rating exceeds 120 sec., so the solenoid has to be designed for continuous operation = 100% duty cycle rating.

In especially critical cases it is possible to adjust the installable electrical power and thus the magnetic force for a certain relative duty cycle rating of the corresponding cycle time and the given thermal time constant of the solenoid as best as possible. In this cases we ask for further enquiry.

5.3 With **short operation (S 2)** it is possible – similar to intermittent operation – to achieve essentially higher powers and thus higher magnetic forces. Also in this cases we ask you for further enquiry and indication of the exact operating conditions.

6. Closing and Opening Times and Influencing Possibilities of the Closing Time

6.1 Closing and Opening Times

To explain the closing and opening times and their components, please see the following oscillogram. (Figure 6.1)

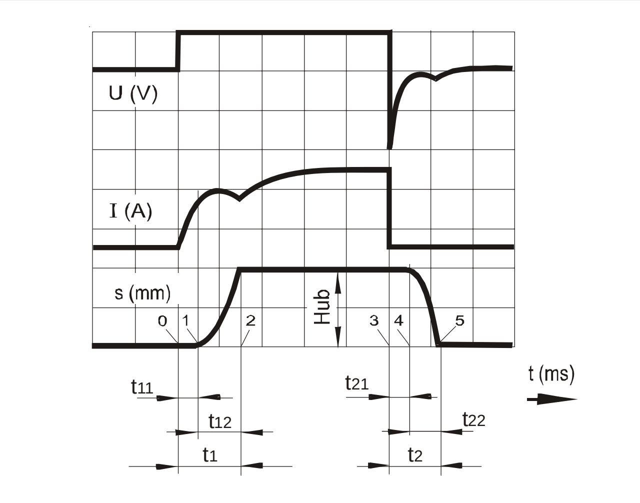

Fig. 6.1

6.1.1 The **closing time t_1** is the sum of response delay t_{11} and stroke time t_{12} (time 0 to time 2).

6.1.1.1 The **response delay t_{11}** is the time between switching-on the current (time 0) and the beginning of the armature movement (time 1). During this time the magnetic field is building up to such an extent that it overcomes the external counteracting force and so moves the armature.

6.1.1.2 The **stroke time t_{12}** is the time between the beginning of the armature movement (time 1) and the reaching of the end of stroke position (time 2).

6.1.2 The **opening time t_2** is the sum of drop-out delay t_{21} and return time t_{22} (time 3 to time 5).

6.1.2.1 The **drop-out delay t21** is the time between switching-off the current (time 3) and beginning of the return movement of the armature (time 4). During this time the magnetic field is breaking down to such an extent that the armature can start to move by the effect of the external counteracting force.

6.1.2.2 The **return time t_{22}** is the time between the beginning of the armature's return movement (time 4) and the reaching of the start of stroke position (time 5).

6.1.3 The **closing and opening times** indicated in the pamphlet were established in accordance with DIN VDE 0580 in an operating-warm condition at rated voltage and at 70% of the rating magnetic force (weight load).

6.2 The Influencing Possibilities of the Closing Time

6.2.1 **High Speed Excitation**

By the series connection of an ohmic resistance and a corresponding increase of the supply voltage (Figure 6.2.1.1) the electromagnetic time constant of the electric circuit is decreased and thus also the closing time is reduced.

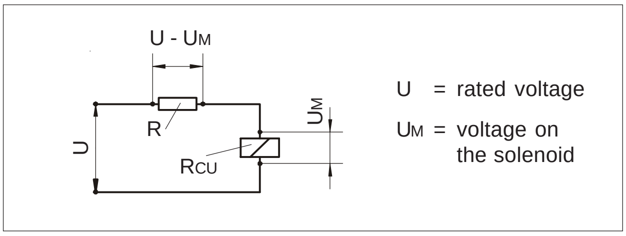

Fig. 6.2.1.1

In the diagram (figure 6.2.1.2) the shortening of the closing time – which is obtained by this measure – is nearly shown.

