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Best Practices in Conveyor Risk Assessment: A Qualitative Study of Certified Safety Professionals in Industrial Settings

ARTICLES

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ABSTRACT

Background: This qualitative study examined the best practices for conducting risk assessments in industrial environments, with a specific focus on evaluating hazards associated with conveyors. Five Certified Safety Professionals (CSPs) who managed facilities with conveyors in Iowa were selected. Each CSP brought a diverse educational and safety background, representing various industries and safety perspectives, with industry experience ranging from 13 to 32 years.

Methods: Data were collected through semi-structured interviews with each of the five CSPs. Transcripts were thematically evaluated using NVivo ('NVivo' 1994) and a grounded theory approach.

Results: The key themes in this study included hazard identification during routine, maintenance, and non-routine tasks (i.e., cleaning and troubleshooting), training of in-house employee auditors, utilizing cross-functional auditors, and industry safety standards.

Conclusion: This study concluded that effective hazard assessments included trained employees for conducting assessments, cross-functional teams with a diverse range of knowledge, and customized assessments that reflect the best practices within their organization to assess conveyor hazards.

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INTRODUCTION

Conveyors are widely used in various industries to support continuous material handling, reducing labor costs, and increasing operational efficiency. Types of conveyors include belt, roller, chain, screw, pneumatic, and overhead conveyors. However, despite their numerous benefits, conveyors can pose mechanical and operational hazards that must be evaluated and mitigated to prevent worker injuries, equipment damage, and costly downtime.

Hazards related to conveyors include nip points, shear points, and entanglement hazards. These hazards are created at moving parts and components, such as those between belts and pulleys, rollers and frames, or chain drives and sprockets. In-running nip points are often found where a belt enters a pulley or near rotating shafts next to a fixed surface, and can pose an unreasonable hazard if proper safeguards, training, and education for workers are not in place. Safeguarding methods include various measures such as design, physical guards, control functions, devices, or methods guarded by location.

The current consensus standard for conveyors is the American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME) B20.1-2021 *Safety Standard for Conveyors and Related Equipment* (American Society of Mechanical Engineers 2021). A consensus standard is a best practice developed and agreed upon by experts with various backgrounds, education, and experience to establish safety practices across an industry. The ASME B20.1-2021 (American Society of Mechanical Engineers 2021) standard applied to the design, construction, installation, maintenance, and inspection of conveyors. This standard addressed the types of hazards and requirements to safeguard conveyors.

The Occupational Safety and Health Act was signed into law by President Nixon on December 29, 1970, and took effect on April 28, 1971. The Occupational Safety and Health Administration's (OSHA) mission was to ensure America's workers have safe and healthy working conditions by setting and enforcing safety standards (*About OSHA | Occupational Safety and Health Administration* n.d.). OSHA has industry safety standards for the general industry (1910) (Occupational Safety and Health Administration n.d.-a), construction (1926) (Occupational Safety and Health Administration n.d.-d), maritime (1917 and 1918; Occupational Safety and Health Administration n.d.-b; Occupational Safety and Health Administration n.d.-c), and the agricultural (1928; Occupational Safety and Health Administration n.d.-e) industry and specified types of safeguarding for conveyors (i.e., guards) but lacks information on how to safeguard a conveyor for a specific application.

Although OSHA and the ASME B20.1 (American Society of Mechanical Engineers 2021) standard offers guidance for safeguard conveyors; however, there is limited research on how safety professionals apply these industry safety standards across different industrial applications, and on providing reasonable safety for employees. It is the employer's responsibility to evaluate the conveyor, the interaction between employees, and a conveyor, and hazards to implement adequate safeguarding methods. Employee interaction with conveyors typically occurs at an operator station or workstation, and during maintenance, cleaning and sanitation, and troubleshooting.

Industry safety standards require conveyors to be locked out and tagged out during service and/or maintenance activities, but there are some exceptions. OSHA's 1910.147 (a)(2)(ii) (Occupational Safety and Health Administration 1989) exemption states

> Minor tool changes and adjustments, and other minor servicing activities, which take place during normal production operations, are not covered by this standard if they are routine, repetitive, and integral to the use of the equipment for production, provided that the work is performed using alternative measures which provide effective protection.

