HAZARD IDENTIFICATION AND RISK ASSESSMENT IN MOULDING INDUSTRY

S. Rahul[1], Prof.P. Karthikeyan[2]

[1]*PG Scholar of Knowledge Institute of Technology*

[2]*Associate Professor of Knowledge Institute of Technology*
Kakapalayam, Salem-637504, Tamil Nadu

[*]*Sekisui DLJM MoldingPvt Ltd.*
VV5 SIPCOT Vallam, vadagal, Sriperumbudur-631604, Tamilnadu

Abstract**—**The molding industry plays a pivotal role in manufacturing, producing a wide array of products essential to our daily lives. However, it is not without its share of occupational hazards that demand diligent attention. This project, "Hazard Identification and Risk Assessment in the Molding Industry," addresses the pressing need to enhance workplace safety, reduce accidents, and ensure regulatory compliance within this dynamic sector. This comprehensive endeavor employs a systematic approach to identify and evaluate hazards associated with molding processes, equipment, materials, and human factors. Drawing on advanced technologies, risk assessment models, and strategies to enhance safety culture, the project aims to transform the molding industry into a safer and more sustainable workspace. By focusing on hazard identification and risk assessment, this project seeks to empower molding companies to proactively mitigate risks, promote a

employees. Additionally, compliance with industry regulations and a commitment to environmental sustainability are integral aspects of this initiative. The outcomes of this project are anticipated to not only reduce workplace accidents but also contribute to the overall efficiency and longevity of the molding industry. This abstract provides a glimpse into a multifaceted project that endeavors to make workplaces safer and healthier while ensuring the molding industry's continued success. This document gives formatting instructions for authors preparing papers for publication in the Proceedings of an IEEE conference. The authors must follow the instructions given in the document
for the papers to be published.

work. ***Keywords*****—** Mold, Workplace Accidents, **Hazard** identification and risk assessment.

I. INTRODUCTION

Hazard identification and risk assessment are crucial components of ensuring safety and preventing workplace accidents in the molding industry. This literature review examines key studies, research findings, and best practices related to hazard identification and risk assessment in the molding industry, shedding light on the strategies and methodologies employed to mitigate workplace risks.

Hazard Identification in Molding:

- Hazard Identification Techniques: Numerous studies emphasize the use of various techniques such as job safety analysis (JSA), hazard and operability studies (HAZOP), and failure mode and effects analysis (FMEA) to identify potential hazards in molding processes. These methods help in systematically recognizing risks associated with machinery, chemicals, and operational practices.
- Human Factors: Research acknowledges the importance of considering human factors in hazard identification. Studies highlight the role of operator behavior, fatigue, and complacency as significant contributors to accidents. Ergonomic assessments and studies on human-machine interaction have been carried out to mitigate these risks.
- Advanced Technologies: Some research explores the integration of advanced technologies like IoT sensors and machine learning algorithms to continuously monitor and identify hazards in real-time. These technologies enable predictive maintenance and early hazard detection.

- Risk Assessment Models: Studies have developed and applied risk assessment models, including quantitative and qualitative methods, to evaluate and prioritize risks in molding operations. These models help in determining the likelihood and severity of potential incidents.
- Process Safety Management (PSM): Research emphasizes the importance of PSM systems, which encompass comprehensive risk assessment, risk reduction measures, and emergency planning. These systems are vital for the prevention of major accidents, especially in high-risk molding operations.
- Safety Culture: Several studies delve into the significance of fostering a safety-conscious culture within molding companies. A strong safety culture encourages employees to report hazards and near misses, leading to better risk assessment and mitigation.

Regulatory Compliance:

Occupational Safety and Health Administration (OSHA): In the United States, OSHA standards and guidelines have been pivotal in shaping safety practices in the molding industry. Compliance with these regulations is critical for hazard identification
and risk reduction.

Case Studies and Best Practices:

- Real-world Examples: Case studies from molding companies showcase practical approaches to hazard identification and risk assessment. These cases highlight the benefits of proactive safety measures in reducing accidents and improving productivity.

- Benchmarking and Best Practices: Some studies focus on benchmarking against industry best practices. This helps molding companies identify areas for improvement and adopt proven risk reduction strategies.