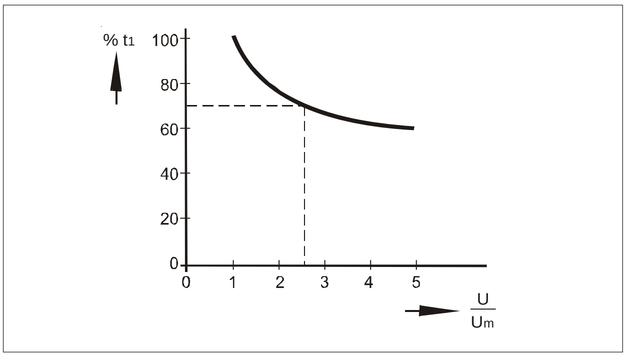

Fig. 6.2.1.2

The level of the series resistor results from the ohmic coil winding resistance R_{CU} by the relation:

$$R = R_{CU} \cdot \frac{U - U_M}{U_M}$$

If the closing time is only to be e.g. 70% of the list value, then the supply voltage has to be $U = 2.6 \cdot U_M$.
(see diagram figure 6.2.1.2)

The series resistor is calculated:

$$R = R_{CU} \cdot \frac{2.6 \cdot U_M - U_M}{U_M} = 1.6 \cdot R_{CU}$$

If only the voltage $U = U_M$ is available, then the solenoid has to be designed for a corresponding lower voltage.

In our example the coil winding would have to be designed for a voltage:

$$U'_M = \frac{U_M}{2.6} = 0.384 \cdot U_M$$

The ohmic resistance then amounts:

$$R = 1.6 \cdot R_{Cu}$$

The operating-warm condition of the coil winding is to be put in for R_{CU}. Estimated, it is calculated for the insulation classification B:

$$R_{Cu} = 1.4 \cdot R_{20}$$

In this it means:

R_{Cu} = operating-warm resistance of the coil winding

R_{20} = resistance of the coil winding at normal temp. of 20° C.

6.2.2 Over Excitation

With the shortening of the closing time by over excitation, the pick-up power and thus the magnetic force which determines the closing time are increased by an increase of the voltage during the closing time.

According to the height of the over excitation temperature, serious shortenings of the closing time can be reached.

The following operations can be applied:

6.2.2.1 Series Resistor with Bypass Switch (Fig 6.2.2.1.1)

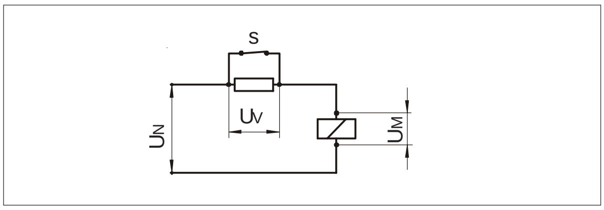

Fig. 6.2.2.1.1

During the closing process the resistance R_V is bypassed by the switch S. By that, the solenoid obtains its full supply voltage. Only after reaching the end of stroke position, or right in front of it, the switch S is opened and the voltage on the solenoid is reduced to U_M because of the voltage drop on the series resistor. The switch S can be actuated by both the solenoid itself and a time delayed relay or an electronic circuit.

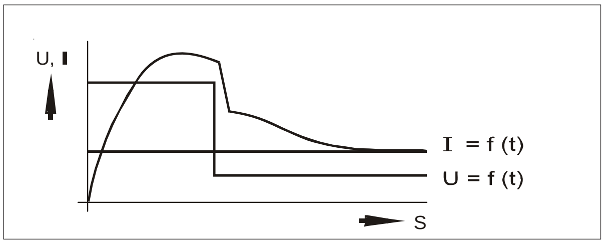

Fig. 6.2.2.1.2 switch is actuated by solenoid

In case of a switch actuation by the solenoid (Figure 6.2.2.1.2) the switching point of the switch has to be adjusted very exactly shortly in front of the end of stroke position. While a positive overlapping of the over excitation time with the use of a time switch is possible (see figure 6.2.2.1.3) and thus the arrangement becomes essentially less sensible.