An example of an alternative measure includes implementing safe work procedures during those activities and ensuring that employees are trained on when and how to use them.

In addition to OSHA's regulations, the American National Standards Institute (ANSI) and the American Society of Safety Engineers (ASSE) Z244.1–2016, *The Control of Hazardous Energy Lockout, Tagout and Alternative Methods* (*ANSI/ASSP Z244.1-2016 (R2020)—The Control of Hazardous Energy Lockout, Tagout and Alternative Methods* 2020) specified requirements for machines and alternative methods to control hazardous energy. The purpose of this standard was to establish requirements that protect personnel from harm that can occur as a result of the unexpected release of hazardous energy. Alternative methods specified in the ASSE Z244.1 standard included the following: 'When lockout or tagout is not used, then alternative methods shall be used only after the hazards have been assessed'. In addition, the ASSE Z2441 standard defined a permit system as 'a process that provides a systematic risk assessment; the precautions required before the work proceeds'. Specifying that an assessment shall be conducted per a permit system.

Before assessing conveyor hazards, employees conducting the assessment should have received training, education, and experience in conveyor operation. Having this expertise is beneficial for effectively identifying and mitigating potential hazards. Equally important is ensuring that employees working near conveyors are adequately trained in the safe operation of conveyors and are familiar with company policies and procedures around safe conveyor operation.

Given the context of this information, it is key to evaluate the hazards associated with a conveyor and to provide a reasonably safe work environment through the implementation of appropriate safeguards while addressing operational needs. This study focused on identifying the best practices for assessing hazards associated with conveyors and selecting appropriate machine safeguarding.

METHODOLOGY

RESEARCH DESIGN

The purpose of this qualitative research was to identify best practices for safeguarding conveyors. Data was collected at five industrial facilities in Iowa through semi-structured interviews, guided by both open-ended and targeted questions based on the researcher's literature review, safety experience, and conducting hazard assessments for thousands of conveyors. An interview guide was then created to ensure consistency during all interviews. To ensure the accuracy of the data, interviews continued until data saturation was reached. The interviews were transcribed using Otter.ai software, with each interview lasting an average of 60 to 75 min. A Grounded Theory approach (Bernard, Wutich & Ryan 2016) was used to analyze the data, allowing themes to emerge inductively from participant responses.

METHODS

Subjects

The target population for this study consisted of facilities in Iowa that utilized conveyor systems, with a focus on those involved in manufacturing and/or distributing various products. The subjects included five certified safety professionals (CPSs; *Certified Safety Professional® (CSP®) | BCSP* 2025). The participants in this study represent a diverse range of industries (i.e., seed distribution, chemical manufacturing, egg distribution, and agricultural equipment manufacturing), with safety perspectives, and industry safety experience spanning 13 to 32 years. The purpose of this selection was to ensure that all participants had a standardized understanding of safety principles and expertise in managing occupational safety with a strong technical knowledge. Interviews were conducted via Zoom (*One Platform to Connect* n.d.) in the spring of 2025. At the start of each interview, verbal consent was obtained from participants, and each participant was informed that all data would be kept confidential and that their identifying information and the company's identity would not be included in this research. At the beginning of each interview, the participants were informed of the study's purpose, the use of the recordings, and their right to withdraw at any time. Once the interviews were completed, all original recordings and transcripts were securely stored on a cloud-based, password-protected system. In addition, this study was reviewed by the Iowa State University Institutional Review Board (IRB) and was deemed exempt from Full IRB review.

Instrumentation

Each participant chose a date and time for their one-on-one Zoom interview. These interviews focused on best practices to address hazards at their facilities and were recorded and transcribed using Otter.ai. The interviews included initial, safety-focused, and ending questions, and incorporated probing questions to gather further explanation of the participants' answers. Examples of these questions included the following:

Initial Questions:
- *Can you describe your job title, how long you've been with the company, and your responsibilities?*

Safety Focused Question:
- *How do you identify hazards associated with conveyors at your facility?*

Ending Questions:
- *If you had advice for other safety professionals managing conveyor safeguarding, what would it be?*

Data collection

The interview and recording were then transcribed for analysis. The interview questions were designed to identify hazards and the most effective conveyor safeguarding practices implemented to prevent workplace injuries. These questions were based on the researcher's literature review, 12 years of experience, training, education, and having assessed the appropriate safeguarding of hazards for thousands of conveyors.

