RISKS OF VIBRATION DETECTORS IN INTRUSION AND HOLD-UP ALARM SYSTEMS

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Abstract. In the time of increasing property crime, it is highly important for detectors to be able to achieve efficiency, reliability and faultlessness. In the case of proposal for placement of detectors it is naturally important to determine the position of the detector, the type of the detector and also to guarantee their capability of detection for using. The problem of vibration detectors affects a large proportion of intrusion and hold-up alarm systems (I&HAS). In the time of increasing property crime, it is highly important for vibration detectors to be able to detect attempts to penetration the monitored surface within the guarded area reliably and free of error. In the case of installation of vibration detectors it is naturally important not only to ensure correct installation, to gauge the external influences impacting upon the detector and ensure proper maintenance, but also to guarantee their capability of detection under more arduous conditions. The tests, which have been conducted, examine both normal operation of the vibration detectors and operation of these detectors under extreme conditions. These tests are important both from an informative perspective and due to the possibilities of development of potential counter-measures, which could lead to their improvement and an enhancement of their level of security. The measurements show that from the tested materials steel is the best, which does not attenuate the vibrations and If transmitted shocks reliably. From the tested detectors based on the best detectors from the producer Risco whose detection is around 60 % for all tests performed. As another detector placed VD-1 from the Satel, where the detection capability was of around 50 %.

Keywords: security risks, sabotage, intrusion and hold-up alarm systems, vibration detector.

Introduction

Intrusion and hold-up alarm systems serve primarily for protecting buildings against unlawful conduct of third parties, and can be used as monitoring and control systems. They are therefore primarily a tool for ensuring a state of security. They operate in the material realm (physical protection of property, life and health) and in the emotional realm (providing a feeling of peace, safety and a certain security). As a result it is important for them not to malfunction and be sufficiently resistant to attack. The critical point of intrusion and hold-up alarm systems is predominantly elements of the building envelope protection [1; 2].

Most types of detectors are essentially fixed from the beginning of their production from the perspective of the physical principle and logic of their activity, and have not changed substantially up to the present. Although their principles and logic do not change, their evaluating circuits have undergone large modernisations both in the evaluation itself and in the protection of itself against potential sabotage [2; 3].

It is true that the standard of security technology is sufficient (even if far from perfect), even presuming its further development. There are a whole range of possibilities for sabotaging the existing systems in order to enable unauthorised entry into the guarded building [1; 2].

These elements are highly susceptible to poor installation, and as a result it is very important to pay attention to this problem. One of the used types of detectors is the vibration detector, which ranks amongst passive detectors. On average, of all the types of the building envelope detectors used a large number of false alarms occur on these detectors. This higher error rate is primarily caused by incorrect installation [1; 3].

Materials and methods

Several security risks may arise during the installation of intrusion and hold-up alarm systems, which impair the security of the entire building. The risks which occur due to poor installation or various sabotage techniques are always a serious danger for the guarded premises [3; 4]. They may jeopardise the guarded property or even the lives of the people who the intrusion and hold-up alarm systems are intended to protect. Above all, however, they have an influence on determining the security risks of buildings.

Measurement and testing to date has been conducted predominantly in the laboratory of the Department of Technological Facilities of Buildings at the Czech University of Life Sciences in

Prague, specifically in the Security Systems Laboratory, under standard laboratory conditions according to EN 60068-1:1994. The standard laboratory conditions are defined in Table 1.

Table 1

Standard conditions of measurement

Temperature	15 ºC to 35 ºC
Relative moisture	25 % to 75 %
Air pressure	86 kPa to 106 kPa

Upon installation of vibration detectors it is necessary to take into account a number of fundamental prerequisites. The first prerequisite is that the detector must be installed on a solid material. The second prerequisite is for the cabling not to be visibly installed [3; 5]. In addition, the relevant norms must be adhered to upon implementation of the cable distribution mechanisms. If the cable distribution mechanisms are installed in such a manner that enables access to them, it is possible to sabotage these systems and thus attack the entire installation of the intrusion and hold-up alarm systems.

