BRITISH STANDARD

BS 7906-1:2005

Use of lifting equipment for performance, broadcast and similar applications —

Part 1: Code of practice for installation, use and removal of above stage equipment (excluding trusses and towers)

ICS 53.020

BSI British Standards

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee MHE/3, Cranes and derricks, to Subcommittee MHE/3/13, Lifting equipment for performance, broadcast and similar applications, upon which the following bodies were represented:

Association of British Theatre Technicians

Broadcasting Entertainment Cinematograph and Theatre Union

HSE — Health and Safety Executive

Lifting Equipment Engineers Association

Professional Lighting and Sound Association

Safety Assessment Federation Ltd.

Theatres Advisory Council

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Contents

Foreword

This part of BS 7906 has been prepared by subcommittee MHE/3/13. It does not supersede any previous British Standard.

BS 7906 *Use of lifting equipment for performance, broadcast and similar applications* is published in two parts:

— *Part 1: Code of practice for installation, use and removal of above stage equipment (excluding trusses and towers)*

— *Part 2: Code of practice for use of aluminium and steel trusses and towers*

The primary object of this code of practice is to ensure that lifting operations in entertainment and similar applications are carried out safely.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and competent people.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Attention is drawn to the following statutory regulations:

The Lifting Operation and Lifting Equipment Regulations (LOLER) 1998 [3];

The Provision and Use of Work Equipment Regulations (PUWER) 1998 [4];

The Supply of Machinery (Safety) Regulations 1992 as amended [5];

The Management of Health and Safety at Work Regulations 1999 [6];

The Manual Handling Operations Regulations 1992 [7].

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 79 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

1 Scope

This British Standard gives recommendations for the safe use of lifting equipment used to lift and traverse equipment and personnel for the following applications:

— film;

— television;

— theatre and similar entertainment events;

— conference and exhibition.

The recommendations cover the supply, installation, use, maintenance and removal of components and systems, documentation and periodic inspection and thorough examination.

Additional requirements might apply to installations in cruise ships.

Lifts and elevators are not covered by this standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 1139-1.2, *Metal scaffolding — Part 1: Tubes — Section 1.2: Specification for aluminium tube.*

BS 2853, *Specification for the design and testing of steel overhead runway beams.*

BS 6521, *Guide for proper use and maintenance of calibrated round steel link lifting chains.* [ISO 7592]

BS 7671, *Requirements for electrical installations — IEE Wiring Regulations — Sixteenth edition.*

BS 7905-1:2001, *Lifting equipment for performance, broadcast and similar applications — Part 1: Specification for the design and manufacture of above stage equipment (excluding trusses and towers).*

BS 7909, *Code of practice for design and installation of temporary distribution systems delivering a.c. electrical supplies for lighting, technical services and other entertainment related purposes.*

BS EN 39:2001, *Loose steel tubes for tube and coupler scaffolds — Technical delivery conditions.*

BS EN 697, *Fibre ropes for general service — Polyester.*

BS EN 698, *Fibre ropes for general service — Manila and sisal.*

BS EN 818-3, *Short link chain for lifting purposes — Safety — Part 3: Medium tolerance chain for chain slings — Grade 4.*

BS EN 818-7, *Short link chain for lifting purposes — Safety — Part 7: Fine tolerance hoist chain, Grade T (Types T, DAT and DT).*

BS EN 1261, *Fibre ropes for general service — Hemp.*

BS EN 1677 (all parts), *Components for slings — Safety.*

BS EN 10219 (all parts), *Cold formed welded structural hollow sections of non-alloy and fine grain steels.*

BS EN 12385-4, *Steel wire ropes — Safety — Part 4: Stranded ropes for general lifting applications.*

BS EN 13411-3, *Terminations for steel wire ropes — Safety — Part 3: Ferrules and ferrule-securing.*

BS EN 13411-5, *Terminations for steel wire ropes — Safety — Part 5: U-bolt wire rope grips.*

BS EN 20898 (all parts), *Mechanical properties of fasteners.*

BS EN 60204, *Safety of machinery — Electrical equipment of machines.*

BS EN ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part: 1 Bolts, screws and studs.*

ISO 1835*, Short link chain for lifting purposes — Grade M(4), non-calibrated, for chain slings etc.*

ISO 3075*, Short link chain for lifting purposes — Grade S(6), non-calibrated, for chain slings etc.*

ISO 3076*, Short link chain for lifting purposes — Grade T(8), non-calibrated, for chain slings etc.*

DIN 15315*, Lift — Cable joints.*

DIN 56925*, Theatre engineering, stage machinery — Scenery hoist — Safety requirements and testing.*

3 Terms and definitions

For the purposes of this part of BS 7906, the following terms and definitions apply.

3.1
anchorage
fixture, forming the interface between the temporary or permanent supporting structure and other items of lifting equipment, by means of which the loads are transmitted into the supporting structure

3.2
attachment point
facility provided to enable the load to be connected to the lifting machine, usually by use of a lifting accessory

3.3
bar
length of tube or other section, usually steel or aluminium, to which loads are attached

NOTE Sometimes referred to as "barrel" or "pipe". Trusses including ladder beams are dealt with in BS 7905-2 and BS 7906-2.

3.4
certified
tested, identified and supplied with a certificate signifying compliance with the standard and/or capacity to carry a specified load

3.5
commissioning
final phase in the installation of equipment, when it is demonstrated to be compliant with all the specified criteria and to be fully operational

3.6
competent person
person who has such practical and theoretical knowledge and such experience as is necessary to carry out the work and is aware of the limits of his/her own competence, expertise and knowledge

3.7
controlled stop
stop at a pre-determined rate

3.8
D:d ratio
pitch circle diameter of the pulley or winding drum divided by the diameter of the rope

3.9
dead
prearranged position for a flown element; indication of prearranged position for example, marked on the hauling rope or electronically recorded

3.10
dynamic working coefficient
breaking load of a component divided by the sum of the maximum static and dynamic loads applied to that component

3.11
emergency stop
device that causes a controlled stop as quickly as safely possible and which overrides all other controls

3.12
ferrule
aluminium, copper or steel sleeve compressed by dies or swages onto a wire rope to form a permanent termination

NOTE Sometimes referred to as "crimp", "swage" or "sleeve".

3.13
fleet angle
angle of deflection of rope as it leaves a drum or pulley

NOTE See Figure 12.

3.14
hoist
lifting machine (including lighting hoist, chain hoist and winch)

3.14.1
Category A hoist
chain or wire rope hoist intended by the manufacturer for entertainment industry use for lifting and suspending loads over people and conforming to BS 7905-1

3.14.2
Category B hoist
chain or wire rope hoist not intended by the manufacturer for lifting or suspending loads over people

3.15
hook clamp
lifting accessory used to support lighting and similar equipment hanging from bars

3.16
in-view flying wire
wire that can be seen by the audience, and which for artistic reasons needs to be as thin as practicably possible without compromising safety

3.17
karabiner
connector with a lockable, self-closing and load bearing gate

3.18
lifting accessory
component or equipment separate from the lifting machine and placed between the lifting machine and the load or on the load to attach it

NOTE Lifting accessories are not capable of providing movement.

3.19
lifting machinery
machine which is intended to raise, lower and suspend materials or persons

3.20
lifting system
assembly of lifting machines and accessories

3.21
limit
means for preventing further lifting and/or lowering

3.21.1
bottom limit
means for preventing lowering below the working range of travel

3.21.2
top limit
means for preventing lifting beyond the working range of travel

3.21.3
ultimate limit
means for preventing further lifting or lowering in case of top or bottom travel limit failure
NOTE Sometimes referred to as "over-travel limit".

3.22
load
suspended item or force related to mass

3.22.1
axial load
force in line with an axis, for example the axis could be the centre line of a hydraulic cylinder

3.22.2
dead load
force arising at any part of a system at rest due to mass in the system and excluding any forces due to live load

3.22.3
design load
maximum force intended by the designer

3.22.4
dynamic load
force arising at any part of a system due to acceleration or deceleration of mass

3.22.5
live load
mass attached to lifting system
NOTE Sometimes referred to as "payload" or "imposed load".

3.22.6
load bearing
withstanding of force, e.g. a load bearing beam is a beam which withstands force due to loading

3.22.7
load capacity
amount of force sustainable by design

3.22.8
load path
assembly of items connected to one another to withstand force whereby each item is subjected to force due to the load considered

3.22.9
load testing
application of known force to assess integrity of equipment

3.22.10
minimum breaking load
MBL
applied force below which an item does not break

3.22.11
overload
suspended mass greater than the safe working load

3.22.12
point load
force applied at one place

3.22.13
safe working load
SWL
maximum mass that is permitted to be raised, lowered or suspended
NOTE The safe working load is not necessarily the same as the working load limit.

3.22.14
shock load
force generated by sudden arrest

3.22.15
static load
force imposed on any part of a system when at rest

3.22.16
uniformly distributed load
UDL
force evenly spread over the force withstanding item

3.22.17
working load limit
WLL
maximum permitted mass that equipment is designed to lift, as specified by the equipment manufacturer

3.23
permanent
assembled by the manufacturer and not intended to be dismantled or decommissioned during the life of the product, except for servicing
NOTE Permanent items are often dedicated to one use. See **3.36** for definition of temporary.

3.24
performer flying
lifting, lowering or suspension of an artiste in performance, to give the impression of levitation or flying

3.25
pitch circle
pitch circle is the effective circle of rolling without slip between transmitting elements, see Figure 1

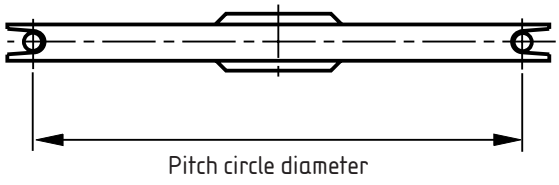


Figure 1 — Pitch circle

3.26
production file
assembly of documents which together contain all the important information relating to the event

3.27
rope diameter
diameter of the smallest circle that can encompass all strands of a rope

3.28
rope lock
device to hold a rope by means of friction

3.29
safety bond
form of secondary suspension capable of arresting the fall of an individual item of equipment in case of dislocation of its primary attachment to the lifting system

3.30
safety factor
minimum breaking load of a component divided by the maximum designed static load

NOTE Safety factor is also known as "working coefficient".

3.31
sling
lifting accessory, usually a length of rope, chain or webbing assembled as an endless loop or provided with terminations to enable ready attachment of the load, for example to the hook of a lifting machine

3.31.1
leg
sling used as part of a multiple sling

3.31.2
drift
single legged sling

NOTE Sometimes referred to as a "flying wire".

3.31.3
bridle
two legged sling

3.32
static test
test during which machinery or a component is subjected to loading equivalent to the SWL multiplied by a static test coefficient

3.33
static test coefficient
factor applied during a static load test to allow for dynamic loading

NOTE Static test coefficient has the following minimum values:

a) manually operated machinery and lifting accessories: 1.5;

b) other machinery: 1.25.

3.34
swivel
device that enables one part to turn relative to the other part while axially loaded

3.35
swivel hook
hook and swivel combined

3.36
temporary
intended to be decommissioned and/or dismantled during the life of the product so the product can be reused

NOTE Temporary items may be reused for a similar or different purpose. See **3.23** for definition of permanent.

3.37
thimble
captive device to protect the eye termination of a rope and which maintains the shape of the eye

3.38
travel range
designed distance between the highest and lowest positions

3.39
trim
adjust a bar, scenic unit or other item so that it is parallel to the floor or positioned as required

3.40
whipping
binding applied to the end of a rope to prevent fraying or unlaying

3.41
wire rope grip
removable device that allows clamping two parts of wire rope together as in forming an eye at the end of a rope

4 Structural integrity

4.1 General

The load-bearing capacity of building elements or structures should be checked to ensure that they are capable of bearing both the static and dynamic loads imposed by the lifting equipment before it is installed. This assessment should include checking the likely anchorages, and also the resulting local and overall effects.

NOTE The choice of method for the assessment of load-bearing capacity is outside the scope of this standard.

4.2 Outdoor applications

Whilst this standard gives recommendations for the safe use of lifting equipment for performance and similar applications which could be used outdoors, special factors such as ground conditions and profile, wind loading and water accumulation on temporary structures should also be taken into account.

NOTE Attention is drawn to *Temporary demountable structures* [1] published by the Institution of Structural Engineers and the HSE publication *The event safety guide* [2].

5 Safety

5.1 General

Safety may be achieved by:

a) designing and installing to avoid progressive collapse;

b) allowing a sufficient margin between design loads and failure loads;

c) adopting appropriate working practices.

5.2 Avoidance of progressive collapse and the use of safety factors

5.2.1 *General*

Design/installation to avoid progressive collapse is intended to ensure that failure of any single component of the load-carrying system does not lead to failure of other components and the dropping of the flown load.

The margin between working loads (design loads) and failure loads is intended to allow sufficient capacity for "normal" overloading (including controlled dynamic loads such as braking) and for "normal" wear and tear so that permanent deformation of the load-carrying system is not caused in everyday use. This ratio of these loads is known as the safety factor.

Recommended safe working loads (SWLs) for a range of flying bars and rope spacings are given in this standard. The maximum loads are chosen so that, even if a rope breaks, the bar should not break, although it might be severely bent.

Different factors of safety are used for bars to those for ropes. This is a reflection of the different susceptibility to wear and tear of bars and ropes, of the degree of warning that each provides before breakage and of the way in which each fails. Ropes can suffer from visible defects, most of which are not suffered by bars. Ropes break suddenly, generally without warning, whereas bars bend and sag when overloaded.

A gradually applied load would have to exceed 8 times the SWL to rupture a rope or lifting accessory with a safety factor of 8; before that it would cause excessive bending of the bar. The safety factor is intended to mitigate the effects of shock loading, which is hard to quantify. If the load-carrying system has been designed and installed correctly, then a shock load which causes a rope or lifting accessory to break should not cause the progressive collapse of the lifting machine.

5.2.2 *Selection of the appropriate safety factor*

Most industrial equipment is not intended for lifting over people. Most equipment as supplied is certified using a safety factor of 5 or less.

This British Standard specifically relates to lifting over people. Therefore safety factors should be reconsidered when designing and selecting suspensions. Generally a safety factor of 8 should apply throughout the load path, including anchorage points, load attachment points, connectors and lifting accessories. However, different safety factors may be applied to bars, trusses, hoists and proprietary equipment provided they have been designed for lifting loads over people.

Details of recommended safety factors for different equipment are given in this British Standard and listed in Annex A together with other relevant data.

NOTE Attention is drawn to LOLER [3], PUWER [4] and the Supply of Machinery (Safety) Regulations [5].

5.2.3 *Safe working load*

It is essential that the SWL of every component including each lifting accessory is equal to or greater than the required SWL of the complete load carrying suspension.

The safety factor used to mark the SWL on individual components should be determined as most industrial lifting accessories are marked with an SWL based on a safety factor of 5 and may therefore need to be de-rated using the following equation:

$$SWL_R = SWL_5 \times 5/R$$

where

R is the required safety factor;

SWL_R is the SWL with a safety factor of R;

SWL_5 is the SWL with a safety factor of 5.

The minimum breaking load (MBL) of rope should be reduced according to the terminations used prior to calculating the SWL of the completed rope assembly.

NOTE Some components are stamped with their Working Load Limit (WLL). This is the manufacturer's statement of the SWL of the equipment before it has been installed. It will generally need to be de-rated as above.

Where the weight of the load is not accurately known and a range of estimates based on differing assumptions has been made in accordance with **7.2.3**, the highest value of estimated weight should be used when deciding the SWL rating required.

5.3 Operational safety

5.3.1 *General*

Hazardous conditions can occur during the installation of equipment, whilst suspending loads, during the run of the event, whilst dismantling the show and during removal of scenery and equipment. It should be emphasized to staff that even small objects can cause serious injury or even death if dropped from a high level.

LOLER [3] requires that all equipment is subject to an inspection and maintenance regime. All equipment should be maintained in accordance with the manufacturer's manual. Any changes in clearances, feel or evidence of wear or even squeaks should be reported to the responsible person and the causes investigated as they often indicate potential major faults.

5.3.2 ***Potential hazards***

The following list of potential hazards is not exhaustive and other hazards might occur.

a) Misuse of equipment:
- — overloading;
- — uneven loading of bars;
- — misalignment of rope or chain;
- — use of rope lock to hold load.

b) Manual handling
- — handling of heavy, large or awkwardly shaped objects;
- — manual hauling of flying bars;
- — loading/unloading counterweight cradles;
- — pulling in pre-loaded counterweight sets;
- — controlling pre-loaded bars until in balance.

c) Machinery hazards:
- — exposure to moving parts;
- — inadequate guarding;
- — inadequate arrangements for stopping.

d) Electrical hazards:
- — damaged cables and equipment;
- — poor or missing earthing;
- — incorrect power rating.

e) Falling objects:
- — badly secured loads;
- — inadequate connections;
- — loose parts not properly secured;
- — unstable loads;
- — break up of loads;
- — objects displaced by the movement of bars;
- — objects knocked off galleries;
- — tools or other objects dropped through grid floor;
- — weak parts of a flown object breaking off;
- — chain falling from bucket;
- — objects accidentally hooked onto a bar or piece of scenery;
- — dropping counterweights while loading cradles.

f) Moving objects:
- — being struck by a moving bar;
- — being lifted by a rising bar;
- — being hit by a swinging rope, bar or item of scenery;
- — being hit by electrical cables being lowered;
- — whiplash from broken wires;
- — walking into the end of a bar.

g) Working at height:

— connecting or disconnecting scenery from a ladder or tower;
— correcting misaligned ropes.

h) People falling:

— overreaching from galleries;
— falling from ladder or work platform;
— inadequate rigging of bosun's chair.

i) Entrapment:

— getting trapped below load;
— getting trapped between moving and fixed objects;
— being dragged into pulleys or drums by ropes.

j) Loss of control:

— multiple hoists;
— load too heavy to sustain manually;
— counterweight set running away during hanging;
— slinging centre of gravity;
— out of balance load on counterweights;
— mechanical failure of winches;
— electrical or electronic failure.

k) Environmental:

— asbestos and other substances hazardous to health;
— temperature and humidity;
— poor lighting;
— failure to use appropriate personal protective equipment.

6 Planning and installation

6.1 Types of installation

6.1.1 *Permanent installations*

Permanent installations include fixed hoists or an entire flying system, which is installed as a facility and has many potential uses. Existing permanent equipment might be modified or new equipment, which is installed to meet an artistic need for a specific show, may be intended to continue to be used after the initial show has ended. Installation of such equipment should be regarded as a permanent installation and the appropriate procedure adopted.

6.1.2 *Temporary installations*

Temporary installations fall into two types:

a) Type A

The attachment of scenic items onto existing permanent lifting equipment should be considered a temporary installation. Each alteration to the load carried by permanent lifting equipment should be treated as a separate event of temporary installation.

b) Type B

This includes lifting equipment installed specifically for the show. Temporary installations involving the assembly of lifting equipment from components should be commissioned as a permanent installation in accordance with **6.5**.

Table 1 gives examples of the types of installation, including temporary installations.

Table 1 — Examples of the types of installation

Permanent installation	Temporary installation	
	Type A	Type B
A flying system intended for long-term use in many shows or, installed specifically for one show but which is intended to remain in use after the closure of that show.	—	A show specific flying system (which might be removed when the show closes.)
A long-term scenic item such as a front-cloth or house tabs used for many productions.	A show specific scenic item attached to an existing theatre flying system.	A show specific scenic item attached to a counterweight set installed specifically for the purpose.
Category A hoists (see **3.14.1**) used as a long-term multi-purpose lifting facility attached to certified anchorages.	Category A hoists (see **3.14.1**) installed for a specific show attached to certified anchorages and removed after the show.	Category B hoists (see **3.14.2**) installed for a specific show and/or attached to anchorages, which should be tested.

6.2 Specification of requirements

For permanent installations a written Specification of Requirements should be prepared by a competent person giving as much detail as possible about the proposed installation. The Specification of Requirements should be agreed with the user prior to installation of the equipment.

For a temporary installation, for example hanging a chain hoist or scenic item, a similar process should be undertaken, possibly not written down. It is essential that information is gathered about the equipment or scenic item to be installed and the nature of its contribution to the show and a rigging scheme prepared.

Table 2 should be considered when specifying an installation and preparing a specification.

Table 2 — Recommended actions when specifying an installation

Action	Permanent installation	Temporary installation
Assess purpose	Assess the performance criteria (e.g. loads, speeds, acceleration rates, accuracy, duty cycle, noise). Consider the operational facilities necessary to meet the most likely future use including growth and changed methods of operation.	Assess the loads, specific artistic requirements in terms of speed, noise, accuracy, operational modes, special effects, and other artistic criteria such as visual appearance of rigging etc.
Assess time constraints	Establish time available for installing the equipment.	
Assess site	Assess constraints due to access, building structure and environmental concerns (visual appearance, noise, heat, humidity etc.).	Assess available lifting equipment and whether it is capable of meeting the requirements or do resources need to be brought in. Consider whether external contractors and/or additional staff are necessary.
Assess implications of regulations	Assess the implications of LOLER [3], PUWER [4], the Supply of Machinery (Safety) Regulations [5], the Management Heath and Safety at Work Regulations [6], BS 7905 and local licensing requirements.	
Assess operational requirements	Assess the level of training and competency of prospective operators and implications in terms of manpower and skills provision.	
Assess maintenance and support requirements	Assess the availability of maintenance support throughout the envisaged life of the installation. Consider manufacturer support, local skills and manpower.	Assess arrangements necessary for routine inspection, repair and adjustment as applicable. Longer-term maintenance and support is not a major consideration.
Assess implications of life cycle	Assess the length of service, level of reliability expected, failure modes, provision of back-up, de-commissioning and removal.	
Prepare specification	Write a Specification of Requirements.	Establish a rigging scheme including lists of equipment necessary and of personnel and the levels of skill required.

6.3 Selection of equipment

Equipment, including lifting accessories, should be selected to best meet the specification for the installation; different solutions should be considered and decisions made in accordance with Table 3.

Table 3 — Recommended actions when selecting equipment

Action	Permanent installation	Temporary installation
Consider specification of requirements	Assess the ability of the supplier to comply with the Specification of Requirements.	Consider whether the available equipment can meet the requirements of the rigging scheme.
Consider safety	Compare risk assessments of the ability of alternative equipment to enable a safe system of work throughout the life of the equipment.	Carry out a risk assessment of the rigging scheme. Consider ability of personnel to install the selected equipment.
Consider cost	Compare costs of competing alternative equipment throughout the life of the equipment.	Likely to be using mainly existing equipment. Seek competitive quotations to compare alternative costs if using purchased/hired-in equipment.
Consider certification	Confirm that the equipment conforms to BS 7905-1. See Note 1.	Confirm reports of inspection for all equipment are available. See Note 1.
Consider quality	Ensure an appropriate system of manufacture, installation and support is utilized. See Note 2.	Ensure equipment is inspected by a competent person prior to installation.
Consider installation and commissioning	Consider the cost, management, warranty and certification complications which can arise if a third party installer is used.	Ensure personnel with the necessary skills are available. Decide who is to carry out the work and confirm their competency for the task.
Prepare a specification of equipment	Select the equipment. Carry out a risk assessment. Prepare a written justification of the chosen equipment.	Identify the sources of appropriate equipment and personnel. Confirm the rigging scheme is safe and consider whether it should be written down.

NOTE 1 Attention is drawn to the Supply of Machinery (Safety) Regulations as amended [5] and related harmonized standards regarding CE marking of products.

NOTE 2 *Assessed capability*. Users of this British Standard are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the BS EN ISO 9000 series by an accredited third-party certification body. Users of this British Standard requiring equipment incorporating software are advised to consider the desirability of quality system assessment and registration against the TickIT Rules and Procedures.

6.4 Installation plan

For permanent installations a Method Statement should be drawn up covering arrangements such as scheduling and detailing the step by step procedures of installation.

For temporary installations a Rigging Method should be prepared. If the competent person who devised the Rigging Method is not expected to supervise the complete installation, that person should ensure that written instructions are provided detailing how the equipment should be installed.

