



Stage Machinery and Automation Systems

Hazard Guide

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Disclaimer

In legislative terms, the requirements of the *Work Health and Safety Act 2011* (the WHS Act) and Work Health and Safety Regulations (the WHS Regulations) are mandatory. In contrast, a guide is designed to assist obligation holders to comply with the requirements of an act or regulation. The information contained in the LPA guides is not mandatory, has no legal status and may not apply in all work situations.

Obligation holders still have a duty to assess the risks in each work situation and take all reasonable steps to eliminate or minimise the risks that are specific to each work activity.

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1. Overview

This guide provides information to assist in managing risks associated with **stage machinery and automation systems** used in live entertainment and events. Information in this guide is based on the Work Health and Safety Act 2011 (WHS Act) and Work Health and Safety Regulations 2011 (WHS Regulations), which are operational in all states except Victoria and WA, where adoption of the legislation is not yet enacted (as at Jan 2018).

It is recommended that this information is referenced during the planning and delivery of events to assist in identifying hazards, assessing risks and determining appropriate control measures to eliminate and or minimise these risks, so far as reasonably practicable.

This guide does not replace the need to develop risk management strategies, undertake research or seek specialist advice.

Each worker and person conducting a business or undertaking (PCBU) has a responsibility to understand their obligations under WHS legislation. Codes of practice and Australian and international standards provide approved guidance on how to meet work health and safety obligations.

Stage machinery and automation systems hazards can result in many types of injuries and in extreme cases death. Types of injuries can include crush, falls, fractures, internal injuries.

The risk of injury from stage machinery and automation systems is strongly linked to the design and construction of these systems, both the physical structures and the control systems. The risks tend to be greater when working with touring/portable equipment, custom made equipment, or with equipment that can be damaged through high frequency use and movement. It is imperative that the initial risk assessment is undertaken at the design stage before the design is implemented in any way.

This stage machinery and automation systems hazard guide provides practical information and suggested control measures for:

- General venue stage machinery (plant)
- Stage elevators and lifts incl. orchestra pits
- Stage wagons, revolves, sound shells and travelators
- Flying systems, gantries and other rigging machinery
- Tracks, sliders, doorways and other staging machinery
- Mobile plant
- Load moving machinery and equipment

Also note that this guide can and should be applied to permanently installed stage machinery in a venue, not just equipment used in a particular production.

Part 1. Safety Guidelines for Live Entertainment and Events provides general information on duties, obligations and risk management.

2. Key Considerations – Stage Machinery and Automation Systems

The following questions must be considered during event design, planning and delivery. Use them to identify hazards and plan how risks will be managed.	Yes	No	Comments/Action
2.1 Design and planning			
<i>Will PCBUs and workers other than those employed at the initial workplace be involved or affected by this activity?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Have arrangements been made to consult with and cooperate and coordinate activities with other PCBUs before and during the undertaking of this activity?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Has the PCBU requested copies of the design risk assessment?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Has the design risk assessment been completed and has the PCBU requested copies of this document?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Has consultation between all parties identified by the risk assessment taken place?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Has the scope of work been defined incl. duration, equipment required, scheduling and location?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Have site-specific safety requirements or procedures been identified?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Have all elements that are subject to movement and/or control by the stage machinery and automation systems been identified?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Are the physical capacities of the areas where the stage machinery and automation systems will be installed suitable for the demands of the</i>	<input type="checkbox"/>	<input type="checkbox"/>	