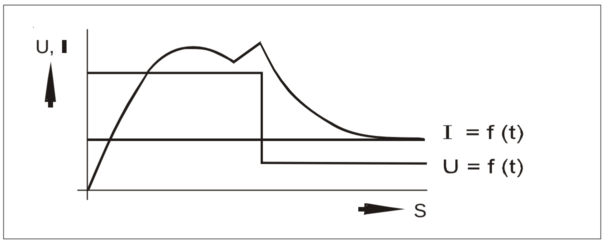

Fig. 6.2.2.1.3 switch is actuated by delayed relay drive unit

6.2.2.2 Series Resistor with Capacitor

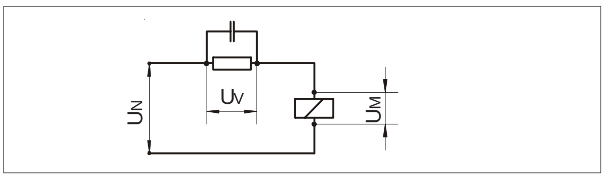

Fig. 6.2.2.2.1

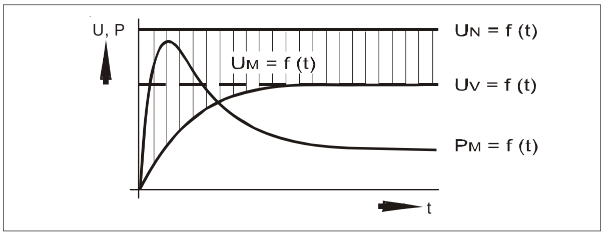

Fig. 6.2.2.2.2

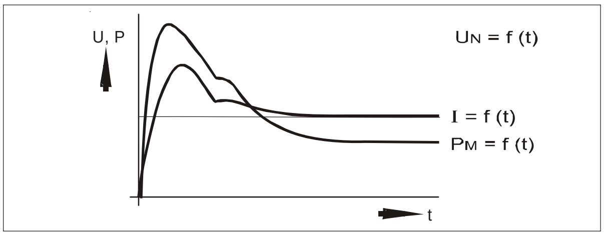

Fig. 6.2.2.2.3

The voltage on the series resistor R is rising slowly in accordance with the capacitor-charging-voltage and so the voltage on the solenoid is dropping slowly correspondingly. The power in dependence on the time is taking the course of an e-function. It does not have a jump function – like described during the switching-over-process. Correspondingly, in the beginning the coil power has a higher and yet during the stroke process a lower value for the coil winding. Nevertheless, with this circuit, short closing times can be reached if the capacitor is designed correctly.

6.2.2.3 Transformer-Tapping and Rectifier

By a stroke- and time-dependent switching-over of the switch S from pull-in voltage to holding voltage, the same effect is achieved as with series resistor and short-circuit switch. However, this has the advantage that there is no such high heat from power dissipation than with series resistor. Of course, the disadvantage is the expense for the transformer and that the circuit can only be made in such cases where A.C. voltage is available.

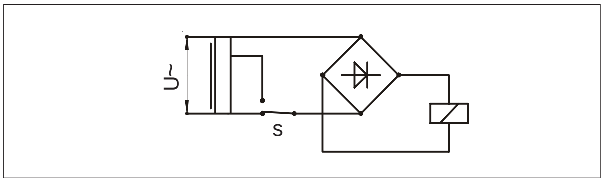

Fig. 6.2.2.3.1

6.2.2.4 Capacitive Resistance in the A.C. Circuit

At closed switch S the solenoid obtains the full pull-in voltage. If the switch S is opened either by stroke-dependent or time-dependent switching, so the voltage applied on the solenoid is reduced to holding voltage by the capacitive resistance of the capacitor C. The advantage is that in the capacitive resistance of the capacitor C there is almost no heat from power dissipation and a transformer is also not necessary. For this circuit A.C. voltage is required.

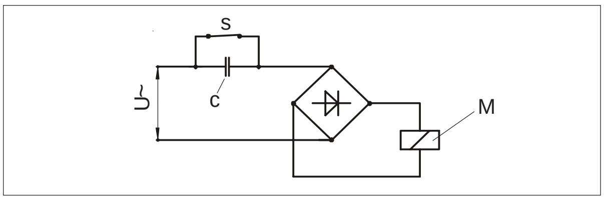

Fig. 6.2.2.4.1

6.2.2.5 **Activation via electronic Switching Device**

If the command is made by the switch S, the activation of the solenoid happens with high pull-in voltage so that a high electric power which causes a high magnetic force is available during the closing phase. By that the closing time is shortened decisively. The device is switching over to a lower holding voltage so that the device does not thermally overload during the following holding phase.

If this activation mode is applied the controllers and the solenoid have to be coordinated with each other under consideration of the application conditions.

