Instruction and safety handbook for mounting cranes on a vehicle

MENU

MODIFICATIONS RECORD - GENERAL INDEX

0.1 - Modifications record

Instructions and safety handbook for mounting cranes on a vehicle
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20	00	12/2001	16	First issue

0.1 - General index

page

page

page

page

MENU

GENERAL INFORMATION

1.2 - Symbols used in this handbook

There will now follow a list of the symbols used in the handbook to draw the reader's attention to the various levels of danger.

DANGER !!!

This warns the reader that if the operations described are not performed correctly or are not performed at all, they **WILL CAUSE** serious injury, death or long term health risks.

ATTENTION!!!

This warns the reader that if the operations described are not performed correctly or are not performed at all, they **COULD CAUSE** serious injury, death or long term health risks.

CAUTION!!!

This warns the reader that if the operations described are not performed correctly or are not performed at all, they **COULD CAUSE** damage to the machine or injuries.

Note

This symbol is used to indicate to the operator the best way of using the crane and the how to optimise the work, as well as how to avoid damaging and guarantee the equipment a long working life.

1.2 - Safety requirements

Read the handbook carefully before proceeding with the installation, start-up, use, maintenance or any other work with or on the machine.

Do not allow unauthorised personnel to carry out work on the machine.

When using the crane, always refer to the "instructions and safety handbook".

When carrying out inspections and maintenance work, whenever possible, lock the controls or place a sign on them stating **"Work in progress - do not perform any manoeuvres"**.

Do not operate the crane-vehicle unit in enclosed areas unless there is a suitable gas extraction and disposal system for the lethal combustion gasses.

In particularly hazardous conditions, there must always be another person present who, in addition to carrying out the work, is ready to intervene in the event of danger.

Before carrying out repairs or other work on the machine, always inform the other operators involved in the work of what you intend to do.

Do not wear rings, wristwatches, jewellery, loose or hanging clothing, such as ties, ripped clothing, scarves, unbuttoned jackets or blouses with open zips which could get caught in the moving parts.

You are advised, instead, to wear accident-prevention gear, such as helmets, non-slip boots, earmuffs, safety goggles, reflective cylinderets and breathing apparatus.

Check with your employer to find out about the safety standards in force and the accident prevention devices.

Always respect the maintenance and technical assistance procedures given in the handbook.

Never insert any part of the body, limbs or fingers in the articulated openings of the machine parts with cutting edges which are not under control without using suitable guards, unless the safety lock is applied.

The ladders or service platforms used in the workshop or on the job must be constructed in compliance with current safety standards.

Do not use your fingers to align the holes or slots: use the equipment provided for that purpose.

Never use petrol, solvents or other inflammable liquids as detergents: use, instead, the authorised non-flammable and non-toxic solvents available in the shops.

When using compressed air for cleaning the parts, always protect yourself with goggles with lateral guards.

Never use naked flames as a lighting means when inspecting the machine or checking for leaks.

When you have to hoist or transport heavy parts, use the winch or hoisting apparatus with a suitable load capacity.

Make sure the harness is made correctly. Use hoisting eyebolts, if provided, and watch out for the people in the vicinity.

Do not use fraying or bent chains or cables and always wear gloves. The chains or cables must be fixed fast: make sure the coupling is sufficiently robust to bear the weight to be hoisted.

There must not be anyone located near the coupling, the chains or the cables during the hoisting phase.

Make sure all the parts of the hydraulic circuit are tightened correctly.

Before dismounting the unions or piping, makes sure there is no pressurised fluid left: oil that leaks out under pressure could cause serious injury.

In the event of an accident seek medical assistance immediately.

Make sure the tools supplied are suitable and in good working order.

In the event of work carried out outside the workshop, take the machine onto a flat surface, whenever possible and lock it or stabilise it safely (see instructions and safety handbook).

If you have to transfer the machine when it is broken, it must be held in place on the means of transport with cables or chains, taking into account road traffic regulations.

ATTENTION!!!

Various parts of the crane are made of a special steel with a high elasticity limit: never weld any part of the machine without the manufacturer's permission and instructions. When carrying out welding work on the crane or the vehicle, always disconnect the batteries' electrical connections to avoid causing damage.

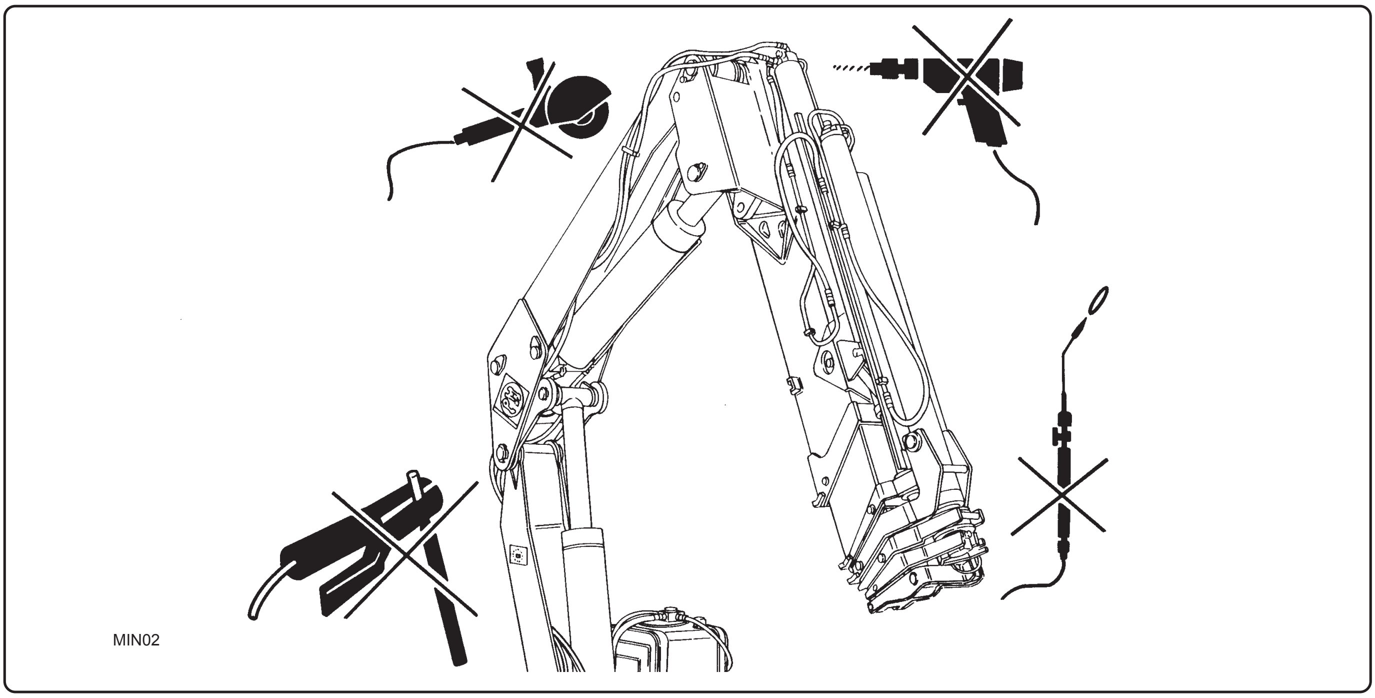


fig. 1.2.1

MENU

PREFACE

2.1- General indications

ATTENTION!!!

Mounting the crane on the vehicle requires specific skills and must be carried out in accordance with the instructions given in this handbook.
This handbook is aimed at professional persons with suitable training and experience, both practical and technical.
Autogru PM S.p.A. cannot be held responsible for an failures, breakages, accidents due to the user's failure to respect or apply the guidelines contained in this handbook.
The chapters and informative annexes are supplied as examples of the correct techniques to be employed but the installer may replace them with other, equally effective practices.

The aim of this handbook is to provide instructions, diagrams, directions and basic guidelines for correct crane and vehicle assembly and for the execution of a series of tests after assembly in order to check operation.

Before beginning to mount the crane on the vehicle, read this handbook and the vehicle manufacturer's handbook carefully.

Make sure you always follow the instructions to the letter. In case of doubt, contact the crane manufacturer.

The crane must only be mounted on the vehicle by qualified personnel and the operations must be carried out in compliance with the instructions given herein an in the vehicle's handbook.

When making changes or fitting any type of equipment it is a general rule that you should not alter anything affecting the proper operation of assemblies and vehicle members when running.

For example:

- there must be free access to all points requiring inspection, maintenance or periodical checks. In the case of enclosed superstructures, special openings and doors must be provided.
- Liberty of movement must be ensured inside tip-up cabs; in the case of superstructures over the cab, it is important to ensure a suitable air flow.
- It must be possible to dismantle the various assemblies for servicing. For example: intervention on the gearbox or clutch must be done without the need to dismantle the main parts of the structure to be fitted.
- The cooling system (calander, radiator, air ducts, cooling circuits, etc.) and the engine air intake system must not be altered.
- Sound-proofing panels must not be altered or removed so as not to change the vehicle's approved noise levels. If it is necessary to make an opening (e.g. for the longitudinal chassis sections), it must be sealed properly using materials with the same inflammable and sound-proofing characteristics as the original ones.
- The brakes and the battery cases must be properly ventilated.
- When positioning mudguards and wheelhouses, the rear wheels must have enough space to move freely even when chains are fitted.
- Upon completion of the assembly work, headlight adjustment must be checked for safety reasons and rectified if necessary. To do this, turn the headlight adjusting screw and check the trim corrector adjustment range with a full load. Proceed as specified in the vehicle handbook, remembering to record in it any new values.
- For any parts supplied separately (e.g. spare wheels, chocks or fuel tank), it is up to the installer to place and secure them in a safe accessible position and comply with any national standards.
- When welding, boring, grinding or cutting in the proximity of braking system pipework (particularly when made of plastic) and electric cables, always take the necessary precautions to protect them or remove them if necessary.

Further precautions must be taken for ABS braking systems.

The following must be borne in mind as regards the electrical system:

a) *Precautions for the alternator*

To prevent damage to the diode rectifier, the battery must never be disconnected with the engine running. If the vehicle needs to be tow-started, make sure the battery is connected. If you need to charge the battery quickly, disconnect it from the vehicle circuit.

b) *Earth connections*

In principle, the vehicle's original earth connections should not be changed. If, however, it is necessary to move them, make sure the system is re-earthed properly to ensure complete efficiency.

c) *Electric cables*

The cables in the electric system must be connected by water-proof joints of the same type as the original ones. Any section of cable added must be suitably sheathed and fixed by means of brackets.

- All the vehicle parts (chassis, driver's cab, superstructure, etc.) involved in the modification or addition must be sufficiently protected from rusting and corrosion.
- All parts involved must be properly protected and painted.
- It is the Manufacturer's aim to continue to upgrade the product, which means that some components are likely to be altered.

  If any discrepancies are found between what is described or illustrated in this handbook and the instructions for the crane to be mounted, contact the Manufacturer for further details.
- This handbook reflects the state of the art at the time of machine selling and cannot be considered incomplete merely because it has subsequently been updated.
- All dimensions and formulas, etc. are expressed in IS (International System) units. For conversions to the British system of measurement, consult the conversion tables in Annex 1.

2.2- Safety requirements

In addition to this handbook, the installer must also meet all the legal requirements concerning accident prevention in the workplace and when handling loads that are in force in the country the machine is being installed in.

2.3- Definitions of responsability

The manufacturer of the crane has precise responsibilities regarding the machine, as does the installer; **the latter is responsible for final approval, including the EC mark,** without which the machine cannot be sold within the EC.

In particular the installer is responsible for:
- planning crane installation on the vehicle;
- installation;
- testing;
- safety and operating instructions;
- delivery to the end user.

The manufacturer must issue the "Declaration of Conformity" (EC directive 98/37, annex II, point A) and apply the EC mark to the crane.
The installer must carry out the installation in compliance with the instructions supplied by the manufacturer.

2.4- Identification of main crane components

For a clear identification of the crane components and to facilitate understanding of this handbook, the main components are listed below.

- *List of crane components*

1) Basement
2) Left outrigger
3) Right outrigger
4) Rotation cylinders
5) Column
6) Bracket
7) Column cylinder
8) Outrigger extensions
9) Cylinder bracket
10) 2nd boom extension cylinder
11) 3rd boom extension cylinder
12) 4th boom extension cylinder
13) 5th boom extension cylinder
14) 6th boom extension cylinder
15) 7th boom extension cylinder
16) 8th boom extension cylinder
17) 1st boom
18) 2nd boom
19) 3rd boom
20) 4th boom
21) 5th boom
22) 6th boom
23) 7th boom
24) 8th boom
25) Crane control distributor
26) Main outrigger extension cylinder
27) Oil tank
28) Left outrigger cylinder
29) Right outrigger cylinder
30) Multifunction outrigger control deviator
31) Dual controls
32) Connecting rods
33) Fixed hook
34) Rotary hook
35) Rocker arm (oscillating support)
36) Counter-chassis
37) Vehicle chassis
38) Anchorage tie rod
39) Upper anchor bracket
40) Lower anchor bracket
41) Anchor nut
42) Power take-off
43) Cardan shaft
44) Pump

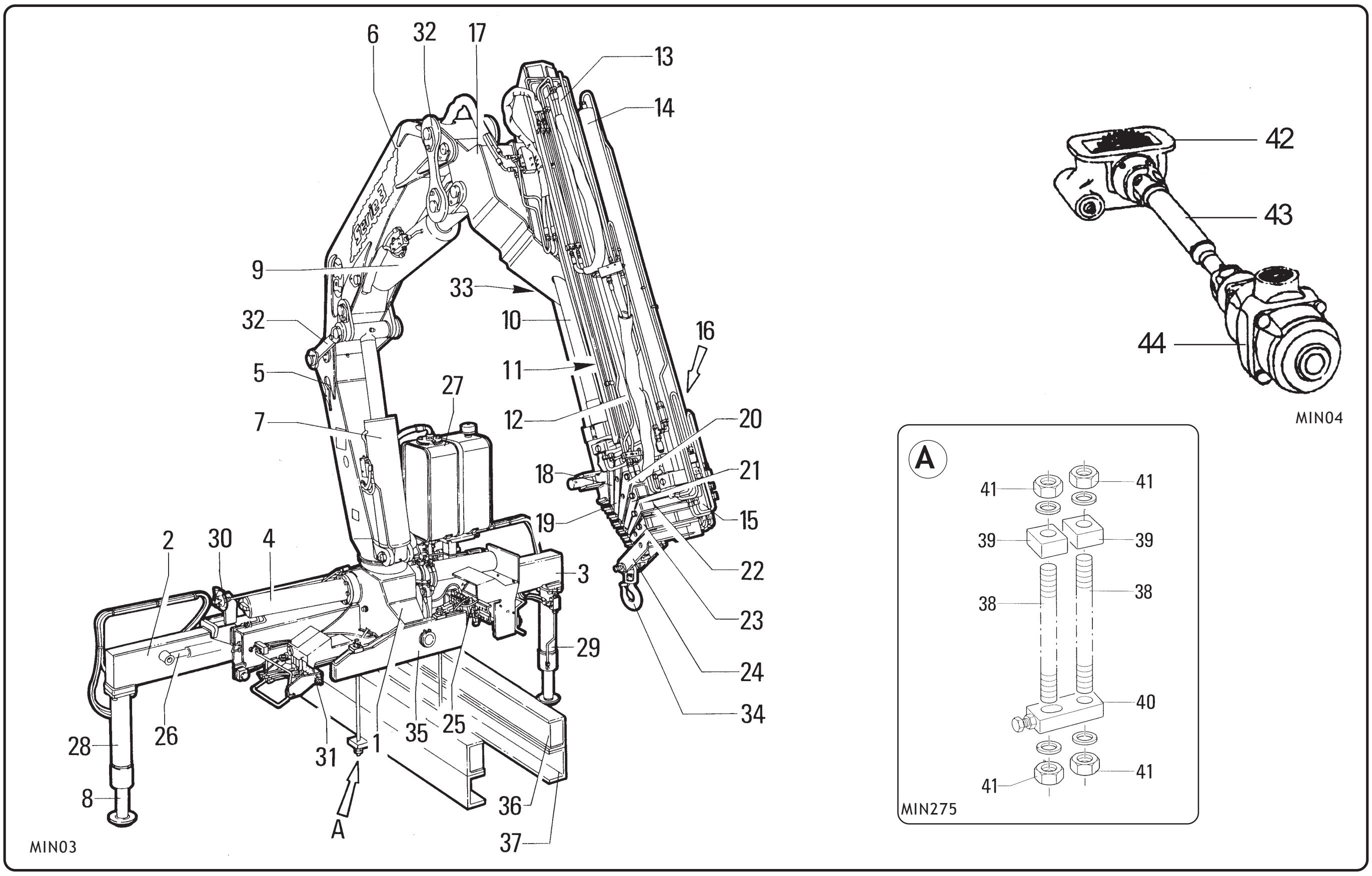


fig. 2.4.1

2.5 - Identification of main crane accessories

1) Jib
2) 1st mechanical jib extension
3) 2nd mechanical jib extension
4) Supplementary outriggers
5) Rotary plates for outriggers
6) Remote control
7) Overhead manoeuvring post
8) Ground manoeuvring post
9) Bucket
10) Pallet holder
11) Bricks grip
12) Mechanical extensions
13) Skeleton bucket
14) Winch
15) Fork
16) Polyp grip
17) Timber grip

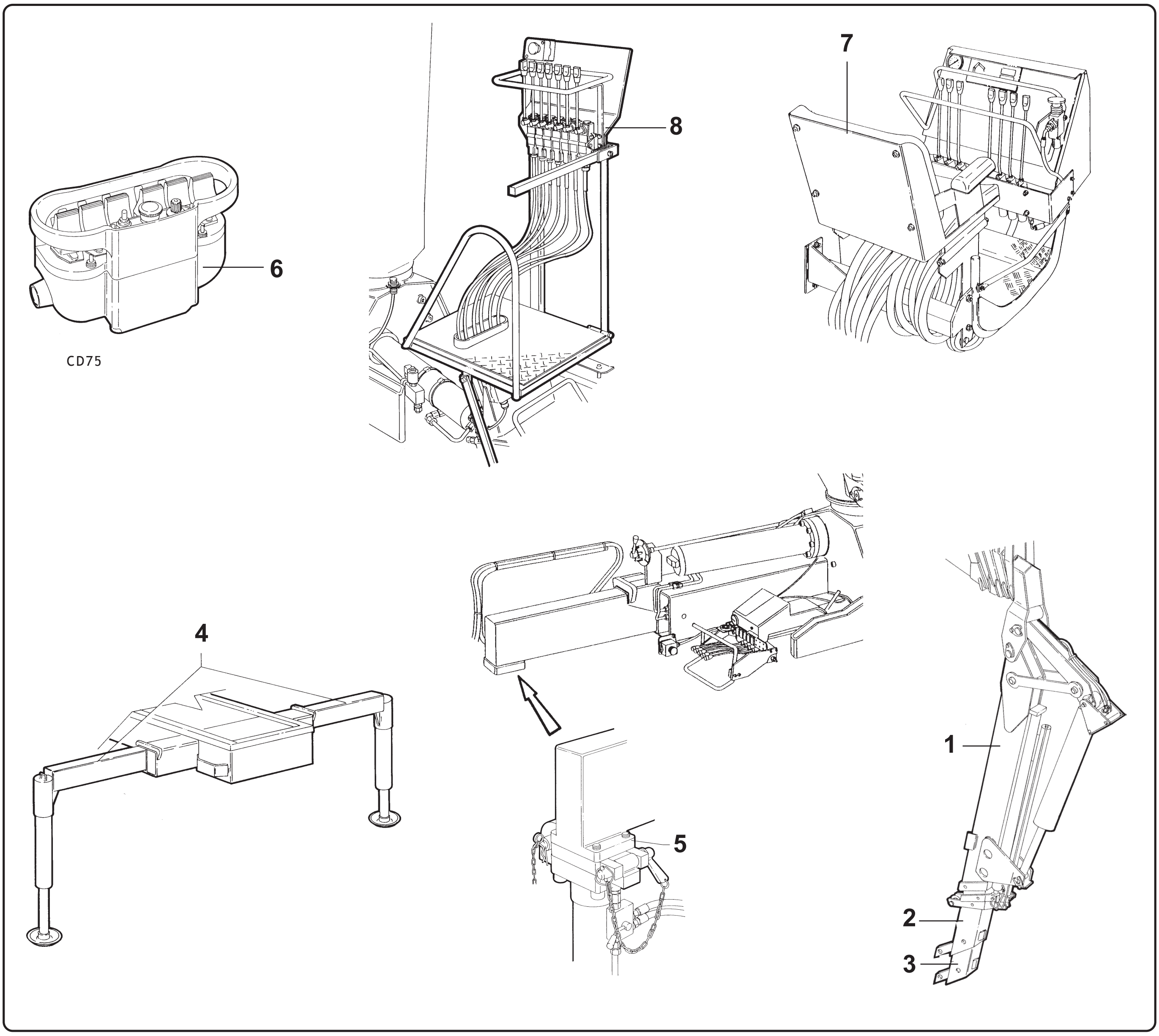


fig. 2.5.1

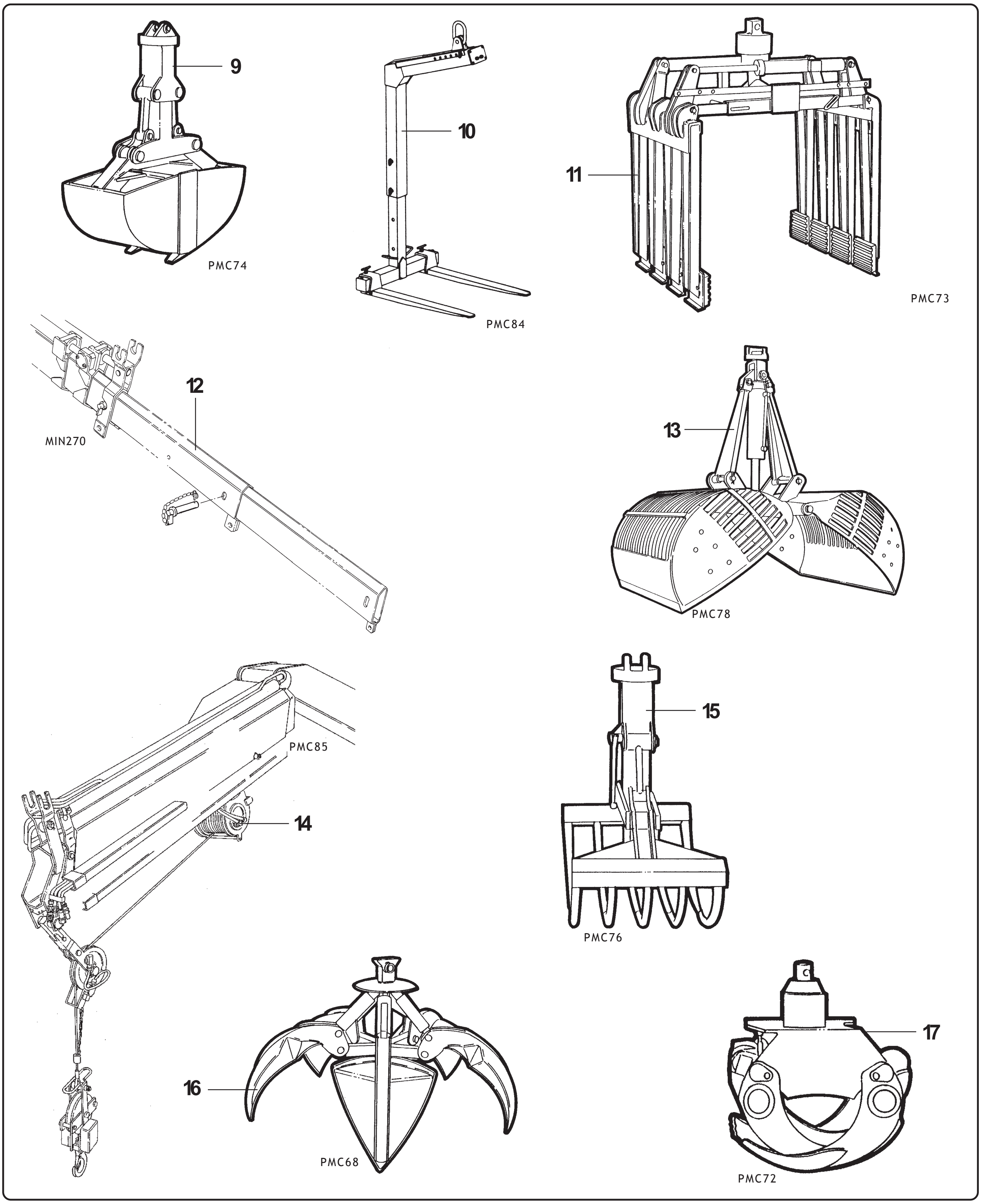

9
PMC74
10
PMC84
11
PMC73
12
MIN270
13
PMC78
PMC85
14
15
PMC76
16
PMC68
17
PMC72

fig. 2.5.2

- Annex 1

UNITS OF MEASUREMENT CONVERSION TABLE

Unit	Measurem. unit	Multiplication factor	Converted unit
Lenght	1 m	3,28084	foot (')
	1 mm	0.03937	inch (")
	1 m	1,09361	yard (yd)
	1 inch (")	25,4	mm
	1 foot (')	0,304	m
	1 yard (yd)	0,9144	m
Surface	1 m^2	10,7639	square foot (sq.ft.)
	1 square foot	0,0929	m^2
Volume	1dm^3	0,03531	cubic foot (cu.ft.)
	1cubic foot	28,317	dm^3
Pressure	1 bar	100	kPa
	1 atm	14,7	psi
	1 psi	0,068	atm
	1 psi	0,0703	kg/cm^2
	1 psi	0,069	bar
Mass	1 g	0.0353	once (oz.)
	1 kg	2,2046	pound (lb)
	1 once	28,3495	g
	1 pound	0,4536	kg
Capacity	1 cm^3 /s	0,01319	g.p.m.
	1 g.p.m.	75,8	cm^3 /s
Torque	kgm	7,233	ft· lbs
	ft· lbs	0,1383	kgm
	kgm	9,80665	Nm
	Nm	0,102	kgm
Power	kW	1,34102	HP
	CV	0,9863	HP
	HP	0,7457	kW
	HP	1,0138	CV
Cinematic viscosity	m^2 /s	$1/10^6$	cSt (centistokes)
	cSt	10^6	m^2 /s
Temperature	° C	° C=(° F-32)· 5/9 ° F=9/5· ° C+32	° F (fahrenheit)

Tab. 1

MENU

CRANE-VEHICLE COMBINATIONS

3.1- Combination principles

When a crane is mounted on a vehicle, a whole set of values are altered (tare weight, capacity, dimensions, weight distribution on axles, etc.), and must therefore be recalculated and checked.

When mounting superstructures, irrespective of the type of equipment, the manufacturers of industrial vehicles assign a set of limit values that must be complied with scrupulously as they are linked to the specific characteristics of each vehicle (stress resistance, power consumption, braking, etc.).

The aim of this handbook is to provide the installer with guidelines so that he can determine as precisely as possible the right vehicle/crane combination in compliance with current legislation and standards laid down by vehicle manufacturers.

The fundamental principles for selecting a crane to mount on a certain type of vehicle can be divided as follows:

- weight distribution on the axles
- vehicle stability.

In all cases the installer must comply with the technical standards supplied by the vehicle and the crane manufacturers.

Autogru PM ca supply the software for determining the weight distribution on the axles, vehicle stability and counter-chassis check. For enquiries refer to the technical assistance service.

DANGER!!!

If the boom is to be placed in the resting position on the vehicle body or on the load, you must:

- install a red danger light in a clearly visible position in the vehicle's cab which will flash when the machine's overall dimensions exceed the maximum height of 4 metres;
- provide a sturdy rest for the boom pack which will prevent any accidental movement of the crane while the vehicle is travelling on the road.

3.2- Axle loads analysis

The following pages contain tables for calculating:
- the crane mounting position;
- the barycenter of the vehicle body;
- the length of the body.

Irrespective of the number of vehicle axles, always use the calculation procedure for beams on two supports (equilibrium of the moments).
For correct distribution of loads on the axles, it is always advisable to analyse all the loads as concentrated, considering their respective barycentric positions.

For example:
- supplementary outrigger cross members;
- counter-chassis;
- number of persons carried in the cab;
- any ballast, tanks, spare wheels, etc.;
- presence of tip-up bodies with hydraulic cylinders not positioned at the barycenter;
- detachable bodies;
- etc....

Note

Before installation, it is good practice to determine the weights/tare weights of the cab vehicle to be outfitted.
This is because the values shown in the manufacturers' specifications refer to vehicle in the standard version; special equipment may involve variations to the loads and their distribution on the axles.
All vehicle manufacturers state that weights may change during production by up to 5%.

3.2.1 - Double-axle vehicle with crane mounted behind cab

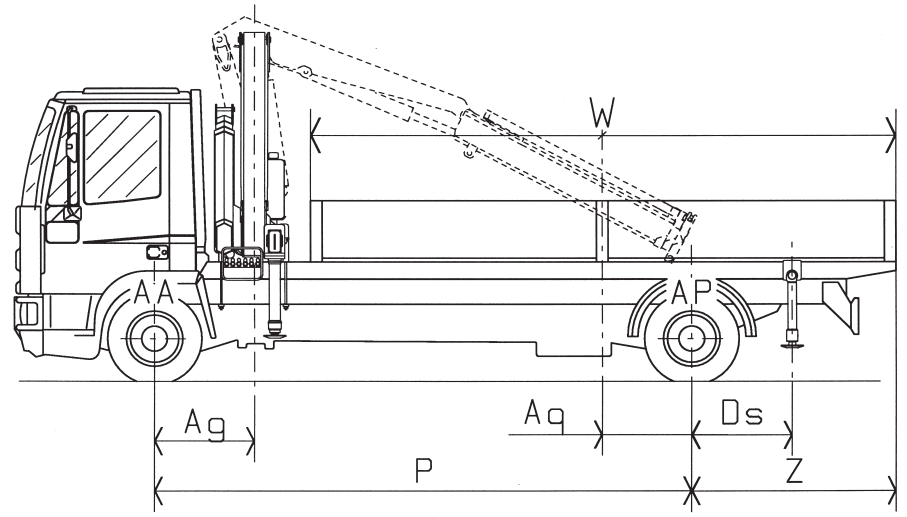


fig. 3.2.1

Key to symbols

	G	= Mass of the crane	(kg)
*	T	= Tare weight of the cab vehicle	(kg)
*	T_1	= Tare weight distribution of cab vehicle on front axle	(kg)
*	T_2	= Tare weight distribution of cab vehicle on rear axle	(kg)
	Pc	= Mass of vehicle body (including mass of the counter-chasis)	(kg)
	Ps	= Mass of supplementary outriggers	(kg)
	TT	= Total tare weight = $T_1+T_2+Pc+Ps+G$	(kg)
	Q	= PTT-TT = Residual capacity	(kg)
*	PTT	= Total mass at full load	(kg)
	P	= Wheelbase	(mm)
	Z	= Rear body overhang	(mm)
	W	= Body length	(mm)
	Ag	= Distance of front axle from crane's barycenter	(mm)
	Aq	= Advance of vehicle body's barycenter ($\frac{W}{2}$ -Z)	(mm)
	Ds	= Distance between supp. outrigger cross member and rear axle	(mm)
**	AA	= Front axle	
	AP	= Rear axle	

Note

As for the barycenter of the crane, the chosen rest position (folded up on the base or extended on the vehicle body) should be considered.

* Values obtained from vehicle type "Approval report" or by "direct weighing".
** For vehicles with two front axles, the wheelbase is calculated starting from their centre line.

3.2.1.1 - Superstructure load distribution

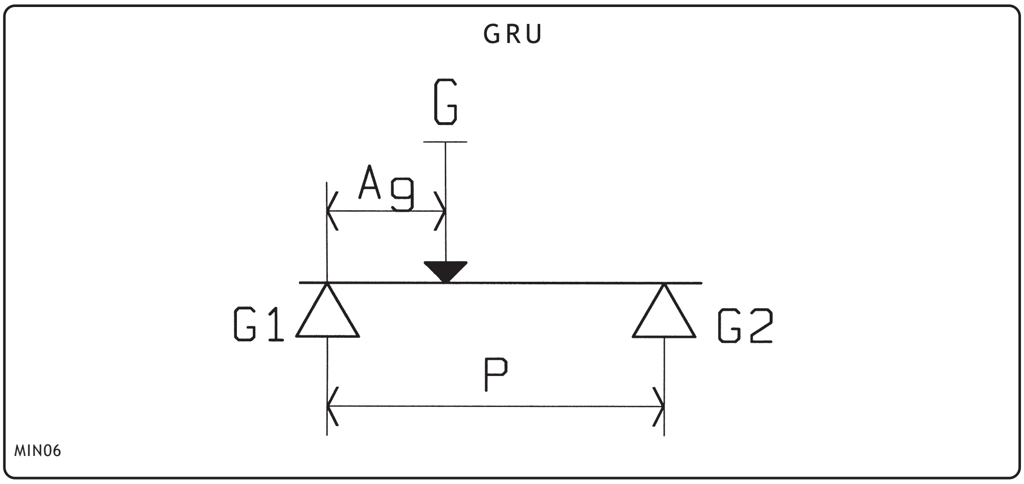


fig. 3.2.2

G_1 = G·(P-Ag)/P = kg................. (Crane mass distribution on front axle)

G_2 = G-G_1 = kg................ (Crane mass distribution on rear axle)

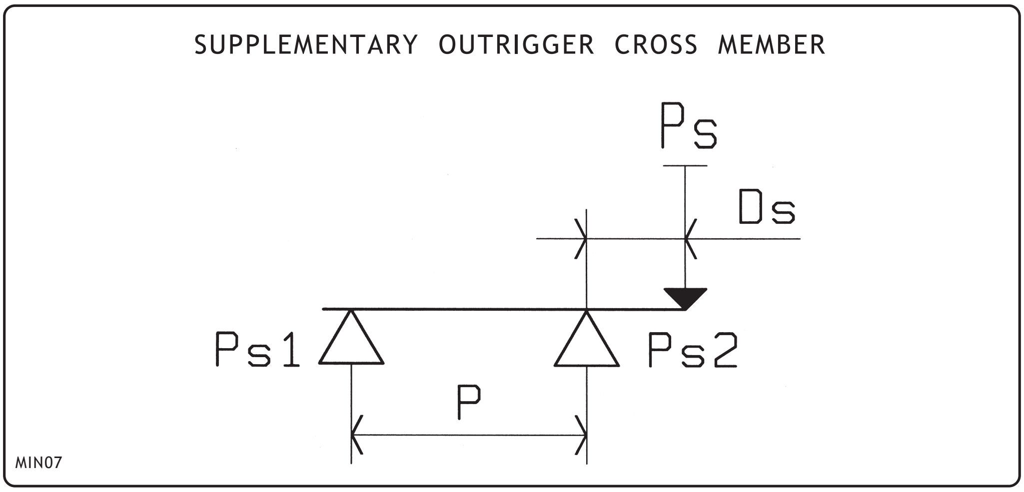


fig. 3.2.3

Ps_1 = (-) Ps·Ds/P = kg................. (Mass distribution of supplementary outrigger cross member on front axle)

Ps_2 = Ps-Ps_1 = kg................. (Mass distribution of supplementary outrigger cross member on rear axle)

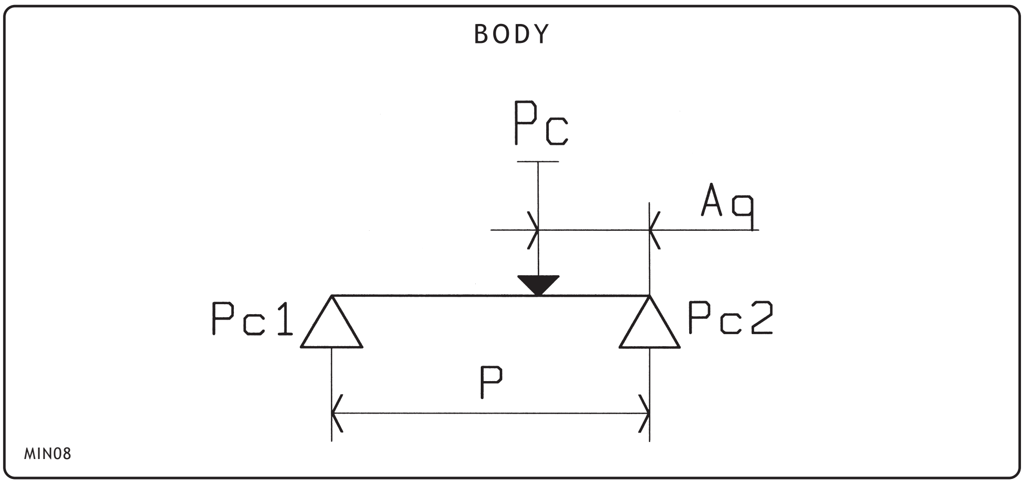


fig. 3.2.3

$Pc_1 = Pc \cdot Aq/P$ = kg.................. (Mass distribution of body on front axle)

$Pc_2 = Pc - Pc_1$ = kg................. (Mass distribution of body on rear axle)

TOTAL TARE WEIGHT

$TT = T+G+Ps+Pc$ = kg.................. (Total tare weight crane plus vehicle)

$TT_1 = T_1+G_1+Ps_1+Pc_1$ = kg.................. (Total tare weight distribution on front axle)

$TT_2 = T_2+G_2+Ps_2+Pc_2$ = kg.................. (Total tare weight distribution on rear axle)

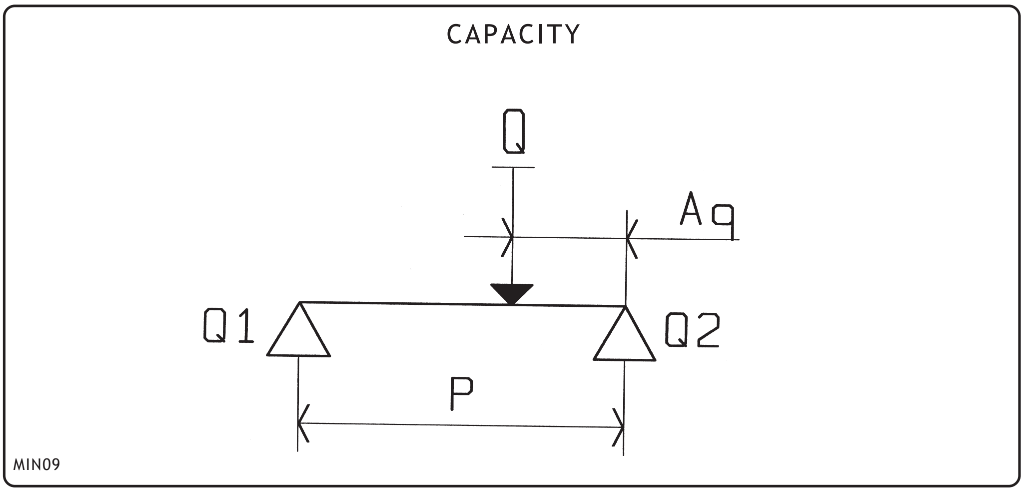


fig. 3.2.4

$Q = PTT-TT$ = kg.................. (Residual total load capacity)

$Q_1 = Q \cdot Aq/p$ = kg.................. (Load capacity distribution on front axle)

$Q_2 = Q-Q_1$ = kg.................. (Load capacity distribution on rear axle)

3.2.1.2 - Summary chart and check

	1^{ST} AXLE	2^{ND} AXLE	TOTAL
CHASSIS TARE WEIGHT	T1	T2	T
CRANE	G1	G2	G
SUPPLEMENTARY OUTRIGGER CROSS MEMBERS	Ps1	Ps2	Ps
BODY	Pc1	Pc2	Pc
TOTAL TARE WEIGHT	TT1	TT2	TT
LOAD CAPACITY	Q1	Q2	Q
TOTAL	TOT1	TOT2	PTT
MAX LIMIT - VEHICLE MANUFACTURER	MAX1	MAX2	

Tab. 1

3.2.1.3 - Front / rear axle mass ratio check

Empty $= \frac{TT_1}{TT_2}$ =.......... > (Min. ADM C.C. vehicle)

Full load $= \frac{TOT_1}{TOT_2}$ =..........> (Min. ADM C.C. vehicle)

3.2.2 - Triple-axle vehicle with crane mounted behind cab

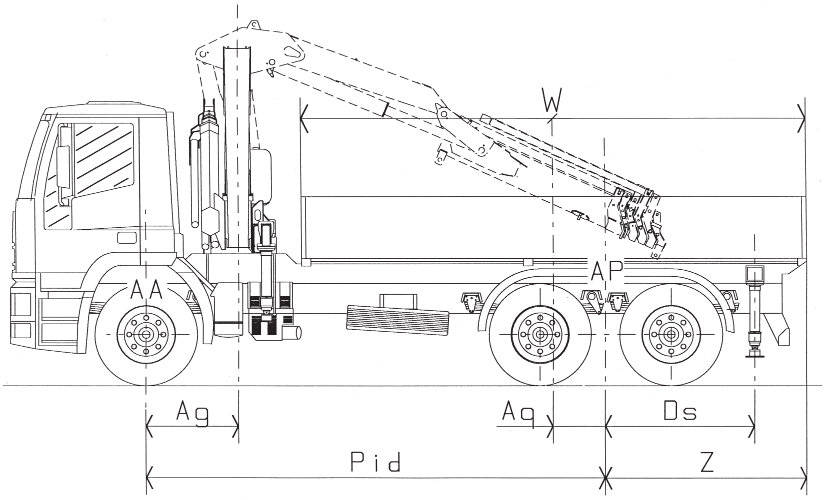


fig. 3.2.5

Key symbols

	G	= Mass of the crane	(kg)
*	T	= Tare weight ogf the cab vehicle	(kg)
*	T_1	= Tare weight distribution of cab vehicule on front axle	(kg)
*	T_2	= Tare weight distribution of cab vehicle on second axle	(kg)
*	T_3	= Tare weight distribution of cab vehicle on third axle	(kg)
	Pc	= Mass of vehicle body (including mass of the counter-chasis)	(kg)
	Ps	= Mass of supplementary outriggers	(kg)
	TT	= Total tare weight = $T_1+T_2+T_3+Pc+Ps+G$	(kg)
	Q	= PTT-TT = Residual capacity	(kg)
*	PTT	= Complete mass at full load	(kg)
	Pid	= Ideal wheelbase	(mm)
	Z	= Rear body overhang	(mm)
	W	= Body length	(mm)
	Ag	= Distance of front axle / crane's barycenter	(mm)
	Aq	= Advance of vehicle body's barycenter $(= \frac{W}{2} - Z)$	(mm)
	Ds	= Distance between supplementary outrigger cross member and rear axle	(mm)
	P_{1-2}	= Front axle/centre axle wheelbase	(mm)
	P_{2-3}	= Centre axle/rear axle wheelbase	(mm)
**	AA	= Front axle	
	AP	= Rear axle	

Note

As for the barycenter of the crane, the chosen rest position (folded up on the base or extended on the vehicle body) should be considered.

* Values obtained from vehicle type "Approval report" or by "direct weighing".

** For vehicles with two front axles, the wheelbase is calculated starting from their centre line.

3.2.2.1 - Calculation of ideal wheelbase

a) Tandem rear axles (6x4 or 6x6 vehicle)

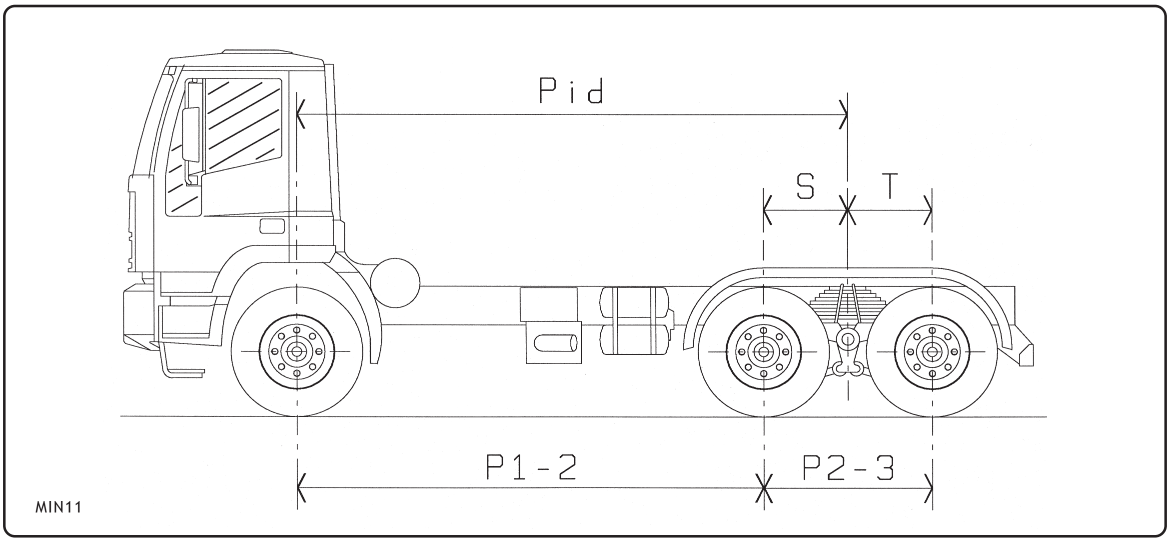


fig. 3.2.6

$$Pid = \frac{P_{2-3}}{2} + P_{1-2}$$

$$S = T = \frac{P_{2-3}}{2}$$

b) Independent rear axles with 3 single wheel axles (6x2 vehicle)

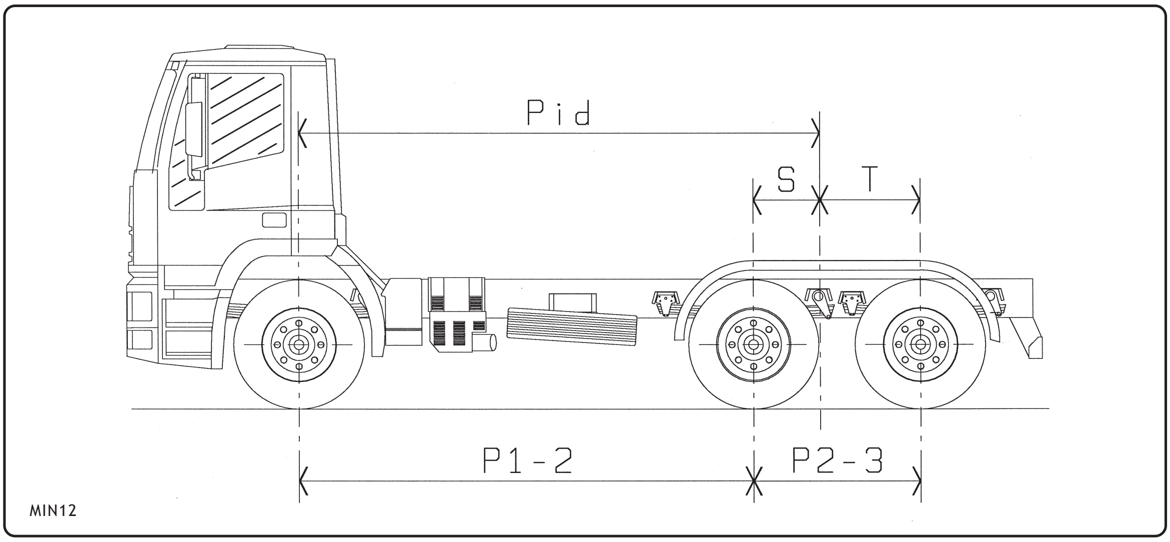


fig. 3.2.7

$$Pid = P_{1-2} + \frac{P_{2-3}}{3}$$

$$P_{2-3} = S+T$$

$$S = \frac{1}{3} P_{2-3}$$

$$T = \frac{2}{3} P_{2-3}$$

3.2.2.2 - Superstructure load distribution

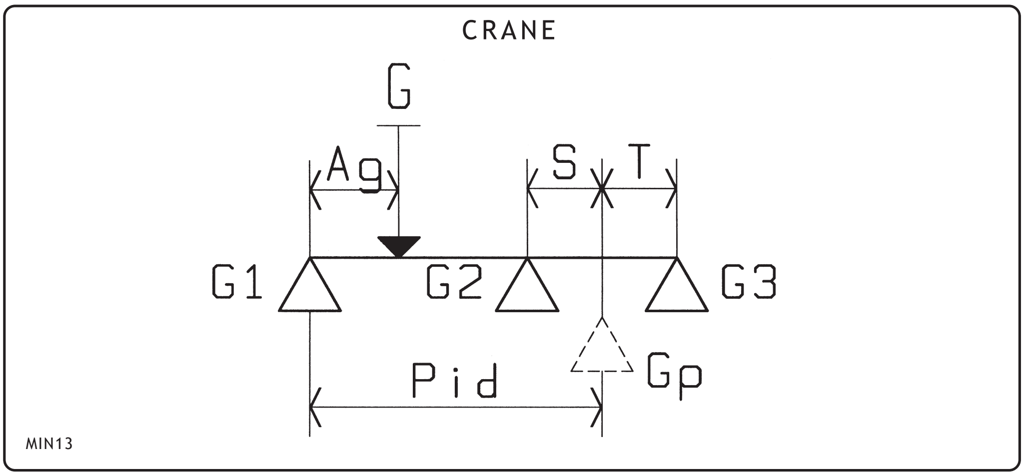


fig. 3.2.8

G_1 = G·(P-Ag)/Pid = kg.................. (Crane mass distribution over front axle)

Gp = G-G_1 = kg.................. (Crane mass distribution over ideal axle)

Distribution over two rear axles:

Independent rear axles (6x2)

G_3 = Gp·S/ P_{2-3} = kg

G_2= Gp - G_3 = kg

Tandem rear axles (6x4-6x6)

G_2 = G_3 = Gp/2 = kg

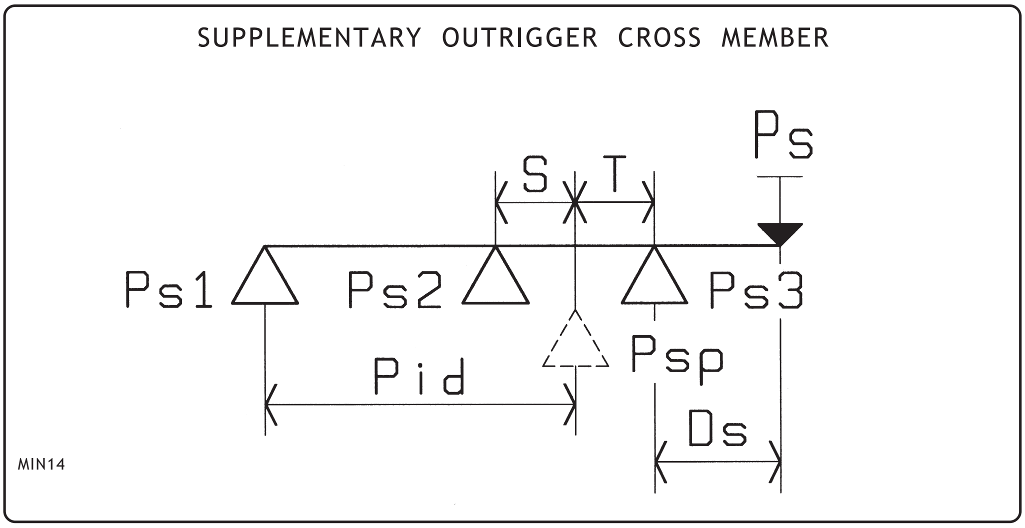


fig. 3.2.9

Ps_1 = (-) Ps·(Ds+T)/Pid =kg.................. (Supp. outrigger cross member distribution on front axle)

Psp= Ps-Ps_1 =kg.................. (Supp. outrigger cross member distribution on ideal axle)

Psp distribution over two rear axles:

Independent rear axles (6x2)

$Ps_3 = Psp \cdot S / P_{2\text{-}3}$ = kg

$Ps_2 = Psp - Ps_3$ = kg

Tandem rear axles (6x4-6x6)

$Ps_2 = Ps_3 = Psp/2$ = kg

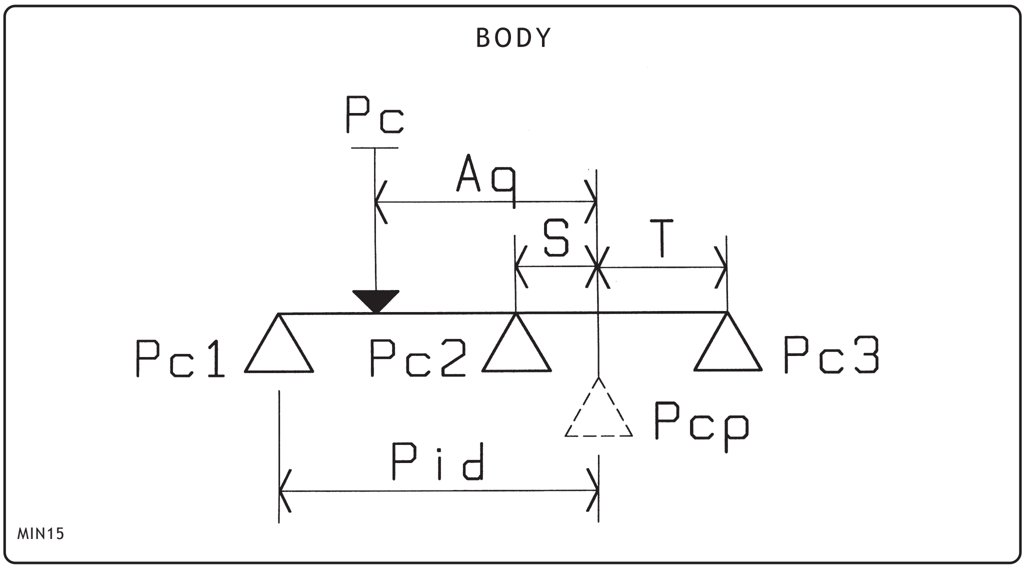


fig. 3.2.10

$Pc_1 = Pc \cdot Aq/Pid$ =kg.................. (Body mass distribution over front axle)

$Pcp = Pc - Pc_1$ =kg.................. (Body mass distribution over ideal axle)

Pcp distribution over two rear axles:

Independent rear axles (6x2)

$Pc_3 = Pcp \cdot S / P_{2\text{-}3}$ = kg

$Pc_2 = Pcp - Pc_3$ = kg

Tandem rear axles (6x4-6x6)

$Pc_2 = Pc_3 = Pcp/2$ = kg

TOTAL TARE WEIGHT

$TT = T+G+Ps+Pc$ = kg.................. (Total tare weight crane + vehicle)

$TT_1 = T_1+G_1+Ps_1+Pc_1$ = kg.................. (Total tare weight distribution over front axle)

$TT_2 = T_2+G_2+Ps_2+Pc_2$ = kg.................. (Total tare weight distribution over 2nd axle)

$TT_3 = T_3+G_3+Ps_3+Pc_3$ = kg.................. (Total tare weight distribution over 3rd axle)

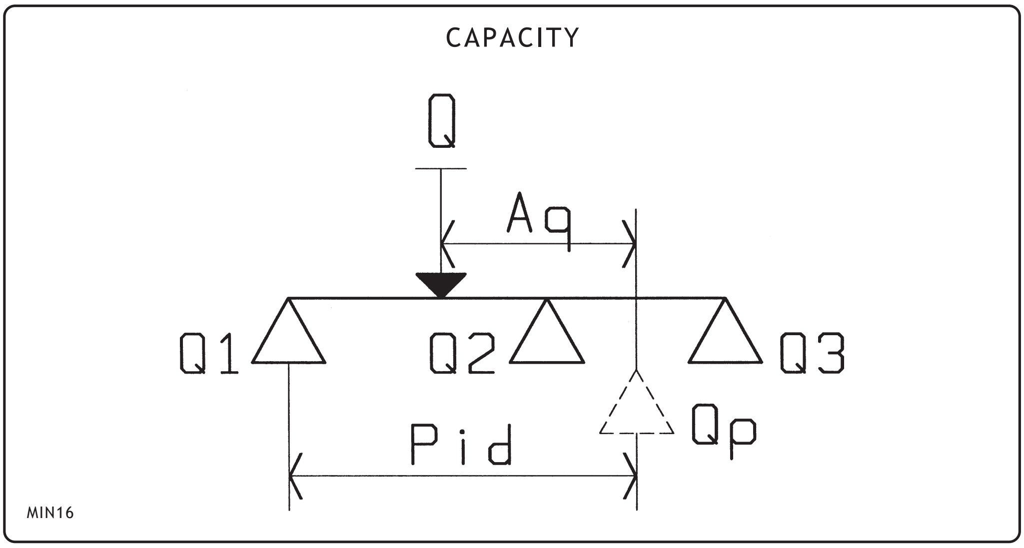


fig. 3.2.11

Q	= PTT-TT	= kg..................	(Total residual capacity)
Q_1	= Q·Aq/Pid	= kg..................	Load distribution over front axle)
Qp	= $Q-Q_1$	= kg..................	(Load distribution over rear axle)

Qp distribution over two rear axles:

Independent rear axles (6x2)

Q_3 = Qp·S/ P_{2-3} = kg

Q_2= Qp-Q_3 = kg

Tandem rear axles (6x4-6x6)

Q_3 = Qp/2 = kg

Q_2 = Qp-Q_3 = kg

3.2.2.3 - Summary chart and check

	1^{ST} AXLE	2^{ND} AXLE	3^{RD} AXLE	TOTAL
CHASSIS TARE WEIGHT	T1	T2	T3	T
CRANE	G1	G2	G3	G
SUPPLEMENTARY OUTRIGGER CROSS MEMBERS	Ps1	Ps2	Ps3	Ps
BODY	Pc1	Pc2	Pc3	Pc
TOTAL TARE WEIGHT	TT1	TT2	TT3	TT
LOAD CAPACITY	Q1	Q2	Q3	Q
TOTAL	TOT1	TOT2	TOT3	PTT
MAX LIMIT - VEHICLE MANUFACTURER	MAX1	MAX2	MAX3	

Tab. 2

3.2.2.4 - Front / rear axle mass ratio check

Empty = $\dfrac{TT_1}{TT_2+TT_3}$ =..........> (Min. value ADM. C.C. vehicle)

Full load = $\dfrac{TOT_1}{TOT_2+TOT_3}$ =..........> (Min. value ADM. C.C. vehicle)

3.2.3 - Double-axle vehicle - with rear-mounted crane

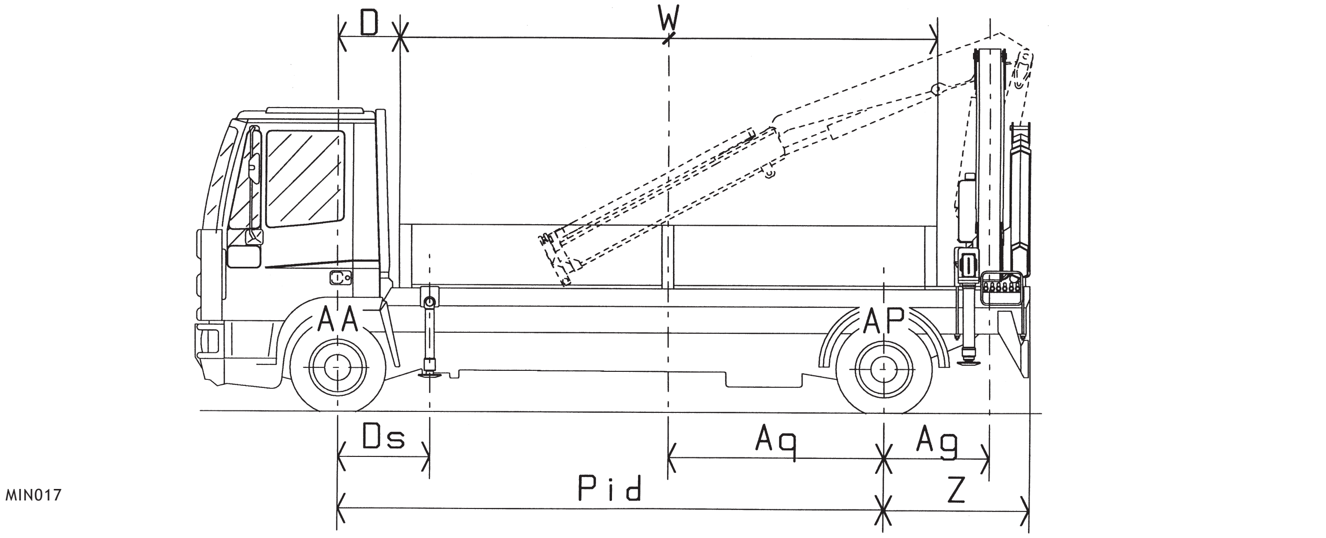


fig. 3.2.12

Key to symbols

	G	= Mass of the crane	(kg)
*	T	= Tare weight of the cab vehicle	(kg)
*	T_1	= Tare weight distribution of cab vehicle on front axle	(kg)
*	T_2	= Tare weight distribution of cab vehicle on rear axle	(kg)
	Pc	= Mass of vehicle body (including mass of counter-chassis)	(kg)
	Ps	= Mass of supplementary outriggers	(kg)
	TT	= Total tare weight = $T_1+T_2+Pc+Ps+G$	(kg)
	Q	= PTT-TT = Residual capacity	(kg)
*	PTT	= Gross weight at full load	(kg)
	P	= Wheelbase	(mm)
	Z	= Rear overhang	(mm)
	W	= Body length	(mm)
	Ag	= Distance of rear axle from crane’s barycente	(mm)
	Aq	= Advance of vehicle body’s barycenter $\left(= P - D - \frac{W}{2} \right)$	(mm)
	D	= Distance between front axle and start of cab	(mm)
	Ds	= Distance between supp. outrigger cross member and front axle	(mm)
**	AA	= Front axle	
	AP	= Rear axle	

☞ Note

As for the barycenter of the crane, the chosen rest position (folded up on the base or extended on the vehicle body) should be considered.

* Values obtained from vehicle type "Approval report" or by "direct weighing".
** For vehicles with two front axles, the wheelbase is calculated according to their centre line.

3.2.3.1 - Superstructure distribution

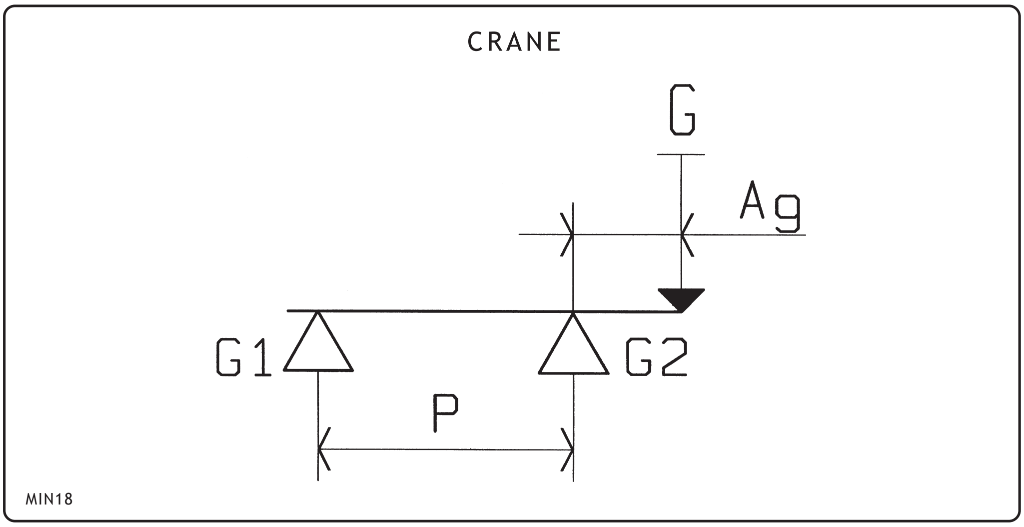


fig. 3.2.13

G_1 = -(G·Ag)/P = kg.................. (Crane mass distribution over front axle)

G_2 = G-G_1 = kg.................. (Crane mass distribution over rear axle)

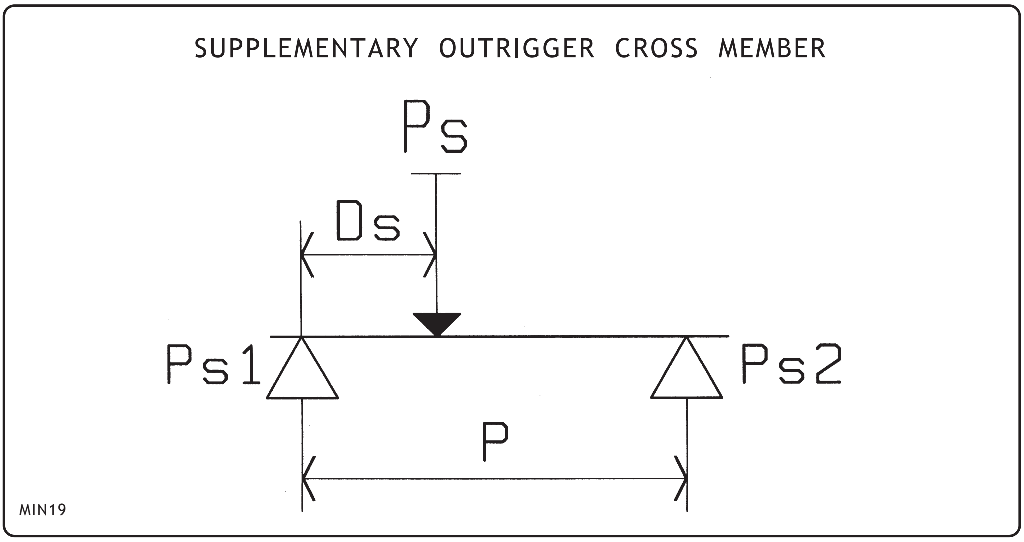


fig. 3.2.14

Ps_1 = Ps·(P-Ds)/P = kg.................. (Mass distribution of supp. outrigger cross member on front axle)

Ps_2 = Ps-Ps_1 = kg.................. (Mass distribution of supp. outrigger cross member over rear axle)

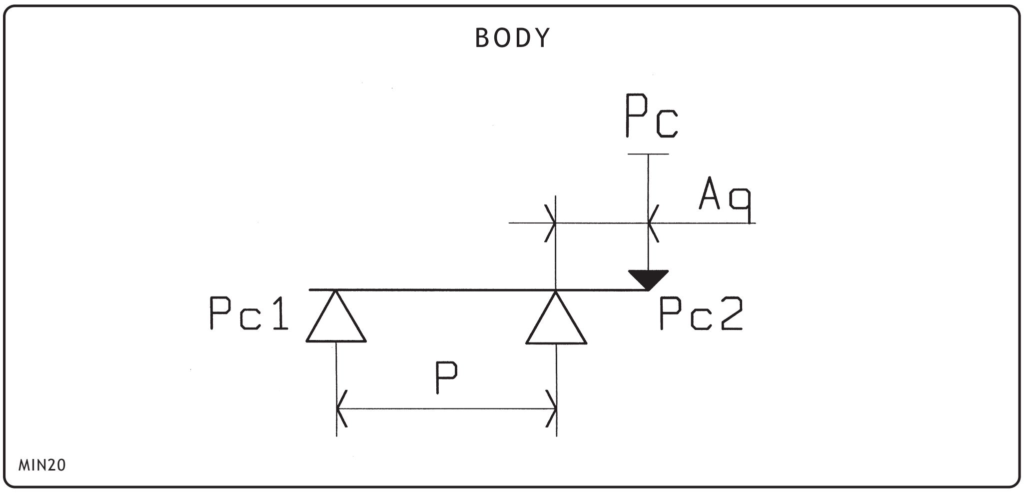


fig. 3.2.15

$Pc_1 = Pc \cdot Aq/P$ =kg................... (Mass distribution of body over front axle)

$Pc_2 = Pc - Pc_1$ =kg................... (Mass distribution of body over rear axle)

TOTAL TARE WEIGHT

$TT = T+G+Ps+Pc$ = kg................... (Total tare weight crane + vehicle)

$TT_1 = T_1+G_1+Ps_1+Pc_1$ = kg................... (Total tare weight distribution on front axle)

$TT_2 = T_2+G_2+Ps_2+Pc_2$ = kg................... (Total tare weight distribution on second axle)

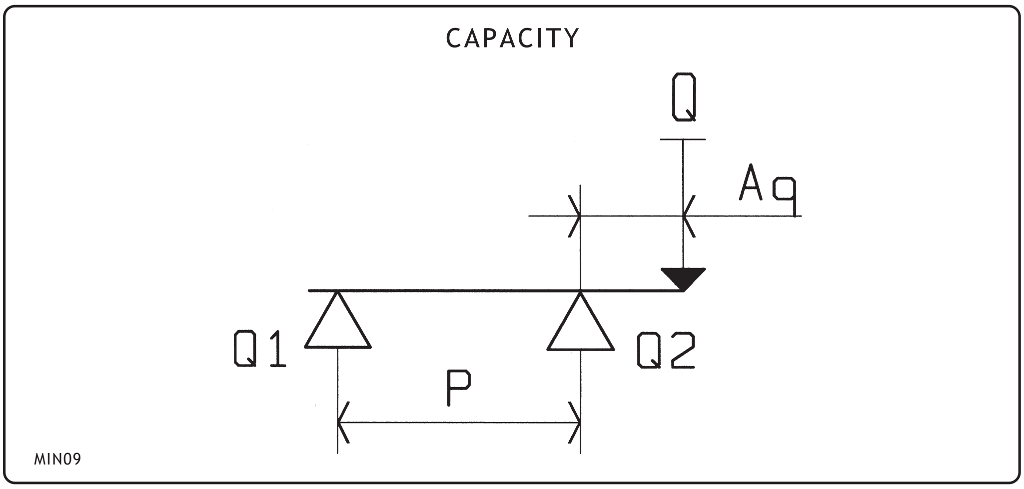


fig. 3.2.16

$Q = PTT-TT$ = kg................... (Total residual capacity)

$Q_1 = Q \cdot Aq/P$ = kg................... (Capacity distribution over front axle)

$Q_2 = Q-Q_1$ = kg................... (Capacity distribution over rear axle)

3.2.3.2 - Summary chart and check

	1^{ST} AXLE	2^{ND} AXLE	TOTAL
CHASSIS TARE WEIGHT	T1	T2	T
CRANE	G1	G2	G
SUPPLEMENTARY OUTRIGGER CROSS MEMBERS	Ps1	Ps2	Ps
BODY	Pc1	Pc2	Pc
TOTAL TARE WEIGHT	TT1	TT2	TT
LOAD CAPACITY	Q1	Q2	Q
TOTAL	TOT1	TOT2	PTT
MAX LIMIT - VEHICLE MANUFACTURER	MAX1	MAX2	

Tab. 3

3.2.3.3 - Front/rear axle mass ratio check

Empty = $\dfrac{TT_1}{TT_2}$ =..........> (Min. value ADM. C.C. vehicle)

Full load = $\dfrac{TOT_1}{TOT_2}$ =...........> (Min. value ADM. C.C. vehicle)

3.2.4 - Triple-axle vehicle with rear-mounted crane

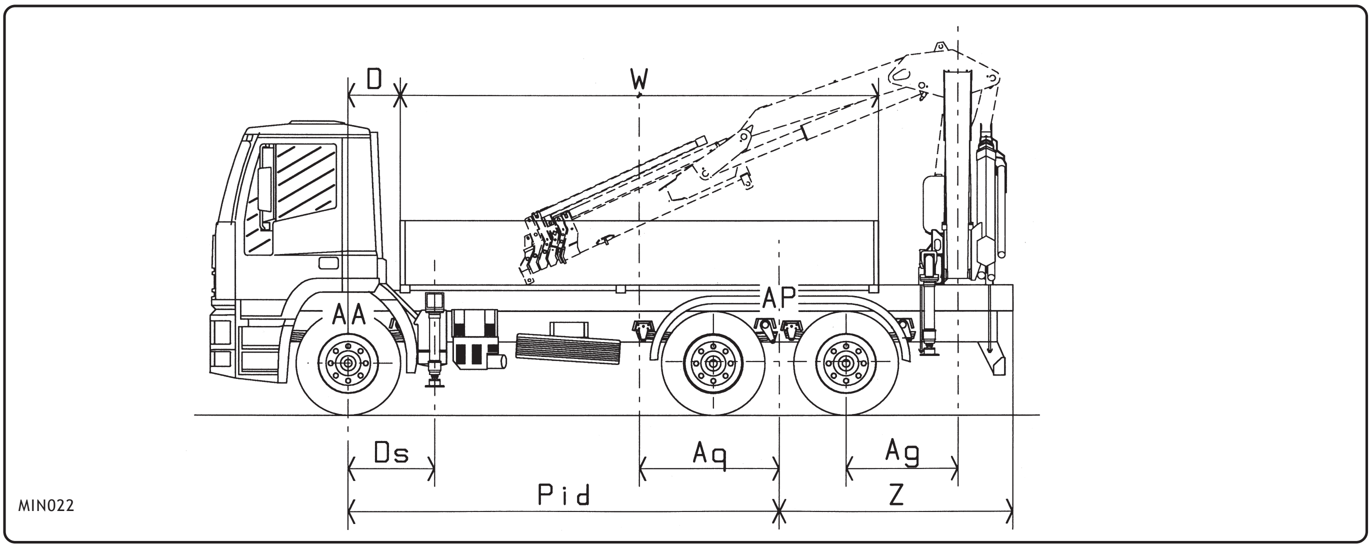


fig. 3.2.17

Key to symbols

	G	= Mass of the crane	(kg)
*	T	= Tare weight of the cab vehicle	(kg)
*	T_1	= Tare weight distribution of cab vehicle on front axle	(kg)
*	T_2	= Tare weight distribution of cab vehicle on second axle	(kg)
*	T_3	= Tare weight distribution of cab vehicle on third axle	(kg)
	Pc	= Mass of vehicle body (including mass of counter-chassis)	(kg)
	Ps	= Mss of supplementary outriggers	(kg)
	TT	= Total tare weight = $T_1+T_2+T_3+Pc+Ps+G$	(kg)
	Q	= PTT-TT = Residual capacity	(kg)
*	PTT	= Mass at full load	(kg)
	Pid	= Ideal wheelbase	(mm)
	Z	= Rear overhang crane + vehicle	(mm)
	W	= Body length	(mm)
	Ag	= Distance between 3rd rear axle/crane's barycenter	(mm)
	Aq	= Advance of vehicle body's barycenter (= Pid - D - $\frac{W}{2}$)	(mm)
	D	= Distance between front axle and start of cab	(mm)
	Ds	= Distance between supp. outrigger cross member and front axle	(mm)
	P_{1-2}	= Front axle/centre axle wheelbase	(mm)
	P_{2-3}	= Centre axle/rear axle wheelbase	(mm)
**	AA	= Front axle	
	AP	= Rear axle	

Note

As for the barycenter of the crane, the chosen rest position (folded up on the base or extended on the vehicle body) should be considered.

* Values obtained from vehicle type "Approval report" or by "direct weighing".

** For vehicles with two front axles, the wheelbase is calculated starting from their centre line.

3.2.4.1 - Ideal calculation of wheelbase

a) Tandem rear axles (vehicle 6x4 o 6x6)

See fig. 3.2.6 - chap. 3 - page 9/44.

$$Pid = + P_{1-2} + \frac{P_{2-3}}{2} \qquad S = T = \frac{P_{2-3}}{2}$$

b) Independent rear axles (with single 3rd axle wheels 6x2 vehicle)

See fig. 3.2.7 - chap. 3 - page 9/44.

$$Pid = + P_{1-2} + \frac{P_{2-3}}{2} \qquad P_{2-3} = S+T$$

$$S = \frac{1}{3} P_{2-3} \qquad T = \frac{2}{3} P_{2-3}$$

3.2.4.2- Superstructure distribution

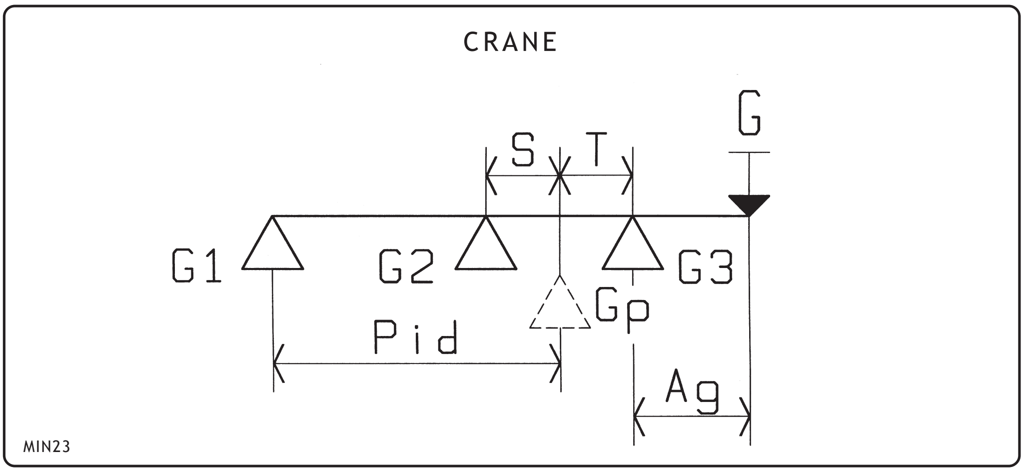


fig. 3.2.18

G_1 = (-)G·(T+Ag)/Pid = kg.................. (Crane mass distribution over front axle)

$Gp = G-G_1$ = kg.................. (Crane mass distribution over ideal axle)

Qp distribution over two rear axles:

Indipendent rear axles (6x2)

$G_3 = Gp \cdot S / P_{2\text{-}3}$ = kg

$G_2 = Gp - G_3$ = kg

Tandem rear axles (6x4-6x6)

$G_2 = G_3 = Gp/2$ = kg

$Q_2 = Qp - Q_3$ = kg

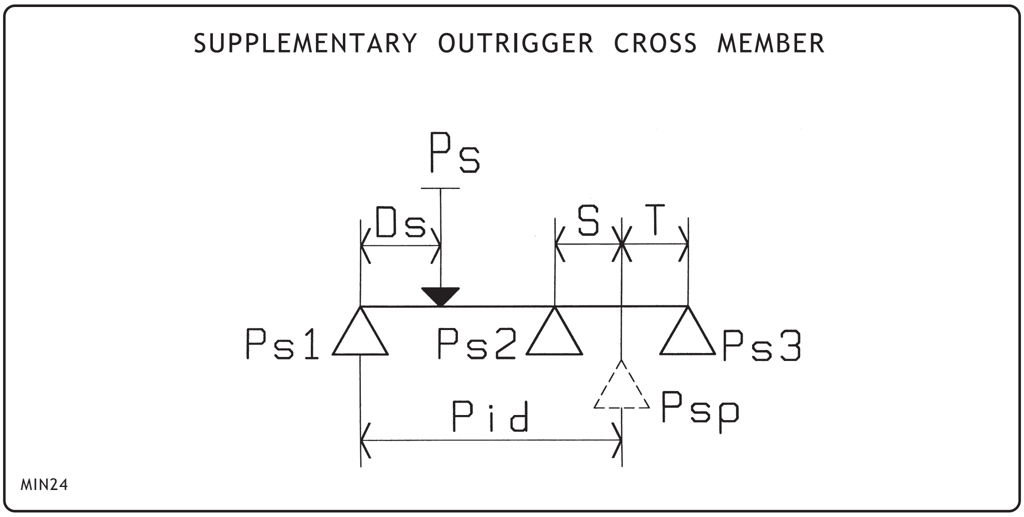


fig. 3.2.19

Ps_1 = Ps·(Pid-Ds)/Pid =kg.................. (Supp. outrigger cross member distribution on front axle)

$Psp = Ps-Ps_1$ = kg.................. (Supp. outrigger cross member distribution on ideal axle)

Psp distribution over two rear axles:

Independent rear axles (6x2)

$Ps_3 = Psp \cdot S / P_{2-3} = kg$

$Ps_2 = Psp - Ps_3 = kg$

Tandem rear axles (6x4-6x6)

$Ps_2 = Ps_3 = Psp/2 = kg$

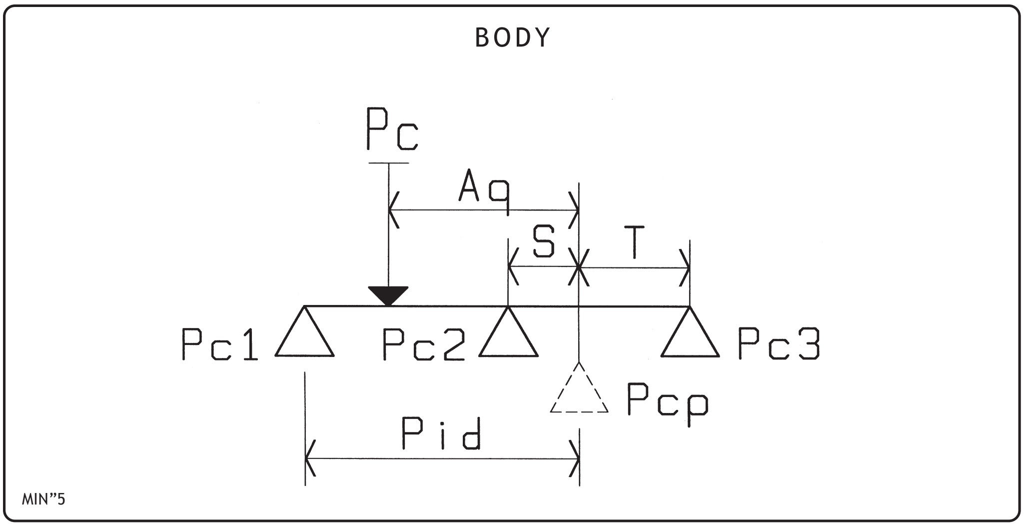


fig. 3.2.20

$Pc_1 = Pc \cdot Aq/Pid$ =kg.................. (Body mass distribution over front axle)

$Pcp = Pc - Pc_1$ =kg.................. (Body mass distribution over ideal axle)

Pcp distribution over two rear axles:

Independent rear axles (6x2)

$Pc_3 = Pcp \cdot S / P_{2-3} = kg$

$Pc_2 = Pcp - Pc_3 = kg$

Tandem rear axles (6x4-6x6)

$Pc_2 = Pc_3 = Pcp/2 = kg$

TOTAL TARE WEIGHT

$TT = T+G+Ps+Pc$ = kg.................. (Total tare weight crane + vehicle)

$TT_1 = T_1+G_1+Ps_1+Pc_1$ = kg.................. (Total tare weight distribution over front axle)

$TT_2 = T_2+G_2+Ps_2+Pc_2$ = kg.................. (Total tare weight distribution over 2nd axle)

$TT_3 = T_3+G_3+Ps_3+Pc_3$ = kg.................. (Total tare weight distribution over 3rd axle)

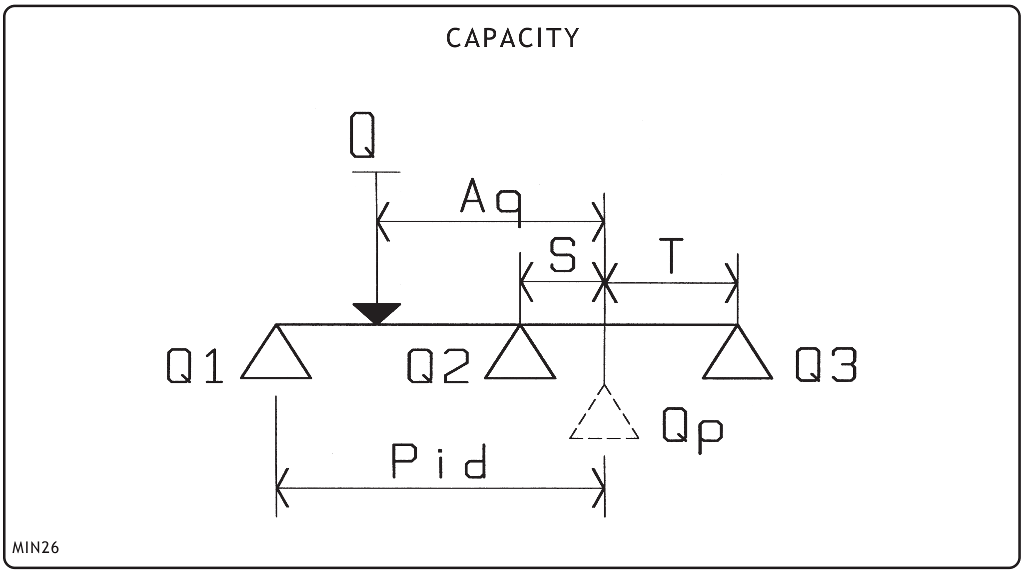


fig. 3.2.21

Q = PTT-TT = kg.................. (Total residual capacity)

Q_1 = $Q \cdot Aq/Pid$ = kg................. (Capacity distribution over front axle)

Qp = $Q-Q_1$ = kg.................. (Capacity distribution over ideal axle)

Qp distribution over rear axles:

Independent rear axles (6x2)

$Q_3 = Qp \cdot S/\ P_{2-3}$ = kg

$Q_2 = Qp-Q_3$ = kg

Tandem rear axles (6x4-6x6)

$Q_3 = Qp/2$ = kg

$Q_2 = Qp-Q_3$ = kg

3.2.4.3 - Summary chart and check

	1ST AXLE	2ND AXLE	3RD AXLE	TOTAL
CHASIS TARE WEIGHT	T1	T2	T3	T
CRANE	G1	G2	G3	G
SUPPLEMENTARY OUTRIGGER CROSS MEMBERS	Ps1	Ps2	Ps3	Ps
BODY	Pc1	Pc2	Pc3	Pc
TOTAL TARE WEIGHT	TT1	TT2	TT3	TT
CAPACITY	Q1	Q2	Q3	Q
TOTAL	TOT1	TOT2	TOT3	PTT
MAX. LIMIT VEHICLE MANUFACTURER	MAX1	MAX2	MAX3	

Tab. 4

3.2.4.4 - Front / rear axle mass ratio check

Empty = $\dfrac{TT_1}{TT_2+TT_3}$ =..........> (Min. value ADM C.C. vehicle)

Full load = $\dfrac{TOT_1}{TOT_2+TOT_3}$ =...........> (Min. value ADM C.C. vehicle)

3.2.5 - Tractor-mounted crane

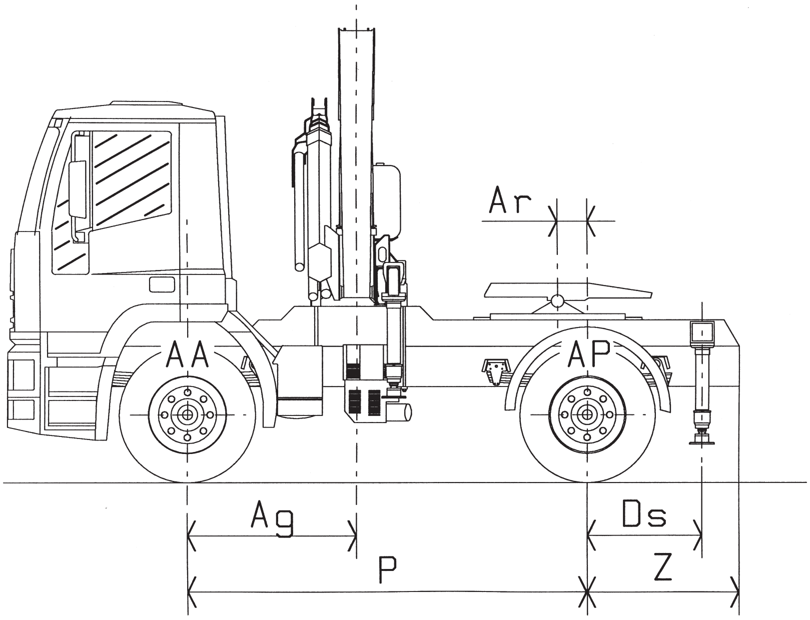


fig. 3.2.22

Key to symbols

	G	= Mass of the crane	(kg)
*	T	= Vehicle tare weight	(kg)
*	T_1	= Tare weight distribution of tractor on front axle	(kg)
*	T_2	= Tare weight distribution of tractor on rear axle	(kg)
	Ps	= Mass of supp. outriggers	(kg)
	TT	= Total tare weight = T_1+T_2+Ps+G	(kg)
	Qr	= PTT-TT = Residual load on thrust bearing	(kg)
*	PTT	= Gross weight at full load	(kg)
	Mr	= Towable mass	(kg)
	P	= Wheelbase	(mm)
	Z	= Rear overhang	(mm)
	Ag	= Distance of front axle from crane's barycenter	(mm)
	Ar	= Advance thrust bearing barycenter	(mm)
	Ds	= Distance between supp. outrigger cross member and rear axle	(mm)
**	AA	= Front axle	
	AP	= Rear axle	

* Values obtained from vehicle type "Approval report" or by "direct weighing".

** For vehicles with two front axles, the wheelbase is calculated starting from their centre line.

In this case, check the maximum admissible weights on the axles and the amount of any load reduction on the thrust bearing.

When mounting the crane behind the cab, it is necessary to move the thrust bearing from its original position (only after authorisation from the vehicle manufacturer).

Current italian law sets a max limit of 1,6% for declassing the overall mass of the semi-trailer to be coupled to the tractor.

For this reason it is advisable to couple to tractors with cranes an ad hoc semi-trailer the weight of which is compatible with the new towable weight values and the overall load on the thrust bearing.

3.2.5.1- Superstructure distribution

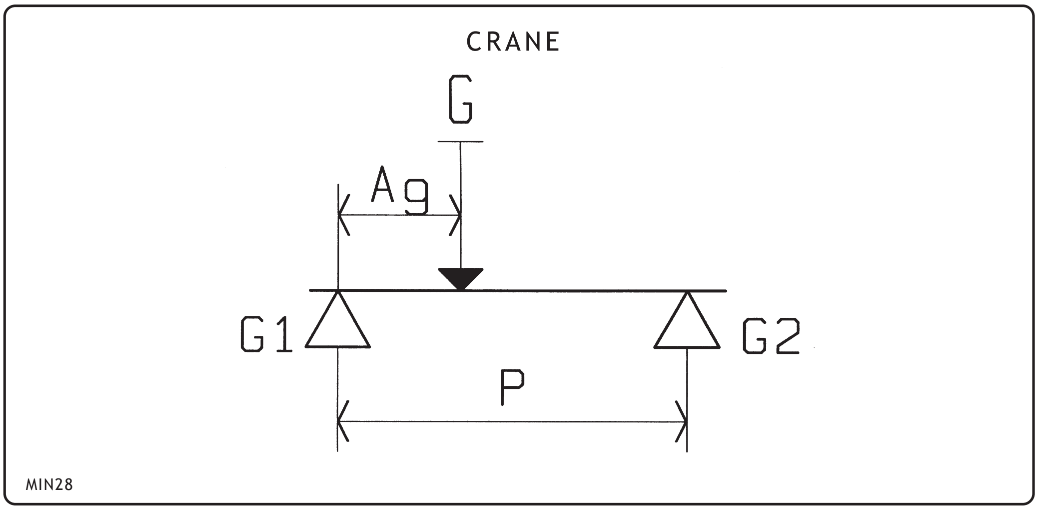


fig. 3.2.23

$G_1 = G \cdot (P-Ag)/P$ = kg.................. (Crane mass distribution on front axle)

$G_2 = G-G_1$ = kg.................. (Crane mass distribution on rear axle)

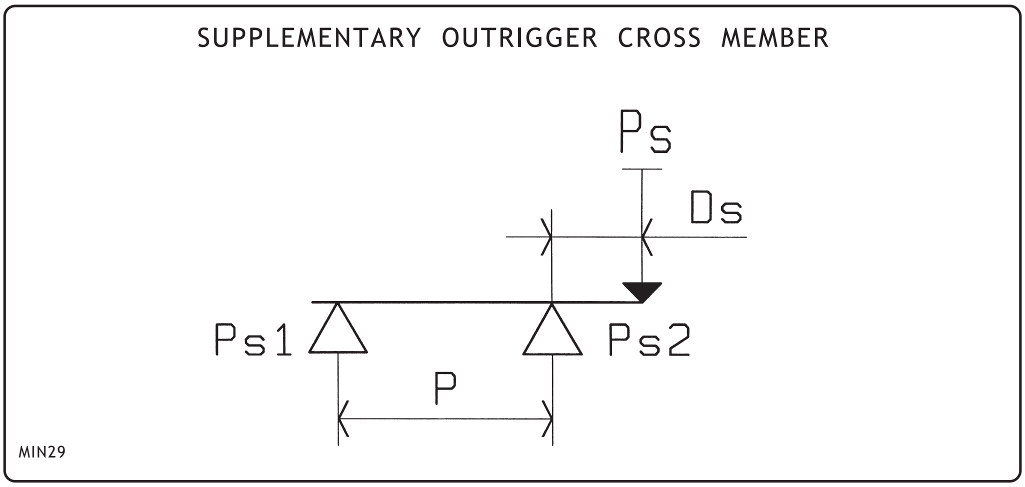


fig. 3.2.24

$Ps_1 = (-)Ps \cdot Ds)/P$ = kg.................. (Distribution of supp. outrigger cross member on front axle)

$Ps_2 = Ps-Ps_1$ = kg.................. (Distribution of supp. outrigger cross member on rear axle)

TOTAL TARE WEIGHT

$TT = T+G+Ps$ = kg.................. (Total tare weight crane + vehicle)

$TT_1 = T_1+G_1+Ps_1$ = kg.................. (Total tare weight distribution on front axle)

$TT_2 = T_2+G_2+Ps_2$ = kg.................. (Total tare weight distribution on rear axle)

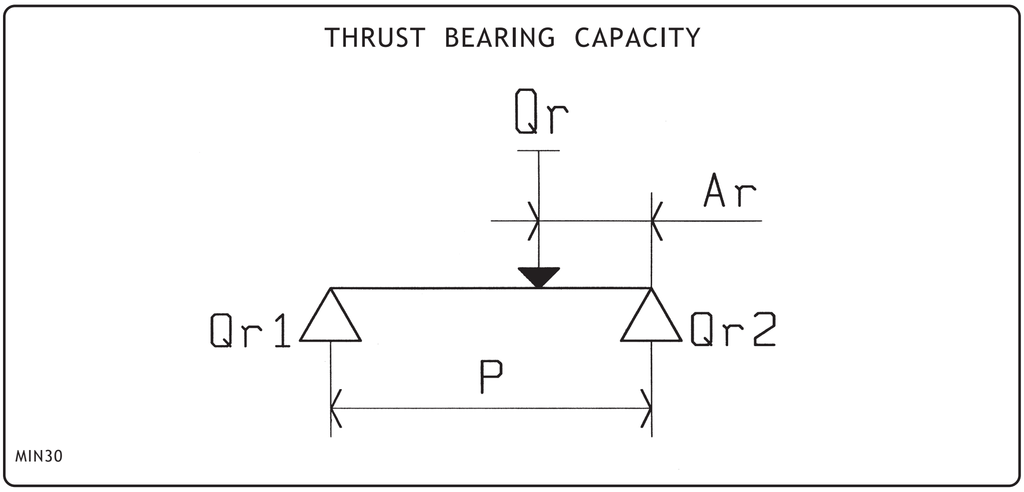


fig. 3.2.25

Qr_1 = $Qr \cdot Ar/P$ = kg.................. (Thrust bearing capacity distr. on front axle)

Qr_2 = $Qr-Qr_1$ = kg.................. (Thrust bearing load distr. on rear axle)

3.2.5.2 - Summary chart and check

	1ST AXLE	2ND AXLE	TOTAL
CHASIS TARE WEIGHT	T1	T2	T
CRANE	G1	G2	G
SUPPLEMENTARY OUTRIGGER CROSS MEMBERS	Ps1	Ps2	Ps
BODY	Pc1	Pc2	Pc
TOTAL TARE WEIGHT	TT1	TT2	TT
CAPACITY	Q1	Q2	Q
TOTAL	TOT1	TOT2	PTT
MAX. LIMIT VEHICLE MANUFACTURER	MAX1	MAX2	

Tab. 5

3.2.5.3 - Front / rear axle mass ratio check

Empty = $\dfrac{TT_1}{TT_2}$ =..........> (Min. value ADM C.C. vehicle)

Full load = $\dfrac{TOT_1}{TOT_2}$ =...........> (Min. value ADM C.C. vehicle)

3.2.5.4 - Towable mass analysis

After mounting the crane, the new towable mass of the tractor is as follows:
Mrim = Mr - G-Ps

3.3 - Theoretical stability analysis

This is a theoretical test (carried out with the help of analyses and graphs) which takes into account:

a) the overturning moment generated by the crane working under the most unfavourable conditions (*);
b) the moment of resistance opposed to it due to the weight of the vehicle and the behaviour of all the parts helping to prevent the vehicle from overturning.

This test is highly simplified in that it does not take into account other factors (height of the chassis from the ground, width or tread width, tare weight distribution, chassis elasticity, etc.) which more or less directly affect the vehicle stability.

As it would be rather complicated to develop a system taking all these factors into account, a simpler more immediate method is preferred although it still maintains a certain safety margin in the face of unknown factors.

However, the results may sometimes differ from theory. In this case it is necessary to use some technical devices (special counter-chassis, supplementary outriggers, etc.) to get an equally good result.

Theoretical stability analysis is carried out in compliance with ISO 4305.

The following pages show a series of crane-vehicle combinations and the formulas to use for the calculations.

Note

(*) It has been decided to assume that the worst working condition is the one with the boom completely extended in horizontal position (as shown on the lifting capacity plate). Should the crane be equipped with additional accessories (such as extension and jib), the test must be executed in the following way:

- basic crane with fully extended horizontally boom (as per lifting capacity plate);
- basic crane plus accessories completely extended horizontally (as per lifting capacity plate for crane with accessories).

3.3.1 - Theoretical stability analysis-analytical methode

3.3.1.1 - Crane behind cab

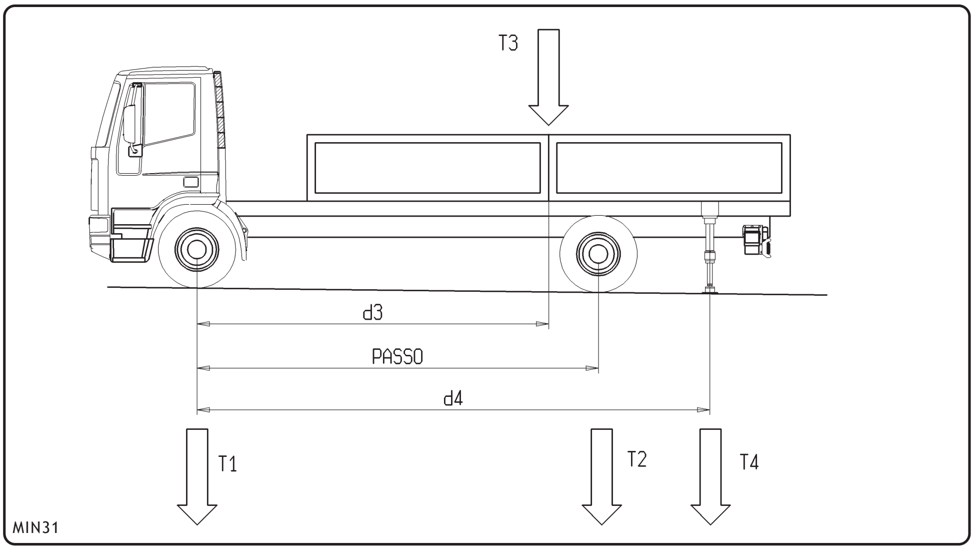


fig. 3.3.1

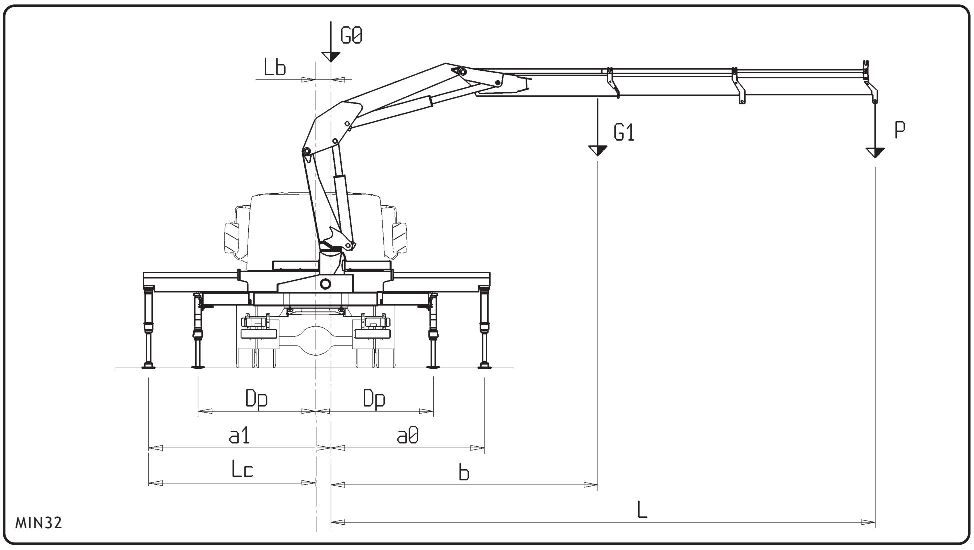


fig. 3.3.2

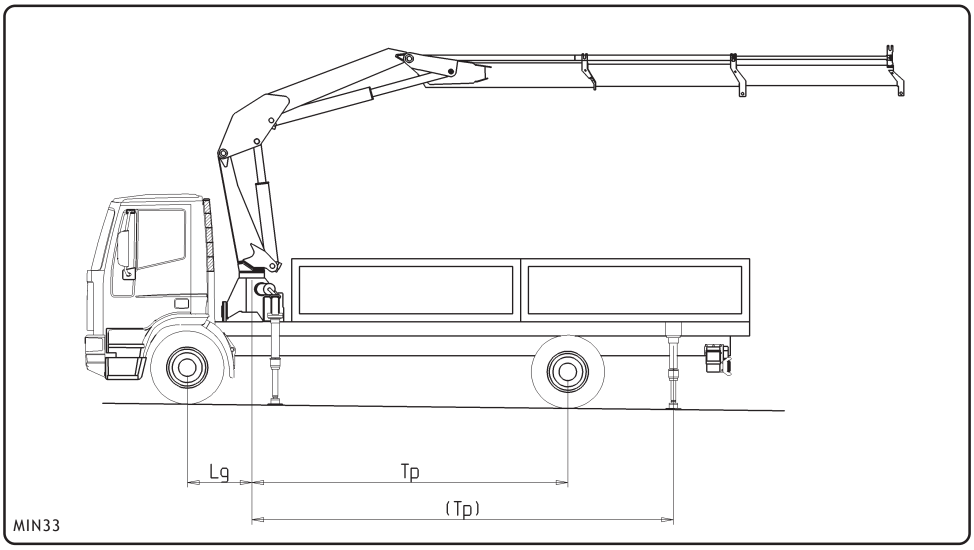


fig. 3.3.3

- VEHICLE (values to be taken from the "truck type approval specifications" or from tests)

T1	=	kg	Mass on front axle without crane
T2	=	kg	Mass on rear axle without crane
T3	=	kg	Mass body and counter-chassis
T4	=	kg	Supplementary outrigger mass - if present, if absent T4 = 0
T	=	kg	T1+T2+T3+T4 = Total tare weight of vehicle
Wheelbase	=	mm	Ideal wheelbase of vehicle
d3	=	mm	Distance between body barycenter and front vehicle axis
d4	=	mm	(with supp. outriggers) Distance between supplementary outrigger centre line and front vehicle axis, without supp. outriggers d4 = 0

- CRANE (values to be taken from the crane's technical specifications sheets)

P	=	kg	Lifting capacity with boom outreach L
L	=	mm	Load P outreach from hook coupling to column axis
G 0	=	kg	Mass of the fixed part of the crane
G 1	=	kg	Mass of the overhang part of the crane
b	=	mm	Distance between G1 and column axis

- MOUNTING CRANE ON VEHICLE (values depend on the installation type planned)

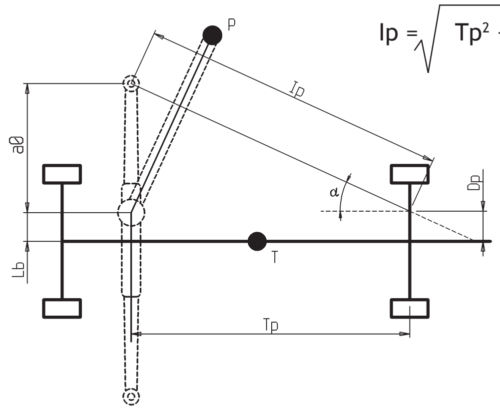
Lb	=	mm	Distance between column axis and vehicle centre line
Lg	=	mm	Distance between column axis and front vehicle axis
a0	=	mm	Distance between column axis and right outrigger
a1	=	mm	Distance between column axis and left outrigger
Lc	=	mm	(a1-Lb) Distance between vehicle's centre line and left outrigger
Tp	=	mm	Distance between column axis and rear outrigger centre line (with supp. outriggers) or the rear vehicle axis (without supp. outriggers)
Dp	=	mm	Distance between supplementary outrigger (tip-up side) from vehicle centre line. If there are no supp. outriggers, the rear vehicle axis must be considered equal to 1/4 of the vehicle's tread width
Kdin	=	1.25	Dynamic load coefficient
Ksbal	=	0.10	Coefficient of load increase due to overhang mass of the crane

LATERAL STABILITY TEST FOR RIGHT-HAND SECTOR

Without supplementary cross members | **With supplementary cross members**

$$\alpha\ (\text{alfa}) = \text{arctg}\left(\frac{a0 + Lb - Dp}{Tp}\right)$$

$$Ip = \sqrt{Tp^2 + (a0 + Lb - Dp)^2}$$



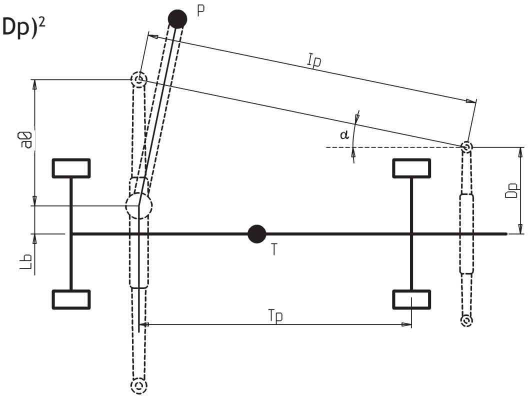
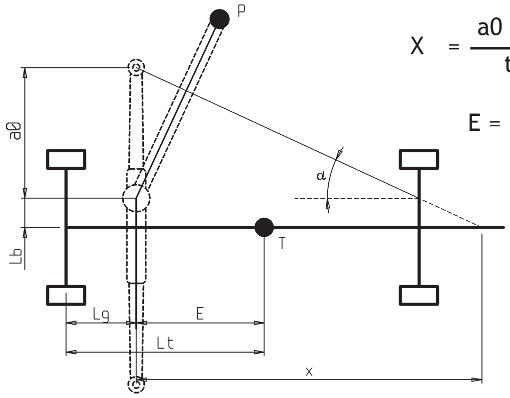


fig. 3.3.4

$$Lt = \frac{T2 \cdot WHEELBASE + T3 \cdot d3 + T4 \cdot d4}{T1 + T2 + T3 + T4}$$

$$X = \frac{a0 + Lb}{tg\,\alpha}\ \text{mm}$$

$$E = Lt - Lg$$



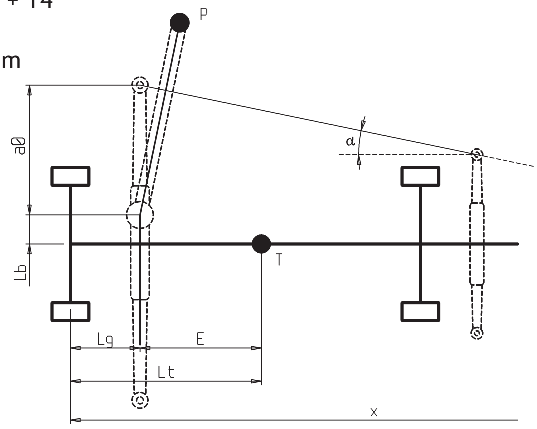
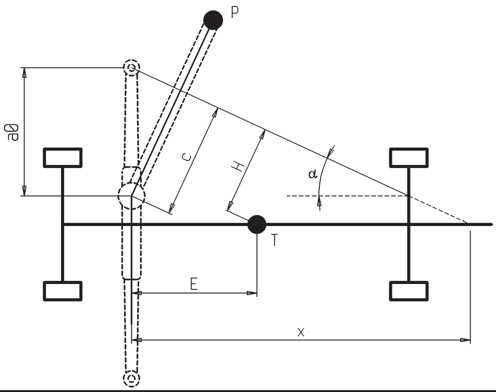


fig. 3.3.5

$$H = \frac{(a0 + Lb - Dp) \cdot (X - E)}{Ip}$$

$$C = a0 \cdot \cos\alpha$$



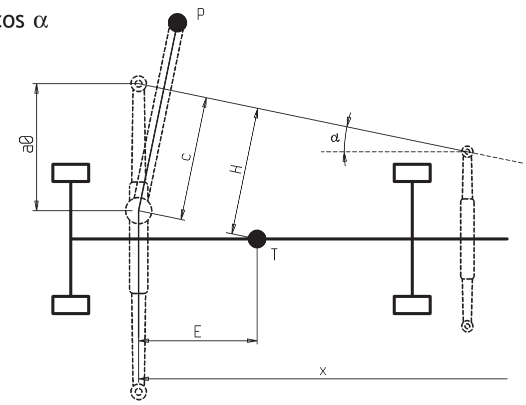


fig. 3.3.6

F = Weight of suspended parts (brackets, bracket cylinder, boom pack) at head of the last boom (in the case of a jibless crane).
Mass of suspended parts (brackets, bracket cylinder, boom pack) + jib mass at jib head (crane with jib).
For F values, see the technical specification sheet of the crane.
If the table is not available the value F can be calculated with the following formula:

$$\mathbf{F} = \frac{(G1 \cdot b)}{L} \quad \text{kg}$$

Ms = $T \cdot H + G0 \cdot C$ daN · mm .... Stabilising moment

Mr = $(Kdin \cdot P + Ksbal \cdot F) \cdot (L-C) + G1 \cdot (b - C)$ daN · mm .... Overturning moment

$$\mathbf{K} = \frac{Ms}{Mr}$$

According to the standards, the side overturn stability requirement is met when K > 1.
According to our experience the requirement is met when K > 1,1.

- STABILITY TEST WITH FRONT LOAD (see following notes and those on pages 42/44 of chap. 3)

Ms = $T \cdot Lt + Lg \cdot G0$ daN · mm .... Stabilising moment

Mr = $(Kdin \cdot P + Ksbal \cdot F) \cdot (L-Lg) + G1 \cdot (b - Lg)$ daN · mm .... Overturning moment

$$\mathbf{K} = \frac{Ms}{Mr}$$

According to the standards, the front overturn stability requirement is met when K > 1.
Experience has taught us that, since a simplified calculation formula is used, the requirement is met when K > 1,3.

-STABILITY TEST WITH REAR LOAD

If the calculation of stability with a side load has been checked, then calculation of stability with a rear load has also been verified.

Note

If stability has not been ascertained in a certain sector and it is not possible to add any ballast, the following procedure represents a necessary alternative:
a) prevent work in that area by locking the rotation beyond the sector permitted;
b) adjust the limiting device (if there is one) to reduce the capacity accordingly.
In theory it is possible to make an approximate calculation of the extent of the reduction in capacity using the following formula.

Pr = $f \cdot P$ where:

f = crane declassing coefficient, when the crane is working in a section where stability is not granted
Pr = reduced lifting capacity of the crane for the outreach L.
- For the front section - (see notes on pages 42/44 of chap. 3).

$$\mathbf{f} = \left[\frac{T \cdot Lt + G0 \cdot Lg - 1{,}3G1 \cdot (b - Lg)}{1{,}3 \cdot (L - Lg) \cdot Kdin \cdot P} \right] - \frac{Ksbal \cdot F}{Kdin \cdot P}$$

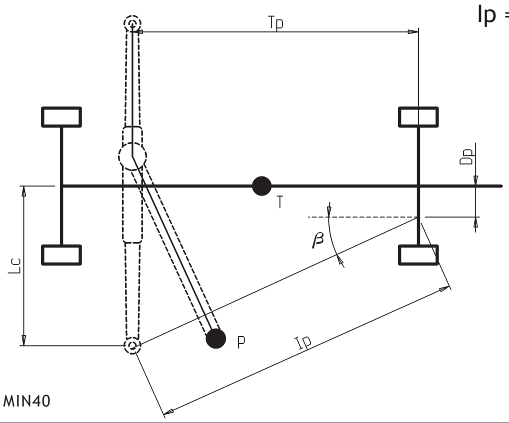
Conclusion: calculation of the stability of a crane mounted behind the cab is verified when the side and front overturn stability calculations have met the standard.

LATERAL STABILITY TEST FOR LEFT-HAND SECTOR

Without supplementary cross members **With supplementary cross members**

$$\beta \text{ (beta)} = \operatorname{arctg}\left(\frac{Lc - Dp}{Tp}\right)$$

$$Ip = \sqrt{Tp^2 + (Lc - Dp)^2}$$



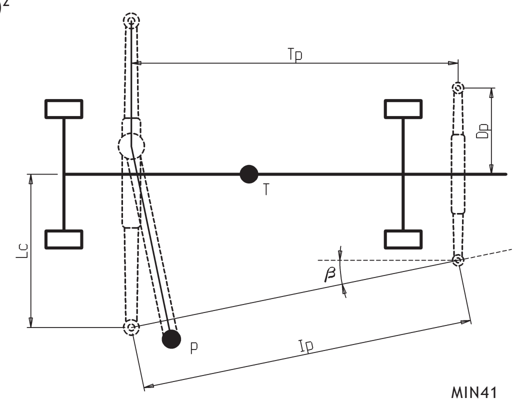
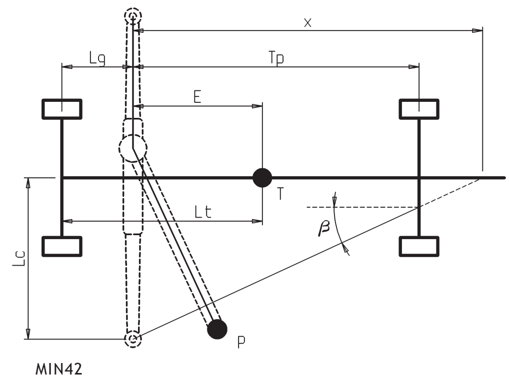


fig. 3.3.7

$$Lt = \frac{T2 \cdot \text{WHEELBASE} + T3 \cdot d3 + T4 \cdot d4}{T1 + T2 + T3 + T4}$$

$$X = \frac{Lc}{\operatorname{tg}\beta}$$

$$E = Lt - Lg$$



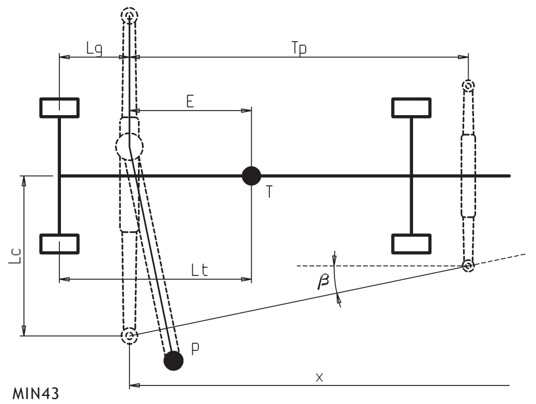
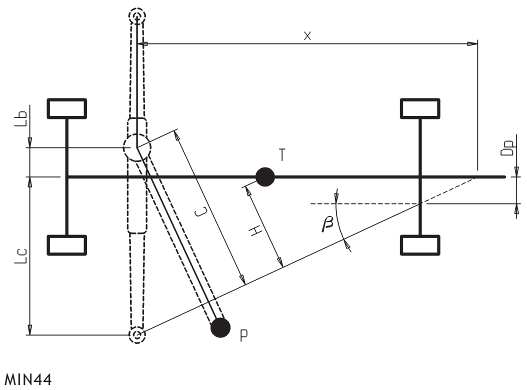


fig. 3.3.8

$$C = (Lc + Lb) \cdot \cos\beta$$

$$H = \frac{(Lc - Dp) \cdot (X - E)}{Ip}$$



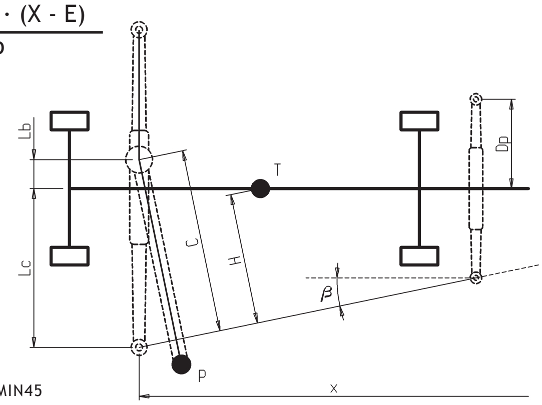


fig. 3.3.9

F = Weight of suspended parts (brackets, bracket cylinder, boom pack) at head of the last boom (in the case of a jibless crane).
Mass of suspended parts (brackets, bracket cylinder, boom pack) + jib mass at jib head (crane with jib).
For F values, see the technical specification sheet of the crane. If the table is not available the value F can be calculated with the following formula:

$$\mathbf{F} = \frac{(G1 \cdot b)}{L} \text{ kg}$$

Ms = T · H + G0 · C daN · mm .... Stabilising moment

Mr = (Kdin · P + Ksbal · F) · (L-C) + G1 · (b - C) daN · mm .... Overturning moment

$$\mathbf{K} = \frac{Ms}{Mr}$$

According to the standards, the side overturn stability requirement is met when K > 1.
According to our experience, the requirement is met when K > 1,1.

- STABILITY TEST WITH FRONT LOAD (see following notes and those on pages 42/44 of chap. 3)

Ms = T · Lt+ Lg · G0 daN · mm .... Stabilising moment

Mr = (Kdin · P + Ksbal · F) · (L-Lg) + G1 · (b - Lg) daN · mm .... Overturning moment

$$\mathbf{K} = \frac{Ms}{Mr}$$

According to the standards, the front overturn stability requirement is met when K > 1.
Experience has taught us that, since a simplified calculation formula has been used, the requirement is met when K > 1,3.

- STABILITY TEST WITH REAR LOAD

If the calculation of stability with a side load has been checked, then calculation of stability with a rear load has also been verified.

☞ Note

If stability has not been ascertained in a certain sector and it is not possible to add any ballast, the following procedure represents a necessary alternative:
a) prevent work in that area by locking the rotation beyond the sector permitted;
b) adjust the limiting device (if there is one) to reduce the capacity accordingly.
In theory it is possible to make an approximate calculation of the extent of the reduction in capacity using the following formula.

Pr = f · P where:

f = crane declassing coefficient, when the crane is working in a section where stability is not granted
Pr = reduced lifting capacity of the crane for the outreach L.
- For the front section - (see notes on pages 42/44 of chap. 3).

$$\mathbf{f} = \left[\frac{T \cdot Lt + G0 \cdot Lg - 1{,}3G1 \cdot (b - Lg)}{1{,}3 \cdot (L - Lg) \cdot Kdin \cdot P} \right] - \frac{Ksbal \cdot F}{Kdin \cdot P}$$

Conclusion: calculation of the stability of a crane mounted behind the cab is verified when the side and front overturn stability calculations have met the standard.

