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Testing of magnetic contacts, development of testing devices and considerable impact on planning physical security of buildings

Milan Kutaj *, Faculty of Security Engineering, University of Zilina ,Univerzitna 8215/1, Zilina 010 26, Slovakia.
Andrej Velas, Faculty of Security Engineering, University of Zilina, Univerzitna 8215/1, Zilina 010 26, Slovakia.
Viktor Soltes, Faculty of Security Engineering, University of Zilina , Univerzitna 8215/1, Zilina 010 26, Slovakia.

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Abstract

The article describes working principles of the magnetic contacts and their place in security alarm systems. Reliability of magnetic contacts was tested as a part of educational activities in the laboratory of the Department of Security management in the Faculty of Security engineering and results are clearly described and summarized in the second part of the article. The article describes the procedure of testing magnetic contacts and it includes the results of the tests of basic detection function as well as of breakthrough resistance. The results of simple tests have a considerable impact on planning physical security of buildings. Based on the findings, it is possible to initiate changes of technical standards for opening magnetic contacts. For even more detailed results obtained from much larger number of magnetic contacts the development of device for testing magnetic contacts was initiated and the last part of article describes fully automated testing device for magnetic contacts.

Keywords: magnetic contacts, security, development, testing, detection, alarm, device.

* ADDRESS FOR CORRESPONDENCE: **Milan Kutaj,** Faculty of Security Engineering, University of Zilina, Univerzitna 8215/1, 010 26 Zilina, Slovakia. *E-mail address*: milan.kutaj@fbi.uniza.sk / Tel.: +421-41-513-6794

1. Introduction

The tests of the basic detection function (BDT) embrace the measurements of approach distance, respectively, of removal distance of the corresponding magnet from the detector, whereas the distance is defined by a manufacturer in the technical documentation of the magnetic contact. The measured values were compared with the values claimed by the producers. Another test dealt with the resistance to disruption by an external magnetic field generated by external interference test magnets. The results of this test are also noted in the article. Based on the findings, it is possible to initiate changes of technical standards. Magnetic contacts consist of a corresponding magnet and a contact (reed relay). The reed relay is composed of a sealed glass tube filled with the inert gas which contains two ferromagnetic contacts. The magnet is mounted on the movable part of the window or door and the reed relay on the fixed part (door or window frame). In the standby state, the contact of reed relay is on-state (off-state) by the magnetic field of the corresponding magnet. Likewise mechanical contacts, the magnetic contacts are designed to protect building openings such as windows, doors, shutters and the like. They belong among the cheapest components of the electrical security system (Uhlar, 2001; Krecek, 2006). The simple operating principle is shown in figure 1.

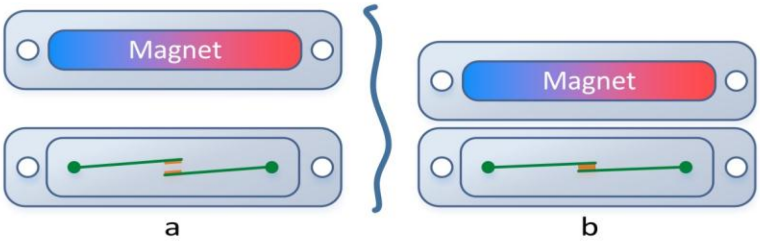

Figure 1. Operating principle of magnetic contacts (a – normally open; b – closed when magnet is near)

The objects with higher risks are provided by the contacts encased in a metal housing whereas the objects with lower risks have contacts in plastic casing. Various types of contacts are being produced which can be installed either on the surface of the window/door (surface mount contact) or contacts with hidden mounting into the frame of the window/door (flush mount contact) (Fig. 2.). The current trend presents contacts which are possible to be drilled in or are concealed in the window frame. Many manufacturers of the window fittings are currently trying to meet the requirements of the companies developing security components by inserting the corresponding magnet into the moveable window/door casements during the production phase (Velas, 2010).

