2015

Horizontal plastic injection molding machines with auxiliary equipment

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Horizontal Plastic Injection Molding Machines with auxiliary equipment

SAFETY CHECKLISTS

RG-882
UPDATED VERSION

This guide has been written to help conduct safety checks of existing installations. It also sets out key concepts that should be taken into consideration when buying equipment and can serve, as well, as a basic resource for training offered to employees or students.

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ACKNOWLEDGMENTS

The IRSST wishes to thank the members of the follow-up committee: Eric Garant, Berry Plastics Canada Inc.; Guylaine Lavoie, PlastiCompétences inc.; Sophie-Emmanuelle Robert, CSST; Tony Venditti, ASFETM; as well as the companies that took part in validating the guide.

We also extend our thanks to AFNOR for allowing us to reproduce Figure 8 from standard NF EN 415-10:2014 in this guide.

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Bibliothèque et Archives nationales 2017
ISBN 978-2-89631-969-5 (PDF)
ISSN 2292-9444

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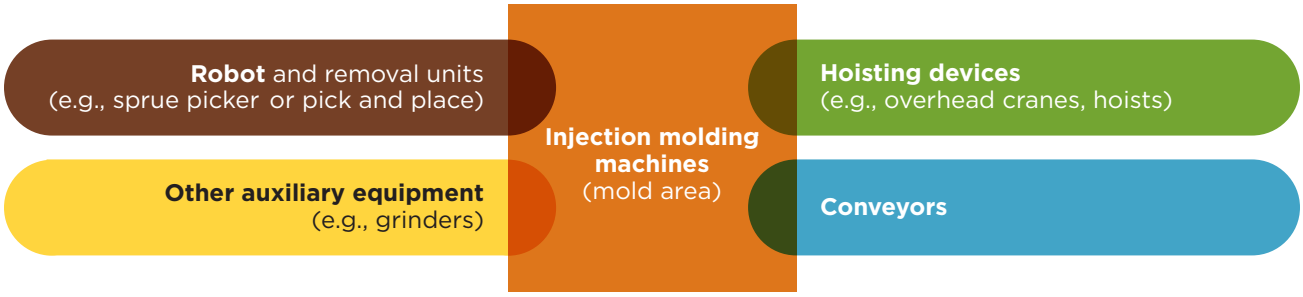
December 2017

Contents

1 Background

The mold of an injection molding machine is a hazard zone. Some of its hazards are related to the molding machine itself, while others stem from the auxiliary equipment used with the machine.

This guide will help identify risk areas and appropriate risk reduction measures for improving worker safety. It focuses specifically on the risks associated with using a horizontal plastic injection molding machine (limited to the mold area) in combination with one or more auxiliary equipment.



SAFETY CHECKLISTS

Integrating this auxiliary equipment into existing systems can present a number of safety challenges. This guide, the bulk of which consists of safety checklists, was designed to help users determine which components are important to consider. The general rule is to ensure that the initial safety level of the injection molding machine is not affected when the user installs and runs auxiliary equipment that was not supplied by the molding machine manufacturer.

For safety assessment purposes, users who fill in the checklists must have a good knowledge of plastic injection molding machines and related equipment, or be able to rely on the assistance of resources who have this knowledge. Users can also refer to IRSST guide RG-687 titled *Horizontal Plastic Injection Molding Machine — Safety Checklists*, which deals with the risks specific to injection molding machines [REF. 20].

IMPORTANT

This guide is not a substitute for the need to conduct a proper risk assessment (e.g., method proposed in standard ISO 12100 [REF. 10]), but is intended as a decision-making support tool. It is therefore important to consider all the hazards to which workers are exposed during all work performed on or with this equipment. Used in conjunction with Appendix C of research report R-822 [REF. 21], which provides a more exhaustive list of the hazards and risk reduction measures associated with the use of plastic injection molding machines with auxiliary equipment, this guide can serve as a starting point for a risk analysis.

2 Hazards and Possible Harm

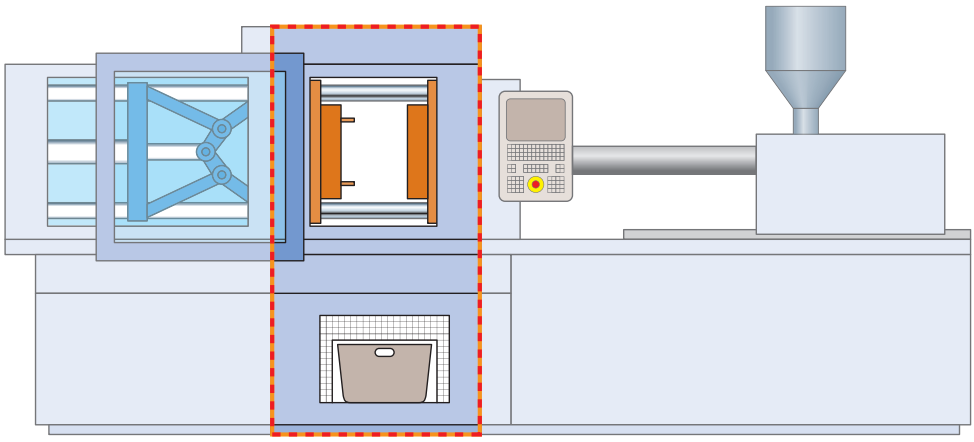
Working on injection molding machines and their auxiliary equipment involves a large number of hazardous situations that can result in worker injuries. While not exhaustive, the tables below summarize the main hazards to which workers may be exposed in the molding area and the injuries they can suffer. The statements in the safety checklists are based on these hazards and potential injuries.

