PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY

e-ISSN: 2773-5303

PEAT

Vol. 7 No. 1 (2026) 808-817
https://publisher.uthm.edu.my/periodicals/index.php/peat

Development of a Structured Machinery Maintenance Inspection Checklist in a New High-Capacity Production Line

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DOI: https://doi.org/10.30880/peat.2026.07.01.091

Article Info

Received: 12 January 2026
Accepted: 20 February 2026
Available online: 25 May 2026

Keywords

Machinery Maintenance Safety, Fryer Machine, Inspection Checklist, HIRARC, High-Capacity Production Line, Occupational Safety and Health

Abstract

The implementation of new high-capacity production lines often emphasizes efficiency and output, while maintenance-related safety risks may receive less attention, particularly during early operational stages. At Kilang Makanan Mamee Sdn. Bhd., Subang, the absence of a structured and machine-specific maintenance inspection checklist for critical equipment highlighted the need for a systematic safety-based approach. This study aims to develop and propose a structured machinery maintenance safety inspection checklist to enhance worker safety and support consistent hazard identification. Hazard Identification, Risk Assessment, and Risk Control (HIRARC) analysis was conducted to identify critical equipment with higher maintenance-related risks. The methodology involved site walkthrough observations, document reviews, and informal discussions with safety, maintenance, and production personnel to understand actual maintenance practices and hazard exposure. Based on the findings, a safety-focused maintenance inspection checklist was developed, emphasizing practical applicability rather than machine performance evaluation. The results indicate that the developed checklist addresses key maintenance safety concerns, including mechanical hazards, thermal exposure, electrical risks, lockout–tagout (LOTO) readiness, safe access, and post-maintenance verification. Feedback from relevant departments confirmed that the checklist is clear, practical, and suitable for routine maintenance use. It is recommended that the checklist be formally adopted into maintenance procedures, periodically reviewed, and expanded to other critical machines to strengthen long-term maintenance safety practices.

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1. Introduction

The implementation of new high-capacity production lines in manufacturing industries is primarily driven by the need to improve efficiency and production output (Alsyouf, 2007). However, during this transition, maintenance-related safety risks are often given less emphasis, particularly in the early stages of operation (Gidiagba et al., 2023). Maintenance activities require direct interaction with machinery components such as moving parts, high-temperature systems, and electrical controls, which significantly increase accident risks if not systematically managed (Down, 2025).

SECTOR	NPD	PD	DEATH	TOTAL
Hotel and Restaurant	176	0	0	176
Utilities (Electricity, Gas, Water and Sanitary Service)	147	0	4	151
Finance, Insurance, Real Estate and Business Services	554	15	15	584
Construction	106	8	45	159
Transport, Storage and Communication	326	7	9	342
Manufacturing	3,961	175	45	4,181
Wholesale and Retail Trade	145	2	0	147
Public Services and Statutory Authorities	117	2	0	119
Mining and Quarrying	23	1	4	28
Agriculture, Forestry and Fishery	1,020	25	19	1,064
TOTAL	6,575	235	141	6,951

LEGEND:
PD - PERMANENT DISABILITY
NPD- NON PERMANENT DISABILITY

Fig. 1 *Occupational Accident Statistics by Sector January- October 2023 in Malaysia*

Accident statistics by sector further emphasize the severity of this issue within the manufacturing industry. As shown in the provided data, the manufacturing sector recorded the highest number of occupational accidents compared to other sectors, with a total of 4,181 cases, including 175 permanent disabilities and 45 fatalities (Department of Occupational Safety and Health [DOSH], 2023). This indicates that manufacturing environments, especially those involving complex machinery and maintenance work, present substantial safety challenges that require focused preventive measures.

At Kilang Makanan Mamee Sdn. Bhd., Subang, the introduction of a new high-capacity production line highlighted the absence of a structured and machine-specific maintenance inspection checklist for critical equipment. Maintenance inspections were largely dependent on individual experience and informal practices, resulting in inconsistent safety checks and the potential for critical hazards to be overlooked (Thomassen et al., 2011). Existing inspection tools available in the industry are generally generic and do not adequately address maintenance-specific risks associated with different machines (Coach, 2025; FMX, 2025).