Site conditions and local working conditions should be considered. The allocation of supervision, lines of responsibility and responsibility for final inspection should be established.

After completing the installation plan, a risk assessment should be carried out to confirm that the proposed methods are safe and that installation may commence.

6.5 Commissioning of the installation

Commissioning of a permanent installation should be planned and carried out by the installer of the equipment in the presence of a competent person with the authority to accept the equipment as appropriately installed. The extent of inspection and testing should be agreed by all parties before commencement.

Where the temporary installation includes the modification or assembly of a lifting system from individual components, for example installing a temporary counterweight set or wire rope winch, testing should be completed and the results recorded.

If there is any cause for concern with the equipment or any test fails, corrective measures should be taken and the complete inspection and testing process repeated. This process should be fully documented and copies provided to all parties concerned.

Table 4 shows the sequence and the procedures to be carried out as part of commissioning an installation.

Table 4 — Sequence and procedures for commissioning an installation

Procedure	Permanent installations	Temporary installations	
		Lifting machinery	Flown item
Visual inspection	The installer and the competent person should both carry out thorough visual inspections before testing. It is essential that safe access is provided to all parts of the installation.		It is essential that the competent person carry out a thorough visual inspection to ensure that the rigging method has been implemented correctly.
	All components and systems should be undamaged and marked in accordance with **8.3**.		
Safety	Ensure all movement of the equipment is unobstructed and any risk to people as the result of any operation is minimal.		
Electrical testing	Carry out testing in accordance with BS 7671 or BS 7909 and BS EN 60204.		
Functional testing	Establish whether the specified performance and operability are satisfactory, including the operation of any travel limits, safety sensors (overload, slack wire, safe-edges etc.) and emergency stop system.		Establish whether operation is satisfactory (e.g. noise, speed, clearances). Check the operation of any safety sensors and whether an emergency stop can be achieved safely.
Load testing and certification	Carry out a static test. Static proof load values are established by applying a static test coefficient to the system SWL. The recommended static test coefficient in accordance with BS 7905-1 for manually operated machinery (e.g. counterweight flying systems, hand winches, manual chain hoists monopoles) is 1.5. For other machinery (e.g. powered winches, powered chain hoists, power assisted counterweight systems) the recommended static test coefficient is 1.25. Load testing should determine whether the SWLs given in the operating instructions are accurate. Ensure that all test loads are safely secured to the lifting system.		Carry out such load testing as determined by a competent person.
	Operate the complete installation at full design load.		Operate the system as installed.
	Harnesses used for performer flying and flying props should be tested in accordance with **9.2**.		
	Check deflections in structure(s), movements of fixtures and unexpected noises during and after testing.		
	Apply for any approvals required by local licensing authorities.		
Set-up	Configure the equipment to suit the intended purpose.	Set deads, cue speeds and sequences for the scenic item or system.	
Documentation	Complete testing certification. Complete risk assessments and indicate whether equipment is ready for use. Ensure all documentation is available on file.	Complete risk assessments and indicate whether scenic item/system ready for use. Ensure all documentation is available in the Production File.	

6.6 Acceptance and hand-over

Completion of a permanent installation should involve a formal hand-over from the installer to the user, whereby the user accepts that the installation fulfils the Specification of Requirements, and has been installed correctly and successfully commissioned.

There may be a less formal hand-over process for a temporary installation. However it is essential that intended users are instructed in the operation of the installation and informed of specific safety hazards.

The acceptance and hand-over of both permanent and temporary installations should include verification of the following.

a) *Training*

Operational staff have completed the necessary training.

Staff are trained to maintain the equipment.

Personnel have been informed of safety considerations and hazards.

All relevant staff have been made aware of the relevant risk assessments.

b) *Warning notices*

All necessary safety and operational warning notices have been displayed in accordance with BS 7905-1:2001, Clause **11**.

c) *Documentation*

As installed drawings have been provided for permanent installations.

Comprehensive and accurate operating and maintenance instructions have been supplied in accordance with BS 7905-1:2001, Clause **12**.

Arrangements for routine inspection and maintenance, as applicable, are set-up and recorded.

Following the assessment for acceptance and hand-over of the installation:

— the equipment is deemed safe and functional, with documented maintenance and inspection arrangements;

— all operational and maintenance staff are trained and training sessions are documented.

6.7 Operational life

The planning required for a satisfactory installation does not end at the acceptance stage. Planning should continue throughout the operational life of the equipment.

Both permanent and temporary installations should undergo periodic inspection. The inspection regime should be based on the manufacturer's manual, insurer's requirements and licensing requirements. The type and frequency of maintenance activities should be established.

NOTE Attention is drawn to LOLER [3] and PUWER [4] regarding inspection and maintenance of equipment.

Reviews of the inspection and maintenance regimes should address operational experience. The following should be considered:

— frequency of operation of the equipment;

— loading/wear patterns;

— the effect of a breakdown on a performance;

— opportunities for withdrawal of the equipment for inspection and maintenance.

Inspection and maintenance regimes should be documented, and the results of all inspection and maintenance activities should be logged. This is to aid future fault-finding and review of the maintenance regime, for example intervals between inspections might need to be altered or, more preventative maintenance carried out.

The following regimes should be maintained throughout the life of both permanent and temporary installations.

a) *Inspection and maintenance regimes*

Establish inspection and test procedures and their frequency (where applicable).

Establish a system for recording inspections and tests and initiating maintenance activity where deficiencies are found.

Establish a preventative maintenance regime if appropriate.

Establish a system for recording maintenance activities.

Ensure that competent staff are available for inspections and that competent staff are available for maintenance activities.

Ensure procedures are set up, as applicable, for:

— safe access to the equipment;

— provision of appropriate personal protective equipment;

— availability of manuals and drawings;

— withdrawal from service;

— spares and tools;

— re-commissioning.

b) *Incident reporting*

Establish a reporting procedure for incidents, operational difficulties and break-downs. The procedure should address:

— defect investigation and inspection;

— repairs and re-commissioning;

— review of operating procedures to prevent future occurrences, for example by inhibiting certain functions;

— operational staff training;

— system modification if required.

6.8 Equipment dismantling and removal

Consideration of the work required to dismantle and remove permanently installed equipment should be a part of installation planning. This can have implications for the design of the equipment and method of installation. A simple Method Statement for dismantling, removal and disposal of equipment should be prepared in response to a risk assessment. See **8.7**.

The dismantling of a temporary installation should be considered when planning the installation, the De-rigging Method is often the reverse of the Rigging Method, and a risk assessment should be completed for the de-rigging process. The procedures given in **6.4** are applicable.

Items which are likely to be re-used for future installations should be inspected prior to being returned to stock. The inspection records should be updated accordingly.

Items which are not suitable for re-use because of their condition or service life should be destroyed prior to being discarded, for example steel wire rope slings should be cut up.

7 Attachment of loads

7.1 General

This clause gives guidance on the attachment of loads to lifting machinery. The load can be lighting equipment, sound equipment, scenery or any item that it is necessary to lift in an entertainment environment and which might be over people.

It is essential that prior to carrying out any lifting operation, the load and the lifting system are assessed and a lifting method devised which meets the criteria imposed by both.

7.2 Assessment of the load

7.2.1 *General*

Wherever possible the manufacturer should be consulted to obtain all relevant information relating to the strength, weight and the recommended lifting method for the load.

The load should be assessed with regard to strength, quality of construction and the provision of suitable attachment points which can be used to attach the load to the lifting equipment. It is essential to assess the following:

a) total weight;

b) weight distribution;

c) location of the centre of gravity;

d) the number and distribution of attachment points and the lifting capacity required for each.

7.2.2 *Integrity*

The following questions should be considered with regard to the integrity of the attachment of the load.

— Is the load designed to be lifted? When possible confirm that the load is certified in terms of being fit for purpose by a competent person and conforms to local licensing requirements. For example, the standard of joints and welding, quality of materials used and strength calculations detailing the behaviour of the load when lifted are all important factors when planning to lift an item.

— Does the load have inherent strength? Is it necessary to provide strengthening within the structure or external to it? For example, extra bracing or stiffening struts.

— Is the load sufficiently strong to withstand the stresses of the lifting process? For example, a large flat which is perfectly stable in the vertical position might break if lifted from a horizontal position, i.e. lying on the floor without sufficient bracing or additional support during the lift.

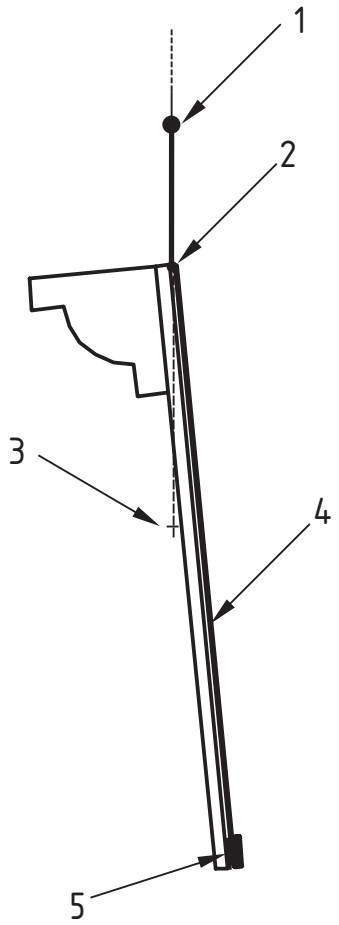
— The load might not have been designed to be suspended and in this case it is desirable to seek guidance from the manufacturer and/or designer when devising a lifting method. Alternatively, guidance should be sought from an appropriately qualified person, such as a chartered engineer.

7.2.3 *Weight distribution and centre of gravity*

It is important to know the total weight of the load as well as the weight distribution and location of the centre of gravity. Weight distribution affects the lifting capacity required for attachment points. For example, it might be necessary to add extra attachment points or use a bar or truss to spread the weight depending on the capacity and location of the lifting machinery.

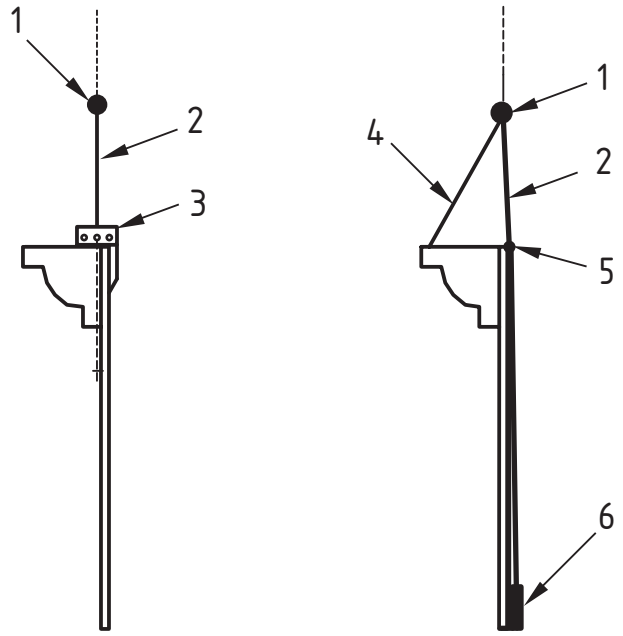
It is essential that the centre of gravity is known so that the load can be suspended in a stable manner without risk of tipping or, more seriously, flipping over when lifted. For example, a flat with heavy moulding on the front face leans forwards if suspended solely from the back, see Figure 2. Figure 3 gives examples of possible methods of hanging the flat vertically.

It is essential that long suspension ropes used to support loads from the bottom are captured at or near the top of the load so that the load cannot fall forward. The method of capture should allow the suspension rope to pass freely, for example a tall flat with hanging irons on the bottom edge and with grommets along the top edge.



Key
1 Lifting accessory.
2 Grommet.
3 Centre of gravity.
4 Suspension rope.
5 Hanging iron.

Figure 2 — Centre of gravity of a flat with a heavy top cornice



Key

1 Lifting accessory.

2 Suspension rope.

3 Trimming bracket.

4 Extra suspension rope.

5 Grommet.

6 Hanging iron.

NOTE 1 The top bracket allows variable positioning of the attachment point. This method is especially suitable for metal flats which do not need to be hung from the bottom.

NOTE 2 Create a bridle by attaching an extra suspension to the front of the cornice. Ensure that the top rail of the cornice is strong enough to withstand the bridle forces and that the attachment points are load bearing.

Figure 3 — Methods of hanging a flat vertically

When determining the weight distribution and centre of gravity the following guidance applies.

a) *Loads where the weight is known*

— Some items of scenery might have their weight marked on them and detailed on design drawings.

NOTE Attention is drawn to the Manual Handling Operations Regulations [7] for information on marking of weight.

— Items of equipment are usually marked with their weight or the information is provided in the documentation accompanying the equipment.

— Where the load consists of two or more elements connected together, marked weights often apply to the marked element only. The total weight is ascertained by adding all the individual marked weights or from drawings and documentation.

— Check whether marked weights include texturing and other effects applied after construction, often they do not. Plywood facias, plaster texturing etc. can add significant weight and alter the centre of gravity.

— A careful judgement should be made, based on the weights of the various elements of the load, as to where the centre of gravity is likely to lie and therefore the distribution of the attachment points required.

b) *Loads where the weight is not known*

— Estimate the weight and weight distribution for the load. Table 5 gives details of the weight of various common materials.

— Where practicable weigh the load or consult the manufacturer and/or design drawings and estimate the weight of the materials used in construction including any texturing or other effects which add weight.

— Where appropriate, seek expert advice, in order to make an informed estimate based on knowledge and experience.

c) *Important factors affecting both known and unknown loads*

— It is common practice to add other equipment such as lighting, speakers or other scenery to suspended scenic items. The weight of these items affect weight distribution and centre of gravity.

— Standard equipment might have had accessories added or have been modified in such a way as to affect the overall weight and centre of gravity. The centre of gravity should be vertically below the attachment point and if the centre of gravity has been changed this can create instability. For example, a luminaire with a heavy projection effect lens added might cause the lighting bar to rotate.

Weight, weight distribution and centre of gravity should be recorded in the production file. If the load is likely to be rigged and de-rigged often this information should be marked on the load, for example for touring productions. It is helpful also to note the number of counterweights required.

Table 5 — Typical weights of materials commonly used for scenic construction

Material	Size/Type	Weight Kg
Timber — Typical softwood	75 mm × 25 mm PAR per m	0.81
Plywood — Far Eastern	4 mm 8 ft × 4 ft flame retardant	9.52
	12 mm 8 ft × 4 ft	23.2
	18 mm 8 ft × 4 ft	34.8
Mild steel	1.5 mm sheet per m^2	11.77
	3 mm sheet per m^2	23.54
	Per m^3	7 850
Steel tube	Scaffold tube (48.3 mm d. × 4.0 mm wall) per m	4.46
	25 mm × 1.6 mm square tube per m	1.18
	18 mm conduit per m	1.2
Aluminium	1.5 mm sheet per m^2	4.1
	3 mm sheet per m^2	8.2
	Per m^3	2 710
	Scaffold tube (48.3 mm d. × 4.47 mm wall) per m	1.67
Scenic fabric	NDFR Scenic flax: ordinary per m^2	0.32
	NDFR Scenic flax: heavy per m^2	0.35
	NDFR Scenic canvas per m^2	0.32
	NDFR Wool serge per m^2	0.53
	NDFR Filled cloth per m^2	0.25
	NDFR Scenic gauze per m^2	0.04
	NDFR Sharkstooth gauze per m^2	0.1

7.2.4 *Attachment points*

Most items of standard equipment which are intended to be lifted incorporate specific attachment points and/or have suspension methods specified by the manufacturer.

Items of scenery, designed to be suspended, often incorporate attachment points; however, this is not always the case. Scenery incorporating attachment points is preferred.

Different considerations apply depending upon whether the loads incorporate attachment points.

a) *Loads with attachment points incorporated*

1) Establish whether the attachment points are marked or documented for capacity and permitted angle of lift. If not, the manufacturer should be asked for this information.

2) Ascertain whether any parts, which appear to be capable of use as attachment points, are capable of suspending the load. Features of the equipment that look as though they would provide good attachment points for lifting accessories might not be suitable for the purpose. Refer to documentation and/or the manufacturer.

b) *Loads without attachment points*

1) Consider whether the load is designed to be suspended and whether it can be safely suspended. For example, scenery built for standing on the floor is not necessarily suitable for suspension. A safe method of lifting should be devised using available knowledge, experience and, where necessary, expert advice. The manufacturer and/or the drawings should be consulted.

2) Ascertain where the load-bearing members are located and confirm that the proposed method of attachment, such as drilling holes to fit hanging irons, does not affect the structural integrity of the load before installing attachment point(s).

The number and distribution of attachment points should then be assessed in accordance with the following:

1) *Structural integrity and weight distribution*

Establish whether the number and distribution of the attachment points are adequate considering lifting capacity and weight distribution. Take into account any intended additions to the load, such as electrical equipment or scenic textures.

2) *Centre of gravity*

Establish whether the number and distribution of attachment points enable a stable lift in the correct attitude.

3) *Duality*

Assess the likelihood of failure of any attachment point on the load and whether this would lead to a dangerous situation. If so, consider adding extra attachment point(s) to provide redundancy.

4) *Lifting machinery*

Establish whether the lifting machinery has the necessary capacity and distribution to provide for the number and distribution of attachment points.

If the lifting machinery has the necessary lifting capacity but not the necessary distribution of suspension points to match the attachment points on the load, then bridle techniques may be used to combine two or more attachment points to one suspension point. In this case careful consideration should be given to the structural integrity of the load and the forces acting through the structure of the load between attachment points. See **8.15**.

5) *Visual appearance*

Artistic demands can result in pressure to reduce both the number and visible "size" of the suspension:

— It might be possible to reduce the overall number of suspensions by increasing the weight carried by others.

— Careful siting of suspensions, for example by alignment with structural members, might help.

— Careful choice of materials might help diminish visibility. For example, suitably blackened wire rope is thinner than PVC coated wire rope of the same SWL and is virtually invisible against dark backgrounds.

However, it is essential that the criteria given in items 1) to 4) take precedence over visual appearance, item 5).

7.3 Assessment of the lifting machinery

7.3.1 *General*

The available lifting machinery should be assessed in terms of:

a) lifting capacity;

b) location relative to the attachment points on the load;

c) type of lifting machinery, which might affect the attachment method;

d) ability to move the load safely and meet artistic demands.

7.3.2 *Type of lifting machinery*

Different types of lifting machinery and different types of lifting accessories impose different restrictions on the method used to attach the load to the lifting machinery. The following criteria should be considered when determining the type of lifting machinery and lifting accessories appropriate for the task.

a) *Single suspensions*, e.g. manual winch, powered hoist or chain hoist hook, spot-line.

1) Assess the likelihood of failure of the load attachment and the structural integrity of the load as a whole to ensure that a single suspension is safe. It is essential that the load attachment and/or any part of the load cannot become detached, for example due to rotation resulting in an eye-bolt unscrewing. It may be necessary to add a second suspension which might be load bearing or may carry no load in normal use but provide security should the primary suspension fail. The latter type is often referred to as a "secondary suspension". For example, a safety bond securing a luminaire to a lighting bar to retain the luminaire should the hook clamp fail or be dislodged. See **7.4.4**.

2) Required orientation can be achieved by using extra ropes, which need not be load bearing. For example, fine black cord might be used either side of a centrally hung chandelier to stop it rotating.

3) Rope with anti-rotational properties should be used where the load is free to rotate on a single suspension rope.

4) A rope or "tag line" may be attached to one or both ends of a load so that rotational movement can be controlled. Tag lines should be long enough to ensure that operatives need not stand under the load during the lift. Under no circumstances should a tag line be used to balance the load or for any purpose other than controlling the rotation of the load.

b) *Bar or truss*, e.g. hemp set, counterweight set, powered bar, bar or truss on multiple point hoists or chain hoists.

1) Most entertainment lifting systems incorporate manually or power operated bars designed primarily for lifting thin flat loads, for example theatre drapes.

2) It is essential that the loading criteria for the bar, in terms of uniformly distributed load and point load capacity, be known. The individual load attachments should remain within the point load capacity and the load should remain within the uniformly distributed load capacity of the bar.

3) For greater loading the following should be considered.

i) Where the point loads exceed those allowed but the total weight of the load does not exceed the total lifting capacity of the machine, the number of load attachments may be increased or a stronger bar with a higher point load capacity used. For example, a single barrel could be replaced by truss bar. The extra weight of the stronger bar would need to be considered.

NOTE Changing a bar could be considered to constitute a modification to the lifting machinery in which case see **6.5**.

ii) Where the weight of the load exceeds the lifting capacity of a single machine it might be acceptable to use multiple lifting machines, e.g. bars, to share the load. Load sharing should be maintained by either mechanical or electronic interlocks to prevent overloading of any bar due to bars operating out of sequence. For example, counterweight systems might be designed to enable adjacent weight cradles to be connected together to enable a single load to be distributed across two bars.

4) Ensure that the centre of gravity of the load is located well inside the extreme bar suspensions. This is especially important where a bar extends beyond the suspensions. A load hung on the end of the bar, so that the centre of gravity is located beyond the last suspension, might cause the bar to tip even when both point load and total load criteria are met.

5) The lengths of the suspensions should be accurately determined to ensure that weight is correctly distributed. The same material should be used for each rope as different materials have different stretch properties. Inaccuracy between lengths of suspensions can cause greater weight to be carried by some suspensions than others. It is best practice to use rigging screws in the suspensions to enable fine adjustment of rope length.

6) For a load such as a theatre ceiling piece the attachment points might need to be distributed over a wide area requiring the use of several lifting machines. It is essential that a safe method is devised to ensure that correct load sharing is maintained.

c) *Grouped individual hoist suspensions*, e.g. manual or powered chain hoists; powered wire rope hoists.

1) Individual powered or manually operated hoists grouped together to lift a single load impose restrictions:

i) the lifting capacity of each hoist should not be exceeded;

ii) the hoists should have synchronized control. With powered systems this is usually available. With individually operated manual or powered hoists, clear and precise communication between operators is essential.

2) Do not assume that the stated maximum lifting capacity can be achieved by high speed hoists when used at high speeds/rates of acceleration as the dynamic forces applied to the system when carrying near maximum loads might cause overload sensors to "nuisance" trigger during acceleration.

3) With powered systems it is important to consider the behaviour of the load if a rapid stop is performed, for example by the operation of an emergency stop. This becomes more important the higher the speed of operation. It is essential that the structural integrity of the load is maintained during the rapid deceleration.

4) Should one hoist within a group fail during a lifting operation, the weight distribution between hoists would change significantly. Plan the attachment method and consider using more hoists to provide redundancy or, distribute weight by using a bar or truss to provide a rigid frame for maintaining the integrity of the load, however some slight flexibility can assist load sharing.

5) It might be impractical or wasteful to dedicate a hoist to each attachment point. A bar may be used to distribute several attachment points to a lesser number of hoists. It is essential that the overall load capacity and the point load capacity of the bar are not exceeded.

6) It is best practice to use multiple hoists so that the failure of one hoist would not cause a dangerous situation.

7) It is essential that multiple powered hoists are interlocked when used to lift a single load.

d) *Bridle suspensions*, may be used with all types of lifting machinery.

1) Bridles and slings provide a method of combining two or more attachment points to a single lifting machine and thereby achieve a method of lifting a load where the number of lifting machines is less than the number of attachment points.

2) Where a single bridle assembly is used to suspend a load, problems of rotation and orientation similar to those encountered with single suspensions can occur, see **7.3.2**a).

7.3.3 *Artistic criteria*

It is essential that speed of motion, dynamic loading and changing distribution of load are considered. The following criteria should be considered when determining the appropriate methods of suspension for performance.

a) *Moving loads,* e.g. flown scenery

The movements required should be established and especially the speed of motion as this can dictate the type of lifting machinery to be used, for example slow chain hoists or fast wire rope hoists.

It is important to evaluate dynamic loading especially with high speed, high acceleration lifting machines.

b) *Static loads*

Where the load is static during a performance it might be appropriate to use temporarily installed lifting machines such as chain hoists to raise the load into position prior to adding permanent suspensions and releasing the lifting machines for other use.

c) *Load distribution*

The load distribution might change during motion, for example a tilting structure. It is essential that the lifting system is assessed for each different weight distribution state. The change of direction of forces acting on attachment points and within the load should also be considered.