After each interview, transcripts were reviewed and organized to identify emerging themes based on their frequency, leading to key findings. All participant information remained strictly confidential. Identifiable details, such as names and company identifiers, were de-identified from the transcripts.

Data analysis

Once an interview was complete, the transcription was reviewed for accuracy. Any unclear sections or technical jargon were clarified by revisiting the original audio recordings and comparing the recordings to the transcripts. To increase data validity, the researcher conducted cross-verification by comparing the participants' responses against industry safety standards and by triangulating similar themes across the interviews of other participants. The analysis followed Grounded Theory methodology (Bernard, Wutich & Ryan 2016), using inductive techniques to identify conveyor hazards and best practices to safeguard conveyors. A thematic

PARTICIPANT	EDUCATION	EXPERIENCE (YEARS)	JOB TITLE
P1	Master	19	Occupational Health Manager
P2	Bachelor	14	Industrial Hygienist
P3	Master	29	Occupational Safety Engineer
P4	PhD	32	Director of Health and Safety
P5	Bachelor	13	Environmental Health and Safety Specialist

Table 1 Characteristics of participants based on education, years of experience, and occupation.

analysis was conducted to identify codes and themes. A summary of the findings was prepared, excluding all identifiers of participants and facilities to protect confidentiality. Memoing and theorizing were used throughout to connect, interpret, and evaluate emerging themes, utilizing NVivo qualitative analysis software.

RESULTS

Before conducting interviews, participants were selected based on three criteria: having a facility in Iowa, currently managing occupational safety, and being an active certified safety professional (CSP). The participant's education level, years of experience, and job title are summarized in Table 1. This sample of participants consisted of five CSPs, all of whom had diverse educational backgrounds, job roles, and years of experience in occupational safety. Participants P1 and P3 held both bachelor's and master's degrees. While P2 and P5 had completed bachelor's degrees. One participant (P4) held a Ph.D., which was the highest level of academic achievement among the participants. Degrees from all five participants had a focus on occupational safety and health.

The Participants' professional experience in the field of occupational safety ranged from 13 to 32 years, with an average of approximately 21 years. The most experienced participant, P4, reported 32 years of experience, while P5, the least experienced, had 13 years. This range indicated that the participants in this study comprised a mix of mid-career to senior-level professionals.

The job titles of the participants also reflected different roles and responsibilities, including Occupational Health Manager, Industrial Hygienist, Occupational Safety Engineer, Environmental Health and Safety Specialist, and Director of Health and Safety. This diverse mix of backgrounds across various industries provided a solid foundation for evaluating best practices in assessing hazards, risks, and safeguarding methods with conveyors.

Based on the data collected, the central theme was hazard assessments, which encompassed nine sub-themes: hazards with conveyor systems, injuries experienced, safeguarding practices, hazard assessment approaches, use of third-party consultants and services, composition of safety teams, training of in-house auditors, frequency of hazard assessments, and knowledge of industry safety standards are depicted in Table 2.

THEME	SUBTHEMES
Hazard Assessment	Hazards with Conveyor Systems
	Injuries Experienced
	Safeguarding Practices/Methodologies
	Hazard Assessment Approaches
	Use of Third-Party Consultants and Services
	Composition of Safety Teams
	Training of In-House Auditors
	Frequency of Hazard Assessments
	Knowledge of Federal Industry Safety Standards

Table 2 Theme with subthemes regarding hazard assessments.

HAZARDS ASSOCIATED WITH CONVEYOR SYSTEMS

In this study, it was evident that participants were aware of the hazards associated with conveyors, particularly nip and pinch points, which were identified as the primary hazard associated with their conveyors. Specifically, P4 identified 'nip and points created by moving belts, moving chains' as hazards in their facility with conveyors. P5 also addressed 'The biggest hazards come into non-routine scenarios'. In addition, P5 specified that 'Having a safe work permit process, a non-routine work permit process requires a permit issuer and permit acceptor, which is a fundamental component of risk identification for non-routine tasks'. This implied that hazards are encountered not only during normal operations but also during non-routine activities (i.e., cleaning or troubleshooting). This information also suggested that having a process in place to evaluate non-routine tasks did require collaboration with various members in the organization to address hazards.