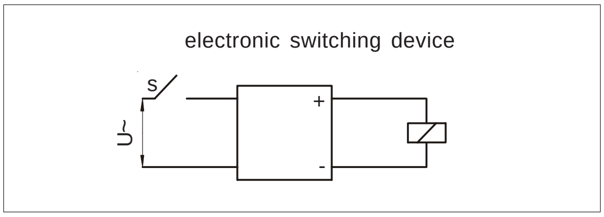

Fig. 6.2.2.5.1

7. Temperatures, Insulation Classification and Cooling Methods

7.1 Temperatures

7.1.1 The **ambient temperature** ϑ_{13} (°C) of a device is the average temperature measured on stipulated places of its environment, in the end of the temperature-measurement.

7.1.2 The **steady-state temperature** ϑ_{23} (°C) of a device or a part of it, is the temperature when supplied and discharged warmths are equal.

7.1.3 The **reference temperature** ϑ_{11} (°C) is the steady temperature in the currentless condition with as directed application. Its value may be different from the ambient temperature, e.g. during adding a solenoid to a hydraulic valve flown through by operating-warm oil.

7.1.4 The upper **limit temperature** ϑ_{21} (°C) is the highest temperature permitted for a device or a part of it.

7.1.5 The **temperature rise** $\Delta\ \vartheta_{31}$ (K) is the difference in temperatures of the device or a part of it and the reference temperature.

7.1.6 The **final temperature rise** $\Delta\ \vartheta_{32}$ (K) is the temperature rise at the end of a heating process. In most cases it is the steady-state temperature.

7.1.7 The **limit temperature rise** $\Delta\ \vartheta_{33}$ (K) is the maximum permitted value at nominal operating conditions.

7.1.8 The **hot spot difference** $\Delta\ \vartheta_{34}$ (K) is the difference between the middle winding temperature and the temperature on the hottest spot of the winding.

7.2 Thermal classes

The insulating materials are arranged in insulation classifications according to their continuous heat resistance. (see table 7.2.1)

The stipulations of the limit temperatures for - D.C. Solenoids base on a reference temperature of +35°C and a hot spot difference of 5 K.

Generally, the coil winding of the -D.C. Solenoids corresponds to the **insulation classification B.** For special operating conditions it is possible to produce these solenoids also in insulation classification F and H. In such cases we ask for further enquiry.

No.	insulation classifications	upper limit temperature °C	limit temperature rise K
1	Y	90	50
2	A	105	65
3	E	120	80
4	B	130	90
5	F	155	115
6	H	180	140
7	200	200	160
	220	220	180
	250	250	210

Table 7.2.1

7.3 Cooling Methods

The following cooling methods can be differed:

a) cooling by resting ambient air
b) cooling by moving ambient air
c) cooling by heat conduction
d) cooling by special coolants

Please indicate the corresponding cooling method when ordering solenoids.

8. Test Voltages

To prove the insulating power of MSM D.C. Solenoids, all solenoids are examined for electric strength prior to leaving the factory.

8.1 Type and Level of the Test Voltage (U_P)

The test is executed with practical sinusoidal A.C. voltage of 50 Hz. Its level complies with the voltage conductor – ground.

$U_{conductor-ground}$ (V)	50	100	150	300	600
U_N (V)	bis 50	>50 ≤100	>100 ≤150	>150 ≤300	>300 ≤600
U_P (V)	800	1500	2500	4000	6000

Voltage conductor-ground. U_N (V) = supply voltage. U_P (V) = Test voltage (rms of the AC, overvoltage category III)

Table 8.1.1

8.2 Performance of the Voltage Test

The voltage test with U_P is to be applied between the coil winding and the touchable metal parts of the device. If there are several electrical-separated coil windings, so all of these windings have to be tested against each other and the touchable metal parts have also to be examined for electric strength. The test voltage is applied in full level and left for approx. 1 sec. on the test specimen.

If there is neither puncture nor sparkover and if the insulation materials do not heat up noticeably, the test is passed.

8.3 Repeated Voltage Test

The voltage test executed during the test in the factory shall not be repeated – if possible. On special request – e.g. acceptance – a second test need only to be executed if applied only with 80% of the values indicated in the table.

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9. Normal Operating Conditions

The -D.C. Solenoids are designed for the following normal operating conditions:

9.1 The **ambient temperature** does not exceed 40°C and its mean value does not exceed 35°C during a period of 24 hours. The lower limit for the ambient temperature is -5°C.

9.2 The **altitude** of the application place does not exceed 1000 m above sea level.

9.3 The **ambient air** shall not be contaminated essentially by dust, smoke, aggressive gasses and vapours or salt content.