7.4 Attachment of the load to the lifting machinery

7.4.1 *General*

After assessment of the load and the lifting machinery in accordance with **7.2** and **7.3** the following information should have been ascertained.

— The number of suspensions taking into account both the load and the lifting machinery.

— The SWL required for each lifting accessory taking into account both dynamic and static loading and any change in weight distribution during motion.

— The visual appearance and layout of load suspensions.

The method used to attach the load to the lifting machinery depends upon:

— type of lifting machine attachment, e.g. hook or bar;

— type of load attachment points, e.g. eye-bolts or flying irons;

— fire and other local regulations;

— availability of certified lifting accessories;

— competence of available personnel.

7.4.2 *Lifting machinery load attachment methods*

Advice on the selection of the load attachment method and compatible lifting accessories is given in Table 6. Advice on the use of lifting accessories, together with advice on the selection of hardware for lifting points, is given in Clause **8**.

Table 6 — Load attachment methods

Load attachment method	Compatible lifting accessories
Bar (see **8.17**) or truss (see BS 7906-2)	Wire rope slings, fibre slings, chain slings, bridles (see **8.15**).
	Bar straps, bar hangers, clamps with eye-bolts; used to attach the suspension lines on a flat to a bar or truss chord (horizontal member) (see **8.13.2**).
	Hook clamps, TV clamps; for example, to enable lighting equipment to be attached to a bar or truss chord (horizontal member) (see **8.13.2**).
	Cloth ties, bungees, proprietary clips and cable ties; used to attach cloths, projection screens and other "softs" to bars.
Hook (see **8.13.2**)	Shackles, karabiners, ring plates (see **8.13.3**), wire rope slings, chain slings, fibre slings, bridles (see **8.15**), direct connection to load where practicable.
Direct connection of suspension to load	Might be practical where the lifting machine terminates in chain (see **8.14**), wire rope eye (see **8.13**), fibre rope knot (see **8.11**). Shackles, karabiners and lifting rings are useful for direct connection of the load to the lifting machine. Any connector used should be compatible with the attachment point, for example by selecting a suitable pin diameter.

7.4.3 *Fire and other local regulations*

Local regulations could prohibit the use of certain lifting accessories or lifting methods or require specific precautions to be taken. For example, where loads are suspended using fibre slings or ropes local licensing authorities or insurers could require secondary steel wire rope or chain suspensions to be installed.

The possible risk of the load falling in the early stages of a fire should be assessed, especially where the load remains suspended for long periods, for example overnight. The fire and heat resistance of lifting accessories and suspensions should be considered. For example, it might be decided to use metal suspensions instead of readily combustible suspensions. Where steel wire rope suspensions are used in order to improve fire resistance it is also important to consider termination methods. For example, it might be advisable to use wedge socket terminations rather than aluminium ferrule terminations (FSET) which release at a lower temperature.

7.4.4 *Secondary Suspensions*

Adequate safety factors are essential for all flying installations, see **5.2**. Therefore, provided the equipment has been rigged and tested appropriately, secondary suspensions should not normally be necessary. If there are any doubts about the quality of the installation it should be re-inspected by a competent person and rectified if necessary. However the competent person may decide that a secondary suspension is required.

Equipment, such as luminaires and loudspeakers hung on bars using hook clamps or similar fittings where an accident with a piece of moving scenery might cause the equipment to be dislodged from the bar, should always be provided with secondary suspensions of limited combustibility.

Secondary suspensions should be:

— selected so as to be able to withstand any likely shock load. Secondary suspensions should be certified and have a SWL at least equal to the required SWL for the primary suspension;

— of limited combustibility, where required to provide fire resistance, such as chains or steel wire bonds;

— securely attached. For example, ensure that luminaire safety bonds are secured to an independent structure, not wrapped around a boom arm which might itself become detached;

— arranged so as to minimize the fall of the load before restraint occurs. A maximum drop of 150 mm is recommended;

— arranged so as to retain the load in the same orientation as established by the primary suspension so that the load will not topple over, swing or rotate should secondary suspension take effect.

8 Operation and use of equipment

8.1 General

Equipment for above stage use should either conform to BS 7905-1 or otherwise be shown to be fit for purpose by a competent person. Only new equipment or equipment with a known history of inspection should be used. All components should be used as part of a complete designed system and all foreseeable loadings and configurations should be considered. Components should only be used within their SWL calculated in accordance with **5.2.3** and in accordance with the manufacturer's instructions.

8.2 Selection and ordering

Equipment should be selected and ordered to take account of the following criteria, where appropriate:

a) required lift or travel;

b) required SWL and any load distribution restrictions;

c) internal or external use;

d) powered or manual operation;

e) operating speed, whether fixed or variable;

f) maximum acceleration and/or deceleration required and identify if this is likely to induce loading in excess of the static load test;

g) required service life;

h) required duty cycles;

i) power requirements and power source and type: electrical (three phase or single, frequency and voltage as well as maximum current and recommended fuse ratings); hydraulic/pneumatic pressure/flow rate;

j) remote control features, limit switch contact ratings, signal voltages and signal power requirements, and control protocol;

k) duality of controls;

l) provision of limits and load sensors;

m) means for hand winding;

n) noise of the motor/mechanism if intended for performance use;

o) length of ropes, hoses, control and power cables and types of connectors;

p) the self-weight;

q) mountings with load distribution, overall dimensions, and dimensions of load attachment devices;

r) suitability for purpose and ease of rigging in the prospective environment;

s) full specification or name and model identification;

t) any particular features, if different from those normally supplied by the manufacturer.

8.3 Marking

Equipment should be legibly marked with the SWL and an identification code or number. The identification code or number should lead to the record of the equipment's history (see **8.4**), and to the information given in BS 7905-1:2001, Clause **11** including the manufacturer's assurance of conformity with European Directives, where applicable. The code or number should preferably be unique. It is essential that any equipment that is not suitable for suspending loads over people is clearly marked as such.

NOTE Attention is drawn to The Supply of Machinery (Safety) Regulations as amended [5] and related harmonized standards regarding CE marking of products.

8.4 Records

Records for all items of equipment should be readily available to the user. Records should relate to the number or code used to mark the equipment (see **8.3**) and include, as appropriate:

a) specification including nominal size or rating, material, length, designation of series or type and serial or batch number;

b) name and address of the manufacturer (or supplier where relevant) together with information relating to the manufacturer's assurance of conformity with European Directives, where appropriate;

c) self-weight;

d) SWL with restrictions for load distribution, if any, together with the safety factor used to calculate the SWL (see **5.2**);

e) year of construction/purchase;

f) maximum permitted speed;

g) maximum acceleration and/or deceleration where this is likely to induce loading in excess of the static load test;

h) correct power supplies and rating of limit switches;

i) dates and results of all tests and inspections together with test certificates;

j) details of servicing procedures;

k) details of all instances of damage or malfunction and any rectification;

l) date and description of any maintenance with details of defects rectified as well as any other relevant history, for example any unexplained problems;

m) date or criteria for date when next inspection is due.

Much of this information should be included on the equipment label where practicable. However a separate record should also be kept.

8.5 Storage

Lifting equipment should be stored indoors at between 5 °C and 45 °C, with the humidity no greater than 75 % and out of sunlight.

8.6 Installation

Installation of equipment items should be in accordance with the manufacturer's instructions, the prepared Method Statement or the Rigging Method (see **6.4**), which should include at least the following checks, as appropriate.

a) Check labelling, records and instructions and ensure that equipment is appropriate for the task.

b) Ensure the proposed fixings or mounts have sufficient load carrying capacity.

c) Plan safe movement of the equipment to place of installation and all related lifting operations and use of lifting accessories.

d) Install the equipment in accordance with instructions, taking special care with all ropes and electrical connections.

e) Set travel limits as required.

f) Ensure correct operation of the equipment.

g) Test as required (see **6.5** and Table 4), and determine whether distortion has occurred as a result. If distortion is suspected, it is essential that equipment is removed from service for examination by a competent person.

h) Examine equipment thoroughly to determine whether the whole installation is safe to use, and enter the results on the equipment records.

i) If items a) to h) are satisfactory formally hand over the equipment for use to a competent person.

8.7 Removal

Removal of equipment from an installation should be in accordance with the manufacturer's manual, the prepared Method Statement or the Rigging Method (see **6.8**), which should include at least the following checks, as appropriate.

a) Refer to instructions and equipment records.

b) Inspect the suspension and fixings/mounts.

c) Remove all loads from the suspension.

d) Plan safe movement of the equipment to next place and all related lifting operations and use of lifting accessories.

e) Set suspension device to an appropriate state for removal, for example a spring pantograph should be fully closed.

f) Isolate any electrical circuits.

g) Ensure the unit is supported so that the permanent fixings/mounts can be disconnected safely.

h) Disconnect the permanent fixings/mounts, checking that there is no risk of damage or injury.

i) Remove the equipment and take it to the next place or hand over for safe keeping.

j) Record any damage or defect observed with recommendations for any remedial actions required before the unit can be re-used.

k) Ensure that starting place is left in safe condition.

8.8 Maintenance and inspection

Equipment should be regularly inspected, tested and maintained in accordance with the manufacturer's manual.

NOTE Attention is drawn to LOLER [3] and PUWER [4] regarding inspection and maintenance of equipment.

Guidance on setting up a suitable inspection regime is given in **6.7**. Electrical equipment, cables and connectors should be regularly maintained and tested. The periodic testing of safety devices and brakes is considered essential.

8.9 Operation and use

Flying operations should be carried out by fully trained staff. Part-time or casual workers especially should be supervised; it cannot be assumed that common sense would always be applied. The basic training given to staff should include where appropriate, information on the relationship between size, mass, SWL, material stress and travel velocity.

A safe system of work should be established that reflects the type of venue/establishment, type of production and the system or equipment to be used. Lifting equipment should only be moved following instruction from the person in charge unless the operator is aware that it is unsafe so to do. Before moving any suspended load its path should be checked for clearance. The use of infra-red devices helps operators "to see in the dark". A detailed and unambiguous flying plot should be recorded by the operator. A clear and precise communication system for cues between staff involved should be established, for example by using lights, signs or words which might use radio links for mobility. Staff involved should be reminded at frequent intervals of the importance of adhering to the established system.

However, no operation should be undertaken unless it is deemed to be safe. It should be checked by the person in charge and the operator as far as reasonably possible that:

a) no one is likely to move into the path of any moving item or be directly underneath it unless this is a deliberate action which can be performed safely;

b) no one leans on or steps over any bar which is being loaded or unloaded, or stands directly beneath a moving bar except as part of a deliberate, rehearsed action;

c) no one is likely to be injured or startled by movement of the load;

d) nothing is likely to be struck by any part of the load or the equipment;

e) severe swinging is unlikely to occur, and no rope is likely to become slack;

f) the SWL is not exceeded;

g) the load remains stable when lifted.

Unattended items should be left in a safe position/mode. In the event of damage, the equipment should be taken out of service, examined by a competent person and rectified as necessary, and either declared safe by a competent person or discarded.

8.10 Ropes

8.10.1 *General*

8.10.1.1 *Selection*

Ropes of differing sizes or made from different materials should not be used to support the load where the stretch of ropes could result in an unsafe situation.

8.10.1.2 *Marking*

Each piece of rope used for lifting should be marked with an identity code in accordance with **8.3**. Marking may be achieved, for example, by a sleeve, a secure label, or by stamping a swaged end termination. Records obtained using the identity code should be in accordance with **8.4**.

8.10.1.3 *Installation*

Ropes should be in continuous lengths and free from joints.

Induced twist and abrasion causes severe rope wear if the fleet angle of the rope is too large. The maximum fleet angle either side of centre for ropes leaving drums and pulleys should preferably be less than 1.5° (1 in 40). See **8.16**.

The MBL of the rope should be reduced to take account of the terminations used prior to calculating the SWL of the completed rope assembly. See **8.13.1**.

A wire or fibre rope in a single suspension of ordinary lay construction tends to rotate and "unlay" if a load is applied to it. If the load is removed the rope will return to its previous state, sometimes quite violently. Therefore a multi-strand rope with layered alternate lay construction having inherent anti-rotational properties should be used for single suspensions.

Most terminations are not as strong as the rope that they terminate. For example, wire rope grips conforming to BS EN 13411-5 when properly applied provide a termination that might support only 80 % of the MBL of the rope. See **8.13.1**c).

8.10.1.4 *Inspection*

An inspection regime should be established based on usage (see **6.7**). All ropes should be regularly inspected for any visible signs of wear or untoward appearance. Any rope that has been unduly stressed, for example by a shock load, should be inspected before use. LOLER [3] requires that the results of all inspections and thorough examinations are recorded in an appropriate form. Rope demonstrating signs of wear or weakness should be withdrawn from service pending examination by a competent person. Damaged ropes should be removed from service, preferably destroyed, and replaced.

8.10.1.5 *Replacement*

After a new rope is fitted, the system should be operated a number of times, preferably at reduced speeds and loads, until the rope has bedded in. The rope should then be carefully examined for any problems or defects. Terminations should be carefully checked and re-torqued as necessary.

It is preferable to replace all the ropes of a set at the same time to minimize problems with stretch. A static load test should be carried out after fitting new ropes.

8.10.1.6 *Operation and use*

Installed ropes should be kept under tension to avoid snagging. If a suspended rope is not attached to a flown item a sandbag may be attached to maintain tension. Ropes should not be left on the floor at any time other than in purpose-intended rope boxes.

8.10.2 ***Wire ropes***

8.10.2.1 *Selection*

Wire rope of 7 × 19 construction from galvanized steel of tensile grade 1770 conforming to BS EN 12385-4 should be specified for general use over pulleys.

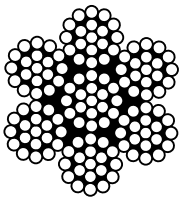
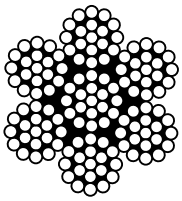
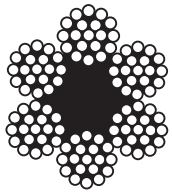
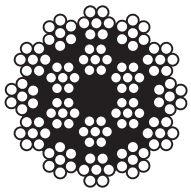
NOTE For some applications stainless steel may be preferred instead of galvanized steel such as where damp or corrosive conditions might occur. Stainless steel wire ropes are specified in BS MA 29.

Wire rope of 6 × 19 construction from galvanized steel of tensile grade 1770 conforming to BS EN 12385-4 may be used for straight lifts. For single suspensions, multi-strand wire ropes, e.g. 18 × 7 construction, are preferred as these reduce the tendency of the load to rotate.

Where colour is important, pre-blackened or PVC-covered ropes should be used. PVC-covered ropes are not suitable for use over pulleys or drums.

Safe working loads with a safety factor of 8 for some of the recommended sizes of steel wire rope are detailed in Table 7.

Table 7 — Safe working loads for steel wire rope with a safety factor of 8

Nominal diameter of rope	Over pulleys and on drums		For straight lifts	To reduce load rotation
	7 × 19 wire rope (also known as 6 × 19 with wire strand core) of tensile grade 1770, galvanized	**7 × 19 wire rope** (also known as 6 × 19 with wire strand core) of tensile grade 1560, stainless	**6 × 19 wire rope** fibre core of tensile grade 1770, galvanized	**Multi-strand rope 18 × 7 construction** of tensile grade 1770
				
mm	kg	kg	kg	kg
3	73	64	62	—
4	131	113	111	—
5	204	177	173	—
6	294	255	267	266
7	400	348	364	362
8	522	453	476	474
10	815	708	744	740

8.10.2.2 *Ordering*

When ordering wire rope the purchaser should specify the material, tensile grade, finish, construction and nominal diameter.

Wire rope can be ordered on the reel or in specified lengths with specified ends. A test certificate identified to the reel or piece should be requested and the delivery rejected unless supplied. For specific lengths, the tolerance should be stated if critical. End terminations should be selected from the following.

a) Fused and tapered (this is useful where the rope has to be threaded through pulleys).

b) Eye termination with ferrule and thimble all conforming to BS 7905-1.

NOTE The required SWL and identification code may be marked on the ferrule.

c) Alternative swaged terminals such as fork end, eye, threaded shank etc.

8.10.2.3 *Handling and storage*

Stout protective gloves should be worn when handling wire rope as sharp broken ends can stand out from the rope.

The following guidelines should be observed for handling and storage of wire ropes.

a) Ensure the rope is clearly identified by a label stating at least the identity code (see **8.3**).

b) Do not allow contact with any contaminant such as dirty flooring.

c) Ensure the rope is not subjected to a bending diameter tighter than 18 times the nominal wire diameter, except within approved end terminations.

d) Avoid kinks or twisting with adjacent ropes.

e) To unwind a reel or coil, rotate the reel or coil either on a spindle or by wheeling along. Do not pull a rope from the centre of the coil as this induces a twist.

8.10.2.4 *Cutting*

Wire ropes should be labelled before cutting to ensure that both parts can be identified to the relevant test certificate. When a rope is to be cut on site, binding, for example PVC tape, should be applied on both sides of the intended cut. This prevents the ends unlaying and so reduces the risk of possible injury to users' hands. Purpose-made rope cutters should be used to cut wire ropes, and not a hacksaw.

Special attention should be paid to multi-strand (low rotation) wire ropes, as inadequate binding allows the rope to unlay and be rendered useless. Ideally the ends of multi-strand ropes should be fused after cutting.

8.10.2.5 *Installation*

Wire ropes should not be kinked or twisted. Wire ropes should not be knotted to form a connection. Wire ropes should be properly terminated (see **8.13.1**) and attached to the load and/or lifting machine using an appropriate lifting accessory (see **8.13.2**).

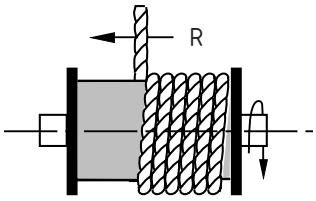
Wire ropes, if painted, could be damaged by corrosion, loss of lubrication and/or damage to fibre cores.

8.10.2.6 *Installing wire ropes onto drums*

A minimum of three dead turns should remain on the drum when the load is at its lowest level.

Ropes should be installed onto drums with as much tension as possible to avoid damage. The fixings for securing the end of the rope to the drum should be clean, free from damage and tightened to the recommended torque.

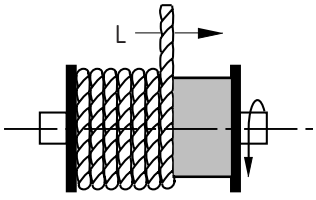
When winding ropes onto plain drums, each wrap should lie tightly against the preceding turn. Poor or uneven coiling causes severe damage to wire rope. The direction of coiling the rope onto a plain drum is critical if satisfactory coiling is to be achieved. Figure 4 shows the location of rope anchorage on a plain drum and the direction of coiling in order to achieve satisfactory coiling. It is unlikely in practice that satisfactory coiling can be achieved with more than three layers on a plain drum; grooved drums are therefore preferred.



Start rope at right flange.

a) Right-hand lay rope-underwind

Right hand



Start rope at left flange.

b) Right-hand lay rope-overwind

Right hand

NOTE Thumb indicates side of rope anchorage. Left-hand lay rope is not illustrated.

Figure 4 — Location of rope anchorage on a plain drum

Excessive lengths of wire rope should not be wound onto pile winding drums as this increases the tendency for damage by crushing to occur. Only the length of wire rope needed to operate the system safely should be installed on the drum. If the lower layers of rope are left loose, subsequent layers of rope under operating tension crush and distort the lower layers.

8.10.2.7 *Inspection*

Cotton waste or cloth should be run over the entire length of the wire rope periodically to detect any snags. The diameter of the rope should be checked with a calliper in several places along the working length of the rope. The correct method of measuring the diameter of a wire rope is shown in Figure 5. If there is apparent loss of lubrication or the diameter is unduly reduced, a competent person should open the wire rope to inspect the core. Loss of lubrication can be detected by the presence of excessive grease or no grease dependent upon the age of the rope.

The wire rope should be withdrawn from service and undergo thorough examination by the competent person if any of the defects listed in Table 8 are found.

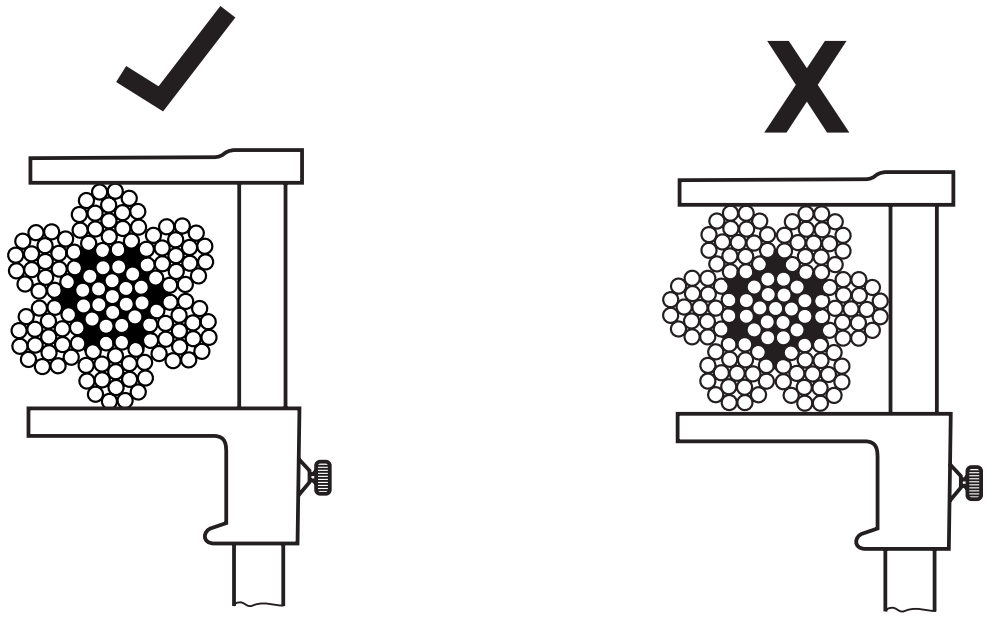


Figure 5 — Method of measuring diameter of a wire rope

Table 8 — Visible defects requiring wire rope to be withdrawn from service for thorough examination by a competent person

Indicator	Withdrawal criteria
Number of broken wires	More than 3
Broken wires within 6 mm of a termination	None acceptable
Core deterioration	Measured loss of diameter exceeds 3 % with no visible wear
Undue wear	Measured loss of diameter exceeds 10 % nominal (3 % with multi-strand ropes) or corrosion suspected
Corrosion	Signs of red dust
Heat damage	Excessive loss of lubrication, weld spatter
Deformation	Kinks, severe bends, strand or core protrusions

8.10.2.8 *Maintenance*

The initial manufacturing lubricant is not intended to last the life of the rope. Wire ropes may be lubricated in accordance with the manufacturer's manual. However, in the entertainment industry it is generally preferable to replace any rope that has lost its lubrication.

Wire ropes incorporated in lifting machines should be maintained in accordance with the manufacturer's manual for the equipment. It is essential when replacing wire rope incorporated in a machine, that the replacement rope conforms to the equipment manufacturer's specification for the equipment.

NOTE BS 6570 provides guidance on the maintenance of wire ropes.

8.10.3 ***Fibre ropes***

NOTE The use of man-made fibre ropes, such as polyester, is widespread in many applications where previously natural fibre ropes would have been used. Polyester is resistant to oil, chemicals, changes in ambient temperature and humidity, and is smoother to touch than manila.

8.10.3.1 *Selection and ordering*

Natural fibre ropes should either conform to BS EN 1261 for hemp ropes or BS EN 698, Grade 1 special quality manila. Man-made fibre ropes should conform to BS EN 697.

Load bearing fibre ropes used for flying should be easy to grip, especially when bunched together. As a guide, a comfortable diameter is between 16 mm and 22 mm. Counterweight hauling ropes should be between 18 mm and 22 mm diameter and be of a diameter compatible with the rope lock and pulleys within the system.