3.3.1.2 - Rear-mounted crane vehicle

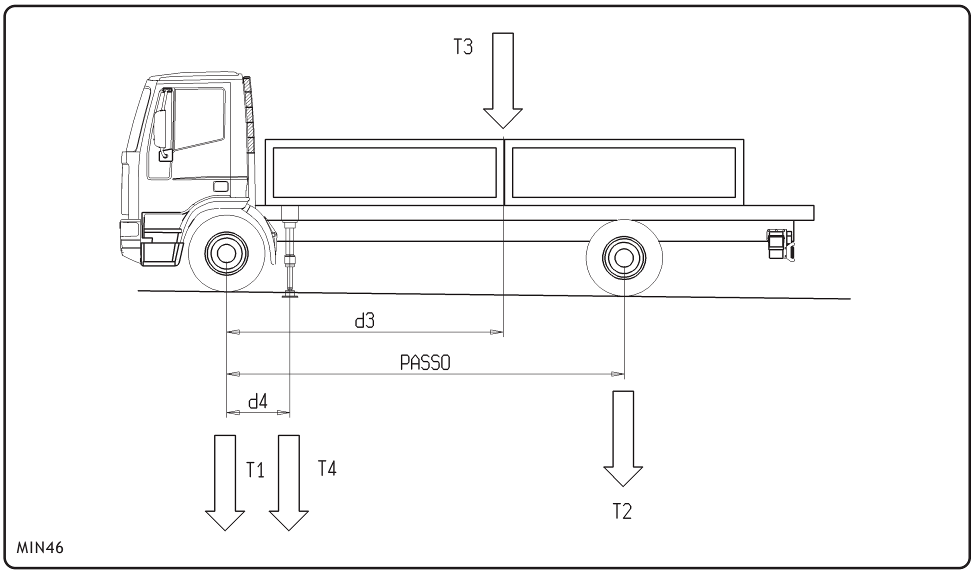


fig. 3.3.10

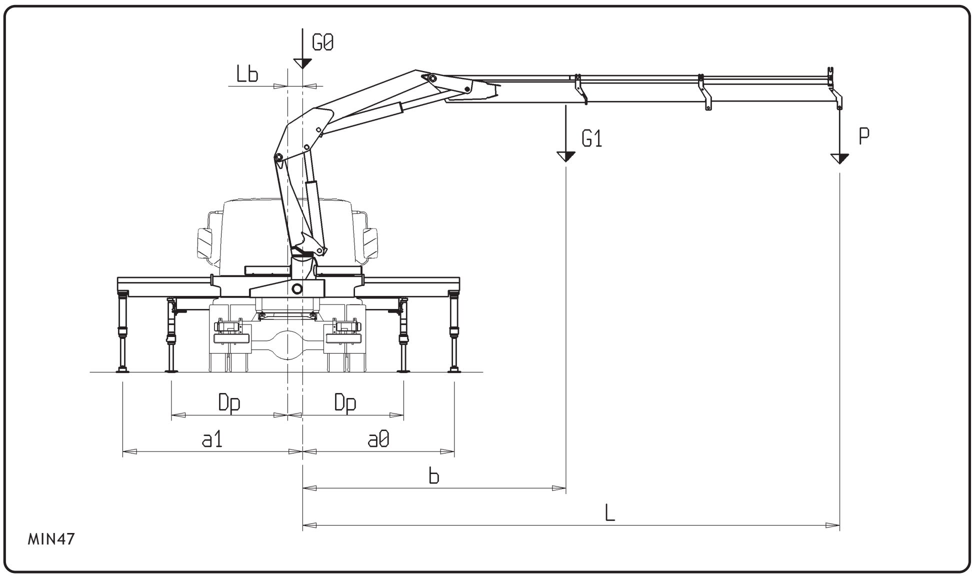


fig. 3.3.11

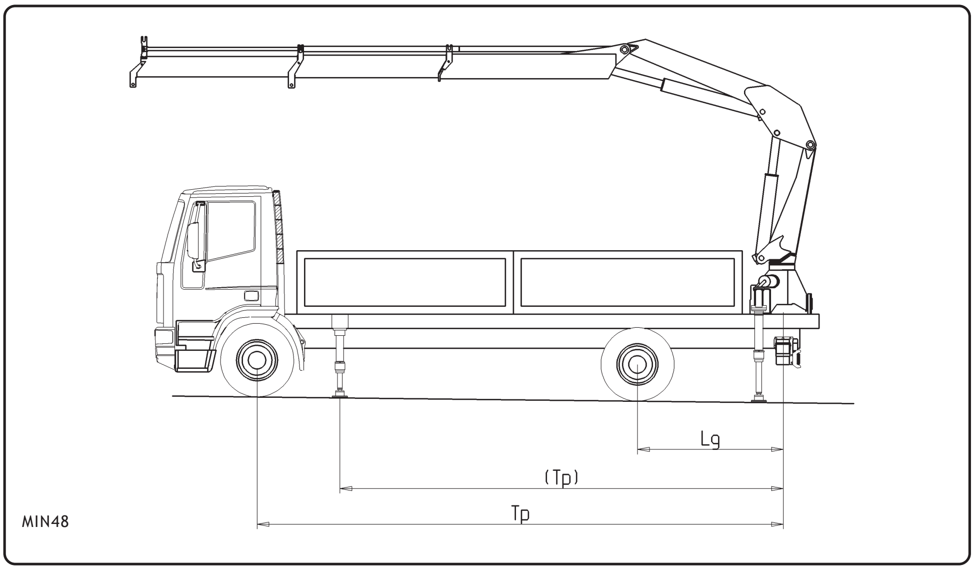


fig. 3.3.12

- VEHICLE (values to be taken from the "truck type approval specifications" or from tests)

T1	=	kg	Mass on chassis front axle
T2	=	kg	Mass on chassis rear axle
T3	=	kg	Mass body and counter-chassis
T4	=	kg	Supplementary outrigger mass if present, if absent T4 = 0
T	=	kg	T1+T2+T3+T4 = Total tare weight of vehicle
WHEELBASE	=	mm	Ideal wheelbase of vehicle
d3	=	mm	Distance between body barycenter and front vehicle axis
d4	=	mm	(with supp. outriggers) Distance between supplementary outrigger centre line and front vehicle axle, if absent d4 = 0

- CRANE (values to be taken from the crane's technical specifications sheets)

P	=	kg	Lifting capacity with boom outreach L
L	=	mm	Load P outreach from hook coupling to column axis
G 0	=	kg	Mass of the fixed part of the crane
G 1	=	kg	Mass of the overhang part of the crane
b	=	mm	Distance between G1 and column axis

- MOUNTING CRANE ON VEHICLE (values depend on the installation type planned)

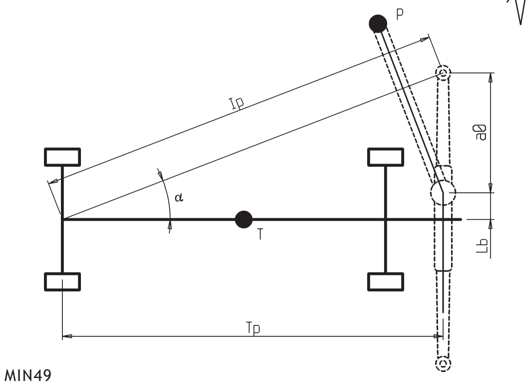
Lb	=	mm	Distance between column axis and vehicle centre line
Lg	=	mm	Distance between column axis and rear vehicle axis
a0	=	mm	Distance between column axis and right outrigger
a1	=	mm	Distance between column axis and left outrigger
Lc	=	mm	(a1-Lb) Distance between vehicle's centre line and left outrigger
Tp	=	mm	Distance between column axis and rear outrigger centre line (with supp. outriggers) or the rear vehicle axis (without supp. outriggers)
Dp	=	mm	(with supplementary outriggers) Distance between supplementary outrigger (tip-up side) from vehicle centre line
Dp vehicle tread	=	mm	(without supplementary outriggers) Distance of the axis of the leaf spring (tip-up side) from centre line. If this information is not available Dp is considered equal to 1/4 of the vehicle's width
Kdin	=	1.25	Dynamic load coefficient
Ksbal	=	0.10	Coefficient of load increase due to crane overhang mass

STABILITY TEST FOR RIGHT-HAND SECTOR

Without supplementary cross members | With supplementary cross members

$$\alpha\ (\text{alfa}) = \text{arctg}\left(\frac{a0 + Lb - Dp}{Tp}\right)$$

$$Ip = \sqrt{Tp^2 + (a0 + Lb - Dp)^2}$$



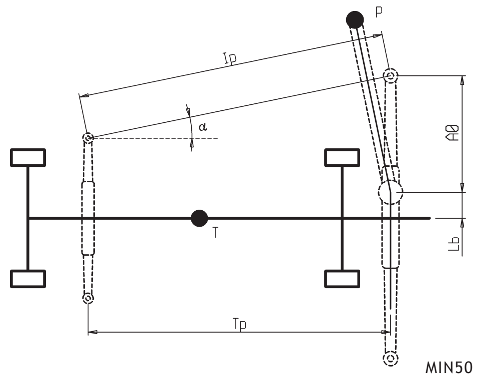
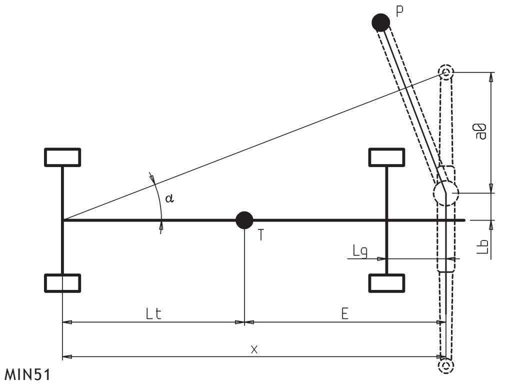


fig. 3.3.13

$$Lt = \frac{T2 \cdot \text{WHEELBASE} + T3 \cdot d3 + T4 \cdot d4}{T1 + T2 + T3 + T4}$$

$$X = \frac{a0 + Lb}{tg\,\alpha}$$

$$E = \text{WHEELBASE} - Lt + Lg$$



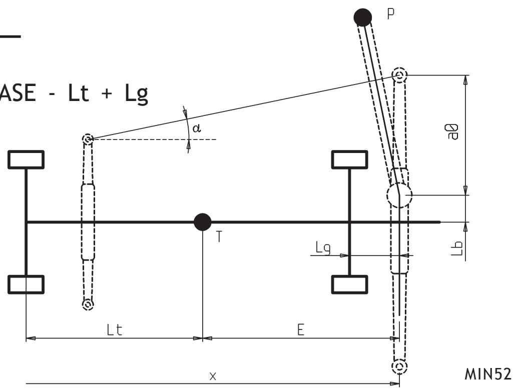
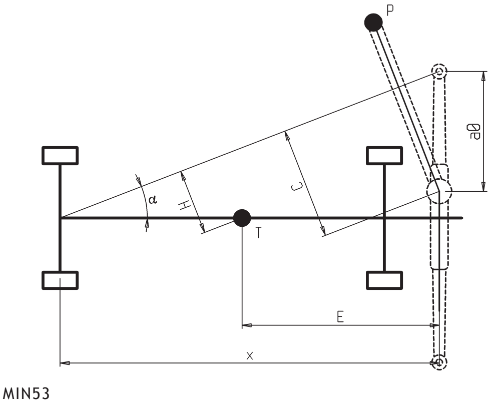


fig. 3.3.14

$$H = \frac{(a0 + Lb - Dp) \cdot (X - E)}{Ip}$$

$$C = a0 \cdot \cos\alpha$$



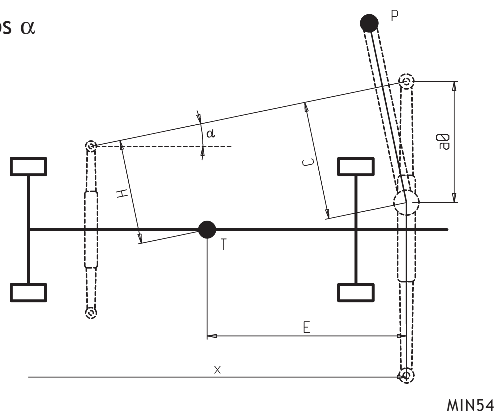


fig. 3.3.15

F = Weight of suspended parts (brackets, bracket cylinder, boom pack) at head of the last boom (in the case of a jibless crane).
Weight of suspended parts (brackets, bracket cylinder, boom pack) + jib mass at jib head (crane with jib).
For F values, see the technical specification sheet of the crane.
If the table is not available, the value F can be calculated with the following formula:

$$\mathbf{F} = \frac{(G1 \cdot b)}{L} \text{ kg}$$

Ms = $T \cdot H + G0 \cdot C$ daN · mm .... Stabilising moment

Mr = $(Kdin \cdot P + Ksbal \cdot F) \cdot (L\text{-}C) + G1 \cdot (b - C)$ daN · mm .... Overturning moment

$$\mathbf{K} = \frac{Ms}{Mr}$$

According to the standards, the side overturn stability requirement is met when K > 1.
According to our experience, the requirement is met when K > 1,1.

- STABILITY TEST WITH FRONT LOAD (see following notes and those on pages 42/44)

Ms = $T \cdot Lt + Lg \cdot G0$ daN · mm .... Stabilising moment

Mr = $(Kdin \cdot P + Ksbal \cdot F) \cdot (L\text{-}Lg) + G1 \cdot (b - Lg)$ daN · mm .... Overturning moment

$$\mathbf{K} = \frac{Ms}{Mr}$$

According to the standards, the side overturn stability requirement is met when K > 1.
Experience has taught us that the requirement is met when K > 1,1.

- STABILITY TEST WITH FRONT LOAD

If the calculation of stability with a side load has been checked, then calculation of stability with a front load has also been verified.

☞ Note

If stability has not been ascertained in a certain sector and it is not possible to add any ballast, the following procedure represents a necessary alternative:
a) prevent work in that area by locking the rotation beyond the sector permitted;
b) adjust the limiting device (if there is one) to reduce the capacity accordingly.

In theory it is possible to make an approximate calculation of the extent of the reduction in capacity using the following formula.

Pr = $f \cdot P$ where:

f = crane declassing coefficient, when the crane is working in a section where stability is not granted
Pr = reduced lifting capacity of the crane for the outreach L.

$$\mathbf{f} = \left[\frac{T \cdot Lt + G0 \cdot Lg - 1{,}3G1 \cdot (b - Lg)}{1{,}3 \cdot (L - Lg) \cdot Kdin \cdot P} \right] - \frac{Ksbal \cdot F}{Kdin \cdot P}$$

Conclusion: calculation of the stability of a crane mounted behind the cab is verified when the side and rear overturn stability calculations have met the standard.

LATERAL STABILITY TEST FOR RIGHT-HAND SECTOR

Without supplementary cross members | **With supplementary cross members**

$$\beta\ (\text{beta}) = \operatorname{arctg}\left(\frac{Lc - Dp}{Tp}\right)$$

$$Ip = \sqrt{Tp^2 + (Lc - Dp)^2}$$

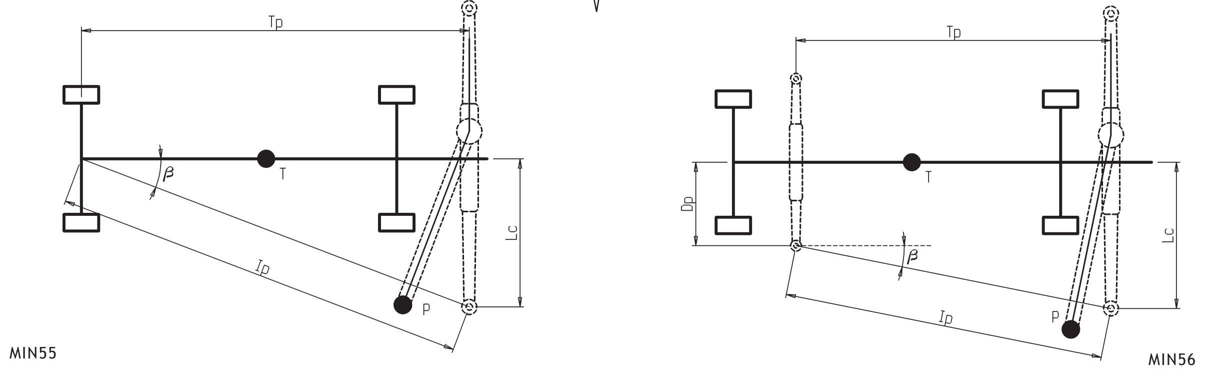
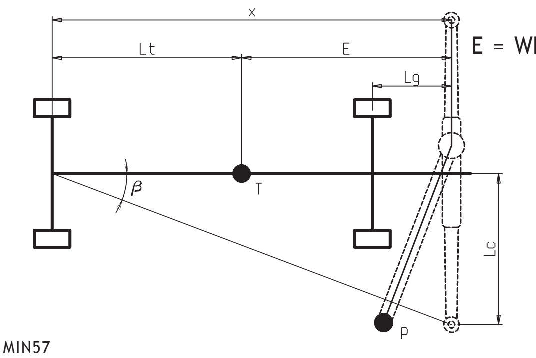


fig. 3.3.16

$$Lt = \frac{T2 \cdot \text{WHEELBASE} + T3 \cdot d3 + T4 \cdot d4}{T1 + T2 + T3 + T4}$$

$$X = \frac{Lc}{tg\,\beta} \quad \text{mm}$$



E = WHEELBASE - Lt + Lg

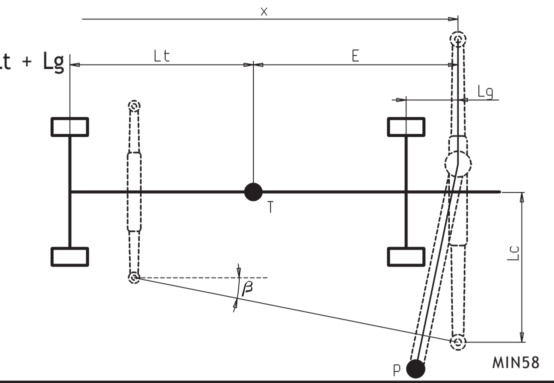


fig. 3.3.17

$$C = (Lc + Lb) \cdot \cos\beta$$

$$H = \frac{(Lc - Dp) \cdot (X - E)}{Ip}$$

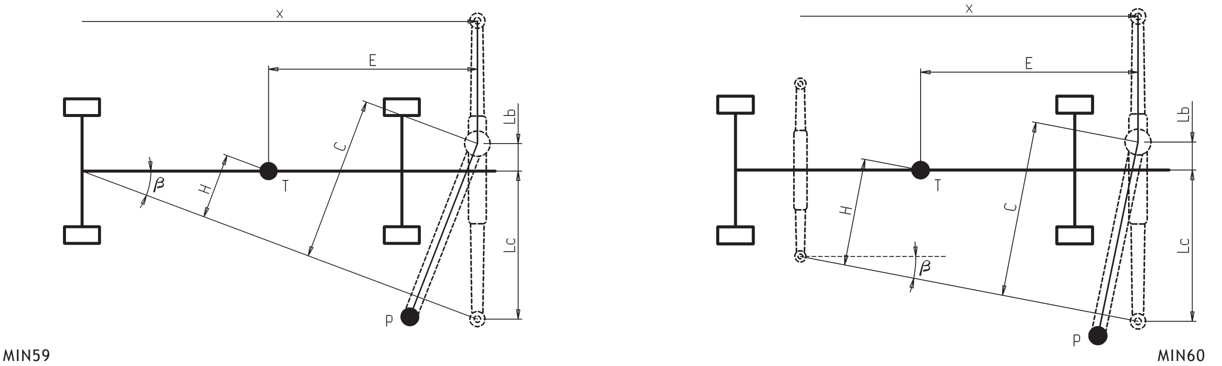


fig. 3.3.18

F = Weight of suspended parts (brackets, bracket cylinder, boom pack) at head of the last boom (in the case of a jibless crane).
Weight of suspended parts (brackets, bracket cylinder, boom pack) + jib mass at jib head (crane with jib).
For F values, see the technical specification sheet of the crane.
If the table is not available the value F can be calculated with the following formula:

$$F = \frac{(G1 \cdot b)}{L} \text{ kg}$$

Ms = T · H + G0 · C daN · mm .... Stabilising moment

Mr = (Kdin · P + Ksbal · F) · (L-C) + G1 · (b - C) daN · mm .... Overturning moment

$$K = \frac{Ms}{Mr}$$

According to the standards, the side overturn stability requirement is met when K > 1.
According to our experience the requirement is met when K > 1,1.

- STABILITY TEST WITH REAR LOAD (see following notes and those on pages 42/44)

Ms = T · Lt+ Lg · G0 daN · mm .... Stabilising moment

Mr = (Kdin · P + Ksbal · F) · (L-Lg) + G1 · (b - Lg) daN · mm .... Overturning moment

$$K = \frac{Ms}{Mr}$$

According to the standards, the rear overturn stability requirement is met when K > 1.
Experience has taught us that the requirement is met when K > 1,1.

- STABILITY TEST WITH FRONT LOAD

If the calculation of stability with a side load has been checked, then calculation of stability with a front load has also been verified.

Note

If stability has not been ascertained in a certain sector and it is not possible to add any ballast, the following procedure represents a necessary alternative:
a) prevent work in that area by locking the rotation beyond the sector permitted;
b) adjust the limiting device to reduce the capacity accordingly.
In theory it is possible to make an approximate calculation of the extent of the reduction in capacity using the following formula.

Pr = f · P where:

f = crane declassing coefficient, when the crane is working in a section where stability is not guaranteed
Pr = reduced lifting capacity of the crane for the outreach L.

$$f = \left[\frac{T \cdot Lt + G0 \cdot Lg - 1{,}3G1 \cdot (b - Lg)}{1{,}3 \cdot (L - Lg) \cdot Kdin \cdot P} \right] - \frac{Ksbal \cdot F}{Kdin \cdot P}$$

Conclusion: calculation of the stability of a crane mounted behind the cab is verified when the side and rear overturn stability calculations have met the standard.

Note

To ensure the front sector is suitable to be worked in, in addition to the stability in that sector you must also check the overload that will be created on the front axle when working with the crane.
This check must be carried out in the following way.

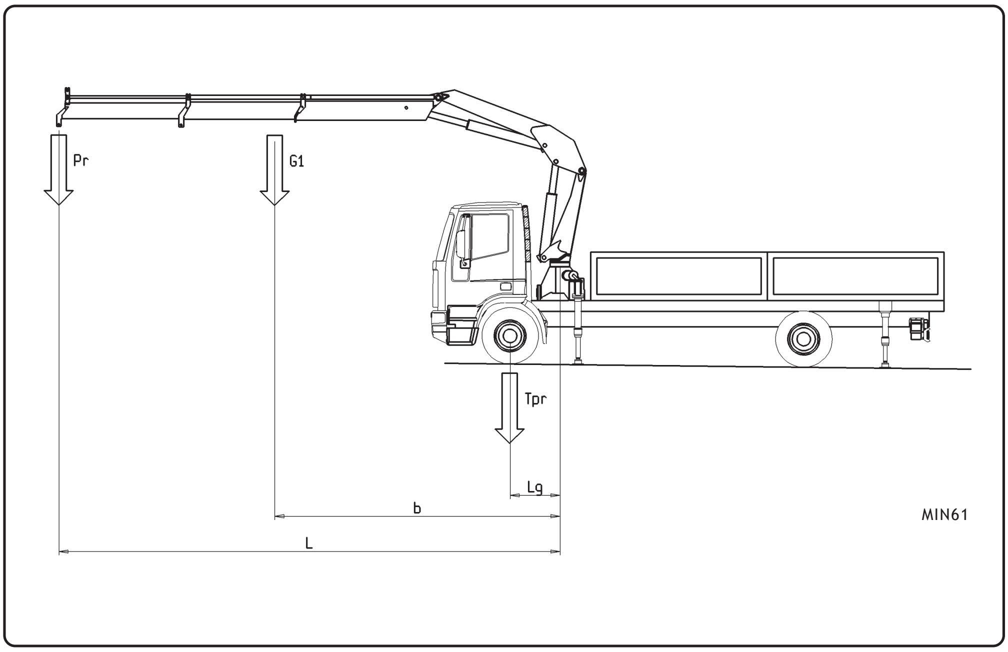


fig. 3.3.19

Tpr = Reaction of Pr load on the rear axle (kg)
Pr = Reduced lifting capacity for the outreach L (kg) (to ascertain the stability of the front sector)

$$\mathbf{Tpr} = \frac{(1{,}25 \cdot Pr + 0{,}10 \cdot F) \cdot L + (G1 \cdot b)}{Lg}$$

To be sure the front sector is suitable for use, the following conditions must have been met:

TPr + T1 < max load value permitted technically on the front axis (this value is generally greater than the max permitted level for road traffic circulation, which must be supplied by the vehicle's manufacturer).

If this condition is not met, you must reduce the value of Pr until it falls within the acceptable limit.

3.3.2 - Theoretical stability check using a graph method

Make a scale drawing on the type of graph paper used for the analytical method.

The missing data (H, C, etc.) must be taken from the scale drawing, and using the formula given in the paragraph entitled "Analytical method", calculate the stabilising and overturning moments.

Also in this case, the value of the stability coefficient K, (K=Ms/Mr), must be calculated for all the working sectors (front, lateral and rear).

According to these standards, the stability calculation standard is considered met when K > 1.

From our experience, we recommend you consider the standard met when K >1,1.

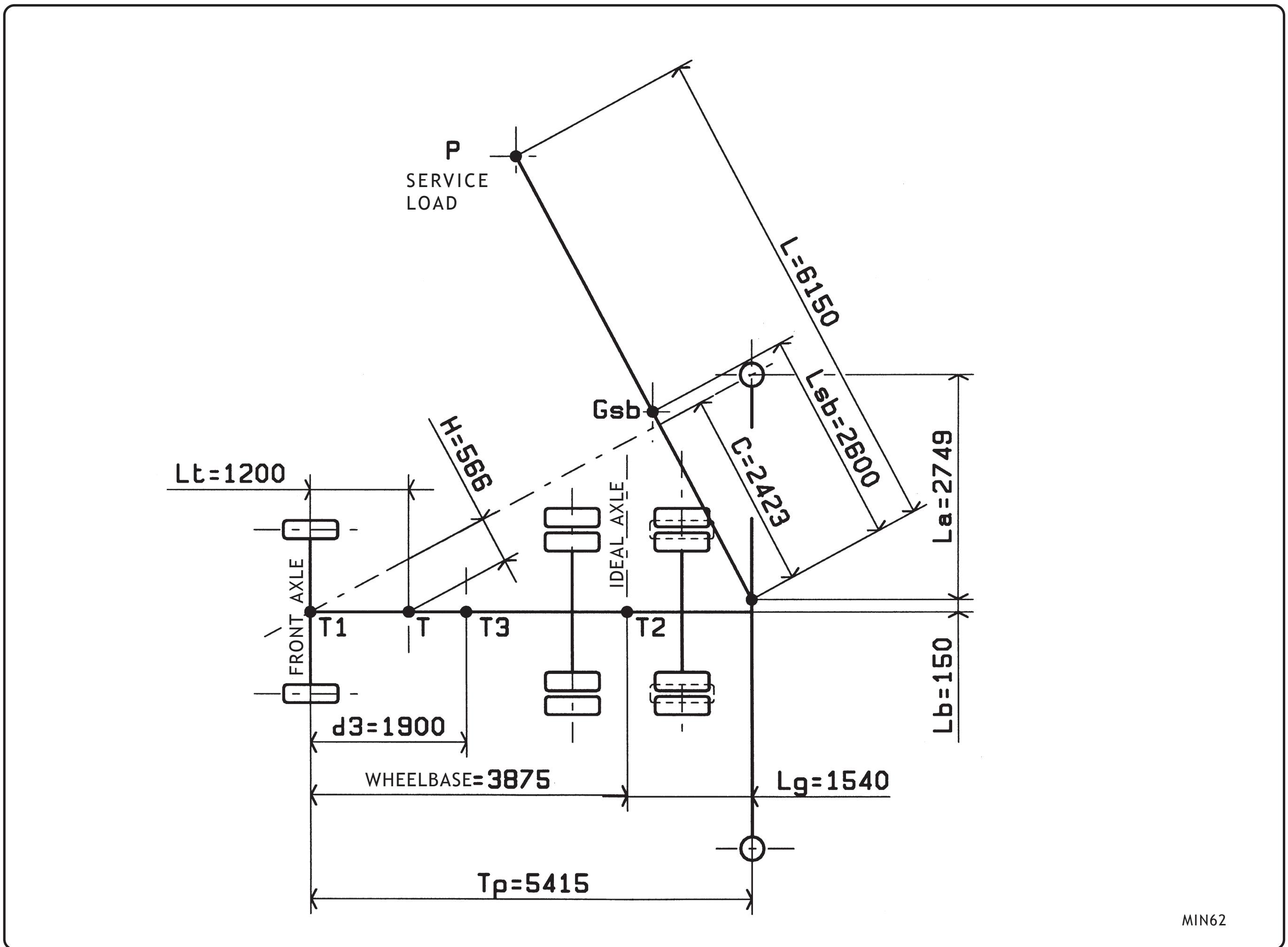


fig. 3.3.20

MENU

SIZING

4.1- Checking the chassis and counter-chassis

Note

Any instructions or modifications by the manufacturer pertaining to the information below have priority. Before making any decisions, consult the manufacturer's mounting guidelines.

When mounting the crane it is also necessary to install a counter-chassis, the dimensions of which depend on the type of vehicle, the use to which it is to be put and the lifting capacity.

ATTENTION!!!

It is the installer's responsibility to ensure the overall dimensions of the crane/vehicle combination when it is on the road (with or without a chassis) respect the regulations in force in the country of use.

The counter-chassis must be able to withstand stress caused by the dynamic moment (flexure) and concentrated load due to reactions on the linking devices.

The moment of flexure (Mf) to take into consideration when testing the frame is the maximum dynamic moment, a typical feature of each individual crane. The value can be found in the table in the technical specification sheet of the crane model.

Even if the vehicle chassis is sufficiently resistant by itself, it is still necessary to place a metal section between it and the crane to protect it from wear and concentrated loads (see fig. 4.1.1).

To accertain beforehand whether the vehicle chassis is sufficiently resistant, you must check that the condition is met:

$$\sigma lt = \frac{Mf}{Wt \cdot 2} \bullet \sigma\ amm \qquad (daN/mm^2)\ (*)$$

(*) If the crane is structured in such a way that the momentum cannot be distributed evenly over the two side members, the number 2 is replaced with the relative ratio or with the unit, if the momentum is transferred onto a single side member (machines with lateral column).

Where:

σlt = Stress to which the material of the truck chassis is subjected to (daN/mm^2)

Mf = Maximum dynamic bending moment of the crane (daN·mm)

Wt = Module of resistance to flexure of a vehicle side member (mm^3) (see manufacturer's instructions or, alternatively, use the Wt calculation procedure given in annexes 1 and 2).

σamm = Maximum permissible stress (daN/mm^2) of the vehicle chassis material (consult the truck manufacturer's guidelines).

If **σlt** is </= of **σamm**, it will not be necessary to install the counter-chassis; it will be sufficient to place an anti-wear section between the crane base and the vehicle chassis to protect it from wear and concentrated loads (see fig 4.1.1).

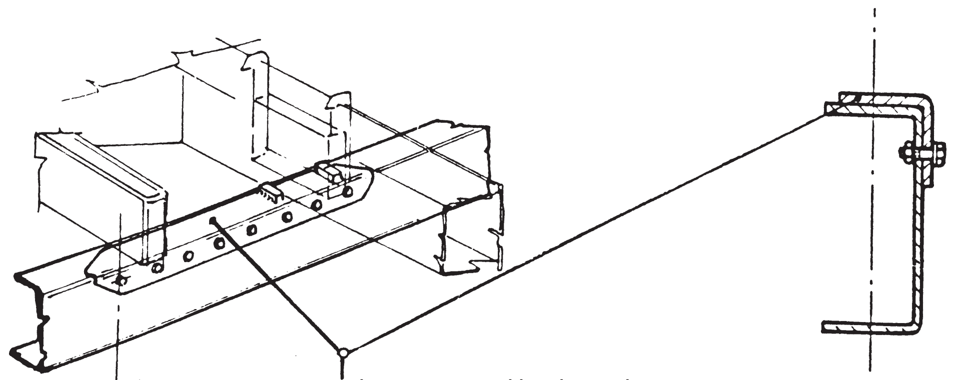


fig. 4.1.1

Note

The anti-wear section must be secured to the core of the side members using bolts. The section must jut out from the crane's resting surfaces by 80 mm on both sides.

If **σlt** is greater than **σamm** the chassis is not sufficiently resistant by itself and therefore a counter-chassis is necessary.

To determine the correct size of the counter-chassis, you must carry out a series of calculations which vary depending on the type of chassis/counter-chassis connection method adopted.

Chassis/counter-chassis connection type A

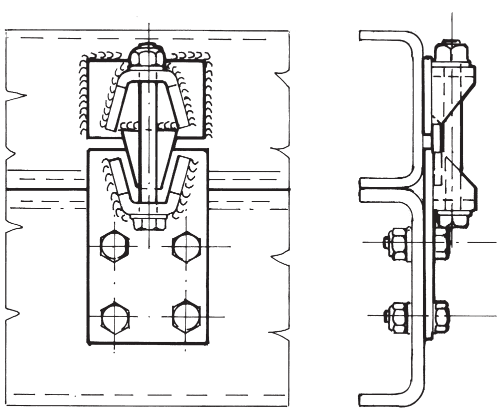


fig. 4.1.2

Chassis/counter-chassis connection type B

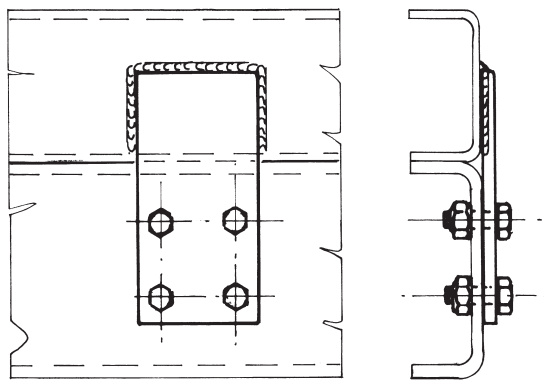


fig. 4.1.3

There are two possible methods for connecting the counter-chassis to the chassis:

A) the first system is the most commonly used. It is simple to realise and does not restrict the vehicle's use in any way.

The chassis and counter-chassis are connected using the crane tie rods and brackets, generally provided by the manufacturer, or equivalent systems that are not shear resistant (see fig. 4.1.2).

The moment of flexure induced by the crane is distributed between the chassis and the counter-chassis in proportion to the respective moment of inertia.

For checking purposes, the rule CUNA NC 034-05 (24 May 1984 edition) is used.

B) In some cases, the shear-resistant chassis/counter-chassis connection makes it possible to construct slightly lower chassises.
The chassis and counter-chassis are connected by means of shear-resistant components (bolts, plates, nails) in order to constitute a single shear-resistant section (see fig. 4.1.3).

Mc = Moment of flexure acting on the counter-chassis (daN·mm)
Mf = Max. dynamic moment of flexure
Mt = Moment of flexure acting on the vehicle chassis (daN·mm)
Jt = Moment of inertia of the vehicle chassis (mm^4)
Jc = Moment of inertia of the counter-chassis (mm^4)
σt = Stress to which the material of the vehicle chassis is subjected to (daN/mm^2)
σc = Stress to which the material of the counter-chassis is subjected to (daN/mm^2)
σamm = Maximum permissible stress of the chassis/counter-chassis material (daN/mm^2)
Wt = Module of resistance to flexure of a chassis side member (mm^3)
Wc = Module of resistance to flexure of a counter-chassis (mm^3)

$$Mc = \frac{Mf \cdot Jc}{Jc+Jt} \qquad Mt = Mf - Mc$$

$$\sigma t = \frac{Mf}{2 \cdot Wt} \qquad \sigma c = \frac{Mc}{2 \cdot Wc}$$

This test consists in separate assessments of the stress to which the chassis and counter-chassis are subjected which are then compared them with the respective permissible stresses to test the following conditions:
σt < σamm (chassis) **σc < σamm** (counter-chassis)

The test procedures of **J** and **W** are given in annexes 1 and 2.

Note

This type of connection is not advisable for off-road vehicles, except in certain cases.

As mentioned above, the two sections are considered as a single unit, so, as they are still asymmetrical sections, it takes longer to calculate the moment of inertia in relation to the horizontal barycentric axis.

Annex 2 shows an example of this calculation.

The resistance test is carried out for the two upper and lower ends of the sections, comparing the respective stress values with permissible values for the counter-chassis (upper) and the chassis (lower).

$$\sigma sup = \sigma c = \frac{Mf}{2 \cdot W\ sup} \qquad \sigma inf = \sigma t = \frac{Mf}{2 \cdot W\ inf}$$

Stress sc and st in each section of the chassis and counter-chassis must never be higher than the maximum permissible for the construction materials.
σc - σamm (counter-chassis) **σt - σamm** (chassis)

For the chassis/counter-chassis unit anchorage system sizing, please refer to the vehicle manufacturer's guidelines.

Rear end (towards the rear axles, in the case of partial counter-chassises)

Taper in height with an angle of 30° to 45° and round off the wing in contact with the chassis to a radius of about 5 mm (alternatively you can chamfer straight figures 4.1.4 and 4.1.5).

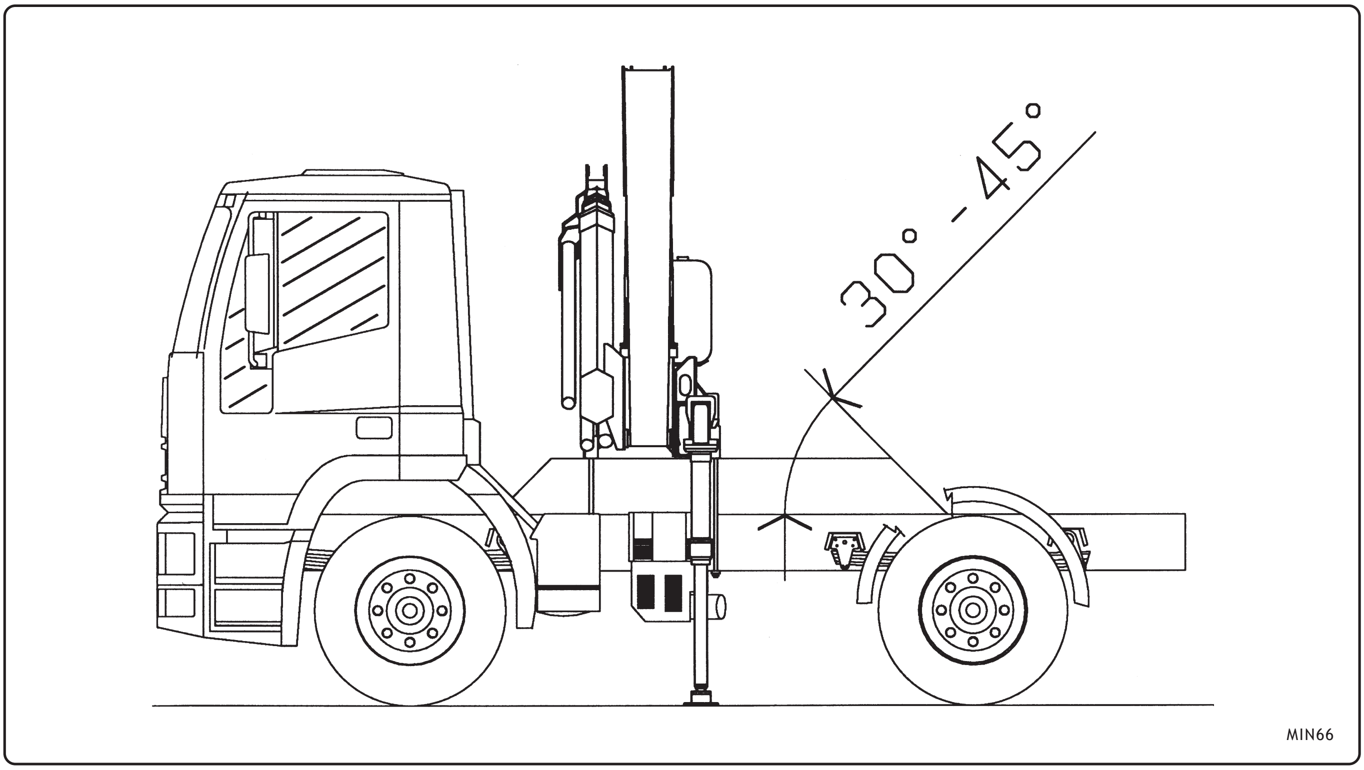


fig. 4.1.4

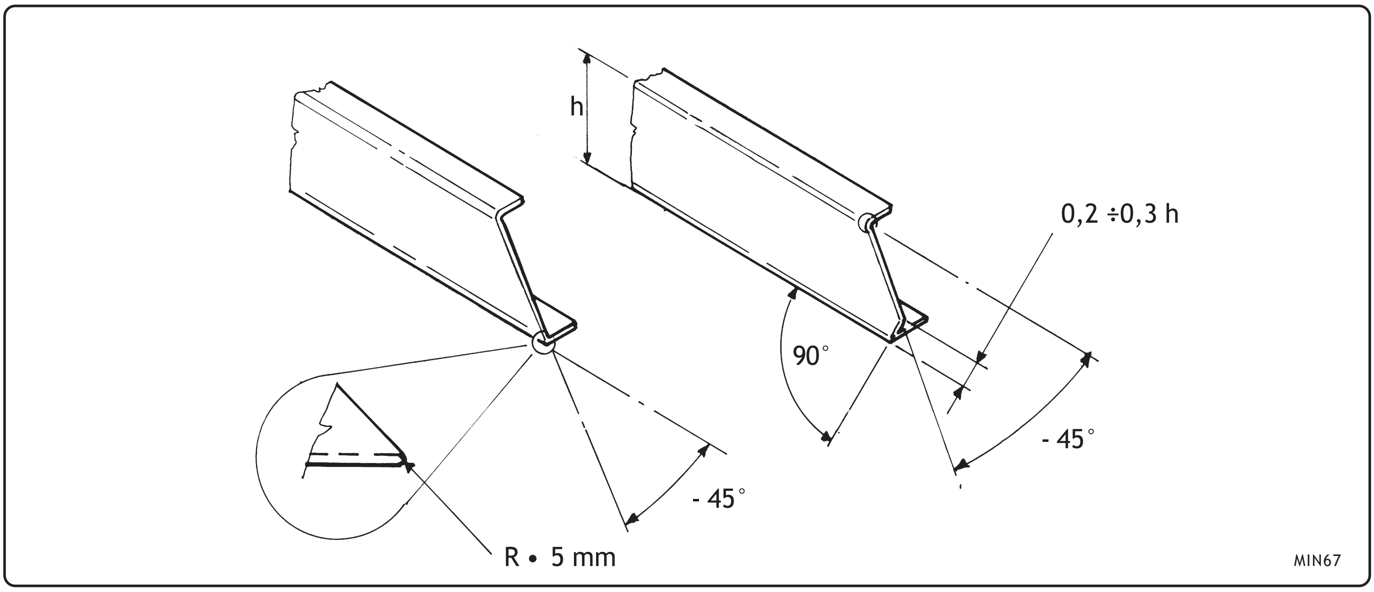


fig. 4.1.5

Rear end (with connection to vehicle's body frame)

Taper in height with an angle of 30° ÷ 45° (fig. 4.1.6 and 4.1.7).

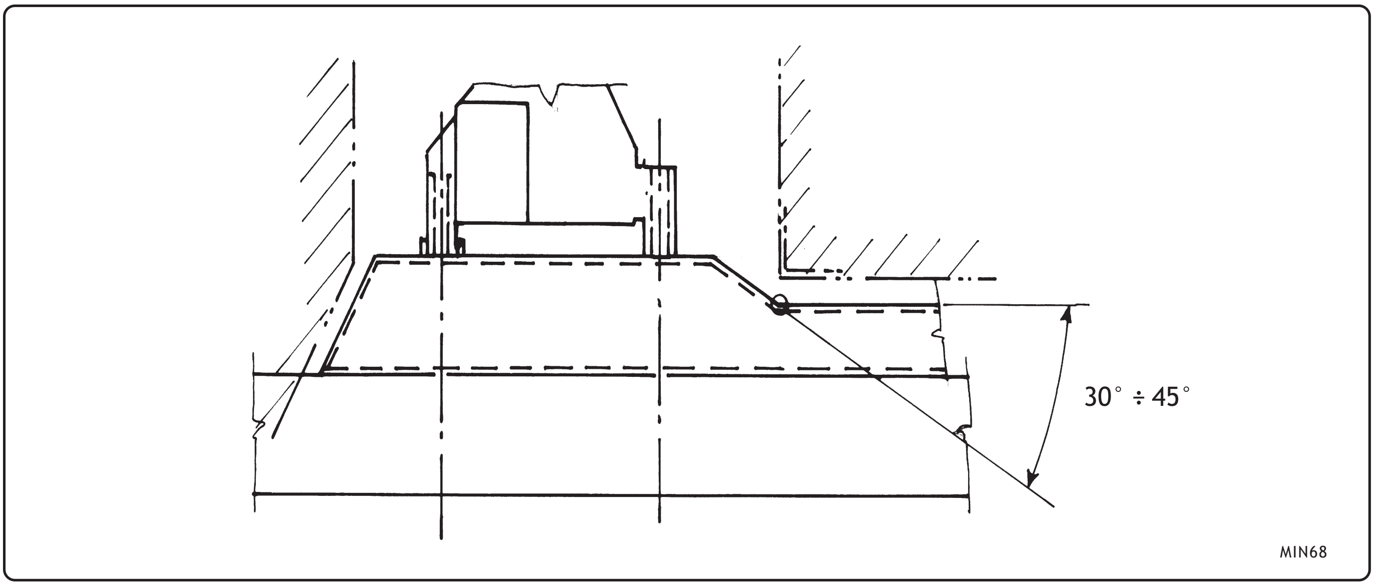


fig. 4.1.6

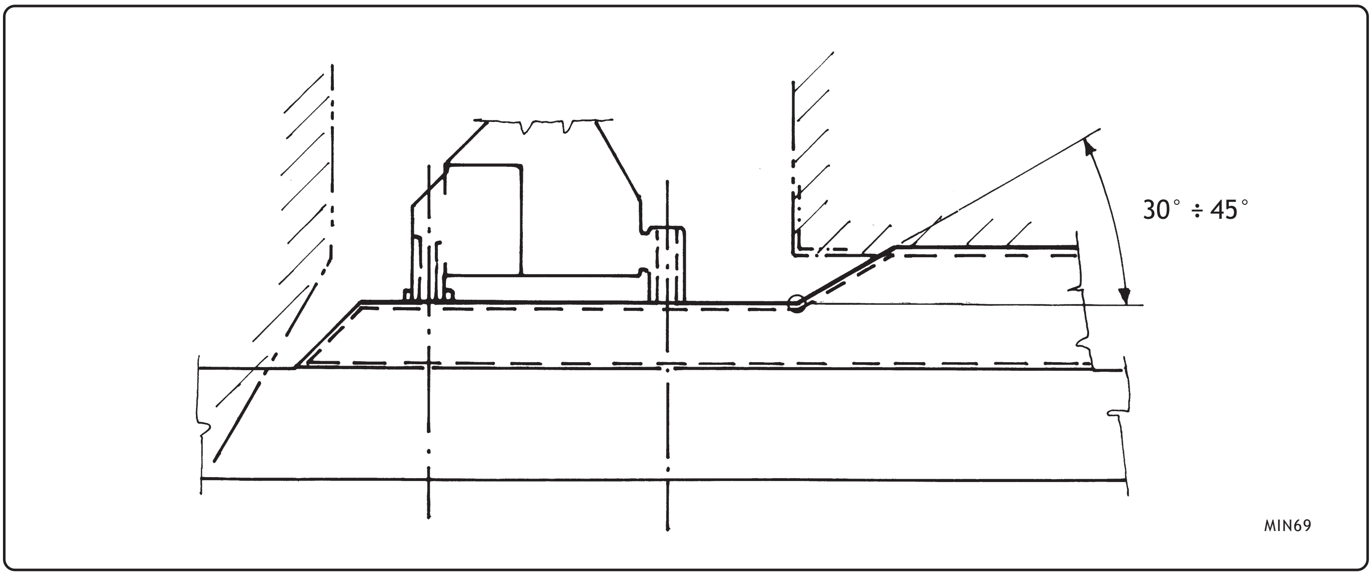


fig. 4.1.7

Note

Equivalent types of taper are always acceptable provided they reduce the resistant section gradually.

All the parts of the counter-chassis need to be tapered (core, reinforcements, see fig. 4.1.8).

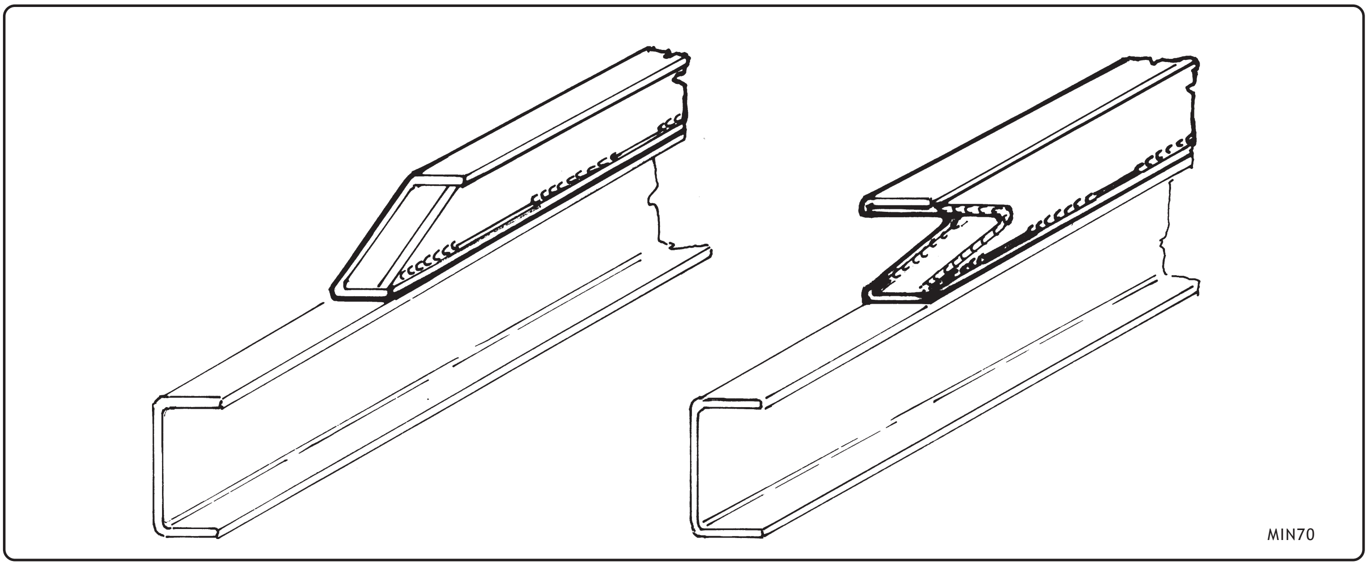


fig. 4.1.8

Interruptions between parts of the counter-chassis must not coincide with variations in the section's height (see fig. 4.1.9).

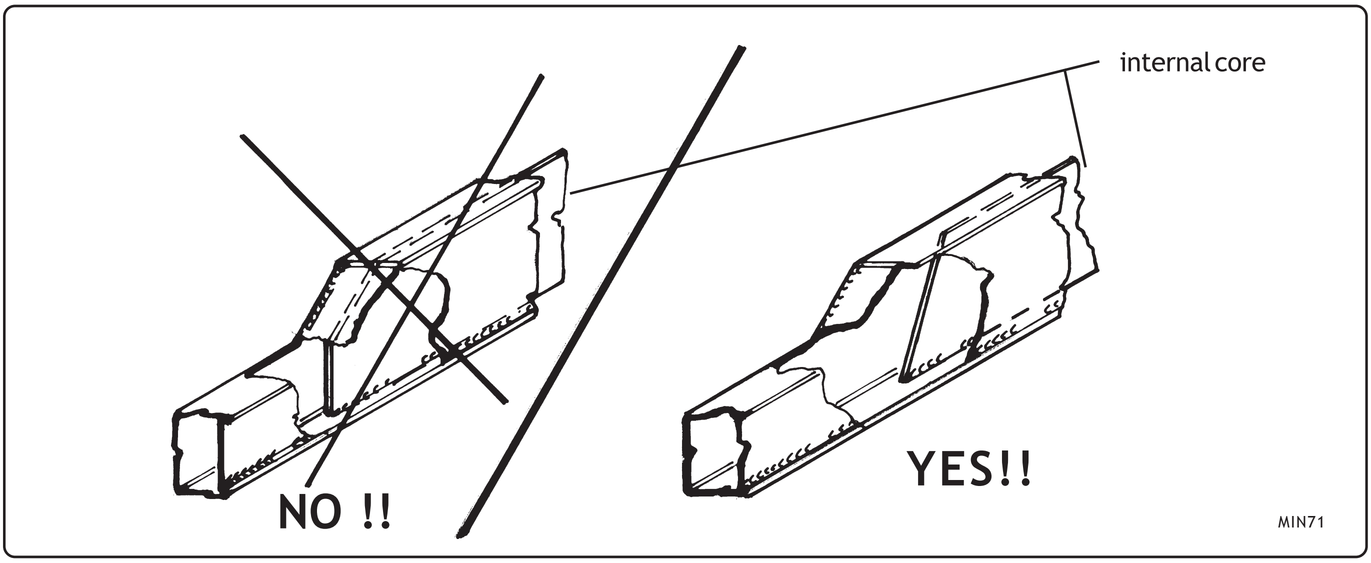


fig. 4.1.9

Note

To avoid dangerous nicks, the passage from a closed section to an open one must always be made gradually (see fig. 4.1.10).

Equivalent forms of taper are always acceptable provided they reduce the section gradually.

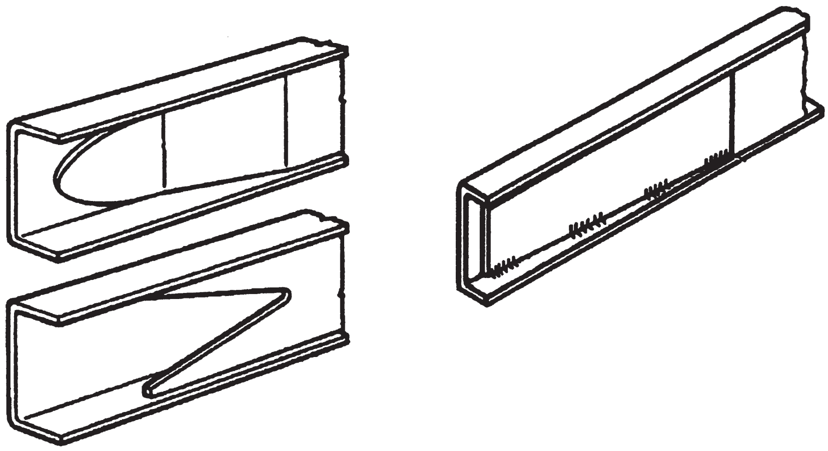


fig. 4.1.10

4.1.1 - Lenght of counter-chassis

- Crane mounted behind cab without supplementary outriggers

The ideal length of the side members is the measurement obtained starting - as far as possible - below the vehicle cab. You must always take account of the rear supporting area of the front suspension and, if necessary, go as far as the front support of the rear suspension (fig. 4.1.11).

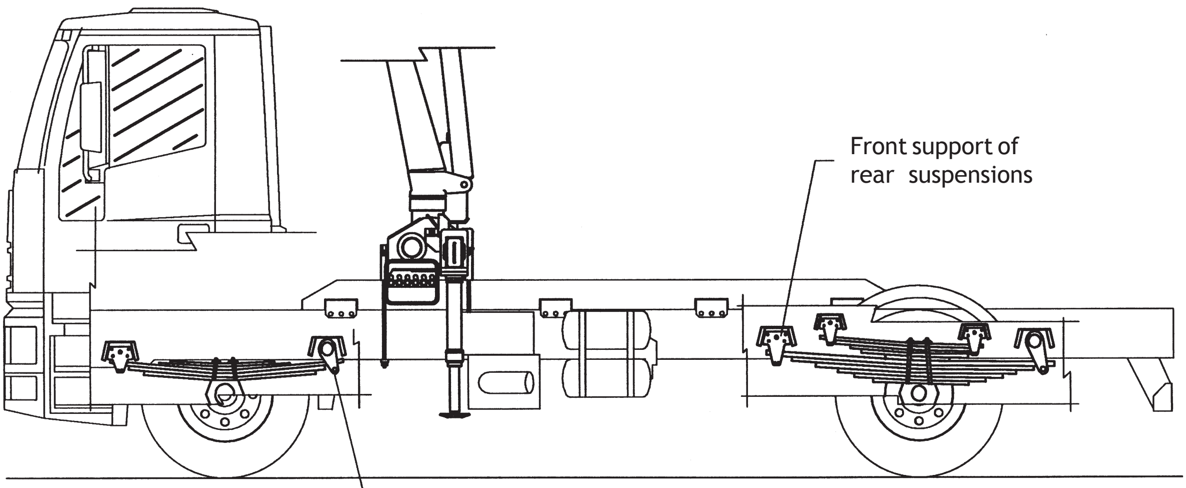


fig. 4.1.11

However, as it is necessary to get a base for the body, you have to assess the need to extend the counter-chassis for the whole actual length of the vehicle.

The counter-chassis of the crane can be integrated towards the rear section with the counter-chassis for the body. Make the necessary connection and taper if required.

The cross section of the crane counter-chassis must always be constant in height, for a length (towards the rear) that is no less than twice the width of the supporting base for the crane on the counter-chassis (see fig. 4.1.12).

Note

This length is defined starting from the beginning of the crane counter-chassis up to the beginning of the connection with the other counter-chassis.

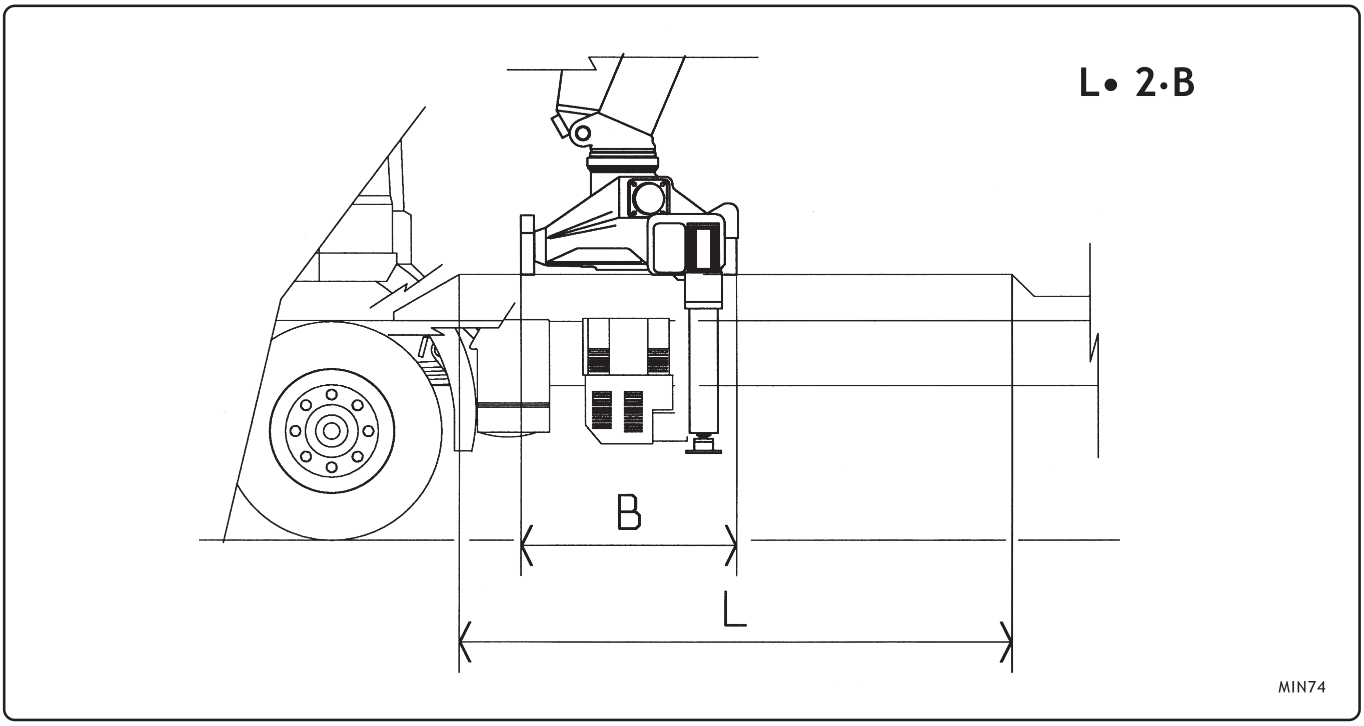


fig. 4.1.12

Note

The local reinforcing elements protecting against concentrated loads (crane support area) must be at least as long as the height of the cross section of the counter-chassis. If they have not been considered in calculating the resistance to flexure of the counter-chassis, they need not necessarily extend beyond the required length (see fig. 4.1.13).

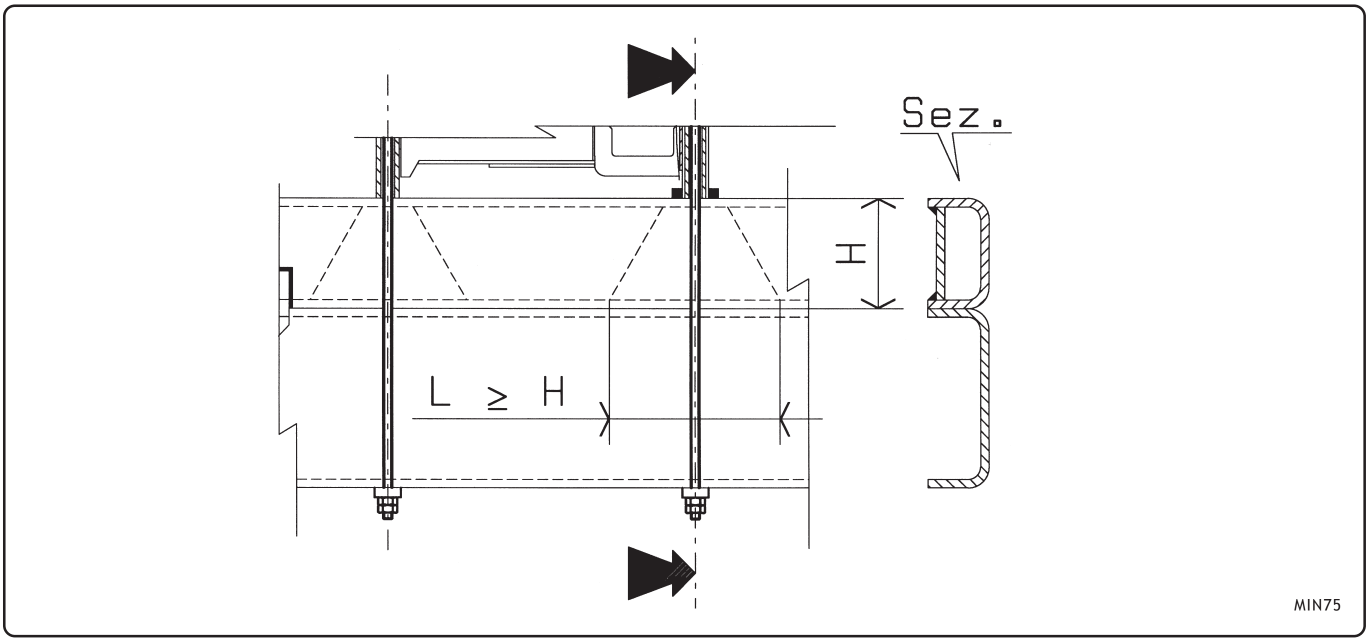


fig. 4.1.13

If the counter-chassis section needs to be reduced, it will be necessary to check the new section before length "L" at the point where the reduction stars. The crane induced moment at that specific point "M1" must be considered (see fig. 4.1.14).

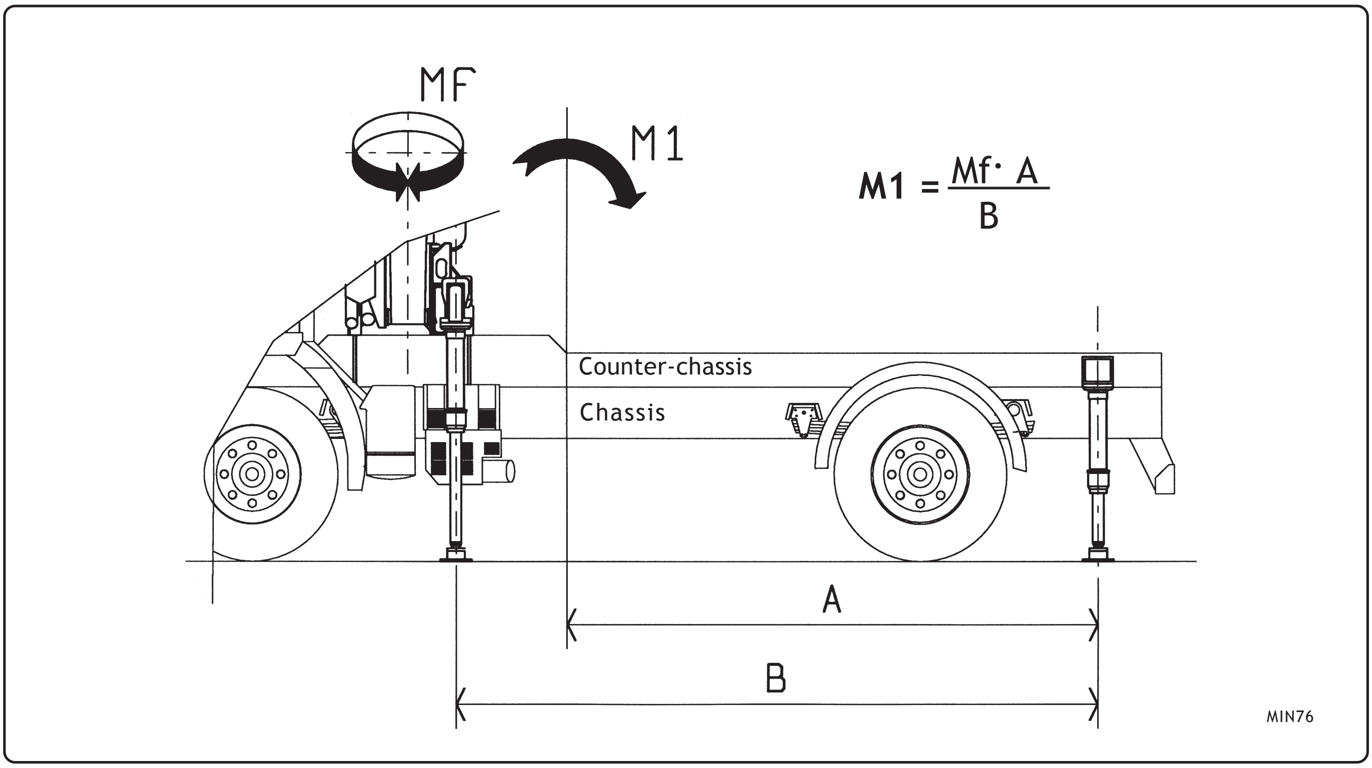


fig. 4.1.14

If there are no supplementary outriggers, distances "A" and "B" must refer to the rear axle of the wheels (see fig. 4.1.15).

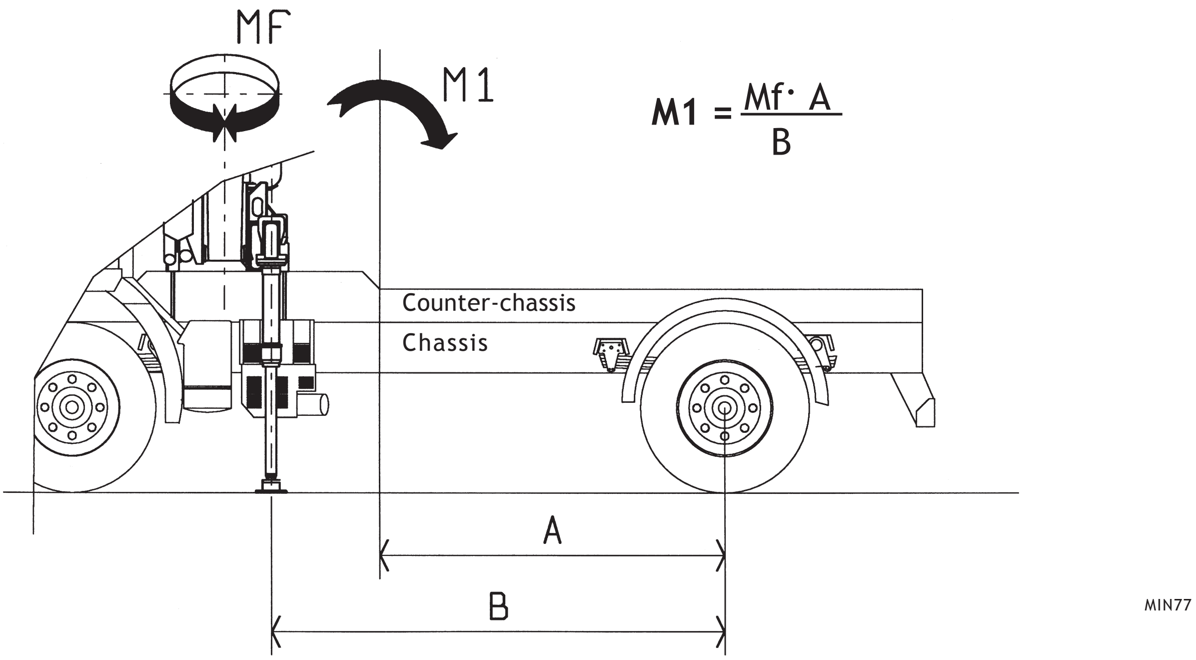


fig. 4.1.15

- Rear-mounted crane with supplementary outriggers

The ideal length of the side members is the measurement obtained starting as far as possible below the vehicle cab. You must always take account of the rear supporting area of the front suspension and go as far as the cross member of the supplementary outriggers (see fig. 4.1.16).

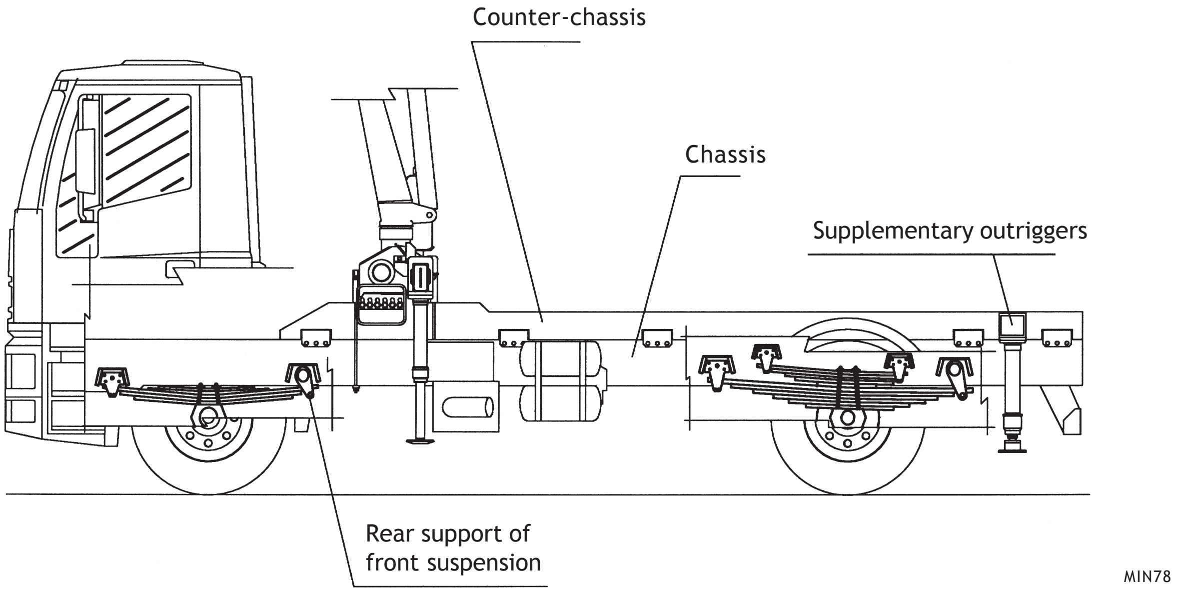


fig. 4.1.16

- Rear-mounted crane with supplementary outriggers

The length of the side members is given by the measurement obtained starting from the cross member of the supplementary outriggers as far as the rear end of the crane.
A tapered counter-chassis element (see fig. 4.1.17) must be installed at the front before the supplementary outrigger cross member.

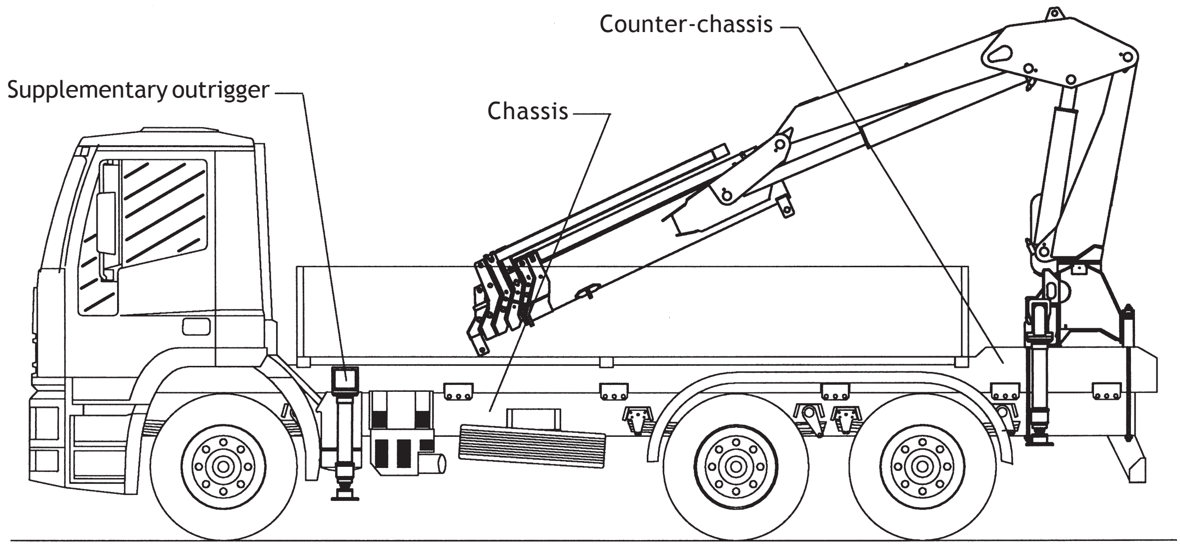


fig. 4.1.17

4.1.2 - Connecting cross members

The side members of the counter-chassis must be connected by means of a series of cross members so as to stiffen them as a precaution against twisting.
The materials and dimensions of these cross members must be the same as those used in the construction of the counter-chassis.
The cross members can have an open section (ex. C), or a closed section if you wish to make them more rigid (see fig. 4.1.18).

1 - Counter-chassis
2 - Open section cross members
3 - Closed section cross members

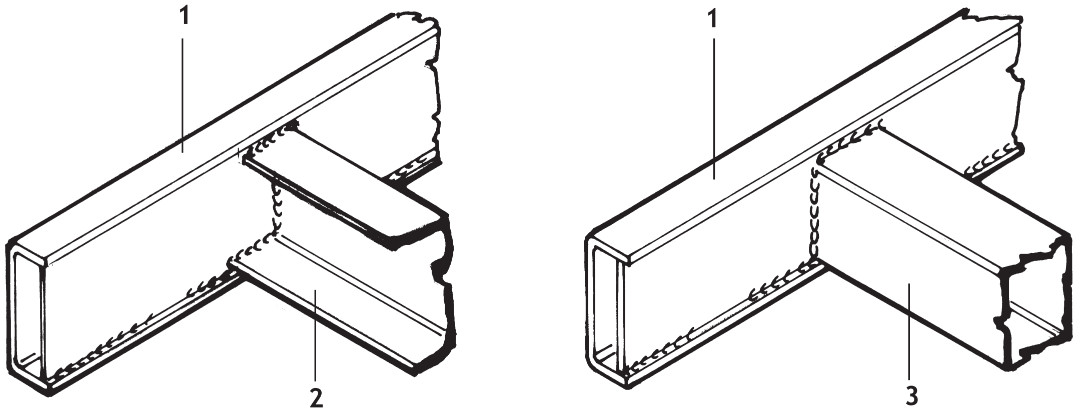


fig. 4.1.18

Normally the same number of cross members is applied as the number of those existing on the vehicle chassis. When there are too many, considering the crane-vehicle combination, the cross members are mounted further apart.

When there are not enough cross members to limit torsion transmitted by the crane to the side members of the vehicle, it is necessary to fit one or more crosses.

It is particularly advisable to fit crosses to the counter-chassis on vehicles with a long wheelbase and rear-mounted cranes, where it is necessary to restrict the twisting effect of the crane (see fig. 4.1.19).

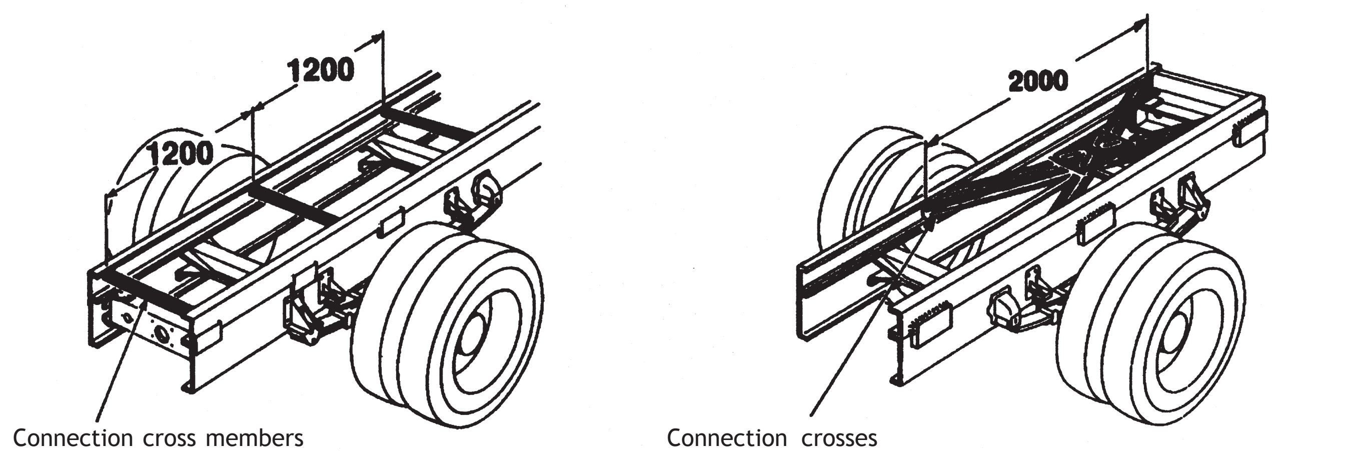


fig. 4.1.19

* Approximate values (see vehicle manufacturer’s handbook).

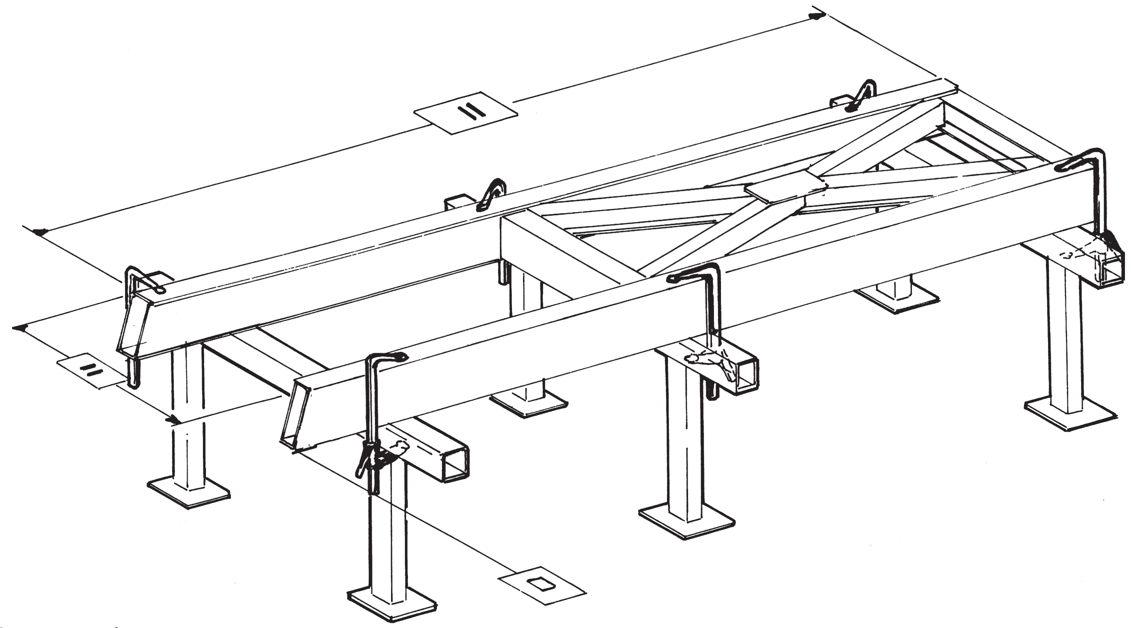
4.1.3 - Counter-chassis construction

- **ASSEMBLY**

The counter-chassis must be assembled on special adjustable supports so that the side members are completely flat and parallel (use a spirit level) - see fig. 4.1.20.

NEVER ASSEMBLE THE COUNTER-CHASSIS DIRECTLY ON THE VEHICLE CHASSIS.

Check that the side members of the counter-chassis are perfectly flat and parallel, particularly after welding. Straighten them (if necessary) using special equipment.



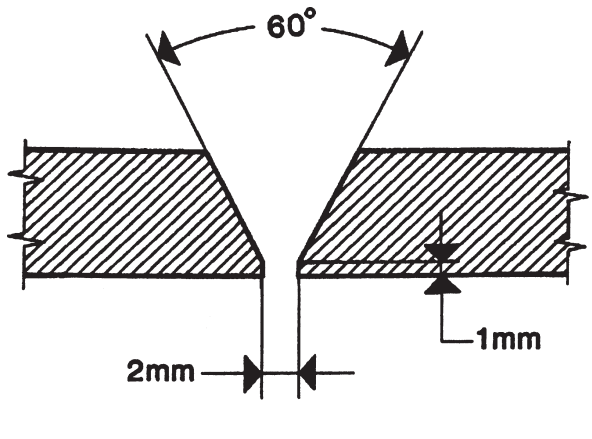
1) Fastening clamps

MIN82

fig. 4.1.20

- **WELDING**

When welding parts during assembly of the counter-chassis, remember the following points:
- welding must only be done by **properly trained personnel** using the right equipment with extreme caution.
- All parts involved in welding must be treated beforehand (sand blasting, grinding, etc.) to remove any rust or oxidation.
- For correct butt welding, make a V-shaped bevel about 60° on the inner side all along the area to be welded (see fig. 4.1.21).



MIN83

fig. 4.1.21

- Before welding, make sure the edges are free from organic and hygroscopic materials.
- If the ambient temperature is below 5° C, preheat the metal to be welded.
- Weld a few points to keep the two parts in contact in the correct position.
- When arc welding, do several passes using carefully dried basic electrodes or MIG-MAG procedures with suitable weld material. Avoid current overloads. The welding must be free from side incisions and slag.
- When back welding, proceed as described in the point above.
- Allow the side members to cool slowly and evenly. **Do not cool with air, water or the like.**
- With butt welding, remove the excess material by grinding.

Note

Vertical welding must be done from the bottom upwards (see fig. 4.1.22).

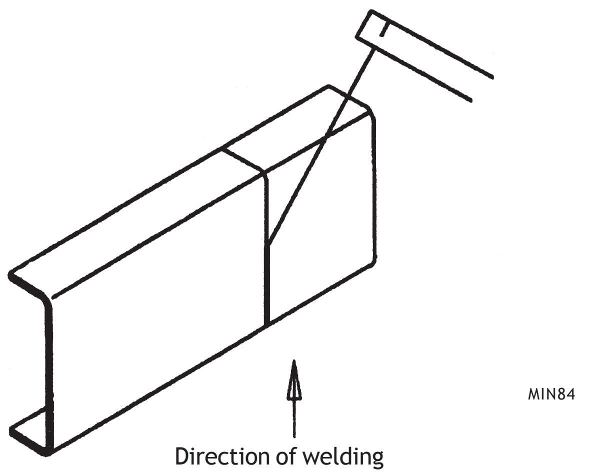


fig. 4.1.22

Any flat sheet steel plates between the chassis and the counter-chassis for support continuity (see fig. 4.1.27) must be applied directly on the lower wing of the counter-chassis.
This must be done with intermittent welds or by weld riveting (see fig. 4.1.23).

1) Counter-chassis
2) Flat sheet steel
3) Intermittent welds
4) Weld rivets

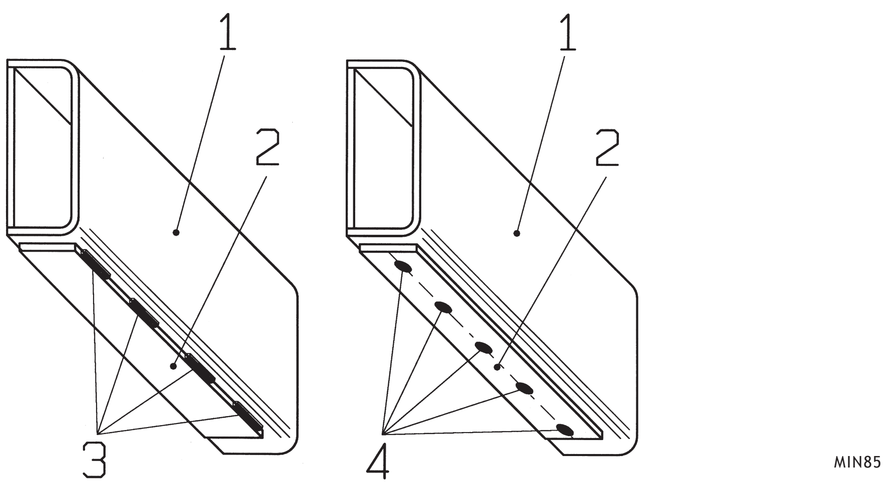


fig. 4.1.23

Contact surfaces between the flat plate and the counter-chassis must be treated against corrosion.
The brackets and plates securing the counter-chassis to the chassis must be welded to the counter-chassis all round the outer perimeter of the centre with continuous seam-type angle welding or intermittent seam-type welding with sealing (see fig. 4.1.24).

1) Continuous seam-type angle welding
2) Intermittent seam-type welding with sealing

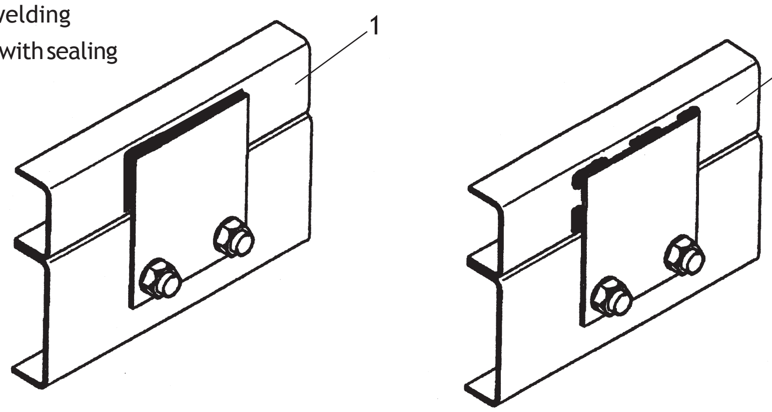


fig. 4.1.24

Contact surfaces between plate and counter-chassis must be previously treated against corrosion.

- **RUST PREVENTION AND PAINTING**

All vehicle parts involved in the conversion or application must be protected against oxidation and corrosion.
All the parts must be treated and painted with great precision.
In particular, when the counter-chassis has been fully assembled, it must be treated as follows:
- degrease the surfaces with suitable non-toxic solvents;
- electrophoresis or rust-proofing;
- paint with suitable products and number of coats (approx. thickness 60 μ m).

1) Welded and sealed plate
2) Counter-chassis
3) Chassis

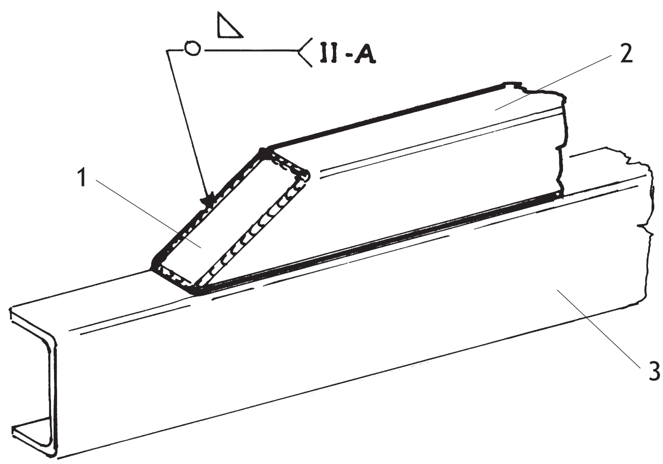


fig. 4.1.25

Note

All the welded parts must be cleaned before painting (if necessary).

Note

The counter-chassis must be closed at the ends with sealed welded plates (see fig. 4.1.25). If the ends of the counter-chassis are open or half-open, they must be protected with oil or wax.
Seal the joints and overlaps and protect areas subject to abrasion using specific products.

Precautions

Due precautions must be taken to protect parts where the paint might affect preservation and operation, such as:
- rubber or plastic hose pipes for pneumatic and hydraulic systems
- rubber or plastic seals or other parts
- piston rods of shock-absorbers and hydraulic or pneumatic cylinders
- rating plates, nameplates, etc.

4.1.4 - Securing the counter-chassis

- Preparing the chassis

For the vehicle to be fully reliable and have a long life, it is of vital importance before mounting the crane to arrange the chassis so that it is completely flat (see fig. 4.1.26).

This means that the side members must be parallel and the chassis must not be distorted.

To make sure that a chassis with pneumatic suspension is flat, it is necessary to use at least 3 adjustable supports, which must not be removed during mounting.

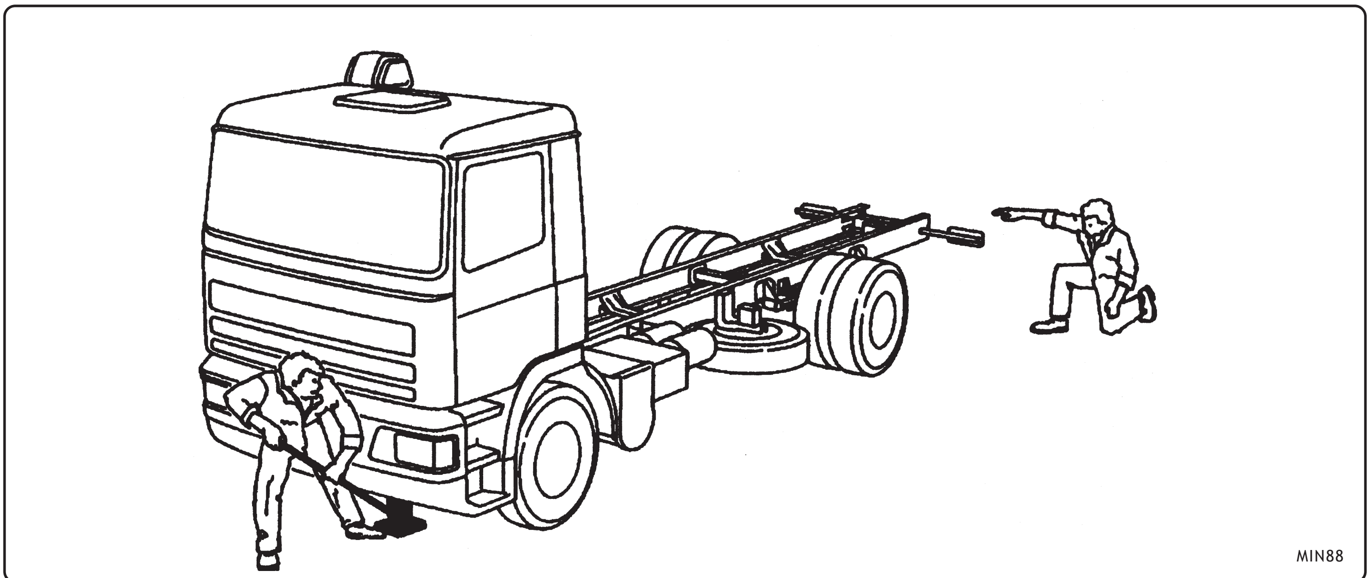


fig. 4.1.26

Note

If the chassis is moved during mounting, it is necessary to re-check that it is flat.

- Securing the counter-chassis

As mentioned in the section on counter-chassis calculations (see paragraph 4.1), the choice of the type of connection is very important as regards the counter-chassis's of resistance and rigidity.

It can be the elastic type (bracketed) or the rigid type resistant to shear stress (lengthways and cross plates).

The choice depends on the type of mounting, taking into consideration the stress the crane transmits to the chassis under static and dynamic conditions (see paragraph 4.1).

The securing elements all along the counter-chassis must be sized and made in such a way as to ensure that the chassis and counter-chassis are connected properly.

It is preferable to use securing elements already existing on the chassis of the vehicle, except when shear resistant couplings are necessary.

☞ Note

When securing the counter-chassis to the chassis, the chassis must not be welded or the wings perforated. Any additional holes in the central elements must only be made in compliance with the instructions in the vehicle manufacturer's handbook.

There must be a continuous support between the sections of the counter-chassis and the vehicle chassis.

If this is not the case, continuity can be restored by interposing flat sheet steel plates of suitable thickness.

Wooden or elastic dowels must not be used. It is not advisable to use light alloy elements because they tend to corrode the parts in contact with the steel.

Sometimes, due to riveting on the upper wing of the vehicle chassis, for support continuity it is necessary to interpose a flat sheet steel plate of suitable thickness with holes bored in line with the rivet heads (see fig. 4.1.27).

This element must not be welded to the chassis (see paragraph 4.1.3 - Welding).

1) Counter-chassis
2) Flat sheet steel plates
3) Chassis
4) Holes bored in line with the rivet heads

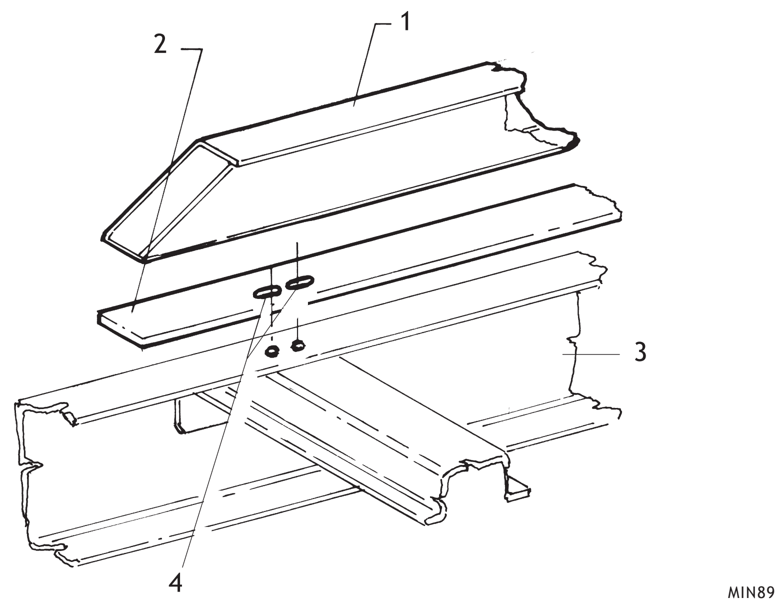
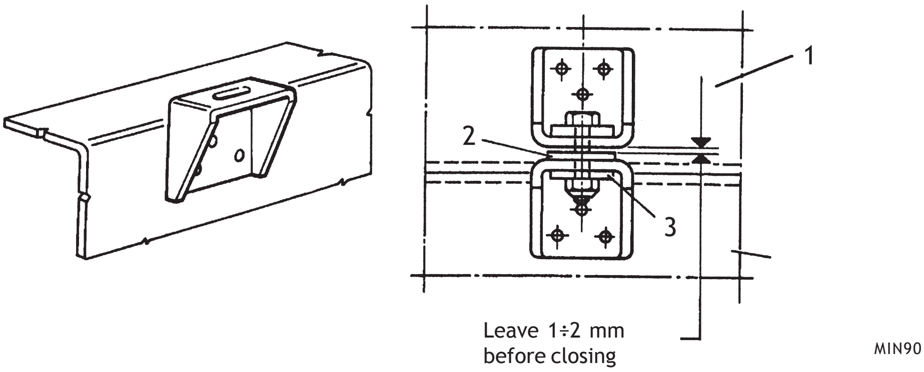


fig. 4.1.27

- Connecting with brackets

This is an elastic type of connection allowing limited movement between chassis and counter-chassis.
Examples of this type are shown in fig. 4.1.28.
Leave 1÷2 mm before closing.

1) Counter-chassis
2) Chassis
3) Shims



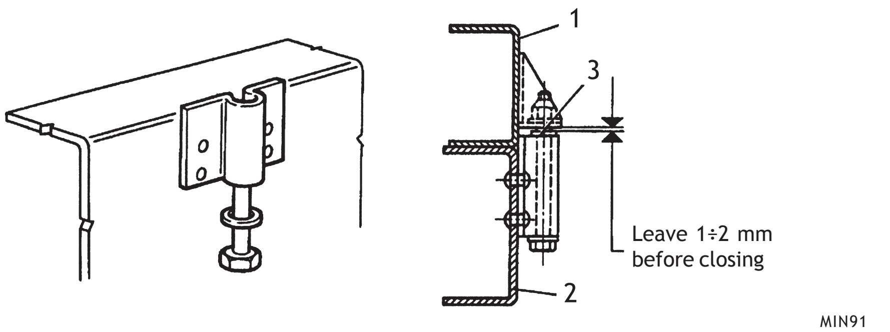


fig. 4.1.28

The brackets must be fitted onto the outer rib of the side members of the vehicle chassis using screws or rivets. They can be welded onto the counter-chassis.

The brackets must be suitably distributed all along the counter-chassis (taking as an indication a minimum wheelbase distance of 750÷1000 mm).

Should it be necessary to make supplementary holes, refer to the manufacturer's relevant guidelines.

To make a flexible connection, before tightening the screws during assembly make sure the distance between the brackets on the chassis and counter-chassis is 1÷2 mm. Greater distances must be reduced using shims.

The connection is more flexible if you use screws of a suitable length.

If there is the risk of the screws coming loose, use screws of 100/120 mm in length.

If you use long screws to secure standard brackets, it is necessary to interpose spacer bushings of suitable length (fig. 4.1.29).

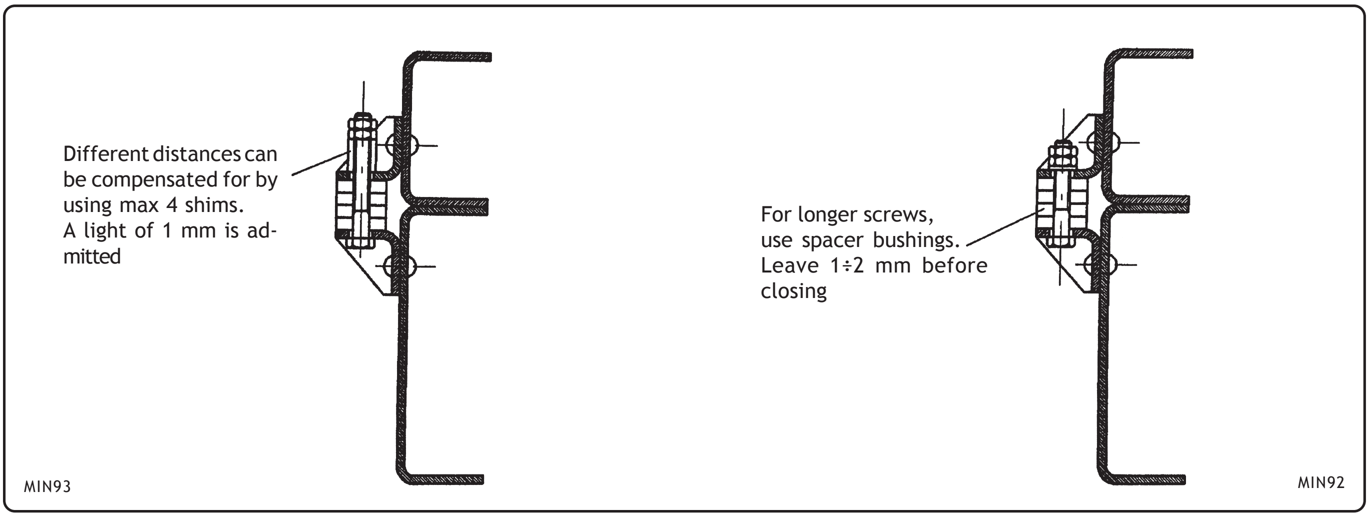


fig. 4.1.29

Fixing brackets on vehicles generally feature slots which develop longitudinally with respect to the vehicle (see fig. 4.1.30).

The slots compensate for tolerances. In the case of connections that do not resist shearing forces, they allow for the lengthways movement of chassis and counter-chassis.

In order to compensate for crosswise movements, the fixing brackets of the counter-chassis can also feature slots that must be transverse to the longitudinal direction of the vehicle.

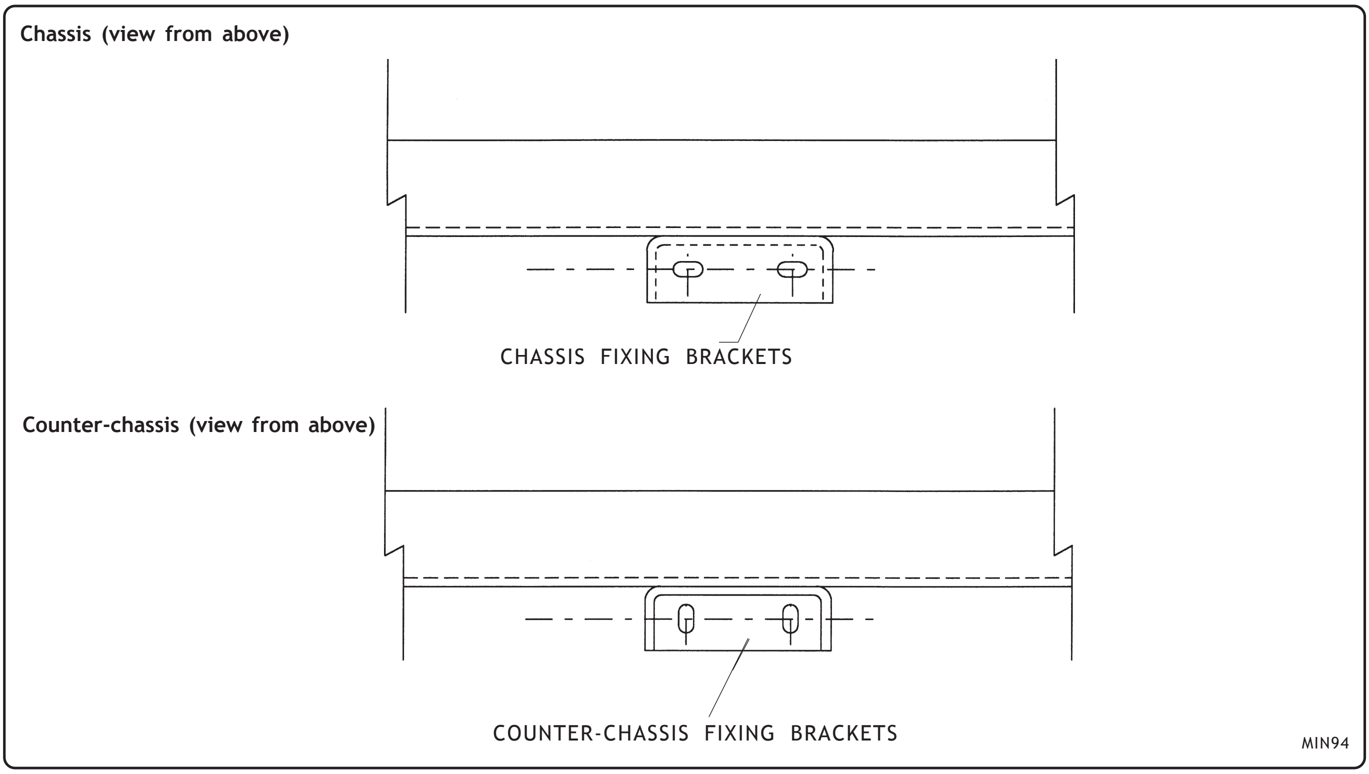


fig. 4.1.30

The type of nut (in particular its material) must be chosen taking into account the type of screws.

We recommend you use nuts fitted with a safety device that prevents them slackening.

In order to guide and contain loads better in a crosswise direction, brackets are usually applied so they project slightly past the upper edge of the chassis.

If in certain cases the brackets are mounted flush with the upper wing of the side member, the lateral guide plate of the crane must be secured by means of other devices (ex.: guide plates connected only to the counter-chassis - fig. 4.1.31 or only to the vehicle chassis - fig. 4.1.31, and resting on the other element).

1) Counter-chassis
2) Chassis
3) Lateral guide plates

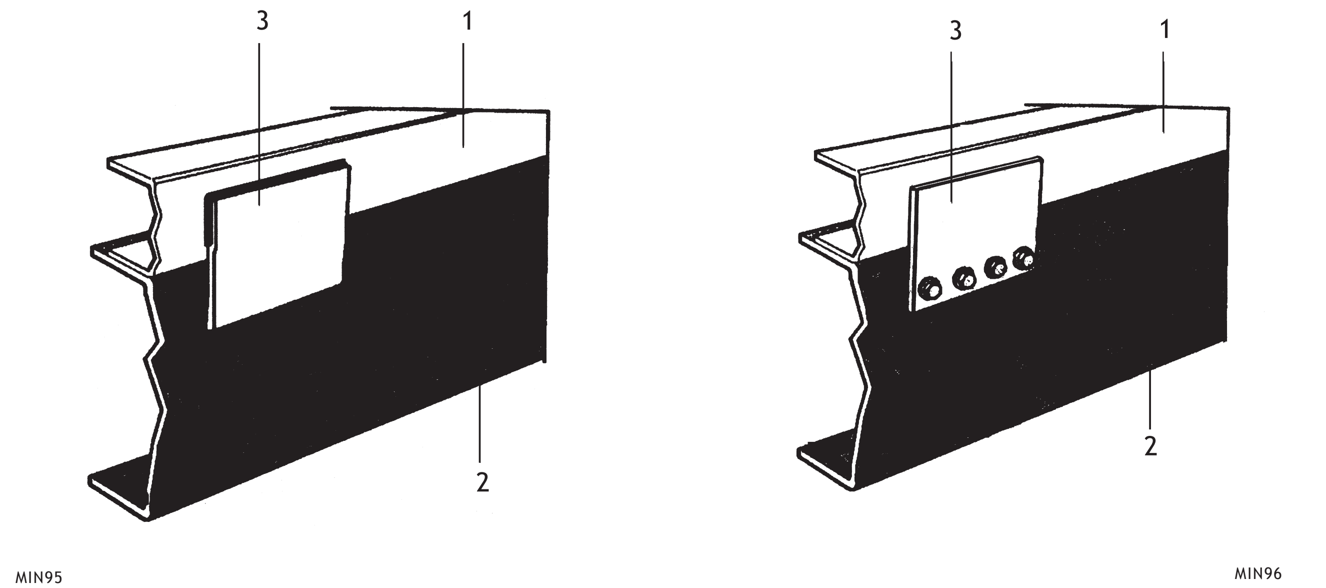


fig. 4.1.31

If you require a more flexible coupling, place elastic elements such as Belleville washers between the couplings (see fig. 4.1.32).

1) Elastic elements (Belleville washers)

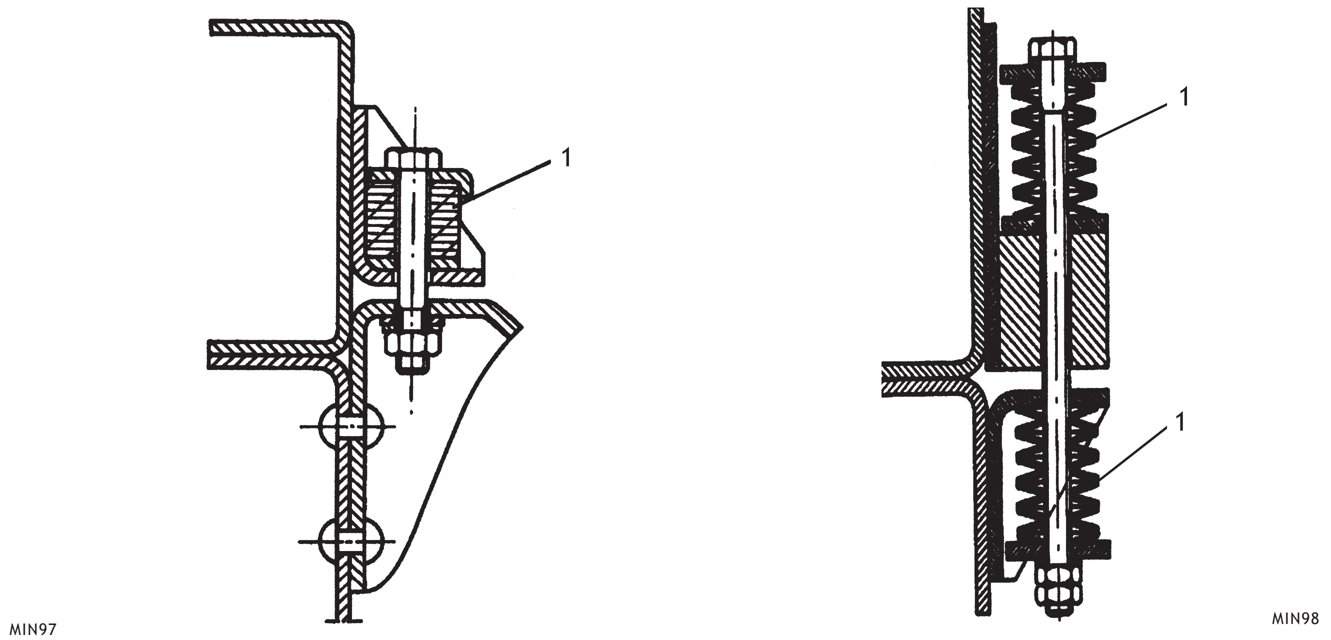


fig. 4.1.32

When selecting components for this securing system, limit the yielding of the elastic element (30-40 mm) to ensure sufficient counter-chassis co-operation and prevent excessive flexion movement on the original chassis.

- Connecting lengthways or crosswise (shear resistant) plates

Note

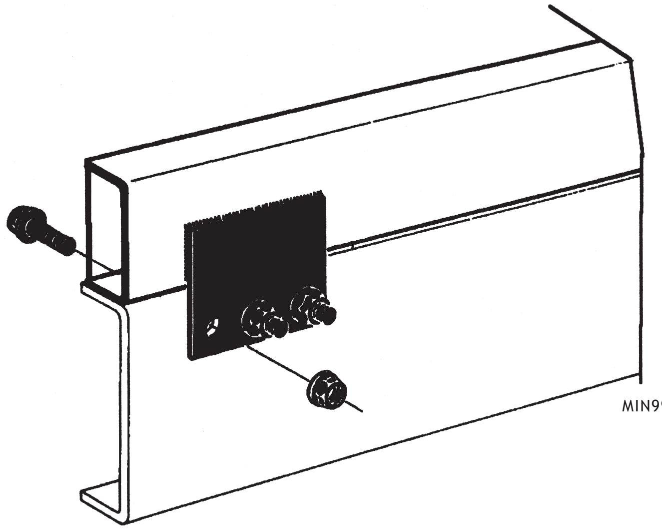
Unless otherwise specified, the material and the thickness of the connecting plates must be equal to or greater than used for the construction of the vehicle chassis, on the basis of the calculation made.

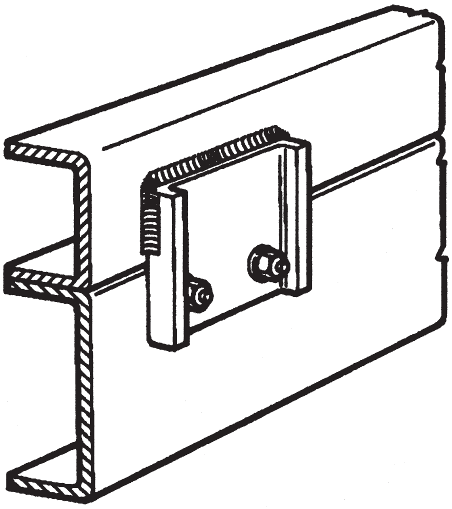
This rigid type of connection provides a good reaction to lengthways and crosswise thrust and makes the whole assembly more rigid.

Rigid connections need only have a single resistant section (chassis/counter-chassis) provided that the number and distribution of the connections are sufficient to withstand the resulting stresses (see paragraph 4.1).

The plates must be fitted onto the outer rib of the side members of the chassis using screws. They can be welded onto the counter-chassis (see paragraph 4.1.3 - welding).

Examples of this type of connection are shown in fig. 4.1.33.





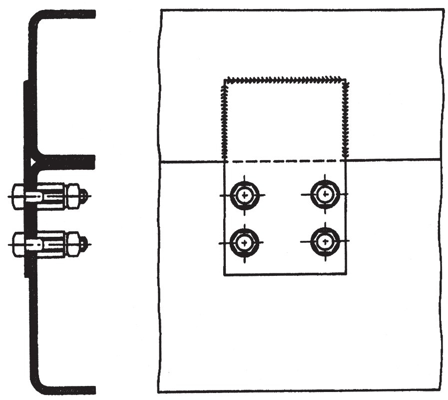


fig. 4.1.33

For a correct use of the plates, there must be a perfect contact between the lower surface of the counter-chassis and the vehicle's chassis.

If this cannot be guaranteed, the contact must be restored by means of the application of an additional steel sheet plate of a suitable thickness (see para.4.1.4 - Securing the counter-chassis).

The connection to shear-withstand plates must be made according to one of the following criteria.

1) The stress between plate and chassis is transmitted by friction

- the screws must have partially threaded shanks. There must be no contact between the thread and the sides of the hole (fig. 4.1.34);
- the quality of the bolts must comply with the vehicle manufacturer's specifications;
- backlash must be 0.2 - 1 mm;
- the surface of the plate and chassis must be cleaned and degreased;
- bolts must be tightened using a torque wrench according to the values stipulated by the vehicle manufacturer;
- grower-type elastic washers must not be used. You should preferably use specific flat high resistance washers for bolts.

2) Shear stress between plate and chassis is mainly transmitted by bolts

- the bolts must have partially threaded shrank. There must be no contact between thread and the sides of the hole (fig. 4.1.34);
- the quality of the bolts must comply with the vehicle manufacturer's specifications;
- backlash must be less than or equal to 0.2 mm;
- all the surfaces of the plates must be protected against corrosion;
- bolts must be tightened using a torque wrench according to the values stipulated by the vehicle manufacturer;
- grower-type elastic washers must not be used. You should preferably use specific flat high- resistance washers for bolts.

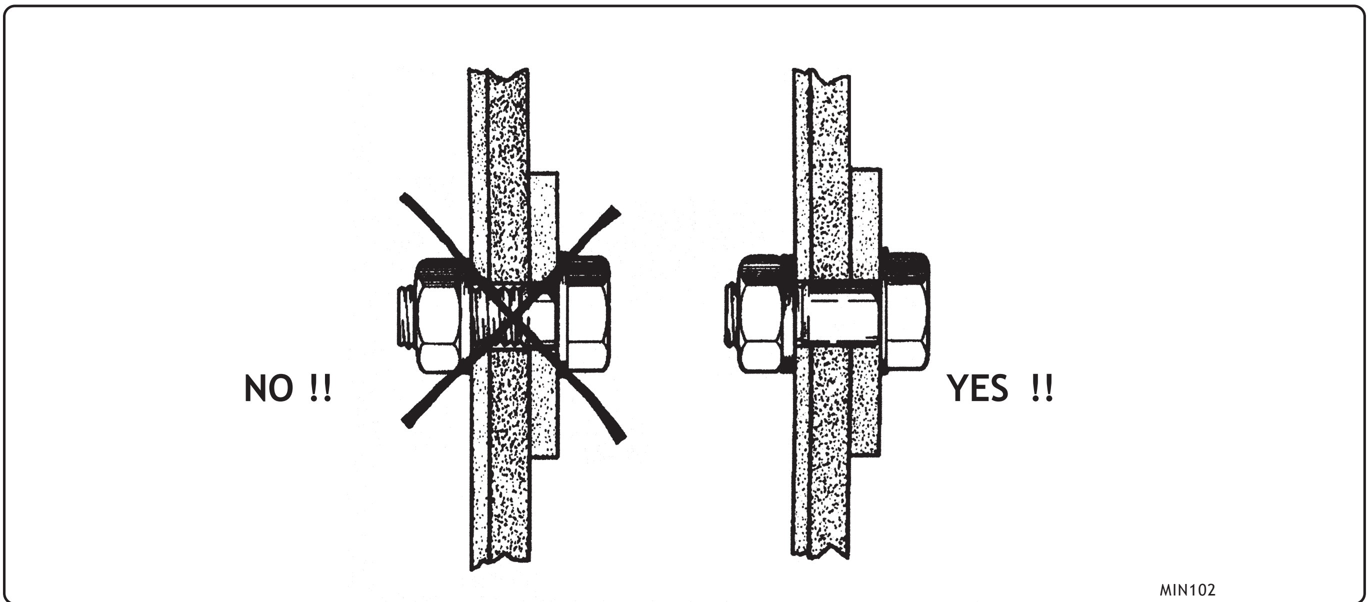


fig. 4.1.34

4.2- Crane anchoring

4.2.1 - General

The first step is to determine the position of the crane on the vehicle.

To do this, position the crane as required on the counter-chassis (behind cab or rear mounted) keeping it slightly suspended by the lifting device (see note on page 31/72 - chap. 4) and check the following visually:

a) the dead centre of rotation must be in the right position depending on the type of mounting. If it is not, refer to the crane manufacturer's instruction handbook.

As a general rule, unless specifically requested otherwise, it is advisable to position the dead centre of rotation where less work is done - over the cab when the crane is behind the cab (fig. 4.2.1), over the body for rear-mounted cranes (see fig. 4.2.2).

To ensure that the operator can get easily away from crane in the event of danger or wrong manoeuvres (see chapter 17 - List of hazards), the outrigger booms should be fitted to the side where the vehicle body is located (see figures 4.2.1 and 4.2.2).

If, because of the dimensions or the free space on the vehicle, this is not possible you must supply additional devices to enable the operator to avoid being located in dangerous areas (upper manoeuvring post, ground manoeuvring post, remote control via cable/radio) or to inform the operator, using warning messages, of the residual risks (limited emergency exit ways).