Mold area of injection molding machine

When working in the mold area (e.g., changing the mold, installing a conveyor, programming a robot), workers may be exposed to the main hazards associated with injection molding machines.

HAZARDS	POSSIBLE HARM
Movements of the movable platen that create a pinching area	Cuts, Crushing, Severing, Amputation, Broken bones, Bruising, Skin discoloration, Eye injury, Pricks, Burns, Death
Movements of ejectors, cores and plates	
Sharp or cutting edges of components	
Flying metal parts or hot plastic	

MOLD AREA OF INJECTION MOLDING MACHINE

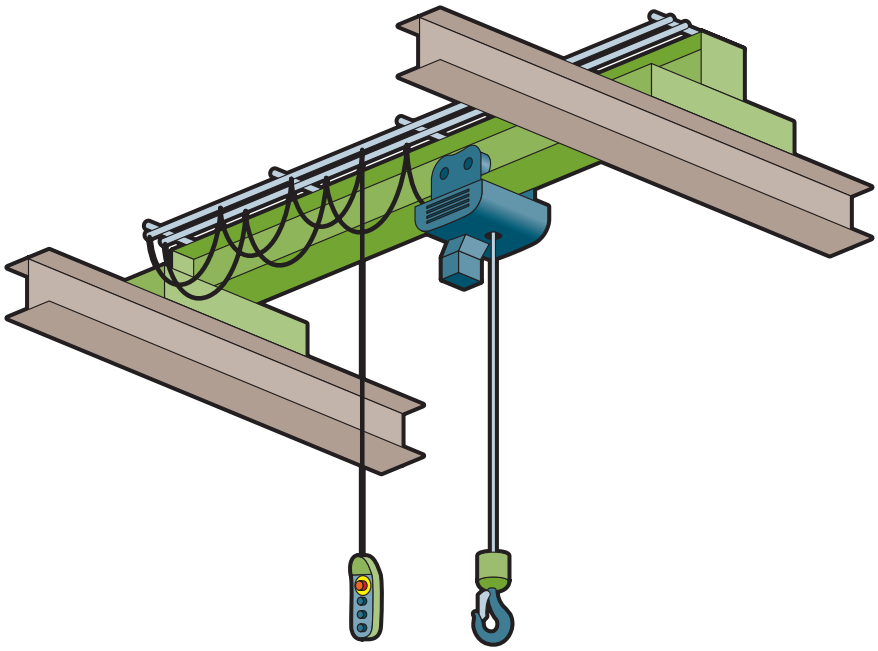


Hoisting devices (overhead crane, hoist, gantry)

Operating a hoisting device in the mold area increases the risks associated with the handling of often very heavy objects at height.

HAZARDS	POSSIBLE HARM
 Gravity (falling of suspended mold)	Pinching, entrapment Impact Broken bones Bruising Crushing Death
 Swinging or tipping of mold during handling	

OVERHEAD CRANE

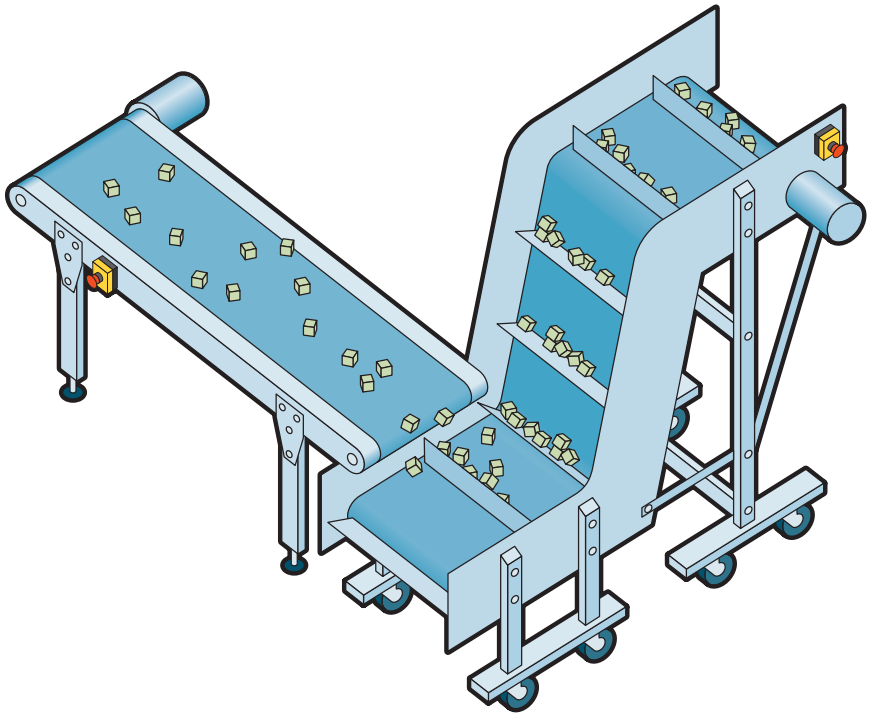


Conveyors

Installing a conveyor in the mold area creates new hazards (e.g., nip points) and brings with it the presence of a potential obstacle to the operations being performed there (e.g., requiring workers to walk on the conveyor).