When ordering fibre ropes obtain a statement of average MBL from the supplier. This should be used as the basis for calculating the SWL to achieve a safety factor of at least 8, see **5.2**.

Smaller diameter ropes may be used for other purposes such as "spot lines".

Self-coloured ropes should be used. Painting fibre ropes could cause stiffening and damage through corrosion or fretting. Where colour is important appropriately coloured ropes should be ordered.

8.10.3.2 *Handling and storage*

Most ropes are right hand laid and should be uncoiled in a counter-clockwise direction.

Ropes should be stored where they are protected from damp, heat and the effects of sunlight (either directly or through glass). The hanging of ropes on cleats or belaying pins permits adequate ventilation.

8.10.3.3 *Cutting*

Fibre ropes should be labelled before cutting to ensure that both parts can be identified to the relevant statement of MBL. The free end of a natural fibre rope should be whipped to prevent unlaying (see **8.11.2**). Man-made fibre ropes may be fused or whipped.

8.10.3.4 *Inspection*

It is important to carry out regular inspections of fibre ropes even if the rope is not in use.

NOTE Attention is drawn to LOLER [3] and PUWER [4] regarding inspection and maintenance of equipment.

The total length of the rope should be examined periodically, the rope being turned to reveal all sides and the strands being twisted slightly to allow examination between the strands before continuing. Denaturing or brittle fibre could be revealed by "wringing" the fibre rope, but this should be carried out carefully to avoid disturbing the rope lay.

Slight damage to the outer fibres, or an occasional torn yarn may be considered to be harmless, but the rope should be replaced if serious reduction in the diameter of any strand has taken place.

8.10.3.5 *Operation and use*

Excess rope should be coiled neatly and parked either on the horn of the top cleat or an adjacent spare cleat. Fibre ropes should be secured to the cleat by two figure of eight turns. The second turn should incorporate a tuck to lock the whole tie.

NOTE For details of knots and whipping used with fibre rope see **8.11**.

Care should be taken that lifting accessories and cleats do not cause damage to fibre ropes through contact with rough or sharp edges. Fibre rope eyes should be protected by thimbles.

8.11 Knots including hitches and splices

8.11.1 *General*

Knots and splices reduce the SWL of the ropes. The efficiency of a knot is stated as a percentage of the strength of the rope itself; thus a 60 % efficient knot reduces the MBL of the rope by 40 %. The highest efficiency knots should be used where practicable. The efficiency of knots is stated where there is general agreement; this applies only when the knot has been properly tied and is appropriate to the rope and its use. In general, knots reduce the SWL of the rope by about 50 % whereas well-made eye splices are 85 % efficient. Knots, hitches and splices for fibre rope which are specifically recommended for use in the entertainment industry are shown in Figure 6 and as follows.

a) *Bowline*

The bowline has an efficiency of 60 %, does not tighten under load and can be undone quite easily. It is used for tying scenery to hanging rings and also for picking up electric cable on spot bars, enabling the cable to slide easily within the knot when the bar is raised or lowered.

b) *Clove hitch*

The clove hitch has an efficiency of 65 % and tightens under load. It is used with a half hitch for hanging scenery from bars, ties on rails, etc.

c) *Figure of eight*

The figure of eight does not tighten under load. It is easily released even in restricted positions. It is used to ensure that a rope cannot run through a pulley block.

d) *Round turn and two half hitches*

The round turn and two half hitches has an efficiency of 70 %, and tightens under load. It is for general use, such as for raising or lowering counterweights.

e) *Reef knot*

The reef knot has an efficiency of 45 % and tightens under load. It is used for joining two ropes of the same size. It is unstable when used to join ropes that differ in any way. This knot should not be used on lengths of rope that pass through pulley blocks. Care should be taken not to tie a granny knot in error.

f) *Rolling hitch*

The rolling hitch tightens under load. This knot is an extension of the clove hitch with an additional first turn with the direction of the pull. It is used, for example, to put a brail directly onto the end of a bar.

g) *Two figure of eight turns and tuck*

The two figure of eight turns and tuck does not tighten under load. It is used to secure a fibre rope on a cleat.

h) *Double sheet bend*

The double sheet bend has an efficiency of 50 % and tightens under load. It is used for joining two ropes of different sizes, for example a light line or sash lowered to pick up a brail or heavy cable.

i) *Alpine butterfly knot*

The alpine butterfly knot does not tighten under load. It is used to tie a loop in the middle of a rope. It is easily undone after use.

j) *Eye splice*

The eye splice has an efficiency of 85 %, it is used to make a loop or eye at the end of a rope, and should be used with a thimble. Splices should have not less than three full tucks for natural fibre ropes and not less than four full tucks for man-made fibre ropes, which should be against the lay of the rope, each with all the yarns in the strand.

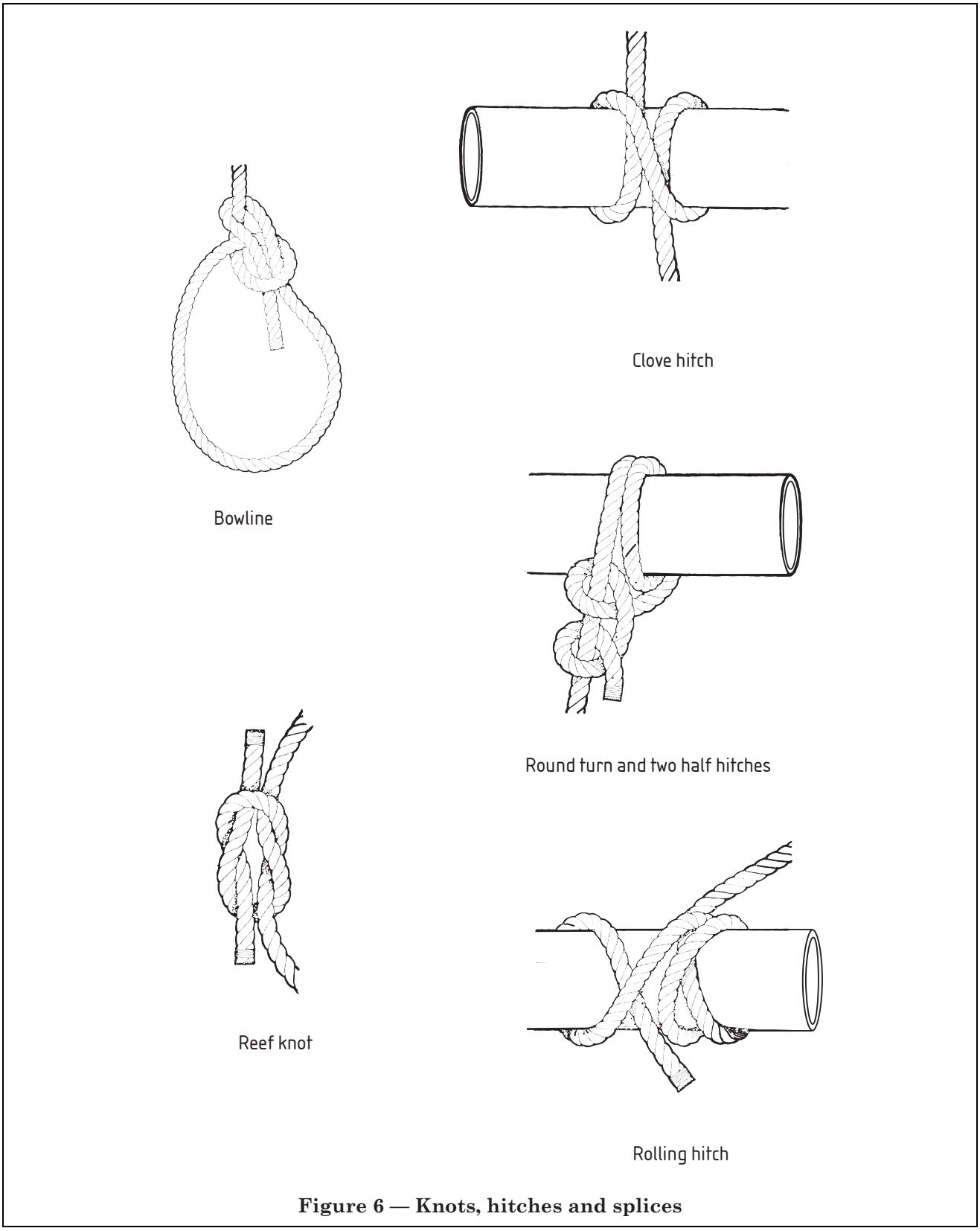
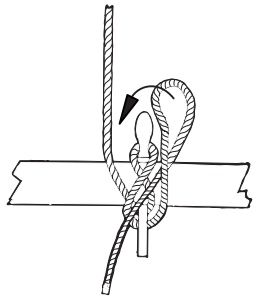
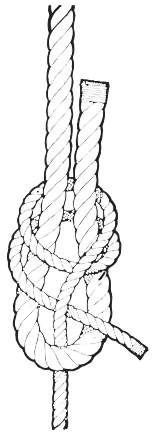


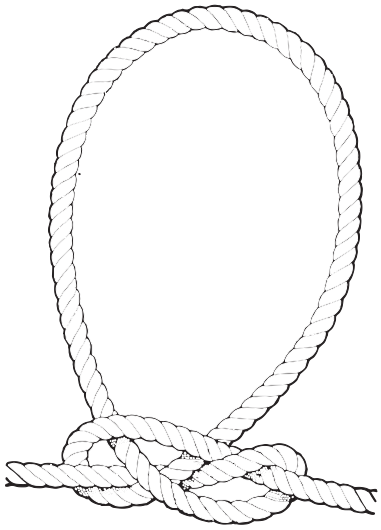
Figure 6 — Knots, hitches and splices



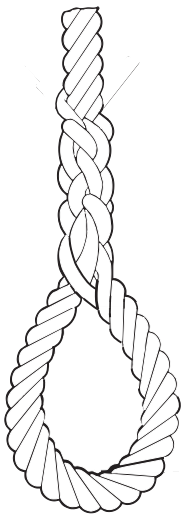
Two figure of eight turns and tuck



Double sheet bend



Alpine butterfly knot



Eye splice
(thimble omitted)

Figure 6 — Knots, hitches and splices *(continued)*

8.11.2 *Whipping*

8.11.2.1 *General*

Cut ends of fibre rope should be prevented from unlaying. This is best achieved by whipping. There are various types of whipping; the most common is detailed in **8.11.2.2**.

8.11.2.2 *Common whipping*

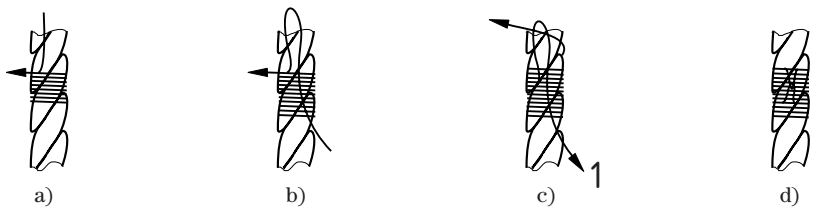
Common whipping should be tied in accordance with Figure 7 and the following method.

a) Lay a length of whipping line along the rope and put some tight turns on it.

b) Continue until the whipping is almost as long as the diameter of the rope, then double back the free end to form a loop.

c) Put three tight turns round the loop and then pass the working end through the loop.

d) Pull the loop tight so that it draws the working end under the three turns. Then tie the two ends together and remove the surplus line.



Key
1 Pull

Figure 7 — Stages in tying common whipping

8.12 Brails and breast ropes

NOTE Brails are used to restrain or move a load by tying rope(s) to it to position the load exactly or to achieve clearance for other (moving) loads. Breast ropes are used to apply pressure directly to the suspension ropes to alter the position of the bar or other load, usually by rigging a near-horizontal rope, for example between two fly galleries.

Brails and breast ropes should be considered as bridles (see **8.15**). The force needed to change the position of a hanging load is considerable and increases dramatically the more the position of the load is changed. Brails and breast ropes should be used only to make relatively slight adjustments to the position of a load. On no account should mechanical assistance be employed to increase tension in the brail or breast rope; if a brail or breast rope were to fail, an accident could occur. Ropes should be appropriate to the load being moved, see **8.10** for further information on the selection of ropes. The anchorages for brail and breast ropes should have appropriate strength. The direction of the applied force should be carefully considered.

Particular attention should be paid to ensure that brails do not over-stress the load or twist it and that brails attached to bars do not bend them; brails should not be attached to bar extensions. Generally it is better to apply breast ropes directly to the suspension ropes so that the load remains suspended vertically; this might not always be the case with brails.

If a load is to be moved when brailed or breasted, suspension ropes should move freely and without damage to the brail or breast ropes. The use of pulleys is recommended, taking account of the necessary D:d ratio, see **8.16**. Ropes, especially fibre ropes, should be protected from chafing or cutting by wire rope suspensions, for example by use of nylon rollers.

8.13 Hardware

8.13.1 *Terminations*

Terminations generally reduce the SWL of the rope. The efficiency of a correctly fitted termination is stated as a percentage of the strength of the rope itself; thus a 60 % efficient termination reduces the MBL of the rope by 40 %. The highest efficiency termination should be used wherever practicable.

Terminations should remain secure in the event of a slack rope. End terminations should not be repositioned so that the residual kink becomes load bearing. It is essential that terminations that require the maintenance of tension or which are designed primarily for use under static load conditions, such as fencing, power lines or guy wires, are not used in dynamic lifting applications. Fittings recommended for terminating, securing or joining ropes in the entertainment industry (other than knots and splices in fibre ropes, see **8.11**) are shown in Figure 8 and as follows.

a) *Thimbles for wire ropes*

Thimbles should be used with wire ropes to provide protection from scuffing and crimping if the rope is looped or tied round shackles, eyes, hooks etc. The groove diameter of the thimble should be not less than 1.1 times the rope diameter.

b) *Thimbles for fibre ropes*

Thimbles should be used when forming eyes in fibre ropes if the eye is to be used over a pin whose diameter is less than twice the diameter of the rope or where damage might otherwise occur. Selection should be on the basis of the rope diameter and the eye size required. Nylon thimbles should not be used if the load is likely to distort the thimble.

c) *Wire rope grips*

Wire rope grips are sometimes known as “dogs”. Correctly fitted wire rope grips have an efficiency of at least 80 %. Wire rope grips should conform to BS EN 13411-5, although grips conforming to DIN 1142 are acceptable in existing installations. Commercial pattern grips should not be used. WARNING The British Standard for wire rope grips, BS 462:1983, was withdrawn on 15 May 1991 on safety grounds. Wire rope grips should be fitted in accordance with the following method:

1) The first grip should be fitted immediately against the thimble.

2) The U-bolt should be on the dead or tail side of the eye.

3) Grips should be fitted between 1.5 and 3 times the width of the grip bridge apart.

4) The minimum number of grips specified in BS EN 13411-5 for a given rope size should be fitted.

5) The use of a torque wrench is essential. Consideration should be given as to how to hold the grip body during the tightening process, especially for the larger sizes.

6) Grips should be tightened to achieve the torque specified by the supplier; this applies when the threads and contact faces are greased. See Table 9.

7) All grips should be checked for correct torque values after the initial application of load, again within 24 hours of installation and at regular intervals thereafter, especially during the early stages of service.

Table 9 — Number and torque for wire rope grips conforming to BS EN 13411-5

Rope size Nominal diameter mm	Number required for a minimum of 80 % efficiency	Torque required for a minimum of 80 % efficiency N·m[a]
5	3	2.0
6.5	3	3.5
8	4	6.0
10	4	9.0
14	4	33
16	4	49
The smallest wire rope grip conforming to BS EN 13411-5 is 5 mm. For smaller ropes an alternative termination method should be used such as a ferrule secured eye.		
[a] N·m times 0.737 is equal to lb·ft.		

d) *Sockets*

These have an efficiency of 100 %. Sockets are not generally recommended for site fitting. BS 463 gives guidance on sockets; BS EN 13411-4 gives guidance on fitting.

e) *Symmetrical wedge sockets*

These have an efficiency of 80 % to 95 %. Symmetrical wedge sockets provide a permanent means of making a loop or thimbled eye at the end of a wire rope. They are compact, easily fitted, reusable and efficient. The wire rope grip and the split pin ensure that the wedge cannot be displaced in a slack rope condition. Symmetrical wedge sockets should conform to DIN 15315. Symmetrical wedge sockets conforming to DIN 15315 should be fitted in accordance with the following method:

1) Remove as much slack from the system as possible before fitting the wedge.

2) Check that the wedge is correctly seated in the body of the socket.

3) Fit one correctly-sized wire rope grip in accordance with **8.13.1**c) across both parts of the rope six rope diameters from the socket.

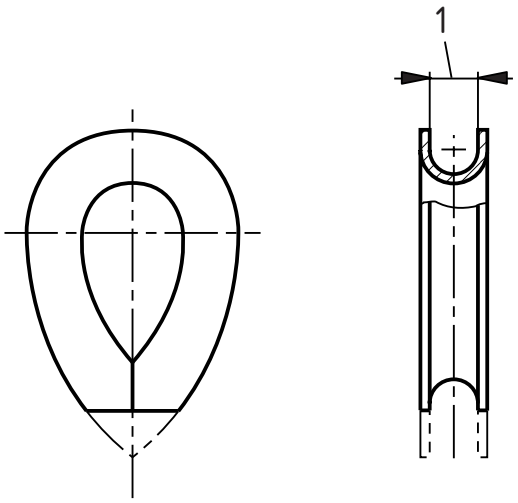
4) If possible refit the split pin.

f) *Asymmetrical wedge sockets*

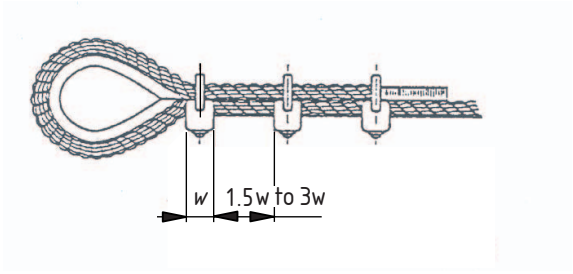
These have an efficiency of 60 %. Asymmetrical wedge sockets provide a permanent means of making a loop or thimbled eye at the end of a wire rope. They are compact, easily fitted, reusable and efficient. Asymmetrical wedge sockets should be fitted in accordance with the manufacturer's instructions. It is essential that only matching parts of sockets are used together. Ends of multi-strand ropes should be properly served to prevent excessive core slippage. BS EN 13411-6 gives guidance on asymmetrical wedge sockets.

g) *Ferrules*

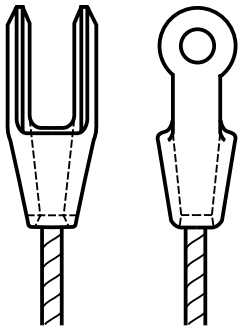
These have an efficiency of 90 %. Ferrules provide a permanent means of making a loop or thimbled eye at the end of a rope. Ferrules used with wire rope should conform to BS EN 13411-3 and be fitted in accordance with the manufacturer's instructions. For wires up to 8 mm in diameter with eye terminations secured by a ferrule, the dead end of the wire should visibly protrude out of the ferrule, but by a maximum of 2 mm. The use of tapered aluminium ferrules is not recommended as corrosion and broken wires can occur within the taper, which are difficult to find in an inspection. Tapered steel ferrules are intended only for use on steel slings and are used in conjunction with a hand-spliced eye, which can only be factory fitted. Ferrules should not be used with wire ropes of 6 × 12 construction.



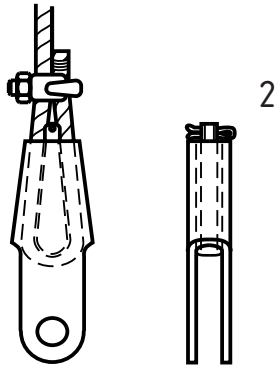
Wire rope thimble



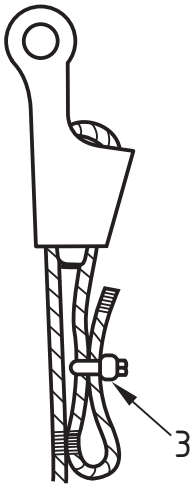
Wire rope grip



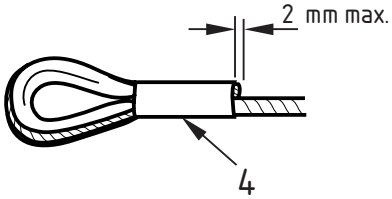
Socket



Symmetrical wedge socket



Asymmetrical wedge socket



Ferrule termination

Key

1 Groove diameter
2 Rope omitted for clarity
3 Wire rope grip
4 Ferrule

NOTE Illustrations are not to scale.

Figure 8 — Terminations

8.13.2 *Lifting accessories*

All lifting accessories should be certified and the SWL known. Lifting accessories used for flying should have a safety factor of at least 8. Slings, sling terminations, hooks, shackles etc. vary considerably in size for a given SWL. It is essential that lifting accessories are compatible both in size and capacity. It might be necessary to add an intermediate link or shackle in order to achieve compatibility. However, the minimum number of components necessary should be used to achieve compatibility between the lifting machine and the load.

Self-coloured materials should be used. Lifting accessories should not be painted as for example, identifying marks might be obscured and threads clogged. Where the appearance of lifting accessories is important, appropriately coloured items should be selected.

The lifting accessories including attachment points recommended for connecting loads to suspensions in the entertainment industry are shown in Figure 9 and are as follows. Scenery fittings used as attachment points are given in **8.13.3**. Trolleys, runners and bobbins used with track systems are described in **8.24**.

a) *Bolts or pins*

Bolts or pins are suitable for insertion through an eye termination, chain link or connection to other lifting accessories such as a shackle. The bolt or pin should be manufactured from steel conforming to class 8.8 of BS EN 20898. The bolt or pin should be of sufficient diameter and the supporting structure of sufficient strength to support the load with the required safety factor. The load bearing section of the bolt should be unthreaded. The bolt or pin should be supported either side of the eye or other connector through which it is inserted. The bolt or pin should be secured by an anti-vibration method, for example self-locking nut, split ring or a split pin through the non-load bearing section.

b) *Bar straps*

Bar straps are short webbing straps with triangular fittings at both ends. The webbing hangs over the bar and the end fittings are connected together with a shackle to carry loads.

c) *Hook clamps*

Hook clamps are used to hang loads such as luminaires on a bar. TV hook clamps are designed to fit TV spigots as used with some luminaires and other equipment. Clamps should be compatible with the bar diameter. Hook clamps should not be over-tightened as this damages the clamping screw or the bar. The use of screw clamp type devices where the screw bears directly on the bar should be avoided with aluminium alloy bars and trussing. A secondary suspension, usually a safety bond or chain, should be used to secure the equipment to the bar independently of the clamp.

d) *Half-couplers*

Half-couplers or other devices which grip the whole bar should be used with aluminium bars to avoid damage to the bar. Eye-nuts and eye-bolts used on half-couplers should be locked to prevent unscrewing.

e) *Hook bolts*

Hook bolts or J-bolts provide a means of fixing moveable items, such as hemp pulleys, to the grid steelwork. Hook bolts should conform to class 8.8 of BS EN ISO 898-1.

f) *Beam clamps*

Beam clamps provide a simple means of attaching lifting equipment to suitable structural steelwork. There are two types: adjustable and non-adjustable. Adjustable clamps are generally only capable of adjustment within specific limits and are therefore manufactured in a range of sizes. Beam clamps should be legibly marked with the width of beam or range of widths for which the clamp is designed and the toe thickness of beam, if applicable. Clamps that rely on the load or the top hook or shackle of the lifting equipment to lock them in place are easily displaced and should not be used. Generally beam clamps are intended for use with the line of force at right angles to the flange of the beam. A suitable design of clamp should be used where the applied force is at an angle to the flange.

g) *Swivel clews*

Swivel clews are used to connect a single hauling rope to multiple ropes. It is preferred that clews be guided to prevent problems with the rotation of the ropes.

h) *Rigging screws*

Rigging screws (bottle screws) provide a simple and effective means of tensioning wire rope, often used in conjunction with shackles. Only rigging screws marked with their SWL should be used. Eye or fork terminations should be used. It is essential that the force is in line with the long axis of the rigging screw. The thread engagement by the screw in the body should be at least twice the diameter of the screw. The setting should be locked after tensioning by means of lock nuts or a wire bond.

i) *Bar hangers*

Bar hangers (barrel clamps) are used to attach a wire rope to a bar. Clamps should be compatible with the bar diameter. Trimming bar hangers with adjustable clamps allow the wire length to be adjusted. It is preferred that the fixed clamp of a bar hanger is pinned or fixed to the bar to prevent it slipping.

j) *Karabiners*

Karabiners should be self-closing and manual- or self-locking. They should require at least two consecutive deliberate manual actions to release. When karabiners are used as part of a luminaire secondary suspension, the karabiner should be permanently attached to the safety bond.

k) *Trim chains*

Trim chains (barrel chains) should be selected and used in accordance with **8.14**.