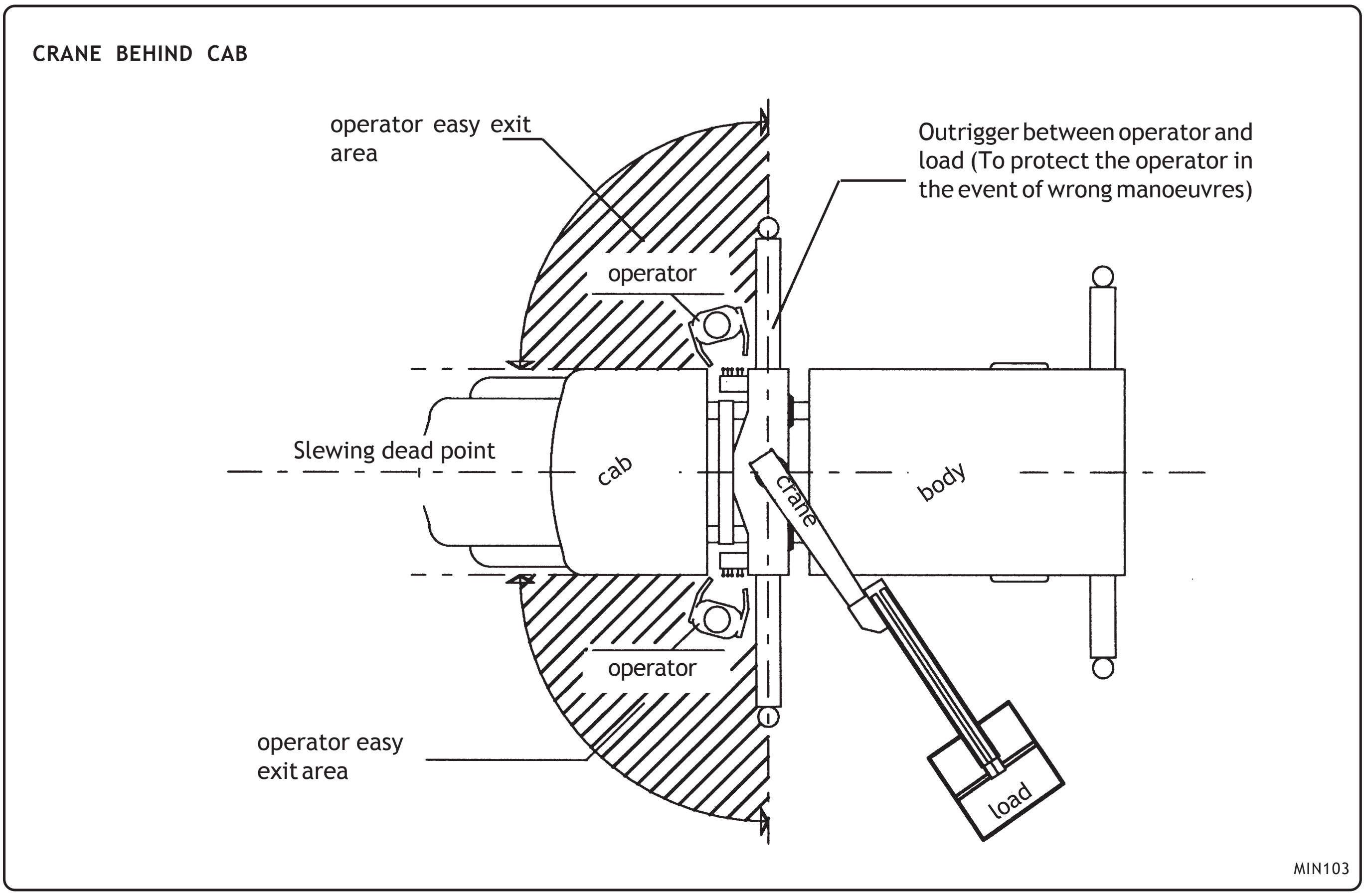


fig. 4.2.1

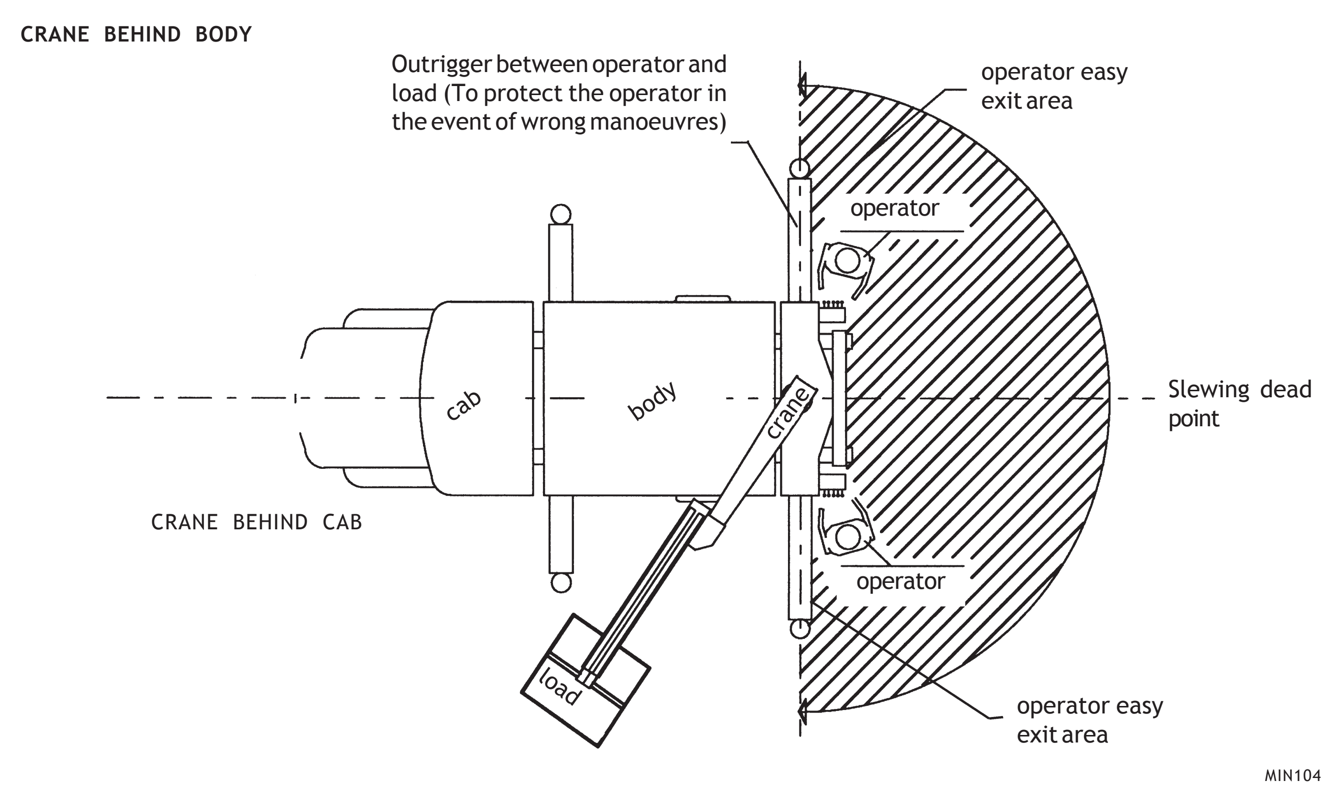


fig. 4.2.2

b) The crane's barycenter must be in the right position according to the calculation of weight distribution on the axles (see paragraph 3.2 - chapter 3).

c) There must be enough space in front of and behind the crane to allow the machine to be opened/closed and provide access for maintenance (see minimum spaces in paragraph 9.3 - chapters 9 and 17 - List of hazards).

d) In their transport position, the outrigger cylinders must not interfere with the vehicle parts (fuel tank, battery box, air tanks, etc.).

If they do and it is absolutely not possible to remedy the situation (ex. by mounting rotary stabiliser plates) the following points must be borne in mind, before moving the crane:

- the braking system must not be modified, unless specifically authorised by the vehicle manufacturer *(refer to the manufacturer's instructions when applying for authorisation);

- the air intake and engine exhaust systems must not be modified, unless specifically authorised by the vehicle manufacturer ** (refer to the manufacturer's instructions when applying for authorisation).

- Certain assemblies such as fuel tanks, battery box and spare wheel can be moved provided that this does not affect their operation, they are remounted exactly as before and their crosswise position on the vehicle chassis is not significantly altered.

e) Nothing must block the passage of the tie rods, which have to link the crane base, counter-chassis and chassis in a single unit.

If this is not the case in one or more points, the parts can be anchored indirectly (or with double anchorage - see page 30/72 - chapter 4).

f) The crane must be centred crosswise with respect to the vehicle and the crane/vehicle assembly layout must be respected (see fig. 4.2.3).

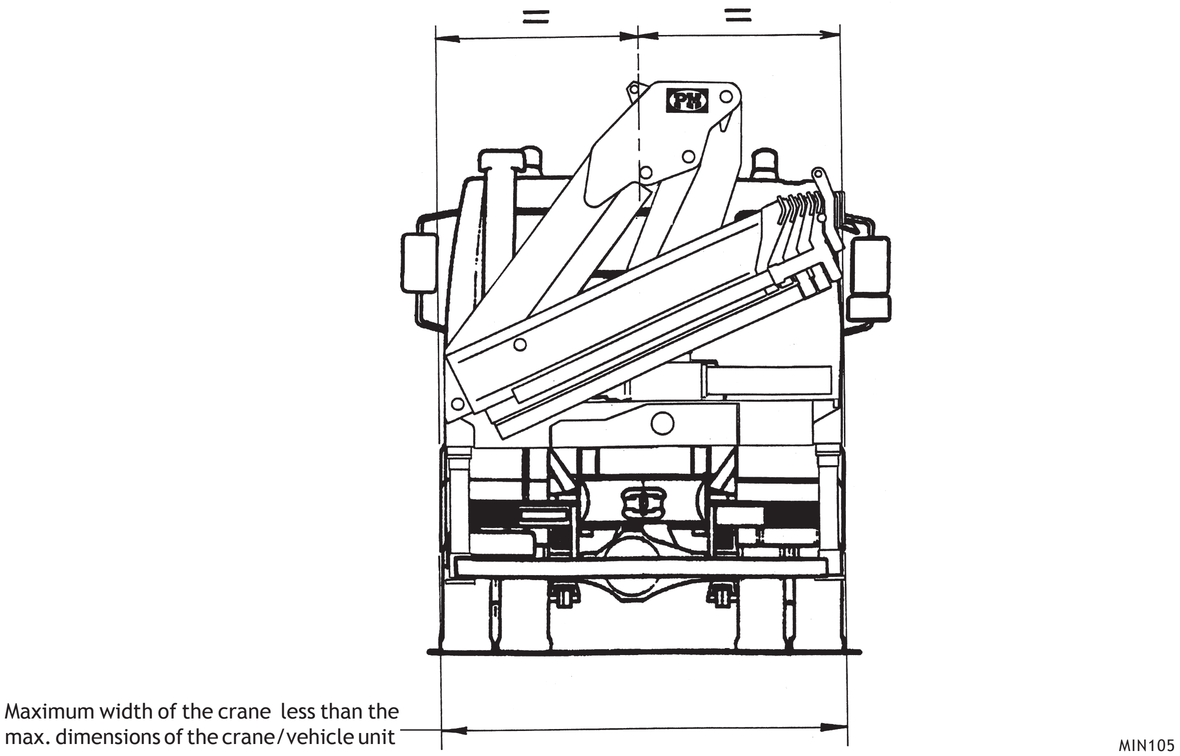


fig. 4.2.3

When you have positioned the crane and checked all the points above, proceed with anchoring operations.

ATTENTION!!!

*** R**emember that the circuit of the braking system must not be modified.
The vehicle manufacturer cannot be held liable if the circuit is modified without prior authorisation.

ATTENTION!!!

**** T**ampering with or altering the intake and engine exhaustion systems without prior authorisation can cause considerable damage to the engine and alter its efficiency, performance and reliability.

First of all, before anchoring the crane, lateral stops must be fitted on the upper part of the counter-chassis to prevent the crane base from slipping (see fig. 4.2.4).

These stops must be welded onto the counter-chassis in line with the rigid part of the base (outrigger boom seat) on both ends (front and back) and on both side members.

These stops are very important because they help to maintain tie rod torque, which makes the whole assembly more compact and stable through time.

These stops must not be applied to the side of the rocker arm of the machine (oscillating support) otherwise it might get damaged.

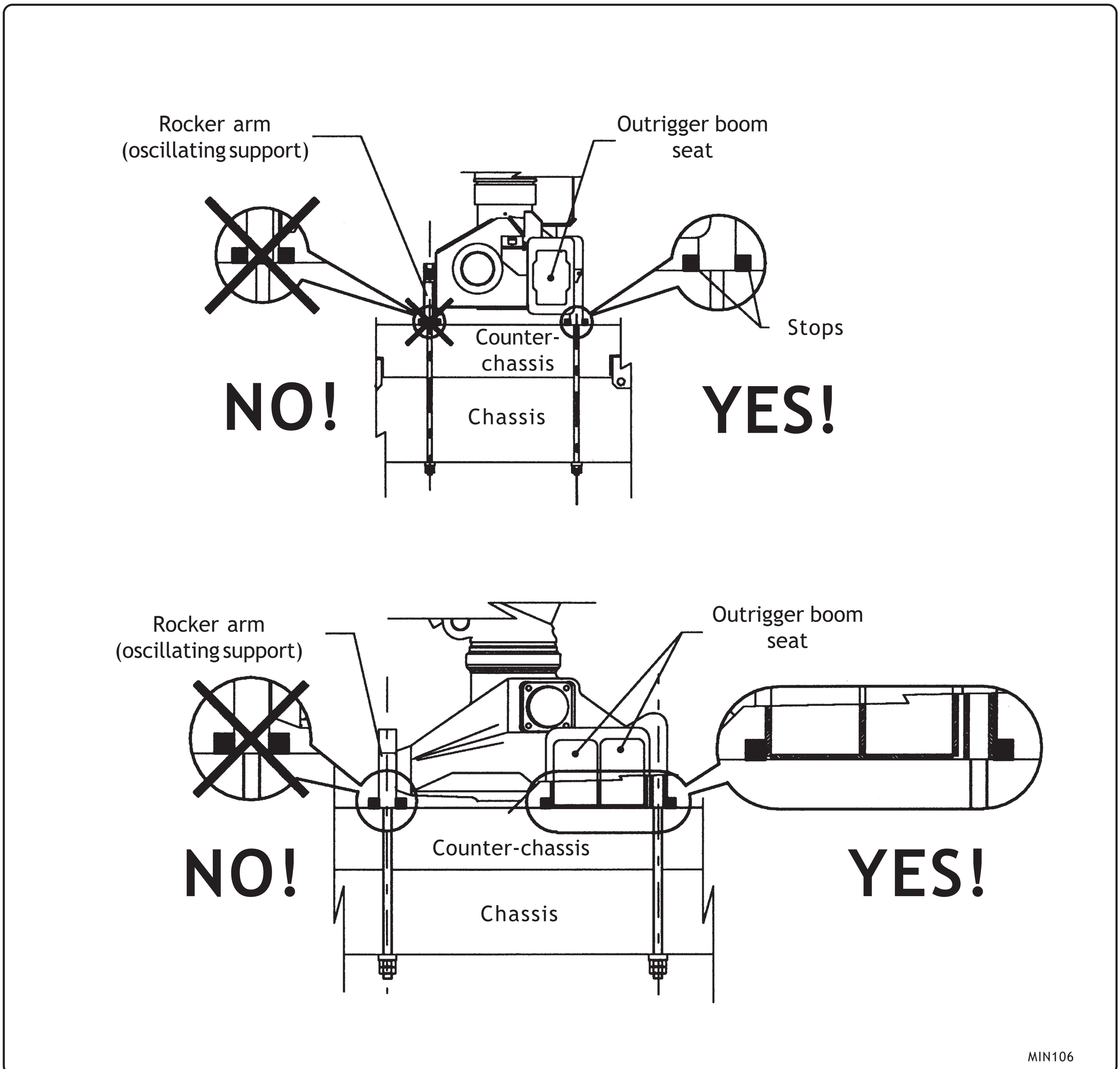


fig. 4.2.4

The crane must be anchored using materials provided by or recommended by the manufacturer as specified below.
There are various types of anchorage:

a) direct anchorage by connecting the crane base, counter-chassis and vehicle chassis on a single unit (see fig. 4.2.5);
b) indirect (or double) anchorage by connecting the crane base to the counter-chassis and the counter-chassis to the vehicle chassis at another point (see fig. 4.2.6).
   This method is used when there are obstacles on the vehicle preventing the through passage of the tie rods.
   When carrying out double anchorage, the anchor points between the counter-chassis and the chassis must always be at a higher distance (towards the outside) with respect to those connecting the base of the crane to the counter-chassis.

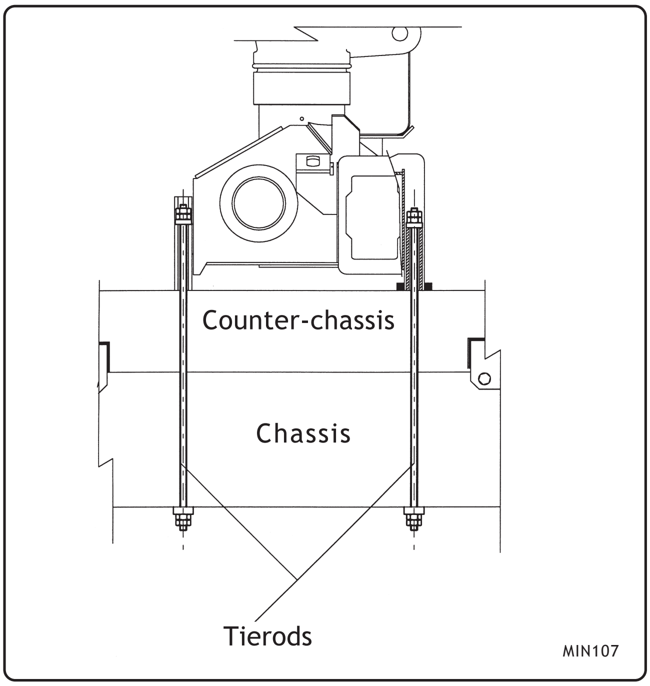


fig. 4.2.5

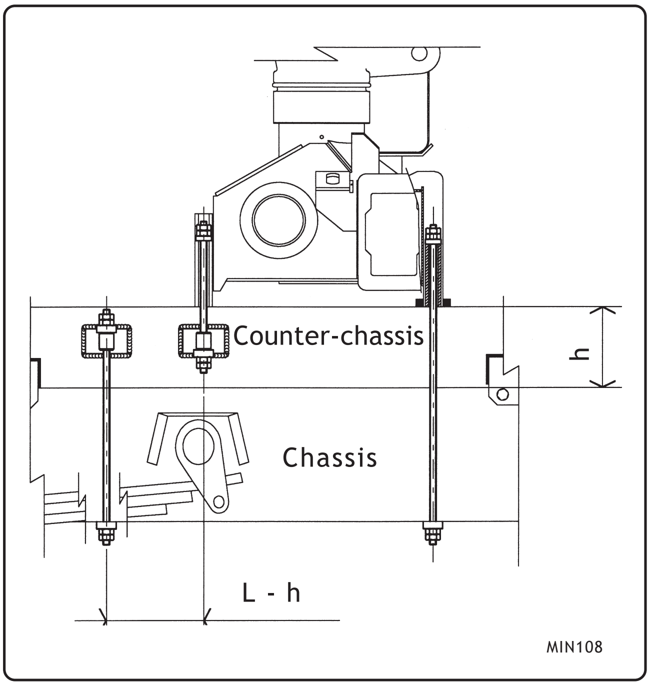


fig. 4.2.6

Note

When using tie rods for anchoring, before locking the nuts insert a vertical reinforcement into the vehicle chassis where the tie rods pass through (see para. 4.2.6).
This is to prevent the sides of the chassis from getting crushed.

c) Anchorage with tie rods and plates bolted onto the vehicle chassis (see fig. 4.2.7).

   This method uses tie rods to connect the base of the crane to an anchor plate that is welded onto the counter-chassis and bolted onto the vehicle chassis.

   This is the vehicle manufacturers' preferred method because it does not subject the sides of the chassis to stress or crush them.

   The quality and dimension of bolts have to be chosen accordingly to the stress produced and to the prescriptions of the vehicle constructor.

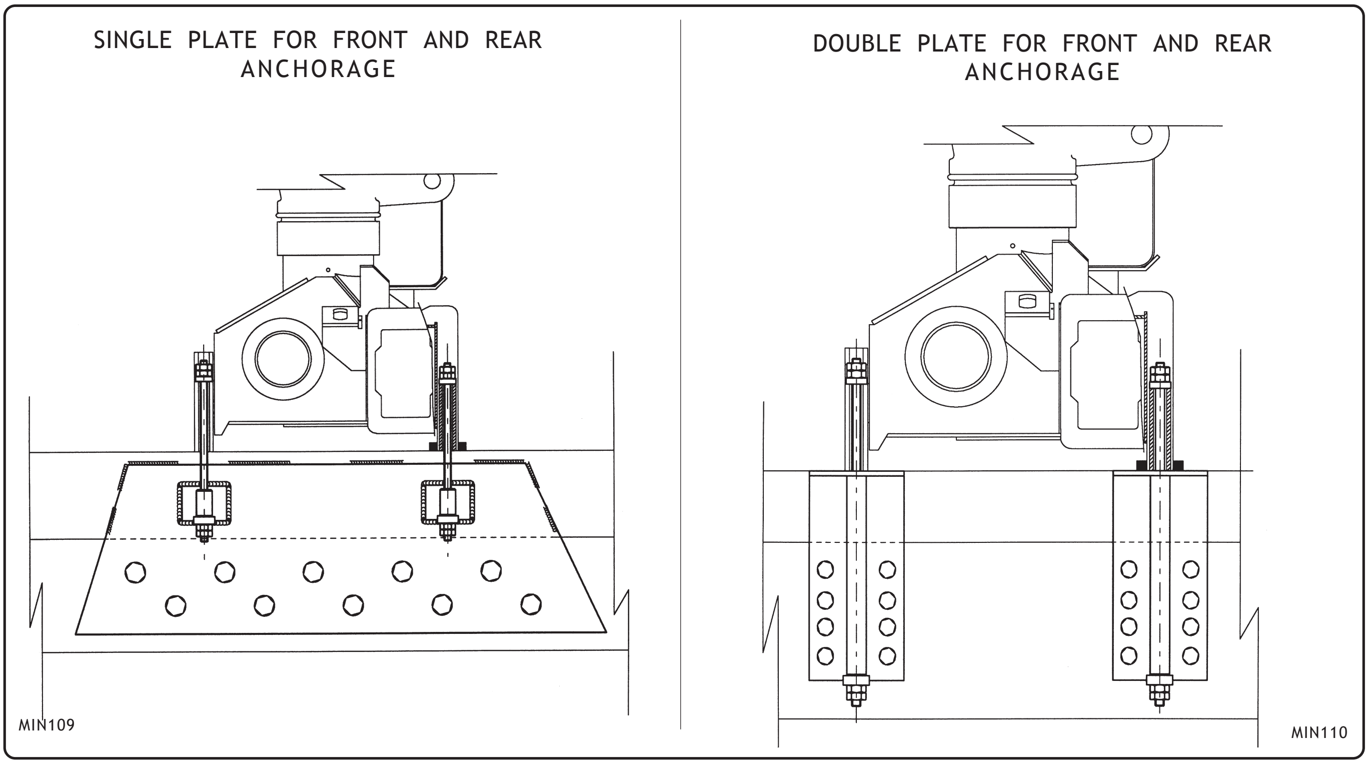


fig. 4.2.7

Note

When lifting or moving the crane, take particular care over the following points.

- Lifting with a hook (see fig. 4.2.8)

Before lifting the crane, check that all the components are secured with a stop in their resting position (arms are secured with stop).

When lifting the crane with the special bracket for use with the hooks, use an ordinary or travelling crane of a suitable capacity (see the technical specification sheet of the crane model).

Be careful of oscillations created during movement, particularly lateral movement of the crane during lifting. The hooking point is never exactly the same as the barycenter.

Always move slowly and cautiously so that the operators do not get hurt or the crane damaged.

The chains, cables and hooks used to lift the crane must be suitable for withstanding its weight.

In particular, make sure the chains or cables are integral and not worn or frayed, which would cause a serious hazard for the operators.

When securing the hook to the crane lifting bracket, use a shackle of a suitable capacity.

1) Lifting bracket
2) Chain/cable of the lifting equipment (crane/travelling crane)

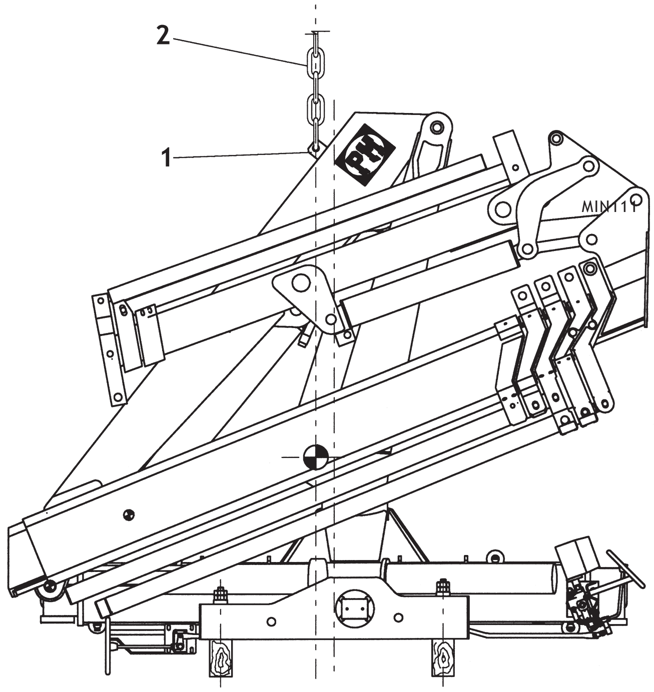


fig. 4.2.8

4.2.2 - Checking the anchorage

We supply all materials needed for anchoring the machine and therefore they are capable of withstanding the maximum stress exerted by the machine.
For this reason, the calculations adopted to test the anchoring elements have not been included in this handbook since they are not necessary.
On request, we can provide the relevant test documents.

4.2.3 - Tie rods

For the correct use of tie-rods, you should keep to the following guidelines:

1) the connection is possible if the tie-rod axis is perpendicular to the chassis longitudinal axis (see fig. 4.2.9). Even if this is not possible, never tilt or bend the tie rods - use other anchoring methods (double anchorage).
2) The tie rods must never be bend or curved, either hot or cold, to fit them in place.
3) Make sure the thread is not damaged when the tie rods are being fitted in place. Protect the thread with suitable sheaths or the like.
4) Never weld tie rods.
5) Do not allow tie rods, installed near sources of heat (ex. engine exhaust piping) to overheat; instead provide them with appropriate protections.
6) Protect tie rods against corrosion (protective paint).

The dimensions and features of the tie rods are shown in the technical specification sheet of the crane model.

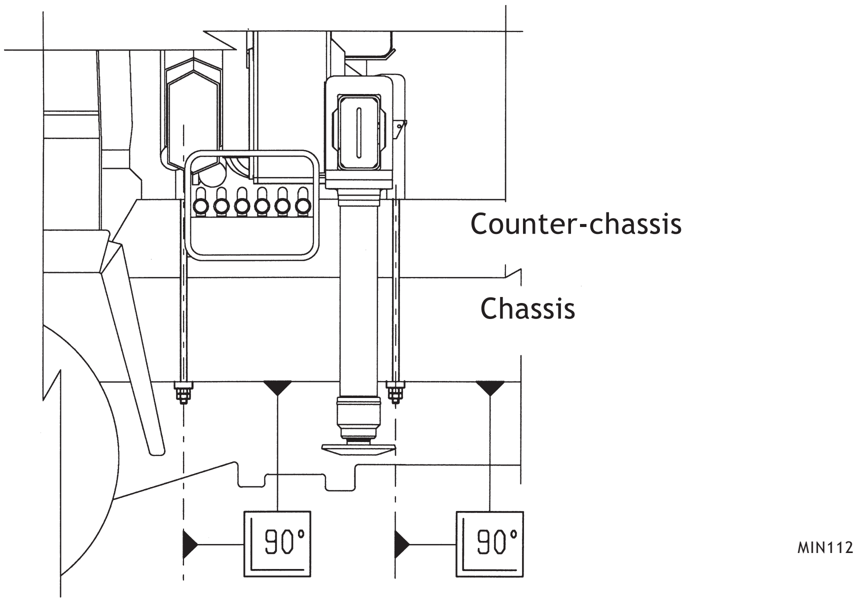


fig. 4.2.9

4.2.4 - Fixing plates

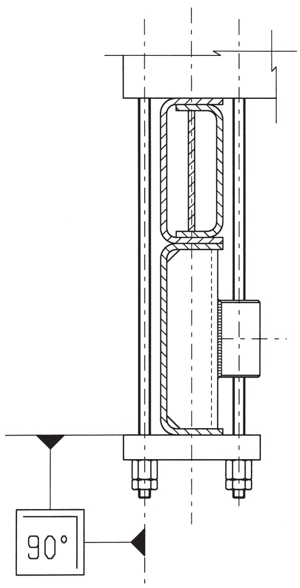


fig. 4.2.10

For the correct use of anchoring plates, you should keep to the following guidelines:

1) fixing plates must always rest on a flat base on the vehicle chassis (perpendicular to the axis of the tie rods - see fig. 4.2.10).
2) Fixing plates should be protected against corrosion (galvanising, paint treatments, etc.).

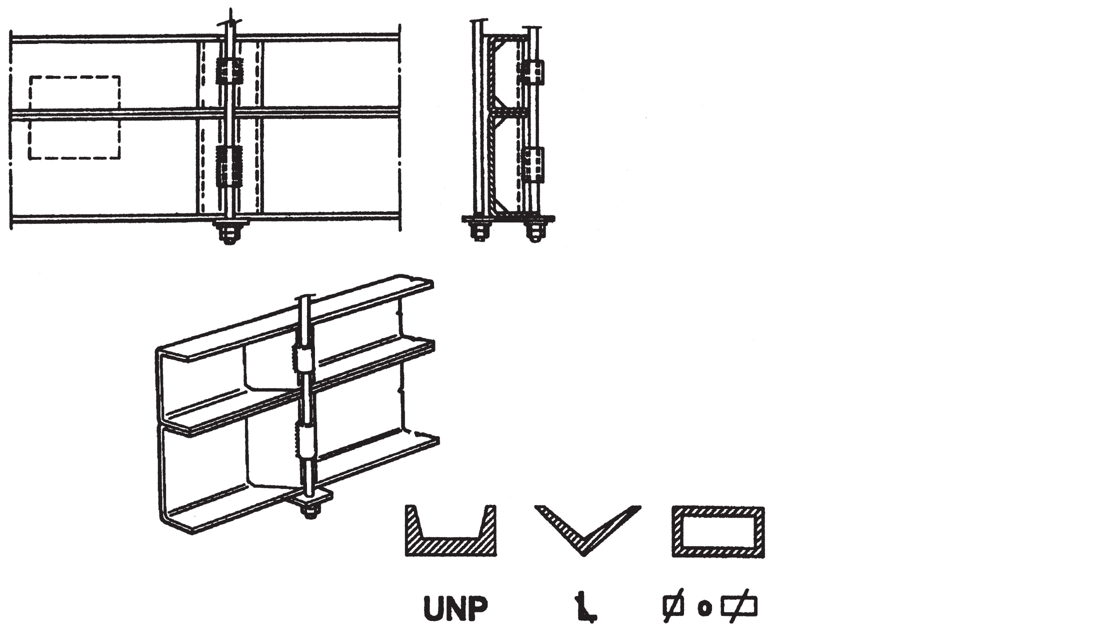
The dimensions and features of the fixing plates are shown in the technical specification sheet of the crane.

4.2.5- Tie rod nuts and counternuts

Always use nuts and counternuts and, if necessary, further locking systems (split pins, plugs, loctite, etc.).
Do not lock the nuts by welding.
The dimensions and features of the nuts are shown in the technical specification sheets specific for each crane.

4.2.6- Devices preventing the chassis from getting crushed

It is necessary to install suitable local reinforcements to prevent the chassis side members from being crushed by the action of the tie rods (see fig. 4.2.11).
These devices must be kept in position by suitable fixing means (pilot bosses on the tie rods).
Do not weld the side member wings.

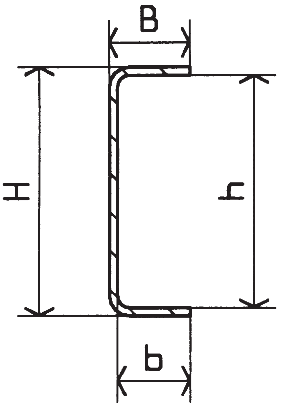


Examples of sections of crushing preventing devices

fig. 4.2.11

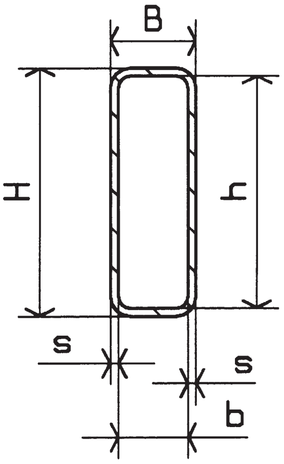
- Annex 1 (for information purposes only)

CALCULATING J AND W IN THE MOST COMMONLY USED CHASSIS AND COUNTER-CHASSIS SECTIONS



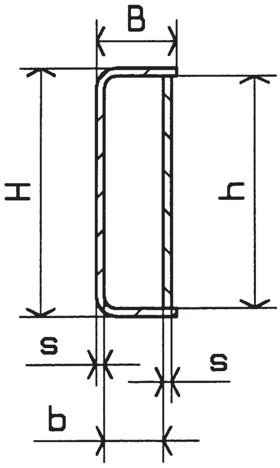
$$J = \frac{B \cdot H^3 - b \cdot h^3}{12} = mm^4$$

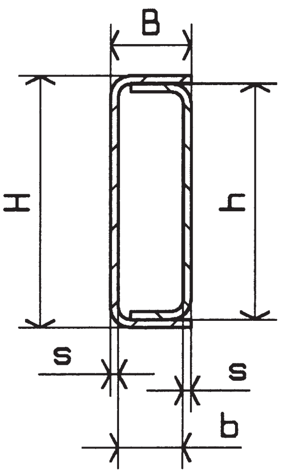
$$w = \frac{B \cdot H^3 - b \cdot h^3}{6H} = mm^3$$



$$J = \frac{B \cdot H^3 - b \cdot h^3}{12} = mm^4$$

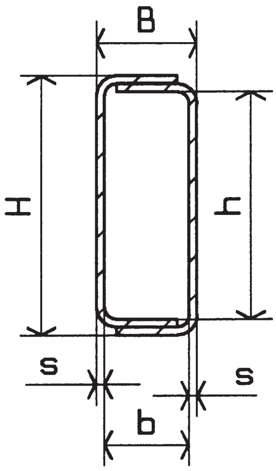
$$w = \frac{B \cdot H^3 - b \cdot h^3}{6H} = mm^3$$





$$J = \frac{B \cdot H^3 - b \cdot h^3}{12} = mm^4$$

$$w = \frac{B \cdot H^3 - b \cdot h^3}{6H} = mm^3$$



MIN115

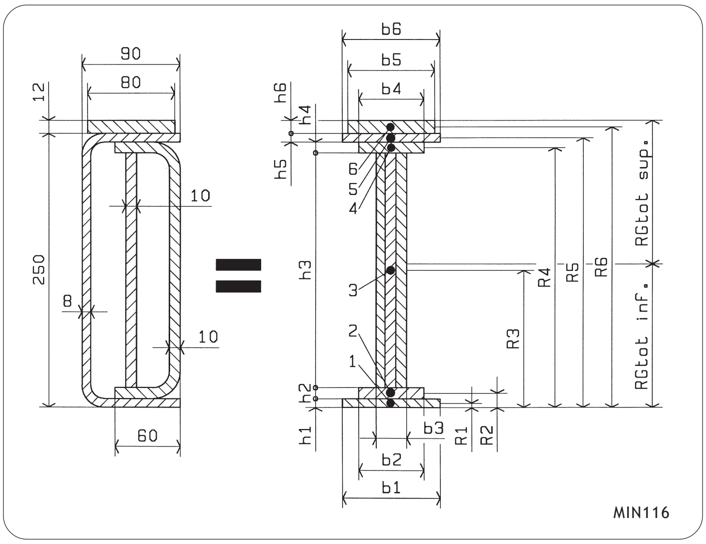
Ann.1 -chap. 4

- Annex 2 (for information purposes only)

CALCULATING THE STRUCTURE WITH NO BARYCENTER (ASYMMETRIC)

A) The structure shown in the figure to the side is formed of 6 different sections. Since the structure is not barycentric, the total barycenter **Rgtot** of the said structure corresponds to:

$$\text{Rgtotinf.} = \frac{a1 \cdot R1 + a2 \cdot R2 + a3 \cdot R3 + \text{ecc..}}{a1 + a2 + a3 + \text{ecc..}}$$



where: **a** = Area of each section (mm^2)
R = Barycentric radius of each section (mm)
R g= Total barycentric radius (mm)
d = Distance between the partial barycenter and the total barycenter: ex. **d1** = Rgtot-R (mm)
d2 = Rgtot-R2 (mm)

B) To calculate the moment of inertia on flexure of the total section (**Jtot**) in relation to the axis, the following formula is used:

Jtot = $jx + ax \cdot d^2 = \Sigma j$ partial (mm^4)
where: **jx** = Moment of inertia on flexure of each section = $b \cdot h^3/12$ (mm^4)
ax = Area of each section = $b \cdot h$ (mm^2)
d = Distance from the partial to the total barycenter of a section (mm)

Jtot = (j1+a1·d1)+(j2+a2·d2)+(j3+a3·d3)+ecc..= replacing the values with those found in this case

$$= \left[\frac{b1 \cdot h1^3}{12} + (b1 \cdot h1) \cdot d1^2\right] + \left[\frac{b2 \cdot h2^3}{12} + (b2 \cdot h2) \cdot d2^2\right] + \left[\frac{b3 \cdot h3^3}{12} + (b3 \cdot h3) \cdot d3^2\right] + \text{ecc.} \quad (mm^4)$$

C) To calculate the greater and lesser flexure resistance module (W), the following formula is used:

Wsup.=Jtot/Rgtotsup (mm^3) Winf.=Jtot/Rgtotinf (mm^3)

it being known that: Rgtotsup = Htot-Rgtotinf. (mm)
Htot = h1+h2+h3+ecc.. (mm)

Ann.2 -chap. 4

- Annex 3 (for information purposes only)

TECHNICAL FEATURES OF MATERIALS USED IN THE COUNTER-CHASSIS CONSTRUCTION

The new european standard EN 10210-1 specifies the technical supply conditions for the hollow section bars manufactured using heat processes or normalised with circular, square or rectangular sections.

The creation of these new specifications has made it possible to standardise the various steel standards and qualities in a new designation.

COMPARISON TABLE

EN 10210-1			NF A 49501 NF A 35501	DIN 17100 DIN 17123/4/5	BS 4360	UNI 7806
S 235	JR	H	E 24-2	St 37-2		Fe 360 B
S 275	JO	H	E 28-3	St 44-3U	43 C	Fe 430 C
S 275	J2	H	E 28-4	St44-3N	43 D	Fe 430 D
S 355	JO	H	E 36-3	St 52-3U	50 C	Fe 510 C
S 355	J2	H	E 36-4	St 52-3N	50 D	Fe 510 D
S 275	N	H		St E 285 N		
S 275	NL	H		TSt E 285 N	43 EE	
S 355	N	H	E 355 R	St E 355 N		
S 355	NL	H		TSt E 355 N	50 EE	
S 460	N	H	E 460 R	St E 460 N		
S 460	NL	H		TSt E 460 N	55 EE	

MIN117

Ann.3 -chap. 4

The alphanumerical designations have been attributed according to the standard EN 10027/1 and ECISS IC 10 and must be interpreted as follows:

- the upper case "S" indicates "STEEL FOR STRUCTURAL USES";
- the number which follows indicates the minimum unitary yield load prescribed for thicknesses less than or equal to 16 mm;
- the letter "H" indicates "HOLLOW SECTION BAR".

The tables that are shown hereafter, taken from standard EN 10210-1, relate to the chemical and mechanical features of the most commonly used and requested quality of steel.

- Annex 4 (for information purposes only)

HOLLOW SQUARE AND RECTANGULAR SECTION BARS

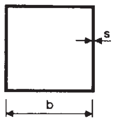
Chemical composition

Designation		C % max Nominal thickness (mm)		Si % max	Mn% max	P% max	S% max	N% max (3) (4)
According to EN 10027/1 and IC 10	According to EN 10027/2	≤ 40	> 40 ≤ 65					
S235JRH	1.0039	0,17	0,20	–	1,40	0,045	0,045	0,009
S275J0H	1.0149	0,20	0,22	–	1,50	0,040	0,040	0,009
S275J2H	1.0138	0,20	0,22	–	1,50	0,035	0,035	–
S355J0H	1.0547	0,22	0,22	0,55	1,60	0,040	0,040	0,009
S355J2H	1.0576	0,22	0,22	0,55	1,60	0,035	0,035	–

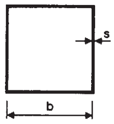
Mechanical features

Designation		Minimum unitary yelding load R_{eH} in N/mm²			Traction resistance R_m in N/mm²		Minimum extension percentage $L_o = 5,65 \sqrt{So}$				Impact resistance features	
According to EN 10027/1 and IC 10	According to EN 10027/2	Nominal thickness (mm)			Nominal thickness (mm)		Longitud.		Transvers.		Trial temperature °C	Minimum average resilience (J) per standard test piece (2)
		≤ 16	> 16 ≤ 40	> 40 ≤ 65	< 3	≥ 3 ≤65	≤ 40	> 40 ≤ 65	≤ 40	> 40 ≤ 65		
S235JRH	1.0039	235	225	215	360-510	340-470	26	25	24	23	20	27
S275J0H	1.0149	275	265	255	430-580	410-560	22	21	20	19	0	27
S275J2H	1.0138	275	265	255	430-580	410-560	22	21	20	19	- 20	27
S355J0H	1.0547	355	345	335	510-680	490-630	22	21	20	19	0	27
S355J2H	1.0576	355	345	335	510-680	490-630	22	21	20	19	- 20	27

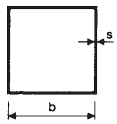
HOLLOW SQUARE SECTION BARS MANUFACTURED USING HEAT PROCESSES



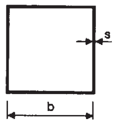
External sides dimension b mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion I cm⁴	Radius of inertia i cm	Resistance module W cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
30	2,0	1,76	2,24	2,923	1,142	1,949	4,519	2,759
	2,5	2,11	2,68	3,330	1,110	2,220	5,400	3,220
	3,0	2,47	3,14	3,740	1,090	2,500	6,160	3,600
	4,0	3,27	4,16	4,665	1,059	3,110	7,432	4,214
	5,0	3,93	5,00	5,172	1,017	3,448	8,350	4,587
	6,0	4,52	5,76	5,480	0,9754	3,653	8,938	4,774
40	2,0	2,39	3,04	7,311	1,551	3,656	11,210	5,242
	2,5	2,89	3,68	8,540	1,520	4,270	13,600	6,220
	3,0	3,41	4,34	9,780	1,500	4,890	15,700	7,100
	4,0	4,39	5,59	11,800	1,450	5,910	19,500	8,540
	5,0	5,28	6,73	13,400	1,410	6,680	22,500	9,600
	6,0	6,41	8,16	15,630	1,384	7,815	25,070	10,490
	7,0	7,25	9,24	16,650	1,342	8,323	26,950	11,020
	8,0	8,04	10,24	17,320	1,301	8,660	28,250	11,320
45	2,5	3,34	4,25	12,780	1,734	5,681	19,660	8,111
	3,0	3,96	5,04	14,800	1,714	6,577	22,880	9,311
	4,0	5,15	6,56	18,340	1,672	8,150	28,640	11,360
	5,0	6,28	8,00	21,260	1,630	9,450	33,540	12,980
	6,0	7,35	9,36	23,620	1,588	10,500	37,620	14,220
	7,0	8,35	10,64	25,450	1,547	11,310	40,910	15,140
	8,0	9,29	11,84	26,810	1,505	11,920	43,450	15,760
	9,0	10,20	12,96	27,740	1,463	12,330	45,250	16,110
50	2,5	3,68	4,68	17,500	1,930	6,990	27,500	10,200
	3,0	4,35	5,54	20,200	1,910	8,080	32,100	11,800
	4,0	5,64	7,19	25,000	1,860	9,990	40,400	14,500
	5,0	6,85	8,73	28,900	1,820	11,600	47,600	16,700
	6,0	7,99	10,20	32,000	1,770	12,800	53,600	18,400
	6,3	8,31	10,60	32,800	1,760	13,100	55,200	18,800
	7,0	9,45	12,04	36,910	1,751	14,770	58,970	19,930
	8,0	10,60	13,44	39,260	1,709	15,700	63,220	20,960
	9,0	11,60	14,76	41,030	1,667	16,410	66,540	21,680
	10,0	12,60	16,00	42,280	1,626	16,910	68,970	22,100
55	2,5	4,12	5,25	24,100	2,143	8,765	36,890	12,620
	3,0	4,90	6,24	28,100	2,122	10,220	43,190	14,600
	4,0	6,41	8,16	35,320	2,081	12,840	54,750	18,100
	5,0	7,85	10,00	41,570	2,039	15,120	64,980	21,030
	6,0	9,23	11,76	46,910	1,997	17,060	73,940	23,450
	7,0	10,60	13,44	51,390	1,955	18,690	81,650	25,410
	8,0	11,80	15,04	55,070	1,913	20,020	88,180	26,950
	9,0	13,00	16,56	58,010	1,872	21,090	93,550	28,110
	10,0	14,10	18,00	60,270	1,830	21,920	97,800	28,920



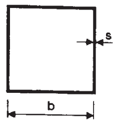
External sides dimension b mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion I cm⁴	Radius of inertia i cm	Resistance module W cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
60	2,5	4,46	5,68	31,10	2,340	10,40	48,50	15,2
	3,0	5,29	6,74	36,20	2,320	12,10	56,90	17,70
	4,0	6,90	8,79	45,40	2,270	15,10	72,50	22,00
	5,0	8,42	10,70	53,30	2,230	17,80	86,40	25,70
	6,0	9,87	12,60	59,90	2,180	20,00	98,60	28,80
	6,3	10,30	13,10	61,60	2,170	20,50	102,00	29,60
	7,0	11,60	14,84	69,22	2,160	23,07	109,50	31,58
	8,0	12,50	16,00	69,70	2,090	23,20	118,00	33,40
	9,0	14,40	18,36	79,13	2,076	26,38	126,90	35,41
	10,0	15,70	20,00	82,76	2,034	27,59	133,60	36,70
65	2,5	4,91	6,25	40,67	2,551	12,51	62,06	18,12
	3,0	5,84	7,44	47,64	2,530	14,66	72,94	21,08
	4,0	7,66	9,76	60,46	2,489	18,60	93,24	26,44
	5,0	9,42	12,00	71,88	2,447	22,12	111,60	31,07
	6,0	11,10	14,16	81,96	2,406	25,22	128,20	35,05
	7,0	12,70	16,24	90,76	2,364	27,93	143,00	38,43
	8,0	14,30	18,24	98,37	2,322	30,27	156,00	41,26
	9,0	15,80	20,16	104,80	2,280	32,26	167,40	43,58
	10,0	17,30	22,00	110,20	2,239	33,92	177,10	45,44
	11,0	18,70	23,76	114,70	2,197	35,28	185,30	46,86
70	2,5	5,30	6,75	51,24	2,755	14,64	78,08	21,24
	3,0	6,24	7,94	59,00	2,730	16,90	92,20	24,80
	4,0	8,15	10,40	74,70	2,680	21,30	118,00	31,20
	5,0	9,99	12,70	88,50	2,640	25,30	142,00	36,80
	6,0	11,80	15,00	101,00	2,590	28,70	163,00	41,60
	6,3	12,30	15,60	104,00	2,580	29,70	169,00	42,90
	7,0	13,80	17,64	116,40	2,568	33,25	182,70	45,98
	8,0	15,00	19,20	120,00	2,500	34,20	200,00	49,20
	9,0	17,20	21,96	135,60	2,485	38,74	215,60	52,64
	10,0	18,80	24,00	143,20	2,443	40,92	229,10	55,15
	11,0	20,40	25,96	149,70	2,401	42,76	240,80	57,18
	12,0	21,90	27,84	155,00	2,359	44,28	250,60	58,75
75	3,0	6,78	8,64	74,62	2,939	19,90	113,90	28,77
	4,0	8,92	11,36	95,37	2,897	25,43	146,50	36,37
	5,0	11,00	14,00	114,20	2,856	30,45	176,50	43,10
	6,0	13,00	16,56	131,20	2,814	34,98	204,00	49,04
	7,0	14,90	19,04	146,40	2,773	39,03	229,10	54,22
	8,0	16,80	21,44	159,90	2,731	42,64	251,80	58,72
	9,0	18,70	23,76	171,80	2,689	45,82	272,20	62,58
	10,0	20,40	26,00	182,20	2,647	48,59	290,30	65,84
	11,0	22,10	28,16	191,20	2,605	50,98	306,30	68,56
	12,0	23,70	30,24	198,70	2,564	53,00	320,10	70,75



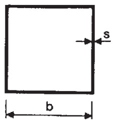
External sides dimension b mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm^2	Moment of inertia during flexion I cm^4	Radius of inertia i cm	Resistance module W cm^3	Moment of inertia during torsion J cm^4	Torsion module C cm^3
80	3,0	7,18	9,14	89,8	3,130	22,50	140,0	33,00
	4,0	9,41	12,00	114,0	3,090	28,60	180,0	41,90
	5,0	11,60	14,70	137,0	3,050	34,20	217,0	49,80
	6,0	13,60	17,40	156,0	3,000	39,10	252,0	56,80
	6,3	14,20	18,10	162,0	2,990	40,50	262,0	58,70
	7,0	16,00	20,44	181,2	2,977	45,29	282,7	63,16
	8,0	17,50	22,40	189,0	2,910	47,30	312,0	68,30
	9,0	20,10	25,56	214,0	2,894	53,50	337,8	73,41
	10,0	22,00	28,00	227,7	2,852	56,93	361,5	77,51
	11,0	23,80	30,36	239,7	2,810	59,93	382,6	81,01
	12,0	25,60	32,64	250,1	2,768	62,52	401,2	83,92
90	3,0	8,20	10,44	131,7	3,551	29,26	200,4	42,54
	4,0	10,70	13,60	166,0	3,500	37,00	260,0	54,20
	5,0	13,10	16,70	200,0	3,450	44,40	316,0	64,80
	6,0	15,50	19,80	230,0	3,410	51,10	367,0	74,30
	6,3	16,20	20,70	238,0	3,400	53,00	382,0	77,00
	7,0	18,20	23,24	266,4	3,386	59,20	413,9	83,12
	8,0	20,10	25,60	281,0	3,320	62,60	459,0	90,50
	9,0	22,90	29,16	318,0	3,302	70,66	499,2	97,73
	10,0	25,10	32,00	340,2	3,260	75,60	536,7	103,80
	11,0	27,30	34,76	360,1	3,219	80,02	571,0	109,10
	12,0	29,40	37,44	377,9	3,177	83,97	602,0	113,80
	13,0	31,40	40,04	393,5	3,135	87,45	629,9	117,70
100	3,0	9,14	11,64	182,5	3,959	36,50	277,4	53,23
	4,0	11,90	15,20	232,0	3,910	46,40	361,0	68,20
	5,0	14,70	18,70	279,0	3,860	55,90	439,0	81,80
	6,0	17,40	22,20	323,0	3,820	64,60	513,0	94,30
	6,3	18,20	23,20	336,0	3,800	67,10	534,0	97,80
	7,0	20,40	26,04	374,8	3,794	74,97	580,3	105,90
	8,0	22,60	28,80	400,0	3,730	79,90	646,0	116,00
	9,0	25,70	32,76	451,1	3,711	90,22	704,9	125,60
	10,0	27,40	34,90	462,0	3,640	92,40	761,0	133,00
	11,0	30,70	39,16	515,3	3,627	103,10	812,5	141,60
	12,0	33,20	42,24	543,1	3,586	108,60	860,2	148,30
	13,0	35,50	45,24	568,1	3,544	113,60	903,8	154,30
	14,0	37,10	47,20	571,0	3,479	114,30	940,0	158,50



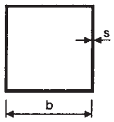
External sides dimension b mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion I cm⁴	Radius of inertia i cm	Resistance module W cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
110	3,0	10,1	12,84	245,0	4,368	44,54	371,9	65,11
	4,0	13,3	16,96	317,5	4,327	57,72	484,0	83,72
	5,0	16,5	21,00	385,6	4,285	70,12	590,3	100,90
	6,0	19,6	24,96	449,6	4,244	81,74	691,0	116,80
	7,0	22,6	28,84	509,4	4,203	92,61	786,2	131,40
	8,0	25,6	32,64	565,1	4,161	102,80	876,0	144,80
	9,0	28,5	36,36	617,0	4,119	112,20	960,5	157,10
	10,0	31,4	40,00	665,1	4,078	120,90	1040,0	168,30
	11,0	34,2	43,56	709,6	4,036	129,00	1114,0	178,40
	12,0	36,9	47,04	750,5	3,994	136,50	1183,0	187,60
	13,0	39,6	50,44	788,0	3,953	143,30	1247,0	195,90
120	3,0	11,0	14,04	320,3	4,776	53,38	485,7	78,19
	4,0	14,6	18,56	416,1	4,735	69,35	633,4	100,80
	5,0	17,8	22,70	498,0	4,680	83,00	777,0	122,00
	6,0	21,2	27,00	579,0	4,630	96,60	911,0	141,00
	6,3	22,2	28,20	603,0	4,620	100,00	950,0	147,00
	7,0	24,8	31,64	672,7	4,611	112,10	1036,0	159,70
	8,0	27,6	35,20	726,0	4,550	121,00	1160,0	176,00
	9,0	31,4	39,96	819,3	4,528	136,50	1271,0	192,10
	10,0	33,7	42,90	852,0	4,460	142,00	1382,0	206,00
	11,0	37,6	47,96	947,5	4,445	157,90	1482,0	219,60
	12,0	39,5	50,30	958,0	4,360	160,00	1578,0	230,00
	12,5	40,9	52,10	982,0	4,340	164,00	1623,0	236,00
130	3,0	12,0	15,24	409,6	5,184	63,02	620,7	92,47
	4,0	15,8	20,16	533,3	5,143	82,04	810,9	119,60
	5,0	19,6	25,00	650,8	5,102	100,10	992,9	144,90
	6,0	23,4	29,76	762,2	5,061	117,30	1167,0	168,70
	7,0	27,0	34,44	867,7	5,019	133,50	1333,0	190,80
	8,0	30,6	39,04	967,4	4,978	148,80	1492,0	211,50
	9,0	34,2	43,56	1061,0	4,936	163,30	1643,0	230,70
	10,0	37,7	48,00	1150,0	4,895	176,90	1786,0	248,60
	11,0	41,1	52,36	1233,0	4,853	189,70	1922,0	265,10
	12,0	44,5	56,64	1311,0	4,812	201,70	2051,0	280,40



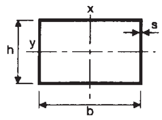
External sides dimension b mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion I cm⁴	Radius of inertia i cm	Resistance module W cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
140	4,0	17,1	21,76	670,6	5,552	95,80	1019	139,9
	5,0	21,0	26,70	807,0	5,500	115,00	1253	170,0
	6,0	24,9	31,80	944,0	5,450	135,00	1475	198,0
	6,3	26,1	33,30	984,0	5,440	141,00	1540	206,0
	7,0	29,2	37,24	1097,0	5,428	156,70	1683	224,8
	8,0	32,6	41,60	1195,0	5,360	171,00	1892	249,0
	9,0	37,0	47,16	1347,0	5,345	192,50	2080	272,9
	10,0	40,0	50,90	1416,0	5,270	202,00	2272	294,0
	11,0	44,6	56,76	1572,0	5,262	224,50	2443	315,0
	12,0	47,0	59,90	1609,0	5,180	230,00	2616	333,0
	12,5	48,7	62,10	1653,0	5,160	236,00	2696	342,0
	14,0	55,4	69,60	1822,0	5,116	260,30	2924	367,0
150	4,0	17,9	22,87	803,2	5,927	107,10	1268	161,6
	5,0	22,6	28,70	1002,0	5,900	134,00	1550	197,0
	6,0	26,8	34,20	1174,0	5,860	156,00	1828	230,0
	6,3	28,1	35,80	1223,0	5,850	163,00	1909	240,0
	8,0	35,1	44,80	1491,0	5,770	199,00	2351	291,0
	10,0	43,1	54,90	1773,0	5,680	236,00	2832	344,0
	11,0	45,1	57,42	1781,0	5,570	237,50	3061	365,6
	12,0	50,8	64,70	2023,0	5,590	270,00	3272	391,0
	12,5	52,7	67,10	2080,0	5,570	277,00	3375	402,0
	14,0	58,1	74,10	2241,0	5,500	299,00	3669	432,0
	16,0	65,2	83,00	2430,0	5,410	324,00	4026	467,0
160	5,0	23,7	30,23	1194,0	6,285	149,30	1901	225,6
	6,0	28,7	36,60	1437,0	6,270	180,00	2233	264,0
	6,3	30,1	38,30	1499,0	6,260	187,00	2333	275,0
	8,0	37,6	48,00	1831,0	6,180	229,00	2880	335,0
	10,0	46,3	58,90	2186,0	6,090	273,00	3478	398,0
	12,0	54,6	69,50	2502,0	6,000	313,00	4028	454,0
	12,5	56,6	72,10	2576,0	5,980	322,00	4158	467,0
	14,0	62,5	79,70	2783,0	5,910	348,00	4531	503,0
	16,0	70,2	89,40	3028,0	5,820	379,00	4988	546,0
180	5,0	26,9	34,23	1726,0	7,102	191,80	2731	289,7
	6,0	32,5	41,40	2077,0	7,090	231,00	3215	340,0
	6,3	34,0	43,30	2168,0	7,070	241,00	3361	355,0
	8,0	42,7	54,40	2661,0	7,000	296,00	4162	434,0
	10,0	52,5	66,90	3193,0	6,910	355,00	5048	518,0
	12,0	62,1	79,10	3677,0	6,820	409,00	5873	595,0
	12,5	64,4	82,10	3790,0	6,800	421,00	6070	613,0
	14,0	71,3	90,90	4113,0	6,730	457,00	6638	663,0
	16,0	80,2	102,00	4504,0	6,640	500,00	7343	724,0



External sides dimension b mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion I cm⁴	Radius of inertia i cm	Resistance module W cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
200	5,0	30,0	38,23	2397	7,919	239,7	3772	361,7
	6,0	36,2	46,20	2883	7,900	288,0	4449	426,0
	6,3	38,0	48,40	3011	7,890	301,0	4653	444,0
	8,0	47,7	60,80	3709	7,810	371,0	5778	545,0
	10,0	58,8	74,90	4471	7,720	447,0	7031	655,0
	12,0	69,6	88,70	5171	7,640	517,0	8208	754,0
	12,5	72,3	92,10	5336	7,610	534,0	8491	778,0
	14,0	80,1	102,00	5811	7,550	581,0	9311	845,0
	16,0	90,3	115,00	6394	7,460	639,0	10340	927,0
220	5,0	33,1	42,23	3222	8,736	292,9	5048	441,7
	6,0	40,0	51,00	3875	8,720	352,0	5963	521,0
	6,3	41,9	53,40	4049	8,710	368,0	6240	544,0
	8,0	52,7	67,20	5002	8,630	455,0	7765	669,0
	10,0	65,1	82,90	6050	8,540	550,0	9473	807,0
	12,0	77,2	98,30	7023	8,450	638,0	11091	933,0
	12,5	80,1	102,00	7254	8,430	659,0	11481	963,0
	14,0	88,9	113,00	7922	8,360	720,0	12617	1049,0
	16,0	100,0	128,00	8749	8,270	795,0	14054	1156,0
250	5,0	37,9	48,23	4785	9,961	382,8	7458	576,7
	6,0	45,7	58,20	5752	9,940	460,0	8825	681,0
	6,3	47,9	61,00	6014	9,930	481,0	9238	712,0
	8,0	60,3	76,80	7455	9,860	596,0	11525	880,0
	10,0	74,5	94,90	9055	9,770	724,0	14106	1065,0
	12,0	88,5	113,00	10556	9,680	844,0	16567	1237,0
	12,5	91,9	117,00	10915	9,660	873,0	17164	1279,0
	14,0	102,0	130,00	11959	9,590	957,0	18911	1398,0
	16,0	115,0	147,00	13267	9,500	1061,0	21138	1546,0
260	6,0	47,0	59,85	6373	10,320	490,2	9991	739,2
	8,0	62,8	80,00	8423	10,300	648,0	13006	956,0
	10,0	77,7	98,90	10242	10,200	788,0	15932	1159,0
	12,0	92,2	117,00	11954	10,100	920,0	18729	1348,0
	12,5	95,8	122,00	12365	10,100	951,0	19409	1394,0
	14,0	106,0	136,00	13559	10,000	1043,0	21399	1525,0
	16,0	120,0	153,00	15061	9,910	1159,0	23942	1689,0
300	6,0	54,5	69,45	9922	11,950	661,5	15460	996,5
	8,0	72,8	92,80	13128	11,900	875,0	20194	1294,0
	10,0	90,2	115,00	16026	11,800	1068,0	24807	1575,0
	12,0	107,0	137,00	18777	11,700	1252,0	29249	1840,0
	12,5	112,0	142,00	19442	11,700	1296,0	30333	1904,0
	14,0	124,0	158,00	21384	11,600	1426,0	33520	2090,0
	16,0	141,0	179,00	23850	11,500	1590,0	37622	2325,0

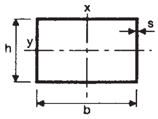


External sides dimension b mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm^2	Moment of inertia during flexion I cm^4	Radius of inertia i cm	Resistance module W cm^3	Moment of inertia during torsion J cm^4	Torsion module C cm^3
350	6,0	63,9	81,45	15950	13,99	911,5	24730	1372
	8,0	85,4	109,00	21129	13,90	1207,0	32384	1789
	10,0	106,0	135,00	25884	13,90	1479,0	39886	2185
	12,0	126,0	161,00	30435	13,80	1739,0	47154	2563
	12,5	131,0	167,00	31541	13,70	1802,0	48934	2654
	14,0	146,0	186,00	34787	13,70	1988,0	54188	2922
	16,0	166,0	211,00	38942	13,60	2225,0	60990	3264
400	8,0	96,9	123,40	31357	15,93	1567,0	48873	2362
	10,0	122,0	155,00	39128	15,90	1956,0	60092	2895
	12,0	145,0	185,00	46130	15,80	2306,0	71181	3405
	12,5	151,0	192,00	47839	15,80	2392,0	73906	3530
	14,0	168,0	214,00	52867	15,70	2643,0	81964	3894
	16,0	191,0	243,00	59344	15,60	2967,0	92444	4362
	20,0	235,0	300,00	71535	15,40	3577,0	112489	5237

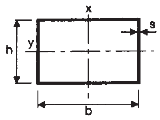


HOLLOW RECTANGULAR SECTION BARS MANUFACTURED USING HEAT PROCESSES

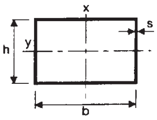
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion Ix cm⁴	Moment of inertia during flexion Iy cm⁴	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm³	Resistance module Wy cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
50 x 30	2,0	2,39	3,04	10,13	4,494	1,825	1,216	4,051	2,996	9,717	4,847
	2,5	2,89	3,68	11,80	5,220	1,790	1,190	4,730	3,480	11,700	5,730
	3,0	3,41	4,34	13,60	5,940	1,770	1,170	5,430	3,960	13,500	6,510
	4,0	4,39	5,59	16,50	7,080	1,720	1,130	6,600	4,720	16,600	7,770
	5,0	5,28	6,73	18,70	7,890	1,970	1,080	7,490	5,260	19,000	8,670
	6,0	6,41	8,16	22,25	9,008	1,651	1,051	8,901	6,005	20,970	9,399
60 x 30	3,0	3,96	5,04	22,38	7,220	2,107	1,197	7,459	4,813	17,420	7,991
	4,0	5,15	6,56	27,92	8,753	2,063	1,155	9,308	5,835	21,520	9,624
	5,0	6,28	8,00	32,60	9,922	2,019	1,114	10,870	6,615	24,830	10,850
	6,0	7,35	9,36	36,46	10,770	1,974	1,073	12,150	7,181	27,410	11,730
60 x 40	2,5	3,68	4,68	22,80	12,100	2,210	1,600	7,610	6,030	25,100	9,730
	3,0	4,35	5,54	26,50	13,900	2,180	1,580	8,820	6,950	29,200	11,200
	4,0	5,64	7,19	32,80	17,000	2,140	1,540	10,900	8,520	36,700	13,700
	5,0	6,85	8,73	38,10	19,500	2,090	1,500	12,700	9,770	43,000	15,700
	6,0	7,99	10,20	42,30	21,400	2,040	1,450	14,100	10,700	48,200	17,300
	6,3	8,31	10,60	43,50	21,900	2,020	1,440	14,500	11,000	49,500	17,600
	7,0	9,45	12,04	49,44	24,380	2,026	1,423	16,480	12,190	52,820	18,640
	8,0	10,60	13,44	52,83	25,680	1,983	1,382	17,610	12,840	56,340	19,520
	9,0	11,60	14,76	55,48	26,580	1,939	1,342	18,490	13,290	58,970	20,090
60 x 50	3,0	4,90	6,24	32,13	24,060	2,269	1,964	10,710	9,625	42,400	14,450
	4,0	6,41	8,16	40,49	30,150	2,228	1,922	13,500	12,060	53,710	17,900
	5,0	7,85	10,00	47,77	35,370	2,186	1,881	15,920	14,150	63,700	20,790
	6,0	9,23	11,76	54,03	39,790	2,143	1,839	18,010	15,910	72,410	23,170
	7,0	10,60	13,44	59,33	43,440	2,101	1,798	19,780	17,380	79,900	25,080
	8,0	11,80	15,04	63,74	46,400	2,059	1,756	21,250	18,560	86,210	26,580
	9,0	13,00	16,56	67,30	48,720	2,016	1,715	22,430	19,490	91,380	27,700
70 x 40	3,0	4,90	6,24	39,91	16,290	2,529	1,616	11,400	8,144	36,310	13,270
	4,0	6,41	8,16	50,43	20,220	2,486	1,574	14,410	10,110	45,710	16,350
	5,0	7,85	10,00	59,66	23,480	2,443	1,532	17,050	11,740	53,860	18,870
	6,0	9,23	11,76	67,67	26,140	2,399	1,491	19,330	13,070	60,810	20,890
	7,0	10,60	13,44	74,52	28,250	2,355	1,450	21,290	14,130	66,610	22,480
	8,0	11,80	15,04	80,27	29,860	2,310	1,409	22,940	14,930	71,310	23,660
	9,0	13,00	16,56	84,99	31,030	2,265	1,369	24,280	15,520	74,960	24,490
	10,0	14,10	18,00	88,73	31,810	2,220	1,329	25,350	15,900	77,610	24,990



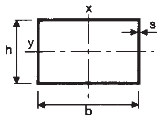
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion I_x cm⁴	Moment of inertia during flexion I_y cm⁴	Radius of inertia i_x cm	Radius of inertia i_y cm	Resistance module W_x cm³	Resistance module W_y cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
70 x 50	3,0	5,37	6,84	46,65	27,38	2,611	2,001	13,33	10,95	53,34	17,10
	4,0	7,03	8,96	59,15	34,39	2,569	1,959	16,90	13,76	67,77	21,29
	5,0	8,64	11,00	70,24	40,46	2,527	1,918	20,07	16,18	80,63	24,84
	6,0	10,20	12,96	79,99	45,63	2,484	1,876	22,86	18,25	91,98	27,81
	7,0	11,60	14,84	88,47	49,97	2,442	1,835	25,28	19,99	101,90	30,25
	8,0	13,10	16,64	95,73	53,54	2,399	1,794	27,35	21,42	110,30	32,22
	9,0	14,40	18,36	101,90	56,40	2,355	1,753	29,10	22,56	117,50	33,76
	10,0	15,70	20,00	106,90	58,62	2,312	1,712	30,54	23,45	123,30	34,90
80 x 40	3,0	5,29	6,74	54,20	18,00	2,840	1,630	13,60	9,00	43,80	15,30
	4,0	6,90	8,79	68,20	22,20	2,790	1,590	17,10	11,10	55,20	18,90
	5,0	8,42	10,70	80,30	25,70	2,740	1,550	20,10	12,90	65,10	21,90
	6,0	9,87	12,60	90,50	28,50	2,680	1,500	22,60	14,20	73,40	24,20
	6,3	10,30	13,10	93,30	29,20	2,670	1,490	23,30	14,60	75,60	24,80
	7,0	11,60	14,84	106,30	32,12	2,677	1,471	26,58	16,06	80,73	26,32
	8,0	12,50	16,00	106,00	32,10	2,580	1,420	26,50	16,10	85,80	27,40
	9,0	14,40	18,36	122,80	35,48	2,586	1,390	30,70	17,74	91,33	28,89
	10,0	15,70	20,00	129,00	36,47	2,540	1,350	32,26	18,24	94,85	29,61
80 x 50	3,0	5,84	7,44	64,58	30,70	2,946	2,031	16,14	12,28	64,66	19,75
	4,0	7,66	9,76	82,29	38,64	2,904	1,990	20,57	15,46	82,32	24,67
	5,0	9,42	12,00	98,22	45,54	2,861	1,948	24,55	18,22	98,16	28,88
	6,0	11,10	14,16	112,40	51,47	2,818	1,907	28,11	20,59	112,20	32,46
	7,0	12,70	16,24	125,00	56,50	2,775	1,865	31,26	22,60	124,60	35,44
	8,0	14,30	18,24	136,10	60,68	2,731	1,824	34,01	24,27	135,30	37,89
	9,0	15,80	20,16	145,60	64,09	2,687	1,783	36,40	25,64	144,40	39,85
	10,0	17,30	22,00	153,70	66,78	2,643	1,742	38,43	26,71	152,00	41,36
	11,0	18,70	23,76	160,50	68,83	2,599	1,702	40,12	27,53	158,20	42,46
80 x 60	3,0	6,31	8,04	73,47	46,77	3,023	2,412	18,37	15,59	87,87	24,18
	4,0	8,29	10,56	93,85	59,34	2,981	2,370	23,46	19,78	112,50	30,42
	5,0	10,20	13,00	112,30	70,52	2,939	2,329	28,08	23,51	135,00	35,86
	6,0	12,10	15,36	128,90	80,38	2,897	2,288	32,23	26,79	155,30	40,58
	7,0	13,80	17,64	143,70	89,00	2,855	2,246	35,93	29,67	173,60	44,64
	8,0	15,60	19,84	156,90	96,44	2,812	2,205	39,22	32,15	189,90	48,08
	9,0	17,20	21,96	168,40	102,80	2,769	2,163	42,10	34,26	204,20	50,96
	10,0	18,80	24,00	178,40	108,10	2,726	2,122	44,59	36,03	216,70	53,31
	11,0	20,40	25,96	186,90	112,40	2,683	2,081	46,72	37,48	227,30	55,18



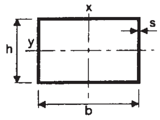
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion Ix cm⁴	Moment of inertia during flexion Iy cm⁴	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm³	Resistance module Wy cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
90 x 50	3,0	6,24	7,94	84,40	33,50	3,260	2,050	18,80	13,40	76,50	22,40
	4,0	8,15	10,40	107,00	41,90	3,210	2,010	23,80	16,80	97,50	28,00
	5,0	10,00	12,70	127,00	49,20	3,160	1,970	28,30	19,70	116,00	32,90
	6,0	11,80	15,00	145,00	55,40	3,110	1,920	32,20	22,10	133,00	37,00
	6,3	12,30	15,60	150,00	57,00	3,100	1,910	33,30	22,80	138,00	38,10
	7,0	13,80	17,64	169,70	63,03	3,102	1,890	37,71	25,21	147,90	40,63
	8,0	15,00	19,20	174,00	64,60	3,010	1,840	38,60	25,80	160,00	43,20
	9,0	17,20	21,96	199,40	71,78	3,013	1,808	44,31	28,71	172,10	45,95
	10,0	18,80	24,00	211,50	74,95	2,969	1,767	47,00	29,98	181,50	47,83
	11,0	20,40	25,96	221,90	77,42	2,924	1,727	49,32	30,97	189,30	49,25
90 x 70	3,0	7,25	9,24	108,90	73,60	3,434	2,822	24,21	21,03	134,50	32,47
	4,0	9,55	12,16	139,90	94,04	3,392	2,781	31,09	26,87	173,30	41,15
	5,0	11,80	15,00	168,40	112,60	3,350	2,740	37,41	32,16	209,10	48,89
	6,0	13,90	17,76	194,40	129,30	3,308	2,698	43,19	36,94	242,10	55,75
	7,0	16,00	20,44	218,00	144,30	3,266	2,657	48,45	41,22	272,30	61,80
	8,0	18,10	23,04	239,50	157,60	3,224	2,615	53,21	45,02	299,80	67,10
	9,0	20,10	25,56	258,70	169,30	3,181	2,574	57,49	48,38	324,70	71,70
	10,0	22,00	28,00	275,80	179,60	3,139	2,532	61,30	51,30	347,00	75,64
	11,0	23,80	30,36	291,00	188,40	3,096	2,491	64,67	53,83	366,80	78,97
100 x 40	3,0	6,31	8,04	97,78	22,46	3,487	1,671	19,56	11,23	58,79	19,43
	4,0	8,29	10,56	125,20	28,02	3,443	1,629	25,03	14,01	74,28	24,14
	5,0	10,20	13,00	150,10	32,73	3,398	1,587	30,02	16,37	87,86	28,09
	6,0	12,10	15,36	172,60	36,65	3,352	1,545	34,53	18,33	99,62	31,36
	7,0	13,80	17,64	192,90	39,86	3,307	1,503	38,58	19,93	109,60	34,02
	8,0	15,60	19,84	210,90	42,41	3,260	1,462	42,18	21,20	118,00	36,13
	9,0	17,20	21,96	226,80	44,37	3,214	1,421	45,36	22,18	124,80	37,73
	10,0	18,80	24,00	240,70	45,81	3,167	1,382	48,13	22,90	130,10	38,88
100 x 50	3,0	6,71	8,54	110,00	36,80	3,580	2,080	21,90	14,70	88,40	25,00
	4,0	8,78	11,20	140,00	46,20	3,530	2,030	27,90	18,50	113,00	31,40
	5,0	10,80	13,70	167,00	54,30	3,480	1,990	33,30	21,70	135,00	36,90
	6,0	12,70	16,20	190,00	61,20	3,430	1,950	38,10	24,50	154,00	41,60
	6,3	13,30	16,90	197,00	63,00	3,420	1,930	39,40	25,20	160,00	42,90
	8,0	16,30	20,80	230,00	71,70	3,330	1,860	46,00	28,70	186,00	48,90
	9,0	18,70	23,76	264,20	79,46	3,335	1,829	52,84	31,78	200,20	52,06
	10,0	20,40	26,00	281,30	83,12	3,289	1,788	56,26	33,25	211,50	54,31
	11,0	22,10	28,16	296,30	86,00	3,244	1,748	59,27	34,40	220,90	56,07



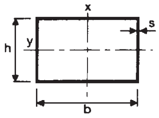
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion Ix cm⁴	Moment of inertia during flexion Iy cm⁴	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm³	Resistance module Wy cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
100 x 60	3,0	7,18	9,14	124,0	55,7	3,680	2,470	24,70	18,60	121,00	30,70
	4,0	9,41	12,00	158,0	70,5	3,630	2,430	31,60	23,50	156,00	38,70
	5,0	11,60	14,70	189,0	83,6	3,580	2,380	37,80	27,90	188,00	45,90
	6,0	13,60	17,40	217,0	95,0	3,530	2,340	43,40	31,70	216,00	52,10
	6,3	14,20	18,10	225,0	98,1	3,520	2,330	45,00	32,70	224,00	53,80
	8,0	17,50	22,40	264,0	113,0	3,440	2,250	52,80	37,80	265,00	62,20
	9,0	20,10	25,56	301,6	126,4	3,435	2,224	60,32	42,14	286,70	66,60
	10,0	22,00	28,00	322,0	133,4	3,391	2,183	64,40	44,47	305,30	70,04
	11,0	23,80	30,36	340,1	139,3	3,347	2,142	68,02	46,43	321,50	72,89
100 x 70	3,0	7,72	9,84	140,1	80,34	3,774	2,857	28,03	22,95	156,90	36,31
	4,0	10,20	12,96	180,5	102,8	3,732	2,816	36,10	29,36	202,30	46,12
	5,0	12,60	16,00	217,8	123,2	3,690	2,774	43,57	35,19	244,50	54,92
	6,0	14,90	18,96	252,3	141,6	3,648	2,733	50,45	40,46	283,40	62,77
	7,0	17,10	21,84	283,9	158,2	3,605	2,691	56,77	45,20	319,30	69,73
	8,0	19,30	24,64	312,7	173,0	3,563	2,650	62,55	49,44	352,00	75,88
	9,0	21,50	27,36	339,0	186,2	3,520	2,609	67,79	53,20	381,90	81,26
	10,0	23,60	30,00	362,7	197,7	3,477	2,567	72,53	56,50	408,80	85,93
	11,0	25,60	32,56	383,9	207,8	3,434	2,526	76,78	59,36	432,90	89,92
100 x 80	3,0	8,20	10,44	154,3	109,1	3,844	3,232	30,85	27,27	195,20	41,95
	4,0	10,80	13,76	198,9	140,1	3,802	3,191	39,79	35,03	252,40	53,47
	5,0	13,30	17,00	240,4	168,6	3,761	3,150	48,08	42,16	305,90	63,90
	6,0	15,80	20,16	278,8	194,8	3,719	3,108	55,76	48,69	355,70	73,31
	7,0	18,20	23,24	314,2	218,6	3,677	3,067	62,84	54,64	402,00	81,75
	8,0	20,60	26,24	346,7	240,2	3,635	3,025	69,33	60,04	444,80	89,30
	9,0	22,90	29,16	376,4	259,6	3,593	2,984	75,27	64,90	484,10	96,00
	10,0	25,10	32,00	403,3	277,0	3,550	2,942	80,66	69,26	520,20	101,90
	11,0	27,30	34,76	427,7	292,5	3,508	2,901	85,54	73,13	552,90	107,10
	12,0	29,40	37,44	449,6	306,2	3,465	2,860	89,91	76,54	582,50	111,50
120 x 40	3,0	7,25	9,24	156,0	26,58	4,108	1,696	25,99	13,29	74,26	23,55
	4,0	9,55	12,16	200,7	33,23	4,063	1,653	33,45	16,61	93,92	29,34
	5,0	11,80	15,00	242,0	38,90	4,017	1,610	40,34	19,45	111,20	34,25
	6,0	13,90	17,76	280,0	43,66	3,971	1,568	46,67	21,83	126,30	38,36
	7,0	16,00	20,44	314,7	47,59	3,924	1,526	52,45	23,80	139,10	41,74
	8,0	18,10	23,04	346,3	50,77	3,877	1,484	57,71	25,38	150,00	44,46
	9,0	20,10	25,56	374,8	53,26	3,829	1,444	62,46	26,63	158,90	46,59
	10,0	22,00	28,00	400,3	55,14	3,781	1,403	66,71	27,57	166,00	48,17



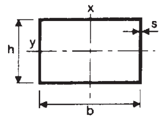
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm^2	Moment of inertia during flexion Ix cm^4	Moment of inertia during flexion Iy cm^4	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm^3	Resistance module Wy cm^3	Moment of inertia during torsion J cm^4	Torsion module C cm^3
120 x 50	3,0	7,72	9,84	176,5	43,97	4,235	2,114	29,42	17,59	112,4	30,36
	4,0	10,20	12,96	227,6	55,61	4,191	2,071	37,94	22,24	143,6	38,22
	5,0	12,60	16,00	275,1	65,87	4,147	2,029	45,85	26,35	171,9	45,11
	6,0	14,90	18,96	319,0	74,85	4,102	1,987	53,17	29,94	197,3	51,10
	7,0	17,10	21,84	359,5	82,61	4,057	1,945	59,91	33,05	220,0	56,25
	8,0	19,30	24,64	396,5	89,25	4,012	1,903	66,09	35,70	240,1	60,63
	9,0	21,50	27,36	430,3	94,83	3,966	1,862	71,72	37,93	257,6	64,29
	10,0	23,60	30,00	460,9	99,45	3,920	1,821	76,82	39,78	272,7	67,31
	11,0	25,60	32,56	488,5	103,20	3,873	1,780	81,42	41,27	285,4	69,72
120 x 60	3,0	8,20	10,44	197,0	66,28	4,344	2,520	32,84	22,09	155,6	37,18
	4,0	10,70	13,60	249,0	83,10	4,280	2,470	41,50	27,70	201,0	47,10
	5,0	13,10	16,70	299,0	98,80	4,230	2,430	49,90	32,90	242,0	56,00
	6,0	15,50	19,80	345,0	113,00	4,180	2,390	57,50	37,50	279,0	63,80
	6,3	16,20	20,70	358,0	116,00	4,160	2,370	59,70	38,80	290,0	65,90
	7,0	18,20	23,24	404,2	128,60	4,170	2,352	67,37	42,85	313,1	70,89
	8,0	20,10	25,60	425,0	135,00	4,080	2,300	70,80	45,00	344,0	76,60
	9,0	22,90	29,16	485,9	150,10	4,082	2,269	80,98	50,03	372,3	82,28
	10,0	24,30	30,90	488,0	152,00	3,970	2,210	81,40	50,50	396,0	86,10
	11,0	27,30	34,76	554,1	166,20	3,992	2,186	92,34	55,38	419,4	90,67
120 x 70	3,0	8,67	11,04	217,6	93,81	4,439	2,915	36,26	26,80	203,2	44,00
	4,0	11,40	14,56	281,5	120,20	4,397	2,873	46,92	34,35	262,4	56,08
	5,0	14,10	18,00	341,3	144,30	4,354	2,832	56,88	41,24	317,6	66,99
	6,0	16,80	21,36	397,1	166,30	4,312	2,790	66,18	47,50	368,9	76,81
	7,0	19,30	24,64	449,0	186,10	4,269	2,748	74,83	53,17	416,4	85,62
	8,0	21,90	27,84	497,0	204,00	4,225	2,707	82,84	58,28	460,0	93,47
	9,0	24,30	30,96	541,4	219,90	4,182	2,665	90,24	62,83	500,1	100,40
	10,0	26,70	34,00	582,3	234,10	4,138	2,624	97,05	66,88	536,5	106,50
	11,0	29,00	36,96	619,6	246,50	4,094	2,583	103,30	70,43	569,5	111,90
120 x 80	3,0	9,14	11,64	238,1	126,90	4,523	3,301	39,69	31,72	254,3	50,84
	4,0	11,90	15,20	303,0	161,00	4,460	3,250	50,40	40,20	330,0	65,00
	5,0	14,70	18,70	365,0	193,00	4,420	3,210	60,90	48,20	401,0	77,90
	6,0	17,40	22,20	423,0	222,00	4,370	3,170	70,60	55,60	468,0	89,60
	6,3	18,20	23,20	440,0	230,00	4,360	3,150	73,30	57,60	487,0	92,90
	7,0	20,40	26,04	493,7	256,00	4,354	3,135	82,28	64,00	528,0	100,40
	8,0	22,60	28,80	525,0	273,00	4,270	3,080	87,50	68,10	587,0	110,00
	9,0	25,70	32,76	597,0	305,20	4,269	3,052	99,50	76,31	638,7	118,70
	10,0	27,40	34,90	609,0	313,00	4,180	2,990	102,00	78,10	688,0	126,00
	11,0	30,70	39,16	685,2	345,30	4,183	2,970	114,20	86,33	733,0	133,30
	12,0	33,20	42,24	723,9	362,20	4,140	2,928	120,60	90,55	774,2	139,30



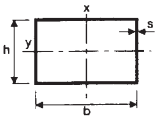
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm^2	Moment of inertia during flexion Ix cm^4	Moment of inertia during flexion Iy cm^4	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm^3	Resistance module Wy cm^3	Moment of inertia during torsion J cm^4	Torsion module C cm^3
120 x 100	3,0	10,10	12,84	279,2	210,70	4,663	4,051	46,53	42,14	365,40	64,51
	4,0	13,30	16,96	362,3	272,70	4,622	4,010	60,38	54,54	475,40	82,92
	5,0	16,50	21,00	440,5	330,80	4,580	3,969	73,42	66,15	579,70	99,93
	6,0	19,60	24,96	514,1	385,00	4,539	3,927	85,69	77,00	678,30	115,60
	7,0	22,60	28,84	583,2	435,50	4,497	3,886	97,20	87,10	771,50	130,00
	8,0	25,60	32,64	647,8	482,40	4,455	3,845	108,00	96,49	859,30	143,20
	9,0	28,50	36,36	708,1	525,90	4,413	3,803	118,00	105,20	941,80	155,30
	10,0	31,40	40,00	764,3	566,00	4,371	3,762	127,40	113,20	1019,00	166,30
	11,0	34,20	43,56	816,3	602,80	4,329	3,720	136,10	120,60	1091,00	176,30
	12,0	36,90	47,04	864,4	636,60	4,287	3,679	144,10	127,30	1159,00	185,30
140 x 60	3,0	9,14	11,64	288,9	76,04	4,982	2,556	41,28	25,35	191,10	43,68
	4,0	12,10	15,36	374,6	97,03	4,938	2,513	53,52	32,34	248,00	55,51
	5,0	14,90	19,00	455,2	116,00	4,894	2,471	65,02	38,67	296,70	66,13
	6,0	17,70	22,56	530,7	133,10	4,850	2,429	75,81	44,36	343,30	75,62
	7,0	20,40	26,04	601,4	148,30	4,806	2,387	85,91	49,44	386,00	84,04
	8,0	23,10	29,44	667,3	161,80	4,761	2,345	95,32	53,95	424,80	91,48
	9,0	25,70	32,76	728,5	173,70	4,716	2,303	104,10	57,91	459,90	97,99
	10,0	28,30	36,00	785,2	184,10	4,670	2,261	112,20	61,36	491,40	103,60
	11,0	30,70	39,16	837,5	193,00	4,625	2,220	119,60	64,34	519,40	108,50
140 x 70	3,0	9,61	12,24	317,1	107,30	5,090	2,961	45,30	30,65	250,90	51,70
	4,0	12,70	16,16	411,6	137,70	5,047	2,919	58,80	39,33	324,50	66,03
	5,0	15,70	20,00	500,7	165,50	5,004	2,877	71,53	47,28	393,20	79,06
	6,0	18,70	23,76	584,6	190,90	4,960	2,835	83,52	54,55	457,10	90,86
	7,0	21,50	27,44	663,3	214,00	4,917	2,793	94,76	61,14	516,50	101,50
	8,0	24,40	31,04	737,0	234,90	4,873	2,751	105,30	67,11	571,40	111,10
	9,0	27,10	34,56	805,9	253,60	4,829	2,709	115,10	72,47	621,90	119,60
	10,0	29,80	38,00	869,9	270,40	4,785	2,668	124,30	77,26	668,10	127,20
	11,0	32,50	41,36	929,3	285,20	4,740	2,626	132,80	81,50	710,20	133,90
140 x 80	3,0	10,10	12,84	345,3	144,70	5,185	3,357	49,32	36,16	315,70	59,73
	4,0	13,20	16,80	441,0	184,00	5,12	3,310	62,90	46,00	411,00	76,50
	5,0	16,30	20,70	534,0	221,00	5,08	3,270	76,30	55,30	499,00	91,90
	6,0	19,30	24,60	621,0	255,00	5,03	3,220	88,70	63,80	583,00	106,00
	6,3	20,20	25,70	646,0	265,00	5,01	3,210	92,30	66,20	607,00	110,00
	7,0	22,60	28,84	725,3	293,40	5,015	3,190	103,60	73,35	658,70	119,00
	8,0	25,10	32,00	776,0	314,00	4,93	3,140	111,00	78,50	733,00	130,00
	9,0	28,50	36,36	883,2	350,80	4,929	3,106	126,20	87,71	799,00	141,40
	10,0	30,60	38,90	908,0	362,00	4,83	3,050	130,00	90,50	862,00	150,00
	11,0	34,20	43,56	1021,0	398,20	4,841	3,023	145,90	99,54	919,70	159,50



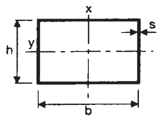
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion Ix cm⁴	Moment of inertia during flexion Iy cm⁴	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm³	Resistance module Wy cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
140 x 120	3,0	12,00	15,24	457,9	361,30	5,481	4,869	65,41	60,22	613,0	91,87
	4,0	15,80	20,16	596,6	470,00	5,440	4,828	85,23	78,33	800,7	118,80
	5,0	19,60	25,00	728,7	572,90	5,399	4,787	104,10	95,48	980,3	144,00
	6,0	23,40	29,76	854,1	670,20	5,357	4,746	122,00	111,70	1152,0	167,50
	7,0	27,00	34,44	973,2	762,20	5,316	7,704	139,00	127,00	1316,0	189,50
	8,0	30,60	39,04	1086,0	848,90	5,274	4,663	155,10	141,50	1472,0	209,90
	9,0	34,20	43,56	1193,0	930,40	5,232	4,622	170,40	155,10	1620,0	229,00
	10,0	37,70	48,00	1293,0	1007,00	5,191	4,580	184,70	167,80	1762,0	246,60
	11,0	41,10	52,36	1388,0	1079,00	5,149	4,539	198,30	179,80	1895,0	263,00
	12,0	44,50	56,64	1477,0	1146,00	5,107	4,497	211,00	190,90	2022,0	278,10
150 x 50	3,0	9,14	11,64	311,1	53,92	5,169	2,152	41,47	21,57	149,6	38,31
	4,0	12,10	15,36	403,3	68,34	5,124	2,109	53,77	27,33	191,4	48,40
	5,0	14,90	19,00	490,1	81,12	5,079	2,066	65,34	32,45	229,3	57,30
	6,0	17,70	22,56	571,4	92,38	5,033	2,024	76,19	36,95	263,5	65,10
	7,0	20,40	26,04	647,5	102,20	4,987	1,981	86,33	40,88	294,2	71,88
	8,0	23,10	29,44	718,4	110,70	4,940	1,939	95,79	44,27	321,4	77,72
	9,0	25,70	32,76	784,4	117,90	4,893	1,897	104,60	47,16	345,4	82,68
	10,0	28,30	36,00	845,4	123,90	4,846	1,856	112,70	49,58	366,2	86,84
150 x 60	3,0	9,61	12,24	343,5	80,91	5,297	2,571	45,80	26,97	209,1	46,93
	4,0	12,70	16,16	445,9	103,30	5,253	2,529	59,46	34,44	269,3	59,70
	5,0	15,70	20,00	542,6	123,60	5,209	2,486	72,35	41,20	324,9	71,18
	6,0	18,70	23,76	633,7	141,90	5,164	2,444	84,49	47,29	376,0	81,46
	7,0	21,50	27,44	719,1	158,20	5,119	2,401	95,88	52,74	422,9	90,62
	8,0	24,40	31,04	799,2	172,70	5,074	2,359	106,60	57,58	465,7	98,73
	9,0	27,10	34,56	873,9	185,60	5,029	2,317	116,50	61,85	504,3	105,90
	10,0	29,80	38,00	943,5	196,80	4,983	2,275	125,80	65,59	539,1	112,10
	11,0	32,50	41,36	1008,0	206,40	4,937	2,234	134,40	68,81	570,1	117,40
150 x 70	3,0	10,10	12,84	375,9	114,00	5,411	2,980	50,12	32,58	275,2	55,55
	4,0	13,30	16,96	488,6	146,40	5,367	2,938	65,15	41,82	356,0	71,01
	5,0	16,50	21,00	595,2	176,10	5,324	2,896	79,36	50,31	431,6	85,10
	6,0	19,60	24,96	695,9	203,20	5,280	2,853	92,79	58,07	502,0	97,89
	7,0	22,60	28,84	790,8	228,00	5,236	2,811	105,40	65,13	567,4	109,50
	8,0	25,60	32,64	879,9	250,30	5,192	2,769	117,30	71,53	628,0	119,90
	9,0	28,50	36,36	963,5	270,50	5,148	2,728	128,50	77,29	683,8	129,20
	10,0	31,40	40,00	1042,0	288,60	5,103	2,686	138,90	82,45	735,0	137,60
	11,0	34,20	43,56	1115,0	304,60	5,058	2,644	148,60	87,03	781,7	144,90



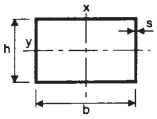
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion I_x cm⁴	Moment of inertia during flexion I_y cm⁴	Radius of inertia i_x cm	Radius of inertia i_y cm	Resistance module W_x cm³	Resistance module W_y cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
150 x 75	3,0	10,3	13,14	392,1	133,00	5,463	3,181	52,28	35,46	310,5	59,86
	4,0	13,6	17,36	509,9	171,10	5,420	3,139	67,99	45,62	402,4	76,68
	5,0	16,9	21,50	621,5	206,20	5,377	3,097	82,87	54,99	488,6	92,07
	6,0	20,1	25,56	727,0	238,60	5,333	3,055	96,94	63,62	569,4	106,10
	7,0	23,2	29,54	826,6	268,20	5,290	3,013	110,20	71,52	644,9	118,90
	8,0	26,3	33,44	920,3	295,20	5,246	2,971	122,70	78,72	715,1	130,50
	9,0	29,2	37,26	1008,0	319,80	5,202	2,929	134,40	85,27	780,3	141,00
	10,0	32,2	41,00	1091,0	341,90	5,158	2,888	145,40	91,18	840,5	150,40
	11,0	35,1	44,66	1168,0	361,80	5,114	2,846	155,70	96,48	895,8	158,80
	12,0	37,9	48,24	1240,0	379,50	5,069	2,805	165,30	101,20	946,4	166,20
150 x 100	3,0	11,5	14,64	473,1	253,10	5,685	4,158	63,09	50,62	505,2	81,44
	4,0	15,1	19,20	607,0	324,00	5,630	4,110	81,00	64,80	660,0	105,00
	5,0	18,6	23,70	739,0	392,00	5,580	4,070	98,50	78,50	807,0	127,00
	6,0	22,1	28,20	862,0	456,00	5,530	4,020	115,00	91,20	946,0	147,00
	6,3	23,1	29,50	898,0	474,00	5,520	4,010	120,00	94,80	986,0	153,00
	7,0	25,9	33,04	1006,0	526,50	5,517	3,992	134,10	105,30	1075,0	166,30
	8,0	28,9	36,80	1087,0	569,00	5,440	3,940	145,00	114,00	1203,0	183,00
	9,0	32,8	41,76	1232,0	638,10	5,432	3,909	164,30	127,60	1318,0	200,00
	10,0	35,3	44,90	1282,0	665,00	5,340	3,850	171,00	133,00	1432,0	214,00
	11,0	39,4	50,16	1434,0	734,20	5,347	3,826	191,20	146,80	1534,0	228,50
	12,0	41,4	52,70	1450,0	745,00	5,250	3,760	193,00	149,00	1633,0	240,00
	12,5	42,8	54,60	1488,0	763,00	5,220	3,740	198,00	153,00	1679,0	246,00
160 x 60	3,0	10,1	12,84	404,1	85,79	5,610	2,585	50,52	28,60	227,3	50,18
	4,0	13,3	16,96	525,4	109,60	5,566	2,542	65,67	36,53	292,7	63,88
	5,0	16,5	21,00	640,1	131,20	5,521	2,499	80,01	43,73	353,2	76,23
	6,0	19,6	24,96	748,5	150,70	5,476	2,457	93,56	50,22	409,0	87,31
	7,0	22,6	28,84	850,6	168,10	5,431	2,414	106,30	56,04	460,1	97,20
	8,0	25,6	32,64	946,6	183,70	5,385	2,372	118,30	61,22	506,8	106,00
	9,0	28,5	36,36	1037,0	197,40	5,340	2,330	129,60	65,80	549,0	113,70
	10,0	31,4	40,00	1121,0	209,40	5,293	2,288	140,10	69,81	587,1	120,50
	11,0	34,2	43,56	1199,0	219,90	5,247	2,247	149,90	73,29	621,1	126,30



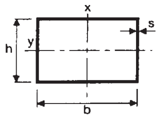
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion Ix cm⁴	Moment of inertia during flexion Iy cm⁴	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm³	Resistance module Wy cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
160 x 80	3,0	11,0	14,04	478,1	162,50	5,835	3,402	59,76	40,61	378,8	68,62
	4,0	14,4	18,40	612,0	207,00	5,770	3,350	76,50	51,70	493,0	88,10
	5,0	17,8	22,70	744,0	249,00	5,720	3,310	93,00	62,30	600,0	106,00
	6,0	21,2	27,00	868,0	288,00	5,670	3,270	108,00	72,00	701,0	122,00
	6,3	22,2	28,20	903,0	299,00	5,660	3,260	113,00	74,80	730,0	127,00
	7,0	24,8	31,64	1015,0	330,80	5,663	3,234	126,80	82,71	792,9	137,70
	8,0	27,6	35,20	1091,0	356,00	5,570	3,180	136,00	89,00	883,0	151,00
	9,0	31,4	39,96	1242,0	396,50	5,575	3,150	155,30	99,11	963,5	164,10
	10,0	33,7	42,90	1284,0	411,00	5,470	3,100	161,00	103,00	1041,0	175,00
	11,0	37,6	47,96	1444,0	451,00	5,487	3,066	180,50	112,70	1111,0	185,80
	12,0	39,5	50,30	1449,0	455,00	5,370	3,010	181,00	114,00	1175,0	194,00
	12,5	40,9	52,10	1485,0	465,00	5,340	2,990	186,00	116,00	1204,0	198,00
160 x 90	3,0	11,5	14,64	515,1	211,20	5,931	3,798	64,38	46,93	463,6	77,85
	4,0	15,2	19,36	671,4	273,10	5,889	3,756	83,93	60,70	603,4	100,30
	5,0	18,8	24,00	820,4	331,10	5,847	3,714	102,50	73,58	736,0	121,00
	6,0	22,4	28,56	962,0	385,20	5,804	3,673	120,30	85,60	861,6	140,30
	7,0	25,9	33,04	1097,0	435,60	5,761	3,631	137,10	96,79	980,4	158,00
	8,0	29,4	37,44	1224,0	482,30	5,718	3,589	153,00	107,20	1092,0	174,40
	9,0	32,8	41,76	1345,0	525,50	5,675	3,547	168,10	116,80	1198,0	189,50
	10,0	36,1	46,00	1459,0	565,30	5,632	3,506	182,40	125,60	1297,0	203,30
	11,0	39,4	50,16	1566,0	601,90	5,588	3,464	195,80	133,80	1390,0	215,80
	12,0	42,6	54,24	1667,0	635,40	5,544	3,423	208,40	141,20	1476,0	227,30
180 x 60	3,0	11,0	14,04	545,0	95,55	6,230	2,609	60,55	31,85	263,9	56,68
	4,0	14,6	18,56	710,0	122,20	6,185	2,566	78,89	40,72	340,0	72,25
	5,0	18,1	23,00	867,1	146,40	6,140	2,523	96,34	48,78	410,5	86,33
	6,0	21,5	27,36	1016,0	168,20	6,094	2,480	112,90	56,07	475,5	99,01
	7,0	24,8	31,64	1158,0	187,90	6,048	2,437	128,60	62,63	535,1	110,40
	8,0	28,1	35,84	1291,0	205,50	6,002	2,394	143,50	68,48	589,7	120,50
	9,0	31,4	39,96	1418,0	221,00	5,956	2,352	157,50	73,68	639,2	129,50
	10,0	34,5	44,00	1536,0	234,80	5,909	2,310	170,70	78,25	683,8	137,30
	11,0	37,6	47,96	1648,0	246,70	5,862	2,268	183,10	82,24	723,8	144,20
	12,0	40,7	51,84	1753,0	257,00	5,815	2,227	194,80	85,67	759,3	150,10
180 x 80	3,0	12,0	15,24	639,0	180,20	6,475	3,439	71,00	45,06	443,2	77,52
	4,0	15,8	20,16	834,0	232,60	6,432	3,397	92,66	58,15	575,7	99,68
	5,0	19,6	25,00	1020,0	281,30	6,388	3,354	113,40	70,33	700,9	120,20
	6,0	23,4	29,76	1198,0	326,50	6,344	3,312	133,10	81,62	818,8	139,00
	7,0	27,0	34,44	1367,0	368,20	6,300	3,270	151,90	92,06	929,7	156,40
	8,0	30,6	39,04	1528,0	406,70	6,256	3,228	169,80	101,70	1034,0	172,30
	9,0	34,2	43,56	1681,0	442,10	6,212	3,186	186,80	110,50	1131,0	186,90
	10,0	37,7	48,00	1826,0	474,40	6,167	3,144	202,90	118,60	1222,0	200,10
	11,0	41,1	52,36	1963,0	503,80	6,123	3,102	218,10	125,90	1306,0	212,10
	12,0	44,5	56,64	2092,0	530,40	6,078	3,060	232,50	132,60	1384,0	223,00



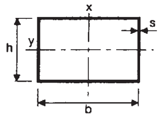
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion Ix cm⁴	Moment of inertia during flexion Iy cm⁴	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm³	Resistance module Wy cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
180 x 90	4,0	16,5	20,96	895,9	302,7	6,538	3,801	99,55	67,28	708,6	113,4
	5,0	20,4	26,00	1097,0	367,3	6,495	3,758	121,90	81,62	864,9	137,1
	6,0	24,3	30,96	1289,0	427,6	6,452	3,716	143,20	95,03	1013,0	159,1
	7,0	28,1	35,84	1472,0	483,9	6,409	3,674	163,50	107,50	1154,0	179,5
	8,0	31,9	40,64	1647,0	536,2	6,365	3,632	182,90	119,20	1286,0	198,4
	9,0	35,6	45,36	1813,0	584,8	6,321	3,591	201,40	130,00	1411,0	215,8
	10,0	39,3	50,00	1970,0	629,7	6,278	3,549	218,90	139,90	1529,0	231,8
	11,0	42,8	54,56	2120,0	671,0	6,234	3,507	235,60	149,10	1640,0	246,4
	12,0	46,3	59,04	2262,0	709,0	6,190	3,465	251,30	157,60	1743,0	259,8
180 x 100	4,0	16,9	21,60	945,0	379,0	6,610	4,190	105,00	75,90	852,0	127,0
	5,0	21,0	26,70	1153,0	460,0	6,570	4,150	128,00	92,00	1042,0	154,0
	6,0	24,9	31,80	1350,0	536,0	6,520	4,110	150,00	107,00	1224,0	179,0
	6,3	26,1	33,30	1407,0	557,0	6,500	4,090	156,00	111,00	1277,0	186,0
	7,0	29,2	37,24	1577,0	617,5	6,507	4,072	175,20	123,50	1393,0	202,6
	8,0	32,6	41,60	1713,0	671,0	6,420	4,020	190,00	134,00	1560,0	224,0
	9,0	37,0	47,16	1944,0	750,2	6,421	3,988	216,00	150,00	1711,0	244,7
	10,0	40,0	50,90	2036,0	787,0	6,320	3,930	226,00	157,00	1862,0	263,0
	11,0	44,6	56,76	2277,0	865,6	6,334	3,905	253,00	173,10	1997,0	280,9
	12,0	47,0	59,90	2320,0	886,0	6,220	3,850	258,00	177,00	2130,0	296,0
	12,5	48,7	62,10	2385,0	908,0	6,200	3,820	265,00	182,00	2191,0	303,0
	14,2	52,0	66,30	2390,0	921,0	6,000	3,730	265,00	184,00	2330,0	344,2
	16,0	57,1	72,80	2530,0	968,0	5,890	3,650	281,00	194,00	2480,0	387,8
180 x 120	4,0	17,9	22,87	1043,0	560,8	6,755	4,953	115,90	93,47	1163,0	154,5
	5,0	22,2	28,23	1267,0	679,3	6,699	4,906	140,80	113,20	1427,0	187,7
	6,0	26,3	33,45	1476,0	789,6	6,644	4,859	164,00	131,60	1681,0	218,9
	8,0	34,1	43,46	1853,0	986,5	6,530	4,764	205,90	164,40	2155,0	275,3
	10,0	41,5	52,91	2177,0	1153,0	6,415	4,669	241,90	192,20	2583,0	324,4
180 x 140	5,0	23,7	30,23	1420,0	966,6	6,854	5,655	157,80	138,10	1838,0	221,7
	6,0	28,1	35,85	1658,0	1127,0	6,801	5,607	184,20	161,00	2169,0	259,1
	8,0	36,6	46,66	2090,0	1417,0	6,693	5,510	232,30	202,40	2794,0	327,8
	10,0	44,7	56,91	2466,0	1667,0	6,583	5,413	274,00	238,20	3366,0	388,3



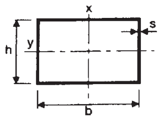
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion Ix cm⁴	Moment of inertia during flexion Iy cm⁴	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm³	Resistance module Wy cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
200 x 100	4,0	17,9	22,87	1191	408,7	7,218	4,228	119,1	81,74	987,5	141,7
	5,0	22,6	28,70	1495	505,0	7,210	4,190	149,0	101,00	1204,0	172,0
	6,0	26,8	34,20	1754	589,0	7,160	4,150	175,0	118,00	1414,0	200,0
	6,3	28,1	35,80	1829	613,0	7,150	4,140	183,0	123,00	1475,0	208,0
	8,0	35,1	44,80	2234	739,0	7,060	4,060	223,0	148,00	1804,0	251,0
	10,0	43,1	54,90	2664	869,0	6,960	3,980	266,0	174,00	2156,0	295,0
	11,0	45,1	57,42	2640	876,1	6,780	3,906	264,0	175,20	2314,0	312,0
	12,0	50,8	64,70	3047	979,0	6,860	3,890	305,0	196,00	2469,0	333,0
	12,5	52,7	67,10	3136	1004,0	6,840	3,870	314,0	201,00	2541,0	341,0
	14,0	58,1	74,10	3385	1072,0	6,760	3,800	338,0	214,00	2744,0	365,0
	16,0	65,2	83,00	3678	1147,0	6,660	3,720	368,0	229,00	2982,0	391,0
200 x 120	5,0	23,7	30,23	1637	745,5	7,358	4,966	163,7	124,20	1656,0	209,7
	6,0	28,7	36,60	1980	862,0	7,360	4,940	198,0	149,00	1942,0	245,0
	6,3	30,1	38,30	2065	929,0	7,340	4,920	207,0	155,00	2028,0	255,0
	8,0	37,6	48,00	2529	1128,0	7,260	4,850	253,0	188,00	2495,0	310,0
	10,0	46,3	58,90	3026	1337,0	7,170	4,760	303,0	223,00	3001,0	367,0
	12,0	54,6	69,50	3472	1520,0	7,070	4,680	347,0	253,00	3461,0	417,0
	12,5	56,6	72,10	3576	1562,0	7,040	4,660	358,0	260,00	3569,0	428,0
	14,0	62,5	79,70	3870	1679,0	6,970	4,590	387,0	280,00	3876,0	460,0
	16,0	70,2	89,40	4221	1813,0	6,870	4,500	422,0	302,00	4247,0	497,0
200 x 150	5,0	26,1	33,23	1922	1238,0	7,605	6,103	192,2	165,00	2397,0	266,7
	6,0	31,0	39,45	2249	1447,0	7,551	6,056	224,9	192,90	2833,0	312,5
	8,0	40,4	51,46	2851	1828,0	7,443	5,960	285,1	243,70	3661,0	397,0
	10,0	49,4	62,91	3383	2163,0	7,333	5,864	338,3	288,40	4426,0	472,5
	12,0	57,9	73,79	3848	2454,0	7,221	5,766	384,8	327,20	5129,0	539,4
200 x 180	6,0	33,8	43,05	2588	2203,0	7,754	7,154	258,8	244,80	3794,0	380,1
	8,0	44,2	56,26	3293	2801,0	7,651	7,056	329,3	311,20	4921,0	485,3
	10,0	54,1	68,91	3925	3334,0	7,547	6,956	392,5	370,50	5975,0	580,5
	12,0	63,6	80,99	4485	3807,0	7,441	6,856	448,5	423,00	6955,0	666,1
220 x 80	4,0	17,9	22,87	1323	271,6	7,605	3,446	120,2	67,90	751,4	122,6
	5,0	22,2	28,23	1604	326,5	7,539	3,401	145,8	81,64	915,6	148,0
	6,0	26,3	33,45	1867	376,7	7,471	3,356	469,7	94,18	1070,0	171,3
	8,0	34,1	43,46	2337	463,5	7,333	3,265	212,4	115,90	1350,0	212,4
	10,0	41,5	52,91	2735	533,4	7,190	3,175	248,7	133,30	1590,0	246,5
220 x 100	5,0	23,7	30,23	1835	538,9	7,792	4,222	166,9	107,80	1373,0	189,8
	6,0	28,1	35,85	2142	625,4	7,730	4,177	194,7	125,10	1614,0	221,0
	8,0	36,6	46,66	2697	778,8	7,602	4,085	245,1	155,80	2059,0	277,2
	10,0	44,7	56,91	3177	907,8	7,471	3,994	288,8	181,60	2456,0	325,6



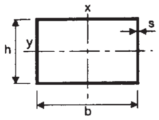
External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm²	Moment of inertia during flexion Ix cm⁴	Moment of inertia during flexion Iy cm⁴	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm³	Resistance module Wy cm³	Moment of inertia during torsion J cm⁴	Torsion module C cm³
220 x 120	5,0	25,3	32,23	2067	811,7	8,008	5,018	187,9	135,30	1889,0	231,80
	6,0	30,0	38,25	2417	945,7	7,949	4,973	219,7	157,60	2227,0	270,80
	8,0	39,1	49,86	3056	1188,0	7,829	4,880	277,9	197,90	2862,0	342,30
	10,0	47,8	60,91	3618	1396,0	7,707	4,788	328,9	232,70	3441,0	405,10
	12,5	58,7	74,70	4310	1640,0	7,600	4,690	392,0	274,00	4040,0	506,30
	14,2	65,4	83,30	4680	1770,0	7,500	4,610	426,0	295,00	4430,0	575,10
	16,0	72,7	92,00	5020	1890,0	7,390	4,530	457,0	315,00	4780,0	648,00
220 x 140	5,0	26,9	34,23	2298	1149,0	8,193	5,794	208,9	164,10	2452,0	273,70
	6,0	31,9	40,65	2691	1343,0	8,137	5,747	244,7	191,80	2898,0	320,70
	8,0	41,7	53,06	3416	1696,0	8,024	5,654	310,6	242,30	3742,0	407,40
	10,0	51,0	64,91	4059	2006,0	7,908	5,559	369,0	286,60	4521,0	484,80
	12,0	59,8	76,19	4624	2275,0	7,791	5,465	420,4	325,00	5235,0	553,40
220 x 160	6,0	33,8	43,05	2966	1821,0	8,301	6,503	269,7	227,60	3616,0	370,60
	8,0	44,2	56,26	3776	2311,0	8,192	6,408	343,3	288,80	4685,0	472,60
	10,0	54,1	68,91	4501	2746,0	8,082	6,313	409,2	343,30	5681,0	564,70
	12,0	63,6	80,99	5144	3130,0	7,969	6,216	467,6	391,20	6604,0	647,30
220 x 180	5,0	30,0	38,23	2760	2033,0	8,497	7,292	250,9	225,90	3693,0	357,70
	6,0	35,7	45,45	3241	2385,0	8,445	7,244	294,7	265,00	4375,0	420,50
	8,0	46,7	59,46	4136	3038,0	8,340	7,147	376,0	337,50	5681,0	537,80
	10,0	57,2	72,91	4942	3624,0	8,233	7,050	449,3	402,60	6908,0	644,60
	12,0	67,3	85,79	5664	4146,0	8,125	6,952	514,9	460,70	8053,0	741,30
220 x 200	6,0	37,6	47,85	3516	3040,0	8,572	7,971	319,6	304,00	5168,0	470,40
	8,0	49,2	62,66	4495	3884,0	8,470	7,873	408,7	388,40	6723,0	603,10
	10,0	60,4	76,91	5383	4647,0	8,366	7,773	489,4	464,70	8190,0	724,60
	12,0	71,1	90,59	6183	5334,0	8,262	7,673	562,1	533,40	9568,0	835,40
250 x 50	4,0	17,9	22,87	1474	108,1	8,028	2,174	117,9	43,23	356,8	82,15
	5,0	22,2	28,23	1783	127,9	7,948	2,129	142,7	51,16	427,5	97,59
	6,0	26,3	33,45	2070	145,2	7,867	2,083	165,6	58,08	491,0	111,20
	8,0	34,1	43,46	2577	172,8	7,700	1,994	206,2	69,11	596,6	133,30
250 x 100	5,0	26,1	33,23	2534	606,6	8,732	4,273	202,7	121,30	1623,0	216,90
	6,0	31,0	39,45	2963	705,0	8,667	4,227	237,1	141,00	1908,0	252,90
	8,0	40,4	51,46	3749	880,7	8,535	4,137	299,9	176,10	2438,0	317,90
	10,0	49,4	62,91	4439	1030,0	8,400	4,046	355,1	206,00	2912,0	374,30
	12,0	57,9	73,79	5036	1154,0	8,261	3,955	402,9	230,90	3330,0	422,50



External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm^2	Moment of inertia during flexion Ix cm^4	Moment of inertia during flexion Iy cm^4	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm^3	Resistance module Wy cm^3	Moment of inertia during torsion J cm^4	Torsion module C cm^3
250 x 150	5,0	30,0	38,23	3284	1501,0	9,269	6,266	262,7	200,1	3292	336,7
	6,0	36,2	46,20	3965	1796,0	9,270	6,240	317,0	239,0	3877	396,0
	6,3	38,0	48,40	4143	1874,0	9,250	6,220	331,0	250,0	4054	413,0
	8,0	47,7	60,80	5111	2298,0	9,170	6,150	409,0	306,0	5021	506,0
	10,0	58,8	74,90	6174	2755,0	9,080	6,060	494,0	367,0	6090	605,0
	12,0	69,6	88,70	7154	3168,0	8,980	5,980	572,0	422,0	7088	695,0
	12,5	72,3	92,10	7387	3265,0	8,960	5,960	591,0	435,0	7326	717,0
	14,0	80,1	102,00	8055	3541,0	8,880	5,890	644,0	472,0	8014	777,0
	16,0	90,3	115,00	8879	3873,0	8,790	5,800	710,0	516,0	8868	849,0
260 x 120	6,0	33,8	43,05	3663	1102,0	9,224	5,059	281,8	183,6	2791	322,8
	8,0	44,2	56,26	4658	1389,0	9,099	4,968	358,3	231,4	3591	409,2
	10,0	54,1	68,91	5546	1639,0	8,971	4,877	426,6	273,1	4324	485,9
	12,0	63,6	80,99	6330	1854,0	8,841	4,785	486,9	309,1	4989	553,3
260 x 140	5,0	30,0	38,23	3449	1331,0	9,499	5,901	265,3	190,2	3091	325,8
	6,0	35,7	45,45	4050	1558,0	9,440	5,855	311,5	222,6	3654	382,2
	8,0	46,7	59,46	5166	1975,0	9,321	5,763	397,4	282,2	4726	487,0
	10,0	57,2	72,91	6172	2345,0	9,200	5,671	474,7	335,0	5720	581,4
	12,0	67,3	85,79	7069	2670,0	9,077	5,578	543,8	381,4	6637	665,8
	14,2	78,8	100,00	8110	3030,0	8,990	5,490	624,0	433,0	7490	787,8
	16,0	87,3	111,00	8780	3260,0	8,890	5,410	675,0	465,0	8160	887,7
260 x 180	5,0	33,1	42,23	4100	2339,0	9,853	7,443	315,3	259,9	4705	425,7
	6,0	40,0	51,00	4942	2804,0	9,850	7,420	380,0	312,0	5554	502,0
	6,3	41,9	53,40	5166	2929,0	9,830	7,400	397,0	325,0	5810	524,0
	8,0	52,7	67,20	6390	3608,0	9,750	7,330	492,0	401,0	7221	644,0
	10,0	65,1	82,90	7741	4351,0	9,660	7,240	595,0	483,0	8798	775,0
	12,0	77,2	98,30	8999	5034,0	9,570	7,160	692,0	559,0	10285	895,0
	12,5	80,1	102,00	9299	5196,0	9,540	7,130	715,0	577,0	10643	924,0
	14,0	88,9	113,00	10166	5660,0	9,470	7,070	782,0	629,0	11684	1005,0
	16,0	100,0	128,00	11245	6231,0	9,380	6,980	865,0	692,0	12993	1106,0
300 x 100	5,0	30,0	38,23	4036	719,5	10,280	4,339	269,1	143,9	2048	262,1
	6,0	35,7	45,45	4735	837,7	10,210	4,293	315,7	167,5	2408	305,9
	8,0	46,7	59,46	6028	1050,0	10,070	4,203	401,9	210,1	3079	385,8
	10,0	57,2	72,91	7184	1233,0	9,927	4,113	479,0	246,6	3682	455,6
	12,0	67,3	85,79	8208	1388,0	9,781	4,022	547,2	277,6	4219	515,8
300 x 150	5,0	33,9	43,23	5124	1764,0	10,890	6,387	341,6	235,1	4223	406,8
	6,0	40,4	51,45	6032	2069,0	10,830	6,342	402,1	275,9	4999	478,3
	8,0	53,0	67,46	7734	2636,0	10,710	6,250	515,6	351,4	6483	612,0
	10,0	65,1	82,91	9288	3145,0	10,580	6,159	619,2	419,3	7872	733,8
	12,0	76,8	97,79	10700	3599,0	10,460	6,067	713,2	479,9	9164	844,2
	14,0	88,0	112,10	11970	4002,0	10,330	5,975	797,9	533,5	10360	943,6



External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm^2	Moment of inertia during flexion Ix cm^4	Moment of inertia during flexion Iy cm^4	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm^3	Resistance module Wy cm^3	Moment of inertia during torsion J cm^4	Torsion module C cm^3
300 x 200	5,0	37,90	48,23	6212	3348,0	11,35	8,332	414,1	334,8	6849	551,7
	6,0	45,70	58,20	7486	4013,0	11,30	8,310	499,0	401,0	8100	651,0
	6,3	47,90	61,00	7829	4193,0	11,30	8,290	522,0	419,0	8476	681,0
	8,0	60,30	76,80	9717	5184,0	11,30	8,220	648,0	518,0	10562	840,0
	10,0	74,50	94,90	11819	6278,0	11,20	8,130	788,0	628,0	12908	1015,0
	12,0	88,50	113,00	13797	7294,0	11,10	8,050	920,0	729,0	15137	1178,0
	12,5	91,90	117,00	14273	7537,0	11,00	8,020	952,0	754,0	15677	1217,0
	14,0	102,00	130,00	15653	8237,0	11,00	7,960	1044,0	824,0	17252	1329,0
	16,0	115,00	147,00	17390	9109,0	10,90	7,870	1159,0	911,0	19252	1468,0
350 x 100	5,0	33,90	43,23	6017	832,5	11,80	4,388	343,8	166,5	2478	307,2
	6,0	40,40	51,45	7075	970,4	11,73	4,343	404,3	194,1	2915	359,0
	8,0	53,00	67,46	9050	1220,0	11,58	4,253	517,2	244,0	3729	453,6
	10,0	65,10	82,91	10840	1436,0	11,44	4,162	619,5	287,3	4463	536,8
	12,0	76,80	97,79	12450	1622,0	11,28	4,072	711,6	324,4	5119	609,2
350 x 150	5,0	37,90	48,23	7505	2027,0	12,47	6,482	428,8	270,2	5179	476,9
	6,0	45,10	57,45	8850	2380,0	12,41	6,437	505,7	317,4	6133	561,3
	8,0	59,20	75,46	11390	3039,0	12,29	6,346	650,8	405,2	7958	719,6
	10,0	72,90	92,91	13730	3636,0	12,16	6,255	784,7	484,7	9672	864,6
	12,0	86,20	109,80	15880	4172,0	12,03	6,164	907,5	556,3	11270	996,7
350 x 250	6,0	54,50	69,45	12400	7429,0	13,36	10,340	708,6	594,4	14580	966,6
	8,0	71,80	91,46	16070	9607,0	13,25	10,250	918,2	768,6	19110	1253,0
	10,0	88,60	112,90	19510	11640,0	13,15	10,150	1115,0	931,4	23470	1523,0
	12,0	105,00	133,80	22740	13540,0	13,04	10,060	1299,0	1083,0	27650	1777,0
	14,0	120,97	154,10	25749	15307,0	12,93	9,960	1471,4	1224,1	31652	2014,9
400 x 100	5,0	37,90	48,23	8537	945,4	13,31	4,427	426,9	189,1	2913	352,4
	6,0	45,10	57,45	10060	1103,0	13,23	4,382	502,9	220,6	3427	412,1
	8,0	59,20	75,46	12920	1390,0	13,08	4,291	645,8	278,0	4385	521,5
	10,0	72,90	92,91	15530	1640,0	12,93	4,201	776,7	328,0	5251	618,1
	12,0	86,20	109,80	17920	1856,0	12,78	4,111	896,0	371,1	6026	702,7
400 x 200	6,0	54,50	69,45	14720	5073,0	14,56	8,547	735,8	507,3	12090	876,8
	8,0	72,80	92,80	19562	6660,0	14,50	8,470	978,0	666,0	15735	1135,0
	10,0	90,20	115,00	23914	8084,0	14,40	8,390	1196,0	808,0	19259	1376,0
	12,0	107,00	137,00	28059	9418,0	14,30	8,300	1403,0	942,0	22622	1602,0
	12,5	112,00	142,00	29063	9738,0	14,30	8,280	1453,0	974,0	23438	1656,0
	14,0	124,00	158,00	31998	10664,0	14,20	8,210	1600,0	1066,0	25826	1813,0
	16,0	141,00	179,00	35738	11824,0	14,10	8,130	1787,0	1182,0	28871	2010,0