9.4 The **relative humidity** of the ambient air is not to exceed 50% at 40°C. With lower temperatures higher air humidities may be permitted, e.g. 90% at 20°C. Please consider the occasionally moderate appearing of condensed water.

9.5 During installation of the device our **installation guidelines** have to be adhered to.

9.6 If there are any **deviations** from this **normal operating conditions** during the practice, corresponding measures have to be taken, such as a higher protection class, special protection for the surface etc. In such cases we ask for further enquiry indicating the current operating conditions.

10. Service Life

The **service life of the devices** and of electromagnetic devices' wearing parts not only depends on the design but also strongly on the external conditions like the installation attitude, type and level of the load. Therefore decisions regarding the service life have to be made by the customer together with MSM.

11. Connection of the D.C. Solenoid

11.1 D.C. Voltage Connection (Fig. 11.1.1)

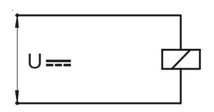

Fig. 11.1.1

11.2 A.C. Voltage Connection (Figure 11.2.1)

If no D.C. voltage is available, so the connection of the D.C. solenoid is made by a rectifier, mostly in bridge circuit. Both selenium and silicon rectifiers can be used.

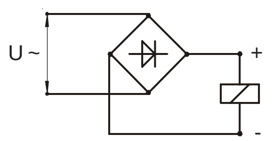

Fig. 11.2.1

If the supply voltage is ~ 230 V and if silicon rectifiers are used, so the D.C. solenoid has to be designed for ⎓ 205 V. Silicon rectifiers are also delivered by us as a unit with the D.C. solenoid, namely most installed in the terminals of the respective solenoid. As far as this is not indicated in the pamphlets we ask for enquiry – if required.

12. Tips to eliminate the Disconnect-Overvoltage and Spark Arresting

12.1 Elimination of Disconnect-Overvoltages

The inductance with which a solenoid is loaded causes high disconnect-overvoltages – especially with larger solenoids – which may lead to the disruptive discharge of the electrical insulation.

The following measures are recommended to suppress it:

12.1.1 **Suppression by Ohm's Resistance** (Figure 12.1.1.1)

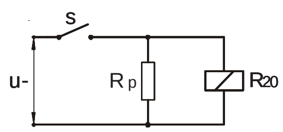

Fig. 12.1.1.1

R_p = parallel resistance

R_{20} = resistance of the coil winding at reference temperature +20°C

By the parallel resistance R the disconnect-overvoltage is limited to the value:

$$U_Ü = U \frac{R_P}{R_{20}}$$

With this switching arrangement the opening time is delayed slightly.

12.1.2 **Suppression by Varistors** (Figure 12.1.2.1)

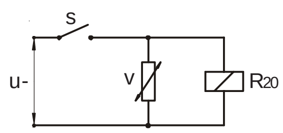

Fig. 12.1.2.1

The varistor V is designed in such a way that with rated voltage U it has a very high resistance and thus only leads a small current with closed switch S. But the resistance of the varistor is decreasing considerably during the appearance of the disconnect-overvoltage through which it is suppressed. The opening time is hardly delayed noticeably.

12.1.3 **Suppression by Mains Rectifier** (Figure 12.1.3.1)

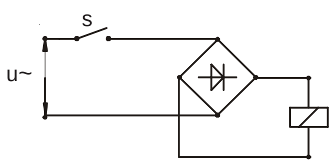

Fig. 12.1.3.1

If the disconnect-overvoltage is switched with A.C. voltage it is fully suppressed. However, the armature drop is delayed very strongly.

12.2 Spark Arresting

With the used switches – as far as no spark arresting methods are planned – the high disconnect-overvoltage causes arcs and thus burning away of the contacts and material creep. The most usual spark arresting method is the spark arresting by means of varistors and R_C element. (Figure 12.2.1)

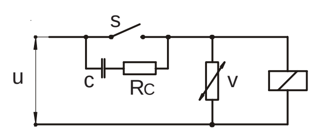

Fig. 12.2.1

By the varistor V the disconnect-overvoltage is suppressed to the peak voltage of the used capacitor.

The R_C element – which lies parallel to the switching contact – causes that the voltage occurring on the contact does not exceed the arc-minimum-voltage. By that an arc is avoided surely.