Figure 2. Different mounting types of magnetic contacts (a – surface mount, b – flush mount)

Considering that magnetic contacts are fairly simple components of Intrusion and hold-up systems, they are easily overcome (by bridging, external magnets etc.). Quite frequent reason for this is their incorrect installation (in terms of location or balance of resistors) and inefficient combination with other safety features. In practice, it is quite common for people moving around the object in its standby state to remove the corresponding magnet, which can be declared by the control and indicating equipment as sabotage and disables the activation of the Intrusion and hold-up system during the guard state. With regard to above considerations, it is necessary to test the distance between the corresponding magnet and ability or inability to overcome magnetic contacts by the external magnetic field generated by external interference test magnets (Lovecek, 2008). This is a non-destructive testing (Sebok, Gutten, Kucera, Korenciak & Kołtunowicz, 2014).

2. Testing methods

Magnetic contact testing is defined by the norm STN EN 50131-2-6 on electric safety systems. Requirements on magnetic contacts are available in English language only, respectively, in its Czech translation (Lovecek, 2008). One of the most important tests is the test of resistance to intrusion of magnetic field by the external magnetic field generated by external interference test magnets. Magnetic contacts should be immune to this form of sabotage and should generate responding signal (alarm, intrusion, sabotage or other appropriate signal.) The tests of basic detection function include measurement of approach distance or removal distance of the corresponding magnets from the detector whereby the distance is defined by a manufacturer in the technical documentation of the magnetic contact. Similar to the testing of resistance of passive infrared detectors towards the interference by an external magnetic field, various types of commonly available magnets are not taken into consideration (Kampova, 2012)

In March 2015, within the frame of the research activity at the Faculty of Security Engineering at University of Zilina, we conducted tests of magnetic contacts (random selected) which were available on the market. We obtained seven types of different contacts by different producers. Two out of six were designed to be drilled into the frame of the window/door (Koczo, 2014). According to the norm, the detector must generate an alarm signal or a message in the mutual breaking of both parts (contact and magnet) at a distance specified by the producer (removal distance). This distance must be specified for all axes of movement (Fig. 3.). The detector must also generate a signal or a message at approaching minimal distance specified by the producer (approach distance).

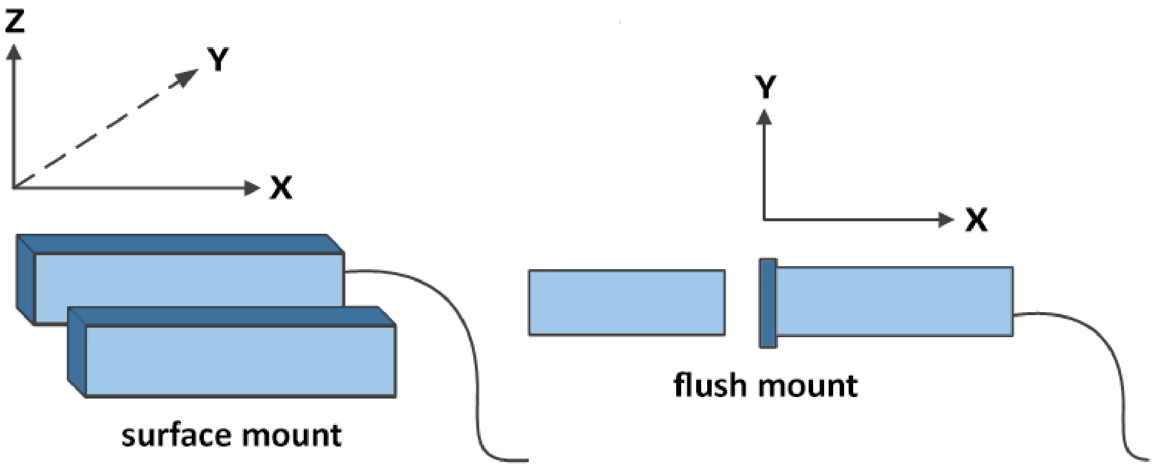

Figure 3. Possible movements of magnetic contacts (surface mount – 3 axis, flush mount – 2 axis)

All tests were performed under laboratory conditions, as described in the standard:

- temperature of 15 °C to 35 °C,

- relative humidity of 25% to 75%,
- air pressure of 86 kPa to 106 kPa [4].