The detectors VD-1 (Satel), VIBRO (Optex), RK601/600SM ShockTec (Risco), IMPAQ plus (Texecom), RK 66S (Risco) were used for measurement – see Fig. 1. These are frequently used detectors, which are installed in both small buildings and large firms. All the tested vibration detectors are loop detectors with a simple type of sending of alarm information, which are cheap in comparison to other types of vibration detectors (using a different type of data transmission).

Fig. 1. **Vibration detector:** 1 – VD-1; 2 – VIBRO; 3 – RK601/600SM ShockTec; 4 – IMPAQ plus; 5 – RK 66S

This measurement was carried out on five samples of each vibration detector and was repeated ten times. The measurement on different materials was carried out according to the requirements of ČSN EN 50131-2-8. Tests were conducted in all vibration detectors as well. The vibration detector was always fixed to the material for testing. In tests simulating shocks were used to create an alarm situation. At the same time even small shocks were tested. To small shocks the detector does not respond. After shock it was evaluated whether the detector is causing the alarm. The size of the shock is specified in Table 2. Shocks are created according to the following procedure. Weights are hung up in a pre-specified height above the board monitored. Then the weights are released and allowed to fall in the monitoring board.

Table 2

The size of the used shock

Weight, kg	0.1	0.2	0.3	0.4	0.5	0.3	0.4	0.5
Height of suspension, m	0.15	0.15	0.15	0.15	0.15	0.30	0.30	0.30
Potential energy of the weights, J ***(rounded to four decimal places)***	0.1472	0.2944	0.4416	0.5888	0.736	0.8832	1.1777	1.4720

The following materials were selected for testing: steel, aluminum, spruce wood, beechwood, particleboard (width 20mm), PVC, double-sided tape (width 1 mm) and particle board plate (width 5 mm). For clarity of the results these are average percentage values for all samples tested.

Vibration detectors should evaluate the alarm even at 0.736 joules. It is a limit value of where a single shock should default to run these detectors [3; 6].

The first tests carried out were on the vibration detector VD-1 (with magnetic contact) from the manufacturer Satel – see Table 3.

Table 3

Percentage detecting vibrations of the detector VD-1

Potential energy of the weights, J	**0.1472**	**0.2944**	**0.4416**	**0.5888**	**0.7360**	**0.8832**	**1.1777**	**1.4720**
Steel, %	8	32	64	84	100	100	100	100
Aluminum, %	6	24	60	76	90	100	100	100
Spruce wood, %	2	18	48	58	74	92	100	100
Beechwood, %	4	22	56	66	82	100	100	100
Particleboard (*width 20mm*), %	0	0	24	30	38	44	66	86
PVC, %	0	20	34	44	48	64	78	98
Double-sided tape (*width 1 mm*), %	0	0	0	0	20	32	46	60
Particle board plate (*width 5 mm*), %	0	0	0	26	38	50	64	80

The second tests carried out were on the vibration detector VIBRO from the manufacturer Optex – see Table 4.

Table 4

Percentage detecting vibrations of the detector VIBRO

Potential energy of the weights, J	**0.1472**	**0.2944**	**0.4416**	**0.5888**	**0.7360**	**0.8832**	**1.1777**	**1.4720**
Steel, %	6	28	48	74	90	100	100	100
Aluminum, %	4	18	46	60	78	96	100	100
Spruce wood, %	0	12	40	48	64	84	96	100
Beechwood, %	2	16	42	54	76	92	100	100
Particleboard (*width 20mm*), %	0	0	18	26	32	38	54	72
PVC, %	0	6	26	36	40	54	66	82
Double-sided tape (*width 1 mm*), %	0	0	0	0	14	26	38	48
Particle board plate (*width 5 mm*), %	0	0	0	20	28	40	54	72

The third tests carried out were on the vibration detector RK601/600SM ShockTec from the manufacturer Risco – see Table 5.

