Guidelines to fitting bodies

TRUCKNOLOGY® GENERATION A (TGA)

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The ESC numbers stated in the illustrations are purely for internal reference.

They are of no consequence to the reader.

If not otherwise stated: all dimensions in mm, all weights and loads in kg

1. Applicability and legal agreements

1.1 Applicability

The statements in this guide are binding. If technically feasible, exceptions will be approved only if a written request has been submitted to the ESC department at MAN, (see „Publisher" above).

1.2 Legal agreements and approval procedure

1.2.1 Preconditions

In addition to this Guide, the company carrying out the work must observe all

•   laws and decrees
•   accident prevention regulations
•   operating instructions

relating to the operation and construction of the vehicle. Standards are technical standards; they are therefore minimum requirements. Anyone who does not endeavour to observe these minimum requirements is regarded as operating negligently.
Standards are binding when they form part of regulations.

Information given by MAN in reply to telephone enquiries is not binding unless confirmed in writing. Enquiries are to be directed to the relevant MAN department. Information refers to conditions of use that are usual within Europe. Dimensions, weights and other basic data that differ from these must be taken into consideration when designing the body, mounting the body and designing the subframe. The company carrying out the work must ensure that the entire vehicle can withstand the conditions of use that it is expected to experience.

For certain types of equipment, such as loading cranes, tail-lifts, cable winches etc, the respective manufacturers have developed their own body regulations. If, when compared with this MAN Guide, they impose further conditions, then these too must be observed.

References to

•   legal stipulations
•   accident prevention regulations
•   decrees from professional associations
•   work regulations
•   other guidelines and sources of information

are not in any way complete and are only intended as ideas for further information.
They do not replace the company's obligation to carry out its own checks.

Fuel consumption is considerably affected by modifications to the vehicle, by the body and its design and by the operation of equipment driven by the vehicle's engine. It is therefore expected that the company carrying out the work implements a design that facilitates the lowest possible fuel consumption.

1.2.2   Responsibility

The responsibility for proper

*   design
*   production
*   installation of bodies
*   modification to the chassis

always lies fully with the company that is manufacturing the body, installing it or carrying out modifications (manufacturer's liability). This also applies if MAN has expressly approved the body or the modification. Bodies/conversions that have been approved in writing by MAN do not release the body manufacturer from his responsibility for the product. Should the company carrying out the work detect a mistake either in the planning stage or in the intentions of

*   the customer
*   the user
*   its own personnel
*   the vehicle manufacturer

then that mistake must be brought to the attention of the respective party.

The company is responsible for seeing that the vehicle's

*   operational safety
*   traffic safety
*   maintenance possibilities and
*   handling characteristics

do not exhibit any disadvantageous properties.

With regard to traffic safety, the company must operate in accordance with the state of the art and in line with the recognised rules in the field in matters relating to

*   the design
*   the production of bodies
*   the installation of bodies
*   the modification of chassis
*   instructions and
*   operating instructions.

Difficult conditions of use must also be taken into account.

1.2.3   Quality assurance

In order to meet our customers' high quality expectations and in view of international product/manufacturer liability legislation an on-going quality monitoring programme is also required for conversions and body manufacture/installation. This requires a functioning quality assurance system. It is recommended that the body manufacturer sets up and provides evidence of a quality system that complies with the general requirements and recognised rules (e.g. DIN EN ISO 9000 et seq. or VDA 8).
Evidence of a qualified system can be provided for example by:

If MAN is the party awarding the contract for the body or conversion evidence of qualification will be requested.
MAN Truck & Bus AG reserves the right to carry out its own system audit in accordance with VDA 8 or a corresponding process check at the supplier's premises. VDA volume 8 has been agreed with the following body manufacturers' associations:
ZKF (Zentralverband Karosserie- und Fahrzeugtechnik – Central Association of Body and Vehicle Engineering) and
BVM (Bundesverband Metall Vereinigung Deutscher Metallhandwerke – Federation of German Metal Trades Associations).
It has also been agreed with the **ZDH** (Zentralverband des Deutschen Handwerks – Central Association of German Craft Trades).

Documents:
VDA Volume 8
„Minimum quality assurance requirements for trailer, body manufacturers", obtainable from the Verband der Automobilindustrie e.V (VDA) (German Engine Industry Association), http://www.vda-qmc.de.

1.2.4   Approval

Approval from MAN for a body or a chassis modification is not required if the bodies or modifications are carried out in accordance with this Guide. If MAN approves a body or a chassis modification, then this approval refers

*   In the case of bodies only to the body's fundamental compatibility with the respective chassis and the interfaces to the body (e.g. dimensions and mounting of the subframe)
*   In the case of chassis modifications only to the fact that, from a design point of view, the modifications to the chassis in question are fundamentally permissible.

The approval note that MAN enters on the submitted technical documents does not indicate a check on the

*   Function
*   Design
*   Equipment of the body or the modification.

Observance of this Guide does not free the user from responsibility to perform modifications and manufacture bodies properly from a technical point of view. The approval note only refers to such measures or components as are to be found in the submitted technical documents.

MAN reserves the right to refuse to issue approvals for bodies or modifications, even if a comparable approval has already been issued. Later submissions for approval are not automatically treated the same as earlier ones, because technical advances achieved in the interim period have to be taken into account.

MAN also reserves the right to change this Guide at any time or to issue instructions that differ from this Guide for individual chassis.

If several identical chassis have the same bodies or modifications MAN can, to simplify matters, issue a collective approval.

1.2.5   Submission of documents

Documents should only be sent to MAN if bodies/conversions diverge from this Guide. Before work begins on the vehicle, technical documents that require approval or inspection must be sent to the ESC Department at MAN (see „Publisher" above).

For an approval process to proceed swiftly, the following are required:

*   Documents should be submitted in duplicate
*   The number of individual documents should be kept to a minimum
*   All the technical data and documents must be submitted.

The following information should be included:

- Vehicle model (see Chapter 2.2 for model code) with
  - cab design
  - wheelbase
  - frame overhang
- · Vehicle identification number or vehicle number (if already available, see Chapter 2.2)
  Identification of deviations from this Guide to Fitting Bodies in all documentation!
- Loads and their load application points:
  - Forces from the body
  - Axle load calculation
- Special conditions of use:
- Subframe:
  - Material and cross-sectional data
  - Dimensions
  - Type of section
  - Arrangement of cross members in the subframe
  - Special features of the subframe design
  - Cross-section modifications
  - Additional reinforcements
  - Upsweeps, etc.
- Means of connection:
  - Positioning (in relation to the chassis)
  - Type
  - Size
  - Number.

The following are not sufficient for inspection or approval:

- Parts lists
- Brochures
- Photographs
- Other not binding information.

Drawings are only valid if they bear the number that has been assigned to them. It is therefore not permitted to draw in the bodies or modifications on chassis drawings that have been provided by MAN and to submit these for approval.

1.2.6   Liability for defects

Liability claims in respect of defects only exist within the framework of the purchasing contract between buyer and seller.
In accordance with this, liability for defects lies with the respective seller of the goods.

Claims against MAN are not valid if the fault that is the subject of the complaint was due to the fact that

- This Guide was not observed
- In view of the purpose for which the vehicle is used, an unsuitable chassis has been selected
- The damage to the chassis has been caused by
  - the body
  - the type of body mounting or how the body has been mounted
  - the modification to the chassis
  - improper use.

1.2.7 Product liability

Any faults in the work that are identified by MAN are to be corrected. Insofar as is legally permissible, MAN disclaims all liability, in particular for consequential damage.

Product liability regulates:

- The liability of the manufacturer for its product or component
- The compensation claim made by the manufacturer against whom a claim has been made against the manufacturer of an integral component, if the damage that has occurred is due to a fault in that component.

The company that has made the body or carried out the modification is to relieve MAN of any liability to its customer or other third party if the damage that has occurred is due to the fact that

- The company did not observe this Guide
- The body or chassis modification has caused damage on account of its faulty
    - design
    - manufacture
    - installation
    - instructions
- The fundamental rules that are laid down have not been complied with in any other way.

1.2.8 Safety

Companies carrying out work on the chassis/vehicle are liable for any damage that may be caused by poor functional and operational safety or inadequate operating instructions. Therefore, MAN requires the body manufacturer or vehicle conversion company to:

- Ensure the highest possible safety, in line with the state of the art
- Provide comprehensible, sufficient operating instructions
- Provide permanent, easily visible instruction plates on hazardous points for operators and/or third parties
- Observe the necessary protection measures (e.g. fire and explosion prevention)
- Provide full toxicological information
- Provide full environmental information.

Safety is top priority! All available technical means of avoiding incidents that will undermine operational safety are to be implemented. This applies equally to

- Active safety = prevention of accidents. This includes:
    - Driving safety achieved by the overall vehicle design, including the body
    - Safety as a consequence of the driver's well-being achieved by keeping occupant stress caused by vibrations, noise, climatic conditions etc. to a minimum
    - Safety as a consequence of observation and perception, in particular through the correct design of lighting systems, warning equipment, providing sufficient direct and indirect visibility
    - Safety as a consequence of operating equipment and controls this includes optimising the ease of operation of all equipment, including that of the body.
- Passive safety = avoidance and reduction of the consequences of accidents. This includes:
    - Exterior safety such as the design of the outside of the vehicle and body with respect to deformation behaviour and the installation of protective devices
    - Interior safety including the protection of occupants of vehicles and cabs that are installed by the body builders.

Climatic and environmental conditions have effects on:

- Operational safety
- Readiness for use
- Operational performance
- Service life
- Cost-effectiveness.

Climatic and environmental conditions are, for example:

- The effects of temperature
- Humidity
- Aggressive substances
- Sand and dust
- Radiation.

Sufficient space for all parts required to carry out a movement, including all pipes and cables, must be guaranteed. The operating instructions for MAN trucks provide information about the maintenance points on the vehicle. Regardless of what type of body is fitted, good access to the maintenance points must be ensured in all cases. It must be possible to carry out maintenance unhindered and without having to remove any components. Sufficient ventilation and/or cooling of the components is to be guaranteed.

1.2.9   Manuals from body and conversion companies

In the event of a body being added or modifications to the vehicle being carried out, the operator of the vehicle is also entitled to receive operating instructions from the conversion company. All specific advantages offered by the product are of no use if the customer is not able to:

- Handle the product safely and properly
- Use it rationally and effortlessly
- Maintain it properly
- Master all of its functions.

As a result, every vehicle body builder and converter must check his technical instructions for:

- Clarity
- Completeness
- Accuracy
- Comprehensibility
- Product-specific safety instructions.

Inadequate or incomplete operating instructions carry considerable risks for the user. Possible effects are:

- Reduced benefit, because the advantages of the product remain unknown
- Complaints and annoyance
- Faults and damage, which are normally blamed on the chassis
- Unexpected and unnecessary additional cost through repairs and time lost
- A negative image and thereby less inclination to buy the same product or brand again.

Depending on the vehicle body or modification, the operating personnel must be instructed about operation and maintenance. Such instruction must also include the possible effects on the static and dynamic performance of the vehicle.

1.2.10 Limitation of liability for accessories/spare parts

Accessories and spare parts that MAN has not manufactured or approved for use in its products may affect the traffic safety and operational safety of the vehicle and create hazardous situations. MAN Truck & Bus AG (or the seller) accepts
no liability for claims of any kind resulting from a combination of the vehicle together with an accessory that was made by another manufacturer, regardless of whether MAN Truck & Bus AG (or the seller) has sold the accessory itself or fitted it to the vehicle (or the subject of the contract).

2. Product designations

2.1 Vehicle designation and wheel formula

To enable unique and easily comprehensible identification of the different variants new vehicle designations have been systematically introduced. The vehicle designation system is based on three levels:

- Door designation
- Variant descriptor (in the sales and technical documentation e.g. data sheets, chassis drawings)
- Model code.

2.1.1 Door designation

The door designation comprises:
Model range + permissible weight + engine power
TGA 18.400

Model range	+ Permissible weight	+ Engine power
T G A	1 8	. 4 0 0

Abbreviated notation of model range TGA = Trucknology® Generation A,
technically permissible weight in [t],
engine power [DIN-hp] rounded to the nearest 10hp

2.1.2 Variant descriptor

The variant descriptor = vehicle designation which comprises the door designation + wheel formula + suffix.
The terms 'wheel formula' and 'suffix' are defined in the following sections.

Model range + permissible weight + engine power + wheel formula + suffix
TGA 25.480 6x2-2 LL-U

Model range	+ Permissible weight	+ Engine power		
T G A	2 5	. 4 8 0	6 x 2 - 2	L L - U
			Wheel formula	Suffix

2.1.3 Wheel formula

The wheel formula stipulates the number of axles and provides additional identification of drive, steered and leading/trailing axles.
Wheel formula is a commonly used, but not standardised term. It is "wheel locations" that are counted and not the individual wheels.
Twin tyres are therefore regarded as one wheel.

The following two examples illustrate the wheel formula:

Table 1:   Wheel formula examples

6 x 2 - 4		
6 x 2 / 4		
6	=	Total number of wheel locations, i.e. 3 axles
x	=	No function
2	=	Number of driven wheels
-	=	Trailing axle behind the rear drive-axle assembly
/	=	Leading axle ahead of the rear drive-axle assembly
4	=	Number of steered wheels

The number of steered wheels is only stated if, aside from steered front wheels, leading axles or trailing axles are also involved.
A leading axle is located "ahead of" a rear drive-axle assembly and a trailing axle is "behind" the rear drive-axle assembly.
A slash "/" represents a leading axle and a hyphen "-" represents a trailing axle.
If a chassis is fitted with both leading and trailing axles the number of steered wheels follows the hyphen "-".
If the vehicle is fitted with MAN HydroDrive® hydrostatic front axle drive then the wheel formula receives an additional H,
e.g. 6x4H = a front axle with MAN HydroDrive®, 2 rear axles, one of which is driven.

Currently the following wheel formulae are available ex-works:

Table 2:   TGA wheel formulae

4x2	Two-axle vehicle with one drive axle
4x4	Two-axle vehicle with two drive axles "All-wheel drive"
4x4H	Two-axle vehicle with two drive axles, front axle with MAN HydroDrive®
6x2/2	Three-axle vehicle with non-steered "Pusher" leading axle
6x2/4	Three-axle vehicle with steered leading axle
6x2-2	Three-axle vehicle with non-steered trailing axle
6x2-4	Three-axle vehicle with steered trailing axle
6x4	Three-axle vehicle with two driven non-steered rear axles
6x4/4	Three-axle vehicle with 2 driven axles (first and last axles), steered leading axle
6x4-4	Three-axle vehicle with 2 driven axles, (first and second axles), steered trailing axle
6x4H/2	Three-axle vehicle with MAN HydroDrive® front axle drive, one driven rear axle, non-steered leading axle
6x4H/4	Three-axle vehicle with MAN HydroDrive® front axle drive, one driven rear axle, steered leading axle
6x4H-2	Three-axle vehicle with MAN HydroDrive® front axle drive, one driven rear axle, non-steered trailing axle
6x4H-4	Three-axle vehicle with MAN HydroDrive® front axle drive, one driven rear axle, steered trailing axle

Table 2:   TGA wheel formulae (continuation)

6x6	Three-axle vehicle with all-wheel drive
6x6-4	Three-axle vehicle with all-wheel drive, steered and driven trailing axle
6x6H	Three-axle vehicle with all-wheel drive, front axle with MAN HydroDrive®
8x2-4	Four-axle vehicle with one drive axle, two steered front axles, non steered trailing axle **or** four-axle vehicle with three rear axles with front and trailing axles steered
8x2-6	Four-axle vehicle with one drive axle, two steered front axles, steered trailing axle
8x4	Four-axle vehicle with two steered front axles and two driven rear axles
8x4/4	Four-axle vehicle with one front axle, one steered leading axle and two driven rear axles
8x4-4	Four-axle vehicle with one front axle, two driven rear axles and one steered trailing axle
8x4H-4	Four-axle vehicle with two steered front axles (2nd front axle with MAN HydroDrive®), one driven rear axle and a non-steered trailing axle
8x4H-6	Four-axle vehicle with two steered front axles (2nd front axle with MAN HydroDrive®), one driven rear axle and a steered trailing axle
8x6	Four-axle vehicle "All wheel drive" with two front axles (2nd driven) and two driven rear axles
8x6H	Four-axle vehicle "All wheel drive" with two front axles (2nd front axle with MAN HydroDrive®) and two driven rear axles
8x8	Four-axle vehicle "All wheel drive" with two front axles and two rear axles, all driven

2.1.4   Suffix

The suffix to the vehicle designation defines the type of suspension, differentiates trucks from tractor units and describes special product features.

T G A 2 5 . 4 8 0 6 x 2 - 2	LL-U
	Suffix

Types of suspension (Digits 1 and 2 of suffix)

Table 3:   Types of suspension

BB	Leaf suspension on front axle(s), leaf suspension on rear axle(s)
BL	Leaf suspension on front axle(s), air suspension on rear axle(s)
LL	Air suspension on front axle(s), air suspension on rear axle(s)
BH	Leaf suspension on front axle(s), hydropneumatic on rear axle(s)

Semitrailer tractor units are designated with an 'S' suffix. Trucks have no special designation.

Example for semitrailer tractor:

T G A 3 3 . 4 4 0 6 x 6	BBS
	S = Semitrailer tractor

Special product (design) features are added separately following a hyphen '-' after the first section of the suffix:

Example for special product features:

T G A 1 8 . 3 5 0 4 x 2 B L S	-TS
	-TS = Weight optimised version for silo tanker

Table 4:   Designations for special designs produced to-date (to be supplemented with further designs)

-U	For low design 'Ultra' e.g.: TGA 18.410 4x2 LLS-U
-TS	Weight optimised version for silo tanker, e.g.: TGA 18.400 4x2 BLS-TS
-WW	"World wide" variant, eligible for licensing outside Europe only, e.g. TGA 40.460 6x6 BB-WW
-LE	"Low entry" cab with lowered entry, e.g.: TGA 28.310 6x2-4 LL-LE
-CKD	"Completely knocked down", for assembly in MAN factory of the recipient country, e.g.: TGA 40.480 6x4-4 WW-CKD

2.2   Model number, vehicle identification number, vehicle number, basic vehicle number

The three-digit model number, also called model code, provides a technical identification of the MAN chassis and also identifies to which vehicle range it belongs. This number is part of the 17-digit vehicle identification number (VIN) and is located at digits 4 to 6 in the VIN. The basic vehicle number, formulated for sales purposes, also contains the model number at digits 2 to 4.
The seven-figure vehicle number describes the technical equipment on a vehicle; it contains the model number at digits 1 to 3, followed by a four-digit sequential number. The vehicle number is to be found in the vehicle papers and on the vehicle's manufacturing plate.
The vehicle number can be quoted instead of the 17-digit vehicle identification number in the event of any technical queries regarding conversions and bodies. Table 5 gives some examples of the model number, vehicle identification number, basic vehicle number and vehicle number.

Table 5:   Example vehicle designation, model number, vehicle identification number, basic vehicle number and vehicle number

Vehicle designation	Model number Model code	Vehicle identification number (VIN)	Basic vehicle number	Vehicle number
TGA 18.440 4x2 BLS	**H06**	WMA**H06**ZZ14M000479	L**H06**AG53	**H06**0057
TGA 26.410 6x2-4 LL	**H21**	WMA**H21**ZZ94G144924	L**H21**E 05	**H21**0058
TGA 33.540 6x4 BB	**H26**	WMA**H26**ZZ75M350354	L**H26**LR04	**H26**1158

Up to the date of going to press (03/2007) the Trucknology® Generation A or TGA for short, comprises the following model numbers:

Table 6:   Model numbers, tonnage class, vehicle designation and suspension on the TGA

Model number	Tonnage	Designation , xxx stands for various engine powers	Engine	Suspension
H01	18 t	TGA 18.xxx 4x2 BLS-TS	D28 R6	BL
H02	18 t	TGA 18.xxx 4x2 BB	D28 R6	BB
H03	18 t	TGA 18.xxx 4x2 BB	D20/D26 R6	BB
H05	18 t	TGA 18.xxx 4x2 BL	D28 R6	BL
H06	18 t	TGA 18.xxx 4x2 BL	D20/D26 R6	BL
H07	18 t	ECT 18.ISM 4x2 BL	ISM^e	BL
H08	18 t	TGA 18.xxx 4x2 BLS-TS	D20/D26 R6	BL
H09	18 t	TGA 18.xxx 4x2 LL	D28 R6	LL
H10	18 t	TGA 18.xxx 4x2 LL	D20/D26 R6	LL
H11	40 t	TGA 40.xxx 6x4 BB-WW-CKD	D20/D26 R6	BBB
H12	18 t	TGA 18.xxx 4x2 LLS-U	D28 R6	LL
H13	18 t	TGA 18.xxx 4x2 LLS-U	D20/D26 R6	LL
H14	18 t	TGA 18.xxx 4x2 LL-U	D28 R6	LL
H15	18 t	TGA 18.xxx 4x2 LL-U	DD20/D26 R6	LL
H16	26 t	TGA 26.xxx 6x2-4 BL	D08 R6	BLL
H17	26 t	TGA 26.xxx 6x2-2, 6x2-4 BL	D28 R6	BLL
H18	26 t	TGA 26.xxx 6x2-2, 6x2-4 BL	D20/D26 R6	BLL
H19	26 t	TGA 26.xxx 6x2-4 LL	D08 R6	LLL
H20	26 t	TGA 26.xxx 6x2-2, 6x2-4 LL	D28 R6	LLL
H21	26 t	TGA 26.xxx 6x2-2, 6x2-4 LL	D20/D26 R6	LLL
H22	18 t	TGA 18.xxx 4x4H BL	D20/D26 R6	BL
H23	26 t	TGA 26.xxx 6x2/2, 6x2/4 BL	D28 R6	BLL
H24	26 t	TGA 26.xxx 6x2/2, 6x2/4 BL	D20/D26 R6	BLL
H25	26/33 t	TGA 26/33.xxx 6x4 BB	D28 R6	BBB
H26	26/33 t	TGA 26/33.xxx 6x4 BB	D20/D26 R6	BBB
H27	26 t	ECT 26.ISM 6x2-2, 6x2-4 BL	ISM^e	BLL
H28	33 t	TGA 33.xxx 6x4 BB-WW	D28 R6	BBB
H29	26/33 t	TGA 26/33.xxx 6x4 BL	D28 R6	BLL
H30	26/33 t	TGA 26/33.xxx 6x4 BL	D20/D26 R6	BLL
H31	26 t	ECT 26.ISM 6x2-2 LL	ISM^e	LLL
H32	26 t	ECT 26.ISM 6x2/2 BL	ISM^e	BLL
H33	40 t	TGA 40.xxx 6x4 BB-WW	D28 R6	BBB
H34	40 t	TGA 40.xxx 6x4 BB-WW	D20/D26 R6	BBB
H35	26 t	TGA 26.xxx 6x4H-2 BL, 6x4H-4 BL	D20/D26 R6	BLL
H36	35 t	TGA 35.xxx 8x4 BB	D28 R6	BBBB
H37	35 t	TGA 35.xxx 8x4 BB	D20/D26 R6	BBBB

Model number	Tonnage	Designation , xxx stands for various engine powers	Engine	Suspension
H38	41 t	TGA 41.xxx 8x4 BB	D28 R6	BBBB
H39	41 t	TGA 41.xxx 8x4 BB	D20/D26 R6	BBBB
H40	35 t	TGA 35.xxx 8x4 BL	D28 R6	BBLL
H41	35 t	TGA 35.xxx 8x4 BL	D20/D26 R6	BBLL
H42	26 t	TGA 26.xxx 6x4H/2 BL, 6x4H/4 BL	D20/D26 R6	BLL
H43	19 t	TGA 19.xxx 4x2 BBS-WW	D28 R6	BB
H44	25 t	TGA 25.xxx 6x2-2 LL-U	D28 R6	LLL
H45	25 t	TGA 25.xxx 6x2-2 LL-U	D20/D26 R6	LLL
H46	41 t	TGA 41.xxx 8x4 BB-WW	D28 R6	BBBB
H47	26/33 t	TGA 26/33.xxx 6x6H BB	D20/D26 R6	BBB
H48	32 t	TGA 32.xxx 8x4 BB	D28 R6	BBBB
H49	32 t	TGA 32.xxx 8x4 BB	D20/D26 R6	BBBB
H50	35 t	TGA 35.xxx 8x6H BB	D20/D26 R6	BBBB
H51	18 t	TGA 18.xxx 4x4 BB	D28 R6	BB
H52	18 t	TGA 18.xxx 4x4 BB	D20/D26 R6	BB
H54	33 t	TGA 33.xxx 6x6 BB-WW	D28 R6	BBB
H55	26/33 t	TGA 26/33.xxx 6x6 BB	D28 R6	BBB
H56	26/33 t	TGA 26/33.xxx 6x6 BB	D20/D26 R6	BBB
H57	40 t	TGA 40.xxx 6x6 BB-WW	D28 R6	BBB
H58	40 t	TGA 40.xxx 6x6 BB-WW	D20/D26 R6	BBB
H59	35 t	TGA 35.xxx 8x6H BL	D20/D26 R6	BBLL
H60	19 t	TGA 19.xxx 4x2 BBS-WW-CKD	D28 R6	BB
H61	18 t	TGA 18.xxx 4x2 BLS-WW-CKD	D28 R6	BL
H62	33 t	TGA 33.xxx 6x4 BB-WW-CKD	D28 R6	BBB
H63	26 t	TGA 26.xxx 6x4 BL-WW-CKD	D28 R6	BLL
H64	19 t	TGA 19.xxx 4x2 BBS-WW-CKD	D20/D26 R6	BB
H65	18 t	TGA 18.xxx 4x2 BLS-WW-CKD	D20/D26 R6	BL
H66	33 t	TGA 33.xxx 6x4 BB-WW-CKD	D20/D26 R6	BBB
H67	26 t	TGA 26.xxx 6x4 BL-WW-CKD	D20/D26 R6	BLL
H68	40 t	TGA 40.xxx 6x4 BB-WW-CKD	D28 R6	BBB
H69	39 t	TGA 39.xxx 8x2-4 BL	D20/D26 R6	BBLL
H70	18 t	TGA 18.xxx 4x4 BL	D28 R6	BL
H71	28 t	TGA 28.xxx 6x2-4 BL TGA 28.xxx 6x2-4 LL	D28 R6	BLLLLL
H72	26/33 t	TGA 26/33.xxx 6x6 BL	D28 R6	BLL
H73	35/41 t	TGA 35/41.xxx 8x6 BB	D28 R6	BBBB
H74	28 t	TGA 28.xxx 6x2-4 BL	D20/D26 R6	BLL
H75	28 t	TGA 28.xxx 6x2-4 LL	D20/D26 R6	LLL
H76	35/41 t	TGA 35/41.xxx 8x8 BB	D28 R6	BBBB
H77	28 t	TGA 28.xxx 6x4-4 BL	D20/D26 R6	BLL
H80	18 t	TGA 18.xxx 4x4 BL	D20/D26 R6	BL

Model number	Tonnage	Designation , xxx stands for various engine powers	Engine	Suspension
H81	28 t	TGA 28.xxx 6x4-4 BL	D28 R6	BLL
H82	26/33 t	TGA 26/33.xxx 6x6 BL	D20/D26 R6	BLL
H83	28 t	TGA 28.xxx 6x6-4 BL	D20/D26 R6	BLL
H84	28 t	TGA 28.xxx 6x4-4 BL	D20/D26 R6	BLL
H85	28 t	TGA 28.xxx 6x2-2 LL	D20/D26 R6	LLL
H86	28 t	TGA 28.xxx 6x2-2 BL	D28 R6	BLL
H87	28 t	TGA 28.xxx 6x2-2 LL	D28 R6	LLL
H88	35 t	TGA 35.xxx 8x2-4, 8x2-6 BL	D28 R6	BBLL
H89	28 t	TGA 28.xxx 6x2-2 BL	D20/D26 R6	BLL
H90	35 t	TGA 35.xxx 8x2-4, 8x2-6 BL	D20/D26 R6	BBLL
H91	35 t	TGA 35.xxx 8x4-4 BL	D28 R6	BLLL
H92	35 t	TGA 35.xxx 8x4-4 BL	D20/D26 R6	BLLL
H93	35/41 t	TGA 35/41.xxx 8x6 BB	D20/D26 R6	BBBB
H94	41 t	TGA 41.xxx 8x4/4 BB TGA 41.xxx 8x4/4 BL	D28 R6	BLBB BLLL
H95	41 t	TGA 41.xxx 8x4/4 BB TGA 41.xxx 8x4/4 BL	D28 V10	BLBB BLLL
H96	35/41 t	TGA 35/41.xxx 8x8 BB	D20/D26 R6	BBBB
H97	18 t	TGA 18.xxx 4x2 LL-LE	D20/D26 R6	LL
H98	26 t	TGA 26.xxx 6x2/4 LL-LE	D20/D26 R6	LLL
H99	28 t	TGA 28.xxx 6x2-4 LL-LE	D20/D26 R6	LLL
HH1	26/33 t	TGA 26/33.xxx 6x6H BL	D20/D26 R6	BLL
HH2	28 t	TGA 28.xxx 6x4H-4	D20/D26 R6	BLL
HH4	35 t	TGA 35.xxx 8x4H-4, 8x4H-6 BL	D20/D26 R6	BBLL
HV1	26 t	TGA 26.xxx 6X2-2, 6x2-4 BL-WW	D20/D26 R6	BLL
HV2	26/33 t	TGA 26/33.xxx 6X4 BL-WW	D20/D26 R6	BLL
HV3	39 t	TGA 39.xxx 8X2-4 BL-WW	D20 R6	BBLL
HV4	28 t	TGA 28.xxx 6X2-2 BL-WW	D20/D26 R6	BLL
HV5	18 t	TGA 18.xxx 4X4 BB-WW	D20 R6	BB
HV6	35/41 t	TGA 35/41.xxx 8X8 BB-WW	D20 R6	BBBB
HV7	28 t	TGA 28.xxx 6X2-2 BL-WW-CKD	D20/D26 R6	BLL
HV8	32 t	TGA 32.xxx 8X4 BB-WW	D20 R6	BBBB
HW1	19 t	TGA 19.xxx 4x2 BBS-WW	D20/D26 R6	BB
HW2	33 t	TGA 33.xxx 6x4 BB-WW	D20/D26 R6	BBB
HW3	41 t	TGA 41.xxx 8x4 BB-WW	D20/D26 R6	BBBB
HW4	33 t	TGA 33.xxx 6x6 BB-WW	D20/D26 R6	BBB
HW5	19 t	TGA 19.xxx 4x2 BLS-WW-CKD	D20/D26 R6	BL
HW6	41 t	TGA 41.xxx 8x4 BB-WW-CKD	D20/D26 R6	BBBB
HW7	19 t	TGA 19.xxx 4x2 BLS-WW	D20/D26 R6	BL
HW8	33 t	TGA 33.xxx 6x4 BBS-WW	D20/D26 R6	BBB
HW9	33 t	TGA 33.xxx 6x4 BBS-WW-CKD	D20/D26 R6	BBB

2.3 Use of logos

MAN logos on the chassis may not be removed or modified in any way without prior approval from MAN.
Modifications to the chassis or body that do not conform with this Guide to Fitting Bodies and that have not received MAN approval by the ESC department (for address see „Publisher" above) must receive a new vehicle identification number (VIN) from the manufacturer responsible for the modification (normally the vehicle conversion company).
In such cases where the chassis/vehicle has received a new VIN, the logos on the radiator grille (MAN lettering, lion emblem) and the doors (door designation – see Section 2.1.1) must be removed.
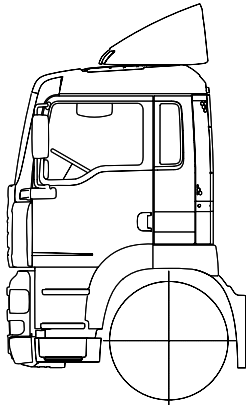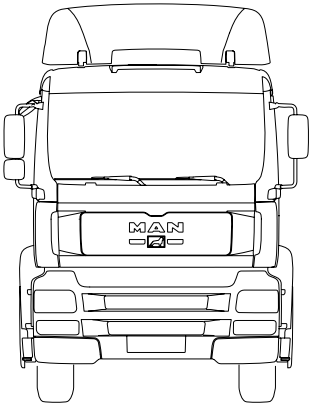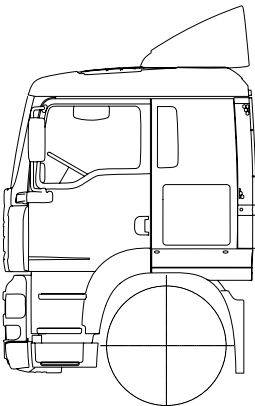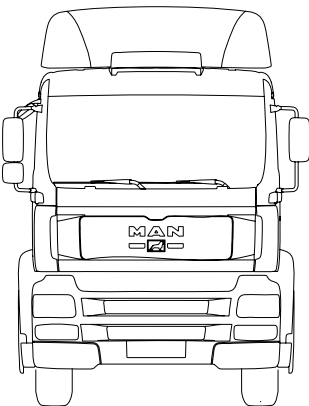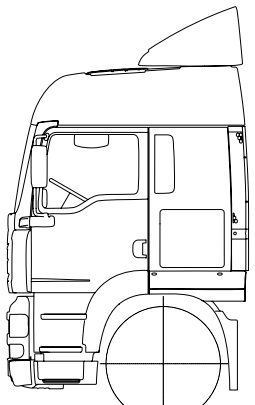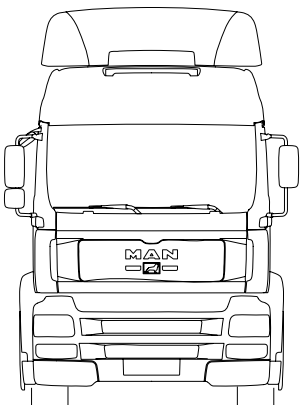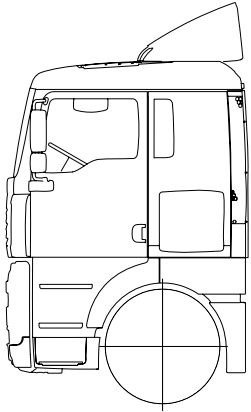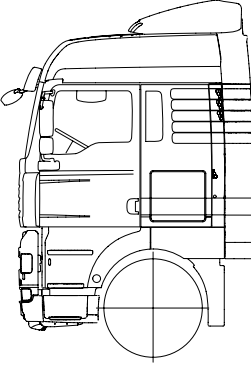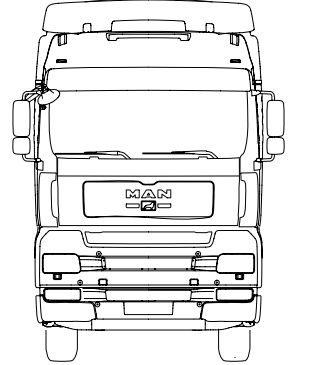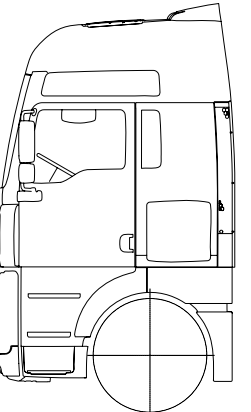
2.4 Cabs

There are 6 different Trucknology® Generation A cabs:

Table 7: Trucknology® Generation A cabs

| Description | | Dimensions* | | | Views | |
Name	Technical description	Length	Width	High roof	Side	Front
M	LHD F99**L15**S RHD F99**R15**S	1.880	2.240			
L	LHD F99**L32**S RHD F99**R32**S	2.280	2.240			
LX	LHD F99**L37**S RHD F99**R37**S	2.280	2.240	yes		

*) Dimensions refer to the cab without attachments such as mudguards, front spoiler, mirrors, roof spoiler etc.

Description		Dimensions*			Views	
Name	Technical description	Length	Width	High roof	Side	Front
XL	LHD F99**L40**S RHD F99**R40**S	2.280	2.440			
XLX	LHD F99 **L47** S RHD F99 **R47** S	2.280	2.440	yes, low		
XXL	LHD F99**L41**S RHD F99**R41**S	2.280	2.440	yes		

*) Dimensions refer to the cab without attachments such as mudguards, front spoiler, mirrors, roof spoiler etc.

2.5 Engine variants

In-line six-cylinder Diesel engines (R6) and a V10 with 4-valve technology from the D28 family of engines are installed in the TGA (D28 = 1st – 3rd digits of the engine designation). Engines with common rail injection are new additions to the range.
The engine programme has been extended since 2004 with two further engine ranges – the well known engines from the D08 range and the new D20 Common Rail range that are also available as Euro 4 engines with the PM-Kat®. Cummins engines of the ISMe range are only installed in ERF brand trucks (see table 6, model numbers).

Table 8:   TGA engines/engine designations D08D08 / D20 / D26 / D28

Vehicle designation	Emission class	Power [kW] at [rpm]	OBD generation	EGR	Exhaust gas after treatment	Max. torque [Nm] / at [rpm]	Engine type	Engine designation
xx.280	Euro 3	206 kW / 2.400	No OBD	With AGR	None	1.100 at 1.200 - 1.800 rpm	R6	D0836LF41
xx.330		240 kW / 2.400				1.250 at 1.200 - 1.800 rpm		D0836LF44
xx.310		228 kW / 1.900				1.500 at 900 - 1.300 rpm		D2866LF26
xx.310		228 kW / 1.900				1.550 at 1.000 - 1.300 rpm		D2066LF04
xx.360		265 kW / 1.900				1.700 at 900 - 1.400 rpm		D2866LF27
xx.350		257 kW / 1.900				1.750 at 1.000 - 1.300 rpm		D2066LF03
xx.410		301 kW / 1.900				1.850 at 900 - 1.300 rpm		D2866LF28
xx.390		287 kW / 1.900				1.900 at 1.000 - 1.300 rpm		D2066LF02
xx.430		316 kW / 1.900				2.100 at 1.000 - 1.300 rpm		D2066LF01
xx.460		338 kW / 1.900				2.100 at 900 - 1.300 rpm		D2876LF04
xx.510		375 kW / 1.900				2.300 at 1.000 - 1.300 rpm		D2876LF05
xx.480		353 kW / 1.900				2.300 at 1.000 - 1.400 rpm		D2876LF12
xx.530		390 kW / 1.900				2.400 at 1.000 - 1.400 rpm		D2876LF13
xx.660		485 kW / 1.900				2.700 at 1.000 - 1.600 rpm	V10	D2840LF25
xx.360		265 kW / 1.900				1.800 at 1.000 - 1.400 rpm	R6	D2066LF48
xx.400		294 kW / 1.900				1.900 at 1.000 - 1.400 rpm		D2066LF49
xx.440		324 kW / 1.900				2.100 at 1.000 - 1.400 rpm		D2066LF50
xx.480		353 kW / 1.900				2.300 at 1.050 - 1.400 rpm		D2676LF31
xx.310	Euro 4	228 kW / 1.900			PM-Kat®	1.550 at 1.000 - 1.400 rpm	R6	D2066LF14
xx.350		257 kW / 1.900				1.750 at 1.000 - 1.400 rpm		D2066LF13
xx.390		287 kW / 1.900				1.900 at 1.000 - 1.400 rpm		D2066LF12
xx.430		316 kW / 1.900				2.100 at 1.000 - 1.400 rpm		D2066LF11
xx.320		235 kW / 1.900	OBD 1			1.600 at 1.000 - 1.400 rpm		D2066LF35
xx.360		265 kW / 1.900				1.800 at 1.000 - 1.400 rpm		D2066LF33
xx.400		294 kW / 1.900				1.900 at 1.000 - 1.400 rpm		D2066LF32
xx.440		324 kW / 1.900				2.100 at 1.000 - 1.400 rpm		D2066LF31
xx.480		353 kW / 1.900				2.300 at 1.050 - 1.400 rpm		D2676LF01
xx.320		235 kW / 1.900	OBD 1 + NO_x control			1.600 at 1.000 - 1.400 rpm		D2066LF39

Vehicle designation	Emission class	Power [kW] at [rpm]	OBD generation	EGR	Exhaust gas after treatment	Max. torque [Nm] / at [rpm]	Engine type	Engine designation
xx.360	Euro 4	265 kW / 1.900	OBD 1 + NO$_X$ control	With EGR	PM-Kat®	1.800 at 1.000 - 1.400 rpm		D2066LF38
xx.400		294 kW / 1.900				1.900 at 1.000 - 1.400 rpm		D2066LF37
xx.440		324 kW / 1.900				2.100 at 1.000 - 1.400 rpm		D2066LF36
xx.480		353 kW / 1.900				2.300 at 1.050 - 1.400 rpm		D2676LF05
xx.400	Euro 5	294 kW / 1.900	NO OBD	No EGR	SCR	1.900 at 1.000 - 1.400 rpm	R6	D2066LF22
xx.440		321 kW / 1.900				2.100 at 1.000 - 1.400 rpm		D2066LF21
xx.400		294 kW / 1.900	OBD 1			1.900 at 1.000 - 1.400 rpm		D2066LF24
xx.440		324 kW / 1.900				2.100 at 1.000 - 1.400 rpm		D2066LF23
xx.480		353 kW / 1.900				2.300 at 1.050 - 1.400 rpm		D2676LF12
xx.540		397 kW / 1.900				2.500 at 1.050 - 1.350 rpm		D2676LF11
xx.320		235 kW / 1.900	OBD 1 + NO$_X$ control			1.600 at 1.000 - 1.400 rpm		D2066LF28
xx.360		265 kW / 1.900				1.800 at 1.000 - 1.400 rpm		D2066LF27
xx.400		294 kW / 1.900				1.900 at 1.000 - 1.400 rpm		D2066LF26
xx.440		324 kW / 1.900				2.100 at 1.000 - 1.400 rpm		D2066LF25
xx.480		353 kW / 1.900				2.300 at 1.050 - 1.400 rpm		D2676LF14
xx.540		397 kW / 1.900				2.500 at 1.050 - 1.350 rpm		D2676LF13
xx.320*		235 kW / 1.900				1.600 at 1.000 - 1.400 rpm		D2066LF20
xx.360*		265 kW / 1.900				1.800 at 1.000 - 1.400 rpm		D2066LF19
xx.400*		294 kW / 1.900				1.900 at 1.000 - 1.400 rpm		D2066LF18
xx.440*		324 kW / 1.900				2.100 at 1.000 - 1.400 rpm		D2066LF17
xx.480*		353 kW / 1.900				2.300 at 1.050 - 1.400 rpm		D2676LF16
xx.540*		397 kW / 1.900				2.500 at 1.050 - 1.350 rpm		D2676LF15

* = In case of NO$_X$ system failure, engines fitted with OBD 1b or OBD 2 are without torque reduction (TR). Only applies to engines for fire services, rescue services and military vehicles in accordance with Annex I.6558 of Directive 2005/55/EC, version 2006/81/EC

3.   General

National and international regulations take priority over technically permissible dimensions and weights if they limit the technically permissible dimensions and weights. The following data can be obtained from the quotation documents and documents contained in MANTED® at www.manted.de:

- Dimensions
- Weights
- Centre of gravity position for payload and body (minimum and maximum position for body) for the production standard chassis / tractor unit.

The data contained in these documents may vary depending on what technical features the vehicle is actually fitted with upon delivery. The critical factor is the vehicle's actual configuration and condition at the time delivery.
To achieve optimum payload carrying capability the chassis must be weighed before work starts on the body.
Calculations can then be made to determine the best centre of gravity position for payload and body as well as the optimum body length. As a result of component tolerances the weight of the standard chassis is allowed to vary by ± 5%, in accordance with DIN 70020. Any deviations from the standard equipment level will have a greater or lesser effect on dimensions and weights. Changes in equipment may result in deviations in the dimensions and weights, particularly if different tyres are fitted that then also lead to a change in the permissible loads.

In each individual case when a body is fitted care needs to be taken to ensure the following

- Under no circumstances may the permissible axle weights be exceeded
- A sufficient minimum front axle load is achieved
- The position of the centre of gravity and loading must not be one-sided
- The permissible overhang (vehicle overhang) is not exceeded.

3.1 Axle overload, one-sided loading

Fig. 1: Overloading the front axle ESC-052
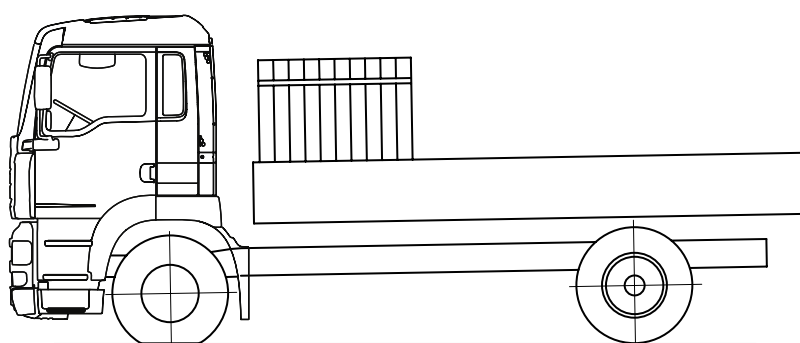
Fig. 2: Difference in wheel load ESC-126
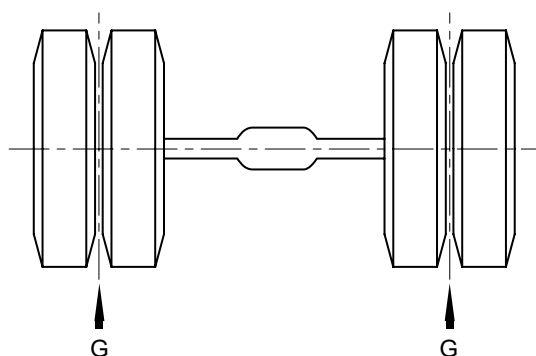
Formula 1: Difference in wheel load

$$\Delta G \leq 0{,}05 \cdot G_{tat}$$

The body must be designed such that one-sided wheel loads do not occur. Following checks, a maximum wheel load difference of 5 % is permitted (where 100 % represents the actual axle load and not the permissible axle load).

Example:

Actual axle load G_{tat} = 11.000kg

Therefore, the permissible wheel load difference is:

$$\Delta G \quad = \quad 0{,}05\ G_{tat} \ = \ 0{,}05 \cdot 11.000\ kg$$
$$\Delta G \quad = \quad 550\ kg$$

This means for example that the wheel load on one side is 5,225 kg and 5,775 kg on the other.
The calculated maximum wheel load provides no information on the permissible individual wheel load for the tyres fitted.
Information on this can be found in the technical manuals supplied by the tyre manufacturers.

3.2   Minimum front axle load

In order to maintain steerability, the stipulated minimum front axle load must be ensured under all vehicle load conditions, see table 11.

Fig. 3:   Minimum front axle loading ESC-051
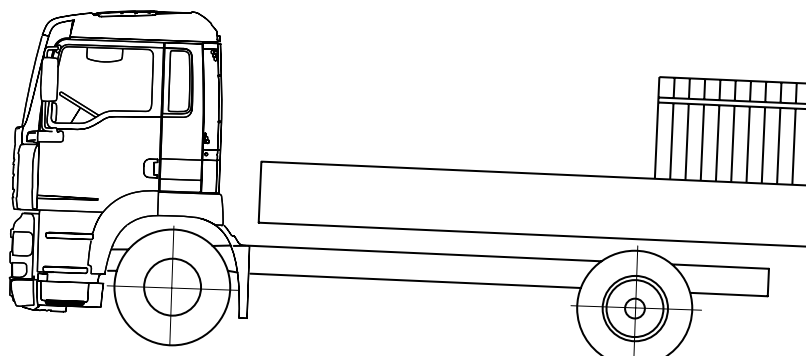
Table 9:   Minimum front axle loading for any load condition as a % of the respective actual vehicle weight

Minimum front axle loading for any load condition as a % of the respective actual vehicle weight SDAH = Rigid drawbar trailer ZAA = Centre-axle trailer GVW = Gross vehicle weight (vehicle/trailer)					
Number of axles	Wheel formula	Without SDAH /ZAA	With SDAH /ZAA GG ≤ 18 t	Tridem SDAH /ZAA GG > 18 t	Other rear load e.g. crane
Two-axle vehicle	4x2, 4x4H 4x4	25 %	25 %	30 %	30 %
More than 2 axles Three axle vehicles with lifting leading or trailing axles must be treated as having two axles when the lifting axles are raised. In this condition the higher minimum front axle load for two axle vehicles applies.	6x2/2, 6x2/4 6x2-2, 6x2-4 6x4, 6x4-4 6x4H/2, 6x4H/4 6x4H-2, 6x4H-4 6x6, 6x6H 8x2-4, 8x2-6 8x4, 8x4/4, 8x4-4 8x4H-6, 8x6, 8x6H, 8x8	20 %*	25 %*	30 %*	25 %*
If more than one front axle is fitted the % value is the total of the front axle loads. When operating with rigid drawbar trailers / centre-axle trailers + additional rear loads (e.g. tail-lift, crane) the higher value should be applied *= -2 % for steered leading/trailing axles					

These values are inclusive of any additional rear loads such as: Nose weights exerted by a centre-axle trailer

- loading cranes
- tail lifts
- fork lift trucks.

3.3 Wheels, rolling circumference

Different tyre sizes on the front and rear axle(s) can only be fitted to all-wheel-drive vehicles if the difference in rolling circumference of the tyres used does not exceed 2% or 1.5% if the MAN HydroDrive® system is installed. The notes in Chapter 5 "Body" relating to anti-skid chains, load rating and clearance must be observed.

3.4 Permissible overhang

The permissible overhang length is defined as the distance between the rear axle centreline (resulting from the theoretical wheelbase) and the end of the vehicle (including the bodywork). For definition see the following the following paragraph 3.5.

The following maximum values are permitted, expressed as a percentage of the theoretical wheelbase

- Two-axle vehicles 65 %
- all other vehicles 70 %.

If the vehicle is not equipped to tow trailers the above values may be exceeded by 5 %.
The basic requirement is that the minimum front axle loads given in table 9 (par. 3.2.) must be observed for every operating condition.

3.5   Theoretical wheelbase, overhang, theoretical axle centreline

The theoretical wheelbase is an aid for calculating the position of the centre of gravity and the axle loads.
The definition is given in the following figures.