External sides dimension b x h mm	Thickness s mm	Linear mass Kg/m	Metal section area A cm^2	Moment of inertia during flexion Ix cm^4	Moment of inertia during flexion Iy cm^4	Radius of inertia ix cm	Radius of inertia iy cm	Resistance module Wx cm^3	Resistance module Wy cm^3	Moment of inertia during torsion J cm^4	Torsion module C cm^3
400 x 250	10,0	98,1	125,00	27718	13378	14,90	10,300	1386,0	1070,0	28255	1756,0
	12,0	117,0	149,00	32576	15658	14,80	10,300	1629,0	1253,0	33311	2052,0
	12,5	121,0	155,00	33757	16208	14,80	10,200	1688,0	1297,0	34544	2124,0
	14,0	135,0	172,00	37216	17813	14,70	10,200	1861,0	1425,0	38171	2333,0
	16,0	153,0	195,00	41639	19848	14,60	10,100	2082,0	1588,0	42838	2597,0
400 x 300	6,0	63,90	81,45	19370	12520	15,42	12,400	968,6	834,4	23690	1342,0
	8,0	84,40	107,50	25210	16260	15,32	12,300	1261,0	1084,0	31140	1748,0
	10,0	104,00	132,90	30750	19800	15,21	12,210	1537,0	1320,0	38350	2133,0
	12,0	124,00	157,80	35990	23150	15,10	12,110	1800,0	1543,0	45330	2500,0
	12,5	129,00	165,00	37580	94130	15,00	12,100	1880,0	1610,0	46840	2604,0
	14,0	142,90	182,10	40944	26294	14,99	12,010	2047,0	1753,0	52071	2847,0
	16,0	163,00	207,00	46140	29550	14,90	11,900	2310,0	1970,0	58250	3253,0
450 x 150	6,0	54,50	69,45	16720	3003	15,51	6,576	742,9	400,4	8458	727,2
	8,0	71,80	91,46	21630	3847	15,38	6,485	961,4	512,9	10980	934,8
	10,0	88,60	112,90	26230	4617	15,24	6,395	1166,0	615,6	13360	1126,0
	12,0	105,00	133,80	30520	5318	15,10	6,304	1356,0	709,0	15590	1302,0
450 x 250	6,0	63,90	81,45	22630	9216	16,67	10,640	1006,0	737,3	20720	1252,0
	8,0	84,40	107,50	29450	11950	16,55	10,550	1309,0	956,1	27190	1628,0
	10,0	104,00	132,90	35910	14520	16,44	10,450	1596,0	1162,0	33430	1984,0
	12,0	124,00	157,80	42030	16940	16,32	10,360	1868,0	1355,0	39440	2321,0
	12,5	129,00	165,00	43910	17650	16,30	10,300	1950,0	1410,0	40730	2417,7
	14,0	142,90	182,00	47810	19200	16,20	10,270	2125,0	1536,0	45220	2639,0
	16,0	163,00	207,00	53920	21530	16,10	10,200	2400,0	1720,0	50480	2973,5
500 x 200	8,0	84,36	107,00	33260	8010	17,59	8,640	1330,0	801,5	21200	1429,0
	10,0	104,30	133,00	40540	9710	17,46	8,550	1621,0	970,6	25970	1735,0
	12,0	123,80	158,00	47410	11280	17,33	8,450	1897,0	1128,0	30530	2023,0
	12,5	132,00	168,00	51510	12020	17,50	8,460	2060,0	1202,0	31480	2097,0
	16,0	167,00	213,00	63930	14670	17,30	8,310	2557,0	1467,0	38830	2554,0
500 x 300	8,0	96,90	123,40	42943	19673	18,65	12,620	1717,0	1311,0	42716	2202,0
	10,0	122,00	155,00	53762	24439	18,60	12,600	2150,0	1629,0	52450	2696,0
	12,0	145,00	185,00	63446	28736	18,50	12,500	2538,0	1916,0	62039	3167,0
	12,5	151,00	192,00	65813	29780	18,50	12,500	2633,0	1985,0	64389	3281,0
	14,0	168,00	214,00	72785	32844	18,40	12,400	2911,0	2190,0	71331	3616,0
	16,0	191,00	243,00	81783	36768	18,30	12,300	3271,0	2451,0	80329	4044,0
	20,0	235,00	300,00	98777	44078	18,20	12,100	3951,0	2939,0	97447	4842,0

- Addendum to chap. 4 -

DOUBLE-AXLE CRANE MOUNTED BEHIND CAB

DISTRIBUTION OVER THE SUPERSTRUCTURE

- CRANE

$$G1 = \frac{\boxed{G} \times \left(\boxed{P} - \boxed{Ag}\right)}{\boxed{P}} = \boxed{} \text{ kg}$$

$$G2 = \boxed{G} - \boxed{G1} = \boxed{} \text{ kg}$$

- SUPPLEMENTARY OUTRIGGER CROSS MEMBER

$$Ps1 = -\frac{\boxed{Ps} \times \boxed{Ds}}{\boxed{P}} = \boxed{} \text{ kg}$$

- BODY

$$Pc2 = \boxed{Pc} - \boxed{Pc1} = \boxed{} \text{ kg}$$

TOTAL TARE WEIGHT

$$TT = \boxed{T} + \boxed{G} + \boxed{Ps} + \boxed{Pc} = \boxed{} \text{ kg}$$

$$TT1 = \boxed{T1} + \boxed{G1} + \boxed{Ps1} + \boxed{Pc1} = \boxed{} \text{ kg}$$

$$TT2 = \boxed{T2} + \boxed{G2} + \boxed{Ps2} + \boxed{Pc2} = \boxed{} \text{ kg}$$

- CAPACITY

$$Q = \boxed{PTT} - \boxed{TT} = \boxed{} \text{ kg}$$

$$Q1 = \frac{\boxed{Q} \times \boxed{Aq}}{\boxed{p}} = \boxed{} \text{ kg}$$

$$Q2 = \boxed{Q} - \boxed{Q1} = \boxed{} \text{ kg}$$

FRONT/REAR-WHEEL AXLE MASS RATIO CHECK

Unloaded vehicle

$$\frac{TT1}{TT2} = \boxed{} \quad > \quad \text{Min. value ADM C.C. vehicle}$$

TRIPLE- AXLE CRANE MOUNTED BEHIND CAB

FINDING THE IDEAL WHEELBASE

- TANDEM REAR AXLES

$$S = T = \frac{P\ 2\text{-}3}{2} = \square$$

- INDEPENDENT REAR AXLES

$$P\ id = P\ 1\text{-}2 + \frac{P\ 2\text{-}3}{3} = \square$$

$$P\ 2\text{-}3 = S + T = \square$$

$$S = \frac{1}{3} \times P\ 2\text{-}3 = \square$$

$$T = \frac{2}{3} \times P\ 2\text{-}3 = \square$$

DISTRIBUTION OVER THE SUPERSTRUCTURE

- CRANE

$$G1 = \frac{G \times (P\ id - Ag)}{P\ id} = \square \text{ kg}$$

$$Gp = G - G1 = \square \text{ kg}$$

*DISTRIBUTION OF **Gp** OVER THE TWO REAR AXLES*

INDEPENDENT REAR AXLES (6x2)

$$G3 = \frac{Gp \times S}{P\ 2\text{-}3} = \square \text{ kg}$$

$$G2 = Gp - G3 = \square \text{ kg}$$

TANDEM REAR AXLES (6x4 - 6x6)

$$G3 = \frac{Gp}{2} = \square \text{ kg}$$

$$G2 = Gp - G3 = \square \text{ kg}$$

- SUPPLEMENTARY OUTRIGGER CROSS MEMBER

$$Ps1 = \frac{-\overset{Ps}{\boxed{}} \times \left(\overset{Ds}{\boxed{}} + \overset{T}{\boxed{}}\right)}{\underset{Pid}{\boxed{}}} = \boxed{} \ \text{kg}$$

$$Psp = \overset{Ps}{\boxed{}} - \overset{Ps1}{\boxed{}} = \boxed{} \ \text{kg}$$

*DISTRIBUTION OF **Psp** OVER THE TWO REAR AXLES*

- INDEPENDENT REAR AXLES (6x2)

$$Ps3 = \frac{\overset{Psp}{\boxed{}} \times \overset{S}{\boxed{}}}{\underset{P\ 2\text{-}3}{\boxed{}}} = \boxed{} \ \text{kg}$$

$$Ps2 = \overset{Psp}{\boxed{}} - \overset{Ps3}{\boxed{}} = \boxed{} \ \text{kg}$$

- TANDEM REAR AXLES (6x4 - 6x6)

$$Ps3 = \frac{\overset{Psp}{\boxed{}}}{2} = \boxed{} \ \text{kg}$$

$$Ps2 = \overset{Psp}{\boxed{}} - \overset{Ps3}{\boxed{}} = \boxed{} \ \text{kg}$$

- BODY

$$Pc1 = \frac{\overset{Pc}{\boxed{}} \times \overset{Aq}{\boxed{}}}{\underset{Pid}{\boxed{}}} = \boxed{} \ \text{kg}$$

$$Pcp = \overset{Pc}{\boxed{}} - \overset{Pc1}{\boxed{}} = \boxed{} \ \text{kg}$$

*DISTRIBUTION OF **Pcp** OVER THE TWO REAR AXLES*

- INDEPENDENT REAR AXLES (6x2)

$$Pc3 = \frac{\overset{Pcp}{\boxed{}} \times \overset{S}{\boxed{}}}{\underset{P\ 2\text{-}3}{\boxed{}}} = \boxed{} \ \text{kg}$$

$$Pc2 = \overset{Pcp}{\boxed{}} - \overset{Pc3}{\boxed{}} = \boxed{} \ \text{kg}$$

- TANDEM REAR AXLES (6x4 - 6x6)

$$Pc3 = \frac{\overset{Pcp}{\boxed{}}}{2} = \boxed{} \ \text{kg}$$

$$Pc2 = \overset{Pcp}{\boxed{}} - \overset{Pc3}{\boxed{}} = \boxed{} \ \text{kg}$$

- TOTAL TARE WEIGHT

TT = T + G + Ps + Pc = ______ kg

TT1 = T2 + G1 + Ps1 + Pc1 = ______ kg

TT3 = T3 + G3 + Ps3 + Pc3 = ______ kg

- CAPACITY

Q = PTT - TT = ______ kg

$$Q1 = \frac{Q \times Aq}{P\ id} = \text{______ kg}$$

Qp = Q - Q1 = ______ kg

*DISTRIBUTION OF **Qp** OVER THE TWO REAR AXLES*

- INDEPENDENT REAR AXLES (6x2)

$$Q3 = \frac{Qp \times S}{P\ 2\text{-}3} = \text{______ kg}$$

Q2 = Qp - Q3 = ______ kg

- TANDEM REAR AXLES (6x4 - 6x6)

$$Q3 = \frac{Qp}{2} = \text{______ kg}$$

Q2 = Qp - Q3 = ______ kg

FRONT/REAR-WHEEL AXLE MASS RATIO CHECK

Unloaded vehicle = $\frac{TT1}{TT2 + TT3}$ = ______ > **Min. value ADM C.C. vehicle**

DOUBLE- AXLE CRANE MOUNTED ON REAR

DISTRIBUTION OVER THE SUPERSTRUCTURE

- CRANE

$$G1 = -\frac{\overset{G}{\boxed{\quad\quad}} \times \overset{Ag}{\boxed{\quad\quad}}}{\underset{P}{\boxed{\quad\quad}}} = \boxed{\quad\quad}\ \text{kg}$$

$$G2 = \overset{G}{\boxed{\quad\quad}} - \overset{G1}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

- SUPPLEMENTARY OUTRIGGER CROSS MEMBER

$$Ps1 = \frac{\overset{Ps}{\boxed{\quad\quad}} \times \left(\overset{P}{\boxed{\quad\quad}} - \overset{Ds}{\boxed{\quad\quad}}\right)}{\underset{P}{\boxed{\quad\quad}}} = \boxed{\quad\quad}\ \text{kg}$$

$$Ps2 = \overset{Ps}{\boxed{\quad\quad}} - \overset{Ps1}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

- BODY

$$Pc1 = \frac{\overset{Pc}{\boxed{\quad\quad}} \times \overset{Aq}{\boxed{\quad\quad}}}{\underset{P}{\boxed{\quad\quad}}} = \boxed{\quad\quad}\ \text{kg}$$

$$Pc2 = \overset{Pc}{\boxed{\quad\quad}} - \overset{Pc1}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

- TOTAL TARE WEIGHT

$$TT = \overset{T}{\boxed{\quad\quad}} + \overset{G}{\boxed{\quad\quad}} + \overset{Ps}{\boxed{\quad\quad}} + \overset{Pc}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

$$TT1 = \overset{T1}{\boxed{\quad\quad}} + \overset{G1}{\boxed{\quad\quad}} + \overset{Ps1}{\boxed{\quad\quad}} + \overset{Pc1}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

$$TT2 = \overset{T2}{\boxed{\quad\quad}} + \overset{G2}{\boxed{\quad\quad}} + \overset{Ps2}{\boxed{\quad\quad}} + \overset{Pc2}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

- CAPACITY

$$Q = \overset{PTT}{\boxed{\quad\quad}} - \overset{TT}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

$$Q1 = \frac{\overset{Q}{\boxed{\quad\quad}} \times \overset{Aq}{\boxed{\quad\quad}}}{\underset{P}{\boxed{\quad\quad}}} = \boxed{\quad\quad}\ \text{kg}$$

$$Q2 = \overset{Q}{\boxed{\quad\quad}} - \overset{Q1}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

FRONT/REAR-WHEEL AXLE MASS RATIO CHECK

Unloaded vehicle = $\frac{TT1}{TT2}$ = ______ > **Min. value ADM C.C. vehicle**

TRIPLE- AXLE CRANE MOUNTED ON REAR

FINDING THE IDEAL WHEELBASE

- TANDEM REAR AXLES (6x4 - 6x6)

$$P\ id = \overset{P\ 1\text{-}2}{\boxed{\quad\quad}} + \frac{\overset{P\ 2\text{-}3}{\boxed{\quad\quad}}}{2} = \boxed{\quad\quad}$$

$$S = T = \frac{\overset{P2\text{-}3}{\boxed{\quad\quad}}}{2} = \boxed{\quad\quad}$$

- INDEPENDENT REAR AXLES (6x2)

$$P\ 2\text{-}3 = \overset{S}{\boxed{\quad\quad}} + \overset{T}{\boxed{\quad\quad}} = \boxed{\quad\quad}$$

$$S = \frac{1}{3} \times \overset{P\ 2\text{-}3}{\boxed{\quad\quad}} = \boxed{\quad\quad}$$

$$T = \frac{2}{3} \times \overset{P\ 2\text{-}3}{\boxed{\quad\quad}} = \boxed{\quad\quad}$$

DISTRIBUTION OVER THE SUPERSTRUCTURE

- CRANE

$$G1 = -\frac{\overset{G}{\boxed{\quad\quad}} \times \left(\overset{T}{\boxed{\quad\quad}} + \overset{Ag}{\boxed{\quad\quad}} \right)}{\underset{P\ id}{\boxed{\quad\quad}}} = \boxed{\quad\quad}\ \text{kg}$$

$$Gp = \overset{G}{\boxed{\quad\quad}} - \overset{G1}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

*DISTRIBUTION OF **Gp** OVER THE REAR AXLES*

- INDEPENDENT REAR AXLES (6x2)

$$G3 = \frac{\overset{Gp}{\boxed{\quad\quad}} \times \overset{s}{\boxed{\quad\quad}}}{\underset{P\ 2\text{-}3}{\boxed{\quad\quad}}} = \boxed{\quad\quad}\ \text{kg}$$

$$G2 = \overset{Gp}{\boxed{\quad\quad}} - \overset{G3}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

- TANDEM REAR AXLES (6x4 - 6x6)

$$G3 = \frac{\overset{Gp}{\boxed{\quad\quad}}}{2} = \boxed{\quad\quad}\ \text{kg}$$

$$G2 = \overset{Gp}{\boxed{\quad\quad}} - \overset{G3}{\boxed{\quad\quad}} = \boxed{\quad\quad}\ \text{kg}$$

- SUPPLEMENTARY OUTRIGGER CROSS MEMBER

$$Ps1 = \frac{\overset{Ps}{\boxed{}} \times \left(\overset{P\ id}{\boxed{}} - \overset{Ds}{\boxed{}}\right)}{\underset{P\ id}{\boxed{}}} = \boxed{} \text{ kg}$$

$$Psp = \overset{Ps}{\boxed{}} - \overset{Ps1}{\boxed{}} = \boxed{} \text{ kg}$$

*DISTRIBUTION OF **Psp** OVER THE REAR AXLES*

- INDEPENDENT REAR AXLES (6x2)

$$Ps3 = \frac{\overset{Psp}{\boxed{}} \times \overset{S}{\boxed{}}}{\underset{P\ 2\text{-}3}{\boxed{}}} = \boxed{} \text{ kg}$$

$$Ps2 = \overset{Psp}{\boxed{}} - \overset{Ps3}{\boxed{}} = \boxed{} \text{ kg}$$

- TANDEM REAR AXLES (6x4 - 6x6)

$$Ps3 = \frac{\overset{Psp}{\boxed{}}}{2} = \boxed{} \text{ kg}$$

$$Ps2 = \overset{Psp}{\boxed{}} - \overset{Ps3}{\boxed{}} = \boxed{} \text{ kg}$$

- BODY

$$Pc1 = \frac{\overset{Pc}{\boxed{}} \times \overset{Aq}{\boxed{}}}{\underset{P\ id}{\boxed{}}} = \boxed{} \text{ kg}$$

$$Pcp = \overset{Pc}{\boxed{}} - \overset{Pc1}{\boxed{}} = \boxed{} \text{ kg}$$

*DISTRIBUTION OF **Pcp** OVER THE REAR AXLES*

- INDEPENDENT REAR AXLES (6x2)

$$Pc3 = \frac{\overset{Pcp}{\boxed{}} \times \overset{S}{\boxed{}}}{\underset{P\ 2\text{-}3}{\boxed{}}} = \boxed{} \text{ kg}$$

$$Pc2 = \overset{Pcp}{\boxed{}} - \overset{Pc3}{\boxed{}} = \boxed{} \text{ kg}$$

- TANDEM REAR AXLES (6x4 - 6x6)

$$Pc3 = \frac{\overset{Pcp}{\boxed{}}}{2} = \boxed{} \text{ kg}$$

$$Pc2 = \overset{Pcp}{\boxed{}} - \overset{Pc3}{\boxed{}} = \boxed{} \text{ kg}$$

- TOTAL TARE WEIGHT

TT1 = T1 + G1 + Ps1 + Pc1 = ______ kg

TT2 = T2 + G2 + Ps2 + Pc2 = ______ kg

TT3 = T3 + G3 + Ps3 + Pc3 = ______ kg

- CAPACITY

Q = PTT - TT = ______ kg

$$Q1 = \frac{Q \times Aq}{P\ id} = \_\_\_\_\_\_ \text{ kg}$$

Qp = Q - Q1 = ______ kg

*DISTRIBUTION OF **Qp** OVER THE REAR AXLES*

- INDEPENDENT REAR AXLES (6x2)

$$Q3 = \frac{Qp \times S}{P\ 2\text{-}3} = \_\_\_\_\_\_ \text{ kg}$$

Q2 = Qp - Q3 = ______ kg

- TANDEM REAR AXLES (6x4 - 6x6)

$$Q3 = \frac{Qp}{2} = \_\_\_\_\_\_ \text{ kg}$$

Q2 = Qp - Q3 = ______ kg

FRONT/REAR-WHEEL AXLE MASS RATIO CHECK

$$\underline{\text{Unloaded vehicle}} = \frac{TT1}{TT2 + TT3} = \_\_\_\_\_\_ > \text{Min. value ADM C.C. vehicle}$$

CRANE MOUNTED ON A TRACTOR

DISTRIBUTION OVER THE SUPERSTRUCTURE

- CRANE

$$G1 = \frac{G \times (P - Ag)}{P} = \_\_\_\_ \text{ kg}$$

$$G2 = G - G1 = \_\_\_\_ \text{ kg}$$

- SUPPLEMENTARY OUTRIGGER CROSS MEMBER

$$Ps1 = - \frac{Ps \times Ds}{P} = \_\_\_\_ \text{ kg}$$

$$Ps2 = Ps - Ps1 = \_\_\_\_ \text{ kg}$$

- TOTAL TARE WEIGHT

$$TT = T + G + Ps = \_\_\_\_ \text{ kg}$$

$$TT1 = T1 + G1 + Ps1 = \_\_\_\_ \text{ kg}$$

$$TT2 = T2 + G2 + Ps2 = \_\_\_\_ \text{ kg}$$

- THRUST BEARING CAPACITY

$$Qr1 = \frac{Qr \times Ar}{P} = \_\_\_\_ \text{ kg}$$

$$Qr2 = Qr - Qr1 = \_\_\_\_ \text{ kg}$$

FRONT/REAR-WHEEL AXLE MASS RATIO CHECK

Unloaded vehicle = $\frac{TT1}{TT2} = \_\_\_\_ >$ **Min. value ADM C.C. vehicle**

TOWABLE MASS ANALYSIS

MENU

MOUNTING THE SUPPLEMENTARY OUTRIGGER CROSS MEMBER

5.1- General

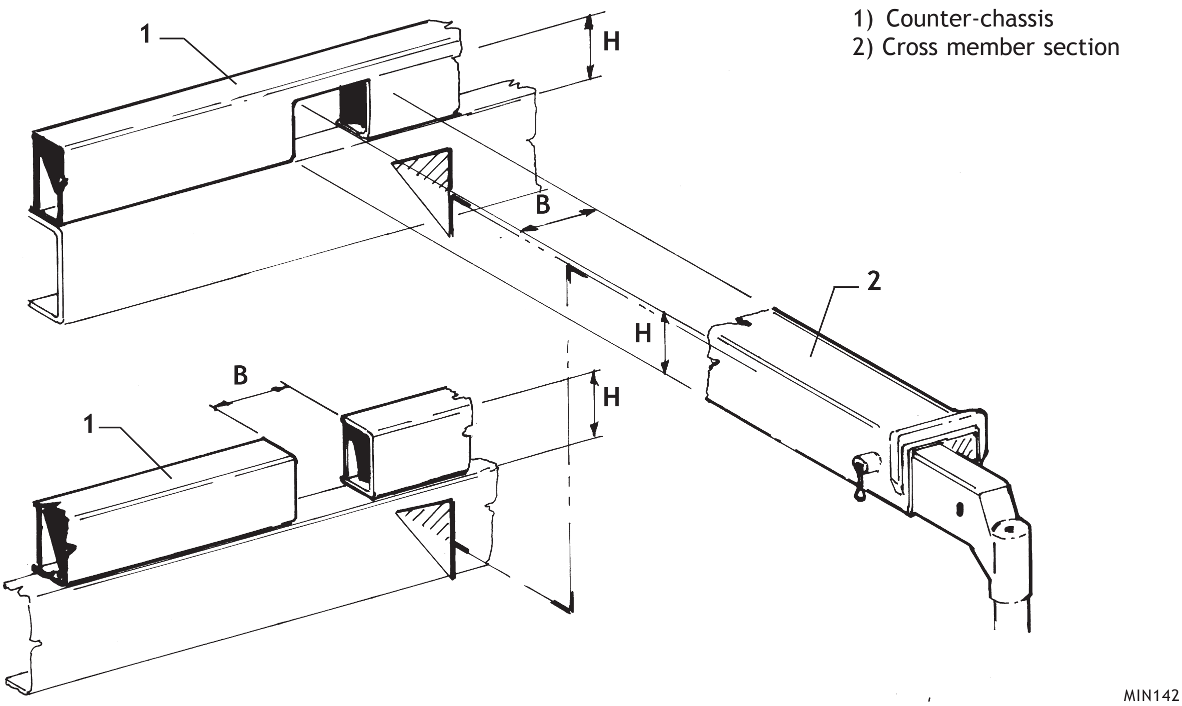
When selecting the outrigger cross member for the crane, it is necessary to satisfy the stability requisites for the installation and the strength requisites of the crane manufacturer (for combinations see technical specification sheets for each crane).

When positioning the supplementary outrigger cross member, it is important to keep to the minimum distance between the centre of the crane column and the centre line of the cross member in line with the crane manufacturer's instructions to guarantee mechanical strength (see technical specification sheets for relevant values).

There are two different ways of securing the cross member to the installation:
- on the vehicle chassis
- under the vehicle chassis.

5.2- On-chassis mounting

For this type of application, you must provide an opening in the side members of the counter-chassis (in an appropriate position). The opening should have the same size as the outer seat of the cross member (see fig. 5.2.1) for the purpose of inserting the latter and welding it to the counter-chassis side members along the whole perimeter.



1) Counter-chassis
2) Cross member section

fig. 5.2.1

Note

If the cross member has the same height as the counter-chassis, provide an opening for the cross-member insertion by interrupting the counter-chassis in the position you have chosen. The counter-chassis will continue after the cross member of the supplementary outriggers (see fig. 5.2.1).

The supplementary cross member will be secured to the chassis by means of an L-shaped plate that must be welded to the cross member and bolted to the vehicle chassis (see fig. 5.2.2).

The quantity, size and type of bolt that should be used is given in para. 5.5.

The thickness of the plate must be at least the same as the thickness of the vehicle chassis, and the dimensions must be compatible with the number of bolts according to the minimum centre distance of the holes recommended by the vehicle manufacturer.

Note

When mounting the supplementary cross member at the front (behind the cab), the number of bolts securing the plate must be double (see the technical specification sheet of the crane in question).

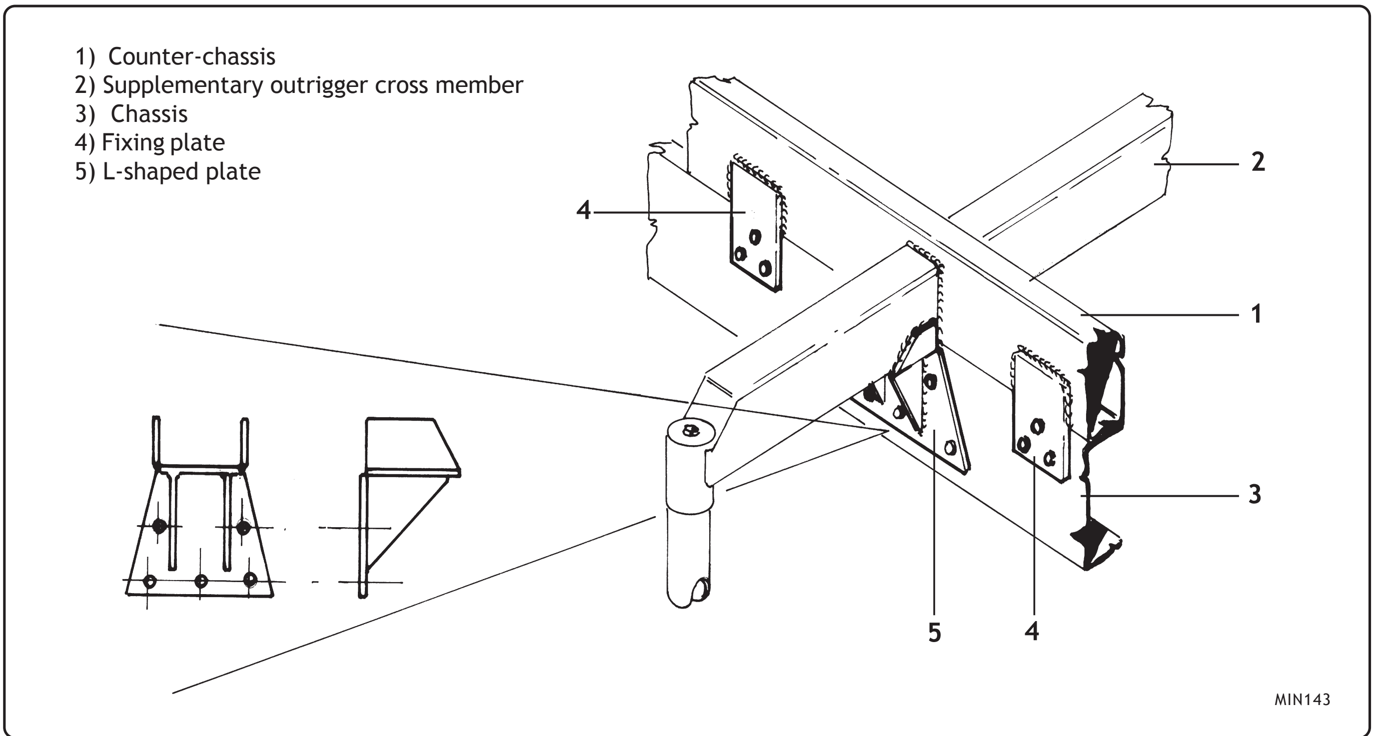


fig. 5.2.2

Once the securing operations are complete, to guarantee the chassis - counter-chassis - cross member connection, it is wise to provide a set of plates for fixing the chassis to the counter-chassis both crosswise and lengthways, upstream and downstream to the cross member (see fig. 5.2.2).

Note

The supplementary outrigger cross member can also be secured using a set of tie rods and brackets. These replace the L-shaped supports connecting the cross member to the vehicle chassis (see fig. 5.2.3).
However, this system is generally not adopted, as on top side, the tie rods and brackets could interfere with the body when it is resting on the chassis.

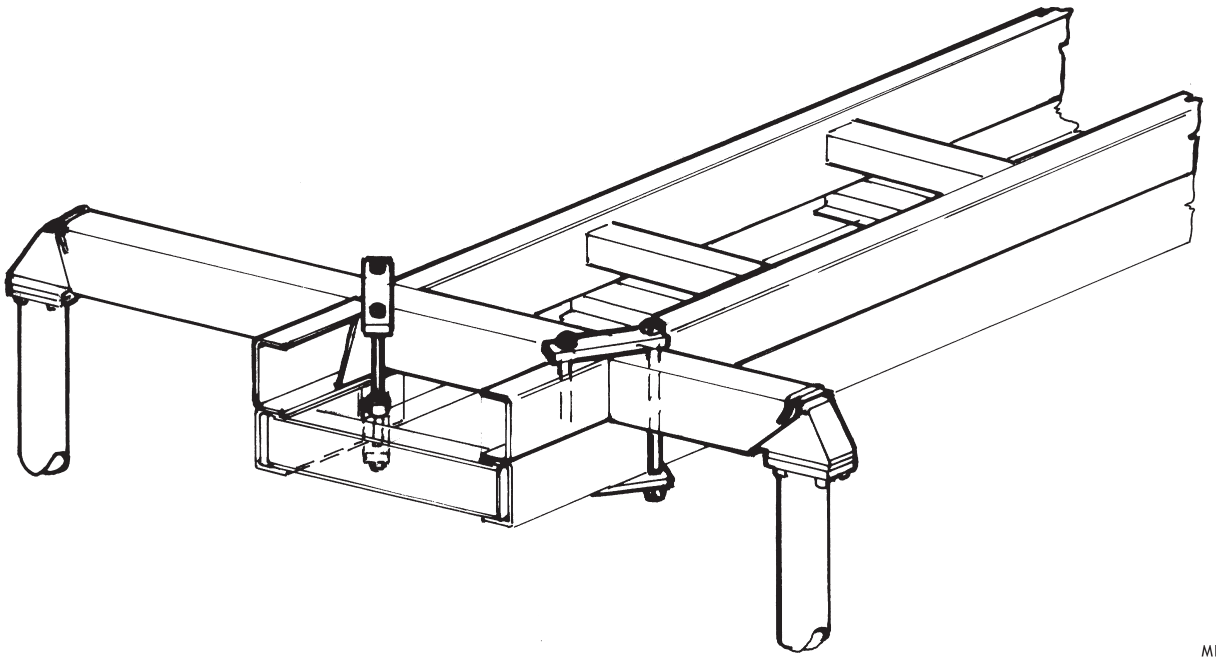


fig. 5.2.3

5.3 - Under-chassis mounting

The additional cross member must be secured by means of an L-shaped plate welded onto it, bolted onto the chassis and weld-riveted onto the counter-chassis (see fig. 5.2.4).

The quantity, size and type of bolt that should be used is given in para. 5.5.

With this method it is not possible to remove the cross member rapidly afterwards.

The installation can be easily disassembled if a 2-plate system is used - one (the L-shaped plate) welded to the cross member and bolted to the chassis, the other welded onto the counter-chassis (perimeter continuous welding or weld-riveting) and bolted to the chassis with the same number of bolts as for the first plate (see fig. 5.2.5).

The quantity, size and type of bolt that should be used is given in para. 5.5.

1) Fixing plate
2) Counter-chassis
3) Chassis
4) Supplementary outrigger cross member
5) L-shaped plate

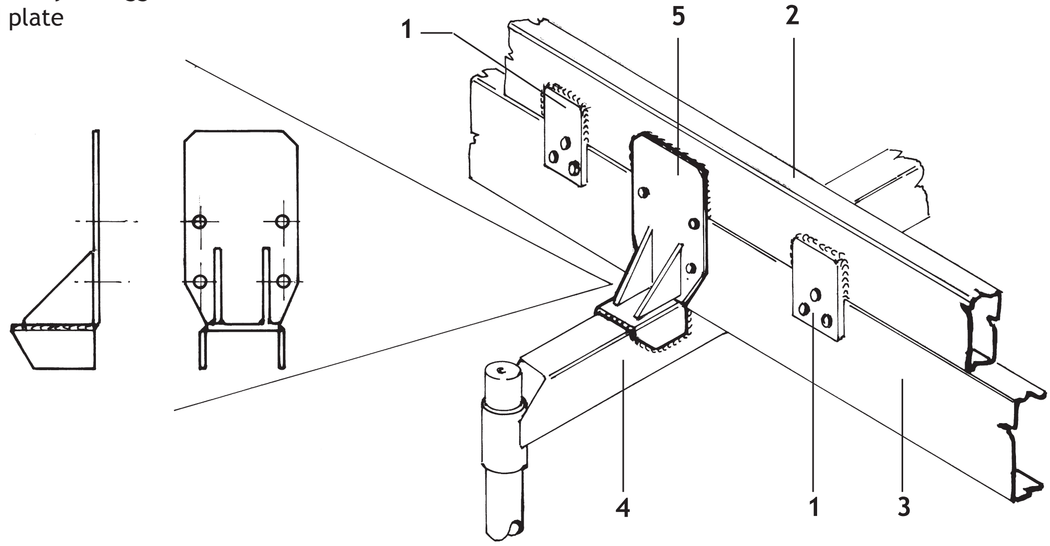


fig. 5.2.4

1) Fixing plate
2) Counter-chassis
3) Chassis
4) Supplementary outrigger cross member
5) L-shaped plate

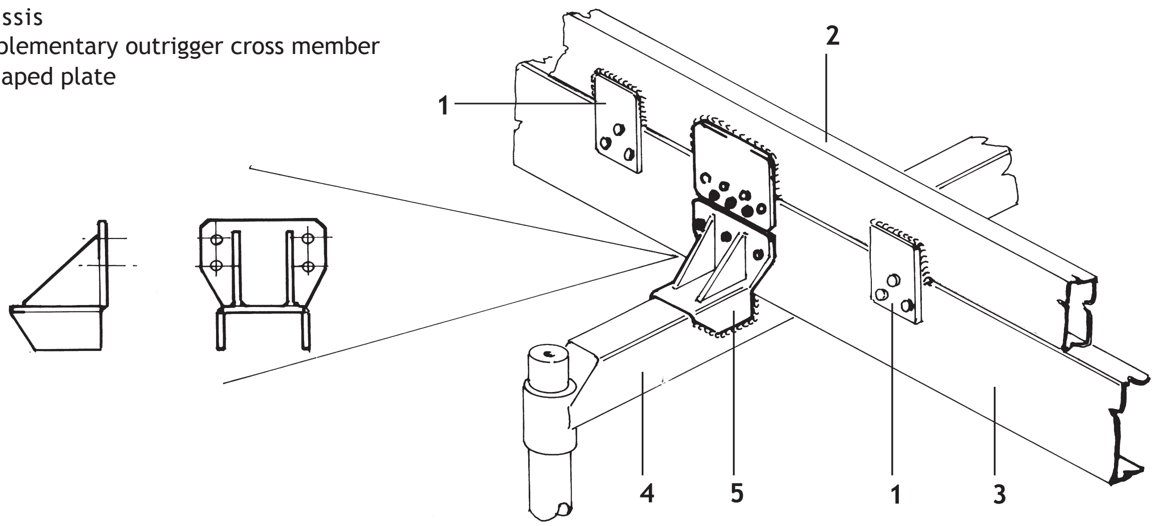


fig. 5.2.5

The thickness of the plates must be at least the same as the thickness of the vehicle chassis, and their dimensions must be compatible with the number of bolts, according to the minimum centre distance of the holes recommended by the vehicle manufacturer.

Once the securing operations are complete, to guarantee the chassis - counter-chassis - cross member connection, it is wise to provide a set of plates for fixing the chassis to the counter-chassis both crosswise and lengthways, upstream and downstream to the cross member (see figures 5.2.4 and 5.2.5).

5.4 - Hydraulic connections for the supplementary outrigger cross member

For the hydraulic connections for the supplementary outrigger cross member, use the materials supplied or recommended by the manufacturer.
For the connection diagrams and the materials to use, see chapter 7 - Hydraulic system.

5.5 - Calculations to determine the number and diameter of the bolts to use to secure the supplementary outrigger cross members

DATA REQUIRED

F = max cylinder thrust permitted (daN) (can be found on the supplementary outriggers technical sheet)

f = metal /metal friction coefficient = 0,3 for perfectly clean surfaces; 0.1 in all other cases

Rs · 0,7 = screw material unitary yield limit (Rs) multiplied by the reduction coefficient (0.7) - see Table 1 - daN/mm^2

Dn = core diameter (resistant diameter) - mm

Sr = resistant section = core area = $\frac{4}{\pi}$ Dn^2

Screew class	4,8	5,8	8,8	10,9	12,9
Rs · 0,7 (daN/mm^2)	22,4	28,0	44,8	63,0	75.6

Tab. 1

Example

Cross member 35 S 95
Max. permitted reaction (F) = 9500 da N
friction force between the plate and the chassis to prevent detachment: $\frac{F}{f} = \frac{9500}{0,3}$ = 31667 daN

using bolts with, for example, class 8,8 (0,7 · Rs = 44,8 daN/mm^2)

the result will be:

$$\text{Total resistant section } A = \frac{31667 \text{ daN}}{44{,}8 \text{ daN/mm}^2} = 706 \text{ mm}^2$$

To calculate the number of bolts required, divide the total resistant area by the resistant area for the bolt chosen.

Example

Ø x wheelbase	Sr (mm^2) see Ann. 1	A/Sr	n° Bolts required
M 12 x 1,25	92,1	7,66	8
M 14 x 2	115	6,13	7
M 16 x 2	157	4,49	5
M 18 x 1,5	216	3,27	4

Tab. 2

☞ Note

Obviously, the number of bolts must be greater than or equal to the first integer greater than the result of A / Sr.

As for the bolts' tightening torque, this is given in annex n° 1 in the form of a table which can be obtained from any bolt manufacturer and which shows the tightening moment (torque) for the bolts in the class chosen.

Example

Ø x wheelbase	Tightening torque (N · m)
M 12 x 1,25	90,6
M 14 x 2	135
M 16 x 2	205
M 18 x 1,5	308

Tab. 3

5.6- Unpacking the machinery and disposing of the packing

- Unpack the supplementary cross members.

- Divide the packing elements up to facilitate their disposal or recycling.

- If any elements are to be disposed of, this must be done in accordance with the regulations in force in the country of installation of the machine, taking into account the different kinds of material present.

5.7- Hoisting and handling the supplementary cross member

Note

When lifting, moving and handling al the heavy parts, always use a hoisting means whose capacity is greater than the load to be lifted.
Make sure all the parts are supported by the relative harnesses and use suitable hooks.
Make sure there is no-one in the vicinity of the load to be lifted.

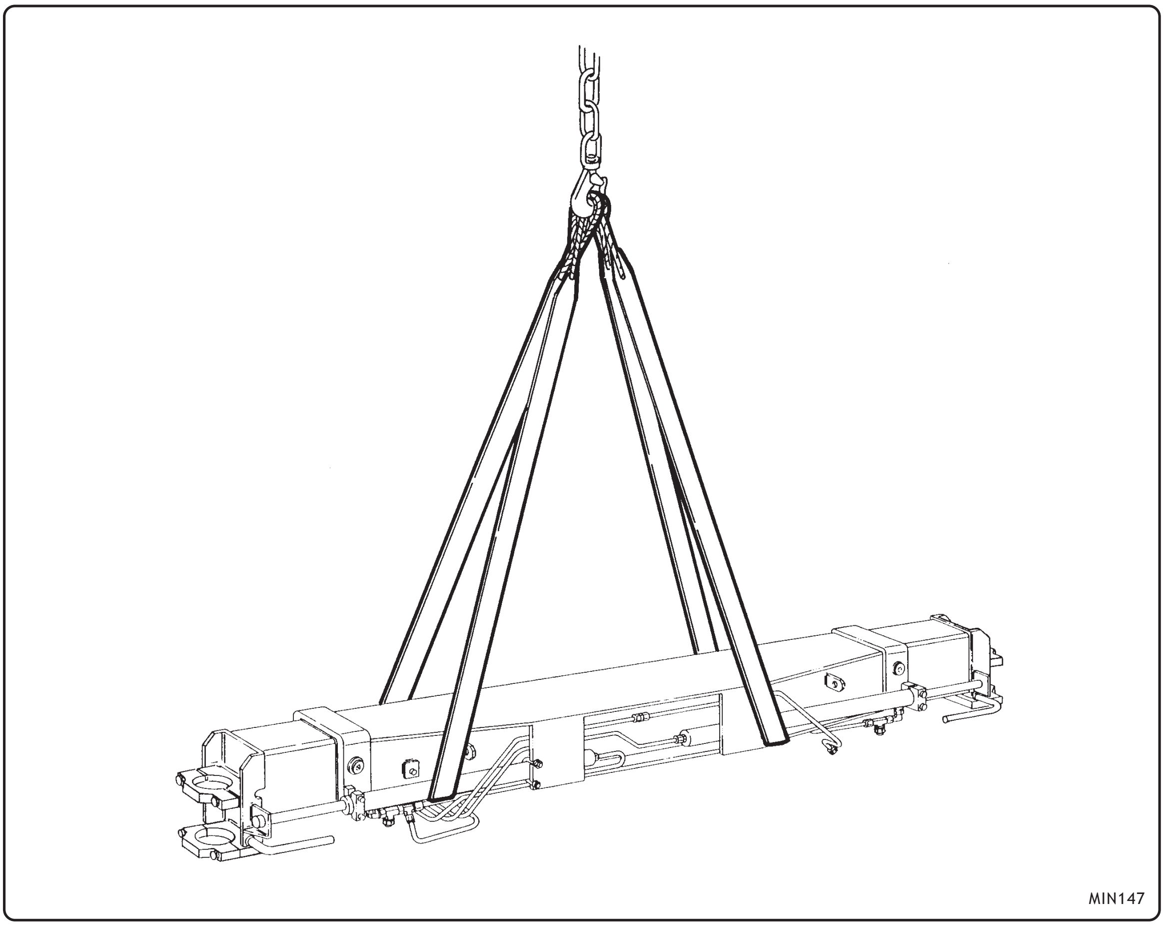


fig. 5.7.1

- Harness the machine with the band in the position shown in fig. 5.7.1.

- Lift the machine just off the ground to check it is properly balanced and move it keeping it close to the ground as possible.

5.8 - Model denominations

The cross member codename contains indications of its version and technical features.

The meaning of said figures is shown here under.

Example

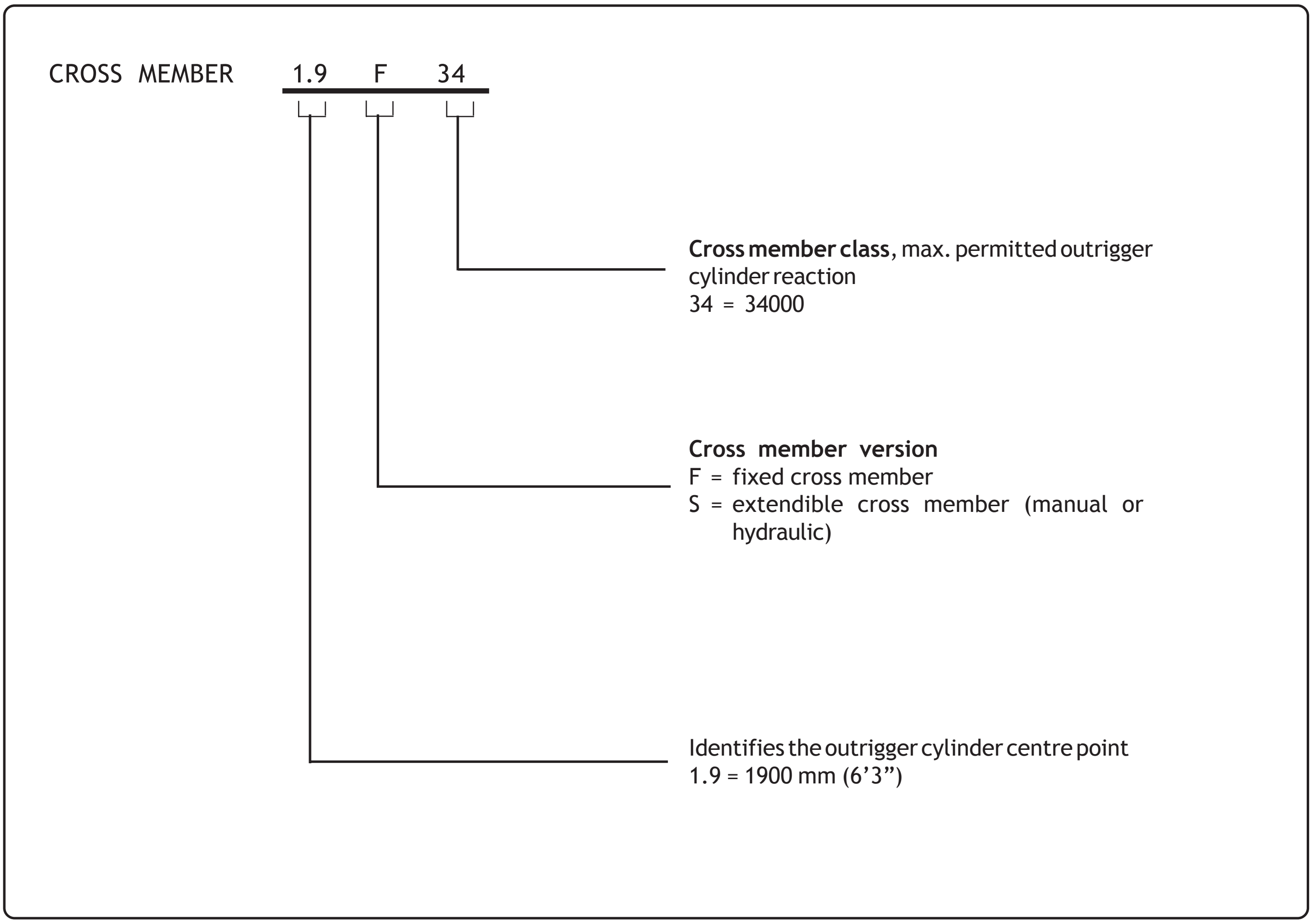


fig. 5.8.1

5.8.1- Outrigger cylinder coupling types

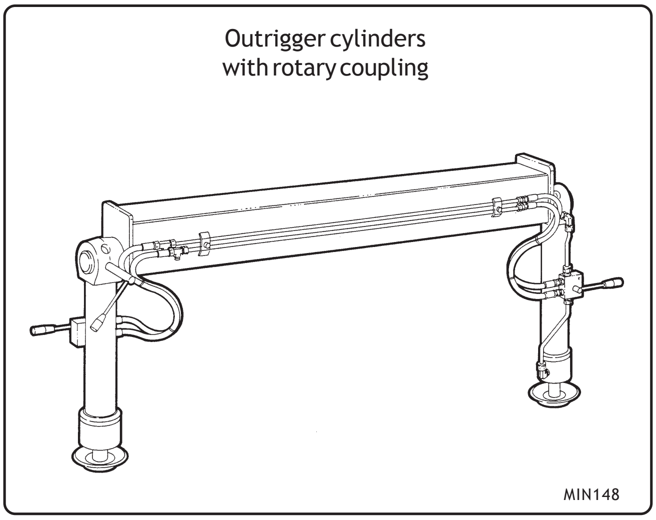


fig. 5.8.2

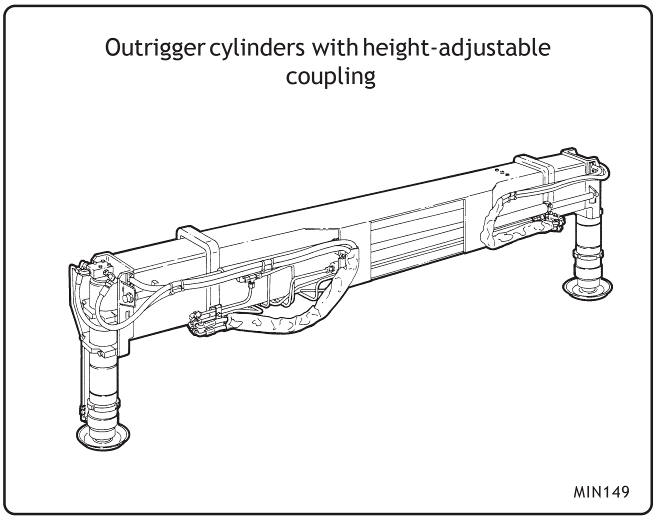


fig. 5.8.3

5.8.2- Mounting the outrigger cylinders with a rotary coupling

MIN150

fig. 5.8.4

- Extract the check pin "1" (to extract it you must first rotate it by 180° in relation to the lock position).
- Clean the outrigger pin "3" carefully.
- Coat the inside of the cylinder bushing with a suitable rust-proofing treatment.
- Slide the cylinder into the pin "3" and lock it into position with the snap ring "2".
- Reinsert the check pin "1".

5.8.3- Mounting the outrigger cylinder with a height-adjustable coupling

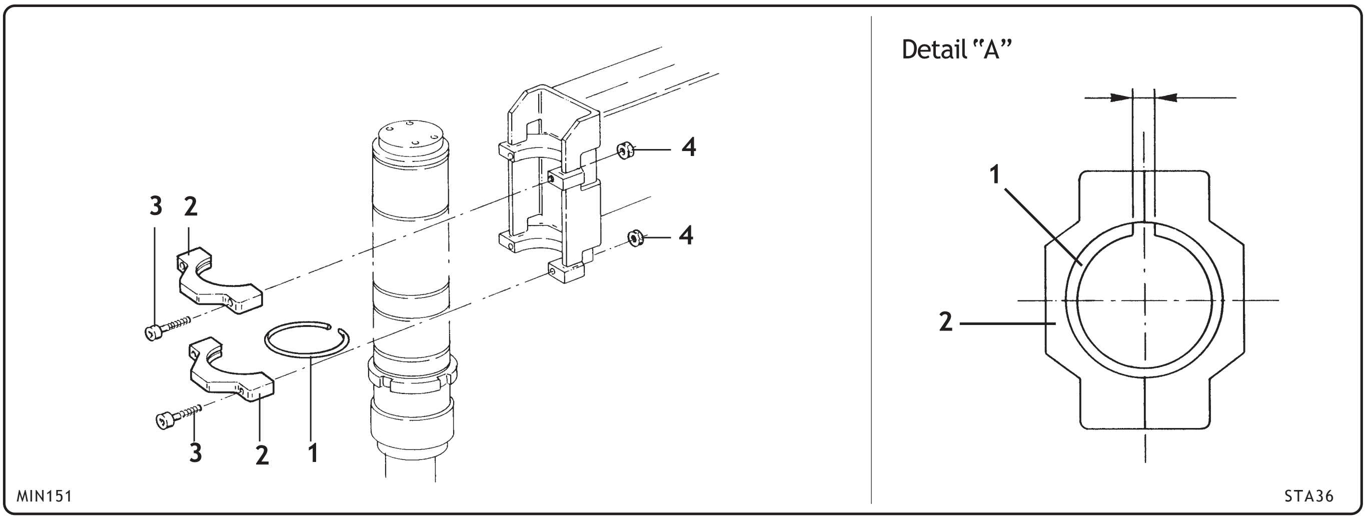


fig. 5.8.5

Once you have established the height the cylinder must be off the ground (see chapter 10, page 14/18), mount the snap ring "1" in the desired seating on the outrigger cylinder.

ATTENTION!!!

The snap ring "1" must always be inserted in the seating of the coupling flange 2".
The open section of the snap ring "1" must always be rotated by 90° in relation to its seating in the fastening flange (see detail A).

- Mount the cylinder.
- Mount the flange "2" wit the screws "3" and the nuts "4".
- Add a few drops of medium thread brake fluid.
- Tighten the screws "3" with a suitable tightening torque.

5.8.4- Mounting the extension and the cap

Please refer to chapter 10 for mounting and welding the extension bushings and the outrigger cylinder caps.

5.8.5- Hydraulic connections

When connecting the supplementary cross member to the hydraulic system, refer to the specific technical sheet for the correct connections.

5.8.6- Using the supplementary cross member

When using the crane with supplementary cross members, refer to the "Instructions and safety handbook".

- Annex 1 (for information purposes only)

MEAN STRESS "P" AND TIGHTENING TORQUE MOMENT "M" FOR SCREWS WITH ISO METRIC THREADING

A screw is tightened correctly when it is exposed to a mean axial stress which is slightly less than theto the elastic limit load.
To take this and the tangential tensions into account during start-up, we recommend you adopt a mean axial stress of 70% of the load at the minimum yield limit, multiplied by the screw's resistance class.
Then the mean axial stress is doing by the formula:

$$P = c \cdot Rs \cdot Sr \tag{1}$$

where:

P is the mean axial stress in N (newton)
c = 0,7 is the reduction coefficient
R s is the unitary yield load in N/mm²
S r is the resistant section of the screw in mm²

The great difficulty in checking the mean stresses generated on the tightened screws leads, in the majority of cases, to the desire to establish the corresponding tightening moments.

However, since approximately 90% of their value is only used to overcome the resistance of the friction between the surfaces in contact during the tightening procedure, these moments can assume remarkably different values, even when the mean stress is the same, when the state of the contact surfaces and the screwing method changes.

The following simple formula can be used to obtain the tightening moment:

$$M = \frac{K \cdot d \cdot p}{1000} \tag{2}$$

where:

M is the tightening moment in N·m
d is the nominal thread diameter in mm
P is the mean axial stress in N
K is the torsion coefficient

The torsion coefficient K depends on:

- the shape and size of the contact surfaces
- the friction coefficient of the contact surfaces
- the tightening methods

As a first approximate evaluation, apart from the increases or reductions specified later, in the case of screws similar to the standardised ones, the following value can be taken for K:

$$K = 0{,}21 \div 0{,}17 \tag{3}$$

Higher values for screws with smaller diameters, or for those with the same size diameter and heads with larger resting surfaces.
The table that follows provides the data for a number of diameters and wheelbases, the torsion coefficient K as well as the mean stresses P and the tightening moment M for various nuts and bolts categories.

The coefficient K and the corresponding moments M have been ascertained with a good level of accuracy for the following conditions:

- UNI 5737-65 type hexagonal-head screws, UNI 5931-67 type cylindrical-head countersunk hexagonal screws and UNI 6107-67 type cylindrical-head notched screws
- the friction coefficient has been taken as 0,14 and is valid for worked, blackened or oiled worked surfaces
- the tightening moment is applied slowly with dynamometric wrenches

For other conditions, with the same mean stress values, by varying the coefficient K, the tightening moments vary and can only be given approximately as follows:

- for UNI 5712-65 type hexagonal-head screws for metal structural work, M must be increased by 50%
- for galvanised screws, M must be reduced by 10%
- for cadmium-plated screws, M must be reduced by 20%
- if the screws are tightened using automatic battery-operated tightening means, M must be reduced by 10%

- Annex 2 (for information purposes only)

MEAN STRESS "P" AND TIGHTENING TORQUE MOMENT "M" FOR SCREWS WITH ISO METRIC THREADING

$$M = \frac{K \cdot d \cdot p}{1000} \qquad P = 0,7 \cdot Rs \cdot Sr$$

K is calculated by taking the coefficient for the friction between the contact surfaces as 0.14.

d x p	S_r	K	4 · 8		5 · 8		8 · 8		10 · 9		12 · 9	
			$0,7\ R_s = 224$		$0,7\ R_s = 280$		$0,7\ R_s = 448$		$0,7\ R_s = 630$		$0,7\ R_s = 756$	
mm	mm^2		P N	M mN	P N	M mN	P N	M mN	P N	M mN	P N	M mN
3 x 0,5	5,03	0,198	1130	0,67	1400	0,84	2550	1,5	3170	1,9	3800	2,3
4 x 0,7	8,78	0,195	1970	1,5	2500	1,9	3930	3,1	5530	4,3	6640	5,2
5 x 0,8	14,2	0,189	3180	3	4000	3,8	6360	6	8950	8,5	10700	10,1
6 x 1	20,1	0,192	4500	5,2	5600	6,5	9000	10,4	12700	14,6	15200	17,5
8 x 1,25	36,6	0,188	8200	12,3	10250	15,4	16400	24,6	23100	34,7	27700	41,6
8 x 1	39,2	0,185	8780	13	11000	16,3	17600	26	24700	36,6	29600	43,9
10 x 1,5	58	0,193	13000	25,1	16200	31,3	26000	50,1	36500	70,5	43900	84,6
10 x 1,25	61,2	0,191	13700	26,2	17100	32,7	27400	52,4	38500	73,6	46300	88,4
12 x 1,75	84,3	0,187	18900	42,4	23600	53	37800	84,8	53000	119	63700	143
12 x 1,25	92,1	0,183	20600	45,3	25800	56,6	41300	90,6	58000	127	69600	153
14 x 2	115	0,187	25800	67,4	32200	84,3	51500	135	72500	190	86900	228
14 x 1,5	125	0,183	28000	71,7	35000	89,6	56000	143	78800	202	94500	242
16 x 2	157	0,182	35200	102	44000	128	70300	205	98900	288	119000	346
16 x 1,5	167	0,179	37400	107	46800	134	74800	214	105000	302	126000	362
18 x 2,5	192	0,183	43000	142	53800	177	86000	283	121000	398	145000	478
18 x 1,5	216	0,177	48400	154	60500	193	96800	308	136000	434	163000	520
20 x 2,5	245	0,182	54900	200	68600	250	110000	400	154000	562	185000	674
20 x 1,5	272	0,177	60900	216	76200	270	122000	431	171000	607	206000	728
22 x 2,5	303	0,178	67900	266	84800	322	136000	532	191000	748	229000	897
22 x 1,5	333	0,174	74600	286	93200	357	149000	571	210000	803	252000	964
24 x 3	353	0,182	79100	345	98800	432	158000	691	222000	971	267000	1170
24 x 2	384	0,177	86000	365	108000	457	172000	731	242000	1030	290000	1230
27 x 3	459	0,182	103000	505	129000	631	206000	1010	289000	1420	347000	1700
27 x 2	496	0,178	111000	534	139000	667	222000	1070	312000	1500	375000	1800
30 x 3,5	561	0,182	126000	686	157000	857	251000	1370	353000	1930	424000	2310
30 x 2	621	0,177	139000	738	174000	923	278000	1480	391000	2080	469000	2490

MENU

POWER TAKE-OFF AND PUMP

6.1 - General

For crane control, various types of power take-off can be used.
The application can be as follows, depending on the type of use and performance required:

- on the gearbox (or on the torque distributor)
- on the transmission
- on the front of the engine
- on the rear of the engine.

For the various features and performance of these parts, consult the handbooks published by the manufacturer of the vehicles and the power take-off. Hereunder is some general advice about the installation of pumps and power take-off in case of absence of instructions by the vehicle manufacturers.

6.2 - Selecting the power take-off and pump

The correct choice of power take-off and pump is vital for the crane to work properly and perform as specified by the manufacturer. Below is the most practical method of selecting the power take-off to apply to the gearbox because it is the commonest method used for vehicle-mounted cranes.

The first points to consider are:
1) the type of vehicle on which the crane is to be mounted and the features of the gearbox and power take-offs available;
2) the oil flow rate **Q** and pressure **p** required by the crane; (see the technical specification sheet).

Once the installer has obtained the rate of the oil flow to the distributor and the maximum working pressure he must now mount a suitable pump (with characteristics in line with the power take-off and vehicle gearbox).
First determine the vehicle engine speed, e.g.: 800 - 1000 r.p.m = $\mathbf{N_1}$ obtained by adjusting the engine speed accordingly.
The power take-off transmission ratio is the ratio between the number of revs of the power take-off shaft $\mathbf{N_2}$ and that of the engine $\mathbf{N_1}$.
Since each gearbox can be coupled with several types of power take-offs, each with a different transmission ratio

RpTO = $\frac{N_2}{N_1}$, select the one giving a speed $\mathbf{N_2}$ between the limits recommended by the pump manufacturer (the standard version is usually preferable for reasons of costs and availability).

It is very important to check the crane's power absorption and correct the transmission rate in order to obtain power take-off in the operating field controlled by the engine, avoiding low speeds (less than 800 r.p.m.) which might cause irregular operation.

Example:

N2 = N1 · RpTO

RpTO \ N_1	800	1000
1:0,8	640	800
1:1	800	1000
1:1,3	1040	1300

Tab. 1

It is necessary to check compliance with the maximum values for the vehicle and power take-off.
All the calculations and checks so far can be simplified using the diagrams supplied by the pump manufacturer (see fig. 6.2.1).
If you enter the number of r.p.m. and the flow rate **Q** in the diagram, you can determine the type of pump.
If you trace a horizontal line to the relevant pressure, this gives the absorbed power, which must be less than the available power.
As an example let us use the diagrams for selecting a pump with axial pistons.

Data
The vehicle engine is used at N_1 = 1000 r.p.m.
The power take-off is selected according to the requirements (rear, lower or side doors, etc.) the number of revs. and the cost. Let us assume a power take-off with a ratio RpTO = 0.8, ignoring the output for the moment.

N2 = 800 r.p.m.

The crane requires:

Q = 30 l/min
p = 250 bar

Max power that can be transmitted by the power take-off (Nmax) = 22 kw (30 HP)

By using the diagrams, it is possible to determine:
- pump selected = Model type 3.1.6.1.037.1.0.0
- power absorbed = 17 HP<30 HP (N max)

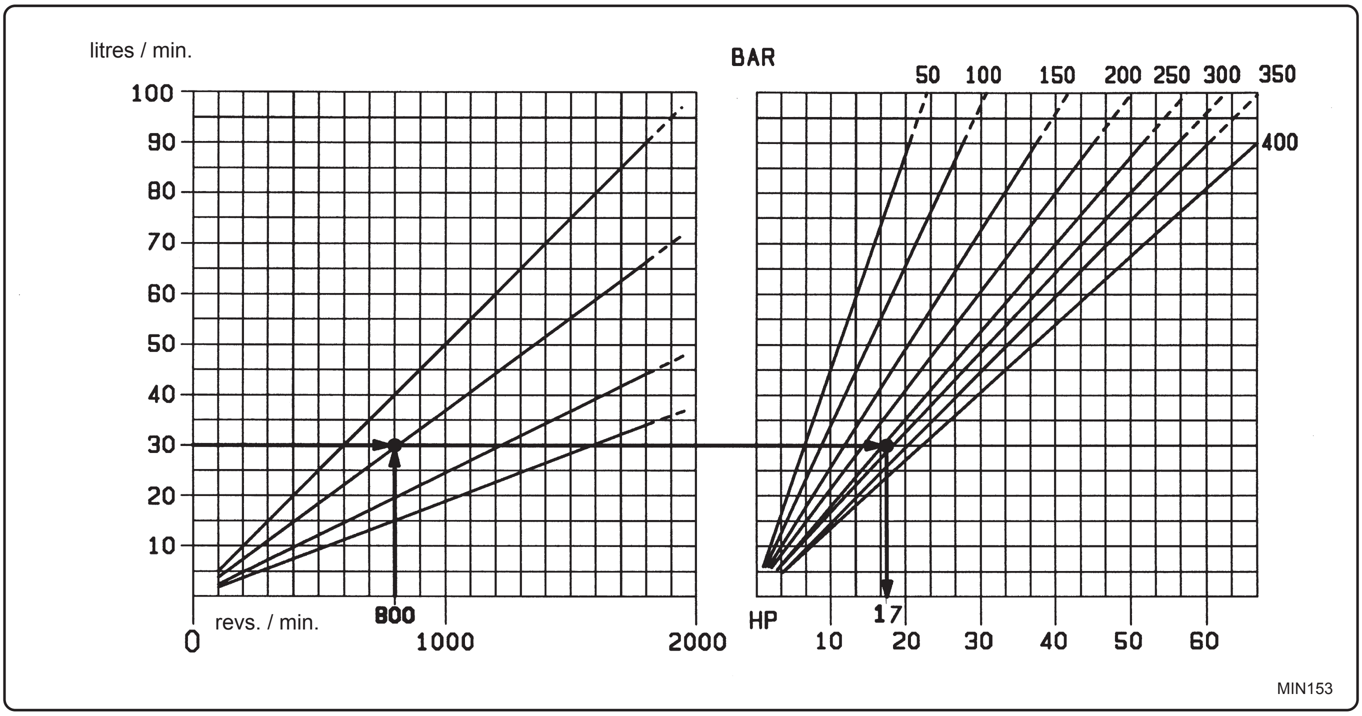


fig. 6.2.1

6.3 - Pumps

6.3.1 - General

It is extremely important to choose the correct pump to install since as the pump has moving parts it is one of the first of the system's components to wear.

The reliability of the machine with the passing of time depends on correct choice of pump.

This chapter furnishes the system designer with a guide to the choice of pump and also the sizing of the parts of the system that could be affected by the pump.

6.3.2 - Operative parameters

The following pages show the pump's main operating parameters.

Speed

the pump's shaft speed is usually governed by the primary engine and the power take-off. If you can select the speed, it is better to remain within the field in which the pumps work best.

Extreme limits governed by the following factors

- the minimum speed limit is governed by the volumetric efficiency (which is reduced as the speed decreases);
- the maximum speed is governed by the limits of the air intake valves (when the speed is excessive the pump cavitates).

Optimum field: 700 ÷ 1300 r.p.m.

Pressure

In the pumps, the usual extreme limits caused by the pressures of use are governed by the working life of the conical bearings which bear the thrust of the pistons. If the maximum limits are exceeded there is a risk of rapid structural yielding.

When sizing a system, you are advised to follow the selection criteria below:

- the normal operating pressure must be less than **p1**, i.e. the pump's maximum continuous operating pressure;
- the calibration pressure of the max pressure valve, which is the overload pressure, must be less than **p2** (pump's maximum intermittent operating pressure); the max. pressure valve can only be calibrated within the system at the value **p2** if the overloads are not too frequent (see figure 6.3.1) otherwise calibrate the valve at **p1**.

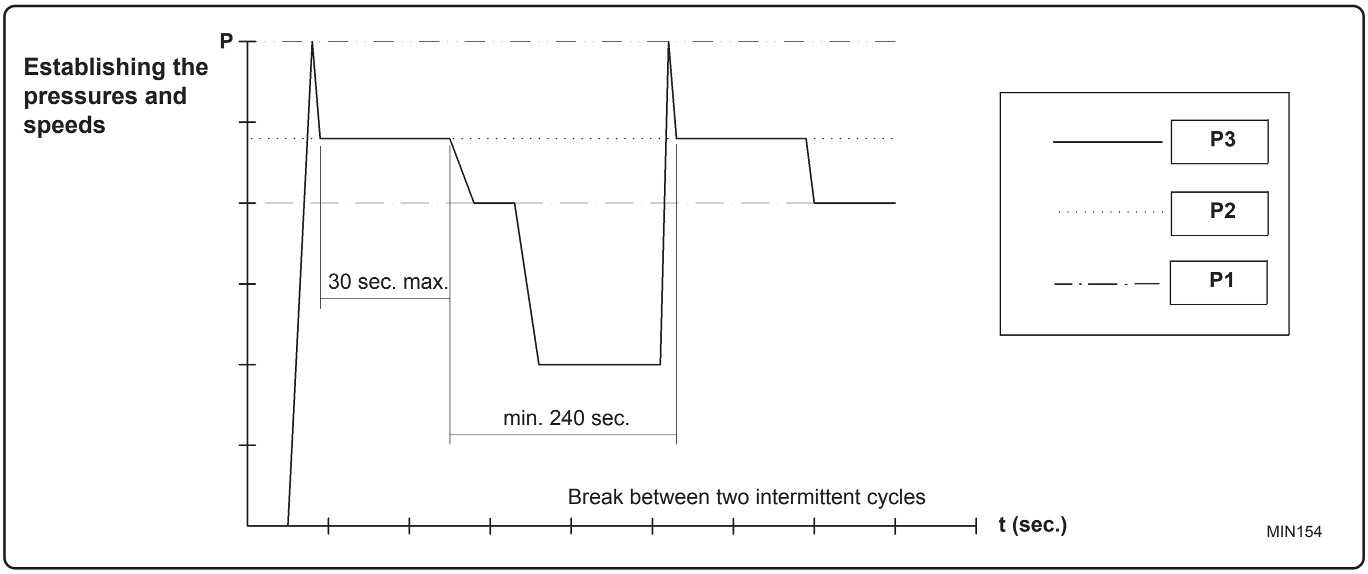


fig. 6.3.1

Establishing the pressure values p1, p2 and p3

p1 Continuous operating pressure.
p2 Max. intermittent operating pressure (max. 30 sec). This pressure is the maximum at which the valve can be calibrated.
p3 Max. peak pressure. If the maximum valve (calibrated at p2) intervenes, there is generally a pressure peak which will weaken after a short while.

Speed

n1 Speed that can be maintained in continuous operation (max. pressure is p1).
n2 Max. speed that can be reached with intermittent operation (max. 30 sec) (max. pressure is p2). Consecutive intermittent cycles must have intervals of at least 240 sec.
n3 Maximum speed that can be reached with intermittent operation (max. 30 sec) unloaded (max. pressure is 30 bar).
n4 Minimum speed that can be maintained with intermittent operation (max. 30 sec) (max. pressure is p2).

6.3.3 - Piston pump efficiency levels

The efficiency levels given in the catalogue are obtained from tests run on new pumps in optimum conditions (50 °C). In actual fact, these depend on the operating conditions and factors linked to wear. Therefore, during the design phase, you should use precautionary values which take into account the negative situations that could occur in reality.
The following tables provide a line indicating the typical performance values, how they vary and the safety values to use in the formulas.

- **Volumetric efficient (hv)**
  This is normally given in the catalogue, and depends on the rotation speed and the pressure.

  Value in optimum conditions: > 0.95.

  Variations
  - increases (greatly) as the number of r.p.m increases;
  - decreases as the operating pressure increases;
  - increases as the temperature of the hydraulic fluid used decreases;
  - decreases as the pump is used.

  Formula values

Below 700 r.p.m	=>	0.88
700 ÷ 1500 r.p.m	=>	0.92
over 1500 r.p.m	=>	0.95

- **Mechanical efficiency (hm)**
  This is fundamental for the calculation of the torque and the absorbed power (formula 4, para. 6.4).

  Value in optimum conditions: > 0.90.

  Variations
  - decreases slightly as the number of r.p.m increases;
  - decreases greatly as the viscosity of the hydraulic fluid used increases (temperature decreases).

  Formula values

used cool	=>	0.85
used normally	=>	0.90

- Total efficiency (ht)

Since this is the product of the fist two, the total efficiency is highly variable depending on the operating conditions, and so we recommend you not to use it, as you risk errors in accuracy.

In fact, the field of variation is 0,83 ÷ 0,90

If you do wish to use it (formula 5, para. 6.4), to be as accurate as possible, use the value 0,85.

6.3.4 - Gear pump efficiency levels

Speed

The shaft speed is usually governed by the primary engine. If you can select the speed, it is wise to remain within the field in which the pumps work best.
For extremely high or low speeds, never exceed the max. limits and always bear in mind the type of use the pump is being put to, optimising the choice of oil accordingly. The table below provides data to help you make your selection.

Field	Type of use / advice
300 ÷ 750	Minimum speed field: intermittent use applications or those with low pressure levels, with light-duty and non-continuous use (tip-ups, light-weight side panels). At low speeds (below 600r.p.m) gear pumps have good volumetric efficiency levels, however, the effect the oil of the dynamic subsistence is reduced and the wear accelerates. To counteract this effect, keep a minimum viscosity level of 40-50 cSt. For continuous use with medium to high pressure levels, we recommend you use a piston pump.
750 ÷ 1300	Medium to low field: this field is typical of industrial vehicles: for continuous use with medium to high pressure levels and medium-duty use (buckets, light cranes).
1300 ÷ 1800	Optimum field: continuous use even with high pressure levels and heavy-duty use with overloading acceptable (cranes and medium buckets with frequent use and industrial systems).
Over 1800	Maximum speed field: continuous use with high pressure levels and limited overloading; there is a risk of cavitating and overheating so the suction line must be oversized and the temperature of the system must be checked, keeping the oil viscosity at between 14 and 20 cSt.

Pressure

Gear pumps can operate with high pressure levels, however, it is wise to remember that, like with all hydraulic pumps: **the greater the pressure, the shorter the working life of the pump.**
Listed below are the criteria used to carry out these checks.

- The normal operating pressure must be below **p1**, i.e. the pump's maximum continuous operating pressure;
- the maximum valve calibration pressure (i.e. the overload pressure) must be lower than **p2** (pump's maximum intermittent operating pressure). The maximum pressure valve can only be calibrated at **p2** if the overloads do not last longer than 20 seconds, otherwise the valve must be calibrated at **p1**.

If the pressure levels exceed the gear pumps' maximums, you must change to piston pumps, which can bear higher pressure levels.

Efficiency

The efficiency levels given in the catalogue are obtained from tests run on new pumps in optimum conditions (oil with viscosity level 30 cSt). In actual fact these depend on the operating conditions and factors linked to wear. Therefore, during the design phase, you should use precautionary values which take into account the negative situations that could occur in reality.
The following tables provide a line indicating the typical performance values, how they vary and the safety values to use in the formulas.

- **Volumetric efficient (hv)**

  This is normally given in the catalogue, and depends on the rotation speed and the pressure.

  Value in optimum conditions: > 0.95.

  Variations
  - increases (greatly) as the number of r.p.m increases;
  - decreases as the operating pressure increases;
  - increases as the temperature of the hydraulic fluid used decreases;
  - decreases as the pump is used.

  Formula values

Below 700 r.p.m	=>	0.88
700 ÷ 1500 r.p.m	=>	0.92
over 1500 r.p.m	=>	0.95

- **Mechanical efficiency (hm)**
  This is fundamental for the calculation of the torque and the absorbed power (formula 4, para. 6.4).

  Value in optimum conditions: ~ 0.90.

  Variations
  - decreases slightly as the number of r.p.m increases;
  - decreases greatly as the viscosity of the hydraulic fluid used increases (temperature decreases).

  Formula values

used cool	=>	0.90
used normally	=>	0.95

- **Total efficiency (ht)**
  Since this is the product of the fist two, the total efficiency is highly variable depending on the operating conditions, and so we recommend you not to use it, as you risk errors in accuracy.

  In fact, the field of variation is 0,83 ÷ 0,93

  If you do wish to use it (formula 5, para. 6.4), to ensure as greater accuracy as possible, use the value 0,88.

6.4 - Selecting the pump

Fundamental formulas
The following formulas (and the key to the symbols used therein) are normally used to select the pump.
The use of the formulas will be illustrated in the paragraphs that follow this chapter.

Key to symbols

V	=	Pump capacity	(cm^3/rev.)
M	=	Absorbed torque	(Nm)
Q	=	Rate of flow	(l/min)
N1	=	Engine revolution speed	(r.p.m.)
RpTO	=	Transmission ratio	
N2	=	Pump revolution speed	(r.p.m.)
Δp	=	Pressure	(bar)
W	=	Absorbed power	(kW)
ηt	=	Total efficiency	(%)
ηv	=	Volumetric efficiency	(%)
ηm	=	Mechanical efficiency	(%)
d	=	Internal pipe diameter	(mm)
v	=	Oil flow speed inside pipe	(m/s)

Pump revolution speed (see para. 6.2)
N2 = N1 · RpTO

Capacity/displacement
Formula (1) expresses the capacity delivered by a pump whose displacement and speed are known; formula (2) expresses the displacement required to produce a capacity, when the speed is known:

(1) $$Q = \frac{V \cdot N2 \cdot \eta_v}{1000}$$

(2) $$V = \frac{Q \cdot 1000}{N2.\ \eta_v}$$

Torque
Formula (3) expresses the toque absorbed by the shaft of a pump in use depending on the pressure.

(3) $$M = \frac{V \cdot \Delta p}{20 \cdot \pi \cdot \eta_m}$$

Mechanical power
Formulas (4) and (5) both express the power absorbed by the pump shaft when the pressure and speed are known.
Formula (6) establishes the total efficiency to be used in formula (5).

(4) $$W = \frac{V \cdot \Delta p \cdot N2}{600000 \cdot \eta_m}$$

(5) $$W = \frac{Q \cdot \Delta p}{600 \cdot \eta_t}$$

with **(6)** $\eta_t = \eta \cdot \eta_m$

Speed in the piping
Formula (7) provides the speed of the fluid when the capacity an diameter of the pipe is known; formula (8) on the other hand, provides the capacity when the speed and the diameter are known:

(7) $$V = \frac{200 \cdot Q}{3 \cdot \pi \cdot d}$$

(8) $$Q = \frac{3. \pi . d^2 . v}{200}$$

6.5 - Calculation examples

Data

Motor rotation speed = 1000 r.p.m.
RpTO = 1 : 1,4
Capacity required = 90 l/min
Maximum operating pressure = 290 bar

Pump rotation speed:
N2 = RpTO · N1 =1000 · 1,4 = 1400 r.p.m

Preliminary displacement calculation:
from (2), you can obtain

$$V= \frac{90 \cdot 1000}{1400 \cdot 0,95} = 67,7 \text{ cm}^3\text{/turn}$$

Efficiencies: $\eta v = 0,95$ $\eta m = 0,85$
Pump selected: PE 70W (68,1 cm^3/t. ,p1 max. = 330 bar)

Checks

Effective capacity with (1)
$$Q = \frac{68,1 \cdot 1400 \cdot 0,95}{1000} = 90,51/min$$

Absorbed torque: with (4)
$$M = \frac{68,1 \cdot 290}{20 \cdot \pi \cdot 0,85} = 370 \text{ Nm}$$

Absorbed power: with (5)
$$W = \frac{68,1 \cdot 290 \cdot 1400}{600000 \cdot 0,85} = 54,2 \text{ kW}$$

Note

Make sure the capacity is compatible with the system requirements and the power take-off can transmit the torque and power.
If this is not the case, select a pump with a smaller displacement rate or change the power take-off. Whichever measure you take, always repeat the calculations.

6.6 - Installing the power take-off on the gearbox

Installing the power take-off on the gearbox requires extreme care. If the job is done roughly, the vehicle may get seriously damaged in the gearbox. Always take the following precautions:

1) empty the gearbox of oil and remove the cover;
2) mount the U-bolts on the gearbox and tighten. If the gearbox has through threads, check that the U-bolts do not interfere with the gearing inside. Apply a sealant to the thread of the U-bolts;
3) backlash between the teeth of the gears and the power take-off must be 0.15 - 0.35 mm. This is done by inserting gaskets between the cover and the power take-off box (max. 4 gaskets together).
   The backlash can be regulated by running the engine briefly to listen for any noise as follows:
   - grating (too tight with no backlash)
   - knocking (too much backlash).
   Modern P.T.Os have special openings (inspection holes) so that backlash can be checked visually.
4) Secure the power take-off tightly using safety washers and loctite. Generally the driving torque is 2.4 kgm (22-25 Nm) for M8 threads, 5 kgm (45-50 Nm) for M10 and 8 kgm (70-75 Nm) for M12.
5) Top up the oil in the gearbox. Top up the gearbox oil level considering the higher amount of oil caused by the addition of the power take-off.

6.6.1 - Limitations

The P.T.O shafts only transmit torsional stress, which means that cardan shafts connected to them should be equipped with sliding grooved joints to prevent axial thrust.
Do not mount pulleys or gears because they would cause equally hazardous radial loads.

6.6.2 - Final check

On completion of the installation, including topping up the oil, start the engine to check operation of the power take-off: oil seal, engaging, disengaging and noise, which must be within acceptable limits although it may increase as the oil temperature rises.
Check the nuts are tight after initial operation.

6.7 - Power take-off - special cases

- 4- or 6-wheel drive vehicles

You can apply the power take-off directly to the relative output on the torque distributor.
In this case you must always remember that the number of output revotutions generated by the power take-off can be selected by engaging the most suitable gear.

- Vehicles with torque converter

You can use the same power take-offs as those used with normal gearboxes.
When the engine is performing less than 60% of its maximum number of revolutions, the converter is operating on a hydraulic basis; this means that, depending on the power absorbed, the number of revolutions of the power take-off may vary despite the number of engine revolutions remaining constant.

- Vehicles without an adapter on the gearbox for power take-off

In vehicles without an adapter on the gearbox for the power take-off, the crane's hydraulic systems can be powered in two ways:
- with an electro-hydraulic unit connected to the vehicle battery (see fig. 6.7.1);
- with power take-off from the engine (see fig. 6.7.2).

Operation by means of an electro-hydraulic unit is the standard method for cranes of small size and lifting capacity, considering the high absorption and the electric power available.
If you need more powerful batteries or you have to install extra ones, check the ability of the alternator on the vehicle to recharge them. Install more powerful alternators, if necessary.
If you are installing an electric pump, the crane must be transformed by providing electrical activating clearance devices on the control valve block.
Owing to the high absorption of the electric pump assembly, keep the engine running while using the crane to keep the battery sufficiently charged.

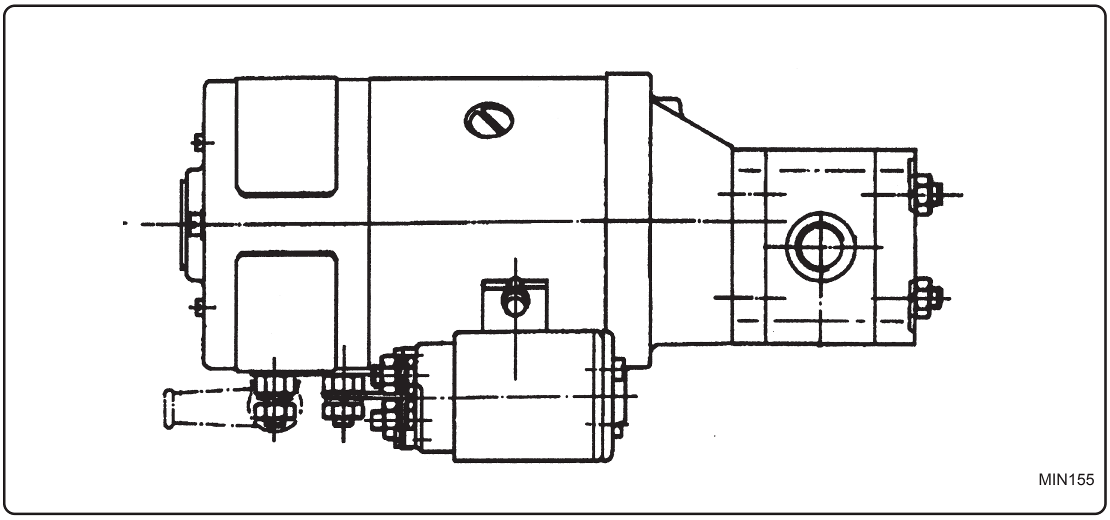


fig. 6.7.1

In the case of power take-off from the engine, it is necessary to have the power take-off on the front part of the drive shaft and, by means of belt transmission, transmit the said power to the electro-magnetic clutch unit on which a gear pump is fixed (fig. 6.7.2).

In light of the fact that the application of the device must be assessed on each occasion depending on the type of vehicle and the space available in the engine compartment, at this point we can only offer a number of hints and recommendations to be considered during the various installation phases.

a) The pump and coupling must be connected directly to the engine block using a system enabling adjustment of the reciprocal positions.
b) Do not reduce the structural resistance of any elements that may have been modified (cross member, bumpers, etc.).
c) The radiator must maintain its original heat dispersion capacity.
d) When using cranes over long periods, pay particular attention to the engine cooling liquid and oil temperature. If necessary, fit additional heat exchangers.
e) Power take-off from the drive shaft must be done using flexible systems so as not to transmit anomalous vibrations to the shaft.
f) In particular, reduce to a minimum projection of the drive pulley with respect to the 1st support of the motor.

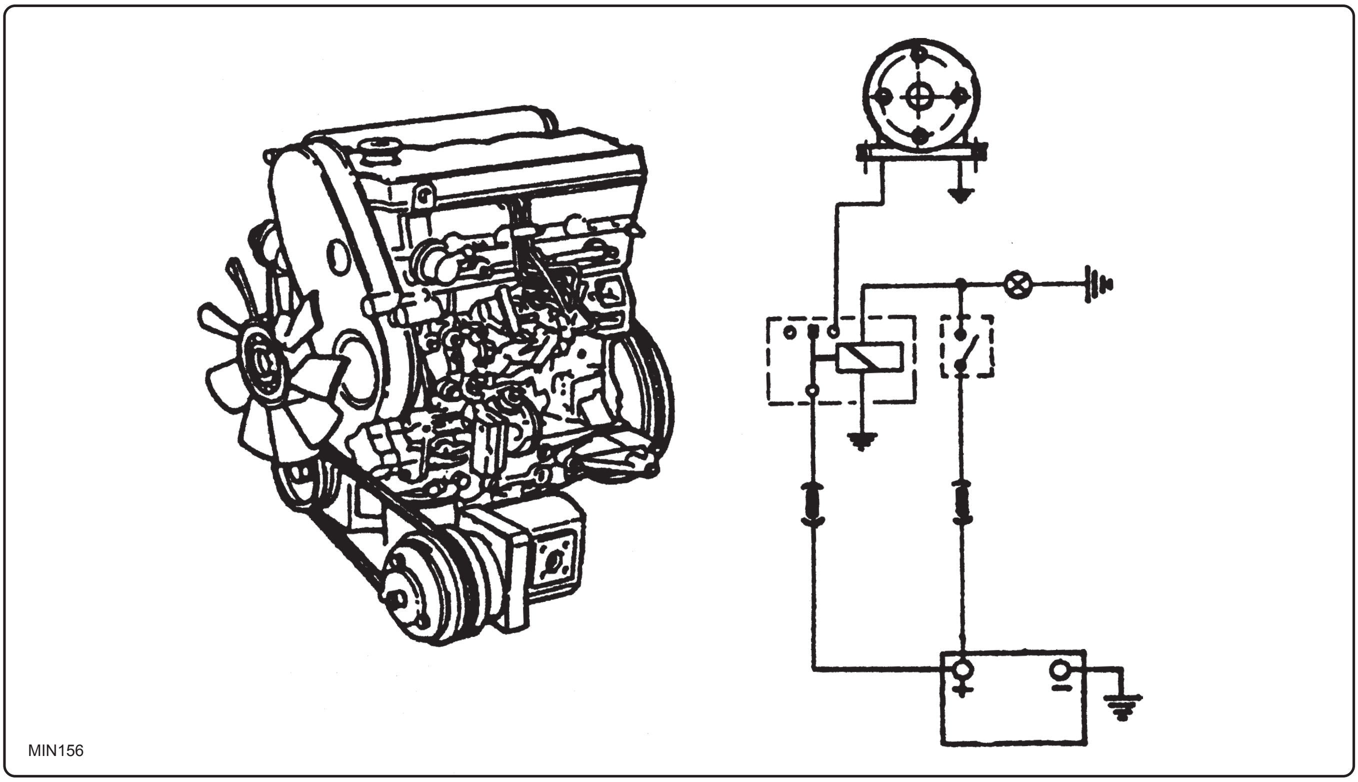


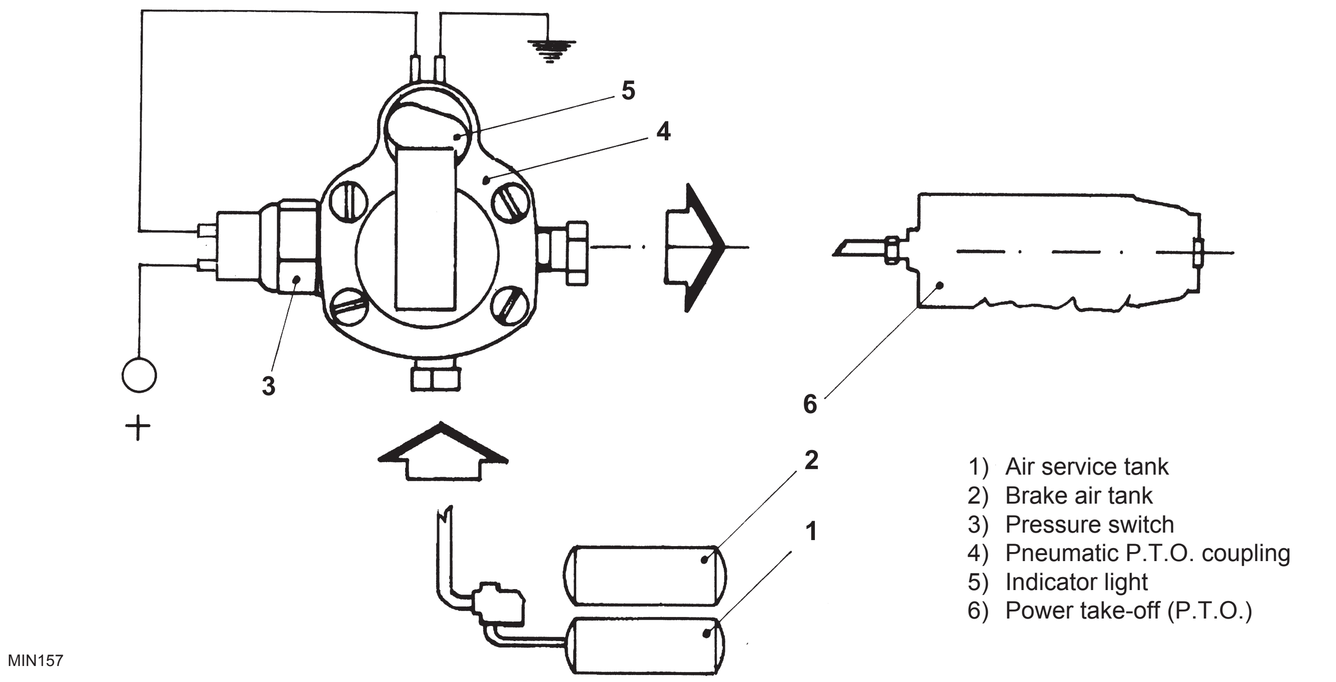
fig. 6.7.2

6.8 - Pneumatic power take-off coupling

The pneumatic deviator must be situated in the cab near the control panel.
When the power take-off is on, a light must be clearly visible to the driver (fig. 6.8.1).
Pneumatic connections must be made with extreme care, using coupled unwelded pipes to prevent air leakage, which might affect other services (for instance the brakes).
The inside of the new pipes must be cleaned thoroughly inside before being used (e.g. by blowing hot air into them with an air compressor).
Always respect the safety distance relating to moving parts and heat sources.

Note

After any work has been carried out on the system or the equipment, the brake system must be checked to ensure it is operating correctly.



1) Air service tank
2) Brake air tank
3) Pressure switch
4) Pneumatic P.T.O. coupling
5) Indicator light
6) Power take-off (P.T.O.)

fig. 6.8.1

The air must always be taken from the service tank.

Do not touch the braking system under any circumstances!!!

6.9 - Mechanical coupling of the power take-off

The lever and support for the flexible cable must be fitted in the cab behind the driver's seat (fig. 6.9.1).

Make sure you position the cable properly so that it runs freely inside the sheath.

1) Coupling lever
2) Flexible cable
3) Power take-off

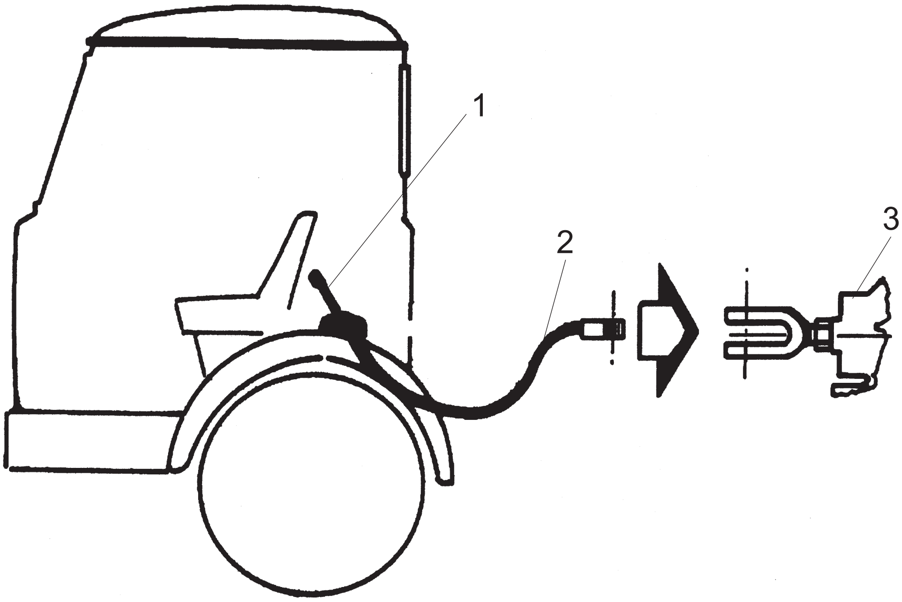


fig. 6.9.1

6.10 - Installing the pump

There are two types of application when installing the pump onto the truck.

1) Package-type pump flange-coupled directly onto the P.T.O (see fig. 6.10.1).
   This can be done when there is sufficient space near the gearbox, the vehicle is not for off-highway use and the gearbox is able to withstand vibration caused by the power take-off and the pump which are mounted not in line. Refer to the power take-off manufacturer for details.

ATTENTION!!!

For the power take-offs, keep to the torque values specified by the manufacturer.
For prolonged use, make sure the gearbox oil temperature does not exceed 120 °C and the water temperature 100 °C.
Not all types of power take-offs available are suitable for continuous use. Always follows the manufacturer's recommendations (running times, off-times, etc.).

Note

To prevent cavitation, the pump must always be mounted below the minimum oil level in the tank.

1) Power take-off
2) Pump

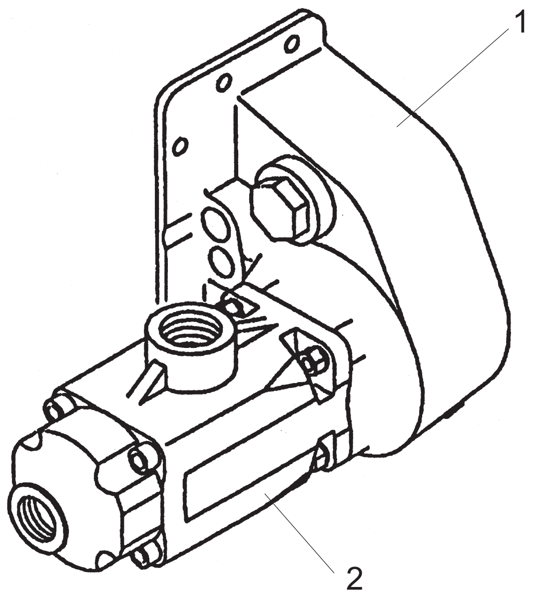


fig. 6.10.1

2) Pump fitted with interposition of a cardan shaft (see fig. 6.10.2).
   In this case, a pump is flanged onto a support fixed to the counter-chassis and connected to the power take-off with a cardan shaft fitted with coupling flanges, keeping to the manufacturer's recommended angle and min. - max. r.p.m. This type of installation must be used when there is not enough space for the first type or installation, when the vehicle is used for heavy-duty operation or the gearbox is unable to withstand the weight of the package-type application (pump and power take-off weighing on the gearbox).

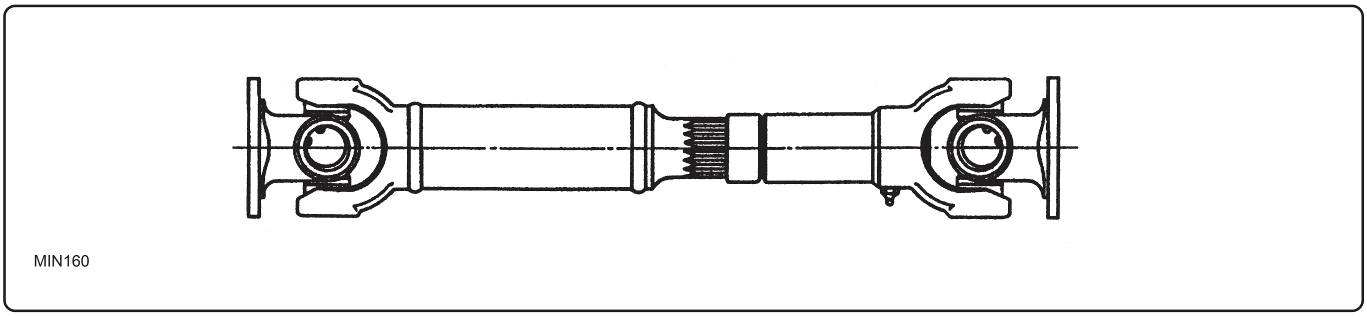


fig. 6.10.2

Incorrect installation of the cardan shaft may shorten the life of the shaft itself and also that of the power take-off and pump.

Note

For the safety of the operator, use cardan shafts with protective devices fitted to their joints.

To use the cardan shaft properly, the angles of the two end joints must be the same, they must not exceed the maximum recommended angle, and the joints must be synchronised (see fig. 6.10.3).

In short:
- suspend the pump on the counter-chassis, tilting it at the same angle as the gearbox to the chassis;
- check that the forks at the ends of the cardan shaft are on the same plane.

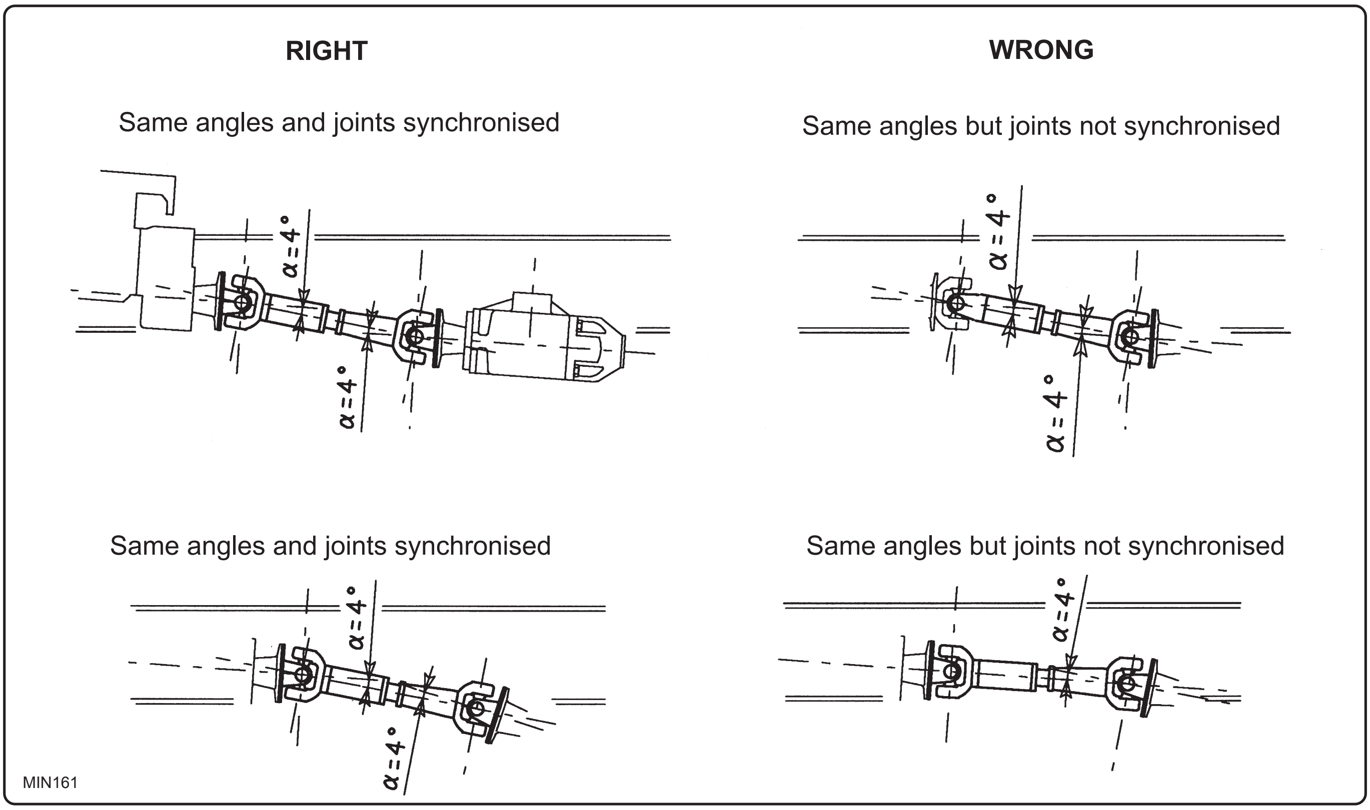


fig. 6.10.3

6.10.1 - How to start up piston pumps

When starting systems with piston pumps, there may be an uneven oil flow. In this case, proceed as follows:
- turn the pump at 1000 -1200 revs for one minute without pressurising the circuit;
- turn off the pump for a few minutes;
- repeat the operation until the delivery flow settles down.

If it is difficult to release the air, undo the plug at the top to help the air escape.

If the oil temperature is particularly low, run the pump empty for a few minutes before executing a work cycle to warm the oil up.

6.10.2 - Regulating the engine speed for power take off

In power take-off applications, depending on the type of crane and its use, it may in certain cases be necessary to use injection pump regulators with particular characteristics.

When the crane needs to run at certain engine speeds, irrespective of the power required, it is necessary to use all speed regulators with an additional hand accelerator.

MENU

HYDRAULIC SYSTEM AND GREASING

7.1 - General

Hydraulic oil must be used, with anti-emulsifiers and anti-wear additives at the recommended viscosity levels (see para. 7.4.1 - Selecting the hydraulic oil).

The oil temperature should never exceed 75 °C otherwise a heat exchanger must be installed.

It is very important to keep the crane's hydraulic system clean (see para. 7.4.2).

Whenever you remove any hydraulic components, keep the openings closed to prevent dirt getting in and do not weld or grind near the disassembled components.

ATTENTION!!!

Do not use filters on the intake.

It is advisable to install the tanks in such a way that that the oil level gauges are clearly visible.

If the tanks are made of plastic follow these instructions when mounting the intake system:
- for tanks with a cock installed, you must avoid any rotation of the cock body, using a spanner to hold the pump's intake pipe (or any other intermediary elements e.g. union elbows) in place during the assembly;
- apply a suitable sealing product to the threads to guarantee the hydraulic seal: mount the union elbow "1" and/or the cock "2" on the tank, using a spanner to prevent the union "3" rotating. In any case, never exert a greater tightening torque than 30 Nm on the union elbow and/or cock.

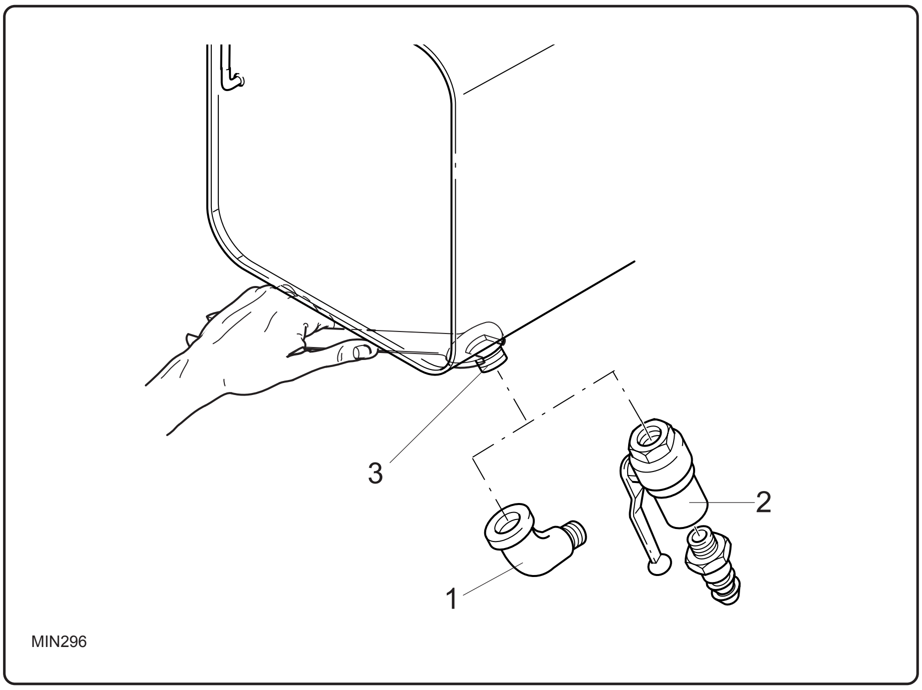


fig. 7.1.1

The intake pipe must also be fastened in such a way as to prevent the flexion or vibrations transmitted by the pipe being discharged into the tank, otherwise it could suffer irreparable damage and start leaking.
The intake pipe must always be located below the minimum oil level.

ATTENTION!!!

Take special care when connecting the intake pipe to the tank cock and use a spanner to prevent the pipe rotating.

As for hydraulic piping, the connection of the pump and tank to the crane must be done with proper pipes.

It is necessary to clean the pipes and the relevant connections with compressed air before fixing them to the hydraulic system.

7.2 - Intake and delivery piping sizing

The sections of the pipes used must be suitable for the rate of flow specified by the crane manufacturer in the technical specifications sheet and in the “Instructions and Safety Warnings” handbook and they also in relation to the average oil flow rate.
To avoid cavitation in the intake pipes, we recommend you keep to the pipe diameters indicated in the chart below.

Flow rate (l/min.)	(inches) Internal pipe diameter (mm)	
0-17	3/4”	19
18-30	1”	25
31-45	1¼”	32
46-65	1½”	38
66-120	2”	50

Tab. 1

To calculate the dimensions of the intake piping, you can also use the alignment chart (fig. 7.2.1).

Note

The average oil flow speed in the oil piping must be kept between the following values:
- DELIVERY pipes = 3 - 6 m/sec
- INTAKE pipes = 0,5 - 1,5 m/sec (depending on the pump construction).

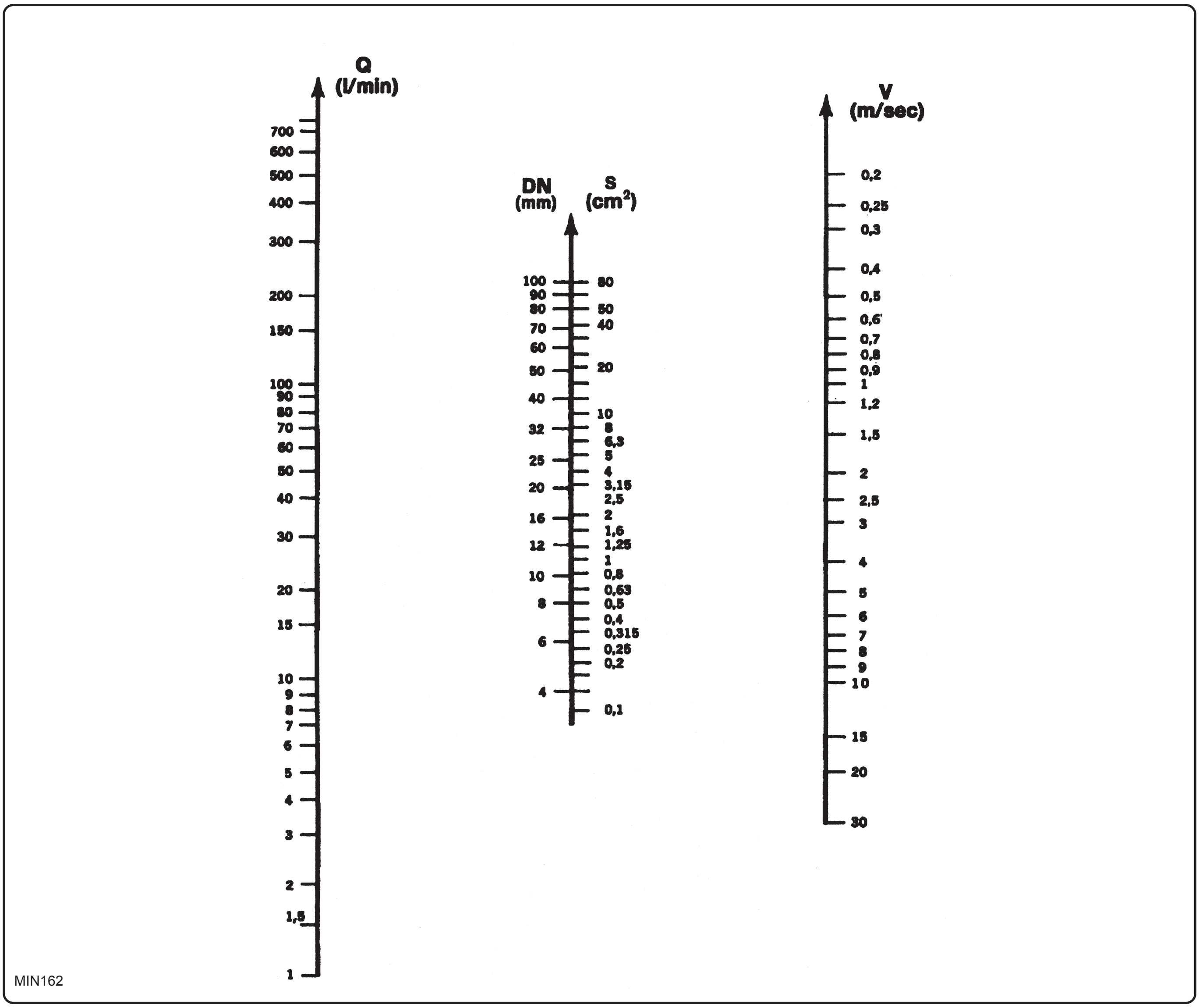


fig. 7.2.1

Alignment chart for determining the nominal diameter of the pipe using the flow rate and speed.

$S = \frac{Q}{6 \cdot V}$ (cm²)

where:

S = pipe section (cm²) = $\frac{\pi . Dn^2}{4}$

Q = rate of fluid (l/min)
V = fluid velocity (m/sec)
Dn = nominal pipe diameter (inside ø mm)

7.3 - Mistakes to avoid when positioning the piping

Take great care over the curvature of the pipes to prevent excessive load loss and dangerous stress. Make sure the pipe length is suited to the position of the system.

THE DIAGRAMS BELOW SHOW THE CORRECT INSTALLATIONS AND THE MISTAKES COMMONLY MADE WHEN POSITIONING THE FLEXIBLE PIPING (FIG. 7.3.1)

CORRECT INSTALLATION | **INCORRECT INSTALLATION**

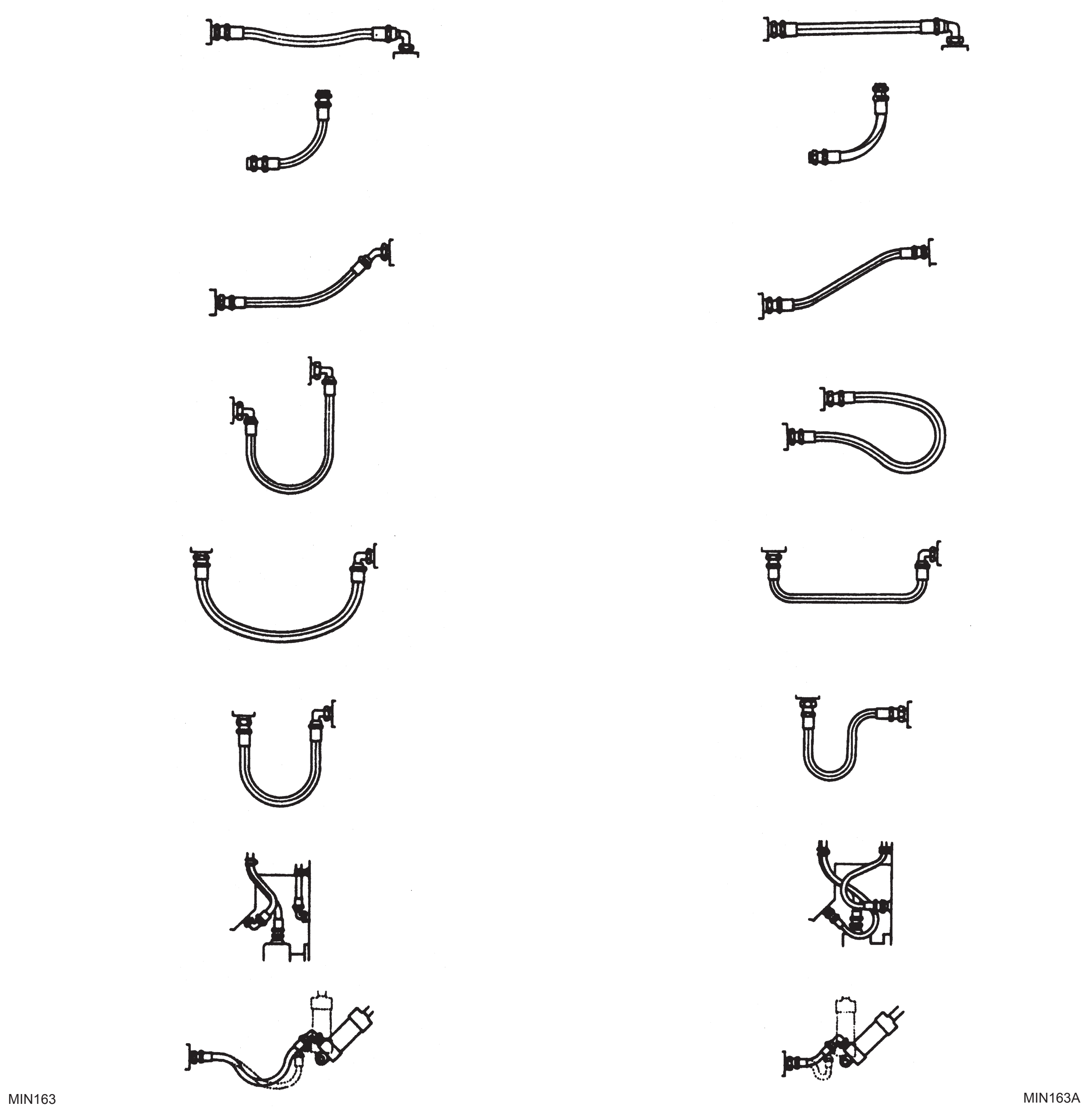


fig. 7.3.1

7.4 - Hydraulic oil refuelling

The standard versions of the crane are delivered with the tank empty (however all cylinders fitted to the crane - with the exception of the outriggers - are filled with ESSO NUTO H46 oil).

The installer must fill the tank with hydraulic oil of the type best suiting the crane, its use and the ambient conditions in which it will be used.

Here below you will find information and instructions to be taken into account when choosing the hydraulic oil to be used on the crane.

7.4.1 - Selecting the hydraulic oil

When choosing hydraulic oil, bear in mind the following parameters the define their features:

1. VISCOSITY
- It must range between the values mentioned hereunder.

- Cold start:	max. viscosity 250 cSt
- Machine running:	min./max. viscosity 13/45 cSt.

2. TEMPERATURE

The oil viscosity tends to thin as the temperature increases. Therefore, before choosing a hydraulic fluid, carefully consider the ambient and operating conditions of the crane.

To ensure maximum performance and maximum life of the oil and of the hydraulic circuit in general, never allow the temperature of the oil to exceed 45 °C - 50 °C.

The charts hereunder show indications about the oil to use in relation to ambient temperature and the comparison of different producers.

Figure 7.4.1 is a viscosity/temperature chart of mineral hydraulic oils belonging to ISO viscosity classes.
By referring to the chart, it is possible to choose the hydraulic fluid that is most suitable for the crane.

3. ADDITIVES

Usually, hydraulic oils contain additives apt to protect it from deterioration.

Generally, the hydraulic mineral oils that are commercially available are suitable for use on our machines, provided that they comply with the DIN 51524 part 2-HL-P standard.