<p>The following questions must be considered during event design, planning and delivery. Use them to identify hazards and plan how risks will be managed.</p>	<p>Yes</p>	<p>No</p>	<p>Comments/Action</p>
<p><i>automation?</i></p>			
<p><i>Is approval needed from the venue to install temporary stage machinery and/or automation system/s?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Is the stage machinery and/or automation system/s fit for purpose and compliant with legislation?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p>2.2 Event delivery</p>			
<p><i>Will environmental conditions affect the stage machinery or automation system?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Will engineering certificates be required?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Is it clear who will conduct the risk assessment?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Do workers have the appropriate licences?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Will workers be exposed to the risk of falls?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Will movements of stage machinery and automation systems be part of the performance?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Have the procedures and authority for calling stop and go/no go been established?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Have communication protocols been established?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Are adequate inspections delegated and scheduled?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Is the activity co-ordinated with other PCBUs?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Can the testing and rehearsals of stage machinery and automation systems be scheduled to minimise exposure to other workers/services?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	
<p><i>Have all workers who will be in the area during the testing and rehearsals of the stage machinery and automation been identified and consulted/inducted?</i></p>	<input type="checkbox"/>	<input type="checkbox"/>	

The following questions must be considered during event design, planning and delivery. Use them to identify hazards and plan how risks will be managed.	Yes	No	Comments/Action
<i>How will exclusion zones be established and maintained?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Have machinery lock down/key lock or power disconnect procedures been implemented to avoid accidental triggering of the machinery?</i>	<input type="checkbox"/>	<input type="checkbox"/>	

3. General Guide – Stage Machinery and Automation Systems

3.1 Responsibilities

The Work Health and Safety Regulations impose specific requirements on PCBUs concerning work that involves risk of falls, plant and structures and construction work, including:

- To manage risks associated with falls
- Designers, manufacturers, importers and suppliers to supply safeguards such as guarding, operator controls, emergency stops and warning devices, as well as user information and instructions
- PCBUs who install, construct or commission plant or structures to comply with designer or manufacturer information and relevant health and safety instructions
- PCBUs who commission construction work, to consult with the designer regarding health and safety; the designer must provide a written report on this

Duty holders may also have additional responsibilities under state regulations.

3.2 Training and competence

Different licensing and competency requirements apply across Australian states and territories. There are regulated, non-regulated and legislated requirements for the many stage machinery and automation systems used in the industry. Responsible persons should check with their state authorities to clarify any specific requirements.

The rehearsal of stage machinery and automation systems under show conditions is imperative to their ongoing and repeated safe use. In circumstances where multiple pieces of stage machinery and automation systems are designed to run sequentially or concurrently, it is important to structure rehearsals in a manner that progressively builds to the full effect. For example, start under work light with limited other distractions and, as competence and familiarity builds, add in other elements systematically, introducing one piece of movement/stage machinery and automation at a time – stage lighting, sound, special effects –

until the full array of effects are operating safely and predictably within the performance environment.

3.3 Consultation, co-operation and co-ordination

The Model WHS Act makes consultation with workers a legal requirement. Consultation, cooperation and coordination between PCBUs is a requirement where they share a duty for the safety of a worker or for work to be done.

PCBUs should use the information in this guide as a basis to consult with workers including event staff to determine the hazards and risks associated with planned use of stage machinery and automation systems and how to best eliminate or minimise these risks using the hierarchy of controls.

Consultation should start as early as possible, before decisions are made, and continue through the duration of the event. Consider the other parties who will need to be involved in the consultation process in the planning stages of the event and determine what information needs to be shared and discussed.

During an event, PCBUs are required to consult, co-operate and co-ordinate with other PCBUs such as the venue or site management, unions, production companies, designers, event promoters, catering providers, security, subject matter experts such as licensed riggers, technicians or safety officers, local authorities or governments, rigging companies, performers, suppliers of plant or equipment.

If employees are represented by health and safety representatives, the consultation must involve those representatives.

Areas to address during consultation may include induction, schedules, floor plans, set elements, lighting and sound designs, site specific requirements, risk assessments, SWMS, hazards and control measures, legislative requirements, licences, plant movement, traffic management, exclusion zones, key contacts, emergency procedures, permits to work etc. Opportunities for consultation include at toolbox talks, event briefings, site inspections, stakeholder meetings, post event reviews, working groups or forums.