Fig. 4:   Theoretical wheelbase and overhang – two-axle vehicle ESC-046
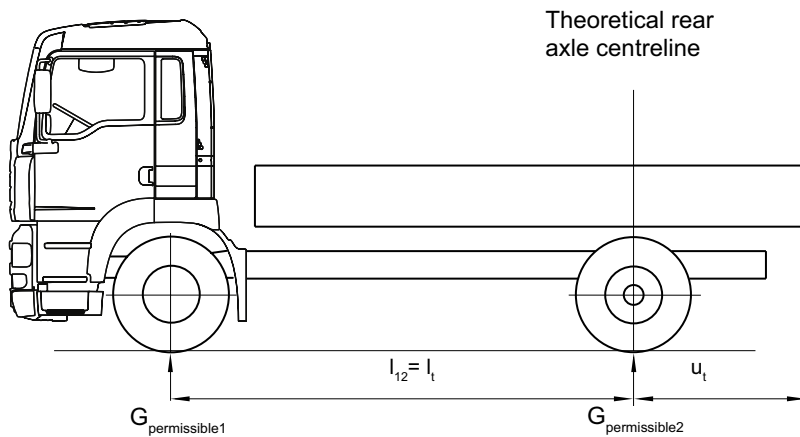
Formula 2:   Theoretical wheelbase for a two-axle vehicle

$$l_t = l_{12}$$

Formula 3:   Permissible overhang for a two-axle vehicle

$$U_t \leq 0{,}65 \cdot l_t$$

Fig. 5:   Theoretical wheelbase and overhang for a three-axle vehicle with two rear axles and identical rear axle loads ESC-047
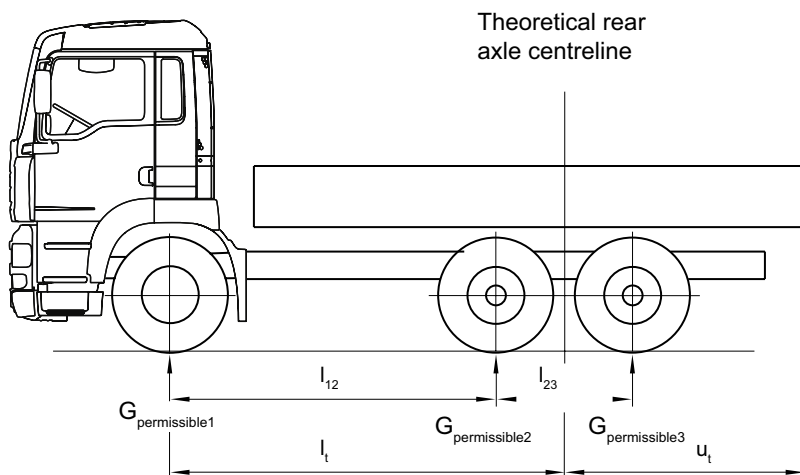
Formula 4:   Theoretical wheelbase for a three-axle vehicle with two rear axles and identical rear axle loads

$$l_t = l_{12} + 0,5 \cdot l_{23}$$

Formula 5:   Permissible overhang for a three-axle vehicle with two rear axles and identical rear axle loads

$$U_t \leq 0,70 \cdot l_t$$

Fig. 6:   Theoretical wheelbase and overhang for a three-axle vehicle with two rear axles and different rear axle loads (e.g. in the MAN vehicle range all 6x2's) ESC-048
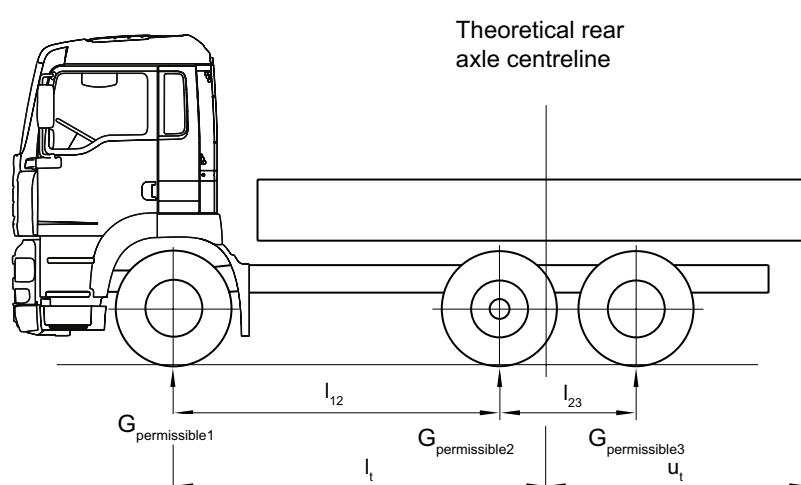
Formula 6:   Theoretical wheelbase for a three-axle vehicle with two rear axles and different rear axle loads

$$l_t = l_{12} + \frac{G_{permissible3} \cdot l_{23}}{G_{permissible2} + G_{permissible3}}$$

Formula 7:   Permissible overhang length three-axle vehicle with two rear axles and unequal rear axle loads

$$U_t \leq 0,70 \cdot l_t$$

Fig. 7:   Theoretical wheelbase and overhang for a four-axle vehicle with two front and two rear axles
          (any axle load distribution) ESC-050
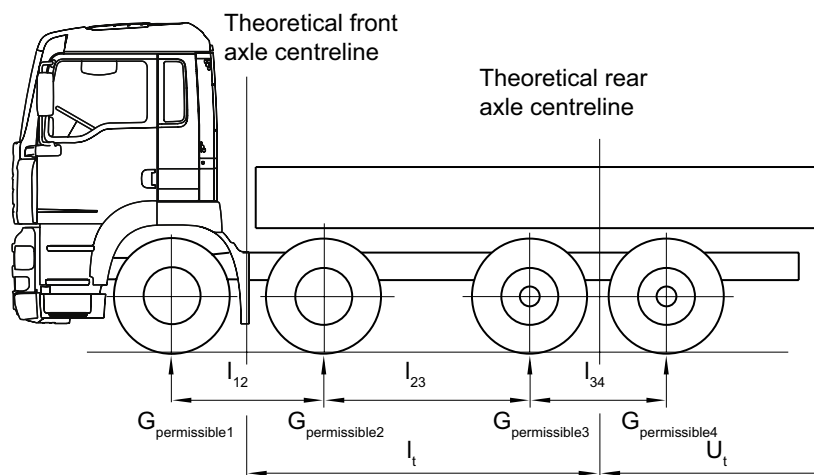
Formula 8:   Theoretical wheelbase for a four-axle vehicle with two front and two rear axles (any axle load distribution)

$$l_t = l_{23} + \frac{G_{permissible1} \cdot l_{12}}{G_{permissible1} + G_{permissible2}} + \frac{G_{permissible4} \cdot l_{34}}{G_{permissible3} + G_{permissible4}}$$

Formula 9:   Permissible overhang length for a four-axle vehicle with two front and two rear axles

$$U_t \leq 0{,}70 \cdot l_t$$

3.6   Calculating the axle load and weighing procedure

It is essential that an axle load calculation be completed in order to ensure correct design of the body.
Achieving optimum compatibility between bodywork and truck is only possible if the vehicle is weighed before any work on the body is commenced. The weights thus obtained are then taken as a basis for an axle load calculation. The weights given in the sales documents only apply to production standard vehicles. Manufacturing inaccuracies (within tolerances) may occur.

The vehicle must be weighed:

*   Without the driver
*   With a full fuel tank
*   With the handbrake released and the vehicle secured with chocks
*   If fitted with air suspension, raise the vehicle to normal driving position
*   Lower any liftable axles
*   Do not actuate any moving-off aid.

Observe the following sequence when weighing a vehicle:

Two-axle vehicles

- 1st axle
- 2nd axle
- whole vehicle as a check

Three-axle vehicles with two rear axles

- 1st axle
- 2nd together with 3rd axle
- whole vehicle as a check

Four axle vehicle with two front and two rear axles

- 1st together with 2nd axle
- 3rd together with 4th axle
- whole vehicle as a check

Four-axle vehicle with one front and three rear axles

- 1st axle
- 2nd together with 3rd and 4th axles
- whole vehicle as a check.

3.7 Checking and adjustment procedures once body has been fitted

On the TGA do **not** check or adjust:

- ALB settings: No adjustments necessary once bodywork has been fitted
- Tachograph 'MTCO' – this has already been calibrated at the factory
- Digital tachograph 'DTCO' – this has also been calibrated at the factory.

According to EU Directives however, a person authorised to carry out tests must enter the registration number (normally this has not been issued when the vehicle leaves the MAN factory).

Checking and adjustment procedures that must be completed by the bodybuilder once the body has been fitted:

- Basic beam alignment of the headlamps, see also Section 6.6 in this booklet for details
- Check battery charge status according to the charging schedule, sign battery charging log.
  See also the Chapter "Electrics, electronics, wiring"
- Check rear underride protection for compliance with statutory regulations, see Section 4.11.1" and adjust as necessary.
- Check sideguards for compliance with statutory regulations (for dimensions see the Chapter "Modifying the chassis")
  and adjust as necessary.

3.8 Notes on MAN Hydrodrive®

MAN Hydrodrive® is a hydrostatic front axle drive that employs wheel hub motors. The system is selectable and operates in the speed range between 0 and 28 km/h. Vehicles fitted with Hydrodrive® are legally regarded as off-road vehicles as defined by 70/156 EEC (as last amended by 2005/64/EU and 2005/66/EG).

The Hydrodrive® hydraulic circuit is solely approved for the regulated drive of the front axle and may not be used to supply other hydraulic systems. Modifications to the Hydrodrive® hydraulic system (including relocating pipework) may only be carried out by specifically authorised companies.

In the case of semi-trailer tippers and other bodies where there is a risk of the cargo falling into the area around the oil cooler an oil cooler cover must be fitted. This is available fitted ex-works or as a retrofit solution under the name ‚Protective cover for oil cooler/fan for HydroDrive®'. (Installation no. 81.36000.8134).

4. Modifying the chassis

To provide customers with the products they want, additional components sometimes need to be installed, attached or modified. For uniformity of design and ease of maintenance, we recommend that original MAN components be used as long as these comply with the vehicle's structural design. To keep maintenance work to a minimum, we recommend the use of components that have the same maintenance intervals as the MAN chassis.

Modifications to safety-critical components of wheel/axle guides, steering and brakes are not allowed. Existing anti-roll bars may neither be removed nor modified.

Installation and/or modification of components frequently requires intervention in the control unit's CAN architecture (e.g. when extending the EBS electronic braking system). The necessary modifications and/or expansion of the vehicle programming are described under the corresponding topic in these guidelines.

Such modifications may only be undertaken with assistance from the electronics experts at MAN service centres and the programming must be approved by the ESC department (for address see "Publisher" above). Retrofitted systems may, under certain circumstances, not be assimilated into the vehicles' on-board Trucknology® systems "Time maintenance system" of "Flexible maintenance system". For this reason it is not possible to achieve the same degree of maintenance convenience as is possible with original equipment.

4.1 Frame material

When carrying out modifications to the chassis longitudinal and cross-members only use of the original frame material S500MC (QStE 500TM) is approved.
Exception: For profile 33, the longitudinal members are made of S420MC = QStE420TM.

Table 10:　　　Steel for TGA frame

Material number	Previous material designation	Previous standard	$\sigma_{0,2}$ N/mm^2	σ_B N/mm^2	New material designation	New standard	Profile codes as per table 11
1.0980	QStE420TM	SEW 092	≥ 420	480-620	S420MC	DIN EN 10149-2	33
1.0984	QStE500TM	SEW 092	≥ 500	550-700	S500MC	DIN EN 10149-2	31 32 34

For subframe longitudinal and cross-members only steels with a yield point of $\sigma_{0,2}$ ≥ 350 N/mm^2 may be used. For additional details on subframes see the Subframe Chapter 5.3.3.
For the TGA the following longitudinal frame members are used, depending on the model.

Fig. 8: Profile data for longitudinal frame members ESC-112

Table 11: Profile data for longitudinal frame members, profiles in bold are used for the TGA range

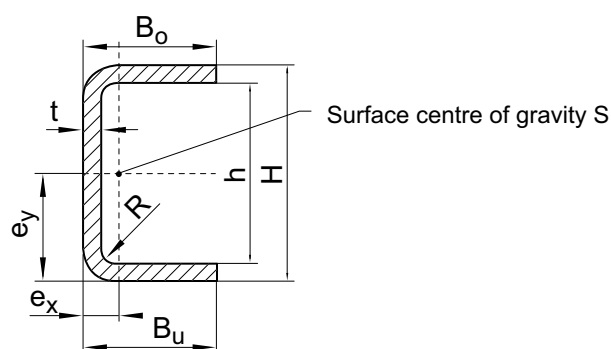| No	H mm	h mm	B_o mm	B_u mm	t mm	R mm	G kg/m	$\sigma_{0,2}$ N/mm²	σ_B N/mm²	A Mm²	e_x mm	e_y mm	I_x cm⁴	W_{x1} cm³	W_{x2} cm³	I_y cm⁴	W_{y1} cm³	W_{y2} cm³
1	220	208	80	85	6	10	17	420	480..620	2.171	21	110	1.503	138	135	135	64	21
2	222	208	80	80	7	10	20	420	480..620	2.495	20	111	1.722	155	155	142	71	24
3	222	208	75	75	7	10	19	420	480..620	2.425	18	111	1.641	148	148	118	66	21
4	224	208	75	75	8	10	22	420	480..620	2.768	19	112	1.883	168	168	133	70	24
5	220	208	70	70	6	10	16	420	480..620	2.021	16	110	1.332	121	121	85	53	16
6	322	306	80	80	8	10	29	420	480..620	3.632	17	161	4.821	299	299	176	104	28
7	262	246	78	78	8	10	24	420	480..620	3.120	18	131	2.845	217	217	155	86	26
8	260	246	78	78	7	10	21	420	480..620	2.733	18	130	2.481	191	191	138	77	23
9	224	208	80	80	8	10	22	420	480..620	2.848	20	112	1.976	176	176	160	80	27
10	262	246	80	80	8	10	25	420	480..620	3.152	19	131	2.896	221	221	167	88	27
11	273	247	85	85	7[1]	6[2]	31	355	510	3.836	26	136	4.463	327	327	278	108	47
12	209	200	65	65	4,5	8	11	260	420	1.445	15	105	868	83	83	52	35	10
13	210	200	65	65	5	8	13	260	420	1.605	15	105	967	92	92	58	39	12
14	220	208	70	80	6	10	16	420	480..620	2.081	18	107	1.399	131	124	105	58	17
15	222	208	70	80	7	10	19	420	480..620	2.425	18	108	1.638	152	144	120	67	19
16	234	220	65	65	7	8	19	420	480..620	2.381	15	117	1.701	145	145	80	53	16
17	220	208	75	75	6	10	16	420	480..620	2.081	18	110	1.400	127	127	103	57	18
18	218	208	70	70	5	10	13	420	480..620	1.686	16	109	1.105	101	101	72	45	13
19	222	208	70	70	7	10	18	420	480..620	2.355	17	111	1.560	141	141	97	57	18
20	260	246	70	70	7	10	21	420	480..620	2.621	15	130	2.302	177	177	101	67	18
21	210	200	65	65	5	8	13	420	480..620	1.605	15	105	967	92	92	58	39	12
22	330	314	80	80	8	10	29	420	480..620	3.696	17	165	5.125	311	311	177	104	28
23	270	254	80	80	8	10	25	420	480..620	3.216	18	135	3.118	231	231	168	93	27
24	274	254	80	80	10	10	31	420	480..620	4.011	19	137	3.919	286	286	204	107	33
25	266	254	80	80	6	10	19	420	480..620	2.417	18	133	2.325	175	175	130	72	21
26	224	208	70	70	8	10	21	420	480..620	2.688	17	112	1.789	160	160	109	64	21
27	268	254	70	70	7	10	21	420	480..620	2.677	15	134	2.482	185	185	102	68	19
28	270	254	70	70	8	10	24	420	480..620	3.056	15	135	2.843	211	211	114	76	21

Table 11: Profile data for longitudinal frame members, profiles in bold are used for the TGA range

No	H mm	h mm	B_o mm	B_u mm	t mm	R mm	G kg/m	$\sigma_{0,2}$ N/mm²	σ_B N/mm²	A Mm²	e_x mm	e_y mm	I_x cm⁴	W_{x1} cm³	W_{x2} cm³	I_y cm⁴	W_{y1} cm³	W_{y2} cm³
29	334	314	80	80	10	10	36	420	480..620	4.611	17	167	6.429	385	385	215	126	34
30	328	314	80	80	7	10	25	420	480..620	3.237	16	164	4.476	273	273	158	99	25
31	**270**	**254**	**85**	**85**	**8**	**10**	**26**	**500**	**550..700**	**3.296**	**20**	**135**	**3.255**	**241**	**241**	**201**	**101**	**31**
32	**270**	**251**	**85**	**85**	**9,5**	**10**	**30**	**500**	**550..700**	**3.879**	**21**	**135**	**3.779**	**280**	**280**	**232**	**110**	**36**
33	**334**	**314**	**85**	**85**	**10**	**10**	**37**	**420**	**480..620**	**4.711**	**19**	**167**	**6.691**	**401**	**401**	**257**	**135**	**39**
34	**270**	**256**	**85**	**85**	**6,8**	**10**	**22**	**500**	**550..700**	**2.821**	**19**	**135**	**2.816**	**209**	**209**	**174**	**92**	**26**
35	220	212	70	70	4	10	11	420	480..620	1.367	16	110	921	84	84	59	37	11
36	220	211	70	70	4,5	10	12	420	480..620	1.532	16	110	1.026	93	93	65	41	12
37	220	206	70	70	7	10	18	420	480..620	2.341	17	110	1.526	139	139	97	57	18
38	220	204	70	70	8	10	21	420	480..620	2.656	17	110	1.712	156	156	108	64	20
39	270	256	70	70	7	10	21	420	480..620	2.691	15	135	2.528	187	187	102	68	19
40	270	256	70	70	7	10	21	500	550..700	2.691	15	135	2.528	187	187	102	68	19
41	270	254	70	70	8	10	24	420	480...620	3.056	15	135	2.843	211	211	114	76	21
42	**270**	**254**	**85**	**85**	**8**	**10**	**26**	**500**	**480...620**	**3.296**	**20**	**135**	**3.255**	**241**	**241**	**201**	**101**	**31**
43[3]	**270**	**254**	**85**	**85**	**8**	**10**	**26**	**500**	**560...700**	**3.296**	**20**	**135**	**3.255**	**241**	**241**	**201**	**101**	**31**

[1] Upper and lower flange 13 mm thick
[2] Outside radius 10 mm
[3] LNE500 in accordance with Brazilian Standard NBR 6656:2008, for TGX in Latin America (status 03 2010: CKD types 28X. 88X)

Table 12 gives the standard model-related allocation of longitudinal frame members valid on the date of publication of this guide.
No guarantee is given or implied as to the currentness or completeness of this data.
Up-to-date and binding instructions on the longitudinal frame member profile to be used can be found in:

•   the chassis drawing
•   the technical data sheet

which can be found for the corresponding vehicle at www.manted.de under "Chassis".

Table 12:   Model-related allocation of longitudinal frame member profiles for TGA

Tonnage	Vehicle	Suffix	Model	Profile code	Specifics
18 t	TGA 18.xxx 4x2	BLS-TS BLS-TS BLS-TS	H01 H08 H11	34	Tractor unit for tanker /Silo
		BB BB BL BL BL LL LL LLS-U LLS-U LL-U LL-U BL-WW	H02 H03 H05 H06 H07 H09 H10 H12 H13 H14 H15 H61	31 42 31	
	TGA 18.xxx 4x4 TGA 18.xxx 4x4H	BB BB BL BL BL	H51 H52 H22 H70 H80	31	
19 t	TGA 19.xxx 4x2	BBS-WW BB-WW	H43 H60	32 32	
25 t	TGA 25.xxx 6x2-2, 6x2-4	LL-U LL-U	H44 H45	31	
26 t	TGA 26.xxx 6x2-2, 6x2-4 TGA 26.xxx 6x4H	BL BL BL LL LL LL BL BL LL	H16 H17 H18 H19 H20 H21 H35 H27 H31	31	
26 t	TGA 26.xxx 6x2/2, 6x2/4 TGA 26.xxx 6x4H	BL BL BL BL	H23 H24 H32 H42	31	
26 t	TGA 26.xxx 6x4	BB BB	H25 H26	31/32	Profile 31 for wheelbase ≤ 3.900+1.400 Profile 32 for wheelbase > 3.900+1.400
		BL BL BL-WW	H29 H30 H63	31	
26 t	TGA 26.xxx 6x6 TGA 26.xxx 6x6H	BB BB BB BL BL	H55 H47 H56 H72 H82	31/32	Profile 31 for wheelbase ≤ 3.900+1.400 Profile 32 for wheelbase > 3.900+1.400

Tonnage	Vehicle	Suffix	Model	Profile code	Specifics
28 t	TGA 28.xxx 6x2-4 TGA 28.xxx 6x2-2	BL, LL LL BL LL BL	H71 H85 H86 H87 H89	31	TA steered TA with twin tyres TA with twin tyres TA with twin tyres TA with twin tyres
28 t	TGA 28.xxx 6x4-4	BL	H81	31	TA steered
28 t	TGA 28.xxx 6x6-4	BL	H83	31	TA steered and driven
32 t	TGA 32.xxx 8x4	BB BB	H48 H49	34	Only transport mixers and rear tippers
33 t	TGA 33.xxx 6x4	BB BB BB-WW BB-WW	H25 H26 H28 H62	31/32	Profile 31 for wheelbase ≤ 3.900+1.400 Profile 32 for wheelbase > 3.900+1.400
		BLBL	H29 H30	31	
33 t	TGA 33.xxx 6x6 TGA 33.xxx 6x6H	BB BB-WW BB BB BL BL	H47 H54 H55 H56 H72 H82	31/32	Profile 31 for wheelbase ≤ 3.900+1.400 Profile 32 for wheelbase > 3.900+1.400
35 t	TGA 35.xxx 8x2-4, 8x2-6	BL BL	H88 H90	31	
	TGA 35.xxx 8x4	BB BB BL BL	H36 H37 H40 H41	31	
	TGA 35.xxx 8x4-4	BL BL	H91 H92	31	
35 t	TGA 35.xxx 8x6	BB BB	H73 H93	31	At permissible gross weights ≤ 35 t
35 t	TGA 35.xxx 8x8	BB BB	H76 H96	31	At permissible gross weights ≤ 35 t
40 t	TGA 40.xxx 6x4	BB-WW BB	H33 H34	32	
40 t	TGA 40.xxx 6x6	BB-WW BB	H57 H58	32	
41 t	TGA 41.xxx 8x4	BB BB BB-WW	H38 H39 H46	32	
41 t	TGA 41.xxx 8x4/4	BB, BLBB, BL	H94 H95	33	
41 t	TGA 41.xxx 8x6	FFDA FFDA	H73 H93	32	At permissible gross weights > 35 t
	TGA 41.xxx 8x8	FFDA FFDA	H76 H96	32	At permissible gross weights > 35 t

4.2 Corrosion protection

Surface and corrosion protection affects the service life and appearance of the product. In general, the quality of the coatings on body components should be equal to that of the chassis.

In order to fulfil this requirement, the **MAN Works Standard M 3297 "Corrosion protection and coating systems for non-MAN bodies"** is binding for bodies that are ordered by MAN. If the customer commissions the body, this standard becomes a recommendation only. Should the standard not be observed, MAN provides no guarantee for any consequences.
MAN-works standards may be sourced via www.normen.man-nutzfahrzeuge.de, registration required.

Series production MAN chassis are coated with environmentally friendly, water-based 2-component chassis top-coat paints at approx. 80°C. To guarantee uniform coating, the following coating structure is required for all metal component assemblies on the body and subframe:

- Bare metal or blasted component surface (SA 2.5)
- Primer coat: 2-component epoxy primer, approved in accordance with MAN works standard M 3162-C or, if possible, cathodic dip painting to MAN works standard M 3078-2, with zinc phosphate pre-treatment
- Top coat: 2-component top-coat paint to MAN works standard M 3094, preferably water-based; if there are no facilities for this, then solvent-based paint is also permitted. (www.normen.man-nutzfahrzeuge.de, registration required).

Instead of priming and painting the vehicle with a top coat, the substructure of the body (e.g. longitudinal and cross-members, corner plates) may also be galvanised. See the relevant paint manufacturer's data sheets for information on tolerances for drying and curing times and temperatures. When selecting and combining materials the compatibility of the different metals (e.g. aluminium and steel) must be taken into consideration as must the effects of the 'electrochemical series' (cause of contact corrosion).

After all work on the chassis has been completed:

- Remove any drilling swarf
- Remove burrs from the edges
- Apply wax preservative to any cavities

Mechanical connections (e.g. bolts, nuts, washers, pins) that have not been painted over must be given optimum corrosion protection. To prevent the occurrence of salt corrosion whilst the vehicle is stationary during the body-building phase, all chassis must be washed with clean water to remove any salt residues as soon as they arrive at the body manufacturer's premises.

4.3 Drill holes, riveted joints and screw connections on the frame

If possible, use the holes already drilled in the frame. No drilling should be carried out in the flanges of the longitudinal frame member profiles, i.e. in the upper and lower flanges (see Fig. 9). The only exception to this is at the rear end of the frame, outside the area of all the parts fitted to the frame that have a load-bearing function for the rearmost axle (see Fig. 10).
This also applies to the subframe.

Fig. 9:   Frame drill holes in the upper and lower flange ESC-155   **Fig. 10:**   Drill holes at frame end ESC-032
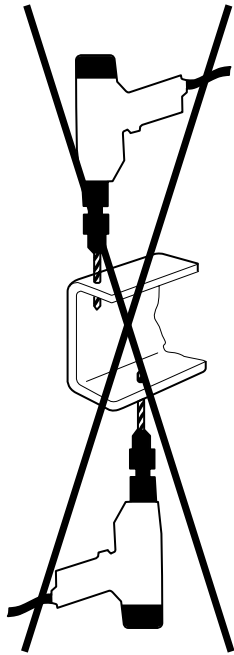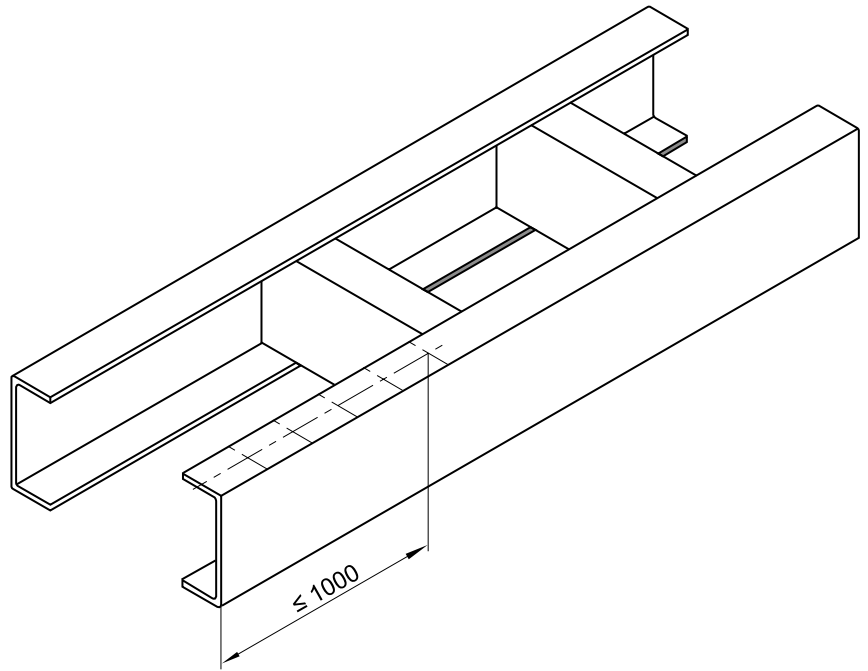
It is allowable to make drillings in the frame along its total useable length. However, the permissible distances between holes must be observed (see Fig. 11). After drilling, rub down all holes and remove any burrs.

Fig. 11:   Distances between drill holes ESC-021
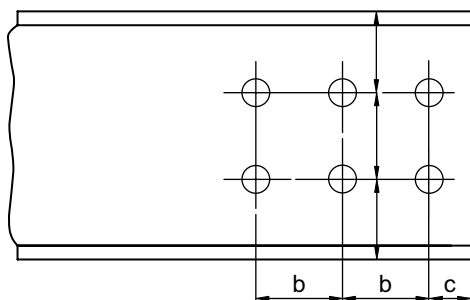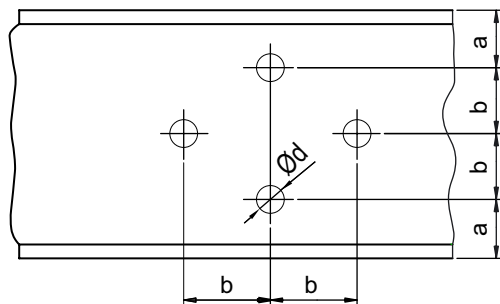
a ≥ 40
b ≥ 50
c ≥ 25
TGA: d ≤ 16

Several frame components and add-on components (e.g. corner plates with cross member, shear plates, platform corner pieces) are riveted to the frame during production. If modifications to these components need to be carried out afterwards, screw connections with a minimum strength class of 10.9 and mechanical locking device are permitted. MAN recommends double nip countersunk bolts/nuts to MAN standard M 7.012.04 (may be sourced via www.normen.man-nutzfahrzeuge.de). The manufacturer's stipulated tightening torque must be observed. If double nip countersunk bolts are reinstalled then new bolts/nuts must be used on the tightening side. The tightening side can be recognised by slight marks on the bolt's nips or nut flange (see Fig. 12).

Fig. 12:   Marks on the bolt's nips on the tightening side ESC-216
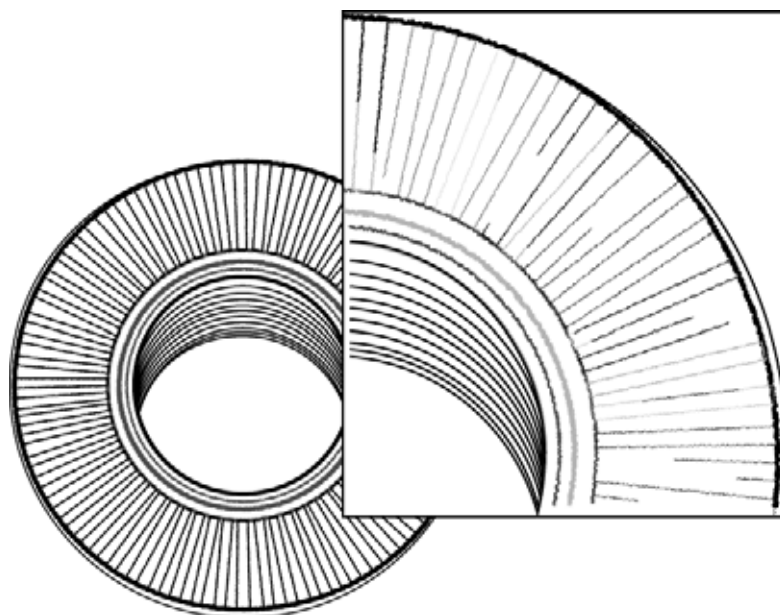
Alternatively, it is possible to use high-strength rivets (e.g. Huck®-BOM, blind fasteners) – manufacturers' installation instructions must be followed. The riveted joint must be at least equivalent to the screw connection in terms of design and strength.
In principle it is also possible to use flange bolts. MAN draws your attention to the fact that such flange bolts place high requirements on installation accuracy. This applies particularly when the grip length is short.

4.4 Modifying the frame

4.4.1 Welding the frame

As a rule, no welding work is to be carried out on the frame and axle mountings other than that described in these guidelines or in the MAN repair instructions. Welding work on components and assemblies that are subject to design approval (e.g. coupling devices, underride protection) may only be carried out by the design approval holder. Welding work on these components will otherwise lead to the withdrawal of the design approval!

Welders must have specialist knowledge in chassis welding. The workshop must therefore employ suitably trained and qualified personnel to carry out the required welding work (e.g. in Germany, according to the DVS leaflets 2510 – 2512 "Carrying out repair welding work on commercial vehicles", available from the DVS publishing house).

The frames of MAN commercial vehicles are made from high-strength fine-grain steels. Welding work on the frame is only permitted using the respective original frame material; see Chapter 4.1. The fine-grain steels used during manufacture are well suited for welding. Performed by a qualified welder, the MAG (metal-active gas) and MMA (manual metal arc) welding methods ensure high quality, long lasting welded joints.

Recommended welding materials:

    MAG   SG 3 welding wire
    E   B 10 electrode.

It is important to prepare the area of the weld thoroughly before welding so that a high-quality joint can be achieved.
Heat-sensitive parts must be protected or removed. The areas where the part to be welded joins the vehicle and the earth terminal on the welding equipment must be bare; therefore any paint, corrosion, oil, grease, dirt, etc., must be removed.
Only direct current welding may be employed; note the polarity of the electrodes.
Pipes/wires (air, electric) in the vicinity of the weld must be protected against heat. It is better to remove them completely.

Fig. 13:   Protecting heat-sensitive parts ESC-156

Plastic tube
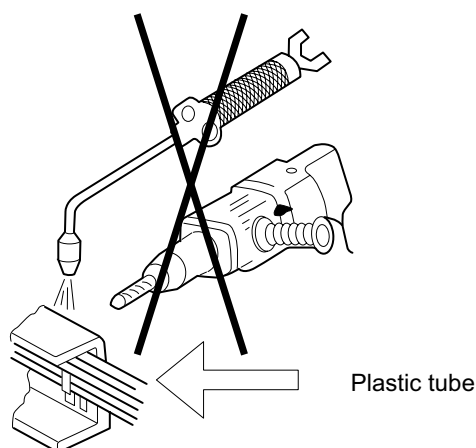
Welding should not be attempted if the ambient temperature falls below +5°C.
No undercuts are to be made whilst carrying out welding work (see fillet welds, Fig. 14). Cracks in the weld seam are not permitted.
Joint seams on the longitudinal members are to be made as V or X seams in several passes. Vertical welds should be carried out from bottom to top (see Fig. 16).

Fig. 14: Undercuts ESC-150
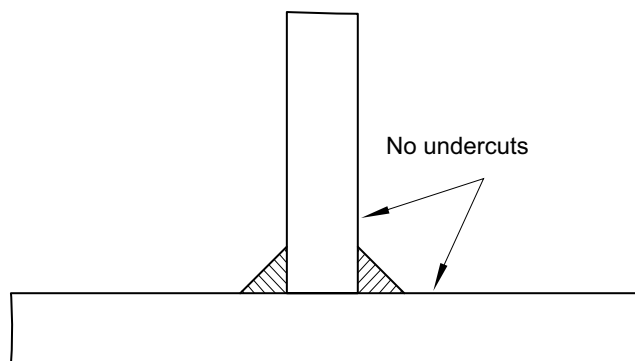
Fig. 15: Welding at X and Y seam ESC-003

No undercuts

at least 2 passes

Root pass
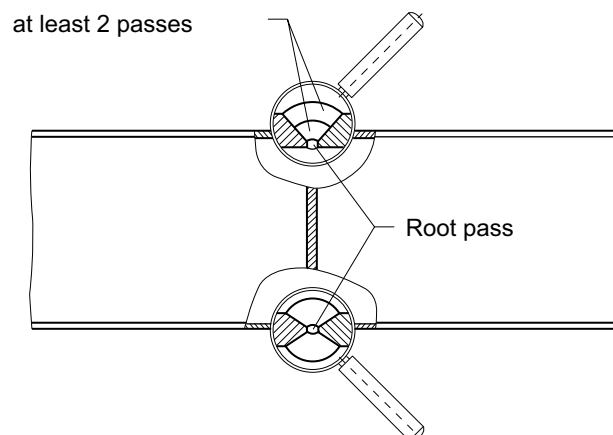
Fig. 16: Vertical welds on the frame ESC-090

Direction of welding
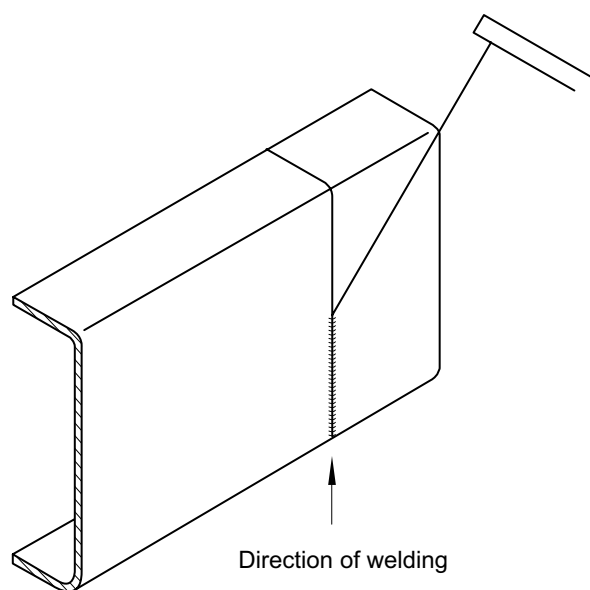
To prevent damage to electronic assemblies (e.g. alternator, radio, FFR, EBS, EDC, ECAS), adhere to the following procedure:

- Disconnect the positive and negative leads at the battery; join the loose ends of the cables together (- with +)
- Turn on the battery master switch (mechanical switch) or bypass the electric battery master switch on the solenoid (disconnect cables and join together)
- Attach the earth clip of the welding equipment directly to the area to be welded, ensuring there is good conductivity (see above)
- If two parts are to be welded together, connect them together first, ensuring good conductivity (e.g. connect both parts to the earth clip)

It is not necessary to disconnect electronic components and assemblies if the procedure detailed above is followed exactly.

4.4.2 Modifying the frame overhang

If the rear overhang is modified, the centre of gravity of the payload and the body shifts and, as a result, the axle loads change.
Only an axle load calculation can show whether this is within the permissible range. Such a calculation is therefore essential and must be carried out before beginning the work. The frame overhang may only be extended using the same material as was used for the frame during manufacture, see Chapter 4.1.
Extending the frame using several profile sections is not permissible.

Fig. 17: Extending the frame overhang ESC-093

Frame extension

Frame extension
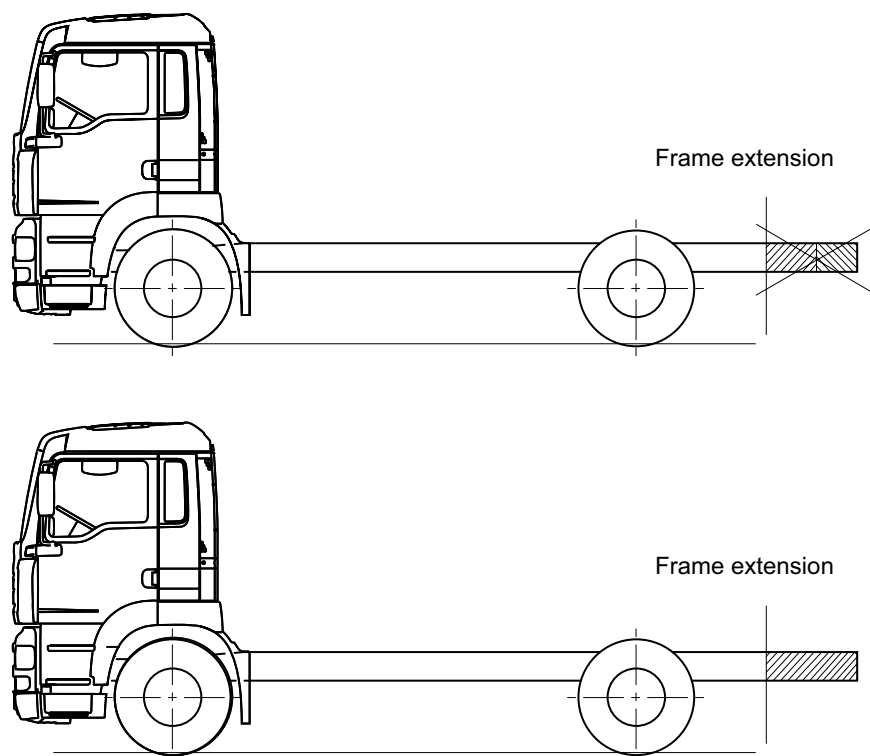
CAN wiring harnesses may never be cut and lengthened.
Pre-prepared wiring harnesses are available from MAN for rear lights, auxiliary rear lights, trailer sockets, side marker lamps and ABS cables. Detailed procedures are given the booklet 'TG Interfaces'.

If it is intended to extend vehicles with short overhangs, the existing cross member between the rear spring hangers must be left in place.

An additional frame cross member must be fitted if the distance between the cross members is more than 1,500 mm (see Fig. 18). A tolerance of +100 mm is permitted. There must always be an end cross member fitted.

Fig. 18: Max. distance between frame cross members ESC-092

≤ 1500
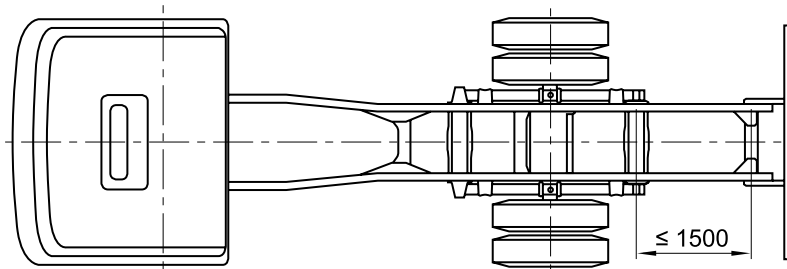
The rear frame end may be tapered (see Fig. 19).
The resulting reduced cross-section of the longitudinal frame member profile must still be of sufficient strength.
No taperings are allowed in the vicinity of the axle locating parts.

Fig. 19: Tapered frame end ESC-108

Interior height ≥ end cross member height

≤ 30°

≤ 800

No taper in the area of axle
location parts
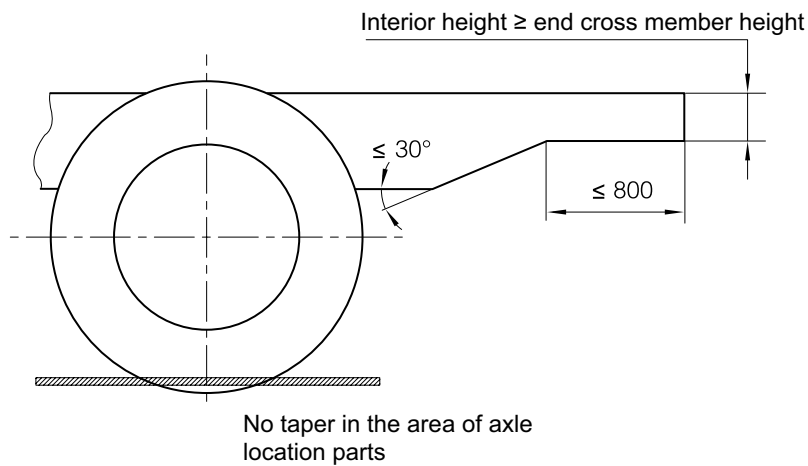
If a frame overhang is shortened as far as the axle guide or suspension (e.g. rear spring hanger, stabiliser bracket) the cross members in this area (normally tubular cross-members) must either remain in place or be replaced with suitable original MAN end cross members (see Fig. 20).

Fig. 20: Frame end of a tractor unit ESC-503
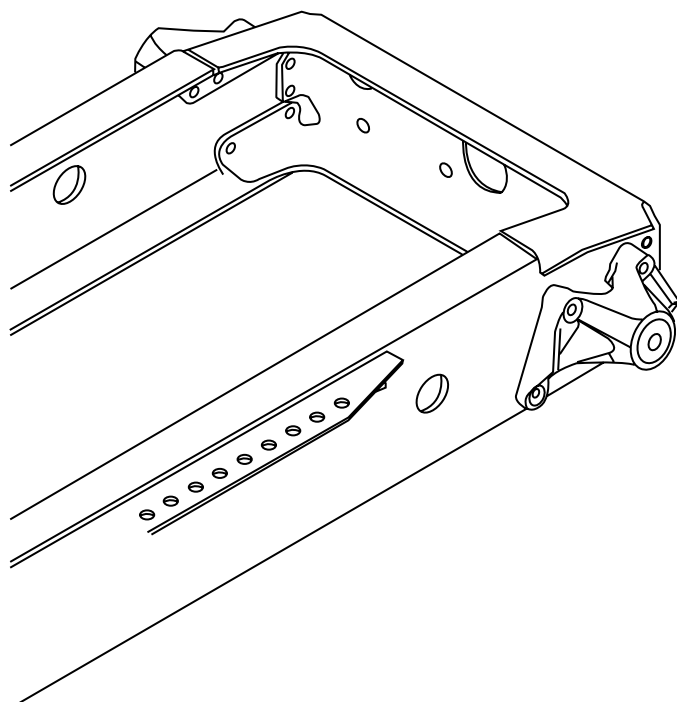
4.4.3   Modifications to the wheelbase

Technical design specifications applicable to steering (in particular 70/311 EEC, last amended by 2004/09/24) mean that, depending upon the number and type of steered axles, wheelbase, tyres axle loads and permissible gross weight, chassis of the TGA range are fitted with different steering wheels (diameter), steering gear (range of ratios) and steering oil piping (cooling coils). **Therefore, when considering wheelbase extensions the ESC Department at MAN (for address see "Publisher" above) should always be first consulted as to whether the planned change to the wheelbase will require other steering component modifications.** Parameterisation of the wheelbase modification (see next paragraph) is only possible if the correct components have been installed. MAN shall not be liable for errors, made as a result of late consultations, that lead to increased cost. In addition, before commencing any work, an application must be made to the MAN repair shop for a conversion data file (vehicle parameterisation) quoting the new wheelbase. Parameterisation is carried out using the MAN-cats® diagnosis system.

Modifications to the wheelbase can be made by:

*   Moving the entire rear axle assembly
*   Disconnecting the longitudinal frame members and inserting or removing a section of frame.

Provided modifications are carried out in accordance with all of the following points, wheelbase modifications will have been carried out properly and approval will not be necessary.

The new wheelbase must remain between the minimum and maximum standard wheelbase for the same model according to model code (see Chapter 2.2, Table 5). Exceptions only with the approval of the ESC department (for address see "Publisher" above). The maximum distance between the cross members following a wheelbase modification is 1,500 mm. A tolerance of +100 mm is permitted. Any modifications to the driveshaft section of the driveline must be carried out according to the guidelines contained in this Guide to Fitting Bodies, see Chapter 4.6.3.1 and the instructions provided by the driveshaft manufacturer. If the new wheelbase is the same as a series wheelbase on a production model, then the arrangement of the driveshaft and cross members must be the same as that for a series wheelbase vehicle. Guidelines on moving air pipes and electric cables are contained in Chapter 6, "Electrics, electronics and wiring"). CAN wiring harnesses may not be cut, therefore when shortening the wheelbase, the wiring harness should simply be routed over a longer distance. Do not form rings or loops. During wheelbase extensions all rear axle related control units and sensors must be moved with the axle. Appropriate wiring harness adapters are therefore available for all rear axle related control units and sensors. System, method and item numbers are described in detail in the booklet 'Interfaces TG'. Axle guide components and suspension (e.g. spring hangers, trailing arm brackets) may not be located in the area ahead of and within the bends in the frame, a minimum clearance of 100 mm to the 2nd frame break must be adhered to (see Fig. 21).

Fig. 21:   Forbidden zone for rear axle locating parts ESC-500
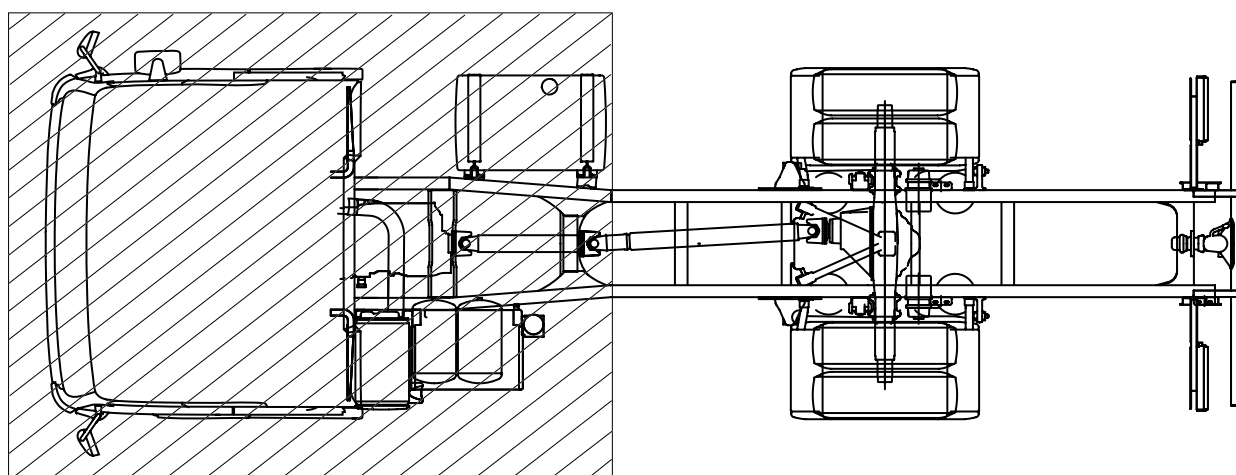
On types with hydraulic forced steering of the trailing axle "ZF-Servocom® RAS" (all 6x2-4), depending upon the extent of the wheelbase modification, steering arms with different steering angles must be installed on the 1st and 2nd axles, according to table 13.

Table 13:   Steering arms for 6x2-4 with "ZF-Servocom® RAS" trailing axle steering

Wheelbase [mm] 1st –2nd axle	Steering armitem no.	max. steering angle steering arm
3.900 ≤ 4.200	81.46705.0508	19°
> 4.200 ≤ 4.800	81.46705.0004	16,5°
> 4.800 ≤ 5.500	81.46705.0509	14,5°
> 5.500	81.46705.0510	13,5°

On types fitted with "ZF-Servocom® RAS-EC" electronic/hydraulic leading axle steering system (all 6x2/4 and 8x4/4 vehicles) extending the wheelbase is not possible – however shortening it is. Modifications to the steering system are inadmissible.
On vehicles with two mechanically steered front axles (e.g. 8x4) steered axles may only be moved by MAN vehicle modification partners. This is because the steering system must be professionally modified and only MAN vehicle modification partners may receive the required software update.

Shortening the wheelbase is possible for these models if the guidelines listed here are followed.

Moving axles

The axle-mounting brackets, axle locating hardware and cross-members should be completed using rivets or MAN double nip countersunk bolts to MAN Standard M 7.012.04 (may be sourced via www.normen.man-nutzfahrzeuge.de) as described in Section 4.3. Observe the hole-to-hole distances specified there!

Welding

The guidelines on welding in this Guide to Fitting Bodies (see Chapter 4.4.1) must be observed. If frame components are to be inserted, such as longitudinal frame members, frame inserts, the original frame material must be used. For frame materials see Chapter 4.1. It is recommended that the longitudinal frame members are pre-heated to 150°C – 200°C.

The frame must not be disconnected in the vicinity of:

- Points where loads are introduced from the body
- Bends in the frame, minimum distance 100 mm
- Axle guides and suspension (e.g. spring hangers, trailing arm mountings), minimum distance 100 mm
- Transmission mountings (including transfer cases on all-wheel drive vehicles), engine mountings

The allowable area for welds when performing wheelbase modifications lies between the bend in the frame and the front-most rear axle guide. Welded seams along the longitudinal axis of the vehicle are not permitted!
Position of weld seams see Fig. 22.

Fig. 22: Allowable weld area ESC-501
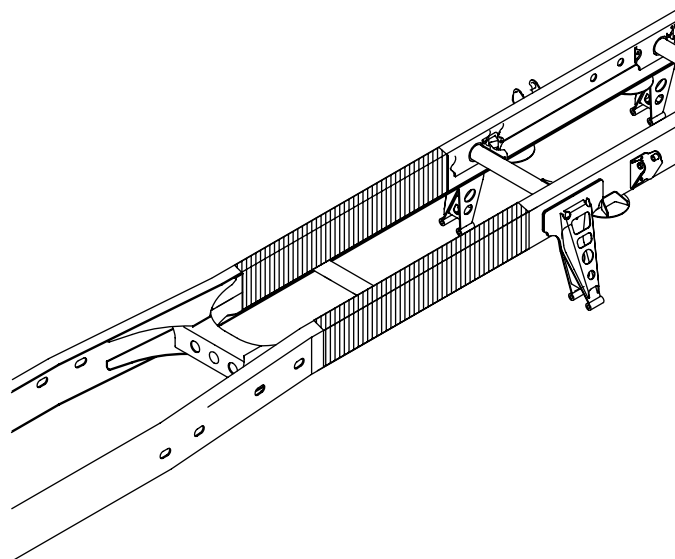
If changing the wheelbase involves disconnecting the longitudinal frame members, the weld seams must be secured with inserts, in accordance with Fig. 23 or Fig. 24.

Fig. 23: Inserts for shortening the wheelbase ESC-012
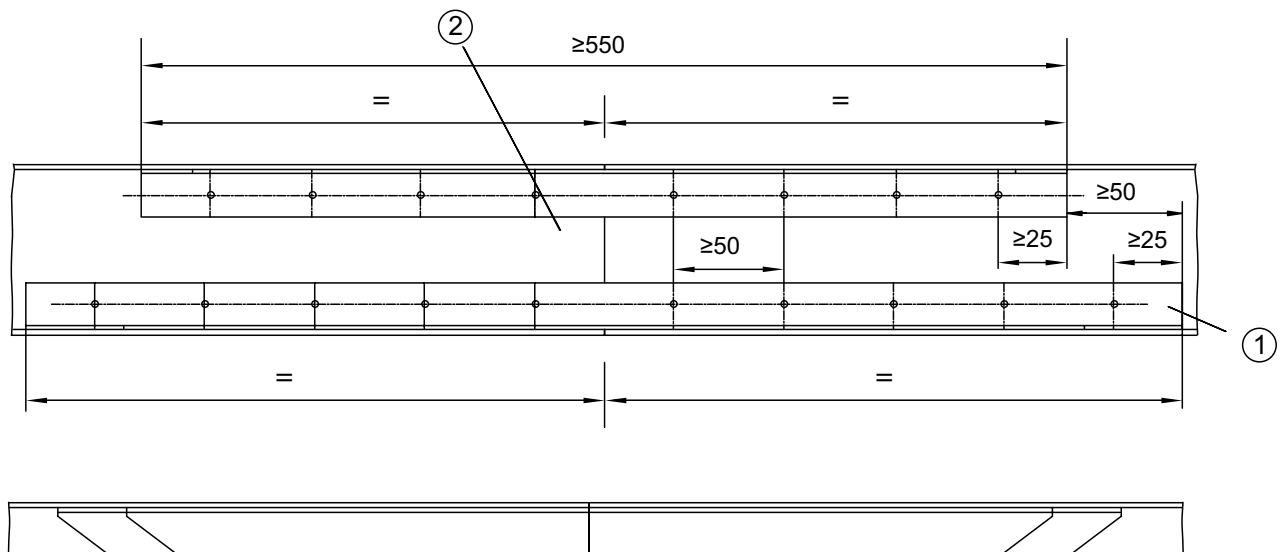
① Use the existing drill holes in the frame in the vicinity of the angle
inserts. Distance between drill holes ≥ 50, Distance between edges ≥ 25

② Level the weld seam where parts should be in contact.
Weld seam by assessment group BS, DIN 8563, part 3.