INJURIES EXPERIENCED

Injuries experienced with conveyors varied from facility to facility. P5 noted 'not my facility', which identified that they had experienced no incidents related to conveyors, while P4 stated a history of injuries linked to maintenance procedures: 'We've had a number of injuries that have to do with these systems not being properly locked out before service and maintenance is done'. This identified that during maintenance, there may be a greater risk to employees when they are not following industry safety standards, the company's polices, or their training and education.

SAFEGUARDING PRACTICES

Each participant described a variety of safeguarding methodologies used at their facilities. P3 addressed 'physical barrier guards and light curtains' as their primary means of safeguarding. P5 emphasized, 'Safeguarding to me is a management system approach to identifying the hazards'. Additionally, P5 also addressed, 'We rely on the manufacturer'. This reflected a more passive approach, placing responsibility on the manufacturer rather than within the facility, and highlighted the diversity of safety cultures across organizations. Having this perspective adds nuance to the findings and highlights the ongoing need to promote proactive, organization-driven safeguarding strategies.

HAZARD ASSESSMENT APPROACHES

P1 stated, 'You need to have a process in place to risk assess, hazard identification, implement controls, and evaluate the effectiveness of those controls'. The hazard assessment tools for these facilities focused on resources and documented processes by utilizing industry information and checklists. P1 noted the use of industry guidelines: 'OSHA's guide, 3170, safeguarding equipment and protecting employees from amputations is our primary guide'. Meanwhile, P2 provided additional detail, stating: 'It's an audit sheet that we use', indicating a documented process for employees to follow when assessing hazards.

USE OF THIRD-PARTY CONSULTANTS AND SERVICES

When questioning the use of third-party audits to assess hazards and safeguarding with conveyors, the perceptions from each participant varied from negative to positive experiences. P3 expressed some concerns regarding return on investment: 'We spent money. We didn't get the value out of it'. In contrast, P4 had a favorable view: 'Overwhelmingly positive'. Highlighting the differences in these experiences may reflect the need to understand the auditor's training, education, and knowledge, as well as the communication required around the final delivery of recommendations, specifications, training etc. to receive the 'value add' from a safeguarding audit.

COMPOSITION OF SAFETY TEAMS

Regarding in-house auditing and the use of resources within the organization, it was an apparent best practice. All participants in this study reflected diverse backgrounds and various methodologies in conducting hazard assessments. In-house auditing teams typically included personnel from safety, operations, maintenance, and engineering. P1 stated: 'We have representation from operations, including maintenance personnel, and occasionally site managers, operation managers, and engineers'. P5 described a higher-level involvement, including 'operators, engineers, project managers, chemical engineers, and safety'. Having this diversity supported a risk management process by including those cross-functional teams with various backgrounds.

TRAINING OF IN-HOUSE AUDITORS

Training of in-house auditors was consistent throughout the participants. In particular, P1 addressed 'They have more education'. This suggests that training and education are beneficial for individuals auditing conveyor hazards. The P3 participant provided greater detail, offering examples of what each of their auditors experiences. 'There would be training involved, where we would have a PowerPoint, questions, and then you have a partner, and then you would go, whoever your partner is, that the pair would go to those departments, and then we have an audit sheet that we use, and machine guarding is one of those'. In addition, P5 emphasized the importance of hands-on training, providing auditors with tools, and utilizing their own experience, training, and education to validate. P5 stated, 'I'm mentoring them, providing them tools, providing them feedback and validating the risk assessments'.

FREQUENCY OF HAZARD ASSESSMENTS

P1 identified 'You have to identify, you have to control, and to re-evaluate, making sure those are effective and things haven't changed'. The frequency of hazard assessments varied, but it was a structured process between all participants, with a scheduled frequency between the participants. P4 reported: 'Our goal is to have every square foot of every department gone through by some entity at least once a quarter', while P5 referenced formalized reassessment intervals: 'Hazard identification risk assessment, they have to revalidate that every five years, unless something changes'. These practices listed by the participants reflect a balance between an ongoing and structured periodic review, and continuously assessing conveyors for hazards.