HAZARDS	POSSIBLE HARM
 Nip points between the rollers and the belt	○ Pinching, entrapment ○ Crushing ○ Amputation ○ Friction burns ○ Broken bones ○ Bruising ○ Laceration ○ Death
 Moving rough belt or belt having uneven or cleated surface	

BELT CONVEYOR

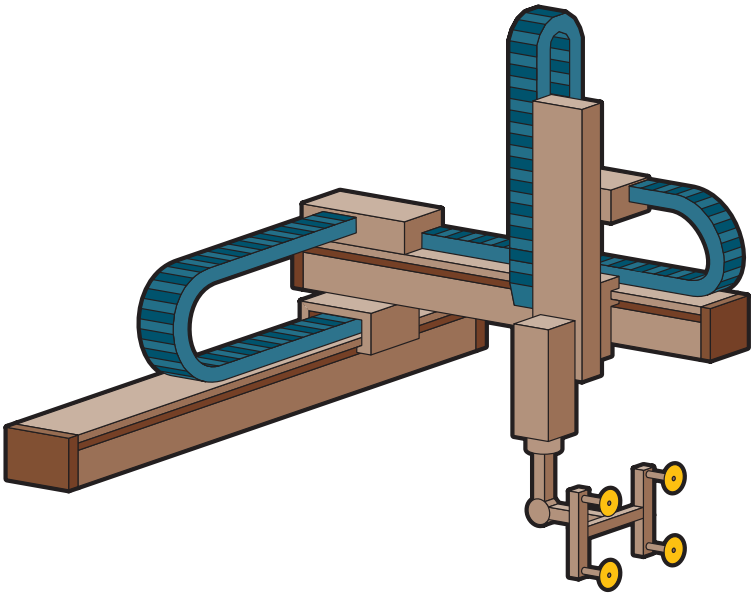


Robots and removal units

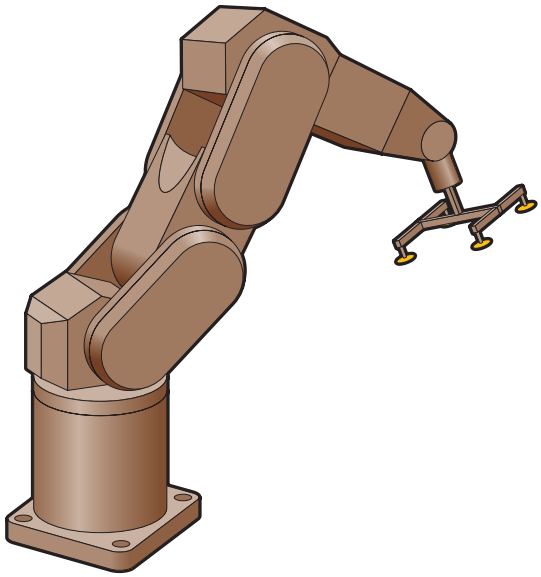
Robots or removal units that operate in the mold area give rise to additional significant safety hazards for workers.

HAZARDS	POSSIBLE HARM
 Movements of arms of robot or removal unit, gripper or load carried	○ Bruising ○ Broken bones ○ Entrapment ○ Eye injury ○ Impact ○ Crushing ○ Death
 Load being handled by robot or removal unit falls or goes flying	

CARTESIAN ROBOT



MULTI-AXIS ROBOT



Other auxiliary equipment

The preceding diagrams illustrate the auxiliary equipment observed during visits for the study that resulted in report R-822 [REF. 21]. Other kinds of auxiliary equipment exist and the potential associated risks must also be considered. For example, granulators and mold-changing systems must also be taken into account in a risk assessment of injection molding machinery. All hazards associated with this equipment must be inventoried and the impact their installation would have on the original safety level of the injection molding machinery determined.

Furthermore, although the rest of this guide does not discuss these other kinds of auxiliary equipment, the concepts examined in the case of overhead cranes, robots, removal units and conveyors are transposable and should be applicable to any auxiliary equipment considered. On the safety checklists, the statements with numbers in a box can be applied to other auxiliary equipment.