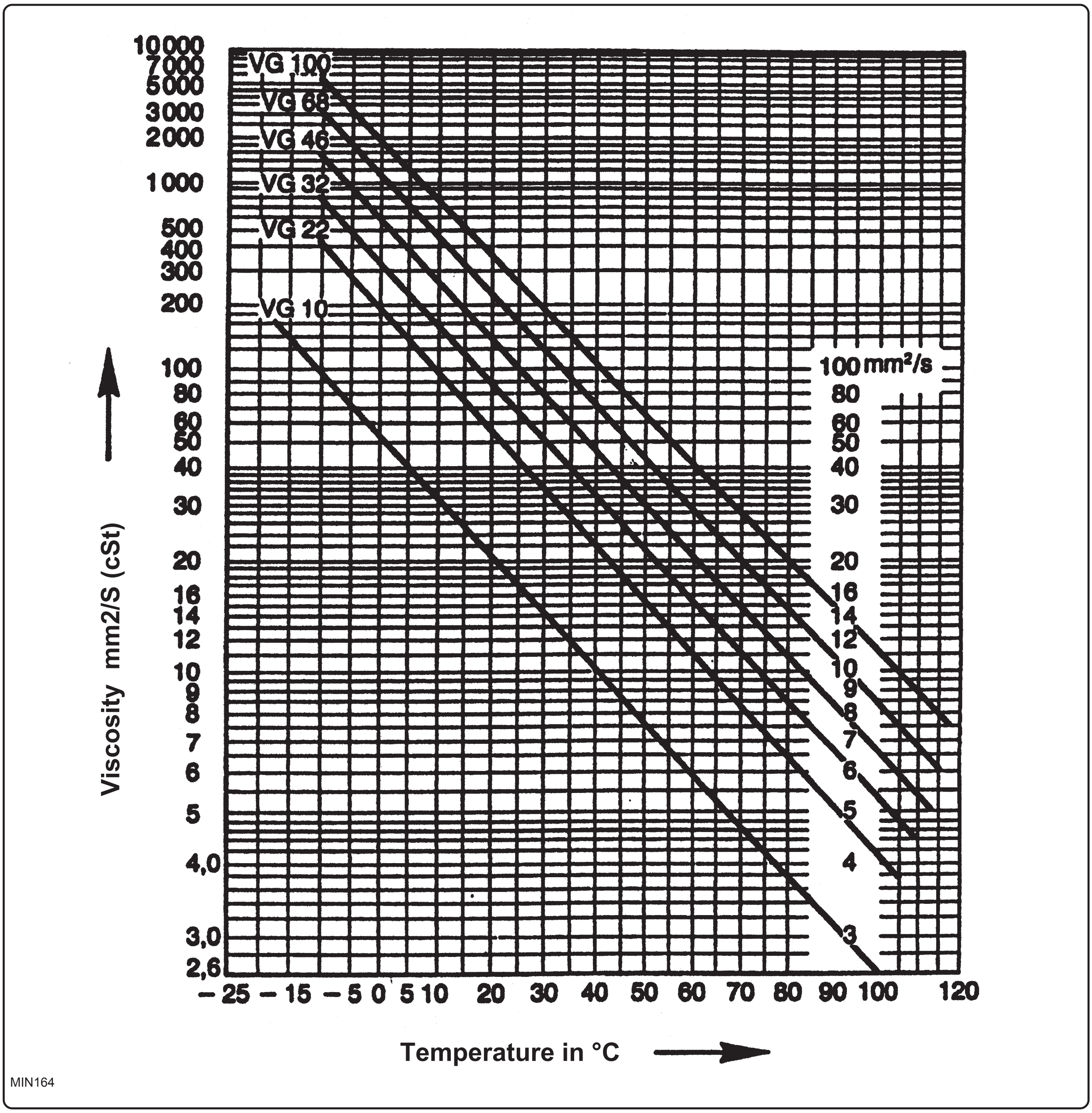


fig. 7.4.1

Another important factor that should be considered when choosing hydraulic fluid is COMPATIBILITY with the materials of the crane.

In other words, a fluid is compatible when it does not affect and it is not affected by the materials used to construct the crane. In any case, it is a good idea to ask the manufacturer of the fluid for information concerning compatibility.

7.4.2 - Filling the tank

After choosing the hydraulic fluid, it is possible to fill the oil tank.
The correct performance of this operation is strictly related to the instructions here below.

- The persons in charge must avoid prolonged contact with the fluid and wash immediately - work clothes included - in the event of contact.
- All equipment used during this operation (piping, drum, funnel, filter, etc.) must be accurately cleaned and pickled before use.
- Before filling the tank, check visually through the filter flange/fixing opening on return side to assess whether it is clean inside.
- To refill or top up the tank use only oils having a max. pollution degree of 18/14 according to standard ISO 4406 (class 9, according to chart NAS 1638).
- In general, to be sure the oil is actually clean, we recommend you clean it by pouring it through a mobile filtering unit.
- When filling and topping up the tank, always use the filling cap, which is fitted with a metal filtering mesh.
- With regards to the quantity of oil, refer to the minimum and maximum level indicators installed on the tank (see fig. 7.4.2).

Note

The oil level should only be checked with the crane folded up completely in its rest position.

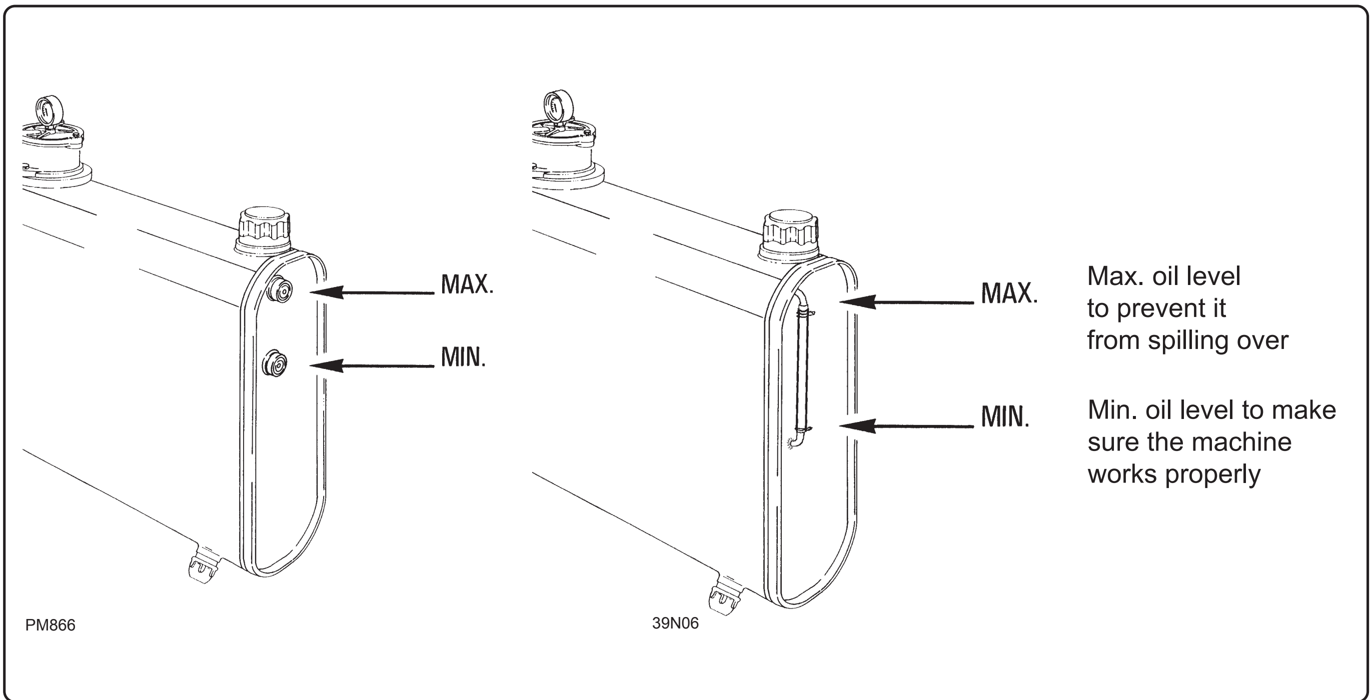


fig. 7.4.2

7.4.3 - Calibrating the rotation limiting device valves

Operation description

When a the limited of the permitted sector for the maximum performances is reached, the machine locks out and to move any further forward you must press the reset button (fig. 7.4.4).

When the reset button (a self-retaining button with a signal lamp) is pressed, a second maximum level valve and a pressure relief valve, both of which are calibrated at much lower levels than normal, are activated and therefore the machine's maximum performance levels are reduced.

When you move back into the maximum capacity sector, you must press the button again to restore the machine's maximum performance levels.

The rotation limit device can be of two types depending on the machine type (see fig. 7.4.3).

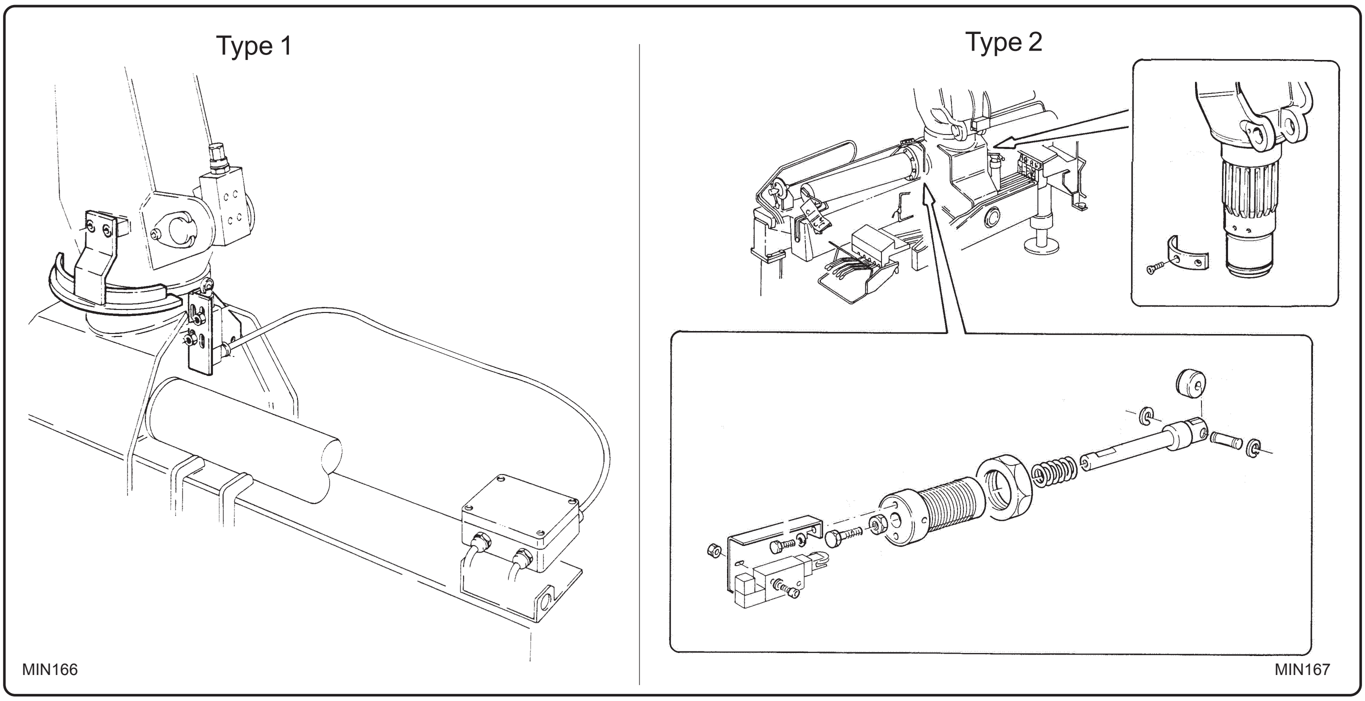


fig. 7.4.3

7.4.4 - Calibrating the valves

When assembling or testing the device, Autogru PM performs an approximate calibration of the valves (maximum valve = 100bar - pressure relief valve = 110 bar).

It is the installer's duty to check the vehicle's stability is in line with the standard calibrations effected. If this is not the case, the installer must proceed to recalibrate the machine in the following way.

- The valve calibration operations must be carried out with the crane boom positioned in the reduced capacities sector (micro-probe on the basement pressed down - fig. 7.4.4) and with the rotation limit button pressed (reset light switched on fig. 7.4.4).

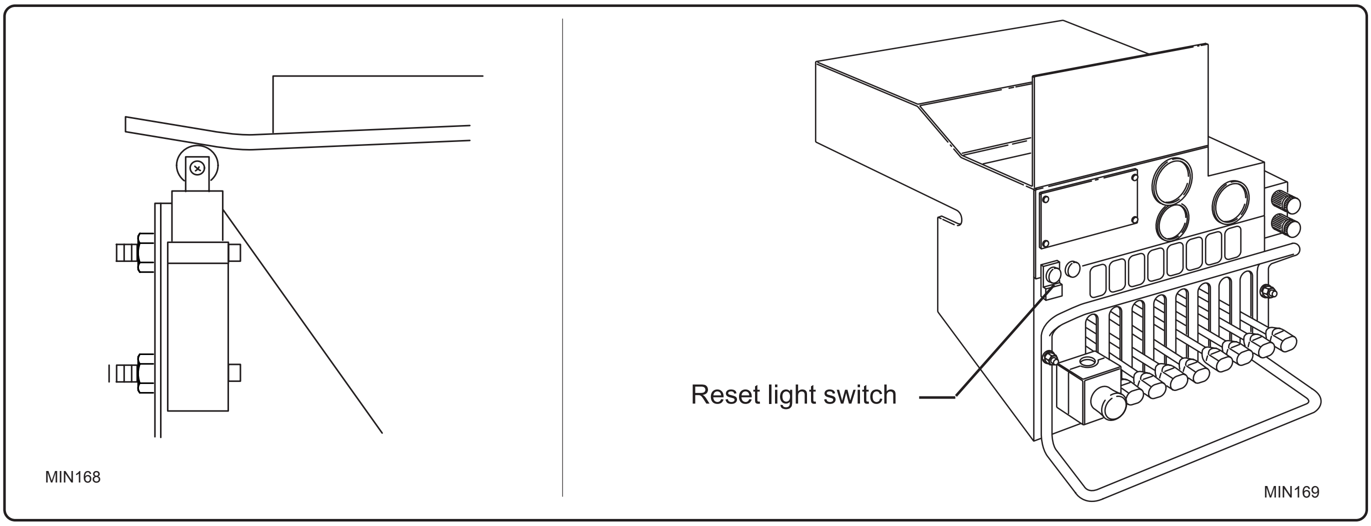


fig. 7.4.4

- Proceed by checking the stability of the vehicle-crane combination in the reduced capacities sector in the way described in the relative chapter of this installation handbook.

- This test provides the calibration value for the rotation device's pressure relief valve. The rotation device's maximum valve must be calibrated 10 bar lower.

- Mount the pressure gauge on the momentum limiting device's pressure relief valve body (fig. 7.4.5).

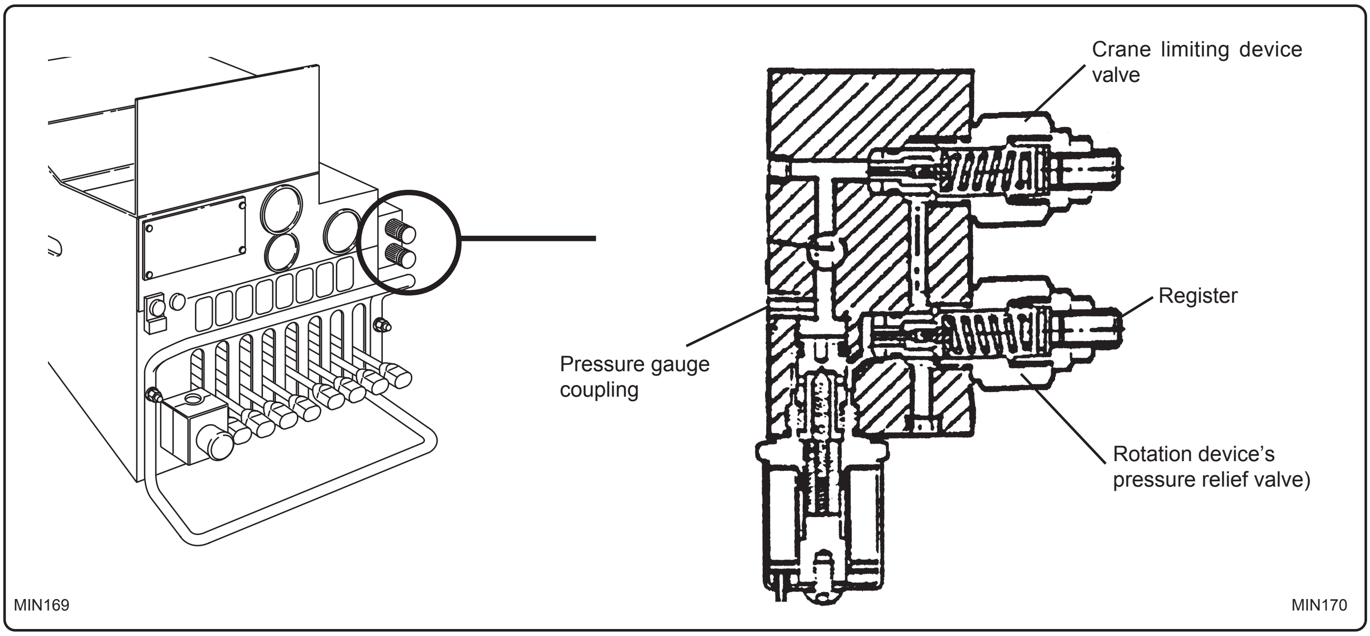


fig. 7.4.5

- Hoist a load with an known weight, which falls into the value fields of the machine's new capacities.

- Extend the booms and, keeping an eye on the pressure gauge, move the pressure relief valve's register on the rotation device (fig. 7.4.5) so that the machine locks out when the pressure required is reached.

- Repeat the procedure a few times to check the momentum limiting device is calibrated correctly.

- Mount the pressure gauge at the distributor input point (fig. 7.4.6).

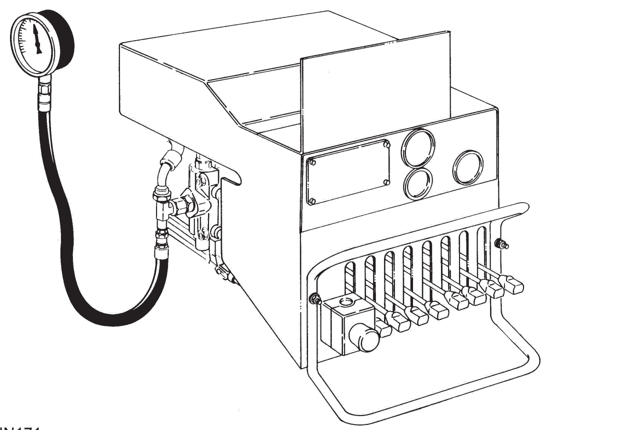
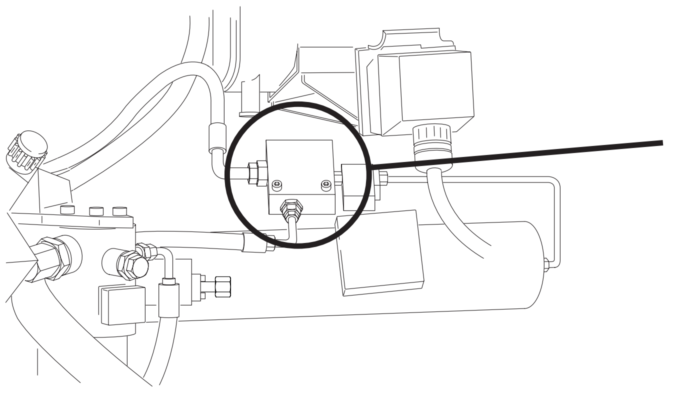

MIN171

fig. 7.4.6

- Adjust the rotation device's maximum pressure valve (fig.7.4.7), setting it at the value required (10 bar lower than the rotation device valve) by taking the boom cylinder retraction control to its stroke limit.

Rotation device maximum pressure valve


MIN172

Adjuster screw

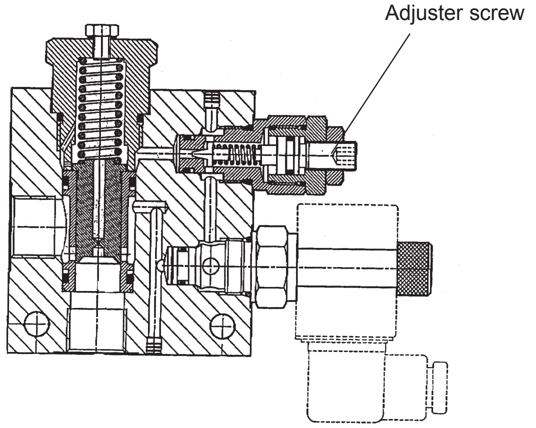

MIN173

fig. 7.4.7

On completion of these operations, the valves must be sealed.

ATTENTION!!!

If the machine is fitted with a Danfoss distributor, you must adjust the sequence valve installed in the bracket cylinder (fig.7.4.8), setting it at 25 bar (rather than the customary 50 bar).

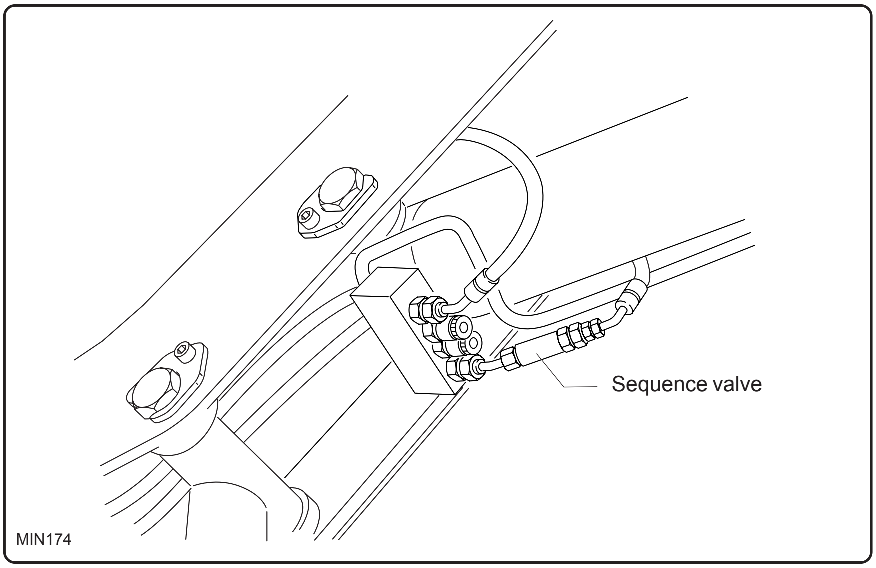


fig. 7.4.8

7.4.5 - Crane performance derating

To calculate the values for derating the crane's operating functions, refer to sub paragraph 7.4.13.

7.4.6 - Calibrating the distributor max. presure valve

- Mount the pressure gauge on the distributor's input flange (fig. 7.4.6).
- You can calibrate the maximum pressure valve by pushing the distributor element's lever to its stroke limit. The said lever controls the following:
  - column up movement cylinder
  - bracket up movement cylinder
  - booms retraction cylinder

  as these are not generally fitted with partial valves.
- Calibrate the maximum valve at the value given in Technical Specifications sheet.
- Once the calibration operation is complete, you must proceed to lock the valve register using the register cover nut. Take special care to ensure the register locking operation does not alter the calibration just carried out.

  To detect possible alterations, you must recheck the calibration value once the maximum valve register locking operations are complete.

7.4.7 - Calibrating the momentum limiting device intervention pressure

- Mount the pressure gauge on the limiting device's maximum pressure valve (fig. 7.4.9).

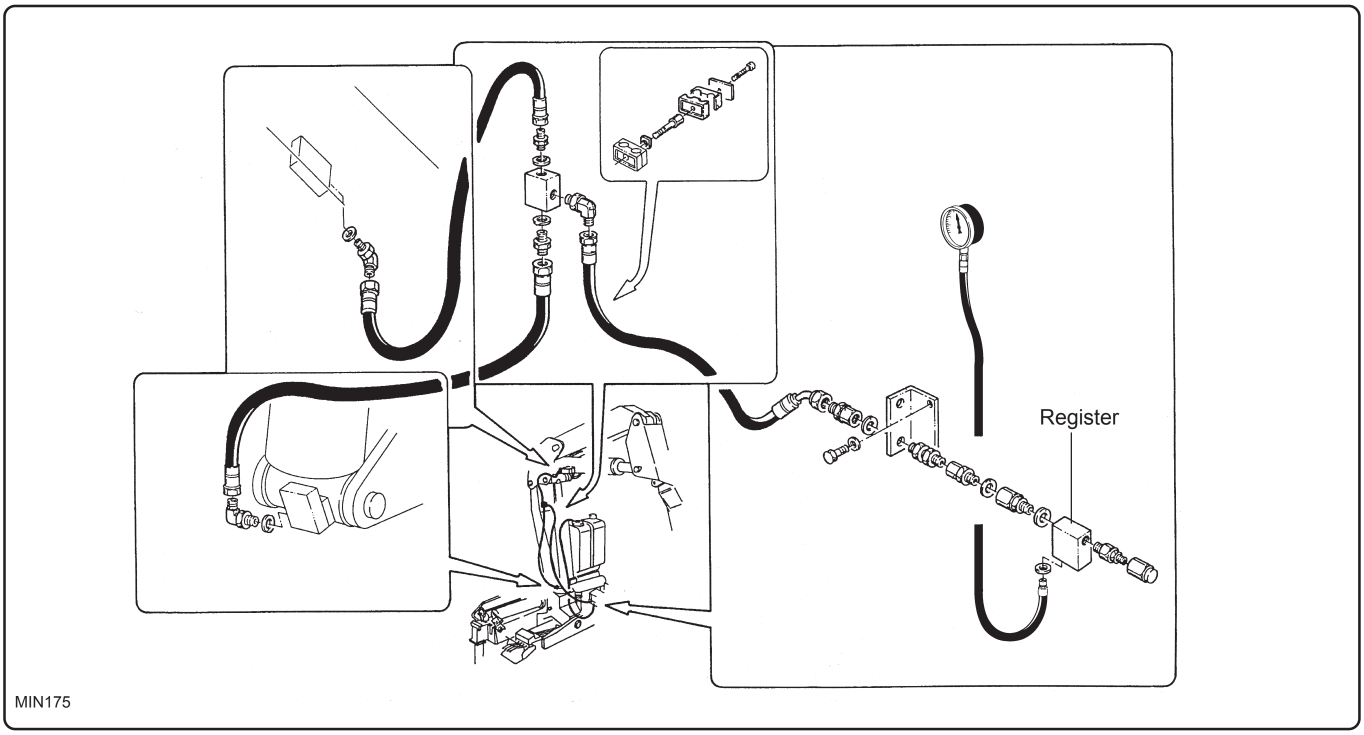


fig. 7.4.9

- Apply a load to the machine's hook which is slightly heavier than the value indicated on the capacities diagram.

DANGER!!!

When the crane has been derated, the load applied must be the reduced load obtained from the stability tests.

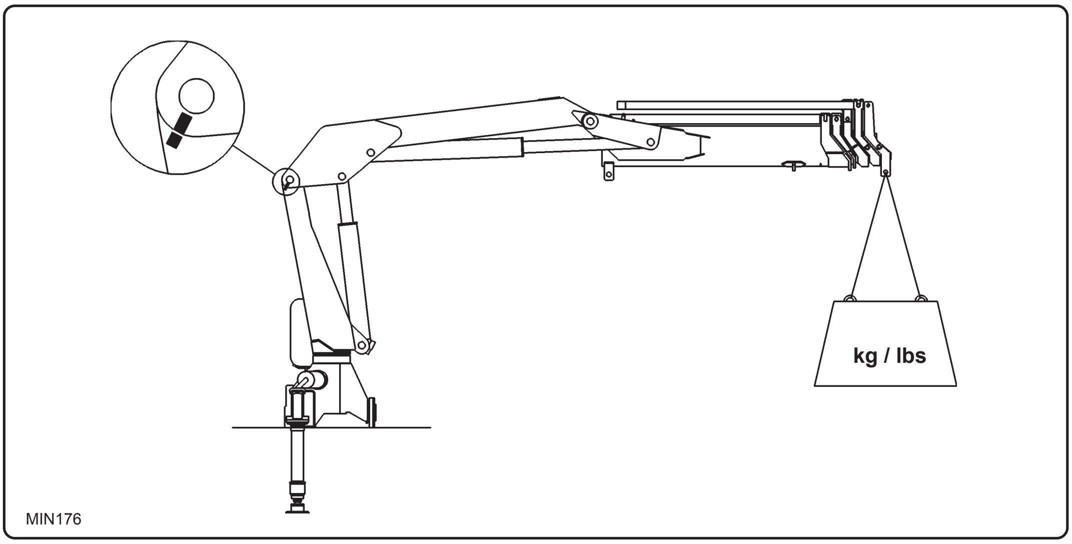


fig. 7.4.10

- Set the machine in the position indicated on the plate (using the references on the column and bracket), with the boom pack closed and parallel with the ground (fig. 7.4.10).

- Begin to extend the boom and check the pressure indicated on the pressure gauge at the same time.

- Once the value required has been reached, the limiting device should start up (and lock out all the machine's movements). If this does not happen, adjust the limiting device valve's register so that this operation is carried out (fig. 7.4.9).

- Check that the machine is effectively "locked" by moving all the manoeuvre levers, except the boom retraction cylinders lever, making sure no movement occurs.

- Repeat the checking operation five times, always starting from the position with the boom pack closed up and make sure the limiting device's calibration value does not change. The same applies for the outreach obtained by the load (tolerance ±10%).

- Once the calibration operation is complete, you must proceed to lock the valve register in place with the register cover nut. Take special care to ensure the register locking operation does not alter the calibration just carried out. To detect possible alterations, you must recheck the calibration value once the maximum valve register locking operations are complete.

7.4.8 - Register seals

Once the crane's performance calibration operations have been performed, you must proceed by sealing the valve registers previously calibrated to prevent them being tampered with.

ATTENTION!!!

After derating operations, it is the installer's responsibility to supply new plates with capacity diagrams to be applied to the machine and also to update the user and maintenance handbook.

7.4.9 - Rotation lock valve

The use of this valve permits the following functions:

- adjustment of the rotation speed to suit the specific user requirements;
- increased safety when controlling the machine on slopes, remember, though, that the maximum limit must never be exceeded, as indicated in the instructions and safety handbook.

Once installed, the valve in question requires three different types of calibration:
- lock valve calibration
- speed adjuster calibration
- pressure compensator calibration

7.4.10 - Calibrating the lock valve

The lock valves are already set at a standard value of 200 bar (remember that each turn of the register corresponds to a variations of approximately 45 bar).

If you need to vary this calibration (admissible field 130 / 250 bar), proceed as follows:

A) Calibration on the bench with central control unit

- Set the pump delivery to the user device R1 (fig. 7.4.12).
- Turn the register of the lock valve concerned (screwing or unscrewing) so that the oil comes out of the user device “A” when the pressure value required is reached (see the hydraulic system for each crane).
- Once this operation is complete, lock the register in place with the relative nut.
- Repeat the operation for R2, checking the oil comes out of “B” (fig. 7.4.12).

B) Calibration on the machine

ATTENTION!!!

For this calibration procedure, the crane-vehicle combination must be sloping. Therefore, given the level of danger involved in this operation, it must be carried out by qualified personnel.

- Using the outriggers, move the crane-vehicle combination into a sloping position (maximum inclination angle = 5°).

Note

The inclination of the vehicle and the load applied must be such as to create a pressure in the retaining cylinder which is slightly greater (approximately 10 bar) than the valve calibration value.

- Apply the relative load to the hook with the outreach at a maximum.
- Connect the pressure gauge to the side of the retaining cylinder (see fig. 7.4.11).
- Turn the register of the lock valve concerned (screwing or unscrewing it) to draw the valve and consequently cause the millimetric rotation movement.
- Once this operation is complete, lock the register in place with the relative nut.
- Repeat the operation for the other side, inverting the crane-vehicle’s angle of inclination.

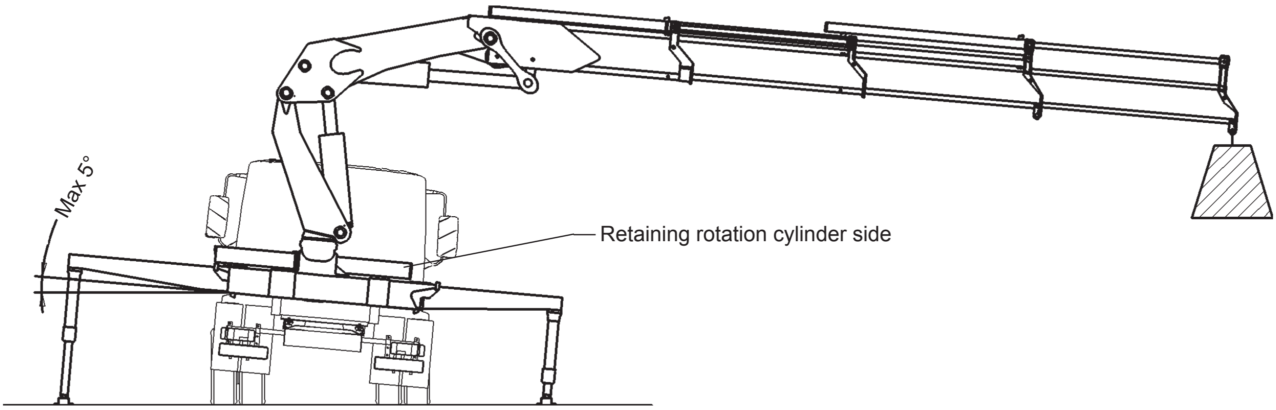


fig. 7.4.11

7.4.11 - Calibrating the speed regulators

- Unscrew the register C3 until its upper part is exactly level with the hexagon that contains it (fig. 7.4.12).

- Turn the two registers C1 and C2 (screwing or unscrewing them) until the rotation speed required is obtained (fig. 7.4.21). For these values, see the technical specifications sheets for each machine which indicate the full rotation times.

CAUTION!!!

The two registers C1 and C2 must be adjusted in such a way as to ensure the rotation speed is the same for both directions (fig.7.4.12).

7.4.12 - Calibrating the pressure compensator

- Mount the pressure gauge on the distributor's inlet head (fig. 7.4.6).

- Activate the rotation (lever fully open) and turn the register C3 at the same time, screwing it until you see the rotation pressure value increase (fig. 7.4.12).

- Now continue to screw up the register C3, turning it gently until the pressure reaches a higher value than 10 bar (maximum).
  Ex.: the machine is rotate (unloaded and on level ground) with 60 bar, you must turn the register C3 until the pressure reaches 70 bar (fig. 7.4.12).

- Repeat the procedure for both sides and check the machine operates correctly.

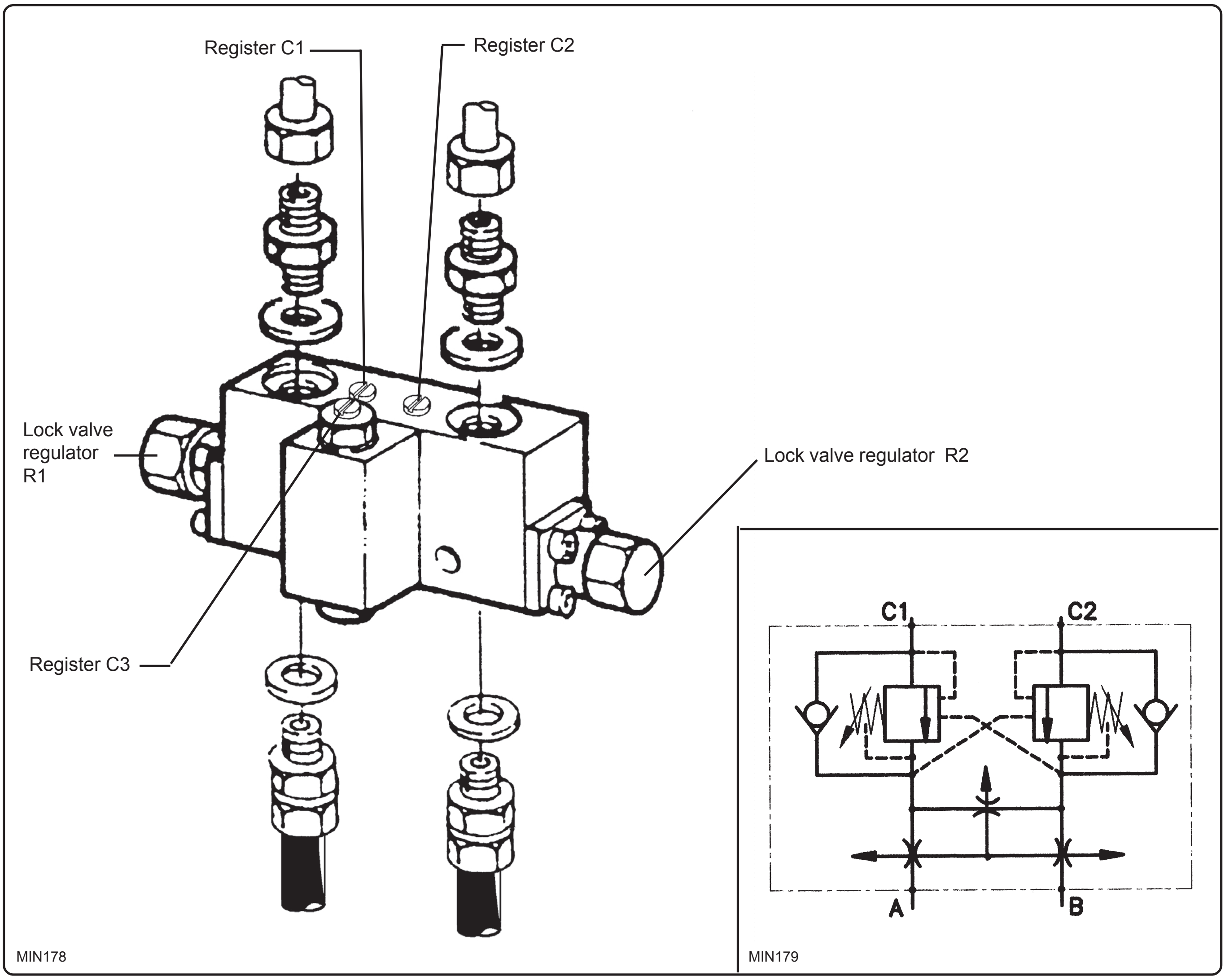


fig. 7.4.12

7.4.13 - Calibrations for crane derating

Once the new reduced theoretical load has been established which renders the crane-vehicle combination stable (see chapter 3), the practical stability test must be carried out with a trial load calculated using the following formula:

Ppr=1.25 Pr+0.1 F

For the crane performance derating, proceed as follows.

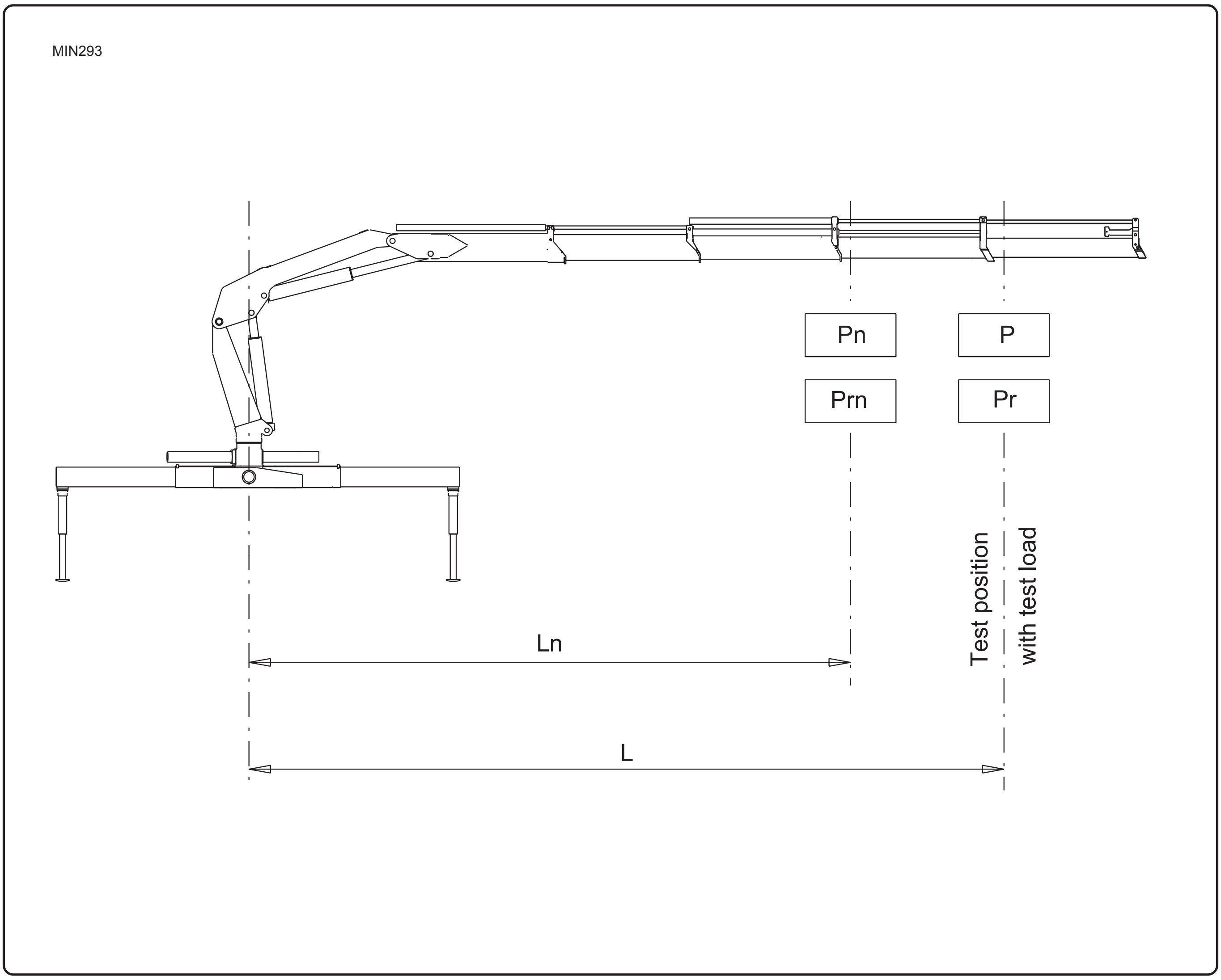


fig. 7.4.13

- With the crane in the position indicated on the plate, hoist the reduced load Pr again with the outreach at slightly less than the outreach envisaged, then extend it and adjust the calibration valve on the limiting device at the same time until the manoeuvre locks when the outreach envisaged by the stability calculation has been reached (see also para. 7.4.3).

- Adjust the maximum valve located on the distributor input head, setting it at 10 bar lower than the limiting device's intervention value (which can be found with the pressure gauge inserted in the relative quick coupling on the limiting device's valve) (see also para. 7.4.6).

- Repeat the boom pack extension/retraction manoeuvve several times to make sure the limiting device intervenes correctly (tolerance = 0 + 10% of the distance reached by the load).

- Correct the load capacity chart obtained experimentally with the following capacities calculated using the formula:

$$Prn = \frac{(P - Pr) \cdot L}{Ln} \qquad (kg)$$

where:

Prn	=	reduced load capacity calculated in position n.	(kg)
Pn	=	nominal load capacity, not reduced, in position n.	(kg)
P	=	nominal load capacity in the trial position.	(kg)
Pr	=	reduced load capacity in the trial position.	(kg)
L	=	distance between load Pr and column centre.	(mm)
Ln	=	distance between load Prn and column centre.	(mm)

- On completion of the trials, replace the seals removed with the new ones provided.

ATTENTION!!!

If the stability is not obtained in one sector, access to that sector must be prevented, or the loads that will be hoisted in that sector must be reduced using the relative devices envisaged for each machine model (refer to the sales list) for example, install a second limiting device with automatic intervention features, following the calibration procedure described in para. 7.4.3.
If the installer has modified the machine (e.g. derating), this latter must correct the data in the instructions and safety handbook.
Furthermore, he must also produce new capacity diagrams and apply them to the control console.

MENU

ELECTRIC SYSTEM

8.1 - Electric systems

8.1.1 - Power supply connections for electrical devices installed in the cranes

For cranes equipped with electric safety devices (emergency lock buttons, winch stroke limit devices, Jib load limiting device, etc) when these are being mounted on the vehicle, the installer must arrange for the following electrical connections to be made with the vehicle's system, to connect the devices to the power supply.

ATTENTION!!!

Every time work must be done on the electrical system, it must be carried out by qualified personnel and in compliance with the installation regulations laid down by the vehicle's manufacturer.
All the electrical parts used (boxes, sockets, etc) must be fastened so that the cables come out the bottom, to prevent water infiltrating the units.
Always respect the polarity indicated on the cables as the inversion of the polarity could cause serious damage to the components installed.
To avoid accidental earthing and contact during the connection operations, make sure the cutting and jointing operations are performed with the machine disconnected from the power source.
If no of the auxiliary control cables are used, always insulate the individual conductors (wires).
For connection cables sizes, please refer to table 13 page 17/18 - chapter 8, where the maximum admissible current value is given according to the length of the cable.
In order to protect the electronic equipment (e.g. remote control cards), you must apply protective diodes which counteract the inductive current peaks.

CAUTION!!!

Unless specified otherwise, the devices are pre-set to function at 24 V.
The installation of devices which run on 12 V is prohibited on vehicles with a 24V electrical system unless a suitable tension reducer is applied (power supply from one battery only in not allowed).

For all electrical devices installed in our cranes, the power supply connection cables are supplied for the following units:

- power supply box
- panel unit

In both cases, the following connections must be made.

THE "POSITIVE" CABLE (+) must be connected (with the shortest cable possible) to one of the vehicle's function that is enabled with the ignition key (see the specific regulations issued by the manufacturer).
For the approximate absorption values required by our systems, see table 12 below.
Connecting directly to the vehicle's batteries (by-passing the ignition key) will result in a continuous supply of power to the system (even when the vehicle or crane are not in use),with the consequent rapid deterioration of the electrical parts (batteries, solenoid valves, electronic cards etc.).

THE "NEGATIVE" CABLE (-) must be connected directly to the battery's negative terminal (with the shortest cable possible).
The negative cable must never be connected to the vehicle's chassis as a connection of this kind could cause disturbances that are damaging for the electrical parts installed.

THE "P.T.O" CABLE must be connected with a positive symbol (+) activated as a result of the crane operation power take-off being engaged (fig. 8.1.1).
Connecting it directly (by-passing the power take-off) will result in a continuous supply of power to the system (even when the vehicle or crane are not in use), with the consequent rapid deterioration of the electrical parts (batteries, solenoid valves, electronic cards etc.).

ATTENTION!!!

The cables are indicated with special plates.

Device	Current absorption with 24 V (A) system	Current absorption with 12 V (A) system
Emergency stop	1	1,5
Electric winch stroke limit	1	1,5
Electric panel for main crane function indicators	3	5
Remote control	3	5
Electric momentum limiting device for jib	1	1,5
Pneumatic coupling for power take-off with signal light	0,5	1
Lock device / rotation limiting device	1,5	2
P.L.U.S unit	1,5	2
Heat exchanger	5	9

Tab. 1

Note

If the machine has several devices installed, the total absorption is given by the sum of the single absorptions.

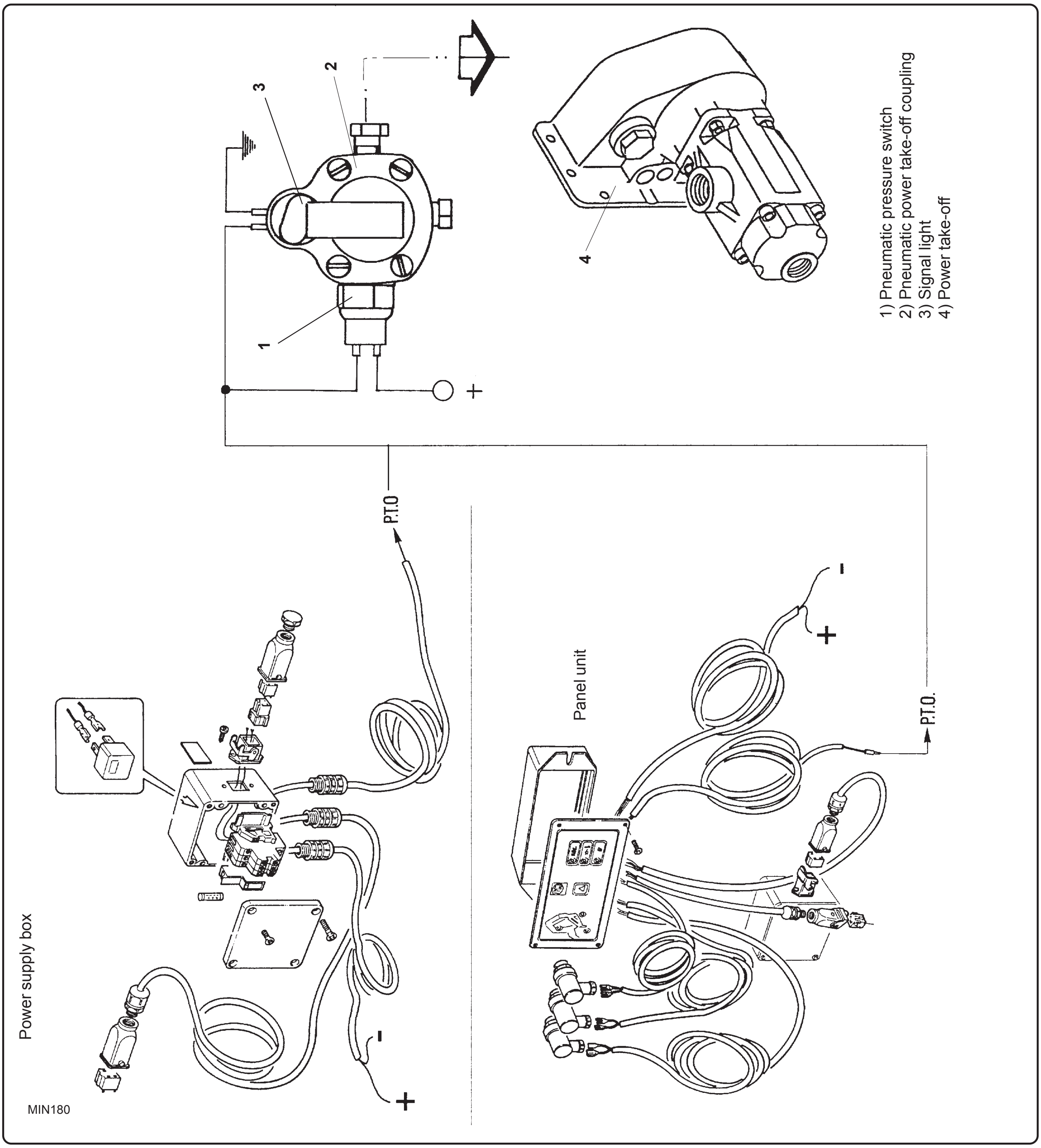


fig. 8.1.1

If the crane does not have the panel unit or the power supply box installed (such as cranes with the P.L.U.S device only), the cables must be connected individually in the following way:

ATTENTION!!!

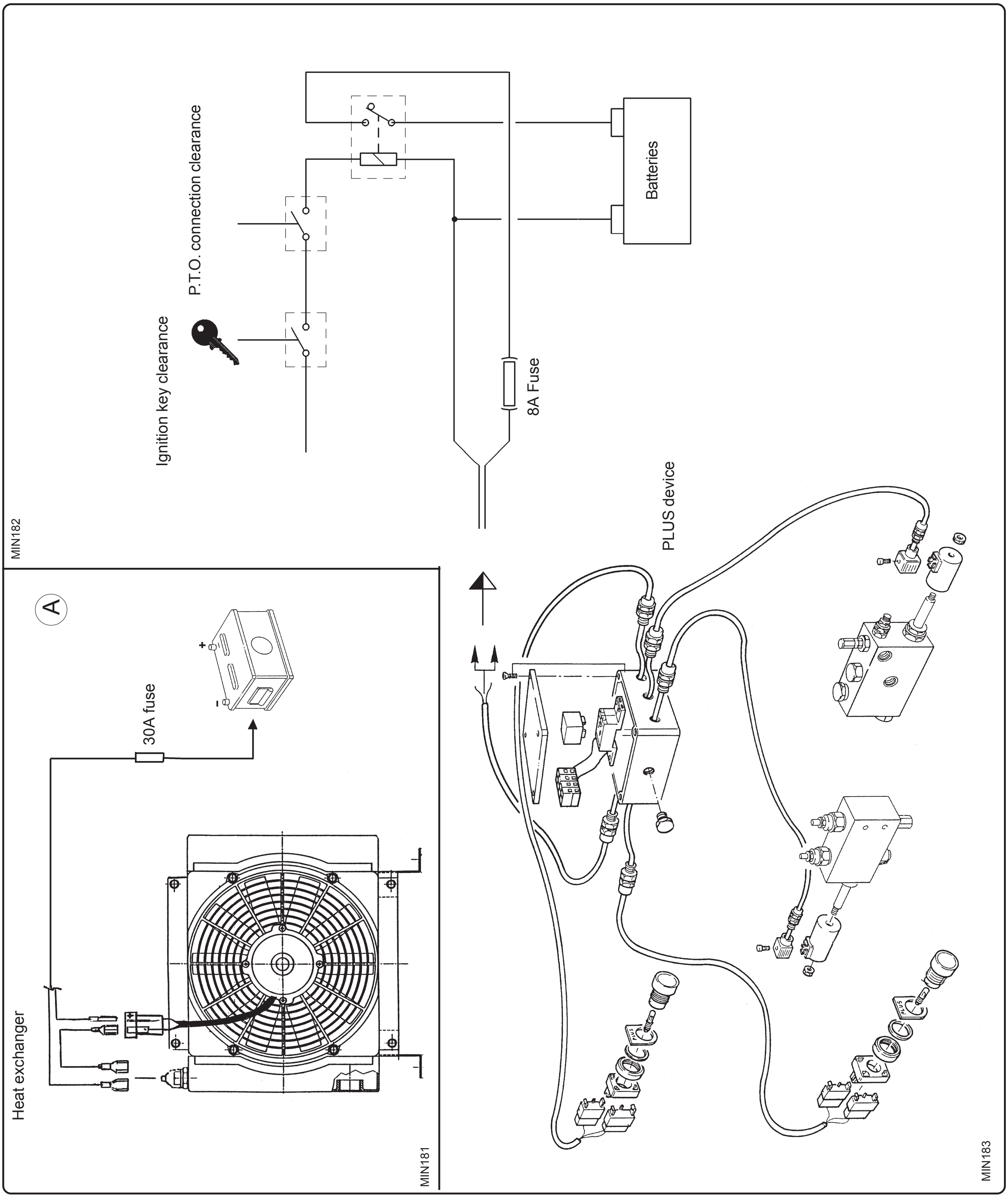
Before proceeding to connect the power supply cables, add a suitably-sized protective fuse to the positive cable (+) using a free fuse carrier on the line. When consigning the vehicle to the final user, point out the location of this fuse.

THE "POSITIVE" CABLE (+) must be connected (with the shortest cable possible) to one of the vehicle's functions that is enabled with the ignition key and by the activation of the power take-off for the crane operation - fig. 8.1.2 (see the specific directives issued by the vehicle's manufacturer).
Connecting directly to the vehicle's batteries (by-passing the ignition key and the power take-off clearance) will result in a continuous supply of power to the system (even when the vehicle or crane are not in use), with the consequent rapid deterioration of the electrical parts (batteries, solenoid valves, electronic cards etc.).

THE "NEGATIVE" CABLE (-) must be connected directly to the battery's negative terminal (with the shortest cable possible).
The negative cable must never be connected to the vehicle's chassis as a connection of this kind could cause disturbances that are damaging for the electrical parts installed.

ATTENTION!!!

The heat exchanger must be connected directly to the battery, making sure the polarity is respected and adding a 30 A fuse to the positive cable (fig. 8.1.2A).



Ignition key clearance
P.T.O. connection clearance
Batteries
8A Fuse
MIN182
A
30A fuse
+
-
Heat exchanger
MIN181
PLUS device
MIN183

fig. 8.1.2

8.1.2 - Electric connection for time counter and radio/remote control

The electric power supply connections must be made as follows.

- Machine without power supply box

Connect the cables (making sure the polarity corresponds to the indications on the cables) directly to the plug “S” (fig. 8.1.3) in the following way:

POSITIVE CABLE “+” to terminals 2 or 3 on the plug “S”
NEGATIVE CABLE “-” to terminals 1 or 4 on the plug “S”

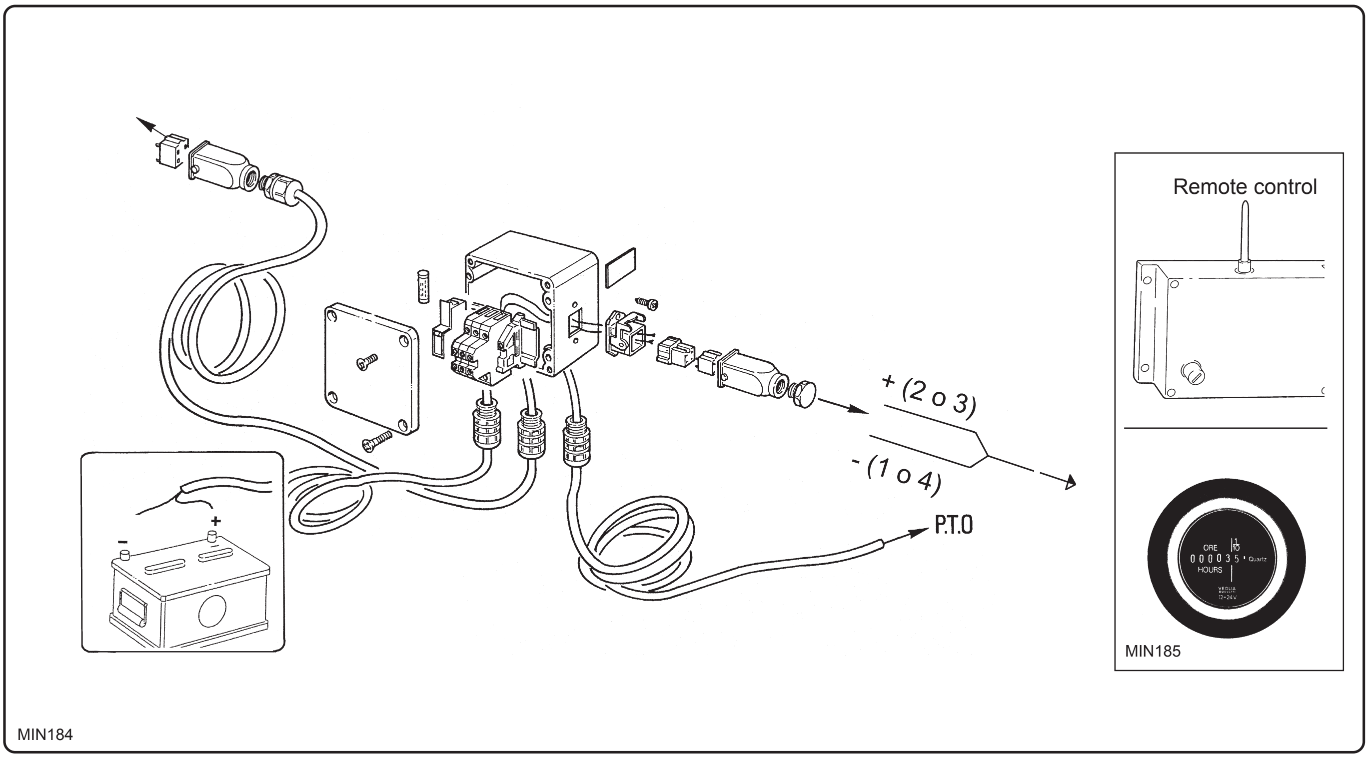


fig. 8.1.3

- Machine with electric panel

Connect the cables (making the sure the polarity is respected) directly to the electric panel terminal board in the following way (fig. 8.1.4):

POSITIVE CABLE “+” to terminals 25 or 26 on the electric panel
NEGATIVE CABLE “-” to terminal 24 on the electric panel

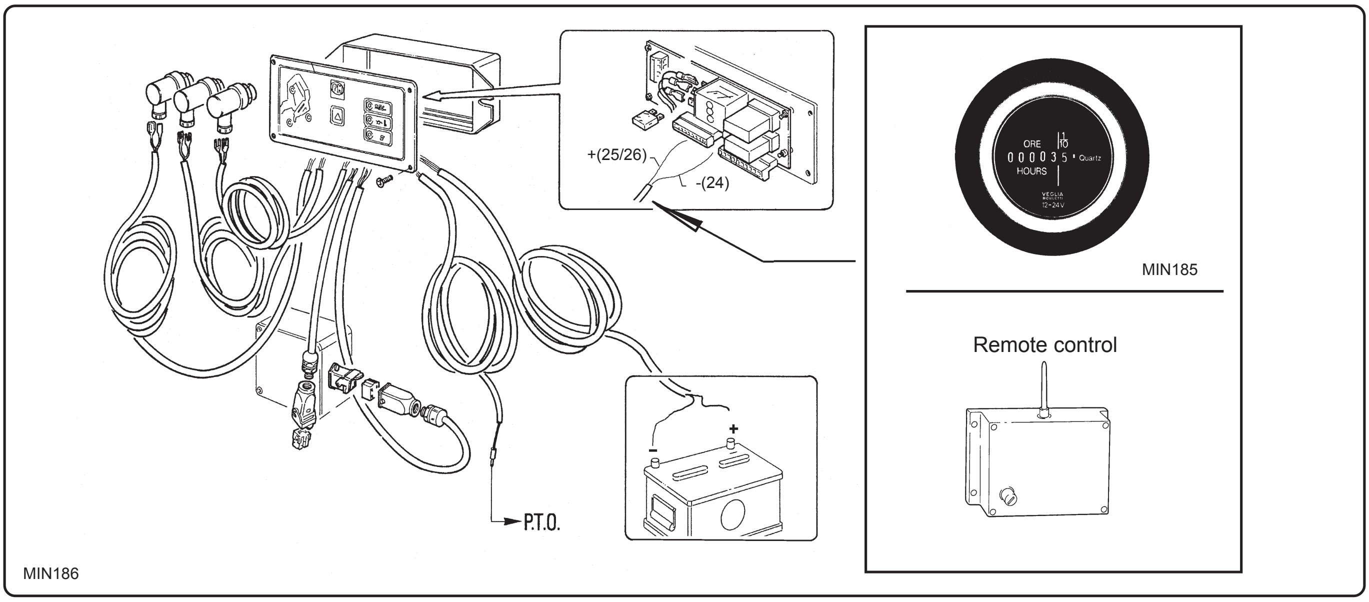


fig. 8.1.4

If no other electrical devices are to be installed in the crane, the power supply cables must be connected as follows.

ATTENTION!!!

Before connecting the power supply cables, make sure the suitable protective fuse has actually been applied to the positive cable (+) with a free fuse carrier. If not, add one now (8 A fuse).

THE POSITIVE CABLE (+) must be connected (with the shortest cable possible) to one of the vehicle's function that is enabled with the ignition key and the crane operation power take-off, fig. 8.1.5 (refer to the specific instructions issued by the vehicle's manufacturer).

THE NEGATIVE CABLE (-) must be connected directly to the battery's negative terminal (with the shortest cable possible).

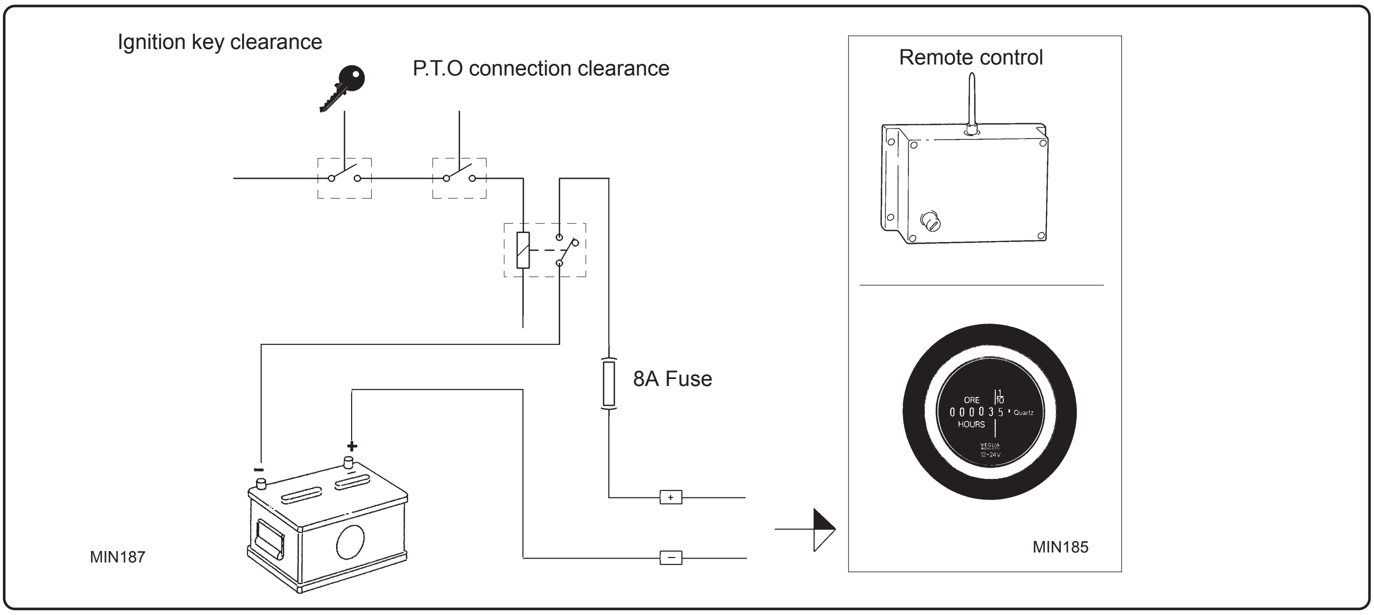


fig. 8.1.5

CAUTION!!!

The negative cable must never be connected to the vehicle's chassis as a connection of this kind could cause disturbances that are damaging for the timer components.

For the crane's timer positioning, see fig. 8.1.6 (support with hole already provided for assembly).

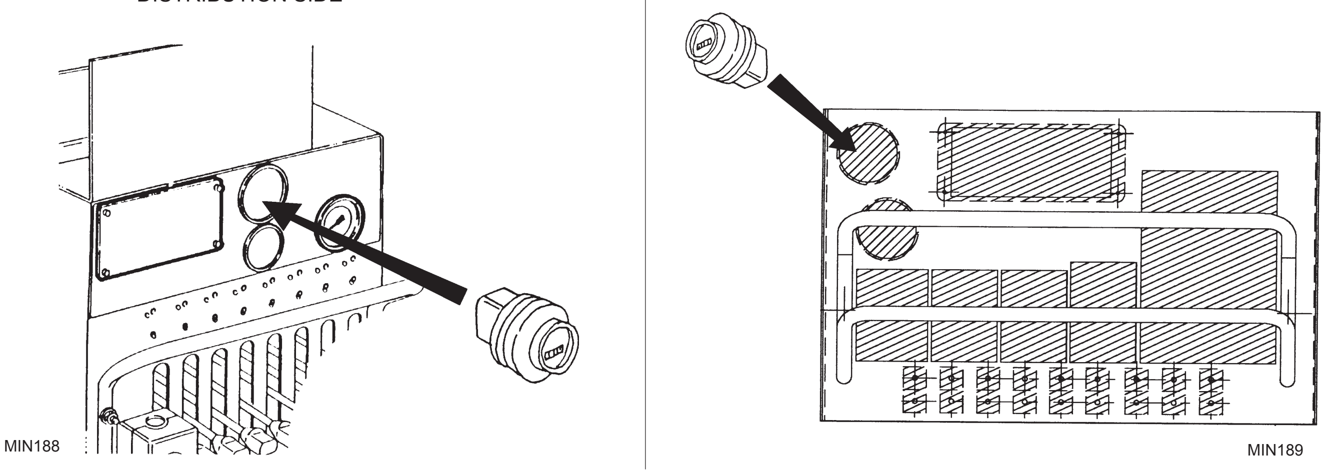


fig. 8.1.6

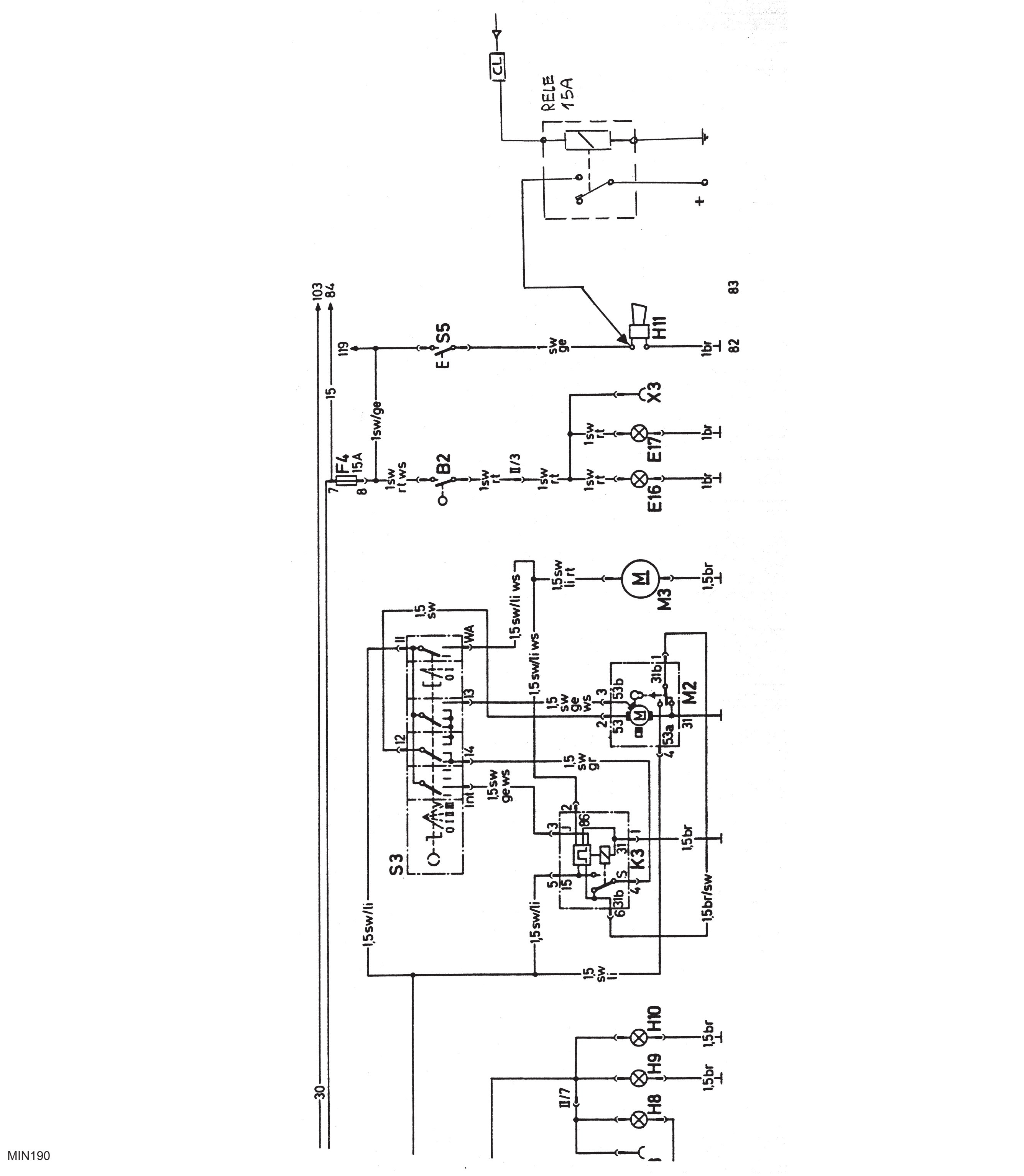
8.2 - Completing the assembly of the remote control

8.2.1 - "CL" cable connection for activating vehicle's horn from the remote control pushbutton panel

Note

In compliance with the requirements of the current safety standards in force, we have provided a special button on the remote control pushbutton panel for activating the vehicle's horn, to allow the operator to signal the beginning of the crane movement via the remote control.

It is the installer's responsibility to connect the "CL" cable to the vehicle's horn system via a suitable power relay on the positive cables (+) (see example provided in fig. 8.2.1).



RELE 15A
CL
H11
S5
F4
15A
B2
E16
E17
X3
M3
M2
K3
S3
H8
H9
H10
30
15
103
84
119
MIN190

fig. 8.2.1

ATTENTION!!!

The cable must never be connected directly as a connection of this kind could cause disturbances that are damaging for the electronic parts of the remote control.

Note

To identify the exact spot at which to connect the vehicle horn's electric system, refer to the vehicle manufacturer's documentation.

8.2.2 - Start/stop cable connections for switching the vehicle's engine on/off from the remote control pushbutton panel (if present)

It is possible to have the on/off button for the vehicle's engine on the remote control pushbutton panel.
It is the installer's responsibility to connect the "START" and "STOP" cables to the engine's ON/Off devices via a power relay (+ signals).

ATTENTION!!!

The cable must never be connected directly as a connection of this kind could cause disturbances that are damaging for the electronic parts of the remote control.

Note

To identify the exact spot at which to connect the vehicle horn's electric system, refer to the vehicle manufacturer's documentation.

8.2.3 - Mounting and connecting the flashing light unit which indicates when the remote control is switched on and the load hoisted is at 90% of the max.

In compliance with the requirements of the current safety standards in force, we have provided a unit on the remote control pushbutton panel composed of two flashing lights which indicate that remote control panel is enabled (flashing yellow light on) and that 90% of the maximum hoisted load capacity has been reached (red flashing light switched on).

A) If the flashing unit is supplied by Autogrup PM, all the electrical connections and the calibration of the pressure switch (to indicate 90% of the maximum load has been reached) have been performed and the installer is only required to secure the two flashing lights.

These flashing lights must be fixed in a clearly visible position for both the operator who is manoeuvring from a distance and also anyone who may be moving around within the crane's field of action.
To offer some examples, we have listed some of the positions where you could fix the flashing lights:
- on the upper part of the crane's column/bracket joint (fig. 8.2.2)
- on the upper part of the vehicle's cab (fig. 8.2.2).
However, other positions may be considered and adopted by the installer depending on the specific crane-vehicle combination.

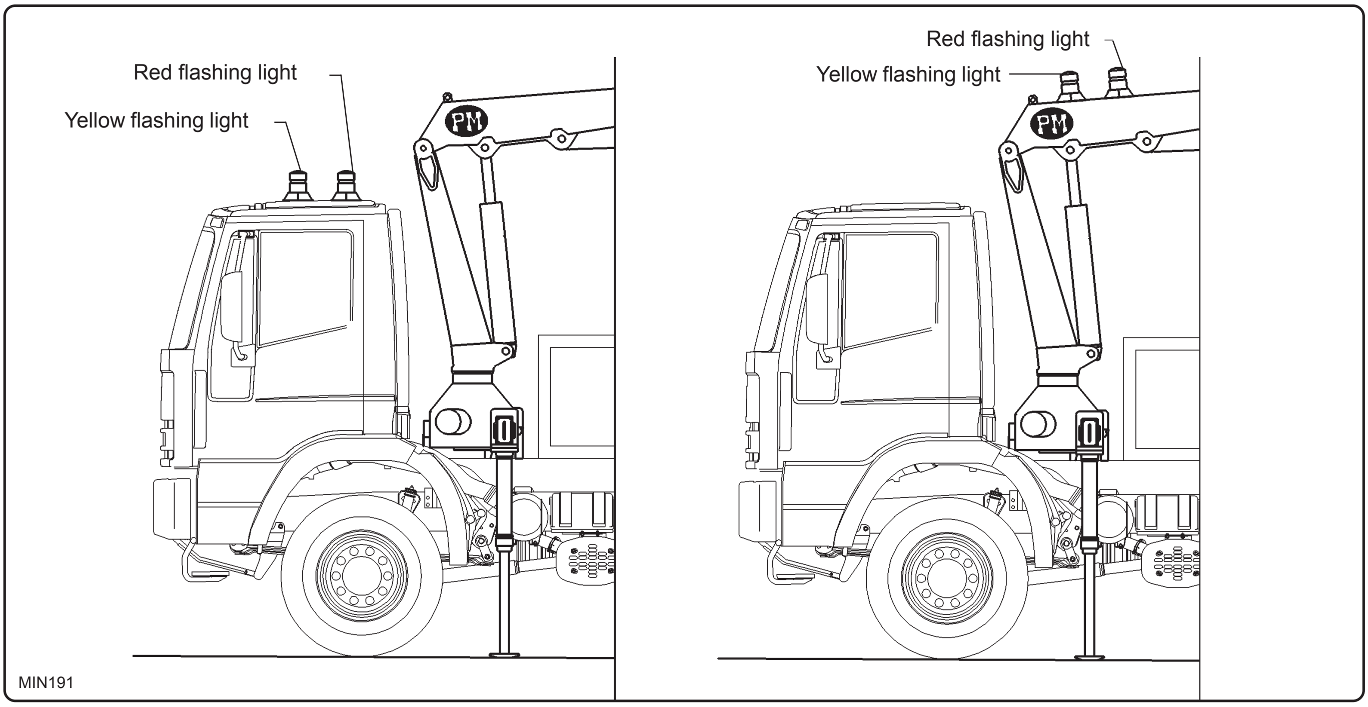


fig. 8.2.2

B) If the flashing light is supplied by the installer, the following operations must be carried out:

- Connecting the yellow flashing light to indicate the remote control pushbutton panel is switched on.

ATTENTION!!!

The flashing light connections must always be made via power relay, never directly.
The cable must never be connected directly as a connection of this kind could cause disturbances that are damaging for the electronic parts of the remote control.

The relay must be connected with the pushbutton panel's ON (+) cable.
Finally, connect the power supply to the relay and the flashing light used with the positive cables provided (fig. 8.2.3).

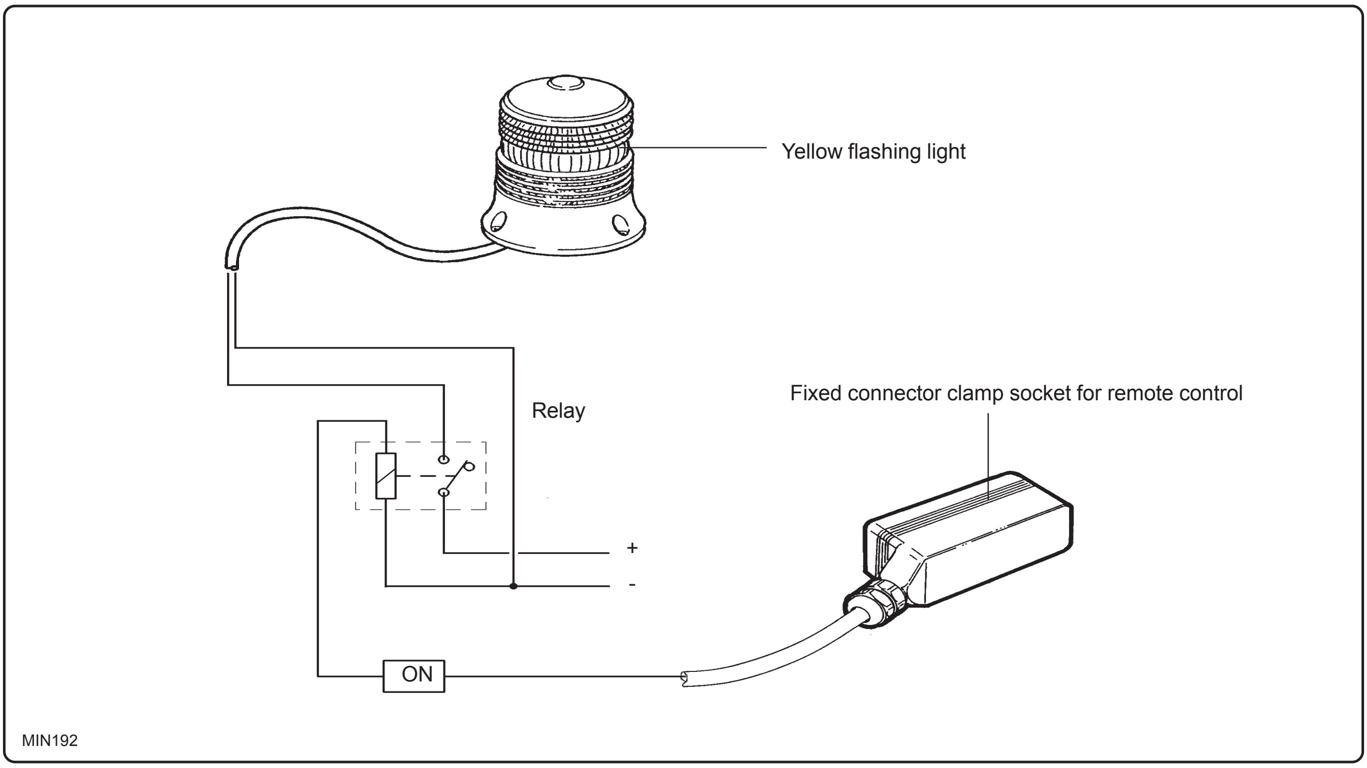


fig. 8.2.3

- ***Connecting the red flashing light to indicate 90% of the maximum hoisted load has been reached***

ATTENTION!!!

The flashing light connections must always be made via power relay, never directly.
The cable must never be connected directly as a connection of this kind could cause disturbances that are damaging for the electronic parts of the remote control.

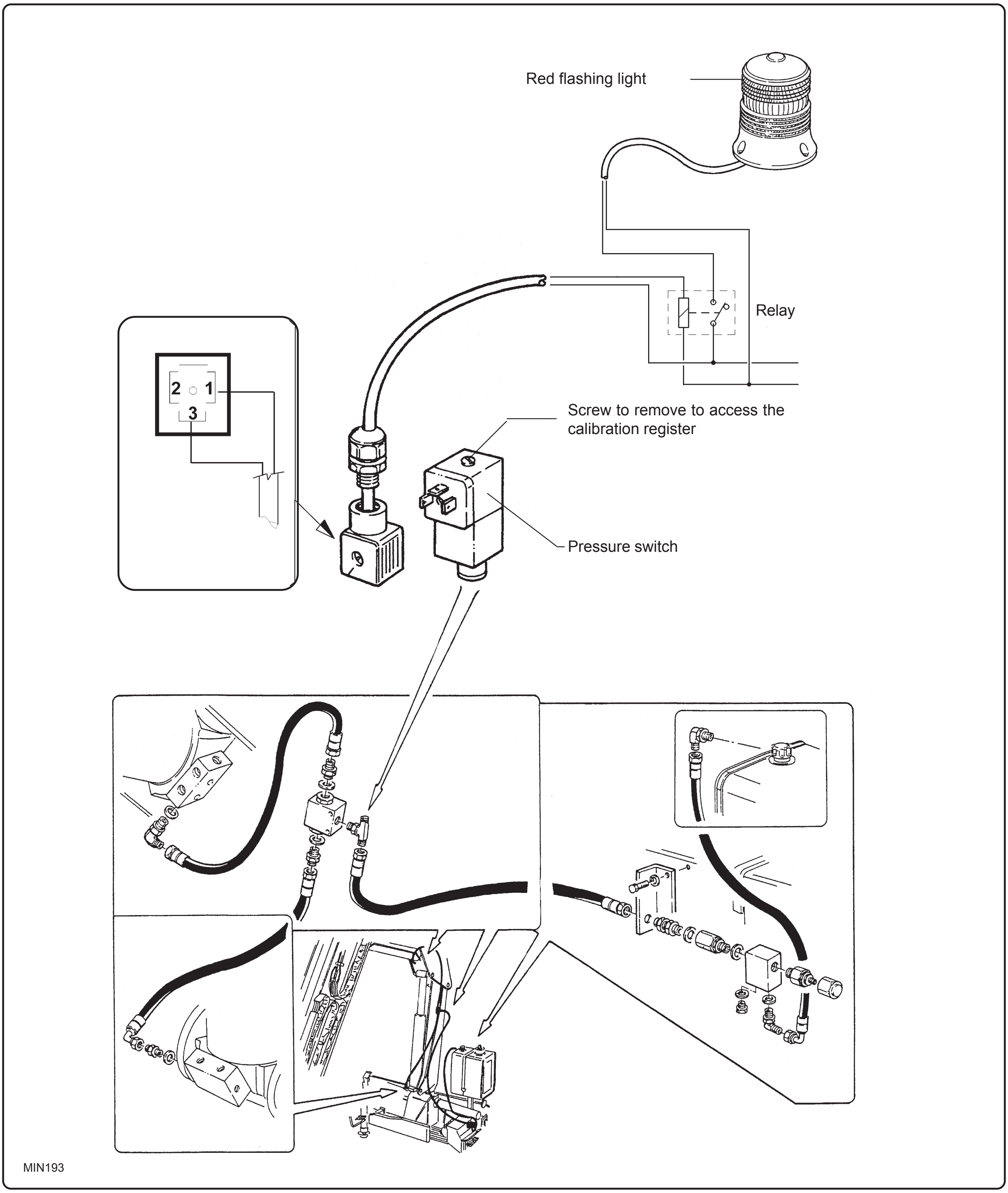

Red flashing light
Relay
2
1
3
Screw to remove to access the calibration register
Pressure switch
MIN193

fig. 8.2.4

The relay must be connected to the crane limiting device's pressure switch (at the NO terminals).
Finally, connect the power supply to the relay and the flashing light using the positive cables provided (fig. 8.2.4).

For the calibration, you must proceed as before when calibrating the moment limiting device (install the pressure gauge, hoist a load, put the crane in the position indicated on the plates and begin to extend the boom).
Use the pressure switch register to put on the red flashing light that indicates 90% of the maximum load has been reached as this corresponds with 90% of the maximum hoisting pressure.

8.2.4 - Connections when the crane is in the resting position laid out over the vehicle's rear

For the case when the crane must be put in the resting position on the vehicle's body or on the load, a red flashing danger light must be installed in the cab if the machine exceeds the maximum height of 4 metres.

8.3 - Electromagnetic compatibility

Since 01/01/1996, in addition to the entry in force of the EEC directive89/392 (Machine Directive), there has also been a further EEC directive introduced: 89/336 (Electromagnetic Compatibility Directive - EMC).

Directive EEC 89/336 concerns all electrical and electronic appliances applied to machines which may generate or could be disturbed by electromagnetic phenomena.

This directive therefore stipulates that any electrical or electronic equipment applied to machines must be built in such a way that:
- the electromagnetic disturbances generated are limited to a level that allows the radio and telecommunications equipment and other apparatus to operate as they are designed to operate;
- the equipment has an adequate level of intrinsic immunity to the electromagnetic disturbances, which permits it to operate as they are designed to operate.

With regards to the electric/electronic equipment installed in the machine (which we supply as standard), we have already run the electromagnetic emission/immunity tests and our EC declaration of conformity (chapter 16) states that they comply with the standards and the relative harmonised regulations used (EN50082-2 and EN50081-2).
If the installer should add any further electric or electronic equipment, it is his responsibility to ensure the components used comply with the standards, to perform the electromagnetic compatibility tests and to issue the relative declaration of conformity.

☞ Note

The directive only applies to equipment which could generate electromagnetic disturbances or whose operation could be effected by this kind of disturbance.
This means the following kinds of equipment/apparatus, can be excluded:
- cables and wiring harness systems
- apparatus containing resistive loads only, with no automatic enabling devices
- batteries and accumulators
- fuses
- manual switches which do not contain live electronic components
- filament lights.

When the installer uses certified electrical parts, which meet legal requirements (for immunity: EN 50082-2, for emissions EN 50081-2) and installs them in accordance with the manufacturer's instructions, the electromagnetic compatibility tests need not be run on the modified system.

Max. admissible current according to cable lenght and section

Lenght (m) / Section (mm^2)	Cable lenght			
	Up to 2 m	2 - 4 m	4 - 8 m	over 8 m
1	9A	5A	4A	/
1,5	22,5 A	13,5 A	7,5 A	6 A
2,5	37,5 A	22,5 A	12,5 A	10 A

Tab. 2

MENU

MANOEUVRING POST

9.1 - Access

The crane's original manoeuvring posts must not be modified.

Particular care must be taken by the installer to create accesses to the manoeuvring posts, which must comply with standard prEN 12999:1999.

From the manoeuvring posts, the operator must have full visibility over the machine's work area.

After the crane has been mounted on the vehicle, make sure the operator can see all the crane's other control points so that he can check there are no other operators.
If the crane is moved with a radio/remote control, make sure access to the other manoeuvring posts is prevented (e.g. the other manoeuvring posts are locked with the key).

If there are any controls which can be used from a standing position, their height must be checked in relation to the foot rest (between 1 m and 1,4 m) and the controls, the capacity diagrams and the relative instructions must be clearly visible.

If these conditions are not met, a foot panel must be installed on which the operator must stand to use the controls: the panel must not be no more than 600 mm off the ground and its dimensions must not exceed 400 x 500 mm.

If the panel is higher than 600 mm, an access ladder must be built as shown in fig. 9.1.3.

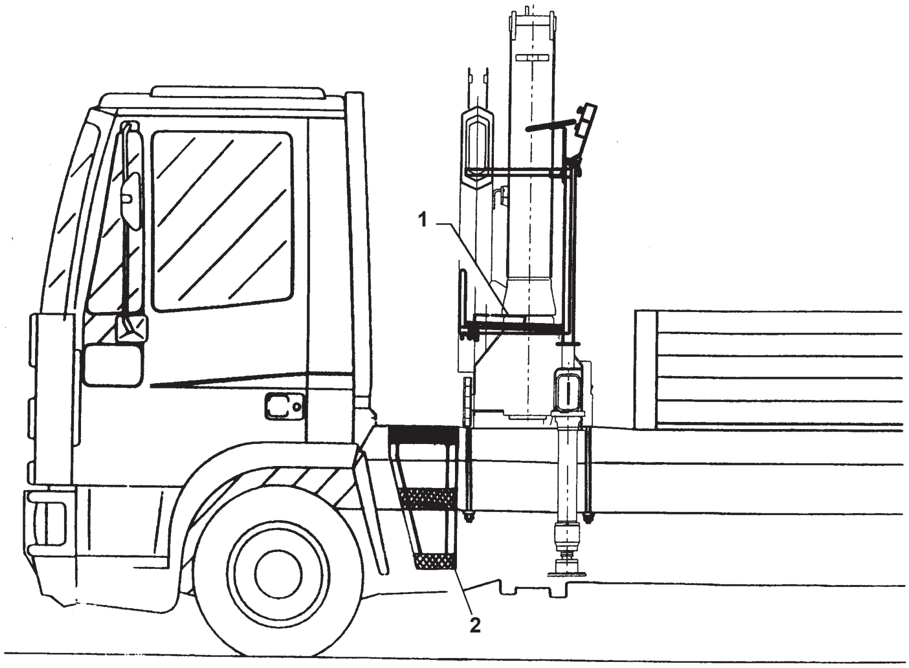
The foot panel must be able to bear a weight of at least 1500 N (150 kg) applied to a circular surface with a diameter of 125 mm.

For the overhead manoeuvring posts (raised from the crane base - see fig. 9.1.1 or the column - see fig. 9.1.2), the installer must build access ladders, the foot panels etc. taking in account the following requirements.

1) The operator must have easy access to steps and handles.
2) He must be able to reach his position without the risk of knocking the controls or clothes getting caught up.
3) Hand grips and hand rails must be smooth and preferably rounded.
4) Handles and rails must be co-ordinated and placed along the route in a position to ensure the user continuous support.
5) All surfaces where feet rest must be non-slip. Steps must not be rounded.
6) The steps must be wide enough to accommodate both feet, except between intermediate levels and the turret position (min. size 300 mm).
7) Any removable steps must be secured safely in both the working and the rest position.
8) Handles and parapets must be able to withstand a 1000 N (100 kg) horizontal force distributed over 100 mm, without deformation.
9) Steps and ladders must comply with the measurements shown in figures 9.1.3 and 9.1.4.
10) Steps must have an angle between 75° and 90° with respect to the horizontal surface.

STANDING MANOEUVRING POST ON CRANE BASE WITH ACCESS LADDER

1 - Platform
2 - Steps

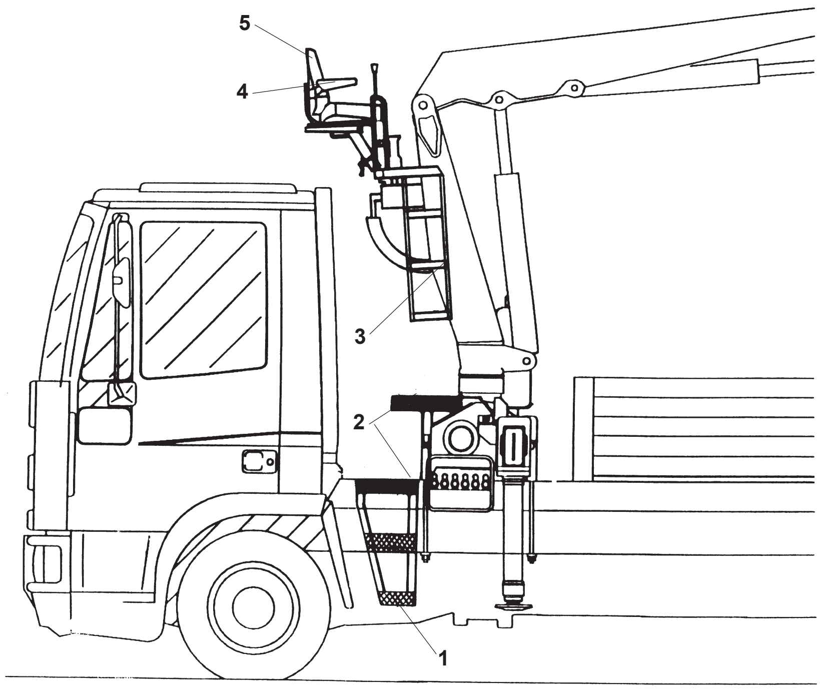


MIN194

fig. 9.1.1

OVERHEAD MANOEUVRING POST ON COLUMN

1 - Steps
2 - Platform
3 - Ladder
4 - Side guard
5 - Seat



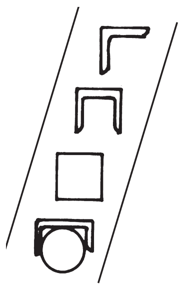
MIN195

fig. 9.1.2

STEPS/LADDERS (DIMENSIONS)

	MIN (mm)	MAX (mm)
A		600
B	220	300
C	300	
D	19	40
E	150	
F_1	240	400
F_2	150	
H		150
R		300

RUNGS CROSS-SECTION



MIN196

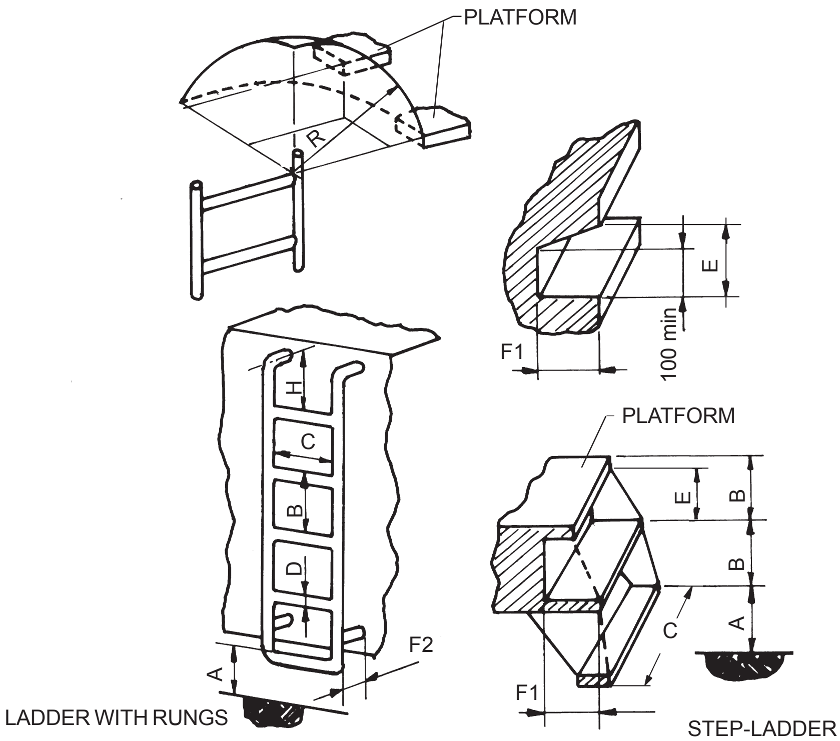
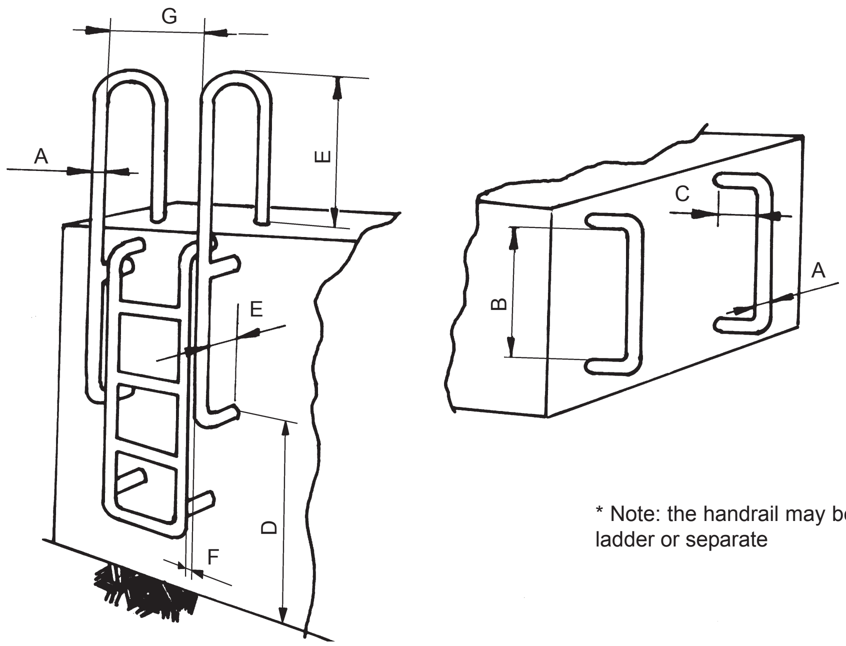


fig. 9.1.3

HANDRAILS AND HAND-GUARDS (DIMENSIONS)

	MIN (mm)	MAX (mm)
A	16	40
B	150	
C	75	
D		1600
E	850	
F	75	200
G	45	



* Note: the handrail may be part of the ladder or separate

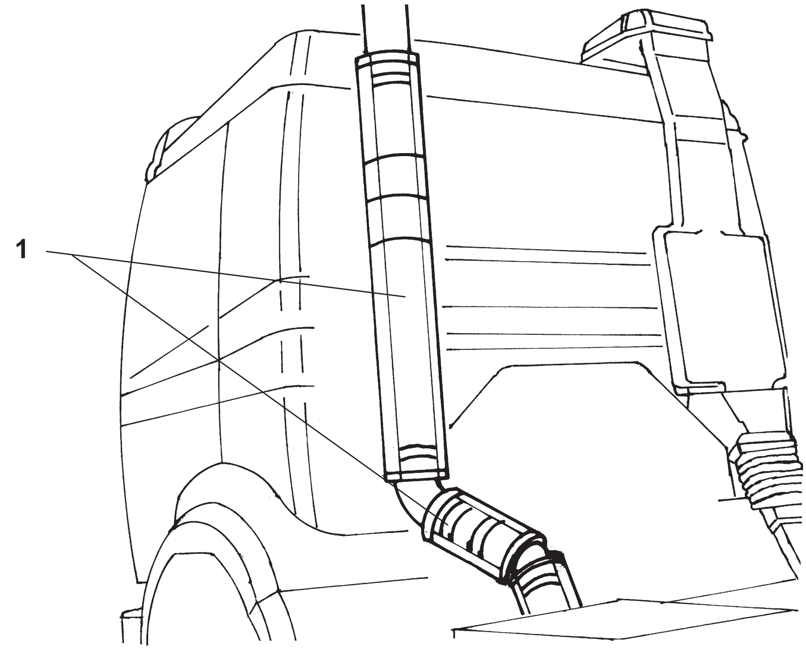
MIN197

fig. 9.1.4

9.2 - Protection against the risk of inhaling exhaust fumes

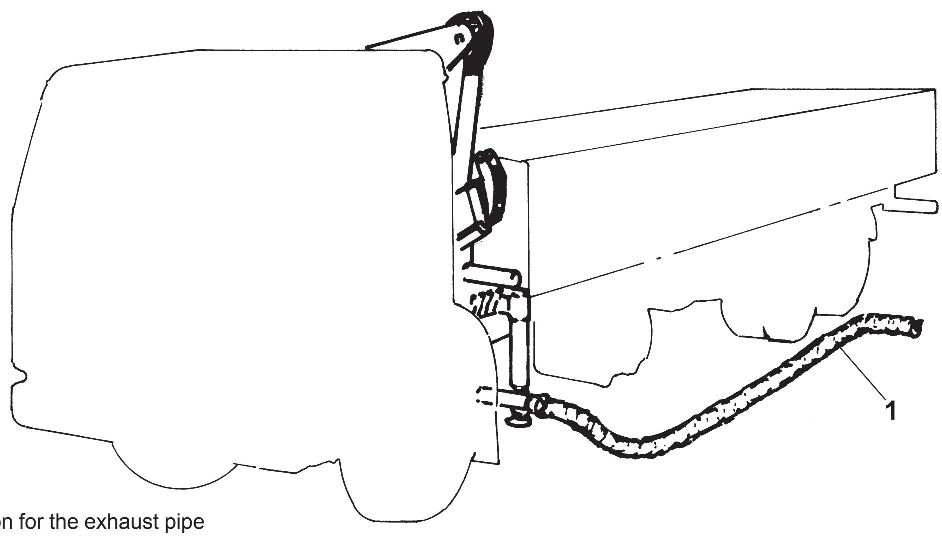
Particular care must be taken over the position of the vehicle's exhaust pipe. If it is too close to the control position, the operator is exposed to the risk of inhaling the fumes. It may be necessary to apply for authorisation from the vehicle manufacturer to vary the route of the piping (fig. 9.2.1) or to arrange a flexible extension (fig. 9.2.2) to be mounted before using the crane.

VEHICLE EXHAUST PIPE ORIENTED UPWARDS



1) Guards/shields to protect against scorching

fig. 9.2.1



1) Flexible extension for the exhaust pipe

fig. 9.2.2

9.3 - Protection against the risk of crushing and shearing

From the natural position in which the operator operates the controls, it must not be possible for any part of the body to reach areas where there is risk of crushing or shearing.

These risks can be avoided if you keep to the distances indicated in fig. 9.3.1 between moving parts extract from the standard EN349.

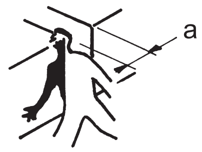
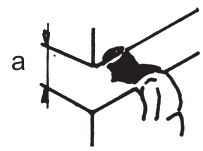
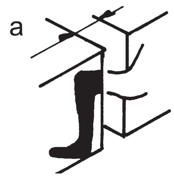
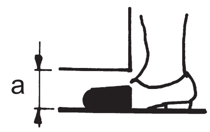
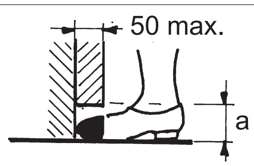
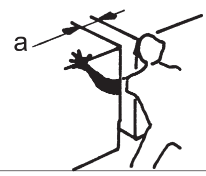
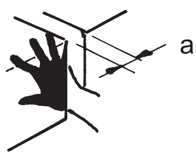
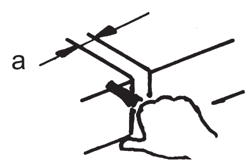
BODY PART	MINIMUM SPACE (mm)	ILLUSTRATION
BODY	500	 MIN200-A
HEAD (last good position)	300	 MIN200-B
LEG	180	 MIN200-C
FOOT	120	 MIN200-D
TOES	50	 MIN200-E
ARM	120	 MIN200-F
HAND	100	 MIN200-G
FINGER	25	 MIN200-H

fig. 9.3.1

☞ Note

Residual risks
If a risk cannot be eliminated completely, it must be reduced to a minimum by instructing the operators exactly how to behave.

9.4 - Noise levels

For cranes mounted on a truck where the engine is the power source, the noise emissions are determined by the engine.

It is the installer's responsibility to asses the levels of noise pollution emitted by the crane-vehicle combination and to make the necessary arrangements such as prescribing the machine's user to wear ear muffs or ear plugs.

For the noise emissions level, refer to the vehicle manufacturer's declaration.

When provided for by the laws in force in the country the machine is being used in, the installer must arrange prescribe the relative personal safety gear (ear muffs, plugs etc.) or reduce the noise levels.

9.5 - Installing the control with flexible cables

9.5.1 - Premise

This kind of control is designed to meet the needs of those who have to use the machine in different positions from the standard one.

This control can be placed in a variety of positions, either vertically or horizontally, depending on the type of crane-vehicle combination and the kind of work that is to be carried out with the crane.

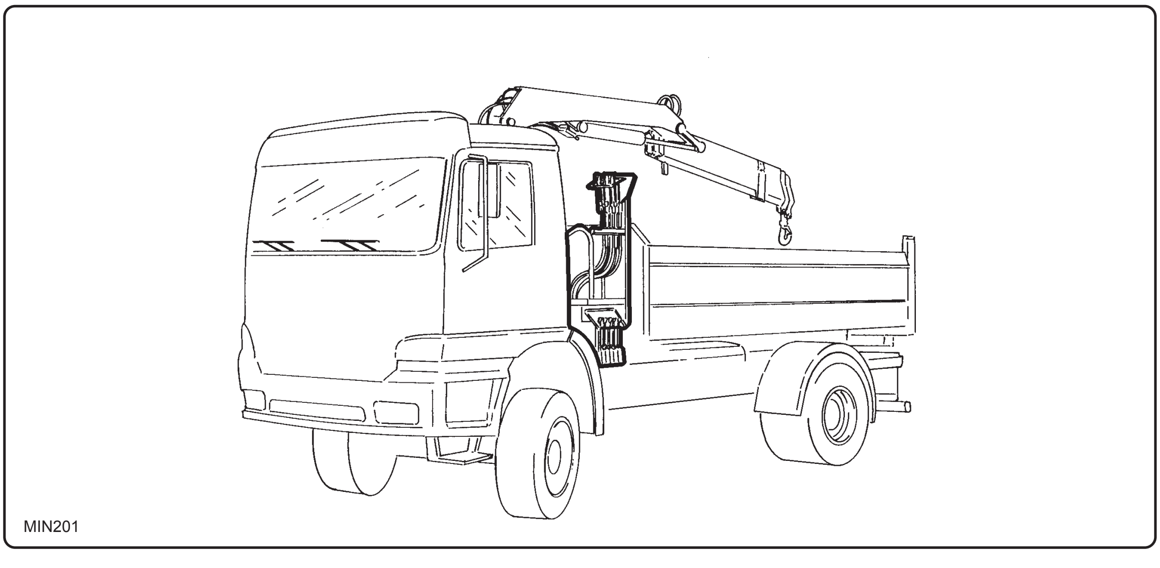


fig. 9.5.1

9.5.2 - Parts description (fig. 9.5.2)

A) Adapters for coupling to the crane's distributor
B) Flexible cables
C) Kit for coupling to the control unit
D Control lever unit
E) Support

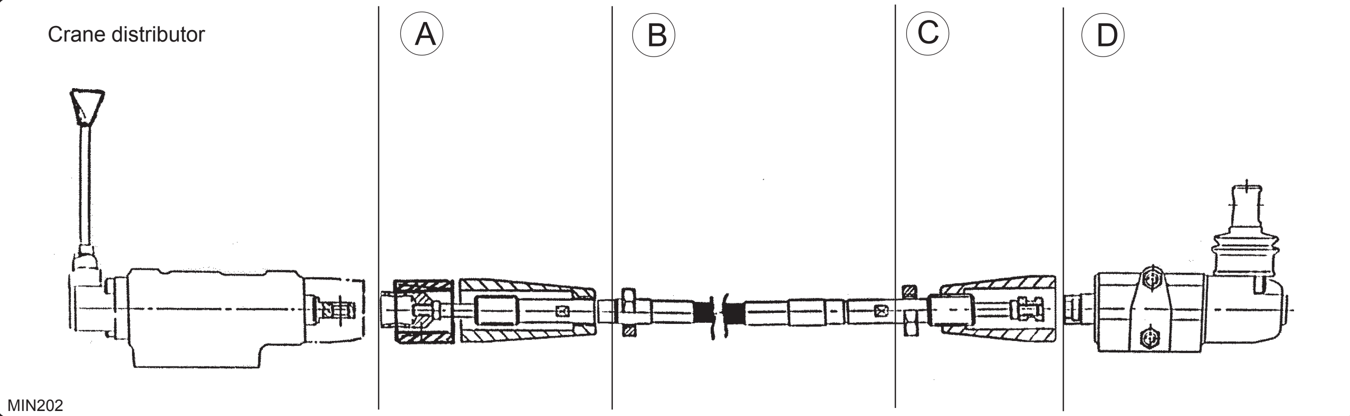
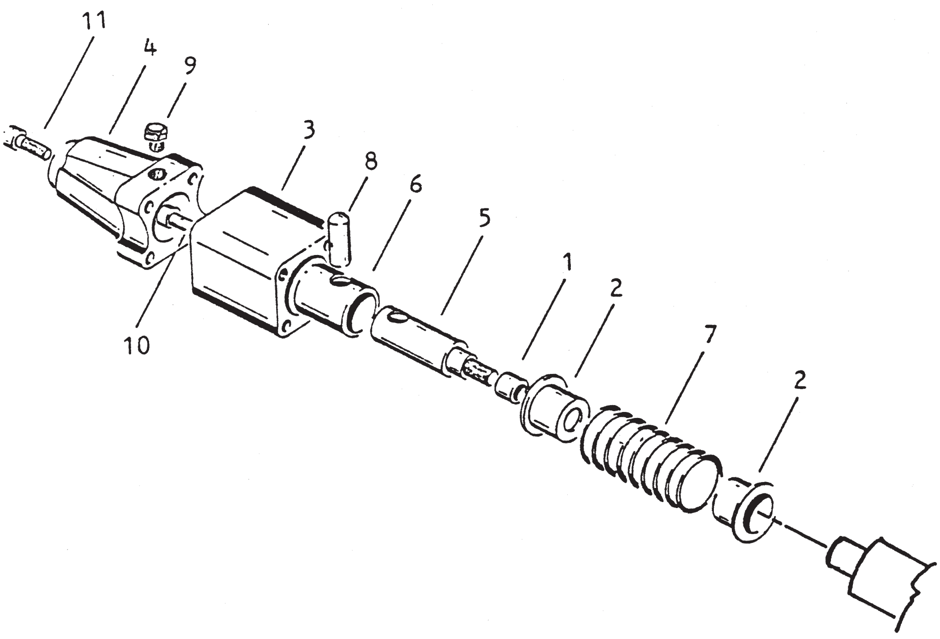


fig. 9.5.2

A) Adapters for coupling to the crane's distributor (fig. 9.5.3)

These allow the distributor to be connected with the flexible cable.
For assembly, see the sequence shown in figure 9.5.3.

1. Ring
2. Bushing
3. Spacer
4. Cap
5. Coupling
6. Joint
7. Spring
8. Pin
9. Plug
10. Screw
11. Screw



MIN203

fig. 9.5.3

B) Flexible cables (fig. 9.5.4)

Technical data:
- Maximum transmittable stress: 600 N (thrust) - 400 N (pull)

- Stroke: +/- 12 mm
- Minimum curve radius: 200 mm
- Operating temperature: -10/+60 °C

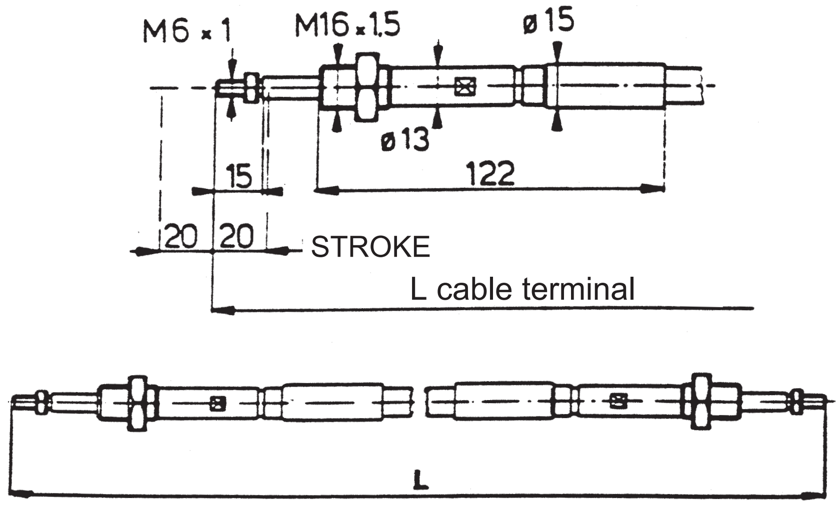


fig. 9.5.4

C) Kit for coupling to the control unit (fig. 9.5.5)

This allows the flexible cables to be connected to the control lever unit.

1. Flange
2. Coupling
3. Screw

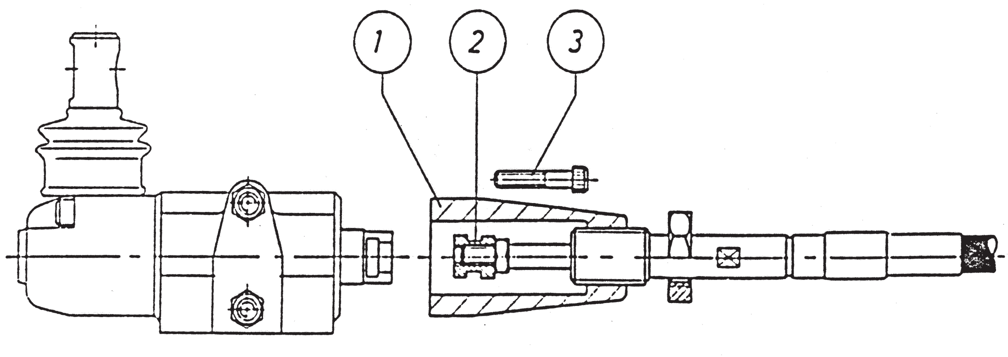


fig. 9.5.5

D) Control lever unit

The number, sequence and operating directions are the same as for the crane's standard controls.

E) Support

The assembly kit includes a support for the control installation with flexible cables.

The support is designed to ensure the parts of the kit are assembled correctly, but it must be completed with the part used to secure it to the machine.

This fastening must be carried out by the installer according to the customer's requirements and the type of work the machine will be put to.

9.5.3 - Installing the control with flexible cables

- Position the manoeuvring post according to the length of the flexible cables.
- Fasten the control lever support onto the machine.
- Mount the control lever unit and the lever guard (fig. 9.5.6).

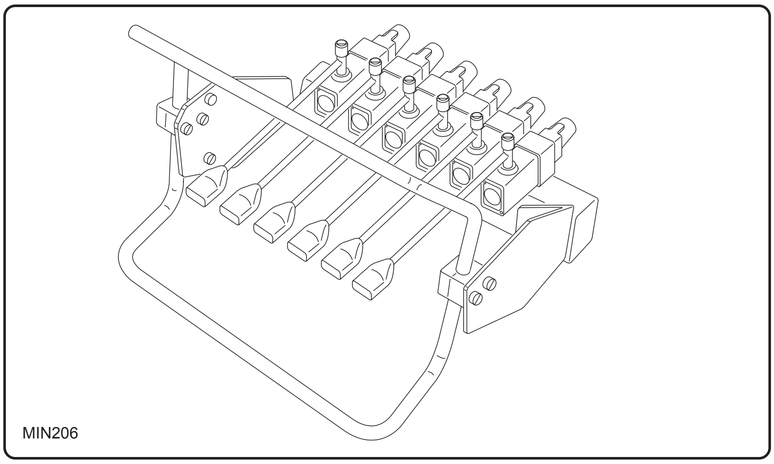


fig. 9.5.6

- Mount the casing for the control plates (A) either vertically or horizontally, depending on how the manoeuvring post is positioned (fig. 9.5.7).

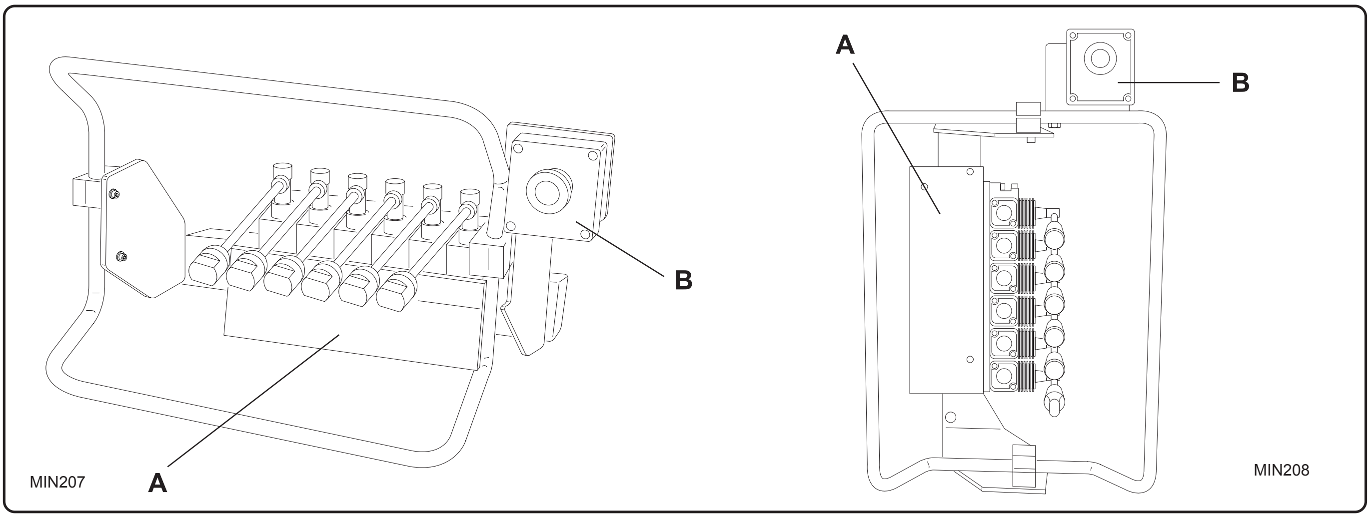


fig. 9.5.7

- Mount the supplementary emergency stop button (B) according to the assembly direction (fig. 9.5.8).

- The button’s electrical connection must be made as shown below (fig. 9.5.8).