Set-up:

- digital multimeter UNI-T70A,
- breadboard,
- LED,
- resistor,
- power supply,
- connection cables,
- measuring tape,
- graph paper.

Tested magnetic contacts (Grad 2):

- SD8561 – surface mount contact,
- Bestkey BR1013 – flush mount contact,
- USP - A1W – flush mount contact,
- BS2031 – surface mount contact,
- USP - 130 SP – surface mount contact,
- USP - 1000SP – surface mount contact,
- Sentrol 1087 HVS – surface mount contact.

Requirements for the magnet field strength depend on the material used, remanence (Br) in mT, produced energy (BH)max in kJm-3 and polarization of the working point in mT (Uhlar, 2001). Corresponding values of the magnets can be found in the tables and technical documentation of manufacturers. The norm considers only the use of so-called “(parasite) external magnet” which is identical with the corresponding magnet supplied with magnetic contact. Potential intruder of the object will not reflect on the type of magnet, but will use the one available (EN 60404-5).

During the first experiments we used a digital multimeter UNI-T 70A switched to measure the integrity of the circuit (short circuit probe). After a few repetitions, we have noticed a slow response of digital multimeter and we decided to create a simple electrical circuit that serves as a visual signalization device (red LED lights up) to indicate a status (open/close) of magnetic contact. In simple terms this basic electric circuit is measuring the integrity of the circuit (Fig. 4.) same as connected digital multimeter, but response of this system is immediate.

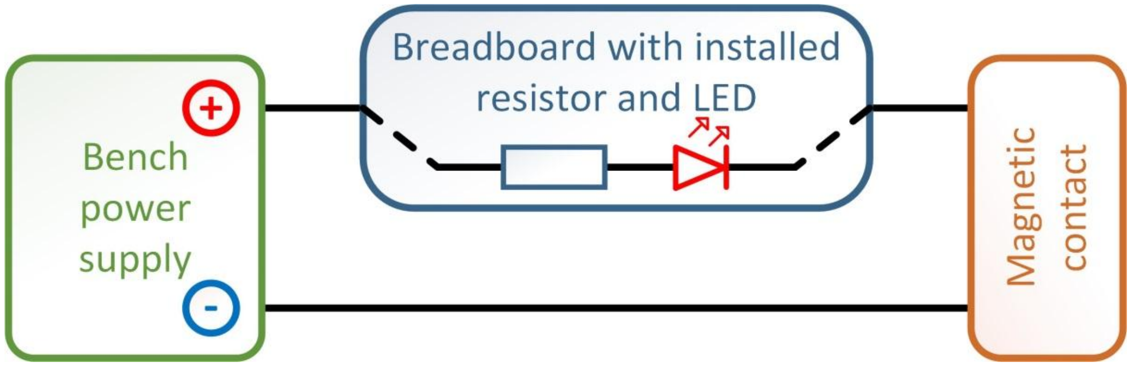

Figure 4. Block diagram of the test circuit

The following steps need to be done to accomplish testing process and obtain necessary data;

1. We have created the circuit described above.
2. Output cables of the magnetic contact are connected to the circuit.
3. The reed relay was mounted to the pad covered with graph paper.
4. We approached the permanent magnet to the reed relay and then removed it from the relay.
5. We marked distance when LED turn on (magnet approached to the reed relay) and then when LED turn off (magnet removed from the reed relay).
6. We have created tables with recorded distances.
7. To calculate arithmetic mean was used equation of $\bar{x} = \sum_{i=1}^{n} x_i / n$. We calculated the arithmetic mean of distances when approaching, respectively when removing the magnet from the relay.
8. The results were compared with the manufacturer's technical documentation.