Other hazards

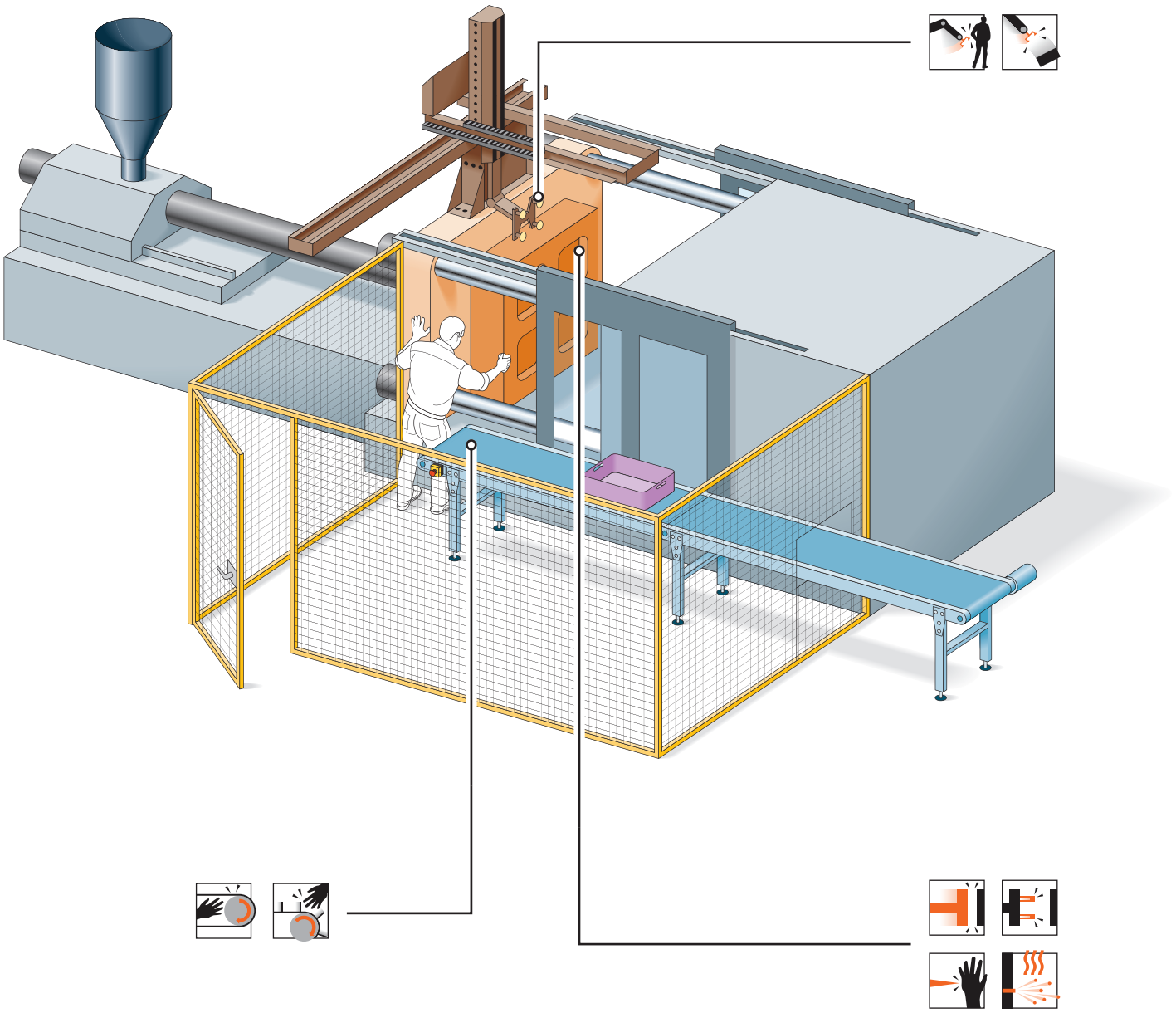
While auxiliary equipment adds new hazards around molding machines, it is important to keep in mind that their use in the mold area must also take into account already determined hazards, such as melting plastic and hot surfaces. Similarly, the new risks created by having auxiliary equipment in the mold area must also be taken into account. Hazards related to the work environment must be considered as well (for example, noise, risk of falling on cluttered or slippery floor).

3 Hazardous Situations

The following figures show typical configurations of injection molding machines used with auxiliary equipment. The purpose of this guide is to help assess worker safety in the hazardous situations these configurations create.

WORKING IN MOLD AREA

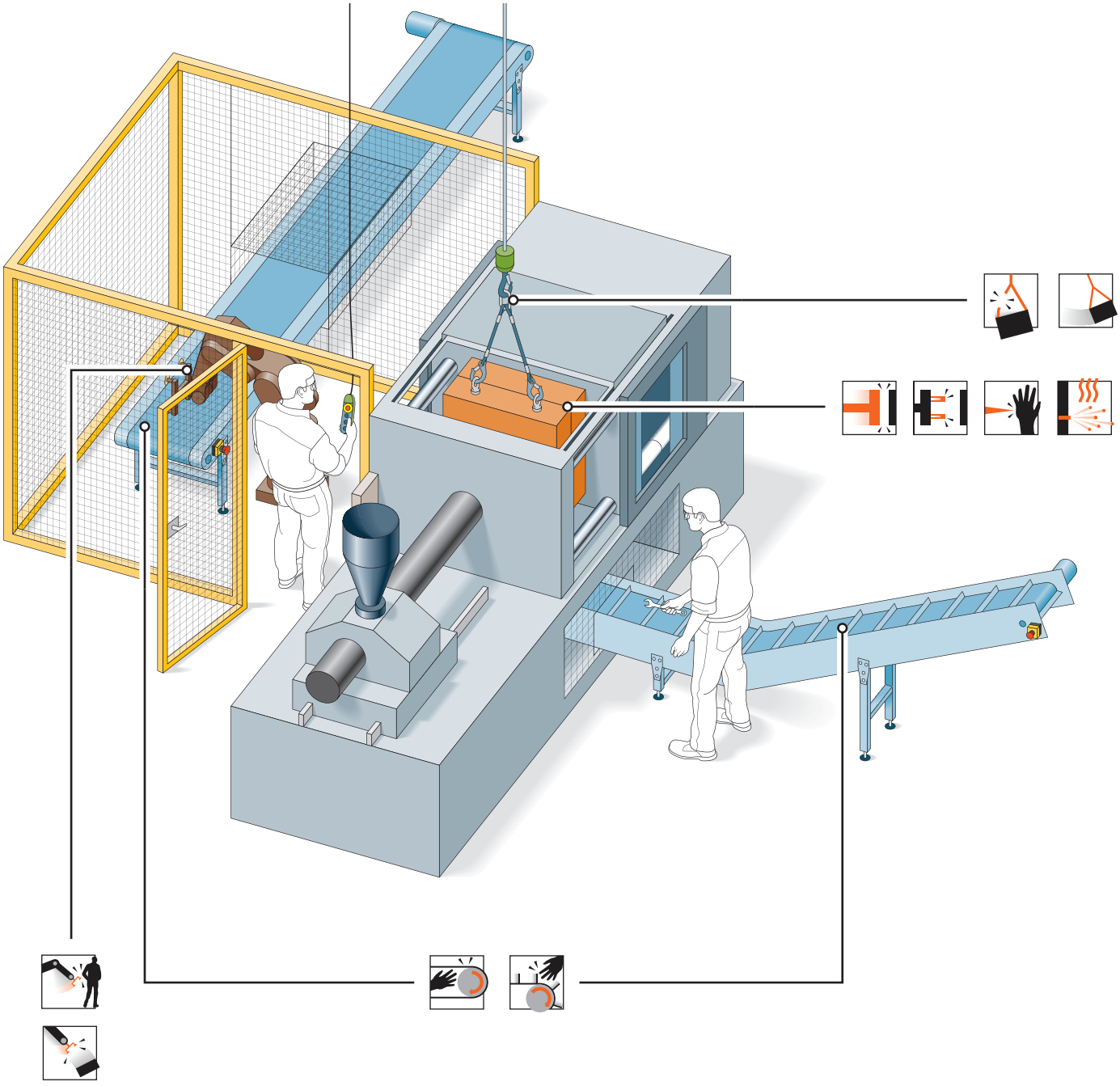
- Large horizontal plastic injection molding machine (accessible mold area)
- Robot located above mold area
- Output conveyor