II. PROCESS

The most widely used technology to produce the wind blades, especially longer blades, is the resin infusion technology. In the resin infusion technology, fibers are placed in closed and sealed Mold, and resin is injected into the Mold cavity under pressure. After the resin fills all the volume between fibres, the component is cured with heat. The resin infusion technologies can be divided into two groups: Resin Transfer Molding (RTM) (resin injection under pressure higher than atmospheric one) and Vacuum Assisted Resin Transfer Molding (VARTM) (or Vacuum Infusion Process) (when resin is injected under vacuum or pressure lower than atmospheric, typically, under a vacuum bag), After infusion, the resin cures at room temperature. In most cases, wind turbine rotor blades are made in large parts, e.g., as two aeroshells with a load-carrying box (spar) or internal webs that are then bonded together. Sometimes, the composite structure is post cured at elevated temperature. After manufacturing, the blades are subjected to quality control and manufacturing defects are repaired.

III. OBJECTIVE AND METHODOLOGY

A. *Objective of the Project*

- **Enhance Workplace Safety:** The primary objective of the project is to improve workplace safety within the molding industry by identifying and mitigating hazards, thus reducing the incidence of accidents and injuries.
- **Comprehensive Hazard Identification:** Develop a systematic approach to identify all potential hazards associated with molding processes, machinery, materials, and human factors. Ensure that all employees are aware of these hazards.
- **Risk Assessment and Prioritization:** Conduct a thorough risk assessment to evaluate the likelihood and severity of identified hazards. Prioritize risks to focus resources on the most critical areas.
- **Implement Advanced Technologies:** Integrate advanced technologies such as IoT sensors, real-time monitoring, and data analytics to enhance hazard identification and early warning systems.
- **Promote a Strong Safety Culture:** Foster a culture of safety within the organization, encouraging employees at all levels to actively participate in hazard identification, reporting, and risk reduction efforts.
- **Compliance with Regulations:** Ensure full compliance with relevant safety regulations, standards, and guidelines, including those set by organizations like OSHA, to avoid legal penalties and enhance safety practices.
- **Reduce Human-Related Risks:** Address human factors contributing to accidents by providing comprehensive training, promoting fatigue management, and assessing operator behavior.
- **Implement Risk Mitigation Measures**: Develop and implement effective risk reduction strategies, including engineering controls, administrative controls, and personal protective equipment (PPE), where necessary.
- **Data Management and Analysis:** Establish robust data management systems to collect, analyze, and report on incidents, near-misses, and hazard reports. Use data-driven insights to continuously improve safety measures.
- **Environmental Sustainability:** Consider environmental hazards and risks associated with molding processes, including waste management, energy consumption, and emissions, and implement strategies to reduce environmental impact.
- **Education and Training:** Provide ongoing education and training programs for employees to ensure they are equipped with the knowledge and skills needed to identify and mitigate hazards effectively.
- **Continuous Improvement:** Establish a mechanism for continuous improvement by regularly reviewing and updating hazard identification and risk assessment processes based on evolving industry best practices and technological advancements.
- **Resource Allocation:** Allocate the necessary resources, including budget, personnel, and time, to effectively execute hazard identification and risk assessment activities.
- **Measure Safety Performance:** Define key performance indicators (KPIs) to measure the effectiveness of hazard identification and risk assessment efforts and track progress in reducing accidents and incidents.
- **Documentation and Reporting:** Maintain comprehensive documentation of hazard identification and risk assessment activities, incident reports, and risk mitigation measures. Provide regular reports to stakeholders and regulatory authorities as required.

By addressing these objectives, the project aims to create a safer working environment in the molding industry, reduce accidents, protect employee well-being, enhance regulatory compliance, and contribute to the overall sustainability of molding operations.

B. *Problem identification*

Similar to the purging process, resin pellets are heated at high temperatures until they reach their melting point. At which time, the melted resins are pressed through a rotating screw and into the Mold.

This process also emits hazardous smoke, fumes and gases that may have adverse health effects if inhaled. the respiratory hazards, heat from plastic, toxic fumes and side effects one may encounter when working with plastic materials.

The safety of your staff isn't the only thing that is compromised without proper use of personal protective equipment. If you don't use PPE correctly, there are legal troubles that your business will face. Employees are put at fault whenever they don't choose to wear the right PPE, and the trouble only adds up if they have refused to wear any on numerous occasions.