This gap in safety practice indicates the need for a systematic approach to guide maintenance personnel in identifying and controlling machine-specific hazards (Shuaib et al., 2021). If left unaddressed, unsafe conditions may persist and increase the likelihood of maintenance-related incidents (Tawfeeq et al., 2024). Therefore, this study focuses on developing a structured machinery maintenance safety inspection checklist based on HIRARC analysis for critical equipment in the new high-capacity production line to strengthen preventive maintenance safety practices (Marzuki et al., 2022).

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2. Methodology

2.1 Materials

The materials used in this study mainly consisted of safety-related documents, machinery references, and industry benchmarking tools rather than physical components or laboratory equipment. Core materials included Hazard Identification, Risk Assessment, and Risk Control (HIRARC) records for the production line, operating and maintenance manuals provided by the fryer machine vendor, and internal documents such as standard operating procedures (SOPs) and maintenance records (Department of Occupational Safety and Health [DOSH], 1994).

Basic office software, including Microsoft Word and Microsoft Excel, was used for documentation, checklist drafting, benchmarking comparison, and final formatting. In addition, three established industry inspection checklists were selected as benchmarking materials to identify common inspection elements, checklist structures, safety themes, and limitations relevant to maintenance safety. These included the FMX Daily Heavy Equipment Inspection Checklist (FMX, 2025), the Secret Recipe Machinery Checklist Sample (Secret Recipe Manufacturing Sdn. Bhd., 2021), and the Machine Safety Inspection Checklist (Coach, 2025). A comparative review of these references, as summarized in the comparison table 1 below, supported the identification of suitable checklist formats, safety focus areas, and gaps that informed the development of the proposed fryer maintenance safety checklist.

Table 1 *Comparison of key features in referenced checklists*

Comparison Criteria	Daily Heavy Equipment Inspection Checklist	Secret Recipe Machinery Checklist	Machine Safety Inspection Checklist
Industry Type	Heavy machinery / mobile equipment	Food manufacturing machinery	General machine safety
Checklist Style	Sequential (pre-start, warm-up, operation, end-of-day)	Hazard-category based (mechanical, electrical, PPE, safeguarding)	Functional area-based (guarding, controls, electrical, housekeeping)
Format	Simple tick-box with remarks	Tick-box with YES/NO/NA Tick-box with remarks	Tick-box with remarks
Safety Elements Covered	Fluids, leaks, and general readiness	Mechanical hazards, electrical hazards, PPE, training	Guarding, controls, LOTO, housekeeping
Maintenance Focus	Basic operational readiness	Includes maintenance log and competence check	Includes LOTO readiness and emergency preparedness
Strengths	Clear daily routine; simple sequence	Very comprehensive; detailed hazard list	Balanced safety layout; covers multiple risk areas
Limitations	Not specific to stationary machinery	Too broad; covers production more than maintenance.	Limited details on maintenance work at height or thermal hazards

2.2 Procedure

The study commenced with site walkthroughs and direct observations of maintenance activities conducted on the existing production line to understand actual working conditions and maintenance practices (Gan, 2019). Informal discussions were held with personnel from the safety, maintenance, and production departments to obtain practical insights into common maintenance tasks, recurring hazards, and existing safety challenges (Musungwa & Kowe). Based on these observations, a Hazard Identification, Risk Assessment, and Risk Control (HIRARC) analysis was carried out to evaluate maintenance-related risks across the production line (Ejovwokoghene et al., 2024).

The HIRARC findings identified the fryer machine as one of the highest-risk equipment due to its involvement with high-temperature oil systems, moving components, and frequent maintenance requirements (Putri & Nuruddin, 2022). Consequently, the fryer machine, as illustrated in Figure 2, was selected as the primary focus for checklist development. Benchmarking was then conducted using selected industry inspection checklists, together with a review of the fryer machine operating and maintenance manual, to identify relevant safety elements, inspection structures, and existing gaps.

Using the combined findings, a draft maintenance safety inspection checklist was developed and structured into pre-maintenance, during maintenance, and post-maintenance sections (Hales & Pronovost, 2006). The draft checklist was subsequently reviewed through informal validation sessions and limited field testing to ensure that the inspection items were clear, practical, and aligned with actual maintenance activities (Tawfeeq et al., 2024).