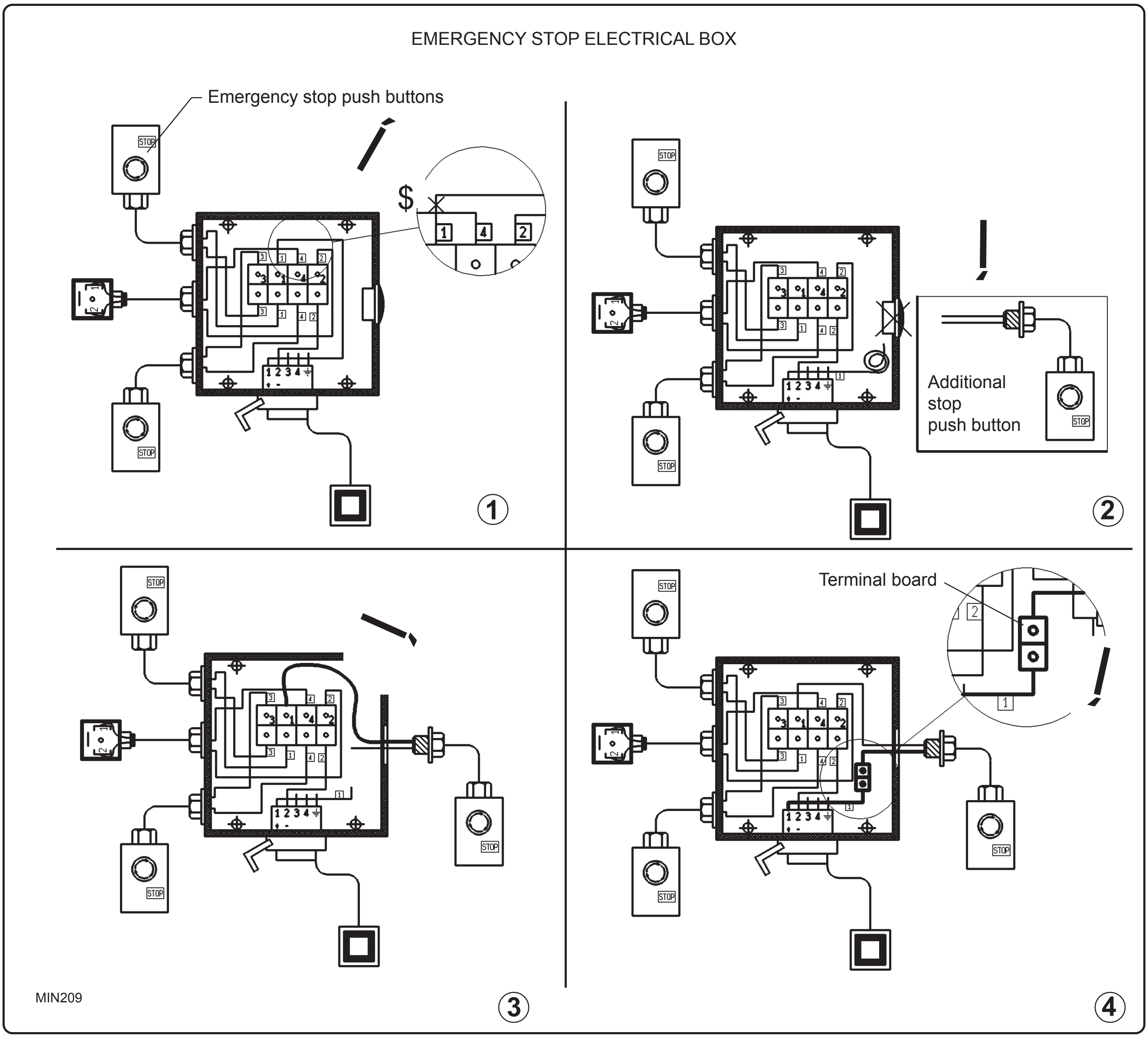


fig. 9.5.8

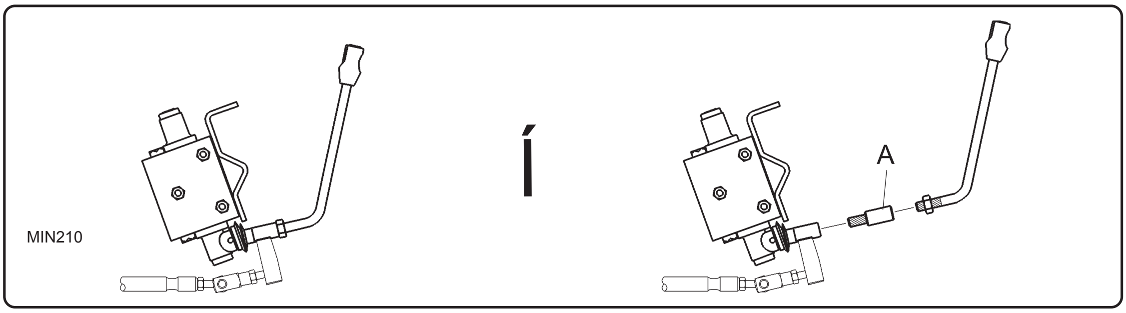


fig. 9.5.9

- For cranes fitted with a SD6 distributor only (crane series 8 -10 -12 -14), carry out the following procedure.

  1) Insert the extensions (A) between the levers and the lever coupling on the distributor (fig. 9.5.9).

  2) Move the distributor's plate holder casing towards the levers and fasten it with the relative holes (fig. 9.5.10).

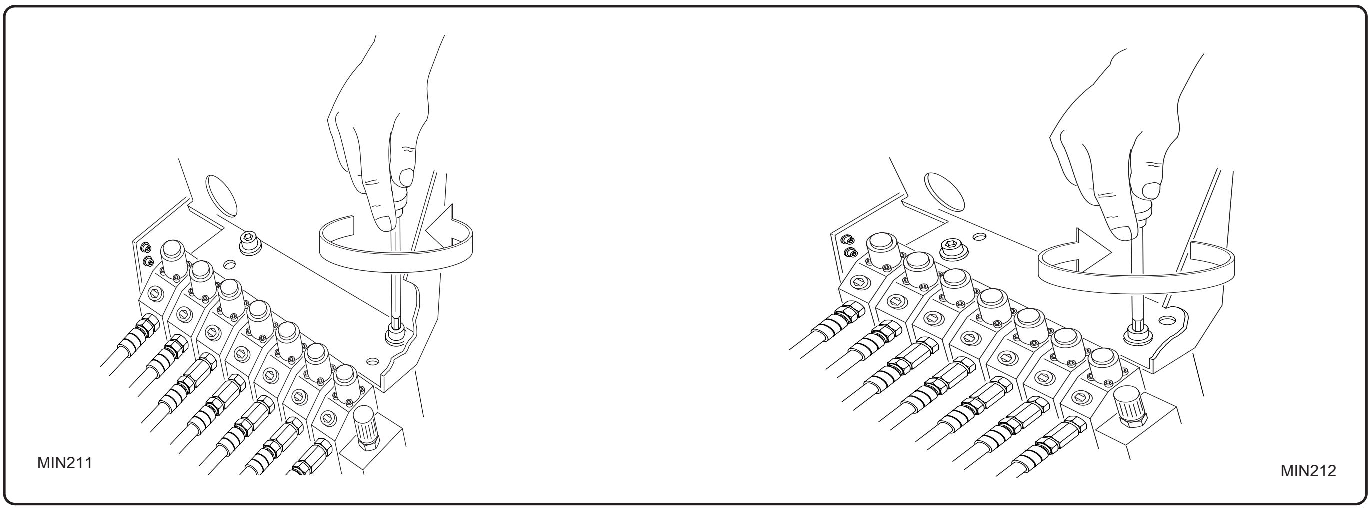


fig. 9.5.10

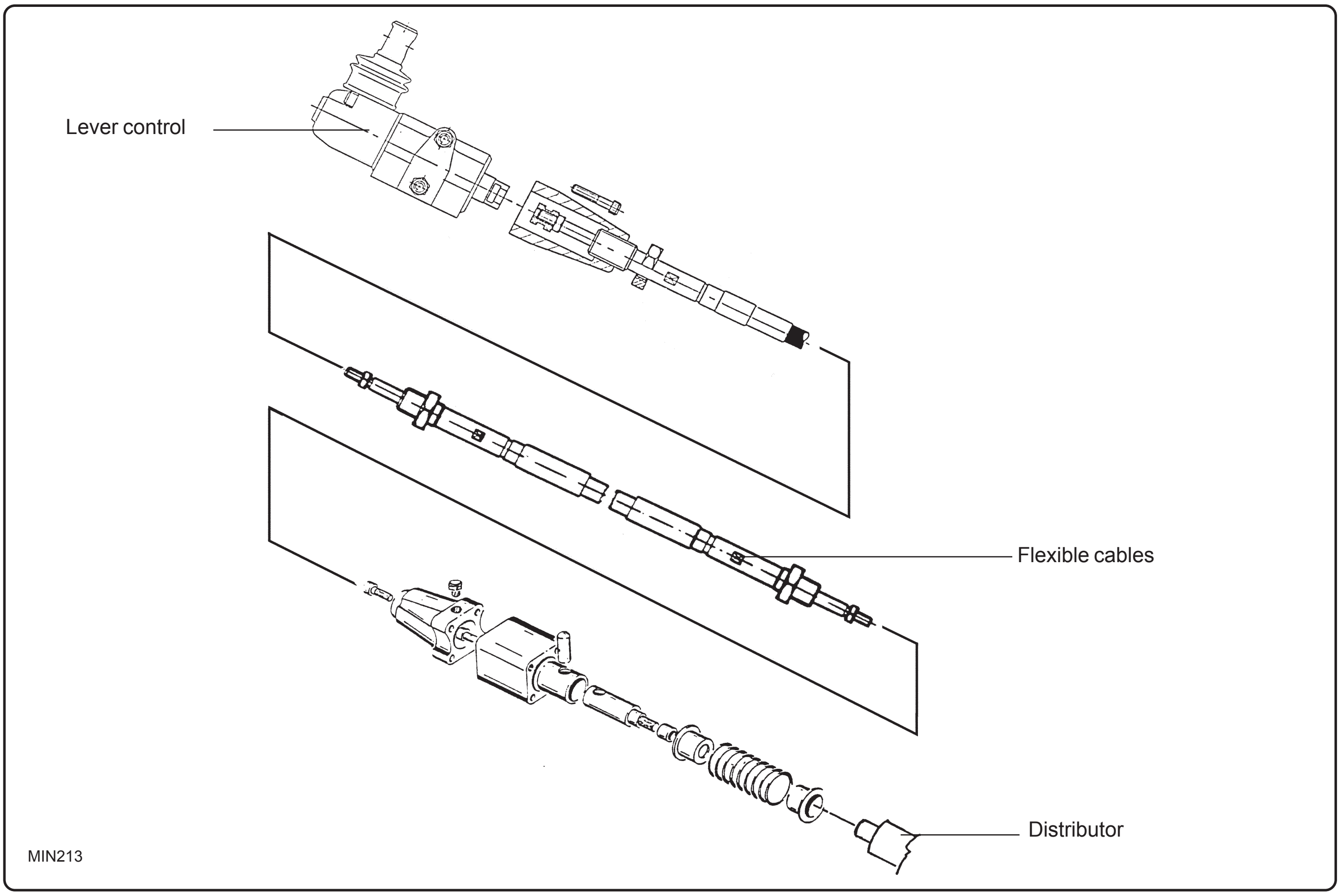


fig. 9.5.11

- Remove the distributor's caps and mount the flexible cables on to the distributor as shown in figure 9.5.11.

- Once the assembly is complete, check the control unit installed is functioning correctly and check the plates indicating the manoeuvres are positioned correctly.

ATTENTION!!!

Make particularly sure you have reduced the bending and curving of the flexible cables to a minimum to prevent stiffness of the controls.

9.6 - Installing the remote control

For the cranes fitted with a remote control (whether cable- or radio-controlled), during the mounting phase, the installer must carry out the following operations.

1) Connect the electricity supply cables (+/-)(see chapter 8 - electric system).

2) Connect the (CL) cable to activate the vehicle's horn from the remote control pushbutton panel (see chapter 8 - electric system).

3) Connect the (START/STOP) cables for switching the engine on/off from the remote control pushbutton panel (when provided) (see chapter 8 - electric system).

4) Mount and connect flashing light unit to indicate the crane is in use and that 90% of the maximum load capacity has been reached (see chapter 8 - electric system).

5) Mount and connect the radio receiver (only for controls with radio transmission).

If the receiver unit has not already been installed by Autogru PM, follow the instructions listed below.

- The receiver must be installed vertically, with the cables output connector/socket facing downwards and in a position which is sheltered from possible contact with water.

- Choose a position in which the receiver unit can be opened easily and which guarantees the visibility of the lights/ indicators, and easy access to the key-operated switch for enabling the manual/radio controls.

- Place the receiver (which contains the antenna) in a high position (no lower than 2m off the ground) and preferably in an area which offers a clear view of the machine's work area without a metal screens around it.

- Find a spot in which to secure the receiver where there are no vibrations and, if necessary, place rubber shock absorbers between the unit and the machine.

- If you should need to dismount the receiver's connector/socket, always install the relative protective cover.

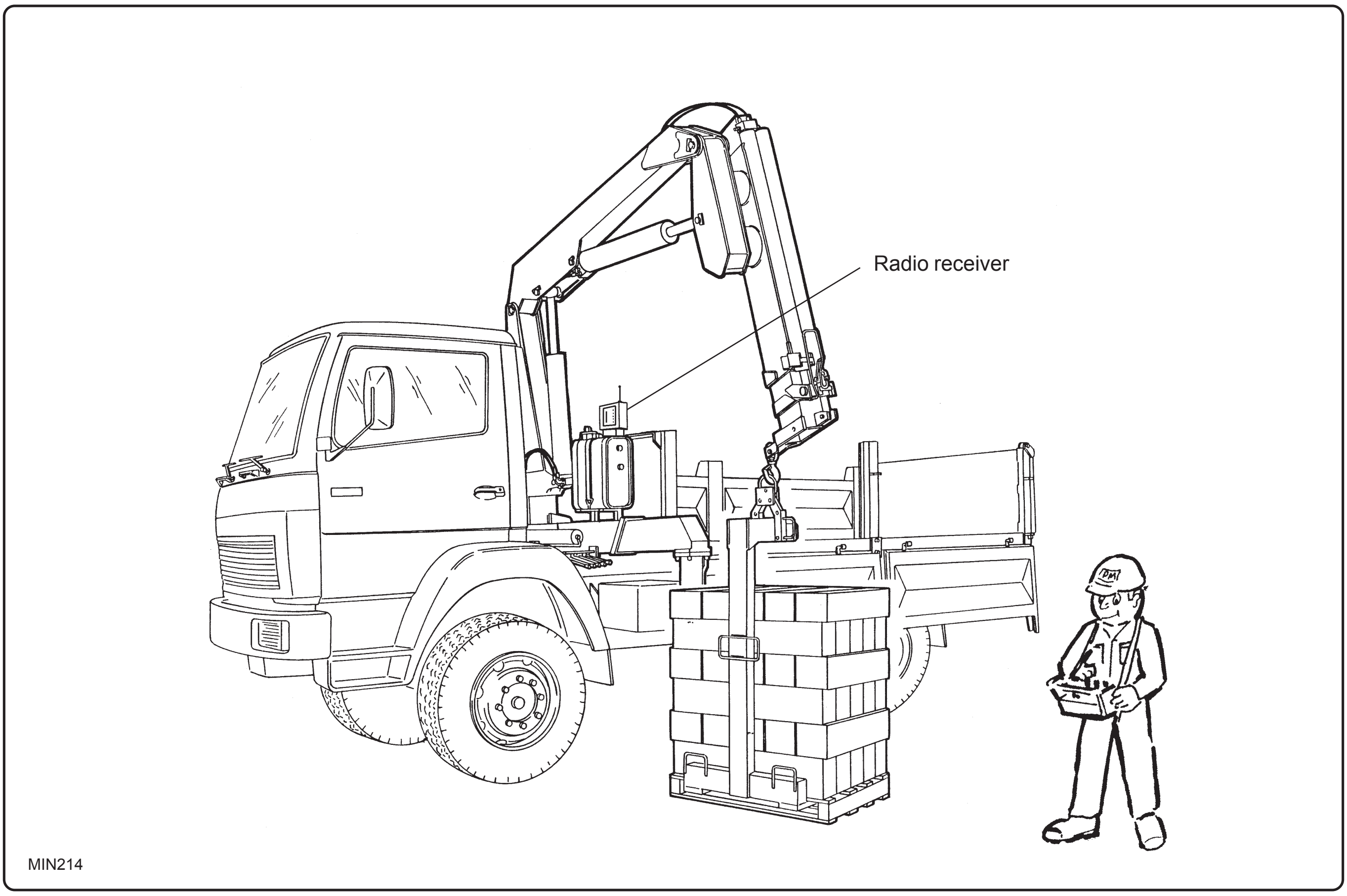


fig. 9.6.1

9.7 - Instructions for starting up the seat in the upper manoeuvring post

9.7.1 - Description

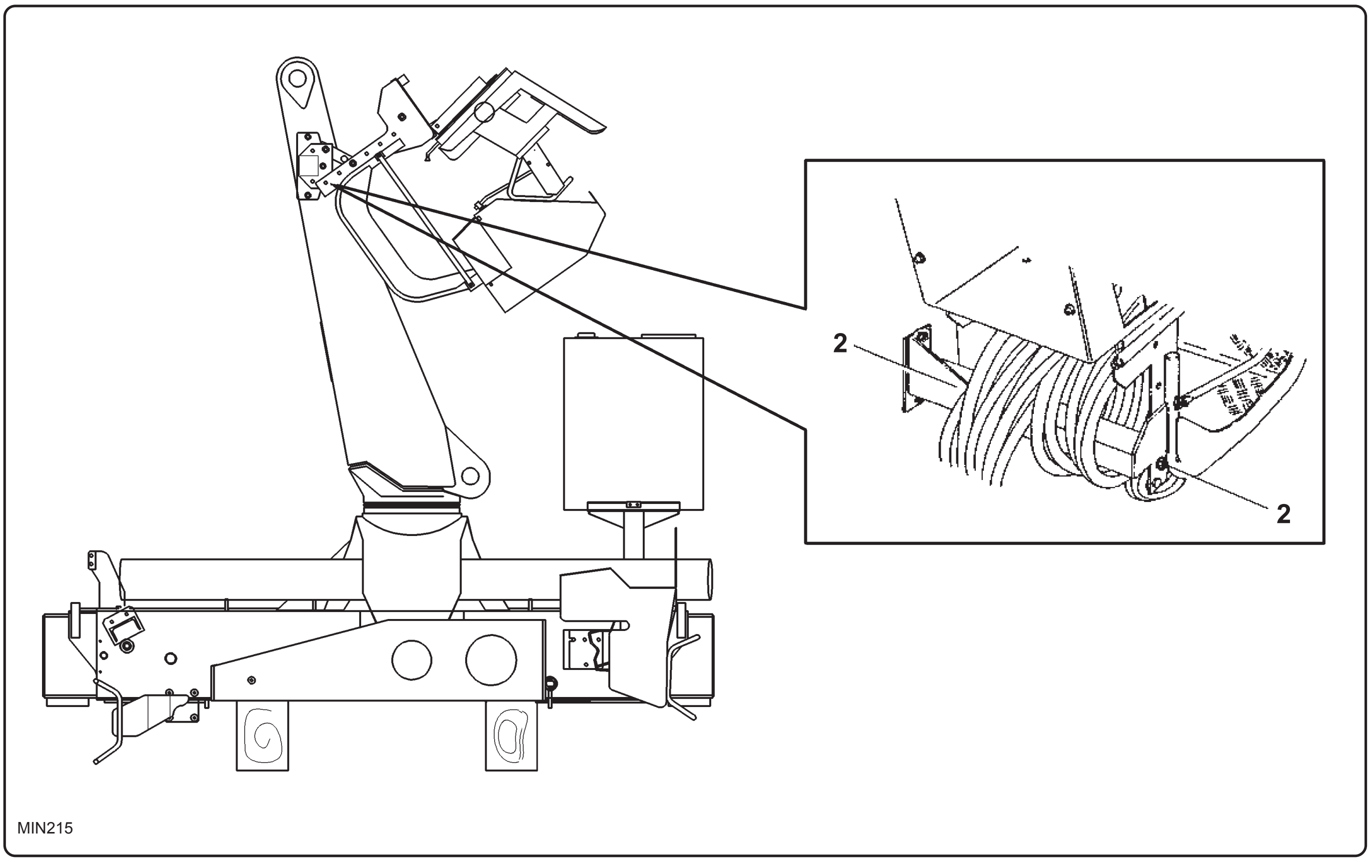


fig. 9.7.1

To limit the height of the machine during delivery/transportation, we supply the machines equipped with the overhead manoeuvring post with the said post facing downwards (the seat “3” is folded up against the control unit) fig. 9.7.1.
Therefore the first operation to perform is the correct positioning of the seat unit, which entails the following steps:
- remove the clamp “1”, used to keep the seat angled;
- unscrew the two screws “2” that hold the seat unit in place slightly (the minimum necessary to allow the seat unit to be rotated) (see detail fig. 9.7.1);
- rotate the seat unit upwards (using suitable hoisting equipment) and lock it into vertical position with the screws “1”, the washers “2” and the self-locking nuts “3” (see detail, fig. 9.7.2).

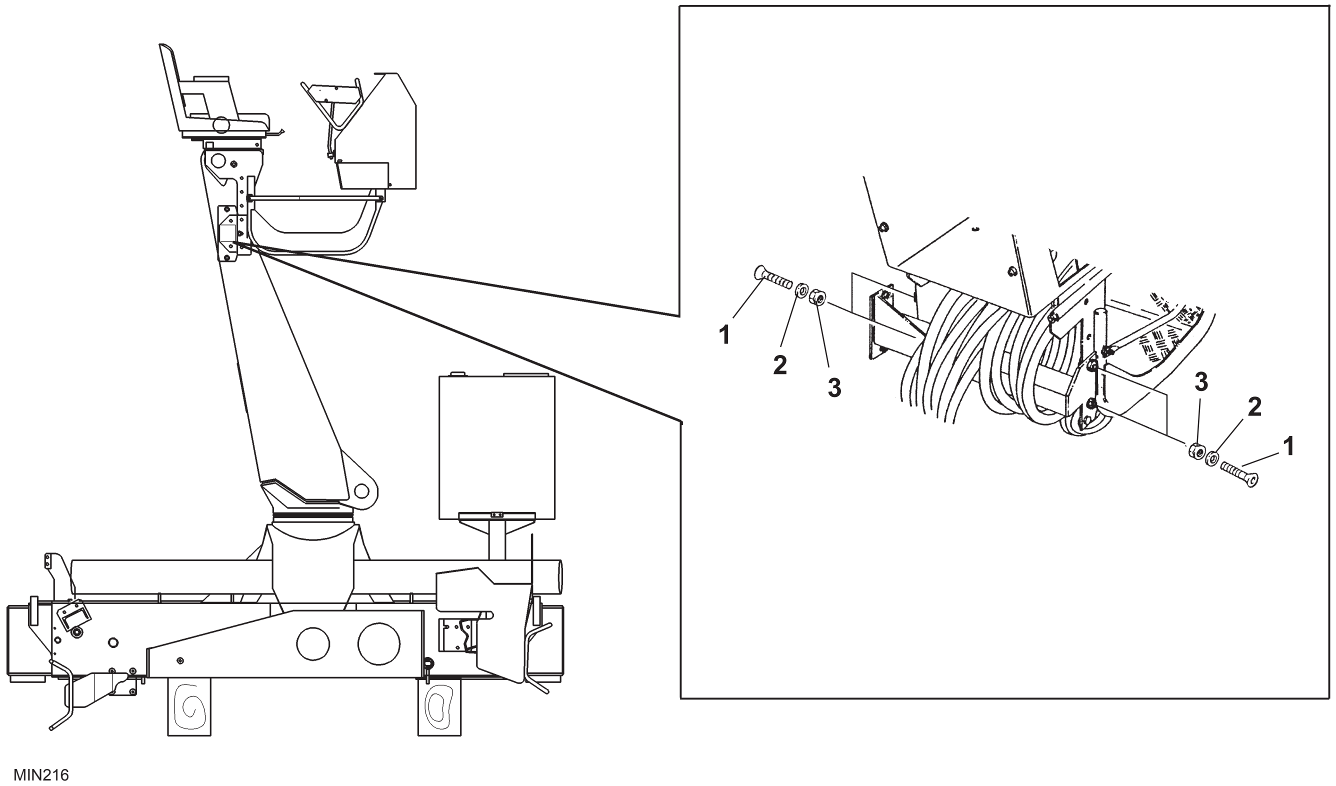


fig. 9.7.2

- All you need to do now is rotate the seat 4 and put it into the correct position.

The seat's anchorage support has a series of holes which allow it to be adjusted heightwise.

The installer must fasten the seat in the most suitable position, depending on the way the crane-vehicle combination is set up, making sure that the two heights A and B meet the conditions indicated in figure 9.7.3.

Amin = Minimum height that allows the seat to rotate freely without affecting any of the vehicle's other dimensions (e.g. driver's cab, pole holder, body side panels etc)

Bmax = Total height of the crane-vehicle combination in relation to the ground must never exceed the maximum admissible limit set by the standards in force in the country of use

MIN217

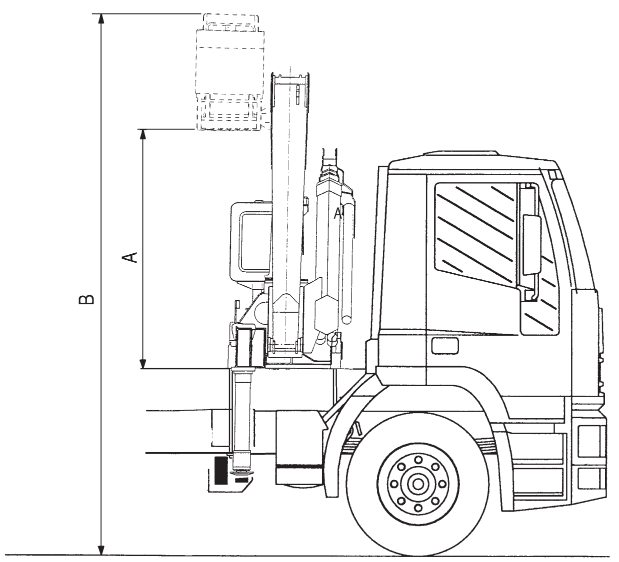


fig. 9.7.3

9.7.2 - Adjusting the seat anchorage

The overhead manoeuvring post seat can be adjusted to suit the operator's physique and posture in order to prevent negative effects caused by an incorrect work position.

Horizontal adjustments
Using the two fastening screws "A" or the lever "B" located underneath the seat, you can move the seat backwards or forwards to suit the operator's physical stature.

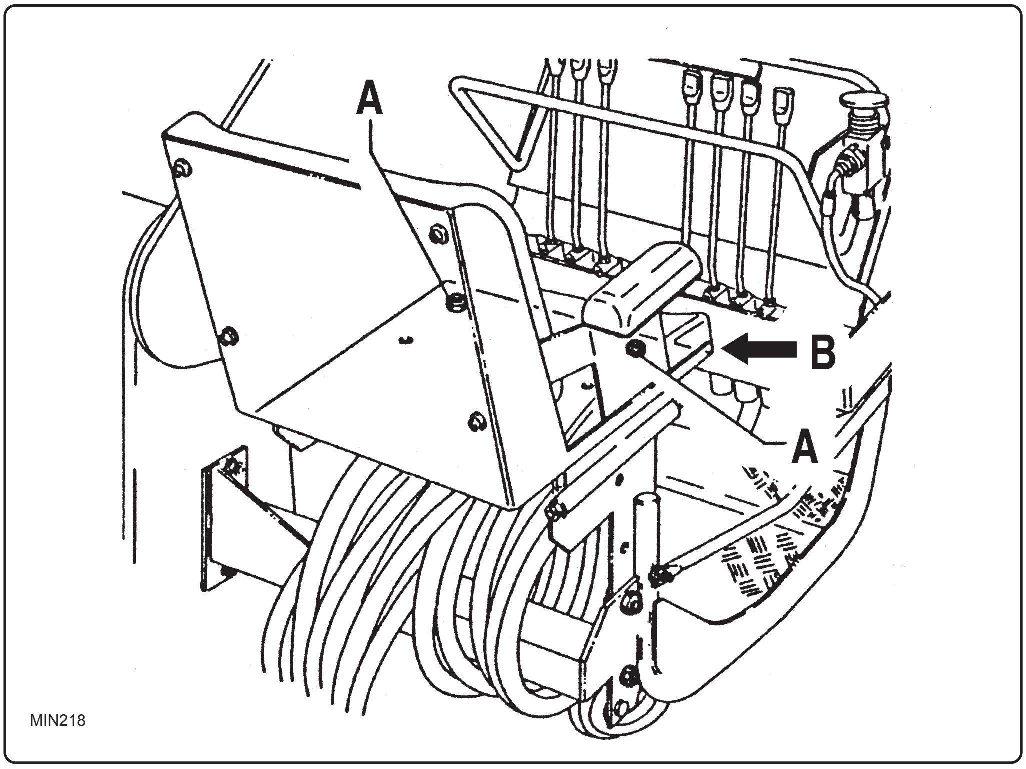


fig. 9.7.4

MENU

OUTRIGGERS

10.1 - Outrigger cylinder extensions

These are accessories which make it possible to increase the length of the outrigger cylinders if they are not long enough to stabilise the crane-vehicle combination.

10.1.1 - Exstension types

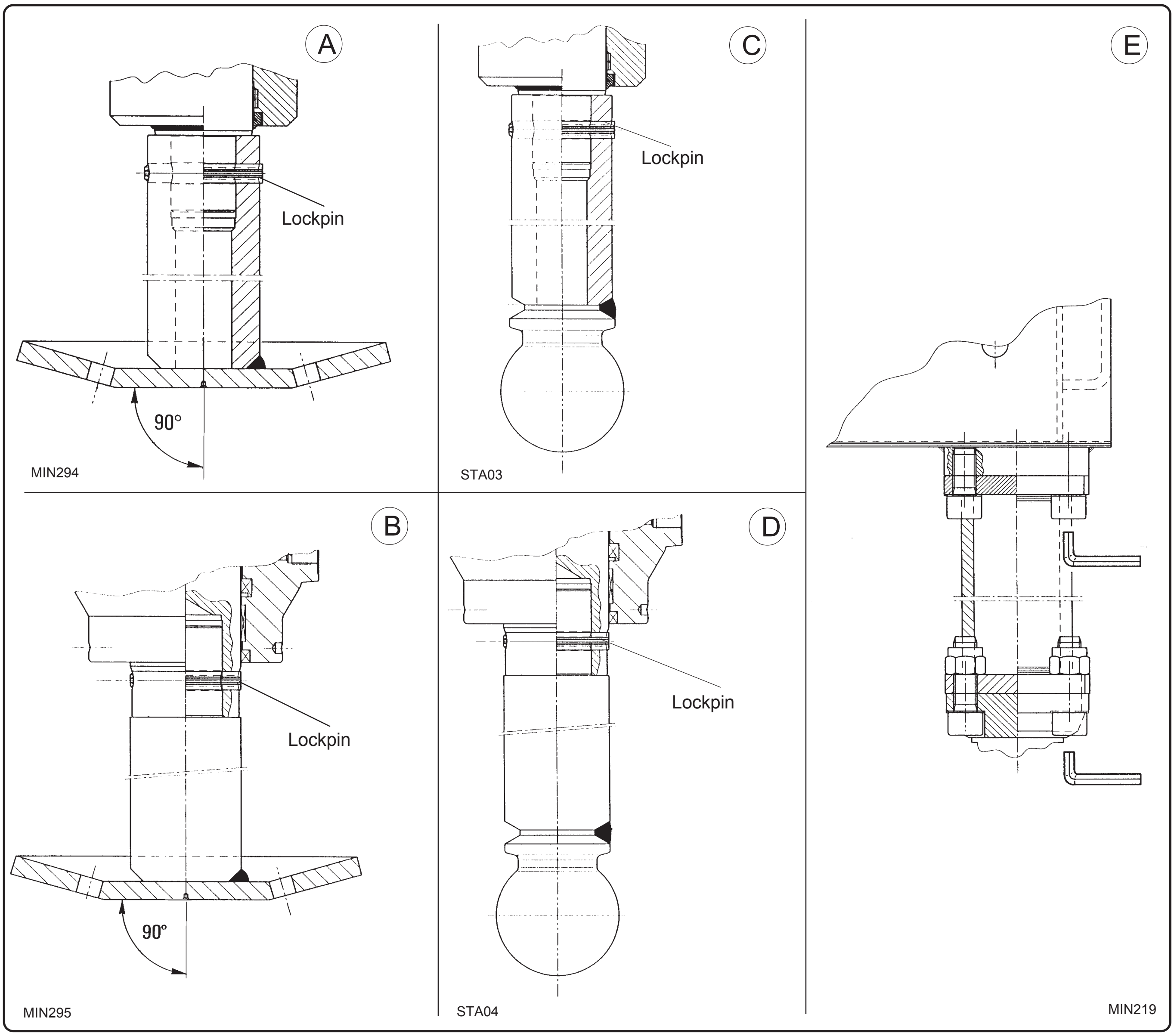


fig. 10.1.1

A) Mounting the extension and plate on the outrigger rod with male coupling by means of lockpin
B) Mounting the extension and plate on the outrigger rod with female coupling by means of lockpin
C) Mounting the extension with ball and articulated plate on the outrigger rod with male coupling by means of lockpin
D) Mounting the extension with ball and articulated plate on the outrigger rod with female coupling by means of lockpin
E) Mounting the plate extensions on the outrigger.

10.1.2 - Establishing the length of the extension

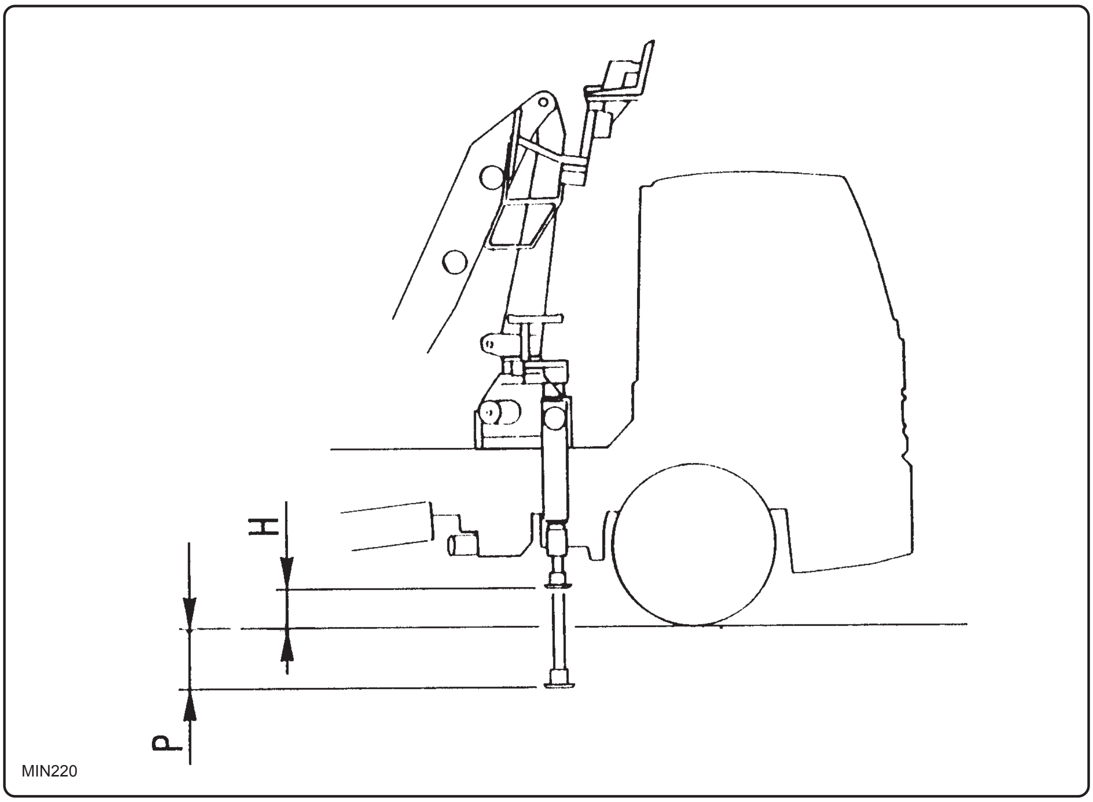


fig. 10.1.2

The optimum extension length must ensure:

1) a distance from the ground (H) which is greater than or equal to the minimum height of the (loaded) truck in relation to the ground when the outrigger cylinder is fully closed up.

2) A distance (P) of 150/220 mm beyond the point at which the outrigger rests on the ground when the outrigger cylinder is fully open, taking into account the actual stroke length of the vehicle's suspensions.

10.1.3 - Mounting the extension and the plate (type A and B)

- Welding the plate onto the extension

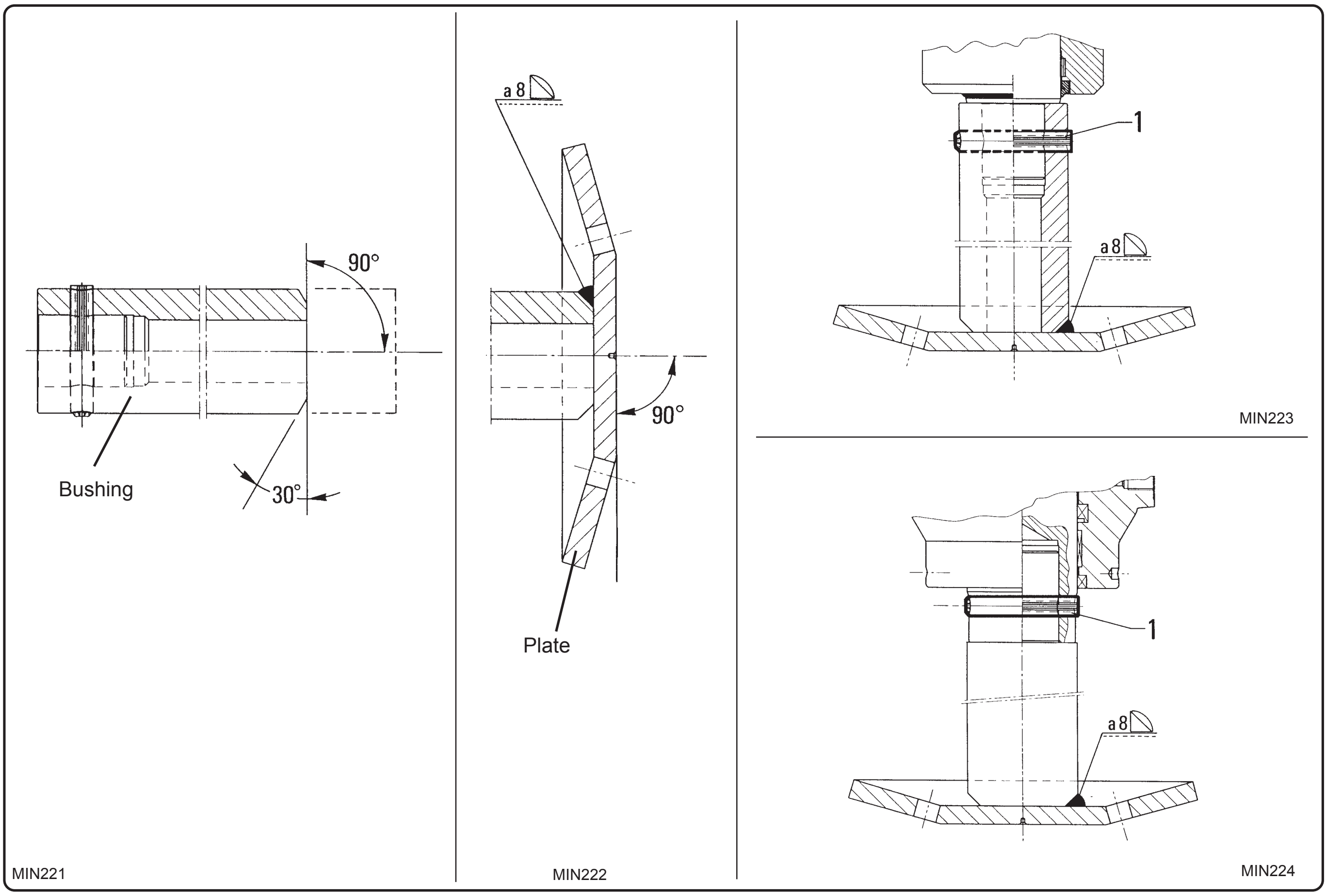


fig. 10.1.3

- Once the extension length required has been established, if necessary, make a cut the same size as the bushing (opposite the pin hole).
- The cut must be perfectly perpendicular to the longitudinal axis of the bushing.
- Perform a preparatory 45° chamfer on the plate's welding seam.
- Weld the extension to the plate following the instructions given in fig. 10.1.3.

Note

Use supplementary materials whose features are compatible with the bushing material. For further information, contact the Technical Assistance Service.
Always perform these operations professionally so that the surface of the plate that rests on the ground is perfectly perpendicular to the longitudinal axis of the bushing.

- Mounting the extension in the outrigger cylinder rod

- Insert the extension into the respective housing of the cylinder rod an lock it into place with the elastic pin “1”.
- Clean/pickle the parts where the paint has come away and re-paint them.

10.1.4 - Mounting the extension with a ball and a jointed plate

- Welding the ball to the extension tube

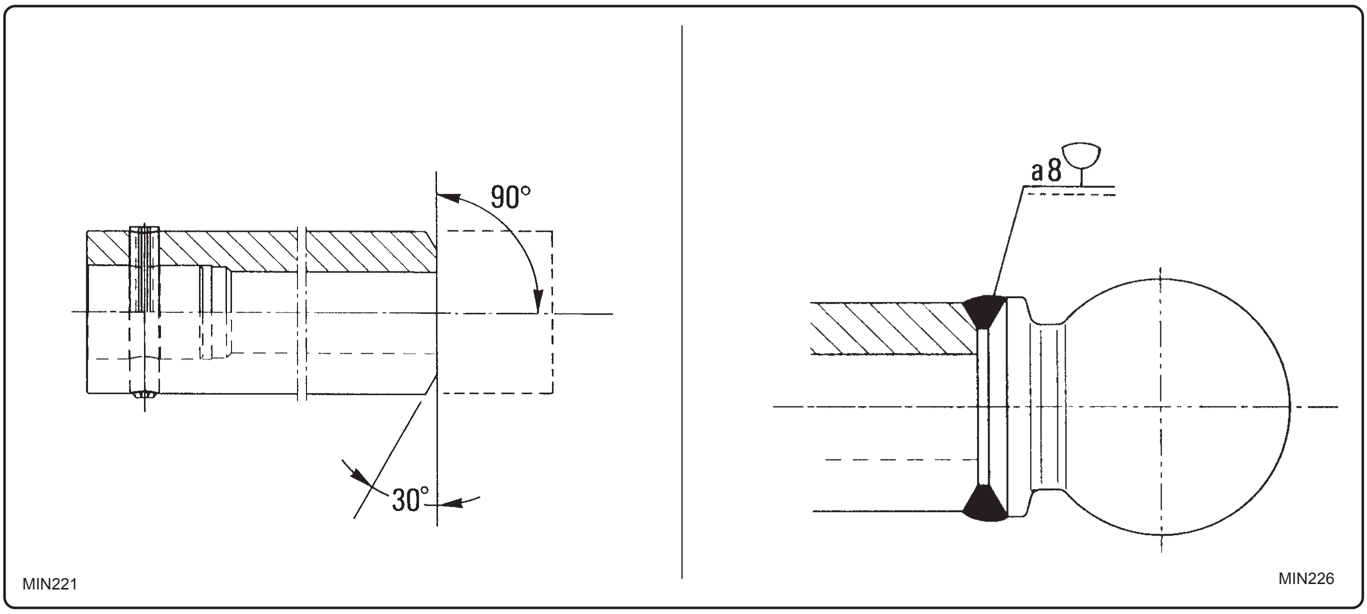


fig. 10.1.4

- Once the extension length required has been established, if necessary, make a cut the same size as the bushing (opposite the pin hole).
- The cut must be perfectly perpendicular to the longitudinal axis of the bushing.
- Perform a preparatory 30° chamfer on the plate’s welding seam.
- Weld the extension to the plate following the instructions given in fig. 10.1.4.

Note

Use materials whose features are compatible with the bushing material. For further information, contact the Technical Assistance Service.
Always perform these operations professionally so that the surface of the plate that rests on the ground is perfectly perpendicular to the longitudinal axis of the bushing.

- Installing the extension in the outrigger cylinder rod

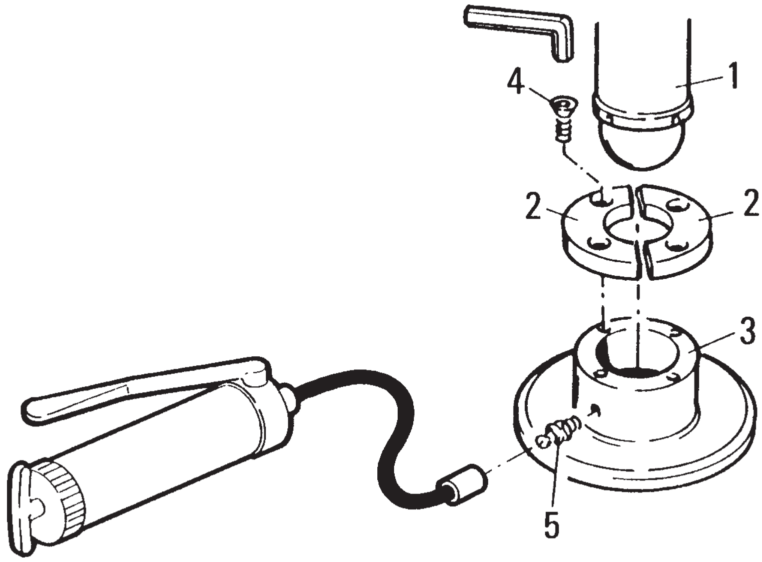


fig. 10.1.5

- Clean the surfaces damaged by the welding and paint them.
  Clean the following parts thoroughly:
  - the ball "1";
  - the ball's housing in the plate "3";
  - the semi-flanges "2".
- Spread a light layer of anti-rusting treatment over the ball "1" and the parts that will come into contact with the ball.
- Apply a medium thread brake fluid to the screws "4".
- Join the cap "3" with the extensions using the semi-flanges "2" and the respective screws "4" with a tightening torque of 3 daN.
- Grease the ball with the greaser "5", using NLGI2-type grease.

10.1.5 - Mounting the extension with a plate on the outriggerboom

Note

To establish the length of the extension, see sub paragraph 10.1.2.

- Welding the plates to the extension tube

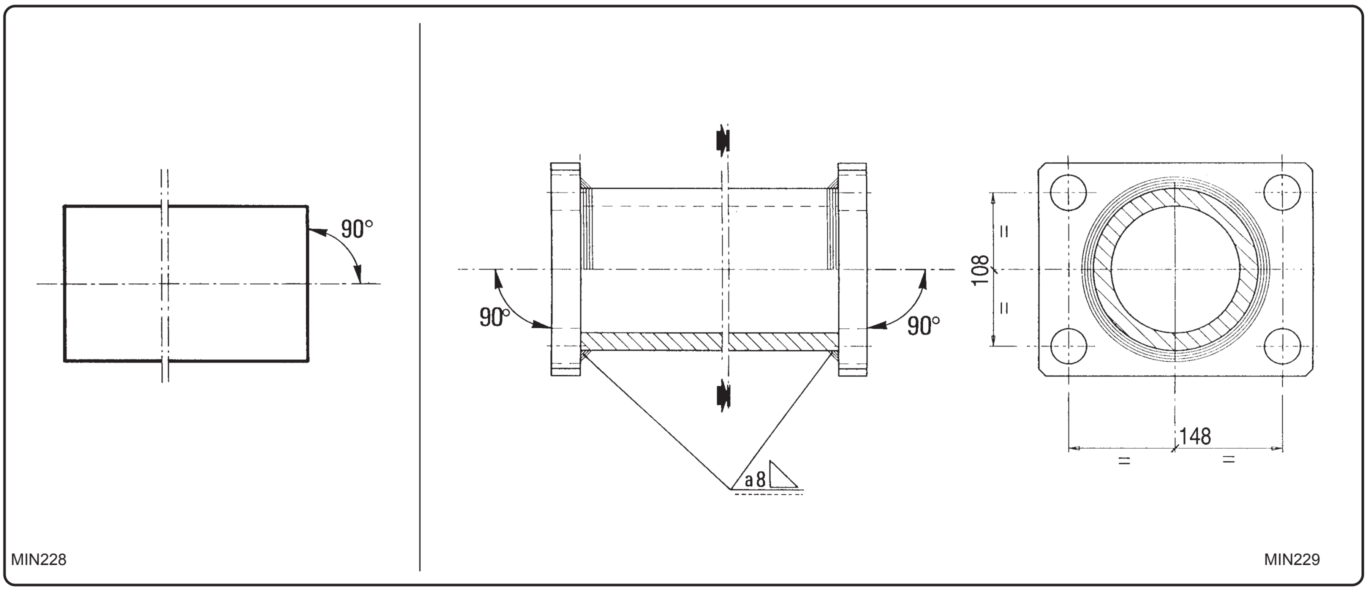


fig. 10.1.6

- Once the extension length required has been established, if necessary, make a cut the same size as the bushing.
- The cut must be perfectly perpendicular to the longitudinal axis of the bushing.
- Weld the extension to the plate following the instructions given in fig. 10.1.6.

Note

Use materials whose features are compatible with the bushing material. For further information, contact the Technical Assistance Service.
Always perform these operations professionally so that the flanges are perfectly perpendicular to extension tube.

- Mounting the extension on the boom and the outrigger cylinder

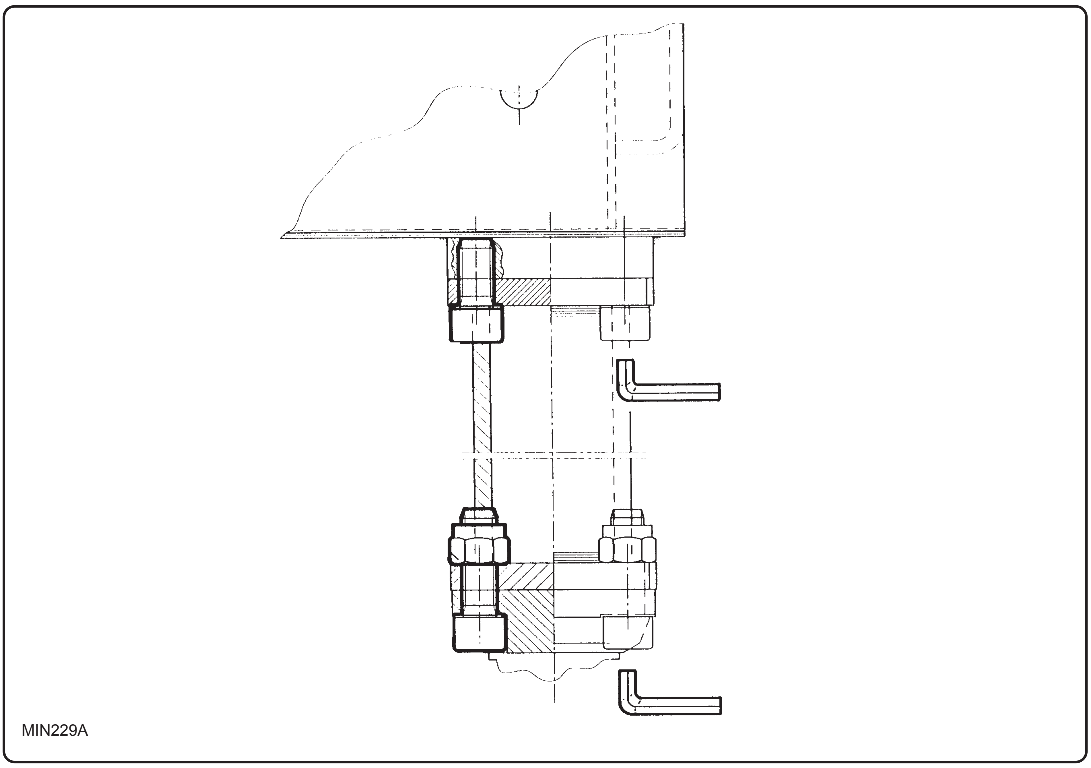


fig. 10.1.7

- Clean the surfaces damaged by the welding and paint them.
- Clean the support surfaces of the extension, the outrigger boom and the outrigger.
- Apply a thread brake to the outrigger boom extension fastening screws.
- Mount the extension on the outrigger boom, the outrigger cylinder and tighten the screws with a tightening torque of 7 daN.

10.2 - Mounting the outrigger cylinders

10.2.1 - Outrigger cylinder coupling types

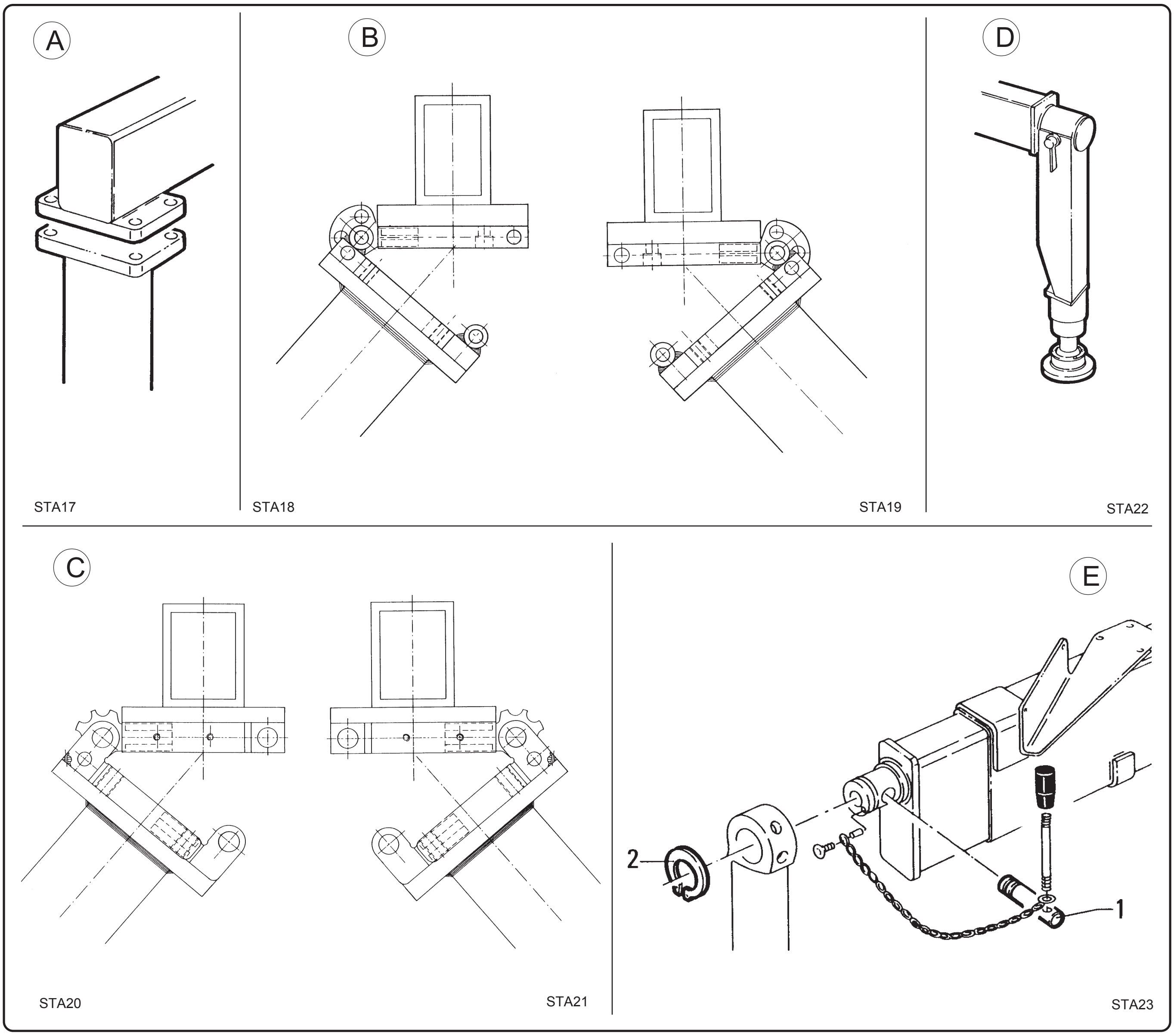


fig. 10.2.1

A) Outrigger cylinders with flanged coupling.
B) Outrigger cylinders with rotary plates fitted with bored joint.
C) Outrigger cylinders with rotary plates fitted with toothed joint.
D) Outrigger cylinders with height-adjustable anchorage.
E) Outrigger cylinders with rotary coupling.

10.2.2 - Mounting outrigger cylinders with flanged coupling

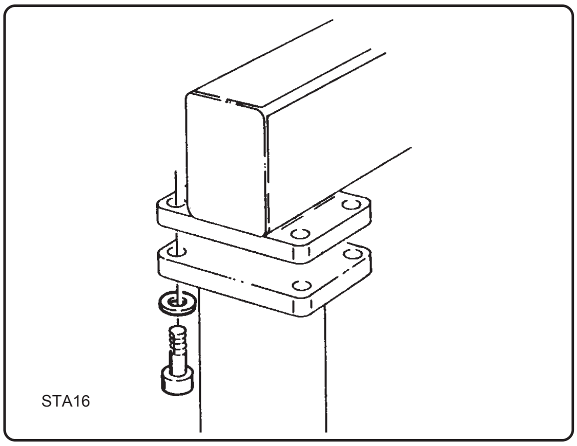


fig. 10.2.2

Clean the following parts carefully:

- the contact surfaces between the outrigger cylinder plate and the outrigger boom plate;
- the holes in the outrigger cylinder plate;
- the threaded holes in the outrigger boom plate.
- Now apply the medium brake fluid to the fastening screws.
- Mount the outrigger cylinder using the relative screws and washers.
- Tighten the screws with a suitable tightening torque.

10.2.3 - Mounting outrigger cylinders with rotary plates fitted with bored joint

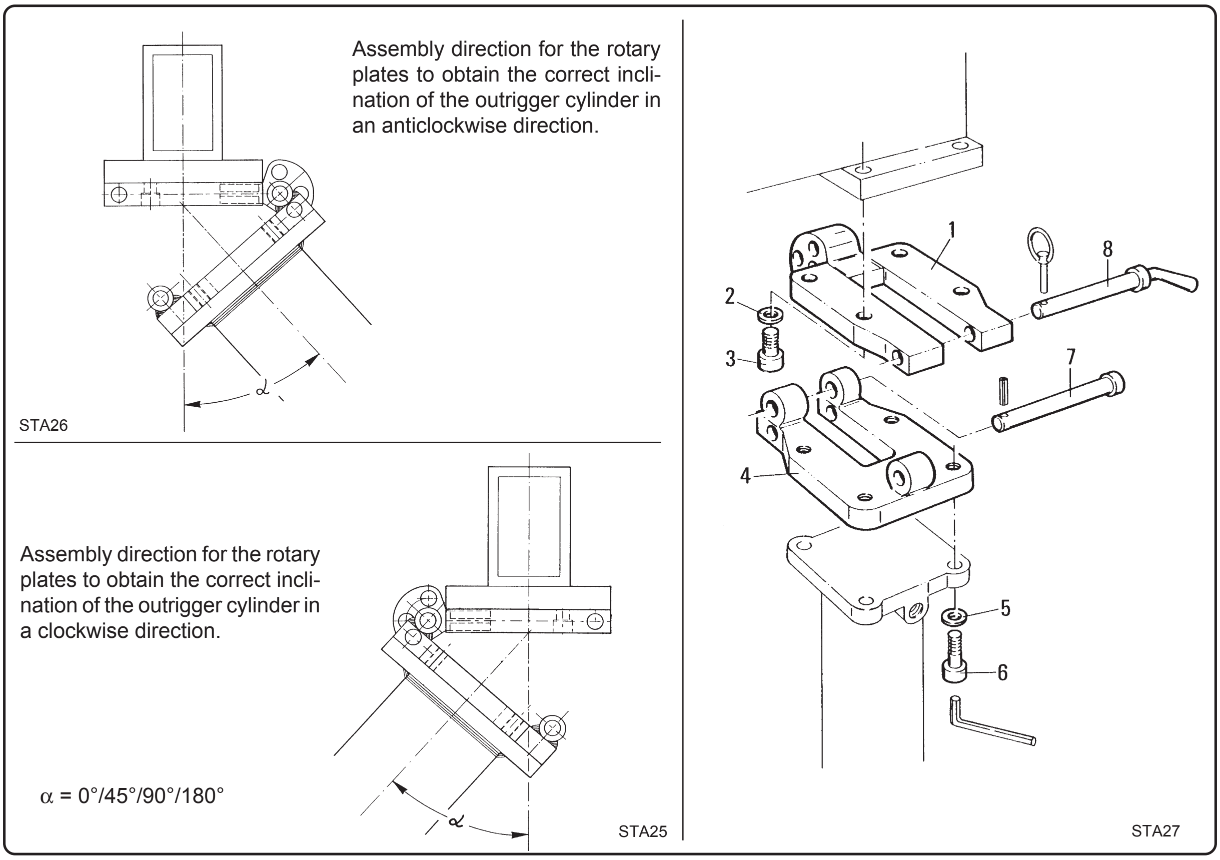


fig. 10.2.3

Clean the following parts carefully:
- all the contact surfaces;
- all the holes and threaded holes for the anchorage of the plates and the outrigger cylinders.
- Apply a medium resistance brake fluid to all the fastening screws.
- Once the assembly direction of the rotary plates has been established (in relation to the inclination you require for the cylinder), fasten the upper flange “1” to the outrigger boom with the relative screws and washers “2” and “3”, using a suitable tightening torque.
- Mount the lower flange “4” on the outrigger cylinder using the relative screws and washers “5” and “6” with a suitable tightening torque.
- Couple the two plates “1” and “4” and insert the two pins “7” and “8” with the relative safety lockpin.

☞ Note

The pin “7” must be inserted in the central hole of the rotation flange.

10.2.4 - Mounting outrigger cylinders with rotary plates fitted with toothed joint

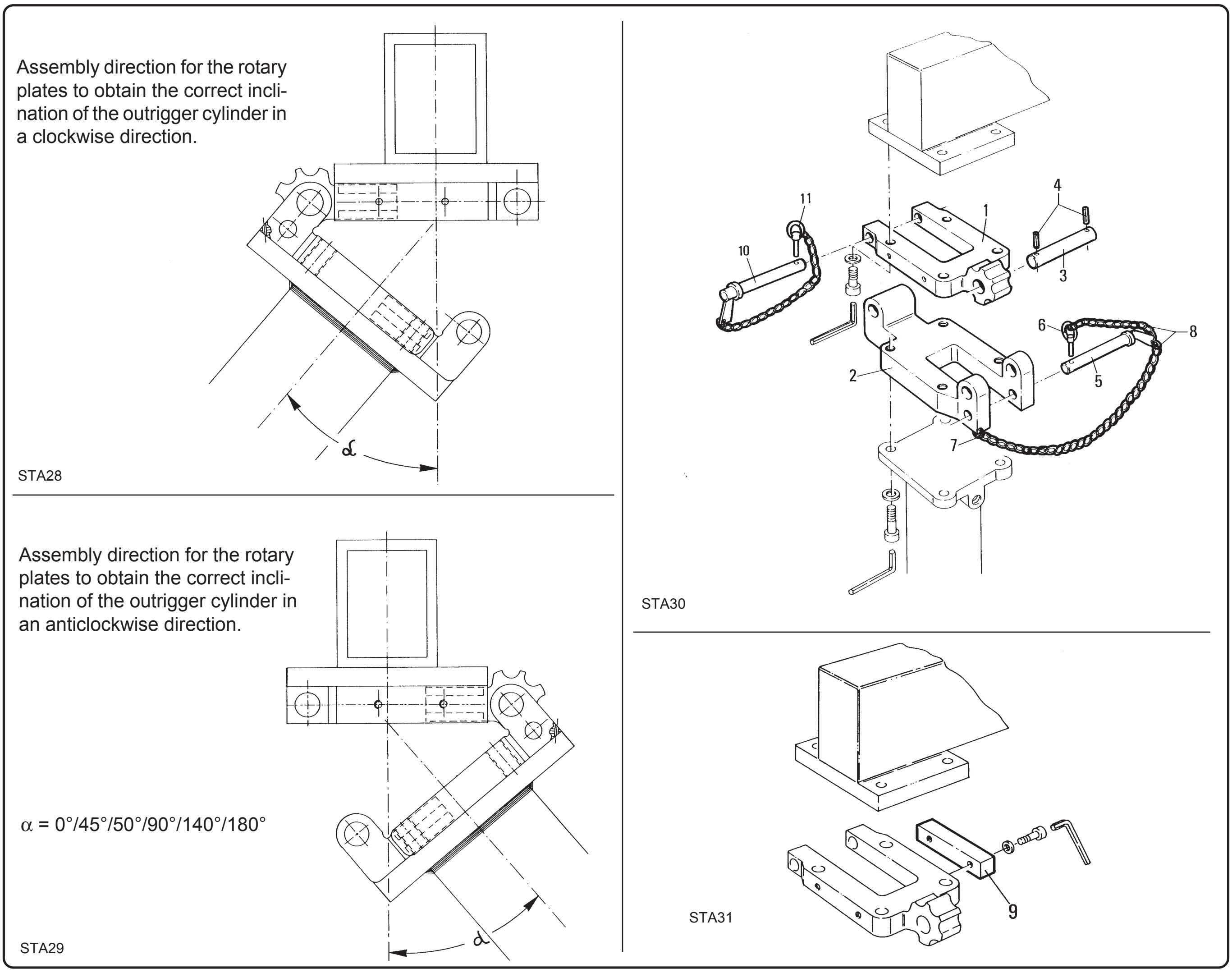


fig. 10.2.4

Clean the following parts carefully:

- all the contact surfaces;
- all the holes and threaded holes for the anchorage of the plates and the outrigger cylinders.
- Apply a medium resistance brake fluid to all the fastening screws.
- Once the assembly direction of the rotary plates has been established (in relation to the inclination you require for the cylinder), mount:
- the upper flange “1” to the outrigger boom with the relative screws and washers using a suitable tightening torque;
- the lower flange “2” on the outrigger cylinder using the relative screws and washers and a suitable tightening torque.

- Couple the two flanges and insert the following pins in the respective holes:
  - the hinge pin “3” with the relative elastic pins “4”;
  - the lockpin “10” with the relative safety lockpin “11”.

- To prevent the pin “5” being lost, lock it to the lower plate “2” using the link “7” of the chain “8”.

10.2.5 - Mounting outrigger cylinders with height-adjustable anchorage

Note

For delivery purposes, the loader is supplied to the installer with the cylinder coupling supports “1” (fig. 10.2.5) turned top face upwards.

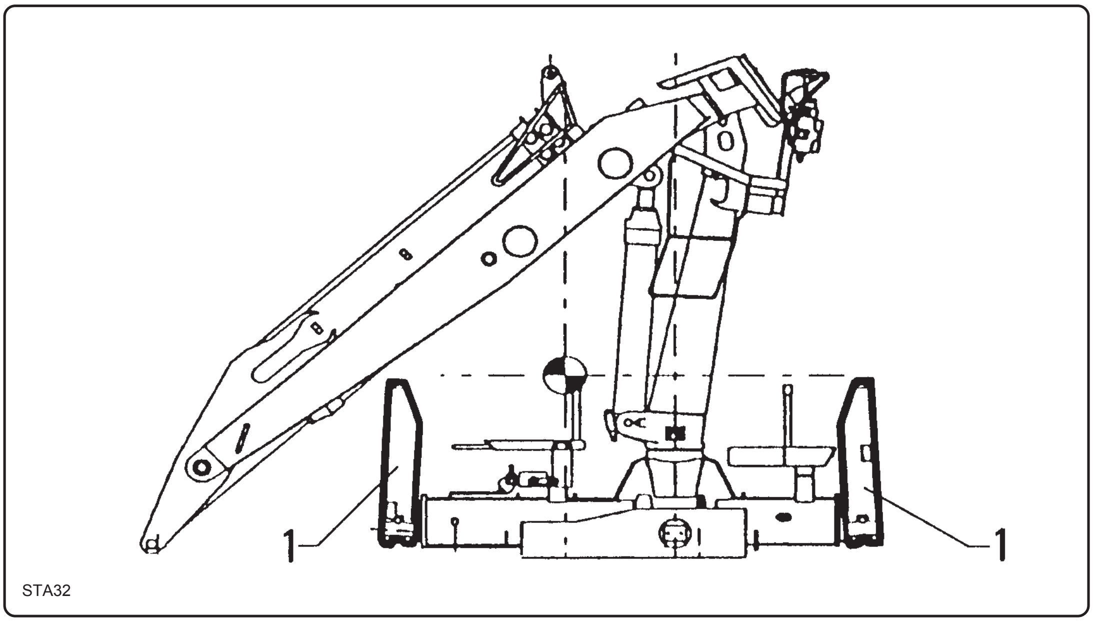


fig. 10.2.5

ATTENTION!!!

Removal of the pin “1” causes an abrupt downwards rotation of the support which could cause accidental injury. The operation must be performed by two operators.

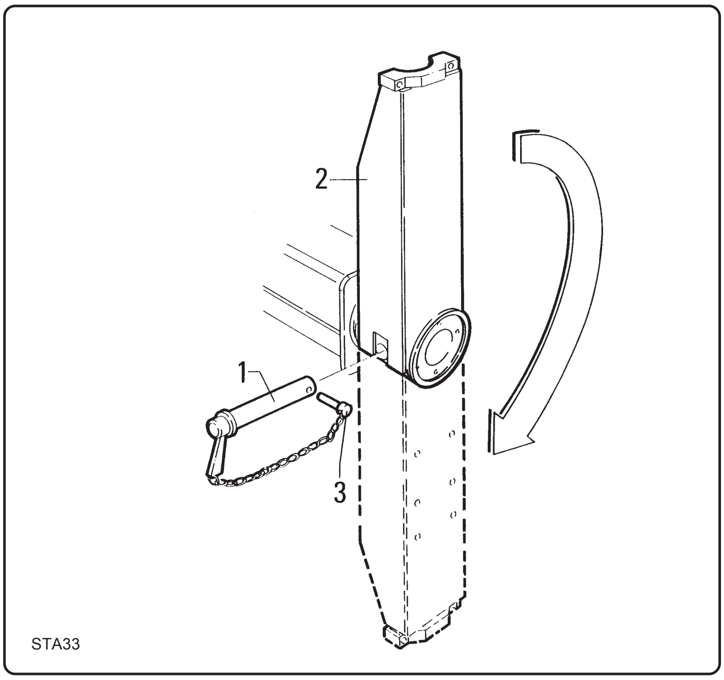


fig. 10.2.6

- Stand facing the support “2” and hold it in the vertical position.
- Remove the safety lockpin and the pin “1”.
- Hold the support as it rotates to reach the perfectly vertical downwards position.
- Lock the support in the downwards position by reinserting the pin and the relative safety lockpin “3”.

- Establishing the outrigger cylinder’s height in relation to the ground

The optimum extension length must ensure:

1) a distance (H) from the ground which is greater than or equal to the minimum height of the (loaded) truck in relation to the ground when the outrigger cylinder is fully closed up;
2) a distance (P) of 150/220 mm beyond the point at which the outrigger rests on the ground when the outrigger cylinder is fully open, taking into account the actual stroke length of the vehicle’s suspensions.

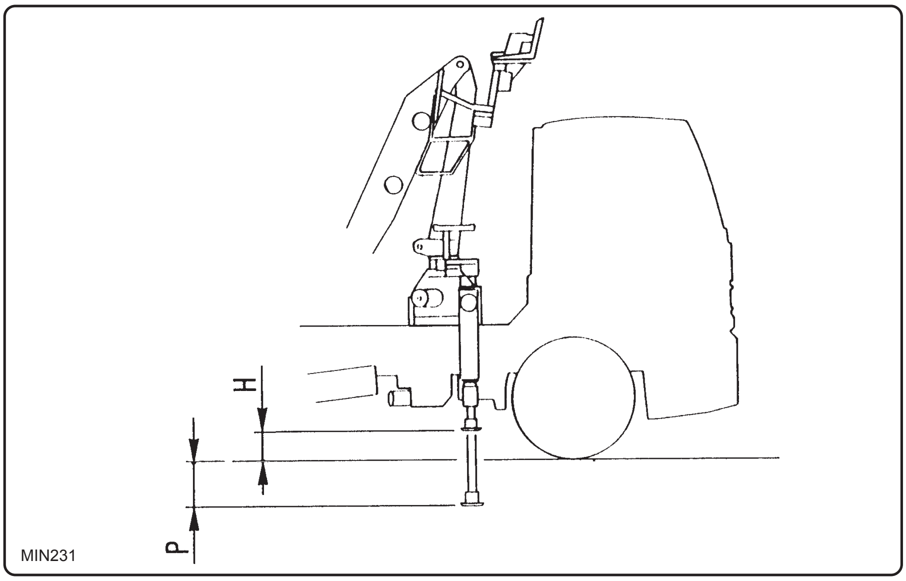


fig. 10.2.7

The best anchorage for the cylinder is when the distance “H” between the outrigger cylinder’s plate and the ground (with the outrigger fully closed up) is as great as possible, (remembering that it must always be equal to or greater than the minimum distance between the vehicle and the ground - fig. 10.2.7).
At the same time, when the outrigger is in the extended work position the anchorage must guarantee an excess stroke distance “P” of 150/220 mm beyond the point at which the outrigger rests on the ground (which can be increased in the case of vehicles with extremely elastic suspension or vehicles designed to work on very loose ground).

- Installing the outrigger cylinder in the support

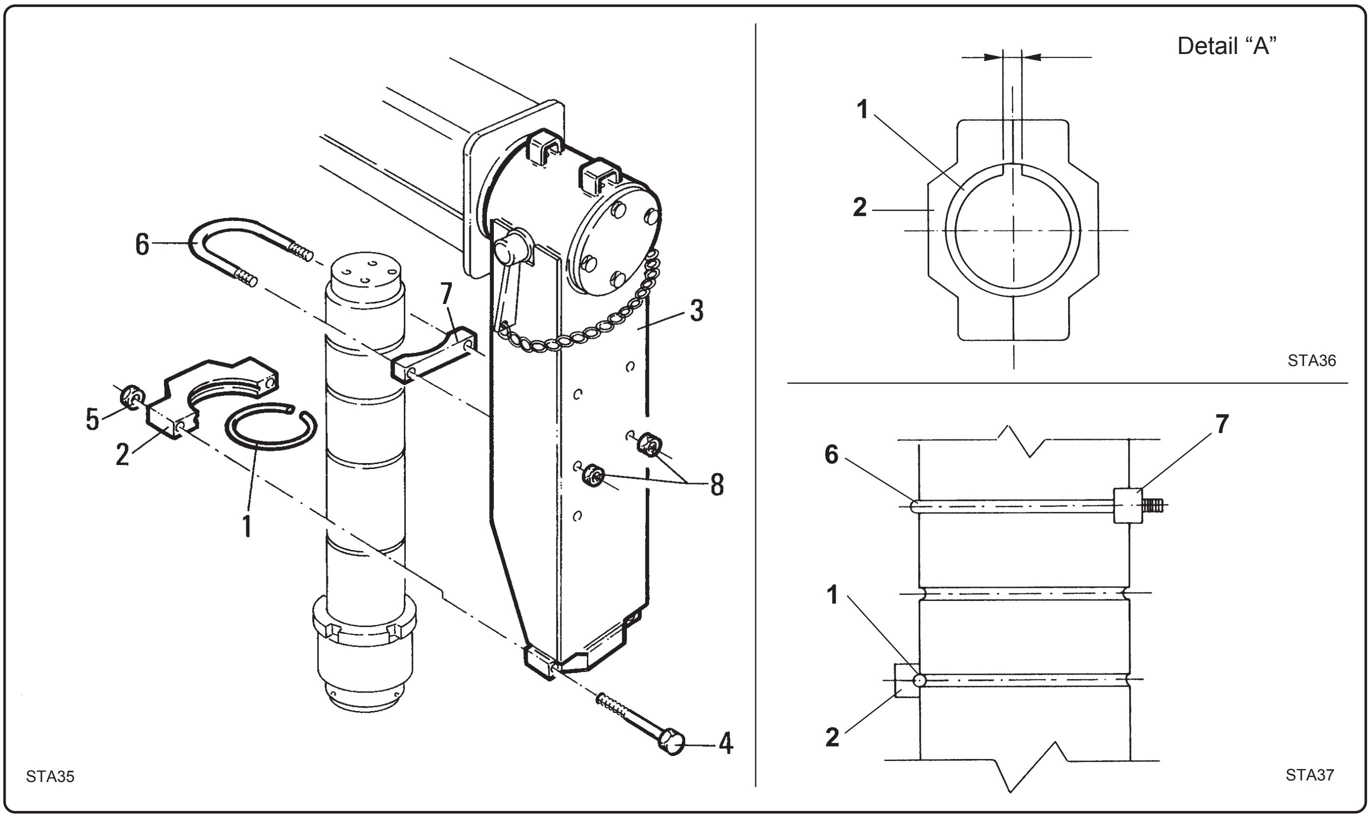


fig. 10.2.8

Once the outrigger cylinder’s height “H” off the ground has been established, mount the snap ring “1” in the housing selected on the outrigger cylinder.

ATTENTION!!!

The snap ring “1” must always be installed inside the cylinder housing and inside the housing of the clamp flange “2”.
The open section of the snap ring “1” must always be rotated by 90° in relation to its housing on the mobile anchorage flange (detail A).

- Mount the cylinder in the support “3”.
- Mount the flange “2” using the screws “4” and the nuts “5”.

- Apply a few drops of medium brake fluid.
- Mount the tie-rod “6”, the plate “7” and the nuts “8”.
- Lock the cylinder into place with nuts “5” and “8” with a tightening torque of 8 daNm.

10.2.6 - Mounting outrigger cylinders with rotary coupling

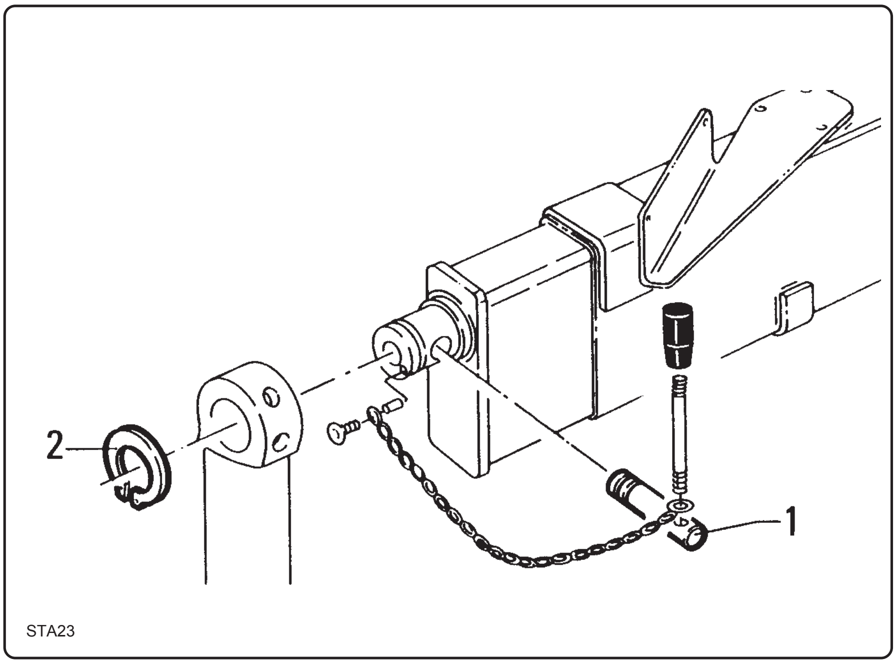


fig. 10.2.9

10.3 - Connecting the outrigger hydraulic system to the machine

ATTENTION!!!

This connection must be made with the crane’s hydraulic system depressurised.

To facilitate the correct piping connections, we have applied a metal plate bearing the letter “B” to one of the pipes. An identical plate is applied to one of the unions positioned on the outrigger cylinder valve.
When carrying out the installation, the two connections marked with the letter “B” must be connected together and consequently, those without any markings must be connected together (repeat this operation for both sides).

10.3.1- Connection types

- Connecting the outrigger cylinders to the distributor (for cranes of up to 6,5 tm - fig. 10.3.1)

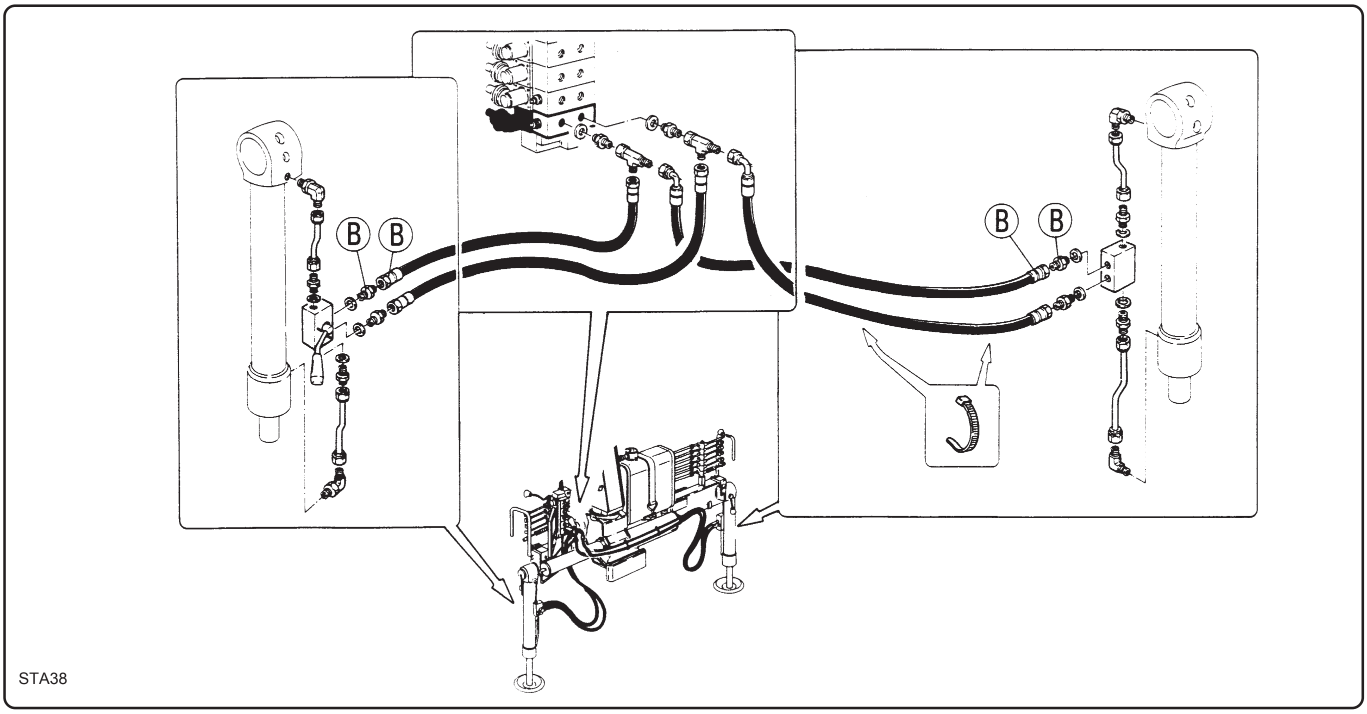


fig. 10.3.1

- Connecting the outrigger cylinders to the iron piping (for cranes of over 8 tm - fig. 10.3.2)

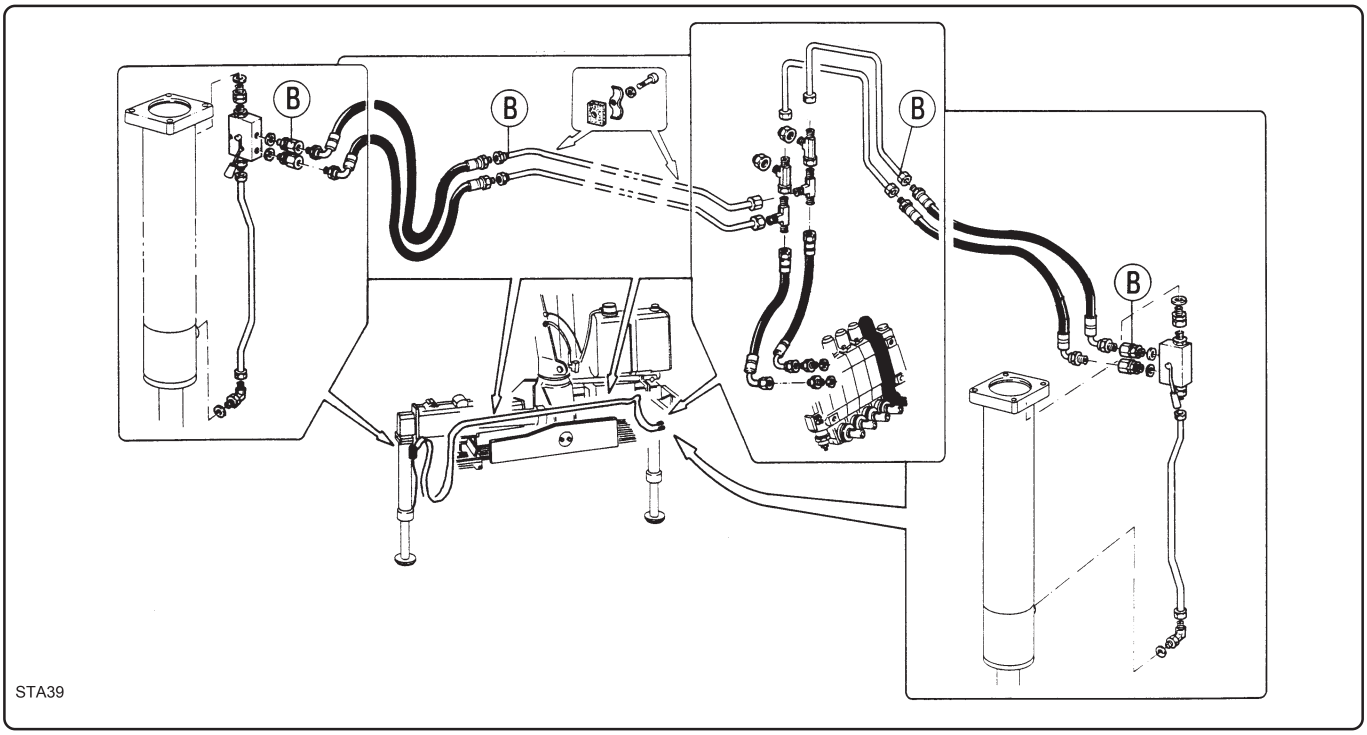
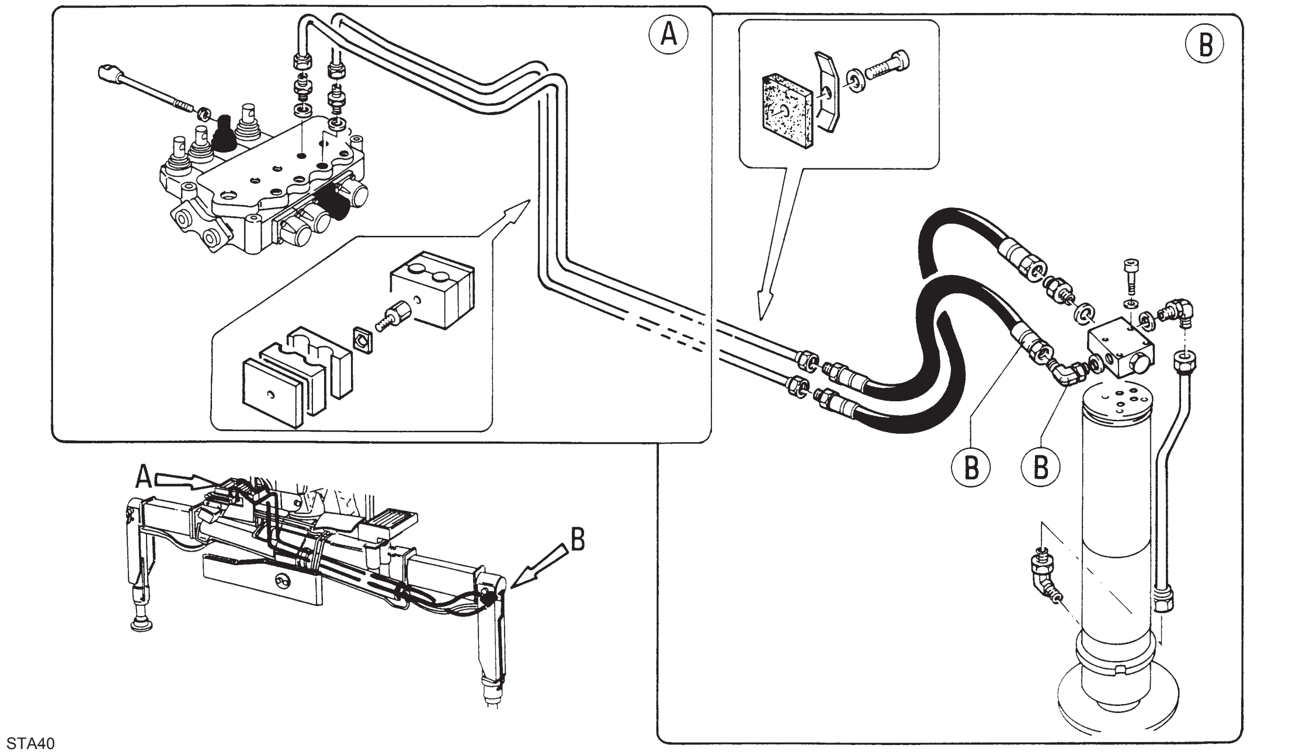


fig. 10.3.2

- Connecting the outrigger cylinders with a flanged valve - fig.10.3.3.



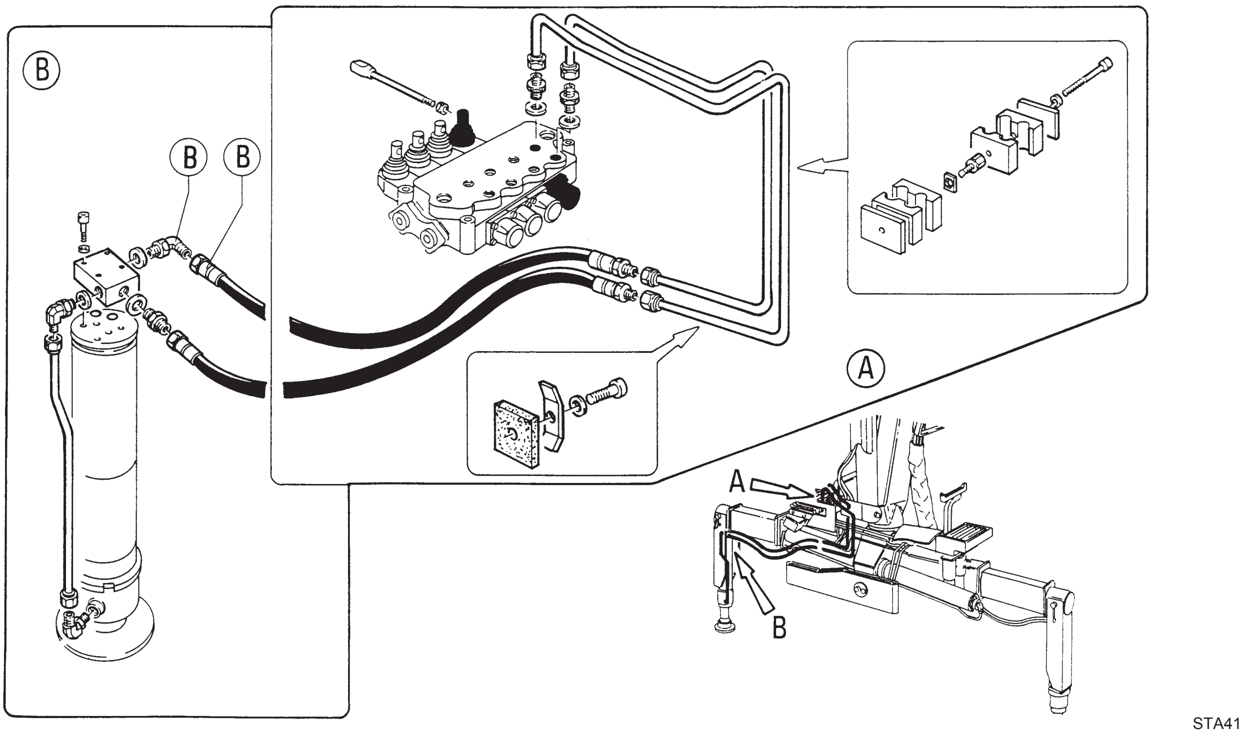


fig. 10.3.3

MENU

BOOMS

11.1 - Mounting the loading hoisting hook

DANGER!!!

The hook may only be mounted on the last boom extended.

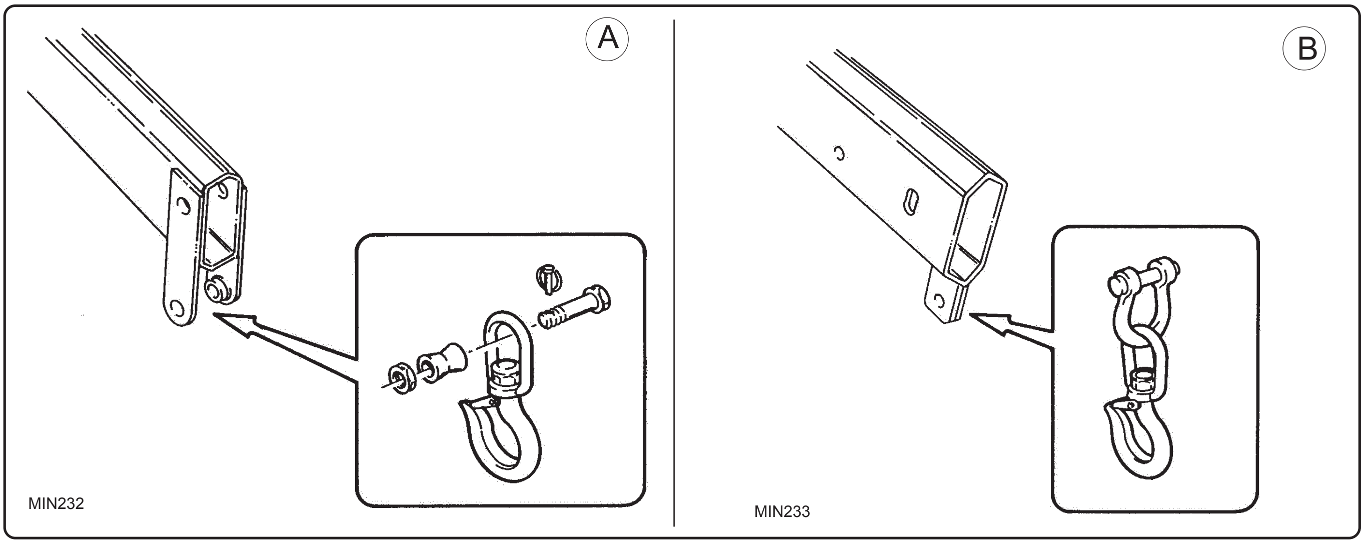


fig. 11.1.1

The hook coupling method depends on the type of coupling the boom has.

There a two kinds of boom couplings:
- fixed female coupling (fig. 11.1.1 - “A”).
- Fixed male coupling (fig. 11.1.1 - “B”).

11.1.1 - Mounting the hook on the boom fitted with a fixed female hook coupling (fig. 11.1.2)

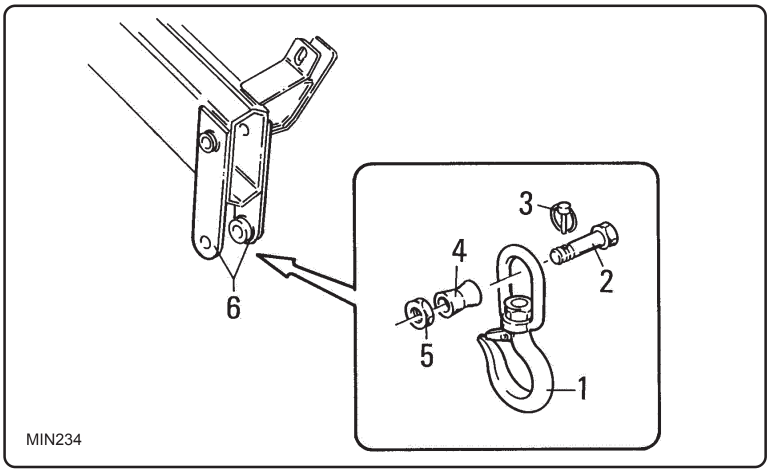


fig. 11.1.2

Slide the bushing “4” into the hook “1”, then position the bushing “4” inside the boom’s female coupling “6”.

Insert the pin “2” and lock it in place with the nut “5” then mount the safety clamp “3”.

11.1.2 - Mounting the hook on the boom fitted with a fixed male coupling (fig. 11.1.3)

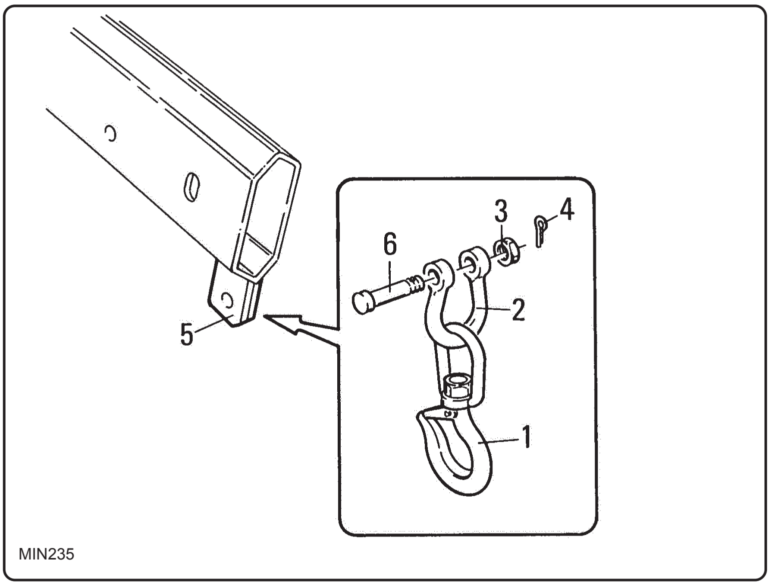
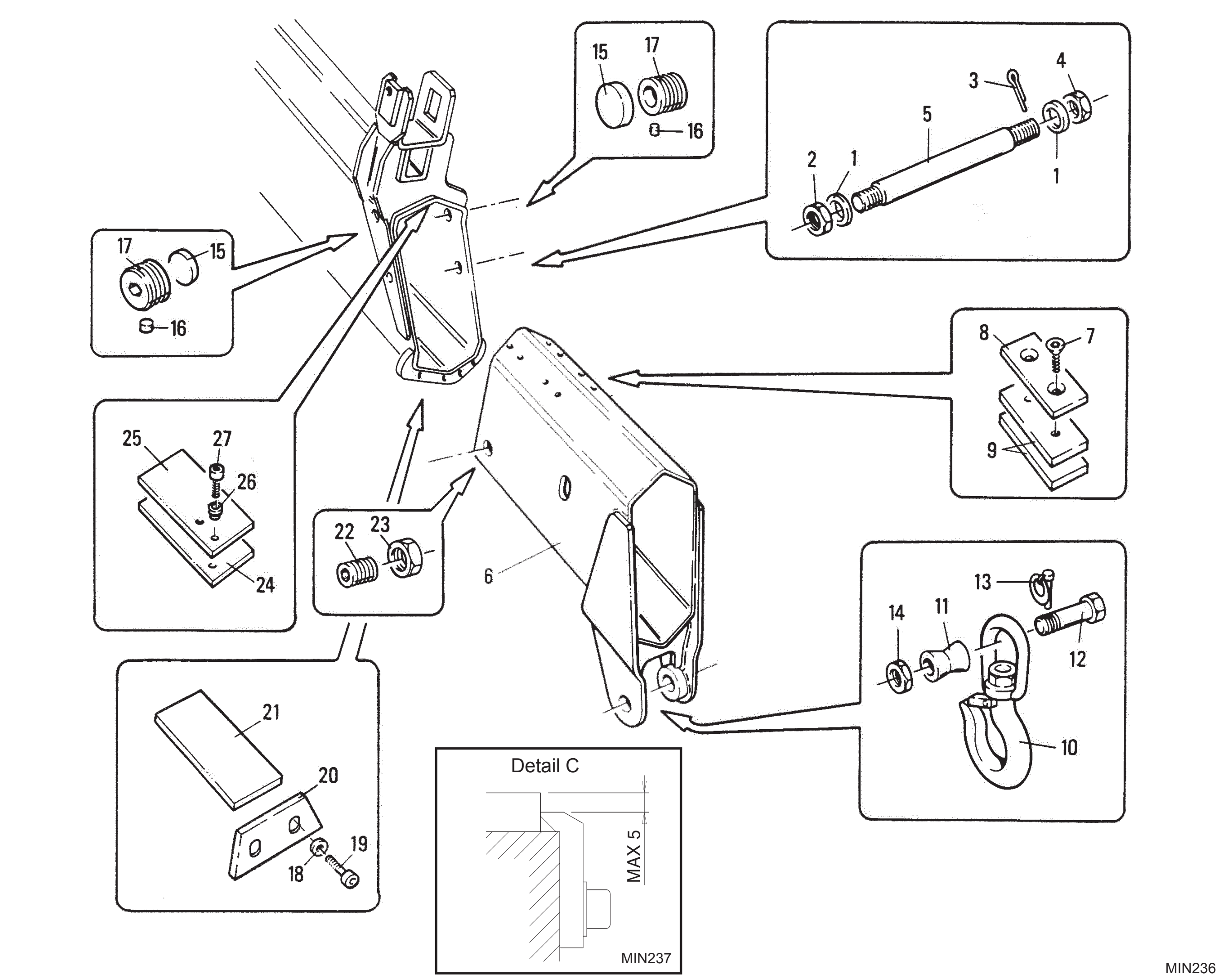
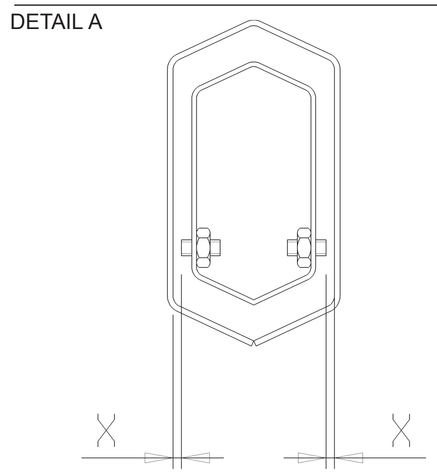


fig. 11.1.3

The hook “1” is fastened to the boom’s fixed male coupling “5” by inserting the shackle “2” which is fixed by means of the pin “6”, the nut “3” and the relative safety clamp “4”.

11.1.3 - Mounting the hook-bearing boom (fig. 11.1.4)





The height **X** must be as low as possible to allow the hook-bearing boom to be extended manually (approximately 1 mm)

MIN238

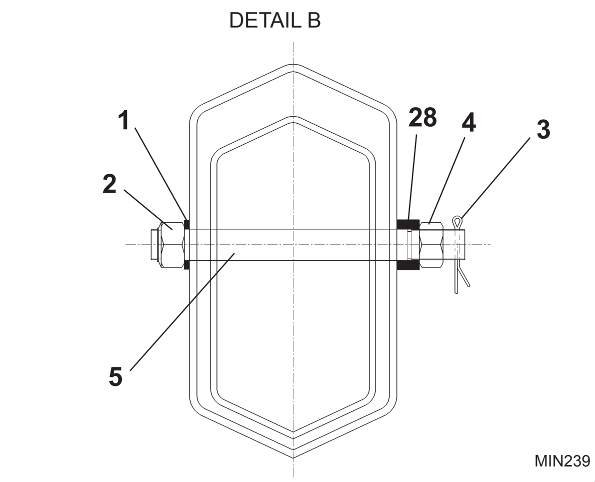


fig. 11.1.4

- Certain versions of the crane need a hook-bearing boom to be installed and if this is the case, proceeds as follows.
- Install the two lower sliding blocks “21” in the internal lower part of the machine’s last hydraulic boom and lock it into place with the clamp “20”, the washer “18” and the screw “19”. The clamp “20” has slots bored in it to allow the sliding block “21” to be locked correctly into place (see detail “C”- fig. 11.1.4).
- Mount and set the lateral registers “22” (locking them in place with the nut “23”) in the lower rear part of the hook-bearing boom (for the correct setting, see detail “A” in fig. 11.1.4).
- Install the sliding blocks “8” with the relative spacers “9” and lock the whole unit in place with the screws “7”.

☞ Note

The correct number of spacers “9” must be established according to measurements of the two booms (male and female) in order to reduce the vertical clearance in the boom as much as possible.

- Slide the hook-bearing boom into the machine’s last hydraulic boom and lock it in place with the pin “5”.

☞ Note

To install the pin “5” correctly, proceed as follows:

- insert the washer “1” in the threaded end without a hole and lock it in position with the nut “2”.
- Insert the pin “5” in the booms’ clamp hole and lock it in place with the spacer “28” and the nut “4”, then insert the safety split pin “3” (see detail “B” - fig. 11.1.4).
- Insert the sliding block “24” and spacer “25” (if necessary) in the upper (frontal) part of the machine’s last hydraulic boom and lock the whole unit in position with the screws “27” and the studs “26”.
- Install the sliding blocks “15” in the machine’s last boom and set them at the stroke limit. To lock the sliding blocks “15” in place, insert the thread brake pad “16” inside the dowel “17” to stop it working loose.

- You may now proceed to mount the hook as indicated in paragraph 11.1.1.

MENU

WINCH AND BLOCKS

12.1 - Safety requirements for use of the crane with a winch

Before using the crane with the winch, read the “Instructions and Safety” handbook.

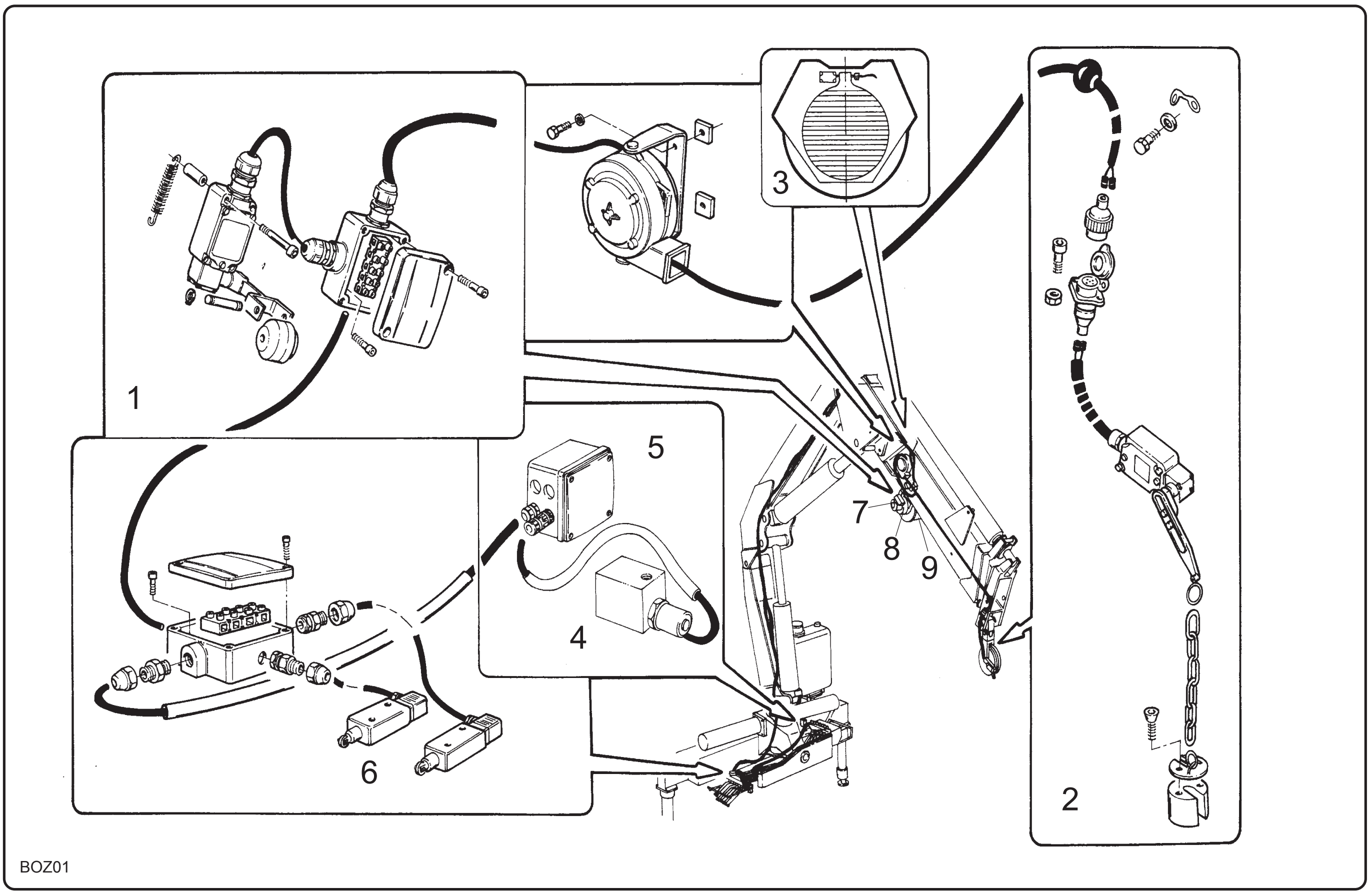


fig. 12.1.1

1 - **Downwards stroke limit**
Automatic device which interrupts the cable’s unreeling movement (hook moving downwards) when there are only three coils of cable left on the drum.

2 - **Upwards stroke limit**
Automatic device which interrupts the cable reeling movement (hook moving upwards), preventing the lower block knocking against the upper block/crane boom.

3 - **Pull limiter**
Automatic device which interrupts the cable’s reeling movement (hook moving upwards) if the load attached is greater than the maximum permitted by the manufacturer.

4 - **Discharge solenoid valve**
Solenoid valve which discharges the pump when one of the devices mentioned above starts working.

5 - **Signalling panel**
Back-lit indicator panel for the crane’s main functions.

6 - **Microswitches**
Microswitches activated by the control levers and used to enable the upwards/downwards stroke limits.

7 - **Downwards control and lock valve**
Flanged valve connected directly to the winch motor which locks the drum's rotation in the event of a breakage in the power supply pipes.

8 - **Cable clamp**
Cable clamp fixed to the winch drum keeps the cable taught and helps it to wind up correctly.

9 - **Multi-disc negative static brake**
Device which locks the winch drum when the operator is not controlling the machine.

12.2 - General description

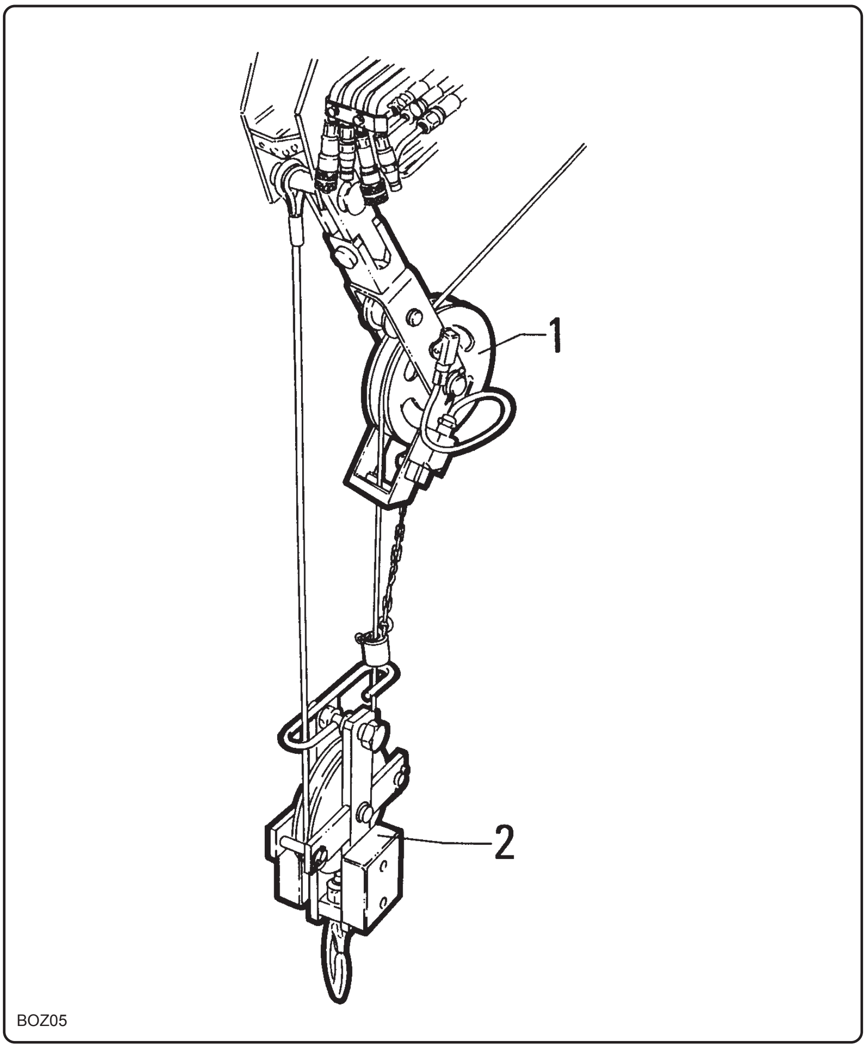
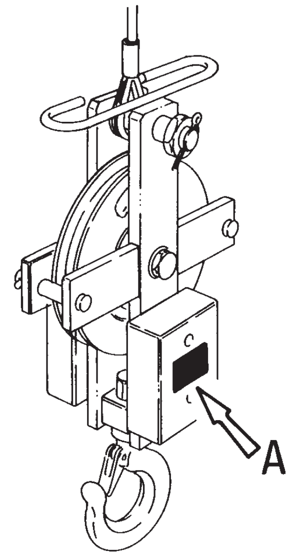


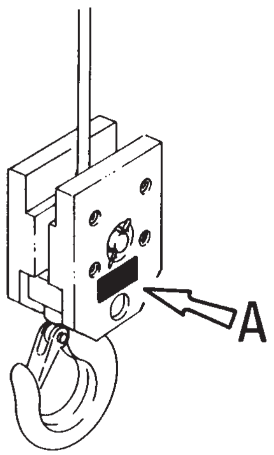
fig. 12.2.1

The block unit for the winch is composed of the following:
- upper block (pos. "1" fig. 12.2.1) which is mounted on the last boom of the crane/jibs;
- lower block (pos. "2" fig. 12.2.1) which holds the hoisting hook.

12.2.1 - Identification plate

BOZ04

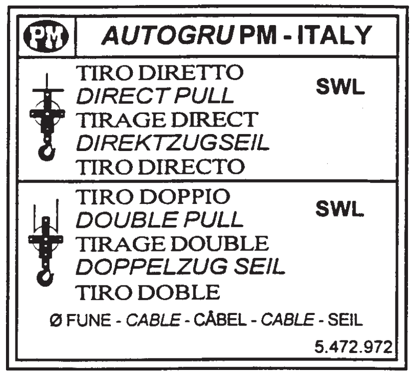




BOZ03

BOZ02

A



1- Capacity with direct pull (kg-lbs)
2- Capacity with double pull (kg-lbs)
3- Cable diameter (mm-ft)

fig. 12.2.2

12.3 - Cable pull combination types

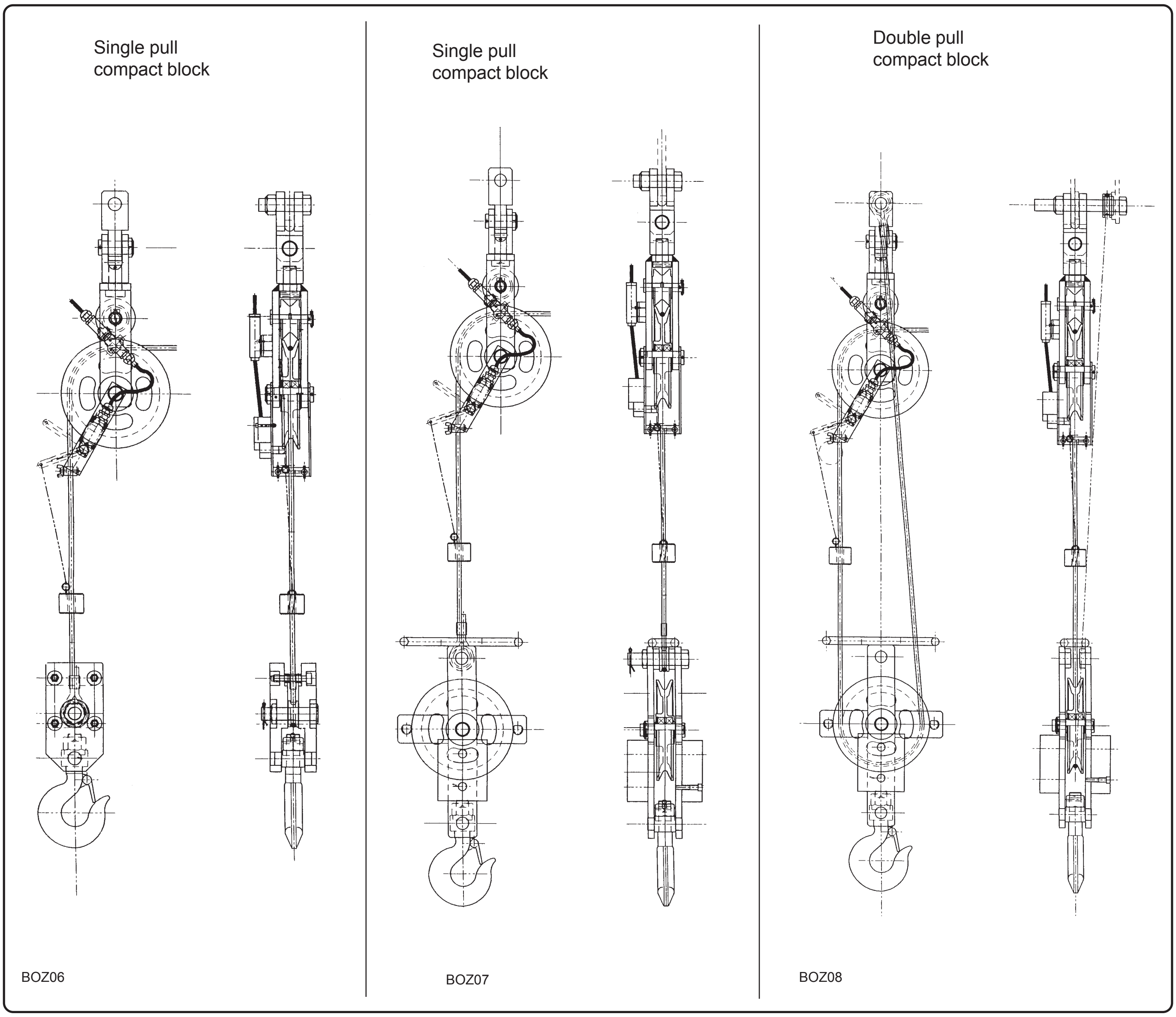


fig. 12.3.1

Note

To hoist the load, check the crane capacity diagram to find out the maximum weight the crane can raise.
The load must never exceed the maximum capacity indicated in the table for the block hook.

12.4 - Block packing and delivery

ATTENTION!!!

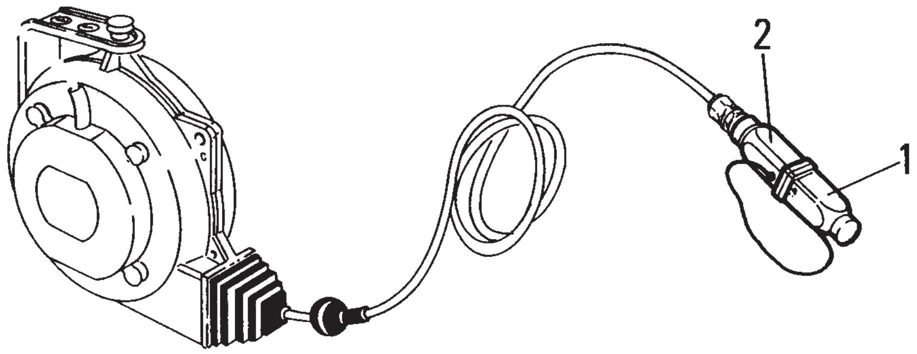
Handle the blocks with great care as you risk crushing your hands in the jointed parts of the upper block and crane coupling.

The blocks are pre-assembled and specially packed with the spacers for the coupling to the crane boom (if included) and the stroke limit micro-switch with the relative counterweight.

The pack contains everything you will need to mount the blocks.

To hoist and transport the pack, use a fork-lift truck with a suitable capacity, checking with the weight indicated on the outside of the pack.

12.5 - Mounting a single pull block



BOZ15

fig. 12.5.1

Note

To allow the machine to move during the blocks assembly operations indicated below, you must first install the special short circuit pin “1” in the socket “2” of the electric cable winder.

The blocks must be mounted by two operators.

