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RISK ASSESSMENT AND RISK REDUCTION MEASURES FOR THERMOVISION EQUIPMENT

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Abstract:
This paper presents a risk assessment, as well as risk reduction measures implemented by the user during the use of a thermographic camera in a production environment. Infrared thermography is a method used for monitoring and diagnostics, quality control, and non-destructive testing. Thermovision enables non-contact temperature measurement and visualization of thermal phenomena in real time, making it highly suitable for industrial diagnostics.
The risk assessment was carried out in accordance with ISO 12100 and ISO 14121-1 standards, based on risk analysis through defining machine limits, hazard identification, and risk estimation. Mechanical, electrical, thermal, laser, ergonomic, and other hazards that may arise during operation in the cutting zone while handling the thermographic camera were identified. A risk matrix was used as the risk estimation method, quantifying risk levels before and after the implementation of risk reduction measures, and performing risk evaluation.
Based on the assessment results, technical, organizational, and personal protective measures were proposed, with special emphasis on measures implemented by the user. These include the development of safe working procedures, operator training, use of personal protective equipment, and organizational safety measures. The results show that after applying the proposed measures, all risks are reduced to an acceptable level, confirming that the use of a thermographic camera in a production environment is safe when prescribed safety measures are consistently applied.

Keywords: *Risk assessment, Thermovision, Risk matrix, Risk reduction.*

Introduction

Infrared thermography, or thermovision, represents a modern, non-invasive method for measuring and visualizing temperature distributions on object surfaces, enabling early detection of potential problems and improvement of maintenance systems.

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In addition to the technical advantages that thermovision offers in diagnostics and quality control, it is necessary to consider the safety aspects of its application. The use of a thermographic camera in an industrial environment, especially near machine tools and cutting zones, exposes operators to various types of hazards. Therefore, conducting a risk analysis—through hazard identification, defining machine limits, and risk estimation—followed by risk evaluation, i.e., risk assessment in accordance with relevant international standards, is of great importance.

The aim of this paper is to present the application of infrared thermography in monitoring machine condition during the production process, as well as to perform a risk assessment of thermographic camera use, in accordance with ISO 12100 and ISO 14121-1 standards.

The ISO 12100 standard is the overarching international standard for machinery safety, defining design principles, risk assessment, and risk reduction throughout the entire machine lifecycle.

It provides a systematic framework for hazard identification, risk analysis and evaluation, as well as methods for reducing risks to an acceptable level [1].

The ISO 14121 standard is the predecessor of ISO 12100 and is specifically focused on risk assessment [2].

Standard EN 292 was the first to clearly define that safety must be integrated into design rather than addressed subsequently through protective measures, forming the foundation of today's principle of inherent safety [3].

In the available scientific and professional literature, infrared thermography is widely represented as a method for condition monitoring, predictive maintenance, quality control, and non-destructive testing. Numerous authors highlight its advantages in terms of non-contact measurement, response speed, and the ability to detect early irregularities in electrical and mechanical systems. However, analysis of the available studies shows that most research focuses on the technical aspects of thermography application, while the assessment of safety risks associated with the use of thermographic cameras in industrial environments is significantly less represented.

Some studies address risk assessment in combination with thermography, mainly in the field of occupational health and safety, where thermographic data are used to identify ergonomic and physiological loads on workers [4].

Additionally, the literature includes research pointing to limitations and potential sources of error in thermographic measurements, such as the influence of emissivity, reflections, and thermogram interpretation, which can indirectly be considered as risk factors in the application of this method [5].

However, a systematic risk assessment of the thermographic camera as a technical device, conducted in accordance with ISO 14121-1 and ISO 12100 standards, is rarely the subject of dedicated scientific studies, thus confirming the justification and importance of the research presented in this paper.

1. Thermovision

Infrared thermography (IRT) – thermovision can be used to identify and document irregularities for the purpose of machine condition monitoring, quality control, and non-destructive testing, as well as for monitoring temperatures in various manufacturing processes, such as temperature in the cutting zone, extrusion temperature during deformation, casting and cooling temperatures of castings, and thermal phenomena in welding.