There are also scenarios in which the employer can be held responsible for those who do not wear the needed personal protective equipment. When the employer doesn't uphold safety regulations in your business, and they don't monitor whether your staff is wearing the gear they need, it means they aren't enforcing their responsibility for promoting staff safety and health.

Wearing PPE can result in physical hazards (e.g., heat stress, slips, trips, and falls) as well as psychological stress, and impaired vision, movement, and communication. Time spent wearing PPE should be limited to maintain responders' safety.

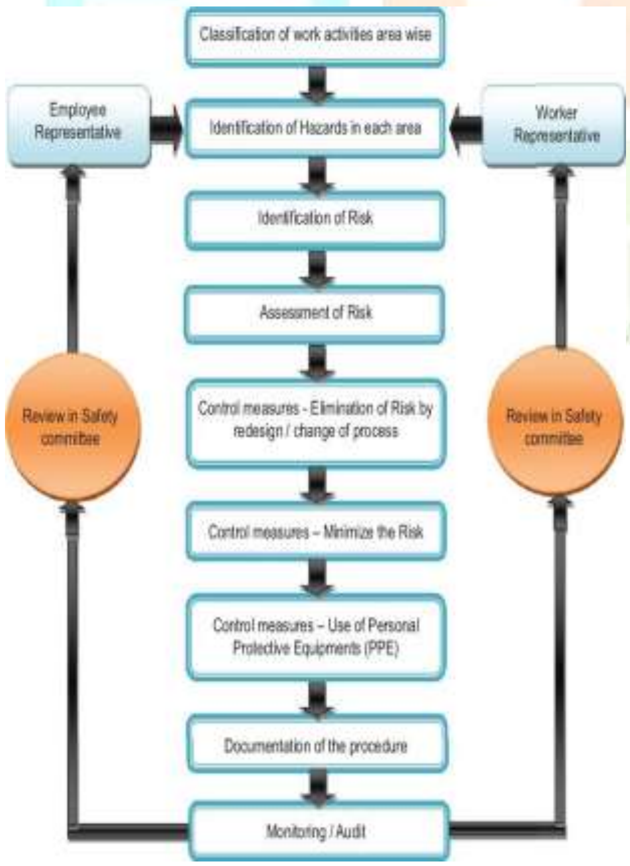
Safety helmets are designed to protect your head from any fatal injuries like shock impacts, electric exposure, anything heavy falling on your head, untoward impacts, etc. According to the numbers, the most common causes of head injuries are heavy or sharp objects falling on your head.

If you're not wearing safety glasses or goggles on the job, you're risking permanent eye damage and blindness. Think about all the work activities you may do each day that can cause eye injury: grinding, sanding, brushing, sawing, drilling, buffing, hammering, cutting, welding and working with chemicals.

Potential hazards to hands and arms include skin absorption of harmful substances, chemical or thermal burns, electrical dangers, bruises, abrasions, cuts, punctures, fractures or amputations.

There are several health conditions that can arise from not wearing footwear – or not wearing the appropriate footwear. Issues such as bunions, corns and calluses, blisters, ingrown nails, hammertoes, and even more painful conditions such as plantar fasciitis can occur.

C. Methodology



1) Hazard identification, risk assessment and control are an on-going process. Therefore, regularly review the effectiveness of your hazard assessment and control measures. Make sure that you undertake a hazard and risk assessment when there is change to the workplace including when work systems, tools, machinery, or equipment changes. Provide additional supervision when the new employees with reduced skill levels or knowledge are introduced to the workplace. The phase of risk identification is essential because it establishes the bases of the risk analysis. Indeed, the data of risk identification will be the input of the evaluation phases. Therefore, it is necessary to make an identification phase in an exhaustive way to get the best results.

2) HIRA is highly dependent on the availability and accuracy of the input data, when provided with complete Input data, a higher confidence on the validity and robustness of the results are obtained. The example of data collection will be specific to operations, building design, personnel / population occupancy levels. HIRA Risk Assessment is employed for risk management and safety improvement in several industries. It provides a quantitative assessment of potential risks known and provides a basis for evaluating process safety with reference to a planned risk acceptance criterion.