NOTE Attention is drawn to the Supply of Machinery (Safety) Regulations [5] Schedule 3, 4.1.25 b) which prohibits the use of long link welded chain for use in lifting accessories.

l) *Shackles*

Shackles should be correctly seated to ensure that the load is transferred through the pin. Shackle pins should be hand-tight. The pin should be either a screwed pin or a bolt and nut as supplied by the manufacturer. It is recommended that shackle pins are secured against unthreading by mousing the pin, for example with a cable tie or by using a split pin to prevent movement of the nut. D-shackles should only be used for straight lifts whilst bow shackles generally accept angular loads up to 45° off centre of the bow.

m) *Eye-bolts and nuts*

Eye-bolts and nuts should be locked to prevent unscrewing. Collared eye-bolts should generally be used and should be screwed tight down onto the collar. This is particularly important where angular (non-axial) loading is possible, for example when using an eye-bolt to attach a bridle leg. Ensure that collared eye-bolts are only used with structures that are strong enough and provide sufficient support to withstand the stresses imposed by the eye-bolts. Eye-bolts that are axially loaded in normal use are often subject to side loads when rigging, for example when lifting an item from the horizontal to vertical position. If the eye-bolt does not have sufficient side load capacity an alternative lifting method should be used. Swivel eye-bolts, certified and marked as suitable for angular lifting, should be used for loads where the axial alignment or angle of suspension changes.

Dynamo eye-bolts should only be used for axial lifting. Long threaded uncollared eye-bolts are only suitable for straight lifts.

n) *Hooks*

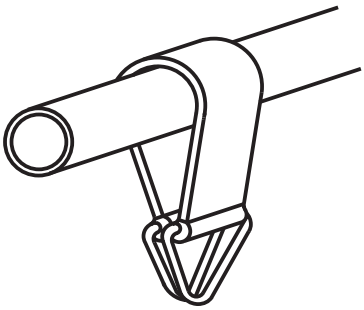
Hooks are a fast, simple attachment for temporary applications. Whether connected to the load directly or, via a lifting accessory, it is essential that all hooks incorporate a safety device to ensure the hook cannot become detached other than through deliberate action. The safety device is normally a spring-loaded gate.

Where a lifting machine hook is attached directly to the load it is essential that the attachment point is compatible with the hook and allows the hook to hang vertically. Swivel hooks should be free to rotate. When a hook is integral with a pulley block, ensure that no part of the load could become trapped in the pulley.

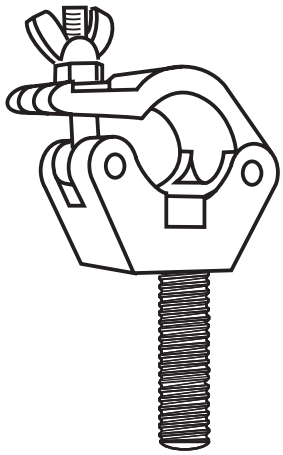
Where the angle of lift changes during use or when rigging, for example when lifting a scenic item from horizontal to vertical position, the attachment point should allow the hook to remain free and in-line throughout the lift. For example, it might be necessary to use lifting accessories such as short slings and shackles between the hook and the attachment point to ensure the force on the hook acts vertically at all times.

o) *Bridle chains*

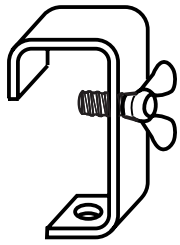
Bridle chains are fitted between the bar clamps and the suspension wire rope to provide a means of increasing the number of pick-ups and also a simple method of trimming the bar. See **8.15**.



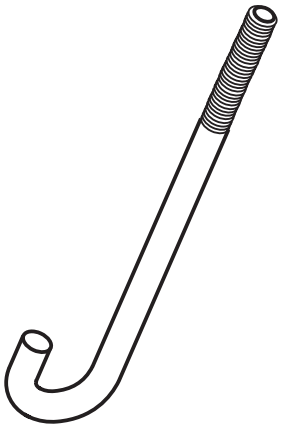
Bar strap



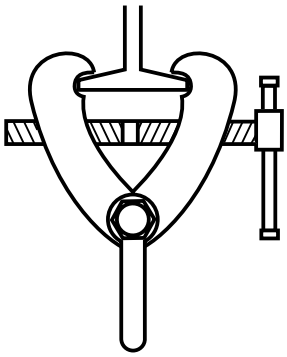
Half coupler



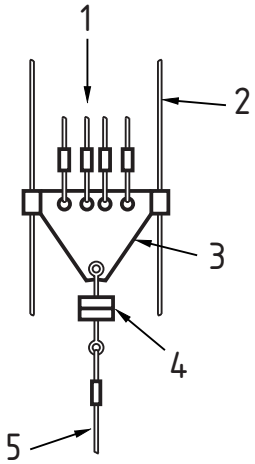
Hook clamp



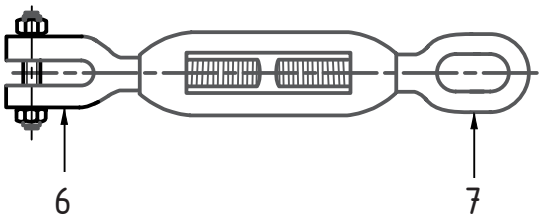
Hook bolt



Beam clamp



Guided swivel clew



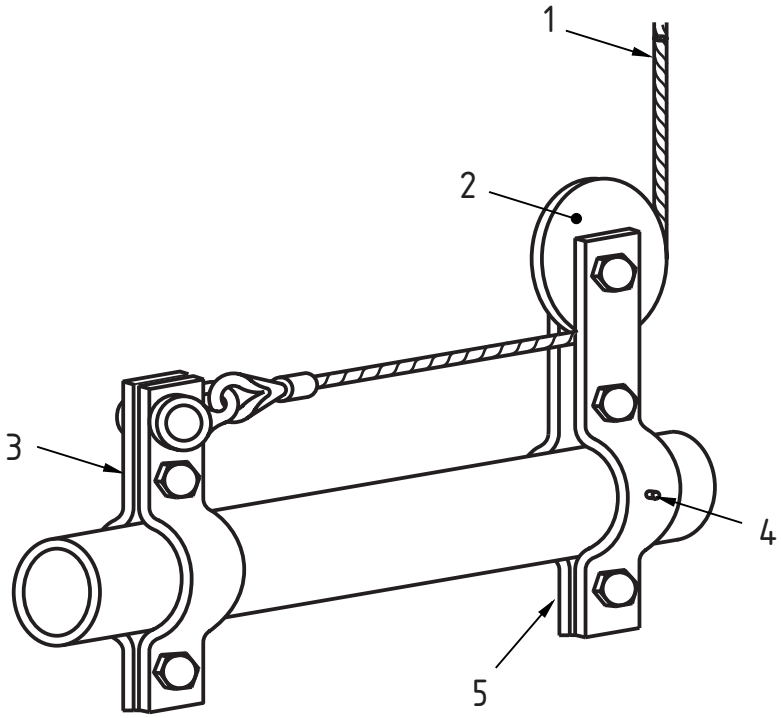
Rigging screw

Key

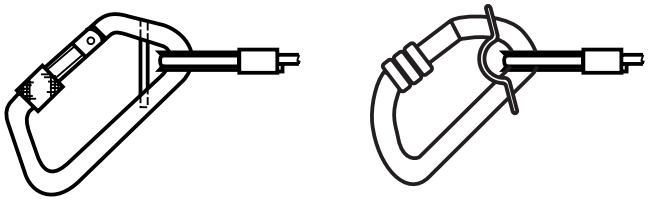
1 Suspension wire ropes
2 Fixed guide wires
3 Clew plate
4 Swivel
5 Hauling wire rope
6 Fork
7 Eye

NOTE Illustrations are not to scale.

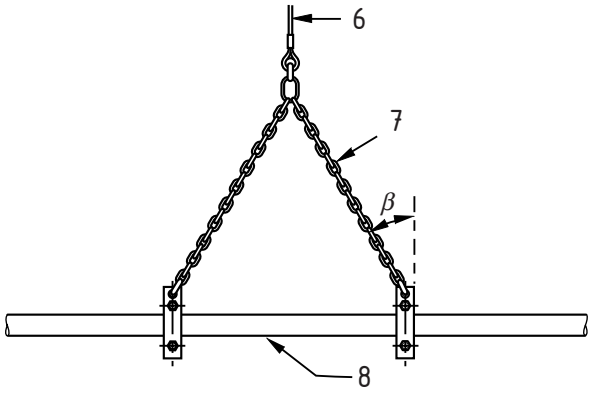
Figure 9 — Lifting accessories



Bar hanger with adjustable clamp



Karabiners (shown with permanent safety bond attached)



Chain bridle

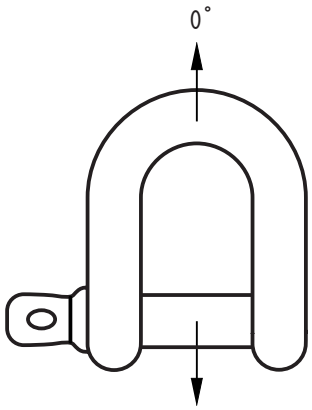
Key

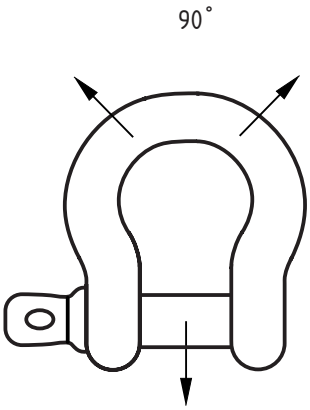
1 Suspension wire rope	3 Adjustable clamp	6 Suspension wire rope
2 Grooved diverter	4 Location pin	7 Chain bridle
	5 Fixed clamp	8 Bar

NOTE 1 Illustrations are not to scale.

NOTE 2 Trim chains are not illustrated.

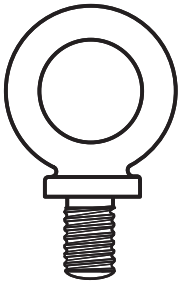
Figure 9 — Lifting accessories *(continued)*

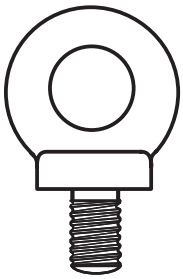




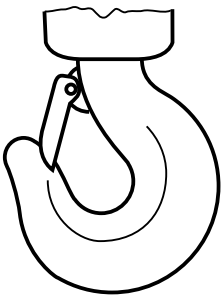
Shackles

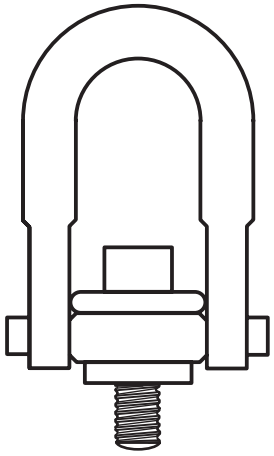

Uncollared


Dynamo


Collared

Eye-bolts


Hook


Swivel eye-bolt

NOTE Illustrations are not to scale.

Figure 9 — Lifting accessories *(continued)*

8.13.3 *Scenery fittings*

Various fittings are used to attach ropes to scenery. Scenery fittings should be marked with their SWL.

Scenery fittings used with wood-framed scenery are attached by wood screws and coach bolts or similar. The loads that can be imposed are therefore limited by the interface with the wood. It is important to ensure that no fixing is overloaded. At least two of the fixings per fitting should be through-bolts and nuts rather than just wood screws as the screws could be pulled out of the timber. Screws should only be used in shear, never in tension. It is essential that the timber to which the scenery fitting is attached is strong enough and connected sufficiently strongly to the rest of the structure so that it is not displaced by the load.

Some scenery fittings recommended for use in the entertainment industry are shown in Figure 10 and are as follows:

a) *Hanging irons*

Hanging irons are the preferred method of attaching wire and fibre ropes to the bottom rail of scenery flats. Hanging irons may be screwed and bolted to timber structures, and welded or bolted to metal structures. They are manufactured in two orientations, with the eye turned in and with the eye turned out, and two types, one for wire ropes and one for fibre ropes. Eye turned in is preferred provided the rope can be accommodated in the thickness of the flat. When used with timber the toe should extend at least half the thickness of the bottom rail and be recessed into the bottom rail.

b) *Flying irons*

Flying irons are hanging irons without toes, which enable the fixing of ropes at other positions, particularly on metal scenery.

c) *Lifting plates*

Lifting plates have holes suitable for the direct connection of a lifting machine hook or other lifting accessory such as the pin of a shackle. It is essential that the diameter of the hole and thickness of the plate is compatible with the lifting accessory or lifting machine hook. The plate should be strong enough to withstand any applied loading without bending.

d) *Grommets*

Grommets are usually saddles fixed to the tops of flats to hold suspension ropes in position. Grommets are not load bearing unless so designed and fitted. Open type grommets speed up rigging but it is important that tension is maintained in the rope to avoid accidents.

e) *Pin hinges*

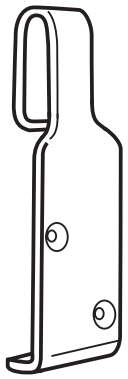
Pin hinges are matching pairs of half back-flap hinges connected by means of removable pins. They are generally used to connect adjacent sections of scenery together and are not load bearing unless purpose made.

f) *Ceiling plates*

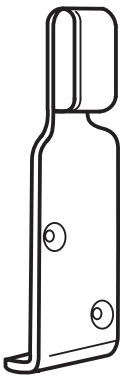
Ceiling plates consist of welded oval rings held captive to mounting plates, which also serve to join adjacent sections together. They are used for assembling and hanging ceiling battens. Ceiling plates which are not marked with their SWL should not be used.

g) *Ring plates*

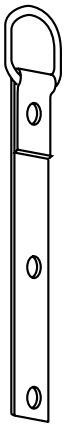
Ring plates consist of welded oval rings held captive to base plates fixed to timber framing. Ring plates which are not marked with their SWL should not be used.



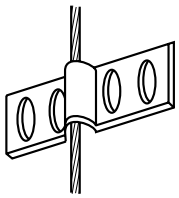
Eye in hanging iron



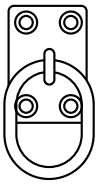
Eye out hanging iron



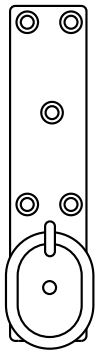
Flying iron



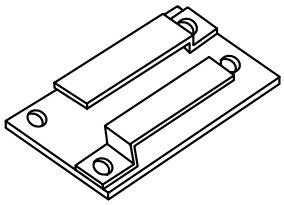
Grommet



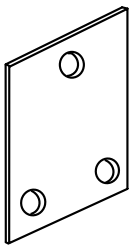
Ring plate



Ceiling plate



Open-type grommet



Lifting plate

NOTE Pin hinges are not illustrated.

Figure 10 — Scenery fittings

8.14 Chains

8.14.1 *Selection and ordering*

Chain for use in bridles should conform to ISO 1835, ISO 3076 or ISO 3075.

Calibrated chain for use in hoists should be specified by the manufacturer and conform to BS EN 818-3 or BS EN 818-7. Chains for use in hoists should be used with terminating connectors which either conform to the relevant part of BS EN 1677 or provide equivalent strength.

8.14.2 *Marking and records*

Each chain should be marked in accordance with **8.3**. Records obtained using the identity code should be in accordance with **8.4**.

8.14.3 *Installation and removal*

Only chains approved by a competent person, preferably the manufacturer, for load carrying purposes should be used in rigging operations. The effective length of chain should only be altered by using a certified load bearing link assembly, specifically intended for that function; nuts and bolts, steel wire rope lashing or wire rope grips should not be used for this purpose.

Replacement of chain in hoists should be carried out in accordance with BS 6521.

8.14.4 *Inspection*

Chains used for lifting should be removed from service for a thorough examination by a competent person if any of the following defects are observed:

a) cracks;

b) nicks or gouges;

c) distortion;

d) corrosion or deposits which cannot easily be removed;

e) an increase in gauge length that exceeds the manufacturer's recommendations. In the absence of manufacturer's recommendations the chain should be replaced if the gauge length measured over any 5 links exceeds that of 5 links of unused chain by 2 %;

f) interlink wear leaving a rough surface which indicates that rapid wear is occurring;

g) chain does not hang true.

8.14.5 *Operation and use*

Chain is intended to support the load in a straight line without rubbing on adjacent surfaces. Chain should not be twisted or knotted.

8.15 Bridles, slings and drifts

8.15.1 *Selection*

Slings should be selected in accordance with the characteristics given in Table 10 and to provide a safety factor of at least 8.

Table 10 — Selection and use of slings

Type of sling	Characteristics	Usage
Chain	Hard, might cause surface damage to load.	Protection might be needed for aluminium, timber or similarly soft materials, e.g. by wrapping with thick PVC.
Wire rope	More prone to damage than chain. Relatively stiff but less damaging than chain.	Ensure that minimum bending radii criteria are observed. Protection might be needed for aluminium, timber or similarly soft materials, e.g. by wrapping with thick PVC.
Fibre rope	Less pliable than other forms of textile slings; more bulky to handle. Liable to heat damage. Presents a hard, point contact to the load, unlike flat woven slings and round slings, though less damaging than chain or wire rope.	Secondary suspensions may be necessary. See **7.4.4**.
Flat woven webbing	Less robust and more liable to damage than equivalent wire rope or chain slings. Liable to heat damage. Easy to handle. Ideal for loads that require some support as the load is spread across the full width of the webbing, thus avoiding point contact as is the case with chains and ropes; less liable to damage finished surfaces.	Secondary suspensions may be needed where textile slings have been used for ease of rigging. See **7.4.4**
Man-made fibre round slings commonly called "spansets" or "strops"	Less robust and more liable to damage than fibre rope or webbing slings. Susceptible to heat damage. Relatively cheap. Soft and pliable, easy to handle and especially useful on delicate surfaces.	Secondary suspensions may be needed where textile slings have been used for ease of rigging. See **7.4.4**.

8.15.2 ***Ordering***

The following information should be provided by the purchaser when ordering bridles, slings and drifts, as appropriate:

a) maximum load to be lifted and the safety factor required;

b) effective working length of the sling;

c) type of sling required such as single or endless;

d) number and length of sling legs;

e) if multi-leg, the range of angles for which the sling is to be certified;

f) material and finish;

g) materials and grade of any terminations;

h) length and number of any protective sleeves;

i) mode of use (whether the sling is to be used in choke hitch or basket hitch formation, if the sling is to be used at 0° to 45° or 0° to 60° vertical angle [known as β] and the maximum load to be lifted in each configuration. For an illustration of β angle see Figure 9, chain bridle);

j) if shortening/tensioning devices are required for adjustment;

k) any special instructions, including any special marking requirements.

8.15.3 *Marking*

Bridles, slings and drifts should be marked in accordance with **8.3**. Purpose-made multiple-leg slings (that cannot be disassembled) should be marked with the SWL in each configuration. Terminal fittings should be individually marked. Slings that incorporate rings or links should be marked on a ring or link or on a suitable tag which is permanently attached. Care should be taken to ensure tags cannot become trapped and thereby damage the sling.

8.15.4 *Handling and storage*

Slings should be clean and dry before being stored. Wet slings should be hung up to dry naturally. Slings should be protected from corrosion. They should not be left lying on the ground where they might sustain damage. Slings, other than chain slings, should be stored away from heat sources and out of direct sunlight.

8.15.5 *Inspection*

A competent person should visually inspect all slings and associated accessories prior to use and before they are returned to store. Slings should be withdrawn from service and undergo thorough examination by a competent person if any of the defects given in Table 11 are found. Similarly if a sling is known to have been subjected to shock- or overloading, it should be withdrawn from service for thorough examination.

Table 11 — Visible defects indicating slings should be withdrawn from service for thorough examination by a competent person

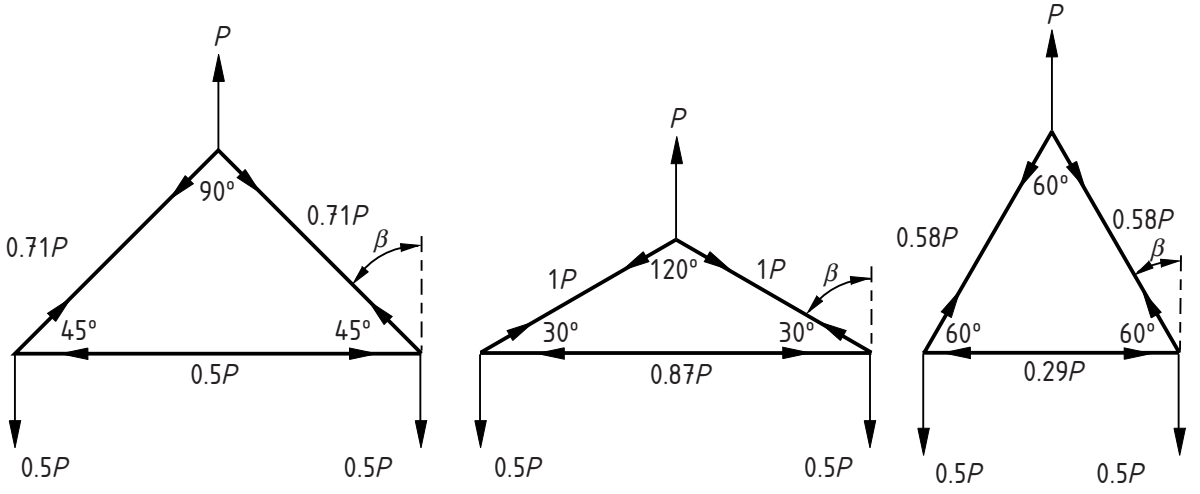
Type of sling	Discard criteria
Wire rope	— Broken wires — Reduced diameter — Corrosion — Distortion — Kinks
Fibre rope	— Crushing, cuts, wear, abrasion — Looseness or fraying of strands — Becoming brittle — Mildew — Kinks
Chain	— Nicks or gouges — Wear — Corrosion — Bent, twisted or stretched links — Faulty safety catches — Wrongly assembled joints
Flat webbing	— Cuts, tears or abrasion — Failure of stitching — Excessive creasing
Round sling	— Exposed core — Failure of stitching — Cuts in cover — Smooth shiny area or surface powdering on cover

8.15.6 *Operation and use*

Bridles may be used to increase the number of attachment points and conversely to share a load between a number of suspensions. Bridles may also be used to position a suspension precisely where there is no supporting structure directly above the attachment point.

Ensure when wrapping a sling around a structural member that it is strong enough to carry the proposed load without deflection. It might be necessary to take turns around more than one structural member to distribute loading. Take care to avoid unacceptable distortion.

The use of bridles or slings requires especial care. The tension in the sling legs and the compressive force between the pick up points can be significant. It is important that the slings, the attachment points and the load can safely sustain the forces applied. The tension in the legs of a symmetrical sling at 45° vertical angle (β) (90° included angle) is equal to 71 % of the load; the compression applied horizontally at each attachment point is 50 % of the load being lifted. If the β angle increases to 60°, the tension in each leg equals the load, and the compression is 87 % of the load. These forces are illustrated in Figure 11.