3.4 Design and planning

In the early stages of design and planning, the following criteria should be addressed:

- Requesting a copy of the risk assessment developed by the system designer
- Consultation with relevant PCBUs and workers
- Consultation with all departments that will be affected by the use of the stage machinery and automation systems



- Development of separate risk assessments and SWMS, including controls agreed to during consultation, for each individual piece of stage machinery and automation system and their intended operations/cues
- Agreed scheduling and allocation of resources to minimise impact on others
- Access to site and delivery logistics
- Maintenance programs for the stage machinery and automation systems
- Emergency procedures in the event the machinery and/or automation system fails at cue time or the cue occurs adversely, pre or post cue
- Identification of any residual hazards that may exist after each cue has been completed, for example, unplanned gaps/holes in the performance platform

3.5 Event delivery

In the delivery stages of an event (bump-in, rehearsal, show, performance and bump-out) the following criteria should be addressed:

- Consultation with relevant PCBUs and workers
- Site specific inductions
- Equipment inspections and/or maintenance
- Work permits or engineering certificate requirements
- Equipment and environment checks daily, weekly and pre and post show
- Post-show analysis and checks ensuring there are no unexpected risks present
- Implementation and monitoring of controls identified in risk assessments or SWMS
- Compliance to legislative requirements
- Review, consultation and adjustment of control measures as required on site
- Incident reporting and management
- Communication procedures
- Sign-off and handover procedures

3.6 Review

After an event, the following criteria should be reviewed in consultation with relevant parties:

- Incident reports and outcomes, including near misses
- Effectiveness of the control measures
- Scheduling
- Areas for improvement



- Incidents of non-compliance
- Any new hazards or risks identified

3.7 Documentation and records

The following documents and records should be created, maintained and kept on site when working with stage machinery and automation systems during an event:

- Risk assessments and SWMS
- Training records, certificates of competency and licences
- Induction records
- Toolbox talk topics and attendance
- Evidence of consultation
- Incident reports, including near-misses
- Maintenance records
- Engineering certification, work permits and sign-off records

Any of the above documents could be requested to be sighted by other PCBUs for verification or clarification and should be available at all times.

Some WHS documents and records need to be retained for a specific period of time – see relevant WHS legislation for details.

4. Suggested Control Measures

The safe and the timely operation of the machinery to achieve the spectacle required by the production and its designers requires skill and training.

As well as being familiar with any equipment being brought into a venue for a touring production, PCBUs must make themselves aware of the extent of the automation installed in the venue. The PCBU will need to ensure that all possible risks have been identified and these risks eliminated or reduced wherever practicable.

4.1 General control measures for stage machinery and automation systems

Traditional stage machines such as counterweight flying systems, hand winches, trapdoors, special effect machines are human powered and manually controlled. This allows immediate feedback to the operator by touch and confers a certain aspect of safety. However they have the potential to cause serious harm when not operated correctly.

A key control measure for manually operated machinery is to have a two-step process for activation. For instance rope lines should always have a brake or locking mechanism that must be consciously released before operating. Similarly winches and lever operated ratchet and



clutch devices should have release locks and/or handles that can be removed when not required. Such two-step activation processes help ensure there is no inadvertent activation of the machine, and act as a double check prior to the intended movement.

Other crucial controls for ensuring safe operation of machinery is always having clearly written cue or movement plots and dedicated supervision of the operations. In traditional theatre supervision was the responsibility of a 'head mechanist' with a 'charge-hand' on each side of the stage. All movements of the flying system would be overseen by a 'head fly'.

By definition powered stage machinery involves non-human energy sources such as electricity, gravity, hydraulic or pneumatic pressure. Such systems always require emergency energy cut off and braking devices normally termed 'E-stops'. Over-travel, overload switches and control system redundancies are also usually incorporated into powered automation machinery.

In contrast to manual systems, powered systems do not generally give an immediate tactile feedback so the potential for such machinery to cause considerable damage if there is an unchecked collision or a system/operational malfunction is much greater. Hence there is great responsibility in the context of live performance to ensure 'clear passage' for the run of the machinery. Engineering control measures such as barriers and electronic exclusion parameters should be used wherever practicable.