Fig. 2 *Fryer Machine*

2.3 Characterization

The characterization process focused on validating the suitability and functionality of the developed checklist rather than measuring mechanical or operational performance. The checklist was tested through a trial application during actual or simulated maintenance activities to assess whether the inspection items were clear, relevant, and easy to follow. Feedback was obtained from the safety team, maintenance executive, and production supervisor to evaluate whether the checklist accurately reflected real maintenance risks and workflows. Key parameters assessed included clarity of wording, logical sequence of inspection items, completeness of safety coverage, and usability under site conditions. The feedback collected was analysed qualitatively, and minor improvements were made, including restructuring sections and adding approval and comment fields to strengthen accountability.

2.4 Data Analytic Strategy

This study adopted a qualitative data analysis approach, as it focuses on safety assessment, checklist design, and practical usability rather than numerical performance measurement. Data were analysed through interpretation of HIRARC risk rankings, comparison of inspection elements across reference checklists, and thematic analysis of feedback obtained from relevant personnel. Observations, document reviews, and expert feedback were synthesised to identify recurring safety concerns and priority control measures. The findings from these qualitative analyses were then translated into structured checklist items to ensure that the final checklist effectively addresses maintenance-related hazards and supports consistent safety inspection practices.

3. Results & Discussion

3.1 Result

The initial phase of this study involved a comprehensive HIRARC assessment conducted in accordance with the DOSH Malaysia guidelines to evaluate safety conditions across three primary machines: the sheeter, the fryer, and the cartooning autopacker. Each hazard was systematically evaluated based on likelihood and severity to assign a specific risk rating, which determined the necessity of immediate safety interventions. The findings revealed that while the sheeter machine and the cartooning autopacker primarily presented medium-risk hazards related to pinch points and pneumatic components, the fryer machine consistently exhibited the highest overall risk. This variation in risk levels is attributed to the unique mechanical complexity, maintenance frequency, and operating mechanisms inherent to each machine type.

The assessment specifically identified the fryer machine as the highest-risk equipment due to its combination of high operating temperatures, hot thermal oil circulation, and continuous mechanical movement. Critical hazards identified include workers being caught between moving molds during conveyor adjustments and the risk of slips, trips, or falls when performing maintenance on elevated platforms or narrow ladders. These activities received a high-risk rating value of 12, reflecting the potential for severe consequences such as bone fractures, finger entrapment, or secondary burns from heated surfaces. Consequently, the fryer machine was prioritized for safety intervention because its maintenance tasks are more frequent and carry significantly higher potential consequences compared to other equipment.

A dedicated safety checklist was designed focusing specifically on fryer maintenance, covering routine tasks like mold-gap adjustments and oil-flow inspections. The checklist utilizes a binary "Yes / No / N/A" format to ensure simplicity and consistency in interpretation during busy production periods. To ensure practical relevance, the draft was validated by a review panel comprising representatives from the safety, maintenance, and production departments. While the initial feedback was highly positive regarding the three-phase structure which is pre-maintenance, during-maintenance, and post-maintenance, reviewers suggested adding a "Comments and Sign-off" section. This recommendation was incorporated into the finalized version to strengthen accountability and provide formal verification of safety protocols.

3.2 Discussion

The results of the HIRARC assessment clearly justify the selection of the fryer machine as the primary focus of the developed safety checklist. Unlike the sheeter or autopacker, which mainly present mechanical pinch-point hazards, the fryer environment exposes maintenance personnel to combined thermal, mechanical, and ergonomic risks. Daily manual interventions, such as conveyor tension adjustments and oil condition inspections, significantly increase the frequency and duration of worker exposure to these hazards. In addition, the assessment revealed a critical reliance on coordinated communication between the technician working at the fryer and the operator at the HMI. Any misalignment during test runs or slow-speed operation can result in unexpected movement or direct exposure, highlighting the need for a structured and task-specific safety control approach.