Key
P Load

Figure 11 — Distribution of forces within a bridle

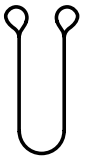
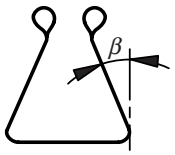
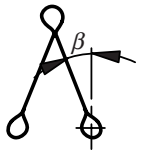
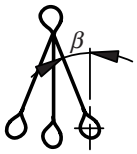
Slings are often not symmetrical but have unequal length legs, and the tension in the legs and the forces imposed on the structure should be calculated. A small variation in height in an asymmetrical sling can result in a significant increase in forces in the legs and the force imposed on the structure or object to be lifted. The angle between the leg of a sling and the horizontal ($90° - \beta$) should be not less than 30°. If there is any doubt a competent person, such as a structural engineer, should be consulted.

A mode factor is used to determine the SWL of a sling in a particular configuration. Factory assembled slings are generally marked with the SWL in various configurations or with the SWL and details of the mode factors to be used. Textile slings might be colour coded by the manufacturer to indicate the SWL but theatre practice is often to require slings to be coloured black, irrespective of capacity. Table 12 gives details of mode factors.

If a bridle or sling is to be assembled from components, each component should have a marked SWL at least equal to the load being lifted and the master-link or shackle where the legs join should have a SWL at least equal to the load to be lifted. Bridles should be used with a vertical angle (β) less than 60°.

When using a basket hitch, ensure that the load is secure as, unlike a choke hitch, there is no gripping action and the sling or load could slip. Multiple-leg slings used in a basket hitch without a spreader are prone to slippage unless there is some positive means to prevent the legs from closing such as a shoulder on the load.

Table 12 — Mode factors for slings

Single leg						Two equal legs "bridle"		Three equal legs	
Vertical "drift"	With choke hitch	With basket hitch							
		parallel	$\beta \leq 22.5°$	$\beta \leq 45°$	$\beta \leq 60°$	$\beta \leq 45°$	$\beta \leq 60°$	$\beta \leq 45°$	$\beta \leq 60°$
									
1	0.8	2	1.8	1.4	1	1.4	1	2	1.5
β is vertical angle (this is half the included angle).									
Mode factor is sometimes written as *M or M*.									

Slings may be fully or partly wrapped around the load, should form as large a radius as possible and not be less than the bending radius of the material of the sling. Slings should not be knotted or twisted. Packing protection pieces should be used on sharp edges. Care should be taken with endless slings so that joints and labels are kept clear of attachment points and hooks. Table 10 provides further advice on the use of slings.

The length of slings can be adjusted by adding or subtracting slings and shackles, by wrapping or choking the slings, or by using products specifically developed for the purpose, such as "K links", "chain clutch slings" and "deck" chain.

Lifting hooks should not be overcrowded. Safety catches should be free to operate. When using more than one sling the slings should be joined with a shackle before they are placed on the hook. Special wide-bodied shackles are available which avoid bunching of textile slings. The master-link of a chain sling should be free to articulate at all times to avoid deformation. Slings should be easily removable by hand to avoid damage and not be trapped by the load after use.

Secondary suspensions may be needed where textile slings have been used for ease of rigging. See **7.4.4**.

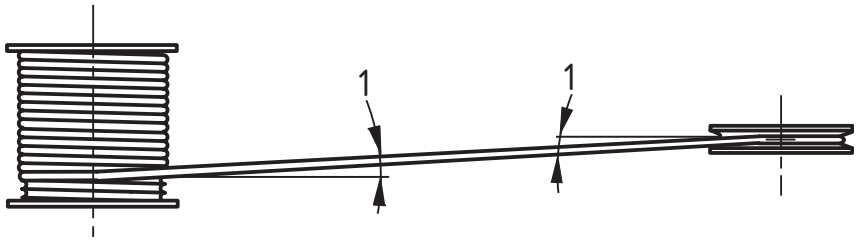
8.16 Pulley blocks

8.16.1 *Selection and ordering*

Pulleys should be silent, free running and support the rope without causing excessive bending stresses or radial pressures. The ratio of the diameter of the sheave to the diameter of the rope (D:d) is critical and is a major factor upon rope life. The larger the pulley diameter the better; a minimum D:d ratio of 30:1 is preferred for wire rope and 12:1 for fibre rope. The groove radius should be approximately 7.5 % larger than the nominal radius of the rope; this gives adequate support to the rope with no tendency to trap it. Groove depth should be not less than 150 % nominal rope diameter for wire rope or 75 % for fibre rope and be smooth with radiussed edges.

8.16.2 *Installation and removal*

Pulley assemblies should be mounted so that the applied load does not cause twist in the pulley axle. It is preferred that the maximum fleet angle either side of centre for ropes leaving drums and pulleys does not exceed 1.5° (1 in 40). When mounting a pulley that feeds rope on/off a drum the pulley block should be aligned with the centre of the horizontal traverse of the rope on the drum. The fleet angle is shown in Figure 12.



Key
1 Fleet angle

Figure 12 — Fleet angle

NOTE The fleet angle may be verified as satisfactory if it conforms to the equation:

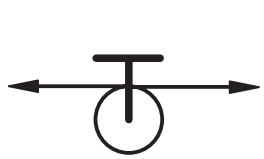
$t \leq 40/l$

where

l is the distance from the centre of the drum (or pulley) to the centre of the nearest pulley;

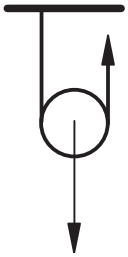
t is the maximum displacement of the rope from a line on the long axis of the nearest pulley.

The means of fixing the pulley assembly should be positive and capable of sustaining the loads placed on it by the total number of all the ropes leaving the pulley assembly. The pulley block should be firmly fixed in place but may be self-aligning. The loads imposed on a pulley block depend upon its use and the way in which it is reeved. For example, a 90° bend over a block imposes a force of 141 % of the load. Figure 13 illustrates forces on pulleys.

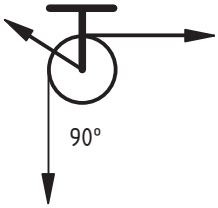


No force on pulley.

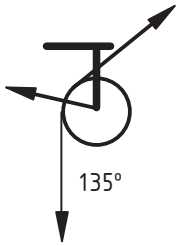
Double the rope load on pulley and structure.



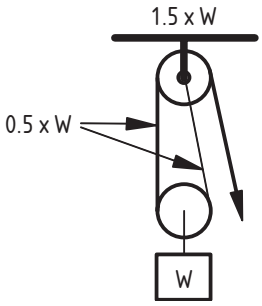
Load in rope half load on pulley. Force on pulley equal to load.



Load on pulley and structure is the load × 1.41 or 141 % of the load.



Load on pulley and structure is the load × 0.76 or 76 % of the load.



Effort equals 0.5 × W.

Key

W Load

Figure 13 — Load factors without allowance for friction

Pulley blocks should be positioned to ensure that ropes are free running at all times. Ropes should not rub against the structure, other ropes or pulley blocks or adjacent scenery. Rope keeps should be fitted to ensure that, if slack rope occurs, the rope is restrained and it cannot leave the pulley groove. Rope keeps should not touch the rope when under operating tension. To obtain reasonable rope life the distance between pulleys should be at least 20 rope diameters or the distance travelled in 0.4 seconds at the design speed, whichever is the greater.

8.17 Bars

8.17.1 *Selection and ordering*

Steel bars of 48.3 mm diameter with 5 mm wall thickness are recommended for general use. Any joints should be purpose designed and be at least as strong as the bar. Consider using a bridle suspension across any joint. For large spans or unusually heavy loads, specialist advice should be sought. The use of trusses is covered in BS 7906-2.

Bars for use with hemp sets should be manufactured from aluminium to minimize dead weight and be of 48.3 mm diameter with 4.47 mm wall thickness. Joints in aluminium bars should be avoided. Aluminium bar is available in lengths up to 13 m and longer to special order.

Table 13 gives recommended maximum loadings for typical steel and aluminium bars.

Table 13 — Recommended SWL for specified steel and aluminium bars of 48.3 mm outside diameter with specified spans

Rope spacing m	Material	Wall thickness mm	Minimum rope SWL kg	Maximum uniformly distributed load (UDL) kg/m		Maximum point load kg	
				Anywhere on "A" (see Note)	Anywhere on "B" (see Note)	Anywhere on "A" (see Note)	Anywhere on "B" (see Note)
2	Grade 275 steel CHS[a]	5	265	26	62	38	125
	Steel scaffold tube[b]	4	169	16	39	23	78
	Aluminium scaffold tube HE30TF[c]	4.47	224	24	55	36	110
3	Grade 275 steel CHS[a]	5	265	13	26	26	77
	Steel scaffold tube[b]	4	169	7	16	15	47
	Aluminium scaffold tube HE30TF[c]	4.47	224	13	24	26	71
4	Grade 275 steel CHS[a]	5	265	7	13	17	51
	Steel scaffold tube[b]	4	169	4	7	9	30
	Aluminium scaffold tube HE30TF[c]	4.47	224	8	13	19	51

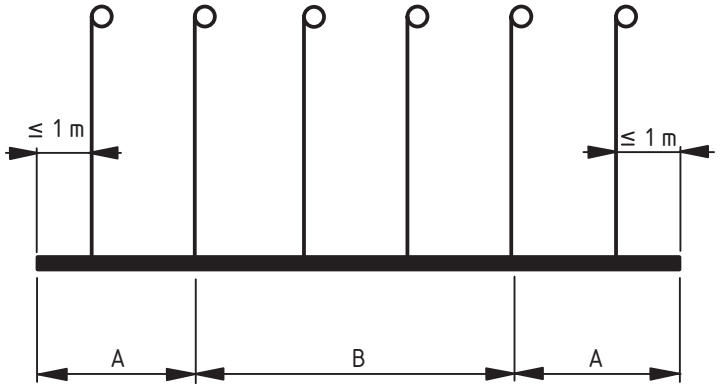
It is assumed that bars are continuous or have full strength connections.

The advice of a competent person should be sought when using trusses instead of bars, different tube or rope spacings or if the bars are connected with less than full strength.

In Table 13 point loads and UDLs are mutually exclusive on the same span (between ropes) or cantilever. The advice of a competent person should be sought when combining point loads and UDLs on the same span or cantilever.

Ropes of less than 6 mm diameter are not generally recommended for the suspension of bars.

NOTE See diagram for explanation of terms "A" and "B".



[a] Steel conforming to BS EN 10219.
[b] Steel scaffold tube conforming to BS EN 39:2001, type 4.
[c] Aluminium scaffold tube conforming to BS 1139-1.2.

8.17.2 *Marking*

SWL notices for bars should be clearly displayed on the fly gallery, loading gallery and grid. Additional notices may be displayed at stage level and on the suspended bars. The mid-point of the stage should be clearly marked on all bars as rigged when appropriate.

8.17.3 ***Installation***

Bars should be installed in accordance with Table 13. Clamps should be compatible with the bar diameter.

Steel bars should be suspended on wire rope; spans between suspensions of 3 m or less are generally recommended. Bridles may be used to avoid spans of more than 3 m. Specialist advice should be sought when dealing with larger spans or unusually heavy loads. Wire ropes should be attached by bar clamps or chain bridles to the steel bar.

Where the span/load value on an aluminium bar is less than shown in Table 13, suspension centres may be increased up to a maximum of 3 m apart. The use of bridles may be necessary to avoid excessive spans. Fibre ropes should be attached to bars by thimbled eye-splices, shackled to bar hangers or by appropriate knots, see **8.11.1**. Aluminium bars should be suitably protected when using wire rope or chain slings. The use of screw clamp type devices where the screw bears directly on the bar should be avoided.

Bridles should be fixed to the bar by hanging rings and clamps. The end overhang should be less than 1 m.

Counterweighted bars should generally be installed so that they are approximately 1 m above the stage at the bottom limit and approximately 250 mm below the grid at the top limit.

For internally-wired bars see **8.25.1**.

8.17.4 ***Operation and use***

Whenever possible, loads should be evenly distributed along the length of the bar. When this is not possible the weight should either be positioned close to the suspensions or bridles be used to distribute the load.

Cloths or drapes should be attached to a bar using ties at frequent intervals, usually secured by a bow. Battened cloths should be attached to a bar either directly by ties, secured by a clove hitch and a half hitch, or by the use of cloth clips. If cord is used to secure a battened cloth, it should be crossed under the bar before a reef knot is tied on the top of the bar.

8.18 Winches

8.18.1 ***General***

8.18.1.1 *Selection and ordering*

There are many types of winches and chain hoists. Table 14 provides guidance on the selection of suitable equipment.

Winches should be sized for the applied SWL plus the self-weight of the bar and fittings and an allowance (typically 2 % for each ball bearing pulley or 4 % for each plain bearing) for the friction in the total system.

Table 14 — Selection of winches, drums and chain hoists

Type	Description	Comments	See
Hand winch	Achieves a mechanical advantage by gearing so that rope(s) can be manually wound onto a drum where rapid movement is not required, for example when lowering luminaires for maintenance.	May be temporary or permanent. Low cost. Slow.	**8.18.2**
Power winch	Achieves the paying-out or hauling-in of a rope by powered effort, for example electric, hydraulic, pneumatic.	May be temporary or permanent. Rapid movement possible, variable speed.	**8.18.3**
Donkey winch	Generally portable. Enables a power drive to be temporarily attached to a piece of equipment so that it operates under power, for example in order to overcome a loading problem or a failure of a winch. Many donkey winches are hand held tools. Often referred to as "power assists".	Temporary. Not intended for permanent use.	**8.18.4**
Jaw-operated winch	Pulls a steel wire rope through two sets of parallel jaws on operation of a hand lever. Often used as a temporary aid to positioning or tensioning items.	Temporary. Highly dangerous if rope not in good condition.	**8.18.5**
Chain hoist	Manufactured in two basic types: manual or powered. Powered chain hoists can be electrically, pneumatically or hydraulically driven.	May be temporary or permanent. Noisy. Slow if manual.	**8.19**
Lever hoist	A variant of a hand chain hoist, using a ratchet lever instead of a hand chain to operate the lifting mechanism. Often used as a temporary aid to positioning or tensioning items.	Temporary. Slow.	**8.19.6**
Power flying system	Distinguished from a collection of individual powered winches or chain hoists by the provision of a central control that enables groups of lifting machines to be operated by a single operator (via an electronic programmable control desk).	Usually permanent. Costly. Highly skilled operator(s) required.	**8.23**

Winches may be supplied with various types of drum as follows.

a) *Plain drums*

Winches with plain drums are most suitable where infrequent manual operation is envisaged, for example the suspension of a house border. Ropes tend to feed poorly onto plain drums; this is particularly pronounced where several ropes feed onto a multi-compartment drum. The relatively short drum causes problems with over-layering and ropes tend to pile, then slip and crush, causing difficulties with trim and possibly accidents. Rope guides are essential.

b) *Grooved drums*

Winches with grooved drums are usually selected where power operation is intended. Grooved drums are necessarily long, especially if several ropes are fed onto one drum. There should be no problems with layering and limits are easily set when using powered grooved drums.

c) *Pile winding drums*

Pile winding drums were developed to overcome the problems with layering with plain drums. The lift per drum revolution increases with the number of turns on the drum. Pile winding drums are most effective with relatively light loads and short lifts. Winches with pile winding drums are relatively compact and ropes maintain trim. Rope selection is critical as ropes tend to become crushed. Where pile winding drums are used, the drums and side-flanges should be selected to suit the size of wire rope to be used. Pile winding drums are relatively easy to use with donkey winches but setting of limits may be difficult. See BS 7905-1:2001, **6.4.4**.

8.18.1.2 *Installation and removal*

Winches may be installed temporarily or as part of a permanent installation, but in all cases should be firmly fixed to a load-bearing structure.

A minimum of three full turns of rope should remain on the drum at all times.

Where multiple drums are used, care should be taken to ensure each rope is fixed and that layering starts at the same angular position. Where plain drums are used, the positioning of the drum and first diverter pulley (or hauled item) should be arranged to minimize layering of the rope. It is preferred that single and multiple-grooved drums are sized and arranged to ensure that no layering of the rope occurs, unless the drum has been specifically designed for multi-layering by the manufacturer.

8.18.1.3 *Operation and use*

Prior to use the operator should ensure that the proposed load does not exceed the SWL marked on the winch. No attempt should be made to forcibly move a load greater than the SWL.

Crossed or twisted ropes can cause accidents.

8.18.2 ***Hand winches***

8.18.2.1 *Selection and ordering*

Hand winches should be self-sustaining on removal of effort.

8.18.2.2 *Installation and removal*

Hand winches should be installed at a suitable working height which might be approximately 800 mm above the operator's foot level. The operator should have an unrestricted view of the suspended load from the operating position.

8.18.2.3 *Operation and use*

Before operating the hand winch the operator should ensure that the handle is firmly fitted in the operating position and that the mechanism is functioning correctly.

NOTE Some handles are removeable.

No attempt should be made to force a winch where the load appears to be snagged. Forcing the winch could cause damage, breakage and injury.

The operator should ensure that the ropes wind onto the drum evenly. Crossed and twisted ropes can cause accidents.

If the operating handle is removable, it should be reversed after use so that it engages with the rope and thereby provides additional security.

8.18.3 ***Power winches***

8.18.3.1 *General*

Most power winches are manufactured for general industrial lifting and are not appropriate for lifting loads over people without additional precautions. Hoists designed for use in the entertainment industry incorporate safety features, sensors and in-built redundancy which conform to BS 7905-1 and thus may be used for lifting over people without further precautionary measures.

8.18.3.2 *Selection and ordering*

The following criteria should be considered in addition to those listed in **8.2** as appropriate.

a) The requirements of BS 7905-1:2001, **8.4**. Other types of hoist may be used when lifting over people provided the recommendations of **8.18.3** are followed.

b) Whether single or double purchase.

c) Type of drum required, see Table 14.

d) Suspension hooks and load hooks should incorporate swivels and spring-loaded gates to prevent accidental detachment of the load.

e) Type of control, for example single pendant, compatible with existing control gear or provision of new control gear.

8.18.3.3 *Maintenance, inspection and marking*

Ropes should be periodically inspected in accordance with **8.10**. Where there is evidence of leakage of lubrication, unusual noise, damage to power connections, cabling or hoses or incidents where overloading or misuse is suspected, the hoist should be withdrawn from service for inspection by a competent person prior to maintenance and approval or discard.

Where power winches can be used in different configurations, for example single or double purchase, the load and speed criteria should be clearly marked for each configuration.

Power winches that are not suitable for suspending loads over people should be marked as such.

8.18.3.4 *Installation and removal*

Where a power winch can be moved to a number of locations, means should be provided to enable it to be firmly locked in any required location. The operator should have an unrestricted view of the suspended load from the operating position. Rope retainers should be in place to ensure that the ropes wind onto the drum evenly.

Anchorages should be rated for the SWL of the power winch, including its self-weight plus any overload which could be lifted prior to overload protection mechanisms preventing further lifting. Typically this is between 140 % and 180 % of the SWL of the hoist as supplied.

Hooks should be free to rotate to eliminate twists in ropes.

After installation of a power winch, ensure that the direction of motor rotation is consistent with control panel labels, indicators and switch action for all the hoists within a given system.

Ensure top, bottom and ultimate travel limits are correctly fitted and the fleet angles conform to **8.16.2**.

8.18.3.5 *Operation and use*

Power winches conforming to BS 7905-1:2001, Clause **8** may be used for lifting operations over people without additional safety measures.

It is essential that hoists which do not conform to BS 7905-1 are not used for lifting operations over people unless the following precautions are taken.

— Where the load remains static after lifting, people should be prevented from moving under the load whilst it is being lifted and until secondary suspensions have been fitted. See **7.4.4** for guidance on secondary suspensions.

— Where the load is to move over people during a performance, suitable safety devices should be used which provide complete back-up against failure of the hoist, for example inertia-reel load arrestors. It is important that only competent operators control power winches.

— The operator should be made aware that acceleration forces impose greater loads on flown items than their dead weight. The location and operation of all emergency stop buttons should be demonstrated to the operator and to everyone else who might need to bring the equipment to a halt.

— Special attention should be given to any specific safety checks given in the manufacturer's manual.

Prior to operation of power winches the following precautions should be taken.

a) Ensure no part of the load or other item can become trapped by the rope.

b) Ensure no part of the rope can rub on any structure.

c) Ensure that the rope cannot become trapped.

d) Ensure that the path of the rope into the hoist is clear and unobstructed and the rope hangs freely.

e) Where multi-purchase hoists are used, inspect the entire fall to ensure that there are no twists in the rope. Twists can be induced by poor installation of the rope, for example where a hoist has been converted from single to multi-purchase or by allowing the hook block to rotate over and pass between falls.

f) Limits should be set to prevent any load hook running up against a grid, ceiling or other obstruction.

g) Account should be taken of the "snatch" start of many electric power winches. Typically this is equivalent to a momentary 25 % increase in load.

h) The duty rating of electrically powered hoists should not be exceeded. Typically hoists may only be used for 4 minutes in any 10 minute period at full load.

The operator should check that there is a clear path for the load and that no one is at risk prior to operating the start button. The movement of the load should be observed throughout the operation to ensure that other operations do not compromise the lift. The operator should be made aware that the winch is capable of moving irrespective of any scenery, lights, etc. in its way until either it reaches its dead or a safety device operates.

It is preferred that several separately controlled hoists are not attached to the same load. Where this cannot be reasonably avoided there should be a clear and concise method of communication between operators.

The following additional recommendations apply to multiple power winches.

i) Multiple hoists attached to the same load should run at the same speed unless specified otherwise for a given application or effect.

j) Where multiple hoists are operated from a single control panel, controls should be clearly labelled to indicate which control relates to which hoist(s). The layout of hoists in relation to the load and/or venue should be indicated.

k) The operator should either have an unrestricted view of each hoist and its load from the operating position or achieve equivalent vigilance through the use of other personnel or electronic means.

8.18.4 *Donkey winches*

8.18.4.1 *Selection and installation*

Donkey winches should be slow speed devices and be locally controlled. Where a winch is permanently connected to the load it should be considered as a power winch. Donkey winches should be interlocked with the primary drive to ensure that both drives cannot be engaged simultaneously. There should be a clearly identifiable method adjacent to the drive for disabling and stopping movement.

8.18.4.2 *Operation and use*

Donkey winches should be operated adjacent to the primary drive. The operator should have an unrestricted view of the suspended load and the donkey motor from the operating position. It is essential that only equipment which has been designed for use as a donkey winch is used for this purpose.

8.18.5 *Jaw-operated winches*

The handle length is purpose designed and should not be extended.

It is essential that only wire rope as specified by the manufacturer is used with jaw-operated winches.

8.19 Chain hoists

8.19.1 *General*

Most chain hoists are manufactured for general industrial lifting and are not appropriate for lifting loads over people without additional precautions. Hoists designed for use in the entertainment industry incorporate safety features, sensors and in-built redundancy which conform to BS 7905-1 and thus may be used for lifting over people without further precautionary measures.

8.19.2 *Selection and ordering*

The following criteria should be considered in addition to those listed in **8.2**, as appropriate.

a) The requirements of BS 7905-1:2001, **8.4.5**. Other types of hoist may be used when lifting over people provided the recommendations of **8.19.5** are followed.

b) Whether the hoist is to be rigged "hoist up" or inverted in "hoist down" mode (see **8.19.5**).

c) Whether single or double chain fall (single or double purchase).

d) Height of lift, i.e. length of chain required.

e) Whether chain bag or box and required capacity. The chain should fill a maximum of 50 % of the bag/box when the hook is fully retracted. There should be no possibility of the chain being able to spill out of the container because of inadequate capacity.

f) Chain lubrication, i.e. whether dry or wet. Hoists that are moved for different applications can be difficult to handle if the chains are oil-lubricated. Oiled chain quickly picks up contaminants. Oil lubrication is more suitable for permanently installed hoists and reduces chain wear.

g) Suspension hooks and load hooks should incorporate swivels and spring-loaded gates to prevent accidental detachment of the load.

h) Chain stops should be provided to prevent the chain being driven out of the machine.