Therefore, for the proper application of infrared thermography, it is necessary for the operator–thermographer to possess basic knowledge of heat and temperature concepts, as well as heat transfer mechanisms. Thermal energy occurs during the operation of all machines and can arise due to friction, energy losses, fluid characteristics, the technological process itself, or a combination of these factors. For this reason, temperature represents one of the key parameters for monitoring machine operation, assessing their condition, and identifying potential failures.

IRT has proven to be a highly suitable method for temperature monitoring, as it enables comprehensive thermal imaging of machines or their components through non-contact (non-invasive) measurement, with minimal setup and very rapid results [6].

2. Risk assessment

Risk assessment consists of risk analysis and risk evaluation. Risk analysis is carried out through defining machine limits, hazard identification, and risk estimation, while risk evaluation determines

whether the risk has been adequately reduced. According to ISO/TR 14121-2:2012–Part2: Practical guidance and examples, risk assessment methods include: hazard identification using checklists, risk matrices, risk graphs, numerical scoring, quantified risk evaluation, and hybrid methods [7].

2.1. Risk Matrix

The risk matrix is one of the risk estimation methods applied after the risk analysis has been conducted, i.e., after hazards have been identified.

It represents one of the most commonly used risk assessment methods and is applied following the identification of all relevant hazards. This method enables the evaluation of risks associated with machines and equipment across various industrial sectors.

The main purpose of the risk matrix is to rank identified risks according to their magnitude, in order to clearly distinguish those that are unacceptably high and require the implementation of risk reduction measures. In this way, the risk matrix serves as a decision-making tool regarding risk acceptability and the prioritization of preventive and protective measures. Its advantages lie in its simplicity, speed, and efficiency, making it suitable for practical application in industrial environments.

Risk matrices have been in use for many years and have been developed in various forms, such as 5×5 matrices, as well as matrices defined by standards and guidelines, including ANSI B11 TR3:2000 and IEC 61508. Differences between them are reflected in the number of levels and the way risk factors are defined, with four or five levels being the most commonly used in practice.

For each identified hazard or hazardous situation, it is necessary to assess the severity of possible consequences. In addition to severity, the probability of occurrence of a hazardous event is also evaluated for each hazard.

In Table 1 below, a risk assessment for a thermographer operating within the cutting zone is presented using the risk matrix method. Appropriate risk control measures have been defined and implemented. Furthermore, a risk evaluation has been conducted to determine whether the residual risk is acceptable following the application of the prescribed measures.

Table 1: *Risk Estimation Using the Risk Matrix Method*

Operator/Task	Hazard	Initial Risk Estimation			Risk Control Measures	Residual Risk Assessment			Risk Acceptability
		Severity	Probability	Risk categories		Severity	Probability	Risk categories	
Termograf/ monitoring	Mechanical – rotating tools, sharp edges, chips	4	4	16 (High)	Installation of additional guards; personnel training; restricted access to the cutting zone	4	2	8 (Medium)	Accep table
	Mechanical – workpiece, clamping devices, machine components	4	3	12 Increased	Verification of proper workpiece clamping; guarding; maintaining safe distance	4	2	8 (Medium)	Accep table
	Electrical – direct contact	4	2	8 Medium	Use of properly maintained cables; periodic inspection of electrical installations	4	1	4 (Low)	Accep table
	Electrical – indirect contact	3	2	6 Medium	Proper grounding; regular maintenance	3	1	3 (Low)	Accep table
	Thermal – hot tools, workpiece, chips	3	4	12 Increased	Use of personal protective equipment (PPE); maintaining safe distance	3	2	6 (Medium)	Accep table
	Radiation – camera laser pointer	3	2	6 Medium	Avoid directing laser toward personnel; adequate training	3	1	3 (Low)	Accep table
	Noise	2	3	6 Medium	Use of PPE; timely tool replacement	2	2	4 (Low)	Accep table
	Substances – dust, hazardous substances, fumes	2	3	6 Medium	Local exhaust ventilation; use of PPE	2	2	4 (Low)	Accep table
	Ergonomics – camera handling	2	3	6 Medium	Support devices; Rest breaks	2	2	4 (Low)	Accep table

3. Risk reduction measures

Measures for preventing, eliminating, or reducing risks are determined based on the assessed risk, in accordance with occupational safety and health regulations, technical regulations, and standards, and are aimed at achieving risk reduction. Risk reduction measures implemented by the manufacturer include: inherently safe design, safeguarding and complementary protective measures, and information for use (instructions, operating manuals, warnings).