At 30 repetitions, all of the tested contacts opened and closed within the distances set in their technical documentation. The movement was performed according to the type of the contact. It is possible to claim that the tested contacts are reliable and their efficiency is close to 30 reps (closure and opening) while the detection value is on 30.

In our paper, we present for example complete results for 1 magnetic contact USP –1000SP of which the working distance is 25 mm (see in Table 1). Given the measured values it meets the standards (EN 50131-2-6; VdS-Rules for Intruder Alarm Systems). Out of the measured contacts, it was the only one which did not keep the constant distance of approach and removal on every repetition.

Table 1. Measuring values of the magnetic contact USP–1000SP

Measurement No.	1	2	3	4	5	6	7	8	9	10
Approach (in mm)	3.7	3.8	3.7	4	3.8	4	4	4	3.8	4
Removal (in cm)	3.2	3.1	3.1	3.2	3.2	3.2	3.1	3.2	3.2	3.2
Measurement No.	11	12	13	14	15	16	17	18	19	20
Approach (in cm)	3.9	4	4	3.8	3.9	4.2	3.8	3.9	4	4
Removal (in cm)	3.2	3.2	3.2	3.1	3.2	3.2	3.2	3.2	3.1	3.2
Measurement No.	21	22	23	24	25	26	27	28	29	30
Approach (in cm)	3.9	4	3.9	4	3.8	3.9	4	3.9	4.1	3.9
Removal (in cm)	3.2	3.2	3.2	3.1	3.2	3.2	3.2	3.2	3.1	3.2

The measuring values of the other magnetic contacts are listed in the following Table 2.

Table 2. Measuring values of magnetic contacts (in mm)

Type	Approach distance	Removal distance	Distance from technical documentation
SD8561	24	46.5	12.7-25.4
Bestkey BR1013	24	31	up to 25
USP - A1W	31	31	20
BS2031	39	46	up to 31
USP - 130 SP	30	30	25
Sentrol 1087 HVS	13	14	9.52-31.75

When comparing the measured results with the data provided by the manufacturer, we found noticeable inaccuracies between the data from the technical documentation and the measured values in five cases. At removal, which is more important indicator than the approach, the data did not correspond with these contacts:

- SD8651,
- USP - A1W,
- BS2031,
- USP – 130 SP.

Besides the testing of opening and closing of magnetic contacts, we conducted the test of their ability to resist a breakthrough by attaching other corresponding magnet (we used the available permanent magnet). The test was carried out with four types of magnets of various construction materials. On that ground, it can be stated, that there are permanent magnets which can influence the detection ability of the magnetic contact – detection distance gets wider and through the opening between the wings of doors or windows, it is possible to get a hand in or open the door or the window without detection. Subsequently, it is enough to attach a permanent magnet to the magnetic contacts and it is possible to pass through the window or the door. Overcoming the buildings protection in this manner makes it difficult to investigate the security incidents.

3. Development of device for testing the magnetic contacts

Development of device for testing the magnetic contact was established for a number of reasons. The magnetic contacts are sold in huge amounts and manual testing is time consuming. The main idea was to develop a device that can repeatedly test the magnetic contact from constant distance.

The first version of the device was relatively simple. The construction was made of wood and it was based on a low-speed electric motor with mounted carrier for permanent magnet. Device is not equipped with any electronics and motor speed was controlled only with simple change of output voltage on bench power supply. As a carrier of the permanent magnet was used vinyl record. Attaching to the shaft was not very rigid and the permanent magnet was "floating".

For more reliable testing, we decided to develop a second version (Fig. 5). It is directly inspired by the previous model and also uses the same wooden construction. The changes affected mainly the drive. The low-speed electric motor was replaced by the high power servo.