The following additional criteria should be considered for powered hoists, where appropriate.

i) Type of control, for example single pendant, compatible with existing control gear or provision of new control gear.

j) Length of hoses, control/power cabling and type of connectors.

Table 15 provides additional guidance on the selection of electric chain hoists.

Table 15 — Selection of electric chain hoists for lifting or suspending loads over people

Hoist type as defined	Lifting (dynamic loading)		Suspension (static load)	
	Category A hoist	Category B hoist	Category A hoist	Category B hoist
Brake type	Double brake essential	May be single	—	May be single
Brake position	Brake acts directly to stop load	Brake may act via clutch	—	Brake may act via clutch
Limits	Top, bottom and (two) ultimate limits essential	Top and bottom limits desirable	—	May not be provided
Mechanical stops	End of travel stops essential	End of travel stops desirable	—	May not be provided
Emergency stop	Essential	Essential	—	May not be provided
Secondary suspension	Not necessary	Inertia reel load arrestor or similar device essential	Not necessary	Secondary suspension essential
Controller	Desirable	May not be provided	—	May not be provided

NOTE Category A hoists are declared by the manufacturer as intended for use by the entertainment industry for lifting and suspending loads over people and meeting the requirements of BS 7905-1 or DIN 56925. Category B hoists are not intended by the manufacturer for lifting or suspending loads over people.

8.19.3 *Maintenance, inspection and marking*

Chains should be periodically inspected in accordance with **8.8**. Where there is evidence of leakage of lubrication, unusual noise, damaged power connections, cabling or hoses or incidents where overloading or misuse is suspected, the hoist should be withdrawn from service for inspection by a competent person prior to maintenance or discard.

Where chain hoists can be used in different configurations, for example single or double chain fall (single or double purchase), the load and speed criteria should be clearly marked for each configuration.

Chain hoists that are not suitable for suspending loads over people should be marked as such.

8.19.4 *Installation*

Anchorages should be rated for the SWL of the chain hoist, plus its self-weight and any overload which could be lifted prior to overload protection mechanisms preventing further lifting. Typically this is between 140 % and 180 % of the SWL of the hoist as supplied.

Hooks should be free to rotate to eliminate twists in chains.

After installation of the chain hoist, ensure that the direction of motor rotation is consistent with control panel labels, indicators and switch action for all the hoists within a given system.

Chain stops and other limits on the chain hoist should be correctly fitted.

8.19.5 ***Operation and use***

Chain hoists conforming to BS 7905-1:2001, Clause **8** may be used for lifting operations over people without additional safety measures.

It is essential that hoists which do not conform to BS 7905-1 are not used for lifting operations over people unless the following precautions are taken.

— Where the load remains static after lifting, people should be prevented from moving under the load whilst it is being lifted and until secondary suspensions have been fitted. See **7.4.4** for guidance on secondary suspensions.

— Where the load is required to move over people during a performance, suitable safety devices should be used which provide failure back-up throughout the lift, for example inertia-reel load arrestors.

There are two methods of rigging chain hoists:

1) Hoist up, i.e. hoist suspended from anchorage with load chain below.

2) Hoist down, i.e. hoist inverted and suspended by load chain with load supported on machine hook so that the hoist "climbs" the chain. Only hoists which have been specified as suitable for use hoist down by the manufacturer should be rigged in this way. The chain bag should be securely attached, compatible with the hoist and correctly positioned so that chain runs naturally into bag. Power and control cables should be secured clear of the hoist path and arrangements made to feed sufficient cable for the travel of the hoist. The weight of the cable loop hanging below the hoist should not cause undue strain on power or control connectors; cabling should not become entangled in either the hoist or load.

During operation and use of chain hoists the following precautions should be taken.

a) Ensure no part of the load or other item can become trapped in the chain.

b) Ensure no part of the chain can rub on any structure.

c) Ensure that the chain cannot become trapped, for example between grid slats.

d) Ensure that the path of the chain into the hoist is clear and unobstructed and the chain hangs freely.

e) Ensure chain bags/boxes are correctly fitted and have sufficient capacity for the volume of chain.

f) Ensure manual operating chains are clear of obstructions.

g) Where hoists with double chain fall are used, inspect the entire chain fall to ensure that there are no twists in the chain. Twists can be induced by poor installation of the chain, for example where a hoist has been converted from single to double chain fall or by allowing the hook block to rotate over and pass between chain falls.

It is preferred that several separately controlled hoists are not attached to the same load. Where this cannot be reasonably avoided there should be a clear and concise method of communication between operators.

The following additional recommendations apply to powered chain hoists.

h) Multiple hoists attached to the same load should run at the same speed unless specified otherwise for a given application or effect.

i) Where multiple hoists are operated from a single control panel, controls should be clearly labelled to indicate which control relates to which hoist(s). The layout of hoists in relation to the load and/or venue should be indicated.

j) The operator should either have an unrestricted view of each hoist and its load from the operating position or achieve equivalent vigilance through the use of other personnel or electronic means.

k) Where hoists are rigged out of view, for example above a grid or in a roof void, regular checks should be made of the integrity and stability of chain bags and to ensure that chains are running correctly into them.

l) Limits should be set to prevent any load hook or hoist, if inverted, running up against a grid, ceiling or other obstruction.

m) Account should be taken of the "snatch" start of many electric chain hoists. Typically this is equivalent to a momentary 25 % increase in load.

n) The duty rating of electrically powered hoists should not be exceeded. Typically hoists may only be used for 4 minutes in any 10 minute period at full load.

8.19.6 *Lever hoists*

The handle length is purpose designed and should not be extended.

Due to the relatively short chain used in lever hoists, twists develop readily, especially if the hook is in direct contact with the load. The chain should not contact any surface when under load.

8.20 Hemp sets and direct hauled fibre ropes

NOTE In this clause hemp set refers to any use of fibre ropes for direct lifting of scenery by manual effort. The ropes are generally taken over pulley blocks mounted above the performance area, on a grid or under structural members, and thence via head blocks (pulleys) above the operating position to the fly gallery or floor level. Other arrangements include using wire rope suspensions from the bar clewed to a fibre rope for manual operation which may be reeved to provide mechanical advantage.

8.20.1 *Selection and ordering*

The load to be carried by any hemp set is determined by the effort that can be applied by the operator (or operators). Rope sizes used for hemp sets vary between 16 mm to 22 mm diameter. It is impracticable to use anything larger than 16 mm rope for multiple rope sets because of the bulk to be gripped by the operator's hands.

8.20.2 *Marking*

Ropes of different lengths used in hemp sets should be colour coded, for example the ends dyed or one strand coloured, for easy identification and assembly into sets.

8.20.3 *Installation and removal*

Ropes used in hemp sets should be free-running. They should not rub or chafe against structures, pulley blocks or adjacent scenery. Ropes should not run in close proximity to luminaires as this can cause scorching, burning and failure of the ropes.

8.20.4 *Maintenance*

Rope ends of hemp sets should be reversed periodically to equalize wear.

8.20.5 *Attachment of load*

Frayed ropes should not be used for lifting or suspending a load.

Assuming the bar is at grid level, the operator should check that the stage is clear, then slowly lower the bar. When the bar is at the required height, the ropes should be tied off to the cleat and the load attached. The weight of the load should have been checked prior to its attachment to the bar.

Once the load is attached, the operator(s) should first tug the ropes while they are still tied-off to check the weight of the load. If the load cannot be raised easily then either the load is too great and needs reducing or stronger operator(s) are needed. It is good practice not to use more than two operators. If more than two are needed a different method of suspension should be chosen; this might be by using a counterweight to assist. Specialist experience is needed if this method is adopted.

Once the load can be safely raised, the ropes should be untied from the cleat using one hand, whilst holding the ropes in the other to take the strain. The ropes should then be pulled down to raise the bar to the required position and the ropes tied off on the top cleat.

Where fibre ropes are used for hanging lighting equipment, wire rope or chain secondary suspensions should be provided. Consideration should also be given to the use of wire rope or chain secondary suspensions where static scenery is hung on fibre ropes.

8.20.6 *Operation and use*

The following guidance is applicable to the operation and use of hemp sets.

a) A hemp set depends upon the direct pulling force of the operator on the hauling ropes. Therefore it is essential that the operator be of a reasonable strength. Gloves should be worn for safety reasons.

b) If the load is moved during the performance, deads should be marked on the hauling ropes. Deads may be of coloured adhesive tape stretched around the rope or, preferably, fabric threaded through the rope lay and whipped/knotted in position. The position of the dead should relate to the top cleat of the cleat rail with the load in the "out" position. The lower cleat is used to hold the load in the (lowest) "in" position. Further deads are necessary if there are multiple positions for the load. Warning indicators of approaching deads may also be necessary, depending upon the speed of operation.

c) Sudden jerks should be avoided. The strain should be applied to, and removed from ropes smoothly and progressively. The kinking of ropes should be avoided. Damage can occur if a kinked rope is pulled through a pulley block.

d) Ropes should be secured to the cleat by two figure of eight turns. The second turn should incorporate a tuck to lock the whole tie. (See **8.11**).

e) To lower a bar under load, the operator should first pull on the ropes to check the weight before carefully lowering the bar by easing the ropes through the cleat to aid control. If the bar is felt to be too heavy it should not be moved and assistance sought.

f) To level a bar, the operator should hold two ropes tightly and pull or slacken the third or other ropes as required. This adjusts the level of the barrel. Once adjusted, the ropes should be retied to a cleat.

8.21 Counterweight systems

8.21.1 *General*

The counterweight system is a method of reducing the force necessary to raise loads by balancing part of the load with weights. It permits the comparatively fast and controlled movement of loads by hand. The load is suspended by wire ropes attached to a counterweight cradle that is guided to move vertically. The cradle is moved by manual hauling of a fibre rope.

The two methods of balancing and hauling the load define the types of counterweight system in common use. The types of counterweight system in common use are:

a) *Single purchase (direct balance)*

The suspension ropes from the load pass over pulleys and are attached to a variable counterweight. The counterweight typically consists of a cradle into which weights are placed to nearly balance the load. A fibre rope, attached to top and bottom of the counterweight, is used to haul the counterweight up and down. See Figure 14.

b) *Double purchase (indirect balance)*

The suspension ropes from the load pass around pulleys fixed to the top of the cradle and are made-off to a suitable point of the building. This system requires more effort from the operators and also requires adding and removing twice as many weights from the cradle. The hauling rope on such systems is generally also double purchase to reduce the force required. See Figure 15.

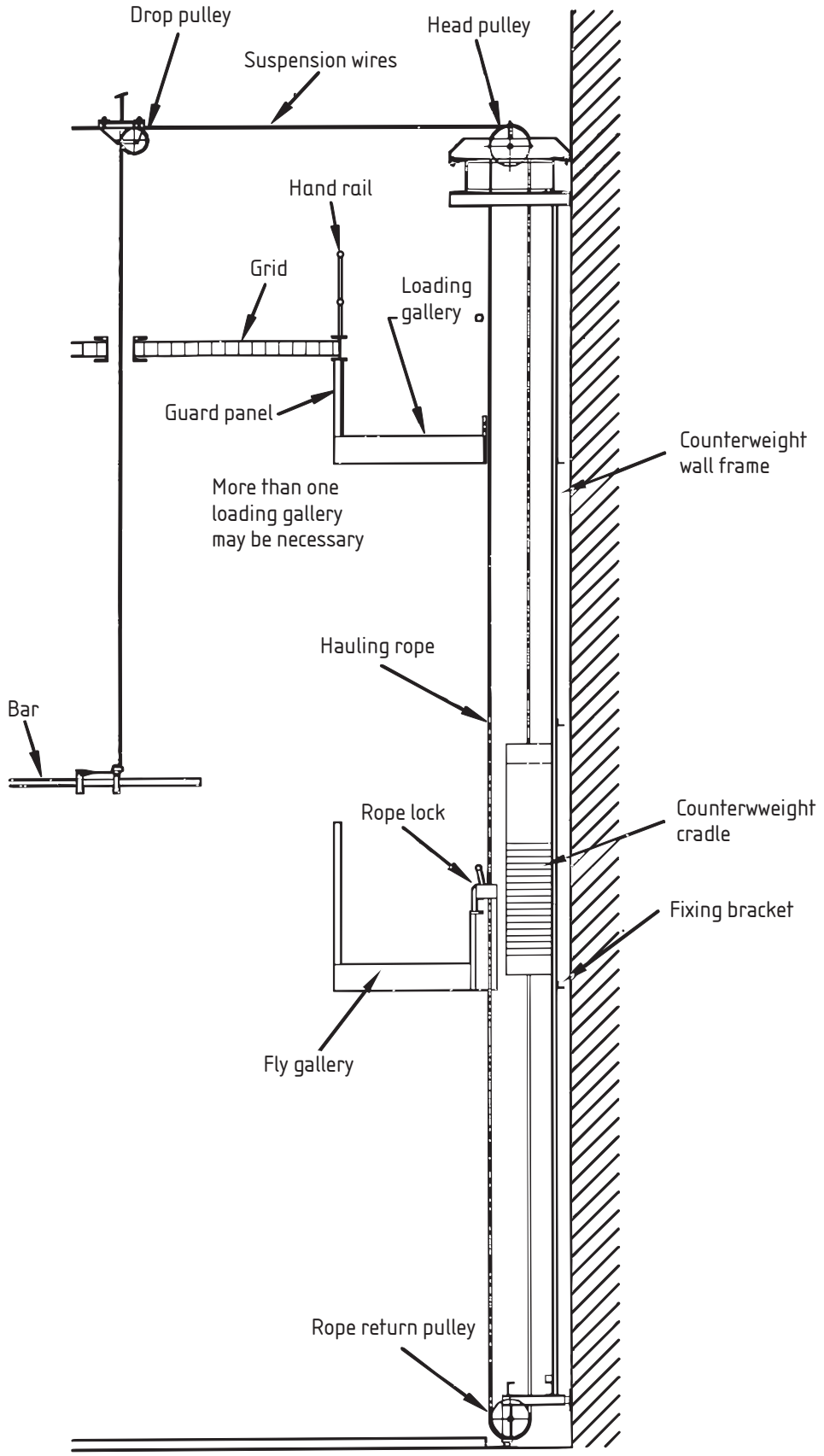


Figure 14 — Single purchase counterweight system

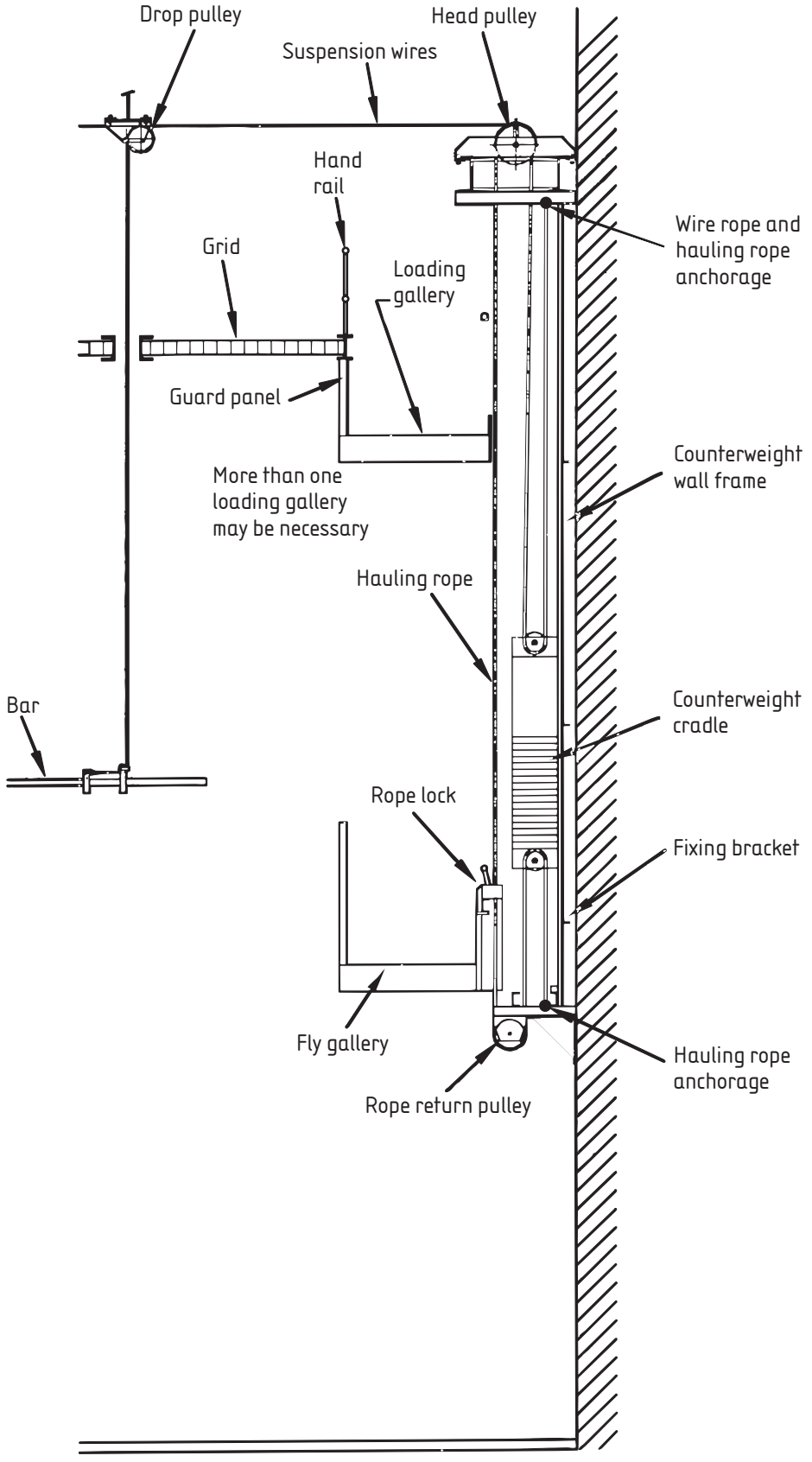


Figure 15 — Double purchase counterweight system

8.21.2 *Selection and ordering*

Counterweight systems are available from many sources but it should be noted that components might not be interchangeable and performance and operational features vary.

8.21.3 *Attachment of load*

Assuming that the bar is empty and at its top dead below the grid, the operator should check that the stage is clear, then, whilst holding both parts of the hauling rope together, slowly release the rope lock. The bar should either remain stationary or if it moves, the rope lock should be reapplied and the reason for the movement investigated. Once any problem has been resolved, the operator should pull down carefully on the hauling rope until the cradle touches its top stop when the rope lock should be applied.

The bar should now be at a safe working height from the stage floor. The load should be attached to the bar, ensuring as far as possible that it is evenly spread along the full length of the bar.

It may be possible to rig an unwieldy item such as a large ceiling piece by attaching the load to two or more bars. This should only be attempted after a risk assessment confirms that controlled operation will be achieved and that the load will withstand any stresses that might be imposed if uniform speeds of lifting were not maintained. If the load is heavy or doubts remain about the possibility of a controlled lift, a different suspension system should be used.

When the load has been securely attached to the bar, balance weights should be placed into the cradle one at a time. During this procedure the balance should be assessed by checking the tension in the hauling rope. Care should be taken when loading the cradle. If in doubt wear a safety harness.

A counterweight cradle, when properly designed accepts only the necessary number of weights to counterbalance the maximum SWL for the bar. Therefore, if the cradle is filled to capacity and excessive force is required to move it, the load on the bar is too great. Extra weights or winches should not be utilized to compensate for an overweight load. It might be possible to link two counterweight cradles together in order to share the load between two counterweight sets; however this should only be attempted by a competent person.

Once near-balance has been achieved, the cradle should be lowered to fly floor working height and the rope lock applied. Trimming weights should then be loaded into the cradle as necessary to ensure that the weight in the cradle is slightly heavier than the weight on the bar. Where half-weights are used these should be located under full weights. It is important that, in the unlikely event of rope lock failure, the bar will rise slowly and not fall in an uncontrolled manner towards the stage. Once trimmed the counterweight is ready for use.

8.21.4 *Operation and use*

The following guidance is applicable to the operation and use of counterweight systems.

a) Gloves should be worn for safety reasons.

b) The rope lock should not be used to brake the movement of the cradle.

c) The rope lock should not be used to hold a significantly out-of-balance load.

d) The counterweight frame guards should be removed only for maintenance.

e) Nothing should be leant into the counterweight wall frame.

f) The cradle should be slightly heavier than the load at all times.

g) The rope lock should be applied when the counterweight is not in use. If the counterweight is not going to be moved for a long time, the cradle should be secured against movement, for example by lashing to the bottom stop, and the rope lock left unlocked as this helps prevent the rope from deforming.

h) Where two rope locks are fitted, for example at gallery and at stage level, only one should be in use at any one time. It is recommended that the out of use lock is removed or otherwise rendered inoperable to guard against accidental engagement.

i) It may be necessary to raise or lower the bar during a performance to given positions. Experience will help to determine these. Deads should be marked, for example by stretching coloured tape around the hauling rope which lines up with the rope lock or with a mark on the guide channel when in the correct position for the cue. Warning indicators of approaching deads may also be necessary, depending on the speed of operation.

8.21.5 *Removal of load*

To remove the load from the bar, the cradle should first be raised to its top stop and the rope lock applied. The balance weights should then be carefully removed, leaving only any permanent weights which should always remain in the cradle; to balance the dead weight of the bar and cradle. These weights should either be permanently secured within the cradle or be colour coded, to warn against accidental removal.

Once the balance weights have been removed, the load may be removed from the bar. It is then safe to raise the bar to its storage position. It is essential that the load is not removed from the bar until the cradle has been unloaded; to reverse the sequence is very dangerous.

8.21.6 *Motorizing counterweight sets*

If it is proposed to motorize an existing counterweight set, the information on power-assisted counterweight sets given in BS 7905-1:2001, **8.4.7** should be considered.

8.22 Drum and shaft systems

NOTE Drum and shaft systems were extremely popular until the mid-twentieth century, particularly for transformation scenes. The systems offer a method of achieving mechanical advantage by using a hauling rope to turn a large diameter drum that winds suspension ropes onto a smaller diameter shaft. This permits the synchronous movement of multiple scenic items. The suspension lines are directly attached to the load; this makes drum and shaft systems particularly useful for low grids and lifting large items such as ceilings.

8.22.1 *Selection and ordering*

No standard equipment exists for these systems. Ratios between drum and shaft vary, typically drums are between 1 m and 2.5 m diameter with shafts around 300 mm diameter.

The loading depends on the SWL of the ropes and components used. The need to avoid deflection of the shaft normally determines the maximum loading achievable. A typical loading on the shaft would not exceed 250 kg unless the system is specifically designed to cope with greater loads.

8.22.2 *Installation and use*

All the ropes, and wherever possible the bearings, should be replaced if the mechanism has not been used for a long period. The mechanism should also be checked for any loose components.

The hauling rope should be of at least 25 mm diameter for ease of handling. The hauling rope should take three or four turns around the drum. Both ends of the rope should then be reeved though head blocks above the fly floor and spliced into a loose loop. Hauling on either part of the rope will cause the drum to revolve. The rope may be secured to a suitable cleat.

The hauling rope should not be attached to a winch or windlass. The mechanism's inherent mechanical advantage should ensure that two men can haul out the scenery. Any additional gearing introduced by means of a winch would simply slow down the rate at which the scenery can be raised, although motorizing is possible.

Most drum and shaft mechanisms are located with the shaft running up and down stage. The suspension ropes should be attached to the shaft so as to ensure that no over-layering of the ropes occurs, typically centres are approximately 600 mm with fibre ropes. Wire ropes should only be used on a shaft intended for this purpose. Moveable plates should be attached to the shaft to limit the winding area of each rope. If over-layering occurred, the differential uptake on the shaft would cause the scenery to hang at an angle. Ropes can be re-located through different pulley blocks provided the recommended maximum fleet angle is not exceeded. The positioning of the suspension ropes on the shaft cannot be permanent as different productions require the scenery to be hung in different positions. Levelling of the suspensions should be carried out at the attachment to the scenery as adjustment on the shaft is difficult.