③ Use profile sections with equal flange lenghts.
Width is the same as the inner width of the frame. Tolerance - 5 mm.
Thickness same as frame thickness. Tolerance -1. Material min. S355J2G3 (St52-3)
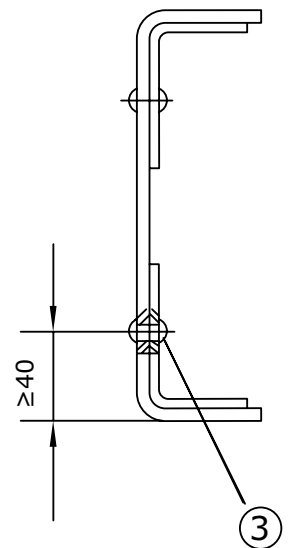
Fig. 24: Inserts for extending the wheelbase ESC-013
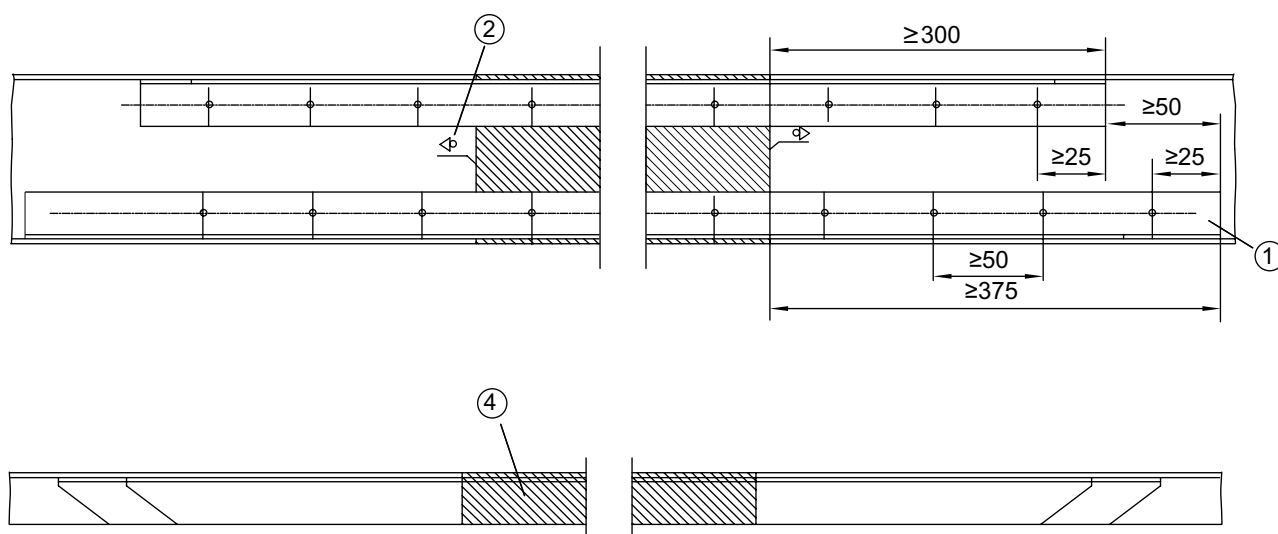
① Use the existing frame drill holes in the area of the angle inserts.
Angle inserts must be of one piece.
Distance between drill holes ≥ 50, edge distance ≥ 25

② Level the weld seam where parts should be in contact.
Weld seam by assesment group BS, DIN 8563, part 3.

③ Use profile sections with equal flange lengths.
Width is the same as the inner width of the frame. Tolerance -5.
Rolled sections are not permitted.
Thickness same as frame thickness. Tolerance -1. Material S355J3G3 (St52-3)

④ Extend the wheelbase using a section of the original frame longitudinal member.
Material as stated in the Guide to Fitting Bodies, frame profile list.
Observe max. distance between frame cross members as stated in the Guide to Fitting Bodies.
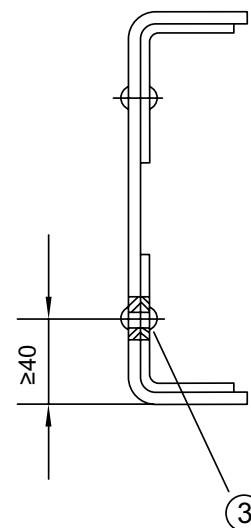
On some long-wheelbase chassis, frame inserts are already fitted between the front and rear axles at the factory.

Frame inserts may not be welded together with the longitudinal frame members. This can be avoided for example, by inserting a copper-based separating foil which is removed once the welding work is completed. Inserts used in changing the wheelbase may be simply butted-up to one another and may either be welded together or joined with an overlapping plate (see Fig. 25).

Fig. 25:   Overlapping inserts on inside and outside ESC-504
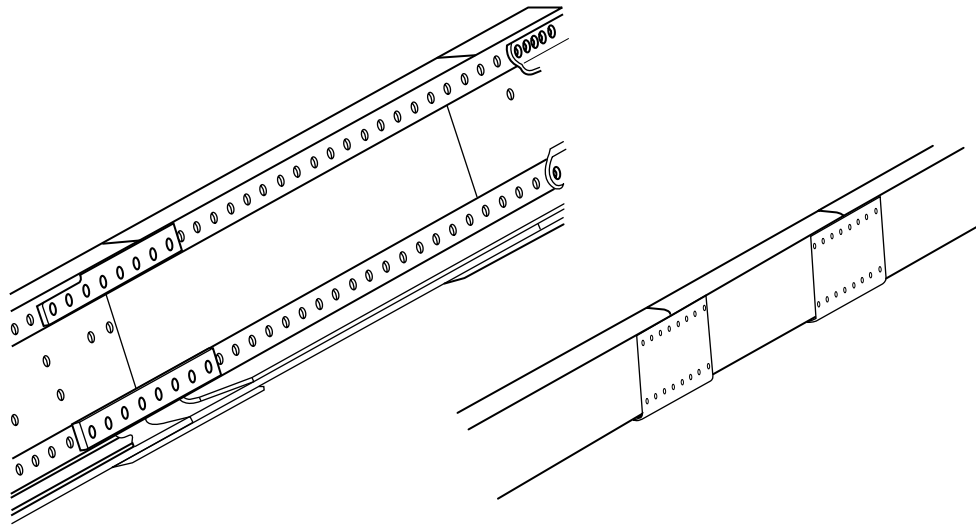
The section point between the frame and the insert joint may not coincide with a welded joint in the frame.
A distance between the joints of 100 mm must be observed. This is easy to achieve if during cutting of the frame the location of the frame-insert joint is already taken into account.

Fig. 26:   Overlapping insert on inside and outside ESC-505
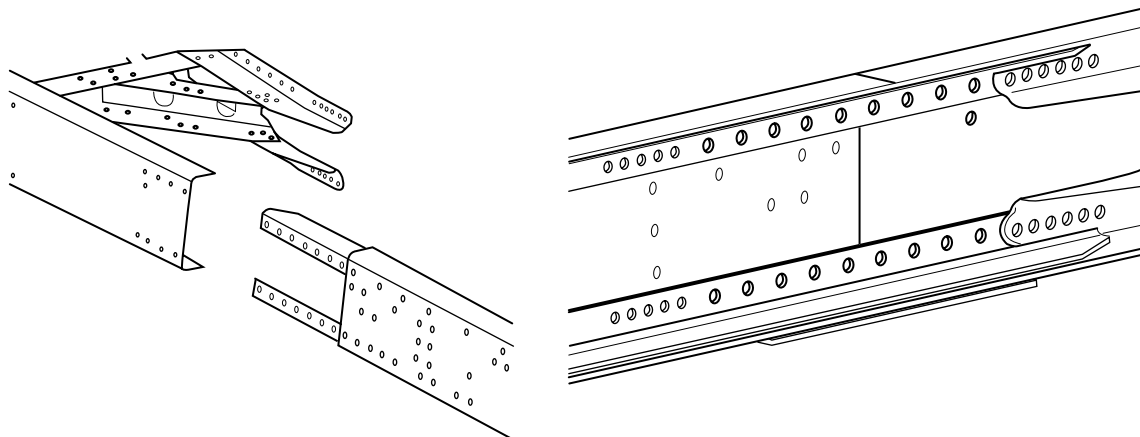
4.5   Retrofitting additional equipment add-on components or accessories

The manufacturer of an assembly, add-on component or accessory must co-ordinate the installation with MAN.
Retrofit installation of components frequently requires intervention in the control unit's CAN architecture (e.g. when extending the EBS electronic braking system).
Such work always requires modification of the vehicle parameterisation. Retrofitted systems may, under certain circumstances, not be assimilated into the vehicles' on-board Trucknology® systems "Time maintenance system" of "Flexible maintenance system".
For this reason it is not possible to achieve the same degree of maintenance convenience as is possible with original equipment.
Subsequent modification or expansion of the vehicle parameterisation can only be carried out with the help of the electronics specialists at MAN service centres with subsequent approval by MAN. As a result, retrofit installation of components must be agreed with the ESC Department (see "Publisher" above) at the planning stage. ESC will first check to see if it is actually possible to carry out the planned work. For the approval procedure it is essential therefore, that full and verifiable documentation be provided.
Under no circumstances does MAN accept responsibility for the design or for the consequences of non-approved retrofitted equipment. The conditions stated in this Guide and in the approvals must be observed. Approvals, reports and clearance certificates that have been compiled by third parties (e.g. test and inspection authorities) do not automatically mean that MAN will also issue approval. MAN reserves the right to refuse approval even though third parties may have issued clearance certificates.
Unless otherwise agreed, approval only refers to the actual installation of the equipment. Approval does not mean that MAN has checked the entire system with regard to strength, vehicle handling etc., and has accepted responsibility for warranty of products. The responsibility for this lies with the company carrying out the work. Retrofitting of equipment may change the vehicle's technical data. The equipment manufacturer and/or the dealer / importer is responsible for determining and issuing this new data.

4.5.1   Retrofitting additional or larger fuel tanks after factory delivery

Fuel is taxed at different rates – even within the EU. If larger or additional fuel tanks are fitted after the vehicle has been delivered from the manufacturer's factory then the additional tank volume becomes subject to the mineral oil excise duty applicable in the country into which it is being imported upon crossing the border. Only fuel that is carried in the so-called „standard tanks" (plus fuel carried in reserve fuel canisters up to a maximum quantity of 20 litres) is free of duty. Standard tanks are the fuel tanks fitted to the vehicle when it was delivered from the factory and not fuel tanks added at a later time by a body builder or workshop for example.

4.6 Propshafts

Jointed shafts located in areas where people walk or work must be encased or covered.

4.6.1 Single joint

When a single cardan joint, universal joint or ball joint is rotated uniformly whilst bent it results in a non-uniform movement on the output side (see Fig. 27). This non-uniformity is often referred to as cardan error. The cardan error causes sinusoidal-like fluctuations in rotational speed on the output side. The output shaft leads and trails the input shaft. The output torque of the propshaft fluctuates in line with this, despite constant input torque and input power.

Fig. 27: Single joint ESC-074
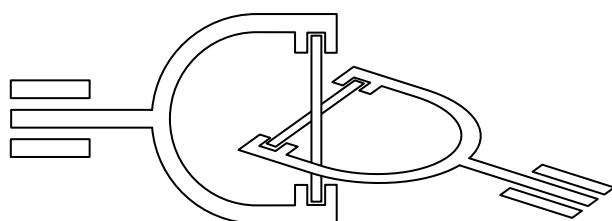
Because acceleration and deceleration occur twice during each revolution, this type of propshaft and layout cannot be permitted for attachment to a power take-off. A single joint is feasible only if it can be proven without doubt that because of the

* mass moment of inertia
* rotational speed and
* the angle of deflection

the vibrations and loads are not significant.

4.6.2   Jointed shaft with two joints

The non-uniformity of the single joint can be compensated for by combining two single joints in one propshaft.
However, full compensation of the movement can be achieved only if the following conditions are met:

*   Both joints have the same working angle, i.e. $ß_1 = ß_2$
*   The two inner yokes of the joint must be in the same plane
*   The input and output shafts must also be in the same plane, see Figs. 28 and 29.

All three conditions must always be met simultaneously so that the cardan error can be compensated for.
These conditions exist in the so-called Z and W arrangements (see Figs. 28 and 29). The common working plane that exists for Z or W arrangements may be freely rotated about the longitudinal axis.

The exception is the three-dimensional propshaft layout, see Fig. 30.

Fig. 28:   W propshaft layout ESC-075
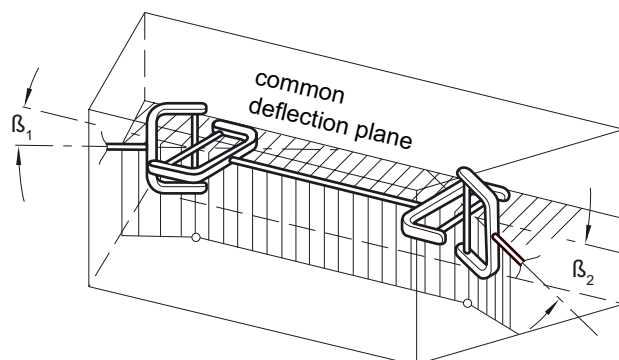
Fig. 29:   Z propshaft layout ESC-076
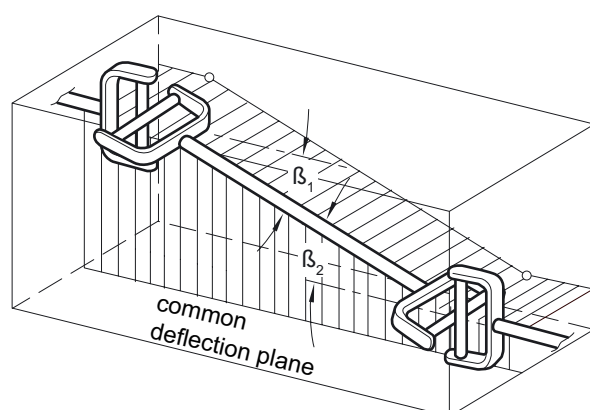
4.6.3 Three-dimensional propshaft layout

If the input and output shafts are not in the same plane the layout is three-dimensional. The centre lines of the input and output shafts are not parallel. There is no common plane and therefore, to compensate for the fluctuations in angular velocity, the inner yokes (forks) of the joint must be offset by angle „γ" (Gamma) - see Fig. 30.

Fig. 30: Three-dimensional propshaft layout ESC-077
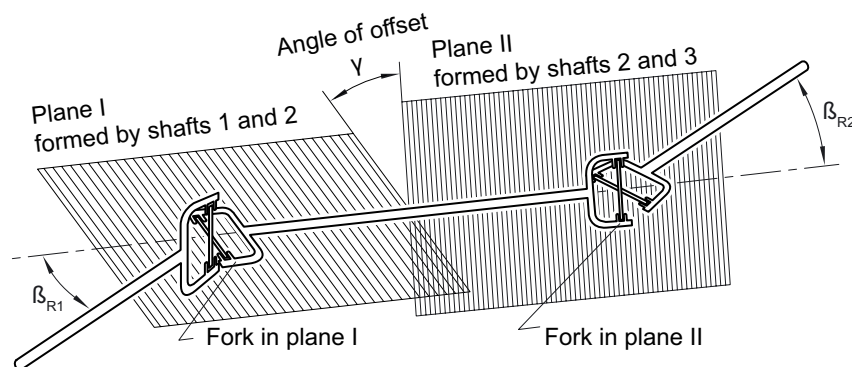
The condition that the resulting working angle $ß_{R1}$ on the input shaft must be exactly the same as the working angle $ß_{R2}$ on the output shaft still applies.

Therefore:

$$ß_{R1} = ß_{R2}$$

Where:

$ß_{R1}$	=	three-dimensional angle of shaft 1
$ß_{R2}$	=	three-dimensional angle of shaft 2.

Three-dimensional working angle $ß_R$ is a function of the vertical and horizontal angle of the propshafts and is calculated as:

Formula 10: Three-dimensional working angle

$$\tan^2 ß_R = \tan^2 ß_v + \tan^2 ß_h$$

The required angle of offset γ (Gamma) can be calculated using the joint angles in the horizontal and vertical planes as follows:

Formula 11: Angle of offset γ

$$\tan γ_1 = \frac{\tan ß_{h1}}{\tan ß_{v1}}; \quad \tan γ_2 = \frac{\tan ß_{h2}}{\tan ß_{v2}}; \quad γ = γ_1 + γ_2$$

Where:

$ß_R$	=	Three-dimensional working angle
$ß_v$	=	Vertical working angle
$ß_h$	=	Horizontal working angle
γ	=	Angle of offset.

Note:

In the case of three-dimensional offset of a propshaft with two joints only the three-dimensional working angles need to be equal. In theory therefore, an infinite number of layout options can be achieved from the combination of the vertical and horizontal working angles.

We recommend that the manufacturers' advice be sought for determining the angle of offset of a three-dimensional propshaft layout.

4.6.3.1 Propshaft train

If the design dictates that greater lengths have to be spanned, propshaft systems comprising two or more shafts may be used. Fig. 31 shows three basic forms of propshaft system in which the position of the joints and the drivers with respect to each other were assumed to be arbitrary. Drive dogs and joints are to be matched to each other for kinematic reasons. Propshaft manufacturers should be consulted when designing the system.

Fig. 31:   Propshaft train ESC-078
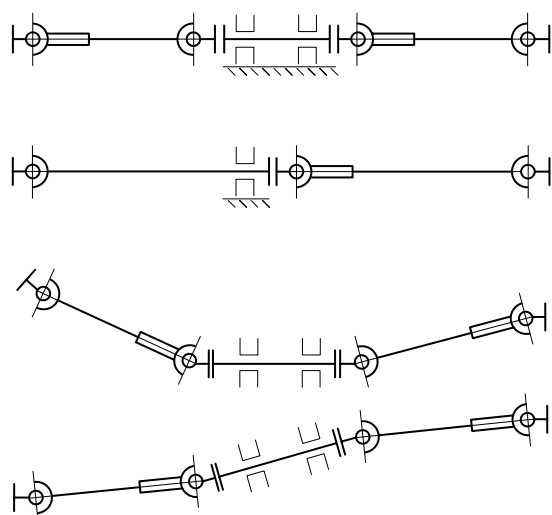
4.6.3.2 Forces in the propshaft system

The joint angles in propshaft systems inevitably introduce additional forces and moments. If a telescoping propshaft is extended or compressed whilst under load whilst under load further additional forces will be introduced.

Dismantling the propshaft, twisting the two halves of the shaft and then putting them back together again will not compensate for the imbalances, it is more likely to exacerbate the problem. Such „trial and error" may cause damage to the propshafts, the bearings, the joint, the splined shaft profile and assemblies. It is therefore essential that the markings on the propshaft are observed. The marks must therefore be aligned when the joints are fitted (see Fig. 32).

Fig. 32:   Marking on propshaft ESC-079
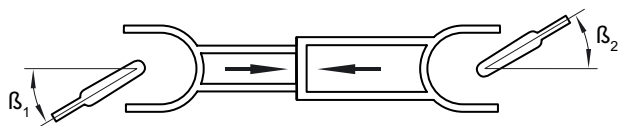
Do not remove existing balancing plates and do not confuse propshaft parts otherwise imbalances will occur again.
If one of the balancing plates is lost or propshaft parts are replaced, the propshaft should be re-balanced.

Despite careful design of a propshaft system, vibrations may occur that may cause damage if the cause is not eliminated.
Suitable measures must be used to cure the problem such as installing dampers, the use of constant velocity joints or changing the entire propshaft system and the mass ratios.

4.6.4   Modifying the propshaft layout in the driveline of MAN chassis

Body manufacturers normally modify the propshaft system when:

*   Modifying the wheelbase as a retrofit operation
*   Installing pumps on the driveshaft flange of the power take-off.

In such cases the following must be observed:

*   The working angle of each cardan shaft in the driveline must be 7° maximum in each plane when loaded.
*   If propshafts are to be extended the entire propshaft system must be re-designed by a propshaft manufacturer.
*   Every propshaft must be balanced before installation.

4.7   Modifying the wheel formula

Modifying the wheel formula means:

*   The installation of extra axles
*   The removal of axles
*   Changing the type of suspension (e.g. from leaf suspension to air suspension)
*   Making non-steered axles steerable

Modifying the wheel formula are forbidden.
These modifications will be only carried out by MAN Truch & Bus AG and their suppliers.

4.8 Coupling devices

4.8.1 Basics

If the truck is intended to pull loads, the equipment required to do this must be fitted and approved. Compliance with the minimum engine power required by legislation and/or the installation of the correct trailer coupling does not provide any guarantee that the truck is suitable for pulling loads. The ESC department at MAN (for address see "Publisher" above) must be contacted if the standard or ex-works permissible gross vehicle weight is to be changed.

Contact must not occur between the truck and the trailer during manoeuvring. Adequate drawbar lengths should therefore be selected. The legal requirements pertaining to trailer couplings (EU: 94/20/EC and country-specific regulations) must be observed. The required clearances must also be taken into consideration (in Germany, these are defined in DIN 74058 and EC Directive 94/20/EC).

The bodybuilder is obliged to ensure that the body is designed and constructed such that the coupling process can be performed and monitored unhindered and without incurring any risks. The freedom of movement of the trailer drawbar must be guaranteed. If coupling heads and sockets are installed offset to one side (e.g. on the driver's side rear light holder) the trailer manufacturer and vehicle operator must ensure that the cables/pipes are long enough for cornering.

Fig. 33: Clearances for trailer couplings in accordance with 94/20/EC ESC-006
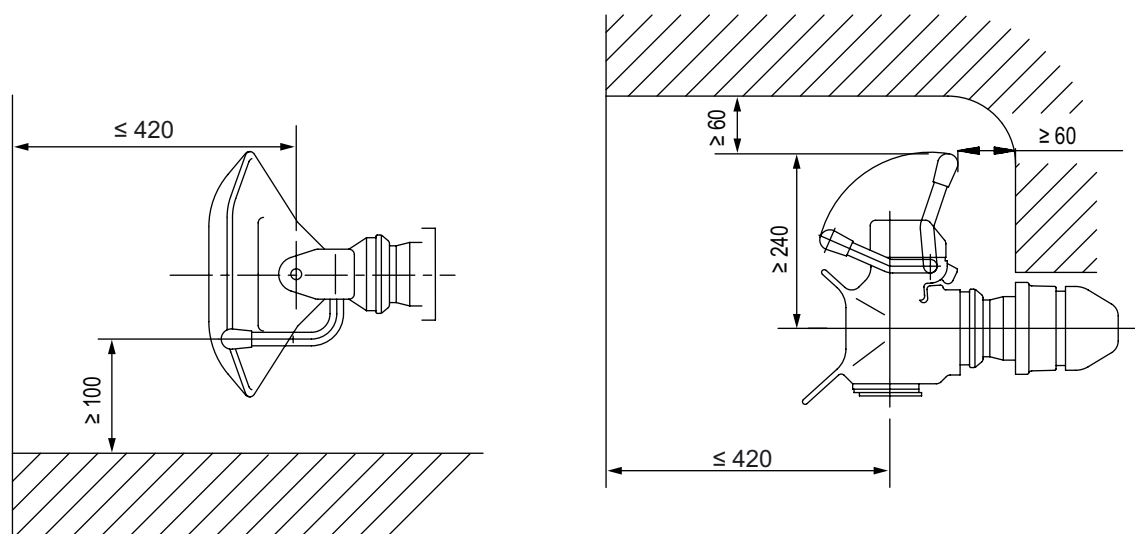
Fig. 34:   Clearances for trailer couplings in accordance with DIN 74058 ESC-152
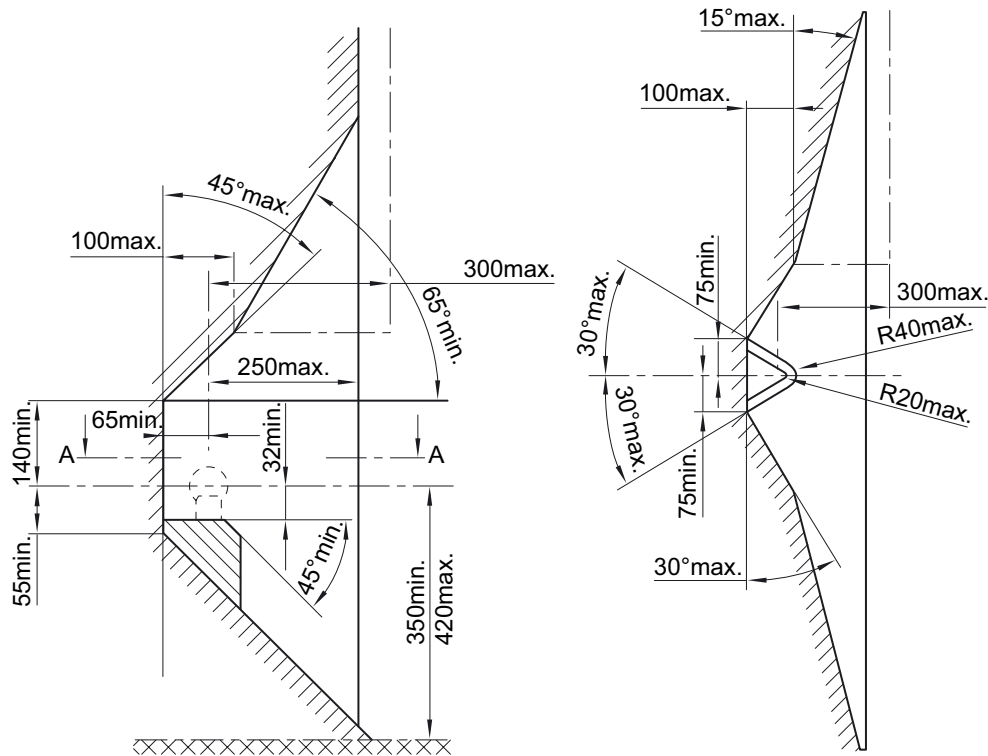
Only original MAN end cross members and their associated reinforcement plates may be used when fitting trailer couplings.
End cross members have a hole pattern that matches that of the associated trailer coupling. This hole pattern may under no circumstances be modified to suit a different trailer coupling. The guidelines provided in the coupling manufacturers' installation instructions must be observed (e.g. tightening torques and their checking).
Lowering the trailer coupling without also lowering the end cross member is not permitted!
Some examples of how the coupling may be lowered are shown in Figs. 35 and 36.
These examples are purposely represented only schematically – they do not form a design instruction.
Design responsibility rests with the respective bodybuilder/ converter.

Fig. 35:   Lowered trailer coupling ex.ESC-015 ESC-515
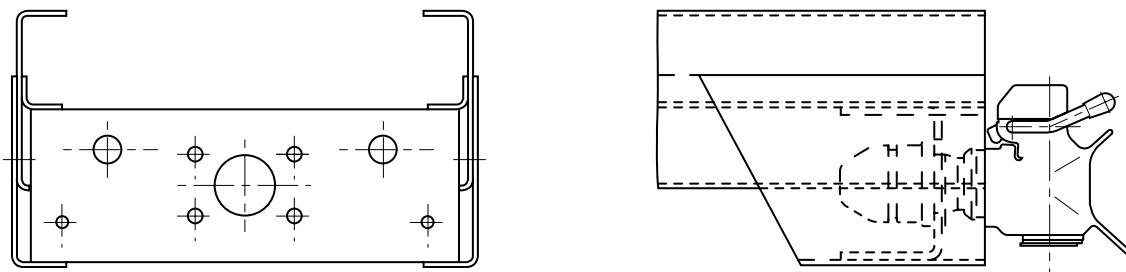
Fig. 36:   Trailer coupling fitted below the frame ex. ESC-042 ESC-542
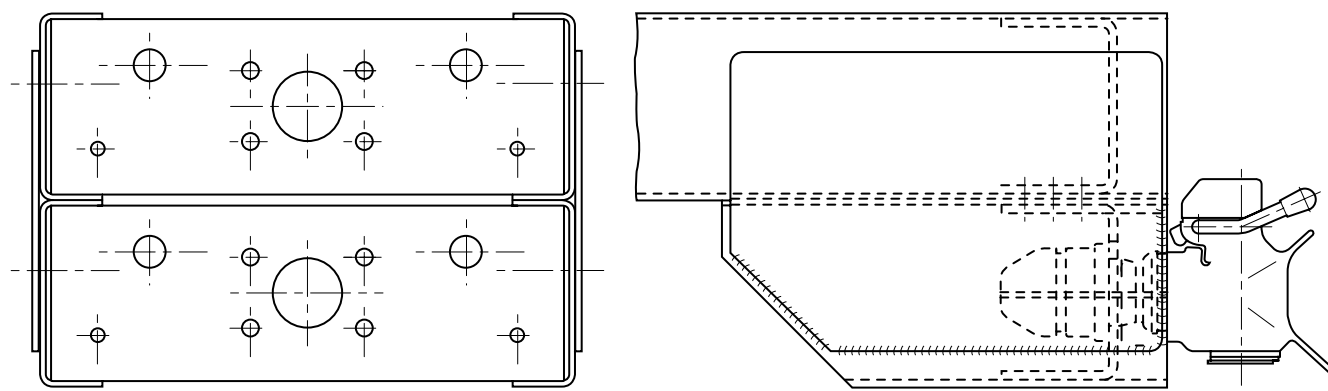
4.8.2   Trailer coupling, D value

See the booklet 'Coupling devices TG' for detailed derivation of the D value and – for rigid drawbar trailers – D_c and V values.
Example calculations can be found in the 'Calculations' Chapter.

4.9   Tractor units and converting the vehicle type - truck / tractor

4.9.1   Articulated vehicles

The weight and size of semitrailers and semitrailer tractors must be checked to see if they are suitable for forming an articulated vehicle.

The following must therefore be checked:

•   Slew radii
•   Fifth-wheel height
•   Fifth-wheel load
•   Freedom of movement of all parts
•   Legal requirements.

In order to achieve maximum fifth-wheel load the following actions are required before the vehicle goes into operation:

•   Weigh the vehicle
•   Calculate the axle loads
•   Determine the optimum fifth-wheel lead
•   Check the front slew radius
•   Check the rear slew radius
•   Check the front angle of inclination
•   Check the rear angle of inclination
•   Check the overall length of the articulated vehicle
•   Install the fifth-wheel coupling accordingly.

The required angles of inclination are 6° to the front, 7° to the rear and 3° to the side, in accordance with DIN-ISO 1726. Different tyre sizes, spring ratings or fifth-wheel heights between tractor unit and semitrailer may possibly reduce these angles so that they no longer comply with the standard. In addition to the inclination of the semitrailer to the rear the following must also be taken into account: Body roll when cornering, suspension compression travel (axle guide, brake cylinder, wheel covers), antiskid chains, the pendulum motion of the axle unit on vehicles with tandem axles and the slew radii.

The plane of the fifth-wheel pick-up plate on the semitrailer should run parallel with the road at permissible fifth-wheel load. The height of the fifth-wheel coupling and/or its mounting plate must therefore be designed accordingly.

Fig. 37: Dimensions for semitrailer tractor units ESC-002
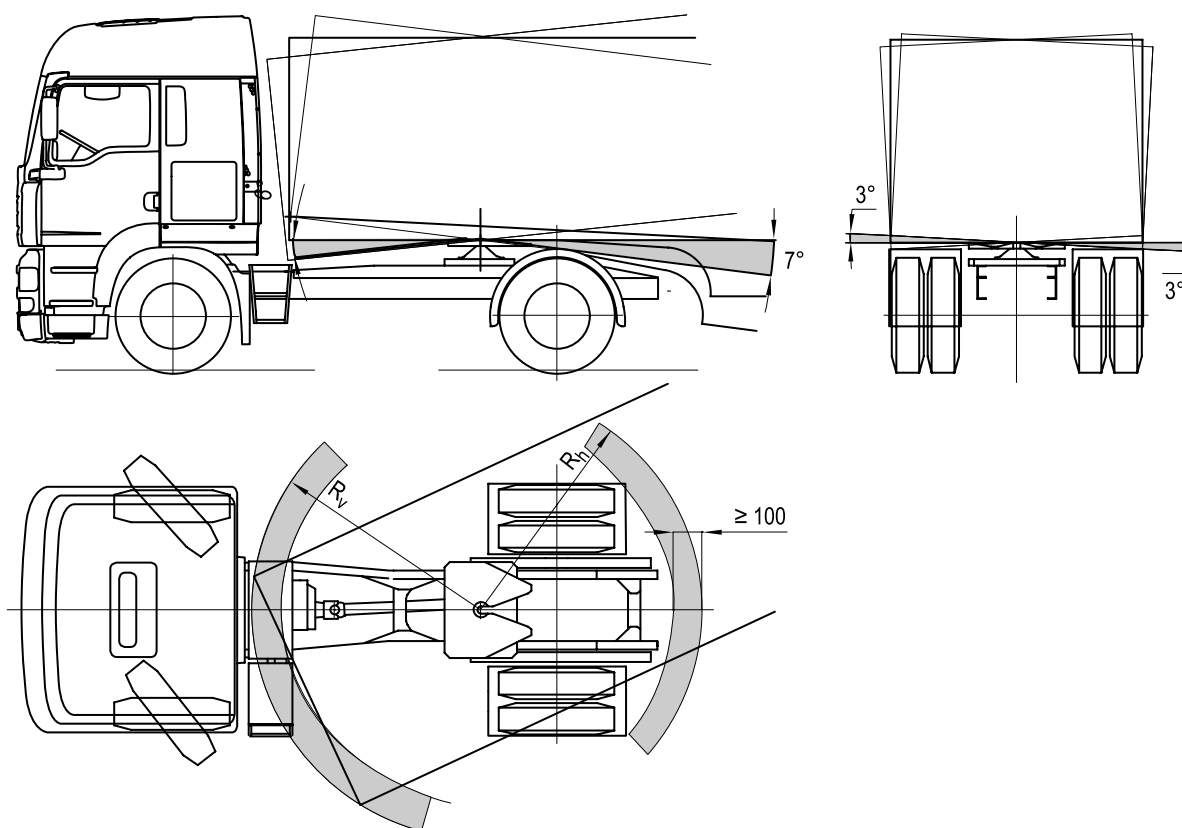
The fifth-wheel lead, as stated in the sales documentation or the chassis drawings, is applicable to the standard vehicle only. Under some circumstances, equipment that affects the vehicle's unladen weight or dimensions requires, among others, the fifth-wheel lead to be modified. This can also change the payload capacity and the combination's overall length.

Only type-approved fifth-wheel couplings and mounting plates that comply with Directive 94/20/EC may be used. Installing a fifth-wheel coupling without a subframe is not permitted. Under certain circumstances it is possible to fit a fifth-wheel coupling directly. Here, the fifth-wheel coupling is installed on the subframe together with special bearing brackets and a reinforcing plate (not subject to type approval) and the mounting plate is omitted.

The size of the subframe and the quality of the material ($\sigma_{0,2} > 350$ N/mm^2) must be equivalent to those used on a comparable production vehicle. The fifth-wheel coupling base plate must lie only on the fifth-wheel subframe and not on the frame longitudinal members. The mounting plate must only be attached using bolts approved by MAN or by the fifth-wheel coupling base plate manufacturer. When fitting the fifth-wheel coupling and mounting plate observe the instructions/guidelines provided by the fifth-wheel coupling manufacturer.

Connecting pipes/cables for air supply, brakes, electrics and ABS must not chafe on the body or snag during cornering.
The bodybuilder must therefore check the freedom of movement of all cables/pipes when cornering with a semitrailer.
When operating without a semitrailer, all pipes/cables must be attached securely in dummy couplings or connectors.

Furthermore, these connections must be fitted such that all pipes/cables can be safely connected and disconnected.
If it is not possible to connect the air and electrical pipes/cables from road level then a suitable working platform measuring at least 400 mm x 500 mm together with access steps to the platform must be provided.

The following fifth-wheel kingpins are available:

• Fifth-wheel kingpin, size 50 of 2" diameter
• Fifth-wheel kingpin, size 90 of 3.5" diameter

Which one is to be used depends on various factors. As for trailer couplings, the deciding factor is the D value.

The smaller of the two D values for the kingpin and the fifth-wheel coupling applies for the articulated vehicle as a whole.

The D value itself is marked on the model plates:

Formula 12: D value for fifth-wheel coupling

$$D = \frac{0,6 \cdot 9,81 \cdot T \cdot R}{T + R - U}$$

If the D value is known, the following formula is applied to calculate the permissible gross weight of the semitrailer:

Formula 13: Permissible gross weight of the semitrailer

$$R = \frac{D \cdot (T - U)}{(0,6 \cdot 9,81 \cdot T) - D}$$

If the permissible gross weight of the semitrailer and the D value of the fifth-wheel coupling are known, the permissible gross weight of the semitrailer tractor unit can be calculated with the following formula:

Formula 14: Permissible gross weight of the tractor unit

$$T = \frac{D \cdot (R - U)}{(0,6 \cdot 9,81 \cdot R) - D}$$

If the fifth-wheel load is required and all other loads are known, the following formula can be used:

Formula 15: Fifth-wheel load

$$U = T + R - \frac{0,6 \cdot 9,81 \cdot T \cdot R}{D}$$

Where:

D	=	D value [in kN]
R	=	Permissible gross weight of the semitrailer [in t], including the fifth-wheel load
T	=	Permissible gross weight of the semitrailer tractor [in t], including the fifth-wheel load
U	=	Fifth-wheel load [in t]

Examples of calculations can be found in the „Calculations" Chapter.

4.9.2 Converting trucks into tractor units or tractor units into trucks

Never attempt conversion of a tractor unit to a truck if the vehicle is fitted with ESP (= Electronic Stability Program)!
When converting a tractor unit to a truck or vice-versa, it is necessary to modify the vehicle's EBS (brake) parameterisation. Depending upon the vehicle undergoing conversion this may also involve installing different rear springs or a different level control system on vehicles with air suspension. Conversion of a truck chassis to a tractor unit and vice-versa therefore always requires approval from MAN. The ESC department will provide further information (for address see "Publisher" above).

Parameterisation is carried out using the MAN-cats® diagnostic system in agreement with a MAN service point. If electrical cables have to be modified, wiring harnesses for comparable MAN tractor units must be fitted. These can be obtained from the spare parts department.

4.10 Modifying the cab

4.10.1 General

Modifications to the cab's structure (e.g. incisions/cut-outs, changes to the support structure including the seats and seat mountings, cab extensions) together with modifications to the cab mountings and tilting mechanism **may only be carried out by qualified MAN vehicle conversion partners. The above stated modifications to the cab are safety-relevant and therefore require detailed modification-specific co-ordination between the conversion partner and MAN Truck & Bus AG.**

4.10.2 Spoilers, roof extensions, roofwalk

It is possible to retrofit a roof spoiler or an aerodynamics kit. Original MAN spoilers and aerodynamics kits can be obtained for retrofitting from our spare parts service. Drawings can be found in MANTED® under 'Cabs'. Only the proper mounting points on the cab roof should be used when retrofitting components to the cab roof.

Fig. 38:   Attachments on cab roofs ESC-506

XLX-cab (L/R47)
M 1:10

Pos 3
Pos 4

Reference point
(antenna drilling)
Pos 7
Pos 8
Pos 9
Pos 10

Pos 16
Pos 17
Pos 18
Pos 19
Pos 14
Pos 15
Pos 13
Pos 12
Pos 11

XXL-cab (L/R41)
M 1:10

Pos 3
Pos 4

Reference point
(antenna drilling)
Pos 7
Pos 8
Pos 9
Pos 10

Pos 16
Pos 17
Pos 18
Pos 19
Pos 14
Pos 15
Pos 13
Pos 12
Pos 11

LX-cab (L/R37)
M 1:10

Pos 3
Pos 4

Cab view
L/R 15

POS 2
POS 1

Reference point
(antenna drilling)
Pos 7
Pos 8
Pos 9
Pos 10

Pos 16
Pos 17
Pos 18
Pos 19
Pos 14
Pos 15
Pos 13
Pos 12
Pos 11

XL,i and M-cab (L/R40, 32,15)
M 1:10

Pos.26

Reference point
(antenna drilling)
Pos.21
Pos.20
Pos.23
Pos.22

Pos.25
Pos.24

TGL-cab (L/R10-12)
M 1:10

Pos 26

Reference point
(antenna drilling)
Pos 21
Pos 20
Pos 24
Pos 25

Table 14: Attachment points on cab roofs

Standard attachment	Position	M8 bolt	Additional drillings plastic raised roof	Position	Bolt St 6,3
		Tightening torque 20 Nm			Tightening torque 10 Nm
Roof spoiler High roof Steel roof	3/3a 4/4a 24/24 25/25 26/26a	M8	Sun blind	7/7a 8/8a 9/9a 10/10a	Ø 5,5
			Air horn	14/14a 15/15a 16/16a 17/17a 18/18a 19/19a	Ø 5,5
Sun blind	20/20a 21/21a 22/22a 23/23a	M8	Rotating beacons	11/11a 12/12a 13/13a	Ø 5,5

- Drilling description "a" is symmetric with y = 0
- Maximum load per bolt: 5 kg
- Maximum roof load: 30 kg
- Bolted connections over 3 offset points (not in one line)
- Centre of gravity of roof extensions max. 200 mm above the reference plane for the required bolting
- Additional drillings in the plastic raised roof (laminated-in plates):
  - Drill axis parallel to the surface
  - Drilling at an angle of ±2 to the surface
  - Drilling depth 10+2
  - Bolt St 6.3
  - Tightening torque 10 Nm

Information on fitting a roofwalk:

Table 15: Additional attachments for roofwalk

Additional attachments on rear wall (all cabs)		
Roofwalk on rear wall	1/1a 2/2a	Ø11,2

- A support for the roofwalk must be fitted to the rear wall
- All 4 mounting points 1/1a, 2/2a must be used
- The roofwalk must never be installed ahead of the rear edge of the roof hatch
- maximum weight of the roofwalk must not exceed 30 kg
- maximum roofwalk load 100 kg.

4.10.3 Roof sleeper cabs

It is possible to install roof sleeper cabs (top-sleepers) and raised roofs provided that the following conditions are met:

- Approval must be obtained from MAN. This is the responsibility of the roof cab manufacturer and not the workshop carrying out the work; see Section 4.5 "Retrofitting additional equipment add-on components or accessories" in this Guide to Fitting Bodies.
- The manufacturer of the roof cab is responsible for compliance with regulations (in particular safety regulations, e.g. trade association guidelines), regulations and laws (e.g. GGVS/ADR).
- A suitable method of preventing the cab from closing by itself when it is tilted must be installed (e.g. by fitting a securing device)
- If the tilting process differs from that for the standard MAN cab, a simple but comprehensive operating manual must be drawn up.
- The resulting centre of gravity of the extended cab must be in line with the specifications, and evidence of this compliance must be provided (see Fig. 39).
- Roof sleeper cabs may only be installed on vehicles fitted with an air suspended cab.
- The maximum weights listed in table 16 are to be observed.

The antennas fitted on original MAN cab roofs must be properly moved. This is intended to ensure good quality reception and transmission of electromagnetic radiation in accordance with the EMC Directive. Extension of the antenna cable (by splicing extra cable lengths in) is not permitted.

Fig. 39:   Cab centre of gravity with roof sleeper cab ESC-110
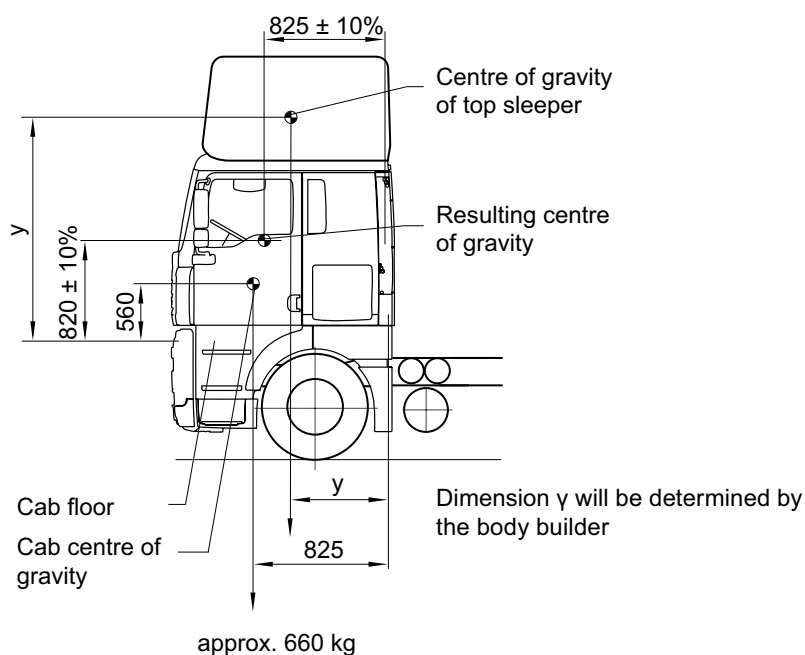
Table 16:   Roof cab, maximum weights of fitted/installed components

Cab designation	Technical code		Requirements	max. mass of roof cab incl. equipment
	LHD	RHD		
M	F99 **L15** S	F99 **R15** S	Air-suspended cab	130 kg
L	F99 **L32** S	F99 **R32** S		180 kg
XL	F99 **L40** S	F99 **R40** S		200 kg
LX	F99 **L37** S	F99 **R37** S	Modifications to factory fitted high roof cabs are not permitted	
XLX	F99 **L47** S	F99 **R47** S		
XXL	F99 **L41** S	F99 **R41** S		

4.11   Add-on frame components

4.11.1   Rear underride guard

TGA-chassis are factory-fitted with MAN rear underride guards of different variants.
The corresponding variant to be fitted is decided by MAN in accordance with the following parameters (see Table 17): wheel formula, overall height, suspension type and wheelbase in combination with the works body (swap body fittings). MAN underride guards are approved in accordance with Directive 70/221/EEC, as last amended by 2006/20/EU.

Table 17:   Underride guard variants (see Fig. 40 for and explanation of the values)

Underride guards fitted by MAN	Version	w	x	Y	Z	α
81.41660-8176	C2$_{WB}$	191 mm	max. 348 mm	340 mm	max. 550 mm	56,3°
81.41660-8177	C1	199 mm	max. 332 mm	432 mm	max. 550 mm	33,8°
81.41660-8178	C2	291 mm	max. 348 mm	340 mm	max. 550 mm	56,3°
81.41660-8180	B1	249 mm	max. 318 mm	507 mm	max. 550 mm	33,8°
81.41660-8181	B2	366 mm	max. 339 mm	391 mm	max. 550 mm	56,3°
81.41660-8183	A1	277 mm	max. 305 mm	549 mm	max. 550 mm	33,8°
81.41660-8184	A2	408 mm	max. 330 mm	418 mm	max. 550 mm	56,3°

The bodybuilder must check that statutory regulations are complied with and ensure that these requirements are adhered to because the dimensions are dependent on the body and can only be determined when the vehicle, including the body, has been completed.

Fig. 40: Dimensional specifications for underride guard ESC-522
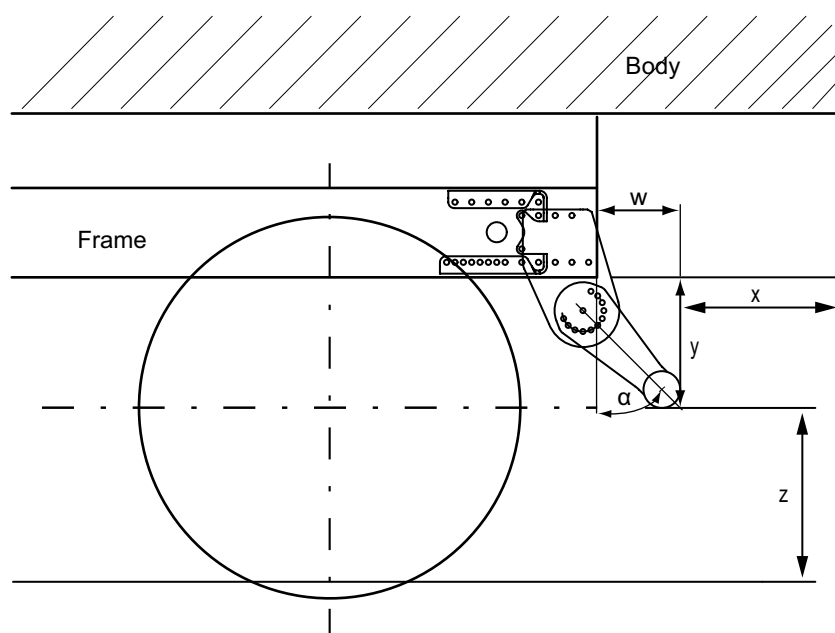
The following dimensions must be observed:

w = horizontal distance from frame end to rear edge of the underride guard.
y = vertical distance from frame lower edge to lower edge of the underride guard.
x = maximum permissible horizontal distance from the rear edge of the underride guard to the rear edge of the body.
z = vertical distance from the lower edge of the underride guard to the road surface for an unladen vehicle, maximum permissible in accordance with Directive 70/221/EEC is 550 mm.
α = angle α depends upon the requirements for dimensions w and y.

Depending upon the chassis variant, a folding underride guard from Ringfeder VBG is available as optional equipment for vehicles fitted with a MAN low coupling system. Alternatively, a folding underride guard for construction site vehicles is available from Meiller. Underride guard systems may never be modified (e.g. by welding or modifying the tube or angle α) because this will invalidate the certification/type approval. This also applies to vehicles with a factory fitted body!
If rear underride guards are retrofitted or refitted, e.g. after shortening the frame, the bodybuilder/modifier is responsible for fitting a rear underride guard in accordance with the regulations.

The following points must then be observed:

• For the bolted connections between the bracket and frame it is imperative that MAN Verbus-Ripp bolts with shaft are used (MAN 06.02813-4915, M14x1.5 10.9), tightening torque 200 Nm on the nut side (see Fig. 41).
• At the lower bolted connections of the underride guard the bolts must be tightened with a torque of 330 Nm. (See Fig. 42).
• Angle α of the underride guard may not be modified at a later time, otherwise the certification will become void.
• If it becomes necessary to insert spacers at the lower bolted connections, for instance in order to mount a rear loading crane, then the certification/type approval will become void. Any modifications must be certified by an officially approved inspector (e.g. an officially recognised expert in Germany).

Fig. 41:   Bolted connection underride guard ESC-523   **Fig. 42:**   Lower bolted connection underride guard bracket ESC-524
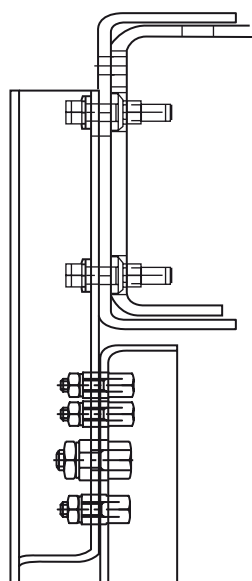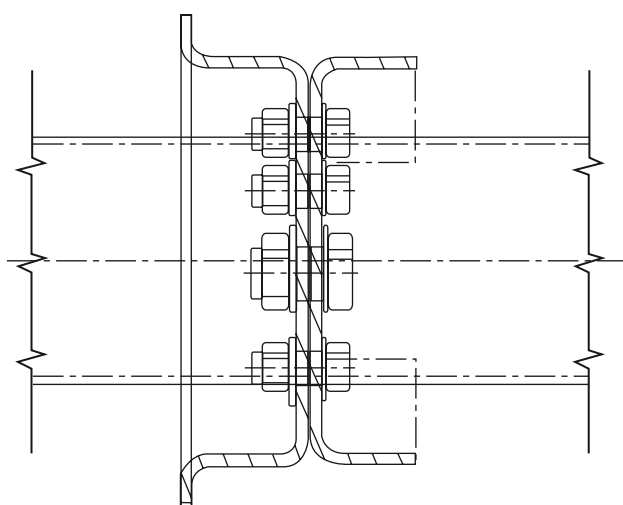
4.11.2   FUP - front underride protection

Motor vehicles used for the transport of goods that have at least four wheels and a maximum permissible mass of over 3.5 t must be fitted with front underride protection that is approved in accordance with Directive 2000/40/EC. This shall not apply to:

•   off-road vehicles, and
•   vehicles that are used for purposes incompatible with the provisions of front underrun protection.

TGA vehicles that do not meet the criteria for an off-road vehicle are fitted with FUP that complies with the requirements of Directive 2000/40/EC. Do not modify these underride protection devices (e.g. by modifying welded seams, drill holes, brackets) because this will invalidate the certification/design approval! TGA all-wheel-drive vehicles (with wheel formulae 4x4, 6x6, 6x6-4, 8x6 and 8x8) and TGA vehicles that fulfil the so-called "off road criteria" can be approved as off-road vehicles and are therefore not fitted with front underride protection at the factory. Ensure therefore, that the criteria for approval as an off-road vehicle is complied with.