A review of the manufacturer's operating and maintenance manual further reinforced this need. Although the manual provides detailed technical guidance, its inspection checks are largely performance-oriented and offer limited emphasis on worker safety aspects such as lockout–tagout (LOTO) verification, thermal oil exposure, and safe access conditions (Badiea et al., 2020). Similar limitations of performance-focused maintenance documentation have been highlighted in previous studies, which emphasize that safety-related risks may be inadequately addressed if inspection activities are not hazard-driven (Manenzhe et al., 2023). To address this gap, benchmarking was conducted using established industry checklists from Secret Recipe Manufacturing and The HSE Coach. These references informed the adoption of a hazard-based structure, allowing the checklist to be organised around mechanical, thermal, electrical, and access-related risks rather than generic operational readiness.

The finalized fryer maintenance safety inspection checklist, as shown in Appendix B, reflects this structured approach and translates the identified risks into clear, actionable inspection items. Organising the checklist into three distinct phases—pre-maintenance, during maintenance, and post-maintenance—mirrors the actual maintenance workflow and reduces the likelihood of human error. The pre-maintenance phase functions as a preventive barrier by ensuring LOTO implementation, temperature stabilization, and communication readiness before work begins, aligning with established occupational safety principles (Department of Occupational Safety and Health [DOSH], 1994; Marzuki et al., 2022). The post-maintenance phase addresses a commonly overlooked industry risk by confirming tool removal, guard reinstallation, and safe machine handover (Gan, 2019).

By formalising these safety checks through a documented sign-off process, the checklist evolves beyond a reference document into a practical accountability tool. This structured design supports consistent application of safety controls, improves inspection traceability, and strengthens maintenance safety discipline for one of the highest-risk machines in the production line.

3.3 Recommendation

The primary recommendation arising from this study is the formal adoption and immediate implementation of the developed fryer maintenance safety inspection checklist into the routine maintenance procedures of the High-Capacity Line. Given that the fryer was identified through HIRARC analysis as the equipment with the highest risk, prioritizing this implementation is both necessary and feasible, as the tool has been pilot-tested and requires minimal cost or systemic changes (Shuaib et al., 2021). Secondly, the Safety and Maintenance Departments should conduct periodic reviews of the checklist to ensure it remains relevant as operating conditions and maintenance practices evolve over time. These reviews can be seamlessly integrated into existing safety meetings without requiring additional resources, preventing the checklist from becoming a mere administrative routine (Musungwa & Kowe, 2022). Finally, for long-term improvement, the organization should consider the digitalization of the checklist system. While this transition offers superior data analysis and traceability, it should be introduced gradually to manage the additional resources required (Brundage et al., 2019).

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3.4 Limitation

This study is subject to several limitations, most notably its restricted scope, which focused only on three primary machines and resulted in a safety checklist developed exclusively for the fryer. Furthermore, the research specifically excluded operational tasks performed by production operators to maintain a clear focus on the risks faced by maintenance personnel. The validation process was also limited to a specific panel of internal representatives from the safety, maintenance, and production departments within a single facility.

To build upon these findings, future studies should expand the HIRARC assessment to encompass all machinery within the high-capacity production line to develop a more holistic safety management framework. Future research could also investigate the integration of operational safety elements into these tools, bridging the gap between maintenance and production safety. Another critical area for future focus is the development and implementation of digital safety systems, such as mobile applications or HMI-integrated checklists, which allow for real-time monitoring. Lastly, conducting longitudinal studies to measure the actual reduction in incident rates over an extended period would provide robust empirical evidence regarding the long-term effectiveness of these structured safety interventions.

4. Conclusion

The study successfully identified that the fryer machine presents the highest overall risk during maintenance activities due to factors such as exposure to hot oil, thermal systems, moving conveyors, and work performed at heights. Consequently, a structured fryer maintenance safety inspection checklist was developed, organized into three phases: pre-maintenance, during-maintenance, and post-maintenance. This checklist was validated through feedback from the safety team, maintenance department, and production supervisors, who confirmed that the tool is clear, relevant, and practical for the operational environment. Improvements were also made based on this feedback, such as adding a "comments and sign-off" section to strengthen accountability. Ultimately, the project achieved its objective of providing a tailored safety tool that fosters a preventive safety culture.

Acknowledgement

The author would like to thank the Faculty Of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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This guide contains examples of common types of APA Style references. Section numbers indicate where to find the examples in the Publication Manual of the American Psychological Association (7th ed.).

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