Table 5

Percentage detecting vibrations of the detector RK601/600SM ShockTec

Potential energy of the weights, J	**0.1472**	**0.2944**	**0.4416**	**0.5888**	**0.7360**	**0.8832**	**1.1777**	**1.4720**
Steel, %	14	42	68	92	100	100	100	100
Aluminum, %	10	36	60	88	100	100	100	100
Spruce wood, %	6	32	48	64	86	100	100	100
Beechwood, %	8	40	60	76	90	100	100	100
Particleboard (*width 20mm*), %	0	2	18	28	42	66	88	100

Table 5 (continued)

Potential energy of the weights, J	0.1472	0.2944	0.4416	0.5888	0.7360	0.8832	1.1777	1.4720
PVC, %	2	24	40	52	70	80	94	100
Double-sided tape (*width 1 mm*), %	0	0	2	16	26	42	54	78
Particle board plate (*width 5 mm*), %	0	0	6	34	48	62	78	96

The fourth tests carried out were on the vibration detector IMPAQ plus from the manufacturer Texecom – see Table 6.

Table 6

Percentage detecting vibrations of the detector IMPAQ plus

Potential energy of the weights, J	0.1472	0.2944	0.4416	0.5888	0.7360	0.8832	1.1777	1.4720
Steel, %	8	30	60	82	98	100	100	100
Aluminum, %	4	22	56	70	84	98	100	100
Spruce wood, %	4	20	44	60	74	92	98	100
Beechwood, %	4	20	48	60	82	98	100	100
Particleboard (*width 20mm*), %	0	0	20	26	36	48	64	80
PVC, %	0	18	32	40	44	60	78	100
Double-sided tape (*width 1 mm*), %	0	0	0	0	18	28	40	58
Particle board plate (*width 5 mm*), %	0	0	0	24	38	50	62	78

The final test was conducted to compare the detector to a higher class. This detector is commonly used to monitor strong room cabinets and belongs to the highest level of security. This last test carried out was on the vibration detector RK 66S from the manufacturer Risco – see Table 7.

Table 7

Percentage detecting vibrations of the detector RK66S

Potential energy of the weights, J	0.1472	0.2944	0.4416	0.5888	0.7360	0.8832	1.1777	1.4720
Steel, %	24	32	64	84	100	100	100	100
Aluminum, %	18	24	60	76	100	100	100	100
Spruce wood, %	14	18	48	58	96	100	100	100
Beechwood, %	18	22	56	66	100	100	100	100
Particleboard (*width 20mm*), %	10	30	48	60	76	88	100	100
PVC, %	8	26	38	50	66	80	94	100
Double-sided tape (*width 1 mm*), %	0	2	14	40	58	78	92	100
Particle board plate (*width 5 mm*), %	2	6	22	50	62	80	96	100

Results and discussion

The tests have shown that only four of the tested materials are suitable for mounting vibration sensors in security grade II (VD-1, VIBRO, RK601/600SM ShockTec, IMPAQ plus). The test materials assessed as suitable for mounting are: steel, aluminum, beech and spruce wood. Steel and spruce wood are most suitable for detection. Other materials in the test failed, and are not suitable for mounting vibration sensors – see Fig. 2.

As it is evident from the works "Self-mixing digital closed-loop vibrometer for high accuracy vibration measurements" [7] and "Active vibration control of flexible cantilever plates using piezoelectric materials and artificial neural networks" [8], vibrations are greatly influenced by the material of which they are transmitted.

It is important, as the authors wrote in the articles "Design of a Digitized Vibration Detector Implemented by CMOS Digitized Capacitive Transducer With In-Plane SoI Accelerometer" [9] and "A novel infrared detector using highly nonlinear twisting vibration" [10], detectors and their detection are constantly improving.