KNOWLEDGE OF INDUSTRY SAFETY STANDARDS

Since all participants were CSPs with foundational and technical safety knowledge. Each participant had some base knowledge of industry safety standards and how the standards applied, particularly to their organization. P1 emphasized compliance: 'Our primary focus within the company is ensuring we're meeting the regulatory requirements', indicating a regulatory-first approach. P3 noted a broader understanding: 'There are specific standards, or consensus standards, of most everything out there', This showed an industry-wide awareness of OSHA's regulatory standards and consensus standards related to conveyor safeguarding.

DISCUSSION

This study examined the best practices and perspectives of CSPs managing conveyors in Iowa, focusing on how they assess and control conveyor-related hazards within a safety management system. The purpose of using CSPs was to provide strong technical competence and managerial skills of occupational safety (Van Wassenhove et al. 2022). The findings in this study highlight several complexities related to the conveyor system itself, procedural awareness, organizational culture, and compliance efforts aimed at creating a reasonably safe work environment with conveyors. Participants reported a variety of conveyor-related hazards, particularly with nip and pinch points caused by moving belts and chains. These hazards were consistent with those commonly documented in industry safety literature, such as the OSHA 3170 guide. The OSHA 3170 guide (*Osha3170-2007.Pdf* n.d.) addressed various aspects, including possible hazardous components, motion hazards, activities, and hazard assessments. However, several participants noted that the most significant risks often emerge from maintenance and non-routine tasks, which was also noted in the OSHA 3170 guide (*Osha3170-2007.Pdf* n.d.) that emphasized the need for employees to address hazards with routine and non-routine operations.

Some of the participants reported incidents involving others, especially during lockout/tagout processes in servicing and maintenance activities, thus alluding to the fact that maintenance and non-routine aspects of conveyors should be continuously evaluated. Participant 5 also addressed having a safe work permit process for non-routine processes, which is reflected in Karimi (Karimi et al. 2019). This article focused on *Hazardous energy control on machinery: Understanding the use of alternative methods to lockout, emphasized evaluating processes to use and select appropriate alternative methods* (Karimi et al. 2019), and suggested that injuries can result from system-level procedural issues rather than mechanical conveyor failures. This highlighted the significance of human behavior and organizational factors in maintaining workplace safety. This also highlights the need for consistent enforcement of lockout/tagout policies, regular audits, employee training and retraining, and a process that has alternative safeguarding measures. To provide further guidance, the American National Standards Institute (ANSI) and the American Society of Safety Professionals (ASSP) Z244.1–2016, *The Control of Hazardous Energy Lockout, Tagout, and Alternative Methods*, offer guidance on lockout/tagout and alternative methods.

Safeguarding methods used at these facilities varied among participants, depending on their application and ranged from devices, such as light curtains, to more systems-based approaches. One participant described safeguarding as a 'management system approach'. A safety management system approach typically consisted of programs, processes, polices, and procedures with a formal function overseeing their development (Wachter & Yorio 2014). A system management approach identifies that you do not need to rely solely on physical safeguarding methods (i.e., barrier guards), but rather have a safety management system that continuously evolves.

When focusing on hazard assessments, it was found that the professionals rely on both standardized documents tailored to an industry standard framework and internally developed tools. Several participants mentioned using the OSHA 3170 guide (*Osha3170-2007.Pdf* n.d.) as a primary reference for safeguarding, while others understood the hazards and what to look for, and they created their own audit assessment checklists. These checklists were then customized to their operational needs by utilizing industry best practices and standards. This reflects that the resources available to address hazards provide a foundation, and organizations can use this foundation to adapt their hazard assessments to reflect their processes and risks associated with conveyors.

Based on this study, conducting in-house facility risk assessments offered significant added value, while the experience with third-party auditors varied among participants. For example, P5 expressed dissatisfaction with the return on investment and the quality of evaluations, noting that external support does not always offer the best solution. Others had more positive experiences with auditors, but still believed there was room for added value, such as gaining new insights or validating current practices within their organization. As such, organizations could have an improved auditor success by defining the scope of the work and understanding the auditors' knowledge and experience prior to evaluating hazards with conveyors.