Hazardous Situations

INSTALLING A MOLD

- Horizontal plastic injection molding machine
- Overhead crane used to install mold
- Robot on operator's side
- Output conveyor



4 Safety Checklists

Auxiliary equipment used with injection molding machines has its own hazards. It may also generate new risks, depending on how it is integrated into the system.

The following checklists consist of statements used to confirm that the important points to be considered in ensuring a safe installation have been taken into account.

RESPONSES

Answering **"yes"** to a checklist statement confirms that a good approach to safety is being taken.

Answering **"no"** does not necessarily mean that the equipment must be modified, but indicates that an optimal solution could involve conducting a risk assessment and taking steps to compensate (safeguards, procedures) in order to ensure the installation is safe. A table titled *Action Plan* at the end of this guide can be used to track such modifications.

Statements with numbers in a box No. **can be applied to other auxiliary equipment.**

STAKEHOLDERS' RESPONSIBILITY

Many of the recommendations in this guide refer to concepts that demand a good understanding of regulatory requirements and standards, especially details of the current state of the art respecting machine safety.

For example, the design, manufacture and installation of a guard or protective device involves a considerable number of rules and regulations—too many to describe here. An in-depth reading of the applicable standards is necessary when carrying out this type of project.

The stakeholders responsible for the safety of a company's facilities must therefore make sure that any modifications to equipment comply with regulatory requirements and standards, in line with the state of the art.

Safety Checklists

Completed by

Signature

Date (DD/MM/YYYY) / /

Identification of horizontal plastic injection molding machine

(e.g., identification number or make, model, serial number, year of manufacture)

Hoisting device

Conveyor

Robot

Removal unit

Ensuring safe use of hoisting devices

No.	TRAINING/INSPECTION/MAINTENANCE	YES	NO
1	Users have taken training on safe operation of hoisting devices[1] (e.g., training offered by sector-based OHS associations on safe use of slings and hoisting devices).	☐	☐
2	Users have taken training on inspection of hoisting devices.[1]	☐	☐
3	Hoisting device is inspected regularly.[2]	☐	☐
4	Hoisting device accessories are inspected regularly.[2]	☐	☐
5	Employer supervises training, inspection and maintenance.	☐	☐

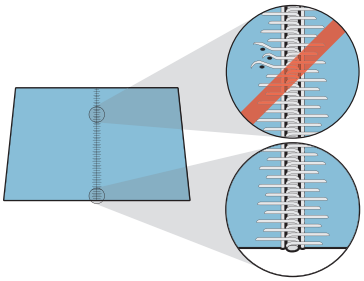
1. ROHS [REF. 1], section 254.1
2. ROHS, section 245

Ensuring safe use of hoisting devices (continued)