The criteria are:

•   At least 50 % of the wheels are driven
•   A differential lock or ASR is fitted
•   Gradeability of the individual vehicle ≥ 25 %
•   Plus at least 4 of the following requirements:
    -        Approach angle ≥ 25°
    -        Departure angle ≥ 25°
    -        Ramp angle ≥ 25°
    -        Ground clearance beneath the front axles at least 250 mm
    -        Ground clearance beneath the rear axles at least 250 mm
    -        Ground clearance beneath the axles at least 300 mm

If it is not possible to locate bodies and ancillaries (e.g. outriggers, tool boxes) such that the above stated criteria are not violated then the vehicle must be retrofitted with front underride protection that is available from the MAN spare parts organisation.

Responsibility for this lies with the body builder. MAN is not liable for any costs arising from the retrofitting of front underride protection to vehicles that were delivered as off-road vehicles.

4.11.3   Sideguards

Trucks, tractor units and their trailers with a permissible gross weight of > 3.5 t must be fitted with sideguards (= SSV).

Exceptions applicable to the truck sector are as follows:

*   Vehicles that are not yet completed (chassis being delivered)
*   Tractor units (not semitrailers)
*   Vehicles built for special purposes that are incompatible with the fitting of sideguards.

In this connection, special vehicles mainly means vehicles with side tipper bodies having an inside length of < 7,500 mm.

Neither vehicles intended for combined transport nor off-road vehicles are exempt from the requirement for sideguards.
For MAN chassis it is possible to obtain sideguards ex-works. If the body manufacturer is to retrofit sideguards to the chassis, then profile sections, profile supports and installation parts are available from MAN in a variety of designs.

If it is necessary for the body builder to modify the original MAN sideguard profile then the relationship between the span "l" and projection "a" apply as illustrated in the following diagram in accordance with Fig. 44. If, according to expert opinion, the permitted dimensions are exceeded then the body builder must arrange for strength testing to be carried out. The illustrations are only intended to clarify the dimensions for which the MAN sideguard strength requirements are met.

Fig. 43:   TGA sideguards ESC-260
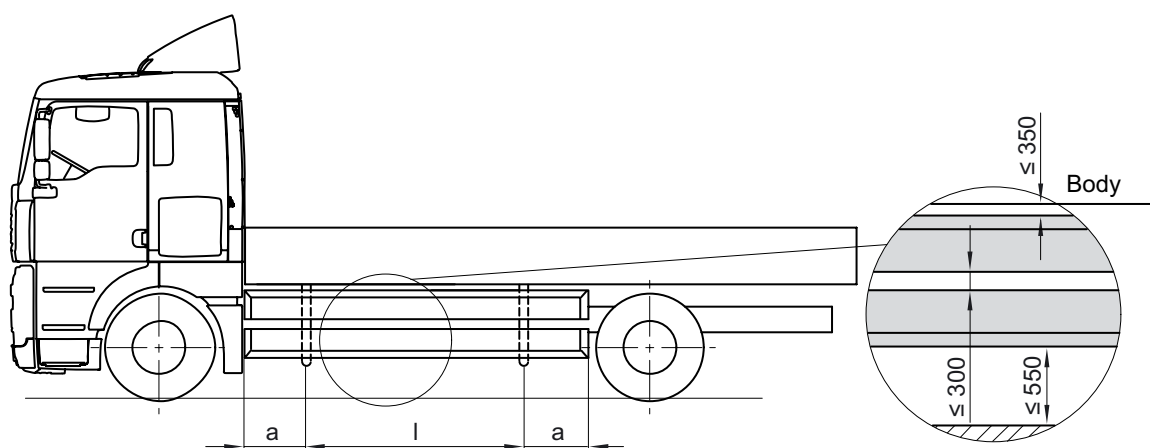
Fig. 44:   Graph for ascertaining the span and projection ESC-220
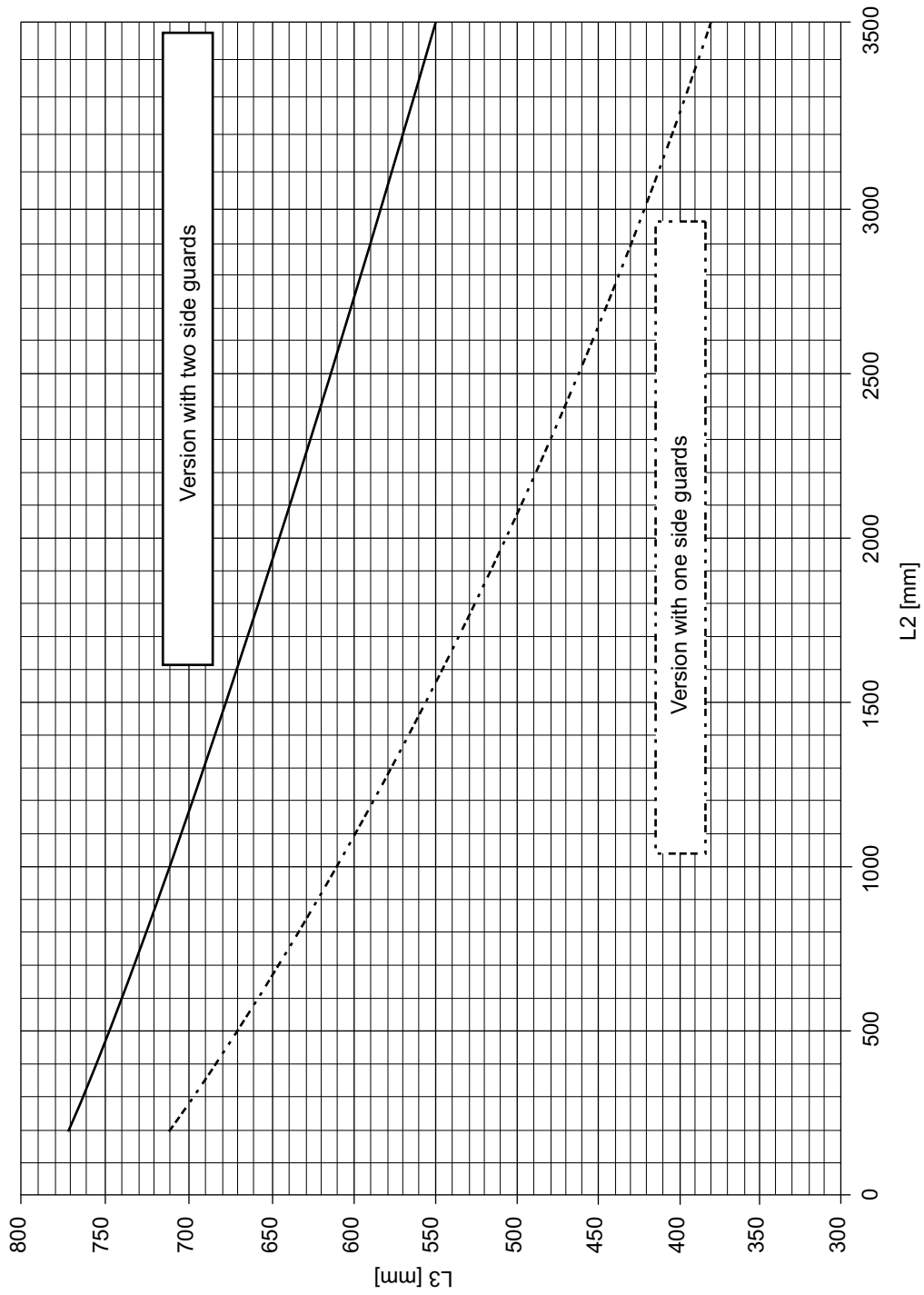
The company installing the sideguards is responsible for compliance with legal regulations.

It is not permissible to attach brake, air or hydraulic pipes to the sideguards; there may be no sharp edges or burrs; the rounding-off radius for all parts cut to size by the bodybuilder must be at least 2.5 mm; rounded bolts and rivets may project by a maximum of 10 mm. If the vehicle is fitted with different tyres or different springs, the height of the guards must be checked and, if necessary, corrected.

4.12 Modifications to engine systems

4.12.1 Modifications to the air intake and exhaust gas routing for engines up to and including EURO4 with On Board Diagnosis

In general modifications to the air intake and exhaust systems are to be avoided. Various factory options are available for the TGA and body builders should check to see if these can be used. The possible variants according to chassis type and engine can be found at www.manted.de. Information on availability for the corresponding vehicle can be obtained from your closest MAN sales branch.

If it is still not possible to avoid making modifications the following requirements must be met:

- The flow of intake of air and the outflow of exhaust gases must not be inhibited in any way.
- The negative pressure in the intake branch and the backpressure in the exhaust must not be allowed to vary.
- When modifying the exhaust or intake system it must be ensured that all statutory regulations are fulfilled that are relevant to noise and emissions.
- All regulations pertaining to the components in question issued by professional associations or similar bodies must also be fulfilled (e.g. surface temperature in the vicinity of handles/grips)
- In the case of modified intake and exhaust systems MAN cannot guarantee compliance with these and other regulations. Responsibility for this remains with the company performing the modification. This also applies to regulations pertaining to on board diagnosis systems (OBD).

- If modifications are made to the exhaust system and the exhaust gas routing then care must be taken to ensure that the exhaust gas stream is not directed at any part of the vehicle and that the direction of the exhaust outlet points away from the vehicle. (observe the relevant national regulations, in Germany this is the StVZO).

The following additional requirements apply when modifying the exhaust system

- When moving the exhaust silencer it should be ensured that the original MAN bracket is re-used.
- The position of the temperature and NOx sensors (where OBD is fitted) on the exhaust silencer must not be changed.
- Conversion work or modifications to the exhaust gas routing from the exhaust manifold to the metal pipe (see Fig. 54) are not permitted.
- No blowing-out of products (e.g. bitumen) using exhaust gas pressure – danger of damage to the exhaust system and engine.
- Do not modify the cross-section (shape or area) of pipes. The original type of material must be used for pipes.
- Do not modify silencers (including the silencer housing) in such a way that would invalidate the type approval.
- The design of mountings and supports and the basic installation position of components must be retained.
- When bending components, the bending radius must be at least double the diameter of the pipe. The formation of wrinkles is not permissible.
- Only continuous bends are permitted, i.e. no mitre cuts.
- MAN can provide no information about changes in fuel consumption or noise characteristics; in some circumstances, a new noise emission approval will be required. If the noise limits are exceeded the type approval will become invalid!
- Neither can MAN provide information on compliance with statutory exhaust emission limits. It may be necessary to carry out an exhaust emission test. If the exhaust emission limits are exceeded the type approval will become invalid!
- The function of the OBD relevant components may not be impaired. Should OBD relevant components be manipulated the type approval will become invalid!
- The connection of the pressure sensor tube on the silencer must always face the top, the following steel pipe must be installed so that it rises continuously to connect with the sensor and it must have a minimum length of 300 mm and a maximum length of 400 mm (including the flexible section). The measurement line must be fabricated of M01-942-X6CrNiTi1810-K3-8x1 D4-T3. The general installation position of the pressure sensor must be retained (connection at bottom).
- Heat-sensitive components (e.g. pipes, spare wheels) must be fitted at least > 200 mm away from the exhaust; if heatshields are fitted, this clearance may be reduced to ≥ 100 mm.
- If modifications are made to the exhaust system and the exhaust gas routing then care must be taken to ensure that the exhaust gas stream is not directed at any part of the vehicle and that the direction of the exhaust outlet points away from the vehicle. (observe the relevant national regulations, in Germany this is the StVZO).

The following additional points apply to air intakes:

- Never change the shape or area of pipework cross-sections.
- Do not modify air filters.
- The installation position of the humidity sensor in the air filter must not be changed.
- The design of mountings and supports and the basic installation position of components must not be changed.
- MAN can provide no information about changes in fuel consumption or noise characteristics; in some circumstances, a new noise emission approval will be required. Components that have an effect on the vehicles acoustics (e.g. the jet in the fresh air intake pipe) may not be modified. If the noise limits are exceeded the type approval will become invalid!
- The air intake must be protected against ingesting warmed air (e.g. engine heat from the wheel arches or in the vicinity of the exhaust silencer). A suitable position for the air intake must be chosen such that the intake air is not warmed by more than 5°C (difference between the ambient air temperature and the temperature at the turbocharger inlet). If the intake air temperature is too high there is a risk that exhaust emission limits will be exceeded. If the exhaust emission limits are exceeded the type approval will become invalid!
- In order to avoid the ingestion of burning cigarette ends or similar a so-called cigarette mesh must be fitted directly over the air intake in the same fashion as the mesh installed on production vehicles (non-flammable material, mesh size SW6, area of the open cross-section at least that of the intake air scoop on the air filter). There is a risk of vehicle fire if this requirement is not observed! MAN can provide no information on the effectiveness of the measure used, responsibility lies with the company performing the modification.

- The air intake must be positioned such that there is a low level of dust and spray ingestion.
- Sufficient drainage and unobstructed dust discharge from the filter housing and the unfiltered side must be ensured.
- Pipework on the filtered-air side must be selected to ensure that it is absolutely sealed from the unfiltered side.
- The inside of the air intake pipes must be smooth – no particles or similar may come loose from the sides.
  It is imperative that the air intake pipe cannot slip out at the sealed joints. Suitable brackets must therefore be fitted.
- The vacuum sensor should be positioned in a straight section of the pipe at the shortest possible distance from the turbocharger. It is the responsibility of the company carrying out the modification to ensure the sensor reads correctly.
  Caution: Risk of engine damage if the sensor under reads!
- All intake trunking must be capable of resisting vacuum pressures of 100 mbar and temperatures of at least 80°C (peaks of 100°C). Flexible tubing (e.g. hoses) are not permitted.
- Sharp bends in the pipework should be avoided, mitre cuts are not permitted.
- The service life of the air filter may be shortened when modifications are made to the air intake system.

4.12.2 Additional requirements if changes are made to the AdBlue® system/exhaust system on Euro5 vehicles

Before commencing with any modification work it should be checked to see if any of the existing MAN variations of the AdBlue® system can be used. All vehicle modifications must be carried out by qualified personnel.

AdBlue® (DIN 70070) is the trade name for an aqueous, synthetically manufactured 32.5% urea solution that is used for exhaust gas after treatment in an SCR (selective catalytic reduction) catalytic converter.

Fig. 45: Schematic overview of the AdBlue® system in Euro5 vehicles ESC-419
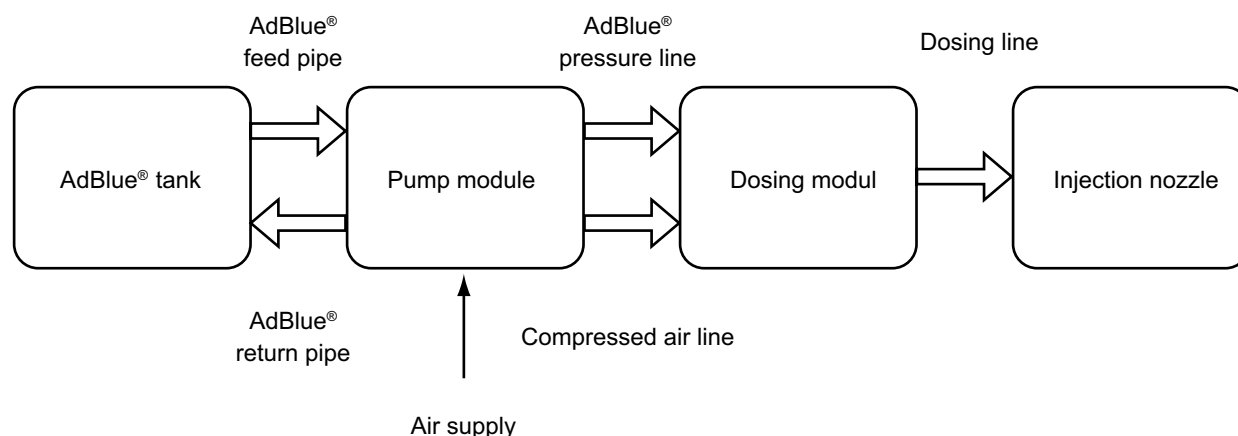
Fig. 46:   Overview of the relevant AdBlue® components on the vehicle overall ESC-420

Pump module

Mixer, dosing module and injection nozzle in the engine area

Cut-off valve between the tank and the pump module pipe

Fuel filler inlet

AdBlue® filler inlet

AdBlue® tank for aqueous urea solution
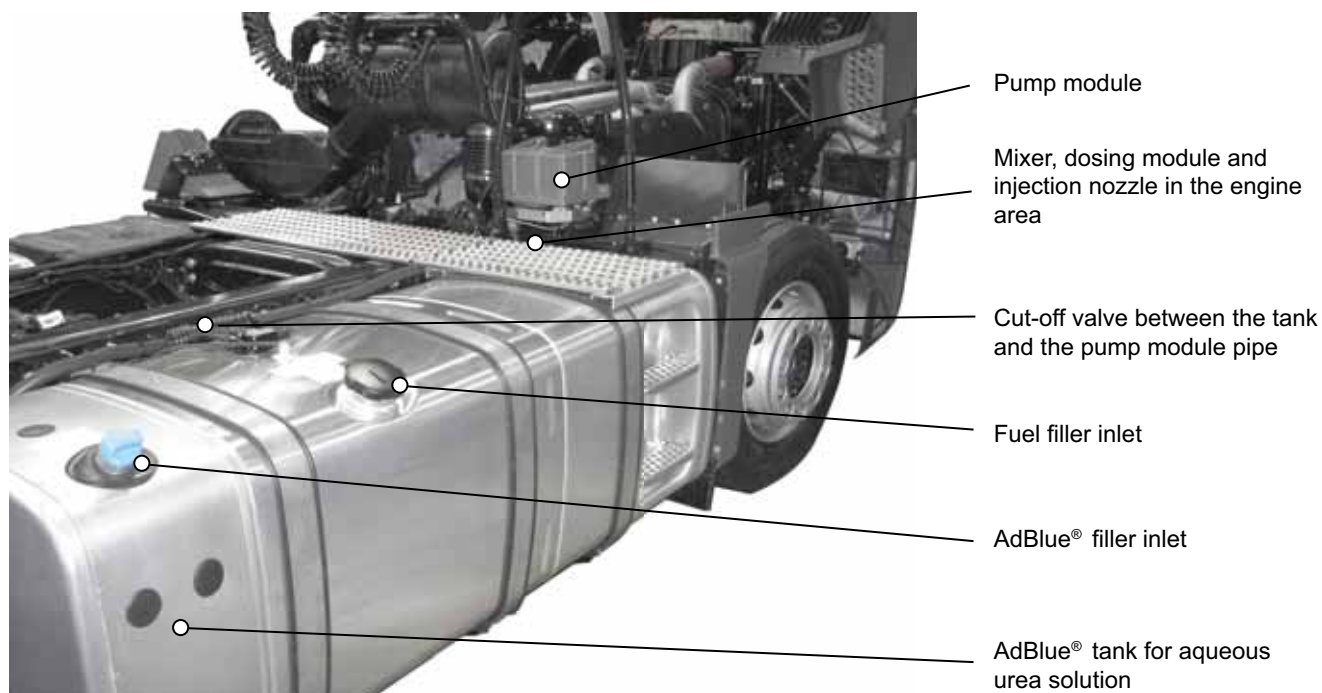
Moving the AdBlue® tank

The following notes explain the basic issues involved in moving the original MAN AdBlue® tank. AdBlue® tanks all have four pipe connections and these are identified with a label so that the pipes are not mixed-up:

-       AdBlue® feed and return lines (size 8.8 x 1.4, material PA-PUR, printed in yellow, pipe colour – black)
-       Engine coolant feed and return lines for heating the AdBlue® system(size 9x1.5, PA12-PHL-Y, printed in white, pipe colour – black)
- Moving the combined/individual tank is only permissible if MAN original tanks are used and then only if a maximum pipe length of 5,000 mm between the tank inlet and pump module inlet pipe is maintained
- The routing of electrical and CAN cabling (e.g. for the fill level sensor, pump module, OBD sensors) is only permitted if original MAN cable harnesses are used (available in future from the MAN spare parts service).

Moving the AdBlue® pump module

- The pump module may only be moved to original MAN installation locations with the associated original MAN brackets. Reason: strength/vibrations

Fig. 47:   Pump module and original MAN bracket ESC-421

Pump module

Original MAN bracket

AdBlue®- cable harness to
AdBlue®- tank
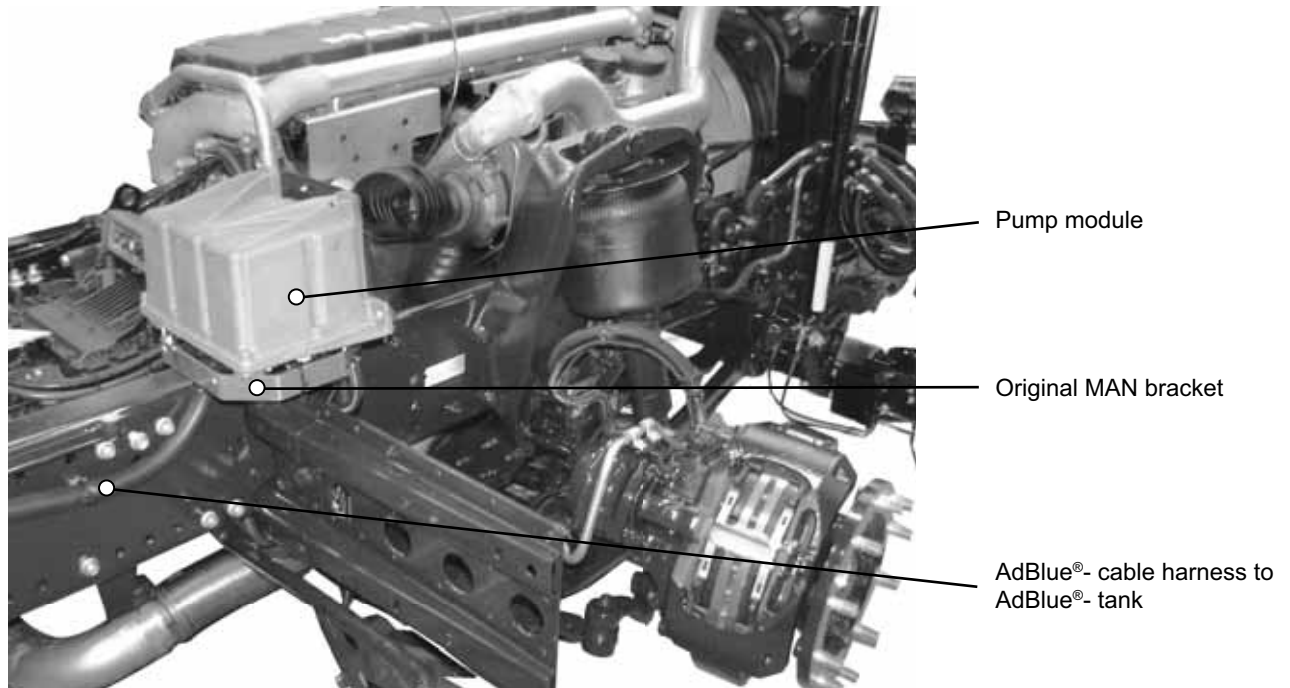
- •   When moving the pump module ensure that either the original cable harness to the dosing module is used or that the overall length does not exceed 3,000 mm.
- •   The maximum possible height difference (delivery head) between the lower edge of the pump module and the lower edge of the tank or the upper edge of the tank (and uppermost pipe position) may not exceed 1,000 mm.
         Should these required specifications not be adhered to the warranty will be rendered invalid.

Fig. 48:   Installation overview ESC-422

B

< 1.0 m

> 0   > 0   > 0

Lower edge of
the pump module

< 1.0 m

A

Source: Bosch installation guidelines
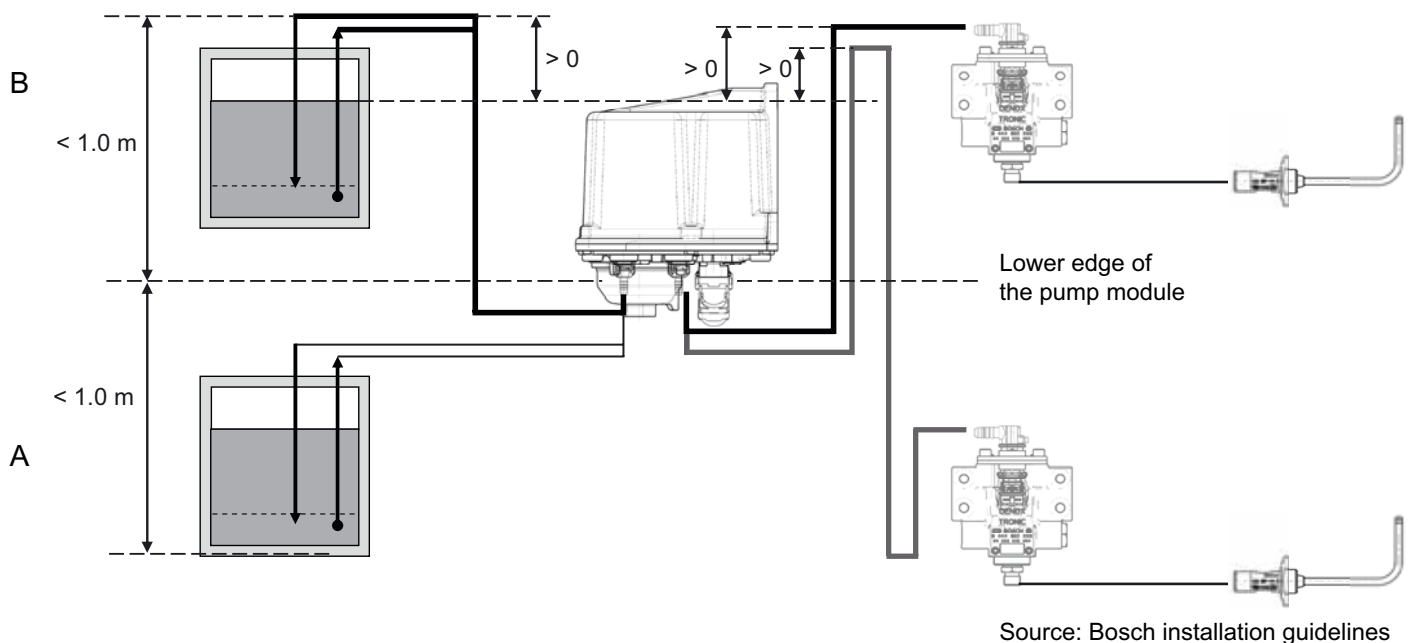
Dosing module

- The position of the dosing module may not be changed.
- Extending the pipe between the dosing module and the pump module is possible up to an overall length of 3,000 mm.

Extending/shortening the AdBlue® and engine coolant pipes

Extensions for repositioning the AdBlue® tank or the combi tank can be achieved by procuring the longest pipe harness or one that matches the installation. These can be procured from the MAN spare parts service. Harnesses may be shortened by trimming the pipe bundle to length at the interface to the AdBlue® pump module. Alternatively, the harness may be looped so it covers a longer distance. Under no circumstances may the pipes from the tank to the pump module be longer than 6,000 mm.

- Generally only pipe-to-pipe unions with pipe connectors manufactured by VOSS are permitted (can be sourced e.g. from the MAN spare parts department).
- Inserting the pipe connector is only permitted using a special tool from Voss (crimping pliers MAN no.80.99625.0023).
- In order to minimise pressure losses a maximum of only one extension is permissible for each corresponding coolant/AdBlue® feed or return pipe.

Fig. 49: Pipe connector (VOSS) for extending/shortening the AdBlue® and coolant pipe ESC-423

- It is not permissible to press the AdBlue® pipes on the plastic plug despite the special tool. For this purpose only pre-fitted plastic plugs with 1,000 mm of pipe from VOSS are permitted (can be sourced e.g. from the MAN spare parts department).
- It is imperative to avoid kinking the lines.
- It is imperative that the lines are isolated against cold in the same way as original lines are protected.

Cable/pipe identifier

Fig. 50: AdBlue® pipe identifier (size 8.8 x 1.4; material PA-PUR, printed in yellow, pipe colour black) ESC-428
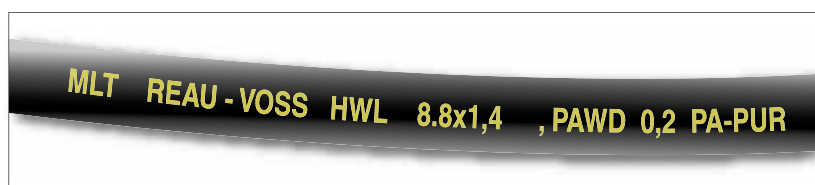
Fig. 51: Engine coolant pipe identifier (size 9 x 1.5; PA12-PHL-Y, printed in white, pipe colour black) ESC-429
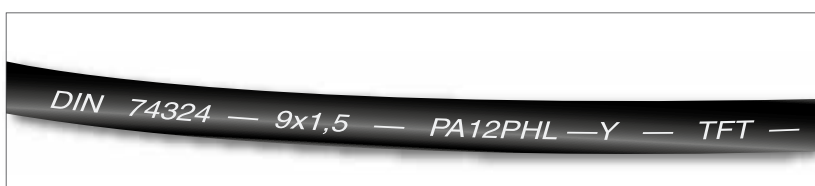
Fig. 52: View of a pipe bundle showing coolant and AdBlue® pipes ESC-430

View X

X

Pipe 3

Pipe 1

Pipe 4

Pipe 2

Pipe 1: Heating pipe - feed

Pipe 2: Heating pipe - return

Pipe 3: AdBlue® return line

Pipe 4: AdBlue® feed line
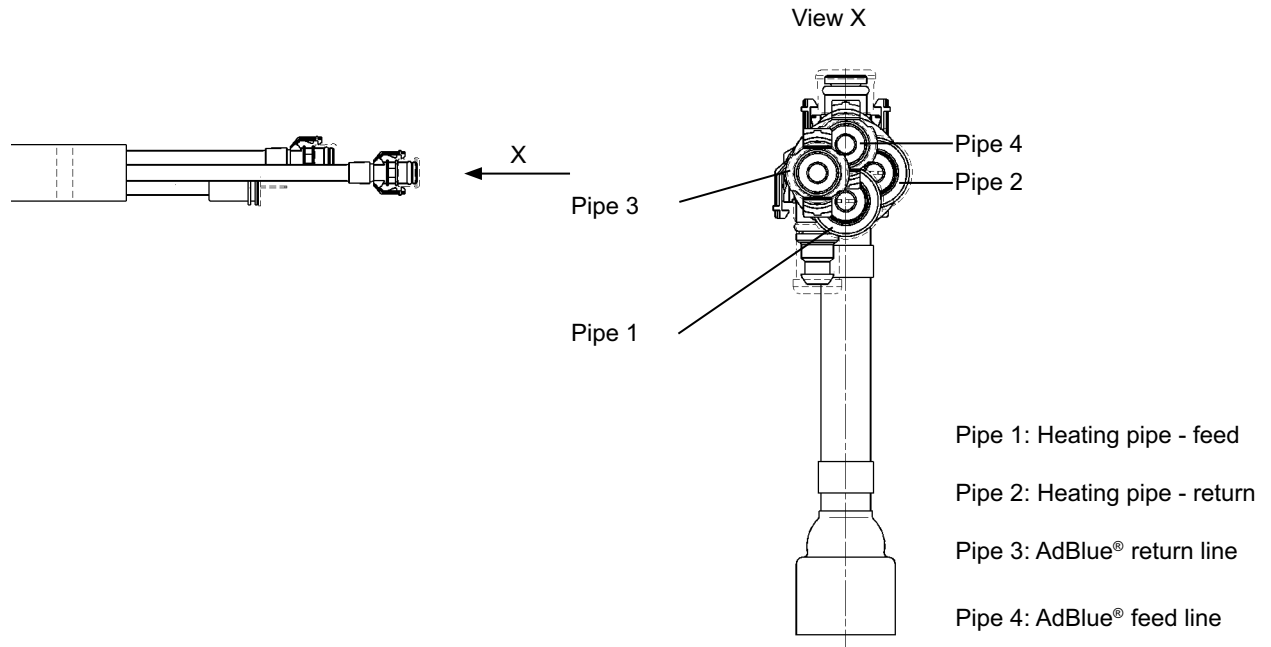
Fig. 53:   Temperature sensor, injection nozzle, dosing module ESC-424

Injection nozzle   Dosing module
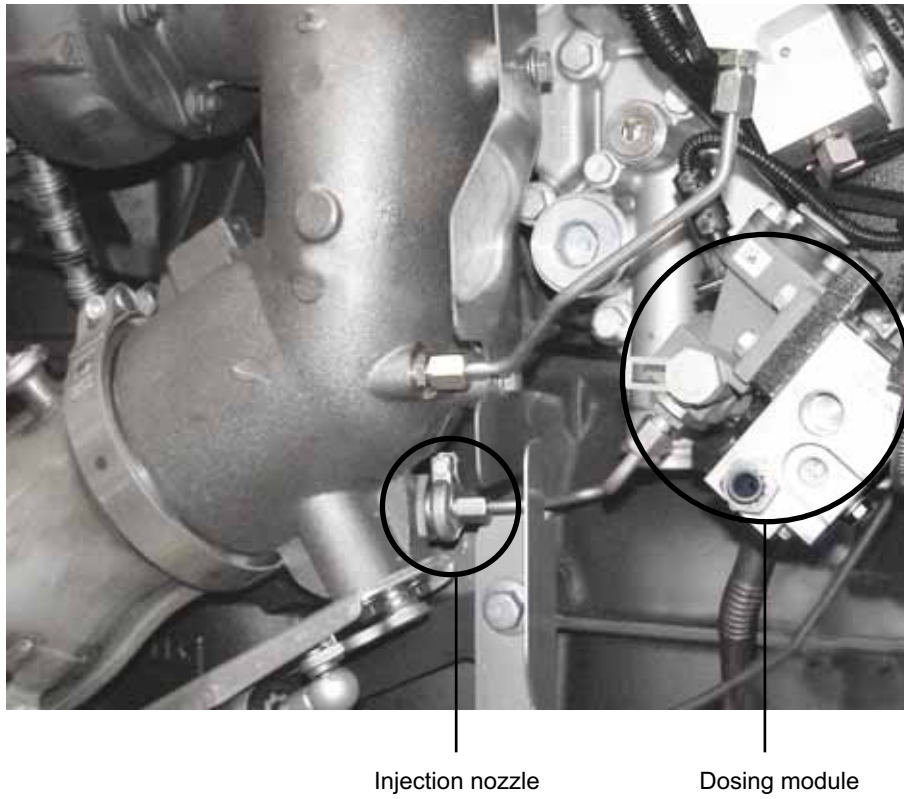
Modifying the exhaust system

- ·   When moving the exhaust silencer it must be ensured that its original MAN support bracket is re-used.

Fig. 54:   View of the exhaust silencer support bracket ESC-425

Metal pipe

Support bracket

Temperature sensor

(On reverse)
NO_x sensor (only on vehicles fitted with OBD with
NO_x analyser, mandatory from 10/2007)
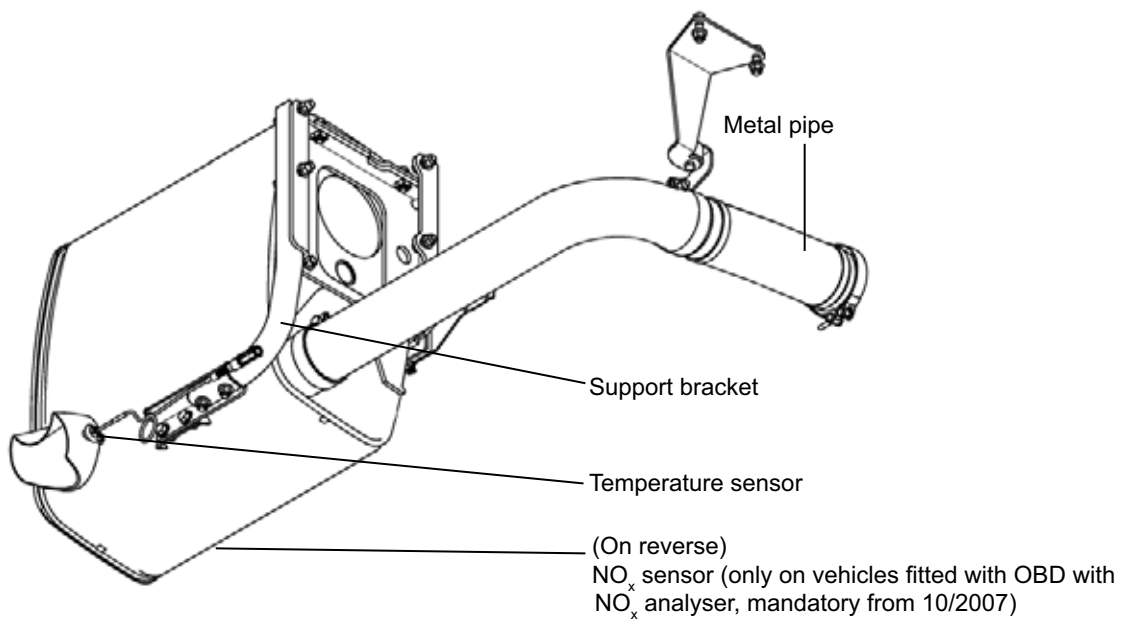
- Extension of the exhaust routing by 1.000 mm is permissible from the metal pipe to the exhaust silencer without fitting high temperature insulation.
- Extension of the exhaust routing by > 1.000 mm to max. 2.000 mm is permissible from the metal pipe to the exhaust silencer if suitable high temperature insulation is fitted.

Fig. 55: Exhaust tract, from mixer to metal pipe ESC-426

Dosing module

Injection nozzle

Mixer

Metal pipe

- The position of the temperature and the NO_x sensor (on OBD) on the exhaust silencer must not be changed.
- Only high-grade austenitic stainless steels may be used for manufacturing exhaust system piping.
  Reason: if otherwise common ferritic steels are used the ammonia (reaction product from AdBlue®) will cause corrosion.
- Stainless steel pipes must be welded using inert gas shielded arc welding (observe the steel manufacturer's instructions) with the work carried out by qualified and authorised personnel.
- Conversions or modifications to the exhaust gas routing between the exhaust manifold and the metal pipe are not permissible.

Fig. 56: Position of the NO_x sensor (only vehicles with OBD and NO_x analyser, mandatory from 10/ 2007) on the exhaust silencer) ESC-427

Temperature sensor

Exhaust silencer

NO_x sensor
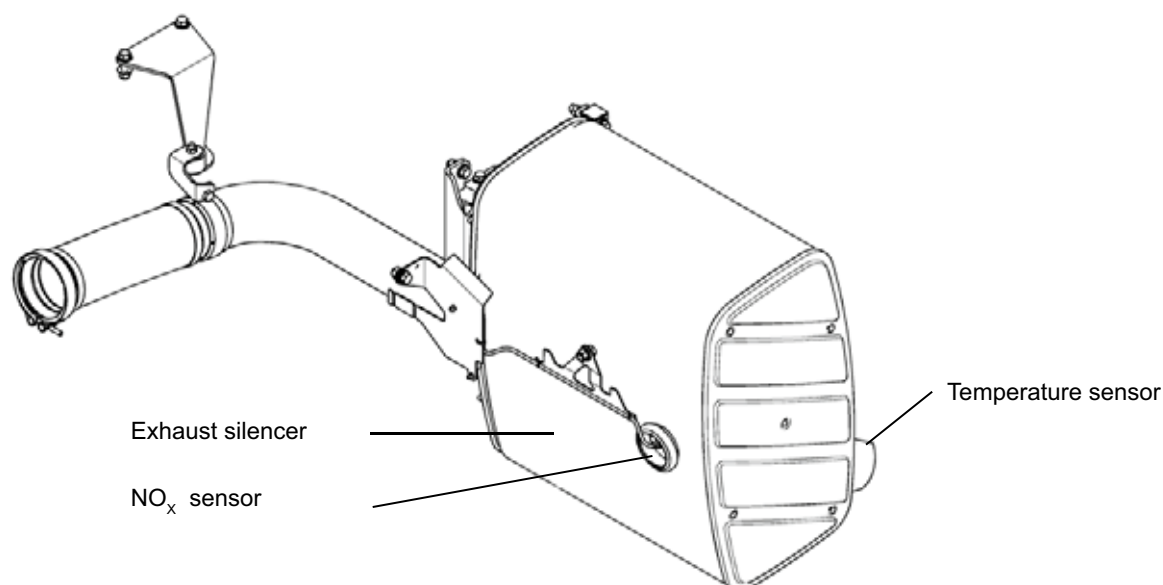
Overview of the austenitic stainless steels to be used in accordance with DIN 17440

Materials:

Description	Material number
X 5 CrNi 18 10	1.4301
X 2 CrNi 19 11	1.4306
X 2 CrNiN 18 10	1.4311
X 6 CrNiTi 18 10	1.4541
X 6 CrNiNb 18 10	1.4550
X 5 CrNiMo 17 12 2	1.4401
X 2 CrNiMo 17 13 2	1.4404
X 6 CrNiMoTi 17 12 2	1.4571
X 2 CrNiMoN 17 13 3	1.4429
X 2 CrNiMo 18 14 3	1.4435
X 5 CrNiMo 17 13 3	1.4436
X 2 CrNiMoN 17 13 5	1.4439

4.12.3   Engine cooling

•   The cooling system (radiator, grille, air ducts, coolant circuit) may not be modified.
•   Exceptions only with the approval of the ESC department at MAN (for address see "Publisher" above).
•   Modifications to the radiator that reduce the cooling surface cannot be approved.

When operating primarily under stationary conditions or in areas with severe climates, a more powerful radiator may possibly be required. The nearest MAN sales centre can provide information on delivery options for the respective vehicle; for retrofit installation, contact the nearest MAN service centre or MAN authorised workshop.

4.12.4   Engine encapsulation, noise insulation

Work on and modifications to factory-fitted engine encapsulation are not permitted. If vehicles are defined as „low-noise",
they will lose this status if retrofit work has been carried out on them.
The company that has carried out the modification will then be responsible for re-obtaining the previous status.

4.13   Fitting other manual gearboxes, automatic transmissions and transfer boxes

Fitting manual or automatic transmissions that have not been documented by MAN is not possible because there is no interface to the CAN powertrain. If non-documented manual or automatic transmissions are fitted malfunctions may occur in safety-relevant electronic systems. Fitting third-party transfer boxes (e.g. for use as power take-offs) disturbs the powertrain electronics.
On vehicles fitted with mechanical manual transmissions it may, under certain circumstances, be possible to adapt the system by parameterisation. Consult the ESC department (for address see "Publisher" above) before any work is commenced.
It is not permitted to install these units to vehicles fitted with MAN TipMatic / ZF ASTRONIC (ZF12AS transmissions).

5.   Bodies

5.1   General

For identification purposes, each body must be fitted with a model plate that must contain the following data as a minimum:

•   Full name of body manufacturer
•   Serial number.

The data must be marked permanently on the model plate.
Bodies have a significant influence on the vehicle's handling characteristics and drag, and consequently also on fuel consumption.
Bodies must therefore not unnecessarily increase drag or negatively affect the vehicle's handling characteristics.
The unavoidable bending and twisting of the frame should not cause any undesirable characteristics in either the body or the vehicle.
The body and chassis must be able to absorb such forces safely. The approximate value for permissible bending can be calculated as follows:

Formula 16:   Approximate value for permissible bending

$$f = \frac{\sum_{1}^{i} l_i + l_{\ddot{u}}}{200}$$

Where:

$$f = \text{Maximum bending, in [mm]}$$
$$l_i = \text{Wheelbases,} \quad \Sigma\, l_i = \text{sum of the wheelbases, in [mm]}$$
$$l_{\ddot{u}} = \text{Frame overhang, in [mm]}$$

The body should transfer as few vibrations as possible to the chassis.
We assume that bodybuilders should at the very least be able to determine approximate ratings for the subframe and assembly.
It is also expected that suitable measures are taken to prevent vehicle overloading.
The unavoidable tolerances and hystereses arising in vehicle design must also be taken into consideration.

These include, for example:

*   the tyres
*   the springs (including hysteresis in air suspension systems)
*   the frame

When the vehicle is in operation, other dimensional changes will occur.
These include:

*   settling of the springs
*   tyre deformation
*   body deformation.

The frame must not be deformed before or during installation. Before positioning the vehicle for installation, it should be driven backwards and forwards a few times to release any trapped stresses. This applies particularly to vehicles fitted with a tandem axle unit due to the axle stiffness that occurs when cornering. The vehicle should be placed on a level surface to install the body. Frame height differences on the left/right of ≤ 1.5% of the ground-to-frame upper edge distance are within the limits of the hysteresis and settling effects outlined above. The body must be able to sustain such differences which should not be compensated by frame alignment, spring inserts or by adjusting the air suspension level because these will inevitably change during operation. Variations > 1.5% must be notified, before any repairs are carried out, to the MAN customer services department which will decide which measures are to be taken by the bodybuilder and/or the MAN service centre. Accessibility, Clearances: Access to the filler necks for fuel and other operating fluids must be ensured as must access to all other frame components (e.g. spare wheel lift, battery box).

The freedom of movement of moving parts in relation to the body must not be adversely affected.

For example:

*   Brake cylinders
*   Gearchange mechanism (gear linkage, cable-controlled gearshift)
*   Axle mounting components
*   Intarder pipework

To ensure minimum clearances the following should be taken into account:

*   Maximum compression of the springs
*   Dynamic compression during the journey
*   Compression when starting off or braking
*   Side tilt when cornering
*   Operation with anti-skid chains
*   Limp-home mode characteristics, for example damage to an air spring bellows during a journey and the resulting side tilt (e.g. 3° side tilt to ISO 1726 on tractor units see also the 'Coupling devices TG' booklet).

5.2   Corrosion protection

Surface and corrosion protection affects the service life and appearance of the product. In general, the quality of the coatings on body components should be equal to that of the chassis.

To ensure this requirement is met, the MAN Works Standard M 3297 „Corrosion protection and coating systems for non-MAN bodies" is binding for bodies that are ordered by MAN. If the customer commissions the body, this standard becomes a recommendation only. Should the standard not be observed, MAN provides no guarantee for any consequences.
MAN-works standards may be obtained from www.normen.man-nutzfahrzeuge.de (registration required).
Series production MAN chassis are coated with environmentally friendly, water-based 2-component chassis top-coat paints at approx. 80°C. To guarantee uniform coating, the following coating structure is required for all metal component assemblies on the body and subframe and, following frame modifications, on the chassis:

- Bare metal or blasted component surface (SA 2.5)
- Primer coat: 2-component epoxy primer, approved in accordance with MAN works standard M 3162-C or, if possible cathodic dip painting to MAN works standard M 3078-2, with zinc phosphate pre-treatment
- Top coat: 2-component top-coat paint to MAN works standard M 3094, preferably water-based; if there are no facilities for this, then solvent-based paint is also permitted (www.normen.man-nutzfahrzeuge.de, registration required).

See the relevant data sheets from the paint manufacturer for information on tolerances for drying and curing times and temperatures. When selecting and combining different metals (e.g. aluminium and steel) the effect of the electrochemical series on the occurrence of corrosion at the boundary surfaces must be taken into consideration (insulation). The compatibility of materials must also be taken into consideration; e.g. the electrochemical series (cause of galvanic corrosion).

After all work on the chassis has been completed:

- Remove any drilling swarf
- Remove burrs from the edges
- Apply wax preservative to any cavities.

Mechanical connections (e.g. bolts, nuts, washers, pins) that have not been painted over must be given optimum corrosion Protection.

To prevent salt corrosion whilst the vehicle is stationary during the body-building phase all chassis must be washed with clean water to remove any salt residues as soon as they arrive at the body manufacturer.

5.3   Subframes

5.3.1   General

Should a subframe be required it must be of a continuous design, it may not be interrupted or bent out to the side (exceptions e.g. for some types of tipper, require approval).
No moving parts may be restricted in their freedom of movement by the subframe structure.

5.3.2   Permissible materials, yield points

The yield point, also called elongation limit or $\sigma_{0,2}$ limit, must not be exceeded under any driving or load conditions.
The safety coefficients must be taken into account. See table 18 for the yield points for different subframe materials.

Table 18:   Subframe materials (examples), standard designations and yield points

Material number	Material designation – old	Old standard	$\sigma_{0,2}$ N/mm²	σ_B N/mm²	Material designation – new	New standard	Suitability for use in TGA subframe
1.0037	St37-2	DIN 17100	≥ 235	340-470	S235JR	DIN EN 10025	Not permitted
1.0570	St52-3	DIN 17100	≥ 355	490-630	S355J2G3	DIN EN 10025	Well suited
1.0971	QStE260N	SEW 092	≥ 260	370-490	S260NC	DIN EN 10149-3	Not permitted
1.0974	QStE340TM	SEW 092	≥ 340	420-540	Withdrawn		Not for point loads
1.0976	N/A	N/A	≥ 355	430-550	S355MC	DIN EN 10149-2	Well suited
1.0978	QStE380TM	SEW 092	≥ 380	450-590	Withdrawn	DIN EN 10149-2	Well suited
1.0980	QStE420TM	SEW 092	≥ 420	480-620	S420MC	DIN EN 10149-2	Well suited
1.0984	QStE500TM	SEW 092	≥ 500	550-700	S500MC	DIN EN 10149-2	Well suited

Materials S235JR (St37-2) and S260NC (QStE260N) are not approved for TGA subframes.

5.3.3   Subframe design

The external width of the subframe must be the same as that of the chassis frame and must follow the exterior lines of the main frame.
The longitudinal members of the subframe must lie flat on the upper flange of the frame longitudinal member.
As far as possible the subframe should be designed to be flexible. The usual chamfered u-profiles used in vehicle construction are the best in terms of complying with the requirement for torsional flexibility.
Rolled sections are not suitable. If a subframe is closed at various points to form a box, the transition from the box to the u-profile must be gradual. The length over which the transition from the closed to the open section occurs must be at least triple the width of the subframe (see Fig. 57).

Fig. 57:   Transition from box to u-profile ESC-043
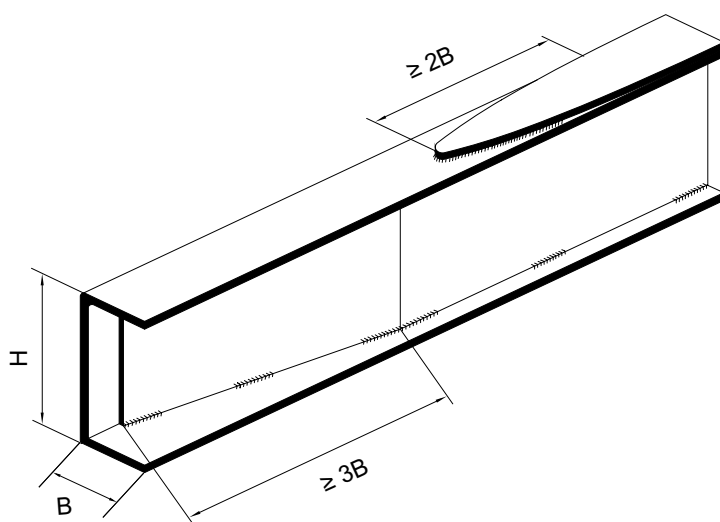
Where possible arrange the subframe cross member above the position of the frame cross member.
When fitting the subframe the main frame connections must not be detached.

Fig. 58: Subframe design ESC-096

Detail A

Mounting holes

On each side, the middle bolt that supports the frame connection must be left in place

Recess Ø 40

All drillings on the subframe-frame-cross-member connection drilled to Ø 14,5 and reamed to Ø 16 + 0,3

Provide cross-members at the bends in the frame

Avoid diagoal welds at the frame bends

Detail B

If the subframe is shorter than the frame round-off here R = 0,5 subframe thickness

A

B

The subframe longitudinal member must reach as far forward as possible – at least beyond the rearmost front spring hanger.
For an air-sprung 1st axle we recommend a clearance of ≤ 600 mm between the wheel centre of the 1st axle and the subframe.