Risk reduction measures implemented by the user include: organization (safe work procedures, supervision, work permits), provision and use of additional protective measures (safeguards), use of personal protective equipment (PPE), training, inspection and testing of work equipment, maintenance, medical examinations, etc.

Risk reduction measures applied by the user, particularly in terms of organization, include the development of a safe work procedure (instruction), which is presented in Table 2. In addition to general information and technical characteristics of the thermographic camera, the instruction describes measures to be taken before, during, and after operation, as well as hazard signs, prohibitions, mandatory requirements (PPE), and first aid measures.

Table 2: *Safe Work Procedure*

SAFE WORK PROCEDURE			
Instruction No.	**Device**	**Manufacturer**	**Model**
01/2025	Thermographic Camera	Flir	TG 298
General rules: The use of equipment by untrained (unqualified) personnel is strictly prohibited.			
If the operator does not possess the required qualifications/licenses or has not been authorized by the client, the thermographer must not perform tasks typically carried out by qualified personnel, including: - removing or replacing covers, - opening or closing cabinets containing electrical or mechanical equipment, - measuring electrical loads of equipment, - making physical contact with inspected equipment, - operating any equipment.			
Measures Before Starting Work			
- Conduct a workplace safety briefing. - Wear complete personal protective equipment (PPE) in accordance with standards. - Perform a risk assessment for the workplace and equipment being measured. - Ensure that a responsible person is always present and visible. - In case of injury, the responsible person must notify the relevant services and report all incidents.			

Measures During Work
- The operator must be aware of additional hazards present in the machine danger zone during thermographic inspection. - Exercise extreme caution when the laser pointer is activated. - Do not direct the laser beam toward the eyes and prevent reflection into the eyes. - Do not use the laser near explosive gases or in potentially explosive environments. - The minimum distance to the target is 26 cm. - When measuring temperatures above 400°C, the high-temperature protection switch must be activated. - Do not open the instrument housing, which is IP54 protected in accordance with EN 61010-1.
Measures After Work
- Wipe the housing with a damp cloth if necessary. Do not use abrasive agents or solvents. - Clean lenses using a high-quality lens cleaner and a lint-free cloth. - Open the cover only for charging and connection to a computer. - Perform regular maintenance.
Hazard signs

Mandatory signs

Prohibition signs

 Procedure in Case of Accident, Failure, or Damage(To be defined according to company procedures) Date:20.12.25 Prepared by: Dr. Dušan Jovanić

Measures taken by the manufacturer to reduce risks in terms of information include the instruction manual, while a warning is provided in the form of a label on the infrared thermographic camera indicating Class1 laser radiation.

4. Conclusion

Temperature monitoring and diagnostics using an IR thermal camera is a safe and non-contact method; however, it requires careful planning, training, and adherence to prescribed safety measures, particularly due to the presence of mechanical and thermal hazards associated with machine tools. Risks related to the IR camera are mainly associated with laser radiation, incorrect measurements, and improper handling.

The developed safe work procedure, as an organizational risk reduction measure implemented by the user, is expected to significantly reduce the probability of hazardous events.

After the implementation of the prescribed risk reduction measures by both the manufacturer and the user, the residual risk is considered acceptable and in compliance with applicable occupational safety and health regulations.

No risks remain in the high-risk category. The highest remaining risks are moderate risks related to mechanical and thermal hazards, while other risks have been reduced to a low level.

The overall assessment of the workplace for the operator–thermographer performing temperature monitoring and diagnostics in the cutting zone using a thermographic camera is acceptable, provided that the defined technical, organizational, and personal protective measures are consistently applied.

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