No.	APPROPRIATENESS OF EQUIPMENT	YES	NO
6	Height of hoisting device, including load raised, allows load to be raised over and into the molding machine without changing existing safeguards.	☐	☐
7	The molding machine is installed within the hoisting device's area of operation for safe use in all circumstances (e.g., no obstacles, all work areas accessible, no area of operation above passageways, etc.).	☐	☐
8	Mold can be inserted without losing settings or partly or totally dismantling the blocking mechanism. ***Note:*** *If guards must be dismantled, make sure they are put back in place before operating molding machine.*	☐	☐
9	Rated load is indicated on hoisting device and accessories.[3]	☐	☐
10	Mass is indicated on loads (e.g., mold).	☐	☐
11	Rated load of hoisting device and accessories is greater than or equal to the mass of the heaviest mold to be handled or hoisting device is equipped with a load limiter.[4]	☐	☐
12	Hoisting device is equipped with a warning device (e.g., alarm, warning light) that can be used manually.[5]	☐	☐
13	Hoisting device is always operated from a safe place from where the operator has an unrestricted view of the molding machine.[6]	☐	☐
14	Hoisting device can only be operated from a single control station or with only one remote control at a time.	☐	☐
15	Using a forklift to lift molds during installation is not recommended in the company. If there is no other option, a forklift may be used to lift molds as long as the proper accessories are used and a safety procedure is followed (e.g., avoid setting the mold down or hanging slings or chains directly on forks).	☐	☐

3. ROHS, section 249
4. ROHS, section 248
5. ROHS, section 259
6. ROHS, section 253

Ensuring safe use of conveyors

No.	INHERENT RISKS OF CONVEYORS	OUI	NON
16	Conveyors are protected to prevent any risk of workers being crushed, rolled or dragged in between the belt and a roller or the load bearing part.[7]	☐	☐
17	Conveyor belt splices (joins) are flawless (e.g., no increased risk of catching). **SPLICES** 	☐	☐
18	It is impossible (i.e., physically impossible) or prohibited to walk on moving conveyors.	☐	☐

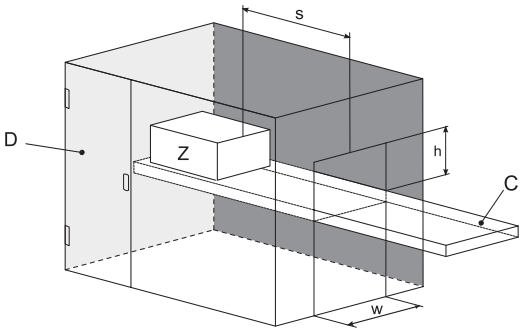
No.	HAZARDOUS SITUATIONS CREATED OR CHANGED BY ADDITION OF CONVEYORS	OUI	NON
19	Mold area remains inaccessible even though guards may have been modified to allow addition or removal of conveyors.[9]	☐	☐
20	Molding machine safeguards remain operational even when conveyors are added.[10] If not, further safeguards were implemented to compensate.	☐	☐
21	Mold area remains visible from control stations despite the addition of conveyors (person at controls must be able to check that there is no one in hazard zone).[11]	☐	☐
22	Work areas (e.g., control station) on molding machine remain safely accessible despite addition of conveyors (e.g., no need to go over or under conveyor to get there).	☐	☐
23	Conveyors are situated in relation to other machinery so as to avoid creating areas where workers could get trapped or crushed (e.g., machinery spaced out far enough).	☐	☐

7. Standard ASME B20.1 [REF. 5], section 5.9.1.1
8. ROHS, section 269
9. Standard EN 201 [REF. 2], section 4.10.4
10. Standard EN 201 [REF. 2], sections 5.10.4 and 7.1.22
11. Standard EN 201 [REF. 2], section 7.1.23

Ensuring safe use of conveyors (continued)

No.	SAFEGUARDS	YES	NO
24	Safeguardsare taken to prevent access to a molding machine's hazard zones, even if there are conveyors, regardless of the conveyor's position (e.g., sides, underneath molding machine) and size of pieces produced (e.g., fixed guards, movable guards, safe openings, tunnels).	☐	☐
25	An interlock system[13] prevents molding machine from operating if conveyors that are removable without use of tools give access to hazard zone.[14]	☐	☐
26	Conveyor is connected to molding machine's control system through an interconnection interface like EUROMAP or SPI.[15]	☐	☐
27	All energy sources (electric, pneumatic, hydraulic or other) of conveyors can be locked out.[16]	☐	☐
28	Conveyors, molding machine and all other auxiliary equipment are equipped with emergency stop devices (buttons or cables) that can safely stop all other equipment.[17, 18]	☐	☐
29	Parts of control systems to do with conveyor safety are compliant with reliability standards (ISO 13849 [REF. 11], IEC 62061 [REF. 12]).[19]	☐	☐
30	Conveyor operating controls are located outside hazard zones and are easily accessible (e.g., no obstacles, no need to step over conveyor, etc.).[20]	☐	☐

EXAMPLE OF DIMENSIONS TO CONSIDER FOR A SAFE OPENING IN A GUARD



Legend
- **Z** Hazard zone
- **D** Interlocked movable guard
- **C** Conveyor
- **h** Height of opening
- **w** Width of opening
- **s** Safety distance

Source: Figure 8, standard NF EN 415-10:2014[12]

12. Excerpts from standard *NF EN 415-10:2014 — Sécurité des machines d'emballage — Partie 10: prescriptions générales* [REF. 14] reproduced by permission of AFNOR. Only the complete original copy of the standard as published by AFNOR Éditions (available from www.boutique.afnor.org) has authority as a standard.
13. The term "interlock" or "interlocking device" refers to the function described in the international standard: "mechanical, electrical or other type of device, the purpose of which is to prevent the operation of hazardous machine functions under specified conditions." ISO 12100 [REF. 10], section 3.28.1
14. Standard EN 201 [REF. 2], section 5.10.4
15. Euromap 12 [REF. 15], Euromap 67 [REF. 16], Euromap 73 [REF. 17], SPI AN-116 [REF. 18], SPI AN-146 [REF. 19]
16. Standard CSA Z460 [REF. 9], section 5.2.1
17. ROHS, section 270
18. ROHS, section 193
19. Standard EN 201 [REF. 2], section 7.1.22
20. Standard ISO 12100 [REF. 10], section 6.2.11.8