If an exceptionally heavy piece of scenery is to be attached to the mechanism, it might be necessary to rig a rope with a counterweight to assist the operator. This is done by attaching a rope to the shaft at any convenient point, ensuring that it is rigged to wind in the opposite direction to the suspension ropes. Thus, when the scenery is raised, the counterweight descends and vice versa. Adequate guarding should be provided for the travel of the counterweight.

Similarly it is possible to rig two sets of suspension ropes wound on to the shaft in opposite directions. This will mean that one of the suspended items is in the lowered position when the other is at top dead. In this case the two loads will tend to counterbalance each other.

After installation the user should be advised of the total weight suspended as this might not be apparent on the hauling rope because of the mechanical advantage and minimal friction losses in the system.

8.23 Power flying systems

NOTE A power flying system may be permanent or temporary and can be distinguished from a collection of individual powered winches or chain hoists by the provision of some form of central control which enables groups of lifting machines to be operated by a single operator via an electronic programmable control desk.

8.23.1 *Selection and ordering*

NOTE 1 Clause **6** gives general guidance on the specification, selection and installation of both temporary and permanent systems.

NOTE 2 Power flying systems rely on safety features such as limits, over-load, slack-wire, out of position and over-speed sensors to ensure safe operation as it is not possible for the operator to monitor every machine and its operation.

The following criteria should be addressed when selecting a power flying system.

a) Individual lifting machines should conform to BS 7905-1:2001, **8.4**, which includes details of requirements for travel limits and safety sensors.

b) System controls should conform to BS 7905-1:2001, Clause **10**, which includes details of features such as emergency stop arrangements, information display and basic control.

c) The availability of personnel skilled in operation and maintenance of the system and training arrangements.

d) Operators should be able to monitor each and every machine in use at any time. The minimum information displayed should include position, speed and direction of movement. An alarm system should provide appropriate warnings if individual safety sensors are triggered or machines operate outside of safe pre-set parameters for acceleration, speed and position. Provision for the indication of load carried by each machine is recommended. This feature can be compared with the "feel" experienced by an operator using a manually hauled lifting machine such as a counterweight flying system. All information should be displayed in a clear and concise way. If the display provides an animated view of current or impending motion, it should be immediately clear whether the information displayed is "real" or "simulated".

e) Where a group of lifting machines are to be used to lift the same load, a method of ensuring synchronized control should be provided such that, in the case of failure of one or more machines within the group, an interlock stops all machines in the group.

f) A method of programming motion of lifting machines for playback in performance is usually required. The proposed system should be intuitive to use and likely to be capable of realizing the demands of designers and directors.

g) Consider the flexibility of the system, for example, whether the operator can intervene in multiple pre-recorded motions in order to adjust the motion of one or more items to react to real events such as performers being in the wrong place or whether it is essential that all motion stops in these circumstances.

h) Consider whether the operator is likely to be able to keep track of what is taking place at any time and be able to make safe decisions when systems malfunction or external untoward events occur.

i) Provision of methods for recording the current use of individual lifting machines, providing cue plots and back-up paperwork is desirable.

8.23.2 *Installation*

Control positions should enable maximum operator vigilance of lifting activities. Control desks should not obstruct observation of the actual machines. Aids such as infra-red enhanced CCTV to assist dark vision should be provided, where appropriate.

8.23.3 *Inspection and maintenance*

NOTE Correct maintenance procedures form a major part of ensuring continuing safe and efficient use of power flying systems. Guidance on the inspection and maintenance of individual lifting machines is provided elsewhere in this standard and applies equally to the lifting machines included in a power flying system.

Preventive maintenance should be planned and carried out according to a documented regime. Logs of all maintenance and inspections should be maintained as these can be useful in predicting maintenance trends and as an aid to fault finding.

A regime should be established to test system functions on a regular basis, for example correct operation and reporting of limits, over-load sensors, emergency stop functions etc.

8.23.4 *Operation and use*

To ensure the safe use of power flying systems attention should be given to the following.

a) Use of the system should be restricted to those who have been trained and shown to be competent. Operator training should include basic knowledge of how the lifting system works and first line fault diagnosis. An important aspect of operator training is to ensure that safe decisions are made if malfunctions occur.

b) Comprehensive information should be readily available to the operator, detailing operational functions and venue specific procedures for rigging/de-rigging, performance and inspection/maintenance activities.

c) Each different use of the system should be pre-planned and involve discussion between experienced operational personnel and designers/directors/production managers to ensure that the proposed use is achievable. All agreed loading and speed of motion as well as numbers of individual actions occurring at one time should be within the capability of the system.

d) Clear and concise communication should be maintained between operators and other personnel when rigging and de-rigging equipment. A clear line of communication should be set up to ensure that the operator can concentrate on the task at hand and not become over-loaded with requests from several sources. Where different operators are responsible for operating different lifting equipment, the areas of responsibility should be clearly defined. Shouting of instructions should be avoided, the use of radios or other focussed communication systems is preferred.

e) In performance situations the signal for initiation of pre-recorded motion should be unambiguous. Cue light signals should be confirmed by verbal commands. Operators should have clear sight of the moving item, spotters or electronic means such as CCTV may be used as aids to achieve adequate vigilance.

f) Measures should be taken to ensure operators are not overstressed. Such measures might include additional operators, sufficient rest periods and good communication.

g) A clear procedure should be in place on operation of any emergency stop. This should include ascertaining the reason for the stoppage and consultation with appropriately competent personnel prior to resetting the system.

h) A system log should be kept detailing any problems encountered whether from system or external sources. Operators should report faults or any abnormality to appropriate personnel.

8.24 Overhead tracks

NOTE There are many types of track, including purpose manufactured extrusions, rolled steel joists (RSJs) and fabricated track sections, which may be used for hanging curtains and other scenic elements. Turntables, drop-out sections and switchable track points may be incorporated in some types of track. Trolleys are wheeled load connectors that allow lateral movement of the load when installed on suitable tracks. Types of trolleys are also known as runners and bobbins. In this clause the various types are all referred to as trolleys.

8.24.1 *Selection and ordering*

When selecting overhead track the following steps should be carried out, as appropriate.

a) Provide a drawing/sketch giving dimensions and showing the general arrangement of the track.

b) Detail any special features required, e.g. turntables, switching track points or drop-out sections including the amount of vertical travel required, and any additional features such as end frames for curtain stretching.

c) Determine the required SWL per trolley, the self-weight and any load distribution restrictions.

d) Decide the number and spacing of trolleys per track.

e) Decide the extent of travel required by the trolley.

f) Establish details of any hoists and diverter pulleys to be used in conjunction with the track and trolleys.

g) Establish if motorized travel is required, specifying type, such as linear motor or rope-hauled operation. Allow approximately 500 mm over-travel.

h) Consider required service life.

i) Supply full specification or name and model identification where known or appropriate. Note any particular features different from those normally supplied by the manufacturer.

Universal beams or RSJs used as runway beams should conform to BS 2853.

8.24.2 *Installation*

When installing overhead track the following steps should be carried out.

a) Establish the required loading.

b) Establish any special requirements, e.g. turntables, switching track points or drop-out sections.

c) Establish length of travel required including any overlaps. If power-operated allow approximately 500 mm over-travel.

d) Ensure an adequate number of mountings are securely fixed. Allow for all positions of trolley travel, such as bunching at ends, which necessitate additional support.

e) Establish required number and capacity of trolleys.

f) Ensure the track is level with correctly aligned joints.

g) Install trolleys and fit end-stops.

h) Fit hauling ropes, tensioners and intermediate rope supports as required.

i) Ensure that hauling ropes and any power cables do not obstruct trolley travel and are not likely to be damaged.

8.24.3 *Operation and use*

During operation and use of overhead track the following steps should be carried out.

a) Ensure operating ropes are correctly tensioned.

b) Do not force trolleys to move. If snagged investigate cause and rectify before continuing operation.

8.25 Luminaire suspensions

NOTE Specialist luminaire suspensions include lighting bars and hoists, monopoles and pantographs which are generally permanently installed. They may support a mixture of luminaires and other items. The bar is usually round, with electrical outlets positioned conveniently above, so items can be supported and plugged into suitable circuits.

8.25.1 *General*

All lighting bars should be level. A temporary "cross" bar may be suspended from two lighting bars or hoists and care should be taken to ensure the temporary bar remains level. Rigging or de-rigging of moveable or portable luminaire suspensions should be carried out in accordance with the manufacturer's handling instructions.

The loading of internally-wired bars should not exceed manufacturer's instructions.

8.25.2 *Selection and ordering*

The lengths of lighting bars should be specified. The capacity of each lighting circuit, the types of circuit outlets connectors, and facilities for connection to site wiring, together with details of any communications outlets should be specified.

8.25.3 *Marking*

Luminaire suspensions should be marked in accordance with **8.3**. Marking should include capacity of each lighting circuit provided as part of the suspension.

8.25.4 *Storage*

Physical support to the luminaire suspension during storage should either be equivalent to the conditions in service, or by means of dedicated fixtures to ensure stability and freedom from adverse loading.

8.25.5 *Lighting bars and hoists*

8.25.5.1 *Loading*

When loading lighting bars or hoists the following steps should be carried out.

a) Ensure that the effective centre of gravity of the combined load is well within the positions of the outermost suspension wires.

b) Ensure the load is secure and within the SWL marked on the equipment. Ensure that any uniformly distributed load restrictions are obeyed.

c) Select a suitable safety chain or bond for each luminaire. Secure it to the secondary suspension point on the luminaire and use up any excess length by wrapping extra turns around the bar so that, should the primary attachment be removed, the luminaire can drop no more than 150 mm before the secondary suspension supports the load.

d) Set the luminaires as they are required when raised to working height.

e) Plug the luminaire into the chosen lighting circuit outlet. Ensure that the cable is routed for protection from damage during movement and from overheating by any luminaire or other equipment.

8.25.5.2 *Raise/lower*

When raising/lowering lighting bars or hoists the following steps should be carried out.

a) Raise or lower carefully for a short distance and stop if there is cause for concern.

b) Observe any cable handling system and ensure correct behaviour.

c) Control the movement in accordance with the manufacturer's manual. Brailing of lighting hoists should be avoided.

d) Take care to ensure any wire rope is unobstructed and runs without chafe. Foreign items should not contact wire ropes.

8.25.5.3 *Unloading*

When unloading lighting hoists the following steps should be carried out.

a) Unplug electrical circuits and disengage safety chains and bonds before removing luminaires.

b) Plan a sequence for unloading luminaires which ensures stability throughout the operation.

8.25.6 *Monopoles*

8.25.6.1 *Loading*

When loading monopoles the following steps should be carried out.

a) Ensure the centre of gravity of the load on the monopole is directly in line with the vertical axis of the telescopic tube set.

b) Monopoles with built-in universal joints that ensure control over the orientation of the luminaire are preferred. Ensure that the universal joint, where provided, is working effectively.

8.25.6.2 *Traverse*

When traversing monopoles the following steps should be carried out.

a) Ensure the monopole is traversed by means of application of effort at grid or track level, do not drag the monopole along by applying lateral force to the telescopic tube assembly.

b) Ensure that tracks for the monopole are smooth, level and without damage or obstruction.

c) Do not tilt the telescopic tube assembly from the vertical.

d) Ensure that during the traverse operation any swing of monopole is controlled and is less than 3°.

8.25.6.3 *Track transfer*

When track transfering monopoles the following steps should be carried out.

a) Follow the method for track transfer of the monopole given in the manufacturer's manual, and take care to avoid damage.

b) Carry out track transfer of the monopole smoothly and avoid any risk of impact, or shock loading.

8.25.7 ***Pantographs***

8.25.7.1 *General*

Pantographs support loads by spring tension, or by wire ropes, hand or motor powered. Pantographs are primarily used for suspending luminaires.

8.25.7.2 *Loading*

When loading pantographs the following steps should be carried out.

a) Ensure that the centre of gravity of the load is in line with the vertical axis of the mechanism to ensure safe operation.

b) Apply balancing weights or adjust the springs as necessary in accordance with the manufacturer's instructions.

8.25.7.3 *Traverse*

When traversing pantographs the following steps should be carried out.

a) Ensure that traverse of pantographs is achieved by means of application of effort at track level, do not drag along by applying lateral force to the load.

b) Ensure that traverse tracking is smooth and level without damage or obstruction.

c) Ensure that all track loading positions of pantographs are closed before any movement takes place.

8.25.7.4 *Raise/lower*

When raising/lowering pantographs the following steps should be carried out.

a) Ensure that movement of pantographs is achieved without undue effort, and ensure slow movement near the ends of travel range.

b) Avoid slack rope condition.

c) Ensure that no rope or electrical cable can come into contact with any spring or scissor mechanism of the pantograph.

8.25.7.5 *Unloading*

When unloading spring type pantographs the following steps should be carried out.

a) Support the load and push the pantograph upwards until the pantograph is fully shut.

b) Detach the luminaire having ensured that the pantograph cannot retract further when the load is removed.

When unloading wire rope type pantographs the following steps should be carried out.

a) Lower the pantograph to a suitable trolley, fixture or surface to accept load, so that the ropes are almost slack.

b) Uncouple the pantograph from the load without any movement of the load and then raise the pantograph clear of the uncoupled load.

9 Flying of performers

NOTE This clause may also be applied to the illusionistic flying of objects. Performer flying often involves the creation of illusion, therefore some of the components used are selected with minimal size as a primary criterion. Typically these components are the steel wire rope(s) attached from the performer to the rest of the flying system. Typically these are of 1x19 construction and are termed in-view flying wires.

9.1 General

All performer flying sequences should be carefully planned to include risk assessments, selection of appropriate equipment, establishment of availability of competent operators and provision for adequate preparation of flown performers.

Performer flying should be supervised by a competent person who is the point of contact for the performer(s) throughout the flying procedure.

9.2 Equipment

Lifting machinery used in performer flying should be installed in accordance with Clause **6**. Lifting machinery and methods of attachment used for the flying of performers should conform to BS 7905-1:2001, Clause **9**.

It is often necessary to design new or modify existing lifting machinery to achieve a specific performer flying effect. Such equipment should be modified/designed by a competent person who has addressed the following criteria:

a) Weight of the performer(s) including props and costumes.

b) Suspension angles, acceleration, deceleration, centrifugal force, performance choreography and any other factors which determine the maximum loading on any component of the system.

c) Lifting accessories should be chosen in accordance with Clause **7**.

d) Harnesses should be designed to fit the specific performer and should not cause discomfort or injury in normal use. Harnesses should be manufactured with a safety factor of 8 and load tested to at least 1.5 times the performer's weight. Costume or make-up effects should not cause any degradation to the harness nor limit access to inspect stitching, adjustments or attachments. Harnesses should be treated as items of lifting equipment not costume. Flying wire connection mechanisms should be certified using a safety factor of 8, remain secure when slack and when under load, and lock positively requiring a definite action to release.

e) Where performers are supported on flying props the props should be treated as part of the lifting equipment and be manufactured with a minimum safety factor of 8 and load tested to at least 1.5 times the weight of the performer. If there is a risk of performers falling off they should be secured to the prop by means of a harness and lifting accessories which conform to **8.13.2**.

f) Wire ropes used in a performer flying system should have a safety factor of 10. This applies to all operating (lift) ropes and any ropes used to support the system over the performance space. It is recognized that in-view flying wires on which performers are suspended need by their nature to be as thin as possible and may use a lower safety factor provided that the flying wire conforms to BS 7905-1:2001, Clause **9**. The safety factor applied should be not less than 5.

g) A minimum safety factor of 5 should be used for all wires in any system of three or less in-view flying wires where the weight of the performer might be primarily supported by a single wire during any part of the performance. In systems of three or more in-view flying wires where the weight of the performer cannot be primarily transferred to one wire a safety factor of 5 may be applied to the combined breaking strength of all flying wires.

h) Manually controlled fibre lift ropes should have a safety factor of 10.

i) Pulleys and drums and other machinery should conform to BS 7905-1:2001, Clause **6**. Special attention should be paid to pulleys carrying wires subject to swing where there is risk of fleet angles being exceeded. Means to prevent this should be incorporated.

j) Wire rope terminations should conform to BS 7905-1:2001, **5.3.4** and be fitted and tested in accordance with the manufacturer's instructions.

k) Care should be taken to ensure that any anchorages are sufficient to withstand the dynamic forces arising from the performance.

l) Motorized systems and controls should conform to BS 7905-1:2001, **8.4** and **9.2.5**.

9.3 Operation and use

Flown performers should be fully prepared for the flying sequence to enable them to be confident about what they are being asked to do. Extra time should be allowed for performers who have never been flown before.

Performer flying sequences should be planned carefully and involve discussions between the director, performer(s) and the competent person supervising the operation of the flying equipment. It is important to ensure that what is proposed is safe for the performer(s) and all other personnel and is within the safe operational capabilities of the equipment and the operators. The flying sequence should be rehearsed in sections in good working light before attempting the full sequence under performance conditions. Once the rehearsal process is complete no changes should be made to the sequence or operating procedures without further rehearsal and consultation between director, competent person and performer(s) as appropriate. Operators should be trained to enable them to have an adequate understanding of the operation of the flying system and controls including an awareness of operational limits and hazards. People who are required to attach or detach flown performers from flying wires during the performance such as other performers, should be adequately trained. An agreed "distress signal" should be established for use by performers. It might be appropriate to agree a system of two-way communication between the operator and the performer where this is practicable.

Harnesses should be made as comfortable as possible and where necessary additional padding should be provided. Harnesses should be uniquely identified and allocated to a specific performer. It is essential that performers are fully rehearsed and have expressed confidence in the use of their harnesses. The fitting and adjustment of harnesses should be checked by competent personnel prior to each use. Procedures should be in place to ensure performers are not suspended for long periods, this is an important consideration in a rehearsal situation.

Flown performers or equipment operators should be instructed not to participate in flying activities if their ability is impaired, for example due to alcohol, drugs or tiredness.

Operators should have a clear unobstructed view of the performer(s) throughout the flying sequence. Where more than one operator is required to achieve an effect, for example separate horizontal and vertical motion of the performer(s), a clear and reliable method of communication between operators should be provided. Where the flying sequence involves multiple performers flown by more than one operator arrangements should be in place to ensure the co-ordination of individual movements is maintained at all times. Methods such as spotters or electronic means, for example infra-red enhanced CCTV, may be used to assist this process.

Where the sequence involves the attachment/detachment of performers to/from flying wires during the performance i.e. on-stage, it is essential to ensure that a clear, unambiguous signalling/communication system is implemented to ensure performers are safely attached prior to lifting or detached prior to lines being flown out. Sandbags should be attached to wires as soon as they are detached from performers to ensure that the wires do not become kinked.

It is important that a compensatory weight is used where necessary to maintain stability, for example with a counterweight system, if the performer has to step on or off a flown item.

For all systems, but especially powered systems, methods of rescue should be provided which are safe for both rescuers and rescued and available to cover failures such as equipment jamming or power failure. Planning of rescue methods should include scenarios where the person is injured/unconscious. It is important that rescue methods are rehearsed.

9.4 Inspection and maintenance

Performer flying harnesses should be inspected by a competent person prior to each performance and competent personnel should ensure that the harnesses have been fitted correctly before each use.

A documented inspection regime in accordance with **6.7** should be in place to ensure periodic inspection of all parts of the performer flying equipment. The entire performer flying system should be visually inspected, as far as is practicable, prior to every performance with close attention being paid to the condition of in-view flying wires. Any in-view flying wire which has a safety factor less than 10 applied should be fully inspected along its entire length including terminations prior to each performance. It is essential to replace wires at the slightest sign of degradation.

Spare wires should be immediately available to enable quick replacement. Spare wires should be handled and stored with great care.

Procedures should be in place to record any unusual occurrences or indications of malfunction such as unusual "feel" sensed by operators/performers or unusual noises etc. These procedures should ensure that all such incidents are addressed through inspection and maintenance by competent personnel prior to the next performance. Operators should be adequately trained in order to make justifiable decisions about the continued use of the equipment during a performance should abnormal incidents occur or if there is reason to doubt the safety of the equipment.

All maintenance and inspection procedures should be carried out by competent personnel.

10 Technician lifting for access purposes

10.1 General

Technicians may be lifted as a method of access using lifting machinery conforming to BS 7905-1 and installed in accordance with Clause **6**. Operational procedure is similar to that recommended in Clause **9** except that all wire ropes used for technician lifting should have a safety factor of 10.

10.2 Equipment

Lifting machinery used for technician lifting should be installed in accordance with Clause **6**. Methods of attachment used for the lifting of technicians should be in accordance with Clause **7**.

It is essential that a secondary means of suspension is provided, for example inertia reel or other fall arrest equipment.

Standard industrial access equipment such as harnesses and bosun's chairs should be used in accordance with the manufacturer's instructions and should not be modified.

Lifting people using lifting machinery which is not specifically designed for the purpose, such as a counterweight set, should only be undertaken in exceptional circumstances when it is not practicable to gain access by less hazardous means.

Powered lifting machinery should conform to BS 7905-1:2001 **8.4**.

10.3 Operation and use

Technicians should be fully briefed in what the task entails and confirm that they are confident about what they are being asked to accomplish.

Technicians and lifting machinery operators should be instructed not to participate in lifting activities if their ability is impaired, for example by alcohol, drugs or tiredness.

Technicians should have a clear and reliable method of communication with the lifting machinery operator such as radios. Operators should have clear sight of the person(s) being lifted, spotters or electronic means such as CCTV may be used as aids to achieve adequate vigilance.

A method of rescue which has been assessed as safe by a competent person for both rescuers and those rescued should be available in the event of equipment failure. It is important that rescue methods are rehearsed.

10.4 Inspection and maintenance

All equipment used for providing access should be regularly inspected and maintained in accordance with the manufacturer's manual. A documented inspection regime should be implemented. It is essential that personnel expected to take part in flown access procedures using harnesses are trained in the use of their harnesses. They should also be responsible for their storage and maintenance.

NOTE Attention is drawn to LOLER [3] regarding inspection and maintenance of equipment.

Annex A (informative)
Recommended safety factors and relevant rigging data

Table A.1 — Recommended safety factors and other relevant rigging data

Equipment	Data	Clause reference
Bars	Safety factor as determined by a competent person, typically 2:1.	**8.17.1**
Bridles, slings, drifts	Safety factor, normal use 8:1.	**8.15.1**
	Maximum β angle 60°.	**8.15.6**
	Maximum included angle 120°.	
Hoists: Chain hoists	Safety factor as determined by the manufacturer, provided expressly intended for lifting over people.	**5.2**
	Otherwise de-rate to 8:1 and take additional precautions.	**8.19.5**
Winches, including power winches and chain hoists	Safety factor as determined by the manufacturer, provided expressly intended for lifting over people.	**5.2**
	Otherwise de-rate to 8:1 and take additional precautions.	**8.18.3.5**
Lifting accessories	Safety factor, normal use 8:1.	**8.13.2**
Performer flying: Flying wires	Safety factor, normal use 10:1.	**9.2**f) and g)
Fibre lift ropes	Safety factor, normal use 10:1.	**9.2**h)
Harnesses and connectors	Safety factor, normal use 8:1.	**9.2**d)
In-view flying wires	Minimum safety factor 5:1 with precautions.	**9.2**f)
Pulleys and drums: D:d ratio	For steel wire ropes 30:1	**8.16.1**
	For fibre ropes 12:1	
Fleet angle	Maximum 1.5°	**8.16.2**
Ropes: Wire	Safety factor, normal use 8:1.	**8.10.2.1**
Fibre	Safety factor, normal use 8:1.	**8.10.3.1**
Knots (in fibre rope)	Safety factor, normal use 8:1 after incorporation in the lifting assembly.	**5.2.2**
	Generally about 50 % efficient.	**8.11.1**
Terminations for wire rope	Safety factor, normal use 8:1 after incorporation in the lifting assembly.	**5.2.2**
	Generally about 80 % efficient.	**8.13.1**
Technician lifting for access	Safety factor, normal use 10:1.	**10.1**
Trusses	As determined by the manufacturer.	BS 7905-2 and BS 7906-2

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[1)] Withdrawn on 15 May 1991.
[2)] Withdrawn on 01 September 2003.

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