12.5.1 - Mounting the upper block on booms with a female coupling

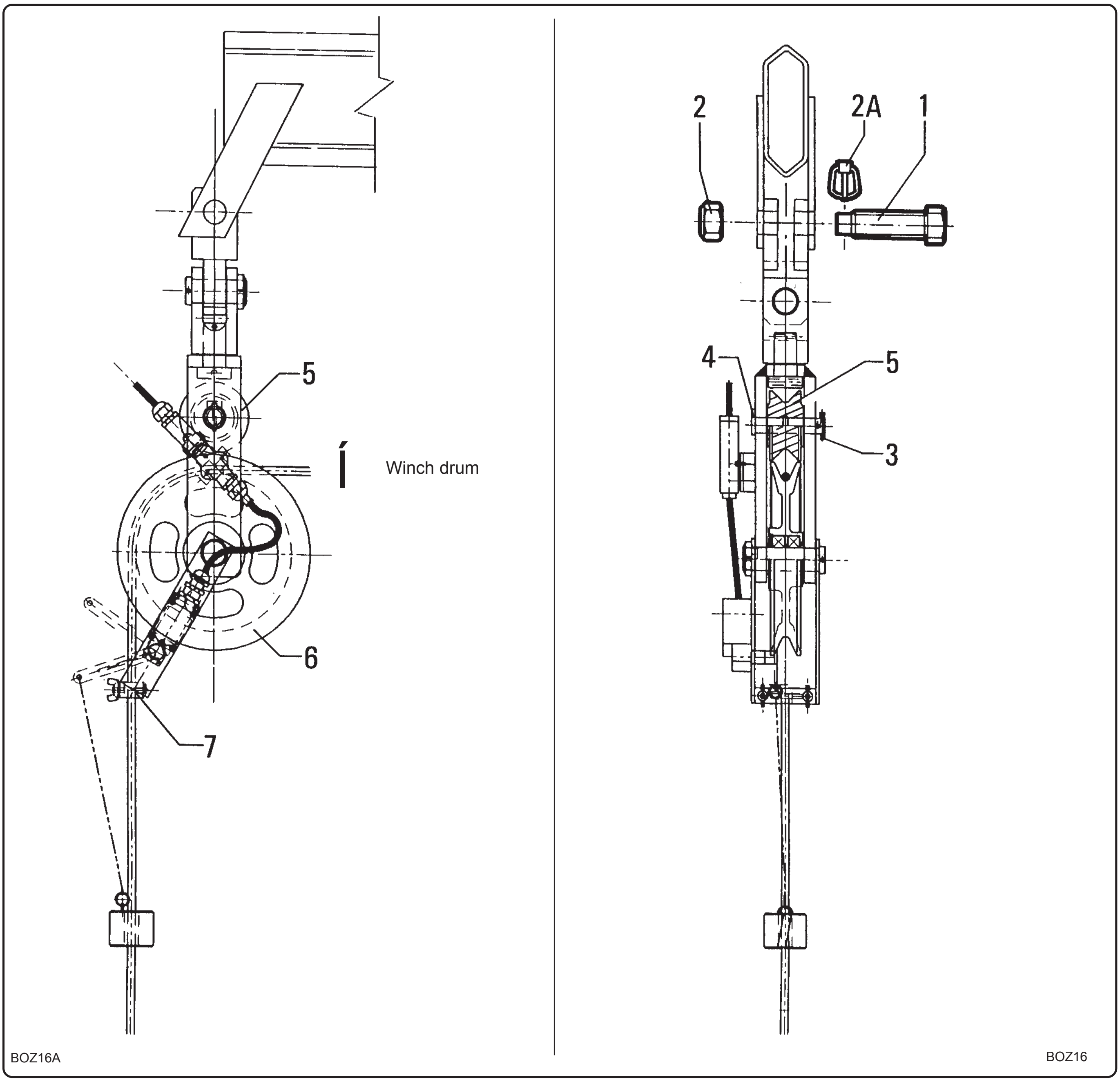


fig. 12.5.2

- If there is a load hoisting hook mounted on the crane boom, dismount it.
- Lift up and insert the block’s coupling joint into the boom’s hook coupling sides (see fig. 12.5.2).
- Lock the upper block in position using the same hook coupling pin “1” with the relative self-locking nut “2” and, when provided, the safety split pin “2A”.

- Uncoil a section of the cable from the winch drum in order to mount the blocks (upper and lower).
- Remove the safety split pin “3”, slide out the pin “4” and dismount the pulley “5”.
- Slide the end of the cable into the pulley “6”, into the cable guide “7”.
- Remount the pulley “5”, the pin “4” and the safety split pin “3”.

Note

If the microswitches and counterweights have not yet been installed, mount them after the lower block.
For their assembly see para. 12.5.5.

12.5.2 - Mounting the upper block on booms with a male hook coupling

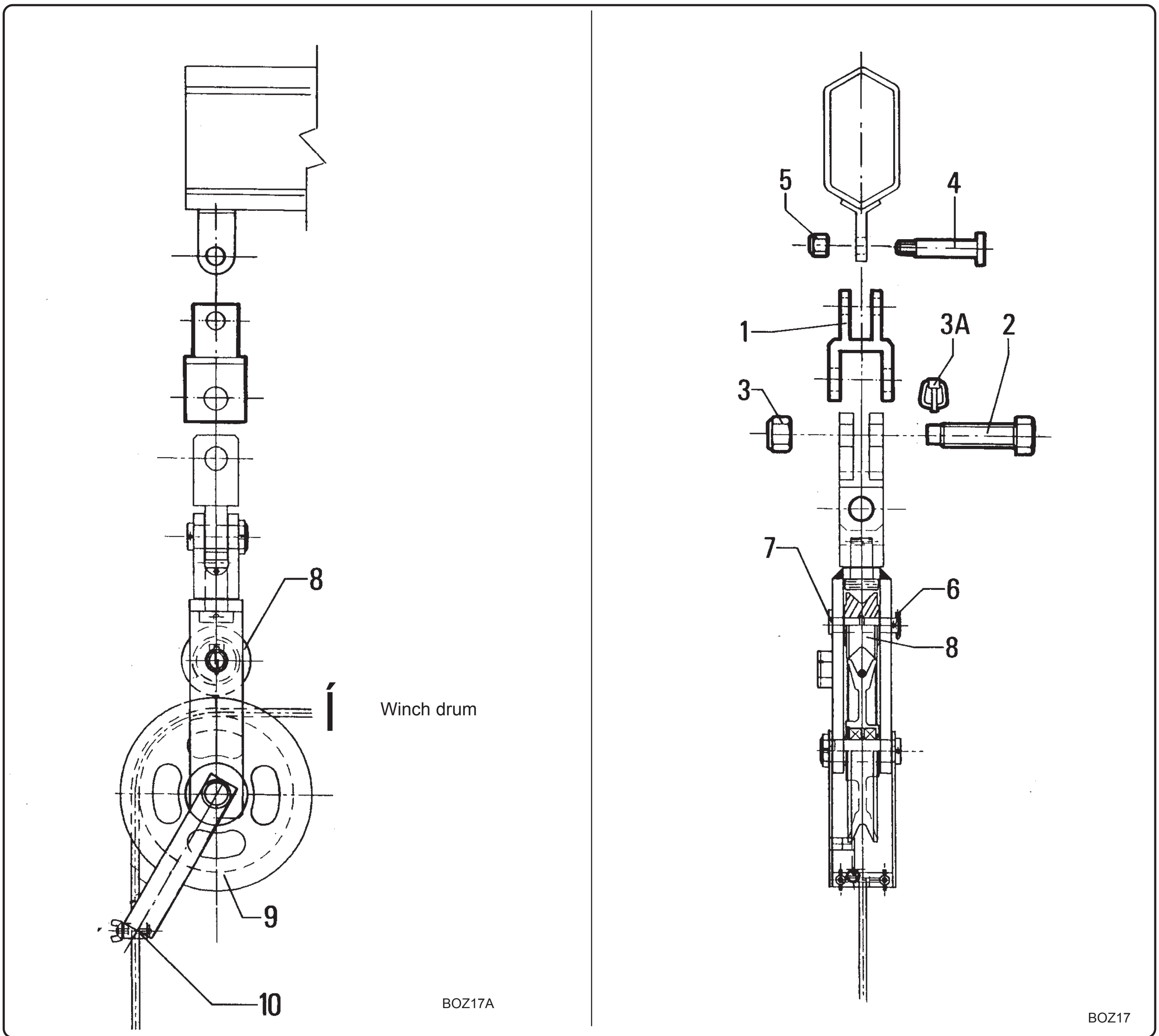


fig. 12.5.3

- If there is a load hoisting hook mounted on the crane boom, dismount it.
- Mount the forked adapter “1” on the upper block and lock it into place using the pin “2”, the self-locking nut “3” and, when provided, the safety split pin “3A”.
- Mount the block on the crane boom’s hook coupling and lock it in place with the pin “4” and the self-locking nut “5”.
- Uncoil a section of the cable from the winch drum in order to mount the blocks (upper and lower).
- Remove the safety split pin “6”, slide out the pin “7” and dismount the pulley “8”.
- Slide the end of the cable into the pulley “9”, into the cable guide “10”.
- Remount the pulley “8”, the pin “7” and the safety split pin “6”.

Note

If the microswitches and counterweights have not yet been installed, mount them after the lower block (see para. 12.5.5).

12.5.3 - Mounting the upper block on booms with a “mobile bracket” type hook coupling

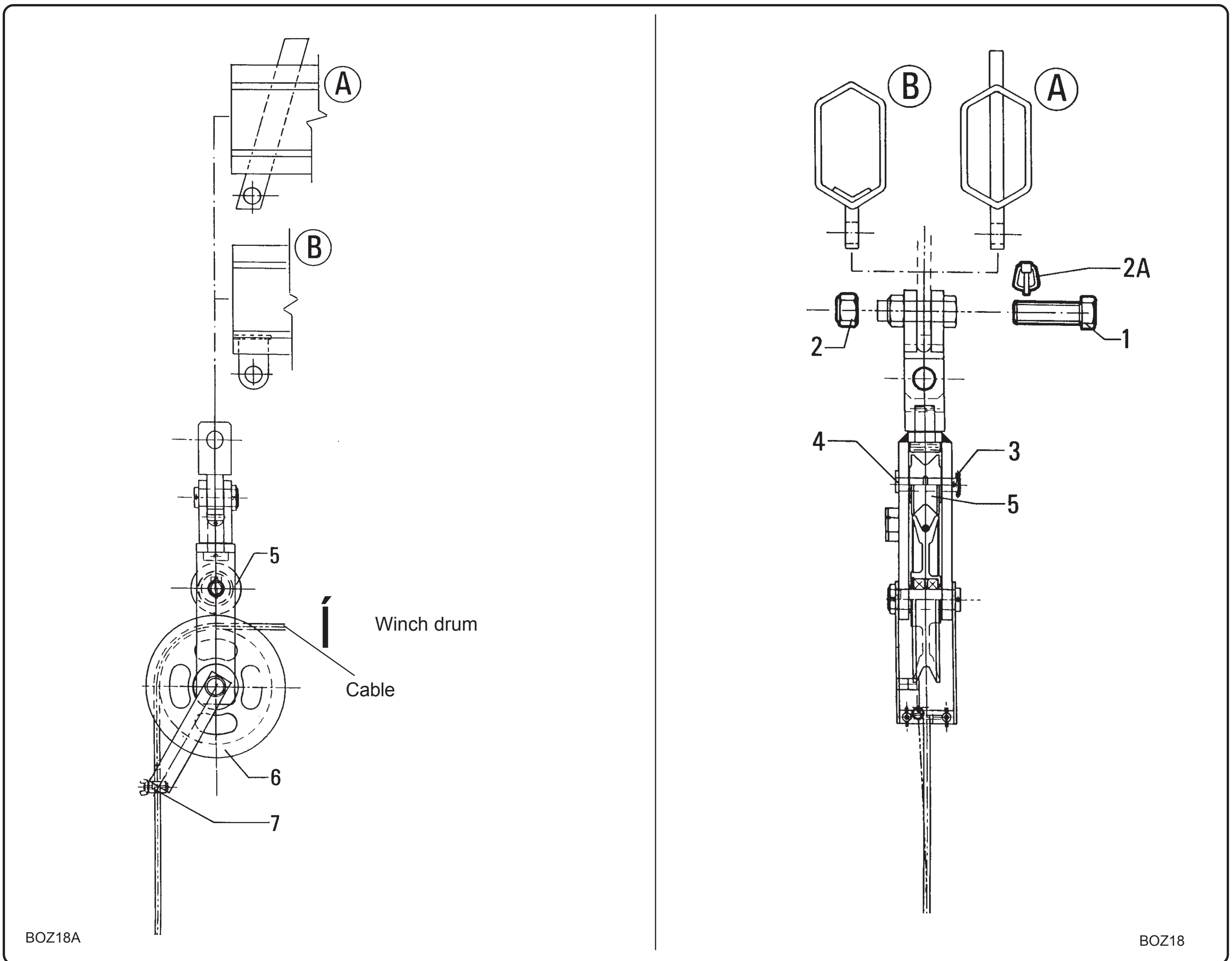


fig. 12.5.4

DANGER!!!

You must not mount a double pull cable on a "mobile bracket" hook coupling booms.

- If there is a load hoisting hook mounted on the crane boom, dismount it.
- Mount the upper block on the mobile bracket, lock it in position using the screw "1", the relative self-locking nut "2" and, when provided, the safety split pin "2A".
- Uncoil a section of the cable from the winch drum in order to mount the blocks (upper and lower).
- Remove the safety split pin "3", slide out the pin "4" and dismount the pulley "5".
- Slide the end of the cable into the pulley "6", into the cable guide "7".
- Remount the pulley "5", the pin "4" and the safety split pin "3".

Note

If the micro-switch and counterweight have not yet been installed, mount them after the lower block (see para. 12.5.5).

12.5.4 - Mounting a compact lower block

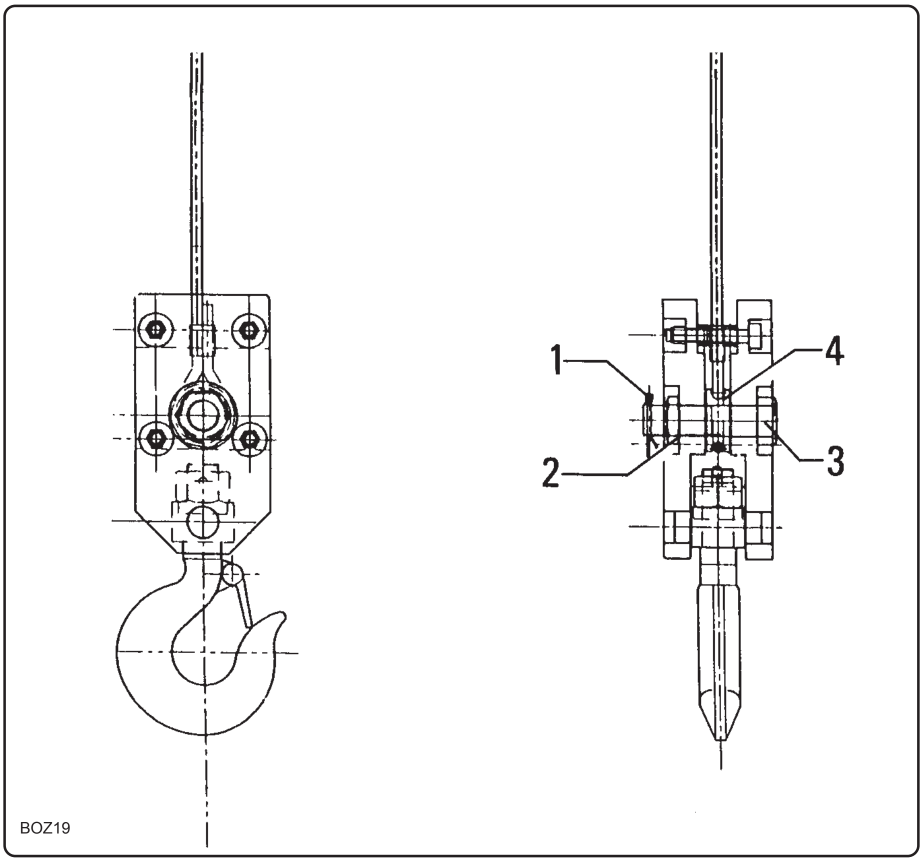


fig. 12.5.5

- Remove the split pin “1”;
- unscrew the nut “2” and remove the pin “3”;
- insert the end of the cable (with the bushing “4”) in the lower block and lock it in place with the pin “3”;
- tighten the nut “2” and insert the split pin “1”.

12.5.5 - Mounting a normal lower block

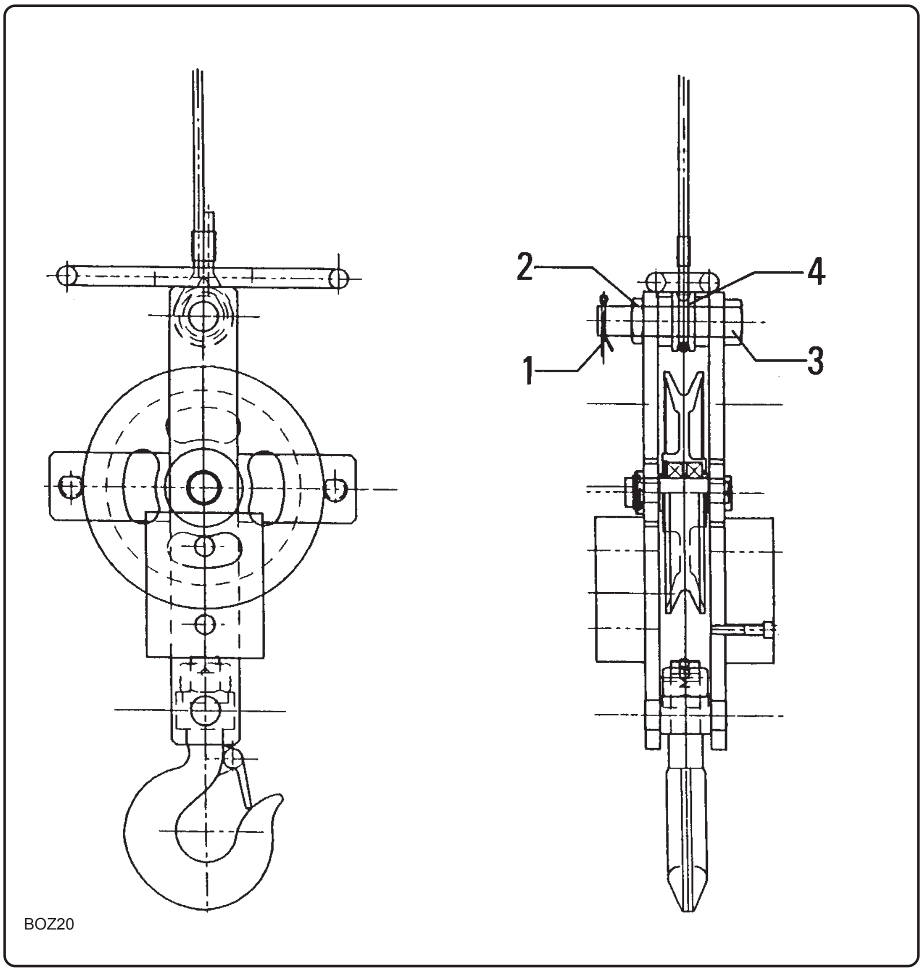


fig. 12.5.6

- Remove the split pin “1”;
- unscrew the nut “2”;
- remove the pin “3”;
- insert the end of the cable (with the bushing “4”) into the lower block and lock it in place with the pin “3”;
- tighten the nut “2” and insert the split pin “1”.

12.6 - Mounting double pull blocks

12.6.1 - Mounting blocks on booms with a female hook coupling

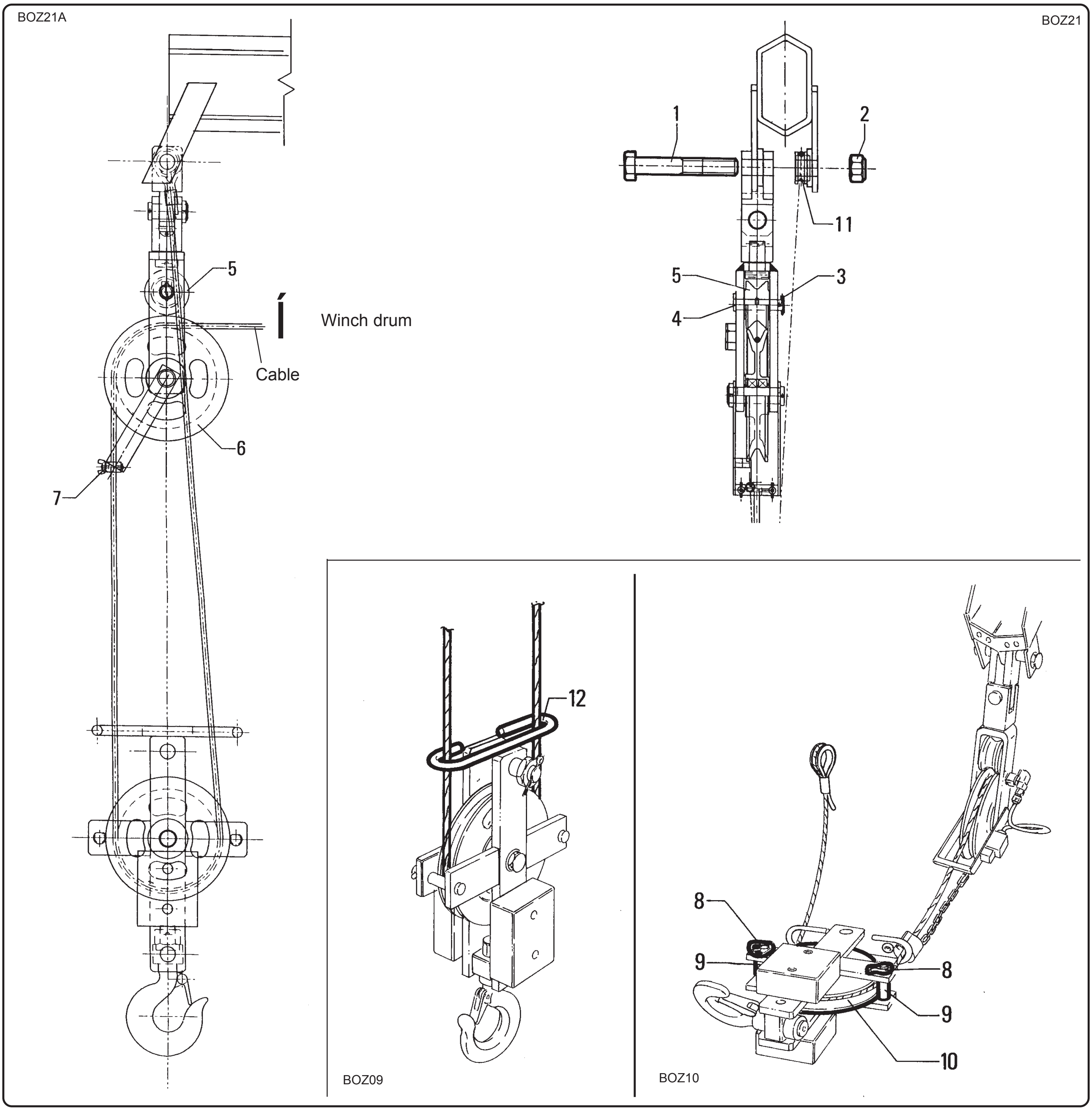


fig. 12.6.1

- If there is a load hoisting hook mounted on the crane boom, dismount it.

- Install the upper block to the crane boom as indicated in fig. 12.6.1.
- Insert the pin “1” into boom coupling hole, from the left to the right in order to provide temporary support for the upper block.
- Screw up the nut “2” to prevent the pin coming out accidentally from the hole and allowing the upper block to fall.
- Uncoil a section of the cable from the winch drum in order to mount the two blocks.
- Remove the safety split pin “3”, slide out the pin “4” and dismount the pulley “5”.
- Slide the end of the cable into the pulley “6”, and into the cable guide “7”.
- Remount the pulley “5”, the pin “4” and the safety split pin “3”.
- Place the lower block on the ground fig. 12.6.1.
- Remove the safety split pin “8” and the pins “9” to allow the cable to move around the pulley “10”.
- Remount the pins “9” and the safety split pin “8”.
- Unscrew the lock nut “2” on the crane boom’s upper block and with a pin extractor slide out the pin “1” as little as possible but enough to mount the end of the cable “11”.

ATTENTION!!!

Take special care and adopt all the appropriate safety measures as if the pin “1” slides out fully, the upper block will fall off.

- Reinsert the pin “1”;
- screw up the self-locking nut “2”;
- rewind the cable onto the winch drum in order to raise the lower block off the ground, making sure the cable is in the cable guide “12”.

12.6.2 - Mounting blocks on booms with a male hook coupling

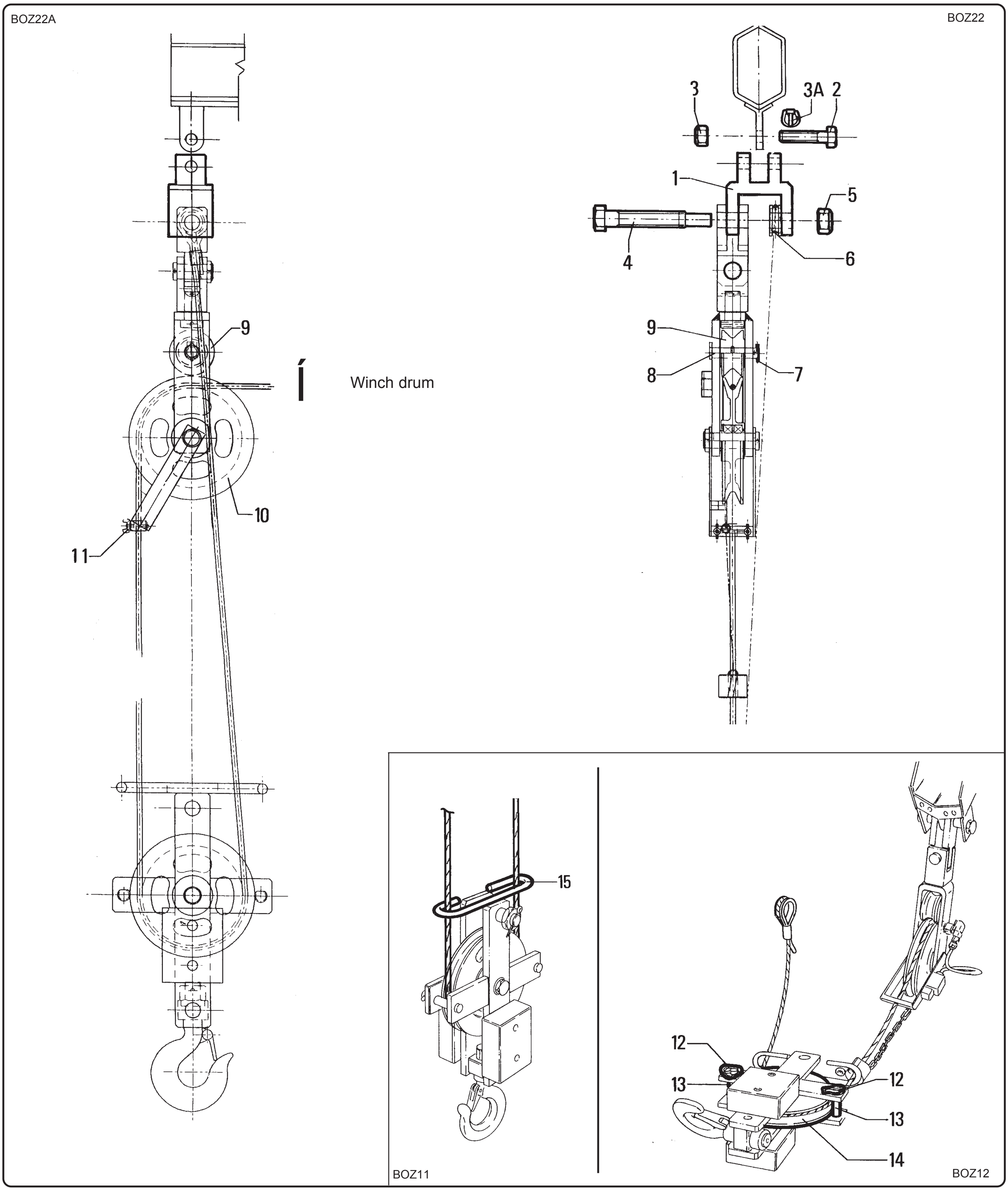


fig. 12.6.2

- If there is a load hoisting hook mounted on the crane boom, dismount it.
- Mount the forked adapter “1” on the crane boom and lock it into place using the pin “2”, the self-locking nut “3” and, when provided, the safety split pin “3A”.
- Mount the upper block on the forked adapter “1” as indicated in fig. 12.6.2.
- Insert the pin “4” supplied (from left to right) into the adapter in order to provide temporary support for the upper block.
- Screw up the nut “5” to prevent the pin coming out accidentally from the hole and allowing the upper block to fall.
- Uncoil a section of the cable from the winch drum in order to mount the blocks.
- Remove the safety split pin “7”, slide out the pin “8” and dismount the pulley “9”.
- Slide the end of the cable into the pulley “10”, intp the cable guide “11”.
- Remount the pulley “9”, the pin “8” and the safety split pin “7”.
- Place the lower block on the ground fig. 12.6.2.
- Remove the safety split pin “12” and the pins “13” to allow the cable to move around the pulley “14”.
- Remount the pins “13” and the safety split pin “12”.
- Unscrew the lock nut “5” which couples the upper block to the forked adapter “1” and -with a pin extractor- slide out the pin “4” as little as possible but enough to mount the end of the cable “6”.

ATTENTION!!!

Take special care and adopt all the appropriate safety measures as if the pin “4” slides out fully, the upper block will fall off.

- Reinsert the pin “4”;
- screw up the self-locking nut “5”;
- rewind the cable onto the winch drum in order to raise the lower block off the ground, making sure the cable is in the cable guide “15”.

12.7 - Mounting special blocks

12.7.1 - Mounting a short upper block and a compact lower block on the jib

Note

These kinds of blocks can only be mounted on the booms of jibs with female hook couplings.

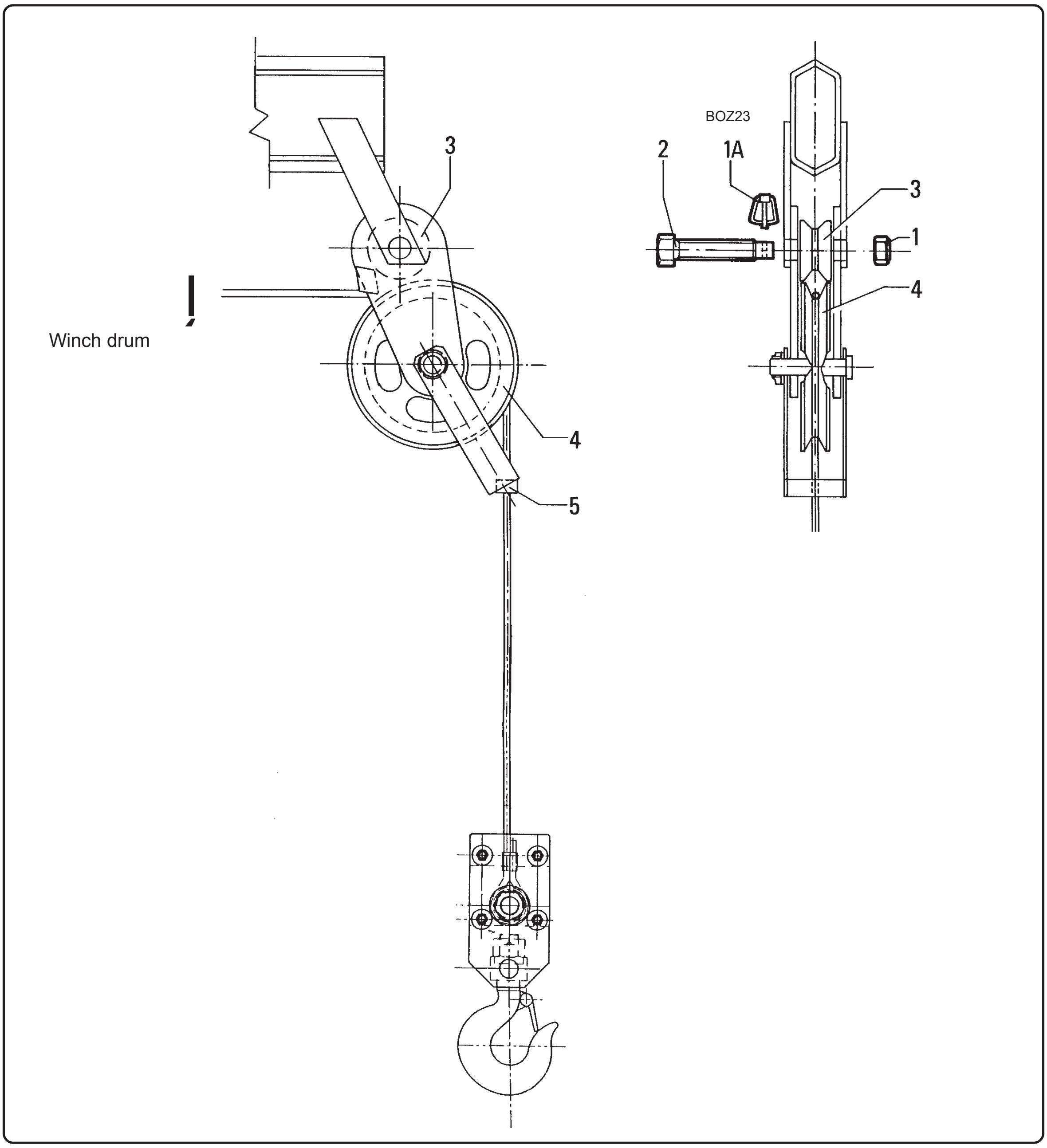


fig. 12.7.1

- If there is a load hoisting hook mounted on the jib boom, dismount it.
- Unscrew the nut “1”, remove the pin “2” ad the pulley “3”.
- Uncoil a section of the cable from the winch drum in order to mount the lower block.
- Slide the end of the cable into the pulley “4”, and into the cable guide “5”.
- Install the upper block together with the pulley “3” inside the jib boom’s hook coupling.
- Lock the upper block into place using the pin “2” and the nut “1” and, when provided, the safety split pin “1A”.
- Install the compact lower block following the procedure described earlier in paragraph 12.5.4.

12.8 - Block (upwards) stroke limit connection

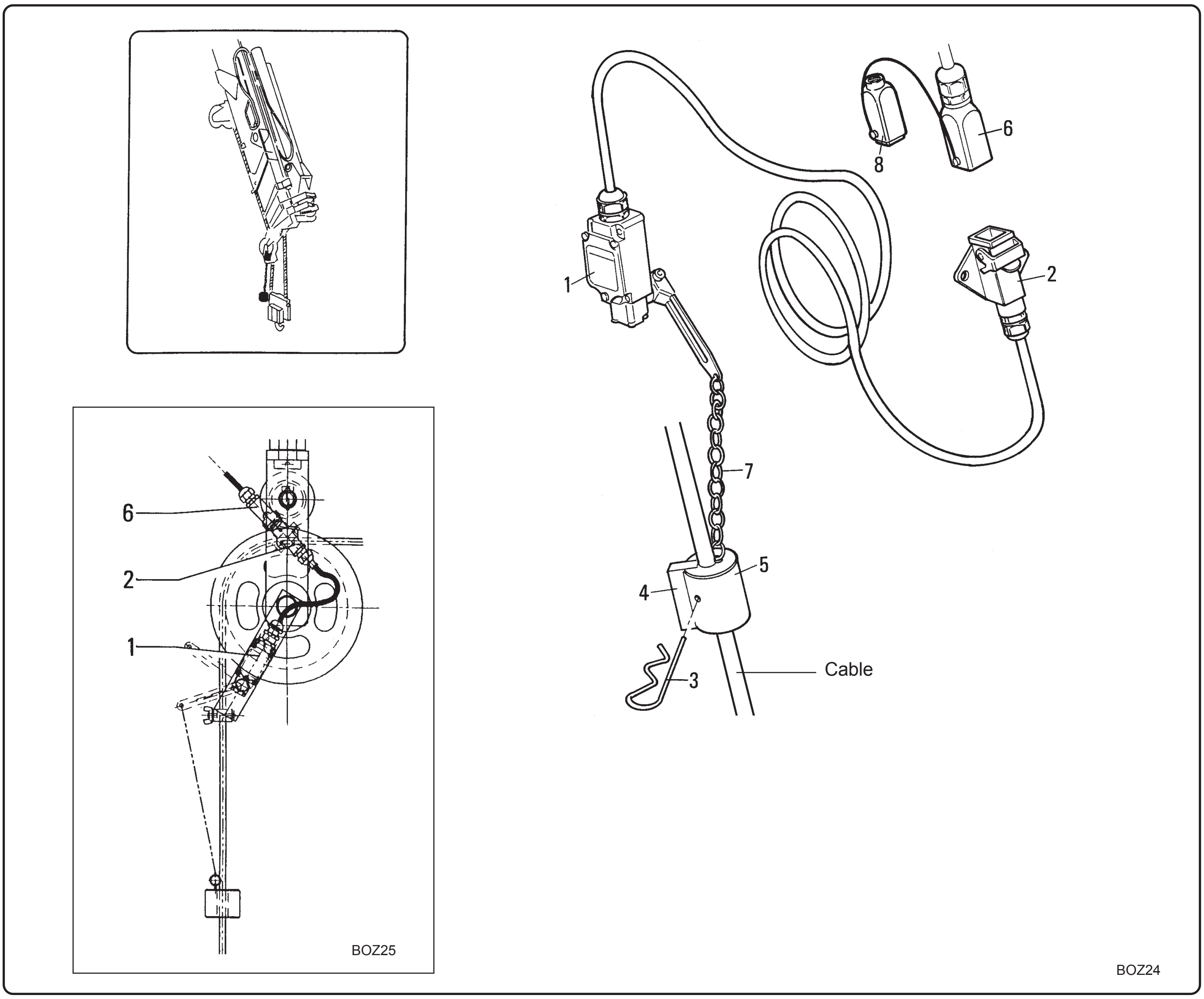


fig. 12.8.1

- If the microswitch “1” and the clamp “2” have not yet been installed on upper block, mount and fasten them with the relative fastening screws.

- Remove the sprung split pin “3” and the clamp “4” to slide the winch cable into the counterweight “5”.
- Remount the clamp “4” and the sprung split pin “3”.
- Mount the chain “7” onto the microswitch “1” and the counterweight “5”.
- Connect the cable with the plug “6” from the electric cable winder to the socket “2” (removing the short circuit pin “8”).
  You can now proceed to check the winch’s upwards stroke limit device is functioning correctly (see instructions manual and crane with winch user manual).

12.9 - Mounting a driving gear pulley on the crane with mechanical extensions or jibs (when provided for)

For a correct use of the winch mounted on the crane with mechanical extensions or a jib, you must mount the driving pulleys on the machine’s last hydraulic boom in order to keep the cable in the guide and aligned with the crane or the jib’s booms.

12.9.1 - Mounting a driving gear pulley on the crane with mechanical extensions (crane boom fitted with female hook coupling)

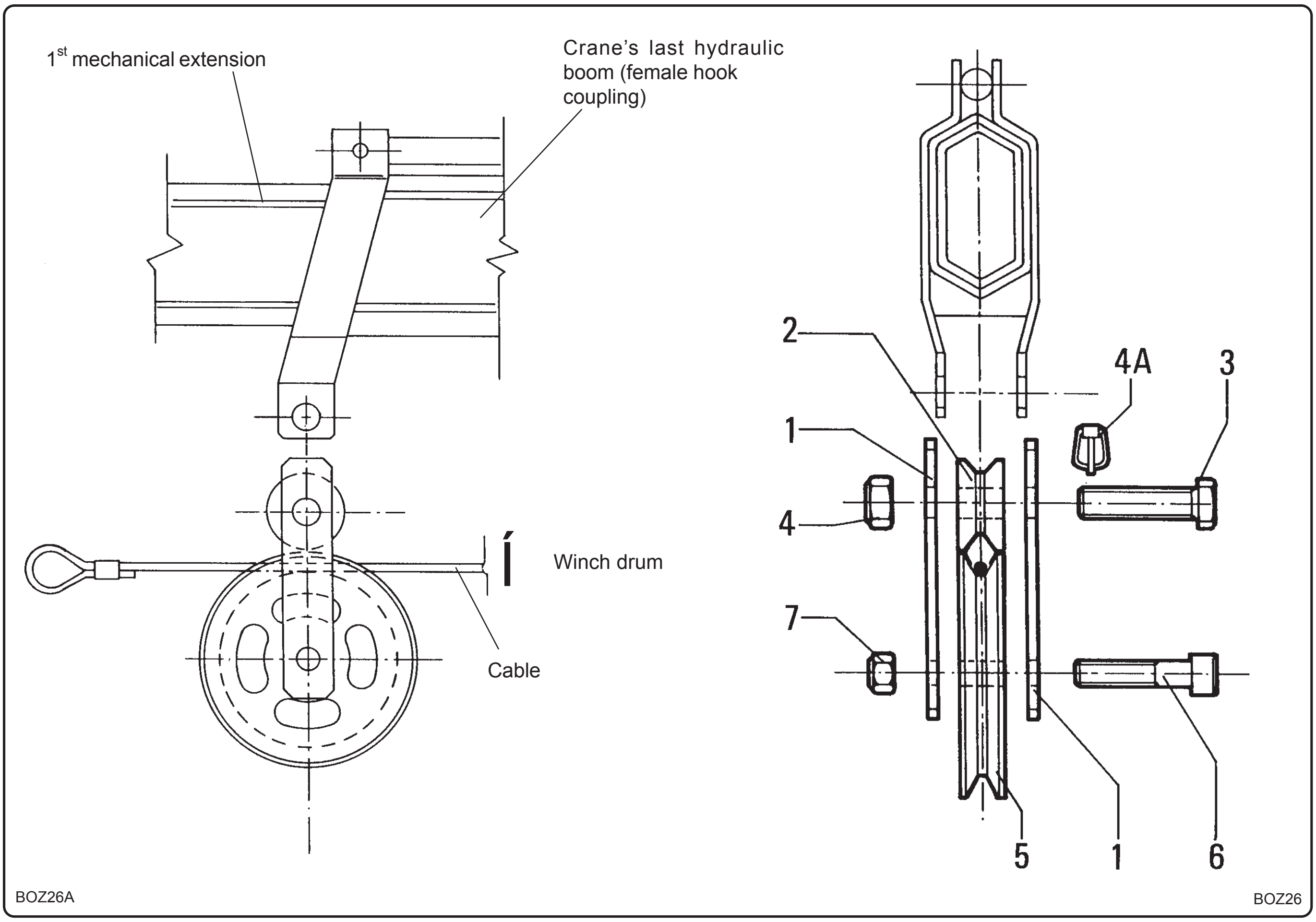


fig. 12.9.1

- If there is a load hoisting hook mounted on the crane last boom, dismount it.
- Install the flanges "1" and the pulley "2" inside the hook coupling on the crane's hydraulic boom, locking them into place with the pin "3" and the self-locking nut "4", and when provided, the safety split pin "4A".
- Pass the winch cable through the inside of the flanges "1";
- mount the pulley "5" using the pin "6" and the self-locking nut "7", making sure the cable is located correctly inside the pulley neck.

12.9.2 - Mounting a driving gear pulley on the crane with mechanical extensions (crane boom fitted with male hook coupling)

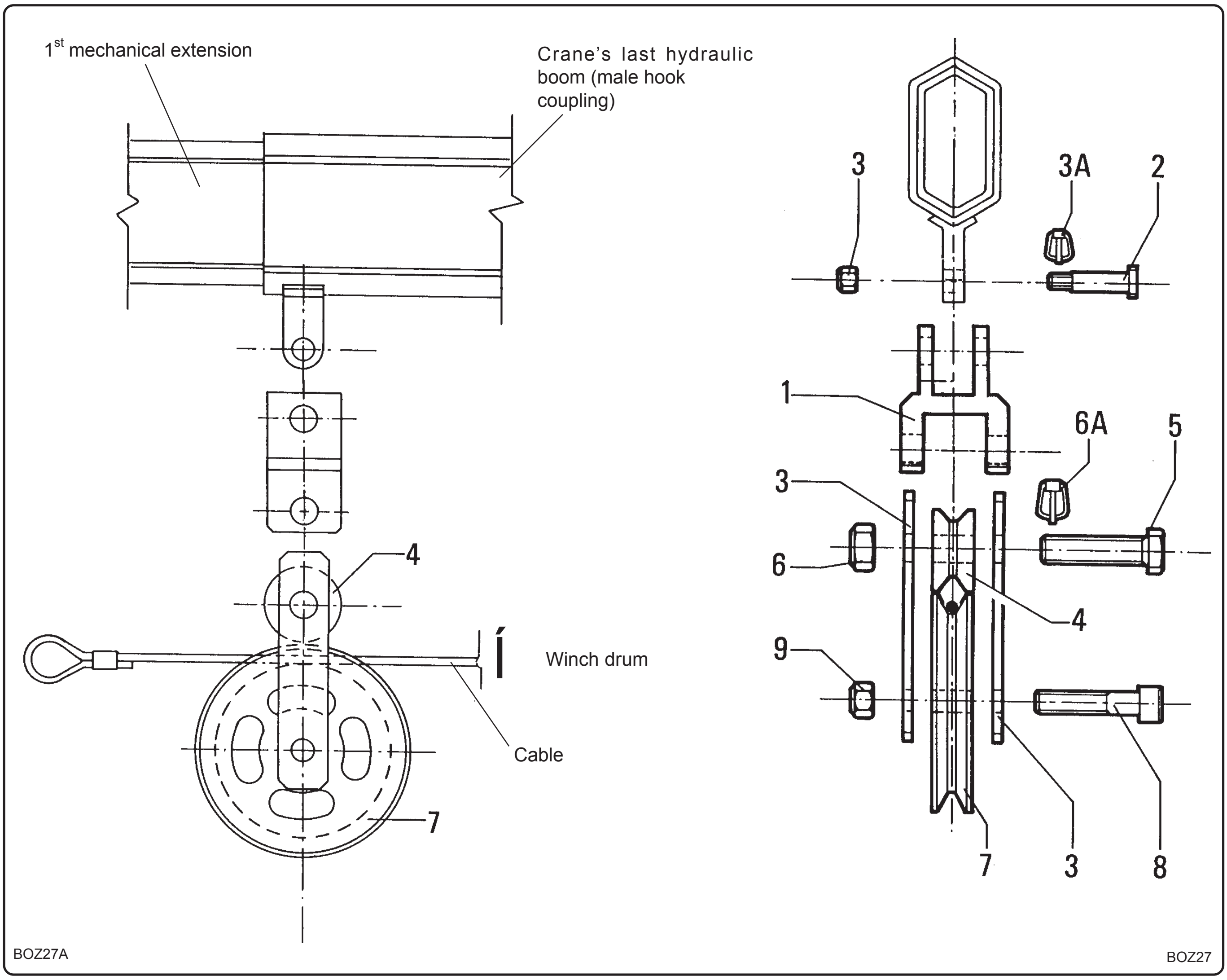


fig. 12.9.2

- If there is a load hoisting hook mounted on the crane last boom, dismount it.
- Mount the forked adapter "1" on the crane boom and lock it into place using the pin "2", the self-locking nut "3" and, when provided, the safety split pin "3A".

- Install the flanges “3” and the pulley “4” inside the forked adapter “1” and lock them in place with the pin “5” and the self-locking nut “6” and, when provided, the safety split pin “6A”;
- pass the winch cable through the inside of the flanges “3”;
- install the pulley “7” and lock it in position with the pin “8” and the self-locking nut “9”, making sure the cable is located correctly inside the pulley neck.

12.9.3 - Mounting an intermediary driving gear pulley on a crane with jib types J62-J63

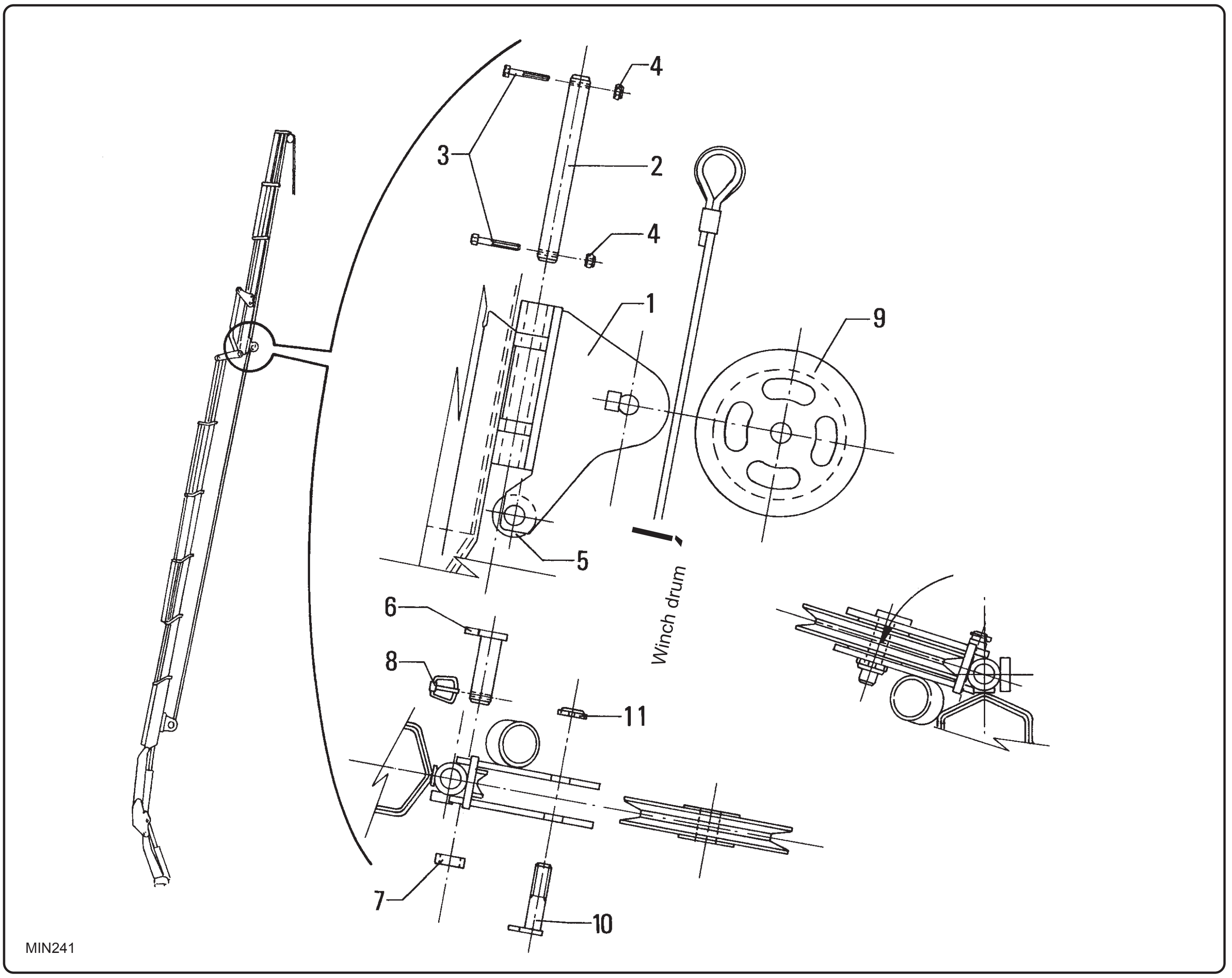


fig. 12.9.3

- Install the support “1” under the jib’s first boom in position with the hinge bushings ad lock it in place with the pin “2”.
- Mount the screws “3” and the self-locking nuts “4” on the pin “2” to prevent the pin sliding out.
- Install the pulley “5” inside the support “1”, locking it in place with the pin “6” the spacer “7” and the clip “8”.

- Slide the cable into the support “1”, resting it on the pulley neck “9”.
- Mount the pulley “9” and lock it into position with the pin “10” and the self-locking ring-nut “11”.

Note

To ensure the jib can close up fully underneath the crane boom, the support “1” can rotate around its anchorage pin “2”.
When this closing movement is performed, rotate the transmission support “1” manually.

12.9.4 - Mounting an intermediary driving gear pulley on a crane with jib types J92-J93-J94

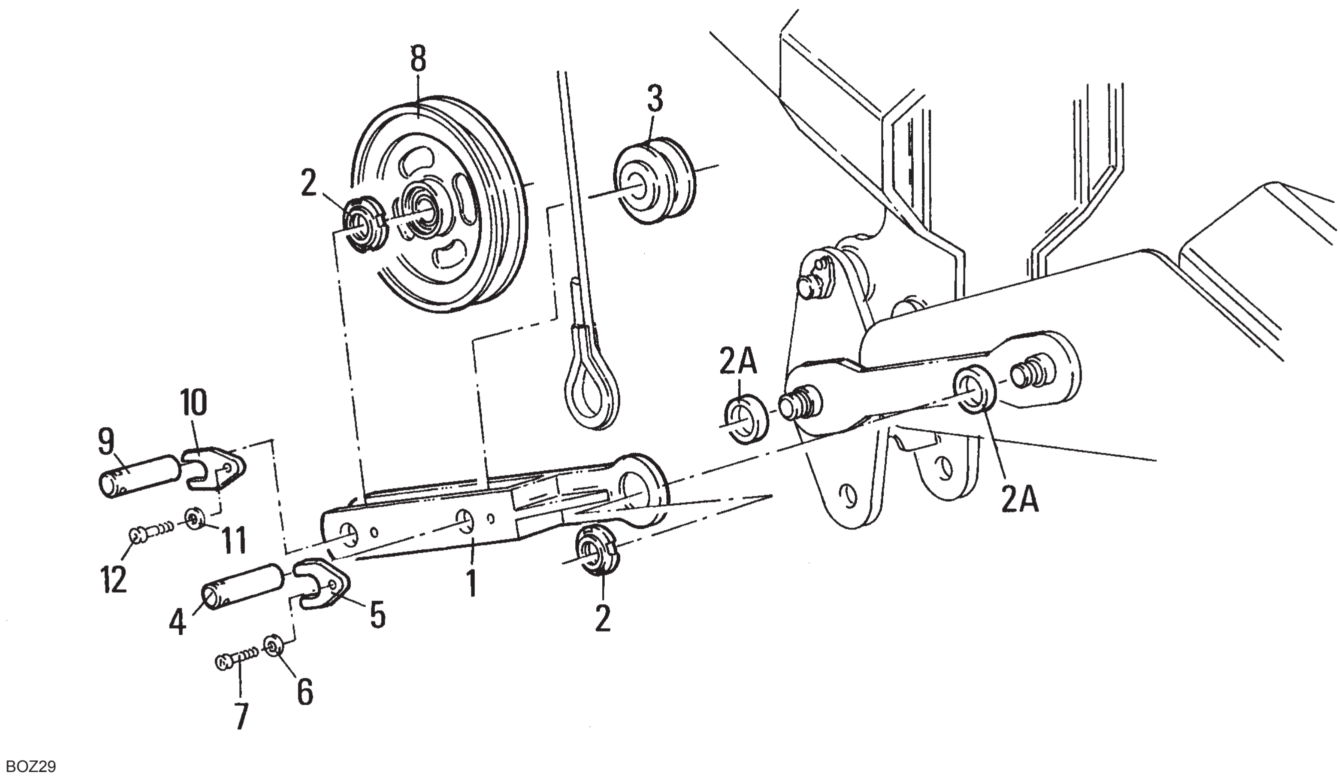


fig. 12.9.4

- Dismount the two ring nuts “2” and the relative rings (spacers) “2A” from the two pins on the jib joint.
- Mount the support “1” on the jib rod from the threaded pin side of the joint and lock it into place with the threaded ring-nuts “2” (tightening torque 20 daNm).
- Install the pulley “3” inside the support “1” and lock it into place with the pin “4”, the pin stop “5” and the washer “6” and the screw “7”.

- Insert the cable and the pulley “8” into the support “1” and lock them in place with the pin “9”, the pin stop “10” and the washer “11” and the screw “12”.
- Make sure that the cable is correctly positioned inside the pulley neck “8”.

Note

The transmission support “1” does not need to be dismounted when the machine is used without the winch, simply remove the cable.

MENU

MECHANICAL EXTENSIONS

13.1 - Hoisting and handling the mechanical extensions

13.1.1 - General installation instructions

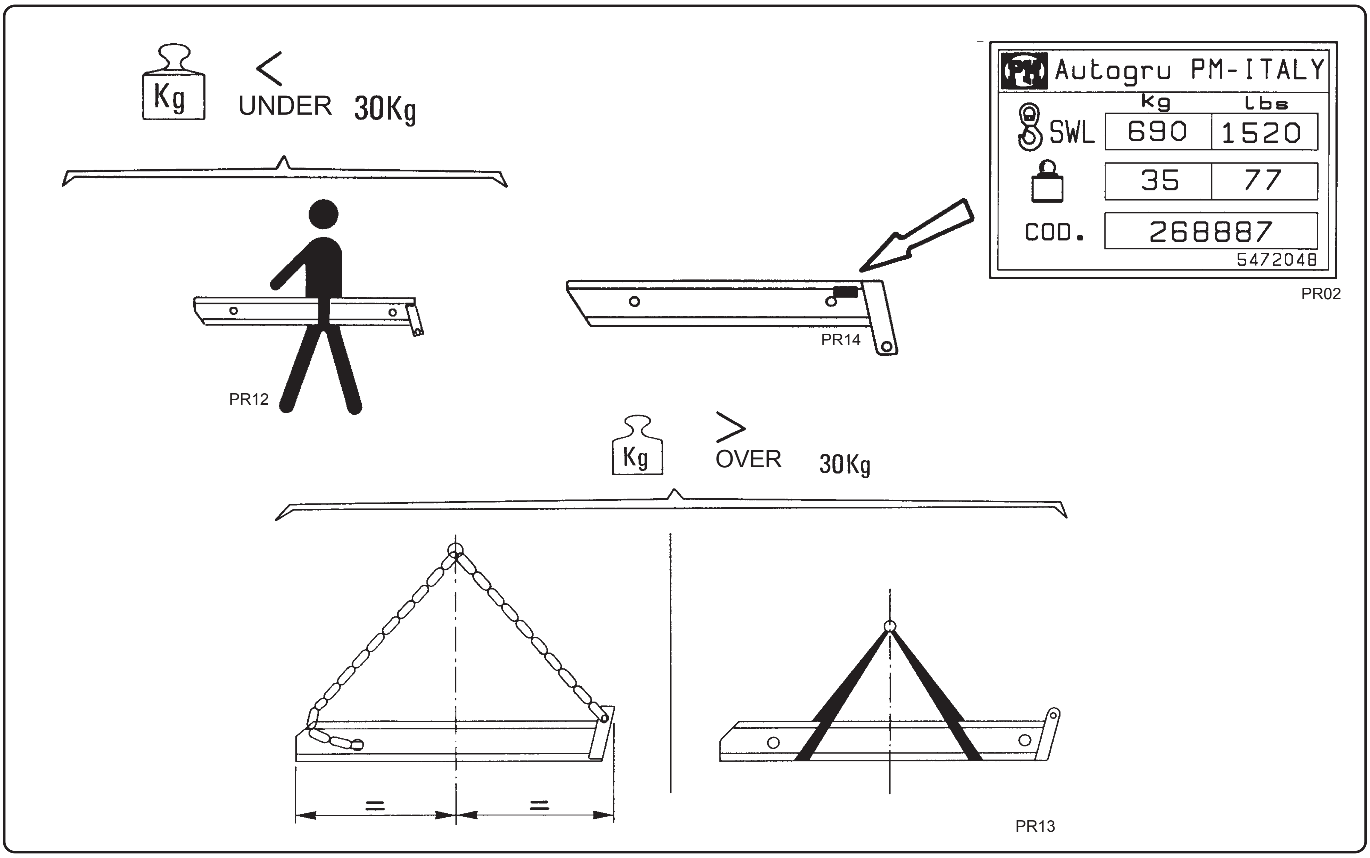


fig. 13.1.1

The crane may only be used with mechanical extensions if the weight handled is controlled by a weight limiting device.

If the crane hydraulic booms mechanical extensions are equal to or greater than 12 metres in length, then alarm devices (visual, audio etc.) must be installed to signal:

A) the beginning of the crane movement (e.g. buzzer or horn)
B) to the operator when the load has reached 90% of its max. limit (e.g. a flashing light)
C) when the load has reached 100% of its max. limit, for both the operator and the people in the crane's work area (e.g. a flashing light).

Note

In cases B and C, it must be a continuous signal.

If the crane (fitted with mechanical extensions) has not been assembled by Autogru PM, the installer mounting the aforesaid devices is responsible for affixing the EC mark, issuing the EC Declaration of Conformity (see enclosure II-A) and supplying the operator with all the instructions and warnings regarding the use of the crane with mechanical extensions.

ATTENTION!!!

When hoisting and moving the mechanical extensions, bear in mind that the barycenter is approximately half way along the extension. The operator must choose the hoisting means to be used depending on the to the weight to be lifted (fig.13.1.1), as indicated in on the plate.

13.2 - Mounting the extension's rear sliding blocks

13.2.1 - Rear sliding block types

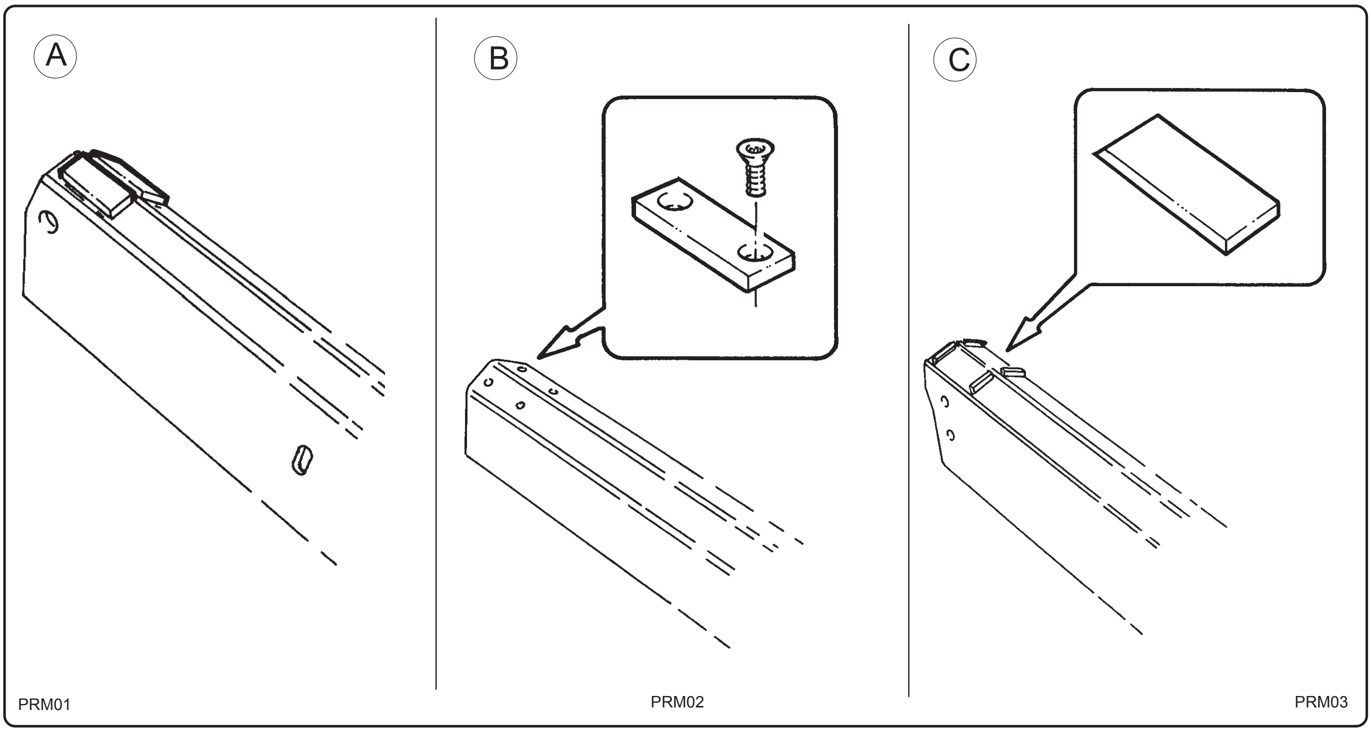


fig. 13.2.1

A) Sliding block welded on by the manufacturer.

B) Metal sliding block to be screwed on.

C) Snap-mounted anti-friction sliding block with 45° chamfer.

13.2.2 - Mounting screw-on sliding block

Note

Clean the threaded holes and the screw for fastening the sliding blocks thoroughly.

Pieces to be mounted:
- 2 x metal sliding blocks;
- 4 x screws.

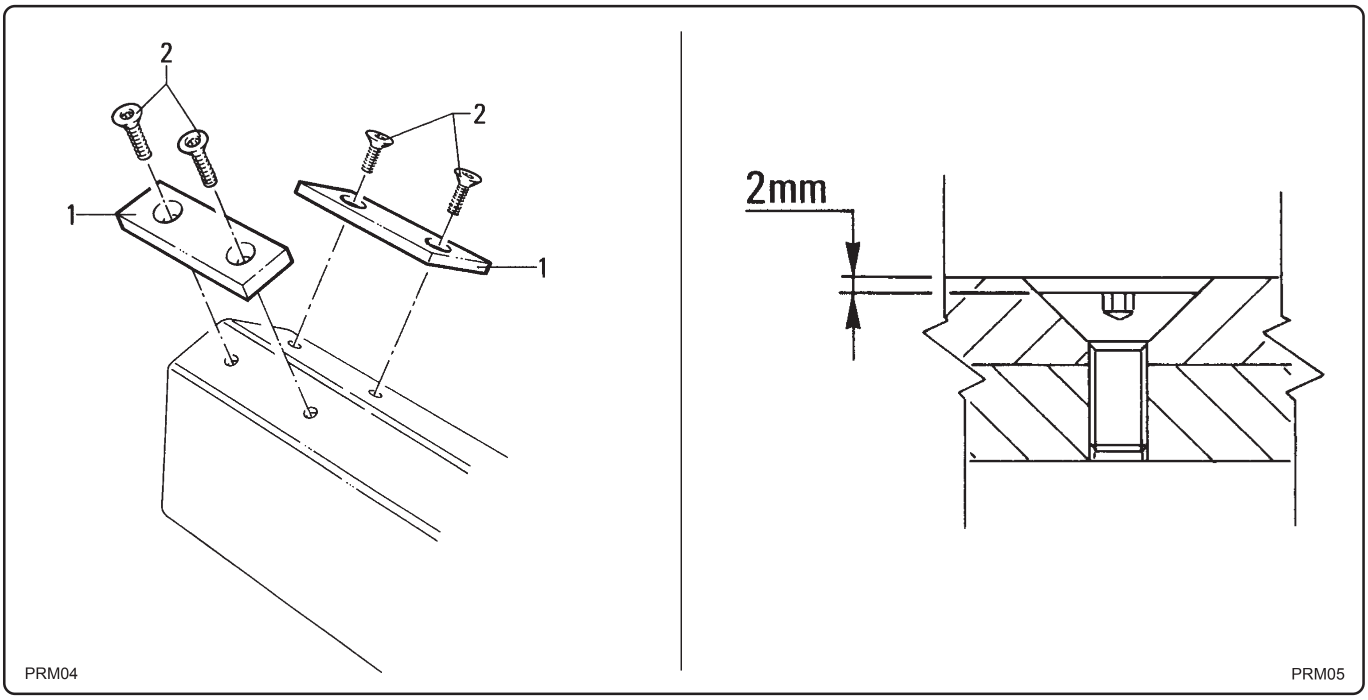


fig. 13.2.2

- Apply some medium thread brake fluid to the screws “2”.
- Mount the sliding blocks “1”.
- Lock the sliding blocks into place on the mechanical extension using the screws “2” with a suitable tightening torque.
- Make sure that once the assembly is complete, the head of the screw is countersunk in the sliding block by at least 2 mm.

13.2.3 - Mounting press-on sliding blocks

Material to be mounted:

- 2 x sliding blocks.

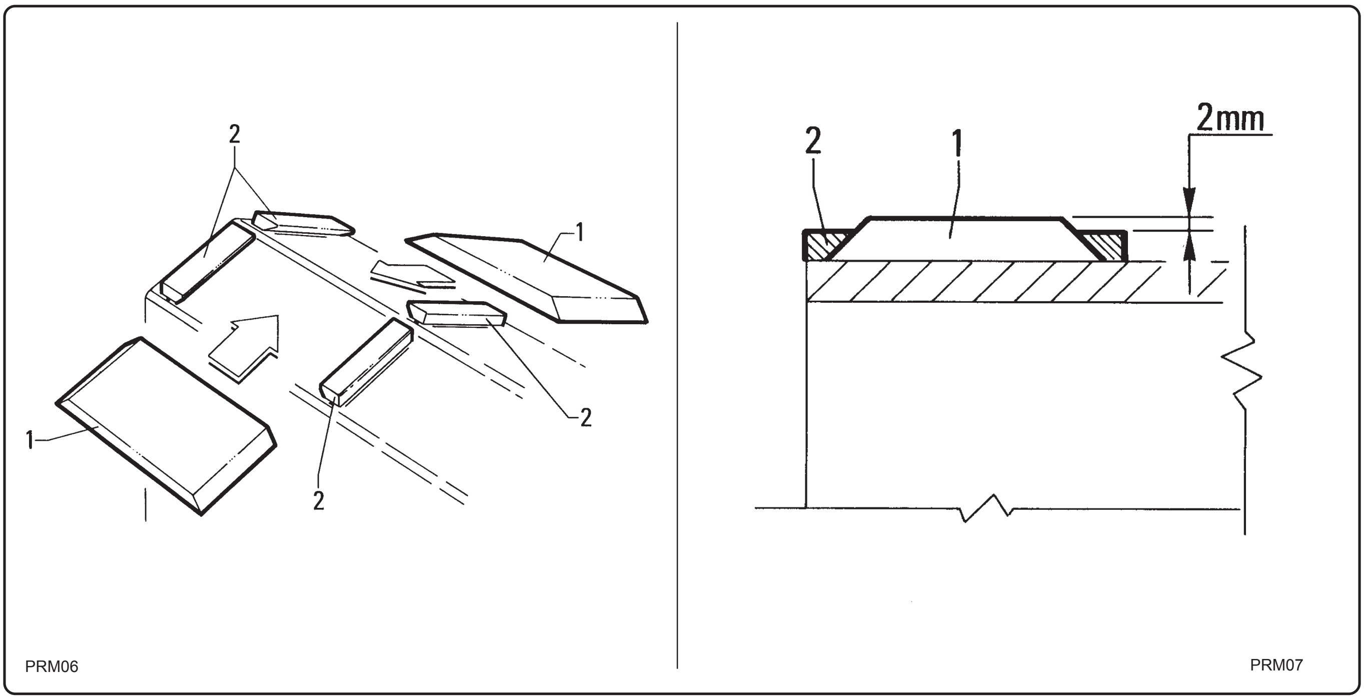


fig. 13.2.3

- Insert the sliding block “1” into the housing “2” on the mechanical extension.

  The blocks are mounted correctly when:
- the sliding block is blocked slightly by the housing;
- the sliding block is protruding from its housing by approximately 2 mm.

13.3 - Mounting sliding blocks and stops on the crane's last hydraulic boom

Note

Clean the threaded holes, the screw for fastening the sliding block plates thoroughly.

13.3.1 - Sliding block types

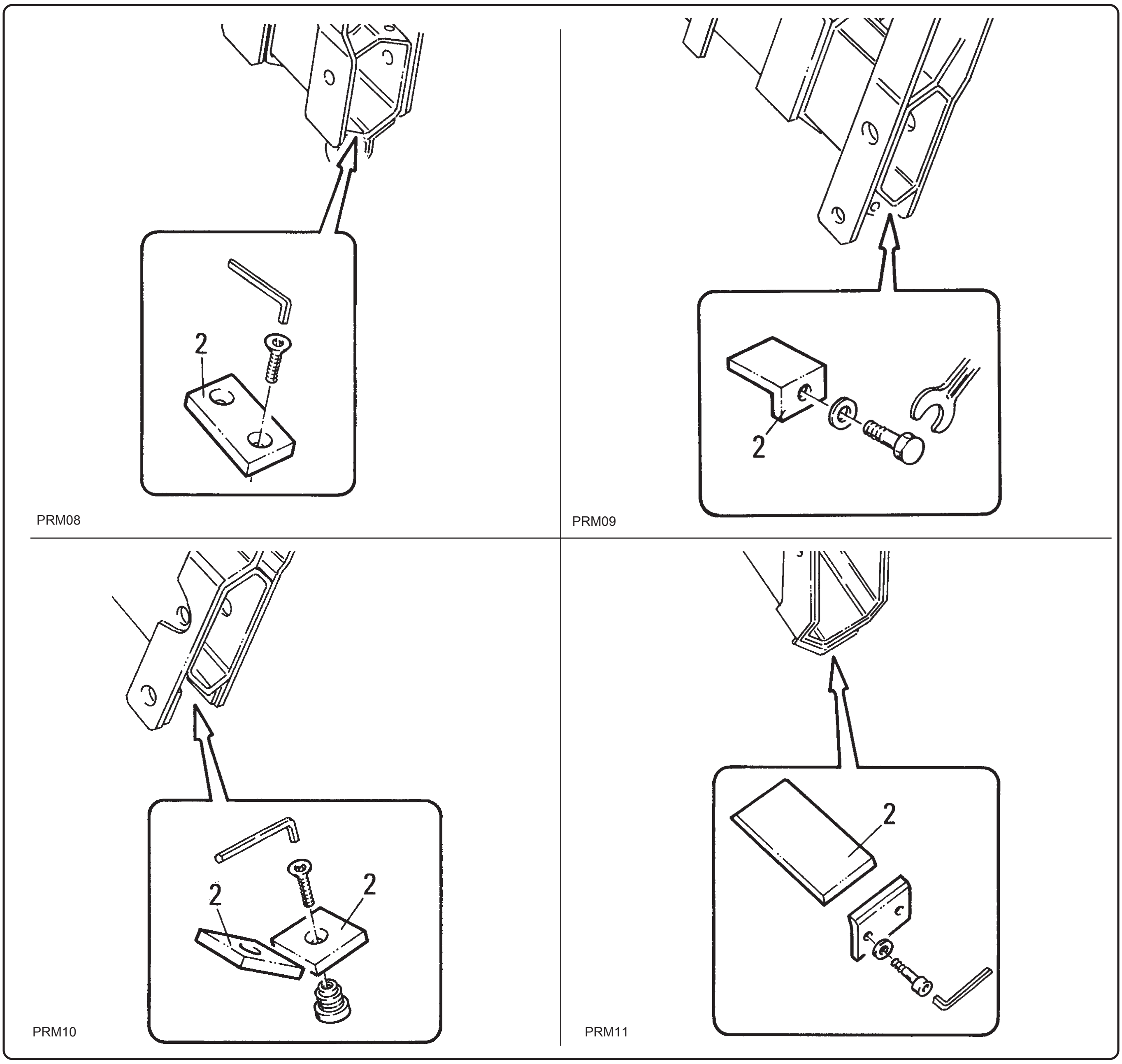


fig. 13.3.1

A) Metal sliding block anchored using a flathead screw.
B) L-shaped metal sliding block anchored using a hexagonal-head screw on the boom exterior.
C) Metal sliding block anchored with a flathead screw and a threaded stud.
D) Anti-friction sliding block anchored with a plate and screws.

13.3.2 - Mounting sliding blocks using a flathead screw anchorage

Pieces to be mounted:
- 2 x sliding blocks;
- 4 x screws.

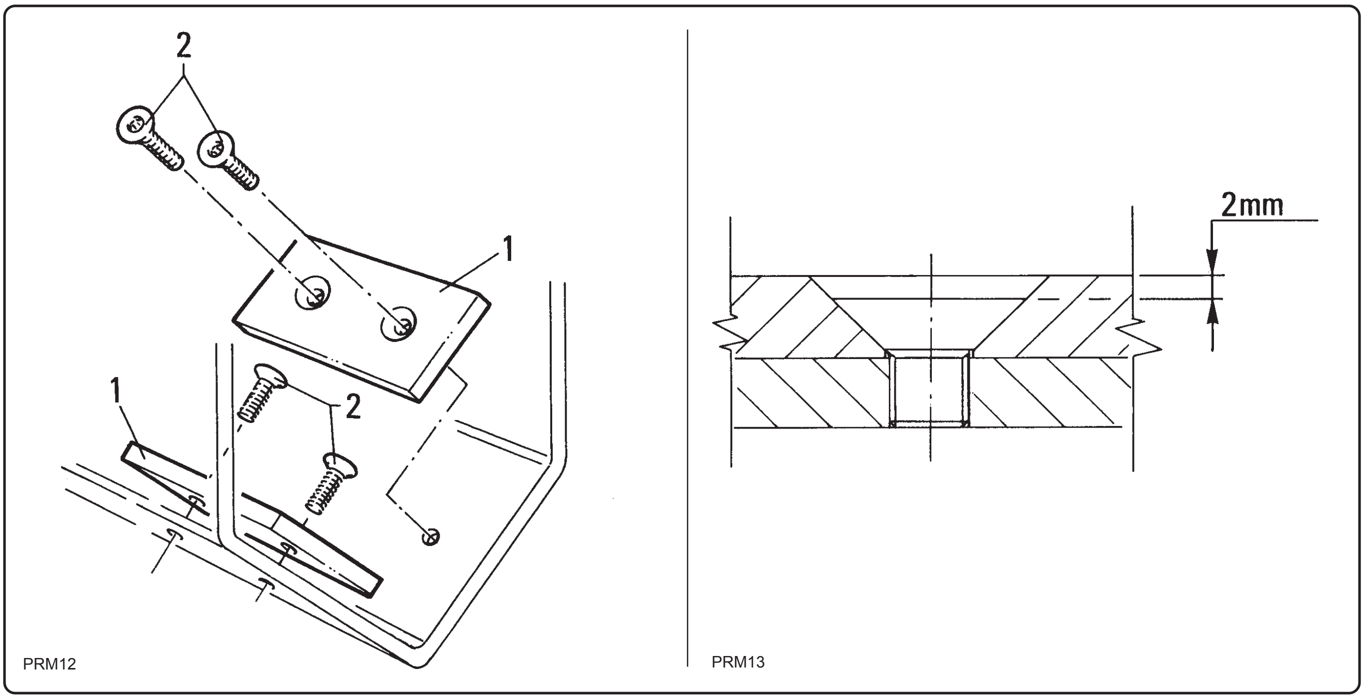


fig. 13.3.2

- Apply some medium thread brake fluid to the screws “2”.
- Mount the sliding blocks “1”.
- Lock the sliding blocks into place onto the last hydraulic boom using the screws “2” with a suitable tightening torque.
- Make sure that once the assembly is complete, the head of the screw is countersunk into the sliding block by at least 2 mm.

13.3.3 - Mounting “L-shaped” sliding blocks using a hexagonal-head screw anchorage on the boom exterior

Pieces to be mounted:
- 2 x “L-shaped” sliding blocks;
- 2 x hexagonal-head screws;
- 2 x washers.

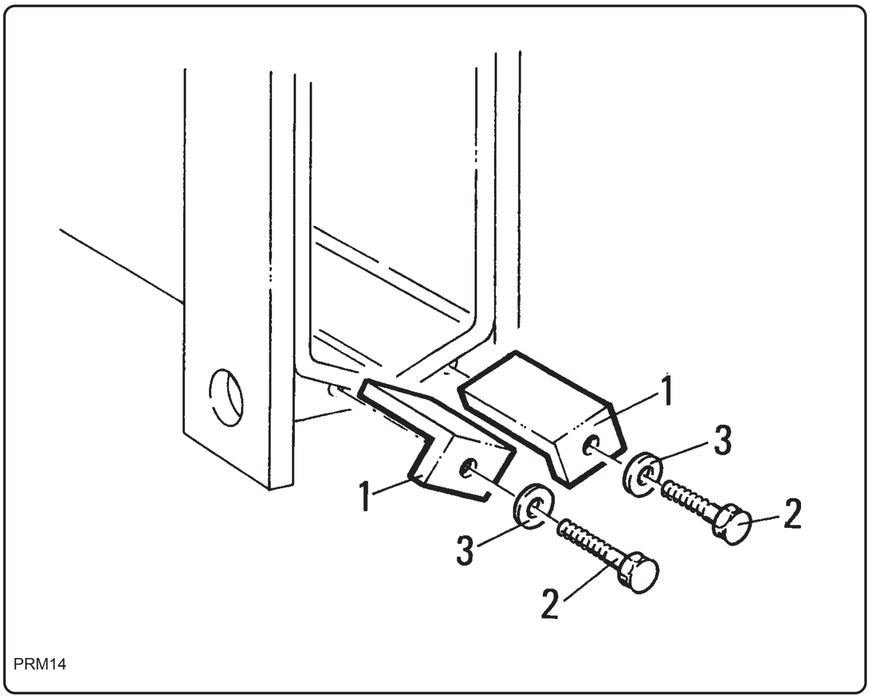


fig. 13.3.3

- Apply some medium thread brake fluid to the screws “2”.
- Mount the sliding blocks “1” and lock them into position inside the boom with the relative washers “3” and screws “2 applying a suitable tightening torque.

13.3.4 - Mounting sliding blocks using a countersunk screw and threaded stud anchorage

Pieces to be mounted:
- 2 x sliding blocks;
- 2 x threaded studs;
- 2 x screws.

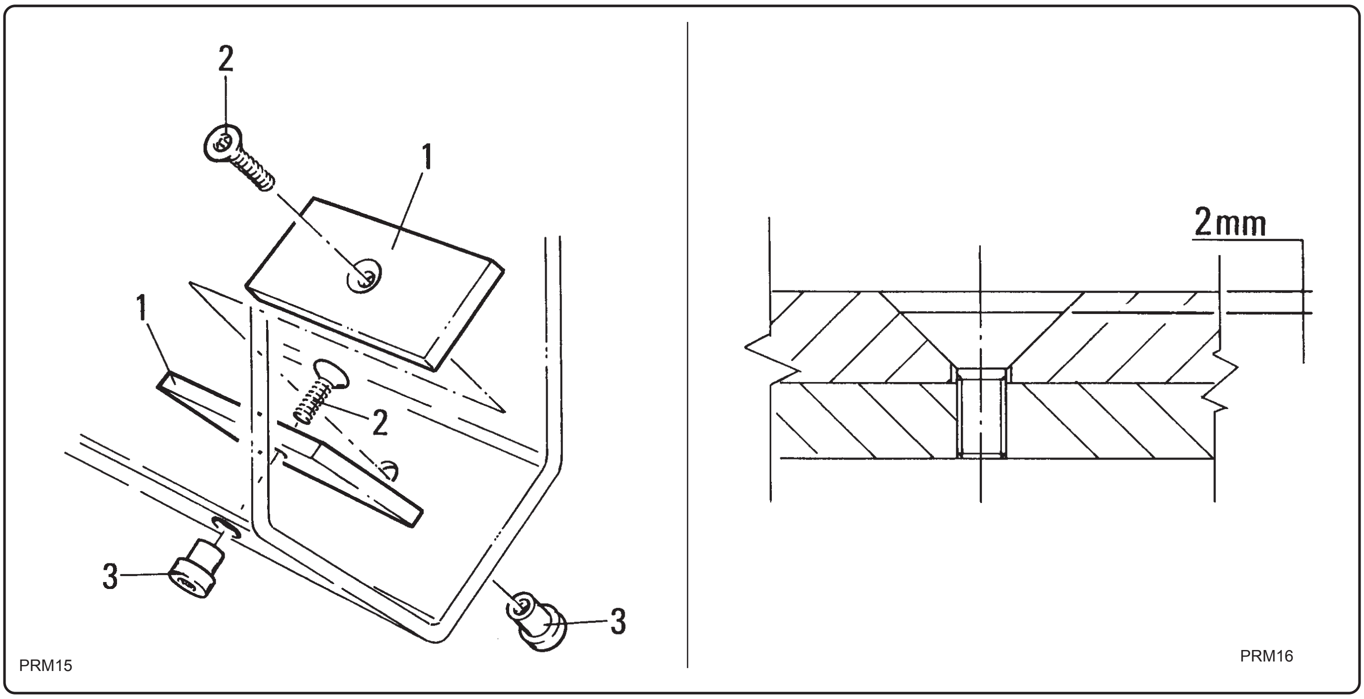
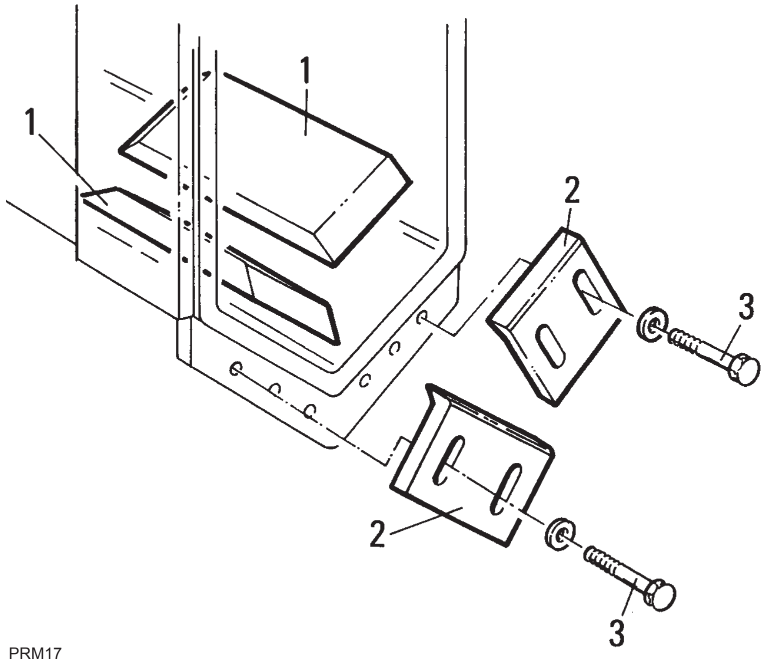


fig. 13.3.4

- Apply some medium thread brake fluid to the screws “2”.
- Mount the sliding blocks “1”.
- Lock the sliding blocks into place inside the last hydraulic boom using the threaded studs “3” and the relative screws with a suitable tightening torque.
- Make sure that once the assembly is complete, the head of the screw is countersunk into the sliding block by at least 2 mm.

13.3.5 - Mounting sliding blocks using a plate and screw anchorage

Pieces to be mounted:
- 2 x sliding blocks;
- 2 x plates;
- 4 x screws;
- 4 x washers.



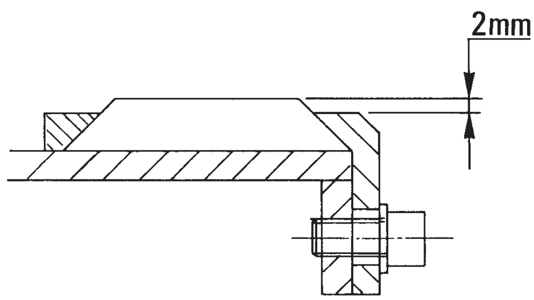


fig. 13.3.5

- Apply some medium thread brake fluid to the screws "3".
- Position the sliding blocks "1" into the housing located inside the crane's last hydraulic boom.
- Mount the plate "2" to hold the sliding block in position and tighten the screws "3" with a suitable tightening torque.
- Make sure that once the assembly is complete, the sliding block protrudes from the clamping plate by at least 2 mm.

13.4 - Mounting the lateral registers

When provided, mount and set the lateral registers in the rear of the mechanical extension correctly.

Note

Clean the threaded holes, the sliding blocks and the nuts thoroughly.

Pieces to be mounted:
- 2 x registers;
- 2 x counternuts.

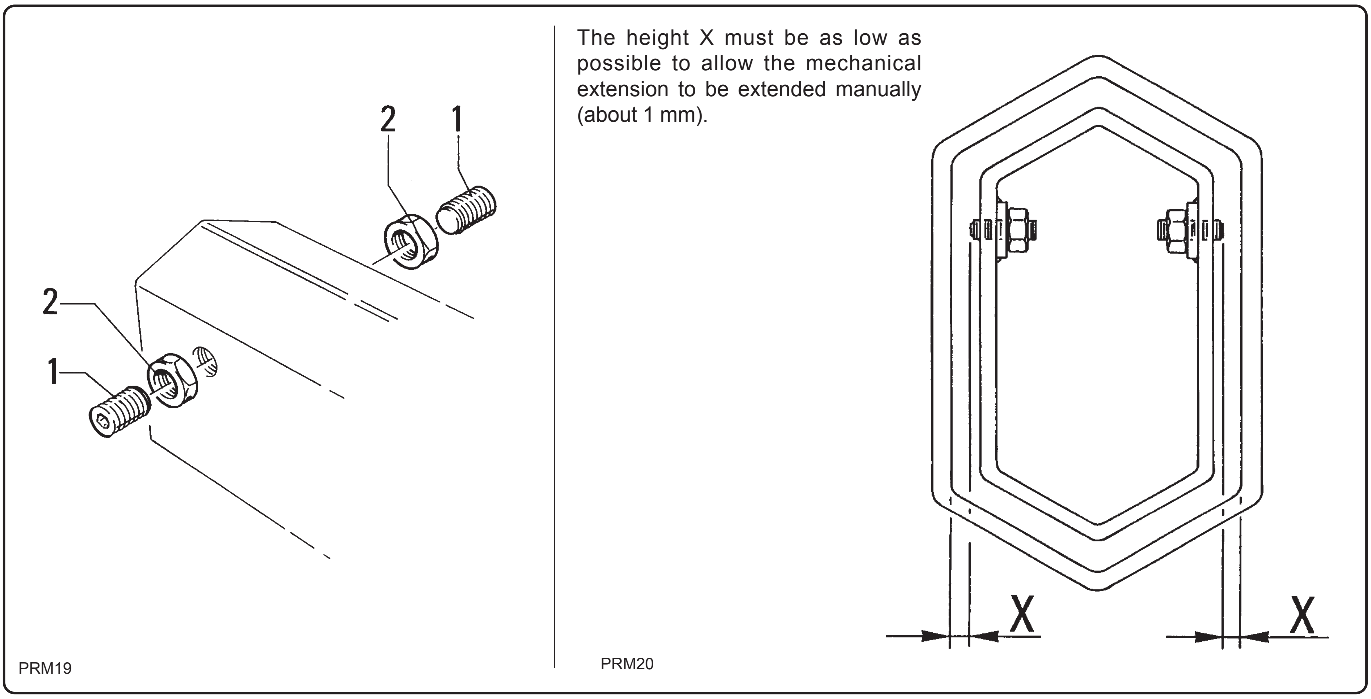


fig. 13.4.1

- Mount the registers “1” on the mechanical extensions.
- Reduce the clearance “X” to a minimum and lock the sliding blocks into place with the counternut “2”.

ATTENTION!!!

You must use the registers to align the various extensions correctly to limit the clearance “X” as much as possible. Excessive lateral clearance would result in strains on the extensions and the load swinging dangerously (fig. 13.4.2).
The registration must be performed in such a away as to allow the extensions to slide fluidly inside the previous boom during the opening and closing manoeuvres.

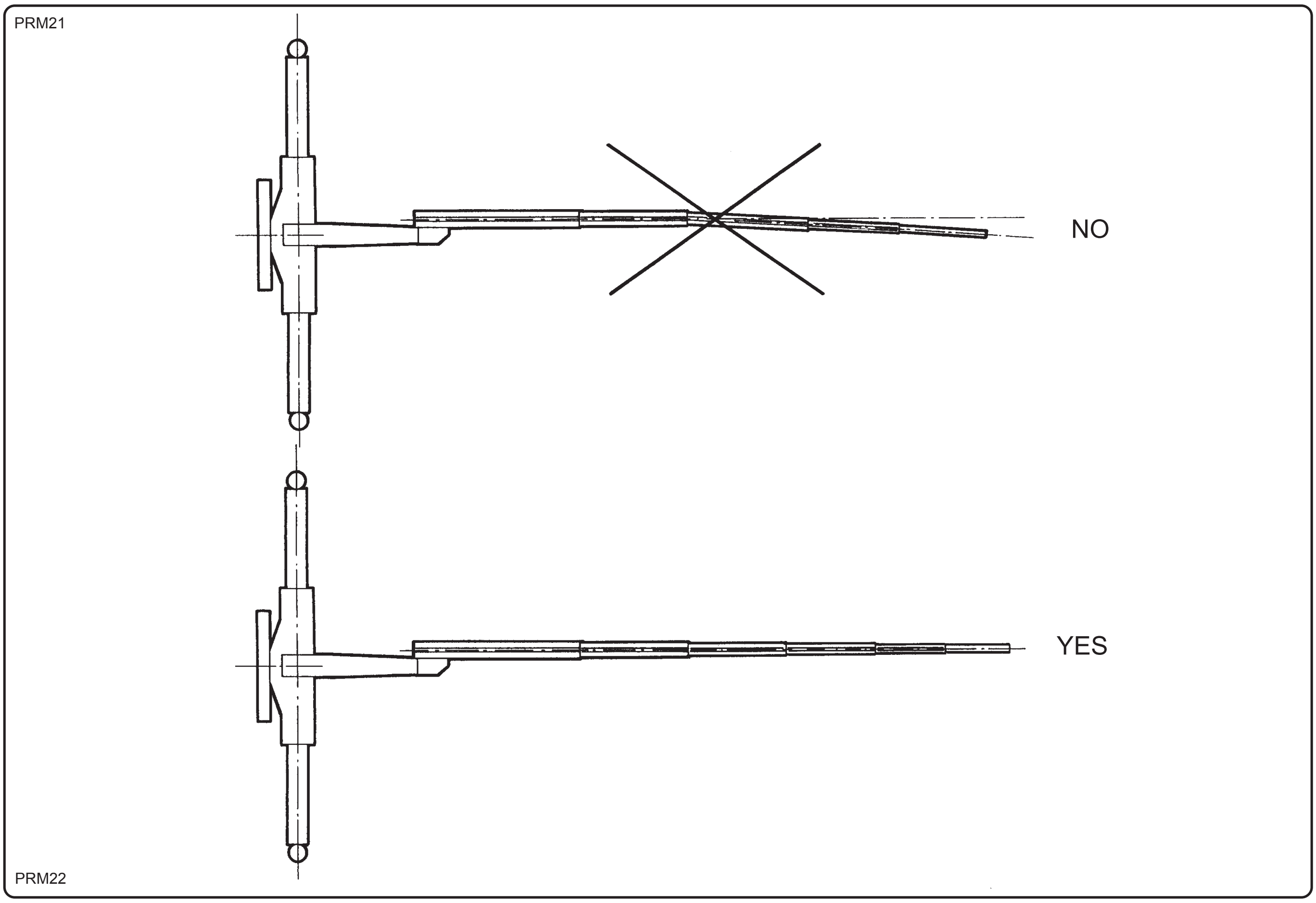


fig. 13.4.2

13.5 - Mounting the stroke limit device

- Stroke limit device types

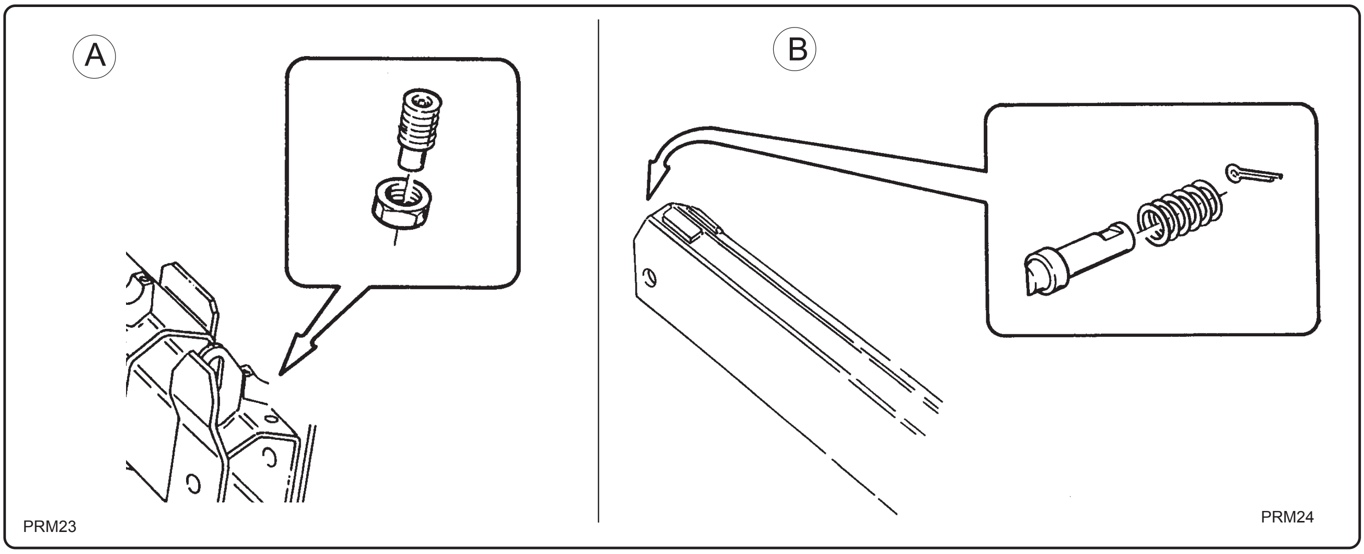


fig. 13.5.1

A) Stroke limit with screw and counternut (mounted on the crane's last hydraulic arm).
B) Automatic stroke limit with pin.

13.5.1 - Mounting the stroke limit with a screw and counternut

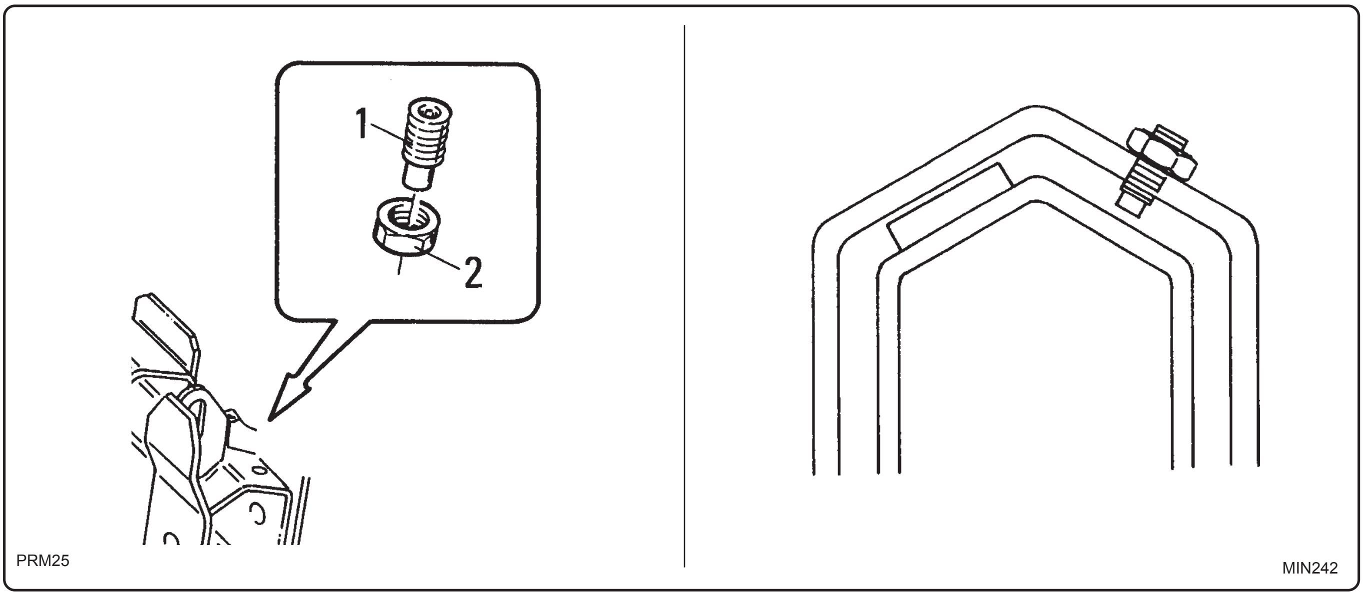


fig. 13.5.1

- Make sure the sliding blocks have been mounted on the rear of the mechanical extension.
- Slide the mechanical extensions fully into the machine's last boom and lock it into position with the relative pin.

ATTENTION!!!

Tighten the mechanical extension firmly since should it slide out of the crane boom it could cause injuries to people.

- Lock the screw "1" to the extension and slacken it by one turn.
- Lock the screw "1" by tightening the counternut "2" (fig. 13.5.1).

DANGER!!!

Check the distance between the internal screws and the interior of the crane's last hydraulic boom is enough to engage with the extension's rear sliding block to prevent the mechanical extension sliding out completely.

- To dismount the extension, you must remove the screws "1" and the counternut "2".

13.5.2 - Mounting an automatic stroke limit with a pin

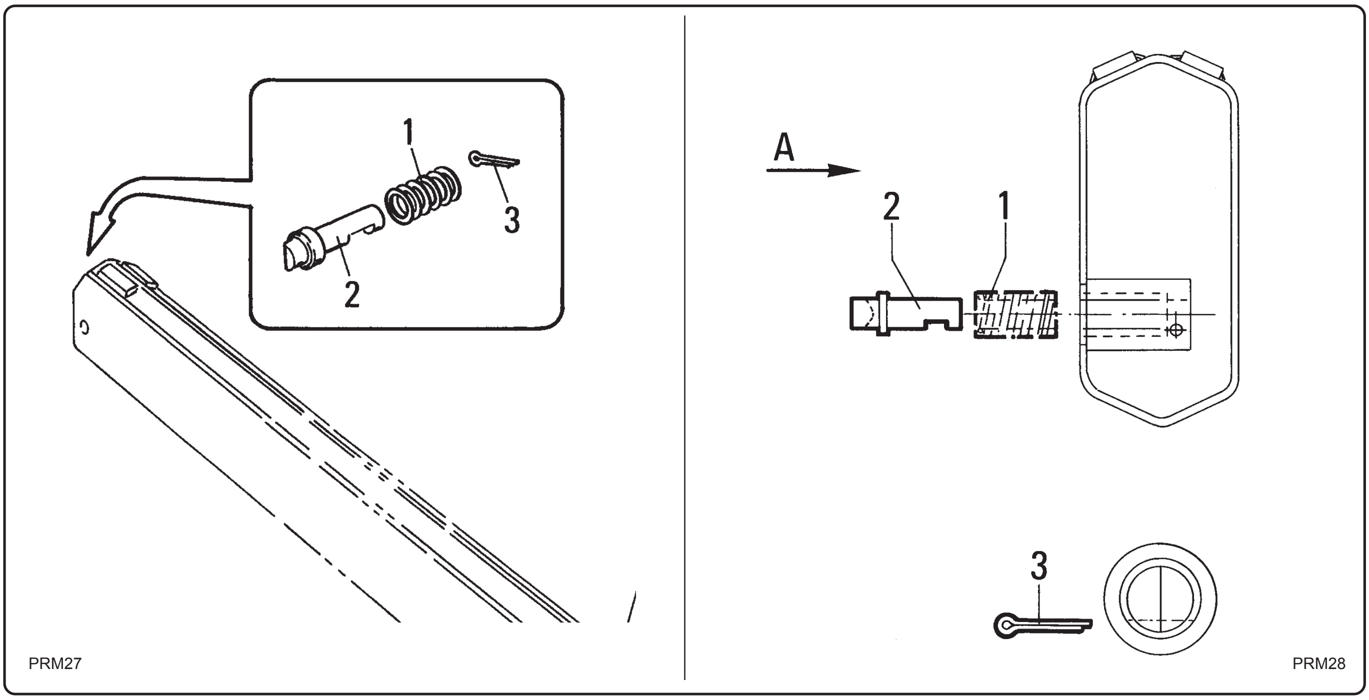


fig. 13.5.2

The pin is normally mounted by the manufacturer, so the installer must simply check it works correctly by carrying out the following procedure:

- using a pin extractor tap the pin "2" several times - it should return to its initial position without any problems.
- Check the pin protrudes from the boom.

If the pin has not been mounted on the extension, you must mount it by proceeding as follows.

- Mount the spring "1" and the pin "2" in the respective housings of the mechanical extension.
  The pin milling should face downwards to allow the split pin "3" to be mounted as this acts as a lock for the pin but should also allow the stroke to be performed at the same time.
- Once the assembly is complete, check the device works correctly in the way described earlier.

13.5.3 - Applying the identification plate

Affix an identification plate on the mechanical extension in the position indicated in fig. 13.5.3.

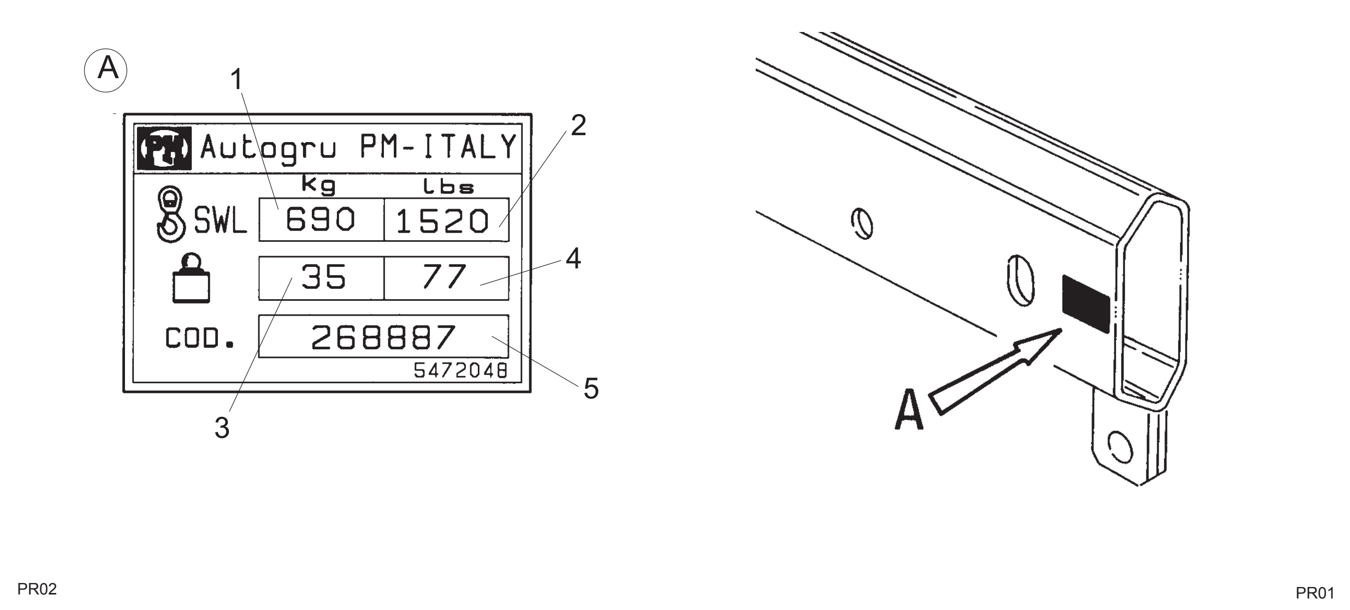


fig. 13.5.3

1 - Max theoretical admissible capacity (kg)
2 - Max theoretical admissible capacity (Lbs)
3 - Extension weight (kg)
4 - Extension weight (Lbs)
5 - Identification code

ATTENTION!!!

The actual capacity (which is monitored by the load limiting device) must be coherent with the capacity diagram of your crane as this vale has been attributed during the stability tests run on the whole crane-vehicle combination.

13.6 - Identifying and functions of the existing holes on the mechanical extensions

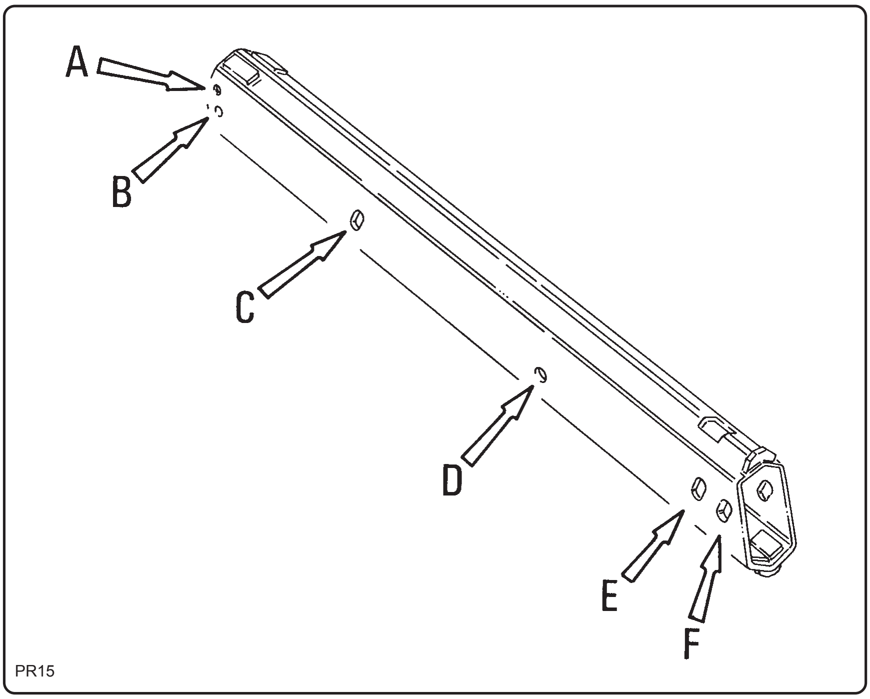


fig. 13.6.1

A = Threaded hole for housing lateral clearance registers (when provided).
B = Hole (on the left-hand side of the extension only) for housing the opening stroke limit pin (when provided).
C = Slot for the insertion of the lockpin for holding the boom in the work position.
D = Hole (on the left-hand side of the boom only) for locking the opening stroke limiting device for the following extension (when provided).
E = Slot for the insertion of the lockpin for the hook mobile coupling bracket (when provided).
F = Slot for the insertion of the lockpin for the resting position.

13.7 - Mounting the extensions for start-up

DANGER!!!

Check the extension output stroke limit device is intact and working correctly.

Make sure the sliding blocks that limit the boom's vertical clearance are mounted correctly (if provided).

Check that the lockpin for the extension is intact, is the right length and has the chain with the safety clip attached.

It is strictly forbidden to mount several extensions closed up inside each other or extended simultaneously.
The extension must be mounted by two operators.

The first operator must control the hoisting means, while the second must remain within the vicinity of the lockpin at the connection to the boom or the previous extension.

Stand next to the boom to prevent it sliding out of its housing accidentally and causing injuries.

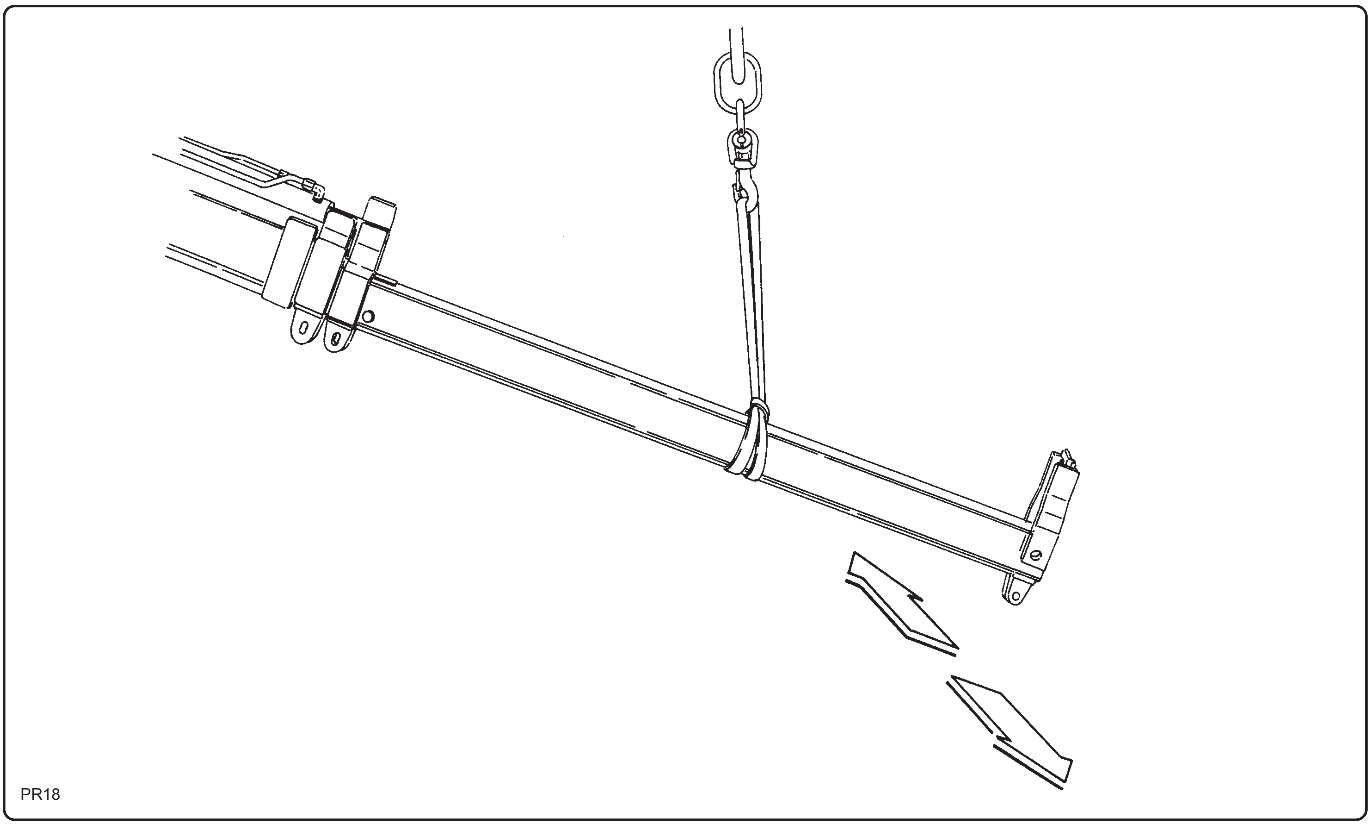
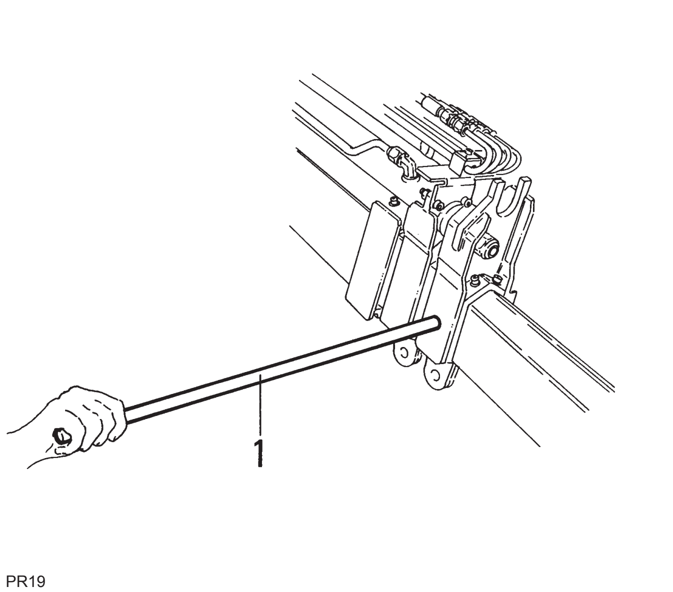


fig. 13.7.1



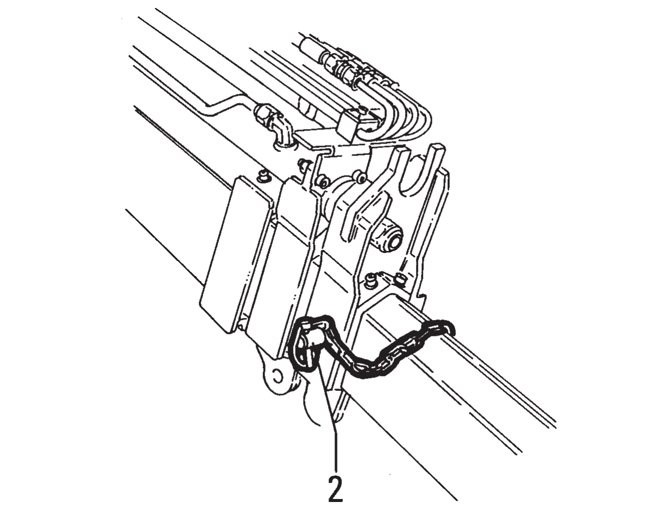


fig. 13.7.2

- Position the crane's boom pack so that it is sloping downwards at an angle that allows the extension to be inserted easily (fig. 13.7.1).
- Harness the extension using a cable with a suitable capacity (at approximately the mid-way point), in order to balance its weight and lift it with appropriate hoisting means.
- Position the extension at the same angle as the boom pack and insert it in the containing boom.
- Stop the vehicle's engine to prevent uncontrolled crane movements.
- Move the extension to the left and right to facilitate the entrance of the stroke limit device into boom or the containing extension (fig. 13.7.1).

  Continue to insert the extension until the outgoing stroke limit device enters its housing.

ATTENTION!!!

Make sure the stroke device enters into its housing.

- Using a crowbar "1" (fig. 13.7.2), align the hole in the boom or the container extension with the hole to be used to lock the extension to be mounted.
- Insert the lockpin with the relative chain (passing it above the extension to prevent it being crushed) and the safety clip.

Note

Proceed in the same way if you wish to mount other extensions.

13.8 - Mounting the load hoisting hook

DANGER!!!

The hoisting hook may only be mounted on the last extension extended.

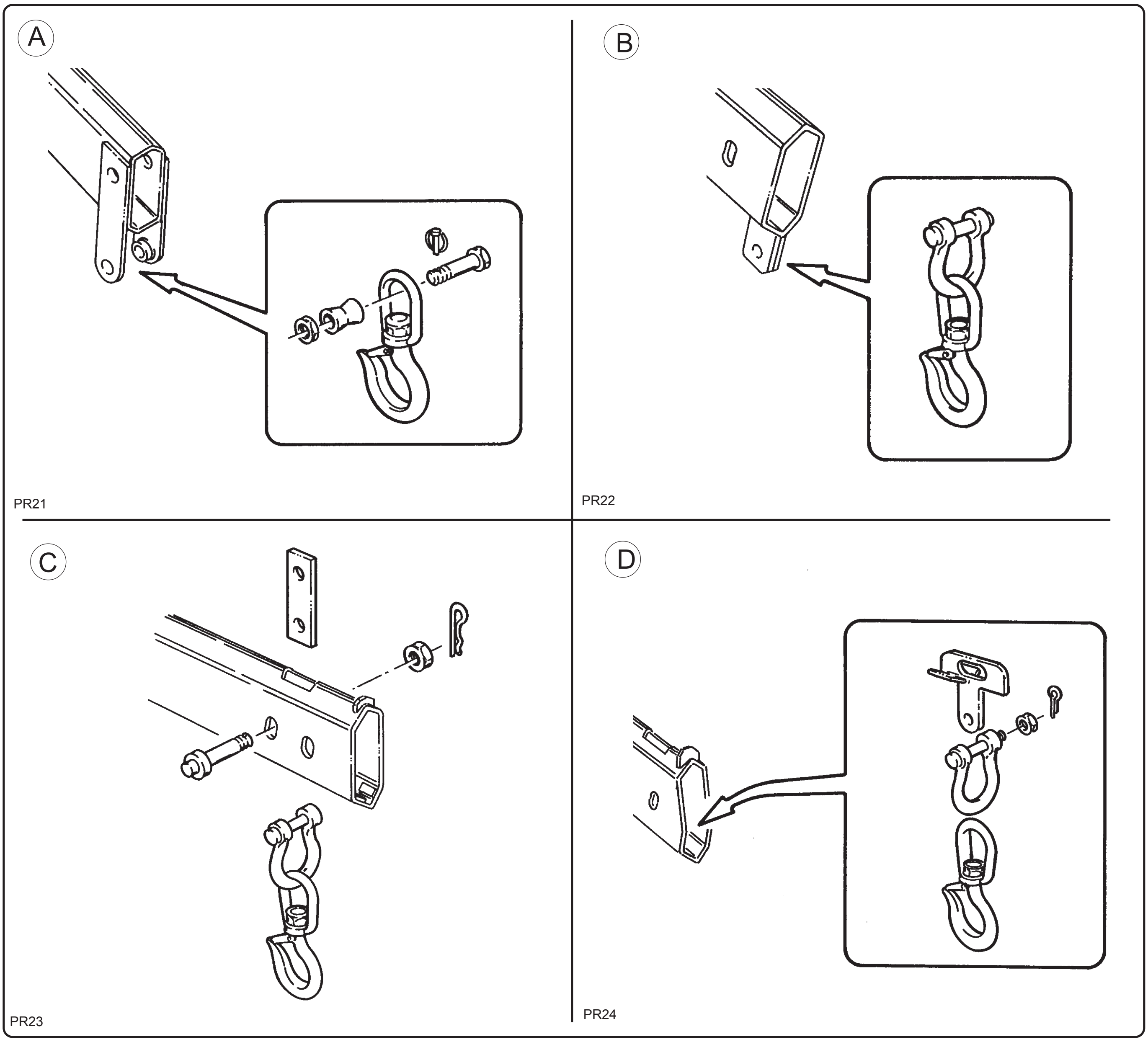


fig. 13.8.1

The way in which the hook is attached depends on the type of coupling the mechanical extension has.
The following types of hook coupling are possible:
- fixed female coupling (fig. 13.8.1 - “A”).
- Fixed male coupling (fig. 13.8.1 - “B”).
- Mobile bracket which goes through the boom (fig. 13.8.1 - “C”).
- Mobile bracket which goes inside the extension (fig. 13.8.1 - “D”).