Ensuring safe use of robots and removal units

No.	INHERENT RISKS OF ROBOTS AND REMOVAL UNITS	YES	NO
31	Hazard zone where robot operates, including the unloading area, ○ is rendered inaccessible by one or more fixed or movable guards, or by an enclosure OR ○ is secured by some other means that automatically protects workers (e.g., surface detector, safety light curtain, pressure-sensitive mat, etc.).	☐	☐
32	Robot's restricted space is clearly identified.[21] **Definition of restricted space:** "Portion of the maximum space restricted by limiting devices that establish limits which will not be exceeded". (Norme ISO 10218-1 [REF. 7], article 3.24.2).	☐	☐

No.	HAZARDOUS SITUATIONS CREATED OR MODIFIED BY ROBOTS AND REMOVAL UNITS	YES	NO
33	Hazard zone where robot operates is inaccessible despite modifications to molding machine safeguards to facilitate addition or removal of robot.[22]	☐	☐
34	Robot was integrated without removing or deactivating safeguardsor, if not, further safeguards were implemented to compensate.	☐	☐
35	Molding machine work areas (especially mold area) are still visible from control station, despite addition of robot.	☐	☐
36	Robot is connected to molding machine's control system by means of interconnection interface like EUROMAP 67 [REF. 16][23], SPI AN-116 [REF. 18] or equivalent[24] (e.g., SPI AN-146 [REF. 19]).	☐	☐
37	When stopped, robot is positioned so it does not hinder work and people won't run into it (e.g., robot always returns to initial position [*Home*] before a worker enters its operating area, including mold area).	☐	☐
38	Robot is positioned so it does not interfere with movements of hoisting devices when handling mold.	☐	☐

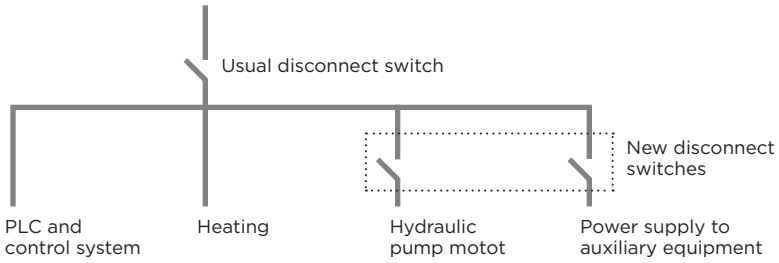
21. Standard ANSI/SPI B151.27 [REF. 4], section 5.1.8
22. Standard EN 201 [REF. 2], section 4.10.4
23. Standard EN 201 [REF. 2], section 7.1.22
24. Standard ANSI/SPI B151.27 [REF. 4], section 5.1.6

Ensuring safe use of robots and removal units (continued)

No.	SAFEGUARDS	YES	NO
39	All of robot's energy sources (electric, pneumatic, hydraulic or other) can be locked out.[25]	☐	☐
40	Robot enclosures are designed to meet robotics standards (CSA Z434 [REF. 6], ISO 10218-1 [REF. 7], ISO 10218-2 [REF. 13]).	☐	☐
41	Robot safety-related parts of control system are compliant with reliability standards (ISO 13849 [REF. 11], IEC 62061 [REF. 12]).[26]	☐	☐
42	Doors of enclosure preventing access to robot are equipped with interlocks with or without guard locking devices.[27]	☐	☐
43	Restarting robot requires human intervention after safeguard has been replaced[28] or loss of energy supply.[29]	☐	☐
44	Both robot's control station (including teach pendant) and molding machine control station are equipped with emergency stop devices that can safely stop both machines.[30]	☐	☐
45	Except for programming purposes, robot cannot move if there is a person in its hazard zone (thanks to protective devices or because other workers are forbidden to activate robot in that situation and they must have a complete, unobstructed view of area.)	☐	☐
46	Opening any of the movable guards (including the molding machine ones) stops all of robot's hazardous movements.	☐	☐
47	If robots are removed, all guards, including the top one, can easily be put back into position and made operational again (in the case of guards with interlocks with or without guard locking devices) to prevent access to molding machine hazard zone.	☐	☐
48	Except for teach pendant, robot's controls are located outside hazard zones.	☐	☐

25. Standard CSA Z460 [REF. 9], section 5.2.1
26. Standard ISO 10218-1 [REF. 7], section 5.4
27. The term "interlocking guard with guard locking device" refers to the function described in the international standard: "guard associated with an interlocking device and a guard locking device ..." ISO 12100 [REF. 10], section 3.27.5 (excerpt)
28. Standard ISO 12100 [REF. 10], sections 3.27.4, 3.27.5 and 6.3.2.5.2
29. Standard ISO 12100 [REF. 10], section 6.2.11.4
30. Standard ISO 10218-1 [Ref. 7], section 5.5.2