Fig. 59:   Distance of subframe from the middle of the 1st axle ESC-697
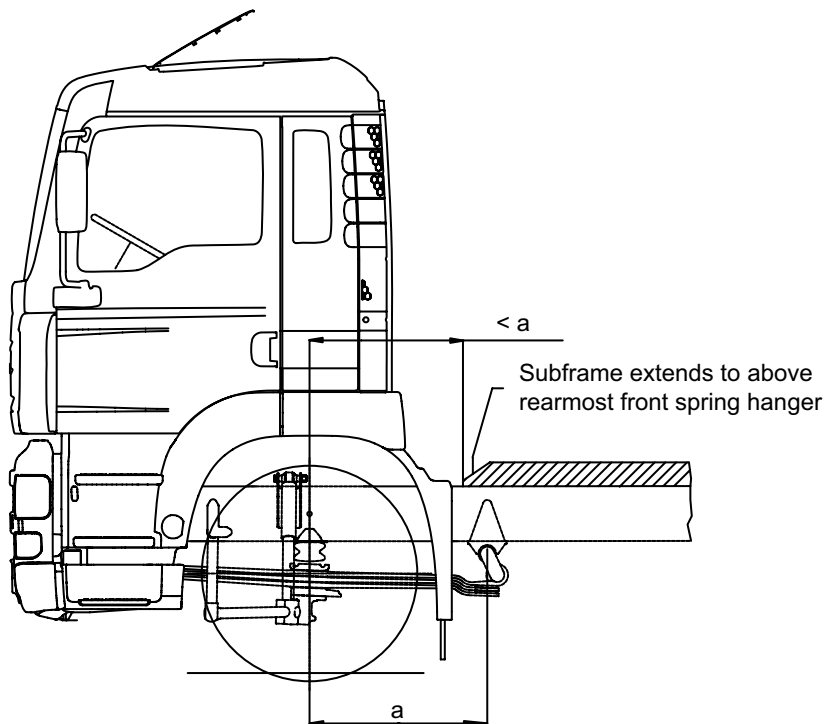
In order to comply with the required dimensions the subframe must follow the contours of the frame. It must be tapered or recessed at the front (see Figs. 60 to 63 for examples).

Fig. 60:   Subframe taper at front ESC-030
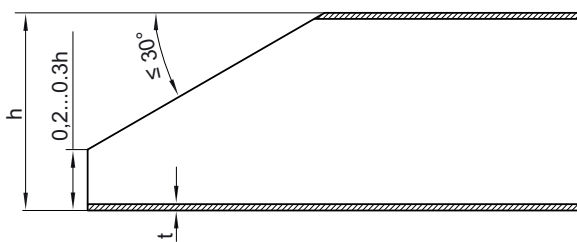
Fig. 61:   Subframe recess at front ESC-031
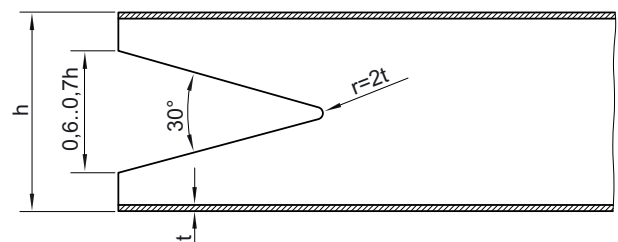
Fig. 62:   Subframe - adapting by widening ESC-098   **Fig. 63:** Subframe - adapting by tapering ESC-099
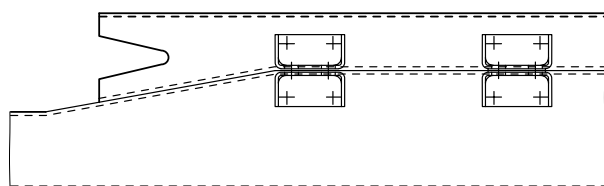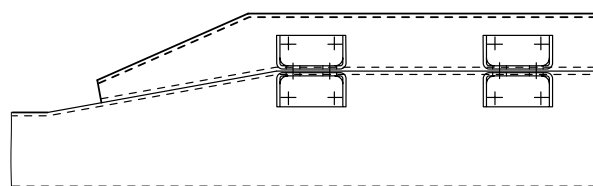
5.3.4   Attaching subframes and bodies

Load transmission from the superstructure to the subframe – in particular the attachment of the superstructure to the vehicle frame – and the corresponding connections – are the responsibility of the body manufacturer. Subframes and chassis frames are to be connected using either a flexible or a rigid connection. Depending on the particular situation, it may be necessary to use both types of subframe to vehicle attachment at the same time (this is then referred to as semi-rigid where the length and area of the rigid connection are stated). The mounting brackets provided by MAN are intended for the flexible installation of loading platforms and box bodies.
This does not mean that they are unsuitable for other add-ons and bodies. However, a check must be made to see whether they are strong enough when equipment and machines requiring drives, lifting equipment, tanker bodies etc. are installed. Wooden or flexible shims between the frame and the subframe or the frame and the body are not permitted (see Fig. 64).

Reasoned exceptions are permitted only if ESC can issue written approval.
(For address see „Publisher" above).

Fig. 64: Flexible shims ESC-026

Flexible shims such as rubber or
similar products are not permitted
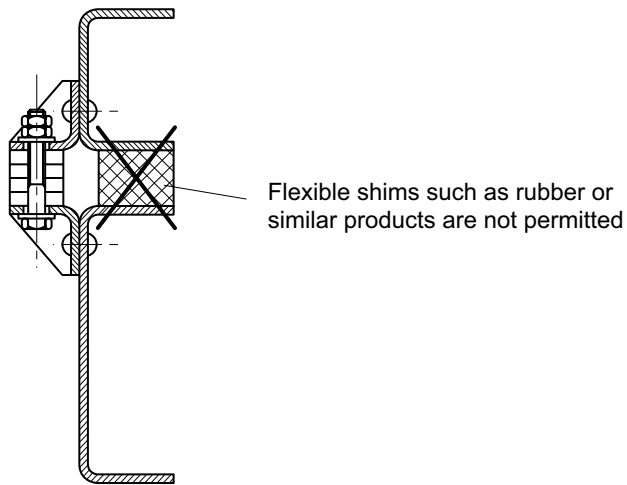
5.3.5 Screw connections and riveted joints

Screw connections with a minimum strength class of 10.9 and mechanical locking device are permitted, for screw connections see Section 4.3 in this booklet. It is also possible to use high-strength rivets (e.g. Huck®-BOM, blind fasteners) – manufacturers' installation instructions must be followed. The riveted joint must be at least equivalent to the screw connection in terms of design and strength. In principle – although never tested by MAN – it is also possible to use flange bolts. MAN draws your attention to the fact that such flange bolts place considerable requirements on installation accuracy because they have no locking device as such. This applies particularly when the grip length is short.

Fig. 65: Riveted joint for open and closed profiles ESC-157
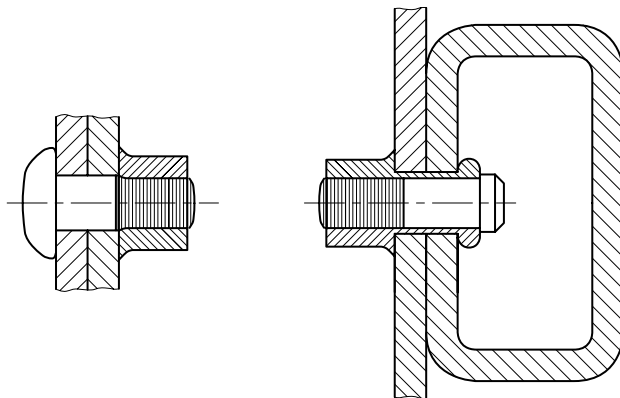
5.3.6 Flexible connection

Flexible connections are non-positive/frictional connections. Relative movement between frame and subframe is possible to a limited degree. All bodies or subframes that are bolted to the vehicle frame by means of mounting brackets are flexible connections.
Even when shear plates are used, these connecting pieces should be regarded as flexible if they do not comply with the requirements of a rigid connection (see Section 5.3.7 below) flexible connections the mounting points located on the chassis must be used first.

If these are not sufficient or cannot be used for design reasons, then additional mountings are to be located at suitable points.
If additional frame holes are required adhere to requirements stated in Section 4.3.

The number of mountings should be selected to ensure that the distance between the mounting point centres does not exceed 1,200 mm (see Fig. 66).

Fig. 66:   Distance between subframe mountings ESC-100
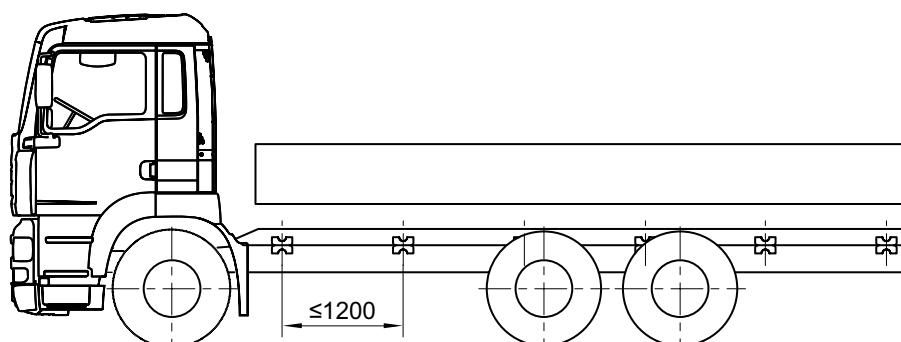
If MAN mounting brackets are supplied, either fitted to the vehicle or as loose components, the bodybuilder is still under obligation to check whether their number and location (existing holes in frame) is correct and adequate for the particular body installation.
The mounting brackets on MAN vehicles have oblong holes that run in the longitudinal direction of the vehicle (see Fig. 67).
They compensate for any tolerances and – for flexible connections – permit the unavoidable longitudinal movement between the frame and the subframe or between the frame and the body. To balance out the width clearances, the subframe mounting brackets may also have oblong holes and these must be arranged at right angles to the longitudinal direction of the vehicle.

Fig. 67:   Mounting brackets with oblong holes ESC-038
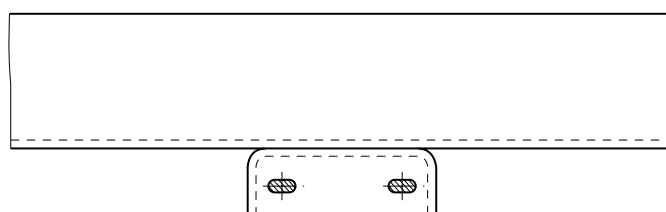
Mounting bracket on frame   Mounting bracket on subframe
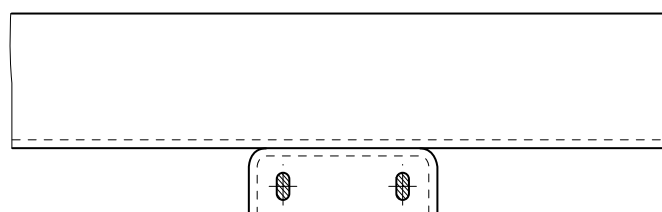
Any gaps between the mounting brackets of frame and subframe may be compensated for by inserting steel shims of appropriate thickness (see Fig. 63), S235JR (= St37-2) grade being adequate.
Avoid inserting more than four shims at any one mounting point.

Fig. 68:   Shims between mounting brackets ESC-628

Compensate for variations in spacing with max. 4 shims, an air gap of max. 1mm is permissible.
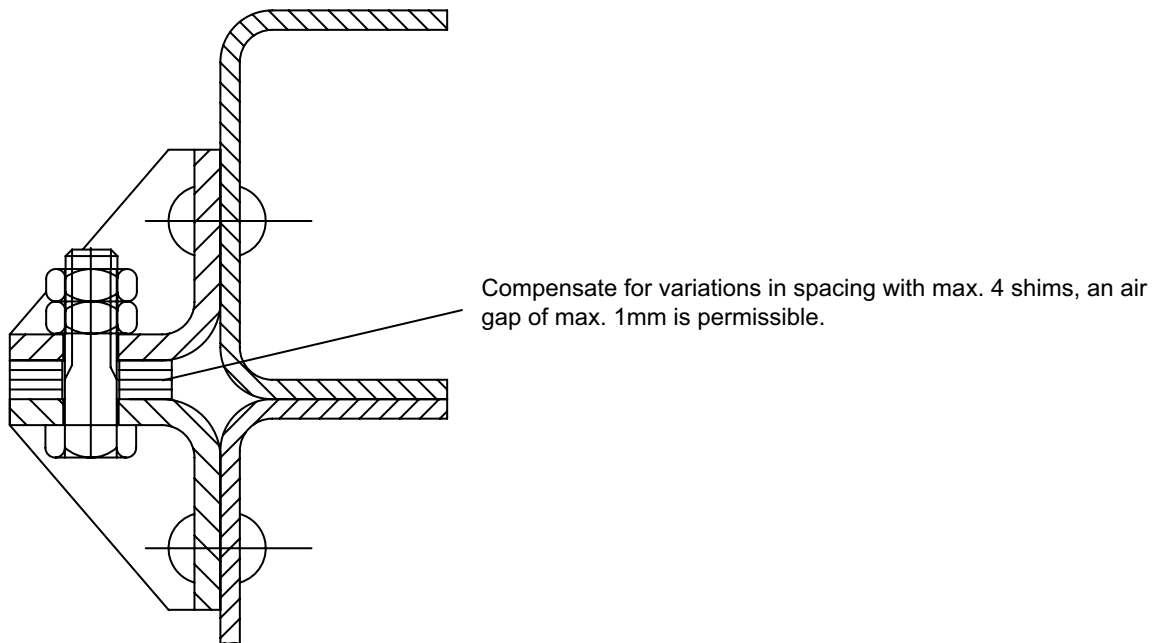
If there is a risk that the mounting bolts will work loose then fit bolts of 100 to 120 mm. This will limit the risk of loosening because longer bolts have greater elastic properties. For long bolts with regular mounting brackets use spacer sleeves. (see Fig. 69).

Fig. 69:   Increasing elasticity by using longer bolts and spacer sleeves ESC-635

≥ 25

Use spacer sleeves with long bolts
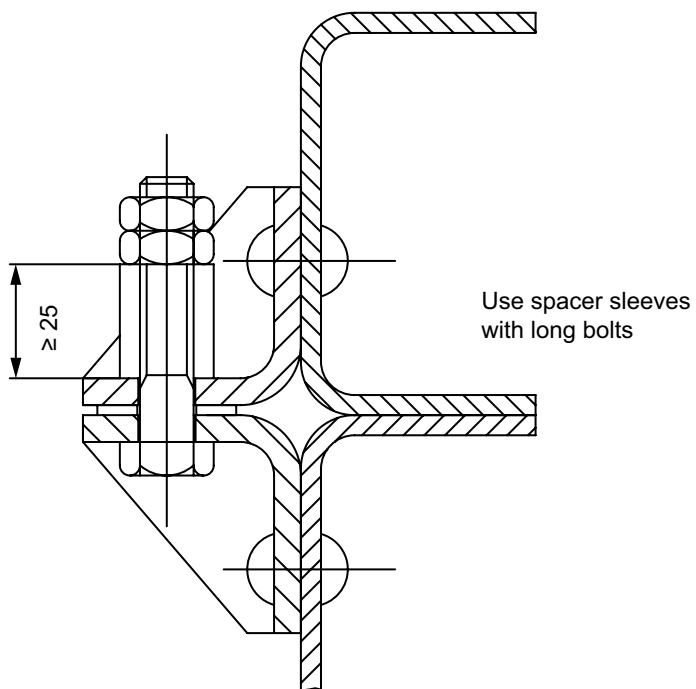
For other types of flexible mounting (e.g. shackle mountings) see Figs. 70 and 71.

Fig. 70: Long bolts and cup springs ESC-101
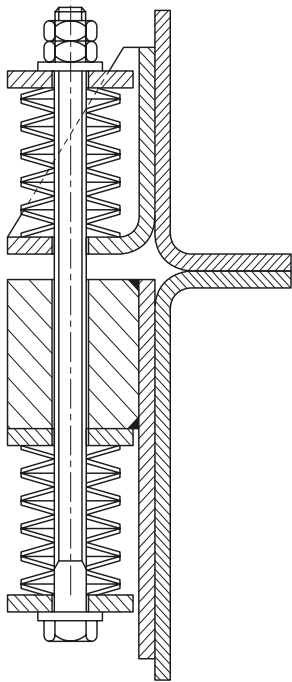
Fig. 71: Shackle mounting ESC-123

Clamp - property class 8.8

Spacer - non elastic

Angle bracket, approx. 5 thickness, fitted

Attached on frame web only

Angular or U-shaped bridging piece
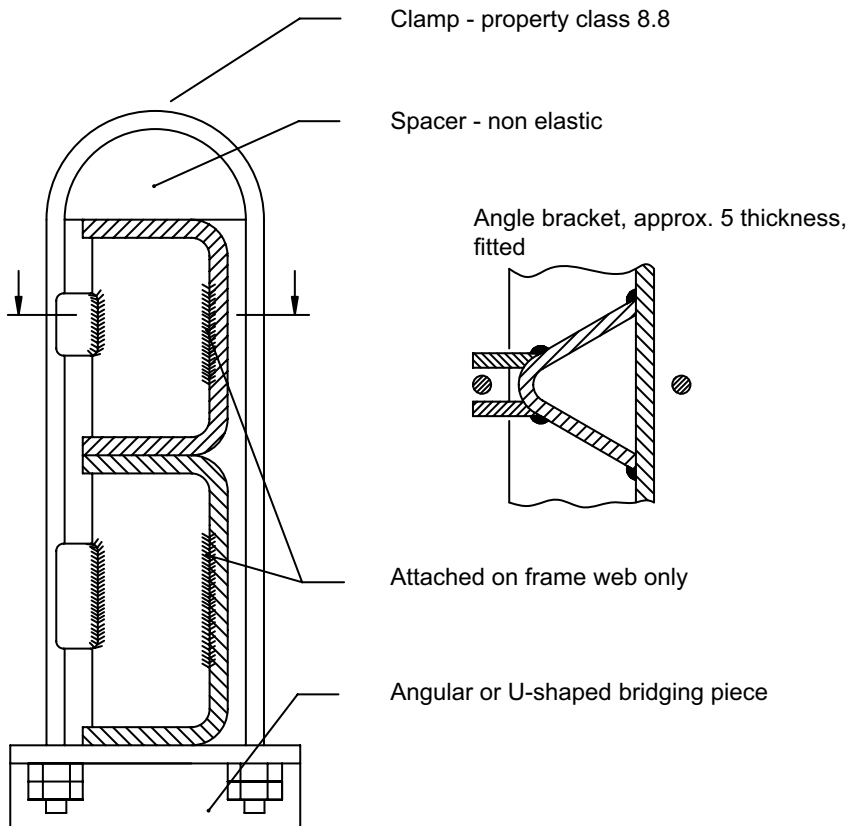
5.3.7 Rigid connection

With rigid connections relative movement between the frame and subframe is no longer possible, the subframe follows all the movements of the frame. If the connection is rigid the frame and the subframe profile in the vicinity of the rigid connection are regarded as one single section for calculation purposes. Mounting brackets supplied ex-works and other connections that are non-positive/frictional are not considered to be rigid connections. Only positive-locking connecting elements are rigid.

Positive-locking connecting elements are rivets or bolts. However, bolts are only classed rigid connectors if a hole tolerance of ≤ 0.2 mm is maintained. If rigid connections are to be made using solid-shank bolts then the bolt's thread may not come into contact with the bolt hole walls (see Fig. 72). The minimum grade for bolts is 10.9.

Fig. 72: Contact of the bolt thread with the hole wall ESC-029
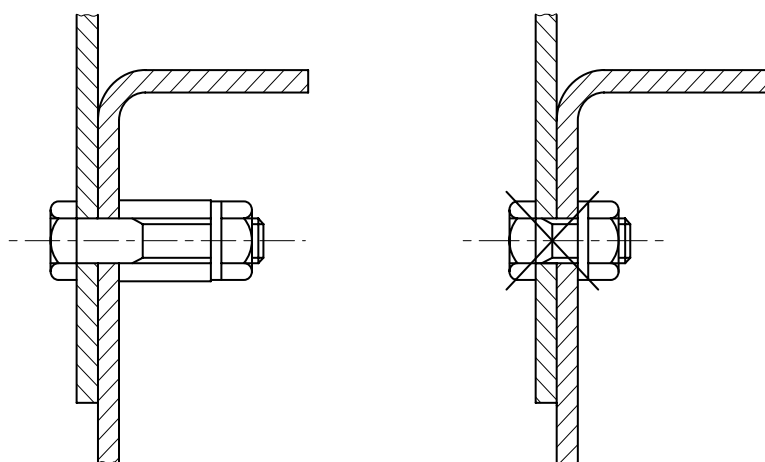
Due to the short grip lengths that are normally required, use may be made of spacer sleeves as shown in Fig. 73.

Subframe

Shear plate

Thread must not touch
the hole wall of the
shear plate or of the
frame

Spacer sleeve

Frame

Welds may only en-
croach into the radii of
the shear plates by a
max. of 45°
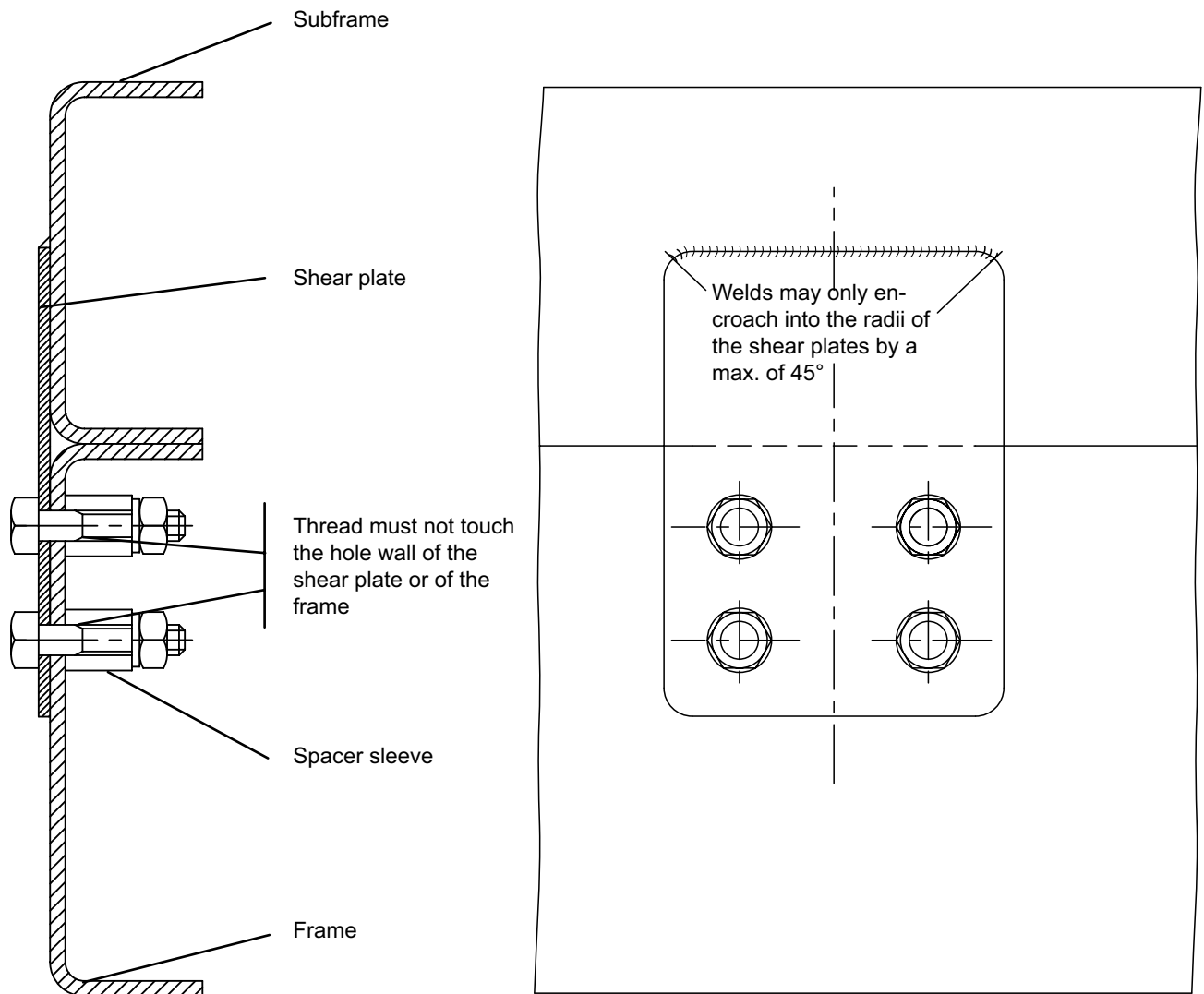
Fig. 74: Twin mounting with plug weld ESC-025
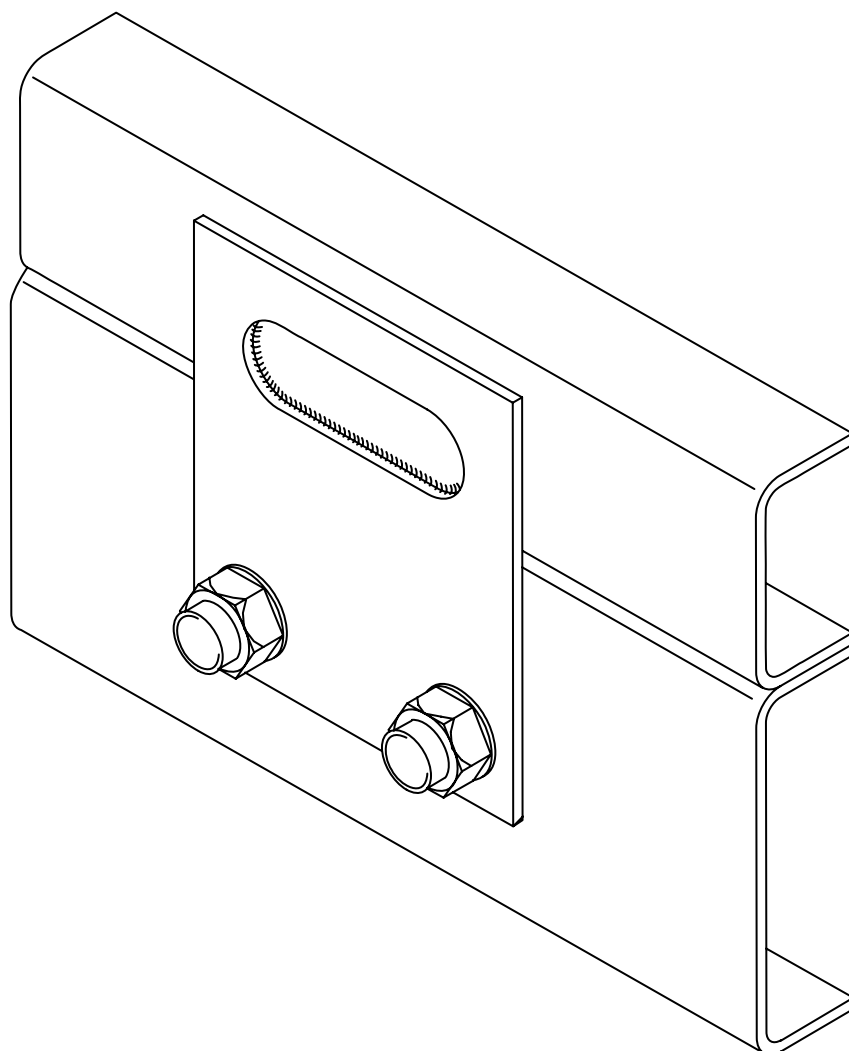
Single piece shear plates may be fitted to each side of the frame. Individual shear plates are preferred however.
The thickness of the shear plate must be the same as the thickness of the frame web; a tolerance of +1 mm is permitted.
In order that the frame's ability to twist is affected as little as possible, the shear plates are to be located only where absolutely necessary. The beginning, end and the required length of a rigid connection can be determined by calculation.
The connection should be designed based on the calculation. Flexible mountings may be selected for the other mounting points outside the defined rigid area.

5.4 Bodies

5.4.1 Testing of bodies

Testing of bodies and subsequent approval in writing by ESC (for address see "Publisher" above) is required when deviations have been made from this Guide to Fitting Bodies and the deviation has been made for valid technical reasons.
For the calculations, two copies of body documentation that must be suitable for inspection are required.
This documentation must contain the following information in addition to a drawing of the body:

→   Identification of the deviations from the Guide to Fitting Bodies in all documentation!

- Loads and their load application points:
    - Loads applied by the body
    - Axle load calculation
- Special conditions of use:
- Subframe:
    - Material and cross-sectional data
    - Dimensions
    - Type of section
    - Arrangement of cross members in the subframe
    - Special features of the subframe design
    - Cross-section modifications
    - Additional reinforcements
    - Upsweeps, etc.
- Means of connection:
    - Positioning (in relation to the chassis)
    - Type
    - Size
    - Number.

Photos, 3D pictures and perspective drawings may be used for purposes of clarity but they may not replace the binding documentation set out above.

5.4.2 Platform and box bodies

To ensure even load distribution on the chassis a subframe is normally used.
Consideration should be given to wheel clearances as early as during the body design stage – including the lowered position/chassis position at full suspension compression. Additional clearance requirements for items such as anti-skid chains, vehicle body roll, degree of axle articulation must also be taken into account. Hinged vehicle sides may not contact the road surface even when the vehicle is in the lowered position or the chassis position is at full suspension compression.
The body must sit torsion free on the longitudinal frame members.

Closed bodies in particular, such as box bodies, are designed to be relatively torsionally stiff with respect to the chassis frame.
So that the desired twisting of the frame (for example when cornering) is not hindered by the body, the body fixtures should be flexible at the front and rigid at the rear. This is particularly important if the vehicle is designed for off-road purposes. For this application, we recommend a front body mount with a three-point or diamond-shaped mounting (see Fig. 75 for mounting principle).

Fig. 75:   Mounting options for torsionally rigid bodies on flexible chassis with three-point and diamond-shaped mountings ESC-158
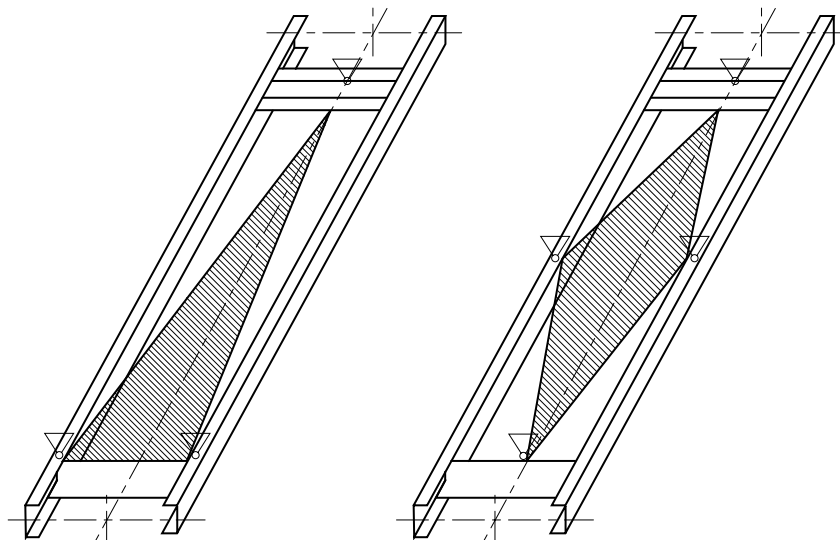
5.4.3   Tail-lifts

Pre-requisites

Before installing a tail-lift (also called lifting platforms, loading platforms, liftgates), its compatibility with the vehicle design, the chassis and the body must be checked.

The installation of a tail-lift affects:

*   Weight distribution
*   Body length
*   Bending of the frame
*   Subframe bending
*   Type of connection between frame and subframe, and
*   The on-board electrical system (battery, alternator, wiring).

The body manufacturer must:

*   Carry out an axle load calculation
*   Observe the stipulated minimum front axle load (see the 'General' Chapter, Section 3.2 'Minimum front axle load')
*   Avoid overloading the rear axles
*   If necessary shorten the body length and rear overhang or extend the wheelbase
*   Check stability
*   Design the subframe and the connections to the frame (flexible, rigid) – see the Section "Subframe specification" in this Chapter
*   Provide batteries of greater capacity (≥ 175 Ah but preferably 225 Ah) and an alternator of sufficient capacity
           (at least 28V 80 A, but preferably 28V 110 A). These can be provided ex-works as optional equipment.

- Install an electrical interface for the tail-lift (available ex-works as optional equipment; for wiring diagrams and pin assignment see the Section on electrical connections).
- Observe statutory regulations, e.g.:
  - EC Machinery Directive (consolidated version of Directive 89/392/EEC: 98/37/EC)
  - Accident prevention regulations
  - Fit an underride guard in accordance with EC Directive 70/221/EEC or ECE R 58
  - Fit approved lighting installations in accordance with 76/756/EEC (in Germany, additional yellow indicator lights and retroreflective red-white warning markers are also required when operating the tail-lift, in accordance with §53b, Paragraph 5, StVZO for lifting platforms).

Defining the sub-frame

The sub-frame tables are applicable subject to the following:

- Minimum front axle load respected in accordance with Section 3.2 of the ‚General' Chapter
- No design overload of the rear axle(s)
- In addition to the support loads occurring on the tail-lift, both minimum front axle load and maximum rear axle load are to be added to the trailer vehicle on testing.
- Vehicles with lifting axles must lower the lifting axle during operation of the tail-lift.
- Overhang limits in respect of max. vehicle overhang must be respected.

The values in the tables are the benchmark values for which, due to strength/deformation reasons, no outriggers are required.

They are only required if:

- The tail-lift loading capacity limits given in the tables is exceeded
- Outriggers are required for stability reasons

If outriggers – although not required – are fitted, this does not affect the size of the extended sub-frame.
It is not permitted to raise the vehicle on the outriggers, as this could damage the frame.

The tables are sorted in ascending order according to tonnage class, variant description, suspension type and wheelbase, where the vehicle designation (e.g. TGA 18.xxx 4x2 BB, TGA 26.xxx 6x2-2) is to be regarded as an aid to orientation. The 3-digit type numbers, also known as type code numbers, which appear at the 2nd and 4th positions of the basic vehicle number and at the 4th and 6th positions of the vehicle identification number are binding (for explanation, see the 'General' Chapter).
All other technical documents, e.g. chassis drawings, assembly directives relate to the type number.
The overhang – always related to the wheel centre of the last axle – includes both the frame overhang of the
standard production chassis and the overall maximum vehicle overhang (including body and tail-lift, see Fig. 76 below),
which must not be exceeded when the tail-lift has been fitted. If the specified maximum vehicle overhang is insufficient,
the sub-frame data in the following lines for which the ≤-condition is satisfied applies (apart from the start of the rigid
connection, which relates only to the wheelbase).
The sub-frames in the tables are examples. For instance **U120/60/6** is a **U** section open to the inside with an outer height of **120** mm,
top and bottom **60** mm wide and **6** mm thick over the entire cross section.
Other steel sections are acceptable if they have at least equivalent values in respect of the moment of inertia I_x, moments of resistance W_{x1} W_{x2} and yield point $\sigma_{0,2}$.

Table 19: Technical data for sub-frame profile

Profile	Height	Width	Thickness	I_x	W_{x1}, W_{x2}	$\sigma_{0,2}$	σ_B	Mass
U100/50/5	100 mm	50 mm	5 mm	136 cm^4	27 cm^3	355 N/mm^2	520 N/mm^2	7,2 kg/m
U100/60/6	100 mm	60 mm	6 mm	182 cm^4	36 cm^3	355 N/mm^2	520 N/mm^2	9,4 kg/m
U120/60/6	120 mm	60 mm	6 mm	281 cm^4	47 cm^3	355 N/mm^2	520 N/mm^2	10,4 kg/m
U140/60/6	140 mm	60 mm	6 mm	406 cm^4	58 cm^3	355 N/mm^2	520 N/mm^2	11,3 kg/m
U160/60/6	160 mm	60 mm	6 mm	561 cm^4	70 m^3	355 N/mm^2	520 N/mm^2	12,3 kg/m
U160/70/7	160 mm	70 mm	7 mm	716 cm^4	90 cm^3	355 N/mm^2	520 N/mm^2	15,3 kg/m
U180/70/7	180 mm	70 mm	7 mm	951 cm^4	106 cm^3	355 N/mm^2	520 N/mm^2	16,3 kg/m

If adequate, the flexible structure of the sub-frame is designated by a **w**. For the partially rigid structure (designated s), the number of screw connections, the weld seam length – in each case per frame side – and the start of the rigid connection from the centre of axle 1 are indicated (see Fig. 71). For the rigid and/or partially rigid connection, the conditions set out in Chapter 5.3.7 'Bodies' apply.

Fig. 71: Tail-lift installation: overhang dimension, dimensions with partially rigid connection ESC-633
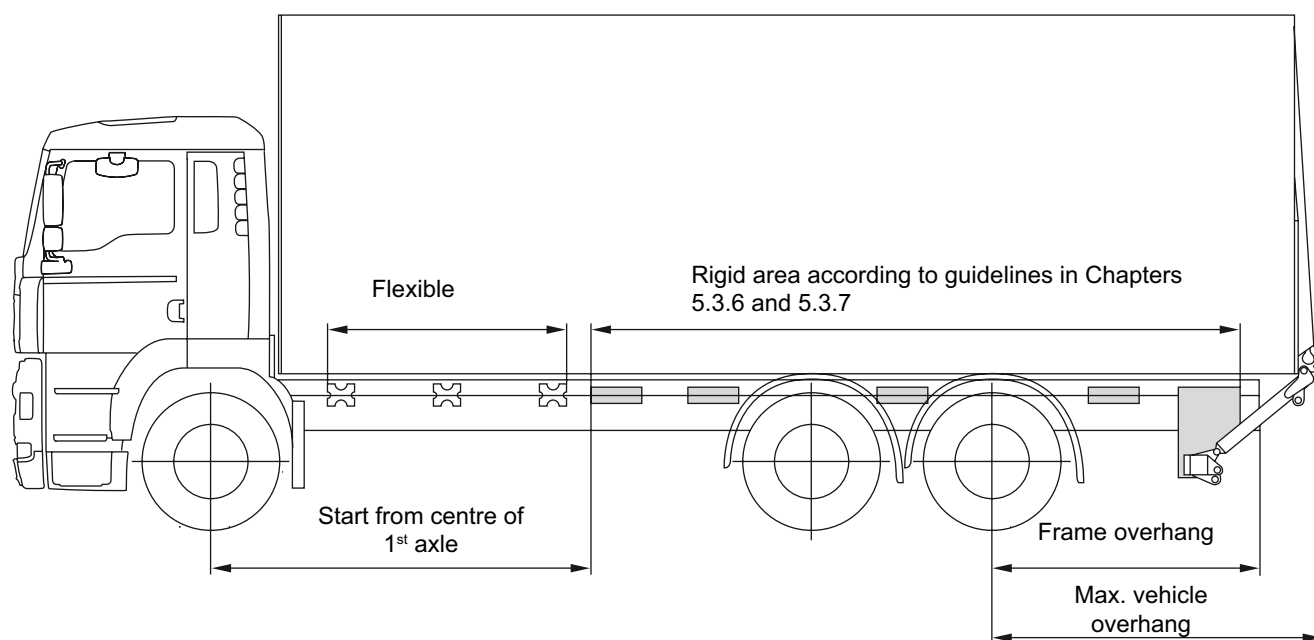
Table 20:   Subframe and mounting method

TGA 18.xxx   Connection method: **w** = flexible **s** = rigid

H02 H03	TGA 18.xxx 4x2 BB (leaf - leaf)					Each frame side ≥		Start from centre of 1st axle ≤
Wheel-base	Standard frame overhang	max. vehicle overhang	LBW useful load	Min. subframe	Type of connection	Bolt diameter Ø16+0,2	Weld length	
≤ 4.800		≤ 2.800	≤ 30,0	No subframe required				
5.100	2.900	≤ 3.000	≤ 20,0	No subframe required				
			30,0	U 160/60/6	w			
				U 100/50/5	s	16	750	2.950
5.500	3.200	≤ 3.300	≤ 15,0	No subframe required				
			20,0	U 120/60/6	w			
				U 100/50/5	s	12	600	3.200
			30,0	U 100/50/5	s	16	800	3.200
5.900	3.400	≤ 3.500	≤ 10,0	No subframe required				
			15,0	U 100/50/5	w			
			20,0	U 180/70/7	w			
				U 100/50/5	s	14	650	3.400
			30,0	U 100/50/5	s	18	850	3.400
6.300	3.700	≤ 3.750	≤ 10,0	No subframe required				
			15,0	U 160/70/7	w			
				U 100/50/5	s	12	550	3.650
			20,0	U 100/50/5	s	14	650	3.650
			30,0	U 120/60/6	s	20	800	3.650
6.700	3.400	≤ 4.000	≤ 7,5	U 100/50/5	s	10	450	3.850
			10,0	U 100/50/5	s	12	550	3.850
Caution: Overall length > 12 meter			15,0	U 100/50/5	s	14	650	3.850
			20,0	U 100/50/5	s	16	750	3.850
			30,0	U 140/60/6	s	24	950	3.850
H01, H08, H12, H13 tractor units – it is not permissible to convert these to trucks with tail-lifts								

H05 H06 H09 H10 H14 H15			TGA 18.xxx 4x2 BL / LL / LL-U (leaf - air / air - air / low build height air - air)					
Wheel-base	Standard frame overhang	max. vehicle overhang	LBW useful load	Min. subframe	Type of connection	Each frame side ≥		Start from centre of 1st axle ≤
						Bolt diameter Ø16+0,2	Weld length	
≤ 4.200		≤ 2.350	≤ 30,0	No subframe required				
4.500	2.350	≤ 2.600	≤ 20,0	No subframe required				
			30,0	U 120/60/6	w			
				U 100/50/5	s	16	700	2.600
4.800	2.500	≤ 2.800	≤ 20,0	No subframe required				
			30,0	U 180/70/7	w			
				U 100/50/5	s	16	750	2.750
5.100	2.900	≤ 3.000	≤ 15,0	No subframe required				
			20,0	U 120/60/6	w			
				U 100/50/5	s	12	550	2.950
			30,0	U 100/50/5	s	16	750	2.950
5.300 H14 H15	2.900	≤ 3.000	≤ 10,0	No subframe required				
			15,0	U 100/50/5	w			
			20,0	U 180/70/7	w			
				U 100/50/5	s	14	550	3.050
			30,0	U 100/50/5	s	18	800	3.050
5.500	3.200	≤ 3.200	≤ 10,0	No subframe required				
			15,0	U 160/60/6	w			
				U 100/50/5	s	12	600	3.200
			20,0	U 100/50/5	s	14	700	3.200
			30,0	U 120/60/6	s	20	800	3.200
5.900	3.400	≤ 3.500	≤ 7,5	No subframe required				
			10,0	U 120/60/6	w			
				U 100/50/5	s	10	450	3.400
			15,0	U 180/70/7	w			
				U 100/50/5	s	12	550	3.400
			20,0	U 100/50/5	s	14	650	3.400
			30,0	U 120/60/6	s	20	750	3.400
6.300	3.700	≤ 3.750	≤ 7,5	U 120/60/6	w			
				U 100/50/5	s	10	400	3.650
			10,0	U 160/70/7	w			
				U 100/50/5	s	10	450	3.650
			15,0	U 100/50/5	s	12	550	3.650
			20,0	U 100/50/5	s	14	650	3.650
			30,0	U 140/60/6	s	20	800	3.650
6.700	3.400	≤ 4.000	≤ 10,0	U 100/50/5	s	12	550	3.850
			15,0	U 120/60/6	s	16	600	3.850
Caution: Overall length > 12 meter			20,0	U 120/60/6	s	18	700	3.850
			30,0	U 160/70/7	s	24	800	3.850

H44 H45	TGA 24.xxx 6x2-2 / 6x2-4 LL-U (low build height air - air)					Each frame side ≥		
Wheel-base	Standard frame overhang	max. vehicle overhang	LBW useful load	Min. subframe	Type of connection	Bolt diameter Ø16+0,2	Weld length	Start from centre of 1st axle ≤
4.500	2.050	≤ 2.450	≤ 7,5	No subframe required				
+ 1.350			10,0	U 140/60/6	w			
				U 100/50/5	s	10	600	3.400
			15,0	U 180/70/7	w			
				U 100/50/5	s	12	700	3.400
			20,0	U 100/50/5	s	14	800	3.400
			30,0	U 120/60/5	s	20	900	3.400
4.800	2.150	≤ 2.650	≤ 7,5	U 160/60/6	w			
+ 1.350				U 100/50/5	s	10	550	3.550
			10,0	U 180/70/7	w			
				U 100/50/5	s	12	600	3.550
			15,0	U 100/50/5	s	14	750	3.550
			20,0	U 100/50/5	s	16	850	3.550
			30,0	U 140/60/6	s	22	1.000	3.550

H16 H17 H18 H19 H20 H21			TGA 26.xxx 6x2-2, 6x2-4 BL / LL (leaf - air / air - air)						
Wheel-base	Standard frame overhang	max. vehicle overhang	LBW useful load	Min. subframe	Type of connection	Each frame side ≥			Start from centre of 1st axle ≤
						Bolt diameter Ø16+0,2	Weld length		
3.900	1.950	≤ 1.950	≤ 20,0	No subframe required					
+ 1.350			30,0	U 120/60/6	w				
				U 100/50/5	s	14	750		3.050
4.200	2.150	≤ 2.200	≤ 20,0	No subframe required					
+ 1.350			30,0	U 180/70/7	w				
				U 100/50/5	s	14	800		3.200
4.500	2.400	≤ 2.450	≤ 10,0	No subframe required					
+ 1.350			15,0	U 120/60/6	w				
				U 100/50/5	s	12	600		3.400
			20,0	U 180/70/7	w				
				U 100/50/5	s	14	700		3.400
			30,0	U 100/50/5	s	16	850		3.400
4.800	2.600	≤ 2.650	≤ 7,5	No subframe required					
+ 1.350			10,0	U 120/60/6	w				
				U 100/50/5	s	10	550		3.550
			15,0	U 180/70/7	w				
				U 100/50/5	s	12	650		3.550
			20,0	U 100/50/5	s	14	700		3.550
			30,0	U 120/60/6	s	18	850		3.550
5.100	2.800	≤ 2.900	≤ 7,5	U 160/60/6	w				
+ 1.350				U 100/50/5	s	10	500		3.700
			10,0	U 180/70/7	w				
				U 100/50/5	s	10	550		3.700
			15,0	U 100/50/5	s	12	650		3.700
			20,0	U 100/50/5	s	14	750		3.700
			30,0	U 120/60/6	s	20	850		3.700
5.500	3.100	≤ 3.200	≤ 7,5	U 100/50/5	s	10	550		3.950
+ 1.350			10,0	U 100/50/5	s	12	650		3.950
			15,0	U 100/50/5	s	14	700		3.950
			20,0	U 120/60/6	s	16	750		3.950
			30,0	U 160/60/6	s	22	950		3.950
5.900	2.900	≤ 3.500	≤ 7,5	U 100/50/5	s	12	650		4.200
+ 1.350			10,0	U 120/60/6	s	14	650		4.200
Caution: Overall length > 12 meter			15,0	U 140/60/6	s	18	750		4.200
			20,0	U 160/60/6	s	20	850		4.200
			30,0	U 180/70/7	s	26	950		4.200

Electrical connection

Electro-hydraulic tail-lifts require most careful design of their electrical supply. It is assumed that the information contained in the Chapter 'Electrics, electronics, cables', of the Guide to Fitting Bodies is applied. Ideally, the electrical interface for the tail-lift should be supplied ex-works (package comprises switches, warning lights, starter inhibitor and power supply for tail-lift). Retrofitting is a complex procedure and requires intervention in the vehicle's power supply, which may only be carried out by correspondingly qualified MAN service staff. The factory-fitted transport securing device must be removed. The body manufacturer must check the circuitry of the tail-lift for its compatibility with MAN vehicles. Under normal circumstances triggering of interface A358 may only be effected with 24V continuous signals – not with flash pulses. In case of failure a clocked signal may be applied briefly to relay K476.

For the tail-lift electric interface see the additional wiring diagram below.

Fig. 77: Additional wiring diagram, tail-lift for MAN no. 81.99192.1920

Disconnect standard plug connector and connect the cab-tail-lift cable harness in between!

Ladebordwand
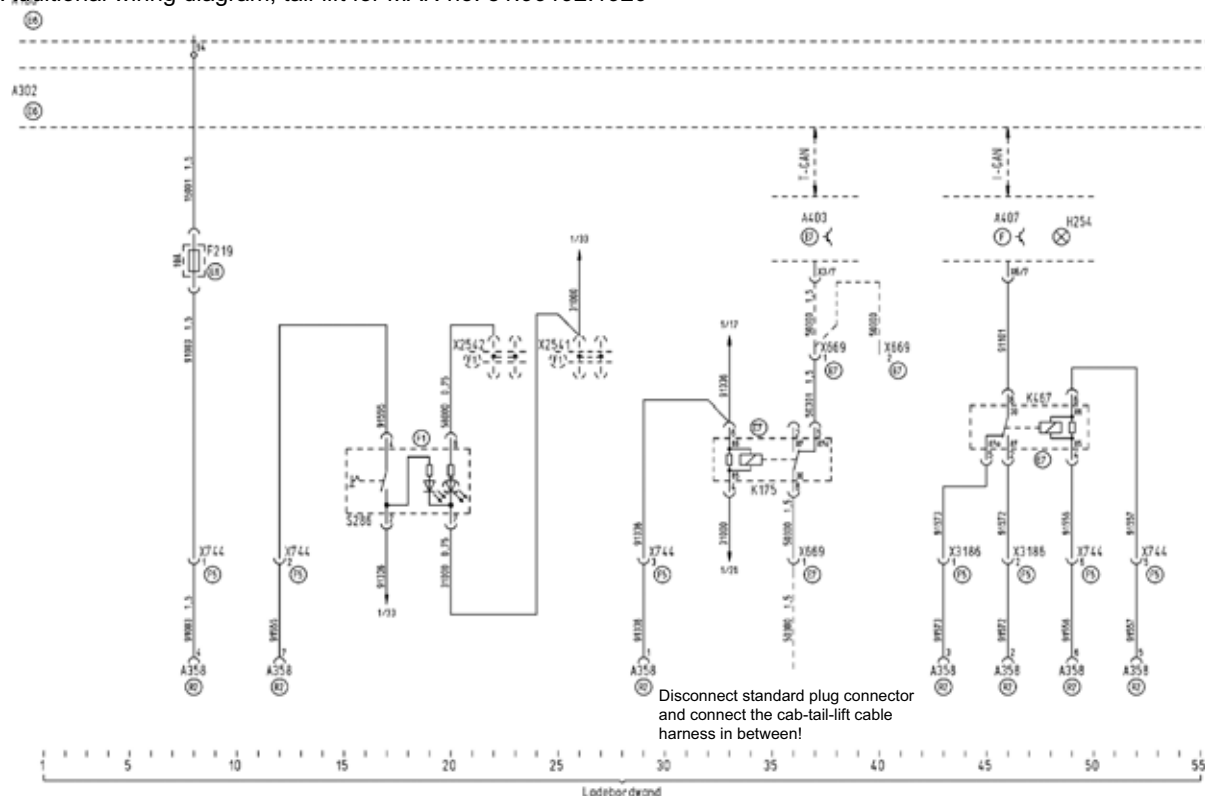
Legende

A100	255	Central electrics box
A302	352	Central computer 2
A358		Control unit – tail-lift
A403	339	Vehicle management computer
A407	342	Instrumentation
F219	118	Tail-lift fuse (pin 15)
H254		Tail-lift warning lamp
K175	281	Starter interlock relay
K467	281	Tail-lift relay
S286	547	Tail-lift switch
X669		Plug connector, starter interlock
X744		Plug connector, tail-lift
X2541	246	Potential distributor 21 pin, lead 31000
X2542	246	Potential distributor 21 pin, lead 58000
X3186		Plug connector, tail-lift

Leads 91003, 91336, 91556, 91557, 91572 and 91573 lead to a 7 pin connector housing on the frame end (rolled up).

5.4.4 Interchangeable containers

MAN swap body fittings: The TGA range includes fully air-sprung vehicles that can be supplied ex-factory with swap body fittings. Installation dimensions and centring devices correspond to the requirements of EN 284. There is a dedicated module in MANTED® where CAD drawings of the MAN swap body fittings can be viewed.

Container and interchangeable platforms that meet the requirements of EN 248 may be fitted to the vehicles stated above.
The standard swap body fittings cannot however be freely utilised if different bodies that do not meet the requirements of EN 248 are to be mounted. The relocation of support points or different dimensions are only permitted if they have been approved by the ESC department at MAN (for address, see 'Publisher' above). Do not remove the centre supports – their use is imperative!
The body must lie along their whole length. If this is not possible for design reasons, then an adequately dimensioned subframe must be fitted. Supports for interchangeable containers are not suitable for absorbing forces that are exerted by mounted machinery and point loads. This means that when, for example, fitting concrete mixers, tippers, fifth-wheel subframes with fifth-wheel couplings, etc, different fixtures and supports must be used.

The body manufacturer must provide evidence that they are suitable for this purpose.

Other interchangeable equipment: Interchangeable containers should lie on the upper side of the frame, along the whole length of the frame. A subframe can be omitted if the requirements in the following Section 5.4.5 „Self-supporting bodies without subframe" are met. Frame longitudinal members must however, be protected from wear (e.g. by fitting an anti-wear profile as shown in Fig. 78).