Safety efforts within each of the participants' organizations focused on forming cross-functional teams, which included personnel from operations, maintenance, engineering, and safety. This approach was consistent across the participants, highlighting various perspectives on hazard identification and control with conveyors. Many participants also emphasized the importance of involving equipment operators and frontline management in hazard safeguarding assessments to gain deeper insights, facilitate discussions, and clarify specific tasks and operator interactions where additional hazards could be identified.

The training of in-house auditors was also consistent among the participants, with each emphasizing the importance of training and educating those responsible for risk identification and equipping them with the necessary knowledge and skills to perform risk assessments effectively. This training involved formal instruction, including PowerPoint presentations, as well as practical mentoring. The combination of classroom learning and mentorship helped emphasize the importance of developing auditors who not only understood industry standards but also effectively evaluated conveyor hazards and recommended proper safeguards for specific applications.

The frequency of these risk assessments did vary among participants, with one facility conducting evaluations every quarter. In contrast, participant 4 emphasized the need for assessments every five years, unless there were changes in equipment or operational practices. This reflects participants' understanding of having set schedules and knowing when to be flexible to conduct hazard assessments, thereby continuously evaluating and mitigating hazards associated with conveyors.

Regarding the participants' knowledge of safety standards, it ranged from a focus on meeting OSHA regulations to having a broader familiarity with consensus standards. While regulatory compliance continues to serve as a baseline for occupational safety, several participants acknowledged the value of understanding consensus standards, such as the ASME B20.1 *Safety Standard for Conveyors and Related Equipment* (American Society of Mechanical Engineers 2021). This suggests that safety professionals are striving to achieve more than just regulatory requirements and are focusing on specific consensus standards to understand hazards associated with conveyors and methodologies for properly safeguarding.

This study had several limitations. All participants were experienced CSPs and may not reflect the perspectives and/or practices of less experienced safety professionals or smaller organizations with fewer resources to assess conveyor hazards and perform risk assessments. The data was also self-reported during semi-structured interviews conducted virtually through Zoom, which may have limited the depth of discussions compared to one-on-one in-person interviews. Despite these limitations, the study offers valuable insights into best practices for assessing hazards associated with conveyors. Future research could expand the scope and methodology to include evaluating the effectiveness of alternative measures and investigating how training and supervision differ between organizations that may rely more heavily on alternative methods than lockout/tagout.

CONCLUSION

This qualitative study evaluated best practices for assessing conveyor hazards from the perspectives of five CPSs that manage facilities in Iowa with technical knowledge and industry safety experience. This study aimed to discover how experienced safety professionals not only manage the safety of conveyors but also the best practices to identify and mitigate risks associated with conveyors in industrial settings.

Findings from this study suggested that the best practices for practical hazard assessments are most successful when organizations:

- Conduct an assessment with trained and experienced internal auditors who are familiar with conveyor operations.
- Create cross-functional teams to gather valuable insights from various departments, which could include safety, engineering, maintenance, and operations.
- Effectively evaluate service, maintenance, and non-routine tasks (e.g., cleaning and troubleshooting).
- Implement a process for alternative measures for non-routine tasks that have a review process and approval from multiple personnel to ensure employees are adequately safeguarded.
- Develop a risk assessment that recognizes hazards based on industry knowledge and tailors safeguarding methodologies to the organization's needs.

Organizations should focus on training, mentoring, and sharing knowledge to ensure that hazards with conveyors are being properly addressed to provide reasonable safety. Once those hazards are addressed, safeguarding methodologies should incorporate a range of techniques tailored to operational needs, with safeguarding measures, procedures, and operator engagement to ensure reasonable protection of all employees.

While this study had some limitations, future research should further investigate the risk assessment process during maintenance and non-routine operations, which could help establish better training and education for employees.

In conclusion, to ensure a reasonably safe work environment around conveyors, a proactive safety management system should be in place to ensure an organization is meeting compliance and incorporates a range of techniques. Safety professionals who lead with technical expertise and cross-functional teams are best positioned to assess hazards, mitigate injuries, and improve workplace safety around conveyors.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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