D. HIRA Flow Chart

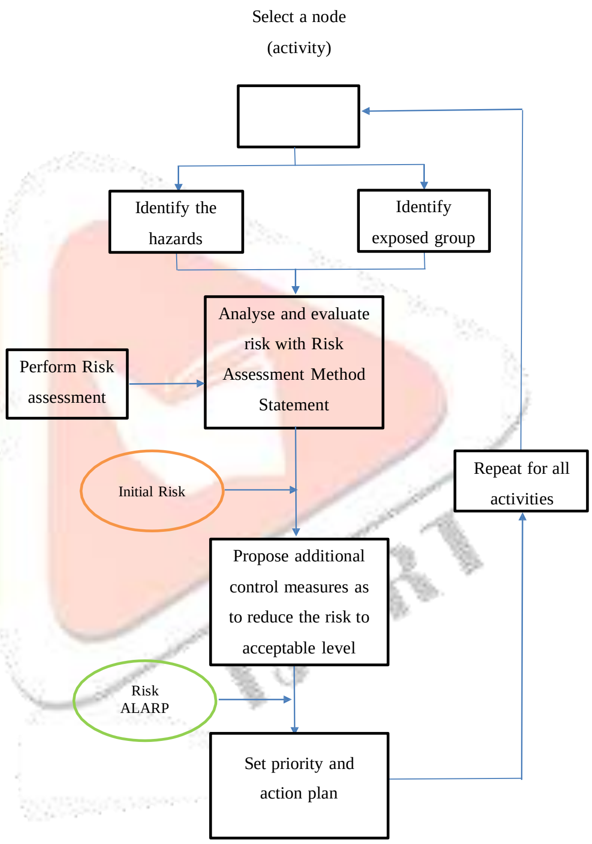


Fig. 1 HIRA Flow Chart

E. Risk Matrix

For each of the identified hazard, the level of risk is assessed based with Risk Assessment Matrix during HIRA review. Risk ranking is firstly performed based on the unmitigated risk for each hazard, and then the level of risk is re- evaluated after taking into consideration of the existing prevention/mitigation measures and controls.

If the risk is in the green region, the risk is acceptable and no further action is required. If the risk is in the yellow region, risk is in tolerable regions and needs to be demonstrated to be as Low as Reasonably Achievable by recommending further action. If the Risk is still in the red region, this is not acceptable and action definitely needs to be taken. HIRA Review team shall discuss the proposed

RISK MATRIX						
LIKELIHOOD	Very Likely - 5	5	10	15	20	25
	Likely - 4	4	8	12	16	20
	Possible - 3	3	6	9	12	15
	Unlikely - 2	2	4	6	8	1(
	Very Unlikely - 1	1	2	3	4	5
		1	*2*	*3*	*4*	*5*
		Negligible	*Slight*	*Moderate*	*High*	*Very High*
		SEVERITY				
Risk	**Risk Level**	**Action**				
1 to 6	Low Risk	May be acceptable but review task to see if risk can be reduced further				
8 to 12	Medium Risk	Task should only be undertaken with appropriate management authorization after consultation with specialist personnel				
15 to 25	High Risk	Task must not proceed. It should be redefined or further control Measures put in place to reduce risk.				

Fig. 2 Risk Matrix

For each of the identified hazard, the level of risk is assessed based with Risk Assessment Matrix during HIRA review. Risk ranking is firstly performed based on the unmitigated risk for each hazard, and then the level of risk is re- evaluated after taking into consideration of the existing prevention/mitigation measures and controls.

If the risk is in the green region, the risk is acceptable and no further action is required. If the risk is in the yellow region, risk is in tolerable regions and needs to be demonstrated to be as Low as Reasonably Achievable by recommending further action. If the Risk is still in the red region, this is not acceptable and action definitely needs to be taken. HIRA Review team shall discuss the proposed actions, where applicable, to address the hazard that is ascribed with a medium to high-risk rating

F. Project Data

A. *Methods:*

This Based on the method of data collection, this research is observational in nature, because the data was obtained through observation and no treatment was carried out on the research object during the research. Based on the time of research, this research is cross-sectional in nature, because data collection was carried out all at once. If reviewed based on analysis, this research is descriptive research that is describing the process without analysing the relationship of variables. In the activity of changing the Mold on the machine, it is carried out by at least 2 people considering the equipment that is unloaded is quite heavy and the complexity in handling it. In general, the activities carried out and the potential hazards that can occur can be described as follows:

TABLE I
EXPERIMENT-1: HAZARD IDENTIFICATION AND RISK ASSESSMENT 1

Description	Location	Type of Hazard	Severity (1-10)	Likelihood (1-10)	Risk Priority
Hazard Machine overheating	Production Floor A	Physical	8	6	48
Chemical exposure	Mixing Area	Chemical	7	5	35
Inadequate ventilation	Storage Room	Ergonomic	6	7	42
Slippery floor	Loading Dock	Physical	7	4	28
Improper machine maintenance	Machine Shop	Mechanical	9	8	72

TABLE III
EXPERIMENT-2: RISK ASSESSMENT

Hazard Description	Risk Assessment Method	Risk Score (1-100)	Control Measures
Machine overheating	Qualitative (Risk Matrix)	60	Implement regular machine inspections and maintenance.
Chemical exposure	Quantitative (Numerical Model)	42	Enhance personal protective equipment (PPE) usage and storage practices.
Inadequate ventilation	Qualitative (Risk Matrix)	42	Improve ventilation system in the storage room.
Slippery floor	Qualitative (Risk Matrix)	28	Implement anti-slip floor treatments.
Improper machine maintenance	Quantitative (Numerical Model)	72	Develop a proactive maintenance schedule.

TABLE IIII
EXPERIMENT-3: ADVANCED TECHNOLOGIES INTEGRATION

Technology Feasibility	Result
IoT Sensors	Feasible; Cost-effective
Real-time Monitoring	For safety beneficial

These are simplified examples, and in a real project, you would have a more comprehensive list of hazards, detailed risk assessment methodologies, and extensive control measures. Additionally, the project would cover all aspects mentioned in the project plan, including human factors analysis, safety culture assessment, regulatory compliance, emergency response preparedness, environmental sustainability assessment, data management system setup, training programs, and continuous improvement initiatives. The results would be more extensive and specific to each aspect of the project.

TABLE IVV
HAZARD IDENTIFICATION AND RISK ASSESSMENT 2

Hazard Description	Location	Type of Hazard	Severity (1-10)	Likelihood (1-10)	Risk Priority
Machine overheating	Production Floor A	Physical	8	6	48
Chemical exposure	Mixing Area	Chemical	7	5	35
Inadequate ventilation	Storage Room	Ergonomic	6	7	42
Slippery floor	Loading Dock	Physical	7	4	28
Improper machine maintenance	Machine Shop	Mechanical	9	8	72

TABLE V
CHANGING MOLD ISBM ANALYSIS ACTIVITIES

S.NO	ACTIVITY	POTENTIAL HAZARD	RISK
1	Turn off Barrel temperature & hot runner	The skin touches the hot cover barrel	Skin blisters / burns
2	Unscrew the ejector rod unit mounting bolts	The operator is caught in the machine/tool	Wounds or defects
3	Lower the Ejector rod unit from the engine	Incorrect body position when lifting the Mold without assistance	Sprain
4	Unscrew the Blow Core fasteners	The operator is caught in the machine/tool	Wounds or defects
5	Lowers the Blow Core unit from the machine	Incorrect body position when lifting the Mold without assistance	Sprain
6	Reducing heating pot binders, cores, lip cavities	The hand is pinched/cut into the Mold/tooling or work tool	Wounds or defects
7	Lowering bottom Mold & blow Mold	The head or limbs hit the Mold machine parts	Wounds or defects
8	Placing the blow Mold and bottom Mold in the trolly	The foot or hand is caught in the Mold	Bruises or broken bones
9	Drain cooling Injection core & Hot runner.	Pressurized hot water spray	blisters or burns
10	Reducing Injection cavity, core, and hot runner	Limbs	
11	Bring trolley Molds and old tooling to MTP	The foot or hand is caught in the Mold	Bruises or broken bones

12	Bringing new Molds and Tooling to the machine	Slipping or pulling a load that is too heavy	Sprain
13	Install injection cavity and hot runner	Pinched finger	Cuts or bruises
14	Install blow Mold, ejector, blow core	Pinched finger	Cuts or bruises
15	Installing heating pots, heating cores.	Hot conditions on the hands directly	Blisters
16	Install Injection core, bottom Mold, blow core unit	Pinched finger	Cuts or bruises
17	Clamping Injection, blow Mold, lip and heating pot.	The foot or hand is caught in the Mold	Bruises or broken bones
18	Tighten all Mold fixing bolts	Pinched finger	Cuts or bruises