Materials with a yield point of $\sigma_{0,2} \leq 350$ N/mm² may be used for the anti-wear profile, but not for the subframe. The anti-wear profile may assume the functions of a subframe only if it can be demonstrated by calculation that it is suitable for this purpose.

Fig. 78:   Anti-wear profile for interchangeable container ESC-121

Anti-wear profile
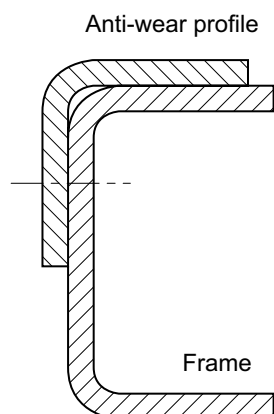
Frame

5.4.5   Self-supporting bodies without subframe

A subframe is possibly not required if:

*   there is a sufficient moment of resistance (affects the bending stress) and
*   there is a sufficient geometrical moment of inertia (affects flexing) and
*   the body is self-supporting.

The prerequisite for vehicles that require a subframe in accordance with the above guideline is written approval from
the ESC Department at MAN (for address see "Publisher" above).
Note on fitting bodies without subframes: The distance between the body cross members may not exceed 600 mm (see Fig. 79).
In the area of the rear axles it is permissible to exceed the distance of 600 mm.

Fig. 79:   Distances between cross members if no subframe is fitted ESC-001
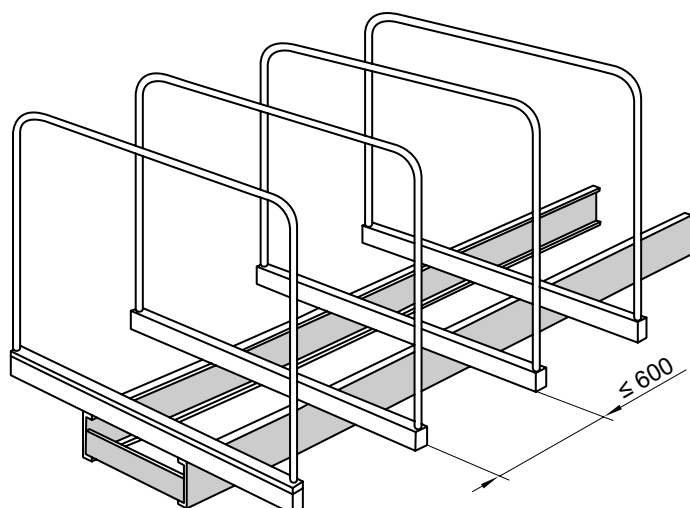
The minimum lengths of the supports on the frame must be calculated according to the rules of Hertzian contact stresses.
For this application, it is assumed that there is "linear contact between two cylinders" rather than "linear contact between a cylinder and
a flat surface". Fig. 80 illustrates an exaggerated deformation of two U-sections placed one on top of the other.
An example of the calculation can be found in Chapter 9 "Calculations".

Fig. 80:   Deformation of two U-sections ESC-120
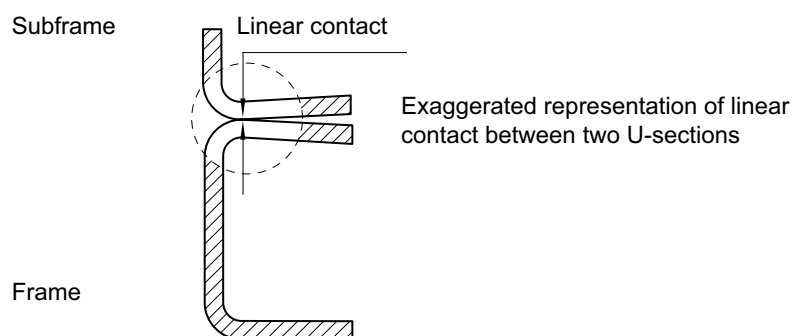
Vibration problems cannot be ruled out on bodies not fitted with subframes. MAN cannot make any statements on the vibration behaviour of vehicles fitted with bodies that have no subframes, since the vibration behaviour depends on the body.
If inadmissible vibrations develop, the cause must be eliminated, which may mean that a subframe has to be retrofitted after all.
Even on designs without subframe, access to the filler necks for fuel and other operating fluids must be ensured as must access to all other frame components (e.g. spare wheel lift, battery box).
The freedom of movement of moving parts in relation to the body must not be adversely affected.

5.4.6   Single-pivot body

The single-pivot body, which is comparable with a fifth-wheel coupling, always requires a subframe. Positioning of the pivot point for the single-pivot body behind the theoretical rear axle centreline must be approved with regard to axle load distribution and handling.
In this case approval must be granted by the ESC department (for address see "Publisher" above).

5.4.7   Tank and container bodies

Depending on the type of goods being transported, the responsible party must ensure that the vehicles are equipped in accordance with national requirements, guidelines and regulations. In Germany, the technical inspection organisations (DEKRA, TÜV) can provide information regarding the transportation of hazardous goods (subject to the Hazardous Goods Regulations). Tank and container bodies generally require a continuous subframe as described in Chapter 5.3 "Subframes".
The conditions for approved exceptions for tanker and container bodies without subframes are listed below.
The front connection between the body and chassis must be designed so that it does not hinder the frame's ability to twist.
This can be achieved using front mountings that are as flexible as possible, e.g.:

•   Pendulum-type mounting (Fig. 81)
•   Flexible mounting (Fig. 82)

Fig. 81:   Front mounting of pendulum type ESC-103   **Fig. 82:**   Front mounting of flexible type ESC-104
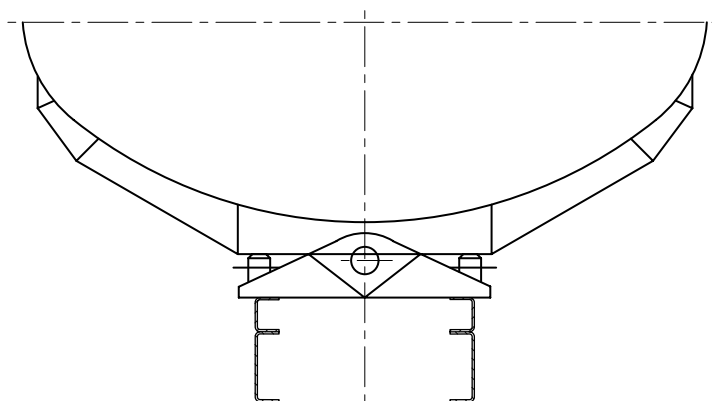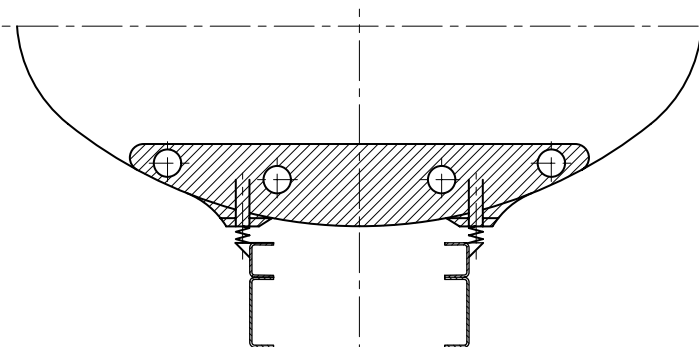
The front mounting point should be as close as possible to the front axle centreline. (see Fig. 83).
The rear, laterally stiff body support must be fitted in the vicinity of the theoretical rear axle centreline. At this point the connection to the frame should also be of sufficient size. The distance between the theoretical rear axle centreline and the centre of the support must be <1,000 mm (see Fig. 83). See Section 3.5. 'Theoretical axle centreline.

Fig. 83: Layout of tanker and bulk container mountings ESC-004

Centre of support if possible the same as the theoretical rear axle centreline and not > 1,000 mm away from it

I_t

≤1000

≥500

≤1400

Design the connection such that it affects frame twisting to the least possible extent
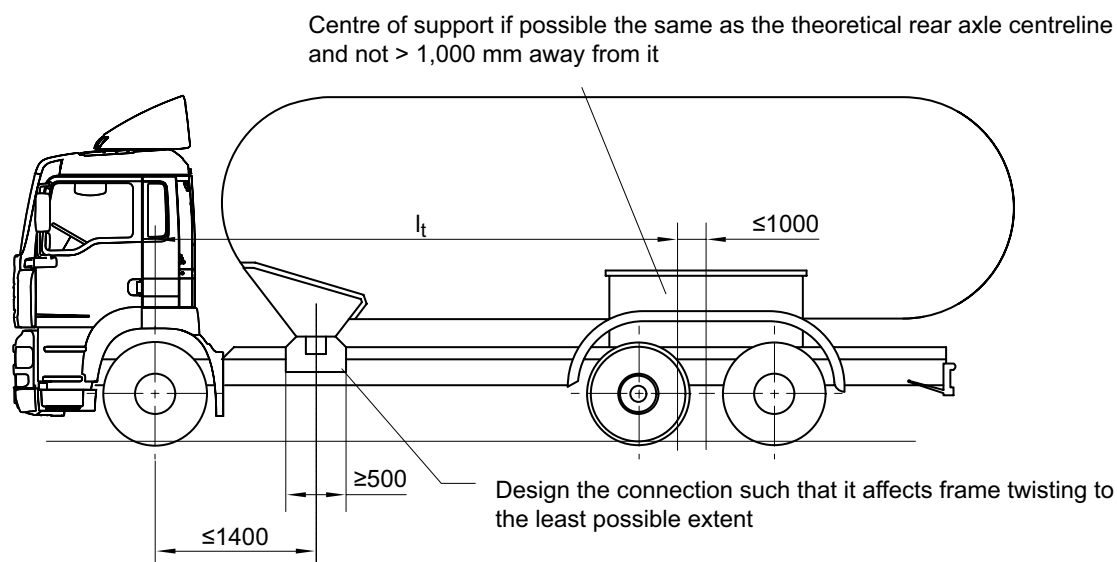
Once the body has been installed it is important that a test is carried out to confirm whether vibrations or other disadvantageous handling characteristics are evident. Vibration can be influenced by correct subframe design and the correct layout of the tank mountings.
Tank and container bodies without subframe: Tanker and container bodies without subframes can be approved if the conditions described here are observed and there are double or triple tank mountings on each side of the frame.
All supports must be arranged at the specified distances. If the permissible range is exceeded, this may cause the frame to bend excessively, which is not permitted. The vehicle may only be used on metalled roads.
Once the body has been fitted it is important that a test is carried out to check for vibrations or other disadvantageous handling characteristics.

Table 21:   Chassis without subframes for tanker bodies with double and triple mountings

Model	Wheel formula	Suspension	Wheelbase
H05	4x2 4x4H	Leaf-air	3.600-4.500
H06			
H07			
H22			
H09		Full air	
H10			
H16	6x2-2 6x2-4 6x4H-2 6x4H-4 6x2-4	Leaf-air	3.900-4.500 + 1.350
H17			
H18			
H35			
H27			
H71			
H74			
H86			
H89			
H19		Full air	
H20			
H21			
H31			
H85			
H87			
H23	6x2/2 6x2/4 6x4H/2 6x4H/4	Leaf-air	2.600-4.150 + 1.350
H24			
H32			
H42			

Double mounting

Triple mounting

4x2/2

≤1200   ≤1000

≥800   ≥1200

Theoretical rear centreline

≤1200   ±500   ≤1000

≥500   ≥1000   ≥500

Theoretical rear centreline

6x2-4
6x2/2

≤1200   ≤1000

≥1100   ≥700

Theoretical rear centreline

≤1200   ±500   ≤1000

≥700   ≥1400   ≥700

Theoretical rear centreline
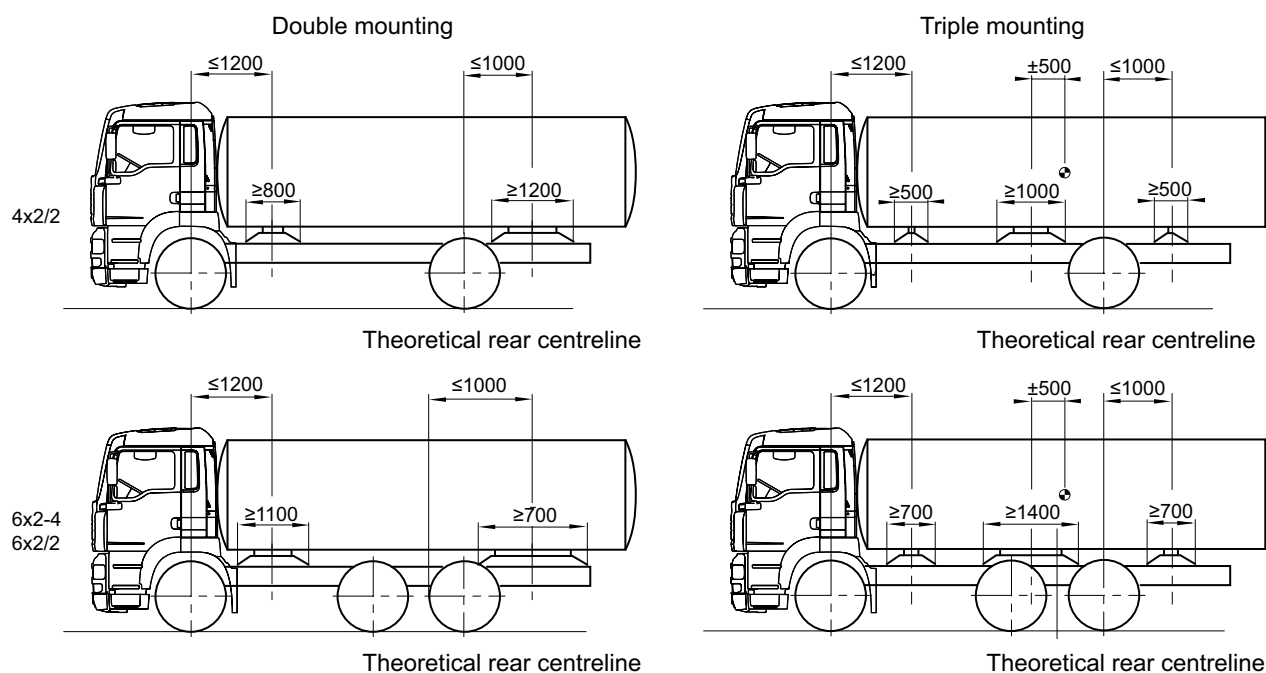
5.4.8   Tippers

Tipper bodies require a chassis designed for their special purpose. MAN has special tipper chassis in its product range.
These may be selected in MANTED® by querying the system by body type.
Factory-built tipper chassis require no additional work if it is ensured that the following points are observed:

*   The permissible gross weight
*   The permissible axle loads
*   The standard tipper body length
*   The standard frame overhang
*   The standard vehicle overhang
*   The maximum tipping angle of 50° to the rear or side

All tipper bodies require a continuous steel subframe. (For information on the minimum yield point and suitable materials see Section 5.3.2 in this booklet).
The body manufacturer is responsible for the connection between the chassis and the subframe.
Tipper rams and tipper mountings must be incorporated into the subframe because the vehicle frame is not designed to take point loads.

The following parameters must be observed:

*   Tipping angle to the rear or side ≤ 50°
*   During tipping to the rear, the centre of gravity of the tipper body with payload should not move behind the centreline of the last axle unless stability of the vehicle is guaranteed.

We recommend:

- That during the tipping operation, the height of the centre of gravity of the tipper body is not exceeded (dimension „a" see Fig. 85 ≤ 1.800).
- The centre of the rear tipper mountings should be located as close to the theoretical rear axle centreline as possible. Recommendation: Do not exceed dimension „b" (see table 22 and Fig. 85) between the centre of the tipper mountings to the theoretical rear axle centreline (1,100 mm-1,250 mm) (theoretical rear axle centreline see Section 3.5).

Table 22: Tippers: Maximum values for centre of gravity height and tipper mounting spacing

Chassis	Dimension „a" [mm]	Dimension „b" [mm]
Two axle vehicle 4x2 u. 4x4	≤ 1.800	≤ 1.100
Three axle vehicle 6x2, 6x4 u. 6x6	≤ 2.000	≤ 1.250
Four axle vehicle 8x2, 8x4, 8x6 u. 8x8	≤ 2.000	≤ 1.250

Fig. 85: Tippers: Maximum values for centre of gravity height and tipper mounting spacing ESC-105
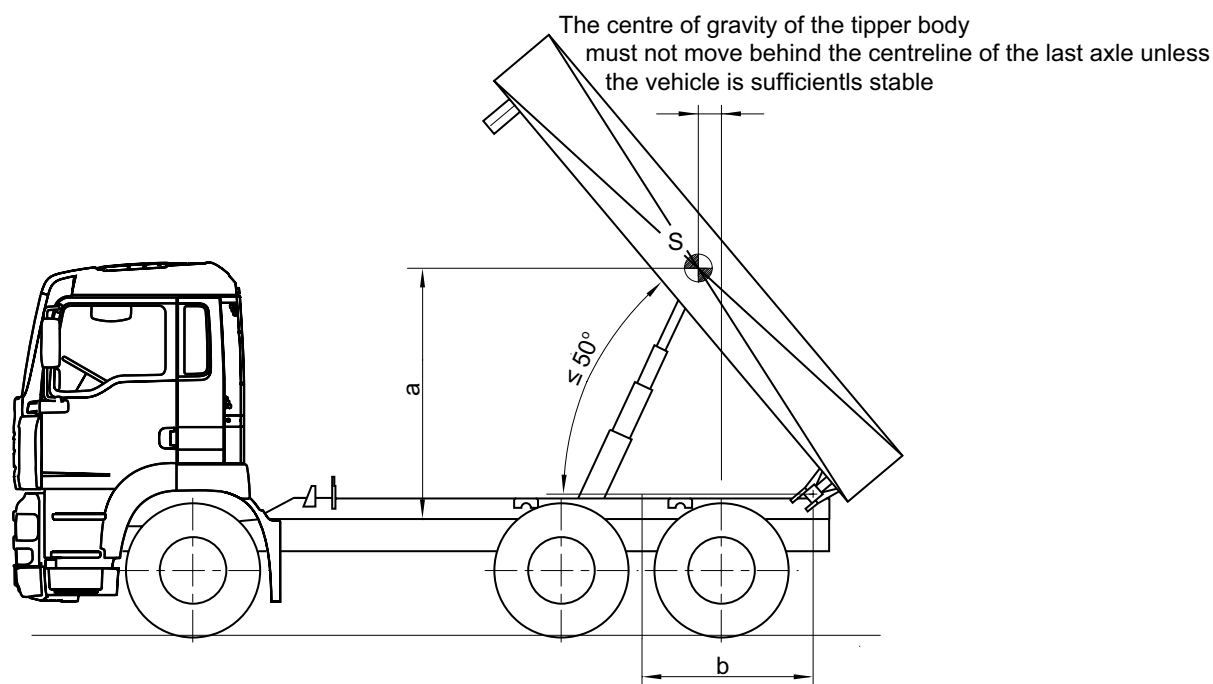
For operational safety reasons, operational conditions or when the above stated values are exceeded, further measures may become necessary, such as the use of hydraulic outriggers to increase stability or the relocation of specific equipment.
It is however assumed that the bodybuilder recognises the requirement for such measures since they are intrinsically dependent upon the design of his product.

To improve stability and operational safety, rear tippers are sometimes required to be fitted with a so-called scissors-action support and/or a support at the end of the frame (see Fig. 86).

Fig. 86:   Rear tipper with scissors-action support and rear support ESC-106

To improve stability on vehicles with air suspension it must be ensured that the air suspension is lowered before commencing the tipping operation. Lowering can either be done manually via the ECAS control unit or it can be automatic using special equipment Code 311PH (input of the ECAS parameters for air suspension lowering to 20 mm above the buffers). Special equipment 311PH automatically lowers the vehicle to the defined level above the buffers if the power take-off is engaged when the vehicle is at a standstill. To ensure that the function provided by Code 311PH is properly activated it is imperative that the correct order of operations is observed when engaging the power take-off (see operating instructions). A check must also be carried out to ensure that the message „No ride height" appears on the display and that the vehicle has actually lowered. If an automatic lowering system is not fitted then the user/driver must be informed of the requirement to manually lower the air suspension.

5.4.9   Set-down, sliding set-down and sliding roll-off tippers

For these types of body, the design often means that the subframes cannot follow the contour of the main frame and special connections to the main frame must therefore be provided. The body manufacturer must ensure that these fixtures are adequately sized and are properly located. Information regarding proven fixtures together with their design and fitting is available in the body manufacturers' installation instructions. MAN mounting brackets are not suitable for fitting these types of body. Because of the low substructure heights, the freedom of movement of all moving parts attached to the chassis (e.g. brake cylinders, transmission shift components, axle guide components, etc) and the body (e.g. hydraulic cylinders, pipes, tipper frame, etc.) must be checked and ensured.

If necessary an intermediate frame must be fitted, the suspension travel must be limited, the pendulum movement of the tandem axle must be limited or other similar measures taken.

When loading and unloading, outriggers are required at the end of the vehicle if:

- The rear axle load is more than twice the technically permissible rear axle load. Here, the tyre and rim load capacity must also be taken into account.
- The front axle loses contact with the ground. For safety reasons, lifting of this kind is strictly forbidden!
- The stability of the vehicle is not guaranteed. This can result from a high centre of gravity height, an inadmissible side tilt when suspension compression occurs on one side, if the vehicle has sunk into soft ground on one side etc.

Rear support by locking the vehicle springs is permitted only if the ESC department at MAN (for address see "Publisher" above) has approved the installation together with the respective load transmissions. The required evidence of stability is to be provided by the body manufacturer.

To improve stability on vehicles with air suspension it must be ensured that the air suspension is lowered before commencing the tipping operation. Lowering can either be done manually via the ECAS control unit or it can be automatic using special equipment Code 311PH (input of the ECAS parameters for air suspension lowering to 20mm above the buffers). Special equipment 311PH automatically lowers the vehicle to the defined level above the buffers if the power take-off is engaged when the vehicle is at a standstill. To ensure that the function provided by Code 311PH is properly activated it is imperative that the correct order of operations is observed when engaging the power take-off (see operating instructions). A check must also be carried out to ensure that the message „No ride height" appears on the display and that the vehicle has actually lowered. If an automatic lowering system is not fitted then the user/driver must be informed of the requirement to manually lower the air suspension.

5.4.10 Propping air-sprung vehicles

The following must always be observed in general when propping leaf/air or fully air-sprung vehicles:

The manufacturer of the body is responsible for the stability of the overall system when in working operation.

To improve stability on vehicles with air suspension it must be ensured that the air suspension is lowered before commencing the tipping operation. Lowering can either be done manually via the ECAS control unit or it can be automatic using special equipment Code 311PE (input of the ECAS parameters for crane operation). Special equipment 311PE automatically lowers the vehicle onto the buffers if the power take-off is engaged when the vehicle is at a standstill. Once the lowering operation has finished the system maintains a defined residual pressure in order to protect the air-suspension bellows. To ensure that the function provided by Code 311PE is properly activated it is imperative that the correct order of operations is observed when engaging the power take-off (see operating instructions). A check must also be carried out to ensure that the message „No ride height" appears on the display and that the vehicle has actually lowered. If an automatic lowering system is not fitted then the user/driver must be informed of the requirement to manually lower the air suspension. Although the complete raising of the axles provides the optimum stability within physical limits, the load that results puts a greater strain on frames and subframes. Completely raising the axles as well as lowering the vehicle without special equipment 311PE may result in damage to the air-suspension bellows.

In order to comply with the specifications set forth in the guidelines and to minimise foreseeable misuse/risks, fitting special equipment Code 311PE is strongly recommended. Exceptions are possible in the case of special purpose vehicles/body designs but this shall be under the bodybuilder's sole responsibility and in agreement with the customer.

Note:
The functions provided by Codes 311PE / 311PH are deactivated when the engine / power take-off or similar is turned on or off and the standard control laws of the ECAS system activated (setting the air-suspension to ride height). In cases where the vehicle is required to remain for a long period at a set level (lowered position of the air-suspension) it may be necessary to completely suppress the controlling function of the ECAS air-suspension system.

Should this be necessary, suppression of the controlling function can be achieved using special equipment 311PK (input of the ECAS parameters with auxiliary circuit for suppressing the automatic levelling suspension system). If this is not already fitted to the vehicle it can be retrofitted by a MAN service outlet (for further details see MAN Service Information 239704a).

We explicitly point out that this measure does not contribute to stability and is therefore not a means of extending the technical limits of body-mounted equipment (e.g. cranes). The ECAS controlling function may only be suppressed during working operation.

5.4.11 Loading cranes

Empty weight and the total moment of a loading crane must be matched to the chassis on which it will be fitted.
The basis for the calculation is the maximum total moment and not the lifting moment. The total moment is the result of the empty weight and the lifting force of the loading crane with the crane arm extended. For calculation of the loading crane total moment see formula 17 below:

Fig. 87:   Moments on the loading crane ESC-040
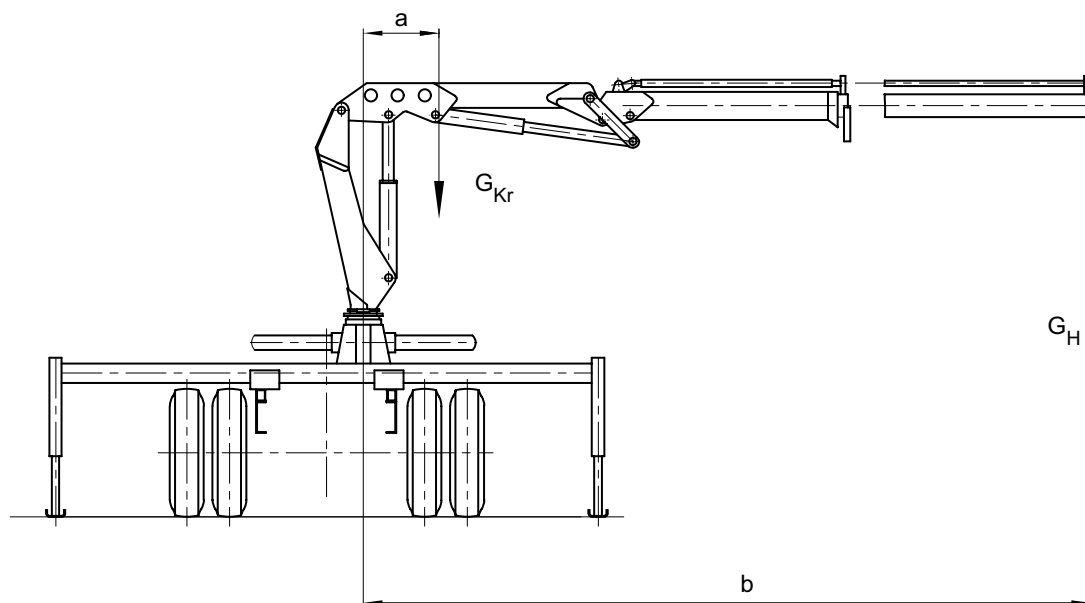
Formula 17:   Total moment of loading crane

$$M_{Kr} = \frac{g \cdot s \cdot (G_{Kr} \cdot a + G_H \cdot b)}{1000}$$

Where:

a	=	Distance of the crane centre of gravity from the centre of the crane pillar in [m], with the crane arm extended to maximum length
b	=	Distance of the maximum lifting load from the centre of the crane pillar in [m], with the crane arm extended to maximum length
G_H	=	Lifting load of the loading crane in [kg]
G_{Kr}	=	Weight of the loading crane in [kg]
M_{Kr}	=	Total moment in [kNm]
s	=	Impact coefficient from details provided by the crane manufacturer (dependent on the crane control system), always ≥ 1
g	=	Acceleration due to gravity 9,81 [m/s²]

The number of outriggers (two or four) and their positions and distance apart is to be determined by the crane manufacturer on the basis of the stability calculation and vehicle load.

For technical reasons, MAN may insist that four outriggers are fitted.

When the crane is operating, the outriggers must always be extended and level with the ground. They must be repositioned accordingly for both loading and unloading. Hydraulic compensation between the outriggers must be blocked. The crane manufacturer must also detail any ballast that is required for ensuring stability.

Amongst other characteristics, the torsional stiffness of the entire frame connection is responsible for the stability.

It must be noted that a high torsional stiffness of the frame connection will necessarily reduce the ride comfort and the off-road capability of the vehicles. The body builder or crane manufacturer is responsible for ensuring that the crane and subframe are properly attached. Operating forces including their safety coefficients must be safely absorbed.

Mounting brackets available ex-works are not suitable for this purpose. Avoid inadmissible (over)loading of the axle(s).

The maximum permissible axle loading during crane operation must not be more than twice the technically permissible axle load.

The impact coefficients provided by the crane manufacturer must be taken into consideration (see Formula 17)!

The permissible axle loads must not be exceeded during vehicle operation, therefore an application-specific axle load calculation is essential.

Asymmetric installation of a crane is not permissible if uneven wheel loads arise as a result (permissible wheel load difference ≤ 5%, see also Chapter 3.1). The body builder must ensure adequate compensation.

The pivoting range of the crane must be limited if this is required to maintain the permissible axle loads or stability.

Methods for ensuring this compliance are the responsibility of the loading crane manufacturer (e.g. by limiting the lifting load dependent on the pivoting range). During installation and operation of the loading crane, the required freedom of movement of all moving parts must be observed. Controls must have the minimum freedom of movement as required by law. Unlike other bodies the minimum load on the front axle(s) for crane bodies in any load state must be 30 % for two-axle vehicles or 25 % for three and four-axle vehicles in order to maintain steerability. For a detailed definition see Section 3.2 in this booklet.

Any nose weights exerted on the trailer coupling must be taken into consideration in the required axle load calculation.

On vehicles with lifting axles, the weight ratios must also be checked with the trailing axle lifted. If necessary, the lifting option must be disabled (see also „Rear loading crane" later in this Chapter).

Depending on the size of the crane (weight and centre of gravity position) and location (behind the cab or at the rear), vehicles must be fitted with reinforced springs, reinforced anti-roll bars or reinforced shock absorbers, if these items are available.

These measures will prevent the chassis from adopting a lopsided position (e.g. due to reduced compression of the reinforced springs) and will prevent or reduce any tendency to roll.

However, with crane superstructures, it is not always possible to prevent the chassis from standing lopsided because of the shift in the vehicle's centre of gravity.

After installation of the body, adjustments or checks may have to be made on the vehicle. This applies particularly to the headlights and the rear underride guard and the sideguards. Approval for a crane superstructure is necessary if the requirements stipulated in this Guide to Fitting Bodies are exceeded.

This is the case if:

-      The permissible total crane moment as stipulated in Fig. 87 is exceeded
-      Four outriggers are fitted
-      Front outriggers are fitted.

Different forces come into play when four outriggers are fitted. This means that the ESC department at MAN (for address see "Publisher" above) must always be consulted. To guarantee stability whilst the crane is operating, the subframe in the area between the two outrigger members must have sufficient torsional stiffness.

For strength reasons, lifting the vehicle on the outriggers is permissible only if the subframe structure absorbs all the forces resulting from the operation of the crane and provided its connection to the chassis frame is not rigid (e.g. mobile cranes).

According to the applicable national regulations, the crane body and its operation must, before first use, be inspected by a crane expert from the technical inspection organisations or by a person authorised to inspect cranes.

Loading crane behind the cab:

If chassis components protrude above the upper edge of the subframe an additional intermediate frame needs to be provided on the subframe (see Fig. 88). This can be designed so that it serves as a reinforcement for the subframe.

Fig. 88: Clearance for loading crane behind the cab ESC-107

Intermediate frame
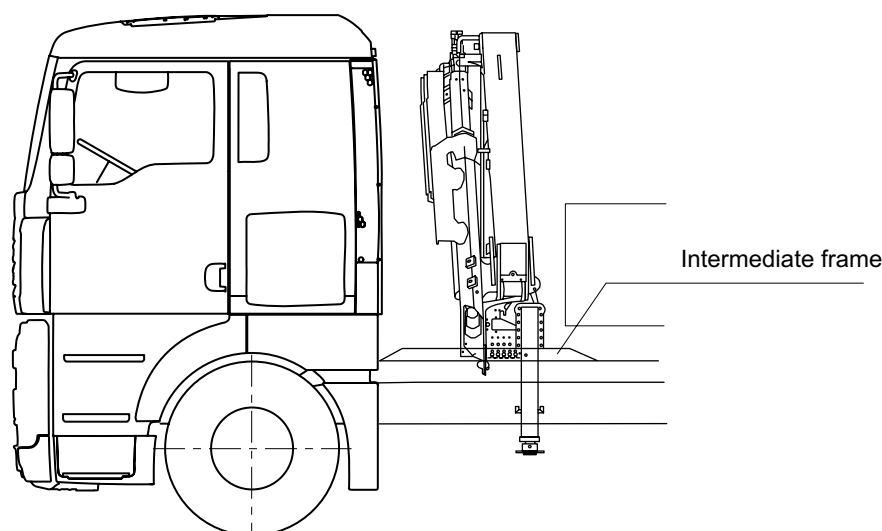
It must still be possible for the cab to tilt and it must be possible to operate the locking mechanism unhindered at any time.

There must be no obstructions that encroach on the arc described by the cab when tilting. The tilt radii of the cabs are given in the chassis drawings (these can be obtained from MANTED® www.manted.de).

Even when the permissible front axle load is observed, care still needs to be taken to prevent excessive top-heaviness of the vehicle for handling reasons. A reduction of the front axle load, for example, can be achieved by relocating equipment.

On some vehicles, the permissible front axle load can be increased if the required technical conditions exist.

See the 'General' Chapter for information on and procedures for increasing the permissible front axle load.

Rear loading crane:

In order to create the required space for the loading crane and achieve a more favourable front axle loading the spare wheel, normally located at the rear, can be moved to a position on the side of the frame.

Stronger springs, a stronger anti-roll bar and other available stabilisation aids from MAN must be installed depending on the size of the crane and the axle load distribution. This will prevent the vehicle from standing lopsided and reduce its tendency to roll.

When a lifting trailing axle is lifted, the front axle of the vehicle experiences a considerable lightening of the load. Because of the point load acting dynamically on the end of the frame as a result of the crane, it is likely that the driving characteristics will not be sufficiently stable. The lifting facility must be disabled if more than 80% of the permissible drive axle load is reached when travelling unladen with the crane and with the axle lifted. It must also be disabled if the minimum front axle load (30 % of the actual vehicle weight of the now two axle vehicle) is not reached.

For manoeuvring purposes the trailing axle can, under certain circumstances, be lifted if the subframe and body are of adequate size. The higher bending and torsional forces acting on the body and the frame structure must then be taken into account. If a centre axle trailer is to be towed then the crane manufacturer must confirm suitability for the purpose. Trailer nose weights must be taken into account during the design stage.

Most importantly, the front axle loads must not be allowed to drop below the values stated in Section 3.2. 'Minimum front axle loads'.

Detachable rear loading cranes:

The centre of gravity of the payload will change depending on whether the crane is attached or not. To achieve the largest possible payload without exceeding the permissible axle loads, we recommend that the centre of gravity of the payload with and without the crane be marked clearly on the body.

The larger overhang resulting from the installation of the coupling device must be taken into consideration.

It is the responsibility of the body manufacturer to ensure that the coupling mounting bracket is of adequate strength and that the bracket support is properly fitted to the vehicle. Forklifts carried on the vehicle are to be treated as attachable loading cranes when being transported.

A second trailer coupling is to be installed on the mounting brackets for detachable rear loading cranes if the vehicle is to be operated with a trailer. This trailer coupling must be connected to the one installed on the vehicle by means of a towing eye (see Fig. 89). Note the instructions in Section 4.8 'Coupling devices'.

The coupling device and the body must be able to safely absorb and transmit forces arising during trailer operation.

If the crane is attached but the vehicle is being operated without a trailer, an underride guard must be fitted to the coupling device together with the lighting installation as required by law.

Fig. 89:   Coupling device for rear loading cranes ESC-023
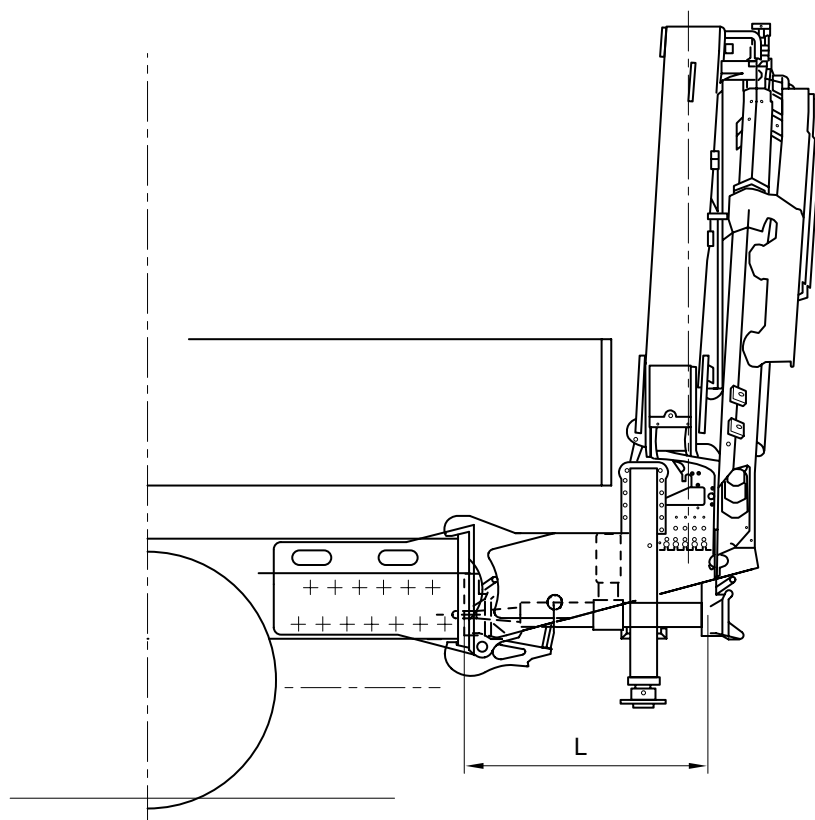
Subframe for loading crane:

All loading crane bodies require a subframe. Even in the case of crane total moments that theoretically produce a required geometrical moment of inertia of below 175 cm^4, a subframe with a geometrical moment of inertia of at least 175 cm^4 must be fitted.
To protect the subframe we recommend fitting an additional upper flange (anti-wear plate) to prevent the base of the crane from wearing into the subframe.
The thickness of the upper flange should be 8-10 mm depending on the size of the crane.
Loading cranes are frequently installed with various types of body, for which a subframe is also required (e.g. on tippers, tractor units, single-pivot bodies). In this case, depending upon the body and its loading, a larger subframe suitable for the entire body structure must be used.
The subframe for a detachable loading crane must be designed to ensure that the coupling device and the loading crane can be supported safely. The body manufacturer is responsible for the design of the mounting bracket (bolt fixings, etc.).
When installing a loading crane behind the cab the subframe must be enclosed to form a box, at least in the area surrounding the crane.
If the loading crane is installed at the rear, a closed section profile must be used from the end of the frame to at least a point forward of the front-most rear axle location element.
In addition, to increase the torsional stiffness of the subframe, a cross-strut (X-shaped connecting piece, see Fig. 90) or an equivalent structure must be fitted.
To be recognised by MAN as an "equivalent structure", it is a pre-requisite that the ESC Department (for address see "Publisher" above) has issued an approval.

Fig. 90:   Cross-strut in the subframe ESC-024
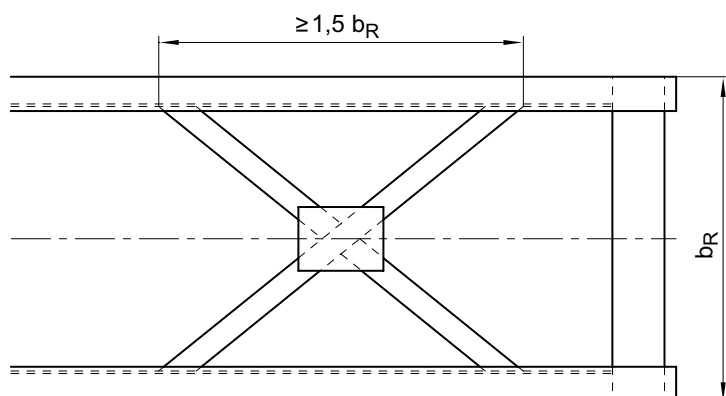
The method of calculating and the correlation between crane total moment and geometrical moment of inertia – dependent upon the chassis frame – applies equally to crane structures with two outriggers located behind the cab or on the frame end.
Safety coefficients have already been taken into account. The crane total moment M_{Kr} however, must be factored into the calculation along with the impact coefficient supplied by the crane manufacturer (see also formula 17 above).
The graph for crane total moment and geometrical moment of inertia is reproduced for the TGA range here (see Fig. 91 below).
No cranes may be mounted on chassis/tractor units with frame profile number 34 (model codes as at 03/2007: H01, H08, H48, H49).

The graphs in Fig. 92 only apply to cranes with double outriggers. They apply equally to crane structures located behind the cab or on the frame end. Safety coefficients have already been taken into account. The crane total moment M_{Kr} however, must be factored into the calculation along with the impact coefficient supplied by the crane manufacturer (see also the formula "Total moment of loading crane" further above in Chapter 5.4.10).

If body conditions (e.g. low container vehicles, breakdown trucks, etc.) mean that the design methods described here cannot be adhered to, the entire body must be approved by the ESC Department at MAN (for address see „Publisher" above).

Example of how to use the graphs in Fig. 91:

A subframe is to be specified for a TGA 18.xxx 4x2 BB, model H03 vehicle, frame section number 31. The vehicle is to be fitted with a crane with a total moment of 160 kNm.

Solution:

A minimum geometrical moment of inertia of approx. 1,250 cm^4 is derived from Fig. 92.

If one U-section with a width of 80 mm and a thickness of 8 mm is formed into a box with an 8 mm thick section, a section height of at least 170 mm is required, see diagram in Fig. 92. If two U-sections of a width/thickness of 80/8 mm are formed into a box, the minimum height is reduced to approx. 140 mm, see Fig. 94.

If, when the values are read off, the section size in question is not available, round up to the next available size; rounding down is not permitted.

The freedom of movement of all moving parts is not taken into consideration here; it must therefore be re-checked when the dimensions have been selected.

An open U-section, as in Fig. 92, must not be used in the area around the crane. It is only shown here because the diagram can also be used for other bodies.

Fig. 91: Crane total moment and geometrical moment of inertia for TGA ESC-516

Profile no. 31

Profile no. 32

Subframe geometrical moment of inertia I_x [cm^4]

Crane total moment [kNm]

Profile no. 31: U 270/85/8
Profile no. 32: U 270/85/9,5
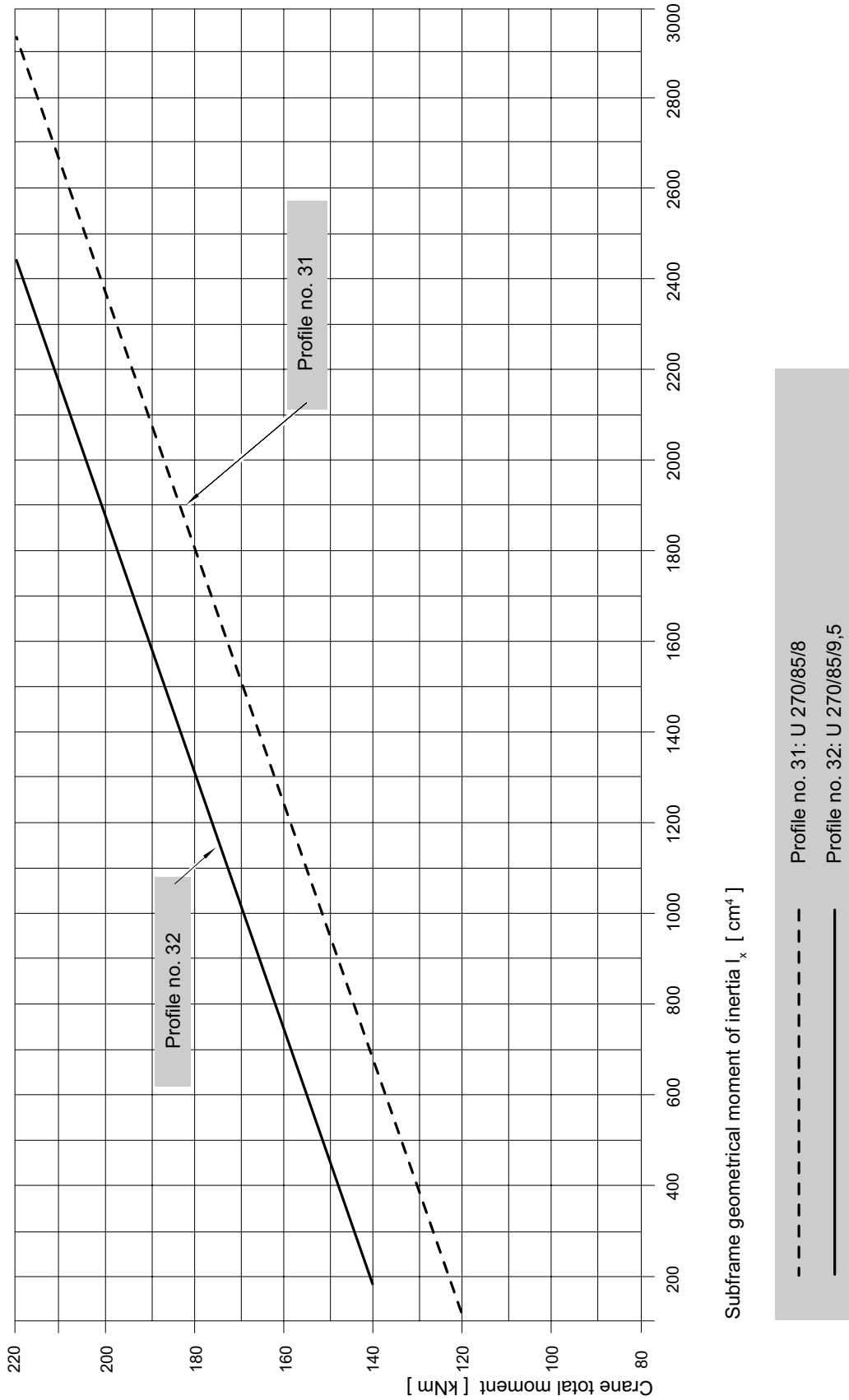
Fig. 92: Geometrical moment of inertia for U-sections ESC-213

Open U-section

Section height in [mm]

Geometrical moment of inertia [cm⁴]

① U80...220/60/6	③ U80...220/70/6	⑤ U80...280/70/8	⑦ U80...280/80/7
② U80...280/60/7	④ U80...280/70/7	⑥ U80...220/80/6	⑧ U80...280/80/8
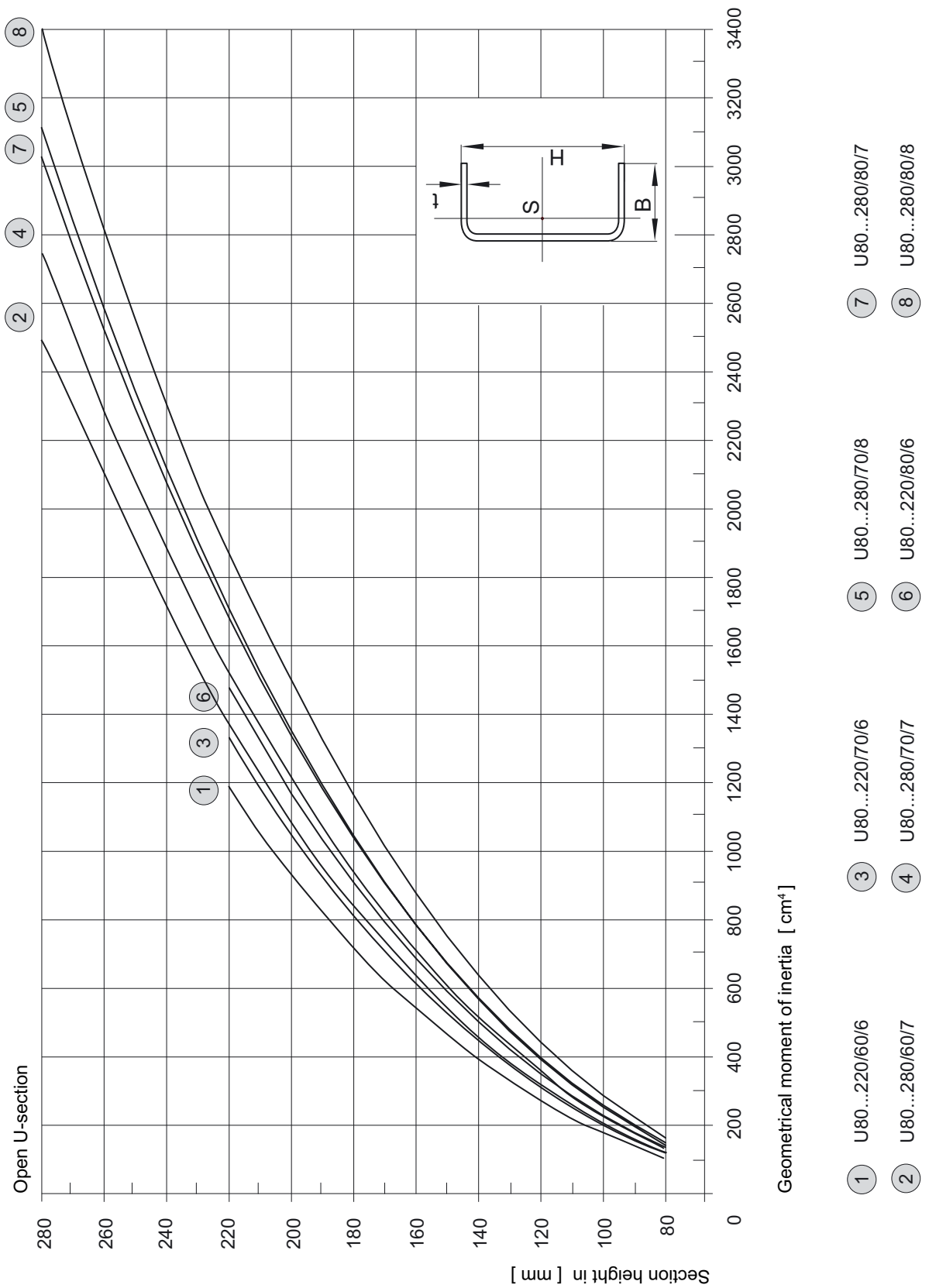
Fig. 93: Geometrical moment of inertia for open U-sections ESC-214

Geometrical moment of inertia [cm⁴]

Section height in [mm]

7 U80...280/80/7	8 U80...280/80/8	
5 U80...280/70/8	6 U80...220/80/6	
3 U80...220/70/6	4 U80...280/70/7	
1 U80...220/60/6	2 U80..280/60/7	

U-section closed
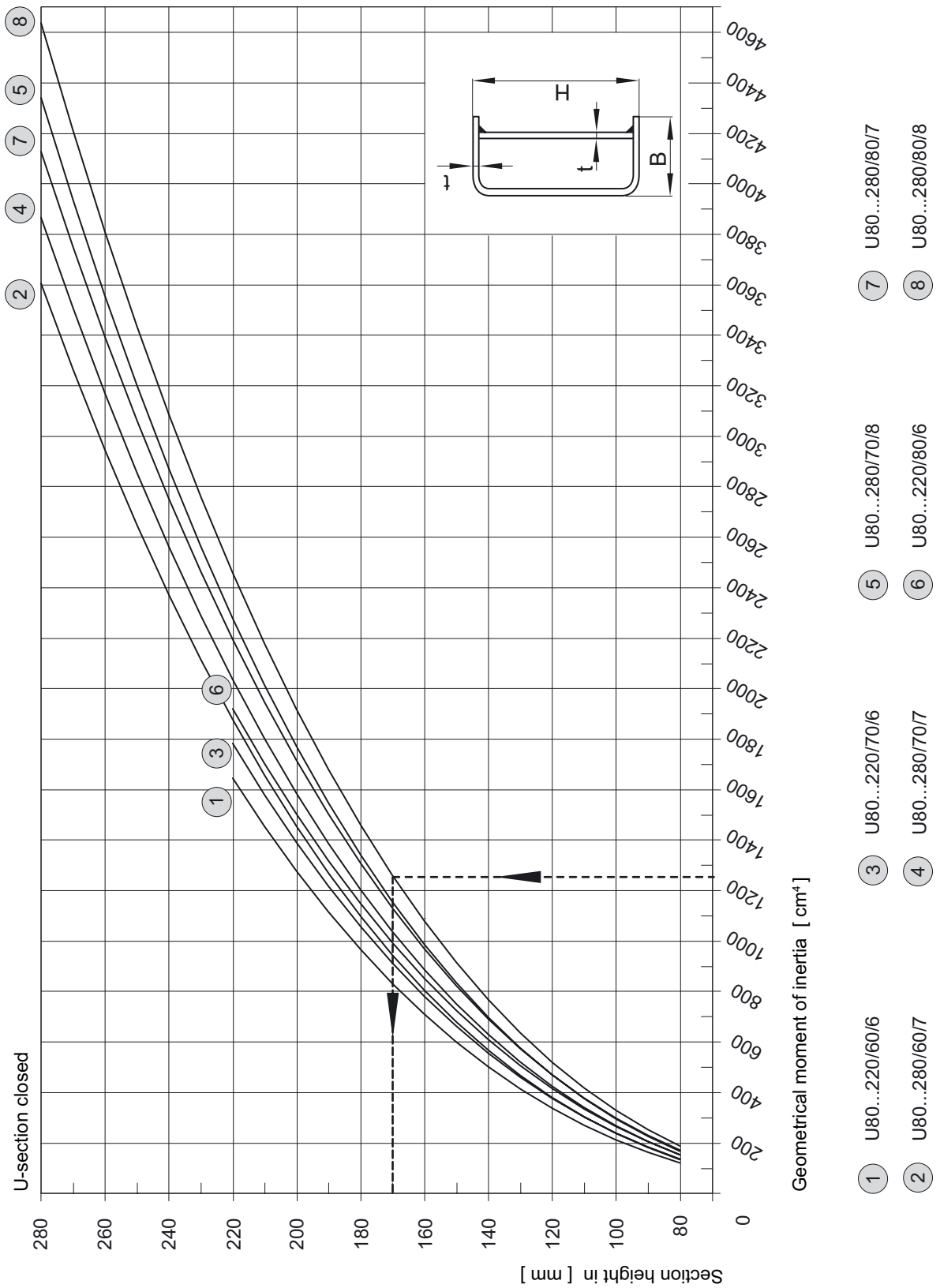
Fig. 94: Geometrical moment of inertia for boxed U-sections ESC-215
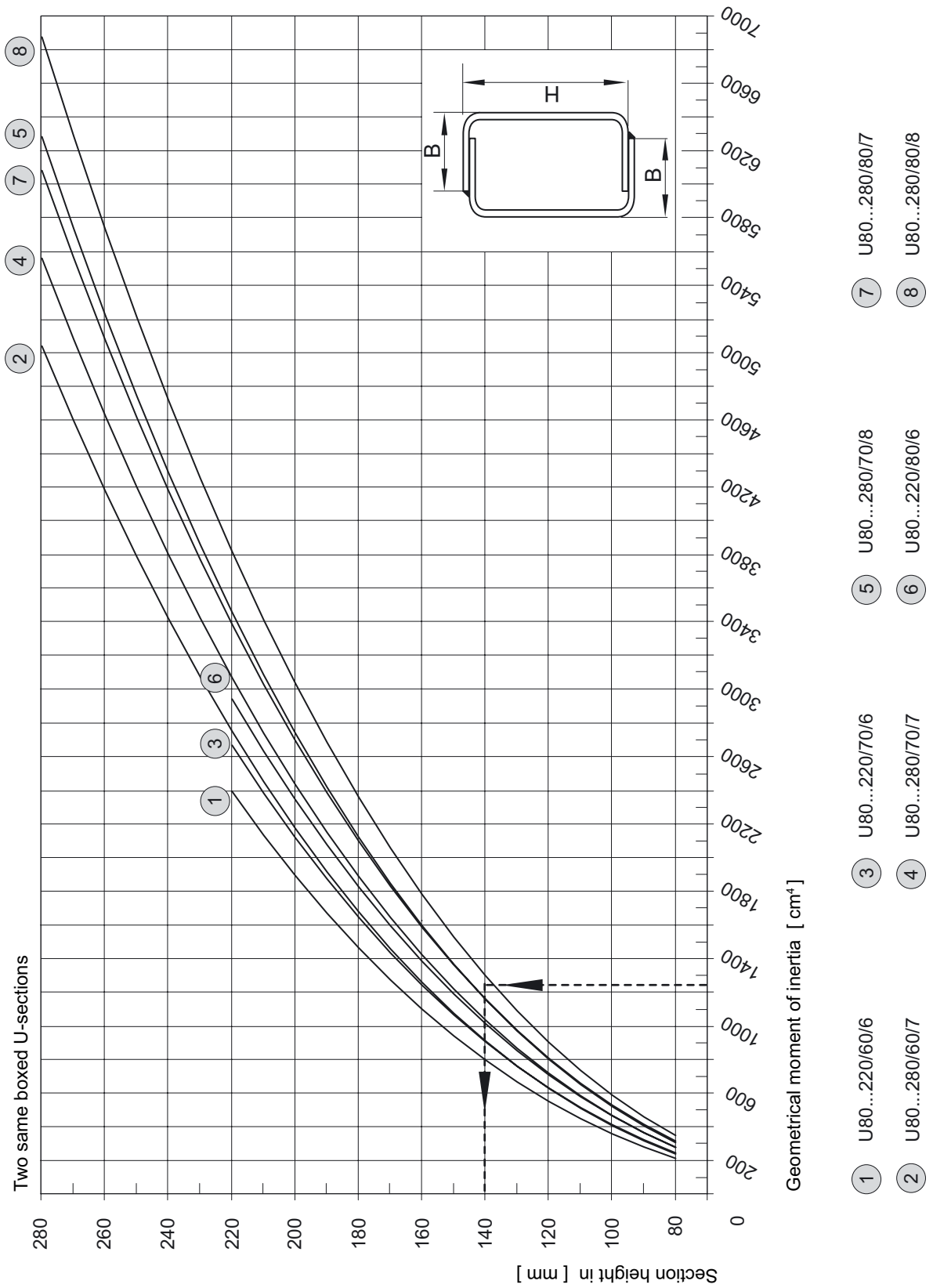
5.4.12 Cable winches

For installation of a cable winch the following points are important:

- Pulling force
- Installation location: Front, centre, rear, side installation
- Type of drive: Mechanical, electromechanical, electrohydraulic.

