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Industrial Control and Systems:
Additional Requirements for Proximity Switches
Suitable for Use in Strong Magnetic Fields

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Foreword

This Standards Publication was prepared by a technical committee of the NEMA Industrial Automation Control Products and Systems Section. It was approved in accordance with the bylaws of NEMA and supersedes the indicated NEMA Standards Publication. This Standards Publication is an addition part to ICS 5-2000: *Control-Circuit and Pilot Devices* and will be included into that standards publication when it is next revised. Annex E provides additional requirements for proximity switches suitable for use in strong magnetic fields.

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Annex E

ADDITIONAL REQUIREMENTS FOR PROXIMITY SWITCHES SUITABLE FOR USE IN STRONG MAGNETIC FIELDS

(Normative)

E.1 General

This annex gives additional requirements applying to proximity switches suitable for use in strong magnetic fields.

E.1.1 Scope and Object

This annex is applicable for proximity switches that operate within strong magnetic fields, for example electric weld fields (normally alternating) or electrolytic fields (normally constant).

The object of this annex is to state the performance and the test conditions for proximity switches that operate in strong magnetic fields.

E.2 Definitions

magnetic field: The magnetic field in the meaning of this standard is defined by the value of the magnetic induction (flux density). The value is stated in teslas [$V.s/m^2$].

alternating magnetic field: A magnetic field with alternating direction of the magnetic induction with a fundamental frequency *f* of 45 Hz to 65 Hz where the reference value is the peak value of the magnetic induction.

constant magnetic field: A magnetic field with a temporal constant value of the magnetic induction, where the reference value is the mean value of the magnetic induction. A total ripple content of ±5 % is allowed.

immunity:

immunity to an alternating magnetic field: A proximity switch is immune to an alternating magnetic field when the state of the output is not changed by the influence of the alternating magnetic field under specified conditions.

immunity to a constant magnetic field: A proximity switch is immune to a constant magnetic field if the change — due to the influence of the constant magnetic field — of the effective operating distance (s_r) is not higher than the value specified.

E.3 Classification

Proximity switches may be classified according to table A-1 with the following additions:

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E.3.1 Classification According to the Type of the Influencing Magnetic Field

E.3.2 Immunity to an Alternating Magnetic Field

The immunity to an alternating magnetic field is designed by a capital letter X, placed in the eighth position.

E.3.3 Immunity to a Constant Magnetic Field

The immunity to a constant magnetic field is designated by a capital letter Y, placed in the eighth position.

E.3.4 Immunity to an Alternating Field and to a Constant Magnetic Field

The immunity to both types of magnetic field is designated by a capital letter Z, placed in the eighth position.

E.4 Construction and Performance Requirements

E.4.1 Frequency of Operating Cycles

E.4.2 Inductive and Capacitive Proximity Switches

The frequency of operating cycles shall be stated by the manufacturer, and measured according to clause 8.5 of Part 4.

E.4.3 Immunity to a Magnetic Field

Table E–1
FIELD STRENGTH CALCULATION – CURRENT VERSUS DISTANCE CHART

	Distance							
Current-amps (AC peak or DC)	**½ in.**	**1 in.**	**2 in**	**3 in.**	**4 in.**	**5 in.**	**6 in.**	**12 in.**
10,000	160mT	80	40	25	20	16	13	7
20,000	315	160	80	50	40	30	25	13
30,000	470	235	120	80	60	50	40	20
40,000	630	315	160	105	80	65	50	25
50,000	790	395	200	130	100	80	65	35

NOTE—The following values shall be applied:
a) magnetic field classifications
b) Gauss (G): 1mT = 10G

Table E–2
MAGNETIC FIELD CLASSIFICATIONS

Immunity Level	Minimum Magnetic Field Peak Value mT (G)
1	100 (1000)
2	160 (1600)
3	250 (2500)

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E.4.4 Performance

E.4.4.1 In an Alternating Magnetic Field

The state of the output shall not change when proximity switch tested in accordance with E.8.9.1.

E.4.4.2 In a Constant Magnetic Field

Subclause 7.2.1.3.1 of part 4 applies, with the following addition for inductive and capacitive proximity switches.

The effective operating distance (s_r) shall not deviate more than ±30% over the state range of the magnetic field.

Test is made according to E.8.9.2.