Other safety-related aspects

No.	LOCKOUT/ENERGY CONTROL	YES	NO
49	The molding machine has its own cutoff devices for heating or IT equipment and the main motor, so that only energy sources deemed hazardous for a given task can be locked out.[31] **ADDITIONAL DISCONNECT SWITCHES FOR MOLDING MACHINE'S HYDRAULIC PUMP AND AUXILIARY EQUIPMENT**  	☐	☐
50	Locking out energy sources is the risk-reduction measure used for maintenance, repair and unjamming work.[32]	☐	☐
51	During work when locking out energy sources is necessary, all auxiliary equipment that could present a risk is locked out.	☐	☐
52	It is possible to lock the operator-side guard in the open position with a personal padlock, to prevent the molding machine from starting up.[33] ***Attention:*** *This recommendation is based on the premise that the reliability of the safety-related parts of the molding machine control system meets standards.*	☐	☐
53	Emergency stop devices (buttons, cables, etc.) are not used as a substitute for locking out energy sources.[34]	☐	☐

31. Standard CSA Z460 [REF. 9], Appendix N
32. ROHS, section 185, and for details, see standard CSA Z460 [REF. 9]
33. Standard CSA Z460 [REF. 9], Appendix N
34. Standard CSA Z460 [REF. 9], section 3, definition of "energy isolating device"

Other safety-related aspects (continued)

No.	WORK ENVIRONMENT AND SAFETY RULES	YES	NO
54	Safeguarding for the molding machine and auxiliary equipment is periodically inspected (malfunction, bypass, neutralization or removal of safeguarding).[35]	☐	☐
55	The molding machine and its auxiliary equipment are equipped with structural components that make it safe for workers to perform tasks that would otherwise expose them to a risk of falling (e.g., suitable steps or catwalks). *For example, it is extremely dangerous to walk or lean on the molding machine tie bars.*	☐	☐
56	Workers have all the equipment they need (ladders, stepladders, etc.) to be in a stable position when working on the molding machine or its auxiliary equipment. ***Note:*** *Ladders and stepladders should only be used occasionally for specific tasks.*	☐	☐
57	Floor is not slippery or cluttered[36] (e.g., oil leak, power cables).	☐	☐

No.	EQUIPMENT PROCUREMENT	YES	NO
58	Molding machine's compliance with an applicable standard (EN 201 [REF. 2], ANSI/SPI B151.1 [REF. 3]) was checked before purchase or machine was delivered with a certificate, signed by an engineer, confirming equivalence with safety level set out in an applicable standard.	☐	☐
59	Compliance of auxiliary equipment with an applicable standard was checked before purchase, or equipment was delivered with a certificate, signed by an engineer, confirming equivalence with safety level set out in an applicable standard.	☐	☐

35. Standard ANSI/SPI B151.1 [REF. 3], section 4.3 (molding machines); ISO 10218-2 [REF. 13], section 5.8.1 (robots); CSA B167 [REF. 8], section 5 (overhead cranes)
36. ROHS, section 14

Other safety-related aspects (continued)

No.	EMERGENCY STOP	YES	NO
60	All emergency stop and reset devices are easily accessible at all times.	☐	☐
61	Triggering an emergency stop device (of molding machine or auxiliary equipment) safely stops the molding machine and all the auxiliary equipment used with it.[37]	☐	☐
62	An emergency stop device that acts on the molding machine as well as all auxiliary equipment is accessible at each control station (molding machine and auxiliary equipment) and anywhere else deemed necessary (e.g., side opposite operator).[38] ***Note:*** *A risk analysis can help determine where emergency stop devices are needed.*	☐	☐

No.	CONTROL SYSTEM RELIABILITY AND SAFETY	YES	NO
63	Original reliability of molding machine safety-related control system has been maintained despite integration of additional safeguarding needed for auxiliary equipment.	☐	☐
64	Reliability of safety-related parts of control systems for auxiliary equipment and molding machine is appropriate for risks for which they were selected (ISO 13849 [REF. 11], CEI 62061 [REF. 12]).	☐	☐
65	Molding machine control system is designed for easy connection of auxiliary equipment (robots, etc.) and additional safeguards (movable guards, emergency stop, etc.) thanks to an interconnection interface like EUROMAP or SPI.[39]	☐	☐

37. ROHS, section 193
38. Standard ANSI/SPI B151.1 [REF. 3], section 7.2.4.4 (5), extended to auxiliary equipment
39. Euromap 12 [REF. 15], Euromap 67 [REF. 16], Euromap 73 [REF. 17], SPI AN-116 [REF. 18], SPI AN-146 [REF. 19]

Other hazards

There are many possible configurations for the use of horizontal plastic injection molding machines with auxiliary equipment. You may observe hazards or hazardous situations related to a particular configuration not covered in this guide. You should note them below and assess the effectiveness of the risk-reduction measures already taken. If there are any shortcomings, additional measures must be taken and monitored (see *Action Plan* table).

No.	EQUIPMENT	HAZARD	RISK-REDUCTION MEASURE

5 Action Plan

For each checklist statement where the **"no"** box was checked and for each risk-reduction measure listed in the *Other Hazards* table, give reasons for noncompliance reported and any corrective measures that must be taken.

No.	REASON AND CORRECTIVE MEASURES	PERSON RESPONSIBLE	DEADLINE

6 References

REGULATION

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16 Europe's Association for plastics and rubber machinery manufacturers (EUROMAP). *Euromap 67 — Electrical interface between injection molding machine and handling device/robot*, version 1.11, 2015.

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