Axles, springs, frames, etc. must under no circumstances be overloaded by the operation of the cable winch.
This is particularly important if the direction of the winch towing force is not in line with the vehicle longitudinal axis. It may be necessary to fit an automatic pulling force limiter, a device that cuts-in depending upon the direction from which the pulling force is applied. Under all circumstances, care must be taken to ensure proper guidance of the cable. The cable should have as few turns in it as possible. At the same time however, it must be ensured that the function of vehicle parts is in no way adversely affected.
A hydraulic winch drive is preferred because it offers better regulation and installation options. The efficiency of the hydraulic pump and motor is to be taken into account (see also the Chapter 'Calculations').
A check should be made to see whether existing hydraulic pumps such as those on the loading crane or the tipper can be used.
This can sometimes avoid the need for installing several power take-offs.
On worm gears in mechanical winches, the permissible input speed must be observed (normally < 2,000 rpm).
The reduction ratio of the power take-off is to be selected accordingly.
Take the low efficiency of the worm gear into consideration when calculating the minimum torque at the power take-off.
Observe the instructions contained in the Chapter 'Electrics, electronics wiring' for electromechanical and electrohydraulic winches.

5.4.13 Transport mixers

In order to reduce the tendency to roll, transport mixers chassis must be fitted with anti-roll bars on both rear axles.
The cement mixer body is generally driven by the power take-off, on D28 engines by PTO at the camshaft drive, and on D20/26 engines by PTO at the flywheel. Alternatively, an engine-dependent NMV power take-off from ZF may be fitted.
Retrofit installation of both these power take-off solutions is highly complicated and is therefore not recommended.
The factory fitted solution is simpler and less expensive. Further information on power take-offs can be found in the 'Power take-offs' booklet. The MAN range includes chassis that are already prepared for mounting a transport mixer body. On such chassis, the requirements detailed above are already met, the shear plates are already positioned in the correct locations - it is only necessary to select the required power take-off. If a different chassis (e.g. a tipper chassis) is to be used for mounting a transport mixer it is assumed that a shear plate layout equivalent to that of a comparable transport mixer body is fitted and that the above mentioned anti-roll bars for both rear axles are fitted.
The shear plate arrangement of tipper chassis and the mounting brackets for loading platforms are not suitable for mounting transport mixer bodies. Fig. 95 illustrates an example.
The body is rigid along virtually its entire length, the only exception being the front end of the subframe ahead of the drum mounting.
The first two shear plates must be positioned in the area of the front mounting brackets for the drum.
Concrete conveyor belts and concrete pumps cannot easily be fitted onto standard concrete mixer chassis. In some circumstances, a different subframe structure from that of the normal mixer subframe or a cross connection on the frame end is required (similar to rear loading crane bodies, see Fig. 90). Approval from the ESC department at MAN (for address see 'Publisher' above) and from the transport mixer manufacturer is essential.

Fig. 95:   Transport mixer body ESC-016

Example of the installation of shear plates

8mm thick
Min. quality St52-3

300

40

130

Strap fixtures using M16 solid-shank bolts, minimum property class 10,9 hole clearance 0,3 in accordance with DIN 18800

Front shear plates in the area of the mixer drum mounting brackets
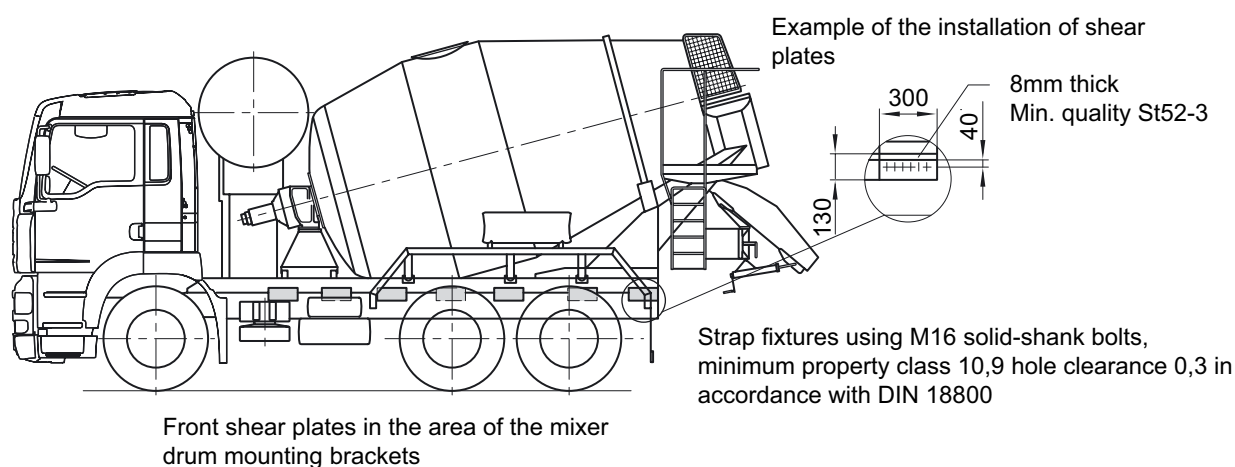
5.4.14   Car transporter

Car transporters are normally built on the basis of a two-axle tractor unit and have an interchangeable body. The body is fastened to the tractor unit using releasable connections at the front, the fifth-wheel coupling at the rear and additional connectors. The transmission of loads from the body to the chassis, in particular the fastening of the body and the associated connections, are always the responsibility of the bodybuilder.
The basic tractor unit shall be equipped as follows in order that the vehicle can be used as a car transporter:
(The equipment specifications listed below relate solely to a tractor unit used as the basis vehicle. Bodies mounted on truck chassis with a longer wheelbase are not discussed here):

- No approval for constructing car transporter body on H01/H08 (TGA 18.xxx BLS-TS) and H13 (TGA 18.xxx LLS-U)
- Maximum wheelbase 3,900 mm
- It is imperative that a anti-roll bar is fitted to the front axle
- The vehicle type entered onto the official papers must be "Vehicle for interchangeable operation"
  (option to use as tractor unit and truck for car transport). This corresponds to use as a car transporter and no parameterisation is required. Under no circumstances may a vehicle be reparameterised as a truck.
- ESP must not be fitted (as at 08/2007) or if fitted it must be uninstalled through corresponding parameterisation
- The tractor unit end cross member with hole pattern for trailer coupling must be fitted (no. 81.41250.0141).
  Because of its greater thickness (9.5 mm) only this end cross member is suitable for supporting the forces exerted by the rear body connection (never use 5 mm tractor unit end cross members).
  In its so-called "second life" (after use as a car transporter) the vehicle can solely be used as a tractor unit but not as a truck!

6. Electrics, electronics, wiring

6.1 General

The Chapter 'Electrics, electronics, wiring' does not attempt to provide fully comprehensive information on all issues relating to the vehicle electrical systems of modern commercial vehicles. Further information on individual systems can be found in the respective repair manuals, which can be obtained from the spare parts service. The electrics, electronics and wiring installed in commercial vehicles complies with the relevant applicable national and European standards and directives, which are to be regarded as minimum requirements. MAN's own standards often considerably exceed those minimum requirements of national and international standards. As a result, many electronic systems have been adapted and expanded. In some situations, for reasons of quality or safety, MAN stipulates the condition that MAN standards are used. This is stated in the corresponding sections. Body manufacturers can obtain relevant MAN standards from www.normen.man-nutzfahrzeuge.de (registration required). There is no automatic updating and replacement service.

6.2 Routing cables, earth cable

The basic cable laying principles set out in the Chapters 'Electrics, electronics, wiring' and 'Brakes' apply.
On MAN vehicles the frame is not misused as the earth cable; instead, a separate earth cable should be laid to the electric consumer along with the positive lead. Common earth points to which the bodybuilder can connect earth cables are located:

- In the central electrics compartment (at rear, see Fig. 96).
- Behind the instrumentation.
- On the rear right-hand engine mount.

For detailed instructions see section 6.5 additional power consumers, below.
No more than 10A (actual current consumption) in total may be drawn at the earth points behind the central electrics box and behind the instrumentation.

Cigarette lighters and any additional sockets have their own power limits, please refer to the respective instruction manual.
The housingsof single-pole motors of third-party equipment must be connected to the common earth point on the corresponding engine mount by means of an earth cable. This is to prevent any damage to mechanical parts or the electrical system when the starter is switched on. All vehicles have a plate located inside the battery box, which expressly states that the vehicle frame is not connected to the battery negative terminal. The body builder's negative cable must not be connected to the minus pole of the battery – it must be connected to the common earth point at the rear right engine mount.

6.3 Handling batteries

6.3.1 Handling and maintaining batteries

The test and charging cycle in accordance with the charging log/charging schedule applies (e.g. when the vehicle is not being used whilst the body is being fitted).
Checking/charging the battery is to be carried out according to the charging log supplied with the vehicle and is to be initialled.
Rapid charging or assist-starting equipment is not permitted for trickle charging since their use may damage control units.
Vehicle to vehicle assist-starting is permitted, provided the instructions in the operating manual are followed.

When the engine is running:

- Do not switch off the battery main switch
- Do not loosen or disconnect the battery terminals.

Caution!

Always follow this sequence when disconnecting the batteries and actuating the battery main switch:

•   Switch off all electric consumers (e.g. lights, hazard warning lights)
•   Switch off ignition
•   Close the doors
•   Wait for a period of 20 seconds before disconnecting the batteries (negative terminal first)
•   The electric battery main switch requires an additional run-down time of 15 seconds.

Reason:

Many vehicle functions are controlled by the central on-board computer (ZBR) that must first save its last status before it can be isolated. If, for example, the doors remain open, it will be 5 minutes before the computer can stop operating, because the computer also monitors the door-closing function. If the doors are open a waiting period of over 5 minutes is therefore necessary before the batteries can be disconnected. Closing the doors will shorten this waiting time to 20 seconds.
If the above sequence is not followed some control units will inevitably have incorrect entries (e.g. the ZBR central on-board computer).

6.3.2   Handling and maintaining batteries with PAG technology

When original factory-fitted batteries are exhausted MAN specialist workshops will only fit maintenance free PAG technology batteries (PAG = positive Ag, positive electrode with thin silver plating). These differ from conventional batteries through improved resistance to deep-discharge damage, longer shelf-life and better charging rate. The conventional filler caps have been replaced by „charge eyes". The test and charging cycle in accordance with the charging log/charging schedule is monitored with the help of these charge eyes which indicate the state of charge by the colour of the ball in the middle of the filler cap.

Caution!

The filler caps (charge eyes) of maintenance-free batteries must not be opened.

Table 23:   Charge eye indications

Indication	Battery condition	Procedure
Green	Correct electrolyte level, acid density above 1.21 g/cm^3	The battery is charged and in order. Note check completed in the charging log
Black	Correct electrolyte level, but acid density below 1.21 g/cm^3	The battery must be charged. Note the recharge in the charging log
White	Electrolyte level too low, acid density may lie above or below 1.21 g/cm^3	The battery must be replaced

A detailed Service Information, „SI Number: Amendment 2, 114002 Battery" is available from MAN specialist workshops.

6.4   Additional wiring diagrams and wiring harness drawings

Additional wiring diagrams and wiring harness drawings that contain or describe body fittings can be obtained from the ESC department at MAN (for address see 'Publisher' above). It is the responsibility of body manufacturer to ensure that the documents he uses, for example wiring diagrams and wiring harness drawings, correspond with the current status of equipment fitted to the vehicle. Further technical information can be obtained from the repair manuals. These can be obtained from the spare parts service.

6.5   Fuses, additional power consumers

Do not modify or extend the vehicle's electrical system! This applies to the central electrics box in particular.
Any damage resulting from modifications will be the responsibility of those who carried out the modifications.

The following points must be observed when retrofitting additional electric consumers:
There are no spare fuses in the central electrics box for use by the body manufacturer. Additional fuses can be fitted in a plastic holder located in front of the central electrics box.
Do not tap into existing vehicle circuits or connect additional electric consumers to fuses that are already occupied.
Each circuit installed by the body manufacturer must be adequately rated and have its own fuses. The rating of the fuse should ensure the protection of the wiring and not that of the system connected to it. Electrical systems must ensure adequate protection against all possible faults, without affecting the vehicle electrics. Freedom from feedback must always be ensured.
When selecting the size of the wire cross-section, the voltage drop and the heating of the conductor must be taken into account.
Cross-sections below 1 mm2 are to be avoided because their mechanical strength is not sufficient. Positive and negative wires must have the same minimum cross-section.
Current draw for 12 V equipment must be effected only via a voltage converter. Power draw from just one battery is not permitted because unequal charge statuses may cause the other battery to become overcharged and damaged.
Under certain circumstances, e.g. for equipment with a high power requirement (e.g. electrohydraulic tail-lifts) or in extreme climatic conditions, higher capacity batteries will be required.
In order to provide extra power, a larger capacity alternator is available ex-works. If the body manufacturer installs larger batteries, the cross-section of the battery cable must be adapted to suit the new power draw.
If consumers are directly connected to terminal 15 (pin 94 in the central electrics box; see Fig. 96) it is possible that entries will be logged in the error memories of control units as a result of a reverse flow of current into the vehicle's electrical system. Consumers must therefore, be connected in accordance with the following instructions.

Power supply terminal 15

Always fit a relay that is triggered via terminal 15 (pin 94). The load must be connected through a circuit breaker at terminal 30 (pins 90-1, 90-2 and 91 at the rear of the central electrics box) (see Fig. 96). The maximum load must not exceed 10 amperes.

Power supply terminal 30

*   For maximum loads of up to 10 amperes the load must be connected through a circuit breaker at terminal 30 (pins 90-1, 90-2 and 91, see Fig. 94 rear of the central electrics box).
*   For loads > 10 amperes connect through a circuit breaker directly at the batteries.

Power supply terminal 31

*   Do not connect at the batteries, instead connect to the earth points inside (see Fig. 96 rear of the central electrics box) and outside (rear left engine mounting) the cab.

Fig. 96: Central electrics box, rear view ESC-720

No cables are connected here as standard. However, the pin may be used as an additional connecting pin – using a bridge to pin 94 – for terminal 15.

Terminal 31

96

>PC - GF 10 <

⊕ 89 60 71

MAN

81.25444.6074

A1   A2

C   A3   B

G

H

D

F

92

95

94

91

90

90

Terminal 31
for sensors

Terminal 15
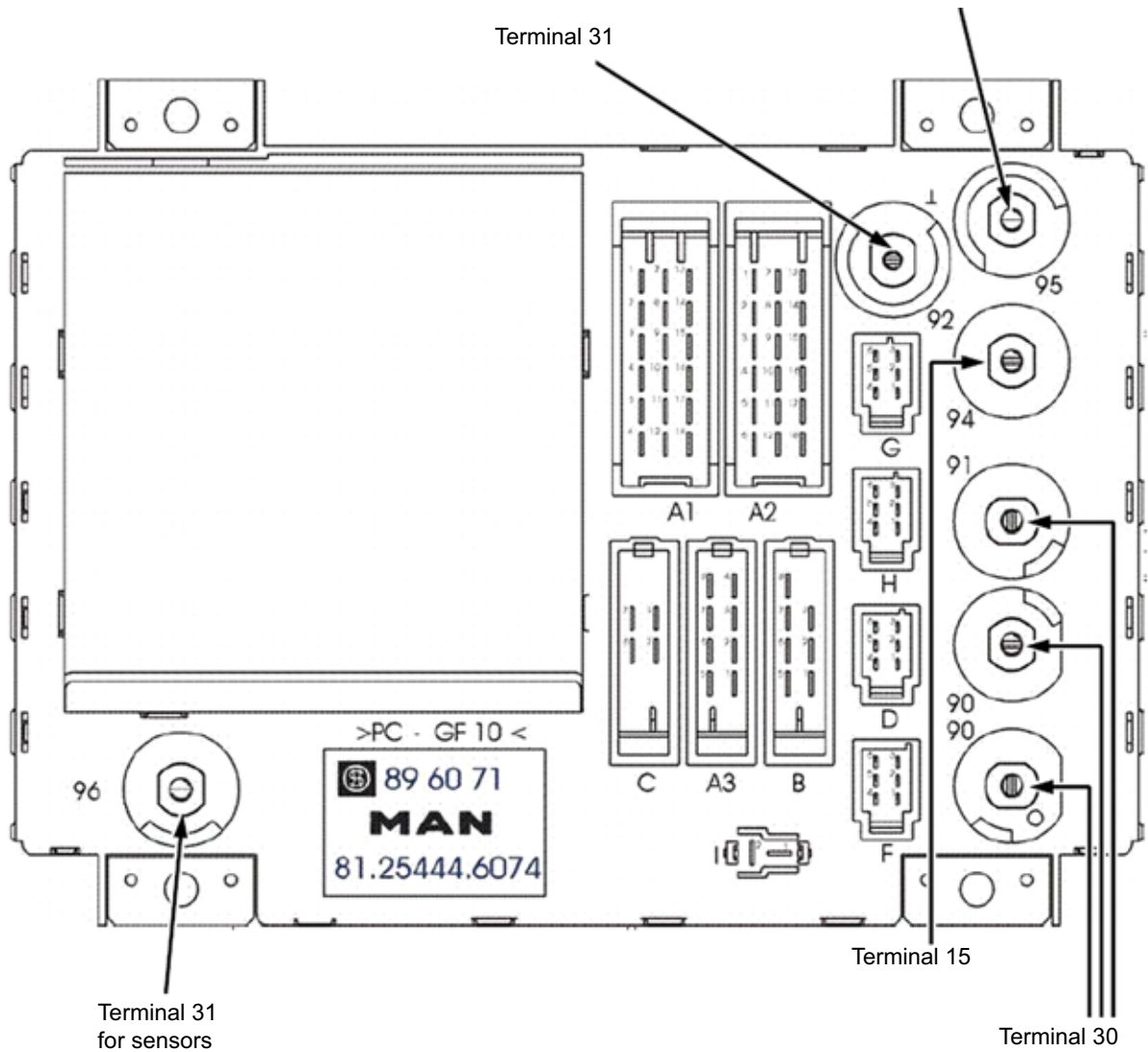
Terminal 30

Wiring diagram, additional consumers

Circuit breaker in accordance with the rated current of the additional consumer (maximum 10 amperes)

Additional consumer (rated current maximum 10 amperes)

Only connect voltage supply terminal 15 to this terminal from consumers that could also be installed as standard (exception: relay control for additional consumers).

Relay for voltage supply terminal 15 for the additional consumers (e.g. 81.25902-0473).

Key:

A1 00   central electrics box
F354   main circuit breaker terminal 30
F355   main circuit breaker terminal 30
F400   circuit breaker steering lock
F522   circuit breaker cable 30000
F523   circuit breaker cable 30000
G100   battery 1
G101   battery 2
G102   alternator
K171   relay terminal 15
M100   starter
Q101   ignition switch
X1 00   earth connection engine
X1 364 bridge between connector pins 90-1 and 90-2 of the central electrics box
X1 365 bridge between connector pins 90-2 and 91 of the central electrics box
X1 539
X1 557 plug connection cab connection point
X1 642 earth point in cab behind instrumentation
X1 644 earth point in cab next to the central electrics box
X1 913 bridge for cable 30076 in the cable conduit on the engine

6.6   Lighting installations

If the lighting system is modified, the partial operating permit to EU Directive 76/756/EEC, as amended by 97/28/EC is rendered void. This is particularly true if the design of the lighting installation has been changed (number/size of lights) or if a light has been replaced with a different light that is not approved by MAN. The bodybuilder is responsible for compliance with all statutory provisions. It is particularly important that LED side marker lamps are not extended using other types of lamp as this will destroy the ZBR (central on-board computer)!

The maximum allowable load applied to the lighting current paths must be observed.
Fitting higher rated fuses than the corresponding ratings in the central electrics box is nor permitted.

The following reference values should be taken as maximum values:

Parking light	5A	per side
Brake light	4x21W	solely lamps
Indicators	4x21W	solely lamps
Rear fog lamps	4x21W	solely lamps
Reversing light	5A	total.

The term "solely lamps" refers to the fact that these current paths are monitored for errors by the central on-board computer and that any errors will be displayed. The installation of LED lighting elements that are not approved by MAN is prohibited.
Note that on MAN vehicles an earth cable is used. Earthing to the frame is not permitted (see also Section 6.2, "Routing cables, earth cable").

After the body has been installed, the basic beam alignment of the headlights must be reset. This is to be carried out directly on the headlamps, even if the vehicle is fitted with headlight levelling control. This is necessary because altering the setting of the levelling control does not adjust the basic beam alignment for the vehicle. Extensions or modifications to the lighting system must be completed in co-operation with the nearest MAN service centre using MAN-cats® because it may become necessary to re-parameterise the vehicle's electronics. See also Section 6.10.2.

6.7   Electromagnetic compatibility

Due to the interaction between the various electrical components, electronic systems, the vehicle itself and the environment, the electromagnetic compatibility (EMC) must be tested. All systems fitted to MAN commercial vehicles comply with the requirements of MAN standard M 3285, available from www.normen.man-nutzfahrzeuge.de (registration required).

MAN vehicles comply with the requirements of EC Directive 72/245/EEC, including 95/54/EC and as amended by 2004/104/EU when they leave the factory. All equipment (definition of equipment as in 89/336/EEC) that is installed in the vehicle by the body manufacturer must meet the corresponding statutory regulations in force at the time.
The body manufacturer is responsible for the EMC of his components or systems.
After installing such systems or components, the body manufacturer remains responsible for ensuring that the vehicle still meets the current legal requirements.
Freedom from feedback between the body-side electrics/electronics and those of the vehicle must be ensured, especially where body-side interference could affect the operation of onboard units for road toll logging, telematics equipment, telecommunications systems or other equipment fitted to the vehicle.

6.8 Radio equipment and aerials

All equipment that is installed on the vehicle must comply with the current legal requirements.
All radio equipment (e.g. radio units, mobile telephones, navigation systems, onboard units for road toll logging etc.)
must be properly equipped with external aerials.

In this context 'properly' means:

- Radio equipment, e.g. radio control systems for remotely operating various vehicle body functions, must be installed such that the functions of the commercial vehicle are not affected.
- Existing cables must not be moved or used for additional purposes.
- Use as a power supply is not permitted (the exception being approved MAN active aerials and their cables).
- Access to other vehicle components for maintenance or repair must not be impaired.
- Only drill into the roof at the locations provided for in the MAN design and only use installation components (for example self-tapping sheet metal screws, seals) approved for this purpose.

MAN-approved aerials, wiring, cables, bushes and connectors can be obtained from the spare parts service
Annex I of EU-Council Directive 72/245/EEC, version 2004/104/EU, stipulates that possible installation positions for transmission antennas, approved frequency bands and the transmit power must be published.

For the following frequency bands the proper fitment at the mounting points stipulated by MAN (see Fig. 97) on the cab roof is permitted.

Table 24: Frequency bands and the approved mounting position on the roof

Frequency band	Frequency range	max. transmit power
Short wave	< 50 MHz	10 W
4 m band	66 MHz to 88 MHz	10 W
2 m band	144 MHz to 178 MHz	10 W
70 cm band	380 MHz to 480 MHz	10 W
GSM 900	880 MHz to 915 MHz	10 W
GSM 1800	1.710,2 MHz to 1.785 MHz	10 W
GSM 1900	1.850,2 MHz to 1.910 MHz	10 W
UMTS	1.920 MHz to 1.980 MHz	10 W

Fig. 97:   Antenna installation positions ESC-560

Cross-section GSM & GPS antenna 81.28205.0080
sheet metal roofs

81.28240.0151
Tightening torque 6 NM
Transition resistance ≤ 1Ω

Cross-section GSM & GPS antenna 81.28205.0080
High roof

81.28240.0151
Tightening torque 6 NM
Transition resistance ≤ 1Ω

Schematic view –
sheet metal roofs
L/R10;12;15;32;40

Position 3
Position 1
Position 2

Schematic view –
high roofs
L/R37;41;47

Position 3
Position 1
Position 2

Cross-section Y=0
sheet metal roofs

81.28200.8355
Tightening torque 6 NM
Transition resistance ≤ 1Ω

Cross-section Y=0
High roof

81.28200.8355
Tightening torque 6 NM
Transition resistance ≤ 1Ω

Description	Item number	Item	For antennas see electrical parts list
Antenna installation	81.28200.8365	Pos. 1	Radio antenna
Antenna installation	81.28200.8367	Pos. 1	Radio antenna + D & E-Net
Antenna installation	81.28200.8369	Pos. 1	Radio antenna + D & E-Net + GPS
Installation of radio antenna LHD	81.28200.8370	Pos. 2	CB radio antenna
Installation of radio antenna RHD	81.28200.8371	Pos. 3	
Installation of radio antenna LHD	81.28200.8372	Pos. 2	Trunked radio antenna
Installation of radio antenna RHD	81.28200.8373	Pos. 3	
Einbau Funkantenne LL	81.28200.8374	Pos. 2	Trunked radio antenna 2m band
Einbau Funkantenne RL	81.28200.8375	Pos. 3	
Antenna installation LHD	81.28200.8377	Pos. 3	GSM and GPS antenna for the road toll collection system
Antenna installation RHD	81.28200.8378	Pos. 2	
Installation of radio antenna LHD	81.28200.8004	Pos. 2	CB and radio antenna
Installation of combi antenna RHD	81.28205.8005	Pos. 3	GSM + D & E-Net + GPS + CB radio antenna
Installation of combi antenna LHD	81.28205.8004	Pos. 2	

6.9 Interfaces on the vehicle, preparations for the body

No work is permitted on the vehicle's electrical system other than via the interfaces provided by MAN (e.g. for tail-lifts, for start/stop equipment, for intermediate speed regulation, FMS interface). Tapping into the CAN buses is prohibited except in the case of the Body builder CAN bus – see the control unit TG interface for external data exchange (KSM).
The interfaces are described in detail in the 'Interfaces TG' booklet.

If the vehicle is ordered with body fittings (e.g. start/stop device on the end of the frame), these are already fitted at the factory and partly connected. The instrumentation is prepared in accordance with the order.
Before first operation of the body fittings, the body manufacturer must ensure that valid, up-to-date versions of wiring diagrams and wiring harness drawings are in use (see also Section 6.4).
Transport securing devices are fitted by MAN (on the interfaces behind the front panel on the passenger side) for delivery of the vehicle to the body manufacturer.
Before using each interface the transport securing devices must be properly removed.
The retrofitting of interfaces and/or body fittings is often extremely complicated. It should not be attempted without enlisting the help of an electronics specialist from the MAN service organisation.

Connecting to the D+ signal (engine running)
Caution: D+ may not be tapped from the alternator on TG vehicles.

In addition to the signals and information provided through the KSM interface it is also possible to tap into the D+ signal as follows:
The central on-board computer (ZBR) provides an "Engine running" signal (+24V).
This can be tapped into directly at the ZBR (socket F2 pin 17).
The maximum load on this connection may not exceed 1 Ampere. It should be noted that other internal consumers may also
be connected here. It must be ensured that this connection is free from feedback.
Transmission of data from the mass storage of digital tachographs and information contained on the driver card. MAN supports the manufacturer-independent transmission of data from the mass storage of digital tachographs and information contained on the driver card (RDL = remote download). The corresponding interface is published on the Internet at www.fms-standard.com.

6.9.1 Electrical connections for tail-lifts

See Chapter ‚Tail-lifts'

6.9.2 Start-stop control on frame end

The start-stop control is a system that works independently of the intermediate speed control interface and must be ordered separately. If the body manufacturer has installed the circuitry, the designation **start-stop** must be used. This must not be confused with the term **emergency stop**.

6.10 Electronics

The TGA range employs many electronic systems for controlling, regulating and monitoring vehicle functions.
The electronic braking system (EBS), electronic air suspension (ECAS) and the electronic diesel injection system (EDC) are just a
few examples. Full networking of the equipment fully guarantees that sensor readings can be processed to the same extent by all control
units. This enables the number of sensors, cables and connections to be reduced, which in turn reduces the number of possible
fault-sources. On the vehicle, network cables can be recognised because they are twisted. Several CAN bus systems are used in
parallel and this enables them to be optimally adapted to perform their respective tasks.
All data bus systems are reserved for exclusive use by the MAN vehicle electronics system; access to these bus systems is prohibited
except in the case of the Body builder CAN bus – see the control unit TG interface for external data exchange (KSM).

6.10.1 Display and instrumentation concept

The instrument cluster installed in the TGA is incorporated into the control unit network by means of a CAN bus system.
Faults are displayed in plain text directly in the central display or through error codes. The instrumentation receives all the information
that is displayed in the form of a CAN message. Long-life LEDs are used instead of bulbs. The annunciator panel is vehicle-specific,
i.e. only functions and fittings that have been ordered are present. If other functions are retrofitted at a later date and these are to be
displayed (e.g. retrofitted tail-lift, seatbelt tensioner, tipper display in the cab) the system has to be re-parameterised using MAN-cats®.
An annunciator panel that matches the new parameters can be ordered from the MAN spare parts service.
In this way, body manufacturers may elect to have the superstructure functions, e.g. tail-lift or tipper operation, parameterised on
the vehicle and the instrumentation, together with the required symbols on the annunciator panel, installed during manufacture.
It is neither possible to incorporate superstructure functions on an „in reserve" basis nor is it permitted for the body manufacturer
to incorporate his own functions into the central display or tap signals from the back of the instrumentation.

6.10.2 Diagnostics concept and parameterisation using MAN-cats®

MAN-cats® is the second generation MAN tool for diagnosis and parameterisation of electronic vehicle systems. MAN-cats® is therefore
used by all MAN service centres. If the body manufacturer or the customer informs MAN of the intended use or the body type
(e.g. for the intermediate speed control interface) when the vehicle is ordered, these can be incorporated into the vehicle at
the factory using EOL programming (EOL = end of line). MAN-cats® must be used if these parameters are to be changed.
For certain types of intervention in the vehicle systems the electronics specialists at MAN service centres are able to contact systems
specialists at the MAN factory to obtain the appropriate clearances, approvals and system solutions.

6.10.3 Parameterisation of the vehicle electronics

If any modifications that require approval or that are critical to safety are carried out on the vehicle, or if the chassis needs to
be modified to adapt it to the body, or if conversion work or retrofitting work needs to be carried out, a MAN-cats® specialist at
the nearest MAN service station must be consulted before any work commences to see if the vehicle needs to be re-parameterised.

7. Power take-off → See separate booklet

8. Brakes, lines

The braking system is among the most important safety items on a truck. No changes should be made to any part of the brake system including the brake lines except by suitably trained personnel. After any change a complete visual, audible, function and efficiency test of the complete braking system is to be performed.

8.1 ALB, EBS braking system

Due to the EBS it is not necessary for the body manufacturer to check the ALB (automatic load-dependent brake system); it is in any case not possible to make adjustments. A check may possibly be required in line with the scheduled inspection of the braking system (in Germany SP and section 29 StVZO). Should such an inspection of the braking system become necessary then a voltage measurement using the MAN-cats diagnosis system or a visual check of the angle of the linkage at the axle load sensor must be carried out. Never pull-out the plug on the axle load sensor. Before exchanging leaf springs, e.g. replacing them with stronger ones, it should be checked with the MAN workshop whether reparameterisation of the vehicle is necessary in order to be able to set the ALB correctly.

8.2 Brake and compressed air lines

All brake lines leading to the spring-loaded parking brake must be corrosion and heat-resistant according to DIN 14502 Part 2 'Fire service vehicles – general requirements'. The most important basic principles to observe when installing air lines are repeated here.

8.2.1 Basic principles

- Polyamide (PA) tubes must in all circumstances:
    - be kept away from heat sources
    - be laid in such a way that no abrasion can occur
    - be free from trapped stresses
    - be laid without kinking.
- Only PA tubing in accordance with MAN standard M 3230 Part 1 is to be used (www.normen.man-nutzfahrzeuge.de, registration required. In accordance with the standard this tubing is marked with a number starting with 'M 3230' every 350 mm.
- Remove lines to protect them before welding work takes place.
- For welding work, see also the Chapter „Modifying the chassis" – „Welding the frame" section.
- In view of the risk of heat build-up, PA pipes must not be attached to metal pipes or holders that are connected to the following assemblies:
    - Engine
    - Air compressor
    - Heating
    - Radiator
    - Hydraulic system.

8.2.2 Voss 232 system plug connectors

For brake/air lines, only Voss 232 (MAN standard: M 3298) and Voss 230 system plug connectors (for NG6 smaller diameter pipes and special connectors such as the double mandrel; MAN standard: M 3061) are permitted (www.normen.man-nutzfahrzeuge.de, registration required). The standard referred to contains detailed instructions that must be applied in all cases when installing pneumatic lines and assemblies. Body manufacturers can obtain the MAN standards listed here from www.normen.man-nutzfahrzeuge.de (registration required).

The system has two detent stages. If the plug element has only been inserted as far as the first detent, the System 232 connection leaks deliberately; incorrect plug element engagement can be identified immediately by the noise that occurs.

- The system must be relieved of pressure before the union screw is slackened.
- After the connection between plug element and union screw has been separated the union screw must be renewed, since the retaining element is rendered unfit for further use when it is unscrewed.
- The union screw must therefore be slackened off when a line is detached from an assembly. The plastic pipe with plug element, union screw and retaining element constitutes a re-usable unit. Only the O-ring that seals the thread (see Fig. 98) has to be renewed. (Grease the O-ring and clean the union screw when installing).
- The plug connection unit described above is to be screwed into the assembly hand-tight, then finally tightened to 12 ± 2 Nm (in metal) or 10 ± 1 Nm (in plastic).

Fig. 98: Voss System 232, functional principle ESC-174
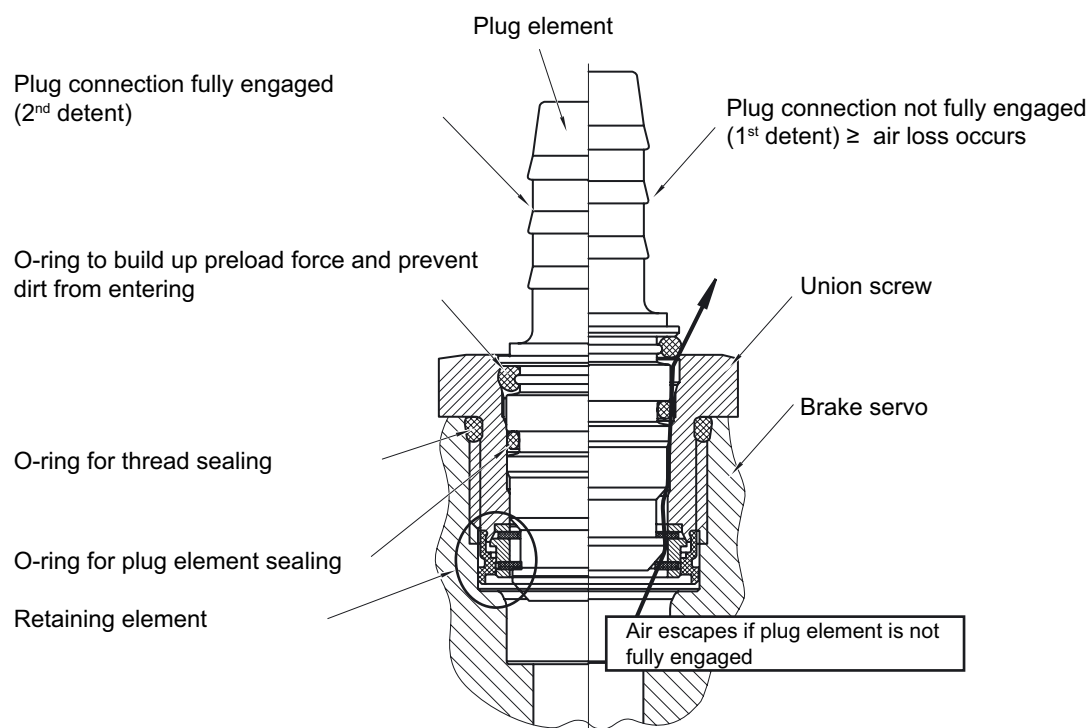
8.2.3   Installing and attaching lines

Basics of installing lines:

- Lines must not be laid loose; existing means of attachment and/or conduits are to be used.
- Do not heat plastic pipes when installing them, even if they are to follow a curved path.
- When attaching pipes, make sure that the PA pipes cannot become twisted.
- Install a pipe clip or, in the case of a cluster of pipes, a cable tie at the beginning and end in each case.
- Corrugated wiring harness pipes are to be attached to plastic consoles in the frame or, in the engine area, to prepared cable routes using cable ties or clips.
- Never attach more than one line to the same hose clip.
- Only PA pipes (PA = polyamide) designed to DIN 74324 Part 1 or MAN Standard M 3230 Part 1 (extension of DIN 74324 Part 1) may be used (www.normen.man-nutzfahrzeuge.de, registration required).
- Add 1 % to the length of the PA pipe (corresponding to 10mm for each metre of cable), because plastic pipes contract in the cold and the vehicles must be capable of working at temperatures down to - 40°C.
- The pipes must not be heated when being installed.
- When cutting plastic pipes to length, use plastic pipe cutters; sawing them to length creates ridges on the cut faces and chippings get into the pipe.
- PA pipes may rest on the edges of the frame or in the frame openings. A minimal amount of flattening at the points of contact is tolerated (maximum depth of 0.3 mm). However, notched abrasion is not permitted.
- PA pipes are allowed to come into contact with each other. There should be minimal flattening at the points where the pipes come into contact with each other.
- PA pipes can be bundled together with a cable tie but must be positioned parallel to each other (they should not cross over each other). PA pipes and corrugated pipes should only be bundled together with pipes of the same type. The restriction in movement caused by the pipes becoming stiffer when bundled together should be taken into account.
- Covering the edges of the frame with a cut corrugated pipe will cause damage; the PA pipe will be worn at the point where it comes into contact with the corrugated pipe.
- Points of contact with the edges of the frame can be protected with a protective spiral (see Fig. 99). The protective spiral must tightly and completely grip the pipe it is protecting. Exception: PA pipes ≤ 6 mm).

Fig. 99:   Protective spiral on a PA pipe ESC-151
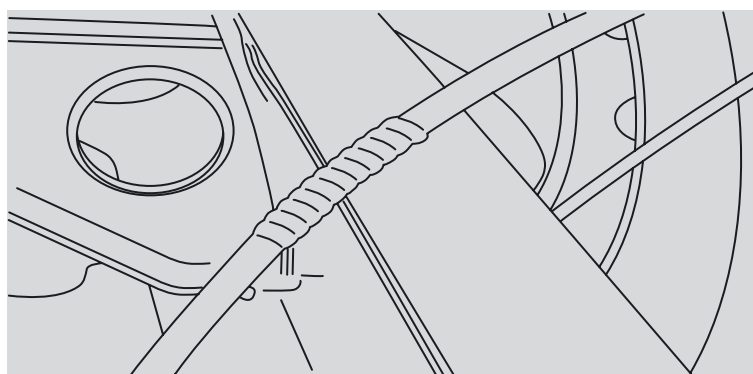
- PA pipes/PA corrugated pipes must not come into contact with aluminium alloys, e.g. aluminium tank, fuel filter housing; aluminium alloys are subject to mechanical wear (fire risk).
- Pipes that cross over and pulsate (e.g. fuel pipes) must not be joined together with a cable tie at the cross-over point (risk of chafing).
- No cables/pipes should be fixed rigidly to injection pipes and steel fuel feed pipes for the flame starting system (fire risk, risk of chafing).
- Accompanying central lubricating cables and ABS sensor cables may be attached to air hoses only if a rubber spacer is fitted.
- Nothing may be attached to coolant hoses and hydraulic hoses (e.g. steering hoses) by means of cable ties (risk of chafing).
- Under no circumstances should starter cables be bundled together with fuel or oil pipes; this is because it is essential that the cable from the positive terminal does not chafe.
- Effects of heat: watch out for a build-up of heat in encapsulated areas. Resting the pipes/cables on heat shields is not permitted (minimum distance from heat shields ≥ 100 mm, from the exhaust ≥ 200 mm)
- Metal pipes are pre-strengthened and must not be bent or installed in such a way that they bend during operation.

If assemblies/components are mounted in such a way that they can move with respect to each other, then the following basic rules must be followed when routing cables/pipes:

- The cable/pipe must be able to follow the movement of the assembly without any problem; ensure that there is sufficient distance between the moving parts for this (rebound/compression, steering angle, tilting of cab). The cables must not be stretched.
- The respective starting and end point of the movement is to be defined exactly and used as the fixed clamping point. The PA or corrugated pipe is gripped tightly at the clamping point using the widest cable tie possible or a clip suitable for the diameter of the pipe.
- If PA and corrugated pipes are laid at the same junction, the stiffer PA pipe is laid first. The softer corrugated pipe is then attached to the PA pipe.
- If a pipe is to tolerate movements at right angles to the direction in which it is laid, then sufficient distance between the clamping points must be guaranteed (rule of thumb: distance between clamping points ≥ 5 x the amplitude of movement to be withstood).
- Large amplitudes of movement are best withstood by laying the pipe in a U-shape and by permitting movement along the arms of the „U".

Rule of thumb for the minimum length of the slack loop:
Minimum length of the slack loop = 1/2 · amplitude of movement · minimum radius · π

- The following minimum radii are to be observed for PA pipes (the respective start and end point of the movement is to be defined precisely as the fixed clamping point):

Table 25:   Minimum bending radii for PA pipes

Nominal pipe diameter - Ø [mm]	4	6	9	12	14	16
Bending radius r ≥ [mm]	20	30	40	60	80	95

- Use plastic clips to secure the lines and comply with the maximum clip spacing stated in Table 26.

Table 26:   Maximum space between clips used to secure pipes in relation to pipe size

Pipe size	4x1	6x1	8x1	9x1,5	11x1,5	12x1,5	14x2	14x2,5	16x2
Clip spacing [mm]	500	500	600	600	700	700	800	800	800

8.2.4 Compressed air loss

Compressed air systems cannot achieve 100 % efficiency and slight leakage is often unavoidable despite the most careful installation work. The question is therefore what degree of air pressure loss is unavoidable and when does the loss become too high? Simply put, any loss of air pressure that would render a vehicle undriveable once the engine is started after a period of 12 hours parked must be regarded as unacceptable. Based on this requirement there are two different methods of determining whether air loss is unavoidable or not:

•   Within 12 hours of the system having been charged to its cut-off pressure, the pressure must not be below < 6 bar in any circuit. The check must be made with depressurised spring-loaded brake release units, in other words with the parking brake applied.
•   The pressure in the tested circuit must not have fallen by more than 2 % within ten minutes of charging the system to its cut-off pressure.

If air loss is greater than described above, an unacceptable leak is present and must be eliminated.

8.3 Connecting additional air consumers

All of the compressed air system pipework on the TGA uses the Voss systems 232 and 230 (for small pipes NG6 and special connectors e.g. double mandrel). Only use of the original system components is permitted when working on the chassis.
Additional air consumers on the superstructure may only be connected to the compressed-air system via the additional consumers circuit. A dedicated pressure relief valve must be fitted for each additional consumer with a pneumatic connection > NG6 (6x1mm).

The connection of additional air consumers to the following is not permitted:

•   To the service and parking brake circuits
•   To the test connections (mounted on a distribution panel in an easily accessible location on the driver's side)
•   Directly to the ECAM (electronic controlled air manufacturing) or four circuit protection valve

MAN uses a distribution rail on the solenoid-valve block to connect its own air-consumers.
This is installed on to the cross member at the bend in the frame.

Body manufacturers have two connection options:

In the centre of the distribution block there is a distributor for additional consumers (see Fig. 100).
Its connection 52 (blind closed) is reserved for superstructure-mounted additional air-consumers. The consumer can then be connected up using the Voss 232 NG8 system via a pressure relief valve that is to be installed separately by the body manufacturer.

Fig. 100:   Location of the distribution block for additional air-consumers ESC-180
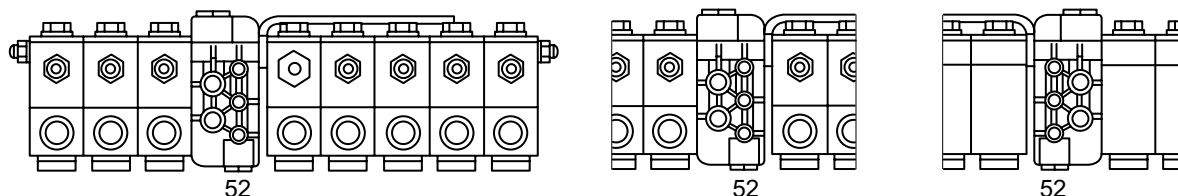
The other possibility is a connection to a pressure relief and non-return valve, available from the factory for ancillary consumers mounted on the body. Location and variants according to Fig. 101 / item number 81.51000.8114.
This is a threaded connector M22x1.5.

Fig. 101: Location on the frame and connection variants at the pressure relief valve for body manufacturers Drawing 81.51000.8114
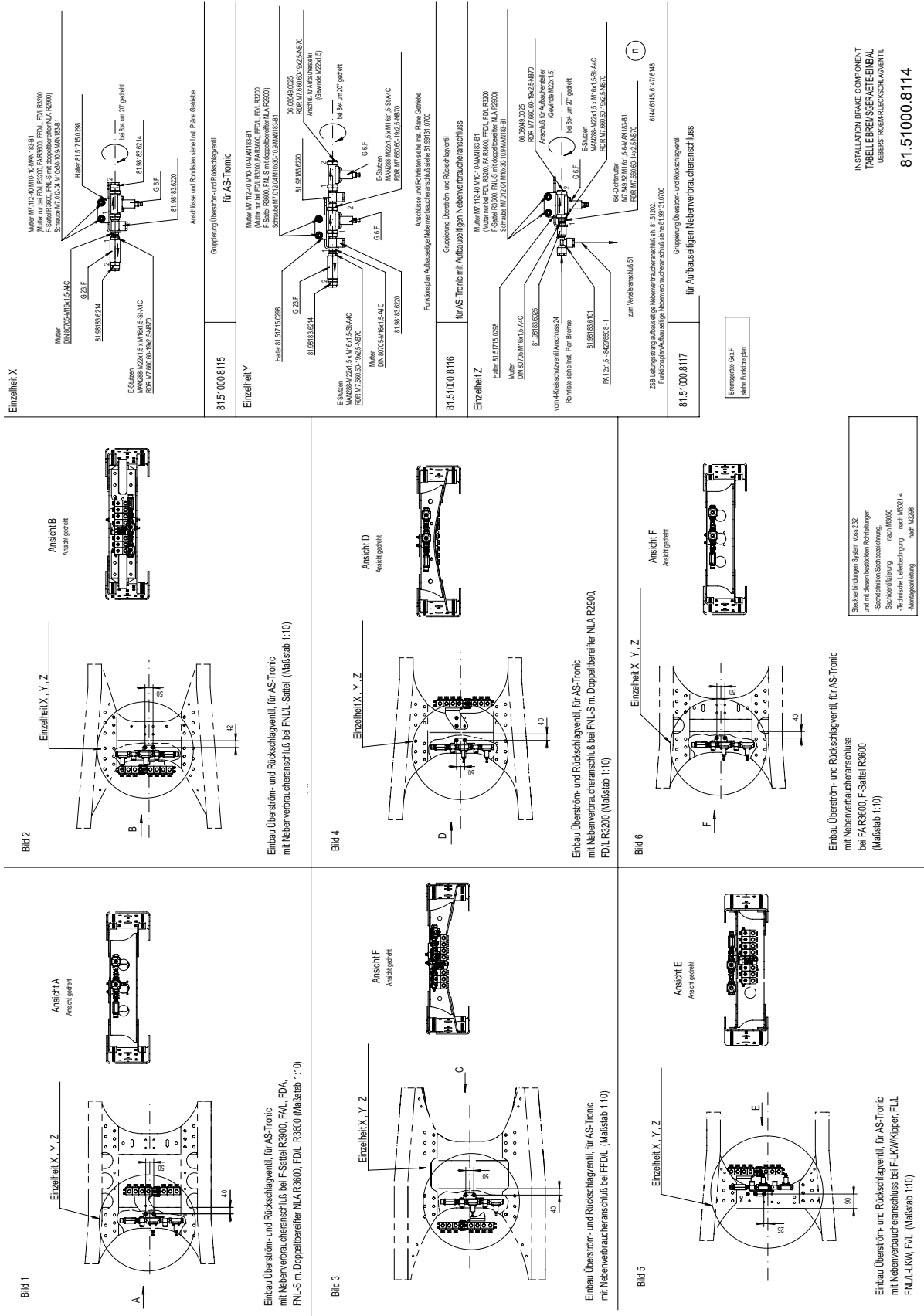
8.4 Retrofitting continuous brakes not manufactured by MAN

Fitting continuous braking systems (retarders, eddy current brakes) that have not been documented by MAN is fundamentally not possible. Retrofitting of continuous brakes not manufactured by MAN is not permitted because the necessary intervention in the electronically controlled braking system (EBS) and the vehicle's on-board braking and drivetrain management system is not permitted.