4.2 Site-specific venue stage machinery (plant)

Entertainment venues are all equipped with a certain level of stage machinery. From a town hall with 3 ancient hand winches that raise and lower the lighting bars to venues that run all electric fly lines, stage lifts, revolving stages, stage wagons, sound shells, travelators, gantries, cranes, orchestra pit mechanisms and various rigging apparatus. All venues have an obligation to ensure that the equipment is installed, maintained and operated safely.

There is also the WHS requirement for the designer, in some cases the consultant, to ensure the risk assessment has been done and all foreseeable risks have been identified and eliminated.

Key requirements for operating venue specific machinery will include strict use of the plant in accordance with the manufacturer's operations manual and only authorised use of the plant in accordance with venue operational policies, procedures and training, which should instruct and uphold all control measures determined by an operational risk assessment undertaken by the venue.

Venue stage machinery requires regular inspections and maintenance. This includes items defined as a crane or hoist, which require annual inspections under the various codes, and end of life (nominally 10 years) major inspections and certification. Workers must be trained in conducting routine inspections and clearly understand how to report worn, faulty or damaged



machinery. Machinery must not be used if it appears faulty. Unsafe machinery must be disconnected or isolated and 'out of service' ('lockout') tagging procedures must be understood. 'Return to service' procedures should be understood and include testing of equipment prior to use. Log books should be kept where all relevant notes on the system can be checked.

The operators employed by the venue should be able to produce evidence of training and/or experience in the equipment they are being employed to operate. Where venue staff is not available the PCBU should provide suitable training.

4.3 Stage elevators and lifts

Stages that move either in a vertical and/or horizontal plane and possibly also tilting on an angle are generally the heaviest items that can be moved during a performance. These stage elevators and/or lifts can also be designed to carry a variety of loads including performers. The control system and safety mechanisms integral to the design are paramount in achieving this safely.

Stage elevators and lifts can be permanent venue plant or temporary installations. They may be used to extend the stage area, form an orchestra pit, provide access to storage or loading facilities, enable performer entrances and exits or create elevated platforms.

Like all stage machinery, stage elevators and lifts require specific risk assessments for safe operations. Typically this type of machinery will be associated with high risk fall hazards or the risk of collision, both of which need to be controlled with engineering rather than administrative measures. Usually this is achieved with physical barriers and electronic interlocks that prevent machinery movements unless the barriers are installed or the interlocks engaged. Other safety controls will normally include emergency stops, travel limit switches, electronic safe edges, guarding covers, safety nets and SWMS (safe work method statements) for specified tasks involving the machinery.

Operation of stage elevators and lifts must be done by authorised trained technicians. Where performers are riding stage elevators and lifts, specific risk assessment should be undertaken and initial rehearsals done in full light with a stage manager and/or supervising technician monitoring all movements through rehearsals and performances. Continuity of operators from design through rehearsal to performance is recommended. All equipment lifting or operating over people needs to be specifically designed for the task.

4.4 Stage wagons, revolves, sound shells and travellators

Stage wagons, revolves, sound shells and travelators may be part of venue machinery plant but are more frequently installed temporarily in venues for a specific event. This type of machinery is usually used for creating large staging effects involving scenic changes and coordinated movement of performers.

Stage wagons, revolves, sound shells and travelators require specific risk assessments for safe operations. Crush, shear, trip and slip hazards are frequently associated with this type of machinery. Control measures will typically involve guarding of moving parts and exclusion zones for safe travel. Other safety controls normally include emergency stops and travel limit switches. Electronic safe edges, machine movement monitors and closed circuit TV including infrared for black-out circumstance are also frequently used to ensure safety. Operation of stage wagons, revolves, sound shells and travelators must be done by authorised trained technicians. Pre-performance cue testing with reference to a safety checklist should be undertaken before using this type of machinery with performers. Initial rehearsals should be carried out in full work light and a stage manager and/or supervising technician is required to monitor all movements through rehearsals and performances.