13.8.1 - Mounting the hook on the extension fitted with a fixed female hook coupling (fig. 13.8.2)

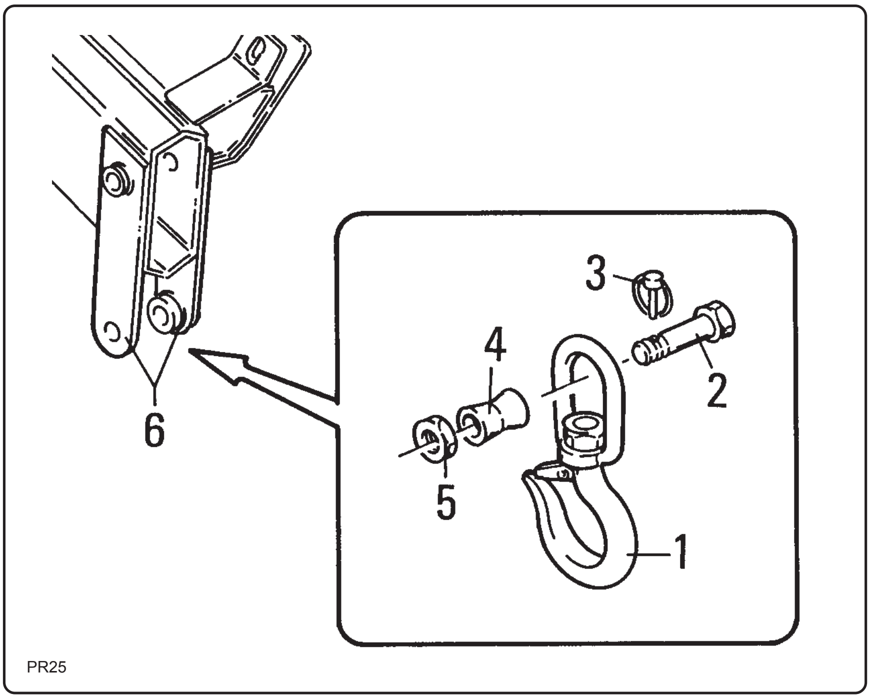


fig. 13.8.2

Slide the bushing “4” into the hook “1”, then position the bushing “4” inside the female coupling “6” on the manual extension.
Insert the pin “2” and lock it into place with the nut “5”, then insert the safety lockpin “3”.

13.8.2 - Mounting the hook on the extension fitted with a fixed male hook coupling (fig. 13.8.3)

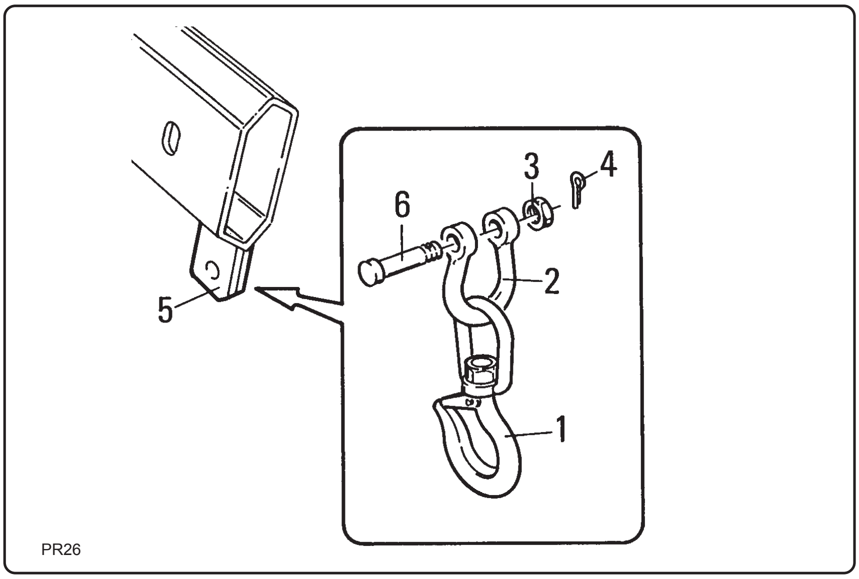


fig. 13.8.3

The hook “1” can be fastened to the fixed male coupling “5” on the extension by placing the shackle “2” in between the pin “6”, the nut “3” and the relative safety lockpin “4”.

13.8.3 - Mounting the hook on the extension fitted with a mobile coupling which passes through the boom (fig. 13.8.4)

Note

The mobile hook coupling can only mounted on the extension if there are no other mechanical extensions inside the extension you intend to use.

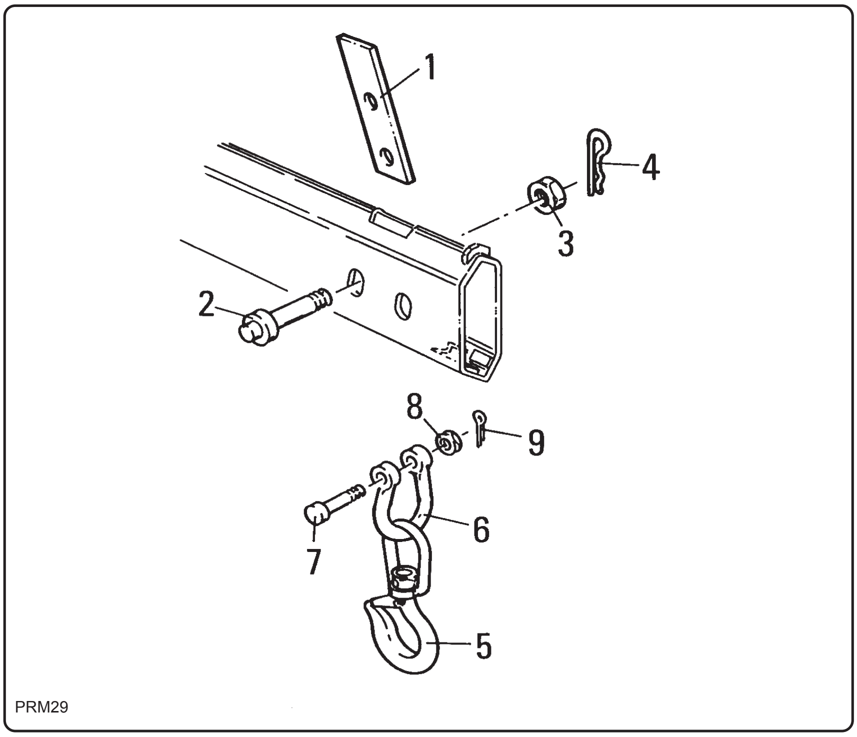


fig. 13.8.4

- Insert the bracket “1” into the slit in the boom; lock it into position with the relative pin “2”, nut “3” and clip “4”.
  The hook “5” is mounted on the bracket “1” by placing a shackle “6” which is locked in position with the pin “7”, the nut “8” and the split pin “9”.

13.8.4 - Mounting the hook on the extension fitted with a mobile coupling which passes inside the boom (fig. 13.8.5)

Note

The mobile hook coupling can only mounted on the extension if there are no other mechanical extensions inside the extension you intend to use.

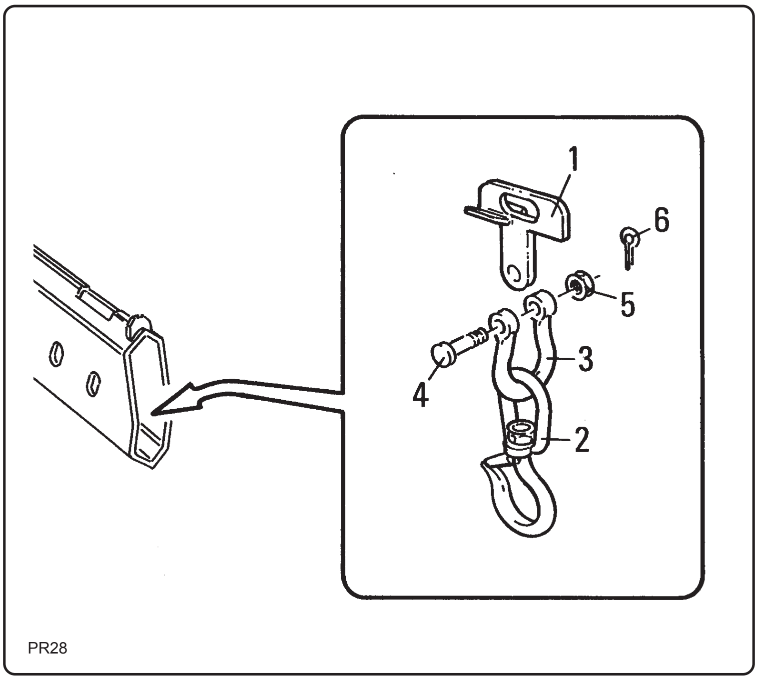


fig. 13.8.5

- Insert the bracket “1” into the mechanical extension;
- place the hook ring “2” in the shackle “3”;
- mount the shackle on the bracket “1” and lock it in place with the pin “4”, the nut “5” and the split pin “6”.

13.9 - Dismounting the crane extensions

DANGER!!!

You must not dismount several extensions (either closed up inside each other or extended) at the same time.
They must be dismounted separately starting with the smallest first.
Make sure none of the mechanical extensions slides out abruptly and uncontrolled.
The extension must be dismounted by two operators.
The first operator must control the hoisting means, while the second must remain within the vicinity of the lockpin at the connection to the boom or the previous extension.
Stand next to the boom to prevent it sliding out of its housing accidentally and causing injuries.

13.9.1 - Dismounting the extension from a mechanical extension

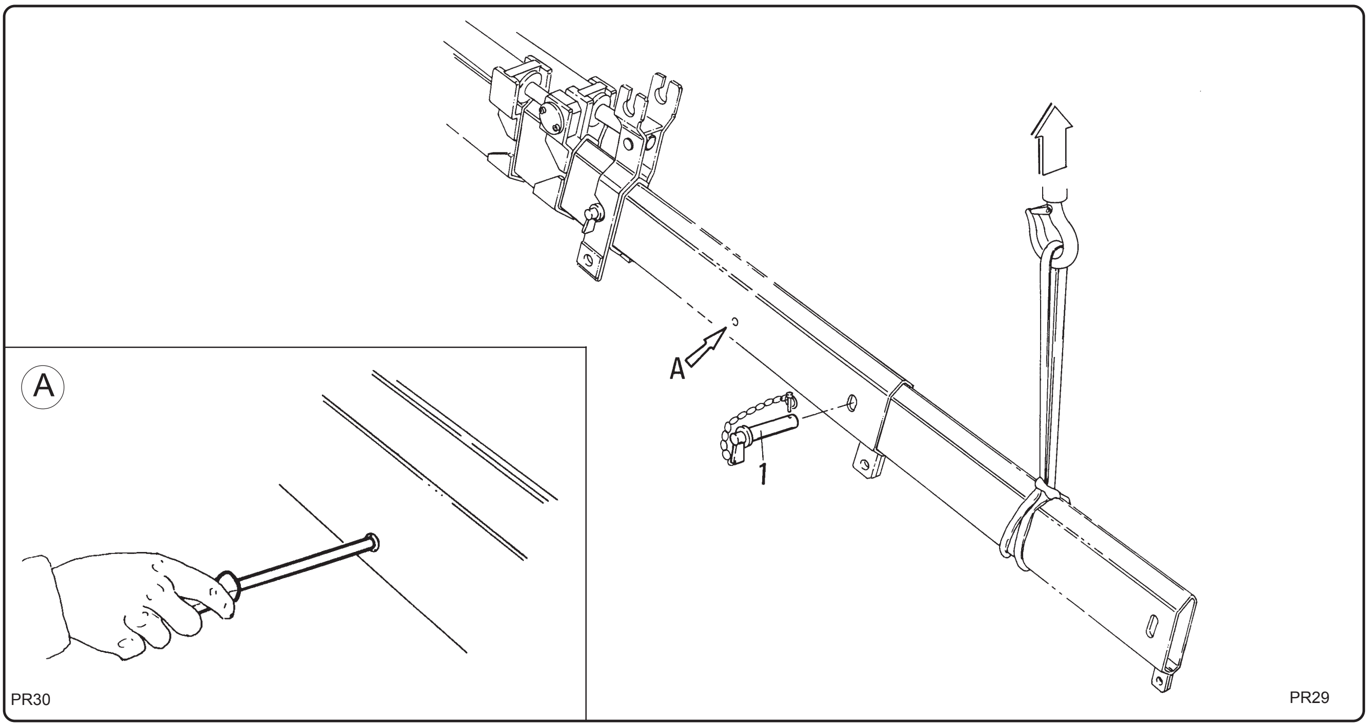


fig. 13.9.1

- If there is a load hoisting hook mounted on the mechanical extension, dismount it;
- lower the crane boom until the mechanical extension is resting on the ground;
- harness the extension with a suitable lifting means at approximately halfway along its length to ensue its weight is balanced;
- remove the lockpin “1” from the extension in the work position;

- raise the crane boom to a height that allows the mechanical extension to be slid out and support it at the same time with a hoisting means;
- using a pin extractor, push the pin on the stroke limit device out to unlock it and then extend the extension.

ATTENTION!!!

Be careful not to let the load swing as it could cause injuries.

13.9.2 - Dismounting the extension from the base crane's hydraulic boom

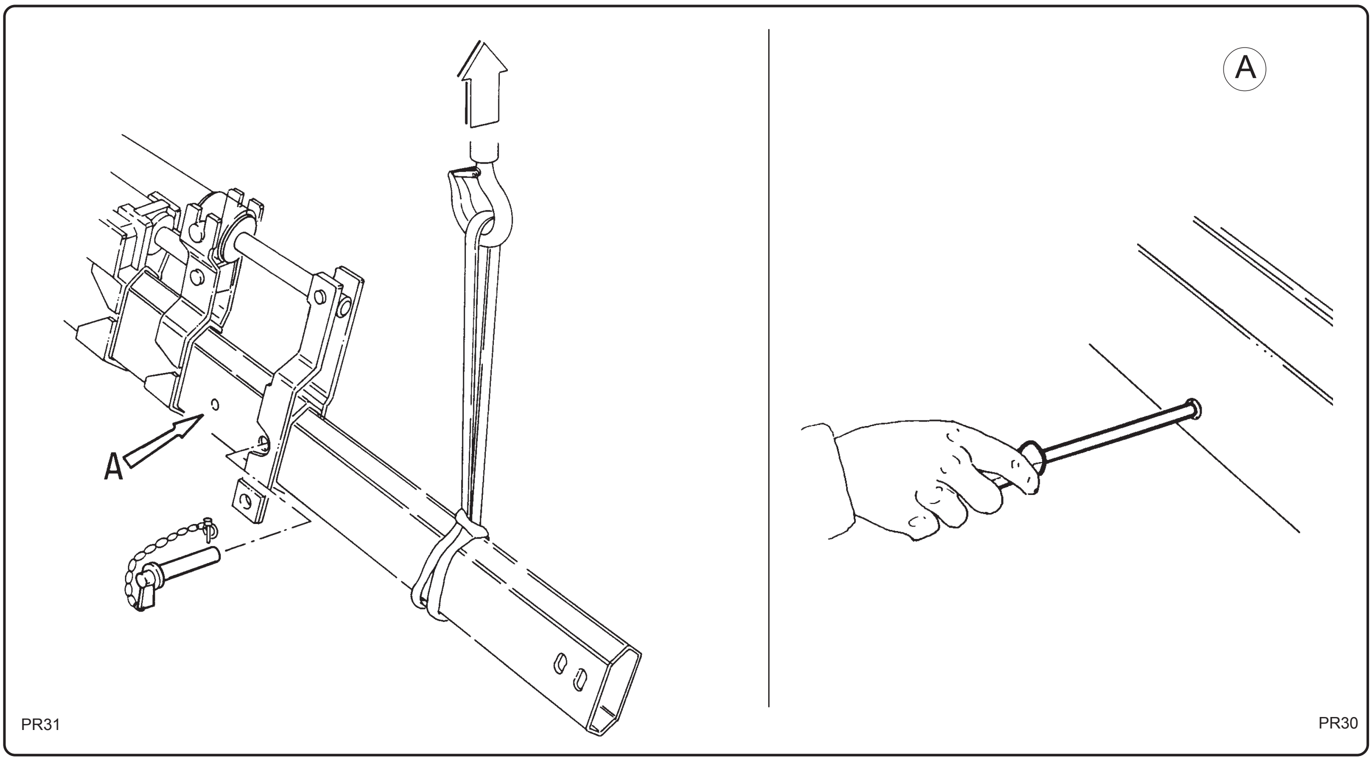


fig. 13.9.1

- If there is a load hoisting hook mounted on the mechanical extension, dismount it;
- extend the hydraulic boom by approximately 500 mm so that the stop hole of the extension's stroke limit device appears;
- lower the crane boom until the mechanical extension is resting on the ground;
- harness the extension with a suitable lifting means at approximately halfway along its length to ensue its weight is balanced;
- remove the lockpin "1" from the extension in the work position;
- raise the crane boom to a height that allows the mechanical extension to be dismounted and support it at the same time with a hoisting means;

- using a pin extractor, push the pin on the stroke limit device out to unlock it and then extend the extension.
- If the stop is composed of a screw with a nut, after harnessing the mechanical extension you will need to unscrew the nut “2” and remove the screw “1” in order to dismount the extension (fig. 13.5.2 - page 15/26).

ATTENTION!!!

Be careful not to let the load swing as it could cause injuries.

MENU

THE JIB

14.1 - Packing and unpacking

The type of packing used is normally agreed up on with the customer, taking into account the means of transport chosen and the destination of the goods.

The jib is sent:

- fixed firmly to a base pallet and wrapped in a heat-sealed plastic sheet;
- inside a slatted crate and fixed to the base surface.

ATTENTION!!!

To hoist the unpacked machine, you will need a crane and a bridge crane with a suitable bearing capacity. Check the weight of your jib.

- Jib fastened to the pallet

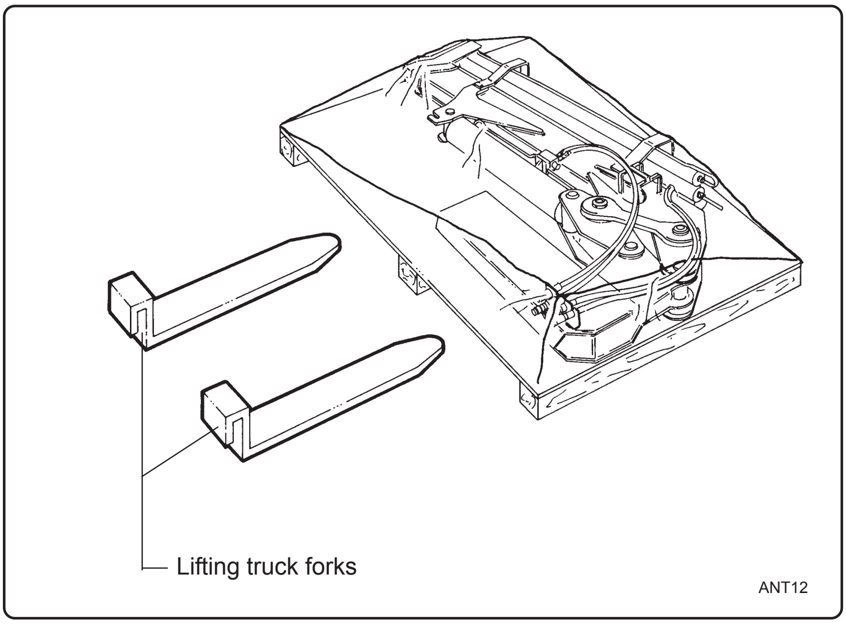


fig. 14.1.1

Move the packed equipment with a lifting truck.

- Packed jib inside slatted crate

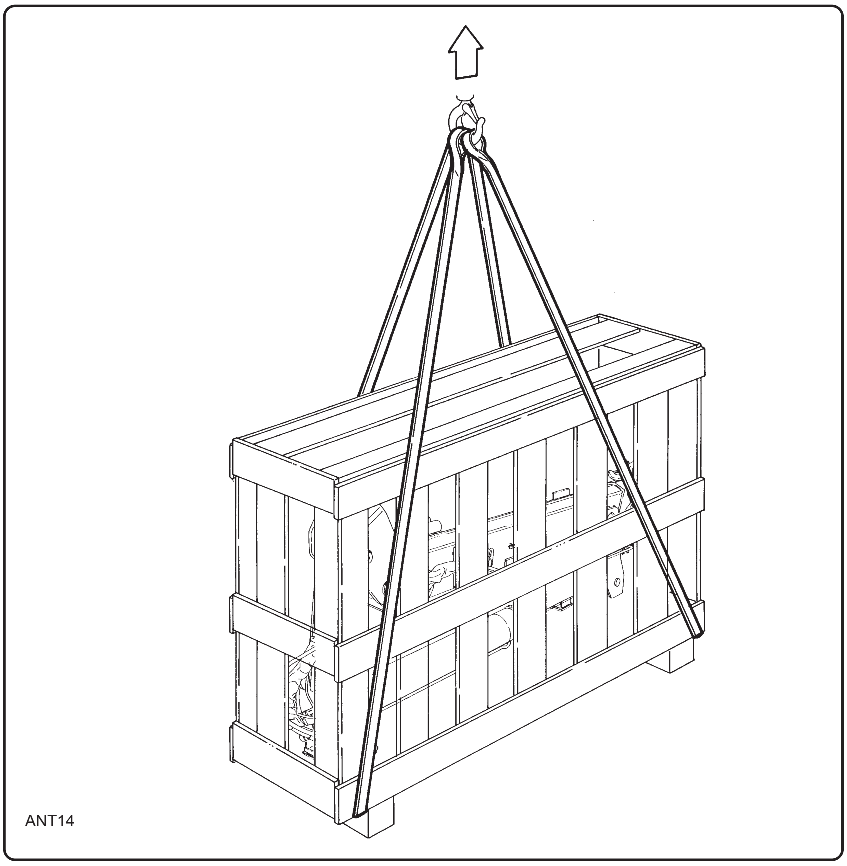


fig. 14.1.2

You will need a crane and a bridge crane to move the packed jib inside the slatted crate.

14.2 - Disposing of the packing

- Unpack the jib and remove all the clamps fastening it to the base pallet.
- Divide up the various packing materials in order to facilitate their disposal of recycling.
- All packing must be disposed of in compliance with the regulations in force in the country the machine is installed taking into account the various kinds of materials used.

14.3 - Mounting the jib on the crane

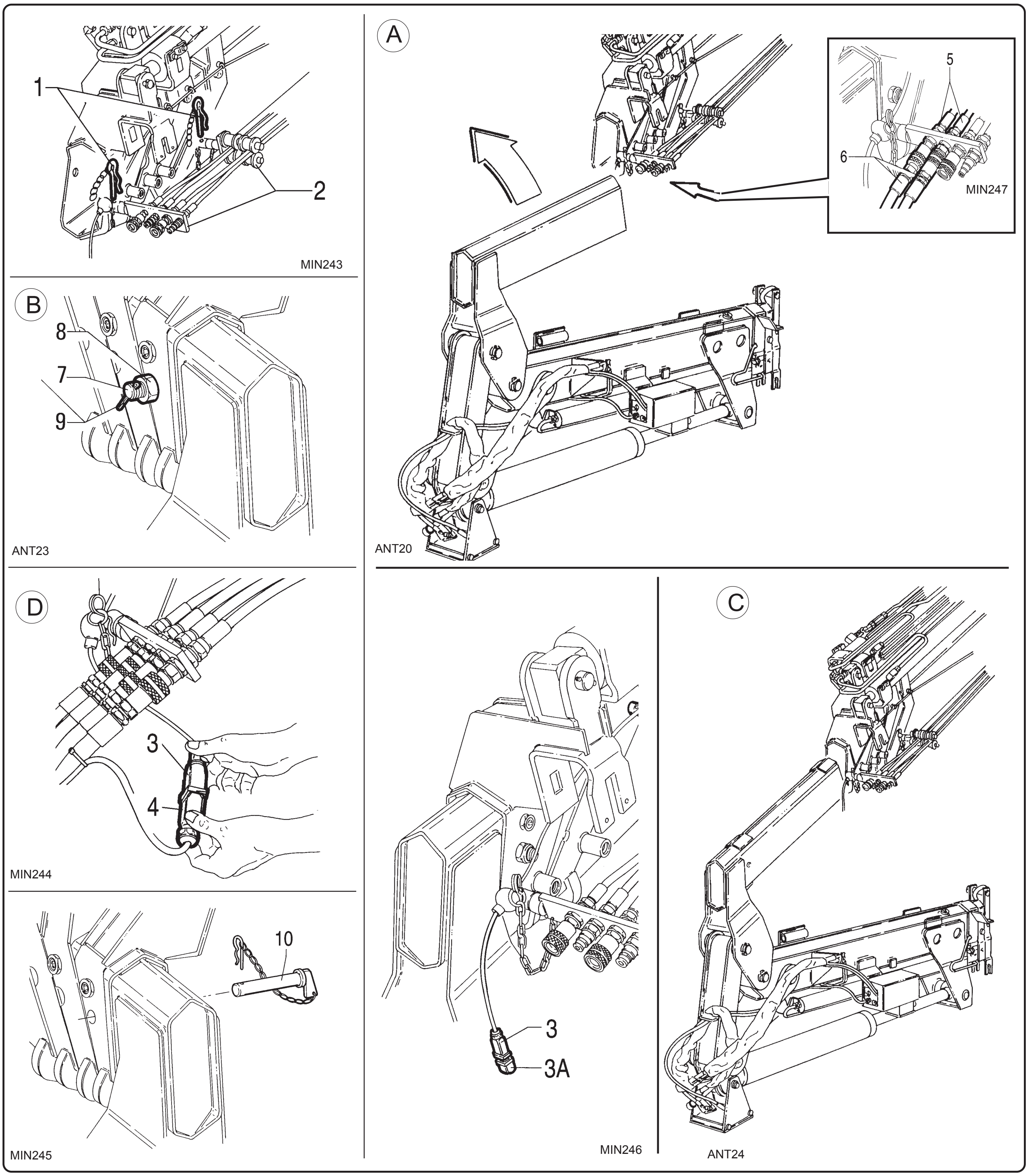


fig. 14.3.1

- Set up the vehicle as described in the crane's instructions and safety handbook.
- Open the crane as indicated in the handbook.
- If the crane has a hook coupling arm, you must dismount it.
- For the cranes with a piping reel for the hydraulic power supply, you will need to mount the supports "2" for the quick unions and the pipe guides (see fig.14.3.1) and lock them in place on the crane boom using the safety pin "1".
- Extend the crane boom by at least 1500 mm and align it with the jib coupling (see "A" fig.14.3.1).
- Connect the connector "3" with the connector "4" (fig. 14.3.1).
- Connect the quick unions for the rubber piping from the jib joint "6" cylinder to the respective unions on the crane boom "5", matching up the colours on the unions' protective caps (red with red, blue with blue).
- Use the joint cylinder opening control lever to align the jib's coupling arm with the crane's boom (see "A" fig. 14.3.1).
- Push the boom extension control lever extremely slowly so that you can slide the jib coupling into the crane's last boom (see "C" fig. 14.3.1).

ATTENTION!!!

This operation may be dangerous as if the jib joint is controlled incorrectly, it could result in damage to the crane and the jib.

- Once the stroke is complete, lock the jib into position on the crane with the pin "10" and the relative safety clip, or with the pin "7" and the nut "8" and the split pin "9", depending on the version.
- Connect the quick unions for the jib's hosing to the respective quick unions on the crane boom, matching up the colours on the unions' protections (red with red, blue with blue, yellow with yellow, green with green) - see fig. 14.3.2.
- Use the sliding blocks/lateral registers on the crane's last boom to align the jib perfectly with the crane's boom.
- The jib is now installed and therefore you must try out a few manoeuvres with the crane unloaded to bleed the hydraulic system and then move over to the selected work area.

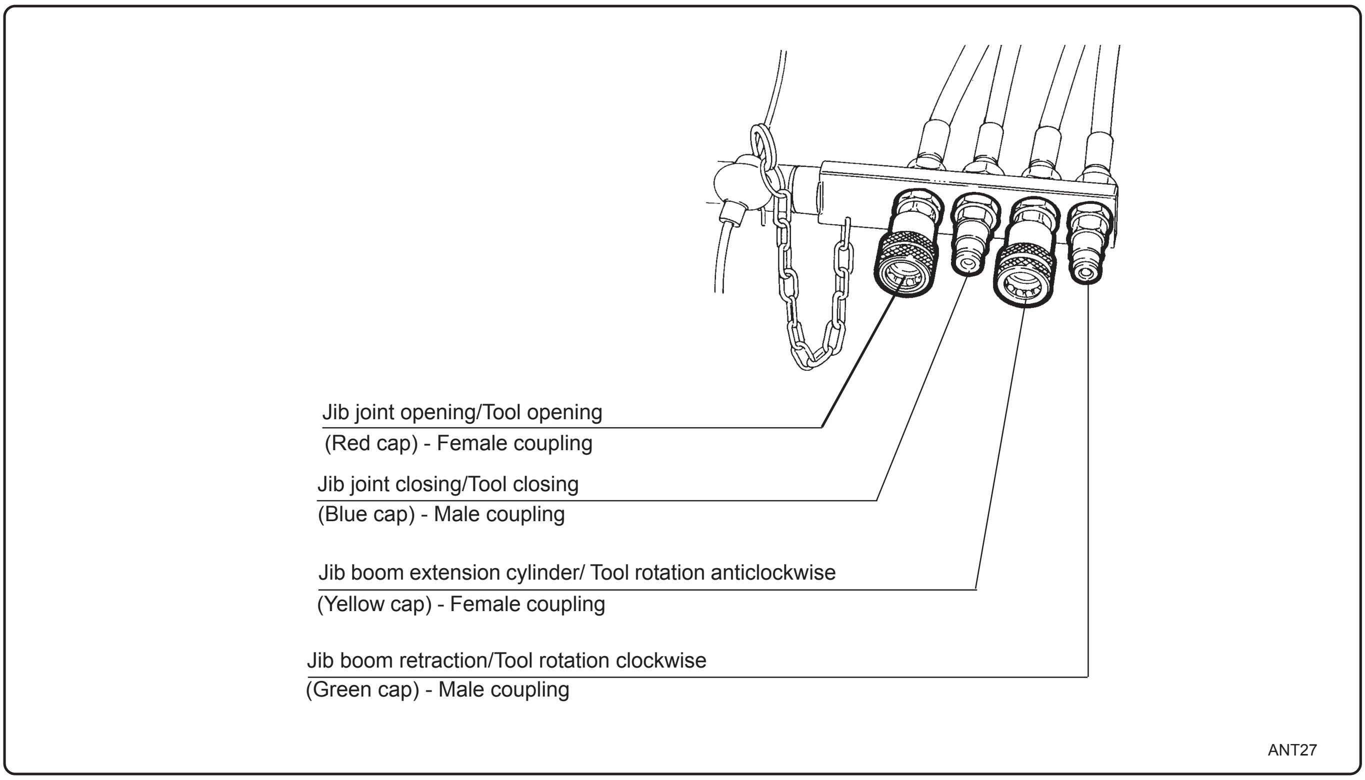

Jib joint opening/Tool opening
(Red cap) - Female coupling
Jib joint closing/Tool closing
(Blue cap) - Male coupling
Jib boom extension cylinder/ Tool rotation anticlockwise
(Yellow cap) - Female coupling
Jib boom retraction/Tool rotation clockwise
(Green cap) - Male coupling
ANT27

fig. 14.3.2

14.4 -Dismounting the jib

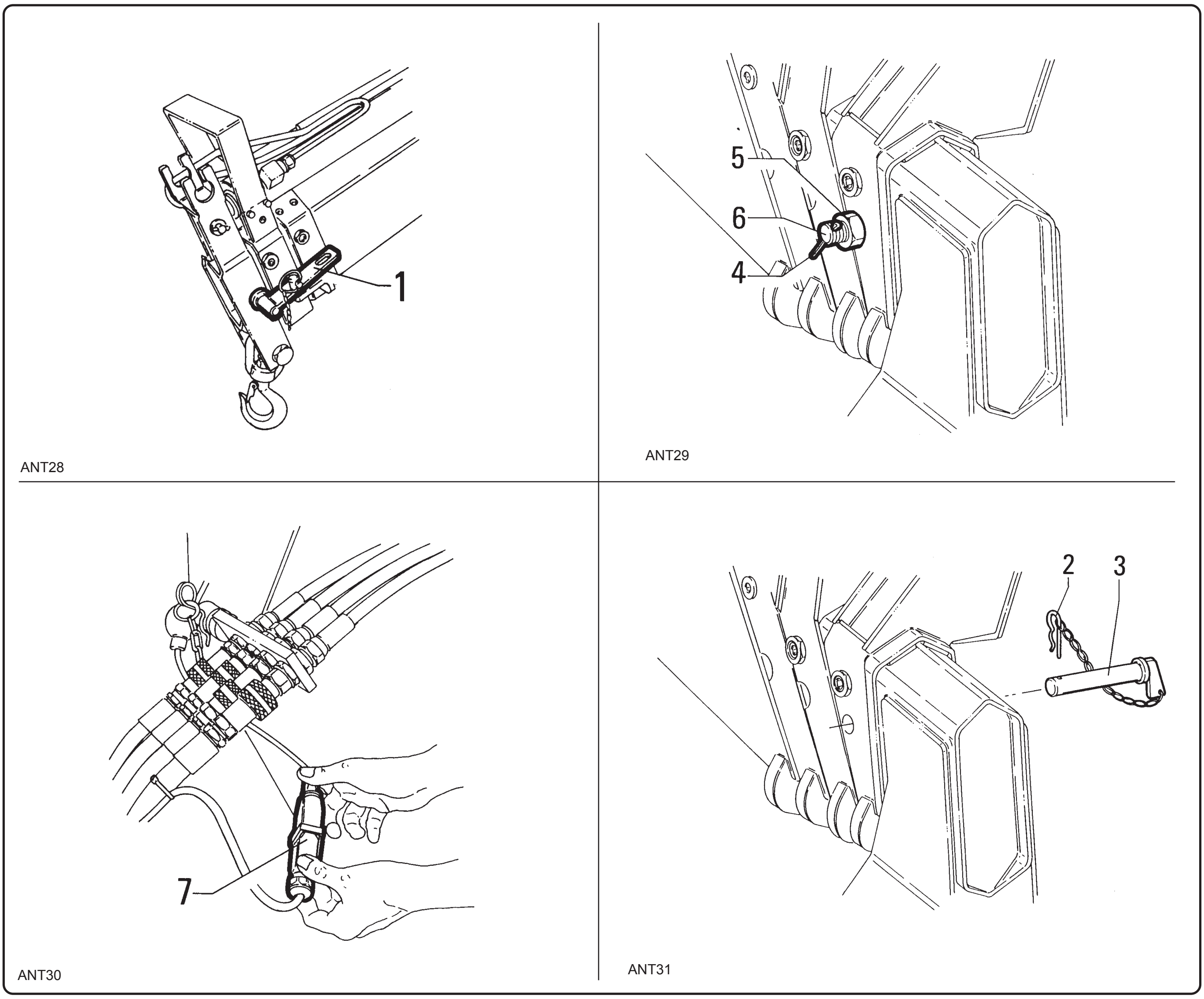


fig. 14.4.1

- Close the jib booms up fully.
- With the crane boom extended by at least 1500 mm, rest the jib on the ground (see fig. 14.3.1).
- Insert the safety pin “1”, if present.
- Stop the vehicle’s engine to make sure the hydraulic system is depressurised.
- Disconnect the quick unions for the jib’s hydraulic power supply line, taking care not to leave oil spills.
- Cover the union with the relative protective caps.
- Remove the split pin “4”, the nut “5” and the pin “6”.
- Start up the vehicle’s engine.

- Retract the crane’s boom pack gradually by approximately 200 mm to de-energise the microswitch on the crane’s hydraulic boom (if present).
- Disconnect the connector “7” (fig. 14.4.1) and connect it to the cap or, if present, the microswitch on the crane’s hydraulic boom.

Note

If the microswitch is not connected to the hydraulic boom, the crane will not work.

- When provided, install the hook coupling arm inside the crane’s last boom and lock it in position with the relative pin.
- The jib is now dismounted and therefore you must fasten it securely to stop it falling over sideways.
- If it is to be stored in an area which is open to the elements or it is not going to be used for long periods, protect/ grease the worked parts which will be exposed (pins, cylinder rods, etc.).

MENU

PRACTICAL TESTS BY THE INSTALLER

15.1 - General

- Chapter aim

Listed below are the tests and procedures to follow in order to ascertain conformity of the completed installation with the intended aims and envisaged load lifting capacity.

There is also an indication of the procedures and test loads for assessing the stability limits of the completed installation.

- Load lifting tests

These tests must include:
- static and stability tests;
- dynamic tests.

- Safety device tests

15.2 - Static and stability tests

All the tests performed on machinery must comply with the standard pr EN 12999.

For the purpose of simplification, the static and stability tests are carried out together, as the parameters (test loads, position, outreach) are identical.

The aim of the **static tests** is to prove the structural capacity of the lifting means and its components (counter-chassis, tie rods, etc.)
The tests are considered satisfactory if no lesion, permanent deformation, paint flaking or damage affecting the operation and safety of the lifting means is visible to the naked eye and if no connection has come loose or been damaged.

The aim of the **stability test** is to ascertain stability of the installation.
As required by ISO 4310 (hoisting means - codes and test methods) the installation is considered stable if it does not overturn.

In this case, the following criterion has been adopted for assessing installation.

General stability criterion

The installation is considered stable if the surface on which the base of the crane is resting does not exceed a 10% (6°) inclination and the parameters listed below (fig. 15.1.2, 15.1.3, 15.1.4, 15.1.5) for the various work areas are respected simultaneously.

A wheel is considered as resting on the ground if it does not rotate when pushed by hand.

If one wheel is braked, this criterion cannot be applied, so a visual test is required.

An outrigger is considered as resting on the ground when it exercises a certain pressure on the ground. This pressure can be assessed by exercising a lateral force with the hands at the end of the outrigger boom, which should not move.
The test load must be Pp =1,25P+0.1F.
Where P is the capacity specified by the manufacturer at a set outreach and F is the weight of the boom (suspended part) at the end (the values are extracted from the technical specification sheet of the crane).

The tests must be performed in the positions and configurations for which the stability is at the minimum value, within the specific working area.

If different loads are envisaged for different positions or working areas, the tests must be carried out to ascertain stability for a set series of positions.

The following is recommended as an indication:
- basic crane - stability test in maximum outreach position with relevant loads.
- Crane with manual extensions - a set of stability tests on the basic crane, as described above - a set of tests on the extension in maximum outreach position with relevant load.
- Crane with hydraulic jib - a set of stability tests on the basic crane, as described above - a set of tests on the jib in all positions (with relevant load), as shown in the capacities chart.

The test load must be applied gradually and statically, and kept at a maximum height of 100 mm from the ground.

In order to apply the test load gradually, it is advisable to raise the test load with a lower outreach, then put the machine in the rated configuration and extend the boom slowly until it reaches the required outreach. During these manoeuvres, check the stability parameters.

In order to apply the test load statically, perform the above manoeuvres at the machine's minimum speeds so as to prevent dynamic effects due to the velocity from affecting the test results.

When stability is not ensured, adjust the limiting devices to reduce the capacities or prevent access from the unstable area.

Re-calibrating and resealing the crane

During the static stability test on the installation carried out by the installer, it is necessary to overload the crane. To do this, switch off the limiting device which would prevent the possibility of overloading.
Operate the stopcock cock sealed by the crane manufacturer and normally mounted in the valve which blocks the moment at the input of the signal from the discharge valve (fig. 15.1.1).

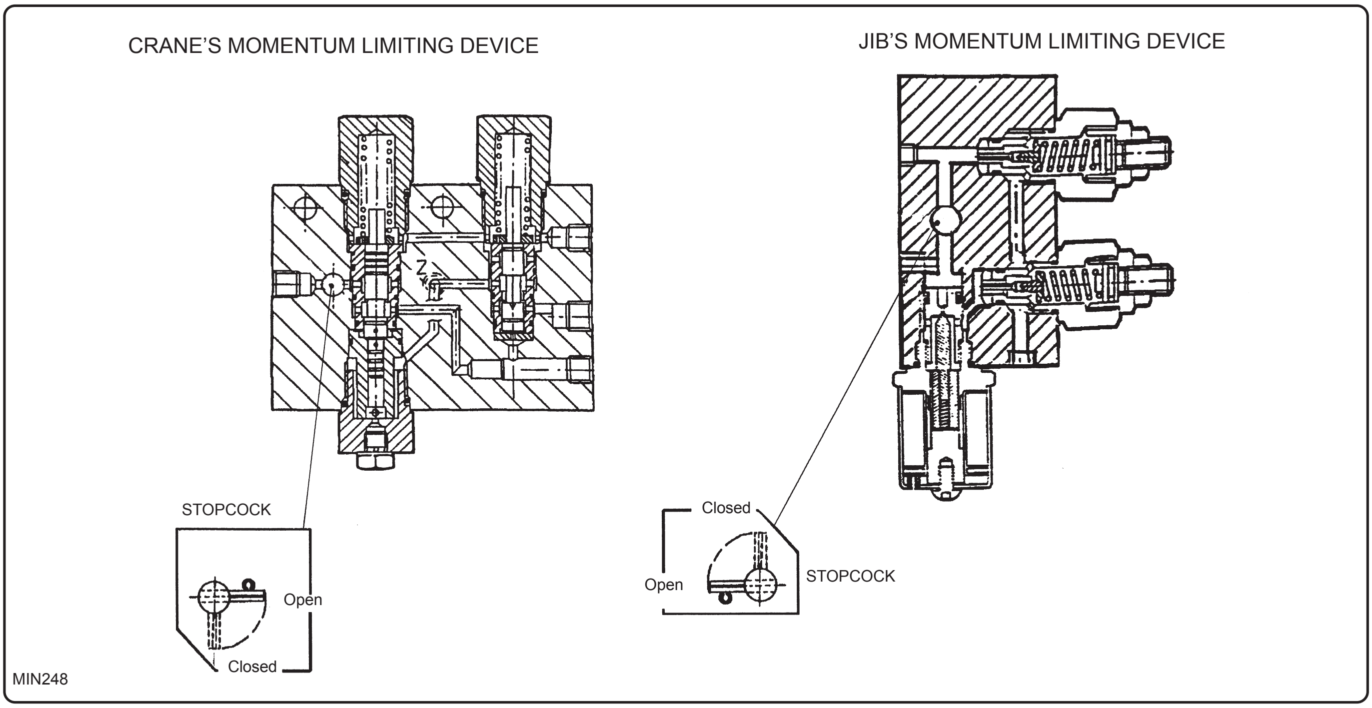


fig. 15.1.1

Overload must be reached by means of the extending booms. Apply the test load to the hook of the crane and lift it with the booms extended 50% (or fully retracted if you think stability may be critical), 100 mm from the ground. Then extend the booms slowly until you reach the test position.

If the stability is not sufficient, you must proceed by degrading the crane's functions, reducing the load capacities and delaying the momentum limiting device, as described in para. 7.4.5.

- Crane behind cab without supplementary outriggers

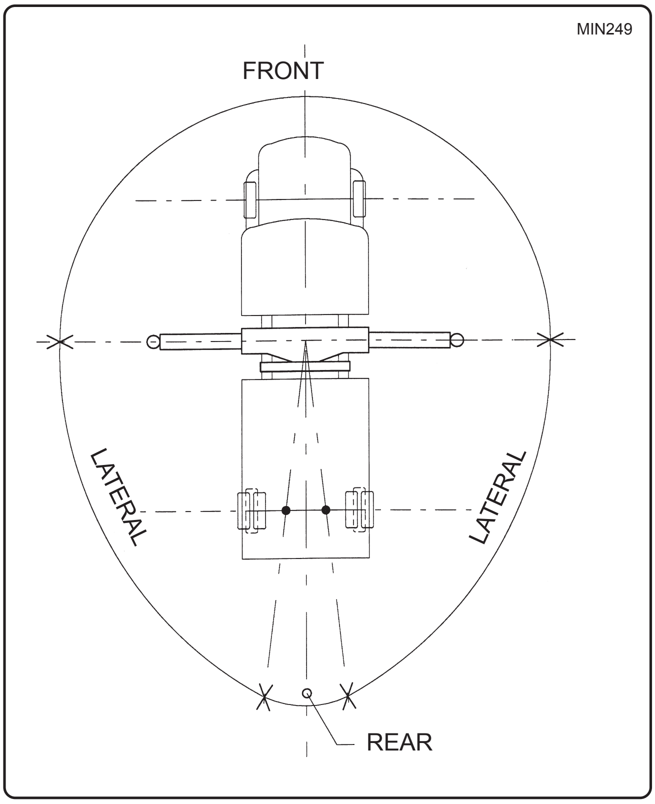


fig. 15.1.2

Front working area
- General stability criterion
- All wheels must rest on the ground

Lateral working area
- General stability criterion
- At least 3 wheels must rest on the ground

Rear working area
- General stability criterion
- All wheels must rest on the ground

- Crane behind cab with supplementary outriggers

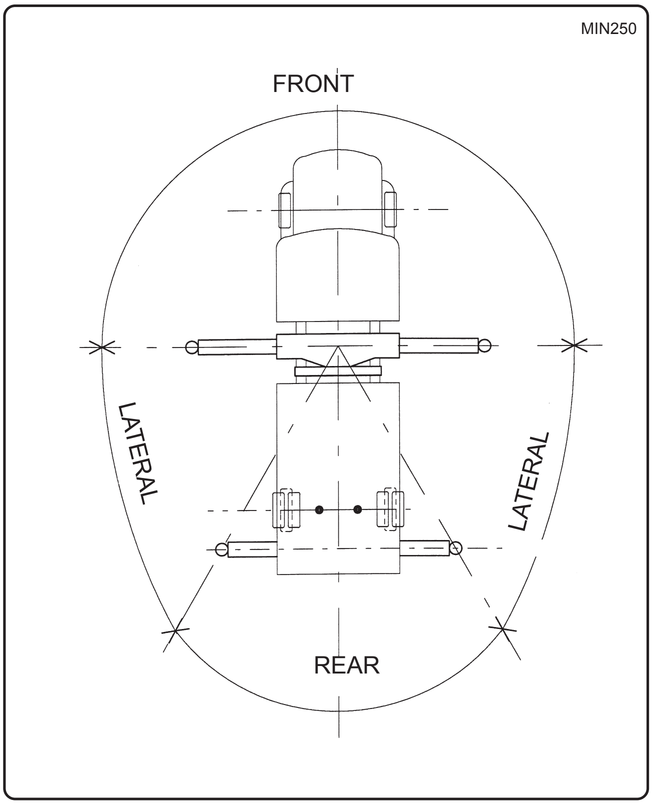


fig. 15.1.3

Front working area
- General stability criterion
- All wheels must rest on the ground
- All outriggers must rest on the ground

Lateral working area
- General stability criterion
- At least 3 outriggers must rest on the ground

Rear working area
- General stability criterion
- All wheels must rest on the ground
- At least 3 outriggers must rest on the ground

- ***Rear-mounted crane without supplementary outriggers***

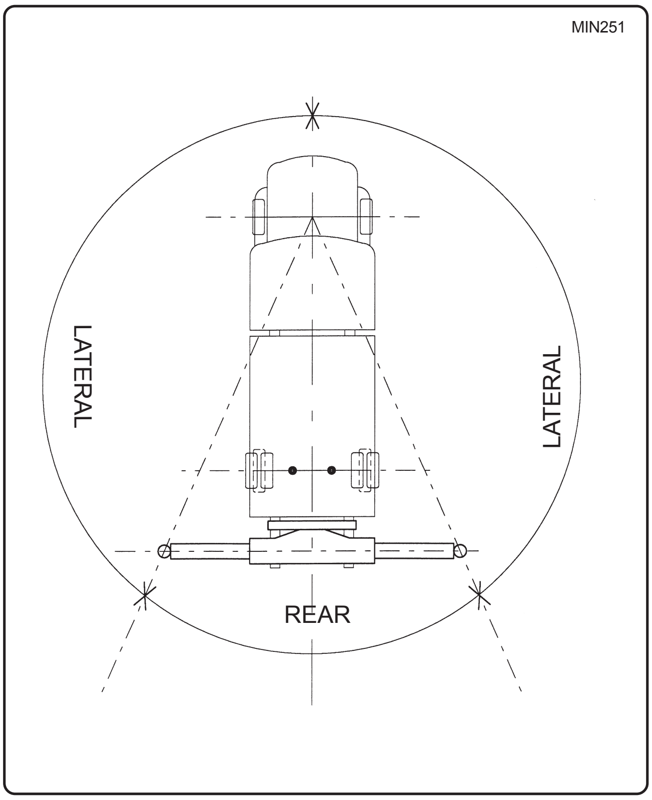


fig. 15.1.4

Front working area
- Not envisaged

Lateral working area
- General stability criterion
- All wheels must rest on the ground
- At least 3 outriggers must rest on the ground

Rear working area
- General stability criterion
- All wheels must rest on the ground
- At least one outrigger must rest on the ground

- ***Rear-mounted crane with supplementary outriggers***

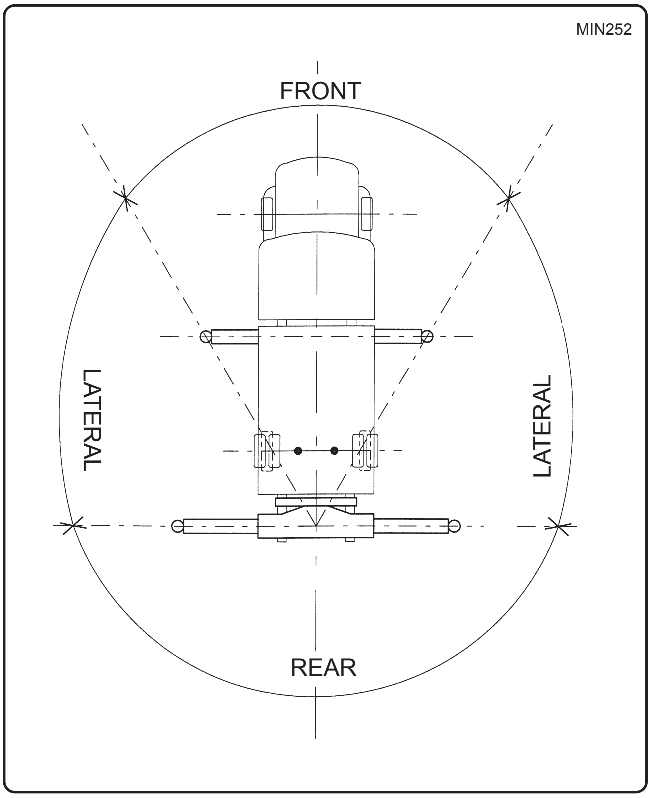


fig. 15.1.5

Front working area
- General stability criterion
- All wheels must rest on the ground
- At least 3 outriggers must rest on the ground

Lateral working area
- General stability criterion
- All wheels must rest on the ground
- At least 3 outriggers must rest on the ground

Rear working area
- General stability criterion
- All wheels must rest on the ground
- At least 3 outriggers must rest on the ground

15.3 - Dynamic tests

The main aim of the dynamic tests is to see whether the mechanisms of the lifting means work.

The test results are considered satisfactory if all the components involved are able to carry out their functions and if a visual inspection after the test has not highlighted any damage to the structural mechanisms and no connection has come loose or been damaged.

During the test, the lifting means must be controlled as shown in the instructions in the handbook. The acceleration, deceleration and speed must be limited to those normally used by the lifting means.

The dynamic tests must be performed separately for each movement of the lifting means, and if necessary with simultaneous movements, in all the positions and configurations shown on the capacity chart.

The tests must include repeated stops and starts for each movement and for the entire movement itself, and must be continued for at least an hour.

The tests must include lifting of the test weight applied by raising the load and then stopping movement for long enough time to enable the dynamic effects to be dampened. Then operate the lift control again and check that the load is immediately and really raised.

The test load should be 1.1 P, where P is the capacity granted by the manufacturer at a certain outreach.

15.4 - Safety devices

Testing the safety devices serves to assess whether they are in working order.

The installer should test the devices installed on the crane by simulating the conditions in which they will actually be activated.

This handbook contains a list of the safety devices installed on the crane and a description of their function.

15.5 - Tests report

For the technical records, a report must be drawn up on completion of the above tests, setting out the conclusions and test results.

The test report must include the identification data of the lifting means tested, together with the test location and the name of the test supervisor.

It must include details as regards the loads, positions, configurations, procedures and results in each case.

An example is given in annex 3 of chap. 20.

15.6 - Test conditions

The lifting means must be placed on a hard horizontal surface (±0,5%=0,3°).

The wind speed during the test must not exceed 8,3 m/second (30 km/h).

The crane must be stabilised, with the outriggers fully extended and levelled and so that the base is horizontal (±0,5%=0,3°).

The outriggers should lift the crane-vehicle unit sufficiently to release the vehicle suspensions with the wheels still in contact with the ground.

The vehicle body must be empty and the fuel tank must be at least one third full.

MENU

CHECKING MAXIMUM MASS ON AXLES AND OVERALL DIMENSIONS

16.1 - Checking the max. mass on axles

In chapter 3 all the crane/vehicle configurations were analysed to determine the axle loads. It is now important to check that mass distribution is correct.

This check consists of a simple test, on completion of the installation, of the direct weight on the overall vehicle empty (fig. 16.1.1) and on the individual axles (fig. 16.1.2).

This involves the tare weight of the vehicle chassis, the crane and any additional outrigger cross member, and the body mass.

The only calculation required is distribution of the actual load on the axles, using the formulas highlighted in chapter 3.

By comparing these values with the test results, you can ascertain whether the result is less than the masses recommended by the vehicle manufacturer (fig. 16.1.3).

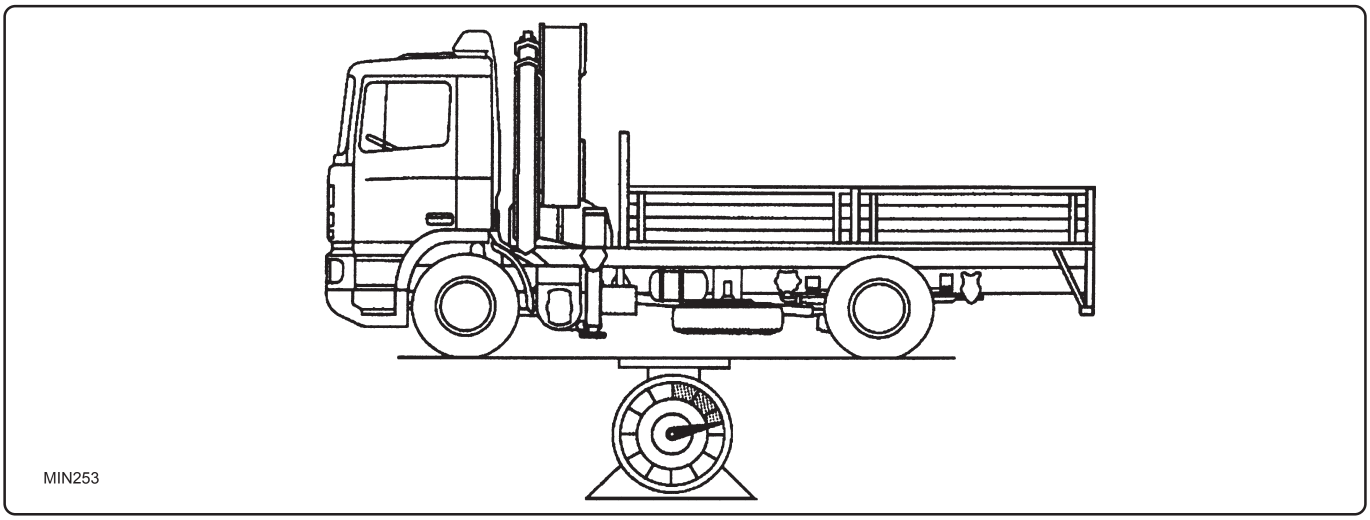


fig. 16.1.1

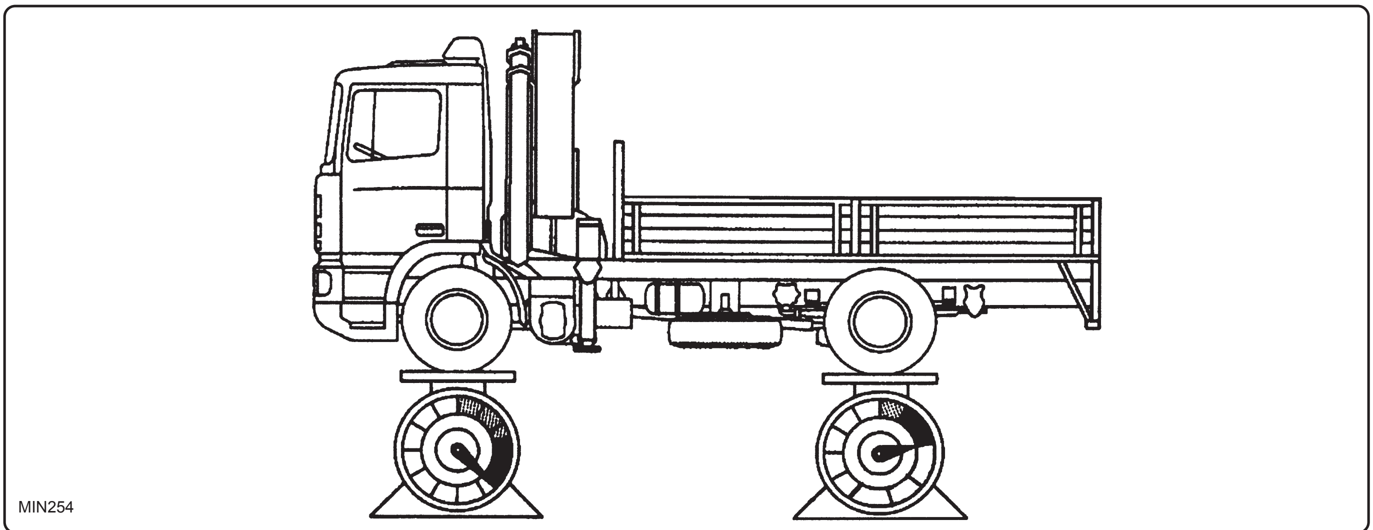


fig. 16.1.2

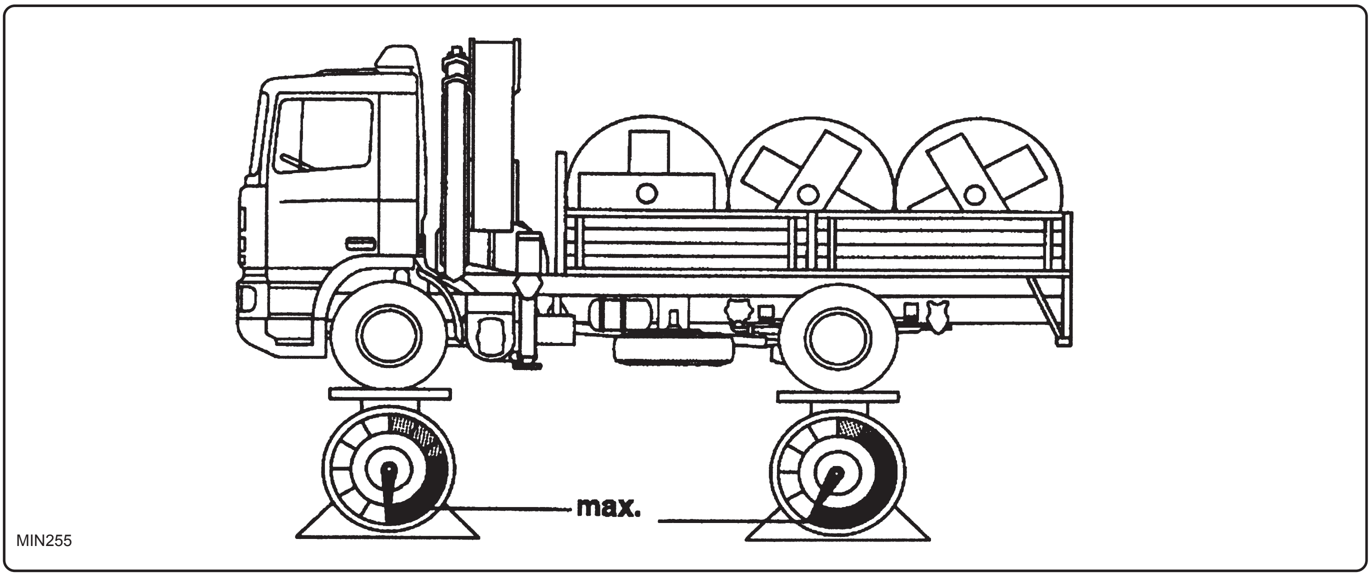


fig. 16.1.3

16.2 - Overall dimensions

Once the installation is complete, the overall dimensions must be checked to ensure the profile of the vehicle-crane combination falls within the limits set for road traffic (fig. 16.2.1).

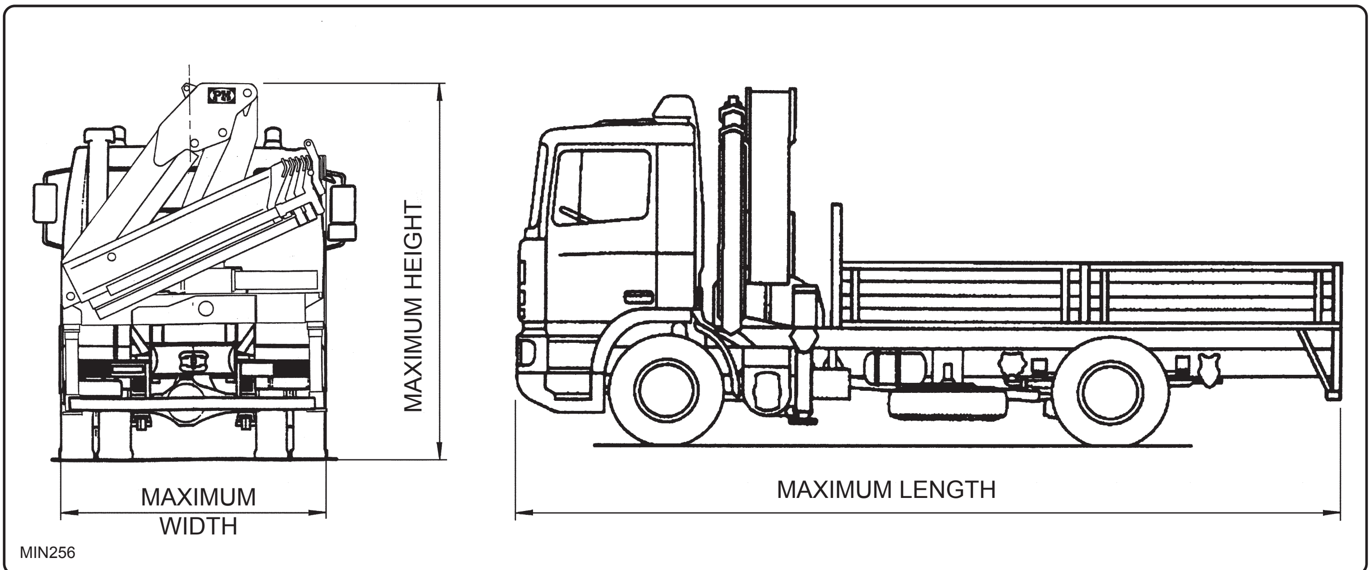


fig. 16.2.1

Note

If the crane's boom has to be rested on the vehicle body or the load, you must install a red signal light in the cab, in a clearly visible position, to warn the driver if the boom is lowered below the angle envisaged to remain below the maximum height.

MENU

LIST OF HAZARDS

17.1 - List of hazards

During all the various operations involved in mounting the crane on the vehicle, the installer must check very carefully that the hazards the operator could encounter when using the machine are prevented or reduced to a minimum.

This check must be carried out using the list of hazards given in the final draft of the standard prEN 12999, which is specific to cranes mounted on trucks (annex 1).

For each item mentioned the installer must check for the potential hazard on the part of the installation carried out and describe how he has prevented or minimised the said hazard risk (and the reference for the standard adopted).

If the hazard risk has not been prevented fully, the operator must be informed of the residual risk.

These instructions/warnings must outline the procedures and operation methods required to overcome the hazard risks and they should indicate whether special training or safety gear is necessary.

The risk analysis report/prospectus, carried out by the installer, must be kept inside the equipment's technical file.

Later on (annex 2) you will find an approximate (incomplete) draft of a prospectus for the analysis of the risks/hazards relating to a general crane-vehicle combination.

- Annex n° 1 (for information only)

LIST OF HAZARDS

Table 1 contains a list of the potential hazards and dangerous situations which could result in injury during normal use of the machine and in envisaged cases of improper use of the machine.

It also contains the cross- references to certain parts of EN 292 and the parts of this standard that must be complied with to reduce or prevent hazard risks.

LIST OF HAZARD	***Annex A to EN 292-2: 1991/A1: 1995***	***Paragraphs relating to the standard pr EN 12999***
1. -Mechanical hazard caused by the crane and its parts: e) insufficient mechanical resistance.	1.3, 1.4 4.1.2.3/4/5, 4.2.1.4	5.1, 5.2, 5.3, 5.5.1, 5.5.4, 5.5.5, 5.5.8, 5.5.9, 5.8.2.1, 5.8.2.2, 5.10.2.1, 5.10.2, 7.2.3.7
1.1 -Crushing hazard	1.3, 1.3.4, 1.3.7	5.8.1, 5.8.2.2, 5.8.2.3, 5.10.2.3
1.2 -Shearing hazard		
1.3 -Cutting or severing hazard		
1.4 -Entanglement hazard		
1.5 -Drawing-in or trapping hazard		
1.6 -Impact hazard		
1.7 -Stabbing or abrasion hazard		
1.8 -Friction or abrasion hazard		
1.9 -High pressure fluid ejection	1.3.2	5.5.1, 5.5.5, 5.10.7, 7.2.3.5, 7.2.4.2
1.10 -Ejection of parts	1.3.3	5.4.1.1, 5.4.1.2, 5.4.2, 5.4.3
1.11 -Loss of stability	1.5.4	5.6.1, 5.6.2, 5.6.4, 5.6.5, 5.6.6.2, 5.10.3
1.12 -Slip, trip, fall hazard	1.6.2, 4.2.3	5.8.2.2, 5.8.2.3, 5.8.2.4, 5.10.8
2. -Electrical hazard caused by:		
2.1 -Electrical contact between persons and live parts (direct contact)	1.5.1, 1.6.3	5.6.31.3, 5.9, 5.10.6, 7.2.3.1d)
2.2 - Electrical contact between live parts as a result of a fault (indirect contact)	1.5.1	
2.3 -Proximity with live parts	1.5.1, 1.6.3	
2.4 -Electrostatic phenomena	1.5.2	
2.5 -Thermal radiation or other phenomena such as fused particles and the chemical effects of short-circuits, overloads etc.	1.5.1, 1.5.5	

LIST OF HAZARDS	***Annex A to EN 292-2: 1991/A1: 1995***	***Paragraphs relating to this standard***
3. -Thermal hazards:		
3.1 -Burns and scalding to people, caused by a contact with flames orexplosions or heat source radiation	1.5.5, 1.5.6, 1.5.7	5.5.5, 5.10.2.3, 7.2.4.1
3.2 -Damaging effects on the personnel's health due to excessively hot or cold working environments	1.5.5	7.2.3.7
4. -Hazard generated by noise.	1.5.8	5.10.4
5. -Hazard generated by vibration.	1.5.9	5.10.5
7. - Hazard generated by materials or substances worked, used or discharged by the machine		5.10.2.3
7.1 -Hazard resulting from contact with or inhalation of harmful substances (gases, mists, fumes, powders).	1.1.3, 1.5.13, 1.6.5	7.2.4.1
8. -Hazard generated by ergonomic principles being neglected in the machine's design (failure to design the machine to suit the features and capacities of the human body) caused by, for example:		
8.1 - Unhealthy postures or excessive efforts.	1.1.2d), 2.2	5.7, 5.8
8.2 - Inadequate consideration of human anatomy (hand/arm/foot/leg).	1.1.2d, 2.2	5.7, 5.8
8.3 -Negligent use of personal protection equipment	1.1.2e)	7.2.4.1
8.4 -Inadequate area lighting	1.1.4	5.8.1, 7.2.4.1, 7.2.3.6d)
8.6 -Human error	1.1.2d), 1.2.2, 1.2.5, 1.2.8, 1.5.4, 1.7	5.6, 5.7.1, 5.7.2, 7.2.37.2.4
8.7 -Unsuitable design regarding manual controls position and ease-of-identification	1.2.2	5.4.1.2. 5.4.3, 5.7, 5.8
8.8 -Unsuitable design or position of indicators	1.7.1	
9. -Combined hazards		5.2.3, 5.2.4
10. -Unexpected start-up, unexpected stroke overrun /unexpected excess speed (or other similar faults) caused by:		
10.1 - Control system failure or malfunction	1.2.6, 1.6.3	5.5.6.1, 5.5.6.2, 5.5.7, 5.6.6, 5.6.8, 5.7.1

LIST OF HAZARDS	*Annex A to EN 292-2: 1991/A1: 1995*	*Paragraphsrelating to this standard*
11. -Hazard caused by (temporarily) missing and/or incorrectly positioned safety measures		
11.1 -All kind of guards	1.2.5, 1.4.2.2, 1.4.3	5.5.5, 5.7.1, 5.8.2.2, 5.8.2.3, 5.10.2.3
11.2 -All kind of safety-related devices	1.2.5, 1.4.2.2, 1.4.3	5.4.1, 5.4.3, 5.6.3, 5.6.6, 5.6.7
11.3 -Safety signs and signals.	1.7.1, 1.7.2	5.4.1.2, 5.6.7, 5.7.2, 7.2.3.5, 7.3.4, 7.3.5
11.4. -All kinds of information or warning devices	1.7.0, 1.7.1	5.6.1, 5.6.2, 5.6.4, 5.6.7, 7.1, 7.2, 7.3
11.5 - Visibility	3.2.1, 4.1.2.7	5.4.3, 5.8.1, 7.3.4.1
11.6 -Emergency devices	1.2.4	5.6.3, 5.6.8
15 -Assembly errors	1.5.4	7.2.2, 7.2.4
18 -Unexpected loss of stability or machine overturns	1.3.1	5.4.1, 5.6.1, 5.6.2, 5.6.4, 5.6.5, 5.6.6, 5.10.3

- Additional hazards and dangerous situations caused by hoisting operations

LIST OF HAZARDS	*Annex A to EN 292-2: 1991/A1: 1995*	*Paragraphs releting to this standard*
27. -Mechanical hazards and dangerous situations		
27.1 -Caused by the load falling, collisions, the machine overturning due to:		
27.1.1 -Lack of stability	4.1.2.1	5.10.3, 6.2.5
27.1.2 -Uncontrolled load - overload - overturn limit exceeded	4.2.1.4, 4.3.3, 4.4.2a)	5.5.4, 5.6.1, 5.6.2, 5.6.3, 5.6.4, 5.6.5
27.1.3 -Range of movements	4.1.2.6a), 4.2.1.3	5.6.6
27.1.4 -Unexpected load movements	4.1.2.6c)	5.5.6, 5.5.7, 5.5.8
27.1.5 -Unsuitable clamping devices / accessories	4.1.2.6e), 4.4.1	5.4.2, 7.2.3.6
27.2 -Persons on the load support	4.3.3	1, 7.2.3.1e)
27.4 - Insufficient mechanical resistance of parts	4.1.2.3	5.1, 5.2, 5.3, 5.5.8, 5.5.9, 5.10.2
27.8 -Abnormal assembly / testing / use / maintenance conditions	4.4.1, 4.4.2d)	5.10, 7.1, 7.2, 7.3
29 -Hazards caused by failure to observe ergonomic principles		
29.1 -Inadequate visibility at driver operator's position	4.1.2.7, 4.4.2c)	5.8.1

- Annex n° 2 (for information only)

Type of hazard	Description of potential hazard	Solutions adopted	Reference standard adopted
1 - Mechanical hazards caused by the insufficient mechanical resistance of the crane's part	- Mechanical breakages in the counter-chassisor the parts connecting the chassis/counter-chassis as a result of incorrect sizing - Mechanical breakages in the supplementary outrigger cross beam due to mismatched supplementary outriggers/crane	- The counter-chassisand the parts connecting the chassis/counter chassis have been designed to meet the safety coefficients prescribed - Once the installation is complete and before the machine is handed over to the end client the relative practical load tests are performed (see chapter 15) - The supplementary outriggers and the relative connecting parts have been selected and co-ordinated on the basis of the manufacturer's instructions given in the crane handbook - Once the installation is complete and before it is handed over to the end client the relative practical load tests are performed (see chapter 15)	The counter-chassis and the connecting parts have been sized in compliance with the standard prEN 12999
1.1 - Shearing hazards 1.2 - Crushing hazards	- Parts of the operator's body may be crushed during the crane opening/closing manoeuvres - Parts of the operator's body may be crushed during the hydraulic outrigger boom opening/closing manoeuvres	- The crane's moving parts and the other equipment (inside the operator's working range) have been spaced to ensure this risk is prevented (e.g. the space between the crane and the vehicle body) - The outrigger booms' moving parts (inside the operator' s working range) have been suitably spaced to ensure this risk is prevented. The outrigger (closure) stroke limit blocks are installed inside the outrigger and are therefore inaccessible to the operator.	The spaces/ distances adopted are as indicated in standard EN 349
1.3 - Cutting or severing hazards	- Parts of the operator's body may be cut or severed during the crane opening/closing manoeuvres and during the hydraulic outrigger boom opening/closing manoeuvres	- The crane's moving parts, the outriggers and the other equipment (inside the operator's working range) have been chamfered and rounded to prevent these risks (e.g. the vehicle body's side members)	
1.4 - Entanglement hazards 1.5 - Drawing-in or trapping hazards	- The operator's clothes may become tangled or be drawn into the machine during the crane opening/closing manoeuvres and during the hydraulic outrigger boom opening/closing manoeuvres	- In the design and production phases all the precautions/ measures regarding the moving parts have been taken (protruding parts removed, guards put on the rotary parts) - The handbook clearly states the kind of clothing (approved accident-prevention gear) that the operators should wear when operating the machine	

1.9 - High pressure fluid ejection hazards	- The operator may be injured as a result of the high-pressure fluid piping breaking/ exploding	- Hydraulic components with suitable safety coefficients are used to complement the hydraulic system (rigid/flexible piping and unions for connecting the pump to the crane and supplementary outriggers distributor) - The hosing located within a one-metre radius of the operator and which contains high pressure fluid has been fitted with an external protective sheath	The hydraulic components used comply with the standards EN982 and prEN 12999
1.11 - Hazards due to loss of stability of the crane-vehicle combination	- The operator may be injured as a result of the crane-vehicle combination becoming unstable (the vehicle tipping over/ overturning) said condition being caused by a mismatched crane-vehicle combination	- The crane-vehicle combination is designed on the basis of the manufacturer's instructions given in the crane handbook - Once the installation is complete and before it is handed over to the end client, the relative practical load tests are performed (see chapter 15)	
3.1 - Risk of burns and scalding to persons, caused by contact with flames or explosions or heat source radiation	- The operator may be injured by accidentally touching the end of the vehicle's vertical exhaust pipe - The operator may be injured by accidentally touching the hot parts of the hydraulic system	- A special anti-burns device has been installed on the vertical exhaust pipe near the operator's control post - The machine's hydraulic system has been tested to make sure that temperature does not exceed dangerous levels for the operator as a consequence of intensive use (max 60 ° C) however, a suitable heat exchanger has been installed to lower this temperature further	
4 - Hazards generated by noise	- The operator may be injured by the noise of the vehicle's engine running constantly	- The noise pollution levels generated by the vehicle's engine have been checked to ensure they fall within the admissible limits when the machine is in use.	
7.1 - Hazards resulting from inhalation of harmful substances (gases, mists, fumes, powders)	- The operator may be injured by inhaling the vehicle's exhaust fumes	- A special flexible extension cable has been installed on the exhaust pipe near the operator's control post in order to divert the fumes away from the operator.	
8.1 - Hazards relating to unhealthy postures or excessive efforts	The operator may be injured by working with incorrectly positioned controls (too high for the operator's height)	- Suitable stools and foot panels have been installed to enable the operator to work in the best position possible and to have full access to the controls	The stools/foot panels and their access areas are built in compliance with the standard prEN 12999
29.1 - Hazards due to inadequate visibility at driver/operator's point	Objects may be damaged as a result of collisions with the machine due to the operator's poor visibility over the work area (vehicle's body side members too high and block view).	- An additional control and manoeuvring post has been installed (above the machine's base) to ensure the operator has a perfect visibility over the machine's work area	The access footboards and footrest of the new manoeuvre site have been executed in accordance with the standard prEN 12999

MENU

WARNING, DANGER AND INSTRUCTION PLATES

18.1- Plates supplied with the crane

Plates provided with the crane: see the operator’s handbook for the specific model showing the position and application conditions.

Before delivering the crane to the customer, the installer must assess whether all the plates have been positioned correctly on the crane.

18.2 - Adhesive plates

For production reasons, Autogru PM delivers all the machines with the adhesive plates in italian and encloses an adhesive sheet with the accessories kit bearing the translations of the texts found on the plates in the language of the country where the machine is due to be installed (ex. fig. 18.12.1).
Once the installation is complete it is the installer’s responsibility to apply the plates bearing the translation on top of the corresponding italian text.

ATTENTION!!!

Before applying the adhesives, clean the surfaces of the plates already on the machine using suitable detergents (do not use solvents or varnish removers, as they will remove the printing from the plates).

ATTENTION!!!

When applying the adhesives, take care not to cover the figures.

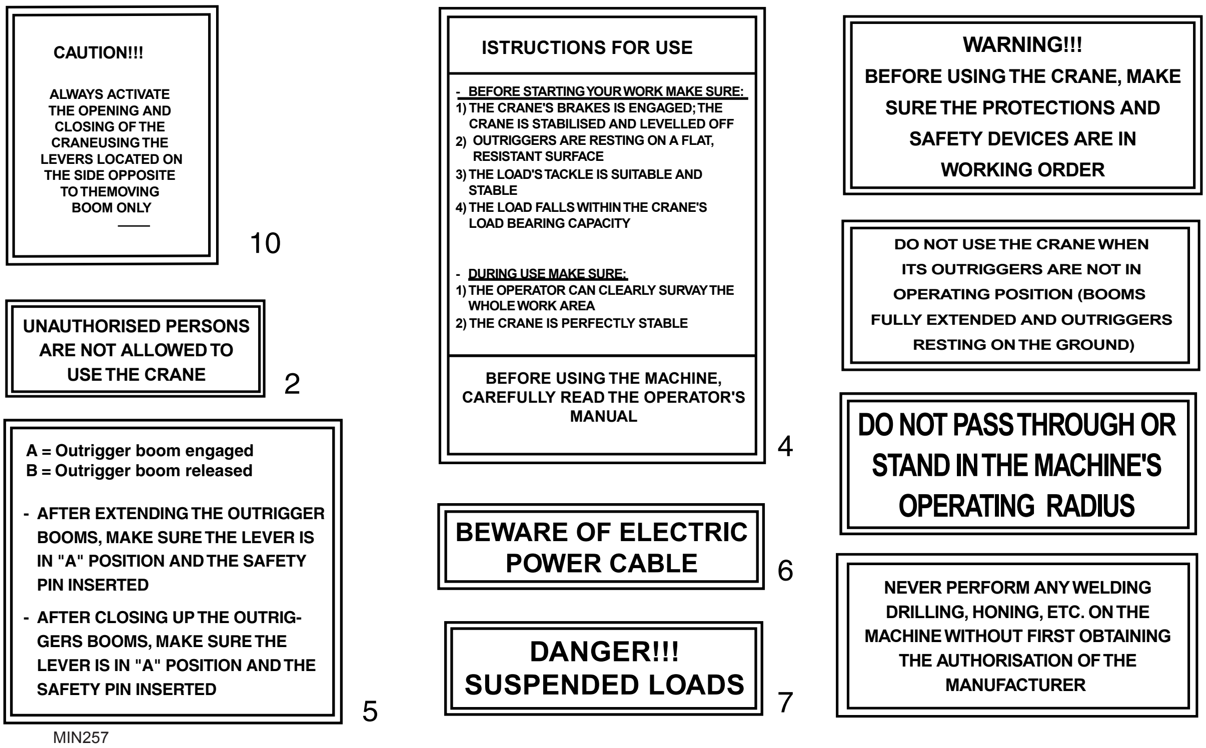


fig. 18.2.1

When matching up the translated texts with the Italian, refer to the figures below.

To facilitate this job still further, we have given each plate a number, so the installer simply has to match up the numbers.

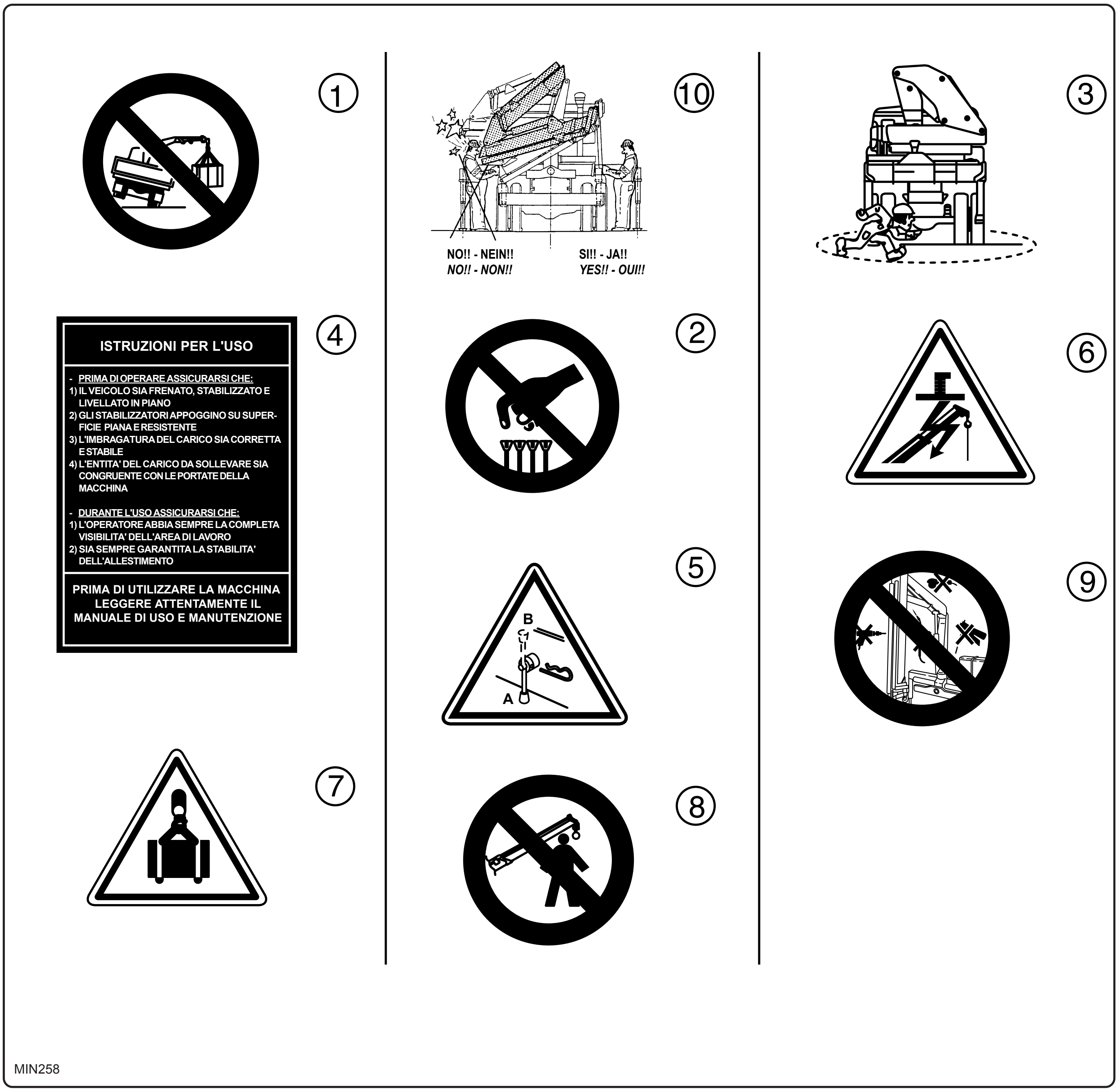


fig. 18.2.2

18.3 - Plates for the crane-vehicle combination

The plates concerning the crane/vehicle combination must be prepared and applied by the installer of the complete unit, depending on the potential hazards analysis carried out (see para. 17).

When preparing the plates, refer to the instructions concerning shape, design, colour and dimensions set forth in recognised standards (for istance: ISO 3864-84, UNI 7543, ISO 7000,etc..).

MENU

SPECIAL CASES

Contact the Autogru PM'S engineering department for all special cases not contemplated in this handbook.

19.1 - Installing the crane with a side column (see fig. 19.1.1)

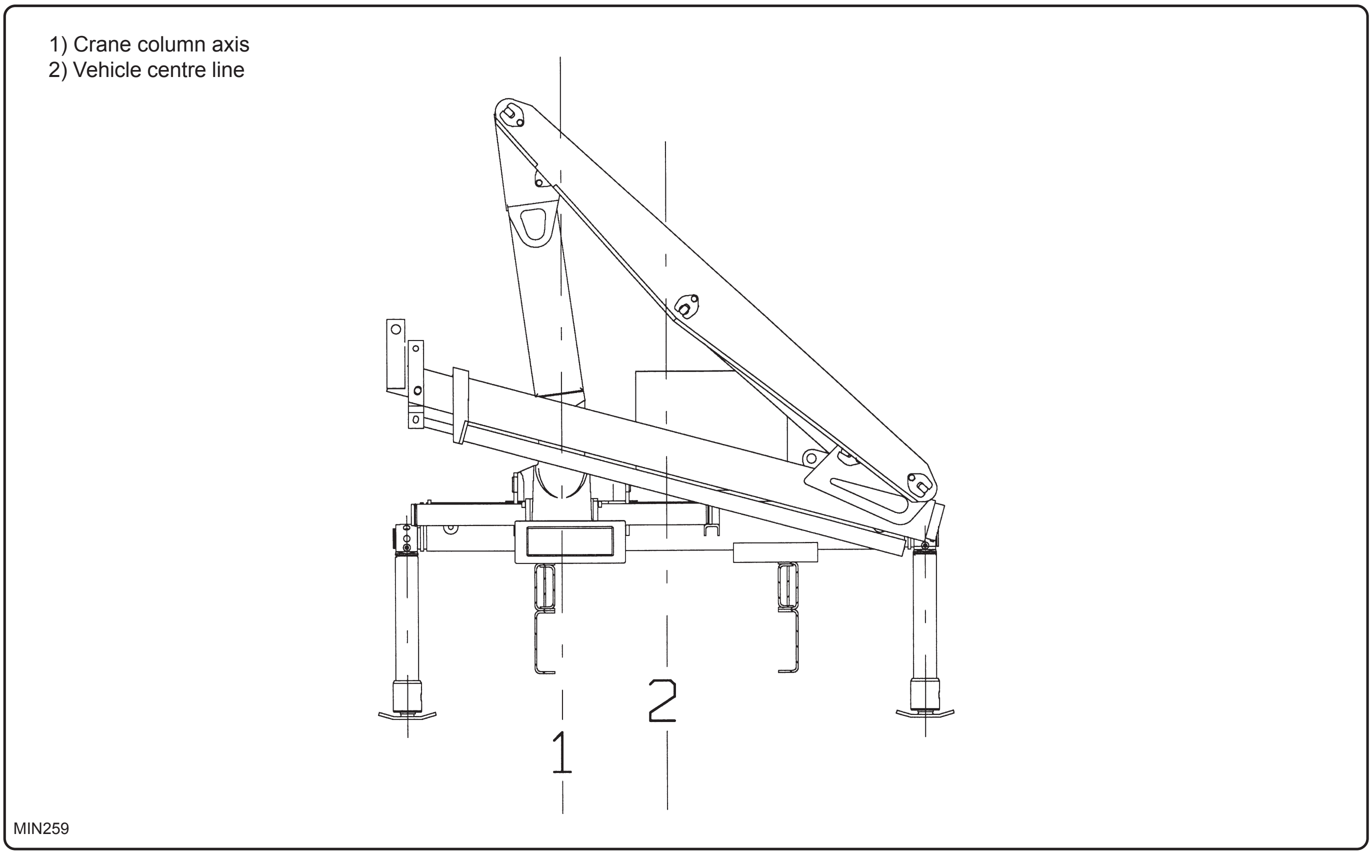


fig. 19.1.1

In the case of installations of this kind, it is very important to remember that all the stress generated by the crane is exerted on the side members of the chassis/counter-chassis on the column side as the column is offset on this side.

For this reason, always calculate the cross-section of the counter-chassis using the method described in chapter 4 (paragraph 4.1) and link the two side members of the chassis/counter-chassis unit (see fig. 19.1.2) by placing a cross member (whose section is the same as the counter-chassis and which is made of the same material) in the space between the crane's equaliser and the cross beam.

By taking this precaution, it is possible to distribute the stress generated by the crane in use over both side members of the vehicle's chassis/counter-chassis, contribute to maintaining the stability of the crane and, above all, safeguard the chassis integrity.

1) Linking cross member
2) Counter-chassis
3) Chassis

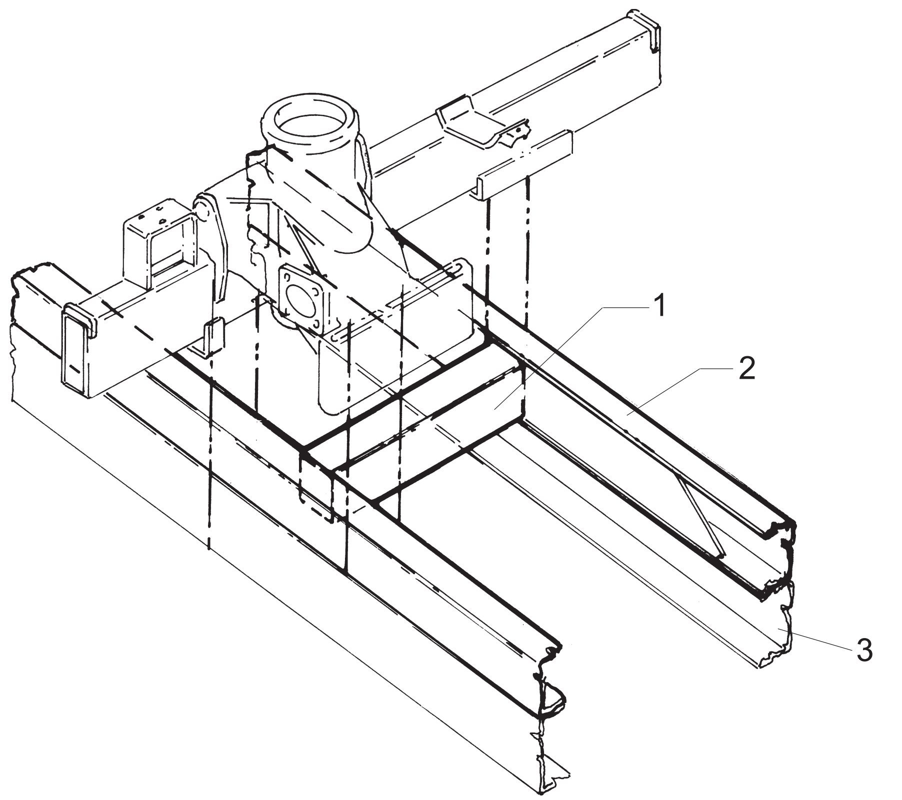


fig. 19.1.2

19.2 - Installing the crane on vehicles with a unitised body (see fig. 19.2.1)

In the case of cranes mounted on vehicles featuring a unitised body (double omega type side members), apart from following the general instructions in chapters 3 and 4, you must also have the vehicle chassis appropriately stiffened.

In fact, this kind of vehicle features a chassis made of thick pressed sheet metal that cannot withstand the stress generated by the crane (fig. 19.2.1).

In compliance with the dispositions provided by the different manufacturers of the vehicles, we recommend the following arrangements:

a) provide a single unit counter-chassis capable of absorbing the entire stress of the crane, for the purpose of releasing the vehicle from the latter.

b) Stiffen the parts of the vehicle to which the crane fixing tie rods are fitted by means of vertical shims in hard wood or similar materials, or by means of vertical webs, for the purpose of preventing the vehicle from getting crushed during the closing phase (fig. 19.2.2).

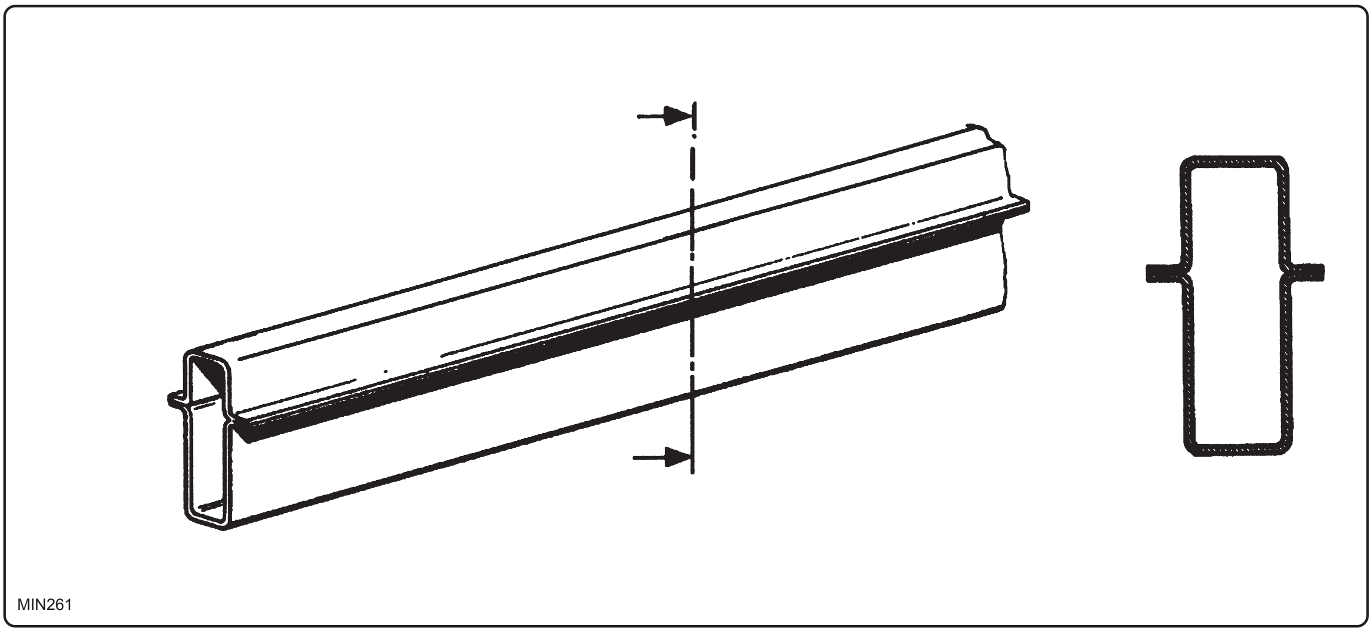
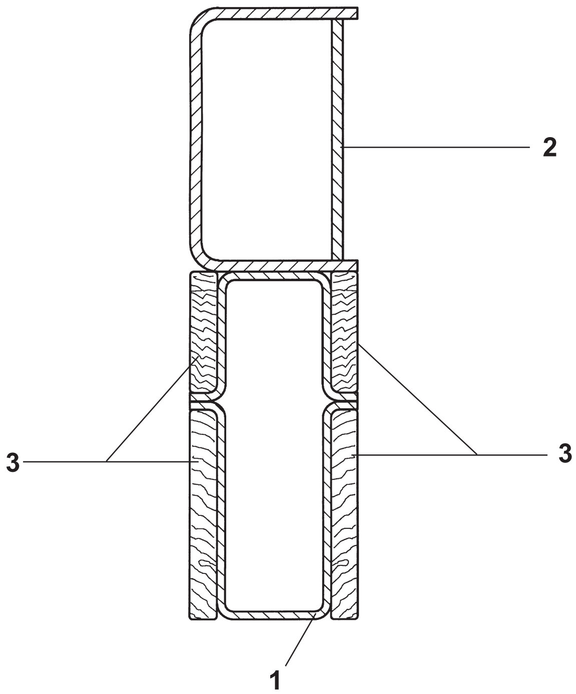


fig. 19.2.1

MIN262



1) Vehicle chassis with a unitised body
2) Single unit counter-chassis
3) Shims to protect the chassis against crushing (in hard wood, plastic or the like)

fig. 19.2.2

MENU

TECHNICAL DOCUMENTATION

20.1 - General

The aim of this chapter is to identify the documentation the installer must include in the technical file he provides for the user and which documentation must be filed and kept as a record of the checks performed and the work to be carried out.

20.2 - Crane delivery

On completion of the installation and delivery to purchaser, the installer must provide the latter with the following documents:

- EC Declaration of conformity issued by Autogru PM
- Instruction and safety handbook for the crane and the relative accessories installed
- Installer's declaration (see annex).

20.3 - The technical documentation file

To ensure all the documentation regarding the crane's technical assembly is easy to retrieve, we recommend the installer keeps it for a period of 13 years from the delivery date.

- Crane/vehicle unit identification data
- Drawing of the cranes position and of any supplementary outriggers
- Diagram of the chassis and counter-chassis with relevant anchorages and calculation reports
- Check of mass distribution over crane/vehicle installation through weighing (weighing statements to be enclosed)
- Hydraulic system and wiring diagrams if the original system has been modified
- Results of tests performed by the installer
- List of hazards concerning the crane/vehicle installation
- List of the documents issued and the operations carried out before the machine is handed over to the purchaser. Enclose a copy of the checklist of the documents issued and the operations carried out when the machine is delivered and before it is started up. This must be duly completed and signed by the final user.

- Annex 1 (for information only)

IDENTIFICATION DATA OF THE CRANE/VEHICLE COMBINATION

Identification data

(Order number)

NB: It is advisable to attach some photographs of the main points of installation.

CRANE:	type............	model...................................... serial number............................ year built....................................
INSTALLER:		company.................................... ....
VEHICLE:		type.. chassis n.................................. regis... n° of ax....................................
ASSEMBLY TYPE:		....
BODYWORK TYPE:		....
N° OF OUTRIGGERS		....
OIL USED		make and type.......................... ISO grade................................
PUMP		make and model:...................... capacity...................................
POWER TAKE-OFF		make and model:...................... ratio...

ENGINE SPEED FOR CRANE USE:.......................r.p.m

EC DECLARATION OF CONFORMITY

EC DECLARATION OF CONFORMITY for machines

(Presidential Decree 459/96, EC Directive 98/37 Annex II, part A)

FAC-SIMILE

AUTOGRU PM spa
Via Emilia Est 1058
41100 Modena

HEREBY DECLARES THAT THE CRANE

SERIES	SERIAL N°

COMPLIES ENTIRELY WITH DIRECTIVES EC 89/336 AND EC 98/37

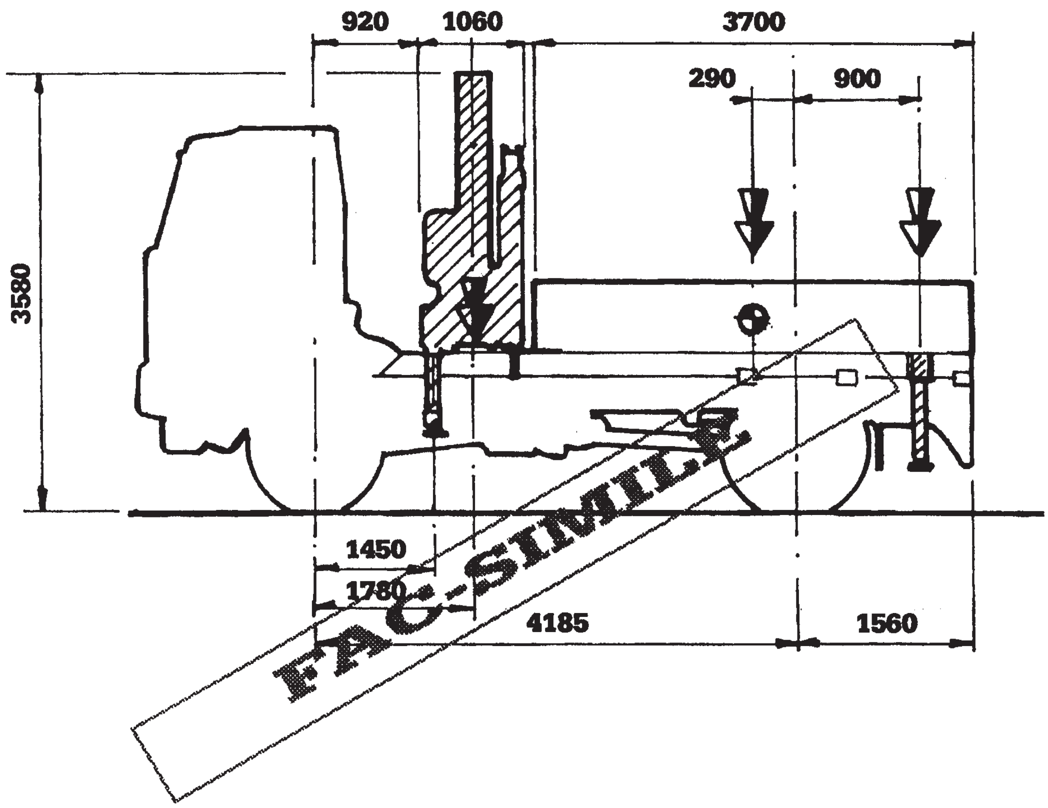
AND THAT THE MACHINE IS DESIGNED AND BUILT IN COMPLIANCE WITH HARMONISED STAND ARDS EN 292/1-EN 292/2 AND PERTAINING STANDARDS DIN 15018/1

Modena, date

AUTOGRU PM spa
Legal representative

- *Annex 2 (for information only)*

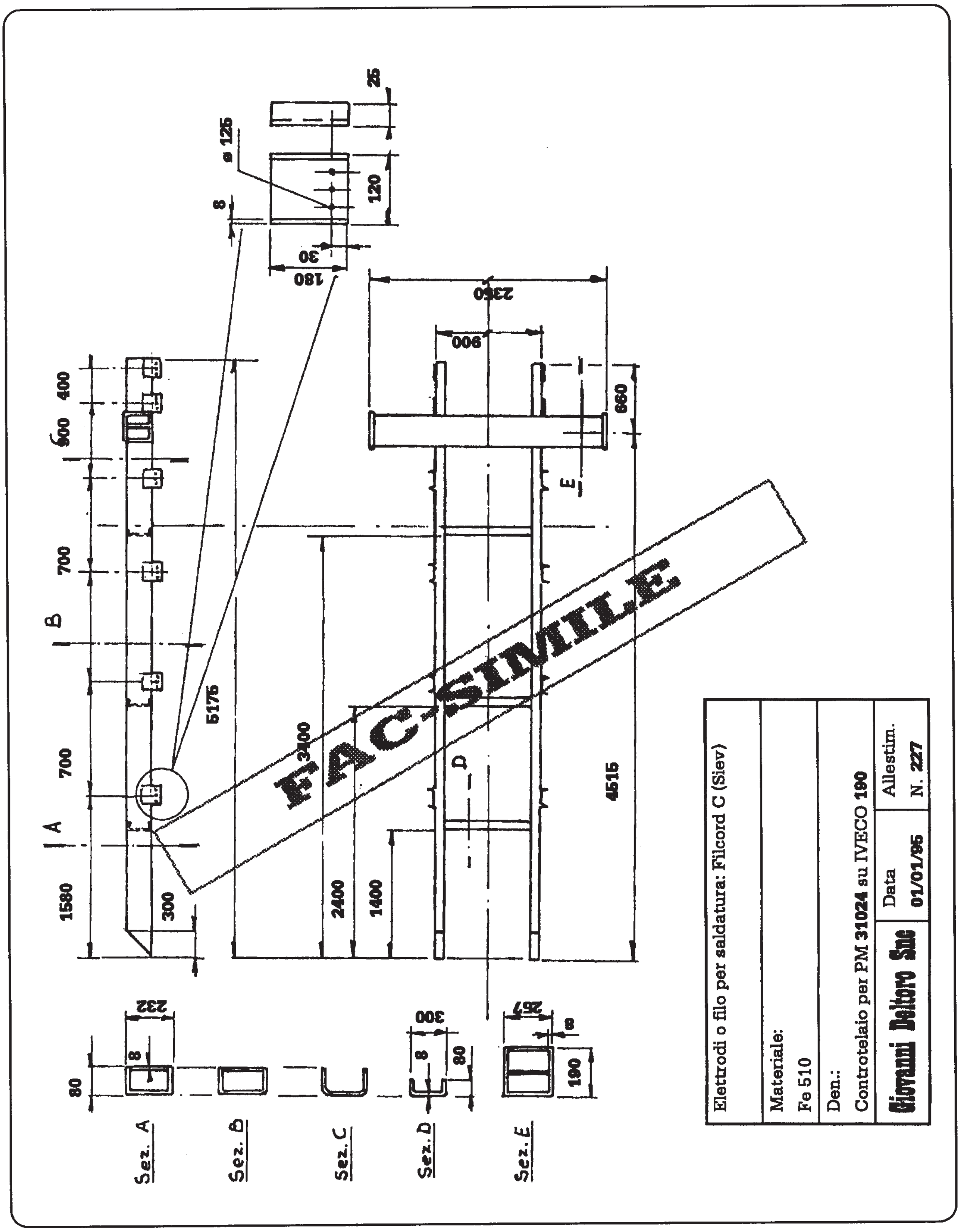
DRAWING OF THE CRANES-VEHICLE COMBINATION



Allestimento composto da:		
Gru PM **31024** Matricola N. **59660**		
Autocarro IVECO **190** - Telaio N. **00789**		
Giovanni Deltoro Snc	Data **01/01/95**	Allest. N. **227**

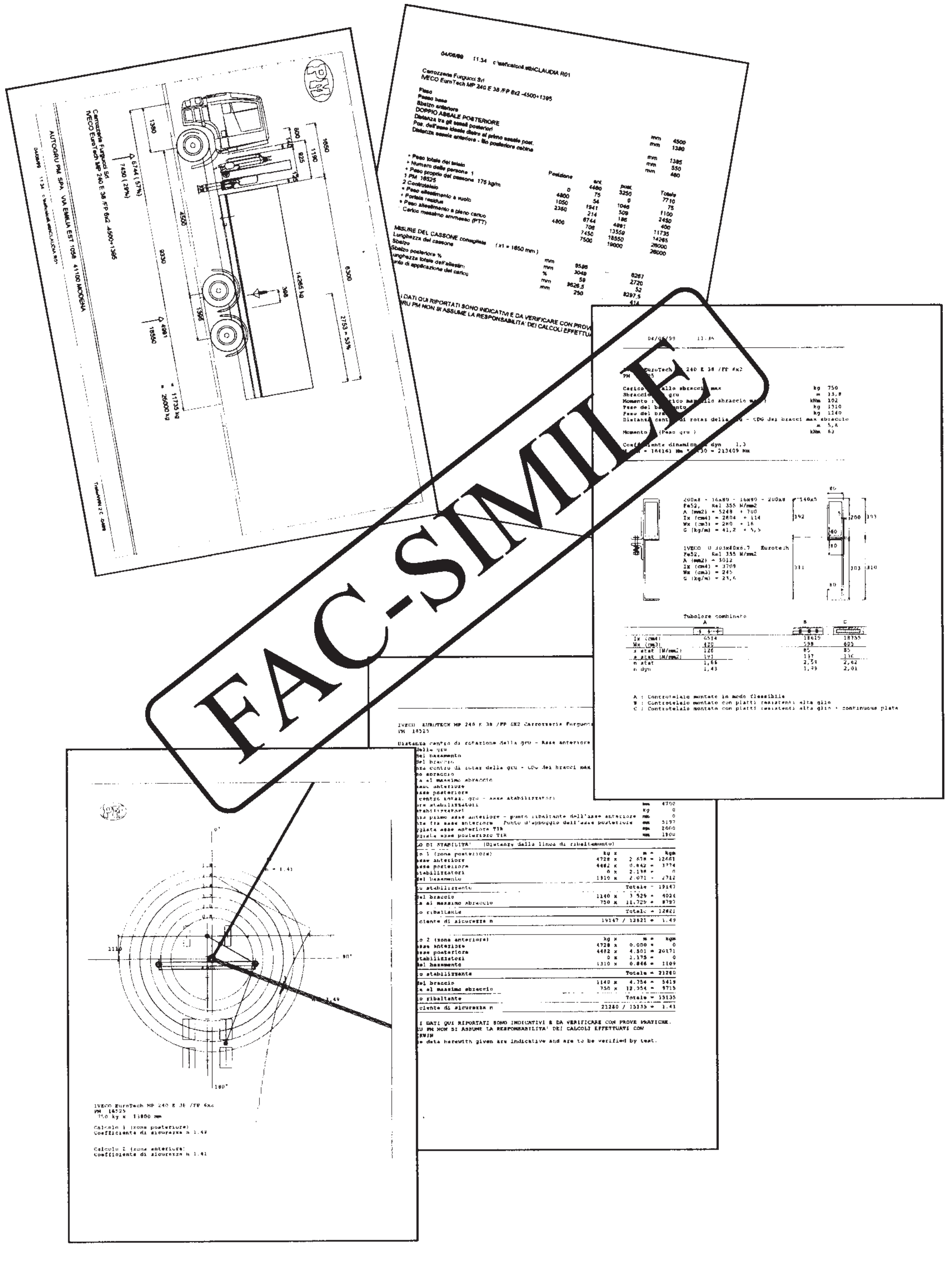
MIN290

DRAWING OF THE COUNTER-CHASSIS



MIN291

COUNTER-CHASSIS TEST, MASS DISTRIBUTION AND STABILITY



MIN292

- Annex 3 (for information only)

TESTS REPORT

TESTS REPORT

A) Identification data

- Installer ....
  ....
  ....
- Installation
  vehicle type ....
  chassis n° ....
  crane type ....
- Date of tests ....
- Place ....
  ....
  ....
- Test conditions ....
  ....
  ....
- Person responsible for testing ....

TESTS REPORT

TESTS REPORT

B) Static stability tests (see chapter 15)

- Work area: front: see note

LOADS HANDLED 1,25 P+0,1F (kg)	DISTANCE FROM COLUMN AXIS L (mm)	TEST RESULT	NOTES

- Work area: side

LOADS HANDLED 1,25 P+0,1F (kg)	DISTANCE FROM COLUMN AXIS L (mm)	TEST RESULT	NOTES

- Work area: rear

LOADS HANDLED 1,25 P+0,1F (kg)	DISTANCE FROM COLUMN AXIS L (mm)	TEST RESULT	NOTES

Note: stability is not granted in the front working area; for this purpose, mechanical stops have been provided on the slewing system to prevent access to the area.

TESTS REPORT

TESTS REPORT

C) Dynamic tests (see chapter 15)

- Work area: front
  side
  rear

LOADS HANDLED 1,25 P+0,1F (kg)	DISTANCE FROM COLUMN AXIS L (mm)	TEST RESULT	NOTES

D) Safety device tests (see para. 10.4)

Safety device tested	Test	Test result	Notes

- *Annex 4 (for information only)*

LIST OF HAZARDS

Type of hazard	Description of potential hazard	Solutions adopted	Reference standard adopted
1 - Mechanical hazards caused by the insufficient mechanical resistance of the crane's part	- Mechanical breakages in the counter-chassisor the parts connecting the chassis/counter-chassis as a result of incorrect sizing - Mechanical breakages in the supplementary outrigger cross beam due to mismatched supplementary outriggers/crane	- The counter-chassisand the parts connecting the chassis/counter chassis have been designed to meet the safety coefficients prescribed - Once the installation is complete and before the machine is handed over to the end client the relative practical load tests are performed (see chapter 15) - The supplementary outriggers and the relative connecting parts have been selected and co-ordinated on the basis of the manufacturer's instructions given in the crane handbook - Once the installation is complete and before it is handed over to the end client the relative practical load tests are performed (see chapter 15)	The counter-chassis and the connecting parts have been sized in compliance with the standard prEN 12999
1.1 - Shearing hazards 1.2 - Crushing hazards	- Parts of the operator's body may be crushed during the crane opening/closing manoeuvres - Parts of the operator's body may be crushed during the hydraulic outrigger boom opening/closing manoeuvres	- The crane's moving parts and the other equipment (inside the operator's working range) have been spaced to ensure this risk is prevented (e.g. the space between the crane and the vehicle body) - The outrigger booms' moving parts (inside the operator's working range) have been suitably spaced to ensure this risk is prevented. The outrigger (closure) stroke limit blocks are installed inside the outrigger and are therefore inaccessible to the operator.	The spaces/ distances adopted are as indicated in standard EN 349
1.3 - Cutting or severing hazards	- Parts of the operator's body may be cut or severed during the crane opening/closing manoeuvres and during the hydraulic outrigger boom opening/closing manoeuvres	- The crane's moving parts, the outriggers and the other equipment (inside the operator's working range) have been chamfered and rounded to prevent these risks (e.g. the vehicle body's side members)	
1.4 - Entanglement hazards 1.5 - Drawing-in or trapping hazards	- The operator's clothes may become tangled or be drawn into the machine during the crane opening/closing manoeuvres and during the hydraulic outrigger boom opening/closing manoeuvres	- In the design and production phases all the precautions/ measures regarding the moving parts have been taken (protruding parts removed, guards put on the rotary parts) - The handbook clearly states the kind of clothing (approved accident-prevention gear) that the operators should wear when operating the machine	

1.9 - High pressure fluid ejection hazards	- The operator may be injured as a result of the high-pressure fluid piping breaking/ exploding	- Hydraulic components with suitable safety coefficients are used to complement the hydraulic system (rigid/flexible piping and unions for connecting the pump to the crane and supplementary outriggers distributor) - The hosing located within a one-metre radius of the operator and which contains high pressure fluid has been fitted with an external protective sheath	The hydraulic components used comply with the standards EN982 and prEN 12999
1.11 - Hazards due to loss of stability of the crane-vehicle combination	- The operator may be injured as a result of the crane-vehicle combination becoming unstable (the vehicle tipping over/ overturning) said condition being caused by a mismatched crane-vehicle combination	- The crane-vehicle combination is designed on the basis of the manufacturer's instructions given in the crane handbook - Once the installation is complete and before it is handed over to the end client, the relative practical load tests are performed (see chapter 15)	
3.1 - Risk of burns and scalding to persons, caused by contact with flames or explosions or heat source radiation	- The operator may be injured by accidentally touching the end of the vehicle's vertical exhaust pipe - The operator may be injured by accidentally touching the hot parts of the hydraulic system	- A special anti-burns device has been installed on the vertical exhaust pipe near the operator' s control post - The machine's hydraulic system has been tested to make sure that temperature does not exceed dangerous levels for the operator as a consequence of intensive use (max 60 ° C) however, a suitable heat exchanger has been installed to lower this temperature further	
4 - Hazards generated by noise	- The operator may be injured by the noise of the vehicle's engine running constantly	- The noise pollution levels generated by the vehicle's engines have been checked to ensure they fall within the admissible limits when the machine is in use.	
7.1 - Hazards resulting from inhalation of harmful substances (gases, mists, fumes, powders)	- The operator may be injured by inhaling the vehicle's exhaust fumes	- A special flexible extension cable has been installed on the exhaust pipe near the operator's control post in order to divert the fumes away from the operator.	
8.1 - Hazards relating to unhealthy postures or excessive efforts	The operator may be injured by working with incorrectly positioned controls (too high for the operator's height)	- Suitable stools and foot panels have been installed to enable the operator to work in the best position possible and to have full access to the controls	The stools/foot panels and their access areas are built in compliance with the standard prEN 12999
29.1 - Hazards due to inadequate visibility at driver/operator's point	Objects may be damaged as a result of collisions with the machine due to the operator's poor visibility over the work area (vehicle's body side members too high and block view).	- An additional control and manoeuvring post has been installed (above the machine's base) to ensure the operator has a perfect visibility over the machine's work area	The access footboards and footrest of the new manoeuvre site have been executed in accordance with the standard prEN 12999

- *Annex 5 (for infomation only)*

OPERATOR'S MANUAL

Since 1959

Cranes, in all the languages of the world

Uso e Manutenzione

Operator's Manual

Serie 34-37

- GA42 -

Valido a partire dalla matricola
Valid with the serial number
GA420001

N° codice - *Code N°* 4.150.258
Edizione - *Edition* 03/2000

- Annex 6 (for information only)

CHECK LIST

CHECK LIST OF THE DOCUMENTS ISSUED AND OF THE OPERATIONS CARRIED OUT UPON DELIVERY OF THE MACHINE AND BEFORE STARTING UP

CRANE:
type: .... model:.......................
serial number: ....
year built: ....

VEHICLE:
type: ....
chassis n°: ....
registration n°: ....
number of axle: ....

INSTALLER:
company: ....
....
....

Documents consigned

- EC declaration of conformity issued by Autogru PM
- Operator's manual of the crane and relevant accessories
- Declaration of proper installation (see enclosure)

Operations carried out

- SAFETY DEVICE CHECK
- Stopcock
- Limiting device
- Emergency button
- Etc...

- OPERATING CHECK
- Lifting tests with loads
- Stability tests with loads
- Check to assess whether the material supplied is complete

- CRANE AND ACCESSORIES USAGE INSTRUCTIONS
- ROUTINE MAINTENANCE INSTRUCTIONS

The company (on behalf of Autogru PM)...

represented by.......................................as ....

declares that the above checks/tests have been performed in the presence of:

Company...represented by Mr/Ms..

in his/her capacity as ....who signs in approval...

and that, having complied with the obligations of directive 89/392, 89/336 and subsequent amendments, the equipment can be put to use.

....on........................ Stamp and signature