9. Calculations

9.1 Speed

The following generally applies for the calculation of the driving speed on the basis of engine speed, tyre size and overall ratio:

Formula 18: Speed

$$v = \frac{0,06 \cdot n_{Mot} \cdot U}{i_G \cdot i_v \cdot i_A}$$

Where:

v	=	Driving speed, in [km/h]
n_{Mot}	=	Engine speed, in [rpm]
U	=	Tyre rolling circumference, in [m]
I_G	=	Transmission ratio
i_V	=	Transfer case ratio
i_A	=	Final drive ratio of the driven axle(s)

To calculate the theoretical maximum speed (or the design top speed), the engine speed is increased by 4 %.
The formula therefore is as follows:

Formula 19: Theoretical maximum speed

$$v = \frac{0,0624 \cdot n_{Mot} \cdot U}{i_G \cdot i_v \cdot i_A}$$

Caution: This calculation is used exclusively to calculate the theoretical final speed on the basis of engine speed and transmission ratios. The formula does not take into consideration the fact that the actual maximum speed will be below this speed when driving resistances offset the driving forces. An estimate of the actual achievable speeds using a driving performance calculation in which air, rolling and climbing resistance on the one side and tractive force on the other offset each other, can be found in Section 9.8, „Driving resistances". On vehicles with a speed limiter in accordance with 92/24/EEC, the design top speed is generally 85 km/h.

Example of a calculation:

Vehicle:	Model H56 TGA 33.430 6x6 BB
Tyre size:	315/80 R 22,5
Rolling circumference:	3,280 m
Transmission:	ZF 16S 2522 TO
Transmission ratio in lowest gear:	13,80
Transmission ratio in highest gear:	0,84
Minimum engine speed at maximum engine torque:	1.000/min
Maximum engine speed:	1.900/min
Ratio for transfer case G 172 in on-road applications:	1,007
Ratio for transfer case G 172 in off-road applications:	1,652
Final drive ratio:	4,00

The solution to following is required:

1. Minimum speed in off-road applications at maximum torque

2. Theoretical maximum speed without speed limiter

Solution 1:

$$v = \frac{0{,}06 \cdot 1000 \cdot 3{,}280}{13{,}8 \cdot 1{,}652 \cdot 4{,}00}$$

$$v = 2{,}16 \text{ km/h}$$

Solution 2:

$$v = \frac{0{,}0624 \cdot 1900 \cdot 3{,}280}{0{,}84 \cdot 1{,}007 \cdot 4{,}00}$$

$$v = 115 \text{ km/h}$$

A speed of 115 km/h is theoretically possible, however the speed limiter limits this to 90 km/h.
(The speed is actually set to 89 km/h as a result of the tolerances that must be taken into account).

9.2　Efficiency

The efficiency is the ratio of the power output to the power input. Since the power output is always smaller than the power input, efficiency η is always < 1 or < 100%.

Formula 20:　Efficiency

$$\eta = \frac{P_{ab}}{P_{zu}}$$

When several units are connected in series, the individual efficiencies are multiplied.

Example of a calculation for individual efficiency:

Efficiency of a hydraulic pump η = 0,7. If the required power output P_{ab} is 20 kW, what should the power input P_{zu} be?

Solution:

$$P_{zu} = \frac{P_{ab}}{\eta}$$

$$P_{zu} = \frac{20}{0{,}7}$$

$$P_{zu} = 28{,}6 \text{ kW}$$

Example of calculation for several efficiencies:

Efficiency of a hydraulic pump η_1 = 0,7. This pump drives a hydraulic motor via a jointed shaft system with two joints.

Individual efficiencies:

Hydraulic pump:	η_1	=	0,7
Jointed shaft joint a:	η_2	=	0,95
Jointed shaft joint b:	η_3	=	0,95
Hydraulic motor:	η_4	=	0,8

Power required, i.e., power output P_{ab} = 20 kW

What is the power input P_{zu}?

Solution:

Overall efficiency:

$$\eta_{ges} = \eta_1 \cdot \eta_2 \cdot \eta_3 \cdot \eta_4$$

$$\eta_{ges} = 0,7 \cdot 0,95 \cdot 0,95 \cdot 0,8$$

$$\eta_{ges} = 0,51$$

Power input:

$$P_{zu} = \frac{20}{0,51}$$

$$P_{zu} = 39,2 \text{ kW}$$

9.3 Tractive force

The tractive force is dependent on:

- Engine torque
- Overall ratio (including that of the wheels)
- Efficiency of power transmission

Formula 21: Tractive force

$$F_z = \frac{2 \cdot \pi \cdot M_{Mot} \cdot \eta \cdot i_G \cdot i_V \cdot i_A}{U}$$

F_Z	=	Tractive force, in [N]
M_{Mot}	=	Engine torque, in [Nm]
η	=	Overall efficiency in the drive train – see guideline values in Table 28
i_G	=	Transmission ratio
i_V	=	Transfer case ratio
i_A	=	Final drive ratio of the driven axle(s)
U	=	Tyre rolling circumference, in [m]

For an example of tractive force, see 9.4.3 Calculating gradeability.

9.4 Gradeability

9.4.1 Distance travelled on uphill or downhill gradients

The gradeability of a vehicle is expressed as a percentage (%). For example, the figure 25 % means that for a
horizontal length of l = 100 m, a height of h = 25 m can be overcome. The same applies correspondingly to downhill gradients.
The actual distance travelled c is calculated as follows:

Formula 22: Distance travelled on uphill or downhill gradients

$$c = \sqrt{l^2 + h^2} = l \cdot \sqrt{1 + \left[\frac{p}{100}\right]^2}$$

c = Distance travelled, in [m]
l = Horizontal length of an uphill or downhill gradient, in [m]
h = Vertical height of an uphill/downhill gradient, in [m]
p = Uphill/downhill gradient, in [%]

Example of a calculation:

Gradient p = 25 %. What is the distance travelled for a length of 200 m?

$$c = \sqrt{l^2 + h^2} = 200 \cdot \sqrt{1 + \left[\frac{25}{100}\right]^2}$$

c = 206 m

9.4.2 Angle of uphill or downhill gradient

The angle of the uphill or downhill gradient a is calculated using the following formula:

Formula 23: Angle of uphill or downhill gradient

$$\tan \alpha = \frac{p}{100} , \quad \alpha = \arctan\frac{p}{100} , \quad \sin \alpha = \frac{h}{c} , \quad \alpha = \arcsin \frac{h}{c}$$

a = Angle of gradient, in [°]
p = Uphill/downhill gradient, in [%]
h = Vertical height of an uphill/downhill gradient, in [m]
c = Distance travelled, in [m]

Example of a calculation:

If the gradient is 25%, what is the angle of the gradient?

$$\tan \alpha = \frac{p}{100} = \frac{25}{100}$$

α = arctan 0,25
α = 14°

Fig. 102: Gradient ratios, gradient, angle of gradient ESC-171
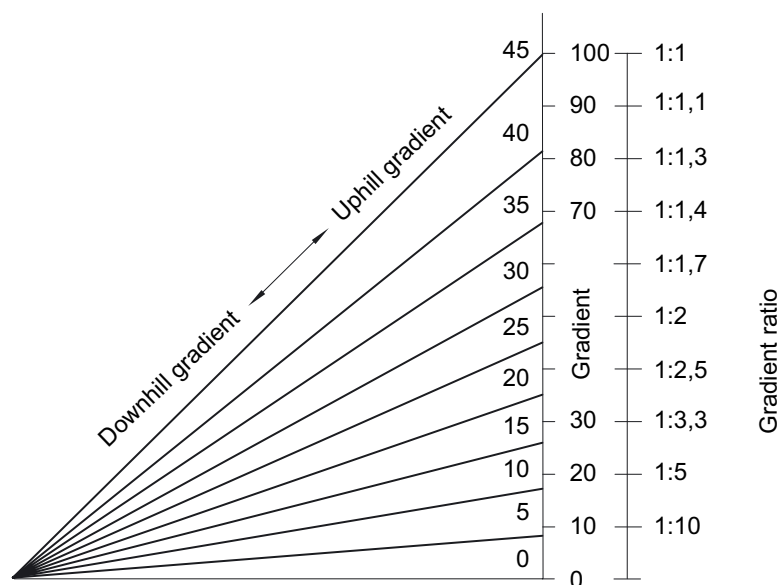
9.4.3 Calculating the gradeability

Gradeability is dependent on:

*   Tractive force (see Formula 21)
*   Overall combined mass, including overall mass of the trailer or semi-trailer
*   Rolling resistance
*   Adhesion (friction)

The following applies for gradeability:

Formula 24: Gradeability

$$p = 100 \cdot \left[\frac{F_z}{9,81 \cdot G_z} - f_R \right]$$

Where:

p	=	Gradeability, [%]
M_{Mot}	=	Engine torque, in [Nm]
F_z	=	Tractive force in [N] (calculated in accordance with Formula 21)
G_z	=	Overall combined mass, in [kg]
f_R	=	Coefficient of rolling resistance, see Table 27
i_G	=	Transmission ratio
i_A	=	Driven axle ratio
i_V	=	Transfer case ratio
U	=	Tyre rolling circumference, [m]
η	=	Overall efficiency in the drive train, see Table 28

Formula 24 calculates the vehicle's gradeability based on its characteristics of

- Engine torque
- Transmission, transfer case, final drive and tyre ratio and
- Overall combined mass

Here, only the vehicle's ability to tackle a specific gradient based on its characteristics is considered. Not taken into consideration is the actual adhesion between wheels and road which, in poor conditions (e.g. wet roads) can reduce traction so that hill-climbing performance is far below the value calculated here. Calculation of the actual conditions based on adhesion is addressed in Formula 25.

Table 27: Coefficients of rolling resistance

Road surface	Coefficient f_R
Good asphalt road	0,007
Wet asphalt road	0,015
Good concrete road	0,008
Rough concrete road	0,011
Block paving	0,017
Poor road	0,032
Dirt track	0,15...0,94
Loose sand	0,15...0,30

Table 28: Overall efficiency in the drive train

Number of driven axles	η
One driven axle	0,95
Two driven axles	0,9
Three driven axles	0,85
Four driven axles	0,8

Example of calculation:

Vehicle:			Model H56 TGA 33.430 6x6 BB
Max. engine torque:	M_{Mot}	=	2.100 Nm
Efficiency with three driven axles:	η_{ges}	=	0,85
Transmission ratio in lowest gear:	i_G	=	13,80
Transfer case ratio - in on-road gear:	i_V	=	1,007
- in off-road gear:	i_V	=	1,652
Final drive ratio:	i_A	=	4,00
Tyre 315/80 R 22.5 with rolling circumference:	U	=	3,280 m
Overall combined mass:	G_Z	=	100.000 kg
Coefficient of rolling resistance:			
- smooth asphalt	f_R	=	0,007
- poor, rutted road	f_R	=	0,032

Required is:

Maximum gradeability p_f in on-road and off-road conditions.

Solution:

1. Maximum tractive force (for definition, see Formula 21) in on-road gear:

$$F_z = \frac{2\pi \cdot M_{Mot} \cdot \eta \cdot i_G \cdot i_V \cdot i_A}{U}$$

$$F_z = \frac{2\pi \cdot 2100 \cdot 0,85 \cdot 13,8 \cdot 1,007 \cdot 4,00}{3,280}$$

$$F_z = 190070N = 190,07 \text{ kN}$$

2. Maximum tractive force (for definition, see Formula 21) in off-road gear:

$$F_z = \frac{2\pi \cdot M_{Mot} \cdot \eta \cdot i_G \cdot i_V \cdot i_A}{U}$$

$$F_z = \frac{2\pi \cdot 2100 \cdot 0,85 \cdot 13,8 \cdot 1,007 \cdot 4,00}{3,280}$$

$$F_z = 311812N = 311,8 \text{ kN}$$

3. Maximum gradeability in on-road gear on good asphalt road:

$$p = 100 \cdot \left[\frac{F_z}{9,81 \cdot G_z} - f_R \right]$$

$$p = 100 \cdot \left[\frac{190070}{9,81 \cdot 100000} - 0,007 \right]$$

$$p = 18,68 \%$$

4. Maximum gradeability in on-road gear on poor, rutted road:

$$p = 100 \cdot \left[\frac{190070}{9,81 \cdot 100000} - 0,032 \right]$$

$$p = 16,18 \%$$

5. Maximum gradeability in off-road gear on good asphalt road:

$$p = 100 \cdot \left[\frac{311812}{9,81 \cdot 100000} - 0,007 \right]$$

$$p = 31,09 \text{ \%}$$

6. Maximum gradeability in off-road gear on poor, rutted road:

$$p = 100 \cdot \left[\frac{311812}{9,81 \cdot 100000} - 0,032 \right]$$

$$p = 28,58 \text{ \%}$$

Note:

The examples shown do not take into consideration whether adhesion between road and driven wheels (friction) will allow the tractive force required for tackling the gradient to be transmitted. The following formula is applied for this:

Formula 25:   Gradeability taking into account road/tyre adhesion

$$p_R = 100 \cdot \left[\frac{\mu \cdot G_{an}}{G_z} - f_R \right]$$

Where:

p_R	=	Gradeability taking friction into account, in [%]
μ	=	Tyre/road surface coefficient of friction, on wet asphalt surface ~ 0,5
f_R	=	Coefficient of rolling resistance, on wet asphalt road surface ~ 0,015
G_{an}	=	Sum of the axle loads of the driven axles as mass, in [kg]
G_Z	=	Overall combined mass, in [kg]

Example of calculation:

Above vehicle:	Model H56 TGA 33.430 6x6 BB		
Coefficient, wet asphalt road:	μ	=	0,5
Coefficient of rolling resistance, wet asphalt:	f_R	=	0,015
Overall combined mass:	G_Z	=	100.000 kg
Sum of the axle loads of all driven axles:	G_{an}	=	26.000 kg

$$p_R = 100 \cdot \left[\frac{0,5 \cdot 26000}{100000} - 0,015 \right]$$

$$p_R = 11,5 \text{ \%}$$

9.5 Torque

If force and effective separation are known:

Formula 26: Torque with force and effective separation

$$M = F \cdot l$$

If power output and rotational speed are known:

Formula 27: Torque with power output and rotational speed

$$M = \frac{9550 \cdot P}{n \cdot \eta}$$

In hydraulic systems, if delivery rate (volume flow rate), pressure and rotational speed are known:

Formula 28: Torque with delivery rate, pressure and rotational speed

$$M = \frac{15{,}9 \cdot Q \cdot p}{n \cdot \eta}$$

Where:

M	=	Torque, in [Nm]
F	=	Force, in [N]
l	=	Distance from the line of action of the force to the centre of rotation, in [m]
P	=	Power output, in [kW]
n	=	Rotational speed, in [rpm]
η	=	Efficiency
Q	=	Volume flow rate, in [l/min]
p	=	Pressure, in [bar]

Example of calculation when force and effective separation are known:

A cable winch with a pulling force F of 50,000 N has a drum diameter d = 0.3 m.
Without taking efficiency into account, what is the torque?

Solution:

$$M = F \cdot l = F \cdot 0{,}5 \, d \text{ (the drum radius is the leverage)}$$

$$M = 50000 \, N \cdot 0{,}5 \cdot 0{,}3 \, m$$

$$M = 7500 \, Nm$$

Example when power output and rotational speed are known:

A power take-off is to transmit a power P of 100 kW at n = 1500/min.
Without taking efficiency into account, what torque must the power take-off be able to transmit?

Solution:

$$M = \frac{9550 \cdot 100}{1500}$$

$$M = 637 Nm$$

Example if delivery rate (volume flow rate), pressure and rotational speed are known for a hydraulic pump:

A hydraulic pump delivers a volume flow rate Q of 80 l/min at a pressure p of 170 bar and a pump rotational speed n of 1000/min. Without taking efficiency into account, what torque is required?

Solution:

$$M = \frac{15,9 \cdot 80 \cdot 170}{1000}$$

$$M = 216 Nm$$

If efficiency is to be taken into account, the torques calculated in each case must be divided by the overall efficiency (see also Section 9.2, Efficiency).

9.6   Power output

For lifting motion:

Formula 29:   Power output for lifting motion

$$M = \frac{9,81 \cdot m \cdot v}{1000 \cdot \eta}$$

For plane motion:

Formula 30:   Power output for plane motion

$$P = \frac{F \cdot v}{1000 \cdot \eta}$$

For rotational motion:

Formula 31:   Power output for rotational motion

$$P = \frac{M \cdot n}{9550 \cdot \eta}$$

In hydraulic systems:

Formula 32:   Power output in hydraulic systems

$$P \;=\; \frac{Q \cdot p}{600 \cdot \eta}$$

Where:

P	=	Power output, in [kW]
m	=	Mass, in [kg]
v	=	Speed, in [m/s]
η	=	Efficiency
F	=	Force, in [N]
M	=	Torque, in [Nm]
n	=	Rotational speed, in [rpm]
Q	=	Delivery rate (volume flow rate), in [l/min]
p	=	Pressure, in [bar]

Example 1 = Lifting motion:

Tail-lift payload including its own weight	m =	2. 600 kg
Lift speed	v =	0,2 m/s

If efficiency is not taken into consideration, what is the power output?

Solution:

$$P \;=\; \frac{9,81 \cdot 2600 \cdot 0,2}{1000}$$

$$P \;=\; 5,1 \text{ kW}$$

Example 2: Plane motion:

Cable winch	F =	100.000 N
Cable speed	v =	0,15 m/s

If efficiency is not taken into consideration, what is the power output requirement?

$$P \;=\; \frac{100000 \cdot 0,15}{1000}$$

$$P \;=\; 15 \text{ kW}$$

Example 3 – Rotational motion:

Power take-off rotational speed	n =	1.800/min
Permissible torque	M =	600 Nm

If efficiency is not taken into consideration, what power output is possible?

Solution:

$$P = \frac{600 \cdot 1800}{9550}$$

$$P = 113 \text{ kW}$$

Example 4: Hydraulic system:

Volume flow rate of the pump	Q	=	60 l/min
Pressure	p	=	170 bar

If efficiency is not taken into consideration, what is the power output?

Solution:

$$P = \frac{60 \cdot 170}{600}$$

$$P = 17 \text{ kW}$$

9.7 Rotational speeds for power take-offs at the transfer case

If the power take-off is operating on the transfer case and its operation is distance-dependent, its rotational speed n_N is given in revolutions per metre of distance covered. It is calculated from the following:

Formula 33: Revolutions per meter, power take-off at the transfer box

$$n_N = \frac{i_A \cdot i_V}{U}$$

The distance s in metres covered per revolution of the power take-off (reciprocal value of n_N) is calculated with:

Formula 34: Distance per revolution, power take-off on the transfer case

$$s = \frac{U}{i_A \cdot i_V}$$

Where:

n_N	=	Power take-off rotational speed, in [1/m]
i_A	=	Final drive ratio
i_V	=	Transfer case ratio
U	=	Tyre circumference, in [m]
s	=	Distance travelled, in [m]

Example:

Vehicle:		Model H80 TGA 18.480 4x4 BL
Tyres 315/80 R22.5 with rolling circumference:	U =	3,280 m
Final drive ratio:	i_A =	5,33
Transfer case G172, ratio in on-road gear:	i_V =	1,007
Ratio in off-road applications:	i_V =	1,652

Power take-off rotational speed in on-road gear:

$$n_N = \frac{5,33 \cdot 1,007}{3,280}$$

$$n_N = 1,636/m$$

This corresponds to a distance of:

$$s = \frac{3,280}{5,33 \cdot 1,007}$$

$$s = 0,611 \text{ m}$$

Power take-off rotational speed in off-road gear:

$$n_N = \frac{5,33 \cdot 1,652}{3,280}$$

$$n_N = 2,684/m$$

This corresponds to a distance of:

$$s = \frac{3,280}{5,33 \cdot 1,652}$$

$$s = 0,372 \text{ m}$$

9.8   Driving resistances

The main driving resistances are:

•   Rolling resistance
•   Climbing resistance
•   Air resistance (drag).

A vehicle can move along only if the sum of all resistances is overcome. Resistances are forces that either balance out the driving force (uniform movement) or are smaller than the driving force (accelerated movement).

Formula 35:   Rolling resistance force

$$F_R = 9,81 \cdot f_R \cdot G_z \cdot \cos\alpha$$

Formula 36:   Climbing resistance force

$$F_S = 9,81 \cdot G_z \cdot \sin\alpha$$

Angle of gradient (= formula 23, see Section 9.4.2, Angle of uphill and downhill gradients)

$$\tan \alpha = \frac{p}{100} \, , \quad \alpha = \arctan \frac{p}{100}$$

Formula 37: Air resistance force

$$F_L = 0{,}6 \cdot c_W \cdot A \cdot v^2$$

Where:

F_R	=	Rolling resistance force, in [N]
f_R	=	Coefficient of rolling resistance, see Table 27
G_Z	=	Overall combined mass, in [kg]
α	=	Angle of uphill gradient, in [°]
F_S	=	Climbing resistance force, in [N]
p	=	Uphill gradient, in [%]
F_L	=	Air resistance force, in [N]
c_W	=	Drag coefficient
A	=	Vehicle frontal area, in [m²]
v	=	Speed, in [m/s]

Example:

Articulated vehicle:	G_Z	=	40.000 kg
Speed:	v	=	80 km/h
Gradient:	p_f	=	3 %
Vehicle frontal area:	A	=	7 m²
Coefficient of rolling resistance for good asphalt road: f_R		=	0,007

A distinction is to be made between the following:

- with spoiler, $\quad c_{W1} = 0{,}6$
- without spoiler, $\quad c_{W2} = 1{,}0$

Solution:

Additional calculation 1:

Conversion of driving speed from km/h into m/s:

$$v = \frac{80}{3{,}6} = 22{,}22 \text{ m/s}$$

Additional calculation 2:

Conversion of gradeability from % into degrees:

$$\alpha = \arctan \frac{3}{100} = \arctan 0{,}03$$

$$\alpha = 1{,}72°$$

1. Calculation of rolling resistance:

$$F_R = 9{,}81 \cdot 0{,}007 \cdot 40000 \cdot \cos 1{,}72°$$

$$F_R = 2746 \text{ N}$$

2. Calculation of climbing resistance:

$$F_S = 9{,}81 \cdot 40000 \cdot \sin 1{,}72°$$

$$F_S = 11778 \text{ N}$$

3. Calculation of air resistance F_{L1} with spoiler:

$$F_{L1} = 0{,}6 \cdot 0{,}6 \cdot 7 \cdot 22{,}22^2$$

$$F_{L1} = 1244 \text{ N}$$

4. Calculation of air resistance F_{L2} without spoiler:

$$F_{L2} = 0{,}6 \cdot 1 \cdot 7 \cdot 22{,}22^2$$

$$F_{L2} = 2074 \text{ N}$$

5. Overall resistance F_{ges1} with spoiler:

$$F_{ges1} = F_R + F_s + F_{L1}$$

$$F_{ges1} = 2746 + 11778 + 1244$$

$$F_{ges1} = 15768 \text{N}$$

6. Overall resistance F_{ges2} without spoiler:

$$F_{ges2} = F_R + F_s + F_{L2}$$

$$F_{ges2} = 2746 + 11778 + 2074$$

$$F_{ges2} = 16598 \text{ N}$$

7. Power output requirement P_1 with spoiler, not taking efficiency into consideration:

(power output in accordance with Formula 30, Power output for plane motion)

$$P_1{'} = \frac{F_{ges1} \cdot v}{1000}$$

$$P_1{'} = \frac{15768 \cdot 22{,}22}{1000}$$

$$P_1{'} = 350 \text{ kW (476 PS)}$$

8. Power output requirement P_2 without spoiler, not taking efficiency into consideration:

$$P_2' = \frac{F_{ges2} \cdot v}{1000}$$

$$P_2' = \frac{16598 \cdot 22,22}{1000}$$

$$P_2' = 369 \text{ kW (502 PS)}$$

9. Power output requirement P_1 with spoiler and overall driveline efficiency of η = 0,95:

$$P_1 = \frac{P_1'}{\eta} = \frac{350}{0,95}$$

$$P_1 = 368 \text{kW (501PS)}$$

10. Power output requirement P_2 with spoiler and overall driveline efficiency of η = 0,95:

$$P_2 = \frac{P_2'}{\eta} = \frac{369}{0,95}$$

$$P_2 = 388 \text{ kW (528 PS)}$$

9.9   Turning circle

When a vehicle is cornering, each wheel describes a turning circle. The outer turning circle, or its radius, is the main subject of interest. The calculation is not precise because when a vehicle is cornering the perpendiculars through the centres of all wheels do not intersect at the curve centre point (Ackermann condition). In addition, while the vehicle is moving dynamic forces will arise that will affect the cornering manoeuvre. However, the following formulae can be used for estimation purposes:

Formula 38:   Distance between steering axes

$$j = s - 2r_o$$

Formula 39:   Theoretical value of the outer steer angle

$$\cot\beta_{ao} = \cot\beta_i + \frac{j}{l_{kt}}$$

Formula 40:   Steer angle deviation

$$\beta_F = \beta_a - \beta_{ao}$$

Formula 41:   Turning circle radius

$$r_s = \frac{l_{kt}}{\sin\beta_{ao}} + r_o - 50 \cdot \beta_F$$

Fig. 103: Kinematic interrelationships when calculating the turning circle ESC-172
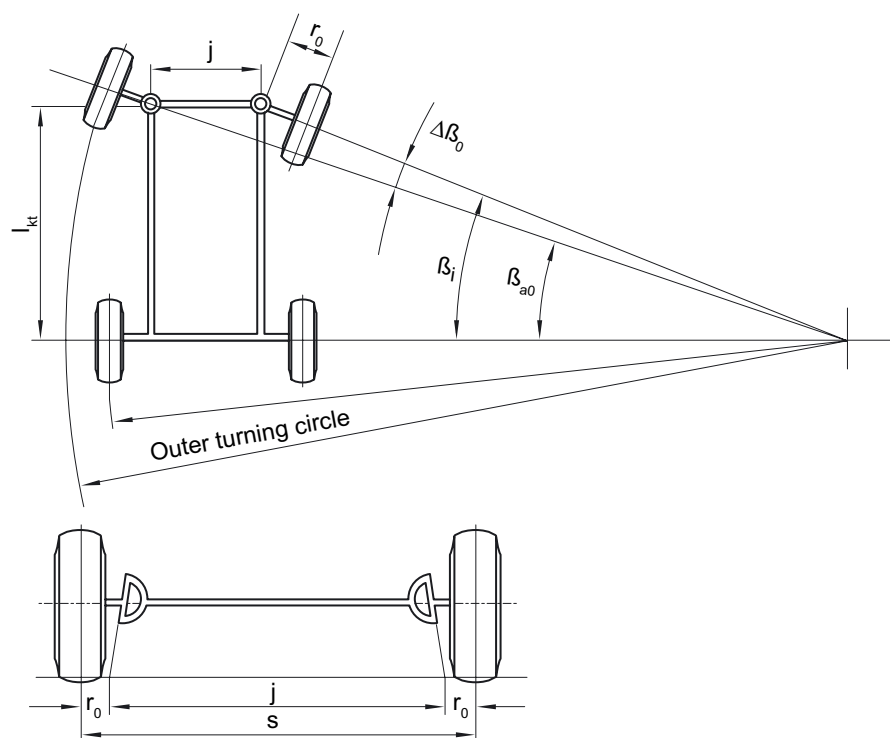
Example:

Vehicle:	Model H06 18.350 4x2 BL
Wheelbase:	l_{kt} = 3.900 mm
Front axle:	Model VOK-09
Tyres:	315/80 R 22.5
Rims:	22.5 x 9.00
Track width:	s = 2.048 mm
Scrub radius:	r_0 = 49 mm
Inner steer angle:	β_i = 49,0°
Outer steer angle:	β_a = 32°45' = 32,75°

1. Distance between steering axes

$$j = s - 2 \cdot r_0 = 2048 - 2 \cdot 49$$
$$j = 1950$$

2. Theoretical value for outer steer angle

$$\cot\beta_{ao} = \cot\beta_i + \frac{j}{l_{kt}} = 0,8693 + \frac{1950}{3900}$$

$$\cot\beta_{ao} = 1,369$$

$$\beta_{ao} = 36,14°$$

3. Steering deviation

$$\beta_F \;=\; \beta_a - \beta_{ao} \;=\; 32{,}75° - 36{,}14° \;=\; -3{,}39°$$

4. Turning circle radius

$$r_s \;=\; \frac{3900}{\sin 36{,}14°} + 49 - 50 \cdot (-3{,}39°)$$

$$r_s \;=\; 6831 \text{ mm}$$

9.10 Axle load calculation

9.10.1 Performing an axle load calculation

To optimise the vehicle and achieve the correct superstructure ratings, an axle load calculation is essential. The body can be matched properly to the truck only if the vehicle is weighed before any body building work is carried out. The weights obtained in the weighing process are to be included in the axle load calculation.

The following section will explain an axle load calculation. The moment theorem is used to distribute the weight of the equipment to the front and rear axles. All distances are with respect to the theoretical front axle centreline. For ease of understanding, weight is not used in the sense of weight force (in N) in the following formulae but in the sense of mass (in kg).

Example:

A 400 litre tank is to be installed instead of a 140 litre tank.
A calculation of the weight distribution between the front and rear axles is required.

Difference in weight:	ΔG	=	400 - 140 = 260 kg
Distance from theoretical front axle centreline		=	1.600 mm
Theoretical wheelbase	l_t	=	4.500 mm

Fig. 104: Axle load calculation: Tank layout ESC-550
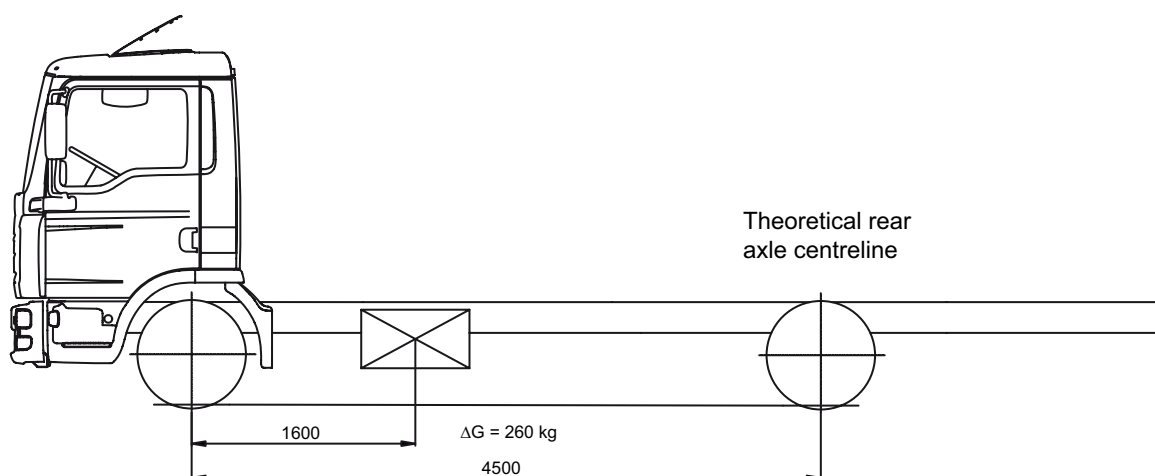
Solution:

Formula 42:   Rear axle weight difference:

$$\Delta G_H = \frac{\Delta G \cdot a}{l_t}$$

$$= \frac{260 \cdot 1600}{4500}$$

$$\Delta G_H = 92 \text{ kg}$$

Formula 43:   Front axle weight difference:

$$\Delta G_V = \Delta G \cdot \Delta G_H$$

$$= 260 - 92$$

$$\Delta G_V = 168 \text{ kg}$$

Rounding up or down to whole kilograms is sufficient in practice. Attention should be paid to the mathematically correct symbol, to which the following rule applies:

- Dimensions
  - all distances/clearances that are IN FRONT OF the theoretical front axle centreline have a MINUS sign (-)
  - all distances that are BEHIND the theoretical front axle centreline have a PLUS sign (+)
- Weights
  - all weights that are ADDED TO the vehicle have a PLUS sign (+)
  - all equipment weights that are REMOVED FROM the vehicle have a MINUS sign (-)

Example – Snowplough plate:

Weight:	ΔG	=	120 kg
Distance from first axle centreline:	a	=	-1.600 mm
Theoretical wheelbase:	l_t	=	4.500 mm

A calculation of the weight distribution to the front and rear axle is required.

Rear axle:

$$\Delta G_H = \frac{\Delta G \cdot a}{l_t} = \frac{120 \cdot (-1600)}{4500}$$

$$\Delta G_H = -43 \text{kg, the weight on the rear axle is reduced.}$$

Front axle:

$$\Delta G_V = \Delta G - \Delta G_H = 120 - (-43)$$

$$\Delta G_V = 163 \text{ kg, the weight on the front axle is increased.}$$

The following table shows an example of a full axle load calculation. In this example, two variants are compared (for variants see Table 29.

Table 29:   Example of an axle load calculation

<table>
<tr><td colspan="9">AXLE LOAD CALCULATION
MAN - Truck & Bus AG, Postf. 500620, 80976 Munich</td></tr>
<tr><td colspan="9">
Dpt.   :ESC   Vehicle, cab   :   TGL 8.210 4x2 BB   2006-12-20
Compiled by   :   Wheelbase   :   3600   Calc. - no.   :   N03..........
Code   :   W - tech.   :   3600   KSW - no.   :
Tel.   :   Overhang   :   1275 = Serie   AE - no.   :
                             Overhang   :   = Sonder   Veh. - no   :
                             Overhang tech.   :   1275   File-no.   :
VN   :   Vec.-drg. no.   :   81.99126.0186   ESC-no.   :
Customer   :   Body   :   3.800mm loading platform and rear-mounted crane -
Location   :   rigidly fixed, total crane moment approx. 67 kNm
</td></tr>
<tr>
<td rowspan="2">Name</td>
<td>Dist. from techn.</td>
<td colspan="3">Weight distribution to</td>
<td>Dist. from techn.</td>
<td colspan="3">Weight distribution to</td>
</tr>
<tr>
<td>FA-centre</td><td>FA</td><td>RA</td><td>Total</td>
<td>FA-centre</td><td>FA</td><td>RA</td><td>Total</td>
</tr>
<tr><td>Chassis with driver, tools and spare wheel</td><td></td><td>2.610</td><td>875</td><td>3.485</td><td></td><td>2.610</td><td>875</td><td>3.485</td></tr>
<tr><td>Trailer coupling</td><td>4.875</td><td>-12</td><td>47</td><td>35</td><td>4.875</td><td>-12</td><td>47</td><td>35</td></tr>
<tr><td>High-mounted exhaust pipe, left</td><td>480</td><td>30</td><td>5</td><td>35</td><td>480</td><td>30</td><td>5</td><td>35</td></tr>
<tr><td>Seat for driver, comfort</td><td>-300</td><td>16</td><td>-1</td><td>15</td><td>-300</td><td>16</td><td>-1</td><td>15</td></tr>
<tr><td>Fuel tank steel, 150 ltr. (Serie 100 ltr.)</td><td>2.200</td><td>27</td><td>43</td><td>70</td><td>2.200</td><td>27</td><td>43</td><td>70</td></tr>
<tr><td></td><td>4.925</td><td>-4</td><td>14</td><td>10</td><td>4.925</td><td>-4</td><td>14</td><td>10</td></tr>
<tr><td>Fender plastic   RA</td><td>3.600</td><td>0</td><td>25</td><td>26</td><td>3.600</td><td>0</td><td>25</td><td>25</td></tr>
<tr><td></td><td>2.905</td><td>4</td><td>16</td><td>20</td><td>2.905</td><td>4</td><td>16</td><td>20</td></tr>
<tr><td>Power take-off and pump</td><td>1.500</td><td>11</td><td>4</td><td>15</td><td>1.500</td><td>11</td><td>4</td><td>15</td></tr>
<tr><td>Tyres RA 225/75 R 17,5</td><td>3.600</td><td>0</td><td>10</td><td>10</td><td>3.600</td><td>0</td><td>10</td><td>10</td></tr>
<tr><td>Tyres FA 225/75 R 17,5</td><td>0</td><td>5</td><td>0</td><td>5</td><td>0</td><td>5</td><td>0</td><td>5</td></tr>
<tr><td></td><td>4.875</td><td>-11</td><td>41</td><td>30</td><td>4.875</td><td>-11</td><td>41</td><td>30</td></tr>
<tr><td>Seat bench</td><td>-300</td><td>22</td><td>-2</td><td>20</td><td>-300</td><td>22</td><td>-2</td><td>20</td></tr>
<tr><td>Stabilisator RA</td><td>3.900</td><td>-3</td><td>33</td><td>30</td><td>3.900</td><td>-3</td><td>33</td><td>30</td></tr>
<tr><td>Other</td><td>1.280</td><td>29</td><td>16</td><td>45</td><td>1.280</td><td>29</td><td>16</td><td>45</td></tr>
<tr><td>Oil tank</td><td>1.559</td><td>60</td><td>45</td><td>105</td><td>1.559</td><td>60</td><td>45</td><td>105</td></tr>
<tr><td>Rear crane, arm folded down **</td><td>1.020</td><td>631</td><td>249</td><td>880</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Reinforcement in the crane area</td><td>1.100</td><td>31</td><td>14</td><td>45</td><td>1.100</td><td>31</td><td>14</td><td>45</td></tr>
<tr><td>Subframe u. Kippbrücke</td><td>3.250</td><td>90</td><td>840</td><td>930</td><td>3.250</td><td>90</td><td>840</td><td>930</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Rear crane, arm craned ***</td><td></td><td></td><td></td><td></td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td></td><td></td><td></td><td></td><td>1.770</td><td>447</td><td>433</td><td>880</td></tr>
<tr><td></td><td></td><td></td><td></td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td></td><td></td><td></td><td></td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

Chassis - unladen weight		3.540	2.275	5.815		3.357	2.458	5.815
Permissible loads		3.700	5.600	7.490		3.700	5.600	7.490
Difference between unladen weight & perm. loads		160	3.325	1.675		343	3.142	1.675
Centre of gravity for payload and FA fully laden X1 =	344	160	1.515	1.675	738	343	1.332	1.675
body with respect to RA fully laden X2 =	-3.547	-1.650	3.325	1.675	-3153	-1467	3.142	1.675
techn. RA centreline actual X3 =	250	116	1.559	1.675	250	116	1.559	1.675
Axel overload		-44	-1766			-227	-1.583	
Loss of payload through axle overload				0				0
With even loading there remains		116	1559	1675		116	1.559	1.675
Payload	0	0	0	0	0	0	0	0
Vehicle laden		3.656	3834	7490		3473	4.017	7.490
Axle or vehicle loading		98,8%	68,5%	100,0%		93,9%	71,7%	100,0%
Axle load distribution		48,8%	51,2%	100,0%		46,4%	53,6%	100,0%
Vehicle unladen		3540	2275	5815		3357	2458	5815
Axle or vehicle loading		95,7%	40,6%	77,6%		90,7%	43,9%	77,6%
Axle load distribution		60,9%	39,1%	100,0%		57,7%	42,3%	100,0%
Vehicle overhang 47,2 %								
*** Crane arm rests to the rear (relieves load on FA!!)								
Observe the weight tolerances acc. to DIN 70020 Information supplied withour liability								

9.10.2 Calculation of weight with trailing axle lifted

The weights given for trailing axle vehicles in the MANTED® system (www.manted.de) and other technical documents have been calculated with the trailing axle lowered. Distribution of the axle loads to the front and driven axle after the trailing axle has been lifted is easy to determine by calculation.

Weight on the 2nd axle (driven axle) with the 3rd axle (trailing axle) lifted.

Formula 44: Weight on the 2nd axle with 3rd axle lifted

$$G_{2an} = \frac{G_{23} \cdot l_t}{l_{12}}$$

Where:

G_{2an}	=	Unladen weight on the 2nd axle with the 3rd axle lifted, in [kg]
G_{23}	=	Unladen weight on the 2nd and 3rd axles, in [kg]
l_{12}	=	Wheelbase between 1st and 2nd axles, in [mm]
l_t	=	Theoretical wheelbase, in [mm]

Weight on the front axle with the 3rd axle (trailing axle) lifted:

Formula 45: Weight on the 1st axle with the 3rd axle lifted

$$G_{1an} = G - G_{2an}$$

Where:

G_{1an} = Unladen weight on the 1st axle with the trailing axle lifted, in [kg]
G = Unladen weight of the vehicle, in [kg]

Example:

Vehicle: Model H21 TGA 26.400 6x2-2 LL
Wheelbase: 4.800 + 1.350
Frame overhang: 2.600
Cab: XXL

Unladen weight with the trailing axle lowered:

Front axle G_{1ab} = 5.100 kg

Drive and trailing axle G_{23} = 3.505 kg

Unladen weight G = 8.605 kg

Permissible axle loads: 7.500 kg / 11.500 kg / 7.500 kg

Solution:

1. Calculation of the theoretical wheelbase (see „General" Chapter):

$$l_t = l_{12} + \frac{G_3 \cdot l_{23}}{G_2 + G_3}$$

$$l_t = 4.800 + \frac{7.500 \cdot 1.350}{11.500 + 7.500}$$

$$l_t = 5.333 \text{ mm}$$

2. Calculation of the unladen weight of the 2nd axle (= driven axle) with the 3rd axle (= trailing axle) lifted:

$$G_{2an} = l_{12} + \frac{G_{23} \cdot l_t}{l_{12}} = \frac{3.505 \cdot 5.333}{4.800}$$

$$G_{2an} = 3.894{,}2 \text{ kg}$$

3. Calculation of the unladen weight of the 1st axle (+ front axle) with the 3rd axle (= trailing axle) lifted:

$$G_{1an} = G - G_{2an}$$

$$G_{1an} = 8.605 - 3.894{,}2$$

$$G_{1an} = 4.710{,}8 \text{ kg}$$

9.11   Support length for bodies without subframes

The calculation of the required support length in the following example does not take all influences into account.
However, it does show one option and provides some good reference values for practical applications.

The support length is calculated using the following:

Formula 46:   Formula for support length when no subframe is used

$$l \; = \; \frac{0{,}175 \cdot F \cdot E \, (r_R + r_A)}{\sigma_{0,2} \cdot r_R \cdot r_A}$$

If the frame and support are made of different materials, then the following applies:

Formula 47:   Modulus of elasticity in the case of different materials

$$E \; = \; \frac{2E_R \cdot E_A}{E_R + E_A}$$

Where:

l	=	Support length for each support, in [mm]
F	=	Force per support, in [N]
E	=	Modulus of elasticity, in [N/mm²]
r_R	=	External radius of frame longitudinal member profile section, in [mm]
r_A	=	External radius of support profile section, in [mm]
$\sigma_{0,2}$	=	Yield point of the lower value material, in [N/mm²]
E_R	=	Modulus of elasticity of frame longitudinal member profile section, in [N/mm²]
E_A	=	Modulus of elasticity of support profile section, in [N/mm²]

Example:

Interchangeable body chassis H21 TGA 26.400 6x2-2 LL, wheelbase 4,500 + 1,350, large-capacity cab,
permissible gross weight 26,000 kg, chassis unladen weight 8,915 kg.

Solution:

For payload and body there remains approx.	26.000 kg – 8.915 kg = 17.085 kg
For each support if there are 6 bearing points on the chassis	17.085: 6 = 2.847 kg
Force	F = 2.847 kg • 9,81 kg • m/s² = 27.933 N
External radius of frame profile section	r_R = 18 mm
External radius of support profile section	r_A = 16 mm
Modulus of elasticity for steel	E = 210.000 N/mm²
Yield point for both materials	$\sigma_{0,2}$ = 420 N/mm²

Formula 46 can then be used to determine the approximate minimum length for every support:

$$l \; = \; \frac{0{,}175 \cdot 27.933 \cdot 210.000 \cdot (18+16)}{430^2 \cdot 18 \cdot 16}$$

$$l \; = \; 655 \text{ mm}$$

9.12 Coupling devices

9.12.1 Trailer coupling

The required trailer coupling size is determined by the D value.

The formula for the D value is as follows:

Formula 48:   D value

$$D = \frac{9{,}81 \cdot T \cdot R}{T + R}$$

D	=	D value, in [kN]
T	=	Permissible gross weight of the towing vehicle, in [t]
R	=	Permissible gross weight of the trailer, in [t]

Example:

Vehicle   TGA H05 18.460 4x2 BL

Permissible gross weight   18,000 kg = T = 18 t

Trailer load   26,000 kg = R = 26 t

D value:

$$D = \frac{9{,}81 \cdot 18 \cdot 26}{18 + 26}$$

D   =   104 kN

If the trailer gross weight R and the D value of the coupling device are specified, the permissible gross weight of the towing vehicle T can be determined using the following formula:

$$T = \frac{R \cdot D}{(9{,}81 \cdot R) - D}$$

If the permissible gross weight of the towing vehicle T and the D value of the coupling device are specified, the maximum permissible trailer load R can be determined using the following formula:

$$R = \frac{T \cdot D}{(9{,}81 \cdot T) - D}$$

9.12.2 Rigid drawbar trailers / central axle trailers

Other conditions apply for the rigid drawbar and central axle trailers in addition to the D value. Trailer couplings and end cross members have lower trailer loads because in this case the nose weight acting on the trailer coupling and the end cross member has to be taken into account.

In order to harmonise the regulations within the European Union, the terms D_c value and V value were introduced with Directive 94/20/EC:

The following formulae apply:

Formula 49: D_C value formula for rigid drawbar and central axle trailers

$$D_C = \frac{9,81 \cdot T \cdot C}{T + C}$$

Formula 50: V value formula for central axle and rigid drawbar trailers with a permissible nose weight of < 10 % of the trailer mass and not more than 1,000 kg

$$V = a \cdot \frac{X^2}{l_2} \cdot C$$

If the values for x^2/l^2 have been calculated as < 1, a value of 1.0 is to be used.

Where:

D_C	=	Lower D value when operating with a central axle trailer, in [kN]
T	=	Permissible gross weight of the towing vehicle, in [t]
C	=	Sum of the axle loads of the central axle trailer loaded with the permissible mass, in [t] ,not including nose weight S
V	=	V value, in [kN]
a	=	Reference acceleration in the coupling point, in m/s2. Two values are to be used: 1.8 m/s2 for air suspension or comparable suspension on the towing vehicle, and 2.4m/s2 on all other vehicles
x	=	Length of trailer body, see Fig. 105
l	=	Theoretical drawbar length, see Fig. 105
S	=	Nose weight of the drawbar on the coupling point, in [kg]

Fig. 105: Length of the trailer body and theoretical drawbar length (see also booklet „Coupling devices") ESC-510
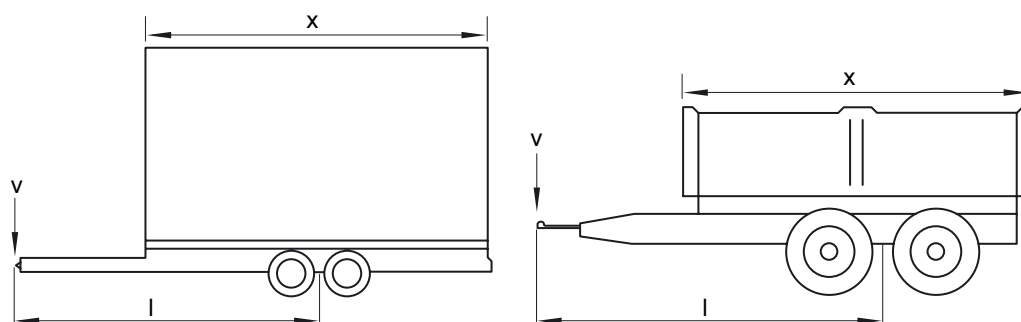
Example:

Vehicle:	Model N13 TGL 8.210 4x2 BL
Permissible gross weight	7.490 kg = T = 7,49 t
Trailer:	
Sum of the trailer axle loads:	11.000 kg = C = 11 t
Nose weight:	S = 700 kg
Length of body:	x = 6,2 m
Theoretical drawbar length:	l = 5,2 m

Question: Can both vehicles be used in combination as a road train if the reinforced end cross member and the Ringfeder 864 trailer coupling are fitted to the truck?

Solution:

D_C value:

$$D_C = \frac{9,81 \cdot T \cdot C}{T + C} = \frac{9,81 \cdot 7,49 \cdot 11}{7,49 + 11}$$

$$D_C = 43,7 \text{ kN}$$

D_C value for end cross member = 64kN (see booklet „Coupling devices TG", Table 2)

$$\frac{x^2}{l^2} = \frac{6,2^2}{5,2^2} = 1,42$$

$$V = a \frac{x^2}{l^2} \cdot C = 1,8 \cdot 1,42 \cdot 11 \text{ (1,8 at air suspension rearaxel)}$$

$$V = 28,12 \text{ kN}$$

V value for end cross member = 35 kN (see bokklet „Coupling devices TG", Table 2)

Both vehicles can be combined to form a road train; however, the minimum front axle load of 30 % of the respective vehicle weight (including nose weight) must be observed in accordance with the General technical basics in the TGL/TGM Guide to Fitting Bodies.

An unladen truck may pull only an unladen central axle trailer.

9.12.3 Fifth-wheel coupling

The required fifth-wheel coupling size is determined by the D value. The D value formula for fifth-wheel couplings is as follows:

Formula 51:   D value for fifth-wheel coupling

$$D = \frac{0,6 \cdot 9,81 \cdot T \cdot R}{T + R - U}$$

If the D value is known and the permissible gross weight of the semitrailer is sought, the following applies:

Formula 52:   Permissible gross weight of the semitrailer

$$R = \frac{D \cdot (T - U)}{(0,6 \cdot 9.81 \cdot T) - D}$$

If the permissible gross weight of the semitrailer and the D value of the fifth-wheel coupling are specified, the permissible gross weight of the tractor unit can be calculated with the following formula:

Formula 53:   Permissible gross weight of the tractor unit

$$T = \frac{D \cdot (R - U)}{(0,6 \cdot 9.81 \cdot R) - D}$$

If the fifth-wheel load is sought and all other loads are known, the following formula can be used:

Formula 54: Formula for fifth-wheel load

$$U = T + R - \frac{0,6 \cdot 9,81 \cdot T \cdot R}{D}$$

Where:

D	=	D value, in [kN]
R	=	Permissible gross weight of the semitrailer in [t], including the fifth-wheel load
T	=	Permissible gross weight of the tractor unit in [t], including the fifth-wheel load
U	=	Fifth-wheel load, in [t]

Example:

Tractor unit:	TGA 18.390 4x2 LL
Fifth wheel load, in accordance with trailer type plate:	U = 10.750 kg = 10,75 t
Permissible gross weight of the tractor unit:	18.000 kg = T = 18 t
Permissible gross weight of the semitrailer:	32.000 kg = R = 32 t

D value:

$$D = \frac{0,6 \cdot 9,81 \cdot 18 \cdot 32}{18 + 32 - 10,75}$$

$$D = 86,38 \text{ kN}$$