E.5 Tests

E.5.1 Verification of Immunity

E.5.2 Immunity to an Alternating Magnetic Field

E.5.3 Inspection and Test Sequence (See Figure E–1)

NOTE—Other test configurations may be set up.

The test shall be performed as follows:

a) The sensor (1) for measuring the magnetic field shall be arranged in the centre of the interior of the air-core inductor (4).

b) The air-core inductor (4) shall be energized with alternating current (A), until the oscilloscope (3) shows a peak value of the magnetic induction per Table E.2. This value $/_{ref}$ of the current shall be noted.

NOTE—To adjust the value $/_{ref}$, it is allowed to use a phase control up to 30°.

c) The sensor (1) is removed and the proximity switch (I) shall be arranged in the air-core inductor, so that the reference axis of the proximity switch is identical with the axis of the air-core inductor (4) and the sensing face of the proximity switch is at the mid point (L/2) of the air-core inductor.

   Tests should be performed with the orientations of the proximity switches in line and perpendicular to the magnetic field.

d) The air-core inductor (4) shall be energized with the value $/_{ref}$ for an approximate time t (s) = 3/*f*, but not less than 0, 1 s.

e) The test according to d) shall be performed;

   - with the target located at 3 x s_n from the sensing face;

   - with the target located at 1/3 x s_n from the sensing face.

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E.5.4 Results to be Obtained

The state of the output shall not change by switching on and switching off $/_{ref}$ or during the time $/_{ref}$ current flows in the air-core inductor.

After the test, the effective operating distance (s_r) shall remain in accordance with subclause 7.2.1.3.1 of part 4.

NOTE - For sensing face diameters larger than 18 mm, the target in the off condition may be removed.

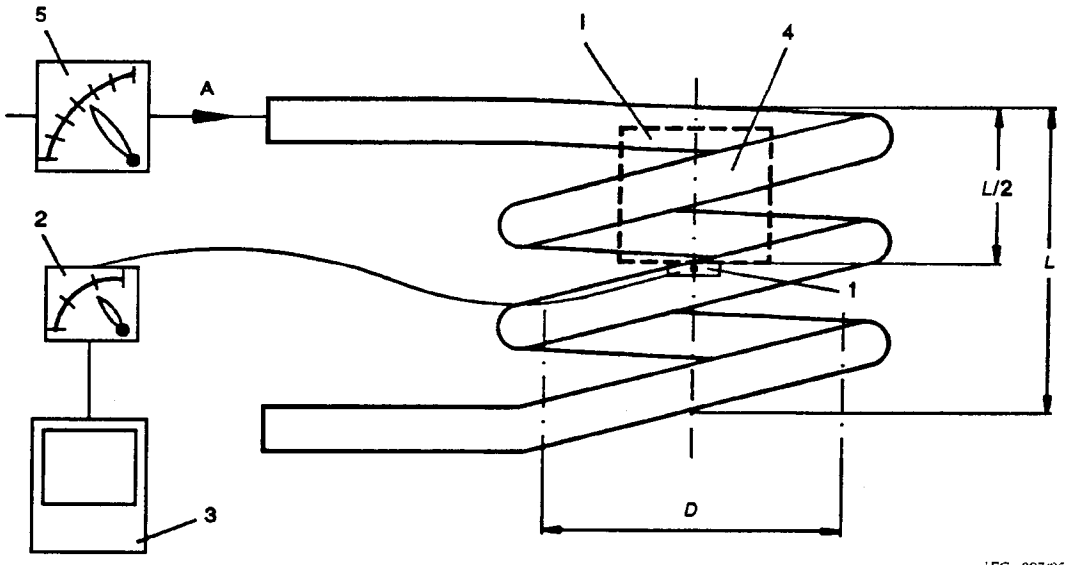


Figure E–1
EXAMPLES OF TEST CONFIGURATION FOR VERIFICATION OF THE IMMUNITY TO AN ALTERNATING FIELD

1	Sensor
2	Measuring instrument for the magnetic induction
3	Oscilloscope (to indicate the peak value)
4	Air-core inductor (the number of windings is not stated)
5	AC ammeter
A	Alternating current
I	Proximity switch
D	Interior diameter of the air-core inductor ≥100 mm
L	Length of the air-core inductor ≥100 mm