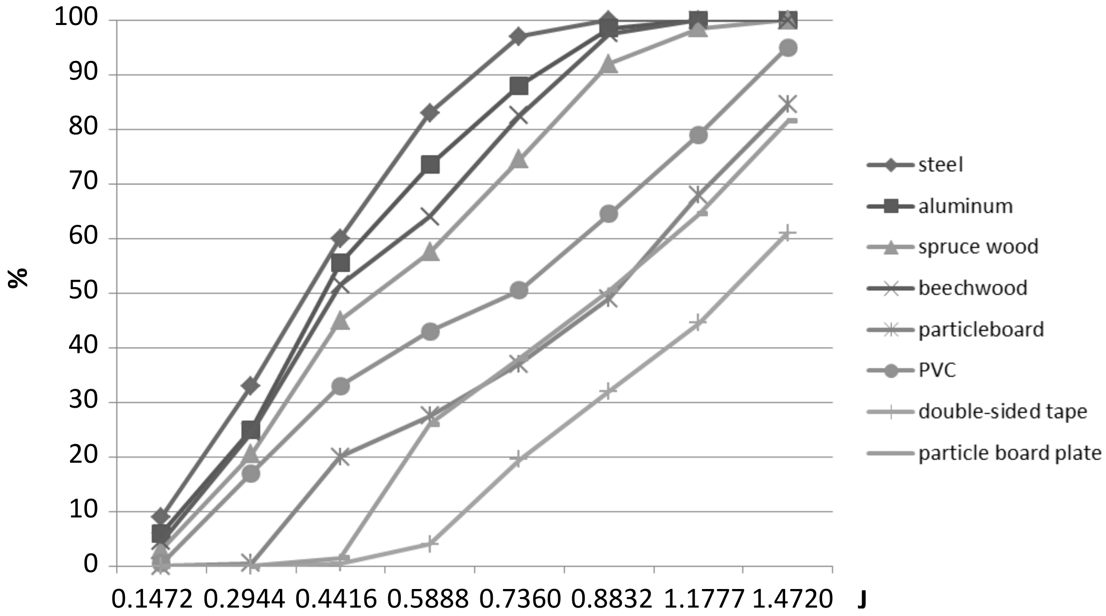

Fig. 2. **Testing of materials for mounting of vibration sensors on detectors in security grade II**

Also comparative measurements on the detector in the security grade IV were carried out. From this measurement it is clear that this detector is sensitive and can detect vibrations on materials that dampen vibration – see Fig. 3.