From the results of observing the activity of replacing the Mold or Mold consisting of 20 work activities both routine and non-routine, the work activity is broadly divided into 4 stages, namely removing the Mold, lowering the Mold from the machine, raising the replacement, and installing Mold to the machine. Hazard identification was carried out in 20 work activities, both routine and non-routine, during Mold replacement work using the Job Safety Analysis (JSA) method and continued with the steps of carrying out a risk assessment. In In carrying out a risk assessment there are two stages, namely risk analysis and evaluation.

And the method which consists of three aspects of assessment . The three aspects assessed and evaluated in the semiquantitative risk analysis method include likelihood . Furthermore, the handling of these hazard risks is carried out using the HIRA method, where the overall results can be seen in table 2 below.

TABLE VV
RISK ANALYSIS AND COUNTER MEASURES

S.NO	ACTIVITY	POTENTIAL HAZARD	RISK	RISK CALCULATION	MITIGATION
1	Turn off Barrel temperature & hot runner	The skin touches the hot cover barrel	Skin blisters /burns	Currently	PPE, with gloves
2	Unscrew the ejector rod unit mountingbolts	The operator is caughtin the machine/tool	Wounds or defects	Low	Adm, by makingWI
3	Lower the Ejector rod unit from the engine	Incorrect body positionwhen lifting the mold	Sprain	Currently	Technically, by using a lifter
4	Unscrew the Blow Core fasteners	The operator is caught in the machine/tool	Wounds or defects	Low	by making WI
5	Lowers the Blow Core unit from the Machine	Incorrect body positionwhen lifting the mold	Sprain	Currently	Technically, by using a lifter
6	Lowering bottom Mold & blow mold	limbs hit by parts of the mold or machine	Wounds or defects	Tall	Technically, by using a lifter
7	Placing the blow mold and bottom mold in the trolly	The foot or hand is caught in the mold	Bruises or broken bones	Tall	Technically, by using a crane
8	Drain cooling Injection core & Hot runner	Pressurized hot water spray	blisters or burns	Low	Adm, by making WI
9	Reducing Injection cavity, core and hot runner	Incorrect body position when lifting the mold	Sprain	Currently	Technically, by using a lifter

10	Bring trolly molds and old tooling to MTP	The foot or hand is caught in the mold	Bruises or broken bones	Low	Substitution, using a forklift
11	Bringing new Molds and Tooling to the machine	Slipping or pulling a load that is too heavy	Sprain	Currently	Substitution, using a forklift
12	Install injection cavity and hot runner	Pinched finger	Cuts or bruises	Currently	Adm, by making WI
13	Install blow mold, ejector, blow core	Body crushed by equipment	Wounds or Broken Bones	Tall	Technically, a retaining tool is Made
14	Installing heating pots, heating cores and lip cav	Hot conditions on the hands directly	Blisters	Currently	PPE, with gloves
15	Install Injection core, bottom mold, blow core unit	Pinched finger	Cuts or bruises	Currently	Adm, by making WI
16	Clamping Injection cav, blow mold, lip cav, heating pot	The foot or hand is caught in the mold	Bruises or broken bones	Tall	Technically, a retaining tool is made
17	Tighten the mold fixing bolts	Pinched finger	Cuts or bruises	Low	Adm, by making WI
18	Take material from MPC	Back pain due to wrong body position when lifting	Sprain or backpain	Tall	Technically, a material suction tool is made

IV. Conclusion

In The hazard identification that has been carried out resulted in 20 potential hazards contained in the process of replacing the ISBM machine mold from all work activities that could pose a risk. The results of the risk assessment carried out are 20 risks with a risk rating consisting of 6 risks with high-risk rating, 11 medium risk, 6 low risk. Risk control for workers in the ISBM machine mold replacement process has been carried out based on a risk control hierarchy, namely Elimination, Substitution, technical, administrative and use of PPE. Whereby carrying out these controls, the risk of workers experiencing work accidents can be minimized and even eliminated as well. Henceforth, the JSA and HIRA analysis processes must also be applied to other processes and machines, where this will reduce the potential for work accidents which in the end can be detrimental to the company if they occur.

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