E.5.5 Immunity to a Constant Magnetic Field

E.5.6 Inspection and Test Sequence (See Figure E–2)

NOTE—Other test configurations may be set up

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The test shall be performed as follows:

a) The sensor (1) for measuring the magnetic induction shall be arranged in the centre of the air gap between the iron cores (3).

b) The inductance coils (4) shall be energized with direct current (A) until the measuring instrument for the magnetic induction (2) shows the magnetic induction values shown in Table E.2. The value $/_{ref}$ of the current shall be noted.

c) The sensor (1) is removed and the proximity switch (I) shall be arranged in the middle of the air gap between the iron cores (3) and so that the sensing face is in line with the outsides of the iron cores (3).

d) The effective operating distance s_r shall be measured by axis approach of the target with the direct current A being adjusted to each of the following values:

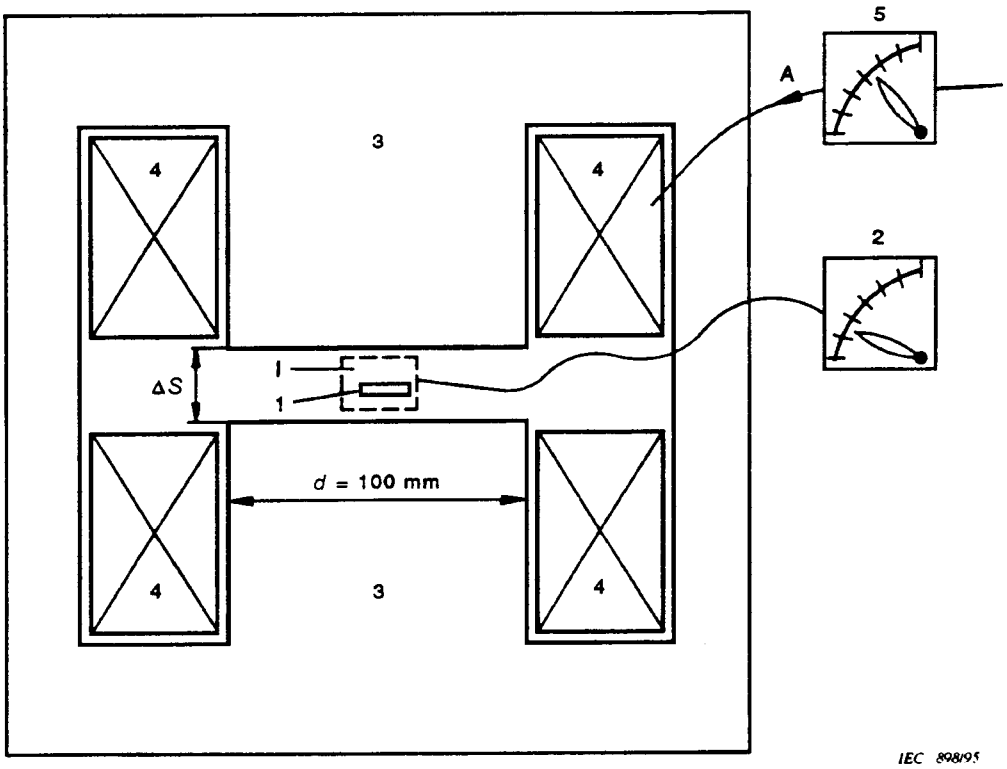
0 $/_{ref}$
0,2 $/_{ref}$
0,4 $/_{ref}$
0,6 $/_{ref}$
0,8 $/_{ref}$
1,0 $/_{ref}$

E.5.7 Results to be Obtained

In the whole range of the direct current A, the deviation of the effective operating distance s_r shall be within ±30 % of the value measured at 0 $/_{ref}$.

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1 Sensor
2 Measuring instrument for the magnetic induction
3 Iron core of the magnetic inductor
(inner diameter of iron core = 100 mm)
4 Inductance coils
5 DC ammeter
A Direct current
I Proximity switch
AS Air gap between core (3) >2 x proximity switch diameter with a minimum of 40 mm.

NOTE—For test purposes, the parts of the proximity switch affected by the magnetic field may be separated from the rest of the switch.

Figure E–2
EXAMPLE OF TEST CONFIGURATION FOR VERIFICATION OF THE IMMUNITY IN A CONSTANT MAGNETIC FIELD

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