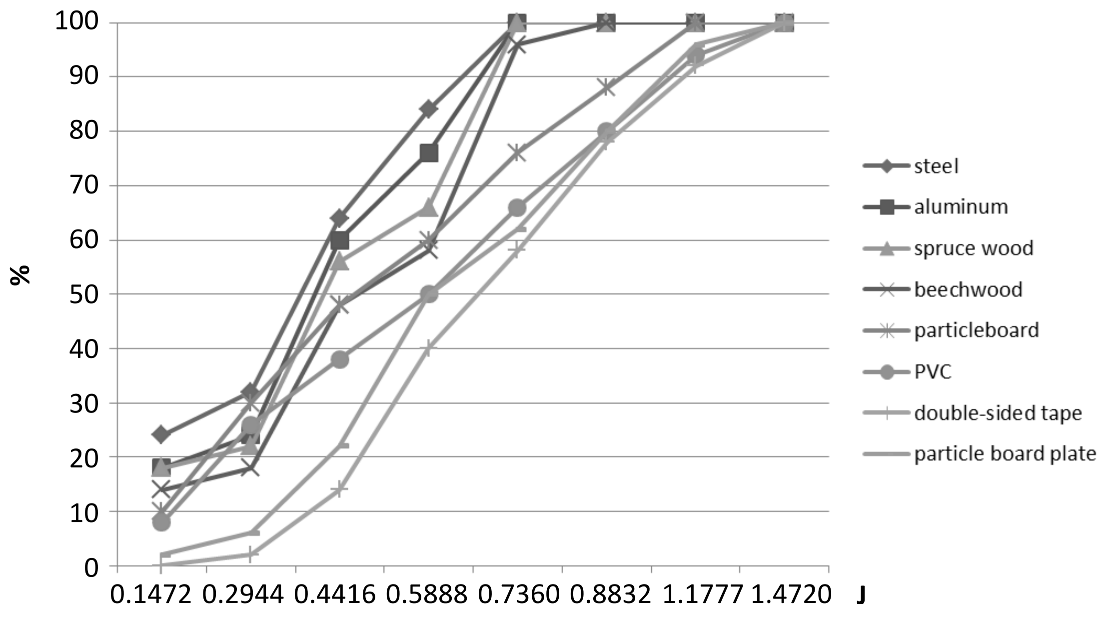

Fig. 3. **Testing of materials for mounting of vibration sensors on detector in security grade IV**

At the end comparison was made for the various types of vibration sensors. It is the average of all tests performed – see Fig. 4. This comparison points out the fact that the vibration detectors from manufacturers Risco have the best detection capabilities of the tested detectors.

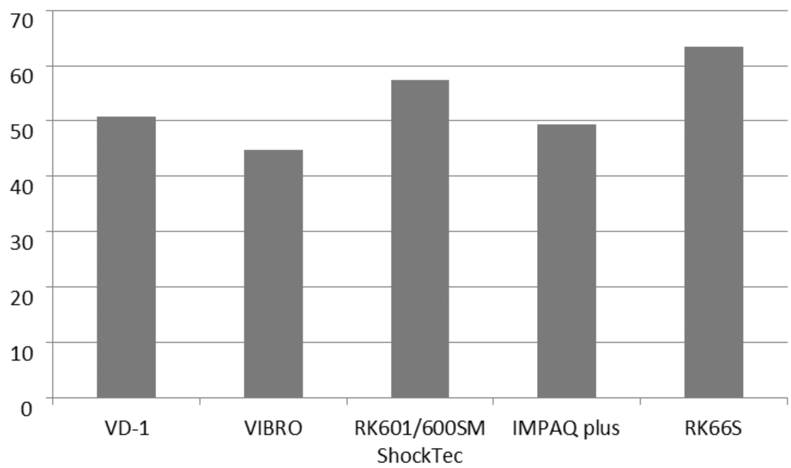

Fig. 4. **Accuracy of detection in different types of detectors (in percent)**

Based on the paired t-test it was proved that when five percent level of significance is tested the detector in security grade IV is more sensitive than the other tested detectors in security grade II.

Conclusions

The technical design of security systems is unique for the majority of manufacturers. In the case of every manufacturer it is possible to find some poor technical designs which require modification. This deficiency can be resolved by technical development of the given product and adaptation to the customer requirements.

The practical tests conducted on vibration detectors brought an insight into their functionality and usability in practice. It was clearly shown that different types of materials have a big impact on the functionality of vibration sensors. For mounting the vibration sensors (as measured) "hard" materials such as steel, aluminum, beech or spruce wood suited best. These materials transmit vibrations to the vibration detector well. Vibration detectors can better evaluate vibration. The tests showed that the worst of the tested materials is double-sided tape. Unfortunately, installers often use double-sided tape for mounting vibration sensors. It is therefore very important that installers adhere to certain guidelines when mounting.

From the tested detectors based on the best detectors from the producer Risco whose detection is around 60 % for all tests performed (RK66S – 63 %, ShockTec – 57 %). As another detector placed VD-1 from the Satel, where the detection capability was 51 %. Based on the paired t-test it was proved that when five percent level of significance is tested the detector in security grade IV is more sensitive than the other tested detectors in security grade II.

It is also important to keep open for the development of new technologies. And, of course, it is important also to improve the existing technology. Without this development security systems would have reached a point of stagnation and thereby weaken these systems.

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