Figure 5. Device for testing the magnetic contacts (version 2)

The servo is highly modified because it is not possible to rotate continuously by default. Some mechanical parts have been removed and some electronic parts have been replaced. The servo is powered from voltage regulator based on LM7805 and controlled by PWM signal generated by the controller unit. Now we can change not only the speed of rotation, but also its direction. The rotational speed (and direction) is no longer adjusted by changing the electric voltage at the output of bench power supply, but by changing the width of pulses generated by the control unit. The presence of the voltage regulator LM7805 allows us to connect any source of electrical power in the range of 7.5 to 35 V. The carrier was also modified and it is much more stable now. The shaft in servo is mounted in ball bearing and the shaft has deep metric thread. Thanks to that modification “the floating” of the carrier was minimized to the lowest level.

As we mentioned above, both versions have been intended to test the magnetic contacts from constant distance from the reed relay. These testing devices make the test process easier but human presence is still needed. In order to automate the testing process we have begun with development of a third version (fig. 6). This new device has completely different type of construction, as a drive is no longer used a low-speed electric motor neither a servo. The rotary carrier from previous versions was replaced with universal platform suitable for every type of permanent magnet. Also rotary motion of carrier is no longer present. The universal platform is moving on a straight line to the reed relay. The new version of testing device is able to measure distance when the permanent magnet approaches to the reed relay and also when it is removed from the reed relay which is the biggest improvement over its predecessors. Relatively simple control electronics is replaced by a control unit, which is based on the MCU Atmel ATmega328. This control unit is capable to record data from exact number of repetitions which can be easily configured on PC. Gathered data is saved to the SD card in CSV format, which can be converted into any spreadsheet. LCD is capable to display information about distance, number of ongoing and passed repetitions and optical LED system informs us about current state as follows:

- white – the device is ready to start testing process,
- blue – platform with a permanent magnet is in motion, the device performs a set number of repeated measurements.
- green – the device stops for a few seconds, the display will show the distance of the permanent magnet when approached to the reed relay,
- red – the device stops for a few seconds, the display will show the distance of the permanent magnet when removed from the reed relay,
- flashing blue – the device has completed all set measurements

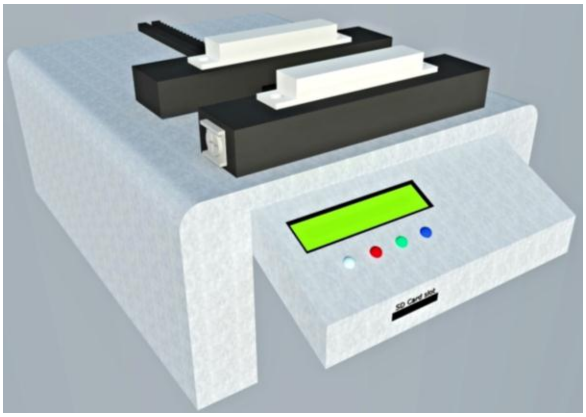

Figure 6. 3D model of testing device

The device can perform the movement with precision up to one tenth of a millimeter and delay of recording measured distance is less than one millisecond, so it can be considered as instantaneous. These properties are very important because measurement error is reduced almost to zero.

4. Summary

The article describes conducted pilot tests, the methodology of testing, and results of the tests for chosen types of magnetic contacts. Our main objective was to verify detection capability and possibility to overcome magnetic contacts by commonly available means.

Magnetic contacts are the most commonly used and the cheapest detectors used for the peripheral intrusion security. Such contacts are fairly reliable, unless they are within the range of other magnetic field. The norms establishing the parameters for testing and certifying of the magnetic contact do not take into consideration all types of magnets available on the market. The drawback is that magnetic contacts for the second level of security do not have to be tested for intrusion by external magnet even though it is a simple way to overcome the peripheral intrusion security of the object without any complicated procedures.

With a possibility of breakthrough, it is necessary to consider this at designing the security of the object (testing of alarm components must be included in security systems design) and within the framework of legislative activity in TK SUTN (Technical Committee of the Slovak Standards Institute), it is appropriate to recommend toughening the norm for the level 2 in respect to the found results.

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