4.5 Flying systems, cranes and other rigging equipment

Safety information related to flying systems, cranes and other rigging equipment such as chain motor truss, winches may be found in the *Event Rigging Hazard Guide*.

Often electronic flying system plant and the like are operated in combination with other automated stage machinery and will have a common control platform as well as integrated safety features. In other circumstances, particularly involving manual systems, machinery systems operate independently and risks can arise from uncontrolled interactions between systems such as the flies and stage level machinery. Venue and event risk assessments therefore need to consider risks arising from potential interactions of different systems of machinery. Commonly there is a need to control such risks with strict overall supervision of all staging operations. This may be achieved by having a designated 'hands-off' supervisor who has responsibility to coordinate and check all movement of machines.

4.6 Tracks, sliders, doorways and other staging machinery

Smaller stage machinery such as stage tracks with winch lines for moving scenic elements and props, mechanical slider panels and other doorway devices may be controlled by either manual or powered means. Crush, shear and entanglement injury arising from mistimed use of such machinery are common risks associated with these devices. Having consistent operators, very clear cue plots, adequate rehearsal time and easily followed SWMS all reduce the risks associated with this type of machinery.

4.7 Mobile plant

Elevated work platforms, forklifts, pallet stackers, pushers and other plant all have differing licencing requirements for the operators as well as storage issues for the differing fuel types. Most of these items have industrial applications that lie outside of the entertainment industry and there are many issues to be considered by the PCBU and the staff that operate them.

Ensure that where appropriate all staff have the necessary licences and experience. Ensure that records of licenses, experience and any associated training are recorded.

4.8 Load moving machinery and equipment

This range of handling aids includes dock scenery lifts, truck loading ramps, dock levellers, pallet movers, flat carriers, trolleys and dollies, which are all intrinsic parts of a modern backstage system.

Where in the past items were moved by hand it is generally safer and more cost effective to move loads with mechanical assistance. This however comes with its own set of hazards that have to be addressed by the PCBU and the staff handling the loads and the equipment moving the loads.

Any operation ranging from lifting a road-case by hand out of a utility, to moving a major item of scenery out of a semi-trailer using the combination of crew, palette jacks, electric tugs and dock levellers should be covered by SWMS. Documents for all the tasks to be undertaken should have been prepared using a risk assessment method, with the required consultation with the staff and designers. The SWMS should cover all situations without extensive further risk assessment. The SWMS will generally have the provision for a quick 'toolbox talk' before work begins to point out any problems that may differ from the situation covered in the SWMS.

Ensure that where appropriate all staff have the necessary licences and experience. Ensure that records of licenses, experience and any associated training are recorded.

5. Legislation, Standards and Guidance

Please note that information is available from both state and federal sources and these should be used as the reference for preparing risk assessments, SWMS and venue policy and training documentation.

Log books and instruction manuals for the various pieces of equipment are also invaluable in ensuring that all the risks have been identified in the risk assessment and that they have all been addressed before implementation

General Information – Managing Risk of Plant

<https://www.safeworkaustralia.gov.au/system/files/documents/1705/mcop-managing-risks-of-plant-in-the-workplace-v1.pdf>

Model Code of Practice – Managing the Work Environment and Facilities

https://www.safeworkaustralia.gov.au/system/files/documents/1702/managing_work_environment_and_facilities2.pdf

Model Codes of Practice – Hazardous Manual Tasks

<https://www.safeworkaustralia.gov.au/system/files/documents/1705/mcop-hazardous-manual-tasks-v2.pdf>



Fork Lifts

<https://www.safeworkaustralia.gov.au/system/files/documents/1703/forklifts-information-sheet.pdf>

Hoists and Cranes

Guide to Inspecting and Maintaining Cranes

<https://www.safeworkaustralia.gov.au/system/files/documents/1703/guide-to-inspecting-and-maintaining-cranes.pdf>

Structures

https://www.safeworkaustralia.gov.au/system/files/documents/1702/safe_design_of_structures2.pdf