13. Electromagnetic Time Constant (τ) and Inductance

To determine the inductances of the D.C. high duty solenoids, the electromagnetic time constants at the armature's start of stroke position are indicated in the pamphlets. The inductances for the various operating modes and supply voltages can be determined from these time constants according to the following example:

Given: solenoid typeG TC A 070K
duty cycle rating = 100 %
rated voltag= ⎓ 180 V

Searched: inductance L_1 (H) at armature's start of stroke position
inductance L_2 (H) at armature's end of stroke position

Solution: rated power from pamphlet: P_N = 33 W

The resistance of the coil winding results from the rated power as follows:

$$R = \frac{U^2}{P_N} = \frac{180^2}{33} = 980\ \Omega$$

Inductance in start of stroke position

$$L_1 = \tau_1 \times R = 31 \times 10^{-3} \times 980 = 30.4\ (H)$$

Inductance in end of stroke position

$$L_2 = \tau_2 \times R = 35 \times 10^{-3} \times 980 = 34.3\ (H)$$

It has to be noticed that in this calculation the time constants are indicated in seconds, i.e. the values of the time constants indicated in the pamphlets have to be multiplied with 10^{-3}.

14. Order details for D.C. Solenoids

a) type

b) voltage

c) stroke s and magnetic force F as well as the requested magnetic force/stroke characteristic

d) operating mode (% duty cycle rating) or starting and switch-off time of each circuit or cycle sequence

e) number of operations (operations per hour)

f) operating hours per day

g) application mode or, respectively, arrangement and closer indications about the installation conditions

h) indications about operating conditions, such as reference temperature, nature of the ambient air, indications about planned protection classes (e.g. splashing water, spraying water, very dusty etc.)

15. Installation Guidelines for - D.C. Solenoids

15.1 Working Position

-D.C. Solenoids can be applied in any installation attitude. In the interest of the storage service life it is to be noticed that the forces are accepted in axial direction.

15.2 Installation

The connection of the solenoid armature to the engine part to be actuated shall be agile – not fix – with allround play by means of straps or fork end.

15.3 Setting-up

The connection voltage has to be in accordance with the rated voltage which is indicated on the rating plate. Solenoids are no ready-to-use devices as defined by DIN VDE 0580. The user has to notice the requirements and protection measures described in DIN VDE 0580.

15.4 External Counteracting Forces

At least 2/3 of the magnetic force shall be utilized with all solenoids. By that the sticking of the armature is surely avoided.

If the solenoid has to overcome external spring forces then the solenoid is to be selected in such a way that the spring characteristic is adjusted to the magnetic force/stroke characteristic.

15.5 Protection

The current consumption in Ampere is calculated to

$$I = \frac{P}{U}$$

P = rated power (W), U = rated voltage(V)

The corresponding protection can be selected according to the calculated amperage.

15.6 Voltage Drop and Cross-section of the Conductor

The solenoids have to be supplied by the necessary rated voltages. The voltage drop shall be held in tight limits (normally to 5%) during the conductor-moving by a correct measurement of the cross-section of the conductor.

15.7 Outside Interventions or Modifications

Each modification, e.g. spot-drilling of the magnetic body, insertion of other push-rods etc. can lead to operative malfunctions of the solenoid (e.g. damage of the coil). In such cases we cannot make any guarantee

15.8 Note on the technical harmonisation guidelines within the EU

Electromagnetic solenoids of this product range are subject to the low-voltage guideline 73 / 23 EWG.

To guarantee the targets of this regulation, products are manufactured and inspected to the valid edition of DIN VDE 0580. This also equals a declaration of conformity by the manufacturer.

Note on the EMC (electromagnetic compatibility) guideline 89/336 EWG

Electromagnetic solenoids are not affected by this guideline because neither do they cause electromagnetic disturbances nor can they be disturbed through electromagnetic disturbances. Therefore, the adherence to the EMC guideline has to be guaranteed by the user through appropriate circuitry wiring.

- Technical Explanations	
G XX	D.C. solenoids
G XX E	D.C. solenoids in explosion protected type
G XX 2. Suppl.	D.C. proportional solenoids
G XX V	D.C. shotbolt lock-units
W XX	A.C. solenoids
P XX	D.C. or A.C. valve solenoids for pneumatics
H XX	D.C. or A.C. control solenoids for hydraulics
D XX	3-phase solenoids
Y XX	vibratory solenoids